Intended for

Illinois Power Generating Company
134 Cip Lane
Coffeen, Illinois 62017

Date
April 1, 2025

Project No.
1940110241-001

CORRECTIVE ACTION PLAN

ILLINOIS POWER GENERATING COMPANY, COFFEEN POWER PLANT, ASH POND NO. 2, IEPA ID NO. W1350150004-02

Bright ideas. Sustainable change.

CORRECTIVE ACTION PLAN ILLINOIS POWER GENERATING COMPANY, COFFEEN POWER PLANT, ASH POND NO. 2, IEPA ID NO. W1350150004-02

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Description	**Corrective Action Plan for 35 I.A.C. § 845**

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APPENDICES

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
AP1	Ash Pond No. 1
AP2	Ash Pond No. 2 (“the site”)
CA GMP	Corrective Action Groundwater Monitoring Plan
CAAA	Corrective Action Alternatives Analysis
CAAA-SIR	Corrective Action Alternatives Analysis Supporting Information Report
CAP	Corrective Action Plan
CCR	coal combustion residuals
CIP	closure-in-place
CMA	Corrective Measures Assessment
cm/s	centimeters per second
COC	constituent of concern
COI	contaminant of interest
CP	Construction Permit
CPP	Coffeen Power Plant
DA	deep aquifer
DCU	deep confining unit
Gradient	Gradient Corporation
GWE	groundwater extraction
GWP	groundwater polishing
GWPS	groundwater protection standard(s)
HCR	Hydrogeologic Site Characterization Report
HDPE	high-density polyethylene
ID	identification
IEPA	Illinois Environmental Protection Agency
in/yr	inches per year
ILWATER	Illinois Water and Related Wells (ILWATER)
IPGC	Illinois Power Generating Company
ISGS	Illinois State Geological Survey
kV	kilovolt
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
PMP	potential migration pathway
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

Illinois Power Generating Company (IPGC) is the owner of the inactive coal-fired Coffeen Power Plant (CPP), also referred to as the Coffeen Power Station, in Coffeen, Montgomery County, Illinois. This Corrective Action Plan (CAP) has been prepared for Ash Pond number (No.) 2 (AP2) at the CPP (site). Groundwater corrective action for AP2 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 coal combustion residuals (CCR) Rule [2]. AP2 is identified by Illinois Environmental Protection Agency (IEPA) identification (ID) No. W1350150004-02, CCR Unit ID No. 102, and National Inventory of Dams No. IL50723.

1.2 Organization of the Corrective Action Plan

This CAP is organized in the following manner:

- **Section 1** includes an introduction to AP2, 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 Corrective Action Construction Permit Application, as required by 35 I.A.C. § 845.220(a) and (c).

1.3 Permit Status

An Operating Permit (OP) application, as required by 35 I.A.C. § 845.230, was submitted on to IEPA by IPGC on October 25, 2021 [3]. As of the date of this CAP, IPGC's OP for AP2 is pending with IEPA.

1.4 Closure and Source Control Status

IPGC completed significant source control in 2020 as part of final closure of AP2 [4]. The final closure was performed in accordance with the Closure and Post-Closure Care Plan [5] that was developed in accordance with 40 C.F.R. § 257 and approved by IEPA on January 30, 2018 [6].

The AP2 closure construction included closure-in-place (CIP) of the entire AP2 and installation of an alternative geomembrane cover system. This was accomplished by constructing a final cover system that complies with 40 C.F.R. § 257.102 to minimize water infiltration into the closed AP2 and improve surface water drainage off the cover system, thus reducing generation of potentially impacted water and ultimately reducing the extent of CCR impacts to groundwater. The source control was predicted to lower water levels and decrease the potential transport of CCR constituents away from AP2 [7]. These completed source control activities will serve as the primary groundwater corrective measure at AP2. The remedy presented within this CAP is intended to be supplementary to the primary remedy, which is the completed source control.

1.5 Selected Corrective Action Remedy

A horizontal groundwater extraction (GWE) well, combined with the source control completed in 2020 [4] as presented within the Final Closure Plan [5], has been identified as the most appropriate remedy for AP2, based on the CAAA provided in **Appendix A**. Potential remedies evaluated in the CAAA included source control with groundwater polishing (GWP), source control with upgradient barrier wall and GWE trench, and source control with horizontal GWE well.

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 [8] is also attached to the CAAA. This report presents results from geochemical modeling of exceedance[1] parameters addressed at AP2 by the CAP. Geochemical modeling supports the assessment of GWP 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 groundwater protection standards (GWPS) estimated in the flow and transport model.

1.5.1 Narrative Description of Selected Corrective Action Remedy

Corrective action will consist of the completed source control (see **Section 1.4**) and the construction and operation of a horizontal GWE well beneath the eastern portion of AP2, which will serve to collect CCR-impacted groundwater. This will reduce, to the maximum extent feasible, further releases of constituents listed in 845.600 in accordance with 845.670(d)(3).

The horizontal GWE well will be continuously operated during the corrective action period, outside of routine shutdowns for maintenance and/or power outages. Groundwater corrective action performance will be monitored in accordance with the Corrective Action Groundwater Monitoring Plan (CA GMP). Estimated timelines for horizontal GWE well system operation and times to reach 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 Groundwater Monitoring and Corrective Action Report, in accordance with the Corrective Action Groundwater Monitoring Plan (CA GMP). The horizontal GWE well will be operated continuously until monitoring wells attain the GWPS and a determination has been made that COCs will not rebound above the GWPS after the system is removed from operation. Monitoring, groundwater modeling, and adaptive site management practices presented in the corrective action groundwater monitoring plan describe how stability in groundwater data will be evaluated before assessing if compliance with the GWPS has been attained to allow any transient effects of treatment on the groundwater (*e.g.,* rebounding concentrations) to dissipate.

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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 GWPSs as described in the proposed groundwater monitoring program, which was submitted to the IEPA on October 25, 2021 as part of IPGC’s operating permit application for COF AP2. That operating permit application, including the proposed groundwater monitoring program, remains under review by the IEPA and, therefore, IPGC has not identified any actual exceedances

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).

1.5.1.1 Narrative Discussion of Remedy Design and Function

The horizontal GWE design includes one horizontal well installed along an approximately 1,300-foot alignment which will be initiated from the south end of the AP2 at the base of the existing berm and run north under AP2 (*i.e.,* intersecting or perpendicular to the existing groundwater flow direction) at an approximate depth which coincides with the expected base of the CCR/native soil interface. Permit-level engineering drawings depicting the proposed remedy are provided in **Appendix B** and a list of key design components includes the following:.

- The well will extend from the south end of AP2 at the base of the existing berm. The target elevation for the well is the bottom of CCR/top of the uppermost aquifer (UA) interface, which his expected to range from 600 to 606 feet[2] along the well alignment.
- The well casing will consist of slotted well screen over two targeted collection areas (expected to be around 400 feet total in length), with solid sections for areas where collection of liquids is not required.
- Following installation, the well will be developed to remove remaining drilling mud/solids. Water will be managed and discharged in accordance with applicable permits.
- The entry point will be sealed with grout to reduce surface water infiltration into the well, and a concrete pad will be constructed at the exit point of the well.

Electrical and piping infrastructure to support the horizontal GWE well system will be installed. The infrastructure is expected to include:

- A shed structure to be constructed at the extraction well vault pad. The structure will house: a well vault; an air compressor to power a submersible pneumatic pump; and a shut-off valve, sample port, and flow totalizer to measure the extracted water.
- Piping will be used to convey groundwater from the extraction well sump for treatment, as needed, prior to discharge in accordance with applicable permits. This will include the installation of miscellaneous electrical controls to support data collection and system operation.

1.5.2 Narrative Description of Proposed Remedy Operations

Operations, Monitoring, and Maintenance (OMM) will be conducted on the horizontal GWE well system on a routine basis. OMM will consist of tracking the totalized flow to evaluate the flow/extraction rates from the horizontal well, and routine maintenance on system components. Waste streams associated with the horizontal GWE well system and its management may include:

- Conveyance piping will be flushed periodically as solids accumulation is observed as part of routine OMM inspections.

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

- If needed, the horizontal well will be re-developed as part of OMM inspections, likely using flushing or another technique to remove solids.

Routine equipment maintenance will be conducted per recommendations provided by the horizontal well and associated infrastructure components' manufacturers. Equipment will be replaced as needed to keep the horizontal GWE well system operating within design specifications. Equipment maintenance and/or replacement may require temporary shutdown of the horizontal GWE well system.

1.5.3 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 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(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 strategies will be employed as an integral part of ongoing CA. The adaptive site management approach will allow timely incorporation of new site information to ensure the achievement of the GWPS. The effectiveness of the remedy at each phase is evaluated using performance metrics designed to assess the goals of that phase. Performance metrics answer questions designed to evaluate multiple aspects of remedy effectiveness with the ultimate goal of holistically guiding management decisions [7]. The goals and performance metrics of each phase of remedy evaluation are presented in Section 3 of the CA GMP included in the CP application.
- Documentation of remedy progress metrics will be provided in the Annual Groundwater Monitoring and CA Report beginning after the second year of data collection: a minimum of eight data points is required to complete meaningful statistical analysis required for evaluation of the remedy progress metrics, which will be available after two years of quarterly sampling. Per USEPA guidance [9], a thorough review of CA progress and remedy effectiveness will be conducted every five years. A Five-Year Annual Groundwater Monitoring and CA Report will evaluate the comprehensive data set and, if triggered by the results of the remedy progress evaluation metrics, evaluate whether adaptive management actions are needed. The five-year time frame allows adaptive management decisions to be based on a robust data sufficient to

complete meaningful statistical analysis while remaining responsive to changing site conditions [9].

- 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 "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).
  - 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 most appropriate alternative for AP2 that, when coupled with the source control previously completed as proposed in the Final Closure Plan [5], would remediate groundwater and provide compliance with the GWPS specified under 35 I.A.C. § 845.600.

2.1 Corrective Measures Assessment

The CMA [10] was performed for AP2 and submitted to the IEPA on June 12, 2024, after the exceedances of the GWPS were identified. The CMA considered four corrective measures for AP2, including:

- Source control with GWP;
- Source control with GWE;
- Source control with groundwater cutoff wall; and
- Source control with in-situ chemical treatment

Based on the CMA, three corrective measures, including source control with GWP, source control with GWE, and source control with groundwater cutoff wall were identified as potentially viable corrective measures for AP2. Of these measures, source control with GWP, source control with GWE, and source control with groundwater cutoff wall were included for further evaluation, design advancement, and comparative assessment within the CAAA. The source control with groundwater cutoff wall was expanded to also include GWE. Additionally, the source control with GWE remedy was further defined as the horizontal GWE well remedy as presented in this CAP. Additional information on these refinements are discussed in the CAAA provided in **Appendix A**.

2.2 Analysis of Corrective Action Alternatives

2.2.1 Corrective Action Alternatives Analysis Supporting Information Report

The CAAA for AP2 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 with GWP, source control with upgradient barrier wall and GWE trench, and source control with horizontal GWE well corrective measures identified as potentially viable for AP2 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.

2.2.2 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, source control with horizontal GWE well was identified as the most appropriate corrective action for AP2 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 with horizontal GWE well contained within the CAP should be considered to supersede 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 with horizontal GWE well 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 AP2 pose no risk to human health or the environment [11]. Concentrations of CCR-derived constituents are anticipated to decline once the horizontal GWE well active remedy is in place as presented in the CAAA (**Appendix A**). The horizontal well would drain water from beneath AP2 reducing hydraulic head beneath AP2, which would accelerate achieving GWPS.

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

Groundwater modeling indicates a horizontal GWE well (Appendix B of the CAAA-SIR, which is attached in **Appendix A**), which is selected as the remedy of this CAP, will result in attainment of the GWPS in the current monitoring system within 14 years.

> *(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;*

AP2 was closed using a closure-in-place approach, which is currently acting as the main control mechanism to prevent further releases of CCR-derived constituents. The horizontal GWE well will, to the maximum extent feasible, prevent further releases 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 and precipitation coming into contact with AP2 CCR prior to completion of the final closure. Surface water infiltration has been controlled, minimized, or eliminated as much as feasible with the final closure completed in 2020 [4]. The horizontal GWE well is designed to provide continuous hydraulic control and capture of groundwater to reduce the time to attain the GWPS. 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 AP2.

> *(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 corrective action (source control with horizontal GWE well) will be done in accordance with all 35 I.A.C. § 845 requirements and the submitted closure plan [5].

3.3 Schedule for Implementation

GWE via horizontal well is effective as an engineering control as it provides hydraulic control at the eastern boundary. GWE has been demonstrated as a reliable and applicable ex-situ remedial technology by the United States Environmental Protection Agency (USEPA) [12]. GWE via horizontal wells (or "directional wells") for remediation is accepted by the USEPA as an effective technology for extraction beneath landfills, interception of vertical features, and/or providing hydraulic control along the leading edge of a plume [12]**.** The horizontal GWE will continue to operate as the CA following source control until (1) GWPS have been met and (2) it has been determined that potential rebound above GWPS is not expected after operation of the GWE is ceased. Monitoring and adaptive site management practices presented in the corrective action groundwater monitoring plan will be used to determine when operations of the GWE will cease after the GWPS has been met. The corrective action groundwater monitoring plan describes how stability in groundwater data will be evaluated before assessing if compliance with the GWPS has been attained to allow any transient effects of treatment on the groundwater (*e.g.,* rebounding concentrations) to dissipate.

The horizontal GWE well remedy will successfully attain GWPS in a reasonable time as discussed in the following subsections. Timeframes to attain GWPS in the groundwater monitoring wells summarized in Table A indicate that 40% of progress is expected to occur within the first 5 years after remedy construction.

Table A. Estimated Timeframes to Attain GWPS Groundwater Monitoring Wells

Description	5 years**	10 years**	14 years**
Percentage of Wells predicted to attain GWPS*	40%	60%	100%

*: 5 wells were used in the 2025 Groundwater Modeling Technical Memorandum.

** Years counted starting from completion of corrective action.

35 I.A.C. § 845.670(f): 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 for implementing and completing the source control with horizontal GWE well remedy at AP2 is included in **Table 1**. The schedule was developed considering the factors required 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 [13], which was submitted to the IEPA on June 12, 2024 and is included as an attachment to the CAAA (**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 (**Appendix A**), and it was determined that the selected remedy (source control with horizontal GWE well) is expected to achieve compliance with 35 I.A.C. § 845.600 in a reasonable timeframe. The potential for remedial technologies to achieve compliance with the GWPS were evaluated using groundwater modeling [14]. The results of the modeling indicates that the groundwater in the UA groundwater unit will attain the GWPS for all constituents within approximately 14 years after remedy construction.

As discussed in the CMA, source control and GWE are proven methods for addressing groundwater contamination [10]. The previously completed closure-in-place approach (*e.g.,* source control) is consistent with the requirements of 40 C.F.R. § 257.

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 horizontal GWE well system is expected to result in the generation and management of a small volume of drill cuttings, which would contain CCR. CCR waste generated during implementation of the remedy would be placed into off-road dump trucks and hauled to the on-site landfill for disposal. The on-site landfill is expected to have sufficient capacity to dispose of the small volume of waste.

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 AP2 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 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.

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

The resource value of the aquifer is discussed in the Hydrogeologic Site Characterization Report (HCR), which is included as Appendix A in the Final Closure Plan [15]. The UA includes the sands, silty sands, and clays at the base of the Hagarstown Member and, in some locations, the uppermost weathered sandy clay portion of the Vandalia Member. This unit is absent in some locations at the CPP due to weathering and in others due to excavation during construction of the CCR units. The underlying lower confining unit (LCU) has been identified as a potential migration pathway (PMP) because downward vertical gradients indicate that there is the potential for impacts to migrate within this unit. Groundwater flows southeasterly below AP2 toward a historic process flume and an unnamed tributary leading to Coffeen Lake.

As set forth in 35 I.A.C. § 620.210, groundwater within the UA at AP2 meets the definition of Class I – Potable Resource Groundwater, as geologic material with a hydraulic conductivity of $1\text{x}10^{-4}$ centimeters per second (cm/s) or greater and located 10 feet or more below the land surface. This information was also considered in the CAAA as part of the Human Health and Ecological Risk Assessment, which concluded that groundwater from the AP2 impoundment and potential groundwater contributions to surface water pose no unacceptable risks to human health or the environment.

The source control with horizontal GWE well remedy will result in decline of concentrations of CCR-derived constituents in the UA and PMPs. No off-site migration of CCR-derived constituents is expected to occur. Groundwater polishing and adaptive site management following source control will function until the GWPS is achieved in accordance with the CA GMP. Paragraphs (A) through (F) from 35 I.A.C. § 845.670(f)(5) are further addressed, as summarized below.

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

Current uses and users of the groundwater are discussed in HCR Section 2.5 [15] and attachments and were considered in the CAAA as part of the Human Health and Ecological Risk Assessment which concluded that groundwater from the AP2 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 changes to current and future uses there is no applicable scheduling consideration.

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

A water well inventory was completed in 2017 for AP2 and in 2021 for Ash Pond No. 1 (AP1), which is located 350 feet south of AP2 [16]. In 2024, Gradient updated the 2017 well survey as part of the HHERA [11].

A search of the Illinois State Geological Survey (ISGS) Illinois Water and Related Wells (ILWATER) Map identified 19 wells located within 1,000 meters of AP2. The wells that were identified included 13 monitoring wells and six farm/domestic wells. There is one farm/domestic well (121352283200) located north of and side-gradient to AP2, and on the west side of the unnamed tributary to Coffeen Lake. The well, which was installed in 1981, is located near the former location of several prior residences. The well was removed during the construction of the Gypsum Management Facility Recycle Pond (GMF RP) in 2010. Additionally, the property in this area has been purchased by IPGC and no residents are currently living or using groundwater in the area. While there is no information available on the current use of the remaining five farm/domestic wells, they are located on the east/southeast side of Coffeen Lake's eastern branch and the unnamed tributary, *i.e.*, the opposite side of the lake from AP2. These surface water bodies are hydraulic boundaries that prevent shallow groundwater from flowing past or underneath them.

The assessment concluded there are no existing off-site water wells, potable or non-potable, that could potentially be impacted by groundwater from AP2. This information was also considered in the CAAA as part of the Human Health and Ecological Risk Assessment, which concluded that groundwater from the AP2 impoundment and potential groundwater contributions to surface water pose no unacceptable risks to human health or the environment. In the absence of changes in current and future uses, there is no applicable scheduling consideration for proximity and withdrawal rates of users.

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

Per 35 I.A.C. § 620.210, groundwater within the UA at AP2 meets the definition of Class I – Potable Resource Groundwater [15]. The Human Health and Ecological Risk Assessment (Appendix A in CAAA Report) concluded that groundwater from the AP2 impoundment and potential groundwater contributions to surface water pose no unacceptable risks to human health or the environment.

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

A comprehensive search of the IDNR Natural Heritage Database and Historic Preservation Division database was performed to identify nature preserves, endangered/threatened species and historic sites in the vicinity of AP2 was completed to address comments received from the IEPA on the Operating Permit [17]. The results of the survey indicated that no nature preserves, protected areas, or historic sites are present within 1,000 meters of the site.

A search of 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 contaminants of interest (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) [18], 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.

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

In addition to the CCR present at AP2, there are five principal layers of unlithified material present above the bedrock, which are categorized into the hydrostratigraphic units described below (from surface downward) based on stratigraphic relationships and common hydrogeologic characteristics:

- **Upper Confining Unit (UCU):** Composed of the Roxana and Peoria Silts (Loess Unit) and the upper clayey portion of the Hagarstown member which are classified as silts to clayey silts and gravelly clay below the surficial soil. Loess Unit thickness ranges from 0 feet (absent) to 16 feet and the clayey portion of the Hagarstown member is up to 6 feet thick. The UCU has been eroded east of AP2, near the unnamed tributary.
- **Uppermost Aquifer (UA)**: The UA is the Hagarstown Member which is classified as primarily sandy to gravelly silts and clays with thin beds of sands. Where present, the sandy portion of the Hagarstown is generally 2 to 4 feet thick. Similar to the Loess Unit, the Hagarstown is absent in some locations near the unnamed tributary. Hydraulic conductivity in the UA is moderate.
- **Lower Confining Unit (LCU):** Comprised of the Vandalia Member, Mulberry Grove Member, and Smithboro Member. These units include a sandy to silty till with thin, discontinuous sand lenses, a discontinuous and limited extent sandy silt which has infilled prior erosional features, and silty to clayey diamicton, respectively. The unit was encountered in all borings on the CPP. This LCU has been identified as a PMP because downward vertical gradients indicate that there is the potential for impacts to migrate within this unit despite very low permeability.
- **Deep Aquifer (DA):** Sand and sandy silt/clay units of the Yarmouth Soil, which include accretionary deposits of fine sediment and organic materials, typically less than 5 feet thick and discontinuous across the CPP. Where present, the DA has been identified as a potential PMP due to presence of downward gradients in the overlying LCU and the relatively greater hydraulic conductivities measured in the DA. Hydraulic conductivity in the DA is moderate.
- **Deep Confining Unit (DCU):** Comprised of the Banner Formation, and generally consists of clays, silts, and sands. The Lierle Clay Member is the upper layer of the Banner Formation which was encountered at the Site. No boring locations penetrated the full thickness of the Lierle Clay.

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 report and Groundwater Polishing Evaluation Report, attached to the CAAA-SIR and CAAA, respectively, included in **Appendix A**, which estimate the time to reach the GWPS for remedial alternatives.

The horizontal GWE well remedy will drain water from beneath AP2, reducing hydraulic head beneath AP2, which will accelerate achieving GWPS. The horizontal GWE well will be operated continuously until monitoring wells attain the GWPS and a determination has been made that COCs will not rebound above the GWPS after the system is removed from operation.

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

As discussed in subsection 670(f)(5)(B), there are 19 water wells within 1,000 meters of AP2 [16]. There is currently no need for an alternative water supply well as there are no current unacceptable risks to human or ecological receptors at the site. There are no applicable schedule concerns regarding the availability of alternative water supplies.

3.3.1 Other Relevant Factors

<u>35 I.A.C. § 845.670(f)(6):</u> Other relevant factors.

No additional factors were identified for consideration.

3.4 Necessity of Interim Measures

Source control using the closure-in-place approach was completed in 2020 [4]. Completion of the horizontal GWE well remedy is projected to be complete within four to six years after approval of the CAP. 35 I.A.C § 845.680(a)(3) states the owner or operator must take any interim measures necessary to reduce the contaminants leaching from the CCR surface impoundment, and/or potential exposures to human or ecological receptors. Because source control has already been completed and current conditions at AP2 pose no risk to human health or the environment, no interim measures are required. Further, all subsections of this requirement are discussed as follows.

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

Completion of the horizontal GWE well remedy is projected to be complete within four to six years after approval of the CAP.

<u>35 I.A.C. § 845.680(a)(3)(B)</u>: 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 (**Appendix A**). It was concluded that shallow groundwater and surface water are not a source of drinking water [11].

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

The nature and extent of exceedances have been evaluated in the Nature and Extent Report [13]. Although there are exceedances of GWPS, there are no impacts to 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, and no unacceptable risks were identified for ecological receptors exposed to surface water and sediment [11]. No potential groundwater receptors are in the vicinity of AP2 [11].

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

Source control, which consisted of the closure-in-place approach, was completed [4] and no unacceptable risks to human health or the environment have been identified. No interim measure is expected to prevent further degradation of the groundwater more expeditiously than implementation of the selected remedy.

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, source control which consisted of the closure-in-place approach was completed in 2020 [4], which isolate CCR contained within AP2 from weather-related impacts that could cause CCR-related constituents to migrate or be released. There are no unacceptable risks presented by AP2 under current conditions 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.

There are no container or handling systems that pose a risk to receptors in the interim.

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 AP2 CCR leachate poses threats to human health and the environment.

4. REFERENCES

[1] "Illinois Administrative Code, Title 35, Subtitle G, Chapter I, Subchapter J, Part 845: Standards for The Disposal Of Coal Combustion Residuals In Surface Impoundments," effective April 21, 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] Burns & McDonnell Engineering Company, Inc., "Initial Operating Permit," Coffeen, IL, October 25, 2021.

[4] Luminant, "Coffeen Power Station; Ash Pond No. 2, Notification of Completion of Closure," 2020.

[5] AECOM, "Closure and Post-Closure Care Plan for the Coffeen Ash Pond No. 2 at Illinois Power Generating Company Coffeen Power Station," 2017.

[6] Illinois Environmental Protection Agency, "Re: Coffeen Power Station W1350150004 Montgomery County, Illinois," Coffeen, IL, January 30, 2018.

[7] Natural Resource Technology, "Groundwater Modeling Report, Ash Pond 2, Coffeen Power Station, Coffeen, Illinois," 2017.

[8] Geosyntec Consultants, Inc., "Groundwater Polishing Evaluation Report Coffeen Power Station - Ash Pond No. 2 (EPA ID No. 102)," Coffeen, IL, 2025.

[9] United States Environmental Protection Agency, "Groundwater Remedy Completion Strategy: Moving Forward with the End in Mind," Office of Solid Waste and Emergency Response, 2014.

[10] Ramboll Americas Engineering Solutions, "35 I.A.C § 845 Corrective Measures Assessment, Coffeen Power Plant, Ash Pond No. 2, IEPA ID No. W135015004-02," Coffeen, IL, June 12, 2024.

[11] Gradient Corp, Human Health and Ecological Risk Assessment, Ash Pond No. 2, Coffeen Power Plant, Coffeen, IL, June 14, 2024.

[12] USEPA, "Federal Remediation Technologies Roundtable, Technology Screening Matrix - Directional Wells," [Online]. Available: https://www.frtr.gov/matrix/Directional-Wells/. [Accessed 9 January 2025].

[13] Ramboll Americas Engineering Solutions, Inc., "Nature and Extent Report, Coffeen Power Plant, Ash Pond No. 2, IEPA ID No. W1350150004-02," Coffeen, IL, June 12, 2024.

[14] Ramboll Americas Engineering Solutions, Inc., Groundwater Modeling Technical Memorandum, Coffeen Power Plant, Ash Pond No. 2, Coffeen, IL, 2025.

[15] Natural Resource Technology, "Hydrogeologic Site Characterization Report, Ash Pond 2, Coffeen Power Station," Coffeen, IL, January 24, 2017.

[16] Ramboll Americas Engineering Solutions, "Hydrogeologic Site Characterization Report, Coffeen Power Plant, Ash Pond No. 1," Coffeen, IL, October 25, 2021.

[17] Illinois Power Generating Company, Initial Review Letter - Part 845 Construction/ Operating Permit Application(s)- Second Submittal, 2025.

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

TABLES

Table 1. Proposed Milestone Schedule for Implementing Corrective Action Remedy (Source Control with Horizontal GWE Well)

Implementation Phase	Implementation Task	Timeframe (Preliminary Estimates)
1: Pre-Construction Activities	Agency Coordination, Approvals, and Permitting	12 to 18 months
	Final Design and Bid Process	24 to 36 months
	Timeframe to Complete Corrective Pre-Construction Activities	36 to 54 months after CAP Approval
2: Corrective Action Construction	Corrective Action Construction	6 to 12 months
	Timeframe to Complete Corrective Action Construction	6 to 12 months
3: Corrective Action O&M and Closeout	Corrective Action O&M	168 months (14 years)
	Corrective Action Confirmation Monitoring	36 months
	Corrective Action Completion	6 months
	Timeframe to Complete Corrective Action O&M and Closeout	210 months (18 years)
	Total Timeline to Complete Corrective Action (after approval of Corrective Action Plan)	252 to 276 months (21 to 23 years)

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

Corrective Action Alternatives Analysis for Ash Pond No. 2 at the Coffeen Power Plant, Coffeen, Illinois

March 28, 2025

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Abbreviations

amsl	Above Mean Sea Level
AP1	Ash Pond No. 1
AP2	Ash Pond No. 2
bgs	Below Ground Surface
BMP	Best Management Practice
CAAA	Corrective Action Alternatives Analysis
CCR	Coal Combustion Residual
CIP	Closure-in-Place
CMA	Corrective Measures Assessment
CPP	Coffeen Power Plant
GHG	Greenhouse Gas
GMP	Groundwater Monitoring Plan
GWE	Groundwater Extraction
GWP	Groundwater Polishing
GWPS	Groundwater Protection Standard
HUC	Hydrologic Unit Code
IAC	Illinois Administrative Code
ID	Identification
IDNR	Illinois Department of Natural Resources
IEPA	Illinois Environmental Protection Agency
IPGC	Illinois Power Generating Company
ISGS	Illinois State Geological Survey
LCU	Lower Confining Unit
LLDPE	Linear Low-Density Polyethylene
NID	National Inventory of Dams
NPDES	National Pollutant Discharge Elimination System
O&M	Operations and Maintenance
SFWA	State Fish and Wildlife Area
Source Control-GWP	Source Control with Groundwater Polishing
Source Control-Horizontal GWE Well	Source Control with a Horizontal Groundwater Extraction Well
Source Control-Upgradient Barrier Wall and GWE Trench	Source Control with Upgradient Barrier Wall and Groundwater Extraction Trench
TDS	Total Dissolved Solids
TMDL	Total Maximum Daily Load
UA	Uppermost Aquifer
UCU	Upper Confining Unit
US DOT	United States Department of Transportation
US EPA	United States Environmental Protection Agency

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 Ash Pond No. 2 (AP2) at the Coffeen Power Plant (CPP) 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, 2024a) in order to remediate groundwater and achieve compliance with the 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 will inherently take many years to complete. While no formal definition of a complex groundwater environment exists, most would agree that there are a number of common characteristics at complex groundwater sites, including the following (National Research Council, 2013):

- Highly heterogeneous subsurface environments;
- Large source zones;
- Multiple, recalcitrant constituents; and
- Long timeframes over which releases occurred.

Each of these characteristics are common at CCR sites. Surface impoundments are often tens to hundreds of acres in size and many have operated for decades, leading to large source zones and prolonged releases. Furthermore, CCR 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, 2015b). 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 active alternatives evaluated in this CAAA is closure-in-place (CIP), which was approved of by Illinois Environmental Protection Agency (IEPA) in 2018 (Buscher, 2018) and completed in 2020 (Appendix B; Ramboll, 2025a). Specifically, this approach includes the removal of impounded water, the installation of a low-permeability final geomembrane cover system designed to limit the infiltration of precipitation into the impounded CCR, and the establishment of the stormwater management system. These activities were designed to control, minimize, or eliminate, post closure infiltration of liquids into the impounded CCR. As demonstrated by the groundwater modeling in support of the Closure and Post-Closure Care Plan (AECOM, 2017; NRT, 2017a), this source control approach would result in a reduction of CCR leachate generation and contraction of the groundwater contaminant plume, demonstrating that source control controls, minimizes, or eliminates post-closure releases of leachate.

Three potential corrective actions are evaluated in this CAAA: Source Control with Groundwater Polishing (Source Control-GWP), Source Control with Upgradient Barrier Wall and Groundwater Extraction Trench (Source Control-Upgradient Barrier Wall and GWE Trench) and Source Control with a Horizontal Groundwater Extraction Well (Source Control-Horizontal GWE Well). Each corrective action was identified as a viable approach in the CMA (Appendix C; Ramboll, 2024a). The residual plume management portions of these corrective action alternatives include groundwater polishing, an upgradient barrier wall in combination with groundwater extraction trenches, and a horizontal groundwater extraction well. It should be noted that Source Control-GWP, Source Control with GWE (Source Control-GWE), and Source Control with Groundwater Cutoff Wall (Source Control-Cutoff Wall) were originally identified in the CMA as viable remedial approaches (Appendix C; Ramboll, 2024a). However, during subsequent evaluations, the remedial approaches were modified. Remedy modifications include the following:

- The Source Control-Cutoff Wall alternative was determined to be infeasible for attaining GWPS in a reasonable amount of time without a supplementary hydraulic control method. The cutoff wall was expanded into the upgradient barrier wall with GWE trench remedy (*i.e.*, Source Control-Upgradient Barrier Wall and GWE Trench alternative).
- The Source Control-GWE alternative was further refined into the Source Control-Horizontal GWE Well remedy, which includes an alternate method of GWE well installation *via* horizontal directional drilling to reduce disturbance of the completed final cover system while allowing for targeted installation near the CCR/native soil interface beneath AP2.

Under the Source Control-GWP alternative, constituent concentrations in groundwater would attenuate naturally over time due to physical and geochemical mechanisms. Site-specific evaluations demonstrated that GWP is appropriate at AP2 because Site conditions are favorable for natural attenuation of inorganic contaminants *via* adsorption (Appendix E; Geosyntec Consultants, Inc., 2025). Under the Source Control-Upgradient Barrier Wall and GWE Trench alternative, a barrier wall would be constructed located adjacent to the northern and western sides of AP2, with an extraction trench running parallel and hydraulically downgradient of the barrier wall, in order to prevent groundwater flowing towards AP2 and to collect impacted groundwater beneath AP2, respectively. Both structures would be constructed from the ground surface to a depth of 8 feet (ft) below ground surface (bgs) and would penetrate the Uppermost Aquifer (UA). The barrier wall and the GWE trench would approximately 2 to 3 ft wide, with 1 to 2 ft of separation between them. Horizontal collection pipes would be installed in the trench, which would be backfilled with clean granular fill and capped with compacted clay to reduce surface water infiltration. The collection pipes would drain to sumps spaced throughout the trenches to extract groundwater. Extracted groundwater would be collected and sent to a new on-Site lined pond and discharged from either a new or existing outfall managed under the National Pollutant Discharge Elimination System (NPDES) permit for the Site. The barrier wall would be constructed using *in-situ* soils with a low-permeability mixture down to the target elevation. The barrier wall would be located upgradient of the extraction trench to limit groundwater from flowing towards AP2 and to reduce the amount of groundwater that needs to be extracted from the trench. Under the Source Control-Horizontal GWE Well alternative, a 1,325 ft long horizontal groundwater extraction well would be constructed within the eastern portion of AP2 at elevations between 600 ft-above mean sea level (amsl) at the southern bank to 606 ft-amsl near the northern bank of AP2, to collect impacted groundwater beneath AP2 (Appendix B; Ramboll, 2025a). The horizontal well would direct extracted water to a freely draining culvert or pump it to a settling pond before discharge.

Table S.1 evaluates the three potentially viable corrective actions evaluated in this CAAA (Source Control-GWP, Source Control-Upgradient Barrier Wall and GWE Trench, and Source Control-Horizontal GWE Well) with regard to each of the factors specified under IAC Section 845.670(d) and IAC Section 845.670(e) (IEPA, 2021). Based on this evaluation and the details provided in Section 2 of this report, the most appropriate corrective action for this Site is the Source Control-Horizontal GWE Well alternative. The timeframe for achieving GWPSs under the Source Control-Horizontal GWE Well alternative (approximately 17.5 to 19.5 years after approval of the Construction Permit Application) is shorter than under Source Control-GWP alternative (over 100 years after approval of Corrective Action Plan) and Source Control-Upgradient Barrier Wall and GWE Trench (approximately 63 to 65 years after approval of the Construction Permit Application). Additionally, risks to worker safety and the community under the Source Control-Horizontal GWE Well alternative are lower compared to the Source Control-Upgradient Barrier Wall and GWE Trench alternative. Thus, Source Control-Horizontal GWE Well is the most appropriate corrective action alternative for AP2.

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-Upgradient Barrier Wall and GWE Trench	Source Control-Horizontal GWE Well
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 AP2, there will be no unacceptable risk to human health or the environment for future conditions since the unit was closed and source control was implemented. Concentrations of CCR-related constituents will decline over time, and consequently potential exposures to CCR-related constituents in the environment will also decline. The magnitude of the reduction of existing risks is the same for the three potential corrective action alternatives, and all 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 AP2, there will be no unacceptable risk to human health or the environment for future conditions since the unit was closed and source control was implemented. Concentrations of CCR-related constituents will decline over time, and consequently potential exposures to CCR-related constituents in the environment will also decline. The magnitude of the reduction of existing risks is the same for the three potential corrective action alternatives, and all 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 AP2, there will be no unacceptable risk to human health or the environment for future conditions since the unit was closed and source control was implemented. Concentrations of CCR-related constituents will decline over time, and consequently potential exposures to CCR-related constituents in the environment will also decline. The magnitude of the reduction of existing risks is the same for the three potential corrective action alternatives, and all 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 using CIP (which is the primary remedial measure) and residual plume management. Modeling results (NRT, 2017a) indicate that the source control approach implemented in 2020 would result in a reduction of CCR leachate generation and contraction of the groundwater contaminant plume. Source control is thus effective at	All three alternatives include source control using CIP (which is the primary remedial measure) and residual plume management. Modeling results (NRT, 2017a) indicate that the source control approach implemented in 2020 would result in a reduction of CCR leachate generation and contraction of the groundwater contaminant plume. Source control is thus effective at	All three alternatives include source control using CIP (which is the primary remedial measure) and residual plume management. Modeling results (NRT, 2017a) indicate that the source control approach implemented in 2020 would result in a reduction of CCR leachate generation and contraction of the groundwater contaminant plume. Source control is thus effective at

Evaluation Factor (Report Section; Part 845 Section)	**Source Control-GWP**	**Source Control-Upgradient Barrier Wall and GWE Trench**	**Source Control-Horizontal GWE Well**
	controlling the source. Under the residual plume management for this alternative, physical and geochemical attenuation mechanisms would mitigate impacts to downgradient groundwater. However, it should be noted that some boron re-mobilization may occur as groundwater returns to background conditions, which may affect the time required to achieve GWPS (Appendix E; Geosyntec Consultants, Inc., 2025). If necessary, remedy optimizations would be implemented under the adaptive site management program.	controlling the source. Under the residual plume management for this alternative, a barrier wall would be constructed to prevent groundwater flowing towards AP2 and by installation of an extraction trench running parallel and hydraulically downgradient of the barrier wall to collect impacted groundwater beneath AP2. If necessary, remedy optimizations would be implemented under the adaptive site management program.	controlling the source. Under the residual plume management for this alternative, a horizontal groundwater extraction well would be installed to collect and drain CCR-impacted groundwater beneath AP2. 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.	For the Source Control-Upgradient Barrier Wall and GWE Trench alternative, it would require construction of a new on-Site settling pond to remove solids from extracted groundwater, prior to discharge *via* an NPDES permitted outfall. If necessary, remedy optimizations would be implemented under the adaptive site management program.	For the Source Control-Horizontal GWE Well alternative, it would require construction of a new on-Site settling pond to settle solids from extracted groundwater from the GWE wells, prior to discharge *via* an NPDES permitted outfall. Other treatment and management technologies may be evaluated at later phases of the design. If necessary, remedy optimizations would be implemented under the adaptive site management program.
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; the CIP source control was completed in 2020. A geosynthetic cover system was installed in 2020, which included a 40-mil linear low-density polyethylene (LLDPE) geomembrane liner, 18 inches	All three corrective action alternatives include source control using CIP; the CIP source control was completed in 2020. A geosynthetic cover system was installed in 2020, which included a 40-mil LLDPE geomembrane liner, 18 in of soil cover and 6 in of erosion soil layer	All three corrective action alternatives include source control using CIP; the CIP source control was completed in 2020. A geosynthetic cover system was installed in 2020, which included a 40-mil LLDPE geomembrane liner, 18 in of soil cover and 6 in of erosion soil layer

Evaluation Factor (Report Section; Part 845 Section)	Source Control-GWP	Source Control-Upgradient Barrier Wall and GWE Trench	Source Control-Horizontal GWE Well
	(in) of soil cover and 6 in of erosion soil layer for vegetative growth, as well as new stormwater control structures. This cover system provides 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 alternatives.	for vegetative growth, as well as new stormwater control structures. This cover system provides 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 alternatives. Any CCR-contact stormwater generated during the construction phase would be managed through a contact stormwater management system. There would be minimal risk of accidental CCR releases occurring post-closure under any of the alternatives.	for vegetative growth, as well as new stormwater control structures. This cover system provides 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 alternatives. Any CCR-contact stormwater generated during the construction phase would be managed through a contact stormwater management system. There would be minimal risk of accidental CCR releases occurring post-closure under any of the alternatives.
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 alternative because it would not require the installation, operation, or maintenance of any engineered systems or structures other than maintenance of the monitoring well network. Post-closure care groundwater monitoring would continue for a minimum of 30 years as required by IAC Section 845.780(c). Corrective action groundwater monitoring would continue for 3 years after GWPSs have been achieved. Based on the adaptive site management approach, remedy	Long-term O&M efforts required under Source Control-Upgradient Barrier Wall and GWE Trench alternative would include the maintenance of the groundwater collection trench system and discharge of extracted groundwater. Non-routine maintenance may include tasks such as repair or replacement of the extraction and/or transfer pumps, repair or replacement of the system air compressor, and flushing or jetting of water conveyance lines in the event organic or inorganic solids accumulate on the interior walls. Extracted groundwater would be managed and treated by a newly-constructed on-Site	Long-term O&M efforts required under Source Control-Horizontal GWE Well would include inspection and maintenance of the horizontal well ensure the continued operation. These activities would include routine inspections of the horizontal well extraction system along with non-routine maintenance such as flushing or jetting of water conveyance lines. Extracted groundwater would be managed to ensure compliance with the Site's NPDES permit for treatment and discharge. Post-closure care groundwater monitoring would continue for a

Evaluation Factor (Report Section; Part 845 Section)	**Source Control-GWP**	**Source Control-Upgradient Barrier Wall and GWE Trench**	**Source Control-Horizontal GWE Well**
	optimizations may be implemented to ensure achievement of the GWPSs.	settling pond before discharge *via* an NPDES permitted Outfall. 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 may be implemented to ensure achievement of the GWPSs.	minimum of 30 years as required by IAC Section 845.780(c). Additionally, corrective action groundwater sampling would continue for 3 years after GWPSs have been achieved. Based on the adaptive site management approach, remedy optimizations may be implemented to ensure achievement of the GWPSs.
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) was implemented in 2020. Thus, there is no further risk of accidents and injuries occurring during the implementation of the source control remedy. 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. Similarly, no off-Site impacts on nearby residents would be expected under the	Source control (*i.e.*, CIP) was implemented in 2020. Thus, there is no further risk of accidents and injuries occurring during the implementation of the source control remedy. Overall, considering worker accidents occurring during residual plume management both on- and off-Site, 0.28 worker injuries and 3.8×10^{-3} worker fatalities would be expected to occur under the Source Control-Upgradient Barrier Wall and GWE Trench alternative, which is the highest among the three alternatives.	Source control (*i.e.*, CIP) was implemented in 2020. Thus, there is no further risk of accidents and injuries occurring during the implementation of the source control remedy. Overall, considering worker accidents occurring during residual plume management both on- and off-Site, 0.21 worker injuries and 2.8×10^{-3} worker fatalities would be expected to occur under the Source Control-Horizontal GWE Well alternative. In total, an estimated 0.038 injuries and

Evaluation Factor (Report Section; Part 845 Section)	Source Control-GWP	Source Control-Upgradient Barrier Wall and GWE Trench	Source Control-Horizontal GWE Well
	Source Control-GWP alternative.	In total, an estimated 0.051 injuries and 6.9×10^{-4} fatalities would be expected to occur among community members due to off-Site activities under this alternative, which is also the highest among the three alternatives.	5.2×10^{-4} fatalities would be expected to occur among community members due to off-Site activities under this alternative.
Cross-Media Impacts to Air	Source control (*i.e.*, CIP) was implemented in 2020. No further air impacts associated with the implementation of the source control remedy are expected. Cross-media impacts to air can include air pollutants and GHG emissions, which are proportional to the potential impact of each 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.	Source control (*i.e.*, CIP) was implemented in 2020. No further air impacts associated with the implementation of the source control remedy are expected. Cross-media impacts to air can include air pollutants and GHG emissions, which are proportional to the potential impact of each alternative on other emissions from construction vehicles and equipment. Residual plume management for the Source Control-Upgradient Barrier Wall and GWE Trench alternative would have the highest air impacts, due to the greatest amount of vehicle travel miles required for construction, operation, and maintenance under this alternative.	Source control (*i.e.*, CIP) was implemented in 2020. No further air impacts associated with the implementation of the source control remedy are expected. Cross-media impacts to air can include air pollutants and GHG emissions, which are proportional to the potential impact of each alternative on other emissions from construction vehicles and equipment. Residual plume management for the Source Control-Horizontal GWE Well alternative would have greater air impacts than the Source Control-GWP, due to the horizontal GWE well installation activities and operation of the extraction system.
Cross-Media Impacts to Surface Water and Sediments	Source control was implemented in 2020 for all three corrective action alternatives, and constituent mass flux from groundwater into surface water will decline over time (AECOM, 2017). The source control approach minimizes the amount of water retained within the impoundment, which reduces the hydraulic flux through the CCR. Due to the reduction in the hydraulic flux out	Source control was implemented in 2020 for all three corrective action alternatives, and constituent mass flux from groundwater into surface water will decline over time (AECOM, 2017). The source control approach minimizes the amount of water retained within the impoundment, which reduces the hydraulic flux through the CCR. Due to the reduction in the hydraulic flux out	Source control was implemented in 2020 for all three corrective action alternatives, and constituent mass flux from groundwater into surface water will decline over time (AECOM, 2017). The source control approach minimizes the amount of water retained within the impoundment, which reduces the hydraulic flux through the CCR. Due to the reduction in the hydraulic flux out

Evaluation Factor (Report Section; Part 845 Section)	**Source Control-GWP**	**Source Control-Upgradient Barrier Wall and GWE Trench**	**Source Control-Horizontal GWE Well**
	of AP2, the mass flux out of AP2 will also be controlled or minimized. As demonstrated by the groundwater modeling in support of the Closure Plan, source control would result in a significant reduction in groundwater concentrations and, overtime, reduce the extent of groundwater impacts to within the footprint of the impoundment (NRT, 2017a). 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.	of AP2, the mass flux out of AP2 will also be controlled or minimized. As demonstrated by the groundwater modeling in support of the Closure Plan, source control would result in a significant reduction in groundwater concentrations and, overtime, reduce the extent of groundwater impacts to within the footprint of the impoundment (NRT, 2017a). Under residual plume management for the Source Control-Upgradient Barrier Wall and GWE Trench alternative, surface water and sediment impacts would be higher than the Source Control-GWP alternative due to the construction of the extraction trench system and barrier wall. Construction can have short-term negative impacts on surface water and sediment quality immediately adjacent to a site due to potential erosion and sediment runoff.	of AP2, the mass flux out of AP2 will also be controlled or minimized. As demonstrated by the groundwater modeling in support of the Closure Plan, source control would result in a significant reduction in groundwater concentrations and, overtime, reduce the extent of groundwater impacts to within the footprint of the impoundment (NRT, 2017a). Under residual plume management for the Source Control-Horizontal GWE Well alternative, surface water and sediment impacts would be higher than the Source Control-GWP alternative due to the construction of horizontal GWE well. Construction can have short-term negative impacts on surface water and sediment quality immediately adjacent to a site due to potential erosion and sediment runoff.
Control of Exposure to Any Residual Contamination During Implementation of the Remedy	Source control (*i.e.*, CIP) was implemented in 2020. Thus, there are no further risks of CCR exposure associated with source control implementation. 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,	Source control (*i.e.*, CIP) was implemented in 2020. Thus, there are no further risks of CCR exposure associated with source control implementation. 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-	Source control (*i.e.*, CIP) was implemented in 2020. Thus, there are no further risks of CCR exposure associated with source control implementation. 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-

Evaluation Factor (Report Section; Part 845 Section)	Source Control-GWP	Source Control-Upgradient Barrier Wall and GWE Trench	Source Control-Horizontal GWE Well
	which would not involve exposure to soil or groundwater waste streams.	Upgradient Barrier Wall and GWE Trench alternative than for the Source Control-GWP alternative, because Source Control-Upgradient Barrier Wall and GWE Trench would involve the production, management, and treatment of extracted groundwater, as well as on-Site disposal of excavated spoils generated during extraction trench and barrier wall construction.	Horizontal GWE Well alternative than for the Source Control-GWP alternative, because Source Control-Horizontal GWE Well would involve on-Site disposal of the excavated spoils generated during the horizontal GWE well installation and the production, management, and treatment of extracted groundwater.
Other Identified Impacts	Source control (*i.e.*, CIP) was implemented in 2020. Thus, there are no further impacts associated with the implementation of source control. The energy demands of construction equipment and vehicles associated with residual plume management would be the lowest under the Source Control-GWP alternative because this alternative would not require any significant construction activity. Similarly, traffic and noise impacts associated with residual plume management would be lowest under the Source Control-GWP alternative because this alternative would not require any significant construction activity. There would be no impacts to natural resources and habitats under the Source Control-GWP alternative because no additional construction activities would be required.	Source control (*i.e.*, CIP) was implemented in 2020. Thus, there are no further impacts associated with the implementation of source control. The energy demands of construction equipment and vehicles associated with residual plume management would be greater under the Source Control-Upgradient Barrier Wall and GWE Trench than the Source Control-GWP alternative, due to the activities that would be required to construct the GWE Trench and barrier wall, as well as additional energy required to operate the extraction system. Similarly, traffic and noise impacts associated with residual plume management would be greater under the Source Control-Upgradient Barrier Wall and GWE Trench than the Source Control-GWP alternative, due to the activities that would be required to construct the GWE Trench system and	Source control (*i.e.*, CIP) was implemented in 2020. Thus, there are no further impacts associated with the implementation of source control. The energy demands of construction equipment and vehicles associated with residual plume management would be greater under the Source Control-Horizontal GWE Well than the Source Control-GWP alternative, due to the construction activities related to installation of the horizontal well. Additional energy would be required to operate the extraction system. Similarly, traffic and noise impacts associated with residual plume management would also be greater under the Source Control-Horizontal GWE Well alternative than the Source Control-GWP alternative, due to the construction activities required to install the horizontal GWE wells and construct the settling pond.

Evaluation Factor (Report Section; Part 845 Section)	**Source Control-GWP**	**Source Control-Upgradient Barrier Wall and GWE Trench**	**Source Control-Horizontal GWE Well**
		barrier wall system. Under the Source Control-Upgradient Barrier Wall and GWE Trench alternative, there would be some negative impacts to natural resources and habitats, including disturbances of some existing habitats atop portions of the construction areas, and potential impacts to aquatic and wetland species in Coffeen Lake and other wetlands due to sediment runoff during construction.	Under the Source Control-Horizontal GWE Well alternative, there would be some negative impacts to natural resources and habitats, including disturbances of some existing habitats atop portions of the construction areas, and potential impacts to aquatic and wetland species in Coffeen Lake and other wetlands due to sediment runoff during construction.
Time Until Groundwater Protection Standards Are Achieved (Section 2.2.6; IAC Section 845.670(e)(1)(E))	Groundwater modeling was performed in support of the Closure Plan (AECOM, 2017). The modeling predicted that source control would result in a reduction of CCR leachate generation and contraction of the groundwater contaminant plume, which was predicted to begin after the completion of the source control (NRT, 2017a). Additional modeling was conducted for each of the corrective action alternatives to evaluate future groundwater quality in the vicinity of AP2 as a result of residual plume management (Appendix B; Ramboll, 2025b). The results of the modeling indicate that groundwater would meet the GWPSs for all constituents identified as having potential groundwater exceedances in the monitoring network within	Groundwater modeling was performed in support of the Closure Plan (AECOM, 2017). The modeling predicted that source control would result in a reduction of CCR leachate generation and contraction of the groundwater contaminant plume, which was predicted to begin after the completion of the source control (NRT, 2017a). Additional modeling was conducted for each of the corrective action alternatives to evaluate future groundwater quality in the vicinity of AP2 as a result of residual plume management (Appendix B; Ramboll, 2025b). The results of the modeling indicate that groundwater would attain the GWPSs for all constituents identified as having potential exceedances within approximately 63 to 65 years (4 to 6 years of pre-	Groundwater modeling was performed in support of the Closure Plan (AECOM, 2017). The modeling predicted that source control would result in a reduction of CCR leachate generation and contraction of the groundwater contaminant plume, which was predicted to begin after the completion of the source control (NRT, 2017a). Additional modeling was conducted for each of the corrective action alternatives to evaluate future groundwater quality in the vicinity of AP2 as a result of residual plume management (Appendix B; Ramboll, 2025b). The results of the modeling indicate that groundwater would attain the GWPSs for all constituents identified as having potential exceedances within approximately 17.5 to 19.5 years (3.5 to 5.5 years of pre-

Evaluation Factor (Report Section; Part 845 Section)	Source Control-GWP	Source Control-Upgradient Barrier Wall and GWE Trench	Source Control-Horizontal GWE Well
	approximately 135 years (Appendix B; Ramboll, 2025a).	construction and construction activities followed by approximately 59 years of post-construction O&M) under the Source Control-Upgradient Barrier Wall and GWE Trench alternative (Appendix B; Ramboll, 2025a).	construction and construction activities followed by approximately 14 years of system operation until the GWPSs are achieved). Current modeling indicates that an additional 25 years of system operation may be required to prevent concentrations from rebounding above the GWPSs (Appendix B; Ramboll, 2025a); however, additional modeling would be performed and additional data would be collected as part of the Corrective Action Groundwater Monitoring Plan to determine the exact required duration of additional system operation.
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 (CIP) was implemented in 2020. As a result of the source control, there would be no risk of CCR releases post-closure, and all three corrective action alternatives are equally and fully protective with regard to exposure to residual CCR.	Source control (CIP) was implemented in 2020. As a result of the source control, there would be no risk of CCR releases post-closure and all three corrective action alternatives are equally and fully protective with regard to exposure to residual CCR. 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.*, controlled discharge into Coffeen Lake and blocking of natural groundwater flow) may occur under	Source control (CIP) was implemented in 2020. As a result of the source control, there would be no risk of CCR releases post-closure and all three corrective action alternatives are equally and fully protective with regard to exposure to residual CCR. Potential risks to workers that come in contact with residual contamination of CCR-related constituents during groundwater extraction and treatment from the GWE wells would be managed through the use of rigorous safety protocols and personal protective equipment. Under the residual plume management for Source Control-Horizontal GWE Well alternative, a horizontal GWE well

Evaluation Factor (Report Section; Part 845 Section)	Source Control-GWP	Source Control-Upgradient Barrier Wall and GWE Trench	Source Control-Horizontal GWE Well
		the Source Control-Upgradient Barrier Wall and GWE Trench alternative, due to the operation of the GWE trench system and installation of subsurface groundwater barrier wall. 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.	would be installed. This remedy would reduce the hydraulic head beneath AP2 and alter the hydraulic gradient and corresponding groundwater patterns. 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; IAC Section 845.670(e)(1)(G))	Source control (CIP) was implemented in 2020. Thus, long-term reliability of source control would be same for all three corrective action alternatives. 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.	Source control (CIP) was implemented in 2020. Thus, long-term reliability of source control would be same for all three corrective action alternatives. GWE Trench and subsurface barrier wall technologies are proven remedies that have been implemented at many sites. Thus, residual plume management under the Source Control-Upgradient Barrier Wall and GWE Trench alternative would be reliable, provided that the barrier wall and extraction trench are constructed in accordance with standard design and specifications. Routine and non-routine maintenance of the GWE trench is required to ensure reliable operation of the extraction trench and pumps, as well as other mechanical components. The barrier wall component provides an inert, continuous, low-permeability barrier to groundwater flow and is not expected to need maintenance. If necessary,	Source control (CIP) was implemented in 2020. Thus, long-term reliability of source control would be same for all three corrective action alternatives. Horizontal GWE well is a proven remedy that has been implemented at many sites. Thus, residual plume management under the Source Control-Horizontal GWE Well alternative would be reliable, provided the horizontal well is constructed in accordance with standard design and specifications. The horizontal well system is a passive drain system; however, conveyance of extracted groundwater would require operation and maintenance of a mechanical system. 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-Upgradient Barrier Wall and GWE Trench**	**Source Control-Horizontal GWE Well**
		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-Upgradient Barrier Wall and GWE Trench alternative would likely be unnecessary, as long as the extraction trench system and barrier wall are constructed, maintained, and serviced appropriately. The GWE Trench system would need ongoing maintenance and potential replacement of system components to ensure its effectiveness. 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-Horizontal GWE Well alternative would likely be unnecessary, as long the horizontal well is constructed, maintained, and serviced appropriately. The conveyance of extracted groundwater to the settling pond would constitute a mechanical system which may require routine maintenance to reliably operate. Adaptive site management strategies would be used to implement remedy optimizations, if necessary, to ensure that remedial goals are achieved.
Degree of Difficulty Associated with Constructing the Remedy (Section 2.3.1; IAC Section 845.670 (e)(3)(A))	Source control (CIP) was implemented in 2020. Thus, there would be no further construction difficulties associated with the implementation of source control. Residual plume management under the Source Control-GWP alternative would rely on physical and geochemical attenuation processes and therefore would not be difficult.	Source control (CIP) was implemented in 2020. Thus, there would be no further construction difficulties associated with the implementation of source control. Residual plume management under the Source Control-Upgradient Barrier Wall and GWE Trench alternative would involve the construction of a barrier wall, an extraction trench, settling pond, and conveyance system to extract and treat impacted groundwater to address downgradient groundwater quality impacts. The construction of the shallow	Source control (CIP) was implemented in 2020. Thus, there would be no further construction difficulties associated with the implementation of source control. Residual plume management under the Source Control-Horizontal GWE Well alternative would involve the installation of a horizontal well to drain water from AP2 to address downgradient groundwater quality impacts. This alternative would require the use of specialty equipment such as horizontal directional drill rigs and other supporting equipment such as

Evaluation Factor (Report Section; Part 845 Section)	**Source Control-GWP**	**Source Control-Upgradient Barrier Wall and GWE Trench**	**Source Control-Horizontal GWE Well**
		groundwater trench and barrier wall required by this alternative are commonly constructed at similar depths and can be performed using specialized (*i.e.*, one-pass trenching) and conventional construction equipment. Therefore, while some construction is necessary, the degree of difficulty for this remedy is expected to be low.	excavating and grading equipment that would need to be mobilized to the site. Horizontal wells are routinely constructed in similar environments, however there may be difficulty due to heterogeneity encountered in the subsurface at the bottom of the CCR and top of the UA interface, and would require specialized techniques/ equipment to address the issue. Therefore, the degree of difficulty is expected to be moderate for the horizontal well component.
Expected Operational Reliability of the Remedy (Section 2.3.2; IAC Section 845.670 (e)(3)(B))	Source control (CIP) was implemented in 2020. The operational reliability of the source control would be the same for all three corrective action alternatives. 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. However, it should be noted that some boron re-mobilization may occur as groundwater returns to background conditions at AP2, which may affect the time to achieve GWPS (Appendix E; Geosyntec Consultants, Inc., 2025). Adaptive site management strategies would be used to implement remedy optimizations, if necessary.	Source control (CIP) was implemented in 2020. The operational reliability of the source control would be the same for all three corrective action alternatives. Residual plume management under the Source Control-Upgradient Barrier Wall and GWE Trench alternative would have high operational reliability because it is an established and commonly used technology, as long as the barrier wall and the extraction trench system are constructed in accordance with standard design and specifications. The barrier wall is an inert, continuous, low-permeability subsurface structure and is not expected to require maintenance after construction. The GWE trench system operates as a mechanical system and would require routine and non-routine	Source control (CIP) was implemented in 2020. The operational reliability of the source control would be the same for all three corrective action alternatives. Residual plume management under the Source Control-Horizontal GWE Well alternative would have high operational reliability if the horizontal GWE well and conveyance system are constructed in accordance with standard design and specifications. The horizontal well system is a passive drain system; however, conveyance of extracted groundwater would require operation and maintenance of a mechanical system. 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-Upgradient Barrier Wall and GWE Trench	Source Control-Horizontal GWE Well
		maintenance to ensure reliable operation. Adaptive site management strategies would be used to implement remedy optimizations, if necessary.	
Need to Coordinate with and Obtain Necessary Approvals and Permits from Other Agencies (Section 2.3.3; IAC Section 845.670 (e)(3)(C))	Specific permits and approvals associated with source control were the same for all corrective action alternatives and were discussed in the Closure Plan (AECOM, 2017). Residual plume management under the Source Control-GWP alternative would not need additional permits from other agencies, other than the approval of the eventual Corrective Action Plan.	Specific permits and approvals associated with source control were the same for all corrective action alternatives and were discussed in the Closure Plan (AECOM, 2017). Residual plume management under the Source Control-Upgradient Barrier Wall and GWE Trench alternative would require regulatory approval and permits. Groundwater extracted from the extraction trench would require a modified NPDES permit, which would likely require renewals depending on the timeline of corrective action implementation. Permits from IEPA for construction stormwater controls, BMPs, and operating would be required. An IDNR Dam Safety modification permit would be obtained for modifications of the embankment.	Specific permits and approvals associated with source control were the same for all corrective action alternatives and were discussed in the Closure Plan (AECOM, 2017). The Source Control-Horizontal GWE Well alternative would require regulatory approval and permits. Modifications would be necessary to the Site's NPDES permit to allow for discharge of groundwater from the horizontal well. Permits from IEPA for construction stormwater controls and BMPs would be required.
Availability of Necessary Equipment and Specialists (Section 2.3.4; IAC Section 845.670 (e)(3)(D))	Source control (CIP) was implemented in 2020. Thus, there are no further equipment and specialist needs associated with the implementation of the source control remedy. Residual plume management under the Source Control-GWP alternative would require standard environmental monitoring equipment and	Source control (CIP) was implemented in 2020. Thus, there are no further equipment and specialist needs associated with the implementation of the source control remedy. Residual plume management under the Source Control-Upgradient Barrier Wall and GWE Trench alternative would require specialists to construct the	Source control (CIP) was implemented in 2020. Thus, there are no further equipment and specialist needs associated with the implementation of the source control remedy. Residual plume management under the Source Control-Horizontal GWE Well alternative would require specialists for horizontal well installation and O&M:

Evaluation Factor (Report Section; Part 845 Section)	Source Control-GWP	Source Control-Upgradient Barrier Wall and GWE Trench	Source Control-Horizontal GWE Well
	groundwater professionals. Specialists such as geologists, hydrogeologists, statisticians (*i.e.*, statistical analysis), and geochemists would be available to collect and evaluate the data.	barrier wall and the GWE trench system and to manage the GWE Trench system throughout its operational period: ▪ Construction of the groundwater extraction system and the barrier wall on the Site is expected to require a specialized contractor, who would most likely need specialized and often custom-built equipment including one-pass construction equipment. The availability of contractors with such equipment may be limited. ▪ Specialists including design engineers, geotechnical experts, construction managers and contractor staff experienced in trench construction and similar geologic environments would be required. ▪ Geotechnical specialists would be required to design the working platform and oversee the AP2 embankment, monitoring for any signs of distress during the one-pass trench installation. ▪ In addition, specialists and equipment may have backlogs due to high demand in similar specialty ground improvement projects in the area, which could delay the project schedule. ▪ After the construction phase,	▪ Construction of the horizontal well would require design engineers, geologists, construction managers, and contractor staff experienced with horizontal well construction and specialized equipment operation. ▪ Contractors would be required during the operation of the system including replacement of components and periodic well re-development (*i.e.*, flushing or jetting of conveyance lines). Specialists and equipment needed for O&M are generally available within close proximity to the Site with the exception of more complex system components, such as transfer pumps and transfer pump controller. ▪ As with the other two alternatives, 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. These activities are already being conducted as part of routine groundwater monitoring.

Evaluation Factor (Report Section; Part 845 Section)	Source Control-GWP	Source Control-Upgradient Barrier Wall and GWE Trench	Source Control-Horizontal GWE Well
		specialists and equipment would be required during the operation of the GWE system for routine and non-routine maintenance. - Specialists and replacement equipment needed to operate the system would generally be available, although some of the more complex equipment (*i.e.*, transfer pumps and transfer pump controller) may have extended lead times for servicing. - This alternative would also 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.	
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 residual plume management under the Source Control-GWP alternative, as GWP would not generate any significant volume of waste or wastewater.	Residual plume management for the Source Control-Upgradient Barrier Wall and GWE Trench alternative would require the construction of the barrier wall, extraction trench, and a new settling pond. Spoils would be generated and would be disposed of in the on-Site landfill. Extracted groundwater would be sent to an on-Site settling pond, which collects solids	Residual plume management for the Source Control-Horizontal GWE Well would send extracted groundwater to a newly constructed on-Site settling pond to settle solids extracted during groundwater recovery. The settling pond would need to be sited, designed, constructed, and maintained properly. The siting of the settling pond would need to consider limiting impacts to

Evaluation Factor (Report Section; Part 845 Section)	**Source Control-GWP**	**Source Control-Upgradient Barrier Wall and GWE Trench**	**Source Control-Horizontal GWE Well**
		removed during groundwater recovery *via* the pneumatic extraction pumps and transfer piping. Discharge from the settling pond would be conveyed to an NPDES permitted outfall.	existing and future Site infrastructure and other surface impoundments at the Coffeen Power Plant (CPP). Flows from the horizontal GWE wells would be discharged through an NPDES permitted outfall.
The Degree to Which Community Concerns Are Addressed by the Remedy (Section 2.4; IAC Section 845.670(e)(4))	Some communities have expressed concerns over groundwater quality at CCR surface impoundments. The combination of source control (*i.e.*, CIP) 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 (Appendix B; Ramboll, 2025b). A public meeting will be held on May 1, 2025, pursuant to requirements under IAC Section 845.710(e). Questions raised by attendees will be answered at the meeting; subsequently, a written summary of all questions and responses will be made available to interested parties.	Some communities have expressed concerns over groundwater quality at CCR surface impoundments. The combination of source control (*i.e.*, CIP) 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 (Appendix B; Ramboll, 2025b). A public meeting will be held on May 1, 2025, pursuant to requirements under IAC Section 845.710(e). Questions raised by attendees will be answered at the meeting; subsequently, a written summary of all questions and responses will be made available to interested parties.	Some communities have expressed concerns over groundwater quality at CCR surface impoundments. The combination of source control (*i.e.*, CIP) 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 (Appendix B; Ramboll, 2025b). A public meeting will be held on May 1, 2025, pursuant to requirements under IAC Section 845.710(e). Questions raised by attendees will be answered at the meeting; subsequently, a written summary of all questions and responses will 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	There have been no known releases of CCR at the AP2. All three potential corrective action alternatives include source control and residual plume management efforts. The source control included removal of impounded water and the installation of a low-permeability final geomembrane cover system designed to limit the infiltration	There have been no known releases of CCR at the AP2. All three potential corrective action alternatives include source control and residual plume management efforts. The source control included removal of impounded water and the installation of a low-permeability final geomembrane cover system designed to limit the infiltration	There have been no known releases of CCR at the AP2. All three potential corrective action alternatives include source control and residual plume management efforts. The source control included removal of impounded water and the installation of a low-permeability final geomembrane cover system designed to limit the infiltration

Evaluation Factor (Report Section; Part 845 Section)	Source Control-GWP	Source Control-Upgradient Barrier Wall and GWE Trench	Source Control-Horizontal GWE Well
(Section 2.5; IAC Section 845.670(d)(4))	of precipitation into the impounded CCR. Groundwater modeling performed in support of the Closure Plan predicted that source control would result in a reduction of CCR leachate production, a decrease in CCR leachate constituent concentrations, and a contraction of the groundwater contaminant plume (NRT, 2017a). Additionally, 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-related constituents in groundwater. Attenuation *via* sorption onto mineral surfaces should remain stable under post-closure conditions, and remobilization is unlikely to impact the time to achieve GWPS for sulfate. It should be noted that remobilization of boron may occur at some locations and affect the time to achieve GWPS compared to sulfate (Appendix E; Geosyntec Consultants, Inc., 2025). No ecosystems would be disturbed because no construction activities are expected under the Source Control-GWP alternative.	of precipitation into the impounded CCR. Groundwater modeling performed in support of the Closure Plan predicted that source control would result in a reduction of CCR leachate production, a decrease in CCR leachate constituent concentrations, and a contraction of the groundwater contaminant plume (NRT, 2017a). Additionally, residual plume management under the Source Control-Upgradient Barrier Wall and GWE Trench alternative would rely on the barrier wall to limit groundwater from flowing towards AP2 and to reduce the amount of groundwater that needs to be extracted from the trench. The GWE trench would collect impacted groundwater and reduce the hydraulic head beneath AP2 which would reduce of prevent migration of impacted groundwater. The construction activities would likely result in some negative impacts to the ecosystem, including disturbances of some existing habitats atop portions of the construction areas, and habitats in the immediate vicinity of these locations by causing alarm and escape behavior in nearby wildlife (*e.g.*, due to noise disturbances). Short-term impacts could also occur to sensitive aquatic and wetland species in Coffeen	of precipitation into the impounded CCR. Groundwater modeling performed in support of the Closure Plan predicted that source control would result in a reduction of CCR leachate production, a decrease in CCR leachate constituent concentrations, and a contraction of the groundwater contaminant plume (NRT, 2017a). Additionally, residual plume management under the Source Control-Horizontal GWE Well alternative would rely on installation of a horizontal extraction well to drain water from beneath AP2, thus reducing the hydraulic head beneath AP2 and accelerating the time to achieve GWPS. The horizontal well would drain water from AP2 which would reduce or prevent migration of impacted groundwater. The construction activities would likely result in some negative impacts to the ecosystem, including disturbances of some existing habitats atop portions of the construction areas, and habitats in the immediate vicinity of these locations by causing alarm and escape behavior in nearby wildlife (*e.g.*, due to noise disturbances). Short-term impacts could also occur to sensitive aquatic and wetland species in Coffeen Lake and other wetlands or surface

Evaluation Factor (Report Section; Part 845 Section)	Source Control-GWP	Source Control-Upgradient Barrier Wall and GWE Trench	Source Control-Horizontal GWE Well
		Lake and other wetlands or surface water bodies located within the SFWA near AP2 (see Section 1.1.3) due to potential sediment runoff during construction at the Site.	water bodies located within the SFWA near AP2 (see Section 1.1.3) due to potential sediment runoff during construction at the Site.

Notes:

AP2 = Ash Pond No. 2; BMP = Best Management Practice; CCR = Coal Combustion Residual; CIP = Closure-in-Place; GHG = Greenhouse Gas; GWE = Groundwater Extraction; GWE Trench = Groundwater Extraction Trench; GWP = Groundwater Polishing; GWPS = Groundwater Protection Standard; IAC = Illinois Administrative Code; IDNR = Illinois Department of Natural Resources; IEPA = Illinois Environmental Protection Agency; LLDPE = Linear Low-Density Polyethylene; NPDES = National Pollutant Discharge Elimination System; O&M = Operations and Maintenance; SFWA = State Fish and Wildlife Area; Source Control-GWP = Source Control with Groundwater Polishing; Source Control-Horizontal GWE Well = Source Control with a Horizontal Groundwater Extraction Well; Source Control-Upgradient Barrier Wall and GWE Trench = Source Control with Upgradient Barrier Wall and Groundwater Extraction Trench.

1 Introduction

1.1 Site Description and History

1.1.1 Site Location and History

Coffeen Power Plant (CPP) is an electric power generating facility with coal-fired units and is operated by Illinois Power Generating Company (IPGC). The Site is located about 2 miles south of the City of Coffeen, Illinois, and situated approximately between two lobes of Coffeen Lake. Historically, three room and pillar coal mines operated within the boundaries of the Site. From south to north, they are the Hillsboro Mine, which operated from 1964 to 1983; the Clover Leaf No. 1 Mine, which operated from 1889 to 1901; and the Clover Leaf No. 4 Mine, which operated from 1906 to 1924 (Ramboll, 2021a; ISGS and University of Illinois at Urbana-Champaign, 2011). The Coffeen Power Plant operated from 1964 to November 2019 when it was retired (Ramboll, 2021a).

1.1.2 CCR Impoundment

The Coffeen Power Plant produced and stored coal combustion residuals (CCRs) as a part of its historical operations. Ash Pond No. 2 (AP2; Vistra identification [ID] No. CCR Unit 102, Illinois Environmental Protection Agency [IEPA] ID No. W1350150004-02, and National Inventory of Dams [NID] ID No. IL50723) is the subject of this report.

AP2 (Figure 1.1) is an inactive and unlined 60-acre bermed CCR Unit that started operation in the early 1970s. AP2 was removed from service and capped in the mid-1980s with a 2-ft clay and soil layer (AECOM, 2017). Four additional CCR units exist on the Site, including Ash Pond No. 1 (AP1) (operated from 1964 to 2019), the Gypsum Management Facility Gypsum Stack Pond (operated from 2010 to 2021), the Gypsum Management Facility Recycling Pond (operated from 2010 to 2021), and the lined Landfill that managed fly ash beginning in 2010 (Ramboll, 2021a).

Source control by removal of impounded water and installation of a geomembrane cover system for AP2 was completed in 2020 in accordance with the closure plan (Ramboll, 2021a); the closure was supported by groundwater modeling approved by IEPA in 2018 (Buscher, 2018), which is discussed in detail in Section 2.1.

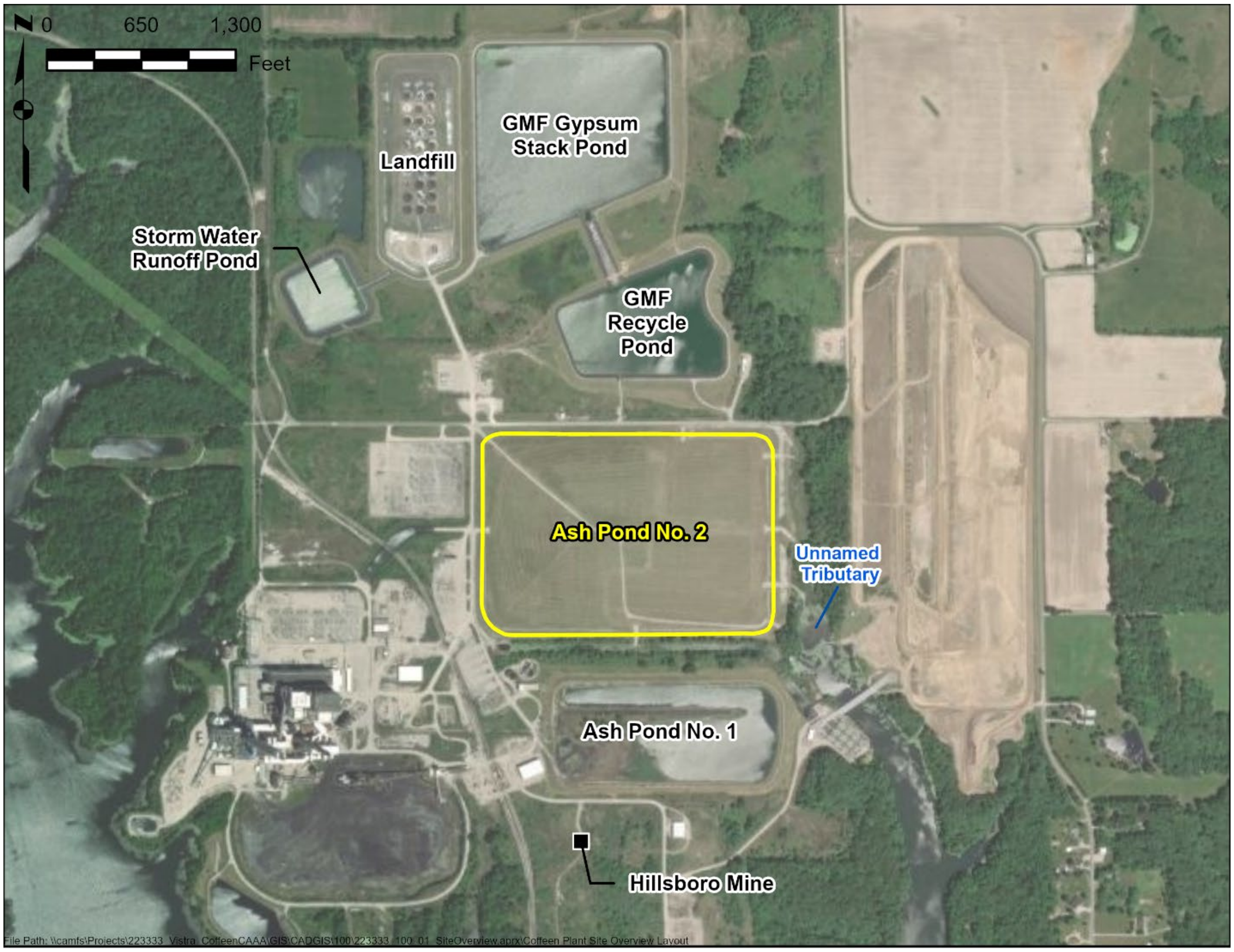

Figure 1.1 Site Location Map. GMF = Gypsum Management Facility. Adapted from NRT (2017b).

1.1.3 Surface Water Hydrology

The CPP is bordered by Coffeen Lake to the west, south, and east. Additionally, to the east, the CPP is also bordered by the Unnamed Tributary. East of the Site, the Unnamed Tributary flows south into the eastern lobe of Coffeen Lake. The facility is permitted to discharge to Coffeen Lake under National Pollutant Discharge Elimination System (NPDES) Permit No. IL 0000108 (IEPA, 2023; Ramboll, 2021a). The northeast corner of AP2 is located approximately several hundred ft west of Coffeen Lake within the Shoal Creek Watershed (Hydrologic Unit Code [HUC] 07140203; Ramboll, 2021a). The Unnamed Tributary flows south into Coffeen Lake approximately 200 ft northeast of AP2, and the East Fork of Shoal Creek is located approximately 4,300 ft east of AP2. Within 1,000 meters (m) of AP2, there are several unnamed freshwater ponds and two freshwater emergent wetlands (Ramboll, 2021a). The ponds range in size from 0.2 acres to 4.8 acres. Emergent wetlands are 0.4 acre in size, located south of AP2, and 1.6 acres, located east and northeast of AP2 where the Unnamed Tributary enters Coffeen Lake.

The 1,100-acre Coffeen Lake was constructed by damming the McDavid Branch of the East Fork of Shoal Creek to aid with cooling for the facility (Ramboll, 2021a). The IEPA classifies Coffeen Lake as a General Use Water (IEPA, 2007): it is designated for aquatic life and use in primary contact recreation; however, it is not designated for use in food processing or as a public water supply. Coffeen Lake (Assessment Unit ID IL_ROG) is listed on the 2018 Illinois Section 303(d) List as being impaired for fish consumption due to mercury (IEPA, 2019; US EPA, 2022). In addition, US EPA approved in 2007 a Total Maximum Daily

Load (TMDL) for phosphorus to address aesthetic quality impairments in Coffeen Lake due to excess algae and total suspended solids (IEPA, 2007).

1.1.4 Hydrogeology

The geology underlying the Site in the vicinity of AP2 consists of several distinct hydrostratigraphic units (Appendix C; Ramboll, 2024a; NRT, 2017b; Ramboll, 2020):

- **Upper Confining Unit (UCU):** The UCU underlies AP2. It consists of the Roxana and Peoria Silts (Loess Unit) and the upper portion of the Hagarstown Member, which has low permeability clays and silts. The Loess Unit in the area of AP2 is relatively thin, with less than 1 ft of thickness and was likely removed during AP2 construction. The upper clayey till portion of the Hagarstown Member has varying thicknesses from 1.9 ft to over 12 ft to the south and west of AP2.
- **Uppermost Aquifer (UA):** The UA comprises moderately permeable sands, silty sand, and clayey gravel of the Hagarstown Member and, in some portions of the Site, the Vandalia Member. The UA unit is thin (generally less than 3 ft), discontinuous, and variable throughout AP2 due deposition and weathering.
- **Lower Confining Unit (LCU):** The LCU underlies the UA. It consists of three low hydraulic conductivity soil layers: the sandy clay till of the Vandalia Member, the silt of the Mulberry Grove Formation, and the compacted clay till of the Smithboro Member. The thickness of LCU ranges approximately 7 to 18 ft thick near AP2. The LCU has been identified as a potential migration pathway (PMP) because downward vertical gradients indicate that there is the potential for impacts to migrate through this unit.
- **Deep Aquifer (DA):** The DA consists of sand and sandy silt/clay units of the Yarmouth Soil, which is discontinuous and, where present, generally less than 5 ft thick. This unit is also identified as a PMP.
- **Deep Confining Unit (DCU):** The DCU is comprised of the Banner Formation, with a mixture of clays, silts, and sands. The Lierle Clay Member is the upper portion of the Banner Formation.

There is a groundwater flow divide within the UA in the center of the CPP property between the two lobes of Coffeen Lake. Groundwater in the UA flows from the center of the CPP property west toward Coffeen Lake and east toward the Unnamed Tributary. Groundwater near AP2 flows east and south toward a former surface water discharge flume and the Unnamed Tributary (NRT, 2017b). There is limited groundwater flow from AP2 toward the west due to a thinning or lower hydraulic conductivity of the Hagarstown Beds (NRT, 2017b). Both the discharge flume and the Unnamed Tributary intersect and cut off the Hagarstown Member in the UA, which blocks any further migration of potentially impacted groundwater (NRT, 2017a). Groundwater flow within the UA is predominantly horizontal due to the underlying low-permeability LCU (NRT, 2017b). Groundwater flow directions in the vicinity of AP2 are typically stable and do not have significant seasonal change. Groundwater elevations are controlled by the water level along the shoreline of Coffeen Lake (NRT, 2017a).

During groundwater interaction with surface water, CCR-related constituents may partition between sediments and the surface water column. It should be noted that many CCR-related constituents occur naturally in sediments and surface water (and can also arise from other industrial sources). As a result, their presence in the sediments and/or surface water of the Coffeen Lake and the Unnamed Tributary does not necessarily signify contributions from AP2.

1.1.5 Site Vicinity

The CPP property is bordered by Coffeen Lake to the west and south, by the Unnamed Tributary and Coffeen Lake to the east, and by agricultural land to the north (Ramboll, 2021a, Figure 1.1). Coal mining operations occurred in the vicinity of AP2 from 1906 until 1983. The former Hillsboro Mine (Illinois State Geological Survey [ISGS] Mine No. 871), which operated from 1964 until 1983, is located to the south of AP2. The Clover Leaf No. 4 Mine (ISGS Mine No. 442) was located north to northwest of AP2 and operated from 1906 until 1924 (Ramboll, 2021a).

Although the area surrounding the CPP is predominantly agricultural, Coffeen Lake and the surrounding land are used for recreational activities. Since 1986, Coffeen Lake State Fish and Wildlife Area (SFWA) has been open to the public under a lease and management agreement between the Illinois Department of Natural Resources (IDNR) and Ameren Energy Generating Company (IDNR, 2014). To the north of the Coffeen Power Plant, there are walking and hiking trails and bank fishing. Coffeen Lake also entertains fishing and picnicking on the western shore. Based on a review of the IDNR Historic Preservation Division database and the Illinois State Archaeological Survey database, there are no historic sites located within 1,000 m of AP2 (Ramboll, 2021a).

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[1] of GWPSs in groundwater associated with AP2 have been identified for boron, cobalt, pH, sulfate, and total dissolved solids (TDS) (Appendix D; Ramboll, 2024b), this report presents a CAAA for AP2 pursuant to the requirements under IAC Section 845.670. 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 (Burns & McDonnell, 2021). That operating permit application, including the proposed groundwater monitoring program, remains under review by IEPA and therefore IPRG 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 (Appendix C; Ramboll, 2024a). 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, 2021).

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 AP2, a CAAA is required because groundwater monitoring associated with AP2 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) 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, pH, sulfate, and TDS were identified as a constituent detected in groundwater at a concentration in excess of its GWPS (Appendix D; Ramboll, 2024b).

Three potentially viable corrective actions for AP2 were selected in the CMA for further consideration in this CAAA. Each of these corrective action alternatives includes source control by closure-in-place (CIP). The corrective actions that are considered in this CAAA are Source Control with Groundwater Polishing (Source Control-GWP), Source Control with an Upgradient Barrier Wall and Groundwater Extraction Trench (Source Control-Upgradient Barrier Wall and GWE Trench) and Source Control with a Horizontal Groundwater Extraction Well (Source Control-Horizontal GWE Well). The corrective actions are described below in Section 2.1.

It should be noted that Source Control-GWP, Source Control with GWE (Source Control-GWE), and Source Control with Groundwater Cutoff Wall (Source Control-Cutoff Wall) were initially identified in the CMA as viable remedial approaches (Appendix C; Ramboll, 2024a). However, during subsequent evaluations, the remedial approaches were modified. Remedy modifications include the following:

- The Source Control-Cutoff Wall alternative was determined to be infeasible for attaining GWPS in a reasonable amount of time without a supplementary hydraulic control method. The cutoff wall was expanded into the upgradient barrier wall with GWE trench (*i.e.*, Source Control-Upgradient Barrier Wall and GWE Trench alternative).

- The Source Control-GWE alternative was further refined into the Source Control-Horizontal GWE well remedy, which includes an alternate method of GWE well installation *via* horizontal directional drilling to reduce disturbance of the completed final cover system while allowing for targeted installation near the CCR/native soil interface beneath AP2.

2.1 Corrective Action Alternatives 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, 2015b). The source control for AP2 consisted of closure-in-place (CIP). Specific elements of this approach completed in 2020 included (AECOM, 2017):

- Removal of impounded water prior to the grading of CCR and fill materials;
- Removing and abandoning existing dewatering wells and piezometers within the previous cover system;
- Installation of a geomembrane cover system consisting of a 40-mil linear low-density polyethylene (LLDPE) geomembrane layer, a geocomposite drainage layer, 18 inches (in) of protective soil cover and at least 6 in of earthen material suitable for supporting vegetative growth; and
- Construction of a stormwater management system to convey stormwater runoff to perimeter drainage channels and to letdown structures.

These source control activities included the removal of impounded water and the installation of a low-permeability final geomembrane over system designed to limit the infiltration of precipitation into the impounded CCR, and the establishment of the stormwater management system. These activities were designed to control, minimize, or eliminate, post closure infiltration of liquids into the impounded CCR. As demonstrated by the groundwater modeling in support in support of the Closure and Post-Closure Care Plan (AECOM, 2017; NRT, 2017a), this source control approach would result in a reduction of CCR leachate generation and contraction of the groundwater contaminant plume, which was predicted to begin after the completion of the source control, demonstrating that source control controls, minimizes, or eliminates post-closure releases 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 AP2:

- **Alternative 1:** Source Control with Groundwater Polishing (Source Control-GWP)
- **Alternative 2:** Source Control with Upgradient Barrier Wall and Groundwater Extraction Trench (Source Control-Upgradient Barrier Wall and GWE Trench)
- **Alternative 3:** Source Control with a Horizontal Groundwater Extraction Well (Source Control-Horizontal GWE Well)

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 (*i.e.*, CIP) combined with residual plume management based on natural physical and geochemical processes that would reduce groundwater concentrations downgradient of AP2. GWP mechanisms were evaluated using geochemical speciation and reaction models. The primary objective of the geochemical model was to support the evaluation of GWP 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., 2025). 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, 2015b).

Components of residual plume management for this 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 GWP would reduce the groundwater concentrations and mobility of inorganic contaminants under post-closure conditions. 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 future conditions, and remobilization is unlikely to impact the time to achieve GWPS as groundwater returns to background conditions for sulfate. Remobilization of boron may occur at some locations and affect the time to achieve GWPS compared to sulfate (Appendix E; Geosyntec Consultants, Inc., 2025).
- 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 facility 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 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; and
- 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 over 100 years after approval of the corrective action plan (Appendix B; Ramboll, 2025a), including:

- Approximately 135 years (1,620 months) of corrective action monitoring (*i.e.*, time to meet GWPSs);
- At least 3 years (36 months) of corrective action confirmation monitoring;[2] and
- Approximately 6 months associated with post-closure reporting.

Although source control (*i.e.*, closure-in-place [CIP]) is a primary component of the corrective action, source control was completed in the 2020 and is not evaluated in this report. Moreover, there is no labor and mileage incurred with the residual plume management under the Source Control-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, 2025a).

2.1.2 Alternative 2: Source Control-Upgradient Barrier Wall and GWE Trench

The second corrective action alternative is Source Control-Upgradient Barrier Wall and GWE Trench. This remedy includes source control (*i.e.*, CIP) with a barrier wall and groundwater extraction trench as the residual plume management approach. The residual plume management would include the construction of a barrier wall located adjacent to the northern and western sides of AP2, with an extraction trench running parallel and hydraulically downgradient of the barrier wall. The combined extraction trench and barrier wall would prevent groundwater flowing towards AP2 from the northwest, to collect impacted groundwater and reduce the hydraulic head beneath AP2. Both structures would be constructed from the ground surface to a depth of 8 ft bgs penetrating the UA. The barrier wall and the GWE trench would be approximately 2 to 3 ft wide, with 1 to 2 ft of separation between them. Horizontal collection pipes would be installed in the trench which would be backfilled with clean granular fill and capped with compacted clay to reduce surface water infiltration. The collection pipes would drain to sumps spaced throughout the trenches to extract groundwater. Extracted groundwater would be collected and sent to a new on-Site lined pond and discharged from either a new or existing outfall managed under the National Pollutant Discharge Elimination System (NPDES) permit for the Site (IEPA, 2023). The barrier wall would be approximately 3,300 ft long and constructed using *in-situ* soils with a low-permeability mixture down to the target elevation. The barrier wall would be located on the outer side (hydraulically upgradient) of the extraction trench to limit groundwater from flowing towards AP2 and to reduce the amount of groundwater that needs to be extracted from the trench (Appendix B; Ramboll, 2025a).

Implementation of the Source Control-Upgradient Barrier Wall and GWE Trench is expected to include various tasks across three major phases: pre-construction activities (Phase 1), corrective action construction (Phase 2), and corrective action operations, maintenance, and closeout (Phase 3). The activities associated with each of these phases 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 extraction trench, settling pond, and minor Site restoration of disturbed areas;

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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).

    - Mobilization of equipment and materials to the Site, and preparation for Site construction including stormwater best management practices (BMPs), modification for Site utilities, and specialty geotechnical techniques for trenching activities;
    - The GWE trench would be constructed using one-pass trenching methods by excavating subgrade soils, placing collection piping and pumps, and backfilling/capping the trench to reduce surface water infiltration; other installation methods may be evaluated at a later phase of design;
    - The barrier wall would be constructed using one-pass technology, although other installation approaches may be evaluated during a later phase of design; a temporary on-Site batch plant or material handling system would be established to generate the low permeability backfill for the wall;
    - Excavated soils from the GWE trench and barrier wall would be hauled and disposed of at an on-Site landfill;
    - The 1-acre, geomembrane-lined settling pond would be constructed to manage extracted groundwater using conventional construction equipment; although other groundwater treatment and management technologies may be evaluated during a later phase of design. Piping and installation of electrical, mechanical, and pneumatic infrastructure would be used to convey water from the settling pond to an appropriate NPDES outfall;
    - Site restoration would be completed following the construction of the GWE trench and settling pond.
- **Phase 3:** Operations, Maintenance (O&M), and Closeout of the barrier wall and GWE trench system. Details pertaining to each of these activities are outlined below.
    - Continuous operation of the GWE trench and barrier wall system;
    - Corrective Action O&M would involve routine and non-routine maintenance of extraction pumps, transfer pumps, air compressor, totalizer data collection, filter system, and other system components, as well as flushing or jetting of water conveyance lines to remove accumulated organic or inorganic solids from the interior walls;
    - Monitoring of extracted groundwater under the NPDES permit;
    - 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 would be performed using a new corrective action groundwater monitoring network designed in accordance with IAC Section 845.680(c), which would be installed within the plume that lies beyond the facility boundary;
    - 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 67 to 69 years after approval of the Construction Permit Application (Appendix B; Ramboll, 2025a), including:

- Approximately 3.5 to 5 years (42 to 60 months) of pre-construction activities (Phase 1),
- Approximately 6 to 12 months of corrective action construction (Phase 2), and

- Approximately 63 years (750 months) of O&M and closeout (Phase 3):
    - It is estimated to include 59 years (708 months) of corrective action monitoring (*i.e.*, time to meet GWPSs), at least 3 years (36 months) of corrective action confirmation monitoring,[3] and 6 months associated with post-closure reporting.

Key parameters for the Source Control-Upgradient Barrier Wall and GWE Trench corrective action alternative are shown in Table 2.1, below.

Table 2.1 Key Parameters for the Source Control-Upgradient Barrier Wall and GWE Trench Corrective Action Alternative[a]

Parameter[b]	Value[c]
Labor Hours	
Total On-Site Labor	16,900 hours
Total Off-Site Labor	0 hours
40% Contingency	6,760 hours
Total Labor Hours:	23,600 hours
Vehicle and Equipment Travel Miles	
Vehicles On-Site	23,300 miles
On-Site Haul Trucks (Unloaded + Loaded)	4,200 miles
Labor Mobilization	152,000 miles
Equipment Mobilization (Unloaded + Loaded)	26,300 miles
Off-Site Haul Trucks (Unloaded + Loaded)	17,400 miles
Material Deliveries (Unloaded + Loaded)	9,000 miles
Total On-Site Vehicle and Equipment Travel Miles:	27,500 miles
Total Off-Site Vehicle and Equipment Travel Miles:	205,000 miles
Total Vehicle and Equipment Travel Miles:	233,000 miles

Notes:
GWE Trench = Groundwater Extraction Trench.
(a) Although source control (*i.e.*, closure-in-place [CIP]) is a primary component of the corrective action, the source control was completed in 2020 and the associated labor time, equipment usage, and mileage are not discussed in this analysis.
(b) Site activities are expected to occur during the corrective action construction and operation and maintenance phases for this alternative.
(c) Values reported in this table were rounded to reflect 3 significant figures.
Source: Appendix B.

2.1.3 Alternative 3: Source Control-Horizontal GWE Well

The third corrective action alternative is Source Control-Horizontal GWE Well. This remedy includes source control (*i.e.*, CIP) with a horizontal extraction well as the residual plume management approach. This residual plume management would include constructing a horizontal extraction well running in the north south direction within the eastern portion of AP2 at the CCR/native soil interface. The GWE well would extract and drain water from beneath the AP2, reduce the hydraulic head, and accelerate the time to achieve the GWPSs (Appendix B; Ramboll, 2025a). The horizontal well would begin at the southern bank of AP2 at an elevation of 600 ft-amsl and extend 1,325 ft to the north at an elevation of 606 ft-amsl. Extracted water would be directed through a culvert or be pumped to a settling pond before discharge to an NPDES permitted outfall.

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[3] It should be noted that post-closure care groundwater monitoring would continue for a minimum of 30 years or until such time as GWPSs are achieved, whichever is longer, as required by IAC Section 845.780(c).

Implementation of the Source Control-Horizontal GWE Well is expected to include various tasks across three major phases: pre-construction activities (Phase 1); corrective action construction (Phase 2); and corrective action operations, maintenance, and closeout (Phase 3). The activities associated with each of these phases are summarized below:

- **Phase 1:** Pre-construction activities, including obtaining permits from agencies, and completing Site investigations and engineering designs;
- **Phase 2:** Construction activities related to installation of the horizontal well, and minor Site restoration of disturbed areas;
  - Mobilization of equipment and materials to the Site and preparation for Site construction, which would include implementing stormwater BMPs around the construction area, modification of Site utilities, and the construction of a work platform;
  - The horizontal well would be installed in a south-north direction at the targeted elevation of the bottom of CCR/top of the UA between 600 and 606 ft-amsl with a length of about 1,300 ft; the well casing would contain a slotted well screen for collection of groundwater;
  - After well installation, the well would be developed by flushing or jetting the system as needed and the entry point would be grout sealed to reduce surface infiltration and any drill cuttings and spoils would be hauled to an on-Site landfill for disposal;
  - The geomembrane-lined settling pond would be constructed to manage extracted groundwater using conventional construction equipment; the settling pond would be approximately 1 acre in size and 2-ft deep; and
  - Site restoration would be completed following the construction of the horizontal well and settling pond.
- **Phase 3:** Operations, maintenance, and closeout. Details pertaining to each of these activities are outlined below.
  - Corrective Action O&M would involve routine inspection of the horizontal well extraction system such as transfer pumps and other system components; non-routine maintenance such as flushing or jetting of water conveyance lines may also occur;
  - 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 would be performed using a new corrective action groundwater monitoring network designed in accordance with IAC Section 845.680(c), which would be installed within the plume that lies beyond the facility boundary;
  - GWPSs are expected to be achieved in approximately 14 years after corrective action operation starts. Current modeling indicates that operation of the horizontal well system may be required for an additional 25 years to prevent concentrations from rebounding above the GWPSs; however, additional modeling would be performed and additional data would be collected as part of the Corrective Action Groundwater Monitoring Plan to evaluate and assess the exact required duration of additional system operation. Therefore, the total operational time period for the horizontal GWE system may be about 39 years. Corrective action monitoring would continue during this time and would include an additional 3 years of corrective action confirmation sampling after the correction action operation has ceased; and

  - 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 46 to 48 years (552 to 576 months) after approval of the Construction Permit Application (Appendix B; Ramboll, 2025a), including:

- Approximately 3 to 4.5 years (36 to 54 months) of pre-construction activities (Phase 1);
- Approximately 6 to12 months of corrective action construction (Phase 2); and
- Approximately 46 years (546 months) of corrective action O&M, and closeout (Phase 3).
  - It is estimated to include 14 years (168 months) of corrective action monitoring (*i.e.*, time to meet GWPSs), 25 years (300 months) of additional operation to prevent concentrations from rebounding above the GWPSs,[4] at least 3 years (36 months) of corrective action confirmation monitoring,[5] and 6 months associated with post-closure reporting.

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[4] Current modeling indicates that an additional 25 years of system operation may be required to prevent concentrations from rebounding above the GWPSs; however, additional modeling would be performed and additional data would be collected as part of the Corrective Action Groundwater Monitoring Plan to evaluate and assess the exact required duration of additional system operation.

[5] 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-Horizontal GWE Well corrective action alternative are shown in Table 2.2, below.

Table 2.2 Key Parameters for the Source Control-Horizontal GWE Well Corrective Action Alternative[a]

Parameter[b]	Value[c]
Labor Hours	
Total On-Site Labor	12,600 hours
Total Off-Site Labor	0 hours
40% Contingency	5,020 hours
Total Labor Hours:	17,600 hours
Vehicle and Equipment Travel Miles	
Vehicles On-Site	16,800 miles
On-Site Haul Trucks (Unloaded + Loaded)	98 miles
Labor Mobilization	116,000 miles
Equipment Mobilization (Unloaded + Loaded)	18,900 miles
Off-Site Haul Trucks (Unloaded + Loaded)	9,950 miles
Material Deliveries (Unloaded + Loaded)	7,570 miles
Total On-Site Vehicle and Equipment Travel Miles:	16,900 miles
Total Off-Site Vehicle and Equipment Travel Miles:	153,000 miles
Total Vehicle and Equipment Travel Miles:	170,000 miles

Notes:
Source Control-Horizontal GWE Well = Source Control with a Horizontal Groundwater Extraction Well.
(a) Although source control (*i.e.*, closure-in-place [CIP]) is a primary component of the corrective action, the source control was completed in 2020 and the associated labor time, equipment usage, and mileage are not discussed in this analysis.
(b) Site activities are expected to occur during the corrective action construction and O&M phases for this alternative.
(c) Values reported in this table were rounded to reflect 3 significant figures.
Source: Appendix B; Ramboll, 2025a.

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 (IAC Section 845.670(e)(1)(A))

There are no current unacceptable risks to human or ecological receptors at this Site associated with AP2 (Appendix A; Gradient, 2025). Because current conditions do not present a risk to human health or the environment at AP2, there will be no unacceptable risk to human health or the environment for future conditions since the unit was already closed and source control was implemented. Concentrations of CCR-related constituents will decline over time and, consequently, potential exposures to CCR-related constituents in the environment will also decline. As a result of this, the magnitude of the reduction of existing risks is the same for the three potential corrective action alternatives (IAC Section 845.670(e)(1)(A)), and each corrective action alternative 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 was implemented for all three corrective action alternatives. Source control (*i.e.*, CIP) included removal of impounded water, and the installation of a low-permeability final geomembrane cover system to limit the infiltration into the impounded CCR, and the establishment of the stormwater management system. As demonstrated by the groundwater modeling in support of the Closure and Post-Closure Care Plan (NRT, 2017a), this source control approach would result in a reduction of CCR leachate generation and contraction of the groundwater contaminant plume, which was predicted to begin after the completion of the source control. Because source control was already completed at the Site, all three corrective action alternatives would remove the potential for CCR within the impoundment to impact groundwater. All three corrective action alternatives would be equally and fully protective with regard to source control. 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 GWP would reduce the groundwater concentrations and mobility of inorganic contaminants under post-closure conditions. 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 as groundwater returns to background conditions, and remobilization is unlikely to impact the time to achieve GWPS for sulfate. Remobilization of boron may occur at some locations and affect the time to achieve GWPS compared to sulfate (Appendix E; Geosyntec Consultants, Inc., 2025). In cases in which observed groundwater concentrations deviate significantly from modeled conditions, alternative methods or techniques would be evaluated under the adaptive site management, and if viable, incorporated as per IAC Section 845.680(b).
- Under the Source Control-Upgradient Barrier Wall and GWE Trench alternative, residual contamination control would be achieved by the construction of a barrier wall to prevent groundwater flowing towards AP2 and by installation of an extraction trench running parallel and hydraulically downgradient of the barrier wall to reduce the hydraulic head and collect impacted groundwater beneath AP2. GWE trench and a subsurface barrier wall are widely used corrective measures that have been effectively implemented at many sites to contain and capture and dissolved-phase groundwater plumes, and their combined implementation increases their efficacy to control the residual contamination. In cases in which observed groundwater concentrations deviate significantly from modeled conditions, alternative methods or techniques would be evaluated under the adaptive site management plan, and if viable, incorporated as per IAC Section 845.680(b).
- Under the Source Control-Horizontal GWE Well alternative, residual contamination control would be achieved by installing a horizontal GWE well to collect and drain CCR-impacted groundwater beneath AP2. Horizontal GWE wells are commonly used corrective measures that have been effectively implemented at many sites to control the residual contamination. In cases in which observed groundwater concentrations deviate significantly from modeled conditions, alternative methods or techniques would be evaluated under the adaptive site management plan, and if viable, incorporated as per IAC Section 845.680(b).

All three corrective action alternatives include source control and residual plume management. Thus, all three potential corrective action alternatives would be effective at reducing 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. The Source Control-Upgradient Barrier Wall and GWE Trench alternative would require construction of a new on-Site settling pond to remove solids from extracted groundwater, prior to discharge *via* an NPDES permitted outfall. For the Source Control-Horizontal GWE Well alternative, extracted water would be managed and treated by a newly constructed on-Site settling pond, although other treatment and management technologies may be evaluated at later phases of the design (Appendix B; Ramboll, 2025a). For all 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 (CIP), which was implemented in 2020. A geosynthetic cover system was previously installed over AP2, which included a 40-mil LLDPE geomembrane liner, 18 in of soil cover and 6 in of erosion soil layer for vegetative growth. A new stormwater control system was also installed. This cover system provides increased protection against berm and surface erosion, precipitation infiltration, and other adverse effects that could potentially trigger a release of CCR. None of the alternatives would disturb the previously installed cover system. Thus, 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 for all corrective action alternatives are summarized as follows:

- 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 corrective action groundwater monitoring and routine maintenance of the monitoring wells, which would continue 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.
- The Source Control-Upgradient Barrier Wall and GWE Trench would require the construction of an extraction trench and barrier wall. Multiple tasks would be completed over three phases: pre-construction activities (Phase 1), corrective action construction (Phase 2), and corrective action O&M, and closeout (Phase 3). Once pre-construction activities are completed, construction of the extraction trench and barrier wall would occur. Corrective action O&M would require regular inspection and maintenance of the extraction trench system, such as extraction pumps, filter system, and other system components. Non-routine maintenance may include tasks such as repair or replacement of the extraction and/or transfer pumps, repair or replacement of the system air

compressor, and flushing or jetting of water conveyance lines in the event organic or inorganic solids accumulate on the interior walls. Extracted groundwater would be managed and treated by a newly-constructed on-Site settling pond before discharge *via* an NPDES Outfall. Additionally, corrective action 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.

- The Source Control-Horizontal GWE Well would require the construction of a horizontal groundwater well. Multiple tasks would be completed over three phases: pre-construction activities (Phase 1), corrective action construction (Phase 2), corrective action O&M, and closeout (Phase 3). Once pre-construction activities are completed, installation of the horizontal GWE well and construction of the settling pond would occur. Corrective action O&M would require inspection and maintenance of the horizontal well to ensure continued operation. These activities would include routine inspection of the horizontal well extraction system along with non-routine maintenance such as flushing or jetting of water conveyance lines. Extracted groundwater would be managed to ensure compliance with the Site's NPDES permit for treatment and discharge. As with the other alternatives, corrective action sampling and routine maintenance of the monitoring well network would continue during the system operation. Once the GWPSs have been reached (approximately 14 years), corrective action monitoring may continue for additional 25 years to prevent groundwater concentrations from rebounding above the GWPSs.[6] Corrective action confirmation monitoring would continue after GWPSs have been achieved for all compliance wells for a period of 3 years after extraction from the horizontal well has been ceased, 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.

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. Because the source control was implemented in 2020, there is no further risk of accidents and injuries occurring during the implementation of the source control remedy. 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 and maintenance of any engineered systems or structures, and therefore no safety impacts are expected.

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[6] The exact duration of additional system operation would be determined as part of Corrective Action Groundwater Monitoring based on additional modeling and data collection.

- The Source Control-Upgradient Barrier Wall and GWE Trench alternative would include the construction of a barrier wall in order to prevent groundwater flowing towards AP2; a groundwater extraction trench system and settling pond to collect, extract, and treat CCR-impacted groundwater. Potential safety concerns would be related to the construction and O&M of the barrier wall, the extraction trench and settling pond.
- The Source Control-Horizontal GWE Well alternative would include construction of a horizontal well to collect CCR-impacted groundwater beneath AP2. Potential safety concerns would be related to the construction activities associated with installation of the horizontal well, as well as activities related to subsequent O&M.

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-Upgradient Barrier Wall and GWE Trench corrective action alternative would require 16,900 hours on-Site labor hours and residual plume management for the Source Control-Horizontal GWE Well corrective action alternative would require 12,600 hours on-Site labor hours (Appendix B; Ramboll, 2025). 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 0.17 worker injuries and 1.5×10^{-3} worker fatalities would occur on-Site under the Source Control-Source Control-Upgradient Barrier Wall and GWE Trench corrective action alternative; and approximately 0.13 worker injuries and 1.1×10^{-3} worker fatalities would occur on-Site under the Source Control-Horizontal GWE Well 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- Source Control-Upgradient Barrier Wall and GWE Trench alternative.

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

Corrective Action Alternative	Injuries	Fatalities
Source Control-GWP	0	0
Source Control-Upgradient Barrier Wall and GWE Trench	0.17	1.5×10^{-3}
Source Control-Horizontal GWE Well	0.13	1.1×10^{-3}

Notes:
Source Control-GWP = Source Control with Groundwater Polishing; Source Control-Horizontal GWE Well = Source Control with a Horizontal Extraction Well; Source Control-Upgradient Barrier Wall and GWE Trench = Source Control with an Upgradient Barrier Wall and Groundwater Extraction Trench.

(a) Although source control (*i.e.*, closure-in-place [CIP]) is a primary component of the corrective action, it was complete in 2020, and the worker accidents associated with source control are not included in this analysis.

(b) Worker accidents associated with groundwater sampling and monitoring are not included in this analysis for any of the alternatives.

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-Upgradient Barrier Wall and GWE Trench compared to the Source Control-Horizontal GWE Well alternative (Tables 2.1-2.2). For residual plume management under the Source Control-Upgradient Barrier Wall and GWE Trench and Source Control-Horizontal GWE Well corrective action alternatives, 205,000 and 153,000 total off-Site vehicle and equipment travel miles would be required, respectively. No off-Site travel miles would be expected under the Source Control-GWP alternative (Appendix B; Ramboll, 2025a). 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 0.10 worker injuries and 2.3×10^{-3} worker fatalities would be expected to occur due to off-Site activities under the Source Control-Upgradient Barrier Wall and GWE Trench alternative; and an estimated 0.077 worker injuries and 1.7×10^{-3} worker fatalities would be expected to occur due to off-Site activities under the Source Control-Horizontal GWE Well alternative. No worker accidents would be expected under the Source Control-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-Upgradient Barrier Wall and GWE Trench		Source Control-Horizontal GWE Well	
	Injuries	Fatalities	Injuries	Fatalities	Injuries	Fatalities
Hauling	0	0	3.7×10^{-3}	2.7×10^{-4}	2.1×10^{-3}	1.6×10^{-4}
Labor Mobilization/Demobilization	0	0	0.09	1.4×10^{-3}	0.069	1.1×10^{-3}
Equipment Mobilization/Demobilization	0	0	5.5×10^{-3}	4.1×10^{-4}	4.0×10^{-3}	3.0×10^{-4}
Material Deliveries	0	0	1.9×10^{-3}	1.4×10^{-4}	9.6×10^{-4}	1.2×10^{-4}
Total:	0	0	0.10	2.3×10^{-3}	0.077	1.7×10^{-3}

Notes:

GWE = Groundwater Extraction; GWE Trench = Groundwater Extraction Trench; Source Control-GWP = Source Control with Groundwater Polishing; Source Control-Horizontal GWE Well = Source Control with a Horizontal Groundwater Extraction Well; Source Control-Upgradient Barrier Wall and GWE Trench = Source Control with Upgradient Barrier Wall and Groundwater Extraction Trench.

(a) Although source control (*i.e.*, closure-in-place [CIP]) is a primary component of the corrective action, it was complete in 2020, and the worker accidents associated with source control are not included in this analysis.

Overall, considering accidents occurring both on- and off-Site, 0.28 worker injuries and 3.8×10^{-3} worker fatalities would be expected to occur for residual plume management under the Source Control-Upgradient Barrier Wall and GWE Trench alternative; and 0.21 worker injuries and 2.8×10^{-3} worker fatalities would be expected to occur for residual plume management under the Source Control-Horizontal GWE Well alternative. Thus, overall risks to workers would be highest under the Source Control-Upgradient Barrier Wall and GWE Trench 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 0.051 injuries and 6.9×10^{-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) for residual plume management under the Source Control-Upgradient Barrier Wall and GWE Trench alternative (Table 2.5). For residual plume management under the Source Control-Horizontal GWE Well alternative, off-Site vehicle accidents could result in an estimated 0.038 community injuries and 5.2×10^{-4} 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 the highest under the Source Control-Upgradient Barrier Wall and GWE Trench alternative.

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

Off-Site Vehicle Use Category	Source Control-GWP		Source Control-Upgradient Barrier Wall and GWE Trench		Source Control-Horizontal GWE Well	
	Injuries	Fatalities	Injuries	Fatalities	Injuries	Fatalities
Hauling	0	0	4.6×10^{-3}	3.4×10^{-5}	2.6×10^{-3}	1.9×10^{-5}
Labor Mobilization/Demobilization	0	0	3.7×10^{-2}	5.9×10^{-4}	2.8×10^{-2}	4.5×10^{-4}
Equipment Mobilization/Demobilization	0	0	6.9×10^{-3}	5.1×10^{-5}	5.0×10^{-3}	3.7×10^{-5}
Material Deliveries	0	0	2.4×10^{-3}	1.7×10^{-5}	2.0×10^{-3}	1.5×10^{-5}
Total:	0	0	0.051	6.9×10^{-4}	0.038	5.2×10^{-4}

Notes:
GWE = Groundwater Extraction; GWE Trench = Groundwater Extraction Trench; Source Control-GWP = Source Control with Groundwater Polishing; Source Control-Horizontal GWE Well = Source Control with a Horizontal Groundwater Extraction Well; Source Control-Upgradient Barrier Wall and GWE Trench = Source Control with Upgradient Barrier Wall and Groundwater Extraction Trench.
(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 performed 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 greenhouse has (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 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 (CIP) was implemented for all three potential corrective action alternatives and there are no further air impacts associated with source control. On-Site emissions would be highest for residual plume management under the Source Control-Upgradient Barrier Wall and GWE Trench alternative due to the greatest amount of on-Site vehicle travel miles required under this corrective action alternative (27,500 total on-Site travel miles under the Source Control-Upgradient Barrier Wall and GWE Trench alternative *versus* 16,900 total on-Site travel miles under the Source Control-Horizontal GWE Well alternative and no off-Site travel miles under the Source Control-GWP alternative; Section 2.1.1; Tables 2.1-2.2). Off-Site emissions would be highest for residual plume management under the Source Control- Upgradient Barrier Wall and GWE Trench alternative due to the greatest amount of off-Site vehicle and equipment travel miles required under this alternative (205,000 total off-Site travel miles under the Source Control-Upgradient Barrier Wall and GWE Trench alternative *versus* 153,000 total off-Site travel miles under the Source Control-Horizontal GWE Well alternative and no off-Site travel miles under the Source Control-GWP alternative). In summary, air impacts would be highest for the Source Control-Upgradient Barrier Wall and

GWE Trench 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, source control was implemented in 2020 (CIP), and, consequently, constituent mass flux from groundwater into surface water is declining over time. The source control approach removes the amount of water retained within the impoundment, which further reduces the hydraulic flux through the CCR. Due to the reduction in the hydraulic flux out of AP2, the mass flux out of AP2 would also be controlled or minimized. As demonstrated by the groundwater modeling in support in support of the Closure and Post-Closure Care Plan (NRT, 2017a), this source control approach would result in a reduction of CCR leachate parameters and thereby contraction of CCR constituents into the groundwater plume.

Under residual plume management for 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 groundwater monitoring wells).

Under residual plume management for the Source Control-Upgradient Barrier Wall and GWE Trench alternative, surface water and sediment impacts would be higher than the Source Control-GWP alternative due to the construction of the extraction trench system and 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. Extracted groundwater would be discharged *via* an NPDES permitted outfall. Any associated impacts would be addressed through BMPs in accordance with Site land disturbance permits.

Similarly, under residual plume management for the Source Control-Horizontal GWE Well alternative, surface water and sediment impacts would be higher than the Source Control-GWP alternative due to the construction of a horizontal GWE well (Appendix B; Ramboll, 2025a). Construction can have short-term negative impacts on surface water and sediment quality immediately adjacent to a site due to potential erosion and sediment runoff. Extracted groundwater would be discharged *via* an NPDES permitted outfall. Any associated impacts would be addressed through 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 (CIP) was implemented for all three potential corrective action alternatives. Thus, there are no further risks of CCR exposure associated with source control implementation. 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-Upgradient Barrier Wall and GWE Trench and Source Control-Horizontal GWE Well than for the Source Control-GWP alternative. The Source Control-Upgradient Barrier Wall and GWE Trench alternative would involve the production, management, and treatment of extracted groundwater, as well as on-Site disposal of excavated spoils generated during extraction trench and barrier wall construction. The Source Control-Horizontal GWE Well alternative would involve the production, management, and treatment of extracted groundwater, as well as on-Site disposal of excavated spoils generated during GWE well installation. 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-Upgradient Barrier Wall and GWE Trench or Source Control-Horizontal GWE Well alternative would be managed through the use of rigorous safety protocols and personal protective equipment.

2.2.5.5 Other Identified Impacts

Source control (CIP) was implemented for all three potential corrective action alternatives (AECOM, 2017). Thus, there are no further risks associated with source control implementation.

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-Upgradient Barrier Wall and GWE Trench Source and Control-Horizontal GWE Well alternatives, while the energy demands under the Source Control-GWP alternative associated with residual plume management are expected to be lower because Source Control-GWP would not require any significant construction activity. Additionally, energy would be required for the operation of the extraction systems and transfer pumps under the Source Control-Upgradient Barrier Wall and GWE Trench Source and Control-Horizontal GWE Well alternatives; there is no operational energy required under the Source Control-GWP because it would rely only on natural physical and geochemical processes.

Traffic and noise impacts associated with residual plume management are expected to be higher under the Source Control-Upgradient Barrier Wall and GWE Trench Source and Control-Horizontal GWE Well alternatives than the Source Control-GWP alternative, due to the construction activities required to construct the barrier wall and the extraction trench system under the Source Control-Upgradient Barrier Wall alternative, and construction activities related to installation of the horizontal well under the Source Control-Horizontal GWE Well alternative, respectively. Traffic may increase temporarily around the Site under the Source Control-Upgradient Barrier Wall and GWE Trench and Source Control-Horizontal GWE Well alternatives 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 alternative is expected to be significantly less than those associated with the Source Control-Upgradient Barrier Wall and GWE Trench Source and Control-Horizontal GWE Well alternative.

Construction activities can negatively impact natural resources and habitats near the Site, as well as scenic, historical, and recreational value. Based on a review of the IDNR Historic Preservation Division database and the Illinois State Archaeological Survey database, there are no historic sites located within 1,000 m of AP2 (Ramboll, 2021a). There would be no impacts under the Source Control-GWP alternative because no additional construction activities would occur after implementation of source control. However, the Source Control-Upgradient Barrier Wall and GWE Trench Source alternative would require construction of a barrier wall, an extraction trench, and an on-Site settling pond. The Source Control-Horizontal GWE Well alternative would require installation of a horizontal well and an on-Site settling pond. These impacts would include disturbance of some existing habitats atop portions of the construction areas, and habitat in the immediate vicinity of these locations by causing alarm and escape behavior in nearby wildlife (*e.g.*, due to noise disturbances). It is also possible that limited negative short-term impacts could occur to sensitive aquatic and wetland species in Coffeen Lake and other wetlands or surface water bodies located within the SFWA near AP2 (see Section 1.1.3) due to sediment runoff during construction required in any residual plume management.

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).

AP2 is underlain by the UCU beneath the majority of the impoundment footprint. There is a groundwater flow divide within the UA in the center of the CPP property between the two lobes of Coffeen Lake. Groundwater in the UA flows from the center of the CPP property west toward Coffeen Lake and east toward the Unnamed Tributary. Groundwater near AP2 flows east and south toward a former surface water discharge flume and the Unnamed Tributary (NRT, 2017b). There is limited groundwater flow from AP2 toward the west due to a thinning or lower hydraulic conductivity of the Hagarstown Beds (NRT, 2017b). Both the discharge flume and the Unnamed Tributary intersect and cut off the Hagarstown Member in the UA, which blocks any further migration of potentially impacted groundwater (NRT, 2017a). Groundwater flow within the UA is predominantly horizontal due to the underlying low-permeability LCU (NRT, 2017b). Groundwater flow directions in the vicinity of AP2 are typically stable and do not have significant seasonal change. Groundwater elevations are controlled by the water level along the shoreline of Coffeen Lake (NRT, 2017a).

Groundwater modeling was performed in support of the Closure Plan (AECOM, 2017). The model predicted that source control would result in a reduction of CCR leachate generation and contraction of the groundwater contaminant plume, which was predicted to begin after the completion of the source control (NRT, 2017a). Additional modeling was conducted for each of the corrective action alternatives to evaluate future groundwater quality in the vicinity of AP2 as a result of residual plume management (Appendix B; Ramboll, 2025b). The results of modeling indicate that groundwater concentrations would meet the GWPSs for all of the constituents[7] identified as having potential groundwater exceedances in approximately 135 years under the Source Control-GWP alternative after approval of the corrective action plan. Under the Source Control-Upgradient Barrier Wall and GWE Trench alternative, the time to achieve GWPSs in all monitoring wells would be approximately 63 to 65 years (4 to 6 years of pre-construction and construction activities followed by approximately 59 years of post-construction O&M) after approval of the Construction Permit Application. Under the Source Control-Horizontal GWE Well alternative, the time to achieve GWPSs would be approximately 17.5 to 19.5 years after approval of the Construction Permit Application (3.5 to 5.5 years of pre-construction and construction activities followed by approximately 14 years of system operation until the GWPSs are achieved). For the Source Control-Horizontal GWE Well

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[7] Sulfate was selected as a surrogate for the contaminant fate and transport simulations to evaluate the effectiveness of each of the corrective action alternative. Sulfate was detected in AP2 groundwater at the highest concentrations relative to its GWPS and it is expected to take the longest time to achieve GWPS. Sulfate has also been detected above the GWPS at more well locations adjacent to AP1 and AP2 than any other IAC Section 845.600 parameter which contributed to its selection for modeling at both units. Modeling all constituents that exceed GWPS or have been detected at lower concentrations relative to their GWPSs is unnecessary, as these constituents will likely more quickly achieve their GWPSs (Ramboll, 2025b).

alternative, current modeling indicates that an additional 25 years of system operation may be required to prevent concentrations from rebounding above the GWPSs (Appendix B; Ramboll, 2025a); however, additional modeling would be performed and additional data would be collected as part of the Corrective Action Groundwater Monitoring Plan to evaluate and assess the exact required duration of additional system operation. The timeframe for achieving GWPS under the Source Control-Horizontal GWE Well is, thus, predicted to be shorter than the timeframe for the other two alternatives (Table 2.6).

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

Implementation Phase	Implementation Task	Timeframe		
		Source Control-GWP[a]	Source Control-Upgradient Barrier Wall and GWE Trench[b]	Source Control-Horizontal GWE Well[b]
1: Pre-Construction Activities	Agency Coordination, Approvals, and Permitting	NA	18 to 24 months	12 to 18 months
	Final Design and Bid Process		24 to 36 months	24 to 36 months
	Total Timeframe to Complete Pre-Construction Activities		42 to 60 months (3.5 to 5 years)	36 to 54 months (3 to 4.5 years)
2: Corrective Action Construction	Corrective Action Construction	NA	6 to 12 months	6 to 12 months
	Total Timeframe to Complete Corrective Action Construction		6 to 12 months	6 to 12 months
3: Corrective Action O&M and Closeout	Corrective Action Operation (Time to Meet GWPS)	1,620 months (135 years)	708 months (59 years)	168 months (14 years)
	Potential Additional Corrective Action Operation (After GWPS have been Achiever)	NA	NA	300 months (25 years)[c]
	Corrective Action Confirmation Monitoring	36 months	36 months	36 months
	Corrective Action Completion Reporting	6 months	6 months	6 months
	Total Timeframe to Complete Corrective Action O&M and Closeout	Over 100 years	750 months (63 years)	510 months (43 years)
Total Timeline to Complete Corrective Action (all phases)		Over 100 years	798 to 822 months (67 to 69 years)	552 to 576 months (46 to 48 years)

Notes:

Source Control-GWP = Source Control with Groundwater Polishing; Source Control-Horizontal GWE Well = Source Control with a Horizontal Groundwater Extraction Well; Source Control-Upgradient Barrer Wall and GWE Trench = Source Control with an Upgradient Barrier Wall and Groundwater Extraction Trench.

(a) All timelines are assumed to occur after approval of the Corrective Action Plan.

(b) All timelines are assumed to occur after approval of the Construction Permit Application.

Source: Appendix B; Ramboll, 2025a.(c) For the Source Control-Horizontal GWE Well alternative, current modeling indicates that an additional 25 years of system operation may be required to prevent concentrations from rebounding above the GWPSs (Appendix B; Ramboll, 2025a); however, additional modeling would be performed and data would be collected as part of the Corrective Action Groundwater Monitoring Plan to evaluate and assess the exact required duration of additional system operation.

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 (CIP) were implemented at the Site in 2020. Thus, all corrective action alternatives would essentially eliminate the potential for a sudden CCR release to occur post-closure (*e.g.*, a dike failure or flooding event) due to the absence of impounded water within the unit and all corrective action alternatives are 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.

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-Upgradient Barrier Wall and GWE Trench and Source Control-Horizontal GWE Well alternatives than for the Source Control-GWP alternative. The Source Control-Upgradient Barrier Wall and GWE Trench would involve the production, management, and treatment of extracted groundwater, as well as on-Site disposal of excavated spoils generated during extraction trench construction. The Source Control-Horizontal GWE Well would involve the construction of the horizontal GWE well and production, management and treatment of extracted groundwater. The Source Control-GWP alternative would not involve exposure to any soils, surface waters or groundwater waste streams. Any potential CCR exposures occurring under Source Control-Upgradient Barrier Wall and GWE Trench and Source Control-Horizontal GWE Well during groundwater extraction and treatment would be managed through the use of rigorous safety protocols, personal protective equipment, and appropriate disposal practices.

Some changes in groundwater flow (*i.e.*, potential controlled discharge of extracted groundwater) may occur under the residual plume management for Source Control-Upgradient Barrier Wall and GWE Trench alternative, due to the operation of the GWE trench system and installation of a subsurface barrier wall in the UA. Hydrogeological changes as a result of this alternative would be lowering the groundwater table in the vicinity of the extraction trench and creating a subsurface barrier wall perpendicular to groundwater flow which would both alter flow patterns in the UA and cause changes in hydraulic gradients. Under the residual plume management for Source Control-Horizontal GWE Well alternative, a horizontal GWE well would be installed. This remedy would reduce hydraulic head beneath AP2, alter the hydraulic gradient and corresponding groundwater flow pattern. 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 for either of these alternatives.

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

Source control (CIP) was implemented in 2020. Thus, long-term reliability during source control would be the same for all three corrective action alternatives (AECOM, 2017). 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 physical and geochemical processes, rather than the installation, operation, and maintenance of engineered systems or structures. Site specific evaluations have shown that chemical attenuation is feasible, and remobilization is unlikely to impact the time to achieve GWPS as groundwater returns to background conditions for sulfate. Remobilization of boron may occur at some locations and affect the time to achieve GWPS compared to sulfate (Appendix E; Geosyntec Consultants, Inc., 2025). 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 AP2 groundwater remediation in response to new Site information and/or the performance of the corrective action alternative.
- GWE trench and barrier wall are proven remedies that have been implemented at many sites. Thus, residual plume management under the Source Control-Upgradient Barrier Wall and GWE Trench alternative would be expected to be reliable provided that the barrier wall and the extraction trench are constructed in accordance with standard design and specifications. Under this alternative, the extraction trench system and settling pond would require engineering design and implementation of the barrier wall, and groundwater extraction and treatment. Routine and non-routine maintenance of the GWE trench are required to ensure reliable operation of the extraction trench and pumps, as well as other mechanical components. The barrier wall component provides an inert, continuous, low-permeability barrier to groundwater flow and is not expected to need maintenance (Appendix B; Ramboll, 2025a). Active groundwater monitoring would be in place, similar to those required under the Source Control-GWP alternative.
- Horizontal GWE well is a proven remedy that has been implemented at many sites. Thus, residual plume management under the Source Control-Horizontal GWE Well alternative would be reliable provided that the horizontal well is constructed in accordance with standard design and specifications. The horizontal well system is a passive drain system; however, conveyance of extracted groundwater to the settling pond operates as a mechanical system and would require routine and non-routine operation and maintenance. Active groundwater monitoring would be in place, similar to the Source Control-GWP alternative.
- For all 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 physical and geochemical processes to achieve reductions in groundwater concentrations to below the 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-Upgradient Barrier Wall and GWE Trench alternative would utilize a subsurface low-permeability barrier wall to prevent flow towards AP2; as well as an extraction trench and settling pond to extract and treat impacted groundwater to achieve reductions in groundwater concentrations to below GWPSs. The barrier wall is a robust, engineered, and maintenance-free subsurface structure and therefore physical replacement is unlikely; while the GWE Trench system would need ongoing maintenance and potential replacement of system components to ensure its effectiveness. It is unlikely that the remedy would need to be replaced, if implemented as designed. 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-Horizontal GWE Well alternative would consist of installing a horizontal GWE well conveyance system to drain and convey groundwater beneath AP2. Physical replacements for this remedy are not likely. The conveyance of extracted groundwater to the settling pond would constitute a mechanical system which may require routine maintenance to reliably operate. Ongoing monitoring and maintenance of the horizontal well would be needed to retain its effectiveness. Similar to other alternatives, 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 (CIP) was previously implemented in 2020. Thus, there would be no further construction difficulties associated with source control. 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-Upgradient Barrier Wall and GWE Trench would involve the construction of a barrier wall, an extraction trench, settling pond and conveyance system to extract and treat impacted groundwater to address downgradient groundwater quality impacts. The construction of the shallow groundwater trench and barrier wall required by this alternative are commonly constructed at similar depths and can be performed using specialized (*i.e.*, one-pass trenching) and conventional construction equipment (Appendix B; Ramboll, 2025a). Therefore, while some construction is necessary, the degree of difficulty is expected to be low. 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-Horizontal GWE Well would involve the installation of a horizontal well to drain water beneath AP2 to address downgradient groundwater

quality impacts. This alternative would require the use of specialty equipment such as horizontal directional drill rigs and other supporting equipment such as excavating and grading equipment that would need to be mobilized to the site. Horizontal wells are routinely constructed in similar environments, however there may be difficulties due to potential heterogeneities encountered in the subsurface at the bottom of the CCR and top of the UA interface, and would require specialized techniques/equipment to address the issue. Therefore, the degree of difficulty is expected to be moderate for the horizontal well component (Appendix B; Ramboll, 2025a). 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 (CIP) was implemented in 2020. Thus, the operational reliability of the remedy would be the same for all three corrective action alternatives. 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 physical and geochemical 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. However, it should be noted that some boron re-mobilization may occur as groundwater returns to background conditions at AP2, which may affect the time to achieve GWPSs (Appendix E; Geosyntec Consultants, Inc., 2025).
- Residual plume management under the Source Control-Upgradient Barrier Wall and GWE Trench alternative would also have high operational reliability because it is an established and commonly used remedial technique, as long as the barrier wall and the extraction trench system are constructed in accordance with standard design and specifications. The barrier wall is an inert, continuous, low-permeability subsurface structure and is not expected to require maintenance after construction. The GWE trench system operates as a mechanical system and would require routine and non-routine maintenance ensure reliable operation.
- Residual plume management under the Source Control-Horizontal GWE Well alternative would also have high operational reliability if the horizontal well and conveyance system are constructed in accordance with standard design and specifications. The horizontal well system is a passive drain system; however, conveyance of extracted groundwater to the settling pond would operate as a mechanical system and require operation and routine/non-routine maintenance to ensure reliable operation.

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 were the same for all corrective action alternatives and were discussed in the Closure Plan (AECOM, 2017). The specific approvals and permits associated with residual plume management for each corrective action alternatives are discussed below.

- Residual plume management under the Source Control-GWP alternative would not need additional permits from other agencies, other than the approval of the eventual Corrective Action Plan.
- Residual plume management under the Source Control-Upgradient Barrier Wall and GWE Trench alternative would require approvals and permits. Groundwater discharge from the extraction trench would require a modified NPDES permit, which would likely require renewals depending on the timeline of corrective action implementation. In addition, permits from IEPA for construction stormwater controls, BMPs, and operating would be required. An IDNR Dam Safety modification permit would be obtained for modifications of the embankment. These permits and plans typically take 18-24 months to obtain (Appendix B; Ramboll, 2025a).
- Residual plume management under the Source Control-Horizontal GWE Well alternative would require approvals and permits. Modifications would be necessary to the Site's NPDES permit to allow for discharge of groundwater from the horizontal well. In addition, permits from IEPA for construction stormwater controls and BMPs would be required. These permits and plans typically take 18 to 24 months to obtain (Appendix B; Ramboll, 2025a).

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 (CIP) was implemented in 2020. Thus, there are no further equipment and specialist needs associated with the implementation of the source control remedy. 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 associated with residual plume management 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-Upgradient Barrier Wall and GWE Trench alternative would require specialists to construct the barrier wall and the GWE trench system and to manage the GWE Trench system throughout its operational period.
    - Construction of the groundwater extraction system and the barrier wall on the Site is expected to require a specialized contractor. The contractor would most likely need specialized and often custom-built equipment including one-pass construction equipment. The availability of contractors with such equipment may be limited.
    - Specialists including design engineers, geotechnical experts, construction managers and contractor staff experienced in trench construction and similar geologic environments would be required as well.
    - Geotechnical specialists would be required to design the working platform and oversee the AP2 embankment, monitoring for any signs of distress during the one-pass trench installation.
    - In addition, specialists and equipment may have backlogs due to high demand in similar specialty ground improvement projects in the area, which could delay the project schedule.

  - After the construction phase, specialists and equipment would be required during the operation of the GWE system. Routine maintenance would include inspection of system components such as totalizers, instrumentation, and the extraction and transfer pumps. Non-routine maintenance such as flushing or jetting of the conveyance lines, replacement of faulty system components, replacement of pumps or pump controllers, and replacement of faulty system instrumentation would also be necessary. Specialists and replacement equipment needed to operate the system would be generally available to the Site, although some of the more complex equipment (*i.e.*, transfer pumps and transfer pump controller) may have extended lead times for servicing.

  - This alternative would also 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-Horizontal GWE Well alternative would require specialists for horizontal well installation and maintenance.

  - Construction of the horizontal well would require design engineers, geologists, construction managers, and contractor staff experienced with horizontal well construction and specialized equipment operation.

  - Contractors would be required during the operation of the system including replacement of components and periodic well re-development (*i.e.*, flushing or jetting of conveyance lines). Specialists and equipment needed for O&M are generally available within close proximity to the Site with the exception of more complex system components, such as transfer pumps and transfer pump controller.

  - As with the other two alternatives, 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. 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 (IAC Section 845.670(e)(3)(D))/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 each alternative 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-Upgradient Barrier Wall and GWE Trench alternative would require the construction of the extraction of the barrier wall, the extraction trench system, and a new settling pond on-Site:
    - The waste materials (*i.e.*, spoils) generated from barrier wall and extraction trench would be disposed of in the on-Site landfill.
    - The extraction trench system would send extracted groundwater to the newly constructed settling pond, which would settle solids removed during groundwater recovery *via* the pneumatic extraction pumps and transfer piping. The settling pond would need to be sited, designed, constructed, and maintained properly. The siting of the settling pond would need to consider limiting impacts to existing and future Site infrastructure and other surface impoundments at CPP.
    - Discharge from the settling pond would be conveyed to an NPDES permitted outfall. Renewal of the NPDES permits may be necessary to continue operations, depending on the timeline of the corrective action implementation in relation to the source control completion.
- Residual plume management for the Source Control-Horizontal GWE Well alternative would require installation of a horizontal well and extracted groundwater conveyance system.
    - The horizontal well system would send extracted groundwater to a newly constructed on-Site settling pond to settle solids extracted during groundwater recovery. The settling pond would need to be sited, designed, constructed, and maintained properly. The siting of the settling pond would need to consider limiting impacts to existing and future Site infrastructure and other surface impoundments at CPP. Flows from the horizontal GWE wells would be discharged through an NPDES permitted outfall. Depending on the timeline of the corrective action, NPDES permit renewals may be required.

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 AP2 on groundwater and surface water quality including Earthjustice, the Prairie Rivers Network, and the Sierra Club (Earthjustice *et al.*, 2018; Lydersen, 2017; Sierra Club and CIHCA, 2014). The combination of source control (*i.e.*, CIP) 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 (NRT, 2017a).

A public meeting will be held on May 1, 2025, pursuant to requirements under IAC Section 845.710(e). Questions raised by attendees will be answered at the meeting; subsequently, a written summary of all questions and responses will 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 (Ramboll, 2025). All three potential corrective action alternatives include source control and would have residual plume management efforts. Source Control for AP2 included CIP with the installation of a low-permeability final geomembrane cover system designed to limit the infiltration of precipitation into the impounded CCR. Groundwater modeling was performed in support of the Closure Plan (AECOM, 2017), and concluded that this source control approach would result in a reduction of CCR leachate production, a decrease in CCR leachate constituent concentrations, and a contraction of the groundwater contaminant plume (NRT, 2017a). Therefore, source control will prevent further releases from AP2 into the environment and remove from the environment as much CCR and impacted material as 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 after remedy implementation in approximately 135 years under the Source Control-GWP alternative, approximately 63 to 65 years (4 to 6 years of pre-construction and construction activities followed by 59 years of post-construction) under the Source Control-Upgradient Barrier Wall and GWE Trench alternative, and approximately 17.5 to 19.5 years (3.5 to 5.5 years of pre-construction and construction activities followed by approximately 14 years of system operation until the GWPSs are achieved) under the Source Control-Horizontal GWE Well alternative. Under the Source Control-Horizontal GWE Well alternative, current modeling indicates that an additional 25 years of system operation may be required to prevent concentrations from rebounding above the GWPSs (see Section 2.2.6; Appendix B; Ramboll, 2025b); however, additional modeling would be performed and additional data would be collected as part of the Corrective Action Groundwater Monitoring Plan to evaluate and assess the exact required duration of additional system operation. 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 natural 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 for sulfate. Remobilization of boron may occur at some locations and affect the time to achieve GWPS compared to sulfate (Appendix E; Geosyntec Consultants, Inc., 2025). In cases in which observed groundwater concentrations deviate significantly from modeled conditions, alternative methods or techniques 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 would be expected under the Source Control-GWP alternative.
- Residual plume management under the Source Control-Upgradient Barrier Wall and GWE Trench alternative would rely on the barrier wall to limit groundwater from flowing towards AP2 and to reduce the amount of groundwater that needs to be extracted from the trench. The GWE trench would collect impacted groundwater and reduce hydraulic head beneath AP2, to reduce or prevent migration of impacted groundwater. Groundwater quality would also be improved as a result of physical and geochemical attenuation processes. This approach would reduce groundwater flow toward AP2 by the barrier wall and remove constituent mass in groundwater through operation of the extraction trench. The construction activities would likely result in some negative impacts to the ecosystem, including disturbances of some existing habitats atop portions of the construction areas, and habitats in the immediate vicinity of these locations by causing alarm and escape behavior in nearby wildlife (*e.g.*, due to noise disturbances). Short-term impacts could also occur to sensitive aquatic and wetland species in Coffeen Lake and other wetlands or surface water bodies located within the SFWA near AP2 (see Section 1.1.3) due to potential sediment runoff during construction at the Site.

- Residual plume management under the Source Control-Horizontal GWE Well alternative would rely on installation of a horizontal extraction well to drain water from beneath AP2, thus reducing the hydraulic head beneath AP2 and accelerating the time to achieve the GWPSs. The horizontal well would drain water from AP2 to reduce or prevent migration of impacted groundwater. Groundwater quality would also be improved as a result of physical and geochemical attenuation processes. The construction activities would likely result in some negative impacts to the ecosystem, and habitats in the immediate vicinity of these locations by causing alarm and escape behavior in nearby wildlife (*e.g.*, due to noise disturbances). Short-term impacts could also occur to sensitive aquatic and wetland species in Coffeen Lake and other wetlands or surface water bodies located within the SFWA near AP2 (see Section 1.1.3) due to sediment runoff during construction at the Site. Stormwater BMPs and turbidity curtains downstream of the weir would be installed to mitigate potential effects on Coffeen Lake.

2.6 Summary

This CAAA evaluates 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 the Source Control-Horizontal GWE Well alternative. The timeframe for achieving GWPSs is expected to be shorter under the Source Control-Horizontal GWE Well alternative (approximately 17.5 to 19.5 years after approval of the Construction Permit Application) than under the Source Control-GWP alternative (over 100 years after approval of the Corrective Action Plan) and Source Control-Upgradient Barrier Wall and GWE Trench (approximately 63 to 65 years after approval of the Construction Permit Application). Additionally, risks to worker safety and the community under the Source Control-Horizontal GWE Well alternative are lower compared to the Source Control-Upgradient Barrier Wall and GWE Trench alternative. Thus, Source Control-Horizontal GWE Well is the most appropriate corrective action alternative for AP2.

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Appendix A

Human Health and Ecological Risk Assessment

Human Health and Ecological Risk Assessment
Ash Pond 2
Coffeen Power Plant
Coffeen, Illinois

March 28, 2025

GRADIENT

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Abbreviations

ADI	Acceptable Daily Intake
AP2	Ash Pond 2
BCF	Bioconcentration Factor
BCG	Biota Concentration Guide
CAAA	Corrective Action Alternatives Analysis
CPP	Coffeen Power Plant
CCR	Coal Combustion Residuals
CEM	Conceptual Exposure Model
COI	Constituent of Interest
COPC	Constituent of Potential Concern
CSF	Cancer Slope Factor
CSM	Conceptual Site Model
ESV	Ecological Screening Value
GMF	Gypsum Management Facility
GWPS	Groundwater Protection Standard
GWQS	Groundwater Quality Standards
HTC	Human Threshold Criteria
IDNR	Illinois Department of Natural Resources
IEPA	Illinois Environmental Protection Agency
ILWATER	Illinois Water and Related Wells
IPGC	Illinois Power Generating Company
ISGS	Illinois State Geological Survey
LCU	Lower Confining Unit
MCL	Maximum Contaminant Level
NRT	Natural Resource Technology
NRWQC	National Recommended Water Quality Criteria
ORNL RAIS	Oak Ridge National Laboratory Risk Assessment Information System
pCi/L	PicoCuries Per Liter
PRG	Preliminary Remediation Goal
RfD	Reference Dose
RME	Reasonable Maximum Exposure
RSL	Regional Screening Level
SI	Surface Impoundment
SWQC	Surface Water Quality Criteria
UA	Uppermost Aquifer
UCU	Upper Confining Unit
USDA	United States Department of Agriculture
US DOE	United States Department of Energy
US EPA	United States Environmental Protection Agency
USGS	United States Geological Survey

1 Introduction

Illinois Power Generating Company's (IPGC) Coffeen Power Plant (CPP, or "the Site") is an electric power generating facility with coal-fired units located approximately two miles south of the City of Coffeen, Illinois. The CPP operated as a coal-fired power plant from 1964 until November 2019 and has five coal combustion residuals (CCR) management units (Ramboll, 2021). The CCR unit that is the subject of this report is Ash Pond 2 (AP2), (Illinois Environmental Protection Agency [IEPA] ID No. W1350150004-02), a 60-acre, unlined surface impoundment (SI) that was used to manage CCR and non-CCR waste streams at the CPP (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 originating from AP2. This risk evaluation was performed to support the Corrective Action Alternative Analysis (CAAA) for AP2 in accordance with requirements in Title 35 Part 845 of the Illinois Administrative Code (IEPA, 2021a). Human and ecological risks were evaluated for Site-specific constituents of interest (COIs). The conceptual site model (CSM) assumed that Site-related COIs in groundwater may migrate to the adjacent Coffeen Lake 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: Constituents detected in groundwater were considered COIs if their maximum detected concentration over the period from 2015 to 2021 exceeded a groundwater protection standard (GWPS) identified in Part 845.600 (IEPA, 2021a), or a relevant surface water quality standard (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 determine 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, we considered evaluation criteria detailed in 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" (US EPA, 2014).

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, no unacceptable risks to human or ecological receptors resulting from CCR exposures associated with AP2 were identified. This means that the risks from the site are likely indistinguishable from normal background risks. Specific risk assessment results include the following:

- No completed exposure pathways were identified for any groundwater receptors; consequently, no risks were identified relating to the use of groundwater.
- No unacceptable risks were identified for recreators boating in Coffeen Lake adjacent to the Site.
- No unacceptable risks were identified for recreators exposed to sediment in Coffeen Lake 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.
- 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, it should be noted that because current conditions do not present a risk to human health or the environment, there will also be no unacceptable risk to human health or the environment for future conditions because AP2 was already closed in 2020. For all future closure scenarios, potential releases of CCR-related constituents will decline over time and, consequently, potential exposures to CCR-related constituents in the environment will also decline.

2 Site Overview

2.1 Site Description

The CPP is located in Montgomery County, Illinois, approximately 2 miles south of the City of Coffeen and about 8 miles southeast of the City of Hillsboro, Illinois. Five CCR units are present on the CPP property, including Ash Pond 1, AP2, Gypsum Management Facility (GMF) Recycle Pond, GMF Gypsum Stack Pond, and the Landfill (Ramboll, 2021). AP2, the subject of this report, is an unlined SI that covers an area of approximately 60 acres (NRT, 2017). AP2 started operation in the early 1970s, and was removed from service and capped in the mid-1980s with a 2-foot clay and soil cap (NRT, 2017). The CPP is bordered by Coffeen Lake to the west, east, and south, and is bordered by agricultural land to the north. An unnamed tributary, located east of AP2, flows south into Coffeen Lake (Figure 2.1) (Ramboll, 2021). Coffeen Lake (approximately 1,100-acres) was formed in 1963 for use as an artificial cooling lake for the CPP, by damming the McDavid Branch of the East Fork of Shoal Creek (Ramboll, 2021).

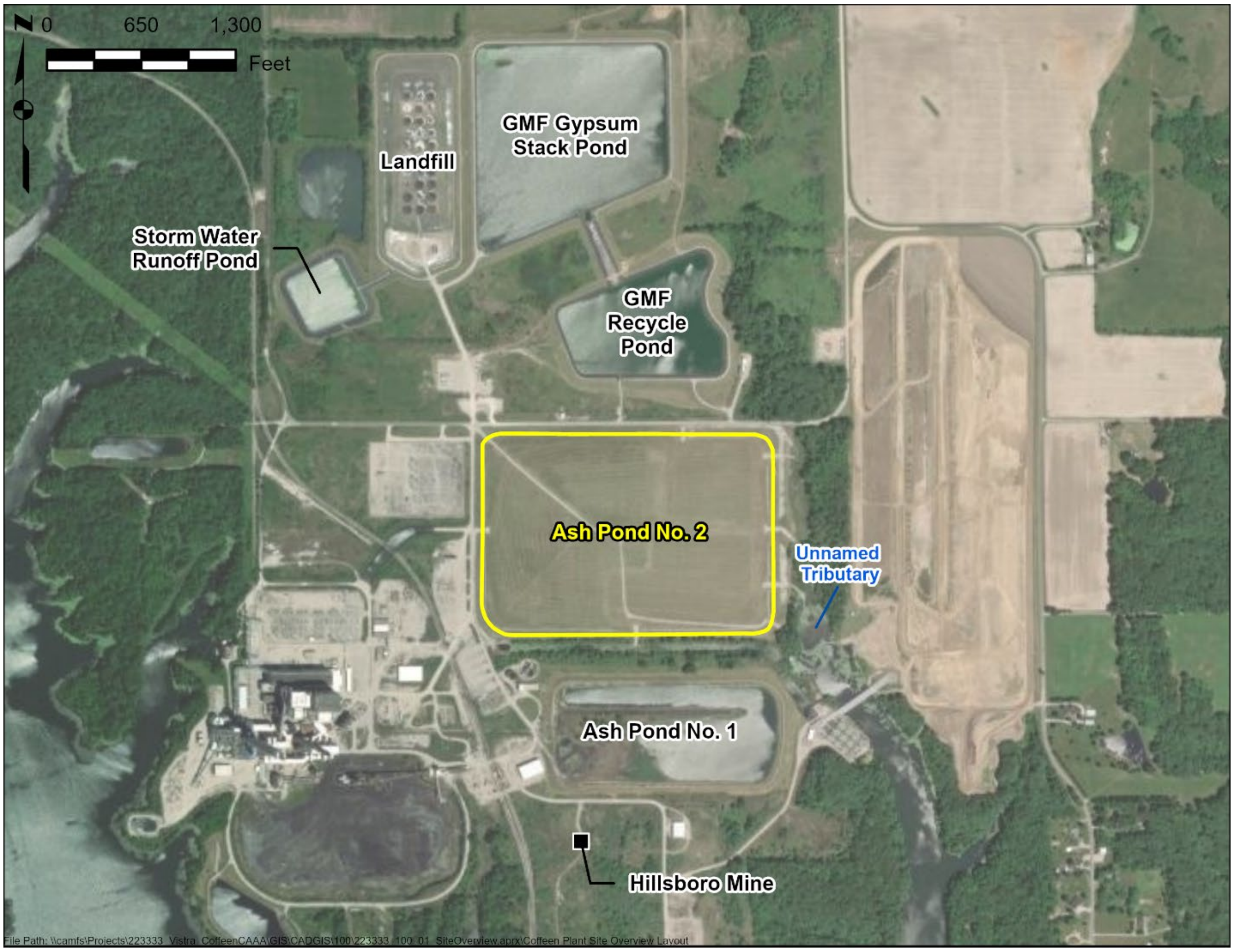

Figure 2.1 Site Location Map. Adapted from NRT (2017).

2.2 Geology/Hydrogeology

The geology underlying the CPP Site in the vicinity of AP2 primarily consists of unlithified deposits (NRT, 2017; Ramboll, 2021). These unlithified deposits were categorized into the following hydrostratigraphic units (moving downward from the ground surface):

- **Upper Confining Unit (UCU):** The UCU underlies AP2. It consists of a Loess Unit and the upper portion of the Hagarstown Member, which has low permeability clays and silts. The Loess Unit in the area of AP2 is relatively thin with less than 1 foot of thickness and was likely removed during AP2 construction. The upper clayey till portion of the Hagarstown Member has varying thicknesses from 1.9 ft to over 12 ft to the south and west of AP2.
- **Uppermost Aquifer (UA):** The UA is comprised of moderately permeable sands, silty sand, and clayey gravel of the Hagarstown Member and, in some portions of the Site, the Vandalia Member. The UA unit is thin (generally less than 3 feet), discontinuous, and variable throughout AP2 due deposition and weathering.
- **Lower Confining Unit (LCU):** The LCU underlies the UA. It consists of three low hydraulic conductivity soils: the sandy clay till of the Vandalia Member, the silt of the Mulberry Grove Formation, and the compacted clay till of the Smithboro Member. The layer has been observed to be generally greater than 15 ft thick.
- **Deep Aquifer (DA):** The DA consists of sand and sandy silt/clay units of the Yarmouth Soil, which is discontinuous and less than 5 ft thick across the Site. This unit is also identified as a PMP.
- **Deep Confining Unit (DCU):** The DCU is comprised of the Banner Formation, with a mixture of clays, silts, and sands. The Lierle Clay Member, which was encountered at the Site, is the upper portion of the Banner Formation.

There is a groundwater flow divide within the UA in the center of the CPP property between the two lobes of Coffeen Lake. Groundwater in the UA flows from the center of the CPP property west toward Coffeen Lake and east toward the Unnamed Tributary. Groundwater near AP2 flows east and south toward a former surface water discharge flume and the Unnamed Tributary which discharges into the Coffeen Lake, respectively (NRT, 2017). There is limited groundwater flow from AP2 toward the west due to a thinning or lower hydraulic conductivity of the Hagarstown Beds (NRT, 2017). Both the discharge flume and the Unnamed Tributary intersect and cut off the Hagarstown Member in the UA, which blocks any further migration of potentially impacted groundwater (NRT 2017). Groundwater flow within the UA is predominantly horizontal due to the underlying low-permeability LCU, and the average horizontal hydraulic gradient calculated for the UA across AP2 is approximately 0.007 ft/ft (NRT, 2017; NRT, 2017). Groundwater flow directions in the vicinity of AP2 are typically stable and do not have significant seasonal change. Groundwater elevations are controlled by the water level along the shoreline of Coffeen Lake (NRT 2017).

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 AP2 migrates and interacts with surface water and sediment in the adjacent Coffeen Lake. The CSM was developed using available hydrogeologic data specific to AP2, including information on groundwater flow and surface water characteristics (NRT, 2017; Ramboll, 2020, 2021).

CCR-related constituents may migrate vertically downward through the UCU from AP2 into the underlying groundwater of the UA. Once in groundwater, CCR-related constituents may migrate to the south to the discharge flume and to the east to the Unnamed Tributary and the eastern branch of Coffeen Lake (NRT, 2017; Ramboll, 2020). Groundwater flow within the UA is mostly in the horizontal direction because the UA is underlain by the LCU, which is a low-permeability till unit inhibiting vertical flow of groundwater.

Groundwater near AP2 may mix with surface water in the Unnamed Tributary and eastern branch of Coffeen Lake, and dissolved constituents in groundwater may partition between the sediments and surface water.

2.4 Groundwater Monitoring

A total of 12 wells have been used to monitor the groundwater quality near and downgradient of AP2 (Figure 2.2). Of these, 11 wells are screened in the UA, 1 well is screened in the LCU (Table 2.1). The analyses presented in this report relied on the recent data from 11 of these wells collected between 2018 and 2023 (G1003 was not used due to lack of data, as the well was dry during the 2021-2023 sampling). Groundwater samples were analyzed for a suite of total metals, specified in Illinois CCR Rule Part 845.600 (IEPA, 2021a).[1] A summary of the groundwater data used in this risk evaluation is presented in Table 2.2. The AP2 well locations used in this risk evaluation are shown in Figure 2.2. The use of groundwater data in this risk evaluation does not imply that detected constituents are associated with AP2 or that they have been identified as potential groundwater exceedances.

Figure 2.2 Monitoring Well Locations. Source: Ramboll (2024a).

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[1] Samples were analyzed for a longer list of inorganic constituents and general water quality parameters (including, but not limited to, fluoride, sulfate, pH, and total dissolved solids); however, these constituents were not evaluated in the risk assessment because toxicological criteria have not been developed. Given that these parameters are not likely to pose a human health or ecological risk concern even in the event of exposure, they are not typically evaluated in risk assessments.

Table 2.1 Groundwater Monitoring Wells Related to Coffeen Ash Pond 2

Well	Date Constructed	Screen Top Depth (ft bgs)	Screen Bottom Depth (ft bgs)	Well Depth from Ground Surface (ft bgs)	Hydrogeologic Unit
G270	2/26/2008	13.1	17.9	18.3	UA
G280	02/26/2008	12.8	17.6	18.0	UA
G281	09/08/2015	15.5	20.2	20.3	UA
G401	09/14/2015	14.4	18.8	19.3	UA
G402	08/27/2010	10.0	20.0	20.4	UA
G403	09/11/2015	13.1	17.8	18.2	UA
G404	05/01/2007	6.4	11.2	11.6	UA
G405	05/01/2007	9.0	13.8	14.2	UA
G406	08/19/2016	13.6	18.4	18.8	UA
G407	08/16/2016	13.8	18.6	19.0	UA
G1001	04/05/2021	6.0	11.0	12.0	LCU
G1003	05/25/2021	8.0	12.0	12.0	UA

Notes:
Source: Ramboll (2021).
bgs = Below Ground Surface; DA = Deep Aquifer; ft = Feet; LCU = Lower Confining Unit; UA = Uppermost Aquifer.

Table 2.2 Groundwater Data Summary (2018-2023)

Constituent	Samples with Constituent Detected	Samples Analyzed	Minimum Detected Value	Maximum Detected Value	Maximum Laboratory Detection Limit
Total Metals (mg/L)					
Antimony	11	179	0.00052	0.0049	0.0019
Arsenic	79	203	0.00040	0.13	0.016
Barium	203	203	0.0092	1.5	0.0043
Beryllium	3	193	0.0015	0.0030	0.00078
Boron	162	204	0.0090	21	0.16
Cadmium	9	200	0.00020	0.018	0.0040
Chromium	30	202	0.00080	0.44	0.0076
Cobalt	80	203	0.00020	0.42	0.0030
Lead	40	198	0.00033	0.043	0.00060
Lithium	89	206	0.0029	0.32	0.0099
Mercury	4	191	0.00016	0.00029	0.00019
Molybdenum	80	203	0.00060	0.016	0.0012
Selenium	18	201	0.00076	0.021	0.016
Thallium	2	181	0.00051	0.0010	0.0010
Dissolved Metals (mg/L)					
Antimony	2	47	0.00050	0.0066	0.00040
Arsenic	30	226	0.00024	0.019	0.00040
Barium	47	47	0.020	0.060	0.00070
Beryllium	1	47	0.031	0.031	0.00023
Boron	190	235	0.0076	17	0.15
Cadmium	1	47	0.028	0.028	0.00020
Chromium	9	47	0.00013	0.031	0.00070
Cobalt	5	48	0.000080	0.028	0.00010
Lead	6	227	0.0010	0.010	0.00060
Lithium	NT	NT	NT	NT	NT
Molybdenum	21	47	0.00032	0.020	0.00060
Selenium	21	47	0.00026	0.022	0.00060
Thallium	1	47	0.0040	0.0040	0.0010
Radionuclides (pCi/L)					
Radium 226 + 228	201	202	0.0063	8.7	4.6
Other (mg/L or SU)					
pH	204	204	5.6	7.7	NA
Chloride	198	204	1.1	710	96
Fluoride	165	203	0.067	0.79	0.19
Sulfate	204	204	15	4600	307
Total Dissolved Solids	203	203	270	6600	40

Notes:
Source: Ramboll (2024b).
NA = Not Applicable; NT = Not Tested; pCi/L = PicoCuries Per Liter.

2.5 Surface Water Monitoring

Geosyntec collected a total of six surface water samples from Coffeen Lake in the vicinity of AP2 in August 2021 (Geosyntec, 2021). The sample locations are shown in Figure 2.3, and the sampling results are summarized in Table 2.3.

Figure 2.3 Surface Water Sampling Locations. Source: Geosyntec (2021).

Table 2.3 Surface Water Data Summary

Constituent	Samples with Constituent Detected	Samples Analyzed	Minimum Detected Value	Maximum Detected Value	Maximum Laboratory Detection Limit
Total Metals (mg/L)					
Boron	5	5	0.086	0.33	0.05
Calcium	5	5	21	53	0.2
Cobalt	0	5	0	0	0.005
Iron	5	5	0.23	0.38	0.2
Lithium	0	5	0	0	0.01
Magnesium	5	5	10	16	0.1
Manganese	5	5	0.03	0.2	0.01
Potassium	5	5	2.5	4.9	0.5
Sodium	5	5	11	19	1
Other (mg/L)					
Chloride	5	5	7.2	11	0.4
Phosphorus	5	5	0.095	0.24	0.15
Sulfate	5	5	31	110	2
Total Dissolved Solids	5	5	120	240	10

Notes:

Source: Geosyntec (2021).

Surface water was analyzed for both total and dissolved metals; only the total metals are reported here because they generally have higher concentrations than dissolved metals. The only exception was iron, which had a maximum dissolved concentration 1.8 times higher than the maximum total concentration. However, iron was not measured in groundwater and, therefore, was not identified as a constituent of interest (COI).

3 Risk Evaluation

3.1 Risk Evaluation Process

A risk evaluation was conducted to determine whether constituents present in groundwater underlying and downgradient of AP2 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.

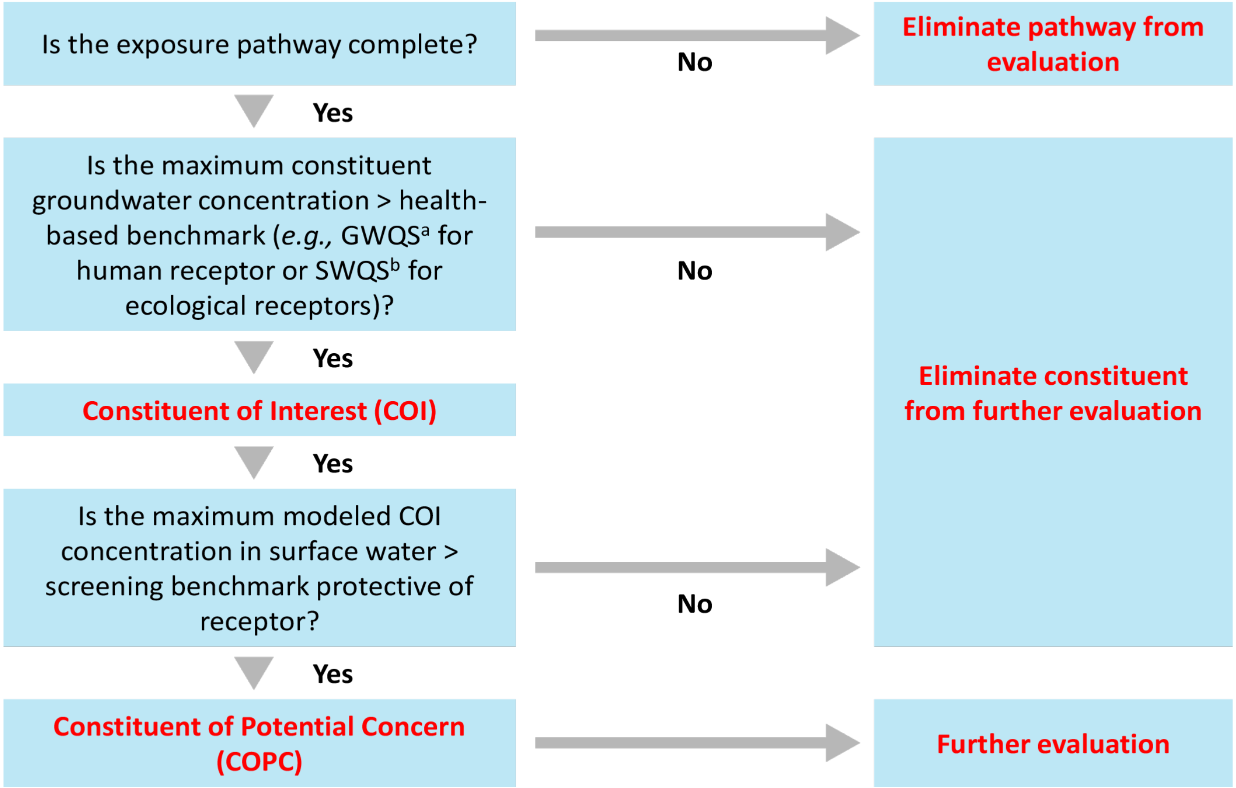

Figure 3.1 Overview of Risk Evaluation Methodology. GWQS = Groundwater Quality Standard; IEPA = Illinois Environmental Protection Agency; SWQS = Surface Water Quality Standard. (a) The IEPA Part 845 GWPS were used to identify COIs. (b) IEPA SWQS protective of chronic exposures to aquatic organisms were used to identify ecological COIs. In the absence of a SWQS, US EPA Region IV ecological screening values 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 surface water quality standards (SWQS) for ecological receptors. Based on the CSM (Section 2.3), some groundwater underlying AP2 has the potential to interact with surface water in Coffeen Lake. Therefore, potential AP2-related constituents in groundwater may potentially flow toward and flow into surface water in Coffeen Lake.

Surface water samples have been collected from Coffeen Lake adjacent to the Site; however, sediment samples have not been collected from the lake. 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 AP2-related wells. The measured and 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 measured or modeled COI concentration exceeding a screening benchmark does not indicate an unacceptable risk, but only 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, this evaluation relied on the screening assessment to demonstrate that constituents present in groundwater underlying AP2 do not pose an unacceptable human health or ecological risk. That is, after the screening step, no COPCs were identified and further assessment was not 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.

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 human receptors that could be exposed to these media. Figure 3.2 presents a human CEM for the Site. It considers a human receptor who could be exposed to COIs hypothetically released from AP2 into groundwater, surface water, sediment, and fish. The following human receptors and exposure pathways were evaluated for inclusion in the Site-specific CEM.

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[2] As discussed further in Section 3.3.2, GWQS 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.

- Residents – exposure to groundwater/surface water as drinking water;
- Residents – exposure to groundwater/surface water used for irrigation;
- Recreators in the lake adjacent to 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, except for residential exposure to groundwater or surface water used for drinking water or irrigation, and swimming. Section 3.2.1.1 explains why the residential drinking water and irrigation pathways are incomplete, and Section 3.2.1.2 provides additional description of the recreational exposures. While a recreator's potential exposure to surface water in Coffeen Lake was evaluated, swimming is prohibited in Coffeen Lake and thus was not evaluated (IDNR, 2014).

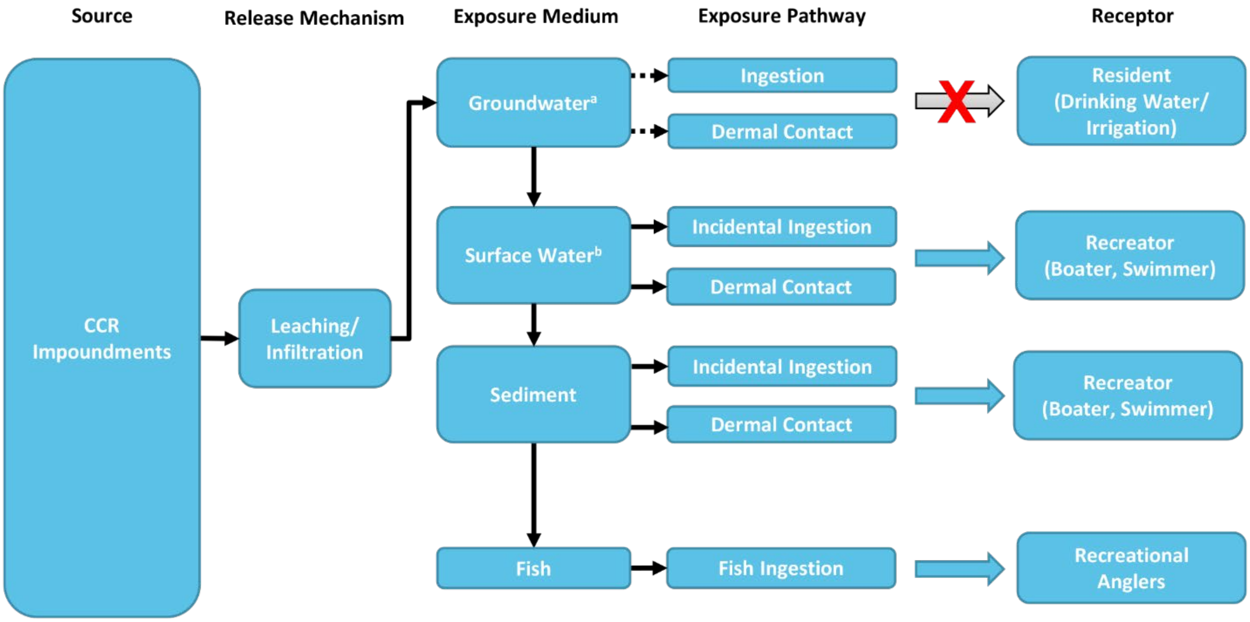

Figure 3.2 Human Conceptual Exposure Model. CCR = Coal Combustion Residuals. Dashed line/Red X = Incomplete or insignificant exposure pathway. (a) Groundwater in the vicinity of the Site is not used as a drinking water or irrigation source. (b) Surface water is not used as a drinking water source.

3.2.1.1 Groundwater or Surface Water as a Drinking Water/Irrigation Source

Using groundwater as a source of drinking water and/or irrigation water is not a complete exposure pathway for CCR-related constituents originating from AP2. Specifically, there are no users of shallow groundwater from the UA in the vicinity of AP2; thus, no receptors can be exposed to any CCR-related constituents in groundwater originating from AP2.

Natural Resource Technology (NRT) completed a water well survey for AP2 in 2017 (NRT, 2017), Ramboll completed a water well survey for AP1 in 2021 (Ramboll, 2021), and Gradient updated the well survey in 2024. A total of 19 water wells were identified within a 1,000-meter radius of the AP2 boundary during a comprehensive search of the Illinois State Geological Survey's (ISGS) Illinois Water and Related Wells (ILWATER) Map (ISGS, 2024b) (Table 3.1). These included 13 monitoring wells and 6 farm/domestic wells (Figure 3.3). There is no information available about the current use of these wells. However, site-specific groundwater flow conditions support the conclusion that none of the six farm/domestic wells are or can ever be affected by potential CCR-related constituents originating from AP2.

- **There is no off-Site migration of CCR-related constituents in groundwater**. Groundwater from the UA flows north/east before flowing into the Unnamed Tributary and the eastern branch of Coffeen Lake (Ramboll, 2021). Five of the six farm/domestic wells within a 1,000 m radius of AP2 are located on the east/southeast side of Coffeen Lake's eastern branch and the unnamed tributary, *i.e.*, the opposite side of the lake from AP2 (Figure 3.3). These surface water bodies are hydraulic boundaries which limits any further migration of potentially impacted groundwater (NRT 2017). Furthermore, the surface waters are regional "sinks", meaning that groundwater flows into the surface water bodies both from the east and the west, but cannot flow past. Thus, because the eastern branch of Coffeen Lake and the unnamed tributary separate the farm/domestic wells from AP2 (Figure 3.3), there is no plausible mechanism by which the wells could be impacted by any potential constituents in groundwater associated with the AP2.
- There is one domestic/farm well located near the northeast corner of AP2 (Well ID 5 on Figure 3.3), side-gradient to AP2 and on the west side of the unnamed tributary. This well, which was installed in 1981, is located near the former location of several prior residents (Figure 3.4). The well was removed during the construction of the Recycle Pond in 2010 (Ramboll, 2021b; NRT, 2017). However, the property in this area has been purchased by IPGC and no residents are currently living or using groundwater in the area.
- **Coffeen Lake is not used as a public water supply.** Coffeen Lake is a cooling water pond owned and maintained by IPGC, and IPGC restricts the use of the lake as a source of drinking water. Therefore, the human exposure pathway of surface water ingestion (as potable water) adjacent to AP2 is not a complete pathway and was not evaluated further.
- **AP2 has a limited hydraulic connection to underlying groundwater.** The LCU underlying the UA forms a hydraulic barrier between AP2 and deeper groundwater resources. Due to the very low hydraulic conductivity of the LCU, downward migration of shallow groundwater is expected to be limited. Therefore, the likelihood of AP2-related impacts to deep groundwater is minimal.

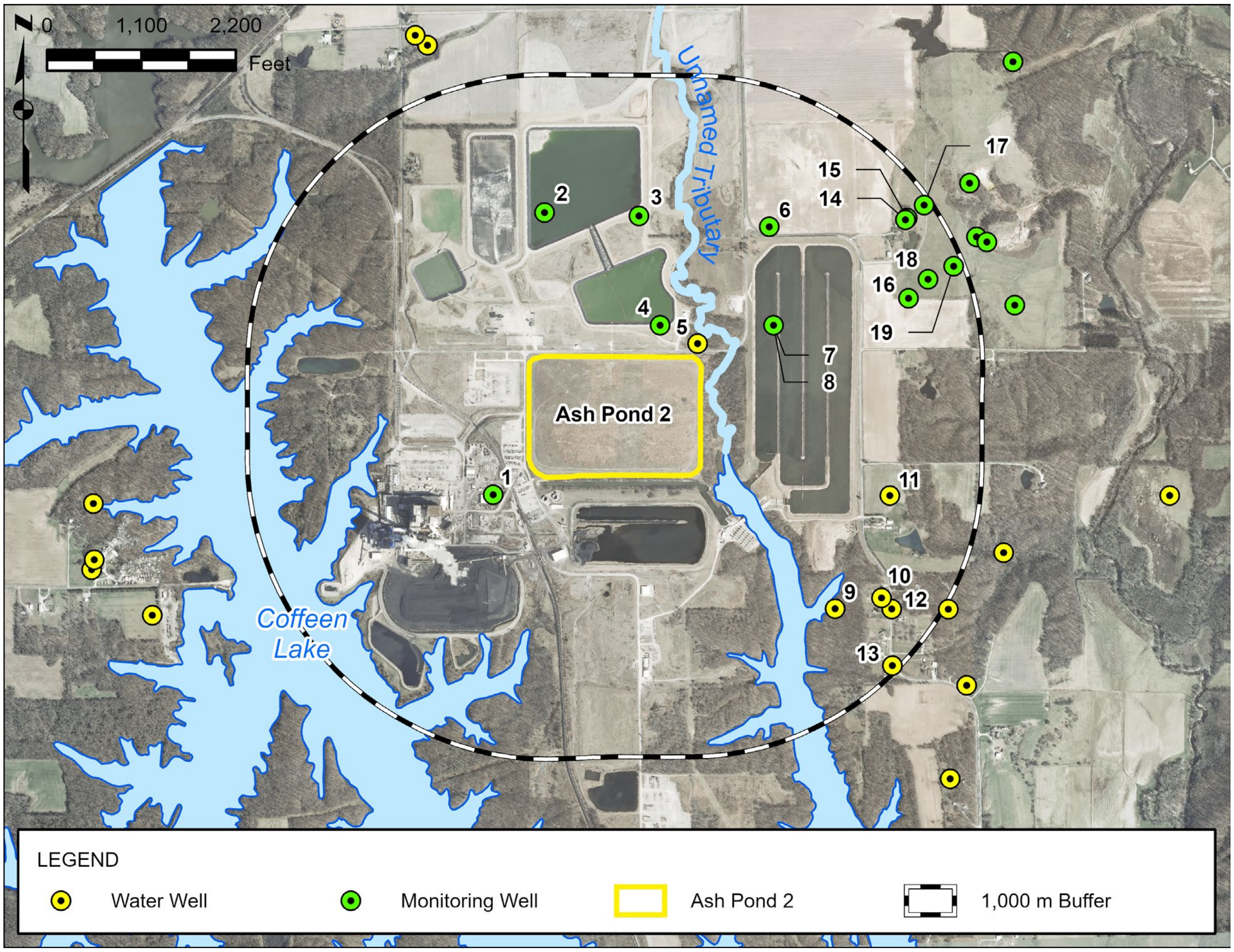

Figure 3.3 Water Wells Within 1,000 Meters of AP2

Table 3.1 Water Wells Within 1,000 Meters of AP2

Map ID #	ISGS API #	Well Depth (ft)	Year Drilled	Owner	Well Use
1	121352423200	20	2015	Illinois Power Holdings, LLC	Monitoring
2	121352423600	18	2015	Illinois Power Holdings, LLC	Monitoring
3	121352425400	16	2017	Coffeen Power Station	Monitoring
4	121352423400	18	2015	Illinois Power Holdings, LLC	Monitoring
6	121352361500	35	1993	White & Brewer	Monitoring
7	121352423300	16	2015	Illinois Power Holdings, LLC	Monitoring
8	121352423500	19	2015	Illinois Power Holdings, LLC	Monitoring
14	121352362000	20	–	White & Brewer	Monitoring
15	121352361900	40	–	White & Brewer	Monitoring
16	121352362100	33	–	White & Brewer	Monitoring
17	121352361800	23	–	White & Brewer	Monitoring
18	121352361700	25	–	White & Brewer	Monitoring
19	121352361600	17	–	White & Brewer	Monitoring
5	121352283200	39	1981	Wibel, William	Private Water Well
9	121350171700	29	1970	Marfield, Mac	Private Water Well
10	121352221400	151	1977	Warfield, William	Private Water Well
11	121352380200	363	1996	O'Dell, Kenneth & Chong	Private Water Well
12	121350172600	32	1971	Schuler, Paul	Private Water Well
13	121352380300	401	1996	Childers, Joe	Private Water Well

Notes:
– = Unknown; LLC = Limited Liability Company.

Figure 3.4 Historic Property Use in the Vicinity of Well 32. (a) 1998; (b) 2005; (c) 2009. Sources: USGS (1998a,b, 2005a,b); USDA (2009a,b).

3.2.1.2 Recreational Exposures

Coffeen Lake is located adjacent to the Site and is owned by IPGC. Property along the lake has been leased to the Illinois Department of Natural Resources (IDNR) for use as a State Fish and Wildlife Area (Ramboll, 2021), and the lake is used for recreational fishing (IDNR, 2022). Recreational exposure to surface water and sediment may occur during activities such as boating or fishing in the lake. Recreational anglers may also consume locally caught fish from Coffeen Lake. Swimming does not occur in Coffeen Lake because it is owned by IPGC and used as a cooling reservoir (IDNR, 2022).

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 and secondary toxicity *via* bioaccumulation. Figure 3.5 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, and 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, and fish).

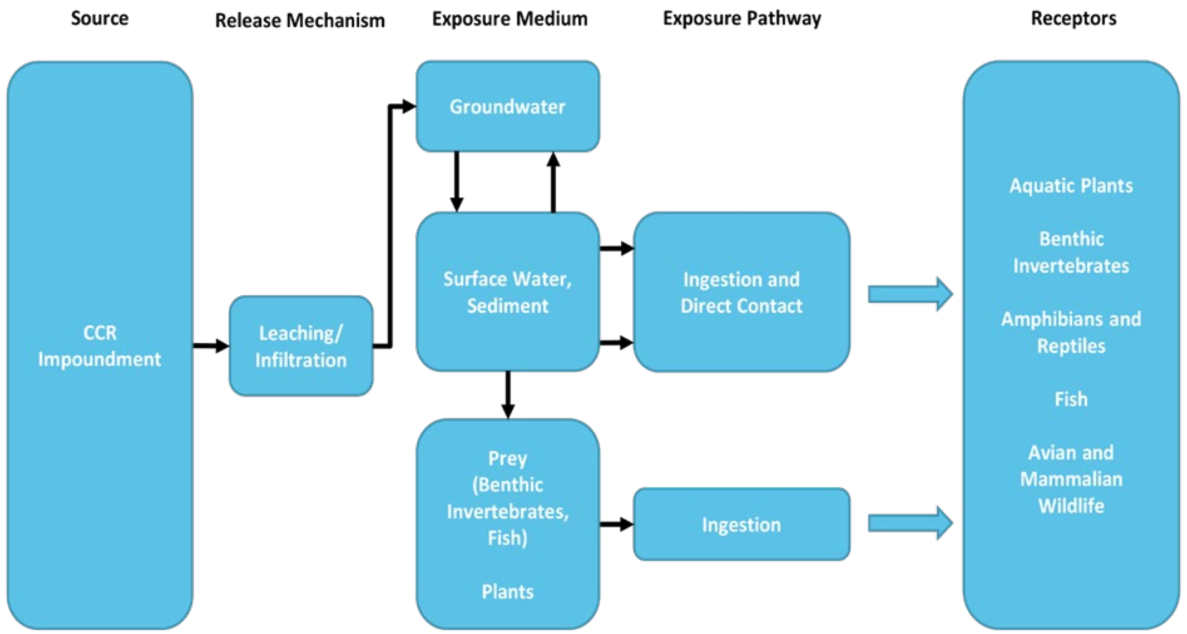

Figure 3.5 Ecological Conceptual Exposure Model. CCR = Coal Combustion Residuals.

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 Part 845.600 (IEPA, 2021a). Gradient used the maximum detected concentrations from groundwater samples collected from all of the AP2-associated wells, regardless of hydrostratigraphic unit. The use of groundwater data in this risk evaluation does not imply that detected constituents are associated with AP2 or that they have been identified as potential groundwater exceedances. Using this approach, 12 COIs (antimony, arsenic, beryllium, boron, cadmium, chromium, cobalt, lead, lithium, thallium, radium-226+228, and chloride) were identified for the human health risk evaluation *via* the surface water pathway (Table 3.1).

The water quality parameters that exceeded the GWPS included sulfate and total dissolved solids; however, these constituents were not included in the risk evaluation because the GWPS are based on aesthetic quality. US EPA set secondary maximum contaminant levels (MCLs) for sulfate and TDS based on aesthetic quality. The secondary MCL for sulfate (250 mg/L) is based on salty taste (US EPA, 2021a). The secondary MCL for total dissolved solids (500 mg/L) is based on hardness, deposits, colored water, staining, and salty taste (US EPA, 2021a). Given that these parameters are not likely to pose a human health risk concern in the event of exposure, they were not considered to be human health COIs.

Table 3.1 Human Health Constituents of Interest

Constituent[a]	Maximum Concentration[b]	GWPS[c]	Human Health COI[d]
Total Metals (mg/L)			
Antimony	0.0049	0.0060	No
Arsenic	0.13	0.010	Yes
Barium	1.5	2.0	No
Beryllium	0.0030	0.0040	No
Boron	21	2.0	Yes
Cadmium	0.018	0.0050	Yes
Chromium	0.44	0.10	Yes
Cobalt	0.42	0.0060	Yes
Lead	0.043	0.0075	Yes
Lithium	0.32	0.040	Yes
Mercury	0.00029	0.0020	No
Molybdenum	0.016	0.10	No
Selenium	0.021	0.050	No
Thallium	0.0010	0.0020	No
Dissolved Metals (mg/L)			
Antimony	0.0066	0.0060	Yes
Arsenic	0.019	0.010	Yes
Barium	0.060	2.0	No
Beryllium	0.031	0.0040	Yes
Boron	17	2.0	Yes
Cadmium	0.028	0.0050	Yes
Chromium	0.031	0.10	No
Cobalt	0.028	0.0060	Yes
Lead	0.010	0.0075	Yes
Molybdenum	0.02	0.1	No
Selenium	0.022	0.05	No
Thallium	0.004	0.002	Yes
Radionuclides (pCi/L)			
Radium 226 + Radium 228	8.66	5	Yes
Other (mg/L, unless otherwise noted)			
pH	7.7	6.5-9.0	No
Chloride	710	200	Yes
Fluoride	0.79	4.0	No
Sulfate	4600	400	No[e]
Total Dissolved Solids	6600	1200	No[e]

Notes:

COI = Constituent of Interest; GWPS = Groundwater Protection Standard; pCi/L = PicoCuries Per Liter.

Shaded = Compound identified as a COI.

(a) The constituents are those listed in the Illinois Part 845.600 GWPS (IEPA, 2021a).

(b) The maximum detected groundwater concentration was used to identify COIs.

(c) The Illinois Part 845.600 GWPS (IEPA, 2021a) were used to identify COIs.

(d) COIs are constituents for which the maximum concentration exceeds the groundwater standard.

(e) This constituent is not likely to pose a human health risk concern due to the absence of studies regarding 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) Surface Water Quality Criteria (SWQC). IEPA SWQC are health-protective benchmarks for aquatic life exposed to surface water on a long-term basis (*i.e.*, chronic exposure). The SWQC 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, 2022).[3]
- US EPA Region IV (2018) surface water Ecological Screening Values (ESVs) for hazardous waste sites.

Benchmarks from the United States Department of Energy's (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 (2019) 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 AP2-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. Boron, cadmium, chromium, cobalt, lead, radium-226+228, and chloride were identified as COIs for ecological receptors (Table 3.2).

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[3] Hardness data are not available for Coffeen Lake adjacent to the Site; therefore, the US EPA (2022) default hardness of 100 mg/L was used. Use of a higher hardness value would result in less stringent screening values; thus, use of the US EPA default hardness is conservative.

Table 3.2 Ecological Constituents of Interest

Constituent[a]	Maximum Groundwater Concentration	Ecological Benchmark[b]	Basis	Ecological COI[c]
Total Metals (mg/L)				
Antimony	0.0049	0.19	EPA R4 ESV	No
Arsenic	0.13	0.19	IEPA SWQC	No
Barium	1.5	5.0	IEPA SWQC	No
Beryllium	0.0030	0.064	EPA R4 ESV	No
Boron	21	7.6	IEPA SWQC	Yes
Cadmium	0.018	0.0011	IEPA SWQC	Yes
Chromium	0.44	0.21	IEPA SWQC	Yes
Cobalt	0.42	0.019	EPA R4 ESV	Yes
Lead	0.043	0.020	IEPA SWQC	Yes
Lithium	0.32	0.44	EPA R4 ESV	No
Mercury	0.00029	0.0011	IEPA SWQC	No
Molybdenum	0.016	7.2	EPA R4 ESV	No
Selenium	0.021	1.0	IEPA SWQC	No
Thallium	0.0010	0.0060	EPA R4 ESV	No
Dissolved Metals (mg/L)				
Antimony	0.0066	0.19	EPA R4 ESV	No
Arsenic	0.019	0.19	IEPA SWQC	No
Barium	0.060	5.0	IEPA SWQC	No
Beryllium	0.031	0.064	EPA R4 ESV	No
Boron	17	7.6	IEPA SWQC	Yes
Cadmium	0.028	0.0011	IEPA SWQC	Yes
Chromium	0.031	0.21	IEPA SWQC	No
Cobalt	0.028	0.019	EPA R4 ESV	Yes
Lead	0.010	0.020	IEPA SWQC	No
Molybdenum	0.020	7.2	EPA R4 ESV	No
Selenium	0.022	1.0	IEPA SWQC	No
Thallium	0.0040	0.0060	EPA R4 ESV	No
Radionuclides (pCi/L)				
Radium 226 + 228	8.7	3.0	US DOE	Yes
Other (mg/L, unless otherwise noted)				
pH	7.7	6.5-9.0	IEPA SWQC	No
Chloride	710	500	IEPA SWQC	Yes
Fluoride	0.79	4.0	IEPA SWQC	No
Sulfate	4600	NA	NA	No
Total Dissolved Solids	6600	NA	NA	No

Notes:

AP2 = Ash Pond 2; COI = Constituent of Interest; ESV = Ecological Screening Value; IEPA = Illinois Environmental Protection Agency; NA = Not Available; pCi/L = picoCuries Per Liter; SWQC = Surface Water Quality Criteria; US DOE = United States Department of Energy; US EPA R4 = US Environmental Protection Agency Region IV.

Shaded = Compound identified as a COI.

(a) The constituents are those listed in the Illinois Part 845.600 GWPS (IEPA, 2021a).

(b) Ecological benchmarks are from the hierarchy of sources discussed in Section 3.3.2: IEPA SWQC (IEPA, 2019); US EPA Region IV "Ecological Risk Assessment Supplemental Guidance" (US EPA Region IV, 2018); and US DOE's 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

Surface water sampling has been conducted in Coffeen Lake adjacent to the Site. To estimate the potential contribution to surface water (and sediment) from groundwater specifically associated with AP2, Gradient modeled concentrations in Coffeen Lake surface water and sediment from groundwater flow into the lake for the detected human and ecological COIs. This is because the constituents detected in groundwater above an 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 or hydrogeologic unit) from 2018 to 2023 were conservatively used to model COI concentrations in surface water and sediment. In cases where the maximum groundwater concentration was from the "total metals" analysis, use of the total metals 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 into and mix with surface water.

This modeling approach does not account for geochemical transformations that may occur during groundwater mixing 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 AP2-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 coal combustion waste risk assessment (US EPA, 2014). 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 partitioning coefficient (K_d). The model assumes a well-mixed groundwater-surface water location, with partitioning among total suspended solids, 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, we ignored the natural attenuation capacity of soil and sediment and estimated the surface water concentration based only on the physical mixing of groundwater and surface water (*i.e.*, dilution) at the point of entry of groundwater to the surface water.

The aquifer and surface water properties used to estimate the volume of groundwater flowing into Coffeen Lake and surface water 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 Coffeen Lake, Gradient used default assumptions (*e.g.*, depth of the upper benthic layer and bed sediment porosity) to model sediment concentrations. The modeled surface water and sediment concentrations are presented in Table 3.5. These modeled concentrations reflect conservative contributions from groundwater flow. 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	Unit	Values	Notes/Source
Groundwater			
COI Concentration	mg/L	Constituent-specific	Maximum detected concentration in groundwater
Cross Section Area for the UA[a]	m^2	960	The average thickness of the UA (*i.e.*, 3 ft or 0.9144 m) multiplied by the length of AP2 affected groundwater intersecting Coffeen Lake (*i.e.*, sum of the eastern and southern sides of AP2, about 1050 m) (Ramboll, 2021)
Hydraulic Gradient	m/m	0.007	The average hydraulic gradient for the UA (Ramboll, 2021)
Hydraulic Conductivity of the UA	cm/s	0.002	The geometric mean horizontal hydraulic conductivity measured for the UA (Ramboll, 2021)
Surface Water			
Surface Water Flow Rate in the Eastern Branch of Coffeen Lake	L/yr	8.0×10^{10}	There are no flow records available for the eastern branch of Coffeen Lake. The flow rate was assumed to be the same (*i.e.*, 90 cfs) as estimated for the unnamed tributary that flows from north to south into the eastern branch of Coffeen Lake (Golder Associates Inc., 2020).
Total Suspended Solids	mg/L	3.2	Average Coffeen Lake concentration (Hanson Professional Services, Inc., 2020)
Depth of the Water Column	m	5.7	Mean depth of Coffeen Lake (Austen *et al*., 1993)
Suspended Sediment to Water Partition Coefficient	mg/L	Constituent-specific	Values based on US EPA (2014)

Notes:

AP2 = Ash Pond 2; cfs = Cubic Feet Per Second; COI = Constituent of Interest; ft = Feet; L/yr = Liter Per Year; UA = Uppermost Aquifer; US EPA = United States Environmental Protection Agency.

(a) Cross-sectional area represents the area through which groundwater flows from the UA into Coffeen Lake (*i.e.*, the groundwater flow area that intersects with Coffeen Lake).

Table 3.4 Sediment Properties Used in Modeling

Parameter	Unit	Value	Notes/Source
Sediment			
Depth of Upper Benthic Layer	m	0.03	Default (US EPA, 2014)
Depth of Water Body	m	5.73	Sum of depth of water column (5.7 m, depth of Coffeen Lake) (Austen *et al*., 1993) and depth of upper benthic layer (0.03 m) (US EPA, 2014)
Bed Sediment Particle Concentration	g/cm^3	1	Default (US EPA, 2014)
Bed Sediment Porosity	-	0.6	Default (US EPA, 2014)
TSS Mass Per Unit Area	kg/m^2	0.018	Depth of water column × TSS × conversion factors (10^{-6} kg/mg and 1,000 L/m^3)
Sediment Mass Per Unit Area	kg/m^2	30	Depth of upper benthic layer × bed sediment particulate concentration × conversion factors (0.001 kg/g, 10^6 cm^3/m^3)
Sediment to Water Partition Coefficients	mg/L	Constituent-specific	Values based on US EPA (2014)

Notes:

TSS = Total Suspended Solids; US EPA = United States Environmental Protection Agency.

Table 3.5 Surface Water and Sediment Modeling Results

COI	Groundwater Concentration (mg/L or pCi/L)	Mass Discharge Rate (mg/yr or pCi/yr)	Total Water Column Concentration (mg/L or pCi/L)	Concentration Sorbed to Bottom Sediments (mg/kg or pCi/kg)
Metals				
Antimony[b]	6.6E-03	2.8E+04	3.5E-07	1.2E-03
Arsenic	1.3E-01	5.5E+05	6.9E-06	1.7E-03
Beryllium[b]	3.1E-02	1.3E+05	1.6E-06	9.9E-04
Boron[b]	2.1E+01	9.0E+07	1.1E-03	6.9E-03
Cadmium	2.8E-02	1.2E+05	1.5E-06	2.4E-03
Chromium	4.4E-01	1.9E+06	2.3E-05	1.3E+00
Cobalt	4.2E-01	1.8E+06	2.2E-05	2.3E-02
Lead	4.3E-02	1.8E+05	2.3E-06	3.5E-02
Lithium	3.2E-01	1.4E+06	1.7E-05	NA[a]
Thallium[b]	4.0E-03	1.7E+04	2.1E-07	4.1E-06
Radionuclides				
Radium 226 + 228	8.7E+00	3.7E+07	4.6E-04	3.3E+00

Notes:

COI = Constituent of Concern; K_d = Equilibrium Partition Coefficient; NA = Not Applicable; pCi/L = PicoCuries Per Liter; pCi/kg = PicoCuries Per Kilogram.

(a) Lithium does not readily sorb to soil or sediment particles; a K_d value of 0 was used for the modeling.

(b) Maximum groundwater concentration was for dissolved metals.

3.4 Human Health Risk Evaluation

The section below presents the results of the human health risk evaluation for recreators (boaters and anglers) in Coffeen Lake adjacent to the Site. Risks were assessed using the maximum measured or modeled COIs in surface water.

3.4.1 Recreators Exposed to Surface Water

Screening Exposures: Recreators could be exposed to surface water *via* incidental ingestion and dermal contact while boating. In addition, anglers could consume fish caught in Coffeen Lake. The maximum measured or 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 boating) and indirectly (consumption of locally caught fish exposed to COIs in surface water).

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

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

where:

HTC = Human health protection criterion in milligrams per liter (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 reference dose (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 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.1.

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 coal combustion ash risk assessment (US EPA, 2014) and BCFs reported by Oak Ridge National Laboratory's Risk Assessment Information System (ORNL RAIS) (ORNL, 2023).[4] Lithium did not have a BCF value available from any authoritative source; therefore, the water quality criterion for lithium was calculated assuming a BCF of 1. This is a conservative assumption, as lithium does not readily bioaccumulate in the aquatic environment (ECHA, 2020).

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.1 presents the calculated HTC for fish consumption and water ingestion, 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 health protection criterion in picoCuries per liter (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

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

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 and measured COI concentrations in surface water were compared to the calculated Illinois HTC values (Table 3.6). All surface water concentrations were below their respective benchmarks. The HTC values are protective of recreational exposure *via* water and/or fish ingestion and do not account for dermal exposures to COIs in surface water while boating. However, given that the measured and modeled COI surface water concentrations are orders of magnitude below an HTC protective of water and/or fish ingestion, dermal exposures to COIs are not expected to be a risk concern. Moreover, the dermal uptake of metals is considered to be minimal and 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 boating or anglers consuming fish caught in Coffeen Lake.

Table 3.6 Risk Evaluation for Recreators Exposed to Surface Water

COI	Maximum Surface Water Concentration		HTC for Water and Fish	HTC for Water Only	HTC for Fish Only	COPC	
	Modeled	Measured[a]				Based on Modeled Concentrations	Based on Measured Concentrations
Total Metals (mg/L)							
Arsenic	6.9E-06	NA	2.2E-02	2.0E+00	2.3E-02	No	NA
Boron	1.1E-03	3.3E-01	4.7E+02	1.4E+03	7.0E+02	No	No
Chromium	2.3E-05	NA	6.1E-01	2.0E+01	6.3E-01	No	NA
Cobalt	2.2E-05	ND	3.5E-03	2.1E+00	3.5E-03	No	No
Lead	2.3E-06	NA	1.5E-02	1.5E-02	1.5E-02	No	NA
Lithium	1.7E-05	ND	4.7E+00	1.4E+01	7.0E+00	No	No
Dissolved Metals (mg/L)							
Antimony	3.5E-07	NA	4.0E-01	1.2E+00	6.0E-01	No	NA
Beryllium	1.6E-06	NA	2.1E-02	8.0E-01	2.1E-02	No	NA
Cadmium	1.5E-06	NA	1.8E-03	1.0E+00	1.9E-03	No	NA
Thallium	2.1E-07	NA	1.7E-03	4.0E-01	1.7E-03	No	NA
Radionuclides (pCi/L)							
Radium 226 + 228	4.6E-04	NA	1.0E+03	1.0E+03	8.7E+04	No	NA

Notes:
COI = Constituent of Interest; COPC = Constituent of Potential Concern; HTC = Human Threshold Criteria; NA = Not Applicable; ND = Not Detected; pCi/L = PicoCuries Per Liter.
(a) Measured concentrations are listed only for the constituents identified as COIs. Measured surface water concentrations may be different from modeled concentrations because measured data include the effects of background and other industrial sources. Modeled concentrations only represent the potential effect on surface water quality resulting from the measured groundwater concentrations. COIs with no measured surface water data were listed as NA.

3.4.2 Recreators Exposed to Sediment

Recreational exposure to sediment may occur during boating activity in Coffeen Lake; 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, and 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 per year (or two weekend days per week for 30 weeks per 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 (Stalcup, 2014). The daily recommended residential soil ingestion rates of 200 mg/day for a child and 100 mg/day for an adult are based on an all-day exposure to residential soils (Stalcup, 2014; US EPA, 2011b). Since recreational exposures to sediment are assumed to occur for less than 4 hours per day, one-third of the daily residential soil ingestion (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 (1,026 cm^2 for the child and 3,026 cm^2 for the adult, based on the age-weighted 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 adherence factor of 0.2 mg/cm^2 based on child exposure to wet soil (US EPA, 2004; Stalcup, 2014), 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 hazard quotient of 1, or a target cancer risk of 1×10^{-5}. Appendix B, Table B.2 presents the calculation of screening benchmarks protective of recreational exposures to sediment. A recreator sediment screening benchmark for radium-226+228 was based on soil Preliminary Remediation Goals (PRGs) calculated for radium-226 and radium-228 using US EPA's PRG calculator (US EPA, 2020). The lower of the two values (7,900) was used as the recreator sediment screening benchmark for radium-226+228 (Appendix B, Table B.3).

Screening Risk Evaluation: The modeled sediment concentrations were well below the recreational sediment screening benchmarks (Table 3.7). Therefore, exposure to sediment is not expected to pose an unacceptable risk to recreators while boating.

Table 3.7 Risk Evaluation for Recreators Exposed to Sediment

COI	Modeled Sediment Concentration	Recreator RSL	COPC
Total Metals (mg/kg)			
Arsenic	1.7E-03	6.8E+01	No
Boron	6.9E-03	2.7E+05	No
Chromium	1.3E+00	2.1E+06	No
Cobalt	2.3E-02	4.1E+02	No
Lead	3.5E-02	2.0E+02	No
Lithium	NA[a]	2.7E+03	NA
Dissolved Metals (mg/kg)			
Antimony	1.2E-03	5.5E+02	No
Beryllium	9.9E-04	2.7E+03	No
Cadmium	2.4E-03	1.2E+02	No
Thallium	4.1E-06	1.4E+01	No
Radionuclides (pCi/kg)			
Radium 226 + 228	3.3E+00	7.9E+03	No

Notes:

COI = Constituent of Interest; COPC = Constituent of Potential Concern; K_d = Equilibrium Partition Coefficient; mg/kg = Milligram Per Kilogram; NA = Not Applicable; pCi/kg = PicoCuries Per Kilogram; RSL = Regional Screening Level.

(a) Lithium does not readily sorb to soil or sediment particles; a K_d value of 0 was used for the modeling.

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 (*i.e.*, boron, cadmium, chromium, cobalt, lead, radium-226+228, and chloride).

3.5.1 Ecological Receptors Exposed to Surface Water

Screening Exposures: The ecological evaluation considered aquatic communities in Coffeen Lake potentially impacted by identified ecological COIs. Measured and 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 SWQC (IEPA, 2019), 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 calculated using a default hardness of 100 mg/L (US EPA, 2022)[5];
- US EPA Region IV (2018) surface water ESVs for hazardous waste sites; and

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

- 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 measured and modeled COI concentrations in surface water were compared to the benchmarks protective of aquatic life (Table 3.8). The measured and modeled surface water concentrations for the COIs were below their respective benchmarks. Thus, none of the COIs evaluated are expected to pose an unacceptable risk to aquatic life in Coffeen Lake.

Table 3.8 Risk Evaluation for Ecological Receptors Exposed to Surface Water

COI	Maximum Surface Water Concentration		Ecological Freshwater Benchmark	Basis	COPC	
	Modeled	Measured[a]			Based on Modeled Concentrations	Based on Measured Concentrations
Total Metals (mg/L)						
Boron	1.1E-03	3.3E-01	7.6E+00	IEPA SWQC	No	No
Chromium	2.3E-05	NA	2.1E-01	IEPA SWQC	No	NA
Cobalt	2.2E-05	ND	1.9E-02	EPA R4 ESV	No	No
Lead	2.3E-06	NA	2.0E-02	IEPA SWQC	No	NA
Dissolved Metals (mg/L)						
Cadmium	1.5E-06	NA	1.1E-03	IEPA SWQC	No	NA
Radionuclides (pCi/L)						
Radium 226 + 228	4.6E-04	NA	3.0E+00	US DOE	No	NA
Other (mg/L)						
Chloride	3.8E-02	1.1E+01	5.0E+02	IEPA SWQC	No	No

Notes:
COI = Constituent of Interest; COPC = Constituent of Potential Concern; ESV = Ecological Screening Value; IEPA = Illinois Environmental Protection Agency; NA = Not Applicable; ND = Not Detected; pCi/L = PicoCuries Per Liter; SWQC = Surface Water Quality Criteria; US DOE = United States Department of Energy; US EPA = United States Environmental Protection Agency.
(a) COIs with no measured surface water data were listed as NA.

3.5.2 Ecological Receptors Exposed to Sediment

Screening Exposures: COIs in impacted groundwater discharging into Coffeen Lake 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 discharge.

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 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).[6] Chloride is not expected to sorb to sediment; therefore, risk to ecological receptors exposed to sediment was not evaluated for chloride. The benchmarks used in this evaluation are listed in Table 3.9.

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[6] US DOE (2019) reported the BCG for sediment as 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.

Screening Risk Results: The maximum modeled COI sediment concentrations were below their respective sediment screening benchmarks (Table 3.9). The modeled sediment concentrations attributed to potential contributions from Site groundwater for all COIs were less than or equal to 3% 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 Coffeen Lake adjacent to the Site.

Table 3.9 Risk Evaluation for Ecological Receptors Exposed to Sediment

COI[a]	Modeled Sediment Concentration	ESV[a]	COPC	% of Benchmark
Metals (mg/kg)				
Boron	6.9E-03	38[b]	No	0.02%
Cadmium[d]	2.4E-03	0.99	No	0.2%
Chromium	1.3E+00	43	No	3%
Cobalt	2.3E-02	50	No	0.05%
Lead	3.5E-02	35.8	No	0.1%
Radionuclides (pCi/kg)				
Radium 226 + Radium 228	3.3E+00	90,000[c]	No	0.004%
Other (mg/kg)				
Chloride	NA	NA	NA	NA

Notes:

COI = Constituent of Interest; COPC = Constituent of Potential Concern; ESV = Ecological Screening Value; NA = Not Applicable; NOEC = No Observed Effect Concentration; pCi/kg = PicoCuries Per Kilogram; US DOE = United States Department of Energy; US EPA = United States Environmental Protection Agency.

(a) ESV from US EPA Region IV (2018).

(b) Boron NOEC of 38 mg/kg was used as a conservative benchmark for boron in the absence of an ESV (ECHA, 2019).

(c) ESV from US DOE (2019); value converted from 90 pCi/g to 90,000 pCi/kg.

(d) Modeled sediment was based on maximum dissolved concentration in groundwater.

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 SWQC (IEPA, 2019) guidance were used to identify constituents with potential bioaccumulative effects.

Risk Evaluation: The ecological COIs 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 Part 845.600 constituents detected in groundwater samples (above GWPS) collected from wells associated with AP2. However, it is possible that not all of the detected constituents are related specifically to AP2.
- 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). Given that exposure estimates based on the maximum concentrations did not exceed risk benchmarks, Gradient has greater confidence that there is no risk concern.
- Only constituents detected in groundwater were used to identify COIs and model COI concentrations in surface water and sediment. For the constituents that were not detected in AP2 groundwater, the detection limits were below the Illinois Part 845.600 GWPS and thus do not require further evaluation.
- COI concentrations in surface water were modeled using the maximum detected total concentrations in groundwater for four of the COIs. Modeling surface water concentrations using total metal concentrations may overestimate surface water concentrations because dissolved concentrations, which are lower than total concentrations, represent the mobile fractions of constituents that could likely flow into 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-AP2-related sources 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 AP2-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-AP2-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 (Stalcup, 2014). 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, 2004). 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 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 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 Site-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. However, hardness data are not available for Coffeen Lake; therefore, Gradient relied on US EPA's default hardness of 100 mg/L. Use of a higher hardness value would increase the cadmium SWQC because benchmarks become less stringent with higher levels of hardness. Regardless of the hardness, the maximum modeled cadmium concentration is orders of magnitude below the SWQC.

- In addition, for the ecological evaluation, Gradient conservatively assumed all constituents to be 100% bioavailable. Modeled COI concentrations in surface water are considered total COI concentrations. In addition, the measured surface water data used in this report represent total concentrations. US EPA recommends using dissolved metals as a measure of exposure to ecological receptors because it represents the bioavailable fraction of metal in water (US EPA, 1993). Therefore, the modeled surface water COI concentrations may be an overestimation of exposure concentrations to 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 which 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.

4 Summary and Conclusions

A screening-level risk evaluation was performed for potential Site-related constituents in groundwater at the CPP in Coffeen, Illinois. The CSM developed for the Site indicates that groundwater beneath AP2 flows into Coffeen Lake 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 recreators (boaters) in Coffeen Lake who are exposed to surface water and sediment, and anglers who consume locally caught fish. Based on the local hydrogeology, residential exposure to groundwater used for drinking water or irrigation is not a complete pathway and was not evaluated. 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 2018 to 2023 were used to estimate exposures. Surface water data collected from Coffeen Lake in 2021 were also evaluated. For groundwater constituents retained as COIs, surface water and sediment concentrations were modeled using the maximum detected groundwater concentration. 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, no unacceptable risks to human or ecological receptors resulting from CCR exposures associated with AP2 were identified. This means that the risks from the site are likely indistinguishable from normal background risks. Specific risk assessment results include the following:

- For recreators exposed to surface water, all COIs were below the conservative risk-based screening benchmarks. Therefore, none of the COIs evaluated in surface water are expected to pose an unacceptable risk to recreators in Coffeen Lake adjacent to the Site.
- For recreators exposed to sediment *via* incidental ingestion and dermal contact, the modeled sediment concentrations were below health-protective sediment benchmarks. Therefore, the modeled sediment concentrations are not expected to pose an unacceptable risk to recreators exposed to sediment in Coffeen Lake adjacent to the Site.
- For anglers consuming locally caught fish, the modeled concentrations of all COIs in surface water (as well as the measured data) were below conservative benchmarks protective of fish consumption. Therefore, none of the COIs evaluated are expected to pose an unacceptable risk to recreators consuming fish caught in Coffeen Lake.
- Ecological receptors exposed to surface water include aquatic and marsh plants, amphibians, reptiles, and fish. The risk evaluation showed that none of the modeled or measured 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. However, none of the ecological COIs were identified as having potential bioaccumulative effects. Therefore, these COIs are not considered to pose an ecological risk *via* bioaccumulation. 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 detected COI concentration for each constituent; 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. In addition, exposure estimates assumed 100% metal bioavailability, which likely results in overestimates of exposure and risks. Further, exposure estimates were based on inputs to evaluate the "reasonable maximum exposure"; thus, most individuals will have lower exposures than those estimated in this risk assessment.

Finally, it should be noted that because current conditions do not present a risk to human health or the environment, there will also be no unacceptable risk to human health or the environment for future conditions because AP2 was already closed in 2020. For all future closure scenarios, potential releases of CCR-related constituents will decline over time and, 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 in eastern Coffeen Lake surface water and sediment based on available groundwater data. First, Gradient estimated the flow rate of constituents of interest (COIs) that may flow into the eastern branch Coffeen Lake *via* groundwater. Then, Gradient adapted United States Environmental Protection Agency's (US EPA's) indirect exposure assessment methodology (US EPA, 1998) in order to model surface water and sediment water concentrations in Coffeen Lake.

Model Overview

Groundwater flow into Coffeen Lake is represented by a one-dimensional steady-state model. In this model, the groundwater plume migrates horizontally in the Uppermost Aquifer (UA) before flowing into the eastern branch of Coffeen Lake. The groundwater flow entering the lake is the flow going through a cross-sectional area with a length equal to the length of the lake adjacent to Ash Pond 2 (AP2) with potential CCR-related impacts and a height equal to the average saturated thickness of the UA. It was assumed that all the groundwater in the UA flowing through this cross-section flows into the eastern branch of Coffeen Lake.

Groundwater flow into Coffeen Lake mixes with the surface water in the lake. The COIs entering the lake *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 concentrations at a location downstream of the groundwater discharge, 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 for each individual COI. Gradient ignored adsorption by subsurface soil and assumed that all the groundwater flowing through the uppermost aquifer flows into the lake.

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

$$Q = K \times i \times A$$

where:

Q = Groundwater flow rate (m^3/s)
K = Hydraulic conductivity (m/s)
i = Hydraulic gradient (m/m)
A = Cross-sectional area (m^2)

For each COI, the mass discharge rate into the lake was then calculated by:

$$m_c = C_c \times Q \times CF$$

where:

m_c = Mass discharge rate of the COI (mg/year)
C_c = Maximum groundwater concentration of the COI (mg/L)
CF = Conversion factors: 1,000 L/m^3; 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.

Surface Water and Sediment Concentration

Groundwater flowing into the lake gets 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" (US EPA, 2014). This model describes the partitioning of constituents between surface water, suspended sediments, and benthic sediments based on equilibrium partition coefficients. 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 the analysis, Gradient used the partitioning coefficients given in Table J-1 of the US EPA CCR Risk Assessment for all COIs (US EPA, 2014). 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 (US EPA, 1998):

$$C_{wtot} = \frac{m_c}{V_f \times f_{water}}$$

where:

C_{wtot} = Total water body concentration of the constituent (mg/L)
m_c = Mass discharge rate of the COI (mg/year)
V_f = Water body annual flow (L/year)
f_{water} = Fraction of COI in the water column (unitless)

There are no flow records available for the eastern branch of Coffeen Lake. The flow rate was assumed to be the same as that estimated for the unnamed tributary (*i.e.*, 90 cfs) (Golder Associates Inc., 2020), which flows from north to south into the eastern branch of the lake. The surface water parameters are presented in Table A.3.

The fraction of COI in the water column was calculated for each COI using the sediment/water and suspended solids/water partition coefficients (US EPA, 2014, Table J-1). The fraction of COI in the water column is defined as (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)
0.000001 = Units conversion factor
d_w = Depth of the water column (m)
d_b = Depth of the upper benthic layer (m), set equal to 0.03 m (US EPA, 2014)
$d_z = d_w + d_b$ = Depth of the water body (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 (US EPA 2014):

$$f_d = \frac{1}{1 + K_{dsw} \times TSS \times 0.000001}$$

The values of the fraction of COIs 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 (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 (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 COIs in the benthic sediments, the model derives the total concentration in benthic sediments (US EPA, 2014, Table J-1-12):

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

where:

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

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

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

where:

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

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

The concentration sorbed to benthic sediments was calculated from (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, the modeled dry weight sediment concentration, and the modeled 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
Uppermost Aquifer	A	Cross-Sectional Area	960	m^2
Uppermost Aquifer	i	Hydraulic Gradient	0.007	m/m
Uppermost Aquifer	K	Hydraulic Conductivity	0.002	cm/s

Notes:
Cross-sectional area calculated by multiplying the average thickness of the UA (i.e., 3 ft or 0.91 m) by the length of AP2 intersecting Coffeen Lake (conservatively assumed to be the sum of the eastern and southern sides of AP2; about 1,050 m).
Source: Hydraulic gradient from Dynegy (2017) and hydraulic conductivity values from Ramboll (2021).

Table A.2 Partition Coefficients

Constituent	Sediment-Water, Mean, K_{dbs}		Suspended Sediment-Water, Mean, K_{dsw}	
	Value ($\log_{10}$) (mL/g)	Value (mL/g)	Value ($\log_{10}$) (mL/g)	Value (mL/g)
Metals				
Antimony	3.6	3.98E+03	4.8	6.31E+04
Arsenic	2.4	2.51E+02	3.9	7.94E+03
Beryllium	2.8	6.31E+02	4.2	1.58E+04
Boron	0.8	6.31E+00	3.9	7.94E+03
Cadmium	3.3	2.00E+03	4.9	7.94E+04
Chromium	4.9	7.94E+04	5.1	1.26E+05
Cobalt	3.1	1.26E+03	4.8	6.31E+04
Lead	4.6	3.98E+04	5.7	5.01E+05
Lithium	-	-	-	-
Thallium	1.3	2.00E+01	4.1	1.26E+04
Radionuclides				
Radium-226+228	-	7.40E+03	-	7.40E+03
Other				
Chloride	-	-	-	-
Sulfate	-	-	-	-

Notes:
Source: US EPA (2014).
Lithium, chloride and sulfate do not readily sorb to soils and sediments. Consequently, sediment concentrations were not modeled for these constituents (K_d was assumed to be 0).

Table A.3 Surface Water Parameters

Parameter	Name	Value	Unit
TSS	Total Suspended Solids	3.2	mg/L
V_{fx}	Surface Water Flow Rate	8.04×10^{10}	L/yr
d_b	Depth of Upper Benthic Layer (default)	0.03	m
d_w	Depth of Water Column	5.70	m
d_z	Depth of Water Body	5.73	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]	0.0182	kg/m^2
M_S	Sediment Mass Per Unit Area[b]	30	kg/m^2

Notes:
Source of default values: US EPA (2014).
Other sources: total suspended solids from Hanson Professional Services, Inc. (2020), surface water flow rate from Golder (2020), and depth of water column from Austen *et al.* (1993).
(a) Determined by multiplying total suspended solids, TSS by the depth of water column, d_w.
(b) Determined by multiplying depth of upper benthic layer, d_b, with sediment bed particle concentration of 1 g/cc.

Table A.4 Calculated Parameters

COI	Fraction of Constituent in the Water Column f_{water}	Fraction of Constituent in the Benthic Sediments $f_{benthic}$	Fraction of Constituent Dissolved in the Water Column $f_{dissolved}$
Antimony	0.0542	0.9458	0.8320
Arsenic	0.436	0.564	0.975
Beryllium	0.2402	0.7598	0.9517
Boron	0.9657	0.0343	0.9752
Cadmium	0.1067	0.8933	0.7973
Chromium	0.0033	0.9967	0.7128
Cobalt	0.153	0.847	0.832
Lead	0.012	0.988	0.384
Lithium	0.997	0.003	
Thallium	0.906	0.094	0.961
Radionuclides			
Radium-226+228	0.026	0.974	0.977

Note:
COI = Constituent of Interest.

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)
Total Metals				
Antimony	6.60E-03	2.80E+04	3.50E-07	1.16E-03
Arsenic	1.30E-01	5.51E+05	6.89E-06	1.69E-03
Boron	3.10E-02	1.31E+05	1.64E-06	9.87E-04
Beryllium	2.12E+01	8.99E+07	1.12E-03	6.92E-03
Cadmium	2.80E-02	1.19E+05	1.48E-06	2.36E-03
Chromium	4.40E-01	1.87E+06	2.33E-05	1.32E+00
Cobalt	4.20E-01	1.78E+06	2.23E-05	2.33E-02
Lead	4.30E-02	1.82E+05	2.28E-06	3.49E-02
Lithium	3.20E-01	1.36E+06	1.70E-05	(a)
Thallium	4.00E-03	1.70E+04	2.12E-07	4.07E-06
Radionuclides				
Radium-226+228	8.66E+00	3.67E+07	4.59E-04	3.32E+00
Other				
Chloride	7.10E+02	3.01E+09	3.76E-02	(a)
Sulfate	4.60E+03	1.95E+10	2.44E-01	(a)

Notes:
pCi/kg = PicoCuries Per Kilogram; pCi/L = PicoCuries Per Liter.
(a) Lithium, chloride, and sulfate do not readily sorb to soil or sediment particles; a K_d value of 0 was used for the modeling.

Appendix A References

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Appendix B

Screening Benchmarks

Table B.3.1 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) yr		26
EF_{rec} (exposure frequency - recreator) day/yr		60
$\text{f}_{\text{p-fowl}}$ (fowl on-site fraction) unitless	1	1
$\text{f}_{\text{p-game}}$ (land game on-site fraction) unitless	1	1
$\text{f}_{\text{s-fowl}}$ (fraction of year fowl is on site) unitless	1	1
$\text{f}_{\text{s-game}}$ (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) yr		26
TR (target risk) unitless	0.000001	0.000001
F(x) (function dependent on $\text{U}_{\text{m}}/\text{U}_{\text{t}}$) 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) yr		26
$\text{ED}_{\text{rec-a}}$ (exposure duration - recreator adult) yr		20
$\text{ED}_{\text{resc-c}}$ (exposure duration - recreator child) yr		6
EF_{rec} (exposure frequency - recreator) day/yr		60
$\text{EF}_{\text{rec-a}}$ (exposure frequency - recreator adult) day/yr		60
$\text{EF}_{\text{rec-c}}$ (exposure frequency - recreator child) day/yr		60
ET_{rec} (exposure time - recreator) hr/day		8
$\text{ET}_{\text{rec-a}}$ (exposure time - recreator) hr/day		8
$\text{ET}_{\text{rec-c}}$ (exposure time - recreator) hr/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) yr		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; yr = year.

Table B.3.2 Recreator PRGs for Soil, Ra-226 and Ra-228

Isotope	ICRP Lung Absorption Type	Soil Ingestion Slope Factor (risk/pCi)	Inhalation Slope Factor (risk/pCi)	External Exposure Slope Factor (risk/yr per pCi/g)	Food Ingestion Slope Factor (risk/pCi)	Lambda (1/yr)	Half-life (yr)	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	Beef Transfer Factor (pCi/kg per pCi/d)	Poultry Transfer Factor (pCi/kg per pCi/d)	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
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:

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

Appendix B

Corrective Action Alternative Analysis – Supporting Information Report

Intended for
Illinois Power Generating Company
134 Cips Lane
Coffeen, Illinois 62017

Date
April 1, 2025

Project No.
1940110241-001

CORRECTIVE ACTION ALTERNATIVES ANALYSIS SUPPORTING INFORMATION REPORT

ASH POND NO. 2
COFFEEN POWER PLANT
IEPA ID NO. W1350150004-02

RAMBOLL Bright ideas. Sustainable change.

CORRECTIVE ACTION ALTERNATIVES ANALYSIS SUPPORTING INFORMATION REPORT IEPA ID NO. W1350150004-02

Project name	**Coffeen Power Plant Ash Pond No. 2**
Project no.	**1940110241-001**
Recipient	**Illinois Power Generating Company**
Document type	**Corrective Action Plan**
Revision	**DRAFT**
Date	**April 1, 2025**
Prepared by	**Katlyn Nohr, Sarah Slagle-Garrett**
Checked by	**J. Austin Bond, PE**
Approved by	**Brian G. Hennings, PG**
Description	**Corrective Action Alternatives Analysis Supporting Information Report**

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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
AP1	Ash Pond No. 1
AP2	Ash Pond No. 2 (“the site”)
bgs	below ground surface
BMP	best management practices
CAAA	Corrective Action Alternatives Analysis
CAAA-SIR	Corrective Action Alternatives Analysis Supporting Information Report
CAP	Corrective Action Plan
CCR	coal combustion residuals
CCR Rule	40 C.F.R. § 257 Subpart D
CIP	closure-in-place
CMA	Corrective Measures Assessment
COC	constituent of concern
COF	Coffeen Power Station
CPP	Coffeen Power Plant
GMF	Gypsum Management Facility (GMF)
Gradient	Gradient Corporation
GSP	Gypsum Stack Pond
GWE	groundwater extraction
GWP	groundwater polishing
GWPS	groundwater protection standard(s)
HDPE	high-density polyethylene
ID	identification
IDNR	Illinois Department of Natural Resources
IEPA	Illinois Environmental Protection Agency
IGPC	Illinois Power Generating Company
Kd	soil adsorption coefficient
LCU	lower confining unit
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
NRT	Natural Resource Technology, Inc.
O&M	operations and maintenance
Ramboll	Ramboll Americas Engineering Solutions, Inc.
RP	Recycle Pond
RS Means	RS Means Heavy Construction Cost Data
SI	surface impoundment
TDS	total dissolved solids
UA	uppermost aquifer
USEPA	United States Environmental Protection Agency

1. INTRODUCTION AND BACKGROUND

1.1 Plant and Site Information

Illinois Power Generating Company (IPGC) is the owner of the inactive coal-fired Coffeen Power Plant (CPP), also referred to as the Coffeen Power Station (COF), in Coffeen, Montgomery County, Illinois. IPGC intends to complete groundwater corrective action at the coal combustion residuals (CCR) surface impoundment (SI) Ash Pond number (No.) 2 (AP2), which is identified by Illinois Environmental Protection Agency (IEPA) identification (ID) No. W1350150004-02, CCR Unit ID 102, and National Inventory of Dams (NID) No. IL50723. Groundwater corrective action for COF AP2 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 COF AP2 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 COF AP2.

This CAAA-SIR was prepared to address specific constituents of concern (COCs) where exceedances[1] of the 35 I.A.C. § 845.600 groundwater protection standards (GWPS) have been detected in the COF AP2's groundwater compliance monitoring wells.

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 (CAP), 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 CAP. 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 CAP.

1.2.1 Identified Corrective Action Alternatives

Corrective action remedies selected for evaluation within this CAAA-SIR include:

- Alternative 1: Source control with groundwater polishing (GWP);

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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 GWPSs as described in the proposed groundwater monitoring program, which was submitted to the IEPA on October 25, 2021 as part of IPGC's operating permit application for COF AP2. That operating permit application, including the proposed groundwater monitoring program, remains under review by the IEPA and, therefore, IPGC has not identified any actual exceedances

- Alternative 2: Source control with upgradient barrier wall with groundwater extraction (GWE) trench; and
- Alternative 3: Source control with horizontal GWE well.

Multiple remedies were evaluated in the Corrective Measures Assessment (CMA) prepared by Ramboll and attached to the CAAA prepared by Gradient, including source control with GWP, source control with GWE, source control with groundwater cutoff wall, and source control with in-situ chemical treatment.

Out of these remedies, source control with GWP, source control with GWE, and source control with groundwater cutoff wall were identified for further assessment, while the remaining remedy was determined to be infeasible. As part of the further assessment performed during this CAAA-SIR modeling and development, the following adjustments were made to the remedies identified by the CMA:

- Following groundwater modeling, the source control with groundwater cutoff wall remedy was determined to be infeasible for attaining GWPS in a reasonable amount of time without a supplementary hydraulic control method. The source control with groundwater cutoff wall remedy expanded into the upgradient barrier wall with GWE trench remedy.
- The source control with GWE remedy was further refined into the source control with horizontal GWE well remedy. The remedy includes an alternate method of GWE well installation via horizontal directional drilling, which would significantly reduce disturbance of the completed final cover system while allowing for targeted installation near the CCR/native soil interface beneath AP2. Additional information on the modified remedy is provided in **Section 4**.

Other remedies, including source control with in-situ treatment (permeable reactive barrier or chemical treatment), 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 upgradient barrier wall and GWE trench) and the Alternative 3 remedy (source control with horizontal GWE well). 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 that include the generation of extracted groundwater.
- 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 in this CAAA-SIR are in conjunction with source control for the AP2, which was completed in 2020 [3] in accordance with the closure plan and supporting groundwater modeling that was submitted to and approved by IEPA in 2018 [4, 5]. Source control was the primary corrective action completed for AP2 and utilized a closure-in-place (CIP) approach. The CIP approach included capping AP2 with a geosynthetic and soil final cover system [6].

1.2.3 Criterion for Estimating Time to Achieve GWPS

Times to achieve GWPS for each of the remedial alternative remedies were estimated using monitoring wells within the existing AP2 compliance monitoring system. This approach was utilized to provide a consistent comparison of the estimated time to reach GWPS for each remedy, as required by 35 I.A.C. § 845.670(e)(f).

Closure for AP2 serves as the primary corrective action for the unit and was completed in 2020, as discussed in **Section 1.2.2**. Supplemental remedial alternatives for AP2 will need to be integrated with the completed closure. This affects the time to reach GWPS for each remedy, as the timeframe for each remedial alternative to become functional varies significantly based on the required level of remedy permitting, design, and construction, or lack thereof. To provide a simplified comparative framework for the remedial alternatives, the groundwater modeling provided in **Appendix B.1** used a remedial action start date of 2024, in order to provide a normalized estimate of time to reach GWPS between the various remedies.

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 upgradient barrier wall and GWE trench;
- **Section 4** includes information for the Alternative 3 remedy: source control with horizontal GWE well;
- **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, includes the completed source control and GWP. 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 for groundwater remediation [7]. GWP has been naturally occurring at AP2 since source control was completed in 2020. For the purposes of this CAAA-SIR, the Alternative 1 remedy would involve formalizing the ongoing natural GWP processes with adaptive management as the corrective action remedy for the AP2.

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 [8] are boron, cobalt, pH, sulfate, and TDS. In 2017, groundwater modeling conducted by Natural Resource Technology, Inc. (NRT) simulated the fate and transport of boron to support the closure of AP2 [9]. In 2024, Ramboll updated this model, using sulfate as the constituent to evaluate the effectiveness of both the completed closure scenario and corrective action alternatives (**Appendix B.2**). Sulfate has been detected in AP2 groundwater at the highest concentrations relative to its GWPS and will likely take the longest time to meet the GWPS (**Appendix B.1**). Sulfate was therefore identified as a surrogate for the exceedances of boron, cobalt, pH, and TDS, as described in the Groundwater Modeling Technical Memorandum. For modeling purposes, it was assumed that sulfate 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. 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) (**Appendix B.1**). 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 [10] and discussed herein.

Groundwater modeling for the Alternative 1 remedy performed to support the closure plan for AP2 was updated to included additional data collected since the 2017 modeling was completed (**Appendix B.1**). Modeling results estimated that GWPS will be met in approximately 135 years for all wells within the existing AP2 monitoring well network.

2.2 Remedy Implementation

Implementation of the source control portions of this remedy (*e.g.,* final closure of AP2) was completed in 2020. Although a formal groundwater polishing remedy has not yet been initiated and approved by IEPA, natural geochemical attenuation processes have been ongoing since the closure was completed. Implementation of GWP would include performing corrective action groundwater monitoring, enacting an adaptive 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 would 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 would be collected for major ions for evaluating groundwater chemistry and COCs. Samples would 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 would 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 would occur during the monitoring period. This would 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 would 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 conceptual site, groundwater, and geochemical models.
  - If remedy progress does not correspond with expectations, additional methods or techniques to achieve compliance with GWPS would 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 would be implemented. This would include monitoring each well for three additional years to confirm that GWPS have been achieved, in accordance 35 I.A.C. § 845.680(c).
  - After completion of the corrective action confirmation monitoring period, a Corrective Action Completion Report and Certification would 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 GWP

Implementation Phase	Implementation Task	Timeframe (Preliminary Estimates)
Corrective Action Implementation	Corrective Action Monitoring (Time to Meet GWPS)	1,620 months (135 years)
	Corrective Action Confirmation Monitoring	36 months
	Corrective Action Completion	6 months
	Timeframe to Complete Corrective Action Implementation	1,662 months (139 years)
	Total Timeline to Complete Corrective Action (after approval of Corrective Action Plan)	1,662 months (139 years)

2.2.2 Management of Extracted Groundwater

No groundwater extraction would 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 AP2 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 would be required for source control with GWP, as a physical remedy would not be constructed.
- Degree of Difficulty Associated with Constructing the Remedy – 35 I.A.C. § 845.670(e)(3)(A)
  - No construction would 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 [10], groundwater geochemical processes anticipated to occur as downgradient groundwater approaches ambient background conditions are not expected to delay the modeled time to achieve GWPS compliance.
  - GWP would 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 would be required.
- 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) would 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 would be required with the source control with GWP remedy, as GWP would not generate any appreciable volume of waste or wastewater.

3. ALTERNATIVE 2 REMEDY: SOURCE CONTROL WITH UPGRADIENT BARRIER WALL AND GWE TRENCH

The Alternative 2 remedy, source control with upgradient barrier wall and GWE trench, would include the construction of a barrier wall that would be located adjacent to the northern and western sides of AP2 with a GWE trench running parallel to and hydraulically downgradient of the barrier wall. The barrier wall and extraction trench would be constructed from grade surface down to approximately 8 feet below ground surface (bgs) (approximate elevation 615 feet[2]), in order to penetrate the uppermost aquifer (UA). The extraction trench and barrier wall are both expected to be on the order of 2 to 3 feet thick, with approximately 1 to 2 feet of separation between them. The purpose of the combined extraction trench and barrier wall is to prevent the flow of groundwater towards AP2 from the northwest, while providing a means to capture groundwater and reduce hydraulic head beneath AP2, which would accelerate achieving GWPS.

The GWE trench portion of the remedy would be constructed by excavating existing subgrade soils, installing a horizontal collection pipe in the trench, backfilling with clean granular fill, and placing a compacted clay cap over the trench to reduce surface water infiltration. The collection pipe will drain to sumps spaced throughout the trench with an extraction pump within each sump. Extracted groundwater would be routed via conveyance piping to a new on-site lined settling pond and discharged through either a new or existing outfall, where it would be managed in accordance with site National Pollutant Discharge Elimination System (NPDES) permits.

The barrier wall portion of the remedy would be constructed adjacent to the extraction trench by mixing in-situ soils with a low-permeability mixture down to the target elevation. The upgradient barrier wall is intended to reduce the flow of groundwater towards AP2 and reduce the volume of groundwater that needs to be extracted from the trench.

A feasibility-level drawing of the source control with upgradient barrier wall and GWE trench remedy is provided as **Figure 1** in **Appendix A.**

3.1 Remedy Scoping and Groundwater Modeling Results

The location of the barrier wall and GWE trench were selected by reviewing physical constraints around AP2 and designating locations on IPGC property where the barrier wall and extraction trench could feasibly be constructed with limited impacts to other site features. The location was additionally selected to avoid sensitive areas such as wetlands and floodplains [11, 12] and avoid areas with steep slopes and/or limited access which could increase construction complexity and risk. This assessment identified that the barrier wall and GWE trench could not be constructed south of AP2 because of the limited space between the toe of the dike and the former CPP cooling water discharge flume. Construction in this area could not be performed without major dike modifications and geotechnical considerations.

Assessment of physical constraints resulted in the barrier wall and GWE trench alignments being located within the open area along the access road to the north of AP2 and between the access road and the dikes west of AP2. These areas provide a generally straight and level alignment for construction of the barrier wall and GWE trench. The location of the barrier wall and GWE trench

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

is generally perpendicular to existing groundwater flow patterns between the Gypsum Management Facility (GMF) Recycle Pond (RP) and AP2.

The depth of the barrier wall and GWE trench was selected based on interception with the existing groundwater table and the base of the UA. The surface elevation at the base of the northern AP2 CIP berm (approximate elevation 623 feet) results in an extraction trench and cutoff wall depth of approximately 8 feet bgs to terminate at the bottom of the UA (approximate elevation 615 feet) in order to reduce the flow of off-site groundwater into the AP2 footprint from the north/west and to direct groundwater from beneath the AP2 footprint into the trench.

Groundwater modeling for the Alternative 2 remedy (**Appendix B.1**) estimated that GWPS will be met approximately 59 years after remedy construction for all wells within the existing AP2 monitoring well network.

3.2 Remedy Implementation

Implementation of the Alternative 2 source control with upgradient barrier wall and GWE trench 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.

3.2.1 Phase 1: Pre-Construction Activities

Pre-construction activities would 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, cutoff wall backfill mix design bench testing, engineering calculations, design drawings, specifications, and a construction quality assurance plan.
  - Bidding and selection of a GWE trench and barrier wall construction contractor.
- Obtaining permits from other agencies including:
  - A general stormwater 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 Illinois Department of Natural Resources (IDNR) Office of Water Resources, Dam Safety modification permit may need to be obtained, for construction of the GWE trench and barrier wall in the vicinity of the embankment.
  - A modification to the site's NPDES permit would be obtained to accept discharge of extracted groundwater for the operational lifetime of the GWE trench.

3.2.2 Phase 2: Corrective Action Construction

Corrective action construction would 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 GWE trench (the trench and associated mechanical elements and piping installation), construction of the barrier wall, construction of a settling pond, and performing post-construction and site restoration activities.

Information associated with each of these activities is described below.

- The contractor would 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 GWE trench/barrier wall alignment.
- Construction of the working platform would include removing, relocating, or modifying existing site infrastructure that may conflict with the construction of the GWE trench/barrier wall, grading to ensure a level working platform, and placing a granular fill working pad to support trench installation equipment. The existing road surfaces along the wall alignment would be saw-cut where necessary for GWE trench/barrier wall construction.
- The approximately 3,300-foot long GWE trench would be installed along the northern and western perimeter of AP2. For the purposes of this CAAA-SIR, the GWE trench was assumed to be installed using one-pass technology, although other installation methods may be evaluated during a later phase of design.
  - The GWE trench would be excavated to an approximate depth of 8 feet bgs (elevation 615 feet), terminating at the bottom of the UA. The trench would be on the order of 2 to 3 feet wide.
  - Sump locations would be installed along the trench, spaced approximately 500 feet apart. Sumps would consist of a vertical pit to collect water, a discharge line, a pneumatic pump to pump water to the conveyance line, and a common air compressor to drive the pumps.
  - Perforated 6-inch-diameter high-density polyethylene (HDPE) collection pipe would be installed approximately 8 inches from the bottom of the trench at a very slight grade (approximately 0.5 to 2 percent) towards the sump locations.
  - Simultaneously with pipe installation, in-situ soils would be removed, and the trench would be backfilled with granular material consisting of premixed sand and gravel.
  - The trench would be backfilled with clean granular material and capped to reduce surface water infiltration into the trench.
    - Where the trench is located within a site access road, the cap would include asphalt or concrete.
    - Where the trench is located outside of a site access road, the cap would include low-permeability clay and topsoil at the surface or a more erosion-resistant material (*i.e.,* a turf-reinforced mat or gravel).
- Following the installation of the GWE trench, an approximately 3,300-foot adjacent barrier wall would be installed on the outer (hydraulically upgradient) side of the trench. For the purposes of this CAAA-SIR, the barrier wall was assumed to be installed using one-pass technology, although other installation methods may be evaluated during a later phase of design.

  - A temporary on-site batch plant and/or material handling system would be established for the purpose of generating low permeability backfill for the barrier wall. This would include either mixing bentonite with the subgrade soils or producing a cement-bentonite slurry to place into the wall.
  - In-situ soils would be either mixed with bentonite or removed and backfilled with a cement-bentonite or soil-bentonite mixture.
  - The wall would likely be constructed in one continuous unit along the western side of AP2, and one continuous unit along the northern side. The wall would be on the order of 2 to 2.5 feet thick and 8 feet deep in order to tie into the lower confining unit (LCU).
- Excavated soils (*e.g.,* spoils) from the GWE trench and barrier wall installations would be placed into off-road dump trucks and hauled to the on-site landfill for disposal.
- An approximately 1-acre settling pond for management of extracted groundwater was assumed to be constructed using conventional construction equipment. However, other groundwater treatment and management technologies may be evaluated during a later phase of design. A temporary wastewater treatment plant that is being constructed on-site to treat existing CCR-contact water within the GMF Gypsum Stack Pond (GSP) and adjacent GMF RP is not expected to operate post-closure, and therefore was assumed to be unavailable for treating extracted groundwater from the GWE trench.
  - The location of the settling pond would be selected to limit adverse impacts or conflicts with future solar redevelopment and other existing and future site infrastructure. The precise location of the pond will be evaluated during later phases of design.
  - The settling pond would be approximately 1 acre in size and 2 feet deep. Soils would be mechanically excavated from the settling pond and used to create 10-foot-wide berms around the perimeter of the settling pond to contain extracted groundwater. All excavated soils from the settling pond would be managed within the settling pond footprint.
  - A geomembrane liner system would be installed in the settling pond to reduce the potential for releases of extracted groundwater.
  - Fused HDPE piping would be used to convey groundwater from the GWE trench to the settling pond and from the settling pond to the appropriate NPDES outfall. This would include the installation of electrical, mechanical, and pneumatic infrastructure to operate the conveyance piping system.
- Site restoration would be completed following the installation of the barrier wall and GWE trench. This would include repairing site infrastructure that was relocated or damaged during construction, restoration of the road surfaces, and minor regrading and seeding of disturbed areas.
  - Temporary BMPs would be installed during the site restoration period, if required in accordance with site land disturbance permits. The BMPs would be removed once vegetation is established.

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

Corrective action operations, maintenance, and closure would be initiated after corrective action construction is completed. It would 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
  - Continued operation of the GWE trench and barrier wall system would require routine scheduled inspections and associated maintenance including, but not limited to, totalizer data collection, filter system maintenance (if needed), and maintenance of extraction pumps, as well as other system components.
  - Non-routine maintenance that may occur during extended operation of the GWE trench may include tasks such as repair or replacement of the extraction and/or transfer pumps, repair or replacement of the system air compressor, and flushing or jetting of water conveyance lines in the event organic or inorganic solids accumulate on the interior walls.
  - Routine monitoring and compliance activities associated with the treatment and discharge of extracted water via the site's NPDES permit.
- Corrective Action Monitoring
  - Regular corrective action groundwater monitoring would be conducted using 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 would 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 would 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 would include an evaluation of the actual performance of the remedy relative to the remedy's expected performance.
    - Routine maintenance of the monitoring well network would be conducted during the monitoring period. This would 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 would be evaluated and, if feasible, implemented in accordance with 35 I.A.C. § 845.680(b).
- Adaptive Management during Monitoring
  - Groundwater monitoring results would 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 conceptual site, groundwater, and geochemical models.

  - If remedy progress does not correspond with expectations, additional methods or techniques to achieve compliance with GWPS would 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 would be considered complete, per 35 I.A.C. § 845.680(c).
  - After completion of the corrective action confirmation monitoring period, a Corrective Action Completion Report and Certification would then be submitted to IEPA, in accordance with 35 I.A.C. § 845.680(e).

3.2.4 Remedy Implementation Schedule

A feasibility-level implementation schedule for the Alternative 2 source control with upgradient barrier wall and GWE trench remedy is provided in **Table B** below.

Table B. Feasibility-Level Implementation Schedule – Alternative 2: Source Control with Upgradient Barrier Wall and GWE Trench

Implementation Phase	Implementation Task	Timeframe (Preliminary Estimates)
1: Pre-Construction Activities	Agency Coordination, Approvals, and Permitting	18 to 24 months
	Final Design and Bid Process	24 to 36 months
	Timeframe to Complete Corrective Pre-Construction Activities	42 to 60 months after CAP Approval
2: Corrective Action Construction	Corrective Action Construction	6 to 12 months
	Timeframe to Complete Corrective Action Construction	6 to 12 months after completion of pre-construction activities.
3: Corrective Action O&M and Closeout	Corrective Action Monitoring (Time to Meet GWPS)	708 months (59 years)
	Corrective Action Confirmation Monitoring	36 months
	Corrective Action Completion	6 months
	Timeframe to Complete Corrective Action O&M and Closeout	750 months (63 years)
Total Timeline to Complete Corrective Action (after approval of Construction Permit Application)		798 to 822 months (67 to 69 years)

3.2.5 Management of Extracted Groundwater

Extracted groundwater from the trench was assumed to be managed and treated by a newly constructed on-site settling pond, although other treatment technologies may be evaluated at a later phase of design. The settling pond would need to be sited to avoid conflict with planned solar redevelopment, other site infrastructure, and closure activities related to AP1 and other SIs at CPP. A settling pond of approximately 1 acre in size was assumed to be sufficient to allow sediments to settle from extracted groundwater prior to discharge. Groundwater collected from the extraction well network would be sent to the settling pond via the pneumatic extraction pumps and transfer piping. Treated water would be discharged via a NDPES outfall, in accordance with site-specific NPDES permit requirements [13].

3.2.6 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 COF AP2 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 upgradient barrier wall and GWE trench would be unlikely to require replacement of the remedy, as the barrier wall would be a robust, engineered, and maintenance-free subsurface structure.
    - No replacement of the GWE trench is expected to be required, although the trench would require 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)
    - The remedy would require use of specialized contractors and equipment (*i.e.,* one-pass trenching/barrier wall contractor and equipment) for the installation of the trench and barrier wall, in addition to general construction equipment (*i.e.,* excavation and grading equipment).
- Expected Operational Reliability of the Remedy - 35 I.A.C. § 845.670(e)(3)(B)
    - The GWE trench and barrier wall system is expected to have a high operational reliability if it is constructed in accordance with the design and specifications.
    - The barrier wall provides an inert, continuous, low-permeability barrier to groundwater flow which is not expected to need maintenance.
    - The GWE trench system is a mechanical system that would require routine maintenance to reliably operate, as outlined in **Section 3.2.3**.
- Need to Coordinate with and Obtain Necessary Approvals and Permits from Other Agencies - 35 I.A.C. § 845.670(e)(3)(C)
    - Agency permits would need to be obtained from IEPA for discharge of extracted groundwater, construction of stormwater controls and BMPs, and potentially an IDNR Dam Safety modification permit. These permits typically take 18 to 24 months to obtain, with the NPDES permit modification taking longer to obtain than the other permits.
- Availability of Necessary Equipment and Specialists - 35 I.A.C. § 845.670(e)(3)(D)
    - Construction of the barrier wall and GWE trench would require a specialized contractor experienced with constructing similar types of trenches and barrier walls in similar geologic environments. Relatively few construction contractors with this experience, particularly using one-pass equipment, are available. The contractor would likely need specialized and often custom-built equipment.
    - Specialists in one-pass trenching and barrier wall methods would also need to be utilized during the design and construction phase. The specialists would include design engineers,

construction managers, and contractor staff experienced with trench construction and equipment operation.

  - Geotechnical specialists would be needed to design the working platform and monitor the AP2 embankment for signs of distress during one-pass trench installation.
  - These types of equipment and specialists have been utilized in the past for other similar types of barrier wall and GWE trench design and construction projects. However, there may be backlogs 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. These backlogs could delay the project schedule beyond current assumptions.
  - Specialists would be needed to maintain the GWE system during the operational timeframe and are currently being utilized as part of GWE O&M. System components that require maintenance include totalizers, 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 in proximity (*i.e.*, 100 to 300 miles) of the site but some of the more complex 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 and groundwater sampling are required for the remedy. Laboratory equipment and specialists would also be required to assess groundwater concentrations of site COCs. Groundwater professionals (*i.e.,* geologists, hydrogeologists, statisticians, geochemists) would 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 barrier wall and GWE trench construction would be limited to spoils; these would be disposed of in the on-site landfill.
  - The GWE trench system would send extracted groundwater to an on-site settling pond to settle solids extracted during groundwater recovery via the pneumatic pumps and transfer piping. This settling pond would be new construction that would need to be sited, designed, constructed, and maintained.
    - The settling pond would need to be sited to not conflict with planned solar redevelopment, wetlands, floodplains, or other site infrastructure.

  - Continued NPDES permit renewals may be required, depending on the timeline of corrective action implementation relative to completion of source control activities.

4. ALTERNATIVE 3 REMEDY: SOURCE CONTROL WITH HORIZONTAL GWE WELL

The Alternative 3 remedy, source control with horizontal GWE well, would include construction of one horizontal well within the eastern portion of AP2 to collect groundwater from beneath AP2. The horizontal well would be single ended, initiating from the southern bank of AP2 at an elevation of approximately 600 feet and terminating approximately 1,325 feet to the north at an elevation of approximately 606 feet. The horizontal well would drain water from beneath AP2 reducing hydraulic head beneath AP2, which would accelerate achieving GWPS. Extracted water would be directed through a freely draining culvert or be pumped to a settling pond prior to discharge.

The discharge flume is was part of CPP operations and was utilized to route plant process water towards Coffeen Lake. Since the CPP is closed, the flume no longer receives any plant process flows and only receives site stormwater. The water level in the flume is currently at an elevation of 598 to 599.3 feet.

A feasibility-level design drawing of the Alternative 3: source control with horizontal GWE well remedy is provided as **Figure 2** in **Appendix A.**

4.1 Remedy Scoping and Groundwater Modeling Results

In the updated groundwater modeling the discharge flume was simulated as a drain located within the upper portion of the lower confining unit clays beneath the sands of the uppermost aquifer, with a drain stage set to 598.7 feet. This elevation was based on typical water level data obtained from the staff gage on the eastern side of the flume and a review of available survey data, which indicated a current bottom elevation of approximately 598 feet in the flume. Therefore, it was assumed that this elevation could be readily obtained without requiring extensive modifications to the flume or the existing weir structure. Further, if slightly higher water levels are present in the flume, up to 600 feet, there is minimal to no change in the time to reach GWPS.

One horizontal GWE well would be installed running north/south along the eastern portion of AP2. The location of the horizontal well was selected by reviewing physical constraints around AP2 and designating locations on the IPGC property where the well could feasibly be constructed with limited impacts to other site features. Sensitive areas, such as wetlands and floodplains were considered, which prevented the placement of the well east of AP2 and resulted in the horizontal extraction well located in a north-south orientation within the CIP footprint of AP2 [11, 12]. The horizontal drilling entry point would be located at the southern perimeter of AP2. While the entry point is not within regulatory flood plains or known wetlands, construction of a working platform would be required to span the flume. The location of the horizontal well would be at the CCR/native soil interface and would generally intersect (*i.e.*, be perpendicular to) the existing groundwater flow directions beneath AP2. The depth of the horizontal well was selected to coincide with the bottom of CCR based on as-built construction information for the bottom of AP2 [14]. The elevation of this base surface results in horizontal well depths at an approximate north to south elevation of 606 to 600 feet.

Groundwater modeling for the Alternative 3 remedy (**Appendix B.1**) estimated that GWPS would be met approximately 14 years after remedy construction for all wells within the existing AP2 monitoring well network. The horizontal well may require that extraction continue for a total of 39 years (*i.e.*, 25 years after GWPS have been met) to prevent concentrations from rebounding above the GWPS.

4.2 Remedy Implementation

Implementation of the Alternative 3 remedy, source control with horizontal GWE well, 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 would 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, design drawings, specifications, and a construction quality assurance plan.
    - Bidding and selection of a construction general contractor.
- Obtaining permits from other agencies including:
    - A general stormwater permit for construction site activities through IEPA, including construction stormwater controls and other BMPs such as silt fences and other measures.
    - A modification to the site’s NPDES permit to allow for the discharge of groundwater from the horizontal well.

4.2.2 Phase 2: Corrective Action Construction

Corrective action construction would be initiated after pre-construction activities are complete. It would include mobilizing construction equipment to the site, preparing the site for construction activities, installation of the horizontal well (and associated piping and mechanical elements), and performing post-construction and site restoration activities.

Information associated with each of these activities is described below.

- The contractor would 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 pad and/or temporary construction access roads to navigate to the southern perimeter of AP2, to allow the horizontal well to be installed.
- Horizontal well installation would be implemented, including the following tasks:
    - A work pad would be constructed within the flume to allow drilling equipment to install the well from the south side of AP2 and drill towards the north. This would include installing

    culverts in an approximately 50-foot-long portion of the flume and backfilling the flume up to surrounding grades with free-draining gravel backfill.

  - Drilling would be initiated from the south end of AP2 at the base of the existing berm. The target elevation of the bottom of CCR/top of the UA is approximately 600 to 606 feet along the CCR/native soil interface. A pilot hole would be drilled from the entry point north, terminating at a length of approximately 1,300 feet.
    - Drill cuttings and drilling fluids (*e.g.,* spoils) generated during drilling would be placed into off-road dump trucks and hauled to the on-site landfill for disposal.
  - The well casing would consist of slotted well screen for targeted collection areas and solid sections for areas where collection is not required. The casing would be assembled at the surface and installed through the pilot borehole.
  - Following installation, the well would be developed, consisting of flushing or jetting the system as needed to fully remove any remaining drilling mud/solids.
  - The entry point would be sealed with grout to reduce surface water infiltration into the well and a concrete bulkhead would be constructed at the exit points of the well.
- An approximately 1-acre settling pond for management of extracted groundwater was assumed to be constructed using conventional construction equipment. However, other groundwater treatment and management technologies may be evaluated during a later phase of design. A temporary wastewater treatment plant that is being constructed on-site to treat existing CCR-contact water within the GMF GSP and adjacent GMF RP is not expected to operate post-closure, and therefore was assumed to be unavailable for treating extracted groundwater.
  - The location of the settling pond would be selected to limit adverse impacts or conflicts with future solar redevelopment and other existing and future site infrastructure. The precise location of the pond would be evaluated during later phases of design.
  - The settling pond would be approximately 1 acre in size and 2 feet deep. Soils would be mechanically excavated from the settling pond and used to create 10-foot-wide berms around the perimeter of the settling pond to contain extracted groundwater. All excavated soils from the settling pond would be managed within the settling pond footprint.
  - A geomembrane liner system would be installed in the settling pond to reduce the potential for releases of extracted groundwater.
  - Fused HDPE piping would be used to convey groundwater from the horizontal well to the settling pond and from the settling pond to the appropriate NPDES outfall. This would include the installation of electrical, mechanical, and pneumatic infrastructure to operate the conveyance piping system.
- Site restoration would be completed following the horizontal well installation. This would include repairing site infrastructure that was relocated or damaged during construction and minor regrading and seeding of disturbed areas, including the work pad and temporary access roads.
  - Temporary BMPs would also be installed during the site restoration period, if required in accordance with site land disturbance permits. The BMPs would be removed once vegetation is established.

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

Corrective action operations, maintenance, and closure would be initiated after corrective action construction is completed. It would 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
  - Continued operation of the horizontal well would require routine scheduled inspections and associated maintenance including maintenance of extraction and transfer pumps as well as other system components.
  - Non-routine maintenance that may occur during extended operation of the horizontal well system may include 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 treatment and discharge of extracted water via the site’s NPDES permit would also be completed during this phase.
- Corrective Action Monitoring
  - Regular corrective action groundwater monitoring would 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 would be collected for major ions for evaluating groundwater chemistry and COCs. Samples would 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 would 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 would include an evaluation of the actual performance of the remedy relative to the remedy’s expected performance.
    - Routine maintenance of the monitoring well network would be conducted during the monitoring period. This would 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 would be evaluated and, if feasible, implemented in accordance with 35 I.A.C. § 845.680(b).
- Adaptive Management during Monitoring
  - Groundwater monitoring results would 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 conceptual site, groundwater, and geochemical models.

  - If remedy progress does not correspond with expectations, additional methods or techniques to achieve compliance with GWPS would 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 would be considered complete, per 35 I.A.C. § 845.680(c).
  - After completion of the corrective action confirmation monitoring period, a Corrective Action Completion Report and Certification would 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 remedy, source control with horizontal GWE well, is provided in **Table C**.

Table C. Feasibility-Level Implementation Schedule – Alternative 3: Source Control with Horizontal GWE Well

Implementation Phase	Implementation Task	Timeframe (Preliminary Estimates)
1: Pre-Construction Activities	Agency Coordination, Approvals, and Permitting	12 to 18 months
	Final Design and Bid Process	24 to 36 months
	Timeframe to Complete Corrective Pre-Construction Activities	36 to 54 months after CAP Approval
2: Corrective Action Construction	Corrective Action Construction	6 to 12 months
	Timeframe to Complete Corrective Action Construction	6 to 12 months
3: Corrective Action O&M and Closeout	Corrective Action Monitoring (Time to Meet GWPS)	168 months (14 years)
	Corrective Action Monitoring (Post-GWPS Operations)	300 months (25 years)
	Corrective Action Confirmation Monitoring	36 months
	Corrective Action Completion	6 months
	Timeframe to Complete Corrective Action O&M and Closeout	510 months (43 years)
Total Timeline to Complete Corrective Action (after approval of Construction Permit Application)		552 to 576 months (46 to 48 years)

4.2.5 Management of Extracted Groundwater

Extracted groundwater from the horizontal well was assumed to be managed and treated by a newly constructed on-site settling pond, although other treatment technologies may be evaluated at a later phase of design. The settling pond would need to be sited to avoid conflict with planned solar redevelopment, other site infrastructure, and closure activities related to AP1 and other surface impoundments at CPP. A settling pond approximately 1 acre in size was assumed to be sufficient to allow sediments to settle from extracted groundwater prior to discharge.

Groundwater collected from the extraction well network would be sent to the settling pond via the pneumatic extraction pumps and transfer piping. Treated water would be discharged via a NDPES outfall, in accordance with site-specific NPDES permit requirements [13].

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 COF AP2 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 horizontal well would require 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)
  - The remedy would require mobilizing specialty equipment to the site (*i.e.,* horizontal directional drill rigs) in addition to other supporting equipment (*i.e.,* excavation and grading equipment).
  - While horizontal wells are routinely constructed to similar depths and profiles in similar geologic environments, they may encounter difficulties during construction. The difficulties could include heterogeneity in the surface of the bottom of the CCR/top of UA interface or encountering obstructions that require specialized techniques and/or equipment to advance past. Therefore, the degree of construction difficulty is expected to be moderate.
- Expected Operational Reliability of the Remedy - 35 I.A.C. § 845.670(e)(3)(B)
  - The horizontal well is expected to have high operational reliability if constructed in accordance with the design and specifications.
  - While the horizontal well system is a passive drain system, the conveyance of extracted groundwater to the settling pond would constitute a mechanical system which would require routine maintenance to reliably operate, as outlined in **Section 4.2.3**.
- Need to Coordinate with and Obtain Necessary Approvals and Permits from Other Agencies - 35 I.A.C. § 845.670(e)(3)(C)
  - Agency permits would need to be obtained from IEPA for construction stormwater controls and BMPs, in addition to modifications to the site's NDPES permit. These permits typically take 18 to 24 months to obtain.

- Availability of Necessary Equipment and Specialists - 35 I.A.C. § 845.670(e)(3)(D)
    - Construction of the horizontal well would require a specialized contractor. The contractor would utilize specialized equipment along with conventional construction support equipment (*i.e.,* excavators, telehandlers).
    - Specialists in horizontal well design and construction would also need to be utilized during the design and construction phase of the horizontal well installation. The specialists would include design engineers, geologists, construction managers, and contractor staff experienced with horizontal well construction and equipment operation.
    - Additionally, specialists are occasionally needed for non-routine O&M which may include periodic re-development of the well (*i.e.*, flushing or jetting of 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 in proximity (*i.e.,* 100 to 300 miles) of the site but some of the more complex and/or equipment, including the transfer pumps and transfer pump controller, may have extended lead times for replacement or servicing.
- Available Capacity and Location of Needed Treatment, Storage, and Disposal Services - 35 I.A.C. § 845.670(e)(3)(E)
    - The horizontal well system would send extracted groundwater to an on-site settling pond to settle solids extracted during groundwater recovery. This settling pond would be new construction that would need to be sited, designed, constructed, and maintained.
    - Settling pond design and construction would need to consider and limit impacts to existing site infrastructure and other SI limitations at CPP.
    - Continued NPDES permit renewals may be required, depending on the timeline of corrective action implementation relative to completion of source control activities.

5. MATERIAL QUANTITY, LABOR, AND MILEAGE ESTIMATES

Estimates of material quantities, total labor hours, and mileage were prepared for Alternative 2 source control with upgradient barrier wall and GWE trench and Alternative 3 source control with horizontal GWE well, 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 O&M of a physical remedy.

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) [15] 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 upgradient barrier wall and GWE trench and Alternative 3 source control with horizontal GWE well active remedies, daily construction and O&M labor mobilization miles were estimated assuming a weekly mobilization/demobilization from Chicago (500 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] "Illinois Administrative Code, Title 35, Subtitle G, Chapter I, Subchapter J, Part 845: Standards for The Disposal Of Coal Combustion Residuals In Surface Impoundments," effective April 21, 2021.

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[11] U.S. Fish and Wildlife Service, "National Wetlands Inventory, Surface Waters and Wetlands," [Online]. Available: https://fwsprimary.wim.usgs.gov/wetlands/apps/wetlands-mapper/.

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[13] Illinois Environmental Protection Agency, "NPDES Permit No. IL0000108," Illinois Environmental Protection Agency, Coffeen, Illinois, 2023.

[14] AECOM, "History of Construction, USEPA Final CCR Rule, 40 CFR § 257.73 (c), Coffeen Power Station, Coffeen, Illinois," 2016.

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APPENDIX A

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

FIGURE 1

ALTERNATIVE 2 REMEDY: UPGRADIENT BARRIER WALL AND GROUNDWATER EXTRACTION TRENCH

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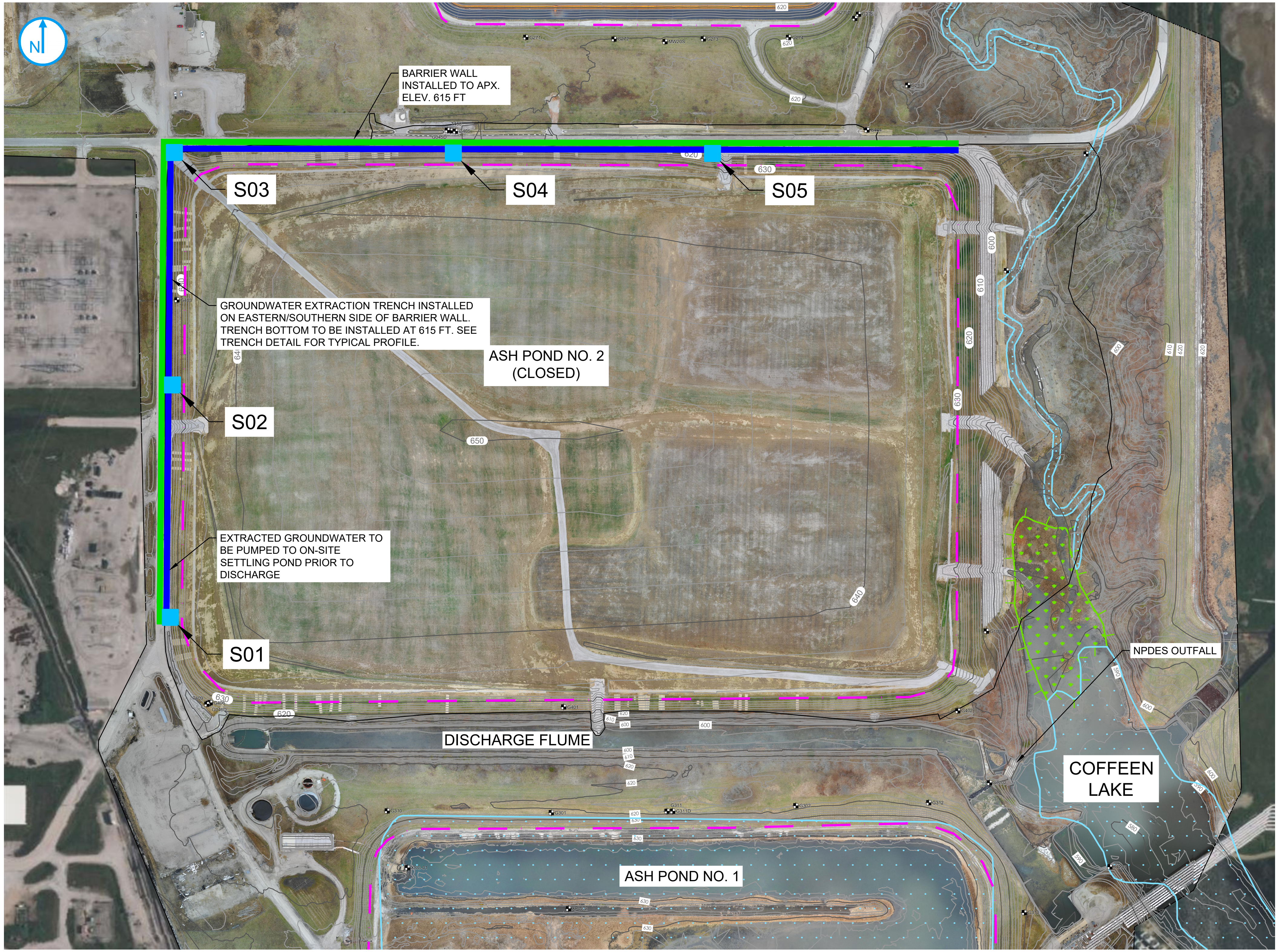
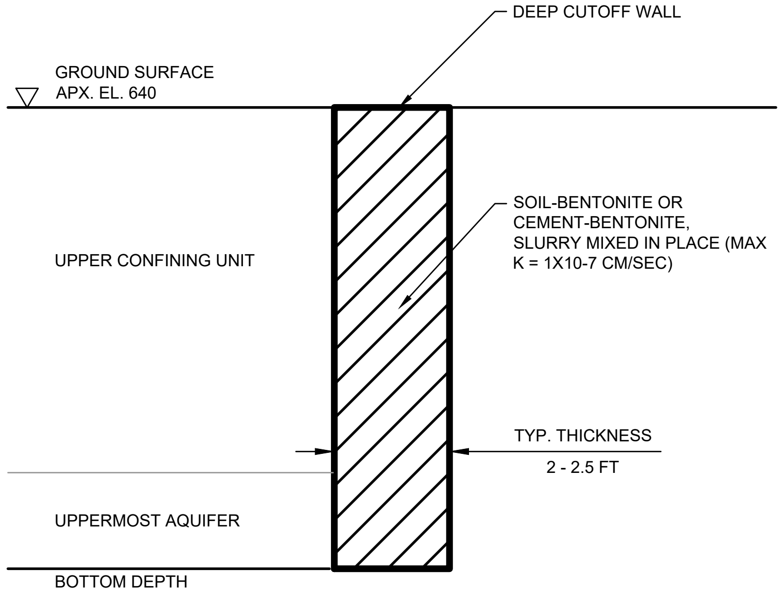
DESIGNER: LEMMONBN
DATED: 12/9/2024
PROJECT: 1940075591



SITE PLAN

0 300 Feet

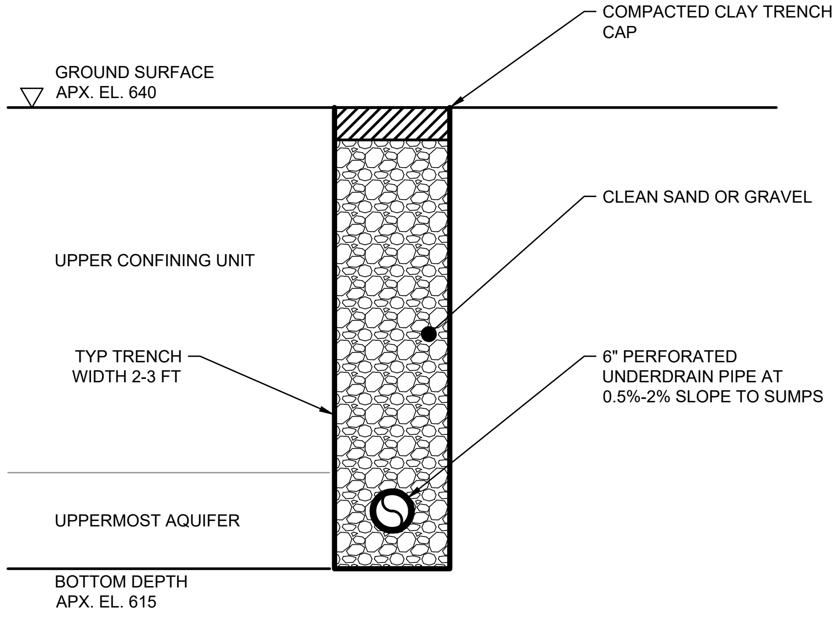
NOTE:
1. EXISTING AND POST-CLOSURE GRADING REPRESENTED PER COFFEEN POWER PLANT ASH POND NO. 2 CLOSURE AS-BUILT DRAWINGS COMPLETED BY GOLDER, NOVEMBER 2020.
2. WETLANDS REPRESENTED AS PER ILLINOIS NATIONAL WETLANDS INVENTORY.



LOWER CONFINING UNIT

BARRIER WALL DETAIL

NOT TO SCALE



LOWER CONFINING UNIT

TRENCH DETAIL

NOT TO SCALE

EXISTING		PROPOSED	
360	MAJOR CONTOUR	🟩	BARRIER WALL
358	MINOR CONTOUR	🟦	GROUNDWATER EXTRACTION TRENCH
▬ ▬	LIMITS OF CCR	■	SUMP PUMP
▨	WETLANDS BOUNDARY (SEE NOTE 2)		
▭	BODY OF WATER		

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UPGRADIENT BARRIER WALL AND GROUNDWATER EXTRACTION TRENCH

FEASABILITY-LEVEL DESIGN

ASH POND NO. 2
Coffeen Power Plant 134 CIPS Lane Coffeen, IL 62017

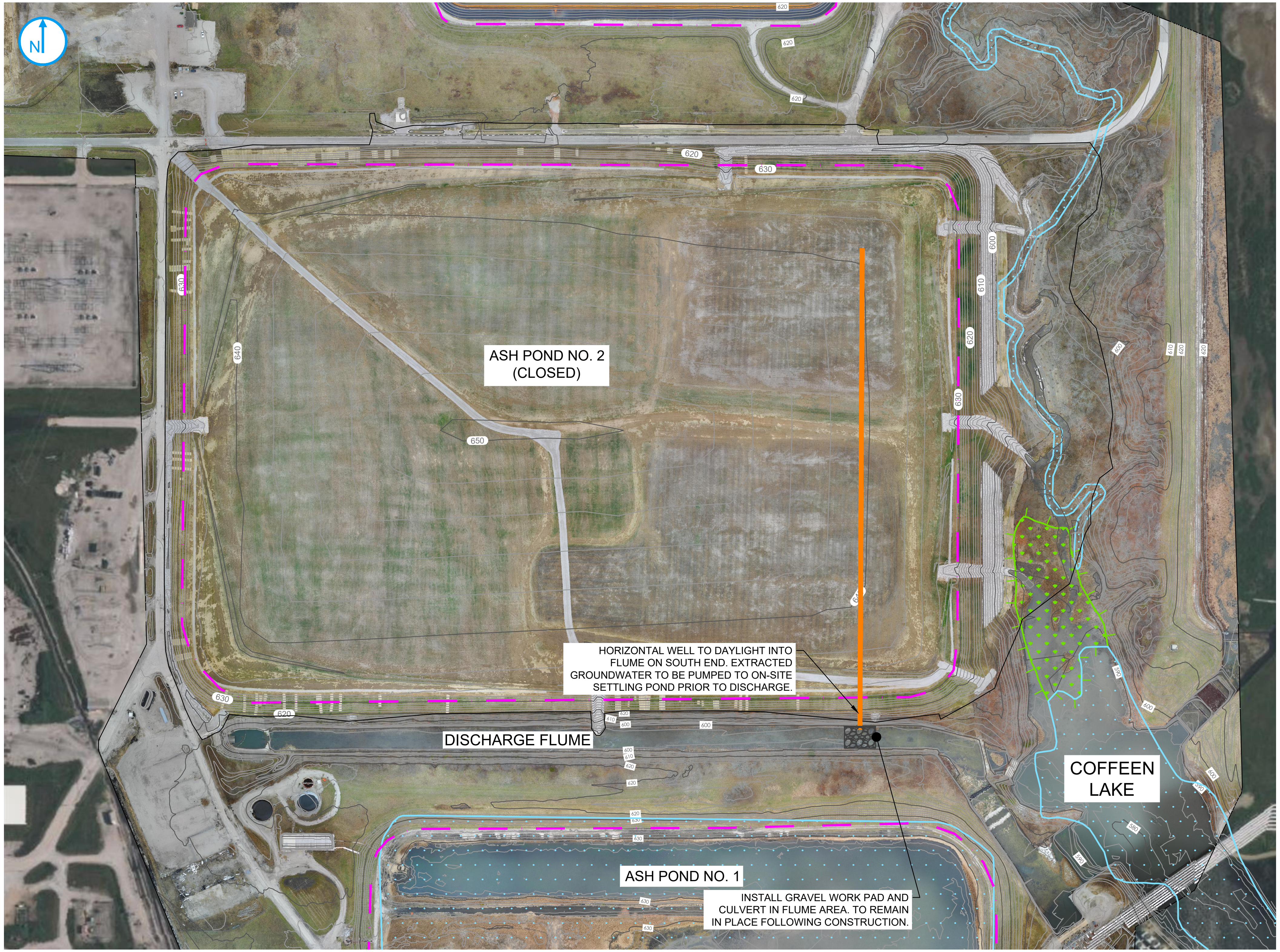
FIGURE 1

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.
A RAMBOLL COMPANY

FIGURE 2

ALTERNATIVE 3 REMEDY: HORIZONTAL GROUNDWATER EXTRACTION WELL

PROJECT: 1940075591 DATED: 12/9/2024 DESIGNER: LEMMONBK C:\DC\ACCDocs\ramboll gruppen as\rus-1940103584-002 vistra energy co\project files\4 delivery\40 WIP\401 civil\Drawings\03_CAAA-SIR\COF-AP2 CAAA-SIR.dwg

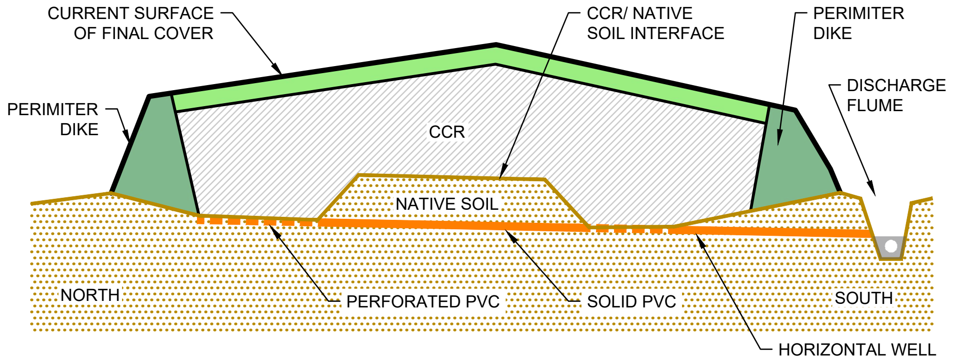


HORIZONTAL WELL TO DAYLIGHT INTO FLUME ON SOUTH END. EXTRACTED GROUNDWATER TO BE PUMPED TO ON-SITE SETTLING POND PRIOR TO DISCHARGE.

INSTALL GRAVEL WORK PAD AND CULVERT IN FLUME AREA. TO REMAIN IN PLACE FOLLOWING CONSTRUCTION.

SITE PLAN

0 300 Feet



ASH POND NO. 2
HORIZONTAL WELL CROSS SECTION

NOT TO SCALE - LOOKING EAST

NOTE:
1. EXISTING GRADING REPRESENTED PER COFFEEN POWER PLANT ASH POND NO. 2 CLOSURE AS-BUILT DRAWINGS COMPLETED BY GOLDER, NOVEMBER 2020.
2. WETLANDS REPRESENTED AS PER ILLINOIS NATIONAL WETLANDS INVENTORY.

EXISTING

360 MAJOR CONTOUR
358 MINOR CONTOUR
LIMITS OF CCR
WETLANDS BOUNDARY (SEE NOTE 2)
BODY OF WATER

PROPOSED

HORIZONTAL WELL
GRAVEL WORK PAD WITH CULVERT

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HORIZONTAL GROUNDWATER EXTRACTION WELL

FEASABILITY-LEVEL DESIGN

ASH POND NO. 2
Coffeen Power Plant 134 CIPS Lane Coffeen, IL 62017

FIGURE 2

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.
A RAMBOLL COMPANY

RAMBOLL

APPENDIX B1
GROUNDWATER MODELING TECHNICAL MEMORANDUM

Intended for

Illinois Power Generating Company
134 Cip Lane
Coffeen, Illinois 62017

Date

April 1, 2025

Project No.

1940110241-001

GROUNDWATER MODELING TECHNICAL MEMORANDUM

COFFEEN POWER PLANT, ASH POND NO. 2, IEPA ID NO. W1350150004-02

RAMBOLL Bright ideas. Sustainable change.

GROUNDWATER MODELING TECHNICAL MEMORANDUM COFFEEN POWER PLANT, ASH POND NO. 2, IEPA ID NO. W1350150004-02

Project name	**Coffeen Power Plant Ash Pond No. 2**
Project no.	**1940103584-002**
Recipient	**Illinois Power Generating Company**
Document type	**Technical Memorandum**
Revision	**DRAFT**
Date	**April 1, 2025**
Prepared by	**Jinjun Wang, PhD**
Checked by	**Katie Moran**
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CONTENTS

TABLES (ATTACHED)

TABLES (IN TEXT)

FIGURES

ACRONYMS AND ABBREVIATIONS

35 I.A.C.	Title 35 of the Illinois Administrative Code
AP1	Ash Pond No. 1
AP2	Ash Pond No. 2
CAAA	Corrective Action Alternatives Analysis
CAP	Corrective Action Plan
CCR	coal combustion residual(s)
CIP	closure-in-place
CPP	Coffeen Power Plant
ft	foot/feet
gpm	gallons per minute
GMF GSP	Gypsum Management Facility Gypsum Stack Pond
GMF RP	Gypsum Management Facility Recycle Pond
Golder	Golder Associates USA, Inc.
GWE	groundwater extraction
GWPS	groundwater protection standard(s)
ID	identification
IEPA	Illinois Environmental Protection Agency
LCU	lower confining unit
mg/L	milligrams per liter
NAVD88	North American Vertical Datum of 1988
NID	National Inventory of Dams
No.	number
NRT	Natural Resource Technology, Inc.
Ramboll	Ramboll Americas Engineering Solutions, Inc.
SI	surface impoundment
UA	uppermost aquifer
UCU	upper confining unit

EXECUTIVE SUMMARY

Ramboll Americas Engineering Solutions, Inc. (Ramboll) has prepared this Groundwater Modeling Technical Memorandum on behalf of the Coffeen Power Plant (CPP), operated by Illinois Power Generating Company, in accordance with requirements of Title 35 of the Illinois Administrative Code (35 I.A.C.) § 845. This document presents the results of predictive groundwater modeling simulations in support of potential Corrective Action Plan (CAP) remedial alternatives identified in the Corrective Action Alternatives Analysis (CAAA) required by 35 I.A.C. § 845,670(e), for Ash Pond No. 2 (AP2) in Coffeen, Illinois, identified by Illinois Environmental Protection Agency (IEPA) identification (ID) number (No.) W1350150004-02 and National Inventory of Dams (NID) No. 50723. A total of three potential remedial alternatives were evaluated, including (1) Alternative 1 remedy: source control with groundwater polishing, (2) Alternative 2 remedy: source control with upgradient barrier wall and groundwater extraction (GWE) trench, and (3) Alternative 3 remedy: source control with horizontal groundwater extraction (GWE) well. Alternative 1 remedy is the closure-in-place (CIP) scenario that was modeled in the Groundwater Modeling Report (Natural Resource Technology, Inc. [NRT], 2017), and was implemented at AP2 in 2020 (Luminant, 2020). Alternative 2 and Alternative 3 remedies were assumed to be implemented in addition to the CIP scenario.

The groundwater modeling efforts described in this Groundwater Modeling Technical Memorandum include groundwater flow modeling using MODFLOW-NWT (Niswonger et al., 2011) and contaminant fate and transport modeling using MT3DMS (Zheng and Wang, 1999) to evaluate how each corrective action will achieve compliance with the applicable groundwater protection standards (GWPSs); and describe fate and transport of contaminants in accordance with 35 I.A.C. § 845.220 (c)(2). The effectiveness of each corrective action was assessed based on the time for simulated sulfate concentrations to decrease below GWPS in twelve groundwater monitoring wells[1] in the vicinity of AP2 (**Figure 1**). Considering the potential need to coordinate groundwater corrective action at AP2 with groundwater corrective actions at adjacent coal combustion residual (CCR) surface impoundment (SI) units, including Ash Pond No. 1 (AP1), Gypsum Management Facility Gypsum Stack Pond (GMF GSP), and Gypsum Management Facility Recycle Pond (GMF RP), corrective action construction for AP2 was assumed to be implemented upon the completion of the closures of the adjacent CCR SI units, as the corrective actions at these SI units are anticipated to occur concurrently with their closures. All timeframes are assumed to start concurrent with final closures of AP1, GMF GSP, and GMF RP.

The Alternative 1 remedy includes a closure in place approach for source control, after which groundwater polishing is implemented. The closure was re-simulated using sulfate as the surrogate for any CCR impacts in groundwater to be consistent with the modeling of AP1 closure, which is an adjacent CCR SI that will be closed in the future via a 35 I.A.C. § 845 closure plan. Using sulfate for both units allows the models to incorporate the potential impact of AP1 closure on fate and transport at AP2. According to the simulation results, sulfate concentrations in all monitoring wells will decrease below the 400 milligrams per liter (mg/L) GWPS for sulfate in 135 years under Alternative 1 remedy.

---

[1] There are 12 groundwater monitoring wells associated with AP2 available for evaluation. Simulated concentrations at G1003 are not presented since this well is typically dry and no groundwater samples have been obtained from this location.

The Alternative 2 remedy consists of source control with installation and operation of upgradient barrier wall and GWE trench. Groundwater modeling results for the remedy indicate that sulfate concentrations in all the groundwater monitoring wells will decrease below the applicable GWPS of 400 mg/L in 59 years. No operation of the GWE trench is required after that, as no rebounding of sulfate concentrations is expected according to the simulation results.

The Alternative 3 remedy consists of source control with installation of a horizontal GWE well at the interface of CCR and underlying soil in the eastern portion of AP2. Groundwater modeling results indicate that sulfate concentrations in AP2's groundwater monitoring wells would achieve the GWPS of 400 mg/L within 14 years. The simulation results also indicate that operating the horizontal well for 39 years (*i.e.*, 25 additional years after attaining the GWPS) may be necessary to effectively prevent the sulfate concentrations from rebounding above GWPS.

1. INTRODUCTION

1.1 Background

This Groundwater Modeling Technical Memorandum is prepared to evaluate how potential CAP remedial alternatives would achieve compliance with the applicable GWPSs and to describe fate and transport of contaminants in accordance with 35 I.A.C. § 845.220 (c)(2). The groundwater modeling efforts consist of predictive groundwater modeling to assess the long-term effectiveness and time to achieve GWPS for sulfate for the following remedial alternatives: (1) Alternative 1 remedy: source control with groundwater polishing; (2) Alternative 2 remedy: source control with upgradient barrier wall and GWE trench; and (3) Alternative 3 remedy: source control with horizontal GWE well. Alternative 1 remedy is the CIP scenario that was modeled in the Groundwater Modeling Report (NRT, 2017), and was implemented at AP2 in 2020 (Luminant, 2020). Alternative 2 and Alternative 3 remedies were assumed to be implemented in addition to the Alternative 1 CIP scenario.

1.2 Previous Groundwater Modeling Reports

NRT developed groundwater flow and transport models for AP2 in 2017 to evaluate AP2 closure scenarios. The groundwater flow model was built using MODFLOW-2005 (Harbaugh, 2005), and the contaminant fate and transport model was built using MT3DMS. The modeling exercises and results were summarized in the Groundwater Modeling Report (NRT, 2017).

Based upon the NRT (2017) models for AP2, Ramboll developed groundwater flow and transport models in 2022 to evaluate closure scenarios for the adjacent CCR SI unit AP1, and the footprint of AP2 falls within the model domain of the AP1 model. The modeling results were summarized in the Groundwater Modeling Report (Ramboll, 2022).

The groundwater modeling efforts presented in this Groundwater Modeling Technical Memorandum are based on the NRT (2017) and Ramboll (2022) groundwater modeling exercises, as detailed in **Section 2**.

2. ALTERNATIVE 1 SIMULATION

The CIP closure of AP2 (*i.e.*, Alternative 1 remedy) was originally simulated as documented in the Groundwater Modeling Report (NRT, 2017). The AP2 closure was implemented in 2020, consisting of a CIP approach for source control with groundwater polishing. In this Groundwater Modeling Technical Memorandum, the CIP closure of AP2 was re-simulated to incorporate the potential influence of closure activities at the adjacent CCR SI units AP1, GMF GSP, and GMF RP, which will also be closed in the future (Golder Associates USA, Inc. [Golder], 2022a,2022b, and 2022c). The updated simulation of CIP closure at AP2 served as the baseline scenario for the additional CAP scenario simulations presented in **Section 3**.

Considering the potential need to coordinate groundwater corrective action at AP2 with groundwater corrective action and closure construction activities at adjacent SI units (*i.e.,* AP1, GMF GSP, and GMF RP), corrective action construction for AP2 was assumed to be implemented upon the completion of closures of adjacent SI units, as AP2 corrective action construction would also occur concurrently with closures of these SI units. Therefore, all timeframes are assumed to start concurrent with final closures of AP1, GMF GSP, and GMF RP.

2.1 NRT (2017) Model Description

The NRT (2017) groundwater modeling simulated groundwater flow and transport of boron to support closure of AP2. The groundwater modeling consisted of the following:

- A steady state groundwater flow was developed using MODFLOW-2005 to represent site conditions for 2016.
- The hydrogeologic properties from the steady state model were used in the calibration of transient MODFLOW-2005 and MT3DMS models which simulated groundwater flow and transport at AP2 from 1970 to 2017. Boron concentrations collected in August 2016 were used to calibrate the transport model.
- Predictive simulations were conducted to evaluate the CIP scenario at AP2.

2.2 Ramboll (2022) Model Description

The NRT (2017) flow and transport models were retained and revised as appropriate to evaluate closure scenarios for AP1 (Ramboll, 2022) and consisted of the following:

- A steady state groundwater flow model was constructed using MODFLOW-2005 and calibrated to match mean groundwater elevations observed between 2015 to 2021. The calibrated flow model was used to simulate the mean groundwater flow conditions at the site.
- Transient flow and transport models were constructed based off of the calibrated steady state model using MODFLOW-2005 and MT3DMS, respectively. These models simulate groundwater flow and transport for 42 years with changes in site conditions through time and match observed sulfate concentrations in groundwater.
- Prediction simulations began with a 2-year dewatering period for AP1 where heads were reduced within the CCR unit and concentrations were removed from CCR removal areas.
- Prediction simulations resumed for CIP following the 2-year dewatering period.

2.3 Groundwater Model Update

The updated simulation of CIP closure at AP2 was based on the Ramboll (2022) models so that the potential influence of the closure activities at adjacent SI units could be incorporated. For the contaminant fate and transport simulation, sulfate was selected as the constituent to evaluate the effectiveness of the closure scenario. Of the analytes which exceed GWPS in site groundwater, sulfate has been detected in AP2 groundwater at the highest concentrations relative to its GWPS and it will likely take the longest time to meet the GWPS. Sulfate has also been detected above the GWPS at more well locations adjacent to AP1 and AP2 than any other 845.600 parameter which contributed to its selection for modeling at both units. It is not necessary to model all constituents that have GWPS exceedances[2] or have been detected at lower concentrations relative to their GWPSs, because those constituents will likely achieve their GWPSs more quickly (Gradient, 2024).

For the purpose of evaluating the potential groundwater remedial alternatives, the groundwater flow modeling program associated with the prediction simulations, including the 2-year dewatering simulation and the 1,000-year CIP simulation, was updated from MODFLOW-2005 to MODFLOW-NWT. MODFLOW-NWT is a modeling program designed to solve nonlinear groundwater flow problems due to unconfined aquifer conditions and is superior in solving problems involving drying and rewetting of unconfined aquifers (Niswonger et al., 2011), which were expected for the selected remedial alternatives. In addition, the layer types associated with model Layers 2 through 4 in the prediction models were updated from "confined" to "unconfined (T Varies)" to accommodate the drying and rewetting conditions. MT3DMS remained as the fate and transport modeling program.

A stream gauge was installed within the discharge flume, located to the south of AP2 and formerly utilized as part of the CPP to route plant process water towards Coffeen Lake, to monitor the surface water elevation in the flume. Historical surface water elevations collected at the stream gauge are summarized in **Table 1**. As shown in the table, the surface water elevation varied from 598.34 ft[3] to 599.36 ft between March 2021 and July 2024, with an average of 598.67 ft. Accordingly, in the 1,000-year CIP prediction model, the discharge flume was simulated as a drain, with a drain stage set to 598.7 ft to represent the average surface water elevation within the flume.

In addition, the drain boundaries simulating the GMF GSP and GMF RP in the 1,000-year CIP prediction model were updated to reflect the final closure design associated with these two SI units (Golder, 2022b and 2022c).

The updated simulation results for Alternative 1 remedy are discussed in **Section 2.4**. The simulated groundwater elevations and sulfate concentrations at the end of the 2-year AP1 dewatering period also served as the initial conditions for the following remedial alternative simulations[4] described in **Section 3**.

---

[2] Throughout this document, "exceedance" or "exceedances" is intended to refer only to potential exceedances of proposed applicable background statistics or GWPSs as described in the proposed groundwater monitoring program, which was submitted to the IEPA on October 25, 2021 as part of IPGC's operating permit application for COF AP2. That operating permit application, including the proposed groundwater monitoring program, remains under review by the IEPA and, therefore, IPGC has not identified any actual exceedances.

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

[4] The remedial alternative simulations assume the remedial alternatives at AP2 will be implemented following the 2-year dewatering at AP1.

2.4 Simulation Results of Updated Model

The simulated sulfate concentrations for the Alternative 1 remedy: source control with groundwater polishing in AP2's groundwater monitoring wells versus time are shown in **Figure 2**. The simulated time to achieve sulfate GWPS in the monitoring wells is summarized in **Table 2**. With the exception of G1001, sulfate concentrations are expected to achieve the GWPS within approximately 25 years. As shown in **Figure 2**, the simulated sulfate concentration in monitoring well G1001 decreases below the 400 mg/L GWPS after about 70 years, increases above the GWPS around 123 years, and eventually decreases and remains below the GWPS after 135 years until the end of the 1,000-year simulation.

Review of the simulation results also indicates the updated groundwater model is likely to overpredict the amount of time to attain the GWPS at monitoring well G1001. As presented in the Nature and Extent Report (Ramboll, 2024a), monitoring wells G1001 and G1003 were installed in 2021 between the eastern edge of AP2 and the Unnamed Tributary. The borings did not identify the presence of either the upper confining unit or uppermost aquifer materials, indicating that the uppermost aquifer is absent east of AP2. Wells G1001 and G1003 were screened in the LCU to evaluate shallow groundwater quality east of AP2. Only G1001 contains measurable amounts of groundwater that can be collected and analyzed; G1003 is routinely dry. As of December of 2024, eight groundwater samples have been collected from G1001 with total sulfate concentrations ranging from 107 mg/L to 630 mg/L with an average concentration of 249 mg/L. The simulated sulfate concentration at G1001 at the beginning of prediction simulation is approximately 1,600 mg/L, which is consistent with the source concentrations used for AP2 in the 2022 model (Ramboll, 2022) present just west of G1001. The simulated concentration at the beginning of the prediction simulation is approximately 2.5 times higher than maximum observed concentration at G1001. Further, total sulfate has not been reported as an exceedance of the GWPS at well G1001 (Ramboll, 2024b and 2025a). Therefore, model simulated time to reach the GWPS at well G1001 is likely to be overpredicted.

3. ALTERNATIVE 2 AND ALTERNATIVE 3 SIMULATIONS

The Alternative 2 and Alternative 3 remedies were simulated to evaluate their impacts, in addition to the Alternative 1 remedy, on sulfate concentrations at Coffeen AP2. Alternative 1 remedy simulation described in **Section 2** provides a baseline scenario for comparison to the two alternative remedies. As discussed in **Section 2**, all timeframes described herein are assumed to start concurrent with closure of the adjacent SI units (*i.e.,* AP1, GMF GSP, and GMF RP).

3.1 Alternative 2 Remedy – Source Control with Upgradient Barrier Wall and GWE Trench

3.1.1 Overview

The Alternative 2 remedy consists of the installation and operation of a GWE trench and barrier wall upgradient of AP2 (**Figure 3**). The barrier wall is assumed to be installed to 616 feet in the simulation. The extraction trench is proposed to be installed between the barrier wall and AP2 to an elevation of 615 feet. According to the simulated groundwater flow pattern for the CIP, the groundwater flow direction within AP2 is to the southeast in general. The goal of Alternative 2 remedy is to prevent the flow of groundwater towards AP2 from the northwest, while providing a means to capture groundwater and reduce hydraulic head beneath AP2. Increasing the rate at which groundwater elevations decrease beneath AP2 also more rapidly decreases the amount of CCR that may come into contact with groundwater, thereby reducing the amount of sulfate potentially released to groundwater and accelerating attainment of GWPS.

3.1.2 Model Approach

The 1,000-year CIP prediction model described in **Section 2** was modified to simulate the Alternative 2 remedy. The proposed barrier wall was simulated as a horizontal flow barrier (Hsieh and Freckleton, 1993) installed within the Upper Confining Unit (UCU) in model Layer 1. The barrier wall was assumed to be 3-foot thick and constructed of cement-bentonite with a permeability of 2.8×10^{-4} ft/day. The GWE trench was simulated as a drain with stage set to 615 feet. The drain was included in model Layer 2, which simulates the lower portion of UCU at the site. The GWE trench was assumed to be 3-foot thick, and the backfill material for the trench was assumed to be sand with a hydraulic conductivity of 62.4 ft/day. Therefore, the hydraulic conductivities in model cells within and above the drain were adjusted to 10 ft/day, both vertically and horizontally, to match the permeability of fill material in the extraction trench.

3.1.3 Simulation Results

The simulated sulfate concentrations in AP2's groundwater monitoring wells versus time for Alternative 2 remedy are shown in **Figure 4**. The simulated time to attain the sulfate GWPS in the monitoring wells is summarized in **Table 2**. According to the results, monitoring well G1001 is the last to attain GWPS compliance, in 59 years under the Alternative 2 remedy followed by well G404 which attains the GWPS at 20 years. As discussed in **Section 2.4**, the model likely overpredicts the time to attain the GWPS at well G1001. According to the simulation results, operation of the GWE trench can be terminated after 59 years, after which no rebounding of sulfate concentrations is expected to occur.

The simulated extraction rate from the GWE trench versus time is plotted in **Figure 5**. As shown in the figure, the extraction rate is higher at the beginning of the operation (about 50 gallons per minute [gpm] on day 24 of the operation) due to the higher initial groundwater elevations near the trench. The groundwater levels near the GWE trench and the extraction rate decrease over time with continued trench operation. The extraction rate decreases to about 2 gpm at the end of the 59-year operation.

3.2 Alternative 3 Remedy – Source Control with Horizontal GWE Well

3.2.1 Overview

The Alternative 3 remedy consists of groundwater removal through a horizontal well (**Figure 6**). The proposed horizontal GWE well will be installed penetrating the estimated bottom of CCR (about 602 feet) located within the historical drainage features. Groundwater removal through the horizontal GWE well will collect CCR-impacted groundwater and thereby reduce the sulfate mass potentially released to groundwater. Groundwater removal from the horizontal well will also induce groundwater flow towards the slotted portions of the well and capture the CCR-impacted groundwater plume in their vicinity.

3.2.2 Model Approach

The 1,000-year CIP prediction model described in **Section 2** was updated to simulate the groundwater removal from the horizontal well. The updated model incorporated one horizontal well as shown in **Figure 6**, with its perforated portions simulated as drains located at the bottom of the UA in model Layer 3, with drain stages set to 602. feet.

3.2.3 Simulation Results

Simulation of Alternative 3 remedy assumed operation of the horizontal well for 39 years. The simulated sulfate concentrations in AP2’s groundwater monitoring wells versus time for Alternative 3 remedy are shown in **Figure 7**. The simulated time to achieve sulfate GWPS in the monitoring wells is summarized in **Table 2**. As shown, monitoring wells G1001 (screened within the LCU) and G404 are the last monitoring wells to achieve GWPS compliance. Under Alternative 3 remedy, the time for sulfate concentration in wells G1001 and G404 to decrease below the GWPS is 14 years. The simulation results also indicate that operating the horizontal well for 39 years will effectively prevent the sulfate concentrations from rebounding above GWPS.

As discussed in **Section 2.4**, the model likely overpredicts the sulfate concentrations at well G1001. Groundwater sampling results indicate there are no current exceedances at this well (Ramboll, 2024b and 2025a); therefore, the model result is very conservative. If sulfate concentration at G1001 continues to remain below the GWPS then this period of additional operation may not be necessary. Monitoring and adaptive site management practices presented in the Corrective Action Groundwater Monitoring Plan (Ramboll, 2025b) describe how stability in groundwater data will be evaluated before assessing if compliance with the GWPS has been attained to allow any transient effects of treatment on the groundwater (e.g., rebounding concentrations) to dissipate.

The simulated groundwater removal rate from the horizontal GWE well versus time is plotted on **Figure 8**. As shown in the figure, the discharge rate is higher at the beginning of the operation (about 30 gpm on day 10 of the operation). Groundwater elevations in AP2 decrease over time due to the operation of the horizontal well, and the discharge rate from the horizontal well decreases gradually to approximately 2 gpm towards the end of the 39-year operation.

4. CONCLUSIONS

The groundwater modeling efforts in this Groundwater Modeling Technical Memorandum consist of flow and transport modeling using MODFLOW-NWT and MT3DMS to assess the time to achieve GWPS for sulfate for three CAP remedy alternatives: Alternative 1 remedy (source control with groundwater polishing), Alternative 2 remedy (source control with upgradient barrier wall and GWE trench), and Alternative 3 remedy (source control with horizontal GWE well).

A summary of predicted time for sulfate concentrations to meet the GWPS at the compliance monitoring wells is provided in **Table 2**. Percentage of compliance monitoring wells predicted to attain GWPS over time is summarized below in **Table A**. According to the simulation results, under both Alternative 1 remedy and Alternative 2 remedy options, monitoring well G1001 (screened within the LCU) is the last monitoring location to achieve GWPS compliance. For Alternative 1 remedy, the time to achieve GWPS compliance is 135 years. For Alternative 2 remedy, the time to achieve GWPS compliance is 59 years. Operation of the GWE trench can be terminated once the GWPS compliance is achieved. Under Alternative 3 remedy, the time to attain the GWPS in compliance wells is 14 years, driven by sulfate concentrations in monitoring wells G1001 and G404. Operating the horizontal well for 39 years may be necessary to mitigate the potential for sulfate concentrations from rebounding above GWPS after remedy operations have ceased.

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

Alternative	Impacted Wells	Percentage of Wells Predicted to Attain GWPS†						
		5 Years‡	10 Years‡	14 Years‡	20 Years‡	40 Years‡	59 Years‡	135 Years‡
1	5	40%	60%	60%	60%	80%	80%	100%
2	4	50%	50%	50%	50%	75%	100%	100%
3	5	40%	60%	100%	100%	100%	100%	100%

†: Estimated timeframes per the number of impacted wells (wells with estimated times to achieve the GWPS) shown in Table 2

‡: Years counted starting from completion of corrective action

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TABLES

TABLE 1. SUMMARY OF SURFACE WATER ELEVATIONS IN DISCHARGE FLUME

GROUNDWATER MODELING TECHNICAL MEMORANDUM
COFFEEN POWER PLANT
ASH POND NO. 2
COFFEEN, ILLINOIS

Date	Surface Water Elevation[1] (ft amsl)
03/29/2021	598.75
04/20/2021	598.56
05/03/2021	598.74
05/17/2021	598.56
06/09/2021	598.37
06/23/2021	598.34
07/12/2021	598.75
07/26/2021	598.44
08/16/2021	598.39
10/25/2021	598.59
02/07/2022	598.52
05/09/2022	598.52
08/23/2022	598.42
02/13/2023	598.62
05/30/2023	598.40
10/24/2023	598.38
11/13/2023	598.51
12/18/2023	598.56
01/12/2024	599.17
02/12/2024	598.82
03/29/2024	599.00
04/29/2024	599.36
05/29/2024	599.18
06/29/2024	598.84
07/30/2024	598.91
Minimum	598.34
Maximum	599.36
Average	598.67

1. All surface water elevations are referenced to North American Vertical Datum of 1988 (NAVD88).

TABLE 2. SIMULATED TIME TO ACHIEVE SULFATE GWPS IN AP2 MONITORING WELLS

GROUNDWATER MODELING TECHNICAL MEMORANDUM
COFFEEN POWER PLANT
ASH POND NO. 2
COFFEEN, ILLINOIS

Monitoring Well	**Time to Achieve GWPS* in Monitoring Well (Year)**		
	Alternative 1 Remedy (Source Control with Groundwater Polishing)	**Alternative 2 Remedy (Source Control with Upgradient Barrier Wall and Groundwater Extraction Trench)**	**Alternative 3 Remedy (Source Control with Horizontal Groundwater Extraction Well)**
G1001	135	59	14
G1003**	-	-	-
G270	0	0	0
G280	0	0	0
G281	0	0	0
G401	3	2	2
G402	1	1	1
G403	0	0	0
G404	25	20	14
G405	8	0	8
G406	0	0	0
G407	0	0	0
Minimum	0	0	0
Maximum	135	59	14
Average	16	7	3

* GWPS - groundwater protection standard
** Simulation results at G1003 are not presented since the well is typically dry.

FIGURES

C:\Projects\Coffeen\GIS\COFFEEN_TechMemo_202402.aprx\AP2_Figure01_SiteMap

PROJECT: 1940103584-002 | DATED: 3/17/2024 | DESIGNER: JWANG

Service Layer Credits: World Imagery: State of Missouri, Maxar

- UA Monitoring Well
- LCU (Vandalia Member) Monitoring Well
- SI Unit

0 250 500 Feet

MONITORING WELL LOCATION MAP

FIGURE 1

RAMBOLL AMERICAS
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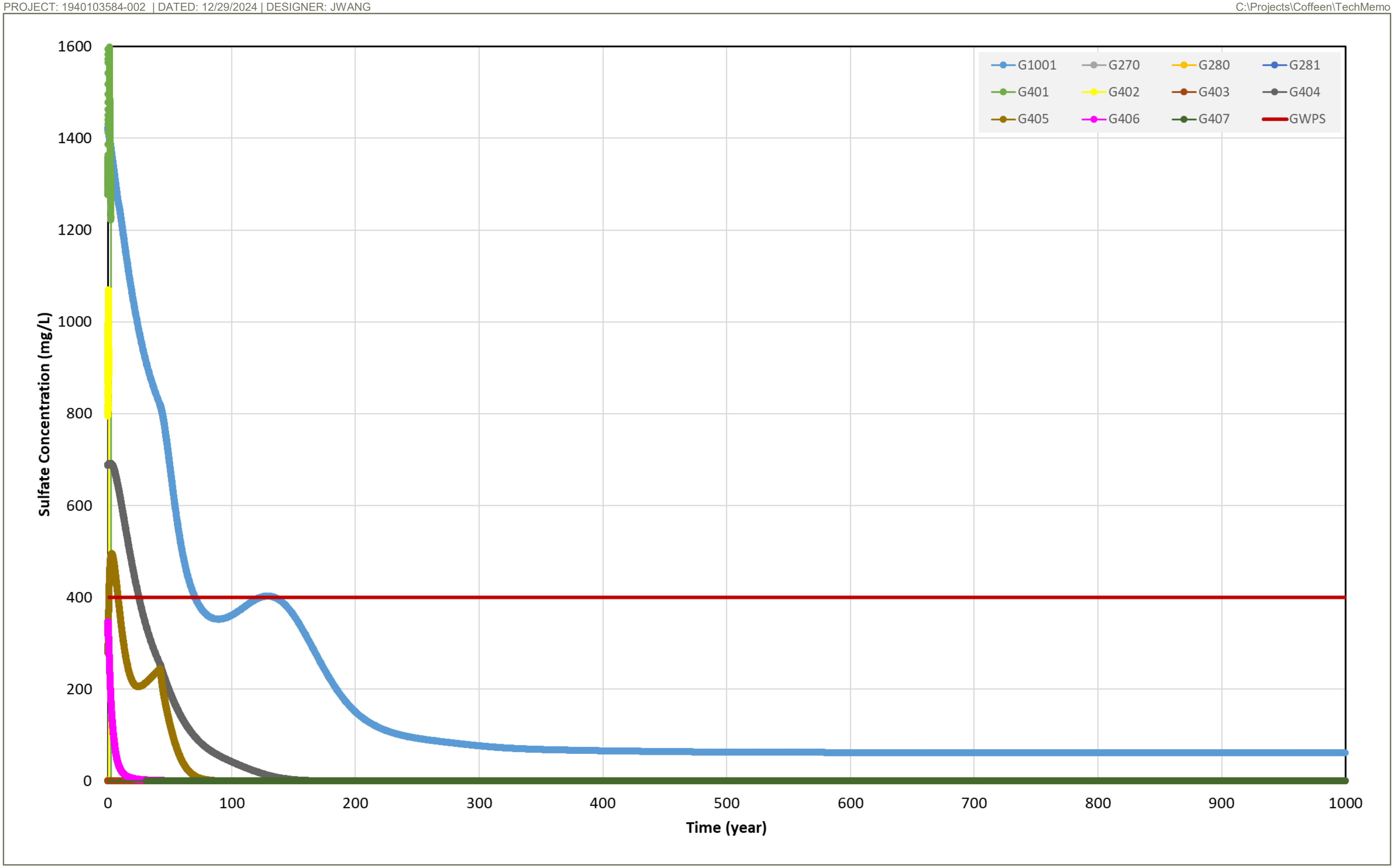
ASH POND NO. 2
COFFEEN POWER PLANT
COFFEEN, ILLINOIS

RAMBOLL



SIMULATED SULFATE CONCENTRATIONS IN AP2 MONITORING WELLS - ALTERNATIVE 1 REMEDY

FIGURE 2

ASH POND NO. 2
COFFEEN POWER PLANT
COFFEEN, ILLINOIS

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.
A RAMBOLL COMPANY

PROJECT: 1940103584-002 | DATED: 1/5/2025 | DESIGNER: JWANG

C:\Projects\Coffeen\GIS\COFFEEN_TechMemo_202402.aprx\AP2_Figure03_ProposedLocOfExtractionTrenchAndBarrier

Service Layer Credits: World Imagery: Maxar

⊕ UA Monitoring Well

⊕ LCU (Vandalia Member) Monitoring Well

▭ SI Unit

🟧 Proposed Extraction Trench Location

━ Proposed Barrier Wall Location

0 300 600 Feet

PROPOSED UPGRADIENT BARRIER WALL AND GROUNDWATER EXTRACTION TRENCH LOCATION - ALTERNATIVE 2 REMEDY

ASH POND NO. 2

COFFEEN POWER PLANT
COFFEEN, ILLINOIS

FIGURE 3

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.
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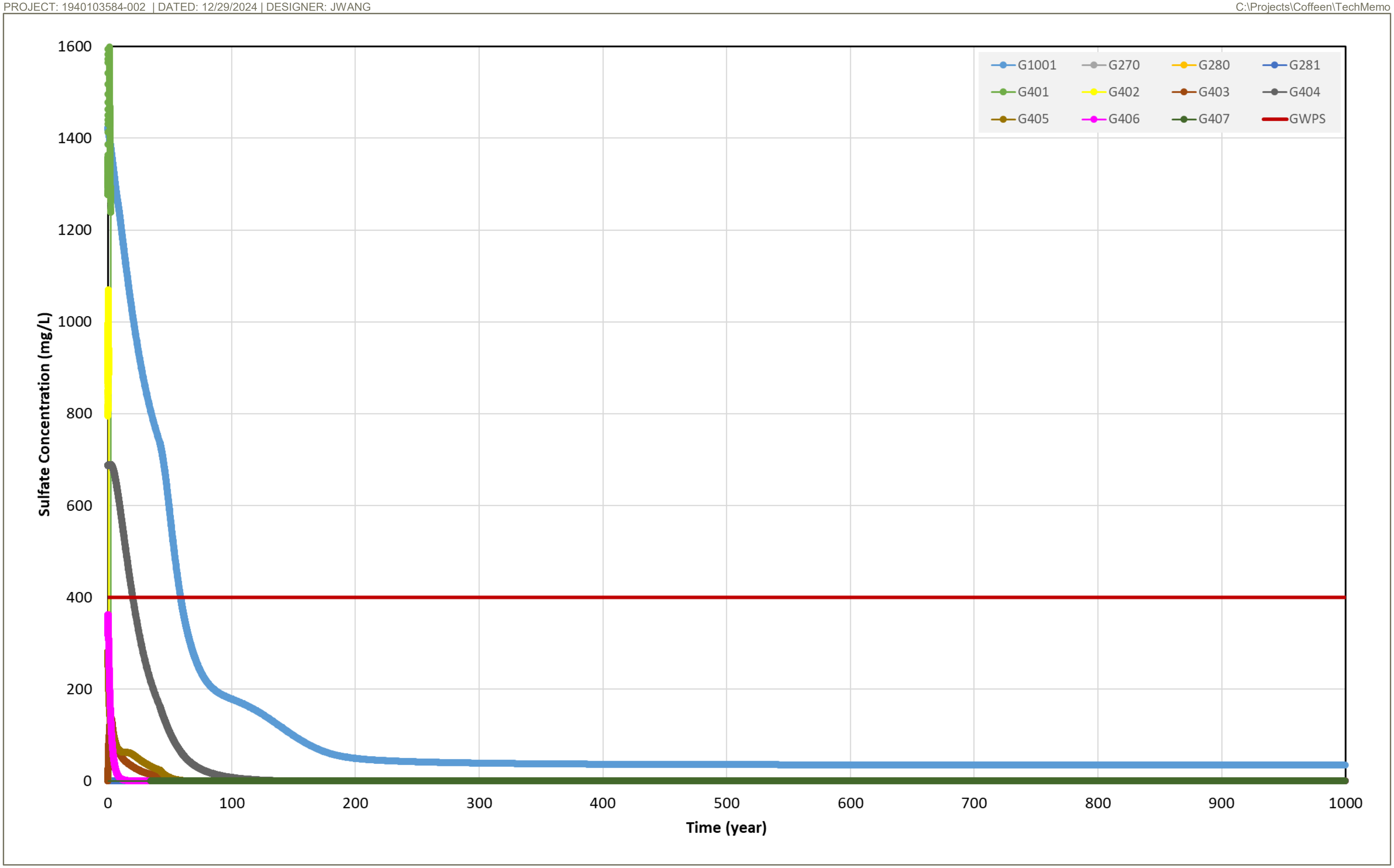

SIMULATED SULFATE CONCENTRATIONS IN AP2 MONITORING WELLS - ALTERNATIVE 2 REMEDY

FIGURE 4

ASH POND NO. 2
COFFEEN POWER PLANT
COFFEEN, ILLINOIS

RAMBOLL AMERICAS
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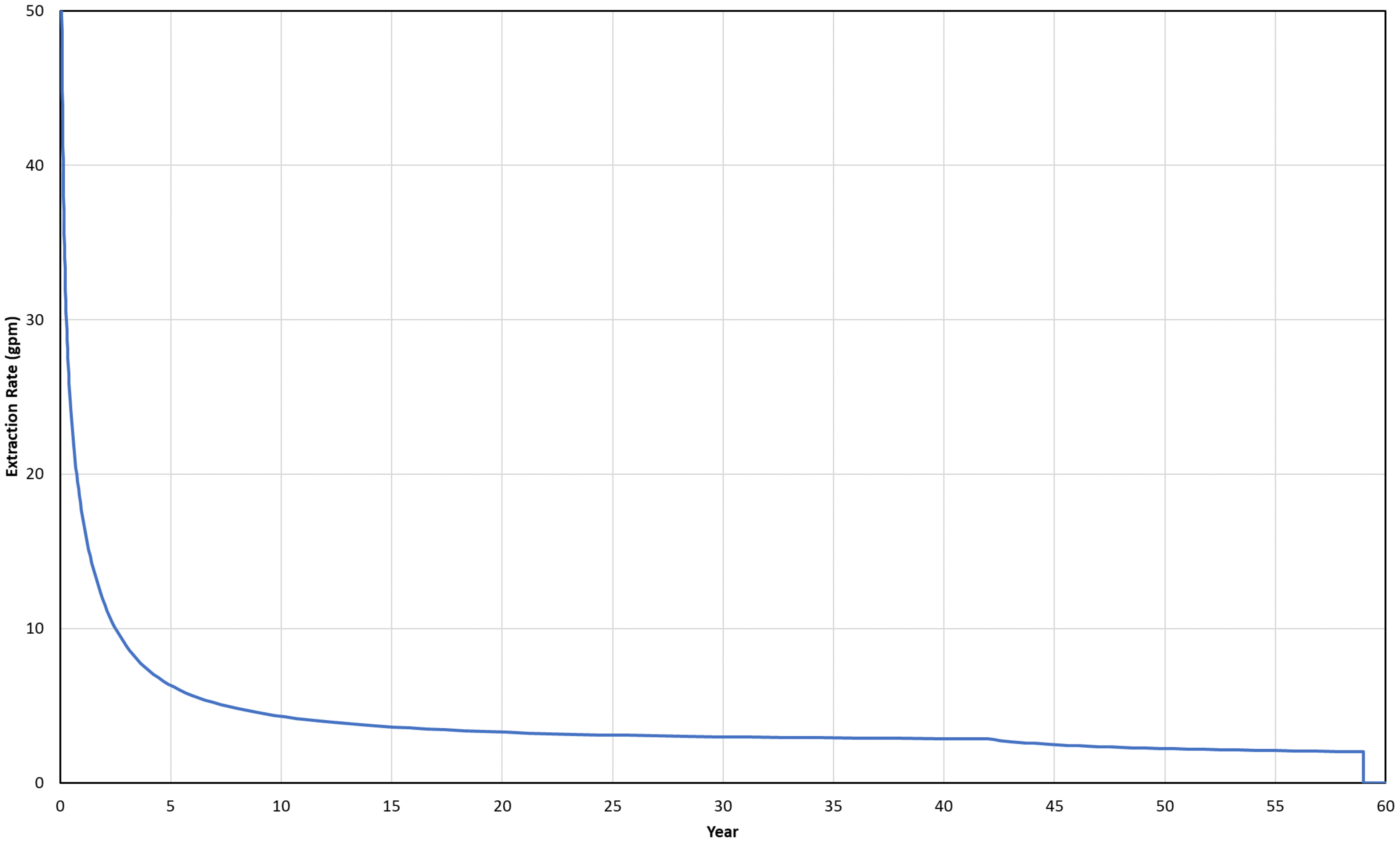

SIMULATED EXTRACTION RATE FROM THE EXTRACTION TRENCH - ALTERNATIVE 2 REMEDY

ASH POND NO. 2
COFFEEN POWER PLANT
COFFEEN, ILLINOIS

FIGURE 5

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.
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PROJECT: 1940103584-002 | DATED: 1/5/2025 | DESIGNER: JWANG

C:\Projects\Coffeen\GIS\COFFEEN_TechMemo_202402.aprx\AP2_Figure06_ProposedDewateringAreaOfCFandHW

Service Layer Credits: World Imagery: Maxar

⊕ UA Monitoring Well
⊕ LCU (Vandalia Member) Monitoring Well
▭ SI Unit
- - Horizontal Well (Perforated)
— Horizontal Well (Non-Perforated)

0 300 600 Feet

PROPOSED HORIZONTAL GROUNDWATER EXTRACTION WELL LOCATION - ALTERNATIVE 3 REMEDY

ASH POND NO. 2

COFFEEN POWER PLANT
COFFEEN, ILLINOIS

FIGURE 6

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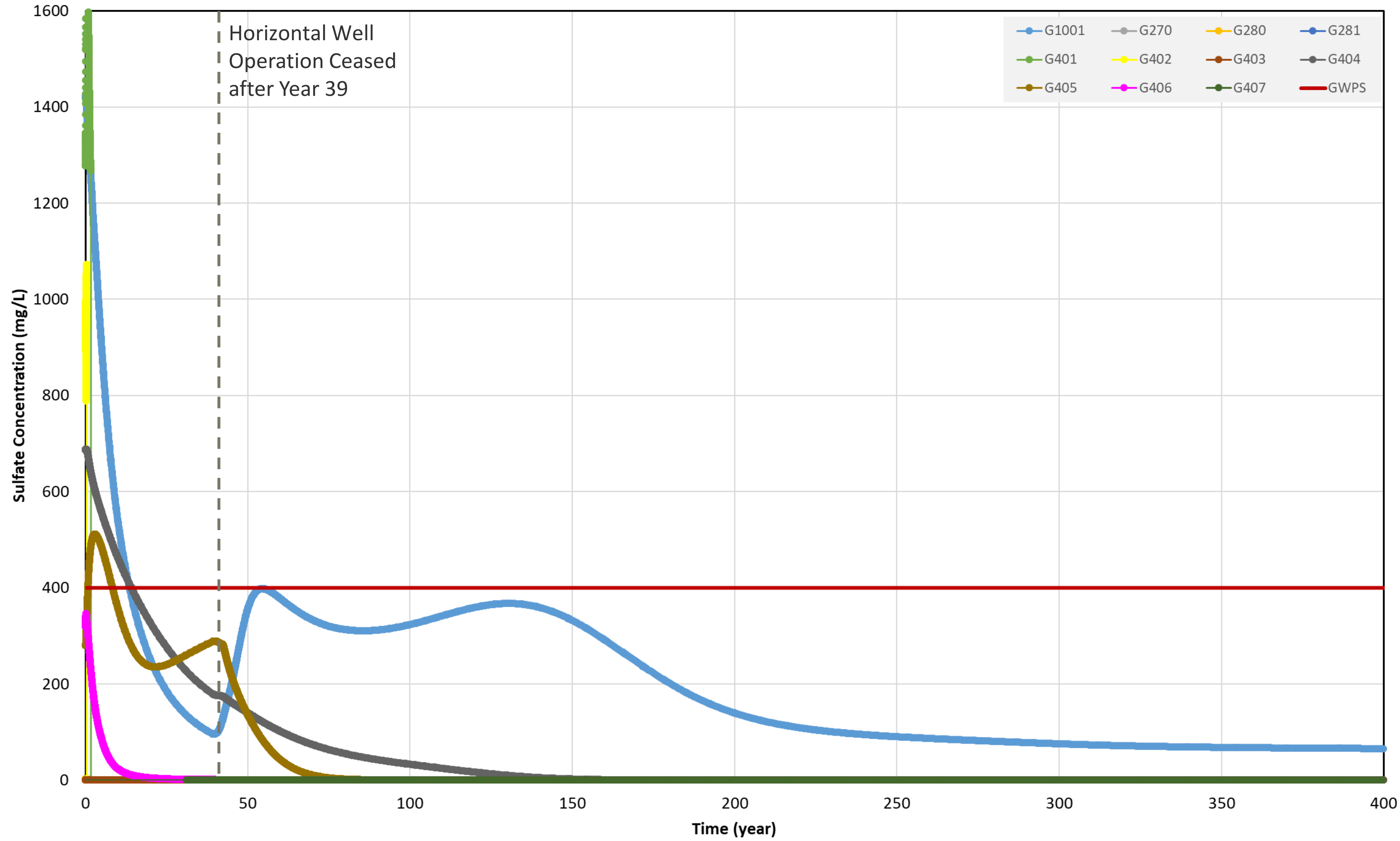

SIMULATED SULFATE CONCENTRATIONS IN AP2 MONITORING WELLS - ALTERNATIVE 3 REMEDY

FIGURE 7

ASH POND NO. 2
COFFEEN POWER PLANT
COFFEEN, ILLINOIS

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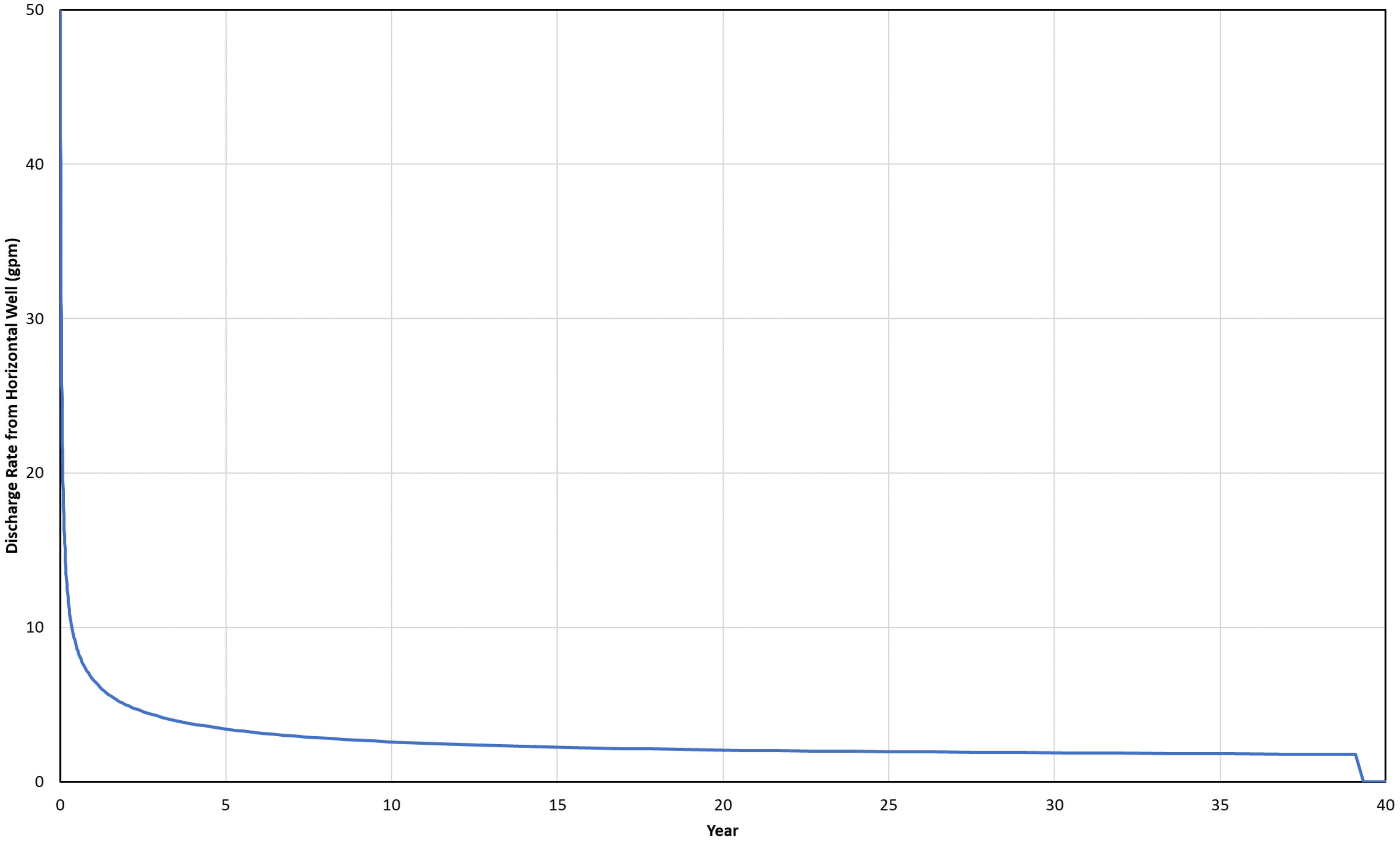
ENGINEERING SOLUTIONS, INC.
A RAMBOLL COMPANY



SIMULATED DISCHARGE RATE FROM HORIZONTAL GROUNDWATER EXTRACTION WELL - ALTERNATIVE 3 REMEDY

ASH POND NO. 2
COFFEEN POWER PLANT
COFFEEN, ILLINOIS

FIGURE 8

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.
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APPENDIX B2
GROUNDWATER MODELING REPORT (2022)

Intended for
Illinois Power Generating Company

Date
July 28, 2022

Project No.
1940101010-008

GROUNDWATER MODELING REPORT

ASH POND NO. 1
COFFEEN POWER PLANT
COFFEEN, ILLINOIS

Bright ideas. Sustainable change.

GROUNDWATER MODELING REPORT
COFFEEN POWER PLANT ASH POND NO. 1

Project name	**Coffeen Power Plant Ash Pond No. 1**
Project no.	**1940101010-008**
Recipient	**Illinois Power Generating Company**
Document type	**Groundwater Model Report**
Revision	**FINAL**
Date	**July 28, 2022**

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TABLES (ATTACHED)

FIGURES (IN TEXT)

FIGURES (ATTACHED)

APPENDICES

ACRONYMS AND ABBREVIATIONS

§	Section
35 I.A.C.	Title 35 of the Illinois Administrative Code
AP1	Ash Pond No. 1
AP2	Ash Pond No. 2
bgs	below ground surface
CBR	closure by removal
CCR	coal combustion residual(s)
CIP	closure in place
cm/s	centimeter per second
CPP	Coffeen Power Plant
CSM	conceptual site model
DA	deep aquifer
DCU	deep confining unit
DEM	Digital Elevation Model
ft^2	square feet
ft/d	feet per day
ft/ft	feet per foot
Geosyntec	Geosyntec Consultants, Inc.
GHB	general head boundary conditions
GMF GSP	Gypsum Management Facility Gypsum Stack Pond
GMF RP	Gypsum Management Facility Recycle Pond
GMP	Groundwater Monitoring Plan
GMR	Groundwater Modeling Report
GWPS	groundwater protection standard(s)
Hanson	Hanson Professional Services, Inc.
HCR	Hydrogeologic Site Characterization Report
HDPE	high density polyethylene
HELP	Hydrologic Evaluation of Landfill Performance
HFB	horizontal flow barrier
HUC	Hydrologic Unit Code
ID	identification
IEPA	Illinois Environmental Protection Agency
IPGC	Illinois Power Generating Company - IPGC
ISGS	Illinois State Geological Survey
K_D	linear isotherm
K_{eff}	effective hydraulic conductivity
K_F	Freundlich isotherm
K_L	Langmuir isotherm
Kd	distribution coefficient
Kh/Kv	anisotropy ratio
LCU	lower confining unit
LF	Landfill
L/kg	liters per kilogram
m	meter
mg/L	milligrams per liter

mil	one thousandth of an inch
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
NRT	Natural Resources Technology, Inc.
Part 845	35 I.A.C. § 845: Standards for the Disposal of Coal Combustion Residuals in Surface Impoundments
R2	correlation coefficient
Ramboll	Ramboll Americas Engineering Solutions, Inc.
SI	surface impoundment(s)
SSR	sum of squared residuals
TDS	total dissolved solids
TR	transient model
TVD	total-variation-diminishing
UA	uppermost aquifer
UCU	upper confining unit
USDA/NRCS	United States Department of Agriculture/Natural Resources Conservation Service
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

EXECUTIVE SUMMARY

Ramboll Americas Engineering Solutions, Inc. (Ramboll) has prepared this Groundwater Modeling Report (GMR) on behalf of the Coffeen Power Plant (CPP), operated by Illinois Power Generating Company - IPGC (IPGC), 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 coal combustion residuals (CCR) management unit Ash Pond Number (No.) 1 (AP1 [(Vistra Identification [ID] No. 101, IEPA ID No. W1350150004-01, and National Inventory of Dams [NID] No. IL50722]). AP1 is a 23-acre, unlined surface impoundment (SI) used to manage CCR and non-CCR waste streams at the CPP. Its total storage capacity is approximately 300 acre-feet.

The CPP is located in Montgomery County, in central Illinois between the two lobes of Coffeen Lake (**Figure 1-1**), which was formed in 1963 by damming the McDavid Branch of the East Fork of Shoal Creek. Coffeen Lake encompasses approximately 1,100 acres and was created to provide a source of cooling water for the CPP. Coffeen Lake borders the CPP to the west, east, and south, and agricultural land is located to the north. Historically coal mines were operated at depth below the site. Mine shafts, processing facilities, and historic coal storage were located on the southern extent of the CPP, south of AP1. The CPP operated as a coal-fired power plant from 1964 until November 2019 and has five CCR management units, with AP1 being the subject of this GMR. Unlithified material present above the bedrock in the vicinity of the CPP was categorized into hydrostratigraphic units as part of the 2021 Hydrogeologic Site Characterization Reports (HCR; Ramboll, 2021a). In addition to the CCR, the hydrostratigraphic units occur in the following order (from ground surface downward) and include:

- **Upper Confining Unit (UCU):** Consists of the Loess Unit and the upper clayey portion of the Hagarstown Member which has generally lower vertical permeability. The UCU has been eroded east of AP1, near the Unnamed Tributary.
- **Uppermost Aquifer (UA):** The UA is the sandy portion of the Hagarstown Member which is classified as primarily sandy to gravelly silts and clays with thin beds of sands. Similar to the Loess Unit, the Hagarstown is absent in some locations near the Unnamed Tributary.
- **Lower Confining Unit (LCU):** Comprised of the Vandalia Member, Mulberry Grove Member, and Smithboro Member. These units include a sandy to silty till with thin, discontinuous sand lenses, a discontinuous and limited extent sandy silt which has infilled prior erosional features, and silty to clayey diamicton, respectively.
- **Deep Aquifer (DA):** Sand and sandy silt/clay units of the Yarmouth Soil, which include accretionary deposits of fine sediment and organic materials, typically less than five feet thick and discontinuous across the CPP.
- **Deep Confining Unit (DCU):** Comprised of the Banner Formation and generally clays, silts, and sands. The Lierle Clay Member is the upper layer of the Banner Formation which was encountered at the CPP.

Flow of groundwater from central portions of the CPP to Coffeen Lake or the Unnamed Tributary through the UA are the primary pathways for contaminant migration. Groundwater elevations are primarily controlled by surface topography, geologic unit topography, and water levels within Coffeen Lake and the Unnamed Tributary. A groundwater divide trending north-south is observed running through the approximate center of the CPP. Phreatic surfaces or water elevations within the SI are generally consistent and have not been observed to fluctuate with groundwater elevations, indicating limited hydraulic connection with the SI.

The conceptual site model (CSM) for modeling the groundwater at the CPP is as follows:

- Most hydrostratigraphic layers are laterally continuous across the area. The flat to gently rolling uplands are dissected by deeply incised streams (into the materials of the UCU, UA, and LCU) that are tributaries to river systems in the area. Coffeen Lake was created by damming one of these tributary streams for use by the CPP.
- The UA is separated from the bottom of the AP1 by a minimum of 10 feet of low-permeability glacial till that comprises the UCU. Erosion caused by incised streams has occurred along the northeast corner of AP1 which likely results in ash being in contact with the UA.
- Surface recharge and groundwater migrate vertically through the low permeability sediments of the UCU. Groundwater migrates horizontally through the higher permeability sediments of the UA.
- Groundwater elevations and lake elevations indicates groundwater flows into Coffeen Lake from the UA.
- AP1 is constructed such that the earthen berm and base are in contact with the UCU with exception of limited areas in the northeast of the SI where the UCU and UA have been eroded and the berm and base are in contact with the LCU.
- The stage within AP1 is managed with minimal (less than 3 feet) variability throughout the year.

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 and summarized in the History of Potential Exceedances (Ramboll, 2021b) 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 2021c), which has not been reviewed or approved by IEPA at the time of submittal of the Part 845 operating permit application. The following constituents with potential exceedances of the GWPS listed in 35 I.A.C. § 845.600 were identified: boron, cobalt, pH, sulfate, and total dissolved solids (TDS) (Ramboll, 2021b) at AP1.

A Technical Memorandum (**Attachment A**) was prepared by Geosyntec Consultants, Inc. (Geosyntec, 2022a), *Evaluation of Potential Groundwater Protection Standard Exceedances, Coffeen Ash Pond No.1, Coffeen Illinois*, to further evaluate potential GWPS exceedances. The results of the evaluation demonstrated that the potential GWPS exceedances of cobalt in well G314 and pH in well G312 are not related to AP1 based on several lines of evidence presented in the Technical Memorandum.

Statistically significant correlations between sulfate concentrations and concentrations of TDS identified as potential exceedances of the GWPS indicate sulfate is an acceptable surrogate for TDS in the groundwater model. Concentrations of TDS are expected to change along with model predicted sulfate concentrations. A potential exceedance of boron was observed at one monitoring well, G313, which also has potential exceedances of both sulfate and TDS. Similar source and behavior in the groundwater system would be expected among boron, sulfate, and TDS at UA monitoring well G313, and boron concentrations are expected to change along with model predicted sulfate concentrations.

It was assumed that sulfate 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 predicting contaminant transport times in the model. Boron, sulfate, and TDS 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).

All available hydrological information were used to construct a CSM and numerical model of the CPP. A steady state, 5-layer numerical model, based on a previous groundwater model of the area, was constructed to characterize the long-term groundwater flow conditions at the site. The hydrostratigraphic units included in the model were the UCU, UA, and LCU. The DA and DCU were not included in the model. Calibration of the model focused on simulating mean groundwater elevations for 95 wells at the site by modifying hydraulic parameters for the different hydrostratigraphic units, alongside river and general head boundary conductance. The calibrated model represents a reasonable match to the observed head and sulfate concentration data.

The calibrated model was used to predict the sulfate concentration for two closure scenarios using information provided in the Final Closure Plan for AP1 (Golder Associates [Golder], 2022a) including:

- **Scenario 1:** closure in place (CIP) including removal of CCR from the eastern portion of AP1, consolidation into the western portion of AP1, and construction of a cover system over the remaining CCR, and;
- **Scenario 2:** closure by removal (CBR) including removal of all CCR and regrading of the removal area.

Prior to the simulation of these scenarios, a dewatering simulation was included, which simulated the removal of free liquids from AP1 prior to the implementation of the two closure scenarios.

Scenario 1 (CIP) was predicted to reduce total flux in and out of the Fill Unit (CCR) by approximately 99.9%, when simulated post-construction heads in the groundwater monitoring wells are predicted to stabilize. Additionally, the base of consolidated CCR was compared to the simulated steady-state groundwater elevations which indicate between 3.2 and 10 feet of separation will be present between the base of CCR and groundwater.

Differences exist in the timeframes to reach the GWPS for most monitoring wells between CIP and CBR. In general, the simulated groundwater concentrations in the monitoring wells within the UA will achieve the GWPS in 15 years and 18 years respectively for the CIP and CBR closure scenarios, with the exception of well G301 in the CIP scenario. The predicted delayed reduction in concentration at well G301, 59 years to reach the GWPS, is a result of the well being located along the flow path of the residual sulfate concentrations released into native geologic materials prior to closure. Reduced percolation rates through the consolidation area at the northwest corner of AP1 in the CIP scenario means that the residual sulfate concentrations in this limited area require a longer time period to migrate through native geologic materials.

1. INTRODUCTION

1.1 Overview

In accordance with the requirements of Part 845 (IEPA, 2021), Ramboll has prepared this GMR on behalf of the CPP, operated by IPGC. This report will apply specifically to the CCR unit referred to as AP1 (**Figure 1-1**). However, information gathered to evaluate other CCR units at the CPP regarding geology, hydrogeology, and groundwater quality is included, where appropriate. AP1 is a 23-acre, unlined SI used to manage CCR and non-CCR waste streams at the CPP. Its total storage capacity is approximately 300 acre-feet. 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 summarized below.

- **Scenario 1:** CIP including removal of CCR from the eastern portion of AP1, consolidation into the western portion of AP1, and construction of a cover system over the remaining CCR.
- **Scenario 2:** CBR including removal of all CCR and regrading of the removal area.

1.2 Previous Groundwater Modeling Reports

Several reports containing groundwater modeling have been completed at the CPP. The information presented in this GMR includes data collected in support of the previous groundwater models as well as data collected as part of a 2021 field investigation to support development of a HCR (Ramboll, 2021a). The HCR was provided as an attachment to the initial operating permit application required by 35 I.A.C. § 845.230. Previous groundwater modeling reports completed for the various CCR units located at the CPP include, but are not limited to, the following (recent to oldest):

- ***Natural Resources Technology, Inc. (NRT), January 24, 2017. Hydrostatic Modeling Report. Coffeen Power Station, Coffeen, Illinois.***
  Utilized the Hydrologic Evaluation of Landfill Performance (HELP) model to predict percolation from Ash Pond No. 2 (AP2) and evaluate AP2 hydrostatic conditions in response to the proposed cover system as described in the Revised 30% Closure Design Package.
- ***NRT, January 24, 2017. Groundwater Modeling Report. Coffeen Power Station, Coffeen, Illinois.***
  Included simulations of the site hydrology, the extent of CCR leachate impacts on groundwater, and the effect of pond closure on groundwater quality.

1.3 Site Location and Background

The CPP is located in Montgomery County, in central Illinois, within Section 11 Township 7 North and Range 7 East (**Figure 1-1**). The CPP is approximately two miles south of the city of Coffeen and about eight miles southeast of the city of Hillsboro, Illinois. AP1 is located between the two lobes of Coffeen Lake (identified as "Coffeen Lake" and "Unnamed Tributary" on **Figure 1-1** and **Figure 1-2**) to the west, east, and south, and is bordered by agricultural land to the north. The approximately 1,100-acre Coffeen Lake was built by damming the McDavid Branch of the East Fork of Shoal Creek in 1963 for use as an artificial cooling lake for the CPP. Historically, several coal mines were operated at depth in the vicinity of the CPP as well as the US Minerals processing facility located to the north. **Figure 1-2** is a site map showing the location of AP1 (Part 845 regulated CCR unit and subject of this GMR), AP2, Gypsum Management Facility Recycle Pond

(GMF RP), Gypsum Management Facility Gypsum Stack Pond (GMF GSP), and Landfill (LF). A surface water pond southwest of the LF collects overflow from the LF, this feature does not contain CCR. The area near AP1 will hereinafter be referred to as the Site.

1.4 Site History and CCR Units

The CPP was a coal-fired electrical generating plant that began operation in 1964. The plant initially burned bituminous coal from Illinois and CCR from the coal fired units was disposed of in AP1. AP2 was also utilized in the early 1970's and AP1 was reconstructed in 1978. Both of these units were used until the mid-1980's. Beginning in 2010, CCR material was placed in the LF and GMF units (*i.e.,* GMF RP and GMF GSP). All approximate dates of construction of each successive stage of the CCR units at the CPP are included in the groundwater model and described here.

AP1: This SI (also known as the Bottom Ash/Recycle Pond) is a reclaimed ash pond that was reconstructed utilizing the existing earthen berms with reinforcement, as provided by Water Pollution Control Permit 1978-EA-389 issued by the IEPA on May 26, 1978. AP1 (existing unlined SI) covers an area of approximately 23 acres, has berms up to 41 feet above the surrounding land surface, and a volume of 300 acre-feet. It primarily received bottom ash and low volume wastes from floor drains in the main power block building. Several years ago, air heater wash and boiler chemical cleaning wastes were directed to AP1, but this practice was discontinued. The bottom ash was periodically removed for beneficial uses by a third-party contractor. Sluicing of waste to AP1 ceased prior to November 4, 2019.

AP2: AP2 is a closed (IEPA approved) SI with a surface area of approximately 60 acres and berms 47 feet higher than the surrounding land surface. AP2 was originally removed from service and capped in the mid 1980's. A clay and soil cap was placed on the surface of the pond with contouring and drainage provided to direct storm water to four engineered revetment down drain structures. Prior to capping, this pond was identified as Outfall 004 in the facility National Pollutant Discharge Elimination System (NPDES) operating permit, IL0000108. Additional closure activities include the construction of a geomembrane cover system that began in July 2019 and was completed on November 17, 2020. The construction was completed in accordance with the Closure and Post Closure Care Plan approved by the IEPA on January 30, 2018.

GMF GSP: The 77-acre GMF GSP received blowdown from the air emission scrubbers and was put into operation in 2010. Construction of the GMF GSP was in accordance with Water Pollution Control Permit 2008-EA-4661 and features a composite 60- one thousandth of an inch (mil) high-density polyethylene (HDPE) liner with 3 feet of recompacted soil with a hydraulic conductivity of 1×10^{-7} centimeters per second (cm/s) with internal piping and drains to collect contact water. Construction of the unit required excavation to approximately 603 feet North American Vertical Datum of 1988 (NAVD88), removal of the sands and silts of the UA prior to construction of the liner, and installation of a groundwater underdrain system to eliminate inward pressure on the liner prior to placement of CCR. The GMF GSP underdrain was actively pumped during construction but is no longer actively pumped. IPGC ceased receipt of waste to the GMF GSP prior to April 11, 2021.

GMF RP: The 17-acre GMF RP received blowdown from the air emission scrubbers and was put into operation in 2010. Construction of the GMF RP was in accordance with Water Pollution Control Permit 2008-EA-4661 and features a composite 60-mil HDPE liner with 3 feet of recompacted soil with a hydraulic conductivity of 1×10^{-7} cm/s with internal piping and drains to collect contact water. Construction of the unit required excavation to approximately 601 feet

NAVD88, removal of the sands and silts of the UA prior to construction of the liner, and installation of a groundwater underdrain system to eliminate inward pressure on the liner prior to placement of CCR. The GMF RP underdrain is a passive, gravity drained system. IPGC ceased receipt of waste to the GMF RP prior to April 11, 2021.

LF: Fly ash was managed in a permitted composite lined landfill constructed in 2010. The LF has an active groundwater underdrain system that is currently being pumped. Additionally, the ash landfill leachate collection system is restricted by rule to no more than one foot of leachate on the composite liner. An IEPA groundwater monitoring program is in effect for the GMF GSP and GMF RP (under Bureau of Water), and LF (under Bureau of Land).

2. SITE GEOLOGY AND HYDROGEOLOGY

2.1 Stratigraphy

The geology and hydrogeology of AP1 are described in detail in the HCR (Ramboll, 2021a) and summarized below.

The unlithified stratigraphy within and immediately surrounding AP1 consists of the following in descending order: fill material and CCR; clays and silts (Loess Unit); gravelly clay till and sandy materials, absent in some locations (Hagarstown Member); a weathered till zone and sandy, silt, or clay till (Vandalia Member); silt and sandy silt/clay unit (Mulberry Grove Member); silty clay diamicton (Smithboro Member); sand and sandy silt/clay, absent in some locations (Yarmouth Soil); and clay and silt with some sand (Lierle Clay Member). The unlithified units overlay Pennsylvanian-age limestone, sandstone, and minor coal beds (Bond Formation). The Bond Formation bedrock was not encountered in any borings advanced at the CPP, so site-specific information is not available.

CCR consisting of bottom ash and other non-CCR waste is present within AP1 at a thickness of up to 18 feet, as estimated from borings advanced within AP1, and an average thickness of 10 feet. However, CCR materials may be thicker near former drainage features in localized areas eroded through the loess and clay (Ramboll, 2021a). One such former drainage feature is located in the northeast corner of AP1 and ash fill may be in contact with the sandy portion of the Hagarstown Member similar to features observed at AP2. Non-CCR fill material consisting of silty clay, sandy lean clay, or lean clay with sand, with trace amounts of fine gravel comprises the berms surrounding AP1.

The Loess Unit is the uppermost unlithified unit identified at the CPP. This unit is comprised of the combined Roxana and Peoria Silt and extends from beneath the topsoil, derived from the loess, to the top of the Hagarstown Member. The loess has been classified as silt or clayey silt, with minor amounts of sand. The Loess Unit ranges in thickness from 0 feet (absent) to 16 feet, and was generally 8 to 14 feet thick, where present near AP1. The Loess Unit is generally considered unsaturated, and the UA is recharged by precipitation that percolates through this unit.

The Hagarstown Member (also referred to as Hagarstown Beds) exhibits two units: the first unit consisting of the gravelly clay till and the second consisting of sandy material overlying the Vandalia Member. The clay till portion had varying thicknesses ranging from approximately 2 to 6 feet as observed adjacent to AP1 (Ramboll, 2021a). The sandy portion of the Hagarstown, where present, was typically encountered between 9 and 34 feet below ground surface (bgs) near AP1, and is generally 1 to 5 feet thick, although thicknesses up to 7 feet have been observed north of the LF (Ramboll, 2021d; Ramboll, 2021e). The composition of the sandy portion of the Hagarstown unit varies across the CPP and has been classified as gravelly till, poorly sorted gravel, well sorted gravel, sand, and silty sand. Based on historic topography, the Hagarstown Member is not present in former drainage features present along the banks of Coffeen Lake and the Unnamed Tributary. During construction of the LF, GMF GSP, and the GMF RP, the Loess Unit and portions of the Hagarstown Member were excavated to facilitate construction.

The Vandalia (*i.e.,* till) Member is a sandy/silty till with thin, discontinuous lenses of silt, sand, and gravel. The Vandalia Member was encountered between 1.5 and 34 feet bgs in all borings advanced at the CPP. The Vandalia Member typically ranged in thickness from 11.7 feet in the northern portion of the CPP, to 31.0 feet between the GMF GSP and the GMF RP. Similar to the observed top elevation of the Hagarstown Member, the top of the Vandalia Member declines in elevation near Coffeen Lake and topographic drainage features. This unit is relatively thick throughout the CPP, with an average thickness of over 15 feet (Hanson Professional Services, Inc. [Hanson], 2009).

The Mulberry Grove (*i.e.,* silt) Member typically consists of a thin, lenticular unit of gray sandy silt (Willman et al., 1975). It represents the interval between the retreat of the glacier that deposited the Smithboro Member and the advance of the glacier that deposited the Vandalia Member. At the CPP, the Mulberry Grove Member is represented by gray sandy silt layers deposited in depressions found in the surface of the underlying Smithboro Member. This unit was absent in many borings through the central portion of the CPP from south to north, and is generally less than 2 feet thick, but was measured at up to 4.9 feet thick near the GMF GSP (Hanson, 2009).

The Smithboro (*i.e.,* till) Member is described as a gray, compact, silty, clayey diamicton that ranges in thickness from 6.7 to 21.2 feet northwest of the LF.

The Yarmouth Soil is described as the weathered zone on the Kansan drift, but in some places, it consists of accretionary deposits of fine sediment and organic material that accumulated in poorly drained areas on the surface of the Kansan deposits. Historical borings in the northern portion of the CPP which encountered the Yarmouth were summarized previously by Hanson (2009) as ranging in thickness from 0 feet (absent) to 5.1 feet.

The Lierle Clay Member is the uppermost member of the Kansan Stage Banner Formation. It is described as an accretion gley with clay, silt, and some sand. It was encountered by Hanson (2009) in all but a few borings on site. During the 2021 investigation, the top of the Lierle Clay was observed between 54 and 57 feet bgs. No borings advanced at the CPP penetrated the full thickness of the Banner Formation.

Pennsylvanian-age Bond Formation bedrock was not encountered in any borings advanced at the CPP, so site-specific information is not available.

2.2 Hydrogeology

Regionally, the water table conforms to the topographic features of the land surface. Recharge occurs in the uplands and flows towards drainage features. Moderate thicknesses of unconsolidated materials fill shallow valleys or are present on the uplands bordering the main valleys. These materials contain thin and discontinuous deposits of sand and gravel.

2.2.1 Groundwater Flow

Monitoring well locations are illustrated in **Figure 2-1**. Monitoring well locations and construction details are summarized in **Table 2-1**. Overall groundwater flow within the UA is divided towards the two lobes of Coffeen Lake. Groundwater generally flows from the center of the CPP west towards Coffeen Lake, and east towards the Unnamed Tributary, the eastern lobe of Coffeen Lake, and the discharge flume, resulting in a groundwater divide (high) running through the middle of the CPP (**Figure 2-2** and **Figure 2-3**). Groundwater flows north to northeast across AP1 toward the former discharge structure and Unnamed Tributary. Although elevations vary seasonally, the groundwater flow direction in the UA is consistent and likely controlled by the proximity and hydraulic connection to Coffeen Lake.

2.2.2 Hydraulic Properties

Over 100 monitoring wells have been installed since 2006 to monitor groundwater conditions around the five CCR units at the CPP for both State and Federal groundwater compliance programs. Six hydrostratigraphic units were described in detail in the HCR (Ramboll, 2021a) and are summarized as follows:

- **CCR**: This unit is composed of CCR, consisting primarily of bottom ash. This also includes earthen fill deposits of predominantly silt and clay materials from on-site excavations that were used to construct berms and roads surrounding the various impoundments across the CPP. Laboratory testing of one CCR (ash) sample from AP1 had a vertical hydraulic conductivity of 8.8 x 10^{-5} cm/s.
- **UCU**: Consists of the Loess Unit and the upper clayey portion of the Hagarstown Member which has generally lower vertical permeability and generally greater than 60 percent fines (Ramboll, 2021a). This unit was encountered across most of the CPP, with the exception of the eastern edges of AP1 near the Unnamed Tributary where the unit was eroded following deposition or locations where it has been excavated for construction. Vertical hydraulic conductivities based on laboratory testing ranged from 1.3 x 10^{-8} to 5.0 x 10^{-7} cm/s.
- **UA** This unit consists primarily of sand and sandy silts and clays at the base of the Hagarstown Member and, in some locations, the uppermost weathered sandy clay portion of the Vandalia Member. This unit is absent in several locations due to weathering and in others due to excavation during construction of CCR Units. Field hydraulic conductivity tests indicated hydraulic conductivities ranged from 1.7 x 10^{-5} to 9.1 x 10^{-3} cm/s near AP1. Laboratory testing of one UA sample, collected near the GMF RP, had a vertical hydraulic conductivity of 1.6 x 10^{-4} cm/s (Ramboll, 2021a).
- **LCU**: This unit is composed of the sandy clay till of the Vandalia Member, the silt of the Mulberry Grove Formation, and the compacted clay till of the Smithboro Member. The unit underlies the UA and was encountered in all boring locations on the CPP. Results from laboratory tests completed for vertical hydraulic conductivity indicate the Vandalia Member has a very low vertical hydraulic conductivity. Field hydraulic conductivity tests indicated hydraulic conductivities from 4.0 x 10^{-8} to 3.4 x 10^{-5} cm/s; however, these likely reflect the isolated and discontinuous sandy lenses. Vertical hydraulic conductivities based on laboratory testing were from 1.3 x 10^{-8} to 5.0 x 10^{-7} cm/s.
- **DA**: This unit consists primarily of sandy silt and sands of the Yarmouth Soil, which are thin (less than 5 feet) and discontinuous across the CPP. Field hydraulic conductivity tests indicated hydraulic conductivities from 8.7 x 10^{-5} to 1.7 x 10^{-3} cm/s within the DA.
- **DCU**: This unit underlies the DA and is composed of the Banner Formation, of which the thick Lierle Clay is the first encountered unit. No boring penetrated the full thickness of this formation.

2.2.3 Groundwater Elevation Data

During the 2021 Part 845 investigation, groundwater elevations in the UA ranged from approximately 591 to 625 feet NAVD88 across the CPP. Groundwater elevations were typically highest towards the northern extent of the CPP, near the GMF GSP and GMF RP, except monitoring well G307 south of AP1, which consistently had the highest groundwater elevation. Groundwater elevations were lowest near the Unnamed Tributary and east of AP1 towards Coffeen Lake. Groundwater elevations in the vicinity of AP1 were typically from 591 to 621 feet NAVD88, with the exception of G307 as noted above, which was typically around 624 feet NAVD88 (**Figure 2-2** and **Figure 2-3**).

No seasonal variation has been observed in the UA monitoring wells, and any seasonal responses may be muted by the proximity and hydraulic connection to Coffeen Lake.

2.2.4 Mining Activity

Several coal mines, both strip and underground types, previously operated in Montgomery County, Illinois. Three mines - the Hillsboro Mine (Illinois State Geological Survey [ISGS] Mine No. 871), the Clover Leaf No. 4 Mine (ISGS Mine No. 442), and the Clover Leaf No. 1 Mine (ISGS Mine No. 3001) – were operated as room and pillar mines in the vicinity of the site beginning as early as 1889. The mines extracted coal from the Herrin (No. 6) Coal at depths of approximately 500 to 535 feet bgs (ISGS, 2019). All nearby mining operations ceased in 1983.

The Hillsboro Mine showed indications of small-scale faulting, roof stability issues, and floor heaving. Mine shafts, processing facilities, and some historic coal storage associated with these historic mines were located south of AP1. AP1 directly overlies the Hillsboro Mine. AP1 is outside of the buffer zone of the Clover Leaf No. 4 and Clover Leaf No. 1 mines (Ramboll, 2021a).

3. GROUNDWATER QUALITY

3.1 Groundwater Classification

Per 35 I.A.C. § 620.210, groundwater within the UA at AP1 meets the definition of Class I - Potable Resource Groundwater based on the following criteria:

- Groundwater in the UA is located 10 feet or more below the land surface and
- Within a geologic material which is capable of a hydraulic conductivity of 1 x 10^{-4} cm/s or greater using a slug test.

Field hydraulic conductivity tests performed in the UA near AP1 in 2021 had a geometric mean of 2.0 x 10^{-3} cm/s (Ramboll, 2021a). Based on this information, groundwater is classified as Class I – Potable Resource Groundwater.

However, background (upgradient) groundwater originates from areas southwest of AP1 that have historically been used for coal storage and present a potential alternate source for groundwater impacts.

3.2 Potential Groundwater Exceedances

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 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, 2021c) attached to the operating permit application.

Groundwater concentrations from 2015 to 2021 are summarized in the History of Potential Exceedances (Ramboll, 2021b) (attached to the operating permit application) and are considered potential exceedances because the methodology used to determine them is proposed in the Statistical Analysis Plan (Appendix A to the GMP, Ramboll 2021c), which has not been reviewed or approved by IEPA at the time of submittal of the Part 845 operating permit application.

The History of Potential Exceedances attached to the operating permit application summarizes all potential groundwater exceedances following the proposed Statistical Analysis Plan. The following potential exceedances were identified:

- Boron – determined at well G313.
- Cobalt - determined at well G314.
- pH (lower limit) - determined at well G312.
- Sulfate - determined at wells G301, G303, G304/G307, G305, G307D, G308, G309, G310, G311, G312, G313, G314, G314D, G315, and G317.
- TDS - determined at wells G303, G304/G307, G305, G307D, G308, G309, G310, G311, G312, G313, G314, G315, and G317.

A Technical Memorandum (**Attachment A**) was prepared by Geosyntec Consultants, Inc. (Geosyntec, 2022a), *Evaluation of Potential Groundwater Protection Standard Exceedances, Coffeen Ash Pond No.1, Coffeen Illinois*, to further evaluate potential GWPS exceedances. The results of the evaluation demonstrated that the potential GWPS exceedances of cobalt in well G314 and pH in well G312 are not related to AP1 based on several lines of evidence presented in the Technical Memorandum. Since potential GWPS exceedances for cobalt and pH are not related to AP1, these parameters will not be discussed further in this GMR.

4. GROUNDWATER MODEL

4.1 Overview

Data collected at the Site from 2015 to the 2021 field investigation were used to update an existing groundwater model of the CPP (NRT, 2017b). The updated model was then used to evaluate the results of predictive groundwater modeling simulations for two proposed closure scenarios, including CCR consolidation and CIP, and CBR. The modeling results are summarized and evaluated in this GMR. The associated model files are included as **Appendix B**.

4.2 Description of Existing Model

The NRT (2017b) contaminant fate and transport model simulated boron and was performed to support closure of AP2 using MODFLOW and MT3DMS. AP1, GMF GSP, GMF RP, and LF were present within the previous model domain.

The NRT (2017b) modeling consisted of the following:

- Steady-state MODFLOW model was developed to represent site conditions for 2016. This model was calibrated to a set of groundwater elevation data collected during November 2016.
- The hydraulic properties from the steady-state model were used in the calibration of the transient MODFLOW and MT3DMS models which simulated groundwater flow and transport at the AP2 from 1970 to 2017. Boron concentrations collected in August 2016 were used to calibrate the transport model.
- Predictive simulations to estimate future boron concentrations for a baseline (no action) and capping closure scenario for AP2 were completed. Closure action was modeled over a period of 1,500 years, beginning in January 2018.
- Predicted boron concentrations were simulated to reach compliance for CIP at AP2 after 101 years (NRT, 2017b). These modeling results were part of the closure plan approved by IEPA on January 30, 2018.

4.3 Conceptual Model

The HCR (Ramboll, 2021a) forms the foundation of the AP1 hydrogeological setting. The AP1 overlies the recharge area for the underlying transmissive geologic media, which are composed of unlithified deposits.

4.3.1 Hydrogeology

As discussed in **Section 2.2**, groundwater flow in the UA at the CPP is divided towards the two lobes of Coffeen Lake. The loess of the UCU and sands of the UA are hydraulically connected. The groundwater flow in the silts and clays of the UCU and LCU are expected to be primarily vertical. The Hagarstown member is where the majority of the horizontal migration is expected to occur. The hydrogeological CSM consists of the following layers:

- Hagarstown Loess Unit (*i.e.,* UCU) – Loess Unit and the upper clayey portion of the Hagarstown Member.
- Hagarstown Member (*i.e.,* UA) – sand and sandy silts and clays at the base of the Hagarstown Member and, in some locations, the uppermost weathered sandy clay portion of the Vandalia Member.

- Vandalia Member/Mulberry Grove Member (*i.e.,* LCU) – unweathered sandy clay till and discontinuous silts.
- Smithboro Till (*i.e.,* LCU) – compacted clay till of the Smithboro Member.

The hydrostratigraphic units included in the model were the UCU, UA, and LCU. The DA and DCU were not included in the model, which includes consistency with the original model (NRT, 2017b). No potential GWPS exceedances have been observed in the DA. This, coupled with the limited groundwater data available for the DA and DCU, meant that these layers were not included in the model. Therefore, the Smithboro Till (*i.e.,* LCU) represents the lower boundary of the CSM.

Surfaces for each of the three major geological units (Loess Unit, Hagarstown Member, Vandalia/Mulberry Grove Member and Smithboro Till Member) were taken from the NRT model (2017b). The NRT model (2017b) used available information from well logs to interpolate the top and base of the UA.

4.3.2 Extent and Boundaries

The United States Geological Survey (USGS) National Map places the CPP within the East Fork Shoal Creek watershed subbasin (Hydrologic Unit Code [HUC] 071402030303).

The CPP CSM extent is bounded by a hydrological catchment (watershed) divide to the east based on watershed data from USGS. Along the north, south, and east, the model boundary has been placed along known waterbodies as much as possible. As such, it is assumed groundwater inflow from adjacent watersheds is negligible through both the UA and LCU.

The Coffeen Lake water levels are managed an average elevation 591.0 feet NAVD88. Coffeen Lake and Unnamed Tributary are the receiving body of water for surface water in the area encompassed by the CSM.

Infiltration of precipitation to the groundwater table is applied as recharge at the site. Groundwater in the UCU migrates downward into the Hagarstown Formation. As discussed in **Section 2.2.1**, the Hagarstown Formation is considered the UA for groundwater adjacent to AP1.

4.3.3 Ash Pond No. 1

AP1 is constructed such that the earthen berm and base are in contact with the UCU with exception of limited areas in the northeast of the SI where the UCU and UA have been eroded and the berm and base of CCR are in contact with the LCU. Findings from the HCR (Ramboll, 2021a) indicate that AP1 does influence the UA flow system, where there is a component of radial flow from AP1. However, this radial flow system appears to be centered around the southwest corner of AP1 resulting in a northerly and easterly component of groundwater flow within the UA.

Sulfate was selected for transport modeling. Sulfate is commonly used as an indicator parameter for contaminant transport modeling for CCR because: (i) it is commonly present in coal ash leachate; and (ii) it is mobile and typically not very reactive but conservative (*i.e.*, low rates of sorption or degradation) in groundwater.

4.5 Model Approach

4.5.1 Potential Groundwater Exceedances

A comparison of observed TDS concentrations to sulfate (**Figure A** below) indicates a statistically significant correlation between these parameters in UA wells where these potential exceedances were observed. 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 A**. 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 correlation has a p value less than the target of 0.05, indicating the correlation is statistically significant. The statistically significant correlation associated with sulfate concentrations indicate sulfate is an acceptable surrogate for TDS in the groundwater model, and concentrations of this parameter are expected to change along with model predicted sulfate concentrations.

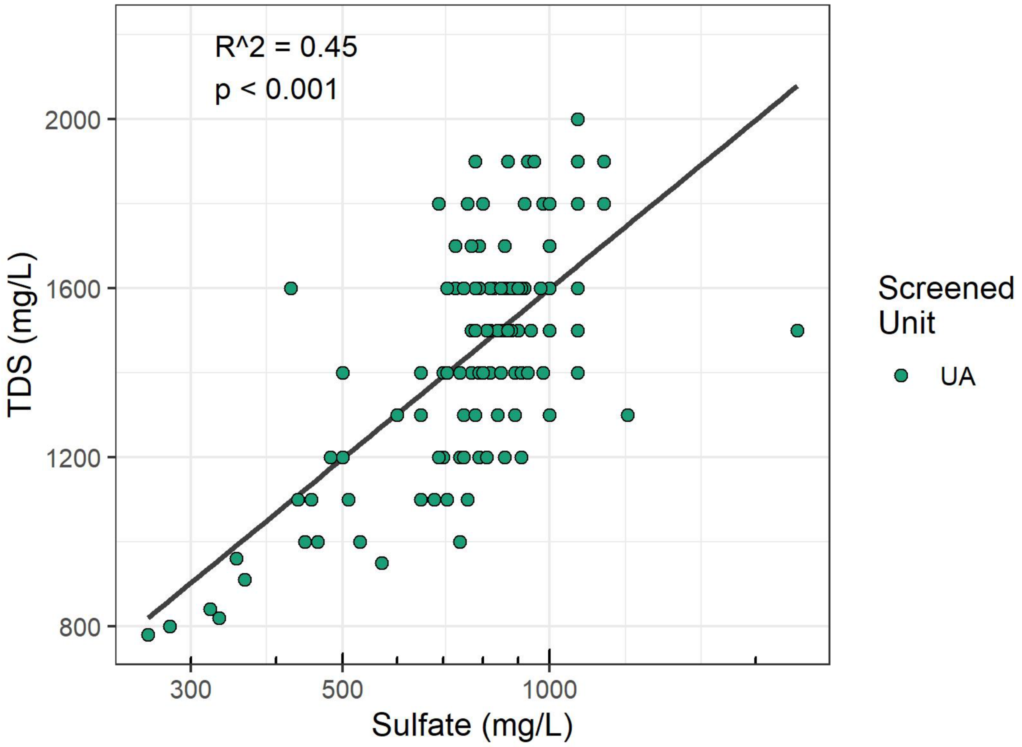

Figure A. Sulfate Correlation with TDS in UA Wells

A potential exceedance of boron was also observed at one monitoring well, G313, in the vicinity of AP1, based on the History of Potential Exceedances (Ramboll, 2021b). Correlations between sulfate and boron for the same AP1 UA wells did not indicate a statistically significant correlation between these constituents. However, UA monitoring well G313 has potential exceedances of both sulfate and TDS along with the potential exceedance of boron (**Section 3.2**). Boron, like sulfate, is a common indicator parameter used for contaminant transport modeling of CCR; and boron is less likely than other constituents to be present in background groundwater from natural or other anthropogenic sources. The only significant source of boron is AP1. With potential exceedances of boron, sulfate, and TDS present in the same well (G313) and having the same source (AP1), boron concentrations are expected to change along with model predicted sulfate concentrations.

4.5.2 Summary of Modeling Activities

A three-dimensional groundwater flow model was calibrated to represent the conceptual flow system described above. Prediction simulations were performed to evaluate the effects of closure (source control) measures (CCR consolidation and CIP and CBR scenarios) for the CCR units on groundwater quality following initial corrective action measures, which includes removal of free liquids (dewatering). **Figure 4-1** illustrates the calibration and predictive modeling timelines.

Three model codes were used to simulate groundwater flow and contaminant transport:

- Groundwater flow was modeled in three dimensions using MODFLOW 2005.
- Contaminant transport was modeled in three dimensions using MT3DMS.
- Percolation (recharge) was modeled using the results of HELP model.

Modeling steps are a summarized below:

- A steady state model was created in MODFLOW 2005 and used to simulate the mean groundwater flow conditions at the site. The model was calibrated to match mean groundwater elevations observed between 2015 to 2021 (**Table 4-1**).
- Transient flow models based off of the calibrated steady state model were used to simulate groundwater flow and transport for 42 years using MODFLOW 2005 and MT3DMS to simulate changes in site conditions through time and match currently observed concentrations of sulfate in groundwater (**Table 4-1**).
- Prediction simulations began with a 2-year dewatering period simulated in MODFLOW 2005 and MT3DMS where heads were reduced within the CCR unit and concentrations were removed from CCR removal areas.
- Prediction simulations resumed for CIP and CBR following the 2-year dewatering period using the results of HELP modeling as input values for recharge rates in the construction areas.
- The prediction simulations were run using MODFLOW 2005 and MT3DMS to estimate the time for sulfate concentrations to meet the GWPS in the compliance wells and to evaluate the differences between the two closure scenarios.

5. MODEL SETUP AND CALIBRATION

5.1 Model 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 the 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 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 McDonald and Harbaugh (1988). MODFLOW 2005 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 this model. 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) completed for the groundwater model were used to estimate the hydraulic flux from closure construction.

5.2 Flow and Transport Model Setup

The 2017 flow and transport models were retained and revised as appropriate to perform simulations for the AP1.

The modeled area was approximately 10,000 feet by 15,025 feet (150,250,000 square feet [ft^2]) centered on the CPP (**Figure 5-1**). The model boundaries along the northern and eastern edges of the model were selected to maintain sufficient distance from the CPP to reduce boundary interference with model calculations, while not extending too far past the extent of available calibration data. The eastern edge of the model also approximates topographic highs, surface water divides, and watershed boundaries.

The steady state MODFLOW model was calibrated to mean groundwater elevation collected from 2015 to 2021 as presented in **Table 4-1**. MT3DMS was run on the transient flow model and model-simulated concentrations were calibrated to observed sulfate concentration values at the monitoring wells from January 2015 to July 2021 as presented in **Table 4-1**. Multiple iterations of MODFLOW and MT3DMS calibration were performed to achieve an acceptable match to observed flow and transport data. For AP1, the calibrated flow and transport models were used in predictive modeling to evaluate the CIP and CBR closure scenarios. Prior to simulation of CIP and CBR, a dewatering phase, which simulated the removal of free liquid from the CCR material in the AP1 was completed. Closure scenarios were simulated by removing saturated ash cells from removal areas and using HELP modeled recharge values to simulate changes proposed in the closure scenarios.

5.2.1 Grid and Boundary Conditions

A five-layer, 326 x 211 node grid was established with a variable grid spacing between 25 and 100 feet (**Figures 5-2 through 5-6**), with a total number of 284,575 active cells.

The main body of Coffeen Lake is immediately adjacent to CPP on the west and south and the Unnamed Tributary borders CPP to the east. These surface water features form the southern, eastern, and western boundaries of the model. The northern boundary of the model domain is a general head boundary. Vertically, the model domain extends from the top of the saturated zone to the base of the Smithboro Member. The thick clays of the Banner Formation are relatively impermeable compared to the overlying unconsolidated sediments and provides a base for the model.

The northern boundaries for layers 3, 4, and 5 are general head boundaries placed to simulate flow in the sandier soils of the Hagarstown Member, Vandalia/Mulberry Grove Member and Smithboro Till composing the UA (layer 3), and LCU (layer 4 and 5). The northern boundary represents the regional flow conditions within these units. The eastern edge is no-flow boundary in all model layers.

Coffeen Lake is represented as a constant head boundary based on an average surface water elevation of 591.0 feet NAVD88. The constant head boundary was simulated with an elevation equal to 591.0 feet. The lake is in hydraulic connection with multiple layers within the model.

The bottom of the model was also a no-flow boundary. The top of the model was a time-dependent specified flux boundary, with specified flux rates equal to the recharge rate. A specified mass flux boundary was used to simulate downward percolation of solute mass from the AP1. This boundary condition assigns a specified concentration to recharge water entering the cells within AP1, and the resulting concentration in the AP1 cells is a function of the relative rate and concentration of recharge water (water percolating from the impoundment) compared to the rate and concentration of other water entering the node.

5.2.2 Flow Model Input Values and Sensitivity

Evaluation of monitoring well data for the CPP has not identified statistically significant seasonal trends in groundwater flow or quality which could affect model applicability for prediction of transport. The MODFLOW model was calibrated to mean groundwater elevations from 2015 to 2021. Multiple iterations of MODFLOW calibration were performed to achieve an acceptable match to observed flow data.

Sensitivity analysis was conducted by changing input values and observing changes in the sum of squared residuals (SSR). Horizontal conductivity, vertical conductivity, and river and general head conductance terms were all varied by one order of magnitude (*i.e.*, between one-tenth and ten times) of the calibrated values. Recharge terms were varied between one-half and two times calibrated values. River stage was obtained from the 10 meter (m) Digital Elevation Model (DEM) from the United States Department of Agriculture/Natural Resources Conservation Service (USDA/NRCS) National Geospatial Center of Excellence (USDA/NRCS, 2022). The vertical error of the 10 m DEM is 0.82 m (2.7 feet); therefore, the stream stage was varied by adding and subtracting 2.7 feet. Where appropriate, drain stage was modified based on the DEM error. Where this was inappropriate, drain stage increased and decreased by 2 feet. General head boundary head terms were varied between 90 and 110 percent of calibrated values. The HFB was varied by increasing the hydraulic conductivity by a factor of 100 and 1,000. When the calibrated model was tested, the SSR was 351. Sensitivity test results were categorized into negligible, low, moderate, moderately high, and high sensitivity based on the change in the SSR as summarized in the notes in **Table 5-1**.

5.2.2.1 Layer Top/Bottom

The top of the saturated zone was used as the top of the model. The elevations for the base of each hydrostratigraphic layer were obtained from the NRT model (2017b) and were imported as grid data into MODFLOW. The upper Loess Unit of the Hagarstown Member (UCU) was divided into two layers to accommodate the explicit inclusion of the CCR in AP1 and AP2. The sand and silts of the Hagarstown Member which form the UA were represented using a single layer. The LCU was represented by two layers, the upper LCU (layer 4) represents the unweathered Vandalia/Mulberry Grove Member and the lower LCU (layer 5) represents the Smithboro Member.

The UCU layer was split into two layers (layers 1 and 2) to simulate the construction of AP1 and AP2. Within AP1 and AP2, layer 1 represents ash fill and layer 2 represents the UCU present below the ash and above the UA. Outside of AP1 and AP2, both layers 1 and 2 represent the UCU. Layer 3 represents the UA and the LCU is present in layers 4 and 5. **Figures 5-7 through 5-11** show the bottom elevations of the five model layers. The resulting model layers represent the distribution and change in thickness of each water-bearing unit across the model domain. **Table A** below provides elevation and thickness information for the model layers and hydrostratigraphic units used in the model.

Table A. Flow Model Layer Descriptions

Layer	Hydrostratigraphic Unit Name	Hydrostratigraphic Unit Used to Determine Layer Thickness	Top Elevation [1]	Bottom Elevation [1]	Thickness (feet)
			Mean (Minimum – Maximum)		
1&2	UCU and CCR	Loess Unit of Hagarstown Member and CCR	640 (-)	607.73 (604.0-614.15)	27.1 (26.0-29.85)
3	UA	Hagarstown Member	607.73 (604.0-614.15)	600.9 (580.0-612.0)	5.2 (2.0-34.0)
4	LCU	Vandalia/Mulberry Grove Member	600.9 (580.0-612.0)	588.5 (578.0-594.0)	18.83 (2.0-30.0)
5	LCU	Base of Coffeen Lake	588.5 (578.0-594.0)	540.0 (-)	48.4 (38.0-51.1)

Notes:

[1] Elevation is measured in feet, referenced to NAVD88.

5.2.2.2 Hydraulic Conductivity

Hydraulic conductivity values and sensitivity results are summarized in **Table 5-1.** The spatial distribution of the hydraulic conductivities within the UCU, UA and LCU were considered homogenous. **Figures 5-12 through 5-16** show the spatial distribution of the hydraulic conductivity zones, AP1 and other units on site for each of the five model layers. Construction of the GMF units removed the sands and silts of the UA prior to construction of the liner, therefore the UA is absent beneath these units and liner hydraulic properties are assigned. Conductivity zones that did not have representative site data (*i.e.,* zones 19 and 21, representing the cells above the river cells and the disturbed sediments between the LF and GMF GSP, respectively) were determined through model calibration.

Where available, hydraulic conductivity values were derived from field measured or laboratory tested values reported in the HCR (Ramboll, 2021a) (**Section 2.2.2**). No horizontal anisotropy was assumed. Vertical anisotropy was applied to conductivity zones to simulate preferential flow in the horizontal direction in these materials, and are presented as anisotropy ratio (Kh/Kv) in **Table 5-1**.

The model was highly sensitive to changes in horizontal and vertical hydraulic conductivity in zones 1 (UCU), 2 (UA), and 3 (LCU - unweathered Vandalia), and moderately sensitive to changes in horizontal and vertical hydraulic conductivity in zones 10 (CCR fill-AP1) and 19 (UCU-fill). The model exhibited a negligible to low sensitivity in the remaining zones for both horizontal and vertical conductivity.

5.2.2.3 Recharge

Recharge rates were determined through calibration of the model to observed groundwater elevations. For the calibration model, recharge was applied to the uppermost active layer and the rates varied based on different units, namely the AP1, AP2, GMF GSP, GMF RP, LF, Surface Water Pond, and Cooling Pond. Model inputs are summarized in **Table 5-1**. The distribution of recharge is shown in **Figure 5-17**. Changes in operational history, such as the addition of AP1 to the site in 1977 and the GMF units in 2010 as illustrated in **Figures 5-18 through 5-21,** have been incorporated into the transient model simulation (**Table 5-2**). See **Section 5.2.3.1** for additional discussion of time discretization.

The model had a high sensitivity to changes in recharge in zones 1 (UCU) and 7 (CCR fill - AP1). The model had negligible to low sensitivity to changes in recharge in the remaining zones, with the exception of zone 6 (CCR fill - AP2), where the sensitivity was moderate.

5.2.2.1 Storage and Specific Yield

The flow calibration model did not use these terms because it was run at steady state. For the transport model, which was run as a transient simulation, no field data defining these terms were available so published values were used consistent with Fetter (1988). Specific yield was set to equal effective porosity values described in **Section 5.2.3.5**. The spatial distribution of the storage and specific yield zones were consistent with those of the hydraulic conductivity zones. The sensitivity of these parameters was tested by evaluating their effect on the transport model as described in **Section 5.2.3.6**.

5.2.2.2 River Parameters

Five river reaches were included in the model as head dependent flux boundaries that required inputs for elevation of the surface water, bottom of the stream, width, bed thickness, and bed hydraulic conductivity (**Table 5-1**). The five river reaches were the Unnamed Tributary east of the CPP (reach 0 and reach 5), the Unnamed Tributary west of the CPP (reach 1), ponded surface water west of the LF (reach 2), and the condenser cooling water discharge flume (reach 3). The river and drain information is summarized in **Table B** below.

Table B. River and Drain Information

Name	Boundary Type	Length (feet)	Slope (ft/ft)
Unnamed Tributary East	River	8959.0	-0.0031
Unnamed Tributary East – downstream reach	River	1438.3	-0.0026
Unnamed Tributary West	River	3436.5	-0.0098
Ponded Surface Water West	River	-	-
Condenser Cooling Flume	River	-	-
Active Landfill Underdrain	Drain	2147.0	-
Gravity Drain Recycle Pond	Drain	2181.8	-
North Drain	Drain	3032.0	-

Notes:
ft/ft = feet per foot

In the absence of river geometry information, the DEM was used to estimate stream stage at the upstream and downstream limits of the Unnamed Tributary east of the CPP and the Unnamed Tributary west of the CPP. The surface water stages for the ponded surface water west of the LF and the Condenser Cooling Flume were constant (not sloped) and were also obtained from the DEM. For both Unnamed Tributaries (east and west), the slope of the river was then linearly interpolated along the reaches, providing an estimation of stream stage along the length of each reach for each model grid cell though which the river flows. Bed thickness was set at 2 foot and river width was set at 10 feet. The river bottom is set 3 feet below the stage for both the

Unnamed Tributaries. The downstream reach (reach 5) of the Unnamed Tributary is located in layer 5 of the model adjacent to the SI unit AP2, this layer represents the LCU-Smithboro till and has a low hydraulic conductivity. To increase connectivity of the tributary to the overlying layers, the hydraulic conductivity of the streambed was modified during calibration.

The Condenser Cooling flume stage is maintained at 604.0 feet and the ponded surface water west of the LF was maintained at 617.5 feet, and bed thicknesses for these reaches were set to 1 foot. The width of the Cooling Flume (approximately 52 feet) and ponded surface water west of the LF are larger than the grid cell dimensions (25 feet by 25 feet); therefore, the conductance term for both were based on the area of the cells which coincide with the flume and ponded water.

The model had low to moderate sensitivity to changes in river stage. The model had low to moderately high sensitivity to changes in river conductance, with the exceptions of reach 0 (Unnamed Tributary East) and reach 3 (Condenser Cooling Flume) which had high sensitivity.

5.2.2.3 Drain Parameters

The LF has an active underdrain, which is actively pumped to prevent more than 1-foot of groundwater head above the liner. This was estimated to be 603.5 feet. The GMF RP has a passive drain beneath the liner which discharges water towards the Unnamed Tributary east of the unit. This was estimated to be 600.5 feet. Both the active LF drain and passive GMF RP drain were placed in layer 4 (LCU) below the low hydraulic conductivity zones which represent the base of the lined units. A surface water drain in the north of the model was also included; the placement of this northern drain was determined using google earth imagery. The Northern drain appears to be a man-made feature and no hydrological data are available as to its flow conditions. Therefore, its implementation in the model as a drain makes the fewest assumptions of its interaction with the aquifer. This surface water drain is located in layer 1 and has an elevation of 622.0 feet.

The model had low sensitivity to changes in drain stage. The model had negligible to moderate sensitivity to changes in drain conductance, with the exception of reach 0 (Active LF Underdrain) where the model had moderately high sensitivity to changes in drain conductance.

5.2.2.4 GMF Unit Parameters

All GMF units (GMF GSP, GMF RP, and LF) have a similar liner construction (**Table C** below); they were all implemented into the model using horizontal flow barrier (HFB) package to represent the liner system on the sides of the units. The bottom of the liner is implemented by assigning the liner system hydraulic conductance to model layer 3 within the footprint of the pond. The base elevation of layer 3 within the footprint of the GMF units simulates the base elevation of the liner. The thickness of model layer 3 within the footprint of the pond was set to three feet. Removal of the sands and silts below the GMF units (as described in **Sections 1.4** and **2.1**) means that the liner is in direct contact with the Vandalia Member. The groundwater flow dynamics beneath/around the Ash Landfill and GMF Units is affected by several factors, including: removal of the Hagarstown Member from beneath the Units; presence of the construction dewatering systems around the units; and the lateral variability of lithology within the Hagarstown Member (Hanson, 2016). Drains discussed above were used to represent the underdrains associated with the GMF units. The hydraulic properties within the GMF units were set to represent the CCR.

Estimates of the hydraulic properties of each of the components within the liner system were derived using values from the HELP model; see **Section 5-1** for more information about HELP. For flow perpendicular to the layer orientation, as is the case in the liner where the hydraulic gradient is vertical for the base and horizontal for the sides of the pond, the harmonic mean was used to obtain the effective hydraulic conductivity (K_{eff}) (Fetter, 1988). The harmonic mean was determined by:

$$K_{eff} = \frac{\sum b}{\sum \frac{b}{K}}$$

where b is the layer thickness and K is the horizontal hydraulic conductivity.

HFB input parameters are presented in **Table 5-1**. The model had low to moderate sensitivity to changes in the hydraulic conductivity in the HFB.

Table C. Liner System Properties From Top to Bottom for the GMF GSP, GMF RP, and LF

Liner Component	Thickness (feet)	Hydraulic Conductivity (cm/s)	Hydraulic Conductivity (ft/d)
HDPE geomembrane (60 mil)	0.06	2.0×10^{-13}	5.7×10^{-10}
Recompacted Soil	3.0	1.0×10^{-7}	2.8×10^{-4}
Vertical Harmonic Mean of liner system	**NA**	**NA**	***2.89×10^{-8}***

* Estimated based on available information
ft/d = feet per day
NA = not applicable

5.2.2.5 General Head Boundary

General head boundary conditions (GHB) were used along the northern boundary of the model for layer 3 through 5 (**Figures 5-4 through 5-6**). The GHB at the northern limit of the model represents groundwater entering the model domain from upgradient areas. The GHB is present in layers 3 through 5 and was used to simulate groundwater flow into the model via the UA and LCU. The groundwater levels used for the northern boundary of the model in layers 3 through 5 were estimated using the Dupuit equation for steady state flow in an unconfined aquifer with recharge.

The DEM of the site provided estimates of the surface water levels for Coffeen Lake on the west of the model (591 feet), and Rocky Ford Sportsman Club North Lake (604 feet) on the east of the model domain (refer to **Figure 5-1**). The calibrated ambient recharge to the UCU was used in the calculation of the groundwater level distribution at the northern boundary. The hydraulic conductivity value used in the Dupuit equation was estimated during model calibration.

This GHB was only applied to cells along the northern boundary where the base of the cell was below the calculated groundwater head for a given distance from the constant head boundaries, the head was determined by the Dupuit equation. Cell conductance was then calculated using the cells' saturated thickness and cell width, and hydraulic conductivity were based on cell hydraulic conductivities and adjusted if appropriate during calibration.

The GHB elevation for northern boundary in the UA was established during calibration (**Table 5-1**). The distance to the GHB head was set to 1, and the GHB conductivity was calculated using the cell width, cell thickness, and calibrated hydraulic conductivity from the model.

The sensitivity to changes in specified head was low to moderate, with the exception of reach 3 (Northern Model Boundary in LCU Layer 4) where the model sensitivity was high. The flow calibration model had a negligible sensitivity to changes in conductance.

5.2.3 Transport Model

MT3DMS input values are listed in **Table 5-2** and described below. Sensitivity of the transport model is summarized in **Table 5-3**.

Groundwater transport was calibrated to groundwater sulfate concentration ranges at each well as measured from the monitoring wells between 2015 (where available) and 2021. The transport model calibration targets are summarized in **Table 4-1**.

Sensitivity analysis was conducted by changing input values and observing percent change in sulfate concentration at each well from the calibrated model sulfate concentration. Effective porosity was varied by decreasing and increasing calibrated model values by 0.05. Storage values were multiplied and divided by a factor of 10, and specific yield by a factor of 2. The dispersivity values in the calibrated model were increased by a factor of 5 and 10. The sensitivity of the transport model to changes in the liner conductance was also investigated by increasing and decreasing the hydraulic conductivity of the liner by one order of magnitude (*i.e.*, between one-tenth and ten times).

The transport model had a negligible to moderate sensitivity to changes in storage and specific yield (**Table 5-3**) as discussed in **Section 5.2.3.6**. The transport model ranged from negligible to moderate sensitivity to effective porosity and dispersivity as discussed in **Sections 5.2.3.5** and **5.2.3.7**, respectively. The sensitivity to the liner conductivity was negligible to low as discussed in **Section 5.2.3.2**.

5.2.3.1 Time Discretization and Stress Periods

The evolution of the CPP required changes to the hydraulic properties within the model; this is not possible in a single model where hydraulic properties as assumed to remain constant. As a result, the changes in the site (*e.g.,* inclusion of the GMF units) are simulated in three consecutive numerical models, as summarized in **Table D** below. The simulation length was revised from the existing model to extend to the current time (2022).

Table D. Transient Model Setup and Time Discretization

Date	Model	Stress Period	Operational Change	Previous model
Pre-1970	Steady-State	NA	No CCR units present	Not applicable
1970-2010	Transient (TR-1)	1:1970-1985	AP2 only	Steady State Pre-1970 flow
		2:1985-2010	AP2 and AP1 in operation	
2010-2018	Transient (TR-2)	1:2010-2018.	AP1, GMF GSP and GMF RP in operation.	TR-1 as initial flow and concentrations

2018-2022	Transient (TR-3)	1:2018-2022	Modification to lined units GMF GSP and GMF RP, AP2 capped	TR-2 as initial flow and concentrations

Notes:
TR = transient model

5.2.3.2 GMF Units

Groundwater chemistry data from wells G215 (located adjacent to the GMF GSP), and wells G275 and G279 (located adjacent to the GMF RP), indicate an increase in sulfate concentrations post 2018 when compared with sulfate concentrations in adjacent wells. Sulfate concentrations in G215 have experienced further increases since 2021. Sulfate concentrations around the GMF RP tend to be higher than those around the GMF GSP, with elevated sulfate concentrations observed since 2015 (the earliest sampling date). Elevated sulfate concentrations along the southern boundary of the GMF RP are associated with historic groundwater impacts from AP2. However, wells G275 and G279 are located along the eastern boundary of the pond and have elevated sulfate concentrations. To simulate observed sulfate concentrations at these isolated wells (GMF GSP well G215, and GMF RP wells G275 and G279), the hydraulic conductivity of the liner (simulated using HFB) was increased to allow sulfate migration from the CCR unit in the transient model TR-3, as shown in **Figure B** below and **Table D** above.

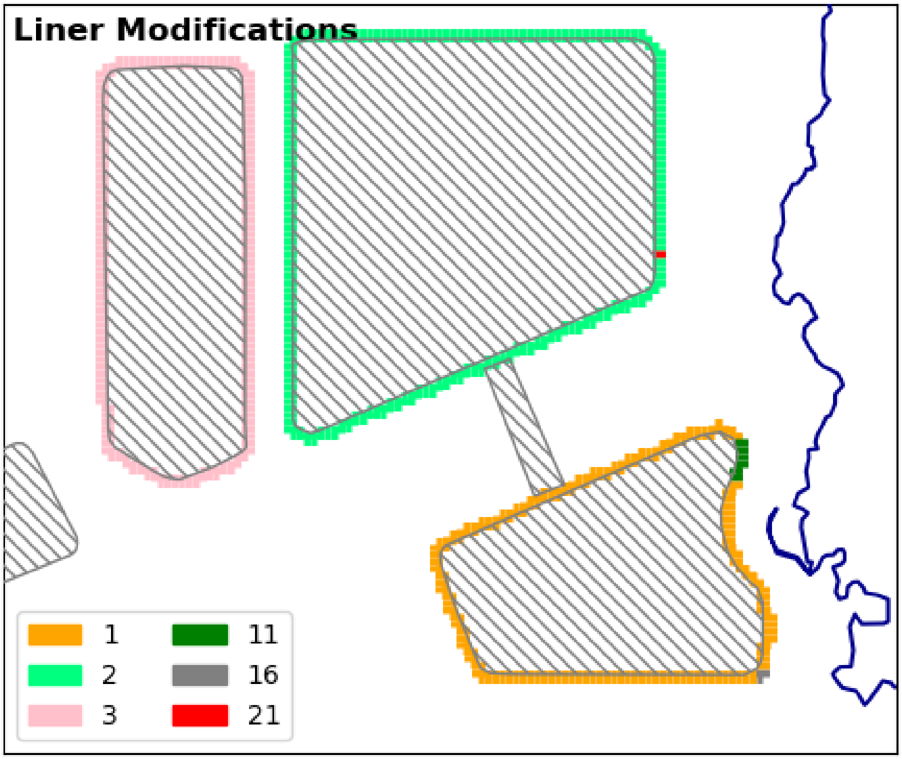

Figure B. Liner Modification Zones

As part of the transport calibration process, the hydraulic conductivity of HFB reaches 11, 16, and 21 were modified to simulate the observed rises in sulfate. The changes are summarized in **Table 5-2**. Model sensitivity near the GMF ponds is discussed in the Groundwater Modeling

Report, *GMF Gypsum Stack Pond and GMF Recycle Pond, Coffeen Power Plant, Coffeen Illinois* (Ramboll, 2022).

The monitoring wells associated with AP1 show negligible to low sensitivity to changes in the GMF liner conductivity (**Table 5-3**). AP1 Is located approximately 2,500 foot south of the GMF SIs, any changes in groundwater flow and transport will be minimal in proximity to AP1.

5.2.3.3 Initial Concentration

No initial concentrations were placed in the steady state flow calibration model. The flow model was run as transient and concentration was added to the model through recharge starting at the same time as the transient flow simulation. Modeling was performed for a sufficient period (42 years) to allow modeled concentrations in the primary transport layer (*i.e.,* UA) to reach recently observed levels.

Modeling was performed over three numerical models which mirror the operational developments at the CPP. **Table 5-2** provides an overview of how the source concentrations and recharge rates change through time.

5.2.3.4 Source Concentration

Five sources in the form of vertical percolation (recharge) and constant concentration cells were simulated in the CCR material for calibration (**Table 5-2**) (in chronological order): (i) percolation through CCR in AP2 (1970-2022), (ii) percolation through CCR in AP1 (1978-2022), (iii) percolation through CCR in GMF RP (2010-2022), (iv) percolation through CCR in GMF GSP (2010-2022), and (v) percolation through CCR in GMF LF (2010-2022). All five sources were simulated by assigning concentration to the recharge input. The CCR sources were also simulated with constant concentration cells placed where CCR was present (**Figures 5-18 through 5-21**) to simulate saturated CCR conditions. From the model perspective, this means that when the simulated water level is above the base of these cells, water that passes through the cell will take on the assigned concentration. All source concentrations were calibrated in the transport model to the sulfate concentration data collected from November 2015 to August 2021. The source concentrations applied to the recharge zones and saturated ash cells immediately below the recharge zones have the same concentration values. **Table 4-1** indicates that the background sulfate concentrations (identified with a "B" for background in the "CCR unit" column) at CPP show considerable variability across the site, from 11 mg/L (G286) to 770.0 mg/L (G288). No background sulfate concentration was applied to recharge beyond the source areas in the model.

Because these are the sources of concentration in the model, the model will be highly sensitive to changes in the input values. For that reason, sensitivity testing was not completed for the source values.

5.2.3.5 Effective Porosity

Effective porosity for each modeled hydraulic conductivity zones were based on the NRT model (2017b), data from the HCR (Ramboll, 2021a), and literature values (Fetter, 2001) and are presented in **Table 5-2**.

The model had a negligible to moderate sensitivity to changes in porosity values (**Table 5-3**). The greatest sensitivity for porosity was moderate for the high porosity sensitivity test at monitoring locations G305, G306, and G317. Moderate sensitivity at monitoring well G317 was also observed for the low porosity sensitivity test.

5.2.3.6 Storage and Specific Yield

The transport model had a negligible to low sensitivity to changes in storage and specific yield, with the exception of sensitivity at monitoring wells G306, G307, and G317, where sensitivity was moderate (**Table 5-3**).

5.2.3.7 Dispersivity and Diffusion

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).

Longitudinal dispersivity was 10 feet in the UA and 1 foot in the UCU and LCU, with transverse and vertical dispersion coefficients assuming a ratio of 1/10 and 1/100.

The model had a negligible to moderate sensitivity to changes in dispersivity values (**Table 5-3**). The greatest sensitivity for dispersivity was moderate for the highest dispersivity sensitivity test at monitoring well locations G313, G314, G316, and G317. Sensitivity was also moderate for the lower dispersivity sensitivity test at monitoring well locations G313 and G317.

5.2.3.8 Retardation and Decay

It was assumed that sulfate 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, sulfate, and TDS 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 and sulfate (Geosyntec, 2022b; **Appendix C**) for locations G311 and G313. Results of the testing are summarized below:

- Boron: The Freundlich isotherm (K_F) fit the data best for G313/SB306 and G313/SB313, yielding K_F values of 0.65 liters per kilogram (L/kg) and 2.03 L/kg, respectively. Though slightly higher at G313/SB313, these values are comparable to boron partition coefficients reported in 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). No partition coefficient was calculated for G311.
- Sulfate: The G311 partition coefficient for sulfate ranged from -624 L/kg for the Langmuir isotherm (K_L) to 10.11 L/kg for the linear isotherm (K_D), but the best-fitting Freundlich isotherm yielded a low K_F value of 9.2×10^{-12} L/kg. None of the isotherms showed a high goodness-of-fit (*i.e.,* R^2) for either G313/SB306 or G313/SB313, with the highest correlation being 0.05, and were associated with erroneously high (1,700 L/kg) and low (-690 L/kg) partition coefficients. An accurate sulfate partition coefficient could therefore not be calculated from any of the data. These results are consistent with the findings of Strenge and Peterson

(1989), who found that partition coefficients for sulfate are 0.0 L/kg, regardless of pH conditions and the amount of sorbent present.

The results from site samples are variable with poor goodness of fit which supports modeling sulfate without retardation. The potential exceedances identified in groundwater (boron, sulfate, and TDS) 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 sulfate transport in the model (*i.e.*, Kd was set to 0 mL/g). Sensitivity tests were not run for retardation.

5.3 Flow and Transport Model Assumptions and Limitations

Simplifying assumptions were made while developing this model:

- Leading up to 2022, the groundwater flow system cannot be simulated as steady state.
- Natural recharge is constant over the long term.
- Fluctuations in lake stage do not affect groundwater flow and transport over the long term.
- Hydraulic conductivity is consistent within hydrostratigraphic units.
- The approximate base of ash surface in the AP1, GMF GSP, GMF RP, and LF were developed with Golder using soil borings and historic topographic maps.
- Source concentrations are assumed to remain constant over time.
- Sulfate 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 located near the units on site, 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 in 2021.

5.4 Calibration Flow Model

The groundwater model was manually calibrated to best approximate the mean groundwater elevations in 95 wells at the site. The mean elevations used for calibration and locations of wells within the flow model are summarized in **Table 4-1** Well locations are shown in **Figure 2-1**. This involved modifying the hydraulic conductivities of the different hydrostratigraphic units, recharge rate, and conductance of the drains, rivers, and general head boundaries within the model to minimize the difference between the mean observed groundwater elevation and simulated groundwater elevation. Where possible, the range of the parameter values used during calibration were based on observed values (*i.e.,* for the range in hydraulic conductivity estimates from the HCR). Where this was not possible, such as for the drain and general head boundary conductance, the range of parameter values were based on other site information or inferred from knowledge from similar sites. Where data were limited, the parameter values were less constrained during calibration (*e.g.,* parameter values had wider ranges). The SSR was used as a metric to identify the optimal values for the different parameters.

5.5 Calibration Flow and Transport Model Results

Results of the MODFLOW modeling are presented below. The model files accompany this report (**Appendix B**). **Table 5-1** shows the calibrated hydraulic conductivity for the different units shown in **Figures 5-12 through 5-16**.

Groundwater model calibration results are presented in **Figure 5-22** and **Figure 5-23**, which shows the observed and simulated groundwater elevations and the observed groundwater elevations versus residuals. The near-linear relationship between observed and simulated values presented on **Figure 5-22** indicates that the model adequately represents the calibration dataset. The root mean squared error of the groundwater elevation across all wells was 1.92 feet. The mass balance error for the flow model was 0.00 percent and the ratio of the residual standard deviation to the range of heads was 9.0 percent, which is below the desired target value of 10 percent. Another flow model calibration goal is that residuals are evenly distributed such that there is no bias affecting modeled flow. The observed heads are plotted versus the simulated heads in **Figure 5-23** and simulated values are evenly distributed above and below observed values. The residual mean was also near zero with a value of 0.10 feet, indicating a small bias towards underestimating the groundwater elevations in the calibrated model; this is also illustrated in the observed versus residuals plot in **Figure 5-23**.

The simulated groundwater elevations within the UA (layer 3) for the entire site are shown in **Figure 5-24**. **Figure 5-25** shows the simulated groundwater elevations in proximity to AP1. In general, the model is able to simulate the groundwater flow patterns for the UA (**Figure 2-2** and **Figure 2-3**) at AP1 as interpreted from the site well data for April and July 2021, respectively. The simulated groundwater flow pattern also captures the radial flow pattern centered on the southwest area of AP1. Fourteen wells provided calibration targets for the simulated groundwater level around AP1. The simulated groundwater levels for five of these wells are within 1 foot; six wells are within 2 feet. G303 and G312 are underestimated by 2.14 feet and 3.06 feet respectively, and G309 is overestimated by 2.24 feet.

The range of observed sulfate concentrations for transport calibration locations are summarized in **Table 4-1**. The goals of the transport model calibration were to have predicted concentrations fall within the range of observed concentrations, and to have predicted concentrations above and below the GWPS for sulfate (400 mg/L) match observed concentrations above or below the standard at each well. One or both of these goals were achieved at all of the transport calibration location wells, except G317, where concentrations were underpredicted (**Figure 5-26**). Deviations from the observed ranges are discussed below.

The model underpredicts concentrations at G305 and G317. The observed sulfate concentrations range from 710 to 930 mg/L and 780 to 1100 mg/L for G305 and G317, respectively. The predicted concentrations are 424.8 mg/L and 146.8 mg/L for G305 and G317, respectively. G305 is located south of AP1 (**Figure 2-1**) in close proximity to the mine entrance discussed in **Section 2.2.4** and shown in **Figure 1-2**. The disturbance associated with the former mining activity may be associated with the elevated sulfate concentrations in this well. G317 is located southeast of AP1, downgradient of G303 (whose predicted sulfate concentration is within the observed range). Groundwater flow in this area is predominantly towards Coffeen Lake (west to east). There is aerial and topographic evidence supporting the presence of a soil pile related to the mining activities in the area west (upgradient) of G317 (see **Section 2.2.4**). One soil boring completed through the soil pile documents the presence of coal in the boring log, indicating the soil pile may be another source of sulfate. This soil pile may potentially leach sulfate into the groundwater thereby increasing the sulfate concentration at G317 above that which would be attributed to AP1 alone.

The remaining calibration locations had predicted concentrations that fall within the range of observed concentrations and/or have predicted concentrations above and below the GWPS for sulfate (400 mg/L) matching observed concentrations above or below the standard at each well. In other words, there was a very good match between predicted and observed sulfate concentrations relative to wells with concentrations above and below the GWPS. The transport model has achieved a very good calibration using a sulfate source concentration of 1,000 mg/L, even though some wells have observed concentrations that are greater than the source concentration used. The distribution of sulfate concentrations in the calibrated model are presented on **Figure 5-27**.

6. PREDICTIVE SIMULATIONS

6.1 Overview and Prediction Model Development

Prediction simulations were performed to evaluate the effects of closure (source control measures) for AP1 on groundwater quality. The prediction simulations evaluated changes in groundwater sulfate concentrations from Scenario 1: CIP (removal of CCR from the eastern portion of AP1 and consolidation into the western portion of the AP1) and Scenario 2: CBR (removal of all CCR material from AP1). As discussed in **Section 5.2.3.7** physical attenuation (dilution and dispersion) of contaminants in groundwater is simulated in MT3DMS, which captures the physical process of natural attenuation as part of corrective actions for both closure scenarios simulated. No retardation was applied to sulfate transport in the model (*i.e.,* Kd was set to 0 mL/g) as discussed in **Section 5.2.3.8**.

Closure scenarios were simulated by initially removing free liquids from the CCR material over the course of 2 years by placing drain cells within AP1 with an elevation of 618 feet and applying zero recharge to simulate dewatering of the CCR units.

HELP-calculated percolation rates, based on removal and final soil backfill grading designs provided in the Final Closure Plans for AP1 (Golder, 2022a), GMF GSP (Golder, 2022b), and GMF RP (Golder, 2022c), were applied for the different closure scenarios. HELP modeling input and output values are summarized in **Table 6-1** and described in detail below.

The CIP and CBR scenarios were simulated for a 100-year period. The following simplifying assumptions were made during the simulations:

- Removal of free liquids from CCR takes place prior to the CIP and CBR closure scenarios. Drain cells were placed within the units to simulate the removal of free water within the ponds; and recharge was set to zero.
- In the CIP and CBR closure scenarios, HELP-calculated average annual percolation rates were developed from a 30-year HELP model run. This 30-year HELP-calculated percolation rate remained constant over duration of the closure scenario prediction model runs following CCR dewatering period.
- Changes in recharge resulting from removal of free liquids (decrease calibration model recharge rates to zero) and CCR fill removal/final soil backfill grading (recharge rates are based on HELP-calculated average annual percolation rates) have an instantaneous effect on recharge and percolation through surface materials.
- Sulfate source concentrations were assumed to be negligible (0 mg/L) in CCR removal areas in both the CIP and CBR scenarios. The spatial distribution of CCR concentrations within the consolidation area for the CIP scenario were maintained from the initial transport simulation.
- Cap construction in CIP scenario was assumed to be completed with a cover system consisting of the following (listed from ground surface down): a vegetative cover (6 inches thick), rooting zone (18 inches thick), a 200-mil geocomposite drainage layer and a 40-mil linear HDPE geomembrane.
- The start of each closure prediction simulation was initiated at the end of the calibration model period of 42 years plus 2 years to complete removal of free liquids. For example, the

simulation of Scenario 1: CIP begins at 44 years (42 years for calibration plus 2 years). The prediction modeling timeline for each scenario is illustrated in **Figure 4-1**.

- CCR consolidation/removal areas were assumed to be graded and include proper drainage controls to remove excess water from the surface using the design drawings provided (Golder, 2022a).
- The CIP scenario includes the placement of a stormwater pond within the removal area. The outflow elevation of this stormwater pond is 625 feet, which will discharge into Coffeen Lake adjacent to the AP2. This is represented as a drain in the model whose elevation is equal to the stormwater pond outflow elevation.
- Local fill materials applied to the prediction models have similar hydraulic properties as the UCU materials used in the transport calibration models. However, the local fill materials were assumed to have reduced vertical anisotropy ratios, approaching isotropic, due to reworking of the material as it is placed as backfill (Kh/Kv decreased from measured values of 10 to 1 for reworked material).

6.2 HELP Model Setup and Results

HELP (Version 4.0; Tolaymat and Krause, 2020) was used to estimate percolation through AP1 in areas of CCR removal with soil backfill, and areas of CCR consolidation with final cover system. 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 Belleville Scott Air Force Base in Belleville, Illinois (the closest weather station included in the HELP database). Precipitation, temperature, and solar radiation was simulated based on the latitude of CPP. Thickness of soil backfill and soil runoff input parameters were developed for the ash fill removal scenarios using data provided in the Final Closure Plans for AP1 (Golder, 2022a), GMF GSP (Golder, 2022b), and GMF RP (Golder, 2022c).

HELP model results (**Table 6-1**) indicated 7.85 inches of percolation per year for AP1 CCR removal and soil backfill area in the CIP scenario and 0.00027 inches of percolation per year through the CCR and final cover system for the CIP scenario. Results indicated 7.85 inches and 6.28 inches of percolation per year for AP1 eastern and western CCR removal and soil backfill area in the CBR scenario, respectively. The differences in HELP model runs for each area included the following parameters: area, soil backfill thickness, slopes, 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 B.**

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 D**.

6.3 Simulation of Closure Scenarios

The calibrated model was used to evaluate the effectiveness of the two closure scenarios by defining CCR removal and consolidation areas, reducing head to simulate removal of free liquids, removing source concentrations from the removal areas, adding drain cells and removing recharge to simulate stormwater management within the removal areas, and applying reduced recharge in the CCR consolidation areas to simulate the effects of the cover system on flow and transport. Removal of source inputs from the ash removal areas was simulated by reducing the sulfate concentrations associated with recharge in the areas to 0 mg/L and removing constant concentration cells.

Each prediction scenario was simulated as a continuation of the AP1 dewatering simulation which followed the transient calibrated model. The prediction model input values are summarized in **Table 6-2,** and the modifications to the recharge zones and drain placement for the CIP scenario are illustrated in **Figure 6-1**. **Figure 6-2** illustrates the CCR removal area for the CBR at the AP1. The two closure scenarios are discussed in this report based on predicted changes in sulfate concentrations as described below and results are presented in **Figure 6-3 to Figure 6-6**.

6.3.1 Closure in Place Model Results

The design for Scenario 1: CIP includes an initial 2-year dewatering period to remove free liquids followed by CCR removal from AP1, consolidation in the western area of AP1, and construction of a cover system over the remaining CCR (**Figure 6-1**). Stormwater drainage will be present within the eastern area of AP1 with an outflow elevation of 625 feet.

Predicted concentrations start to decline at all monitoring wells with observations above the GWPS for sulfate (400 mg/L) once closure actions are initiated within the prediction model. These declines occur first in the eastern area where CCR is removed and saturated ash cells (constant concentration cells) are reduced in the area of the highest modeled source concentrations. Following removal of CCR in the eastern area, sulfate concentrations are no longer entering the model domain from recharge or from saturated ash cells (constant concentration cells). Dewatering also reduces the head within AP1. These low heads are maintained following completion of closure by the drain cells that simulate storm water management designs within the removal area to the east, and by the greatly reduced infiltration rates (recharge) that result from placement of the cover system over the consolidated CCR in the western end of AP1. As a result of the reduced heads and recharge, downward percolation of solute mass from AP1 is reduced, which decreases the sulfate concentration entering the model domain.

The predictive model indicates that most wells will reach the GWPS (400 mg/L) in under 14.8 years following closure, with one exception. **Figure 6-3** and **Figure 6-4** show the extent of the plume in the UA after 14.8 years and the maximum extent of the plume in the model after 14.8 years, respectively. The predicted delayed reduction in concentration at well G301, 58.8 years, is a result of the well's location along the flow path of the residual sulfate concentrations released into native geologic materials prior to closure. All UA groundwater monitoring wells are below the GWPS within 58.8 years (**Figure 6-5** and **Figure 6-6**). The residual sulfate plume in the UA from the calibrated model remains in close proximity to AP1 as it recedes over time. The predicted footprint of the sulfate plume in the UA after 58.8 years shown in **Figure 6-5** is considerably reduced from that at the end of the transient model simulation (**Figure 5-27**).

The predicted delayed reduction in concentration at well G301 is a result of the well's location along the flow path of the residual sulfate concentrations released into native geologic materials prior to closure. Reduced percolation rates through the consolidation area within AP1 in the CIP scenario means that the residual sulfate concentrations require a longer time period to migrate through native geologic materials.

Evaluations of post-construction water flux through the consolidated and covered Fill Unit (CCR) were completed using data obtained from the Scenario 1 (CIP) prediction model when simulated post-construction heads in the groundwater monitoring wells are predicted to stabilize (once heads stabilized in the model, the post-construction movement of water in and out of the Fill Unit [CCR] were compared to pre-construction conditions). The pre-construction (calibration model) and post-construction Scenario 1 (CIP) prediction model simulated water flux values are summarized in **Appendix E** and discussed below. Data export files used for flux evaluations are found along with model files in **Appendix B**.

Scenario 1 (CIP) was predicted to reduce total flux in and out of the Fill Unit (CCR) by approximately 99.9%, when simulated post-construction heads in the groundwater monitoring wells are predicted to stabilize (approximate hydraulic steady state) as illustrated in **Figure 6-7**. **Figure 6-8** is a plot showing the changes in flux reduction (shown as negative percentage) over time starting from implementation of Scenario 1 (CIP) through approximate hydraulic steady state conditions. Following implementation of Scenario 1 (CIP), influx into the CCR unit decreases rapidly as illustrated in **Figure 6-8**. Following removal of free-liquids, the consolidated CCR is no longer in contact with groundwater. Thus, the modeling indicates consolidation and closure with the proposed cover system result in 99.9% reduction in outflux after 10 days (**Figure 6-8**). The outflux from the CCR unit remains relatively constant throughout the CIP simulation.

Further, the base of consolidated CCR was compared to the simulated steady-state groundwater elevations which indicate between 3.2 and 10 feet of separation will be present between the base of CCR and groundwater (**Figure 6-9**).

6.3.2 Closure by Removal Model Results

The design for Scenario 2: CBR includes an initial 2-year dewatering period followed by CCR removal from AP1 (**Figure 6-2**). Stormwater drainage is present within AP1 with an outflow elevation of 625 feet.

For most wells, predicted concentrations for CBR start to decline at monitoring wells with observations above the standard GWPS for sulfate (400 mg/L) once the closure actions are initiated within the prediction model. The concentration of sulfate in some wells (most notably G315, G307 and G308) show short term fluctuations (less than 5 years) following the removal of concentration during the dewatering phase, such that sulfate concentrations decline and are followed by a short rise before the impacts of the CBR are clearly observed. The general decline in sulfate concentration occur as the CCR is removed from AP1 and saturated ash cells (constant concentration cells) are removed. Following removal of CCR, sulfate concentrations are no longer entering the model domain from recharge or from saturated ash cells (constant concentration cells); all source concentrations are removed. Dewatering through removal of free liquids also reduces the head within AP1. These low heads are maintained following completion of closure by the drain cells that simulate storm water management designs within AP1. The removal of the CCR sources leads to the gradual reduction the residual sulfate concentrations released into native geologic materials prior to closure. All monitoring wells with observations above the standard GWPS for sulfate (400 mg/L) are predicted to be below the GWPS 18.1 years after closure implementation (**Figure 6-3**).

The sulfate plume in the CBR prediction model differs from that in the CIP prediction model. Higher recharge rates are present in the western portion of the pond because there is no cover system. The relatively higher recharge rates maintain components of the radial flow pattern described in **Section 2.2** at AP1. However, the stormwater drainage within the pond does constrain the groundwater elevation beneath AP1. As a result of the radial flow pattern, the prediction model indicates that a portion of the historic plume will remain along the western edge of AP1 as the plume recedes over time. The maximum extent of the plume at 14.8 years is illustrated in **Figure 6-4**. The maximum extent of the plume remains in close proximity to AP1 and is no longer present above the GWPS (400 mg/L) at 58.8 years as illustrated in **Figure 6-6**.

7. CONCLUSIONS

This GMR has been prepared to evaluate how proposed CIP and CBR scenarios will achieve compliance with the applicable groundwater standards at the CPP for AP1. An existing groundwater model was updated to include data collected from the recent 2021 field investigations and used to predict the impacts of the closure scenarios on groundwater quality at the CPP. Statistically significant correlations between sulfate concentrations and concentrations of TDS identified as potential exceedances of the GWPS indicate sulfate is an acceptable surrogate for TDS in the groundwater model. Concentrations of TDS are expected to change along with model predicted sulfate concentrations. A potential exceedance of boron was observed at one monitoring well, G313, which also has potential exceedances of both sulfate and TDS. Similar source and behavior in the groundwater system would be expected among boron, sulfate, and TDS at UA monitoring well G313, and boron concentrations are expected to change along with model predicted sulfate concentrations. It was assumed that sulfate would not significantly sorb or chemically react with aquifer solids (Kd was set to 0 mL/g) which is a conservative estimate for predicting contaminant transport times in the model. The MODFLOW and MT3DMS models were used to evaluate two scenarios using information provided in the Final Closure Plan for AP1 (Golder, 2022a):

- **Scenario 1:** CIP including removal of CCR from the eastern portion of AP1, consolidation into the western portion of AP1, and construction of a cover system over the remaining CCR.
- **Scenario 2:** CBR including removal of all CCR and regrading of the removal area.

Scenario 1 (CIP) was predicted to reduce total flux in and out of the Fill Unit (CCR) by approximately 99.9%, when simulated post-construction heads in the groundwater monitoring wells are predicted to stabilize. Additionally, the base of consolidated CCR was compared to the simulated steady-state groundwater elevations which indicate between 3.2 and 10 feet of separation will be present between the base of CCR and groundwater.

Differences exist in the timeframes to reach the GWPS for most monitoring wells between CIP and CBR. In general, the simulated groundwater concentrations in the monitoring wells within the UA will achieve the GWPS in 15 years and 18 years respectively for the CIP and CBR closure scenarios, with the exception of well G301 in the CIP scenario. The predicted delayed reduction in concentration at well G301, 59 years to reach the GWPS, is a result of the well's location along the flow path of the residual sulfate concentrations released into native geologic materials prior to closure. Reduced percolation rates through the consolidation area at the northwest corner of AP1 in the CIP scenario means that the residual sulfate concentrations in this limited area require a longer time period to migrate through native geologic materials.

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TABLES

TABLE 2-1. MONITORING WELL LOCATIONS AND CONSTRUCTION DETAILS

GROUNDWATER MODELING REPORT
COFFEEN POWER PLANT
ASH POND NO. 1
COFFEEN, ILLINOIS

Well Number	HSU	Date Constructed	Top of PVC Elevation (feet)	Measuring Point Elevation (feet)	Measuring Point Description	Ground Elevation (feet)	Screen Top Depth (feet bgs)	Screen Bottom Depth (feet bgs)	Screen Top Elevation (feet)	Screen Bottom Elevation (feet)	Well Depth (feet bgs)	Bottom of Boring Elevation (feet)	Screen Length (feet)	Screen Diameter (inches)	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)
G045D	LCU	08/17/2016	623.81	623.81	Top of PVC	620.94	31.88	41.52	589.06	579.42	41.92	578.90	9.6	2	39.064349	-89.396281
G046D	LCU	08/19/2017	625.24	625.24	Top of PVC	621.91	41.61	51.26	580.30	570.65	51.65	569.90	9.7	2	39.060305	-89.398524
G101	UA	02/02/2010	--	627.60	Top of Disk	625.27	15.68	20.32	609.59	604.95	20.89	603.40	4.6	2	39.071386	-89.400107
G102	UA	04/28/2006	--	629.04	Top of Disk	626.18	12.02	16.78	614.16	609.40	17.15	609.00	4.8	2	39.071387	-89.398991
G103	UA	02/15/2010	--	633.80	Top of Disk	627.94	15.88	20.67	612.06	607.27	21.09	606.90	4.8	2	39.070412	-89.399107
G104	UA	02/15/2010	--	632.94	Top of Disk	627.96	14.91	19.61	613.05	608.35	20.08	605.80	4.7	2	39.069451	-89.399104
G105	UA	02/16/2010	--	632.08	Top of Disk	626.86	16.11	20.90	610.75	605.96	21.37	604.40	4.8	2	39.068491	-89.3991
G106	UA	02/16/2010	--	631.15	Top of Disk	625.96	14.37	18.96	611.59	607.00	19.44	605.50	4.6	2	39.06753	-89.399097
G107	UA	02/17/2010	630.22	630.22	Top of Disk	628.20	13.87	18.50	614.33	609.70	19.00	607.50	4.6	2	39.067106	-89.399646
G108	UA	02/12/2010	--	630.22	Top of Disk	625.58	16.82	21.50	608.76	604.08	22.00	603.60	4.7	2	39.066984	-89.400035
G109	UA	02/11/2010	--	629.76	Top of Disk	624.79	15.39	19.93	609.40	604.86	20.50	604.30	4.5	2	39.067045	-89.400423
G110	UA	02/11/2010	--	629.65	Top of Disk	624.81	15.05	19.59	609.76	605.22	20.16	604.70	4.5	2	39.067172	-89.400704
G111	UA	02/11/2010	--	629.90	Top of Disk	625.28	14.61	19.15	610.67	606.13	19.72	605.60	4.5	2	39.067292	-89.40097
G119	UA	02/09/2010	--	631.55	Top of Disk	626.57	17.29	21.83	609.28	604.74	22.38	604.20	4.5	2	39.068986	-89.401213
G120	UA	02/08/2010	--	631.87	Top of Disk	627.21	15.10	19.62	612.11	607.59	20.21	605.10	4.5	2	39.069479	-89.401214
G121	UA	02/04/2010	--	632.83	Top of Disk	627.94	16.79	21.47	611.15	606.47	21.95	603.80	4.7	2	39.069781	-89.401216
G122	UA	02/04/2010	--	632.69	Top of Disk	628.05	16.51	21.05	611.54	607.00	21.66	606.20	4.5	2	39.070098	-89.401218
G123	UA	02/04/2010	--	632.96	Top of Disk	628.12	20.94	25.46	607.18	602.66	26.07	602.10	4.5	2	39.070399	-89.401219
G124	UA	02/03/2010	--	633.39	Top of Disk	628.70	15.98	20.51	612.72	608.19	21.06	606.70	4.5	2	39.070715	-89.40122
G125	UA	02/03/2010	--	633.51	Top of Disk	628.85	17.03	21.56	611.82	607.29	22.04	606.80	4.5	2	39.071003	-89.401221
G126	UA	02/10/2010	--	625.39	Top of Disk	622.96	12.89	17.43	610.07	605.53	18.00	605.00	4.5	2	39.067304	-89.401274
G151	UA	12/19/2011	--	625.93	Top of Disk	622.82	15.34	19.84	607.48	602.98	20.46	602.40	4.5	2	39.0672	-89.40159
G152	UA	12/20/2011	--	626.52	Top of Disk	623.06	13.59	18.09	609.47	604.97	18.57	604.50	4.5	2	39.066275	-89.401289
G153	UA	12/15/2011	626.35	626.40	Top of Disk	623.23	15.90	20.34	607.33	602.89	20.80	602.50	4.4	2	39.065857	-89.402567
G154	UA	12/16/2011	--	626.35	Top of Disk	623.52	14.26	18.76	609.26	604.76	19.10	603.50	4.5	2	39.067089	-89.403574
G155	UA	12/19/2011	--	625.86	Top of Disk	622.89	15.09	19.58	607.80	603.31	23.23	599.70	4.5	2	39.067493	-89.402659
G200	UA	02/25/2008	--	625.94	Top of Disk	623.27	12.19	16.98	611.08	606.29	17.36	605.30	4.8	2	39.075139	-89.395009
G201	UA	02/25/2008	627.15	627.15	Top of Riser	624.19	13.01	17.80	611.18	606.39	18.15	606.00	4.8	2	39.075141	-89.397829
G205	UA	02/21/2008	--	624.34	Top of Disk	622.10	10.04	14.53	612.06	607.57	15.07	606.10	4.5	2	39.068596	-89.394147
G206	UA	10/14/2010	--	632.82	Top of Disk	630.53	17.51	21.92	613.02	608.61	22.42	606.50	4.4	2	39.067399	-89.398548
G206D	DA	01/25/2021	634.14	634.14	Top of PVC	631.41	49.20	59.00	582.21	572.41	59.39	571.41	9.8	2	39.067428	-89.398493
G207	UA	10/08/2010	--	633.21	Top of Disk	630.61	18.24	22.77	612.37	607.84	23.30	606.60	4.5	2	39.067568	-89.397952
G208	UA	10/07/2010	--	633.16	Top of Disk	630.57	17.53	22.06	613.04	608.51	22.60	606.60	4.5	2	39.067743	-89.397402
G209	UA	10/07/2010	--	632.91	Top of Disk	630.57	17.74	22.28	612.83	608.29	22.81	606.60	4.5	2	39.067923	-89.39685
G210	UA	10/06/2010	--	632.99	Top of Disk	630.48	19.39	23.93	611.09	606.55	24.46	605.50	4.5	2	39.068088	-89.396322
G211	UA	10/11/2010	--	632.64	Top of Disk	630.31	17.34	21.88	612.97	608.43	22.41	606.30	4.5	2	39.068263	-89.395792
G212	UA	10/11/2010	--	632.89	Top of Disk	630.59	16.74	21.29	613.85	609.30	21.81	606.60	4.6	2	39.06843	-89.395318
G213	UA	10/12/2010	--	632.81	Top of Disk	630.34	16.75	21.29	613.59	609.05	21.82	606.30	4.5	2	39.068585	-89.394822
G214	UA	10/14/2010	--	632.85	Top of Disk	630.39	17.75	22.14	612.64	608.25	22.65	606.40	4.4	2	39.068919	-89.393982
G215	UA	10/13/2010	--	633.06	Top of Disk	630.48	19.41	23.80	611.07	606.68	24.31	606.20	4.4	2	39.069309	-89.39394

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G216	UA	10/13/2010	--	632.76	Top of Disk	630.28	20.04	24.42	610.24	605.86	24.93	604.30	4.4	2	39.069765	-89.393946
G217	UA	10/12/2010	--	633.10	Top of Disk	630.67	20.49	24.88	610.18	605.79	25.38	604.70	4.4	2	39.07034	-89.393959
G218	UA	10/12/2010	--	633.11	Top of Disk	630.64	20.33	24.77	610.31	605.87	25.27	604.60	4.4	2	39.070876	-89.393956
G270	UA	02/26/2008	--	625.86	Top of Disk	623.73	13.13	17.92	610.60	605.81	18.27	605.50	4.8	2	39.066564	-89.397403
G271	UA	09/10/2009	--	625.57	Top of Disk	622.89	9.96	14.31	612.93	608.58	14.79	606.90	4.4	2	39.065007	-89.395587
G272	UA	09/10/2009	--	623.81	Top of Disk	620.72	9.11	13.98	611.61	606.74	14.32	606.40	4.9	2	39.064989	-89.394785
G273	UA	09/10/2009	--	623.02	Top of Disk	620.17	9.08	14.56	611.09	605.61	15.10	604.20	5.5	2	39.064985	-89.393973
G274	UA	09/16/2009	--	624.04	Top of Disk	621.67	12.90	17.67	608.77	604.00	18.06	603.60	4.8	2	39.064991	-89.393198
G275	UA	09/16/2009	--	618.26	Top of Disk	616.14	8.22	12.62	607.92	603.52	13.19	603.00	4.4	2	39.065151	-89.392561
G275D	DA	01/14/2021	620.31	620.31	Top of PVC	617.52	49.76	59.55	567.76	557.97	59.89	517.80	9.8	2	39.065121	-89.392595
G276	UA	09/16/2009	--	632.00	Top of Disk	629.14	22.41	27.22	606.73	601.92	27.65	601.10	4.8	2	39.065534	-89.392617
G277	UA	09/14/2009	--	623.08	Top of Disk	620.79	14.29	18.77	606.50	602.02	19.24	600.80	4.5	2	39.065927	-89.392572
G278	UA	09/11/2009	631.19	631.17	Top of Disk	628.85	18.93	23.70	609.92	605.15	24.06	604.80	4.8	2	39.066737	-89.393161
G279	UA	09/10/2009	--	632.04	Top of Disk	629.19	22.40	26.79	606.79	602.40	27.30	601.20	4.4	2	39.067156	-89.392998
G280	UA	02/26/2008	625.35	625.35	Top of Riser	623.11	12.79	17.63	610.32	605.48	17.98	605.10	4.8	2	39.067216	-89.394992
G281	UA	09/08/2015	--	626.36	Top of Disk	623.82	15.51	20.16	608.31	603.66	20.30	603.50	4.7	2	39.065405	-89.399322
G283	LCU	01/14/2021	610.75	610.75	Top of PVC	608.30	8.39	18.17	599.91	590.13	18.36	589.90	9.8	2	39.064645	-89.392119
G284	UA	02/03/2021	618.42	618.42	Top of PVC	615.33	8.08	12.85	607.25	602.48	13.23	601.30	4.8	2	39.065487	-89.390631
G285	LCU	01/25/2021	613.52	613.52	Top of PVC	610.54	13.68	23.45	596.86	587.09	23.83	584.50	9.8	2	39.066513	-89.391474
G286	UA	01/18/2021	613.13	613.13	Top of PVC	609.97	3.37	8.16	606.60	601.81	8.50	600.00	4.8	2	39.067277	-89.391883
G287	UA	01/20/2021	617.45	617.45	Top of PVC	614.34	5.43	10.25	608.91	604.09	10.59	602.50	4.8	2	39.068297	-89.392388
G288	UA	01/19/2021	620.07	620.07	Top of PVC	617.08	7.59	12.26	609.49	604.82	12.75	603.10	4.7	2	39.067834	-89.390082
G301	UA	09/04/2015	--	622.65	Top of Disk	620.88	11.31	15.96	608.96	604.31	16.21	604.10	4.7	2	39.05951	-89.395415
G302	UA	09/04/2015	--	620.04	Top of Disk	618.52	13.21	17.86	604.74	600.09	18.39	599.60	4.7	2	39.059544	-89.393192
G303	UA	08/26/2010	--	622.02	Top of Disk	619.33	10.00	20.00	609.07	599.07	20.40	598.70	10	2	39.057144	-89.391721
G304	UA	08/26/2010	--	626.72	Top of Disk	623.32	10.00	20.00	613.32	603.32	20.40	602.90	10	2	39.057205	-89.395663
G305	UA	05/03/2016	625.67	625.67	Top of PVC	623.23	13.44	18.27	609.10	604.27	18.50	604.10	4.8	2	39.056558	-89.396798
G306	UA	05/03/2016	625.91	625.91	Top of PVC	623.57	13.07	17.68	609.77	605.16	17.90	604.80	4.6	2	39.056494	-89.393556
G307	UA	07/27/2016	624.60	624.60	Top of PVC	624.73	12.96	17.80	609.12	604.28	18.22	603.90	4.8	2	39.057214	-89.395545
G307D	LCU	01/19/2021	624.88	624.88	Top of PVC	622.51	48.98	58.75	573.53	563.76	59.60	562.50	9.8	2	39.05721	-89.39552
G308	UA	01/18/2021	624.59	624.59	Top of PVC	621.59	10.10	14.89	611.49	606.70	15.24	605.80	4.8	2	39.057379	-89.397134
G309	UA	01/21/2021	625.88	625.88	Top of PVC	622.77	12.97	17.75	609.80	605.02	18.10	604.70	4.8	2	39.058508	-89.397243
G310	UA	02/09/2021	622.87	622.87	Top of PVC	619.89	10.24	15.03	609.65	604.86	15.38	604.00	4.8	2	39.059532	-89.396907
G311	UA	01/13/2021	621.04	621.04	Top of PVC	618.32	9.27	14.04	609.05	604.28	14.40	603.90	4.8	2	39.059513	-89.394363
G311D	LCU	01/12/2021	621.24	621.24	Top of PVC	618.39	50.16	60.10	568.23	558.29	60.58	557.80	9.9	2	39.059513	-89.394312
G312	UA	01/15/2021	619.78	619.78	Top of PVC	616.92	9.79	14.58	607.13	602.34	14.93	601.70	4.8	2	39.059558	-89.391983
G313	UA	02/05/2021	614.30	614.30	Top of PVC	611.51	6.30	11.11	605.21	600.40	11.46	599.50	4.8	2	39.058773	-89.391124
G314	LCU	02/05/2021	613.88	613.88	Top of PVC	611.11	14.56	19.58	596.55	591.53	20.02	591.10	5	2	39.05782	-89.390964
G314D	DA	02/04/2021	613.70	613.70	Top of PVC	610.87	39.34	49.11	571.53	561.76	49.47	510.60	9.8	2	39.057852	-89.390958
G315	UA	01/14/2021	623.52	623.52	Top of PVC	620.94	9.69	14.48	611.25	606.46	14.85	605.00	4.8	2	39.057165	-89.393667

TABLE 2-1. MONITORING WELL LOCATIONS AND CONSTRUCTION DETAILS

GROUNDWATER MODELING REPORT
COFFEEN POWER PLANT
ASH POND NO. 1
COFFEEN, ILLINOIS

Well Number	HSU	Date Constructed	Top of PVC Elevation (feet)	Measuring Point Elevation (feet)	Measuring Point Description	Ground Elevation (feet)	Screen Top Depth (feet bgs)	Screen Bottom Depth (feet bgs)	Screen Top Elevation (feet)	Screen Bottom Elevation (feet)	Well Depth (feet bgs)	Bottom of Boring Elevation (feet)	Screen Length (feet)	Screen Diameter (inches)	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)
G316	LCU	02/26/2021	602.59	602.59	Top of PVC	599.64	10.02	14.82	589.62	584.82	15.16	583.90	4.8	2	39.057847	-89.389698
G317	UA	02/12/2021	641.93	641.93	Top of PVC	638.85	30.14	34.93	608.71	603.92	35.28	602.90	4.8	2	39.056727	-89.390148
G401	UA	09/14/2015	--	625.57	Top of Disk	623.03	14.36	18.79	608.67	604.24	19.29	603.70	4.4	2	39.060259	-89.395295
G402	UA	08/27/2010	--	613.37	Top of Disk	610.36	10.00	20.00	600.36	590.36	20.40	590.00	10	2	39.060207	-89.391712
G403	UA	09/11/2015	--	626.47	Top of Disk	623.81	13.11	17.78	610.70	606.03	18.15	605.70	4.7	2	39.063167	-89.398779
G404	UA	05/01/2007	--	615.67	Top of Disk	613.57	6.42	11.17	607.15	602.40	11.62	601.60	4.8	2	39.064329	-89.392493
G405	UA	05/01/2007	--	623.63	Top of Disk	621.40	9.01	13.76	612.39	607.64	14.21	607.20	4.8	2	39.064345	-89.396234
G406	UA	08/19/2016	625.36	625.36	Top of PVC	621.86	13.56	18.37	608.30	603.49	18.75	603.10	4.8	2	39.060309	-89.398508
G407	UA	08/16/2016	621.32	621.32	Top of PVC	618.35	13.78	18.61	604.57	599.74	19.04	598.40	4.8	2	39.061574	-89.402004
G410	UA	02/23/2018	--	619.79	Top of Disk	617.21	8.89	13.68	608.32	603.53	14.09	603.10	4.8	2	39.061572	-89.403763
G411	UA	02/22/2018	--	623.25	Top of Disk	620.49	11.21	16.07	609.28	604.42	16.47	604.00	4.9	2	39.063979	-89.404033
MW01D	DA	05/03/2006	609.02	609.02	Top of PVC	607.08	33.29	38.05	573.79	569.03	38.41	567.10	4.8	2	39.067068	-89.402747
MW02S	UA	05/05/2006	627.12	627.12	Top of PVC	624.16	10.34	15.12	613.82	609.04	15.51	608.70	4.8	2	39.071017	-89.403648
MW02D	LCU	05/05/2006	626.99	626.99	Top of PVC	624.14	22.03	26.83	602.11	597.31	27.22	596.90	4.8	2	39.071031	-89.403649
MW03D	DA	04/27/2006	629.01	629.01	Top of PVC	625.86	52.29	57.06	573.57	568.80	57.40	567.90	4.8	2	39.071386	-89.398976
MW04S	UA	05/11/2006	625.89	625.89	Top of PVC	622.63	9.83	14.26	612.80	608.37	14.77	607.90	4.4	2	39.075356	-89.399232
MW05S	UA	05/17/2006	625.95	625.95	Top of PVC	622.65	12.66	17.41	609.99	605.24	17.71	604.90	4.8	2	39.075866	-89.40333
MW05D	DA	05/17/2006	625.91	625.91	Top of PVC	622.65	45.57	50.33	577.08	572.32	50.72	568.70	4.8	2	39.075863	-89.403313
MW06S	UA	05/04/2006	626.15	626.15	Top of PVC	623.37	11.04	15.62	612.33	607.75	16.08	607.30	4.6	2	39.078189	-89.403644
MW07S	UA	05/09/2006	627.60	627.60	Top of PVC	624.90	9.91	13.79	614.99	611.11	14.39	610.50	3.9	2	39.0786	-89.399383
MW08S	UA	05/10/2006	628.01	628.01	Top of PVC	625.09	11.51	16.00	613.58	609.09	16.60	608.00	4.5	2	39.080234	-89.399079
MW09S	UA	05/03/2006	627.62	627.62	Top of PVC	624.70	11.21	15.62	613.49	609.08	16.20	608.50	4.4	2	39.079954	-89.394899
MW09D	LCU	05/03/2006	627.61	627.61	Top of PVC	624.68	45.81	50.57	578.87	574.11	51.00	570.70	4.8	2	39.07994	-89.394899
MW10S	UA	05/02/2006	624.45	624.45	Top of PVC	621.43	11.28	15.76	610.15	605.67	16.30	605.10	4.5	2	39.07601	-89.394068
MW10D	LCU	05/01/2006	624.47	624.47	Top of PVC	621.33	41.74	46.57	579.59	574.76	47.02	572.60	4.8	2	39.075995	-89.39407
MW11S	UA	04/28/2006	625.27	625.27	Top of PVC	622.04	8.89	13.63	613.15	608.41	14.08	608.00	4.7	2	39.071888	-89.393913
MW11D	LCU	04/28/2006	625.52	625.52	Top of PVC	622.19	28.31	33.04	593.88	589.15	33.50	585.90	4.7	2	39.071888	-89.393894
MW12S	UA	05/10/2006	625.31	625.31	Top of PVC	622.24	10.61	15.18	611.63	607.06	15.61	606.60	4.6	2	39.068514	-89.394199
MW12D	DA	05/10/2006	625.21	625.21	Top of PVC	622.24	42.46	46.99	579.78	575.25	47.47	572.20	4.5	2	39.068501	-89.394199
MW13S	UA	05/09/2006	625.96	625.96	Top of PVC	622.80	11.43	16.23	611.37	606.57	16.62	606.20	4.8	2	39.066297	-89.40118
MW13D	DA	05/09/2006	625.86	625.86	Top of PVC	622.85	49.81	54.60	573.04	568.25	55.00	567.90	4.8	2	39.066293	-89.401163
MW14S	UA	05/02/2006	626.88	626.88	Top of PVC	624.62	12.26	17.02	612.36	607.60	17.38	607.20	4.8	2	39.069153	-89.400442
MW15S	UA	04/25/2006	626.66	626.66	Top of PVC	623.83	14.41	19.16	609.42	604.67	19.62	604.20	4.8	2	39.069772	-89.397088
MW15D	LCU	04/25/2006	626.44	626.44	Top of PVC	623.83	33.68	38.45	590.15	585.38	38.80	585.00	4.8	2	39.06977	-89.397073
MW16S	UA	04/25/2006	629.47	629.47	Top of PVC	626.32	14.59	19.41	611.73	606.91	19.76	606.40	4.8	2	39.073571	-89.397006
MW16D	DA	04/25/2006	629.38	629.38	Top of PVC	626.37	45.90	50.34	580.47	576.03	50.78	575.40	4.4	2	39.073571	-89.397036
MW17S	UA	05/04/2006	630.56	630.56	Top of PVC	627.28	14.02	23.56	613.26	603.72	24.11	603.20	9.5	2	39.07715	-89.396978
MW17D	DA	05/04/2006	630.29	630.29	Top of PVC	627.47	48.82	53.32	578.65	574.15	53.87	573.60	4.5	2	39.077151	-89.396958
MW18S	UA	05/11/2006	628.66	628.66	Top of PVC	625.69	11.31	15.79	614.38	609.90	16.40	609.30	4.5	2	39.077033	-89.401698
MW20S	UA	05/01/2007	622.90	622.90	Top of PVC	620.26	8.41	13.22	611.85	607.04	13.67	604.30	4.8	2	39.064968	-89.394322

TABLE 2-1. MONITORING WELL LOCATIONS AND CONSTRUCTION DETAILS

GROUNDWATER MODELING REPORT
COFFEEN POWER PLANT
ASH POND NO. 1
COFFEEN, ILLINOIS

Well Number	HSU	Date Constructed	Top of PVC Elevation (feet)	Measuring Point Elevation (feet)	Measuring Point Description	Ground Elevation (feet)	Screen Top Depth (feet bgs)	Screen Bottom Depth (feet bgs)	Screen Top Elevation (feet)	Screen Bottom Elevation (feet)	Well Depth (feet bgs)	Bottom of Boring Elevation (feet)	Screen Length (feet)	Screen Diameter (inches)	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)
R104	UA	10/08/2010	--	632.84	Top of Disk	629.03	14.59	19.32	614.44	609.71	19.85	609.20	4.7	2	39.069474	-89.399109
R201	UA	10/08/2010	--	626.34	Top of Disk	624.02	14.59	19.32	609.43	604.70	19.85	604.20	4.7	2	39.075142	-89.397855
R205	UA	03/20/2017	--	624.52	Top of Disk	621.91	11.32	16.01	610.59	605.90	16.42	605.50	4.7	2	39.068593	-89.394164
T127	UA	02/10/2010	--	630.96	Top of Disk	625.53	17.53	22.07	608.00	603.46	22.64	602.90	4.5	2	39.068119	-89.40121
T128	UA	02/09/2010	631.03	630.93	Top of Disk	626.27	16.53	21.04	609.74	605.23	21.64	602.20	4.5	2	39.068532	-89.401211
T202	UA	10/15/2010	--	628.63	Top of Disk	626.22	12.27	16.65	613.95	609.57	17.21	608.20	4.4	2	39.071776	-89.397705
T408	LCU	08/17/2016	624.08	624.08	Top of PVC	621.09	20.66	25.49	600.43	595.60	25.92	595.20	4.8	2	39.064353	-89.396307
T409	LCU	08/19/2016	625.01	625.01	Top of PVC	621.85	21.79	26.59	600.06	595.26	26.99	594.90	4.8	2	39.0603	-89.398538
TA31	UA	10/28/2014	626.55	626.55	Top of PVC	623.89	15.09	19.57	608.80	604.32	20.19	603.70	4.5	2	39.071368	-89.401366
TA32	UA	10/27/2014	621.42	621.42	Top of PVC	618.93	11.31	15.68	607.62	603.25	16.47	602.50	4.4	2	39.074093	-89.402223
TA33	UA	06/02/2015	625.27	625.27	Top of PVC	622.51	12.23	16.89	610.28	605.62	17.44	605.10	4.7	2	39.071556	-89.403506
TA34	UA	06/03/2015	626.52	626.52	Top of PVC	624.10	10.92	15.41	613.18	608.69	16.10	608.00	4.5	2	39.069631	-89.402759
TR32	UA	07/02/2021	621.68	621.68	Top of PVC	619.28	11.00	15.68	608.28	603.60	16.17	603.11	4.68	2	39.074064	-89.397758
X201	S	--	--	618.47	--	--	--	--	--	--	--	--	--	--	39.065278	-89.3925
SG-02	SW	--	--	605.87	Top of Prot Casing	605.87	--	--	--	--	--	--	--	--	39.059695	-89.391429
SG-03	SW	--	--	594.94	Top of Prot Casing	594.94	--	--	--	--	--	--	--	--	39.059092	-89.390342
SG-04	SW	--	--	599.52	Top of Prot Casing	599.52	--	--	--	--	--	--	--	--	39.064146	-89.390504

Notes:
All elevation data are presented relative to the North American Vertical Datum 1988 (NAVD88), GEOID 12A
-- = data not available
bgs = below ground surface
DA = deep aquifer
ft = foot or feet
HSU = hydrostratigraphic Unit
LCU = lower confining unit
PVC = polyvinyl chloride
S = source water
SW = surface water
UA = uppermost aquifer
generated 10/05/2021, 2:15:37 PM CDT

TABLE 4-1. FLOW AND TRANSPORT MODEL CALIBRATION TARGETS

GROUNDWATER MODELING REPORT
COFFEEN POWER PLANT
ASH POND NO. 1
COFFEEN, ILLINOIS

					Flow Targets								Transport Targets							
Well Name	Easting	Northing	HSU	CCR Unit	Number of Samples	mean GWL^1 (feet)	std GWL^1 (feet)	min GWL^1 (feet)	max GWL^1 (feet)	Earliest Sample Date	Latest Sample Date	Flow Calibration Wells	Number of Samples	mean Sulfate (mg/L)	std Sulfate (mg/L)	min Sulfate (mg/L)	max Sulfate (mg/L)	Earliest Sample Date	Latest Sample Date	Transport Calibraiton Well
G101	2514214.26	876551.76	UA	LF	20	617.989	2.504194166	612.95	623.65	15/01/2019	16/11/2015	Yes	-	-	-	-	-	-	-	-
G102	2514531.1	876554.8	UA	GSP	25	622.8612	1.751842649	618.96	627.12	15/01/2019	16/11/2015	Yes	19	90.6	29.7	49	140	04/08/2015	01/26/2021	Yes
G103	2514501.17	876199.41	UA	GSP	19	622.0884211	1.754825927	617.95	624.93	15/01/2019	11/12/2016	Yes	3	66.3	11.2	54	76	04/08/2015	10/06/2015	Yes
G105	2514509.06	875499.78	UA	GSP	19	622.0884211	2.178504235	613.96	624	15/01/2019	11/12/2016	Yes	3	116.7	11.5	110	130	04/08/2015	10/06/2015	Yes
G106	2514512.87	875149.77	UA	GSP	20	620.763	1.194844628	617.46	622.6	15/01/2019	16/11/2015	Yes	19	66.1	23.3	36	140	04/08/2015	01/26/2021	Yes
G107	2514358.3	874994.03	UA	LF	19	619.1036842	1.658802147	615.46	622.33	15/01/2019	11/12/2016	Yes	-	-	-	-	-	-	-	-
G108	2514248.22	874948.67	UA	LF	19	619.4994737	1.31911786	616.24	622.22	15/01/2019	11/12/2016	Yes	-	-	-	-	-	-	-	-
G109	2514137.87	874969.96	UA	LF	19	618.7294737	1.25543031	615.7	620.84	15/01/2019	11/12/2016	Yes	-	-	-	-	-	-	-	-
G110	2514057.7	875015.54	UA	LF	20	618.104	1.590105591	613.27	620.65	15/01/2019	16/11/2015	Yes	-	-	-	-	-	-	-	-
G111	2513981.81	875058.61	UA	LF	19	616.9310526	1.267626368	613.16	618.53	15/01/2019	11/12/2016	Yes	-	-	-	-	-	-	-	-
G119	2513907.62	875675	UA	LF	19	615.9689474	1.16332328	612.24	617.45	15/01/2019	11/12/2016	Yes	-	-	-	-	-	-	-	-
G120	2513905.82	875854.56	UA	LF	19	614.3242105	1.834418817	612.13	617.69	15/01/2019	16/11/2015	Yes	-	-	-	-	-	-	-	-
G121	2513904.33	875964.54	UA	LF	18	614.6861111	2.034979806	611.93	618.73	15/01/2019	11/12/2016	Yes	-	-	-	-	-	-	-	-
G122	2513902.79	876080	UA	LF	18	615.3283333	2.095957594	612.94	620.41	15/01/2019	11/12/2016	Yes	-	-	-	-	-	-	-	-
G123	2513901.58	876189.62	UA	LF	18	614.5494444	3.842648401	610.31	622.79	15/01/2019	11/12/2016	Yes	-	-	-	-	-	-	-	-
G124	2513900.33	876304.71	UA	LF	19	617.8857895	2.128430083	615.09	622.86	15/01/2019	11/12/2016	Yes	-	-	-	-	-	-	-	-
G125	2513899.16	876409.6	UA	LF	20	619.676	2.365809976	614.6	622.96	15/01/2019	16/11/2015	Yes	-	-	-	-	-	-	-	-
G126	2513895.46	875062.25	UA	LF	19	614.87	1.340053896	612.28	616.87	15/01/2019	11/12/2016	Yes	-	-	-	-	-	-	-	-
G151	2513806.06	875023.62	UA	LF	16	614.468125	0.894980214	612.13	615.49	15/01/2019	11/12/2016	Yes	-	-	-	-	-	-	-	-
G152	2513894.35	874687.44	UA	SW	16	615.421875	1.122949799	612.77	617.44	15/01/2019	11/12/2016	Yes	-	-	-	-	-	-	-	-
G153	2513532.77	874532.15	UA	SW	16	614.5425	1.204416871	612.37	616.3	15/01/2019	11/12/2016	Yes	-	-	-	-	-	-	-	-
G154	2513243.08	874978.46	UA	SW	16	614.16	1.731546515	610.33	618.28	15/01/2019	11/12/2016	Yes	-	-	-	-	-	-	-	-
G155	2513501.64	875127.78	UA	SW	16	613.686875	1.278998143	609.91	615.99	15/01/2019	11/12/2016	Yes	-	-	-	-	-	-	-	-
G200	2515650.03	877930.9	UA	B	26	621.4965385	1.461968378	618.16	623.29	15/01/2019	16/11/2015	Yes	25	101.2	8.3	87	120	01/20/2015	07/28/2021	-
G205	2515915	875549.93	UA	GSP	8	619.71	1.482912193	616.33	621.45	02/04/2017	11/12/2016	Yes	-	-	-	-	-	-	-	-
G206	2514669.15	875103.38	UA	GSP	25	621.286	1.444036588	616.61	622.76	15/01/2019	16/11/2015	Yes	20	119.4	24.7	32	150	01/21/2015	01/27/2021	Yes
G207	2514837.85	875166.36	UA	GSP	19	621.9526316	1.135658605	619.41	623.39	15/01/2019	11/12/2016	Yes	4	44.5	30.1	16	72	01/21/2015	10/07/2015	Yes
G208	2514993.46	875231.42	UA	GSP	19	622.0989474	1.175154339	618.97	624.07	15/01/2019	11/12/2016	Yes	4	53.5	37.7	33	110	01/21/2015	10/07/2015	Yes
G209	2515149.64	875298.3	UA	GSP	25	621.6212	1.211081885	617.76	623.18	15/01/2019	16/11/2015	Yes	20	248.8	51.6	95	310	01/21/2015	01/27/2021	Yes
G210	2515299.04	875359.67	UA	GSP	19	620.8747368	1.372254303	616.82	622.5	15/01/2019	11/12/2016	Yes	4	90.3	6.5	84	99	01/21/2015	10/07/2015	Yes
G211	2515448.98	875424.68	UA	GSP	19	621.1094737	1.148145721	618.14	622.45	15/01/2019	11/12/2016	Yes	4	79.8	5.4	74	87	01/21/2015	10/07/2015	Yes
G212	2515583.04	875486.65	UA	GSP	25	620.7644	1.197814259	617.19	622.12	15/01/2019	16/11/2015	Yes	20	55.9	4.2	49	66	01/21/2015	01/26/2021	Yes
G213	2515723.38	875544.3	UA	GSP	19	620.6210526	0.889262458	618.62	621.72	15/01/2019	11/12/2016	Yes	4	53.3	3.3	50	57	01/21/2015	10/07/2015	Yes
G214	2515960.85	875667.97	UA	GSP	19	617.8473684	1.193332598	614.52	619.39	15/01/2019	11/12/2016	Yes	4	71.3	3.9	68	76	01/21/2015	10/07/2015	Yes
G215	2515971.56	875810.11	UA	GSP	25	617.9504	1.033285537	615.48	619.51	15/01/2019	16/11/2015	Yes	21	167.1	109.9	100	490	01/21/2015	06/29/2021	Yes
G216	2515968.45	875976.18	UA	GSP	19	617.8368421	1.365349172	614.37	619.86	15/01/2019	11/12/2016	Yes	4	217.5	9.6	210	230	01/21/2015	10/07/2015	Yes
G217	2515962.98	876185.57	UA	GSP	19	617.5063158	1.127668246	614.32	619.13	15/01/2019	11/12/2016	Yes	4	132.5	5.0	130	140	01/21/2015	10/07/2015	Yes
G218	2515962.17	876380.8	UA	GSP	25	618.3172	1.25211328	614.46	620.1	01/15/2019	11/16/2015	Yes	20	135.8	34.0	94	220	01/21/2015	01/26/2021	Yes
G270	2514996.81	874802.01	UA	RP	26	620.3503846	2.547542315	614.45	623.38	01/15/2019	11/16/2015	Yes	21	69.8	25.8	49	140	01/20/2015	03/30/2021	Yes
G271	2515517.24	874239.3	UA	RP	25	615.7952	1.212807075	613.31	617.95	01/15/2019	11/16/2015	Yes	6	455.0	89.6	340	610	08/10/2018	02/01/2021	Yes
G272	2515745.01	874234.68	UA	RP	19	614.3836842	1.271854335	611.45	616.88	01/15/2019	12/11/2016	Yes	4	332.5	45.7	270	380	01/21/2015	10/08/2015	Yes

TABLE 4-1. FLOW AND TRANSPORT MODEL CALIBRATION TARGETS

GROUNDWATER MODELING REPORT
COFFEEN POWER PLANT
ASH POND NO. 1
COFFEEN, ILLINOIS

					Flow Targets								Transport Targets							
Well Name	Easting	Northing	HSU	CCR Unit	Number of Samples	mean GWL^1 (feet)	std GWL^1 (feet)	min GWL^1 (feet)	max GWL^1 (feet)	Earliest Sample Date	Latest Sample Date	Flow Calibration Wells	Number of Samples	mean Sulfate (mg/L)	std Sulfate (mg/L)	min Sulfate (mg/L)	max Sulfate (mg/L)	Earliest Sample Date	Latest Sample Date	Transport Calibraiton Well
G273	2515975.58	874235.18	UA	RP	25	611.5884	1.339299195	608.82	614.2	01/15/2019	11/16/2015	Yes	20	475.0	89.5	360	690	01/21/2015	02/01/2021	Yes
G274	2516195.61	874239.23	UA	RP	19	610.4968421	1.009549144	607.79	612	01/15/2019	12/11/2016	Yes	4	322.5	53.2	260	390	01/21/2015	10/08/2015	Yes
G275	2516375.98	874299.05	UA	RP	19	604.7021053	0.833210517	602.97	605.97	01/15/2019	12/11/2016	Yes	3	780.0	147.3	650	940	01/21/2015	07/23/2015	Yes
G276	2516358.89	874438.41	UA	RP	24	604.3108333	0.781508667	603.11	606.6	01/15/2019	11/16/2015	Yes	19	223.6	59.6	19	310	01/21/2015	06/28/2021	Yes
G277	2516370.45	874581.65	UA	RP	15	602.6546667	0.949126415	601.23	603.79	01/15/2019	12/11/2016	Yes	-	-	-	-	-	-	-	-
G278	2516200.7	874875.24	UA	RP	19	605.7357895	1.268819731	604.29	608.15	01/15/2019	12/11/2016	Yes	-	-	-	-	-	-	-	-
G279	2516245.69	875028.24	UA	RP	24	607.4420833	2.205378759	599.69	611.08	01/15/2019	11/16/2015	Yes	20	569.0	336.3	170	1600	01/21/2015	01/28/2021	Yes
G280	2515679.35	875045.28	UA	RP	26	618.8873077	1.884508546	614.47	622.33	01/15/2019	11/16/2015	Yes	27	78.1	12.2	52	94	01/21/2015	07/27/2021	Yes
G281	2514455.52	874375.28	UA	B	27	619.6537037	1.162395233	616.41	621.68	01/15/2019	11/16/2015	Yes	24	296.3	34.2	250	380	11/20/2015	07/27/2021	-
G283	2516503.05	874115.82	LCU	AP2	9	605.86	1.027898341	604.56	607.8	03/29/2021	08/16/2021	Yes	8	242.5	7.1	230	250	03/31/2021	07/27/2021	Yes
G284	2516922.93	874426.1	UA	B	9	607.9777778	1.492646792	606.17	611.14	03/29/2021	08/16/2021	Yes	8	69.5	10.8	60	95	03/30/2021	07/27/2021	-
G285	2516680.39	874797.74	LCU	B	9	606.5866667	1.509014579	604.33	608.62	03/29/2021	08/16/2021	Yes	8	570.0	40.0	490	620	03/30/2021	07/27/2021	-
G286	2516561.89	875075	UA	B	6	606.6166667	1.448346183	604.68	609.08	03/29/2021	12/07/2021	Yes	8	13.5	2.1	11	16	03/31/2021	07/27/2021	-
G287	2516415.34	875445.28	UA	B	7	608.9657143	1.217249045	607.59	610.83	03/29/2021	08/16/2021	Yes	8	44.4	2.7	41	50	03/29/2021	07/27/2021	-
G288	2517071.51	875282.23	UA	B	9	613.6466667	1.259801572	611.9	616.32	03/29/2021	08/16/2021	Yes	8	200.5	302.5	29	770	03/30/2021	07/27/2021	-
G301	2515583.06	872237.64	UA	AP1	25	615.0272	1.602722995	610.39	618.07	01/15/2019	11/16/2015	Yes	16	742.5	79.8	570	860	11/20/2015	01/27/2021	Yes
G302	2516214.19	872255.38	UA	AP1	25	609.8508	2.621329052	604.64	615.41	01/15/2019	11/16/2015	Yes	16	414.4	86.0	260	530	11/20/2015	01/27/2021	Yes
G303	2516639.34	871384.83	UA	AP1	25	615.7748	1.750197894	611.18	618.05	01/15/2019	11/16/2015	Yes	16	770.0	76.2	600	870	11/20/2015	01/26/2021	Yes
G304	2515519.76	871397.53	UA	AP1	2	623.99	0.113137085	623.91	624.07	08/02/2016	09/05/2016	Yes	3	1033.3	57.7	1000	1100	11/20/2015	05/20/2016	-
G305	2515199.45	871159.15	UA	AP1	23	618.0413043	1.084004798	615.3	620.49	01/15/2019	12/11/2016	Yes	5	864.0	87.6	710	930	05/19/2016	11/17/2016	Yes
G306	2516120.28	871143.66	UA	AP1	26	618.9373077	1.290400117	616.12	621.73	01/15/2019	12/11/2016	Yes	24	284.0	113.3	5.9	700	05/19/2016	07/27/2021	Yes
G307	2515553.24	871401.09	UA	AP1	17	624.0317647	1.239890294	619.33	624.6	01/15/2019	12/11/2016	Yes	13	1029.2	113.1	850	1300	08/16/2016	01/27/2021	Yes
G308	2515101.51	871457.36	UA	AP1	11	619.7218182	0.671190259	618.54	621.03	03/29/2021	08/16/2021	Yes	8	1125.0	46.3	1100	1200	03/29/2021	07/27/2021	Yes
G309	2515067.07	871868.3	UA	AP1	11	618.9445455	0.814350829	617.89	621.09	03/29/2021	08/16/2021	Yes	8	787.5	38.8	740	840	03/29/2021	07/27/2021	Yes
G310	2515159.33	872242.06	UA	AP1	11	614.4509091	1.049528032	613.2	617.27	03/29/2021	08/16/2021	Yes	8	990.0	552.5	420	2300	03/29/2021	07/28/2021	Yes
G311	2515881.77	872241.27	UA	AP1	11	613.6636364	1.07212194	612.45	616.54	03/29/2021	08/16/2021	Yes	8	811.3	35.6	750	860	03/30/2021	07/27/2021	Yes
G312	2516557.45	872263.4	UA	AP1	11	608.9363636	1.307511168	606.99	612.19	03/29/2021	08/16/2021	Yes	8	838.8	143.6	600	1000	03/30/2021	07/27/2021	Yes
G314	2516852.2	871632.87	UA	AP1	10	605.13	3.49532386	596.4	608.6	03/29/2021	08/16/2021	Yes	8	1953.8	473.9	830	2400	03/30/2021	07/27/2021	Yes
G315	2516086.68	871387.77	UA	AP1	10	620.529	0.69468538	619.17	621.24	03/29/2021	08/16/2021	Yes	8	908.8	81.1	850	1100	03/30/2021	07/28/2021	Yes
G316	2517211.619	871645.77	UA	AP1	10	590.022	3.016792999	581.54	591.63	03/29/2021	08/16/2021	-	8	691.3	156.1	330	840	03/30/2021	07/27/2021	Yes
G317	2517087.319	871236.76	UA	AP1	10	609.619	1.740890258	606.57	611.75	03/29/2021	08/16/2021	-	8	952.5	93.6	780	1100	03/30/2021	07/28/2021	Yes
G401	2515614.82	872510.72	UA	AP2	18	607.6811111	1.846264556	603.94	609.8	01/15/2019	11/16/2015	Yes	-	-	-	-	-	-	-	-
G402	2516632.39	872500.43	UA	AP2	20	603.743	1.213286533	600.77	605.36	01/15/2019	11/16/2015	Yes	-	-	-	-	-	-	-	-
G403	2514616.58	873561.48	UA	AP2	20	621.055	1.263622612	618.36	622.45	01/15/2019	11/16/2015	Yes	-	-	-	-	-	-	-	-
G404	2516397.84	873999.83	UA	AP2	20	610.838	1.183783408	607.58	612.14	01/15/2019	11/16/2015	Yes	-	-	-	-	-	-	-	-
G405	2515335.58	873996.63	UA	AP2	20	617.8585	1.158348529	614.47	619.28	01/15/2019	11/16/2015	Yes	-	-	-	-	-	-	-	-
G406	2514702.32	872521.21	UA	AP2	16	615.141875	1.675395351	611.27	617.52	01/15/2019	12/11/2016	Yes	-	-	-	-	-	-	-	-
G407	2513705.74	872973.57	UA	B	16	613.60625	0.84114109	612.11	614.86	01/15/2019	12/11/2016	Yes	-	-	-	-	-	-	-	-
MW04S	2514450.47	877999.78	UA	B	19	618.2110526	2.142835335	613.88	621.62	01/15/2019	12/11/2016	Yes	-	-	-	-	-	-	-	-
MW05S	2513285.52	878175.73	UA	B	19	617.8810526	1.843543975	613.32	620.92	01/15/2019	12/11/2016	Yes	-	-	-	-	-	-	-	-
MW10S	2515914.48	878250.4	UA	B	18	617.255	1.690963004	614.36	620.43	01/15/2019	12/11/2016	Yes	-	-	-	-	-	-	-	-

TABLE 4-1. FLOW AND TRANSPORT MODEL CALIBRATION TARGETS

GROUNDWATER MODELING REPORT

COFFEEN POWER PLANT

ASH POND NO. 1

COFFEEN, ILLINOIS

					Flow Targets								**Transport Targets**							
Well Name	**Easting**	**Northing**	**HSU**	**CCR Unit**	**Number of Samples**	**mean GWL[1] (feet)**	**std GWL[1] (feet)**	**min GWL[1] (feet)**	**max GWL[1] (feet)**	**Earliest Sample Date**	**Latest Sample Date**	**Flow Calibration Wells**	**Number of Samples**	**mean Sulfate (mg/L)**	**std Sulfate (mg/L)**	**min Sulfate (mg/L)**	**max Sulfate (mg/L)**	**Earliest Sample Date**	**Latest Sample Date**	**Transport Calibraiton Well**
MW11S	2515971.24	876749.49	UA	GSP	24	620.7020833	1.218373753	617.19	622.19	01/15/2019	12/11/2016	Yes	-	-	-	-	-	-	-	-
MW12S	2515900.49	875519.94	UA	GSP	24	617.9708333	2.049907562	611.42	620.48	01/15/2019	12/11/2016	Yes	-	-	-	-	-	-	-	-
MW16S	2515087.93	877355.01	UA	B	24	622.0208333	2.003932908	618.34	625.59	01/15/2019	12/11/2016	Yes	-	-	-	-	-	-	-	-
MW20S	2515876.54	874228.14	UA	B	19	612.0194737	1.76501959	607.74	615.4	01/15/2019	12/11/2016	Yes	-	-	-	-	-	-	-	-
R104	2514503.48	875857.78	UA	B	20	623.479	1.640654234	619.38	625.92	01/15/2019	11/16/2015	Yes	7	74.4	2.2	72	77	04/08/2015	08/03/2016	-
R201	2514842.05	877925.14	UA	B	26	621.8242308	1.348306117	618.3	623.52	01/15/2019	11/16/2015	Yes	28	211.0	55.8	89	370	01/20/2015	07/28/2021	-
T127	2513911.13	875359.24	UA	B	20	615.954	1.042297058	612.33	617.05	01/15/2019	11/16/2015	Yes	-	-	-	-	-	-	-	-
T128	2513909.58	875509.65	UA	B	19	615.1989474	1.45420805	611.33	617.25	01/15/2019	12/11/2016	Yes	-	-	-	-	-	-	-	-
T202	2514895.01	876699.56	UA	GSP	19	620.5410526	2.211231167	615.31	624.22	01/15/2019	12/11/2016	Yes	-	-	-	-	-	-	-	-
T408	2515314.82	873999.37	UA	B	16	617.25875	1.507615667	614.45	619.46	01/15/2019	12/11/2016	Yes	-	-	-	-	-	-	-	-
T409	2514693.83	872517.86	UA	B	16	615.403125	1.232908316	612.16	617.16	01/15/2019	12/11/2016	Yes	-	-	-	-	-	-	-	-
TA31	2513856.87	876542.19	UA	B	19	619.7289474	2.10867756	614.89	622.93	01/15/2019	12/11/2016	Yes	-	-	-	-	-	-	-	-
TA32	2513605.22	877532.63	UA	B	10	615.309	1.097172629	612.42	616.3	01/20/2020	12/11/2016	Yes	-	-	-	-	-	-	-	-
TA33	2513248.73	876605.56	UA	B	19	617.2257895	1.90237663	612.91	620.35	01/15/2019	12/11/2016	Yes	-	-	-	-	-	-	-	-
TA34	2513466.7	875906.23	UA	B	19	617.0926316	1.535020239	613.48	619.58	01/15/2019	12/11/2016	Yes	-	-	-	-	-	-	-	-

Notes:

[O: SLN 04/20/22; C: EGP 4/29/22]

[1] GWL = Groundwater Elevation

AP1 = Ash Pond No. 1

AP2 = Ash Pond No. 2

B = Background

GSP = Gypsum Management Facility Gypsum Stack Pond

LF = Landfill

max=maximum

mg/l = milligrams per liter

min=minimum

RP = Gypsum Management Facility Recycle Pond

std=standard deviation from the mean

HSU = Hydrostratigraphic Unit

CCR = coal combustion residuals

UA = uppermost aquifer

LCU = lower confining unit

TABLE 5-1. FLOW MODEL INPUT AND SENSITIVITY ANALYSIS RESULTS

GROUNDWATER MODELING REPORT
COFFEEN POWER PLANT
ASH POND NO. 1
COFFEEN, ILLINOIS

Zone	Hydrostratigraphic Unit	Materials	ft/d	cm/s	Kh/Kv	Value Source	Sensitivity[1]
Horizontal Hydraulic Conductivity			**Calibration Model**				
1	UCU	loess and clay	0.51	1.80E-04	NA	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	High
2	UA	sand and sandy silt	4.04	1.43E-03	NA	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	High
3	LCU (unweathered Vandalia)	sand clay till	0.83	2.93E-04	NA	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	High
4	LCU (Smithboro Formation)	sand clay till	0.0014	4.94E-07	NA	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	Low
5	SW Pond	NA	2.89E-09	1.02E-12	NA	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	Negligible
6	LF-CCR	CCR	13.6	4.80E-03	NA	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	Negligible
7	GSP-CCR	CCR	13.6	4.80E-03	NA	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	Negligible
8	RP-CCR	CCR	13.6	4.80E-03	NA	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	Negligible
9	AP2	CCR	13.6	4.80E-03	NA	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	Negligible
10	AP1	CCR	13.6	4.80E-03	NA	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	Moderate
11	Cooling Pond	clay and silt	0.51	1.80E-04	NA	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	Low
12	GSP-RP connector	lined channel within UCU	0.51	1.80E-04	NA	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	Negligible
13	AP2 -berm	loess and clay	0.51	1.80E-04	NA	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	Negligible
14	AP1-berm	loess and clay	0.51	1.80E-04	NA	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	Negligible
15	Pond (west)	loess and clay	0.51	1.80E-04	NA	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	Negligible
16	GSP-liner	liner	2.89E-08	1.02E-11	NA	Harmonic mean of liner layers	Negligible
17	RP-liner	liner	2.89E-08	1.02E-11	NA	Harmonic mean of liner layers	Negligible
18	LF-liner	liner	2.89E-08	1.02E-11	NA	Harmonic mean of liner layers	Negligible
19	UCU- fill (drain/river)	NA	10	3.53E-03	NA	Calibrated - Conductivity Value to Allow Groundwater Flow from UCU to River and Drain Boundary Conditions	Moderate
21	LF-GSP shared embankment	reworked silts and clays	0.01	3.53E-06	NA	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	Negligible
Vertical Hydraulic Conductivity			**Calibration Model**				
1	UCU	loess and clay	0.0510	1.80E-05	10	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	High
2	UA	sand and sandy silt	0.4040	1.43E-04	10	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	High
3	LCU (unweathered Vandalia)	sand clay till	0.0830	2.93E-05	10	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	High
4	LCU (Smithboro Formation)	sand clay till	0.0001	4.94E-08	10	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	Low
5	SW Pond	lined	2.89E-09	1.02E-12	1	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	Negligible
6	LF-CCR	CCR	0.2500	8.82E-05	54	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	Negligible
7	GSP-CCR	CCR	0.2500	8.82E-05	54	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	Negligible
8	RP-CCR	CCR	0.2500	8.82E-05	54	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	Negligible
9	AP2	CCR	0.2500	8.82E-05	54	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	Negligible
10	AP1	CCR	0.2500	8.82E-05	54	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	Moderate
11	Cooling Pond	clay and silt	0.0510	1.80E-05	10	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	Low
12	GSP-RP connector	lined channel within UCU	0.0510	1.80E-05	10	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	Negligible
13	AP2 -berm	loess and clay	0.0510	1.80E-05	10	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	Negligible
14	AP1-berm	loess and clay	0.0510	1.80E-05	10	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	Negligible
15	Pond (west)	loess and clay	0.0510	1.80E-05	10	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	Negligible
16	GSP-liner	liner	2.89E-08	1.02E-11	1	Harmonic mean of liner layers	Negligible
17	RP-liner	liner	2.89E-08	1.02E-11	1	Harmonic mean of liner layers	Negligible
18	LF-liner	liner	2.89E-08	1.02E-11	1	Harmonic mean of liner layers	Negligible
19	UCU- fill (drain/river)	NA	10.0000	3.53E-03	1	Calibrated - Conductivity Value to Allow Groundwater Flow from UCU to River and Drain Boundary Conditions	Moderate

TABLE 5-1. FLOW MODEL INPUT AND SENSITIVITY ANALYSIS RESULTS

GROUNDWATER MODELING REPORT
COFFEEN POWER PLANT
ASH POND NO. 1
COFFEEN, ILLINOIS

Zone	Hydrostratigraphic Unit	Materials	ft/d	cm/s	Kh/Kv	Value Source	Sensitivity[1]
Vertical Hydraulic Conductivity (Continued)			**Calibration Model**				
21	LF-GSP shared embankment	reworked silts and clays	0.0100	3.53E-06	1	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	Negligible
Zone	**Hydrostratigraphic Unit**	**Materials**	**ft/d**	**in/yr**	**Kh/Kv**	**Value Source**	**Sensitivity[1]**
Recharge			**Calibration Model**				
1	UCU	clay and silt	0.00055	2.41	NA	Calibrated	High
2	SW Pond	clay and silt	1.50E-08	6.57E-05	NA	Calibrated	Negligible
3	LF	CCR	8.00E-08	3.50E-04	NA	Calibrated	Negligible
4	GSP	CCR	8.00E-08	3.50E-04	NA	Calibrated	Negligible
5	RP	CCR	8.00E-08	3.50E-04	NA	Calibrated	Negligible
6	AP2	CCR	0.0005	2.19	NA	Calibrated	Moderate
7	AP1	CCR	0.0024	10.51	NA	Calibrated	High
8	Cooling pond	clay and silt	1.40E-05	0.06	NA	Calibrated	Negligible
9	GSP-RP connector	clay and silt	0.00055	2.41	NA	Calibrated	Low
10	AP2-Berm	clay and silt	0.00055	2.41	NA	Calibrated	Negligible
11	AP1-Berm	clay and silt	0.00055	2.41	NA	Calibrated	Negligible
12	Pond (west)	clay and silt	5.50E-04	2.41	NA	Calibrated	Negligible
Storage							
1	UCU	loess and clay	*Not used in steady-state calibration model*				
2	UA	sand and sandy silt					
3	LCU (unweathered Vandalia)	sand clay till					
4	LCU (Smithboro Formation)	sand clay till					
5	SW Pond	lined					
6	LF-CCR	CCR					
7	GSP-CCR	CCR					
8	RP-CCR	CCR					
9	AP2	CCR					
10	AP1	CCR					
11	Cooling Pond	clay and silt					
12	GSP-RP connector	lined channel within UCU					
13	AP2 -berm	loess and clay					
14	AP1-berm	loess and clay					
15	Pond (west)	loess and clay					
16	GSP-liner	liner					
17	RP-liner	liner					
18	LF-liner	liner					
19	UCU- fill (drain/river)	NA					
21	LF-GSP shared embankment	reworked silts and clays					

TABLE 5-1. FLOW MODEL INPUT AND SENSITIVITY ANALYSIS RESULTS
GROUNDWATER MODELING REPORT
COFFEEN POWER PLANT
ASH POND NO. 1
COFFEEN, ILLINOIS

River Parameters							
	Relative Location	**River Width (feet)**	**River depth (feet)**	**Bed Thickness (feet)**	**Hydraulic Conductivity (ft/d)**	**Head (feet)**	**River Boundary Conductance (ft^2/d)**
Reach 0	Unnamed Tributary East Coffeen Lake	10	3	2	4.00E-02	594.7-621.84	0.08-20.4
Sensitivity[1]	NA	- - -	- - -	- - -	- - -	Moderate	High
Reach 5	Unnamed Tributary East Coffeen Lake - downstream in layer 5	10	3	2	4.00E-01	591.0-594.7	1.5-109.2
Sensitivity[1]	NA	- - -	- - -	- - -	- - -	Moderate	Low
Reach 1	Unnamed Tributary West Coffeen Lake	10	3	2	4.80E-02	591.0-622.45	0.04-12.3
Sensitivity[1]	NA	- - -	- - -	- - -	- - -	Low	Moderately High
Reach 2	Pond (west)	cell dimensions	3	1	3.20E-03	617.50	4.0
Sensitivity[1]	NA	- - -		- - -		Low	Low
Reach 3	Condenser Cooling Flume	cell dimensions	4	1	5.00	604.00	5.00
Sensitivity[1]	NA	- - -	- - -	- - -	- - -	Moderate	High
Value Source	NA	Calibrated	Calibrated	Calibrated	Calibrated	Estimated based on DEM	Calibrated

Drain Parameters							
	Name	**Drain Width (feet)**	**Drain depth (feet)**	**Bed Thickness (feet)**	**Hydraulic Conductivity (ft/d)**	**Stage (feet)**	**Drain Conductance (ft^2/d)**
Reach 0	Active LF Underdrain	2	2	1.5	2.40E-02	603.5	6.6e-5-0.47
Sensitivity[1]	NA	- - -	- - -	- - -	- - -	Low	Moderately High
Reach 1	Gravity Driven GRP Drain	cell dimensions	2	1.5	2.50E-02	600.5	9.7e-5-0.51
Sensitivity[1]		- - -	- - -	- - -	- - -	Low	Moderate
Reach 2	Northern Drain	cell dimensions	2	1.5	2.00E+00	622	5.1-135.46
Sensitivity[1]		- - -	- - -	- - -	- - -	Low	Negligible
Value Source	NA	Calibrated	Calibrated	Calibrated	Calibrated	Estimated based on DEM	Calibrated

General Head Parameters							
	Relative Location	**Width of General Head Boundary Cell (feet)**	**Distance to General Head Boundary Head (feet)**	**Saturated Thickness of Cell (feet)**	**Hydraulic Conductivity (ft/d)**	**Head (feet)**	**General Head Boundary Conductance (ft^2/d)**
Reach 2	Northern Model Boundary in UA	*variable*	1	variable	4.54	591-610.66	1.4-7032.9
Sensitivity[1]	NA	- - -	- - -	- - -	- - -	Moderate	Negligible
Reach 3	Northern Model Boundary in LCU ayer 4	*variable*	1	variable	0.83	591-610.66	166-1812.6
Sensitivity[1]	NA	- - -	- - -	- - -	- - -	High	Negligible
Reach 4	Northern Model Boundary in LCU ayer 5	*variable*	1	variable	0.0014	591-610.66	1.61-6.0
Sensitivity[1]	NA	- - -	- - -	- - -	- - -	Low	Negligible
Value Source	NA	Calibrated	Calibrated	Calibrated	Calibrated	Estimated based on Groundwater Elevation Targets in UA around the GSP/GRP/LF	Calibrated

TABLE 5-1. FLOW MODEL INPUT AND SENSITIVITY ANALYSIS RESULTS
GROUNDWATER MODELING REPORT
COFFEEN POWER PLANT
ASH POND NO. 1
COFFEEN, ILLINOIS

Hydraulic Flow Boundary Parameters

	Relative Location	**Width of HFB (feet)[2]**	**Hydraulic Conductivity (feet)**		
Reach 1	GSP	1	2.89E-08		
Sensitivity[1]	NA	- - -	Low		
Reach 2	RP	1	2.89E-08		
Sensitivity[1]	NA	- - -	Moderate		
Reach 3	LF	1	2.89E-08		
Sensitivity[1]	NA	- - -	Low		
Value Source	NA	Calibrated	Harmonic mean of construction material		

Notes:

[O: SLN 04/01/22; C: EGP 4/29/22]

[1] Sensitivity Explanation:
Negligible - SSR changed by less than 1%
Low - SSR change between 1% and 10%
Moderate - SSR change between 10% and 50%
Moderately High - SSR change between 50% and 100%
High - SSR change greater than 100%

[2] Liner thickness accounted for in harmonic mean calculation

SSR = sum of squared residuals
- - - = not tested
AP1 = Ash Pond No. 1
AP2 = Ash Pond No. 2
CCR = coal combustion residuals
cm/s = centimeters per second
ft/d = feet per day
ft^2/day = feet squared per day
GSP = Gypsum Management Facility Gypsum Stack Pond
in/yr = inches per year
Kh/Kv = anisotropy ratio
LF = Landfill
NA = not applicable
RP = Gypsum Management Facility Recycle Pond
SW = Surface Water

Hydrostratigraphic Unit
UCU = upper confining unit
UA = uppermost aquifer
LCU = lower confining unit

TABLE 5-2. TRANSPORT MODEL INPUT VALUES (CALIBRATION)

GROUNDWATER MODELING REPORT
COFFEEN POWER PLANT
ASH POND NO. 1
COFFEEN, ILLINOIS

Zone	Hydrostratigraphic Unit	Materials	Calibration Model									
			Recharge (ft/d)				Sulfate Concentration (mg/L)				Value Source	Sensitivity
Initial Concentration												
Entire Domain	NA	NA	0.00055				0				NA	- - -
Source Concentration (recharge and constant concentration cells)												
			Pre-GMF		**Post-GMF**		**Pre-GMF**		**Post-GMF**			
	Model Name and Stress Period		**TR1 - STP 1**	**TR1 - STP 2**	**TR2 - STP 1**	**TR3 - STP 1**	**TR1 - STP 1**	**TR1 - STP 2**	**TR2 - STP 1**	**TR3 - STP 1**		
	Time Period		**1970-1984**	**1985-2009**	**2010-2017**	**2018-2022**	**1970-1984**	**1985-2009**	**2010-2017**	**2018-2022**		
6	AP2	CCR	0.0005	0.0005	0.0005	0.00027	1,600	1,600	1,600	0	Leachate sulfate concentrations	- - -
13	AP2 Northwest seep area	-	0.002	0.002	0.002	0.00055	1,600	1,600	1,600	0	Based on previous model	- - -
14	AP2 East and Southwest seep area	-	0.01	0.01	0.01	0.00055	300	300	300	0	Based on previous model	- - -
13	AP2 closure structures	-									Based on previous model	- - -
7	AP1	CCR	0.00055	0.00240	0.00240	0.00240	0	1,000	1,000	1,000	Calibrated	- - -
5	RP	CCR	NA	NA	8.00E-08	8.00E-08	NA	NA	15,000	15,000	Leachate sulfate concentrations	- - -
4	GSP	CCR	NA	NA	8.00E-08	8.00E-08	NA	NA	11,000	11,000	Leachate sulfate concentrations	- - -
3	LF	CCR	NA	NA	8.00E-08	8.00E-08	NA	NA	7,500	7,500	Leachate sulfate concentrations	- - -
GMF Units liner modification (HFB)												
		Well Data	**Hydraulic Conductivity (ft/d)**									
			Pre-GMF		**Post-GMF**							
	Model Name and Stress Period		**TR1 - STP 1**	**TR1 - STP 2**	**TR2 - STP 1**	**TR3 - STP 1**						
	Time Period		**1970-1984**	**1985-2009**	**2010-2017**	**2018-2022**						
1	RP		NA	NA	2.89E-08	2.89E-08					Harmonic Mean	see Table 5-3
11	RP-northeast	G279	NA	NA	2.89E-08	3.00E-04					Calibrated	see Table 5-3
16	RP-southeast	G275	NA	NA	2.89E-08	6.54E-04					Calibrated	see Table 5-3
2	GSP		NA	NA	2.89E-08	2.89E-08					Harmonic Mean	see Table 5-3
21	GSP-east	G215	NA	NA	2.89E-08	6.00E-04					Calibrated	see Table 5-3
3	LF		NA	NA	2.89E-08	2.89E-08					Harmonic Mean	see Table 5-3
Storage, Specific Yield and Effective Porosity				**Calibration Model**								
Zone	**Hydrostratigraphic Unit**	**Materials**	**Storage**	**Specific Yield**	**Effective Porosity**						**Value Source**	**Sensitivity**
1	UCU	loess and clay	0.0034	0.35	0.35	NA					Ramboll (2021a) HCR	see Table 5-3
2	UA	sand and sany silt	0.0034	0.16	0.16						Ramboll (2021a) HCR	see Table 5-3
3	LCU (unweathered Vandalia)	sand clay till	0.0034	0.19	0.19						Ramboll (2021a) HCR	see Table 5-3
4	LCU (Smithboro Formation)	sand clay till	0.0034	0.28	0.28						Ramboll (2021a) HCR	see Table 5-3
5	SW Pond	NA	0.0034	0.35	0.35						Ramboll (2021a) HCR	see Table 5-3
6	LF-CCR	CCR	0.0034	0.19	0.19						Ramboll (2021a) HCR	see Table 5-3
7	GSP-CCR	CCR	0.0034	0.19	0.19						Ramboll (2021a) HCR	see Table 5-3
8	RP-CCR	CCR	0.0034	0.19	0.19						Ramboll (2021a) HCR	see Table 5-3
9	AP2	CCR	0.0034	0.19	0.19						Ramboll (2021a) HCR	see Table 5-3
10	AP1	CCR	0.0034	0.19	0.19						Ramboll (2021a) HCR	see Table 5-3
11	Cooling Pond	clay and silt	0.0034	0.35	0.35						Ramboll (2021a) HCR	see Table 5-3
12	GSP-RP connector	lined channel within UCU	0.0034	0.35	0.35						Ramboll (2021a) HCR	see Table 5-3
13	AP2 -berm	loess and clay	0.0034	0.35	0.35						Ramboll (2021a) HCR	see Table 5-3

TABLE 5-2. TRANSPORT MODEL INPUT VALUES (CALIBRATION)
GROUNDWATER MODELING REPORT
COFFEEN POWER PLANT
ASH POND NO. 1
COFFEEN, ILLINOIS

Storage, Specific Yield and Effective Porosity				**Calibration Model**				
Zone	**Hydrostratigraphic Unit**	**Materials**	**Storage**	**Specific Yield**	**Effective Porosity**		**Value Source**	**Sensitivity**
14	AP1-berm	loess and clay	0.0034	0.35	0.35	NA	Ramboll (2021a) HCR	see Table 5-3
15	Pond (west)	loess and clay	0.0034	0.35	0.35		Ramboll (2021a) HCR	see Table 5-3
16	GSP-liner	liner	0.0034	0.16	0.16		Ramboll (2021a) HCR	see Table 5-3
17	RP-liner	liner	0.0034	0.16	0.16		Ramboll (2021a) HCR	see Table 5-3
18	LF-liner	liner	0.0034	0.16	0.16		Ramboll (2021a) HCR	see Table 5-3
19	UCU- fill (drain/river)	NA	0.0034	0.5	0.5		Calibrated	see Table 5-3
21	LF-GSP shared embankment	reworked silts and clays	0.0034	0.16	0.16		Calibrated	see Table 5-3
Dispersivity								
Applicable Region	**Hydrostratigraphic Unit**	**Materials**	**Longitudinal (feet)**	**Transverse (feet)**	**Vertical (feet)**		**Value Source**	**Sensitivity**
1	UCU	loess and clay	1	0.1	0.01	NA	calibrated	see Table 5-3
2	UA	sand and sany silt	10	1	0.1		calibrated	see Table 5-3
3	LCU (unweathered Vandalia)	sand clay till	1	0.1	0.01		calibrated	see Table 5-3
4	LCU (Smithboro Formation)	sand clay till	1	0.1	0.01		calibrated	see Table 5-3

[O: SLN 04/01/22; C: EGP 04/29/22]

Notes:
- - - = not tested
AP1 = Ash Pond No. 1
AP2 = Ash Pond No. 2
CCR = coal combustion residuals
ft/d = feet per day
GMF = Gypsum Management Facility
GSP = Gypsum Management Facility Gypsum Stack Pond
LF = Landfill
mg/L = milligrams per liter
NA = not applicable
RP = Gypsum Management Facility Recycle Pond
SS = Steady State model
STP = Stress Period
SW = Surface Water
TR = Transient model

Hydrostratigraphic Unit
UCU = upper confining unit
UA = uppermost aquifer
LCU = lower confining unit

TABLE 5-3. TRANSPORT MODEL INPUT SENSITIVITY (CALIBRATION)

GROUNDWATER MODELING REPORT
COFFEEN POWER PLANT
ASH POND NO. 1
COFFEEN, ILLINOIS

			Storage and Specific Yield				Effective Porosity			
Well ID	**SI**	**Calibration on Sulfate Concentration (mg/L)**	**Sulfate Concentration (mg/L)**	**Sensitivity [1]**	**Sulfate Concentration (mg/L)**	**Sensitivity [1]**	**Sulfate Concentration (mg/L)**	**Sensitivity [1]**	**Sulfate Concentration (mg/L)**	**Sensitivity [1]**
G301	AP1	961.2	961.3	Negligible	958.1	Negligible	964.1	Negligible	954.2	Negligible
G302	AP1	954.3	951.2	Negligible	937.3	Low	954.8	Negligible	950.7	Negligible
G303	AP1	626.7	613.2	Low	572.0	Low	643.3	Low	598.3	Low
G305	AP1	426.0	408.8	Low	442.1	Low	451.3	Low	379.3	Moderate
G306	AP1	427.0	371.0	Moderate	400.9	Low	463.5	Low	375.8	Moderate
G307	AP1	779.7	762.4	Low	911.7	Moderate	786.0	Negligible	768.6	Low
G308	AP1	880.0	868.7	Low	813.0	Low	883.2	Negligible	872.2	Negligible
G309	AP1	922.0	901.3	Low	867.1	Low	924.2	Negligible	916.0	Negligible
G310	AP1	921.9	925.6	Negligible	916.5	Negligible	926.7	Negligible	915.6	Negligible
G311	AP1	966.6	965.5	Negligible	956.7	Low	967.0	Negligible	964.8	Negligible
G312	AP1	934.7	940.5	Negligible	924.4	Low	936.7	Negligible	933.5	Negligible
G313	AP1	908.8	908.3	Negligible	903.2	Negligible	909.3	Negligible	907.0	Negligible
G314	AP1	848.0	845.7	Negligible	838.1	Low	850.8	Negligible	841.8	Negligible
G315	AP1	786.7	737.7	Low	791.7	Negligible	789.6	Negligible	776.3	Low
G316	AP1	507.5	509.6	Negligible	494.8	Low	532.8	Low	469.7	Low
G317	AP1	146.9	149.8	Low	116.4	Moderate	202.9	Moderate	93.4	Moderate
			S*0.1 Sy*0.5		S*10 Sy*2		Porosity-0.05		Porosity+0.05	

TABLE 5-3. TRANSPORT MODEL INPUT SENSITIVITY (CALIBRATION)

GROUNDWATER MODELING REPORT
COFFEEN POWER PLANT
ASH POND NO. 1
COFFEEN, ILLINOIS

		Dispersivity				**HFB (GMF GSP and GMF RP Liner)**			
Well ID	**SI**	**Sulfate Concentration (mg/L)**	**Sensitivity [1]**	**Sulfate Concentration (mg/L)**	**Sensitivity [1]**	**Sulfate Concentration (mg/L)**	**Sensitivity [1]**	**Sulfate Concentration (mg/L)**	**Sensitivity [1]**
G301	AP1	931.7	Low	909.6	Low	959.2	Negligible	937.3	Low
G302	AP1	914.3	Low	887.2	Low	953.4	Negligible	956.9	Negligible
G303	AP1	620.4	Negligible	589.4	Low	626.1	Negligible	622.1	Negligible
G305	AP1	415.1	Low	387.9	Low	425.8	Negligible	425.0	Negligible
G306	AP1	420.1	Low	390.5	Low	426.9	Negligible	426.2	Negligible
G307	AP1	756.7	Low	720.4	Low	779.6	Negligible	779.1	Negligible
G308	AP1	843.3	Low	800.4	Low	879.4	Negligible	879.2	Negligible
G309	AP1	892.9	Low	858.2	Low	922.8	Negligible	916.7	Negligible
G310	AP1	882.3	Low	853.6	Low	922.3	Negligible	915.6	Negligible
G311	AP1	943.7	Low	926.1	Low	965.1	Negligible	963.6	Negligible
G312	AP1	900.6	Low	869.2	Low	934.9	Negligible	933.7	Negligible
G313	AP1	774.1	Moderate	693.3	Moderate	908.4	Negligible	908.6	Negligible
G314	AP1	799.7	Low	756.2	Moderate	848.5	Negligible	848.5	Negligible
G315	AP1	764.9	Low	722.5	Low	785.7	Negligible	786.4	Negligible
G316	AP1	461.4	Low	426.2	Moderate	507.4	Negligible	507.5	Negligible
G317	AP1	123.6	Moderate	124.2	Moderate	146.9	Negligible	146.9	Negligible
		Disp*5		Disp*10		HFB*0.1		HFB*10	

[O: SLN 04/10/22; C: EGP 5/5/22]

Notes:

[1] Sensitivity Explanation:
Negligible = concentration changed by less than 1%
Low = concentration change between 1% and 10%
Moderate = concentration change between 10% and 50%
Moderately High = concentration change between 50% and 100%
High = concentration change greater than 100%

[2] sensitivity test used transient transport

AP1 = Ash Pond No. 1
AP2 = Ash Pond No. 2
Disp = dispersivity
GSP = Gypsum Management Facility Gypsum Stack Pond
HFB = Horizontal Flow Boundary
ID = identification
mg/L = milligrams per liter
RP = Gypsum Management Facility Recycle Pond
S = storativity
Sy = specific yield

TABLE 6-1. HELP MODEL INPUT AND OUTPUT VALUES
GROUNDWATER MODELING REPORT
COFFEEN POWER PLANT
ASH POND NO. 1
COFFEEN, ILLINOIS

Closure Scenario Number (Drainage Length)	**Ash Pond 1 - CIP Consolidation and Cover System Area**	**Ash Pond 1 - CIP Removal Area (1 foot) - CBR East Side (1 foot)**	**Ash Pond 1 - CBR West Side (3 feet)**	**Notes**
Input Parameter				
Climate-General				
City	Coffeen, Illinois	Coffeen, Illinois	Coffeen, Illinois	Nearby city to the Site within HELP database
Latitude	39.06	39.06	39.06	Site latitude
Evaporative Zone Depth	18	12	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	Belleville Scott Air Force Base Belleville, Illinois	Belleville Scott Air Force Base Belleville, Illinois	Belleville Scott Air Force Base Belleville, Illinois	Nearby city to the Coffeen Power Plant 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: 39.06/-89.39	Precipitation, temperature, and solar radiation was simulated based on HELP V4 weather simulation for: Lat/Long: 39.06/-89.39	Precipitation, temperature, and solar radiation was simulated based on HELP V4 weather simulation for: Lat/Long: 39.06/-89.39	
Soils-General				
% where runoff possible	100	100	100	
Area (acres)	10	13	10	CBR - Removal Area based on HCR (Ramboll, 2021); CIP - Consolidation and Cover System Area based on construction drawing for Ash Pond No. 1; 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])	Protective Cover Layer (HELP Final Cover Soil [topmost layer])	Protective Cover Layer (HELP Final Cover Soil [topmost layer])	Layers details for CBR, CIP, and Landfill areas based on grading plans, construction drawings, and cover system design for Ash Pond No. 1
2	Protective Soil Layer (HELP Vertical Percolation Layer)	--	--	
3	Nonwoven Geotextile (HELP Custom Layer)	--	--	
4	Geomembrane Liner	--	--	
5	Unsaturated CCR Material (HELP Waste)	--	--	
6	HELP Vertical Percolation Layer	--	--	
7	--	--	--	

TABLE 6-1. HELP MODEL INPUT AND OUTPUT VALUES
GROUNDWATER MODELING REPORT
COFFEEN POWER PLANT
ASH POND NO. 1
COFFEEN, ILLINOIS

Closure Scenario Number (Drainage Length)	Ash Pond 1 - CIP Consolidation and Cover System Area	Ash Pond 1 - CIP Removal Area (1 foot) - CBR East Side (1 foot)	Ash Pond 1 - CBR West Side (3 feet)	Notes
Soil Parameters--Layer 1				
Type	1	1	1	Vertical Percolation Layer (Cover Soil)
Thickness (in)	6	12	36	For CBR and CIP removal areas, layer 1 thickness is the average thickness of unsaturated backfill material placed after removal
Texture	12	14	14	Defaults used
Description	Silty Clay Loam	Silty Clay	Silty Clay	
Saturated Hydraulic Conductivity (cm/s)	4.20E-05	2.50E-05	2.50E-05	Defaults used
Soil Parameters--Layer 2				
Type	1	--	--	Vertical Percolation Layer
Thickness (in)	18	--	--	design thickness
Texture	14	--	--	Defaults used
Description	Silty Clay	--	--	
Saturated Hydraulic Conductivity (cm/s)	2.50E-05	--	--	Defaults used
Soil Parameters--Layer 3				
Type	2	--	--	Lateral Drainage Layer
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				
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
Soil Parameters--Layer 5				
Type	1	--	--	Vertical Percolation Layer (Waste)
Thickness (in)	360	--	--	design thickness
Texture	84	--	--	Defaults used
Description	High-Density Electric Plant Coal Bottom Ash	--	--	
Saturated Hydraulic Conductivity (cm/s)	8.80E-05	--	--	defaults used

TABLE 6-1. HELP MODEL INPUT AND OUTPUT VALUES
GROUNDWATER MODELING REPORT
COFFEEN POWER PLANT
ASH POND NO. 1
COFFEEN, ILLINOIS

Closure Scenario Number (Drainage Length)	Ash Pond 1 - CIP Consolidation and Cover System Area	Ash Pond 1 - CIP Removal Area (1 foot) - CBR East Side (1 foot)	Ash Pond 1 - CBR West Side (3 feet)	Notes
Soil Parameters--Layer 6				
Type	1	--	--	Background Silty Clay (Ash Pond No. 1)
Thickness (in)	60	--	--	Background clay thickness (Ash Pond No. 1)
Texture	43	--	--	Custom (Ash Pond No. 1) Defaults used (GSP and Landfill)
Description	Loess Unit Silty Clay	--	--	
Saturated Hydraulic Conductivity (cm/s)	3.85E-06	--	--	Average for Loess Unit (Ash Pond No. 1)
Soil Parameters--Layer 7				
Type	--	--	--	Drainage Liner
Thickness (in)	--	--	--	design thickness
Texture	--	--	--	Defaults used
Description	--	--	--	
Saturated Hydraulic Conductivity (cm/s)	--	--	--	Defaults used
Soils--Runoff				
Runoff Curve Number	85.9	88.6	89.2	HELP-computed curve number
Slope	5.00%	0.50%	0.50%	Estimated from construction design drawings
Length (ft)	350	1,000	350	estimated maximum flow path
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				
Unsaturated Percolation Rate (in/yr)	**0.00090**	**7.85**	**6.28**	

Notes:
% = percent
CBR = closure by removal
CIP = closure in place
cm/s = centimeters per second
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. AP1, GMF GSP, Coffeen Power Plant. Coffeen, Illinois.

TABLE 6-2. PREDICTION MODEL INPUT VALUES

GROUNDWATER MODELING REPORT
COFFEEN POWER PLANT
ASH POND NO. 1
COFFEEN, ILLINOIS

Hydrostratigraphic Unit/Recharge Area	Notes	Recharge Zone	Sulfate Concentration (mg/L)	Recharge (ft/day)	Recharge (inches/yr)	Constant Concentration Layer	Constant Concentration (mg/L)
Scenario 1: CIP							
AP1 - removal area east	FILL	7	0	1.8E-03	7.85	2&3	130.0
AP1 - consolidation area west	CCR	16	1,000	6.26E-08	2.74E-04	- - -	- - -
Scenario 2: CBR							
AP1 - removal area east	FILL	7	0	1.8E-03	7.85	- - -	- - -
AP1 - removal area west	FILL	16	0	1.4E-03	6.28	- - -	- - -

[O: SLN 04/01/22; C: EGP 04/29/22]

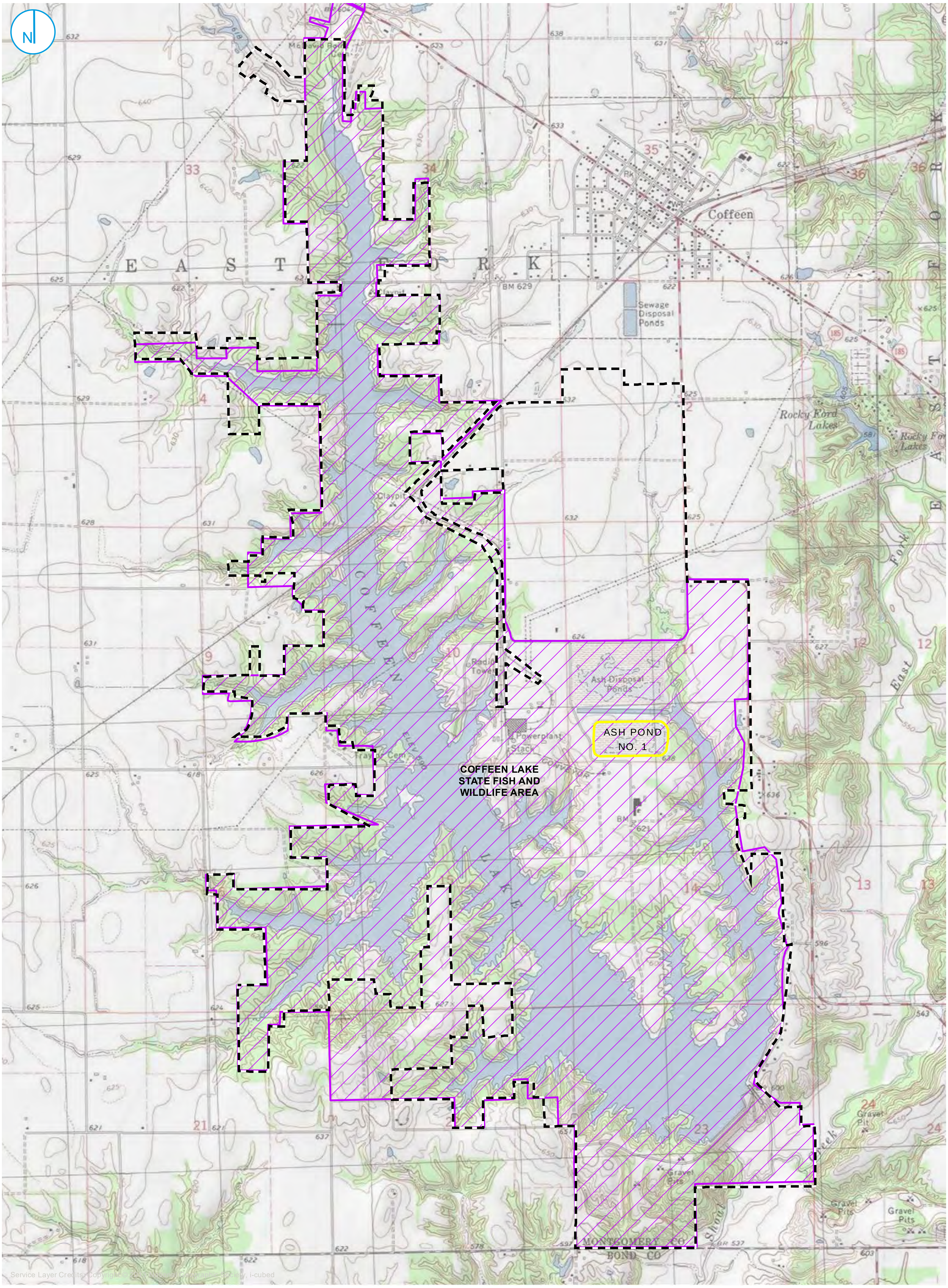
Notes:

- - - = not included
AP1 = Ash Pond No. 1
CCR = coal combustion residuals
ft/day = feet per day
inches/yr = inches per year
mg/L = milligrams per liter

FIGURES

PROJECT: 169000XXXX | DATED: 10/12/2021 | DESIGNER: HOTCALD

Y:\Mapping\Projects\22\2285\MXD\845_Operating_Permit\Coffeen\AP1\Figure 1-1_Site Location Map AP1.mxd



PART 845 REGULATED UNIT (SUBJECT UNIT)

PROPERTY BOUNDARY

COFFEEN LAKE STATE FISH AND WILDLIFE AREA

0 1,000 2,000
Feet

SITE LOCATION MAP

FIGURE 1-1

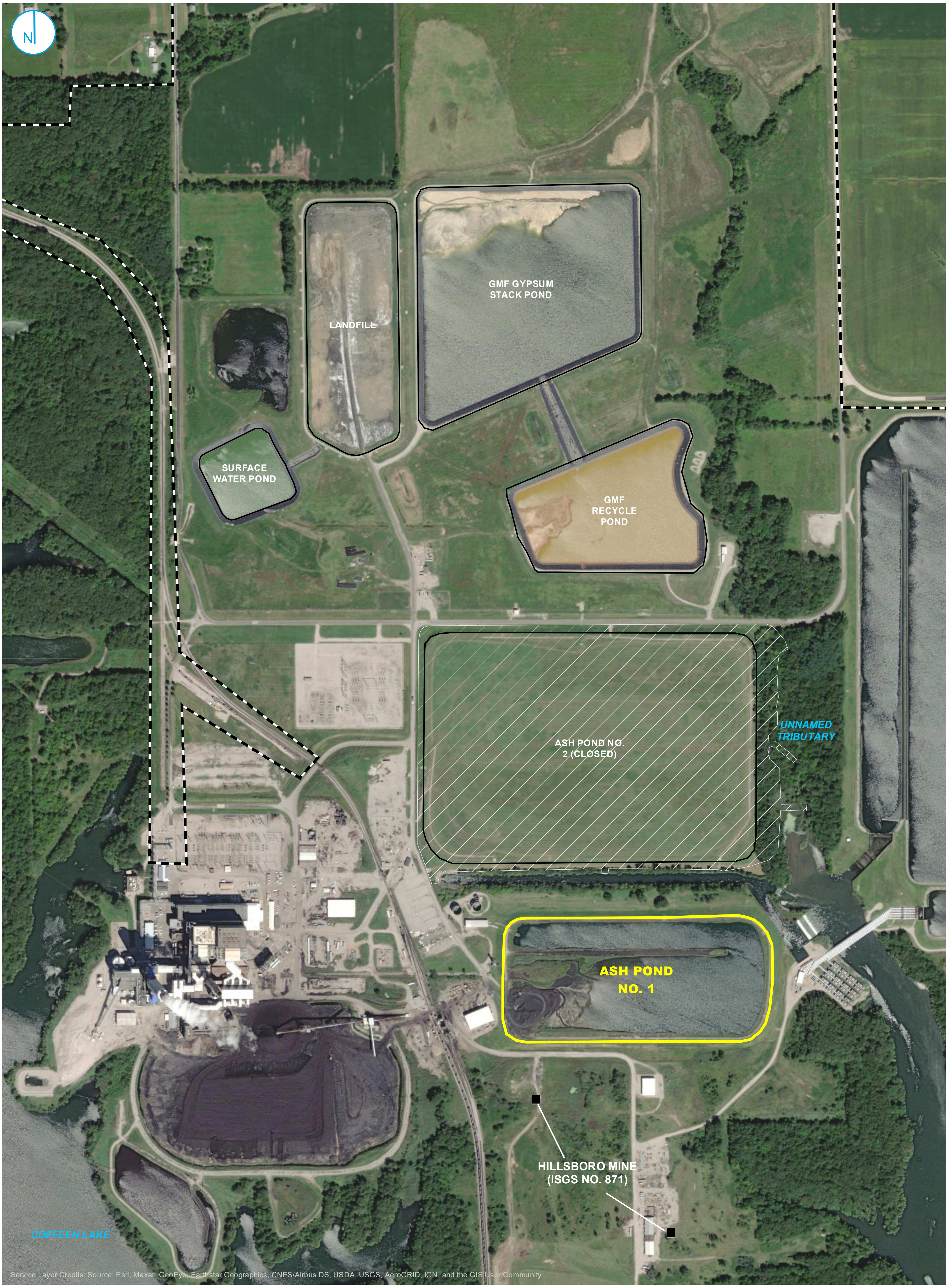
GROUNDWATER MODELING REPORT
ASH POND NO. 1
COFFEEN POWER PLANT
COFFEEN, ILLINOIS

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL

PROJECT: 169000XXXX | DATED: 5/5/2022 | DESIGNER: galammc

Y:\Mapping\Projects\22\2285\MXD\Model_Figures\Coffeen\AP1\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

■ COAL MINE SHAFT

▭ PART 845 REGULATED UNIT (SUBJECT UNIT)

▭ SITE FEATURE

▨ LIMITS OF FINAL COVER

▭ PROPERTY BOUNDARY

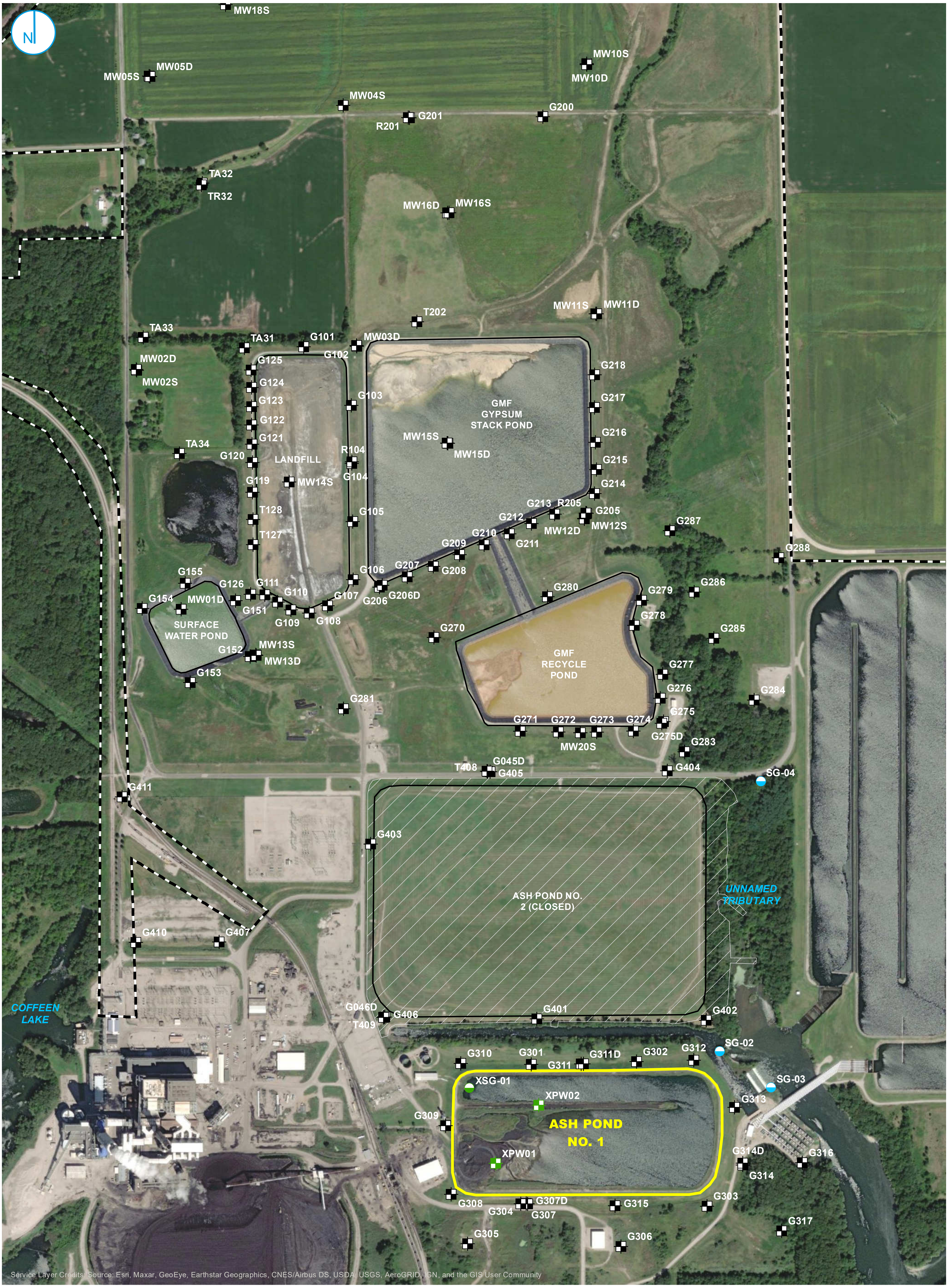
0 275 550 Feet

SITE MAP

FIGURE 1-2

GROUNDWATER MODELING REPORT
ASH POND NO. 1
COFFEEN POWER PLANT
COFFEEN, ILLINOIS

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.



⊞ MONITORING WELL

🟩 PORE WATER WELL

◓ STAFF GAGE, RIVER

◓ STAFF GAGE, CCR UNIT

▭ PART 845 REGULATED UNIT (SUBJECT UNIT)

▭ SITE FEATURE

▨ LIMITS OF FINAL COVER

⬚ PROPERTY BOUNDARY

0 275 550 Feet

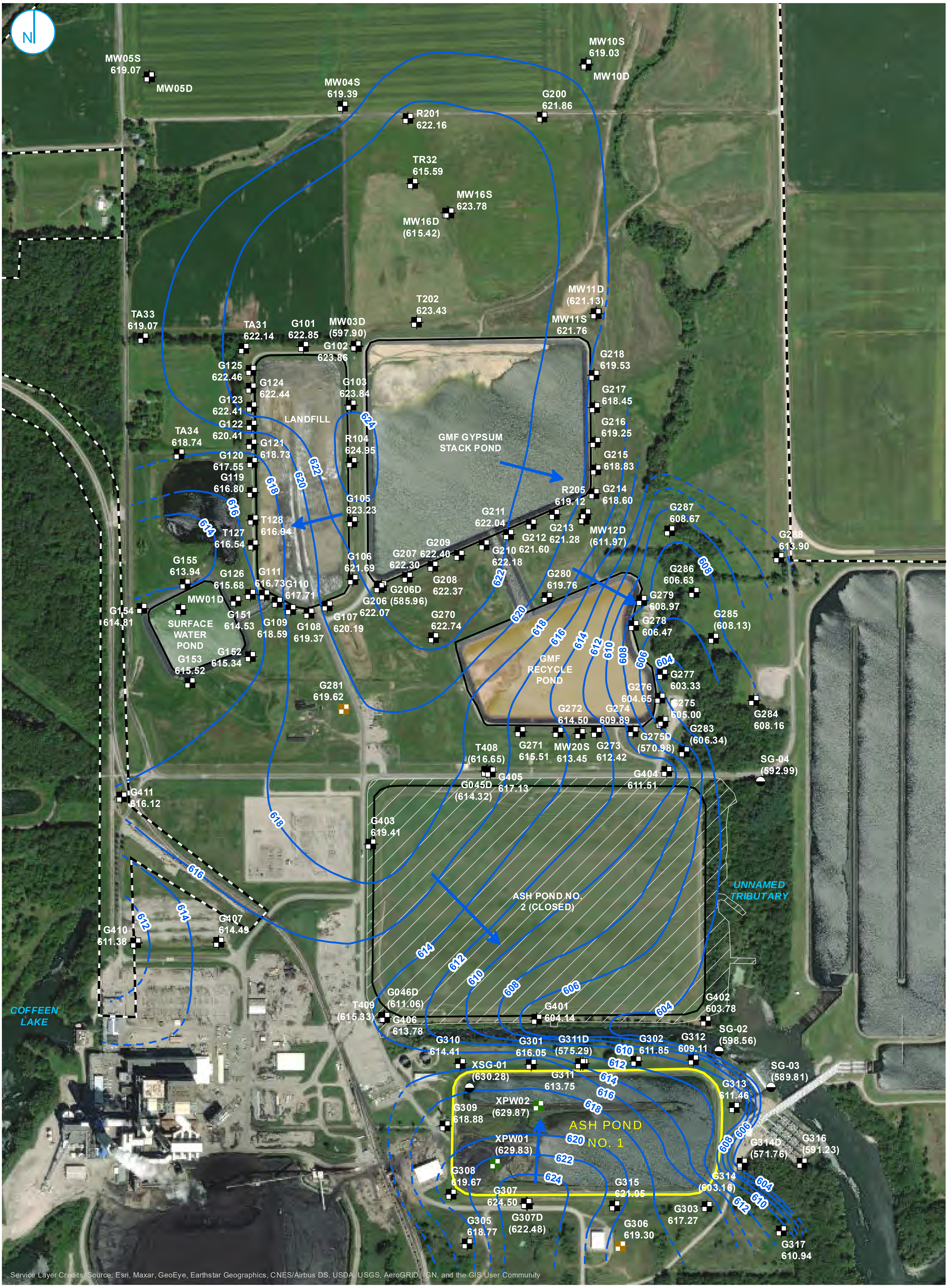
MONITORING WELL LOCATION MAP

FIGURE 2-1

GROUNDWATER MODELING REPORT
ASH POND NO. 1
COFFEEN POWER PLANT
COFFEEN, ILLINOIS

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL



BACKGROUND WELL

MONITORING WELL

SOURCE SAMPLE LOCATION

◓ STAFF GAGE

GROUNDWATER ELEVATION CONTOUR (2-FT CONTOUR INTERVAL, NAVD88)

INFERRED GROUNDWATER ELEVATION CONTOUR

GROUNDWATER FLOW DIRECTION

0 275 550 Feet

PART 845 REGULATED UNIT (SUBJECT UNIT)

SITE FEATURE

LIMITS OF FINAL COVER

PROPERTY BOUNDARY

NOTE:
ELEVATIONS IN PARENTHESES WERE NOT USED FOR CONTOURING.

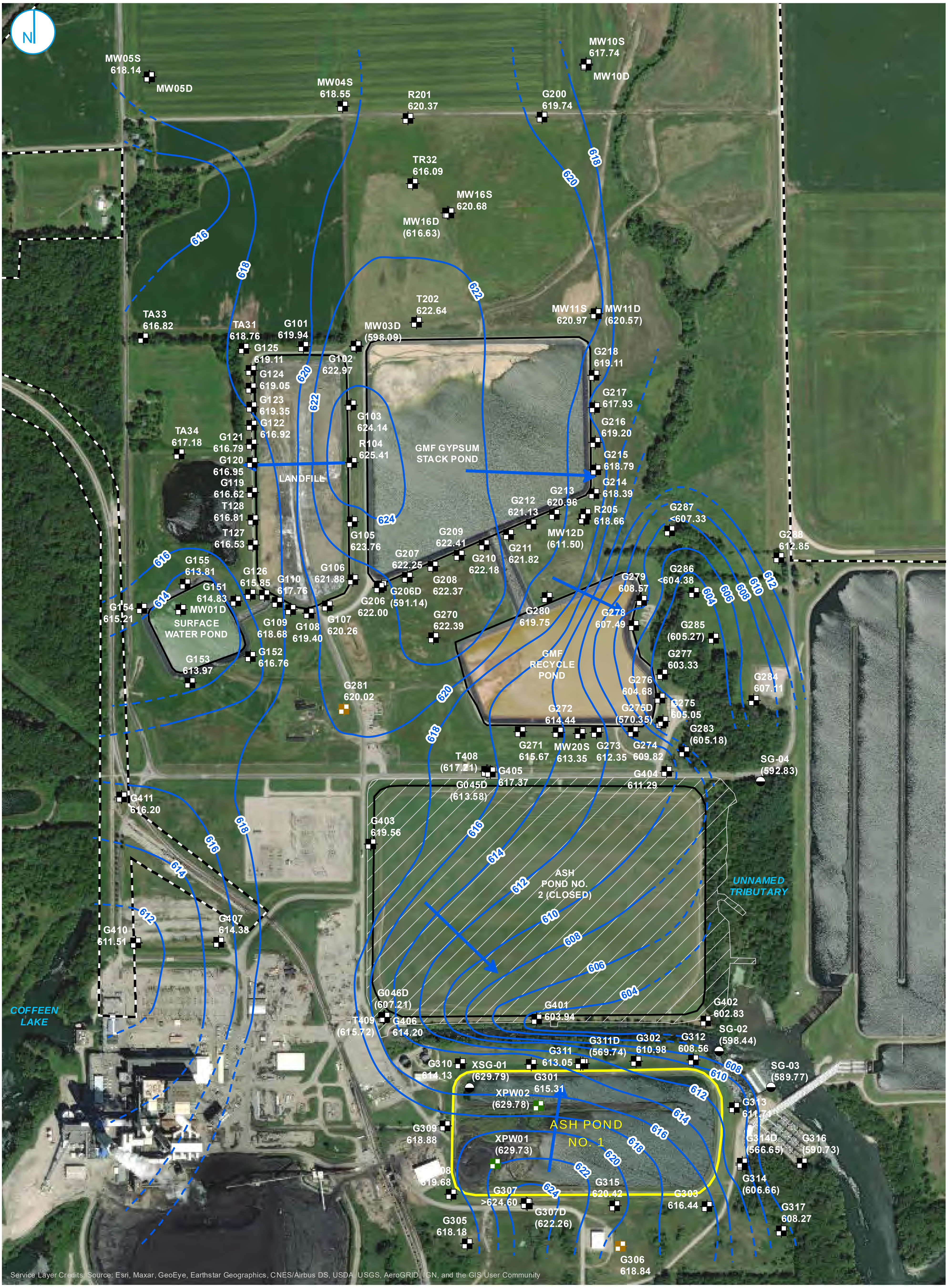
UPPERMOST AQUIFER POTENTIOMETRIC SURFACE MAP
APRIL 20, 2021

FIGURE 2-2

GROUNDWATER MODELING REPORT
ASH POND NO. 1
COFFEEN POWER PLANT
COFFEEN, ILLINOIS

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL



▨	BACKGROUND WELL
▨	MONITORING WELL
🟩	SOURCE SAMPLE LOCATION
◒	STAFF GAGE
—	GROUNDWATER ELEVATION CONTOUR (2-FT CONTOUR INTERVAL, NAVD88)
- -	INFERRED GROUNDWATER ELEVATION CONTOUR
→	GROUNDWATER FLOW DIRECTION
🟨	PART 845 REGULATED UNIT (SUBJECT UNIT)
☐	SITE FEATURE
▨	LIMITS OF FINAL COVER
☐	PROPERTY BOUNDARY

0 275 550
Feet

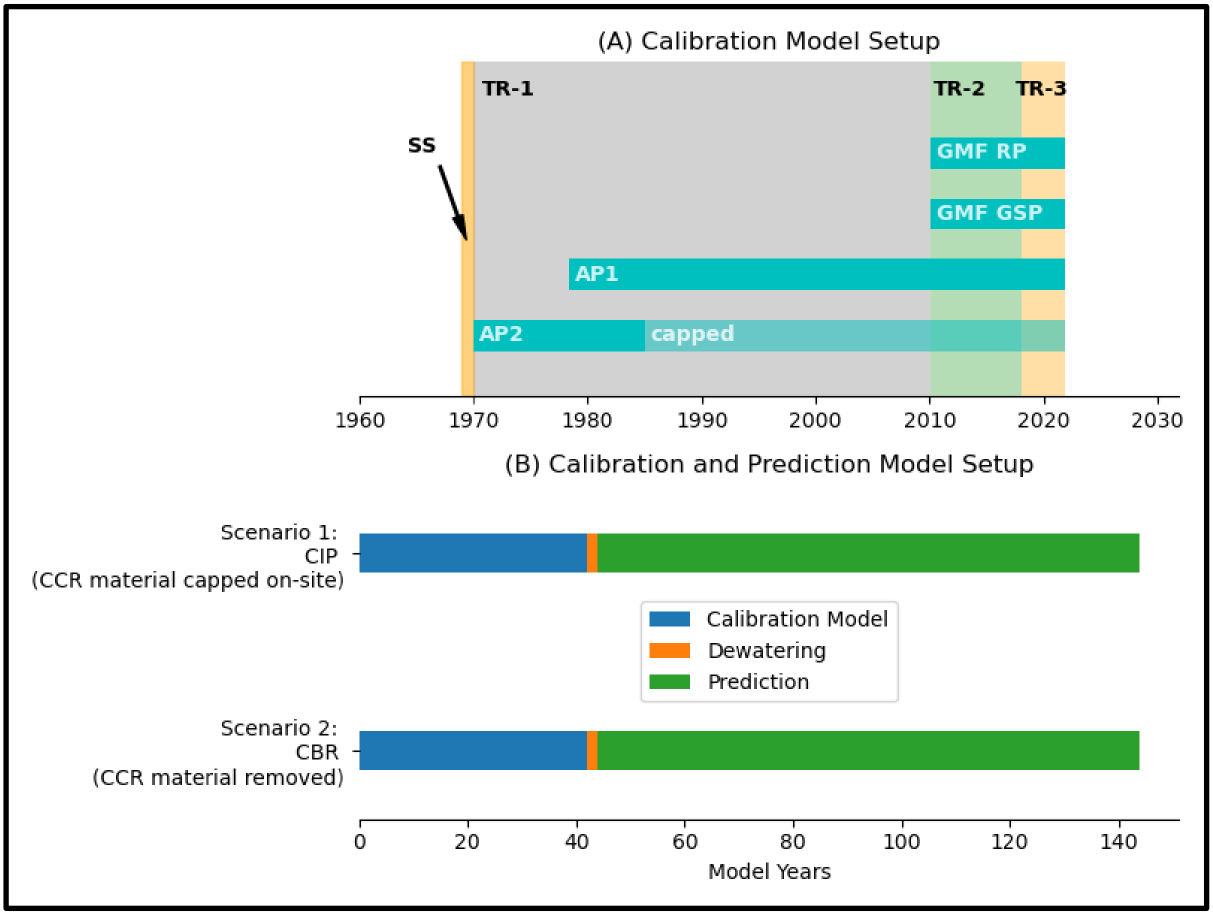
NOTE:
ELEVATIONS IN PARENTHESES WERE NOT USED FOR CONTOURING.

UPPERMOST AQUIFER POTENTIOMETRIC SURFACE MAP
JULY 26, 2021

FIGURE 2-3

GROUNDWATER MODELING REPORT
ASH POND NO. 1
COFFEEN POWER PLANT
COFFEEN, ILLINOIS

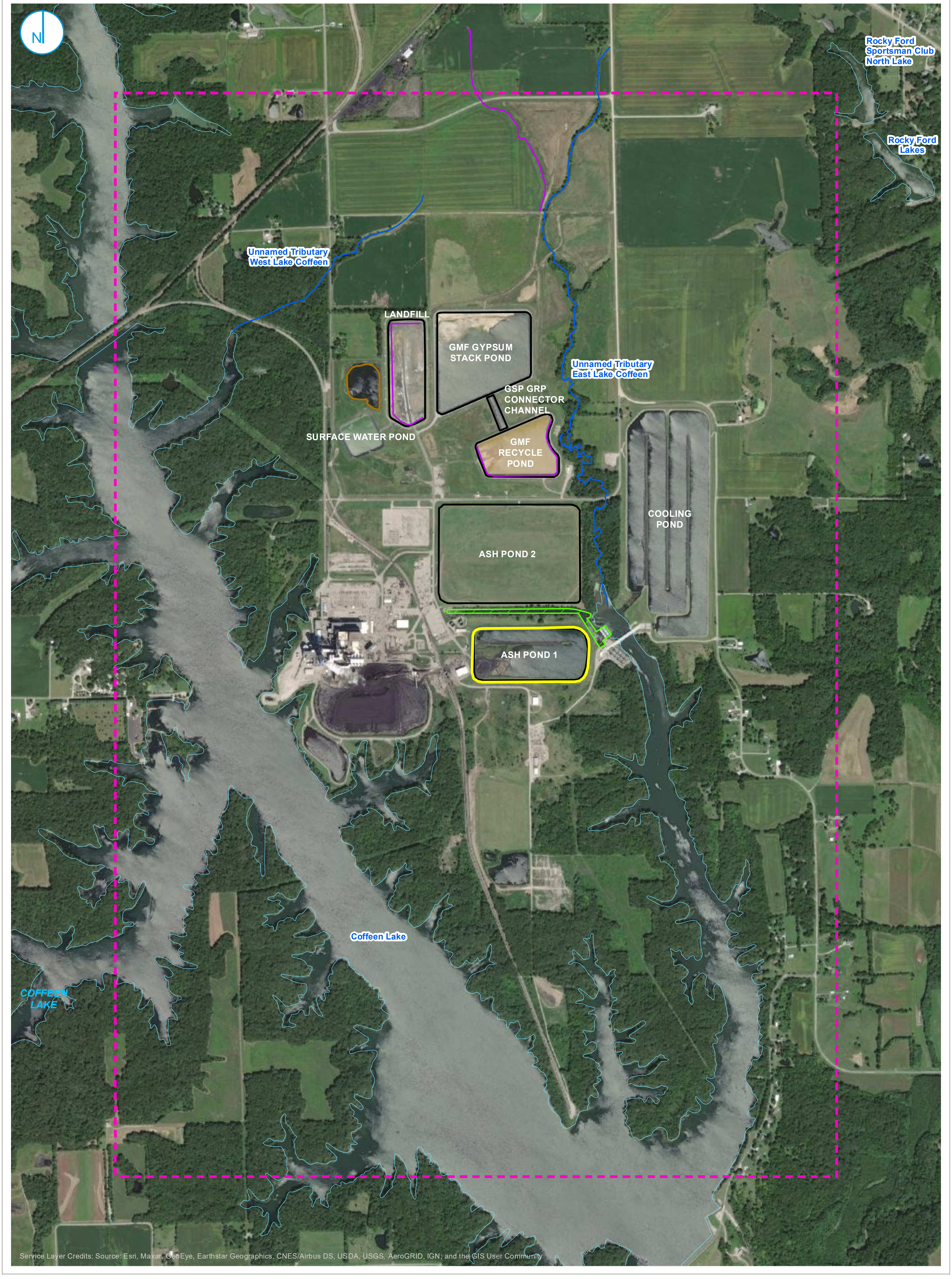
RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.



CALIBRATION AND PREDICTIVE TIMELINE
(SS = STEADY STATE MODEL AND TR = TRANSIENT MODEL)

GROUNDWATER MODELING REPORT
ASH POND NO. 1
COFFEEN POWER PLANT
COFFEEN, ILLINOIS

RAMBOLL

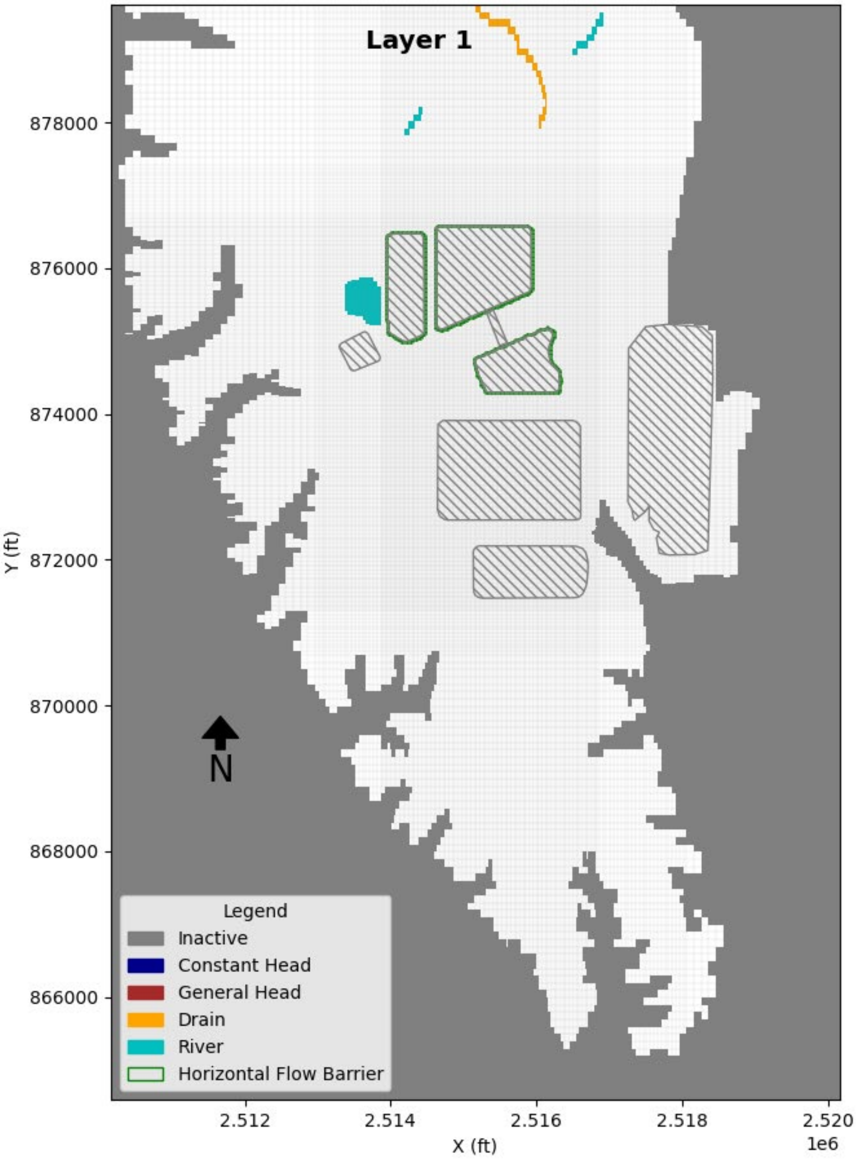


MODEL AREA MAP

FIGURE 5-1

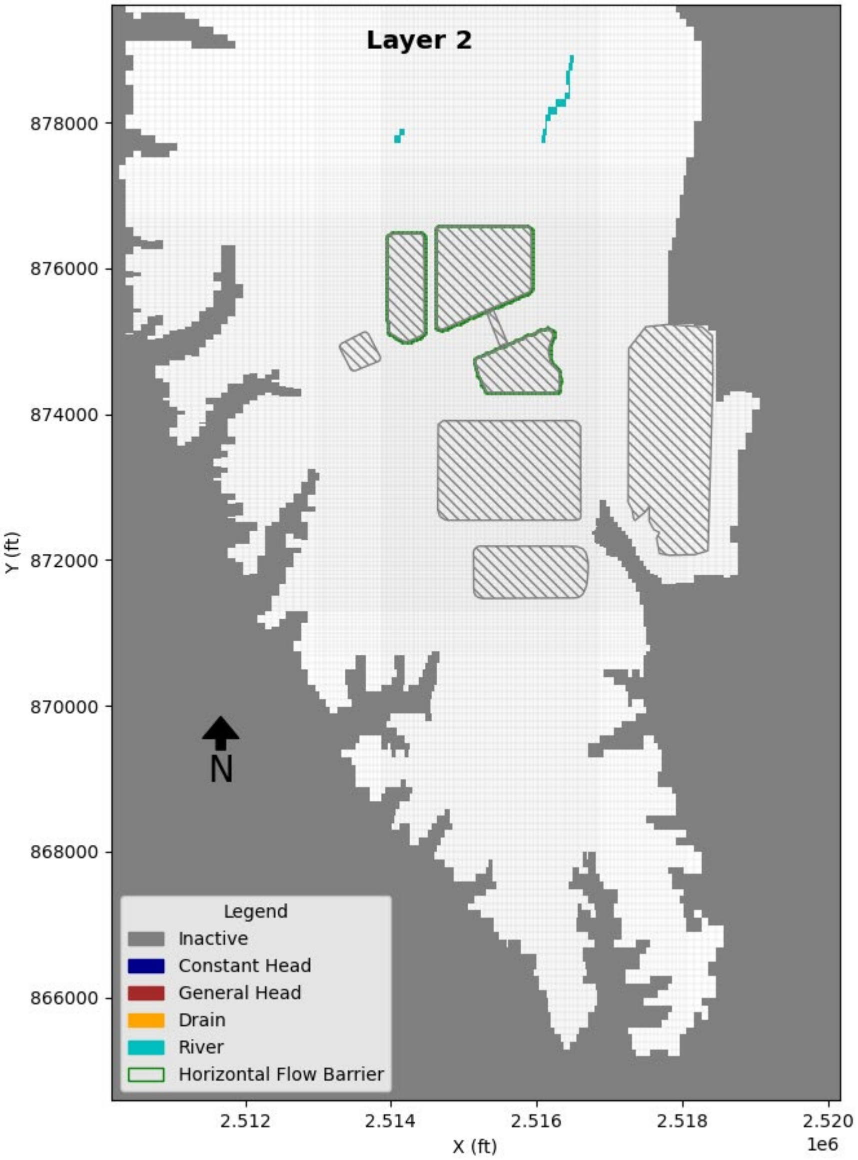
GROUNDWATER MODELING REPORT
ASH POND NO. 1
COFFEEN POWER PLANT
COFFEEN, ILLINOIS

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.



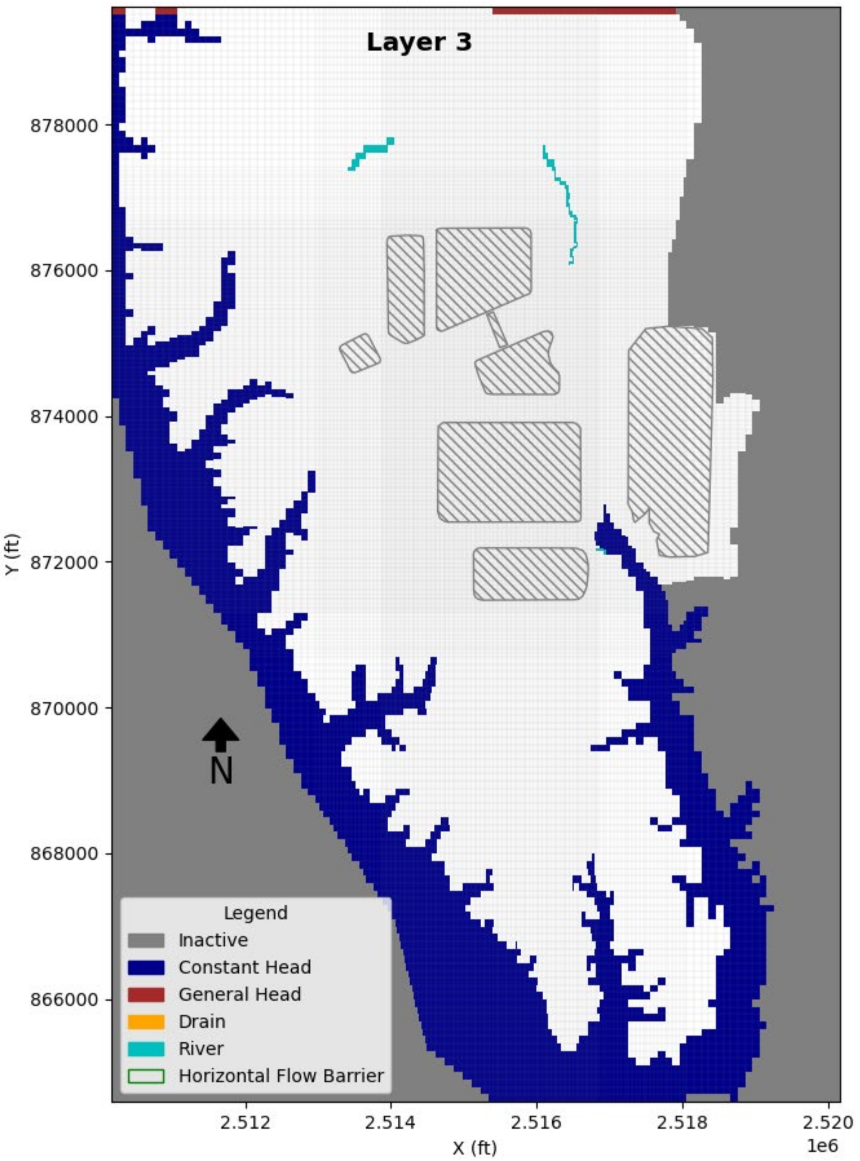
BOUNDARY CONDITIONS FOR LAYER 1

GROUNDWATER MODELING REPORT
ASH POND NO. 1
COFFEEN POWER PLANT
COFFEEN, ILLINOIS



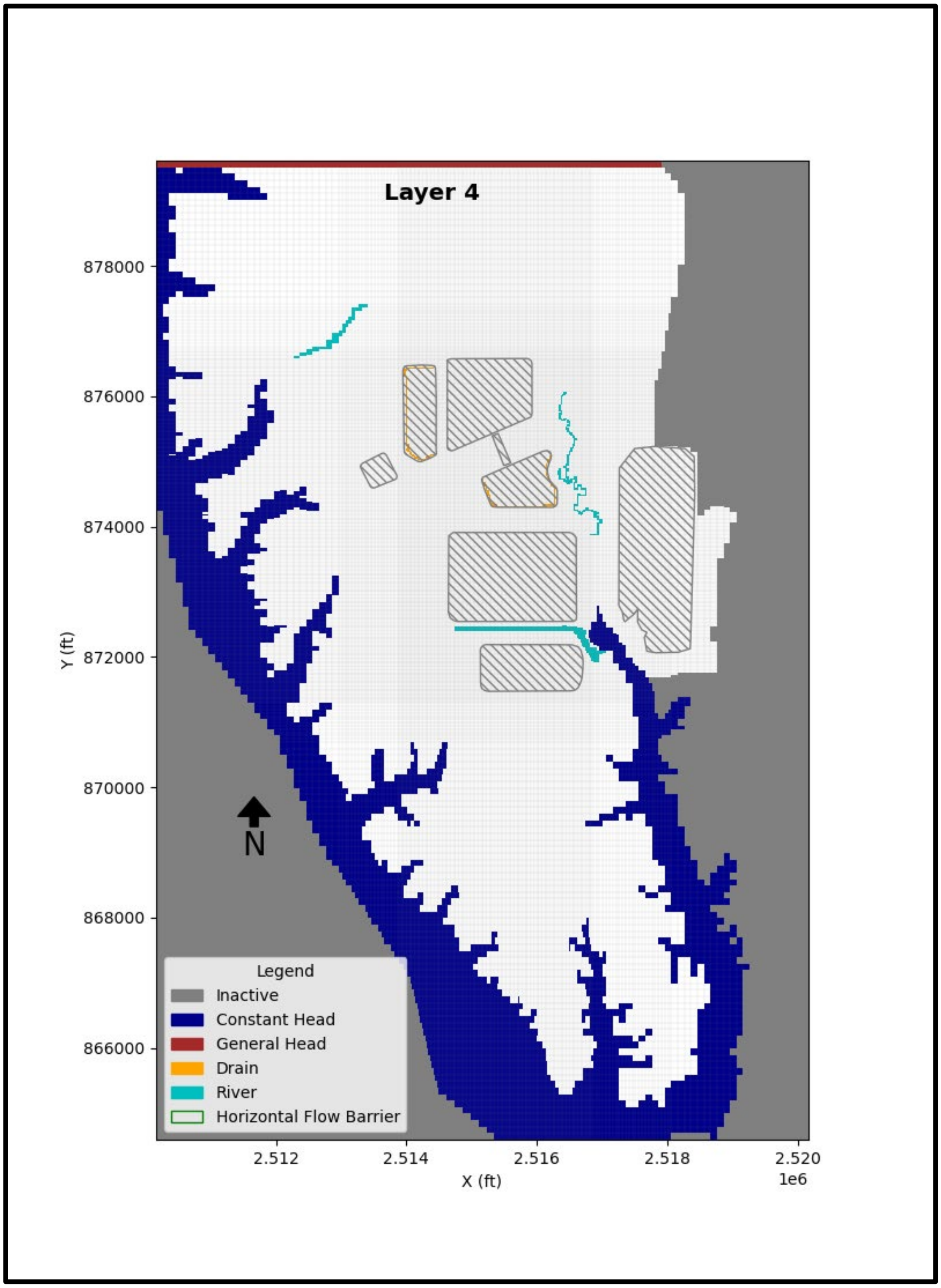
BOUNDARY CONDITIONS FOR LAYER 2

GROUNDWATER MODELING REPORT
ASH POND NO. 1
COFFEEN POWER PLANT
COFFEEN, ILLINOIS



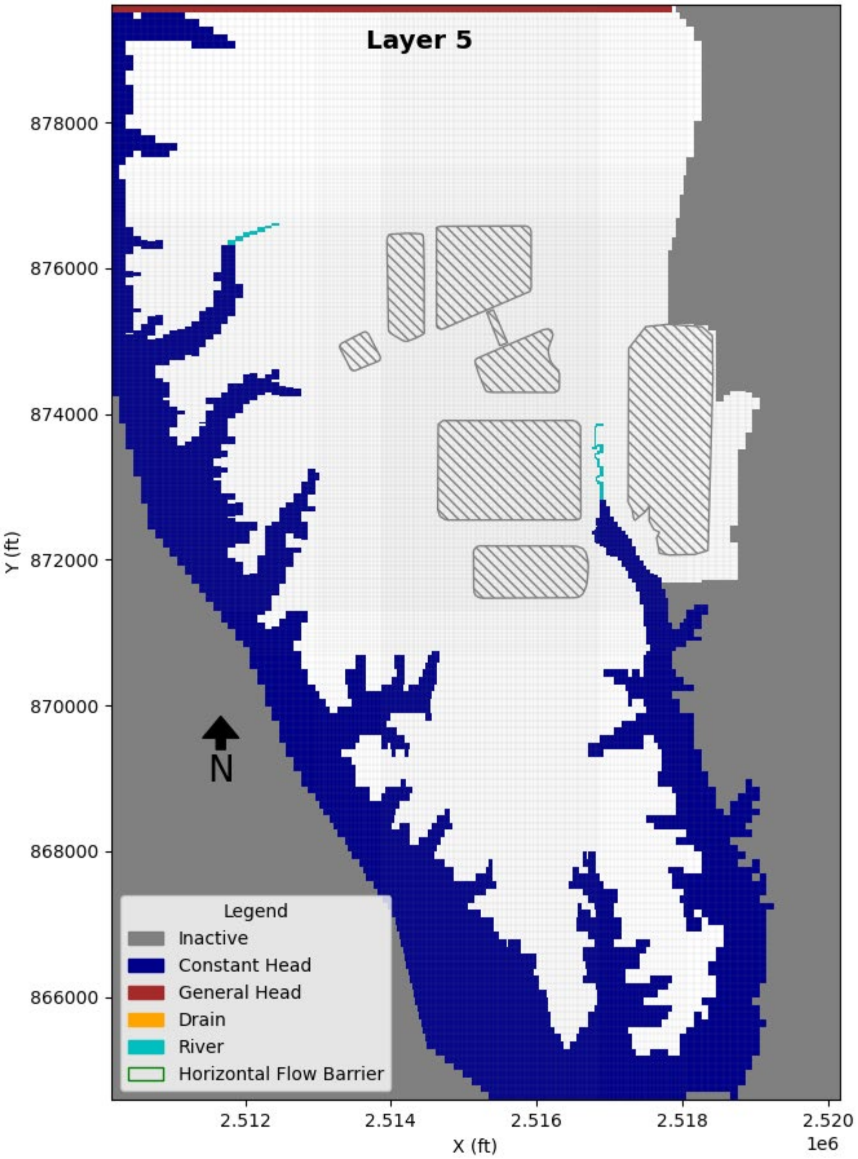
BOUNDARY CONDITIONS FOR LAYER 3

GROUNDWATER MODELING REPORT
ASH POND NO. 1
COFFEEN POWER PLANT
COFFEEN, ILLINOIS



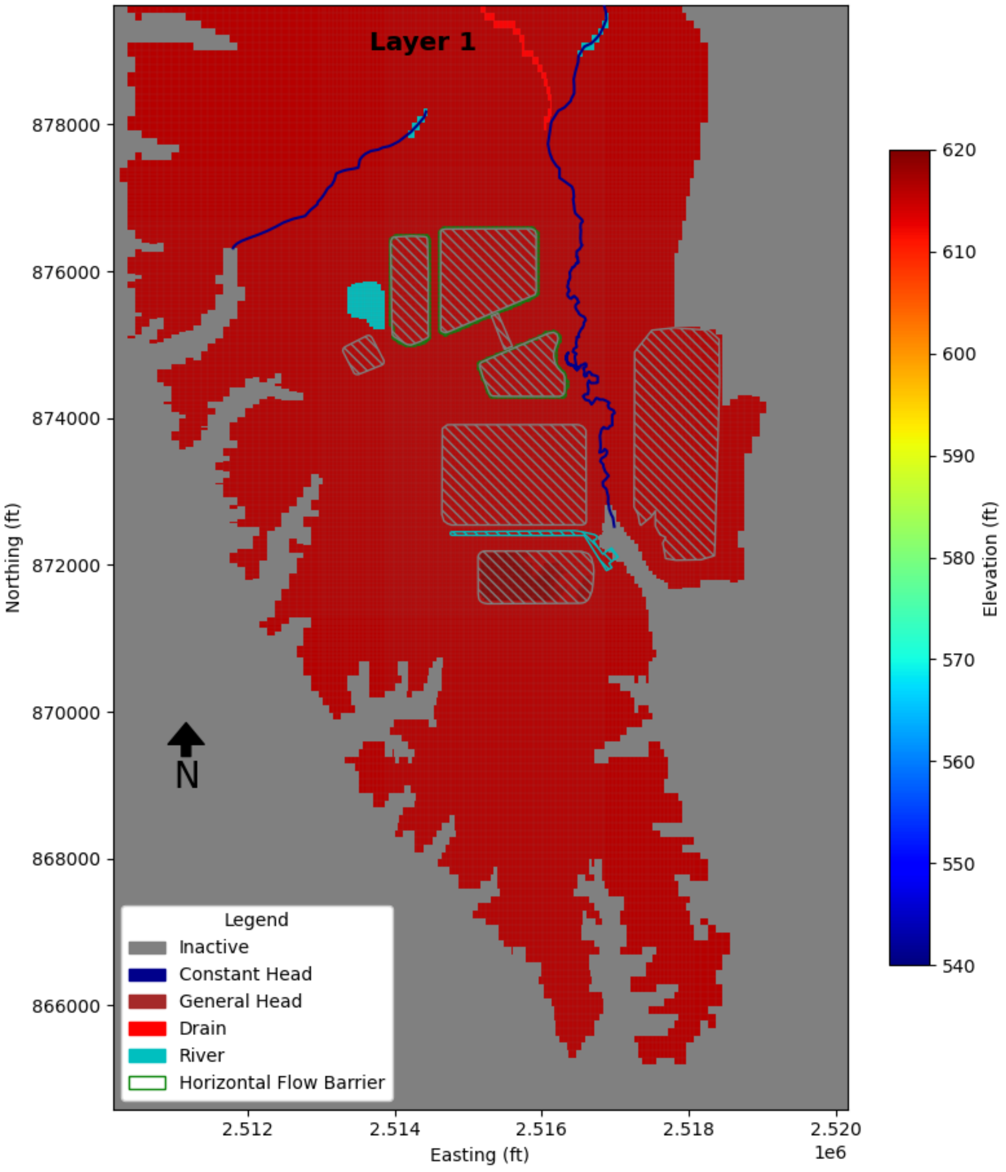
BOUNDARY CONDITIONS FOR LAYER 4

GROUNDWATER MODELING REPORT
ASH POND NO. 1
COFFEEN POWER PLANT
COFFEEN, ILLINOIS



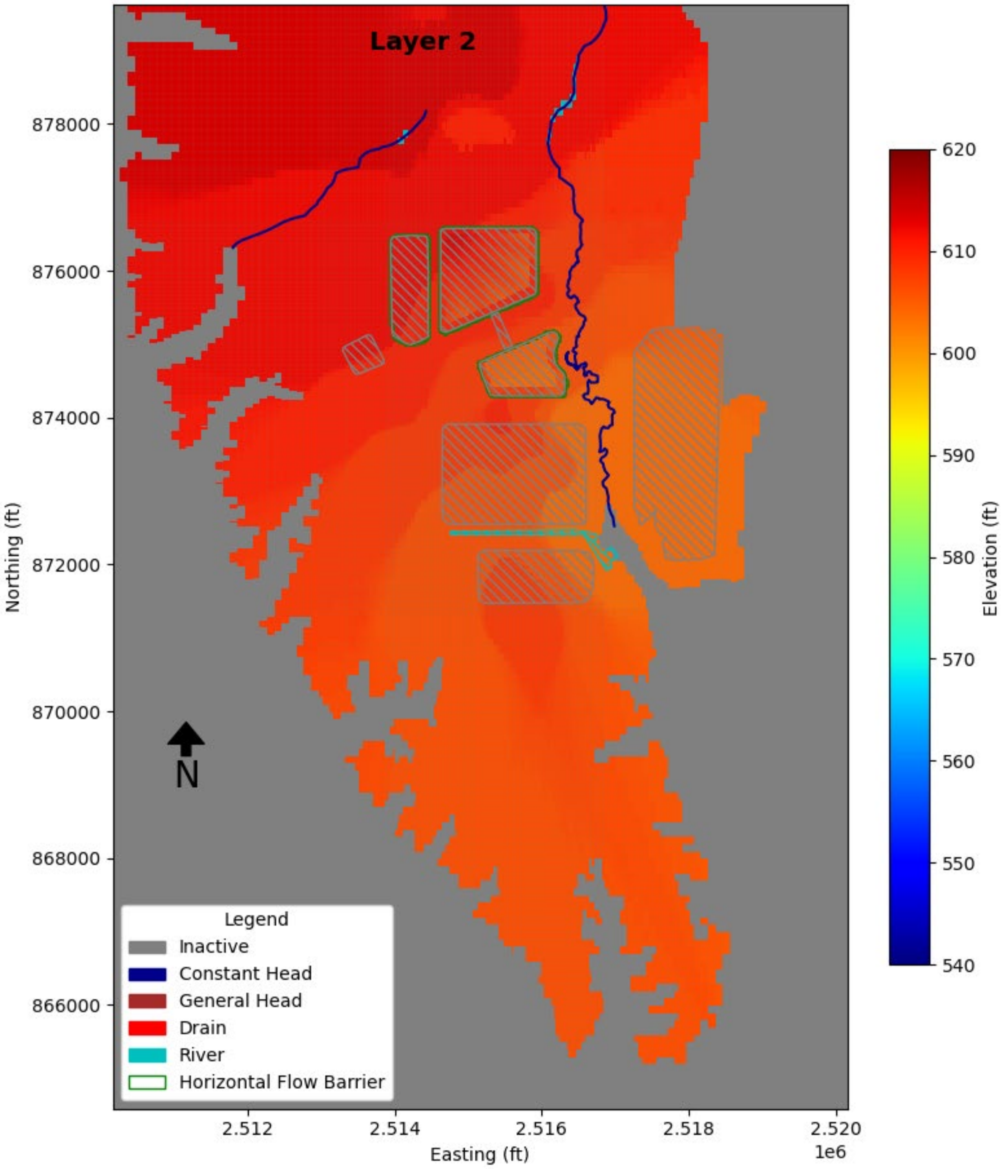
BOUNDARY CONDITIONS FOR LAYER 5

GROUNDWATER MODELING REPORT
ASH POND NO. 1
COFFEEN POWER PLANT
COFFEEN, ILLINOIS



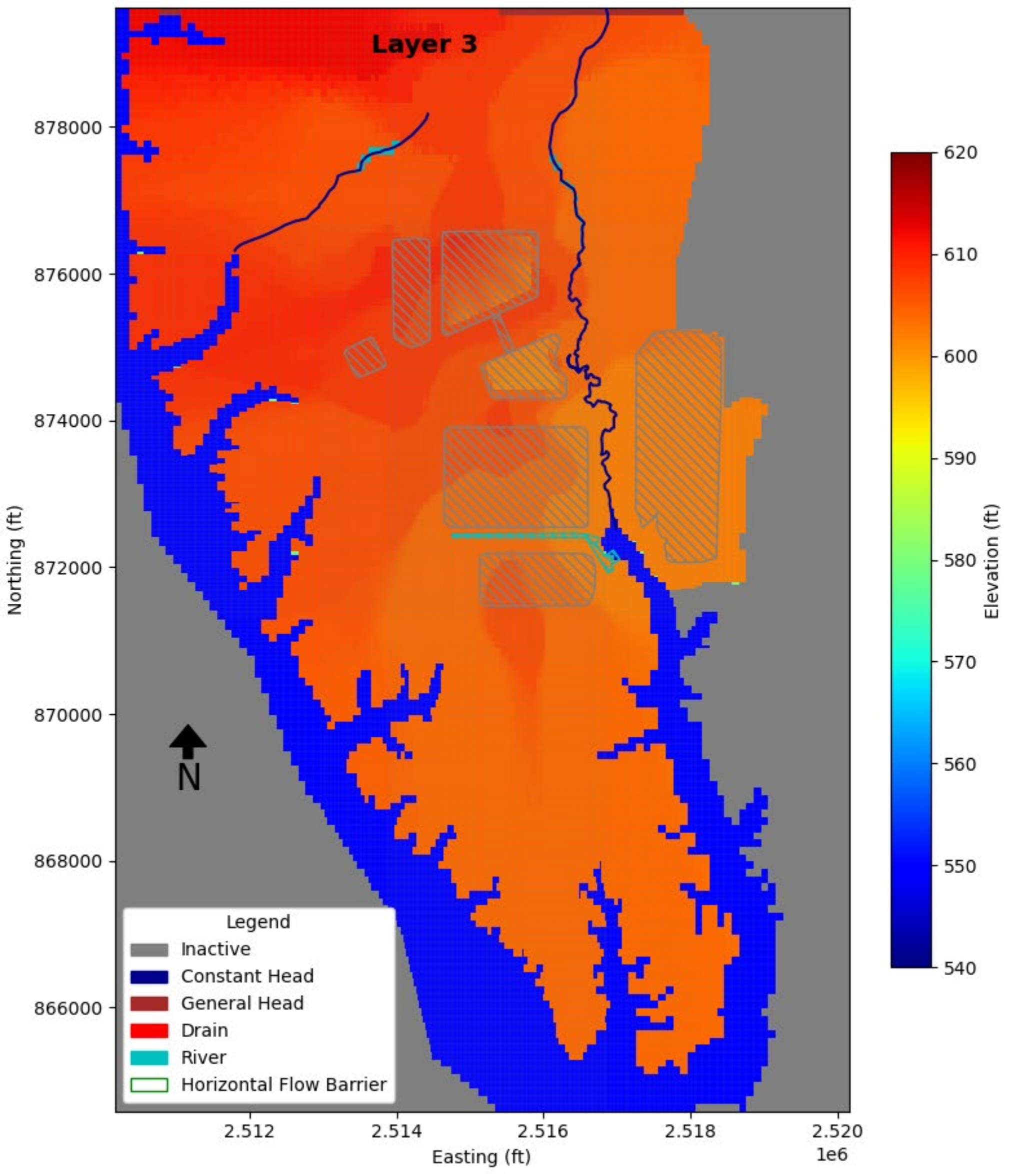
BASE OF MODEL FOR LAYER 1

GROUNDWATER MODELING REPORT
ASH POND NO. 1
COFFEEN POWER PLANT
COFFEEN, ILLINOIS



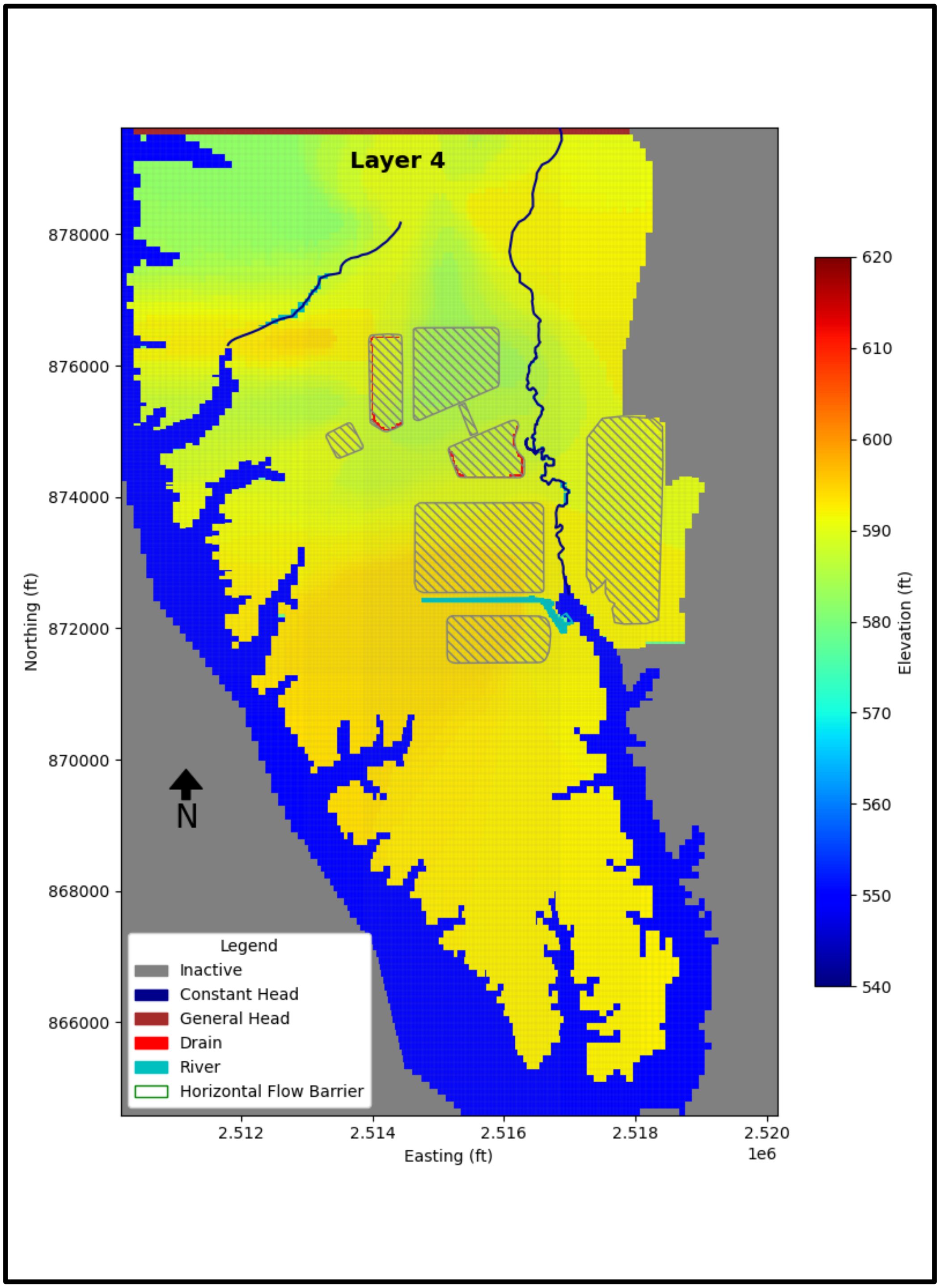
BASE OF MODEL FOR LAYER 2

GROUNDWATER MODELING REPORT
ASH POND NO. 1
COFFEEN POWER PLANT
COFFEEN, ILLINOIS



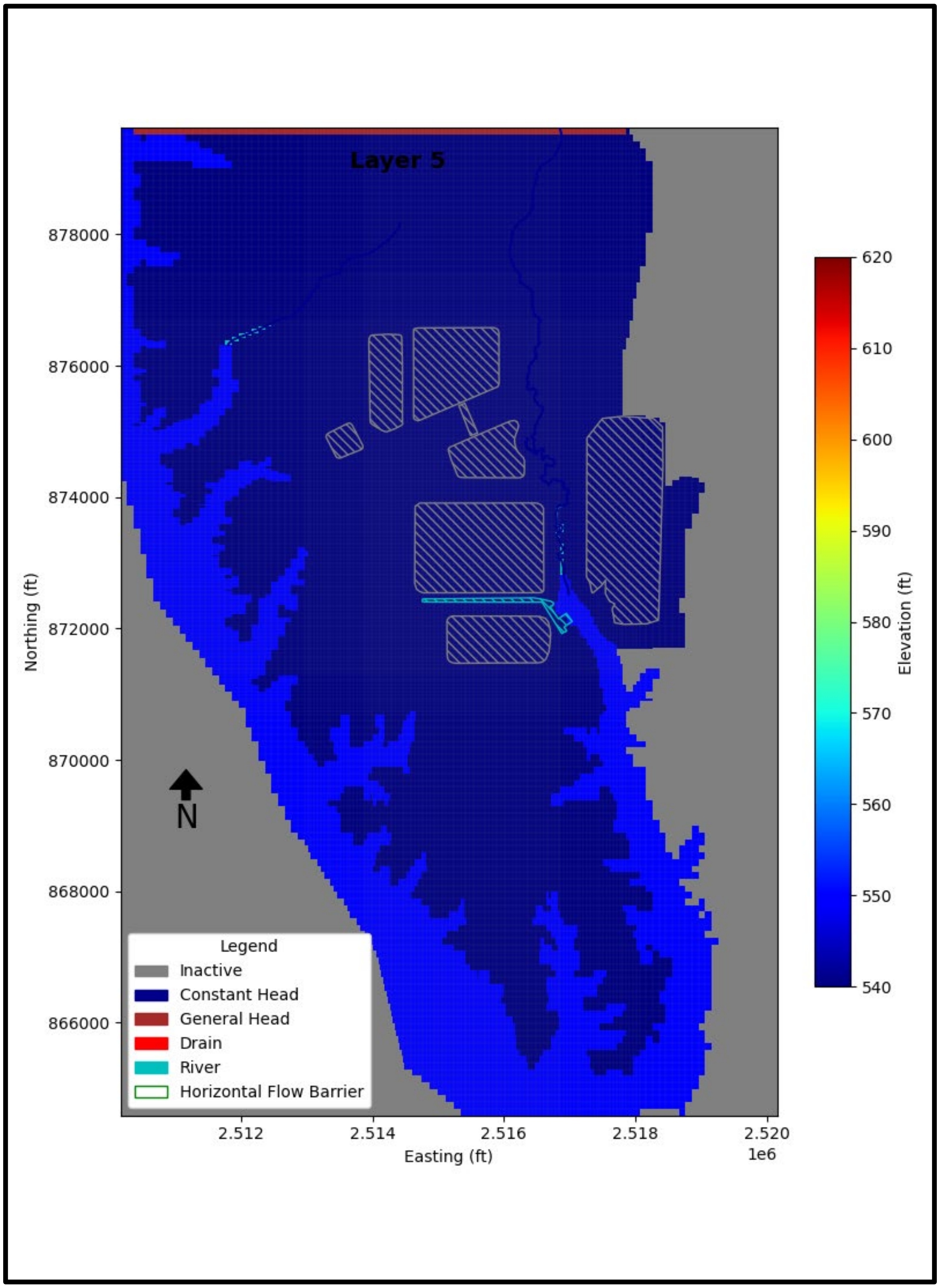
BASE OF MODEL FOR LAYER 3

GROUNDWATER MODELING REPORT
ASH POND NO. 1
COFFEEN POWER PLANT
COFFEEN, ILLINOIS



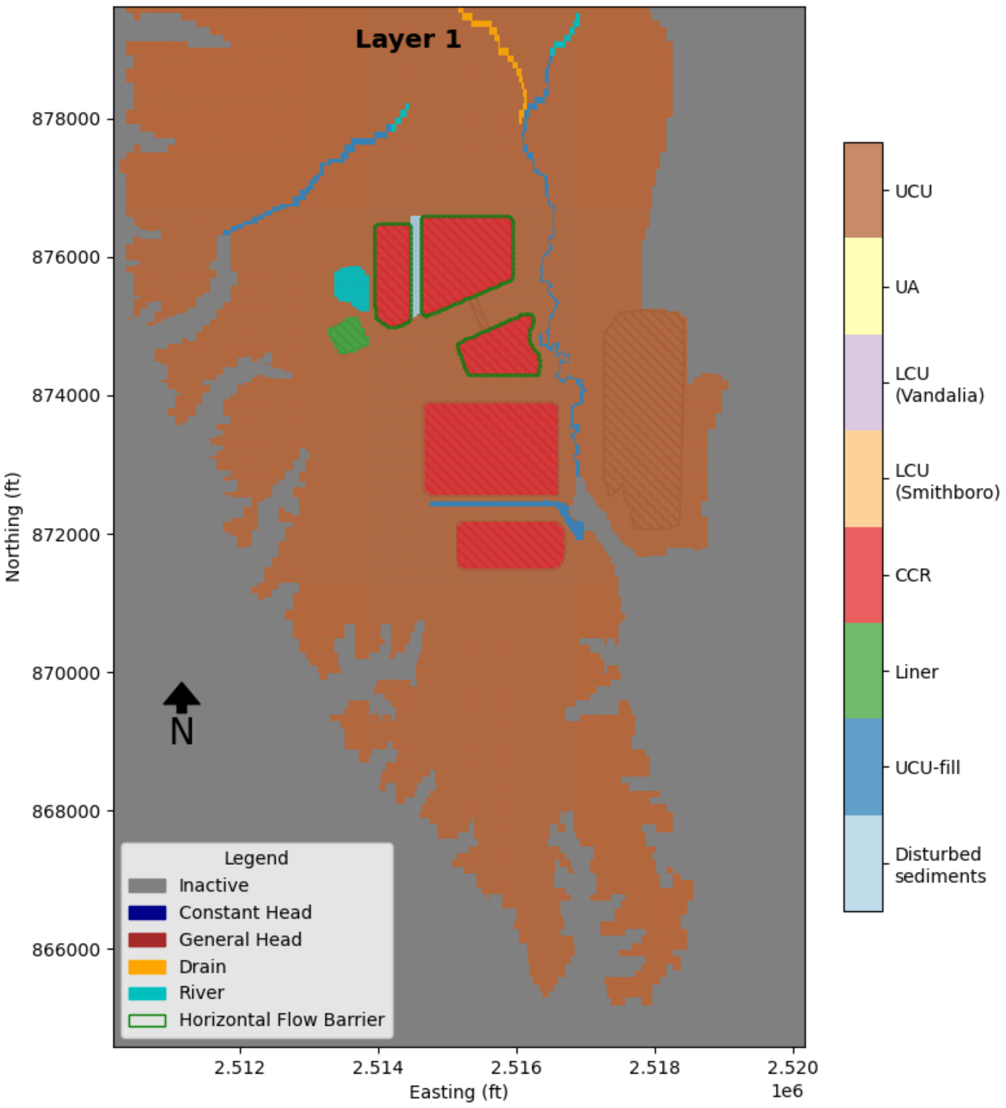
BASE OF MODEL FOR LAYER 4

GROUNDWATER MODELING REPORT
ASH POND NO. 1
COFFEEN POWER PLANT
COFFEEN, ILLINOIS



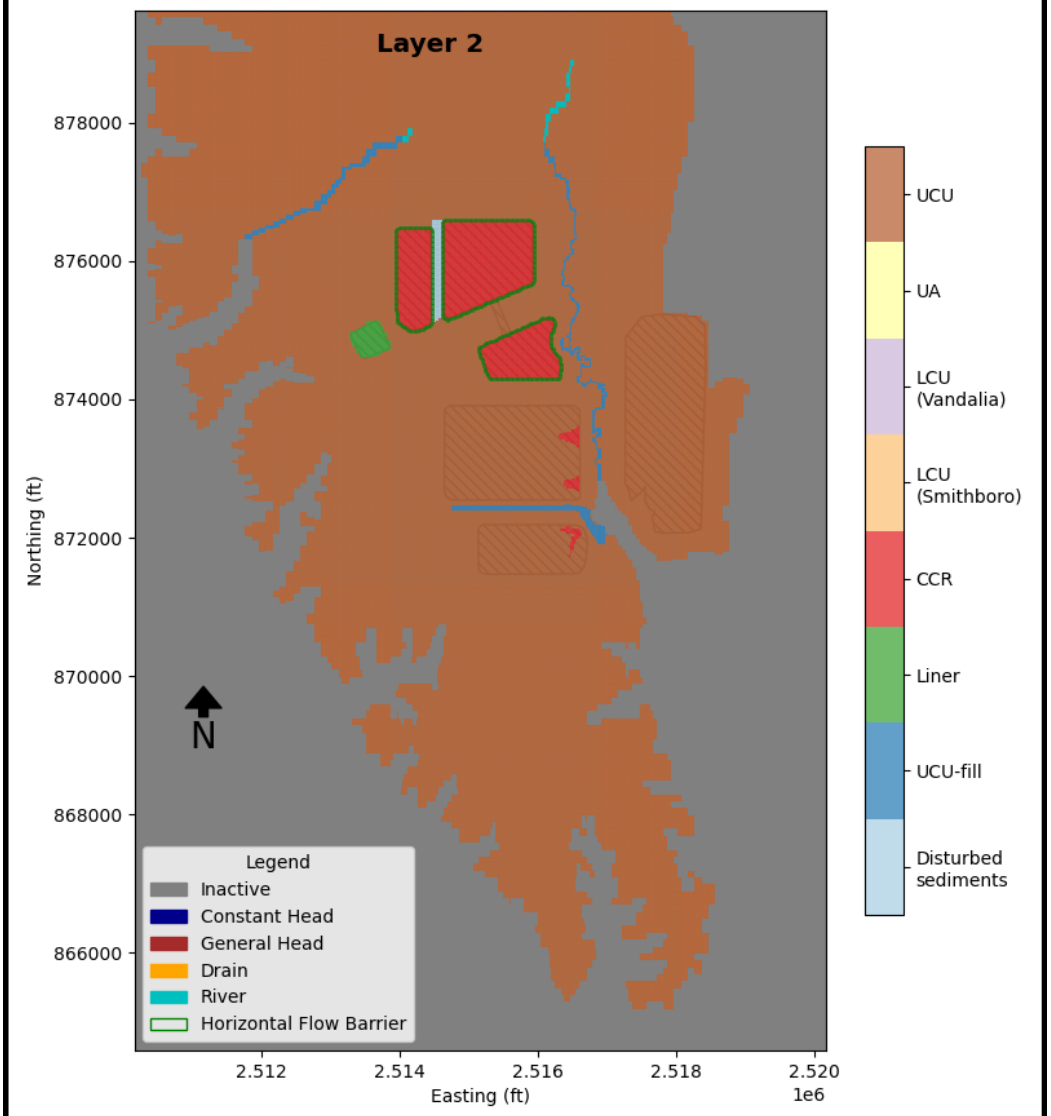
BASE OF MODEL FOR LAYER 5

GROUNDWATER MODELING REPORT
ASH POND NO. 1
COFFEEN POWER PLANT
COFFEEN, ILLINOIS



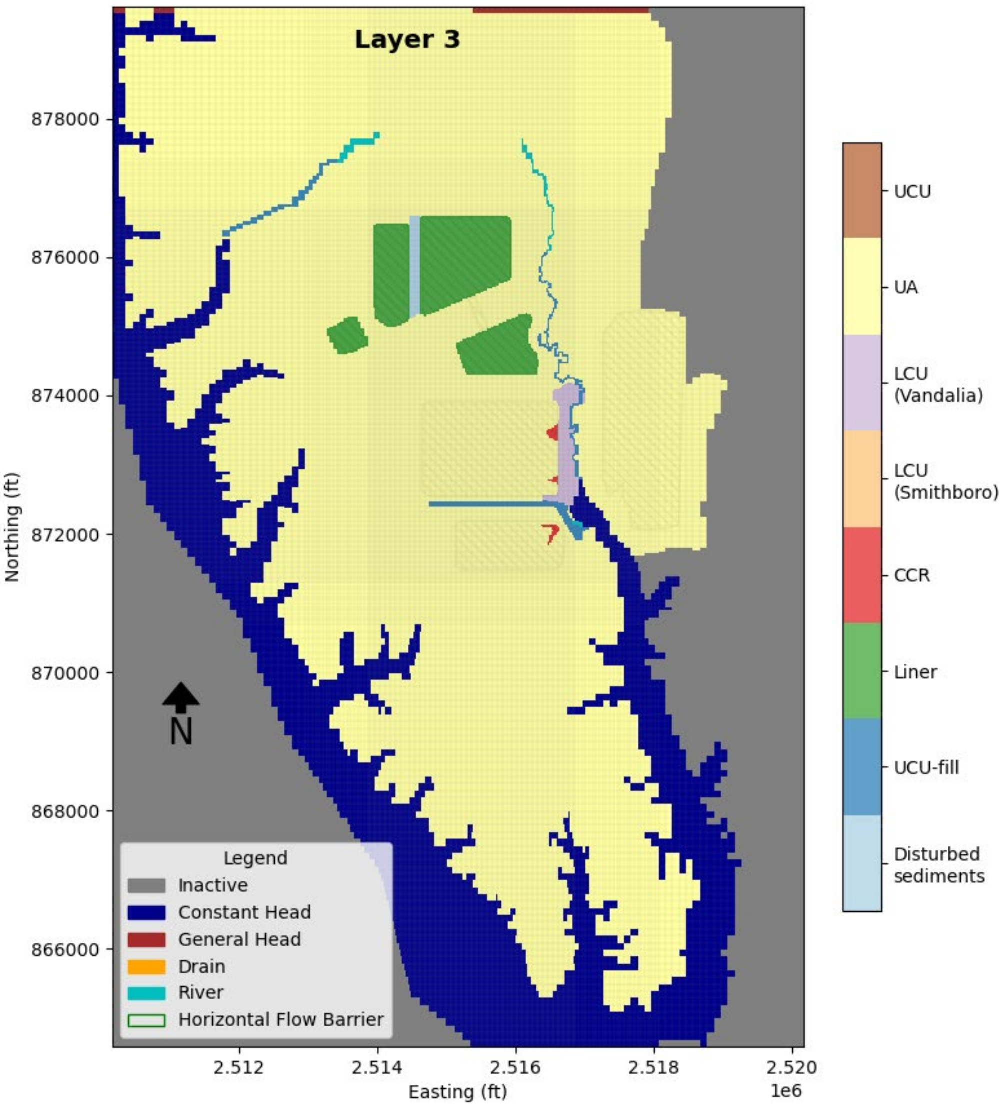
HYDRAULIC CONDUCTIVITY ZONES FOR LAYER 1

GROUNDWATER MODELING REPORT
ASH POND NO. 1
COFFEEN POWER PLANT
COFFEEN, ILLINOIS



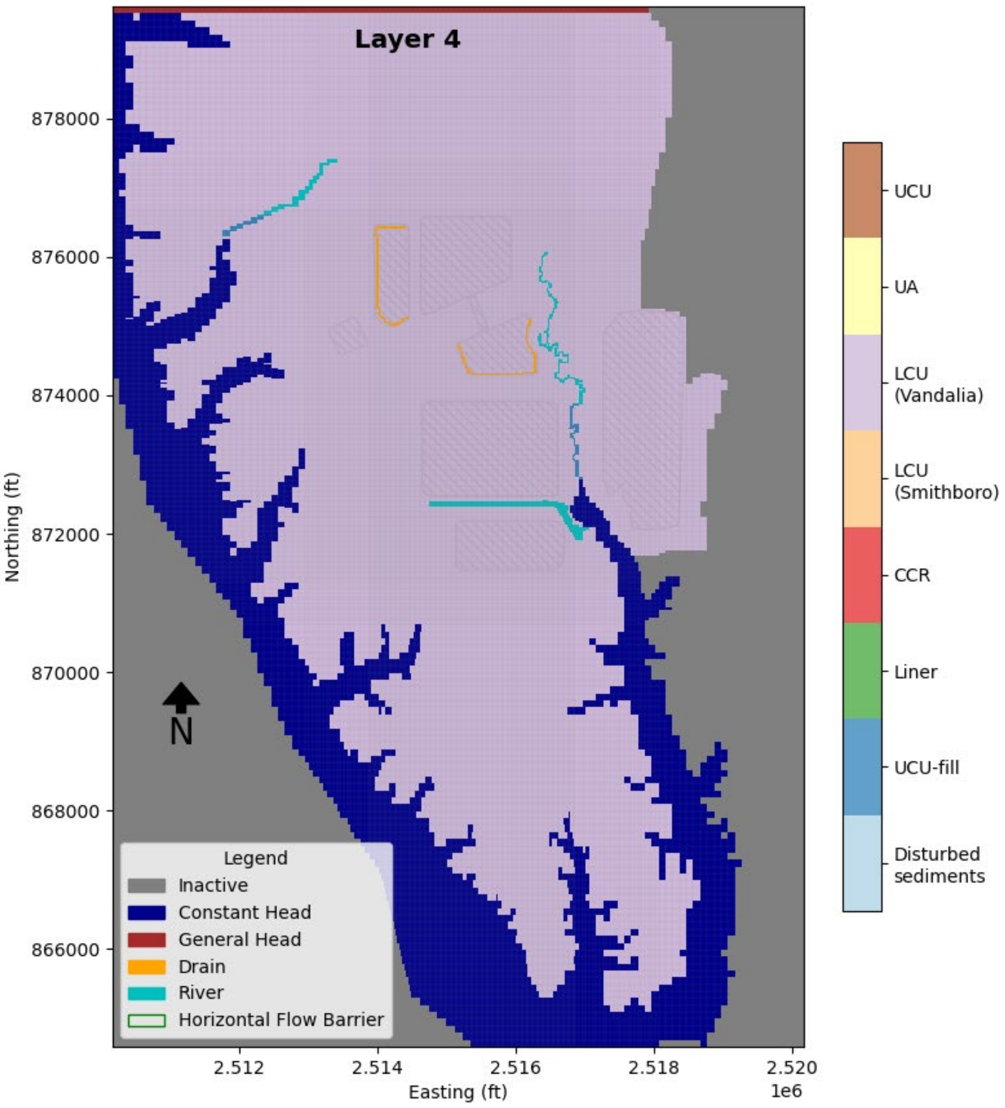
HYDRAULIC CONDUCTIVITY ZONES FOR LAYER 2

GROUNDWATER MODELING REPORT
ASH POND NO. 1
COFFEEN POWER PLANT
COFFEEN, ILLINOIS



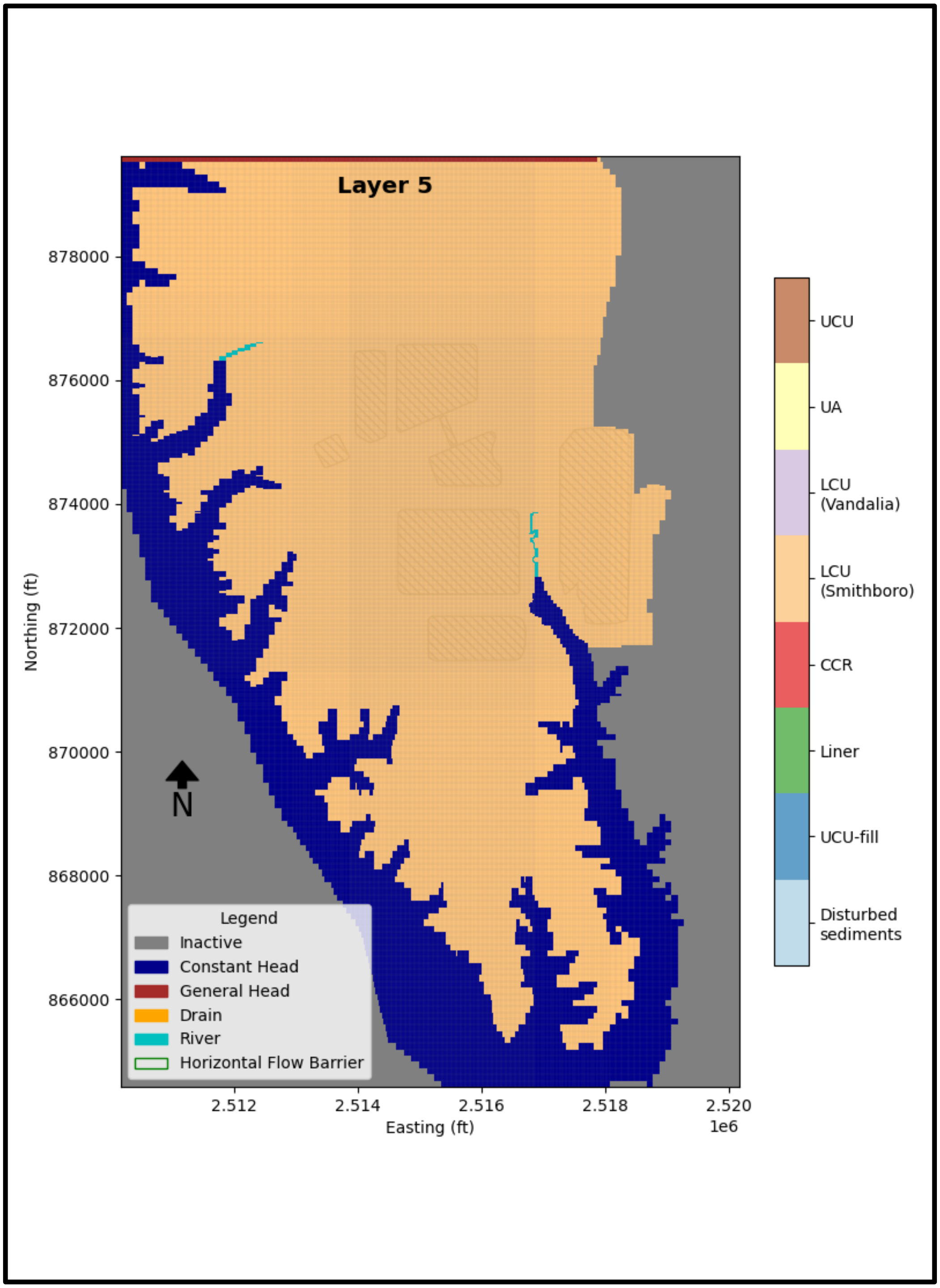
HYDRAULIC CONDUCTIVITY ZONES FOR LAYER 3

GROUNDWATER MODELING REPORT
ASH POND NO. 1
COFFEEN POWER PLANT
COFFEEN, ILLINOIS



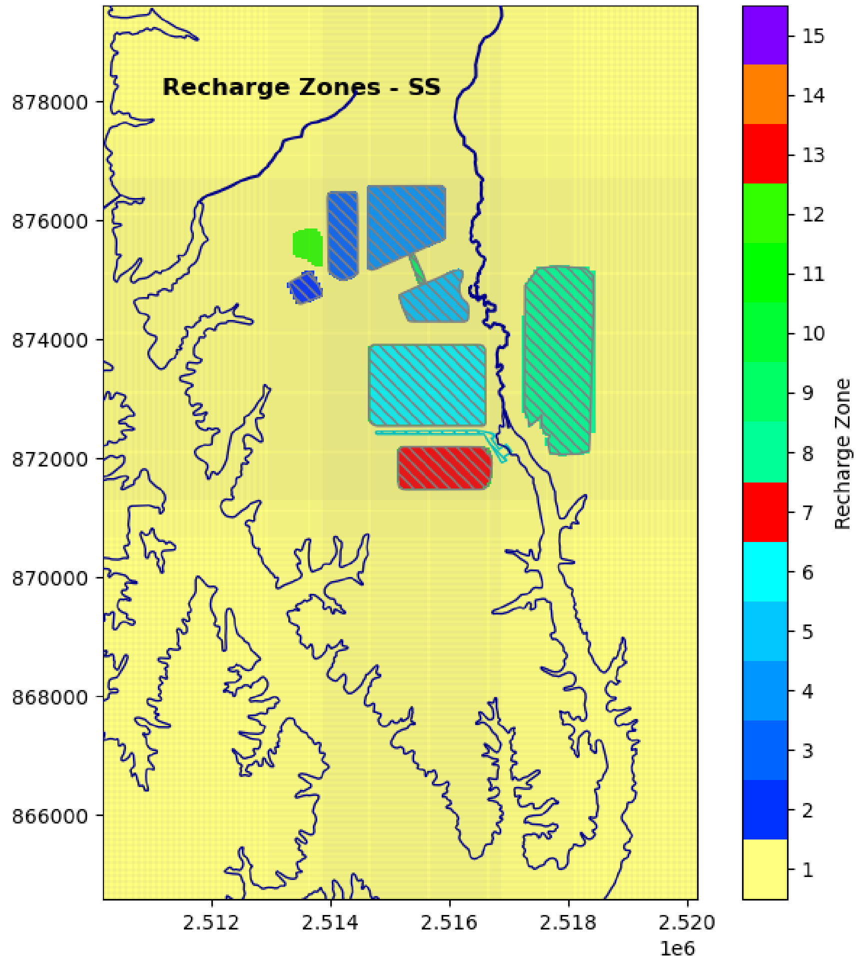
HYDRAULIC CONDUCTIVITY ZONES FOR LAYER 4

GROUNDWATER MODELING REPORT
ASH POND NO. 1
COFFEEN POWER PLANT
COFFEEN, ILLINOIS



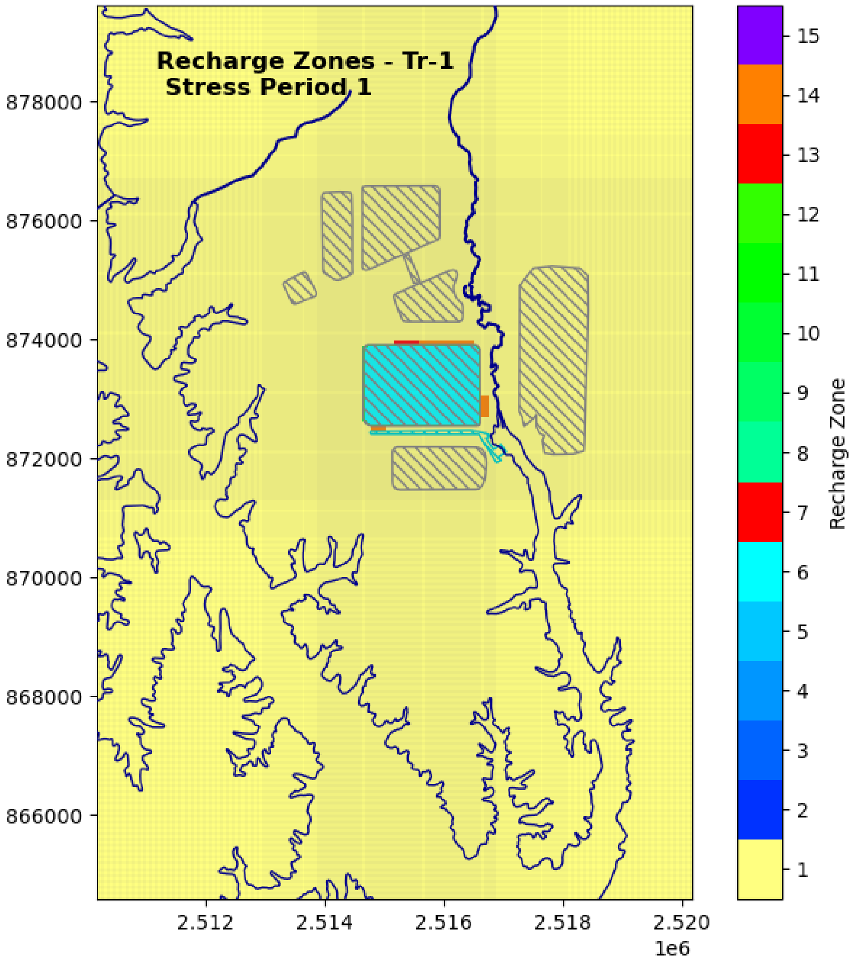
HYDRAULIC CONDUCTIVITY ZONES FOR LAYER 5

GROUNDWATER MODELING REPORT
ASH POND NO. 1
COFFEEN POWER PLANT
COFFEEN, ILLINOIS



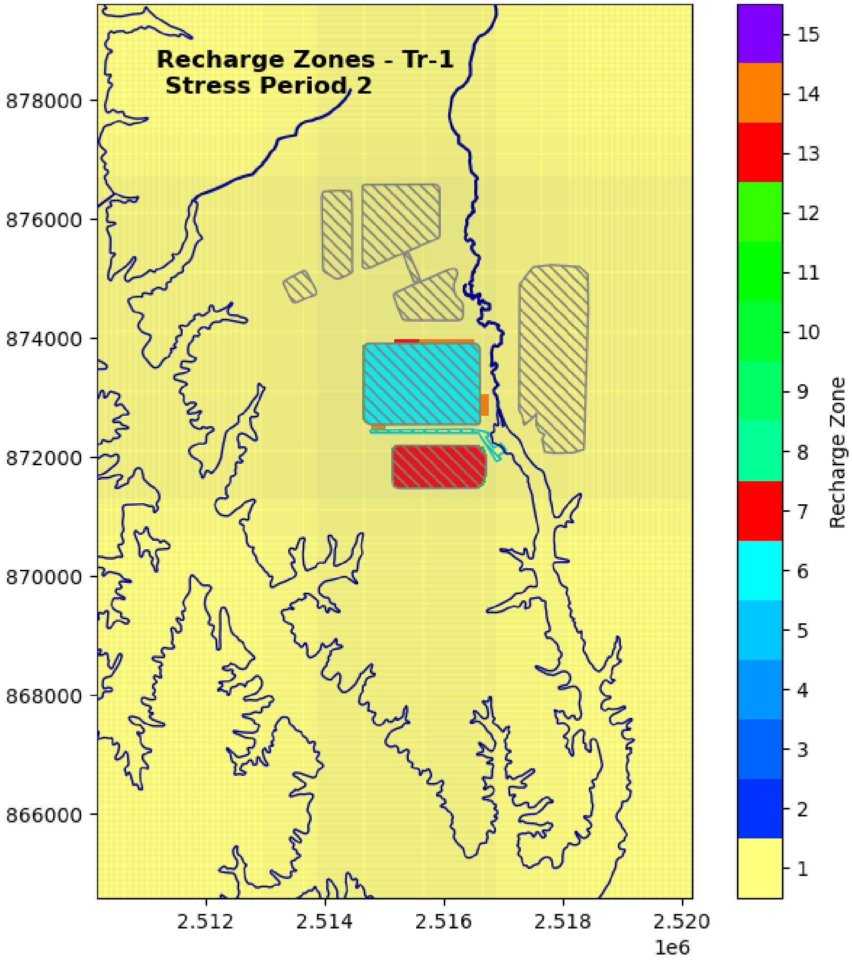
MODEL RECHARGE DISTRIBUTION STEADY STATE (SS) MODEL

GROUNDWATER MODELING REPORT
ASH POND NO. 1
COFFEEN POWER PLANT
COFFEEN, ILLINOIS



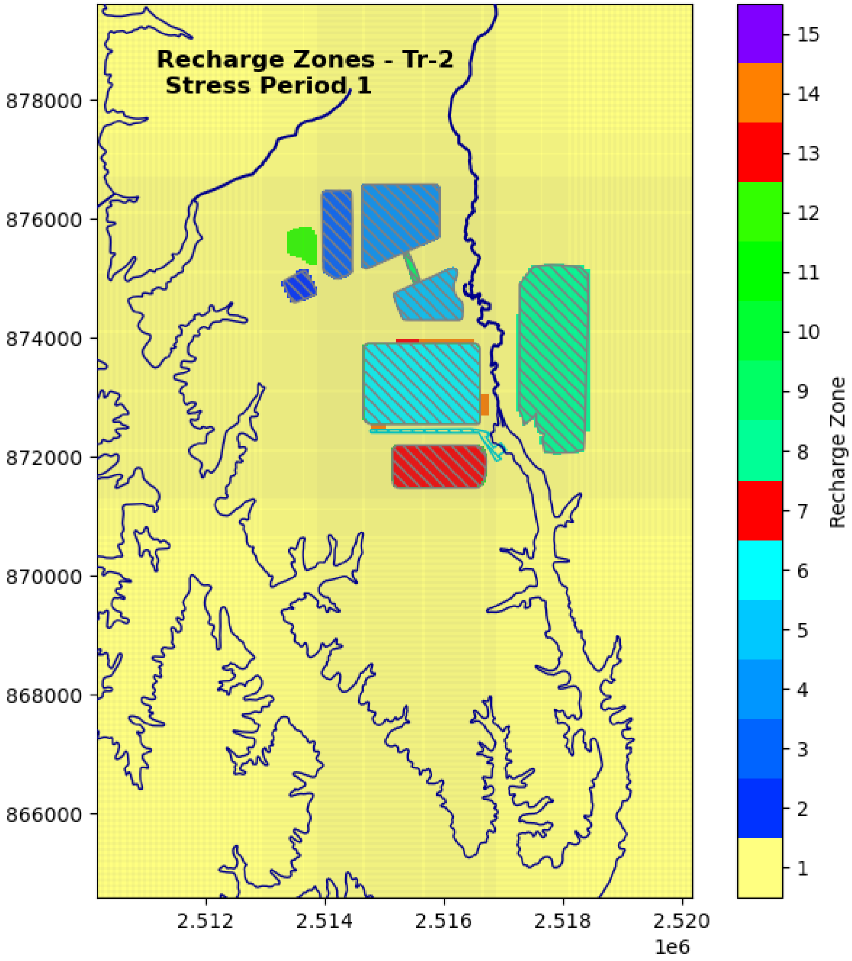
MODEL RECHARGE DISTRIBUTION FOR THE TRANSIENT (TR) MODEL TR-1
STRESS PERIOD 1

GROUNDWATER MODELING REPORT
ASH POND NO. 1
COFFEEN POWER PLANT
COFFEEN, ILLINOIS



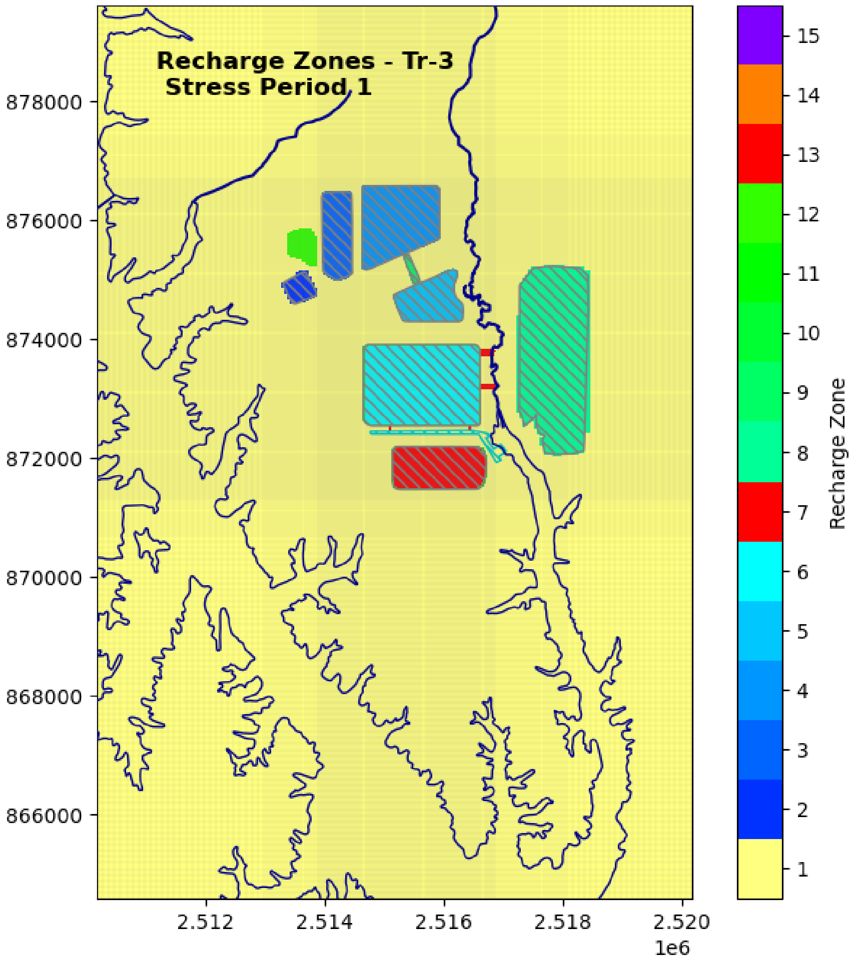
MODEL RECHARGE DISTRIBUTION FOR THE TRANSIENT (TR) MODEL TR-1
STRESS PERIOD 2

GROUNDWATER MODELING REPORT
ASH POND NO. 1
COFFEEN POWER PLANT
COFFEEN, ILLINOIS



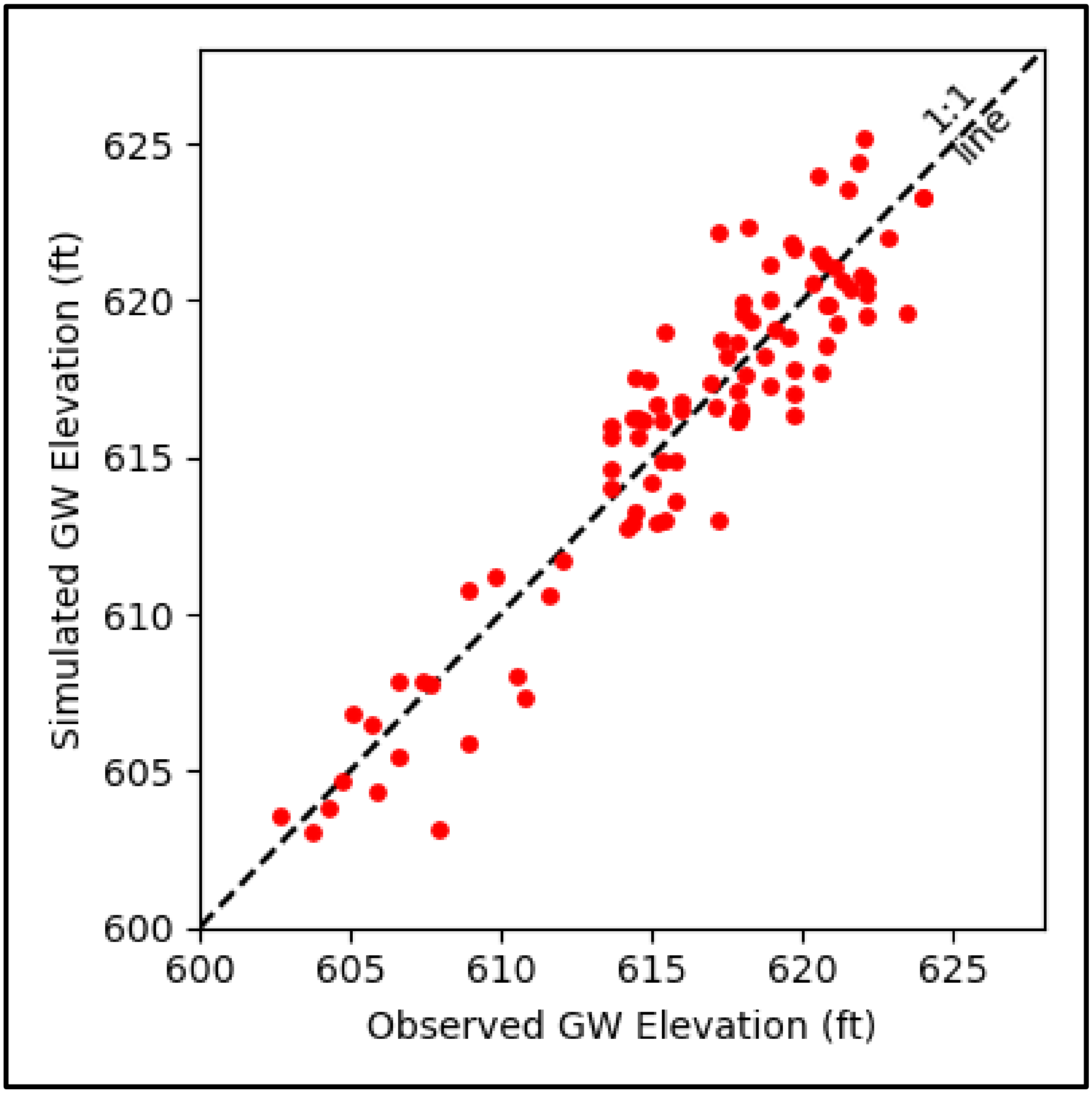
MODEL RECHARGE DISTRIBUTION FOR THE TRANSIENT (TR) MODEL TR-2
STRESS PERIOD 1

GROUNDWATER MODELING REPORT
ASH POND NO. 1
COFFEEN POWER PLANT
COFFEEN, ILLINOIS



MODEL RECHARGE DISTRIBUTION FOR THE TRANSIENT (TR) MODEL TR-3
STRESS PERIOD 1

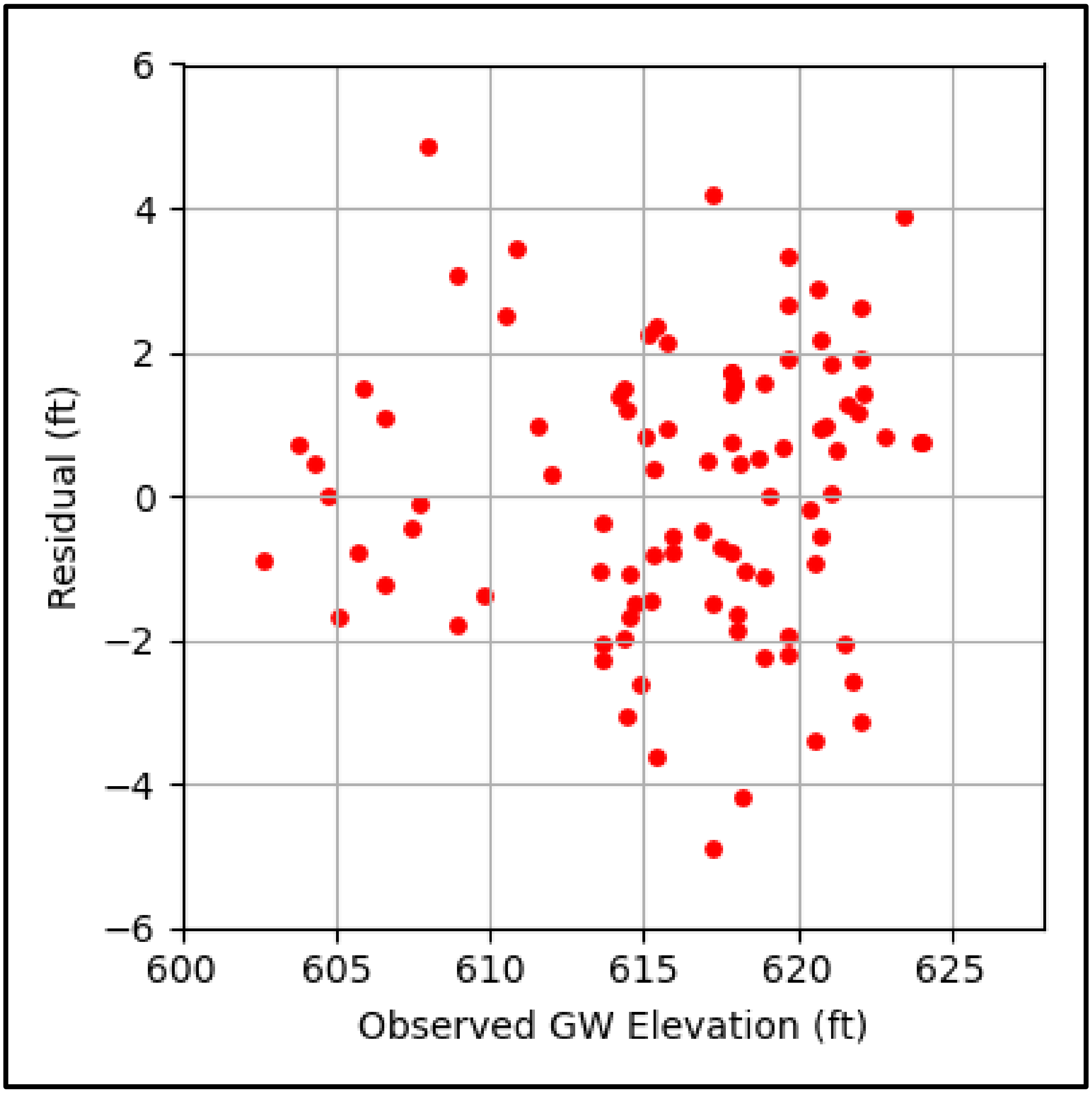
GROUNDWATER MODELING REPORT
ASH POND NO. 1
COFFEEN POWER PLANT
COFFEEN, ILLINOIS



OBSERVED VERSUS SIMULATED STEADY STATE GROUNDWATER LEVELS FROM THE CALIBRATED MODEL

GROUNDWATER MODELING REPORT
ASH POND NO. 1
COFFEEN POWER PLANT
COFFEEN, ILLINOIS

RAMBOLL

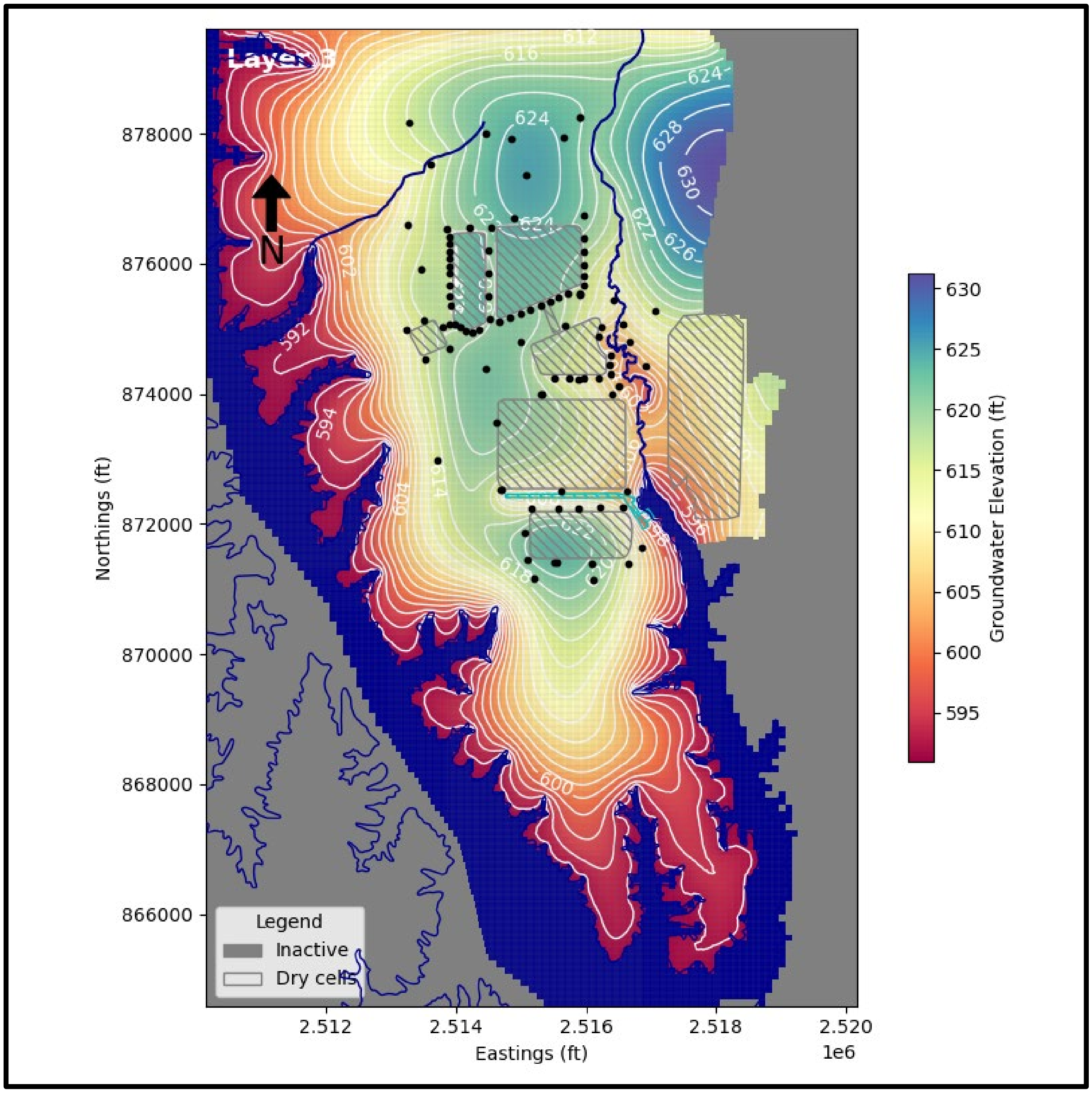


SIMULATED GROUNDWATER LEVEL RESIDUALS FROM THE CALIBRATED MODEL

GROUNDWATER MODELING REPORT
ASH POND NO. 1
COFFEEN POWER PLANT
COFFEEN, ILLINOIS

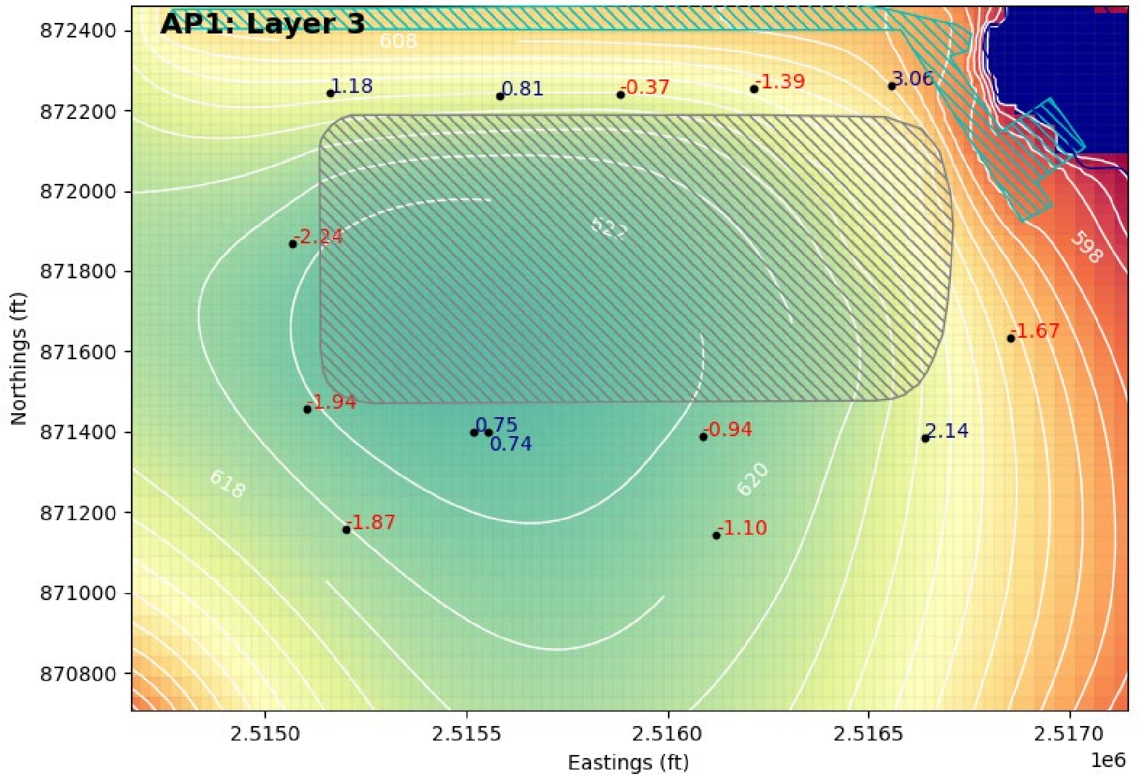
RAMBOLL

FIGURE 5-24



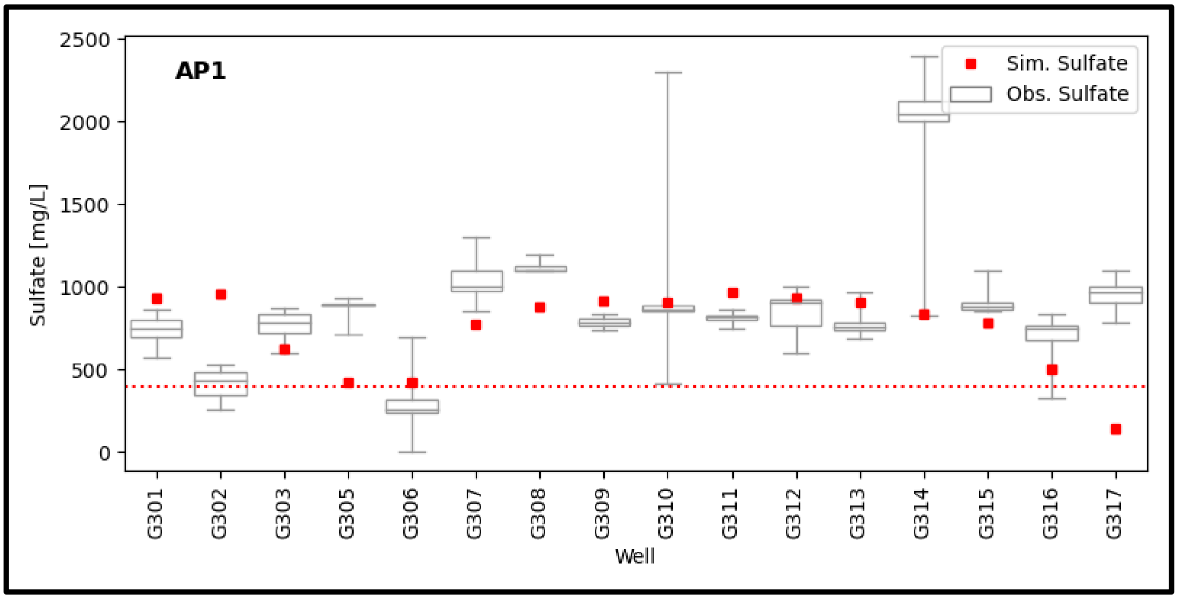
SIMULATED STEADY STATE GROUNDWATER LEVEL CONTOURS FROM UA (LAYER 3) FROM THE CALIBRATED MODEL

GROUNDWATER MODELING REPORT
ASH POND NO. 1
COFFEEN POWER PLANT
COFFEEN, ILLINOIS



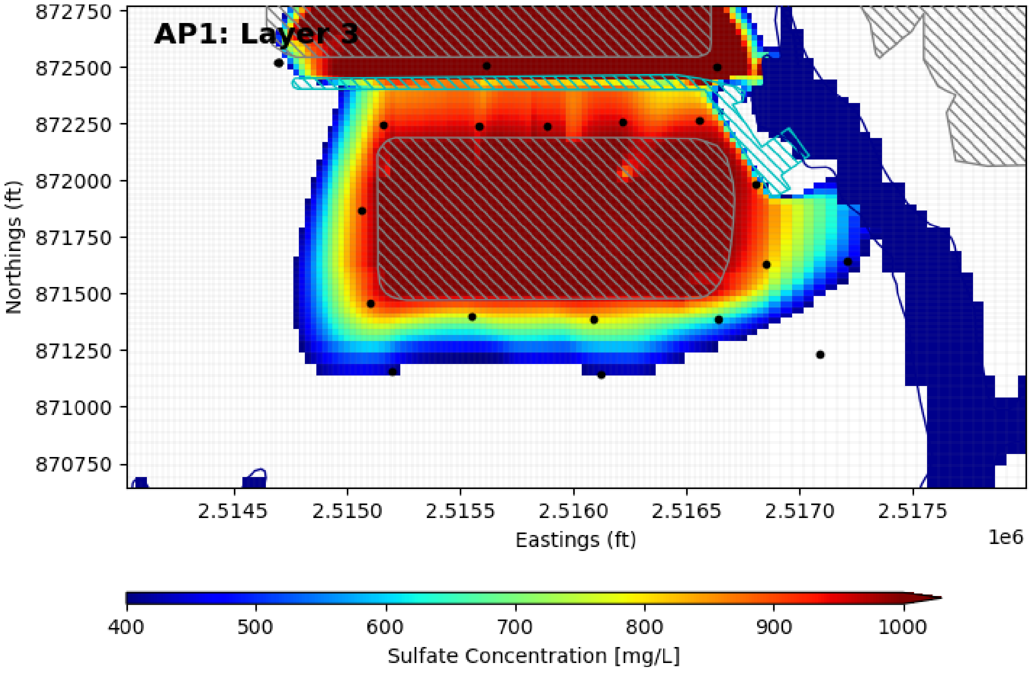
SIMULATED STEADY STATE GROUNDWATER LEVEL CONTOURS IN PROXIMITY TO AP1 FROM UA (LAYER 3) FROM THE CALIBRATED MODEL

GROUNDWATER MODELING REPORT
ASH POND NO. 1
COFFEEN POWER PLANT
COFFEEN, ILLINOIS



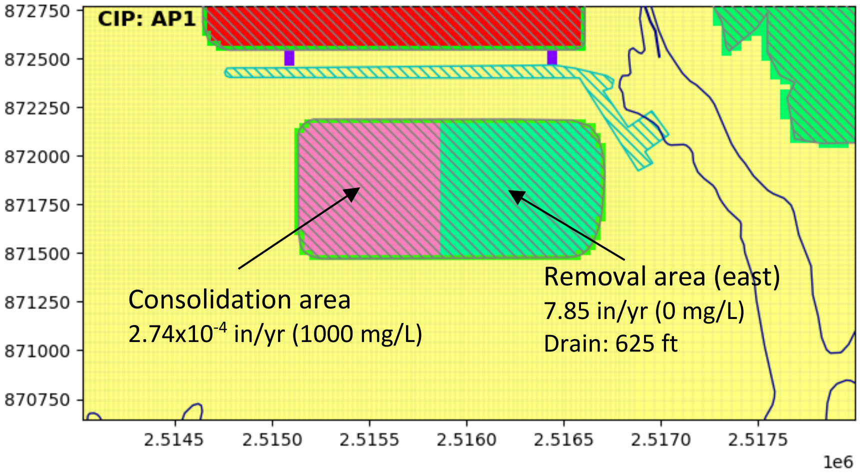
OBSERVED VERSUS SIMULATED SULFATE CONCENTRATIONS (mg/L)

GROUNDWATER MODELING REPORT
ASH POND NO. 1
COFFEEN POWER PLANT
COFFEEN, ILLINOIS



SIMULATED SULFATE PLUME IN THE UA FROM THE TRANSIENT MODEL

GROUNDWATER MODELING REPORT
ASH POND NO. 1
COFFEEN POWER PLANT
COFFEEN, ILLINOIS

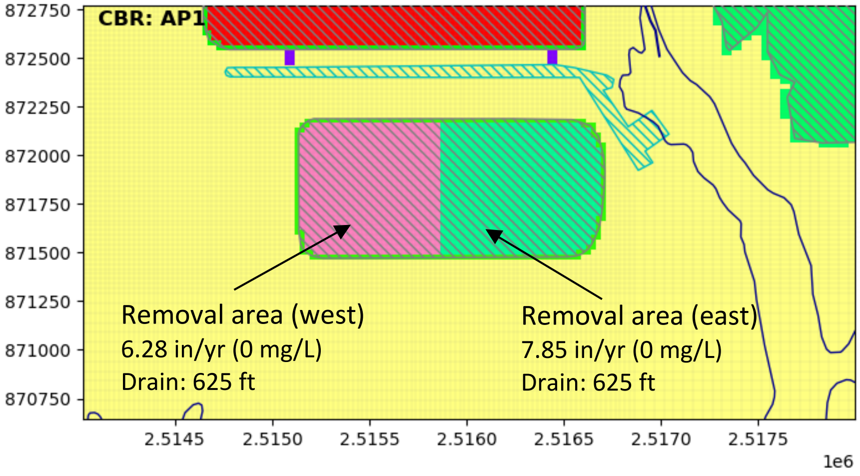


Consolidation area
$2.74\text{x}10^{-4}$ in/yr (1000 mg/L)

Removal area (east)
7.85 in/yr (0 mg/L)
Drain: 625 ft

CIP RECHARGE AND STORMWATER POND MODIFICATIONS

GROUNDWATER MODELING REPORT
ASH POND NO. 1
COFFEEN POWER PLANT
COFFEEN, ILLINOIS



Removal area (west)
6.28 in/yr (0 mg/L)
Drain: 625 ft

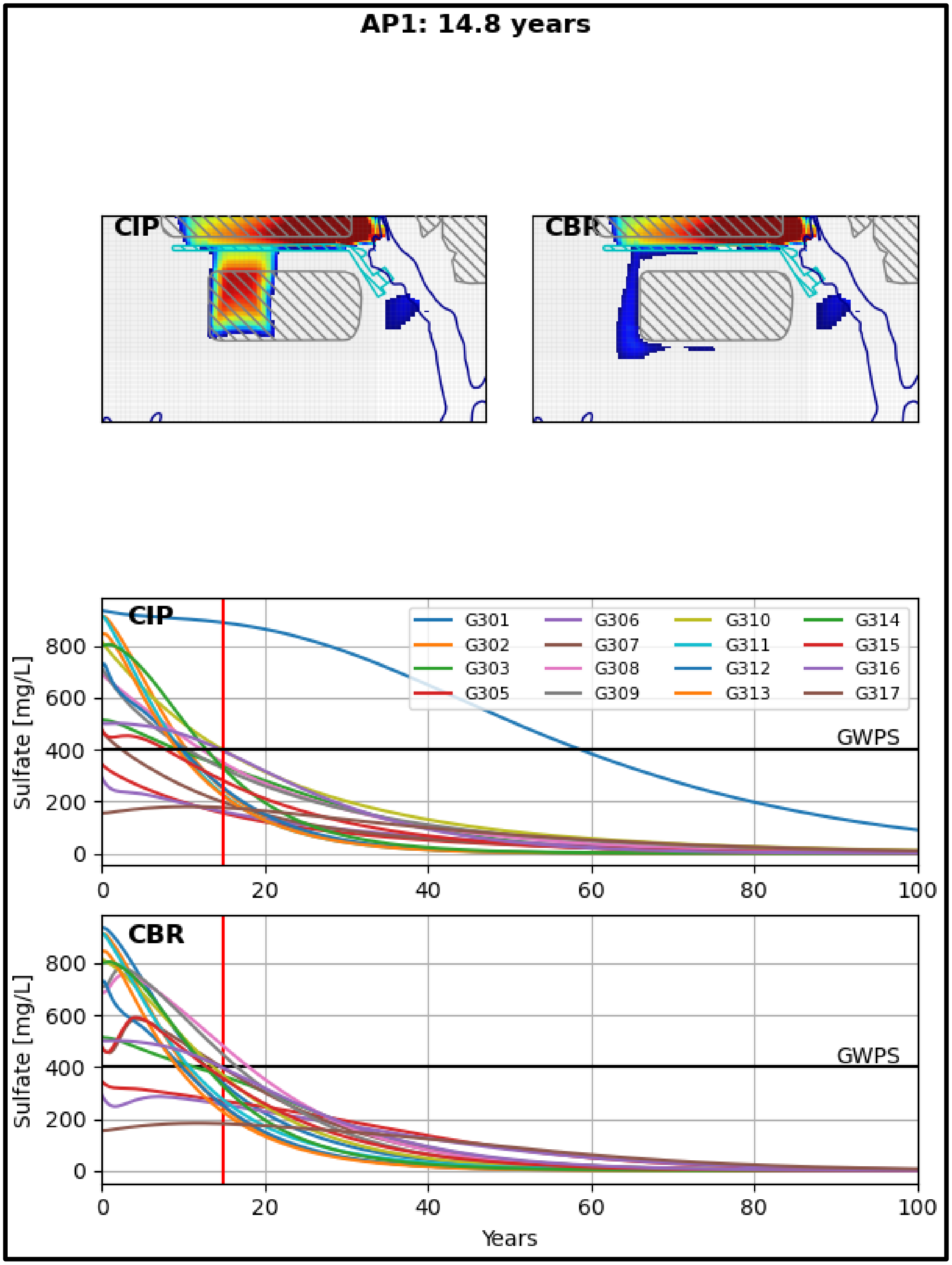
Removal area (east)
7.85 in/yr (0 mg/L)
Drain: 625 ft

CBR RECHARGE AND STORMWATER POND MODIFICATIONS

GROUNDWATER MODELING REPORT
ASH POND NO. 1
COFFEEN POWER PLANT
COFFEEN, ILLINOIS

RAMBOLL

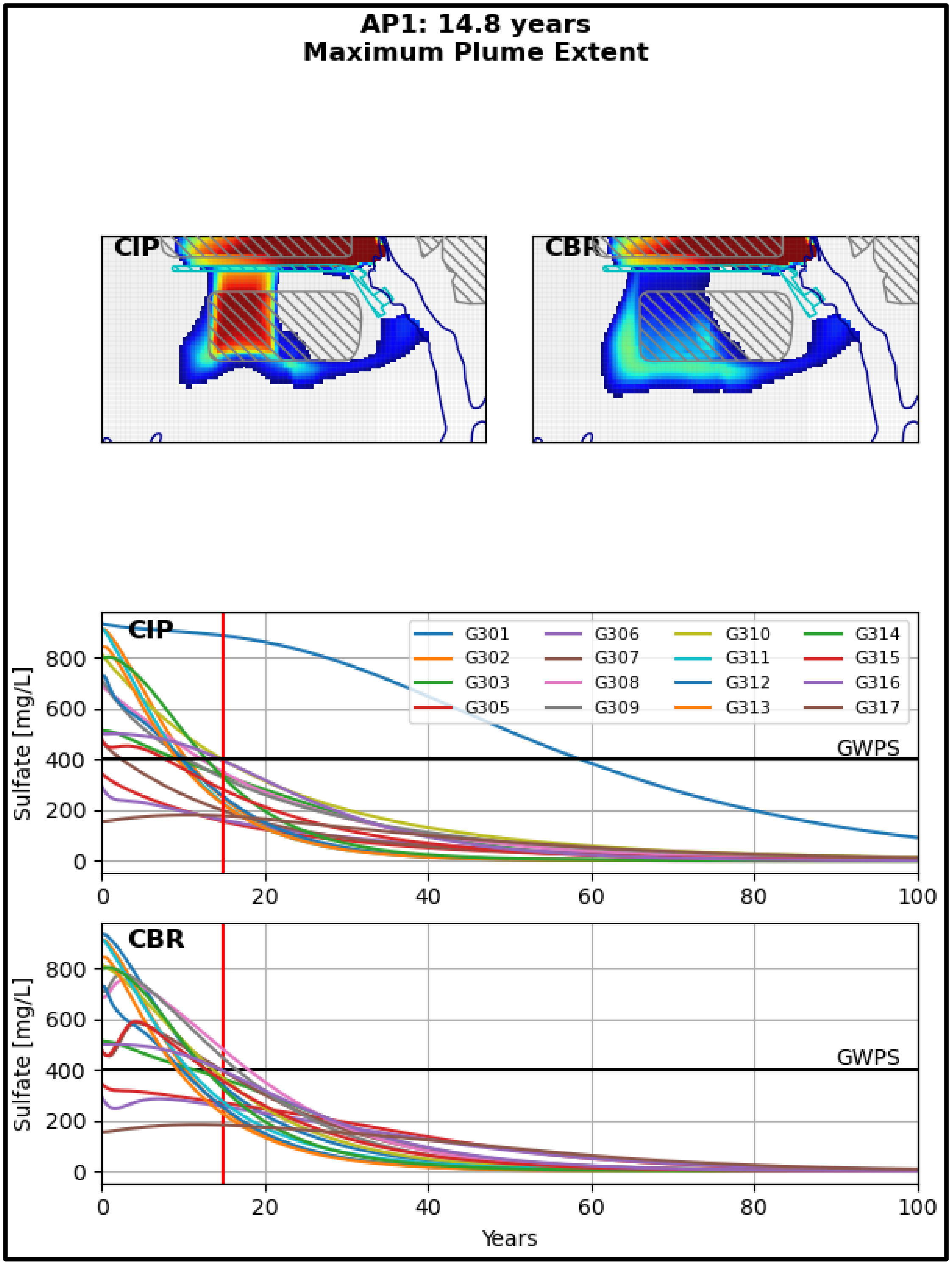
FIGURE 6-3



SIMULATED SULFATE PLUME OF THE UA FOR THE CIP AND CBR SCENARIOS AFTER 14.8 YEARS

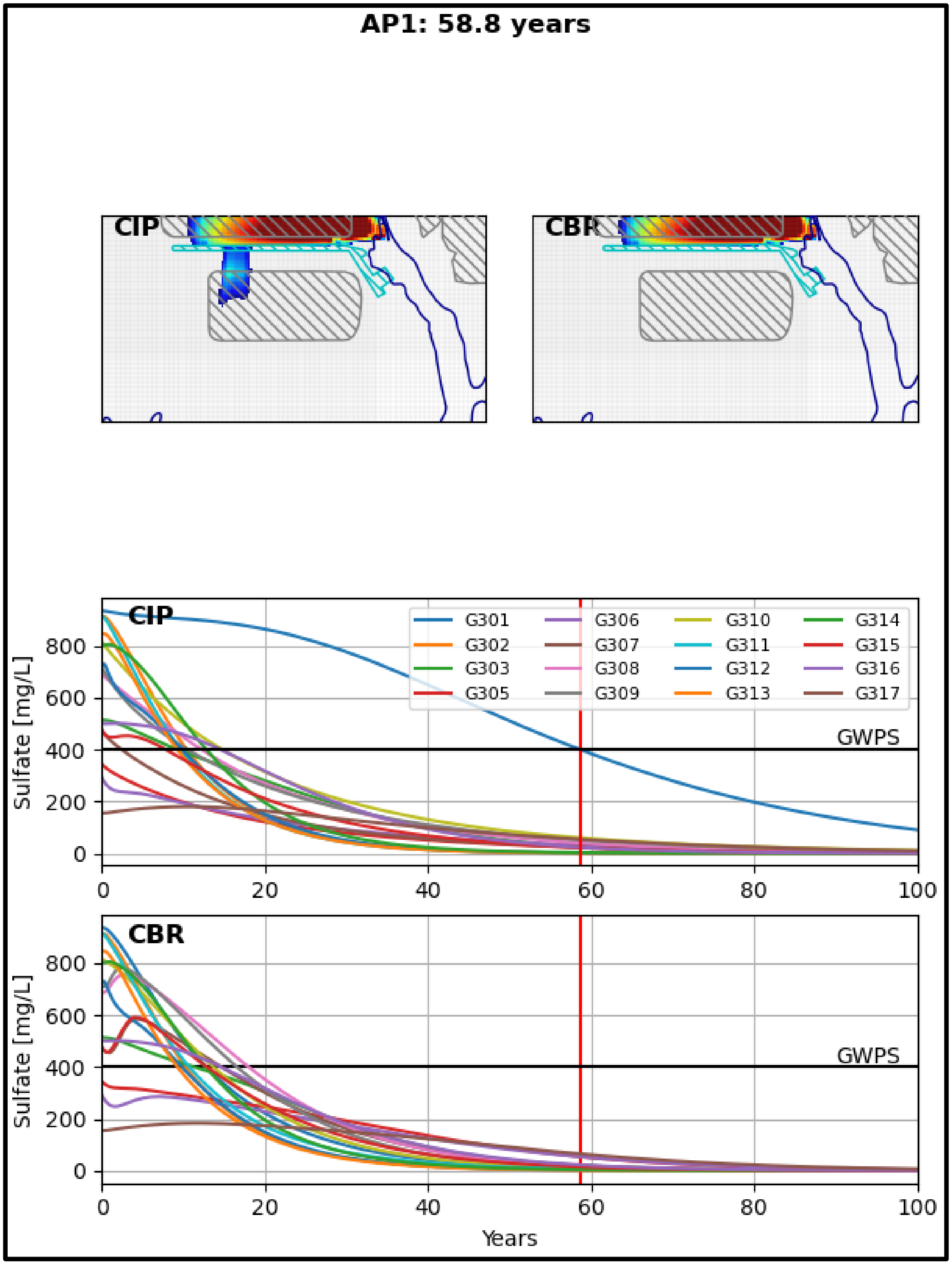
GROUNDWATER MODELING REPORT
ASH POND NO. 1
COFFEEN POWER PLANT
COFFEEN, ILLINOIS

FIGURE 6-4



SIMULATED MAXIMUM EXTENT OF THE SULFATE PLUME FOR THE CIP AND CBR SCENARIOS AFTER 14.8 YEARS

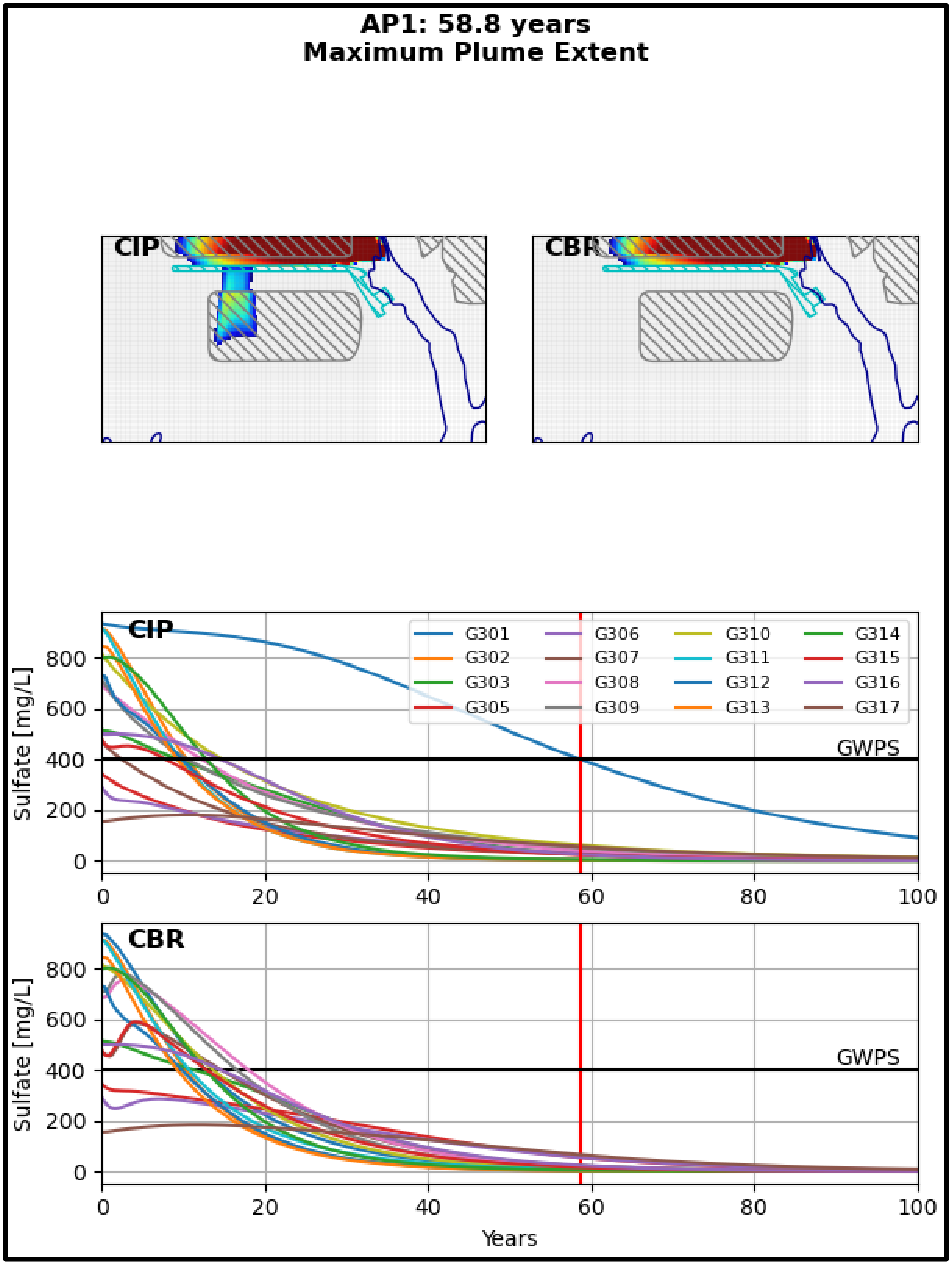
GROUNDWATER MODELING REPORT
ASH POND NO. 1
COFFEEN POWER PLANT
COFFEEN, ILLINOIS



SIMULATED SULFATE PLUME OF THE UA FOR THE CIP AND CBR SCENARIOS AFTER 58.8 YEARS

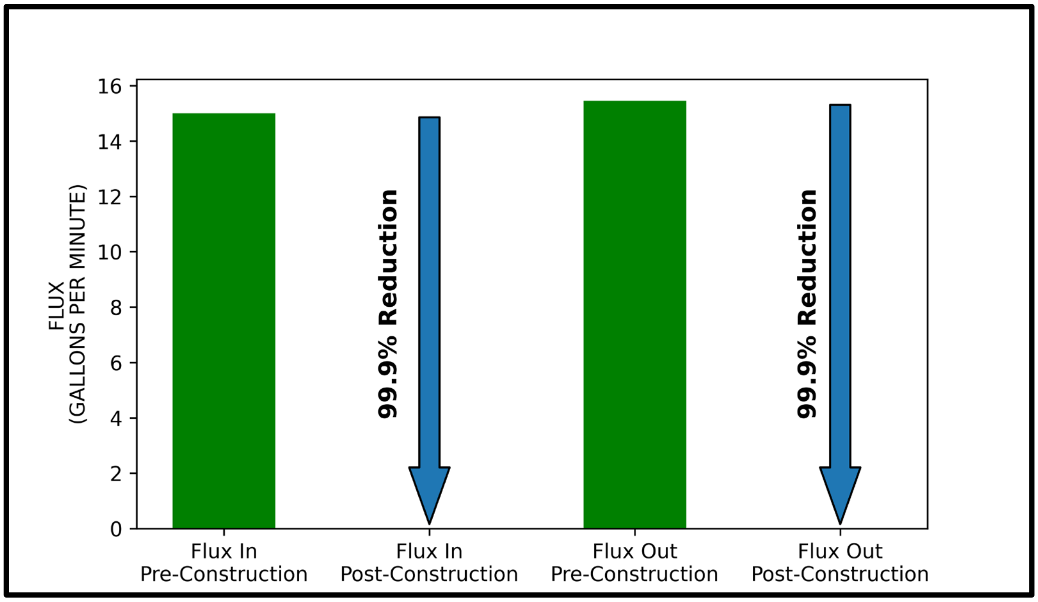
GROUNDWATER MODELING REPORT
ASH POND NO. 1
COFFEEN POWER PLANT
COFFEEN, ILLINOIS

FIGURE 6-6



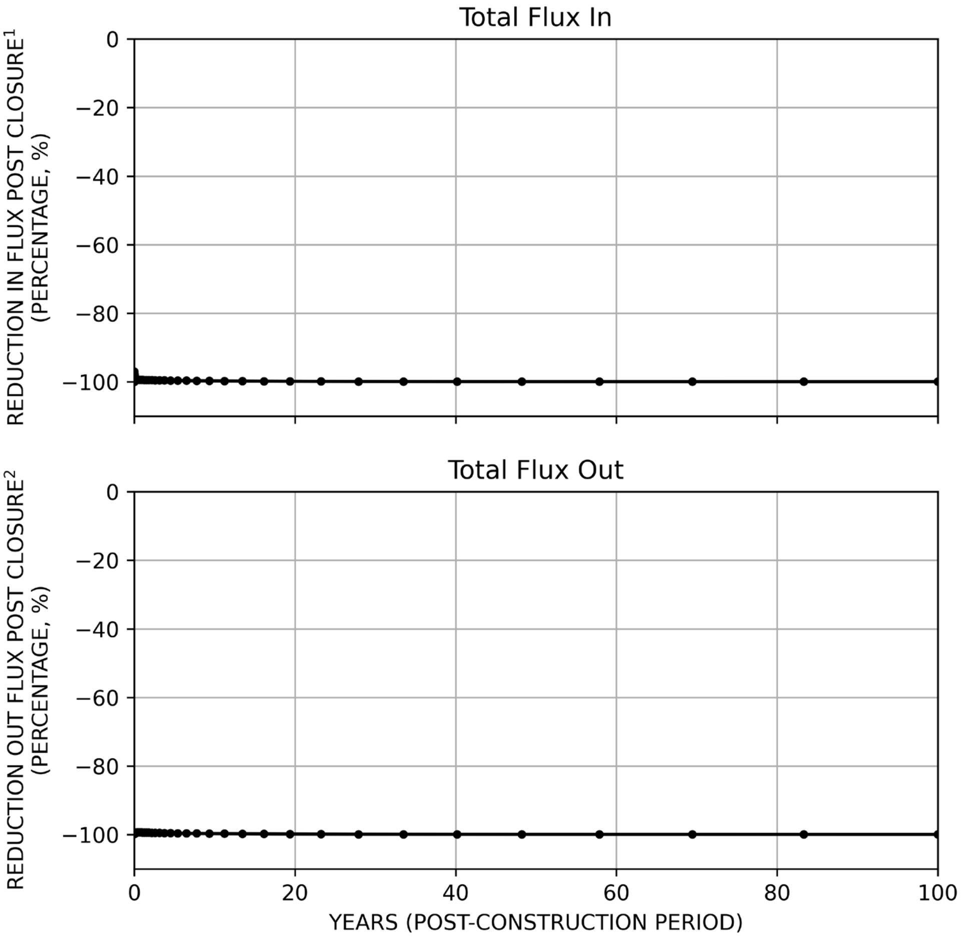
SIMULATED MAXIMUM EXTENT OF THE SULFATE PLUME FOR THE CIP AND CBR SCENARIOS AFTER 58.8 YEARS

GROUNDWATER MODELING REPORT
ASH POND NO. 1
COFFEEN POWER PLANT
COFFEEN, ILLINOIS



SCENARIO 1 (CIP) –
HYDRAULIC STEADY STATE REDUCTIONS IN TOTAL FLUX IN AND OUT OF FILL UNIT (CCR)

GROUNDWATER MODELING REPORT
ASH POND NO. 1
COFFEEN POWER PLANT
COFFEEN, ILLINOIS



[1] Reduction in flux in compared to flux in at the end of the calibration model (model period of 42 years). Reduction in flux in are expressed as negative percentages to illustrate decreases in flux over time.

[2] Reduction in flux out compared to flux out at the end of the calibration model (model period of 42 years). Reduction in flux out are expressed as negative percentages to illustrate decreases in flux over time.

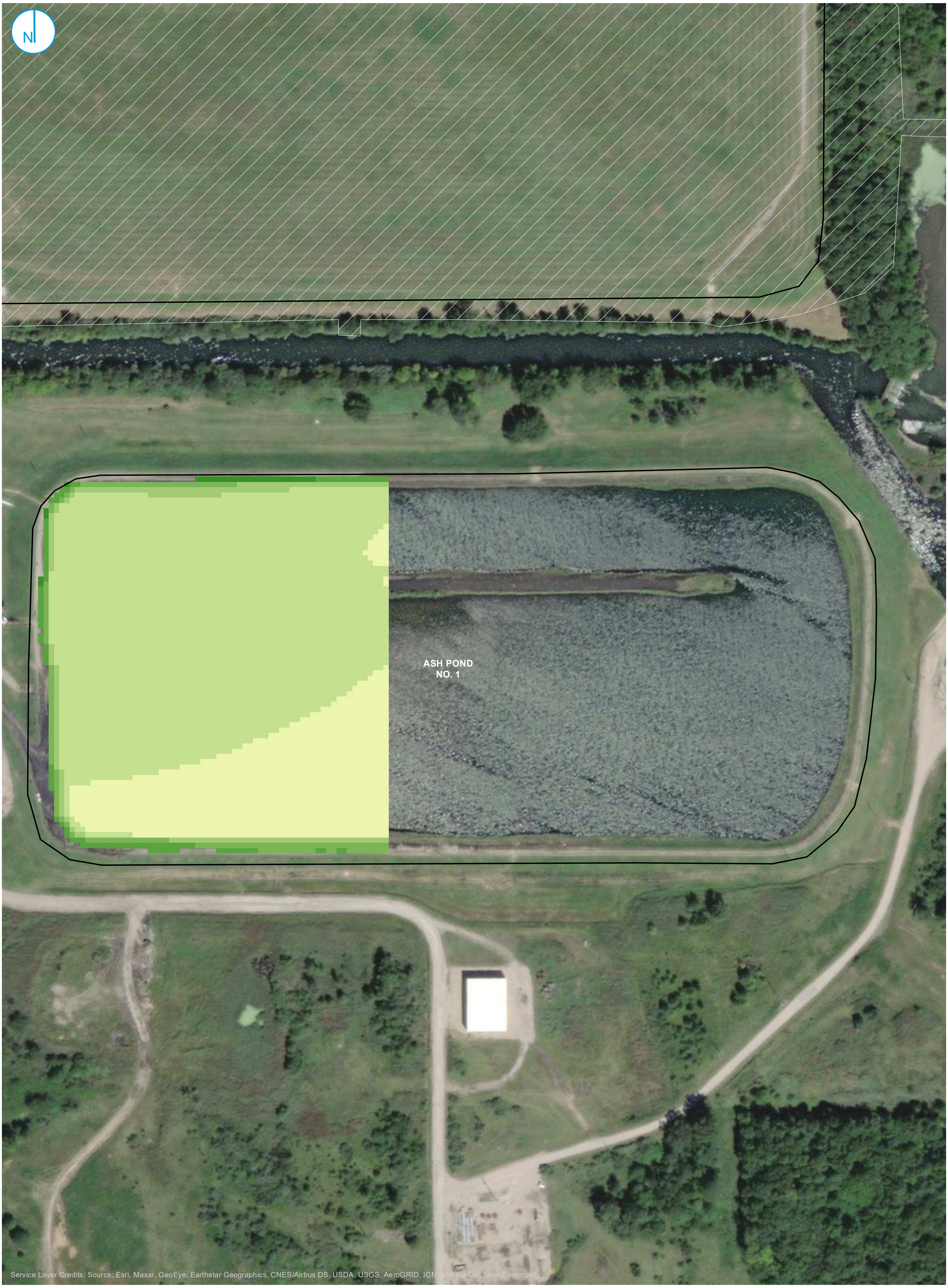
SCENARIO 1 (CIP) –
REDUCTIONS IN TOTAL FLUX IN AND OUT OF FILL UNIT (CCR)

GROUNDWATER MODELING REPORT
ASH POND NO. 1
COFFEEN POWER PLANT
COFFEEN, ILLINOIS

RAMBOLL

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

Y:\Mapping\Projects\22\2285\MXD\IntersectingGW_2022\COF AP1 BOA Saturation CIP.mxd



☐ SITE FEATURE

▨ LIMITS OF FINAL COVER

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

🟩	🟩	🟩	🟩	🟩	🟩
0 - 5	5.1 - 10	10.1 - 15	15.1 - 20	20.1 - 25	25.1 - 30

0 87.5 175
Feet

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

POTENTIAL ASH SATURATION
SIMULATED CLOSURE IN PLACE
GROUNDWATER SURFACE

COFFEEN POWER PLANT
COFFEEN, ILLINOIS

FIGURE 6-9

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL

APPENDICES

APPENDIX A
EVALUATION OF POTENTIAL GWPS EXCEEDANCES

EVALUATION OF POTENTIAL GROUNDWATER PROTECTION STANDARD EXCEEDANCES

Coffeen Ash Pond No. 1
Coffeen, Illinois

Prepared for

Illinois Power Generating Company

Submitted by

Geosyntec
consultants

engineers | scientists | innovators

1 McBride and Son Center Dr Suite 202
Chesterfield, Missouri 63005

July 5, 2022

GLP8029

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LIST OF ACRONYMS AND ABBREVIATIONS

AP1	Ash Pond No. 1
AP2	Ash Pond No. 2
CCR	Coal Combustion Residuals
CFR	Code of Federal Regulations
CPP	Coffeen Power Plant
DA	Deep Aquifer
DCU	Deep Confining Unit
IPGC	Illinois Power Generation Company
LCU	Lower Confining Unit
mg/L	Milligram per Liter
NID	National Inventory of Dams
ORP	Oxidation-Reduction Potential
QC	Quality Control
SI	Saturation Index
SU	Standard Units
TDS	Total Dissolved Solids
UA	Uppermost Aquifer
UCU	Upper Confining Unit
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

SECTION 1

INTRODUCTION

The Illinois Power Generation Company (IPGC) currently operates the Coffeen Power Plant (CPP) and its associated ash ponds. In October 2021, the IPGC submitted an Operating Permit application for the coal combustion residual (CCR) Unit referred to as the Ash Pond Number (No.) 1 (AP1), Vistra identification (ID) No. 101, IEPA ID No. W1350150004-01, and National Inventory of Dams (NID) No. IL50722 (Burns & McDonnell, 2021). The Operating Permit was prepared to comply with Part 845 "Standards of the Disposal of Coal Combustion Residuals in Surface Impoundments (Part 845), which was promulgated by the Illinois Pollution Control Board on April 21, 2021. Ramboll Americas Engineer Solutions, Inc. (Ramboll) identified potential groundwater protection standard (GWPS) exceedances for multiple constituents in groundwater samples collected from monitoring wells in the vicinity of AP1, as presented in the Operating Permit Application. This report was developed to further evaluate the potential GWPS exceedances identified.

SECTION 2

BACKGROUND

A brief description of the site location, AP1 design, geology, and groundwater assessment activities to date are described below.

2.1 Site Location and Description

The CPP, operated by the IPGC is located in Montgomery County, Illinois approximately two miles south of the City of Coffeen in Section 11, Township 7 North, and Range 7 East. The CPP is located between the two lobes of Coffeen Lake to the west, east, and south, and is bordered by agricultural land to the north. The CPP operated as a coal-fired power plant from 1964 to November 2019 and has five CCR management units. The approximately 1,100-acre Coffeen Lake was built by damming the McDavid Branch of the East Fork of Shoal Creek in 1963 for use as an artificial cooling lake for the CPP. Historically, coal mines were operated at depth in the vicinity of the CPP as well as a US Minerals processing facility located to the north. Mine shafts, processing facilities, and coal storage associated with these historical operations were located south of AP1.

2.2 Ash Pond 1 Design

Coffeen AP1 is a 23-acre, unlined surface impoundment used to manage CCR and non-CCR waste streams at the CPP. The location of AP1 relative to the proposed monitoring well network is displayed on Figure 2-1 of the Groundwater Monitoring Plan Report (Ramboll, 2021a) and is provided herein as **Appendix A**. AP1 (also known as the Bottom Ash/Recycle Pond) is a reclaimed ash pond that was constructed utilizing the existing earthen berms with reinforcement. AP1 is an unlined surface impoundment which covers an area of approximately 23 acres, has berms up to 41 feet above the surrounding land surface, and a capacity of 300 acre-feet. It primarily received bottom ash and low volume wastes from floor drains in the main power block building. Several years ago, air heater wash and boiler chemical cleaning wastes were directed to AP1, but this practice was discontinued. The bottom ash is periodically removed from AP1 for beneficial uses by a third-party contractor. Sluicing of waste to AP1 ceased prior to November 4, 2019.

2.3 Geology and Hydrogeology

The AP1 geologic and hydrogeologic setting summarized below is excerpted from the Hydrogeologic Site Characterization Report (HCR) for AP1 (Ramboll, 2021b).

There are five principal layers of unlithified material present below AP1 and above bedrock which are categorized into hydrostratigraphic units listed below (from the surface downward) based on stratigraphic relationships and hydrogeologic characteristics:

- **Upper Confining Unit (UCU):** Composed of the Roxana and Peoria Silts (Loess Unit) and the upper clayey portion of the Hagarstown member which are classified as silts-clayey silts and gravelly clay below the surficial soil. The UCU has been eroded east of AP1, near the Unnamed Tributary.

- **Uppermost Aquifer (UA):** The uppermost aquifer is the Hagarstown Member which is classified as primarily sandy-gravelly silts and clays with thin beds of sands. Similar to the Loess Unit, the Hagarstown is absent in some locations near the Unnamed Tributary.

- **Lower Confining Unit (LCU):** Comprised of the Vandalia Member, Mulberry Grove Member, and Smithboro Member. These units include a sandy-silty till with thin, discontinuous sand lenses, a discontinuous and limited extent sandy silt which has infilled prior erosional features, and silty-clayey diamicton, respectively. This unit has been identified as a potential migration pathway (PMP) because downward vertical gradients indicate that there is the potential for impacts to migrate within this unit.

- **Deep Aquifer (DA):** Comprised of sand and sandy silt/clay units of the Yarmouth Soil, which include accretionary deposits of fine sediment and organic materials, typically less than five feet thick and discontinuous across the CPP. This unit is also identified as a PMP, because it is the first permeable unit below the uppermost aquifer.

- **Deep Confining Unit (DCU):** Comprised of the Banner Formation, generally consisting of clays, silts, and sands. The Lierle Clay Member is the upper layer of the Banner Formation which was encountered at the Site.

Bedrock is comprised of the Bond Formation, which consists of limestone and calcareous clays and shale. Bedrock was not encountered in the borings advanced to date at CPP.

Flow of groundwater from central portions of the CPP to Coffeen Lake or the Unnamed Tributary through the UA are the primary pathways for contaminant migration. The LCU and DA underlying the UA have been identified as PMPs. Groundwater elevations are primarily controlled by surface topography, geologic unit topography, and water levels within Coffeen Lake and the Unnamed Tributary. A groundwater divide trending north-south is observed running through the approximate center of the CPP (Figure 1-3 of Ramboll [2021a], provided as **Appendix B**). Phreatic surfaces or water elevations within the surface impoundments are generally consistent and have not been observed to fluctuate with groundwater elevations, indicating limited hydraulic connection with the surface impoundments.

2.4 Groundwater and AP1 Monitoring

The proposed Part 845 monitoring well network for AP1 was established in the Groundwater Monitoring Plan (Ramboll, 2021a). The proposed monitoring well network consists of sixteen (16) monitoring wells, which are installed in the UA, LCU, DA, and temporary water-level only surface water staff gages. Two of the installed wells are background monitoring wells (G281 and G306) and the remaining fourteen are compliance monitoring wells. Both background wells and most compliance wells are screened within the UA. G307D, G314, and G316 are screened within the LCU, and G314D is screened within the DA. Well locations are shown on **Appendix A**.

SECTION 3
POTENTIAL GROUNDWATER PROTECTION STANDARD EXCEEDANCE REVIEW

An evaluation of the history of potential GWPS exceedances was completed for the Operating Permit application in October 2021 (Burns & McDonnell, 2021). Groundwater concentrations from 2015 to 2021 were evaluated for potential exceedances in accordance with the Statistical Analysis Plan proposed in the Operating Permit application. Potential exceedances are summarized below:

- Boron at monitoring well G313: The boron statistical result at G313 is 3.5 milligrams per liter (mg/L), which exceeds the Part 845 GWPS (3.2 mg/L).

- Cobalt at monitoring well G314: The cobalt statistical result at G314 is 0.00959 mg/L which exceeds the Part 845 GWPS (0.006 mg/L).

- pH (field) at monitoring well G312: The pH statistical result at G312 is 6.4 standard units (SU), which is below the lower limit of the Part 845 GWPS (6.5/9.0 SU).

- Sulfate at monitoring wells G301, G303, G304, G305, G307, G307D, G308, G309, G310, G311, G312, G313, G314, G314D, G315, and G317: The sulfate statistical results ranged from 464 to 1100 mg/L and individually exceed their relevant Part 845 GWPS (400 to 700 mg/L) for the identified wells.

- Total dissolved solids (TDS) at monitoring wells G303, G304, G305, G307, G307D, G308, G309, G310, G311, G312, G313, G314, G315, and G317: The TDS statistical results ranged from 1210 to 1900 mg/L which exceed the Part 845 GWPS (1200 mg/L).

A review of groundwater, porewater, soil, and ash data indicates that the potential exceedances of cobalt at G314 and pH at G312 are not related to AP1, as documented in Section 4. An evaluation of alternative sources of the boron, sulfate, and TDS potential exceedances was not completed at this time.

SECTION 4
LINES OF EVIDENCE

A review of groundwater, porewater, soil, and ash data indicates that the potential GWPS exceedances of cobalt at G314 and the pH value at G312 are not related to AP1, as supported by the lines of evidence (LOE) below:

1. AP1 porewater samples do not contain detectable concentrations of cobalt.
2. Cobalt concentrations in ash samples collected from AP1 are comparable to or lower than cobalt concentrations in soil samples near AP1.
3. Monitoring well G314 has experienced significant changes in oxidation-reduction (redox) conditions since well installation occurred, which may impact cobalt behavior in groundwater.
4. AP1 porewater is slightly basic and would not result in low pH measurements at monitoring well G312.
5. pH values within the proposed monitoring well network are strongly correlated with saturation indices of carbonate minerals in soil near AP1.

4.1 LOE #1: AP1 porewater samples do not contain detectable concentrations of cobalt

Of the three AP1 porewater sampling locations analyzed for cobalt (AP1d, XPW01, and XPW02), none have ever contained cobalt concentrations above the method detection limit of 0.002 mg/L; therefore, cobalt concentrations detected at G314 cannot be derived from a mixing scenario between groundwater and AP1 porewater. In contrast, both background monitoring wells have at times contained cobalt concentrations within the range observed at G314. This indicates that aqueous cobalt is naturally present in groundwater at CPP at variable concentrations.

Figure 1 displays cobalt concentrations over time for G314, background wells G306 and G281, and porewater samples from AP1. Cobalt concentrations at G314 display an increasing trend, but this trend is punctuated by a concentration decrease in the most recent sampling event. The highest values at G314 are comparable to or lower than select results observed at background well G306, suggesting there is variability within the aquifer.

4.2 LOE #2: Cobalt concentrations in ash samples collected from AP1 are comparable to or lower than cobalt concentrations in soil samples near AP1

Soil samples were collected in May 2021 and September 2021 adjacent to select existing monitoring wells and analyzed for total metals. Cobalt concentrations in soil are displayed in **Table 1** along with total cobalt concentrations in ash material collected from AP1. Cobalt concentrations in ash from AP1 (4.3 – 4.8 mg/kg) fall within the range of cobalt concentrations observed in CPP soil (4.0 – 10 mg/kg). Cobalt concentrations in soil are highest at Ash Pond No.2 (AP2) background monitoring well G270, which is in a background location relative to AP1 (**Appendix B**). **Table 1** indicates variability in cobalt concentrations detected in soil across the CPP. Three sample locations (two background locations and one compliance location) contained greater cobalt concentrations than ash samples, indicating that naturally occurring cobalt exists in solid phase across the CPP at equivalent or greater concentrations than within AP1 itself.

4.3 LOE #3: Monitoring well G314 has experienced significant changes in oxidation-reduction (redox) conditions since well installation occurred, which may impact cobalt behavior in groundwater

Groundwater oxidation-reduction potential (ORP) was measured as a field parameter during the sample collection process at monitoring wells in the proposed network. ORP is a measure of the redox conditions of water which, along with other parameters like pH, temperature, and chemical composition, govern the stability of minerals comprising groundwater aquifer solids. ORP values over time at recently installed compliance monitoring wells are displayed on **Figure 2**. ORP values for recently installed wells display a decreasing trend, indicating a shift from highly oxic to near reducing conditions. This decreasing trend is hypothesized to be attributable to stabilization of the new wells following the potential introduction of drilling water involved in the well installation process. Such a change in geochemical conditions can influence the stability of redox-sensitive mineral phases such as iron and manganese oxides. Significantly, decreases in ORP are commonly correlated with dissolution of iron and manganese bearing minerals, leading to the release of ions associated with these mineral phases.

Cobalt is known to undergo isomorphic substitution for iron in crystalline iron minerals such as iron oxides, iron sulfides, and iron carbonates due to the similar ionic radii of approximately 1.56 angstroms (Å) for iron vs. 1.52 Å for cobalt (Clementi and Raimondi, 1963; Krupka and Serne, 2002; Hitzman et al., 2017). Soil samples around AP1 were collected and submitted for mineralogical analysis via X-ray diffraction (XRD) to determine the mineralogical composition of the natural aquifer material. XRD results are shown in **Table 2**. **Table 2** indicates that the majority component of site soils consists of geochemically inert minerals quartz and feldspar (microcline and albite). No iron oxides or iron sulfides were detected in XRD analysis, but iron-bearing carbonate mineral ankerite ($Ca,Fe(CO_3)_2$) was detected at a maximum abundance of 7.7 wt.%.

An Eh-pH diagram displaying the thermodynamic stability of iron phases was generated using the average composition of G314 groundwater (**Figure 3**). Geochemical conditions during initial sampling events favored thermodynamic stability of the ferric (Fe^{3+}) iron hydroxide mineral $Fe(OH)_3$; however, no iron hydroxide or oxide minerals were present in XRD results above the detection limit of 0.5%. **Figure 3** indicates G314 groundwater conditions have shifted in recent sampling events, favoring the formation of ferrous (Fe^{2+}) carbonate mineral siderite ($FeCO_3$). The modeled shift of thermodynamic stability away from iron hydroxide and oxide minerals and towards iron carbonates would result in the release of iron and isomorphically substituted cobalt into groundwater through mineral dissolution reactions.

While siderite was not detected in the XRD results, iron-bearing carbonate mineral ankerite was detected at abundances of up to 7.7 wt.%. Ankerite exists in nature as a solid-solution mineral without a fixed mineral formula. As a result, accurate thermodynamic information is not available for modeling purposes and ankerite was consequently not included in the thermodynamic database used to generate **Figure 3**. It is likely that ankerite thermodynamic stability is favored over siderite stability at G314 and the ankerite detected in XRD analyses is a product of the formation of carbonate minerals in an iron-rich environment.

Naturally occurring cobalt is known to substitute for iron in iron-bearing minerals. Thermodynamic modeling indicates that a recent trend in redox conditions has resulted in a mineral stability shift from iron hydroxides and oxides towards iron carbonates. The presence of ankerite, an iron-bearing carbonate mineral, has been confirmed across the site. The modeled dissolution of iron hydroxide and oxide minerals may have resulted in isomorphically substituted cobalt being released from the crystal structure of these minerals and entering groundwater. The presence of observed iron carbonate minerals in soil samples supports the occurrence of this mineralogical shift.

4.4 LOE #4: AP1 porewater is slightly basic and would not result in low pH measurements at monitoring well G312

Groundwater pH conditions were measured as a field parameter during the sample collection process at monitoring wells within the proposed monitoring well network. A time series plot of field pH measurements at G312, background wells G281 and G306, and AP1 porewater monitoring locations XPW-01 and XPW-02 is provided as **Figure 4**. Groundwater at monitoring well G312 contains pH levels below the calculated lower GWPS for pH of 6.5 SU. Low pH values at G312 cannot be attributed to AP1, because AP1 porewater samples are consistently slightly basic (pH values range from 7.78-8.08). Physical mixing of AP1 porewater with G312 groundwater would result in an increase in pH at G312. In contrast, pH values at background well G306 were occasionally measured at 6.5 SU, which is within the range of measurements observed at G312. Therefore, low pH conditions at G312 are attributable to natural variability within the aquifer.

4.5 LOE #5: pH values within the proposed monitoring well network are strongly correlated with saturation indices of carbonate minerals in soil near AP1

As mentioned in Section 4.3, composite soil samples from various locations surrounding AP1 were collected and submitted for mineral identification analysis via XRD (**Table 2**). Soil surrounding AP1 contains variable abundances of carbonate minerals such as calcite, dolomite, and ankerite, with the total abundance of carbonates at each location ranging an order of magnitude from 2.7-27.5 wt.%. Carbonate minerals in nature function as pH buffers, capable of neutralizing acidity through reaction with carbonate (CO_3) (Drever, 1988). pH levels at individual wells may be significantly influenced by the presence and abundance of carbonate minerals comprising localized sections of the aquifer unit. Although soil samples were not collected for all wells of interest, carbonate saturation indices (SIs) provide a method to assess the role of carbonate minerals in soil buffering capacity in the absence of XRD results.

United States Geologic Survey (USGS) software package PHREEQC was used to calculate SIs of carbonate minerals at G312 and background wells G281 and G306 based on groundwater compositions. A mineral's SI is an expression of its thermodynamic equilibrium state relative to a liquid (groundwater). If the calculated SI for a mineral is negative, then that mineral is undersaturated relative to groundwater and is thermodynamically favored to dissolve. If the calculated SI for a mineral is positive, then that mineral is supersaturated relative to groundwater and is thermodynamically favored to precipitate. If a mineral's SI is approximately 0 (+\- 0.2), then the mineral is in thermodynamic equilibrium with groundwater. SIs for calcite ($CaCO_3$) and dolomite ($Ca,Mg(CO_3)_2$) were plotted against pH for individual samples (**Figure 5**). **Figure 5** demonstrates a strong positive correlation between pH and carbonate SI. pH values tend to be lower in groundwater that is undersaturated with respect to carbonate minerals. This relationship is expected – monitoring wells which favor carbonate dissolution are likely to contain less carbonate in the solid phase. Absence of carbonate in localized portions of the aquifer results in the inability of these locations to buffer low pH groundwater. According to **Figure 5**, background wells G281 and G306 are near equilibrium or supersaturated with respect to carbonate minerals and are likely to have these minerals present and stable. These wells would then have greater capability to buffer acidic water and retain near-neutral pH values. G312 was not sampled for mineralogy, although **Figure 5** demonstrates that groundwater from this well is undersaturated with respect to carbonate minerals, suggesting that large abundances of carbonate are not likely to be present in aquifer solids at this location.

XRD analyses indicate carbonate mineral abundances around AP1 vary up to an order of magnitude (**Table 2**). Evaluation of carbonate SIs reveals that a strong correlation exists between carbonate SIs and pH. G312 is undersaturated with respect to calcite and dolomite; therefore, these minerals are likely not present as pH buffers, resulting in lower groundwater pH values where acid neutralizing minerals are not available.

SECTION 5

CONCLUSIONS

Based on these five LOEs, it has been demonstrated that AP1 is not the source of the potential cobalt and pH exceedances identified.

1. AP1 porewater samples do not contain detectable concentrations of cobalt, whereas cobalt concentrations in background well G306 occasionally exceed the relevant GWPS.

2. Cobalt concentrations in ash samples collected from AP1 are comparable to or lower than cobalt concentrations in soil samples from downgradient and background monitoring wells.

3. Monitoring well G314 has experienced significant changes in oxidation-reduction (redox) conditions since well installation occurred, which may cause destabilization of iron-bearing minerals capable of hosting cobalt ions in their crystal structure.

4. AP1 porewater is slightly basic and would not result in low pH measurements at monitoring well G312.

5. pH values within the proposed monitoring well network are strongly correlated with saturation indices of carbonate minerals which are detected at variable abundances across soil near AP1.

SECTION 6

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TABLES

Table 1: Cobalt Concentrations in Soil and Ash
Coffeen Power Plant - Ash Pond No. 1

Sample Location	**Description**	**Sample Depth (feet)**	**Cobalt (mg/kg)**
G270	Background	16-20	10
G306	Background	14-16	6.0
G311	Compliance	14-15	4.0
G313	Compliance	8-9	7.0
G316	Compliance	13-16	4.0
XPW01	Ash Pond 1	NA	4.8
XPW02	Ash Pond 1	NA	4.3

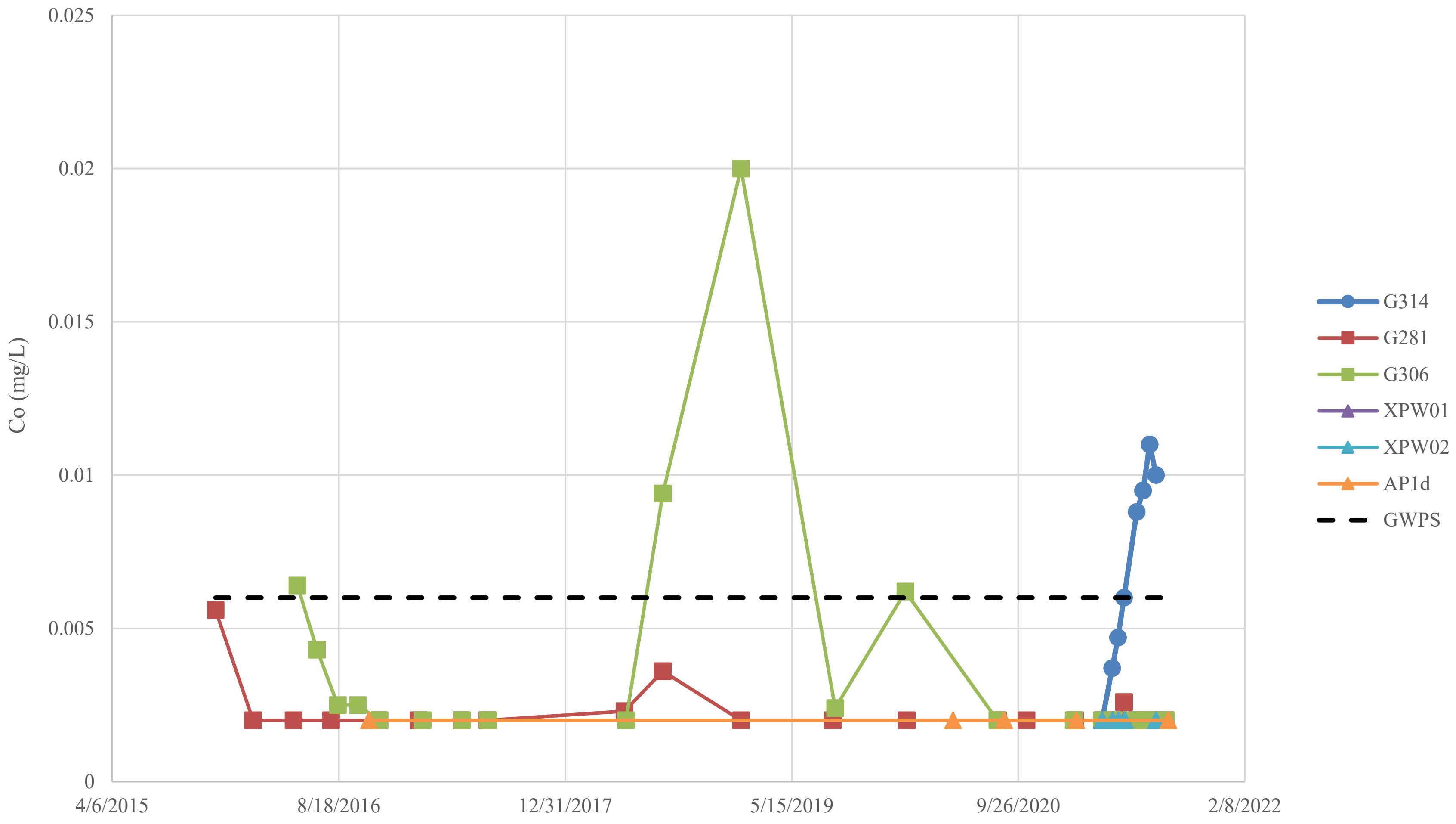
Notes:
Soil samples were composite samples collected over the indicated depth range

Table 2: Summary of X-ray Diffraction Results
Coffeen Power Plant - Ash Pond No. 1

Sample ID	**SB-306**	**SB-311**	**SB-313**	**SB-316**
Sample Depth (ft.) **Mineral**	14-16	14-15	8-9	13-16
Quartz	70.9	58.9	51.3	67.6
Microcline	8.5	7.4	7.6	9.8
Albite	9.6	8.6	7.9	9.6
Chlorite	1.8	1.7	1.1	1.7
Diopside	3.1	3.8	4.6	1.3
Muscovite	-	-	-	7.3
Carbonate Minerals				
Calcite	0.5	2.5	4.1	-
Dolomite	3.5	12.1	15.7	1.9
Ankerite	2.1	5	7.7	0.8
Carbonate Total	*6.1*	*19.6*	*27.5*	*2.7*

Notes:
Results presented in units of weight %
 - : Mineral was not detected in sample
Weight % quantities have been normalized to a sum of 100% to remove reporting of amorphous material
Carbonate total consists of calcite, dolomite, and ankerite

FIGURES



Notes: Data displayed for compliance well G314, background wells G281 and G306, and pore water samples XPW01, XPW02, and AP1d. The calculated Groundwater Protection Standard (GWPS) is indicated by the dashed line. Samples which did not contain cobalt concentrations above the method detection limit of 0.002 mg/L are displayed on the figure as having a detected concentration of 0.002 mg/L.

Aqueous Cobalt Time Series

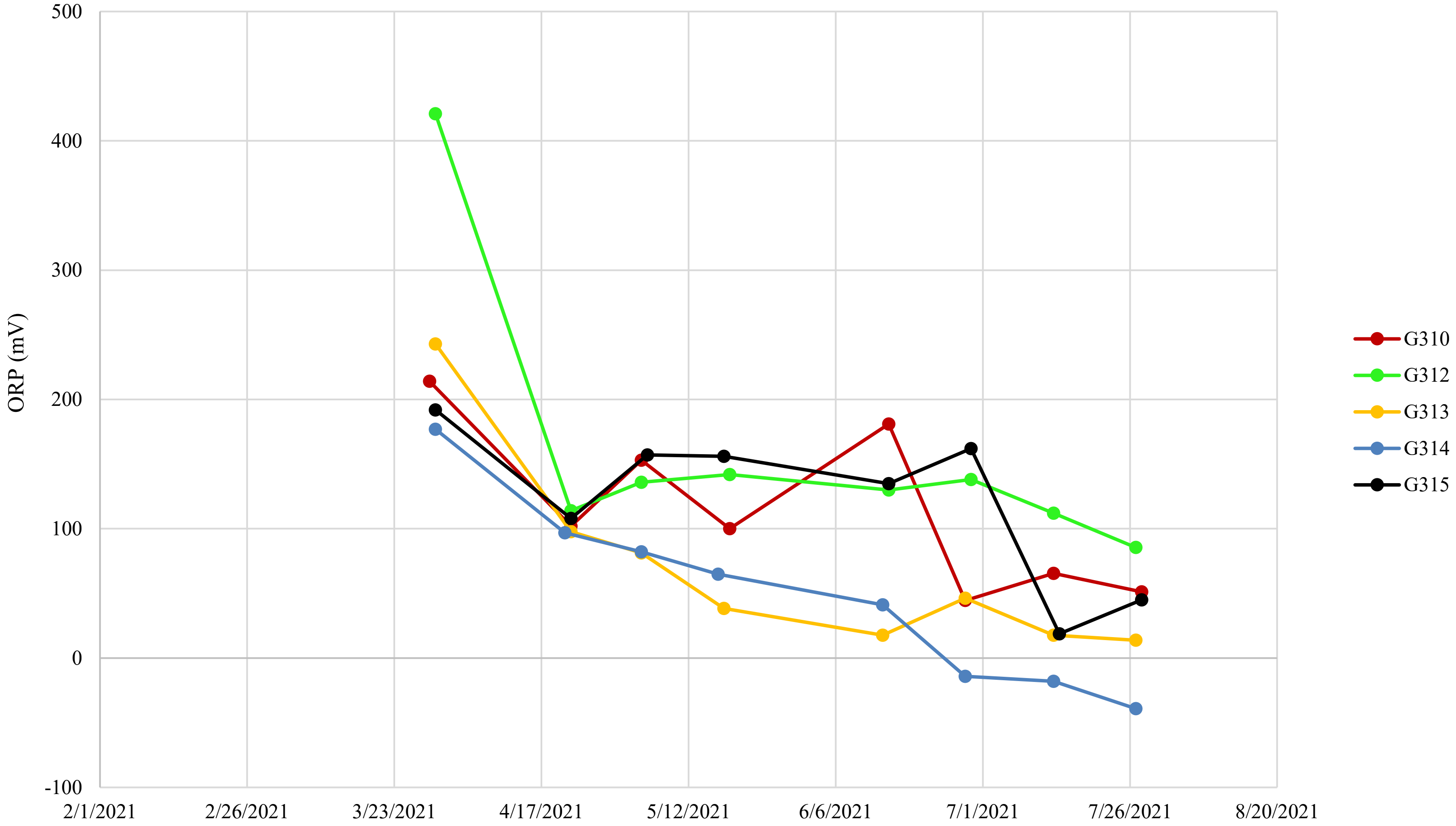
Coffeen Power Plant

Geosyntec consultants

Figure 1

Columbus, OH

April 2022



Notes: Groundwater monitoring began at all wells displayed in March 2021. Positive ORP values are considered indicative of oxic environments, and negative ORP values are considered indicative of anoxic environments.

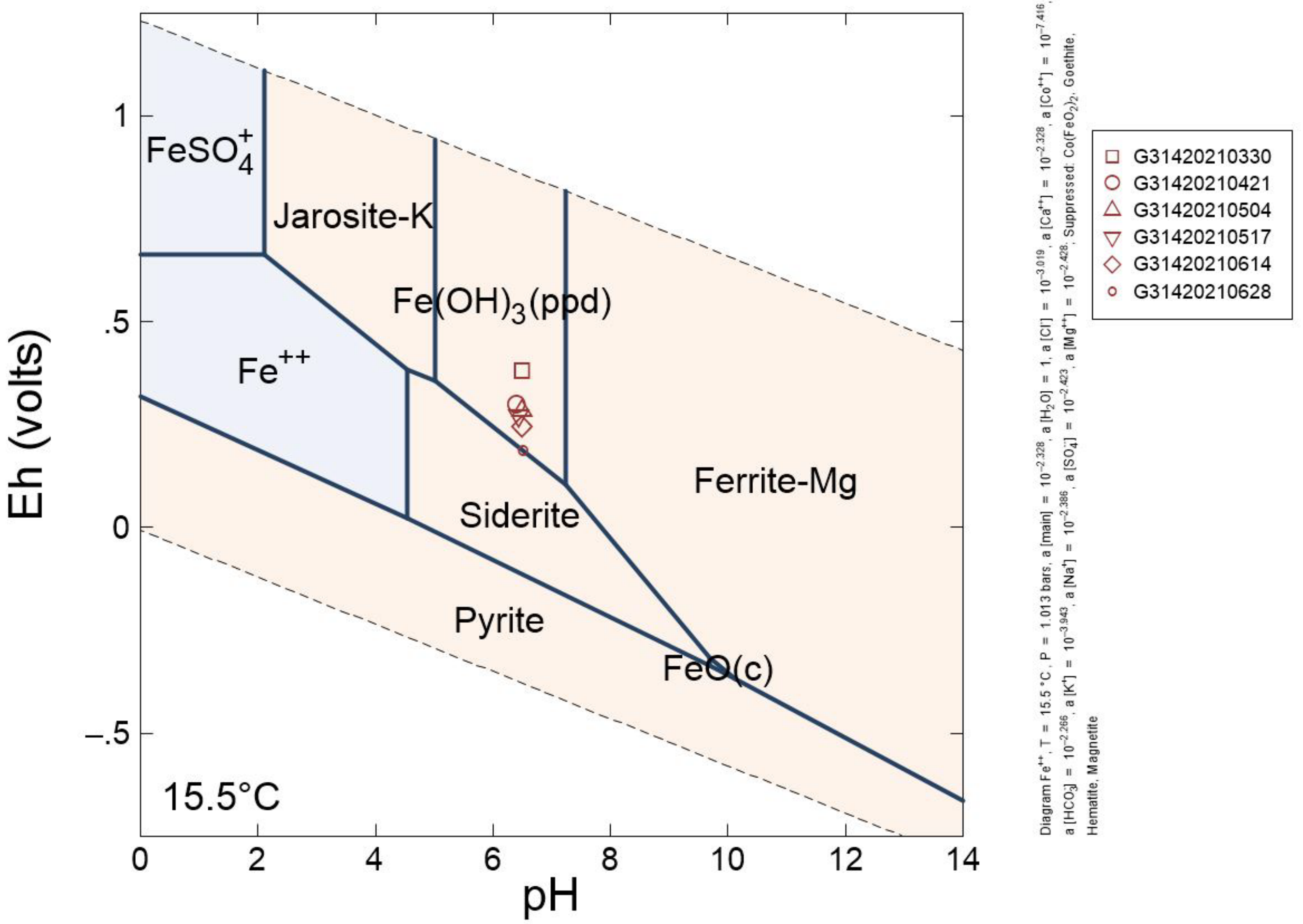
Oxidation-Reduction Potential (ORP) Time Series – Recently Installed Wells

Coffeen Power Plant

Geosyntec consultants

Figure 2

Columbus, OH | April 2022



Notes: The average groundwater composition of compliance monitoring well G314 was used to establish baseline conditions for the diagram. Eh and pH values for sampling dates at G314 are shown on the diagram. Fe-oxide phases hematite, goethite, and magnetite were suppressed to reflect detected mineralogy from XRD analysis.

G314 Eh-pH Diagram - Iron

Coffeen Power Plant

Geosyntec consultants

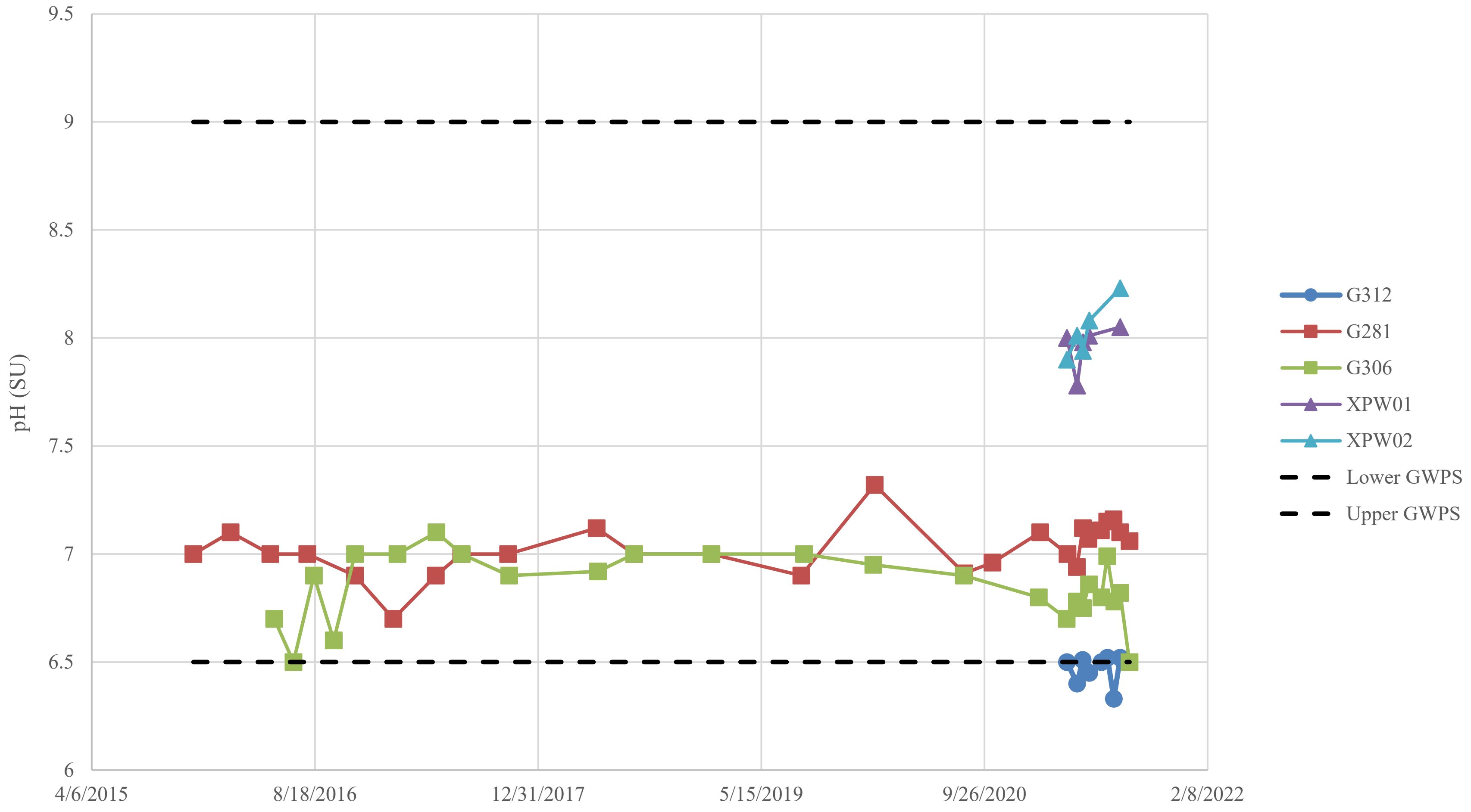
Columbus, Ohio

April 2022

Figure

3

internal info: path, date revised, author



Notes: Data displayed for compliance well G312, background wells G281 and G306, and pore water samples XPW01 and XPW02. The calculated GWPS for the upper and lower pH values are indicated by dashed lines.

pH Time Series

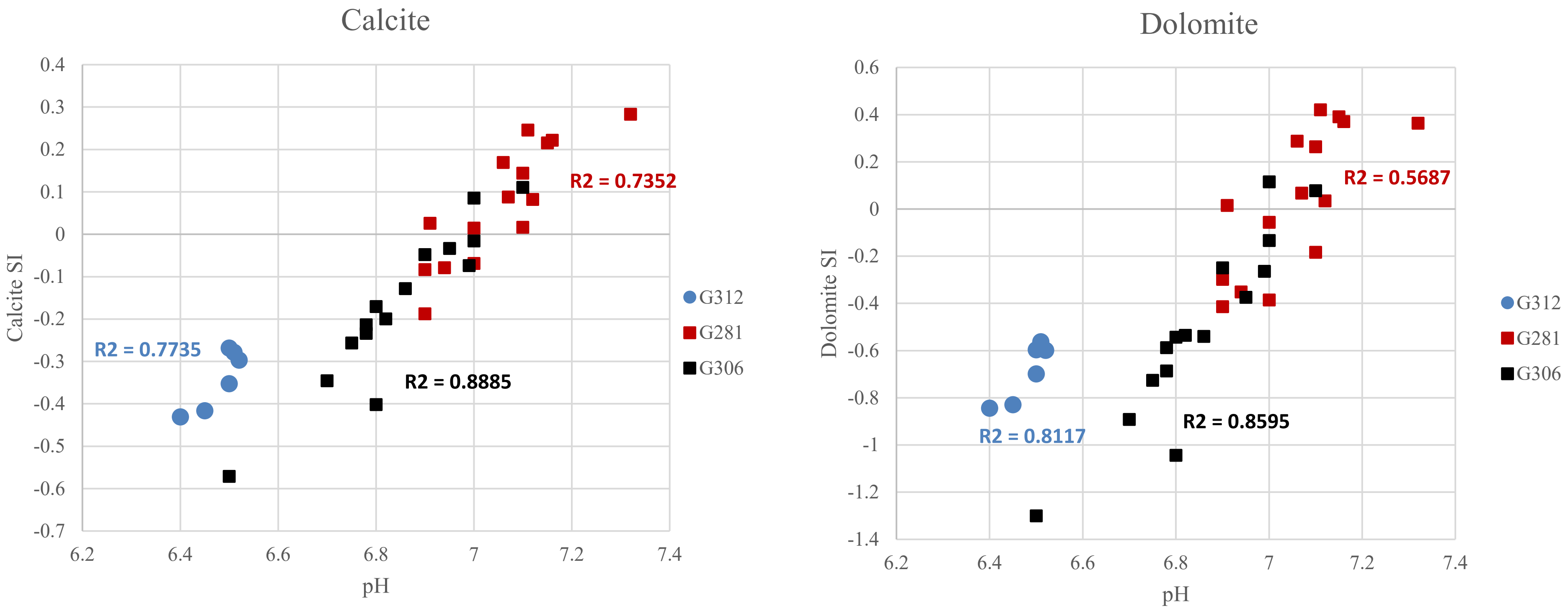
Coffeen Power Plant

Geosyntec consultants

Figure
4

Columbus, OH

April 2022



Notes: Saturation indices (SIs) were calculated using PHREEQC based on groundwater composition and geochemical characteristics. R^2 values for linear trendlines for each individual well are displayed.

pH vs. Carbonate Saturation Indices

Coffeen Power Plant

Geosyntec consultants

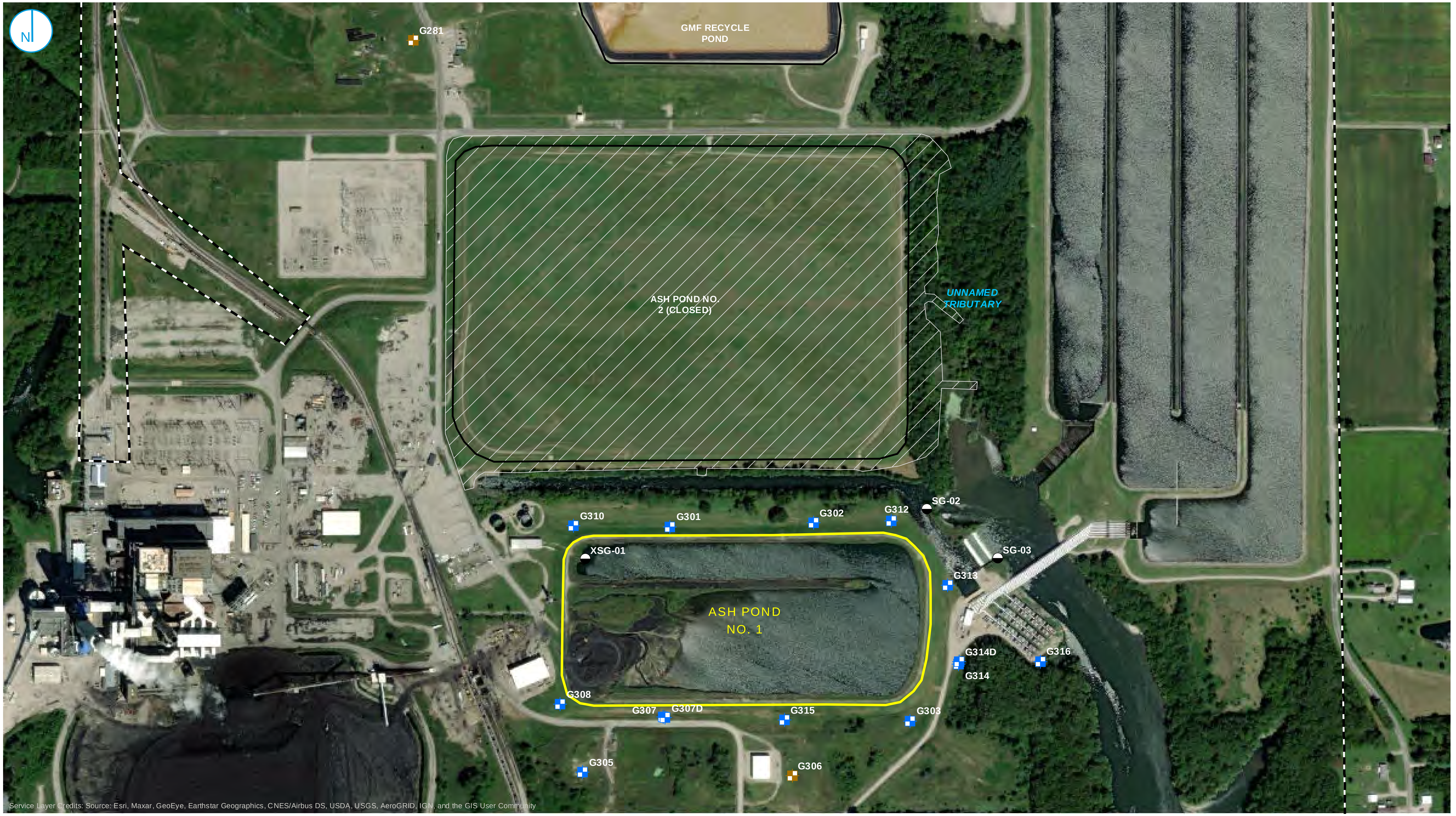
Figure **5**

Columbus, OH

April 2022

APPENDIX A

Figure 2-1: Proposed 845 Groundwater Monitoring Well Network. From Groundwater Monitoring Plan, Ash Pond No. 1, Coffeen Power Plant



Y:\Mapping\Projects\22\2285\MXD\845_Operating_Permit\Coffeen\AP1\GMP\Figure 2-1_Proposed Monitoring Well Network.mxd

PROJECT: 169000XXXX | DATED: 10/12/2021 | DESIGNER: HOTCALD

▣ COMPLIANCE WELL
▣ BACKGROUND WELL
◓ STAFF GAGE

▭ PART 845 REGULATED UNIT (SUBJECT UNIT)
▭ SITE FEATURE
▨ LIMITS OF FINAL COVER
⬚ PROPERTY BOUNDARY

0 200 400 Feet

PROPOSED 845 GROUNDWATER MONITORING WELL NETWORK

GROUNDWATER MONITORING PLAN
ASH POND NO.1
COFFEEN POWER PLANT
COFFEEN, ILLINOIS

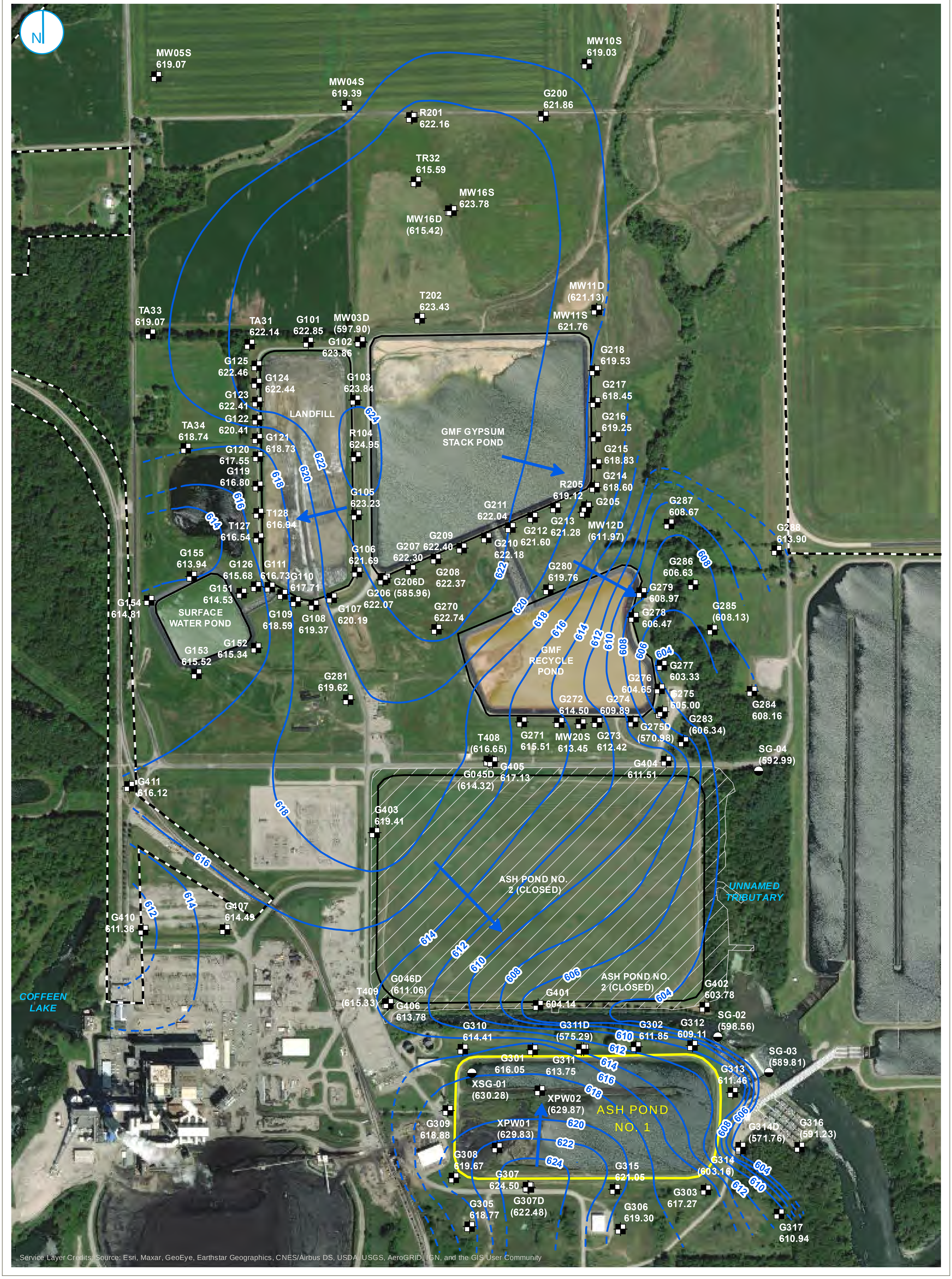
FIGURE 2-1

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL

APPENDIX B

Figure 1-3: Uppermost Aquifer Groundwater Elevation Contours, April 20, 2021. From Groundwater Monitoring Plan, Ash Pond No. 1, Coffeen Power Plant



⊞	MONITORING WELL
◒	STAFF GAGE
▭	PART 845 REGULATED UNIT (SUBJECT UNIT)
▭	SITE FEATURE
▨	LIMITS OF FINAL COVER
⬚	PROPERTY BOUNDARY
—	GROUNDWATER ELEVATION CONTOUR (2-FT CONTOUR INTERVAL, NAVD88)
- -	INFERRED GROUNDWATER ELEVATION CONTOUR
→	GROUNDWATER FLOW DIRECTION

0 275 550
Feet

NOTE:
ELEVATIONS IN PARENTHESES WERE NOT USED FOR CONTOURING.

UPPERMOST AQUIFER GROUNDWATER ELEVATION CONTOURS APRIL 20, 2021

FIGURE 1-3

GROUNDWATER MONITORING PLAN
ASH POND NO.1
COFFEEN POWER PLANT
COFFEEN, ILLINOIS

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

APPENDIX B
MODFLOW, MT3DMS, HELP MODEL, AND FLUX EVALUATION DATA EXPORT FILES (ELECTRONIC ONLY)

APPENDIX C
EVALUATION OF PARTITION COEFFICIENT RESULTS

Geosyntec consultants

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Memorandum

Date: July 5, 2022

To: David Mitchell, Stu Cravens, Vic Modeer
Illinois Power Generating Company

Copies to: Brian Hennings - Ramboll

From: Allison Kreinberg, Ryan Fimmen – Geosyntec Consultants, Inc.

Subject: Evaluation of Partition Coefficient Results – Coffeen Ash Pond No. 1
CCR Unit 101, Coffeen Power Plant, Coffeen, Illinois

INTRODUCTION

The Illinois Power Generation Company (IPGC) currently operates the Coffeen Power Plant (CPP) and its associated ash ponds located in Coffeen, Illinois. Ash Pond Number (No.) 1 (AP1) (Vistra identification (ID) No. 101; Illinois Environmental Protection Agency [IEPA] ID No. W1350150004-01; National Inventory of Dams [NID] No. IL50722) is a 23-acre, unlined SI used to manage CCR (bottom ash) and non-CCR waste streams at the CPP in accordance with the plant's Water Pollution Control Permit 1978-EA-389 issued by the Agency on May 26, 1978. Geosyntec Consultants (Geosyntec) is assisting IPGC with Part 845 compliance at the Site.

IPGC is currently preparing a Construction Permit application for AP1 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 compounds potentially associated with AP1, including boron, cobalt, pH (field), sulfate, and total dissolved solids (TDS). An evaluation of potential exceedances of applicable GWPS found that both cobalt and pH potential exceedances are not related to AP1 (Geosyntec, 2022). Batch adsorption testing was conducted for boron and sulfate 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 AP1 which included completion of four (4) soil/rock borings ranging in depth from 13 to 18 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. A summary of the soil samples used for the batch testing is provided in **Table 1**.

Two groundwater samples (G311 and G313) and three soil samples (SB-306, SB-311, and SB-313) 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, depending on the ratio) and equilibrated over a seven-day period. Each microcosm was amended (i.e., spiked) with sodium sulfate (Na_2SO_4), and the microcosms with G313 groundwater were also amended with boric acid (H_3BO_3), to achieve a target concentration of sulfate and boron, respectively (**Table 2**). The G311 microcosm was not amended with boric acid because potential boron exceedances were not identified in the vicinity of G311. G313 groundwater was combined with aquifer solids both adjacent to downgradient location G311 and background location G306 to understand how partitioning behavior may be affected by position relative to AP1.

An initial sample of the stock solution for each experimental design was collected on Day 0, and a control sample (i.e., only amended G311 or G313 groundwater with no aquifer solids) was collected on Day 7 after tumbling in polypropylene bottleware to evaluate any loss to interactions with the bottleware or 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 sulfate and/or 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 tests (**Tables 3** and **4**) were used to construct isotherms for boron and sulfate; 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]). Some of 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 **Tables 5** and **6**.

SUMMARY OF RESULTS

The partition coefficient values for G311 and G313 (denoted below as G313/SB-306 when combined with SB-306 geologic material and G313/SB-313 when combined with the SB-313 geologic material) are presented in **Tables 5** and **6**, respectively. Figures which show the linear, Langmuir, and Freundlich isotherms for boron and sulfate are provided in **Appendix A**.

A boron partition coefficient was not calculated for G311, since the microcosm was not amended with boric acid because potential boron exceedances were not identified in the vicinity. The Freundlich isotherm fit the data best for G313/SB-306 and G313/SB-313, yielding K_F values of 0.65 L/kg and 2.03 L/kg, respectively. Though slightly higher at G313/SB-313, these values are comparable to boron partition coefficients 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).

The G311 partition coefficient for sulfate ranged from -624 L/kg for the Langmuir isotherm to 10.11 L/kg for the linear isotherm, but the best-fitting Freundlich isotherm yielded a low K_F value of 9.2×10^{-12} L/kg. None of the isotherms showed a high goodness-of-fit (i.e., R^2) for either G313/SB-306 or G313/SB-313, with the highest correlation being 0.51, and were associated with erroneously high (1700 L/kg) and low (-690 L/kg) partition coefficients. An accurate sulfate partition coefficient could therefore not be calculated from any of the data. These results are consistent with the findings of Strenge and Peterson (1989), who found that partition coefficients for sulfate are 0.0 L/kg, regardless of pH conditions and the amount of sorbent present.

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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).

Geosyntec. 2022. Evaluation of Potential Groundwater Protection Standard Exceedances. Coffeen Ash Pond No. 1. Coffeen, Illinois. May

TABLES

Table 1 - Batch Attenuation Testing Data Summary
Coffeen AP1

Groundwater Sample ID	Soil Sample ID	Soil: Water Ratio
G311	SB-311 (14-15 ft bgs)	2:1.4
		1:1.3
		1:5.7
		1:11.3
		1:27.8
G313	SB-306 (14-16 ft bgs)	2:1.5
		1:1.3
		1:6.0
		1:11.7
		1:28.8
G313	SB-313 (8-9 ft bgs)	2:1.5
		1:1.3
		1:6.0
		1:11.7
		1:28.8

Notes:

ft bgs = feet below ground surface

Table 2 - Microcosm Amendment and Target Concentrations
Coffeen AP1

Groundwater Sample ID	Soil Sample ID	Compound	Amendment	Target Concentration (mg/L)
G311	SB-311 (14-15 ft bgs)	Boron	--	--
		Sulfate	2.76 g of Na_2SO_4	1500
G313	SB-306 (14-16 ft bgs)	Boron	19.73 mL of a 2 g/L H_3BO_3	5
		Sulfate	1.98 g of Na_2SO_4	1500
G313	SB-313 (8-9 ft bgs)	Boron	19.73 mL of a 2 g/L H_3BO_3	5
		Sulfate	1.98 g of Na_2SO_4	1500

Notes:
ft bgs - feet below ground surface
mg/L - milligrams per liter
Na_2SO_4 - sodium sulfate
H_3BO_3 - boric acid

Table 3 - Batch Attenuation Testing Results, G311
Coffeen AP1

Groundwater Sample ID	Geologic Material Sample ID	Treatment	Date	Day	Replicate	Dissolved Sulfate	pH	ORP
						mg/L	SU	mV
G311	--	Groundwater Only Control	25-Jan-22	0	G311-1a	1,589	6.83	-62
					G311-2a	1,826	6.88	-66
					Average Concentration (mg/L)	**1,708**	**6.86**	**-64**
			1-Feb-22	7	G311-1	1,617	6.85	42
					G311-2	1,478	6.85	38
					Average Concentration (mg/L)	**1,548**	**6.85**	**40**
	G311 SB-311 Geologic Material	2:1 Soil:Water Ratio	25-Jan-22	0				
			1-Feb-22	7	SB-311:G311 2:1-1	1,321	6.92	50
					SB-311:G311 2:1-2	1,302	6.86	100
					Average Concentration (mg/L)	**1,311**	**6.89**	**75**
		1:1 Soil:Water Ratio	25-Jan-22	0				
			1-Feb-22	7	SB-311:G311 1:1-1	1,727	6.92	51
					SB-311:G311 1:1-2	860	6.88	24
					Average Concentration (mg/L)	**1,294**	**6.90**	**38**
		1:5 Soil:Water Ratio	25-Jan-22	0				
			1-Feb-22	7	SB-311:G311 1:5-1	1,326	6.87	93
					SB-311:G311 1:5-2	1,516	6.88	56
					Average Concentration (mg/L)	**1,421**	**6.88**	**75**
		1:10 Soil:Water Ratio	25-Jan-22	0				
			1-Feb-22	7	SB-311:G311 1:10-1	1,570	6.89	27
					SB-311:G311 1:10-2	1,551	6.86	133
					Average Concentration (mg/L)	**1,560**	**6.88**	**80**
		1:20 Soil:Water Ratio	25-Jan-22	0				
			1-Feb-22	7	SB-311:G311 1:20-1	1,511	6.88	88
					SB-311:G311 1:20-2	1,588	6.86	39
					Average Concentration (mg/L)	**1,550**	**6.87**	**64**

Notes:

mg/L - milligrams per liter
mV - millivolts
SU - Standard Units
ORP - oxidation/reduction potential

Table 4 - Batch Attenuation Testing Results, G313
Coffeen AP1

Groundwater Sample ID	Geologic Material Sample ID	Treatment	Date	Day	Replicate	Dissolved Boron	Dissolved Sulfate	pH	ORP
						mg/L	mg/L	SU	mV
G313	**--**	Groundwater Only Control	25-Jan-22	0	G313-1a	6.5	1,372	6.98	-60
					G313-2a	6.7	1,473	6.98	-21
					Average Concentration (mg/L)	**6.6**	**1,423**	**6.98**	**-41**
			1-Feb-22	7	G313-1	6.3	1,158	6.98	113
					G313-2	6.2	1,058	6.97	40
					Average Concentration (mg/L)	**6.2**	**1,108**	**6.98**	**77**
	G313 SB-306 Geologic Material	2:1 Soil:Water Ratio	25-Jan-22	0					
			1-Feb-22	7	SB-306:G313 2:1-1	4.5	884	6.95	46
					SB-306:G313 2:1-2	4.7	779	6.95	44
					Average Concentration (mg/L)	**4.6**	**831**	**6.95**	**45**
		1:1 Soil:Water Ratio	25-Jan-22	0					
			1-Feb-22	7	SB-306:G313 1:1-1	5.3	1,049	6.94	75
					SB-306:G313 1:1-2	5.3	976	6.93	44
					Average Concentration (mg/L)	**5.3**	**1,012**	**6.94**	**60**
		1:5 Soil:Water Ratio	25-Jan-22	0					
			1-Feb-22	7	SB-306:G313 1:5-1	5.8	243	6.95	80
					SB-306:G313 1:5-2	6.1	1,005	6.96	-5
					Average Concentration (mg/L)	**5.9**	**624**	**6.96**	**38**
		1:10 Soil:Water Ratio	25-Jan-22	0					
			1-Feb-22	7	SB-306:G313 1:10-1	6.1	958	6.96	203
					SB-306:G313 1:10-2	6.1	832	6.97	90
					Average Concentration (mg/L)	**6.1**	**895**	**6.97**	**147**
		1:20 Soil:Water Ratio	25-Jan-22	0					
			1-Feb-22	7	SB-306:G313 1:20-1	6.0	881	6.96	39
					SB-306:G313 1:20-2	6.0	1,409	6.94	81
					Average Concentration (mg/L)	**6.0**	**1,145**	**6.95**	**60**
	G313 SB-313 Geologic Material	2:1 Soil:Water Ratio	25-Jan-22	0					
			1-Feb-22	7	SB-313:G313 2:1-1	4.3	852	6.96	164
					SB-313:G313 2:1-2	4.6	900	6.93	143
					Average Concentration (mg/L)	**4.5**	**876**	**6.95**	**154**
		1:1 Soil:Water Ratio	25-Jan-22	0					
			1-Feb-22	7	SB-313:G313 1:1-1	4.9	482	6.99	78
					SB-313:G313 1:1-2	5.0	1,000	6.95	39
					Average Concentration (mg/L)	**4.9**	**741**	**6.97**	**59**
		1:5 Soil:Water Ratio	25-Jan-22	0					
			1-Feb-22	7	SB-313:G313 1:5-1	6.0	1,227	6.96	23
					SB-313:G313 1:5-2	6.2	837	6.97	25
					Average Concentration (mg/L)	**6.1**	**1,032**	**6.97**	**24**
		1:10 Soil:Water Ratio	25-Jan-22	0					
			1-Feb-22	7	SB-313:G313 1:10-1	6.0	1,459	6.97	63
					SB-313:G313 1:10-2	5.8	2,105	6.98	85
					Average Concentration (mg/L)	**5.9**	**1,782**	**6.98**	**74**
		1:20 Soil:Water Ratio	25-Jan-22	0					
			1-Feb-22	7	SB-313:G313 1:20-1	5.8	1,000	6.96	125
					SB-313:G313 1:20-2	6.0	1,043	6.97	47
					Average Concentration (mg/L)	**5.9**	**1,022**	**6.97**	**86**

Notes:

mg/L - milligrams per liter

mV - millivolts

SU - Standard Units

ORP - oxidation/reduction potential

Table 5 - Partition Coefficient Results, G311
Coffeen AP1

Analyte	Isotherm	Variable	Value
Sulfate	**Linear**	**R^2**	0.61
		K_D (L/kg)	10.11
	Langmuir	**R^2**	0.65
		q_m (mg/g)	-0.10
		K_L (L/kg)	-6.24E+02
	Freundlich	**R^2**	0.78
		1/n	10.27
		K_F (L/kg)	9.20E-12

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

Table 6 - Partition Coefficient Results, G313
Coffeen AP1

Materials	Analyte	Isotherm	Variable	Value
G313/SB-306	Boron	Linear	R^2	0.37
			K_D (L/kg)	6.13
		Langmuir	R^2	0.76
			q_m (mg/g)	0.00
			K_L (L/kg)	-1.51E+05
		Freundlich	R^2	0.64
			1/n	6.65
			K_F (L/kg)	6.50E-01
	Sulfate	Linear	R^2	0.05
			K_D (L/kg)	3.97
		Langmuir	R^2	0.01
			q_m (mg/g)	2.20
			K_L (L/kg)	1.19E+03
		Freundlich	R^2	0.00
			1/n	-0.06
			K_F (L/kg)	1.70E+03
G313/SB-313	Boron	Linear	R^2	0.24
			K_D (L/kg)	5.68
		Langmuir	R^2	0.50
			q_m (mg/g)	0.00
			K_L (L/kg)	-1.43E+05
		Freundlich	R^2	0.46
			1/n	5.25
			K_F (L/kg)	2.03E+00
	Sulfate	Linear	R^2	0.21
			K_D (L/kg)	-6.50
		Langmuir	R^2	0.51
			q_m (mg/g)	-0.66
			K_L (L/kg)	-6.91E+02
		Freundlich	R^2	--
			1/n	--
			K_F (L/kg)	--

Notes:

The Freundlich isotherm was not calculated for G313/SB-313 because the data were not conducive to log transformation

K_D - linear partition coefficient

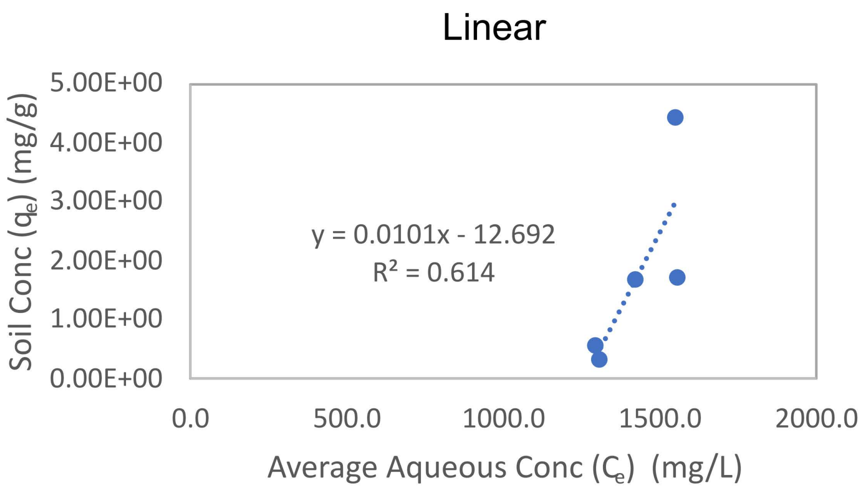
K_L - Langmuir partition coefficient

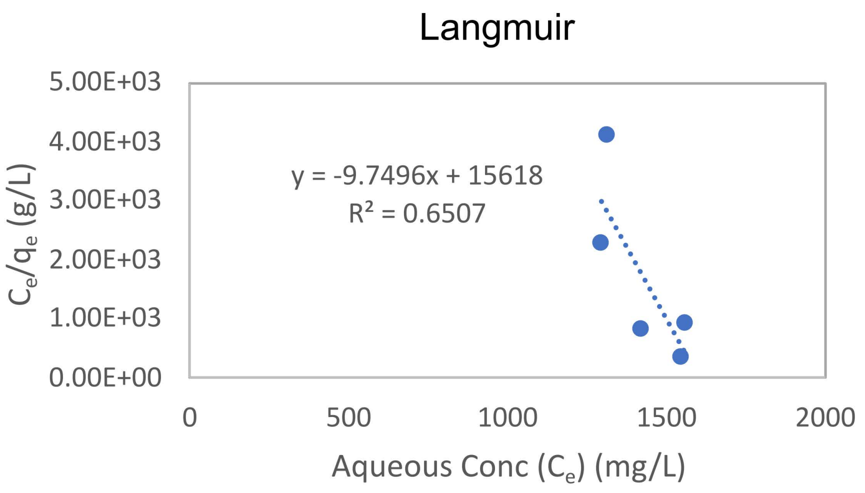
K_F - Freundlich partition coefficient

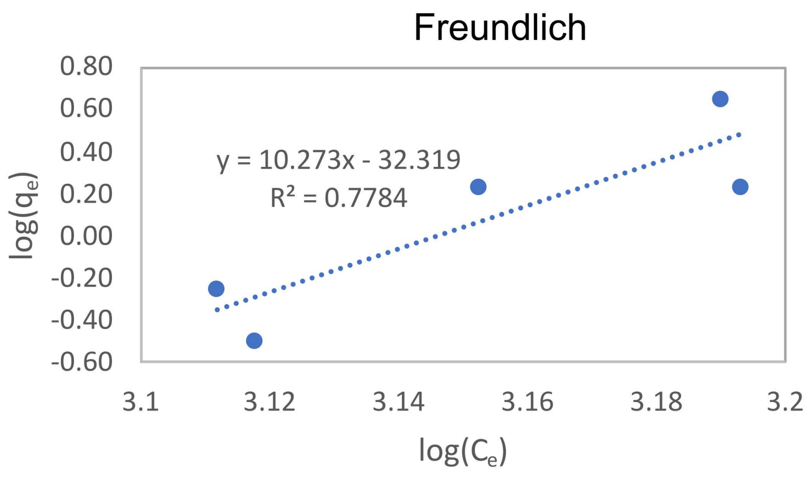
q_m - inverse of the slope of the linearized Langmuir isotherm

n - non-linearity constant of the Freundlich isotherm

APPENDIX A
BATCH TESTING ISOTHERM PLOTS


Linear


Langmuir


Freundlich

Notes:

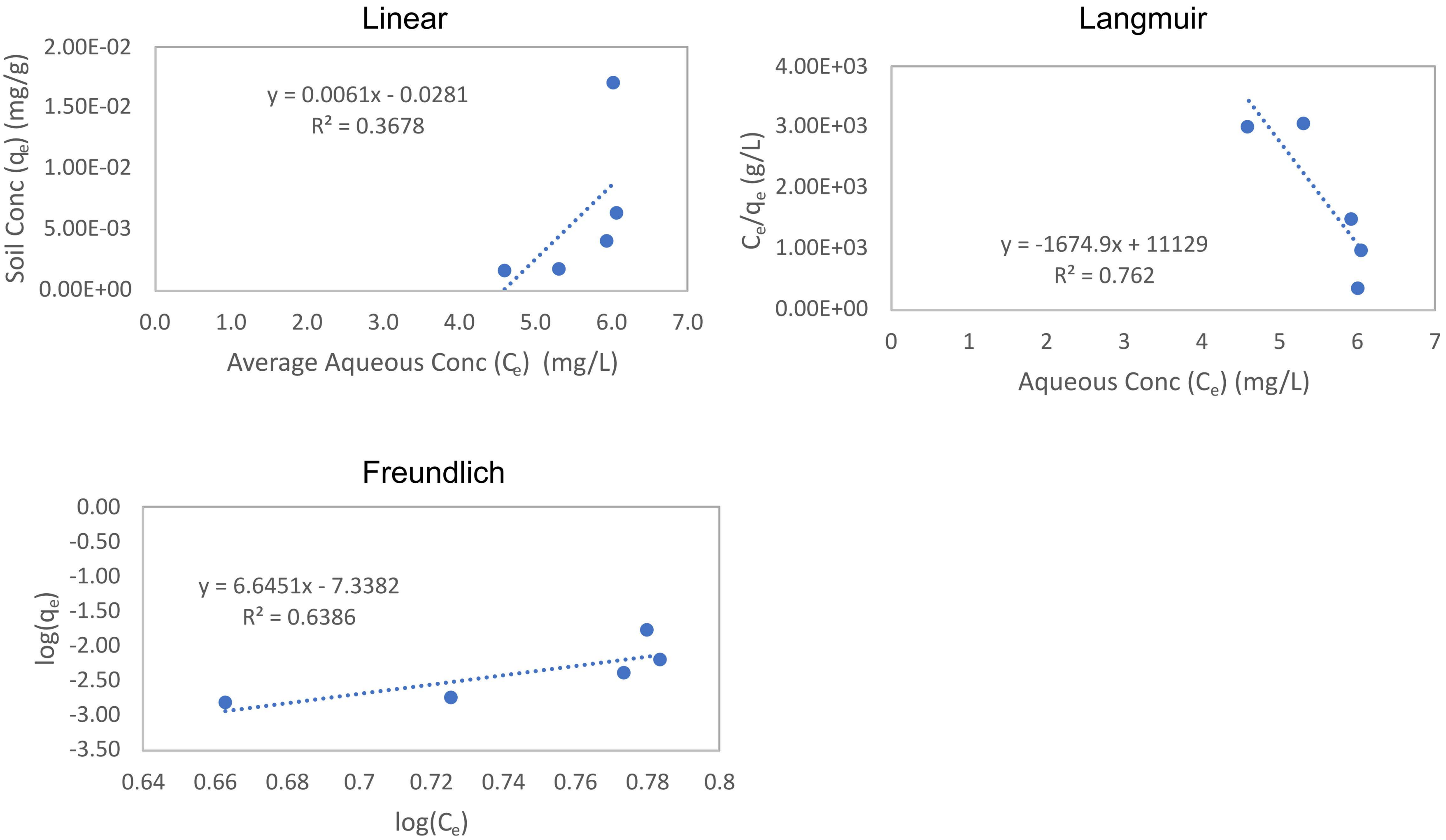
q_e - mass of constituent adsorbed to the solid phase
C_e - remaining aqueous constituent concentration
mg/L - milligrams per liter
mg/g - milligrams per gram
g/L - grams per liter

G311 Sulfate Partitioning Coefficients
Coffeen Power Plant AP-1
Coffeen, Illinois

Geosyntec
consultants

Columbus, OH
May 2022

Figure
1


Linear

Langmuir

Freundlich

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

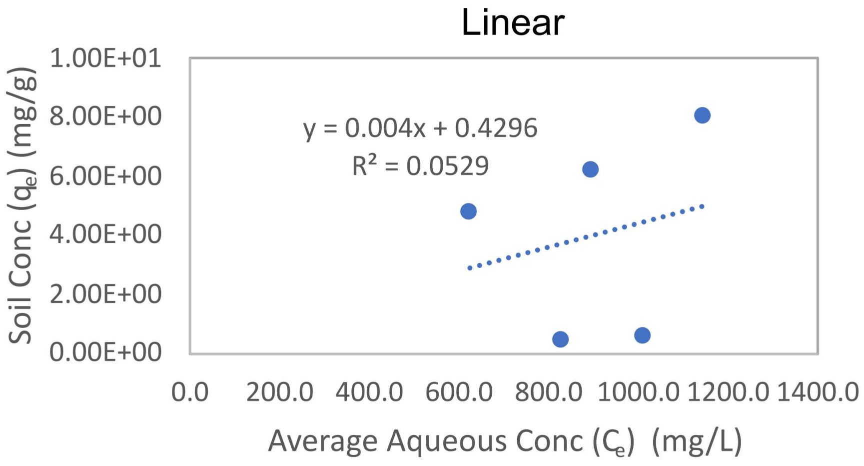
G313/SB-306 Boron Partitioning Coefficients
Coffeen Power Plant AP-1
Coffeen, Illinois

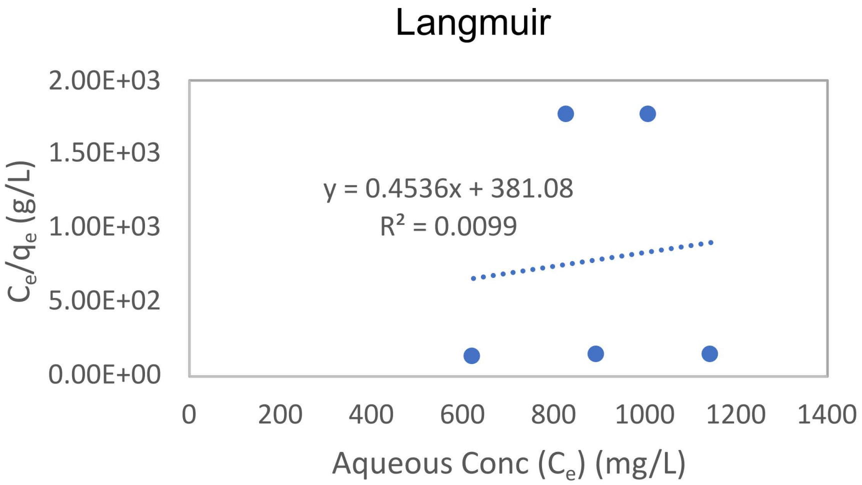
Geosyntec
consultants

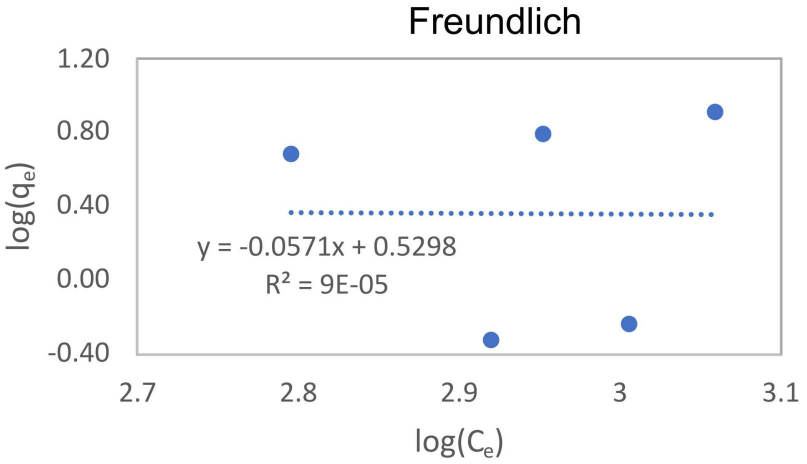
Columbus, OH

May 2022

Figure
2


Linear


Langmuir


Freundlich

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

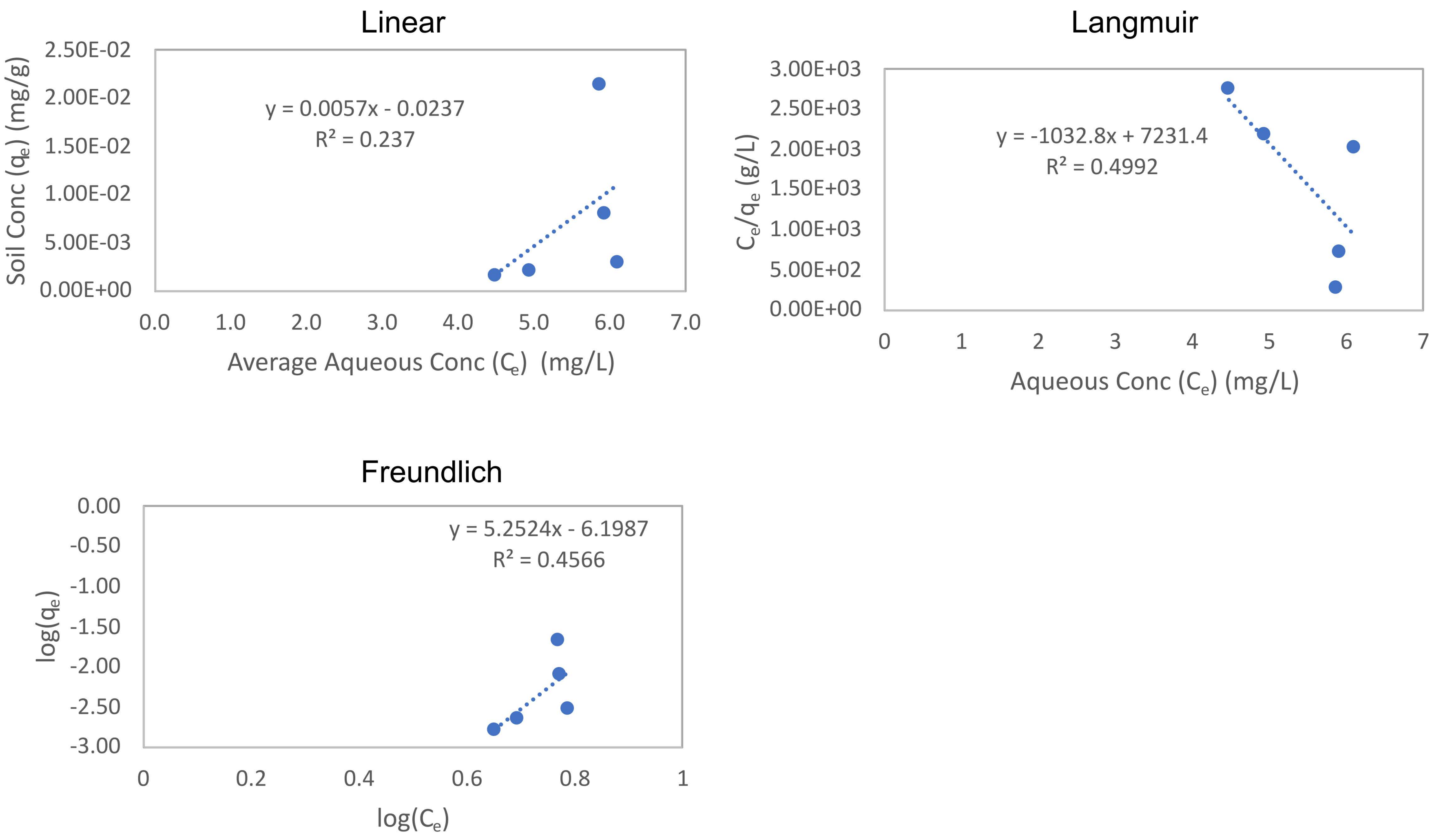
G313/SB-306 Sulfate Partitioning Coefficients
Coffeen Power Plant AP-1
Coffeen, Illinois

Geosyntec
consultants

Columbus, OH

May 2022

Figure
3



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

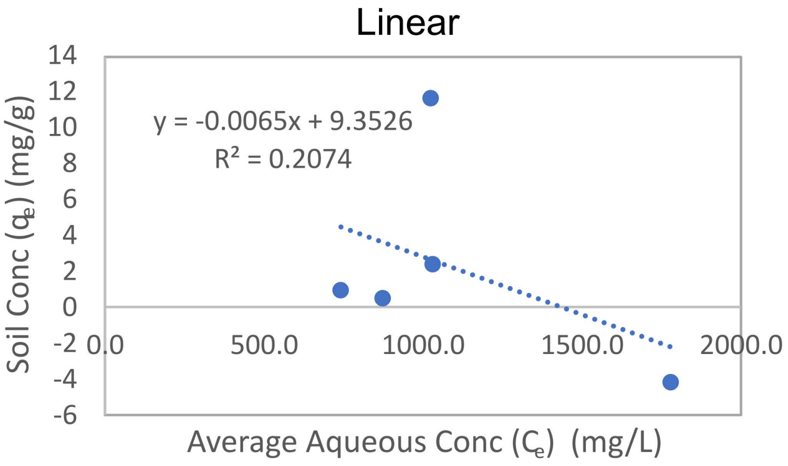
G313/SB-313 Boron Partitioning Coefficients
Coffeen Power Plant AP-1
Coffeen, Illinois

Geosyntec
consultants

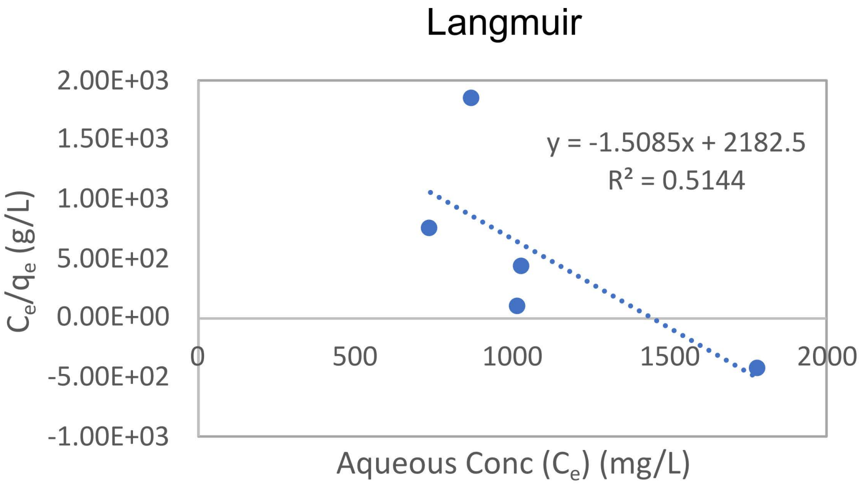
Columbus, OH

May 2022

Figure
4



Linear



Langmuir

Notes:

The Freundlich isotherm was not calculated because the data were not conducive to log transformation.

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

G313/SB-313 Sulfate Partitioning Coefficients
Coffeen Power Plant AP-1
Coffeen, Illinois

Geosyntec
consultants

Columbus, OH

May 2022

Figure
5

APPENDIX D
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: COF AP1 CIP **Simulated On:** 6/23/2022 13:38

Layer 1
Type 1 - Vertical Percolation Layer (Cover Soil)
SiCL - Silty Clay Loam
Material Texture Number 12

Thickness = 6 inches
Porosity = 0.471 vol/vol
Field Capacity = 0.342 vol/vol
Wilting Point = 0.21 vol/vol
Initial Soil Water Content = 0.2544 vol/vol
Effective Sat. Hyd. Conductivity = 4.20E-05 cm/sec

Layer 2
Type 1 - Vertical Percolation Layer
SiC - Silty Clay
Material Texture Number 14

Thickness = 18 inches
Porosity = 0.479 vol/vol
Field Capacity = 0.371 vol/vol
Wilting Point = 0.251 vol/vol
Initial Soil Water Content = 0.3554 vol/vol
Effective Sat. Hyd. Conductivity = 2.50E-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 = 0.5445 vol/vol
Effective Sat. Hyd. Conductivity = 3.00E-01 cm/sec
Slope = 5 %
Drainage Length = 350 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)
High Density Electric Plant Coal Bottom Ash
Material Texture Number 84

Thickness = 360 inches
Porosity = 0.578 vol/vol
Field Capacity = 0.076 vol/vol
Wilting Point = 0.025 vol/vol
Initial Soil Water Content = 0.0762 vol/vol
Effective Sat. Hyd. Conductivity = 8.80E-05 cm/sec

Layer 6

Type 2 - Lateral Drainage Layer
Loess Unit Silty Clay
Material Texture Number 43

Thickness = 60 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 = 3.85E-08 cm/sec
Slope = 0 %
Drainage Length = 0 ft

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 = 87.9
Fraction of Area Allowing Runoff = 100 %
Area projected on a horizontal plane = 10.37 acres
Evaporative Zone Depth = 18 inches
Initial Water in Evaporative Zone = 5.654 inches
Upper Limit of Evaporative Storage = 8.574 inches

Lower Limit of Evaporative Storage	=	4.272	inches
Initial Snow Water	=	0.088108	inches
Initial Water in Layer Materials	=	57.664	inches
Total Initial Water	=	57.752	inches
Total Subsurface Inflow	=	0	inches/year

Note: SCS Runoff Curve Number was calculated by HELP.

Evapotranspiration and Weather Data

Station Latitude	=	39.06	Degrees
Maximum Leaf Area Index	=	4.5	
Start of Growing Season (Julian Date)	=	97	days
End of Growing Season (Julian Date)	=	302	days
Average Wind Speed	=	8	mph
Average 1st Quarter Relative Humidity	=	72	%
Average 2nd Quarter Relative Humidity	=	64	%
Average 3rd Quarter Relative Humidity	=	71	%
Average 4th Quarter Relative Humidity	=	72	%

Note: Evapotranspiration data was obtained for Coffeen, Illinois

Normal Mean Monthly Precipitation (inches)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
2.353618	2.511085	2.81508	3.241374	3.956664	4.312863
4.375035	2.656228	3.284204	3.675466	3.677412	3.106835

Note: Precipitation was simulated based on HELP V4 weather simulation for:
Lat/Long: 39.06/-89.39

Normal Mean Monthly Temperature (Degrees Fahrenheit)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
37.3	37.1	50	61.9	69.7	80.6
84.2	81	72.2	62.4	48.1	38

Note: Temperature was simulated based on HELP V4 weather simulation for:
Lat/Long: 39.06/-89.39
Solar radiation was simulated based on HELP V4 weather simulation for:
Lat/Long: 39.06/-89.39

Average Annual Totals Summary

Title: COF AP1 CIP
Simulated on: 6/23/2022 13:40

	Average Annual Totals for Years 1 - 30*			
	(inches)	[std dev]	(cubic feet)	(percent)
Precipitation	39.97	[4.83]	1,504,439.0	100.00
Runoff	5.219	[2.734]	196,475.1	13.06
Evapotranspiration	30.032	[3.266]	1,130,503.8	75.14
Subprofile1				
Lateral drainage collected from Layer 3	4.5549	[1.2488]	171,460.7	11.40
Percolation/leakage through Layer 4	0.195970	[0.082153]	7,376.9	0.49
Average Head on Top of Layer 4	4.4608	[1.8873]	---	---
Subprofile2				
Percolation/leakage through Layer 6	0.000911	[0.001146]	34.3	0.00
Water storage				
Change in water storage	0.1585	[1.4776]	5,965.1	0.40

* 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:        COF AP1 CBR E 1ft                        Simulated On:     18/04/2022 12:42
----------------------------------------------------------------------------------------------------------------

                                          Layer 1
                        Type 1 - Vertical Percolation Layer (Cover Soil)
                                       SiC - Silty Clay
                                  Material Texture Number 14
       Thickness                                          =           12 inches
       Porosity                                           =        0.479 vol/vol
       Field Capacity                                     =        0.371 vol/vol
       Wilting Point                                      =        0.251 vol/vol
       Initial Soil Water Content                         =       0.2751 vol/vol
       Effective Sat. Hyd. Conductivity                   =     2.50E-05 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                            =         88.6
       Fraction of Area Allowing Runoff                   =          100 %
       Area projected on a horizontal plane               =        14.28 acres
       Evaporative Zone Depth                             =           12 inches
       Initial Water in Evaporative Zone                  =        3.302 inches
       Upper Limit of Evaporative Storage                 =        5.748 inches
       Lower Limit of Evaporative Storage                 =        3.012 inches
       Initial Snow Water                                 =     0.088108 inches
       Initial Water in Layer Materials                   =        3.302 inches
       Total Initial Water                                =         3.39 inches
       Total Subsurface Inflow                            =            0 inches/year
       --------------------------------------------------------
       Note:         SCS Runoff Curve Number was calculated by HELP.

                            Evapotranspiration and Weather Data

       Station Latitude                                   =        39.06 Degrees
       Maximum Leaf Area Index                            =          4.5
       Start of Growing Season (Julian Date)              =           97 days
       End of Growing Season (Julian Date)                =          302 days
```

Average Wind Speed = 8 mph
Average 1st Quarter Relative Humidity = 72 %
Average 2nd Quarter Relative Humidity = 64 %
Average 3rd Quarter Relative Humidity = 71 %
Average 4th Quarter Relative Humidity = 72 %

Note: Evapotranspiration data was obtained for Coffeen, Illinois

Normal Mean Monthly Precipitation (inches)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
2.353618	2.511085	2.81508	3.241374	3.956664	4.312863
4.375035	2.656228	3.284204	3.675466	3.677412	3.106835

Note: Precipitation was simulated based on HELP V4 weather simulation for:
Lat/Long: 39.06/-89.39

Normal Mean Monthly Temperature (Degrees Fahrenheit)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
37.3	37.1	50	61.9	69.7	80.6
84.2	81	72.2	62.4	48.1	38

Note: Temperature was simulated based on HELP V4 weather simulation for:
Lat/Long: 39.06/-89.39
Solar radiation was simulated based on HELP V4 weather simulation for:
Lat/Long: 39.06/-89.39

Average Annual Totals Summary

Title: COF AP1 CBR E 1ft
Simulated on: 18/04/2022 12:43

	Average Annual Totals for Years 1 - 30*			
	(inches)	[std dev]	(cubic feet)	(percent)
Precipitation	39.97	[4.83]	2,071,686.5	100.00
Runoff	4.098	[2.566]	212,424.0	10.25
Evapotranspiration	28.031	[2.833]	1,453,011.5	70.14
Subprofile1				
Percolation/leakage through Layer 1	7.845754	[2.291827]	406,695.7	19.63
Water storage				
Change in water storage	-0.0086	[0.9272]	-444.6	-0.02

* 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: COF AP1 CBR W 3ft Simulated On: 18/04/2022 17:19

Layer 1
Type 1 - Vertical Percolation Layer (Cover Soil)
SiC - Silty Clay
Material Texture Number 14

Thickness = 36 inches
Porosity = 0.479 vol/vol
Field Capacity = 0.371 vol/vol
Wilting Point = 0.251 vol/vol
Initial Soil Water Content = 0.3502 vol/vol
Effective Sat. Hyd. Conductivity = 2.50E-05 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 = 89.2
Fraction of Area Allowing Runoff = 100 %
Area projected on a horizontal plane = 10.38 acres
Evaporative Zone Depth = 18 inches
Initial Water in Evaporative Zone = 5.826 inches
Upper Limit of Evaporative Storage = 8.622 inches
Lower Limit of Evaporative Storage = 4.518 inches
Initial Snow Water = 0.088108 inches
Initial Water in Layer Materials = 12.606 inches
Total Initial Water = 12.694 inches
Total Subsurface Inflow = 0 inches/year

Note: SCS Runoff Curve Number was calculated by HELP.

Evapotranspiration and Weather Data

Station Latitude = 39.06 Degrees
Maximum Leaf Area Index = 4.5
Start of Growing Season (Julian Date) = 97 days
End of Growing Season (Julian Date) = 302 days

Average Wind Speed	=	8 mph
Average 1st Quarter Relative Humidity	=	72 %
Average 2nd Quarter Relative Humidity	=	64 %
Average 3rd Quarter Relative Humidity	=	71 %
Average 4th Quarter Relative Humidity	=	72 %

Note: Evapotranspiration data was obtained for Coffeen, Illinois

Normal Mean Monthly Precipitation (inches)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
2.353618	2.511085	2.81508	3.241374	3.956664	4.312863
4.375035	2.656228	3.284204	3.675466	3.677412	3.106835

Note: Precipitation was simulated based on HELP V4 weather simulation for:
Lat/Long: 39.06/-89.39

Normal Mean Monthly Temperature (Degrees Fahrenheit)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
37.3	37.1	50	61.9	69.7	80.6
84.2	81	72.2	62.4	48.1	38

Note: Temperature was simulated based on HELP V4 weather simulation for:
Lat/Long: 39.06/-89.39
Solar radiation was simulated based on HELP V4 weather simulation for:
Lat/Long: 39.06/-89.39

Average Annual Totals Summary

Title: COF AP1 CBR W 3ft
Simulated on: 18/04/2022 17:20

	Average Annual Totals for Years 1 - 30*			
	(inches)	[std dev]	(cubic feet)	(percent)
Precipitation	39.97	[4.83]	1,505,889.7	100.00
Runoff	4.277	[2.541]	161,157.5	10.70
Evapotranspiration	29.447	[3.212]	1,109,534.9	73.68
Subprofile1				
Percolation/leakage through Layer 1	6.278209	[2.388206]	236,559.2	15.71
Water storage				
Change in water storage	-0.0361	[1.2459]	-1,361.9	-0.09

* 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: COF AP1 CIP Default **Simulated On:** 6/21/2022 16:04

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	=	0.154	vol/vol
Effective Sat. Hyd. Conductivity	=	1.20E-04	cm/sec

Layer 2

Type 1 - Vertical Percolation Layer
SiC - Silty Clay
Material Texture Number 14

Thickness	=	30	inches
Porosity	=	0.479	vol/vol
Field Capacity	=	0.371	vol/vol
Wilting Point	=	0.251	vol/vol
Initial Soil Water Content	=	0.3698	vol/vol
Effective Sat. Hyd. Conductivity	=	2.50E-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	=	0.6794	vol/vol
Effective Sat. Hyd. Conductivity	=	3.00E-01	cm/sec
Slope	=	5	%
Drainage Length	=	350	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)
High Density Electric Plant Coal Bottom Ash
Material Texture Number 84

Thickness = 360 inches
Porosity = 0.578 vol/vol
Field Capacity = 0.076 vol/vol
Wilting Point = 0.025 vol/vol
Initial Soil Water Content = 0.0762 vol/vol
Effective Sat. Hyd. Conductivity = 8.80E-05 cm/sec

Layer 6

Type 2 - Lateral Drainage Layer
Loess Unit Silty Clay
Material Texture Number 43

Thickness = 60 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 = 3.85E-08 cm/sec
Slope = 0 %
Drainage Length = 0 ft

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 = 85.9
Fraction of Area Allowing Runoff = 100 %
Area projected on a horizontal plane = 10.37 acres
Evaporative Zone Depth = 18 inches
Initial Water in Evaporative Zone = 5.059 inches
Upper Limit of Evaporative Storage = 8.136 inches

Lower Limit of Evaporative Storage = 3.828 inches
Initial Snow Water = 0.088108 inches
Initial Water in Layer Materials = 61.794 inches
Total Initial Water = 61.882 inches
Total Subsurface Inflow = 0 inches/year

Note: SCS Runoff Curve Number was calculated by HELP.

Evapotranspiration and Weather Data

Station Latitude = 39.06 Degrees
Maximum Leaf Area Index = 4.5
Start of Growing Season (Julian Date) = 97 days
End of Growing Season (Julian Date) = 302 days
Average Wind Speed = 8 mph
Average 1st Quarter Relative Humidity = 72 %
Average 2nd Quarter Relative Humidity = 64 %
Average 3rd Quarter Relative Humidity = 71 %
Average 4th Quarter Relative Humidity = 72 %

Note: Evapotranspiration data was obtained for Coffeen, Illinois

Normal Mean Monthly Precipitation (inches)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
2.353618	2.511085	2.81508	3.241374	3.956664	4.312863
4.375035	2.656228	3.284204	3.675466	3.677412	3.106835

Note: Precipitation was simulated based on HELP V4 weather simulation for:
Lat/Long: 39.06/-89.39

Normal Mean Monthly Temperature (Degrees Fahrenheit)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
37.3	37.1	50	61.9	69.7	80.6
84.2	81	72.2	62.4	48.1	38

Note: Temperature was simulated based on HELP V4 weather simulation for:
Lat/Long: 39.06/-89.39
Solar radiation was simulated based on HELP V4 weather simulation for:
Lat/Long: 39.06/-89.39

Average Annual Totals Summary

Title: COF AP1 CIP
Simulated on: 6/21/2022 16:05

	Average Annual Totals for Years 1 - 30*			
	(inches)	[std dev]	(cubic feet)	(percent)
Precipitation	39.97	[4.83]	1,504,439.0	100.00
Runoff	4.089	[2.542]	153,905.0	10.23
Evapotranspiration	30.058	[3.318]	1,131,459.1	75.21
Subprofile1				
Lateral drainage collected from Layer 3	5.5133	[1.5623]	207,537.5	13.80
Percolation/leakage through Layer 4	0.344465	[0.16843]	12,966.7	0.86
Average Head on Top of Layer 4	7.8378	[3.8306]	---	---
Subprofile2				
Percolation/leakage through Layer 6	0.049311	[0.128508]	1,856.2	0.12
Water storage				
Change in water storage	0.2572	[1.781]	9,681.1	0.64

* Note: Average inches are converted to volume based on the user-specified area.

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                    HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE
                          HELP MODEL VERSION 4.0 BETA (2018)
       DEVELOPED BY USEPA NATIONAL RISK MANAGEMENT RESEARCH LABORATORY
-----------------------------------------------------------------------------------------------------------------
       Title:        COF AP1 Default Earth                    Simulated On:     27/06/2022 18:16
-----------------------------------------------------------------------------------------------------------------

                                        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                   =            0.1542 vol/vol
       Effective Sat. Hyd. Conductivity             =          1.20E-04 cm/sec

                                        Layer 2
                          Type 1 - Vertical Percolation Layer
                                    SiC - Silty Clay
                              Material Texture Number 14
       Thickness                                    =                30 inches
       Porosity                                     =             0.479 vol/vol
       Field Capacity                               =             0.371 vol/vol
       Wilting Point                                =             0.251 vol/vol
       Initial Soil Water Content                   =             0.436 vol/vol
       Effective Sat. Hyd. Conductivity             =          2.50E-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)
                       High Density Electric Plant Coal Bottom Ash
```

Material Texture Number 84

Thickness = 360 inches
Porosity = 0.578 vol/vol
Field Capacity = 0.076 vol/vol
Wilting Point = 0.025 vol/vol
Initial Soil Water Content = 0.0805 vol/vol
Effective Sat. Hyd. Conductivity = 8.80E-05 cm/sec

Layer 5
Type 2 - Lateral Drainage Layer
Loess Unit Silty Clay

Material Texture Number 43

Thickness = 60 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 = 3.85E-08 cm/sec
Slope = 0 %
Drainage Length = 0 ft

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 = 85.9
Fraction of Area Allowing Runoff = 100 %
Area projected on a horizontal plane = 10.37 acres
Evaporative Zone Depth = 18 inches
Initial Water in Evaporative Zone = 5.382 inches
Upper Limit of Evaporative Storage = 8.136 inches
Lower Limit of Evaporative Storage = 3.828 inches
Initial Snow Water = 0.088108 inches
Initial Water in Layer Materials = 80.625 inches
Total Initial Water = 80.713 inches
Total Subsurface Inflow = 0 inches/year

Note: SCS Runoff Curve Number was calculated by HELP.

Evapotranspiration and Weather Data

Station Latitude = 39.06 Degrees
Maximum Leaf Area Index = 4.5

Start of Growing Season (Julian Date)	=	97	days
End of Growing Season (Julian Date)	=	302	days
Average Wind Speed	=	8	mph
Average 1st Quarter Relative Humidity	=	72	%
Average 2nd Quarter Relative Humidity	=	64	%
Average 3rd Quarter Relative Humidity	=	71	%
Average 4th Quarter Relative Humidity	=	72	%

Note: Evapotranspiration data was obtained for Coffeen, Illinois

Normal Mean Monthly Precipitation (inches)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
2.353618	2.511085	2.81508	3.241374	3.956664	4.312863
4.375035	2.656228	3.284204	3.675466	3.677412	3.106835

Note: Precipitation was simulated based on HELP V4 weather simulation for:
Lat/Long: 39.06/-89.39

Normal Mean Monthly Temperature (Degrees Fahrenheit)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
37.3	37.1	50	61.9	69.7	80.6
84.2	81	72.2	62.4	48.1	38

Note: Temperature was simulated based on HELP V4 weather simulation for:
Lat/Long: 39.06/-89.39
Solar radiation was simulated based on HELP V4 weather simulation for:
Lat/Long: 39.06/-89.39

Average Annual Totals Summary

Title: COF AP1 Default Earth
Simulated on: 27/06/2022 18:17

	Average Annual Totals for Years 1 - 30*			
	(inches)	[std dev]	(cubic feet)	(percent)
Precipitation	39.97	[4.83]	1,504,439.0	100.00
Runoff	6.862	[3.483]	258,316.2	17.17
Evapotranspiration	31.176	[3.425]	1,173,551.9	78.01
Subprofile1				
Percolation/leakage through Layer 3	1.992946	[0.073666]	75,020.7	4.99
Average Head on Top of Layer 3	21.7496	[2.1124]	---	---
Subprofile2				
Percolation/leakage through Layer 5	1.698973	[0.713508]	63,954.6	4.25
Water storage				
Change in water storage	0.2289	[1.8082]	8,616.3	0.57

* Note: Average inches are converted to volume based on the user-specified area.

APPENDIX E
FLUX EVALUATION DATA

Appendix E. Flux Evaluation Data

GROUNDWATER MODELING REPORT
COFFEEN POWER PLANT
ASH POND NO. 1
COFFEEN, ILLINOIS

Calibration Model

Model	Model Period (years)	HSU	Total Flux In[1] (ft^3/d)	Total Flux In (gpm)
Calibration Model	42	Fill Unit (CCR)	2888.39	15.00

Model	Model Period (years)	HSU	Total Flux Out[1] (ft^3/d)	Total Flux Out (gpm)
Calibration Model	42	Fill Unit (CCR)	-2975.75	-15.46

Scenario 1: CIP (CCR removal from the northwest areas of the Ash Pond, consolidation to the northeast, central and southern areas of the Ash Pond, and construction of a cover system over the remaining CCR)

Prediction Model	Construction Period (years)	HSU	Total Flux In[1] (ft^3/d)	Total Flux In (gpm)	Reduction in Flux In Post Closure[2] (Percentage, %)
CIP	56	Fill Unit (CCR)	2.20	0.01	99.92%

Prediction Model	Construction Period (years)	HSU	Total Flux Out[1] (ft^3/d)	Total Flux Out (gpm)	Reduction in Flux Out Post Closure[2] (Percentage, %)
CIP	56	Fill Unit (CCR)	-2.21	-0.01	99.93%

[O: SLN 6/25/22; C: BGH 6/29/22]

Notes:

1. Total flux in and out source data provided in flux calculation data files included in Appendix B.
2. Reduction in flux as compared to flux at the end of calibration model (model period of 42 years).

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

ILLINOIS POWER GENERATING COMPANY - COFFEEN POWER PLANT - ASH POND 2
CORRECTIVE ACTION ALTERNATIVES ANALYSIS SUPPORTING INFORMATION REPORT (CAAA-SIR)
ALTERNATIVE 2 - UPGRADIENT BARRIER WALL AND GROUNDWATER EXTRACTION TRENCH[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	1,728	0	Assumed labor and equipment hours based on Ramboll project experience.
	PRE-CONSTRUCTION ESTIMATED SUBTOTAL					**1,728**	**0**	
ITEM NO.	**SITE PREPARATION**	**Units**	**Quantity**	**Crew**	**Daily Output**	**Labor Hours**	**Equipment Hours**	**Notes**
2	Staging Area & Temporary Roads Preparation	-	-	-	-	473	146	Assumes some work general preparation of temporary access roads along the trench alignment will be needed specific to extraction trench construction.
	Subsurface Stabilization Nonwoven Geotextile	SY	5,600	2 Clab	2500	36	0	313219161550: Geosynthetic soil stabilization, geotextile fabric, non-woven, 120 lb tensile strength includes scarifying and compaction. Assumes 0.5 acre staging area and approximately 2,500 ft of temporary access road.
	Construct Staging Area & Temporary Roads	SY	5,600	B14	615	437	146	015523500100: Temporary, roads, gravel fill, 8" gravel depth, excluding surfacing. Assumes 0.5 acre staging area and approximately 2,500 ft of temporary access road.
3	Construction Soil Erosion & Sediment Controls	-	-	-	-	241	80	Assumes soil erosion and sediment controls will be implemented only during the groundwater extraction trench construction.
	Silt Fence	LF	3,600	B62	650	133	44	312514161000: Synthetic erosion control, silt fence, install and remove, 3' high. Assumes silt fence is installed down both sides of the extraction trench alignment (3,600 ft total).
	Sediment Log, Filter Sock	LF	4,500	A2	1000	108	36	312514160705: Sediment Log, Filter Sock, 9". Assume sediment log is needed along alignment of extraction trench (3,600 LF total) and settling pond perimeter (~900 LF).
4	Temporary Electrical Installation	EA	1	R1B	-	144	0	Electrical installation based on Ramboll experience to install two power drops for low-voltage (120V) power for the pneumatic extraction pumps along the extraction trench, and for the pneumatic transfer pump at the settling pond for discharge of water to outfall.
5	Work Pad Construction	-	-	-	-	1,124	409	Working surface 45 ft wide needed for trench and barrier wall installation. Existing roads along northern and western perimeter of AP2 will be saw-cut as needed for trench and barrier wall installation.
	Remove Asphalt Roads Along Perimeter	SY	10,833	B38	690	628	251	024113175010: Demolish, remove pavement and curb, remove bituminous pavement, up to 3" thick, excludes hauling and disposal. Assumes saw cutting and removal asphalt roads along the entire perimeter of AP2 for trench and wall installation (30-ft wide road).
	Surface Grading	MSF	50	B11L	30	27	13	312216103600: Fine grading, work pad area. Assumes grading along banks of AP2 between the bottom of the berm and the road to complete the needed working surface.
	Subsurface Stabilization Nonwoven Geotextile	SY	5,555	2 Clab	2500	36	0	313219161550: Geosynthetic soil stabilization, geotextile fabric, non-woven, 120 lb tensile strength includes scarifying and compaction. Assume stabilization needed for 15-ft wide swath between berm and road.
	Install Crushed Gravel Work Pad (8" Thick)	SY	5,555	B14	615	434	145	015523500100: Temporary, roads, gravel fill, 8" gravel depth, excluding surfacing. Assume stabilization needed for 15-ft wide swath between berm and road.
6	Geotechnical Monitoring	LS	-	GM	-	600	0	Assumes installation of inclinometers, survey prisms, and settlement monitoring devices. Assumes a 4-person crew installs the monitoring system over a period of 3 weeks. Based on Ramboll experience.
	SITE PREPARATION ESTIMATED SUBTOTAL					**2,580**	**640**	
ITEM NO.	**BARRIER WALL & GROUNDWATER EXTRACTION TRENCH CONSTRUCTION**	**Units**	**Quantity**	**Crew**	**Daily Output**	**Labor Hours**	**Equipment Hours**	**Notes**
7	Materials Import	-	-	-	-	134	106	Includes materials associated with barrier wall and extraction trench and labor costs associated with hauling. Purchase of sand/granular material for backfilling the extraction trench.
	Sand/Granular Backfill	CY	725	B13D	376	31	15	Sand/granular backfill for extraction trenches. Assumes trench is 3,250 ft long, 8 ft deep, and 2.5 ft wide and ~30% of trench volume needs to be backfilled with granular material. Based on Ramboll and Specialty Contractor experience.
	Clay Trench Cap	CY	150	B13D	100	24	12	Clay material for extraction trench cap. Assumes trench is 3,250 ft long, 2.5 ft wide, and cap is approximately 0.5 feet thick. Based on Ramboll experience.
	Haul material to Site	LCY	875	B34C	99	71	71	312323203104: Cycle hauling (wait, load, travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 15 min load/wait/unload, 16.5 C.Y. truck, cycle 50 miles, 45 mph, excludes loading equipment.
	Haul material to Trench Locations	CY	875	B34G	850	8	8	312323206170: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld./uld., 15 MPH, cycle 1 mile. Daily output extrapolated down to 10 min wait. Assumes onsite stockpile locations average of 0.25 mile from trench dumping location.
8	Installation of Groundwater Extraction Trench	-	-	-	-	544	544	Assumes mobilization and demobilization, trench excavation, and construction of clay trench cap.
	Mobilization, Assembly, & Demobilization of Specialty Contractor	LS	1	-	-	-	-	Mobilization, assembly, and demobilization from One-Pass technology specialty contractor.
	Trench Excavation	LF	3,250	OP	300	542	542	OP crew determined from crew information provided by specialty contractor. Assumes total trench length 3,250 ft with an approximate average depth of 8 ft and 2 ft wide.
	Spread Lifts for Clay Trench Cap	CY - as excavated	120	B10B	1000	1	1	312323170020: Spread dumped material, no compaction, by dozer. Daily output edited to match excavation based on experience.
	Compaction of Clay Trench Cap	CY - in place	120	B10F	5200	1	1	312323235060: Compaction; Riding, vibrating roller, 6" lifts, 2 passes. RS Means Crew is B10Y; altered to B10F based on experience.
9	Installation of Barrier Wall	-	-	-	-	1,083	1,083	Assumes same mobilization and specialty contractor as extraction trench construction. Barrier wall to be installed immediately following trench installation.
	Installation of Barrier Wall	LF	3,250	OP	150	1,083	1,083	Assumes barrier wall construction and materials (bentonite and standard Portland cement) provided by specialty contractor. OP crew determined from crew information provided by specialty contractor. Assumes total wall length is 3,250 ft with approximate average depth of 7 ft and 2.5 ft wide.
	Barrier Wall Mix Design	LS	1	-	-	0	0	Specialty contractor for creating mix design to achieve specifications. Mix design will include 1 soil bore to obtain a representative soil sample.
10	Groundwater Extraction Trench Mechanical Installation	-	-	-	-	1,174	403	Includes installation of sumps, equalization tank, transfer pumps and controllers, and associated excavation and backfill.
	Install Sumps	EA	5	Q1	2	44	0	Sump installation from specialty contractor. 8-20" diameter Sch. 40-304 Stainless Steel. Daily output adjusted for scale.
	Install Equalization Tank	EA	2	B6	1	180	60	Installation of equalization tank at each trench and associated site preparation and instrumentation. Assumes 2 days each for installation.
	Install Transfer Pumps and Controllers	EA	2	R30	1	52	0	Installation of transfer pump and pump controller at each extraction trench to convey water from settling pond to discharge outfall based on Ramboll project experience. Assumes inclusion of housing structure and 2 days for installation.
	Excavate Utility Trench for Lines to Compressors and Extraction Pumps	LF	500	B54	860	5	5	312316142750: Utility trench excavating, chain trencher, 40 HP operator riding, 12" wide trench and backfill, 18" deep. Trench installed from power drop/compressor shed to extraction trench to supply compressed air and power to sump pits. Assumes 500 ft distance from compressor shed to trench.
	Install Mechanical Elements and Piping	EA	1	R30	-	260	0	Assumes furnishing all mechanical elements (air compressors, pneumatic extraction pumps, transfer pumps) and associated HDPE housing piping for distribution of power and housing of mechanical elements throughout the extraction trench system. Assumes approximately 10 days of work.
	Excavate Utility Trench for Conveyance to Settling Pond	LF	2,500	B10R	100	300	200	312316142750: Utility trench excavating, chain trencher, 40 HP operator riding, 12" wide trench and backfill, 18" deep. Trench installed from groundwater extraction trench to convey extracted water to the settling pond.
	Install 8" HDPE Conveyance Pipe to Settling Pond	LF	2,500	B22A	320	313	125	331413350300: Water supply distribution piping, piping HDPE, butt fusion joints, 40' lengths, 8" diameter, SDR 21. Includes labor, materials, and machine for installation and welding of HDPE pipe for conveying extracted water from trench to settling pond.
	Backfill with Granular Trench Backfill	LCY	166	B10R	100	20	13	312316133060: Backfill trench, F.E. loader, wheel mtd., 1 C.Y. bucket, 200' haul. Backfill with granular trench backfill. Quantity based on trench dimensions 12" wide, 18" deep, 3,000 ft (500 ft and 2,500 ft) long.
11	Construction of Compressor Shed	-	-	-	-	180	60	Based on Ramboll experience for construction of housing unit for air compressor shed.
	Construct Compressor Shed	EA	1	B6	-	180	60	Assumes pre-fabricated air compressor shelter, installed primarily by hand with light equipment assistance. Hours are based on Ramboll experience
12	Installation of Settling Pond	-	-	-	-	226	89	Quantity based on 1-acre pond, 2 feet deep. Assume all excavated material is reused for berm construction.
	Excavation and Loading of Settling Pond Material	BCY	3,300	B12D	2080	25	13	312316420300: Excavating, bulk bank measure, hydraulic, crawler mtd., 3 C.Y. cap (300 CY/hr). Assumes loading of material onto trucks.
	Hauling and Placement of Settling Pond Material	LCY	3,300	B34G	3287	8	8	312323206130: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld./uld., 15 MPH, cycle 2,000 ft. Daily output extrapolated down to 600 ft cycle.
	Spreading/Drying Material in Berm	CY	3,300	B10B	1000	40	26	312323170020: Spread dumped material, no compaction, by dozer. Daily output edited to match excavation based on experience.
	Compaction of Material in Berm	BCY	3,300	B10F	2600	15	10	312323235060: Compaction; Riding, vibrating roller, 12" lifts, 2 passes. RS Means Crew is B10Y; altered to B10F based on experience.
	Fine Grading of Berm	MSF	36	B11L	30	19	10	312216103600: Fine grading, tops of lagoon banks for compaction. Assumes 10 ft-wide berm around perimeter of 1-acre settling pond.
	Subsurface Stabilization Nonwoven Geotextile	SY	5,000	2 Clab	2500	32	0	313219161550: Geosynthetic soil stabilization, geotextile fabric, non-woven, 120 lb tensile strength includes scarifying and compaction. Assumes 1 acre settling pond.
	Settling Pond Liner	SF	5,000	B63B	1850	86	22	310519531100: Reservoir liners, membrane lining, 40 mil, LLDPE.
13	Extracted Water Discharge Management	-	-	-	-	193	64	Based on approximate 1,000 ft distance from settling pond to discharge outfall.
	Install Transfer Pump and Controller	EA	1	R30	1	52	0	Installation of transfer pump and pump controller to convey water from settling pond to discharge outfall based on Ramboll project experience. Assumes inclusion of housing structure. Assume 2 days for installation.
	Excavate Utility Trench for Conveyance to Discharge	LF	1,000	B54	860	9	9	312316142750: Utility trench excavating, chain trencher, 40 HP operator riding, 12" wide trench and backfill, 18" deep. Trench installed from settling pond to convey settled water to outfall for discharge.
	Install 8" HDPE Conveyance Pipe to Discharge	LF	1,000	B22A	320	125	50	331413350300: Water supply distribution piping, piping HDPE, butt fusion joints, 40' lengths, 8" diameter, SDR 21. Includes labor, materials, and machine for installation and welding of HDPE pipe for conveying water from settling pond to discharge point.
	Backfill with Granular Trench Backfill	LCY	57	B10R	100	7	5	312316133060: Backfill trench, F.E. loader, wheel mtd., 1 C.Y. bucket, 200' haul. Backfill with granular trench backfill. Quantity based on trench dimensions 12" wide, 18" deep, 1,000 ft long.
14	Trench & Wall Spoils Management	-	-	-	-	24	18	Quantity based on average area of trench excavation 2.5 ft wide by 8 ft deep over 3,250 ft extraction trench alignment. Spoils assumed to be disposed of in on-site landfill.
	Loading	CY - as excavated	725	B14B	5000	2	1	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). Spoils volume is 30% of total trench volume per Contractor experience.
	Hauling and Placement to On-site Landfill	CY - as excavated	725	B34G	850	7	7	312323206170: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld./uld., 15 MPH, cycle 1 mile.
	Spreading/Drying Moisture Conditioning	CY - as excavated	375	B10B	1000	5	3	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	650	B10B	1000	8	5	312323170020: Spread dumped material, no compaction, by dozer. Daily output edited to match excavation based on experience.
	Compaction of Material	CY - in place	650	B10F	2600	3	2	312323235060: Compaction; Riding, vibrating roller, 12" lifts, 2 passes. RS Means Crew is B10Y; altered to B10F based on experience.
	BARRIER WALL & GROUNDWATER EXTRACTION TRENCH CONSTRUCTION					**3,560**	**2,370**	

ITEM NO.	SITE RESTORATION	Units	Quantity	Crew	Daily Output	Labor Hours	Equipment Hours	Notes
15	Site Restoration	-	-	-	-	317	88	Assumes restoration of grade surface following extraction trench installation
	Erosion Control Blanket	SF	8,000	B1	2500	77	0	312514160100: Rolled erosion control mats and blankets, plastic netting stapled, 2" x 1" mesh, 20 mil. Assumes erosion control blanket installed over settling pond berm.
	Lime	MSF	100.0	B66	700	2	2	329113234250: Soil preparation, structural soil mixing, spread soil conditioners, ground limestone, 1#/S.Y., tractor spreader. Assumes soils possibly being void of nutrients. Quantity disturbed areas including staging area, temporary roads, and working surface (~2.3 acre total) excluding settling pond.
	Fertilizer	MSF	144.0	B66	700	2	2	329113234150: Soil preparation, structural soil mixing, spread soil conditioners, fertilizer, 0.2#/S.Y., tractor spreader. Assumes soils possibly being void of nutrients. Quantity all disturbed areas including staging area, temporary roads, and working surface (~2.3 acre total) and new settling pond (1 acre).
	Grassland Mix	MSF	144.0	B66	52	22	22	329219142300: Seeding athletic fields, seeding fescue, tall, 5.5 lb. per M.S.F., tractor spreader. Quantity all disturbed areas including staging area, temporary roads, and working surface (~2.3 acre total) and new settling pond (1 acre).
	Mulch	MSF	144.0	B65	530	4	4	329113160350: Mulching, Hay, 1" deep, power mulcher, large.
	Road Pavement Replacement	SY	10,833	B25	4545	210	57	321216130160: Plant-mixed asphalt paving, for highways and large paved areas, binder course, 3" thick, no hauling.
	SITE RESTORATION ESTIMATED SUBTOTAL					**317**	**88**	
ITEM NO.	**Corrective Action Operation and Maintenance**	**Units**	**Quantity**	**Crew**	**Daily Output**	**Labor Hours**	**Equipment Hours**	**Notes**
16	Groundwater Extraction Trench Operation & Maintenance	-	-	-	-	4800	-	Assumes routine maintenance required over the maximum 30 years of operation. Operation excludes the 3 years of confirmation monitoring.
	Field Maintenance	Event	120	TM	-	4800	0	Assumes quarterly maintenance on pneumatic pumps and air compressors over 30 years of operation. Each maintenance event assumes 2 staff for 3 days to check, clean, and service all mechanical parts.
	Electrical Distribution and Service Charges	MO	360	-	-	-	-	Assumes electrical distribution and usage for operating the extraction and transfer pumps.
17	Non-routine System O&M	-	-	-	-	3960	990	Assumes non-routine tasks including flushing of groundwater conveyance lines and periodic site visits (e.g., alarm responses or equipment troubleshooting) over 30 years of operation. Operation excludes the 3 years of confirmation monitoring.
	Groundwater Conveyance Line Flushing - Vacuum Truck	LF	105,000	VT	-	1,980	990	330130116140: Pipe, internal cleaning and inspection, cleaning, power rudder with header & cutts, 4"-12" diameter. Assumes one 3-day cleaning event of 3,500 LF of 8" HDPE pipe per year for a total of 30 years of operation.
	Non-Routine Site Visits/Alarm Responses	LS	180	OM	-	1,980	0	Assumes 6 non-routine site visits per year over 30 years of operation. Each non-routine event assumes 2 staff for 1 day.
	CORRECTIVE ACTION OPERATION AND MAINTENANCE SUBTOTAL					**8,760**	**990**	
						Total Labor Hours	**Total Equipment Hours**	
	ENGINEERING AND CONSTRUCTION SUBTOTAL					**8,200**	**3,100**	
	CORRECTIVE ACTION OPERATION AND MAINTENANCE SUBTOTAL					**8,760**	**990**	
	ENGINEER'S ESTIMATE OF TOTAL CONSTRUCTION AND ENGINEERING HOURS					**17,000**	**4,100**	

NOTES:

1. Alternative 2: Source Control with groundwater extraction trench and barrier wall is estimated to take greater than 30 years to achieve groundwater protection standards (GWPS-35 I.A.C Section 845.600) at all perimeter wells associated with AP2. For the purposes of this estimate, a maximum of 30 years of operation & compliance monitoring followed by 3 years of confirmation monitoring was assumed.
2. RS Means refers to the 2023 Quarter 4 online edition of RS Means Commercial New Construction.
3. See crew tab (Alt 2 - Crews) for assumptions regarding crew size, total labor hours and required construction equipment, as needed, for each task.
4. See mileage tab (Alt 2 - Mileage) for assumptions regarding total mileage for tasks outlined in this alternative.

ACRONYMS:

AC = Acre
AP2 = Ash Pond No. 2
CY = Cubic Yard
Loose: Material swelled when removed from compacted state
EA = Each
GWPS = groundwater protection standards
LF = Linear Foot
LS = Lump Sum
MSF = square feet divided by 1000
MO = Month
O&M = Operation & Maintenance
SF = Square Feet
SY = Square Yard

CREW CODES
ILLINOIS POWER GENERATING COMPANY - COFFEEN POWER PLANT - ASH POND 2
CORRECTIVE ACTION ALTERNATIVES ANALYSIS SUPPORTING INFORMATION REPORT (CAAA-SIR)
ALTERNATIVE 2 - UPGRADIENT BARRIER WALL AND GROUNDWATER EXTRACTION TRENCH

Item No.	Crew Code	Labor	Daily Labor Hours	Equipment	Daily Equipment Hours	Crew Size	Onsite Labor Hours	Onsite Heavy Equipment Hours
Construction								
2,5,12	2 Clab	Laborer x2	16	None	0	2	103	0
3	A2	Laborer x2 Truck Driver x1	24	Flatbed Truck, Gas, 1.5 ton	8	3	108	36
15	B1	Labor Foremanx1 Laborer x2	24	None	0	3	77	0
10,11	B6	Laborer x 2 Operator (light) x 1	24	Backhoe Loader, 48 H.P.	8	3	360	120
8,12,14	B10B	Operator x1 Laborer x0.5	12	Dozer, 200 H.P.	8	1.5	53	36
8,12,14	B10F	Operator (med) x1 Laborer x0.5	12	Tandem Roller, 10, Ton	8	1.5	19	13
10,13	B10R	Operator (med) x 1 Laborer x 0.5	12	Frontend loader, W.M., 1 C.Y.	8	1.5	327	218
5,12	B11L	Operator (med) x 1 Laborer x 1	16	Grader, 30,000lb	8	2	46	23
12	B12D	Operator (crane) x 1 Laborer x 1	16	Hydraulic excavator, 3.5 C.Y.	8	2	25	13
7	B13D	Operator (crane) x 1 Laborer x 1	16	Hydraulic excavator, 1 C.Y. Trench Box	8	2	55	27
2,5	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	871	290
14	B14B	Operator (crane) x 1 Laborer x 0.5	12	Hydraulic excavator, 6. C.Y.	8	1.5	2	1
10,13	B22A	Labor Foreman x1 Skilled Worker x1 Laborer x2 Operator (crane) x1	40	S.P. Crane, 4x4, 5 ton Butt Fusion Machine, 4-12" diam.	16	5	438	175
15	B25	Labore Foreman x1 Laborer x7 Operator x3	88	Asphalt Paver, 130 H.P. Tandem Roller, 10 ton Roller, Pneum. Whl, 12 ton	24	11	210	57
7	B34C	Truck Driver x1	8	Truck Tractor, 6x4, 380 H.P. Dump Trailer, 16.5 C.Y.	8	1	71	71
7,12,14	B34G	Truck Driver x1	8	Dump Truck, Off Hwy., 50 ton	8	1	23	23
5	B38	Labor Foreman x1 Laborer x2 Operator (light) x1 Operator (med) x1	40	Backhoe Loader, 48 H.P. Hyd. Hammer (1200 lb) F.E. Loader, W.M., 4 C.Y. Pvmt. Rem. Bucket	16	5	628	251
10,13	B54	Operator (light) x1	8	Trencher, Chain, 40 H.P.	8	1	14	14
3	B62	Laborer x2 Operator x 1	24	Loader, Skid Steer, 30 H.P.	8	3	133	44
12	B63B	Labor Foreman x1 Laborer x2 Operator (light) x1	32	Loader, Skid Steer, 78 H.P.	8	4	86	22
15	B65	Laborer x1 Truck Driver (light) x1	16	Power Mulcher (large) Flatbed Truck, Gas, 1.5 ton	16	2	4	4
15	B66	Operator (light) x1	8	Loader-Backhoe, 40 H.P.	8	1	26	26
10	Q1	Plumber x1 Plumber Apprentice x1	16	None	0	2	44	0
4	R1B	Electrician x1 Electrician Apprentice x2	24	None	0	3	144	0
10,13	R30	Electrician Foreman x0.25 Electrician x1 Laborer (Semi-Skilled) x2	26	None	0	3.25	312	0
6	GM	Engineering Staff x4	40	Service Vehicle x 2	0	4	600	0
8,9	OP	Operator x3 Laborer x 2	50	CAT 950 Loader x 3, CAT 374 Excavator x 1 CAT 349 Excavator x 1 Manlift x 1, Telehandlers x 2	50	5	1,625	1,625
1	Eng	Engineering Staff x1.2	10	Rental Vehicle x1	0	1.2	1,728	0
				Construction Subtotals			8,200	3,100
Corrective Action Operation & Maintenance								
16	TM	Maintenance Crew x2	20	Service Truck x2 Hand Tools	0	2	4,800	0
17	VT	Laborer x1 Operator x1	20	Vacuum Truck with Flushing Capabilities	10	2	1,980	990
17	OM	Laborer x1	10	Service Truck x1	0	1	1,980	0
				O&M Subtotals			8,760	990
						Totals	**17,000**	**4,100**

Note: Blue shaded crew codes were created by Ramboll based on experience (not pulled from RS Means).

CONSTRUCTION MILEAGE AND LABOR ESTIMATES
ILLINOIS POWER GENERATING COMPANY - COFFEEN POWER PLANT - ASH POND 2
CORRECTIVE ACTION ALTERNATIVES ANALYSIS SUPPORTING INFORMATION REPORT (CAAA-SIR)
ALTERNATIVE 2 - UPGRADIENT BARRIER WALL AND GROUNDWATER EXTRACTION TRENCH

Construction Mileage and Labor Estimates - Alternative 2: Upgradient Barrier Wall and Groundwater Extraction Trench

Item	Quantity	Assumptions
Labor Total Hours	8,132	Per projected Construction total in cost estimate (does not include contingency)
Duration of Onsite Construction Days	135	Total Days
Average Daily Crew Size	5.0	Assumes multiple crew sizes and a 10 hour work day Assumes 1 Ramboll personnel daily for construction oversight
Daily Labor Mobilization Miles	47,274	Includes light and medium commercial vehicles Average of 70 miles round trip per day
Vehicles Miles Onsite	10,130	Includes light and medium commercial vehicles 5 miles per day for onsite miles No contingency Included
Equipment Mobilization Miles - Unloaded	5,628	Average of 250 miles one-way for equipment hauling (from Chicago, IL) Average 1 load of equipment per working week
Equipment Mobilization Miles - Loaded	5,628	Average of 250 miles one-way for equipment hauling (from Chicago, IL) Average 1 load of equipment per working week
Onsite Haul Truck Miles - Unloaded	2,098	34 CY Off Road Dump Truck 1 mile round trip per load
Onsite Haul Truck Miles - Loaded	2,098	34 CY Off Road Dump Truck 1 mile round trip per load
Offsite Haul Truck Miles - Unloaded	8,697	Assumes 16 CY loads of fill materials (gravel/sand backfill and clay cap) are delivered to the site from a regional supplier located within 100 miles of the site
Offsite Haul Truck Miles - Loaded	8,697	Assumes truck is returning to the regional supplier located within 100 miles of the site
Material Delivery Miles - Unloaded	4,502	Misc. construction materials (erosion controls, piping, geotextile) Assumes 200 mile round trip, average 2 trips per working week
Material Delivery Miles - Loaded	4,502	Misc. construction materials (erosion controls, piping, geotextile) Assumes 200 mile round trip, average 2 trips per working week

Operation & Maintenance (O&M) Mileage and Labor Estimates - Alternative 2: Upgradient Barrier Wall and Groundwater Extraction Trench

Item	Quantity	Assumptions
Labor Total Hours	8,760	Per projected CM total in cost estimate (does not include contingency)
Duration of Onsite OMM Days	240	Total Days
Average Daily Crew Size	4	Assumes multiple crew sizes and a 10 hour work day
Daily Labor Mobilization Miles	105,120	Includes mob/demob from Chicago (260 miles round trip) and local daily commute mileage (40 round trip miles per day). Assumes 6 work days per week
Vehicles Miles Onsite	13,140	Includes light and medium commercial vehicles 15 miles per day for onsite miles No contingency Included
Equipment Mobilization Miles - Unloaded	7,500	Average of 250 miles one-way for equipment mobilization (from Chicago, IL) Average 1 mobilization/demobilization per year for jetting/flushing of conveyance lines over 30 years of operation
Equipment Mobilization Miles - Loaded	7,500	Average of 250 miles one-way for equipment mobilization (from Chicago, IL) Average 1 mobilization/demobilization per year for jetting/flushing of conveyance lines over 30 years of operation
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	-

CAGM = Corrective Action Groundwater Monitoring

ILLINOIS POWER GENERATING COMPANY - COFFEEN POWER PLANT - ASH POND 2
CORRECTIVE ACTION ALTERNATIVES ANALYSIS SUPPORTING INFORMATION REPORT (CAAA-SIR)
ALTERNATIVE 3 - HORIZONTAL EXTRACTION WELL[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	1440	0	Assumed labor and equipment hours based on Ramboll project experience.
	ENGINEERING, PRE-CONSTRUCTION, AND CONSTRUCTION SUPPORT TASK ESTIMATED SUBTOTAL					**1,440**	**0**	
ITEM NO.	**SITE PREPARATION**	**Units**	**Quantity**	**Crew**	**Daily Output**	**Labor Hours**	**Equipment Hours**	**Notes**
2	Staging Area & Temporary Roads Preparation	-	-	-	-	524	161	Assumes some work general preparation of temporary access roads to access the horizontal well installation point
	Subsurface Stabilization Nonwoven Geotextile	SY	6,200	2 Clab	2500	40	0	313219161550: Geosynthetic soil stabilization, geotextile fabric, non-woven, 120 lb tensile strength includes scarifying and compaction. Assumes 0.25 acre staging area and approximately 1,500 ft of temporary access road along the southern edge of flume for access to the horizontal well installation point in southeast corner of AP2.
	Construct Staging Area & Temporary Roads	SY	6,200	B14	615	484	161	015523500100: Temporary, roads, gravel fill, 8" gravel depth, excluding surfacing. Assumes 0.25 acre staging area and approximately 1,500 ft of temporary access road along the southern edge of flume for access to the horizontal well installation point in southeast corner of AP2.
3	Construction Soil Erosion Controls	-	-	-	-	27	9	Assumes soil erosion controls will be implemented throughout horizontal well construction.
	Silt Fence	LF	450	B62	650	17	6	312514161000: Synthetic erosion control, silt fence, install and remove, 3' high. Assumes silt fence is installed around perimeter of work pad.
	Sediment Log, Filter Sock	LF	450	A2	1000	11	4	312514160705: Sediment Log, Filter Sock, 9". Assumes silt fence is installed around perimeter of work pad.
4	Temporary Electrical Installation	EA	1	R1B	-	72	0	Electrical installation based on Ramboll experience to install one power drop for low-voltage (120V) power for the pneumatic transfer pump at the settling pond for discharge of water to outfall.
5	Work Pad Construction for Horizontal Well Installation	-	-	-	-	134	48	Construction of work pad within the flume for access during horizontal well construction, approximately 50 feet long by 50 feet wide and 10 feet deep. Gravel in flume will be left in place after construction with a free-draining culvert.
	Clearing & Grubbing for Work Surface	Acre	0.35	B7	0.3	56	28	311110100020: Clearing & grubbing, cut & chip light trees to 6" diameter. Clearing of 100 ft by 150 ft total area salong northern bank of flume/southern side of AP2.
	Surface Grading	MSF	15	B11L	30	8	4	312216103600: Fine grading, work pad area. Assumes grading in cleared area 100 ft by 150 ft along northern bank of flume/southern side of AP2.
	Subsurface Stabilization Nonwoven Geotextile	SY	1,670	2 Clab	2500	11	0	313219161550: Geosynthetic soil stabilization, geotextile fabric, non-woven, 120 lb tensile strength includes scarifying and compacting. Assumes reinforcement for graded slope area on northern bank of flume/southern side of AP2, 100 ft by 150 ft.
	Install Crushed Gravel Work Pad in Flume	SY	926	B10R	800	14	9	312323155050: Borrow, select granular fill, 3/4 C.Y. bucket, loading and/or spreading, front end loader, wheel mounted. Work pad in flume for horizontal well installation assumed 10 ft deep (flume depth), 50 ft wide (flume width) and extending 300 ft long for placement of drill rig for horizontal well installation.
	Install Concrete Culverts	LY	50	B13	62	45	6	334211601594: Public storm utility drainage piping, reinforced concrete pipe (RCP), 36" diameter, class 2, excludes excavation and backfill, gaskets. Assumes culvert extends the length of the area of placed rip-rap and gravel work pad.
	SITE PREPARATION ESTIMATED SUBTOTAL					**760**	**220**	
ITEM NO.	**HORIZONTAL WELL CONSTRUCTION**	**Units**	**Quantity**	**Crew**	**Daily Output**	**Labor Hours**	**Equipment Hours**	**Notes**
6	Installation of Horizontal Well	-	-	-	-	1,640	1,204	Installation of one single-ended well in north-south alignment at the base of AP2, performed in one mobilization.
	Drill Pilot Bore for 4" Single-Ended Well	LF	1,325	OP	-	700	500	Quantities for labor of well assembly and installation in the pilot bore for one horizontal well per specialty contractor estimate. Assumes one well takes approximately 5 full days to bore.
	Assembly and Installation of 4" Well Materials	LF	1,325	OP	-	700	500	Quantities for labor of well assembly and installation in the pilot bore for one horizontal well per specialty contractor estimate. Assumes one well takes approximately 5 full days to assemble and install after drilling of the borehole.
	Install Entry Grout Seal	EA	1	SUP	-	40	40	Quantities for one horizontal well per specialty contractor estimate. Assume each seal takes approximately half a day to complete.
	Install Surface Pad	EA	1	SUP	-	40	4	Installation of concrete surface pad for 4" well per specialty contractor estimate. Assume one pad takes approximately half a day to install.
	Well Development	EA	1	SUP	-	160	160	Quantities for one horizontal well per specialty contractor estimate. Purge water to be managed by settling pond.
7	Horizontal Well Mechanical Installation	-	-	-	-	551	139	Includes installation of sumps, equalization tank, transfer pumps and controllers, and associated excavation and backfill.
	Install Equalization Tank	EA	1	B6	1	180	60	Installation of equalization tank at end of each horizontal well and associated site preparation and instrumentation. Assumes 2 days each for installation.
	Install Transfer Pumps and Controllers	EA	1	R30	1	26	0	Installation of transfer pump and pump controller at end of one horizontal well to convey water from settling pond to discharge outfall based on Ramboll project experience. Assumes inclusion of housing structure and 2 days for installation.
	Excavate Utility Trench for Lines to Compressors and Extraction Pumps	LF	1,200	B54	860	11	11	312316142750: Utility trench excavating, chain trencher, 40 HP operator riding, 12" wide trench and backfill, 18" deep. Trench installed from power drop/compressor shed to extraction trench to supply compressed air and power to sump pits. Assumes 1,200 ft distance from compressor shed to end of horizontal well.
	Install Mechanical Elements and Piping	EA	1	R30	-	208	0	Assumes furnishing all mechanical elements (air compressors, pneumatic extraction pumps, transfer pumps) and associated HDPE housing piping for distribution of power and housing of mechanical elements throughout the extraction trench system. Assumes approximately 8 days of work.
	Excavate Utility Trench for Conveyance to Settling Pond	LF	500	B10R	100	60	40	312316142750: Utility trench excavating, chain trencher, 40 HP operator riding, 12" wide trench and backfill, 18" deep. Trench installed from horizontal well to convey extracted water to the settling pond.
	Install 8" HDPE Conveyance Pipe to Settling Pond	LF	500	B22A	320	63	25	331413350300: Water supply distribution piping, piping HDPE, butt fusion joints, 40' lengths, 8" diameter, SDR 21. Includes labor, materials, and machine for installation and welding of HDPE pipe for conveying extracted water from horizontal well to settling pond.
	Backfill with Granular Trench Backfill	LCY	30	B10R	100	4	2	312316133060: Backfill trench, F.E. loader, wheel mtd., 1 C.Y. bucket, 200' haul. Backfill with granular trench backfill. Quantity based on trench dimensions 12" wide, 18" deep, 500 ft long.
8	Construction of Compressor Shed	-	-	-	-	180	60	Based on Ramboll experience for construction of housing unit for air compressor shed.
	Construct Compressor Shed	EA	1	B6	-	180	60	Assumes pre-fabricated air compressor shelter, installed primarily by hand with light equipment assistance. Hours are based on Ramboll experience
9	Installation of Settling Pond	-	-	-	-	226	89	Quantity based on 1-acre pond, 2 feet deep. Assume all excavated material is reused for berm construction.
	Excavation and Loading of Settling Pond Material	BCY	3,300	B12D	2080	25	12.7	312316420300: Excavating, bulk bank measure, hydraulic, crawler mtd., 3 C.Y. cap (300 CY/hr).
	Hauling and Placement of Settling Pond Material	LCY	3,300	B34G	3287	8	8.0	312323206130: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld./uld., 15 MPH, cycle 2,000 ft. Daily output extrapolated down to 600 ft cycle.
	Spreading/Drying Material in Berm	CY	3,300	B10B	1000	40	26.4	312323170020: Spread dumped material, no compaction, by dozer. Daily output edited to match excavation based on experience.
	Compaction of Material in Berm	BCY	3,300	B10F	2600	15	10.2	312323235060: Compaction; Riding, vibrating roller, 12" lifts, 2 passes. RS Means Crew is B10Y; altered to B10F based on experience.
	Fine Grading of Berm	MSF	36	B11L	30	19	10	312216103600: Fine grading, tops of lagoon banks for compaction. Assumes 10 ft-wide berm around perimeter of 1-acre settling pond.
	Subsurface Stabilization Nonwoven Geotextile	SY	5,000	2 Clab	2500	32	0	313219161550: Geosynthetic soil stabilization, geotextile fabric, non-woven, 120 lb tensile strength includes scarifying and compaction. Assumes 1 acre settling pond.
	Settling Pond Liner	SF	5,000	B63B	1850	86	22	310519531100: Reservoir liners, membrane lining, 40 mil, LLDPE.
10	Extracted Water Discharge Management	-	-	-	-	123	32	Management of water extracted from the horizontal well to convey from settling pond to discharge. Based on approximate distance of 500 ft from settling pond to discharge outfall.
	Install Transfer Pump and Controller	EA	1	R30	1	52	0	Installation of transfer pump and pump controller to convey water from settling pond to discharge outfall based on Ramboll project experience. Assumes inclusion of housing structure. Assume 2 days for installation.
	Excavate Utility Trench for Conveyance to Discharge	LF	500	B54	860	5	5	312316142750: Utility trench excavating, chain trencher, 40 HP operator riding, 12" wide trench and backfill, 18" deep. Trench installed from settling pond to convey settled water to outfall for discharge.
	Install 8" HDPE Conveyance Pipe to Discharge	LF	500	B22A	320	63	25	331413350300: Water supply distribution piping, piping HDPE, butt fusion joints, 40' lengths, 8" diameter, SDR 21. Includes labor, materials, and machine for installation and welding of HDPE pipe for conveying water from settling pond to discharge point.
	Backfill with Granular Trench Backfill	LCY	30	B10R	100	4	2	312316133060: Backfill trench, F.E. loader, wheel mtd., 1 C.Y. bucket, 200' haul. Backfill with granular trench backfill. Quantity based on trench dimensions 12" wide, 18" deep, 500 ft long.
	HORIZONTAL WELL CONSTRUCTION					**2,720**	**1,530**	
ITEM NO.	**SITE RESTORATION**	**Units**	**Quantity**	**Crew**	**Daily Output**	**Labor Hours**	**Equipment Hours**	**Notes**
11	Site Restoration	-	-	-	-	126	6	Assumes restoration of grade surface following horizontal well installation for staging area (50x150 ft) and bank restoration (50x100 ft). Gravel backfill and culvert will remain in place in flume. Gravel access road will remain in place for O&M access.
	Erosion Control Blanket	SF	12,500	B1	2500	120	0	312514160100: Rolled erosion control mats and blankets, plastic netting stapled, 2" x 1" mesh, 20 mil. Assumes erosion control blanket installed on work pad (150x50 ft).
	Lime	MSF	13.8	B66	700	1	1	329113234250: Soil preparation, structural soil mixing, spread soil conditioners, ground limestone, 1#/S.Y., tractor spreader. Assumes soils possibly being void of nutrients. Quantity disturbed areas staging area and northern bank of flume.
	Fertilizer	MSF	13.8	B66	700	1	1	329113234150: Soil preparation, structural soil mixing, spread soil conditioners, fertilizer, 0.2#/S.Y., tractor spreader. Assumes soils possibly being void of nutrients. Quantity disturbed areas staging area and northern bank of flume.
	Grassland Mix	MSF	13.8	B66	52	3	3	329219142300: Seeding athletic fields, seeding fescue, tall, 5.5 lb. per M.S.F., tractor spreader. Quantity disturbed areas including staging area and northern tank of flume. Assume that gravel in flume and temporary roads are to remain in place.
	Mulch	MSF	13.8	B65	530	1	1	329113160350: Mulching, Hay, 1" deep, power mulcher, large.
	SITE RESTORATION ESTIMATED SUBTOTAL					**126**	**6**	

ITEM NO.	Corrective Action Operation and Maintenance	Units	Quantity	Crew	Daily Output	Labor Hours	Equipment Hours	Notes
12	Horizontal Well Operation & Maintenance	-	-	-	-	4800	-	Assumes routine maintenance required over the maximum of 30 years of operation. Operation excludes the 3 years of confirmation monitoring.
	Field Maintenance	Event	120	TM	-	4800	0	Assumes quarterly maintenance on transfer pumps and air compressors over a maximum of 30 years of operation. Each maintenance event assumes 2 staff for 2 days to check, clean, and service all mechanical parts. Assumes all labor, equipment, mobilization over 2 days.
13	Non-routine System O&M	-	-	-	-	2,760	300	Assumes non-routine tasks including flushing of groundwater conveyance lines and periodic site visits (e.g., alarm responses or equipment troubleshooting) over a maximum of 30 years of operation. Operation excludes the 3 years of confirmation monitoring.
	Groundwater Conveyance Line Flushing - Vacuum Truck	LF	30,000	VT	-	600	300	330130116140: Pipe, internal cleaning and inspection, cleaning, power rudder with header & cutts, 4"-12" diameter. Assumes one 2-day cleaning event of 1,000 LF of 8" HDPE pipe per year for a total of 15 years.
	Non-Routine Site Visits/Alarm Responses	LS	180	OM	-	1,800	-	Assumes 6 non-routine site visits per year over a maximum of 30 years of operation. Each non-routine event assumes 2 staff for 1 day.
	Extraction Well Development and Maintenance	LS	6	WD	-	360	-	Assumes extraction well will be developed once every 5 years to remove potential accumulation of organic or inorganic solids in the extraction well over 30 years of operation. Assumes re-development is completed with a two man crew over a 3 day period total for the one well.
	CORRECTIVE ACTION OPERATION AND MAINTENANCE SUBTOTAL					**7,560**	**300**	

			Total Labor Hours	Total Equipment Hours
ENGINEERING AND CONSTRUCTION SUBTOTAL			**5,100**	**1,800**
CORRECTIVE ACTION OPERATION AND MAINTENANCE SUBTOTAL			**7,560**	**300**
ENGINEER'S ESTIMATE OF TOTAL CONSTRUCTION AND ENGINEERING HOURS			**12,700**	**1,800**

NOTES:

1. Alternative 3: Source Control with horizontal extraction well is estimated to take greater than 30 years to achieve and maintain groundwater protection standards (GWPS-35 I.A.C Section 845.600) at all perimeter wells associated with AP2 following alternative implementation.
2. RS Means refers to the 2023 Quarter 4 online edition of RS Means Commercial New Construction.
3. See crew tab (Alt 3 - Crews) for assumptions regarding crew size, total labor hours and required construction equipment, as needed, for each task.
4. See mileage tab (Alt 3 - Mileage) for assumptions regarding total mileage for tasks outlined in this alternative.

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AP2 = Ash Pond No. 2
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    Loose: Material swelled when removed from compacted state
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RAMBOLL

CREW CODES
ILLINOIS POWER GENERATING COMPANY - COFFEEN POWER PLANT - ASH POND 2
CORRECTIVE ACTION ALTERNATIVES ANALYSIS SUPPORTING INFORMATION REPORT (CAAA-SIR)
ALTERNATIVE 3 - HORIZONTAL EXTRACTION WELL

Item No.	Crew Code	Labor	Daily Labor Hours	Equipment	Daily Equipment Hours	Crew Size	Onsite Labor Hours	Onsite Heavy Equipment Hours
Construction								
2,5,9	2 Clab	Laborer x2	16	None	0	2	82	0
3	A2	Laborer x2 Truck Driver x1	24	Flatbed Truck, Gas, 1.5 ton	8	3	11	4
11	B1	Labor Foremanx1 Laborer x2	24	None	0	3	120	0
7,8	B6	Laborer x 2 Operator (light) x 1	24	Backhoe Loader, 48 H.P.	8	3	360	120
5	B7	Labore Foreman (outside) x1 Laborer x4 Operator (medium) x1	48	Brush Chipper, 12", 130 H.P. Crawl Loader, 3 C.Y. Chain Saws, Gas, 36" Long x2	24	6	56	28
9	B10B	Operator x1 Laborer x0.5	12	Dozer, 200 H.P.	8	1.5	40	26
9	B10F	Operator (med) x1 Laborer x0.5	12	Tandem Roller, 10, Ton	8	1.5	15	10
5,7,10	B10R	Operator (med) x 1 Laborer x 0.5	12	Frontend loader, W.M., 1 C.Y.	8	1.5	81	54
5,9	B11L	Operator (med) x 1 Laborer x 1	16	Grader, 30,000lb	8	2	27	14
9	B12D	Operator (crane) x 1 Laborer x 1	16	Hydraulic excavator, 3.5 C.Y.	8	2	25	13
5	B13	Laborer Foreman x1 Laborer x4 Operator (crane) x1 Operator (oiler) x1	56	Hydraulic Crane, 25 ton	8	6	45	6
2	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	498	171
7,10	B22A	Labor Foreman x1 Skilled Worker x1 Laborer x2 Operator (crane) x1	40	S.P. Crane, 4x4, 5 ton Butt Fusion Machine, 4-12" diam.	16	5	125	50
9	B34G	Truck Driver x1	8	Dump Truck, Off Hwy., 50 ton	8	1	8	8
7,10	B54	Operator (light) x1	8	Trencher, Chain, 40 H.P.	8	1	16	16
3	B62	Laborer x2 Operator x 1	24	Loader, Skid Steer, 30 H.P.	8	3	17	6
9	B63B	Labor Foreman x1 Laborer x2 Operator (light) x1	32	Loader, Skid Steer, 78 H.P.	8	4	86	22
11	B65	Laborer x1 Truck Driver (light) x1	16	Power Mulcher (large) Flatbed Truck, Gas, 1.5 ton	16	2	1	1
11	B66	Operator (light) x1	8	Loader-Backhoe, 40 H.P.	8	1	5	5
4	R1B	Electrician x1 Electrician Apprentice x2	24	None	0	3	72	0
7,10	R30	Electrician Foreman x0.25 Electrician x1 Laborer (Semi-Skilled) x2	26	None	0	3.25	260	0
6	SUP	Operator x2 Laborer x2	40	CAT 950 Loader x 3, CAT 374 Excavator x 1 CAT 349 Excavator x 1 Manlift x 1, Telehandler x 1	40	4	200	200
6	OP	Operator x4 Laborer x3	70	Drill Rig x1 Drill Cab, Trailer-Mtd x1 CAT Excavator x 1 Mud Recycling System x1 Water Truck x1 Manlift x 1, Telehandlers x 2	50	7	1,400	1,000
1	Eng	Engineering Staff x1.2	10	Rental Vehicle x1	0	1.2	1,440	0
				Construction Subtotals			5,000	1,800
Corrective Action Operation & Maintenance								
12	TM	Maintenance Crew x2	20	Service Truck x2 Hand Tools	0	2	4,800	0
13	VT	Laborer x1 Operator x1	20	Vacuum Truck with Flushing Capabilities	10	2	600	300
13	WD	Laborer x1 Operator x1	20	Well Development Rig, Mounted Winch or Hoisting System	8	2	360	0
13	OM	Laborer x1	10	Service Truck x1	0	1	1,800	0
				O&M Subtotals			7,560	300
						Totals	**12,600**	**2,100**

Note: Blue shaded crew codes were created by Ramboll based on experience (not pulled from RS Means).

CONSTRUCTION MILEAGE AND LABOR ESTIMATES
ILLINOIS POWER GENERATING COMPANY - COFFEEN POWER PLANT - ASH POND 2
CORRECTIVE ACTION ALTERNATIVES ANALYSIS SUPPORTING INFORMATION REPORT (CAAA-SIR)
ALTERNATIVE 3 - HORIZONTAL EXTRACTION WELL

Construction Mileage and Labor Estimates - Alternative 3: Horizontal Extraction Wells

Item	Quantity	Assumptions
Labor Total Hours	5,000	Per projected Construction total in cost estimate (does not include contingency)
Duration of Onsite Construction Days	69	Total Days
Average Daily Crew Size	5.3	Assumes multiple crew sizes and a 10 hour work day Assumes 1 Ramboll personnel daily for construction oversight
Daily Labor Mobilization Miles	25,586	Includes light and medium commercial vehicles Average of 70 miles round trip per day
Vehicles Miles Onsite	5,483	Includes light and medium commercial vehicles 5 miles per day for onsite miles No contingency Included
Equipment Mobilization Miles - Unloaded	5,711	Average of 500 miles round trip for equipment hauling (from Chicago, IL) Average 1 load of equipment per working week
Equipment Mobilization Miles - Loaded	5,711	Average of 500 miles round trip for equipment hauling (from Chicago, IL) Average 1 load of equipment per working week
Onsite Haul Truck Miles - Unloaded	49	34 CY Off Road Dump Truck 1 mile round trip per load
Onsite Haul Truck Miles - Loaded	49	34 CY Off Road Dump Truck 1 mile round trip per load
Offsite Haul Truck Miles - Unloaded	4,973	Assumes 16 CY loads of fill materials (gravel/sand backfill and clay cap) are delivered to the site from a regional supplier and 16 CY loads of recyced concrete are hauled to a facility located within 50 miles of the site
Offsite Haul Truck Miles - Loaded	4,973	Assumes truck is returning to the regional supplier/recycling facility located within 50 miles of the site
Material Delivery Miles - Unloaded	2,284	Misc. construction materials (erosion controls, piping, geotextile) Assumes 200 mile round trip, average 2 trips per working week
Material Delivery Miles - Loaded	2,284	Misc. construction materials (erosion controls, piping, geotextile) Assumes 200 mile round trip, average 2 trips per working week

Operation & Maintenance (O&M) Mileage and Labor Estimates - Alternative 3: Horizontal Extraction Wells

Item	Quantity	Assumptions
Labor Total Hours	7,560	Per projected CM total in cost estimate (does not include contingency)
Duration of Onsite OMM Days	240	Total Days
Average Daily Crew Size	3	Assumes multiple crew sizes and a 10 hour work day
Daily Labor Mobilization Miles	90,720	Includes mob/demob from Chicago (260 miles round trip) and local daily commute mileage (40 round trip miles per day). Assumes 6 work days per week
Vehicles Miles Onsite	11,340	Includes light and medium commercial vehicles 15 miles per day for onsite miles No contingency Included
Equipment Mobilization Miles - Unloaded	3,750	Average of 250 miles one-way for equipment mobilization (from Chicago, IL) Average 1 mobilization/demobilization per year for jetting/flushing of conveyance lines over 30 years of operation
Equipment Mobilization Miles - Loaded	3,750	Average of 250 miles one-way for equipment mobilization (from Chicago, IL) Average 1 mobilization/demobilization per year for jetting/flushing of conveyance lines over 30 years of operation
Onsite Haul Truck Miles - Unloaded	0	No onsite hauling during this phase
Onsite Haul Truck Miles - Loaded	0	No onsite hauling during this phase
Offsite Haul Truck Miles - Unloaded	0	No spoil handling off-site will occur under this alternative
Offsite Haul Truck Miles - Loaded	0	No spoil handling off-site will occur under this alternative
Material Delivery Miles - Unloaded	1,500	Misc. vegetation maintenance materials (seeding, etc.) Assumes 200 mile round trip, 1 load per mobilization (once per year)
Material Delivery Miles - Loaded	1,500	Misc. vegetation maintenance materials (seeding, etc.) Assumes 200 mile round trip, 1 load per mobilization (once per year)

CAGM = Corrective Action Groundwater Monitoring

Appendix C

Corrective Measures Assessment

Intended for
Illinois Power Generating Company

Date
June 12, 2024

Project No.
1940103584-002

35 I.A.C. § 845 CORRECTIVE MEASURES ASSESSMENT

ASH POND NO. 2

COFFEEN POWER PLANT

COFFEEN, ILLINOIS

IEPA ID: W135015004-02

RAMBOLL Bright ideas. Sustainable change.

35 I.A.C. § 845 CORRECTIVE MEASURES ASSESSMENT COFFEEN POWER PLANT ASH POND NO. 2

Project name	**Coffeen Power Plant Ash Pond No. 2**
Project no.	**1940103584-002**
Recipient	**Illinois Power Generating Company**
Document type	**35 I.A.C. § 845 Corrective Measures Assessment**
Revision	**FINAL**
Date	**June 12, 2024**
Prepared by	**A. 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

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ACRONYMS AND ABBREVIATIONS

35 I.A.C.	Title 35 of the Illinois Administrative Code
AP1	Ash Pond No. 1
AP2	Ash Pond No. 2
ASD	alternative source demonstration
CAAA	Corrective Action Alternatives Analysis
CAP	Corrective Action Plan
CCR	coal combustion residuals
CIP	closure-in-place
CMA	Corrective Measures Assessment
cm/s	centimeters per second
CPP	Coffeen Power Plant
CSM	conceptual site model
DA	deep aquifer
DCU	deep confining unit
EPRI	Electric Power Research Institute
E001	Event 1; quarter 2, 2023
GMF	Gypsum Management Facility
GMF GSP	GMF Gypsum Stack Pond
GMF RP	GMF Recycle Pond
GMP	Groundwater Monitoring Plan
GWPS	groundwater protection standard(s)
ID	identification
IDNR	Illinois Department of Natural Resources
IEPA	Illinois Environmental Protection Agency
IPCB	Illinois Pollution Control Board
IPGC	Illinois Power Generating Company
ITRC	National Research Council, Interstate Technology & Regulatory Council
LCU	lower confining unit
NID	National Inventory of Dams
No.	number
NPDES	National Pollutant Discharge Elimination System
NRT	Natural Resource Technology
PMP	potential migration pathway
PRB	Permeable Reactive Barrier
Ramboll	Ramboll Americas Engineering Solutions, Inc.
SI	surface impoundment
Site	Coffeen Power Plant
TDS	total dissolved solids
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 Illinois Power Generating Company (IPGC) 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) unit referred to as the Ash Pond Number (No.) 2 (AP2) at the Coffeen Power Plant (CPP), also referred to as CCR unit identification (ID) No. 102, Illinois Environmental Protection Agency (IEPA) ID No. W1350150004-02, and National Inventory of Dams (NID) No. IL50723. This report addresses content requirements specific to 35 I.A.C. § 845.660 (Assessment of Corrective Measures) for exceedances of boron, cobalt, pH, sulfate, and total dissolved solids (TDS) at AP2.

1.1 Source Control and Residual Plume Management

IPGC completed significant source control and residual plume management efforts in 2020 as part of final closure of AP2 (Golder Associates, Inc., 2021). The final closure was performed in accordance with the Closure and Post-Closure Care Plan (AECOM, 2017) that was developed in accordance with Title 40 of the Code of Federal Regulations (40 C.F.R.) § 257 and approved by IEPA on January 30, 2018.

The AP2 closure construction included closure-in-place (CIP) of the entire AP2 and installation of an alternative geomembrane cover system. This was accomplished by constructing a final cover system that complies with 40 C.F.R. § 257.102 to minimize water infiltration into the closed AP2 and improve surface water drainage off the cover system, thus reducing generation of potentially impacted water and ultimately reducing the extent of CCR impacts to groundwater. The source control was predicted to lower water levels and decrease the potential transport of CCR constituents off-site (Natural Resource Technology [NRT], 2017a). These source control activities will serve as the primary groundwater corrective measure at AP2. The potentially feasible corrective measures presented herein are intended to be supplementary to the primary source control and are intended to serve as management measures to address any residual plume that may remain after completion of source control.

1.2 Adaptive Site Management

Adaptive site management strategies will be employed as an integral part of ongoing corrective action at AP2. The adaptive site management approach will allow timely incorporation of new site information over the closure and post-closure life cycle of AP2 to ensure the achievement of the groundwater protection standards (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 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 the 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 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 United States Environmental Protection Agency (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 AP2 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 AP2. 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 AP2. 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 AP2.

3. Ongoing groundwater monitoring at AP2 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 CPP is located in Montgomery County in central Illinois, approximately two miles south of the city of Coffeen and about eight miles southeast of the city of Hillsboro. AP2 is a closed CCR surface impoundment (SI) located in Section 11, Township 7 North and Range 7 East. AP2 is located south of the power plant and situated in a predominantly agricultural area (**Figure 2-1**). AP2 is located between two lobes of Coffeen Lake (the western lobe is identified as "Coffeen Lake" and the upper reaches of the eastern lobe are fed by a stream labeled as "Unnamed Tributary" on Figures 2-1 and 2-2), which surround the SI to the west, east, and south. The southern edge of AP2 is adjacent to the former discharge flume for the closed generating plant. AP2 is bordered by other CCR units and agricultural land to the north. **Figure 2-2** is a site map showing the location of AP2 (35 I.A.C. § 845 regulated CCR Unit and subject of this CMA), Ash Pond No. 1 (AP1), the Gypsum Management Facility (GMF) Gypsum Stack Pond (GMF GSP), GMF Recycle Pond (GMF RP), and Landfill. The area near AP2 will hereinafter be referred to as the Site.

The CPP was a coal-fired electrical generating plant that began operation in 1964. The plant initially burned bituminous coal from Illinois and CCR from the coal fired units was disposed of in surface impoundments. AP2 was utilized in the early 1970's until the mid-1980's, beginning in 2010 CCR material was placed in the Landfill and GMF Units.

2.1 Conceptual Site Model

Significant site investigation has been completed at the CPP to characterize the geology, hydrogeology, and groundwater quality. Based on extensive investigation and monitoring, AP2 has been well characterized and detailed in the Hydrogeologic Characterization Report (NRT, 2017b). The conceptual site model (CSM) is presented below.

In addition to the CCR present at AP2, there are five principal layers of unlithified material present above the bedrock, which are categorized into hydrostratigraphic units below (from surface downward) based on stratigraphic relationships and common hydrogeologic characteristics.

- **Upper Confining Unit (UCU):** Composed of the Roxana and Peoria Silts (Loess Unit) and the upper clayey portion of the Hagarstown member which are classified as silts to clayey silts and gravelly clay below the surficial soil. Loess Unit thickness ranges from 0 feet (absent) to 16 feet and the clayey portion of the Hagarstown member is up to 6 feet thick. The UCU has been eroded east of AP2, near the Unnamed Tributary.
- **Uppermost Aquifer:** The uppermost aquifer is the Hagarstown Member which is classified as primarily sandy to gravelly silts and clays with thin beds of sands. Where present the sandy portion of the Hagarstown is generally 2 to 4 feet thick, and 1 to 2 feet thick near AP2. Similar to the Loess Unit and upper Hagarstown, the lower Hagarstown is absent in some locations near the Unnamed Tributary. Historical hydraulic conductivities near AP2 ranged from 4.3 x 10^{-5} to 9.8 x 10^{-4} centimeters per second (cm/s) (geometric mean of 2.7 x 10^{-4} cm/s).
- **Lower Confining Unit (LCU):** Comprised of the Vandalia Member, Mulberry Grove Member, and Smithboro Member. These units include a sandy to silty till with thin, discontinuous sand lenses, a discontinuous and limited extent sandy silt which has infilled prior erosional features, and silty to clayey diamicton, respectively. The Vandalia Member typically ranged in thickness

from 11.7 feet in the northern portion of the CPP, to 31.0 feet between the GMF GSP and the GMF RP; the Mulberry Grove Member is represented by pockets (generally less than 2 feet thick); and the Smithboro Member ranges in thickness from 6.7 to 21.2 feet northwest of the landfill. This LCU has been identified as a potential migration pathway (PMP) because downward vertical gradients indicate that there is the potential for impacts to migrate through this unit. The LCU is approximately 7 to 18 feet thick near AP2. Historical hydraulic conductivities ranged from 4.0×10^{-8} to 3.4×10^{-5} cm/s (geometric mean of 5.6×10^{-6} cm/s).

- **Deep Aquifer (DA):** Sand and sandy silt/clay units of the Yarmouth Soil, which include accretionary deposits of fine sediment and organic materials, typically less than five feet thick and discontinuous across the CPP. This unit is also identified as a PMP due to presence of downward gradients in the overlying LCU and the relatively greater hydraulic conductivities measured in the DA. Historical hydraulic conductivity in the DA ranged from 7.5×10^{-8} to 3.6×10^{-5} cm/s (geometric mean of 4.4×10^{-4} cm/s).
- **Deep Confining Unit (DCU):** Comprised of the Banner Formation, generally consists of clays, silts, and sands. The Lierle Clay Member is the upper layer of the Banner Formation which was encountered at the Site. No monitoring wells are screened only within the DCU, and no field hydraulic conductivity tests were conducted for the DCU.

In the UA, groundwater generally migrates from central portions of the CPP towards Coffeen Lake or the Unnamed Tributary. The LCU and DA underlying the UA have been identified as PMPs. Groundwater elevations are primarily controlled by surface topography, geologic unit topography, and water levels within Coffeen Lake and the Unnamed Tributary. Groundwater generally flows from the center of the CPP west towards Coffeen Lake, and east towards the Unnamed Tributary, the eastern lobe of Coffeen Lake, and the former discharge flume present along the southern perimeter of AP2 and northern perimeter of AP1, resulting in a groundwater divide (high) running through the middle of the CPP. Groundwater elevations and contours for the quarter 2, 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 AP2 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 10 wells screened in the UA (three background and seven compliance), one compliance well screened in the LCU, and three temporary water level only surface water staff gages. The groundwater samples collected from the 11 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 sampling event was completed on June 8, 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, 2023):

- Boron in UA wells G401, G402, G404, and G405
- Cobalt in UA well G401
- pH in UA well G401

- Sulfate in UA wells G401, G402, G404, G405, G406, and G407
- TDS in UA wells G401, G402, G404, G405, and G407

Pursuant to 35 I.A.C. § 845.650(e), an alternative source demonstration (ASD) was prepared and submitted to IEPA that presented evidence demonstrating that sources other than AP2 were the cause of the cobalt GWPS exceedance in G401, and sulfate and TDS GWPS exceedances in G407 listed above (Geosyntec Consultants, Inc., 2023).

The IEPA did not concur with the cobalt ASD due to the following alleged data gaps:

1. Source characterization of the CCR at AP2 must include total solids sampling in accordance with SW846.
2. Research on porewater characterization of CCR does not come from an independent peer reviewed publication.

The IEPA did not concur with the G407 sulfate and TDS ASD due to the following alleged data gaps:

1. Characterization to include sample and analysis in accordance with 35 I.A.C. § 845.640 must be provided with the ASD.
2. Updated geologic cross sections must be provided and must include data surrounding the hydrogeologic divide and the exceedance well G407 in accordance with § 845.620(b)(9).

IPGC 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 cobalt, sulfate, and TDS GWPS exceedances at AP2. The IEPA had no objection to the requested stay, which was granted by IPCB on April 18, 2024. Therefore, the CMA will address identified GWPS exceedances summarized above, exclusive of the cobalt exceedance at well G401, and the sulfate and TDS exceedances in G407, in accordance with 35 I.A.C. § 845.660 and the partial stay. 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.

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 AP2 during the E001 groundwater monitoring event (Ramboll, 2023). The CMA was initiated on January 14, 2024, 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 AP2, 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 AP2. 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 AP2 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 actions, namely the completed source control activities described in **Section 1.1** (CIP with an alternative geomembrane cover system). The completed source control has significantly reduced infiltration rates relative to pre-closure conditions. 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 completed 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 were completed for AP2 in 2020, as described in **Section 1.1**; all of the evaluated additional 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 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, the United States Environmental Protection Agency (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 completed source control activities at the site, which consisted of CIP with an alternative 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, 2015). 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, 2015):

Both physical and chemical processes can contribute to the reduction of the small amount of residual mass remaining since closure of AP2, 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, physical mechanisms most often exert the dominant control on the CCR constituents of interest, such as sulfate and chloride, and lithium to a more variable degree. Chemical mechanisms are also likely to be active, though not often dominant, such as adsorption, ion exchange, and organic complexation. 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, 2015) 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 trenches 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 and operating at a rate to allow capture of CCR impacted groundwater within the UA and/or the LCU and DA.
- Management of extracted groundwater, which may include modification to the existing National Pollutant Discharge Elimination System (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.

4.3 Source Control with a 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 transport of impacted groundwater and can isolate soils that have been impacted by CCR to prevent contact 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 & 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 a cutoff wall and groundwater extraction in specific areas may provide advantages over independent use of these potential corrective technologies. Cutoff walls can also be used in combination with groundwater extraction or as part of a PRB system (as the “funnel” in a funnel-and-gate system; **Section 3.4**).

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 and sulfate 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. Alternately, treatment via PRB, where reactive materials are placed in the subsurface 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 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 as 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 emplaced 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 zero-valent iron 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, pH, sulfate, and TDS (exclusive of the sulfate and TDS exceedances in G407) at the downgradient waste boundary of AP2 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 3** 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 corrective action plan; and
- Institutional requirements, such as State or local permit requirement or other environmental or public health requirements that may substantially affect implementation of the corrective action plan.

Table 5-1 presents the qualitative CMA evaluation of each corrective technology relative to these requirements, as well as their ability to address boron, pH, sulfate, and TDS GWPS exceedances. The following sections provide a summary of these evaluations and a 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 35 I.A.C. § 845.670 CAAA process for selecting the final remedy for AP2.

5.2 Groundwater Corrective Technology Assessment

Source control, consisting of CIP with an alternate geomembrane cover system, is the primary groundwater corrective measure for AP2 and was completed in 2020. Each of the potential groundwater corrective measure technologies would supplement the positive impact of the prior closure activities. The following sections evaluate groundwater corrective measure technologies that, when combined with site closure, may be viable to address the boron, pH, sulfate, and TDS GWPS exceedances (exclusive of the sulfate and TDS exceedances in G407). Technologies that are not viable for addressing the GWPS at AP2 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

Completed source control corrective measures (**Section 1.1**) have reduced the mass loading to the groundwater system. Performance of groundwater polishing, which is currently occurring at the site to some degree, could decrease the timeframe for attainment of GWPS for one or more parameters in the UA. The time estimated for plume contraction at AP2 is relatively long, based on previous groundwater modeling (NRT, 2017c). Groundwater polishing is dependent on site-specific conditions and may not significantly reduce the time to attain the GWPS for all parameters at AP2.

Groundwater polishing by natural geochemical processes is a widely accepted component of groundwater remediation and is routinely approved by the USEPA 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 regulatory approval. Site conditions are favorable for physical attenuation, while chemical attenuation may be limited under normal UA conditions.

Naturally occurring geochemical processes are currently ongoing at post-closure AP2 and will continue to affect post-closure groundwater constituent concentrations. 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 approximately 90 days after CAP permit approval.

No potential safety impacts or exposure to human health or environmental receptors are expected to result from implementing 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 AP2 will require approval of the CAP permit by the IEPA.

Monitoring the groundwater polishing to track progress toward achievement of the GWPS, in conjunction with source control at AP2, 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. Monitoring activities could be initiated immediately after approval of the CAP permit.

Groundwater polishing processes will continue to occur naturally at AP2. It may be a viable corrective measure for the boron, pH, sulfate, and TDS exceedances at AP2. Therefore, it is being advanced to the CAAA for further evaluation.

5.2.2 Source Control with Groundwater Extraction

Source control is currently reducing mass loading to the AP2 groundwater system and implementing a downgradient groundwater extraction system may reduce the time required to attain the GWPS in the UA. However, the groundwater impacts already present in the low permeability PMP may limit the reduction in time to attain the GWPS that can be achieved by a groundwater extraction system.

Groundwater extraction is a widely accepted corrective measure with a long track record of performance and reliability. It is routinely approved by the IEPA. For a corrective measure using groundwater extraction to effectively control off-site flow and/or to remove potentially contaminated groundwater, horizontal and vertical capture zone(s) must be created. Additionally, the groundwater flow direction and location of the existing former discharge flume may complicate design and may affect performance of a pumping well system. An alternative method for controlling groundwater flow and removing potentially contaminated groundwater could include constructing a discharge trench by lowering the normal water level in the former discharge flume (*i.e.,* dewatering). This approach could passively increase the hydraulic gradient and corresponding groundwater flow velocities between AP2 and the former discharge flume, without the need for groundwater collection or active pumping. More active methods, such as groundwater extraction trenches, collection sumps, or horizontal wells could also be utilized. Cutoff walls (**Section 4.3**) could also be used in conjunction with a pumping system to control potential groundwater movement from the flume.

Implementation of a groundwater extraction system presents design challenges due to heterogeneous, varied nature of the UA. An extraction system in the UA would have to consider the potential for extracting water from the former discharge flume. Extracted groundwater would require management, possibly including treatment, which may require specialized equipment and/or contractors. Construction of an extraction system to intercept the natural groundwater flow to the south and east would introduce challenges related to construction access and relocating compliance wells so that they are not affected by other site features.

There could be some impacts associated with constructing and operating a groundwater extraction system, including altering the groundwater flow system and some limited exposure to extracted groundwater. The construction of trenches could also cause stability impacts to the AP2 dikes and/or adjacent structures. Additional data collection and analyses would be required to design an extraction system. Construction could be completed within 1 year following completion of a final design. Time of implementation is approximately 3 to 4 years after approval of the CAP permit, including characterization, design, permitting, and construction. Timeframes to achieve GWPS are dependent on site-specific conditions. An extraction system may reduce the time to attain GWPS in the UA relative to the post-closure timeframe predicted by the groundwater modeling. However, accelerated attainment of the GWPS may be limited by the heterogeneity of the UA.

Implementing a groundwater extraction system at AP2 would require IEPA approval of the CAP permit, and extracted groundwater could likely be discharged under the NPDES permit. Additional permitting related to construction in wetlands and/or Waters of the United States may be required, if they are determined to be present at the site and in the vicinity of the extraction system. Depending upon the location of the extraction system, an Illinois Department of Natural Resources (IDNR) dam safety modification permit may also be required to construct an extraction system.

Groundwater extraction could be a viable corrective measure for the boron, pH, sulfate, and TDS exceedances at AP2. Implementation of groundwater extraction may require combining an extraction system with a cutoff wall to provide directional control of groundwater flow. Therefore, groundwater extraction is being advanced to the CAAA for further evaluation.

5.2.3 Source Control with Groundwater Cutoff Wall

Source control is reducing mass loading to the groundwater system and implementing additional groundwater corrective measures may reduce the time required to attain the GWPS in the UA. A low permeability cutoff wall could be used in combination with a groundwater extraction system in the UA to reduce the water management and treatment requirements for an extraction system.

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 geologic materials they are in contact with. A cutoff wall designed with hydraulic conductivity of 1×10^{-7} cm/s would two to four orders of magnitude lower than the UA, which has hydraulic conductivities from 1.7×10^{-5} to 9.1×10^{-3} cm/s (NRT, 2017a), and would be an effective containment method in the UA and could improve the performance of a UA extraction system.

Constructing a cutoff wall could result in structural impacts to the AP1 and AP2 embankment dikes, depending on the location of the wall. Specialized construction contractor(s) may be required depending upon the required construction methodology and site access considerations, which could delay implementation.

Additional data collection and analyses would be required to design a cutoff wall. The time to implement a cutoff wall is approximately 4 to 5 years, including characterization, design, permitting and construction. 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 AP2 would require IEPA approval of the CAP permit and, depending on the location, an IDNR dam safety modification permit may be required. Construction of a cutoff wall may also require an evaluation and/or permits related to wetlands if they are determined to be present in the area of the proposed remedy.

A cutoff wall alone would not be a viable corrective measure for the boron, pH, sulfate, and TDS exceedances at AP2. However, a cutoff wall may provide directional control, which, when combined with other corrective measures, would reduce the time required to achieve and attain GWPS. Therefore, the cutoff wall is being advanced to the CAAA for further evaluation.

5.2.4 Source Control with In-Situ Chemical Treatment

Source control is reducing mass loading to the groundwater system and implementing additional groundwater corrective measures 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 and sulfate 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 due to the heterogeneous and varied nature of the UA. Depending upon the location of a PRB system, construction may affect AP2 embankment and/or final cover system and periodic change-outs of ion exchange 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 regulatory hurdles, in-situ chemical treatment is not a viable corrective measure for the boron and sulfate exceedances at AP2 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.

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TABLES

TABLE 5-1. CORRECTIVE MEASURES ASSESSMENT MATRIX
ASH POND NO. 2
COFEEN POWER PLANT
COFFEEN, ILLINOIS
June 12, 2024

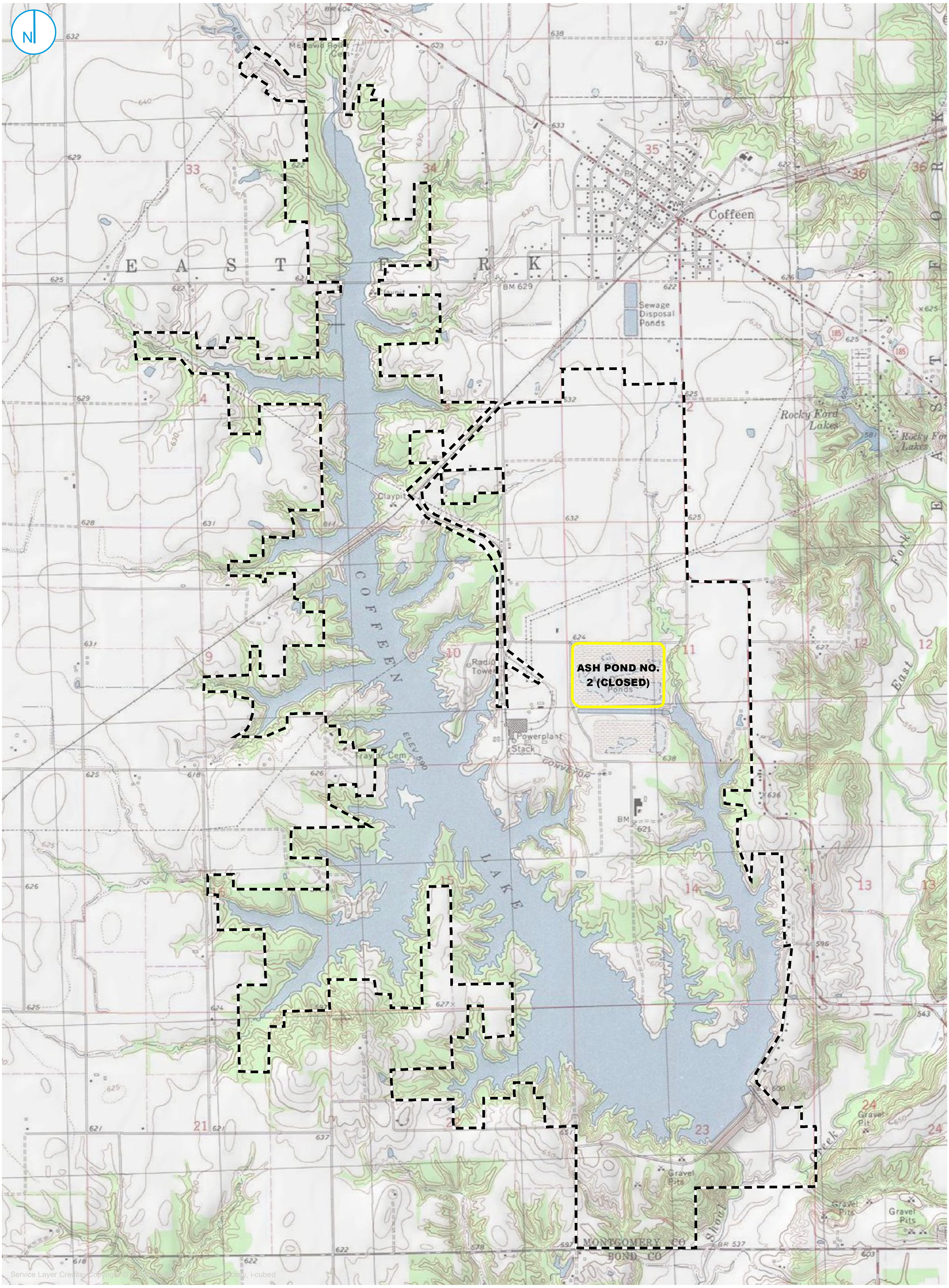
Remedy	Evaluation Factors						
	Performance	**Reliability**	**Ease of Implementation**	**Potential Impacts of Remedy (safety impacts, cross-media impacts, control of exposure to any residual contamination)**	**Time Required to Begin and Implement Remedy[1]**	**Time to Attain Groundwater Protection Standards**	**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 was completed by closure in place with an alternate cover system in 2020. Site conditions are favorable for physical processes, while attenuation processes may be limited under normal aquifer conditions.	Ongoing analysis will evaluate if the attenuation mechanism has low reversibility, the aquifer has sufficient capacity, and the hydrogeology is favorable for physical processes.	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.	Approximately 90 days after CAP permit approval.	Dependent on site-specific conditions including source decay rate. Less than the post-closure timeframe predicted by the groundwater model.	IEPA approval of the CAP is required.
Source Control with Groundwater Extraction	Widely accepted and routinely approved technology; variable performance of a pumping system is anticipated in the heterogeneous uppermost aquifer and possibly due to proximity of CPP discharge flume (might capture water from the extraction system). A downgradient extraction trench, or alternately, deepening the discharge flume, combined with a groundwater pumping system, may be more effective that an independent groundwater pumping system.	Reliable if properly designed, constructed and maintained. Heterogeneous, varied nature of uppermost aquifer may present reliability challenges for pumping wells.	Design challenges due to heterogeneous, varied nature of uppermost aquifer. Specialized contractors may be-necessary. Extracted groundwater would require management, possibly including treatment, which may require specialized equipment/contractors. Construction of an extraction system to intercept the natural groundwater flow to the south and east, would introduce challenges related to construction access and relocating compliance wells so that they are not affected by other site features.	Alters groundwater flow system. Potential for some limited exposure to extracted groundwater. Groundwater extraction may induce settlement, which could cause structural impacts to the AP1 or AP2 embankments and/or adjacent structures.	Design, permitting and construction is expected to take 3 to 4 years after CAP permit approval. Additional time may be required to permit a trench and a new compliance monitoring well network.	May be similar to the timeframe predicted by the groundwater model due to the low permeability Upper Confining Unit.	IEPA approval of the CAP permit is required. Extracted groundwater could likely be discharged under the NPDES permit. Approval from IEPA for modifications to the compliance monitoring well network proposed in the operating permit would be required. An IDNR dam safety modification permit might also be required, depending on location of wells and settlement. If an extraction trench is used, additional permitting related to construction in wetlands and/or Waters of the United States may be required, if they are determined to be present in the area of the proposed remedy.
Source Control with Groundwater Cutoff Wall	Widely accepted and routinely approved technology with good performance if properly designed and constructed. If not combined with groundwater extraction, a cutoff wall will provide directional control only, thus redirecting flow to other areas where GWPS may be exceeded.	Reliable for groundwater directional control if properly designed and constructed.	Widely used, established technology. May require specialized contractors depending upon the construction/implementation method.	Alters groundwater flow system but does not provide any treatment. Can result in unintended consequences resulting from redirecting contaminants to areas where they are not currently present. May cause structural impacts to the embankment, depending on the location of the wall.	Design, permitting and construction is expected to take 4 to 5 years after CAP approval. Implementation could potentially be accelerated by combining with closure construction activities.	Provides groundwater directional control only. Combination with other groundwater corrective measure(s), such as groundwater extraction or permeable reactive barrier, would reduce the time required to attain GWPS. Time required may be similar to the groundwater model prediction due to the low permeability Upper Confining Unit.	IEPA approval of the CAP permit is required. An IDNR dam safety permit may also be required depending on the location of the cutoff wall. May also require an evaluation and/or permits related to wetlands, if determined to be present in the area of the proposed remedy.
Source Control with In-Situ Treatment	In-situ treatment using IX resins not well established for sulfate or boron, therefore performance is unknown.	Unknown reliability for sulfate or boron.	Design challenges related to reactive material delivery and due to heterogenous, discontinuous nature of uppermost aquifer. Could require periodic change-outs of resin media.	A permeable reactive barrier may cause structural impacts to the embankment, depending on the location of the barrier.	May require bench scale and/or pilot scale testing as part of design. Design, permitting and construction is expected to take 4 to 6 years after CAP approval.	There is uncertainty regarding whether a in-situ treatment would reduce sulfate or boron concentrations to achieve the GWPS. Dependent on conditions specific to the reactive media used and the site. Treatment technology is 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 dam safety permit may also be required depending on the location of the barrier. May also require an evaluation and/or permits related to wetlands, if determined to be present in the area of the proposed remedy.

Notes:
[1] Time required to begin and implement remedy includes design, permitting, and construction.
AP1 - Ash Pond No. 1
AP2 - Ash Pond No. 2
CAP - Corrective Action Plan
CPS - Coffeen Power Station
GWPS - groundwater protection standard
IDNR - Illinois Department of Natural Resources
IEPA - Illinois Environmental Protection Agency
IX - Ion Exchange
NPDES - National Pollutant Discharge and Elimination System

FIGURES

PROJECT: 169000XXXX | DATED: 10/13/2021 | DESIGNER: STOLZSD

Y:\Mapping\Projects\22\2285\MXD\845_Operating_Permit\Coffeen\AP2_GMP\Figure 1-1_Site Location Map AP2.mxd



▭ REGULATED UNIT (SUBJECT UNIT)

⬚ PROPERTY BOUNDARY

0 1,000 2,000 Feet

SITE LOCATION MAP

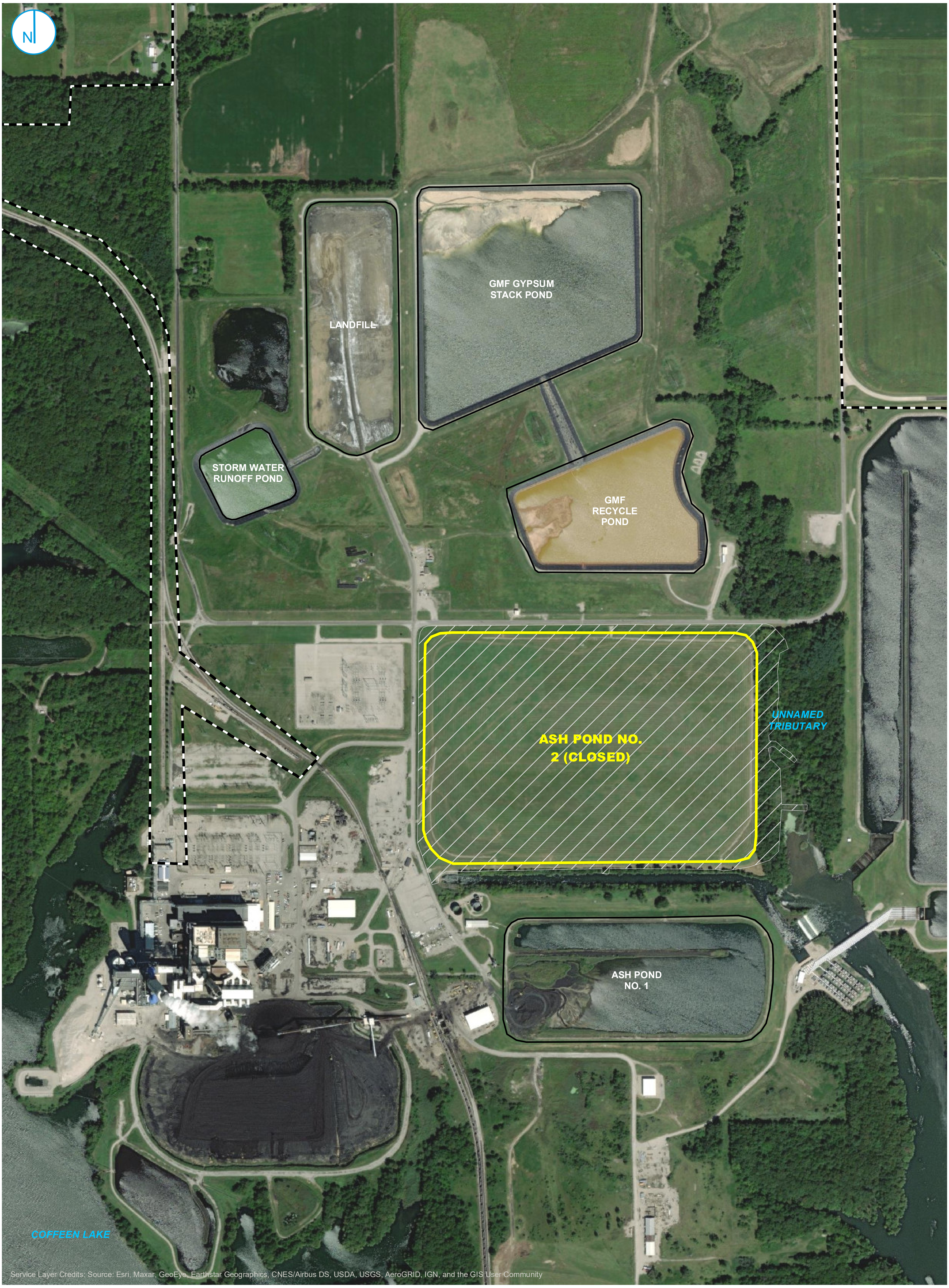
FIGURE 2-1

35 I.A.C. § 845 CORRECTIVE MEASURES ASSESSMENT
ASH POND NO.2
COFFEEN POWER PLANT
COFFEEN, ILLINOIS

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

PROJECT: 169000XXXX | DATED: 10/6/2021 | DESIGNER: STOLZSD

Y:\Mapping\Projects\22\2285\MXD\845_Operating_Permit\Coffeen\AP2_GMP\Figure 1-2_Site Map AP2.mxd



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

🟨 REGULATED UNIT (SUBJECT UNIT)

▭ SITE FEATURE

▨ LIMITS OF FINAL COVER

⬚ PROPERTY BOUNDARY

0 275 550 Feet

SITE MAP

FIGURE 2-2

35 I.A.C. § 845 CORRECTIVE MEASURES ASSESSMENT
ASH POND NO.2
COFFEEN POWER PLANT
COFFEEN, ILLINOIS

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL

🟦	COMPLIANCE MONITORING WELL
🟫	BACKGROUND MONITORING WELL
⬛	MONITORING WELL
🟩	SOURCE SAMPLE LOCATION
⊕	LEACHATE 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)
▭	SITE FEATURE
⬚	PROPERTY BOUNDARY

0 325 650 Feet

NOTES:
1. ELEVATIONS IN PARENTHESES WERE NOT USED FOR CONTOURING.
2. ELEVATION CONTOURS SHOWN IN FEET, NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88)

POTENTIOMETRIC SURFACE MAP
APRIL 30, 2023

35 I.A.C. § 845 CORRECTIVE MEASURES ASSESSMENT
ASH POND NO. 2
COFFEEN POWER PLANT
COFFEEN, ILLINOIS

FIGURE 2-3

RAMBOLL AMERICAS ENGINEERING SOLUTIONS, INC.

RAMBOLL

Y:\Mapping\Projects\22\2285\MXD\845_Operating_Permit\Coffeen\AP2_GMP\Figure 2-1_Proposed Monitoring Well Network.mxd

PROJECT: 169000XXXX | DATED: 10/6/2021 | DESIGNER: STOLZSD

▣	COMPLIANCE WELL
▣	BACKGROUND WELL
▣	MONITORING WELL
◒	STAFF GAGE
🟨	REGULATED UNIT (SUBJECT UNIT)
☐	SITE FEATURE
▨	LIMITS OF FINAL COVER
⬚	PROPERTY BOUNDARY

0 200 400 Feet

MONITORING WELL LOCATION MAP

35 I.A.C. § 845 CORRECTIVE MEASURES ASSESSMENT
ASH POND NO.2
COFFEEN POWER PLANT
COFFEEN, ILLINOIS

FIGURE 2-4

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL

Appendix D

Nature and Extent Report

Intended for

Illinois Power Generating Company
134 CIPS Lane
Coffeen, IL 62017
Montgomery County

Date

June 12, 2024

Project No.

1940103584-002

NATURE AND EXTENT REPORT

COFFEEN POWER PLANT, ASH POND NO. 2, IEPA ID NO. W1350150004-02

RAMBOLL Bright ideas. Sustainable change.

NATURE AND EXTENT REPORT
COFFEEN POWER PLANT, ASH POND NO. 2, IEPA ID NO. W1350150004-02

Project name	**Coffeen Power Plant Ash Pond No. 2**
Project no.	**1940103584-002**
Recipient	**Illinois Power Generating Company**
Document type	**Nature and Extent Report**
Revision	**Final**
Date	**June 12, 2024**
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ACRONYMS AND ABBREVIATIONS

35 I.A.C.	Title 35 of the Illinois Administrative Code
AP1	Ash Pond No. 1
AP2	Ash Pond No. 2
bgs	below ground surface
CCR	coal combustion residuals
cm/s	centimeters per second
CPP	Coffeen Power Plant
CSM	conceptual site model
DA	deep aquifer
DCU	deep confining unit
E001	Event 1
E002	Event 2
E003	Event 3
ft/ft	feet per foot
GCSM	geochemical conceptual site model
GMF	Gypsum Management Facility
GSP	Gypsum Stack Pond
GWPS	groundwater protection standard
HCR	Hydrogeologic Site Characterization Report
HDPE	high-density polyethylene
IEPA	Illinois Environmental Protection Agency
IPGC	Illinois Power Generating Company
IPCB	Illinois Pollution Control Board
Kd	soil adsorption coefficient
LCL	lower confidence limit
LCU	lower confining unit
LF	Landfill
mg/L	milligrams per liter
NAVD88	North American Vertical Datum of 1988
No.	number
PMP	potential migration pathway
Ramboll	Ramboll Americas Engineering Solutions, Inc.
RP	Recycle Pond
SI	surface impoundment
TDS	total dissolved solids
UA	uppermost aquifer
UCU	upper confining unit
USGS	United States Geological Survey
WPCP	Water Pollution Control Permit

EXECUTIVE SUMMARY

Groundwater samples collected at the Coffeen Power Plant (CPP) Ash Pond Number (No.) 2 (AP2) during May and June 2023 for the Quarter 2, 2023 compliance sampling event (Event 1 [E001]) were evaluated for statistical exceedances of the groundwater protection standards (GWPS) described in Title 35 of the Illinois Administrative Code (35 I.A.C.) § 845.600. Statistical exceedances were identified in the following hydrostratigraphic units and wells:

- Detected Uppermost aquifer (UA) Exceedances:
    - Boron at G401, G402, G404, and G405
    - Cobalt at G401
    - pH at G401
    - Sulfate at G401, G402, G404, G405, G406, and G407
    - Total dissolved solids (TDS) at G401, G402, G404, G405, and G407

As a result of the identified E001 statistical exceedances, a Corrective Measures Assessment (CMA) was initiated on January 14, 2024 in accordance with 35 I.A.C. § 845.660 and submitted on June 12, 2024 [1]. The subsequent compliance sampling events for the Quarter 3 and Quarter 4, 2023 sampling events (Event 2 [E002] and Event 3 [E003]) were completed in August and November 2023 and groundwater samples were evaluated for statistical exceedances of the GWPS as described in 35 I.A.C. § 845.600. Statistical exceedances identified during the E002 and E003 events were consistent with those listed above, with the notable exception of a sulfate statistical exceedance absent at G402 during E003.

In accordance with 35 I.A.C. § 845.650(e), Alternative Source Demonstrations (ASD) were completed on December 15, 2023 for sulfate and TDS statistical exceedances at well G407 and the cobalt statistical exceedance at well G401 [2, 3]. The Illinois Environmental Protection Agency (IEPA) provided a non-concurrence letter for both ASDs on January 11, 2024 [4, 5]. The non-concurrences were appealed, and the Illinois Pollution Control Board (IPCB) granted a partial stay on March 7, 2024 [6, 7]. As a result of the IPCB partial stay, GWPS statistical exceedances of cobalt (G401), and sulfate and TDS (G407) will not be discussed in this nature and extent report.

As required by 35 I.A.C. § 845.650(d)(1), this report characterizes the nature and extent of boron, pH, sulfate, and TDS, and relevant site conditions to determine how they may affect the corrective measures ultimately selected for AP2 and documents the additional measures taken in accordance with 35 I.A.C. § 845.650(d).

Statistical exceedances of boron greater than the GWPS were encountered within the UA at multiple monitoring well locations. The lateral extent of boron statistical exceedances are defined to the west by monitoring wells G403 and G406 (and additionally the groundwater divide running north-south across the CPP), to the east by the Unnamed Tributary and Coffeen Lake, and to the south by the former discharge flume. Due to erosion, the UA is absent east of monitoring wells G402 and G404 and boron statistical exceedances are ultimately defined by Coffeen Lake. The boron concentrations in the groundwater system may be attenuated via surface complexation reactions and via interactions with clay minerals, which are present in solids across the UA and lower confining unit (LCU).

The boron concentrations from monitoring wells around AP1, the discharge flume, and Coffeen Lake were used to evaluate risk to Human Health or ecological receptors and findings indicate they do not present unacceptable risk [8]. Comparison of boron concentrations from AP1 used in the analysis (7.5 mg/L) to the maximum measured in G401 and G402 at AP2 (8.1 mg/L) suggests that results for AP2 would also not present an unacceptable risk. At both AP1 and AP2 the vertical extent of boron greater than the GWPS is limited by the presence of low permeability tills.

Measurements of pH less than the lower GWPS were encountered only within the UA at G401. The lateral extent of pH statistical exceedances are defined to the west by G406, to the east by G402, and to the south by the former discharge flume. Vertically, the extent of pH less than the lower GWPS is limited by the presence of low permeability tills.

Statistical exceedances of sulfate and TDS greater than the GWPS were encountered within the UA at multiple monitoring well locations. The extent of sulfate and TDS statistical exceedances greater than the GWPS are laterally defined as follows: to the west of AP2 by the groundwater divide running north-south across the CPP; to the east by the Unnamed Tributary and Coffeen Lake; and to the south by the former discharge flume. Due to erosion, the UA is absent east of monitoring wells G402 and G404 and sulfate and TDS statistical exceedances are ultimately defined by Coffeen Lake. Sulfate and TDS statistical exceedances are not expected to extend a significant distance to the north or west due to observed groundwater flow direction in the vicinity of AP2. The sulfate concentrations in the groundwater system may be attenuated via surface complexation reactions. Attenuation of the constituents contributing to TDS, such as sulfate, will reduce TDS concentrations as well. Sulfate and TDS concentrations in Coffeen Lake and the former discharge flume were evaluated for AP1 and they do not present unacceptable risk [8]. Vertically, the extent of sulfate and TDS statistical exceedances greater than the GWPS is limited by the presence of low permeability tills.

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 CPP AP2.

The groundwater data and analysis in this report includes results from historical sampling (initiated in 2015) through E003, which was completed on November 21, 2023. Results of the E001, E002, and E003 events were submitted and placed in the facility's operating record by October 16, 2023; January 20, 2024; and March 10, 2024, respectively, as required by 35 I.A.C. § 845.800(d)(15), within 60 days of receiving final laboratory analytical data [9, 10, 11]. The statistical determination presented in the report identified the following statistical exceedances of the GWPS at compliance groundwater wells in the following hydrostratigraphic unit:

- Detected UA Exceedances:
  - Boron at G401, G402, G404, and G405
  - Cobalt at G401
  - pH at G401
  - Sulfate at G401, G402, G404, G405, G406, and G407
  - TDS at G401, G402, G404, G405, and G407

An ASD, as allowed by 35 I.A.C. § 845.650(e), was completed for the cobalt statistical exceedance at UA monitoring well G401 [2] and an ASD was completed for the sulfate and TDS statistical exceedances at UA monitoring well G407 [3]. The IEPA did not concur with the ASDs. The non-concurrences were appealed, and the IPCB granted partial stays on March 7, 2024 [6] [7]. Therefore, the nature and extent of cobalt at G401, and sulfate and TDS at G407, are not discussed in this document. Evaluations were not conclusive in demonstrating an alternative source for the other identified GWPS statistical exceedances. This Nature and Extent Report discusses in detail the extent of the boron, pH, sulfate, and TDS statistical exceedances as well as a geochemical conceptual site model (GCSM) describing the nature of these statistical exceedances.

2. UNIT BACKGROUND

2.1 Site Location and Description

The CPP is located in Montgomery County in central Illinois, approximately two miles south of the City of Coffeen and about eight miles southeast of the City of Hillsboro (**Figure 2-1**). The CPP was a coal-fired power plant with five CCR units present: AP2 (35 I.A.C. § 845 regulated CCR Unit and subject of this report), Ash Pond No. 1 (AP1), the Gypsum Management Facility (GMF) Gypsum Stack Pond (GSP), GMF Recycle Pond (RP), and Landfill (LF). AP2 is located in Section 11, Township 7 North and Range 3 West. AP2 is located south of the CPP and situated in a predominantly agricultural area (**Figure 2-2**). AP2 is located between two lobes of Coffeen Lake (the western lobe is identified as "Coffeen Lake" and the upper reaches of the eastern lobe are fed by a stream labeled as "Unnamed Tributary" on **Figures 2-1** and **2-2**), which surround the SI to the west, east, and south. The southern edge of AP2 is adjacent to the former discharge flume for the closed generating plant. AP2 is bordered by other CCR units and agricultural land to the north.

2.2 Description of CCR Unit

The CPP was a coal-fired electrical generating plant that began operation in 1964. The plant initially burned bituminous coal from Illinois and CCR from the coal fired units was disposed of in AP1. AP2 was utilized for CCR disposal beginning in the early 1970's and AP1 was reconstructed in 1978. Both of these units were used until the mid-1980's, beginning in 2010 CCR material was placed in the LF and GMF Units.

- **AP2:** AP2 is a closed (IEPA-approved) SI with a surface area of approximately 60 acres and berms 47 feet higher than the surrounding land surface. AP2 was originally removed from service and capped in the mid 1980's. A clay and soil cap was placed on the surface of the pond with contouring and drainage provided to direct storm water to four engineered revetment down drain structures. Prior to capping, this pond was identified as Outfall 004 in the facility National Pollutant Discharge Elimination System operating permit, IL0000108. Additional closure activities include the construction of a geomembrane cover system that began in July 2019 and was completed on November 17, 2020. Construction was completed in accordance with the Closure and Post Closure Care Plan approved by the IEPA on January 30, 2018 [12]. No CCR was sampled in 2021 because the pond was closed and capped [13]. The unit contains bottom ash and fly ash and the base of CCR at AP2 is shown in **Figure 2-3**.

  Water that may come into contact with CCR within the footprint of AP2 becomes CCR source water. Results from CCR source water samples collected from porewater wells and historically from porewater grab samples [13] are used to provide information for groundwater transport modeling[1].

- **AP1:** This SI (also known as the Bottom Ash/Recycle Pond) is a reclaimed ash pond that was reconstructed utilizing the existing earthen berms with reinforcement, as provided by Water

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[1] Per Federal Register 80 (21302), which promulgated the final Title 40 of the Code of Federal Regulations. § 257 rule, porewater concentrations should be used to characterize potential leaching from impoundments. As discussed further in USEPA's risk assessment of CCR surface impoundments (USEPA 2014), porewater is "collected from the interstitial water between waste particles in surface impoundments as it occurs in the field," and concentrations within the porewater are "the most representative data available for impoundments because these data are field-measured concentrations of leachate." Therefore, CCR source water collected from porewater wells within the unit, represent the CCR source term.

Pollution Control Permit (WPCP) 1978-EA-389 issued by the IEPA on May 26, 1978. AP1 (existing unlined SI) covers an area of approximately 23 acres, has berms up to 41 feet above the surrounding land surface, and a volume of 300 acre-feet. It primarily received bottom ash and low volume wastes from floor drains in the main power block building. Several years ago, air heater wash and boiler chemical cleaning wastes were directed to AP1, but this practice was discontinued. The bottom ash was periodically removed for beneficial uses by a third-party contractor. Sluicing of waste to AP1 ceased prior to November 4, 2019.

- **GMF GSP:** The 37-acre GMF GSP received blowdown from the air emission scrubbers and was put into operation in 2010. Construction of the GMF GSP was in accordance with WPCP 2008-EA-4661 and features a composite 60-mil high-density polyethylene (HDPE) liner with 3 feet of recompacted soil with a hydraulic conductivity of 1 x 10^{-7} centimeters per second (cm/s) with internal piping and drains to collect contact water. Construction of the unit required excavation to an elevation of approximately 603 feet[2] and installation of a groundwater underdrain system to eliminate inward pressure on the liner prior to placement of CCR. The GMF GSP underdrain was actively pumped during construction but is no longer used. Illinois Power Generating Company (IPGC) ceased receipt of waste to the GMF GSP prior to April 11, 2021.
- **GMF RP:** The 17-acre GMF RP received blowdown from the air emission scrubbers and was put into operation in 2010. Construction of the GMF RP was in accordance with WPCP 2008-EA-4661 and features a composite 60-mil HDPE liner with 3 feet of recompacted soil with a hydraulic conductivity of 1 x 10^{-7} cm/s with internal piping and drains to collect contact water. Construction of the unit required excavation to an elevation of approximately 601 feet and installation of a groundwater underdrain system to eliminate inward pressure on the liner prior to placement of CCR. The GMF RP underdrain is a passive, gravity drained system. IPGC ceased receipt of waste to the GMF RP prior to April 11, 2021.
- **LF:** Fly ash was managed in a permitted composite lined landfill constructed in 2010. The LF has an active groundwater underdrain system that is currently being operated. Additionally, the ash landfill leachate collection system is restricted by rule to no more than one foot of leachate on the composite liner. An IEPA groundwater monitoring program is in effect for the GMF (under Bureau of Water) and Ash Landfill (under Bureau of Land).

2.3 Geology and Hydrogeology

Significant site investigation has been completed at the CPP to characterize the geology, hydrogeology, and groundwater quality. Based on extensive investigation and monitoring, AP2 has been well characterized and detailed in the Hydrogeologic Site Characterization Report (HCR) [13].

2.3.1 Hydrostratigraphic Units

In addition to the CCR, five hydrostratigraphic units have been identified at the CPP based on stratigraphic relationships and common hydrogeologic characteristics, and are summarized as follows:

- **Upper Confining Unit (UCU)**: Consists of the Loess Unit and the upper clayey portion of the Hagarstown Member which has generally lower vertical permeability and generally greater than 60 percent fines. This Unit was encountered across most of the CPP, with the exception

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

of the eastern edges of the SIs near the Unnamed Tributary where the unit was eroded following deposition or locations where it has been excavated for construction.

- **Uppermost Aquifer (UA)**: This unit consists primarily of sand and sandy silts and clays at the base of the Hagarstown Member and, in some locations, the uppermost weathered sandy clay portion of the Vandalia Member. This unit is absent in several locations due to weathering and in others due to excavation during construction of CCR Units. The hydraulic characteristics of the Hagarstown Member are variable due to the different material compositions, but generally indicate the unit has a moderate hydraulic conductivity.
- **Lower Confining Unit (LCU)**: This unit is composed of the sandy clay till of the Vandalia Member, the silt of the Mulberry Grove Formation, and the compacted clay till of the Smithboro Member. The unit underlies the UA and was encountered in all boring locations on the CPP. Results from laboratory tests completed for vertical hydraulic conductivity indicate the Vandalia Member has a very low vertical hydraulic conductivity.
- **Deep Aquifer (DA)**: This unit consists primarily of sandy silt and sands of the Yarmouth Soil, which are thin (less than 5 feet) and discontinuous across the CPP.
- **Deep Confining Unit (DCU)**: This unit underlies the DA and is composed of the Banner Formation, of which the thick Lierle Clay is the first encountered unit. No boring penetrated the full thickness of this formation.

2.3.2 Uppermost Aquifer

The UA has been identified as the base of the Hagarstown Member and, in some locations, the uppermost weathered sandy clay portion of the Vandalia Member. This unit is continuous across the site, but hydraulic characteristics are variable as a result of the unit composition. The UA is likely absent in several locations due to weathering. The UA exhibits a moderate hydraulic conductivity and is the most likely unit to indicate potential impacts from AP2. Based on the geologic information, the top of the aquifer is highest in elevation at the northern side of AP2, with an elevation of approximately 610 feet. Except in areas where the UCU and UA have been eroded (adjacent to the Unnamed Tributary), the top of the UA is typically separated from overlying CCR material by several feet of the low permeability UCU, which consists of the Loess Unit and the upper clayey portion of the Hagarstown Member (**Figure 2-4**, **Appendix A**). The base of the UA is the top of the LCU, which contains the low permeability Vandalia Member, Mulberry Grove Member, and Smithboro Till. In 2021, soil borings and monitoring wells (G1001 and G1003) were completed between the eastern edge of AP2 and the Unnamed Tributary. The borings did not identify the presence of either the UCU or UA, indicating that the UA is absent east of AP2. Wells G1001 and G1003 were screened in the LCU to evaluate shallow groundwater quality east of AP2. Only G1001 contains measurable amounts of groundwater that can be collected and analyzed; G1003 is routinely dry.

2.3.3 Potential Migration Pathways

Potential migration pathways (PMP) were interpreted using the lithologic composition and hydrogeologic properties (hydraulic conductivity, hydraulic position with respect to the unit) of the screened materials. In addition to the physical properties, the analytical results from the baseline groundwater monitoring performed in wells screened in the confining units and DA were used to identify PMPs. The UA is the first occurrence of groundwater and therefore the PMPs identified are in geologic units located below the UA. Monitoring wells G1001 and G1003 are considered LCU PMP monitoring locations. Wells G1001 and G1003 are used to evaluate the potential for migration of impacts through the LCU where the UCU and UA are absent.

2.3.4 Regional Bedrock Geology

Bedrock has not been investigated at the site due to the depth to bedrock and presence of two low permeability confining units underlying the UA and above the bedrock, and the intermittent coal beds found within the bedrock. There are no known monitoring wells or production wells screened within the bedrock at the CPP. Bedrock has not been encountered at any borings on-site. A literature review was completed to supplement the site geology.

Detailed descriptions of the Pennsylvanian strata of Illinois were published by Willman et al. [14] and Kolata [15]. The Bond Formation includes all strata from the base of the Shoal Creek Limestone Member or the LaSalle Limestone Member to the top of the Millersville Limestone Member or the Livingstone Limestone Member. It is overlain by the Mattoon Formation and underlain by the Modesto Formation. It varies from less than 150 feet thick in eastern Illinois to over 300 feet thick in southeastern Illinois, averaging about 250 feet. The Bond Formation is characterized by a high percentage of limestone and calcareous clays and shales. The Bond and Modesto Formations of the McLeansboro Group also contain multiple thin (typically less than 2 feet) intermittent coal beds. The upper formation of the Kewanee Group is the Carbondale Formation which contains multiple coal beds, including the Herrin (No. 6) Coal, of varying thicknesses (up to 7 feet) [16]. It is bound by thick limestone members (up to 50 feet), the thickest and purest limestones in the Pennsylvanian System of Illinois. Gray shales constitute the greatest part of the formation, although thick channel sandstones are developed locally.

Two mines were operated historically in the vicinity of the site. The Hillsboro Mine located east/southeast of the GSP was operated by the Truax-Traer Coal Company from 1964-1970 and by the Consolidation Coal Company from 1971 through 1983. The mine targeted the Herrin Coal at a depth of 500 to 510 feet below ground surface (bgs), and geological reports included roof problems and slight floor heaving. The Clover Leaf No. 4 Mine located north of the GSP was operated by the Clover Leaf Coal Mining company and the Coffeen Coal Mining Company from 1906 through 1924. The mine targeted the Herrin Coal at a depth of 510 to 544 feet bgs. Geologic reports indicate a massive black shale roof, and unmined areas which could be related to water-bearing sandstones above the roof [17].

2.3.5 Water Table Elevation and Groundwater Flow Direction

Porewater (*i.e.,* CCR source water) elevations within AP2 (as observed in AP2-D) are greater than the surrounding areas. The phreatic surface within AP2 in 2023 averaged approximately 624.1 feet, ranging from 623.7 to 624.8 feet (**Appendix B**). As indicated in **Section 2.3.2**, UA groundwater is typically separated from overlying CCR material by several feet of the low permeability soils of the UCU, except along the eastern edge of AP2 where two incised stream gullies were backfilled to construct the eastern berm of AP2.

Overall groundwater flow within the UA is divided towards the two lobes of Coffeen Lake. The groundwater divide runs approximately through the center of the CPP, with groundwater east of the divide flowing east to southeast towards the Unnamed Tributary or the eastern lobe of Coffeen Lake and groundwater west of the divide flowing west to southwest towards the western lobe of Coffeen Lake. Groundwater flows southeast to east across AP2 (**Figure 2-5** and **Table 2-1**) toward the former discharge flume and Unnamed Tributary. Groundwater elevations are lowest near the Unnamed Tributary and east of AP2 towards the eastern lobe of Coffeen Lake. Based on the elevations of the tributary and groundwater elevations measured east of the tributary (**Appendix B** and **Table 2-1)**, the Unnamed Tributary may be a local groundwater receiving body and prevent or reduce groundwater migration east of the Unnamed Tributary. During 2023, groundwater elevations in the UA in the vicinity of AP2 ranged from approximately 601 to 621 feet (**Figure 2-5**). Although elevations vary seasonally, the groundwater flow direction in the UA is consistent and likely controlled by the proximity and hydraulic connection to both the eastern and western lobes of Coffeen Lake.

LCU (PMP) groundwater elevations are slightly lower than those in the UA and exhibit similar variability in seasonal groundwater elevation as the UA. Groundwater elevation within the LCU ranged from about 590 to 623 feet in 2023 (**Figure 2-5** and **Table 2-1**). LCU monitoring wells G1001, G1003, T408, and T409 are nearest AP2 and typically have groundwater elevations ranging from approximately 591 to 618 feet. Monitoring well G1003 was dry for the entirety of 2023 and groundwater elevation could not be established at this location.

DA (PMP) groundwater elevations are generally lower than those in the UA and LCU (PMP) and ranged from about 576 to 618 feet in 2023 (**Figures 2-6** and **Table 2-1**). Monitoring well G275D (south of the GMF RP) is nearest AP2 and typically had groundwater elevations ranging from about 576 to 589 feet during 2023. A groundwater contour map was generated for the DA for the E002 event and groundwater flow within the DA generally follows subsurface topography for the unit (**Figure 2-6**).

No monitoring wells were installed in the UCU during 2021 investigation activities and no wells have historically been installed across solely the UCU because it is not present or is unsaturated where present at the CPP. Groundwater elevations within the DCU and bedrock unit are unknown because no wells are screened within these low hydraulic conductivity units.

2.3.5.1 Vertical Hydraulic Gradients

Vertical hydraulic gradients were calculated using available groundwater elevation data from February 2017 to November 2023 at nested well locations within the UA, LCU (upper and lower), and DA. Vertical hydraulic gradients for AP2 are presented in **Table 2-2** and well locations are shown on **Figure 2-5**. Vertical hydraulic gradients for other nested well locations at the CPP, discussed below, are presented in **Appendix C**. The results of the vertical hydraulic gradient calculations between hydrostratigraphic units are summarized below:

- UA to Upper LCU (Vandalia Member):
  - Vertical gradients at well nest G405/T408, located north of AP2, vary between upward and downward with an average (downward) vertical gradient of 0.02 feet per foot (ft/ft).
  - Vertical gradients at well nest G406/T409, located south of AP2/northwest of AP1, vary between upward and downward with an average (upward) vertical gradient of -0.06 ft/ft. Since 2021, the vertical gradient observed at this well nest has been consistently upward, with the exception of August 2022.
- Upper LCU (Vandalia Member) to Lower LCU (Smithboro Member)
  - Well nest T408/G45D, located north of AP2, has consistently downward vertical gradients, with an average vertical gradient of 0.98 ft/ft. Beginning in 2020, vertical gradients observed at this well nest have become less strongly downward.

  - Vertical gradients at well nest G406/T409, located south of AP2/northwest of AP1, are consistently downward, with the exception of August 2022, with an average vertical gradient of 0.64 ft/ft. Beginning in 2020, vertical gradients observed at this well nest have become less strongly downward.
- UA to Lower LCU (Smithboro Member)
  - Well nest G307/G307D, located south of AP1, has consistently downward vertical gradients with an average vertical gradient of 0.13 ft/ft.
  - In well nest G311/G311D gradients are consistently strongly downward, with an average vertical gradient of 0.71 ft/ft.
- LCU to DA
  - Vertical gradients at well nest G314/G314D, located east of AP1, are consistently downward, with an average vertical gradient of 0.69 ft/ft. Beginning in 2022, vertical gradients observed at this well nest have become progressively less strongly downward and the vertical gradient was observed to be upward (-0.01 ft/ft) during December 2023.

Vertical hydraulic gradients indicate there is consistently downward migration of groundwater in most areas of the CPP, with the exception being southwest of AP2, where consistent upward gradients were measured between the UA and upper LCU. However, there has been a decrease in magnitude of downward gradients since approximately 2020, which is likely a result of plant shutdown and placement of a geomembrane on AP2.

2.3.5.2 Impact of Surface Water Bodies on Groundwater Flow

Surface water elevations were measured from various locations along the Unnamed Tributary from March 2021 to December 2023 (**Figure 2-5**). Elevations at SG-04 (near CIPS Trail and determined to be destroyed in October 2023) ranged from 591.94 to 593.38 feet. Surface water elevations near the former discharge flume located between AP1 and AP2 were measured at SG-02 and ranged from 598.34 to 598.75 feet. Surface water elevations from Coffeen Lake at SG-03 (near the outfall east of AP1) ranged from 585.09 to 589.97 feet.

Groundwater contour maps prepared from elevation data measured in monitoring wells indicate groundwater elevations can be variable, but flow directions are generally consistent.

Groundwater near AP2 discharges locally to the former discharge flume to the south and the Unnamed Tributary to the east, which flows south into the eastern lobe of Coffeen Lake. The Unnamed Tributary is a local groundwater receiving body that may prevent or reduce groundwater migration east of the Unnamed Tributary.

Construction of the LF, GMF GSP, and GMF RP required removal of the Hagarstown Member, in effect removing the aquifer beneath the footprint of these units [18]. It is uncertain whether these constructed units significantly limit lateral groundwater flow, either by creating no flow zones, or by capturing groundwater via their dewatering [19].

2.3.6 Hydraulic Conductivities

2.3.6.1 Field Hydraulic Conductivities

Field hydraulic conductivity tests were performed historically by Hanson as part of initial characterization efforts for the CPP [13]. In 2021, additional field hydraulic conductivity tests were completed by Hanson to support 35 I.A.C. § 845 requirements for AP1, the GMF GSP, and the GMF RP [20, 21, 22]. Historical field hydraulic conductivity test results are included in **Appendix D** and tests completed for other CCR units in 2021 are included in **Appendix E** [13].The results of the tests are summarized as follows:

- **UA:** Historical tests completed in UA monitoring wells (G401, G402, G403, G404, and G405) indicated hydraulic conductivities ranged from 4.3 x 10^{-5} to 9.8 x 10^{-4} cm/s, with a geometric mean of 2.7 x 10^{-4} cm/s.
- **LCU:** Historical tests completed in the LCU for monitoring wells and temporary piezometers (G45D, G46D, T408, and T409) indicated hydraulic conductivities ranged from 7.5 x 10^{-8} to 3.6 x 10^{-5} cm/s, with a geometric mean of 5.6 x 10^{-6} cm/s.
- **DA:** Geometric mean hydraulic conductivity at DA well G314D, near AP1, was 8.7 x 10^{-5} cm/s and was slightly lower than tests completed in the northern portion of the CPP in 2009 that estimated hydraulic conductivity values ranged from 1.3 x 10^{-4} to 1.7 x 10^{-3} cm/s, with a geometric mean of 4.4 x 10^{-4} cm/s.
- No monitoring wells are screened only within the DCU, and no field hydraulic conductivity tests have been conducted for the DCU.

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 investigations at the CPP [22, 21, 20] and historically [13]. The results are summarized in **Appendix D** and discussed below.

- **CCR:** No laboratory vertical hydraulic conductivity tests were completed during 2021 on CCR materials in AP2.
- **UCU:**
  - The 2021 sitewide geometric mean of vertical hydraulic conductivities of three samples collected from the UCU is 2.5 x 10^{-8} cm/s, which is consistent with historically reported values.
  - Geotechnical tests conducted prior to 2017 indicated UCU vertical hydraulic conductivity values ranged from 1.3 x 10^{-8} to 5.0 x 10^{-7} cm/s, with a geometric mean of 1.0 x 10^{-7} cm/s.
- **UA:** One geotechnical sample of UA material was collected from G275D, near the GMF RP and immediately northeast of AP2, with a vertical hydraulic conductivity of 1.6 x 10^{-4} cm/s.
- **LCU:**
  - The 2021 sitewide geometric mean of vertical hydraulic conductivities of three samples collected from the LCU is 1.8 x 10^{-7} cm/s. Vertical hydraulic conductivities from 2021 are consistent with those observed historically.
  - Intermittently present within the LCU is the Mulberry Grove Member. Historical vertical hydraulic conductivities of the Mulberry Grove Member were measured as 1.6 x 10^{-6} and 1.9 x 10^{-6} cm/s.
  - Historical laboratory tests reported LCU vertical hydraulic conductivity values ranged from 6.8 x 10^{-9} to 4.5 x 10^{-6} cm/s, with a geometric mean of 3.0 x 10^{-8} cm/s.

- **DA:** No laboratory vertical hydraulic conductivity tests were completed during 2021 on DA materials.
- **DCU**: No laboratory vertical hydraulic conductivity tests were completed during 2021 on DCU materials. Historical vertical hydraulic conductivity tests were performed on samples collected north and west of the GMF GSP. Vertical hydraulic conductivities of 6.8×10^{-9} and 4.5×10^{-6} cm/s were reported.
- **Bedrock**: No bedrock samples were analyzed for vertical hydraulic conductivity.

2.4 Groundwater Monitoring

The monitoring system for AP2 is shown on **Figure 2-2** and consists of three background monitoring wells (G270, G280, and G281), eight compliance monitoring wells (G401, G402, G403, G404, G405, G406, G407, and G1001), one water level only monitoring well (G1003), and three temporary water level only surface water staff gages (SG-02, SG-03, and SG-04) to monitor potential impacts from AP2 [23]. The monitoring wells are screened within the UA (G270, G280, G281, G401, G402, G403, G404, G405, G406, and G407) and LCU (G1001 and G1003) along the perimeter of AP2. Porewater samples are not regularly collected as part of the groundwater monitoring plan for AP2 (**Figure 2-2**), but porewater samples were collected from dewatering locations in 2016 [13], and a leachate sample was collected from the C102 PumpQbox in 2020 to provide information on the source concentrations. Additional porewater samples are collected as needed from an existing porewater monitoring well (AP2D) (**Figure 2-2**).

2.5 Hydrogeologic Conceptual Site Model

The HCR [13] and information provided above forms the foundation of the AP2 hydrogeological setting. AP2 overlies a potential recharge area for the underlying transmissive geologic media, which are composed of unlithified deposits. Recharge migrates downward into and through the UCU, into the UA, where present.

Groundwater flow in the UA at the CPP is divided towards the two lobes of Coffeen Lake. The loess of the UCU and sands of the UA are hydraulically connected. Groundwater flow in the silts and clays of the UCU and LCU is expected to be primarily vertical. The majority of horizontal groundwater migration is expected to be within the lower Hagarstown Member (*i.e.,* UA). The geologic conceptual model for the site used for closure plan groundwater modeling [24] consists of the following layers:

- Hagarstown Loess Unit (*i.e.,* UCU) – Loess Unit and the upper clayey portion of the Hagarstown Member.
- Hagarstown Member (*i.e.,* UA) – sand and sandy silts and clays at the base of the Hagarstown Member and, in some locations, the uppermost weathered sandy clay portion of the Vandalia Member.
- Vandalia Member/Mulberry Grove Member (*i.e.,* LCU) – unweathered sandy clay till and discontinuous silts.
- Smithboro Till (*i.e.,* LCU) – compacted clay till of the Smithboro Member.
- The Deep Aquifer (*i.e.,* DA) and Deep Confining Unit (*i.e.,* DCU) were not included in the model, for consistency with the original model [25].

The United States Geological Survey (USGS) National Map places the CPP within the East Fork Shoal Creek watershed subbasin (Hydrologic Unit Code 071402030303). The CPP conceptual site model (CSM) extent is bounded by a hydrological catchment (watershed) divide to the east based on watershed data from USGS. Along the north, south, and east, the model boundary was placed along known waterbodies as much as possible. As such, it is assumed groundwater inflow from adjacent watersheds is negligible through both the UA and LCU. The Coffeen Lake water levels are managed at an average elevation of 591.0 feet. Coffeen Lake and Unnamed Tributary are the receiving surface water bodies in the area encompassed by the CSM.

Precipitation infiltrates and recharges the groundwater table throughout the site and upgradient of the site. Groundwater in the UCU migrates downward into the sandy material of the lower Hagarstown Formation, or weathered Vandalia Till, which is considered the UA. The sands of the UA are separated from the base of CCR in AP2 by the laterally continuous low permeability UCU. Erosion caused by incised streams has occurred along the eastern side of AP2 which likely results in ash being in contact with the UA. Water that percolates downward from layers overlying the UA is most likely to travel laterally from the site within the UA due to the relatively high permeability (as compared to the underlying LCU) and horizontal gradients present within the UA as described above. Groundwater and surface water elevations indicate groundwater flows towards Coffeen Lake, which is a local receiving body for the UA. Further downward migration is also limited by the relatively thick and low permeability LCU.

Based on the geology and hydrogeology, monitoring wells at AP2 can be separated into two distinct groupings that exhibit similar geologic and hydraulic characteristics. Monitoring well groupings are summarized as follows:

- UA wells: shallow wells (generally less than 20 feet bgs) screened in moderate permeability materials (generally about 10^{-3} cm/s) including G270, G280, G281, G401, G402, G403, G404, G405, G406, and G407.
- LCU wells: shallow wells (less than 15 feet bgs) east of AP2 where the UCU and UA have been eroded (G1001 and G1003). LCU wells are screened across moderate permeability (generally about 10^{-4} cm/s) sand lenses within the low permeability till.

3. OCCURRENCE AND DISTRIBUTION OF GROUNDWATER EXCEEDANCES (EXTENT)

Results from groundwater samples collected from AP2 during E001, E002, and E003 were received on August 17, 2023; November 21, 2023; and January 10, 2024, respectively. 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 statistical exceedances of the GWPS was completed [9, 10, 11]. Statistical exceedances for which an ASD was not completed include the following parameters and wells by hydrostratigraphic unit:

- UA (**Figure 3-1**):
  - Boron at G401, G402, G404, and G405
  - pH at G401
  - Sulfate at G401, G402, G404, G405, and G406
  - TDS at G401, G402, G404, and G405

The extents of statistical exceedances discussed below were defined using existing monitoring wells, including wells present on-site (**Table 3-1** and **Figure 3-2**) that may not be included in the 35 I.A.C. § 845 monitoring program.

3.1 Additional Investigation to Define Nature and Extent

Following initial sampling in 2021, potential statistical exceedances of the GWPS were identified for the parameters and locations identified above [9, 10, 11]. A total of three borings were advanced later in 2021 adjacent to locations with potential statistical exceedances (G401 and G1001), and background well (G270). Solids samples were collected and analyzed for the following:

- 6010B for 7-step sequential extraction (arsenic, boron, cobalt, lithium, and molybdenum);
- EPA 6010B for Total Metals (aluminum, arsenic, beryllium, calcium, chromium, cobalt, iron, lead, lithium, manganese, molybdenum, and selenium);
- Bulk Mineralogy by Reitveld x-ray diffraction analysis;
- Bulk elemental composition by X-ray fluorescence
- Cation Exchange Capacity Analysis; and,
- Total Organic Carbon Analysis and Loss on Ignition.

Six surface water samples were collected later in 2021 to characterize the water quality in Coffeen Lake and supplement previous samples collected in 2016 (**Appendix F**) [26]. Surface water samples were analyzed for 35 I.A.C. § 845.600 parameters (total and dissolved), ferrous and ferric iron, major ions, and monitored natural attenuation parameters. Data from surface water sampling has been incorporated into this report where applicable.

3.2 Extent in the Uppermost Aquifer

Groundwater samples are evaluated quarterly and statistical 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 statistical exceedances, because there is no single value for LCLs.

3.2.1 Boron

Boron GWPS (2 milligrams per liter [mg/L]) statistical exceedances were encountered within the UA at monitoring well locations (G401, G402, G404, and G405). Concentrations of boron from locations where the GWPS was exceeded range from 1.1 to 21.2 mg/L (**Table 3-3**) and generally exhibit stable to declining trends except for G404. Concentrations of boron at G404 have increased from approximately 2.8 mg/L in 2020, prior to completion of closure, to 21 mg/L in November 2023. Review of porewater elevations within AP2 (Appendix X) indicate an increase during closure activities that has since stabilized and started to decline after closure was completed. Modeling completed as part of the Closure Plan [27] indicated that water levels beneath the cover system would equilibrate in approximately 46 years, suggesting that concentrations in G404 may be a result of altered flow conditions following placement of the geomembrane and closure of AP2.

The extents of statistical exceedances above the GWPS are defined laterally in the UA to the west by monitoring wells G403 and G406 (and additionally the groundwater divide running north-south across the CPP), to the east by the Unnamed Tributary and Coffeen Lake, and to the south by the former discharge flume (**Figure 3-1**). The boring logs from G1001 and G1003, and historical topographic maps, indicate that the UA has been eroded east of AP2 and statistical exceedances are not expected to extend a significant distance in these directions due to the absence of UA materials. The eastern lobe of Coffeen Lake is located approximately 200 feet downgradient of G402. The former discharge flume is located approximately 60 feet downgradient of G401. Comparison of water elevations indicates that groundwater migrates toward Coffeen Lake and the former discharge flume from AP2. The eastern extent of boron is defined downgradient by surface water sample CL-1, collected east of G402 from the eastern lobe of Coffeen Lake, which had a boron concentration of 0.1 mg/L (**Appendix F**). The southern extent of boron is defined downgradient by surface water samples D-1 and D-2, collected south of G402 from the former discharge flume, which had boron concentrations of 0.33 and 0.3 mg/L, respectively (**Appendix F**). Concentrations of boron at CL-1, D-1, and D-2 are a similar magnitude to boron concentrations measured in a Coffeen Lake background sample (BKG-1; 0.086 mg/L).

Downward migration of boron in the UA is inhibited by the underlying Vandalia Till, Mulberry Grove Member, and Smithboro Till which are, on average, greater than 15 feet thick at the site. Vertical hydraulic conductivity tests completed on samples of the LCU beneath the UA indicate hydraulic conductivities from 5.5 x 10^{-8} to 3.7 x 10^{-7} cm/s. This is very low relative to the horizontal hydraulic conductivity measured within the UA (geometric mean of 2.7 x 10^{-4} cm/s). The significant contrast in permeability (greater than two orders of magnitude) indicates groundwater will preferentially migrate horizontally toward the Unnamed Tributary and ultimately Coffeen Lake and the elevated boron concentrations will not extend into the underlying hydrostratigraphic units.

3.2.2 pH

Lower limit pH GWPS (6.5 Standard Units [S.U.]) statistical exceedances in the UA are limited to G401. Monitoring well G401 is located south of the south berm between AP2 and the former discharge flume. Measurements of pH in G401 range from 5.6 to 6.4 S.U. (**Table 3-3**). The extents of measurements less than the lower GWPS are defined laterally in the UA to the west by monitoring well G406, to the east by monitoring well G402, to the north by wells G404 and G405, and to the south by the former discharge flume (**Figure 3-1**). Measurements of pH from the former discharge flume (CLb in 2016) and Coffeen Lake (CL-1 and CL-2 in 2021) were 7.52, 8.90 and 8.13 S.U, respectively (**Appendix F**).

Downward migration of low pH conditions in the UA at G401 is inhibited by the underlying Vandalia Till, Mulberry Grove Member, and Smithboro Till which are, on average, greater than 15 feet thick at the site. Vertical hydraulic conductivity tests completed on samples of the LCU beneath the UA indicate hydraulic conductivities from 5.5×10^{-8} to 3.7×10^{-7} cm/s. This is very low relative to the horizontal hydraulic conductivity measured within the UA (geometric mean of 2.0×10^{-3} cm/s). The significant contrast in permeability (greater than two orders of magnitude) indicates groundwater will preferentially migrate horizontally toward and the former discharge flume and lower limit pH GWPS statistical exceedances will not extend into the underlying hydrostratigraphic units.

3.2.3 Sulfate

Sulfate statistical exceedances in the UA have been measured in monitoring wells G401, G402, G404, G405, and G406 for events E001, E002, and E003. Concentrations of sulfate in these wells ranged from 25 to 4,600 mg/L (**Table 3-3)**. The extents of the sulfate statistical exceedances are limited laterally to the west by the groundwater divide, running north-south across the CPP, to the east by the Unnamed Tributary and Coffeen Lake, and to the south by the former discharge flume. Erosion of the UA east of monitoring wells G402 and G404 limits migration of sulfate impacts horizontally as the LCU has a much lower hydraulic conductivity (See **Section 2.3.6**) than the materials in the UA. Migration of potentially impacted groundwater is expected to have a limited extent to the north and west as groundwater tends to flow south and east in the vicinity of AP2.

The eastern extent of sulfate is defined downgradient by surface water sample CL-1, collected east of G402 from the eastern lobe of Coffeen Lake, which had a sulfate concentration of 33 mg/L (**Appendix F**). The southern extent of sulfate is defined downgradient by surface water samples D-1 and D-2, collected south of G402 from the former discharge flume, which had sulfate concentrations of 110 and 69 mg/L, respectively (**Appendix F**). Concentrations of sulfate at CL-1, D-1, and D-2 are a similar magnitude as sulfate concentrations measured in a Coffeen Lake background sample (BKG-1; 36 mg/L).

Downward migration of sulfate in the UA is inhibited by the underlying Vandalia Till, Mulberry Grove Member, and Smithboro Till which are, on average, greater than 15 feet thick at the site. Vertical hydraulic conductivity tests completed on samples of the LCU beneath the UA indicate hydraulic conductivities from 7.5×10^{-8} to 3.6×10^{-5} cm/s. This is very low relative to the horizontal hydraulic conductivity measured within the UA (geometric mean of 2.7×10^{-4} cm/s). The significant contrast in permeability (up to four orders of magnitude) indicates groundwater will preferentially migrate horizontally toward Coffeen Lake and the elevated sulfate concentrations will not extend into the underlying hydrostratigraphic units.

3.2.4 Total Dissolved Solids

TDS results indicate the mass of dissolved material in groundwater and is a representation of multiple constituents present in the groundwater. Typically, major ions (such as sulfate) represent the primary contributors to TDS. TDS statistical exceedances in the UA are coincident with most of the sulfate statistical exceedances except for well G406, which has a sulfate statistical exceedance without a TDS statistical exceedance. TDS statistical exceedances in the UA have been measured in monitoring wells G401, G402, G404, and G405 for events E001, E002, and E003. Concentrations of TDS in these wells ranged from 1,250 to 2,800 mg/L during 2023 compliance sampling events (**Table 3-2)**. The extent of the TDS statistical exceedances, similar to sulfate, are limited laterally to the west by the groundwater divide running north-south across the CPP and to the east by the Unnamed Tributary and Coffeen Lake, to the south by the former discharge flume. Erosion of the UA east of monitoring wells G402 and G404 limits migration of sulfate impacts horizontally as the LCU has a much lower hydraulic conductivity (see **Section 2.3.6**) than the materials in the UA. Migration of potentially impacted groundwater is expected to have a limited extent to the north and west as groundwater in the vicinity of AP2 tends to flow south and east.

The eastern extent of TDS is defined downgradient by surface water sample CL-1 collected east of G402 from the eastern lobe of Coffeen Lake, which had a TDS concentration of 120 mg/L (**Appendix F**).The southern extent of sulfate is defined downgradient by surface water samples D-1 and D-2 collected south of G402 from the former discharge flume, which each had a TDS concentration of 240 mg/L (**Appendix F**). Concentrations of TDS at CL-1, D-1, and D-2 are a similar magnitude as TDS concentrations measured in a Coffeen Lake background sample (BKG-1; 72 mg/L).

Downward migration of TDS in the UA is inhibited by the underlying Vandalia Till, Mulberry Grove Member, and Smithboro Till which are, on average, greater than 15 feet thick at the site. Vertical hydraulic conductivity tests completed on samples of the LCU beneath the UA indicate hydraulic conductivities from 7.5×10^{-8} to 3.6×10^{-5} cm/s. This is very low relative to the horizontal hydraulic conductivity measured within the UA (geometric mean of 2.7×10^{-4} cm/s). The significant contrast in permeability (up to four orders of magnitude) indicates groundwater will preferentially migrate horizontally toward Coffeen Lake and the elevated TDS concentrations will not extend into the underlying hydrostratigraphic units.

4. GEOCHEMICAL CONCEPTUAL SITE MODEL (NATURE)

A GCSM was developed to describe the conditions of the groundwater in the vicinity of the CPP AP2 and is summarized here (full analysis presented in **Appendix G**). The GCSM describes the geochemical processes that contribute to the mobilization, distribution, and attenuation of chemicals in the environment. Only parameters that have exceeded the GWPS in AP2 groundwater and will be addressed in the Corrective Action Plan are included in the GCSM. As discussed in previous sections, the statistical exceedances observed at AP2 include boron, pH, sulfate, and TDS.

CCR porewater is water "collected from the interstitial water between waste particles in surface impoundments as it occurs in the field" [28] and represents the material potentially leached from impoundments. CCR materials are the primary source of constituent loading to CCR porewater (*i.e.*, CCR source water). Over an extended period (*e.g.*, months to years), CCR porewater (*i.e.*, water contained within the interstitial pore spaces of CCR that can be sampled by low-flow groundwater sampling methods) reaches equilibrium with the CCR materials. Porewater is therefore representative of the mobile phase constituents capable of migrating into the underlying materials and potentially downgradient in groundwater. AP2 CCR source water is therefore the primary indicator of constituents *available* to groundwater and is considered as the primary source term for environmental investigation and fate and transport modeling.

Conditions within UA groundwater are predicted to favor amorphous iron oxide stability at most locations, which indicates that a portion of the boron and sulfate in the groundwater system may be attenuated via surface complexation reactions. Attenuation of the constituents contributing to TDS, such as sulfate, will reduce TDS concentrations as well. Boron may be further attenuated via interactions with clay minerals, which are present in solids across the UA and LCU. Site-specific partition coefficients could not be calculated from the results of batch attenuation testing completed with solids from the site. These results indicate that chemical attenuation of boron and sulfate could be minimal. Low pH at one downgradient location is potentially caused by geochemical reactions driven by the mixing of porewater and groundwater, although the specific drivers are still under investigation.

5. COMBINED GEOCHEMICAL AND HYDROGEOLOGIC CONCEPTUAL SITE MODELS

5.1 Boron

The CSM describing current conditions at AP2 combining the hydrogeologic and geochemical CSMs for boron is as follows. Water that may come into contact with CCR in AP2 becomes porewater within the closed and geomembrane capped CCR unit. Porewater containing elevated concentrations of boron is capable of migrating into and mixing with groundwater of the UA. Groundwater within the higher hydraulic conductivity zones of the UA in the vicinity of AP2 travels horizontally south and southeast outward from AP2. The horizontal migration of groundwater outward from AP2 is influenced by groundwater flow gradients towards adjacent receiving water bodies, including the former discharge flume, Unnamed Tributary, and ultimately into the east lobe of Coffeen Lake.

Conditions within the UA are predicted to favor amorphous iron oxide stability at most locations and the presence of iron oxides in some site solids indicates a portion of the boron in the groundwater system may be attenuated via surface complexation reactions. Boron may be further attenuated via interactions with clay minerals, which are present in solids across the UA and LCU. However, batch attenuation testing results indicate that chemical attenuation of boron downgradient of AP2 could be minimal.

5.2 pH Conceptual Site Model

The CSM describing current conditions at AP2 combining the hydrogeologic and geochemical CSMs for pH is as follows. Water that may come into contact with CCR in AP2 becomes porewater within the closed and geomembrane capped CCR unit. Porewater with a geochemical signature distinct from groundwater is capable of migrating into and mixing with groundwater of the UA. Statistical exceedances of sulfate and TDS indicate that AP2 porewater is influencing groundwater at G401. AP2 porewater does not have sufficiently low pH to directly cause the pH values observed at G401, suggesting that geochemical reactions driven by interaction of porewater with the underlying UCU materials and/or mixing of porewater with groundwater may cause a low pH. These reactions may include iron oxidation and precipitation or carbonate mineral precipitation. Geochemical modeling to support evaluation of corrective actions may clarify the drivers of low pH at AP2.

5.3 Sulfate and TDS Conceptual Site Model

The CSM describing current conditions at AP2 combining the hydrogeologic and geochemical CSMs for sulfate and TDS is as follows. Water that may come into contact with CCR in AP2 becomes porewater within the closed and geomembrane capped CCR unit. Porewater containing elevated concentrations of sulfate and TDS is capable of migrating into and mixing with groundwater of the UA. Groundwater within the higher hydraulic conductivity zones of the UA in the vicinity of AP2 travels horizontally south and southeast outward from AP2. The horizontal migration of groundwater south and southeast outward from AP2 is influenced by groundwater flow gradients towards adjacent receiving water bodies, including the former discharge flume, Unnamed Tributary, and ultimately into the east lobe of Coffeen Lake.

Conditions within UA groundwater are predicted to favor amorphous iron oxide stability at most locations and the presence of iron oxides in some site solids indicates a portion of the sulfate in the groundwater system may be attenuated via surface complexation reactions. Attenuation of the constituents contributing to TDS, such as sulfate, will reduce TDS concentrations as well. However, batch attenuation testing results indicate that chemical attenuation of sulfate downgradient of AP2 could be minimal.

Surface water samples collected from the former discharge flume and Coffeen Lake indicate concentrations are below the GWPS. In addition, a screening level human health and ecological risk assessment [8] was performed to characterize potential risks to human and ecological receptors that may be exposed to CCR constituents present in Coffeen Lake that may have originated from AP1. Given the similar CCR constituents and concentrations in AP1 and AP2, and the same local groundwater receiving bodies for each SI, the constituents of concern that were identified in the AP1 risk assessment are appropriate for assessing human health and ecological risks that may be attributable to AP2. The risk assessment evaluation considered contaminants of interest if the maximum detected constituent concentration in groundwater exceeded a human health-based benchmark or a maximum detected constituent concentrations in groundwater exceeded an ecological surface water benchmark protective of aquatic life. Based on the evaluation presented in the risk assessment, no unacceptable risks to human or ecological receptors in Coffeen Lake resulting from CCR exposures associated with AP1 (which has concentrations similar to AP2) were identified. This means that the risks from the site, in particular the migration of constituents in groundwater to Coffeen Lake that are attributable to either AP1 or AP2, are likely indistinguishable from normal background risks.

6. CONCLUSIONS AND FUTURE ACTIVITIES

In accordance with 35 I.A.C. § 845.650(d)(1), the nature and extent of GWPS statistical exceedances of boron, pH, sulfate, and TDS 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 AP2.

The lateral extents of statistical exceedances in the UA are illustrated in **Figure 3-1**. As discussed in **Sections 3.2.1** through **3.2.4**, boron, pH, sulfate, and TDS statistical exceedances are defined downgradient by surface water samples collected from the former discharge flume to the south of AP2, and by surface water samples collected from the east lobe of Coffeen Lake to the southeast of AP2. GWPS statistical exceedances of boron, pH, sulfate, and TDS are not expected to extend a significant distance to the west due to the north-south groundwater divide or to the north due to groundwater flow directions surrounding AP2. Boron, pH, sulfate, and TDS statistical exceedances are constrained vertically by the underlying Vandalia Till.

Boron was selected for modeling source control as presented in the Closure Plan [12] and Groundwater Modeling Report [25]. For modeling purposes, it was assumed that boron would not significantly sorb or chemically react with aquifer solids in the UA (soil adsorption coefficient [Kd] was set to 0 milliliters per gram), which is a conservative estimate for predicting contaminant transport times in the model. A Kd value of 0.7 cubic centimeters per gram was used for the UCU and LCU.

7. REFERENCES

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TABLES

Table 2-1. Summary of Groundwater Elevations
Nature and Extent Report
Coffeen Power Plant
Ash Pond No. 2
Coffeen, IL

Well ID	Well Type	Date	Depth to Groundwater (feet BMP)	Groundwater Elevation (feet NAVD88)
G1001	Compliance	05/30/2023	6.61	590.99
G1003	Water Level	05/30/2023	10.97	599.82
G270	Background	05/30/2023	5.06	620.79
G280	Background	05/30/2023	3.96	621.38
G281	Background	05/30/2023	6.64	619.71
G401	Compliance	05/30/2023	21.72	603.85
G402	Compliance	05/30/2023	10.56	602.80
G403	Compliance	05/30/2023	8.13	618.33
G404	Compliance	05/30/2023	5.42	610.24
G405	Compliance	05/30/2023	6.83	616.79
G406	Compliance	05/30/2023	13.06	612.29
G407	Compliance	05/30/2023	7.35	613.96
SG-02	Water Level	05/30/2023	7.47	598.40
SG-03	Water Level	05/30/2023	9.85	585.09
SG-04	Water Level	05/30/2023	6.41	593.11

Notes:
BMP = below measuring point
NAVD88 = North American Vertical Datum of 1988

Table 2-1. Summary of Groundwater Elevations
Nature and Extent Report
Coffeen Power Plant
Ash Pond No. 2
Coffeen, IL

Well ID	Well Type	Date	Depth to Groundwater (feet BMP)	Groundwater Elevation (feet NAVD88)
G1001	Compliance	08/08/2023	6.32	591.29
G1003	Water Level	08/08/2023	Dry	
G270	Background	08/14/2023	[8.52]	[617.34]
G280	Background	08/08/2023	5.80	619.55
G281	Background	08/08/2023	6.39	619.97
G401	Compliance	08/08/2023	21.75	603.82
G402	Compliance	08/08/2023	11.65	601.72
G403	Compliance	08/08/2023	7.45	619.02
G404	Compliance	08/14/2023	[5.62]	[610.05]
G405	Compliance	08/08/2023	6.85	616.78
G406	Compliance	08/08/2023	11.49	613.87
G407	Compliance	08/08/2023	8.79	612.53
SG-03	Water Level	08/08/2023	9.65	585.29

Notes:
Only wells with groundwater elevations measured are included.
BMP = below measuring point
Bracketing [ ] indicates that the measurement was obtained outside of the 24-hour period from initiation of depth to groundwater measurements.
NAVD88 = North American Vertical Datum of 1988

Table 2-1. Summary of Groundwater Elevations
Nature and Extent Report
Coffeen Power Plant
Ash Pond No. 2
Coffeen, IL

Well ID	Well Type	Date	Depth to Groundwater (feet BMP)	Groundwater Elevation (feet NAVD88)
G1001	Compliance	11/13/2023	6.49	591.12
G1003	Water Level	11/13/2023	Dry	
G270	Background	11/13/2023	10.90	614.96
G280	Background	11/13/2023	8.91	616.44
G281	Background	11/13/2023	8.59	617.77
G401	Compliance	11/13/2023	13.63	611.94
G402	Compliance	11/13/2023	11.71	601.66
G403	Compliance	11/13/2023	8.27	618.20
G404	Compliance	11/13/2023	6.48	609.19
G405	Compliance	11/13/2023	7.73	615.90
G406	Compliance	11/13/2023	13.83	611.53
G407	Compliance	11/13/2023	8.31	613.01
SG-02	Water Level	11/13/2023	7.36	598.51
SG-03	Water Level	11/13/2023	9.71	585.23
SG-04	Water Level	11/13/2023	Not Measured	

Notes:
Only wells with groundwater elevations measured are included.
BMP = below measuring point
NAVD88 = North American Vertical Datum of 1988

Table 2-2. Vertical Hydraulic Gradients

Nature and Extent Report
Coffeen Power Plant
Ash Pond No. 2
Coffeen, IL

Date	G405 Groundwater Elevation (ft NAVD88)	T408 Groundwater Elevation (ft NAVD88)	Head Change (ft)	Distance Change [1] (ft)	Vertical Hydraulic Gradient [2] (dh/dl)	
	UA	LCU (upper)				
2/4/2017	618.47	619.46	-0.99	12.00	-0.08	up
5/13/2017	618.74	619.00	-0.26	12.00	-0.02	up
7/8/2017	618.54	619.12	-0.58	12.00	-0.05	up
10/21/2017	614.47	614.81	-0.34	12.00	-0.03	up
5/8/2018	618.94	615.82	3.12	12.00	0.26	down
8/2/2018	617.55	614.45	3.10	12.00	0.26	down
10/23/2018	616.40	616.30	0.10	12.00	0.01	down
1/15/2019	616.81	617.01	-0.20	12.00	-0.02	up
8/5/2019	617.72	617.15	0.57	12.00	0.05	down
1/20/2020	619.28	619.13	0.15	12.00	0.01	down
8/10/2020	617.62	617.38	0.24	12.00	0.02	down
1/20/2021	617.12	616.85	0.27	12.00	0.02	down
4/20/2021	617.13	616.65	0.48	12.00	0.04	down
7/26/2021	617.37	617.21	0.16	12.00	0.01	down
8/16/2021	617.28	617.22	0.06	12.00	0.00	down
10/25/2021	618.12	615.50	2.62	12.00	0.22	down
2/7/2022	617.28	616.88	0.40	12.00	0.03	down
5/9/2022	617.91	617.78	0.13	12.00	0.01	down
8/23/2022	616.85	616.99	-0.14	12.00	-0.01	up
2/13/2023	617.50	617.16	0.34	12.00	0.03	down
5/30/2023	616.79	616.66	0.13	12.00	0.01	down
8/8/2023	616.78	616.62	0.16	12.00	0.01	down
10/24/2023	615.79	615.97	-0.18	12.00	-0.02	up
11/13/2023	615.90	616.06	-0.16	12.00	-0.01	up
			Middle of screen elevation G405D			610.0
			Middle of screen elevation T408			598.0

Table 2-2. Vertical Hydraulic Gradients

Nature and Extent Report
Coffeen Power Plant
Ash Pond No. 2
Coffeen, IL

Date	G406 Groundwater Elevation (ft NAVD88)	T409 Groundwater Elevation (ft NAVD88)	Head Change (ft)	Distance Change [1] (ft)	Vertical Hydraulic Gradient [2] (dh/dl)	
	UA	**LCU (upper)**				
2/4/2017	617.52	615.93	1.59	8.23	0.19	down
5/13/2017	616.20	616.75	-0.55	8.23	-0.07	up
7/8/2017	616.29	617.05	-0.76	8.23	-0.09	up
10/21/2017	611.27	612.16	-0.89	8.23	-0.11	up
5/8/2018	615.47	616.02	-0.55	8.23	-0.07	up
8/2/2018	615.75	615.25	0.50	8.23	0.06	down
10/23/2018	614.11	613.96	0.15	8.23	0.02	down
1/15/2019	615.36	614.78	0.58	8.23	0.07	down
8/5/2019	616.50	615.10	1.40	8.23	0.17	down
1/20/2020	617.48	617.16	0.32	8.23	0.04	down
8/10/2020	615.54	615.43	0.11	8.23	0.01	down
1/20/2021	612.97	614.41	-1.44	8.23	-0.17	up
4/20/2021	613.78	615.33	-1.55	8.23	-0.19	up
7/26/2021	614.20	615.72	-1.52	8.23	-0.18	up
8/16/2021	613.82	615.42	-1.60	8.23	-0.19	up
10/25/2021	614.93	616.43	-1.50	8.23	-0.18	up
2/7/2022	613.55	614.97	-1.42	8.23	-0.17	up
5/9/2022	615.36	616.81	-1.45	8.23	-0.18	up
8/23/2022	613.47	610.73	2.74	8.23	0.33	down
2/13/2023	614.11	615.65	-1.54	8.23	-0.19	up
5/30/2023	612.29	613.74	-1.45	8.23	-0.18	up
8/8/2023	613.87	615.02	-1.15	8.23	-0.14	up
10/24/2023	611.28	612.55	-1.27	8.23	-0.15	up
11/13/2023	611.53	613.01	-1.48	8.23	-0.18	up
			Middle of screen elevation G406			605.9
			Middle of screen elevation T409			597.7

Table 2-2. Vertical Hydraulic Gradients

Nature and Extent Report

Coffeen Power Plant

Ash Pond No. 2

Coffeen, IL

Date	T408 Groundwater Elevation (ft NAVD88)	G45D Groundwater Elevation (ft NAVD88)	Head Change (ft)	Distance Change [1] (ft)	Vertical Hydraulic Gradient [2] (dh/dl)	
	LCU (upper)	LCU (lower)				
2/4/2017	619.46	587.71	31.75	13.78	2.30	down
5/13/2017	619.00	586.19	32.81	13.78	2.38	down
7/8/2017	619.12	586.29	32.83	13.78	2.38	down
10/21/2017	614.81	584.69	30.12	13.78	2.19	down
5/8/2018	615.82	587.56	28.26	13.78	2.05	down
8/2/2018	614.45	585.81	28.64	13.78	2.08	down
10/23/2018	616.30	584.60	31.70	13.78	2.30	down
1/15/2019	617.01	586.96	30.05	13.78	2.18	down
8/5/2019	617.15	588.04	29.11	13.78	2.11	down
8/10/2020	617.38	614.21	3.17	13.78	0.23	down
1/20/2021	616.85	614.60	2.25	13.78	0.16	down
4/20/2021	616.65	614.32	2.33	13.78	0.17	down
7/26/2021	617.21	613.58	3.63	13.78	0.26	down
8/16/2021	617.22	613.83	3.39	13.78	0.25	down
10/25/2021	615.50	614.51	0.99	13.78	0.07	down
2/7/2022	616.88	615.01	1.87	13.78	0.14	down
5/9/2022	617.78	614.95	2.83	13.78	0.21	down
8/23/2022	616.99	614.58	2.41	13.78	0.17	down
2/13/2023	617.16	614.69	2.47	13.78	0.18	down
5/30/2023	616.66	613.99	2.67	13.78	0.19	down
8/8/2023	616.62	613.47	3.15	13.78	0.23	down
10/24/2023	615.97	613.40	2.57	13.78	0.19	down
11/13/2023	616.06	613.55	2.51	13.78	0.18	down
			Middle of screen elevation T408			598.0
			Middle of screen elevation G45D			584.2

Table 2-2. Vertical Hydraulic Gradients

Nature and Extent Report
Coffeen Power Plant
Ash Pond No. 2
Coffeen, IL

Date	T409 Groundwater Elevation (ft NAVD88)	G46D Groundwater Elevation (ft NAVD88)	Head Change (ft)	Distance Change [1] (ft)	Vertical Hydraulic Gradient [2] (dh/dl)	
	LCU (upper)	LCU (lower)				
2/4/2017	615.93	586.06	29.87	22.19	1.35	down
5/13/2017	616.75	584.87	31.88	22.19	1.44	down
7/8/2017	617.05	585.22	31.83	22.19	1.43	down
5/8/2018	616.02	585.86	30.16	22.19	1.36	down
8/2/2018	615.25	583.95	31.30	22.19	1.41	down
10/23/2018	613.96	582.05	31.91	22.19	1.44	down
1/15/2019	614.78	583.17	31.61	22.19	1.42	down
8/5/2019	615.10	583.68	31.42	22.19	1.42	down
8/10/2020	615.43	609.00	6.43	22.19	0.29	down
1/20/2021	614.41	610.49	3.92	22.19	0.18	down
4/20/2021	615.33	611.06	4.27	22.19	0.19	down
7/26/2021	615.72	607.21	8.51	22.19	0.38	down
8/16/2021	615.42	608.17	7.25	22.19	0.33	down
10/25/2021	616.43	609.87	6.56	22.19	0.30	down
2/7/2022	614.97	610.71	4.26	22.19	0.19	down
5/9/2022	616.81	611.34	5.47	22.19	0.25	down
8/23/2022	610.73	615.13	-4.40	22.19	-0.20	up
2/13/2023	615.65	610.39	5.26	22.19	0.24	down
5/30/2023	613.74	610.70	3.04	22.19	0.14	down
8/8/2023	615.02	610.14	4.88	22.19	0.22	down
10/24/2023	612.55	609.65	2.90	22.19	0.13	down
11/13/2023	613.01	609.70	3.31	22.19	0.15	down
			Middle of screen elevation T409			597.7
			Middle of screen elevation G46D			575.5

[O: KLT 6/4/21, C:YMD 6/7/21; U:KLT 8/25/21, C:EDP 8/31/21]
[KLT 5/3/24, C: 5/7/24]

Notes:

[1] Distance change was calculated using the midpoint of the piezometer screen and water table surface. If the water table surface was above the top of the monitoring well screen, then distance change was calculated using the midpoint of both screens.

[2] Vertical gradients between ±0.0015 are considered flat, and typically have less than 0.02 foot difference in groundwater elevation between wells.

- - = no data collected on date / no vertical gradient calculated
DA = deep aquifer
dh = head change
dl = distance change
ft = foot/feet
LCU (lower) = lower confining unit (Smithboro)
LCU (upper) = lower confining unit (Vandalia)
NAVD88 = North American Vertical Datum of 1988
PMP = potential migration pathway
UA = uppermost aquifer

Table 3-1. Monitoring Well Construction Details

Nature and Extent Report
Coffeen Power Plant
Ash Pond No. 2
Coffeen, 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)
G270	UA	02/26/2008	--	625.43	Top of Disk	623.73	13.13	17.92	610.60	605.81	18.27	605.50	4.8	2	39.0665638	-89.3974031
G280	UA	02/26/2008	625.35	625.26	Top of Riser	623.11	12.79	17.63	610.32	605.48	17.98	605.10	4.8	2	39.0672155	-89.3949916
G281	UA	09/08/2015	--	626.43	Top of Disk	623.82	15.51	20.16	608.31	603.66	20.3	603.50	4.7	2	39.0654052	-89.3993221
G401	UA	09/14/2015	--	625.57	Top of Disk	623.03	14.36	18.79	608.67	604.24	19.29	603.70	4.4	2	39.0602586	-89.3952949
G402	UA	08/27/2010	--	613.06	Top of Disk	610.36	10	20	600.36	590.36	20.4	590.00	10	2	39.0602071	-89.3917118
G403	UA	09/11/2015	--	626.24	Top of Disk	623.81	13.11	17.78	610.70	606.03	18.15	605.70	4.7	2	39.0631666	-89.3987788
G404	UA	05/01/2007	--	615.67	Top of Disk	613.57	6.42	11.17	607.15	602.40	11.62	601.60	4.8	2	39.0643292	-89.3924931
G405	UA	05/01/2007	--	623.41	Top of Disk	621.40	9.01	13.76	612.39	607.64	14.21	607.20	4.8	2	39.064345	-89.3962337
G406	UA	08/19/2016	625.36	625.05	Top of PVC	621.86	13.56	18.37	608.30	603.49	18.75	603.10	4.8	2	39.0603094	-89.3985078
G407	UA	08/16/2016	621.32	620.95	Top of PVC	618.35	13.78	18.61	604.57	599.74	19.04	598.40	4.8	2	39.0615735	-89.4020036
G1001	LCU	04/05/2021	597.61	597.78	Top of PVC	594.82	6	11	588.82	583.82	11	562.82	5	4	39.0633242	-89.39123631
G1003	LCU	05/25/2021	610.791	610.791	Top of PVC	608.01	8	12	600.01	596.01	14.79	587.01	4	2	39.06077048	-89.3914461

Notes:

All elevation data are presented relative to the North American Vertical Datum 1988 (NAVD88), GEOID 12A
-- = not measured/recorded
bgs = below ground surface
ft = foot or feet
HSU = Hydrostratigraphic Unit
LCU = Lower Confining Unit
PVC = polyvinyl chloride
UA = Uppermost Aquifer

Table 3-2. Exceedance Parameter Statistical Results

Nature and Extent Report
Coffeen Power Plant
Ash Pond No. 2
Coffeen, IL

Location	Parameter	Unit	Groundwater Protection Standard	2023 Q2 LCL	2023 Q3 LCL	2023 Q4 LCL
G401	Boron, total	mg/L	2	3.50	3.50	3.50
G402	Boron, total	mg/L	2	4.43	4.50	5.44
G404	Boron, total	mg/L	2	5.52	6.35	7.42
G405	Boron, total	mg/L	2	9.19	9.25	9.42
G401	Cobalt, total	mg/L	0.006	0.0629	0.0656	0.0692
G401	Sulfate, total	mg/L	400	2,000	2,000	1,410
G402	Sulfate, total	mg/L	400	442	427	393
G404	Sulfate, total	mg/L	400	422	452	478
G405	Sulfate, total	mg/L	400	412	436	442
G406	Sulfate, total	mg/L	400	450	450	450
G407	Sulfate, total	mg/L	400	440	440	830
G401	Total Dissolved Solids	mg/L	1,200	2,800	2,800	2,800
G402	Total Dissolved Solids	mg/L	1,200	1,310	1,300	1,290
G404	Total Dissolved Solids	mg/L	1,200	1,250	1,300	1,320
G405	Total Dissolved Solids	mg/L	1,200	1,530	1,540	1,540
G407	Total Dissolved Solids	mg/L	1,200	1,920	1,910	1,920
G401	pH (field)	SU	6.5/9.0	5.9/6.1	5.9/6.1	5.9/6.1

Notes:

LCL = Lower Confidence Level
mg/L = milligrams per liter
SU = standard units

Table 3-3. Summary of Groundwater Data

Nature and Extent Report
Coffeen Power Plant
Ash Pond No. 2
Coffeen, IL

HSU	Location	Parameter	Unit	Sample Count	Non-Detect Result Count	Percent Non-Detect Results	First Sample	Last Sample	Minimum	Median	Mean	Maximum
LCU	G1001	Boron, total	mg/L	4	0	0	05/12/2021	11/14/2023	0.720	1.03	1.04	1.40
LCU	G1001	Cobalt, total	mg/L	4	1	25	05/12/2021	11/14/2023	0.000200	0.00119	0.0129	0.0490
LCU	G1001	Sulfate, total	mg/L	4	0	0	05/12/2021	11/14/2023	140	236	310	630
LCU	G1001	Total Dissolved Solids	mg/L	3	0	0	02/15/2023	11/14/2023	830	900	1,143	1,700
LCU	G1001	pH (field)	SU	3	0	0	02/15/2023	11/14/2023	6.8	6.97	6.92	7.0
UA	G270	Boron, total	mg/L	39	25	64	01/20/2015	11/17/2023	<0.0071	0.0100	0.0170	0.120
UA	G270	Cobalt, total	mg/L	37	34	92	04/13/2015	11/17/2023	0.000200	0.00200	0.00170	<0.002
UA	G270	Sulfate, total	mg/L	39	0	0	01/20/2015	11/17/2023	48.0	54.0	62.4	140
UA	G270	Total Dissolved Solids	mg/L	39	0	0	01/20/2015	11/17/2023	340	420	436	570
UA	G270	pH (field)	SU	39	0	0	01/20/2015	11/17/2023	6.6	7.10	7.09	7.5
UA	G280	Boron, total	mg/L	40	19	48	01/21/2015	11/20/2023	<0.0071	0.0105	0.0539	1.00
UA	G280	Cobalt, total	mg/L	37	32	86	04/13/2015	11/20/2023	0.000200	0.00200	0.00195	0.00600
UA	G280	Sulfate, total	mg/L	40	0	0	01/21/2015	11/20/2023	43.0	82.0	100	910
UA	G280	Total Dissolved Solids	mg/L	40	0	0	01/21/2015	11/20/2023	350	460	476	1,100
UA	G280	pH (field)	SU	39	0	0	01/21/2015	11/20/2023	6.0	7.26	7.24	7.7
UA	G281	Boron, total	mg/L	35	19	54	11/20/2015	11/20/2023	<0.0071	0.0100	0.0170	0.110
UA	G281	Cobalt, total	mg/L	34	26	76	11/20/2015	11/20/2023	0.000400	0.00200	0.00189	0.00560
UA	G281	Sulfate, total	mg/L	35	0	0	11/20/2015	11/20/2023	140	280	287	380
UA	G281	Total Dissolved Solids	mg/L	35	0	0	11/20/2015	11/20/2023	700	870	866	1,000
UA	G281	pH (field)	SU	35	0	0	11/20/2015	11/20/2023	6.7	7.00	7.0	7.3
UA	G401	Boron, total	mg/L	28	0	0	11/21/2015	11/21/2023	1.10	3.90	3.77	5.37
UA	G401	Cobalt, total	mg/L	27	0	0	11/21/2015	11/21/2023	0.0460	0.240	0.222	0.420
UA	G401	Sulfate, total	mg/L	28	0	0	11/21/2015	11/21/2023	870	2,100	2,345	4,600
UA	G401	Total Dissolved Solids	mg/L	28	0	0	11/21/2015	11/21/2023	1,200	2,920	3,028	6,600
UA	G401	pH (field)	SU	30	0	0	11/21/2015	11/21/2023	5.6	6.00	6.03	6.4
UA	G402	Boron, total	mg/L	28	0	0	11/21/2015	11/21/2023	4.60	5.70	5.84	8.13
UA	G402	Cobalt, total	mg/L	27	5	19	11/21/2015	11/21/2023	0.000930	0.00370	0.00587	0.0190
UA	G402	Sulfate, total	mg/L	28	0	0	11/21/2015	11/21/2023	78.0	840	790	1,200
UA	G402	Total Dissolved Solids	mg/L	28	0	0	11/21/2015	11/21/2023	1,300	1,600	1,554	1,800
UA	G402	pH (field)	SU	28	0	0	11/21/2015	11/21/2023	6.4	6.79	6.76	7.3
UA	G403	Boron, total	mg/L	28	5	18	11/23/2015	11/20/2023	<0.0023	0.0309	0.0393	0.110
UA	G403	Cobalt, total	mg/L	27	13	48	11/23/2015	11/20/2023	<0.00048	0.00200	0.00201	0.00340
UA	G403	Sulfate, total	mg/L	28	0	0	11/23/2015	11/20/2023	4.90	34.5	34.7	74.0
UA	G403	Total Dissolved Solids	mg/L	28	0	0	11/23/2015	11/20/2023	270	355	369	508
UA	G403	pH (field)	SU	28	0	0	11/23/2015	11/20/2023	6.5	6.92	6.92	7.3
UA	G404	Boron, total	mg/L	29	0	0	10/07/2015	11/21/2023	1.40	4.10	5.68	21.2
UA	G404	Cobalt, total	mg/L	28	25	89	10/07/2015	11/21/2023	<0.00048	0.00200	0.00176	0.00330
UA	G404	Sulfate, total	mg/L	29	0	0	10/07/2015	11/21/2023	140	310	375	840

Table 3-3. Summary of Groundwater Data
Nature and Extent Report
Coffeen Power Plant
Ash Pond No. 2
Coffeen, IL

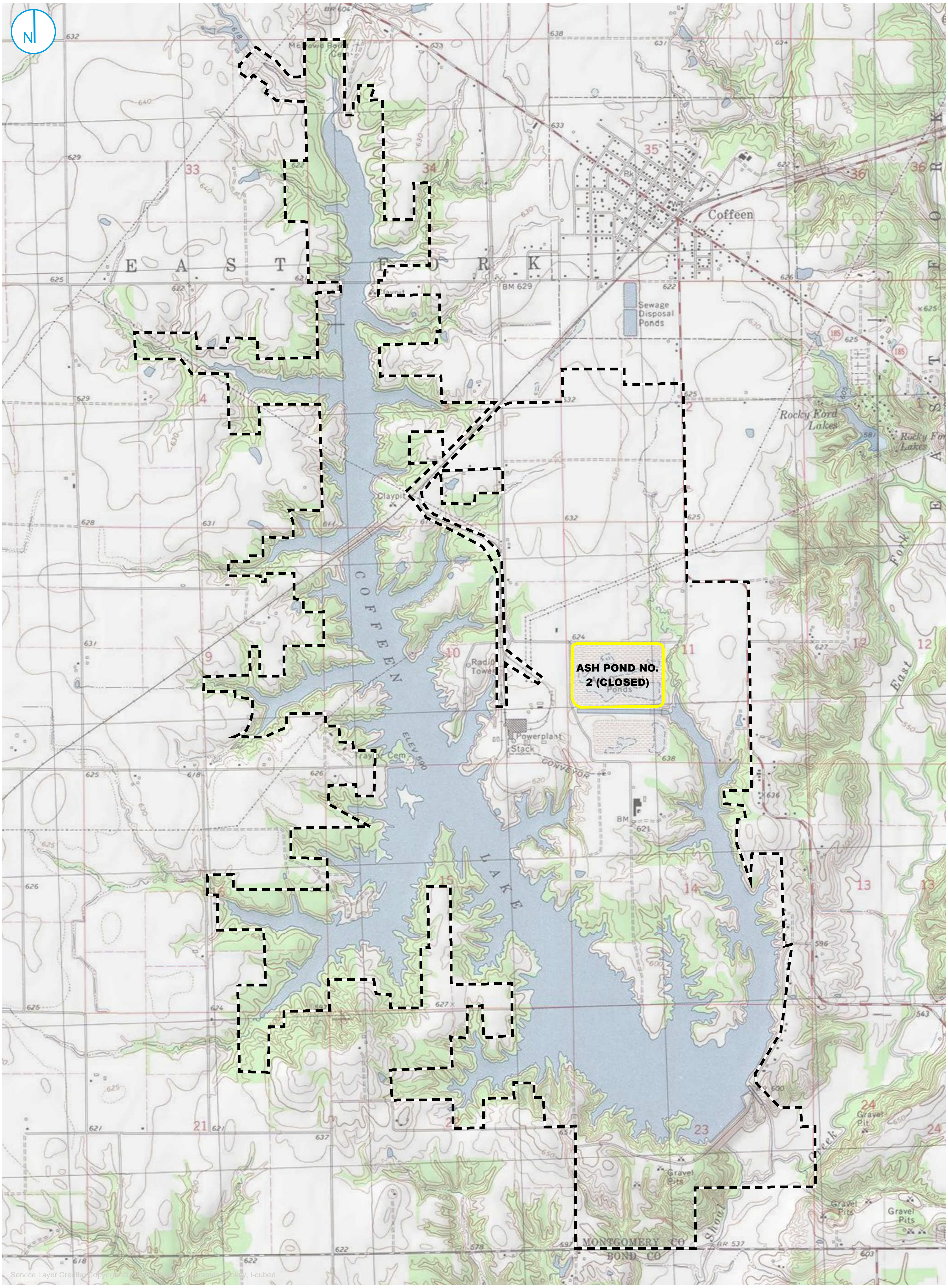
HSU	Location	Parameter	Unit	Sample Count	Non-Detect Result Count	Percent Non-Detect Results	First Sample	Last Sample	Minimum	Median	Mean	Maximum
UA	G404	Total Dissolved Solids	mg/L	29	0	0	10/07/2015	11/21/2023	460	950	1,037	1,900
UA	G404	pH (field)	SU	29	0	0	10/07/2015	11/21/2023	6.4	6.80	6.89	7.5
UA	G405	Boron, total	mg/L	29	0	0	10/07/2015	11/21/2023	4.00	10.8	11.3	20.0
UA	G405	Cobalt, total	mg/L	28	14	50	10/07/2015	11/21/2023	0.000790	0.00200	0.00211	0.00440
UA	G405	Sulfate, total	mg/L	29	0	0	10/07/2015	11/21/2023	340	1,000	1,095	1,900
UA	G405	Total Dissolved Solids	mg/L	29	0	0	10/07/2015	11/21/2023	720	1,700	1,763	2,900
UA	G405	pH (field)	SU	29	0	0	10/07/2015	11/21/2023	6.6	6.95	6.92	7.4
UA	G406	Boron, total	mg/L	13	0	0	10/14/2020	11/20/2023	0.170	1.50	1.44	2.29
UA	G406	Cobalt, total	mg/L	13	10	77	10/14/2020	11/20/2023	<0.00048	0.000800	0.00123	<0.002
UA	G406	Sulfate, total	mg/L	13	0	0	10/14/2020	11/20/2023	25.0	480	464	610
UA	G406	Total Dissolved Solids	mg/L	13	0	0	10/14/2020	11/20/2023	920	1,070	1,078	1,200
UA	G406	pH (field)	SU	13	0	0	10/14/2020	11/20/2023	6.4	6.56	6.60	7.0
UA	G407	Boron, total	mg/L	13	0	0	10/14/2020	11/20/2023	0.0614	0.0900	0.0970	0.150
UA	G407	Cobalt, total	mg/L	13	7	54	10/14/2020	11/20/2023	<0.00048	0.00200	0.00170	0.00620
UA	G407	Sulfate, total	mg/L	13	0	0	10/14/2020	11/20/2023	400	960	897	1,100
UA	G407	Total Dissolved Solids	mg/L	13	0	0	10/14/2020	11/20/2023	1,800	2,000	2,022	2,200
UA	G407	pH (field)	SU	13	0	0	10/14/2020	11/20/2023	6.4	6.66	6.65	6.9

Notes:
< = less than the method detection limit
HSU = Hydrostratigraphic Unit
LCU = Lower Confining Unit
mg/L = milligrams per liter
SU = standard units
UA = Uppermost Aquifer

FIGURES

PROJECT: 169000XXXX | DATED: 5/16/2024 | DESIGNER: GALARNMC

Y:\Mapping\Projects\22\2285\MXD\Nature_and_Extent\COF\Nature_and_Extent_Report\102\Figure 2-1_Site Location Map AP2.mxd



▭ REGULATED UNIT (SUBJECT UNIT)

▭ PROPERTY BOUNDARY

0 1,000 2,000
Feet

SITE LOCATION MAP

FIGURE 2-1

NATURE AND EXTENT REPORT
ASH POND NO. 2
COFFEEN POWER PLANT
COFFEEN, ILLINOIS

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL

▦ COMPLIANCE MONITORING WELL	▭ REGULATED UNIT (SUBJECT UNIT)
▦ BACKGROUND MONITORING WELL	▭ SITE FEATURE
▦ MONITORING WELL	▨ LIMITS OF FINAL COVER
◓ STAFF GAGE, RIVER	⬚ PROPERTY BOUNDARY
▦ PORE WATER WELL	

0 275 550
Feet

NOTE:
STAFF GAGE SG-04 WAS IDENTIFIED AS DESTROYED DURING OCTOBER 2023.

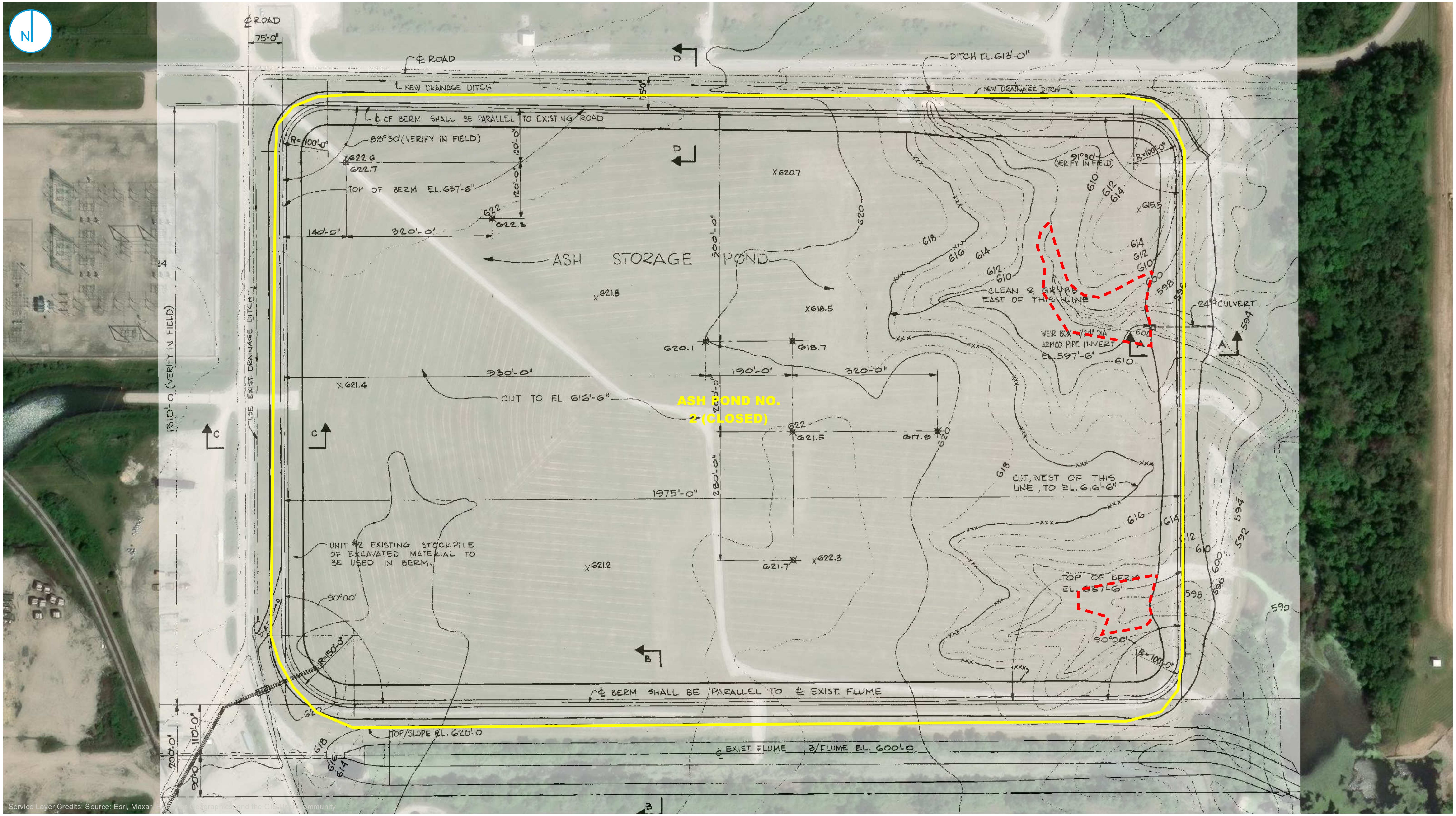
MONITORING WELL LOCATION MAP

FIGURE 2-2

NATURE AND EXTENT REPORT
ASH POND NO. 2
COFFEEN POWER PLANT
COFFEEN, ILLINOIS

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL



🟥 HAGARSTOWN BEDS POTENTIALLY IN CONTACT WITH ASH

🟨 REGULATED UNIT (SUBJECT UNIT)

0 100 200 Feet

NOTES:
BACKGROUND DRAWING SOURCE: SARGENT & LUNDY, 1/21/1971

BASE OF CCR

FIGURE 2-3

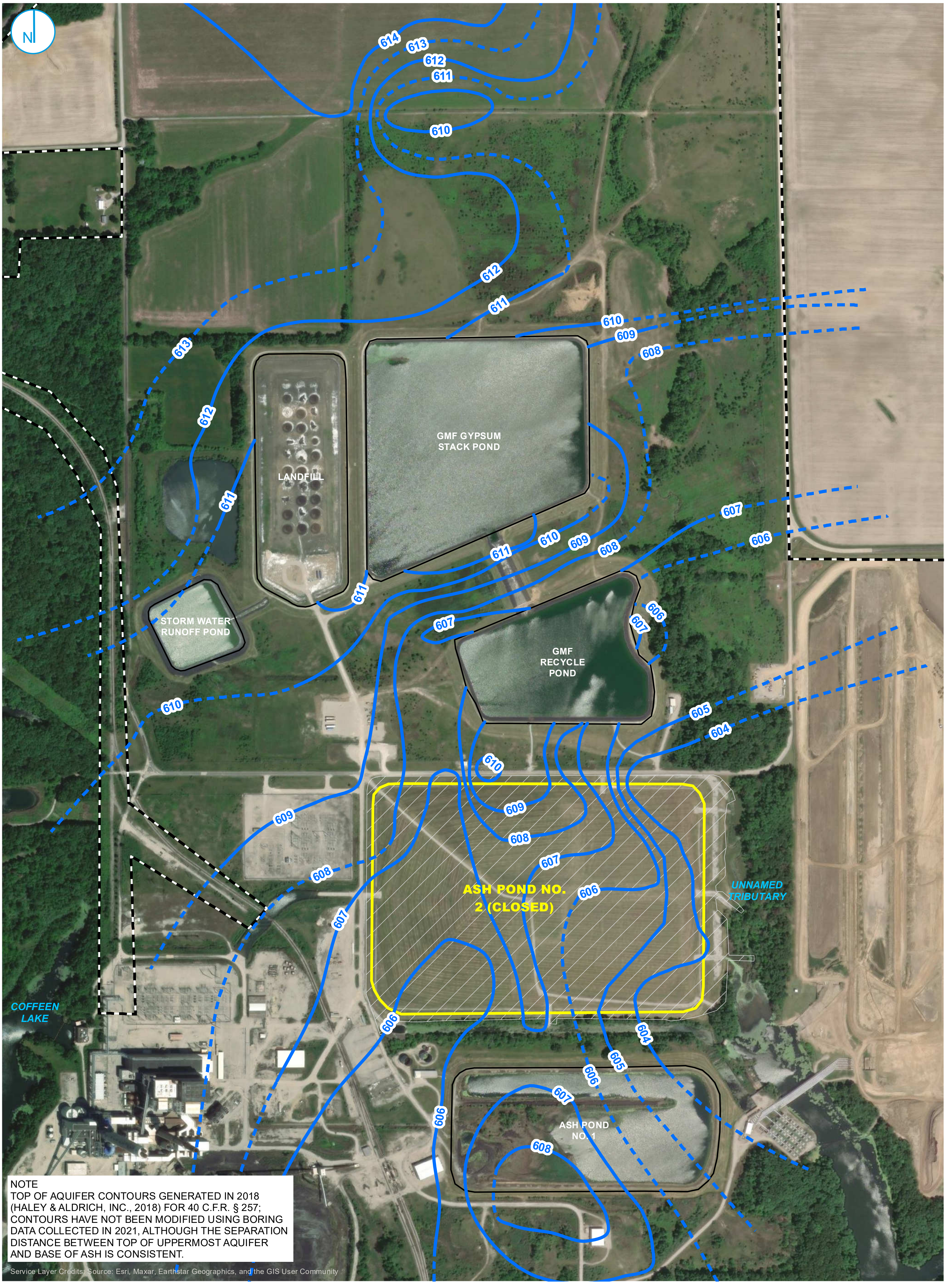
NATURE AND EXTENT REPORT
ASH POND NO. 2
COFFEEN POWER PLANT
COFFEEN, ILLINOIS

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL

Y:\Mapping\Projects\22\2285\MXD\Nature_and_Extent\COF\Nature_and_Extent_Report\102\Figure 2-4. Base of CCR.mxd

PROJECT: 169000XXXX | DATED: 6/6/2024 | DESIGNER: GALARNMC



NOTE
TOP OF AQUIFER CONTOURS GENERATED IN 2018 (HALEY & ALDRICH, INC., 2018) FOR 40 C.F.R. § 257; CONTOURS HAVE NOT BEEN MODIFIED USING BORING DATA COLLECTED IN 2021, ALTHOUGH THE SEPARATION DISTANCE BETWEEN TOP OF UPPERMOST AQUIFER AND BASE OF ASH IS CONSISTENT.

Service Layer Credits: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

- HAGARSTOWN MEMBER ELEVATION CONTOUR (1-FT INTERVAL, NAVD88)
- INFERRED HAGARSTOWN MEMBER ELEVATION CONTOUR
- REGULATED UNIT (SUBJECT UNIT)
- SITE FEATURE
- LIMITS OF FINAL COVER
- PROPERTY BOUNDARY

0 275 550
Feet

TOP OF UPPERMOST AQUIFER

FIGURE 2-4

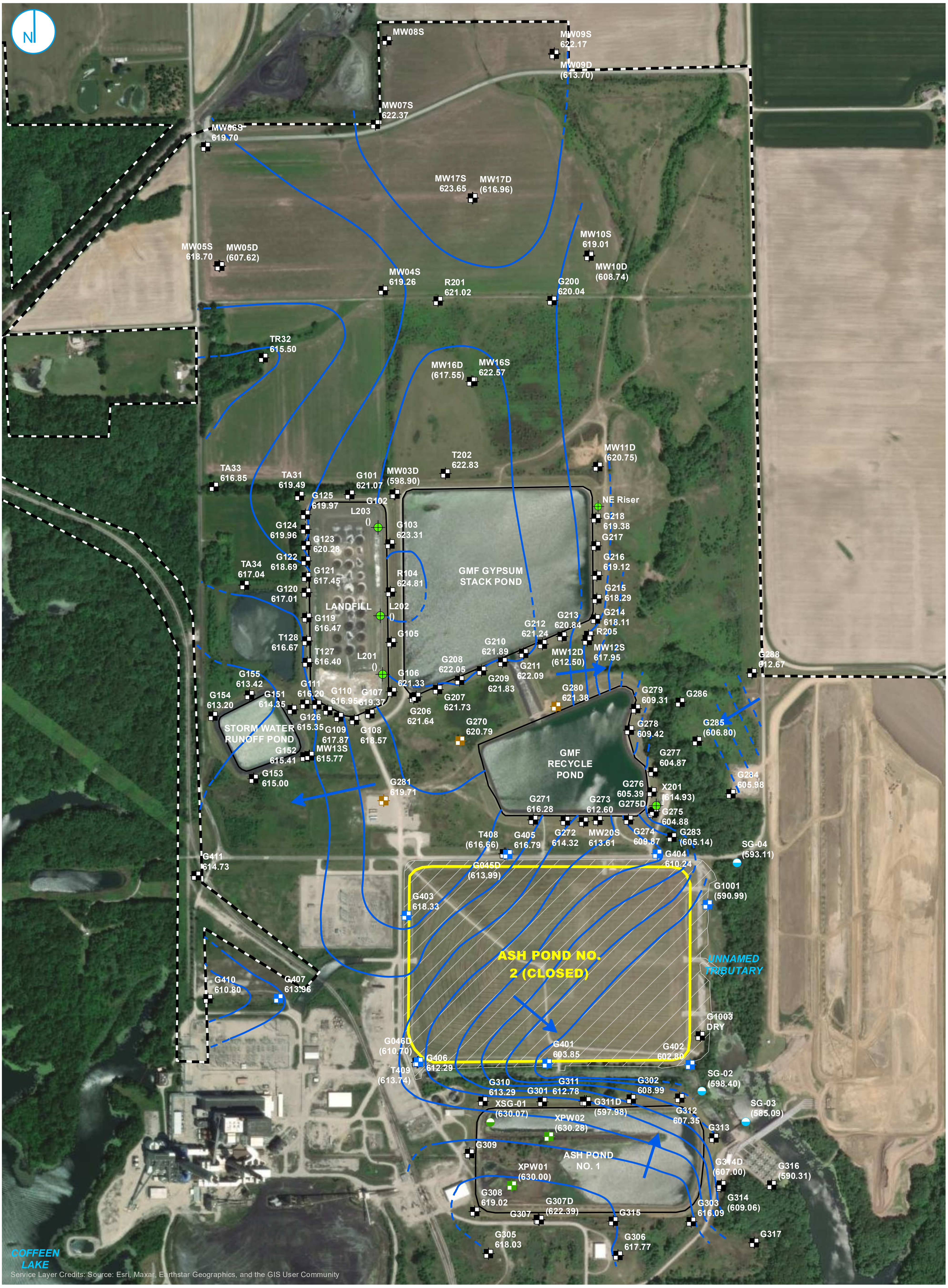
NATURE AND EXTENT REPORT
ASH POND NO. 2
COFFEEN POWER PLANT
COFFEEN, ILLINOIS

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL

PROJECT: 169000XXXX | DATED: 5/16/2024 | DESIGNER: GALARNMC

Y:\Mapping\Projects\22\2285\MXD\Nature_and_Extent\COF\Nature_and_Extent_Report\102\Figure 2-6. COF 102 Pot Surface 20230530.mxd



Service Layer Credits: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

🟦	COMPLIANCE MONITORING WELL
🟫	BACKGROUND MONITORING WELL
■	MONITORING WELL
🟩	PORE WATER WELL
⊕	LEACHATE WELL
◒	STAFF GAGE, CCR UNIT
◒	STAFF GAGE, RIVER
—	GROUNDWATER ELEVATION CONTOUR (2-FT CONTOUR INTERVAL, NAVD88)
- -	INFERRED GROUNDWATER ELEVATION CONTOUR
→	GROUNDWATER FLOW DIRECTION
🟨	REGULATED UNIT (SUBJECT UNIT)
☐	SITE FEATURE
▨	LIMITS OF FINAL COVER
⬚	PROPERTY BOUNDARY

0 325 650 Feet

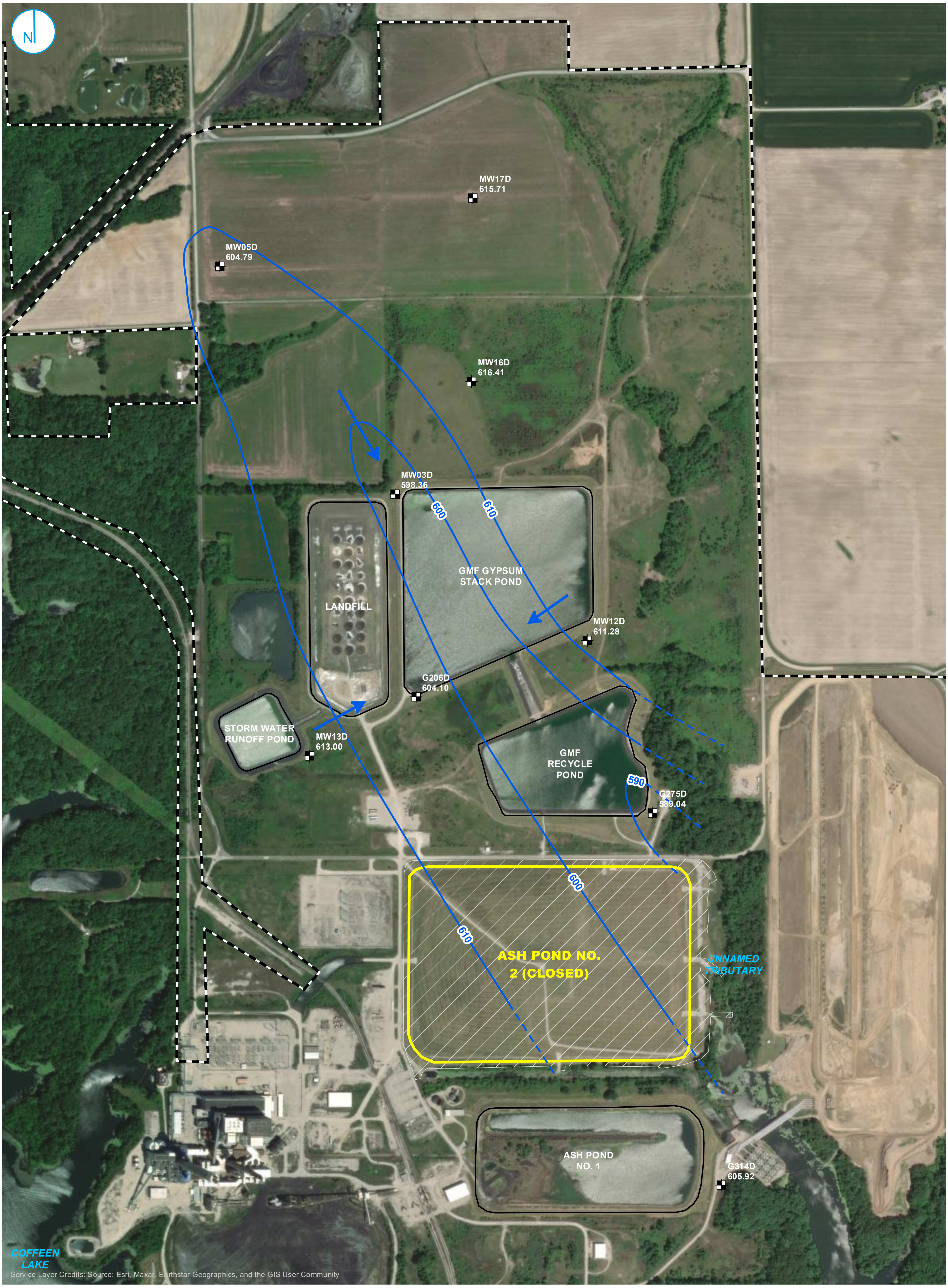
UPPERMOST AQUIFER POTENTIOMETRIC SURFACE MAP
MAY 30, 2023 (E001)

FIGURE 2-5

NATURE AND EXTENT REPORT
ASH POND NO. 2
COFFEEN POWER PLANT
COFFEEN, ILLINOIS

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL



Service Layer Credits: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

▪	MONITORING WELL
—	GROUNDWATER ELEVATION CONTOUR (2-FT CONTOUR INTERVAL, NAVD88)
- - -	INFERRED GROUNDWATER ELEVATION CONTOUR
→	GROUNDWATER FLOW DIRECTION
▭	REGULATED UNIT (SUBJECT UNIT)
▭	SITE FEATURE
▨	LIMITS OF FINAL COVER
⬚	PROPERTY BOUNDARY

0 325 650
Feet

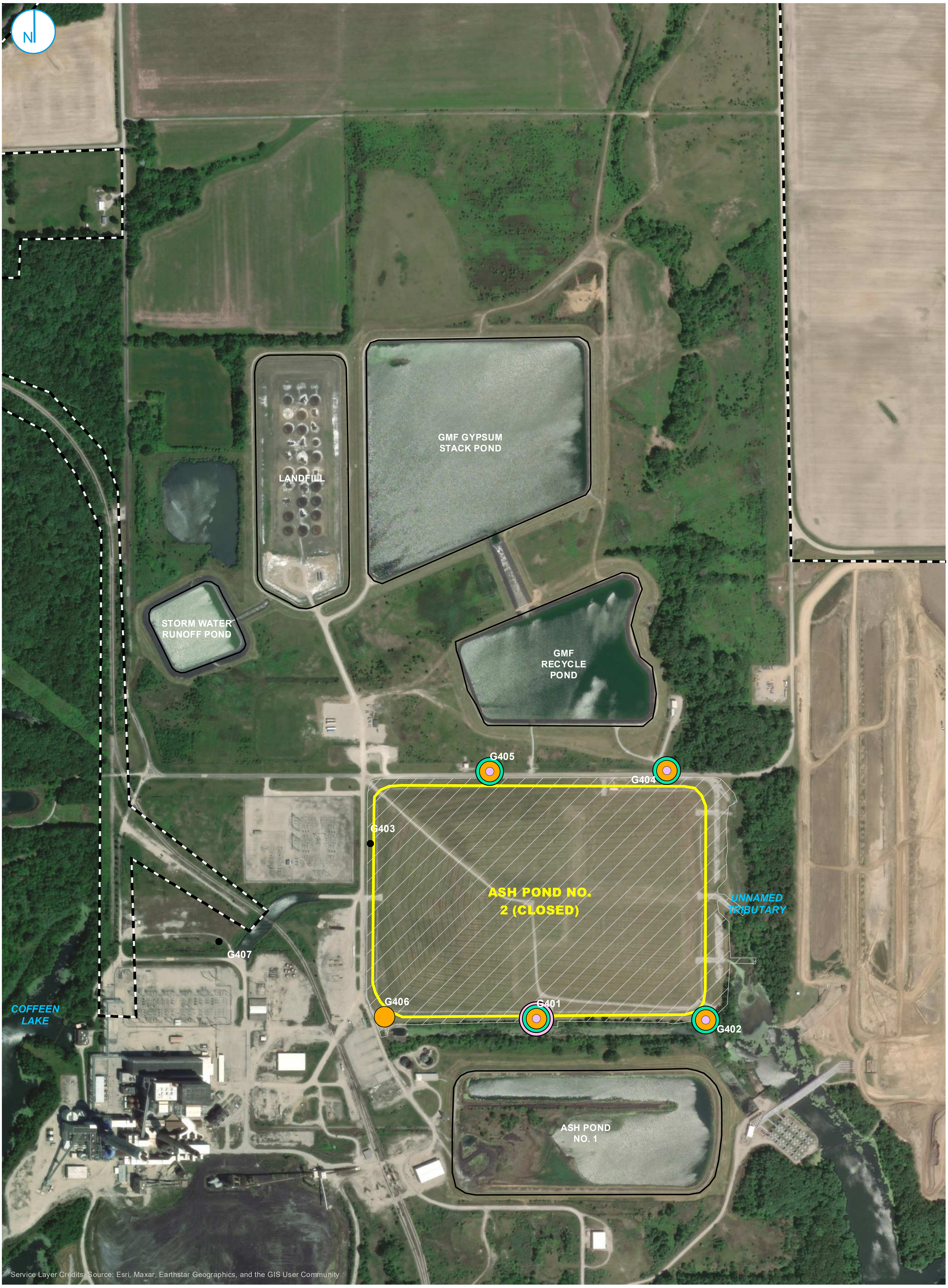
DEEP AQUIFER POTENTIOMETRIC SURFACE MAP
AUGUST 8, 2023 (E002)

NATURE AND EXTENT REPORT
ASH POND NO. 2
COFFEEN POWER PLANT
COFFEEN, ILLINOIS

FIGURE 2-6

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL



● TOTAL BORON EXCEEDANCE

● TOTAL SULFATE EXCEEDANCE

● TOTAL DISSOLVED SOLIDS EXCEEDANCE

● pH EXCEEDANCE

● COMPLIANCE WELL WITHOUT EXCEEDANCE

▭ REGULATED UNIT (SUBJECT UNIT)

▭ SITE FEATURE

▨ LIMITS OF FINAL COVER

▭ PROPERTY BOUNDARY

0 275 550 Feet

GWPS EXCEEDANCE MAP
UPPERMOST AQUIFER

FIGURE 3-1

NATURE AND EXTENT REPORT
ASH POND NO. 2
COFFEEN POWER PLANT
COFFEEN, ILLINOIS

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL

● COMPLIANCE WELL WITHOUT EXCEEDANCE

REGULATED UNIT (SUBJECT UNIT)

SITE FEATURE

LIMITS OF FINAL COVER

PROPERTY BOUNDARY

GWPS EXCEEDANCE MAP LOWER CONFINING UNIT

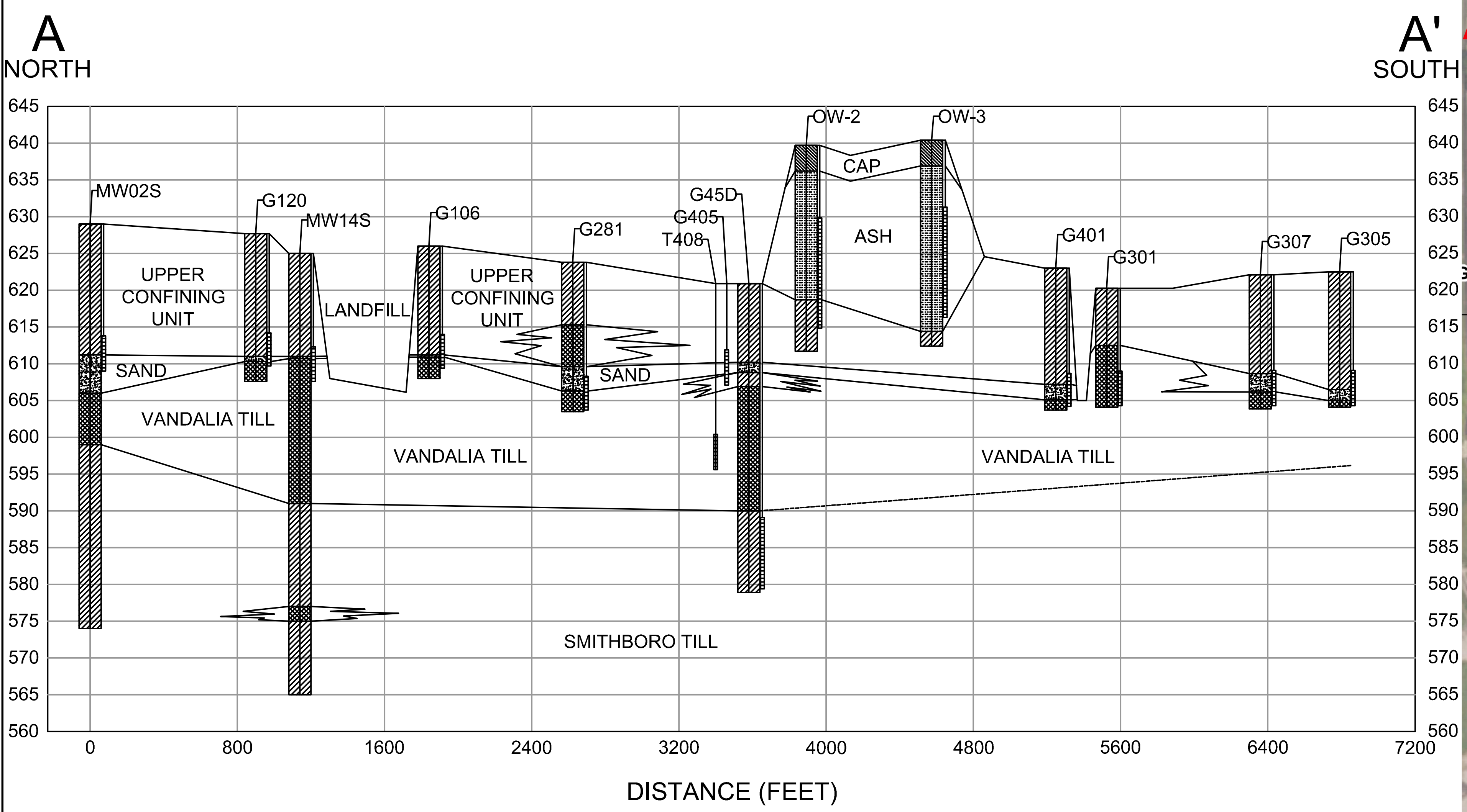
FIGURE 3-2

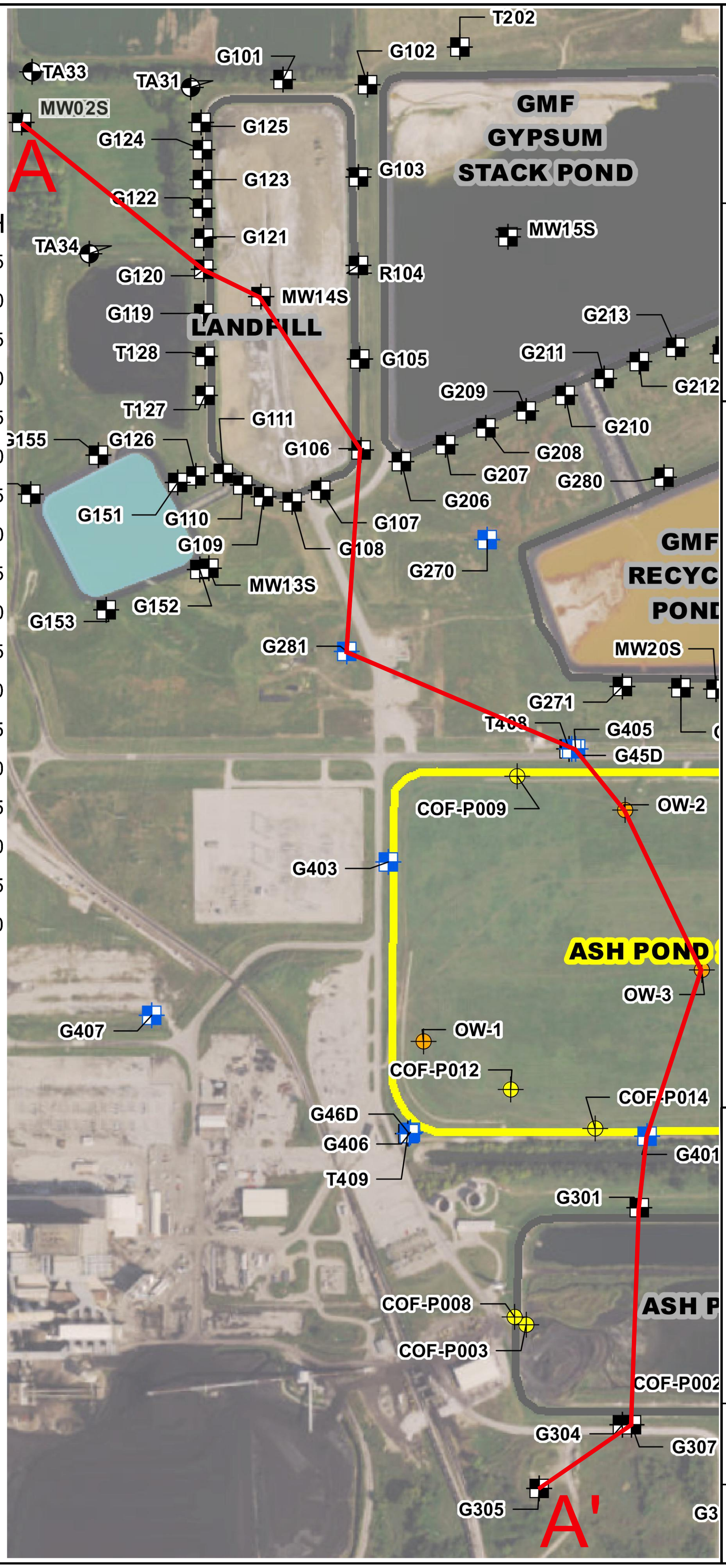
NATURE AND EXTENT REPORT
ASH POND NO. 2
COFFEEN POWER PLANT
COFFEEN, ILLINOIS

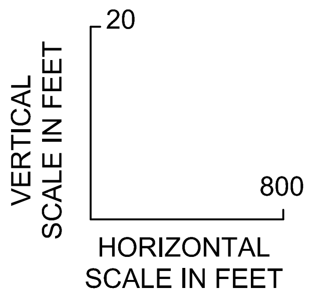
RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

APPENDICES

APPENDIX A
Hydrogeologic Characterization Report Cross-Sections







VERTICAL EXAGGERATION =40

B—B' CROSS-SECTION TRANSECT

▨ CLAY

▨ SOIL

▩ SAND

▩ SILT

▦ ASH

▥ WELL SCREEN

DRAWN BY: AGC DATE: 12/6/16

CHECKED BY: NRK DATE: 12/20/16

APPROVED BY: SJC DATE: 12/20/16

DRAWING NO: Fig 9_Geologic Cross-Section A-A'

REFERENCE: SEE INFO BLOCK

GEOLOGIC CROSS-SECTION A-A'

HYDROGEOLOGIC CHARACTERIZATION REPORT
ASH POND 2
COFFEEN POWER STATION
COFFEEN, IL

NATURAL
RESOURCE
TECHNOLOGY

PROJECT NO.
2380/2.0

FIGURE NO.
9

Dec 21, 2016 12:07pm PLOTTED BY: amillspaugh SAVED BY: acawrse
Y:\Mapping\Projects\23\2380\CAD\2-0\Figure 9_Geologic Cross-Section A-A'.dwg Layout1
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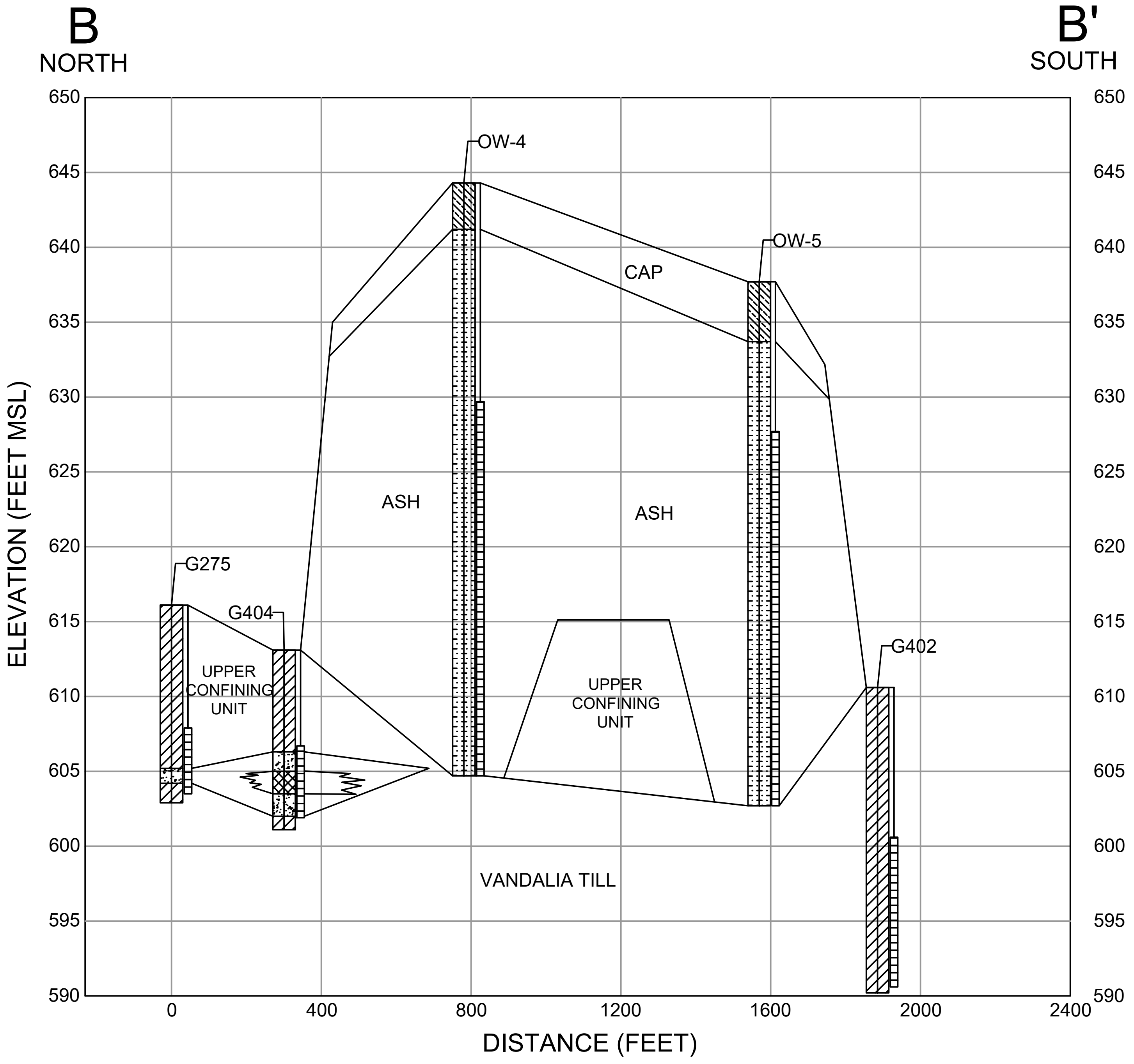
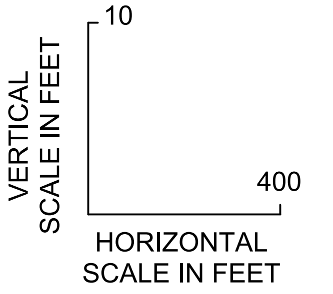
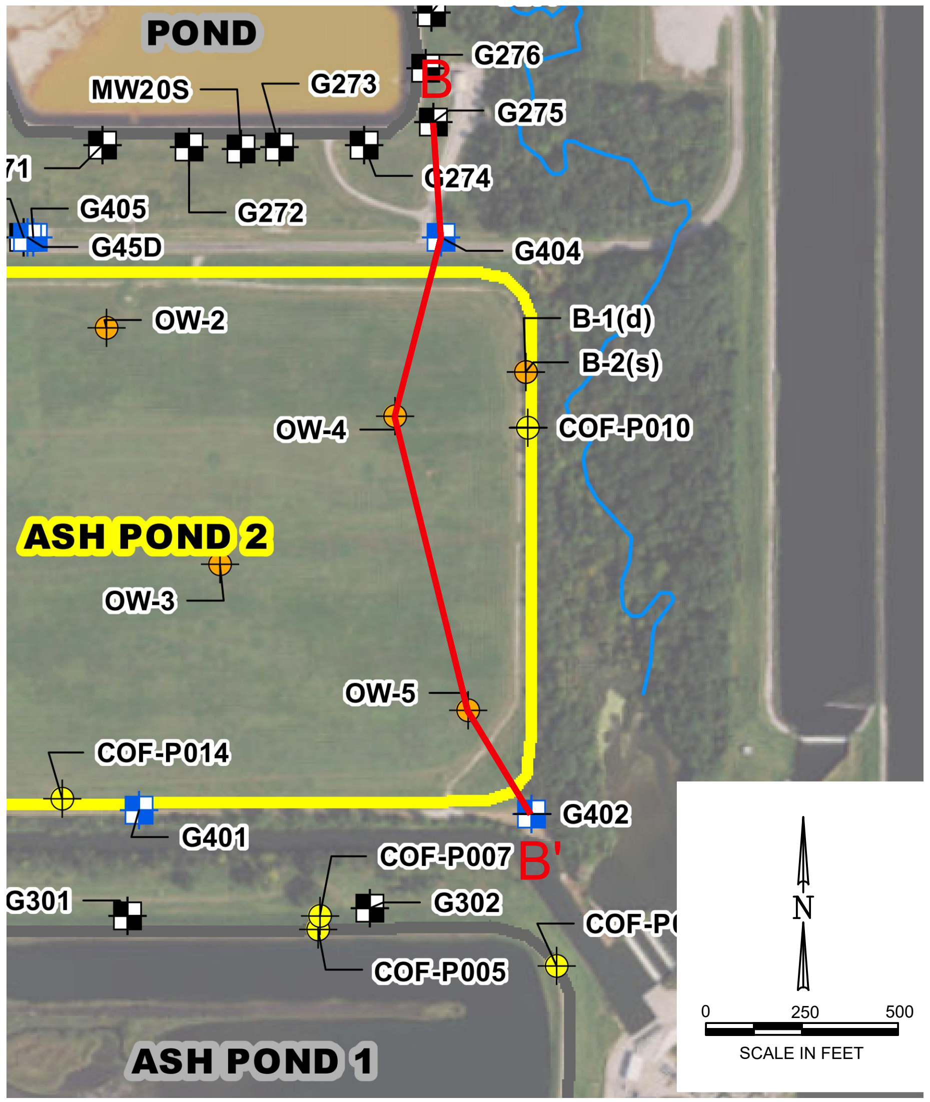


NOTE: FIGURE UPDATED IN 2024 TO MAINTAIN CONSISTENCY WITH CROSS-SECTION C-C'



VERTICAL EXAGGERATION =40

B — B' CROSS-SECTION TRANSECT
▨ CLAY
▨ SOIL
▒ SAND
▩ SILT
▤ ASH
▥ WELL SCREEN



DRAWN BY: AGC DATE: 11/30/16
CHECKED BY: NRK DATE: 12/20/16
APPROVED BY: SJC DATE: 12/20/16
DRAWING NO: Fig 10_Geologic Cross-Section B-B'
REFERENCE: SEE INFO BLOCK

GEOLOGIC CROSS-SECTION B-B'

HYDROGEOLOGIC CHARACTERIZATION REPORT
ASH POND 2
COFFEEN POWER STATION
COFFEEN, IL

NATURAL
RESOURCE
TECHNOLOGY

PROJECT NO.
2380/2.0

FIGURE NO.
10

Jun 11, 2024 8:25am PLOTTED BY: CAWRSEAG SAVED BY: CAWRSEAG
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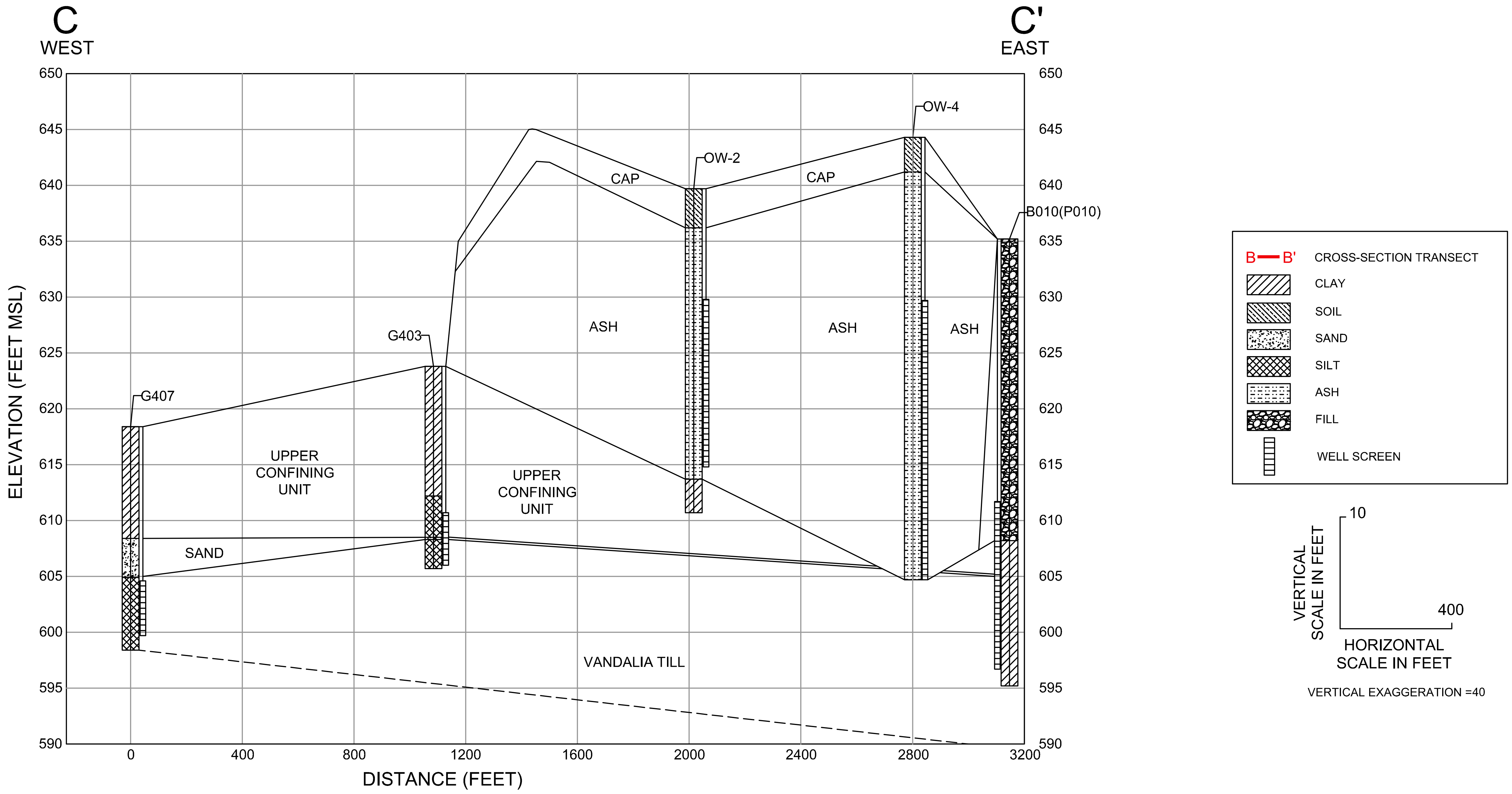

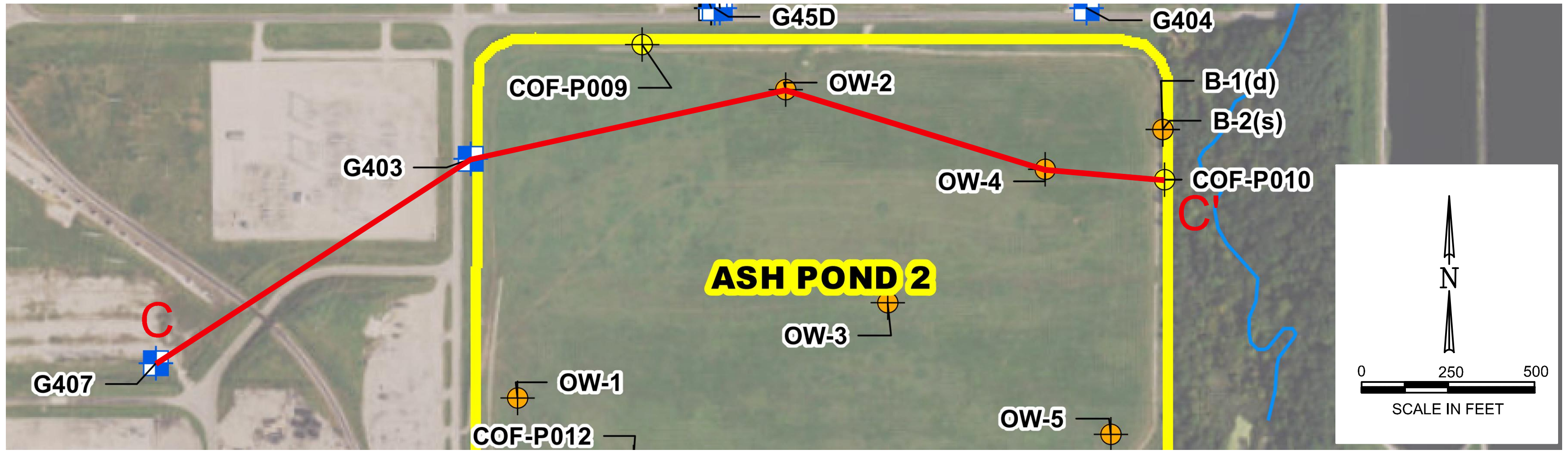

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APPROVED BY: SJC DATE: 12/20/16
DRAWING NO: Fig 11_Geologic Cross-Section C-C'
REFERENCE: SEE INFO BLOCK

GEOLOGIC CROSS-SECTION C-C'

HYDROGEOLOGIC CHARACTERIZATION REPORT
ASH POND 2
COFFEEN POWER STATION
COFFEEN, IL

NATURAL RESOURCE TECHNOLOGY

PROJECT NO.
2380/2.0

FIGURE NO.
11

Dec 21, 2016 12:13pm PLOTTED BY: amillspaugh SAVED BY: acawrse
Y:\Mapping\Projects\23\2380\CAD\2-0\Figure 11_Geologic Cross-Section C-C'.dwg Layout1
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APPENDIX B
Site-Wide Groundwater Elevations

Appendix B. Site-Wide Groundwater Elevations
Nature and Extent Report
Coffeen Power Plant
Ash Pond No. 2
Coffeen, IL

Well ID	Well Type	Monitored Unit	Date	Depth to Groundwater (feet BMP)	Groundwater Elevation (feet NAVD88)
G045D	Water Level	LCU	02/13/2023	9.12	614.69
G045D	Water Level	LCU	05/30/2023	9.82	613.99
G045D	Water Level	LCU	08/08/2023	10.34	613.47
G045D	Water Level	LCU	10/24/2023	10.41	613.40
G045D	Water Level	LCU	11/13/2023	10.26	613.55
G046D	Water Level	LCU	02/13/2023	14.85	610.39
G046D	Water Level	LCU	05/30/2023	14.54	610.70
G046D	Water Level	LCU	08/08/2023	15.10	610.14
G046D	Water Level	LCU	10/24/2023	15.59	609.65
G046D	Water Level	LCU	11/13/2023	15.54	609.70
G1001	Water Level	LCU	02/13/2023	6.12	591.49
G1001	Water Level	LCU	03/30/2023	6.09	591.51
G1001	Water Level	LCU	04/30/2023	6.53	591.07
G1001	Water Level	LCU	05/30/2023	6.61	590.99
G1001	Water Level	LCU	08/08/2023	6.32	591.29
G1001	Water Level	LCU	09/25/2023	6.14	591.46
G1001	Water Level	LCU	10/24/2023	6.20	591.41
G1001	Water Level	LCU	11/13/2023	6.49	591.12
G1001	Water Level	LCU	12/18/2023	5.88	591.73
G1003	Water Level	LCU	02/13/2023	Dry	Dry
G1003	Water Level	LCU	05/30/2023	Dry	Dry
G1003	Water Level	LCU	08/08/2023	Dry	Dry
G1003	Water Level	LCU	10/24/2023	Dry	Dry
G1003	Water Level	LCU	11/13/2023	Dry	Dry
G101	Water Level	UA	02/13/2023	4.71	622.89
G101	Water Level	UA	05/30/2023	6.53	621.07
G101	Water Level	UA	08/08/2023	11.16	616.44
G101	Water Level	UA	10/25/2023	14.15	613.45
G101	Water Level	UA	11/13/2023	13.95	613.65
G102	Water Level	UA	02/13/2023	4.80	624.24
G102	Water Level	UA	08/08/2023	10.34	618.70
G102	Water Level	UA	10/24/2023	12.60	616.44
G102	Water Level	UA	11/13/2023	12.84	616.20
G102	Water Level	UA	12/18/2023	12.82	616.22

Appendix B. Site-Wide Groundwater Elevations

Nature and Extent Report
Coffeen Power Plant
Ash Pond No. 2
Coffeen, IL

Well ID	Well Type	Monitored Unit	Date	Depth to Groundwater (feet BMP)	Groundwater Elevation (feet NAVD88)
G103	Water Level	UA	02/13/2023	9.59	624.21
G103	Water Level	UA	03/30/2023	7.94	625.85
G103	Water Level	UA	04/30/2023	9.58	624.21
G103	Water Level	UA	05/30/2023	10.49	623.31
G103	Water Level	UA	06/08/2023	11.00	622.80
G103	Water Level	UA	07/08/2023	12.05	621.74
G103	Water Level	UA	08/08/2023	13.53	620.27
G103	Water Level	UA	09/25/2023	14.74	619.06
G103	Water Level	UA	10/25/2023	15.66	618.14
G103	Water Level	UA	11/13/2023	16.00	617.80
G103	Water Level	UA	12/18/2023	16.24	617.56
G105	Water Level	UA	02/13/2023	8.24	623.84
G105	Water Level	UA	08/08/2023	10.84	621.24
G105	Water Level	UA	09/25/2023	15.74	616.34
G105	Water Level	UA	10/25/2023	12.90	619.18
G105	Water Level	UA	11/13/2023	13.46	618.62
G105	Water Level	UA	12/18/2023	13.63	618.45
G106	Water Level	UA	02/13/2023	8.44	622.71
G106	Water Level	UA	03/30/2023	7.82	623.32
G106	Water Level	UA	04/30/2023	9.16	621.98
G106	Water Level	UA	05/30/2023	9.81	621.33
G106	Water Level	UA	06/08/2023	10.39	620.76
G106	Water Level	UA	07/08/2023	10.50	620.65
G106	Water Level	UA	08/08/2023	12.17	618.98
G106	Water Level	UA	09/25/2023	12.97	618.18
G106	Water Level	UA	10/25/2023	14.01	617.14
G106	Water Level	UA	11/13/2023	14.21	616.94
G106	Water Level	UA	12/18/2023	13.87	617.28
G107	Water Level	UA	02/13/2023	9.07	621.15
G107	Water Level	UA	05/30/2023	10.85	619.37
G107	Water Level	UA	08/08/2023	12.76	617.46
G107	Water Level	UA	10/25/2023	14.31	615.91
G107	Water Level	UA	11/13/2023	14.40	615.82
G108	Water Level	UA	02/13/2023	9.67	620.55

Appendix B. Site-Wide Groundwater Elevations
Nature and Extent Report
Coffeen Power Plant
Ash Pond No. 2
Coffeen, IL

Well ID	Well Type	Monitored Unit	Date	Depth to Groundwater (feet BMP)	Groundwater Elevation (feet NAVD88)
G108	Water Level	UA	05/30/2023	11.65	618.57
G108	Water Level	UA	08/08/2023	13.24	616.98
G108	Water Level	UA	10/25/2023	14.89	615.33
G108	Water Level	UA	11/13/2023	14.96	615.26
G109	Water Level	UA	02/13/2023	9.81	619.95
G109	Water Level	UA	05/30/2023	11.89	617.87
G109	Water Level	UA	08/08/2023	13.64	616.12
G109	Water Level	UA	10/25/2023	14.89	614.87
G109	Water Level	UA	11/13/2023	15.09	614.67
G110	Water Level	UA	02/13/2023	10.80	618.85
G110	Water Level	UA	05/30/2023	12.70	616.95
G110	Water Level	UA	08/08/2023	14.16	615.49
G110	Water Level	UA	10/25/2023	15.31	614.34
G110	Water Level	UA	11/13/2023	15.43	614.22
G111	Water Level	UA	02/13/2023	12.91	616.99
G111	Water Level	UA	05/30/2023	13.70	616.20
G111	Water Level	UA	08/08/2023	14.95	614.95
G111	Water Level	UA	10/25/2023	16.00	613.90
G111	Water Level	UA	11/13/2023	16.09	613.81
G119	Water Level	UA	02/13/2023	14.64	616.91
G119	Water Level	UA	05/30/2023	15.08	616.47
G119	Water Level	UA	08/08/2023	15.65	615.90
G119	Water Level	UA	10/25/2023	16.40	615.15
G119	Water Level	UA	11/13/2023	16.25	615.30
G120	Water Level	UA	02/13/2023	14.43	617.44
G120	Water Level	UA	05/30/2023	14.86	617.01
G120	Water Level	UA	08/08/2023	16.31	615.56
G120	Water Level	UA	10/25/2023	17.18	614.69
G120	Water Level	UA	11/13/2023	17.08	614.79
G121	Water Level	UA	02/13/2023	14.72	618.11
G121	Water Level	UA	05/30/2023	15.38	617.45
G121	Water Level	UA	08/08/2023	18.40	614.43
G121	Water Level	UA	10/25/2023	19.45	613.38
G121	Water Level	UA	11/13/2023	18.96	613.87

Appendix B. Site-Wide Groundwater Elevations
Nature and Extent Report
Coffeen Power Plant
Ash Pond No. 2
Coffeen, IL

Well ID	Well Type	Monitored Unit	Date	Depth to Groundwater (feet BMP)	Groundwater Elevation (feet NAVD88)
G122	Water Level	UA	02/13/2023	13.89	618.80
G122	Water Level	UA	05/30/2023	14.00	618.69
G122	Water Level	UA	08/08/2023	19.54	613.15
G122	Water Level	UA	10/25/2023	21.21	611.48
G122	Water Level	UA	11/13/2023	20.40	612.29
G123	Water Level	UA	02/13/2023	11.80	621.16
G123	Water Level	UA	05/30/2023	12.68	620.28
G123	Water Level	UA	08/08/2023	18.57	614.39
G123	Water Level	UA	10/25/2023	20.09	612.87
G123	Water Level	UA	11/13/2023	19.94	613.02
G124	Water Level	UA	02/13/2023	12.14	621.25
G124	Water Level	UA	05/30/2023	13.43	619.96
G124	Water Level	UA	08/08/2023	18.49	614.90
G124	Water Level	UA	10/25/2023	21.05	612.34
G124	Water Level	UA	11/13/2023	Dry	Dry
G125	Water Level	UA	02/13/2023	11.99	621.52
G125	Water Level	UA	05/30/2023	13.54	619.97
G125	Water Level	UA	08/08/2023	18.53	614.98
G125	Water Level	UA	10/25/2023	21.21	612.30
G125	Water Level	UA	11/13/2023	Dry	Dry
G126	Water Level	UA	02/13/2023	8.92	616.47
G126	Water Level	UA	05/30/2023	10.04	615.35
G126	Water Level	UA	08/08/2023	10.93	614.46
G126	Water Level	UA	10/25/2023	11.85	613.54
G126	Water Level	UA	11/13/2023	11.91	613.48
G151	Water Level	UA	02/13/2023	10.88	615.05
G151	Water Level	UA	05/30/2023	11.58	614.35
G151	Water Level	UA	08/08/2023	12.22	613.71
G151	Water Level	UA	10/25/2023	12.99	612.94
G151	Water Level	UA	11/13/2023	12.97	612.96
G152	Water Level	UA	02/13/2023	10.25	616.27
G152	Water Level	UA	05/30/2023	11.11	615.41
G152	Water Level	UA	08/08/2023	12.40	614.12
G152	Water Level	UA	10/25/2023	13.42	613.10

Well ID	Well Type	Monitored Unit	Date	Depth to Groundwater (feet BMP)	Groundwater Elevation (feet NAVD88)
G152	Water Level	UA	11/13/2023	13.07	613.45
G153	Water Level	UA	02/13/2023	12.24	614.16
G153	Water Level	UA	05/30/2023	11.40	615.00
G153	Water Level	UA	08/08/2023	13.08	613.32
G153	Water Level	UA	10/25/2023	14.81	611.59
G153	Water Level	UA	11/13/2023	14.90	611.50
G154	Water Level	UA	02/13/2023	10.91	615.44
G154	Water Level	UA	05/30/2023	13.15	613.20
G154	Water Level	UA	08/08/2023	14.60	611.75
G154	Water Level	UA	10/25/2023	15.90	610.45
G154	Water Level	UA	11/13/2023	15.76	610.59
G155	Water Level	UA	02/13/2023	11.56	614.30
G155	Water Level	UA	05/30/2023	12.44	613.42
G155	Water Level	UA	08/08/2023	13.21	612.65
G155	Water Level	UA	10/25/2023	14.01	611.85
G155	Water Level	UA	11/13/2023	13.92	611.94
G200	Water Level	UA	02/13/2023	2.91	623.03
G200	Water Level	UA	03/30/2023	3.01	622.92
G200	Water Level	UA	04/30/2023	4.51	621.42
G200	Water Level	UA	05/30/2023	5.89	620.04
G200	Water Level	UA	06/08/2023	6.44	619.49
G200	Water Level	UA	08/08/2023	9.21	616.73
G200	Water Level	UA	09/25/2023	10.61	615.33
G200	Water Level	UA	10/25/2023	11.51	614.43
G200	Water Level	UA	11/13/2023	11.88	614.06
G200	Water Level	UA	12/18/2023	11.48	614.46
G206	Water Level	UA	02/13/2023	9.20	623.62
G206	Water Level	UA	03/30/2023	9.12	623.69
G206	Water Level	UA	04/30/2023	10.27	622.54
G206	Water Level	UA	05/30/2023	11.17	621.64
G206	Water Level	UA	07/08/2023	12.13	620.69
G206	Water Level	UA	08/08/2023	13.89	618.93
G206	Water Level	UA	09/25/2023	14.74	618.08
G206	Water Level	UA	10/25/2023	15.71	617.11

Well ID	Well Type	Monitored Unit	Date	Depth to Groundwater (feet BMP)	Groundwater Elevation (feet NAVD88)
G206	Water Level	UA	11/13/2023	16.16	616.66
G206	Water Level	UA	12/18/2023	15.85	616.97
G206D	Water Level	DA	02/13/2023	9.92	624.22
G206D	Water Level	DA	02/16/2023	[29.69]	[604.16]
G206D	Water Level	DA	03/30/2023	32.14	601.99
G206D	Water Level	DA	04/30/2023	30.53	603.60
G206D	Water Level	DA	05/30/2023	30.22	603.91
G206D	Water Level	DA	07/08/2023	30.10	604.04
G206D	Water Level	DA	08/08/2023	30.04	604.10
G206D	Water Level	DA	09/25/2023	30.08	604.06
G206D	Water Level	DA	10/25/2023	30.34	603.80
G206D	Water Level	DA	11/13/2023	30.40	603.74
G206D	Water Level	DA	12/18/2023	30.32	603.82
G207	Water Level	UA	02/13/2023	10.25	622.96
G207	Water Level	UA	03/30/2023	9.67	623.53
G207	Water Level	UA	04/30/2023	10.55	622.65
G207	Water Level	UA	05/30/2023	11.47	621.73
G207	Water Level	UA	07/08/2023	12.45	620.76
G207	Water Level	UA	08/08/2023	14.20	619.01
G207	Water Level	UA	09/25/2023	15.27	617.94
G207	Water Level	UA	10/25/2023	16.24	616.97
G207	Water Level	UA	11/13/2023	16.67	616.54
G207	Water Level	UA	12/18/2023	16.31	616.90
G208	Water Level	UA	02/13/2023	10.28	622.88
G208	Water Level	UA	03/30/2023	9.65	623.50
G208	Water Level	UA	04/30/2023	10.30	622.85
G208	Water Level	UA	05/30/2023	11.10	622.05
G208	Water Level	UA	06/08/2023	12.38	620.78
G208	Water Level	UA	07/08/2023	12.32	620.83
G208	Water Level	UA	08/08/2023	14.08	619.08
G208	Water Level	UA	09/25/2023	15.31	617.84
G208	Water Level	UA	10/25/2023	16.25	616.91
G208	Water Level	UA	11/13/2023	16.66	616.50
G208	Water Level	UA	12/18/2023	16.24	616.92

Well ID	Well Type	Monitored Unit	Date	Depth to Groundwater (feet BMP)	Groundwater Elevation (feet NAVD88)
G209	Water Level	UA	02/13/2023	10.01	622.90
G209	Water Level	UA	03/30/2023	9.63	623.27
G209	Water Level	UA	04/30/2023	10.25	622.65
G209	Water Level	UA	05/30/2023	11.07	621.83
G209	Water Level	UA	07/08/2023	11.82	621.08
G209	Water Level	UA	08/08/2023	13.79	619.12
G209	Water Level	UA	09/25/2023	14.78	618.13
G209	Water Level	UA	10/25/2023	15.60	617.31
G209	Water Level	UA	11/13/2023	16.24	616.67
G209	Water Level	UA	12/18/2023	16.04	616.87
G210	Water Level	UA	02/13/2023	10.49	622.50
G210	Water Level	UA	03/30/2023	9.73	623.25
G210	Water Level	UA	04/30/2023	10.36	622.62
G210	Water Level	UA	05/30/2023	11.09	621.89
G210	Water Level	UA	06/08/2023	11.76	621.23
G210	Water Level	UA	07/08/2023	12.29	620.70
G210	Water Level	UA	08/08/2023	13.75	619.24
G210	Water Level	UA	09/25/2023	14.67	618.32
G210	Water Level	UA	10/25/2023	15.52	617.47
G210	Water Level	UA	11/13/2023	15.82	617.17
G210	Water Level	UA	12/18/2023	15.99	617.00
G211	Water Level	UA	02/13/2023	9.90	622.74
G211	Water Level	UA	03/30/2023	9.18	623.45
G211	Water Level	UA	04/30/2023	9.99	622.64
G211	Water Level	UA	05/30/2023	10.54	622.09
G211	Water Level	UA	06/08/2023	11.76	620.88
G211	Water Level	UA	07/08/2023	12.43	620.21
G211	Water Level	UA	08/08/2023	13.44	619.20
G211	Water Level	UA	09/25/2023	14.74	617.90
G211	Water Level	UA	10/25/2023	15.15	617.49
G211	Water Level	UA	11/13/2023	15.61	617.03
G211	Water Level	UA	12/18/2023	15.93	616.71
G212	Water Level	UA	02/13/2023	10.38	622.51
G212	Water Level	UA	03/30/2023	9.77	623.11

Well ID	Well Type	Monitored Unit	Date	Depth to Groundwater (feet BMP)	Groundwater Elevation (feet NAVD88)
G212	Water Level	UA	04/30/2023	10.89	621.99
G212	Water Level	UA	05/30/2023	11.64	621.24
G212	Water Level	UA	06/08/2023	12.80	620.08
G212	Water Level	UA	07/08/2023	13.48	619.41
G212	Water Level	UA	08/08/2023	14.61	618.28
G212	Water Level	UA	09/25/2023	15.97	616.92
G212	Water Level	UA	10/25/2023	16.46	616.43
G212	Water Level	UA	11/13/2023	16.92	615.97
G212	Water Level	UA	12/18/2023	17.00	615.89
G213	Water Level	UA	02/13/2023	10.83	621.98
G213	Water Level	UA	03/30/2023	10.15	622.65
G213	Water Level	UA	04/30/2023	11.04	621.76
G213	Water Level	UA	05/30/2023	11.96	620.84
G213	Water Level	UA	06/08/2023	12.80	620.00
G213	Water Level	UA	07/08/2023	13.50	619.31
G213	Water Level	UA	08/08/2023	15.05	617.76
G213	Water Level	UA	09/25/2023	15.90	616.91
G213	Water Level	UA	10/25/2023	16.81	616.00
G213	Water Level	UA	11/13/2023	17.41	615.40
G213	Water Level	UA	12/18/2023	17.34	615.47
G214	Water Level	UA	02/13/2023	14.53	618.32
G214	Water Level	UA	03/30/2023	13.04	619.80
G214	Water Level	UA	04/30/2023	13.98	618.86
G214	Water Level	UA	05/30/2023	14.73	618.11
G214	Water Level	UA	06/08/2023	15.56	617.29
G214	Water Level	UA	07/08/2023	16.44	616.41
G214	Water Level	UA	08/08/2023	17.64	615.21
G214	Water Level	UA	09/25/2023	18.42	614.43
G214	Water Level	UA	10/25/2023	19.14	613.71
G214	Water Level	UA	11/13/2023	19.35	613.50
G214	Water Level	UA	12/18/2023	19.23	613.62
G215	Water Level	UA	02/13/2023	14.38	618.68
G215	Water Level	UA	03/30/2023	13.16	619.89
G215	Water Level	UA	04/30/2023	14.03	619.02

Well ID	Well Type	Monitored Unit	Date	Depth to Groundwater (feet BMP)	Groundwater Elevation (feet NAVD88)
G215	Water Level	UA	05/30/2023	14.76	618.29
G215	Water Level	UA	06/08/2023	15.46	617.59
G215	Water Level	UA	07/08/2023	16.06	616.99
G215	Water Level	UA	08/08/2023	17.22	615.84
G215	Water Level	UA	09/25/2023	18.06	614.99
G215	Water Level	UA	10/25/2023	18.41	614.65
G215	Water Level	UA	11/13/2023	19.03	614.03
G215	Water Level	UA	12/18/2023	18.75	614.31
G216	Water Level	UA	02/13/2023	13.54	619.22
G216	Water Level	UA	03/30/2023	12.27	620.48
G216	Water Level	UA	04/30/2023	12.94	619.81
G216	Water Level	UA	05/30/2023	13.63	619.12
G216	Water Level	UA	06/08/2023	14.99	617.77
G216	Water Level	UA	07/08/2023	15.42	617.33
G216	Water Level	UA	08/08/2023	16.51	616.25
G216	Water Level	UA	09/25/2023	17.38	615.38
G216	Water Level	UA	10/25/2023	17.86	614.90
G216	Water Level	UA	11/13/2023	18.21	614.55
G216	Water Level	UA	12/18/2023	18.00	614.76
G217	Water Level	UA	02/13/2023	14.72	618.38
G217	Water Level	UA	08/08/2023	18.29	614.81
G217	Water Level	UA	10/25/2023	19.51	613.59
G217	Water Level	UA	11/13/2023	19.68	613.42
G217	Water Level	UA	12/18/2023	19.33	613.77
G218	Water Level	UA	02/13/2023	13.71	619.40
G218	Water Level	UA	03/30/2023	12.50	620.60
G218	Water Level	UA	04/30/2023	12.98	620.12
G218	Water Level	UA	05/30/2023	13.72	619.38
G218	Water Level	UA	06/08/2023	15.11	618.00
G218	Water Level	UA	07/08/2023	15.80	617.31
G218	Water Level	UA	08/08/2023	16.98	616.13
G218	Water Level	UA	09/25/2023	17.95	615.16
G218	Water Level	UA	10/25/2023	18.48	614.63
G218	Water Level	UA	11/13/2023	18.67	614.44

Well ID	Well Type	Monitored Unit	Date	Depth to Groundwater (feet BMP)	Groundwater Elevation (feet NAVD88)
G218	Water Level	UA	12/18/2023	18.38	614.73
G270	Water Level	UA	02/13/2023	2.53	623.33
G270	Water Level	UA	03/30/2023	2.41	623.44
G270	Water Level	UA	04/30/2023	2.83	623.02
G270	Water Level	UA	05/30/2023	5.06	620.79
G270	Water Level	UA	08/14/2023	[8.52]	[617.34]
G270	Water Level	UA	10/25/2023	10.92	614.94
G270	Water Level	UA	11/13/2023	10.90	614.96
G270	Water Level	UA	12/18/2023	9.84	616.02
G271	Water Level	UA	02/13/2023	8.93	616.64
G271	Water Level	UA	03/30/2023	7.12	618.44
G271	Water Level	UA	04/30/2023	8.97	616.59
G271	Water Level	UA	05/30/2023	9.28	616.28
G271	Water Level	UA	06/08/2023	9.57	615.99
G271	Water Level	UA	07/08/2023	9.83	615.73
G271	Water Level	UA	08/08/2023	11.20	614.37
G271	Water Level	UA	09/25/2023	12.44	613.13
G271	Water Level	UA	10/25/2023	12.95	612.62
G271	Water Level	UA	11/13/2023	13.00	612.57
G271	Water Level	UA	12/18/2023	12.79	612.78
G272	Water Level	UA	02/13/2023	8.55	615.26
G272	Water Level	UA	03/30/2023	6.96	616.84
G272	Water Level	UA	04/30/2023	9.20	614.60
G272	Water Level	UA	05/30/2023	9.48	614.32
G272	Water Level	UA	08/08/2023	10.55	613.26
G272	Water Level	UA	09/25/2023	11.63	612.18
G272	Water Level	UA	10/25/2023	12.03	611.78
G272	Water Level	UA	11/13/2023	12.01	611.80
G272	Water Level	UA	12/18/2023	11.81	612.00
G273	Water Level	UA	02/13/2023	8.95	614.07
G273	Water Level	UA	03/30/2023	7.80	615.21
G273	Water Level	UA	04/30/2023	10.09	612.92
G273	Water Level	UA	05/30/2023	10.41	612.60
G273	Water Level	UA	08/08/2023	11.56	611.46

Well ID	Well Type	Monitored Unit	Date	Depth to Groundwater (feet BMP)	Groundwater Elevation (feet NAVD88)
G273	Water Level	UA	09/25/2023	12.39	610.63
G273	Water Level	UA	10/25/2023	12.78	610.24
G273	Water Level	UA	11/13/2023	12.71	610.31
G273	Water Level	UA	12/18/2023	12.40	610.62
G274	Water Level	UA	02/13/2023	13.22	610.82
G274	Water Level	UA	03/30/2023	11.96	612.07
G274	Water Level	UA	04/30/2023	13.85	610.18
G274	Water Level	UA	05/30/2023	14.16	609.87
G274	Water Level	UA	06/08/2023	14.41	609.63
G274	Water Level	UA	07/08/2023	14.33	609.70
G274	Water Level	UA	08/08/2023	14.99	609.05
G274	Water Level	UA	09/25/2023	15.46	608.57
G274	Water Level	UA	10/25/2023	Dry	Dry
G274	Water Level	UA	11/13/2023	15.77	608.27
G274	Water Level	UA	12/18/2023	15.53	608.51
G275	Water Level	UA	02/13/2023	13.02	605.24
G275	Water Level	UA	05/30/2023	13.38	604.88
G275	Water Level	UA	08/08/2023	Dry	Dry
G275	Water Level	UA	11/13/2023	Dry	Dry
G275D	Water Level	DA	02/13/2023	39.49	580.82
G275D	Water Level	DA	08/08/2023	31.27	589.04
G275D	Water Level	DA	09/25/2023	42.29	578.02
G275D	Water Level	DA	10/25/2023	39.74	580.57
G275D	Water Level	DA	12/18/2023	43.46	576.85
G276	Water Level	UA	02/13/2023	27.37	604.63
G276	Water Level	UA	03/30/2023	25.78	606.21
G276	Water Level	UA	04/30/2023	26.04	605.95
G276	Water Level	UA	05/30/2023	26.60	605.39
G276	Water Level	UA	06/08/2023	26.84	605.16
G276	Water Level	UA	07/08/2023	27.27	604.73
G276	Water Level	UA	08/08/2023	27.75	604.25
G276	Water Level	UA	10/25/2023	28.49	603.51
G276	Water Level	UA	11/13/2023	28.59	603.41
G276	Water Level	UA	12/18/2023	28.71	603.29

Well ID	Well Type	Monitored Unit	Date	Depth to Groundwater (feet BMP)	Groundwater Elevation (feet NAVD88)
G277	Water Level	UA	02/13/2023	19.67	603.41
G277	Water Level	UA	05/30/2023	18.21	604.87
G277	Water Level	UA	08/08/2023	19.76	603.32
G277	Water Level	UA	11/13/2023	Dry	Dry
G278	Water Level	UA	02/13/2023	19.95	611.22
G278	Water Level	UA	05/30/2023	21.75	609.42
G278	Water Level	UA	08/08/2023	20.98	610.19
G278	Water Level	UA	10/25/2023	23.48	607.69
G278	Water Level	UA	11/13/2023	24.23	606.94
G279	Water Level	UA	02/13/2023	20.83	611.21
G279	Water Level	UA	05/30/2023	22.73	609.31
G279	Water Level	UA	08/08/2023	23.69	608.35
G279	Water Level	UA	10/25/2023	24.56	607.48
G279	Water Level	UA	11/13/2023	23.39	608.65
G280	Water Level	UA	02/13/2023	3.01	622.34
G280	Water Level	UA	03/30/2023	2.74	622.60
G280	Water Level	UA	04/30/2023	3.52	621.82
G280	Water Level	UA	05/30/2023	3.96	621.38
G280	Water Level	UA	08/08/2023	5.80	619.55
G280	Water Level	UA	09/25/2023	7.42	617.92
G280	Water Level	UA	10/25/2023	8.56	616.79
G280	Water Level	UA	11/13/2023	8.91	616.44
G280	Water Level	UA	12/18/2023	9.04	616.31
G281	Water Level	UA	02/13/2023	4.63	621.73
G281	Water Level	UA	03/30/2023	3.94	622.41
G281	Water Level	UA	04/30/2023	6.44	619.91
G281	Water Level	UA	05/30/2023	6.64	619.71
G281	Water Level	UA	08/08/2023	6.39	619.97
G281	Water Level	UA	10/24/2023	8.64	617.72
G281	Water Level	UA	11/13/2023	8.59	617.77
G281	Water Level	UA	12/18/2023	6.83	619.53
G283	Water Level	LCU	02/13/2023	4.61	606.14
G283	Water Level	LCU	03/30/2023	3.55	607.19
G283	Water Level	LCU	04/30/2023	4.71	606.03

Well ID	Well Type	Monitored Unit	Date	Depth to Groundwater (feet BMP)	Groundwater Elevation (feet NAVD88)
G283	Water Level	LCU	05/30/2023	5.60	605.14
G283	Water Level	LCU	08/14/2023	[7.45]	[603.30]
G283	Water Level	LCU	10/24/2023	7.79	602.96
G283	Water Level	LCU	11/13/2023	7.22	603.53
G283	Water Level	LCU	12/18/2023	6.49	604.26
G284	Water Level	UA	02/13/2023	9.72	608.70
G284	Water Level	UA	03/30/2023	8.65	609.76
G284	Water Level	UA	04/30/2023	11.62	606.79
G284	Water Level	UA	05/30/2023	12.43	605.98
G284	Water Level	UA	08/14/2023	[12.28]	[606.14]
G284	Water Level	UA	10/24/2023	Dry	Dry
G284	Water Level	UA	11/13/2023	Dry	Dry
G284	Water Level	UA	12/18/2023	12.91	605.51
G285	Water Level	LCU	02/13/2023	6.12	607.40
G285	Water Level	LCU	03/30/2023	4.18	609.33
G285	Water Level	LCU	04/30/2023	5.80	607.71
G285	Water Level	LCU	05/30/2023	6.71	606.80
G285	Water Level	LCU	07/08/2023	8.14	605.37
G285	Water Level	LCU	08/08/2023	8.25	605.26
G285	Water Level	LCU	08/14/2023	[8.44]	[605.08]
G285	Water Level	LCU	09/25/2023	8.47	605.05
G285	Water Level	LCU	10/24/2023	8.96	604.56
G285	Water Level	LCU	11/13/2023	9.38	604.14
G285	Water Level	LCU	12/18/2023	8.03	605.49
G286	Water Level	UA	02/13/2023	6.18	606.95
G286	Water Level	UA	08/10/2023	[Dry]	[Dry]
G286	Water Level	UA	10/24/2023	Dry	Dry
G286	Water Level	UA	11/13/2023	Dry	Dry
G286	Water Level	UA	12/18/2023	Dry	Dry
G287	Water Level	UA	02/13/2023	5.75	611.70
G288	Water Level	UA	02/13/2023	9.78	610.29
G288	Water Level	UA	03/30/2023	4.70	615.37
G288	Water Level	UA	04/30/2023	6.66	613.41
G288	Water Level	UA	05/30/2023	7.40	612.67

Well ID	Well Type	Monitored Unit	Date	Depth to Groundwater (feet BMP)	Groundwater Elevation (feet NAVD88)
G288	Water Level	UA	06/08/2023	8.05	612.02
G288	Water Level	UA	07/08/2023	7.65	612.42
G288	Water Level	UA	08/08/2023	8.62	611.45
G288	Water Level	UA	08/11/2023	[8.70]	[611.37]
G288	Water Level	UA	09/25/2023	9.57	610.50
G288	Water Level	UA	10/24/2023	9.95	610.12
G288	Water Level	UA	11/13/2023	9.84	610.23
G288	Water Level	UA	12/18/2023	8.56	611.51
G301	Water Level	UA	02/13/2023	5.30	617.35
G301	Water Level	UA	06/08/2023	7.70	614.94
G301	Water Level	UA	07/08/2023	7.82	614.82
G301	Water Level	UA	08/08/2023	8.11	614.54
G301	Water Level	UA	10/24/2023	8.51	614.14
G301	Water Level	UA	11/13/2023	8.43	614.22
G301	Water Level	UA	12/18/2023	8.00	614.65
G302	Water Level	UA	02/13/2023	7.16	612.88
G302	Water Level	UA	03/30/2023	4.68	615.35
G302	Water Level	UA	04/30/2023	9.10	610.93
G302	Water Level	UA	05/30/2023	11.04	608.99
G302	Water Level	UA	06/08/2023	11.57	608.46
G302	Water Level	UA	07/08/2023	12.07	607.96
G302	Water Level	UA	08/08/2023	12.68	607.36
G302	Water Level	UA	09/25/2023	13.12	606.92
G302	Water Level	UA	11/13/2023	13.16	606.88
G302	Water Level	UA	12/18/2023	12.47	607.57
G303	Water Level	UA	02/13/2023	4.20	617.82
G303	Water Level	UA	03/30/2023	3.62	618.39
G303	Water Level	UA	04/30/2023	4.62	617.39
G303	Water Level	UA	05/30/2023	5.92	616.09
G303	Water Level	UA	08/08/2023	8.40	613.62
G303	Water Level	UA	09/25/2023	9.18	612.83
G303	Water Level	UA	10/24/2023	9.71	612.31
G303	Water Level	UA	11/13/2023	9.32	612.70
G303	Water Level	UA	12/18/2023	8.22	613.80

Well ID	Well Type	Monitored Unit	Date	Depth to Groundwater (feet BMP)	Groundwater Elevation (feet NAVD88)
G305	Water Level	UA	02/13/2023	6.08	619.59
G305	Water Level	UA	03/30/2023	5.81	619.85
G305	Water Level	UA	04/30/2023	6.59	619.07
G305	Water Level	UA	05/30/2023	7.63	618.03
G305	Water Level	UA	06/08/2023	8.35	617.31
G305	Water Level	UA	07/08/2023	8.23	617.43
G305	Water Level	UA	08/08/2023	9.19	616.48
G305	Water Level	UA	10/24/2023	9.95	615.72
G305	Water Level	UA	11/13/2023	8.50	617.17
G305	Water Level	UA	12/18/2023	8.24	617.43
G306	Water Level	UA	02/13/2023	5.80	620.11
G306	Water Level	UA	03/30/2023	5.41	620.49
G306	Water Level	UA	04/30/2023	6.64	619.26
G306	Water Level	UA	05/30/2023	8.13	617.77
G306	Water Level	UA	06/08/2023	9.18	616.72
G306	Water Level	UA	07/08/2023	8.60	617.30
G306	Water Level	UA	08/08/2023	9.70	616.21
G306	Water Level	UA	10/24/2023	10.81	615.10
G306	Water Level	UA	11/13/2023	10.13	615.78
G306	Water Level	UA	12/18/2023	7.56	618.35
G307	Water Level	UA	02/13/2023	Above Top of Casing	Above Top of Casing
G307	Water Level	UA	08/08/2023	0.70	623.90
G307	Water Level	UA	11/13/2023	1.96	622.64
G307D	Water Level	LCU	02/13/2023	2.75	622.13
G307D	Water Level	LCU	03/30/2023	2.32	622.55
G307D	Water Level	LCU	04/30/2023	2.41	622.46
G307D	Water Level	LCU	05/30/2023	2.48	622.39
G307D	Water Level	LCU	08/08/2023	7.89	616.99
G307D	Water Level	LCU	10/24/2023	11.33	613.55
G307D	Water Level	LCU	11/13/2023	12.36	612.52
G307D	Water Level	LCU	12/18/2023	7.55	617.33
G308	Water Level	UA	02/13/2023	3.88	620.71
G308	Water Level	UA	03/30/2023	3.79	620.79
G308	Water Level	UA	04/30/2023	4.84	619.74

Well ID	Well Type	Monitored Unit	Date	Depth to Groundwater (feet BMP)	Groundwater Elevation (feet NAVD88)
G308	Water Level	UA	05/30/2023	5.56	619.02
G308	Water Level	UA	06/08/2023	5.93	618.66
G308	Water Level	UA	07/08/2023	5.37	619.22
G308	Water Level	UA	08/08/2023	5.09	619.50
G308	Water Level	UA	09/25/2023	6.16	618.42
G308	Water Level	UA	10/24/2023	6.19	618.40
G308	Water Level	UA	11/13/2023	6.00	618.59
G308	Water Level	UA	12/18/2023	4.71	619.88
G309	Water Level	UA	02/13/2023	9.64	616.24
G309	Water Level	UA	08/08/2023	8.04	617.84
G309	Water Level	UA	09/25/2023	8.24	617.64
G309	Water Level	UA	10/24/2023	8.69	617.19
G309	Water Level	UA	11/13/2023	8.32	617.56
G309	Water Level	UA	12/18/2023	7.60	618.28
G310	Water Level	UA	02/13/2023	7.09	615.78
G310	Water Level	UA	03/30/2023	6.42	616.44
G310	Water Level	UA	04/30/2023	8.94	613.92
G310	Water Level	UA	05/30/2023	9.57	613.29
G310	Water Level	UA	06/08/2023	9.96	612.90
G310	Water Level	UA	08/08/2023	10.30	612.57
G310	Water Level	UA	09/25/2023	10.73	612.14
G310	Water Level	UA	10/24/2023	10.82	612.05
G310	Water Level	UA	11/13/2023	10.56	612.31
G310	Water Level	UA	12/18/2023	9.95	612.92
G311	Water Level	UA	05/30/2023	8.26	612.78
G311	Water Level	UA	08/08/2023	9.08	611.96
G311	Water Level	UA	10/24/2023	9.29	611.75
G311	Water Level	UA	11/13/2023	9.38	611.66
G311D	Water Level	LCU	02/13/2023	23.66	597.58
G311D	Water Level	LCU	05/30/2023	23.26	597.98
G311D	Water Level	LCU	08/08/2023	23.52	597.72
G311D	Water Level	LCU	10/24/2023	23.51	597.73
G311D	Water Level	LCU	11/13/2023	24.15	597.09
G312	Water Level	UA	03/30/2023	8.28	611.49

Well ID	Well Type	Monitored Unit	Date	Depth to Groundwater (feet BMP)	Groundwater Elevation (feet NAVD88)
G312	Water Level	UA	04/30/2023	10.81	608.96
G312	Water Level	UA	05/30/2023	12.42	607.35
G312	Water Level	UA	06/08/2023	12.87	606.91
G312	Water Level	UA	07/08/2023	13.42	606.36
G312	Water Level	UA	08/08/2023	14.00	605.78
G312	Water Level	UA	10/24/2023	Dry	Dry
G312	Water Level	UA	11/13/2023	Dry	Dry
G312	Water Level	UA	12/18/2023	14.45	605.33
G313	Water Level	UA	02/13/2023	3.24	611.06
G313	Water Level	UA	08/08/2023	3.01	611.29
G313	Water Level	UA	10/24/2023	3.08	611.22
G313	Water Level	UA	11/13/2023	3.36	610.94
G313	Water Level	UA	12/18/2023	3.48	610.82
G314	Water Level	LCU	02/13/2023	6.14	607.74
G314	Water Level	LCU	03/30/2023	8.96	604.91
G314	Water Level	LCU	04/30/2023	5.53	608.34
G314	Water Level	LCU	05/30/2023	4.81	609.06
G314	Water Level	LCU	06/08/2023	9.43	604.44
G314	Water Level	LCU	07/08/2023	5.67	608.20
G314	Water Level	LCU	08/08/2023	4.88	609.00
G314	Water Level	LCU	09/25/2023	4.96	608.92
G314	Water Level	LCU	10/24/2023	5.30	608.58
G314	Water Level	LCU	11/13/2023	5.67	608.21
G314	Water Level	LCU	12/18/2023	7.39	606.49
G314D	Water Level	DA	02/13/2023	16.40	597.30
G314D	Water Level	DA	03/30/2023	9.98	603.71
G314D	Water Level	DA	04/30/2023	7.48	606.21
G314D	Water Level	DA	05/30/2023	6.69	607.00
G314D	Water Level	DA	06/08/2023	11.80	601.90
G314D	Water Level	DA	07/08/2023	7.25	606.45
G314D	Water Level	DA	08/08/2023	7.78	605.92
G314D	Water Level	DA	09/25/2023	8.50	605.20
G314D	Water Level	DA	10/24/2023	8.56	605.14
G314D	Water Level	DA	11/13/2023	7.97	605.73

Appendix B. Site-Wide Groundwater Elevations
Nature and Extent Report
Coffeen Power Plant
Ash Pond No. 2
Coffeen, IL

Well ID	Well Type	Monitored Unit	Date	Depth to Groundwater (feet BMP)	Groundwater Elevation (feet NAVD88)
G314D	Water Level	DA	12/18/2023	7.04	606.66
G315	Water Level	UA	02/13/2023	2.08	621.44
G315	Water Level	UA	08/08/2023	3.50	620.02
G315	Water Level	UA	10/24/2023	4.04	619.48
G315	Water Level	UA	11/13/2023	4.11	619.41
G315	Water Level	UA	12/18/2023	2.55	620.97
G316	Water Level	LCU	02/13/2023	11.53	591.06
G316	Water Level	LCU	05/30/2023	12.28	590.31
G316	Water Level	LCU	08/08/2023	11.70	590.89
G316	Water Level	LCU	10/24/2023	12.54	590.05
G316	Water Level	LCU	11/13/2023	12.46	590.13
G317	Water Level	UA	02/13/2023	34.52	607.41
G317	Water Level	UA	08/08/2023	Dry	Dry
G317	Water Level	UA	09/25/2023	37.42	604.51
G317	Water Level	UA	10/24/2023	Dry	Dry
G317	Water Level	UA	11/13/2023	Dry	Dry
G317	Water Level	UA	12/18/2023	38.02	603.91
G401	Water Level	UA	02/13/2023	21.17	604.40
G401	Water Level	UA	05/30/2023	21.72	603.85
G401	Water Level	UA	08/08/2023	21.75	603.82
G401	Water Level	UA	10/24/2023	21.66	603.91
G401	Water Level	UA	11/13/2023	13.63	611.94
G402	Water Level	UA	02/13/2023	8.83	604.54
G402	Water Level	UA	03/30/2023	8.23	605.13
G402	Water Level	UA	04/30/2023	9.59	603.77
G402	Water Level	UA	05/30/2023	10.56	602.80
G402	Water Level	UA	06/08/2023	10.94	602.43
G402	Water Level	UA	07/08/2023	11.08	602.29
G402	Water Level	UA	08/08/2023	11.65	601.72
G402	Water Level	UA	10/24/2023	12.01	601.36
G402	Water Level	UA	11/13/2023	11.71	601.66
G402	Water Level	UA	12/18/2023	11.48	601.89
G403	Water Level	UA	02/13/2023	6.05	620.42
G403	Water Level	UA	03/30/2023	5.81	620.65

Well ID	Well Type	Monitored Unit	Date	Depth to Groundwater (feet BMP)	Groundwater Elevation (feet NAVD88)
G403	Water Level	UA	04/30/2023	7.09	619.37
G403	Water Level	UA	05/30/2023	8.13	618.33
G403	Water Level	UA	06/08/2023	8.74	617.73
G403	Water Level	UA	07/08/2023	7.21	619.26
G403	Water Level	UA	08/08/2023	7.45	619.02
G403	Water Level	UA	09/25/2023	8.82	617.64
G403	Water Level	UA	10/24/2023	8.62	617.85
G403	Water Level	UA	11/13/2023	8.27	618.20
G403	Water Level	UA	12/18/2023	6.64	619.83
G404	Water Level	UA	02/13/2023	3.46	612.21
G404	Water Level	UA	03/30/2023	3.24	612.42
G404	Water Level	UA	04/30/2023	4.64	611.02
G404	Water Level	UA	05/30/2023	5.42	610.24
G404	Water Level	UA	08/14/2023	[5.62]	[610.05]
G404	Water Level	UA	10/24/2023	7.09	608.58
G404	Water Level	UA	11/13/2023	6.48	609.19
G404	Water Level	UA	12/18/2023	4.70	610.97
G405	Water Level	UA	02/13/2023	6.13	617.50
G405	Water Level	UA	03/30/2023	5.87	617.75
G405	Water Level	UA	04/30/2023	6.53	617.09
G405	Water Level	UA	05/30/2023	6.83	616.79
G405	Water Level	UA	06/08/2023	7.08	616.55
G405	Water Level	UA	07/08/2023	6.59	617.04
G405	Water Level	UA	08/08/2023	6.85	616.78
G405	Water Level	UA	09/25/2023	7.59	616.04
G405	Water Level	UA	10/24/2023	7.84	615.79
G405	Water Level	UA	11/13/2023	7.73	615.90
G405	Water Level	UA	12/18/2023	6.55	617.08
G406	Water Level	UA	02/13/2023	11.25	614.11
G406	Water Level	UA	03/30/2023	9.94	615.41
G406	Water Level	UA	04/30/2023	12.48	612.87
G406	Water Level	UA	05/30/2023	13.06	612.29
G406	Water Level	UA	06/08/2023	13.75	611.61
G406	Water Level	UA	07/08/2023	11.92	613.44

Appendix B. Site-Wide Groundwater Elevations
Nature and Extent Report
Coffeen Power Plant
Ash Pond No. 2
Coffeen, IL

Well ID	Well Type	Monitored Unit	Date	Depth to Groundwater (feet BMP)	Groundwater Elevation (feet NAVD88)
G406	Water Level	UA	08/08/2023	11.49	613.87
G406	Water Level	UA	09/25/2023	13.95	611.41
G406	Water Level	UA	10/24/2023	14.08	611.28
G406	Water Level	UA	11/13/2023	13.83	611.53
G406	Water Level	UA	12/18/2023	12.03	613.33
G407	Water Level	UA	02/13/2023	5.60	615.72
G407	Water Level	UA	03/30/2023	5.49	615.82
G407	Water Level	UA	04/30/2023	6.91	614.40
G407	Water Level	UA	05/30/2023	7.35	613.96
G407	Water Level	UA	06/08/2023	8.75	612.57
G407	Water Level	UA	07/08/2023	8.22	613.10
G407	Water Level	UA	08/08/2023	8.79	612.53
G407	Water Level	UA	10/24/2023	8.39	612.93
G407	Water Level	UA	11/13/2023	8.31	613.01
G407	Water Level	UA	12/18/2023	6.76	614.56
G410	Water Level	UA	02/13/2023	7.44	612.35
G410	Water Level	UA	05/30/2023	8.99	610.80
G410	Water Level	UA	08/08/2023	9.66	610.13
G410	Water Level	UA	10/24/2023	10.88	608.91
G410	Water Level	UA	11/13/2023	10.68	609.11
G411	Water Level	UA	02/13/2023	6.15	617.10
G411	Water Level	UA	05/30/2023	8.52	614.73
G411	Water Level	UA	08/08/2023	8.69	614.56
G411	Water Level	UA	10/24/2023	11.33	611.92
G411	Water Level	UA	11/13/2023	11.20	612.05
MW03D	Water Level	DA	02/13/2023	30.75	598.26
MW03D	Water Level	DA	03/30/2023	30.43	598.57
MW03D	Water Level	DA	04/30/2023	30.00	599.01
MW03D	Water Level	DA	05/30/2023	30.11	598.90
MW03D	Water Level	DA	06/08/2023	30.17	598.83
MW03D	Water Level	DA	07/08/2023	30.39	598.62
MW03D	Water Level	DA	08/08/2023	30.65	598.36
MW03D	Water Level	DA	09/25/2023	29.29	599.72
MW03D	Water Level	DA	10/25/2023	29.64	599.37

Well ID	Well Type	Monitored Unit	Date	Depth to Groundwater (feet BMP)	Groundwater Elevation (feet NAVD88)
MW03D	Water Level	DA	11/13/2023	32.01	597.00
MW03D	Water Level	DA	12/18/2023	32.08	596.93
MW04S	Water Level	UA	02/13/2023	4.30	621.59
MW04S	Water Level	UA	05/30/2023	6.63	619.26
MW04S	Water Level	UA	08/08/2023	9.80	616.09
MW04S	Water Level	UA	11/13/2023	12.20	613.69
MW05S	Water Level	UA	02/13/2023	5.22	620.73
MW05S	Water Level	UA	05/30/2023	7.25	618.70
MW05S	Water Level	UA	08/08/2023	9.35	616.60
MW05D	Water Level	DA	02/13/2023	19.65	606.26
MW05D	Water Level	DA	05/30/2023	18.29	607.62
MW05D	Water Level	DA	08/08/2023	21.12	604.79
MW06S	Water Level	UA	02/13/2023	4.51	621.64
MW06S	Water Level	UA	05/30/2023	6.45	619.70
MW06S	Water Level	UA	08/08/2023	8.72	617.43
MW06S	Water Level	UA	10/24/2023	9.94	616.21
MW06S	Water Level	UA	11/13/2023	8.91	617.24
MW07S	Water Level	UA	02/13/2023	3.15	624.45
MW07S	Water Level	UA	05/30/2023	5.23	622.37
MW07S	Water Level	UA	08/08/2023	7.79	619.81
MW07S	Water Level	UA	10/24/2023	9.37	618.23
MW07S	Water Level	UA	11/13/2023	8.48	619.12
MW09S	Water Level	UA	02/13/2023	3.14	624.48
MW09S	Water Level	UA	05/30/2023	5.45	622.17
MW09S	Water Level	UA	08/08/2023	8.11	619.51
MW09D	Water Level	LCU	05/30/2023	13.91	613.70
MW09D	Water Level	LCU	08/08/2023	14.73	612.88
MW10S	Water Level	UA	05/30/2023	5.44	619.01
MW10S	Water Level	UA	08/08/2023	8.67	615.78
MW10D	Water Level	LCU	02/14/2023	3.41	621.06
MW10D	Water Level	LCU	05/30/2023	15.73	608.74
MW10D	Water Level	LCU	08/08/2023	18.69	605.78
MW11S	Water Level	UA	02/14/2023	3.78	621.49
MW11S	Water Level	UA	08/08/2023	8.00	617.27

Well ID	Well Type	Monitored Unit	Date	Depth to Groundwater (feet BMP)	Groundwater Elevation (feet NAVD88)
MW11D	Water Level	LCU	02/14/2023	4.73	620.79
MW11D	Water Level	LCU	03/30/2023	3.97	621.55
MW11D	Water Level	LCU	04/30/2023	4.00	621.51
MW11D	Water Level	LCU	05/30/2023	4.76	620.75
MW11D	Water Level	LCU	06/08/2023	6.52	618.99
MW11D	Water Level	LCU	07/08/2023	7.38	618.14
MW11D	Water Level	LCU	08/08/2023	8.57	616.95
MW12S	Water Level	UA	02/14/2023	5.30	620.01
MW12S	Water Level	UA	05/30/2023	7.36	617.95
MW12S	Water Level	UA	08/08/2023	10.87	614.44
MW12S	Water Level	UA	10/25/2023	12.51	612.80
MW12S	Water Level	UA	11/13/2023	12.80	612.51
MW12D	Water Level	DA	02/14/2023	13.63	611.58
MW12D	Water Level	DA	03/30/2023	13.17	612.04
MW12D	Water Level	DA	04/30/2023	12.69	612.52
MW12D	Water Level	DA	05/30/2023	12.71	612.50
MW12D	Water Level	DA	06/08/2023	12.80	612.41
MW12D	Water Level	DA	07/08/2023	13.31	611.90
MW12D	Water Level	DA	08/08/2023	13.93	611.28
MW12D	Water Level	DA	09/25/2023	14.86	610.35
MW12D	Water Level	DA	10/25/2023	15.32	609.89
MW12D	Water Level	DA	11/13/2023	15.64	609.57
MW12D	Water Level	DA	12/18/2023	16.00	609.21
MW13S	Water Level	UA	02/13/2023	8.55	617.41
MW13S	Water Level	UA	05/30/2023	10.19	615.77
MW13S	Water Level	UA	08/08/2023	11.34	614.62
MW13S	Water Level	UA	10/25/2023	12.79	613.17
MW13S	Water Level	UA	11/13/2023	12.33	613.63
MW13D	Water Level	DA	02/13/2023	1.20	624.66
MW13D	Water Level	DA	05/30/2023	13.52	612.34
MW13D	Water Level	DA	08/08/2023	12.86	613.00
MW13D	Water Level	DA	10/25/2023	12.75	613.11
MW13D	Water Level	DA	11/13/2023	12.45	613.41
MW16S	Water Level	UA	02/14/2023	6.61	622.86

Appendix B. Site-Wide Groundwater Elevations
Nature and Extent Report
Coffeen Power Plant
Ash Pond No. 2
Coffeen, IL

Well ID	Well Type	Monitored Unit	Date	Depth to Groundwater (feet BMP)	Groundwater Elevation (feet NAVD88)
MW16S	Water Level	UA	03/30/2023	3.70	625.77
MW16S	Water Level	UA	04/30/2023	5.10	624.37
MW16S	Water Level	UA	05/30/2023	6.89	622.57
MW16S	Water Level	UA	06/08/2023	8.31	621.16
MW16S	Water Level	UA	07/08/2023	9.95	619.52
MW16S	Water Level	UA	08/08/2023	11.63	617.84
MW16D	Water Level	DA	02/14/2023	14.63	614.75
MW16D	Water Level	DA	03/30/2023	13.05	616.33
MW16D	Water Level	DA	04/30/2023	12.09	617.29
MW16D	Water Level	DA	05/30/2023	11.83	617.55
MW16D	Water Level	DA	06/08/2023	11.85	617.53
MW16D	Water Level	DA	07/08/2023	12.34	617.04
MW16D	Water Level	DA	08/08/2023	12.97	616.41
MW17S	Water Level	UA	05/30/2023	6.91	623.65
MW17S	Water Level	UA	08/08/2023	10.81	619.75
MW17D	Water Level	DA	02/14/2023	19.92	610.37
MW17D	Water Level	DA	05/30/2023	13.33	616.96
MW17D	Water Level	DA	08/08/2023	14.58	615.71
MW20S	Water Level	UA	02/13/2023	8.21	614.69
MW20S	Water Level	UA	03/30/2023	6.59	616.31
MW20S	Water Level	UA	04/30/2023	8.97	613.93
MW20S	Water Level	UA	05/30/2023	9.28	613.61
MW20S	Water Level	UA	06/08/2023	9.56	613.33
MW20S	Water Level	UA	07/08/2023	9.63	613.26
MW20S	Water Level	UA	08/08/2023	10.60	612.30
MW20S	Water Level	UA	09/25/2023	11.53	611.37
MW20S	Water Level	UA	10/25/2023	11.74	611.16
MW20S	Water Level	UA	11/13/2023	11.96	610.94
MW20S	Water Level	UA	12/18/2023	11.60	611.30
R104	Water Level	UA	02/14/2023	7.44	625.40
R104	Water Level	UA	03/30/2023	6.14	626.69
R104	Water Level	UA	04/30/2023	7.47	625.36
R104	Water Level	UA	05/30/2023	8.02	624.81
R104	Water Level	UA	06/08/2023	8.41	624.43

Well ID	Well Type	Monitored Unit	Date	Depth to Groundwater (feet BMP)	Groundwater Elevation (feet NAVD88)
R104	Water Level	UA	07/08/2023	8.92	623.92
R104	Water Level	UA	08/08/2023	10.45	622.39
R104	Water Level	UA	09/25/2023	11.50	621.34
R104	Water Level	UA	10/25/2023	12.52	620.32
R104	Water Level	UA	11/13/2023	12.91	619.93
R104	Water Level	UA	12/18/2023	12.81	620.03
R201	Water Level	UA	02/14/2023	2.80	623.54
R201	Water Level	UA	03/30/2023	2.56	623.77
R201	Water Level	UA	04/30/2023	3.95	622.38
R201	Water Level	UA	05/30/2023	5.31	621.02
R201	Water Level	UA	06/08/2023	6.13	620.21
R201	Water Level	UA	07/08/2023	6.75	619.59
R201	Water Level	UA	08/08/2023	11.61	614.73
R201	Water Level	UA	09/25/2023	10.12	616.22
R201	Water Level	UA	10/24/2023	11.20	615.14
R201	Water Level	UA	11/13/2023	11.73	614.61
R201	Water Level	UA	12/18/2023	11.37	614.97
R205	Water Level	UA	02/13/2023	7.49	617.03
R205	Water Level	UA	08/08/2023	9.69	614.83
R205	Water Level	UA	10/25/2023	11.16	613.36
R205	Water Level	UA	11/13/2023	11.48	613.04
R205	Water Level	UA	12/18/2023	11.16	613.36
T127	Water Level	UA	02/13/2023	14.15	616.81
T127	Water Level	UA	05/30/2023	14.56	616.40
T127	Water Level	UA	08/08/2023	15.20	615.76
T127	Water Level	UA	10/25/2023	15.99	614.97
T127	Water Level	UA	11/13/2023	15.95	615.01
T128	Water Level	UA	02/13/2023	13.97	616.96
T128	Water Level	UA	05/30/2023	14.26	616.67
T128	Water Level	UA	08/08/2023	14.80	616.13
T128	Water Level	UA	10/25/2023	15.54	615.39
T128	Water Level	UA	11/13/2023	15.50	615.43
T202	Water Level	UA	02/13/2023	5.04	623.59
T202	Water Level	UA	05/30/2023	5.80	622.83

Well ID	Well Type	Monitored Unit	Date	Depth to Groundwater (feet BMP)	Groundwater Elevation (feet NAVD88)
T202	Water Level	UA	08/08/2023	9.23	619.40
T202	Water Level	UA	10/24/2023	11.02	617.61
T202	Water Level	UA	11/13/2023	11.66	616.97
T408	Water Level	LCU	02/13/2023	6.92	617.16
T408	Water Level	LCU	05/30/2023	7.42	616.66
T408	Water Level	LCU	08/08/2023	7.46	616.62
T408	Water Level	LCU	10/24/2023	8.11	615.97
T408	Water Level	LCU	11/13/2023	8.02	616.06
T409	Water Level	LCU	02/13/2023	9.36	615.65
T409	Water Level	LCU	05/30/2023	11.27	613.74
T409	Water Level	LCU	08/08/2023	9.99	615.02
T409	Water Level	LCU	10/24/2023	12.46	612.55
T409	Water Level	LCU	11/13/2023	12.00	613.01
TA31	Water Level	UA	02/13/2023	5.00	621.55
TA31	Water Level	UA	05/30/2023	7.06	619.49
TA31	Water Level	UA	08/08/2023	11.98	614.57
TA31	Water Level	UA	10/24/2023	14.65	611.90
TA31	Water Level	UA	11/13/2023	14.31	612.24
TA33	Water Level	UA	02/13/2023	8.04	617.23
TA33	Water Level	UA	05/30/2023	8.42	616.85
TA33	Water Level	UA	08/08/2023	12.10	613.17
TA33	Water Level	UA	10/24/2023	13.86	611.41
TA33	Water Level	UA	11/13/2023	13.98	611.29
TA34	Water Level	UA	02/13/2023	8.03	618.49
TA34	Water Level	UA	05/30/2023	9.48	617.04
TA34	Water Level	UA	08/08/2023	18.31	608.21
TA34	Water Level	UA	10/24/2023	12.98	613.54
TA34	Water Level	UA	11/13/2023	12.60	613.92
TR32	Water Level	UA	02/13/2023	6.11	615.57
TR32	Water Level	UA	05/30/2023	6.18	615.50
TR32	Water Level	UA	10/24/2023	9.02	612.66
TR32	Water Level	UA	11/13/2023	9.67	612.01
X201	Water Level	S	02/14/2023	--	614.71
X201	Water Level	S	03/30/2023	--	614.53

Well ID	Well Type	Monitored Unit	Date	Depth to Groundwater (feet BMP)	Groundwater Elevation (feet NAVD88)
X201	Water Level	S	04/30/2023	--	614.69
X201	Water Level	S	05/30/2023	--	614.93
X201	Water Level	S	08/08/2023	--	615.31
X201	Water Level	S	11/13/2023	[34.00]	[584.47]
X201	Water Level	S	12/12/2023	--	617.10
XPW01	Water Level	CCR	02/13/2023	4.51	630.06
XPW01	Water Level	CCR	03/30/2023	3.99	630.57
XPW01	Water Level	CCR	04/30/2023	4.24	630.32
XPW01	Water Level	CCR	05/30/2023	4.56	630.00
XPW01	Water Level	CCR	08/08/2023	5.29	629.28
XPW01	Water Level	CCR	10/24/2023	6.03	628.54
XPW01	Water Level	CCR	11/13/2023	6.32	628.25
XPW01	Water Level	CCR	12/18/2023	6.11	628.46
XPW02	Water Level	CCR	02/13/2023	9.38	630.31
XPW02	Water Level	CCR	03/30/2023	8.87	630.81
XPW02	Water Level	CCR	04/30/2023	9.11	630.57
XPW02	Water Level	CCR	05/30/2023	9.40	630.28
XPW02	Water Level	CCR	08/08/2023	10.30	629.39
XPW02	Water Level	CCR	09/25/2023	10.71	628.98
XPW02	Water Level	CCR	10/24/2023	10.93	628.76
XPW02	Water Level	CCR	11/13/2023	11.12	628.57
XPW02	Water Level	CCR	12/18/2023	11.02	628.67
NE Riser	Water Level	S	02/14/2023	--	625.24
XSG-01	Water Level	CCR	02/13/2023	5.40	630.12
XSG-01	Water Level	CCR	05/30/2023	5.45	630.07
XSG-01	Water Level	CCR	08/08/2023	6.25	629.27
XSG-01	Water Level	CCR	10/24/2023	7.02	628.50
XSG-01	Water Level	CCR	11/13/2023	10.38	625.14
XSG-01	Water Level	CCR	12/18/2023	7.04	628.48
SG-02	Water Level	SW	02/13/2023	7.25	598.62
SG-02	Water Level	SW	05/30/2023	7.47	598.40
SG-02	Water Level	SW	10/24/2023	7.49	598.38
SG-02	Water Level	SW	11/13/2023	7.36	598.51
SG-02	Water Level	SW	12/18/2023	7.31	598.56

Well ID	Well Type	Monitored Unit	Date	Depth to Groundwater (feet BMP)	Groundwater Elevation (feet NAVD88)
SG-03	Water Level	SW	02/13/2023	9.55	585.39
SG-03	Water Level	SW	05/30/2023	9.85	585.09
SG-03	Water Level	SW	08/08/2023	9.65	585.29
SG-03	Water Level	SW	10/24/2023	8.96	585.98
SG-03	Water Level	SW	11/13/2023	9.71	585.23
SG-03	Water Level	SW	12/18/2023	8.92	586.02
SG-04	Water Level	SW	02/13/2023	6.27	593.25
SG-04	Water Level	SW	05/30/2023	6.41	593.11

Notes:
Bracketing [] indicates that the measurement was obtained outside of the 24-hour period from initiaion of depth to groundwater measurements.
BMP = below measuring point
CCR = coal combustion residuals
DA = deep aquifer
LCU = lower confining unit
NAVD88 = North American Vertical Datum of 1988
S = source
SW = surface water

Appendix B. Site-Wide Groundwater Elevations

Nature and Extent Report
Coffeen Power Plant
Ash Pond No. 2
Coffeen, IL

Well ID	Well Type	Monitored Unit	Date	Depth to Groundwater (feet BMP)	Groundwater Elevation (feet NAVD88)
OW-1	Water Level	Porewater	1/23/2023	17.38	624.34
OW-1	Water Level	Porewater	2/21/2023	17.06	624.30
OW-1	Water Level	Porewater	3/15/2023	17.32	624.35
OW-1	Water Level	Porewater	4/19/2023	17.19	624.17
OW-1	Water Level	Porewater	5/24/2023	17.29	623.90
OW-1	Water Level	Porewater	6/22/2023	17.34	623.76
OW-1	Water Level	Porewater	7/24/2023	17.41	624.08
OW-1	Water Level	Porewater	8/18/2023	17.49	623.82
OW-1	Water Level	Porewater	9/14/2023	17.58	623.95
OW-1	Water Level	Porewater	10/18/2023	17.47	623.85
OW-1	Water Level	Porewater	11/17/2023	17.55	623.80
OW-1	Water Level	Porewater	12/15/2023	17.56	623.73
OW-2	Water Level	Porewater	1/23/2023	17.73	624.37
OW-2	Water Level	Porewater	2/21/2023	17.42	624.28
OW-2	Water Level	Porewater	3/15/2023	17.72	624.35
OW-2	Water Level	Porewater	4/19/2023	17.55	624.17
OW-2	Water Level	Porewater	5/24/2023	17.65	623.90
OW-2	Water Level	Porewater	6/22/2023	17.71	623.77
OW-2	Water Level	Porewater	7/24/2023	17.80	624.08
OW-2	Water Level	Porewater	8/18/2023	17.90	623.78
OW-2	Water Level	Porewater	9/14/2023	17.89	623.95
OW-2	Water Level	Porewater	10/18/2023	17.83	623.85
OW-2	Water Level	Porewater	11/17/2023	17.91	623.79
OW-2	Water Level	Porewater	12/15/2023	17.91	623.70
OW-3	Water Level	Porewater	1/23/2023	28.39	624.38
OW-3	Water Level	Porewater	2/21/2023	27.30	624.27
OW-3	Water Level	Porewater	3/15/2023	28.36	624.41
OW-3	Water Level	Porewater	4/19/2023	28.19	624.10
OW-3	Water Level	Porewater	5/24/2023	28.31	624.45
OW-3	Water Level	Porewater	6/22/2023	28.33	623.71
OW-3	Water Level	Porewater	7/24/2023	28.45	624.80
OW-3	Water Level	Porewater	8/18/2023	28.55	623.74
OW-3	Water Level	Porewater	9/14/2023	28.53	623.91
OW-3	Water Level	Porewater	10/18/2023	28.47	623.79
OW-3	Water Level	Porewater	11/17/2023	28.57	623.77
OW-3	Water Level	Porewater	12/15/2023	28.53	623.65
OW-5	Water Level	Porewater	1/23/2023	17.73	624.64
OW-5	Water Level	Porewater	2/21/2023	17.57	624.65

Appendix B. Site-Wide Groundwater Elevations

Nature and Extent Report
Coffeen Power Plant
Ash Pond No. 2
Coffeen, IL

Well ID	Well Type	Monitored Unit	Date	Depth to Groundwater (feet BMP)	Groundwater Elevation (feet NAVD88)
OW-5	Water Level	Porewater	3/15/2023	17.90	624.70
OW-5	Water Level	Porewater	4/19/2023	17.70	624.32
OW-5	Water Level	Porewater	5/24/2023	17.79	624.41
OW-5	Water Level	Porewater	6/22/2023	17.84	624.27
OW-5	Water Level	Porewater	7/24/2023	17.84	624.43
OW-5	Water Level	Porewater	8/18/2023	17.86	624.10
OW-5	Water Level	Porewater	9/14/2023	17.92	624.30
OW-5	Water Level	Porewater	10/18/2023	18.02	624.21
OW-5	Water Level	Porewater	11/17/2023	18.07	624.16
OW-5	Water Level	Porewater	12/15/2023	18.22	624.16
AP2-D	Water Level	Porewater	1/23/2023	20.20	623.90
AP2-D	Water Level	Porewater	2/21/2023	19.86	624.24
AP2-D	Water Level	Porewater	3/15/2023	20.19	623.91
AP2-D	Water Level	Porewater	4/19/2023	20.01	624.09
AP2-D	Water Level	Porewater	5/24/2023	20.10	624.00
AP2-D	Water Level	Porewater	6/22/2023	20.17	623.93
AP2-D	Water Level	Porewater	7/24/2023	20.25	623.85
AP2-D	Water Level	Porewater	8/18/2023	20.36	623.74
AP2-D	Water Level	Porewater	9/14/2023	20.33	623.77
AP2-D	Water Level	Porewater	10/18/2023	20.28	623.82
AP2-D	Water Level	Porewater	11/17/2023	20.34	623.76
AP2-D	Water Level	Porewater	12/15/2023	20.35	623.75

Notes:
BMP = below measuring point
NAVD88 = North American Vertical Datum of 1988

APPENDIX C
Supplemental Vertical Hydraulic Gradients

Appendix C. Supplemental Vertical Hydraulic Gradients

Nature and Extent Report
Coffeen Ash Pond No. 1
Coffeen Power Plant
Coffeen, IL

Date	G405 Groundwater Elevation (ft NAVD88)	T408 Groundwater Elevation (ft NAVD88)	Head Change (ft)	Distance Change [1] (ft)	Vertical Hydraulic Gradient [2] (dh/dl)	
	UA	LCU (upper)				
2/4/2017	618.47	619.46	-0.99	12.00	-0.08	up
5/13/2017	618.74	619.00	-0.26	12.00	-0.02	up
7/8/2017	618.54	619.12	-0.58	12.00	-0.05	up
10/21/2017	614.47	614.81	-0.34	12.00	-0.03	up
5/8/2018	618.94	615.82	3.12	12.00	0.26	down
8/2/2018	617.55	614.45	3.10	12.00	0.26	down
10/23/2018	616.40	616.30	0.10	12.00	0.01	down
1/15/2019	616.81	617.01	-0.20	12.00	-0.02	up
8/5/2019	617.72	617.15	0.57	12.00	0.05	down
1/20/2020	619.28	619.13	0.15	12.00	0.01	down
8/10/2020	617.62	617.38	0.24	12.00	0.02	down
1/20/2021	617.12	616.85	0.27	12.00	0.02	down
4/20/2021	617.13	616.65	0.48	12.00	0.04	down
7/26/2021	617.37	617.21	0.16	12.00	0.01	down
8/16/2021	617.28	617.22	0.06	12.00	0.00	down
10/25/2021	618.12	615.50	2.62	12.00	0.22	down
2/7/2022	617.28	616.88	0.40	12.00	0.03	down
5/9/2022	617.91	617.78	0.13	12.00	0.01	down
8/23/2022	616.85	616.99	-0.14	12.00	-0.01	up
2/13/2023	617.50	617.16	0.34	12.00	0.03	down
5/30/2023	616.79	616.66	0.13	12.00	0.01	down
8/8/2023	616.78	616.62	0.16	12.00	0.01	down
10/24/2023	615.79	615.97	-0.18	12.00	-0.02	up
11/13/2023	615.90	616.06	-0.16	12.00	-0.01	up
			Middle of screen elevation G405D			610.0
			Middle of screen elevation T408			598.0

Appendix C. Supplemental Vertical Hydraulic Gradients

Nature and Extent Report
Coffeen Ash Pond No. 1
Coffeen Power Plant
Coffeen, IL

Date	G406 Groundwater Elevation (ft NAVD88)	T409 Groundwater Elevation (ft NAVD88)	Head Change (ft)	Distance Change [1] (ft)	Vertical Hydraulic Gradient [2] (dh/dl)	
	UA	LCU (upper)				
2/4/2017	617.52	615.93	1.59	8.23	0.19	down
5/13/2017	616.20	616.75	-0.55	8.23	-0.07	up
7/8/2017	616.29	617.05	-0.76	8.23	-0.09	up
10/21/2017	611.27	612.16	-0.89	8.23	-0.11	up
5/8/2018	615.47	616.02	-0.55	8.23	-0.07	up
8/2/2018	615.75	615.25	0.50	8.23	0.06	down
10/23/2018	614.11	613.96	0.15	8.23	0.02	down
1/15/2019	615.36	614.78	0.58	8.23	0.07	down
8/5/2019	616.50	615.10	1.40	8.23	0.17	down
1/20/2020	617.48	617.16	0.32	8.23	0.04	down
8/10/2020	615.54	615.43	0.11	8.23	0.01	down
1/20/2021	612.97	614.41	-1.44	8.23	-0.17	up
4/20/2021	613.78	615.33	-1.55	8.23	-0.19	up
7/26/2021	614.20	615.72	-1.52	8.23	-0.18	up
8/16/2021	613.82	615.42	-1.60	8.23	-0.19	up
10/25/2021	614.93	616.43	-1.50	8.23	-0.18	up
2/7/2022	613.55	614.97	-1.42	8.23	-0.17	up
5/9/2022	615.36	616.81	-1.45	8.23	-0.18	up
8/23/2022	613.47	610.73	2.74	8.23	0.33	down
2/13/2023	614.11	615.65	-1.54	8.23	-0.19	up
5/30/2023	612.29	613.74	-1.45	8.23	-0.18	up
8/8/2023	613.87	615.02	-1.15	8.23	-0.14	up
10/24/2023	611.28	612.55	-1.27	8.23	-0.15	up
11/13/2023	611.53	613.01	-1.48	8.23	-0.18	up
			Middle of screen elevation G406			605.9
			Middle of screen elevation T409			597.7

Appendix C. Supplemental Vertical Hydraulic Gradients
Nature and Extent Report
Coffeen Ash Pond No. 1
Coffeen Power Plant
Coffeen, IL

Date	T408 Groundwater Elevation (ft NAVD88)	G45D Groundwater Elevation (ft NAVD88)	Head Change (ft)	Distance Change [1] (ft)	Vertical Hydraulic Gradient [2] (dh/dl)	
	LCU (upper)	LCU (lower)				
2/4/2017	619.46	587.71	31.75	13.78	2.30	down
5/13/2017	619.00	586.19	32.81	13.78	2.38	down
7/8/2017	619.12	586.29	32.83	13.78	2.38	down
10/21/2017	614.81	584.69	30.12	13.78	2.19	down
5/8/2018	615.82	587.56	28.26	13.78	2.05	down
8/2/2018	614.45	585.81	28.64	13.78	2.08	down
10/23/2018	616.30	584.60	31.70	13.78	2.30	down
1/15/2019	617.01	586.96	30.05	13.78	2.18	down
8/5/2019	617.15	588.04	29.11	13.78	2.11	down
8/10/2020	617.38	614.21	3.17	13.78	0.23	down
1/20/2021	616.85	614.60	2.25	13.78	0.16	down
4/20/2021	616.65	614.32	2.33	13.78	0.17	down
7/26/2021	617.21	613.58	3.63	13.78	0.26	down
8/16/2021	617.22	613.83	3.39	13.78	0.25	down
10/25/2021	615.50	614.51	0.99	13.78	0.07	down
2/7/2022	616.88	615.01	1.87	13.78	0.14	down
5/9/2022	617.78	614.95	2.83	13.78	0.21	down
8/23/2022	616.99	614.58	2.41	13.78	0.17	down
2/13/2023	617.16	614.69	2.47	13.78	0.18	down
5/30/2023	616.66	613.99	2.67	13.78	0.19	down
8/8/2023	616.62	613.47	3.15	13.78	0.23	down
10/24/2023	615.97	613.40	2.57	13.78	0.19	down
11/13/2023	616.06	613.55	2.51	13.78	0.18	down
			Middle of screen elevation T408			598.0
			Middle of screen elevation G45D			584.2

Appendix C. Supplemental Vertical Hydraulic Gradients

Nature and Extent Report
Coffeen Ash Pond No. 1
Coffeen Power Plant
Coffeen, IL

Date	T409 Groundwater Elevation (ft NAVD88)	G46D Groundwater Elevation (ft NAVD88)	Head Change (ft)	Distance Change [1] (ft)	Vertical Hydraulic Gradient [2] (dh/dl)	
	LCU (upper)	LCU (lower)				
2/4/2017	615.93	586.06	29.87	22.19	1.35	down
5/13/2017	616.75	584.87	31.88	22.19	1.44	down
7/8/2017	617.05	585.22	31.83	22.19	1.43	down
5/8/2018	616.02	585.86	30.16	22.19	1.36	down
8/2/2018	615.25	583.95	31.30	22.19	1.41	down
10/23/2018	613.96	582.05	31.91	22.19	1.44	down
1/15/2019	614.78	583.17	31.61	22.19	1.42	down
8/5/2019	615.10	583.68	31.42	22.19	1.42	down
8/10/2020	615.43	609.00	6.43	22.19	0.29	down
1/20/2021	614.41	610.49	3.92	22.19	0.18	down
4/20/2021	615.33	611.06	4.27	22.19	0.19	down
7/26/2021	615.72	607.21	8.51	22.19	0.38	down
8/16/2021	615.42	608.17	7.25	22.19	0.33	down
10/25/2021	616.43	609.87	6.56	22.19	0.30	down
2/7/2022	614.97	610.71	4.26	22.19	0.19	down
5/9/2022	616.81	611.34	5.47	22.19	0.25	down
8/23/2022	610.73	615.13	-4.40	22.19	-0.20	up
2/13/2023	615.65	610.39	5.26	22.19	0.24	down
5/30/2023	613.74	610.70	3.04	22.19	0.14	down
8/8/2023	615.02	610.14	4.88	22.19	0.22	down
10/24/2023	612.55	609.65	2.90	22.19	0.13	down
11/13/2023	613.01	609.70	3.31	22.19	0.15	down
			Middle of screen elevation T409			597.7
			Middle of screen elevation G46D			575.5

Appendix C. Supplemental Vertical Hydraulic Gradients

Nature and Extent Report
Coffeen Ash Pond No. 1
Coffeen Power Plant
Coffeen, IL

Date	G307 Groundwater Elevation (ft NAVD88)	G307D Groundwater Elevation (ft NAVD88)	Head Change (ft)	Distance Change [1] (ft)	Vertical Hydraulic Gradient [2] (dh/dl)	
	UA	LCU (lower)				
4/20/2021	624.50	622.48	2.02	38.06	0.05	down
5/17/2021	624.45	622.44	2.01	38.06	0.05	down
7/12/2021	624.45	622.59	1.86	38.06	0.05	down
8/16/2021	624.46	621.49	2.97	38.06	0.08	down
2/7/2022	624.60	622.32	2.28	38.06	0.06	down
5/9/2022	624.60	616.31	8.29	38.06	0.22	down
8/23/2022	624.60	615.09	9.51	38.06	0.25	down
2/13/2023	624.60	622.13	2.47	38.06	0.06	down
8/8/2023	623.90	616.99	6.91	38.06	0.18	down
11/13/2023	622.64	612.52	10.12	38.06	0.27	down
			Middle of screen elevation G307			606.7
			Middle of screen elevation G307D			568.6

Date	G311 Groundwater Elevation (ft NAVD88)	G311D Groundwater Elevation (ft NAVD88)	Head Change (ft)	Distance Change [1] (ft)	Vertical Hydraulic Gradient [2] (dh/dl)	
	UA	LCU (lower)				
3/29/2021	616.54	575.42	41.12	43.41	0.95	down
4/22/2021	613.68	575.74	37.94	43.41	0.87	down
5/3/2021	614.01	573.09	40.92	43.41	0.94	down
5/17/2021	613.86	572.40	41.46	43.41	0.96	down
6/9/2021	613.13	573.85	39.28	43.41	0.90	down
6/15/2021	612.78	575.25	37.53	43.41	0.86	down
6/23/2021	612.45	571.74	40.71	43.41	0.94	down
7/12/2021	613.75	571.63	42.12	43.41	0.97	down
7/26/2021	613.05	569.74	43.31	43.41	1.00	down
8/16/2021	613.30	570.34	42.96	43.41	0.99	down
10/25/2021	615.13	583.70	31.43	43.41	0.72	down
2/7/2022	614.28	593.14	21.14	43.41	0.49	down
5/9/2022	615.74	596.43	19.31	43.41	0.44	down
8/23/2022	613.19	597.46	15.73	43.41	0.36	down
5/30/2023	612.78	597.98	14.80	43.41	0.34	down
8/8/2023	611.96	597.72	14.24	43.41	0.33	down
10/24/2023	611.75	597.73	14.02	43.41	0.32	down
11/13/2023	611.66	597.09	14.57	43.41	0.34	down
			Middle of screen elevation G311			606.7
			Middle of screen elevation G311D			563.3

Appendix C. Supplemental Vertical Hydraulic Gradients

Nature and Extent Report

Coffeen Ash Pond No. 1

Coffeen Power Plant

Coffeen, IL

Date	G314 Groundwater Elevation (ft NAVD88)	G314D Groundwater Elevation (ft NAVD88)	Head Change (ft)	Distance Change [1] (ft)	Vertical Hydraulic Gradient [2] (dh/dl)	
	LCU (upper)	DA (PMP)				
3/29/2021	596.40	572.75	23.65	29.76	0.79	down
4/20/2021	603.16	571.76	31.40	27.40	1.15	down
5/3/2021	604.66	568.77	35.89	27.40	1.31	down
5/17/2021	605.61	566.84	38.77	27.40	1.42	down
6/9/2021	607.54	567.45	40.09	27.40	1.46	down
6/14/2021	608.16	568.60	39.56	27.40	1.44	down
6/23/2021	605.19	566.77	38.42	27.40	1.40	down
7/12/2021	605.32	566.88	38.44	27.40	1.40	down
7/26/2021	606.66	566.65	40.01	27.40	1.46	down
8/16/2021	608.60	567.28	41.32	27.40	1.51	down
10/25/2021	610.36	581.05	29.31	27.40	1.07	down
2/7/2022	607.85	590.46	17.39	27.40	0.63	down
5/9/2022	609.11	594.81	14.30	27.40	0.52	down
8/23/2022	610.58	595.70	14.88	27.40	0.54	down
2/13/2023	607.74	597.30	10.44	27.40	0.38	down
3/30/2023	604.91	603.71	1.20	27.40	0.04	down
4/30/2023	608.34	606.21	2.13	27.40	0.08	down
5/30/2023	609.06	607.00	2.06	27.40	0.08	down
6/8/2023	604.44	601.90	2.54	27.40	0.09	down
7/8/2023	608.20	606.45	1.75	27.40	0.06	down
8/8/2023	609.00	605.92	3.08	27.40	0.11	down
9/25/2023	608.92	605.20	3.72	27.40	0.14	down
10/24/2023	608.58	605.14	3.44	27.40	0.13	down
11/13/2023	608.21	605.73	2.48	27.40	0.09	down
12/18/2023	606.49	606.66	-0.17	27.40	-0.01	up
			Middle of screen elevation G314			594.0
			Middle of screen elevation G314D			566.6

[O: KLT 6/4/21, C:YMD 6/7/21; U:KLT 8/25/21, C:EDP 8/31/21]

[KLT 5/3/24, C: SSW 5/7/24]

Notes:

[1] Distance change was calculated using the midpoint of the piezometer screen and water table surface. If the water table surface was above the top of the monitoring well screen, then distance change was calculated using the midpoint of both screens.

[2] Vertical gradients between ±0.0015 are considered flat, and typically have less than 0.02 foot difference in groundwater elevation between wells.

- - = no data collected on date / no vertical gradient calculated

DA = deep aquifer

dh = head change

dl = distance change

ft = foot/feet

LCU (lower) = lower confining unit (Smithboro)

LCU (upper) = lower confining unit (Vandalia)

NAVD88 = North American Vertical Datum of 1988

PMP = potential migration pathway

UA = uppermost aquifer

Appendix C. Supplemental Vertical Hydraulic Gradients

Nature and Extent Report
Coffeen GMF Gypsum Stack Pond
Coffeen Power Plant
Coffeen, IL

Date	G206 Groundwater Elevation (ft NAVD88)	G206D Groundwater Elevation (ft NAVD88)	Head Change (ft)	Distance Change [1] (ft)	Vertical Hydraulic Gradient [2] (dh/dl)	
	UA	DA (PMP)				
4/20/2021	622.07	585.96	36.11	33.51	1.08	down
5/3/2021	622.60	587.42	35.18	33.51	1.05	down
5/17/2021	622.31	587.81	34.50	33.51	1.03	down
6/9/2021	621.71	584.19	37.52	33.51	1.12	down
6/23/2021	620.54	589.66	30.88	33.51	0.92	down
7/12/2021	622.39	590.72	31.67	33.51	0.95	down
7/26/2021	622.00	591.14	30.86	33.51	0.92	down
8/16/2021	622.08	592.00	30.08	33.51	0.90	down
10/25/2021	622.94	595.04	27.90	33.51	0.83	down
2/7/2022	622.37	598.22	24.15	33.51	0.72	down
5/9/2022	623.70	601.30	22.40	33.51	0.67	down
8/23/2022	621.61	602.86	18.75	33.51	0.56	down
3/30/2023	623.69	601.99	21.70	33.51	0.65	down
4/30/2023	622.54	603.60	18.94	33.51	0.57	down
5/30/2023	621.64	603.91	17.73	33.51	0.53	down
7/8/2023	620.69	604.04	16.65	33.51	0.50	down
8/8/2023	618.93	604.10	14.83	33.51	0.44	down
9/25/2023	618.08	604.06	14.02	33.51	0.42	down
10/25/2023	617.11	603.80	13.31	33.51	0.40	down
11/13/2023	616.66	603.74	12.92	33.51	0.39	down
12/18/2023	616.97	603.82	13.15	33.51	0.39	down
			Middle of screen elevation G206			610.8
			Middle of screen elevation G206D			577.3

[O: KLT 6/4/21, C:YMD 6/7/21][U:KLT 8/25/21, C:EDP 8/31/21]
[KLT 5/3/24, C: SSW 5/7/24]

Notes:

[1] Distance change was calculated using the midpoint of the piezometer screen and water table surface. If the water table surface was above the top of the monitoring well screen, then distance change was calculated using the midpoint of both screens.

[2] Vertical gradients between ±0.0015 are considered flat, and typically have less than 0.02 foot difference in groundwater elevation between wells.

-- = no data collected on date / no vertical gradient calculated
DA = deep aquifer
dh = head change
dl = distance change
ft = foot/feet
NAVD88 = North American Vertical Datum of 1988
PMP = potential migration pathway
UA = uppermost aquifer

Appendix C. Supplemental Vertical Hydraulic Gradients

Nature and Extent Report
Coffeen GMF Recycle Pond
Coffeen Power Plant
Coffeen, IL

Date	G405 Groundwater Elevation (ft NAVD88)	T408 Groundwater Elevation (ft NAVD88)	Head Change (ft)	Distance Change [1] (ft)	Vertical Hydraulic Gradient [2] (dh/dl)	
	UA	LCU (upper)				
2/4/2017	618.47	619.46	-0.99	12.00	-0.08	up
5/13/2017	618.74	619.00	-0.26	12.00	-0.02	up
7/8/2017	618.54	619.12	-0.58	12.00	-0.05	up
10/21/2017	614.47	614.81	-0.34	12.00	-0.03	up
5/8/2018	618.94	615.82	3.12	12.00	0.26	down
8/2/2018	617.55	614.45	3.10	12.00	0.26	down
10/23/2018	616.40	616.30	0.10	12.00	0.01	down
1/15/2019	616.81	617.01	-0.20	12.00	-0.02	up
8/5/2019	617.72	617.15	0.57	12.00	0.05	down
1/20/2020	619.28	619.13	0.15	12.00	0.01	down
8/10/2020	617.62	617.38	0.24	12.00	0.02	down
1/20/2021	617.12	616.85	0.27	12.00	0.02	down
4/20/2021	617.13	616.65	0.48	12.00	0.04	down
7/26/2021	617.37	617.21	0.16	12.00	0.01	down
8/16/2021	617.28	617.22	0.06	12.00	0.005	down
10/25/2021	618.12	615.50	2.62	12.00	0.218	down
2/7/2022	617.28	616.88	0.40	12.00	0.033	down
5/9/2022	617.91	617.78	0.13	12.00	0.011	down
8/23/2022	616.85	616.99	-0.14	12.00	-0.012	up
2/13/2023	617.50	617.16	0.34	12.00	0.028	down
5/30/2023	616.79	616.66	0.13	12.00	0.011	down
8/8/2023	616.78	616.62	0.16	12.00	0.013	down
10/24/2023	615.79	615.97	-0.18	12.00	-0.015	up
11/13/2023	615.90	616.06	-0.16	12.00	-0.013	up
			Middle of screen elevation G405D			610.0
			Middle of screen elevation T408			598.0

Appendix C. Supplemental Vertical Hydraulic Gradients

Nature and Extent Report

Coffeen GMF Recycle Pond

Coffeen Power Plant

Coffeen, IL

Date	G275 Groundwater Elevation (ft NAVD88)	G275D Groundwater Elevation (ft NAVD88)	Head Change (ft)	Distance Change [1] (ft)	Vertical Hydraulic Gradient [2] (dh/dl)	
	UA	DA (PMP)				
4/20/21-4/21/20	605.00	568.33	36.67	42.14	0.87	down
7/12/21-7/13/21	605.63	570.43	35.20	42.77	0.82	down
7/26/2021	605.05	570.35	34.70	42.18	0.82	down
8/16/2021	605.09	571.48	33.61	42.23	0.80	down
10/25/2021	605.17	578.52	26.65	42.30	0.63	down
2/7/2022	605.10	580.46	24.64	42.24	0.58	down
5/9/2022	605.67	581.11	24.56	42.80	0.57	down
2/13/2023	605.24	580.82	24.42	42.38	0.58	down
			Middle of screen elevation G275			605.7
			Middle of screen elevation G275D			562.9

Appendix C. Supplemental Vertical Hydraulic Gradients

Nature and Extent Report

Coffeen GMF Recycle Pond

Coffeen Power Plant

Coffeen, IL

Date	T408 Groundwater Elevation (ft NAVD88)	G45D Groundwater Elevation (ft NAVD88)	Head Change (ft)	Distance Change[1] (ft)	Vertical Hydraulic Gradient[2] (dh/dl)	
	LCU (upper)	LCU (lower)				
2/4/2017	619.46	587.71	31.75	13.78	2.30	down
5/13/2017	619.00	586.19	32.81	13.78	2.38	down
7/8/2017	619.12	586.29	32.83	13.78	2.38	down
10/21/2017	614.81	584.69	30.12	13.78	2.19	down
5/8/2018	615.82	587.56	28.26	13.78	2.05	down
8/2/2018	614.45	585.81	28.64	13.78	2.08	down
10/23/2018	616.30	584.60	31.70	13.78	2.30	down
1/15/2019	617.01	586.96	30.05	13.78	2.18	down
8/5/2019	617.15	588.04	29.11	13.78	2.11	down
8/10/2020	617.38	614.21	3.17	13.78	0.23	down
1/20/2021	616.85	614.60	2.25	13.78	0.16	down
4/20/2021	616.65	614.32	2.33	13.78	0.17	down
7/26/2021	617.21	613.58	3.63	13.78	0.26	down
8/16/2021	617.22	613.83	3.39	13.78	0.25	down
10/25/2021	615.50	614.51	0.99	13.78	0.07	down
2/7/2022	616.88	615.01	1.87	13.78	0.14	down
5/9/2022	617.78	614.95	2.83	13.78	0.21	down
8/23/2022	616.99	614.58	2.41	13.78	0.17	down
2/13/2023	617.16	614.69	2.47	13.78	0.18	down
5/30/2023	616.66	613.99	2.67	13.78	0.19	down
8/8/2023	616.62	613.47	3.15	13.78	0.23	down
10/24/2023	615.97	613.40	2.57	13.78	0.19	down
11/13/2023	616.06	613.55	2.51	13.78	0.18	down
			Middle of screen elevation T408			598.0
			Middle of screen elevation G45D			584.2

[O: KLT 6/4/21, C:YMD 6/7/21][U:KLT 8/25/21, C:EDP 8/31/21]
[KLT 5/3/24, C: 5/7/24]

Notes:

[1] Distance change was calculated using the midpoint of the piezometer screen and water table surface. If the water table surface was above the top of the monitoring well screen, then distance change was calculated using the midpoint of both screens.

[2] Vertical gradients between ±0.0015 are considered flat, and typically have less than 0.02 foot difference in groundwater elevation between wells.

-- = no data collected on date / no vertical gradient calculated
DA = deep aquifer
dh = head change
dl = distance change
ft = foot/feet
LCU (lower) = lower confining unit (Smithboro)
LCU (upper) = lower confining unit (Vandalia)
NAVD88 = North American Vertical Datum of 1988
PMP = potential migration pathway
UA = uppermost aquifer

APPENDIX D
Historical Field and Laboratory Hydraulic Conductivities

Appendix D. Historical Field and Laboratory Hydraulic Conductivities

Nature and Extent Report
Coffeen Power Plant
Ash Pond No. 2
Coffeen, IL

Well ID	Unit	Method (fh)	Method (rh)	K (fh)	K (rh)	Well Geometric Mean	Approximate Screened Elevation (ft)	Interpreted Unit
Upper-most Aquifer								
R104	Landfill	KGS	B-R	7.0E-05	2.8E-04	1.4E-04	614.4-609.7	Hagarstown Beds
G105		KGS	KGS	1.5E-04	5.7E-05	9.2E-05	613.2-608.4	
G106		B-R	B-R	4.0E-05	7.4E-04	1.7E-04	614.0-609.4	
G107		KGS	KGS	6.3E-05	8.9E-05	7.5E-05	613.9-609.3	
G110		KGS	KGS	4.7E-05	2.0E-05	3.1E-05	612.0-607.4	
G119		KGS	KGS	8.6E-05	8.2E-05	8.4E-05	611.6-607	
G120		low water elevation; no test conducted					614.2-609.7	
G125		KGS	KGS	4.8E-05	4.1E-05	4.4E-05	613.7-609.1	
T127		KGS	KGS	1.2E-03	1.7E-05	1.4E-04	610.5-606	
			Unit Geometric Mean			8.5E-05		
T202	Gypsum Pond	KGS	KGS	4.5E-04	5.5E-04	5.0E-04	614.0-609.6	Hagarstown Beds
G206		B-R	KGS	3.0E-04	1.6E-04	2.2E-04	613.0-608.6	
G208		KGS	KGS	6.0E-05	2.1E-05	3.5E-05	613.0-608.5	
G209		KGS	KGS	2.0E-04	1.6E-04	1.8E-04	612.8-608.3	
G210		KGS	KGS	5.0E-04	4.8E-04	4.9E-04	611.1-606.6	
G212		KGS	KGS	1.3E-04	1.8E-04	1.5E-04	613.9-609.3	
G215		KGS	KGS	5.0E-04	3.5E-04	4.2E-04	611.1-606.7	
G218		KGS	KGS	4.1E-04	4.1E-04	4.1E-04	610.3-605.9	
			Unit Geometric Mean			2.3E-04		
G270	Recycle Pond	KGS	KGS	5.5E-04	4.8E-04	5.1E-04	609.8-605.0	Hagarstown Beds
G271		KGS	KGS	1.6E-04	1.1E-03	4.2E-04	612.9-608.6	
G273		KGS	KGS	1.0E-03	8.3E-04	9.1E-04	611.1-605.6	
G276		low water					606.7-601.9	Hagarstown Beds, v. thin
G279		KGS	KGS	1.7E-03	1.5E-03	1.6E-03	606.8-602.4	Hagarstown Beds
G280		KGS	KGS	1.3E-03	1.3E-03	1.3E-03	610.2-605.3	
G281		KGS	KGS	2.1E-03	8.9E-04	1.4E-03	608.3-603.7	
			Unit Geometric Mean			9.0E-04		
G301	Ash Pond 1	KGS	KGS	2.7E-04	5.0E-04	3.7E-04	609-604.3	Upper Vandalia Till
G302		KGS	KGS	4.9E-04	6.3E-04	5.6E-04	604.7-600.1	
G303		KGS	KGS	5.6E-05	3.1E-05	4.2E-05	609.1-599.1	Hagarstown/Vandalia Till Contact
G304		KGS	KGS	8.9E-04	1.0E-03	9.4E-04	613.5-603.5	Hagarstown Beds
			Unit Geometric Mean			3.0E-04		
G401	Ash Pond 2	B-R	B-R	1.8E-04	2.8E-04	2.2E-04	608.7-603.7	Hagarstown Beds
G402		KGS	KGS	4.5E-04	1.9E-04	2.9E-04	600.6-590.6	Upper Vandalia Till
G403		KGS	KGS	4.3E-05	7.2E-05	5.6E-05	610.7-606.0	Hagarstown Beds, v. thin
G404		KGS	KGS	4.2E-04	3.8E-04	4.0E-04	606.7-601.9	Hagarstown Beds
G405		KGS	KGS	9.8E-04	9.7E-04	9.7E-04	611.9-607.1	
			Unit Geometric Mean			2.7E-04		
G153	SW Pond	KGS	KGS	2.5E-04	5.4E-04	3.7E-04	607.5-603.0	Hagarstown Beds
			Unit Geometric Mean			3.7E-04		
MW03S	2009 Hydrogeo. Invest.	B-R	B-R	6.0E-04	1.1E-03	8.1E-04	613.7-608.6	Hagarstown Beds
MW04S		B-R	B-R	1.3E-03	8.0E-04	1.0E-03	612.6-607.6	
MW10S		B-R	B-R	8.0E-04	8.0E-04	8.0E-04	610.9-604.9	
MW13S		B-R	B-R	1.0E-03	2.0E-04	4.5E-04	611.3-606.1	
MW14S		B-R	B-R	1.0E-03	5.0E-04	7.1E-04	612.4-607.2	
MW15S		B-R	B-R	1.5E-04	8.1E-05	1.1E-04	609.3-604.2	
MW16S		B-R	B-R	6.0E-04	4.5E-04	5.2E-04	611.5-606.3	
MW17S		B-R	B-R	5.8E-04	5.5E-04	5.6E-04	613.1-603	
			Unit Geometric Mean			5.4E-04		

Well ID	Unit	Method (fh)	Method (rh)	K (fh)	K (rh)	Well Geometric Mean	Approximate Screened Elevation (ft)	Interpreted Unit
Lower Confining Unit (Vandalia and Smithboro Till)								
T408	Ash Pond 2	KGS	KGS	2.15E-06	7.50E-08	9.02E-07	600.4-595.2	Vandalia Till
T409		KGS	KGS	3.6E-05	3.20E-05	3.41E-05	600.1-594.9	Vandalia Till (sand seam)
G405D		KGS	KGS			4.90E-07	589.1-579	Smithboro Till
G406D		KGS	KGS			4.00E-08	580.3-570.3	
			Unit Geometric Mean			5.55E-06		

Notes:
fh = Falling head test
rh = Rising head test

Hydraulic Conductivity tests analyzed using Aqtesolv® Pro version 4.50 (HydroSOLVE, Inc.)

Test Methods

B-R	Bouwer and Rice, 1976. "A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifer with Completely or Partially Penetrating Wells", Water Resources Research v.12, no. 3. American Geophysical Union, Washington, DC. pp. 423-428.
KGS	Hyder, Z., J.J. Butler, C.D. McElwee, and W. Liu, 1974. "Slug tests in partially penetrating wells", Water Resources Research, v. 30, no. 11. American Geophysical Union, Washington, DC. pp. 2945-2957.

Appendix D. Historical Field and Laboratory Hydraulic Conductivities
Nature and Extent Report
Coffeen Power Plant
Ash Pond No. 2
Coffeen, IL

Laboratory Tests			
Well/ Soil Boring ID	**Approximate Sample Elevation (ft)**	**Hydraulic Conductivity (cm/sec)**	**Interpreted Unit**
COF-B001	613.0	1.3E-08	Loess - Upper Confining Unit
COF-B003	606.5	2.2E-07	
COF-B004	610.5	5.0E-07	
COF-B007	615.0	7.0E-08	
	Geometric Mean	**1.0E-07**	
G46D	599.2	4.5E-06	Vandalia Till
T408	597.6	1.5E-07	
SB-12	577.7-572.7	6.8E-09	
SB-13	598-593	7.0E-09	
SB-18	603.5-603	8.8E-09	
	Geometric Mean	**4.9E-08**	
SB-09	598.5-598	1.9E-06	Mulberry Grove Silt
SB-16	589-588.5	1.6E-06	
	Geometric Mean	**1.7E-06**	
G45D	586.4	1.0E-07	Smithboro Till
G46D	578.9	2.1E-08	
SB-07	572-571.5	1.1E-09	
	Geometric Mean	**1.3E-08**	
SB-19	569-564	3.4E-09	Deep Confining Unit
SB-16	548-547.5	1.3E-08	
	Geometric Mean	**6.6E-09**	

APPENDIX E
Supplemental Field Hydraulic Conductivities

Appendix E. Supplemental Field Hydraulic Conductivities
Nature and Extent Report
Coffeen Ash Pond No. 1
Coffeen Power Plant
Coffeen, IL

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) Hydraulic Conductivity (cm/s)	Rising Head (Slug Out) Hydraulic Conductivity (cm/s)	Minimum Hydraulic Conductivity (cm/s)	Maximum Hydraulic Conductivity (cm/s)	Hydraulic Conductivity Geometric Mean (cm/s)
Uppermost Aquifer											
G301	D	604.31	4.65	(ML)s	solid	Kansas Geological Survey	1.1E-03	1.2E-03	2.6E-04	9.1E-03	2.0E-03
G303	D	599.07	10	CL	solid	Kansas Geological Survey	2.8E-04	2.6E-04			
G308	D	606.70	4.79	s(ML), s(CL), (CL)s	solid	Kansas Geological Survey	5.5E-03	1.6E-03			
G309	D	605.02	4.78	SP, s(CL), (ML)s	solid	Kansas Geological Survey	9.1E-03	8.8E-04			
G310	D	604.86	4.79	SM, s(ML)	solid	Kansas Geological Survey	7.5E-03	5.9E-03			
G311	D	604.28	4.77	s(ML), s(CL)	solid	Bouwer-Rice	1.5E-03	- -			
G312	D	602.34	4.79	s(ML), s(CL)	solid	Kansas Geological Survey	1.1E-03	1.1E-03			
G313	D	600.40	4.81	SP, s(ML), (CL)s	solid	Kansas Geological Survey	2.7E-03	3.5E-03			
G315	D	606.46	4.79	s(CL)	solid	Kansas Geological Survey	6.6E-03	5.8E-03			
Lower Confining Unit											
G307D	D	563.76	9.77	(CL)s	solid	Kansas Geological Survey	3.2E-04	1.2E-04	1.2E-04	2.3E-03	5.0E-04
G311D	D	558.29	9.94	CL	solid	Kansas Geological Survey	3.8E-04	2.1E-04			
G316	D	584.82	4.80	SP, s(ML), (CL)s	solid	Kansas Geological Survey	2.3E-03	2.3E-03			
Deep Aquifer (PMP)											
G314D	D	561.76	9.77	SP, s(CL)	solid	Bouwer-Rice	3.3E-04	2.3E-05	2.3E-05	3.3E-04	8.7E-05

[O: KLT 07/09/21; C:EDP 8/31/21]

Notes:
1. All wells are constructed from 2 inch PVC with 0.01 inch slotted screens.
- - = Test not analyzed/performed
cm/s = centimeters per second
D = downgradient
ft = foot/feet
NAVD88 = North American Vertical Datum of 1988
PMP= potential migration pathway
PVC = polyvinyl chloride

USCS = Unified Soil Classification System
CL = Lean Clay
s(CL) = Sandy Lean Clay
(CL)s = Lean Clay with Sand
s(ML) = Sandy Silt
(ML)s = Silt with Sand
SP = Poorly-Graded Sand

Appendix E. Supplemental Field Hydraulic Conductivities

Nature and Extent Report
GMF Gypsum Stack Pond
Coffeen Power Plant
Coffeen, IL

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) Hydraulic Conductivity (cm/s)	Rising Head (Slug Out) Hydraulic Conductivity (cm/s)	Minimum Hydraulic Conductivity (cm/s)	Maximum Hydraulic Conductivity (cm/s)	Hydraulic Conductivity Geometric Mean (cm/s)
Uppermost Aquifer											
G206	D	608.61	4.41	SM, s(CL), CL	solid	Kansas Geological Survey	5.0E-04	4.9E-04	2.5E-04	4.0E-03	1.4E-03
G209	D	608.29	4.54	CL	solid	Kansas Geological Survey	- -	2.5E-04			
G212	D	609.30	4.55	SM, s(CL), CL	solid	Kansas Geological Survey	2.1E-03	1.8E-03			
G215	D	606.68	4.39	SM, s(CL), ML	solid	Kansas Geological Survey	4.0E-03	3.5E-03			
G218	D	605.87	4.44	SM, SC, CL	solid	Kansas Geological Survey	2.6E-03	2.4E-03			

[O: KLT, C:EDP 8/31/21]

Notes:

1. All wells are constructed from 2 inch PVC with 0.01 inch slotted screens.

- - = Test not analyzed/performed
cm/s = centimeters per second
D = downgradient
ft = foot/feet
NAVD88 = North American Vertical Datum of 1988
PVC = polyvinyl chloride

USCS = Unified Soil Classification System
CL = Lean Clay
s(CL) = Sandy Lean Clay
ML = Silt
SC = Clayey Sand
SM = Silty Sand

Appendix E. Supplemental Field Hydraulic Conductivities

Nature and Extent Report
GMF Recycle Pond
Coffeen Power Plant
Coffeen, IL

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) Hydraulic Conductivity (cm/s)	Rising Head (Slug Out) Hydraulic Conductivity (cm/s)	Minimum Hydraulic Conductivity (cm/s)	Maximum Hydraulic Conductivity (cm/s)	Hydraulic Conductivity Geometric Mean (cm/s)
Uppermost Aquifer											
G272	D	606.74	4.87	SP to ML, (CL)s	solid	Kansas Geological Survey	1.7E-03	- -	7.8E-04	1.7E-03	1.1E-03
G284	D	602.48	4.77	ML	solid	Kansas Geological Survey	1.2E-03	7.8E-04			
G286	D	601.81	4.79	SP, ML, CL	solid	Kansas Geological Survey	1.2E-03	- -			
G287	D	604.09	4.82	SP, ML, CL	solid	Kansas Geological Survey	1.1E-03	1.1E-03			
Lower Confining Unit (PMP)											
G283	D	590.13	9.78	SP, ML	solid	Kansas Geological Survey	4.2E-03	4.5E-03	2.7E-04	4.5E-03	1.2E-03
G285	D	587.09	9.77	CL	solid	Bouwer-Rice	2.7E-04	4.3E-04			

[O: KLT, C:EDP 8/31/21]

Notes:
1. All wells are constructed from 2 inch PVC with 0.01 inch slotted screens.

- - = Test not analyzed/performed
cm/s = centimeters per second
D = downgradient
ft = foot/feet
NAVD88 = North American Vertical Datum of 1988
PVC = polyvinyl chloride
PMP = potential migration pathway

USCS = Unified Soil Classification System
CL = Lean Clay
(CL)s = Lean Clay with Sand
ML = Silt
SP = Poorly-Graded Sand

APPENDIX F
Surface Water Sampling Locations and Laboratory Analytical Report

🟠 GSI Surface Water Sample

🟢 Background Surface Water Sample

Figure adapted by Ramboll from Geosyntec-provided figure

Notes:
Locations are approximate

Surface Water Sampling Locations

134 Cips Lane
Coffeen, Illinois

Geosyntec
consultants

St. Louis

July 2021

Figure

3

S:\Company\Projects_post_2014\GLP8005_Coffeen MNA\GIS\Porewater and Sediment Sampling Loactions.mxd 7/22/2021 8:27:18 AM eurofins | Environment Testing America

ANALYTICAL REPORT

Eurofins TestAmerica, Chicago
2417 Bond Street
University Park, IL 60484
Tel: (708)534-5200

Laboratory Job ID: 500-203343-1
Client Project/Site: GLP8029 Coffeen, IL

For:
Geosyntec Consultants, Inc.
2100 Commonwealth Blvd.
Suite 100
Ann Arbor, Michigan 48105

Attn: Brian Ares

Robin M Kintz

Authorized for release by:
8/20/2021 1:48:27 PM

Robin Kintz, Project Manager II
(708)534-5200
Robin.Kintz@Eurofinset.com

LINKS

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www.eurofinsus.com/Env

The test results in this report meet all 2003 NELAC, 2009 TNI, and 2016 TNI requirements for accredited parameters, exceptions are noted in this report. This report may not be reproduced except in full, and with written approval from the laboratory. For questions please contact the Project Manager at the e-mail address or telephone number listed on this page.

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.

Table of Contents

Case Narrative

Client: Geosyntec Consultants, Inc.
Project/Site: GLP8029 Coffeen, IL

Job ID: 500-203343-1

Job ID: 500-203343-1

Laboratory: Eurofins TestAmerica, Chicago

Narrative

Job Narrative
500-203343-1

Comments

No additional comments.

Receipt

The samples were received on 8/5/2021 9:45 AM. Unless otherwise noted below, the samples arrived in good condition, and where required, properly preserved and on ice. The temperatures of the 2 coolers at receipt time were 1.1º C and 2.5º C.

Metals

No analytical or quality issues were noted, other than those described in the Definitions/Glossary page.

Field Service / Mobile Lab

No analytical or quality issues were noted, other than those described in the Definitions/Glossary page.

General Chemistry

Methods 300.0, 9056A: Due to the high concentration of Chloride, the matrix spike / matrix spike duplicate (MS/MSD) for analytical batch 500-614638 could not be evaluated for accuracy and precision. The associated laboratory control sample (LCS) met acceptance criteria.

Method 9060A: One of the CCV replicates failed to meet criteria at 89% recovery for DOC. The average was within control; therefore, the data have been reported. The RPD was within control as well. The following samples are affected: D-2-20210803 (500-203343-1), D-1-20210803 (500-203343-2), BKG-1-20210803 (500-203343-3), CL-1-20210803 (500-203343-4), DUP-20210803 (500-203343-5), CL-2-20210803 (500-203343-6), CL-3-20210803 (500-203343-7), (CCB 500-613783/21) and (CCV 500-613783/20).

No additional analytical or quality issues were noted, other than those described above or in the Definitions/Glossary page.

Detection Summary

Client: Geosyntec Consultants, Inc.
Project/Site: GLP8029 Coffeen, IL

Job ID: 500-203343-1

Client Sample ID: D-2-20210803

Lab Sample ID: 500-203343-1

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Boron	0.30		0.050	0.0056	mg/L	1		6010B	Total/NA
Calcium	45		0.20	0.053	mg/L	1		6010B	Total/NA
Iron	0.24		0.20	0.082	mg/L	1		6010B	Total/NA
Magnesium	13	B	0.10	0.049	mg/L	1		6010B	Total/NA
Manganese	0.20		0.010	0.0023	mg/L	1		6010B	Total/NA
Potassium	3.2	B	0.50	0.066	mg/L	1		6010B	Total/NA
Sodium	13	B	1.0	0.097	mg/L	1		6010B	Total/NA
Boron, Dissolved	0.30		0.050	0.0056	mg/L	1		6010B	Dissolved
Calcium, Dissolved	46		0.20	0.053	mg/L	1		6010B	Dissolved
Iron, Dissolved	0.15	J	0.20	0.082	mg/L	1		6010B	Dissolved
Magnesium, Dissolved	13	B	0.10	0.049	mg/L	1		6010B	Dissolved
Manganese, Dissolved	0.20		0.010	0.0023	mg/L	1		6010B	Dissolved
Potassium, Dissolved	3.2	B	0.50	0.066	mg/L	1		6010B	Dissolved
Sodium, Dissolved	13	B	1.0	0.097	mg/L	1		6010B	Dissolved
Chloride	7.2		0.20	0.17	mg/L	1		9056A	Total/NA
Sulfate	69		4.0	1.9	mg/L	20		9056A	Total/NA
Alkalinity	100		5.0	3.7	mg/L	1		SM 2320B	Total/NA
Total Dissolved Solids	240		10	4.3	mg/L	1		SM 2540C	Total/NA
Ferric Iron	0.24		0.20	0.10	mg/L	1		SM 3500	Total/NA
Phosphorus as PO4	0.24		0.15	0.073	mg/L	1		SM 4500 P E	Total/NA
Sulfide	0.25	J	1.0	0.23	mg/L	1		SM 4500 S2 F	Total/NA
Dissolved Organic Carbon - Duplicate	3.6		1.0	0.47	mg/L	1		9060A	Dissolved

Client Sample ID: D-1-20210803

Lab Sample ID: 500-203343-2

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Boron	0.33		0.050	0.0056	mg/L	1		6010B	Total/NA
Calcium	53		0.20	0.053	mg/L	1		6010B	Total/NA
Iron	0.23		0.20	0.082	mg/L	1		6010B	Total/NA
Magnesium	16	B	0.10	0.049	mg/L	1		6010B	Total/NA
Manganese	0.030		0.010	0.0023	mg/L	1		6010B	Total/NA
Potassium	2.5	B	0.50	0.066	mg/L	1		6010B	Total/NA
Sodium	19	B	1.0	0.097	mg/L	1		6010B	Total/NA
Boron, Dissolved	0.32		0.050	0.0056	mg/L	1		6010B	Dissolved
Calcium, Dissolved	52		0.20	0.053	mg/L	1		6010B	Dissolved
Iron, Dissolved	0.13	J	0.20	0.082	mg/L	1		6010B	Dissolved
Magnesium, Dissolved	16	B	0.10	0.049	mg/L	1		6010B	Dissolved
Manganese, Dissolved	0.024		0.010	0.0023	mg/L	1		6010B	Dissolved
Potassium, Dissolved	2.5	B	0.50	0.066	mg/L	1		6010B	Dissolved
Sodium, Dissolved	18	B	1.0	0.097	mg/L	1		6010B	Dissolved
Chloride	9.1		0.40	0.34	mg/L	2		9056A	Total/NA
Sulfate	110		5.0	2.4	mg/L	25		9056A	Total/NA
Alkalinity	100		5.0	3.7	mg/L	1		SM 2320B	Total/NA
Total Dissolved Solids	240		10	4.3	mg/L	1		SM 2540C	Total/NA
Ferric Iron	0.23		0.20	0.10	mg/L	1		SM 3500	Total/NA
Phosphorus as PO4	0.13	J	0.15	0.073	mg/L	1		SM 4500 P E	Total/NA
Dissolved Organic Carbon - Duplicate	3.3		1.0	0.47	mg/L	1		9060A	Dissolved

Client Sample ID: BKG-1-20210803

Lab Sample ID: 500-203343-3

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Boron	0.082		0.050	0.0056	mg/L	1		6010B	Total/NA

This Detection Summary does not include radiochemical test results.

Client Sample ID: BKG-1-20210803 (Continued) Lab Sample ID: 500-203343-3

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Calcium	20		0.20	0.053	mg/L	1		6010B	Total/NA
Iron	0.27		0.20	0.082	mg/L	1		6010B	Total/NA
Magnesium	10	B	0.10	0.049	mg/L	1		6010B	Total/NA
Manganese	0.037		0.010	0.0023	mg/L	1		6010B	Total/NA
Potassium	4.9	B	0.50	0.066	mg/L	1		6010B	Total/NA
Sodium	12	B	1.0	0.097	mg/L	1		6010B	Total/NA
Boron, Dissolved	0.079		0.050	0.0056	mg/L	1		6010B	Dissolved
Calcium, Dissolved	20		0.20	0.053	mg/L	1		6010B	Dissolved
Iron, Dissolved	0.19	J	0.20	0.082	mg/L	1		6010B	Dissolved
Magnesium, Dissolved	10	B	0.10	0.049	mg/L	1		6010B	Dissolved
Potassium, Dissolved	4.9	B	0.50	0.066	mg/L	1		6010B	Dissolved
Sodium, Dissolved	12	B	1.0	0.097	mg/L	1		6010B	Dissolved
Chloride	12		2.0	1.7	mg/L	10		9056A	Total/NA
Sulfate	36		2.0	0.95	mg/L	10		9056A	Total/NA
Alkalinity	65		5.0	3.7	mg/L	1		SM 2320B	Total/NA
Total Dissolved Solids	72		10	4.3	mg/L	1		SM 2540C	Total/NA
Ferric Iron	0.27		0.20	0.10	mg/L	1		SM 3500	Total/NA
Phosphorus as PO4	0.12	J	0.15	0.073	mg/L	1		SM 4500 P E	Total/NA
Dissolved Organic Carbon - Duplicate	5.0		1.0	0.47	mg/L	1		9060A	Dissolved

Client Sample ID: CL-1-20210803 Lab Sample ID: 500-203343-4

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Boron	0.10		0.050	0.0056	mg/L	1		6010B	Total/NA
Calcium	23		0.20	0.053	mg/L	1		6010B	Total/NA
Iron	0.38		0.20	0.082	mg/L	1		6010B	Total/NA
Magnesium	11	B	0.10	0.049	mg/L	1		6010B	Total/NA
Manganese	0.037		0.010	0.0023	mg/L	1		6010B	Total/NA
Potassium	4.5	B	0.50	0.066	mg/L	1		6010B	Total/NA
Sodium	11	B	1.0	0.097	mg/L	1		6010B	Total/NA
Boron, Dissolved	0.12		0.050	0.0056	mg/L	1		6010B	Dissolved
Calcium, Dissolved	26		0.20	0.053	mg/L	1		6010B	Dissolved
Iron, Dissolved	0.68		0.20	0.082	mg/L	1		6010B	Dissolved
Magnesium, Dissolved	11	B	0.10	0.049	mg/L	1		6010B	Dissolved
Manganese, Dissolved	0.062		0.010	0.0023	mg/L	1		6010B	Dissolved
Potassium, Dissolved	4.7	B	0.50	0.066	mg/L	1		6010B	Dissolved
Sodium, Dissolved	12	B	1.0	0.097	mg/L	1		6010B	Dissolved
Chloride	11		0.40	0.34	mg/L	2		9056A	Total/NA
Sulfate	33		2.0	0.95	mg/L	10		9056A	Total/NA
Alkalinity	68		5.0	3.7	mg/L	1		SM 2320B	Total/NA
Total Dissolved Solids	120		10	4.3	mg/L	1		SM 2540C	Total/NA
Ferric Iron	0.38		0.20	0.10	mg/L	1		SM 3500	Total/NA
Phosphorus as PO4	0.21		0.15	0.073	mg/L	1		SM 4500 P E	Total/NA
Dissolved Organic Carbon - Duplicate	5.4		1.0	0.47	mg/L	1		9060A	Dissolved

Client Sample ID: DUP-20210803 Lab Sample ID: 500-203343-5

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Boron	0.086		0.050	0.0056	mg/L	1		6010B	Total/NA
Calcium	21		0.20	0.053	mg/L	1		6010B	Total/NA
Iron	0.39		0.20	0.082	mg/L	1		6010B	Total/NA
Magnesium	10	B	0.10	0.049	mg/L	1		6010B	Total/NA

This Detection Summary does not include radiochemical test results.

Client Sample ID: DUP-20210803 (Continued) Lab Sample ID: 500-203343-5

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Manganese	0.052		0.010	0.0023	mg/L	1		6010B	Total/NA
Potassium	4.7	B	0.50	0.066	mg/L	1		6010B	Total/NA
Sodium	11	B	1.0	0.097	mg/L	1		6010B	Total/NA
Boron, Dissolved	0.086		0.050	0.0056	mg/L	1		6010B	Dissolved
Calcium, Dissolved	21		0.20	0.053	mg/L	1		6010B	Dissolved
Iron, Dissolved	0.087	J	0.20	0.082	mg/L	1		6010B	Dissolved
Magnesium, Dissolved	10	B	0.10	0.049	mg/L	1		6010B	Dissolved
Potassium, Dissolved	4.7	B	0.50	0.066	mg/L	1		6010B	Dissolved
Sodium, Dissolved	11	B	1.0	0.097	mg/L	1		6010B	Dissolved
Chloride	11		0.40	0.34	mg/L	2		9056A	Total/NA
Sulfate	33		2.0	0.95	mg/L	10		9056A	Total/NA
Alkalinity	65		5.0	3.7	mg/L	1		SM 2320B	Total/NA
Total Dissolved Solids	110		10	4.3	mg/L	1		SM 2540C	Total/NA
Ferric Iron	0.39		0.20	0.10	mg/L	1		SM 3500	Total/NA
Phosphorus as PO4	0.14	J	0.15	0.073	mg/L	1		SM 4500 P E	Total/NA
Dissolved Organic Carbon - Duplicate	4.9		1.0	0.47	mg/L	1		9060A	Dissolved

Client Sample ID: CL-2-20210803 Lab Sample ID: 500-203343-6

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Boron	0.086		0.050	0.0056	mg/L	1		6010B	Total/NA
Calcium	21		0.20	0.053	mg/L	1		6010B	Total/NA
Iron	0.38		0.20	0.082	mg/L	1		6010B	Total/NA
Magnesium	10	B	0.10	0.049	mg/L	1		6010B	Total/NA
Manganese	0.051		0.010	0.0023	mg/L	1		6010B	Total/NA
Potassium	4.7	B	0.50	0.066	mg/L	1		6010B	Total/NA
Sodium	11	B	1.0	0.097	mg/L	1		6010B	Total/NA
Boron, Dissolved	0.087		0.050	0.0056	mg/L	1		6010B	Dissolved
Calcium, Dissolved	22		0.20	0.053	mg/L	1		6010B	Dissolved
Iron, Dissolved	0.13	J	0.20	0.082	mg/L	1		6010B	Dissolved
Magnesium, Dissolved	10	B	0.10	0.049	mg/L	1		6010B	Dissolved
Potassium, Dissolved	4.7	B	0.50	0.066	mg/L	1		6010B	Dissolved
Sodium, Dissolved	11	B	1.0	0.097	mg/L	1		6010B	Dissolved
Chloride	11		0.40	0.34	mg/L	2		9056A	Total/NA
Sulfate	31		2.0	0.95	mg/L	10		9056A	Total/NA
Alkalinity	65		5.0	3.7	mg/L	1		SM 2320B	Total/NA
Total Dissolved Solids	160		10	4.3	mg/L	1		SM 2540C	Total/NA
Ferric Iron	0.38		0.20	0.10	mg/L	1		SM 3500	Total/NA
Phosphorus as PO4	0.12	J	0.15	0.073	mg/L	1		SM 4500 P E	Total/NA
Dissolved Organic Carbon - Duplicate	4.9		1.0	0.47	mg/L	1		9060A	Dissolved

Client Sample ID: CL-3-20210803 Lab Sample ID: 500-203343-7

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Boron	0.086		0.050	0.0056	mg/L	1		6010B	Total/NA
Calcium	21		0.20	0.053	mg/L	1		6010B	Total/NA
Iron	0.31		0.20	0.082	mg/L	1		6010B	Total/NA
Magnesium	11	B	0.10	0.049	mg/L	1		6010B	Total/NA
Manganese	0.046		0.010	0.0023	mg/L	1		6010B	Total/NA
Potassium	4.9	B	0.50	0.066	mg/L	1		6010B	Total/NA
Sodium	11	B	1.0	0.097	mg/L	1		6010B	Total/NA
Boron, Dissolved	0.084		0.050	0.0056	mg/L	1		6010B	Dissolved

This Detection Summary does not include radiochemical test results.

Detection Summary

Client: Geosyntec Consultants, Inc.
Project/Site: GLP8029 Coffeen, IL

Job ID: 500-203343-1

Client Sample ID: CL-3-20210803 (Continued)

Lab Sample ID: 500-203343-7

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Calcium, Dissolved	21		0.20	0.053	mg/L	1		6010B	Dissolved
Magnesium, Dissolved	10	B	0.10	0.049	mg/L	1		6010B	Dissolved
Potassium, Dissolved	4.6	B	0.50	0.066	mg/L	1		6010B	Dissolved
Sodium, Dissolved	11	B	1.0	0.097	mg/L	1		6010B	Dissolved
Chloride	11		0.40	0.34	mg/L	2		9056A	Total/NA
Sulfate	32		2.0	0.95	mg/L	10		9056A	Total/NA
Alkalinity	63		5.0	3.7	mg/L	1		SM 2320B	Total/NA
Total Dissolved Solids	150		10	4.3	mg/L	1		SM 2540C	Total/NA
Ferric Iron	0.31		0.20	0.10	mg/L	1		SM 3500	Total/NA
Phosphorus as PO4	0.095	J	0.15	0.073	mg/L	1		SM 4500 P E	Total/NA
Dissolved Organic Carbon - Duplicate	4.9		1.0	0.47	mg/L	1		9060A	Dissolved

This Detection Summary does not include radiochemical test results.

Method Summary

Method	Method Description	Protocol	Laboratory
6010B	Metals (ICP)	SW846	TAL CHI
9056A	Anions, Ion Chromatography	SW846	TAL CHI
9060A	Organic Carbon, Dissolved (DOC)	SW846	TAL CHI
SM 2320B	Alkalinity	SM	TAL CHI
SM 2540C	Solids, Total Dissolved (TDS)	SM	TAL CHI
SM 3500	Iron, Ferric	SM	TAL CHI
SM 3500 Fe B	Iron, Ferrous	SM	TAL CHI
SM 4500 P E	Phosphorus	SM	TAL CHI
SM 4500 S2 F	Sulfide, Total	SM	TAL CHI
3010A	Preparation, Total Metals	SW846	TAL CHI
SM 4500 P B	Phosphorous, Total and Ortho	SM	TAL CHI

Protocol References:

SM = "Standard Methods For The Examination Of Water And Wastewater"

SW846 = "Test Methods For Evaluating Solid Waste, Physical/Chemical Methods", Third Edition, November 1986 And Its Updates.

Laboratory References:

TAL CHI = Eurofins TestAmerica, Chicago, 2417 Bond Street, University Park, IL 60484, TEL (708)534-5200

Sample Summary

Client: Geosyntec Consultants, Inc.
Project/Site: GLP8029 Coffeen, IL

Job ID: 500-203343-1

Lab Sample ID	Client Sample ID	Matrix	Collected	Received
500-203343-1	D-2-20210803	Water	08/03/21 10:15	08/05/21 09:45
500-203343-2	D-1-20210803	Water	08/03/21 10:50	08/05/21 09:45
500-203343-3	BKG-1-20210803	Water	08/03/21 12:45	08/05/21 09:45
500-203343-4	CL-1-20210803	Water	08/03/21 13:20	08/05/21 09:45
500-203343-5	DUP-20210803	Water	08/03/21 13:30	08/05/21 09:45
500-203343-6	CL-2-20210803	Water	08/03/21 13:50	08/05/21 09:45
500-203343-7	CL-3-20210803	Water	08/03/21 14:20	08/05/21 09:45

Client Sample Results

Client: Geosyntec Consultants, Inc.
Project/Site: GLP8029 Coffeen, IL

Job ID: 500-203343-1

Client Sample ID: D-2-20210803

Date Collected: 08/03/21 10:15
Date Received: 08/05/21 09:45

Lab Sample ID: 500-203343-1
Matrix: Water

Method: 6010B - Metals (ICP)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Boron	**0.30**		0.050	0.0056	mg/L		08/10/21 08:44	08/10/21 23:27	1
Calcium	**45**		0.20	0.053	mg/L		08/10/21 08:44	08/10/21 23:27	1
Cobalt	<0.0050		0.0050	0.00078	mg/L		08/10/21 08:44	08/10/21 23:27	1
Iron	**0.24**		0.20	0.082	mg/L		08/10/21 08:44	08/10/21 23:27	1
Lithium	<0.010		0.010	0.0044	mg/L		08/10/21 08:44	08/10/21 23:27	1
Magnesium	**13**	**B**	0.10	0.049	mg/L		08/10/21 08:44	08/10/21 23:27	1
Manganese	**0.20**		0.010	0.0023	mg/L		08/10/21 08:44	08/10/21 23:27	1
Potassium	**3.2**	**B**	0.50	0.066	mg/L		08/10/21 08:44	08/10/21 23:27	1
Sodium	**13**	**B**	1.0	0.097	mg/L		08/10/21 08:44	08/10/21 23:27	1

Method: 6010B - Metals (ICP) - Dissolved

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Boron, Dissolved	**0.30**		0.050	0.0056	mg/L		08/10/21 08:44	08/10/21 23:31	1
Calcium, Dissolved	**46**		0.20	0.053	mg/L		08/10/21 08:44	08/10/21 23:31	1
Cobalt, Dissolved	<0.0050		0.0050	0.00078	mg/L		08/10/21 08:44	08/10/21 23:31	1
Iron, Dissolved	**0.15**	**J**	0.20	0.082	mg/L		08/10/21 08:44	08/10/21 23:31	1
Lithium, Dissolved	<0.010		0.010	0.0044	mg/L		08/10/21 08:44	08/10/21 23:31	1
Magnesium, Dissolved	**13**	**B**	0.10	0.049	mg/L		08/10/21 08:44	08/10/21 23:31	1
Manganese, Dissolved	**0.20**		0.010	0.0023	mg/L		08/10/21 08:44	08/10/21 23:31	1
Potassium, Dissolved	**3.2**	**B**	0.50	0.066	mg/L		08/10/21 08:44	08/10/21 23:31	1
Sodium, Dissolved	**13**	**B**	1.0	0.097	mg/L		08/10/21 08:44	08/10/21 23:31	1

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Chloride	**7.2**		0.20	0.17	mg/L			08/17/21 16:12	1
Sulfate	**69**		4.0	1.9	mg/L			08/18/21 12:53	20
Alkalinity	**100**		5.0	3.7	mg/L			08/15/21 19:00	1
Total Dissolved Solids	**240**		10	4.3	mg/L			08/09/21 09:49	1
Ferric Iron	**0.24**		0.20	0.10	mg/L			08/19/21 14:42	1
Ferrous Iron	<0.050	HF	0.050	0.050	mg/L			08/11/21 04:46	1
Phosphorus as PO4	**0.24**		0.15	0.073	mg/L		08/15/21 12:30	08/18/21 12:20	1
Sulfide	**0.25**	**J**	1.0	0.23	mg/L			08/10/21 00:05	1

General Chemistry - Dissolved

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Dissolved Organic Carbon - Duplicate	**3.6**		1.0	0.47	mg/L			08/09/21 23:09	1

Client Sample Results

Client: Geosyntec Consultants, Inc.
Project/Site: GLP8029 Coffeen, IL

Job ID: 500-203343-1

Client Sample ID: D-1-20210803

Date Collected: 08/03/21 10:50
Date Received: 08/05/21 09:45

Lab Sample ID: 500-203343-2

Matrix: Water

Method: 6010B - Metals (ICP)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Boron	**0.33**		0.050	0.0056	mg/L		08/10/21 08:44	08/10/21 23:34	1
Calcium	**53**		0.20	0.053	mg/L		08/10/21 08:44	08/10/21 23:34	1
Cobalt	<0.0050		0.0050	0.00078	mg/L		08/10/21 08:44	08/10/21 23:34	1
Iron	**0.23**		0.20	0.082	mg/L		08/10/21 08:44	08/10/21 23:34	1
Lithium	<0.010		0.010	0.0044	mg/L		08/10/21 08:44	08/10/21 23:34	1
Magnesium	**16**	**B**	0.10	0.049	mg/L		08/10/21 08:44	08/10/21 23:34	1
Manganese	**0.030**		0.010	0.0023	mg/L		08/10/21 08:44	08/10/21 23:34	1
Potassium	**2.5**	**B**	0.50	0.066	mg/L		08/10/21 08:44	08/10/21 23:34	1
Sodium	**19**	**B**	1.0	0.097	mg/L		08/10/21 08:44	08/10/21 23:34	1

Method: 6010B - Metals (ICP) - Dissolved

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Boron, Dissolved	**0.32**		0.050	0.0056	mg/L		08/10/21 08:44	08/10/21 23:38	1
Calcium, Dissolved	**52**		0.20	0.053	mg/L		08/10/21 08:44	08/10/21 23:38	1
Cobalt, Dissolved	<0.0050		0.0050	0.00078	mg/L		08/10/21 08:44	08/10/21 23:38	1
Iron, Dissolved	**0.13**	**J**	0.20	0.082	mg/L		08/10/21 08:44	08/10/21 23:38	1
Lithium, Dissolved	<0.010		0.010	0.0044	mg/L		08/10/21 08:44	08/10/21 23:38	1
Magnesium, Dissolved	**16**	**B**	0.10	0.049	mg/L		08/10/21 08:44	08/10/21 23:38	1
Manganese, Dissolved	**0.024**		0.010	0.0023	mg/L		08/10/21 08:44	08/10/21 23:38	1
Potassium, Dissolved	**2.5**	**B**	0.50	0.066	mg/L		08/10/21 08:44	08/10/21 23:38	1
Sodium, Dissolved	**18**	**B**	1.0	0.097	mg/L		08/10/21 08:44	08/10/21 23:38	1

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Chloride	**9.1**		0.40	0.34	mg/L			08/19/21 11:37	2
Sulfate	**110**		5.0	2.4	mg/L			08/18/21 13:07	25
Alkalinity	**100**		5.0	3.7	mg/L			08/15/21 19:07	1
Total Dissolved Solids	**240**		10	4.3	mg/L			08/09/21 09:51	1
Ferric Iron	**0.23**		0.20	0.10	mg/L			08/19/21 14:42	1
Ferrous Iron	<0.050	HF	0.050	0.050	mg/L			08/11/21 04:55	1
Phosphorus as PO4	**0.13**	**J**	0.15	0.073	mg/L		08/15/21 12:30	08/18/21 12:21	1
Sulfide	<1.0		1.0	0.23	mg/L			08/10/21 00:08	1

General Chemistry - Dissolved

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Dissolved Organic Carbon - Duplicate	**3.3**		1.0	0.47	mg/L			08/09/21 23:16	1

Client Sample Results

Client Sample ID: BKG-1-20210803

Date Collected: 08/03/21 12:45
Date Received: 08/05/21 09:45

Lab Sample ID: 500-203343-3

Matrix: Water

Method: 6010B - Metals (ICP)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Boron	**0.082**		0.050	0.0056	mg/L		08/10/21 08:44	08/10/21 23:42	1
Calcium	**20**		0.20	0.053	mg/L		08/10/21 08:44	08/10/21 23:42	1
Cobalt	<0.0050		0.0050	0.00078	mg/L		08/10/21 08:44	08/10/21 23:42	1
Iron	**0.27**		0.20	0.082	mg/L		08/10/21 08:44	08/10/21 23:42	1
Lithium	<0.010		0.010	0.0044	mg/L		08/10/21 08:44	08/10/21 23:42	1
Magnesium	**10**	**B**	0.10	0.049	mg/L		08/10/21 08:44	08/10/21 23:42	1
Manganese	**0.037**		0.010	0.0023	mg/L		08/10/21 08:44	08/10/21 23:42	1
Potassium	**4.9**	**B**	0.50	0.066	mg/L		08/10/21 08:44	08/10/21 23:42	1
Sodium	**12**	**B**	1.0	0.097	mg/L		08/10/21 08:44	08/10/21 23:42	1

Method: 6010B - Metals (ICP) - Dissolved

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Boron, Dissolved	**0.079**		0.050	0.0056	mg/L		08/10/21 08:44	08/10/21 23:46	1
Calcium, Dissolved	**20**		0.20	0.053	mg/L		08/10/21 08:44	08/10/21 23:46	1
Cobalt, Dissolved	<0.0050		0.0050	0.00078	mg/L		08/10/21 08:44	08/10/21 23:46	1
Iron, Dissolved	**0.19**	**J**	0.20	0.082	mg/L		08/10/21 08:44	08/10/21 23:46	1
Lithium, Dissolved	<0.010		0.010	0.0044	mg/L		08/10/21 08:44	08/10/21 23:46	1
Magnesium, Dissolved	**10**	**B**	0.10	0.049	mg/L		08/10/21 08:44	08/10/21 23:46	1
Manganese, Dissolved	<0.010		0.010	0.0023	mg/L		08/10/21 08:44	08/10/21 23:46	1
Potassium, Dissolved	**4.9**	**B**	0.50	0.066	mg/L		08/10/21 08:44	08/10/21 23:46	1
Sodium, Dissolved	**12**	**B**	1.0	0.097	mg/L		08/10/21 08:44	08/10/21 23:46	1

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Chloride	**12**		2.0	1.7	mg/L			08/17/21 17:48	10
Sulfate	**36**		2.0	0.95	mg/L			08/18/21 13:48	10
Alkalinity	**65**		5.0	3.7	mg/L			08/15/21 19:14	1
Total Dissolved Solids	**72**		10	4.3	mg/L			08/09/21 09:54	1
Ferric Iron	**0.27**		0.20	0.10	mg/L			08/19/21 14:42	1
Ferrous Iron	<0.050	HF	0.050	0.050	mg/L			08/11/21 04:58	1
Phosphorus as PO4	**0.12**	**J**	0.15	0.073	mg/L		08/15/21 12:30	08/18/21 12:22	1
Sulfide	<1.0		1.0	0.23	mg/L			08/10/21 00:12	1

General Chemistry - Dissolved

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Dissolved Organic Carbon - Duplicate	**5.0**		1.0	0.47	mg/L			08/09/21 23:26	1

Client Sample Results

Client Sample ID: CL-1-20210803 Lab Sample ID: 500-203343-4

Date Collected: 08/03/21 13:20 **Matrix: Water**
Date Received: 08/05/21 09:45

Method: 6010B - Metals (ICP)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Boron	**0.10**		0.050	0.0056	mg/L		08/10/21 08:44	08/10/21 23:50	1
Calcium	**23**		0.20	0.053	mg/L		08/10/21 08:44	08/10/21 23:50	1
Cobalt	<0.0050		0.0050	0.00078	mg/L		08/10/21 08:44	08/10/21 23:50	1
Iron	**0.38**		0.20	0.082	mg/L		08/10/21 08:44	08/10/21 23:50	1
Lithium	<0.010		0.010	0.0044	mg/L		08/10/21 08:44	08/10/21 23:50	1
Magnesium	**11**	**B**	0.10	0.049	mg/L		08/10/21 08:44	08/10/21 23:50	1
Manganese	**0.037**		0.010	0.0023	mg/L		08/10/21 08:44	08/10/21 23:50	1
Potassium	**4.5**	**B**	0.50	0.066	mg/L		08/10/21 08:44	08/10/21 23:50	1
Sodium	**11**	**B**	1.0	0.097	mg/L		08/10/21 08:44	08/10/21 23:50	1

Method: 6010B - Metals (ICP) - Dissolved

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Boron, Dissolved	**0.12**		0.050	0.0056	mg/L		08/10/21 08:44	08/10/21 23:54	1
Calcium, Dissolved	**26**		0.20	0.053	mg/L		08/10/21 08:44	08/10/21 23:54	1
Cobalt, Dissolved	<0.0050		0.0050	0.00078	mg/L		08/10/21 08:44	08/10/21 23:54	1
Iron, Dissolved	**0.68**		0.20	0.082	mg/L		08/10/21 08:44	08/10/21 23:54	1
Lithium, Dissolved	<0.010		0.010	0.0044	mg/L		08/10/21 08:44	08/10/21 23:54	1
Magnesium, Dissolved	**11**	**B**	0.10	0.049	mg/L		08/10/21 08:44	08/10/21 23:54	1
Manganese, Dissolved	**0.062**		0.010	0.0023	mg/L		08/10/21 08:44	08/10/21 23:54	1
Potassium, Dissolved	**4.7**	**B**	0.50	0.066	mg/L		08/10/21 08:44	08/10/21 23:54	1
Sodium, Dissolved	**12**	**B**	1.0	0.097	mg/L		08/10/21 08:44	08/10/21 23:54	1

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Chloride	**11**		0.40	0.34	mg/L			08/17/21 18:01	2
Sulfate	**33**		2.0	0.95	mg/L			08/18/21 14:01	10
Alkalinity	**68**		5.0	3.7	mg/L			08/15/21 19:21	1
Total Dissolved Solids	**120**		10	4.3	mg/L			08/09/21 09:56	1
Ferric Iron	**0.38**		0.20	0.10	mg/L			08/19/21 14:42	1
Ferrous Iron	<0.050	HF	0.050	0.050	mg/L			08/11/21 05:00	1
Phosphorus as PO4	**0.21**		0.15	0.073	mg/L		08/15/21 12:30	08/18/21 12:23	1
Sulfide	<1.0		1.0	0.23	mg/L			08/10/21 00:16	1

General Chemistry - Dissolved

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Dissolved Organic Carbon - Duplicate	**5.4**		1.0	0.47	mg/L			08/09/21 23:33	1

Client Sample ID: DUP-20210803

Lab Sample ID: 500-203343-5

Date Collected: 08/03/21 13:30
Date Received: 08/05/21 09:45
Matrix: Water

Method: 6010B - Metals (ICP)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Boron	**0.086**		0.050	0.0056	mg/L		08/10/21 08:44	08/10/21 23:58	1
Calcium	**21**		0.20	0.053	mg/L		08/10/21 08:44	08/10/21 23:58	1
Cobalt	<0.0050		0.0050	0.00078	mg/L		08/10/21 08:44	08/10/21 23:58	1
Iron	**0.39**		0.20	0.082	mg/L		08/10/21 08:44	08/10/21 23:58	1
Lithium	<0.010		0.010	0.0044	mg/L		08/10/21 08:44	08/10/21 23:58	1
Magnesium	**10**	**B**	0.10	0.049	mg/L		08/10/21 08:44	08/10/21 23:58	1
Manganese	**0.052**		0.010	0.0023	mg/L		08/10/21 08:44	08/10/21 23:58	1
Potassium	**4.7**	**B**	0.50	0.066	mg/L		08/10/21 08:44	08/10/21 23:58	1
Sodium	**11**	**B**	1.0	0.097	mg/L		08/10/21 08:44	08/10/21 23:58	1

Method: 6010B - Metals (ICP) - Dissolved

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Boron, Dissolved	**0.086**		0.050	0.0056	mg/L		08/10/21 08:44	08/11/21 00:14	1
Calcium, Dissolved	**21**		0.20	0.053	mg/L		08/10/21 08:44	08/11/21 00:14	1
Cobalt, Dissolved	<0.0050		0.0050	0.00078	mg/L		08/10/21 08:44	08/11/21 00:14	1
Iron, Dissolved	**0.087**	**J**	0.20	0.082	mg/L		08/10/21 08:44	08/11/21 00:14	1
Lithium, Dissolved	<0.010		0.010	0.0044	mg/L		08/10/21 08:44	08/11/21 00:14	1
Magnesium, Dissolved	**10**	**B**	0.10	0.049	mg/L		08/10/21 08:44	08/11/21 00:14	1
Manganese, Dissolved	<0.010		0.010	0.0023	mg/L		08/10/21 08:44	08/11/21 00:14	1
Potassium, Dissolved	**4.7**	**B**	0.50	0.066	mg/L		08/10/21 08:44	08/11/21 00:14	1
Sodium, Dissolved	**11**	**B**	1.0	0.097	mg/L		08/10/21 08:44	08/11/21 00:14	1

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Chloride	**11**		0.40	0.34	mg/L			08/17/21 18:28	2
Sulfate	**33**		2.0	0.95	mg/L			08/18/21 14:15	10
Alkalinity	**65**		5.0	3.7	mg/L			08/15/21 19:28	1
Total Dissolved Solids	**110**		10	4.3	mg/L			08/09/21 09:59	1
Ferric Iron	**0.39**		0.20	0.10	mg/L			08/19/21 14:42	1
Ferrous Iron	<0.050	HF	0.050	0.050	mg/L			08/11/21 05:03	1
Phosphorus as PO4	**0.14**	**J**	0.15	0.073	mg/L		08/15/21 12:30	08/18/21 12:42	1
Sulfide	<1.0		1.0	0.23	mg/L			08/10/21 00:20	1

General Chemistry - Dissolved

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Dissolved Organic Carbon - Duplicate	**4.9**		1.0	0.47	mg/L			08/09/21 23:40	1

Client Sample Results

Client: Geosyntec Consultants, Inc.
Project/Site: GLP8029 Coffeen, IL

Job ID: 500-203343-1

Client Sample ID: CL-2-20210803

Date Collected: 08/03/21 13:50
Date Received: 08/05/21 09:45

Lab Sample ID: 500-203343-6

Matrix: Water

Method: 6010B - Metals (ICP)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Boron	**0.086**		0.050	0.0056	mg/L		08/10/21 08:44	08/11/21 00:18	1
Calcium	**21**		0.20	0.053	mg/L		08/10/21 08:44	08/11/21 00:18	1
Cobalt	<0.0050		0.0050	0.00078	mg/L		08/10/21 08:44	08/11/21 00:18	1
Iron	**0.38**		0.20	0.082	mg/L		08/10/21 08:44	08/11/21 00:18	1
Lithium	<0.010		0.010	0.0044	mg/L		08/10/21 08:44	08/11/21 00:18	1
Magnesium	**10**	**B**	0.10	0.049	mg/L		08/10/21 08:44	08/11/21 00:18	1
Manganese	**0.051**		0.010	0.0023	mg/L		08/10/21 08:44	08/11/21 00:18	1
Potassium	**4.7**	**B**	0.50	0.066	mg/L		08/10/21 08:44	08/11/21 00:18	1
Sodium	**11**	**B**	1.0	0.097	mg/L		08/10/21 08:44	08/11/21 00:18	1

Method: 6010B - Metals (ICP) - Dissolved

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Boron, Dissolved	**0.087**		0.050	0.0056	mg/L		08/10/21 08:44	08/11/21 00:21	1
Calcium, Dissolved	**22**		0.20	0.053	mg/L		08/10/21 08:44	08/11/21 00:21	1
Cobalt, Dissolved	<0.0050		0.0050	0.00078	mg/L		08/10/21 08:44	08/11/21 00:21	1
Iron, Dissolved	**0.13**	**J**	0.20	0.082	mg/L		08/10/21 08:44	08/11/21 00:21	1
Lithium, Dissolved	<0.010		0.010	0.0044	mg/L		08/10/21 08:44	08/11/21 00:21	1
Magnesium, Dissolved	**10**	**B**	0.10	0.049	mg/L		08/10/21 08:44	08/11/21 00:21	1
Manganese, Dissolved	<0.010		0.010	0.0023	mg/L		08/10/21 08:44	08/11/21 00:21	1
Potassium, Dissolved	**4.7**	**B**	0.50	0.066	mg/L		08/10/21 08:44	08/11/21 00:21	1
Sodium, Dissolved	**11**	**B**	1.0	0.097	mg/L		08/10/21 08:44	08/11/21 00:21	1

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Chloride	**11**		0.40	0.34	mg/L			08/17/21 18:55	2
Sulfate	**31**		2.0	0.95	mg/L			08/18/21 14:29	10
Alkalinity	**65**		5.0	3.7	mg/L			08/15/21 19:35	1
Total Dissolved Solids	**160**		10	4.3	mg/L			08/09/21 10:02	1
Ferric Iron	**0.38**		0.20	0.10	mg/L			08/19/21 14:42	1
Ferrous Iron	<0.050	HF	0.050	0.050	mg/L			08/11/21 05:06	1
Phosphorus as PO4	**0.12**	**J**	0.15	0.073	mg/L		08/15/21 12:30	08/18/21 12:43	1
Sulfide	<1.0		1.0	0.23	mg/L			08/10/21 00:23	1

General Chemistry - Dissolved

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Dissolved Organic Carbon - Duplicate	**4.9**		1.0	0.47	mg/L			08/09/21 23:47	1

Client Sample Results

Client Sample ID: CL-3-20210803

Date Collected: 08/03/21 14:20
Date Received: 08/05/21 09:45

Lab Sample ID: 500-203343-7

Matrix: Water

Method: 6010B - Metals (ICP)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Boron	**0.086**		0.050	0.0056	mg/L		08/10/21 08:44	08/11/21 00:25	1
Calcium	**21**		0.20	0.053	mg/L		08/10/21 08:44	08/11/21 00:25	1
Cobalt	<0.0050		0.0050	0.00078	mg/L		08/10/21 08:44	08/11/21 00:25	1
Iron	**0.31**		0.20	0.082	mg/L		08/10/21 08:44	08/11/21 00:25	1
Lithium	<0.010		0.010	0.0044	mg/L		08/10/21 08:44	08/11/21 00:25	1
Magnesium	**11**	**B**	0.10	0.049	mg/L		08/10/21 08:44	08/11/21 00:25	1
Manganese	**0.046**		0.010	0.0023	mg/L		08/10/21 08:44	08/11/21 00:25	1
Potassium	**4.9**	**B**	0.50	0.066	mg/L		08/10/21 08:44	08/11/21 00:25	1
Sodium	**11**	**B**	1.0	0.097	mg/L		08/10/21 08:44	08/11/21 00:25	1

Method: 6010B - Metals (ICP) - Dissolved

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Boron, Dissolved	**0.084**		0.050	0.0056	mg/L		08/10/21 08:44	08/11/21 00:29	1
Calcium, Dissolved	**21**		0.20	0.053	mg/L		08/10/21 08:44	08/11/21 00:29	1
Cobalt, Dissolved	<0.0050		0.0050	0.00078	mg/L		08/10/21 08:44	08/11/21 00:29	1
Iron, Dissolved	<0.20		0.20	0.082	mg/L		08/10/21 08:44	08/11/21 00:29	1
Lithium, Dissolved	<0.010		0.010	0.0044	mg/L		08/10/21 08:44	08/11/21 00:29	1
Magnesium, Dissolved	**10**	**B**	0.10	0.049	mg/L		08/10/21 08:44	08/11/21 00:29	1
Manganese, Dissolved	<0.010		0.010	0.0023	mg/L		08/10/21 08:44	08/11/21 00:29	1
Potassium, Dissolved	**4.6**	**B**	0.50	0.066	mg/L		08/10/21 08:44	08/11/21 00:29	1
Sodium, Dissolved	**11**	**B**	1.0	0.097	mg/L		08/10/21 08:44	08/11/21 00:29	1

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Chloride	**11**		0.40	0.34	mg/L			08/17/21 19:23	2
Sulfate	**32**		2.0	0.95	mg/L			08/18/21 14:42	10
Alkalinity	**63**		5.0	3.7	mg/L			08/15/21 19:41	1
Total Dissolved Solids	**150**		10	4.3	mg/L			08/09/21 10:04	1
Ferric Iron	**0.31**		0.20	0.10	mg/L			08/19/21 14:42	1
Ferrous Iron	<0.050	HF	0.050	0.050	mg/L			08/11/21 05:09	1
Phosphorus as PO4	**0.095**	**J**	0.15	0.073	mg/L		08/15/21 12:30	08/18/21 12:44	1
Sulfide	<1.0		1.0	0.23	mg/L			08/10/21 00:27	1

General Chemistry - Dissolved

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Dissolved Organic Carbon - Duplicate	**4.9**		1.0	0.47	mg/L			08/09/21 23:55	1

Definitions/Glossary

Qualifiers

Metals

Qualifier	Qualifier Description
B	Compound was found in the blank and sample.
J	Result is less than the RL but greater than or equal to the MDL and the concentration is an approximate value.

General Chemistry

Qualifier	Qualifier Description
4	MS, MSD: The analyte present in the original sample is greater than 4 times the matrix spike concentration; therefore, control limits are not applicable.
HF	Field parameter with a holding time of 15 minutes. Test performed by laboratory at client's request.
J	Result is less than the RL but greater than or equal to the MDL and the concentration is an approximate value.

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

QC Association Summary

Client: Geosyntec Consultants, Inc.
Project/Site: GLP8029 Coffeen, IL

Job ID: 500-203343-1

Metals

Prep Batch: 613499

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
500-203343-1	D-2-20210803	Dissolved	Water	3010A	
500-203343-1	D-2-20210803	Total/NA	Water	3010A	
500-203343-2	D-1-20210803	Dissolved	Water	3010A	
500-203343-2	D-1-20210803	Total/NA	Water	3010A	
500-203343-3	BKG-1-20210803	Dissolved	Water	3010A	
500-203343-3	BKG-1-20210803	Total/NA	Water	3010A	
500-203343-4	CL-1-20210803	Dissolved	Water	3010A	
500-203343-4	CL-1-20210803	Total/NA	Water	3010A	
500-203343-5	DUP-20210803	Dissolved	Water	3010A	
500-203343-5	DUP-20210803	Total/NA	Water	3010A	
500-203343-6	CL-2-20210803	Dissolved	Water	3010A	
500-203343-6	CL-2-20210803	Total/NA	Water	3010A	
500-203343-7	CL-3-20210803	Dissolved	Water	3010A	
500-203343-7	CL-3-20210803	Total/NA	Water	3010A	
MB 500-613499/1-A	Method Blank	Total/NA	Water	3010A	
LCS 500-613499/2-A	Lab Control Sample	Total/NA	Water	3010A	

Analysis Batch: 613679

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
500-203343-1	D-2-20210803	Dissolved	Water	6010B	613499
500-203343-1	D-2-20210803	Total/NA	Water	6010B	613499
500-203343-2	D-1-20210803	Dissolved	Water	6010B	613499
500-203343-2	D-1-20210803	Total/NA	Water	6010B	613499
500-203343-3	BKG-1-20210803	Dissolved	Water	6010B	613499
500-203343-3	BKG-1-20210803	Total/NA	Water	6010B	613499
500-203343-4	CL-1-20210803	Dissolved	Water	6010B	613499
500-203343-4	CL-1-20210803	Total/NA	Water	6010B	613499
500-203343-5	DUP-20210803	Dissolved	Water	6010B	613499
500-203343-5	DUP-20210803	Total/NA	Water	6010B	613499
500-203343-6	CL-2-20210803	Dissolved	Water	6010B	613499
500-203343-6	CL-2-20210803	Total/NA	Water	6010B	613499
500-203343-7	CL-3-20210803	Dissolved	Water	6010B	613499
500-203343-7	CL-3-20210803	Total/NA	Water	6010B	613499
MB 500-613499/1-A	Method Blank	Total/NA	Water	6010B	613499
LCS 500-613499/2-A	Lab Control Sample	Total/NA	Water	6010B	613499

General Chemistry

Analysis Batch: 613305

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
500-203343-1	D-2-20210803	Total/NA	Water	SM 2540C	
500-203343-2	D-1-20210803	Total/NA	Water	SM 2540C	
500-203343-3	BKG-1-20210803	Total/NA	Water	SM 2540C	
500-203343-4	CL-1-20210803	Total/NA	Water	SM 2540C	
500-203343-5	DUP-20210803	Total/NA	Water	SM 2540C	
500-203343-6	CL-2-20210803	Total/NA	Water	SM 2540C	
500-203343-7	CL-3-20210803	Total/NA	Water	SM 2540C	
MB 500-613305/1	Method Blank	Total/NA	Water	SM 2540C	
LCS 500-613305/2	Lab Control Sample	Total/NA	Water	SM 2540C	
500-203340-B-2 MS	Matrix Spike	Total/NA	Water	SM 2540C	
500-203340-B-3 DU	Duplicate	Total/NA	Water	SM 2540C	

General Chemistry

Analysis Batch: 613311

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
500-203343-1	D-2-20210803	Total/NA	Water	SM 3500 Fe B	
500-203343-2	D-1-20210803	Total/NA	Water	SM 3500 Fe B	
500-203343-3	BKG-1-20210803	Total/NA	Water	SM 3500 Fe B	
500-203343-4	CL-1-20210803	Total/NA	Water	SM 3500 Fe B	
500-203343-5	DUP-20210803	Total/NA	Water	SM 3500 Fe B	
500-203343-6	CL-2-20210803	Total/NA	Water	SM 3500 Fe B	
500-203343-7	CL-3-20210803	Total/NA	Water	SM 3500 Fe B	
MB 500-613311/1	Method Blank	Total/NA	Water	SM 3500 Fe B	
LCS 500-613311/2	Lab Control Sample	Total/NA	Water	SM 3500 Fe B	
500-203343-1 MS	D-2-20210803	Total/NA	Water	SM 3500 Fe B	
500-203343-1 MSD	D-2-20210803	Total/NA	Water	SM 3500 Fe B	

Analysis Batch: 613518

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
500-203343-1	D-2-20210803	Total/NA	Water	SM 4500 S2 F	
500-203343-2	D-1-20210803	Total/NA	Water	SM 4500 S2 F	
500-203343-3	BKG-1-20210803	Total/NA	Water	SM 4500 S2 F	
500-203343-4	CL-1-20210803	Total/NA	Water	SM 4500 S2 F	
500-203343-5	DUP-20210803	Total/NA	Water	SM 4500 S2 F	
500-203343-6	CL-2-20210803	Total/NA	Water	SM 4500 S2 F	
500-203343-7	CL-3-20210803	Total/NA	Water	SM 4500 S2 F	
MB 500-613518/1	Method Blank	Total/NA	Water	SM 4500 S2 F	
LCS 500-613518/2	Lab Control Sample	Total/NA	Water	SM 4500 S2 F	
180-125221-A-1 MS	Matrix Spike	Total/NA	Water	SM 4500 S2 F	
180-125221-A-1 MSD	Matrix Spike Duplicate	Total/NA	Water	SM 4500 S2 F	

Analysis Batch: 613783

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
500-203343-1	D-2-20210803	Dissolved	Water	9060A	
500-203343-2	D-1-20210803	Dissolved	Water	9060A	
500-203343-3	BKG-1-20210803	Dissolved	Water	9060A	
500-203343-4	CL-1-20210803	Dissolved	Water	9060A	
500-203343-5	DUP-20210803	Dissolved	Water	9060A	
500-203343-6	CL-2-20210803	Dissolved	Water	9060A	
500-203343-7	CL-3-20210803	Dissolved	Water	9060A	
MB 500-613783/9	Method Blank	Dissolved	Water	9060A	
LCS 500-613783/10	Lab Control Sample	Dissolved	Water	9060A	

Prep Batch: 614309

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
500-203343-1	D-2-20210803	Total/NA	Water	SM 4500 P B	
500-203343-2	D-1-20210803	Total/NA	Water	SM 4500 P B	
500-203343-3	BKG-1-20210803	Total/NA	Water	SM 4500 P B	
500-203343-4	CL-1-20210803	Total/NA	Water	SM 4500 P B	
500-203343-5	DUP-20210803	Total/NA	Water	SM 4500 P B	
500-203343-6	CL-2-20210803	Total/NA	Water	SM 4500 P B	
500-203343-7	CL-3-20210803	Total/NA	Water	SM 4500 P B	
MB 500-614309/1-A	Method Blank	Total/NA	Water	SM 4500 P B	
LCS 500-614309/2-A	Lab Control Sample	Total/NA	Water	SM 4500 P B	

General Chemistry

Analysis Batch: 614414

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
500-203343-1	D-2-20210803	Total/NA	Water	SM 2320B	
500-203343-2	D-1-20210803	Total/NA	Water	SM 2320B	
500-203343-3	BKG-1-20210803	Total/NA	Water	SM 2320B	
500-203343-4	CL-1-20210803	Total/NA	Water	SM 2320B	
500-203343-5	DUP-20210803	Total/NA	Water	SM 2320B	
500-203343-6	CL-2-20210803	Total/NA	Water	SM 2320B	
500-203343-7	CL-3-20210803	Total/NA	Water	SM 2320B	
MB 500-614414/3	Method Blank	Total/NA	Water	SM 2320B	
LCS 500-614414/4	Lab Control Sample	Total/NA	Water	SM 2320B	
500-203363-E-1 DU	Duplicate	Total/NA	Water	SM 2320B	

Analysis Batch: 614638

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
500-203343-1	D-2-20210803	Total/NA	Water	9056A	
500-203343-3	BKG-1-20210803	Total/NA	Water	9056A	
500-203343-4	CL-1-20210803	Total/NA	Water	9056A	
500-203343-5	DUP-20210803	Total/NA	Water	9056A	
500-203343-6	CL-2-20210803	Total/NA	Water	9056A	
500-203343-7	CL-3-20210803	Total/NA	Water	9056A	
MB 500-614638/3	Method Blank	Total/NA	Water	9056A	
LCS 500-614638/4	Lab Control Sample	Total/NA	Water	9056A	
500-203337-F-2 MS	Matrix Spike	Total/NA	Water	9056A	
500-203337-F-2 MSD	Matrix Spike Duplicate	Total/NA	Water	9056A	

Analysis Batch: 614916

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
500-203343-1	D-2-20210803	Total/NA	Water	SM 4500 P E	614309
500-203343-2	D-1-20210803	Total/NA	Water	SM 4500 P E	614309
500-203343-3	BKG-1-20210803	Total/NA	Water	SM 4500 P E	614309
500-203343-4	CL-1-20210803	Total/NA	Water	SM 4500 P E	614309
500-203343-5	DUP-20210803	Total/NA	Water	SM 4500 P E	614309
500-203343-6	CL-2-20210803	Total/NA	Water	SM 4500 P E	614309
500-203343-7	CL-3-20210803	Total/NA	Water	SM 4500 P E	614309
MB 500-614309/1-A	Method Blank	Total/NA	Water	SM 4500 P E	614309
LCS 500-614309/2-A	Lab Control Sample	Total/NA	Water	SM 4500 P E	614309

Analysis Batch: 614951

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
500-203343-1	D-2-20210803	Total/NA	Water	9056A	
500-203343-2	D-1-20210803	Total/NA	Water	9056A	
500-203343-3	BKG-1-20210803	Total/NA	Water	9056A	
500-203343-4	CL-1-20210803	Total/NA	Water	9056A	
500-203343-5	DUP-20210803	Total/NA	Water	9056A	
500-203343-6	CL-2-20210803	Total/NA	Water	9056A	
500-203343-7	CL-3-20210803	Total/NA	Water	9056A	
MB 500-614951/3	Method Blank	Total/NA	Water	9056A	
LCS 500-614951/4	Lab Control Sample	Total/NA	Water	9056A	

Analysis Batch: 615118

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
500-203343-2	D-1-20210803	Total/NA	Water	9056A	

General Chemistry (Continued)

Analysis Batch: 615118 (Continued)

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
MB 500-615118/3	Method Blank	Total/NA	Water	9056A	
LCS 500-615118/4	Lab Control Sample	Total/NA	Water	9056A	

Analysis Batch: 615136

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
500-203343-1	D-2-20210803	Total/NA	Water	SM 3500	
500-203343-2	D-1-20210803	Total/NA	Water	SM 3500	
500-203343-3	BKG-1-20210803	Total/NA	Water	SM 3500	
500-203343-4	CL-1-20210803	Total/NA	Water	SM 3500	
500-203343-5	DUP-20210803	Total/NA	Water	SM 3500	
500-203343-6	CL-2-20210803	Total/NA	Water	SM 3500	
500-203343-7	CL-3-20210803	Total/NA	Water	SM 3500	

Method: 6010B - Metals (ICP)

Lab Sample ID: MB 500-613499/1-A
Matrix: Water
Analysis Batch: 613679

Client Sample ID: Method Blank
Prep Type: Total/NA
Prep Batch: 613499

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Boron	<0.050		0.050	0.0056	mg/L		08/10/21 08:44	08/10/21 22:21	1
Boron, Dissolved	<0.050		0.050	0.0056	mg/L		08/10/21 08:44	08/10/21 22:21	1
Calcium	<0.20		0.20	0.053	mg/L		08/10/21 08:44	08/10/21 22:21	1
Calcium, Dissolved	<0.20		0.20	0.053	mg/L		08/10/21 08:44	08/10/21 22:21	1
Cobalt	<0.0050		0.0050	0.00078	mg/L		08/10/21 08:44	08/10/21 22:21	1
Cobalt, Dissolved	<0.0050		0.0050	0.00078	mg/L		08/10/21 08:44	08/10/21 22:21	1
Iron	<0.20		0.20	0.082	mg/L		08/10/21 08:44	08/10/21 22:21	1
Iron, Dissolved	<0.20		0.20	0.082	mg/L		08/10/21 08:44	08/10/21 22:21	1
Lithium	<0.010		0.010	0.0044	mg/L		08/10/21 08:44	08/10/21 22:21	1
Lithium, Dissolved	<0.010		0.010	0.0044	mg/L		08/10/21 08:44	08/10/21 22:21	1
Magnesium	0.0812	J	0.10	0.049	mg/L		08/10/21 08:44	08/10/21 22:21	1
Magnesium, Dissolved	0.0812	J	0.10	0.049	mg/L		08/10/21 08:44	08/10/21 22:21	1
Manganese	<0.010		0.010	0.0023	mg/L		08/10/21 08:44	08/10/21 22:21	1
Manganese, Dissolved	<0.010		0.010	0.0023	mg/L		08/10/21 08:44	08/10/21 22:21	1
Potassium	0.185	J	0.50	0.066	mg/L		08/10/21 08:44	08/10/21 22:21	1
Potassium, Dissolved	0.185	J	0.50	0.066	mg/L		08/10/21 08:44	08/10/21 22:21	1
Sodium	0.165	J	1.0	0.097	mg/L		08/10/21 08:44	08/10/21 22:21	1
Sodium, Dissolved	0.165	J	1.0	0.097	mg/L		08/10/21 08:44	08/10/21 22:21	1

Lab Sample ID: LCS 500-613499/2-A
Matrix: Water
Analysis Batch: 613679

Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 613499

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Boron	1.00	0.822		mg/L		82	80 - 120
Boron, Dissolved	1.00	0.822		mg/L		82	80 - 120
Calcium	10.0	10.7		mg/L		107	80 - 120
Calcium, Dissolved	10.0	10.7		mg/L		107	80 - 120
Cobalt	0.500	0.498		mg/L		100	80 - 120
Cobalt, Dissolved	0.500	0.498		mg/L		100	80 - 120
Iron	1.00	1.15		mg/L		115	80 - 120
Iron, Dissolved	1.00	1.15		mg/L		115	80 - 120
Lithium	0.500	0.525		mg/L		105	80 - 120
Lithium, Dissolved	0.500	0.525		mg/L		105	80 - 120
Magnesium	10.0	10.0		mg/L		100	80 - 120
Magnesium, Dissolved	10.0	10.0		mg/L		100	80 - 120
Manganese	0.500	0.522		mg/L		104	80 - 120
Manganese, Dissolved	0.500	0.522		mg/L		104	80 - 120
Potassium	10.0	10.1		mg/L		101	80 - 120
Potassium, Dissolved	10.0	10.1		mg/L		101	80 - 120
Sodium	10.0	9.94		mg/L		99	80 - 120
Sodium, Dissolved	10.0	9.94		mg/L		99	80 - 120

QC Sample Results

Method: 9056A - Anions, Ion Chromatography

Lab Sample ID: MB 500-614638/3
Matrix: Water
Analysis Batch: 614638

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Chloride	<0.20		0.20	0.17	mg/L			08/17/21 11:40	1

Lab Sample ID: LCS 500-614638/4
Matrix: Water
Analysis Batch: 614638

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Chloride	3.00	2.81		mg/L		94	80 - 120

Lab Sample ID: 500-203337-F-2 MS
Matrix: Water
Analysis Batch: 614638

Client Sample ID: Matrix Spike
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits
Chloride	430		100	487	4	mg/L		60	80 - 120

Lab Sample ID: 500-203337-F-2 MSD
Matrix: Water
Analysis Batch: 614638

Client Sample ID: Matrix Spike Duplicate
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Chloride	430		100	491	4	mg/L		64	80 - 120	1	15

Lab Sample ID: MB 500-614951/3
Matrix: Water
Analysis Batch: 614951

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Chloride	<0.20		0.20	0.17	mg/L			08/18/21 11:04	1
Sulfate	<0.20		0.20	0.095	mg/L			08/18/21 11:04	1

Lab Sample ID: LCS 500-614951/4
Matrix: Water
Analysis Batch: 614951

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Chloride	3.00	3.27		mg/L		109	80 - 120
Sulfate	5.00	5.30		mg/L		106	80 - 120

Lab Sample ID: MB 500-615118/3
Matrix: Water
Analysis Batch: 615118

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Chloride	<0.20		0.20	0.17	mg/L			08/19/21 11:03	1
Sulfate	<0.20		0.20	0.095	mg/L			08/19/21 11:03	1

QC Sample Results

Method: 9056A - Anions, Ion Chromatography (Continued)

Lab Sample ID: LCS 500-615118/4
Client Sample ID: Lab Control Sample
Matrix: Water
Prep Type: Total/NA
Analysis Batch: 615118

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Chloride	3.00	3.27		mg/L		109	80 - 120
Sulfate	5.00	5.30		mg/L		106	80 - 120

Method: 9060A - Organic Carbon, Dissolved (DOC)

Lab Sample ID: MB 500-613783/9
Client Sample ID: Method Blank
Matrix: Water
Prep Type: Dissolved
Analysis Batch: 613783

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Dissolved Organic Carbon - Duplicate	<1.0		1.0	0.47	mg/L			08/09/21 21:30	1

Lab Sample ID: LCS 500-613783/10
Client Sample ID: Lab Control Sample
Matrix: Water
Prep Type: Dissolved
Analysis Batch: 613783

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
DOC Result 1	10.0	9.57		mg/L		96	86 - 116
DOC Result 2	10.0	9.57		mg/L		96	86 - 116
Dissolved Organic Carbon - Duplicate	10.0	9.57		mg/L		96	86 - 116

Method: SM 2320B - Alkalinity

Lab Sample ID: MB 500-614414/3
Client Sample ID: Method Blank
Matrix: Water
Prep Type: Total/NA
Analysis Batch: 614414

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Alkalinity	<5.0		5.0	3.7	mg/L			08/15/21 16:27	1

Lab Sample ID: LCS 500-614414/4
Client Sample ID: Lab Control Sample
Matrix: Water
Prep Type: Total/NA
Analysis Batch: 614414

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Alkalinity	500	454		mg/L		91	90 - 110

Lab Sample ID: 500-203363-E-1 DU
Client Sample ID: Duplicate
Matrix: Water
Prep Type: Total/NA
Analysis Batch: 614414

Analyte	Sample Result	Sample Qualifier	DU Result	DU Qualifier	Unit	D	RPD	RPD Limit
Alkalinity	180		181		mg/L		2	20

QC Sample Results

Method: SM 2540C - Solids, Total Dissolved (TDS)

Lab Sample ID: MB 500-613305/1 **Client Sample ID: Method Blank**
Matrix: Water **Prep Type: Total/NA**
Analysis Batch: 613305

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Total Dissolved Solids	<10		10	4.3	mg/L			08/09/21 09:31	1

Lab Sample ID: LCS 500-613305/2 **Client Sample ID: Lab Control Sample**
Matrix: Water **Prep Type: Total/NA**
Analysis Batch: 613305

Analyte			Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits		
Total Dissolved Solids			250	238		mg/L		95	80 - 120		

Lab Sample ID: 500-203340-B-2 MS **Client Sample ID: Matrix Spike**
Matrix: Water **Prep Type: Total/NA**
Analysis Batch: 613305

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits		
Total Dissolved Solids	490		250	792		mg/L		120	75 - 125		

Lab Sample ID: 500-203340-B-3 DU **Client Sample ID: Duplicate**
Matrix: Water **Prep Type: Total/NA**
Analysis Batch: 613305

Analyte	Sample Result	Sample Qualifier		DU Result	DU Qualifier	Unit	D			RPD	RPD Limit
Total Dissolved Solids	480			472		mg/L				2	5

Method: SM 3500 Fe B - Iron, Ferrous

Lab Sample ID: MB 500-613311/1 **Client Sample ID: Method Blank**
Matrix: Water **Prep Type: Total/NA**
Analysis Batch: 613311

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Ferrous Iron	<0.050		0.050	0.050	mg/L			08/11/21 04:41	1

Lab Sample ID: LCS 500-613311/2 **Client Sample ID: Lab Control Sample**
Matrix: Water **Prep Type: Total/NA**
Analysis Batch: 613311

Analyte			Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits		
Ferrous Iron			0.500	0.500		mg/L		100	80 - 120		

Lab Sample ID: 500-203343-1 MS **Client Sample ID: D-2-20210803**
Matrix: Water **Prep Type: Total/NA**
Analysis Batch: 613311

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits		
Ferrous Iron	<0.050	HF	0.500	0.500		mg/L		100	75 - 125		

QC Sample Results

Client: Geosyntec Consultants, Inc.
Project/Site: GLP8029 Coffeen, IL

Job ID: 500-203343-1

Method: SM 3500 Fe B - Iron, Ferrous (Continued)

Lab Sample ID: 500-203343-1 MSD
Matrix: Water
Analysis Batch: 613311

Client Sample ID: D-2-20210803
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Ferrous Iron	<0.050	HF	0.500	0.500		mg/L		100	75 - 125	0	20

Method: SM 4500 P E - Phosphorus

Lab Sample ID: MB 500-614309/1-A
Matrix: Water
Analysis Batch: 614916

Client Sample ID: Method Blank
Prep Type: Total/NA
Prep Batch: 614309

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Phosphorus as PO4	<0.15		0.15	0.073	mg/L		08/15/21 12:30	08/18/21 11:49	1

Lab Sample ID: LCS 500-614309/2-A
Matrix: Water
Analysis Batch: 614916

Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 614309

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Phosphorus as PO4	1.54	1.56		mg/L		101	88 - 123

Method: SM 4500 S2 F - Sulfide, Total

Lab Sample ID: MB 500-613518/1
Matrix: Water
Analysis Batch: 613518

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Sulfide	<1.0		1.0	0.23	mg/L			08/09/21 23:35	1

Lab Sample ID: LCS 500-613518/2
Matrix: Water
Analysis Batch: 613518

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Sulfide	3.84	3.87		mg/L		101	85 - 115

Lab Sample ID: 180-125221-A-1 MS
Matrix: Water
Analysis Batch: 613518

Client Sample ID: Matrix Spike
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits
Sulfide	<1.0		3.84	3.57		mg/L		93	75 - 125

Lab Sample ID: 180-125221-A-1 MSD
Matrix: Water
Analysis Batch: 613518

Client Sample ID: Matrix Spike Duplicate
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Sulfide	<1.0		3.84	3.75		mg/L		98	75 - 125	5	20

Lab Chronicle

Client Sample ID: D-2-20210803 Lab Sample ID: 500-203343-1

Date Collected: 08/03/21 10:15 **Matrix: Water**
Date Received: 08/05/21 09:45

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Dissolved	Prep	3010A			613499	08/10/21 08:44	BDE	TAL CHI
Dissolved	Analysis	6010B		1	613679	08/10/21 23:31	EEN	TAL CHI
Total/NA	Prep	3010A			613499	08/10/21 08:44	BDE	TAL CHI
Total/NA	Analysis	6010B		1	613679	08/10/21 23:27	EEN	TAL CHI
Total/NA	Analysis	9056A		1	614638	08/17/21 16:12	EAT	TAL CHI
Total/NA	Analysis	9056A		20	614951	08/18/21 12:53	EAT	TAL CHI
Dissolved	Analysis	9060A		1	613783		TMS	TAL CHI
					(Start)	08/09/21 23:09		
					(End)	08/09/21 23:09		
Total/NA	Analysis	SM 2320B		1	614414	08/15/21 19:00	MS	TAL CHI
Total/NA	Analysis	SM 2540C		1	613305	08/09/21 09:49	CLB	TAL CHI
Total/NA	Analysis	SM 3500		1	615136	08/19/21 14:42	PFK	TAL CHI
Total/NA	Analysis	SM 3500 Fe B		1	613311	08/11/21 04:46	CLB	TAL CHI
Total/NA	Prep	SM 4500 P B			614309	08/15/21 12:30	JMP	TAL CHI
Total/NA	Analysis	SM 4500 P E		1	614916	08/18/21 12:20	JMP	TAL CHI
Total/NA	Analysis	SM 4500 S2 F		1	613518		CLB	TAL CHI
					(Start)	08/10/21 00:05		
					(End)	08/10/21 00:08		

Client Sample ID: D-1-20210803 Lab Sample ID: 500-203343-2

Date Collected: 08/03/21 10:50 **Matrix: Water**
Date Received: 08/05/21 09:45

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Dissolved	Prep	3010A			613499	08/10/21 08:44	BDE	TAL CHI
Dissolved	Analysis	6010B		1	613679	08/10/21 23:38	EEN	TAL CHI
Total/NA	Prep	3010A			613499	08/10/21 08:44	BDE	TAL CHI
Total/NA	Analysis	6010B		1	613679	08/10/21 23:34	EEN	TAL CHI
Total/NA	Analysis	9056A		25	614951	08/18/21 13:07	EAT	TAL CHI
Total/NA	Analysis	9056A		2	615118	08/19/21 11:37	EAT	TAL CHI
Dissolved	Analysis	9060A		1	613783		TMS	TAL CHI
					(Start)	08/09/21 23:16		
					(End)	08/09/21 23:16		
Total/NA	Analysis	SM 2320B		1	614414	08/15/21 19:07	MS	TAL CHI
Total/NA	Analysis	SM 2540C		1	613305	08/09/21 09:51	CLB	TAL CHI
Total/NA	Analysis	SM 3500		1	615136	08/19/21 14:42	PFK	TAL CHI
Total/NA	Analysis	SM 3500 Fe B		1	613311	08/11/21 04:55	CLB	TAL CHI
Total/NA	Prep	SM 4500 P B			614309	08/15/21 12:30	JMP	TAL CHI
Total/NA	Analysis	SM 4500 P E		1	614916	08/18/21 12:21	JMP	TAL CHI
Total/NA	Analysis	SM 4500 S2 F		1	613518		CLB	TAL CHI
					(Start)	08/10/21 00:08		
					(End)	08/10/21 00:12		

Lab Chronicle

Client: Geosyntec Consultants, Inc. Job ID: 500-203343-1
Project/Site: GLP8029 Coffeen, IL

Client Sample ID: BKG-1-20210803 Lab Sample ID: 500-203343-3

Date Collected: 08/03/21 12:45 **Matrix: Water**
Date Received: 08/05/21 09:45

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Dissolved	Prep	3010A			613499	08/10/21 08:44	BDE	TAL CHI
Dissolved	Analysis	6010B		1	613679	08/10/21 23:46	EEN	TAL CHI
Total/NA	Prep	3010A			613499	08/10/21 08:44	BDE	TAL CHI
Total/NA	Analysis	6010B		1	613679	08/10/21 23:42	EEN	TAL CHI
Total/NA	Analysis	9056A		10	614638	08/17/21 17:48	EAT	TAL CHI
Total/NA	Analysis	9056A		10	614951	08/18/21 13:48	EAT	TAL CHI
Dissolved	Analysis	9060A		1	613783		TMS	TAL CHI
					(Start)	08/09/21 23:26		
					(End)	08/09/21 23:26		
Total/NA	Analysis	SM 2320B		1	614414	08/15/21 19:14	MS	TAL CHI
Total/NA	Analysis	SM 2540C		1	613305	08/09/21 09:54	CLB	TAL CHI
Total/NA	Analysis	SM 3500		1	615136	08/19/21 14:42	PFK	TAL CHI
Total/NA	Analysis	SM 3500 Fe B		1	613311	08/11/21 04:58	CLB	TAL CHI
Total/NA	Prep	SM 4500 P B			614309	08/15/21 12:30	JMP	TAL CHI
Total/NA	Analysis	SM 4500 P E		1	614916	08/18/21 12:22	JMP	TAL CHI
Total/NA	Analysis	SM 4500 S2 F		1	613518		CLB	TAL CHI
					(Start)	08/10/21 00:12		
					(End)	08/10/21 00:16		

Client Sample ID: CL-1-20210803 Lab Sample ID: 500-203343-4

Date Collected: 08/03/21 13:20 **Matrix: Water**
Date Received: 08/05/21 09:45

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Dissolved	Prep	3010A			613499	08/10/21 08:44	BDE	TAL CHI
Dissolved	Analysis	6010B		1	613679	08/10/21 23:54	EEN	TAL CHI
Total/NA	Prep	3010A			613499	08/10/21 08:44	BDE	TAL CHI
Total/NA	Analysis	6010B		1	613679	08/10/21 23:50	EEN	TAL CHI
Total/NA	Analysis	9056A		2	614638	08/17/21 18:01	EAT	TAL CHI
Total/NA	Analysis	9056A		10	614951	08/18/21 14:01	EAT	TAL CHI
Dissolved	Analysis	9060A		1	613783		TMS	TAL CHI
					(Start)	08/09/21 23:33		
					(End)	08/09/21 23:33		
Total/NA	Analysis	SM 2320B		1	614414	08/15/21 19:21	MS	TAL CHI
Total/NA	Analysis	SM 2540C		1	613305	08/09/21 09:56	CLB	TAL CHI
Total/NA	Analysis	SM 3500		1	615136	08/19/21 14:42	PFK	TAL CHI
Total/NA	Analysis	SM 3500 Fe B		1	613311	08/11/21 05:00	CLB	TAL CHI
Total/NA	Prep	SM 4500 P B			614309	08/15/21 12:30	JMP	TAL CHI
Total/NA	Analysis	SM 4500 P E		1	614916	08/18/21 12:23	JMP	TAL CHI
Total/NA	Analysis	SM 4500 S2 F		1	613518		CLB	TAL CHI
					(Start)	08/10/21 00:16		
					(End)	08/10/21 00:20		

Client Sample ID: DUP-20210803 Lab Sample ID: 500-203343-5

Date Collected: 08/03/21 13:30 **Matrix: Water**
Date Received: 08/05/21 09:45

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Dissolved	Prep	3010A			613499	08/10/21 08:44	BDE	TAL CHI
Dissolved	Analysis	6010B		1	613679	08/11/21 00:14	EEN	TAL CHI
Total/NA	Prep	3010A			613499	08/10/21 08:44	BDE	TAL CHI
Total/NA	Analysis	6010B		1	613679	08/10/21 23:58	EEN	TAL CHI
Total/NA	Analysis	9056A		2	614638	08/17/21 18:28	EAT	TAL CHI
Total/NA	Analysis	9056A		10	614951	08/18/21 14:15	EAT	TAL CHI
Dissolved	Analysis	9060A		1	613783		TMS	TAL CHI
					(Start)	08/09/21 23:40		
					(End)	08/09/21 23:40		
Total/NA	Analysis	SM 2320B		1	614414	08/15/21 19:28	MS	TAL CHI
Total/NA	Analysis	SM 2540C		1	613305	08/09/21 09:59	CLB	TAL CHI
Total/NA	Analysis	SM 3500		1	615136	08/19/21 14:42	PFK	TAL CHI
Total/NA	Analysis	SM 3500 Fe B		1	613311	08/11/21 05:03	CLB	TAL CHI
Total/NA	Prep	SM 4500 P B			614309	08/15/21 12:30	JMP	TAL CHI
Total/NA	Analysis	SM 4500 P E		1	614916	08/18/21 12:42	JMP	TAL CHI
Total/NA	Analysis	SM 4500 S2 F		1	613518		CLB	TAL CHI
					(Start)	08/10/21 00:20		
					(End)	08/10/21 00:23		

Client Sample ID: CL-2-20210803 Lab Sample ID: 500-203343-6

Date Collected: 08/03/21 13:50 **Matrix: Water**
Date Received: 08/05/21 09:45

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Dissolved	Prep	3010A			613499	08/10/21 08:44	BDE	TAL CHI
Dissolved	Analysis	6010B		1	613679	08/11/21 00:21	EEN	TAL CHI
Total/NA	Prep	3010A			613499	08/10/21 08:44	BDE	TAL CHI
Total/NA	Analysis	6010B		1	613679	08/11/21 00:18	EEN	TAL CHI
Total/NA	Analysis	9056A		2	614638	08/17/21 18:55	EAT	TAL CHI
Total/NA	Analysis	9056A		10	614951	08/18/21 14:29	EAT	TAL CHI
Dissolved	Analysis	9060A		1	613783		TMS	TAL CHI
					(Start)	08/09/21 23:47		
					(End)	08/09/21 23:47		
Total/NA	Analysis	SM 2320B		1	614414	08/15/21 19:35	MS	TAL CHI
Total/NA	Analysis	SM 2540C		1	613305	08/09/21 10:02	CLB	TAL CHI
Total/NA	Analysis	SM 3500		1	615136	08/19/21 14:42	PFK	TAL CHI
Total/NA	Analysis	SM 3500 Fe B		1	613311	08/11/21 05:06	CLB	TAL CHI
Total/NA	Prep	SM 4500 P B			614309	08/15/21 12:30	JMP	TAL CHI
Total/NA	Analysis	SM 4500 P E		1	614916	08/18/21 12:43	JMP	TAL CHI
Total/NA	Analysis	SM 4500 S2 F		1	613518		CLB	TAL CHI
					(Start)	08/10/21 00:23		
					(End)	08/10/21 00:27		

Lab Chronicle

Client: Geosyntec Consultants, Inc.
Project/Site: GLP8029 Coffeen, IL

Job ID: 500-203343-1

Client Sample ID: CL-3-20210803
Date Collected: 08/03/21 14:20
Date Received: 08/05/21 09:45

Lab Sample ID: 500-203343-7
Matrix: Water

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Dissolved	Prep	3010A			613499	08/10/21 08:44	BDE	TAL CHI
Dissolved	Analysis	6010B		1	613679	08/11/21 00:29	EEN	TAL CHI
Total/NA	Prep	3010A			613499	08/10/21 08:44	BDE	TAL CHI
Total/NA	Analysis	6010B		1	613679	08/11/21 00:25	EEN	TAL CHI
Total/NA	Analysis	9056A		2	614638	08/17/21 19:23	EAT	TAL CHI
Total/NA	Analysis	9056A		10	614951	08/18/21 14:42	EAT	TAL CHI
Dissolved	Analysis	9060A		1	613783		TMS	TAL CHI
					(Start)	08/09/21 23:55		
					(End)	08/09/21 23:55		
Total/NA	Analysis	SM 2320B		1	614414	08/15/21 19:41	MS	TAL CHI
Total/NA	Analysis	SM 2540C		1	613305	08/09/21 10:04	CLB	TAL CHI
Total/NA	Analysis	SM 3500		1	615136	08/19/21 14:42	PFK	TAL CHI
Total/NA	Analysis	SM 3500 Fe B		1	613311	08/11/21 05:09	CLB	TAL CHI
Total/NA	Prep	SM 4500 P B			614309	08/15/21 12:30	JMP	TAL CHI
Total/NA	Analysis	SM 4500 P E		1	614916	08/18/21 12:44	JMP	TAL CHI
Total/NA	Analysis	SM 4500 S2 F		1	613518		CLB	TAL CHI
					(Start)	08/10/21 00:27		
					(End)	08/10/21 00:31		

Laboratory References:

TAL CHI = Eurofins TestAmerica, Chicago, 2417 Bond Street, University Park, IL 60484, TEL (708)534-5200

Laboratory: Eurofins TestAmerica, Chicago

The accreditations/certifications listed below are applicable to this report.

Authority	Program	Identification Number	Expiration Date
Illinois	NELAP	IL00035	04-29-22

Eurofins TestAmerica, Chicago
2417 Bond Street
University Park IL 60484
Phone 708-534-5200 Fax 708-534-5211

Chain of Custody Record

eurofins Environment Testing America

500-203343 COC

Client Information	Sampler: Nick Williams	Lab PM: Kintz Robin M	COC No: 500-93566-41606 1
Client Contact: Brian Ares	Phone: 317 694 9143	E-Mail: Robin Kintz@Eurofinset com	Page: Page 1 of ~~8~~ 1
Company: Geosyntec Consultants Inc	PWSID:		Job #: 500-203343

Ca
Sta

Address: 2100 Commonwealth Blvd Suite 100	**Due Date Requested:**
City: Ann Arbor	**TAT Requested (days):**
State Zip: MI 48105	**Compliance Project:** ∆ Yes ∆ No
Phone: 734-794-1548(Tel)	PO #: Purchase Order not required
Email: bares@geosyntec com	WO #:
Project Name: GLP8029 Coffeen IL	Project #: 50019213
Site:	SSOW#:

Analysis Requested

	Sample Identification	Sample Date	Sample Time	Sample Type (C=comp, G=grab)	Matrix (W=water S=solid O=waste/oil, BT=Tissue, A=Air)	Field Filtered Sample (Yes or No)	Perform MS/MSD (Yes or No)	9056A - Chloride, Sulfate	6010B - Metals (ICP) - 9 elements	6010B - Dissolved Metals (ICP) - 9 elements	4500_P_E - Phosphorus as PO4	SM4500_S2_F - Sulfide	9060A_Diss - Organic Carbon Dissolved (DOC)	2320B 2540C 3500_F+2_B_Calc 3500_F+3_B_Calc	~~9056A - Chloride, Sulfate (Dissolved)~~	Total Number of containers	Special Instructions/Note
					Preservation Code:	X	X	N	D	D	S	CB	S	N	~~Z~~	X	
1	D-2-20210803	8/3/21	1015	G	W		N	X	X	X	X	X	X	X	~~X~~		Filtered in field for
2	D-1-20210803	↓	1050	G	W		N	X	X	X	X	X	X	X	~~X~~		Dissolved Metals, DOC,
3	BKG-1-20210803		1245	G	W		N	X	X	X	X	X	X	X	~~X~~		~~and Dissolved Chloride,~~
4	CL-1-20210803		1320	G	W		N	X	X	X	X	X	X	X	~~X~~		~~Sulfate~~ NW
5	DUP-20210803		1330	G	W		N	X	X	X	X	X	X	X	~~X~~		↓
6	CL-2-20210803		1350	G	W		N	X	X	X	X	X	X	X	~~X~~		
7	CL-3-20210803		1420	G	W		N	X	X	X	X	X	X	X	~~X~~ NW		

Preservation Codes:

A	HCL	M	Hexane
B	NaOH	N	None
C	Zn Acetate	O	AsNaO2
D	Nitric Acid	P	Na2O4S
E	NaHSO4	Q	Na2SO3
F	MeOH	R	Na2S2O3
G	Amchlor	S	H2SO4
H	Ascorbic Acid	T	TSP Dodecahydrate
I	Ice	U	Acetone
J	DI Water	V	MCAA
K	EDTA	W	pH 4-5
L	EDA	Z	other (specify)

Other:

Possible Hazard Identification
☒ *Non-Hazard* ☐ *Flammable* ☐ *Skin Irritant* ☐ *Poison B* ☐ *Unknown* ☐ *Radiological*

Sample Disposal (A fee may be assessed if samples are retained longer than 1 month)
☐ *Return To Client* ☒ *Disposal By Lab* ☐ *Archive For* ________ *Months*

Deliverable Requested I II III IV Other (specify)

Special Instructions/QC Requirements

Empty Kit Relinquished by	Date	Time	Method of Shipment

Relinquished by:	Date/Time: 8/4/21 930	Company: Geo	Received by: Jeff James	Date/Time: 8/5/21 0945	Company: ETA
Relinquished by:	Date/Time	Company	Received by:	Date/Time	Company
Relinquished by:	Date/Time	Company	Received by:	Date/Time	Company

Custody Seals Intact
∆ Yes ∆ No

Custody Seal No

Cooler Temperature(s) °C and Other Remarks

Login Sample Receipt Checklist

Client: Geosyntec Consultants, Inc.

Job Number: 500-203343-1

Login Number: 203343
List Number: 1
Creator: James, Jeff A

List Source: Eurofins TestAmerica, Chicago

Question	Answer	Comment
Radioactivity wasn't checked or is </= background as measured by a survey meter.	True	
The cooler's custody seal, if present, is intact.	True	
Sample custody seals, if present, are intact.	True	
The cooler or samples do not appear to have been compromised or tampered with.	True	
Samples were received on ice.	True	
Cooler Temperature is acceptable.	True	
Cooler Temperature is recorded.	True	1.1, 2.5
COC is present.	True	
COC is filled out in ink and legible.	True	
COC is filled out with all pertinent information.	True	
Is the Field Sampler's name present on COC?	True	
There are no discrepancies between the containers received and the COC.	True	
Samples are received within Holding Time (excluding tests with immediate HTs)	True	
Sample containers have legible labels.	True	
Containers are not broken or leaking.	True	
Sample collection date/times are provided.	True	
Appropriate sample containers are used.	True	
Sample bottles are completely filled.	True	
Sample Preservation Verified.	True	
There is sufficient vol. for all requested analyses, incl. any requested MS/MSDs	True	
Containers requiring zero headspace have no headspace or bubble is <6mm (1/4").	True	
Multiphasic samples are not present.	True	
Samples do not require splitting or compositing.	True	
Residual Chlorine Checked.	N/A	

PDC Laboratories, Inc.
PROFESSIONAL • DEPENDABLE • COMMITTED

November 08, 2016

Rhonald Hasenyager
Hanson Professional Services, Inc.
1525 South Sixth Street
Springfield, IL 62703-2886

Dear Rhonald Hasenyager:

Please find enclosed the analytical results for the sample(s) the laboratory received on **10/25/16 7:45 am** and logged in under work order **6103663**. All testing is performed according to our current TNI certifications unless otherwise noted. This report cannot be reproduced, except in full, without the written permission of PDC Laboratories, Inc.

If you have any questions regarding your report, please contact your project manager. Quality and timely data is of the utmost importance to us.

PDC Laboratories, Inc. appreciates the opportunity to provide you with analytical expertise. We are always trying to improve our customer service and we welcome you to contact the Vice President , John LaPayne with any feedback you have about your experience with our laboratory.

Sincerely,

Gail g Schindler

Gail Schindler
Project Manager
(309) 692-9688 x1716
gschindler@pdclab.com

NELAP ACCREDITED
TNI
LABORATORY

ANALYTICAL RESULTS

Sample: **6103663-01**
Name: AP1a
Matrix: Surface Water - Grab

Sampled: 10/24/16 11:52
Received: 10/25/16 07:45

Parameter	Result	Unit	Qualifier	Prepared	Analyzed	Analyst	Method
Anions - PIA							
Chloride	3.2	mg/L		10/25/16 11:16	10/25/16 11:16	TAS	EPA 300.0
Fluoride	< 0.250	mg/L		10/25/16 11:16	10/25/16 11:16	TAS	EPA 300.0
Nitrite-N	< 0.15	mg/L		10/25/16 11:16	10/25/16 11:16	TAS	EPA 300.0
Sulfate	1500	mg/L		10/27/16 13:02	10/27/16 13:02	TAS	EPA 300.0
Field - PIA							
pH, Field Measured	6.99	pH Units		10/24/16 11:52	10/24/16 11:52	FIELD	Field*
General Chemistry - PIA							
Alkalinity - bicarbonate as CaCO3	90	mg/L		10/31/16 13:36	10/31/16 13:36	LAM	SM 2320B*
Alkalinity - carbonate as CaCO3	< 2.0	mg/L		10/31/16 13:36	10/31/16 13:36	LAM	SM 2320B*
Solids - total dissolved solids (TDS)	1800	mg/L		10/25/16 14:59	10/25/16 15:33	DMB/ARL	SM 2540C
Total Metals - PIA							
Antimony	3.1	ug/L		10/26/16 13:38	11/02/16 12:10	JMW	SW 6020
Arsenic	7.2	ug/L		10/26/16 13:38	11/01/16 11:23	JMW	SW 6020
Barium	130	ug/L		10/26/16 13:38	11/01/16 11:23	JMW	SW 6020
Beryllium	< 1.0	ug/L		10/26/16 13:38	11/01/16 11:23	JMW	SW 6020
Boron	3800	ug/L		10/26/16 13:38	11/03/16 07:54	JMW	SW 6020
Cadmium	< 1.0	ug/L		10/26/16 13:38	11/01/16 11:23	JMW	SW 6020
Calcium	380	mg/L		10/26/16 13:38	11/01/16 11:23	JMW	SW 6020
Chromium	< 4.0	ug/L		10/26/16 13:38	11/01/16 11:23	JMW	SW 6020
Cobalt	< 2.0	ug/L		10/26/16 13:38	11/01/16 11:23	JMW	SW 6020
Lithium	39	ug/L		10/26/16 13:38	10/27/16 11:24	KJP	SW 6010*
Magnesium	67	mg/L		10/26/16 13:38	11/01/16 11:23	JMW	SW 6020
Mercury	< 0.20	ug/L		10/26/16 13:38	11/01/16 13:53	JMW	SW 6020
Molybdenum	47	ug/L		10/26/16 13:38	11/01/16 11:23	JMW	SW 6020
Potassium	7.3	mg/L		10/26/16 13:38	11/01/16 11:23	JMW	SW 6020
Selenium	3.0	ug/L		10/26/16 13:38	11/01/16 11:23	JMW	SW 6020
Sodium	33	mg/L		10/26/16 13:38	11/01/16 11:23	JMW	SW 6020
Thallium	< 1.0	ug/L		10/26/16 13:38	11/01/16 11:23	JMW	SW 6020

ANALYTICAL RESULTS

Sample:	**6103663-02**	**Sampled:**	10/24/16 11:56
Name:	AP1b	**Received:**	10/25/16 07:45
Matrix:	Surface Water - Grab		

Parameter	Result	Unit	Qualifier	Prepared	Analyzed	Analyst	Method
Anions - PIA							
Chloride	13	mg/L		10/27/16 13:20	10/27/16 13:20	TAS	EPA 300.0
Nitrite-N	< 0.15	mg/L		10/25/16 12:45	10/25/16 12:45	TAS	EPA 300.0
Sulfate	1300	mg/L		10/27/16 13:38	10/27/16 13:38	TAS	EPA 300.0
Field - PIA							
pH, Field Measured	7.01	pH Units		10/24/16 11:56	10/24/16 11:56	FIELD	Field*
General Chemistry - PIA							
Alkalinity - bicarbonate as CaCO3	120	mg/L		10/31/16 13:36	10/31/16 13:36	LAM	SM 2320B*
Alkalinity - carbonate as CaCO3	< 2.0	mg/L		10/31/16 13:36	10/31/16 13:36	LAM	SM 2320B*
Fluoride	0.977	mg/L		10/27/16 13:26	10/27/16 13:26	TTH	SM 4500-F C
Solids - total dissolved solids (TDS)	1600	mg/L		10/25/16 14:59	10/25/16 15:33	DMB/ARL	SM 2540C
Total Metals - PIA							
Antimony	3.3	ug/L		10/26/16 13:38	11/02/16 12:23	JMW	SW 6020
Arsenic	17	ug/L		10/26/16 13:38	11/01/16 11:36	JMW	SW 6020
Barium	100	ug/L		10/26/16 13:38	11/01/16 11:36	JMW	SW 6020
Beryllium	< 1.0	ug/L		10/26/16 13:38	11/01/16 11:36	JMW	SW 6020
Boron	3100	ug/L		10/26/16 13:38	11/03/16 07:59	JMW	SW 6020
Cadmium	< 1.0	ug/L		10/26/16 13:38	11/01/16 11:36	JMW	SW 6020
Calcium	320	mg/L		10/26/16 13:38	11/01/16 11:36	JMW	SW 6020
Chromium	< 4.0	ug/L		10/26/16 13:38	11/01/16 11:36	JMW	SW 6020
Cobalt	< 2.0	ug/L		10/26/16 13:38	11/01/16 11:36	JMW	SW 6020
Lithium	47	ug/L		10/26/16 13:38	10/27/16 11:33	KJP	SW 6010*
Magnesium	52	mg/L		10/26/16 13:38	11/01/16 11:36	JMW	SW 6020
Mercury	< 0.20	ug/L		10/26/16 13:38	11/01/16 14:06	JMW	SW 6020
Molybdenum	100	ug/L		10/26/16 13:38	11/01/16 11:36	JMW	SW 6020
Potassium	18	mg/L		10/26/16 13:38	11/01/16 11:36	JMW	SW 6020
Selenium	6.9	ug/L		10/26/16 13:38	11/01/16 11:36	JMW	SW 6020
Sodium	53	mg/L		10/26/16 13:38	11/01/16 11:36	JMW	SW 6020
Thallium	< 1.0	ug/L		10/26/16 13:38	11/01/16 11:36	JMW	SW 6020

ANALYTICAL RESULTS

Sample: **6103663-03**
Name: AP1c
Matrix: Surface Water - Grab

Sampled: 10/24/16 12:10
Received: 10/25/16 07:45

Parameter	Result	Unit	Qualifier	Prepared	Analyzed	Analyst	Method
Anions - PIA							
Chloride	13	mg/L		10/27/16 13:55	10/27/16 13:55	TAS	EPA 300.0
Nitrite-N	< 0.15	mg/L		10/25/16 13:21	10/25/16 13:21	TAS	EPA 300.0
Sulfate	1600	mg/L		10/27/16 14:13	10/27/16 14:13	TAS	EPA 300.0
Field - PIA							
pH, Field Measured	7.05	pH Units		10/24/16 12:10	10/24/16 12:10	FIELD	Field*
General Chemistry - PIA							
Alkalinity - bicarbonate as CaCO3	80	mg/L		10/31/16 13:36	10/31/16 13:36	LAM	SM 2320B*
Alkalinity - carbonate as CaCO3	< 2.0	mg/L		10/31/16 13:36	10/31/16 13:36	LAM	SM 2320B*
Fluoride	0.614	mg/L		10/27/16 13:30	10/27/16 13:30	TTH	SM 4500-F C
Solids - total dissolved solids (TDS)	1900	mg/L		10/25/16 14:59	10/25/16 15:33	DMB/ARL	SM 2540C
Total Metals - PIA							
Antimony	< 3.0	ug/L		10/26/16 13:38	11/02/16 12:26	JMW	SW 6020
Arsenic	18	ug/L		10/26/16 13:38	11/01/16 11:39	JMW	SW 6020
Barium	130	ug/L		10/26/16 13:38	11/01/16 11:39	JMW	SW 6020
Beryllium	< 1.0	ug/L		10/26/16 13:38	11/01/16 11:39	JMW	SW 6020
Boron	2900	ug/L		10/26/16 13:38	11/03/16 08:01	JMW	SW 6020
Cadmium	< 1.0	ug/L		10/26/16 13:38	11/01/16 11:39	JMW	SW 6020
Calcium	390	mg/L		10/26/16 13:38	11/01/16 11:39	JMW	SW 6020
Chromium	< 4.0	ug/L		10/26/16 13:38	11/01/16 11:39	JMW	SW 6020
Cobalt	< 2.0	ug/L		10/26/16 13:38	11/01/16 11:39	JMW	SW 6020
Lithium	51	ug/L		10/26/16 13:38	10/27/16 11:36	KJP	SW 6010*
Magnesium	49	mg/L		10/26/16 13:38	11/01/16 11:39	JMW	SW 6020
Mercury	< 0.20	ug/L		10/26/16 13:38	11/01/16 14:10	JMW	SW 6020
Molybdenum	81	ug/L		10/26/16 13:38	11/01/16 11:39	JMW	SW 6020
Potassium	18	mg/L		10/26/16 13:38	11/01/16 11:39	JMW	SW 6020
Selenium	3.1	ug/L		10/26/16 13:38	11/01/16 11:39	JMW	SW 6020
Sodium	59	mg/L		10/26/16 13:38	11/01/16 11:39	JMW	SW 6020
Thallium	< 1.0	ug/L		10/26/16 13:38	11/01/16 11:39	JMW	SW 6020

ANALYTICAL RESULTS

Sample: **6103663-04**
Name: AP1d
Matrix: Surface Water - Grab

Sampled: 10/24/16 12:15
Received: 10/25/16 07:45

Parameter	Result	Unit	Qualifier	Prepared	Analyzed	Analyst	Method
Anions - PIA							
Chloride	18	mg/L		10/27/16 14:31	10/27/16 14:31	TAS	EPA 300.0
Nitrite-N	< 0.15	mg/L		10/25/16 13:57	10/25/16 13:57	TAS	EPA 300.0
Sulfate	1000	mg/L		10/27/16 14:48	10/27/16 14:48	TAS	EPA 300.0
Field - PIA							
pH, Field Measured	7.21	pH Units		10/24/16 12:15	10/24/16 12:15	FIELD	Field*
General Chemistry - PIA							
Alkalinity - bicarbonate as CaCO3	90	mg/L		10/25/16 09:29	10/25/16 09:29	CJN	SM 2320B*
Alkalinity - carbonate as CaCO3	< 20	mg/L		10/25/16 09:29	10/25/16 09:29	CJN	SM 2320B*
Fluoride	1.08	mg/L		10/27/16 13:43	10/27/16 13:43	TTH	SM 4500-F C
Solids - total dissolved solids (TDS)	980	mg/L		10/25/16 14:59	10/25/16 15:33	DMB/ARL	SM 2540C
Total Metals - PIA							
Antimony	< 3.0	ug/L		10/26/16 13:38	11/02/16 12:30	JMW	SW 6020
Arsenic	2.0	ug/L		10/26/16 13:38	11/01/16 11:43	JMW	SW 6020
Barium	200	ug/L		10/26/16 13:38	11/01/16 11:43	JMW	SW 6020
Beryllium	< 1.0	ug/L		10/26/16 13:38	11/01/16 11:43	JMW	SW 6020
Boron	2000	ug/L		10/26/16 13:38	11/03/16 08:02	JMW	SW 6020
Cadmium	< 1.0	ug/L		10/26/16 13:38	11/01/16 11:43	JMW	SW 6020
Calcium	210	mg/L		10/26/16 13:38	11/01/16 11:43	JMW	SW 6020
Chromium	< 4.0	ug/L		10/26/16 13:38	11/01/16 11:43	JMW	SW 6020
Cobalt	< 2.0	ug/L		10/26/16 13:38	11/01/16 11:43	JMW	SW 6020
Lithium	55	ug/L		10/26/16 13:38	10/27/16 11:39	KJP	SW 6010*
Magnesium	35	mg/L		10/26/16 13:38	11/01/16 11:43	JMW	SW 6020
Mercury	< 0.20	ug/L		10/26/16 13:38	11/01/16 14:13	JMW	SW 6020
Molybdenum	31	ug/L		10/26/16 13:38	11/01/16 11:43	JMW	SW 6020
Potassium	26	mg/L		10/26/16 13:38	11/01/16 11:43	JMW	SW 6020
Selenium	1.5	ug/L		10/26/16 13:38	11/01/16 11:43	JMW	SW 6020
Sodium	83	mg/L		10/26/16 13:38	11/01/16 11:43	JMW	SW 6020
Thallium	< 1.0	ug/L		10/26/16 13:38	11/01/16 11:43	JMW	SW 6020

ANALYTICAL RESULTS

Sample: **6103663-05**
Name: AP1e
Matrix: Surface Water - Grab

Sampled: 10/24/16 12:01
Received: 10/25/16 07:45

Parameter	Result	Unit	Qualifier	Prepared	Analyzed	Analyst	Method
Anions - PIA							
Chloride	18	mg/L		10/27/16 18:37	10/27/16 18:37	TAS	EPA 300.0
Fluoride	1.00	mg/L		10/25/16 13:26	10/25/16 13:26	TAS	EPA 300.0
Nitrite-N	< 0.15	mg/L		10/25/16 13:26	10/25/16 13:26	TAS	EPA 300.0
Sulfate	960	mg/L		10/28/16 11:36	10/28/16 11:36	TAS	EPA 300.0
Field - PIA							
pH, Field Measured	7.12	pH Units		10/24/16 12:01	10/24/16 12:01	FIELD	Field*
General Chemistry - PIA							
Alkalinity - bicarbonate as CaCO3	80	mg/L		10/31/16 13:36	10/31/16 13:36	LAM	SM 2320B*
Alkalinity - carbonate as CaCO3	< 2.0	mg/L		10/31/16 13:36	10/31/16 13:36	LAM	SM 2320B*
Solids - total dissolved solids (TDS)	1200	mg/L		10/25/16 14:59	10/25/16 15:33	DMB/ARL	SM 2540C
Total Metals - PIA							
Antimony	< 3.0	ug/L		10/26/16 13:38	11/02/16 12:45	JMW	SW 6020
Arsenic	1.4	ug/L		10/26/16 13:38	11/01/16 11:46	JMW	SW 6020
Barium	160	ug/L		10/26/16 13:38	11/01/16 11:46	JMW	SW 6020
Beryllium	< 1.0	ug/L		10/26/16 13:38	11/01/16 11:46	JMW	SW 6020
Boron	2100	ug/L		10/26/16 13:38	11/03/16 08:03	JMW	SW 6020
Cadmium	< 1.0	ug/L		10/26/16 13:38	11/01/16 11:46	JMW	SW 6020
Calcium	200	mg/L		10/26/16 13:38	11/01/16 11:46	JMW	SW 6020
Chromium	< 4.0	ug/L		10/26/16 13:38	11/01/16 11:46	JMW	SW 6020
Cobalt	< 2.0	ug/L		10/26/16 13:38	11/01/16 11:46	JMW	SW 6020
Lithium	55	ug/L		10/26/16 13:38	10/27/16 11:48	KJP	SW 6010*
Magnesium	34	mg/L		10/26/16 13:38	11/01/16 11:46	JMW	SW 6020
Mercury	< 0.20	ug/L		10/26/16 13:38	11/01/16 14:17	JMW	SW 6020
Molybdenum	30	ug/L		10/26/16 13:38	11/01/16 11:46	JMW	SW 6020
Potassium	26	mg/L		10/26/16 13:38	11/01/16 11:46	JMW	SW 6020
Selenium	1.2	ug/L		10/26/16 13:38	11/01/16 11:46	JMW	SW 6020
Sodium	80	mg/L		10/26/16 13:38	11/01/16 11:46	JMW	SW 6020
Thallium	< 1.0	ug/L		10/26/16 13:38	11/01/16 11:46	JMW	SW 6020

ANALYTICAL RESULTS

Sample: **6103663-06**
Name: AP1f
Matrix: Surface Water - Grab

Sampled: 10/24/16 12:40
Received: 10/25/16 07:45

Parameter	Result	Unit	Qualifier	Prepared	Analyzed	Analyst	Method
Anions - PIA							
Chloride	17	mg/L		10/27/16 15:06	10/27/16 15:06	TAS	EPA 300.0
Fluoride	1.00	mg/L		10/25/16 14:03	10/25/16 14:03	TAS	EPA 300.0
Nitrite-N	< 0.15	mg/L		10/25/16 14:03	10/25/16 14:03	TAS	EPA 300.0
Sulfate	1000	mg/L		10/27/16 15:23	10/27/16 15:23	TAS	EPA 300.0
Field - PIA							
pH, Field Measured	7.20	pH Units		10/24/16 12:40	10/24/16 12:40	FIELD	Field*
General Chemistry - PIA							
Alkalinity - bicarbonate as CaCO3	110	mg/L		10/25/16 09:29	10/25/16 09:29	CJN	SM 2320B*
Alkalinity - carbonate as CaCO3	< 20	mg/L		10/25/16 09:29	10/25/16 09:29	CJN	SM 2320B*
Solids - total dissolved solids (TDS)	1200	mg/L		10/25/16 14:59	10/25/16 15:33	DMB/ARL	SM 2540C
Total Metals - PIA							
Antimony	< 3.0	ug/L		10/26/16 13:38	11/02/16 12:48	JMW	SW 6020
Arsenic	1.5	ug/L		10/26/16 13:38	11/01/16 11:50	JMW	SW 6020
Barium	150	ug/L		10/26/16 13:38	11/01/16 11:50	JMW	SW 6020
Beryllium	< 1.0	ug/L		10/26/16 13:38	11/01/16 11:50	JMW	SW 6020
Boron	2100	ug/L		10/26/16 13:38	11/03/16 08:13	JMW	SW 6020
Cadmium	< 1.0	ug/L		10/26/16 13:38	11/01/16 11:50	JMW	SW 6020
Calcium	200	mg/L		10/26/16 13:38	11/01/16 11:50	JMW	SW 6020
Chromium	< 4.0	ug/L		10/26/16 13:38	11/01/16 11:50	JMW	SW 6020
Cobalt	< 2.0	ug/L		10/26/16 13:38	11/01/16 11:50	JMW	SW 6020
Lithium	57	ug/L		10/26/16 13:38	10/27/16 11:51	KJP	SW 6010*
Magnesium	35	mg/L		10/26/16 13:38	11/01/16 11:50	JMW	SW 6020
Mercury	< 0.20	ug/L		10/26/16 13:38	11/01/16 14:21	JMW	SW 6020
Molybdenum	31	ug/L		10/26/16 13:38	11/01/16 11:50	JMW	SW 6020
Potassium	26	mg/L		10/26/16 13:38	11/01/16 11:50	JMW	SW 6020
Selenium	1.2	ug/L		10/26/16 13:38	11/01/16 11:50	JMW	SW 6020
Sodium	82	mg/L		10/26/16 13:38	11/01/16 11:50	JMW	SW 6020
Thallium	< 1.0	ug/L		10/26/16 13:38	11/01/16 11:50	JMW	SW 6020

ANALYTICAL RESULTS

Sample: **6103663-07**
Name: AP1g
Matrix: Surface Water - Grab

Sampled: 10/24/16 12:50
Received: 10/25/16 07:45

Parameter	Result	Unit	Qualifier	Prepared	Analyzed	Analyst	Method
Anions - PIA							
Chloride	17	mg/L		10/27/16 15:41	10/27/16 15:41	TAS	EPA 300.0
Fluoride	1.00	mg/L		10/25/16 15:34	10/25/16 15:34	TAS	EPA 300.0
Nitrite-N	< 0.15	mg/L		10/25/16 15:34	10/25/16 15:34	TAS	EPA 300.0
Sulfate	970	mg/L		10/28/16 11:54	10/28/16 11:54	TAS	EPA 300.0
Field - PIA							
pH, Field Measured	7.21	pH Units		10/24/16 12:50	10/24/16 12:50	FIELD	Field*
General Chemistry - PIA							
Alkalinity - bicarbonate as CaCO3	75	mg/L		10/31/16 13:36	10/31/16 13:36	LAM	SM 2320B*
Alkalinity - carbonate as CaCO3	< 2.0	mg/L		10/31/16 13:36	10/31/16 13:36	LAM	SM 2320B*
Solids - total dissolved solids (TDS)	1200	mg/L		10/25/16 14:59	10/25/16 15:33	DMB/ARL	SM 2540C
Total Metals - PIA							
Antimony	< 3.0	ug/L		10/26/16 13:38	11/02/16 12:52	JMW	SW 6020
Arsenic	1.3	ug/L		10/26/16 13:38	11/01/16 12:09	JMW	SW 6020
Barium	140	ug/L		10/26/16 13:38	11/01/16 14:37	JMW	SW 6020
Beryllium	< 1.0	ug/L		10/26/16 13:38	11/01/16 12:09	JMW	SW 6020
Boron	2100	ug/L		10/26/16 13:38	11/03/16 08:16	JMW	SW 6020
Cadmium	< 1.0	ug/L		10/26/16 13:38	11/01/16 12:09	JMW	SW 6020
Calcium	210	mg/L		10/26/16 13:38	11/02/16 12:52	JMW	SW 6020
Chromium	< 4.0	ug/L		10/26/16 13:38	11/01/16 14:37	JMW	SW 6020
Cobalt	< 2.0	ug/L		10/26/16 13:38	11/02/16 12:52	JMW	SW 6020
Lithium	56	ug/L		10/26/16 13:38	10/27/16 11:54	KJP	SW 6010*
Magnesium	32	mg/L		10/26/16 13:38	11/01/16 14:37	JMW	SW 6020
Mercury	< 0.20	ug/L		10/26/16 13:38	11/01/16 14:37	JMW	SW 6020
Molybdenum	29	ug/L		10/26/16 13:38	11/01/16 12:09	JMW	SW 6020
Potassium	26	mg/L		10/26/16 13:38	11/01/16 12:09	JMW	SW 6020
Selenium	1.4	ug/L		10/26/16 13:38	11/01/16 12:09	JMW	SW 6020
Sodium	100	mg/L		10/26/16 13:38	11/02/16 12:52	JMW	SW 6020
Thallium	< 1.0	ug/L		10/26/16 13:38	11/01/16 12:09	JMW	SW 6020

ANALYTICAL RESULTS

Sample: **6103663-08**
Name: AP1h
Matrix: Surface Water - Grab

Sampled: 10/24/16 12:55
Received: 10/25/16 07:45

Parameter	Result	Unit	Qualifier	Prepared	Analyzed	Analyst	Method
Anions - PIA							
Chloride	17	mg/L		10/27/16 16:51	10/27/16 16:51	TAS	EPA 300.0
Fluoride	0.980	mg/L		10/25/16 16:11	10/25/16 16:11	TAS	EPA 300.0
Nitrite-N	< 0.15	mg/L		10/25/16 16:11	10/25/16 16:11	TAS	EPA 300.0
Sulfate	1000	mg/L		10/28/16 12:12	10/28/16 12:12	TAS	EPA 300.0
Field - PIA							
pH, Field Measured	7.41	pH Units		10/24/16 12:55	10/24/16 12:55	FIELD	Field*
General Chemistry - PIA							
Alkalinity - bicarbonate as CaCO3	90	mg/L		10/25/16 09:29	10/25/16 09:29	CJN	SM 2320B*
Alkalinity - carbonate as CaCO3	< 20	mg/L		10/25/16 09:29	10/25/16 09:29	CJN	SM 2320B*
Solids - total dissolved solids (TDS)	1200	mg/L		10/25/16 14:59	10/25/16 15:33	DMB/ARL	SM 2540C
Total Metals - PIA							
Antimony	< 3.0	ug/L		10/26/16 13:38	11/02/16 12:55	JMW	SW 6020
Arsenic	1.5	ug/L		10/26/16 13:38	11/01/16 12:12	JMW	SW 6020
Barium	180	ug/L		10/26/16 13:38	11/01/16 14:40	JMW	SW 6020
Beryllium	< 1.0	ug/L		10/26/16 13:38	11/01/16 12:12	JMW	SW 6020
Boron	2200	ug/L		10/26/16 13:38	11/03/16 08:18	JMW	SW 6020
Cadmium	< 1.0	ug/L		10/26/16 13:38	11/01/16 12:12	JMW	SW 6020
Calcium	230	mg/L		10/26/16 13:38	11/02/16 12:55	JMW	SW 6020
Chromium	< 4.0	ug/L		10/26/16 13:38	11/01/16 14:40	JMW	SW 6020
Cobalt	< 2.0	ug/L		10/26/16 13:38	11/02/16 12:55	JMW	SW 6020
Lithium	55	ug/L		10/26/16 13:38	10/27/16 11:57	KJP	SW 6010*
Magnesium	30	mg/L		10/26/16 13:38	11/01/16 14:40	JMW	SW 6020
Mercury	< 0.20	ug/L		10/26/16 13:38	11/01/16 14:40	JMW	SW 6020
Molybdenum	31	ug/L		10/26/16 13:38	11/01/16 12:12	JMW	SW 6020
Potassium	27	mg/L		10/26/16 13:38	11/01/16 12:12	JMW	SW 6020
Selenium	1.2	ug/L		10/26/16 13:38	11/01/16 12:12	JMW	SW 6020
Sodium	110	mg/L		10/26/16 13:38	11/02/16 12:55	JMW	SW 6020
Thallium	< 1.0	ug/L		10/26/16 13:38	11/01/16 12:12	JMW	SW 6020

ANALYTICAL RESULTS

Sample: **6103663-09**
Name: AP2e
Matrix: Surface Water - Grab

Sampled: 10/24/16 11:30
Received: 10/25/16 07:45

Parameter	Result	Unit	Qualifier	Prepared	Analyzed	Analyst	Method
Anions - PIA							
Chloride	< 5.0	mg/L		10/27/16 17:27	10/27/16 17:27	TAS	EPA 300.0
Nitrite-N	< 0.15	mg/L		10/25/16 14:33	10/25/16 14:33	TAS	EPA 300.0
Sulfate	1500	mg/L		10/28/16 12:31	10/28/16 12:31	TAS	EPA 300.0
Field - PIA							
pH, Field Measured	6.49	pH Units		10/24/16 11:30	10/24/16 11:30	FIELD	Field*
General Chemistry - PIA							
Alkalinity - bicarbonate as CaCO3	55	mg/L		10/25/16 09:29	10/25/16 09:29	CJN	SM 2320B*
Alkalinity - carbonate as CaCO3	< 20	mg/L		10/25/16 09:29	10/25/16 09:29	CJN	SM 2320B*
Fluoride	0.438	mg/L		10/27/16 13:58	10/27/16 13:58	TTH	SM 4500-F C
Solids - total dissolved solids (TDS)	1700	mg/L		10/25/16 14:59	10/25/16 15:33	DMB/ARL	SM 2540C
Total Metals - PIA							
Antimony	< 3.0	ug/L		10/26/16 13:38	11/02/16 12:59	JMW	SW 6020
Arsenic	23	ug/L		10/26/16 13:38	11/01/16 12:16	JMW	SW 6020
Barium	26	ug/L		10/26/16 13:38	11/01/16 14:44	JMW	SW 6020
Beryllium	< 1.0	ug/L		10/26/16 13:38	11/02/16 12:59	JMW	SW 6020
Boron	5300	ug/L		10/26/16 13:38	11/03/16 08:19	JMW	SW 6020
Cadmium	< 1.0	ug/L		10/26/16 13:38	11/01/16 12:16	JMW	SW 6020
Calcium	210	mg/L		10/26/16 13:38	11/02/16 12:59	JMW	SW 6020
Chromium	< 4.0	ug/L		10/26/16 13:38	11/01/16 14:44	JMW	SW 6020
Cobalt	< 2.0	ug/L		10/26/16 13:38	11/02/16 12:59	JMW	SW 6020
Lithium	190	ug/L		10/26/16 13:38	10/27/16 12:00	KJP	SW 6010*
Magnesium	40	mg/L		10/26/16 13:38	11/01/16 14:44	JMW	SW 6020
Mercury	< 0.20	ug/L		10/26/16 13:38	11/01/16 14:44	JMW	SW 6020
Molybdenum	90	ug/L		10/26/16 13:38	11/01/16 12:16	JMW	SW 6020
Potassium	27	mg/L		10/26/16 13:38	11/01/16 12:16	JMW	SW 6020
Selenium	< 1.0	ug/L		10/26/16 13:38	11/01/16 12:16	JMW	SW 6020
Sodium	25	mg/L		10/26/16 13:38	11/02/16 12:59	JMW	SW 6020
Thallium	< 1.0	ug/L		10/26/16 13:38	11/01/16 12:16	JMW	SW 6020

ANALYTICAL RESULTS

Sample: **6103663-10**
Name: AP2f
Matrix: Surface Water - Grab

Sampled: 10/24/16 11:20
Received: 10/25/16 07:45

Parameter	Result	Unit	Qualifier	Prepared	Analyzed	Analyst	Method
Anions - PIA							
Chloride	< 5.0	mg/L		10/27/16 18:02	10/27/16 18:02	TAS	EPA 300.0
Nitrite-N	< 0.15	mg/L		10/25/16 15:09	10/25/16 15:09	TAS	EPA 300.0
Sulfate	1500	mg/L		10/28/16 12:49	10/28/16 12:49	TAS	EPA 300.0
Field - PIA							
pH, Field Measured	6.42	pH Units		10/24/16 11:20	10/24/16 11:20	FIELD	Field*
General Chemistry - PIA							
Alkalinity - bicarbonate as CaCO3	100	mg/L		10/25/16 09:29	10/25/16 09:29	CJN	SM 2320B*
Alkalinity - carbonate as CaCO3	< 20	mg/L		10/25/16 09:29	10/25/16 09:29	CJN	SM 2320B*
Fluoride	0.398	mg/L		10/27/16 14:02	10/27/16 14:02	TTH	SM 4500-F C
Solids - total dissolved solids (TDS)	1700	mg/L		10/25/16 14:59	10/25/16 15:33	DMB/ARL	SM 2540C
Total Metals - PIA							
Antimony	< 3.0	ug/L		10/26/16 13:38	11/02/16 13:03	JMW	SW 6020
Arsenic	1.2	ug/L		10/26/16 13:38	11/01/16 12:20	JMW	SW 6020
Barium	22	ug/L		10/26/16 13:38	11/01/16 14:47	JMW	SW 6020
Beryllium	< 2.0	ug/L		10/26/16 13:38	11/02/16 13:54	JMW	SW 6020
Boron	2000	ug/L		10/26/16 13:38	11/03/16 08:20	JMW	SW 6020
Cadmium	< 1.0	ug/L		10/26/16 13:38	11/01/16 12:20	JMW	SW 6020
Calcium	170	mg/L		10/26/16 13:38	11/02/16 13:54	JMW	SW 6020
Chromium	< 4.0	ug/L		10/26/16 13:38	11/01/16 14:47	JMW	SW 6020
Cobalt	< 2.0	ug/L		10/26/16 13:38	11/02/16 13:03	JMW	SW 6020
Lithium	130	ug/L		10/26/16 13:38	10/27/16 12:03	KJP	SW 6010*
Magnesium	33	mg/L		10/26/16 13:38	11/01/16 14:47	JMW	SW 6020
Mercury	< 0.20	ug/L		10/26/16 13:38	11/01/16 14:47	JMW	SW 6020
Molybdenum	3.2	ug/L		10/26/16 13:38	11/01/16 12:20	JMW	SW 6020
Potassium	21	mg/L		10/26/16 13:38	11/01/16 12:20	JMW	SW 6020
Selenium	< 1.0	ug/L		10/26/16 13:38	11/01/16 12:20	JMW	SW 6020
Sodium	14	mg/L		10/26/16 13:38	11/02/16 13:03	JMW	SW 6020
Thallium	< 1.0	ug/L		10/26/16 13:38	11/01/16 12:20	JMW	SW 6020

ANALYTICAL RESULTS

Sample: **6103663-11**
Name: AP2g
Matrix: Surface Water - Grab

Sampled: 10/24/16 11:10
Received: 10/25/16 07:45

Parameter	Result	Unit	Qualifier	Prepared	Analyzed	Analyst	Method
Anions - PIA							
Chloride	< 5.0	mg/L		10/27/16 19:12	10/27/16 19:12	TAS	EPA 300.0
Nitrite-N	< 0.15	mg/L		10/25/16 16:20	10/25/16 16:20	TAS	EPA 300.0
Sulfate	2300	mg/L		10/28/16 13:07	10/28/16 13:07	TAS	EPA 300.0
Field - PIA							
pH, Field Measured	6.46	pH Units		10/24/16 11:10	10/24/16 11:10	FIELD	Field*
General Chemistry - PIA							
Alkalinity - bicarbonate as CaCO3	4.0	mg/L		10/31/16 13:36	10/31/16 13:36	LAM	SM 2320B*
Alkalinity - carbonate as CaCO3	< 2.0	mg/L		10/31/16 13:36	10/31/16 13:36	LAM	SM 2320B*
Fluoride	0.506	mg/L		10/27/16 14:07	10/27/16 14:07	TTH	SM 4500-F C
Solids - total dissolved solids (TDS)	2400	mg/L		10/25/16 14:59	10/25/16 15:33	DMB/ARL	SM 2540C
Total Metals - PIA							
Antimony	< 3.0	ug/L		10/26/16 13:38	11/02/16 13:06	JMW	SW 6020
Arsenic	5.5	ug/L		10/26/16 13:38	11/01/16 12:23	JMW	SW 6020
Barium	20	ug/L		10/26/16 13:38	11/01/16 14:51	JMW	SW 6020
Beryllium	< 2.0	ug/L		10/26/16 13:38	11/02/16 13:57	JMW	SW 6020
Boron	4300	ug/L		10/26/16 13:38	11/03/16 08:22	JMW	SW 6020
Cadmium	4.6	ug/L		10/26/16 13:38	11/01/16 12:23	JMW	SW 6020
Calcium	410	mg/L		10/26/16 13:38	11/02/16 13:57	JMW	SW 6020
Chromium	< 4.0	ug/L		10/26/16 13:38	11/01/16 14:51	JMW	SW 6020
Cobalt	< 2.0	ug/L		10/26/16 13:38	11/02/16 13:06	JMW	SW 6020
Lithium	180	ug/L		10/26/16 13:38	10/27/16 12:06	KJP	SW 6010*
Magnesium	51	mg/L		10/26/16 13:38	11/01/16 14:51	JMW	SW 6020
Mercury	< 0.20	ug/L		10/26/16 13:38	11/01/16 14:51	JMW	SW 6020
Molybdenum	41	ug/L		10/26/16 13:38	11/01/16 12:23	JMW	SW 6020
Potassium	29	mg/L		10/26/16 13:38	11/01/16 12:23	JMW	SW 6020
Selenium	< 1.0	ug/L		10/26/16 13:38	11/01/16 12:23	JMW	SW 6020
Sodium	27	mg/L		10/26/16 13:38	11/02/16 13:06	JMW	SW 6020
Thallium	< 1.0	ug/L		10/26/16 13:38	11/01/16 12:23	JMW	SW 6020

ANALYTICAL RESULTS

Sample:	**6103663-12**	**Sampled:**	10/24/16 11:40
Name:	AP2h	**Received:**	10/25/16 07:45
Matrix:	Surface Water - Grab		

Parameter	Result	Unit	Qualifier	Prepared	Analyzed	Analyst	Method
Anions - PIA							
Chloride	1.7	mg/L		10/25/16 16:56	10/25/16 16:56	TAS	EPA 300.0
Fluoride	0.406	mg/L		10/25/16 16:56	10/25/16 16:56	TAS	EPA 300.0
Nitrite-N	< 0.15	mg/L		10/25/16 16:56	10/25/16 16:56	TAS	EPA 300.0
Sulfate	1300	mg/L		10/28/16 14:57	10/28/16 14:57	TAS	EPA 300.0
Field - PIA							
pH, Field Measured	7.17	pH Units		10/24/16 11:40	10/24/16 11:40	FIELD	Field*
General Chemistry - PIA							
Alkalinity - bicarbonate as CaCO3	140	mg/L		10/31/16 13:36	10/31/16 13:36	LAM	SM 2320B*
Alkalinity - carbonate as CaCO3	< 2.0	mg/L		10/31/16 13:36	10/31/16 13:36	LAM	SM 2320B*
Solids - total dissolved solids (TDS)	1500	mg/L		10/25/16 14:59	10/25/16 15:33	DMB/ARL	SM 2540C
Total Metals - PIA							
Antimony	< 3.0	ug/L		10/26/16 13:38	11/02/16 13:10	JMW	SW 6020
Arsenic	75	ug/L		10/26/16 13:38	11/01/16 12:27	JMW	SW 6020
Barium	23	ug/L		10/26/16 13:38	11/01/16 14:55	JMW	SW 6020
Beryllium	< 1.0	ug/L		10/26/16 13:38	11/01/16 12:27	JMW	SW 6020
Boron	14000	ug/L		10/26/16 13:38	11/03/16 08:23	JMW	SW 6020
Cadmium	< 1.0	ug/L		10/26/16 13:38	11/01/16 12:27	JMW	SW 6020
Calcium	310	mg/L		10/26/16 13:38	11/02/16 13:10	JMW	SW 6020
Chromium	< 4.0	ug/L		10/26/16 13:38	11/01/16 14:55	JMW	SW 6020
Cobalt	< 2.0	ug/L		10/26/16 13:38	11/02/16 13:10	JMW	SW 6020
Lithium	120	ug/L		10/26/16 13:38	10/27/16 12:09	KJP	SW 6010*
Magnesium	29	mg/L		10/26/16 13:38	11/01/16 14:55	JMW	SW 6020
Mercury	< 0.20	ug/L		10/26/16 13:38	11/01/16 14:55	JMW	SW 6020
Molybdenum	570	ug/L		10/26/16 13:38	11/01/16 12:27	JMW	SW 6020
Potassium	40	mg/L		10/26/16 13:38	11/03/16 08:23	JMW	SW 6020
Selenium	< 1.0	ug/L		10/26/16 13:38	11/01/16 12:27	JMW	SW 6020
Sodium	39	mg/L		10/26/16 13:38	11/02/16 13:10	JMW	SW 6020
Thallium	< 1.0	ug/L		10/26/16 13:38	11/01/16 12:27	JMW	SW 6020

ANALYTICAL RESULTS

Sample: **6103663-13**
Name: CLa
Matrix: Surface Water - Grab

Sampled: 10/24/16 15:30
Received: 10/25/16 07:45

Parameter	Result	Unit	Qualifier	Prepared	Analyzed	Analyst	Method
Anions - PIA							
Chloride	23	mg/L		10/27/16 20:41	10/27/16 20:41	TAS	EPA 300.0
Fluoride	0.443	mg/L		10/25/16 17:32	10/25/16 17:32	TAS	EPA 300.0
Nitrite-N	< 0.15	mg/L		10/25/16 17:32	10/25/16 17:32	TAS	EPA 300.0
Sulfate	55	mg/L		10/25/16 17:50	10/25/16 17:50	TAS	EPA 300.0
Field - PIA							
pH, Field Measured	7.22	pH Units		10/24/16 15:30	10/24/16 15:30	FIELD	Field*
General Chemistry - PIA							
Alkalinity - bicarbonate as CaCO3	80	mg/L		10/31/16 13:36	10/31/16 13:36	LAM	SM 2320B*
Alkalinity - carbonate as CaCO3	< 2.0	mg/L		10/31/16 13:36	10/31/16 13:36	LAM	SM 2320B*
Solids - total dissolved solids (TDS)	190	mg/L		10/25/16 14:59	10/25/16 15:33	DMB/ARL	SM 2540C
Total Metals - PIA							
Antimony	< 3.0	ug/L		10/26/16 13:38	11/02/16 13:14	JMW	SW 6020
Arsenic	1.8	ug/L		10/26/16 13:38	11/01/16 12:30	JMW	SW 6020
Barium	54	ug/L		10/26/16 13:38	11/01/16 14:58	JMW	SW 6020
Beryllium	< 1.0	ug/L		10/26/16 13:38	11/01/16 12:30	JMW	SW 6020
Boron	270	ug/L		10/26/16 13:38	11/03/16 08:24	JMW	SW 6020
Cadmium	< 1.0	ug/L		10/26/16 13:38	11/01/16 12:30	JMW	SW 6020
Calcium	23	mg/L		10/26/16 13:38	11/02/16 13:14	JMW	SW 6020
Chromium	< 4.0	ug/L		10/26/16 13:38	11/01/16 14:58	JMW	SW 6020
Cobalt	< 2.0	ug/L		10/26/16 13:38	11/02/16 13:14	JMW	SW 6020
Lithium	< 10	ug/L		10/26/16 13:38	10/27/16 12:12	KJP	SW 6010*
Magnesium	12	mg/L		10/26/16 13:38	11/01/16 14:58	JMW	SW 6020
Mercury	< 0.20	ug/L		10/26/16 13:38	11/01/16 14:58	JMW	SW 6020
Molybdenum	5.0	ug/L		10/26/16 13:38	11/01/16 12:30	JMW	SW 6020
Potassium	7.4	mg/L		10/26/16 13:38	11/01/16 12:30	JMW	SW 6020
Selenium	< 1.0	ug/L		10/26/16 13:38	11/01/16 12:30	JMW	SW 6020
Sodium	19	mg/L		10/26/16 13:38	11/02/16 13:14	JMW	SW 6020
Thallium	< 1.0	ug/L		10/26/16 13:38	11/01/16 12:30	JMW	SW 6020

ANALYTICAL RESULTS

Sample: **6103663-14** **Sampled:** 10/24/16 13:35
Name: CLb **Received:** 10/25/16 07:45
Matrix: Surface Water - Grab

Parameter	Result	Unit	Qualifier	Prepared	Analyzed	Analyst	Method
Anions - PIA							
Chloride	22	mg/L		10/27/16 20:58	10/27/16 20:58	TAS	EPA 300.0
Fluoride	0.425	mg/L		10/25/16 18:08	10/25/16 18:08	TAS	EPA 300.0
Nitrite-N	< 0.15	mg/L		10/25/16 18:08	10/25/16 18:08	TAS	EPA 300.0
Sulfate	56	mg/L		10/25/16 18:26	10/25/16 18:26	TAS	EPA 300.0
Field - PIA							
pH, Field Measured	7.52	pH Units		10/24/16 13:35	10/24/16 13:35	FIELD	Field*
General Chemistry - PIA							
Alkalinity - bicarbonate as CaCO3	80	mg/L		10/31/16 13:36	10/31/16 13:36	LAM	SM 2320B*
Alkalinity - carbonate as CaCO3	< 2.0	mg/L		10/31/16 13:36	10/31/16 13:36	LAM	SM 2320B*
Solids - total dissolved solids (TDS)	180	mg/L		10/25/16 14:59	10/25/16 15:33	DMB/ARL	SM 2540C
Total Metals - PIA							
Antimony	< 3.0	ug/L		10/26/16 13:38	11/02/16 13:17	JMW	SW 6020
Arsenic	1.8	ug/L		10/26/16 13:38	11/01/16 12:34	JMW	SW 6020
Barium	52	ug/L		10/26/16 13:38	11/01/16 15:02	JMW	SW 6020
Beryllium	< 1.0	ug/L		10/26/16 13:38	11/01/16 12:34	JMW	SW 6020
Boron	280	ug/L		10/26/16 13:38	11/03/16 08:26	JMW	SW 6020
Cadmium	< 1.0	ug/L		10/26/16 13:38	11/01/16 12:34	JMW	SW 6020
Calcium	23	mg/L		10/26/16 13:38	11/02/16 13:17	JMW	SW 6020
Chromium	< 4.0	ug/L		10/26/16 13:38	11/01/16 15:02	JMW	SW 6020
Cobalt	< 2.0	ug/L		10/26/16 13:38	11/02/16 13:17	JMW	SW 6020
Lithium	< 10	ug/L		10/26/16 13:38	10/27/16 12:15	KJP	SW 6010*
Magnesium	11	mg/L		10/26/16 13:38	11/01/16 15:02	JMW	SW 6020
Mercury	< 0.20	ug/L		10/26/16 13:38	11/01/16 15:02	JMW	SW 6020
Molybdenum	4.9	ug/L		10/26/16 13:38	11/01/16 12:34	JMW	SW 6020
Potassium	7.8	mg/L		10/26/16 13:38	11/01/16 12:34	JMW	SW 6020
Selenium	< 1.0	ug/L		10/26/16 13:38	11/01/16 12:34	JMW	SW 6020
Sodium	19	mg/L		10/26/16 13:38	11/02/16 13:17	JMW	SW 6020
Thallium	< 1.0	ug/L		10/26/16 13:38	11/01/16 12:34	JMW	SW 6020

ANALYTICAL RESULTS

Sample:	**6103663-15**	**Sampled:**	10/24/16 13:15
Name:	CLc	**Received:**	10/25/16 07:45
Matrix:	Surface Water - Grab		

Parameter	Result	Unit	Qualifier	Prepared	Analyzed	Analyst	Method
Anions - PIA							
Chloride	22	mg/L		10/27/16 21:16	10/27/16 21:16	TAS	EPA 300.0
Fluoride	0.426	mg/L		10/25/16 18:43	10/25/16 18:43	TAS	EPA 300.0
Nitrite-N	< 0.15	mg/L		10/25/16 18:43	10/25/16 18:43	TAS	EPA 300.0
Sulfate	54	mg/L		10/25/16 19:01	10/25/16 19:01	TAS	EPA 300.0
Field - PIA							
pH, Field Measured	7.62	pH Units		10/24/16 13:15	10/24/16 13:15	FIELD	Field*
General Chemistry - PIA							
Alkalinity - bicarbonate as CaCO3	75	mg/L		10/31/16 13:36	10/31/16 13:36	LAM	SM 2320B*
Alkalinity - carbonate as CaCO3	< 2.0	mg/L		10/31/16 13:36	10/31/16 13:36	LAM	SM 2320B*
Solids - total dissolved solids (TDS)	160	mg/L		10/25/16 14:59	10/25/16 15:33	DMB/ARL	SM 2540C
Total Metals - PIA							
Antimony	< 3.0	ug/L		10/26/16 13:38	11/02/16 13:29	JMW	SW 6020
Arsenic	1.8	ug/L		10/26/16 13:38	11/01/16 12:38	JMW	SW 6020
Barium	56	ug/L		10/26/16 13:38	11/01/16 15:05	JMW	SW 6020
Beryllium	< 1.0	ug/L		10/26/16 13:38	11/01/16 12:38	JMW	SW 6020
Boron	280	ug/L		10/26/16 13:38	11/03/16 08:27	JMW	SW 6020
Cadmium	< 1.0	ug/L		10/26/16 13:38	11/01/16 12:38	JMW	SW 6020
Calcium	23	mg/L		10/26/16 13:38	11/02/16 13:29	JMW	SW 6020
Chromium	< 4.0	ug/L		10/26/16 13:38	11/01/16 15:05	JMW	SW 6020
Cobalt	< 2.0	ug/L		10/26/16 13:38	11/02/16 13:29	JMW	SW 6020
Lithium	< 10	ug/L		10/26/16 13:38	10/27/16 12:24	KJP	SW 6010*
Magnesium	12	mg/L		10/26/16 13:38	11/01/16 15:05	JMW	SW 6020
Mercury	< 0.20	ug/L		10/26/16 13:38	11/01/16 15:05	JMW	SW 6020
Molybdenum	4.7	ug/L		10/26/16 13:38	11/01/16 12:38	JMW	SW 6020
Potassium	7.4	mg/L		10/26/16 13:38	11/01/16 12:38	JMW	SW 6020
Selenium	< 1.0	ug/L		10/26/16 13:38	11/01/16 12:38	JMW	SW 6020
Sodium	19	mg/L		10/26/16 13:38	11/02/16 13:29	JMW	SW 6020
Thallium	< 1.0	ug/L		10/26/16 13:38	11/01/16 12:38	JMW	SW 6020

ANALYTICAL RESULTS

Sample: **6103663-16**
Name: CLd
Matrix: Surface Water - Grab

Sampled: 10/24/16 15:55
Received: 10/25/16 07:45

Parameter	Result	Unit	Qualifier	Prepared	Analyzed	Analyst	Method
Anions - PIA							
Chloride	23	mg/L		10/27/16 21:34	10/27/16 21:34	TAS	EPA 300.0
Fluoride	0.421	mg/L		10/25/16 19:55	10/25/16 19:55	TAS	EPA 300.0
Nitrite-N	< 0.15	mg/L		10/25/16 19:55	10/25/16 19:55	TAS	EPA 300.0
Sulfate	54	mg/L		10/25/16 20:13	10/25/16 20:13	TAS	EPA 300.0
Field - PIA							
pH, Field Measured	7.30	pH Units		10/24/16 15:55	10/24/16 15:55	FIELD	Field*
General Chemistry - PIA							
Alkalinity - bicarbonate as CaCO3	80	mg/L		10/31/16 13:36	10/31/16 13:36	LAM	SM 2320B*
Alkalinity - carbonate as CaCO3	< 2.0	mg/L		10/31/16 13:36	10/31/16 13:36	LAM	SM 2320B*
Solids - total dissolved solids (TDS)	170	mg/L		10/25/16 14:59	10/25/16 15:33	DMB/ARL	SM 2540C
Total Metals - PIA							
Antimony	< 3.0	ug/L		10/26/16 13:38	11/02/16 13:32	JMW	SW 6020
Arsenic	1.8	ug/L		10/26/16 13:38	11/01/16 12:41	JMW	SW 6020
Barium	54	ug/L		10/26/16 13:38	11/01/16 15:09	JMW	SW 6020
Beryllium	< 1.0	ug/L		10/26/16 13:38	11/01/16 12:41	JMW	SW 6020
Boron	270	ug/L		10/26/16 13:38	11/03/16 08:41	JMW	SW 6020
Cadmium	< 1.0	ug/L		10/26/16 13:38	11/01/16 12:41	JMW	SW 6020
Calcium	23	mg/L		10/26/16 13:38	11/02/16 13:32	JMW	SW 6020
Chromium	< 4.0	ug/L		10/26/16 13:38	11/01/16 15:09	JMW	SW 6020
Cobalt	< 2.0	ug/L		10/26/16 13:38	11/02/16 13:32	JMW	SW 6020
Lithium	< 10	ug/L		10/26/16 13:38	10/27/16 12:27	KJP	SW 6010*
Magnesium	12	mg/L		10/26/16 13:38	11/01/16 15:09	JMW	SW 6020
Mercury	< 0.20	ug/L		10/26/16 13:38	11/01/16 15:09	JMW	SW 6020
Molybdenum	4.8	ug/L		10/26/16 13:38	11/01/16 12:41	JMW	SW 6020
Potassium	7.5	mg/L		10/26/16 13:38	11/01/16 12:41	JMW	SW 6020
Selenium	< 1.0	ug/L		10/26/16 13:38	11/01/16 12:41	JMW	SW 6020
Sodium	20	mg/L		10/26/16 13:38	11/02/16 13:32	JMW	SW 6020
Thallium	< 1.0	ug/L		10/26/16 13:38	11/01/16 12:41	JMW	SW 6020

ANALYTICAL RESULTS

Sample: **6103663-17**
Name: GPa
Matrix: Surface Water - Grab

Sampled: 10/24/16 14:00
Received: 10/25/16 07:45

Parameter	Result	Unit	Qualifier	Prepared	Analyzed	Analyst	Method
Anions - PIA							
Chloride	1900	mg/L		10/27/16 21:51	10/27/16 21:51	TAS	EPA 300.0
Nitrite-N	< 3.0	mg/L		10/26/16 11:42	10/26/16 11:42	TAS	EPA 300.0
Sulfate	17000	mg/L		11/01/16 09:58	11/01/16 09:58	TAS	EPA 300.0
Field - PIA							
pH, Field Measured	7.16	pH Units		10/24/16 14:00	10/24/16 14:00	FIELD	Field*
General Chemistry - PIA							
Alkalinity - bicarbonate as CaCO3	4.0	mg/L		10/31/16 13:36	10/31/16 13:36	LAM	SM 2320B*
Alkalinity - carbonate as CaCO3	< 2.0	mg/L		10/31/16 13:36	10/31/16 13:36	LAM	SM 2320B*
Fluoride	42.7	mg/L		10/27/16 17:31	10/27/16 17:31	TTH	SM 4500-F C
Solids - total dissolved solids (TDS)	17000	mg/L		10/27/16 12:04	10/27/16 12:28	ARL	SM 2540C
Total Metals - PIA							
Antimony	< 3.0	ug/L		10/26/16 13:38	11/02/16 13:36	JMW	SW 6020
Arsenic	4.7	ug/L		10/26/16 13:38	11/02/16 15:00	JMW	SW 6020
Barium	120	ug/L		10/26/16 13:38	11/02/16 13:36	JMW	SW 6020
Beryllium	2.6	ug/L		10/26/16 13:38	11/02/16 14:16	JMW	SW 6020
Boron	59000	ug/L		10/26/16 13:38	11/03/16 08:44	JMW	SW 6020
Cadmium	40	ug/L		10/26/16 13:38	11/02/16 15:53	JMW	SW 6020
Calcium	450	mg/L		10/26/16 13:38	11/02/16 14:16	JMW	SW 6020
Chromium	< 4.0	ug/L		10/26/16 13:38	11/01/16 15:20	JMW	SW 6020
Cobalt	52	ug/L		10/26/16 13:38	11/02/16 15:00	JMW	SW 6020
Lithium	300	ug/L		10/26/16 13:38	10/27/16 12:30	KJP	SW 6010*
Magnesium	1500	mg/L		10/26/16 13:38	11/02/16 14:16	JMW	SW 6020
Mercury	< 0.80	ug/L		10/26/16 13:38	11/02/16 15:00	JMW	SW 6020
Molybdenum	130	ug/L		10/26/16 13:38	11/02/16 14:16	JMW	SW 6020
Potassium	210	mg/L		10/26/16 13:38	11/03/16 09:03	JMW	SW 6020
Selenium	890	ug/L		10/26/16 13:38	11/02/16 15:00	JMW	SW 6020
Sodium	620	mg/L		10/26/16 13:38	11/02/16 13:36	JMW	SW 6020
Thallium	< 1.0	ug/L		10/26/16 13:38	11/01/16 15:20	JMW	SW 6020

ANALYTICAL RESULTS

Sample: **6103663-18**
Name: GPb
Matrix: Surface Water - Grab

Sampled: 10/24/16 14:10
Received: 10/25/16 07:45

Parameter	Result	Unit	Qualifier	Prepared	Analyzed	Analyst	Method
Anions - PIA							
Chloride	2600	mg/L		10/27/16 22:26	10/27/16 22:26	TAS	EPA 300.0
Nitrite-N	< 3.0	mg/L		10/26/16 12:00	10/26/16 12:00	TAS	EPA 300.0
Sulfate	27000	mg/L		10/28/16 14:39	10/28/16 14:39	TAS	EPA 300.0
Field - PIA							
pH, Field Measured	6.65	pH Units		10/24/16 14:10	10/24/16 14:10	FIELD	Field*
General Chemistry - PIA							
Alkalinity - bicarbonate as CaCO3	10	mg/L		10/31/16 13:36	10/31/16 13:36	LAM	SM 2320B*
Alkalinity - carbonate as CaCO3	< 2.0	mg/L		10/31/16 13:36	10/31/16 13:36	LAM	SM 2320B*
Fluoride	69.4	mg/L		10/27/16 15:56	10/27/16 15:56	TTH	SM 4500-F C
Solids - total dissolved solids (TDS)	28000	mg/L		10/27/16 12:04	10/27/16 12:28	ARL	SM 2540C
Total Metals - PIA							
Antimony	8.6	ug/L		10/26/16 13:38	11/02/16 14:20	JMW	SW 6020
Arsenic	92	ug/L		10/26/16 13:38	11/02/16 15:03	JMW	SW 6020
Barium	1100	ug/L		10/26/16 13:38	11/02/16 14:20	JMW	SW 6020
Beryllium	< 20	ug/L		10/26/16 13:38	11/02/16 14:34	JMW	SW 6020
Boron	97000	ug/L		10/26/16 13:38	11/03/16 08:45	JMW	SW 6020
Cadmium	67	ug/L		10/26/16 13:38	11/02/16 15:55	JMW	SW 6020
Calcium	1400	mg/L		10/26/16 13:38	11/02/16 14:34	JMW	SW 6020
Chromium	150	ug/L		10/26/16 13:38	11/02/16 15:03	JMW	SW 6020
Cobalt	110	ug/L		10/26/16 13:38	11/02/16 15:03	JMW	SW 6020
Lithium	480	ug/L		10/26/16 13:38	10/27/16 12:33	KJP	SW 6010*
Magnesium	2500	mg/L		10/26/16 13:38	11/02/16 14:34	JMW	SW 6020
Mercury	27	ug/L		10/26/16 13:38	11/02/16 15:03	JMW	SW 6020
Molybdenum	140	ug/L		10/26/16 13:38	11/02/16 15:03	JMW	SW 6020
Potassium	360	mg/L		10/26/16 13:38	11/03/16 08:45	JMW	SW 6020
Selenium	1500	ug/L		10/26/16 13:38	11/02/16 15:03	JMW	SW 6020
Sodium	1000	mg/L		10/26/16 13:38	11/02/16 14:34	JMW	SW 6020
Thallium	< 4.0	ug/L		10/26/16 13:38	11/07/16 15:07	JMW	SW 6020

ANALYTICAL RESULTS

Sample: **6103663-19**
Name: GPc
Matrix: Surface Water - Grab
Sampled: 10/24/16 14:20
Received: 10/25/16 07:45

Anions - PIA

Parameter	Result	Unit	Qualifier	Prepared	Analyzed	Analyst	Method
Chloride	1800	mg/L		10/28/16 01:58	10/28/16 01:58	TAS	EPA 300.0
Nitrite-N	< 3.0	mg/L		10/26/16 12:18	10/26/16 12:18	TAS	EPA 300.0
Sulfate	20000	mg/L		10/28/16 02:16	10/28/16 02:16	TAS	EPA 300.0

Field - PIA

Parameter	Result	Unit	Qualifier	Prepared	Analyzed	Analyst	Method
pH, Field Measured	6.73	pH Units		10/24/16 14:20	10/24/16 14:20	FIELD	Field*

General Chemistry - PIA

Parameter	Result	Unit	Qualifier	Prepared	Analyzed	Analyst	Method
Alkalinity - bicarbonate as CaCO3	5.5	mg/L		10/31/16 13:36	10/31/16 13:36	LAM	SM 2320B*
Alkalinity - carbonate as CaCO3	< 2.0	mg/L		10/31/16 13:36	10/31/16 13:36	LAM	SM 2320B*
Fluoride	49.2	mg/L		10/27/16 17:35	10/27/16 17:35	TTH	SM 4500-F C
Solids - total dissolved solids (TDS)	17000	mg/L		10/27/16 12:04	10/27/16 12:28	ARL	SM 2540C

Total Metals - PIA

Parameter	Result	Unit	Qualifier	Prepared	Analyzed	Analyst	Method
Antimony	< 6.0	ug/L		10/26/16 13:38	11/02/16 14:23	JMW	SW 6020
Arsenic	4.4	ug/L		10/26/16 13:38	11/02/16 15:07	JMW	SW 6020
Barium	110	ug/L		10/26/16 13:38	11/02/16 13:43	JMW	SW 6020
Beryllium	2.6	ug/L		10/26/16 13:38	11/02/16 14:23	JMW	SW 6020
Boron	72000	ug/L		10/26/16 13:38	11/03/16 08:46	JMW	SW 6020
Cadmium	41	ug/L		10/26/16 13:38	11/02/16 15:56	JMW	SW 6020
Calcium	570	mg/L		10/26/16 13:38	11/02/16 14:38	JMW	SW 6020
Chromium	< 4.0	ug/L		10/26/16 13:38	11/01/16 15:27	JMW	SW 6020
Cobalt	54	ug/L		10/26/16 13:38	11/02/16 15:07	JMW	SW 6020
Lithium	300	ug/L		10/26/16 13:38	10/27/16 12:36	KJP	SW 6010*
Magnesium	1500	mg/L		10/26/16 13:38	11/02/16 14:23	JMW	SW 6020
Mercury	< 0.80	ug/L		10/26/16 13:38	11/02/16 15:07	JMW	SW 6020
Molybdenum	120	ug/L		10/26/16 13:38	11/02/16 14:23	JMW	SW 6020
Potassium	260	mg/L		10/26/16 13:38	11/03/16 08:46	JMW	SW 6020
Selenium	890	ug/L		10/26/16 13:38	11/02/16 15:07	JMW	SW 6020
Sodium	650	mg/L		10/26/16 13:38	11/02/16 13:43	JMW	SW 6020
Thallium	< 1.0	ug/L		10/26/16 13:38	11/01/16 15:27	JMW	SW 6020

ANALYTICAL RESULTS

Sample: **6103663-20**
Name: GPd
Matrix: Surface Water - Grab

Sampled: 10/24/16 14:30
Received: 10/25/16 07:45

Parameter	Result	Unit	Qualifier	Prepared	Analyzed	Analyst	Method
Anions - PIA							
Chloride	1900	mg/L		10/28/16 03:09	10/28/16 03:09	TAS	EPA 300.0
Nitrite-N	< 3.0	mg/L		10/26/16 12:36	10/26/16 12:36	TAS	EPA 300.0
Sulfate	19000	mg/L		10/28/16 03:26	10/28/16 03:26	TAS	EPA 300.0
Field - PIA							
pH, Field Measured	6.73	pH Units		10/24/16 14:30	10/24/16 14:30	FIELD	Field*
General Chemistry - PIA							
Alkalinity - bicarbonate as CaCO3	6.0	mg/L		10/31/16 13:36	10/31/16 13:36	LAM	SM 2320B*
Alkalinity - carbonate as CaCO3	< 2.0	mg/L		10/31/16 13:36	10/31/16 13:36	LAM	SM 2320B*
Fluoride	51.3	mg/L		10/27/16 17:39	10/27/16 17:39	TTH	SM 4500-F C
Solids - total dissolved solids (TDS)	16000	mg/L		10/27/16 12:04	10/27/16 12:28	ARL	SM 2540C
Total Metals - PIA							
Antimony	< 3.0	ug/L		10/26/16 13:38	11/02/16 13:47	JMW	SW 6020
Arsenic	4.2	ug/L		10/26/16 13:38	11/02/16 15:10	JMW	SW 6020
Barium	110	ug/L		10/26/16 13:38	11/02/16 13:47	JMW	SW 6020
Beryllium	< 20	ug/L		10/26/16 13:38	11/02/16 14:41	JMW	SW 6020
Boron	66000	ug/L		10/26/16 13:38	11/03/16 08:48	JMW	SW 6020
Cadmium	38	ug/L		10/26/16 13:38	11/02/16 15:57	JMW	SW 6020
Calcium	560	mg/L		10/26/16 13:38	11/02/16 14:41	JMW	SW 6020
Chromium	< 4.0	ug/L		10/26/16 13:38	11/01/16 15:31	JMW	SW 6020
Cobalt	52	ug/L		10/26/16 13:38	11/02/16 15:10	JMW	SW 6020
Lithium	300	ug/L		10/26/16 13:38	10/27/16 12:39	KJP	SW 6010*
Magnesium	1500	mg/L		10/26/16 13:38	11/02/16 14:27	JMW	SW 6020
Mercury	< 0.80	ug/L		10/26/16 13:38	11/02/16 15:10	JMW	SW 6020
Molybdenum	120	ug/L		10/26/16 13:38	11/02/16 14:27	JMW	SW 6020
Potassium	230	mg/L		10/26/16 13:38	11/03/16 08:48	JMW	SW 6020
Selenium	800	ug/L		10/26/16 13:38	11/01/16 15:31	JMW	SW 6020
Sodium	660	mg/L		10/26/16 13:38	11/02/16 13:47	JMW	SW 6020
Thallium	< 1.0	ug/L		10/26/16 13:38	11/01/16 15:31	JMW	SW 6020

ANALYTICAL RESULTS

Sample: **6103663-21**
Name: RPb
Matrix: Surface Water - Grab

Sampled: 10/24/16 14:50
Received: 10/25/16 07:45

Parameter	Result	Unit	Qualifier	Prepared	Analyzed	Analyst	Method
Anions - PIA							
Chloride	1800	mg/L		10/28/16 03:44	10/28/16 03:44	TAS	EPA 300.0
Nitrite-N	< 3.0	mg/L		10/26/16 12:53	10/26/16 12:53	TAS	EPA 300.0
Sulfate	18000	mg/L		10/28/16 04:01	10/28/16 04:01	TAS	EPA 300.0
Field - PIA							
pH, Field Measured	6.49	pH Units		10/24/16 14:50	10/24/16 14:50	FIELD	Field*
General Chemistry - PIA							
Alkalinity - bicarbonate as CaCO3	< 2.0	mg/L		10/31/16 13:36	10/31/16 13:36	LAM	SM 2320B*
Alkalinity - carbonate as CaCO3	< 2.0	mg/L		10/31/16 13:36	10/31/16 13:36	LAM	SM 2320B*
Fluoride	44.4	mg/L		10/27/16 17:44	10/27/16 17:44	TTH	SM 4500-F C
Solids - total dissolved solids (TDS)	16000	mg/L		10/27/16 12:04	10/27/16 12:28	ARL	SM 2540C
Total Metals - PIA							
Antimony	< 3.0	ug/L		10/26/16 11:03	11/01/16 09:42	JMW	SW 6020
Arsenic	2.8	ug/L		10/26/16 11:03	11/02/16 11:16	JMW	SW 6020
Barium	90	ug/L		10/26/16 11:03	11/01/16 09:42	JMW	SW 6020
Beryllium	2.1	ug/L		10/26/16 11:03	11/01/16 10:30	JMW	SW 6020
Boron	56000	ug/L		10/26/16 11:03	11/02/16 16:34	JMW	SW 6020
Cadmium	33	ug/L		10/26/16 11:03	11/02/16 11:32	JMW	SW 6020
Calcium	380	mg/L		10/26/16 11:03	11/01/16 10:30	JMW	SW 6020
Chromium	< 4.0	ug/L		10/26/16 11:03	11/01/16 09:42	JMW	SW 6020
Cobalt	45	ug/L		10/26/16 11:03	11/01/16 09:42	JMW	SW 6020
Lithium	310	ug/L		10/26/16 11:03	10/27/16 11:01	KJP	SW 6010*
Magnesium	1200	mg/L		10/26/16 11:03	11/01/16 10:30	JMW	SW 6020
Mercury	< 0.40	ug/L		10/26/16 11:03	11/02/16 11:16	JMW	SW 6020
Molybdenum	64	ug/L		10/26/16 11:03	11/01/16 10:30	JMW	SW 6020
Potassium	210	mg/L		10/26/16 11:03	11/02/16 11:32	JMW	SW 6020
Selenium	780	ug/L		10/26/16 11:03	11/02/16 11:16	JMW	SW 6020
Sodium	470	mg/L		10/26/16 11:03	11/01/16 09:42	JMW	SW 6020
Thallium	< 1.0	ug/L		10/26/16 11:03	11/01/16 09:42	JMW	SW 6020

ANALYTICAL RESULTS

Sample: **6103663-22**
Name: RPc
Matrix: Surface Water - Grab

Sampled: 10/24/16 15:00
Received: 10/25/16 07:45

Parameter	Result	Unit	Qualifier	Prepared	Analyzed	Analyst	Method
Anions - PIA							
Chloride	2000	mg/L		10/28/16 04:19	10/28/16 04:19	TAS	EPA 300.0
Nitrite-N	< 3.0	mg/L		10/26/16 14:05	10/26/16 14:05	TAS	EPA 300.0
Sulfate	20000	mg/L		10/28/16 04:37	10/28/16 04:37	TAS	EPA 300.0
Field - PIA							
pH, Field Measured	6.32	pH Units		10/24/16 15:00	10/24/16 15:00	FIELD	Field*
General Chemistry - PIA							
Alkalinity - bicarbonate as CaCO3	< 2.0	mg/L		10/31/16 13:36	10/31/16 13:36	LAM	SM 2320B*
Alkalinity - carbonate as CaCO3	< 2.0	mg/L		10/31/16 13:36	10/31/16 13:36	LAM	SM 2320B*
Fluoride	45.0	mg/L		10/27/16 17:48	10/27/16 17:48	TTH	SM 4500-F C
Solids - total dissolved solids (TDS)	16000	mg/L		10/27/16 12:04	10/27/16 12:28	ARL	SM 2540C
Total Metals - PIA							
Antimony	< 3.0	ug/L		10/26/16 11:03	11/01/16 09:46	JMW	SW 6020
Arsenic	3.1	ug/L		10/26/16 11:03	11/02/16 11:20	JMW	SW 6020
Barium	88	ug/L		10/26/16 11:03	11/01/16 09:46	JMW	SW 6020
Beryllium	2.2	ug/L		10/26/16 11:03	11/01/16 10:34	JMW	SW 6020
Boron	59000	ug/L		10/26/16 11:03	11/02/16 16:36	JMW	SW 6020
Cadmium	37	ug/L		10/26/16 11:03	11/02/16 11:36	JMW	SW 6020
Calcium	380	mg/L		10/26/16 11:03	11/01/16 10:34	JMW	SW 6020
Chromium	< 4.0	ug/L		10/26/16 11:03	11/01/16 09:46	JMW	SW 6020
Cobalt	43	ug/L		10/26/16 11:03	11/01/16 09:46	JMW	SW 6020
Lithium	310	ug/L		10/26/16 11:03	10/27/16 11:04	KJP	SW 6010*
Magnesium	1200	mg/L		10/26/16 11:03	11/01/16 10:34	JMW	SW 6020
Mercury	< 0.20	ug/L		10/26/16 11:03	11/02/16 10:36	JMW	SW 6020
Molybdenum	64	ug/L		10/26/16 11:03	11/01/16 10:34	JMW	SW 6020
Potassium	200	mg/L		10/26/16 11:03	11/02/16 11:36	JMW	SW 6020
Selenium	830	ug/L		10/26/16 11:03	11/02/16 11:20	JMW	SW 6020
Sodium	440	mg/L		10/26/16 11:03	11/01/16 09:46	JMW	SW 6020
Thallium	< 1.0	ug/L		10/26/16 11:03	11/01/16 09:46	JMW	SW 6020

ANALYTICAL RESULTS

Sample: **6103663-23**
Name: RPd
Matrix: Surface Water - Grab

Sampled: 10/24/16 15:05
Received: 10/25/16 07:45

Parameter	Result	Unit	Qualifier	Prepared	Analyzed	Analyst	Method
Anions - PIA							
Chloride	1600	mg/L		10/28/16 04:25	10/28/16 04:25	TAS	EPA 300.0
Nitrite-N	< 3.0	mg/L		10/26/16 14:23	10/26/16 14:23	TAS	EPA 300.0
Sulfate	16000	mg/L		10/28/16 04:43	10/28/16 04:43	TAS	EPA 300.0
Field - PIA							
pH, Field Measured	6.32	pH Units		10/24/16 15:05	10/24/16 15:05	FIELD	Field*
General Chemistry - PIA							
Alkalinity - bicarbonate as CaCO3	< 2.0	mg/L		10/31/16 13:36	10/31/16 13:36	LAM	SM 2320B*
Alkalinity - carbonate as CaCO3	< 2.0	mg/L		10/31/16 13:36	10/31/16 13:36	LAM	SM 2320B*
Fluoride	51.2	mg/L		10/27/16 17:53	10/27/16 17:53	TTH	SM 4500-F C
Solids - total dissolved solids (TDS)	17000	mg/L		10/27/16 12:04	10/27/16 12:28	ARL	SM 2540C
Total Metals - PIA							
Antimony	< 3.0	ug/L		10/26/16 11:03	11/01/16 09:49	JMW	SW 6020
Arsenic	3.4	ug/L		10/26/16 11:03	11/02/16 11:23	JMW	SW 6020
Barium	89	ug/L		10/26/16 11:03	11/01/16 09:49	JMW	SW 6020
Beryllium	2.4	ug/L		10/26/16 11:03	11/01/16 10:37	JMW	SW 6020
Boron	59000	ug/L		10/26/16 11:03	11/02/16 16:37	JMW	SW 6020
Cadmium	36	ug/L		10/26/16 11:03	11/02/16 11:40	JMW	SW 6020
Calcium	400	mg/L		10/26/16 11:03	11/01/16 10:37	JMW	SW 6020
Chromium	< 4.0	ug/L		10/26/16 11:03	11/01/16 09:49	JMW	SW 6020
Cobalt	45	ug/L		10/26/16 11:03	11/01/16 09:49	JMW	SW 6020
Lithium	310	ug/L		10/26/16 11:03	10/27/16 11:13	KJP	SW 6010*
Magnesium	1300	mg/L		10/26/16 11:03	11/01/16 10:37	JMW	SW 6020
Mercury	< 0.20	ug/L		10/26/16 11:03	11/02/16 10:39	JMW	SW 6020
Molybdenum	66	ug/L		10/26/16 11:03	11/01/16 10:37	JMW	SW 6020
Potassium	200	mg/L		10/26/16 11:03	11/02/16 11:40	JMW	SW 6020
Selenium	860	ug/L		10/26/16 11:03	11/02/16 11:23	JMW	SW 6020
Sodium	460	mg/L		10/26/16 11:03	11/01/16 09:49	JMW	SW 6020
Thallium	< 1.0	ug/L		10/26/16 11:03	11/01/16 09:49	JMW	SW 6020

ANALYTICAL RESULTS

Sample: **6103663-24**
Name: RPa
Matrix: Surface Water - Grab

Sampled: 10/24/16 14:40
Received: 10/25/16 07:45

Parameter	Result	Unit	Qualifier	Prepared	Analyzed	Analyst	Method
Anions - PIA							
Chloride	1600	mg/L		10/28/16 05:02	10/28/16 05:02	TAS	EPA 300.0
Nitrite-N	< 3.0	mg/L		10/26/16 13:11	10/26/16 13:11	TAS	EPA 300.0
Sulfate	17000	mg/L		10/28/16 05:20	10/28/16 05:20	TAS	EPA 300.0
Field - PIA							
pH, Field Measured	6.70	pH Units		10/24/16 14:40	10/24/16 14:40	FIELD	Field*
General Chemistry - PIA							
Alkalinity - bicarbonate as CaCO3	< 2.0	mg/L		10/31/16 13:36	10/31/16 13:36	LAM	SM 2320B*
Alkalinity - carbonate as CaCO3	< 2.0	mg/L		10/31/16 13:36	10/31/16 13:36	LAM	SM 2320B*
Fluoride	47.0	mg/L		10/27/16 15:52	10/27/16 15:52	TTH	SM 4500-F C
Solids - total dissolved solids (TDS)	16000	mg/L		10/27/16 12:04	10/27/16 12:28	ARL	SM 2540C
Total Metals - PIA							
Antimony	< 3.0	ug/L		10/26/16 11:03	11/01/16 09:53	JMW	SW 6020
Arsenic	3.3	ug/L		10/26/16 11:03	11/02/16 11:27	JMW	SW 6020
Barium	89	ug/L		10/26/16 11:03	11/01/16 09:53	JMW	SW 6020
Beryllium	2.3	ug/L		10/26/16 11:03	11/01/16 10:41	JMW	SW 6020
Boron	60000	ug/L		10/26/16 11:03	11/02/16 16:38	JMW	SW 6020
Cadmium	37	ug/L		10/26/16 11:03	11/02/16 11:43	JMW	SW 6020
Calcium	380	mg/L		10/26/16 11:03	11/01/16 10:41	JMW	SW 6020
Chromium	< 4.0	ug/L		10/26/16 11:03	11/01/16 09:53	JMW	SW 6020
Cobalt	44	ug/L		10/26/16 11:03	11/01/16 09:53	JMW	SW 6020
Lithium	310	ug/L		10/26/16 11:03	10/27/16 11:16	KJP	SW 6010*
Magnesium	1200	mg/L		10/26/16 11:03	11/01/16 10:41	JMW	SW 6020
Mercury	< 0.20	ug/L		10/26/16 11:03	11/02/16 10:43	JMW	SW 6020
Molybdenum	63	ug/L		10/26/16 11:03	11/01/16 10:41	JMW	SW 6020
Potassium	190	mg/L		10/26/16 11:03	11/02/16 11:43	JMW	SW 6020
Selenium	840	ug/L		10/26/16 11:03	11/02/16 11:27	JMW	SW 6020
Sodium	450	mg/L		10/26/16 11:03	11/01/16 09:53	JMW	SW 6020
Thallium	< 1.0	ug/L		10/26/16 11:03	11/01/16 09:53	JMW	SW 6020

NOTES

Specific method revisions used for analysis are available upon request.

Certifications

PIA - Peoria, IL
- TNI Accreditation for Drinking Water, Wastewater, Hazardous and Solid Wastes Fields of Testing through IL EPA Lab No. 100230
- Illinois Department of Public Health Bacteriological Analysis in Drinking Water Approved Laboratory Registry No. 17553
- Missouri Department of Natural Resources Certificate of Approval for Microbiological Laboratory Service No. 870
- Drinking Water Certifications: Iowa (240); Kansas (E-10338); Missouri (870)
- Wastewater Certifications: Arkansas (88-0677); Iowa (240); Kansas (E-10338)
- Hazardous/Solid Waste Certifications: Arkansas (88-0677); Iowa (240); Kansas (E-10338)

SPMO - Springfield, MO
- USEPA DMR-QA Program

STL - St. Louis, MO
- TNI Accreditation for Wastewater, Hazardous and Solid Wastes Fields of Testing through KS Lab No. E-10389
- Illinois Department of Public Health Bacteriological Analysis in Drinking Water Approved Laboratory Registry No. 171050
- Drinking Water Certifications: Missouri (1050)
- Missouri Department of Natural Resources

* Not a TNI accredited analyte

Gail J Schindler

Certified by: Gail Schindler, Project Manager

PDC LABORATORIES, INC.
2231 WEST ALTORFER DRIVE
PEORIA, IL 61615

PHONE # 309-692-9688
FAX # 309-692-9689

CHAIN OF CUSTODY RECORD

EJS 10-26-16

ALL SHADED AREAS MUST BE COMPLETED BY CLIENT (PLEASE PRINT)

① CLIENT Hanson Professional Services COFFEEN ENERGY CENTER	PROJECT NUMBER	P.O. NUMBER	MEANS SHIPPED	③ ANALYSIS REQUESTED EJS 10-26-16
ADDRESS 134 CIPS LANE	PHONE NUMBER	FAX NUMBER	DATE SHIPPED	
CITY STATE ZIP COFFEEN IL 62017	SAMPLER (PLEASE PRINT) R. ZINSER		MATRIX TYPES: WW- WASTEWATER DW- DRINKING WATER GW- GROUND WATER WWSL- SLUDGE NAS- SOLID OTHER:	
CONTACT PERSON JOHN ROMANG	SAMPLER'S SIGNATURE			

(FOR LAB USE ONLY)
LOGIN # 6103663-24
LOGGED BY: [illegible]
NATURAL RESOURCE TECHNOLOGY
COFFEEN POND LAKE
GAIL J SCHINDLER

Custom list

② SAMPLE DESCRIPTION	DATE COLLECTED	TIME COLLECTED	SAMPLE TYPE GRAB	SAMPLE TYPE COMP	MATRIX TYPE	TOTAL # OF CONT	SB,AS,BA,BE,ALKHCO3	B,CD,CA,ALK CO3, CL	CR,CR+6,CO,CU,CN,F	FE,PB,LI,MG,MN,HG,MO	NI,G&O,PHENOL,P,SE,	AG,NA,SO4,TL,TDS,ZN	TSS,NO2,NO3,NH3,TKN	REMARKS
AP1 a	10/24/16	11:52	X		SW	7	per	email			/	/	/	pH 6.99
AP1 b	10/24/16	11:56	X		SW	7	/	[illegible]		/	/	/	/	pH 7.01
AP1 c	10/24/16	12:10	X		GW	7	/	/	/	/	/	/	/	pH 7.05
AP1 d	10/24/16	12:15	X		GW	7	/	/	/	/	/	/	/	pH 7.21
AP1 e	10/24/16	12:01	X		SW	7	/	/	/	/	/	/	/	pH 7.12
AP1 f	10/24/16	12:40	X		SW	7	/	/	/	/	/	/	/	pH 7.20
AP1 g	10/24/16	12:50	X		SW	7	/	/	/	/	/	/	/	pH 7.21
AP1 h	10/24/16	12:55	X		SW	7	/	/	/	/	/	/	/	pH 7.41
AP2 e	10/24/16	11:30	X		SW	7	/	/	/	/	/	/	/	pH 6.49
AP2 f	10/24/16	11:20	X		SW	7	/	/	/	/	/	/	/	pH 6.42
AP2 g	10/24/16	11:10	X		SW	7	/	/	/	/	/	/	/	pH 6.46

⑤ TURNAROUND TIME REQUESTED (PLEASE CIRCLE) NORMAL RUSH
X(RUSH TAT IS SUBJECT TO PDC LABS APPROVAL AND SURCHARGE)
RUSH RESULTS VIA (PLEASE CIRCLE) FAX PHONE
FAX # IF DIFFERENT FROM ABOVE:
PHONE # IF DIFFERENT FROM ABOVE:

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⑦ RELINQUISHED BY: (SIGNATURE)	DATE 10/25/16 TIME 7:45	RECEIVED BY: (SIGNATURE)	DATE TIME
RELINQUISHED BY: (SIGNATURE)	DATE TIME	RECEIVED AT LAB BY: (SIGNATURE)	DATE 10/25/16 TIME 7:45

⑧ COMMENTS: (FOR LAB USE ONLY)

SAMPLE TEMPERATURE UPON RECEIPT 6 °C
CHILL PROCESS STARTED PRIOR TO RECEIPT [✓ Y] OR N
SAMPLE(S) RECEIVED ON ICE [✓ Y] OR N
BOTTLES RECEIVED IN GOOD CONDITION [✓ Y] OR N
BOTTLES FILLED TO APPROX. THE NECK [✓ Y] OR N
SAMPLES RECEIVED WITHIN HOLD TIME(S) [✓ Y] OR N

PDC LABORATORIES, INC.
2231 WEST ALTORFER DRIVE
PEORIA, IL 61615
GJS 10-26-16

PHONE # 309-692-9688
FAX # 309-692-9689

CHAIN OF CUSTODY RECORD

ALL SHADED AREAS MUST BE COMPLETED BY CLIENT (PLEASE PRINT)

① CLIENT Hanson Professional Services
COFFEEN ENERGY CENTER

ADDRESS
134 CIPS LANE

CITY STATE ZIP
COFFEEN IL 62017

CONTACT PERSON
JOHN ROMANG

PROJECT NUMBER
P.O. NUMBER
MEANS SHIPPED
PHONE NUMBER
FAX NUMBER
DATE SHIPPED

SAMPLER (PLEASE PRINT) R. Zinser
SAMPLER'S SIGNATURE

MATRIX TYPES:
WW- WASTEWATER
DW- DRINKING WATER
GW- GROUND WATER
WWSL- SLUDGE
NAS- SOLID
OTHER: ______

③ ANALYSIS REQUESTED GJS 10-26-16

(FOR LAB USE ONLY)
LOGIN # ______
LOGGED BY: ______
NATURAL RESOURCE TECHNOLOGY
COFFEEN POND LAKE
GAIL J SCHINDLER

② SAMPLE DESCRIPTION	DATE COLLECTED	TIME COLLECTED	SAMPLE TYPE GRAB	SAMPLE TYPE COMP	MATRIX TYPE	TOTAL # OF CONT	SB,AS,BA,BE,ALKHCO3	B,CD,CA,ALK CO3, CL	CR,CR+6,CO,CU,CN,F	FE,PB,LI,MG,MN,HG,MO	NI,G&O,PHENOL,P,SE,	AG,NA,SO4,TL,TDS,ZN	TSS,NO2,NO3,NH3,TKN	REMARKS
AP2 h	10/24/16	11:40	X		SW	7	/	/	/	/	/	/	/	pH 7.17
CL a	10/24/16	15:30	X		SW	7	/	/	/	/	/	/	/	pH 7.22
CL b	10/24/16	13:35	X		SW	7	/	/	/	/	/	/	/	pH 7.52
CL c	10/24/16	13:15	X		SW	7	/	/	/	/	/	/	/	pH 7.62
CL d	10/24/16	15:55	X		SW	7	/	/	/	/	/	/	/	pH 7.30
GP a	10/24/16	14:00	X		SW	7	/	/	/	/	/	/	/	pH 7.16
GP b	10/24/16	14:10	X		SW	7	/	/	/	/	/	/	/	pH 6.65
GP c	10/24/16	14:20	X		SW	7	/	/	/	/	/	/	/	pH 6.73
GP d	10/24/16	14:30	X		SW	7	/	/	/	/	/	/	/	pH 6.73
RP b	10/24/16	14:50	X		SW	7	/	/	/	/	/	/	/	pH 6.49
RP c	10/24/16	15:00	X		SW	7	/	/	/	/	/	/	/	pH 6.32

⑤ TURNAROUND TIME REQUESTED (PLEASE CIRCLE) NORMAL RUSH
X(RUSH TAT IS SUBJECT TO PDC LABS APPROVAL AND SURCHARGE)
RUSH RESULTS VIA (PLEASE CIRCLE) FAX PHONE
FAX # IF DIFFERENT FROM ABOVE:
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⑦ RELINQUISHED BY: (SIGNATURE)
DATE 10/25/16
TIME 7:45
RECEIVED BY: (SIGNATURE)
DATE
TIME

RELINQUISHED BY: (SIGNATURE)
DATE
TIME
RECEIVED AT LAB BY: (SIGNATURE)
DATE 10/25/16
TIME 745

⑧ COMMENTS: (FOR LAB USE ONLY)

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CHILL PROCESS STARTED PRIOR TO RECEIPT [✓ Y] OR N
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GJS 10-26-16

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SAMPLER (PLEASE PRINT) R. Zinser

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WWSL- SLUDGE
NAS- SOLID
OTHER: ______

③ ANALYSIS REQUESTED GJS 10-26-16

(FOR LAB USE ONLY)
LOGIN # ______
LOGGED BY: ______
NATURAL RESOURCE TECHNOLOGY
COFFEEN POND LAKE
GAIL J SCHINDLER

② SAMPLE DESCRIPTION	DATE COLLECTED	TIME COLLECTED	SAMPLE TYPE GRAB	SAMPLE TYPE COMP	MATRIX TYPE	TOTAL # OF CONT	SB,AS,BA,BE,ALKHCO3	B,CD,CA,ALK CO3, CL	CR,CR+6,CO,CU,CN,F	FE,PB,LI,MG,MN,HG,MO	NI,G&O,PHENOL,P,SE,	AG,NA,SO4,TL,TDS,ZN	TSS,NO2,NO3,NH3,TKN	REMARKS
RPd	10/24/16	15:05	X		SW	7	/	/	/	/	/	/	/	pH 6.32
RPa	10/24/16	14:40	X		SW	7	/	/	/	/	/	/	/	pH 6.70

⑤ TURNAROUND TIME REQUESTED (PLEASE CIRCLE) NORMAL RUSH
X(RUSH TAT IS SUBJECT TO PDC LABS APPROVAL AND SURCHARGE)
RUSH RESULTS VIA (PLEASE CIRCLE) FAX PHONE
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⑦

RELINQUISHED BY: (SIGNATURE)	DATE / TIME	RECEIVED BY: (SIGNATURE)	DATE / TIME
	DATE 10/25/16 TIME 7:45		DATE TIME
RELINQUISHED BY: (SIGNATURE)	DATE TIME	RECEIVED AT LAB BY: (SIGNATURE)	DATE 10/25/16 TIME 7:45

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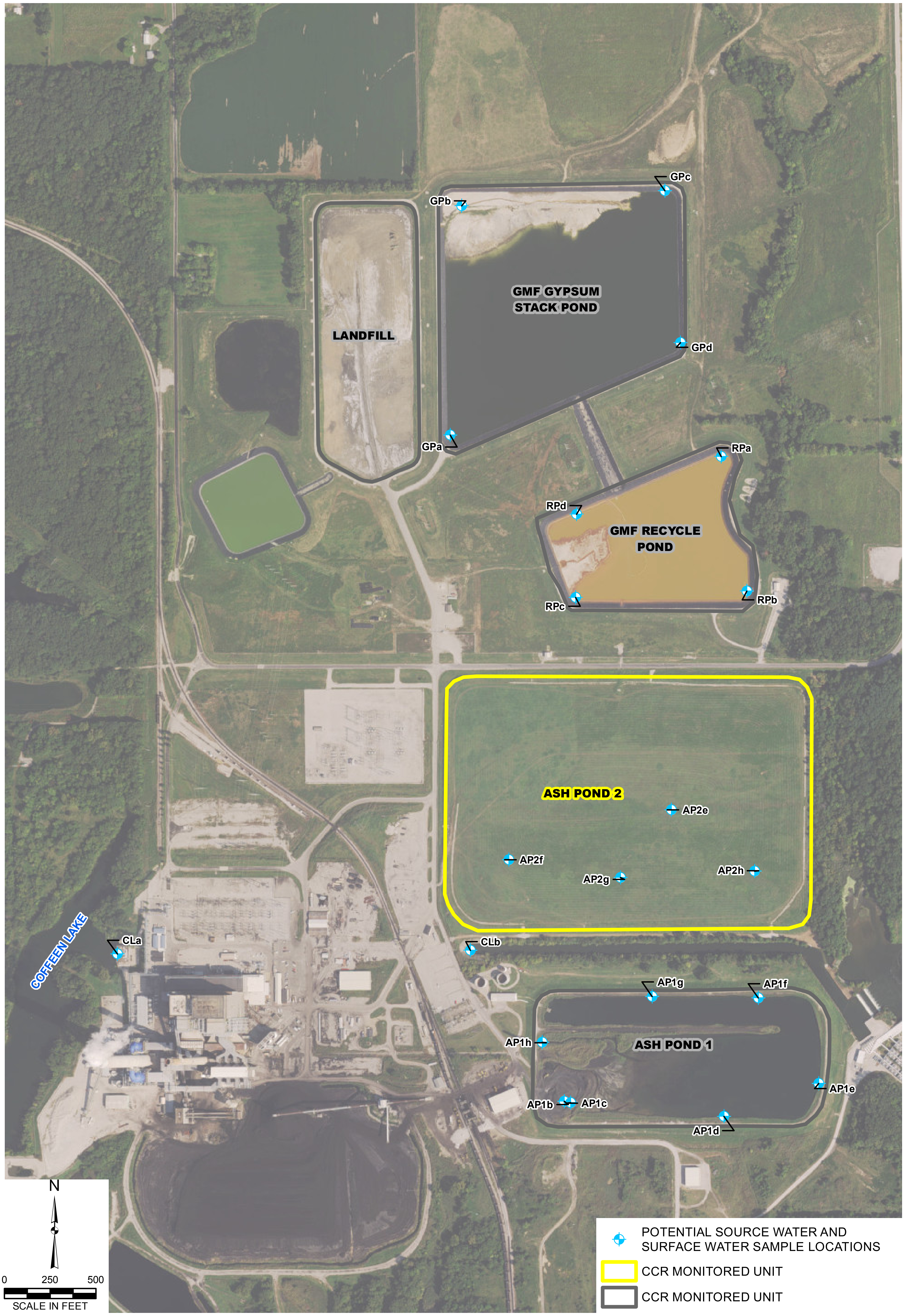
SAMPLE(S) RECEIVED ON ICE [✓ Y] OR N
BOTTLES RECEIVED IN GOOD CONDITION [✓ Y] OR N
BOTTLES FILLED TO APPROX. THE NECK [✓ Y] OR N
SAMPLES RECEIVED WITHIN HOLD TIME(S) [✓ Y] OR N

Chain of Custody Parameters (as totals)

- Antimony
- Arsenic
- Barium
- Beryllium
- Bicarbonate Alkalinity
- Boron
- Cadmium
- Calcium
- Carbonate Alkalinity
- Chloride
- Chromium
- Cobalt
- Fluoride
- Lithium
- Magnesium
- Mercury
- Molybdenum
- Nitrite
- pH
- Potassium
- Selenium
- Sodium
- Sulfate
- Thallium
- Total Dissolved Solids (TDS)



DRAWN BY/DATE:
SDS 12/21/16
REVIEWED BY/DATE:
NRK 12/21/16
APPROVED BY/DATE:
SJC 12/22/16

POTENTIAL SOURCE WATER AND SURFACE WATER SAMPLE LOCATIONS

HYDROGEOLOGIC CHARACTERIZATION REPORT
ASH POND 2
COFFEEN POWER STATION
COFFEEN, IL

PROJECT NO: 2380

FIGURE NO: 14

Natural
Resource
Technology

Y:\Mapping\Projects\23\2380\MXD\HGCR\Figure 14_Potential Source Water And Surface Water Sample Locations.mxd Author: tcushman; Date/Time: 12/22/2016, 2:59:50 PM

Surface Water Sample Location Map

Coffeen Power Station

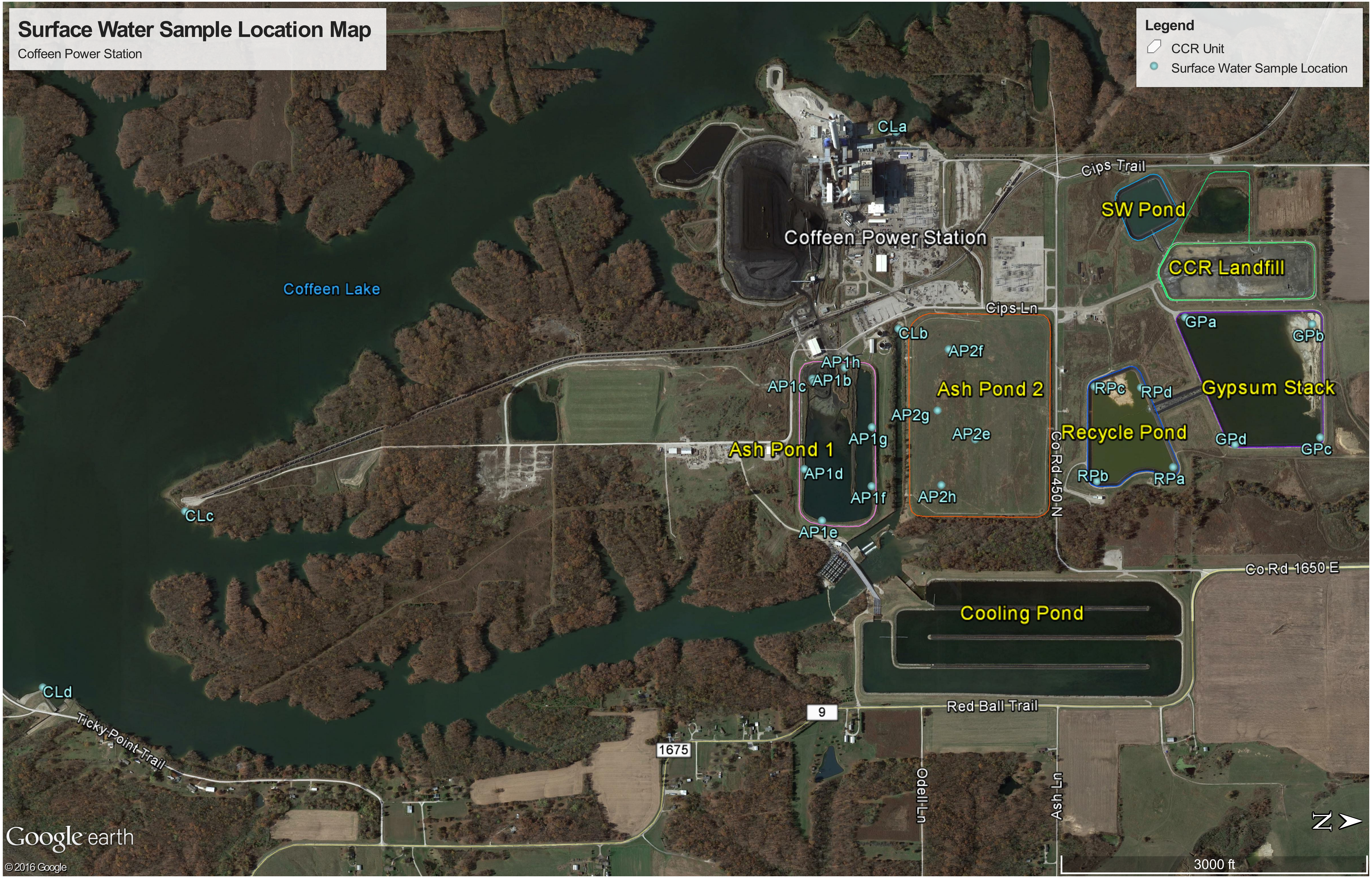


Table 10
Potential Source Water and Surface Water Sampling Results - October 24, 2016
Hydrogeologic Characterization Report
Coffeen Energy Center

Sample ID	Sample Location	Alkalinity, bicarbonate mg/L	Alkalinity, carbonate mg/L	Antimony, Total ug/L	Arsenic, Total ug/L	Barium, Total ug/L	Beryllium, Total ug/L	Boron, Total ug/L	Cadmium, Total ug/L	Calcium, Total mg/l	Chloride, Total mg/L	Chromium, Total ug/L	Cobalt, Total ug/L	Fluoride, Total mg/L	Lithium, Total ug/L	Magnesium, Total mg/L	Mercury, Total ug/L	Molybdenum, Total ug/L	pH	Potassium, Total mg/L	Selenium, Total ug/L	Sodium, Total mg/l	Solids - total dissolved solids (TDS) mg/L	Sulfate, Total mg/L	Thallium, Total ug/L
AP1a	Ash Pond 1	90	< 2.0	3.1	7.2	130	< 1.0	3800	< 1.0	380	3.2	< 4.0	< 2.0	< 0.250	39	67	< 0.20	47	6.99	7.3	3.0	33	1800	1500	< 1.0
AP1b		120	< 2.0	3.3	17	100	< 1.0	3100	< 1.0	320	13	< 4.0	< 2.0	0.977	47	52	< 0.20	100	7.01	18	6.9	53	1600	1300	< 1.0
AP1c		80	< 2.0	< 3.0	18	130	< 1.0	2900	< 1.0	390	13	< 4.0	< 2.0	0.614	51	49	< 0.20	81	7.05	18	3.1	59	1900	1600	< 1.0
AP1d		90	< 20	< 3.0	2.0	200	< 1.0	2000	< 1.0	210	18	< 4.0	< 2.0	1.08	55	35	< 0.20	31	7.21	26	1.5	83	980	1000	< 1.0
AP1e		80	< 2.0	< 3.0	1.4	160	< 1.0	2100	< 1.0	200	18	< 4.0	< 2.0	1.00	55	34	< 0.20	30	7.12	26	1.2	80	1200	960	< 1.0
AP1f		110	< 20	< 3.0	1.5	150	< 1.0	2100	< 1.0	200	17	< 4.0	< 2.0	1.00	57	35	< 0.20	31	7.20	26	1.2	82	1200	1000	< 1.0
AP1g		75	< 2.0	< 3.0	1.3	140	< 1.0	2100	< 1.0	210	17	< 4.0	< 2.0	1.00	56	32	< 0.20	29	7.21	26	1.4	100	1200	970	< 1.0
AP1h		90	< 20	< 3.0	1.5	180	< 1.0	2200	< 1.0	230	17	< 4.0	< 2.0	0.980	55	30	< 0.20	31	7.41	27	1.2	110	1200	1000	< 1.0
AP2e	Ash Pond 2	55	< 20	< 3.0	23	26	< 1.0	5300	< 1.0	210	< 5.0	< 4.0	< 2.0	0.438	190	40	< 0.20	90	6.49	27	< 1.0	25	1700	1500	< 1.0
AP2f		100	< 20	< 3.0	1.2	22	< 2.0	2000	< 1.0	170	< 5.0	< 4.0	< 2.0	0.398	130	33	< 0.20	3.2	6.42	21	< 1.0	14	1700	1500	< 1.0
AP2g		4.0	< 2.0	< 3.0	5.5	20	< 2.0	4300	4.6	410	< 5.0	< 4.0	< 2.0	0.506	180	51	< 0.20	41	6.46	29	< 1.0	27	2400	2300	< 1.0
AP2h		140	< 2.0	< 3.0	75	23	< 1.0	14000	< 1.0	310	1.7	< 4.0	< 2.0	0.406	120	29	< 0.20	570	7.17	40	< 1.0	39	1500	1300	< 1.0
CLa	Coffeen Lake	80	< 2.0	< 3.0	1.8	54	< 1.0	270	< 1.0	23	23	< 4.0	< 2.0	0.443	< 10	12	< 0.20	5.0	7.22	7.4	< 1.0	19	190	55	< 1.0
CLb		80	< 2.0	< 3.0	1.8	52	< 1.0	280	< 1.0	23	22	< 4.0	< 2.0	0.425	< 10	11	< 0.20	4.9	7.52	7.8	< 1.0	19	180	56	< 1.0
CLc		75	< 2.0	< 3.0	1.8	56	< 1.0	280	< 1.0	23	22	< 4.0	< 2.0	0.426	< 10	12	< 0.20	4.7	7.62	7.4	< 1.0	19	160	54	< 1.0
CLd		80	< 2.0	< 3.0	1.8	54	< 1.0	270	< 1.0	23	23	< 4.0	< 2.0	0.421	< 10	12	< 0.20	4.8	7.30	7.5	< 1.0	20	170	54	< 1.0
GPa	Gypsum Stack Pond	4.0	< 2.0	< 3.0	4.7	120	2.6	59000	40	450	1900	< 4.0	52	42.7	300	1500	< 0.80	130	7.16	210	890	620	17000	17000	< 1.0
GPb		10	< 2.0	8.6	92	1100	< 20	97000	67	1400	2600	150	110	69.4	480	2500	27	140	6.65	360	1500	1000	28000	27000	< 4.0
GPc		5.5	< 2.0	< 6.0	4.4	110	2.6	72000	41	570	1800	< 4.0	54	49.2	300	1500	< 0.80	120	6.73	260	890	650	17000	20000	< 1.0
GPd		6.0	< 2.0	< 3.0	4.2	110	< 20	66000	38	560	1900	< 4.0	52	51.3	300	1500	< 0.80	120	6.73	230	800	660	16000	19000	< 1.0
RPa	Gypsum Recycle Pond	< 2.0	< 2.0	< 3.0	3.3	89	2.3	60000	37	380	1600	< 4.0	44	47.0	310	1200	< 0.20	63	6.70	190	840	450	16000	17000	< 1.0
RPb		< 2.0	< 2.0	< 3.0	2.8	90	2.1	56000	33	380	1800	< 4.0	45	44.4	310	1200	< 0.40	64	6.49	210	780	470	16000	18000	< 1.0
RPc		< 2.0	< 2.0	< 3.0	3.1	88	2.2	59000	37	380	2000	< 4.0	43	45.0	310	1200	< 0.20	64	6.32	200	830	440	16000	20000	< 1.0
RPd		< 2.0	< 2.0	< 3.0	3.4	89	2.4	59000	36	400	1600	< 4.0	45	51.2	310	1300	< 0.20	66	6.32	200	860	460	17000	16000	< 1.0

[O:MDM 12/2016, NRK 12/2016]

APPENDIX G
Geochemical Conceptual Site Model

Geosyntec consultants

engineers | scientists | innovators

Geochemical Conceptual Site Model

Coffeen Power Plant –Ash Pond No. 2

(CCR Unit #102)

Prepared for

Illinois Power Generating Company
1500 Eastport Plaza Drive
Collinsville, Illinois 62234

Prepared by

Geosyntec Consultants, Inc.
134 N. Lasalle Street, Suite 300
Chicago, Illinois 60602

Project Number: GLP8078

June 2024

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Attachment F:	X-Ray Fluorescence Analytical Data
Attachment G:	X-Ray Diffraction Analytical Data
Attachment H:	Site Evaluation Groundwater Data
Attachment I:	Antidegradation Assessment Report (Hansen 2017)

ACRONYMS AND ABBREVIATIONS

AP1	Ash Pond No. 1
AP2	Ash Pond No. 2
ASD	alternative source demonstration
bgs	below ground surface
CEC	cation exchange capacity
CCR	coal combustion residuals
cm/s	centimeters per second
COCs	constituents of concern
CPP	Coffeen Power Plant
DA	deep aquifer
DCU	deep confining unit
GCSM	geochemical conceptual site model
GWPS	groundwater protection standards
HSU	hydrostratigraphic unit
I.A.C.	Illinois Administrative Code
IEPA	Illinois Environmental Protection Agency
LCU	lower confining unit
LOI	loss on ignition
meq/100 g	milliequivalents per 100 grams
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
N&E	nature and extent
ORP	oxidation-reduction potential
PMP	potential migration pathway
SU	standard units
TDS	total dissolved solids
UA	uppermost aquifer
UCU	upper confining unit
XRD	X-Ray diffraction
XRF	X-Ray fluorescence

1. EXECUTIVE SUMMARY

A geochemical conceptual site model (GCSM) has been developed to describe subsurface conditions at the Coffeen Power Plant Ash Pond No. 2 (AP2) coal combustion residuals unit (Unit #102). A GCSM describes the environmental media and 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 AP2 groundwater and which will be addressed in the corrective action plan. The exceedances detected at AP2 were boron, sulfate, pH, and total dissolved solids. Constituents of concern (COC) exceedances are present in one hydrostratigraphic unit at the Site: the uppermost aquifer (UA), comprised predominantly of sandy to gravelly silts with thin sand beds.

Coal combustion residual (CCR) materials are the primary source of constituent loading to the CCR contact water (i.e., CCR porewater or source water). Over an extended period (e.g., months to years), the CCR porewater (i.e., water contained within the interstitial pore spaces of the CCR that can be sampled by low-flow groundwater sampling methods) reaches equilibrium with the CCR materials. The porewater is therefore representative of the mobile phase constituents capable of migrating into the underlying materials and potentially downgradient in groundwater. The AP2 CCR source water is therefore the primary indicator of boron and sulfate available to the groundwater and is considered as the primary source term for environmental investigation and fate and transport modeling. TDS is a measure of inorganic and organic substances in solution. TDS trends are generally consistent with those of sulfate in the AP1 groundwater system.

Conditions within UA groundwater are predicted to favor amorphous iron oxide stability at most locations, and the presence of iron oxides in some Site solids indicates a portion of the boron and sulfate in the groundwater system might be attenuated via surface complexation reactions. Attenuation of the constituents contributing to TDS, such as sulfate, will reduce TDS concentrations as well. Boron may be further attenuated via interactions with clay minerals, which are present in solids across the UA and LCU. Site-specific partition coefficients could not be calculated from the results of batch attenuation testing completed with solids from the Site. These results indicate that chemical attenuation of boron and sulfate is expected to be limited.

Low pH at G401 is potentially caused by geochemical reactions driven by the mixing of porewater and groundwater, although the specific drivers are still under investigation. The low pH values at G401 are likely to be buffered further downgradient by the abundance of carbonate minerals identified in site solids via XRD.

2. INTRODUCTION

This report documents the development of a geochemical conceptual site model (GCSM) to describe subsurface conditions at the Coffeen Power Plant (CPP) Ash Pond No. 2 (AP2) coal combustion residuals (CCR) unit (Unit #102). A GCSM describes the environmental media and geochemical processes that contribute to the mobilization, distribution, and attenuation of constituents of concern (COCs) in the environment. The GCSM was prepared in support of an evaluation of the nature and extent of exceedances of COCs above the groundwater protection standards (GWPS) at AP2. The document has been prepared as an appendix to the CPP AP2 Nature and Extent (N&E) Report prepared by Ramboll Americas Engineering Solutions. Inc. (Ramboll).

Constituents with statistical exceedances above the GWPS at CPP AP2 for the second, third, and fourth quarters of 2023 (Q2 2023, Q3 2023, and Q4 2023) monitoring events completed under Title 35 of the Illinois Administrative Code (35 I.A.C.) § Section 845.630 are boron, sulfate, pH, and total dissolved solids (TDS). For the 2023 events discussed above, exceedances of boron were detected at compliance monitoring wells G401, G402, G404, and G405; exceedances of sulfate were detected at G401, G402, G404, G405, and G406; an exceedance of pH below the GWPS was detected at G401; and exceedances of TDS were detected at G401, G402, G404, and G405 (Ramboll 2024). All exceedances are present within the uppermost aquifer (UA).

An exceedance above the GWPS of cobalt was detected at compliance monitoring well G401 during the Q2 2023 monitoring event. An alternative source demonstration (ASD), as allowed by 35 I.A.C. § 845.650(e), was completed for the cobalt exceedance (Geosyntec 2023a). The cobalt ASD was rejected by the Illinois Environmental Protection Agency (IEPA) on January 11, 2024 (IEPA 2024a); however, the Illinois Power Generating Company has filed a motion for stay with Office of the Clerk of the Pollution Control Board. Therefore, cobalt is not included as a COC in this GCSM.

Exceedances above the GWPS of both sulfate and TDS were detected at compliance monitoring well G407 during the Q2 2023 monitoring event. An ASD, as allowed by 35 I.A.C. § 845.650(e), was completed for the exceedances of TDS and sulfate at G407 (Geosyntec 2023b). The G407 sulfate and TDS ASD was rejected by IEPA on January 11, 2024 (IEPA 2024b); however, the Illinois Power Generating Company has filed a motion for stay with Office of the Clerk of the Pollution Control Board. Therefore, these constituents are not presented as exceedances at G407 within this report, although data for these analytes is included in figures for completeness.

3. SITE BACKGROUND

3.1 Site Overview

An overview of Site characteristics and hydrogeology is presented in the CPP AP2 N&E Report. A Site layout figure is provided in Attachment A.[1] Briefly, the CPP AP2 impoundment is located to the north of the Ash Pond No. 1 CCR unit (Unit #101), and south of the Gypsum Management Facility Recycle Pond (Unit #104). The CPP property is located approximately two miles south of the city of Coffeen, Illinois, and bordered by two lobes of Coffeen Lake to the west, east, and south, and by agricultural land to the north. An unnamed tributary runs north to south to the east of AP2.

AP2 is a 78-acre unlined surface impoundment that received bottom ash and fly ash between 1972 until the mid-1980's, when it was capped with a 2-foot compacted clay and soil cap. AP2 was recapped starting in 2019 using a geomembrane cover system in accordance with a closure plan submitted to the IEPA (AECOM 2017). The cover system installation was completed on November 17, 2020. The geomembrane cap design addresses the potential for slope failure and water infiltration into the closed CCR unit by directing the drainage of surface water (i.e., precipitation) off the cover system.

A Hydrogeologic Site Characterization Report (NRT 2017) has previously described the hydrostratigraphic units (HSUs) present in the vicinity of the CPP AP2, which consist of an Upper Confining Unit (UCU), Uppermost Aquifer (UA), Lower Confining Unit (LCU), Deep Aquifer (DA), and Deep Confining Unit (DCU). The UCU consists of the silt or clayey silt of the Loess Unit and the upper clayey portion of the Hagarstown Member. The UA is predominantly sandy to gravelly silts with thin sand beds, with lithology identified as the Hagarstown Member. The LCU, which contains the Vandalia Member, Mulberry Grove Member, and Smithboro Member, is comprised primarily of sandy to silty till, with discontinuous sand lenses that have been identified as potential migration pathways (PMPs). The DA is predominantly sand and sandy silt/clay units of the Yarmouth Soil and is discontinuous beneath the CPP. CCR within AP2 is underlain by the UCU in the majority of the footprint, with limited direct contact with the UA in pre-construction ravines on the eastern edge of AP2.

Vertical gradients measured near the CPP indicate variable flow directions, although on average it is downward from the UA to the LCU north of AP2 in G405/T408 (0.02 feet per foot); and in G406/T409, south of AP2 near the former discharge flume, it is upward with an average of –0.06 feet per foot. Vertical gradients between the LCU and DA are consistently downward (CPP AP2 N&E Report). Both the DA and the LCU have been identified as PMPs due to the presence of these downward gradients.

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[1] This figure is also provided as Figure 2-1 of the CPP AP2 N&E Report.

3.2 Groundwater Monitoring Network

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 IEPA for AP2. The proposed groundwater monitoring network is described in the Groundwater Monitoring Plan (Ramboll 2021b) and shown in Attachment B.[2] Well construction information, including the HSU in which each well is screened, is provided in Attachment C.[3]

Groundwater flow in the vicinity of AP2 is generally to the south and east. The groundwater to the west of AP2 is separated from the groundwater flow regime under AP2 by a groundwater divide. Groundwater flow directions are generally consistent across seasons. A detailed discussion of the hydrology of the Site is presented in Section 2 of the CPP AP2 N&E Report.

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[2] This figure is also provided as Figure 2-2 of the CPP AP2 N&E Report.
[3] This table is also provided as Table 3-1 of the CPP AP2 N&E Report.

4. GEOCHEMICAL SITE CONDITIONS

The general behavior of the COCs is discussed in Section 4.1. Summaries of Site solids and aqueous conditions within the relevant HSUs is provided in Section 4.2 and 4.3, respectively, with discussion of how groundwater both upgradient and downgradient of AP2 may interact with the Site solids to affect constituent behavior. This includes discussion of potential sorbing or precipitating phases and how the stability of those phases may be affected by variable groundwater pH and redox conditions.

4.1 Constituent Transport and Fate

Boron is primarily present in groundwater as boric acid ($H_3BO_3^o$) or borate ($B[OH]_4^-$) (Bolan et al., 2023). The speciation of boron depends on pH: at pH below 9.2 standard units (SU), H_3BO_3 is the dominant species (NCBI 2024). Boron is not subject to oxidation/reduction reactions (Lemarchand et al. 2015; Bolan et al. 2023). Boron primarily sorbs to positively charged sites on solid metal oxide phases, including iron and aluminum oxides (Goldberg and Glaubig 1985; Bolan et al. 2023). Boron sorbs most extensively to amorphous metal oxides between pH 7 SU and 8 SU (Goldberg and Glaubig, 1985). Boron can also sorbs 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.

Sulfate is the primary form of oxidized sulfur (S(VI)) in the environment and is a divalent oxyanion at pH values greater than 2 SU (Stumm and Morgan 1996). Sulfate in groundwater may sorb onto positively charged sites on solid metal oxide phases, most commonly iron and manganese oxides (Brown et al. 1999). The extent and strength of sulfate sorption to metal oxide surfaces depends on pH, ionic strength, and oxide surface area available for sorption. Sulfate can also form insoluble complexes such as barite ($BaSO_4$) (NCBI 2024). Sulfate in groundwater may be reduced to elemental sulfur (S(0)) or sulfide (S(-II)) under sufficiently reducing conditions, a process governed by local microbial communities (Stumm and Morgan 1996). Generally, reduced sulfur is less mobile in groundwater than sulfate because reduced sulfur readily precipitates as metal sulfides (Stumm and Morgan 1996).

TDS is a measure of the mass of dissolved material in water, rather than a specific chemical constituent. Individual constituent contributions to TDS depends on the concentration of that constituent. Typically, major ions (i.e., calcium, sodium, magnesium, potassium, chloride, sulfate, and carbonate species) represent the primary contributors to TDS. As such, TDS is often positively correlated with electrical conductivity and ionic strength (Rusydi 2018, Ghalib et al. 2020). TDS concentrations can be reduced by the removal from aqueous phases of the individual constituents that contribute to TDS.

pH is a measure of the concentration of proton (H^+) species in solution and is presented on a logarithmic scale. pH represents the acidity or basicity of an aqueous solution and is one of the master variables that controls ion speciation and chemical processes within groundwaters. The carbonic acid – carbonate system is the most important acid-base system in groundwaters, typically controlling pH conditions within groundwaters such that they are circumneutral to slightly alkaline, with a pH range between 6-9 SU. The pH of groundwater can be affected by weathering and dissolution reactions of minerals, as wells as the biogeochemical processes associated with sulfur cycling, nitrification, and humic and fulvic acids (Brezonik and Arnold 2011), among other processes.

4.2 Site Solids Characterization

Solid phase data for the CCR source material within the unit were not collected, as the unit has been closed since the mid-1980s.

Solids from across the CPP were characterized to determine the type and abundance of minerals present in the UA and LCU. Solids were characterized using a variety of analytical techniques, to characterize their geochemical properties and to understand their effect on the geochemistry of the groundwater system.[4] The results from these analyses are presented in Tables 1 – 4. Solids were collected from five locations adjacent to the following existing wells in the AP2 monitoring network:

- G270, located upgradient of AP2 to the northwest. Solids were collected within the UA and are considered representative of background conditions for AP2.
- G1001, located downgradient of AP2 to the east, with solids collected within the LCU.
- G401, located downgradient of AP2 to the south, with solids collected within the UA. Statistical exceedances of boron, sulfate, TDS, and pH outside the GWPS limits were determined at G401 during 2023.
- G407, located side-gradient of AP2 to the west. Solids were collected within the UA.
- G410, located side-gradient of AP2 to the west, with solids collected within two intervals within the UA.

The monitoring well locations are shown on Attachment B. Boring logs for these locations are provided in Attachment D.

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[4] Sequential extraction procedures are chemical extractions used to dissolve metals from specific solid-associated phases. While useful for solid phase characterization, reporting limits are often elevated for sulfate and boron and samples from the vicinity of CPP AP2 were not submitted for analysis via this technique.

Samples from six additional locations across the Site were analyzed as part of investigations at CPP AP1 but are representative of conditions within the same HSUs beneath AP2. These solids were collected adjacent to existing wells, specifically:

- G306, located upgradient of AP1 to the south and considered representative of background conditions, with solids collected within the UA.
- G307 and G307D, located upgradient of AP1 to the south, with solids collected within five intervals representing the UCU, UA, and LCU.
- G311 and G311D, located downgradient of AP1 to the north, with solids collected within four intervals representing the UCU, UA, and LCU.
- G313, located downgradient of AP1 to the east, with solids collected within the UA.
- G314 and G314D, located downgradient of AP1 to the east, with solids collected within six intervals representing the UCU, UA, LCU, and DA.
- G316, located downgradient of AP1 to the east, with solids collected within two intervals within the UA that were combined for analysis.

A map showing these monitoring well locations and boring logs for these locations are provided in Attachment D.

4.2.1 Bulk Characterization: Organic Carbon, Loss on Ignition, Cation Exchange Capacity and Sulfur 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 cation exchange capacity (CEC) of a solid represents the total negative surface charge of that material, which is related to the material's surface potential to sorb cations. Amorphous iron hydroxides, organic matter, and clays at circumneutral pH all tend to possess high negative surface charges and therefore tend to contribute to higher CEC values.

The CEC, TOC, and LOI values for Site solids are presented in Table 1 and the analytical data is provided in Attachment E. CEC values range from 3.32 – 31.02 milliequivalents per 100 g of sample (meq/100g), with lower CEC values reported for sandier lithologies (i.e., G307D). TOC abundances range from 0.06 – 1.74 percent by dry weight [% wt], whereas the reported LOI abundances ranged from 2.5 – 12.4 % wt). No clear patterns in CEC, TOC or LOI between HSUs is observed for solids across the Site.

Total sulfur within Site solids was low across all lithologies with all detections less than 0.15% wt. Acid volatile sulfide (AVS) represents the portion of sulfide within a solid material that can be liberated to hydrogen sulfide (H_2S) gas after the acidification of the sample. Sulfide was only detected at one location (G1001 within the LCU at 0.05 % wt) and the highest detection of AVS was 0.28 milligrams per kilogram (mg/kg), indicating that sulfides have a limited abundance in the Site solids and sulfur is primarily present within other mineral phases. Sulfate concentrations, as measured in solid leachate after HCl digestion, were higher in solids at G307D (UCU and UA; 170-220 mg/kg) and G314D (UA/LCU, 210 mg/kg) compared to similar lithologic units (e.g. G311D). Higher sulfate concentrations at these two locations are consistent with the highest sulfur wt % values detected for these intervals (0.09 – 0.14 wt %).

4.2.2 Total Metals and Boron via Bulk Characterization

Total metals were analyzed to determine the major and trace metal content of the solids. The abundance of total aluminum, iron, and manganese can provide insights into the presence of adsorbing phases, as oxyhydroxides of these metals can provide sorption capacity. The total metals results are presented in Table 2 and the analytical data is provided in Attachment E.

Total iron concentrations are relatively similar between UA solids (4,900 milligrams per kilogram [mg/kg] to 22,000 mg/kg) and those detected for LCU solids (10,000 to 21,000 mg/kg). The abundance of iron within the bulk solids matrix of both the UA and LCU indicates the likelihood of iron-bearing minerals within the system. The presence of iron-bearing minerals was confirmed via X-Ray diffraction (XRD) as discussed in Section 4.2.3. Total manganese concentrations follow a similar pattern to iron, with concentrations in UA solids (34 mg/kg to 1,200 mg/kg) spanning those detected in LCU solids (370 to 470 mg/kg). Aluminum concentrations in UA solids vary from 9,600 mg/kg at the background location G270 to 32,000 mg/kg at the downgradient AP1 compliance location G316. Boron concentrations within solids were analyzed in the vicinity of AP2, with concentrations ranging between 4 to 6 mg/kg.

X-Ray fluorescence (XRF) was conducted for identification of the bulk elemental composition of solids. The XRF data are presented in Table 3 and the analytical data is provided in Attachment F. Solids from across all geologic units at the Site are predominantly composed of silicon (61.7 to 84.6 wt%), followed by calcium (0.5 to 9.1 wt%) and aluminum (4.9 to 8.4 wt%), consistent with the sandy, silty, and clayey lithologies described for these units. Iron is detected in all Site solid samples ranging from 1.69 to 3.71 wt %, with UA solids having lower wt % iron than LCU and DA solids. Manganese was detected in all Site solid samples with concentrations ranging from 0.03 to 0.13 wt %.

4.2.3 Mineralogical Analysis

XRD with Rietveld refinement was conducted for identification of minerals in 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 XRD data are presented in Table 4 and the analytical data is provided in Attachment G. Solids from all HSUs across the Site were predominantly composed of quartz, ranging from 46.3 to 73.5% of the minerals present. Feldspar minerals including albite (6.1 to 10.4%) and microcline (5.1 to 9.8%), carbonates such as dolomite (0.0 to 15.7 %) and calcite (0.4 to 4.1%), and a variety of clays (1.1 to 12.0% total) were detected as additional primary crystalline mineral phases. Low abundances of magnetite (detected up to 0.2%) were detected in UA solids side gradient of AP2 (G407 and G410), and in LCU and DA solids adjacent to AP1, but otherwise crystalline forms of iron oxides were not detected in Site solids. Metal oxides such as iron, manganese, or aluminum oxides can serve as attenuating surfaces for boron. Ankerite, an iron-bearing carbonate mineral, was detected in all Site solids at abundances from 0.5 to 9.4%. Compared to the XRF detections of iron abundances between 1.7 to 3.7 wt %, these results indicate that the total iron within Site solids is largely associated with minerals other than crystalline iron oxides. No crystalline manganese oxide minerals were detected in Site solids. The manganese-bearing mineral kutnohorite (0.1 to 0.5 %) was detected at low abundances, consistent with the presence of dolomite-like carbonates.

Kaolinite, montmorillonite, and illite have been correlated with boron retention in soils (Goldberg 1997). Of those three clay types, illite has the greatest rate of boron adsorption, and was detected in solid samples from the UA, DA and LCU at abundances ranging from 1.7 to 4.0%. Montmorillonite and kaolinite were also present in a subset of solids from these units (1.0 to 3.2% and 0.6 to 1.1%, respectively). Chlorite was also identified at abundances ranging from 1.1 to 3.9%. The presence of clay minerals within solids presents an additional, if limited, potential attenuation mechanism for boron across the Site.

4.3 Aqueous Geochemistry

Groundwater from wells across the UA and LCU in the vicinity of AP2 were analyzed for a range of geochemical parameters, as presented in Figures 1–9. For clarity in interpretation, the figures present data from the UA and the LCU with differing symbology. UA well locations are shown with circular symbology on the figures and LCU locations are shown with triangular symbology. Background locations G270, G280, and G281, all of which are screened in the UA, are shown with hollow symbology. The groundwater data used in the Site evaluation is summarized in Attachment H.

A limited set of porewater (i.e., CCR contact water) samples have been collected in the recent past, including porewater collected from four locations screened within AP2 CCR in 2016 (AP2e-h; data originally presented in the 2017 *Antidegradation Assessment for Management of Coal Combustion Residuals Impoundment Waters, Coffeen Power Station*; Attachment I) and one sample of leachate collected during construction closure activities in 2020 (CO 102 Pump Q Box). The 2020 leachate sample pH value was analyzed by the analytical laboratory following sampling and was qualified as being analyzed after the acceptable holding time window; it has therefore been excluded from figures and the following discussion. Other analytes measured for the 2020 AP2 leachate sample were unimpacted and are included throughout.

CCR porewater is water "collected from the interstitial water between waste particles in surface impoundments as it occurs in the field" (USEPA 2014) and represents the material potentially leached from impoundments. The CCR materials are the primary source of constituent loading to the CCR porewater. Over an extended period (e.g., months to years), the CCR porewater (i.e., water) reaches equilibrium with the CCR materials. The concentrations within the porewater are "the most representative data available for impoundments because these data are field-measured concentrations of leachate" (USEPA 2014). Porewater is therefore the most appropriate source term for potential flux out of CCR impoundments.

4.3.1 Redox/pH Summary

The oxidation-reduction (redox) potential (ORP) and pH in aqueous systems are major controls on the speciation and mobility of reactive constituents such as iron, manganese, and sulfate.

AP2 porewater pH values ranged between 6.4 to 7.2 standard units (SU). In wells across the groundwater monitoring network, pH values appear to be stable and circumneutral, with the exception of G401 (Figure 1). Compliance UA groundwater pH values largely range between 6.4 to 7.5 SU, which is a relatively lower range than detected for background UA groundwater with pH values 6.8 to 7.9 SU. Lower pH values were detected at UA well G401 relative to similarly located downgradient UA wells (e.g. G402), with reported values ranging from 5.6 to 6.4 SU, consistently below the GWPS of 6.5 SU. These pH values are also lower than the reported pH values within the AP2 unit. LCU groundwater pH, as represented by values reported for G1001, ranged between 6.8 to 7.0 SU.

Since 2020, positive ORP values have been reported in all groundwater monitoring network wells across the Site (Figure 2). Prior to 2020, groundwater at background wells G270, G280, and G281 was consistently more oxidizing than downgradient UA wells G401, G402, G403, and G404. After cessation of combustion activities and initiation of pond-recapping activities in late 2019 and early 2020, redox conditions at G401, G402, G403, and G404 shifted to more oxidizing conditions that are more consistent with the background locations. G401, G402, G403, and G404 are distributed around AP2, representing upgradient, side gradient, and downgradient locations, such that the detected shift in redox conditions likely relates to changes related to new flow patterns following plant cessation and re-closure activities. Many of the UA wells across the network (G402, G403, G404, and G405) appear to fluctuate seasonally between relatively more oxidizing (winter) and more reducing (summer) conditions. This pattern is not consistently observed across the monitoring network and appears to have developed after the completion of closure construction in 2020, which may have altered recharge conditions at these locations.

4.3.2 Exceedance Parameters

Total boron concentrations in AP2 porewaters and leachate varied from 2.0 to 14 milligrams per liter (mg/L), with concentrations detected above the site-specific GWPS for boron of 2.0 mg/L

(Table 5; Figure 3a). UA background wells G270, G280, and G281 are not detected to exceed the GWPS for boron (Figure 3a). Boron concentrations appear to increase as the sampling location moves east across AP2 (i.e., lower concentrations at G403 compared to G405; locations shown in Attachment B), consistent with the general direction of groundwater flow within the UA beneath the unit. Boron concentrations have been stable above the GWPS at downgradient UA compliance wells G401 and G402, and stable below the GWPS at G403, G406, G407, and G1001. Boron concentrations have increased at G404 following the completion of closure construction, and concentrations at G405 have also increased after a period of decline. Boron dynamics at G404 and G405 may be influenced by increasing porewater elevations within AP2 during closure that are still returning to equilibrium (Section 3.2.1 of the CPP AP2 N&E Report). When measured, dissolved boron represents the majority of total boron at all locations (Figure 3b), consistent with the expectation that the majority of boron is present as neutral boric acid at the pH ranges detected within the monitoring network and would have limited associations with particulates.

Total sulfate concentrations within AP2 porewater and leachate ranged between 1,300 to 2,300 mg/L, above the GWPS of 400 mg/L (Table 5; Figure 4a). Sulfate concentrations in groundwater are largely stable through time across the monitoring network, with sulfate concentrations detected at higher concentrations at G401 (Figure 4a). Sulfate concentration trends at both G404 and G405 are consistent with the changes in boron concentrations described above, although at a lesser magnitude. Measurements of dissolved sulfate within compliance well groundwaters are limited; when measured, dissolved sulfate represents the majority of total sulfate at all locations (Figure 4b), indicative of limited association with suspended solids in the unfiltered samples.

TDS values in AP2 porewater and leachate ranged between 1,500 to 2,400 mg/L, above the GWPS of 1,200 mg/L (Table 5; Figure 5). UA background wells G270 (60 to 510 mg/L), G280 (400 to 608 mg/L), and G281 (700 to 1,000 mg/L) have a similar range of TDS concentrations relative to UA compliance wells (270 to 1,200 mg/L; excluding exceedance wells) and LCU well G1001 (830 to 1,700 mg/L). TDS concentrations at wells with statistically significant exceedances of TDS are higher (460 to 6,600 mg/L), exceeding the range of values for AP2 porewater (1,500 to 2,400 mg/L) at some locations. Total sulfate concentrations are positively linearly correlated with TDS concentrations across wells in the monitoring network ($R^2 = 0.81$; Figure 6), indicating that sulfate is a major contributor to TDS across the AP2 monitoring network.

4.3.3 Pourbaix Diagrams

Eh-pH (Pourbaix) diagrams can be used to illustrate the predicted stability of specific phases at thermodynamic equilibrium under the conditions detected for a groundwater sample. Select crystalline mineral species were suppressed to be representative of groundwater conditions (e.g. mineral formation not anticipated to be kinetically favored for igneous and metamorphic minerals in the low temperature near-surface environment), except when identified in XRD data from solids in the site.

Using conditions detected at compliance well G402 on 6 June 2023 to represent downgradient groundwater within the UA (Table 6), amorphous ferrihydrite is predicted to be the predominant iron species under groundwater conditions at all locations, except for G401, where solid phase iron minerals are not expected to be stable (Figure 7a).[5] The lower predicted stability of ferrihydrite at G401 appears to be driven by the low pH values detected at this location. Conditions at most UA wells, including background wells G270 and G281, are poised on the redox boundary for solid phase iron stability under conditions at G402; the lower aqueous concentrations of iron at other locations (see Table 7) would tend to shift the redox boundary upwards such that aqueous iron is more likely to occur under conditions at other UA wells. Additionally, the higher abundance of total iron at G402, which was used to inform the Eh-pH diagram generation, compared to dissolved iron at G402 (Table 7) may overestimate the stability of solid phase iron species.

When not suppressed, crystalline magnetite is expected to be stable at all locations except G401 (Figure 7b), consistent with the detection of magnetite via XRD near G407 and G410 (Table 4). Magnetite is likely in a dynamic state at G401, with its stability poised between dissolution to aqueous iron and subsequent reprecipitation as amorphous iron oxides. Ankerite, which was identified via XRD and is an analogous iron-bearing carbonate species to siderite, is not expected to be thermodynamically stable within the UA based upon the detected pH and redox conditions. Dissolution of ankerite or magnetite (where present) may provide a source of iron for the subsequent formation of amorphous iron oxide coatings. Overall, these modeling results indicate that amorphous iron oxides (the formation of which is more kinetically favorable than crystalline iron oxides) might be present, although potentially unstable, at some locations within the UA.

The Eh-pH diagrams for manganese show that solid phase manganese minerals, including manganese oxides, are not predicted to be thermodynamically stable under conditions across the Site (Figure 8). Background UA well G280 is the exception, as manganese carbonate mineral rhodochrosite was predicted to be thermodynamically stable. Mineralogical analyses were not completed at well G280 to verify the presence of rhodochrosite, although manganese-bearing carbonate mineral kutnohorite was detected in XRD results throughout the site.[6]

4.3.4 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. Paired total and dissolved iron and manganese data are only available across the Site for the Q2 and Q3, 2023 sampling events, with results also available for Q4 2023 at the background locations. A comparison of the total and dissolved iron and manganese data for these events is provided in Table 7.

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[5] Field ORP measurements were converted to Eh by adding +200 millivolts to correct for the Ag/AgCl electrode.

[6] Kutnohorite is a solid-solution carbonate mineral with the chemical formula $(Ca,Mn^{2+})(CO_3)_2$ which is not included in most thermodynamic databases used for geochemical model calculations. Rhodochrosite (manganese carbonate) represents the most analogous mineral to kutnohorite in geochemical modeling efforts.

Total iron concentrations ranged from 0.012 mg/L at UA compliance well G406 on 31 May 2023 to 101 mg/L at downgradient UA well G401 on 11 August 2023. Dissolved iron concentrations ranged from below reporting limits to 93.8 mg/L at downgradient UA well G401 on 11 August 2023. The total and dissolved iron concentrations detected at G401 were over an order of magnitude higher than the reported values elsewhere in the network. Where dissolved iron was detected, the dissolved concentration was at typically less than 50% of the total iron value, and frequently only about 10%, indicating that iron is largely associated with suspended particulates across the AP2 monitoring network. However, dissolved iron concentrations at G401 are more than 93% of the total iron, consistent with the Eh-pH diagram results indicating geochemical conditions favor the stability of dissolved iron at this location driven by consistently lower pH and ORP (Figure 7a).

Total manganese concentrations ranged from 0.0159 mg/L at background UA well G280 on 14 August to 28.8 mg/L at downgradient UA well G401 on 11 August 2023 (Table 7). Dissolved manganese concentrations ranged from 0.0014 mg/L at background UA well G280 on 8 June to 36 mg/L at downgradient UA well G401 on 11 August 2023. Total and dissolved manganese were also much higher at G401 compared to other locations in the monitoring network, consistent with the iron results. Dissolved manganese represents the majority of total manganese concentrations at all locations except for UA background wells G270, G280, and G281 and LCU well G1001. This is consistent with the predicted greater manganese-carbonate mineral stability at G280 (Figure 8).

4.3.5 Major Ion Distribution and Groundwater Signatures

A Piper diagram was constructed using data from AP2 to visualize major ion distributions in groundwater (Figure 9). Piper diagrams are a common tool for assessing geochemical similarities or differences between aqueous samples. The cation composition of the AP2 leachate is dominated by calcium, with the major anion composition sulfate-dominated. Groundwater composition for background wells G270, G280, and G281 has lower contributions of sulfate, greater contributions of carbonate alkalinity (consistent with the presence of carbonates in the UA solids), and major cation distributions of near equal contributions of both monovalent and divalent cations. Groundwater from side gradient UA compliance well G403 and downgradient LCU well G1001 (neither of which exhibited GWPS exceedances) cluster with these background wells. Groundwater from the compliance network wells spans the range between the background wells and AP2 leachate, indicating variable influences from the AP2 CCR unit on groundwater at these locations. G401 groundwater composition is most similar to AP2 porewater leachate, consistent with the relatively higher concentrations of sulfate detected at this location (Figure 4a). These results provide further evidence for the influence of AP2 source water on compliance wells for the unit.

5. EVALUATION OF PARTITION COEFFICIENT RESULTS

Batch test studies combine soil and groundwater collected from the Site to evaluate the attenuation of chemical constituents. Batch attenuation testing was conducted for sulfate and boron to evaluate the potential for sorption and to attempt to generate Site-specific distribution coefficients between the solid and aqueous phase.

5.1 Batch Attenuation Testing

In 2021, Geosyntec conducted a field investigation at AP2 which included completion of one soil boring at G270 ranging in depth from 12 to 16 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 (G401) and one soil sample (G270) were used for batch attenuation testing at five soil:solution ratios (Table 8), each ran in duplicate. Statistically significant exceedances of for boron, sulfate, and TDS were identified at G401, as well as being below the bounds of the GWPS for pH, while G270 is representative of background conditions at AP2. For each treatment, ~0.1 liter of groundwater was brought into contact with varying amounts of soil (0.003 to 0.17 kg, depending on the ratio) and equilibrated over a seven-day period.

An initial sample of the stock solution for each experimental design was collected on Day 0, and a control sample (i.e., G401 groundwater with no aquifer solids) was collected on Day 7 after tumbling in polypropylene bottleware to evaluate any loss to interactions with the bottleware or 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 sulfate and/or boron. Analysis of the dissolved phase is important to adequately measure the partitioning of mass between the solid and liquid fractions of the experiment. The 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 tests (Table 8) were used to construct isotherms for boron and sulfate; 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]).

Some of 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 9.

5.2 Partition Coefficient Results

The partition coefficient values for G401 groundwater combined with G270 geologic material are presented in Table 9. The linear and Langmuir isotherms for sulfate and boron are provided in Figures 10a and 10b, respectively.

The G401 partition coefficient for boron ranged from -464,440 L/kg for the Langmuir isotherm to -11.08 L/kg for the linear isotherm. A Freundlich isotherm was not fit to the data due to the lack of suitability for log transformation. Neither isotherm showed a high goodness-of-fit (i.e., R^2), with the highest correlation constant 0.44. An accurate boron coefficient could therefore not be calculated from the data.

The G401 partition coefficient for sulfate ranged from -564 L/kg for the Langmuir isotherm to -11.08 L/kg for the linear isotherm. A Freundlich isotherm was not fit to the data due to the lack of suitability for log transformation. Both of the isotherms showed reasonable goodness-of-fit with correlations between 0.56 and 0.60, but both isotherms predicted a negative relationship. An accurate sulfate partition coefficient could therefore not be calculated from the data.

6. GEOCHEMICAL CONCEPTUAL SITE MODEL

6.1 Source and Mobilization Mechanisms

Boron is naturally abundant in coals associated with organic matrices and is concentrated within CCR, primarily as polyborate (B_2O_3) surface coatings on particles (EPRI, 1998; Izquierdo & Querol, 2012). Boron was identified in the CCR porewater or leachate at concentrations up to 14 mg/L. The likely primary source of boron to the UA is the AP2 CCR porewater based on boron concentrations within the source.

Reduced sulfur species (e.g. pyrite) can be naturally abundant in coals; after coal fly ash production, sulfate is the dominant sulfur species associated with fly ash. Sulfate is concentrated on the surface of fly ash particles and the majority of sulfate mineral phases are soluble under environmental conditions, such that sulfate associated with fly ash is leachable (Izquierdo & Querol, 2012). The primary source of sulfate to the UA is AP2 CCR porewater. Sulfate was identified in the CCR leachate or porewater at concentrations up to 2,300 mg/L. Elevated concentrations of sulfate are a major contributor to the exceedances of TDS identified at G401, G402, G404 and G405.

Statistical exceedances of sulfate and TDS indicate that AP2 porewater is influencing groundwater at G401. The reported pH values at G401 (5.6 to 6.4 SU) are lower than those reported in AP2 leachate or porewater (6.4 to 7.2 SU), suggesting that geochemical reactions driven by interaction of porewater with the underlying UCU materials and/or mixing of porewater with groundwater may cause a low pH. These reactions may include iron oxidation and precipitation or carbonate mineral precipitation. Geochemical modeling to support evaluation of corrective actions may clarify the drivers of low pH at AP2. The low pH values at G401 are likely to be buffered further downgradient by the abundance of carbonate minerals identified in site solids via XRD.

6.2 Potential and Observed Attenuation Mechanisms

Boron exceedances were identified in the UA. Boron is anticipated to largely be present as the neutral $B(OH)_3^o$ boric acid species as groundwater pH values in the UA are below the pK_a for boric acid (9.2). The presence of iron oxides in some UA solids (Table 4) and the potential for amorphous ferrihydrite formation based on modeling of Eh-pH conditions indicates a portion of the boron in the groundwater system might be attenuated via surface complexation reactions within portions of the UA. Given the low abundance of total manganese in the solids (Table 2) and the predicted instability of solid manganese phases (Figure 8), manganese oxides are not expected to be an important source of adsorption sites. Boron is also known to be attenuated via interactions with clay minerals (Goldberg 1997); the XRD results identified the presence of clay minerals across the UA (Table 4). These lines of evidence are not supported by batch attenuation testing for boron, which indicated boron chemical attenuation is limited at locations downgradient of AP2.

Sulfate exceedances are currently limited to the UA. Sulfate is typically considered to be a conservative species within groundwater at circumneutral pH conditions, although sorption onto mineral surfaces is a potential attenuation mechanism. Sulfate attenuation is expected to occur largely as the result of sorption onto positively charged iron oxides and oxyhydroxides associated with solids. XRD analyses (Table 4) support the presence of iron oxides crystalline phases across the Site in the UA, with the additional potential for amorphous phases to form at some locations based on modeled redox conditions. However, chemical attenuation of sulfate is anticipated to be limited, as batch attenuation testing was not able to determine a partition coefficient for sulfate at the Site. Any attenuation of sulfate will likely contribute to a reduction of TDS in the groundwater. The low pH values at G401 are likely to be buffered by the abundance of carbonate minerals identified in site solids via XRD.

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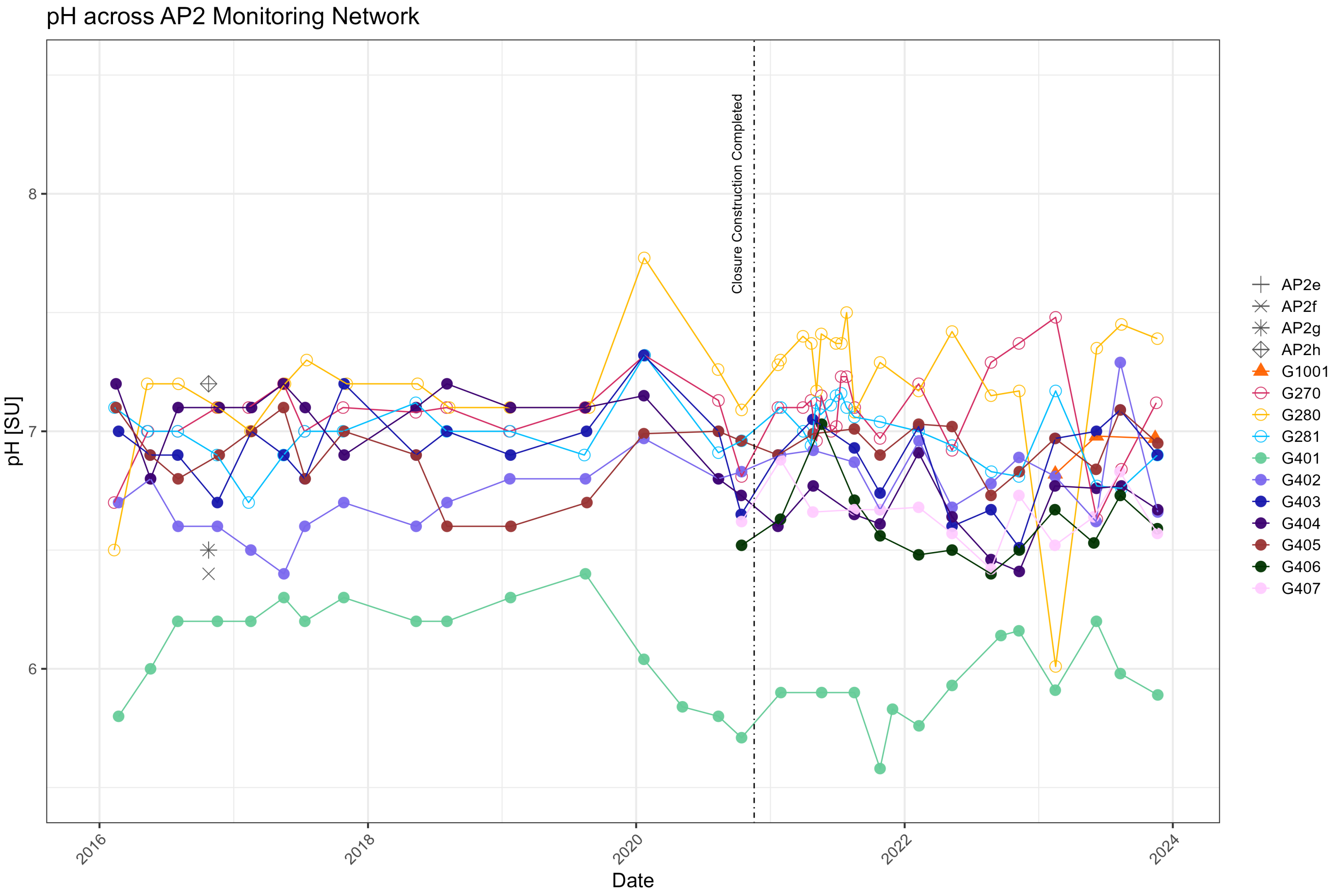
FIGURES



Notes:
SU: Standard Units
Background wells shown with open symbols.

pH Time Series

Coffeen Power Plant – Ash Pond No. 2

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Figure

1

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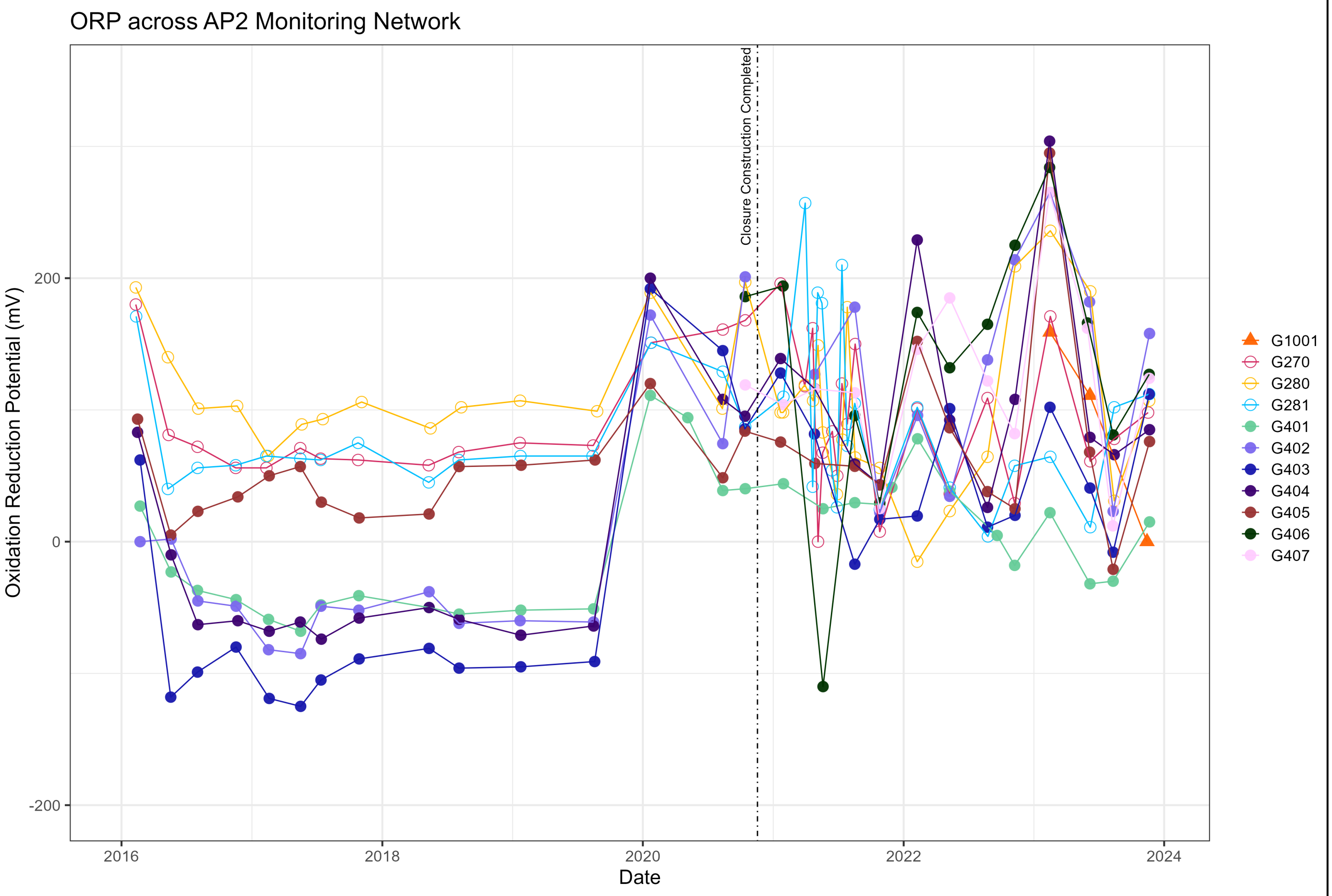

Notes:
mV: millivolts
Background wells shown with open symbols.

ORP Time Series

Coffeen Power Plant – Ash Pond No. 2

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Figure 2

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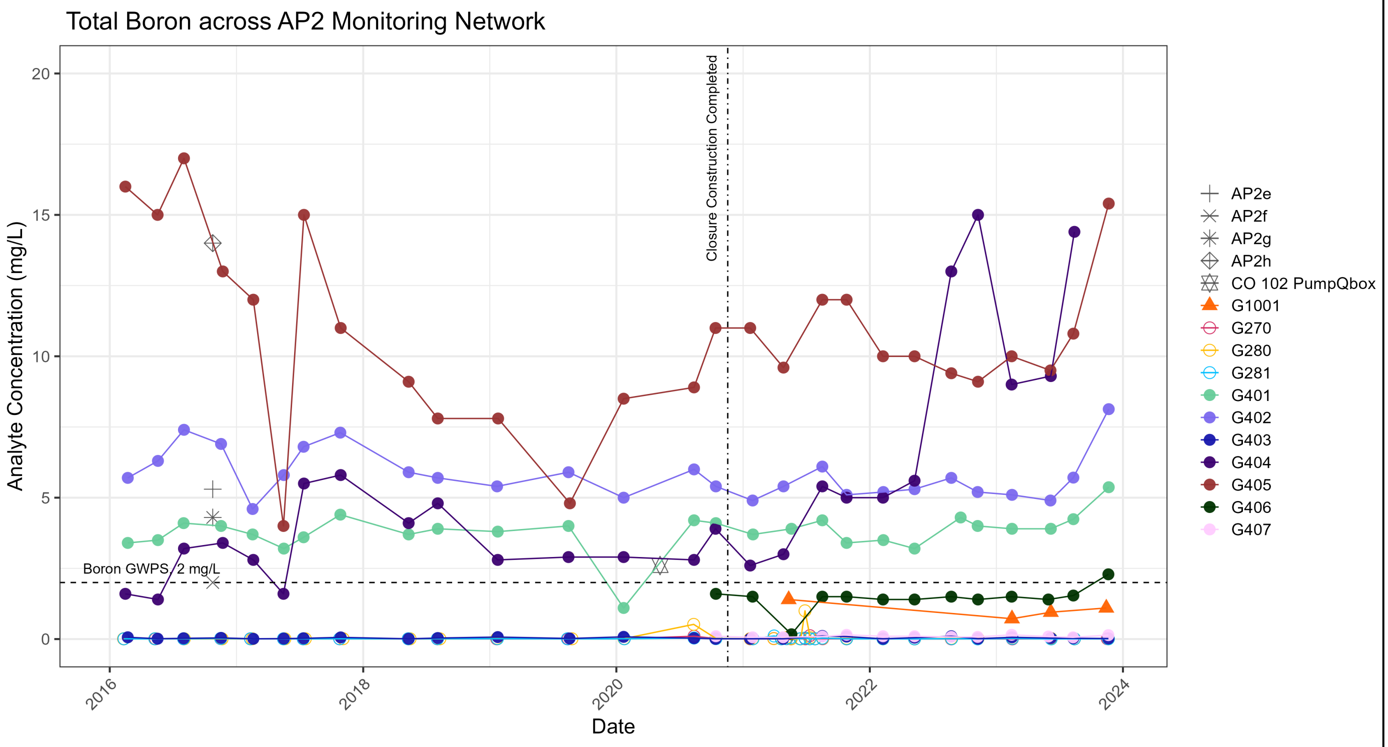

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Notes:
mg/L: milligrams per liter
GWPS: Groundwater Protection Standard
Background wells shown with open symbols.

Total Boron Concentration Time Series

Coffeen Power Plant – Ash Pond No. 2

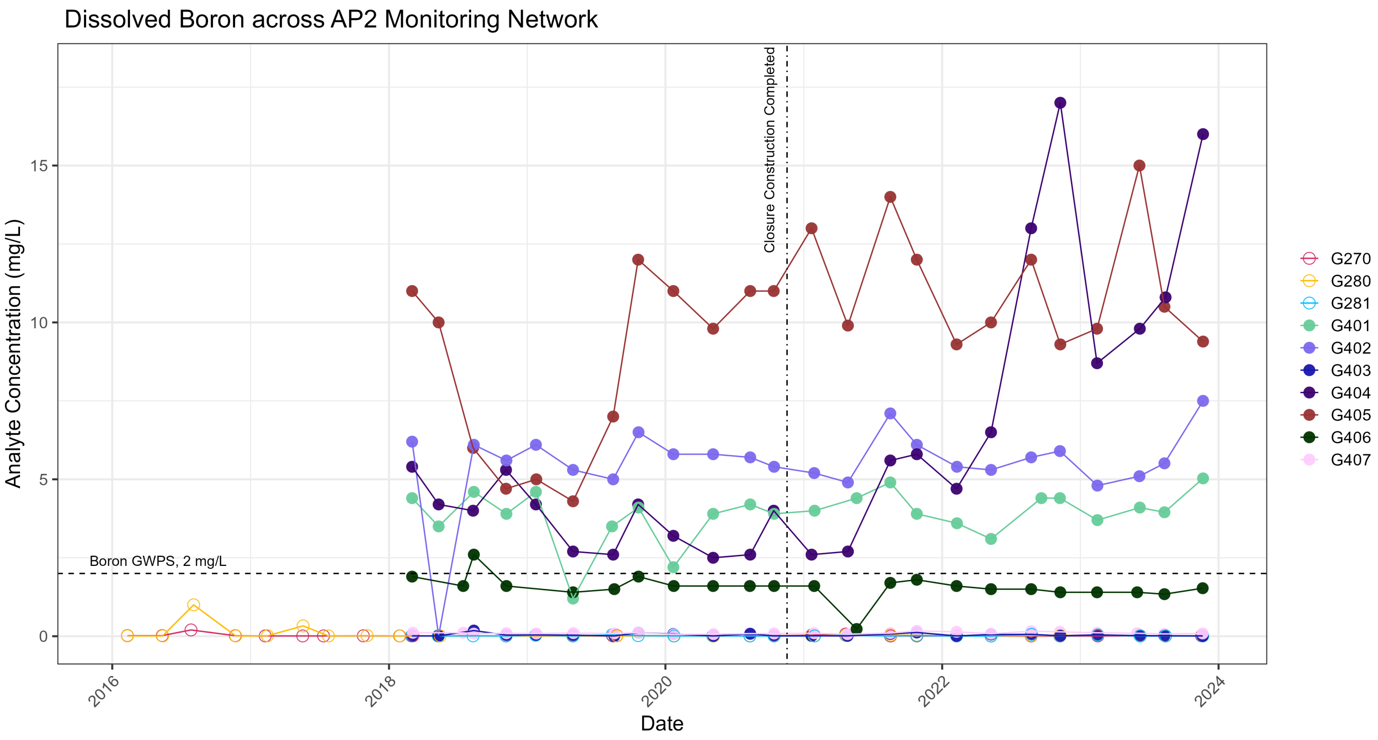
Geosyntec
consultants

Figure

3a

Columbus, Ohio

May 2024



Notes:
mg/L: milligrams per liter
GWPS: Groundwater Protection Standard
Background wells shown with open symbols.

Dissolved Boron Concentration Time Series

Coffeen Power Plant – Ash Pond No. 2

Geosyntec consultants

Columbus, Ohio

May 2024

Figure

3b

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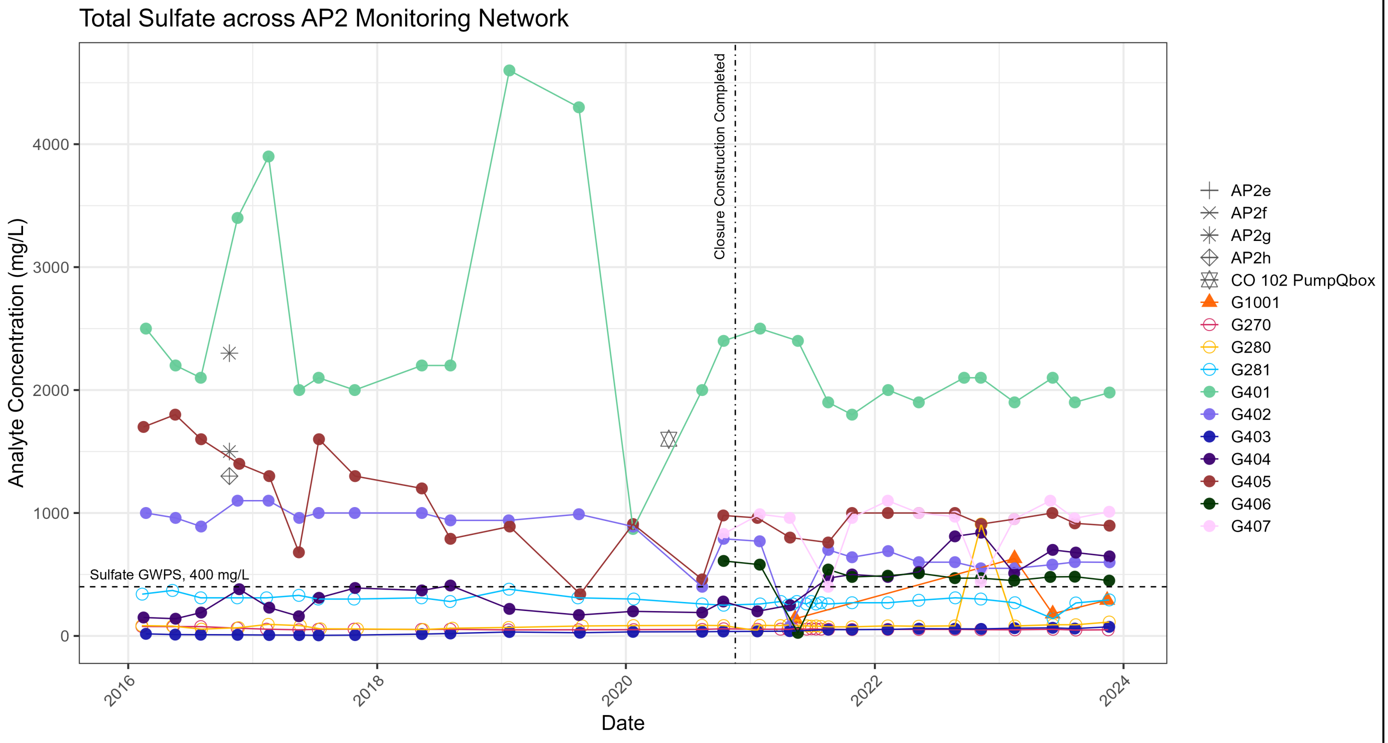


Notes:
mg/L: milligrams per liter
GWPS: Groundwater Protection Standard
Background wells shown with open symbols.

Total Sulfate Concentration Time Series

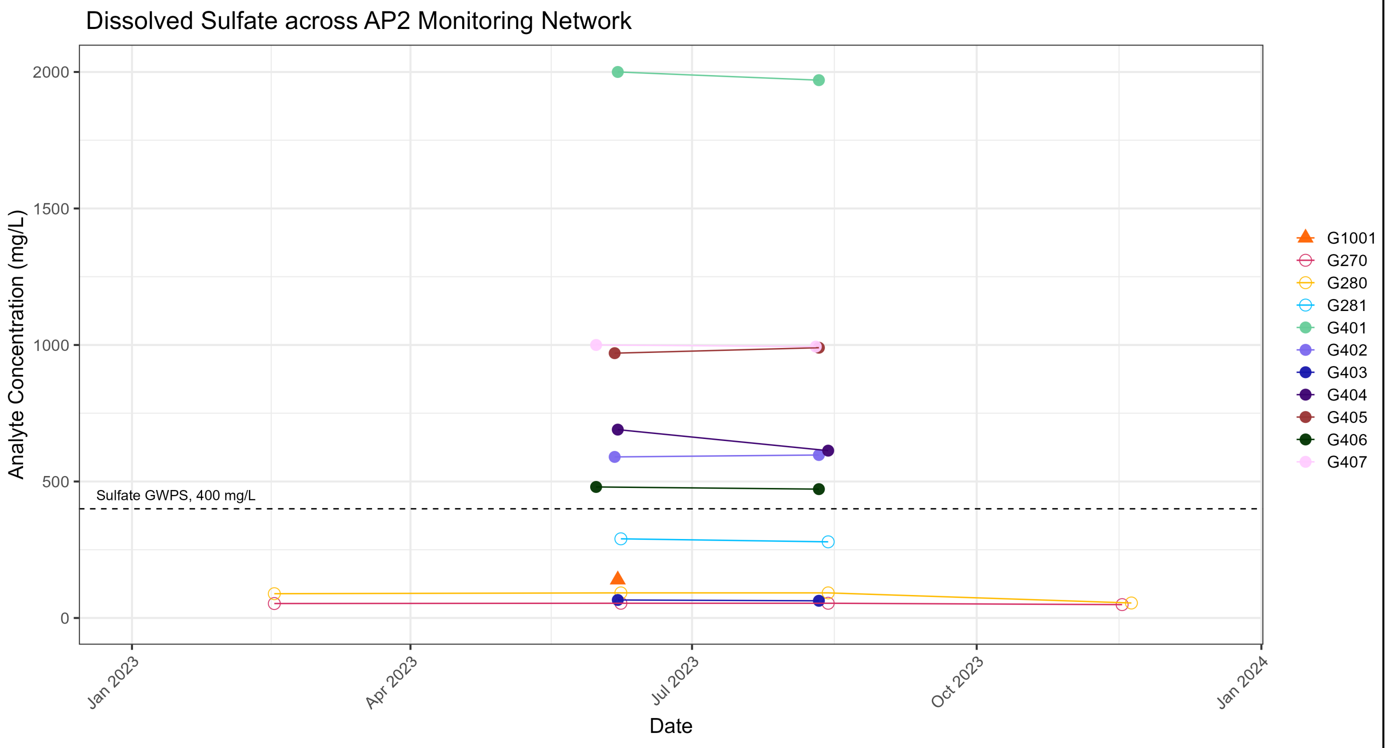
Coffeen Power Plant – Ash Pond No. 2

Geosyntec consultants

Figure
4a

Columbus, Ohio

May 2024



Notes:
mg/L: milligrams per liter
GWPS: Groundwater Protection Standard
Background wells shown with open symbols.

Dissolved Sulfate Concentration Time Series

Coffeen Power Plant – Ash Pond No. 2

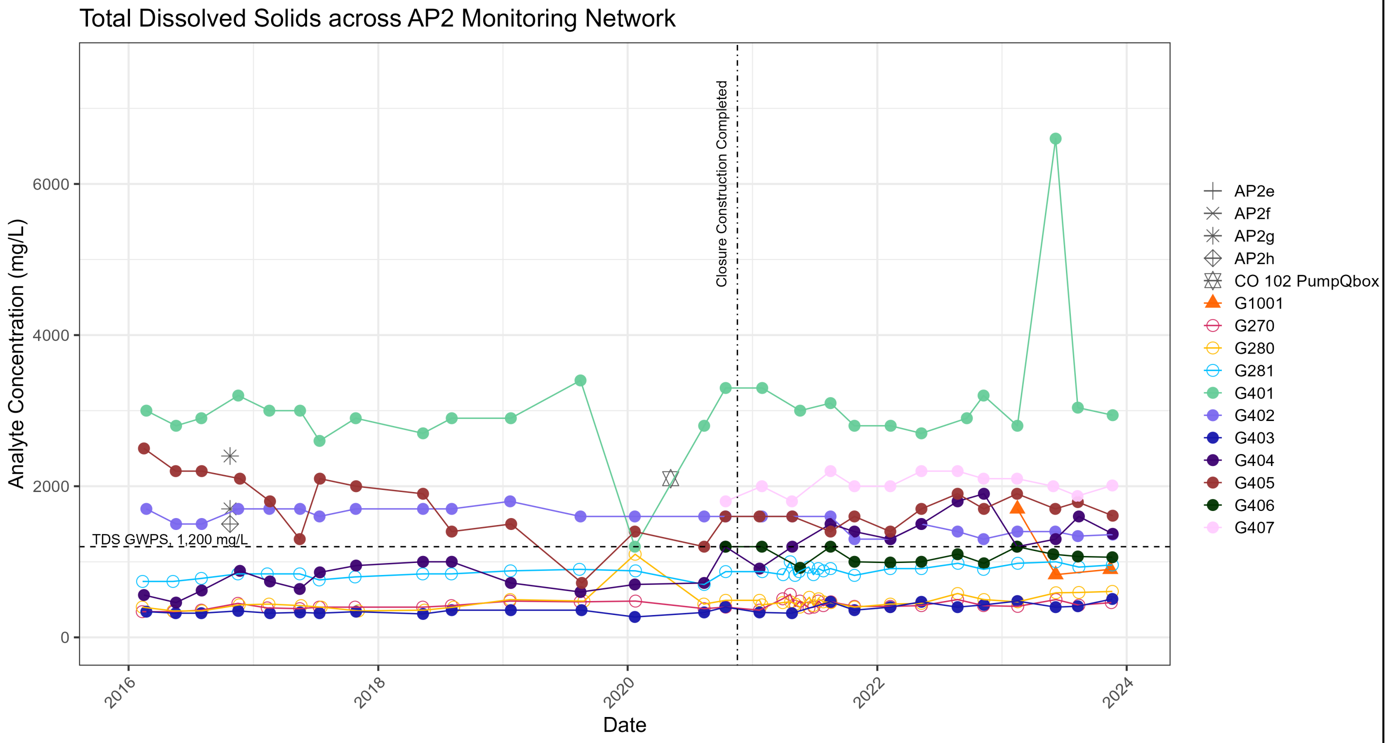
Geosyntec consultants

Figure

4b

Columbus, Ohio

May 2024



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Notes:
mg/L: milligrams per liter
GWPS: Groundwater Protection Standard
Background wells shown with open symbols.

Total Dissolved Solids Concentration Time Series

Coffeen Power Plant – Ash Pond No. 2

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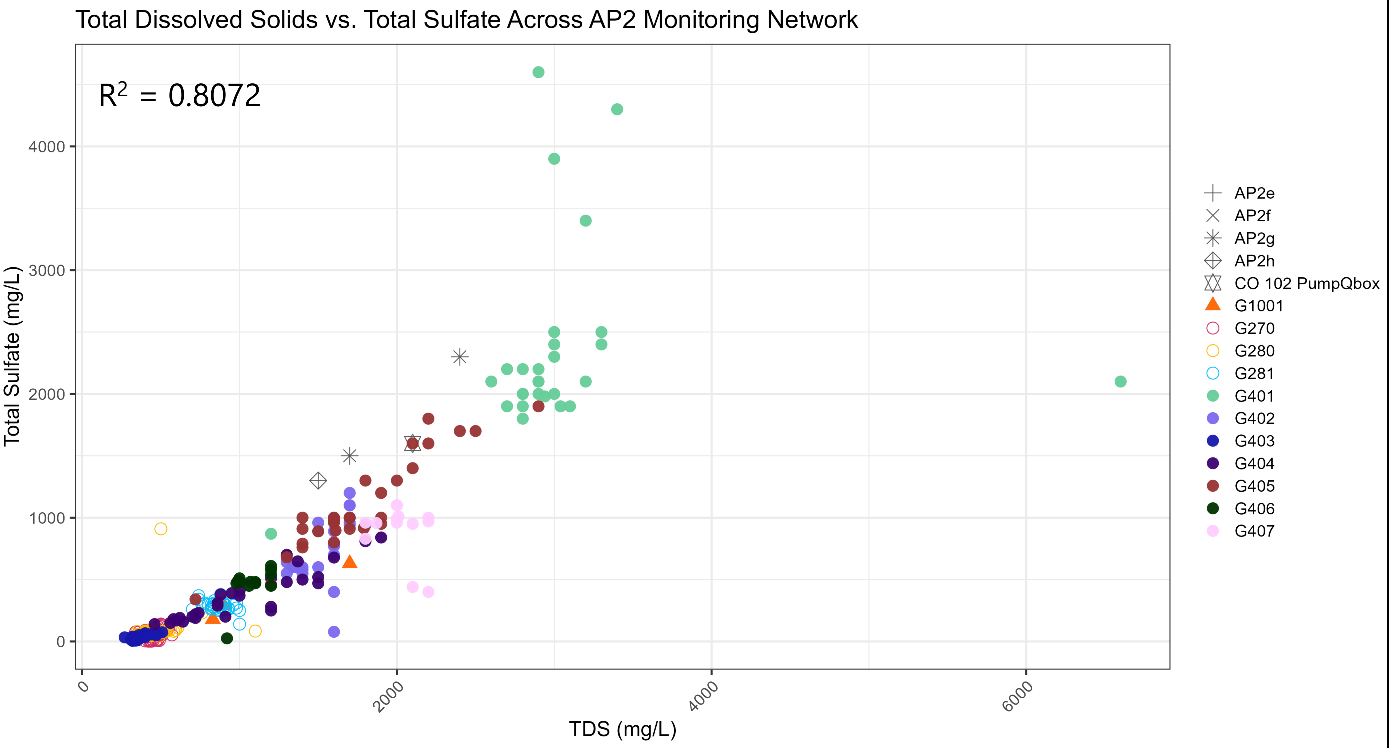
Figure

5



Notes:
mg/L: milligrams per liter
GWPS: Groundwater Protection Standard
Background wells shown with open symbols.
Regression was run using only groundwater results.

TDS Concentration vs Sulfate Concentration

Coffeen Power Plant – Ash Pond No. 2

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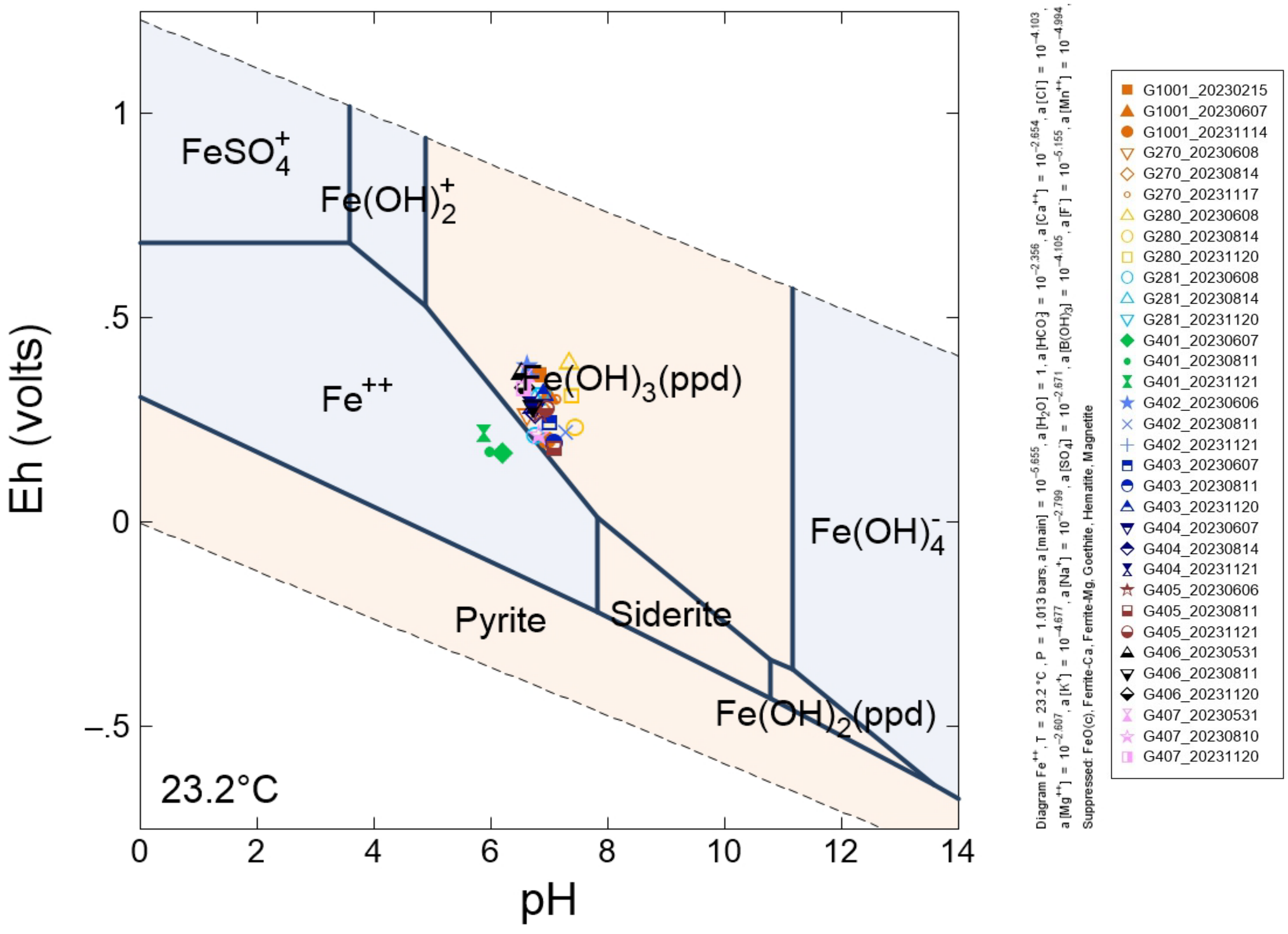
May 2024

Figure

6



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Notes:

1. Diagram was generated using conditions detected at well G402 on 6/6/2023.
2. Well G402 is screened in the uppermost aquifer.
3. The most recent available pH and ORP data for each location are displayed.
4. Ferrite-Ca, ferrite-Mg, goethite, crystalline iron oxide, hematite, and magnetite were suppressed during model generation.

Iron Pourbaix Diagram; Crystalline Phases Suppressed

Coffeen Power Plant – Ash Pond No. 2

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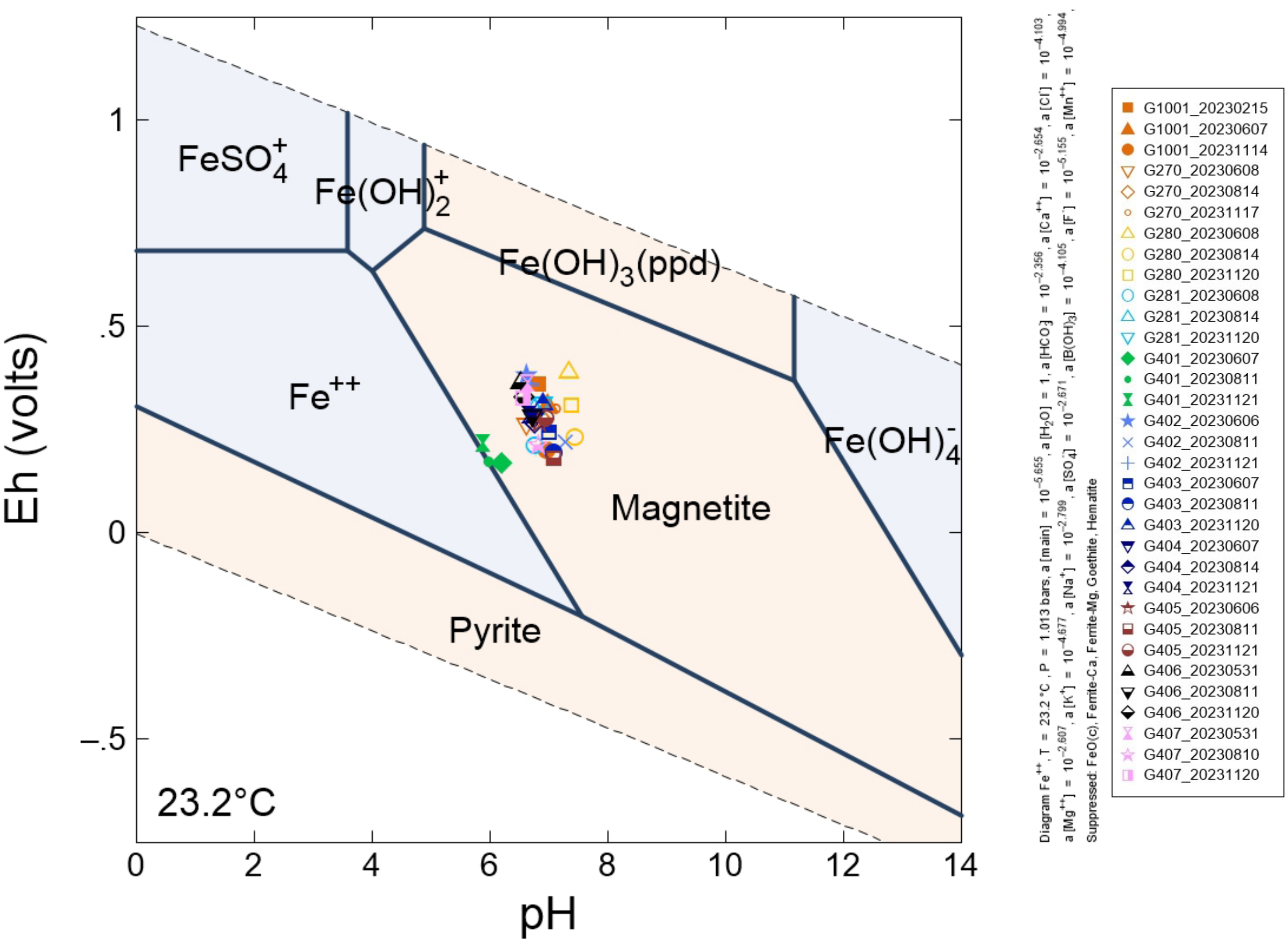
Figure

7a

Columbus, Ohio

March 2024



Notes:

1. Diagram was generated using conditions detected at well G402 on 6/6/2023.
2. Well G402 is screened in the uppermost aquifer.
3. The most recent available pH and ORP data for each location are displayed.
4. Ferrite-Ca, ferrite-Mg, goethite, crystalline iron oxide, and hematite were suppressed during model generation.

Iron Pourbaix Diagram

Coffeen Power Plant – Ash Pond No. 2

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Figure
7b

Columbus, Ohio

March 2024

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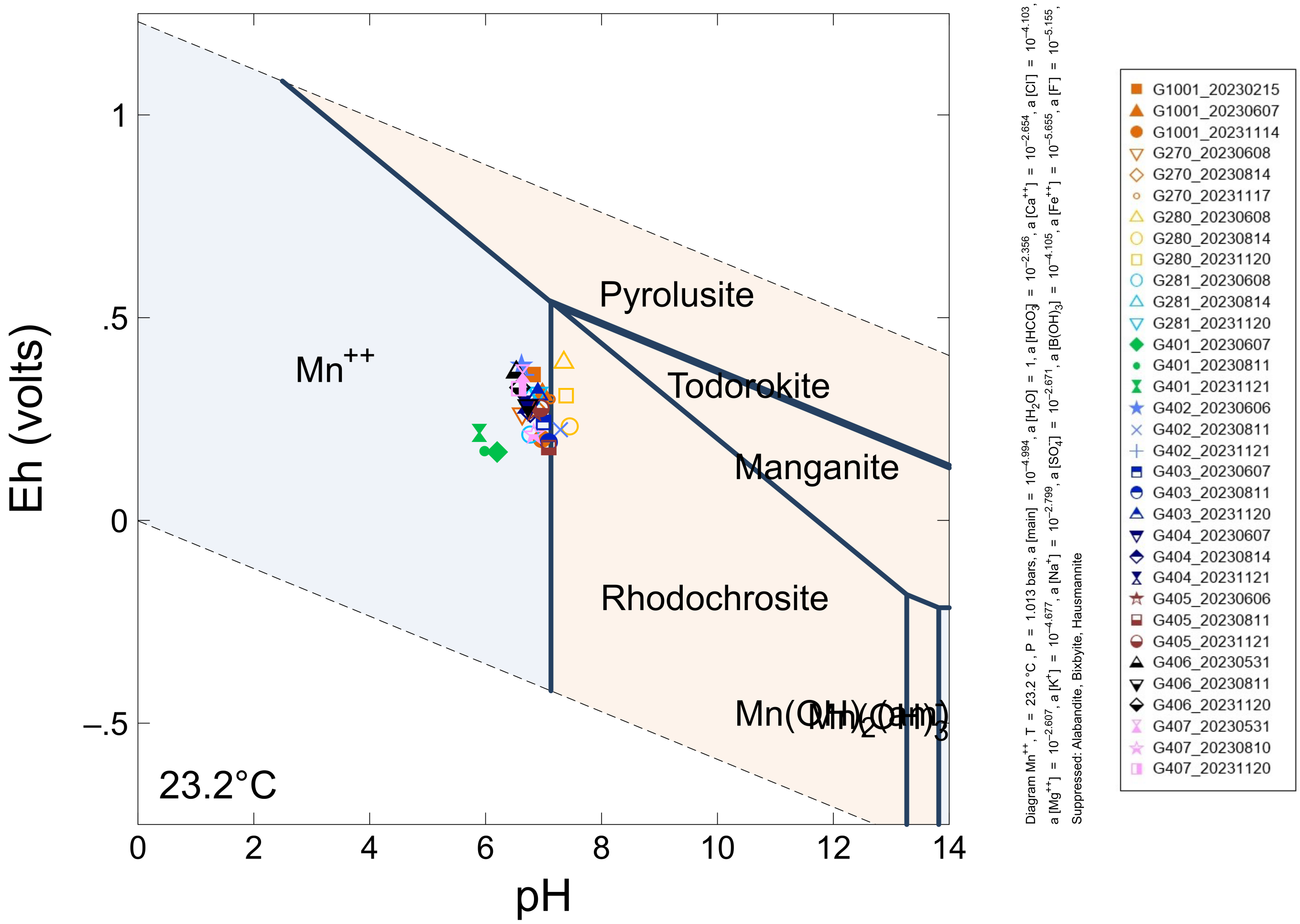

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Notes:
1. Diagram was generated using conditions detected at well G402 on 6/6/2023.
2. Well G402 is screened in the uppermost aquifer.
3. The most recent available pH and ORP data for each location are displayed.
4. Alabandite, bixbyite, and hausmannite were suppressed during model generation.

Manganese Pourbaix Diagram

Coffeen Power Plant – Ash Pond No. 2

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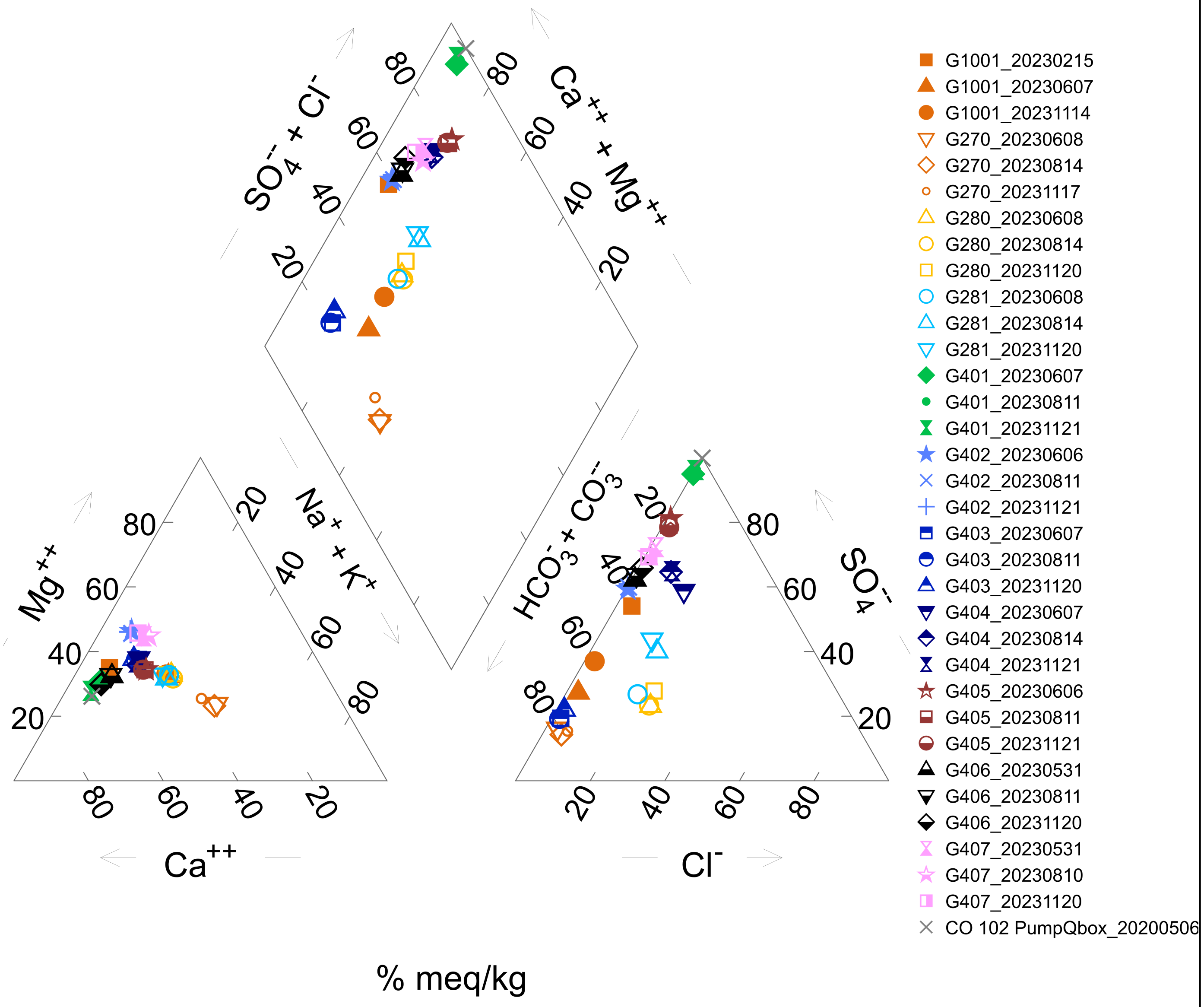
Columbus, Ohio

March 2024

Figure
8



Notes:

1. The three most recent available data points for each location are displayed.
2. Background wells shown with open symbols.

% meq/kg: percent milliequivalents per kilogram

Piper Diagram

Coffeen Power Plant – Ash Pond No. 2

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Figure
9

Columbus, Ohio

March 2024

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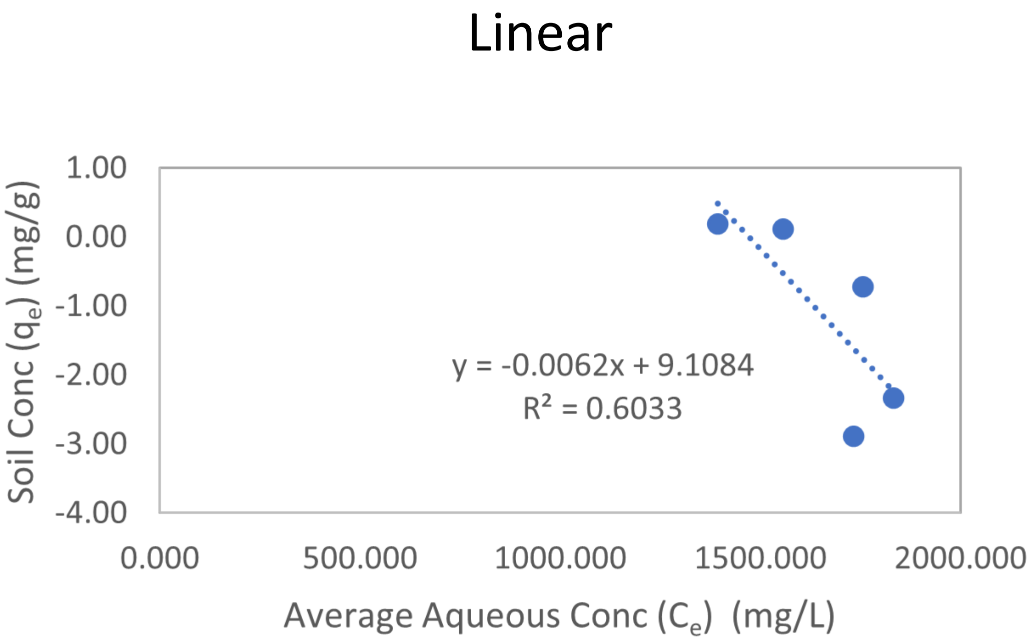

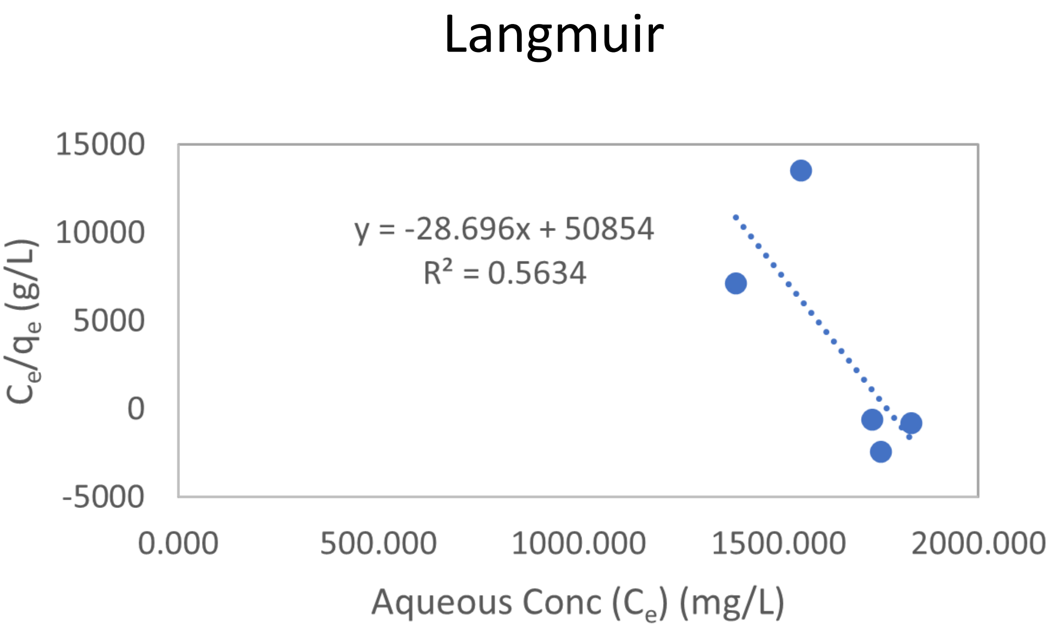

Notes:

1. The Freundlich isotherm was not calculated because the data were not conducive to log transformation.

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

G401 Sulfate Partitioning Coefficients

Coffeen Power Plant – Ash Pond No. 2

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Figure

10a

Columbus, Ohio

March 2024

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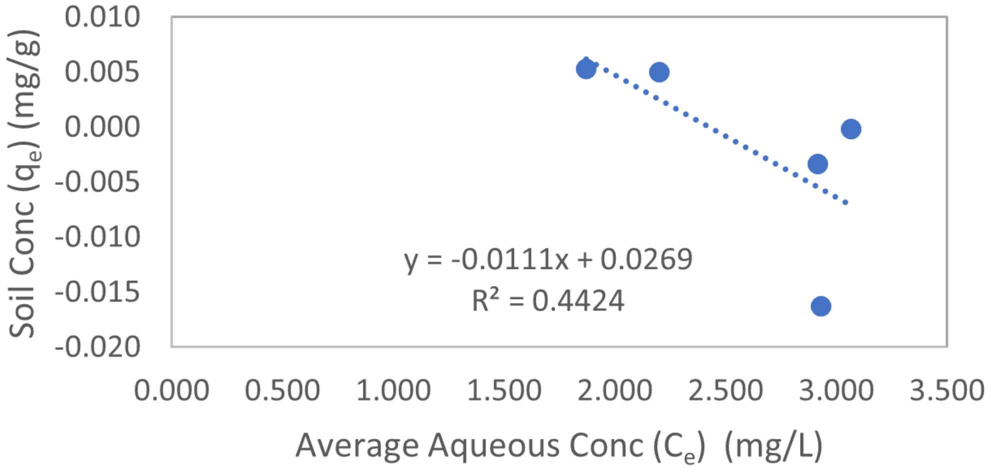
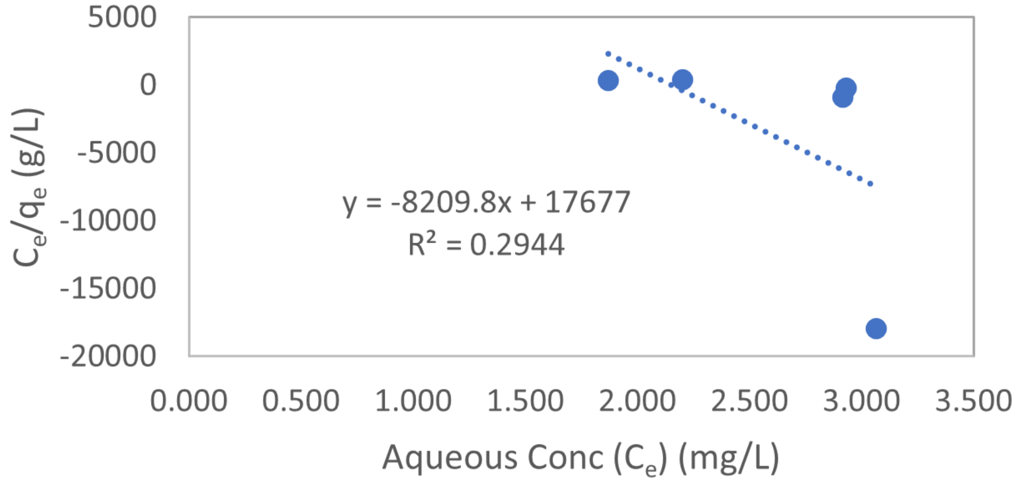
Linear



Langmuir



Notes:

1. The Freundlich isotherm was not calculated because the data were not conducive to log transformation.

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

G401 Boron Partitioning Coefficients

Coffeen Power Plant – Ash Pond No. 2

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March 2024

Figure

10b

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TABLES

Table 1. CEC and LOI of Site Solids
Geochemical Conceptual Site Model
Coffeen Power Plant - Ash Pond No. 2

Well ID	**G270**	**G306**	**G311**	**G313**	**G316**	**G314**	**G314**	**G314**	**G401**	**G407**	**G410**	**G410**	**G307D**
Depth (ft bgs)	**(12-16)**	**(14-16)**	**(14-15)**	**(8-9)**	**(13-14, 15-16)**	**(13-18)**	**(18-23)**	**(38-43)**	**(16-20)**	**(10-13)**	**(11-12)**	**(12.5-13)**	**(4-12.8)**
Well Characterization	**AP2 Background**	**AP1 Background**	**AP1 Adjacent**	**AP1 Compliance**	**AP1 Compliance**	**AP1 Compliance**	**AP1 Compliance**	**AP1 Compliance**	**AP2 Compliance**	**AP2 Compliance**	**AP2 Sidegradient**	**AP2 Sidegradient**	**AP1 Compliance**
Sampled Aquifer Unit	**UA**	**UA**	**UA**	**UA**	**UA**	**LCU**	**LCU**	**DA**	**UA**	**UA**	**UA**	**UA**	**UCU**
Field Boring Log Description	**Silty Sand**	**Sand**	**Sand**	**Sand**	**Sand**	**Sandy to silty till**	**Sandy to silty till**	**Sand and sandy silt/clay**	**Sand to Sandy Clay**	**Sandy to gravelly silt**	**Sandy to gravelly silt**	**Sandy to gravelly silt**	**Clay**
CEC (meq/100 g solid)	-	-	-	-	-	17.84	18.95	14.39	-	11.41	15.39	31.02	18.82
LOI (%)	-	-	-	-	-	12.43	12.33	12.30	-	2.54	3.75	11.96	-
TOC (%)	0.14	0.41	0.77	0.78	0.26	-	-	-	0.08	-	-	-	0.06
AVS (mg/kg)	<0.19	<0.18	0.24	<0.16M	0.28	<0.22	<0.22	<0.22	<0.19	<0.23	<0.23	<0.21	-
Total Carbon (%)	-	1.65	2.76	3.26	0.46	-	-	-	-	-	-	-	-
Sulfur (%)	<0.005	0.01	0.01	0.01	0.01	-	-	-	0.01	-	-	-	0.01
Sulfide (%)	<0.04	<0.04	<0.04	<0.04	<0.04	-	-	-	<0.04	-	-	-	-

Well ID	**G307D**	**G307D**	**G307D**	**G307D**	**G311D**	**G311D**	**G311D**	**G311D**	**G314D**	**G314D**	**G314D**	**G1001**
Depth (ft bgs)	**(12.8-14)**	**(18-34.9)**	**(40-54)**	**(54-60)**	**(4-12)**	**(12-14)**	**(18-42)**	**(44-52)**	**(4.2-17)**	**(17.3-21.6)**	**(21.8-45.5)**	**(6-11)**
Well Characterization	**AP1 Compliance**	**AP1 Compliance**	**AP1 Compliance**	**AP1 Compliance**	**AP1 Adjacent**	**AP1 Adjacent**	**AP1 Adjacent**	**AP1 Adjacent**	**AP1 Compliance**	**AP1 Compliance**	**AP1 Compliance**	**AP2 Compliance**
Sampled Aquifer Unit	**UA**	**UA**	**LCU**	**LCU**	**UCU**	**UA**	**UA**	**LCU**	**UCU/UA**	**UA/LCU**	**LCU**	**LCU**
Field Boring Log Description	**Sand**	**Sandy to gravelly silt**	**Clay**	**Clay**	**Clay**	**Sand and sandy silt/clay**	**Clay**	**Clay**	**Clay with trace sand**	**Clay with trace sand**	**Clay**	**Clay with trace sand**
CEC (meq/100 g solid)	3.32	3.91	8.31	17.24	9.36	9.23	9.61	13.05	9.44	9.72	12.45	-
LOI (%)	-	-	-	-	-	-	-	-	-	-	-	-
TOC (%)	1.12	1.67	1.24	0.11	<0.0318	1.15	1.48	0.06	<0.0498	1.74	0.85	0.85
AVS (mg/kg)	-	-	-	-	-	-	-	-	-	-	-	-
Total Carbon (%)	-	-	-	-	-	-	-	-	-	-	-	-
Sulfur (%)	<0.0066	0.14	0.09	0.01	0.01	0.08	0.08	0.08	0.01	0.11	<0.008	0.03
Sulfide (%)	-	-	-	-	-	-	-	-	-	-	-	0.05

Notes

Sample depth is shown in feet below ground surface (ft bgs)
Dashes indicate sample was not analyzed for analyte
meq/100 g solid: milliequivalents per 100 grams solids
M - Reporting limit elevated due to matrix interference
LOI: loss on ignition
TOC: total organic carbon
AVS: acid volatile sulfides
mg/kg: milligrams per kilogram
AP1: Ash Pond 1
AP2: Ash Pond 2
CCR: Coal combustion residual
UCU: Upper Confining Unit
LCU: Lower Confining Unit
DA: Deep Aquifer
UA: Uppermost Aquifer

Table 2. Bulk Characterization of Site Solids
Geochemical Conceptual Site Model
Coffeen Power Plant - Ash Pond No. 2

Well ID	**G270**	**G306**	**G311**	**G313**	**G316**	**G307D**	**G307D**	**G307D**	**G307D**	**G307D**	**G311D**	**G311D**	**G311D**	**G311D**	**G314D**	**G314D**	**G314D**	**G401**	**G1001**
Depth (ft bgs)	**(12-16)**	**(14-16)**	**(14-15)**	**(8-9)**	**(13-14, 15-16)**	**(4-12.8)**	**(12.8-14)**	**(18-34.9)**	**(40-54)**	**(54-60)**	**(4-12)**	**(12-14)**	**(18-42)**	**(44-52)**	**(4.2-17)**	**(17.3-21.6)**	**(21.8-45.5)**	**(16-20)**	**(6-11)**
Well Characterization	**AP2 Background**	**AP1 Background**	**AP1 Adjacent**	**AP1 Compliance**	**AP1 Compliance**	**AP1 Compliance**	**AP1 Compliance**	**AP1 Compliance**	**AP1 Compliance**	**AP1 Compliance**	**AP1 Adjacent**	**AP1 Adjacent**	**AP1 Adjacent**	**AP1 Adjacent**	**AP1 Compliance**	**AP1 Compliance**	**AP1 Compliance**	**AP2 Compliance**	**AP2 Compliance**
Sampled Aquifer Unit	**UA**	**UA**	**UA**	**UA**	**UA**	**UCU**	**UA**	**UA**	**LCU**	**LCU**	**UCU**	**UA**	**UA**	**LCU**	**UCU/UA**	**UA/LCU**	**LCU**	**UA**	**LCU**
Field Boring Log Description	**Silty Sand**	**Sand**	**Sand**	**Sand**	**Sand**	**Clay**	**Sand**	**Sandy to gravelly silt**	**Clay**	**Clay**	**Clay**	**Sand and sandy silt/clay**	**Clay**	**Clay**	**Clay with trace cand**	**Clay with trace sand**	**Clay**	**Sand to Sandy Clay**	**Clay with trace sand**
Analyte	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Aluminum	9600	13000	11000	31000	32000	-	-	-	-	-	-	-	-	-	-	-	-	9700	8200
Antimony	<0.8	<0.8	<0.8	<0.8	<0.8	<2.6	<2	<2.6	<2.8	<2.4	<3	<3.2	<3	<2.8	<2.8	<3	<2.4	<0.8	<0.8
Arsenic	12	6.7	2.7	5.6	5.1	7.5	1.7	2.9	5.7	4.2	3.2	3.5	2.8	3.2	1.3	2.7	3.8	5.5	6.2
Barium	210	98	58	310	320	150	10	20	93	110	57	44	69	90	63	27	140	190	120
Beryllium	0.48	0.5	0.4	0.7	0.7	<0.86	<0.66	<0.87	<0.93	<0.79	<1	<1.1	<1	<0.95	<0.93	<1	<0.8	0.35	0.45
Bismuth	0.18	0.1	0.1	0.1	0.1	-	-	-	-	-	-	-	-	-	-	-	-	0.25	0.23
Boron	5	-	-	-	-	<8.6	<6.6	<8.7	<9.3	<7.9	<10	<11	<10	<9.5	<9.3	<10	<8	4	6
Cadmium	0.12	0.1	0.1	0.2	0.1	1.2	<0.66	<0.87	<0.93	<0.79	<1	<1.1	<1	<0.95	<0.93	<1	<0.8	0.03	0.13
Calcium	5000	35000	52000	69000	10000	-	-	-	-	-	-	-	-	-	-	-	-	1900	42000
Chloride	-	-	-	-	-	<10	19	<10	<10	<10	<1	<1	<1	<1	<10	<10	<10	-	-
Chromium	16	130.0	100.0	130.0	150.0	9.5	3.8	8.5	10.0	8.5	10.0	8.0	10.0	12.0	8.7	9.9	25.0	14	15
Cobalt	10	6.0	4.0	7.0	4.0	25.0	1.4	4.5	7.1	6.0	3.1	4.0	5.0	5.9	<1.9	5.2	10.0	6.1	8.8
Copper	12	14	10	12	10	-	-	-	-	-	-	-	-	-	-	-	-	7.8	11
Fluoride	-	-	-	-	-	3.1	<2.5	<2.5	4.2	6.8	<0.25	<0.25	<0.25	<0.25	<2.5	<2.5	3.1	-	-
Iron	22000	-	-	-	-	20000	4900	11000	10000	19000	10000	8600	11000	12000	4900	11000	21000	14000	16000
Lead	12	9.0	7.0	11.0	12.0	15.0	3.3	5.9	7.7	7.2	8.1	5.4	6.9	8.7	5.5	7.3	11.0	9.5	11
Lithium	11	11.0	11.0	19.0	14.0	<4.3	<3.3	10.0	7.1	6.8	<5	6.4	8.4	10.0	<4.6	9.1	28.0	7	9
Magnesium	4700	15000	27000	35000	6700	-	-	-	-	-	-	-	-	-	-	-	-	1600	18000
Manganese	1200	470	310	1200	260	3100	120	290	430	470	110	250	290	380	34	320	370	54	450
Mercury	-	-	-	-	-	<0.17	<0.13	<0.17	<0.19	<0.16	<0.2	<0.21	<0.2	<0.19	<0.19	<0.2	<0.16	-	-
Molybdenum	0.8	5.8	2.7	1.6	8.1	1.3	<0.66	<0.87	1.4	<0.79	<1	1.2	1.2	1.3	<0.93	1.2	<0.8	0.4	1.5
Nickel	20	15	11	17	13	-	-	-	-	-	-	-	-	-	-	-	-	10	15
Nitrogen (total)	-	-	-	-	-	160	<63	260	360	310	510	360	370	530	140	360	260	-	-
Potassium	1400	3700	3600	13000	14000	-	-	-	-	-	-	-	-	-	-	-	-	770	1100
Selenium	<0.7	<0.7	<0.7	<0.7	<0.7	<0.86	<0.66	<0.87	<0.93	<0.79	<1	<1.1	<1	<0.95	<0.93	<1	1.0	<0.7	<0.7
Silver	< 0.05	<0.5	<0.5	<0.5	<0.5	-	-	-	-	-	-	-	-	-	-	-	-	< 0.05	< 0.05
Sodium	110	590	830	6000	6400	-	-	-	-	-	-	-	-	-	-	-	-	80	110
Strontium	10	26	35	100	89	-	-	-	-	-	-	-	-	-	-	-	-	9.1	35
Sulfate	-	-	-	-	-	220	170	30	<10	<10	2	<1	<1	<1	76	210	<10	-	-
Thallium	0.16	0.2	0.1	0.3	0.3	<0.86	<0.66	<0.87	<0.93	<0.79	<1	<1.1	<1	<0.95	<0.93	<1	<0.8	0.12	0.16
Tin	< 0.5	<6	<6	<6	<6	-	-	-	-	-	-	-	-	-	-	-	-	< 0.5	0.6
Titanium	230	370	320	1500	1200	-	-	-	-	-	-	-	-	-	-	-	-	65	170
Uranium	1.46	0.5	0.6	1.0	1.0	-	-	-	-	-	-	-	-	-	-	-	-	0.39	0.82
Vanadium	22	28	20	35	29	-	-	-	-	-	-	-	-	-	-	-	-	14	19
Yttrium	9.4	9	8	11	10	-	-	-	-	-	-	-	-	-	-	-	-	8.2	8.1
Zinc	50	35	27	41	34	-	-	-	-	-	-	-	-	-	-	-	-	28	35

Notes:
Sample depth is shown in feet below ground surface (ft bgs)
Dashes indicate analyte was not reported by lab for sample
Non-detect values are shown as less than the reporting limit
mg/kg: milligrams per kilogram
AP1: Ash Pond 1
AP2: Ash Pond 2
CCR: Coal Combustion Residual
UCU: Upper Confining Unit
LCU: Lower Confining Unit
UA: Uppermost Aquifer

Table 3. XRF Analysis of Site Solids
Geochemical Conceptual Site Model
Coffeen Power Plant - Ash Pond No. 2

Well ID	**G314**	**G314**	**G314**	**G407**	**G410**	**G410**
Depth (ft bgs)	**(13-18)**	**(18-23)**	**(38-43)**	**(10-13)**	**(11-12)**	**(12.5-13)**
Well Characterization	**AP1 Compliance**	**AP1 Compliance**	**AP1 Compliance**	**AP2 Compliance**	**AP2 Sidegradient**	**AP2 Sidegradient**
Sampled Aquifer Unit	**LCU**	**LCU**	**DA**	**UA**	**UA**	**UA**
Field Boring Log Description	**Sandy to silty till**	**Sandy to silty till**	**Sand and sandy silt/clay**	**Sandy to gravelly silt**	**Sandy to gravelly silt**	**Sandy to gravelly silt**
Analyte	(wt %)	(wt %)	(wt %)	(wt %)	(wt %)	(wt %)
Al_2O_3	8.36	8.41	8.35	6.73	8.14	4.92
CaO	6.73	6.72	6.69	0.52	1.04	9.10
Cr_2O_3	<0.01	0.02	0.02	0.01	<0.01	<0.01
Fe_2O_3	3.19	3.48	3.71	2.08	2.77	1.69
K_2O	1.88	1.88	1.89	2.01	2.42	1.59
MgO	3.71	3.66	3.62	0.54	0.77	4.44
Mn_3O_4	0.07	0.07	0.07	0.03	0.13	0.08
Na_2O	0.79	0.80	0.77	0.82	0.85	0.69
P_2O_5	0.07	0.08	0.08	0.06	0.06	0.05
SiO_2	62.07	61.80	61.72	84.59	80.21	64.55
TiO_2	0.49	0.50	0.50	0.36	0.40	0.26
V_2O_5	0.01	<0.01	0.01	<0.01	0.01	<0.01

Notes

Sample depth is shown in feet below ground surface (ft bgs).
Non-detect values are shown as less than the reporting limit.
Results are not normalized to 100%, with some portion of sample mass uncharacterized.
Analytes are presented as the respective oxide species of the element of interest, consistent with the sample processing prior to analysis.
wt %: percentage by weight
AP1: Ash Pond 1
AP2: Ash Pond 2
LCU: Lower Confining Unit
DA: Deep Aquifer
UA: Upper Aquifer

Table 4. XRD Analysis of Site Solids
Geochemical Conceptual Site Model
Coffeen Power Plant - Ash Pond No. 2

Well ID			**G270**	**G306**	**G311**	**G313**	**G316**	**G314**	**G314**	**G314**	**G401**
Depth (ft bgs)			**(12-16)**	**(14-16)**	**(14-15)**	**(8-9)**	**(13-14, 15-16)**	**(13-18)**	**(18-23)**	**(38-43)**	**(16-20)**
Well Characterization			**AP2 Background**	**AP1 Background**	**AP1 Adjacent**	**AP1 Compliance**	**AP1 Compliance**	**AP1 Compliance**	**AP1 Compliance**	**AP1 Compliance**	**AP2 Compliance**
Sampled Aquifer Unit			**UA**	**UA**	**UA**	**UA**	**UA**	**LCU**	**LCU**	**DA**	**UA**
Field Boring Log Description			**Silty Sand**	**Sand**	**Sand**	**Sand**	**Sand**	**Sandy to silty till**	**Sandy to silty till**	**Sand and sandy silt/clay**	**Sand to Sandy Clay**
Mineral/Compound	**Formula**	**Mineral Type**	(wt %)	(wt %)	(wt %)	(wt %)	(wt %)	(wt %)	(wt %)	(wt %)	(wt %)
Quartz	SiO_2	Silicate	60.6	70.9	58.9	51.3	67.6	53.9	67.5	73.5	68.9
Dolomite	$CaMg(CO_3)_2$	Carbonate	0.6	3.5	12.1	15.7	1.9	13.3	0.5	0.0	-
Calcite	$CaCO_3$	Carbonate	-	0.5	2.5	4.1	-	4.1	0.4	-	-
Ankerite	$CaFe(CO_3)_2$	Carbonate	0.5	2.1	5.0	7.7	0.8	7.2	1.2	0.5	0.1
Kutnohorite	$CaMn(CO_3)_2$	Carbonate	-	-	-	-	-	0.5	0.3	0.2	-
Albite	$NaAlSi_3O_8$	Feldspar	9.1	9.6	8.6	7.9	9.6	6.1	8.3	8.2	8.6
Microcline	$KAlSi_3O_8$	Feldspar	9.8	8.5	7.4	7.6	9.8	5.1	9.7	7.8	7.8
Actinolite	$Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2$	Amphibole	3.3	-	-	-	-	0.3	0.7	0.8	1.4
Diopside	$CaMgSi_2O_6$	Pyroxene	1.3	3.1	3.8	4.6	1.3	1.0	0.7	0.7	1.4
Magnetite	Fe_3O_4	Oxide	-	-	-	-	-	-	0.2	0.0	-
Pyrite	FeS_2	Sulfide	0.2	-	-	-	-	-	-	-	-
Biotite	$K(Mg,Fe)_3(AlSi_3O_{10})(OH)_2$	Mica	2.4	-	-	-	-	-	-	-	2.1
Muscovite	$KAl_2(AlSi_3O_{10})(OH)_2$	Mica	9.0	-	-	-	7.3	1.0	4.8	3.3	6.8
Clay Minerals											
Montmorillonite	$(Na,Ca)_{0.3}(Al,Mg)_2Si_4O_{10}(OH)_2\cdot 10H_2O$	Clay	-	-	-	-	-	1.1	1.0	1.1	-
Illite	$(K,H_3O)(Al,Mg,Fe)_2(Si,Al)_4O_{10}[(OH)_2,(H_2O)]$	Clay	-	-	-	-	-	4.0	2.0	1.7	-
Illite-Montmorillonite	$KAl_4(Si,Al)_8O_{20}(OH)_4\cdot 8H_2O$	Clay	-	-	-	-	-	-	-	-	-
Kaolinite	$Al_2Si_2O_5(OH)_4$	Clay	-	-	-	-	-	0.7	1.1	0.7	-
Stilpnomelane	$K(Fe^{2+},Mg,Fe^{3+})_8(Si,Al)_{12}(O,OH)_{27}\cdot n(H_2O)$	Sheet silicate	2.0	-	-	-	-	-	-		2.7
Chlorite	$(Fe,(Mg,Mn)_5,Al)(Si_3Al)O_{10}(OH)_8$	Sheet silicate	1.4	1.8	1.7	1.1	1.7	1.6	1.7	1.5	-
Clay Minerals Total			3.4	1.8	1.7	1.1	1.7	7.4	5.8	5.0	2.7

Notes

Dashes indicate mineral was not identified by lab

Sample depth is shown in feet below ground surface (ft bgs).

ft bgs: feet below ground surface

wt %: percentage by weight

AP1: Ash Pond 1

AP2: Ash Pond 2

LCU: Lower Confining Unit

DA: Deep Aquifer

UA: Uppermost Aquifer

Table 4. XRD Analysis of Site Solids
Geochemical Conceptual Site Model
Coffeen Power Plant - Ash Pond No. 2

Well ID			**G407**	**G410**	**G410**	**G1001**
Depth (ft bgs)			**(10-13)**	**(11-12)**	**(12.5-13)**	**(6-11)**
Well Characterization			**AP2 Compliance**	**AP2 Sidegradient**	**AP2 Sidegradient**	**AP2 Compliance**
Sampled Aquifer Unit			**UA**	**UA**	**UA**	**LCU**
Field Boring Log Description			**Sandy to gravelly silt**	**Sandy to gravelly silt**	**Sandy to gravelly silt**	**Clay with trace sand**
Mineral/Compound	**Formula**	**Mineral Type**	(wt %)	(wt %)	(wt %)	(wt %)
Quartz	SiO_2	Silicate	51.2	50.7	50.5	46.3
Dolomite	$CaMg(CO_3)_2$	Carbonate	6.0	7.6	8.1	11.3
Calcite	$CaCO_3$	Carbonate	2.4	2.6	2.8	4.2
Ankerite	$CaFe(CO_3)_2$	Carbonate	9.4	8.4	8.1	1.5
Kutnohorite	$CaMn(CO_3)_2$	Carbonate	0.1	-	0.2	-
Albite	$NaAlSi_3O_8$	Feldspar	6.8	7.4	7.5	10.4
Microcline	$KAlSi_3O_8$	Feldspar	7.2	5.9	5.8	7.8
Actinolite	$Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2$	Amphibole	0.5	0.6	0.6	0.9
Diopside	$CaMgSi_2O_6$	Pyroxene	0.4	0.5	0.7	0.8
Magnetite	Fe_3O_4	Oxide	0.1	0.1	0.2	-
Pyrite	FeS_2	Sulfide	-	-	-	0.1
Biotite	$K(Mg,Fe)_3(AlSi_3O_{10})(OH)_2$	Mica	-	-	-	2.4
Muscovite	$KAl_2(AlSi_3O_{10})(OH)_2$	Mica	5.5	4.4	4.3	10.3
Montmorillonite	$(Na,Ca)_{0.3}(Al,Mg)_2Si_4O_{10}(OH)_2 \cdot 10H_2O$	Clay	3.2	3.2	2.9	-
Illite	$(K,H_3O)(Al,Mg,Fe)_2(Si,Al)_4O_{10}[(OH)_2,(H_2O)]$	Clay	3.3	3.0	2.9	-
Illite-Montmorillonite	$KAl_4(Si,Al)_8O_{20}(OH)_4 \cdot 8H_2O$	Clay	-	1.3	1.7	-
Kaolinite	$Al_2Si_2O_5(OH)_4$	Clay	0.9	0.6	0.6	-
Stilpnomelane	$K(Fe^{2+},Mg,Fe^{3+})_8(Si,Al)_{12}(O,OH)_{27} \cdot n(H_2O)$	Sheet silicate	-	-	-	2.6
Chlorite	$(Fe,(Mg,Mn)_5,Al)(Si_3Al)O_{10}(OH)_8$	Sheet silicate	3.0	3.9	3.2	1.5
Clay Minerals Total			10.4	12.0	11.3	4.1

Notes

Dashes indicate mineral was not identified by lab

Sample depth is shown in feet below ground surface (ft bgs).

ft bgs: feet below ground surface

wt %: percentage by weight

AP1: Ash Pond 1

AP2: Ash Pond 2

LCU: Lower Confining Unit

DA: Deep Aquifer

UA: Uppermost Aquifer

Table 5. AP2 Porewater Chemistry
Geochemical Conceptual Site Model
Coffeen Power Plant - Ash Pond No. 2

Location Name		**AP2e**	**AP2f**	**AP2g**	**AP2h**	**CO 102 PumpQbox**
Sample Date		**2016/10/24**	**2016/10/24**	**2016/10/24**	**2016/10/24**	**2020/05/06**
Total Boron	(mg/L)	5.3	2	4.3	14	2.6
Dissolved Iron	(mg/L)	-	-	-	-	530
Total Iron	(mg/L)	-	-	-	-	530
Dissolved Manganese	(mg/L)	-	-	-	-	3.2
Total Manganese	(mg/L)	-	-	-	-	3.2
pH	(SU)	6.5	6.4	6.5	7.2	4.82Q
Total Sulfate	(mg/L)	1500	1500	2300	1300	1600
Total Dissolved Solids	(mg/L)	1700	1700	2400	1500	2100
Total Lithium	(mg/L)	0.19	0.13	0.18	0.12	0.14
Dissolved Cobalt	(mg/L)	-	-	-	-	0.0041

Notes

Q - Analysis performed after the acceptable holding time window

SU: standard units

mg/L: milligrams per liter

- : Analyte not included in analyses for sampling date

Table 6. AP2 Eh-pH Diagram Inputs
Geochemical Conceptual Site Model
Coffeen Power Plant - Ash Pond No. 2

Well ID		**G402**
Sample Date		**6/6/2023**
Aquifer Unit		**UA**
Input Parameter	**Unit**	
Temperature	°C	23.2
pH	SU	6.62
Calcium	mg/L	210
Chloride	mg/L	3.4
Bicarbonate Alkalinity	mg/L	500
Magnesium	mg/L	130
Sodium	mg/L	44
Potassium	mg/L	1
Sulfate	mg/L	580
Total Manganese	mg/L	1.3
Total Iron	mg/L	3.5

Notes

°C - degrees Celsius

mg/L - milligrams per liter

SU - standard units

UA - uppermost aquifer

Table 7. Total and Dissolved Aqueous Iron and Manganese Results
Geochemical Conceptual Site Model
Coffeen Power Plant - Ash Pond No. 2

Well ID	Well Characterization	Sampled Aquifer Unit	Date	Total Iron	Dissolved Iron	Total Manganese	Dissolved Manganese
				(mg/L)	(mg/L)	(mg/L)	(mg/L)
G1001	AP2 Compliance	LCU	2023/06/07	0.12	<0.01	0.19	0.14
G270	AP2 Background	UA	2023/06/08	0.68	0.044	0.85	0.079
			2023/08/14	0.147	0.019	0.244	0.157
			2023/11/17	0.119	0.0115	0.197	0.0675
G280	AP2 Background	UA	2023/06/08	0.97	0.0061	0.043	0.0014
			2023/08/14	0.264	<0.0175	0.0159	0.0032
			2023/11/20	0.31	0.0115	0.0452	0.0123
G281	AP2 Background	UA	2023/06/08	0.88	0.016	0.7	0.31
			2023/08/14	0.194	<0.0175	0.352	0.291
G401	AP2 Compliance	UA	2023/06/07	60	84	22	27
			2023/08/11	101	93.8	28.8	36
G402	AP2 Compliance	UA	2023/06/06	3.5	0.0033	1.3	0.86
			2023/08/11	3.58	<0.0115	1.2	0.867
G403	AP2 Compliance	UA	2023/06/07	0.23	0.011	0.4	0.36
			2023/08/11	0.284	0.0763	0.486	0.376
G404	AP2 Compliance	UA	2023/06/07	0.11	0.058	1.3	1.2
			2023/08/14	3.42	0.0718	5.42	2.85
G405	AP2 Compliance	UA	2023/06/06	0.31	0.13	1.1	1.1
			2023/08/11	0.239	0.165	1.15	1.07
G406	AP2 Compliance	UA	2023/05/31	0.012	<0.00072	4.5	4.4
			2023/08/11	0.016	<0.0115	4.76	4.45
G407	AP2 Compliance	UA	2023/05/31	0.073	0.01	0.42	0.38
			2023/08/10	0.0501	0.015	0.285	0.445

Notes

mg/L: milligrams per liter

Non-detect values are shown as less than the reporting limit.

AP2: Ash Pond 2

LCU: Lower Confining Unit

UA: Uppermost Aquifer

Table 8. Batch Attenuation Testing Results, G401
Geochemical Conceptual Site Model
Coffeen Power Plant - Ash Pond No. 2

Groundwater Sample ID	Geologic Material Sample ID	Treatment	Actual Ratio	Date	Day	Replicate	Dissolved Boron	Dissolved Sulfate	pH	ORP
							mg/L	**mg/L**	**SU**	**mV**
G401	--	Groundwater Only Control		19-Aug-21	0	G401-1a	2.6	1,677	3.15	518
						G401-2b	1.9	1,597	3.15	520
						Average Concentration (mg/L)	**2.2**	**1,637**	**3.15**	**519**
				26-Aug-21	7	G401-1	3.2	1,713	3.05	312
						G401-2	3.2	1,618	2.95	369
						Average Concentration (mg/L)	**3.2**	**1,666**	**3.00**	**341**
G401	G270 (12-16 bgs)	2:1 Soil:Water Ratio	2:1.6	19-Aug-21	0					
				26-Aug-21	7	G270:G401 2:1-1	1.8	1,356	6.35	156
						G270:G401 2:1-2	1.9	1,431	6.48	160
						Average Concentration (mg/L)	**1.9**	**1,394**	**6.42**	**158**
		1:1 Soil:Water Ratio	1:1.4	19-Aug-21	0					
				26-Aug-21	7	G270:G401 1:1-1	2.2	1,456	6.42	170
						G270:G401 1:1-2	2.2	1,658	6.46	174
						Average Concentration (mg/L)	**2.2**	**1,557**	**6.44**	**172**
		1:5 Soil:Water Ratio	1:6.1	19-Aug-21	0					
				26-Aug-21	7	G270:G401 1:5-1	3.2	1,708	6.33	347
						G270:G401 1:5-2	3.0	1,805	6.20	327
						Average Concentration (mg/L)	**3.1**	**1,756**	**6.27**	**337**
		1:10 Soil:Water Ratio	1:12.0	19-Aug-21	0					
				26-Aug-21	7	G270:G401 1:10-1	2.7	1,881	6.10	312
						G270:G401 1:10-2	3.1	1,785	6.05	299
						Average Concentration (mg/L)	**2.9**	**1,833**	**6.08**	**306**
		1:20 Soil: Water Ratio	1:29.9	19-Aug-21	0					
				26-Aug-21	7	G270:G401 1:20-1	2.9	1,784	6.05	285
						G270:G401 1:20-2	3.0	1,683	5.86	275
						Average Concentration (mg/L)	**2.9**	**1,734**	**5.96**	**280**

Notes
ID - identification
mg/L - milligrams per liter
mV - millivolts
SU - Standard Units
ORP - oxidation/reduction potential

Table 9. Partition Coefficient Results, G401
Geochemical Conceptual Site Model
Coffeen Power Plant - Ash Pond No. 2

Materials	Analyte	Isotherm	Variable	Value
G401/G270	Boron	Linear	R^2	0.442
			K_D (L/kg)	-11.08
		Langmuir	R^2	0.294
			q_m (mg/g)	0.000
			K_L (L/kg)	-4.64E+05
		Freundlich	R^2	--
			1/n	--
			K_F (L/kg)	--
	Sulfate	Linear	R^2	0.603
			K_D (L/kg)	-6.18
		Langmuir	R^2	0.563
			q_m (mg/g)	-0.035
			K_L (L/kg)	-5.64E+02
		Freundlich	R^2	--
			1/n	--
			K_F (L/kg)	--

Notes

-- - Freundlich isotherm not calculated because the data were not conducive to log transformation

K_D - linear partition coefficient

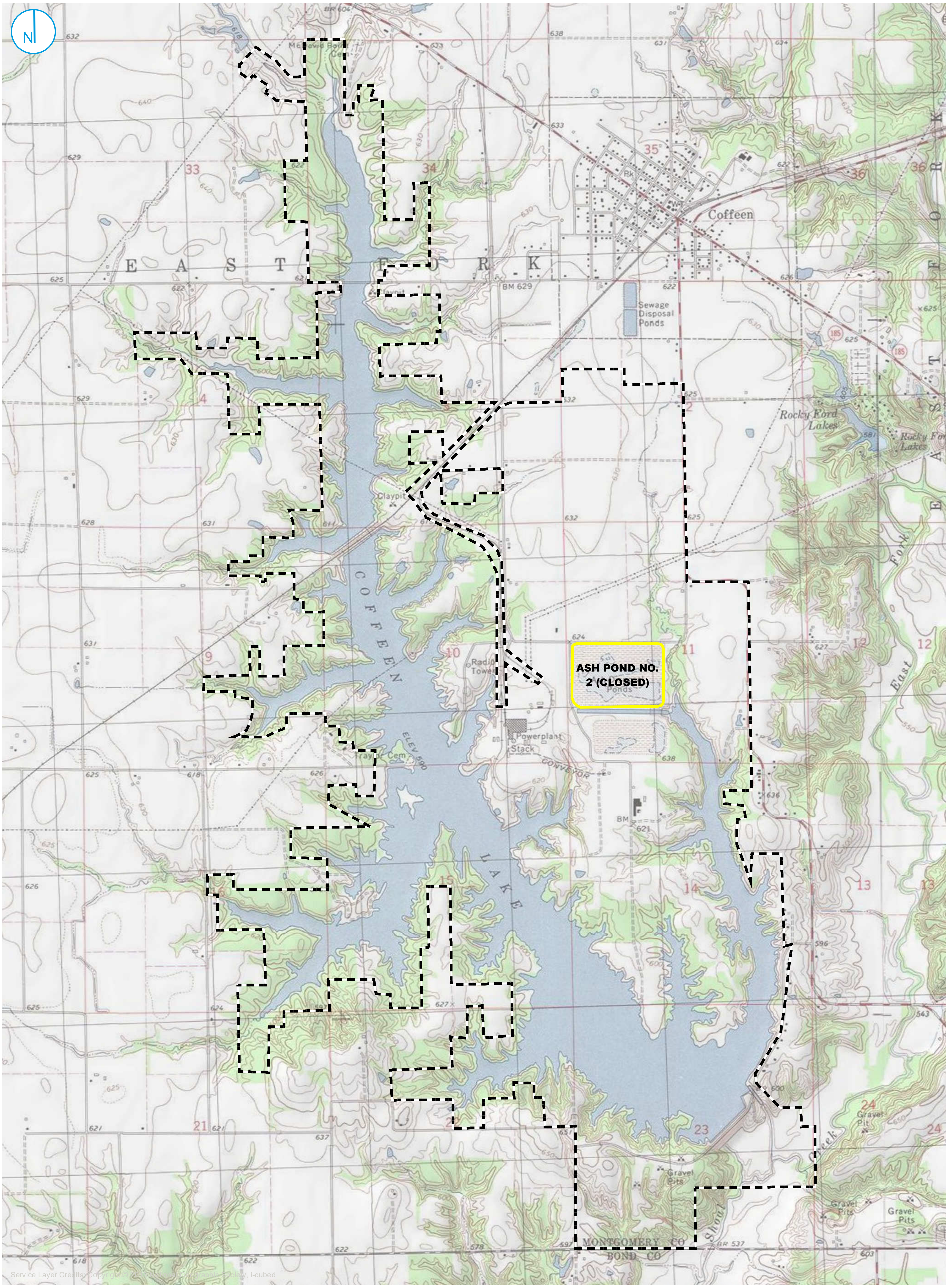
K_L - Langmuir partition coefficient

K_F - Freundlich partition coefficient

q_m - inverse of the slope of the linearized Langmuir isotherm

n - non-linearity constant of the Freundlich isotherm

Attachment A
Site Layout Figure



▭ REGULATED UNIT (SUBJECT UNIT)

⬚ PROPERTY BOUNDARY

0 1,000 2,000
Feet

SITE LOCATION MAP

FIGURE 2-1

NATURE AND EXTENT REPORT
ASH POND NO. 2
COFFEEN POWER PLANT
COFFEEN, ILLINOIS

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Attachment B

Proposed Part 845 Groundwater Monitoring Network

Service Layer Credits: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

- COMPLIANCE MONITORING WELL
- BACKGROUND MONITORING WELL
- STAFF GAGE, RIVER
- REGULATED UNIT (SUBJECT UNIT)
- SITE FEATURE
- LIMITS OF FINAL COVER
- PROPERTY BOUNDARY

0 275 550
Feet

MONITORING WELL LOCATION MAP

FIGURE 2-2

NATURE AND EXTENT REPORT
ASH POND NO. 2
COFFEEN POWER PLANT
COFFEEN, ILLINOIS

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

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Attachment C
Monitoring Well Construction Information

TABLE 2-1. MONITORING WELL LOCATIONS AND CONSTRUCTION DETAILS
GROUNDWATER MONITORING PLAN
COFFEEN POWER PLANT
ASH POND NO. 2
COFFEEN, ILLINOIS

Well Number	Type	HSU	Date Constructed	Top of PVC Elevation (ft)	Measuring Point Elevation (ft)	Measuring Point Description	Ground Elevation (ft)	Screen Top Depth (ft BGS)	Screen Bottom Depth (ft BGS)	Screen Top Elevation (ft)	Screen Bottom Elevation (ft)	Well Depth (ft BGS)	Bottom of Boring Elevation (ft)	Screen Length (ft)	Screen Diameter (inches)	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)
G1001	C	UA	04/05/2021	597.61	--	Top of PVC	594.82	6.00	11.00	588.82	583.82	11.00	562.82	5	4	39.063324	-89.391236
G270	B	UA	02/26/2008	--	625.86	Top of Disk	623.73	13.13	17.92	610.60	605.81	18.27	605.50	4.8	2	39.066564	-89.397403
G280	B	UA	02/26/2008	625.35	625.35	Top of Riser	623.11	12.79	17.63	610.32	605.48	17.98	605.10	4.8	2	39.067216	-89.394992
G281	B	UA	09/08/2015	--	626.36	Top of Disk	623.82	15.51	20.16	608.31	603.66	20.30	603.50	4.7	2	39.065405	-89.399322
G401	C	UA	09/14/2015	--	625.57	Top of Disk	623.03	14.36	18.79	608.67	604.24	19.29	603.70	4.4	2	39.060259	-89.395295
G402	C	UA	08/27/2010	--	613.37	Top of Disk	610.36	10.00	20.00	600.36	590.36	20.40	590.00	10	2	39.060207	-89.391712
G403	C	UA	09/11/2015	--	626.47	Top of Disk	623.81	13.11	17.78	610.70	606.03	18.15	605.70	4.7	2	39.063167	-89.398779
G404	C	UA	05/01/2007	--	615.67	Top of Disk	613.57	6.42	11.17	607.15	602.40	11.62	601.60	4.8	2	39.064329	-89.392493
G405	C	UA	05/01/2007	--	623.63	Top of Disk	621.40	9.01	13.76	612.39	607.64	14.21	607.20	4.8	2	39.064345	-89.396234
G406	C	UA	08/19/2016	625.36	625.36	Top of PVC	621.86	13.56	18.37	608.30	603.49	18.75	603.10	4.8	2	39.060309	-89.398508
G407	C	UA	08/16/2016	621.32	621.32	Top of PVC	618.35	13.78	18.61	604.57	599.74	19.04	598.40	4.8	2	39.061574	-89.402004
SG-02	WLO	SW	--	--	605.87	Top of Prot Casing	605.87	--	--	--	--	--	--	--	--	39.059695	-89.391429
SG-03	WLO	SW	--	--	594.94	Top of Prot Casing	594.94	--	--	--	--	--	--	--	--	39.059092	-89.390342
SG-04	WLO	SW	--	--	599.52	Top of Prot Casing	599.52	--	--	--	--	--	--	--	--	39.064146	-89.390504

Notes:
All elevation data are presented relative to the North American Vertical Datum 1988 (NAVD88), GEOID 12A
Type refers to the role of the well in the monitoring network: background (B), compliance (C), or water level measurements only (WLO)
WLO wells are temporary pending implementation of impoundment closure per an approved Construction Permit application
-- = data not available
BGS = below ground surface
ft = foot or feet
HSU = Hydrostratigraphic Unit
PVC = polyvinyl chloride
SW = surface water
UA = uppermost aquifer

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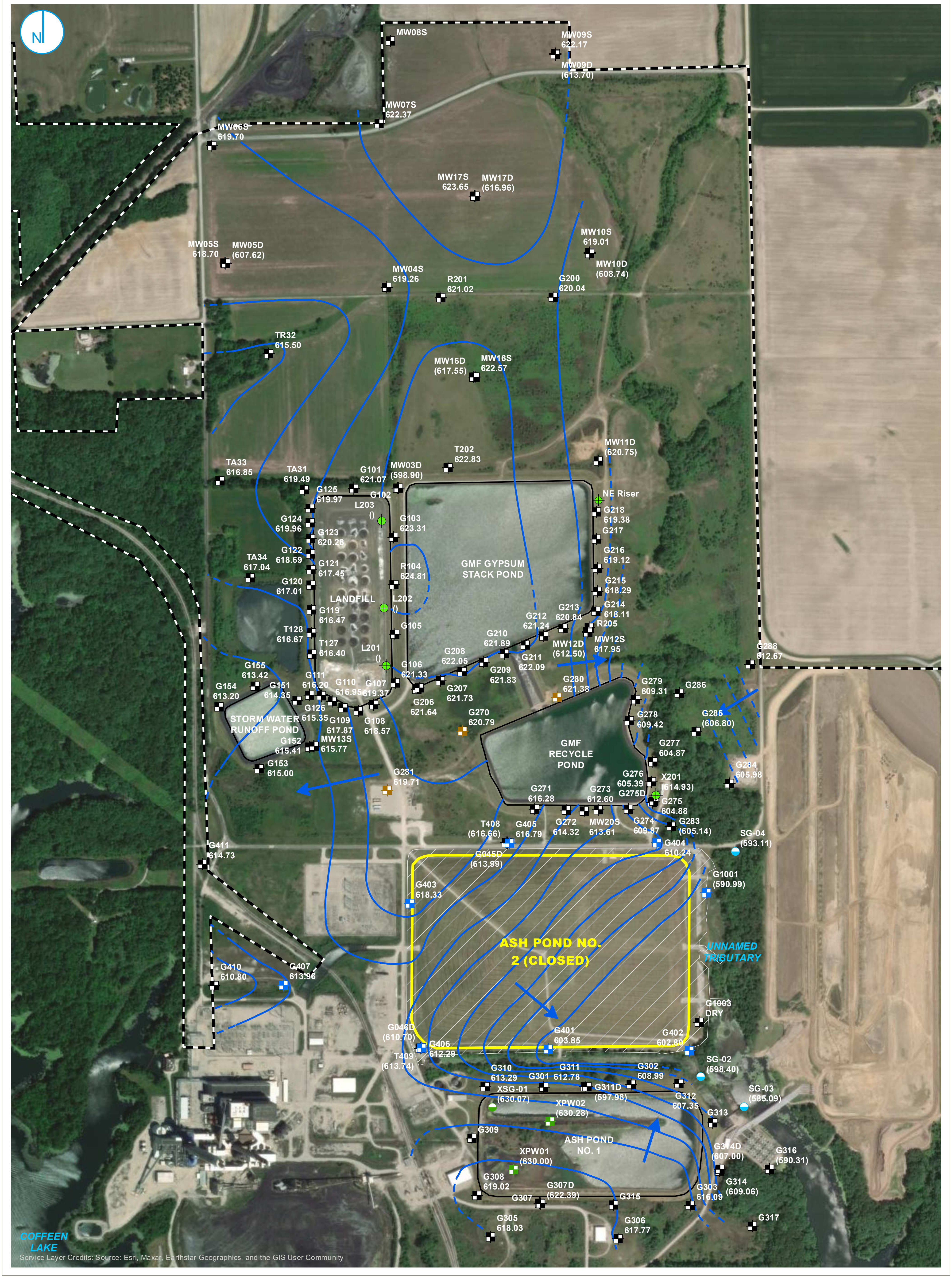
Attachment D
Boring Logs



Service Layer Credits: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

- ▨ COMPLIANCE MONITORING WELL
- ▨ BACKGROUND MONITORING WELL
- ▨ MONITORING WELL
- ▨ PORE WATER WELL
- ⊕ LEACHATE WELL
- ● STAFF GAGE, CCR UNIT
- ● STAFF GAGE, RIVER
- — GROUNDWATER ELEVATION CONTOUR (2-FT CONTOUR INTERVAL, NAVD88)
- - - INFERRED GROUNDWATER ELEVATION CONTOUR
- → GROUNDWATER FLOW DIRECTION
- ☐ REGULATED UNIT (SUBJECT UNIT)
- ☐ SITE FEATURE
- ▨ LIMITS OF FINAL COVER
- ☐ PROPERTY BOUNDARY

0 325 650 Feet

UPPERMOST AQUIFER POTENTIOMETRIC SURFACE MAP MAY 30, 2023 (E001)

FIGURE 2-6

NATURE AND EXTENT REPORT
ASH POND NO. 2
COFFEEN POWER PLANT
COFFEEN, ILLINOIS

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL

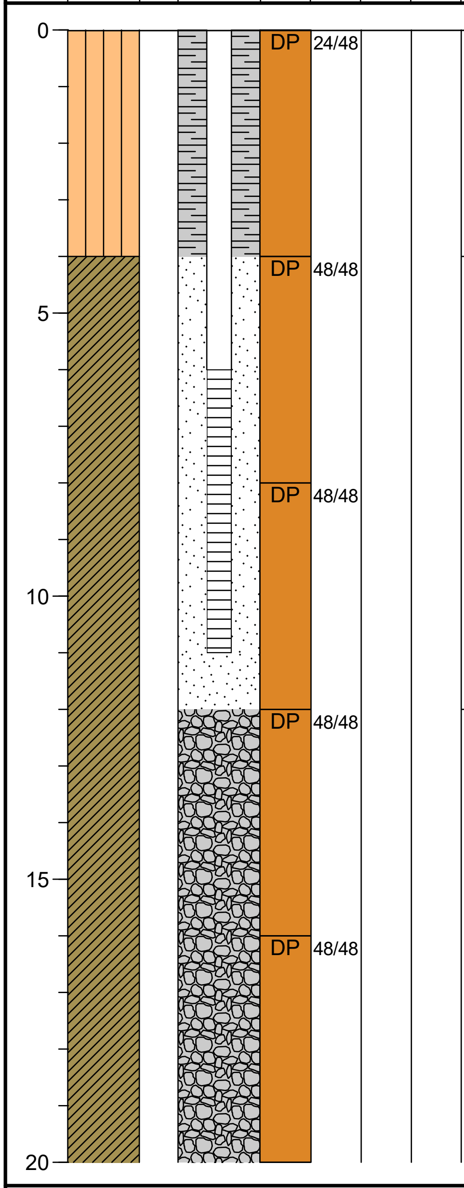
Geosyntec consultants
engineers | scientists | innovators

Client: Dynegy
Project: GLP8005, Coffeen Power Station
Address: Coffeen, IL 62017

WELL LOG

Well No. G1001
Page: 1 of 2

Drilling Start Date:	**04/05/2021**	Boring Depth (ft): **32**		Well Depth (ft):	**12**
Drilling End Date:	**04/05/2021**	Boring Diameter (in): **6**		Well Diameter (in):	**1**
Drilling Company:	**Roberts Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Direct Push**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Geoprobe**	Top of Casing Elev. (ft)		Screen Material:	**Sch 40 PVC Slotted**
Driller:		Ground Elev. (ft):		Seal Material(s):	**Bentonite Chips**
Logged By:	**A. Toye**	Northing, Easting (NAD83):		Filter Pack:	**Sand**



DEPTH (ft)	Sample Type (COLLECT)	Recovery (in)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	Lab Sample (MEASURE)
0	DP	24/48			(0') SILT (ML); very dark grayish brown (2.5Y 3/2), medium soft, moist, trace gravel 2-2.5' bgs.	
4	DP	48/48			(4') CLAY (CL); with trace sand, yellowish brown (10YR 5/6), stiff, moist, trace gravel.	
6						Chem (6-11')
8	DP	48/48			(8') As above: medium stiff, brown (10YR 4/3) with yellowish brown (10YR 5/6) mottling.	
12	DP	48/48			(12') CLAY (CL); dark gray (10YR 4/1), medium stiff, moist.	
16	DP	48/48			(16') As above: dark gray (2.5Y 4/1).	

NOTES: No groundwater encountered.

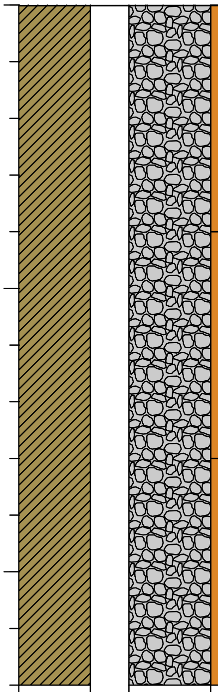
Geosyntec consultants
engineers | scientists | innovators

Client:	**Dynegy**
Project:	**GLP8005, Coffeen Power Station**
Address:	**Coffeen, IL 62017**

WELL LOG

Well No. **G1001**
Page: **2 of 2**

Drilling Start Date:	**04/05/2021**	Boring Depth (ft):	**32**	Well Depth (ft):	**12**
Drilling End Date:	**04/05/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**1**
Drilling Company:	**Roberts Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Direct Push**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Geoprobe**	Top of Casing Elev. (ft)		Screen Material:	**Sch 40 PVC Slotted**
Driller:		Ground Elev. (ft):		Seal Material(s):	**Bentonite Chips**
Logged By:	**A. Toye**	Northing, Easting (NAD83):		Filter Pack:	**Sand**



DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT				SOIL/ROCK VISUAL DESCRIPTION	MEASURE	DEPTH (ft)
				Sample Type	Recovery (in)	Blow Counts	N Value RQD (%)		Lab Sample	
20				DP	48/48			(20') As above: gravel at 1 ft.		20
				DP	48/48			(24') As above: dry pocket at 2.8 ft.		
25										25
				DP	18/48			(28') As above: trace gravel and silt at 2 ft.		
30										30
								(32') End of Boring.		
35										35

NOTES: No groundwater encountered.

FIELD BORING LOG

HANSON

CLIENT: AEG Coffeen Power Station
Site: CCB Management Facility
Location: Coffeen, Illinois
Project: 05S3004A
DATES: Start: 2/26/2008
Finish: 2/26/2008
WEATHER: Overcast, cold

CONTRACTOR: Testing Service Corp.
Rig mfg/model: CME-650 Track Drill
Drilling Method: 3¼" HSA w/SS & CME samplers
FIELD STAFF: Driller: B. Williamson
Helper: R. Keedy
Eng/Geo: .

BOREHOLE ID: G270
Well ID: G270
Surface Elev: 622.92 ft. MSL
Completion: 18.27 ft. BGS
Station: 874,801.92N
2,514,996.84E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Coffeen, IL
Township: East Fork
Section 11, **Tier** 7N; **Range** 3W

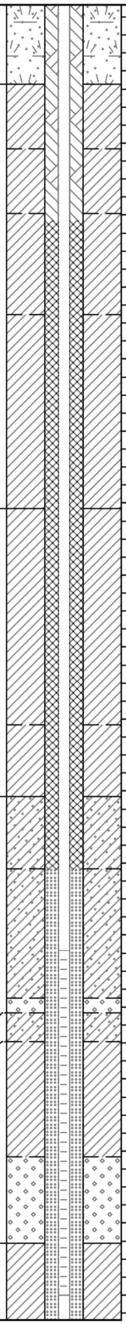
WATER LEVEL INFORMATION:
▼ = 16.00 - While drilling
▼ = 5.62 - 3/12/08
▽ =

SAMPLE Number	Recov / Total (in) *% Recovery*	Type	TESTING *Blows / 6 in* N - Value **RQD**	Moisture (%)	Dry Den. (lb/ft^3)	Qu (tsf) *Qp* (tsf) Failure Type
	20/24 *83%*	SS	*2-2 2-4* N=4			
1A				24		
2A	19/24 *79%*	SS	*3-4 5-9* N=9	22		2.33 B
2B				20		5.04 Sh
	20/24 *83%*	SS	*14-5 7-8* N=12			
3A				17		2.52 Sh
4A	24/24 *100%*	SS	*8-6 7-5* N=13	21		1.24 BSh
4B				21		1.20 B
	22/24 *92%*	SS	*2-3 4-4* N=7			
5A				21		1.36 B
6A	24/24 *100%*	SS	*1-2 2-3* N=4	21		0.74 BSh
6B				24		0.78 B
	17/24 *71%*	SS	*2-2 2-3* N=4			
7A				21		
8A				20		
	19/24 *79%*	SS	*1-3 5-6* N=8			
8B				17		4.46 Sh
9A	24/24 *100%*	SS	*6-8 30-35* N=38	20		
9B				8		

Depth ft. BGS: 2, 4, ▼ 6, 8, 10, 12, 14, ▼ 16, 18

Lithologic Description:

- Dark grayish brown (10YR4/2), moist, firm, clayey SILT
- Dark grayish brown (10YR4/2), moist, firm, silty CLAY
- Dark grayish brown (10YR4/2) with 5% yellowish brown (10YR5/8) mottles, moist, firm, silty CLAY, slight trace sand
- Gray (10YR5/1) with 70% yellowish brown (10YR5/8) mottles, moist, firm, silty CLAY, slight trace sand and gravel
- Dark gray (10YR4/1) with 5% yellowish brown (10YR5/8) mottles, moist, firm, silty CLAY, trace sand, slight trace gravel
- Gray (10YR5/1) with 10% yellowish brown (10YR5/8) mottles, moist, firm, silty CLAY, trace sand, slight trace gravel
- Gray (10YR5/1) with 60% yellowish brown (10YR5/8) mottles, moist, firm, silty CLAY, trace sand, slight trace gravel
- Gray (10YR5/1), moist, soft, sandy CLAY
- Gray (10YR5/1), moist, soft, sandy CLAY, trace gravel
- Gray (10YR5/1), moist, soft, fine- to coarse-grained SAND, trace gravel
- Dark yellowish brown (10YR4/4), moist, soft, sandy CLAY
- Gray (10YR5/1) with 10% yellowish brown (10YR5/8) mottles, moist, firm, silty CLAY, slight trace sand and gravel
- Yellowish brown (10YR5/4), wet, soft, fine to coarse SAND
- Gray (10YR5/1), moist, hard, silty CLAY, trace sand and gravel



Elevation ft. MSL: 622, 620, 618, 616, 614, 612, 610, 608, 606

Remarks

End of Boring = 18.27 ft. BGS

NOTE(S):

FIELD BORING LOG

HANSON

CLIENT: Natural Resource Technology, Inc.
Site: Coffeen Power Station
Location: Coffeen, Illinois
Project: 15E0030
DATES: Start: 5/3/2016
Finish: 5/3/2016
WEATHER: Sunny, calm, warm, lo 60s

CONTRACTOR: Ramsey Geotechnical Engineering LLC
Rig mfg/model: D-50 Turbo Tracked MST 800ATV
Drilling Method: 4 ¼" HSA, split spoon sampler
FIELD STAFF: Driller: B. Williamson
Helper: D. Crump
Eng/Geo: S. Keim

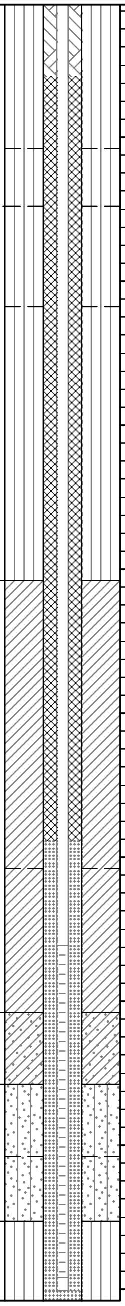
BOREHOLE ID: G306
Well ID: G306
Surface Elev: 622.84 ft. MSL
Completion: 18.00 ft. BGS
Station: 2,516,120.41N
871,140.98E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Coffeen, IL
Township: East Fork
Section 14, **Tier** 7N; **Range** 3W

WATER LEVEL INFORMATION:
▼ = 5.50 - During Drilling
▼ =
▽ =

SAMPLE			TESTING			
Number	Recov / Total (in) *% Recovery*	Type	*Blows / 6 in* N - Value **RQD**	Moisture (%)	Dry Den. (lb/ft^3)	Qu (tsf) *Qp* (tsf) Failure Type
1A	12/24 *50%*	ss	*1-3* *3-4* N=6	14		
2A	24/24 *100%*	ss	*5-4* *5-4* N=9	21		
2B				19		
3A	22/24 *92%*	ss	*2-2* *3-3* N=5	30		
4A	20/24 *83%*	ss	*3-4* *6-6* N=10	26		
5A	24/24 *100%*	ss	*2-2* *3-3* N=5	23		
6A	22/24 *92%*	ss	*1-2* *3-4* N=5	20		
7A	20/24 *83%*	ss	*5-6* *6-6* N=12	21		
8A	20/24 *83%*	ss	*2-2* *8-14* N=10	15		
8B				12		
9A	23/24 *96%*	ss	*14-17* *28-50/5"* N=45	10		
9B				13		

Depth ft. BGS	Lithologic Description	Elevation ft. MSL	Remarks
	Very dark brown (10YR2/2), moist, medium, SILT with little clay and few very fine- to medium-grained sand, roots, trace coal fragments.	622	
2	Dark gray (10YR4/1) with 5% dark yellowish brown (10YR3/6) mottles, moist, stiff, SILT with little clay and trace very fine- to medium-grained sand.		
	Gray (10YR6/1) with 10% yellowish brown (10YR5/6) mottles, moist, very stiff, SILT with little clay and trace very fine-grained sand.	620	
4	Gray (10YR6/1) with 20% yellowish brown (10YR5/6) mottles, moist, very stiff, SILT with some clay and trace very fine-grained sand.	618 616	
8	Gray (10YR5/1) with 30% dark yellowish brown (10YR4/6) mottles, moist, very stiff, silty CLAY with trace very fine- to coarse-grained sand.	614 612	
12	Gray (10YR5/1) with 30% dark yellowish brown (10YR4/6) mottles, moist, stiff, silty CLAY with few very fine- to coarse-grained sand.	610	
14	Yellowish brown (10YR5/6), wet, soft, very fine- to coarse-grained sandy CLAY with little silt.	608	
	Yellowish brown (10YR5/6), wet, medium dense, silty, very fine- to medium-grained SAND with trace coarse-grained sand.		
16	Yellowish brown (10YR5/6), moist, dense, fine- to coarse-grained SAND with little silt, little very fine-grained sand, and trace small gravel.	606	
	Brown (10YR5/3) with 20% dark yellowish brown (10YR4/6) mottles, moist, hard, SILT with little clay, few very fine- to coarse-grained sand, and trace small gravel.		
18	**End of boring = 18.0 feet**		



NOTE(S): G306 installed in borehole.

Page 1 of 1

FIELD BORING LOG

HANSON

CLIENT: Illinois Power Generating Co.
Site: Coffeen Power Station Ash Pond 1
Location: Coffeen, Illinois
Project: 16E0108
DATES: Start: 07/26/2016
Finish: 07/27/2016
WEATHER: Overcast, warm & humid (mid-80s)

CONTRACTOR: Bulldog Drilling, Inc.
Rig mfg/model: CME 55LC Track Drill
Drilling Method: 4¼" Hollow Stem Auger w/Continuous Split Spoon
FIELD STAFF: Driller: J. Gates
Helper: C. Clines
Eng/Geo: R. Hasenyager

BOREHOLE ID: G307
Well ID: G307
Surface Elev: 622.08 ft. MSL
Completion: 18.22 ft. BGS
Station: 871,398.55N
2,515,553.26E

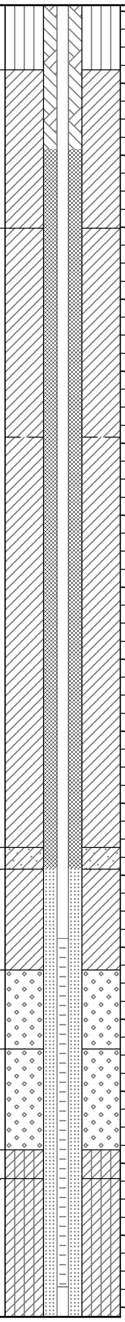
TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Coffeen
Township: East Fork
Section 11, **Tier** 7N; **Range** 3W

WATER LEVEL INFORMATION:
▼ = 14.00 - during drilling
▼ = -1.76 - 7/27/2016 @ 07:30
▽ =

SAMPLE Number	Recov / Total (in) *% Recovery*	Type	TESTING *Blows / 6 in* N - Value **RQD**	Moisture (%)	Dry Den. (lb/ft^3)	Qu (tsf) *Qp* (tsf) Failure Type
1A	18/24 *75%*	SS	*1-3* *3-2* N=6	22		
2A	22/24 *92%*	SS	*2-1* *3-3* N=4	28		
3A	24/24 *100%*	SS	*1-2* *3-4* N=5	26		
4A	24/24 *100%*	SS	*1-3* *3-3* N=6	18		
5A	24/24 *100%*	SS	*3-3* *4-5* N=7	19		
6A	24/24 *100%*	SS	*3-3* *4-5* N=7	20		
7A	24/24 *100%*	SS	*woh-2* *5-13* N=7	20		
7B				11		
8A	24/24 *100%*	SS	*12-9* *6-9* N=15	20		
9A	18/18 *100%*	SS	*8-30* *50* N=80	8		
	0/9 *0%*	BD				

Depth ft. BGS	Lithologic Description	Elevation ft. MSL
▼	Brown (10YR5/3), moist, stiff, SILT with few clay, trace sand, gravel and roots.	
	Gray (10YR5/1), moist, soft, CLAY, with some silt, trace sand, gravel and roots.	
2		620
4	Gray (10YR5/1) with 30% yellowish brown (10YR5/8) mottles, moist, soft, CLAY with some silt, trace sand, gravel and roots.	618
6		616
8	Yellowish brown (10YR5/6) with 20% gray (10YR5/1) mottles, moist, medium CLAY,with some silt, few very fine- to medium-grained sand, and trace gravel.	614
10		612
	Gray (10YR5/1), moist, medium, CLAY with little silt and very fine to very coarse sand, trace gravel.	
12	Gray (10YR5/1) with 25% yellowish brown (10YR5/8) mottles, moist, soft, CLAY with some silt, trace sand and gravel.	610
▼ 14	Gray (10YR6/1), wet, medium dense, very fine- to very coarse-grained SAND with few silt and trace clay.	608
	Yellow brown (10YR5/6), wet. medium dense, very fine- to very coarse-grained SAND, with little silt and trace gravel.	
16	Yellowish brown (10YR5/8), moist, hard, SILT with some clay, little very fine- to very coarse-grained sand and trace gravel.	606
	Gray (10YR5/1), moist, hard, SILT with some clay, little very fine- to very coarse-grained sand and trace gravel.	
18		604

Borehole Detail



Remarks

End of boring = 18.2 feet

NOTE(S):

FIELD BORING LOG

CLIENT: Illinois Power Generating Co.
Site: Coffeen Part 845 Groundwater
Location: Coffeen, Illinois
Project: 20E0111A
DATES: **Start:** 2/5/2021
Finish: 2/5/2021
WEATHER: Clear, cold (20s)

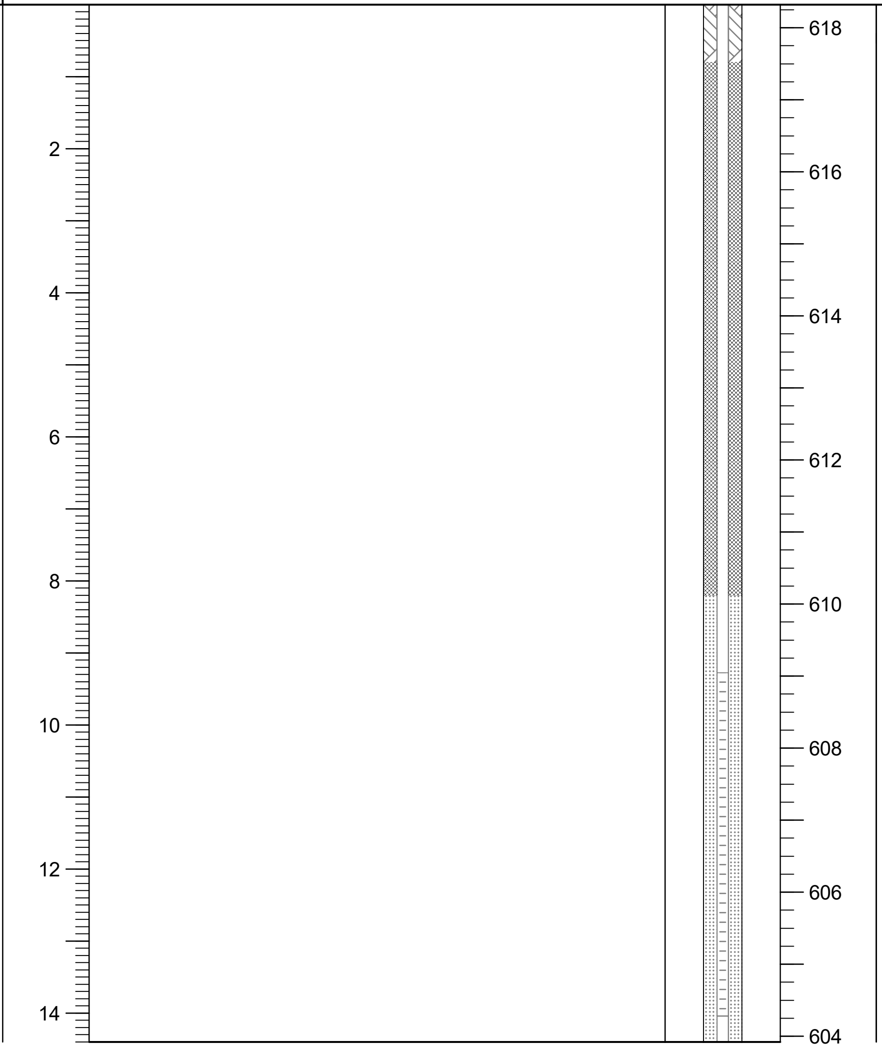
CONTRACTOR: Roberts
Rig mfg/model:
Drilling Method: 4.25" HSA w/SS sampler

FIELD STAFF: **Driller:** Matt
Helper: Corey
Eng/Geo: C. Colin Winter

BOREHOLE ID: G311
Well ID: G311
Surface Elev: 618.32 ft. MSL
Completion: 14.40 ft. BGS
Station: 872,238.70N
2,515,881.80E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Coffeen, IL
Township: East Fork
Section 11, **Tier** 7N; **Range** 3W

SAMPLE			TESTING								
Number	Recov / Total (in) *% Recovery*	Type	*Blows / 6 in* N - Value **RQD**	Water Content (%)	Dry Density (lb/ft^3)	Qu (tsf) *Qp (tsf)* Failure Type	Depth ft. BGS	Lithologic Description	Borehole Detail	Elevation ft. MSL	Remarks



NOTE(S): G311 installed in borehole.

FIELD BORING LOG

HANSON

CLIENT: Illinois Power Generating Co.
Site: Coffeen Part 845 Groundwater
Location: Coffeen, Illinois
Project: 20E0111A
DATES: Start: 2/5/2021
Finish: 2/5/2021
WEATHER: Clear, cold (20s)

CONTRACTOR: Roberts
Rig mfg/model: CME-75 Track Rig
Drilling Method: 3.25" HSA w/SS sampler
FIELD STAFF: Driller: Matt
Helper: Corey
Eng/Geo: C. Colin Winter

BOREHOLE ID: G311D
Well ID: G311D
Surface Elev: 618.39 ft. MSL
Completion: 60.00 ft. BGS
Station: 872,238.70N
2,515,881.80E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Coffeen, IL
Township: East Fork Township
Section 11, **Tier** 7N; **Range** 3W

WATER LEVEL INFORMATION:
∇ = 11.20 - During Drilling
∇ =
∇ =

SAMPLE			TESTING			
Number	Recov / Total (in) *% Recovery*	Type	*Blows / 6 in* N - Value **RQD**	Water Content (%)	Dry Density (lb/ft^3)	Qu (tsf) *Qp (tsf)* Failure Type
1A	13/24 *54%*	SS	*0-4* *4-4* N=8			
2A	24/24 *100%*	SS	*3-4* *5-6* N=9			
3A	24/24 *100%*	SS	*2-4* *5-7* N=9			
4A	24/24 *100%*	SH				
5A	18/24 *75%*	SS	*1-2* *4-5* N=6			
6A	24/24 *100%*	SS	*1-3* *3-4* N=6			
7A	24/24 *100%*	SS	*2-6* *12-13* N=18			
8A	24/24 *100%*	SS	*2-6* *12-13* N=18			
9A	24/24 *100%*	SS	*6-15* *18-22* N=33			
10A	24/24 *100%*	SS	*6-13* *16-22* N=29			

Depth ft. BGS | Lithologic Description | Borehole Detail | Elevation ft. MSL | Remarks

Yellowish brown (10YR5/6), moist, stiff, lean CLAY, with some silt, few very fine- to fine-grained sand, trace small gravel.

Gray (10YR5/1) with 20% yellowish brown (10YR5/6) and 5% very dark grayish brown (10YR3/2) mottles, moist, stiff, lean CLAY, with some silt, trace very fine- to fine-grained sand, and small gravel.

Very dark grayish brown (10YR3/2) with 10% gray (10YR5/1) mottles, moist, stiff, lean CLAY, with some silt, trace very fine- to fine-grained sand, and small gravel.

Gray (10YR5/1) with 15% yellowish brown (10YR5/6) mottles, moist, stiff, lean CLAY, with some silt, little very fine- to fine-grained sand, few small gravel.

∇

Gray (10YR5/1) with 10% yellowish brown (10YR5/6) mottles, moist to wet, medium stiff, lean CLAY, with some very fine- to fine-grained sand, little silt, few small gravel.

Yellowish brown (10YR5/6), moist to wet, medium stiff, lean CLAY, with some very fine- to fine-grained sand, little silt, few small gravel.

Gray (10YR5/1), moist to wet, medium stiff, SILT, with some very fine- to fine-grained sand, few clay, trace small gravel.

Remarks: 1" wet, SAND at 13.5 ft.

Yellowish brown (10YR5/6), moist, hard, SILT, with some clay, some to little sand, few small gravel.

Remarks: Vertical fracture with very fine- to fine-grained sand from 16.9 to 18 ft.

Dark grayish brown (10YR4/2) with frequent yellowish red (5YR4/6) oxidation along fractures, moist, hard, lean CLAY, with some silt, few very fine- to fine-grained sand, trace small gravel.

Depth scale (ft. BGS): 2, 4, 6, 8, 10, 12, 14, 16, 18, 20

Elevation scale (ft. MSL): 618, 616, 614, 612, 610, 608, 606, 604, 602, 600

NOTE(S): G311D installed in borehole.

FIELD BORING LOG

HANSON

CLIENT: Illinois Power Generating Co.
Site: Coffeen Part 845 Groundwater
Location: Coffeen, Illinois
Project: 20E0111A
DATES: Start: 2/5/2021
Finish: 2/5/2021
WEATHER: Clear, cold (20s)

CONTRACTOR: Roberts
Rig mfg/model: CME-75 Track Rig
Drilling Method: 3.25" HSA w/SS sampler

FIELD STAFF: Driller: Matt
Helper: Corey
Eng/Geo: C. Colin Winter

BOREHOLE ID: G311D
Well ID: G311D
Surface Elev: 618.39 ft. MSL
Completion: 60.00 ft. BGS
Station: 872,238.70N
2,515,881.80E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Coffeen, IL
Township: East Fork Township
Section 11, **Tier** 7N; **Range** 3W

WATER LEVEL INFORMATION:
∇ = 11.20 - During Drilling
∇ =
▼ =

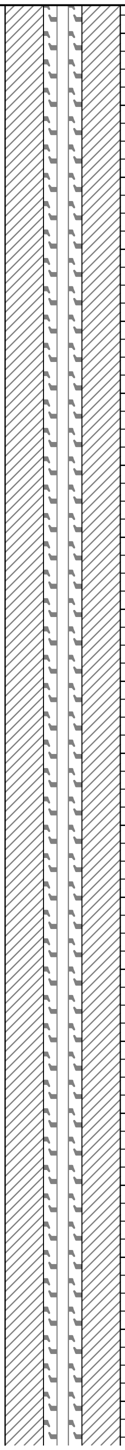
SAMPLE Number	Recov / Total (in) *% Recovery*	Type	*Blows / 6 in* N - Value **RQD**	Water Content (%)	Dry Density (lb/ft³)	Qu (tsf) *Qp (tsf)* Failure Type
11A	24/24 *100%*	SS	*5-15 20-26* N=35			
12A	12/24 *50%*	SS	*2-3 14-17* N=17			
13A	24/24 *100%*	SS	*6-11 14-20* N=25			
14A	24/24 *100%*	SS	*4-8 11-16* N=19			
15A	24/24 *100%*	SH				
16A	24/24 *100%*	SS	*0-3 5-8* N=8			
17A	24/24 *100%*	SS	*2-4 6-8* N=10			
18A	24/24 *100%*	SS	*2-5 7-7* N=12			
19A	13/24 *54%*	SS	*2-7 8-11* N=15			
20A	24/24 *100%*	SS	*2-6 10-8* N=16			

Depth ft. BGS: 22, 24, 26, 28, 30, 32, 34, 36, 38, 40

Lithologic Description

Dark gray (10YR4/1) with frequent yellowish red (5YR4/6) oxidation along fractures, moist, hard, lean CLAY, with some silt, few very fine- to fine-grained sand, trace small gravel.

Borehole Detail



Elevation ft. MSL: 598, 596, 594, 592, 590, 588, 586, 584, 582, 580

Depth ft. BGS	Remarks
22	No oxidation below 22 ft.
24	Trace medium gravel below 24 ft.
34	Gravel plugged shoe in Run 18.
35	Trace large gravel from 35 to 36 ft.
36	Trace lignite and wood fragments below 36 ft.

NOTE(S): G311D installed in borehole.

FIELD BORING LOG

HANSON

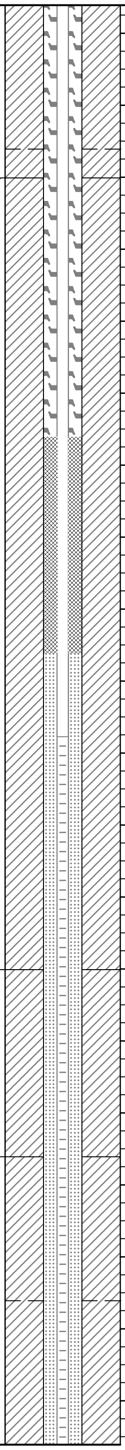
CLIENT: Illinois Power Generating Co.	**CONTRACTOR:** Roberts	
Site: Coffeen Part 845 Groundwater	**Rig mfg/model:** CME-75 Track Rig	**BOREHOLE ID:** G311D
Location: Coffeen, Illinois	**Drilling Method:** 3.25" HSA w/SS sampler	**Well ID:** G311D
Project: 20E0111A		**Surface Elev:** 618.39 ft. MSL
DATES: Start: 2/5/2021	**FIELD STAFF: Driller:** Matt	**Completion:** 60.00 ft. BGS
Finish: 2/5/2021	**Helper:** Corey	**Station:** 872,238.70N
WEATHER: Clear, cold (20s)	**Eng/Geo:** C. Colin Winter	2,515,881.80E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Coffeen, IL
Township: East Fork Township
Section 11, **Tier** 7N; **Range** 3W

WATER LEVEL INFORMATION:
▽ = 11.20 - During Drilling
▽ =
▼ =

SAMPLE			TESTING							
Number	Recov / Total (in) *% Recovery*	Type	*Blows / 6 in* N - Value **RQD**	Water Content (%)	Dry Density (lb/ft³)	Qu (tsf) *Qp (tsf)* Failure Type	Depth ft. BGS	Lithologic Description	Elevation ft. MSL	Remarks
21A	16/24 *67%*	SS	*3-3* *6-8* N=9					Dark gray (10YR4/1) with frequent yellowish red (5YR4/6) oxidation along fractures, moist, hard, lean CLAY, with some silt, few very fine- to fine-grained sand, trace small gravel. *[Continued from previous page]*	578	
22A							42	Greenish gray (GLEY15/1) with 20% dark reddish brown (10YR3/2) mottles, moist, medium stiff, lean CLAY, with some silt.		
22B	24/24 *100%*	SS	*3-4* *7-8* N=11						576	
23A	24/24 *100%*	SS	*1-3* *5-7* N=8				44		574	
24A	20/24 *83%*	SS	*3-4* *10-8* N=14				46	Dark grayish brown (10YR4/1) with frequent yellowish red (5YR4/6) oxidation along fractures, moist, hard, lean CLAY, with some silt, few very fine- to fine-grained sand, trace small to large gravel.	572	
25A	24/24 *100%*	SS	*3-5* *8-13* N=13				48		570	
26A	24/24 *100%*	SS	*2-5* *10-12* N=15				50		568	
27A	24/24 *100%*	SS	*2-6* *10-14* N=16				52		566	
28A	24/24 *100%*	SS	*4-7* *7-11* N=14				54	Dark gray (10YR4/1) with 20% greenish gray (GLEY15/1) and 5% yellowish brown (10YR5/6) mottles, moist, very stiff, lean CLAY, with some silt, trace very fine-grained sand and small gravel.	564	Trace small gravel below 54.3 ft.
29A	24/24 *100%*	SS	*2-5* *9-11* N=14				56	Greenish gray (GLEY16/1) with 40% yellowish brown (10YR5/6) mottles, moist, very stiff, lean CLAY, with some silt, trace very fine-grained sand and small gravel.	562	0.5" small to medium GRAVEL.
30A	24/24 *100%*	SS	*3-7* *10-13* N=17				58	Yellowish brown (10YR5/6) with 30% greenish gray (GLEY16/1) mottles, moist, very stiff, lean CLAY, with some silt, trace very fine-grained sand and small gravel.	560	
							60			

Borehole Detail



NOTE(S): G311D installed in borehole.

FIELD BORING LOG

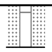
CLIENT: Illinois Power Generating Co.
Site: Coffeen Part 845 Groundwater
Location: Coffeen, Illinois
Project: 20E0111A
DATES: Start: 2/5/2021
Finish: 2/5/2021
WEATHER: Clear, cold (20s)

CONTRACTOR: Roberts
Rig mfg/model: CME-75 Track Rig
Drilling Method: 3.25" HSA w/SS sampler
FIELD STAFF: Driller: Matt
Helper: Corey
Eng/Geo: C. Colin Winter

BOREHOLE ID: G311D
Well ID: G311D
Surface Elev: 618.39 ft. MSL
Completion: 60.00 ft. BGS
Station: 872,238.70N
2,515,881.80E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Coffeen, IL
Township: East Fork Township
Section 11, **Tier** 7N; **Range** 3W

WATER LEVEL INFORMATION:
▽ = 11.20 - During Drilling
▽ =
▼ =

SAMPLE			TESTING								
Number	Recov / Total (in) *% Recovery*	Type	*Blows / 6 in* N - Value **RQD**	Water Content (%)	Dry Density (lb/ft^3)	Qu (tsf) *Qp (tsf)* Failure Type	Depth ft. BGS	Lithologic Description	Borehole Detail	Elevation ft. MSL	Remarks
								End of boring = 60.0 feet			

NOTE(S): G311D installed in borehole.

FIELD BORING LOG

HANSON

CLIENT: Illinois Power Generating Co.
Site: Coffeen Part 845 Groundwater
Location: Coffeen, Illinois
Project: 20E0111A
DATES: Start: 1/14/2021
Finish: 1/14/2021
WEATHER: Overcast, cool (40s)

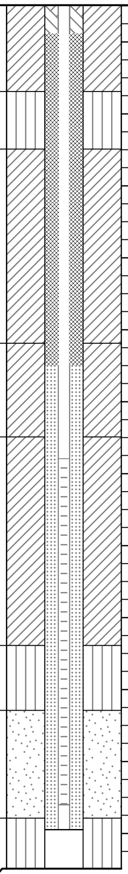
CONTRACTOR: Roberts
Rig mfg/model: GeoProbe 8040DT
Drilling Method: 4.25" HSA w/SS sampler
FIELD STAFF: Driller: Matt
Helper: Corey
Eng/Geo: C. Colin Winter

BOREHOLE ID: G313
Well ID: G313
Surface Elev: 611.51 ft. MSL
Completion: 12.00 ft. BGS
Station: 871,976.80N
2,516,803.70E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Coffeen, IL
Township: East Fork Township
Section 11, **Tier** 7N; **Range** 3W

WATER LEVEL INFORMATION:
▽ = 9.80 - During Drilling
▽ =
▼ =

SAMPLE			TESTING			
Number	Recov / Total (in) *% Recovery*	Type	*Blows / 6 in* N - Value **RQD**	Water Content (%)	Dry Density (lb/ft^3)	Qu (tsf) *Qp (tsf)* Failure Type
1A 1B	17/24 *71%*	SS	*0-2* *3-3* N=5			
2A	13/24 *54%*	SS	*0-2* *2-3* N=4			
3A	19/24 *79%*	SS	*2-3* *5-5* N=8			
4A	22/24 *92%*	SS	*2-3* *4-5* N=7			
5A	22/24 *92%*	SS	*2-5* *9-12* N=14			
6A 6B	21/24 *88%*	SS	*9-12* *21-22* N=33			



Depth ft. BGS	Lithologic Description	Elevation ft. MSL	Remarks
	Dark yellowish brown (10YR4/4), wet, stiff, lean CLAY, with some silt, few roots, trace small gravel.		
2	Gray (10YR6/1) with 15% yellowish brown (10YR5/6) mottles, moist, very stiff, SILT, with little clay, few roots.	610	
4	Dark gray (10YR4/1) with 5% black (10YR2/1) mottles, moist, stiff, lean CLAY, with some silt.	608	
6	Dark gray (10YR4/1) with 20% yellowish brown (10YR5/6) mottles, moist, stiff, lean CLAY, with some silt, trace very fine- to fine-grained sand and small gravel.	606	
8	Very dark gray (10YR3/1), moist, stiff, lean CLAY, with some silt, little very fine- to fine-grained sand and small gravel.	604	
▽	Yellowish brown (10YR5/6) with 10% very dark gray (10YR3/1) mottles, moist, stiff SILT, with some very fine- to fine-grained sand and clay, few small gravel.	602	
10	Yellowish brown (10YR5/4), wet, medium dense, very fine- to medium-grained SAND, with some silt, few small gravel.		
12	Dark grayish brown (10YR4/2) with 10% yellowish brown (10YR5/6) mottles, moist, hard, SILT, with some very fine- to fine-grained sand, few clay and small gravel, trace medium gravel.	600	

End of boring = 12.0 feet

NOTE(S): G313 installed in borehole.

FIELD BORING LOG

CLIENT: Illinois Power Generating Co.
Site: Coffeen Part 845 Groundwater
Location: Coffeen, Illinois
Project: 20E0111A
DATES: Start: 2/10/2021
Finish: 2/12/2021
WEATHER: Overcast, very cold (10s)

CONTRACTOR: Roberts
Rig mfg/model: CME-75 Track Rig
Drilling Method: 4.25" HSA w/SS sampler
FIELD STAFF: Driller: Matt
Helper: Corey
Eng/Geo: C. Colin Winter

BOREHOLE ID: G314D
Well ID: G314D
Surface Elev: 610.87 ft. MSL
Completion: 100.30 ft. BGS
Station: 871,642.00N
2,516,853.90E

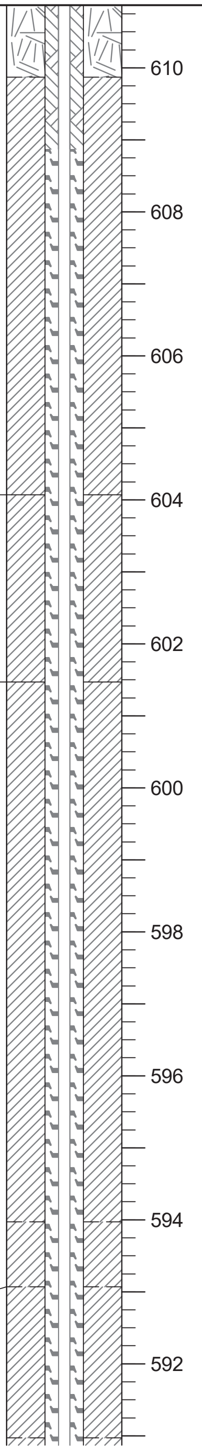
TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Coffeen, IL
Township: East Fork Township
Section 11, **Tier** 7N; **Range** 3W

WATER LEVEL INFORMATION:
▽ = During Drilling
▼ =
▼ =

SAMPLE			TESTING				
Number	Recov / Total (in) *% Recovery*	Type	*Blows / 6 in* N - Value **RQD**	Water Content (%)	Dry Density (lb/ft^3)	Qu (tsf) *Qp (tsf)* Failure Type	Remarks
1A	4/24 *17%*	SS	*13-7 4-5* N=11				
	1/24 *4%*	SS	*3-4 5-5* N=9				
3A	24/24 *100%*	SS	*1-3 4-5* N=7				
4A	24/24 *100%*	SS	*2-5 15-17* N=20				
5A	24/24 *100%*	SS	*4-10 12-16* N=22				
6A	24/24 *100%*	SS	*4-5 14-18* N=19				1" wet, SAND, with some silt at 11.6 ft.
7A	24/24 *100%*	SS	*3-11 14-18* N=25				
8A	24/24 *100%*	SS	*3-9 13-18* N=22				
9A	24/24 *100%*	SS	*1-7 9-13* N=16				

Depth ft. BGS	Lithologic Description
	Moist, dense, small to large GRAVEL. [FILL]
2, 4, 6	Gray (10YR6/1) with 30% yellowish brown (10YR5/6) mottles, moist, stiff, lean CLAY, with some silt, few very fine- to fine-grained sand, trace small gravel.
8	Yellowish brown (10YR5/6) with occasional yellowish red (5YR4/6) oxidation along fractures, moist, hard, lean CLAY, with some silt and very fine- to fine-grained sand, trace small gravel.
10, 12, 14, 16	Yellowish brown (10YR5/6) with 10% very dark grayish brown (10YR3/2) mottles and occasional yellowish red (5YR4/6) oxidation along fractures, moist, hard, lean CLAY, with some silt and very fine- to fine-grained sand, trace small gravel.
18	Yellowish brown (10YR5/6) with 10% very dark grayish brown (10YR3/2) and 10% dark yellowish brown (10YR4/6) mottles and occasional yellowish red (5YR4/6) oxidation along fractures, moist, hard, lean CLAY, with some silt and very fine- to fine-grained sand, trace small gravel.
20	Dark grayish brown (10YR4/2) with 15% yellowish brown (10YR5/6) mottles and occasional yellowish red (5YR4/6) oxidation along fractures, moist, hard, lean CLAY, with some silt and very fine- to fine-grained sand, trace small gravel.

Borehole Detail
Elevation ft. MSL



NOTE(S): G314D installed in borehole.

FIELD BORING LOG

HANSON

CLIENT: Illinois Power Generating Co.
Site: Coffeen Part 845 Groundwater
Location: Coffeen, Illinois
Project: 20E0111A
DATES: Start: 2/10/2021
Finish: 2/12/2021
WEATHER: Overcast, very cold (10s)

CONTRACTOR: Roberts
Rig mfg/model: CME-75 Track Rig
Drilling Method: 4.25" HSA w/SS sampler
FIELD STAFF: Driller: Matt
Helper: Corey
Eng/Geo: C. Colin Winter

BOREHOLE ID: G314D
Well ID: G314D
Surface Elev: 610.87 ft. MSL
Completion: 100.30 ft. BGS
Station: 871,642.00N
2,516,853.90E

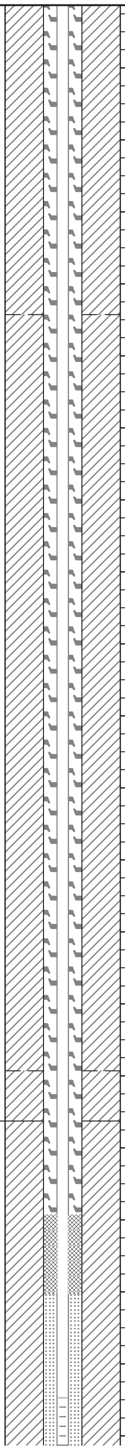
TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Coffeen, IL
Township: East Fork Township
Section 11, **Tier** 7N; **Range** 3W

WATER LEVEL INFORMATION:
▽ = During Drilling
▼ =
▼ =

SAMPLE Number	Recov / Total (in) *% Recovery*	Type	TESTING *Blows / 6 in* N - Value **RQD**	Water Content (%)	Dry Density (lb/ft^3)	Qu (tsf) *Qp (tsf)* Failure Type
10A	24/24 *100%*	SS	*1-5* *10-13* N=15			
11A	24/24 *100%*	SS	*1-6* *9-12* N=15			
12A	24/24 *100%*	SS	*4-7* *10-13* N=17			
13A	24/24 *100%*	SS	*3-7* *10-13* N=17			
14A	24/24 *100%*	SS	*4-6* *10-10* N=16			
15A	24/24 *100%*	SS	*3-9* *10-12* N=19			
16A	24/24 *100%*	SS	*2-3* *7-8* N=10			
17A	24/24 *100%*	SS	*2-4* *7-9* N=11			
18A	21/24 *88%*	SH				
			2-5			

Depth ft. BGS	Lithologic Description	Elevation ft. MSL	Remarks
20–24.3 (22, 24)	Dark grayish brown (10YR4/2) with 15% yellowish brown (10YR5/6) and 5% dark yellowish brown (10YR4/6) mottles and occasional yellowish red (5YR4/6) oxidation along fractures, moist, hard, lean CLAY, with some silt and very fine- to fine-grained sand, trace small gravel. *[Continued from previous page]*	590, 588	1" wet, SAND, with some silt at 20 ft. Frequent oxidation below 21.7 ft.
24.3–34.8 (26, 28, 30, 32, 34)	Dark grayish brown (10YR4/2), moist, hard, lean CLAY, with some silt and very fine- to fine-grained sand, trace small gravel.	586, 584, 582, 580, 578	1 ft vertical fracture with yellowish red (5YR4/6) oxidation at 28.3 ft. Trace roots below 34 ft.
34.8–35.5	Gray (GLEY15/), moist, stiff, lean CLAY, with some silt.	576	
35.5–40 (36, 38, 40)	Dark grayish brown (10YR4/2), moist, hard, lean CLAY, with some silt and very fine- to fine-grained sand, trace small gravel and roots.	574, 572	

Borehole Detail



NOTE(S): G314D installed in borehole.

FIELD BORING LOG

HANSON

CLIENT: Illinois Power Generating Co.
Site: Coffeen Part 845 Groundwater
Location: Coffeen, Illinois
Project: 20E0111A
DATES: Start: 2/10/2021
Finish: 2/12/2021
WEATHER: Overcast, very cold (10s)

CONTRACTOR: Roberts
Rig mfg/model: CME-75 Track Rig
Drilling Method: 4.25" HSA w/SS sampler
FIELD STAFF: Driller: Matt
Helper: Corey
Eng/Geo: C. Colin Winter

BOREHOLE ID: G314D
Well ID: G314D
Surface Elev: 610.87 ft. MSL
Completion: 100.30 ft. BGS
Station: 871,642.00N
2,516,853.90E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Coffeen, IL
Township: East Fork Township
Section 11, **Tier** 7N; **Range** 3W

WATER LEVEL INFORMATION:
▽ = During Drilling
▽ =
▼ =

SAMPLE			TESTING			
Number	Recov / Total (in) *% Recovery*	Type	*Blows / 6 in* N - Value **RQD**	Water Content (%)	Dry Density (lb/ft^3)	Qu (tsf) *Qp (tsf)* Failure Type
19A	24/24 *100%*	SS	*7-12* N=12			
20A	24/24 *100%*	SS	*4-8* *10-14* N=18			
21A	24/24 *100%*	SS	*3-9* *13-16* N=22			
22A 22B	24/24 *100%*	SS	*12-31* *14-11* N=45			
23A	24/24 *100%*	SS	*3-4* *6-9* N=10			
24A	24/24 *100%*	SS	*5-11* *14-17* N=25			
25A	24/24 *100%*	SS	*4-6* *11-15* N=17			
26A	20/24 *83%*	SS	*4-5* *18-30* N=23			
27A	20/24 *83%*	SS	*9-22* *33-33* N=55			
28A	24/24 *100%*	SS	*7-19* *29-43*			

Depth ft. BGS | Lithologic Description | Borehole Detail | Elevation ft. MSL | Remarks

Dark grayish brown (10YR4/2), moist, hard, lean CLAY, with some silt and very fine- to fine-grained sand, trace small gravel and roots.
[Continued from previous page]

Gray (10YR5/1), wet, dense, SAND, with some silt, few small gravel.

Gray (GLEY15/) with 10% yellowish brown (10YR5/6) mottles, moist, stiff, lean CLAY, with some silt, trace very fine-grained sand.

Yellowish brown (10YR5/6) with 20% gray (GLEY15/) mottles, moist, stiff, lean CLAY, with some silt, trace very fine-grained sand.

Yellowish brown (10YR5/6), moist, hard, lean CLAY, with some silt, little very fine- to fine-grained sand and small gravel.

Yellowish brown (10YR5/6) with 20% gray (GLEY15/) mottles, moist, hard, lean CLAY, with some silt, little very fine- to fine-grained sand and small gravel.

Yellowish brown (10YR5/6) with 10% gray (GLEY15/) and 5% dark yellowish brown (10YR4/6) mottles, moist, hard, lean CLAY, with some silt, little very fine- to fine-grained sand and small gravel.

Depth (ft. BGS): 42, 44, 46, 48, 50, 52, 54, 56, 58, 60

Elevation (ft. MSL): 570, 568, 566, 564, 562, 560, 558, 556, 554, 552

Remarks:

Trace medium gravel below 41.3 ft.

1" SILT, with some sand at 48.2 ft.

NOTE(S): G314D installed in borehole.

FIELD BORING LOG

HANSON

CLIENT: Illinois Power Generating Co.
Site: Coffeen Part 845 Groundwater
Location: Coffeen, Illinois
Project: 20E0111A
DATES: Start: 2/10/2021
Finish: 2/12/2021
WEATHER: Overcast, very cold (10s)

CONTRACTOR: Roberts
Rig mfg/model: CME-75 Track Rig
Drilling Method: 4.25" HSA w/SS sampler
FIELD STAFF: Driller: Matt
Helper: Corey
Eng/Geo: C. Colin Winter

BOREHOLE ID: G314D
Well ID: G314D
Surface Elev: 610.87 ft. MSL
Completion: 100.30 ft. BGS
Station: 871,642.00N
2,516,853.90E

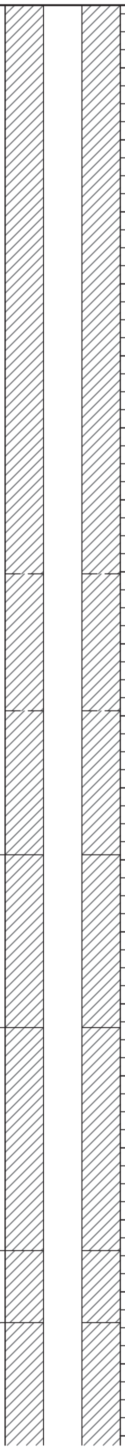
TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Coffeen, IL
Township: East Fork Township
Section 11, **Tier** 7N; **Range** 3W

WATER LEVEL INFORMATION:
▽ = During Drilling
▼ =
▼ =

Number	Recov / Total (in) % Recovery	Type	Blows / 6 in N - Value **RQD**	Water Content (%)	Dry Density (lb/ft^3)	Qu (tsf) Qp (tsf) Failure Type
			N=48			
29A	20/24 *83%*	SS	*13-20* *30-38* N=50			
30A	24/24 *100%*	SS	*8-15* *30-34* N=45			
31A	24/24 *100%*	SS	*5-17* *28-29* N=45			
32A	24/24 *100%*	SS	*7-18* *29-43* N=47			
33A	24/24 *100%*	SS	*5-14* *32-26* N=46			
34A	24/24 *100%*	SS	*8-17* *26-38* N=43			
35A	24/24 *100%*	SS	*5-12* *24-24* N=36			
36A	24/24 *100%*	SS	*14-24* *20-33* N=44			
37A	24/24 *100%*	SS	*6-14* *17-31* N=31			

Depth ft. BGS	Lithologic Description	Elevation ft. MSL	Remarks
60–67.9	Yellowish brown (10YR5/6) with 10% gray (GLEY15/) and 5% dark yellowish brown (10YR4/6) mottles, moist, hard, lean CLAY, with some silt, little very fine- to fine-grained sand and small gravel. *[Continued from previous page]*	550, 548, 546, 544	
67.9–69.8	Yellowish brown (10YR5/6) with 10% gray (GLEY15/), 5% dark yellowish brown (10YR4/6) and 5% very dark grayish brown (10YR3/2) mottles, moist, hard, lean CLAY, with some silt, little very fine- to fine-grained sand and small gravel.	542	
69.8–71.8	Dark grayish brown (10YR4/2) with 5% gray (GLEY15/), 5% yellowish brown (10YR5/6), and 5% light gray (10YR7/1) mottles, moist, hard, lean CLAY, with some silt, little sand and gravel.	540	
71.8–74.2	Yellowish brown (10YR5/6) with 5% gray (GLEY15/), 5% dark grayish brown (10YR4/2), and 5% light gray (10YR7/1) mottles.	538	
74.2–77.3	Dark grayish brown (10YR4/2) with 5% gray (GLEY15/), 5% yellowish brown (10YR5/6), and 5% light gray (10YR7/1) mottles.	536, 534	
77.3–78.3	Dark grayish brown (10YR5/2) with 20% reddish brown (5YR4/4) and 5% light gray (10YR7/1) mottles, moist, hard, lean CLAY, with some silt, trace very fine- to fine-grained sand and small gravel.		
78.3–80	Dark gray (10YR4/1) with 5% light gray (10YR7/1) mottles, moist, hard, lean CLAY, with some silt, trace very fine- to fine-grained sand and small gravel.	532	

Depth scale: 62, 64, 66, 68, 70, 72, 74, 76, 78, 80



NOTE(S): G314D installed in borehole.

FIELD BORING LOG

HANSON

CLIENT: Illinois Power Generating Co.
Site: Coffeen Part 845 Groundwater
Location: Coffeen, Illinois
Project: 20E0111A
DATES: Start: 2/10/2021
Finish: 2/12/2021
WEATHER: Overcast, very cold (10s)

CONTRACTOR: Roberts
Rig mfg/model: CME-75 Track Rig
Drilling Method: 4.25" HSA w/SS sampler
FIELD STAFF: Driller: Matt
Helper: Corey
Eng/Geo: C. Colin Winter

BOREHOLE ID: G314D
Well ID: G314D
Surface Elev: 610.87 ft. MSL
Completion: 100.30 ft. BGS
Station: 871,642.00N
2,516,853.90E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Coffeen, IL
Township: East Fork Township
Section 11, **Tier** 7N; **Range** 3W

WATER LEVEL INFORMATION:
▽ = During Drilling
▼ =
▼ =

Number	Recov / Total (in) *% Recovery*	Type	*Blows / 6 in* N - Value **RQD**	Water Content (%)	Dry Density (lb/ft^3)	Qu (tsf) *Qp (tsf)* Failure Type
38A	24/24 *100%*	SS	*7-17 21-29* N=38			
39A	24/24 *100%*	SS	*8-24 26-27* N=50			
40A	24/24 *100%*	SS	*5-9 10-13* N=19			
41A	24/24 *100%*	SS	*6-10 25-33* N=35			
42A	11/11 *100%*	SS	*3-50/5"*			
43A	5/5 *100%*	SS	*50/5"*			
44A	5/5 *100%*	SS	*50/5"*			
45A	8/8 *100%*	SS	*49-50/2"*			
46A	11/11 *100%*	SS	*25-50/5"*			

Lithologic Description	Remarks
Dark gray (10YR4/1) with 5% light gray (10YR7/1) mottles, moist, hard, lean CLAY, with some silt, trace very fine- to fine-grained sand and small gravel. *[Continued from previous page]*	Trace roots at 82 ft.
Very dark gray (10YR3/1), moist, hard, lean CLAY, with some silt.	
Dark gray (10YR4/1) with 5% black (10YR2/1) mottles, moist, hard, lean CLAY, with some silt.	
Dark greenish gray (GLEY14/1) with 5% yellowish brown (10YR5/6) mottles, moist, hard, lean CLAY, with some silt.	Few very fine- to fine-grained sand below 88 ft.
Light reddish brown (2.5YR6/3) with 10% gray (GLEY15/), dry, hard, SILT, with few clay and very fine-grained sand.	
Light reddish brown (2.5YR6/3) with 10% gray (GLEY15/) and 5% dark yellowish brown (10YR4/6) mottles, dry, hard, SILT, with few clay and very fine-grained sand.	

Depth ft. BGS: 82, 84, 86, 88, 90, 92, 94, 96, 98, 100

Elevation ft. MSL: 530, 528, 526, 524, 522, 520, 518, 516, 514, 512

NOTE(S): G314D installed in borehole.

FIELD BORING LOG

CLIENT: Illinois Power Generating Co.
Site: Coffeen Part 845 Groundwater
Location: Coffeen, Illinois
Project: 20E0111A
DATES: Start: 2/10/2021
Finish: 2/12/2021
WEATHER: Overcast, very cold (10s)

CONTRACTOR: Roberts
Rig mfg/model: CME-75 Track Rig
Drilling Method: 4.25" HSA w/SS sampler
FIELD STAFF: Driller: Matt
Helper: Corey
Eng/Geo: C. Colin Winter

BOREHOLE ID: G314D
Well ID: G314D
Surface Elev: 610.87 ft. MSL
Completion: 100.30 ft. BGS
Station: 871,642.00N
2,516,853.90E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Coffeen, IL
Township: East Fork Township
Section 11, **Tier** 7N; **Range** 3W

WATER LEVEL INFORMATION:
▽ = During Drilling
▽ =
▼ =

SAMPLE			TESTING								
Number	Recov / Total (in) *% Recovery*	Type	*Blows / 6 in* N - Value **RQD**	Water Content (%)	Dry Density (lb/ft^3)	Qu (tsf) *Qp (tsf)* Failure Type	Depth ft. BGS	Lithologic Description	Borehole Detail	Elevation ft. MSL	Remarks
47A	3/3 *100%*	☒ SS	*50/3"*					**End of boring = 100.3 feet**			

NOTE(S): G314D installed in borehole.

FIELD BORING LOG

HANSON

CLIENT: Illinois Power Generating Co.
Site: Coffeen Part 845 Groundwater
Location: Coffeen, Illinois
Project: 20E0111A
DATES: Start: 1/14/2021
Finish: 1/14/2021
WEATHER: Overcast, cold (30s)

CONTRACTOR: Roberts
Rig mfg/model: GeoProbe 8040DT
Drilling Method: 4.25" HSA w/SS sampler
FIELD STAFF: Driller: Matt
Helper: Corey
Eng/Geo: C. Colin Winter

BOREHOLE ID: G316
Well ID: G316
Surface Elev: 599.64 ft. MSL
Completion: 15.75 ft. BGS
Station: 871,643.10N
2,517,211.60E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Coffeen, IL
Township: East Fork Township
Section 11, **Tier** 7N; **Range** 3W

WATER LEVEL INFORMATION:
▽ = 8.60 - During Drilling
▼ = 13.80 - During Drilling
▼ =

SAMPLE			TESTING				
Number	Recov / Total (in) *% Recovery*	Type	*Blows / 6 in* N - Value **RQD**	Water Content (%)	Dry Density (lb/ft^3)	Qu (tsf) *Qp (tsf)* Failure Type
1A	15/24 *63%*	SS	*10-9* *5-4* N=14			
2A	10/24 *42%*	SS	*1-3* *4-6* N=7			
3A	14/24 *58%*	SS	*2-2* *3-3* N=5			
4A	10/24 *42%*	SS	*0-1* *1-2* N=2			
5A						
5B	22/24 *92%*	SS	*1-1* *1-2* N=2			
6A	20/24 *83%*	SS	*1-2* *4-7* N=6			
7A	22/24 *92%*	SS	*0-2* *3-3* N=5			
8A	21/17 *124%*	SS	*2-2* *26-50/3"* N=28			
8B						

Depth ft. BGS — Lithologic Description

Brown (10YR5/3), moist, medium dense, small to large GRAVEL, with some clay and fine to coarse grained sand. [FILL]

2

Gray (10YR5/1), moist, hard, lean CLAY, with some silt, few small gravel and very fine- to fine-grained sand.

4

Gray (10YR5/1) with 10% yellowish brown (10YR5/6) mottles, moist, stiff, lean CLAY, with some silt, few small gravel and very fine- to fine-grained sand.

6

Gray (10YR5/1) with 30% black (10YR2/1) mottles, moist, stiff, lean CLAY, with some silt, few very fine-grained sand, organics and wood fragments.

8

▽

Very dark gray (10YR3/1), wet, medium stiff to stiff, SILT, with some clay and very fine- to fine-grained sand.

10

Brown (10YR4/3), moist, very stiff, lean CLAY, with some silt, little very fine- to fine-grained sand, few small gravel.

12

Dark gray (10YR4/1) with 20% yellowish brown (10YR5/6) mottles, moist, medium stiff to stiff, lean CLAY, with some silt, little very fine- to fine-grained sand, few small gravel.

▼

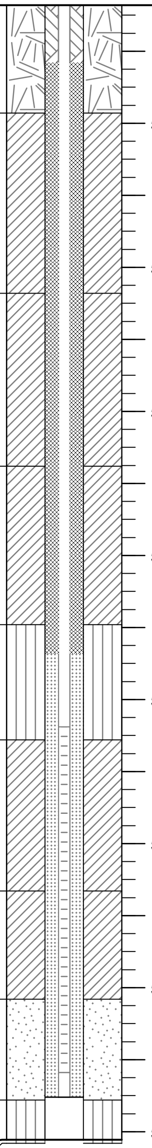
14

Brown (10YR4/3), wet, loose, very fine- to fine-grained SAND, with some silt, trace clay.

Yellowish brown (10YR5/6), moist, hard, SILT, with some very fine- to fine-grained sand, trace small gravel.

End of boring = 15.75 feet

Borehole Detail



Elevation ft. MSL

598
596
594
592
590
588
586
584

Remarks

NOTE(S): G316 installed in borehole.

FIELD BORING LOG

HANSON

CLIENT: Natural Resource Technology, Inc.
Site: Coffeen Energy Center
Location: Coffeen, Illinois
Project: 15E0030
DATES: Start: 9/14/2015
Finish: 9/14/2015
WEATHER: Sunny, hi 60's

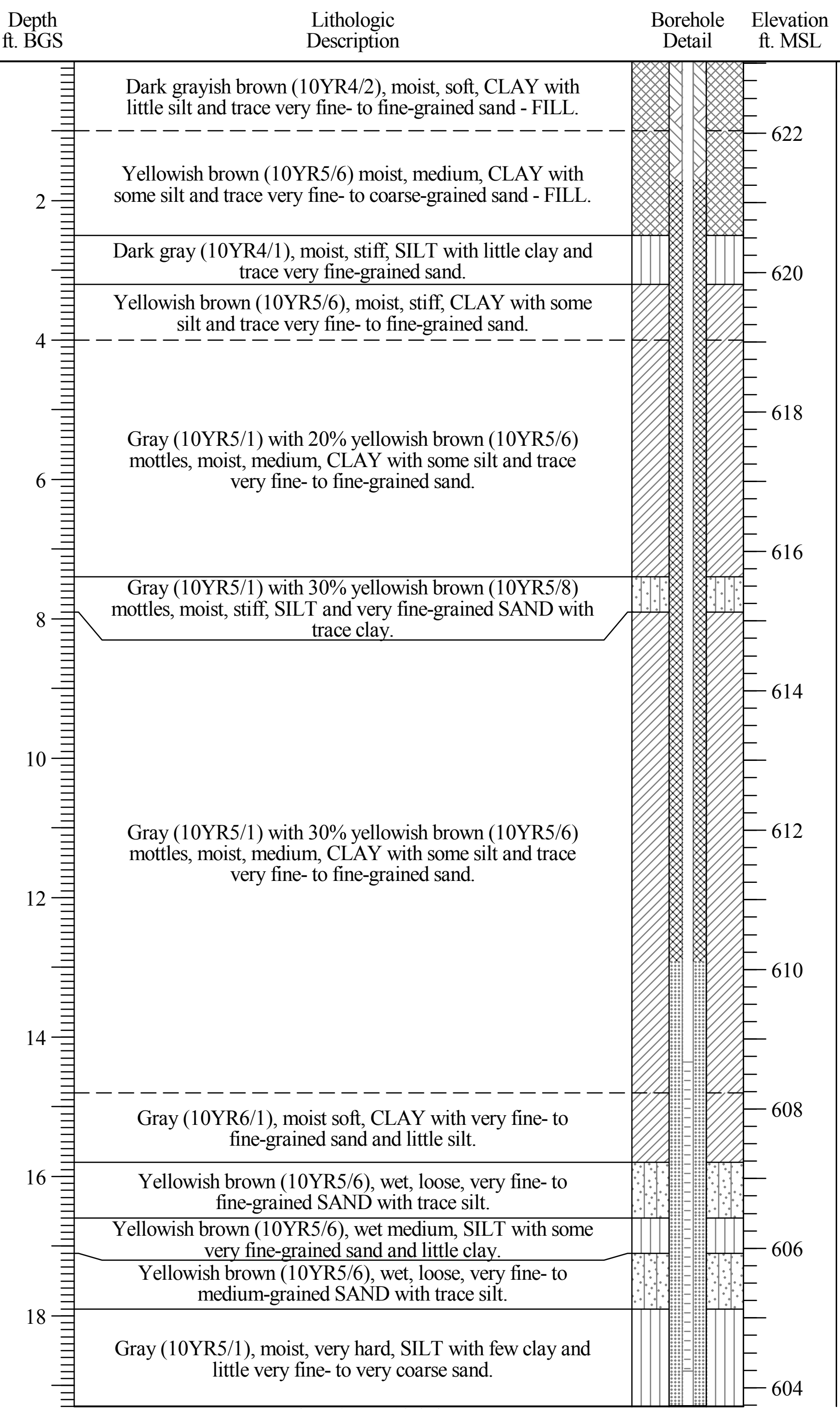
CONTRACTOR: Ramsey Geotechnical Engineering, LLC
Rig mfg/model: D-50 Turbo Tracked MST 800ATV
Drilling Method: Hollow Stem Auger (3¼"overdrill / 4¼")
FIELD STAFF: Driller: D. Crump
Helper: D. Groves
Eng/Geo: R. Hasenyager

BOREHOLE ID: G401
Well ID: G401
Surface Elev: 623.03 ft. MSL
Completion: 19.30 ft. BGS
Station: 2,515,614.84N
872,510.57E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Coffeen, IL
Township: East Fork
Section 11, **Tier** 7N; **Range** 3W

WATER LEVEL INFORMATION:
▼ = Dry - During Drilling
▼ =
▽ =

SAMPLE			TESTING			
Number	Recov / Total (in) *% Recovery*	Type	*Blows / 6 in* N - Value **RQD**	Moisture (%)	Dry Den. (lb/ft^3)	Qu (tsf) *Qp (tsf)* Failure Type
1A	16/24 *67%*	SS	*2-2* *3-7* N=5	17		
2A	21/24 *88%*	SS	*8-11* *8-9* N=19	17		*1.80*
2B				25		
3A	23/24 *96%*	SS	*3-4* *7-8* N=11	23		*2.50*
4A	24/24 *100%*	SS	*8-9* *12-14* N=21	21		*3.30*
4B				19		*2.80*
5A	24/24 *100%*	SS	*2-3* *4-5* N=7	21		*1.30*
6A	24/24 *100%*	SS	*2-4* *5-6* N=9	17		*2.50*
7A	24/24 *100%*	SS	*9-7* *8-9* N=15	21		*1.40*
8A	24/24 *100%*	SS	*2-3* *2-4* N=5	17		*1.30*
8B				19		
9A	20/24 *83%*	SS	*5-4* *5-10* N=9	21		
9B				16		
10A	12/16 *75%*	SS	*23-41* *50/4"*	6		*4.50*



Lithologic Description

Dark grayish brown (10YR4/2), moist, soft, CLAY with little silt and trace very fine- to fine-grained sand - FILL.

Yellowish brown (10YR5/6) moist, medium, CLAY with some silt and trace very fine- to coarse-grained sand - FILL.

Dark gray (10YR4/1), moist, stiff, SILT with little clay and trace very fine-grained sand.

Yellowish brown (10YR5/6), moist, stiff, CLAY with some silt and trace very fine- to fine-grained sand.

Gray (10YR5/1) with 20% yellowish brown (10YR5/6) mottles, moist, medium, CLAY with some silt and trace very fine- to fine-grained sand.

Gray (10YR5/1) with 30% yellowish brown (10YR5/8) mottles, moist, stiff, SILT and very fine-grained SAND with trace clay.

Gray (10YR5/1) with 30% yellowish brown (10YR5/6) mottles, moist, medium, CLAY with some silt and trace very fine- to fine-grained sand.

Gray (10YR6/1), moist soft, CLAY with very fine- to fine-grained sand and little silt.

Yellowish brown (10YR5/6), wet, loose, very fine- to fine-grained SAND with trace silt.

Yellowish brown (10YR5/6), wet medium, SILT with some very fine-grained sand and little clay.

Yellowish brown (10YR5/6), wet, loose, very fine- to medium-grained SAND with trace silt.

Gray (10YR5/1), moist, very hard, SILT with few clay and little very fine- to very coarse sand.

End of boring = 19.3 feet

NOTE(S): G401 installed in borehole.

FIELD BORING LOG

CLIENT: Natural Resources Technology, Inc.
Site: Coffeen Power Station - Ash Pond 2
Location: 134 CIPS Lane, Coffeen, IL 62017
Project: 16E0080
DATES: Start: 8/16/2016
Finish: 8/16/2016
WEATHER: Rain, (mid-70s)

CONTRACTOR: Bulldog Drilling, Inc.
Rig mfg/model: CME-750 ATV Drill
Drilling Method: 4 1/4" Hollow Stem Auger
FIELD STAFF: Driller: J. Dittmaier
Helper: M. Hill
Eng/Geo: K. Theesfeld

BOREHOLE ID: G407
Well ID: G407
Surface Elev: 618.35 ft. MSL
Completion: 20.00 ft. BGS
Station: 2,513,705.87N
2,513,705.87E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Coffeen
Township: East Fork
Section 10, **Tier** 7 N.; **Range** 3 W.

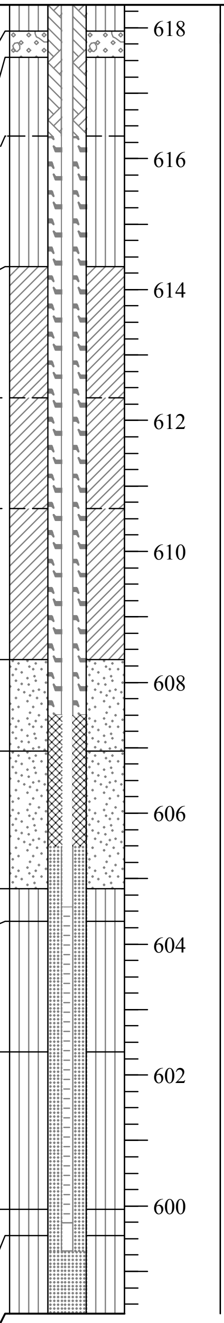
WATER LEVEL INFORMATION:
▼ = 16.00 - During Drilling
▼ =
▽ =

SAMPLE			TESTING			
Number	Recov / Total (in) *% Recovery*	Type	*Blows / 6 in* N - Value **RQD**	Moisture (%)	Dry Den. (lb/ft³)	Qu (tsf) *Qp* (tsf) Failure Type
1A	12/24 *50%*	SS	*4-3 3-3* N=6	14		*3.50*
2A	20/24 *83%*	SS	*2-2 4-4* N=6	18		*1.50*
3A	23/24 *96%*	SS	*1-2 3-4* N=5	19		*1.75*
4A	24/24 *100%*	SS	*1-3 3-5* N=6	19		*1.50*
5A	21/24 *88%*	SS	*1-2 4-4* N=6	19		*0.50*
6A	22/24 *92%*	SS	*1-2 2-1* N=4	17		
7A	24/24 *100%*	SS	*7-29 33-17* N=62	8		
8A	24/24 *100%*	SS	*3-7 12-17* N=19	12		*4.50*
9A	24/24 *100%*	SS	*4-9 14-20* N=23	13		*4.00*
10A	24/24 *100%*	SS	*2-8 14-19* N=22	14		*4.50*

Depth ft. BGS	Lithologic Description
	Very dark gray (10YR3/1), wet, medium, SILT with some organics. [Fill]
	Gray (10YR6/1), wet, loose, SAND with some gravel and little clay. [Fill]
2	Yellowish brown (10YR5/6) with 5% dark yellowish brown (10YR3/6) mottles, moist, very stiff, SILT with some clay and trace very fine- to fine-grained sand.
	Brown (10YR5/3) with 10% yellowish brown (10YR5/6) mottles, moist, stiff, SILT with some clay, little fine- to coarse-grained sand, and trace small gravel.
4	Brown (10YR5/3) with 25% yellowish brown (10YR5/6) mottles, moist, stiff, CLAY with some silt, trace fine-grained sand and trace small gravel.
6	Brown (10YR5/3) with 10% yellowish brown (10YR5/6) mottles, moist, stiff, CLAY with some silt, little fine- to coarse-grained sand and trace small gravel.
8	Yellowish brown (10YR5/6) with 25% brown (10YR5/3) mottles, moist, medium, CLAY with few silt, few fine-grained sand, and trace small gravel.
10	Yellowish brown (10YR5/8) with 5% gray (10YR5/1) mottles, moist, very loose, fine-grained SAND with some clay and trace small gravel.
12	Gray (10YR5/1) with 25% yellowish brown (10YR5/8) mottles, moist, very dense, fine-grained SAND
	Brown (10YR5/3), moist, hard, SILT with some clay and little fine- to coarse-grained sand.
14	Yellowish brown (10YR5/4) with 5% yellowish brown (10YR5/6) and 5% black (10YR2/1) mottles, SILT with some clay and little fine- to coarse-grained sand.
▼ 16	Yellowish brown (10YR5/4) with 5% yellowish brown (10YR5/6), 5% dark gray (10YR4/1) and 5% black (10YR2/1) mottles, moist, hard, SILT with little fine- to coarse-grained sand and trace small gravel.
18	Yellowish brown (10YR5/4) with 5% yellowish brown (10YR5/6), 5% dark gray (10YR4/1) and 5% black (10YR2/1) mottles, wet, stiff, SILT with little fine- to coarse-grained sand and little small gravel.
20	Dark grayish brown (10YR4/2) with 10% dark yellowish brown (10YR3/6) mottles, moist, hard, CLAY with some silt, little fine- to coarse-grained sand and trace small gravel.

End of Boring = 20.0 ft. BGS

Borehole Detail



Remarks

NOTE(S): G407 installed in boring.

FIELD BORING LOG

HANSON

CLIENT: Illinois Power Generating Company
Site: Coffeen Power Station - Ash Pond 2
Location: Coffeen, Illinois
Project: 16E0031A
DATES: Start: 2/23/2018
Finish: 2/23/2018
WEATHER: Overcast, mild (mid-40s)

CONTRACTOR: Bulldog Drilling, Inc.
Rig mfg/model: CME-750 ATV Drill
Drilling Method: 4¼" HSA with continuous split spoon
FIELD STAFF: Driller: C. Dutton
Helper: M. Baetje
Eng/Geo: R. Hasenyager

BOREHOLE ID: G410
Well ID: G410
Surface Elev: 617.21 ft. MSL
Completion: 14.09 ft. BGS
Station: 872,968.54N
2,513,206.33E

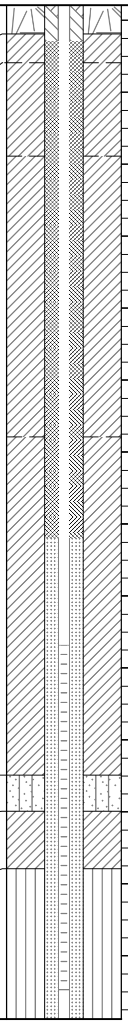
TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Coffeen
Township: East Fork
Section 10, **Tier** 7N; **Range** 3W

WATER LEVEL INFORMATION:
▼ = 11.00 - During drilling
▼ = 13.30 - Upon completion
▽ = 4.82 - 1 March 2018

SAMPLE			TESTING			
Number	Recov / Total (in) *% Recovery*	Type	*Blows / 6 in* N - Value **RQD**	Water Content (%)	Dry Density (lb/ft^3)	Qu (tsf) *Qp (tsf)* Failure Type
1A	14/24 *58%*	SS	*2-3* *1-5* N=4	26.7		
2A	15/24 *63%*	SS	*4-4* *4-5* N=8	25.2		
3A	17/24 *71%*	SS	*2-3* *4-6* N=7	17.9		
4A	20/24 *83%*	SS	*3-4* *5-6* N=9	17.2		
5A	11/24 *46%*	SS	*3-3* *5-6* N=8	17.5		
6A	22/24 *92%*	SS	*2-3* *4-6* N=7	16.9		
6B				16.8		
7A	24/24 *100%*	SS	*6-28* *36-42* N=64	10.3		
	0/1 *0%*	BD				

Depth ft. BGS	Lithologic Description	Elevation ft. MSL	Remarks
	FILL - Light gray (10YR7/1), moist, loose, very fine- to very coarse-grained SAND with few small to medium gravel.		
	Very dark grayish brown (10YR3/2), moist, soft, CLAY with some silt and trace very fine- to fine-grained sand.		
	Yellowish brown (10YR5/4), moist, soft, CLAY with some silt and trace very fine- to fine-grained sand.	616	
2			
4	Gray (10YR6/1) with 25% yellowish brown (10YR5/6) mottles, moist, medium,CLAY with some silt and trace very fine- to fine-grained sand.	614	
▽		612	
6		610	
8	Gray (10YR5/1) with 30% yellowish brown (10YR5/8) mottles, moist, medium, CLAY with some silt, little very fine- to very coarse-grained sand, and trace small to medium gravel.	608	
10			
▼	Gray (10YR6/1), moist, loose, very fine- to medium-grained SAND with few silt and few clay.	606	
	Yellowish brown (10YR5/8) with 10% gray (10YR5/1) mottles, moist, medium, CLAY with some silt, little very fine- to very coarse-grained sand, and trace small to medium gravel.		
12	Yellowish brown (10YR5/6), moist, hard, SILT with some clay, few very fine- to very coarse-grained sand, and trace small to medium gravel.	604	
▼			
14			

Borehole Detail



End of Boring = 14.09 ft bgs

NOTE(S):

Attachment E

Site Solids Bulk Characterization Analytical Data

PRIMA ENVIRONMENTAL INC.
Questions Answered.

September 15, 2021

Michael Healy
SiREM
130 Stone Road West
Guelph, Ontario, Canada   N1G 3Z2

RE: Report of Findings, Measurement of AVS
Client ID: Coffeen AP1 MNA
PRIMA ID: Sirem 08312021-Coffeen AP1

Dear Mr. Healy:

This letter report describes the results of analyses conducted on four soil samples. Each soil was analyzed for acid volatile sulfide (AVS). Results are reported herein.

Sample Receipt and Preparation

Samples were received on August 31, 2021. The samples were placed in an anaerobic glovebox upon receipt. All sample preparation was conducted in the glove box.

Procedures

AVS was measured via sequential extraction of soil based on methods provided by Microseeps, Inc. In order to minimize exposure of the soil or extraction fluid to oxygen, the soil samples were transferred to the extraction vessel while in the glove box and the extractions were carried out on the bench top under a flow of nitrogen. A brief description of the extraction procedure is provided below.

WAS-Fe. Approximately 10 g of soil is extracted with 1 N hydrochloric acid (HCl) for 30 minutes at room temperature (approximately 20° C), after which an aliquot of the HCl is withdrawn and analyzed for ferrous iron and total iron colorimetrically using a Hach DR2800 spectrophotometer and appropriate Hach test kit reagents. Dilutions are made as needed using deoxygenated, deionized (DO/DI) water.

AVS. Hydrogen sulfide generated during the WAS extraction step is collected in a trap filled with 1.25 N sodium hydroxide (NaOH). After collection of the WAS Fe sample, concentrated HCl is added to the soil and the mixture is heated for 30 minutes. The concentration of sulfide in trap is then measured using the methylene blue method via a

Hach DR2800 spectrophotometer and appropriate Hach test kit reagents. Dilutions are made as needed using DO/DI water.

Results

The amount of AVS in each sample is shown in **Table 1** (attached). QC results are given in **Table 2** (attached).

If you have any questions regarding these results, please give me a call at 916-939-7300. Thank you for the opportunity to be of service.

Sincerely,
PRIMA Environmental, Inc.

Cindy G. Schreier

Cindy G. Schreier, Ph.D.
President

Attachments

Table 1. AVS Results.

Sample	AVS, mg/kg
SB-306-(14-16)	< 0.18
SB-311-(14-15)	0.24
SB-313-(8-9)	< 1.6 M
SB-316-(13-14, 15-16)	0.28

M Reporting limit elevated due to matrix interference

Table 2. QC Results for AVS.

Sample ID	Result	Units
Blank *		
AVS	< 0.025	mg/L
FeS standard		
Sulfide concentration	365	g/kg
AVS	378	g/kg
% Recovered as AVS	104	%

* A blank was run in the absence of a solid material. Therefore, values are concentrations in the extraction fluids or traps.

PRIMA ENVIRONMENTAL INC.
Questions Answered.

5070 Robert J Mathews Parkway, Suite 300
El Dorado Hills, CA 95762
916-939-7300
www.primaenvironmental.com

Sample Receipt Summary

Date/Time: 8/31/21 10:40

Client/Company: SiRem - AVS 08312021

Project: Coffeen AP1 MNA

	Yes	No	N/A
Custody seals intact?	☐	☐	☒
Chain of custody Present?	☒	☐	☐
If no, list number of samples and Sample ID			
Ice present?	☒ Blue ice	☐	☐
If no, what is temperature? _____			
Samples in good condition?	☒	☐	☐
If no, explain:			
Do sample IDs on containers match IDs on COC?	☒	☐	☐
If no, explain:			

Other Comments:

electrical tape around lids.
Store in glovebox

P:\Templates_Forms\Shipping Receiving\Sample Receipt Checklist 8-27-19

PRIMA ENVIRONMENTAL INC.
Mathews Parkway, Suite 300 El Dorado Hills, CA 95762
(916) 939-7300; (916) 939-7398 Fax
www.primaenvironmental.com

CHAIN of CUSTODY
Page 1 of 1

Project Manager: Michael Healey
Project Name: Coffeen AP1 MNA
Job Number:
Sampler Signature:

Phone: (519) 822-2265
Fax: (519) 822-3151
Email: mhealey@siremlab.com
TAT: 1 week

SAMPLE ID	Date	Time			Analysis										Comments
			Matrix	# Containers	Acid Volatile Sulfide										
✓ SB-306-(14-16)	26-Aug-21	12:15	S	1	X										
✓ SB-311-(14-15)	26-Aug-21	12:30	S	1	X										
✓ SB-313-(8-9)	26-Aug-21	12:45	S	1	X										
✓ SB-316-(13-14,15-16)	26-Aug-21	1:00	S	1	X										

Special Instructions	Relinquished by:		Received by:
	Company SiREM	Date 26 Aug 21	Company
	Printed Name Rachel Hallman	Time 12:00 pm.	Printed Name
	Signature		Signature
	Relinquished by:		Received by:
	Company	Date 8/31/21	Company PRIMA
	Printed Name	Time 10:40	Printed Name Molly Scott
	Signature		Signature Molly Scott

Matrix key: S - soil/sediment; W - water; OT - other

PRIMA
ENVIRONMENTAL INC.
Questions Answered.

September 1, 2021

Michael Healy
SiREM
130 Stone Road West
Guelph, Ontario, Canada N1G 3Z2

RE: Report of Findings, Measurement of AVS
Client ID: Coffeen MNA
PRIMA ID: Sirem 08202021-Coffeen

Dear Mr. Healy:

This letter report describes the results of analyses conducted on two soil samples. Each soil was analyzed for acid volatile sulfide (AVS). Results are reported herein.

Sample Receipt and Preparation

Samples were received on August 20, 2021. The samples were frozen upon receipt, then thawed in a nitrogen-filled glove box. All sample preparation was conducted in the glove box.

Procedures

AVS was measured via sequential extraction of soil based on methods provided by Microseeps, Inc. In order to minimize exposure of the soil or extraction fluid to oxygen, the soil samples were transferred to the extraction vessel while in the glove box and the extractions were carried out on the bench top under a flow of nitrogen. A brief description of the extraction procedure is provided below.

WAS-Fe. Approximately 10 g of soil is extracted with 1 N hydrochloric acid (HCl) for 30 minutes at room temperature (approximately 20° C), after which an aliquot of the HCl is withdrawn and analyzed for ferrous iron and total iron colorimetrically using a Hach DR2800 spectrophotometer and appropriate Hach test kit reagents. Dilutions are made as needed using deoxygenated, deionized (DO/DI) water.

AVS. Hydrogen sulfide generated during the WAS extraction step is collected in a trap filled with 1.25 N sodium hydroxide (NaOH). After collection of the WAS Fe sample, concentrated HCl is added to the soil and the mixture is heated for 30 minutes. The concentration of sulfide in trap is then measured using the methylene blue method via a Hach DR2800 spectrophotometer and appropriate Hach test kit reagents. Dilutions are made as needed using DO/DI water.

Results

The amount of AVS in each sample is shown in **Table 1** (attached). QC results are given in **Table 2** (attached).

If you have any questions regarding these results, please give me a call at 916-939-7300. Thank you for the opportunity to be of service.

Sincerely,
PRIMA Environmental, Inc.

Cindy G. Schreier
Cindy G. Schreier, Ph.D.
President

Attachments

Table 1. AVS Results.

Sample	AVS, mg/kg
401B-(16-20)	< 0.19
270A-(12-16)	< 0.19

Table 2. QC Results for AVS.

Sample ID	Result	Units
Blank *		
AVS	< 0.025	mg/L
FeS standard		
Sulfide concentration	365	g/kg
AVS	364	g/kg
% Recovered as AVS	100	%

* A blank was run in the absence of a solid material. Therefore, values are concentrations in the extraction fluids or traps.

PRIMA ENVIRONMENTAL INC.
Questions Answered.

5070 Robert J Mathews Parkway, Suite 300
El Dorado Hills, CA 95762
916-939-7300
www.primaenvironmental.com

Sample Receipt Summary

Date/Time: 8/20/21 10:00 AM

Client/Company: SiRem lab – Michael Healey

Project: Coffeen MNA (2)
Miami Fort MNA (4)
Vermillion MNA (5)

	Yes	No	N/A
Custody seals intact?	☐	☐	☒
Chain of custody Present?	☒	☐	☐
If no, list number of samples and Sample ID			
Ice present?	☒	☐	☐
If no, what is temperature? _____			
Samples in good condition?	☒	☐	☐
If no, explain:			

Ice appears melted.

	Yes	No	N/A
Do sample IDs on containers match IDs on COC?	☒	☐	☐
If no, explain:			

3 Chains of custody
11 soil Jars Total

Other Comments:

PRIMA ENVIRONMENTAL INC.
Mathews Parkway, Suite 300 El Dorado Hills, CA 95762
(916) 939-7300; (916) 939-7398 Fax
www.primaenvironmental.com

CHAIN of CUSTODY

Page 1 of 1

Project Manager: Michael Healey
Project Name: Coffeen MNA
Job Number:
Sampler Signature:

Phone: (519) 822-2265
Fax: (519) 822-3151
Email: mhealey@siremlab.com
TAT: 1 week

SAMPLE ID	Date	Time	Matrix	# Containers	Acid Volatile Sulfide	Analysis									Comments
401B-(16-20) ✓	18-Aug-21	3:00	S	1	X										
270A-(12-16) ✓	18-Aug-21	3:15	S	1	X										

Special Instructions	Relinquished by:			Received by:
	Company: SiREM Labs	Date: 18 Aug 21		Company: PRIMA 8/20/21
	Printed Name: Rachel Hallman	Time: 5:30 pm.		Printed Name: ChrisB. 10:00 AM
	Signature:			Signature: CR
	Relinquished by:			**Received by:**
	Company	Date		Company
	Printed Name	Time		Printed Name
	Signature			Signature

Matrix key: S - soil/sediment; W - water; OT - other

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

13-September-2021

SiREM Laboratory
Attn : Michael Healey

130 Stone Road W, Guelph
Canada, N1G 3Z2
Phone: 519-822-2265, Fax:519-822-3151

Date Rec. : 13 September 2021
LR Report: **CA15261-SEP21**
Reference: P.O# 800003210A

Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Sample ID	Sample Date & Time	S %
1: Analysis Start Date		13-Sep-21
2: Analysis Start Time		15:44
3: Analysis Completed Date		13-Sep-21
4: Analysis Completed Time		17:17
5: G1001-(6-11)	17-May-21 10:00	0.031
6: 401B-(16-20)	17-May-21 10:15	0.008
7: 270A-(12-16)	17-May-21 10:30	< 0.005

Catharine Arnold

ASSOCIATION OF THE CHEMICAL PROFESSION OF ONTARIO
CHARTERED
CATHARINE ARNOLD
CHEMIST

Catharine Arnold, B.Sc., C.Chem
Project Specialist,
Environment, Health & Safety

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Test method information available upon request. “Temperature Upon Receipt” is representative of the whole shipment and may not reflect the temperature of individual samples.
SGS Canada Inc. Environment-Health & Safety statement of conformity decision rule does not consider uncertainty when analytical results are compared to a specified standard or regulation.

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

Project : Coffeen AP1 MNA, PO# 800003210A

21-December-2021

SiREM Laboratory
Attn : Michael Healey

130 Stone Road W, Guelph
Canada, N1G 3Z2
Phone: 519-822-2265, Fax:519-822-3151

Date Rec. : 16 November 2021
LR Report: **CA14794-NOV21**
Reference: Project Name: Coffeen AP1 MNA, PO# 800003210A

Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Sample ID	Sample Date & Time	B g/t
5: SB-306-(14-16)	26-Aug-21 10:00	< 40
6: SB-311-(14-15)	26-Aug-21 10:15	< 40
7: SB-313-(8-9)	26-Aug-21 10:30	< 40
8: SB-316-(13-14,15-16)	26-Aug-21 10:45	< 40

Catharine Arnold

CATHARINE ARNOLD

Catharine Arnold, B.Sc., C.Chem
Project Specialist,
Environment, Health & Safety

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SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

13-September-2021

SiREM Laboratory
Attn : Michael Healey

130 Stone Road W
Guelph, ON
N1G 3Z2, Canada

Phone: 519-822-2265
Fax:519-822-3151

Date Rec. : 31 August 2021
LR Report: **CA19062-AUG21**
Reference: Project Name: Coffeen AP1 MNA, PO# 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: SB-306-(14-16)	6: SB-311-(14-15)	7: SB-313-(8-9)	8: SB-316-(13-14,15-16)
Sample Date & Time					26-Aug-21 10:00	26-Aug-21 10:15	26-Aug-21 10:30	26-Aug-21 10:45
Ag [µg/g]	09-Sep-21	19:00	10-Sep-21	10:47	< 0.5	< 0.5	< 0.5	< 0.5
Al [µg/g]	09-Sep-21	19:00	10-Sep-21	10:47	13000	11000	31000	32000
As [µg/g]	09-Sep-21	19:00	10-Sep-21	10:47	6.7	2.7	5.6	5.1
Ba [µg/g]	09-Sep-21	19:00	10-Sep-21	10:47	98	58	310	320
Be [µg/g]	09-Sep-21	19:00	10-Sep-21	10:47	0.45	0.37	0.73	0.69
Bi [µg/g]	09-Sep-21	19:00	10-Sep-21	10:47	0.10	0.10	0.11	0.12
Ca [µg/g]	09-Sep-21	19:00	10-Sep-21	10:47	35000	52000	69000	10000
Cd [µg/g]	09-Sep-21	19:00	10-Sep-21	10:47	0.11	0.08	0.20	0.06
Co [µg/g]	09-Sep-21	19:00	10-Sep-21	10:47	6	4	7	4
Cr [µg/g]	09-Sep-21	19:00	10-Sep-21	10:47	130	100	130	150
Cu [µg/g]	09-Sep-21	19:00	10-Sep-21	10:47	14	10	12	10
Fe [µg/g]	09-Sep-21	19:00	10-Sep-21	10:47	20000	12000	27000	17000
K [µg/g]	09-Sep-21	19:00	10-Sep-21	10:47	3700	3600	13000	14000
Li [µg/g]	09-Sep-21	19:00	10-Sep-21	10:47	11	11	19	14
Mg [µg/g]	09-Sep-21	19:00	10-Sep-21	10:47	15000	27000	35000	6700
Mn [µg/g]	09-Sep-21	19:00	10-Sep-21	10:47	470	310	1200	260
Mo [µg/g]	09-Sep-21	19:00	10-Sep-21	10:47	5.8	2.7	1.6	8.1
Na [µg/g]	09-Sep-21	19:00	10-Sep-21	10:47	590	830	6000	6400
Ni [µg/g]	09-Sep-21	19:00	10-Sep-21	10:47	15	11	17	13
P [µg/g]	09-Sep-21	19:00	10-Sep-21	10:47	230	200	250	230
Pb [µg/g]	09-Sep-21	19:00	10-Sep-21	10:47	9	7	11	12
Sb [µg/g]	09-Sep-21	19:00	10-Sep-21	10:47	< 0.8	< 0.8	< 0.8	< 0.8
Se [µg/g]	09-Sep-21	19:00	10-Sep-21	10:47	< 0.7	< 0.7	< 0.7	< 0.7
Sn [µg/g]	09-Sep-21	19:00	10-Sep-21	10:47	< 6	< 6	< 6	< 6
Sr [µg/g]	09-Sep-21	19:00	10-Sep-21	10:47	26	35	100	89
Ti [µg/g]	09-Sep-21	19:00	10-Sep-21	10:47	370	320	1500	1200
Tl [µg/g]	09-Sep-21	19:00	10-Sep-21	10:47	0.15	0.13	0.26	0.31
U [µg/g]	09-Sep-21	19:00	10-Sep-21	10:47	0.54	0.55	1.0	1.0
V [µg/g]	09-Sep-21	19:00	10-Sep-21	10:47	28	20	35	29
Y [µg/g]	09-Sep-21	19:00	10-Sep-21	10:47	9.1	8.2	11	10
Zn [µg/g]	09-Sep-21	19:00	10-Sep-21	10:47	35	27	41	34
C [%]	10-Sep-21	08:20	10-Sep-21	14:51	1.65	2.76	3.26	0.457

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SGS Canada Inc. Environment-Health & Safety statement of conformity decision rule does not consider uncertainty when analytical results are compared to a specified standard or regulation.

Analysis	**1: Analysis Start Date**	**2: Analysis Start Time**	**3: Analysis Completed Date**	**4: Analysis Completed Time**	**5: SB-306-(14-16)**	**6: SB-311-(14-15)**	**7: SB-313-(8-9)**	**8: SB-316-(13-14,15-16)**
S [%]	10-Sep-21	08:20	10-Sep-21	14:51	0.005	0.014	0.007	0.012
TOC [%]	10-Sep-21	14:26	10-Sep-21	16:31	0.413	0.772	0.775	0.257
Sulphide [%]	10-Sep-21	18:37	13-Sep-21	09:15	< 0.04	< 0.04	< 0.04	< 0.04

Catharine Arnold

CATHARINE ARNOLD

Catharine Arnold, B.Sc., C.Chem
Project Specialist,
Environment, Health & Safety

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SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

Project : Coffeen MNA

09-June-2021

SiREM Laboratory
Attn : Michael Healey

130 Stone Road W
Guelph, ON
N1G 3Z2, Canada

Phone: 519-822-2265
Fax:519-822-3151

Date Rec. : 18 May 2021
LR Report: **CA12646-MAY21**
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: G1001-(6-11)**	**6: 401B-(16-20)**	**7: 270A-(12-16)**
Sample Date & Time					17-May-21 10:00	17-May-21 10:15	17-May-21 10:30
Temp Upon Receipt [°C]	---	---	---	---	5.0	5.0	5.0
Sulphide1 [%]	03-Jun-21	15:12	03-Jun-21	16:31	0.05	< 0.04	< 0.04
TOC [%]	07-Jun-21	09:12	07-Jun-21	15:08	0.852	0.082	0.138
Ag [µg/g]	04-Jun-21	15:33	07-Jun-21	10:42	< 0.05	< 0.05	< 0.05
Al [µg/g]	04-Jun-21	15:33	07-Jun-21	10:42	8200	9700	9600
As [µg/g]	04-Jun-21	15:33	07-Jun-21	10:42	6.2	5.5	12
Ba [µg/g]	04-Jun-21	15:33	07-Jun-21	10:42	120	190	210
Be [µg/g]	04-Jun-21	15:33	07-Jun-21	10:42	0.45	0.35	0.48
B [µg/g]	04-Jun-21	15:33	07-Jun-21	10:42	6	4	5
Bi [µg/g]	04-Jun-21	15:33	07-Jun-21	10:42	0.23	0.25	0.18
Ca [µg/g]	04-Jun-21	15:33	07-Jun-21	10:42	42000	1900	5000
Cd [µg/g]	04-Jun-21	15:33	07-Jun-21	10:42	0.13	0.03	0.12
Co [µg/g]	04-Jun-21	15:33	07-Jun-21	10:42	8.8	6.1	10
Cr [µg/g]	04-Jun-21	15:33	07-Jun-21	10:42	15	14	16
Cu [µg/g]	04-Jun-21	15:33	07-Jun-21	10:42	11	7.8	12
Fe [µg/g]	04-Jun-21	15:33	07-Jun-21	10:42	16000	14000	22000
K [µg/g]	04-Jun-21	15:33	07-Jun-21	10:42	1100	770	1400
Li [µg/g]	04-Jun-21	15:33	07-Jun-21	10:42	9	7	11
Mg [µg/g]	04-Jun-21	15:33	07-Jun-21	10:42	18000	1600	4700
Mn [µg/g]	04-Jun-21	15:33	07-Jun-21	10:42	450	540	1200
Mo [µg/g]	04-Jun-21	15:33	07-Jun-21	10:42	1.5	0.4	0.8
Na [µg/g]	04-Jun-21	15:33	07-Jun-21	10:42	110	80	110
Ni [µg/g]	04-Jun-21	15:33	07-Jun-21	10:42	15	10	20
Pb [µg/g]	04-Jun-21	15:33	07-Jun-21	10:42	11	9.5	12
Sb [µg/g]	04-Jun-21	15:33	07-Jun-21	10:42	< 0.8	< 0.8	< 0.8
Se [µg/g]	04-Jun-21	15:33	07-Jun-21	10:42	< 0.7	< 0.7	< 0.7
Sn [µg/g]	04-Jun-21	15:33	07-Jun-21	10:42	0.6	< 0.5	< 0.5
Sr [µg/g]	04-Jun-21	15:33	07-Jun-21	10:42	35	9.1	10
Ti [µg/g]	04-Jun-21	15:33	07-Jun-21	10:42	170	65	230
Tl [µg/g]	04-Jun-21	15:33	07-Jun-21	10:42	0.16	0.12	0.16
U [µg/g]	04-Jun-21	15:33	07-Jun-21	10:42	0.82	0.39	0.46
V [µg/g]	04-Jun-21	15:33	07-Jun-21	10:42	19	14	22
W [µg/g]	04-Jun-21	15:33	07-Jun-21	10:42	0.07	0.04	0.13

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Test method information available upon request. “Temperature Upon Receipt” is representative of the whole shipment and may not reflect the temperature of individual samples.
SGS Canada Inc. Environment-Health & Safety statement of conformity decision rule does not consider uncertainty when analytical results are compared to a specified standard or regulation.

Analysis	**1: Analysis Start Date**	**2: Analysis Start Time**	**3: Analysis Completed Date**	**4: Analysis Completed Time**	**5: G1001-(6-11)**	**6: 401B-(16-20)**	**7: 270A-(12-16)**
Y [µg/g]	04-Jun-21	15:33	07-Jun-21	10:42	8.1	8.2	9.4
Zn [µg/g]	04-Jun-21	15:33	07-Jun-21	10:42	35	28	50

Catharine Arnold

ASSOCIATION OF THE CHEMICAL PROFESSION OF ONTARIO
CHARTERED
CATHARINE ARNOLD
CHEMIST

Catharine Arnold, B.Sc., C.Chem
Project Specialist,
Environment, Health & Safety

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SGS Canada Inc. Environment-Health & Safety statement of conformity decision rule does not consider uncertainty when analytical results are compared to a specified standard or regulation.

Attachment F

X-Ray Fluorescence Analytical Data

ANALYSIS REPORT BBM23-31378

To

F400101 SGS CANADA INC
LISA THOMPSON
185 Concession Street
Lakefield K0L 2H0
ON
CANADA

Order Number	PO#	Date Received	23-Aug-2023
Submission Number	CA19113-JUL23 / 6 Pulp	Date Analysed	30-Aug-2023 - 06-Sep-2023
Number of Samples	6	Date Completed	09-Sep-2023
		SGS Order Number	BBM23-31378

Methods Summary

Number of Sample	Method Code	Description
6	G_PHY01V	Loss on ignition (LOI), Furnace, variable wt, variable temp
6	GO_XRF72	Borate Fusion, XRF, Ore Grade

Comments

Preparation of samples was performed at the SGS Lakefield site.
Analysis of samples was performed at the SGS Burnaby site.

Authorised Signatory

John Chiang
Laboratory Operations Manager

SCC Accredited LAB
LAB Accrédité CCN
TM

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WARNING: The sample(s) to which the findings recorded herein (the "Findings") relate was(were) drawn and / or provided by the Client or by a third party acting at the Client's direction. The Findings constitute no warranty of the sample's representativeness of any goods and strictly relate to the sample(s). The Company accepts no liability with regard to the origin or source from which the sample(s) is/are said to be extracted. The findings report on the samples provided by the client and are not intended for commercial or contractual settlement purposes.

- not analysed | -- element not determined | I.S. insufficient sample | L.N.R. listed not received

Order Number PO#
Submission Number CA19113-JUL23 / 6 Pulp
Number of Samples 6

ANALYSIS REPORT BBM23-31378

Element	LOI	@Al2O3	@CaO	@Cr2O3	@Fe2O3	@K2O
Method	G_PHY01V	GO_XRF72	GO_XRF72	GO_XRF72	GO_XRF72	GO_XRF72
Lower Limit	-10	0.01	0.01	0.01	0.01	0.01
Upper Limit	100	100	60	5	100	70
Unit	%	%	%	%	%	%
COF1-13-18-20230619	12.4300	8.36	6.73	<0.01	3.19	1.88
COF1-18-23-20230619	12.3300	8.41	6.72	0.02	3.48	1.88
COF1-38-43-20230619	12.3000	8.35	6.69	0.02	3.71	1.89
COF2-10-13-20230619	2.53949	6.73	0.52	0.01	2.08	2.01
COF3-11-12-20230619	3.75000	8.14	1.04	<0.01	2.77	2.42
COF3-12.5-13-20230619	11.9572	4.92	9.10	<0.01	1.69	1.59
*Std OREAS 70b	6.78796	-	-	-	-	-
*Std OREAS 70b	-	7.12	4.28	0.18	7.95	0.71
*Blk BLANK	-	<0.01	<0.01	<0.01	<0.01	<0.01
*Std OREAS 751	-	15.87	1.04	<0.01	2.40	2.89

Element	@MgO	Mn3O4	@Na2O	@P2O5	@SiO2	@TiO2
Method	GO_XRF72	GO_XRF72	GO_XRF72	GO_XRF72	GO_XRF72	GO_XRF72
Lower Limit	0.01	0.01	0.01	0.01	0.01	0.01
Upper Limit	100	100	60	55	100	100
Unit	%	%	%	%	%	%
COF1-13-18-20230619	3.71	0.07	0.79	0.07	62.07	0.49
COF1-18-23-20230619	3.66	0.07	0.80	0.08	61.80	0.50
COF1-38-43-20230619	3.62	0.07	0.77	0.08	61.72	0.50
COF2-10-13-20230619	0.54	0.03	0.82	0.06	84.59	0.36
COF3-11-12-20230619	0.77	0.13	0.85	0.06	80.21	0.40
COF3-12.5-13-20230619	4.44	0.08	0.69	0.05	64.55	0.26
*Std OREAS 70b	22.38	0.16	1.04	0.05	48.48	0.30
*Blk BLANK	<0.01	<0.01	0.01	<0.01	<0.01	<0.01
*Std OREAS 751	0.50	0.10	3.40	0.27	71.34	0.24

- not analysed | -- element not determined | I.S. insufficient sample | L.N.R. listed not received

SGS

Order Number PO#
Submission Number CA19113-JUL23 / 6 Pulp
Number of Samples 6

ANALYSIS REPORT BBM23-31378

Element **Method** **Lower Limit** **Upper Limit** **Unit**	@V2O5 GO_XRF72 0.01 10 %	Sum GO_XRF72 0.01 100 %
COF1-13-18-20230619	0.01	87.60
COF1-18-23-20230619	<0.01	87.86
COF1-38-43-20230619	0.01	87.81
COF2-10-13-20230619	<0.01	97.81
COF3-11-12-20230619	0.01	96.90
COF3-12.5-13-20230619	<0.01	87.45
*Std OREAS 70b	0.01	93.40
*Blk BLANK	<0.01	0.03
*Std OREAS 751	<0.01	98.27

SGS Canada Minerals Burnaby conforms to the requirements of ISO/IEC17025 for specific tests as listed on their scope of accreditation found at https://www.scc.ca/en/search/laboratories/sgs
Tests and Elements marked with an "@" symbol in the report denote ISO/IEC17025 accreditation.

- not analysed | -- element not determined | I.S. insufficient sample | L.N.R. listed not received

Attachment G
X-Ray Diffraction Analytical Data

Quantitative X-Ray Diffraction by Rietveld Refinement

Report Prepared for: *Environmental Services*

Project Number/ LIMS No. *Custom XRD/MI4544-MAY21*

Sample Receipt: *May 27, 2021*

Sample Analysis: *May 31, 2021*

Reporting Date: *June 17, 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.

SGS Minerals
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P.O. Box 4300, 185 Concession Street, Lakefield, Ontario, Canada K0L 2H0
Tel: (705) 652-2000 Fax: (705) 652-6365 www.sgs.com www.sgs.com/met
Member of the SGS Group (SGS SA)

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.

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Summary of Rietveld Quantitative Analysis X-Ray Diffraction Results

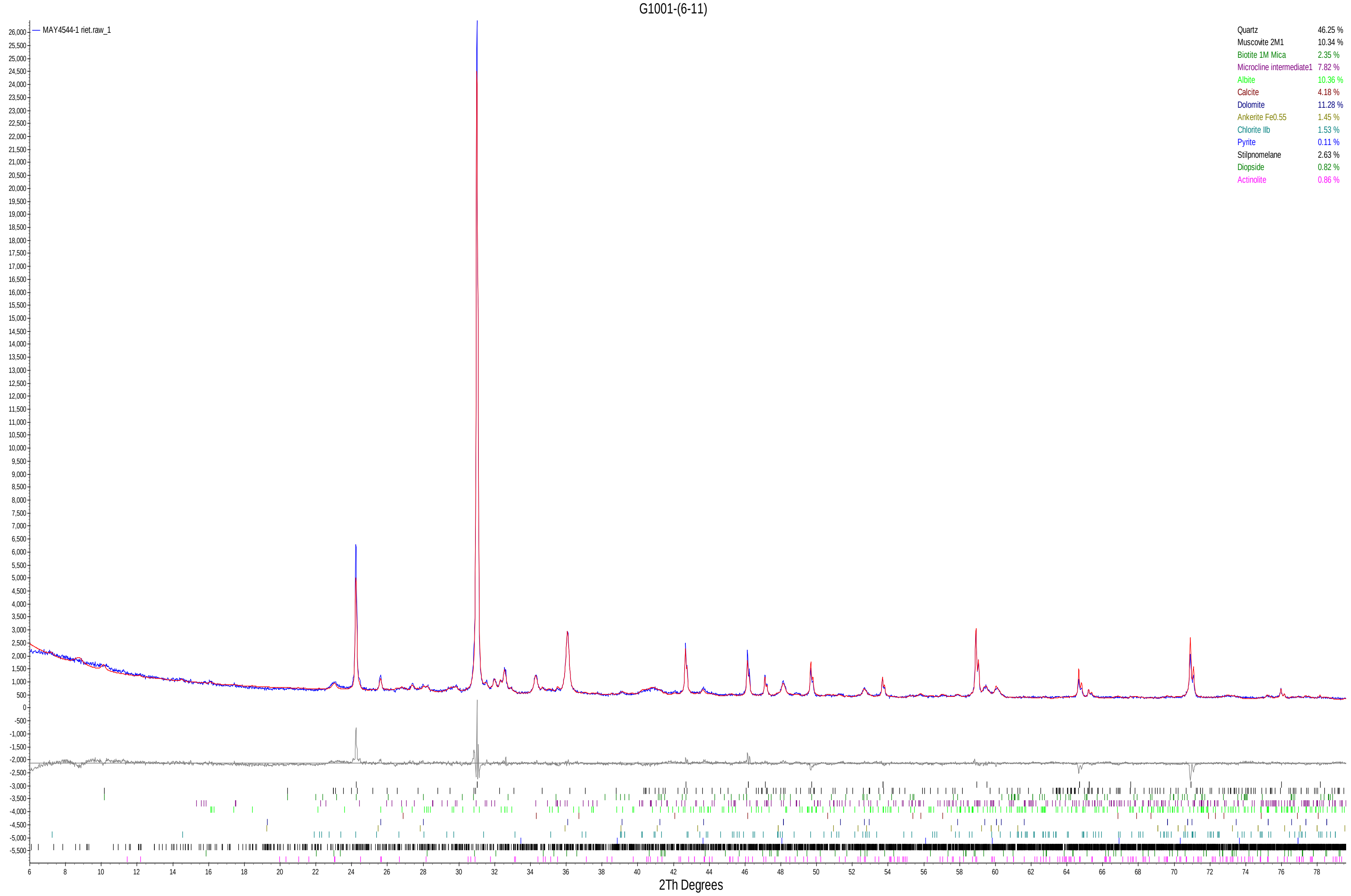
Mineral/Compound	G1001-(6-11) MAY4544-01 (wt %)	401B-(16-20) MAY4544-02 (wt %)	270A-(12-16) MAY4544-03 (wt %)
Quartz	46.3	68.9	60.6
Muscovite	10.3	6.8	9.0
Biotite	2.4	2.1	2.4
Microcline	7.8	7.8	9.8
Albite	10.4	8.6	9.1
Calcite	4.2	-	-
Dolomite	11.3	-	0.6
Ankerite	1.5	0.1	0.5
Chlorite	1.5	-	1.4
Pyrite	0.1	-	0.2
Stilpnomelane	2.6	2.7	2.0
Diopside	0.8	1.4	1.3
Actinolite	0.9	1.4	3.3
TOTAL	100	100	100

Zero values indicate that the mineral was included in the refinement, but the calculated concentration is below a measurable value.

Dashes indicate that the mineral was not identified by the analyst and not included in the refinement calculation for the sample.

The weight percent quantities indicated have been normalized to a sum of 100%. The quantity of amorphous material has not been determined.

Mineral/Compound	Formula
Quartz	SiO_2
Muscovite	$KAl_2(AlSi_3O_{10})(OH)_2$
Biotite	$K(Mg,Fe)_3(AlSi_3O_{10})(OH)_2$
Microcline	$KAlSi_3O_8$
Albite	$NaAlSi_3O_8$
Calcite	$CaCO_3$
Dolomite	$CaMg(CO_3)_2$
Ankerite	$CaFe(CO_3)_2$
Chlorite	$(Fe,(Mg,Mn)_5,Al)(Si_3Al)O_{10}(OH)_8$
Pyrite	FeS_2
Stilpnomelane	$K(Fe^{2+},Mg,Fe^{3+})_8(Si,Al)_{12}(O,OH)_{27}\cdot n(H_2O)$
Diopside	$CaMgSi_2O_6$
Actinolite	$Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2$



G1001-(6-11)

MAY4544-1 riet.raw_1
Quartz 46.25 %
Muscovite 2M1 10.34 %
Biotite 1M Mica 2.35 %
Microcline intermediate1 7.82 %
Albite 10.36 %
Calcite 4.18 %
Dolomite 11.28 %
Ankerite Fe0.55 1.45 %
Chlorite IIb 1.53 %
Pyrite 0.11 %
Stilpnomelane 2.63 %
Diopside 0.82 %
Actinolite 0.86 %
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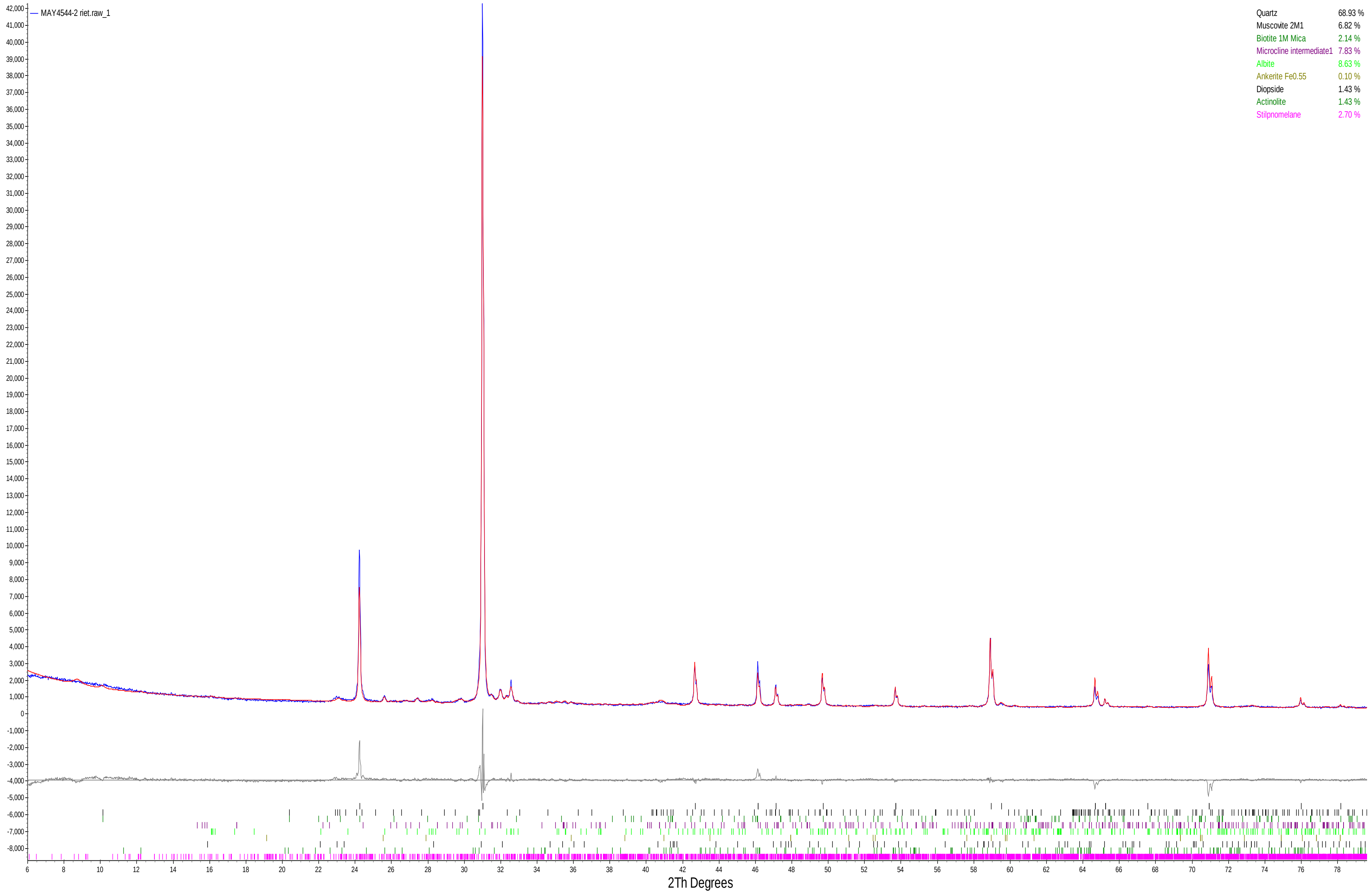
401B-(16-20)


MAY4544-2 riet.raw_1
Quartz 68.93 %
Muscovite 2M1 6.82 %
Biotite 1M Mica 2.14 %
Microcline intermediate1 7.83 %
Albite 8.63 %
Ankerite Fe0.55 0.10 %
Diopside 1.43 %
Actinolite 1.43 %
Stilpnomelane 2.70 %
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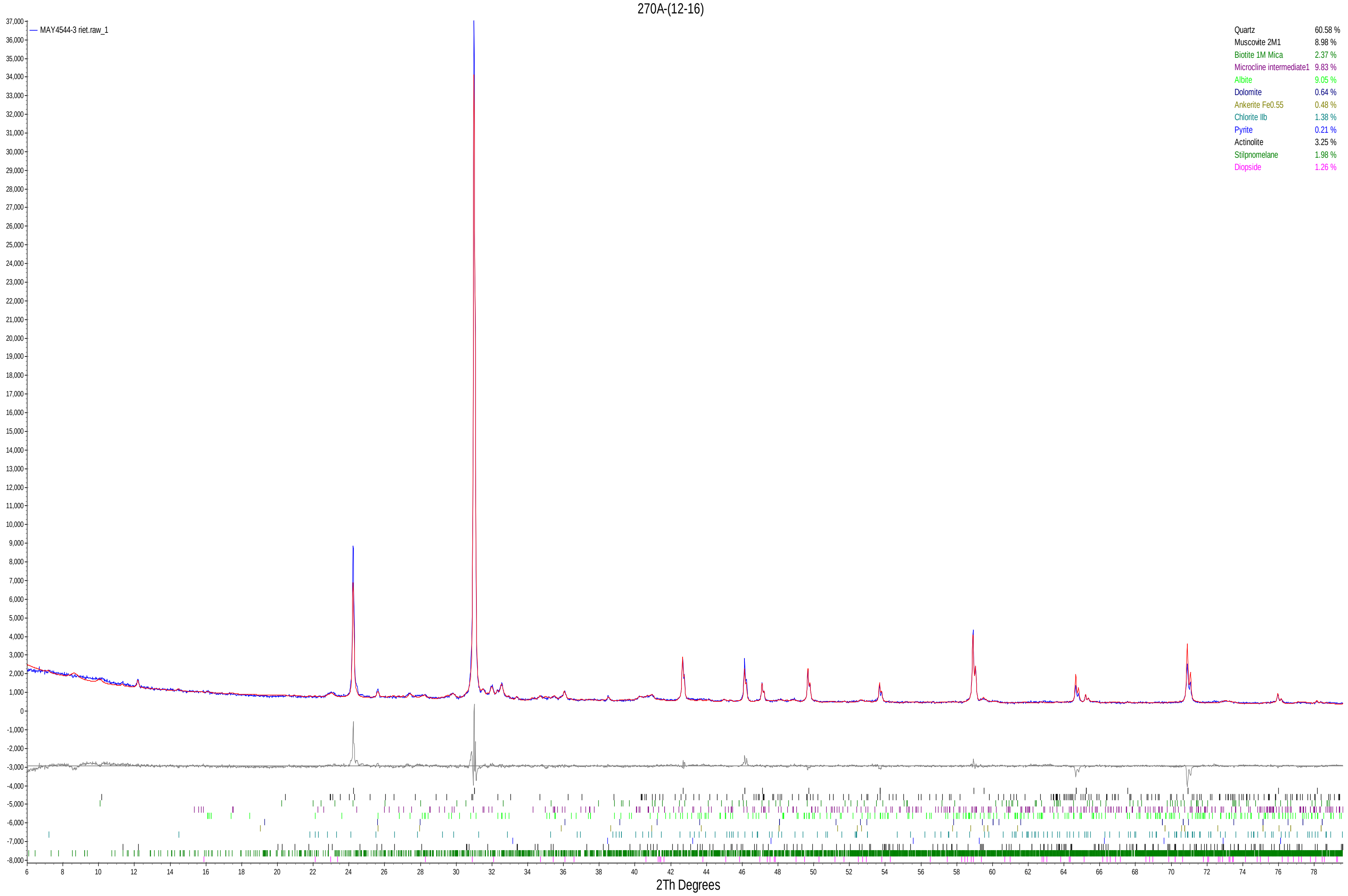
2Th Degrees


270A-(12-16)
MAY4544-3 riet.raw_1
Quartz 60.58 %
Muscovite 2M1 8.98 %
Biotite 1M Mica 2.37 %
Microcline intermediate1 9.83 %
Albite 9.05 %
Dolomite 0.64 %
Ankerite Fe0.55 0.48 %
Chlorite IIb 1.38 %
Pyrite 0.21 %
Actinolite 3.25 %
Stilpnomelane 1.98 %
Diopside 1.26 %
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2Th Degrees

Quantitative X-Ray Diffraction by Rietveld Refinement

Report Prepared for:	*Environmental Services*
Project Number/ LIMS No.	*Custom XRD/MI4509-SEP21*
Sample Receipt:	*September 9, 2021*
Sample Analysis:	*September 24, 2021*
Reporting Date:	*October 22, 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

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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.

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Summary of Rietveld Quantitative Analysis X-Ray Diffraction Results

Mineral/Compound	SB-306-(14-16) SEP4509-01 (wt %)	SB-311-(14-15) SEP4509-02 (wt %)	SB-313-(8-9) SEP4509-03 (wt %)	SB-316-(13-14,15-16) SEP4509-04 (wt %)
Quartz	70.9	58.9	51.3	67.6
Microcline	8.5	7.4	7.6	9.8
Albite	9.6	8.6	7.9	9.6
Calcite	0.5	2.5	4.1	-
Dolomite	3.5	12.1	15.7	1.9
Ankerite	2.1	5.0	7.7	0.8
Chlorite	1.8	1.7	1.1	1.7
Diopside	3.1	3.8	4.6	1.3
Muscovite	-	-	-	7.3
TOTAL	100	100	100	100

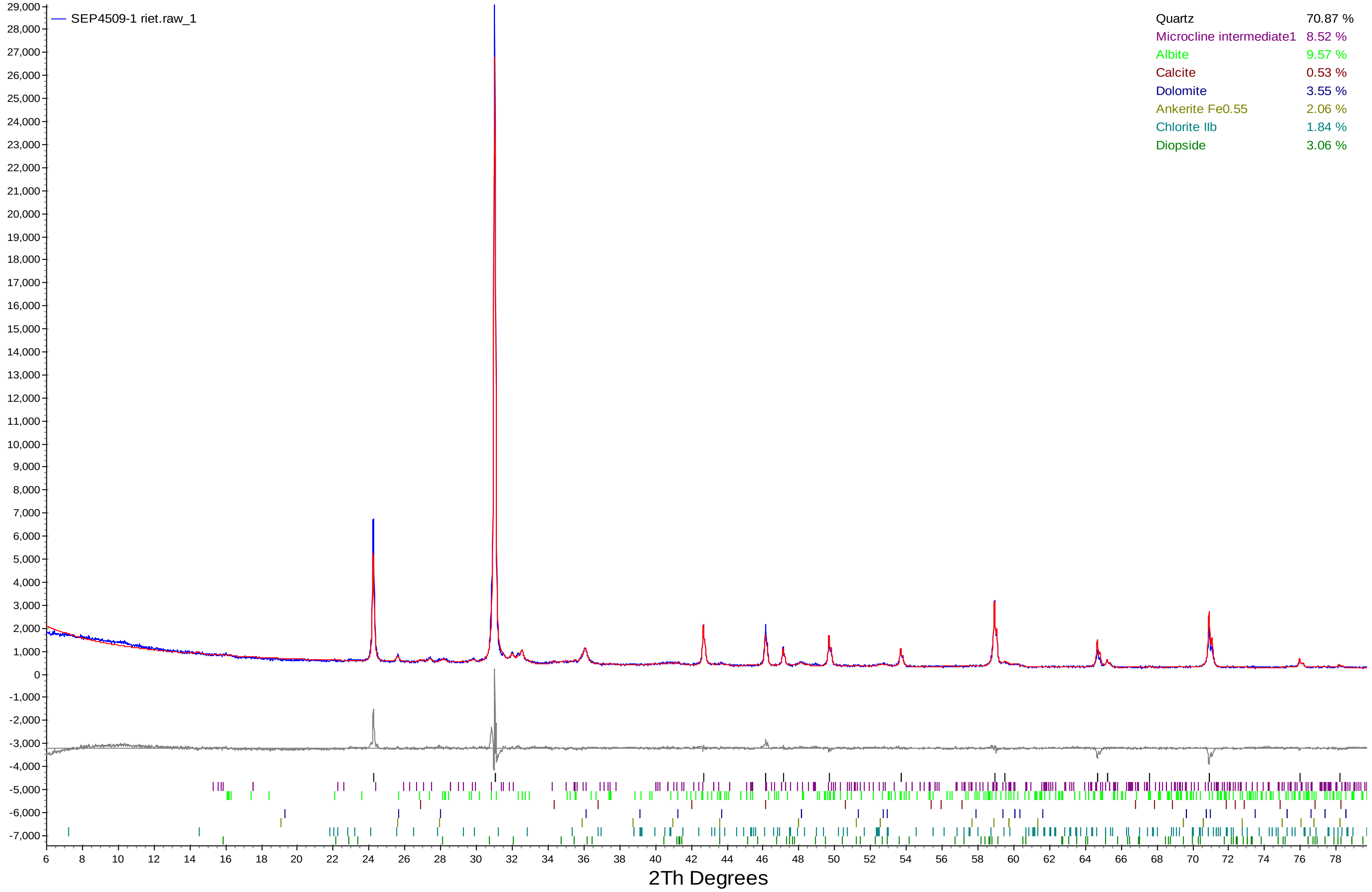
Zero values indicate that the mineral was included in the refinement, but the calculated concentration is below a measurable value.

Dashes indicate that the mineral was not identified by the analyst and not included in the refinement calculation for the sample.

The weight percent quantities indicated have been normalized to a sum of 100%. The quantity of amorphous material has not been determined.

Mineral/Compound	Formula
Quartz	SiO_2
Microcline	$KAlSi_3O_8$
Albite	$NaAlSi_3O_8$
Calcite	$CaCO_3$
Dolomite	$CaMg(CO_3)_2$
Ankerite	$CaFe(CO_3)_2$
Chlorite	$(Fe,(Mg,Mn)_5,Al)(Si_3Al)O_{10}(OH)_8$
Diopside	$CaMgSi_2O_6$
Muscovite	$KAl_2(AlSi_3O_{10})(OH)_2$

SB-306-(14-16)


SEP4509-1 riet.raw_1
Quartz 70.87 %
Microcline intermediate1 8.52 %
Albite 9.57 %
Calcite 0.53 %
Dolomite 3.55 %
Ankerite Fe0.55 2.06 %
Chlorite IIb 1.84 %
Diopside 3.06 %
29,000
28,000
27,000
26,000
25,000
24,000
23,000
22,000
21,000
20,000
19,000
18,000
17,000
16,000
15,000
14,000
13,000
12,000
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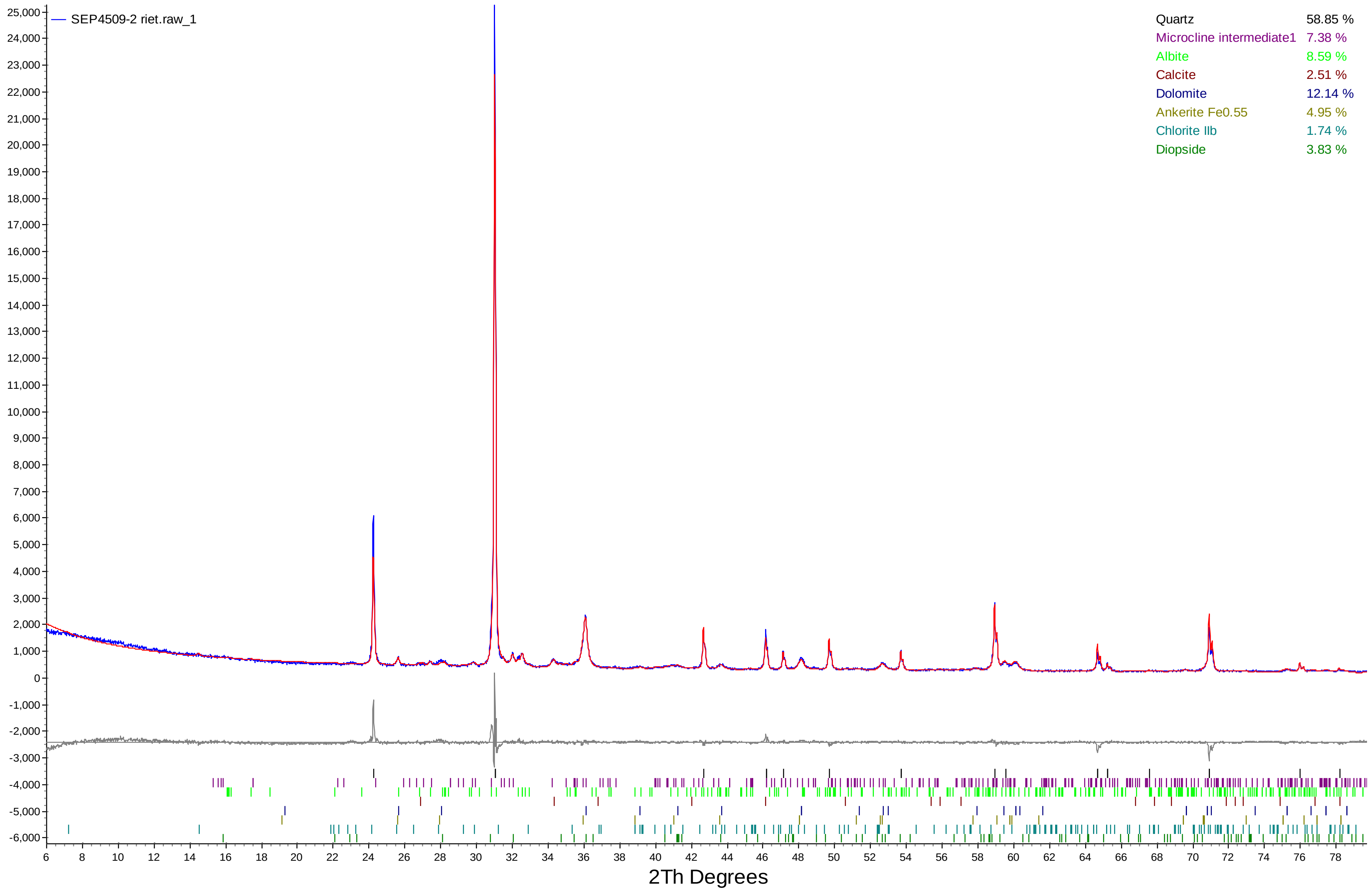
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
-1,000
-2,000
-3,000
-4,000
-5,000
-6,000
-7,000
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
50
52
54
56
58
60
62
64
66
68
70
72
74
76
78
2Th Degrees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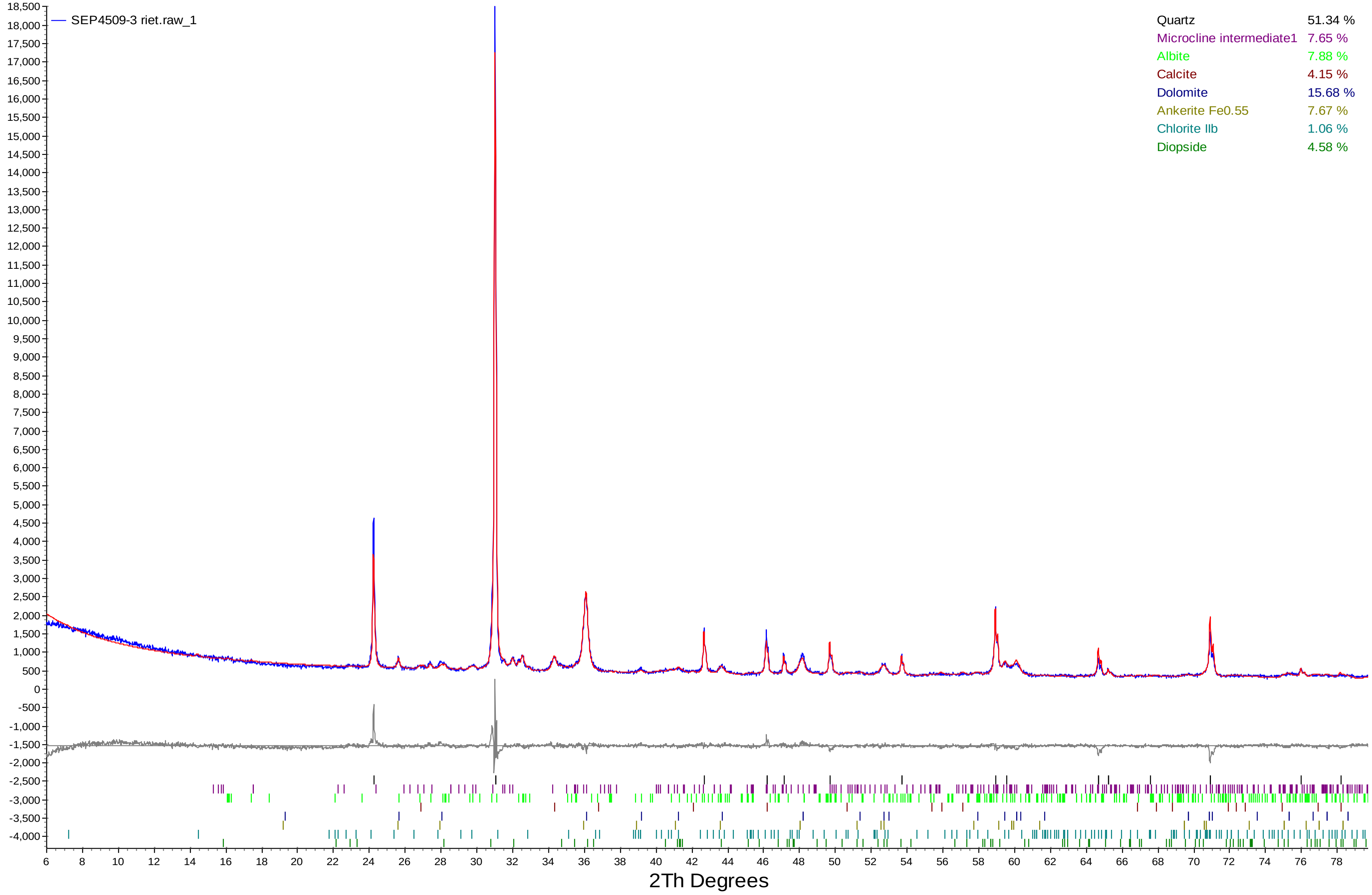
Quartz 58.85 %
Microcline intermediate1 7.38 %
Albite 8.59 %
Calcite 2.51 %
Dolomite 12.14 %
Ankerite Fe0.55 4.95 %
Chlorite IIb 1.74 %
Diopside 3.83 %
25,000
24,000
23,000
22,000
21,000
20,000
19,000
18,000
17,000
16,000
15,000
14,000
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
-1,000
-2,000
-3,000
-4,000
-5,000
-6,000
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
50
52
54
56
58
60
62
64
66
68
70
72
74
76
78
2Th Degrees

SB-311-(14-15)

SB-313-(8-9)


SEP4509-3 riet.raw_1
Quartz 51.34 %
Microcline intermediate1 7.65 %
Albite 7.88 %
Calcite 4.15 %
Dolomite 15.68 %
Ankerite Fe0.55 7.67 %
Chlorite IIb 1.06 %
Diopside 4.58 %
18,500
18,000
17,500
17,000
16,500
16,000
15,500
15,000
14,500
14,000
13,500
13,000
12,500
12,000
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7,000
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6,000
5,500
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4,500
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2,500
2,000
1,500
1,000
500
0
-500
-1,000
-1,500
-2,000
-2,500
-3,000
-3,500
-4,000
6
8
10
12
14
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18
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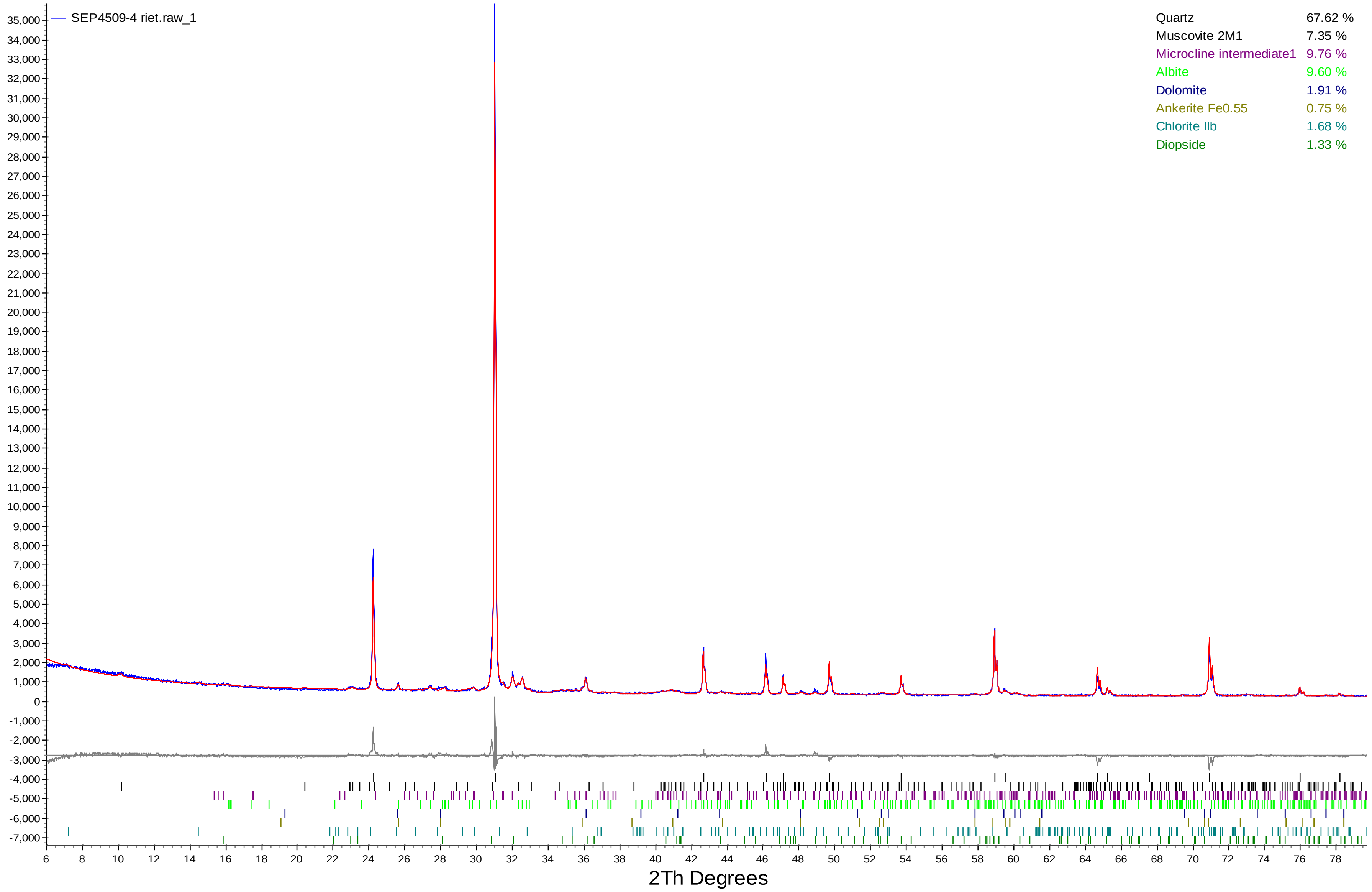
22
24
26
28
30
32
34
36
38
40
42
44
46
48
50
52
54
56
58
60
62
64
66
68
70
72
74
76
78
2Th Degrees

SB-316-(13-14,15-16)



Quantitative X-Ray Diffraction by Rietveld Refinement

Report Prepared for:	*Environmental Services*
Project Number/ LIMS No.	*Custom XRD/MI4528-AUG23*
Sample Receipt:	*August 10, 2023*
Sample Analysis:	*August 31, 2023*
Reporting Date:	*September 15, 2023*

Instrument:	BRUKER AXS D8 Advance Diffractometer
Test Conditions:	Co radiation, 35 kV, 40 mA; Detector: LYNXEYE Regular Scanning: Step: 0.02°, Step time: 0.75s, 2θ range: 6-80° Clay Section Scanning: Step: 0.01°, Step time:0.2s, 2θ range: 3-40°
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, H.B.Sc., P.Geo. Senior Mineralogist	Huyun Zhou, Ph.D., P.Geo. Senior Mineralogist

ACCREDITATION: SGS Natural Resources 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 Inc. - Minerals: https://www.scc.ca/en/search/palcan.

Method Summary

The Rietveld Method of Mineral Identification by XRD (ME-LR-MIN-MET-MN-D05) method used by SGS Natural Resources 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.

Clay Mineral Separation and Identification:

Clay minerals are typically fine-grained (<2 µm) phyllosilicates in sedimentary rock. Due to the poor crystallinity and fine size of clay minerals, separation of the clay fraction from bulk samples by centrifuge is required. A slide of the oriented clay fraction is prepared and scanned followed by a series of procedures (the addition of ethylene glycol and high temperature heating). Clay minerals are identified by their individual diffraction patterns and changes in their diffraction pattern after different treatments. Clay speciation and mineral identification of the bulk sample are performed using DIFFRACplus EVA (Bruker AXS).

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.

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WARNING: The sample(s) to which the findings recorded herein (the "Findings") relate was(were) drawn and / or provided by the Client or by a third party acting at the Client's direction. The Findings constitute no warranty of the sample's representativeness of any goods and strictly relate to the sample(s). The Company accepts no liability with regard to the origin or source from which the sample(s) is/are said to be extracted.

Environmental Services
Custom XRD/MI4528-AUG23
15-Sep-23

Summary of Rietveld Quantitative Analysis X-Ray Diffraction Results

Mineral/Compound	COF1-13-18-20230619 AUG4528-01 (wt %)	COF1-18-23-20230619 AUG4528-02 (wt %)	COF1-38-43-20230619 AUG4528-03 (wt %)	COF2-10-13-20230619 AUG4528-04 (wt %)	COF3-11-12-20230619 AUG4528-05 (wt %)	COF3-12.5-13-20230619 AUG4528-06 (wt %)
Quartz	53.9	67.5	73.5	51.2	50.7	50.5
Chlorite	1.6	1.7	1.5	3.0	3.9	3.2
Albite	6.1	8.3	8.2	6.8	7.4	7.5
Microcline	5.1	9.7	7.8	7.2	5.9	5.8
Calcite	4.1	0.4	-	2.4	2.6	2.8
Ankerite	7.2	1.2	0.5	9.4	8.4	8.1
Dolomite	13.3	0.5	0.0	6.0	7.6	8.1
Actinolite	0.3	0.7	0.8	0.5	0.6	0.6
Diopside	1.0	0.7	0.7	0.4	0.5	0.7
Kutnohorite	0.5	0.3	0.2	0.1	-	0.2
Muscovite	1.0	4.8	3.3	5.5	4.4	4.3
Magnetite	-	0.2	0.0	0.1	0.1	0.2
Clay	-	-	-	-	-	-
Illite	4.0	2.0	1.7	3.3	3.0	2.9
Montmorillonite	1.1	1.0	1.1	3.2	3.2	2.9
Kaolinite	0.7	1.1	0.7	0.9	0.6	0.6
Illite-Montmorillonite	-	-	-	-	1.3	1.7
TOTAL	100	100	100	100	100	100

Zero values indicate that the mineral was included in the refinement, but the calculated concentration is below a measurable value.

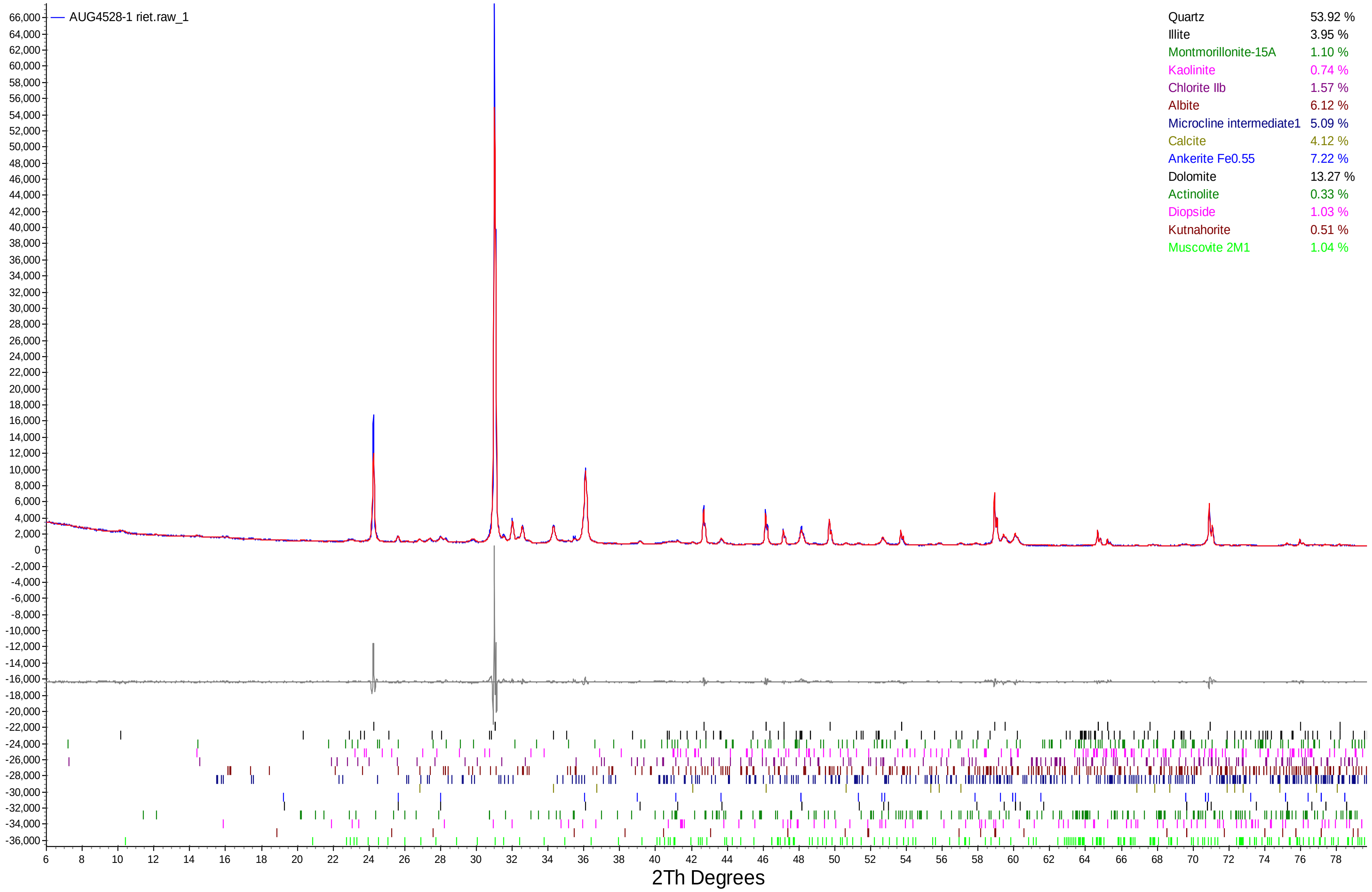
Dashes indicate that the mineral was not identified by the analyst and not included in the refinement calculation for the sample.

The weight percent quantities indicated have been normalized to a sum of 100%. The quantity of amorphous material has not been determined.

Mineral/Compound	Formula
Quartz	SiO_2
Chlorite	$(Fe,(Mg,Mn)_5,Al)(Si_3Al)O_{10}(OH)_8$
Albite	$NaAlSi_3O_8$
Microcline	$KAlSi_3O_8$
Calcite	$CaCO_3$
Ankerite	$CaFe(CO_3)_2$
Dolomite	$CaMg(CO_3)_2$
Actinolite	$Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2$
Diopside	$CaMgSi_2O_6$
Kutnohorite	$CaMn(CO_3)_2$
Muscovite	$KAl_2(AlSi_3O_{10})(OH)_2$
Magnetite	Fe_3O_4
Illite	$(K,H_3O)(Al,Mg,Fe)_2(Si,Al)_4O_{10}[(OH)_2,(H_2O)]$
Montmorillonite	$(Na,Ca)_{0.3}(Al,Mg)_2Si_4O_{10}(OH)_2\cdot 10H_2O$
Kaolinite	$Al_2Si_2O_5(OH)_4$
Illite-Montmorillonite	$KAl_4(Si,Al)_8O_{20}(OH)_4\cdot 8H_2O$

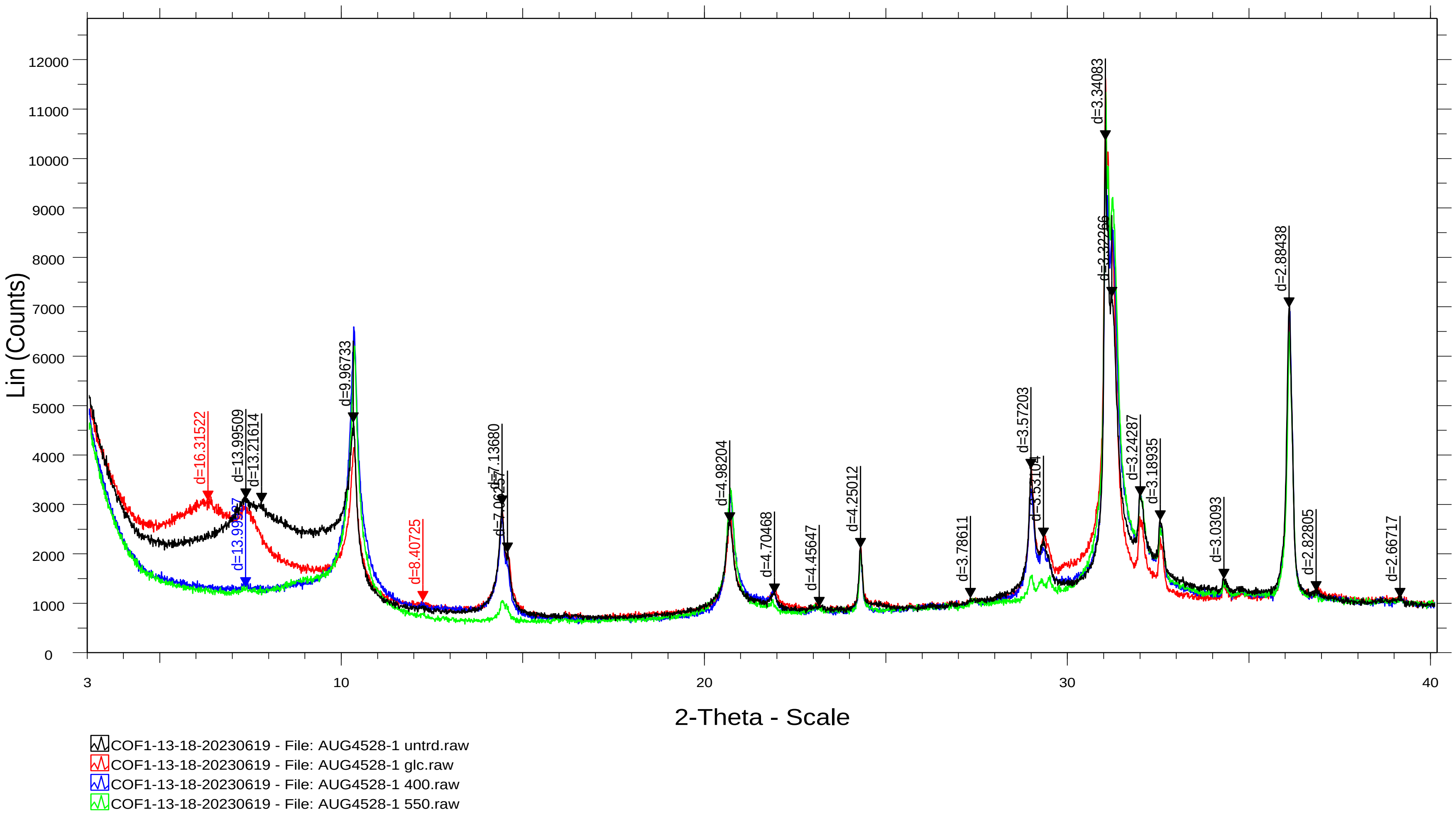
Environmental Services
Custom XRD/MI4528-AUG23
15-Sep-23

COF1-13-18-20230619



Quartz	53.92 %
Illite	3.95 %
Montmorillonite-15A	1.10 %
Kaolinite	0.74 %
Chlorite IIb	1.57 %
Albite	6.12 %
Microcline intermediate1	5.09 %
Calcite	4.12 %
Ankerite Fe0.55	7.22 %
Dolomite	13.27 %
Actinolite	0.33 %
Diopside	1.03 %
Kutnahorite	0.51 %
Muscovite 2M1	1.04 %

COF1-13-18-20230619



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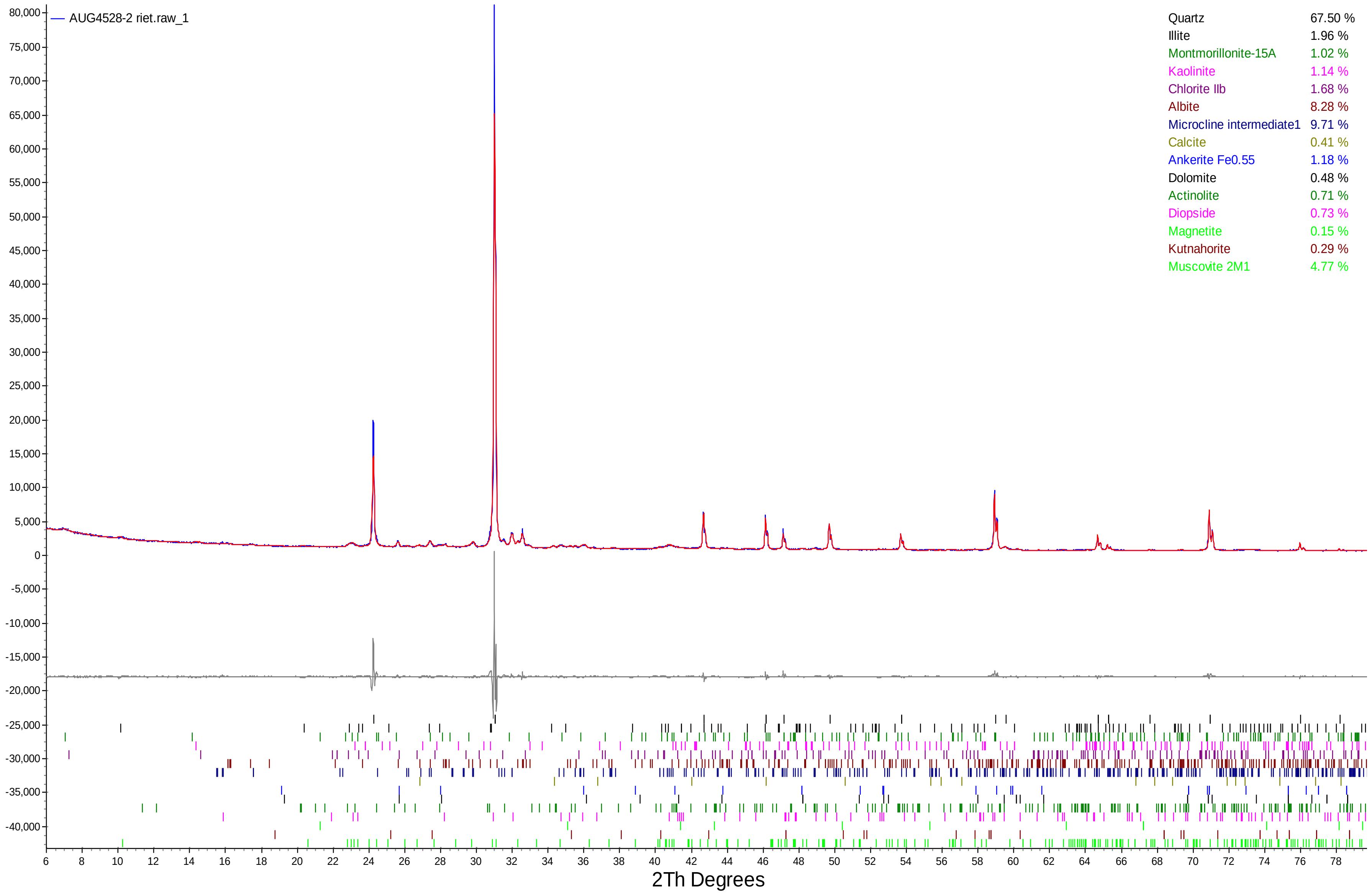

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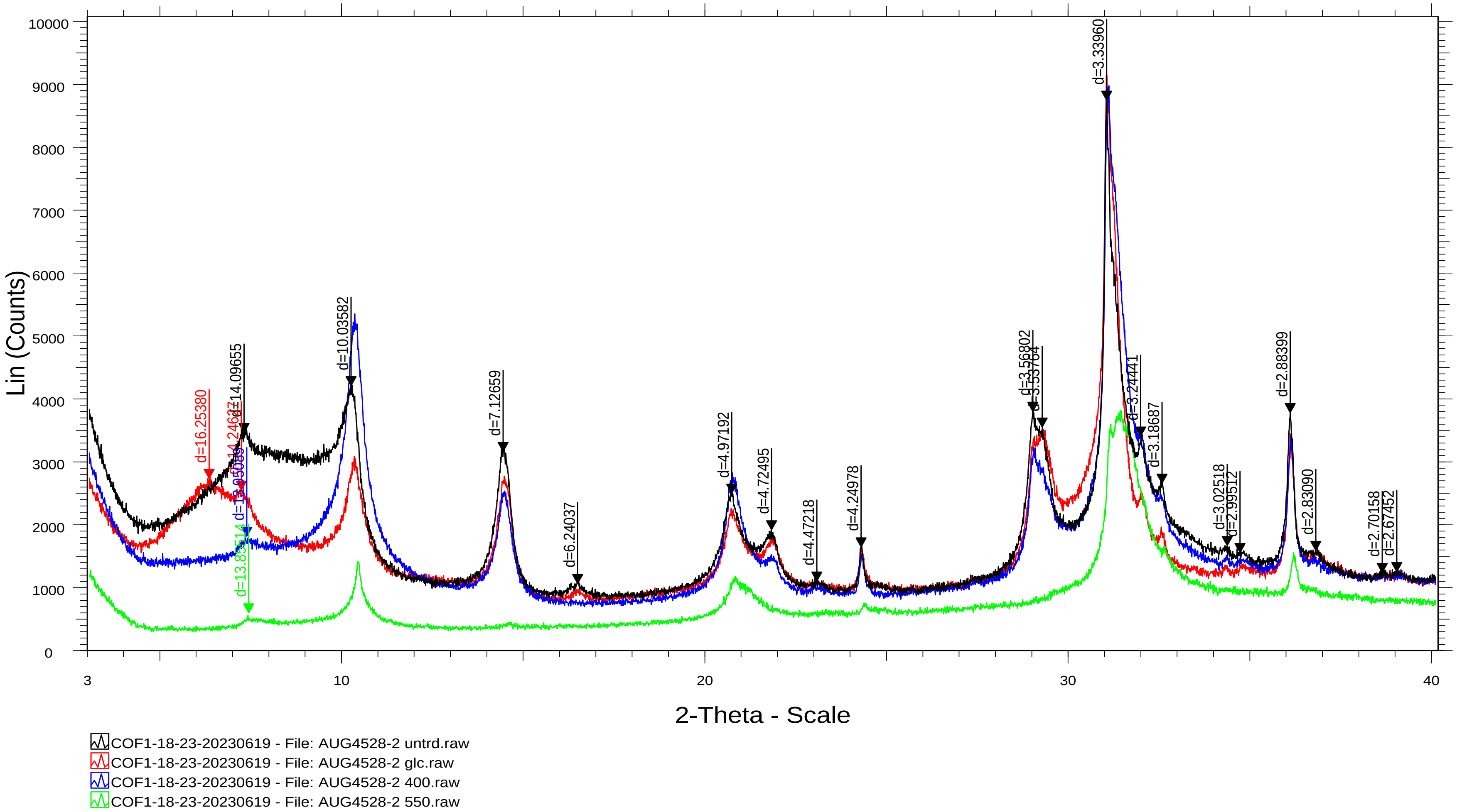
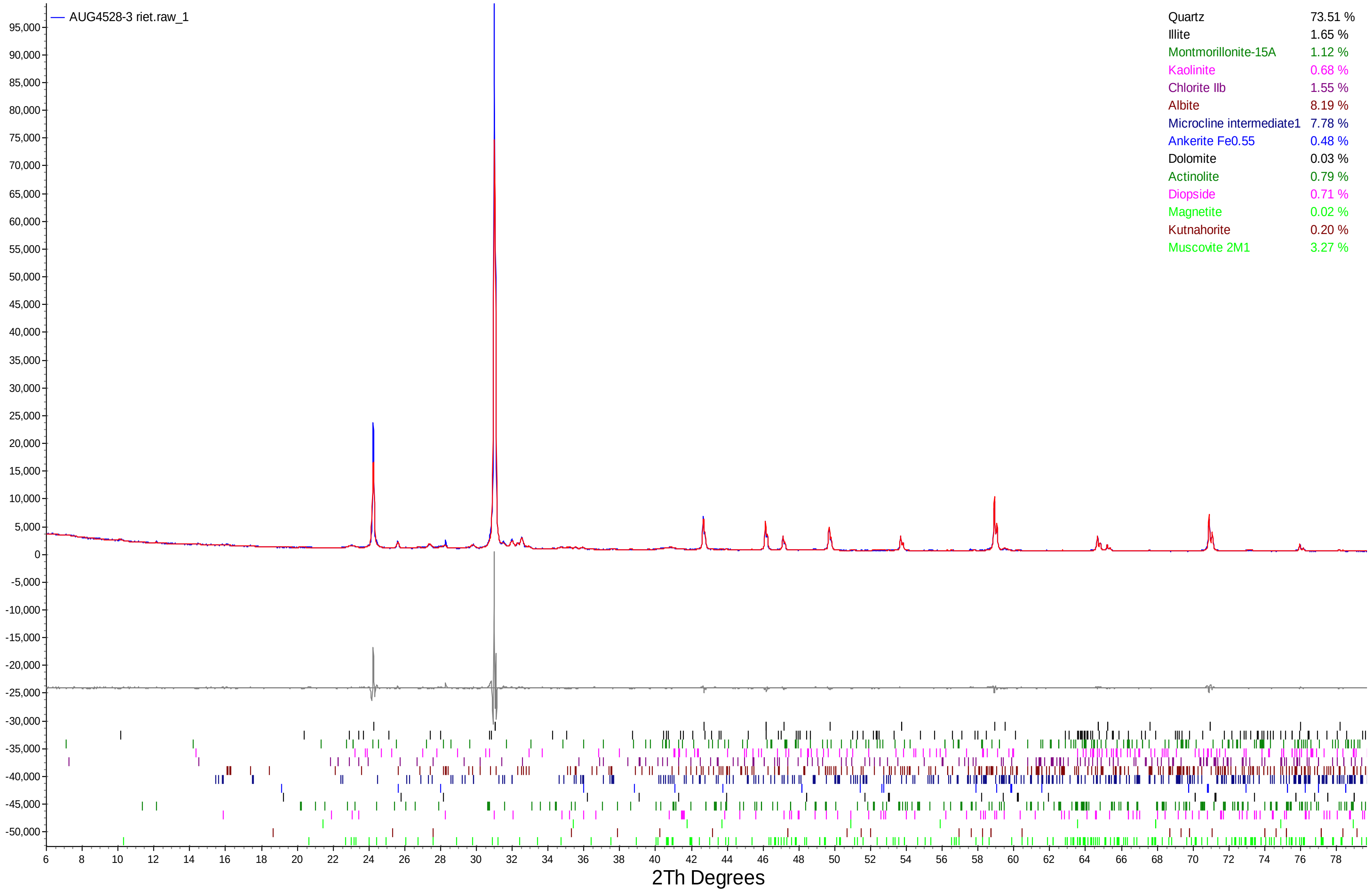
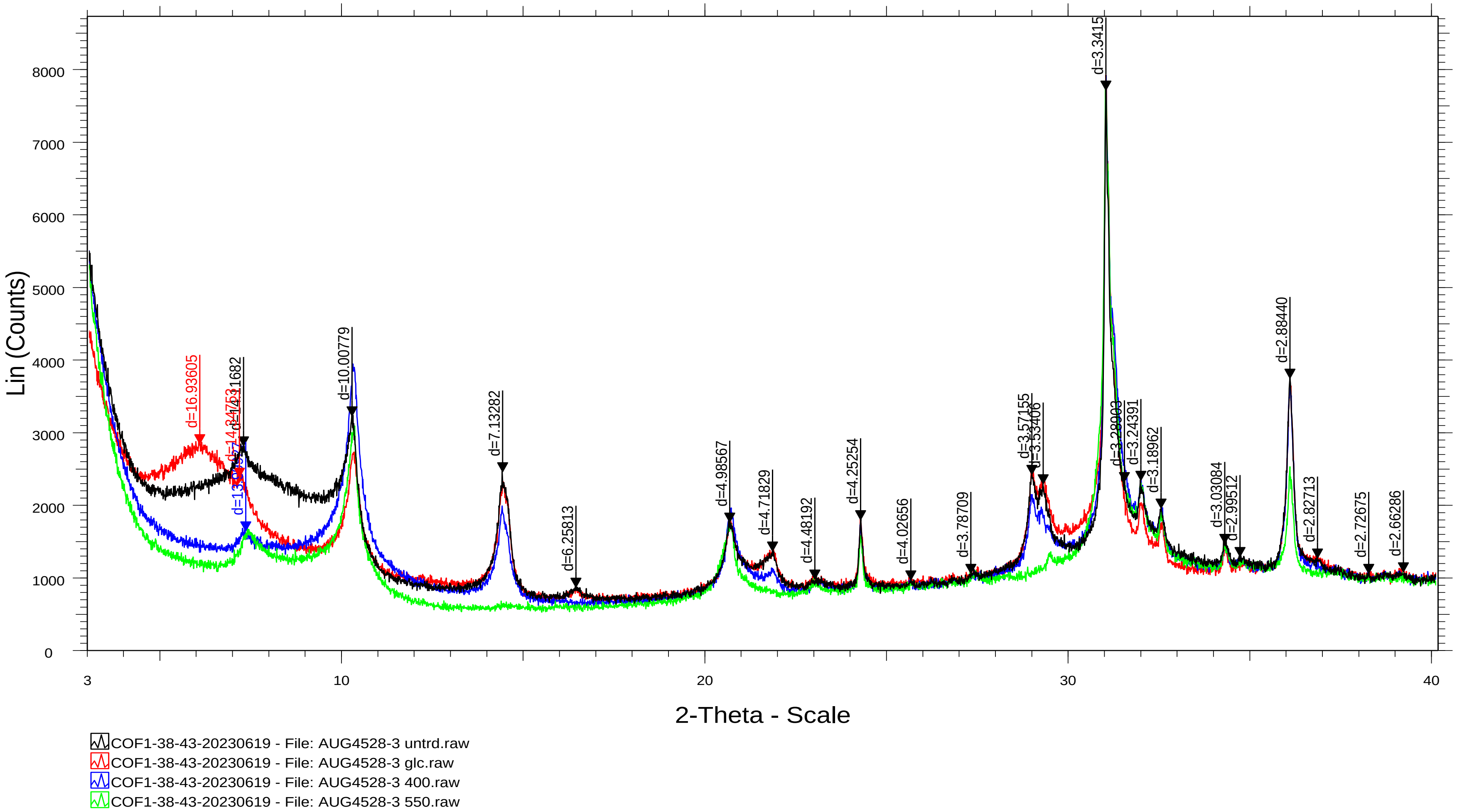



COF1-38-43-20230619

COF1-38-43-20230619



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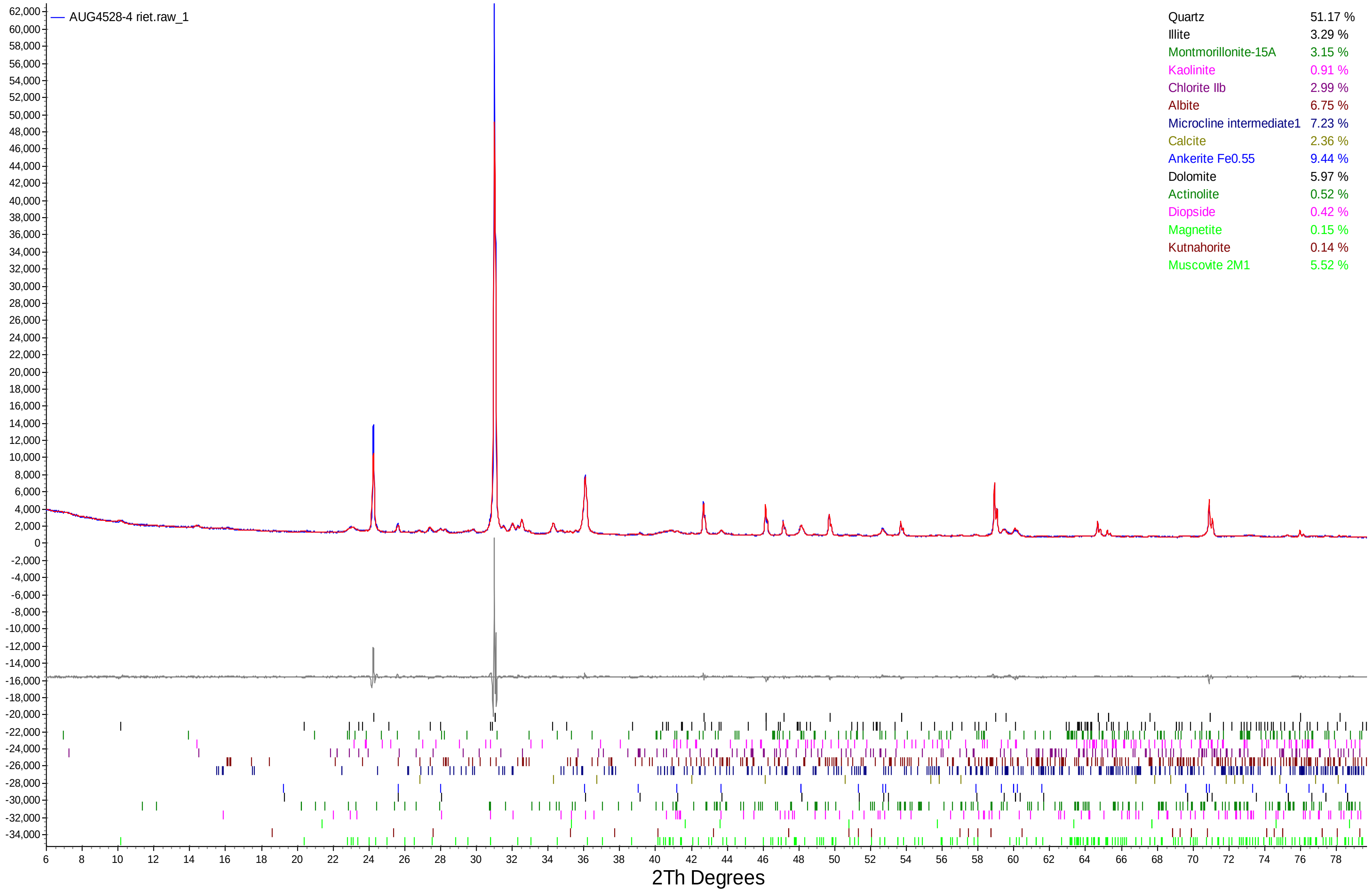
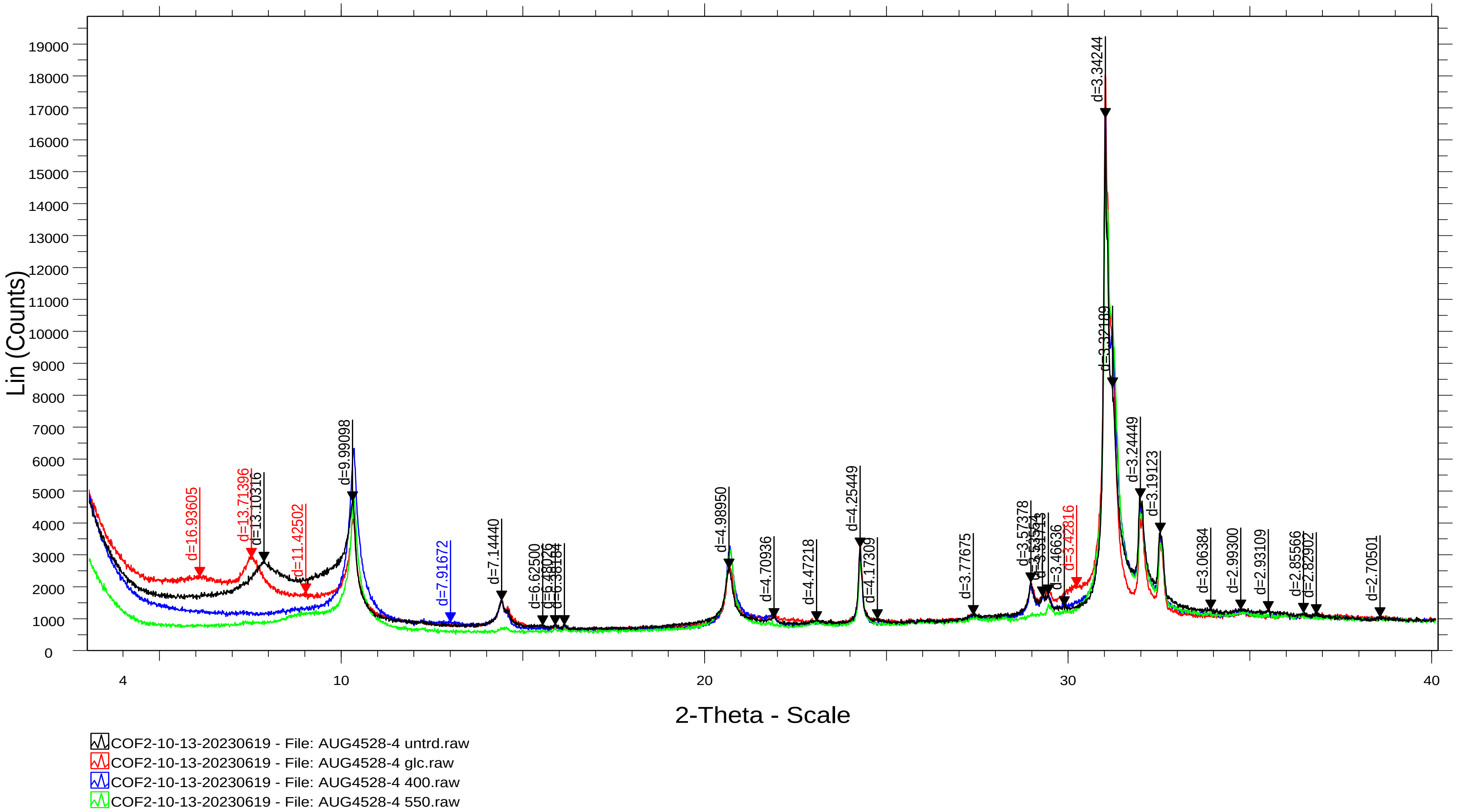


Quartz	51.17 %
Illite	3.29 %
Montmorillonite-15A	3.15 %
Kaolinite	0.91 %
Chlorite IIb	2.99 %
Albite	6.75 %
Microcline intermediate1	7.23 %
Calcite	2.36 %
Ankerite Fe0.55	9.44 %
Dolomite	5.97 %
Actinolite	0.52 %
Diopside	0.42 %
Magnetite	0.15 %
Kutnahorite	0.14 %
Muscovite 2M1	5.52 %

COF2-10-13-20230619



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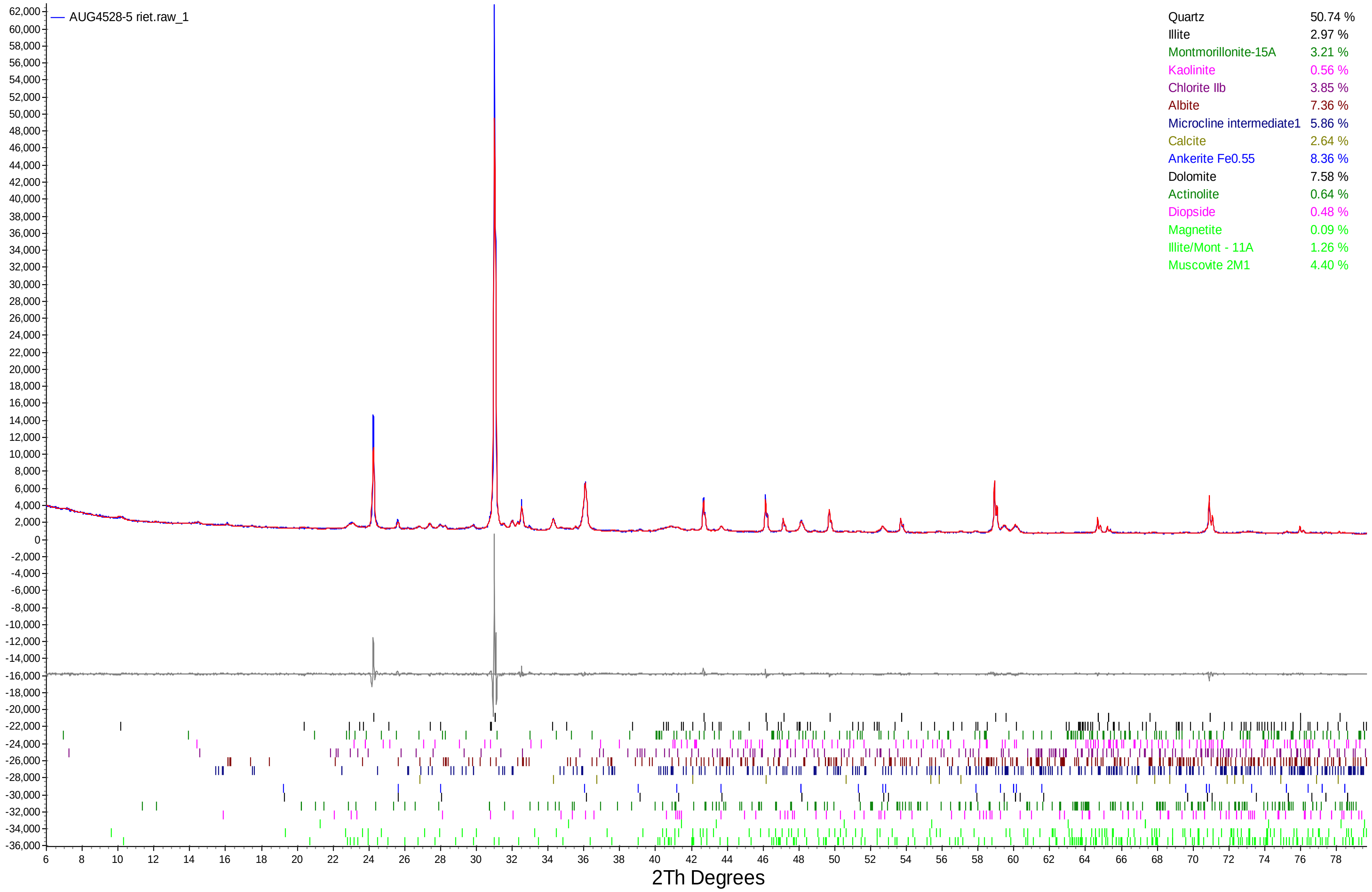

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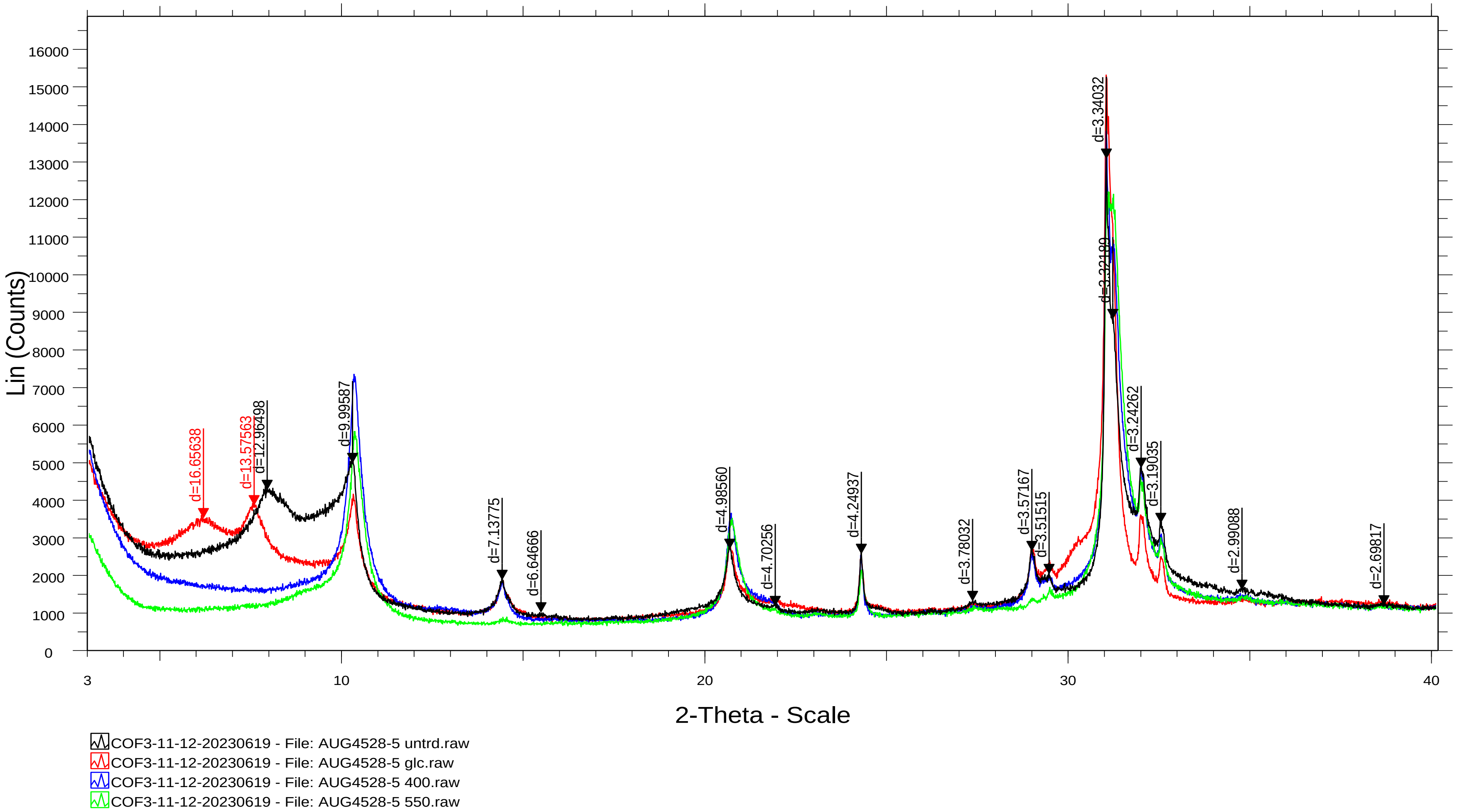
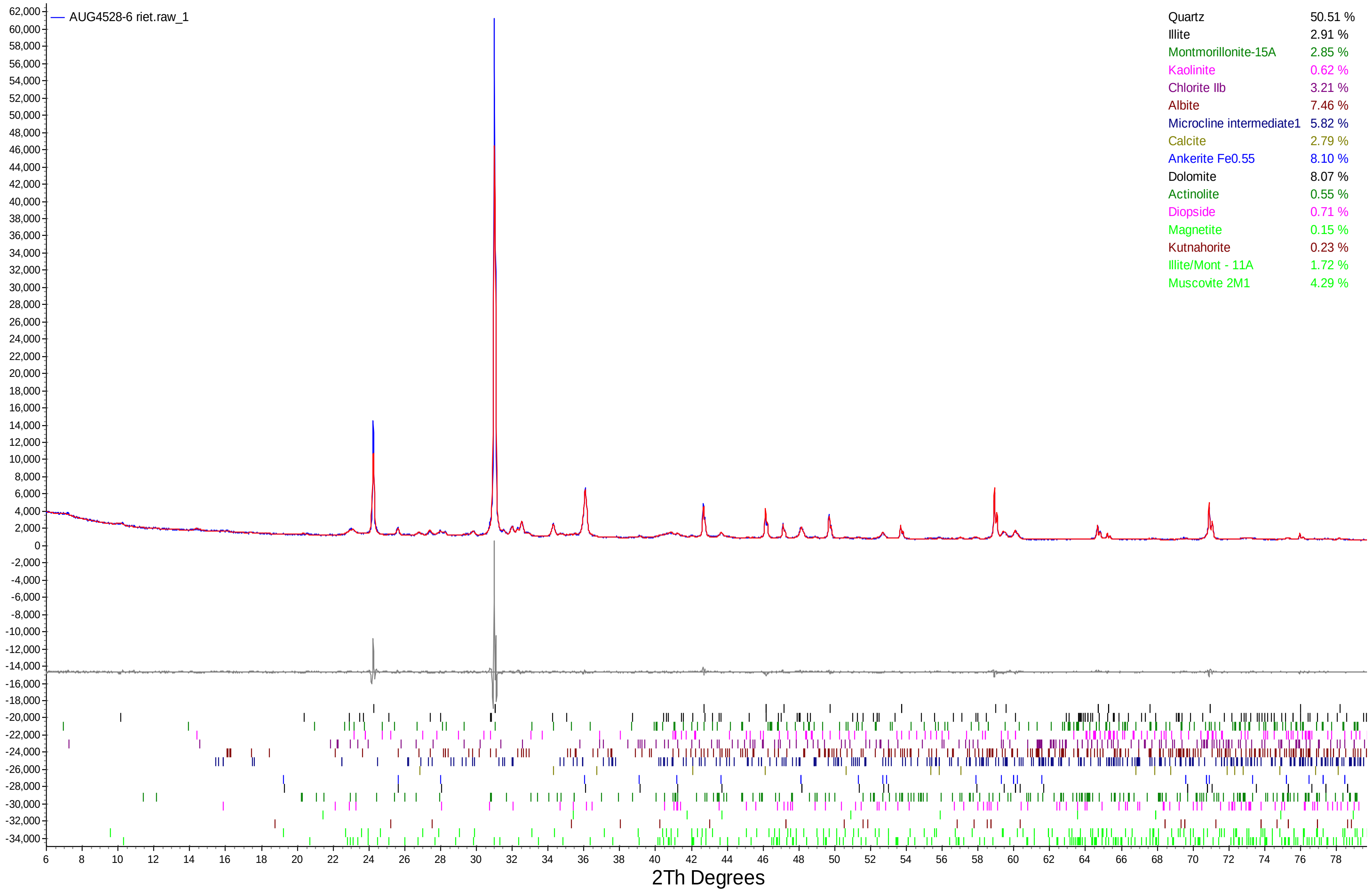
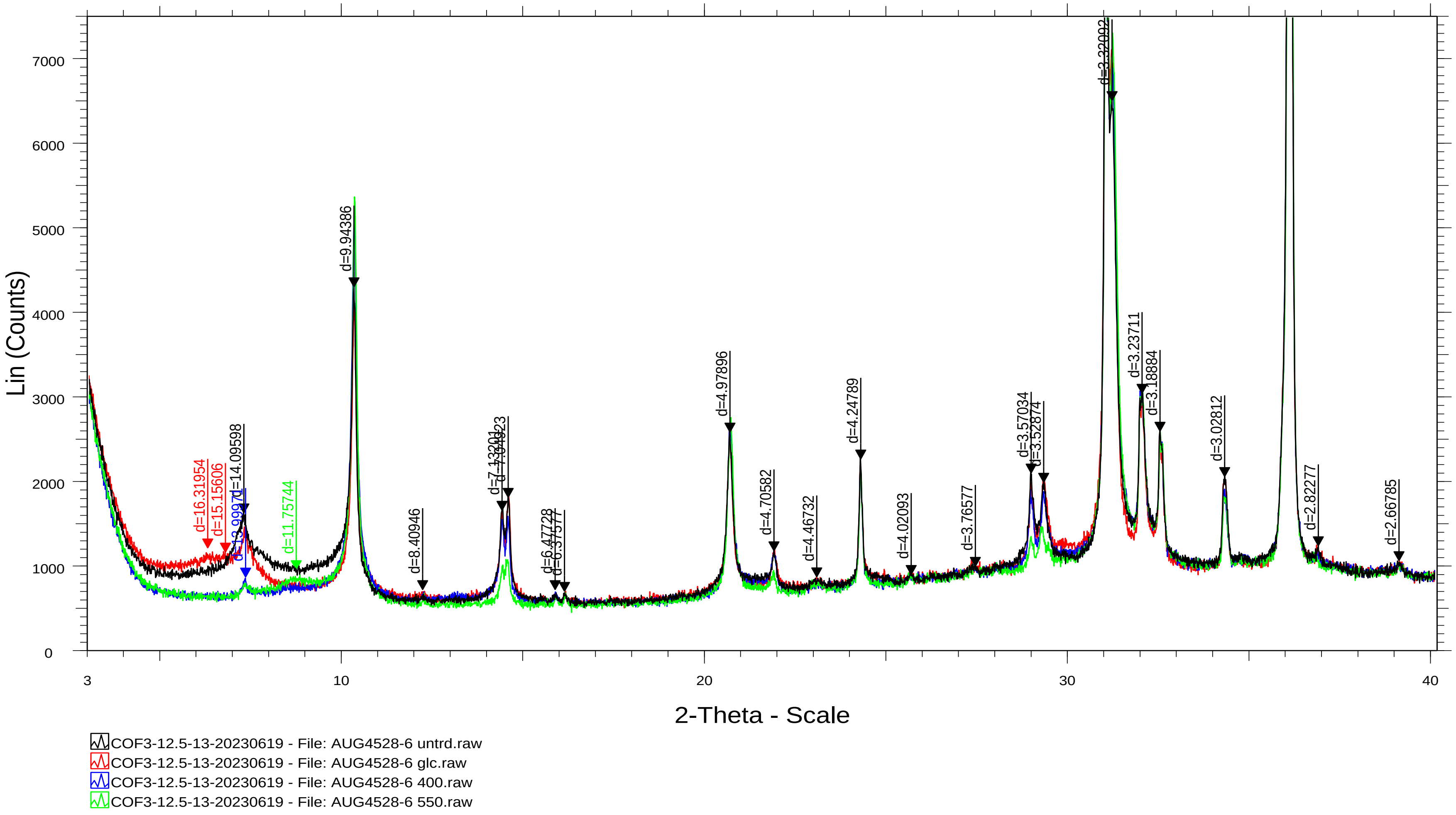


COF3-12.5-13-20230619



Quartz	50.51 %
Illite	2.91 %
Montmorillonite-15A	2.85 %
Kaolinite	0.62 %
Chlorite IIb	3.21 %
Albite	7.46 %
Microcline intermediate1	5.82 %
Calcite	2.79 %
Ankerite Fe0.55	8.10 %
Dolomite	8.07 %
Actinolite	0.55 %
Diopside	0.71 %
Magnetite	0.15 %
Kutnahorite	0.23 %
Illite/Mont - 11A	1.72 %
Muscovite 2M1	4.29 %

COF3-12.5-13-20230619



Attachment H

Site Evaluation Groundwater Data

Attachment H. Site Evaluation Groundwater Data
Geochemical Conceptual Site Model
Coffeen Ash Pond No. 2
Coffeen Power Plant
Coffeen, IL

HSU	Location	Well Type	Date	Parameter	Unit	Result
LCU	G1001	C	2023/02/15	pH (field)	SU	6.8
LCU	G1001	C	2023/06/07	pH (field)	SU	7.0
LCU	G1001	C	2023/11/14	pH (field)	SU	7.0
LCU	G1001	C	2023/02/15	Oxidation Reduction Potential	mV	159
LCU	G1001	C	2023/06/07	Oxidation Reduction Potential	mV	111
LCU	G1001	C	2023/11/14	Oxidation Reduction Potential	mV	<-300
LCU	G1001	C	2023/02/15	Eh	V	0.36
LCU	G1001	C	2023/06/07	Eh	V	0.30
LCU	G1001	C	2023/11/14	Eh	V	-0.11
LCU	G1001	C	2021/05/12	Alkalinity, bicarbonate	mg/L CaCO3	720
LCU	G1001	C	2023/02/15	Alkalinity, bicarbonate	mg/L CaCO3	620
LCU	G1001	C	2023/06/07	Alkalinity, bicarbonate	mg/L CaCO3	580
LCU	G1001	C	2023/11/14	Alkalinity, bicarbonate	mg/L CaCO3	605
LCU	G1001	C	2023/02/15	Barium, total	mg/L	0.200
LCU	G1001	C	2023/06/07	Barium, total	mg/L	0.0710
LCU	G1001	C	2023/11/14	Barium, total	mg/L	0.0917
LCU	G1001	C	2021/05/12	Boron, total	mg/L	1.40
LCU	G1001	C	2023/02/15	Boron, total	mg/L	0.720
LCU	G1001	C	2023/06/07	Boron, total	mg/L	0.950
LCU	G1001	C	2023/11/14	Boron, total	mg/L	1.10
LCU	G1001	C	2021/05/12	Calcium, total	mg/L	160
LCU	G1001	C	2023/02/15	Calcium, total	mg/L	430
LCU	G1001	C	2023/06/07	Calcium, total	mg/L	140
LCU	G1001	C	2023/11/14	Calcium, total	mg/L	131
LCU	G1001	C	2021/05/12	Chloride, total	mg/L	29.0
LCU	G1001	C	2023/02/15	Chloride, total	mg/L	36.0
LCU	G1001	C	2023/06/07	Chloride, total	mg/L	15.0
LCU	G1001	C	2023/11/14	Chloride, total	mg/L	16.0
LCU	G1001	C	2021/05/12	Cobalt, total	mg/L	0.000200
LCU	G1001	C	2023/02/15	Cobalt, total	mg/L	0.0490
LCU	G1001	C	2023/06/07	Cobalt, total	mg/L	<0.00048
LCU	G1001	C	2023/11/14	Cobalt, total	mg/L	0.00190
LCU	G1001	C	2023/06/07	Ferrous Iron, dissolved	mg/L	0.0450
LCU	G1001	C	2021/05/12	Iron, dissolved	mg/L	0.0170
LCU	G1001	C	2023/06/07	Iron, dissolved	mg/L	<0.00072
LCU	G1001	C	2021/05/12	Magnesium, total	mg/L	85.0
LCU	G1001	C	2023/02/15	Magnesium, total	mg/L	160
LCU	G1001	C	2023/06/07	Magnesium, total	mg/L	65.0
LCU	G1001	C	2023/11/14	Magnesium, total	mg/L	61.0
LCU	G1001	C	2021/05/12	Manganese, dissolved	mg/L	0.230
LCU	G1001	C	2023/06/07	Manganese, dissolved	mg/L	0.140
LCU	G1001	C	2021/05/12	Potassium, total	mg/L	6.70
LCU	G1001	C	2023/02/15	Potassium, total	mg/L	6.70
LCU	G1001	C	2023/06/07	Potassium, total	mg/L	2.50
LCU	G1001	C	2023/11/14	Potassium, total	mg/L	2.24
LCU	G1001	C	2023/06/07	Silicon, dissolved	mg/L	8.40
LCU	G1001	C	2021/05/12	Sodium, total	mg/L	34.0
LCU	G1001	C	2023/02/15	Sodium, total	mg/L	67.0
LCU	G1001	C	2023/06/07	Sodium, total	mg/L	94.0
LCU	G1001	C	2023/11/14	Sodium, total	mg/L	84.6
LCU	G1001	C	2021/05/12	Sulfate, total	mg/L	140
LCU	G1001	C	2023/02/15	Sulfate, total	mg/L	630
LCU	G1001	C	2023/06/07	Sulfate, total	mg/L	180
LCU	G1001	C	2023/11/14	Sulfate, total	mg/L	291
LCU	G1001	C	2023/02/15	Temperature (Celsius)	degrees C	10.2
LCU	G1001	C	2023/06/07	Temperature (Celsius)	degrees C	19.1

LCU	G1001	C	2023/11/14	Temperature (Celsius)	degrees C	16.7
LCU	G1001	C	2023/02/15	Total Dissolved Solids	mg/L	1,700
LCU	G1001	C	2023/06/07	Total Dissolved Solids	mg/L	830
LCU	G1001	C	2023/11/14	Total Dissolved Solids	mg/L	900
UA	G270	B	2015/01/20	pH (field)	SU	7.4
UA	G270	B	2015/04/13	pH (field)	SU	6.9
UA	G270	B	2015/07/22	pH (field)	SU	7.4
UA	G270	B	2015/10/05	pH (field)	SU	7.2
UA	G270	B	2015/11/20	pH (field)	SU	6.8
UA	G270	B	2016/02/10	pH (field)	SU	6.7
UA	G270	B	2016/05/12	pH (field)	SU	7.0
UA	G270	B	2016/08/01	pH (field)	SU	7.0
UA	G270	B	2016/11/16	pH (field)	SU	7.1
UA	G270	B	2017/02/10	pH (field)	SU	7.1
UA	G270	B	2017/05/16	pH (field)	SU	7.2
UA	G270	B	2017/07/12	pH (field)	SU	7.0
UA	G270	B	2017/10/25	pH (field)	SU	7.1
UA	G270	B	2018/05/11	pH (field)	SU	7.1
UA	G270	B	2018/08/03	pH (field)	SU	7.1
UA	G270	B	2019/01/21	pH (field)	SU	7.0
UA	G270	B	2019/08/15	pH (field)	SU	7.1
UA	G270	B	2020/01/24	pH (field)	SU	7.3
UA	G270	B	2020/08/12	pH (field)	SU	7.1
UA	G270	B	2020/10/14	pH (field)	SU	6.8
UA	G270	B	2021/01/21	pH (field)	SU	7.1
UA	G270	B	2021/03/30	pH (field)	SU	7.1
UA	G270	B	2021/04/21	pH (field)	SU	7.1
UA	G270	B	2021/05/06	pH (field)	SU	7.0
UA	G270	B	2021/05/19	pH (field)	SU	7.2
UA	G270	B	2021/06/15	pH (field)	SU	7.0
UA	G270	B	2021/06/29	pH (field)	SU	7.0
UA	G270	B	2021/07/12	pH (field)	SU	7.2
UA	G270	B	2021/07/27	pH (field)	SU	7.2
UA	G270	B	2021/08/18	pH (field)	SU	7.1
UA	G270	B	2021/10/26	pH (field)	SU	7.0
UA	G270	B	2022/02/08	pH (field)	SU	7.2
UA	G270	B	2022/05/10	pH (field)	SU	6.9
UA	G270	B	2022/08/24	pH (field)	SU	7.3
UA	G270	B	2022/11/08	pH (field)	SU	7.4
UA	G270	B	2023/02/16	pH (field)	SU	7.5
UA	G270	B	2023/06/08	pH (field)	SU	6.6
UA	G270	B	2023/08/14	pH (field)	SU	6.8
UA	G270	B	2023/11/17	pH (field)	SU	7.1
UA	G270	B	2015/11/20	Oxidation Reduction Potential	mV	-32.0
UA	G270	B	2016/02/10	Oxidation Reduction Potential	mV	180
UA	G270	B	2016/05/12	Oxidation Reduction Potential	mV	81.0
UA	G270	B	2016/08/01	Oxidation Reduction Potential	mV	72.0
UA	G270	B	2016/11/16	Oxidation Reduction Potential	mV	56.0
UA	G270	B	2017/02/10	Oxidation Reduction Potential	mV	56.0
UA	G270	B	2017/05/16	Oxidation Reduction Potential	mV	71.0
UA	G270	B	2017/07/12	Oxidation Reduction Potential	mV	63.0
UA	G270	B	2017/10/25	Oxidation Reduction Potential	mV	62.0
UA	G270	B	2018/05/11	Oxidation Reduction Potential	mV	58.0
UA	G270	B	2018/08/03	Oxidation Reduction Potential	mV	68.0
UA	G270	B	2019/01/21	Oxidation Reduction Potential	mV	75.0
UA	G270	B	2019/08/15	Oxidation Reduction Potential	mV	73.0
UA	G270	B	2020/01/24	Oxidation Reduction Potential	mV	151
UA	G270	B	2020/08/12	Oxidation Reduction Potential	mV	161
UA	G270	B	2020/10/14	Oxidation Reduction Potential	mV	168
UA	G270	B	2021/01/21	Oxidation Reduction Potential	mV	196
UA	G270	B	2021/03/30	Oxidation Reduction Potential	mV	118
UA	G270	B	2021/04/21	Oxidation Reduction Potential	mV	162
UA	G270	B	2021/05/19	Oxidation Reduction Potential	mV	67.5

UA	G270	B	2021/06/15	Oxidation Reduction Potential	mV	83.7
UA	G270	B	2021/06/29	Oxidation Reduction Potential	mV	50.0
UA	G270	B	2021/07/12	Oxidation Reduction Potential	mV	120
UA	G270	B	2021/07/27	Oxidation Reduction Potential	mV	89.3
UA	G270	B	2021/08/18	Oxidation Reduction Potential	mV	150
UA	G270	B	2021/10/26	Oxidation Reduction Potential	mV	7.60
UA	G270	B	2022/02/08	Oxidation Reduction Potential	mV	101
UA	G270	B	2022/05/10	Oxidation Reduction Potential	mV	36.3
UA	G270	B	2022/08/24	Oxidation Reduction Potential	mV	109
UA	G270	B	2022/11/08	Oxidation Reduction Potential	mV	29.2
UA	G270	B	2023/02/16	Oxidation Reduction Potential	mV	171
UA	G270	B	2023/06/08	Oxidation Reduction Potential	mV	61.0
UA	G270	B	2023/08/14	Oxidation Reduction Potential	mV	78.0
UA	G270	B	2023/11/17	Oxidation Reduction Potential	mV	98.0
UA	G270	B	2015/11/20	Eh	V	0.16
UA	G270	B	2016/02/10	Eh	V	0.38
UA	G270	B	2016/05/12	Eh	V	0.28
UA	G270	B	2016/08/01	Eh	V	0.27
UA	G270	B	2016/11/16	Eh	V	0.25
UA	G270	B	2017/02/10	Eh	V	0.25
UA	G270	B	2017/05/16	Eh	V	0.27
UA	G270	B	2017/07/12	Eh	V	0.26
UA	G270	B	2017/10/25	Eh	V	0.26
UA	G270	B	2018/05/11	Eh	V	0.25
UA	G270	B	2018/08/03	Eh	V	0.26
UA	G270	B	2019/01/21	Eh	V	0.27
UA	G270	B	2019/08/15	Eh	V	0.27
UA	G270	B	2020/01/24	Eh	V	0.35
UA	G270	B	2020/08/12	Eh	V	0.35
UA	G270	B	2020/10/14	Eh	V	0.36
UA	G270	B	2021/01/21	Eh	V	0.39
UA	G270	B	2021/03/30	Eh	V	0.32
UA	G270	B	2021/04/21	Eh	V	0.36
UA	G270	B	2021/05/19	Eh	V	0.26
UA	G270	B	2021/06/15	Eh	V	0.28
UA	G270	B	2021/06/29	Eh	V	0.24
UA	G270	B	2021/07/12	Eh	V	0.31
UA	G270	B	2021/07/27	Eh	V	0.28
UA	G270	B	2021/08/18	Eh	V	0.34
UA	G270	B	2022/02/08	Eh	V	0.30
UA	G270	B	2022/05/10	Eh	V	0.23
UA	G270	B	2022/08/24	Eh	V	0.30
UA	G270	B	2022/11/08	Eh	V	0.22
UA	G270	B	2023/02/16	Eh	V	0.37
UA	G270	B	2023/06/08	Eh	V	0.26
UA	G270	B	2023/08/14	Eh	V	0.27
UA	G270	B	2023/11/17	Eh	V	0.29
UA	G270	B	2015/01/20	Alkalinity, bicarbonate	mg/L CaCO3	300
UA	G270	B	2015/04/13	Alkalinity, bicarbonate	mg/L CaCO3	310
UA	G270	B	2016/11/16	Alkalinity, bicarbonate	mg/L CaCO3	300
UA	G270	B	2017/05/16	Alkalinity, bicarbonate	mg/L CaCO3	340
UA	G270	B	2017/07/12	Alkalinity, bicarbonate	mg/L CaCO3	350
UA	G270	B	2020/01/24	Alkalinity, bicarbonate	mg/L CaCO3	360
UA	G270	B	2020/08/12	Alkalinity, bicarbonate	mg/L CaCO3	360
UA	G270	B	2021/01/21	Alkalinity, bicarbonate	mg/L CaCO3	320
UA	G270	B	2021/03/30	Alkalinity, bicarbonate	mg/L CaCO3	320
UA	G270	B	2021/04/21	Alkalinity, bicarbonate	mg/L CaCO3	340
UA	G270	B	2021/05/06	Alkalinity, bicarbonate	mg/L CaCO3	340
UA	G270	B	2021/05/19	Alkalinity, bicarbonate	mg/L CaCO3	310
UA	G270	B	2021/06/15	Alkalinity, bicarbonate	mg/L CaCO3	310
UA	G270	B	2021/06/29	Alkalinity, bicarbonate	mg/L CaCO3	310
UA	G270	B	2021/07/12	Alkalinity, bicarbonate	mg/L CaCO3	340
UA	G270	B	2021/07/27	Alkalinity, bicarbonate	mg/L CaCO3	320

UA	G270	B	2021/08/18	Alkalinity, bicarbonate	mg/L CaCO3	340
UA	G270	B	2022/02/08	Alkalinity, bicarbonate	mg/L CaCO3	340
UA	G270	B	2022/08/24	Alkalinity, bicarbonate	mg/L CaCO3	340
UA	G270	B	2023/02/16	Alkalinity, bicarbonate	mg/L CaCO3	320
UA	G270	B	2023/06/08	Alkalinity, bicarbonate	mg/L CaCO3	350
UA	G270	B	2023/08/14	Alkalinity, bicarbonate	mg/L CaCO3	347
UA	G270	B	2023/11/17	Alkalinity, bicarbonate	mg/L CaCO3	325
UA	G270	B	2022/08/24	Alkalinity, carbonate	mg/L CaCO3	10.0
UA	G270	B	2015/04/13	Barium, total	mg/L	0.0500
UA	G270	B	2015/07/22	Barium, total	mg/L	0.0490
UA	G270	B	2015/10/05	Barium, total	mg/L	0.0370
UA	G270	B	2015/11/20	Barium, total	mg/L	0.0450
UA	G270	B	2016/02/10	Barium, total	mg/L	0.0320
UA	G270	B	2016/05/12	Barium, total	mg/L	0.0340
UA	G270	B	2016/08/01	Barium, total	mg/L	0.0370
UA	G270	B	2016/11/16	Barium, total	mg/L	0.0310
UA	G270	B	2017/02/10	Barium, total	mg/L	0.0360
UA	G270	B	2017/05/16	Barium, total	mg/L	0.0330
UA	G270	B	2017/07/12	Barium, total	mg/L	0.0350
UA	G270	B	2018/05/11	Barium, total	mg/L	0.0380
UA	G270	B	2018/08/03	Barium, total	mg/L	0.0360
UA	G270	B	2019/01/21	Barium, total	mg/L	0.0470
UA	G270	B	2019/08/15	Barium, total	mg/L	0.0400
UA	G270	B	2020/01/24	Barium, total	mg/L	0.0380
UA	G270	B	2020/08/12	Barium, total	mg/L	0.0420
UA	G270	B	2020/10/14	Barium, total	mg/L	0.0430
UA	G270	B	2021/01/21	Barium, total	mg/L	0.0390
UA	G270	B	2021/03/30	Barium, total	mg/L	0.0450
UA	G270	B	2021/04/21	Barium, total	mg/L	0.0360
UA	G270	B	2021/05/06	Barium, total	mg/L	0.0410
UA	G270	B	2021/05/19	Barium, total	mg/L	0.0340
UA	G270	B	2021/06/15	Barium, total	mg/L	0.0340
UA	G270	B	2021/06/29	Barium, total	mg/L	0.0330
UA	G270	B	2021/07/12	Barium, total	mg/L	0.0350
UA	G270	B	2021/07/27	Barium, total	mg/L	0.0330
UA	G270	B	2021/08/18	Barium, total	mg/L	0.0340
UA	G270	B	2021/10/26	Barium, total	mg/L	0.0330
UA	G270	B	2022/02/08	Barium, total	mg/L	0.0330
UA	G270	B	2022/05/10	Barium, total	mg/L	0.0370
UA	G270	B	2022/08/24	Barium, total	mg/L	0.0360
UA	G270	B	2022/11/08	Barium, total	mg/L	0.0380
UA	G270	B	2023/02/16	Barium, total	mg/L	0.0410
UA	G270	B	2023/06/08	Barium, total	mg/L	0.0640
UA	G270	B	2023/08/14	Barium, total	mg/L	0.0467
UA	G270	B	2023/11/17	Barium, total	mg/L	0.0649
UA	G270	B	2015/01/20	Boron, total	mg/L	<0.01
UA	G270	B	2015/04/13	Boron, total	mg/L	0.0470
UA	G270	B	2015/07/22	Boron, total	mg/L	<0.01
UA	G270	B	2015/10/05	Boron, total	mg/L	<0.01
UA	G270	B	2015/11/20	Boron, total	mg/L	<0.0023
UA	G270	B	2016/02/10	Boron, total	mg/L	<0.0023
UA	G270	B	2016/05/12	Boron, total	mg/L	<0.0023
UA	G270	B	2016/08/01	Boron, total	mg/L	<0.0023
UA	G270	B	2016/11/16	Boron, total	mg/L	0.0180
UA	G270	B	2017/02/10	Boron, total	mg/L	<0.0023
UA	G270	B	2017/05/16	Boron, total	mg/L	<0.0023
UA	G270	B	2017/07/12	Boron, total	mg/L	<0.0023
UA	G270	B	2017/10/25	Boron, total	mg/L	0.0110
UA	G270	B	2018/05/11	Boron, total	mg/L	<0.0079
UA	G270	B	2018/08/03	Boron, total	mg/L	<0.0034
UA	G270	B	2019/01/21	Boron, total	mg/L	<0.0034
UA	G270	B	2019/08/15	Boron, total	mg/L	<0.0034
UA	G270	B	2020/01/24	Boron, total	mg/L	0.0150

UA	G270	B	2020/08/12	Boron, total	mg/L	0.100
UA	G270	B	2020/10/14	Boron, total	mg/L	0.0180
UA	G270	B	2021/01/21	Boron, total	mg/L	<0.008
UA	G270	B	2021/03/30	Boron, total	mg/L	0.0200
UA	G270	B	2021/04/21	Boron, total	mg/L	<0.01
UA	G270	B	2021/05/06	Boron, total	mg/L	0.0130
UA	G270	B	2021/05/19	Boron, total	mg/L	<0.008
UA	G270	B	2021/06/15	Boron, total	mg/L	0.0110
UA	G270	B	2021/06/29	Boron, total	mg/L	<0.008
UA	G270	B	2021/07/12	Boron, total	mg/L	0.120
UA	G270	B	2021/07/27	Boron, total	mg/L	<0.008
UA	G270	B	2021/08/18	Boron, total	mg/L	0.0120
UA	G270	B	2021/10/26	Boron, total	mg/L	<0.01
UA	G270	B	2022/02/08	Boron, total	mg/L	0.0120
UA	G270	B	2022/05/10	Boron, total	mg/L	<0.0071
UA	G270	B	2022/08/24	Boron, total	mg/L	<0.0071
UA	G270	B	2022/11/08	Boron, total	mg/L	0.00900
UA	G270	B	2023/02/16	Boron, total	mg/L	<0.0071
UA	G270	B	2023/06/08	Boron, total	mg/L	0.0140
UA	G270	B	2023/08/14	Boron, total	mg/L	<0.0092
UA	G270	B	2023/11/17	Boron, total	mg/L	<0.0125
UA	G270	B	2015/01/20	Calcium, total	mg/L	70.0
UA	G270	B	2015/04/13	Calcium, total	mg/L	70.0
UA	G270	B	2015/11/20	Calcium, total	mg/L	59.0
UA	G270	B	2016/02/10	Calcium, total	mg/L	49.0
UA	G270	B	2016/05/12	Calcium, total	mg/L	57.0
UA	G270	B	2016/08/01	Calcium, total	mg/L	50.0
UA	G270	B	2016/11/16	Calcium, total	mg/L	48.0
UA	G270	B	2017/02/10	Calcium, total	mg/L	53.0
UA	G270	B	2017/05/16	Calcium, total	mg/L	54.0
UA	G270	B	2017/07/12	Calcium, total	mg/L	52.0
UA	G270	B	2017/10/25	Calcium, total	mg/L	56.0
UA	G270	B	2018/05/11	Calcium, total	mg/L	53.0
UA	G270	B	2018/08/03	Calcium, total	mg/L	57.0
UA	G270	B	2019/01/21	Calcium, total	mg/L	56.0
UA	G270	B	2019/08/15	Calcium, total	mg/L	54.0
UA	G270	B	2020/01/24	Calcium, total	mg/L	59.0
UA	G270	B	2020/08/12	Calcium, total	mg/L	58.0
UA	G270	B	2020/10/14	Calcium, total	mg/L	61.0
UA	G270	B	2021/01/21	Calcium, total	mg/L	59.0
UA	G270	B	2021/03/30	Calcium, total	mg/L	58.0
UA	G270	B	2021/04/21	Calcium, total	mg/L	55.0
UA	G270	B	2021/05/06	Calcium, total	mg/L	57.0
UA	G270	B	2021/05/19	Calcium, total	mg/L	53.0
UA	G270	B	2021/06/15	Calcium, total	mg/L	60.0
UA	G270	B	2021/06/29	Calcium, total	mg/L	56.0
UA	G270	B	2021/07/12	Calcium, total	mg/L	55.0
UA	G270	B	2021/07/27	Calcium, total	mg/L	52.0
UA	G270	B	2021/08/18	Calcium, total	mg/L	55.0
UA	G270	B	2021/10/26	Calcium, total	mg/L	49.0
UA	G270	B	2022/02/08	Calcium, total	mg/L	53.0
UA	G270	B	2022/05/10	Calcium, total	mg/L	59.0
UA	G270	B	2022/08/24	Calcium, total	mg/L	56.0
UA	G270	B	2022/11/08	Calcium, total	mg/L	57.0
UA	G270	B	2023/02/16	Calcium, total	mg/L	56.0
UA	G270	B	2023/06/08	Calcium, total	mg/L	57.0
UA	G270	B	2023/08/14	Calcium, total	mg/L	57.9
UA	G270	B	2023/11/17	Calcium, total	mg/L	58.1
UA	G270	B	2015/01/20	Chloride, total	mg/L	18.0
UA	G270	B	2015/04/13	Chloride, total	mg/L	20.0
UA	G270	B	2015/07/22	Chloride, total	mg/L	15.0
UA	G270	B	2015/10/05	Chloride, total	mg/L	11.0
UA	G270	B	2015/11/20	Chloride, total	mg/L	12.0

UA	G270	B	2016/02/10	Chloride, total	mg/L	16.0
UA	G270	B	2016/05/12	Chloride, total	mg/L	12.0
UA	G270	B	2016/08/01	Chloride, total	mg/L	15.0
UA	G270	B	2016/11/16	Chloride, total	mg/L	12.0
UA	G270	B	2017/02/10	Chloride, total	mg/L	11.0
UA	G270	B	2017/05/16	Chloride, total	mg/L	9.70
UA	G270	B	2017/07/12	Chloride, total	mg/L	12.0
UA	G270	B	2017/10/25	Chloride, total	mg/L	13.0
UA	G270	B	2018/05/11	Chloride, total	mg/L	7.90
UA	G270	B	2018/08/03	Chloride, total	mg/L	8.60
UA	G270	B	2019/01/21	Chloride, total	mg/L	9.60
UA	G270	B	2019/08/15	Chloride, total	mg/L	9.80
UA	G270	B	2020/01/24	Chloride, total	mg/L	10.0
UA	G270	B	2020/08/12	Chloride, total	mg/L	12.0
UA	G270	B	2020/10/14	Chloride, total	mg/L	12.0
UA	G270	B	2021/01/21	Chloride, total	mg/L	10.0
UA	G270	B	2021/03/30	Chloride, total	mg/L	14.0
UA	G270	B	2021/04/21	Chloride, total	mg/L	16.0
UA	G270	B	2021/05/06	Chloride, total	mg/L	11.0
UA	G270	B	2021/05/19	Chloride, total	mg/L	10.0
UA	G270	B	2021/06/15	Chloride, total	mg/L	12.0
UA	G270	B	2021/06/29	Chloride, total	mg/L	12.0
UA	G270	B	2021/07/12	Chloride, total	mg/L	11.0
UA	G270	B	2021/07/27	Chloride, total	mg/L	12.0
UA	G270	B	2021/08/18	Chloride, total	mg/L	12.0
UA	G270	B	2021/10/26	Chloride, total	mg/L	9.90
UA	G270	B	2022/02/08	Chloride, total	mg/L	8.70
UA	G270	B	2022/05/10	Chloride, total	mg/L	9.30
UA	G270	B	2022/08/24	Chloride, total	mg/L	9.70
UA	G270	B	2022/11/08	Chloride, total	mg/L	9.00
UA	G270	B	2023/02/16	Chloride, total	mg/L	7.80
UA	G270	B	2023/06/08	Chloride, total	mg/L	8.30
UA	G270	B	2023/08/14	Chloride, total	mg/L	13.0
UA	G270	B	2023/11/17	Chloride, total	mg/L	15.0
UA	G270	B	2015/04/13	Cobalt, total	mg/L	<0.002
UA	G270	B	2015/07/22	Cobalt, total	mg/L	<0.002
UA	G270	B	2015/10/05	Cobalt, total	mg/L	<0.002
UA	G270	B	2015/11/20	Cobalt, total	mg/L	<0.000017
UA	G270	B	2016/02/10	Cobalt, total	mg/L	<0.000017
UA	G270	B	2016/05/12	Cobalt, total	mg/L	<0.000017
UA	G270	B	2016/08/01	Cobalt, total	mg/L	<0.000017
UA	G270	B	2016/11/16	Cobalt, total	mg/L	<0.000017
UA	G270	B	2017/02/10	Cobalt, total	mg/L	<0.000017
UA	G270	B	2017/05/16	Cobalt, total	mg/L	<0.000017
UA	G270	B	2017/07/12	Cobalt, total	mg/L	<0.000017
UA	G270	B	2018/05/11	Cobalt, total	mg/L	<0.00086
UA	G270	B	2018/08/03	Cobalt, total	mg/L	<0.00067
UA	G270	B	2019/01/21	Cobalt, total	mg/L	<0.00067
UA	G270	B	2019/08/15	Cobalt, total	mg/L	<0.00067
UA	G270	B	2020/01/24	Cobalt, total	mg/L	<0.00067
UA	G270	B	2020/08/12	Cobalt, total	mg/L	<0.00022
UA	G270	B	2020/10/14	Cobalt, total	mg/L	<0.002
UA	G270	B	2021/01/21	Cobalt, total	mg/L	<0.00022
UA	G270	B	2021/03/30	Cobalt, total	mg/L	<0.00022
UA	G270	B	2021/04/21	Cobalt, total	mg/L	<0.00022
UA	G270	B	2021/05/06	Cobalt, total	mg/L	<0.00022
UA	G270	B	2021/05/19	Cobalt, total	mg/L	<0.00022
UA	G270	B	2021/06/15	Cobalt, total	mg/L	<0.00022
UA	G270	B	2021/06/29	Cobalt, total	mg/L	<0.00022
UA	G270	B	2021/07/12	Cobalt, total	mg/L	<0.00022
UA	G270	B	2021/07/27	Cobalt, total	mg/L	<0.00022
UA	G270	B	2021/08/18	Cobalt, total	mg/L	<0.00022
UA	G270	B	2021/10/26	Cobalt, total	mg/L	<0.002

UA	G270	B	2022/02/08	Cobalt, total	mg/L	<0.00048
UA	G270	B	2022/05/10	Cobalt, total	mg/L	<0.00048
UA	G270	B	2022/08/24	Cobalt, total	mg/L	<0.00048
UA	G270	B	2022/11/08	Cobalt, total	mg/L	<0.00048
UA	G270	B	2023/02/16	Cobalt, total	mg/L	<0.00048
UA	G270	B	2023/06/08	Cobalt, total	mg/L	0.000640
UA	G270	B	2023/08/14	Cobalt, total	mg/L	0.000300
UA	G270	B	2023/11/17	Cobalt, total	mg/L	0.000200
UA	G270	B	2023/06/08	Ferrous Iron, dissolved	mg/L	0.260
UA	G270	B	2015/01/20	Iron, dissolved	mg/L	<0.01
UA	G270	B	2015/04/13	Iron, dissolved	mg/L	0.0210
UA	G270	B	2015/07/22	Iron, dissolved	mg/L	0.180
UA	G270	B	2015/10/05	Iron, dissolved	mg/L	0.0840
UA	G270	B	2016/02/10	Iron, dissolved	mg/L	0.0180
UA	G270	B	2016/05/12	Iron, dissolved	mg/L	<0.01
UA	G270	B	2016/07/27	Iron, dissolved	mg/L	0.0180
UA	G270	B	2016/11/21	Iron, dissolved	mg/L	<0.01
UA	G270	B	2017/02/08	Iron, dissolved	mg/L	<0.01
UA	G270	B	2017/05/18	Iron, dissolved	mg/L	0.0110
UA	G270	B	2017/07/12	Iron, dissolved	mg/L	0.0760
UA	G270	B	2017/10/25	Iron, dissolved	mg/L	<0.01
UA	G270	B	2018/01/29	Iron, dissolved	mg/L	0.280
UA	G270	B	2018/05/11	Iron, dissolved	mg/L	0.0120
UA	G270	B	2018/08/10	Iron, dissolved	mg/L	0.0570
UA	G270	B	2018/11/06	Iron, dissolved	mg/L	<0.01
UA	G270	B	2019/01/21	Iron, dissolved	mg/L	0.0460
UA	G270	B	2019/05/01	Iron, dissolved	mg/L	<0.01
UA	G270	B	2019/08/15	Iron, dissolved	mg/L	<0.01
UA	G270	B	2019/10/21	Iron, dissolved	mg/L	0.0430
UA	G270	B	2020/01/24	Iron, dissolved	mg/L	<0.01
UA	G270	B	2020/05/07	Iron, dissolved	mg/L	<0.01
UA	G270	B	2020/08/11	Iron, dissolved	mg/L	<0.01
UA	G270	B	2020/10/14	Iron, dissolved	mg/L	<0.01
UA	G270	B	2021/01/21	Iron, dissolved	mg/L	<0.01
UA	G270	B	2021/04/21	Iron, dissolved	mg/L	<0.01
UA	G270	B	2021/08/18	Iron, dissolved	mg/L	<0.01
UA	G270	B	2021/10/26	Iron, dissolved	mg/L	<0.01
UA	G270	B	2022/02/08	Iron, dissolved	mg/L	<0.01
UA	G270	B	2022/05/10	Iron, dissolved	mg/L	0.160
UA	G270	B	2022/08/24	Iron, dissolved	mg/L	<0.00072
UA	G270	B	2022/11/08	Iron, dissolved	mg/L	0.00360
UA	G270	B	2023/02/16	Iron, dissolved	mg/L	<0.00072
UA	G270	B	2023/06/08	Iron, dissolved	mg/L	0.0440
UA	G270	B	2023/08/14	Iron, dissolved	mg/L	0.0190
UA	G270	B	2023/11/17	Iron, dissolved	mg/L	<0.0115
UA	G270	B	2015/04/13	Magnesium, total	mg/L	32.0
UA	G270	B	2016/11/16	Magnesium, total	mg/L	22.0
UA	G270	B	2017/05/16	Magnesium, total	mg/L	27.0
UA	G270	B	2017/07/12	Magnesium, total	mg/L	24.0
UA	G270	B	2020/01/24	Magnesium, total	mg/L	26.0
UA	G270	B	2020/08/12	Magnesium, total	mg/L	25.0
UA	G270	B	2021/01/21	Magnesium, total	mg/L	24.0
UA	G270	B	2021/03/30	Magnesium, total	mg/L	26.0
UA	G270	B	2021/04/21	Magnesium, total	mg/L	26.0
UA	G270	B	2021/05/06	Magnesium, total	mg/L	25.0
UA	G270	B	2021/05/19	Magnesium, total	mg/L	24.0
UA	G270	B	2021/06/15	Magnesium, total	mg/L	25.0
UA	G270	B	2021/06/29	Magnesium, total	mg/L	25.0
UA	G270	B	2021/07/12	Magnesium, total	mg/L	25.0
UA	G270	B	2021/07/27	Magnesium, total	mg/L	24.0
UA	G270	B	2021/08/18	Magnesium, total	mg/L	24.0
UA	G270	B	2022/02/08	Magnesium, total	mg/L	22.0
UA	G270	B	2022/08/24	Magnesium, total	mg/L	25.0

UA	G270	B	2023/02/16	Magnesium, total	mg/L	21.0
UA	G270	B	2023/06/08	Magnesium, total	mg/L	24.0
UA	G270	B	2023/08/14	Magnesium, total	mg/L	23.4
UA	G270	B	2023/11/17	Magnesium, total	mg/L	24.1
UA	G270	B	2015/01/20	Manganese, dissolved	mg/L	0.0110
UA	G270	B	2015/04/13	Manganese, dissolved	mg/L	0.00550
UA	G270	B	2015/07/22	Manganese, dissolved	mg/L	0.470
UA	G270	B	2015/10/05	Manganese, dissolved	mg/L	0.0560
UA	G270	B	2016/02/10	Manganese, dissolved	mg/L	0.0120
UA	G270	B	2016/05/12	Manganese, dissolved	mg/L	0.0290
UA	G270	B	2016/07/27	Manganese, dissolved	mg/L	0.00320
UA	G270	B	2016/11/21	Manganese, dissolved	mg/L	0.0260
UA	G270	B	2017/02/08	Manganese, dissolved	mg/L	0.00110
UA	G270	B	2017/05/18	Manganese, dissolved	mg/L	0.0250
UA	G270	B	2017/07/12	Manganese, dissolved	mg/L	0.400
UA	G270	B	2017/10/25	Manganese, dissolved	mg/L	0.00870
UA	G270	B	2018/01/29	Manganese, dissolved	mg/L	0.0770
UA	G270	B	2018/03/05	Manganese, dissolved	mg/L	0.00240
UA	G270	B	2019/05/01	Manganese, dissolved	mg/L	<0.001
UA	G270	B	2019/08/15	Manganese, dissolved	mg/L	0.00220
UA	G270	B	2020/01/24	Manganese, dissolved	mg/L	<0.001
UA	G270	B	2020/10/14	Manganese, dissolved	mg/L	0.0540
UA	G270	B	2021/01/21	Manganese, dissolved	mg/L	0.00340
UA	G270	B	2021/04/21	Manganese, dissolved	mg/L	<0.001
UA	G270	B	2021/08/18	Manganese, dissolved	mg/L	0.0100
UA	G270	B	2021/10/26	Manganese, dissolved	mg/L	0.0240
UA	G270	B	2022/02/08	Manganese, dissolved	mg/L	<0.001
UA	G270	B	2022/05/10	Manganese, dissolved	mg/L	0.00210
UA	G270	B	2022/08/24	Manganese, dissolved	mg/L	0.00130
UA	G270	B	2022/11/08	Manganese, dissolved	mg/L	0.0150
UA	G270	B	2023/02/16	Manganese, dissolved	mg/L	0.00430
UA	G270	B	2023/06/08	Manganese, dissolved	mg/L	0.0790
UA	G270	B	2023/08/14	Manganese, dissolved	mg/L	0.157
UA	G270	B	2023/11/17	Manganese, dissolved	mg/L	0.0675
UA	G270	B	2023/08/14	Phosphate, dissolved	mg/L	0.0210
UA	G270	B	2015/04/13	Potassium, total	mg/L	0.790
UA	G270	B	2016/11/16	Potassium, total	mg/L	0.720
UA	G270	B	2017/05/16	Potassium, total	mg/L	0.720
UA	G270	B	2017/07/12	Potassium, total	mg/L	0.800
UA	G270	B	2020/01/24	Potassium, total	mg/L	0.880
UA	G270	B	2020/08/12	Potassium, total	mg/L	0.570
UA	G270	B	2021/01/21	Potassium, total	mg/L	1.20
UA	G270	B	2021/03/30	Potassium, total	mg/L	1.00
UA	G270	B	2021/04/21	Potassium, total	mg/L	0.860
UA	G270	B	2021/05/06	Potassium, total	mg/L	0.840
UA	G270	B	2021/05/19	Potassium, total	mg/L	0.500
UA	G270	B	2021/06/15	Potassium, total	mg/L	0.630
UA	G270	B	2021/06/29	Potassium, total	mg/L	0.580
UA	G270	B	2021/07/12	Potassium, total	mg/L	0.630
UA	G270	B	2021/07/27	Potassium, total	mg/L	0.590
UA	G270	B	2021/08/18	Potassium, total	mg/L	0.690
UA	G270	B	2022/02/08	Potassium, total	mg/L	0.580
UA	G270	B	2022/08/24	Potassium, total	mg/L	0.620
UA	G270	B	2023/02/16	Potassium, total	mg/L	0.620
UA	G270	B	2023/06/08	Potassium, total	mg/L	0.670
UA	G270	B	2023/08/14	Potassium, total	mg/L	0.757
UA	G270	B	2023/11/17	Potassium, total	mg/L	0.749
UA	G270	B	2023/06/08	Silicon, dissolved	mg/L	7.40
UA	G270	B	2023/08/14	Silicon, dissolved	mg/L	6.48
UA	G270	B	2015/04/13	Sodium, total	mg/L	91.0
UA	G270	B	2016/11/16	Sodium, total	mg/L	77.0
UA	G270	B	2017/05/16	Sodium, total	mg/L	88.0
UA	G270	B	2017/07/12	Sodium, total	mg/L	78.0

UA	G270	B	2020/01/24	Sodium, total	mg/L	82.0
UA	G270	B	2020/08/12	Sodium, total	mg/L	78.0
UA	G270	B	2021/01/21	Sodium, total	mg/L	87.0
UA	G270	B	2021/03/30	Sodium, total	mg/L	81.0
UA	G270	B	2021/04/21	Sodium, total	mg/L	84.0
UA	G270	B	2021/05/06	Sodium, total	mg/L	88.0
UA	G270	B	2021/05/19	Sodium, total	mg/L	87.0
UA	G270	B	2021/06/15	Sodium, total	mg/L	92.0
UA	G270	B	2021/06/29	Sodium, total	mg/L	85.0
UA	G270	B	2021/07/12	Sodium, total	mg/L	79.0
UA	G270	B	2021/07/27	Sodium, total	mg/L	89.0
UA	G270	B	2021/08/18	Sodium, total	mg/L	100
UA	G270	B	2022/02/08	Sodium, total	mg/L	89.0
UA	G270	B	2022/08/24	Sodium, total	mg/L	98.0
UA	G270	B	2023/02/16	Sodium, total	mg/L	81.0
UA	G270	B	2023/06/08	Sodium, total	mg/L	82.0
UA	G270	B	2023/08/14	Sodium, total	mg/L	80.3
UA	G270	B	2023/11/17	Sodium, total	mg/L	67.1
UA	G270	B	2015/01/20	Sulfate, total	mg/L	140
UA	G270	B	2015/04/13	Sulfate, total	mg/L	120
UA	G270	B	2015/07/22	Sulfate, total	mg/L	110
UA	G270	B	2015/10/05	Sulfate, total	mg/L	82.0
UA	G270	B	2015/11/20	Sulfate, total	mg/L	89.0
UA	G270	B	2016/02/10	Sulfate, total	mg/L	77.0
UA	G270	B	2016/05/12	Sulfate, total	mg/L	76.0
UA	G270	B	2016/08/01	Sulfate, total	mg/L	76.0
UA	G270	B	2016/11/16	Sulfate, total	mg/L	63.0
UA	G270	B	2017/02/10	Sulfate, total	mg/L	55.0
UA	G270	B	2017/05/16	Sulfate, total	mg/L	50.0
UA	G270	B	2017/07/12	Sulfate, total	mg/L	54.0
UA	G270	B	2017/10/25	Sulfate, total	mg/L	55.0
UA	G270	B	2018/05/11	Sulfate, total	mg/L	53.0
UA	G270	B	2018/08/03	Sulfate, total	mg/L	54.0
UA	G270	B	2019/01/21	Sulfate, total	mg/L	49.0
UA	G270	B	2019/08/15	Sulfate, total	mg/L	50.0
UA	G270	B	2020/01/24	Sulfate, total	mg/L	51.0
UA	G270	B	2020/08/12	Sulfate, total	mg/L	53.0
UA	G270	B	2020/10/14	Sulfate, total	mg/L	58.0
UA	G270	B	2021/01/21	Sulfate, total	mg/L	54.0
UA	G270	B	2021/03/30	Sulfate, total	mg/L	55.0
UA	G270	B	2021/04/21	Sulfate, total	mg/L	53.0
UA	G270	B	2021/05/06	Sulfate, total	mg/L	57.0
UA	G270	B	2021/05/19	Sulfate, total	mg/L	58.0
UA	G270	B	2021/06/15	Sulfate, total	mg/L	55.0
UA	G270	B	2021/06/29	Sulfate, total	mg/L	58.0
UA	G270	B	2021/07/12	Sulfate, total	mg/L	56.0
UA	G270	B	2021/07/27	Sulfate, total	mg/L	55.0
UA	G270	B	2021/08/18	Sulfate, total	mg/L	54.0
UA	G270	B	2021/10/26	Sulfate, total	mg/L	52.0
UA	G270	B	2022/02/08	Sulfate, total	mg/L	53.0
UA	G270	B	2022/05/10	Sulfate, total	mg/L	53.0
UA	G270	B	2022/08/24	Sulfate, total	mg/L	53.0
UA	G270	B	2022/11/08	Sulfate, total	mg/L	51.0
UA	G270	B	2023/02/16	Sulfate, total	mg/L	50.0
UA	G270	B	2023/06/08	Sulfate, total	mg/L	54.0
UA	G270	B	2023/08/14	Sulfate, total	mg/L	48.0
UA	G270	B	2023/11/17	Sulfate, total	mg/L	50.0
UA	G270	B	2015/11/20	Temperature (Celsius)	degrees C	16.6
UA	G270	B	2016/02/10	Temperature (Celsius)	degrees C	8.00
UA	G270	B	2016/05/12	Temperature (Celsius)	degrees C	16.8
UA	G270	B	2016/08/01	Temperature (Celsius)	degrees C	17.6
UA	G270	B	2016/11/16	Temperature (Celsius)	degrees C	14.5
UA	G270	B	2017/02/10	Temperature (Celsius)	degrees C	15.0

UA	G270	B	2017/05/16	Temperature (Celsius)	degrees C	15.4
UA	G270	B	2017/07/12	Temperature (Celsius)	degrees C	17.3
UA	G270	B	2017/10/25	Temperature (Celsius)	degrees C	12.7
UA	G270	B	2018/05/11	Temperature (Celsius)	degrees C	13.5
UA	G270	B	2018/08/03	Temperature (Celsius)	degrees C	15.9
UA	G270	B	2019/01/21	Temperature (Celsius)	degrees C	12.0
UA	G270	B	2019/08/15	Temperature (Celsius)	degrees C	17.0
UA	G270	B	2020/01/24	Temperature (Celsius)	degrees C	9.70
UA	G270	B	2020/08/12	Temperature (Celsius)	degrees C	18.5
UA	G270	B	2020/10/14	Temperature (Celsius)	degrees C	16.5
UA	G270	B	2021/01/21	Temperature (Celsius)	degrees C	11.6
UA	G270	B	2021/03/30	Temperature (Celsius)	degrees C	12.2
UA	G270	B	2021/04/21	Temperature (Celsius)	degrees C	11.9
UA	G270	B	2021/05/06	Temperature (Celsius)	degrees C	12.2
UA	G270	B	2021/05/19	Temperature (Celsius)	degrees C	15.2
UA	G270	B	2021/06/15	Temperature (Celsius)	degrees C	19.8
UA	G270	B	2021/06/29	Temperature (Celsius)	degrees C	20.5
UA	G270	B	2021/07/12	Temperature (Celsius)	degrees C	18.5
UA	G270	B	2021/07/27	Temperature (Celsius)	degrees C	20.4
UA	G270	B	2021/08/18	Temperature (Celsius)	degrees C	20.2
UA	G270	B	2022/02/08	Temperature (Celsius)	degrees C	10.4
UA	G270	B	2022/05/10	Temperature (Celsius)	degrees C	14.6
UA	G270	B	2022/08/24	Temperature (Celsius)	degrees C	19.7
UA	G270	B	2022/11/08	Temperature (Celsius)	degrees C	16.4
UA	G270	B	2023/02/16	Temperature (Celsius)	degrees C	8.90
UA	G270	B	2023/06/08	Temperature (Celsius)	degrees C	14.6
UA	G270	B	2023/08/14	Temperature (Celsius)	degrees C	15.2
UA	G270	B	2023/11/17	Temperature (Celsius)	degrees C	15.2
UA	G270	B	2015/01/20	Total Dissolved Solids	mg/L	500
UA	G270	B	2015/04/13	Total Dissolved Solids	mg/L	540
UA	G270	B	2015/07/22	Total Dissolved Solids	mg/L	550
UA	G270	B	2015/10/05	Total Dissolved Solids	mg/L	480
UA	G270	B	2015/11/20	Total Dissolved Solids	mg/L	400
UA	G270	B	2016/02/10	Total Dissolved Solids	mg/L	340
UA	G270	B	2016/05/12	Total Dissolved Solids	mg/L	340
UA	G270	B	2016/08/01	Total Dissolved Solids	mg/L	360
UA	G270	B	2016/11/16	Total Dissolved Solids	mg/L	450
UA	G270	B	2017/02/10	Total Dissolved Solids	mg/L	390
UA	G270	B	2017/05/16	Total Dissolved Solids	mg/L	380
UA	G270	B	2017/07/12	Total Dissolved Solids	mg/L	400
UA	G270	B	2017/10/25	Total Dissolved Solids	mg/L	400
UA	G270	B	2018/05/11	Total Dissolved Solids	mg/L	400
UA	G270	B	2018/08/03	Total Dissolved Solids	mg/L	420
UA	G270	B	2019/01/21	Total Dissolved Solids	mg/L	480
UA	G270	B	2019/08/15	Total Dissolved Solids	mg/L	470
UA	G270	B	2020/01/24	Total Dissolved Solids	mg/L	480
UA	G270	B	2020/08/12	Total Dissolved Solids	mg/L	380
UA	G270	B	2020/10/14	Total Dissolved Solids	mg/L	400
UA	G270	B	2021/01/21	Total Dissolved Solids	mg/L	360
UA	G270	B	2021/03/30	Total Dissolved Solids	mg/L	510
UA	G270	B	2021/04/21	Total Dissolved Solids	mg/L	570
UA	G270	B	2021/05/06	Total Dissolved Solids	mg/L	410
UA	G270	B	2021/05/19	Total Dissolved Solids	mg/L	480
UA	G270	B	2021/06/15	Total Dissolved Solids	mg/L	390
UA	G270	B	2021/06/29	Total Dissolved Solids	mg/L	400
UA	G270	B	2021/07/12	Total Dissolved Solids	mg/L	480
UA	G270	B	2021/07/27	Total Dissolved Solids	mg/L	420
UA	G270	B	2021/08/18	Total Dissolved Solids	mg/L	470
UA	G270	B	2021/10/26	Total Dissolved Solids	mg/L	410
UA	G270	B	2022/02/08	Total Dissolved Solids	mg/L	410
UA	G270	B	2022/05/10	Total Dissolved Solids	mg/L	420
UA	G270	B	2022/08/24	Total Dissolved Solids	mg/L	500
UA	G270	B	2022/11/08	Total Dissolved Solids	mg/L	420

UA	G270	B	2023/02/16	Total Dissolved Solids	mg/L	410
UA	G270	B	2023/06/08	Total Dissolved Solids	mg/L	500
UA	G270	B	2023/08/14	Total Dissolved Solids	mg/L	426
UA	G270	B	2023/11/17	Total Dissolved Solids	mg/L	460
UA	G280	B	2015/01/21	pH (field)	SU	7.6
UA	G280	B	2015/04/13	pH (field)	SU	7.2
UA	G280	B	2015/07/23	pH (field)	SU	7.6
UA	G280	B	2015/10/08	pH (field)	SU	7.7
UA	G280	B	2015/11/24	pH (field)	SU	7.4
UA	G280	B	2016/02/10	pH (field)	SU	6.5
UA	G280	B	2016/05/10	pH (field)	SU	7.2
UA	G280	B	2016/08/03	pH (field)	SU	7.2
UA	G280	B	2016/11/20	pH (field)	SU	7.1
UA	G280	B	2017/02/15	pH (field)	SU	7.0
UA	G280	B	2017/05/20	pH (field)	SU	7.2
UA	G280	B	2017/07/18	pH (field)	SU	7.3
UA	G280	B	2017/11/04	pH (field)	SU	7.2
UA	G280	B	2018/05/16	pH (field)	SU	7.2
UA	G280	B	2018/08/10	pH (field)	SU	7.1
UA	G280	B	2019/01/22	pH (field)	SU	7.1
UA	G280	B	2019/08/26	pH (field)	SU	7.1
UA	G280	B	2020/01/23	pH (field)	SU	7.7
UA	G280	B	2020/08/11	pH (field)	SU	7.3
UA	G280	B	2020/10/14	pH (field)	SU	7.1
UA	G280	B	2021/01/21	pH (field)	SU	7.3
UA	G280	B	2021/01/28	pH (field)	SU	7.3
UA	G280	B	2021/03/30	pH (field)	SU	7.4
UA	G280	B	2021/04/22	pH (field)	SU	7.4
UA	G280	B	2021/05/06	pH (field)	SU	7.2
UA	G280	B	2021/05/19	pH (field)	SU	7.4
UA	G280	B	2021/06/28	pH (field)	SU	7.4
UA	G280	B	2021/07/13	pH (field)	SU	7.4
UA	G280	B	2021/07/27	pH (field)	SU	7.5
UA	G280	B	2021/08/18	pH (field)	SU	7.1
UA	G280	B	2021/10/26	pH (field)	SU	7.3
UA	G280	B	2022/02/08	pH (field)	SU	7.2
UA	G280	B	2022/05/10	pH (field)	SU	7.4
UA	G280	B	2022/08/24	pH (field)	SU	7.2
UA	G280	B	2022/11/09	pH (field)	SU	7.2
UA	G280	B	2023/02/16	pH (field)	SU	6.0
UA	G280	B	2023/06/08	pH (field)	SU	7.3
UA	G280	B	2023/08/14	pH (field)	SU	7.4
UA	G280	B	2023/11/20	pH (field)	SU	7.4
UA	G280	B	2015/11/24	Oxidation Reduction Potential	mV	18.0
UA	G280	B	2016/02/10	Oxidation Reduction Potential	mV	193
UA	G280	B	2016/05/10	Oxidation Reduction Potential	mV	140
UA	G280	B	2016/08/03	Oxidation Reduction Potential	mV	101
UA	G280	B	2016/11/20	Oxidation Reduction Potential	mV	103
UA	G280	B	2017/02/15	Oxidation Reduction Potential	mV	65.0
UA	G280	B	2017/05/20	Oxidation Reduction Potential	mV	89.0
UA	G280	B	2017/07/18	Oxidation Reduction Potential	mV	93.0
UA	G280	B	2017/11/04	Oxidation Reduction Potential	mV	106
UA	G280	B	2018/05/16	Oxidation Reduction Potential	mV	86.0
UA	G280	B	2018/08/10	Oxidation Reduction Potential	mV	102
UA	G280	B	2019/01/22	Oxidation Reduction Potential	mV	107
UA	G280	B	2019/08/26	Oxidation Reduction Potential	mV	99.0
UA	G280	B	2020/01/23	Oxidation Reduction Potential	mV	189
UA	G280	B	2020/08/11	Oxidation Reduction Potential	mV	101
UA	G280	B	2020/10/14	Oxidation Reduction Potential	mV	197
UA	G280	B	2021/01/21	Oxidation Reduction Potential	mV	98.1
UA	G280	B	2021/01/28	Oxidation Reduction Potential	mV	98.1
UA	G280	B	2021/03/30	Oxidation Reduction Potential	mV	119
UA	G280	B	2021/04/22	Oxidation Reduction Potential	mV	107

UA	G280	B	2021/05/06	Oxidation Reduction Potential	mV	149
UA	G280	B	2021/05/19	Oxidation Reduction Potential	mV	82.9
UA	G280	B	2021/06/28	Oxidation Reduction Potential	mV	36.0
UA	G280	B	2021/07/13	Oxidation Reduction Potential	mV	77.4
UA	G280	B	2021/07/27	Oxidation Reduction Potential	mV	178
UA	G280	B	2021/08/18	Oxidation Reduction Potential	mV	63.9
UA	G280	B	2021/10/26	Oxidation Reduction Potential	mV	56.0
UA	G280	B	2022/02/08	Oxidation Reduction Potential	mV	-15.2
UA	G280	B	2022/05/10	Oxidation Reduction Potential	mV	23.2
UA	G280	B	2022/08/24	Oxidation Reduction Potential	mV	64.4
UA	G280	B	2022/11/09	Oxidation Reduction Potential	mV	209
UA	G280	B	2023/02/16	Oxidation Reduction Potential	mV	236
UA	G280	B	2023/06/08	Oxidation Reduction Potential	mV	190
UA	G280	B	2023/08/14	Oxidation Reduction Potential	mV	31.0
UA	G280	B	2023/11/20	Oxidation Reduction Potential	mV	107
UA	G280	B	2015/11/24	Eh	V	0.21
UA	G280	B	2016/02/10	Eh	V	0.39
UA	G280	B	2016/05/10	Eh	V	0.33
UA	G280	B	2016/08/03	Eh	V	0.29
UA	G280	B	2016/11/20	Eh	V	0.30
UA	G280	B	2017/02/15	Eh	V	0.26
UA	G280	B	2017/05/20	Eh	V	0.28
UA	G280	B	2017/07/18	Eh	V	0.28
UA	G280	B	2017/11/04	Eh	V	0.30
UA	G280	B	2018/05/16	Eh	V	0.28
UA	G280	B	2018/08/10	Eh	V	0.30
UA	G280	B	2019/01/22	Eh	V	0.30
UA	G280	B	2019/08/26	Eh	V	0.29
UA	G280	B	2020/01/23	Eh	V	0.39
UA	G280	B	2020/08/11	Eh	V	0.29
UA	G280	B	2020/10/14	Eh	V	0.39
UA	G280	B	2021/01/21	Eh	V	0.30
UA	G280	B	2021/01/28	Eh	V	0.30
UA	G280	B	2021/03/30	Eh	V	0.32
UA	G280	B	2021/04/22	Eh	V	0.30
UA	G280	B	2021/05/06	Eh	V	0.35
UA	G280	B	2021/05/19	Eh	V	0.28
UA	G280	B	2021/06/28	Eh	V	0.23
UA	G280	B	2021/07/13	Eh	V	0.27
UA	G280	B	2021/07/27	Eh	V	0.37
UA	G280	B	2021/08/18	Eh	V	0.26
UA	G280	B	2022/02/08	Eh	V	0.18
UA	G280	B	2022/05/10	Eh	V	0.22
UA	G280	B	2022/08/24	Eh	V	0.26
UA	G280	B	2022/11/09	Eh	V	0.40
UA	G280	B	2023/02/16	Eh	V	0.44
UA	G280	B	2023/06/08	Eh	V	0.39
UA	G280	B	2023/08/14	Eh	V	0.23
UA	G280	B	2023/11/20	Eh	V	0.30
UA	G280	B	2015/01/21	Alkalinity, bicarbonate	mg/L CaCO3	260
UA	G280	B	2015/04/13	Alkalinity, bicarbonate	mg/L CaCO3	250
UA	G280	B	2017/07/18	Alkalinity, bicarbonate	mg/L CaCO3	250
UA	G280	B	2020/01/23	Alkalinity, bicarbonate	mg/L CaCO3	260
UA	G280	B	2021/01/28	Alkalinity, bicarbonate	mg/L CaCO3	250
UA	G280	B	2021/03/30	Alkalinity, bicarbonate	mg/L CaCO3	220
UA	G280	B	2021/04/22	Alkalinity, bicarbonate	mg/L CaCO3	250
UA	G280	B	2021/05/06	Alkalinity, bicarbonate	mg/L CaCO3	240
UA	G280	B	2021/05/19	Alkalinity, bicarbonate	mg/L CaCO3	240
UA	G280	B	2021/06/16	Alkalinity, bicarbonate	mg/L CaCO3	260
UA	G280	B	2021/06/28	Alkalinity, bicarbonate	mg/L CaCO3	220
UA	G280	B	2021/07/13	Alkalinity, bicarbonate	mg/L CaCO3	250
UA	G280	B	2021/07/27	Alkalinity, bicarbonate	mg/L CaCO3	250
UA	G280	B	2022/02/08	Alkalinity, bicarbonate	mg/L CaCO3	220

UA	G280	B	2022/08/24	Alkalinity, bicarbonate	mg/L CaCO3	260
UA	G280	B	2023/02/16	Alkalinity, bicarbonate	mg/L CaCO3	250
UA	G280	B	2023/06/08	Alkalinity, bicarbonate	mg/L CaCO3	260
UA	G280	B	2023/08/14	Alkalinity, bicarbonate	mg/L CaCO3	262
UA	G280	B	2023/11/20	Alkalinity, bicarbonate	mg/L CaCO3	254
UA	G280	B	2022/08/24	Alkalinity, carbonate	mg/L CaCO3	10.0
UA	G280	B	2015/04/13	Barium, total	mg/L	0.0450
UA	G280	B	2015/07/23	Barium, total	mg/L	0.0490
UA	G280	B	2015/10/08	Barium, total	mg/L	0.0560
UA	G280	B	2015/11/24	Barium, total	mg/L	0.110
UA	G280	B	2016/02/10	Barium, total	mg/L	0.0450
UA	G280	B	2016/05/10	Barium, total	mg/L	0.0450
UA	G280	B	2016/08/03	Barium, total	mg/L	0.0450
UA	G280	B	2016/11/20	Barium, total	mg/L	0.0440
UA	G280	B	2017/02/15	Barium, total	mg/L	0.0520
UA	G280	B	2017/05/20	Barium, total	mg/L	0.0420
UA	G280	B	2017/07/18	Barium, total	mg/L	0.0410
UA	G280	B	2018/05/16	Barium, total	mg/L	0.0380
UA	G280	B	2018/08/10	Barium, total	mg/L	0.0380
UA	G280	B	2019/01/22	Barium, total	mg/L	0.0700
UA	G280	B	2019/08/26	Barium, total	mg/L	0.0450
UA	G280	B	2020/01/23	Barium, total	mg/L	0.0410
UA	G280	B	2020/08/11	Barium, total	mg/L	0.210
UA	G280	B	2020/10/14	Barium, total	mg/L	0.0440
UA	G280	B	2021/01/21	Barium, total	mg/L	0.0450
UA	G280	B	2021/01/28	Barium, total	mg/L	0.0430
UA	G280	B	2021/03/30	Barium, total	mg/L	0.0420
UA	G280	B	2021/04/22	Barium, total	mg/L	0.0400
UA	G280	B	2021/05/06	Barium, total	mg/L	0.0400
UA	G280	B	2021/05/19	Barium, total	mg/L	0.0380
UA	G280	B	2021/06/16	Barium, total	mg/L	0.0420
UA	G280	B	2021/06/28	Barium, total	mg/L	0.0430
UA	G280	B	2021/07/13	Barium, total	mg/L	0.0410
UA	G280	B	2021/07/27	Barium, total	mg/L	0.0420
UA	G280	B	2021/08/18	Barium, total	mg/L	0.0460
UA	G280	B	2021/10/26	Barium, total	mg/L	0.0380
UA	G280	B	2022/02/08	Barium, total	mg/L	0.0420
UA	G280	B	2022/05/10	Barium, total	mg/L	0.0400
UA	G280	B	2022/08/24	Barium, total	mg/L	0.0450
UA	G280	B	2022/11/09	Barium, total	mg/L	0.0440
UA	G280	B	2023/02/16	Barium, total	mg/L	0.0420
UA	G280	B	2023/06/08	Barium, total	mg/L	0.0490
UA	G280	B	2023/08/14	Barium, total	mg/L	0.0531
UA	G280	B	2023/11/20	Barium, total	mg/L	0.0611
UA	G280	B	2015/01/21	Boron, total	mg/L	<0.01
UA	G280	B	2015/04/13	Boron, total	mg/L	<0.01
UA	G280	B	2015/07/23	Boron, total	mg/L	<0.01
UA	G280	B	2015/10/08	Boron, total	mg/L	0.0240
UA	G280	B	2015/11/24	Boron, total	mg/L	0.0290
UA	G280	B	2016/02/10	Boron, total	mg/L	<0.0023
UA	G280	B	2016/05/10	Boron, total	mg/L	<0.0023
UA	G280	B	2016/08/03	Boron, total	mg/L	<0.0023
UA	G280	B	2016/11/20	Boron, total	mg/L	<0.0023
UA	G280	B	2017/02/15	Boron, total	mg/L	<0.0023
UA	G280	B	2017/05/20	Boron, total	mg/L	<0.0023
UA	G280	B	2017/07/18	Boron, total	mg/L	<0.0023
UA	G280	B	2017/11/04	Boron, total	mg/L	0.0130
UA	G280	B	2018/05/16	Boron, total	mg/L	<0.0034
UA	G280	B	2018/08/10	Boron, total	mg/L	<0.0034
UA	G280	B	2019/01/22	Boron, total	mg/L	0.0260
UA	G280	B	2019/08/26	Boron, total	mg/L	0.0110
UA	G280	B	2020/01/23	Boron, total	mg/L	0.0150
UA	G280	B	2020/08/11	Boron, total	mg/L	0.520

UA	G280	B	2020/10/14	Boron, total	mg/L	0.0250
UA	G280	B	2021/01/21	Boron, total	mg/L	0.0120
UA	G280	B	2021/01/28	Boron, total	mg/L	<0.008
UA	G280	B	2021/03/30	Boron, total	mg/L	0.0150
UA	G280	B	2021/04/22	Boron, total	mg/L	0.0150
UA	G280	B	2021/05/06	Boron, total	mg/L	0.0570
UA	G280	B	2021/05/19	Boron, total	mg/L	<0.008
UA	G280	B	2021/06/16	Boron, total	mg/L	<0.0046
UA	G280	B	2021/06/28	Boron, total	mg/L	1.00
UA	G280	B	2021/07/13	Boron, total	mg/L	0.0500
UA	G280	B	2021/07/27	Boron, total	mg/L	<0.008
UA	G280	B	2021/08/18	Boron, total	mg/L	0.0280
UA	G280	B	2021/10/26	Boron, total	mg/L	0.0250
UA	G280	B	2022/02/08	Boron, total	mg/L	<0.0046
UA	G280	B	2022/05/10	Boron, total	mg/L	<0.0071
UA	G280	B	2022/08/24	Boron, total	mg/L	0.0230
UA	G280	B	2022/11/09	Boron, total	mg/L	0.0210
UA	G280	B	2023/02/16	Boron, total	mg/L	0.0290
UA	G280	B	2023/06/08	Boron, total	mg/L	0.0200
UA	G280	B	2023/08/14	Boron, total	mg/L	<0.0092
UA	G280	B	2023/11/20	Boron, total	mg/L	0.0100
UA	G280	B	2015/01/21	Calcium, total	mg/L	74.0
UA	G280	B	2015/04/13	Calcium, total	mg/L	71.0
UA	G280	B	2015/11/24	Calcium, total	mg/L	120
UA	G280	B	2016/02/10	Calcium, total	mg/L	60.0
UA	G280	B	2016/05/10	Calcium, total	mg/L	63.0
UA	G280	B	2016/08/03	Calcium, total	mg/L	65.0
UA	G280	B	2016/11/20	Calcium, total	mg/L	63.0
UA	G280	B	2017/02/15	Calcium, total	mg/L	64.0
UA	G280	B	2017/05/20	Calcium, total	mg/L	54.0
UA	G280	B	2017/07/18	Calcium, total	mg/L	67.0
UA	G280	B	2017/11/04	Calcium, total	mg/L	63.0
UA	G280	B	2018/05/16	Calcium, total	mg/L	57.0
UA	G280	B	2018/08/10	Calcium, total	mg/L	62.0
UA	G280	B	2019/01/22	Calcium, total	mg/L	82.0
UA	G280	B	2019/08/26	Calcium, total	mg/L	72.0
UA	G280	B	2020/01/23	Calcium, total	mg/L	73.0
UA	G280	B	2020/08/11	Calcium, total	mg/L	220
UA	G280	B	2020/10/14	Calcium, total	mg/L	78.0
UA	G280	B	2021/01/21	Calcium, total	mg/L	77.0
UA	G280	B	2021/01/28	Calcium, total	mg/L	73.0
UA	G280	B	2021/03/30	Calcium, total	mg/L	62.0
UA	G280	B	2021/04/22	Calcium, total	mg/L	63.0
UA	G280	B	2021/05/06	Calcium, total	mg/L	64.0
UA	G280	B	2021/05/19	Calcium, total	mg/L	64.0
UA	G280	B	2021/06/16	Calcium, total	mg/L	73.0
UA	G280	B	2021/06/28	Calcium, total	mg/L	72.0
UA	G280	B	2021/07/13	Calcium, total	mg/L	70.0
UA	G280	B	2021/07/27	Calcium, total	mg/L	74.0
UA	G280	B	2021/08/18	Calcium, total	mg/L	69.0
UA	G280	B	2021/10/26	Calcium, total	mg/L	65.0
UA	G280	B	2022/02/08	Calcium, total	mg/L	68.0
UA	G280	B	2022/05/10	Calcium, total	mg/L	69.0
UA	G280	B	2022/08/24	Calcium, total	mg/L	80.0
UA	G280	B	2022/11/09	Calcium, total	mg/L	70.0
UA	G280	B	2023/02/16	Calcium, total	mg/L	72.0
UA	G280	B	2023/06/08	Calcium, total	mg/L	79.0
UA	G280	B	2023/08/14	Calcium, total	mg/L	79.5
UA	G280	B	2023/11/20	Calcium, total	mg/L	91.5
UA	G280	B	2015/01/21	Chloride, total	mg/L	62.0
UA	G280	B	2015/04/13	Chloride, total	mg/L	67.0
UA	G280	B	2015/07/23	Chloride, total	mg/L	53.0
UA	G280	B	2015/10/08	Chloride, total	mg/L	54.0

UA	G280	B	2015/11/24	Chloride, total	mg/L	54.0
UA	G280	B	2016/02/10	Chloride, total	mg/L	52.0
UA	G280	B	2016/05/10	Chloride, total	mg/L	50.0
UA	G280	B	2016/08/03	Chloride, total	mg/L	46.0
UA	G280	B	2016/11/20	Chloride, total	mg/L	49.0
UA	G280	B	2017/02/15	Chloride, total	mg/L	46.0
UA	G280	B	2017/05/20	Chloride, total	mg/L	44.0
UA	G280	B	2017/07/18	Chloride, total	mg/L	46.0
UA	G280	B	2017/11/04	Chloride, total	mg/L	48.0
UA	G280	B	2018/05/16	Chloride, total	mg/L	43.0
UA	G280	B	2018/08/10	Chloride, total	mg/L	55.0
UA	G280	B	2019/01/22	Chloride, total	mg/L	52.0
UA	G280	B	2019/08/26	Chloride, total	mg/L	60.0
UA	G280	B	2020/01/23	Chloride, total	mg/L	64.0
UA	G280	B	2020/08/11	Chloride, total	mg/L	68.0
UA	G280	B	2020/10/14	Chloride, total	mg/L	67.0
UA	G280	B	2021/01/21	Chloride, total	mg/L	33.0
UA	G280	B	2021/01/28	Chloride, total	mg/L	64.0
UA	G280	B	2021/03/30	Chloride, total	mg/L	49.0
UA	G280	B	2021/04/22	Chloride, total	mg/L	55.0
UA	G280	B	2021/05/06	Chloride, total	mg/L	43.0
UA	G280	B	2021/05/19	Chloride, total	mg/L	46.0
UA	G280	B	2021/06/16	Chloride, total	mg/L	67.0
UA	G280	B	2021/06/28	Chloride, total	mg/L	65.0
UA	G280	B	2021/07/13	Chloride, total	mg/L	65.0
UA	G280	B	2021/07/27	Chloride, total	mg/L	63.0
UA	G280	B	2021/08/18	Chloride, total	mg/L	59.0
UA	G280	B	2021/10/26	Chloride, total	mg/L	58.0
UA	G280	B	2022/02/08	Chloride, total	mg/L	51.0
UA	G280	B	2022/05/10	Chloride, total	mg/L	58.0
UA	G280	B	2022/08/24	Chloride, total	mg/L	93.0
UA	G280	B	2022/11/09	Chloride, total	mg/L	710
UA	G280	B	2023/02/16	Chloride, total	mg/L	63.0
UA	G280	B	2023/06/08	Chloride, total	mg/L	71.0
UA	G280	B	2023/08/14	Chloride, total	mg/L	70.0
UA	G280	B	2023/11/20	Chloride, total	mg/L	70.0
UA	G280	B	2015/04/13	Cobalt, total	mg/L	<0.002
UA	G280	B	2015/07/23	Cobalt, total	mg/L	<0.002
UA	G280	B	2015/10/08	Cobalt, total	mg/L	<0.002
UA	G280	B	2015/11/24	Cobalt, total	mg/L	0.00590
UA	G280	B	2016/02/10	Cobalt, total	mg/L	<0.000017
UA	G280	B	2016/05/10	Cobalt, total	mg/L	<0.000017
UA	G280	B	2016/08/03	Cobalt, total	mg/L	<0.000017
UA	G280	B	2016/11/20	Cobalt, total	mg/L	<0.000017
UA	G280	B	2017/02/15	Cobalt, total	mg/L	<0.000017
UA	G280	B	2017/05/20	Cobalt, total	mg/L	<0.000017
UA	G280	B	2017/07/18	Cobalt, total	mg/L	<0.000017
UA	G280	B	2018/05/16	Cobalt, total	mg/L	<0.00067
UA	G280	B	2019/01/22	Cobalt, total	mg/L	0.00330
UA	G280	B	2019/08/26	Cobalt, total	mg/L	<0.00067
UA	G280	B	2020/01/23	Cobalt, total	mg/L	<0.00067
UA	G280	B	2020/08/11	Cobalt, total	mg/L	0.00600
UA	G280	B	2020/10/14	Cobalt, total	mg/L	<0.002
UA	G280	B	2021/01/21	Cobalt, total	mg/L	<0.002
UA	G280	B	2021/01/28	Cobalt, total	mg/L	<0.00022
UA	G280	B	2021/03/30	Cobalt, total	mg/L	<0.00022
UA	G280	B	2021/04/22	Cobalt, total	mg/L	<0.00022
UA	G280	B	2021/05/06	Cobalt, total	mg/L	<0.00022
UA	G280	B	2021/05/19	Cobalt, total	mg/L	<0.00022
UA	G280	B	2021/06/16	Cobalt, total	mg/L	<0.00022
UA	G280	B	2021/06/28	Cobalt, total	mg/L	<0.00019
UA	G280	B	2021/07/13	Cobalt, total	mg/L	<0.00022
UA	G280	B	2021/07/27	Cobalt, total	mg/L	<0.00022

UA	G280	B	2021/08/18	Cobalt, total	mg/L	<0.00022
UA	G280	B	2021/10/26	Cobalt, total	mg/L	<0.002
UA	G280	B	2022/02/08	Cobalt, total	mg/L	<0.00019
UA	G280	B	2022/05/10	Cobalt, total	mg/L	<0.00048
UA	G280	B	2022/08/24	Cobalt, total	mg/L	<0.00048
UA	G280	B	2022/11/09	Cobalt, total	mg/L	<0.00048
UA	G280	B	2023/02/16	Cobalt, total	mg/L	<0.00048
UA	G280	B	2023/06/08	Cobalt, total	mg/L	<0.00048
UA	G280	B	2023/08/14	Cobalt, total	mg/L	0.000300
UA	G280	B	2023/11/20	Cobalt, total	mg/L	0.000200
UA	G280	B	2023/06/08	Ferrous Iron, dissolved	mg/L	<0.02
UA	G280	B	2015/01/21	Iron, dissolved	mg/L	0.0180
UA	G280	B	2015/04/13	Iron, dissolved	mg/L	0.270
UA	G280	B	2015/07/23	Iron, dissolved	mg/L	<0.01
UA	G280	B	2015/10/08	Iron, dissolved	mg/L	0.0120
UA	G280	B	2016/02/10	Iron, dissolved	mg/L	0.0200
UA	G280	B	2016/05/13	Iron, dissolved	mg/L	<0.01
UA	G280	B	2016/08/03	Iron, dissolved	mg/L	0.0160
UA	G280	B	2016/11/22	Iron, dissolved	mg/L	0.0520
UA	G280	B	2017/02/14	Iron, dissolved	mg/L	0.0110
UA	G280	B	2017/05/19	Iron, dissolved	mg/L	<0.01
UA	G280	B	2017/07/25	Iron, dissolved	mg/L	0.0120
UA	G280	B	2017/11/04	Iron, dissolved	mg/L	0.400
UA	G280	B	2018/01/30	Iron, dissolved	mg/L	0.130
UA	G280	B	2018/05/16	Iron, dissolved	mg/L	<0.01
UA	G280	B	2018/08/10	Iron, dissolved	mg/L	0.0120
UA	G280	B	2018/11/06	Iron, dissolved	mg/L	<0.01
UA	G280	B	2019/01/22	Iron, dissolved	mg/L	0.0530
UA	G280	B	2019/05/01	Iron, dissolved	mg/L	<0.01
UA	G280	B	2019/08/26	Iron, dissolved	mg/L	<0.01
UA	G280	B	2019/10/22	Iron, dissolved	mg/L	<0.01
UA	G280	B	2020/01/23	Iron, dissolved	mg/L	0.0110
UA	G280	B	2020/05/07	Iron, dissolved	mg/L	<0.01
UA	G280	B	2020/10/14	Iron, dissolved	mg/L	<0.01
UA	G280	B	2021/01/21	Iron, dissolved	mg/L	<0.01
UA	G280	B	2021/01/28	Iron, dissolved	mg/L	<0.01
UA	G280	B	2021/04/22	Iron, dissolved	mg/L	<0.01
UA	G280	B	2021/08/18	Iron, dissolved	mg/L	<0.01
UA	G280	B	2021/10/26	Iron, dissolved	mg/L	0.0180
UA	G280	B	2022/02/08	Iron, dissolved	mg/L	<0.01
UA	G280	B	2022/05/10	Iron, dissolved	mg/L	<0.00072
UA	G280	B	2022/08/24	Iron, dissolved	mg/L	0.0180
UA	G280	B	2022/11/09	Iron, dissolved	mg/L	0.00780
UA	G280	B	2023/02/16	Iron, dissolved	mg/L	0.00470
UA	G280	B	2023/06/08	Iron, dissolved	mg/L	0.00610
UA	G280	B	2023/08/14	Iron, dissolved	mg/L	<0.0175
UA	G280	B	2023/11/20	Iron, dissolved	mg/L	<0.0115
UA	G280	B	2015/04/13	Magnesium, total	mg/L	36.0
UA	G280	B	2017/07/18	Magnesium, total	mg/L	31.0
UA	G280	B	2020/01/23	Magnesium, total	mg/L	36.0
UA	G280	B	2021/01/28	Magnesium, total	mg/L	37.0
UA	G280	B	2021/03/30	Magnesium, total	mg/L	32.0
UA	G280	B	2021/04/22	Magnesium, total	mg/L	33.0
UA	G280	B	2021/05/06	Magnesium, total	mg/L	31.0
UA	G280	B	2021/05/19	Magnesium, total	mg/L	33.0
UA	G280	B	2021/06/16	Magnesium, total	mg/L	36.0
UA	G280	B	2021/06/28	Magnesium, total	mg/L	38.0
UA	G280	B	2021/07/13	Magnesium, total	mg/L	37.0
UA	G280	B	2021/07/27	Magnesium, total	mg/L	36.0
UA	G280	B	2022/02/08	Magnesium, total	mg/L	30.0
UA	G280	B	2022/08/24	Magnesium, total	mg/L	41.0
UA	G280	B	2023/06/08	Magnesium, total	mg/L	38.0
UA	G280	B	2023/08/14	Magnesium, total	mg/L	36.6

UA	G280	B	2023/11/20	Magnesium, total	mg/L	42.7
UA	G280	B	2015/01/21	Manganese, dissolved	mg/L	<0.001
UA	G280	B	2015/04/13	Manganese, dissolved	mg/L	0.0260
UA	G280	B	2015/07/23	Manganese, dissolved	mg/L	0.0740
UA	G280	B	2015/10/08	Manganese, dissolved	mg/L	0.00350
UA	G280	B	2016/02/10	Manganese, dissolved	mg/L	<0.001
UA	G280	B	2016/05/13	Manganese, dissolved	mg/L	<0.001
UA	G280	B	2016/08/03	Manganese, dissolved	mg/L	0.00760
UA	G280	B	2016/11/22	Manganese, dissolved	mg/L	0.0690
UA	G280	B	2017/02/14	Manganese, dissolved	mg/L	<0.001
UA	G280	B	2017/05/19	Manganese, dissolved	mg/L	0.00460
UA	G280	B	2017/07/25	Manganese, dissolved	mg/L	0.00230
UA	G280	B	2017/11/04	Manganese, dissolved	mg/L	0.0590
UA	G280	B	2018/01/30	Manganese, dissolved	mg/L	0.00670
UA	G280	B	2018/03/01	Manganese, dissolved	mg/L	<0.001
UA	G280	B	2018/05/16	Manganese, dissolved	mg/L	<0.001
UA	G280	B	2019/05/01	Manganese, dissolved	mg/L	<0.001
UA	G280	B	2019/08/26	Manganese, dissolved	mg/L	0.00190
UA	G280	B	2020/01/23	Manganese, dissolved	mg/L	<0.001
UA	G280	B	2020/05/07	Manganese, dissolved	mg/L	<0.001
UA	G280	B	2020/10/14	Manganese, dissolved	mg/L	0.00360
UA	G280	B	2021/01/21	Manganese, dissolved	mg/L	<0.001
UA	G280	B	2021/01/28	Manganese, dissolved	mg/L	<0.001
UA	G280	B	2021/04/22	Manganese, dissolved	mg/L	<0.001
UA	G280	B	2021/08/18	Manganese, dissolved	mg/L	<0.001
UA	G280	B	2021/10/26	Manganese, dissolved	mg/L	0.00180
UA	G280	B	2022/02/08	Manganese, dissolved	mg/L	0.00120
UA	G280	B	2022/05/10	Manganese, dissolved	mg/L	<0.00023
UA	G280	B	2022/08/24	Manganese, dissolved	mg/L	0.00100
UA	G280	B	2022/11/09	Manganese, dissolved	mg/L	0.00550
UA	G280	B	2023/02/16	Manganese, dissolved	mg/L	0.00200
UA	G280	B	2023/06/08	Manganese, dissolved	mg/L	0.00140
UA	G280	B	2023/08/14	Manganese, dissolved	mg/L	0.00320
UA	G280	B	2023/11/20	Manganese, dissolved	mg/L	0.0123
UA	G280	B	2023/08/14	Phosphate, dissolved	mg/L	0.0370
UA	G280	B	2015/04/13	Potassium, total	mg/L	0.580
UA	G280	B	2017/07/18	Potassium, total	mg/L	0.580
UA	G280	B	2020/01/23	Potassium, total	mg/L	0.440
UA	G280	B	2021/01/28	Potassium, total	mg/L	0.540
UA	G280	B	2021/03/30	Potassium, total	mg/L	0.570
UA	G280	B	2021/04/22	Potassium, total	mg/L	0.470
UA	G280	B	2021/05/06	Potassium, total	mg/L	0.470
UA	G280	B	2021/05/19	Potassium, total	mg/L	0.350
UA	G280	B	2021/06/16	Potassium, total	mg/L	0.340
UA	G280	B	2021/06/28	Potassium, total	mg/L	0.460
UA	G280	B	2021/07/13	Potassium, total	mg/L	0.330
UA	G280	B	2021/07/27	Potassium, total	mg/L	0.360
UA	G280	B	2022/02/08	Potassium, total	mg/L	6.70
UA	G280	B	2022/08/24	Potassium, total	mg/L	0.420
UA	G280	B	2023/02/16	Potassium, total	mg/L	0.520
UA	G280	B	2023/06/08	Potassium, total	mg/L	0.580
UA	G280	B	2023/08/14	Potassium, total	mg/L	0.539
UA	G280	B	2023/11/20	Potassium, total	mg/L	0.644
UA	G280	B	2023/06/08	Silicon, dissolved	mg/L	8.20
UA	G280	B	2023/08/14	Silicon, dissolved	mg/L	7.33
UA	G280	B	2015/04/13	Sodium, total	mg/L	65.0
UA	G280	B	2017/07/18	Sodium, total	mg/L	49.0
UA	G280	B	2020/01/23	Sodium, total	mg/L	60.0
UA	G280	B	2021/01/28	Sodium, total	mg/L	60.0
UA	G280	B	2021/03/30	Sodium, total	mg/L	61.0
UA	G280	B	2021/04/22	Sodium, total	mg/L	60.0
UA	G280	B	2021/05/06	Sodium, total	mg/L	60.0
UA	G280	B	2021/05/19	Sodium, total	mg/L	61.0

UA	G280	B	2021/06/16	Sodium, total	mg/L	50.0
UA	G280	B	2021/06/28	Sodium, total	mg/L	53.0
UA	G280	B	2021/07/13	Sodium, total	mg/L	54.0
UA	G280	B	2021/07/27	Sodium, total	mg/L	52.0
UA	G280	B	2022/02/08	Sodium, total	mg/L	53.0
UA	G280	B	2022/08/24	Sodium, total	mg/L	62.0
UA	G280	B	2023/02/16	Sodium, total	mg/L	61.0
UA	G280	B	2023/06/08	Sodium, total	mg/L	56.0
UA	G280	B	2023/08/14	Sodium, total	mg/L	58.5
UA	G280	B	2023/11/20	Sodium, total	mg/L	60.7
UA	G280	B	2015/01/21	Sulfate, total	mg/L	87.0
UA	G280	B	2015/04/13	Sulfate, total	mg/L	86.0
UA	G280	B	2015/07/23	Sulfate, total	mg/L	74.0
UA	G280	B	2015/10/08	Sulfate, total	mg/L	92.0
UA	G280	B	2015/11/24	Sulfate, total	mg/L	94.0
UA	G280	B	2016/02/10	Sulfate, total	mg/L	84.0
UA	G280	B	2016/05/10	Sulfate, total	mg/L	80.0
UA	G280	B	2016/08/03	Sulfate, total	mg/L	55.0
UA	G280	B	2016/11/20	Sulfate, total	mg/L	67.0
UA	G280	B	2017/02/15	Sulfate, total	mg/L	94.0
UA	G280	B	2017/05/20	Sulfate, total	mg/L	84.0
UA	G280	B	2017/07/18	Sulfate, total	mg/L	58.0
UA	G280	B	2017/11/04	Sulfate, total	mg/L	57.0
UA	G280	B	2018/05/16	Sulfate, total	mg/L	52.0
UA	G280	B	2018/08/10	Sulfate, total	mg/L	63.0
UA	G280	B	2019/01/22	Sulfate, total	mg/L	69.0
UA	G280	B	2019/08/26	Sulfate, total	mg/L	81.0
UA	G280	B	2020/01/23	Sulfate, total	mg/L	84.0
UA	G280	B	2020/08/11	Sulfate, total	mg/L	86.0
UA	G280	B	2020/10/14	Sulfate, total	mg/L	84.0
UA	G280	B	2021/01/21	Sulfate, total	mg/L	43.0
UA	G280	B	2021/01/28	Sulfate, total	mg/L	86.0
UA	G280	B	2021/03/30	Sulfate, total	mg/L	84.0
UA	G280	B	2021/04/22	Sulfate, total	mg/L	89.0
UA	G280	B	2021/05/06	Sulfate, total	mg/L	92.0
UA	G280	B	2021/05/19	Sulfate, total	mg/L	81.0
UA	G280	B	2021/06/16	Sulfate, total	mg/L	82.0
UA	G280	B	2021/06/28	Sulfate, total	mg/L	79.0
UA	G280	B	2021/07/13	Sulfate, total	mg/L	81.0
UA	G280	B	2021/07/27	Sulfate, total	mg/L	77.0
UA	G280	B	2021/08/18	Sulfate, total	mg/L	74.0
UA	G280	B	2021/10/26	Sulfate, total	mg/L	74.0
UA	G280	B	2022/02/08	Sulfate, total	mg/L	82.0
UA	G280	B	2022/05/10	Sulfate, total	mg/L	79.0
UA	G280	B	2022/08/24	Sulfate, total	mg/L	82.0
UA	G280	B	2022/11/09	Sulfate, total	mg/L	910
UA	G280	B	2023/02/16	Sulfate, total	mg/L	81.0
UA	G280	B	2023/06/08	Sulfate, total	mg/L	91.0
UA	G280	B	2023/08/14	Sulfate, total	mg/L	91.0
UA	G280	B	2023/11/20	Sulfate, total	mg/L	113
UA	G280	B	2015/11/24	Temperature (Celsius)	degrees C	16.0
UA	G280	B	2016/02/10	Temperature (Celsius)	degrees C	8.20
UA	G280	B	2016/05/10	Temperature (Celsius)	degrees C	16.0
UA	G280	B	2016/08/03	Temperature (Celsius)	degrees C	17.7
UA	G280	B	2016/11/20	Temperature (Celsius)	degrees C	14.7
UA	G280	B	2017/02/15	Temperature (Celsius)	degrees C	15.5
UA	G280	B	2017/05/20	Temperature (Celsius)	degrees C	14.9
UA	G280	B	2017/07/18	Temperature (Celsius)	degrees C	22.4
UA	G280	B	2017/11/04	Temperature (Celsius)	degrees C	13.5
UA	G280	B	2018/05/16	Temperature (Celsius)	degrees C	14.9
UA	G280	B	2018/08/10	Temperature (Celsius)	degrees C	15.9
UA	G280	B	2019/01/22	Temperature (Celsius)	degrees C	11.6
UA	G280	B	2019/08/26	Temperature (Celsius)	degrees C	17.0

UA	G280	B	2020/01/23	Temperature (Celsius)	degrees C	10.4
UA	G280	B	2020/08/11	Temperature (Celsius)	degrees C	19.0
UA	G280	B	2020/10/14	Temperature (Celsius)	degrees C	16.5
UA	G280	B	2021/01/21	Temperature (Celsius)	degrees C	12.1
UA	G280	B	2021/01/28	Temperature (Celsius)	degrees C	12.1
UA	G280	B	2021/03/30	Temperature (Celsius)	degrees C	13.4
UA	G280	B	2021/04/22	Temperature (Celsius)	degrees C	13.1
UA	G280	B	2021/05/06	Temperature (Celsius)	degrees C	12.9
UA	G280	B	2021/05/19	Temperature (Celsius)	degrees C	15.0
UA	G280	B	2021/06/28	Temperature (Celsius)	degrees C	20.9
UA	G280	B	2021/07/13	Temperature (Celsius)	degrees C	18.1
UA	G280	B	2021/07/27	Temperature (Celsius)	degrees C	20.2
UA	G280	B	2021/08/18	Temperature (Celsius)	degrees C	19.8
UA	G280	B	2022/02/08	Temperature (Celsius)	degrees C	9.90
UA	G280	B	2022/05/10	Temperature (Celsius)	degrees C	17.8
UA	G280	B	2022/08/24	Temperature (Celsius)	degrees C	19.1
UA	G280	B	2022/11/09	Temperature (Celsius)	degrees C	16.4
UA	G280	B	2023/02/16	Temperature (Celsius)	degrees C	9.90
UA	G280	B	2023/06/08	Temperature (Celsius)	degrees C	15.4
UA	G280	B	2023/08/14	Temperature (Celsius)	degrees C	15.5
UA	G280	B	2023/11/20	Temperature (Celsius)	degrees C	14.7
UA	G280	B	2015/01/21	Total Dissolved Solids	mg/L	540
UA	G280	B	2015/04/13	Total Dissolved Solids	mg/L	480
UA	G280	B	2015/07/23	Total Dissolved Solids	mg/L	480
UA	G280	B	2015/10/08	Total Dissolved Solids	mg/L	450
UA	G280	B	2015/11/24	Total Dissolved Solids	mg/L	460
UA	G280	B	2016/02/10	Total Dissolved Solids	mg/L	400
UA	G280	B	2016/05/10	Total Dissolved Solids	mg/L	350
UA	G280	B	2016/08/03	Total Dissolved Solids	mg/L	350
UA	G280	B	2016/11/20	Total Dissolved Solids	mg/L	430
UA	G280	B	2017/02/15	Total Dissolved Solids	mg/L	440
UA	G280	B	2017/05/20	Total Dissolved Solids	mg/L	420
UA	G280	B	2017/07/18	Total Dissolved Solids	mg/L	400
UA	G280	B	2017/11/04	Total Dissolved Solids	mg/L	350
UA	G280	B	2018/05/16	Total Dissolved Solids	mg/L	360
UA	G280	B	2018/08/10	Total Dissolved Solids	mg/L	400
UA	G280	B	2019/01/22	Total Dissolved Solids	mg/L	500
UA	G280	B	2019/08/26	Total Dissolved Solids	mg/L	480
UA	G280	B	2020/01/23	Total Dissolved Solids	mg/L	1,100
UA	G280	B	2020/08/11	Total Dissolved Solids	mg/L	440
UA	G280	B	2020/10/14	Total Dissolved Solids	mg/L	490
UA	G280	B	2021/01/21	Total Dissolved Solids	mg/L	490
UA	G280	B	2021/01/28	Total Dissolved Solids	mg/L	430
UA	G280	B	2021/03/30	Total Dissolved Solids	mg/L	460
UA	G280	B	2021/04/22	Total Dissolved Solids	mg/L	470
UA	G280	B	2021/05/06	Total Dissolved Solids	mg/L	440
UA	G280	B	2021/05/19	Total Dissolved Solids	mg/L	400
UA	G280	B	2021/06/16	Total Dissolved Solids	mg/L	530
UA	G280	B	2021/06/28	Total Dissolved Solids	mg/L	420
UA	G280	B	2021/07/13	Total Dissolved Solids	mg/L	510
UA	G280	B	2021/07/27	Total Dissolved Solids	mg/L	470
UA	G280	B	2021/08/18	Total Dissolved Solids	mg/L	460
UA	G280	B	2021/10/26	Total Dissolved Solids	mg/L	400
UA	G280	B	2022/02/08	Total Dissolved Solids	mg/L	440
UA	G280	B	2022/05/10	Total Dissolved Solids	mg/L	450
UA	G280	B	2022/08/24	Total Dissolved Solids	mg/L	580
UA	G280	B	2022/11/09	Total Dissolved Solids	mg/L	500
UA	G280	B	2023/02/16	Total Dissolved Solids	mg/L	470
UA	G280	B	2023/06/08	Total Dissolved Solids	mg/L	590
UA	G280	B	2023/08/14	Total Dissolved Solids	mg/L	594
UA	G280	B	2023/11/20	Total Dissolved Solids	mg/L	608
UA	G281	B	2015/11/20	pH (field)	SU	7.0
UA	G281	B	2016/02/11	pH (field)	SU	7.1

UA	G281	B	2016/05/10	pH (field)	SU	7.0
UA	G281	B	2016/08/01	pH (field)	SU	7.0
UA	G281	B	2016/11/16	pH (field)	SU	6.9
UA	G281	B	2017/02/10	pH (field)	SU	6.7
UA	G281	B	2017/05/16	pH (field)	SU	6.9
UA	G281	B	2017/07/12	pH (field)	SU	7.0
UA	G281	B	2017/10/25	pH (field)	SU	7.0
UA	G281	B	2018/05/11	pH (field)	SU	7.1
UA	G281	B	2018/08/03	pH (field)	SU	7.0
UA	G281	B	2019/01/23	pH (field)	SU	7.0
UA	G281	B	2019/08/13	pH (field)	SU	6.9
UA	G281	B	2020/01/24	pH (field)	SU	7.3
UA	G281	B	2020/08/12	pH (field)	SU	6.9
UA	G281	B	2020/10/14	pH (field)	SU	7.0
UA	G281	B	2021/01/29	pH (field)	SU	7.1
UA	G281	B	2021/03/31	pH (field)	SU	7.0
UA	G281	B	2021/04/21	pH (field)	SU	6.9
UA	G281	B	2021/05/05	pH (field)	SU	7.1
UA	G281	B	2021/05/17	pH (field)	SU	7.1
UA	G281	B	2021/06/14	pH (field)	SU	7.1
UA	G281	B	2021/06/28	pH (field)	SU	7.2
UA	G281	B	2021/07/12	pH (field)	SU	7.2
UA	G281	B	2021/07/27	pH (field)	SU	7.1
UA	G281	B	2021/08/17	pH (field)	SU	7.1
UA	G281	B	2021/10/26	pH (field)	SU	7.0
UA	G281	B	2022/02/08	pH (field)	SU	7.0
UA	G281	B	2022/05/10	pH (field)	SU	6.9
UA	G281	B	2022/08/25	pH (field)	SU	6.8
UA	G281	B	2022/11/08	pH (field)	SU	6.8
UA	G281	B	2023/02/16	pH (field)	SU	7.2
UA	G281	B	2023/06/08	pH (field)	SU	6.8
UA	G281	B	2023/08/14	pH (field)	SU	6.8
UA	G281	B	2023/11/20	pH (field)	SU	6.9
UA	G281	B	2015/11/20	Oxidation Reduction Potential	mV	-18.0
UA	G281	B	2016/02/11	Oxidation Reduction Potential	mV	171
UA	G281	B	2016/05/10	Oxidation Reduction Potential	mV	40.0
UA	G281	B	2016/08/01	Oxidation Reduction Potential	mV	56.0
UA	G281	B	2016/11/16	Oxidation Reduction Potential	mV	58.0
UA	G281	B	2017/02/10	Oxidation Reduction Potential	mV	65.0
UA	G281	B	2017/05/16	Oxidation Reduction Potential	mV	63.0
UA	G281	B	2017/07/12	Oxidation Reduction Potential	mV	62.0
UA	G281	B	2017/10/25	Oxidation Reduction Potential	mV	75.0
UA	G281	B	2018/05/11	Oxidation Reduction Potential	mV	45.0
UA	G281	B	2018/08/03	Oxidation Reduction Potential	mV	62.0
UA	G281	B	2019/01/23	Oxidation Reduction Potential	mV	65.0
UA	G281	B	2019/08/13	Oxidation Reduction Potential	mV	65.0
UA	G281	B	2020/01/24	Oxidation Reduction Potential	mV	151
UA	G281	B	2020/08/12	Oxidation Reduction Potential	mV	129
UA	G281	B	2020/10/14	Oxidation Reduction Potential	mV	87.1
UA	G281	B	2021/01/29	Oxidation Reduction Potential	mV	110
UA	G281	B	2021/03/31	Oxidation Reduction Potential	mV	257
UA	G281	B	2021/04/21	Oxidation Reduction Potential	mV	41.7
UA	G281	B	2021/05/05	Oxidation Reduction Potential	mV	189
UA	G281	B	2021/05/17	Oxidation Reduction Potential	mV	181
UA	G281	B	2021/06/14	Oxidation Reduction Potential	mV	54.1
UA	G281	B	2021/06/28	Oxidation Reduction Potential	mV	26.1
UA	G281	B	2021/07/12	Oxidation Reduction Potential	mV	210
UA	G281	B	2021/07/27	Oxidation Reduction Potential	mV	72.7
UA	G281	B	2021/08/17	Oxidation Reduction Potential	mV	105
UA	G281	B	2021/10/26	Oxidation Reduction Potential	mV	24.5
UA	G281	B	2022/02/08	Oxidation Reduction Potential	mV	102
UA	G281	B	2022/05/10	Oxidation Reduction Potential	mV	41.0
UA	G281	B	2022/08/25	Oxidation Reduction Potential	mV	4.00

UA	G281	B	2022/11/08	Oxidation Reduction Potential	mV	57.6
UA	G281	B	2023/02/16	Oxidation Reduction Potential	mV	64.4
UA	G281	B	2023/06/08	Oxidation Reduction Potential	mV	11.0
UA	G281	B	2023/08/14	Oxidation Reduction Potential	mV	102
UA	G281	B	2023/11/20	Oxidation Reduction Potential	mV	112
UA	G281	B	2015/11/20	Eh	V	0.18
UA	G281	B	2016/02/11	Eh	V	0.37
UA	G281	B	2016/05/10	Eh	V	0.24
UA	G281	B	2016/08/01	Eh	V	0.25
UA	G281	B	2016/11/16	Eh	V	0.25
UA	G281	B	2017/02/10	Eh	V	0.26
UA	G281	B	2017/05/16	Eh	V	0.26
UA	G281	B	2017/07/12	Eh	V	0.26
UA	G281	B	2017/10/25	Eh	V	0.27
UA	G281	B	2018/05/11	Eh	V	0.24
UA	G281	B	2018/08/03	Eh	V	0.26
UA	G281	B	2019/01/23	Eh	V	0.26
UA	G281	B	2019/08/13	Eh	V	0.26
UA	G281	B	2020/01/24	Eh	V	0.35
UA	G281	B	2020/08/12	Eh	V	0.32
UA	G281	B	2020/10/14	Eh	V	0.28
UA	G281	B	2021/01/29	Eh	V	0.31
UA	G281	B	2021/03/31	Eh	V	0.46
UA	G281	B	2021/04/21	Eh	V	0.24
UA	G281	B	2021/05/05	Eh	V	0.39
UA	G281	B	2021/05/17	Eh	V	0.38
UA	G281	B	2021/06/14	Eh	V	0.25
UA	G281	B	2021/06/28	Eh	V	0.22
UA	G281	B	2021/07/12	Eh	V	0.40
UA	G281	B	2021/07/27	Eh	V	0.26
UA	G281	B	2021/08/17	Eh	V	0.30
UA	G281	B	2021/10/26	Eh	V	0.22
UA	G281	B	2022/02/08	Eh	V	0.30
UA	G281	B	2022/05/10	Eh	V	0.23
UA	G281	B	2022/08/25	Eh	V	0.20
UA	G281	B	2022/11/08	Eh	V	0.25
UA	G281	B	2023/02/16	Eh	V	0.26
UA	G281	B	2023/06/08	Eh	V	0.20
UA	G281	B	2023/08/14	Eh	V	0.29
UA	G281	B	2023/11/20	Eh	V	0.31
UA	G281	B	2016/11/16	Alkalinity, bicarbonate	mg/L CaCO3	370
UA	G281	B	2017/05/16	Alkalinity, bicarbonate	mg/L CaCO3	380
UA	G281	B	2017/07/12	Alkalinity, bicarbonate	mg/L CaCO3	360
UA	G281	B	2020/01/24	Alkalinity, bicarbonate	mg/L CaCO3	380
UA	G281	B	2020/08/12	Alkalinity, bicarbonate	mg/L CaCO3	380
UA	G281	B	2021/01/29	Alkalinity, bicarbonate	mg/L CaCO3	360
UA	G281	B	2021/03/31	Alkalinity, bicarbonate	mg/L CaCO3	350
UA	G281	B	2021/04/21	Alkalinity, bicarbonate	mg/L CaCO3	380
UA	G281	B	2021/05/05	Alkalinity, bicarbonate	mg/L CaCO3	340
UA	G281	B	2021/05/17	Alkalinity, bicarbonate	mg/L CaCO3	380
UA	G281	B	2021/06/14	Alkalinity, bicarbonate	mg/L CaCO3	380
UA	G281	B	2021/06/28	Alkalinity, bicarbonate	mg/L CaCO3	350
UA	G281	B	2021/07/12	Alkalinity, bicarbonate	mg/L CaCO3	350
UA	G281	B	2021/07/27	Alkalinity, bicarbonate	mg/L CaCO3	360
UA	G281	B	2021/08/17	Alkalinity, bicarbonate	mg/L CaCO3	360
UA	G281	B	2022/02/08	Alkalinity, bicarbonate	mg/L CaCO3	340
UA	G281	B	2022/08/25	Alkalinity, bicarbonate	mg/L CaCO3	390
UA	G281	B	2023/02/16	Alkalinity, bicarbonate	mg/L CaCO3	380
UA	G281	B	2023/06/08	Alkalinity, bicarbonate	mg/L CaCO3	360
UA	G281	B	2023/08/14	Alkalinity, bicarbonate	mg/L CaCO3	357
UA	G281	B	2023/11/20	Alkalinity, bicarbonate	mg/L CaCO3	358
UA	G281	B	2022/08/25	Alkalinity, carbonate	mg/L CaCO3	10.0
UA	G281	B	2015/11/20	Barium, total	mg/L	0.140

UA	G281	B	2016/02/11	Barium, total	mg/L	0.0670
UA	G281	B	2016/05/10	Barium, total	mg/L	0.0720
UA	G281	B	2016/08/01	Barium, total	mg/L	0.0780
UA	G281	B	2016/11/16	Barium, total	mg/L	0.0810
UA	G281	B	2017/02/10	Barium, total	mg/L	0.0800
UA	G281	B	2017/05/16	Barium, total	mg/L	0.0810
UA	G281	B	2017/07/12	Barium, total	mg/L	0.0870
UA	G281	B	2018/05/11	Barium, total	mg/L	0.0810
UA	G281	B	2018/08/03	Barium, total	mg/L	0.100
UA	G281	B	2019/01/23	Barium, total	mg/L	0.0720
UA	G281	B	2019/08/13	Barium, total	mg/L	0.0910
UA	G281	B	2020/01/24	Barium, total	mg/L	0.0700
UA	G281	B	2020/08/12	Barium, total	mg/L	0.0570
UA	G281	B	2020/10/14	Barium, total	mg/L	0.0630
UA	G281	B	2021/01/29	Barium, total	mg/L	0.0640
UA	G281	B	2021/03/31	Barium, total	mg/L	0.0660
UA	G281	B	2021/04/21	Barium, total	mg/L	0.0610
UA	G281	B	2021/05/05	Barium, total	mg/L	0.0650
UA	G281	B	2021/05/17	Barium, total	mg/L	0.0860
UA	G281	B	2021/06/14	Barium, total	mg/L	0.0600
UA	G281	B	2021/06/28	Barium, total	mg/L	0.0620
UA	G281	B	2021/07/12	Barium, total	mg/L	0.0610
UA	G281	B	2021/07/27	Barium, total	mg/L	0.0610
UA	G281	B	2021/08/17	Barium, total	mg/L	0.0650
UA	G281	B	2021/10/26	Barium, total	mg/L	0.0600
UA	G281	B	2022/02/08	Barium, total	mg/L	0.0650
UA	G281	B	2022/05/10	Barium, total	mg/L	0.0630
UA	G281	B	2022/08/25	Barium, total	mg/L	0.0680
UA	G281	B	2022/11/08	Barium, total	mg/L	0.0520
UA	G281	B	2023/02/16	Barium, total	mg/L	0.0650
UA	G281	B	2023/06/08	Barium, total	mg/L	0.0710
UA	G281	B	2023/08/14	Barium, total	mg/L	0.0707
UA	G281	B	2023/11/20	Barium, total	mg/L	0.0651
UA	G281	B	2015/11/20	Boron, total	mg/L	<0.0023
UA	G281	B	2016/02/11	Boron, total	mg/L	0.0100
UA	G281	B	2016/05/10	Boron, total	mg/L	<0.0023
UA	G281	B	2016/08/01	Boron, total	mg/L	0.0120
UA	G281	B	2016/11/16	Boron, total	mg/L	0.0220
UA	G281	B	2017/02/10	Boron, total	mg/L	<0.0023
UA	G281	B	2017/05/16	Boron, total	mg/L	<0.0023
UA	G281	B	2017/07/12	Boron, total	mg/L	<0.0023
UA	G281	B	2017/10/25	Boron, total	mg/L	0.0120
UA	G281	B	2018/05/11	Boron, total	mg/L	<0.0079
UA	G281	B	2018/08/03	Boron, total	mg/L	0.0130
UA	G281	B	2019/01/23	Boron, total	mg/L	0.0130
UA	G281	B	2019/08/13	Boron, total	mg/L	<0.0034
UA	G281	B	2020/01/24	Boron, total	mg/L	0.0110
UA	G281	B	2020/08/12	Boron, total	mg/L	0.0370
UA	G281	B	2020/10/14	Boron, total	mg/L	0.0160
UA	G281	B	2021/01/29	Boron, total	mg/L	<0.008
UA	G281	B	2021/03/31	Boron, total	mg/L	0.110
UA	G281	B	2021/04/21	Boron, total	mg/L	<0.008
UA	G281	B	2021/05/05	Boron, total	mg/L	0.0150
UA	G281	B	2021/05/17	Boron, total	mg/L	0.0430
UA	G281	B	2021/06/14	Boron, total	mg/L	<0.008
UA	G281	B	2021/06/28	Boron, total	mg/L	0.0360
UA	G281	B	2021/07/12	Boron, total	mg/L	<0.008
UA	G281	B	2021/07/27	Boron, total	mg/L	<0.008
UA	G281	B	2021/08/17	Boron, total	mg/L	0.0320
UA	G281	B	2021/10/26	Boron, total	mg/L	<0.01
UA	G281	B	2022/02/08	Boron, total	mg/L	<0.0046
UA	G281	B	2022/05/10	Boron, total	mg/L	<0.0071
UA	G281	B	2022/08/25	Boron, total	mg/L	0.0140

UA	G281	B	2022/11/08	Boron, total	mg/L	<0.0071
UA	G281	B	2023/02/16	Boron, total	mg/L	0.0210
UA	G281	B	2023/06/08	Boron, total	mg/L	<0.0071
UA	G281	B	2023/08/14	Boron, total	mg/L	<0.0092
UA	G281	B	2023/11/20	Boron, total	mg/L	<0.0092
UA	G281	B	2015/11/20	Calcium, total	mg/L	150
UA	G281	B	2016/02/11	Calcium, total	mg/L	120
UA	G281	B	2016/05/10	Calcium, total	mg/L	130
UA	G281	B	2016/08/01	Calcium, total	mg/L	140
UA	G281	B	2016/11/16	Calcium, total	mg/L	110
UA	G281	B	2017/02/10	Calcium, total	mg/L	120
UA	G281	B	2017/05/16	Calcium, total	mg/L	130
UA	G281	B	2017/07/12	Calcium, total	mg/L	130
UA	G281	B	2017/10/25	Calcium, total	mg/L	110
UA	G281	B	2018/05/11	Calcium, total	mg/L	120
UA	G281	B	2018/08/03	Calcium, total	mg/L	130
UA	G281	B	2019/01/23	Calcium, total	mg/L	130
UA	G281	B	2019/08/13	Calcium, total	mg/L	140
UA	G281	B	2020/01/24	Calcium, total	mg/L	140
UA	G281	B	2020/08/12	Calcium, total	mg/L	130
UA	G281	B	2020/10/14	Calcium, total	mg/L	130
UA	G281	B	2021/01/29	Calcium, total	mg/L	130
UA	G281	B	2021/03/31	Calcium, total	mg/L	130
UA	G281	B	2021/04/21	Calcium, total	mg/L	130
UA	G281	B	2021/05/05	Calcium, total	mg/L	130
UA	G281	B	2021/05/17	Calcium, total	mg/L	130
UA	G281	B	2021/06/14	Calcium, total	mg/L	140
UA	G281	B	2021/06/28	Calcium, total	mg/L	130
UA	G281	B	2021/07/12	Calcium, total	mg/L	130
UA	G281	B	2021/07/27	Calcium, total	mg/L	120
UA	G281	B	2021/08/17	Calcium, total	mg/L	140
UA	G281	B	2021/10/26	Calcium, total	mg/L	130
UA	G281	B	2022/02/08	Calcium, total	mg/L	130
UA	G281	B	2022/05/10	Calcium, total	mg/L	140
UA	G281	B	2022/08/25	Calcium, total	mg/L	150
UA	G281	B	2022/11/08	Calcium, total	mg/L	110
UA	G281	B	2023/02/16	Calcium, total	mg/L	130
UA	G281	B	2023/06/08	Calcium, total	mg/L	130
UA	G281	B	2023/08/14	Calcium, total	mg/L	137
UA	G281	B	2023/11/20	Calcium, total	mg/L	152
UA	G281	B	2015/11/20	Chloride, total	mg/L	74.0
UA	G281	B	2016/02/11	Chloride, total	mg/L	55.0
UA	G281	B	2016/05/10	Chloride, total	mg/L	72.0
UA	G281	B	2016/08/01	Chloride, total	mg/L	70.0
UA	G281	B	2016/11/16	Chloride, total	mg/L	68.0
UA	G281	B	2017/02/10	Chloride, total	mg/L	67.0
UA	G281	B	2017/05/16	Chloride, total	mg/L	68.0
UA	G281	B	2017/07/12	Chloride, total	mg/L	75.0
UA	G281	B	2017/10/25	Chloride, total	mg/L	64.0
UA	G281	B	2018/05/11	Chloride, total	mg/L	69.0
UA	G281	B	2018/08/03	Chloride, total	mg/L	66.0
UA	G281	B	2019/01/23	Chloride, total	mg/L	85.0
UA	G281	B	2019/08/13	Chloride, total	mg/L	72.0
UA	G281	B	2020/01/24	Chloride, total	mg/L	75.0
UA	G281	B	2020/08/12	Chloride, total	mg/L	81.0
UA	G281	B	2020/10/14	Chloride, total	mg/L	79.0
UA	G281	B	2021/01/29	Chloride, total	mg/L	100
UA	G281	B	2021/03/31	Chloride, total	mg/L	90.0
UA	G281	B	2021/04/21	Chloride, total	mg/L	120
UA	G281	B	2021/05/05	Chloride, total	mg/L	86.0
UA	G281	B	2021/05/17	Chloride, total	mg/L	85.0
UA	G281	B	2021/06/14	Chloride, total	mg/L	76.0
UA	G281	B	2021/06/28	Chloride, total	mg/L	86.0

UA	G281	B	2021/07/12	Chloride, total	mg/L	73.0
UA	G281	B	2021/07/27	Chloride, total	mg/L	73.0
UA	G281	B	2021/08/17	Chloride, total	mg/L	89.0
UA	G281	B	2021/10/26	Chloride, total	mg/L	160
UA	G281	B	2022/02/08	Chloride, total	mg/L	78.0
UA	G281	B	2022/05/10	Chloride, total	mg/L	85.0
UA	G281	B	2022/08/25	Chloride, total	mg/L	69.0
UA	G281	B	2022/11/08	Chloride, total	mg/L	63.0
UA	G281	B	2023/02/16	Chloride, total	mg/L	76.0
UA	G281	B	2023/06/08	Chloride, total	mg/L	75.0
UA	G281	B	2023/08/14	Chloride, total	mg/L	88.0
UA	G281	B	2023/11/20	Chloride, total	mg/L	74.0
UA	G281	B	2015/11/20	Cobalt, total	mg/L	0.00560
UA	G281	B	2016/02/11	Cobalt, total	mg/L	<0.000017
UA	G281	B	2016/05/10	Cobalt, total	mg/L	<0.000017
UA	G281	B	2016/08/01	Cobalt, total	mg/L	<0.000017
UA	G281	B	2016/11/16	Cobalt, total	mg/L	<0.000017
UA	G281	B	2017/02/10	Cobalt, total	mg/L	<0.000017
UA	G281	B	2017/05/16	Cobalt, total	mg/L	<0.000017
UA	G281	B	2017/07/12	Cobalt, total	mg/L	<0.000017
UA	G281	B	2018/05/11	Cobalt, total	mg/L	0.00230
UA	G281	B	2018/08/03	Cobalt, total	mg/L	0.00360
UA	G281	B	2019/01/23	Cobalt, total	mg/L	<0.00067
UA	G281	B	2019/08/13	Cobalt, total	mg/L	<0.00067
UA	G281	B	2020/01/24	Cobalt, total	mg/L	<0.00067
UA	G281	B	2020/08/12	Cobalt, total	mg/L	<0.00022
UA	G281	B	2020/10/14	Cobalt, total	mg/L	<0.002
UA	G281	B	2021/01/29	Cobalt, total	mg/L	<0.00022
UA	G281	B	2021/03/31	Cobalt, total	mg/L	<0.00022
UA	G281	B	2021/04/21	Cobalt, total	mg/L	<0.00022
UA	G281	B	2021/05/05	Cobalt, total	mg/L	<0.00022
UA	G281	B	2021/05/17	Cobalt, total	mg/L	0.00260
UA	G281	B	2021/06/14	Cobalt, total	mg/L	<0.00022
UA	G281	B	2021/06/28	Cobalt, total	mg/L	<0.00019
UA	G281	B	2021/07/12	Cobalt, total	mg/L	<0.00022
UA	G281	B	2021/07/27	Cobalt, total	mg/L	<0.00022
UA	G281	B	2021/08/17	Cobalt, total	mg/L	<0.00022
UA	G281	B	2021/10/26	Cobalt, total	mg/L	<0.002
UA	G281	B	2022/02/08	Cobalt, total	mg/L	<0.00019
UA	G281	B	2022/05/10	Cobalt, total	mg/L	<0.00048
UA	G281	B	2022/08/25	Cobalt, total	mg/L	0.000740
UA	G281	B	2022/11/08	Cobalt, total	mg/L	<0.00048
UA	G281	B	2023/02/16	Cobalt, total	mg/L	<0.00048
UA	G281	B	2023/06/08	Cobalt, total	mg/L	0.000990
UA	G281	B	2023/08/14	Cobalt, total	mg/L	0.000400
UA	G281	B	2023/11/20	Cobalt, total	mg/L	0.000600
UA	G281	B	2023/06/08	Ferrous Iron, dissolved	mg/L	0.260
UA	G281	B	2020/08/11	Iron, dissolved	mg/L	<0.01
UA	G281	B	2020/10/14	Iron, dissolved	mg/L	<0.01
UA	G281	B	2021/01/29	Iron, dissolved	mg/L	<0.01
UA	G281	B	2021/04/21	Iron, dissolved	mg/L	0.0620
UA	G281	B	2021/08/17	Iron, dissolved	mg/L	<0.01
UA	G281	B	2021/10/26	Iron, dissolved	mg/L	<0.01
UA	G281	B	2022/02/08	Iron, dissolved	mg/L	<0.01
UA	G281	B	2022/05/10	Iron, dissolved	mg/L	0.00350
UA	G281	B	2022/08/25	Iron, dissolved	mg/L	0.00820
UA	G281	B	2022/11/08	Iron, dissolved	mg/L	0.0250
UA	G281	B	2023/02/16	Iron, dissolved	mg/L	1.20
UA	G281	B	2023/06/08	Iron, dissolved	mg/L	0.0160
UA	G281	B	2023/08/14	Iron, dissolved	mg/L	<0.0175
UA	G281	B	2023/11/20	Iron, dissolved	mg/L	<0.0115
UA	G281	B	2016/11/16	Magnesium, total	mg/L	66.0
UA	G281	B	2017/05/16	Magnesium, total	mg/L	59.0

UA	G281	B	2017/07/12	Magnesium, total	mg/L	63.0
UA	G281	B	2020/01/24	Magnesium, total	mg/L	67.0
UA	G281	B	2020/08/12	Magnesium, total	mg/L	60.0
UA	G281	B	2021/01/29	Magnesium, total	mg/L	61.0
UA	G281	B	2021/03/31	Magnesium, total	mg/L	53.0
UA	G281	B	2021/04/21	Magnesium, total	mg/L	58.0
UA	G281	B	2021/05/05	Magnesium, total	mg/L	62.0
UA	G281	B	2021/05/17	Magnesium, total	mg/L	63.0
UA	G281	B	2021/06/14	Magnesium, total	mg/L	61.0
UA	G281	B	2021/06/28	Magnesium, total	mg/L	61.0
UA	G281	B	2021/07/12	Magnesium, total	mg/L	58.0
UA	G281	B	2021/07/27	Magnesium, total	mg/L	59.0
UA	G281	B	2021/08/17	Magnesium, total	mg/L	64.0
UA	G281	B	2022/02/08	Magnesium, total	mg/L	60.0
UA	G281	B	2022/08/25	Magnesium, total	mg/L	67.0
UA	G281	B	2023/02/16	Magnesium, total	mg/L	62.0
UA	G281	B	2023/06/08	Magnesium, total	mg/L	61.0
UA	G281	B	2023/08/14	Magnesium, total	mg/L	61.0
UA	G281	B	2023/11/20	Magnesium, total	mg/L	68.5
UA	G281	B	2018/03/01	Manganese, dissolved	mg/L	0.160
UA	G281	B	2018/05/11	Manganese, dissolved	mg/L	0.0200
UA	G281	B	2018/08/11	Manganese, dissolved	mg/L	0.340
UA	G281	B	2018/11/06	Manganese, dissolved	mg/L	0.360
UA	G281	B	2019/01/23	Manganese, dissolved	mg/L	0.450
UA	G281	B	2019/05/02	Manganese, dissolved	mg/L	0.0590
UA	G281	B	2019/08/13	Manganese, dissolved	mg/L	0.300
UA	G281	B	2019/10/21	Manganese, dissolved	mg/L	0.350
UA	G281	B	2020/01/24	Manganese, dissolved	mg/L	0.0690
UA	G281	B	2020/05/05	Manganese, dissolved	mg/L	0.100
UA	G281	B	2020/08/11	Manganese, dissolved	mg/L	0.170
UA	G281	B	2020/10/14	Manganese, dissolved	mg/L	0.160
UA	G281	B	2021/01/29	Manganese, dissolved	mg/L	0.0390
UA	G281	B	2021/04/21	Manganese, dissolved	mg/L	0.0610
UA	G281	B	2021/08/17	Manganese, dissolved	mg/L	0.110
UA	G281	B	2021/10/26	Manganese, dissolved	mg/L	0.150
UA	G281	B	2022/02/08	Manganese, dissolved	mg/L	0.0300
UA	G281	B	2022/05/10	Manganese, dissolved	mg/L	0.0710
UA	G281	B	2022/08/25	Manganese, dissolved	mg/L	0.180
UA	G281	B	2022/11/08	Manganese, dissolved	mg/L	0.140
UA	G281	B	2023/02/16	Manganese, dissolved	mg/L	0.250
UA	G281	B	2023/06/08	Manganese, dissolved	mg/L	0.310
UA	G281	B	2023/08/14	Manganese, dissolved	mg/L	0.291
UA	G281	B	2023/11/20	Manganese, dissolved	mg/L	0.306
UA	G281	B	2023/08/14	Phosphate, dissolved	mg/L	0.0340
UA	G281	B	2016/11/16	Potassium, total	mg/L	0.880
UA	G281	B	2017/05/16	Potassium, total	mg/L	0.800
UA	G281	B	2017/07/12	Potassium, total	mg/L	1.10
UA	G281	B	2020/01/24	Potassium, total	mg/L	0.620
UA	G281	B	2020/08/12	Potassium, total	mg/L	0.360
UA	G281	B	2021/01/29	Potassium, total	mg/L	0.610
UA	G281	B	2021/03/31	Potassium, total	mg/L	1.40
UA	G281	B	2021/04/21	Potassium, total	mg/L	0.400
UA	G281	B	2021/05/05	Potassium, total	mg/L	1.50
UA	G281	B	2021/05/17	Potassium, total	mg/L	0.840
UA	G281	B	2021/06/14	Potassium, total	mg/L	0.430
UA	G281	B	2021/06/28	Potassium, total	mg/L	0.450
UA	G281	B	2021/07/12	Potassium, total	mg/L	0.440
UA	G281	B	2021/07/27	Potassium, total	mg/L	0.420
UA	G281	B	2021/08/17	Potassium, total	mg/L	0.590
UA	G281	B	2022/02/08	Potassium, total	mg/L	0.510
UA	G281	B	2022/08/25	Potassium, total	mg/L	0.730
UA	G281	B	2023/02/16	Potassium, total	mg/L	0.550
UA	G281	B	2023/06/08	Potassium, total	mg/L	0.530

UA	G281	B	2023/08/14	Potassium, total	mg/L	0.609
UA	G281	B	2023/11/20	Potassium, total	mg/L	0.663
UA	G281	B	2023/06/08	Silicon, dissolved	mg/L	10.0
UA	G281	B	2023/08/14	Silicon, dissolved	mg/L	8.59
UA	G281	B	2016/11/16	Sodium, total	mg/L	86.0
UA	G281	B	2017/05/16	Sodium, total	mg/L	80.0
UA	G281	B	2017/07/12	Sodium, total	mg/L	86.0
UA	G281	B	2020/01/24	Sodium, total	mg/L	90.0
UA	G281	B	2020/08/12	Sodium, total	mg/L	88.0
UA	G281	B	2021/01/29	Sodium, total	mg/L	90.0
UA	G281	B	2021/03/31	Sodium, total	mg/L	79.0
UA	G281	B	2021/04/21	Sodium, total	mg/L	83.0
UA	G281	B	2021/05/05	Sodium, total	mg/L	93.0
UA	G281	B	2021/05/17	Sodium, total	mg/L	88.0
UA	G281	B	2021/06/14	Sodium, total	mg/L	83.0
UA	G281	B	2021/06/28	Sodium, total	mg/L	86.0
UA	G281	B	2021/07/12	Sodium, total	mg/L	78.0
UA	G281	B	2021/07/27	Sodium, total	mg/L	85.0
UA	G281	B	2021/08/17	Sodium, total	mg/L	100
UA	G281	B	2022/02/08	Sodium, total	mg/L	89.0
UA	G281	B	2022/08/25	Sodium, total	mg/L	100
UA	G281	B	2023/02/16	Sodium, total	mg/L	100
UA	G281	B	2023/06/08	Sodium, total	mg/L	89.0
UA	G281	B	2023/08/14	Sodium, total	mg/L	90.7
UA	G281	B	2023/11/20	Sodium, total	mg/L	93.3
UA	G281	B	2015/11/20	Sulfate, total	mg/L	300
UA	G281	B	2016/02/11	Sulfate, total	mg/L	340
UA	G281	B	2016/05/10	Sulfate, total	mg/L	370
UA	G281	B	2016/08/01	Sulfate, total	mg/L	310
UA	G281	B	2016/11/16	Sulfate, total	mg/L	310
UA	G281	B	2017/02/10	Sulfate, total	mg/L	310
UA	G281	B	2017/05/16	Sulfate, total	mg/L	330
UA	G281	B	2017/07/12	Sulfate, total	mg/L	300
UA	G281	B	2017/10/25	Sulfate, total	mg/L	300
UA	G281	B	2018/05/11	Sulfate, total	mg/L	310
UA	G281	B	2018/08/03	Sulfate, total	mg/L	280
UA	G281	B	2019/01/23	Sulfate, total	mg/L	380
UA	G281	B	2019/08/13	Sulfate, total	mg/L	310
UA	G281	B	2020/01/24	Sulfate, total	mg/L	300
UA	G281	B	2020/08/12	Sulfate, total	mg/L	260
UA	G281	B	2020/10/14	Sulfate, total	mg/L	250
UA	G281	B	2021/01/29	Sulfate, total	mg/L	260
UA	G281	B	2021/03/31	Sulfate, total	mg/L	280
UA	G281	B	2021/04/21	Sulfate, total	mg/L	250
UA	G281	B	2021/05/05	Sulfate, total	mg/L	260
UA	G281	B	2021/05/17	Sulfate, total	mg/L	280
UA	G281	B	2021/06/14	Sulfate, total	mg/L	260
UA	G281	B	2021/06/28	Sulfate, total	mg/L	280
UA	G281	B	2021/07/12	Sulfate, total	mg/L	260
UA	G281	B	2021/07/27	Sulfate, total	mg/L	270
UA	G281	B	2021/08/17	Sulfate, total	mg/L	260
UA	G281	B	2021/10/26	Sulfate, total	mg/L	270
UA	G281	B	2022/02/08	Sulfate, total	mg/L	270
UA	G281	B	2022/05/10	Sulfate, total	mg/L	290
UA	G281	B	2022/08/25	Sulfate, total	mg/L	310
UA	G281	B	2022/11/08	Sulfate, total	mg/L	300
UA	G281	B	2023/02/16	Sulfate, total	mg/L	270
UA	G281	B	2023/06/08	Sulfate, total	mg/L	140
UA	G281	B	2023/08/14	Sulfate, total	mg/L	268
UA	G281	B	2023/11/20	Sulfate, total	mg/L	293
UA	G281	B	2015/11/20	Temperature (Celsius)	degrees C	16.8
UA	G281	B	2016/02/11	Temperature (Celsius)	degrees C	8.00
UA	G281	B	2016/05/10	Temperature (Celsius)	degrees C	15.5

UA	G281	B	2016/08/01	Temperature (Celsius)	degrees C	16.7
UA	G281	B	2016/11/16	Temperature (Celsius)	degrees C	13.6
UA	G281	B	2017/02/10	Temperature (Celsius)	degrees C	14.5
UA	G281	B	2017/05/16	Temperature (Celsius)	degrees C	15.4
UA	G281	B	2017/07/12	Temperature (Celsius)	degrees C	16.5
UA	G281	B	2017/10/25	Temperature (Celsius)	degrees C	13.0
UA	G281	B	2018/05/11	Temperature (Celsius)	degrees C	14.3
UA	G281	B	2018/08/03	Temperature (Celsius)	degrees C	16.1
UA	G281	B	2019/01/23	Temperature (Celsius)	degrees C	11.9
UA	G281	B	2019/08/13	Temperature (Celsius)	degrees C	17.4
UA	G281	B	2020/01/24	Temperature (Celsius)	degrees C	9.70
UA	G281	B	2020/08/12	Temperature (Celsius)	degrees C	21.5
UA	G281	B	2020/10/14	Temperature (Celsius)	degrees C	17.9
UA	G281	B	2021/01/29	Temperature (Celsius)	degrees C	9.40
UA	G281	B	2021/03/31	Temperature (Celsius)	degrees C	11.1
UA	G281	B	2021/04/21	Temperature (Celsius)	degrees C	12.0
UA	G281	B	2021/05/05	Temperature (Celsius)	degrees C	14.0
UA	G281	B	2021/05/17	Temperature (Celsius)	degrees C	15.0
UA	G281	B	2021/06/14	Temperature (Celsius)	degrees C	20.8
UA	G281	B	2021/06/28	Temperature (Celsius)	degrees C	20.7
UA	G281	B	2021/07/12	Temperature (Celsius)	degrees C	19.9
UA	G281	B	2021/07/27	Temperature (Celsius)	degrees C	20.4
UA	G281	B	2021/08/17	Temperature (Celsius)	degrees C	20.7
UA	G281	B	2021/10/26	Temperature (Celsius)	degrees C	17.3
UA	G281	B	2022/02/08	Temperature (Celsius)	degrees C	10.6
UA	G281	B	2022/05/10	Temperature (Celsius)	degrees C	17.8
UA	G281	B	2022/08/25	Temperature (Celsius)	degrees C	21.0
UA	G281	B	2022/11/08	Temperature (Celsius)	degrees C	17.9
UA	G281	B	2023/02/16	Temperature (Celsius)	degrees C	9.20
UA	G281	B	2023/06/08	Temperature (Celsius)	degrees C	18.4
UA	G281	B	2023/08/14	Temperature (Celsius)	degrees C	18.6
UA	G281	B	2023/11/20	Temperature (Celsius)	degrees C	16.1
UA	G281	B	2015/11/20	Total Dissolved Solids	mg/L	820
UA	G281	B	2016/02/11	Total Dissolved Solids	mg/L	740
UA	G281	B	2016/05/10	Total Dissolved Solids	mg/L	740
UA	G281	B	2016/08/01	Total Dissolved Solids	mg/L	780
UA	G281	B	2016/11/16	Total Dissolved Solids	mg/L	840
UA	G281	B	2017/02/10	Total Dissolved Solids	mg/L	840
UA	G281	B	2017/05/16	Total Dissolved Solids	mg/L	840
UA	G281	B	2017/07/12	Total Dissolved Solids	mg/L	760
UA	G281	B	2017/10/25	Total Dissolved Solids	mg/L	800
UA	G281	B	2018/05/11	Total Dissolved Solids	mg/L	840
UA	G281	B	2018/08/03	Total Dissolved Solids	mg/L	840
UA	G281	B	2019/01/23	Total Dissolved Solids	mg/L	880
UA	G281	B	2019/08/13	Total Dissolved Solids	mg/L	900
UA	G281	B	2020/01/24	Total Dissolved Solids	mg/L	880
UA	G281	B	2020/08/12	Total Dissolved Solids	mg/L	700
UA	G281	B	2020/10/14	Total Dissolved Solids	mg/L	870
UA	G281	B	2021/01/29	Total Dissolved Solids	mg/L	870
UA	G281	B	2021/03/31	Total Dissolved Solids	mg/L	830
UA	G281	B	2021/04/21	Total Dissolved Solids	mg/L	1,000
UA	G281	B	2021/05/05	Total Dissolved Solids	mg/L	820
UA	G281	B	2021/05/17	Total Dissolved Solids	mg/L	870
UA	G281	B	2021/06/14	Total Dissolved Solids	mg/L	930
UA	G281	B	2021/06/28	Total Dissolved Solids	mg/L	830
UA	G281	B	2021/07/12	Total Dissolved Solids	mg/L	910
UA	G281	B	2021/07/27	Total Dissolved Solids	mg/L	880
UA	G281	B	2021/08/17	Total Dissolved Solids	mg/L	910
UA	G281	B	2021/10/26	Total Dissolved Solids	mg/L	820
UA	G281	B	2022/02/08	Total Dissolved Solids	mg/L	910
UA	G281	B	2022/05/10	Total Dissolved Solids	mg/L	910
UA	G281	B	2022/08/25	Total Dissolved Solids	mg/L	980
UA	G281	B	2022/11/08	Total Dissolved Solids	mg/L	900

UA	G281	B	2023/02/16	Total Dissolved Solids	mg/L	980
UA	G281	B	2023/06/08	Total Dissolved Solids	mg/L	1,000
UA	G281	B	2023/08/14	Total Dissolved Solids	mg/L	930
UA	G281	B	2023/11/20	Total Dissolved Solids	mg/L	958
UA	G401	C	2015/11/21	pH (field)	SU	6.0
UA	G401	C	2016/02/22	pH (field)	SU	5.8
UA	G401	C	2016/05/19	pH (field)	SU	6.0
UA	G401	C	2016/08/01	pH (field)	SU	6.2
UA	G401	C	2016/11/17	pH (field)	SU	6.2
UA	G401	C	2017/02/16	pH (field)	SU	6.2
UA	G401	C	2017/05/17	pH (field)	SU	6.3
UA	G401	C	2017/07/13	pH (field)	SU	6.2
UA	G401	C	2017/10/27	pH (field)	SU	6.3
UA	G401	C	2018/05/12	pH (field)	SU	6.2
UA	G401	C	2018/08/04	pH (field)	SU	6.2
UA	G401	C	2019/01/24	pH (field)	SU	6.3
UA	G401	C	2019/08/16	pH (field)	SU	6.4
UA	G401	C	2020/01/22	pH (field)	SU	6.0
UA	G401	C	2020/05/06	pH (field)	SU	5.8
UA	G401	C	2020/08/12	pH (field)	SU	5.8
UA	G401	C	2020/10/14	pH (field)	SU	5.7
UA	G401	C	2021/01/29	pH (field)	SU	5.9
UA	G401	C	2021/05/20	pH (field)	SU	5.9
UA	G401	C	2021/08/17	pH (field)	SU	5.9
UA	G401	C	2021/10/26	pH (field)	SU	5.6
UA	G401	C	2021/11/29	pH (field)	SU	5.8
UA	G401	C	2022/02/09	pH (field)	SU	5.8
UA	G401	C	2022/05/10	pH (field)	SU	5.9
UA	G401	C	2022/09/20	pH (field)	SU	6.1
UA	G401	C	2022/11/08	pH (field)	SU	6.2
UA	G401	C	2023/02/15	pH (field)	SU	5.9
UA	G401	C	2023/06/07	pH (field)	SU	6.2
UA	G401	C	2023/08/11	pH (field)	SU	6.0
UA	G401	C	2023/11/21	pH (field)	SU	5.9
UA	G401	C	2015/11/21	Oxidation Reduction Potential	mV	-16.0
UA	G401	C	2016/02/22	Oxidation Reduction Potential	mV	27.0
UA	G401	C	2016/05/19	Oxidation Reduction Potential	mV	-23.0
UA	G401	C	2016/08/01	Oxidation Reduction Potential	mV	-37.0
UA	G401	C	2016/11/17	Oxidation Reduction Potential	mV	-44.0
UA	G401	C	2017/02/16	Oxidation Reduction Potential	mV	-59.0
UA	G401	C	2017/05/17	Oxidation Reduction Potential	mV	-68.0
UA	G401	C	2017/07/13	Oxidation Reduction Potential	mV	-48.0
UA	G401	C	2017/10/27	Oxidation Reduction Potential	mV	-41.0
UA	G401	C	2018/05/12	Oxidation Reduction Potential	mV	-50.0
UA	G401	C	2018/08/04	Oxidation Reduction Potential	mV	-55.0
UA	G401	C	2019/01/24	Oxidation Reduction Potential	mV	-52.0
UA	G401	C	2019/08/16	Oxidation Reduction Potential	mV	-51.0
UA	G401	C	2020/01/22	Oxidation Reduction Potential	mV	111
UA	G401	C	2020/05/06	Oxidation Reduction Potential	mV	94.1
UA	G401	C	2020/08/12	Oxidation Reduction Potential	mV	38.8
UA	G401	C	2020/10/14	Oxidation Reduction Potential	mV	40.2
UA	G401	C	2021/01/29	Oxidation Reduction Potential	mV	44.0
UA	G401	C	2021/05/20	Oxidation Reduction Potential	mV	25.0
UA	G401	C	2021/08/17	Oxidation Reduction Potential	mV	29.6
UA	G401	C	2021/10/26	Oxidation Reduction Potential	mV	28.3
UA	G401	C	2021/11/29	Oxidation Reduction Potential	mV	41.2
UA	G401	C	2022/02/09	Oxidation Reduction Potential	mV	78.1
UA	G401	C	2022/05/10	Oxidation Reduction Potential	mV	38.4
UA	G401	C	2022/09/20	Oxidation Reduction Potential	mV	4.70
UA	G401	C	2022/11/08	Oxidation Reduction Potential	mV	-18.0
UA	G401	C	2023/02/15	Oxidation Reduction Potential	mV	22.0
UA	G401	C	2023/06/07	Oxidation Reduction Potential	mV	-32.0
UA	G401	C	2023/08/11	Oxidation Reduction Potential	mV	-30.0

UA	G401	C	2023/11/21	Oxidation Reduction Potential	mV	15.0
UA	G401	C	2015/11/21	Eh	V	0.18
UA	G401	C	2016/02/22	Eh	V	0.22
UA	G401	C	2016/05/19	Eh	V	0.17
UA	G401	C	2016/08/01	Eh	V	0.16
UA	G401	C	2016/11/17	Eh	V	0.15
UA	G401	C	2017/02/16	Eh	V	0.14
UA	G401	C	2017/05/17	Eh	V	0.13
UA	G401	C	2017/07/13	Eh	V	0.15
UA	G401	C	2017/10/27	Eh	V	0.16
UA	G401	C	2018/05/12	Eh	V	0.15
UA	G401	C	2018/08/04	Eh	V	0.14
UA	G401	C	2019/01/24	Eh	V	0.15
UA	G401	C	2019/08/16	Eh	V	0.14
UA	G401	C	2020/01/22	Eh	V	0.31
UA	G401	C	2020/05/06	Eh	V	0.29
UA	G401	C	2020/08/12	Eh	V	0.23
UA	G401	C	2020/10/14	Eh	V	0.23
UA	G401	C	2021/01/29	Eh	V	0.24
UA	G401	C	2021/05/20	Eh	V	0.22
UA	G401	C	2021/08/17	Eh	V	0.22
UA	G401	C	2021/10/26	Eh	V	0.22
UA	G401	C	2021/11/29	Eh	V	0.24
UA	G401	C	2022/02/09	Eh	V	0.27
UA	G401	C	2022/05/10	Eh	V	0.23
UA	G401	C	2022/09/20	Eh	V	0.19
UA	G401	C	2022/11/08	Eh	V	0.18
UA	G401	C	2023/02/15	Eh	V	0.22
UA	G401	C	2023/06/07	Eh	V	0.17
UA	G401	C	2023/08/11	Eh	V	0.16
UA	G401	C	2023/11/21	Eh	V	0.21
UA	G401	C	2020/01/22	Alkalinity, bicarbonate	mg/L CaCO3	110
UA	G401	C	2021/01/29	Alkalinity, bicarbonate	mg/L CaCO3	50.0
UA	G401	C	2021/08/17	Alkalinity, bicarbonate	mg/L CaCO3	88.0
UA	G401	C	2022/02/09	Alkalinity, bicarbonate	mg/L CaCO3	75.0
UA	G401	C	2022/09/20	Alkalinity, bicarbonate	mg/L CaCO3	60.0
UA	G401	C	2023/02/15	Alkalinity, bicarbonate	mg/L CaCO3	80.0
UA	G401	C	2023/06/07	Alkalinity, bicarbonate	mg/L CaCO3	140
UA	G401	C	2023/08/11	Alkalinity, bicarbonate	mg/L CaCO3	96.0
UA	G401	C	2023/11/21	Alkalinity, bicarbonate	mg/L CaCO3	99.0
UA	G401	C	2022/09/20	Alkalinity, carbonate	mg/L CaCO3	10.0
UA	G401	C	2015/11/21	Barium, total	mg/L	0.0370
UA	G401	C	2016/02/22	Barium, total	mg/L	0.0150
UA	G401	C	2016/05/19	Barium, total	mg/L	0.0140
UA	G401	C	2016/08/01	Barium, total	mg/L	0.0530
UA	G401	C	2016/11/17	Barium, total	mg/L	0.0210
UA	G401	C	2017/02/16	Barium, total	mg/L	0.420
UA	G401	C	2017/05/17	Barium, total	mg/L	0.300
UA	G401	C	2017/07/13	Barium, total	mg/L	0.570
UA	G401	C	2018/05/12	Barium, total	mg/L	0.140
UA	G401	C	2018/08/04	Barium, total	mg/L	1.50
UA	G401	C	2019/01/24	Barium, total	mg/L	0.300
UA	G401	C	2019/08/16	Barium, total	mg/L	0.190
UA	G401	C	2020/01/22	Barium, total	mg/L	0.0120
UA	G401	C	2020/08/12	Barium, total	mg/L	0.0100
UA	G401	C	2020/10/14	Barium, total	mg/L	0.0120
UA	G401	C	2021/01/29	Barium, total	mg/L	0.0130
UA	G401	C	2021/05/20	Barium, total	mg/L	0.0120
UA	G401	C	2021/08/17	Barium, total	mg/L	0.00970
UA	G401	C	2021/10/26	Barium, total	mg/L	0.0100
UA	G401	C	2022/02/09	Barium, total	mg/L	0.0110
UA	G401	C	2022/05/10	Barium, total	mg/L	0.0140
UA	G401	C	2022/09/20	Barium, total	mg/L	0.0110

UA	G401	C	2022/11/08	Barium, total	mg/L	0.00920
UA	G401	C	2023/02/15	Barium, total	mg/L	0.0110
UA	G401	C	2023/06/07	Barium, total	mg/L	0.0100
UA	G401	C	2023/08/11	Barium, total	mg/L	0.0118
UA	G401	C	2023/11/21	Barium, total	mg/L	0.0132
UA	G401	C	2015/11/21	Boron, total	mg/L	3.30
UA	G401	C	2016/02/22	Boron, total	mg/L	3.40
UA	G401	C	2016/05/19	Boron, total	mg/L	3.50
UA	G401	C	2016/08/01	Boron, total	mg/L	4.10
UA	G401	C	2016/11/17	Boron, total	mg/L	4.00
UA	G401	C	2017/02/16	Boron, total	mg/L	3.70
UA	G401	C	2017/05/17	Boron, total	mg/L	3.20
UA	G401	C	2017/07/13	Boron, total	mg/L	3.60
UA	G401	C	2017/10/27	Boron, total	mg/L	4.40
UA	G401	C	2018/05/12	Boron, total	mg/L	3.70
UA	G401	C	2018/08/04	Boron, total	mg/L	3.90
UA	G401	C	2019/01/24	Boron, total	mg/L	3.80
UA	G401	C	2019/08/16	Boron, total	mg/L	4.00
UA	G401	C	2020/01/22	Boron, total	mg/L	1.10
UA	G401	C	2020/08/12	Boron, total	mg/L	4.20
UA	G401	C	2020/10/14	Boron, total	mg/L	4.10
UA	G401	C	2021/01/29	Boron, total	mg/L	3.70
UA	G401	C	2021/05/20	Boron, total	mg/L	3.90
UA	G401	C	2021/08/17	Boron, total	mg/L	4.20
UA	G401	C	2021/10/26	Boron, total	mg/L	3.40
UA	G401	C	2022/02/09	Boron, total	mg/L	3.50
UA	G401	C	2022/05/10	Boron, total	mg/L	3.20
UA	G401	C	2022/09/20	Boron, total	mg/L	4.30
UA	G401	C	2022/11/08	Boron, total	mg/L	4.00
UA	G401	C	2023/02/15	Boron, total	mg/L	3.90
UA	G401	C	2023/06/07	Boron, total	mg/L	3.90
UA	G401	C	2023/08/11	Boron, total	mg/L	4.24
UA	G401	C	2023/11/21	Boron, total	mg/L	5.37
UA	G401	C	2015/11/21	Calcium, total	mg/L	440
UA	G401	C	2016/02/22	Calcium, total	mg/L	330
UA	G401	C	2016/05/19	Calcium, total	mg/L	380
UA	G401	C	2016/08/01	Calcium, total	mg/L	450
UA	G401	C	2016/11/17	Calcium, total	mg/L	400
UA	G401	C	2017/02/16	Calcium, total	mg/L	440
UA	G401	C	2017/05/17	Calcium, total	mg/L	470
UA	G401	C	2017/07/13	Calcium, total	mg/L	470
UA	G401	C	2017/10/27	Calcium, total	mg/L	490
UA	G401	C	2018/05/12	Calcium, total	mg/L	450
UA	G401	C	2018/08/04	Calcium, total	mg/L	690
UA	G401	C	2019/01/24	Calcium, total	mg/L	560
UA	G401	C	2019/08/16	Calcium, total	mg/L	550
UA	G401	C	2020/01/22	Calcium, total	mg/L	210
UA	G401	C	2020/08/12	Calcium, total	mg/L	520
UA	G401	C	2020/10/14	Calcium, total	mg/L	530
UA	G401	C	2021/01/29	Calcium, total	mg/L	490
UA	G401	C	2021/05/20	Calcium, total	mg/L	480
UA	G401	C	2021/08/17	Calcium, total	mg/L	550
UA	G401	C	2021/10/26	Calcium, total	mg/L	440
UA	G401	C	2022/02/09	Calcium, total	mg/L	450
UA	G401	C	2022/05/10	Calcium, total	mg/L	410
UA	G401	C	2022/09/20	Calcium, total	mg/L	490
UA	G401	C	2022/11/08	Calcium, total	mg/L	450
UA	G401	C	2023/02/15	Calcium, total	mg/L	480
UA	G401	C	2023/06/07	Calcium, total	mg/L	490
UA	G401	C	2023/08/11	Calcium, total	mg/L	509
UA	G401	C	2023/11/21	Calcium, total	mg/L	553
UA	G401	C	2015/11/21	Chloride, total	mg/L	3.60
UA	G401	C	2016/02/22	Chloride, total	mg/L	6.00

UA	G401	C	2016/05/19	Chloride, total	mg/L	3.00
UA	G401	C	2016/08/01	Chloride, total	mg/L	5.30
UA	G401	C	2016/11/17	Chloride, total	mg/L	<0.1
UA	G401	C	2017/02/16	Chloride, total	mg/L	2.40
UA	G401	C	2017/05/17	Chloride, total	mg/L	3.40
UA	G401	C	2017/07/13	Chloride, total	mg/L	2.60
UA	G401	C	2017/10/27	Chloride, total	mg/L	3.20
UA	G401	C	2018/05/12	Chloride, total	mg/L	2.20
UA	G401	C	2018/08/04	Chloride, total	mg/L	2.10
UA	G401	C	2019/01/24	Chloride, total	mg/L	3.10
UA	G401	C	2019/08/16	Chloride, total	mg/L	2.50
UA	G401	C	2020/01/22	Chloride, total	mg/L	8.60
UA	G401	C	2020/08/12	Chloride, total	mg/L	2.70
UA	G401	C	2020/10/14	Chloride, total	mg/L	4.40
UA	G401	C	2021/01/29	Chloride, total	mg/L	2.30
UA	G401	C	2021/05/20	Chloride, total	mg/L	5.90
UA	G401	C	2021/08/17	Chloride, total	mg/L	14.0
UA	G401	C	2021/10/26	Chloride, total	mg/L	12.0
UA	G401	C	2022/02/09	Chloride, total	mg/L	6.40
UA	G401	C	2022/05/10	Chloride, total	mg/L	6.00
UA	G401	C	2022/09/20	Chloride, total	mg/L	2.90
UA	G401	C	2022/11/08	Chloride, total	mg/L	2.60
UA	G401	C	2023/02/15	Chloride, total	mg/L	4.60
UA	G401	C	2023/06/07	Chloride, total	mg/L	3.60
UA	G401	C	2023/08/11	Chloride, total	mg/L	3.00
UA	G401	C	2023/11/21	Chloride, total	mg/L	3.00
UA	G401	C	2015/11/21	Cobalt, total	mg/L	0.250
UA	G401	C	2016/02/22	Cobalt, total	mg/L	0.240
UA	G401	C	2016/05/19	Cobalt, total	mg/L	0.270
UA	G401	C	2016/08/01	Cobalt, total	mg/L	0.280
UA	G401	C	2016/11/17	Cobalt, total	mg/L	0.270
UA	G401	C	2017/02/16	Cobalt, total	mg/L	0.280
UA	G401	C	2017/05/17	Cobalt, total	mg/L	0.290
UA	G401	C	2017/07/13	Cobalt, total	mg/L	0.360
UA	G401	C	2018/05/12	Cobalt, total	mg/L	0.300
UA	G401	C	2018/08/04	Cobalt, total	mg/L	0.420
UA	G401	C	2019/01/24	Cobalt, total	mg/L	0.310
UA	G401	C	2019/08/16	Cobalt, total	mg/L	0.300
UA	G401	C	2020/01/22	Cobalt, total	mg/L	0.0460
UA	G401	C	2020/08/12	Cobalt, total	mg/L	0.260
UA	G401	C	2020/10/14	Cobalt, total	mg/L	0.280
UA	G401	C	2021/01/29	Cobalt, total	mg/L	0.240
UA	G401	C	2021/05/20	Cobalt, total	mg/L	0.190
UA	G401	C	2021/08/17	Cobalt, total	mg/L	0.170
UA	G401	C	2021/10/26	Cobalt, total	mg/L	0.140
UA	G401	C	2022/02/09	Cobalt, total	mg/L	0.150
UA	G401	C	2022/05/10	Cobalt, total	mg/L	0.110
UA	G401	C	2022/09/20	Cobalt, total	mg/L	0.140
UA	G401	C	2022/11/08	Cobalt, total	mg/L	0.110
UA	G401	C	2023/02/15	Cobalt, total	mg/L	0.120
UA	G401	C	2023/06/07	Cobalt, total	mg/L	0.110
UA	G401	C	2023/08/11	Cobalt, total	mg/L	0.156
UA	G401	C	2023/11/21	Cobalt, total	mg/L	0.206
UA	G401	C	2023/06/07	Ferrous Iron, dissolved	mg/L	6.00
UA	G401	C	2020/08/12	Iron, dissolved	mg/L	190
UA	G401	C	2020/10/14	Iron, dissolved	mg/L	190
UA	G401	C	2021/01/29	Iron, dissolved	mg/L	120
UA	G401	C	2021/05/20	Iron, dissolved	mg/L	130
UA	G401	C	2021/08/17	Iron, dissolved	mg/L	130
UA	G401	C	2021/10/26	Iron, dissolved	mg/L	98.0
UA	G401	C	2022/02/09	Iron, dissolved	mg/L	71.0
UA	G401	C	2022/05/10	Iron, dissolved	mg/L	62.0
UA	G401	C	2022/09/20	Iron, dissolved	mg/L	92.0

UA	G401	C	2022/11/08	Iron, dissolved	mg/L	66.0
UA	G401	C	2023/02/15	Iron, dissolved	mg/L	56.0
UA	G401	C	2023/06/07	Iron, dissolved	mg/L	84.0
UA	G401	C	2023/08/11	Iron, dissolved	mg/L	93.8
UA	G401	C	2023/11/21	Iron, dissolved	mg/L	95.2
UA	G401	C	2017/07/13	Magnesium, total	mg/L	160
UA	G401	C	2020/01/22	Magnesium, total	mg/L	64.0
UA	G401	C	2021/01/29	Magnesium, total	mg/L	140
UA	G401	C	2021/08/17	Magnesium, total	mg/L	160
UA	G401	C	2022/02/09	Magnesium, total	mg/L	140
UA	G401	C	2022/09/20	Magnesium, total	mg/L	160
UA	G401	C	2023/02/15	Magnesium, total	mg/L	140
UA	G401	C	2023/06/07	Magnesium, total	mg/L	150
UA	G401	C	2023/08/11	Magnesium, total	mg/L	141
UA	G401	C	2023/11/21	Magnesium, total	mg/L	142
UA	G401	C	2018/03/03	Manganese, dissolved	mg/L	38.0
UA	G401	C	2018/05/12	Manganese, dissolved	mg/L	32.0
UA	G401	C	2018/08/13	Manganese, dissolved	mg/L	30.0
UA	G401	C	2018/11/07	Manganese, dissolved	mg/L	38.0
UA	G401	C	2019/01/24	Manganese, dissolved	mg/L	45.0
UA	G401	C	2019/05/02	Manganese, dissolved	mg/L	10.0
UA	G401	C	2019/08/13	Manganese, dissolved	mg/L	40.0
UA	G401	C	2019/10/22	Manganese, dissolved	mg/L	39.0
UA	G401	C	2020/01/22	Manganese, dissolved	mg/L	17.0
UA	G401	C	2020/05/06	Manganese, dissolved	mg/L	38.0
UA	G401	C	2020/08/12	Manganese, dissolved	mg/L	44.0
UA	G401	C	2020/10/14	Manganese, dissolved	mg/L	47.0
UA	G401	C	2021/01/29	Manganese, dissolved	mg/L	45.0
UA	G401	C	2021/05/20	Manganese, dissolved	mg/L	43.0
UA	G401	C	2021/08/17	Manganese, dissolved	mg/L	38.0
UA	G401	C	2021/10/26	Manganese, dissolved	mg/L	33.0
UA	G401	C	2022/02/09	Manganese, dissolved	mg/L	27.0
UA	G401	C	2022/05/10	Manganese, dissolved	mg/L	21.0
UA	G401	C	2022/09/20	Manganese, dissolved	mg/L	31.0
UA	G401	C	2022/11/08	Manganese, dissolved	mg/L	28.0
UA	G401	C	2023/02/15	Manganese, dissolved	mg/L	24.0
UA	G401	C	2023/06/07	Manganese, dissolved	mg/L	27.0
UA	G401	C	2023/08/11	Manganese, dissolved	mg/L	36.0
UA	G401	C	2023/11/21	Manganese, dissolved	mg/L	24.5
UA	G401	C	2023/08/11	Phosphate, dissolved	mg/L	0.0610
UA	G401	C	2017/07/13	Potassium, total	mg/L	12.0
UA	G401	C	2020/01/22	Potassium, total	mg/L	2.00
UA	G401	C	2021/01/29	Potassium, total	mg/L	3.90
UA	G401	C	2021/08/17	Potassium, total	mg/L	3.60
UA	G401	C	2022/02/09	Potassium, total	mg/L	3.20
UA	G401	C	2022/09/20	Potassium, total	mg/L	3.00
UA	G401	C	2023/02/15	Potassium, total	mg/L	2.50
UA	G401	C	2023/06/07	Potassium, total	mg/L	2.20
UA	G401	C	2023/08/11	Potassium, total	mg/L	2.86
UA	G401	C	2023/11/21	Potassium, total	mg/L	2.80
UA	G401	C	2023/06/07	Silicon, dissolved	mg/L	16.0
UA	G401	C	2023/08/11	Silicon, dissolved	mg/L	15.2
UA	G401	C	2017/07/13	Sodium, total	mg/L	47.0
UA	G401	C	2020/01/22	Sodium, total	mg/L	79.0
UA	G401	C	2021/01/29	Sodium, total	mg/L	69.0
UA	G401	C	2021/08/17	Sodium, total	mg/L	83.0
UA	G401	C	2022/02/09	Sodium, total	mg/L	81.0
UA	G401	C	2022/09/20	Sodium, total	mg/L	77.0
UA	G401	C	2023/02/15	Sodium, total	mg/L	74.0
UA	G401	C	2023/06/07	Sodium, total	mg/L	71.0
UA	G401	C	2023/08/11	Sodium, total	mg/L	71.4
UA	G401	C	2023/11/21	Sodium, total	mg/L	64.0
UA	G401	C	2015/11/21	Sulfate, total	mg/L	2,300

UA	G401	C	2016/02/22	Sulfate, total	mg/L	2,500
UA	G401	C	2016/05/19	Sulfate, total	mg/L	2,200
UA	G401	C	2016/08/01	Sulfate, total	mg/L	2,100
UA	G401	C	2016/11/17	Sulfate, total	mg/L	3,400
UA	G401	C	2017/02/16	Sulfate, total	mg/L	3,900
UA	G401	C	2017/05/17	Sulfate, total	mg/L	2,000
UA	G401	C	2017/07/13	Sulfate, total	mg/L	2,100
UA	G401	C	2017/10/27	Sulfate, total	mg/L	2,000
UA	G401	C	2018/05/12	Sulfate, total	mg/L	2,200
UA	G401	C	2018/08/04	Sulfate, total	mg/L	2,200
UA	G401	C	2019/01/24	Sulfate, total	mg/L	4,600
UA	G401	C	2019/08/16	Sulfate, total	mg/L	4,300
UA	G401	C	2020/01/22	Sulfate, total	mg/L	870
UA	G401	C	2020/08/12	Sulfate, total	mg/L	2,000
UA	G401	C	2020/10/14	Sulfate, total	mg/L	2,400
UA	G401	C	2021/01/29	Sulfate, total	mg/L	2,500
UA	G401	C	2021/05/20	Sulfate, total	mg/L	2,400
UA	G401	C	2021/08/17	Sulfate, total	mg/L	1,900
UA	G401	C	2021/10/26	Sulfate, total	mg/L	1,800
UA	G401	C	2022/02/09	Sulfate, total	mg/L	2,000
UA	G401	C	2022/05/10	Sulfate, total	mg/L	1,900
UA	G401	C	2022/09/20	Sulfate, total	mg/L	2,100
UA	G401	C	2022/11/08	Sulfate, total	mg/L	2,100
UA	G401	C	2023/02/15	Sulfate, total	mg/L	1,900
UA	G401	C	2023/06/07	Sulfate, total	mg/L	2,100
UA	G401	C	2023/08/11	Sulfate, total	mg/L	1,900
UA	G401	C	2023/11/21	Sulfate, total	mg/L	1,980
UA	G401	C	2015/11/21	Temperature (Celsius)	degrees C	17.0
UA	G401	C	2016/02/22	Temperature (Celsius)	degrees C	13.5
UA	G401	C	2016/05/19	Temperature (Celsius)	degrees C	20.0
UA	G401	C	2016/08/01	Temperature (Celsius)	degrees C	18.9
UA	G401	C	2016/11/17	Temperature (Celsius)	degrees C	13.6
UA	G401	C	2017/02/16	Temperature (Celsius)	degrees C	14.3
UA	G401	C	2017/05/17	Temperature (Celsius)	degrees C	15.2
UA	G401	C	2017/07/13	Temperature (Celsius)	degrees C	17.3
UA	G401	C	2017/10/27	Temperature (Celsius)	degrees C	13.7
UA	G401	C	2018/05/12	Temperature (Celsius)	degrees C	14.7
UA	G401	C	2018/08/04	Temperature (Celsius)	degrees C	17.0
UA	G401	C	2019/01/24	Temperature (Celsius)	degrees C	11.7
UA	G401	C	2019/08/16	Temperature (Celsius)	degrees C	17.1
UA	G401	C	2020/01/22	Temperature (Celsius)	degrees C	12.3
UA	G401	C	2020/05/06	Temperature (Celsius)	degrees C	14.8
UA	G401	C	2020/08/12	Temperature (Celsius)	degrees C	21.0
UA	G401	C	2020/10/14	Temperature (Celsius)	degrees C	18.1
UA	G401	C	2021/01/29	Temperature (Celsius)	degrees C	10.2
UA	G401	C	2021/05/20	Temperature (Celsius)	degrees C	16.6
UA	G401	C	2021/08/17	Temperature (Celsius)	degrees C	21.2
UA	G401	C	2021/10/26	Temperature (Celsius)	degrees C	15.0
UA	G401	C	2021/11/29	Temperature (Celsius)	degrees C	14.0
UA	G401	C	2022/02/09	Temperature (Celsius)	degrees C	13.1
UA	G401	C	2022/05/10	Temperature (Celsius)	degrees C	17.4
UA	G401	C	2022/09/20	Temperature (Celsius)	degrees C	23.4
UA	G401	C	2022/11/08	Temperature (Celsius)	degrees C	18.1
UA	G401	C	2023/02/15	Temperature (Celsius)	degrees C	15.4
UA	G401	C	2023/06/07	Temperature (Celsius)	degrees C	12.3
UA	G401	C	2023/08/11	Temperature (Celsius)	degrees C	17.5
UA	G401	C	2023/11/21	Temperature (Celsius)	degrees C	12.9
UA	G401	C	2015/11/21	Total Dissolved Solids	mg/L	3,000
UA	G401	C	2016/02/22	Total Dissolved Solids	mg/L	3,000
UA	G401	C	2016/05/19	Total Dissolved Solids	mg/L	2,800
UA	G401	C	2016/08/01	Total Dissolved Solids	mg/L	2,900
UA	G401	C	2016/11/17	Total Dissolved Solids	mg/L	3,200
UA	G401	C	2017/02/16	Total Dissolved Solids	mg/L	3,000

UA	G401	C	2017/05/17	Total Dissolved Solids	mg/L	3,000
UA	G401	C	2017/07/13	Total Dissolved Solids	mg/L	2,600
UA	G401	C	2017/10/27	Total Dissolved Solids	mg/L	2,900
UA	G401	C	2018/05/12	Total Dissolved Solids	mg/L	2,700
UA	G401	C	2018/08/04	Total Dissolved Solids	mg/L	2,900
UA	G401	C	2019/01/24	Total Dissolved Solids	mg/L	2,900
UA	G401	C	2019/08/16	Total Dissolved Solids	mg/L	3,400
UA	G401	C	2020/01/22	Total Dissolved Solids	mg/L	1,200
UA	G401	C	2020/08/12	Total Dissolved Solids	mg/L	2,800
UA	G401	C	2020/10/14	Total Dissolved Solids	mg/L	3,300
UA	G401	C	2021/01/29	Total Dissolved Solids	mg/L	3,300
UA	G401	C	2021/05/20	Total Dissolved Solids	mg/L	3,000
UA	G401	C	2021/08/17	Total Dissolved Solids	mg/L	3,100
UA	G401	C	2021/10/26	Total Dissolved Solids	mg/L	2,800
UA	G401	C	2022/02/09	Total Dissolved Solids	mg/L	2,800
UA	G401	C	2022/05/10	Total Dissolved Solids	mg/L	2,700
UA	G401	C	2022/09/20	Total Dissolved Solids	mg/L	2,900
UA	G401	C	2022/11/08	Total Dissolved Solids	mg/L	3,200
UA	G401	C	2023/02/15	Total Dissolved Solids	mg/L	2,800
UA	G401	C	2023/06/07	Total Dissolved Solids	mg/L	6,600
UA	G401	C	2023/08/11	Total Dissolved Solids	mg/L	3,040
UA	G401	C	2023/11/21	Total Dissolved Solids	mg/L	2,940
UA	G402	C	2015/11/21	pH (field)	SU	6.8
UA	G402	C	2016/02/22	pH (field)	SU	6.7
UA	G402	C	2016/05/19	pH (field)	SU	6.8
UA	G402	C	2016/08/02	pH (field)	SU	6.6
UA	G402	C	2016/11/17	pH (field)	SU	6.6
UA	G402	C	2017/02/16	pH (field)	SU	6.5
UA	G402	C	2017/05/17	pH (field)	SU	6.4
UA	G402	C	2017/07/13	pH (field)	SU	6.6
UA	G402	C	2017/10/27	pH (field)	SU	6.7
UA	G402	C	2018/05/12	pH (field)	SU	6.6
UA	G402	C	2018/08/04	pH (field)	SU	6.7
UA	G402	C	2019/01/22	pH (field)	SU	6.8
UA	G402	C	2019/08/16	pH (field)	SU	6.8
UA	G402	C	2020/01/22	pH (field)	SU	7.0
UA	G402	C	2020/08/12	pH (field)	SU	6.8
UA	G402	C	2020/10/14	pH (field)	SU	6.8
UA	G402	C	2021/01/28	pH (field)	SU	6.9
UA	G402	C	2021/04/27	pH (field)	SU	6.9
UA	G402	C	2021/08/17	pH (field)	SU	6.9
UA	G402	C	2021/10/26	pH (field)	SU	6.7
UA	G402	C	2022/02/09	pH (field)	SU	7.0
UA	G402	C	2022/05/10	pH (field)	SU	6.7
UA	G402	C	2022/08/24	pH (field)	SU	6.8
UA	G402	C	2022/11/08	pH (field)	SU	6.9
UA	G402	C	2023/02/15	pH (field)	SU	6.8
UA	G402	C	2023/06/06	pH (field)	SU	6.6
UA	G402	C	2023/08/11	pH (field)	SU	7.3
UA	G402	C	2023/11/21	pH (field)	SU	6.7
UA	G402	C	2015/11/21	Oxidation Reduction Potential	mV	89.0
UA	G402	C	2016/05/19	Oxidation Reduction Potential	mV	2.00
UA	G402	C	2016/08/02	Oxidation Reduction Potential	mV	-45.0
UA	G402	C	2016/11/17	Oxidation Reduction Potential	mV	-49.0
UA	G402	C	2017/02/16	Oxidation Reduction Potential	mV	-82.0
UA	G402	C	2017/05/17	Oxidation Reduction Potential	mV	-85.0
UA	G402	C	2017/07/13	Oxidation Reduction Potential	mV	-49.0
UA	G402	C	2017/10/27	Oxidation Reduction Potential	mV	-52.0
UA	G402	C	2018/05/12	Oxidation Reduction Potential	mV	-38.0
UA	G402	C	2018/08/04	Oxidation Reduction Potential	mV	-62.0
UA	G402	C	2019/01/22	Oxidation Reduction Potential	mV	-60.0
UA	G402	C	2019/08/16	Oxidation Reduction Potential	mV	-61.0
UA	G402	C	2020/01/22	Oxidation Reduction Potential	mV	172

UA	G402	C	2020/08/12	Oxidation Reduction Potential	mV	74.4
UA	G402	C	2020/10/14	Oxidation Reduction Potential	mV	201
UA	G402	C	2021/01/28	Oxidation Reduction Potential	mV	391
UA	G402	C	2021/04/27	Oxidation Reduction Potential	mV	127
UA	G402	C	2021/08/17	Oxidation Reduction Potential	mV	178
UA	G402	C	2021/10/26	Oxidation Reduction Potential	mV	22.2
UA	G402	C	2022/02/09	Oxidation Reduction Potential	mV	95.8
UA	G402	C	2022/05/10	Oxidation Reduction Potential	mV	34.4
UA	G402	C	2022/08/24	Oxidation Reduction Potential	mV	138
UA	G402	C	2022/11/08	Oxidation Reduction Potential	mV	214
UA	G402	C	2023/02/15	Oxidation Reduction Potential	mV	265
UA	G402	C	2023/06/06	Oxidation Reduction Potential	mV	182
UA	G402	C	2023/08/11	Oxidation Reduction Potential	mV	23.0
UA	G402	C	2023/11/21	Oxidation Reduction Potential	mV	158
UA	G402	C	2015/11/21	Eh	V	0.28
UA	G402	C	2016/05/19	Eh	V	0.19
UA	G402	C	2016/08/02	Eh	V	0.15
UA	G402	C	2016/11/17	Eh	V	0.15
UA	G402	C	2017/02/16	Eh	V	0.11
UA	G402	C	2017/05/17	Eh	V	0.11
UA	G402	C	2017/07/13	Eh	V	0.14
UA	G402	C	2017/10/27	Eh	V	0.14
UA	G402	C	2018/05/12	Eh	V	0.16
UA	G402	C	2018/08/04	Eh	V	0.13
UA	G402	C	2019/01/22	Eh	V	0.14
UA	G402	C	2019/08/16	Eh	V	0.13
UA	G402	C	2020/01/22	Eh	V	0.37
UA	G402	C	2020/08/12	Eh	V	0.27
UA	G402	C	2020/10/14	Eh	V	0.39
UA	G402	C	2021/01/28	Eh	V	0.59
UA	G402	C	2021/04/27	Eh	V	0.32
UA	G402	C	2021/08/17	Eh	V	0.37
UA	G402	C	2021/10/26	Eh	V	0.22
UA	G402	C	2022/02/09	Eh	V	0.29
UA	G402	C	2022/05/10	Eh	V	0.23
UA	G402	C	2022/08/24	Eh	V	0.33
UA	G402	C	2022/11/08	Eh	V	0.41
UA	G402	C	2023/02/15	Eh	V	0.46
UA	G402	C	2023/06/06	Eh	V	0.37
UA	G402	C	2023/08/11	Eh	V	0.22
UA	G402	C	2023/11/21	Eh	V	0.35
UA	G402	C	2017/07/13	Alkalinity, bicarbonate	mg/L CaCO3	480
UA	G402	C	2020/01/22	Alkalinity, bicarbonate	mg/L CaCO3	500
UA	G402	C	2021/01/28	Alkalinity, bicarbonate	mg/L CaCO3	490
UA	G402	C	2021/08/17	Alkalinity, bicarbonate	mg/L CaCO3	500
UA	G402	C	2022/02/09	Alkalinity, bicarbonate	mg/L CaCO3	490
UA	G402	C	2022/08/24	Alkalinity, bicarbonate	mg/L CaCO3	490
UA	G402	C	2023/02/15	Alkalinity, bicarbonate	mg/L CaCO3	490
UA	G402	C	2023/06/06	Alkalinity, bicarbonate	mg/L CaCO3	500
UA	G402	C	2023/08/11	Alkalinity, bicarbonate	mg/L CaCO3	508
UA	G402	C	2023/11/21	Alkalinity, bicarbonate	mg/L CaCO3	486
UA	G402	C	2022/08/24	Alkalinity, carbonate	mg/L CaCO3	10.0
UA	G402	C	2015/11/21	Barium, total	mg/L	0.0820
UA	G402	C	2016/02/22	Barium, total	mg/L	0.110
UA	G402	C	2016/05/19	Barium, total	mg/L	0.0850
UA	G402	C	2016/08/02	Barium, total	mg/L	0.0470
UA	G402	C	2016/11/17	Barium, total	mg/L	0.0540
UA	G402	C	2017/02/16	Barium, total	mg/L	0.0280
UA	G402	C	2017/05/17	Barium, total	mg/L	0.0290
UA	G402	C	2017/07/13	Barium, total	mg/L	0.0760
UA	G402	C	2018/05/12	Barium, total	mg/L	0.0410
UA	G402	C	2018/08/04	Barium, total	mg/L	0.0620
UA	G402	C	2019/01/22	Barium, total	mg/L	0.0420

UA	G402	C	2019/08/16	Barium, total	mg/L	0.0360
UA	G402	C	2020/01/22	Barium, total	mg/L	0.0250
UA	G402	C	2020/08/12	Barium, total	mg/L	0.0240
UA	G402	C	2020/10/14	Barium, total	mg/L	0.0300
UA	G402	C	2021/01/28	Barium, total	mg/L	0.0200
UA	G402	C	2021/04/27	Barium, total	mg/L	0.0190
UA	G402	C	2021/08/17	Barium, total	mg/L	0.0240
UA	G402	C	2021/10/26	Barium, total	mg/L	0.0190
UA	G402	C	2022/02/09	Barium, total	mg/L	0.0270
UA	G402	C	2022/05/10	Barium, total	mg/L	0.0310
UA	G402	C	2022/08/24	Barium, total	mg/L	0.0310
UA	G402	C	2022/11/08	Barium, total	mg/L	0.0200
UA	G402	C	2023/02/15	Barium, total	mg/L	0.0240
UA	G402	C	2023/06/06	Barium, total	mg/L	0.0260
UA	G402	C	2023/08/11	Barium, total	mg/L	0.0290
UA	G402	C	2023/11/21	Barium, total	mg/L	0.0281
UA	G402	C	2015/11/21	Boron, total	mg/L	6.60
UA	G402	C	2016/02/22	Boron, total	mg/L	5.70
UA	G402	C	2016/05/19	Boron, total	mg/L	6.30
UA	G402	C	2016/08/02	Boron, total	mg/L	7.40
UA	G402	C	2016/11/17	Boron, total	mg/L	6.90
UA	G402	C	2017/02/16	Boron, total	mg/L	4.60
UA	G402	C	2017/05/17	Boron, total	mg/L	5.80
UA	G402	C	2017/07/13	Boron, total	mg/L	6.80
UA	G402	C	2017/10/27	Boron, total	mg/L	7.30
UA	G402	C	2018/05/12	Boron, total	mg/L	5.90
UA	G402	C	2018/08/04	Boron, total	mg/L	5.70
UA	G402	C	2019/01/22	Boron, total	mg/L	5.40
UA	G402	C	2019/08/16	Boron, total	mg/L	5.90
UA	G402	C	2020/01/22	Boron, total	mg/L	5.00
UA	G402	C	2020/08/12	Boron, total	mg/L	6.00
UA	G402	C	2020/10/14	Boron, total	mg/L	5.40
UA	G402	C	2021/01/28	Boron, total	mg/L	4.90
UA	G402	C	2021/04/27	Boron, total	mg/L	5.40
UA	G402	C	2021/08/17	Boron, total	mg/L	6.10
UA	G402	C	2021/10/26	Boron, total	mg/L	5.10
UA	G402	C	2022/02/09	Boron, total	mg/L	5.20
UA	G402	C	2022/05/10	Boron, total	mg/L	5.30
UA	G402	C	2022/08/24	Boron, total	mg/L	5.70
UA	G402	C	2022/11/08	Boron, total	mg/L	5.20
UA	G402	C	2023/02/15	Boron, total	mg/L	5.10
UA	G402	C	2023/06/06	Boron, total	mg/L	4.90
UA	G402	C	2023/08/11	Boron, total	mg/L	5.71
UA	G402	C	2023/11/21	Boron, total	mg/L	8.13
UA	G402	C	2015/11/21	Calcium, total	mg/L	270
UA	G402	C	2016/02/22	Calcium, total	mg/L	220
UA	G402	C	2016/05/19	Calcium, total	mg/L	270
UA	G402	C	2016/08/02	Calcium, total	mg/L	240
UA	G402	C	2016/11/17	Calcium, total	mg/L	240
UA	G402	C	2017/02/16	Calcium, total	mg/L	240
UA	G402	C	2017/05/17	Calcium, total	mg/L	240
UA	G402	C	2017/07/13	Calcium, total	mg/L	250
UA	G402	C	2017/10/27	Calcium, total	mg/L	260
UA	G402	C	2018/05/12	Calcium, total	mg/L	240
UA	G402	C	2018/08/04	Calcium, total	mg/L	270
UA	G402	C	2019/01/22	Calcium, total	mg/L	260
UA	G402	C	2019/08/16	Calcium, total	mg/L	270
UA	G402	C	2020/01/22	Calcium, total	mg/L	250
UA	G402	C	2020/08/12	Calcium, total	mg/L	250
UA	G402	C	2020/10/14	Calcium, total	mg/L	250
UA	G402	C	2021/01/28	Calcium, total	mg/L	230
UA	G402	C	2021/04/27	Calcium, total	mg/L	230
UA	G402	C	2021/08/17	Calcium, total	mg/L	240

UA	G402	C	2021/10/26	Calcium, total	mg/L	200
UA	G402	C	2022/02/09	Calcium, total	mg/L	230
UA	G402	C	2022/05/10	Calcium, total	mg/L	230
UA	G402	C	2022/08/24	Calcium, total	mg/L	230
UA	G402	C	2022/11/08	Calcium, total	mg/L	180
UA	G402	C	2023/02/15	Calcium, total	mg/L	210
UA	G402	C	2023/06/06	Calcium, total	mg/L	210
UA	G402	C	2023/08/11	Calcium, total	mg/L	212
UA	G402	C	2023/11/21	Calcium, total	mg/L	213
UA	G402	C	2015/11/21	Chloride, total	mg/L	2.80
UA	G402	C	2016/02/22	Chloride, total	mg/L	2.80
UA	G402	C	2016/05/19	Chloride, total	mg/L	1.50
UA	G402	C	2016/08/02	Chloride, total	mg/L	2.20
UA	G402	C	2016/11/17	Chloride, total	mg/L	2.60
UA	G402	C	2017/02/16	Chloride, total	mg/L	2.50
UA	G402	C	2017/05/17	Chloride, total	mg/L	2.50
UA	G402	C	2017/07/13	Chloride, total	mg/L	2.50
UA	G402	C	2017/10/27	Chloride, total	mg/L	3.50
UA	G402	C	2018/05/12	Chloride, total	mg/L	2.20
UA	G402	C	2018/08/04	Chloride, total	mg/L	2.30
UA	G402	C	2019/01/22	Chloride, total	mg/L	1.90
UA	G402	C	2019/08/16	Chloride, total	mg/L	2.20
UA	G402	C	2020/01/22	Chloride, total	mg/L	<0.36
UA	G402	C	2020/08/12	Chloride, total	mg/L	1.10
UA	G402	C	2020/10/14	Chloride, total	mg/L	1.90
UA	G402	C	2021/01/28	Chloride, total	mg/L	<0.96
UA	G402	C	2021/04/27	Chloride, total	mg/L	<1
UA	G402	C	2021/08/17	Chloride, total	mg/L	2.40
UA	G402	C	2021/10/26	Chloride, total	mg/L	<5
UA	G402	C	2022/02/09	Chloride, total	mg/L	2.50
UA	G402	C	2022/05/10	Chloride, total	mg/L	1.90
UA	G402	C	2022/08/24	Chloride, total	mg/L	3.00
UA	G402	C	2022/11/08	Chloride, total	mg/L	1.60
UA	G402	C	2023/02/15	Chloride, total	mg/L	2.10
UA	G402	C	2023/06/06	Chloride, total	mg/L	3.40
UA	G402	C	2023/08/11	Chloride, total	mg/L	3.00
UA	G402	C	2023/11/21	Chloride, total	mg/L	2.00
UA	G402	C	2015/11/21	Cobalt, total	mg/L	0.0140
UA	G402	C	2016/02/22	Cobalt, total	mg/L	0.0150
UA	G402	C	2016/05/19	Cobalt, total	mg/L	0.0190
UA	G402	C	2016/08/02	Cobalt, total	mg/L	0.00740
UA	G402	C	2016/11/17	Cobalt, total	mg/L	0.00700
UA	G402	C	2017/02/16	Cobalt, total	mg/L	0.00470
UA	G402	C	2017/05/17	Cobalt, total	mg/L	0.00690
UA	G402	C	2017/07/13	Cobalt, total	mg/L	0.0170
UA	G402	C	2018/05/12	Cobalt, total	mg/L	0.00770
UA	G402	C	2018/08/04	Cobalt, total	mg/L	0.0100
UA	G402	C	2019/01/22	Cobalt, total	mg/L	0.00760
UA	G402	C	2019/08/16	Cobalt, total	mg/L	0.00450
UA	G402	C	2020/01/22	Cobalt, total	mg/L	0.00210
UA	G402	C	2020/08/12	Cobalt, total	mg/L	<0.00022
UA	G402	C	2020/10/14	Cobalt, total	mg/L	0.00300
UA	G402	C	2021/01/28	Cobalt, total	mg/L	<0.00022
UA	G402	C	2021/04/27	Cobalt, total	mg/L	<0.002
UA	G402	C	2021/08/17	Cobalt, total	mg/L	<0.00022
UA	G402	C	2021/10/26	Cobalt, total	mg/L	<0.002
UA	G402	C	2022/02/09	Cobalt, total	mg/L	0.00440
UA	G402	C	2022/05/10	Cobalt, total	mg/L	0.00370
UA	G402	C	2022/08/24	Cobalt, total	mg/L	0.00360
UA	G402	C	2022/11/08	Cobalt, total	mg/L	0.000930
UA	G402	C	2023/02/15	Cobalt, total	mg/L	0.00260
UA	G402	C	2023/06/06	Cobalt, total	mg/L	0.00350
UA	G402	C	2023/08/11	Cobalt, total	mg/L	0.00240

UA	G402	C	2023/11/21	Cobalt, total	mg/L	0.00150
UA	G402	C	2023/06/06	Ferrous Iron, dissolved	mg/L	0.260
UA	G402	C	2020/08/12	Iron, dissolved	mg/L	<0.01
UA	G402	C	2020/10/14	Iron, dissolved	mg/L	0.0110
UA	G402	C	2021/01/28	Iron, dissolved	mg/L	<0.01
UA	G402	C	2021/04/27	Iron, dissolved	mg/L	<0.01
UA	G402	C	2021/08/17	Iron, dissolved	mg/L	<0.01
UA	G402	C	2021/10/26	Iron, dissolved	mg/L	0.0120
UA	G402	C	2022/02/09	Iron, dissolved	mg/L	<0.01
UA	G402	C	2022/05/10	Iron, dissolved	mg/L	0.00790
UA	G402	C	2022/08/24	Iron, dissolved	mg/L	0.00580
UA	G402	C	2022/11/08	Iron, dissolved	mg/L	0.00860
UA	G402	C	2023/02/15	Iron, dissolved	mg/L	0.00110
UA	G402	C	2023/06/06	Iron, dissolved	mg/L	0.00330
UA	G402	C	2023/08/11	Iron, dissolved	mg/L	<0.0115
UA	G402	C	2023/11/21	Iron, dissolved	mg/L	0.0170
UA	G402	C	2017/07/13	Magnesium, total	mg/L	170
UA	G402	C	2020/01/22	Magnesium, total	mg/L	170
UA	G402	C	2021/01/28	Magnesium, total	mg/L	150
UA	G402	C	2021/08/17	Magnesium, total	mg/L	150
UA	G402	C	2022/02/09	Magnesium, total	mg/L	140
UA	G402	C	2022/08/24	Magnesium, total	mg/L	140
UA	G402	C	2023/02/15	Magnesium, total	mg/L	120
UA	G402	C	2023/06/06	Magnesium, total	mg/L	130
UA	G402	C	2023/08/11	Magnesium, total	mg/L	128
UA	G402	C	2023/11/21	Magnesium, total	mg/L	130
UA	G402	C	2018/03/03	Manganese, dissolved	mg/L	1.90
UA	G402	C	2018/05/12	Manganese, dissolved	mg/L	0.180
UA	G402	C	2018/08/13	Manganese, dissolved	mg/L	0.760
UA	G402	C	2018/11/07	Manganese, dissolved	mg/L	0.620
UA	G402	C	2019/01/24	Manganese, dissolved	mg/L	0.580
UA	G402	C	2019/05/02	Manganese, dissolved	mg/L	0.870
UA	G402	C	2019/08/16	Manganese, dissolved	mg/L	0.790
UA	G402	C	2019/10/22	Manganese, dissolved	mg/L	0.890
UA	G402	C	2020/01/22	Manganese, dissolved	mg/L	1.00
UA	G402	C	2020/05/06	Manganese, dissolved	mg/L	1.00
UA	G402	C	2020/08/12	Manganese, dissolved	mg/L	0.860
UA	G402	C	2020/10/14	Manganese, dissolved	mg/L	0.870
UA	G402	C	2021/01/28	Manganese, dissolved	mg/L	0.610
UA	G402	C	2021/04/27	Manganese, dissolved	mg/L	0.710
UA	G402	C	2021/08/17	Manganese, dissolved	mg/L	0.980
UA	G402	C	2021/10/26	Manganese, dissolved	mg/L	0.910
UA	G402	C	2022/02/09	Manganese, dissolved	mg/L	0.510
UA	G402	C	2022/05/10	Manganese, dissolved	mg/L	0.700
UA	G402	C	2022/08/24	Manganese, dissolved	mg/L	0.890
UA	G402	C	2022/11/08	Manganese, dissolved	mg/L	0.800
UA	G402	C	2023/02/15	Manganese, dissolved	mg/L	0.400
UA	G402	C	2023/06/06	Manganese, dissolved	mg/L	0.860
UA	G402	C	2023/08/11	Manganese, dissolved	mg/L	0.867
UA	G402	C	2023/11/21	Manganese, dissolved	mg/L	0.718
UA	G402	C	2023/08/11	Phosphate, dissolved	mg/L	0.141
UA	G402	C	2017/07/13	Potassium, total	mg/L	3.00
UA	G402	C	2020/01/22	Potassium, total	mg/L	1.10
UA	G402	C	2021/01/28	Potassium, total	mg/L	1.00
UA	G402	C	2021/08/17	Potassium, total	mg/L	1.10
UA	G402	C	2022/02/09	Potassium, total	mg/L	1.20
UA	G402	C	2022/08/24	Potassium, total	mg/L	1.70
UA	G402	C	2023/02/15	Potassium, total	mg/L	0.790
UA	G402	C	2023/06/06	Potassium, total	mg/L	1.00
UA	G402	C	2023/08/11	Potassium, total	mg/L	1.27
UA	G402	C	2023/11/21	Potassium, total	mg/L	0.996
UA	G402	C	2023/06/06	Silicon, dissolved	mg/L	14.0
UA	G402	C	2023/08/11	Silicon, dissolved	mg/L	13.9

UA	G402	C	2017/07/13	Sodium, total	mg/L	55.0
UA	G402	C	2020/01/22	Sodium, total	mg/L	66.0
UA	G402	C	2021/01/28	Sodium, total	mg/L	54.0
UA	G402	C	2021/08/17	Sodium, total	mg/L	54.0
UA	G402	C	2022/02/09	Sodium, total	mg/L	53.0
UA	G402	C	2022/08/24	Sodium, total	mg/L	50.0
UA	G402	C	2023/02/15	Sodium, total	mg/L	45.0
UA	G402	C	2023/06/06	Sodium, total	mg/L	44.0
UA	G402	C	2023/08/11	Sodium, total	mg/L	45.9
UA	G402	C	2023/11/21	Sodium, total	mg/L	43.6
UA	G402	C	2015/11/21	Sulfate, total	mg/L	1,200
UA	G402	C	2016/02/22	Sulfate, total	mg/L	1,000
UA	G402	C	2016/05/19	Sulfate, total	mg/L	960
UA	G402	C	2016/08/02	Sulfate, total	mg/L	890
UA	G402	C	2016/11/17	Sulfate, total	mg/L	1,100
UA	G402	C	2017/02/16	Sulfate, total	mg/L	1,100
UA	G402	C	2017/05/17	Sulfate, total	mg/L	960
UA	G402	C	2017/07/13	Sulfate, total	mg/L	1,000
UA	G402	C	2017/10/27	Sulfate, total	mg/L	1,000
UA	G402	C	2018/05/12	Sulfate, total	mg/L	1,000
UA	G402	C	2018/08/04	Sulfate, total	mg/L	940
UA	G402	C	2019/01/22	Sulfate, total	mg/L	940
UA	G402	C	2019/08/16	Sulfate, total	mg/L	990
UA	G402	C	2020/01/22	Sulfate, total	mg/L	890
UA	G402	C	2020/08/12	Sulfate, total	mg/L	400
UA	G402	C	2020/10/14	Sulfate, total	mg/L	790
UA	G402	C	2021/01/28	Sulfate, total	mg/L	770
UA	G402	C	2021/04/27	Sulfate, total	mg/L	78.0
UA	G402	C	2021/08/17	Sulfate, total	mg/L	700
UA	G402	C	2021/10/26	Sulfate, total	mg/L	640
UA	G402	C	2022/02/09	Sulfate, total	mg/L	690
UA	G402	C	2022/05/10	Sulfate, total	mg/L	600
UA	G402	C	2022/08/24	Sulfate, total	mg/L	600
UA	G402	C	2022/11/08	Sulfate, total	mg/L	550
UA	G402	C	2023/02/15	Sulfate, total	mg/L	550
UA	G402	C	2023/06/06	Sulfate, total	mg/L	580
UA	G402	C	2023/08/11	Sulfate, total	mg/L	601
UA	G402	C	2023/11/21	Sulfate, total	mg/L	599
UA	G402	C	2015/11/21	Temperature (Celsius)	degrees C	17.5
UA	G402	C	2016/02/22	Temperature (Celsius)	degrees C	12.3
UA	G402	C	2016/05/19	Temperature (Celsius)	degrees C	18.9
UA	G402	C	2016/08/02	Temperature (Celsius)	degrees C	19.0
UA	G402	C	2016/11/17	Temperature (Celsius)	degrees C	14.3
UA	G402	C	2017/02/16	Temperature (Celsius)	degrees C	14.9
UA	G402	C	2017/05/17	Temperature (Celsius)	degrees C	15.4
UA	G402	C	2017/07/13	Temperature (Celsius)	degrees C	17.3
UA	G402	C	2017/10/27	Temperature (Celsius)	degrees C	13.0
UA	G402	C	2018/05/12	Temperature (Celsius)	degrees C	13.6
UA	G402	C	2018/08/04	Temperature (Celsius)	degrees C	15.0
UA	G402	C	2019/01/22	Temperature (Celsius)	degrees C	11.2
UA	G402	C	2019/08/16	Temperature (Celsius)	degrees C	17.2
UA	G402	C	2020/01/22	Temperature (Celsius)	degrees C	11.2
UA	G402	C	2020/08/12	Temperature (Celsius)	degrees C	21.6
UA	G402	C	2020/10/14	Temperature (Celsius)	degrees C	17.6
UA	G402	C	2021/01/28	Temperature (Celsius)	degrees C	10.2
UA	G402	C	2021/04/27	Temperature (Celsius)	degrees C	15.1
UA	G402	C	2021/08/17	Temperature (Celsius)	degrees C	19.5
UA	G402	C	2021/10/26	Temperature (Celsius)	degrees C	18.2
UA	G402	C	2022/02/09	Temperature (Celsius)	degrees C	12.1
UA	G402	C	2022/05/10	Temperature (Celsius)	degrees C	15.5
UA	G402	C	2022/08/24	Temperature (Celsius)	degrees C	19.8
UA	G402	C	2022/11/08	Temperature (Celsius)	degrees C	16.7
UA	G402	C	2023/02/15	Temperature (Celsius)	degrees C	12.5

UA	G402	C	2023/06/06	Temperature (Celsius)	degrees C	23.2
UA	G402	C	2023/08/11	Temperature (Celsius)	degrees C	18.1
UA	G402	C	2023/11/21	Temperature (Celsius)	degrees C	15.0
UA	G402	C	2015/11/21	Total Dissolved Solids	mg/L	1,700
UA	G402	C	2016/02/22	Total Dissolved Solids	mg/L	1,700
UA	G402	C	2016/05/19	Total Dissolved Solids	mg/L	1,500
UA	G402	C	2016/08/02	Total Dissolved Solids	mg/L	1,500
UA	G402	C	2016/11/17	Total Dissolved Solids	mg/L	1,700
UA	G402	C	2017/02/16	Total Dissolved Solids	mg/L	1,700
UA	G402	C	2017/05/17	Total Dissolved Solids	mg/L	1,700
UA	G402	C	2017/07/13	Total Dissolved Solids	mg/L	1,600
UA	G402	C	2017/10/27	Total Dissolved Solids	mg/L	1,700
UA	G402	C	2018/05/12	Total Dissolved Solids	mg/L	1,700
UA	G402	C	2018/08/04	Total Dissolved Solids	mg/L	1,700
UA	G402	C	2019/01/22	Total Dissolved Solids	mg/L	1,800
UA	G402	C	2019/08/16	Total Dissolved Solids	mg/L	1,600
UA	G402	C	2020/01/22	Total Dissolved Solids	mg/L	1,600
UA	G402	C	2020/08/12	Total Dissolved Solids	mg/L	1,600
UA	G402	C	2020/10/14	Total Dissolved Solids	mg/L	1,600
UA	G402	C	2021/01/28	Total Dissolved Solids	mg/L	1,600
UA	G402	C	2021/04/27	Total Dissolved Solids	mg/L	1,600
UA	G402	C	2021/08/17	Total Dissolved Solids	mg/L	1,600
UA	G402	C	2021/10/26	Total Dissolved Solids	mg/L	1,300
UA	G402	C	2022/02/09	Total Dissolved Solids	mg/L	1,300
UA	G402	C	2022/05/10	Total Dissolved Solids	mg/L	1,500
UA	G402	C	2022/08/24	Total Dissolved Solids	mg/L	1,400
UA	G402	C	2022/11/08	Total Dissolved Solids	mg/L	1,300
UA	G402	C	2023/02/15	Total Dissolved Solids	mg/L	1,400
UA	G402	C	2023/06/06	Total Dissolved Solids	mg/L	1,400
UA	G402	C	2023/08/11	Total Dissolved Solids	mg/L	1,340
UA	G402	C	2023/11/21	Total Dissolved Solids	mg/L	1,360
UA	G403	C	2015/11/23	pH (field)	SU	7.2
UA	G403	C	2016/02/22	pH (field)	SU	7.0
UA	G403	C	2016/05/18	pH (field)	SU	6.9
UA	G403	C	2016/08/01	pH (field)	SU	6.9
UA	G403	C	2016/11/17	pH (field)	SU	6.7
UA	G403	C	2017/02/18	pH (field)	SU	7.0
UA	G403	C	2017/05/17	pH (field)	SU	6.9
UA	G403	C	2017/07/13	pH (field)	SU	6.8
UA	G403	C	2017/10/28	pH (field)	SU	7.2
UA	G403	C	2018/05/12	pH (field)	SU	6.9
UA	G403	C	2018/08/04	pH (field)	SU	7.0
UA	G403	C	2019/01/24	pH (field)	SU	6.9
UA	G403	C	2019/08/19	pH (field)	SU	7.0
UA	G403	C	2020/01/22	pH (field)	SU	7.3
UA	G403	C	2020/08/12	pH (field)	SU	7.0
UA	G403	C	2020/10/13	pH (field)	SU	6.7
UA	G403	C	2021/01/21	pH (field)	SU	6.9
UA	G403	C	2021/04/26	pH (field)	SU	7.0
UA	G403	C	2021/08/17	pH (field)	SU	6.9
UA	G403	C	2021/10/26	pH (field)	SU	6.7
UA	G403	C	2022/02/08	pH (field)	SU	7.0
UA	G403	C	2022/05/10	pH (field)	SU	6.6
UA	G403	C	2022/08/24	pH (field)	SU	6.7
UA	G403	C	2022/11/09	pH (field)	SU	6.5
UA	G403	C	2023/02/15	pH (field)	SU	7.0
UA	G403	C	2023/06/07	pH (field)	SU	7.0
UA	G403	C	2023/08/11	pH (field)	SU	7.1
UA	G403	C	2023/11/20	pH (field)	SU	6.9
UA	G403	C	2015/11/23	Oxidation Reduction Potential	mV	-23.0
UA	G403	C	2016/02/22	Oxidation Reduction Potential	mV	62.0
UA	G403	C	2016/05/18	Oxidation Reduction Potential	mV	-118
UA	G403	C	2016/08/01	Oxidation Reduction Potential	mV	-99.0

UA	G403	C	2016/11/17	Oxidation Reduction Potential	mV	-80.0
UA	G403	C	2017/02/18	Oxidation Reduction Potential	mV	-119
UA	G403	C	2017/05/17	Oxidation Reduction Potential	mV	-125
UA	G403	C	2017/07/13	Oxidation Reduction Potential	mV	-105
UA	G403	C	2017/10/28	Oxidation Reduction Potential	mV	-89.0
UA	G403	C	2018/05/12	Oxidation Reduction Potential	mV	-81.0
UA	G403	C	2018/08/04	Oxidation Reduction Potential	mV	-96.0
UA	G403	C	2019/01/24	Oxidation Reduction Potential	mV	-95.0
UA	G403	C	2019/08/19	Oxidation Reduction Potential	mV	-91.0
UA	G403	C	2020/01/22	Oxidation Reduction Potential	mV	192
UA	G403	C	2020/08/12	Oxidation Reduction Potential	mV	145
UA	G403	C	2020/10/13	Oxidation Reduction Potential	mV	85.6
UA	G403	C	2021/01/21	Oxidation Reduction Potential	mV	128
UA	G403	C	2021/04/26	Oxidation Reduction Potential	mV	81.7
UA	G403	C	2021/08/17	Oxidation Reduction Potential	mV	-17.1
UA	G403	C	2021/10/26	Oxidation Reduction Potential	mV	17.0
UA	G403	C	2022/02/08	Oxidation Reduction Potential	mV	19.5
UA	G403	C	2022/05/10	Oxidation Reduction Potential	mV	101
UA	G403	C	2022/08/24	Oxidation Reduction Potential	mV	11.0
UA	G403	C	2022/11/09	Oxidation Reduction Potential	mV	20.0
UA	G403	C	2023/02/15	Oxidation Reduction Potential	mV	102
UA	G403	C	2023/06/07	Oxidation Reduction Potential	mV	40.7
UA	G403	C	2023/08/11	Oxidation Reduction Potential	mV	-8.00
UA	G403	C	2023/11/20	Oxidation Reduction Potential	mV	112
UA	G403	C	2015/11/23	Eh	V	0.17
UA	G403	C	2016/02/22	Eh	V	0.26
UA	G403	C	2016/05/18	Eh	V	0.076
UA	G403	C	2016/08/01	Eh	V	0.094
UA	G403	C	2016/11/17	Eh	V	0.12
UA	G403	C	2017/02/18	Eh	V	0.077
UA	G403	C	2017/05/17	Eh	V	0.070
UA	G403	C	2017/07/13	Eh	V	0.089
UA	G403	C	2017/10/28	Eh	V	0.11
UA	G403	C	2018/05/12	Eh	V	0.11
UA	G403	C	2018/08/04	Eh	V	0.099
UA	G403	C	2019/01/24	Eh	V	0.10
UA	G403	C	2019/08/19	Eh	V	0.10
UA	G403	C	2020/01/22	Eh	V	0.39
UA	G403	C	2020/08/12	Eh	V	0.34
UA	G403	C	2020/10/13	Eh	V	0.28
UA	G403	C	2021/01/21	Eh	V	0.33
UA	G403	C	2021/04/26	Eh	V	0.28
UA	G403	C	2021/08/17	Eh	V	0.17
UA	G403	C	2021/10/26	Eh	V	0.21
UA	G403	C	2022/02/08	Eh	V	0.22
UA	G403	C	2022/05/10	Eh	V	0.29
UA	G403	C	2022/08/24	Eh	V	0.20
UA	G403	C	2022/11/09	Eh	V	0.21
UA	G403	C	2023/02/15	Eh	V	0.30
UA	G403	C	2023/06/07	Eh	V	0.24
UA	G403	C	2023/08/11	Eh	V	0.18
UA	G403	C	2023/11/20	Eh	V	0.31
UA	G403	C	2017/07/13	Alkalinity, bicarbonate	mg/L CaCO3	300
UA	G403	C	2020/01/22	Alkalinity, bicarbonate	mg/L CaCO3	320
UA	G403	C	2021/01/21	Alkalinity, bicarbonate	mg/L CaCO3	310
UA	G403	C	2021/08/17	Alkalinity, bicarbonate	mg/L CaCO3	320
UA	G403	C	2022/02/08	Alkalinity, bicarbonate	mg/L CaCO3	310
UA	G403	C	2022/08/24	Alkalinity, bicarbonate	mg/L CaCO3	300
UA	G403	C	2023/02/15	Alkalinity, bicarbonate	mg/L CaCO3	310
UA	G403	C	2023/06/07	Alkalinity, bicarbonate	mg/L CaCO3	340
UA	G403	C	2023/08/11	Alkalinity, bicarbonate	mg/L CaCO3	315
UA	G403	C	2023/11/20	Alkalinity, bicarbonate	mg/L CaCO3	323
UA	G403	C	2022/08/24	Alkalinity, carbonate	mg/L CaCO3	10.0

UA	G403	C	2015/11/23	Barium, total	mg/L	0.140
UA	G403	C	2016/02/22	Barium, total	mg/L	0.130
UA	G403	C	2016/05/18	Barium, total	mg/L	0.160
UA	G403	C	2016/08/01	Barium, total	mg/L	0.240
UA	G403	C	2016/11/17	Barium, total	mg/L	0.200
UA	G403	C	2017/02/18	Barium, total	mg/L	0.150
UA	G403	C	2017/05/17	Barium, total	mg/L	0.140
UA	G403	C	2017/07/13	Barium, total	mg/L	0.170
UA	G403	C	2018/05/12	Barium, total	mg/L	0.150
UA	G403	C	2018/08/04	Barium, total	mg/L	0.150
UA	G403	C	2019/01/24	Barium, total	mg/L	0.140
UA	G403	C	2019/08/19	Barium, total	mg/L	0.140
UA	G403	C	2020/01/22	Barium, total	mg/L	0.130
UA	G403	C	2020/08/12	Barium, total	mg/L	0.120
UA	G403	C	2020/10/13	Barium, total	mg/L	0.110
UA	G403	C	2021/01/21	Barium, total	mg/L	0.110
UA	G403	C	2021/04/26	Barium, total	mg/L	0.110
UA	G403	C	2021/08/17	Barium, total	mg/L	0.120
UA	G403	C	2021/10/26	Barium, total	mg/L	0.110
UA	G403	C	2022/02/08	Barium, total	mg/L	0.130
UA	G403	C	2022/05/10	Barium, total	mg/L	0.120
UA	G403	C	2022/08/24	Barium, total	mg/L	0.110
UA	G403	C	2022/11/09	Barium, total	mg/L	0.0950
UA	G403	C	2023/02/15	Barium, total	mg/L	0.120
UA	G403	C	2023/06/07	Barium, total	mg/L	0.120
UA	G403	C	2023/08/11	Barium, total	mg/L	0.118
UA	G403	C	2023/11/20	Barium, total	mg/L	0.139
UA	G403	C	2015/11/23	Boron, total	mg/L	0.0390
UA	G403	C	2016/02/22	Boron, total	mg/L	0.0640
UA	G403	C	2016/05/18	Boron, total	mg/L	0.0140
UA	G403	C	2016/08/01	Boron, total	mg/L	0.0270
UA	G403	C	2016/11/17	Boron, total	mg/L	0.0420
UA	G403	C	2017/02/18	Boron, total	mg/L	<0.0023
UA	G403	C	2017/05/17	Boron, total	mg/L	0.0170
UA	G403	C	2017/07/13	Boron, total	mg/L	0.0270
UA	G403	C	2017/10/28	Boron, total	mg/L	0.0600
UA	G403	C	2018/05/12	Boron, total	mg/L	0.0100
UA	G403	C	2018/08/04	Boron, total	mg/L	0.0370
UA	G403	C	2019/01/24	Boron, total	mg/L	0.0710
UA	G403	C	2019/08/19	Boron, total	mg/L	0.0220
UA	G403	C	2020/01/22	Boron, total	mg/L	0.0790
UA	G403	C	2020/08/12	Boron, total	mg/L	0.0330
UA	G403	C	2020/10/13	Boron, total	mg/L	<0.01
UA	G403	C	2021/01/21	Boron, total	mg/L	<0.008
UA	G403	C	2021/04/26	Boron, total	mg/L	<0.01
UA	G403	C	2021/08/17	Boron, total	mg/L	0.110
UA	G403	C	2021/10/26	Boron, total	mg/L	0.0880
UA	G403	C	2022/02/08	Boron, total	mg/L	<0.0046
UA	G403	C	2022/05/10	Boron, total	mg/L	0.0500
UA	G403	C	2022/08/24	Boron, total	mg/L	0.100
UA	G403	C	2022/11/09	Boron, total	mg/L	0.0140
UA	G403	C	2023/02/15	Boron, total	mg/L	0.0630
UA	G403	C	2023/06/07	Boron, total	mg/L	0.0350
UA	G403	C	2023/08/11	Boron, total	mg/L	0.0287
UA	G403	C	2023/11/20	Boron, total	mg/L	0.0200
UA	G403	C	2015/11/23	Calcium, total	mg/L	78.0
UA	G403	C	2016/02/22	Calcium, total	mg/L	69.0
UA	G403	C	2016/05/18	Calcium, total	mg/L	71.0
UA	G403	C	2016/08/01	Calcium, total	mg/L	140
UA	G403	C	2016/11/17	Calcium, total	mg/L	72.0
UA	G403	C	2017/02/18	Calcium, total	mg/L	63.0
UA	G403	C	2017/05/17	Calcium, total	mg/L	63.0
UA	G403	C	2017/07/13	Calcium, total	mg/L	67.0

UA	G403	C	2017/10/28	Calcium, total	mg/L	67.0
UA	G403	C	2018/05/12	Calcium, total	mg/L	70.0
UA	G403	C	2018/08/04	Calcium, total	mg/L	71.0
UA	G403	C	2019/01/24	Calcium, total	mg/L	71.0
UA	G403	C	2019/08/19	Calcium, total	mg/L	77.0
UA	G403	C	2020/01/22	Calcium, total	mg/L	74.0
UA	G403	C	2020/08/12	Calcium, total	mg/L	76.0
UA	G403	C	2020/10/13	Calcium, total	mg/L	70.0
UA	G403	C	2021/01/21	Calcium, total	mg/L	77.0
UA	G403	C	2021/04/26	Calcium, total	mg/L	79.0
UA	G403	C	2021/08/17	Calcium, total	mg/L	84.0
UA	G403	C	2021/10/26	Calcium, total	mg/L	70.0
UA	G403	C	2022/02/08	Calcium, total	mg/L	76.0
UA	G403	C	2022/05/10	Calcium, total	mg/L	82.0
UA	G403	C	2022/08/24	Calcium, total	mg/L	80.0
UA	G403	C	2022/11/09	Calcium, total	mg/L	70.0
UA	G403	C	2023/02/15	Calcium, total	mg/L	79.0
UA	G403	C	2023/06/07	Calcium, total	mg/L	78.0
UA	G403	C	2023/08/11	Calcium, total	mg/L	77.7
UA	G403	C	2023/11/20	Calcium, total	mg/L	85.9
UA	G403	C	2015/11/23	Chloride, total	mg/L	6.80
UA	G403	C	2016/02/22	Chloride, total	mg/L	4.10
UA	G403	C	2016/05/18	Chloride, total	mg/L	2.70
UA	G403	C	2016/08/01	Chloride, total	mg/L	4.50
UA	G403	C	2016/11/17	Chloride, total	mg/L	4.00
UA	G403	C	2017/02/18	Chloride, total	mg/L	3.40
UA	G403	C	2017/05/17	Chloride, total	mg/L	3.30
UA	G403	C	2017/07/13	Chloride, total	mg/L	5.80
UA	G403	C	2017/10/28	Chloride, total	mg/L	4.10
UA	G403	C	2018/05/12	Chloride, total	mg/L	3.70
UA	G403	C	2018/08/04	Chloride, total	mg/L	3.90
UA	G403	C	2019/01/24	Chloride, total	mg/L	4.60
UA	G403	C	2019/08/19	Chloride, total	mg/L	3.90
UA	G403	C	2020/01/22	Chloride, total	mg/L	4.60
UA	G403	C	2020/08/12	Chloride, total	mg/L	3.60
UA	G403	C	2020/10/13	Chloride, total	mg/L	4.10
UA	G403	C	2021/01/21	Chloride, total	mg/L	4.50
UA	G403	C	2021/04/26	Chloride, total	mg/L	4.70
UA	G403	C	2021/08/17	Chloride, total	mg/L	4.50
UA	G403	C	2021/10/26	Chloride, total	mg/L	4.70
UA	G403	C	2022/02/08	Chloride, total	mg/L	5.00
UA	G403	C	2022/05/10	Chloride, total	mg/L	5.70
UA	G403	C	2022/08/24	Chloride, total	mg/L	6.00
UA	G403	C	2022/11/09	Chloride, total	mg/L	4.00
UA	G403	C	2023/02/15	Chloride, total	mg/L	5.70
UA	G403	C	2023/06/07	Chloride, total	mg/L	6.20
UA	G403	C	2023/08/11	Chloride, total	mg/L	5.00
UA	G403	C	2023/11/20	Chloride, total	mg/L	5.00
UA	G403	C	2015/11/23	Cobalt, total	mg/L	<0.000017
UA	G403	C	2016/02/22	Cobalt, total	mg/L	<0.000017
UA	G403	C	2016/05/18	Cobalt, total	mg/L	<0.000017
UA	G403	C	2016/08/01	Cobalt, total	mg/L	0.00290
UA	G403	C	2016/11/17	Cobalt, total	mg/L	0.00240
UA	G403	C	2017/02/18	Cobalt, total	mg/L	0.00200
UA	G403	C	2017/05/17	Cobalt, total	mg/L	0.00210
UA	G403	C	2017/07/13	Cobalt, total	mg/L	0.00220
UA	G403	C	2018/05/12	Cobalt, total	mg/L	0.00310
UA	G403	C	2018/08/04	Cobalt, total	mg/L	0.00340
UA	G403	C	2019/01/24	Cobalt, total	mg/L	0.00310
UA	G403	C	2019/08/19	Cobalt, total	mg/L	0.00270
UA	G403	C	2020/01/22	Cobalt, total	mg/L	<0.00067
UA	G403	C	2020/08/12	Cobalt, total	mg/L	<0.00022
UA	G403	C	2020/10/13	Cobalt, total	mg/L	<0.002

UA	G403	C	2021/01/21	Cobalt, total	mg/L	<0.00022
UA	G403	C	2021/04/26	Cobalt, total	mg/L	<0.002
UA	G403	C	2021/08/17	Cobalt, total	mg/L	<0.00022
UA	G403	C	2021/10/26	Cobalt, total	mg/L	<0.002
UA	G403	C	2022/02/08	Cobalt, total	mg/L	0.00230
UA	G403	C	2022/05/10	Cobalt, total	mg/L	0.000790
UA	G403	C	2022/08/24	Cobalt, total	mg/L	<0.00048
UA	G403	C	2022/11/09	Cobalt, total	mg/L	<0.00048
UA	G403	C	2023/02/15	Cobalt, total	mg/L	<0.00048
UA	G403	C	2023/06/07	Cobalt, total	mg/L	0.000760
UA	G403	C	2023/08/11	Cobalt, total	mg/L	0.00250
UA	G403	C	2023/11/20	Cobalt, total	mg/L	0.00260
UA	G403	C	2023/06/07	Ferrous Iron, dissolved	mg/L	<0.02
UA	G403	C	2020/08/12	Iron, dissolved	mg/L	0.0540
UA	G403	C	2020/10/13	Iron, dissolved	mg/L	0.0310
UA	G403	C	2021/01/21	Iron, dissolved	mg/L	<0.01
UA	G403	C	2021/04/26	Iron, dissolved	mg/L	<0.01
UA	G403	C	2021/08/17	Iron, dissolved	mg/L	<0.01
UA	G403	C	2021/10/26	Iron, dissolved	mg/L	0.0500
UA	G403	C	2022/02/08	Iron, dissolved	mg/L	<0.01
UA	G403	C	2022/05/10	Iron, dissolved	mg/L	<0.00072
UA	G403	C	2022/08/24	Iron, dissolved	mg/L	0.00310
UA	G403	C	2022/11/09	Iron, dissolved	mg/L	0.00440
UA	G403	C	2023/02/15	Iron, dissolved	mg/L	<0.00072
UA	G403	C	2023/06/07	Iron, dissolved	mg/L	0.0110
UA	G403	C	2023/08/11	Iron, dissolved	mg/L	0.0763
UA	G403	C	2023/11/20	Iron, dissolved	mg/L	0.0373
UA	G403	C	2017/07/13	Magnesium, total	mg/L	34.0
UA	G403	C	2020/01/22	Magnesium, total	mg/L	36.0
UA	G403	C	2021/01/21	Magnesium, total	mg/L	33.0
UA	G403	C	2021/08/17	Magnesium, total	mg/L	39.0
UA	G403	C	2022/02/08	Magnesium, total	mg/L	35.0
UA	G403	C	2022/08/24	Magnesium, total	mg/L	37.0
UA	G403	C	2023/02/15	Magnesium, total	mg/L	34.0
UA	G403	C	2023/06/07	Magnesium, total	mg/L	37.0
UA	G403	C	2023/08/11	Magnesium, total	mg/L	36.2
UA	G403	C	2023/11/20	Magnesium, total	mg/L	40.2
UA	G403	C	2018/03/03	Manganese, dissolved	mg/L	0.420
UA	G403	C	2018/05/12	Manganese, dissolved	mg/L	0.180
UA	G403	C	2018/08/13	Manganese, dissolved	mg/L	1.40
UA	G403	C	2018/11/07	Manganese, dissolved	mg/L	0.850
UA	G403	C	2019/01/24	Manganese, dissolved	mg/L	0.270
UA	G403	C	2019/05/02	Manganese, dissolved	mg/L	0.180
UA	G403	C	2019/08/19	Manganese, dissolved	mg/L	1.10
UA	G403	C	2019/10/22	Manganese, dissolved	mg/L	1.10
UA	G403	C	2020/01/22	Manganese, dissolved	mg/L	0.00790
UA	G403	C	2020/05/07	Manganese, dissolved	mg/L	0.0360
UA	G403	C	2020/08/12	Manganese, dissolved	mg/L	0.440
UA	G403	C	2020/10/13	Manganese, dissolved	mg/L	0.200
UA	G403	C	2021/01/21	Manganese, dissolved	mg/L	0.00460
UA	G403	C	2021/04/26	Manganese, dissolved	mg/L	0.00440
UA	G403	C	2021/08/17	Manganese, dissolved	mg/L	0.340
UA	G403	C	2021/10/26	Manganese, dissolved	mg/L	0.790
UA	G403	C	2022/02/08	Manganese, dissolved	mg/L	0.00390
UA	G403	C	2022/05/10	Manganese, dissolved	mg/L	0.00350
UA	G403	C	2022/08/24	Manganese, dissolved	mg/L	0.160
UA	G403	C	2022/11/09	Manganese, dissolved	mg/L	0.200
UA	G403	C	2023/02/15	Manganese, dissolved	mg/L	0.000280
UA	G403	C	2023/06/07	Manganese, dissolved	mg/L	0.360
UA	G403	C	2023/08/11	Manganese, dissolved	mg/L	0.376
UA	G403	C	2023/11/20	Manganese, dissolved	mg/L	0.264
UA	G403	C	2023/08/11	Phosphate, dissolved	mg/L	0.0680
UA	G403	C	2017/07/13	Potassium, total	mg/L	0.760

UA	G403	C	2020/01/22	Potassium, total	mg/L	0.710
UA	G403	C	2021/01/21	Potassium, total	mg/L	0.450
UA	G403	C	2021/08/17	Potassium, total	mg/L	0.460
UA	G403	C	2022/02/08	Potassium, total	mg/L	0.760
UA	G403	C	2022/08/24	Potassium, total	mg/L	0.550
UA	G403	C	2023/02/15	Potassium, total	mg/L	0.410
UA	G403	C	2023/06/07	Potassium, total	mg/L	0.450
UA	G403	C	2023/08/11	Potassium, total	mg/L	0.562
UA	G403	C	2023/11/20	Potassium, total	mg/L	0.573
UA	G403	C	2023/06/07	Silicon, dissolved	mg/L	9.20
UA	G403	C	2023/08/11	Silicon, dissolved	mg/L	8.36
UA	G403	C	2017/07/13	Sodium, total	mg/L	22.0
UA	G403	C	2020/01/22	Sodium, total	mg/L	23.0
UA	G403	C	2021/01/21	Sodium, total	mg/L	24.0
UA	G403	C	2021/08/17	Sodium, total	mg/L	26.0
UA	G403	C	2022/02/08	Sodium, total	mg/L	25.0
UA	G403	C	2022/08/24	Sodium, total	mg/L	28.0
UA	G403	C	2023/02/15	Sodium, total	mg/L	29.0
UA	G403	C	2023/06/07	Sodium, total	mg/L	27.0
UA	G403	C	2023/08/11	Sodium, total	mg/L	25.4
UA	G403	C	2023/11/20	Sodium, total	mg/L	26.3
UA	G403	C	2015/11/23	Sulfate, total	mg/L	35.0
UA	G403	C	2016/02/22	Sulfate, total	mg/L	17.0
UA	G403	C	2016/05/18	Sulfate, total	mg/L	11.0
UA	G403	C	2016/08/01	Sulfate, total	mg/L	9.90
UA	G403	C	2016/11/17	Sulfate, total	mg/L	8.90
UA	G403	C	2017/02/18	Sulfate, total	mg/L	7.40
UA	G403	C	2017/05/17	Sulfate, total	mg/L	7.10
UA	G403	C	2017/07/13	Sulfate, total	mg/L	4.90
UA	G403	C	2017/10/28	Sulfate, total	mg/L	7.00
UA	G403	C	2018/05/12	Sulfate, total	mg/L	15.0
UA	G403	C	2018/08/04	Sulfate, total	mg/L	20.0
UA	G403	C	2019/01/24	Sulfate, total	mg/L	32.0
UA	G403	C	2019/08/19	Sulfate, total	mg/L	26.0
UA	G403	C	2020/01/22	Sulfate, total	mg/L	33.0
UA	G403	C	2020/08/12	Sulfate, total	mg/L	34.0
UA	G403	C	2020/10/13	Sulfate, total	mg/L	36.0
UA	G403	C	2021/01/21	Sulfate, total	mg/L	37.0
UA	G403	C	2021/04/26	Sulfate, total	mg/L	39.0
UA	G403	C	2021/08/17	Sulfate, total	mg/L	51.0
UA	G403	C	2021/10/26	Sulfate, total	mg/L	51.0
UA	G403	C	2022/02/08	Sulfate, total	mg/L	53.0
UA	G403	C	2022/05/10	Sulfate, total	mg/L	59.0
UA	G403	C	2022/08/24	Sulfate, total	mg/L	58.0
UA	G403	C	2022/11/09	Sulfate, total	mg/L	57.0
UA	G403	C	2023/02/15	Sulfate, total	mg/L	63.0
UA	G403	C	2023/06/07	Sulfate, total	mg/L	66.0
UA	G403	C	2023/08/11	Sulfate, total	mg/L	60.0
UA	G403	C	2023/11/20	Sulfate, total	mg/L	74.0
UA	G403	C	2015/11/23	Temperature (Celsius)	degrees C	15.8
UA	G403	C	2016/02/22	Temperature (Celsius)	degrees C	11.0
UA	G403	C	2016/05/18	Temperature (Celsius)	degrees C	17.8
UA	G403	C	2016/08/01	Temperature (Celsius)	degrees C	17.9
UA	G403	C	2016/11/17	Temperature (Celsius)	degrees C	14.5
UA	G403	C	2017/02/18	Temperature (Celsius)	degrees C	14.9
UA	G403	C	2017/05/17	Temperature (Celsius)	degrees C	15.2
UA	G403	C	2017/07/13	Temperature (Celsius)	degrees C	17.8
UA	G403	C	2017/10/28	Temperature (Celsius)	degrees C	13.8
UA	G403	C	2018/05/12	Temperature (Celsius)	degrees C	15.7
UA	G403	C	2018/08/04	Temperature (Celsius)	degrees C	15.9
UA	G403	C	2019/01/24	Temperature (Celsius)	degrees C	11.8
UA	G403	C	2019/08/19	Temperature (Celsius)	degrees C	16.9
UA	G403	C	2020/01/22	Temperature (Celsius)	degrees C	9.70

UA	G403	C	2020/08/12	Temperature (Celsius)	degrees C	21.6
UA	G403	C	2020/10/13	Temperature (Celsius)	degrees C	17.0
UA	G403	C	2021/01/21	Temperature (Celsius)	degrees C	12.6
UA	G403	C	2021/04/26	Temperature (Celsius)	degrees C	16.2
UA	G403	C	2021/08/17	Temperature (Celsius)	degrees C	20.7
UA	G403	C	2021/10/26	Temperature (Celsius)	degrees C	16.8
UA	G403	C	2022/02/08	Temperature (Celsius)	degrees C	11.1
UA	G403	C	2022/05/10	Temperature (Celsius)	degrees C	17.4
UA	G403	C	2022/08/24	Temperature (Celsius)	degrees C	19.2
UA	G403	C	2022/11/09	Temperature (Celsius)	degrees C	19.0
UA	G403	C	2023/02/15	Temperature (Celsius)	degrees C	13.4
UA	G403	C	2023/06/07	Temperature (Celsius)	degrees C	15.8
UA	G403	C	2023/08/11	Temperature (Celsius)	degrees C	18.7
UA	G403	C	2023/11/20	Temperature (Celsius)	degrees C	15.1
UA	G403	C	2015/11/23	Total Dissolved Solids	mg/L	320
UA	G403	C	2016/02/22	Total Dissolved Solids	mg/L	340
UA	G403	C	2016/05/18	Total Dissolved Solids	mg/L	320
UA	G403	C	2016/08/01	Total Dissolved Solids	mg/L	320
UA	G403	C	2016/11/17	Total Dissolved Solids	mg/L	350
UA	G403	C	2017/02/18	Total Dissolved Solids	mg/L	320
UA	G403	C	2017/05/17	Total Dissolved Solids	mg/L	330
UA	G403	C	2017/07/13	Total Dissolved Solids	mg/L	320
UA	G403	C	2017/10/28	Total Dissolved Solids	mg/L	340
UA	G403	C	2018/05/12	Total Dissolved Solids	mg/L	310
UA	G403	C	2018/08/04	Total Dissolved Solids	mg/L	360
UA	G403	C	2019/01/24	Total Dissolved Solids	mg/L	360
UA	G403	C	2019/08/19	Total Dissolved Solids	mg/L	360
UA	G403	C	2020/01/22	Total Dissolved Solids	mg/L	270
UA	G403	C	2020/08/12	Total Dissolved Solids	mg/L	330
UA	G403	C	2020/10/13	Total Dissolved Solids	mg/L	400
UA	G403	C	2021/01/21	Total Dissolved Solids	mg/L	330
UA	G403	C	2021/04/26	Total Dissolved Solids	mg/L	320
UA	G403	C	2021/08/17	Total Dissolved Solids	mg/L	470
UA	G403	C	2021/10/26	Total Dissolved Solids	mg/L	360
UA	G403	C	2022/02/08	Total Dissolved Solids	mg/L	400
UA	G403	C	2022/05/10	Total Dissolved Solids	mg/L	470
UA	G403	C	2022/08/24	Total Dissolved Solids	mg/L	400
UA	G403	C	2022/11/09	Total Dissolved Solids	mg/L	430
UA	G403	C	2023/02/15	Total Dissolved Solids	mg/L	480
UA	G403	C	2023/06/07	Total Dissolved Solids	mg/L	400
UA	G403	C	2023/08/11	Total Dissolved Solids	mg/L	412
UA	G403	C	2023/11/20	Total Dissolved Solids	mg/L	508
UA	G404	C	2015/11/21	pH (field)	SU	6.7
UA	G404	C	2016/02/15	pH (field)	SU	7.2
UA	G404	C	2016/05/19	pH (field)	SU	6.8
UA	G404	C	2016/08/02	pH (field)	SU	7.1
UA	G404	C	2016/11/22	pH (field)	SU	7.1
UA	G404	C	2017/02/18	pH (field)	SU	7.1
UA	G404	C	2017/05/16	pH (field)	SU	7.2
UA	G404	C	2017/07/14	pH (field)	SU	7.1
UA	G404	C	2017/10/28	pH (field)	SU	6.9
UA	G404	C	2018/05/12	pH (field)	SU	7.1
UA	G404	C	2018/08/04	pH (field)	SU	7.2
UA	G404	C	2019/01/24	pH (field)	SU	7.1
UA	G404	C	2019/08/16	pH (field)	SU	7.1
UA	G404	C	2020/01/22	pH (field)	SU	7.2
UA	G404	C	2020/08/12	pH (field)	SU	6.8
UA	G404	C	2020/10/13	pH (field)	SU	6.7
UA	G404	C	2021/01/21	pH (field)	SU	6.6
UA	G404	C	2021/04/27	pH (field)	SU	6.8
UA	G404	C	2021/08/17	pH (field)	SU	6.7
UA	G404	C	2021/10/26	pH (field)	SU	6.6
UA	G404	C	2022/02/08	pH (field)	SU	6.9

UA	G404	C	2022/05/10	pH (field)	SU	6.6
UA	G404	C	2022/08/24	pH (field)	SU	6.5
UA	G404	C	2022/11/09	pH (field)	SU	6.4
UA	G404	C	2023/02/14	pH (field)	SU	6.8
UA	G404	C	2023/06/07	pH (field)	SU	6.8
UA	G404	C	2023/08/14	pH (field)	SU	6.8
UA	G404	C	2023/11/21	pH (field)	SU	6.7
UA	G404	C	2015/10/07	pH (field)	SU	7.5
UA	G404	C	2015/11/21	Oxidation Reduction Potential	mV	28.0
UA	G404	C	2016/02/15	Oxidation Reduction Potential	mV	83.0
UA	G404	C	2016/05/19	Oxidation Reduction Potential	mV	-10.0
UA	G404	C	2016/08/02	Oxidation Reduction Potential	mV	-63.0
UA	G404	C	2016/11/22	Oxidation Reduction Potential	mV	-60.0
UA	G404	C	2017/02/18	Oxidation Reduction Potential	mV	-68.0
UA	G404	C	2017/05/16	Oxidation Reduction Potential	mV	-61.0
UA	G404	C	2017/07/14	Oxidation Reduction Potential	mV	-74.0
UA	G404	C	2017/10/28	Oxidation Reduction Potential	mV	-58.0
UA	G404	C	2018/05/12	Oxidation Reduction Potential	mV	-50.0
UA	G404	C	2018/08/04	Oxidation Reduction Potential	mV	-59.0
UA	G404	C	2019/01/24	Oxidation Reduction Potential	mV	-71.0
UA	G404	C	2019/08/16	Oxidation Reduction Potential	mV	-64.0
UA	G404	C	2020/01/22	Oxidation Reduction Potential	mV	200
UA	G404	C	2020/08/12	Oxidation Reduction Potential	mV	108
UA	G404	C	2020/10/13	Oxidation Reduction Potential	mV	95.2
UA	G404	C	2021/01/21	Oxidation Reduction Potential	mV	139
UA	G404	C	2021/04/27	Oxidation Reduction Potential	mV	116
UA	G404	C	2021/08/17	Oxidation Reduction Potential	mV	59.0
UA	G404	C	2021/10/26	Oxidation Reduction Potential	mV	43.2
UA	G404	C	2022/02/08	Oxidation Reduction Potential	mV	229
UA	G404	C	2022/05/10	Oxidation Reduction Potential	mV	92.3
UA	G404	C	2022/08/24	Oxidation Reduction Potential	mV	26.0
UA	G404	C	2022/11/09	Oxidation Reduction Potential	mV	108
UA	G404	C	2023/02/14	Oxidation Reduction Potential	mV	304
UA	G404	C	2023/06/07	Oxidation Reduction Potential	mV	79.2
UA	G404	C	2023/08/14	Oxidation Reduction Potential	mV	66.0
UA	G404	C	2023/11/21	Oxidation Reduction Potential	mV	85.0
UA	G404	C	2015/11/21	Eh	V	0.22
UA	G404	C	2016/02/15	Eh	V	0.28
UA	G404	C	2016/05/19	Eh	V	0.18
UA	G404	C	2016/08/02	Eh	V	0.13
UA	G404	C	2016/11/22	Eh	V	0.13
UA	G404	C	2017/02/18	Eh	V	0.13
UA	G404	C	2017/05/16	Eh	V	0.13
UA	G404	C	2017/07/14	Eh	V	0.12
UA	G404	C	2017/10/28	Eh	V	0.14
UA	G404	C	2018/05/12	Eh	V	0.15
UA	G404	C	2018/08/04	Eh	V	0.14
UA	G404	C	2019/01/24	Eh	V	0.13
UA	G404	C	2019/08/16	Eh	V	0.13
UA	G404	C	2020/01/22	Eh	V	0.40
UA	G404	C	2020/08/12	Eh	V	0.30
UA	G404	C	2020/10/13	Eh	V	0.29
UA	G404	C	2021/01/21	Eh	V	0.34
UA	G404	C	2021/04/27	Eh	V	0.31
UA	G404	C	2021/08/17	Eh	V	0.25
UA	G404	C	2021/10/26	Eh	V	0.24
UA	G404	C	2022/02/08	Eh	V	0.43
UA	G404	C	2022/05/10	Eh	V	0.29
UA	G404	C	2022/08/24	Eh	V	0.22
UA	G404	C	2022/11/09	Eh	V	0.30
UA	G404	C	2023/02/14	Eh	V	0.50
UA	G404	C	2023/06/07	Eh	V	0.27
UA	G404	C	2023/08/14	Eh	V	0.26

UA	G404	C	2023/11/21	Eh	V	0.28
UA	G404	C	2017/07/14	Alkalinity, bicarbonate	mg/L CaCO3	420
UA	G404	C	2020/01/22	Alkalinity, bicarbonate	mg/L CaCO3	330
UA	G404	C	2021/01/21	Alkalinity, bicarbonate	mg/L CaCO3	320
UA	G404	C	2021/08/17	Alkalinity, bicarbonate	mg/L CaCO3	350
UA	G404	C	2022/02/08	Alkalinity, bicarbonate	mg/L CaCO3	310
UA	G404	C	2022/08/24	Alkalinity, bicarbonate	mg/L CaCO3	390
UA	G404	C	2023/02/14	Alkalinity, bicarbonate	mg/L CaCO3	290
UA	G404	C	2023/06/07	Alkalinity, bicarbonate	mg/L CaCO3	390
UA	G404	C	2023/08/14	Alkalinity, bicarbonate	mg/L CaCO3	348
UA	G404	C	2023/11/21	Alkalinity, bicarbonate	mg/L CaCO3	326
UA	G404	C	2022/08/24	Alkalinity, carbonate	mg/L CaCO3	10.0
UA	G404	C	2015/11/21	Barium, total	mg/L	0.0500
UA	G404	C	2016/02/15	Barium, total	mg/L	0.0430
UA	G404	C	2016/05/19	Barium, total	mg/L	0.0410
UA	G404	C	2016/08/02	Barium, total	mg/L	0.0550
UA	G404	C	2016/11/22	Barium, total	mg/L	0.0520
UA	G404	C	2017/02/18	Barium, total	mg/L	0.0440
UA	G404	C	2017/05/16	Barium, total	mg/L	0.0610
UA	G404	C	2017/07/14	Barium, total	mg/L	0.0420
UA	G404	C	2018/05/12	Barium, total	mg/L	0.0420
UA	G404	C	2018/08/04	Barium, total	mg/L	0.0360
UA	G404	C	2019/01/24	Barium, total	mg/L	0.0370
UA	G404	C	2019/08/16	Barium, total	mg/L	0.0500
UA	G404	C	2020/01/22	Barium, total	mg/L	0.0330
UA	G404	C	2020/08/12	Barium, total	mg/L	0.0370
UA	G404	C	2020/10/13	Barium, total	mg/L	0.0370
UA	G404	C	2021/01/21	Barium, total	mg/L	0.0420
UA	G404	C	2021/04/27	Barium, total	mg/L	0.0400
UA	G404	C	2021/08/17	Barium, total	mg/L	0.0480
UA	G404	C	2021/10/26	Barium, total	mg/L	0.0360
UA	G404	C	2022/02/08	Barium, total	mg/L	0.0280
UA	G404	C	2022/05/10	Barium, total	mg/L	0.0270
UA	G404	C	2022/08/24	Barium, total	mg/L	0.0290
UA	G404	C	2022/11/09	Barium, total	mg/L	0.0220
UA	G404	C	2023/02/14	Barium, total	mg/L	0.0170
UA	G404	C	2023/06/07	Barium, total	mg/L	0.0190
UA	G404	C	2023/08/14	Barium, total	mg/L	0.0420
UA	G404	C	2023/11/21	Barium, total	mg/L	0.0369
UA	G404	C	2015/10/07	Barium, total	mg/L	0.0450
UA	G404	C	2015/11/21	Boron, total	mg/L	2.10
UA	G404	C	2016/02/15	Boron, total	mg/L	1.60
UA	G404	C	2016/05/19	Boron, total	mg/L	1.40
UA	G404	C	2016/08/02	Boron, total	mg/L	3.20
UA	G404	C	2016/11/22	Boron, total	mg/L	3.40
UA	G404	C	2017/02/18	Boron, total	mg/L	2.80
UA	G404	C	2017/05/16	Boron, total	mg/L	1.60
UA	G404	C	2017/07/14	Boron, total	mg/L	5.50
UA	G404	C	2017/10/28	Boron, total	mg/L	5.80
UA	G404	C	2018/05/12	Boron, total	mg/L	4.10
UA	G404	C	2018/08/04	Boron, total	mg/L	4.80
UA	G404	C	2019/01/24	Boron, total	mg/L	2.80
UA	G404	C	2019/08/16	Boron, total	mg/L	2.90
UA	G404	C	2020/01/22	Boron, total	mg/L	2.90
UA	G404	C	2020/08/12	Boron, total	mg/L	2.80
UA	G404	C	2020/10/13	Boron, total	mg/L	3.90
UA	G404	C	2021/01/21	Boron, total	mg/L	2.60
UA	G404	C	2021/04/27	Boron, total	mg/L	3.00
UA	G404	C	2021/08/17	Boron, total	mg/L	5.40
UA	G404	C	2021/10/26	Boron, total	mg/L	5.00
UA	G404	C	2022/02/08	Boron, total	mg/L	5.00
UA	G404	C	2022/05/10	Boron, total	mg/L	5.60
UA	G404	C	2022/08/24	Boron, total	mg/L	13.0

UA	G404	C	2022/11/09	Boron, total	mg/L	15.0
UA	G404	C	2023/02/14	Boron, total	mg/L	9.00
UA	G404	C	2023/06/07	Boron, total	mg/L	9.30
UA	G404	C	2023/08/14	Boron, total	mg/L	14.4
UA	G404	C	2023/11/21	Boron, total	mg/L	21.2
UA	G404	C	2015/10/07	Boron, total	mg/L	4.70
UA	G404	C	2015/11/21	Calcium, total	mg/L	110
UA	G404	C	2016/02/15	Calcium, total	mg/L	110
UA	G404	C	2016/05/19	Calcium, total	mg/L	89.0
UA	G404	C	2016/08/02	Calcium, total	mg/L	120
UA	G404	C	2016/11/22	Calcium, total	mg/L	120
UA	G404	C	2017/02/18	Calcium, total	mg/L	120
UA	G404	C	2017/05/16	Calcium, total	mg/L	110
UA	G404	C	2017/07/14	Calcium, total	mg/L	160
UA	G404	C	2017/10/28	Calcium, total	mg/L	160
UA	G404	C	2018/05/12	Calcium, total	mg/L	150
UA	G404	C	2018/08/04	Calcium, total	mg/L	180
UA	G404	C	2019/01/24	Calcium, total	mg/L	120
UA	G404	C	2019/08/16	Calcium, total	mg/L	110
UA	G404	C	2020/01/22	Calcium, total	mg/L	150
UA	G404	C	2020/08/12	Calcium, total	mg/L	140
UA	G404	C	2020/10/13	Calcium, total	mg/L	170
UA	G404	C	2021/01/21	Calcium, total	mg/L	160
UA	G404	C	2021/04/27	Calcium, total	mg/L	180
UA	G404	C	2021/08/17	Calcium, total	mg/L	240
UA	G404	C	2021/10/26	Calcium, total	mg/L	200
UA	G404	C	2022/02/08	Calcium, total	mg/L	200
UA	G404	C	2022/05/10	Calcium, total	mg/L	230
UA	G404	C	2022/08/24	Calcium, total	mg/L	290
UA	G404	C	2022/11/09	Calcium, total	mg/L	250
UA	G404	C	2023/02/14	Calcium, total	mg/L	180
UA	G404	C	2023/06/07	Calcium, total	mg/L	230
UA	G404	C	2023/08/14	Calcium, total	mg/L	216
UA	G404	C	2023/11/21	Calcium, total	mg/L	273
UA	G404	C	2015/11/21	Chloride, total	mg/L	53.0
UA	G404	C	2016/02/15	Chloride, total	mg/L	49.0
UA	G404	C	2016/05/19	Chloride, total	mg/L	46.0
UA	G404	C	2016/08/02	Chloride, total	mg/L	62.0
UA	G404	C	2016/11/22	Chloride, total	mg/L	61.0
UA	G404	C	2017/02/18	Chloride, total	mg/L	62.0
UA	G404	C	2017/05/16	Chloride, total	mg/L	64.0
UA	G404	C	2017/07/14	Chloride, total	mg/L	68.0
UA	G404	C	2017/10/28	Chloride, total	mg/L	57.0
UA	G404	C	2018/05/12	Chloride, total	mg/L	82.0
UA	G404	C	2018/08/04	Chloride, total	mg/L	69.0
UA	G404	C	2019/01/24	Chloride, total	mg/L	100
UA	G404	C	2019/08/16	Chloride, total	mg/L	100
UA	G404	C	2020/01/22	Chloride, total	mg/L	190
UA	G404	C	2020/08/12	Chloride, total	mg/L	170
UA	G404	C	2020/10/13	Chloride, total	mg/L	160
UA	G404	C	2021/01/21	Chloride, total	mg/L	190
UA	G404	C	2021/04/27	Chloride, total	mg/L	200
UA	G404	C	2021/08/17	Chloride, total	mg/L	190
UA	G404	C	2021/10/26	Chloride, total	mg/L	190
UA	G404	C	2022/02/08	Chloride, total	mg/L	160
UA	G404	C	2022/05/10	Chloride, total	mg/L	150
UA	G404	C	2022/08/24	Chloride, total	mg/L	120
UA	G404	C	2022/11/09	Chloride, total	mg/L	110
UA	G404	C	2023/02/14	Chloride, total	mg/L	74.0
UA	G404	C	2023/06/07	Chloride, total	mg/L	140
UA	G404	C	2023/08/14	Chloride, total	mg/L	73.0
UA	G404	C	2023/11/21	Chloride, total	mg/L	71.0
UA	G404	C	2015/10/07	Chloride, total	mg/L	33.0

UA	G404	C	2015/11/21	Cobalt, total	mg/L	<0.000017
UA	G404	C	2016/02/15	Cobalt, total	mg/L	<0.000017
UA	G404	C	2016/05/19	Cobalt, total	mg/L	<0.000017
UA	G404	C	2016/08/02	Cobalt, total	mg/L	<0.000017
UA	G404	C	2016/11/22	Cobalt, total	mg/L	<0.000017
UA	G404	C	2017/02/18	Cobalt, total	mg/L	<0.000017
UA	G404	C	2017/05/16	Cobalt, total	mg/L	<0.000017
UA	G404	C	2017/07/14	Cobalt, total	mg/L	<0.000017
UA	G404	C	2018/05/12	Cobalt, total	mg/L	<0.00086
UA	G404	C	2018/08/04	Cobalt, total	mg/L	<0.00067
UA	G404	C	2019/01/24	Cobalt, total	mg/L	<0.00067
UA	G404	C	2019/08/16	Cobalt, total	mg/L	0.00290
UA	G404	C	2020/01/22	Cobalt, total	mg/L	<0.00067
UA	G404	C	2020/08/12	Cobalt, total	mg/L	<0.00022
UA	G404	C	2020/10/13	Cobalt, total	mg/L	<0.002
UA	G404	C	2021/01/21	Cobalt, total	mg/L	<0.00022
UA	G404	C	2021/04/27	Cobalt, total	mg/L	<0.002
UA	G404	C	2021/08/17	Cobalt, total	mg/L	<0.00022
UA	G404	C	2021/10/26	Cobalt, total	mg/L	<0.002
UA	G404	C	2022/02/08	Cobalt, total	mg/L	<0.00019
UA	G404	C	2022/05/10	Cobalt, total	mg/L	<0.00048
UA	G404	C	2022/08/24	Cobalt, total	mg/L	<0.00048
UA	G404	C	2022/11/09	Cobalt, total	mg/L	<0.00048
UA	G404	C	2023/02/14	Cobalt, total	mg/L	<0.00048
UA	G404	C	2023/06/07	Cobalt, total	mg/L	<0.00048
UA	G404	C	2023/08/14	Cobalt, total	mg/L	0.00330
UA	G404	C	2023/11/21	Cobalt, total	mg/L	0.000600
UA	G404	C	2015/10/07	Cobalt, total	mg/L	<0.002
UA	G404	C	2023/06/07	Ferrous Iron, dissolved	mg/L	0.100
UA	G404	C	2020/08/12	Iron, dissolved	mg/L	0.0330
UA	G404	C	2020/10/13	Iron, dissolved	mg/L	0.130
UA	G404	C	2021/01/21	Iron, dissolved	mg/L	0.0300
UA	G404	C	2021/04/27	Iron, dissolved	mg/L	<0.01
UA	G404	C	2021/08/17	Iron, dissolved	mg/L	0.160
UA	G404	C	2021/10/26	Iron, dissolved	mg/L	0.820
UA	G404	C	2022/02/08	Iron, dissolved	mg/L	0.210
UA	G404	C	2022/05/10	Iron, dissolved	mg/L	0.400
UA	G404	C	2022/08/24	Iron, dissolved	mg/L	0.750
UA	G404	C	2022/11/09	Iron, dissolved	mg/L	0.0490
UA	G404	C	2023/02/14	Iron, dissolved	mg/L	<0.00072
UA	G404	C	2023/06/07	Iron, dissolved	mg/L	0.0580
UA	G404	C	2023/08/14	Iron, dissolved	mg/L	0.0718
UA	G404	C	2023/11/21	Iron, dissolved	mg/L	0.0944
UA	G404	C	2015/10/07	Iron, dissolved	mg/L	0.530
UA	G404	C	2017/07/14	Magnesium, total	mg/L	89.0
UA	G404	C	2020/01/22	Magnesium, total	mg/L	73.0
UA	G404	C	2021/01/21	Magnesium, total	mg/L	71.0
UA	G404	C	2021/08/17	Magnesium, total	mg/L	110
UA	G404	C	2022/02/08	Magnesium, total	mg/L	97.0
UA	G404	C	2022/08/24	Magnesium, total	mg/L	130
UA	G404	C	2023/02/14	Magnesium, total	mg/L	80.0
UA	G404	C	2023/06/07	Magnesium, total	mg/L	110
UA	G404	C	2023/08/14	Magnesium, total	mg/L	95.7
UA	G404	C	2023/11/21	Magnesium, total	mg/L	124
UA	G404	C	2018/03/03	Manganese, dissolved	mg/L	0.520
UA	G404	C	2018/05/12	Manganese, dissolved	mg/L	0.0220
UA	G404	C	2018/08/11	Manganese, dissolved	mg/L	1.50
UA	G404	C	2018/11/06	Manganese, dissolved	mg/L	0.290
UA	G404	C	2019/01/24	Manganese, dissolved	mg/L	0.0610
UA	G404	C	2019/05/02	Manganese, dissolved	mg/L	0.00960
UA	G404	C	2019/08/16	Manganese, dissolved	mg/L	0.170
UA	G404	C	2019/10/21	Manganese, dissolved	mg/L	0.300
UA	G404	C	2020/01/22	Manganese, dissolved	mg/L	0.0320

UA	G404	C	2020/05/06	Manganese, dissolved	mg/L	0.0820
UA	G404	C	2020/08/12	Manganese, dissolved	mg/L	0.330
UA	G404	C	2020/10/13	Manganese, dissolved	mg/L	0.300
UA	G404	C	2021/01/21	Manganese, dissolved	mg/L	0.150
UA	G404	C	2021/04/27	Manganese, dissolved	mg/L	0.200
UA	G404	C	2021/08/17	Manganese, dissolved	mg/L	0.920
UA	G404	C	2021/10/26	Manganese, dissolved	mg/L	1.20
UA	G404	C	2022/02/08	Manganese, dissolved	mg/L	0.100
UA	G404	C	2022/05/10	Manganese, dissolved	mg/L	0.180
UA	G404	C	2022/08/24	Manganese, dissolved	mg/L	1.40
UA	G404	C	2022/11/09	Manganese, dissolved	mg/L	1.80
UA	G404	C	2023/02/14	Manganese, dissolved	mg/L	0.330
UA	G404	C	2023/06/07	Manganese, dissolved	mg/L	1.20
UA	G404	C	2023/08/14	Manganese, dissolved	mg/L	2.85
UA	G404	C	2023/11/21	Manganese, dissolved	mg/L	1.46
UA	G404	C	2015/10/07	Manganese, dissolved	mg/L	0.330
UA	G404	C	2023/08/14	Phosphate, dissolved	mg/L	<0.005
UA	G404	C	2017/07/14	Potassium, total	mg/L	1.20
UA	G404	C	2020/01/22	Potassium, total	mg/L	0.330
UA	G404	C	2021/01/21	Potassium, total	mg/L	0.280
UA	G404	C	2021/08/17	Potassium, total	mg/L	0.480
UA	G404	C	2022/02/08	Potassium, total	mg/L	0.420
UA	G404	C	2022/08/24	Potassium, total	mg/L	0.720
UA	G404	C	2023/02/14	Potassium, total	mg/L	0.230
UA	G404	C	2023/06/07	Potassium, total	mg/L	0.430
UA	G404	C	2023/08/14	Potassium, total	mg/L	0.627
UA	G404	C	2023/11/21	Potassium, total	mg/L	0.594
UA	G404	C	2023/06/07	Silicon, dissolved	mg/L	11.0
UA	G404	C	2023/08/14	Silicon, dissolved	mg/L	10.2
UA	G404	C	2017/07/14	Sodium, total	mg/L	64.0
UA	G404	C	2020/01/22	Sodium, total	mg/L	58.0
UA	G404	C	2021/01/21	Sodium, total	mg/L	56.0
UA	G404	C	2021/08/17	Sodium, total	mg/L	87.0
UA	G404	C	2022/02/08	Sodium, total	mg/L	72.0
UA	G404	C	2022/08/24	Sodium, total	mg/L	96.0
UA	G404	C	2023/02/14	Sodium, total	mg/L	70.0
UA	G404	C	2023/06/07	Sodium, total	mg/L	81.0
UA	G404	C	2023/08/14	Sodium, total	mg/L	78.6
UA	G404	C	2023/11/21	Sodium, total	mg/L	94.0
UA	G404	C	2015/11/21	Sulfate, total	mg/L	180
UA	G404	C	2016/02/15	Sulfate, total	mg/L	150
UA	G404	C	2016/05/19	Sulfate, total	mg/L	140
UA	G404	C	2016/08/02	Sulfate, total	mg/L	190
UA	G404	C	2016/11/22	Sulfate, total	mg/L	380
UA	G404	C	2017/02/18	Sulfate, total	mg/L	230
UA	G404	C	2017/05/16	Sulfate, total	mg/L	160
UA	G404	C	2017/07/14	Sulfate, total	mg/L	310
UA	G404	C	2017/10/28	Sulfate, total	mg/L	390
UA	G404	C	2018/05/12	Sulfate, total	mg/L	370
UA	G404	C	2018/08/04	Sulfate, total	mg/L	410
UA	G404	C	2019/01/24	Sulfate, total	mg/L	220
UA	G404	C	2019/08/16	Sulfate, total	mg/L	170
UA	G404	C	2020/01/22	Sulfate, total	mg/L	200
UA	G404	C	2020/08/12	Sulfate, total	mg/L	190
UA	G404	C	2020/10/13	Sulfate, total	mg/L	280
UA	G404	C	2021/01/21	Sulfate, total	mg/L	200
UA	G404	C	2021/04/27	Sulfate, total	mg/L	250
UA	G404	C	2021/08/17	Sulfate, total	mg/L	470
UA	G404	C	2021/10/26	Sulfate, total	mg/L	500
UA	G404	C	2022/02/08	Sulfate, total	mg/L	480
UA	G404	C	2022/05/10	Sulfate, total	mg/L	520
UA	G404	C	2022/08/24	Sulfate, total	mg/L	810
UA	G404	C	2022/11/09	Sulfate, total	mg/L	840

UA	G404	C	2023/02/14	Sulfate, total	mg/L	510
UA	G404	C	2023/06/07	Sulfate, total	mg/L	700
UA	G404	C	2023/08/14	Sulfate, total	mg/L	678
UA	G404	C	2023/11/21	Sulfate, total	mg/L	647
UA	G404	C	2015/10/07	Sulfate, total	mg/L	290
UA	G404	C	2015/11/21	Temperature (Celsius)	degrees C	17.0
UA	G404	C	2016/02/15	Temperature (Celsius)	degrees C	8.10
UA	G404	C	2016/05/19	Temperature (Celsius)	degrees C	18.7
UA	G404	C	2016/08/02	Temperature (Celsius)	degrees C	19.5
UA	G404	C	2016/11/22	Temperature (Celsius)	degrees C	16.0
UA	G404	C	2017/02/18	Temperature (Celsius)	degrees C	15.9
UA	G404	C	2017/05/16	Temperature (Celsius)	degrees C	15.4
UA	G404	C	2017/07/14	Temperature (Celsius)	degrees C	18.7
UA	G404	C	2017/10/28	Temperature (Celsius)	degrees C	13.6
UA	G404	C	2018/05/12	Temperature (Celsius)	degrees C	14.4
UA	G404	C	2018/08/04	Temperature (Celsius)	degrees C	15.5
UA	G404	C	2019/01/24	Temperature (Celsius)	degrees C	11.3
UA	G404	C	2019/08/16	Temperature (Celsius)	degrees C	17.0
UA	G404	C	2020/01/22	Temperature (Celsius)	degrees C	7.60
UA	G404	C	2020/08/12	Temperature (Celsius)	degrees C	22.9
UA	G404	C	2020/10/13	Temperature (Celsius)	degrees C	18.8
UA	G404	C	2021/01/21	Temperature (Celsius)	degrees C	10.7
UA	G404	C	2021/04/27	Temperature (Celsius)	degrees C	17.6
UA	G404	C	2021/08/17	Temperature (Celsius)	degrees C	24.4
UA	G404	C	2021/10/26	Temperature (Celsius)	degrees C	18.6
UA	G404	C	2022/02/08	Temperature (Celsius)	degrees C	8.90
UA	G404	C	2022/05/10	Temperature (Celsius)	degrees C	18.1
UA	G404	C	2022/08/24	Temperature (Celsius)	degrees C	22.7
UA	G404	C	2022/11/09	Temperature (Celsius)	degrees C	19.8
UA	G404	C	2023/02/14	Temperature (Celsius)	degrees C	10.7
UA	G404	C	2023/06/07	Temperature (Celsius)	degrees C	17.3
UA	G404	C	2023/08/14	Temperature (Celsius)	degrees C	19.4
UA	G404	C	2023/11/21	Temperature (Celsius)	degrees C	13.7
UA	G404	C	2015/11/21	Total Dissolved Solids	mg/L	580
UA	G404	C	2016/02/15	Total Dissolved Solids	mg/L	560
UA	G404	C	2016/05/19	Total Dissolved Solids	mg/L	460
UA	G404	C	2016/08/02	Total Dissolved Solids	mg/L	620
UA	G404	C	2016/11/22	Total Dissolved Solids	mg/L	880
UA	G404	C	2017/02/18	Total Dissolved Solids	mg/L	740
UA	G404	C	2017/05/16	Total Dissolved Solids	mg/L	640
UA	G404	C	2017/07/14	Total Dissolved Solids	mg/L	860
UA	G404	C	2017/10/28	Total Dissolved Solids	mg/L	950
UA	G404	C	2018/05/12	Total Dissolved Solids	mg/L	1,000
UA	G404	C	2018/08/04	Total Dissolved Solids	mg/L	1,000
UA	G404	C	2019/01/24	Total Dissolved Solids	mg/L	720
UA	G404	C	2019/08/16	Total Dissolved Solids	mg/L	600
UA	G404	C	2020/01/22	Total Dissolved Solids	mg/L	700
UA	G404	C	2020/08/12	Total Dissolved Solids	mg/L	720
UA	G404	C	2020/10/13	Total Dissolved Solids	mg/L	1,200
UA	G404	C	2021/01/21	Total Dissolved Solids	mg/L	910
UA	G404	C	2021/04/27	Total Dissolved Solids	mg/L	1,200
UA	G404	C	2021/08/17	Total Dissolved Solids	mg/L	1,500
UA	G404	C	2021/10/26	Total Dissolved Solids	mg/L	1,400
UA	G404	C	2022/02/08	Total Dissolved Solids	mg/L	1,300
UA	G404	C	2022/05/10	Total Dissolved Solids	mg/L	1,500
UA	G404	C	2022/08/24	Total Dissolved Solids	mg/L	1,800
UA	G404	C	2022/11/09	Total Dissolved Solids	mg/L	1,900
UA	G404	C	2023/02/14	Total Dissolved Solids	mg/L	1,200
UA	G404	C	2023/06/07	Total Dissolved Solids	mg/L	1,300
UA	G404	C	2023/08/14	Total Dissolved Solids	mg/L	1,600
UA	G404	C	2023/11/21	Total Dissolved Solids	mg/L	1,370
UA	G404	C	2015/10/07	Total Dissolved Solids	mg/L	860
UA	G405	C	2015/11/21	pH (field)	SU	6.8

UA	G405	C	2016/02/15	pH (field)	SU	7.1
UA	G405	C	2016/05/18	pH (field)	SU	6.9
UA	G405	C	2016/08/02	pH (field)	SU	6.8
UA	G405	C	2016/11/22	pH (field)	SU	6.9
UA	G405	C	2017/02/18	pH (field)	SU	7.0
UA	G405	C	2017/05/16	pH (field)	SU	7.1
UA	G405	C	2017/07/14	pH (field)	SU	6.8
UA	G405	C	2017/10/28	pH (field)	SU	7.0
UA	G405	C	2018/05/12	pH (field)	SU	6.9
UA	G405	C	2018/08/04	pH (field)	SU	6.6
UA	G405	C	2019/01/25	pH (field)	SU	6.6
UA	G405	C	2019/08/20	pH (field)	SU	6.7
UA	G405	C	2020/01/22	pH (field)	SU	7.0
UA	G405	C	2020/08/12	pH (field)	SU	7.0
UA	G405	C	2020/10/13	pH (field)	SU	7.0
UA	G405	C	2021/01/21	pH (field)	SU	6.9
UA	G405	C	2021/04/27	pH (field)	SU	7.0
UA	G405	C	2021/08/17	pH (field)	SU	7.0
UA	G405	C	2021/10/26	pH (field)	SU	6.9
UA	G405	C	2022/02/08	pH (field)	SU	7.0
UA	G405	C	2022/05/10	pH (field)	SU	7.0
UA	G405	C	2022/08/24	pH (field)	SU	6.7
UA	G405	C	2022/11/09	pH (field)	SU	6.8
UA	G405	C	2023/02/14	pH (field)	SU	7.0
UA	G405	C	2023/06/06	pH (field)	SU	6.8
UA	G405	C	2023/08/11	pH (field)	SU	7.1
UA	G405	C	2023/11/21	pH (field)	SU	7.0
UA	G405	C	2015/10/07	pH (field)	SU	7.4
UA	G405	C	2015/11/21	Oxidation Reduction Potential	mV	23.0
UA	G405	C	2016/02/15	Oxidation Reduction Potential	mV	93.0
UA	G405	C	2016/05/18	Oxidation Reduction Potential	mV	5.00
UA	G405	C	2016/08/02	Oxidation Reduction Potential	mV	23.0
UA	G405	C	2016/11/22	Oxidation Reduction Potential	mV	34.0
UA	G405	C	2017/02/18	Oxidation Reduction Potential	mV	50.0
UA	G405	C	2017/05/16	Oxidation Reduction Potential	mV	57.0
UA	G405	C	2017/07/14	Oxidation Reduction Potential	mV	30.0
UA	G405	C	2017/10/28	Oxidation Reduction Potential	mV	18.0
UA	G405	C	2018/05/12	Oxidation Reduction Potential	mV	21.0
UA	G405	C	2018/08/04	Oxidation Reduction Potential	mV	57.0
UA	G405	C	2019/01/25	Oxidation Reduction Potential	mV	58.0
UA	G405	C	2019/08/20	Oxidation Reduction Potential	mV	62.0
UA	G405	C	2020/01/22	Oxidation Reduction Potential	mV	120
UA	G405	C	2020/08/12	Oxidation Reduction Potential	mV	48.5
UA	G405	C	2020/10/13	Oxidation Reduction Potential	mV	83.9
UA	G405	C	2021/01/21	Oxidation Reduction Potential	mV	75.6
UA	G405	C	2021/04/27	Oxidation Reduction Potential	mV	59.4
UA	G405	C	2021/08/17	Oxidation Reduction Potential	mV	57.2
UA	G405	C	2021/10/26	Oxidation Reduction Potential	mV	43.0
UA	G405	C	2022/02/08	Oxidation Reduction Potential	mV	152
UA	G405	C	2022/05/10	Oxidation Reduction Potential	mV	86.4
UA	G405	C	2022/08/24	Oxidation Reduction Potential	mV	38.0
UA	G405	C	2022/11/09	Oxidation Reduction Potential	mV	25.0
UA	G405	C	2023/02/14	Oxidation Reduction Potential	mV	295
UA	G405	C	2023/06/06	Oxidation Reduction Potential	mV	68.0
UA	G405	C	2023/08/11	Oxidation Reduction Potential	mV	-21.0
UA	G405	C	2023/11/21	Oxidation Reduction Potential	mV	76.0
UA	G405	C	2015/11/21	Eh	V	0.22
UA	G405	C	2016/02/15	Eh	V	0.29
UA	G405	C	2016/05/18	Eh	V	0.20
UA	G405	C	2016/08/02	Eh	V	0.22
UA	G405	C	2016/11/22	Eh	V	0.23
UA	G405	C	2017/02/18	Eh	V	0.25
UA	G405	C	2017/05/16	Eh	V	0.25

UA	G405	C	2017/07/14	Eh	V	0.22
UA	G405	C	2017/10/28	Eh	V	0.21
UA	G405	C	2018/05/12	Eh	V	0.22
UA	G405	C	2018/08/04	Eh	V	0.25
UA	G405	C	2019/01/25	Eh	V	0.26
UA	G405	C	2019/08/20	Eh	V	0.26
UA	G405	C	2020/01/22	Eh	V	0.32
UA	G405	C	2020/08/12	Eh	V	0.24
UA	G405	C	2020/10/13	Eh	V	0.28
UA	G405	C	2021/01/21	Eh	V	0.27
UA	G405	C	2021/04/27	Eh	V	0.25
UA	G405	C	2021/08/17	Eh	V	0.25
UA	G405	C	2021/10/26	Eh	V	0.24
UA	G405	C	2022/02/08	Eh	V	0.35
UA	G405	C	2022/05/10	Eh	V	0.28
UA	G405	C	2022/08/24	Eh	V	0.23
UA	G405	C	2022/11/09	Eh	V	0.22
UA	G405	C	2023/02/14	Eh	V	0.49
UA	G405	C	2023/06/06	Eh	V	0.26
UA	G405	C	2023/08/11	Eh	V	0.17
UA	G405	C	2023/11/21	Eh	V	0.27
UA	G405	C	2017/07/14	Alkalinity, bicarbonate	mg/L CaCO3	280
UA	G405	C	2020/01/22	Alkalinity, bicarbonate	mg/L CaCO3	280
UA	G405	C	2021/01/21	Alkalinity, bicarbonate	mg/L CaCO3	280
UA	G405	C	2021/08/17	Alkalinity, bicarbonate	mg/L CaCO3	270
UA	G405	C	2022/02/08	Alkalinity, bicarbonate	mg/L CaCO3	250
UA	G405	C	2022/08/24	Alkalinity, bicarbonate	mg/L CaCO3	260
UA	G405	C	2023/02/14	Alkalinity, bicarbonate	mg/L CaCO3	280
UA	G405	C	2023/06/06	Alkalinity, bicarbonate	mg/L CaCO3	280
UA	G405	C	2023/08/11	Alkalinity, bicarbonate	mg/L CaCO3	286
UA	G405	C	2023/11/21	Alkalinity, bicarbonate	mg/L CaCO3	286
UA	G405	C	2022/08/24	Alkalinity, carbonate	mg/L CaCO3	10.0
UA	G405	C	2015/11/21	Barium, total	mg/L	0.0510
UA	G405	C	2016/02/15	Barium, total	mg/L	0.0180
UA	G405	C	2016/05/18	Barium, total	mg/L	0.0200
UA	G405	C	2016/08/02	Barium, total	mg/L	0.0280
UA	G405	C	2016/11/22	Barium, total	mg/L	0.0220
UA	G405	C	2017/02/18	Barium, total	mg/L	0.0210
UA	G405	C	2017/05/16	Barium, total	mg/L	0.0240
UA	G405	C	2017/07/14	Barium, total	mg/L	0.0350
UA	G405	C	2018/05/12	Barium, total	mg/L	0.0260
UA	G405	C	2018/08/04	Barium, total	mg/L	0.0200
UA	G405	C	2019/01/25	Barium, total	mg/L	0.0410
UA	G405	C	2019/08/20	Barium, total	mg/L	0.0360
UA	G405	C	2020/01/22	Barium, total	mg/L	0.0300
UA	G405	C	2020/08/12	Barium, total	mg/L	0.0220
UA	G405	C	2020/10/13	Barium, total	mg/L	0.0220
UA	G405	C	2021/01/21	Barium, total	mg/L	0.0200
UA	G405	C	2021/04/27	Barium, total	mg/L	0.0140
UA	G405	C	2021/08/17	Barium, total	mg/L	0.0150
UA	G405	C	2021/10/26	Barium, total	mg/L	0.0150
UA	G405	C	2022/02/08	Barium, total	mg/L	0.0150
UA	G405	C	2022/05/10	Barium, total	mg/L	0.0150
UA	G405	C	2022/08/24	Barium, total	mg/L	0.0160
UA	G405	C	2022/11/09	Barium, total	mg/L	0.0140
UA	G405	C	2023/02/14	Barium, total	mg/L	0.0200
UA	G405	C	2023/06/06	Barium, total	mg/L	0.0130
UA	G405	C	2023/08/11	Barium, total	mg/L	0.0158
UA	G405	C	2023/11/21	Barium, total	mg/L	0.0259
UA	G405	C	2015/10/07	Barium, total	mg/L	0.0690
UA	G405	C	2015/11/21	Boron, total	mg/L	17.0
UA	G405	C	2016/02/15	Boron, total	mg/L	16.0
UA	G405	C	2016/05/18	Boron, total	mg/L	15.0

UA	G405	C	2016/08/02	Boron, total	mg/L	17.0
UA	G405	C	2016/11/22	Boron, total	mg/L	13.0
UA	G405	C	2017/02/18	Boron, total	mg/L	12.0
UA	G405	C	2017/05/16	Boron, total	mg/L	4.00
UA	G405	C	2017/07/14	Boron, total	mg/L	15.0
UA	G405	C	2017/10/28	Boron, total	mg/L	11.0
UA	G405	C	2018/05/12	Boron, total	mg/L	9.10
UA	G405	C	2018/08/04	Boron, total	mg/L	7.80
UA	G405	C	2019/01/25	Boron, total	mg/L	7.80
UA	G405	C	2019/08/20	Boron, total	mg/L	4.80
UA	G405	C	2020/01/22	Boron, total	mg/L	8.50
UA	G405	C	2020/08/12	Boron, total	mg/L	8.90
UA	G405	C	2020/10/13	Boron, total	mg/L	11.0
UA	G405	C	2021/01/21	Boron, total	mg/L	11.0
UA	G405	C	2021/04/27	Boron, total	mg/L	9.60
UA	G405	C	2021/08/17	Boron, total	mg/L	12.0
UA	G405	C	2021/10/26	Boron, total	mg/L	12.0
UA	G405	C	2022/02/08	Boron, total	mg/L	10.0
UA	G405	C	2022/05/10	Boron, total	mg/L	10.0
UA	G405	C	2022/08/24	Boron, total	mg/L	9.40
UA	G405	C	2022/11/09	Boron, total	mg/L	9.10
UA	G405	C	2023/02/14	Boron, total	mg/L	10.0
UA	G405	C	2023/06/06	Boron, total	mg/L	9.50
UA	G405	C	2023/08/11	Boron, total	mg/L	10.8
UA	G405	C	2023/11/21	Boron, total	mg/L	15.4
UA	G405	C	2015/10/07	Boron, total	mg/L	20.0
UA	G405	C	2015/11/21	Calcium, total	mg/L	330
UA	G405	C	2016/02/15	Calcium, total	mg/L	320
UA	G405	C	2016/05/18	Calcium, total	mg/L	320
UA	G405	C	2016/08/02	Calcium, total	mg/L	280
UA	G405	C	2016/11/22	Calcium, total	mg/L	250
UA	G405	C	2017/02/18	Calcium, total	mg/L	270
UA	G405	C	2017/05/16	Calcium, total	mg/L	190
UA	G405	C	2017/07/14	Calcium, total	mg/L	320
UA	G405	C	2017/10/28	Calcium, total	mg/L	300
UA	G405	C	2018/05/12	Calcium, total	mg/L	260
UA	G405	C	2018/08/04	Calcium, total	mg/L	220
UA	G405	C	2019/01/25	Calcium, total	mg/L	220
UA	G405	C	2019/08/20	Calcium, total	mg/L	140
UA	G405	C	2020/01/22	Calcium, total	mg/L	240
UA	G405	C	2020/08/12	Calcium, total	mg/L	220
UA	G405	C	2020/10/13	Calcium, total	mg/L	220
UA	G405	C	2021/01/21	Calcium, total	mg/L	250
UA	G405	C	2021/04/27	Calcium, total	mg/L	210
UA	G405	C	2021/08/17	Calcium, total	mg/L	250
UA	G405	C	2021/10/26	Calcium, total	mg/L	230
UA	G405	C	2022/02/08	Calcium, total	mg/L	260
UA	G405	C	2022/05/10	Calcium, total	mg/L	280
UA	G405	C	2022/08/24	Calcium, total	mg/L	250
UA	G405	C	2022/11/09	Calcium, total	mg/L	220
UA	G405	C	2023/02/14	Calcium, total	mg/L	260
UA	G405	C	2023/06/06	Calcium, total	mg/L	250
UA	G405	C	2023/08/11	Calcium, total	mg/L	253
UA	G405	C	2023/11/21	Calcium, total	mg/L	248
UA	G405	C	2015/11/21	Chloride, total	mg/L	14.0
UA	G405	C	2016/02/15	Chloride, total	mg/L	11.0
UA	G405	C	2016/05/18	Chloride, total	mg/L	9.30
UA	G405	C	2016/08/02	Chloride, total	mg/L	3.40
UA	G405	C	2016/11/22	Chloride, total	mg/L	19.0
UA	G405	C	2017/02/18	Chloride, total	mg/L	21.0
UA	G405	C	2017/05/16	Chloride, total	mg/L	47.0
UA	G405	C	2017/07/14	Chloride, total	mg/L	20.0
UA	G405	C	2017/10/28	Chloride, total	mg/L	26.0

UA	G405	C	2018/05/12	Chloride, total	mg/L	23.0
UA	G405	C	2018/08/04	Chloride, total	mg/L	22.0
UA	G405	C	2019/01/25	Chloride, total	mg/L	14.0
UA	G405	C	2019/08/20	Chloride, total	mg/L	17.0
UA	G405	C	2020/01/22	Chloride, total	mg/L	10.0
UA	G405	C	2020/08/12	Chloride, total	mg/L	13.0
UA	G405	C	2020/10/13	Chloride, total	mg/L	12.0
UA	G405	C	2021/01/21	Chloride, total	mg/L	5.90
UA	G405	C	2021/04/27	Chloride, total	mg/L	7.00
UA	G405	C	2021/08/17	Chloride, total	mg/L	7.80
UA	G405	C	2021/10/26	Chloride, total	mg/L	11.0
UA	G405	C	2022/02/08	Chloride, total	mg/L	6.20
UA	G405	C	2022/05/10	Chloride, total	mg/L	5.80
UA	G405	C	2022/08/24	Chloride, total	mg/L	6.90
UA	G405	C	2022/11/09	Chloride, total	mg/L	9.10
UA	G405	C	2023/02/14	Chloride, total	mg/L	9.90
UA	G405	C	2023/06/06	Chloride, total	mg/L	8.90
UA	G405	C	2023/08/11	Chloride, total	mg/L	14.0
UA	G405	C	2023/11/21	Chloride, total	mg/L	17.0
UA	G405	C	2015/10/07	Chloride, total	mg/L	7.10
UA	G405	C	2015/11/21	Cobalt, total	mg/L	0.00340
UA	G405	C	2016/02/15	Cobalt, total	mg/L	<0.000017
UA	G405	C	2016/05/18	Cobalt, total	mg/L	<0.000017
UA	G405	C	2016/08/02	Cobalt, total	mg/L	0.00380
UA	G405	C	2016/11/22	Cobalt, total	mg/L	0.00210
UA	G405	C	2017/02/18	Cobalt, total	mg/L	<0.000017
UA	G405	C	2017/05/16	Cobalt, total	mg/L	<0.000017
UA	G405	C	2017/07/14	Cobalt, total	mg/L	0.00260
UA	G405	C	2018/05/12	Cobalt, total	mg/L	0.00300
UA	G405	C	2018/08/04	Cobalt, total	mg/L	<0.00067
UA	G405	C	2019/01/25	Cobalt, total	mg/L	0.00380
UA	G405	C	2019/08/20	Cobalt, total	mg/L	<0.00067
UA	G405	C	2020/01/22	Cobalt, total	mg/L	<0.00067
UA	G405	C	2020/08/12	Cobalt, total	mg/L	<0.00022
UA	G405	C	2020/10/13	Cobalt, total	mg/L	<0.002
UA	G405	C	2021/01/21	Cobalt, total	mg/L	<0.00022
UA	G405	C	2021/04/27	Cobalt, total	mg/L	<0.002
UA	G405	C	2021/08/17	Cobalt, total	mg/L	<0.00022
UA	G405	C	2021/10/26	Cobalt, total	mg/L	<0.002
UA	G405	C	2022/02/08	Cobalt, total	mg/L	<0.00019
UA	G405	C	2022/05/10	Cobalt, total	mg/L	0.00110
UA	G405	C	2022/08/24	Cobalt, total	mg/L	0.00100
UA	G405	C	2022/11/09	Cobalt, total	mg/L	0.000790
UA	G405	C	2023/02/14	Cobalt, total	mg/L	0.00160
UA	G405	C	2023/06/06	Cobalt, total	mg/L	0.000870
UA	G405	C	2023/08/11	Cobalt, total	mg/L	0.00110
UA	G405	C	2023/11/21	Cobalt, total	mg/L	0.00150
UA	G405	C	2015/10/07	Cobalt, total	mg/L	0.00440
UA	G405	C	2023/06/06	Ferrous Iron, dissolved	mg/L	0.250
UA	G405	C	2020/08/12	Iron, dissolved	mg/L	0.0290
UA	G405	C	2020/10/13	Iron, dissolved	mg/L	0.0520
UA	G405	C	2021/01/21	Iron, dissolved	mg/L	0.0390
UA	G405	C	2021/04/27	Iron, dissolved	mg/L	0.0720
UA	G405	C	2021/08/17	Iron, dissolved	mg/L	0.0690
UA	G405	C	2021/10/26	Iron, dissolved	mg/L	0.0690
UA	G405	C	2022/02/08	Iron, dissolved	mg/L	0.0520
UA	G405	C	2022/05/10	Iron, dissolved	mg/L	0.0630
UA	G405	C	2022/08/24	Iron, dissolved	mg/L	0.0950
UA	G405	C	2022/11/09	Iron, dissolved	mg/L	0.120
UA	G405	C	2023/02/14	Iron, dissolved	mg/L	0.110
UA	G405	C	2023/06/06	Iron, dissolved	mg/L	0.130
UA	G405	C	2023/08/11	Iron, dissolved	mg/L	0.165
UA	G405	C	2023/11/21	Iron, dissolved	mg/L	0.0788

UA	G405	C	2015/10/07	Iron, dissolved	mg/L	<0.01
UA	G405	C	2017/07/14	Magnesium, total	mg/L	160
UA	G405	C	2020/01/22	Magnesium, total	mg/L	110
UA	G405	C	2021/01/21	Magnesium, total	mg/L	100
UA	G405	C	2021/08/17	Magnesium, total	mg/L	110
UA	G405	C	2022/02/08	Magnesium, total	mg/L	120
UA	G405	C	2022/08/24	Magnesium, total	mg/L	100
UA	G405	C	2023/02/14	Magnesium, total	mg/L	110
UA	G405	C	2023/06/06	Magnesium, total	mg/L	110
UA	G405	C	2023/08/11	Magnesium, total	mg/L	110
UA	G405	C	2023/11/21	Magnesium, total	mg/L	107
UA	G405	C	2018/03/03	Manganese, dissolved	mg/L	1.10
UA	G405	C	2018/05/12	Manganese, dissolved	mg/L	<0.001
UA	G405	C	2018/08/11	Manganese, dissolved	mg/L	0.490
UA	G405	C	2018/11/06	Manganese, dissolved	mg/L	0.0690
UA	G405	C	2019/01/25	Manganese, dissolved	mg/L	0.130
UA	G405	C	2019/05/02	Manganese, dissolved	mg/L	0.290
UA	G405	C	2019/08/16	Manganese, dissolved	mg/L	0.580
UA	G405	C	2019/10/21	Manganese, dissolved	mg/L	0.910
UA	G405	C	2020/01/22	Manganese, dissolved	mg/L	1.00
UA	G405	C	2020/05/06	Manganese, dissolved	mg/L	0.870
UA	G405	C	2020/08/12	Manganese, dissolved	mg/L	0.810
UA	G405	C	2020/10/13	Manganese, dissolved	mg/L	0.800
UA	G405	C	2021/01/21	Manganese, dissolved	mg/L	0.880
UA	G405	C	2021/04/27	Manganese, dissolved	mg/L	0.950
UA	G405	C	2021/08/17	Manganese, dissolved	mg/L	1.10
UA	G405	C	2021/10/26	Manganese, dissolved	mg/L	0.990
UA	G405	C	2022/02/08	Manganese, dissolved	mg/L	0.920
UA	G405	C	2022/05/10	Manganese, dissolved	mg/L	1.00
UA	G405	C	2022/08/24	Manganese, dissolved	mg/L	1.20
UA	G405	C	2022/11/09	Manganese, dissolved	mg/L	1.10
UA	G405	C	2023/02/14	Manganese, dissolved	mg/L	1.30
UA	G405	C	2023/06/06	Manganese, dissolved	mg/L	1.10
UA	G405	C	2023/08/11	Manganese, dissolved	mg/L	1.07
UA	G405	C	2023/11/21	Manganese, dissolved	mg/L	0.868
UA	G405	C	2015/10/07	Manganese, dissolved	mg/L	2.00
UA	G405	C	2023/08/11	Phosphate, dissolved	mg/L	0.0520
UA	G405	C	2017/07/14	Potassium, total	mg/L	0.950
UA	G405	C	2020/01/22	Potassium, total	mg/L	0.430
UA	G405	C	2021/01/21	Potassium, total	mg/L	0.460
UA	G405	C	2021/08/17	Potassium, total	mg/L	0.500
UA	G405	C	2022/02/08	Potassium, total	mg/L	0.460
UA	G405	C	2022/08/24	Potassium, total	mg/L	0.560
UA	G405	C	2023/02/14	Potassium, total	mg/L	0.510
UA	G405	C	2023/06/06	Potassium, total	mg/L	0.410
UA	G405	C	2023/08/11	Potassium, total	mg/L	0.566
UA	G405	C	2023/11/21	Potassium, total	mg/L	0.594
UA	G405	C	2023/06/06	Silicon, dissolved	mg/L	8.00
UA	G405	C	2023/08/11	Silicon, dissolved	mg/L	7.81
UA	G405	C	2017/07/14	Sodium, total	mg/L	120
UA	G405	C	2020/01/22	Sodium, total	mg/L	100
UA	G405	C	2021/01/21	Sodium, total	mg/L	110
UA	G405	C	2021/08/17	Sodium, total	mg/L	120
UA	G405	C	2022/02/08	Sodium, total	mg/L	110
UA	G405	C	2022/08/24	Sodium, total	mg/L	100
UA	G405	C	2023/02/14	Sodium, total	mg/L	100
UA	G405	C	2023/06/06	Sodium, total	mg/L	110
UA	G405	C	2023/08/11	Sodium, total	mg/L	109
UA	G405	C	2023/11/21	Sodium, total	mg/L	103
UA	G405	C	2015/11/21	Sulfate, total	mg/L	1,700
UA	G405	C	2016/02/15	Sulfate, total	mg/L	1,700
UA	G405	C	2016/05/18	Sulfate, total	mg/L	1,800
UA	G405	C	2016/08/02	Sulfate, total	mg/L	1,600

UA	G405	C	2016/11/22	Sulfate, total	mg/L	1,400
UA	G405	C	2017/02/18	Sulfate, total	mg/L	1,300
UA	G405	C	2017/05/16	Sulfate, total	mg/L	680
UA	G405	C	2017/07/14	Sulfate, total	mg/L	1,600
UA	G405	C	2017/10/28	Sulfate, total	mg/L	1,300
UA	G405	C	2018/05/12	Sulfate, total	mg/L	1,200
UA	G405	C	2018/08/04	Sulfate, total	mg/L	790
UA	G405	C	2019/01/25	Sulfate, total	mg/L	890
UA	G405	C	2019/08/20	Sulfate, total	mg/L	340
UA	G405	C	2020/01/22	Sulfate, total	mg/L	910
UA	G405	C	2020/08/12	Sulfate, total	mg/L	460
UA	G405	C	2020/10/13	Sulfate, total	mg/L	980
UA	G405	C	2021/01/21	Sulfate, total	mg/L	960
UA	G405	C	2021/04/27	Sulfate, total	mg/L	800
UA	G405	C	2021/08/17	Sulfate, total	mg/L	760
UA	G405	C	2021/10/26	Sulfate, total	mg/L	1,000
UA	G405	C	2022/02/08	Sulfate, total	mg/L	1,000
UA	G405	C	2022/05/10	Sulfate, total	mg/L	1,000
UA	G405	C	2022/08/24	Sulfate, total	mg/L	1,000
UA	G405	C	2022/11/09	Sulfate, total	mg/L	910
UA	G405	C	2023/02/14	Sulfate, total	mg/L	950
UA	G405	C	2023/06/06	Sulfate, total	mg/L	1,000
UA	G405	C	2023/08/11	Sulfate, total	mg/L	916
UA	G405	C	2023/11/21	Sulfate, total	mg/L	897
UA	G405	C	2015/10/07	Sulfate, total	mg/L	1,900
UA	G405	C	2015/11/21	Temperature (Celsius)	degrees C	16.7
UA	G405	C	2016/02/15	Temperature (Celsius)	degrees C	9.40
UA	G405	C	2016/05/18	Temperature (Celsius)	degrees C	17.1
UA	G405	C	2016/08/02	Temperature (Celsius)	degrees C	18.9
UA	G405	C	2016/11/22	Temperature (Celsius)	degrees C	13.8
UA	G405	C	2017/02/18	Temperature (Celsius)	degrees C	15.0
UA	G405	C	2017/05/16	Temperature (Celsius)	degrees C	15.1
UA	G405	C	2017/07/14	Temperature (Celsius)	degrees C	17.8
UA	G405	C	2017/10/28	Temperature (Celsius)	degrees C	13.0
UA	G405	C	2018/05/12	Temperature (Celsius)	degrees C	15.1
UA	G405	C	2018/08/04	Temperature (Celsius)	degrees C	16.0
UA	G405	C	2019/01/25	Temperature (Celsius)	degrees C	12.1
UA	G405	C	2019/08/20	Temperature (Celsius)	degrees C	17.2
UA	G405	C	2020/01/22	Temperature (Celsius)	degrees C	7.60
UA	G405	C	2020/08/12	Temperature (Celsius)	degrees C	24.1
UA	G405	C	2020/10/13	Temperature (Celsius)	degrees C	19.6
UA	G405	C	2021/01/21	Temperature (Celsius)	degrees C	11.9
UA	G405	C	2021/04/27	Temperature (Celsius)	degrees C	17.4
UA	G405	C	2021/08/17	Temperature (Celsius)	degrees C	22.7
UA	G405	C	2021/10/26	Temperature (Celsius)	degrees C	17.7
UA	G405	C	2022/02/08	Temperature (Celsius)	degrees C	9.60
UA	G405	C	2022/05/10	Temperature (Celsius)	degrees C	18.8
UA	G405	C	2022/08/24	Temperature (Celsius)	degrees C	22.8
UA	G405	C	2022/11/09	Temperature (Celsius)	degrees C	19.8
UA	G405	C	2023/02/14	Temperature (Celsius)	degrees C	10.6
UA	G405	C	2023/06/06	Temperature (Celsius)	degrees C	19.7
UA	G405	C	2023/08/11	Temperature (Celsius)	degrees C	18.2
UA	G405	C	2023/11/21	Temperature (Celsius)	degrees C	15.3
UA	G405	C	2015/11/21	Total Dissolved Solids	mg/L	2,400
UA	G405	C	2016/02/15	Total Dissolved Solids	mg/L	2,500
UA	G405	C	2016/05/18	Total Dissolved Solids	mg/L	2,200
UA	G405	C	2016/08/02	Total Dissolved Solids	mg/L	2,200
UA	G405	C	2016/11/22	Total Dissolved Solids	mg/L	2,100
UA	G405	C	2017/02/18	Total Dissolved Solids	mg/L	1,800
UA	G405	C	2017/05/16	Total Dissolved Solids	mg/L	1,300
UA	G405	C	2017/07/14	Total Dissolved Solids	mg/L	2,100
UA	G405	C	2017/10/28	Total Dissolved Solids	mg/L	2,000
UA	G405	C	2018/05/12	Total Dissolved Solids	mg/L	1,900

UA	G405	C	2018/08/04	Total Dissolved Solids	mg/L	1,400
UA	G405	C	2019/01/25	Total Dissolved Solids	mg/L	1,500
UA	G405	C	2019/08/20	Total Dissolved Solids	mg/L	720
UA	G405	C	2020/01/22	Total Dissolved Solids	mg/L	1,400
UA	G405	C	2020/08/12	Total Dissolved Solids	mg/L	1,200
UA	G405	C	2020/10/13	Total Dissolved Solids	mg/L	1,600
UA	G405	C	2021/01/21	Total Dissolved Solids	mg/L	1,600
UA	G405	C	2021/04/27	Total Dissolved Solids	mg/L	1,600
UA	G405	C	2021/08/17	Total Dissolved Solids	mg/L	1,400
UA	G405	C	2021/10/26	Total Dissolved Solids	mg/L	1,600
UA	G405	C	2022/02/08	Total Dissolved Solids	mg/L	1,400
UA	G405	C	2022/05/10	Total Dissolved Solids	mg/L	1,700
UA	G405	C	2022/08/24	Total Dissolved Solids	mg/L	1,900
UA	G405	C	2022/11/09	Total Dissolved Solids	mg/L	1,700
UA	G405	C	2023/02/14	Total Dissolved Solids	mg/L	1,900
UA	G405	C	2023/06/06	Total Dissolved Solids	mg/L	1,700
UA	G405	C	2023/08/11	Total Dissolved Solids	mg/L	1,790
UA	G405	C	2023/11/21	Total Dissolved Solids	mg/L	1,610
UA	G405	C	2015/10/07	Total Dissolved Solids	mg/L	2,900
UA	G406	C	2020/10/14	pH (field)	SU	6.5
UA	G406	C	2021/01/28	pH (field)	SU	6.6
UA	G406	C	2021/05/20	pH (field)	SU	7.0
UA	G406	C	2021/08/17	pH (field)	SU	6.7
UA	G406	C	2021/10/26	pH (field)	SU	6.6
UA	G406	C	2022/02/08	pH (field)	SU	6.5
UA	G406	C	2022/05/10	pH (field)	SU	6.5
UA	G406	C	2022/08/24	pH (field)	SU	6.4
UA	G406	C	2022/11/09	pH (field)	SU	6.5
UA	G406	C	2023/02/14	pH (field)	SU	6.7
UA	G406	C	2023/05/31	pH (field)	SU	6.5
UA	G406	C	2023/08/11	pH (field)	SU	6.7
UA	G406	C	2023/11/20	pH (field)	SU	6.6
UA	G406	C	2020/10/14	Oxidation Reduction Potential	mV	186
UA	G406	C	2021/01/28	Oxidation Reduction Potential	mV	194
UA	G406	C	2021/05/20	Oxidation Reduction Potential	mV	-110
UA	G406	C	2021/08/17	Oxidation Reduction Potential	mV	95.7
UA	G406	C	2021/10/26	Oxidation Reduction Potential	mV	29.4
UA	G406	C	2022/02/08	Oxidation Reduction Potential	mV	174
UA	G406	C	2022/05/10	Oxidation Reduction Potential	mV	132
UA	G406	C	2022/08/24	Oxidation Reduction Potential	mV	165
UA	G406	C	2022/11/09	Oxidation Reduction Potential	mV	225
UA	G406	C	2023/02/14	Oxidation Reduction Potential	mV	284
UA	G406	C	2023/05/31	Oxidation Reduction Potential	mV	166
UA	G406	C	2023/08/11	Oxidation Reduction Potential	mV	81.0
UA	G406	C	2023/11/20	Oxidation Reduction Potential	mV	127
UA	G406	C	2020/10/14	Eh	V	0.38
UA	G406	C	2021/01/28	Eh	V	0.39
UA	G406	C	2021/05/20	Eh	V	0.078
UA	G406	C	2021/08/17	Eh	V	0.29
UA	G406	C	2021/10/26	Eh	V	0.22
UA	G406	C	2022/02/08	Eh	V	0.37
UA	G406	C	2022/05/10	Eh	V	0.33
UA	G406	C	2022/08/24	Eh	V	0.36
UA	G406	C	2022/11/09	Eh	V	0.42
UA	G406	C	2023/02/14	Eh	V	0.48
UA	G406	C	2023/05/31	Eh	V	0.36
UA	G406	C	2023/08/11	Eh	V	0.28
UA	G406	C	2023/11/20	Eh	V	0.32
UA	G406	C	2023/02/14	Alkalinity, bicarbonate	mg/L CaCO3	350
UA	G406	C	2023/05/31	Alkalinity, bicarbonate	mg/L CaCO3	360
UA	G406	C	2023/08/11	Alkalinity, bicarbonate	mg/L CaCO3	347
UA	G406	C	2023/11/20	Alkalinity, bicarbonate	mg/L CaCO3	289
UA	G406	C	2020/10/14	Barium, total	mg/L	0.0130

UA	G406	C	2021/01/28	Barium, total	mg/L	0.0120
UA	G406	C	2021/05/20	Barium, total	mg/L	0.730
UA	G406	C	2021/08/17	Barium, total	mg/L	0.0140
UA	G406	C	2021/10/26	Barium, total	mg/L	0.0140
UA	G406	C	2022/02/08	Barium, total	mg/L	0.0160
UA	G406	C	2022/05/10	Barium, total	mg/L	0.0150
UA	G406	C	2022/08/24	Barium, total	mg/L	0.0130
UA	G406	C	2022/11/09	Barium, total	mg/L	0.0120
UA	G406	C	2023/02/14	Barium, total	mg/L	0.0150
UA	G406	C	2023/05/31	Barium, total	mg/L	0.0130
UA	G406	C	2023/08/11	Barium, total	mg/L	0.0139
UA	G406	C	2023/11/20	Barium, total	mg/L	0.0201
UA	G406	C	2020/10/14	Boron, total	mg/L	1.60
UA	G406	C	2021/01/28	Boron, total	mg/L	1.50
UA	G406	C	2021/05/20	Boron, total	mg/L	0.170
UA	G406	C	2021/08/17	Boron, total	mg/L	1.50
UA	G406	C	2021/10/26	Boron, total	mg/L	1.50
UA	G406	C	2022/02/08	Boron, total	mg/L	1.40
UA	G406	C	2022/05/10	Boron, total	mg/L	1.40
UA	G406	C	2022/08/24	Boron, total	mg/L	1.50
UA	G406	C	2022/11/09	Boron, total	mg/L	1.40
UA	G406	C	2023/02/14	Boron, total	mg/L	1.50
UA	G406	C	2023/05/31	Boron, total	mg/L	1.40
UA	G406	C	2023/08/11	Boron, total	mg/L	1.54
UA	G406	C	2023/11/20	Boron, total	mg/L	2.29
UA	G406	C	2020/10/14	Calcium, total	mg/L	230
UA	G406	C	2021/01/28	Calcium, total	mg/L	210
UA	G406	C	2021/05/20	Calcium, total	mg/L	190
UA	G406	C	2021/08/17	Calcium, total	mg/L	210
UA	G406	C	2021/10/26	Calcium, total	mg/L	190
UA	G406	C	2022/02/08	Calcium, total	mg/L	210
UA	G406	C	2022/05/10	Calcium, total	mg/L	210
UA	G406	C	2022/08/24	Calcium, total	mg/L	220
UA	G406	C	2022/11/09	Calcium, total	mg/L	180
UA	G406	C	2023/02/14	Calcium, total	mg/L	200
UA	G406	C	2023/05/31	Calcium, total	mg/L	190
UA	G406	C	2023/08/11	Calcium, total	mg/L	193
UA	G406	C	2023/11/20	Calcium, total	mg/L	206
UA	G406	C	2020/10/14	Chloride, total	mg/L	3.70
UA	G406	C	2021/01/28	Chloride, total	mg/L	2.40
UA	G406	C	2021/05/20	Chloride, total	mg/L	5.50
UA	G406	C	2021/08/17	Chloride, total	mg/L	3.90
UA	G406	C	2021/10/26	Chloride, total	mg/L	3.50
UA	G406	C	2022/02/08	Chloride, total	mg/L	4.80
UA	G406	C	2022/05/10	Chloride, total	mg/L	<4.8
UA	G406	C	2022/08/24	Chloride, total	mg/L	3.00
UA	G406	C	2022/11/09	Chloride, total	mg/L	2.70
UA	G406	C	2023/02/14	Chloride, total	mg/L	4.10
UA	G406	C	2023/05/31	Chloride, total	mg/L	<4.8
UA	G406	C	2023/08/11	Chloride, total	mg/L	4.00
UA	G406	C	2023/11/20	Chloride, total	mg/L	5.00
UA	G406	C	2020/10/14	Cobalt, total	mg/L	<0.002
UA	G406	C	2021/01/28	Cobalt, total	mg/L	<0.002
UA	G406	C	2021/05/20	Cobalt, total	mg/L	<0.002
UA	G406	C	2021/08/17	Cobalt, total	mg/L	<0.002
UA	G406	C	2021/10/26	Cobalt, total	mg/L	<0.002
UA	G406	C	2022/02/08	Cobalt, total	mg/L	<0.002
UA	G406	C	2022/05/10	Cobalt, total	mg/L	<0.00048
UA	G406	C	2022/08/24	Cobalt, total	mg/L	<0.00048
UA	G406	C	2022/11/09	Cobalt, total	mg/L	<0.00048
UA	G406	C	2023/02/14	Cobalt, total	mg/L	<0.00048
UA	G406	C	2023/05/31	Cobalt, total	mg/L	0.000520
UA	G406	C	2023/08/11	Cobalt, total	mg/L	0.000800

UA	G406	C	2023/11/20	Cobalt, total	mg/L	0.000800
UA	G406	C	2023/05/31	Ferrous Iron, dissolved	mg/L	0.180
UA	G406	C	2020/08/11	Iron, dissolved	mg/L	0.0170
UA	G406	C	2020/10/14	Iron, dissolved	mg/L	<0.01
UA	G406	C	2021/01/28	Iron, dissolved	mg/L	<0.01
UA	G406	C	2021/05/20	Iron, dissolved	mg/L	7.90
UA	G406	C	2021/08/17	Iron, dissolved	mg/L	<0.01
UA	G406	C	2021/10/26	Iron, dissolved	mg/L	<0.01
UA	G406	C	2022/02/08	Iron, dissolved	mg/L	<0.01
UA	G406	C	2022/05/10	Iron, dissolved	mg/L	0.000980
UA	G406	C	2022/08/24	Iron, dissolved	mg/L	0.00580
UA	G406	C	2022/11/09	Iron, dissolved	mg/L	0.00270
UA	G406	C	2023/02/14	Iron, dissolved	mg/L	<0.00072
UA	G406	C	2023/05/31	Iron, dissolved	mg/L	<0.00072
UA	G406	C	2023/08/11	Iron, dissolved	mg/L	<0.0115
UA	G406	C	2023/11/20	Iron, dissolved	mg/L	<0.0115
UA	G406	C	2023/02/14	Magnesium, total	mg/L	76.0
UA	G406	C	2023/05/31	Magnesium, total	mg/L	65.0
UA	G406	C	2023/08/11	Magnesium, total	mg/L	65.7
UA	G406	C	2023/11/20	Magnesium, total	mg/L	60.1
UA	G406	C	2018/07/16	Manganese, dissolved	mg/L	4.80
UA	G406	C	2018/08/13	Manganese, dissolved	mg/L	3.90
UA	G406	C	2019/05/02	Manganese, dissolved	mg/L	4.20
UA	G406	C	2019/08/19	Manganese, dissolved	mg/L	4.50
UA	G406	C	2019/10/22	Manganese, dissolved	mg/L	4.60
UA	G406	C	2020/01/23	Manganese, dissolved	mg/L	4.00
UA	G406	C	2020/05/06	Manganese, dissolved	mg/L	4.50
UA	G406	C	2020/08/11	Manganese, dissolved	mg/L	5.10
UA	G406	C	2020/10/14	Manganese, dissolved	mg/L	5.50
UA	G406	C	2021/01/28	Manganese, dissolved	mg/L	4.30
UA	G406	C	2021/05/20	Manganese, dissolved	mg/L	0.170
UA	G406	C	2021/08/17	Manganese, dissolved	mg/L	4.90
UA	G406	C	2021/10/26	Manganese, dissolved	mg/L	4.10
UA	G406	C	2022/02/08	Manganese, dissolved	mg/L	2.20
UA	G406	C	2022/05/10	Manganese, dissolved	mg/L	2.20
UA	G406	C	2022/08/24	Manganese, dissolved	mg/L	4.20
UA	G406	C	2022/11/09	Manganese, dissolved	mg/L	4.60
UA	G406	C	2023/02/14	Manganese, dissolved	mg/L	2.10
UA	G406	C	2023/05/31	Manganese, dissolved	mg/L	4.40
UA	G406	C	2023/08/11	Manganese, dissolved	mg/L	4.45
UA	G406	C	2023/11/20	Manganese, dissolved	mg/L	4.55
UA	G406	C	2023/08/11	Phosphate, dissolved	mg/L	0.0430
UA	G406	C	2023/02/14	Potassium, total	mg/L	0.160
UA	G406	C	2023/05/31	Potassium, total	mg/L	0.150
UA	G406	C	2023/08/11	Potassium, total	mg/L	0.263
UA	G406	C	2023/11/20	Potassium, total	mg/L	0.255
UA	G406	C	2023/05/31	Silicon, dissolved	mg/L	14.0
UA	G406	C	2023/08/11	Silicon, dissolved	mg/L	11.9
UA	G406	C	2023/02/14	Sodium, total	mg/L	43.0
UA	G406	C	2023/05/31	Sodium, total	mg/L	38.0
UA	G406	C	2023/08/11	Sodium, total	mg/L	37.2
UA	G406	C	2023/11/20	Sodium, total	mg/L	32.5
UA	G406	C	2020/10/14	Sulfate, total	mg/L	610
UA	G406	C	2021/01/28	Sulfate, total	mg/L	580
UA	G406	C	2021/05/20	Sulfate, total	mg/L	25.0
UA	G406	C	2021/08/17	Sulfate, total	mg/L	540
UA	G406	C	2021/10/26	Sulfate, total	mg/L	480
UA	G406	C	2022/02/08	Sulfate, total	mg/L	490
UA	G406	C	2022/05/10	Sulfate, total	mg/L	510
UA	G406	C	2022/08/24	Sulfate, total	mg/L	470
UA	G406	C	2022/11/09	Sulfate, total	mg/L	470
UA	G406	C	2023/02/14	Sulfate, total	mg/L	450
UA	G406	C	2023/05/31	Sulfate, total	mg/L	480

UA	G406	C	2023/08/11	Sulfate, total	mg/L	482
UA	G406	C	2023/11/20	Sulfate, total	mg/L	450
UA	G406	C	2020/10/14	Temperature (Celsius)	degrees C	17.5
UA	G406	C	2021/01/28	Temperature (Celsius)	degrees C	12.1
UA	G406	C	2021/05/20	Temperature (Celsius)	degrees C	26
UA	G406	C	2021/08/17	Temperature (Celsius)	degrees C	18.9
UA	G406	C	2021/10/26	Temperature (Celsius)	degrees C	16.8
UA	G406	C	2022/02/08	Temperature (Celsius)	degrees C	12.3
UA	G406	C	2022/05/10	Temperature (Celsius)	degrees C	16.2
UA	G406	C	2022/08/24	Temperature (Celsius)	degrees C	20.5
UA	G406	C	2022/11/09	Temperature (Celsius)	degrees C	19.1
UA	G406	C	2023/02/14	Temperature (Celsius)	degrees C	12.6
UA	G406	C	2023/05/31	Temperature (Celsius)	degrees C	21.2
UA	G406	C	2023/08/11	Temperature (Celsius)	degrees C	16.9
UA	G406	C	2023/11/20	Temperature (Celsius)	degrees C	15.7
UA	G406	C	2020/10/14	Total Dissolved Solids	mg/L	1,200
UA	G406	C	2021/01/28	Total Dissolved Solids	mg/L	1,200
UA	G406	C	2021/05/20	Total Dissolved Solids	mg/L	920
UA	G406	C	2021/08/17	Total Dissolved Solids	mg/L	1,200
UA	G406	C	2021/10/26	Total Dissolved Solids	mg/L	1,000
UA	G406	C	2022/02/08	Total Dissolved Solids	mg/L	990
UA	G406	C	2022/05/10	Total Dissolved Solids	mg/L	1,000
UA	G406	C	2022/08/24	Total Dissolved Solids	mg/L	1,100
UA	G406	C	2022/11/09	Total Dissolved Solids	mg/L	980
UA	G406	C	2023/02/14	Total Dissolved Solids	mg/L	1,200
UA	G406	C	2023/05/31	Total Dissolved Solids	mg/L	1,100
UA	G406	C	2023/08/11	Total Dissolved Solids	mg/L	1,070
UA	G406	C	2023/11/20	Total Dissolved Solids	mg/L	1,060
UA	G407	C	2020/10/14	pH (field)	SU	6.6
UA	G407	C	2021/01/28	pH (field)	SU	6.9
UA	G407	C	2021/04/26	pH (field)	SU	6.7
UA	G407	C	2021/08/17	pH (field)	SU	6.7
UA	G407	C	2021/10/26	pH (field)	SU	6.7
UA	G407	C	2022/02/08	pH (field)	SU	6.7
UA	G407	C	2022/05/10	pH (field)	SU	6.6
UA	G407	C	2022/08/24	pH (field)	SU	6.4
UA	G407	C	2022/11/08	pH (field)	SU	6.7
UA	G407	C	2023/02/14	pH (field)	SU	6.5
UA	G407	C	2023/05/31	pH (field)	SU	6.6
UA	G407	C	2023/08/10	pH (field)	SU	6.8
UA	G407	C	2023/11/20	pH (field)	SU	6.6
UA	G407	C	2020/10/14	Oxidation Reduction Potential	mV	119
UA	G407	C	2021/01/28	Oxidation Reduction Potential	mV	104
UA	G407	C	2021/04/26	Oxidation Reduction Potential	mV	116
UA	G407	C	2021/08/17	Oxidation Reduction Potential	mV	113
UA	G407	C	2021/10/26	Oxidation Reduction Potential	mV	25.1
UA	G407	C	2022/02/08	Oxidation Reduction Potential	mV	146
UA	G407	C	2022/05/10	Oxidation Reduction Potential	mV	185
UA	G407	C	2022/08/24	Oxidation Reduction Potential	mV	122
UA	G407	C	2022/11/08	Oxidation Reduction Potential	mV	82.0
UA	G407	C	2023/02/14	Oxidation Reduction Potential	mV	265
UA	G407	C	2023/05/31	Oxidation Reduction Potential	mV	162
UA	G407	C	2023/08/10	Oxidation Reduction Potential	mV	12.0
UA	G407	C	2023/11/20	Oxidation Reduction Potential	mV	124
UA	G407	C	2020/10/14	Eh	V	0.31
UA	G407	C	2021/01/28	Eh	V	0.30
UA	G407	C	2021/04/26	Eh	V	0.31
UA	G407	C	2021/08/17	Eh	V	0.30
UA	G407	C	2021/10/26	Eh	V	0.22
UA	G407	C	2022/02/08	Eh	V	0.34
UA	G407	C	2022/05/10	Eh	V	0.38
UA	G407	C	2022/08/24	Eh	V	0.31
UA	G407	C	2022/11/08	Eh	V	0.28

UA	G407	C	2023/02/14	Eh	V	0.46
UA	G407	C	2023/05/31	Eh	V	0.35
UA	G407	C	2023/08/10	Eh	V	0.20
UA	G407	C	2023/11/20	Eh	V	0.32
UA	G407	C	2023/02/14	Alkalinity, bicarbonate	mg/L CaCO3	460
UA	G407	C	2023/05/31	Alkalinity, bicarbonate	mg/L CaCO3	510
UA	G407	C	2023/08/10	Alkalinity, bicarbonate	mg/L CaCO3	502
UA	G407	C	2023/11/20	Alkalinity, bicarbonate	mg/L CaCO3	550
UA	G407	C	2020/10/14	Barium, total	mg/L	0.0140
UA	G407	C	2021/01/28	Barium, total	mg/L	0.0120
UA	G407	C	2021/04/26	Barium, total	mg/L	0.0130
UA	G407	C	2021/08/17	Barium, total	mg/L	0.0120
UA	G407	C	2021/10/26	Barium, total	mg/L	0.0120
UA	G407	C	2022/02/08	Barium, total	mg/L	0.0470
UA	G407	C	2022/05/10	Barium, total	mg/L	0.0120
UA	G407	C	2022/08/24	Barium, total	mg/L	0.0110
UA	G407	C	2022/11/08	Barium, total	mg/L	0.0120
UA	G407	C	2023/02/14	Barium, total	mg/L	0.0130
UA	G407	C	2023/05/31	Barium, total	mg/L	0.0120
UA	G407	C	2023/08/10	Barium, total	mg/L	0.0132
UA	G407	C	2023/11/20	Barium, total	mg/L	0.0193
UA	G407	C	2020/10/14	Boron, total	mg/L	0.100
UA	G407	C	2021/01/28	Boron, total	mg/L	0.0630
UA	G407	C	2021/04/26	Boron, total	mg/L	0.0650
UA	G407	C	2021/08/17	Boron, total	mg/L	0.0900
UA	G407	C	2021/10/26	Boron, total	mg/L	0.150
UA	G407	C	2022/02/08	Boron, total	mg/L	0.100
UA	G407	C	2022/05/10	Boron, total	mg/L	0.100
UA	G407	C	2022/08/24	Boron, total	mg/L	0.0760
UA	G407	C	2022/11/08	Boron, total	mg/L	0.0770
UA	G407	C	2023/02/14	Boron, total	mg/L	0.150
UA	G407	C	2023/05/31	Boron, total	mg/L	0.0900
UA	G407	C	2023/08/10	Boron, total	mg/L	0.0614
UA	G407	C	2023/11/20	Boron, total	mg/L	0.139
UA	G407	C	2020/10/14	Calcium, total	mg/L	250
UA	G407	C	2021/01/28	Calcium, total	mg/L	270
UA	G407	C	2021/04/26	Calcium, total	mg/L	340
UA	G407	C	2021/08/17	Calcium, total	mg/L	290
UA	G407	C	2021/10/26	Calcium, total	mg/L	280
UA	G407	C	2022/02/08	Calcium, total	mg/L	400
UA	G407	C	2022/05/10	Calcium, total	mg/L	280
UA	G407	C	2022/08/24	Calcium, total	mg/L	300
UA	G407	C	2022/11/08	Calcium, total	mg/L	290
UA	G407	C	2023/02/14	Calcium, total	mg/L	270
UA	G407	C	2023/05/31	Calcium, total	mg/L	270
UA	G407	C	2023/08/10	Calcium, total	mg/L	230
UA	G407	C	2023/11/20	Calcium, total	mg/L	397
UA	G407	C	2020/10/14	Chloride, total	mg/L	12.0
UA	G407	C	2021/01/28	Chloride, total	mg/L	11.0
UA	G407	C	2021/04/26	Chloride, total	mg/L	15.0
UA	G407	C	2021/08/17	Chloride, total	mg/L	16.0
UA	G407	C	2021/10/26	Chloride, total	mg/L	15.0
UA	G407	C	2022/02/08	Chloride, total	mg/L	12.0
UA	G407	C	2022/05/10	Chloride, total	mg/L	13.0
UA	G407	C	2022/08/24	Chloride, total	mg/L	11.0
UA	G407	C	2022/11/08	Chloride, total	mg/L	11.0
UA	G407	C	2023/02/14	Chloride, total	mg/L	12.0
UA	G407	C	2023/05/31	Chloride, total	mg/L	17.0
UA	G407	C	2023/08/10	Chloride, total	mg/L	11.0
UA	G407	C	2023/11/20	Chloride, total	mg/L	12.0
UA	G407	C	2020/10/14	Cobalt, total	mg/L	<0.002
UA	G407	C	2021/01/28	Cobalt, total	mg/L	<0.002
UA	G407	C	2021/04/26	Cobalt, total	mg/L	<0.002

UA	G407	C	2021/08/17	Cobalt, total	mg/L	<0.002
UA	G407	C	2021/10/26	Cobalt, total	mg/L	<0.002
UA	G407	C	2022/02/08	Cobalt, total	mg/L	0.00620
UA	G407	C	2022/05/10	Cobalt, total	mg/L	0.000490
UA	G407	C	2022/08/24	Cobalt, total	mg/L	0.000930
UA	G407	C	2022/11/08	Cobalt, total	mg/L	<0.00048
UA	G407	C	2023/02/14	Cobalt, total	mg/L	<0.00048
UA	G407	C	2023/05/31	Cobalt, total	mg/L	0.000700
UA	G407	C	2023/08/10	Cobalt, total	mg/L	0.000800
UA	G407	C	2023/11/20	Cobalt, total	mg/L	0.00200
UA	G407	C	2023/05/31	Ferrous Iron, dissolved	mg/L	0.270
UA	G407	C	2020/08/11	Iron, dissolved	mg/L	0.0150
UA	G407	C	2020/10/14	Iron, dissolved	mg/L	<0.01
UA	G407	C	2021/01/28	Iron, dissolved	mg/L	<0.01
UA	G407	C	2021/04/26	Iron, dissolved	mg/L	0.0170
UA	G407	C	2021/08/17	Iron, dissolved	mg/L	0.0460
UA	G407	C	2021/10/26	Iron, dissolved	mg/L	<0.01
UA	G407	C	2022/02/08	Iron, dissolved	mg/L	<0.01
UA	G407	C	2022/05/10	Iron, dissolved	mg/L	0.0140
UA	G407	C	2022/08/24	Iron, dissolved	mg/L	0.0130
UA	G407	C	2022/11/08	Iron, dissolved	mg/L	0.0310
UA	G407	C	2023/02/14	Iron, dissolved	mg/L	0.0190
UA	G407	C	2023/05/31	Iron, dissolved	mg/L	0.0100
UA	G407	C	2023/08/10	Iron, dissolved	mg/L	0.0150
UA	G407	C	2023/11/20	Iron, dissolved	mg/L	0.0279
UA	G407	C	2023/02/14	Magnesium, total	mg/L	170
UA	G407	C	2023/05/31	Magnesium, total	mg/L	170
UA	G407	C	2023/08/10	Magnesium, total	mg/L	151
UA	G407	C	2023/11/20	Magnesium, total	mg/L	250
UA	G407	C	2018/03/05	Manganese, dissolved	mg/L	0.0770
UA	G407	C	2018/07/16	Manganese, dissolved	mg/L	1.30
UA	G407	C	2018/08/13	Manganese, dissolved	mg/L	0.0740
UA	G407	C	2018/11/07	Manganese, dissolved	mg/L	0.400
UA	G407	C	2019/01/25	Manganese, dissolved	mg/L	0.280
UA	G407	C	2019/05/03	Manganese, dissolved	mg/L	1.20
UA	G407	C	2019/08/19	Manganese, dissolved	mg/L	0.240
UA	G407	C	2019/10/22	Manganese, dissolved	mg/L	1.20
UA	G407	C	2020/01/23	Manganese, dissolved	mg/L	0.430
UA	G407	C	2020/05/07	Manganese, dissolved	mg/L	0.590
UA	G407	C	2020/08/11	Manganese, dissolved	mg/L	0.450
UA	G407	C	2020/10/14	Manganese, dissolved	mg/L	0.160
UA	G407	C	2021/01/28	Manganese, dissolved	mg/L	0.290
UA	G407	C	2021/04/26	Manganese, dissolved	mg/L	0.220
UA	G407	C	2021/08/17	Manganese, dissolved	mg/L	0.260
UA	G407	C	2021/10/26	Manganese, dissolved	mg/L	0.320
UA	G407	C	2022/02/08	Manganese, dissolved	mg/L	0.310
UA	G407	C	2022/05/10	Manganese, dissolved	mg/L	0.220
UA	G407	C	2022/08/24	Manganese, dissolved	mg/L	0.360
UA	G407	C	2022/11/08	Manganese, dissolved	mg/L	0.260
UA	G407	C	2023/02/14	Manganese, dissolved	mg/L	0.210
UA	G407	C	2023/05/31	Manganese, dissolved	mg/L	0.380
UA	G407	C	2023/08/10	Manganese, dissolved	mg/L	0.445
UA	G407	C	2023/11/20	Manganese, dissolved	mg/L	0.316
UA	G407	C	2023/08/10	Phosphate, dissolved	mg/L	<0.005
UA	G407	C	2023/02/14	Potassium, total	mg/L	2.90
UA	G407	C	2023/05/31	Potassium, total	mg/L	2.70
UA	G407	C	2023/08/10	Potassium, total	mg/L	2.76
UA	G407	C	2023/11/20	Potassium, total	mg/L	4.14
UA	G407	C	2023/05/31	Silicon, dissolved	mg/L	9.80
UA	G407	C	2023/08/10	Silicon, dissolved	mg/L	8.89
UA	G407	C	2023/02/14	Sodium, total	mg/L	90.0
UA	G407	C	2023/05/31	Sodium, total	mg/L	88.0
UA	G407	C	2023/08/10	Sodium, total	mg/L	85.8

UA	G407	C	2023/11/20	Sodium, total	mg/L	106
UA	G407	C	2020/10/14	Sulfate, total	mg/L	830
UA	G407	C	2021/01/28	Sulfate, total	mg/L	990
UA	G407	C	2021/04/26	Sulfate, total	mg/L	960
UA	G407	C	2021/08/17	Sulfate, total	mg/L	400
UA	G407	C	2021/10/26	Sulfate, total	mg/L	960
UA	G407	C	2022/02/08	Sulfate, total	mg/L	1,100
UA	G407	C	2022/05/10	Sulfate, total	mg/L	1,000
UA	G407	C	2022/08/24	Sulfate, total	mg/L	970
UA	G407	C	2022/11/08	Sulfate, total	mg/L	440
UA	G407	C	2023/02/14	Sulfate, total	mg/L	950
UA	G407	C	2023/05/31	Sulfate, total	mg/L	1,100
UA	G407	C	2023/08/10	Sulfate, total	mg/L	956
UA	G407	C	2023/11/20	Sulfate, total	mg/L	1,010
UA	G407	C	2020/10/14	Temperature (Celsius)	degrees C	18.3
UA	G407	C	2021/01/28	Temperature (Celsius)	degrees C	9.90
UA	G407	C	2021/04/26	Temperature (Celsius)	degrees C	17.1
UA	G407	C	2021/08/17	Temperature (Celsius)	degrees C	20.5
UA	G407	C	2021/10/26	Temperature (Celsius)	degrees C	17.6
UA	G407	C	2022/02/08	Temperature (Celsius)	degrees C	11.2
UA	G407	C	2022/05/10	Temperature (Celsius)	degrees C	15.2
UA	G407	C	2022/08/24	Temperature (Celsius)	degrees C	21.2
UA	G407	C	2022/11/08	Temperature (Celsius)	degrees C	18.0
UA	G407	C	2023/02/14	Temperature (Celsius)	degrees C	11.5
UA	G407	C	2023/05/31	Temperature (Celsius)	degrees C	19.2
UA	G407	C	2023/08/10	Temperature (Celsius)	degrees C	19.2
UA	G407	C	2023/11/20	Temperature (Celsius)	degrees C	14.2
UA	G407	C	2020/10/14	Total Dissolved Solids	mg/L	1,800
UA	G407	C	2021/01/28	Total Dissolved Solids	mg/L	2,000
UA	G407	C	2021/04/26	Total Dissolved Solids	mg/L	1,800
UA	G407	C	2021/08/17	Total Dissolved Solids	mg/L	2,200
UA	G407	C	2021/10/26	Total Dissolved Solids	mg/L	2,000
UA	G407	C	2022/02/08	Total Dissolved Solids	mg/L	2,000
UA	G407	C	2022/05/10	Total Dissolved Solids	mg/L	2,200
UA	G407	C	2022/08/24	Total Dissolved Solids	mg/L	2,200
UA	G407	C	2022/11/08	Total Dissolved Solids	mg/L	2,100
UA	G407	C	2023/02/14	Total Dissolved Solids	mg/L	2,100
UA	G407	C	2023/05/31	Total Dissolved Solids	mg/L	2,000
UA	G407	C	2023/08/10	Total Dissolved Solids	mg/L	1,870
UA	G407	C	2023/11/20	Total Dissolved Solids	mg/L	2,010

Notes:

< = results is less than detection limit
B = Background
C = Compliance
HSU = Hydrostratigraphic Unit
LCU = Lower Confining Unit
UA = Uppermost Aquifer
mg/L = milligrams per liter
SU = standard units
V = volts

Attachment I

Antidegradation Assessment Report
(Hansen 2017)

ATTACHMENT V

Antidegradation Assessment for Management of Coal Combustion Residuals Impoundment Waters

Coffeen Power Station
Illinois Power Generating Company
NPDES Permit No. IL0000108

November 21, 2017

Prepared for:

Illinois Power Generating Company
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Prepared by:

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HANSON
Engineering | Planning | Allied Services

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Figures and Tables

Appendices

Appendix A EcoCAT Report

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1. Introduction

Illinois Power Generating Company (IPGC) will be applying for a modification to NPDES Permit No. IL0000108 to reflect the planned physical alterations at the Coffeen Power Station (Coffeen, or "plant") required to meet the U.S. Environmental Protection Agency (USEPA) coal combustion residuals (CCR) rules. These physical alterations will require short-term discharge of waters from coal combustion residuals (CCR) surface impoundments, also known as "ash ponds". The ash ponds assessed in this report include Ash Ponds 1 and 2. Ash Pond 1 is currently an existing operating CCR impoundment, while Ash Pond 2 is an inactive CCR impoundment previously covered with a soil cover system that will require replacement in accordance with the federal CCR rules. This report assesses the potential effects of proposed pollutant load increases on the water quality of Coffeen Lake in accordance with the requirements of 35 Ill. Adm. Code §302.105. Alternatives considered to avoid discharging the waters are discussed.

2. Purpose and Anticipated Benefits

USEPA issued a final rule (the "CCR Rule") that regulates the disposal of CCR under Subtitle D of the Resource Conservation and Recovery Act (RCRA). The CCR Rule, effective October 19, 2015, establishes minimum national criteria for continued operation of CCR surface impoundments.[1] To comply with the CCR Rule, IPGC may need to close Coffeen Ash Ponds 1 and 2 by the end of the timeframe allowed by the Rule. Figure 1 illustrates the layout of the Coffeen ash ponds.

The closure plan for the Coffeen ash ponds includes removal of open water from the ash ponds, referred to as "unwatering;" partial removal of pore water contained in CCR-filled portions of the ash ponds, referred to as "dewatering;" grading and shaping the dewatered CCR surface to facilitate storm water runoff; and installation of a compacted vegetated earthen or composite cover system. Both unwatering and dewatering Ash Pond 1 is necessary to grade the CCR and construct the cover system. No unwaters are present in Ash Pond 2. Dewatering Ash Pond 2 will be necessary. The existing dewatering system in Ash Pond 2, which currently directs the dewaters to the Coffeen plant's Gypsum Management Facility (GMF) ponds, may be adequate to maintain the phreatic surface in the pond far enough below the existing cap to facilitate pond closure. However, this report evaluates the Ash Pond 2 dewaters in case the GMF ponds are overwhelmed and discharge of Ash Pond 2 dewaters is needed.

Due to the large volume of water contained in the ash ponds and the schedule constraints, the preferred alternative to remove the water is to discharge it through the existing NPDES-permitted outfall to Coffeen Lake.

The following sections of this report describe the water sampling, analytical laboratory results, hydraulic and concentration modeling, and alternatives considered to demonstrate the proposed short-term discharge of waters from the ash ponds will result in the continued attainment of water quality standards in Coffeen Lake.

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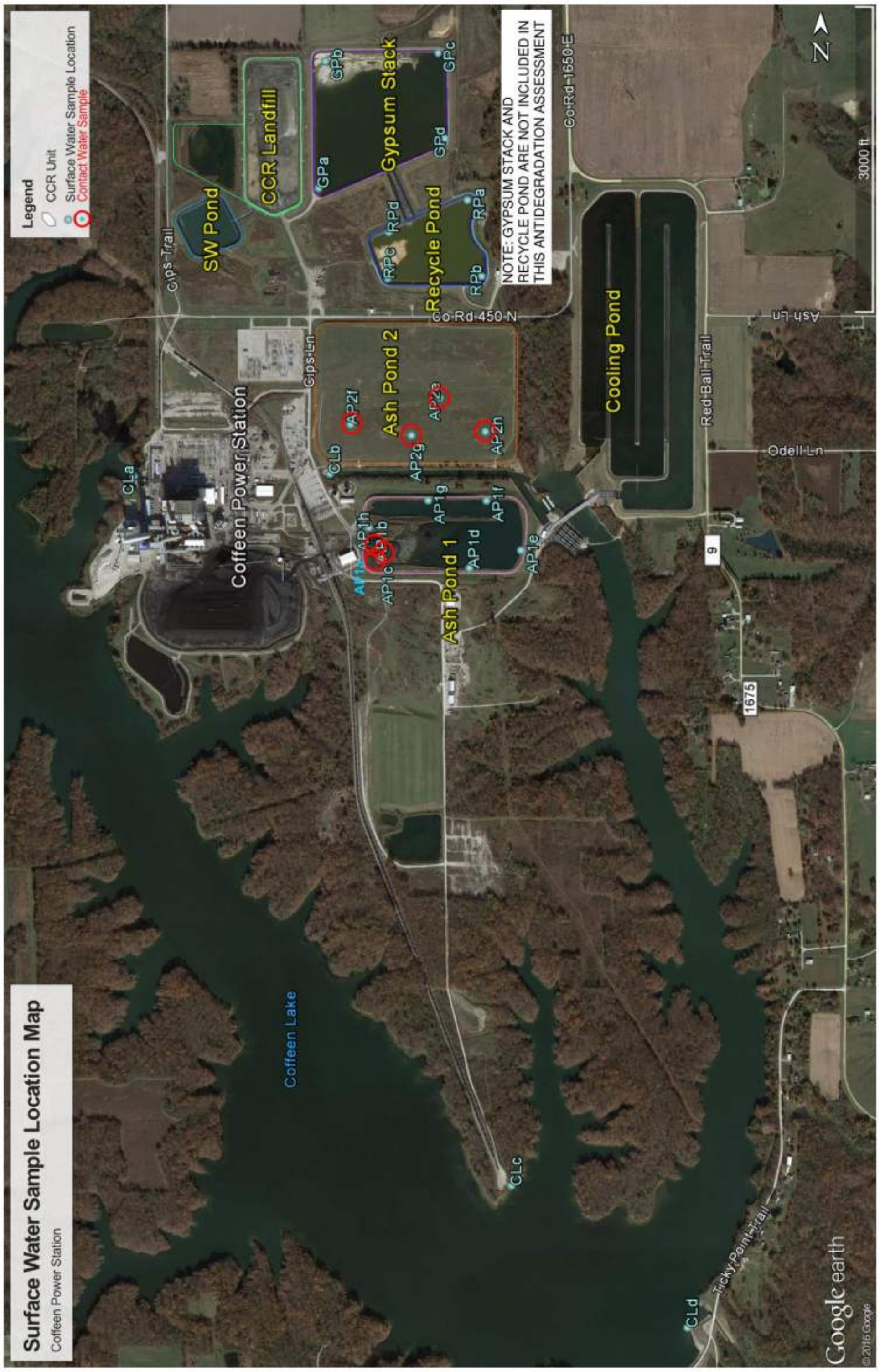
[1] In September 2017, USEPA granted petitions to reconsider the CCR rule. USEPA's reconsideration process may result in revisions to the CCR rule that would change IPGC's current closure plans and future planning regarding the CCR surface impoundments at Coffeen.

Figure 1 Site Map



Surface Water Sample Location Map
Coffeen Power Station

NOTE: GYPSUM STACK AND RECYCLE POND ARE NOT INCLUDED IN THIS ANTIDEGRADATION ASSESSMENT

3. Identification and Characterization of the Affected Water Body

Coffeen Lake (segment ROG) is an artificial cooling lake. The lake is listed on the 2016 *Illinois Integrated Water Quality Report and Section 303(d) List*. Fish consumption use is impaired, with a cause of mercury. A Total Maximum Daily Load (TMDL) has been completed for Coffeen Lake that sets allocations for phosphorus.

The IDNR EcoCAT system does not list any state threatened or endangered aquatic species as residing in the receiving water body near the Coffeen plant. A copy of the EcoCAT report is included in Appendix A.

4. Identification of Proposed Pollutant Load Increases or Potential Impacts on Uses

4.1 Water Sampling and Analyses

PDC Laboratories, Inc. (PDC), under subcontract and field oversight by Hanson Professional Services Inc. (Hanson), collected water samples from the ash ponds and receiving waters on October 24, 2016. Grab samples were collected from open water accumulated in Ash Pond 1 to characterize waters that would be discharged during “unwatering” of the ash pond; these waters are referred to in this report as “unwaters.” Ash Pond 2 is inactive and was previously covered. Unwaters are not associated with Ash Pond 2.

Grab samples were collected from test pits excavated in the CCR-filled portion of Ash Pond 1 and from wells installed in Ash Pond 2 to characterize waters that would be discharged during “dewatering” of the cells; these waters are referred to in this report as “dewaters.” The test pits in Ash Pond 1 were excavated the day before sampling, allowing CCR materials to settle overnight to reduce suspended solids in the samples. Each of the four operable wells in Ash Pond 2 was activated separately and allowed to run until the water appeared clear, then grab samples were collected from the pump discharge. Grab water samples were also collected from Coffeen Lake to evaluate the receiving water that may be affected by the proposed discharges.

In order to further characterize the dewaters as requested by Illinois EPA, an additional round of selected grab samples was collected on January 26, 2017. Table 1 summarizes the water samples collected. Figure 1 shows the sampling locations.

Table 1. Water Samples Collected and Analyzed

Impoundment/Waterbody Sampled	Unwater Samples	Dewater Samples
Ash Pond 1	AP1d, AP1e, AP1f, AP1g, AP1h	AP1a, AP1b, AP1c
Ash Pond 2	None	AP2e, AP2f, AP2g, AP2h

	Receiving Water	
Coffeen Lake	CLa, CLb, CLc, CLd	

The water samples were analyzed by PDC for constituents reviewed and approved by Illinois EPA in an email to Ms. Jacquelyn Bush of IPGC on October 11, 2016. PDC is accredited by Illinois EPA to conduct the laboratory analyses for this assessment. The laboratory analytical reports are included in Appendix B.

Table 2 summarizes the constituents analyzed and the analytical results of samples of the ash pond unwaters and the receiving water. The individual analytical results at each sample location were averaged for evaluation in this antidegradation assessment. None of the representative average unwaters concentrations exceeded the General Effluent Standards listed in 35 Ill. Adm. Code §304.

Table 3 summarizes the constituents analyzed and the analytical results of samples collected from CCR-filled portions of the ash ponds to characterize waters that would be discharged during dewatering the ponds. The individual analytical results at each sample location were averaged for evaluation in this antidegradation assessment. The representative average dewater concentrations of total suspended solids (TSS) in Ash Pond 1, Ash Pond 2, and the combined ash pond dewaters exceeded the General Effluent Standard of 15 mg/L listed in 35 Ill. Adm. Code §304. The representative average dewater concentrations of iron and manganese in Ash Pond 2 dewaters exceeded their respective General Effluent Standards of 2.0 mg/L and 1.0 mg/L. The representative average combined ash pond dewaters concentration of iron exceeded the General Effluent Standard. The representative average concentrations of manganese in Ash Pond 1 dewaters and the combined ash pond dewaters were less than the General Effluent Standard. All other analytes were less than the General Effluent Standards.

4.2 Pollutant Load Increases from Ash Pond Unwatering Discharge

Discharge of unwaters would occur from removal of the free surface water in Ash Pond 1. These waters result from the normal operation of the Coffeen plant and, except for storm water precipitation into the ash pond cells, are generally drawn from Coffeen Lake. These waters are currently discharged under the authorization of the plant’s NPDES permit. No unwaters are present in Ash Pond 2.

The means and methods of collecting and conveying the unwaters are undetermined at this time. For purposes of this antidegradation assessment, substances in unwaters at concentrations less than the General Effluent Standards at 35 Ill. Adm. Code §304 are considered to be protective of the receiving water quality, i.e., would not cause degradation of the receiving water quality. As shown in Table 2, the representative average unwater concentrations of all the analytes were less than the General Effluent Standards.

Table 4 shows the estimated mass of each substance proposed to be discharged through the existing NPDES outfall to the Coffeen Lake receiving water (the “Added Load”). The Added Load calculations compensate for the existing receiving water quality by subtracting the “Source Load” of each substance based on the analytical results of the lake samples. Table 4 also estimates the predicted effects of discharging the unwaters to the lake and demonstrates the proposed discharge will not cause exceedances of the Public and Food Processing Water Supply Use Standards at 35 Ill. Adm. Code §302 Subpart C. For substances with no Public and Food Processing Water Supply Use Standard, the chronic General Use Water Quality Standards at 35 Ill. Adm. Code §302 Subpart B were used for comparison. Lake concentrations were calculated at normal pool volume. For substances where concentrations in the lake already exceed the applicable water quality standards (oil and grease, phenols, and phosphorus), the concentrations of these substances in the proposed unwaters discharge are equivalent to the existing lake concentrations. Table 4 illustrates the proposed unwaters discharge will not increase the existing concentrations of oil and grease, phenols, and phosphorus in the lake.

The estimated volume of unwaters to be discharged as part of the CCR closure plan is 40 million gallons. The unwatering rate for Ash Pond 1 will vary depending on schedule and pump rates. The calculations shown in Table 4 assume pumping rates of about 347 gpm (0.5 million gallons per day (MGD)) could remove the free water in approximately 80 days.

Table 2. Ash Pond Unwaters and Receiving Waters Sample Analytical Results

		General Effluent Standards	Ash pond surface water samples (Collected October 24, 2016) All concentration units converted to mg/L for comparison to limits.						Receiving Water				
			Ash Pond 1 Unwaters					Representative Unwaters Concentrations	Coffeen Lake				Representative Lake Concentrations
Sample Date			10/24/2016	10/24/2016	10/24/2016	10/24/2016	10/24/2016		10/24/2016	10/24/2016	10/24/2016	10/24/2016	
Sample ID	Units	35 IAC 304	AP1d	AP1e	AP1f	AP1g	AP1h		CLa	CLb	CLc	CLd	
Ammonia	mg/L	3	<0.1	<0.1	<0.1	<0.1	<0.1	0.05	<0.1	<0.1	<0.1	<0.1	0.05
Arsenic	mg/L	0.25	0.002	0.0014	0.0015	0.0013	0.0015	0.0015	0.0018	0.0018	0.0018	0.0018	0.0018
Barium	mg/L	2.0	0.2	0.16	0.15	0.14	0.18	0.17	0.054	0.052	0.056	0.054	0.054
Boron	mg/L		2	2.1	2.1	2.1	2.2	2.1	0.27	0.28	0.28	0.27	0.28
Cadmium	mg/L	0.15	<0.001	<0.001	<0.001	<0.001	<0.001	0.0005	<0.001	<0.001	<0.001	<0.001	0.0005
Chloride	mg/L		18	18	17	17	17	17	0.023	0.022	0.022	0.023	0.023
Chromium	mg/L	1.0	<0.004	<0.004	<0.004	<0.004	<0.004	0.002	<0.004	<0.004	<0.004	<0.004	0.002
Chromium (hexavalent)	mg/L	0.1	<0.005	<0.005	0.0074	<0.005	<0.005	0.0035	<0.005	<0.005	<0.005	<0.005	0.0025
Copper	mg/L	0.5	0.033	0.016	0.017	0.015	0.014	0.019	0.0091	0.013	0.011	0.012	0.011
Cyanide	mg/L	0.1	<0.005	<0.005	<0.005	<0.005	<0.005	0.0025	<0.005	<0.005	<0.005	<0.005	0.0025
Fluoride	mg/L	15.0	1.08	1.00	1.00	1.00	0.98	1.01	0.443	0.425	0.426	0.421	0.429
Iron	mg/L	2.0	0.54	0.15	0.11	0.089	0.46	0.27	0.22	0.2	0.27	0.14	0.2
Lead	mg/L	0.2	<0.001	<0.001	<0.001	<0.001	<0.001	0.0005	<0.001	<0.001	<0.001	<0.001	0.0005
Manganese	mg/L	1.0	0.015	0.0095	0.0089	0.0081	0.0097	0.0102	0.015	0.022	0.026	0.024	0.022
Mercury	mg/L	0.0005	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0001	<0.0002	<0.0002	<0.0002	<0.0002	0.0001
Nickel	mg/L	1.0	<0.005	<0.005	<0.005	<0.005	<0.005	0.0025	<0.005	<0.005	<0.005	<0.005	0.0025
Nitrate	mg/L		<0.02	<0.02	<0.02	<0.02	<0.02	0.01	0.07	0.07	0.06	0.07	0.07
Nitrite	mg/L												
Total K Nitrogen	mg/L		<1.0	<1.0	<1.0	<1.0	<1.0	0.5	1.3	1.1	<1.0	<1.0	1.2
Oil and Grease	mg/L	15.0	<6.0	<6.5	<5.7	<5.9	<6.0	6.0	<5.9	<5.7	<5.9	<6.0	2.9
pH		6 to 9	7.21	7.12	7.20	7.21	7.41	7.23	7.22	7.52	7.62	7.30	7.42
Phenols	mg/L	0.3	<0.005	<0.005	<0.005	<0.005	<0.005	0.0025	<0.005	<0.005	<0.005	<0.005	0.0025
Phosphorus	mg/L	1.0	0.18	0.12	0.12	0.12	0.15	0.14	0.16	0.14	0.15	0.17	0.16
Selenium	mg/L		0.0015	0.0012	0.0012	0.0014	0.0012	0.0013	<0.001	<0.001	<0.001	<0.001	0.0005
Silver	mg/L	0.1	<0.005	<0.005	<0.005	<0.005	<0.005	0.0025	<0.005	<0.005	<0.005	<0.005	0.0025
Sulfate	mg/L		1000	960	1000	970	1000	986	55	56	54	54	55
Total Dissolved Solids (TDS)	mg/L		980	1200	1200	1200	1200	1156	190	180	160	170	175
Total Suspended Solids (TSS)	mg/L	15.0	9.2	5.6	8	4	6	6.6	7.6	4.8	4.8	<4.0	4.8
Zinc	mg/L	1.0	<0.006	<0.006	<0.006	<0.006	<0.006	0.003	0.006	0.006	<0.006	0.015	0.0075

Notes:
1. Metals are total concentrations
2. Non-detect results are assumed to be half the laboratory reporting limit for calculations.
3. Ash Pond 2 contains no unwaters.

Table 3. Ash Pond Dewaters Sample Analytical Results

Ash pond CCR contact water samples (Collected October 24, 2016 and January 26, 2017)

All concentration units converted to mg/L for comparison to limits.

		General Effluent Standards	Ash Pond 1						Ash Pond 1 Representative Average Dewater Concentrations	Ash Pond 2								Ash Pond 2 Representative Average Dewater Concentrations	Combined Ash Ponds Representative Average Dewater Concentrations
Sample Date			10/24/2016	1/26/2017	10/24/2016	1/26/2017	10/24/2016	1/26/2017		10/24/2016	1/26/2017	10/24/2016	1/26/2017	10/24/2016	1/26/2017	10/24/2016	1/26/2017		
Sample ID	Units	35 IAC 304	AP1a	AP1a	AP1b	AP1b	AP1c	AP1c		AP2e	AP2e	AP2f	AP2f	AP2g	AP2g	AP2h	AP2h		
Ammonia	mg/L	3	<0.1	<0.1	0.7	0.67	0.42	0.22	0.35	0.65	0.84	1.1	0.92	0.86	0.8	0.82	0.64	0.83	0.59
Arsenic	mg/L	0.25	0.0072	0.0093	0.017	0.0073	0.018	0.01	0.011	0.023	0.014	0.0012	<0.001	0.0055	0.0044	0.075	0.034	0.022	0.017
Barium	mg/L	2.0	0.13	0.13	0.1	0.099	0.13	0.25	0.14	0.026	0.019	0.022	0.014	0.02	0.015	0.023	0.013	0.02	0.08
Boron	mg/L		3.8	1.6	3.1	2.3	2.9	1.6	2.6	5.3	4.2	2	1.6	4.3	3.1	14	6.8	5.2	3.86
Cadmium	mg/L	0.15	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0005	<0.001	<0.001	<0.001	<0.001	0.0046	0.012	<0.001	<0.001	0.0025	0.00
Chloride	mg/L		3.2	9	13	10	13	14	10.4	<5	<5	<5	<5	<5	<5	1.7	1.6	2.3	6.3
Chromium	mg/L	1.0	<0.004	0.0045	<0.004	0.0052	<0.004	0.0057	0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	0.002	0.003
Chromium (hexavalent)	mg/L	0.1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0025	<0.005	<0.005	0.0055	<0.005	<0.005	<0.005	<0.005	<0.005	0.0030	0.0028
Copper	mg/L	0.5	<0.003	<0.003	<0.003	<0.003	0.0043	0.0041	0.0024	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.0015	0.0020
Cyanide	mg/L	0.1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0025	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0025	0.0025
Fluoride	mg/L	15.0	<0.25	0.142	0.977	0.507	0.614	0.512	0.480	0.438	0.485	0.398	0.32	0.506	0.377	0.406	0.181	0.389	0.434
Iron	mg/L	2.0	0.57	0.9	0.83	1.2	0.77	2.2	1.08	350	320	460	380	360	290	24	22	276	138
Lead	mg/L	0.2	<0.001	<0.001	<0.001	0.0012	<0.001	0.0015	0.0008	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0005	0.0006
Manganese	mg/L	1.0	0.012	0.0086	0.074	0.041	0.053	0.022	0.035	2.0	1.9	2.3	2.0	2.9	2.2	1.0	0.9	1.90	0.97
Mercury	mg/L	0.0005	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0001	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0001	0.0001
Nickel	mg/L	1.0	<0.005	<0.005	0.0061	0.0087	<0.005	<0.005	0.0041	<0.005	<0.005	<0.005	<0.005	0.0064	<0.005	<0.005	<0.005	0.0030	0.0036
Nitrate	mg/L		<0.02	<0.1	<0.02	<0.1	<0.02	<0.1	0.06	<0.02	<0.1	<0.02	<0.1	<0.02	<0.1	<0.02	<0.1	0.06	0.06
Nitrite	mg/L			<0.1		<0.1		<0.1	0.05		<0.1		<0.15		<0.15		<0.1	0.11	0.08
Total K Nitrogen	mg/L		<1.0	0.35	1.5	0.0014	1.4	0.6	0.65	1.2	0.78	1.5	0.77	1.1	0.81	1.4	0.9	1.06	0.85
Oil and Grease	mg/L	15.0	<5.7	<3.2	7.8	<3.1	8.3	<3.1	3.9	<6.0	<3.1	<5.9	<3.2	<5.7	<3.3	<5.7	<3	4.5	4.21
pH		6 to 9	6.99	6.52	7.01	6.92	7.05	6.85	6.890	6.49	5.96	6.42	5.99	6.46	6.34	7.17	6.27	6.39	6.64
Phenols	mg/L	0.3	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0025	<0.005	0.019	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.005	0.004
Phosphorus	mg/L	1.0	0.21	0.16	0.16	0.065	0.17	0.22	0.16	0.84	0.16	0.83	0.4	0.17	0.1	0.26	0.038	0.35	0.26
Selenium	mg/L		0.003	0.018	0.0069	0.0021	0.0031	0.003	0.006	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0005	0.0033
Silver	mg/L	0.1	<0.005	<0.003	<0.005	<0.003	<0.005	<0.003	0.002	<0.005	<0.003	<0.005	<0.003	<0.005	<0.003	<0.005	<0.003	0.004	0.003
Sulfate	mg/L		1500	1300	1300	1500	1600	1200	1400	1500	1400	1500	1200	2300	1800	1300	880	1485	1443
Total Dissolved Solids (TDS)	mg/L		1800	1900	1600	2200	1900	1700	1850	1700	1800	1700	1600	2400	2600	1500	1400	1838	1844
Total Suspended Solids (TSS)	mg/L	15.0	17	8.8	27	20	9.6	58	23	120	110	120	160	120	150	22	39	105	64
Zinc	mg/L	1.0	<0.006	<0.006	0.0092	0.0064	0.0082	0.0064	0.006	0.017	0.02	<0.006	<0.006	0.016	0.028	<0.006	<0.006	0.012	0.009

Notes:
1. Metals are total concentrations
2. Non-detect results are assumed to be half the laboratory reporting limit for calculations.

Table 4. Antidegradation Assessment - Ash Pond Unwaters

This table shows the "Added Load" of pollutants from unwaters that would be discharged to Coffeen Lake.
The table shows the proposed discharge will not cause exceedances of the 35 IAC Section 302 Public and Food Processing Water Supply Standards in the lake.

Contaminant	35 IAC 304 (mg/L)	35 IAC 302 Chronic (mg/L)	Ash Pond 1 - Unwaters					Flow Mixing with Process Water			Coffeen Lake					
			Treatment Flowrate (gpm) = 347					Average Flowrate (gpm) = 305,500			Normal Pool Volume (gallons) = 7,039,440,000					
			Total Volume (gallons) = 40,000,000					Process Water Concentration - CLb (mg/L)	Concentration at Outfall (mg/L)	Meet 304?	Coffeen Lake (mg/L)	Lake Meet 302?	Lake Conc. w/ Effluent (mg/L)	Meet 302?	Meet Lake?	Additional Treatment to meet 302 or Lake (lbs)
			Concentration (mg/L)	Meet 304?	Total Load (lbs)	Source Load (lbs)	Added Load (lbs)									
Ammonia	3	2.08	**0.05**	yes	16.69	16.69	0.00	0.05	0.05	yes	0.05	yes	0.05	yes	-	-
Arsenic	0.25	0.05	**0.0015**	yes	0.51	0.60	-0.09	0.0018	0.002	yes	0.002	yes	0.002	yes	-	-
Barium	2	1.0	**0.17**	yes	55.42	18.03	37.39	0.052	0.052	yes	0.054	yes	0.054	yes	-	-
Boron	-	1.0	**2.1**	-	701.06	91.81	609.25	0.28	0.282	-	0.275	yes	0.275	yes	-	-
Cadmium	0.15	0.010	**0.0005**	yes	0.17	0.17	0.00	0.0005	0.0005	yes	0.0005	yes	0.0005	yes	-	-
Chloride	-	250	**17**	-	5,808.8	7.5	5,801.25	0.022	0.042	-	0.023	yes	0.023	yes	-	-
Chromium	1	0.050	**0.002**	yes	0.67	0.67	0.00	0.002	0.0020	yes	0.0020	yes	0.0020	yes	-	-
Chromium (hex)	0.1	0.011	**0.003**	yes	1.16	0.83	0.33	0.0025	0.0025	yes	0.0025	yes	0.0025	yes	-	-
Copper	0.5	0.015	**0.019**	yes	6.34	3.76	2.58	0.013	0.0130	yes	0.0113	yes	0.0113	yes	-	-
Cyanide	0.1	5.2	**0.0025**	yes	0.83	0.83	0.00	0.0025	0.0025	yes	0.0025	yes	0.0025	yes	-	-
Fluoride	15	1.4	**1.01**	yes	337.8	143.1	194.71	0.425	0.426	yes	0.429	yes	0.429	yes	-	-
Iron	2	0.3	**0.27**	yes	90	69.27	20.80	0.20	0.20	yes	0.208	yes	0.207	yes	-	-
Lead	0.2	0.050	**0.0005**	yes	0.17	0.17	0.00	0.0005	0.0005	yes	0.0005	yes	0.0005	yes	-	-
Manganese	1	1.0	**0.0102**	yes	3.42	7.26	-3.84	0.0220	0.0220	yes	0.0218	yes	0.0218	yes	-	-
Mercury	0.0005	0.0011	**0.0001**	yes	0.0334	0.03	0.00	0.0005	0.0005	yes	0.0001	yes	0.0001	yes	-	-
Nickel	1	0.007	**0.0025**	yes	0.83	0.83	0.00	0.0025	0.0025	yes	0.0025	yes	0.0025	yes	-	-
Nitrate (302.304)	-	10	**0.01**	-	3.34	23.37	-20.03	0.07	0.070	-	0.070	yes	0.070	yes	-	-
Nitrite	-	-	**-**	-	-	-	-	-	-	-	-	-	-	-	-	-
O&G	15	0.1	**6.0**	yes	2,009.7	980.6	1,029.05	2.85	2.9	yes	2.9	no	2.9	no	yes	-
pH	6 to 9	6 to 9	**7.23**	yes	-	-	-	7.52	7.52	yes	7.42	yes	7.42	yes	-	-
Phenols	0.3	0.001	**0.0025**	yes	0.83	0.83	0.00	0.0025	0.0025	yes	0.0025	no	0.0025	no	yes	-
Phosphorus	1	0.05	**0.14**	yes	46.07	51.74	-5.68	0.14	0.14	yes	0.16	no	0.15	no	yes	-
Selenium	-	0.01	**0.0013**	-	0.43	0.17	0.27	0.0005	0.0005	-	0.0005	yes	0.0005	yes	-	-
Silver	0.1	0.005	**0.0025**	yes	0.83	0.83	0.00	0.0025	0.0025	yes	0.0025	yes	0.0025	yes	-	-
Sulfate	-	250	**986**	-	329,163	18,278	310,885.71	56.0	57.1	-	54.8	yes	54.8	yes	-	-
TDS	-	500	**1156**	-	385,916	58,421	327,494.10	180	181	-	175	yes	175	yes	-	-
TSS	15	-	**7**	yes	2,190	1,602	587.55	4.8	4.8	yes	4.8	yes	4.8	-	-	-
TKN	-	-	**0.5**	-	166.9	400.6	-233.69	1.1	1.1	-	1.2	yes	1.2	-	-	-
Zinc	1	0.041	**0.003**	yes	1.00	2.50	-1.50	0.0060	0.0060	yes	0.0075	yes	0.0075	yes	-	-

Notes

* Hardness-based numeric water quality standards are calculated using analytical result of 110 mg/L from January 13, 2017 sampling.

* Concentration is represented as a mean of all samples collected. Non-detect results were assumed to be half of the detection limit.

* Concentration at outfall is weighted based on flow rate and concentration of process water flow.

* Additional treatment is the amount of additional treament needed to reduce the concentration of the effluent water to meet either the 302 water quality standard or the concentration of the source water (Coffeen

4.3 Pollutant Load Increases from Ash Pond Dewatering Discharge

Discharge of dewaters would occur from removal of the water from pore spaces in deposited ash in Ash Ponds 1 and 2. The means and methods of collecting and conveying the dewaters are undetermined at this time. This antidegradation assessment assumes the dewaters from Ash Ponds 1 and 2 will be combined for discharge.

For purposes of this antidegradation assessment, substances in dewaters at concentrations less than the General Effluent Standards at 35 Ill. Adm. Code §304 are considered to be protective of the receiving water quality, i.e., would not cause degradation of the receiving water quality. As shown in Table 3 and Table 5, the representative average dewater concentrations of TSS in Ash Pond 1, Ash Pond 2, and the combined ash pond dewaters exceeded the General Effluent Standard. The representative average dewater concentrations of iron and manganese in Ash Pond 2 dewaters exceeded their respective General Effluent Standards. The representative average combined ash pond dewaters concentration of iron exceeded the General Effluent Standard. The representative average concentrations of manganese in Ash Pond 1 dewaters and the combined ash pond dewaters were less than the General Effluent Standard. All other analytes were less than the General Effluent Standards.

Table 5 shows the estimated mass of each substance proposed to be discharged through the existing NPDES outfall to Coffeen Lake receiving water (the “Added Load”). Table 5 estimates the predicted effects of discharging the dewaters to the lake and demonstrates the proposed discharge will not cause exceedances of the Public and Food Processing Water Supply Use Standards at 35 Ill. Adm. Code §302 Subpart C. For substances with no Public and Food Processing Water Supply Use Standard, the chronic General Use Water Quality Standards at 35 Ill. Adm. Code §302 Subpart B were used for comparison. Lake concentrations were calculated at normal pool volume. For substances where concentrations in the lake already exceed the applicable water quality standards (oil and grease, phenols, and phosphorus), the concentrations of these substances in the proposed dewaters discharge are equivalent to the existing lake concentrations. Table 5 illustrates the proposed dewaters discharge will not increase the existing concentrations of oil and grease, phenols, and phosphorus in the lake.

The estimated combined volume of dewaters to be discharged from Ash Ponds 1 and 2 as part of the CCR closure plan is 25 million gallons. The dewaters are expected to be discharged over approximately 120 to 180 days, at a rate of approximately 0.1 to 0.2 MGD. Ash Pond 2 may be dewatered using the pumps in the existing wells. The dewatering volume may be reduced if less dewatering is required to construct the cover system. The proposed short-term CCR dewatering discharge will contribute a negligible effect on receiving water concentrations.

5. Fate and Effect of Parameters Proposed for Increased Loading

Tables 4 and 5 show the estimated mass of each substance proposed to be discharged through the existing NPDES outfall to Coffeen Lake from the ash pond unwatering and dewatering activities (the “Added Load” on each table). The tables also estimate the predicted effects of discharging the unwaters and dewaters and demonstrate the proposed discharges will not cause exceedances of the Public and Food Processing Water Supply Use Standards at 35 Ill. Adm. Code §302 Subpart C or increase the existing lake concentrations. For substances with no Public and Food Processing Water Supply Use Standard, the chronic General Use Water Quality Standards at 35 Ill. Adm. Code §302 Subpart B were used for comparison.

Table 5. Antidegradation Assessment - Ash Pond Dewaters

This table shows the "Added Load" of pollutants from dewaters that would be discharged to Coffeen Lake.
The table shows the proposed discharge will not cause exceedances of the 35 IAC Section 302 Public and Food Processing Water Supply Standards in the lake.

Contaminant	35 IAC 304 (mg/L)	35 IAC 302 Chronic (mg/L)	Ash Ponds 1 and 2 - Dewaters					Flow Mixing with Process Water			Coffeen Lake					
			Treatment Flowrate (gpm) = 100					Average Flowrate (gpm) = 305,500			Normal Pool Volume (gallons) = 7,039,440,000					
			Total Volume (gallons) = 25,000,000					Process Water Concentration - CLb (mg/L)	Concentration at Outfall (mg/L)	Meet 304?	Coffeen Lake (mg/L)	Lake Meet 302?	Lake Conc. w/ Effluent (mg/L)	Meet 302?	Meet Lake?	Additional Treatment to meet 302 or Lake (lbs)
			Concentration (mg/L)	Meet 304?	Total Load (lbs)	Source Load (lbs)	Added Load (lbs)									
Ammonia	3	2.08	**0.59**	yes	123.15	10.43	112.71	0.05	0.05	yes	0.05	yes	0.05	yes	-	-
Arsenic	0.25	0.05	**0.0170**	yes	3.54	0.38	3.16	0.0018	0.002	yes	0.002	yes	0.002	yes	-	-
Barium	2	1.0	**0.08**	yes	16.57	11.27	5.30	0.052	0.052	yes	0.054	yes	0.054	yes	-	-
Boron	-	1.0	**3.9**	-	804.60	57.38	747.22	0.280	0.281	-	0.275	yes	0.275	yes	-	-
Cadmium	0.15	0.010	**0.0015**	yes	0.31	0.10	0.20	0.0005	0.0005	yes	0.0005	yes	0.0005	yes	-	-
Chloride	-	250	**6**	-	1,320.1	4.7	1,315.44	0.022	0.024	-	0.023	yes	0.023	yes	-	-
Chromium	1	0.050	**0.003**	yes	0.58	0.42	0.16	0.002	0.0020	yes	0.0020	yes	0.0020	yes	-	-
Chromium (hex)	0.1	0.011	**0.003**	yes	0.57	0.52	0.05	0.0025	0.0025	yes	0.0025	yes	0.0025	yes	-	-
Copper	0.5	0.015	**0.002**	yes	0.41	2.35	-1.95	0.013	0.0130	yes	0.0113	yes	0.0113	yes	-	-
Cyanide	0.1	5.2	**0.0025**	yes	0.52	0.52	0.00	0.0025	0.0025	yes	0.0025	yes	0.0025	yes	-	-
Fluoride	15	1.4	**0.43**	yes	90.6	89.5	1.13	0.425	0.425	yes	0.429	yes	0.429	yes	-	-
Iron	2	0.3	**138.41**	no	28,880	43.29	28,836.56	0.20	0.25	yes	0.21	yes	0.21	yes	-	-
Lead	0.2	0.050	**0.0006**	yes	0.13	0.10	0.03	0.0005	0.0005	yes	0.0005	yes	0.0005	yes	-	-
Manganese	1	1.0	**0.9657**	yes	201.49	4.54	196.95	0.022	0.0223	yes	0.0218	yes	0.0218	yes	-	-
Mercury	0.0005	0.0011	**0.0001**	yes	0.0209	0.02	0.00	0.0005	0.0005	yes	0.0001	yes	0.0001	yes	-	-
Nickel	1	0.007	**0.0036**	yes	0.74	0.52	0.22	0.0025	0.0025	yes	0.0025	yes	0.0025	yes	-	-
Nitrate (302.304)	-	10	**0.06**	-	12.52	14.61	-2.09	0.07	0.070	-	0.070	yes	0.070	yes	-	-
Nitrite	-	-	**-**	-	-	-	-	-	-	-	-	-	-	-	-	-
O&G	15	0.1	**4.2**	yes	879.4	612.9	266.46	2.85	2.9	yes	2.9	no	2.9	no	yes	-
pH	6 to 9	6 to 9	**6.64**	yes	-	-	-	7.52	7.52	yes	7.42	yes	7.42	yes	-	-
Phenols	0.3	0.001	**0.0035**	yes	0.74	0.52	0.22	0.0025	0.0025	yes	0.0025	no	0.0025	no	yes	-
Phosphorus	1	0.05	**0.26**	yes	53.61	32.34	21.27	0.14	0.14	yes	0.16	no	0.15	no	yes	-
Selenium	-	0.01	**0.0033**	-	0.68	0.10	0.58	0.0005	0.0005	-	0.0005	yes	0.0005	yes	-	-
Silver	0.1	0.005	**0.0030**	yes	0.63	0.52	0.10	0.0025	0.0025	yes	0.0025	yes	0.0025	yes	-	-
Sulfate	-	250	**1443**	-	300,975	11,423	289,551	56	56.5	-	54.8	yes	54.8	yes	-	-
TDS	-	500	**1844**	-	384,695	36,513	348,182	180	181	-	175	yes	175	yes	-	-
TSS	15	-	**64**	no	13,408	1,002	12,406.74	4.8	4.8	yes	4.8	yes	4.8	-	-	-
TKN	-	-	**0.9**	-	178.2	250.4	-72.22	1.1	1.1	-	1.2	yes	1.2	-	-	-
Zinc	1	0.041	**0.009**	yes	1.84	1.56	0.28	0.006	0.0060	yes	0.0075	yes	0.0075	yes	-	-

Notes

* Hardness-based numeric water quality standards are calculated using analytical result of 110 mg/L from January 13, 2017 sampling.
* Concentration is represented as a mean of all samples collected. Non-detect results were assumed to be half of the detection limit.
* Concentration at outfall is weighted based on flow rate and concentration of process water flow.
* Additional treatment is the amount of additional treament needed to reduce the concentration of the effluent water to meet either the 302 water quality standard or the concentration of the source water (Coffeen

Fish consumption use of Coffeen Lake is listed as impaired, with a cause of mercury. A TMDL has been completed for Coffeen Lake that sets allocations for phosphorus. The concentrations of mercury in the proposed discharges will not cause exceedances of the Public and Food Processing Water Supply Use Standards. The proposed unwaters and dewaters discharges will not increase the existing lake concentrations of the causes of impairment. Since the proposed short-term discharges would not cause exceedances of the Public and Food Processing Water Supply Use standards or contribute to the cause of impairment in the lake, adverse impacts to the existing uses of the water body are not anticipated.

6. Assessments of Alternatives for Less Increase in Loading or Minimal Environmental Degradation

6.1 Water Management Alternatives Considered

Discharge of unwaters would occur from removal of the free surface water in Ash Pond 1. These waters result from the normal operation of the Coffeen plant and, except for storm water precipitation into the ash pond cells, are generally drawn from Coffeen Lake. These waters comply with the General Effluent Standards at 35 Ill. Adm. Code §304 and are currently discharged under the authorization of the plant's NPDES permit. No unwaters are present in Ash Pond 2.

IPGC has considered management alternatives for the dewaters that could avoid or minimize increase in pollutant loading to the receiving water. In addition to assessment of potential degradation of receiving waters that could result from the dewatering discharges, an important criterion used in the alternatives analysis is the reliability of the time required to remove the dewaters from the ash ponds. The unwatering and dewatering must be completed in a limited time frame to enable the regulatory-driven CCR closure construction activities. The alternatives are summarized in Table 6 and discussed in the following sections.

Table 6. Water Management Alternatives Considered

<u>Alternatives that Avoid Discharge to Receiving Water</u>

- No action. (No unwatering or dewatering of ash ponds.)
- Mechanical evaporation.
- Agricultural irrigation.
- Land application.
- Use ash pond water in power generation plant processes.

<u>Alternatives that Discharge to Receiving Water</u>

- ✓ Discharge through existing NPDES Outfall 001. This is the preferred alternative.
- Discharge with additional treatment.
    - Coagulation/flocculation.
    - Precipitation/filtration.
    - Reverse osmosis.

6.2 Alternatives that Avoid Discharge to Receiving Water

6.2.1 No Action Alternative

The closure plan for the Coffeen Ash Ponds 1 and 2 includes installation of a compacted earthen material and vegetated or composite cover system. Site preparation for installation of the cover system requires removal of open water from the ash ponds and partial removal of pore water contained in CCR-filled portions of the ash ponds. Impoundment closure to comply with the federal CCR Rule could not be achieved without removing the unwaters and dewaters. Therefore, the no action alternative is not feasible and is excluded from further consideration.

6.2.2 Mechanical Evaporation

IPGC and Hanson evaluated dewatering the ash ponds by mechanical evaporation. Hanson consulted with one mechanical evaporation equipment provider to discuss the feasibility of removing the ash pond dewaters by evaporation. Based on the information reviewed and the typical climate in this project area, mechanical evaporators could each be expected to evaporate approximately 60,000 gallons per day. Multiple evaporators would be needed to remove the estimated 25 million gallons of dewaters from the ash ponds.

Evaporation rates would be dependent upon many factors such as performance of the evaporation equipment, water make-up and chemistry, ambient temperature and humidity, solar radiation, wind, free flow of air over the ash ponds, and other factors. Evaporation could occur only in the warmer months, between approximately April and October, with the most efficient evaporation occurring in mid-summer.

It is unlikely that ideal evaporation conditions would occur for enough duration to eliminate the total 25 million gallons of dewaters. The unpredictability of weather and unreliability of evaporation rates make this alternative infeasible to comply with the CCR closure timeframes.

6.2.3 Agricultural Irrigation

IPGC and Hanson evaluated using the CCR dewaters for agricultural irrigation. The Coffeen plant is located in a rural agricultural area, although the plant is situated between Coffeen Lake and other waterbodies including East Fork Shoal Creek and Rocky Ford Lakes. Review of aerial photography does not indicate that irrigation is currently used in the vicinity of the plant. Dewaters could be pumped from the ash ponds and piped to fields east of the plant. However, the nearest agricultural fields do not appear to be feasible for the installation of large irrigation rigs due to the presence of large high-voltage electric transmission lines. The nearest fields that could potentially be irrigated would require running about 1.2 miles of temporary piping across and along County Road 1650E. It is unknown if permission could be obtained from the landowners and/or tenant farmers to utilize the irrigation rigs in their fields, and what conditions or payments may be required to obtain permission. It is likely IPGC would have to compensate the farmers for at least one season of crops. Since the purpose of the irrigation would be to remove the dewaters from the ash ponds, it is likely that water would be applied at higher rates than desired for crop growth, resulting in damaged crop or diminished yields.

IPGC has not estimated the cost to negotiate permissions and install the temporary piping to the agricultural irrigation rig(s). As with the mechanical evaporation discussed above, it is unlikely that ideal conditions would occur for enough duration to eliminate the total 25 million gallons of dewaters. The unpredictability of weather and unreliability of evaporation and infiltration rates make this alternative infeasible to comply with the CCR closure timeframes. The technical obstacles and potential detrimental effects to local farms make this alternative infeasible for the proposed short-term discharge.

6.2.4 Land Application

IPGC and Hanson evaluated land application of the CCR dewaters. Dewaters could be utilized on site for dust control. Land-applied water would be dissipated by evaporation and infiltration. In order to avoid discharge to the receiving water, land application would need to be controlled so that surface runoff did not occur. Due to the large volume of dewaters to be removed, the relatively compact size of the Coffeen plant, and the small area of pervious surfaces for infiltration, it is unlikely the dewaters could be eliminated in a timely manner by land application on stored coal or ground surfaces without causing plant inefficiency (wet coal) or safety or housekeeping issues. Land application is infeasible to eliminate the total 25 million gallons of dewaters within the CCR closure timeframes.

6.2.5 Use CCR Dewaters in Power Generation Plant Processes

IPGC and Hanson evaluated using the CCR dewaters in power plant processes. The plant uses makeup water for various processes. However, the quality of the dewaters, including concentrations of iron, sulfate, TSS, and total dissolved solids (TDS) would not be usable in the processes without substantial pretreatment. The likely pretreatment processes would generate waste streams that would result in wastewater discharges or disposal. Due to the undesirable water quality and the large volume of dewaters, it is infeasible to eliminate the anticipated total 25 million gallons of dewaters by using it in plant processes.

Currently the existing Ash Pond 2 dewatering system is directed to the GMF system, which recirculates to the “closed-loop” scrubber system. This dewatering system could be adequate to lower the Ash Pond 2 phreatic surface, facilitate Ash Pond 2 closure, and reduce the volume of Ash Pond 2 dewaters that would need to be discharged to Coffeen Lake during Ash Pond 2 closure. However, the GMF ystem could be overwhelmed with the large volume of Ash Pond 2 dewaters. Therefore, the option to discharge Ash Pond 2 dewaters to Coffeen Lake must be available.

6.3 Alternatives that Discharge to Receiving Water

6.3.1 Discharge through Existing NPDES Outfall

IPGC and Hanson evaluated discharging the dewaters through the existing NPDES Outfall 001. This is the normal operation and discharge of the ash pond waters. The dewaters would be conveyed through the outfall using existing infrastructure, including pumps, piping, and outfall structures.

Table 5 estimates the predicted effects of discharging the dewaters to the lake and demonstrates the proposed discharge will not cause exceedances of the Public and Food Processing Water Supply Use Standards or the chronic General Use Water Quality Standards at 35 Ill. Adm. Code §302. For substances where concentrations in the lake already exceed the applicable water quality standards (oil and grease, phenols, and phosphorus), the concentrations of these substances in the proposed dewaters discharge are equivalent to the existing lake concentrations. Table 5 illustrates the proposed dewaters discharge will not increase the existing concentrations of oil and grease, phenols, and phosphorus in the lake.

Pollutant loading from the proposed dewatering would increase during the short-term discharges (approximately 120 to 180 days). Considering the demonstration presented in Table 5, no adverse impacts to the existing uses of the receiving water are anticipated. Pollutant loading would decrease when the short-term dewaters discharges are completed. This alternative eliminates the dewaters in the shortest time and will enable the dewatering to be completed within the CCR closure timeframes.

6.3.2 Direct Discharge with Additional Treatment

IPGC and Hanson conducted cursory evaluations of treatment processes to reduce pollutant concentrations in the dewaters discharges. Wastewater pretreatment processes could conceivably be installed prior to Outfall 001. Pretreatment processes including oxidation, precipitation, coagulation, and flocculation would reduce the TSS in the dewaters and could reduce the dissolved concentrations of certain pollutants such as iron and manganese. However, industry experience has shown that biological treatment, chemical precipitation, or ion exchange processes are not effective in reducing concentrations of boron.

Specialized adsorption processes or reverse osmosis (RO) could be utilized to reduce the concentration of boron in the ash pond dewaters. These technologies are complex, expensive, and generate waste streams that need to be disposed or treated. Considering the large volume of dewaters (25 million gallons total), it is predicted the volumes of wastewaters from the pretreatment processes would be substantially large and concentrated to make these processes infeasible for the proposed short-term discharges of ash pond dewaters.

7. Identification of Preferred Alternative

Discharging the unwaters and dewaters through the existing NPDES outfall is consistent with the plant’s normal operation. This alternative would use existing infrastructure at minimal or no additional cost and has been demonstrated to not cause exceedances of the Public and Food Processing Water Supply Standard or the chronic General Use Water Quality Standards. This alternative will remove the dewaters in the shortest practicable time to comply with the CCR closure timeframes. Discharging the dewaters through the existing NPDES outfall is IPGC’s preferred alternative.

8. References

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Illinois Environmental Protection Agency. *Public Notice/Fact Sheet* (2015, August 31). Notice No. SMT:15070201.smt. NPDES Permit IL0000108.

Appendix

EcoCAT Report

ATTACHMENT V

Applicant: Hanson Professional Services Inc.
Contact: Doug Dorsey
Address: 1525 S. 6th St.
Springfield, IL 62703

IDNR Project Number: 1704719
Date: 11/25/2016

Project: Coffeen Lake
Address: 134 CIPS Lane, Coffeen

Description: Antidegradation study for CCR Discharge

Natural Resource Review Results

This project was submitted for information only. It is not a consultation under Part 1075.

The Illinois Natural Heritage Database shows the following protected resources may be in the vicinity of the project location:

Eastern Blue-Eyed Grass *(Sisyrinchium atlanticum)*

Location

The applicant is responsible for the accuracy of the location submitted for the project.

County: Montgomery

Township, Range, Section:
7N, 3W, 3
7N, 3W, 4
7N, 3W, 9
7N, 3W, 10
7N, 3W, 11
7N, 3W, 14
7N, 3W, 15
7N, 3W, 22
7N, 3W, 23

IL Department of Natural Resources Contact
Impact Assessment Section
217-785-5500
Division of Ecosystems & Environment

Disclaimer

The Illinois Natural Heritage Database cannot provide a conclusive statement on the presence, absence, or condition of natural resources in Illinois. This review reflects the information existing in the Database at the time of this inquiry, and should not be regarded as a final statement on the site being considered, nor should it be a substitute for detailed site surveys or field surveys required for environmental assessments. If additional protected resources are encountered during the project's implementation, compliance with applicable statutes and regulations is required.

IDNR Project Number: 1704719

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ATTACHMENT V

Antidegradation Assessment
Coffeen Power Station

Appendix E

Groundwater Polishing Evaluation Report

Geosyntec
consultants

engineers | scientists | innovators

Groundwater Polishing Evaluation Report

Coffeen Power Plant – Ash Pond No. 2 Unit

(IEPA ID No. W1350150004-02)

Prepared for

Illinois Power Generating Company
1500 Eastport Plaza Drive
Collinsville, Illinois 62234

Prepared by

Geosyntec Consultants, Inc.
500 W. Wilson Bridge Road, Suite 250
Worthington, Ohio 43085

Project Number: GLP8078

April 1, 2025

LIST OF TABLES

LIST OF INTERNAL FIGURES

LIST OF ATTACHMENTS

ACRONYMS AND ABBREVIATIONS

AP1	Ash Pond No. 1
AP2	Ash Pond No. 2
CAAA	Corrective Actions Alternative Analysis
CCR	Coal combustion residuals
COC	Constituent of concern
CPP	Coffeen Power Plant
DA	Deep aquifer
DCU	Deep confining unit
GCSM	Geochemical conceptual site model
GWPS	Groundwater protection standard
IEPA	Illinois Environmental Protection Agency
LCU	Lowermost confining unit
mg/kg	milligrams per kilogram
redox	oxidation-reduction
SEP	Sequential extraction procedure
SRNL	Savannah River National Laboratory
UA	Uppermost aquifer
UCU	Uppermost confining unit
USEPA	United States Environmental Protection Agency
TDS	Total dissolved solids
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 Coffeen Power Plant Ash Pond No. 2 (AP2) Unit. The constituents of concern (COCs) addressed this document are boron, pH, sulfate, and total dissolved solids (TDS), which have been identified as having exceedances[1] of the site-specific groundwater protection standards (GWPS) at the time of this analysis. 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 Coffeen AP2.

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 COCs and for previously attenuated COCs to be mobilized 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 and sulfate is feasible under current conditions through sorption to iron and aluminum oxide solids and, in the case of sulfate, barite precipitation. Modeling indicates that boron and sulfate attenuation via sorption onto mineral surfaces should remain stable under future conditions, as iron and aluminum oxide mineral phases are predicted to experience minor (if any) dissolution with background groundwater interaction. Additionally, barite precipitation was predicted in all future

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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 as described in the proposed groundwater monitoring program which was submitted to the IEPA on October 25, 2021 as part of Illinois Power Resource Generating, LLC's operating permit application for the Coffeen Power Plant Ash Pond No. 2. That operating permit application, including the proposed groundwater monitoring program, remains under review by the IEPA and therefore Illinois Power Resource Generating, LLC has not identified any actual exceedances.

scenarios. Remobilization of sulfate is unlikely to affect the estimated time to reach the GWPS based on modeling results; however, mobilization of currently attenuated boron at some locations could result in a longer time to reach the GWPS compared to sulfate. It is anticipated that attenuation of sulfate will contribute to a reduction in TDS concentrations. The low pH exceedance at a single well is predicted to resolve due to influence from near-neutral pH background groundwater. 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 Coffeen Power Plant (CPP) Ash Pond No. 2 (AP2) 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 constituents of concern (COCs) addressed in this document are boron, pH, sulfate, and total dissolved solids (TDS)[2], which have been identified as having exceedances of the site-specific groundwater protection standard (GWPS) at the time of this analysis. In the CAAA, all corrective actions considered consist 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 Coffeen AP2.[3]

Groundwater polishing processes include both physical and chemical mechanisms within the groundwater 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[4]). 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 Coffeen AP2 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[5]) estimated the time for sulfate (as a conservative surrogate) to reach the GWPS under different potential corrective actions based on physical components of groundwater polishing and did not 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 and sulfate before and after

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[2] TDS measurements represent the total mass of dissolved constituents in a sample rather than a single chemical behavior. Because sulfate is the dominant contributor to TDS, results for sulfate in this analysis also apply to TDS.

[3] The Human Health and Ecological Risk Assessment serves as Appendix A of the CAAA to which this report is attached.

[4] The Groundwater Modeling Technical Memorandum serves as Appendix B of the Corrective Action Alternatives Analysis Supporting Information Report; the Corrective Action Alternatives Analysis Supporting Information Report serves as Appendix B of the CAAA to which this report is attached.

[5] Ibid.

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 Program[6].

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[6] The Corrective Action Groundwater Monitoring Program 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 CPP property is located approximately two miles south of the city of Coffeen, Illinois, and bordered by two lobes of Coffeen Lake to the west, east, and south, and by agricultural land to the north. The CPP AP2 impoundment is located to the north of the CPP Ash Pond No. 1 (AP1) coal combustion residuals (CCR) unit (IEPA No. W1350150004-0101), and south of the Gypsum Management Facility Recycle Pond (IEPAIEPA No. W1350150004-04). An unnamed tributary runs north to south to the east of AP2. AP2 is a 78-acre unlined surface impoundment that received bottom ash and fly ash between 1972 until the mid-1980's, when it was capped with a 2-foot compacted clay and soil cap. AP2 was closed starting in 2019 in accordance with the closure plan that was submitted to and approved by IEPA using a geomembrane cover system. The cover system installation was completed on November 17, 2020. The geomembrane cap design addresses the potential for slope failure and water infiltration into the closed CCR unit by directing the drainage of surface water (i.e., precipitation) off the cover system.

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 AP2 unit (Burns & McDonnell 2021). The proposed groundwater monitoring network is shown in **Attachment A**. The monitoring network consists of 8 compliance monitoring wells (G401, G402, G403, G404, G405, G406, G407, and G1001) and 3 background wells (G270, G280, and G281).

The geology underlying the Site in the vicinity of AP2 consists of five distinct hydrostratigraphic units (NRT, 2017; Ramboll, 2021[7]):

- **Upper Confining Unit (UCU):** The UCU underlies the majority of the AP2 footprint. It consists of a Loess Unit and the upper portion of the Hagarstown Member, which has low permeability clays and silts with generally greater than 60% fines. The UCU was encountered across most of the CPP.
- **Uppermost Aquifer (UA):** The UA is comprised of moderately permeable sands, silty sand, and clayey gravel of the Hagarstown Member and, in some portions of the Site, the Vandalia Member. Limited direct contact between AP2 CCR and the UA may occur in pre-construction ravines on the eastern edge of the AP2 footprint.

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[7] This document references a Hydrogeologic Site Characterization Report prepared by Ramboll that discusses conditions at CPP Ash Pond. No. 1 (Unit No. 101) but is referenced here due to the presence of identical hydrostratigraphic units given their proximity.

- **Lower Confining Unit (LCU):** The LCU underlies the UA. It consists of three low hydraulic conductivity soils: the sandy clay till of the Vandalia Member, the silt of the Mulberry Grove Formation, and the compacted clay till of the Smithboro Member.
- **Deep Aquifer (DA):** The DA is a thin (generally less than 5 ft thick), discontinuous unit composed of sands and silty sand units of the Yarmouth Soil.
- **Deep Confining Unit (DCU):** The DCU underlies the DA. It consists of the Lierle Clay of the Banner Formation and acts as an aquitard due to its low hydraulic conductivity.

There is a groundwater flow divide within the UA in the center of the CPP property between the two lobes of Coffeen Lake. Groundwater in the UA flows from the center of the CPP property west toward Coffeen Lake on the western side of the groundwater flow divide, and east toward the Unnamed Tributary, the eastern lobe of Coffeen Lake, and the discharge flume on the eastern side of the groundwater flow divide. AP2 is east of the groundwater flow divide, so groundwater flow in the vicinity of AP2 is generally to the south and east. The groundwater to the west of AP2 is separated from the groundwater flow regime under AP2 by the groundwater divide. Groundwater flow within the UA has little vertical component due to the underlying low-permeability LCU. The flow direction in the UA is consistent and likely influenced by the proximity to and hydraulic connection with Coffeen Lake. A map showing representative groundwater flow direction in the UA 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 Coffeen AP2 were observed from 2023 Q2 through 2023 Q4 (Ramboll, 2024):

- Boron – Observed at monitoring wells G401, G402, G404, and G405.
- pH – Observed at monitoring well G401.
- Sulfate – Observed at monitoring wells G401, G402, G404, G405, and G406.
- TDS – Observed at monitoring wells G401, G402, G404, and G405.

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.

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 June 12, 2025. Once implemented and completed, the selected remedy will attain the GWPSs.

GWPS exceedances within the AP2 network are only present within the UA. No GWPS exceedances were noted within other hydrostratigraphic units.

2.3 Geochemical Conceptual Site Model

A Geochemical Conceptual Site Model (GCSM)[8] was developed for CPP AP2 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 attenuation of aqueous concentrations at compliance monitoring wells. This discussion relies on lab reports and raw data previously presented in the Nature and Extent Report previously submitted to IEPA on June 12, 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 and sulfate to groundwater of the UA within the monitoring network is AP2 CCR porewater, based on boron and sulfate 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 since the completion of source control in 2020, with pH values in the UA observed to be generally stable and circumneutral, and redox conditions observed to be relatively oxidizing. pH values within background wells are consistently circumneutral, such that mixing with downgradient compliance wells will maintain near-neutral pH conditions. Some wells within the UA appear to have redox fluctuations related to seasonal conditions since completion of closure activities.

Boron and sulfate in the groundwater system may be attenuated via adsorption and surface complexation reactions within portions of the UA. Boron and sorption to iron oxyhydroxide phases in particular is well-studied and is likely occurring within the subsurface near AP2 due to the ubiquitous nature of these materials. Groundwater conditions from the UA are predicted to favor amorphous iron oxide stability at some locations. The detected presence of iron oxides, including magnetite, in some site solids supports the potential for occurrence of this mechanism. The presence of clay minerals (e.g., kaolinite) in UA solids material suggests that adsorption to clays may be another potential attenuation mechanism for boron at locations near AP2. 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 AP2.

The GCSM findings suggest the potential for chemical attenuation of both boron and sulfate based on detected abundances of iron oxide and clay minerals and groundwater redox conditions favorable for the stability of these potential sorbing surfaces.

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[8] 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.

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 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[9], 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 MINETQ v4 thermodynamic database (as described in relevant sections below). The geochemical modeling of groundwater polishing under current/future conditions completed includes speciation and reaction modeling (US EPA 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 COCs 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 be more likely to 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

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[9] 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 of the CAAA to which this report is attached.

(hydr)oxides, carbonates, and some sulfates) as identified in the GCSM[10]. The model therefore 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 and sulfate GWPS exceedances, and background groundwater composition. The PHREEQC input file 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 provided in the Nature and Extent Report[11].

3.1.1.1 Solid Phase Inputs

Iron hydroxide (ferrihydrite, [$Fe(OH)_3$]) and aluminum hydroxide (gibbsite, [$Al(OH)_3$]) are wide-spread in the environment known to act as sorbing phases for many groundwater constituents, including boron and sulfate (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 AP2 samples, model input concentrations for crystalline iron oxide for AP2 were derived using site-specific total metals and mineralogy (X-ray diffraction [XRD]) datasets, and input concentrations for ferrihydrite were taken from an SEP dataset compiled from analogous geological systems as described in greater detail in **Attachment C**. Gibbsite input concentrations for AP2 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 phase present. Both ferrihydrite and goethite were allowed to dissolve or precipitate in the reaction phase of the model.

Calcite and dolomite were included as mineral phases in the model because carbonate mineral formation and dissolution are often major controls on groundwater pH (Stumm and Morgan 1996; Stackelberg et al. 2020). Calcite is present in site aquifer solids in excess. Dolomite was

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[10] 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.

[11] 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).

not detected in site-specific XRD samples. Model inputs for both minerals were based on site-specific XRD results. Both calcite and dolomite were allowed to dissolve or precipitate in the reaction phase of the model.

Barite ($BaSO_4$) and gypsum ($CaSO_4$) are minerals that contain sulfate and have the potential to form under ambient environmental conditions in a timeframe consistent with the remedial effort. These minerals therefore may affect sulfate attenuation. Neither mineral phase was observed in mineralogical results for the site; therefore, both were made available to precipitate from the aqueous solution but did not have initial concentrations provided.

3.1.1.2 Aqueous Inputs

In addition to the boron and sulfate, 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, 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[12].

This 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 with exceedances of boron and/or sulfate (**Section 2.2**), 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 all 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 5** 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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[12] 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

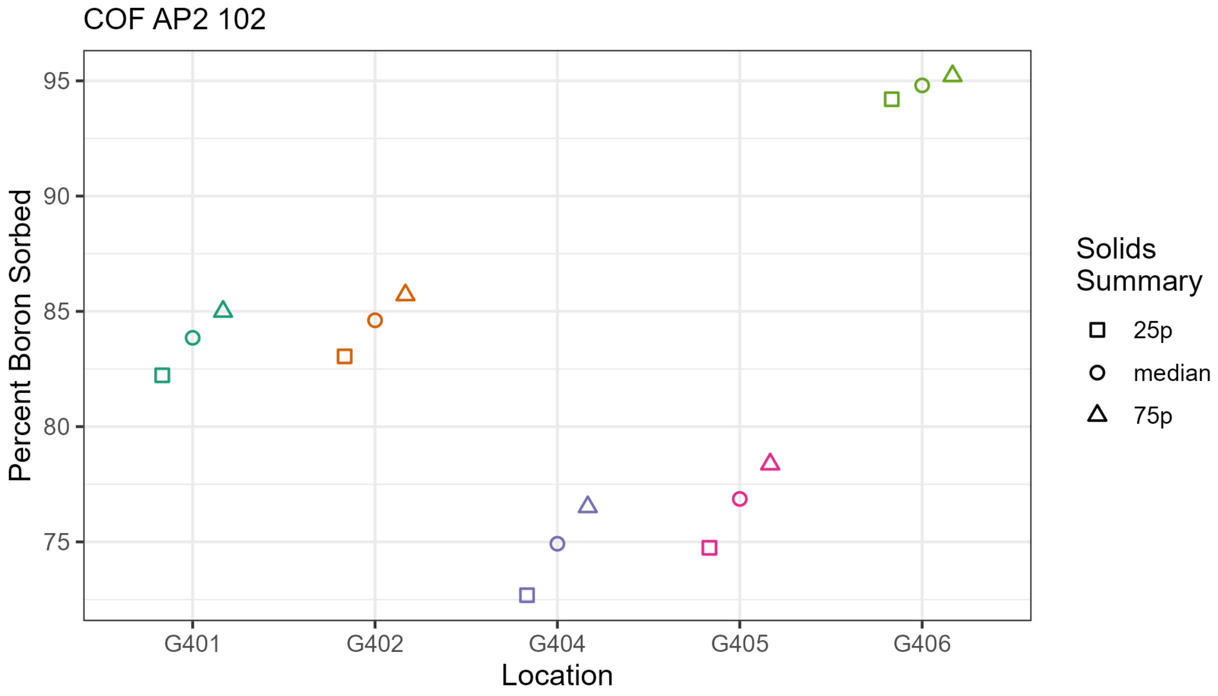


Figure 2: Modeled Boron Behavior

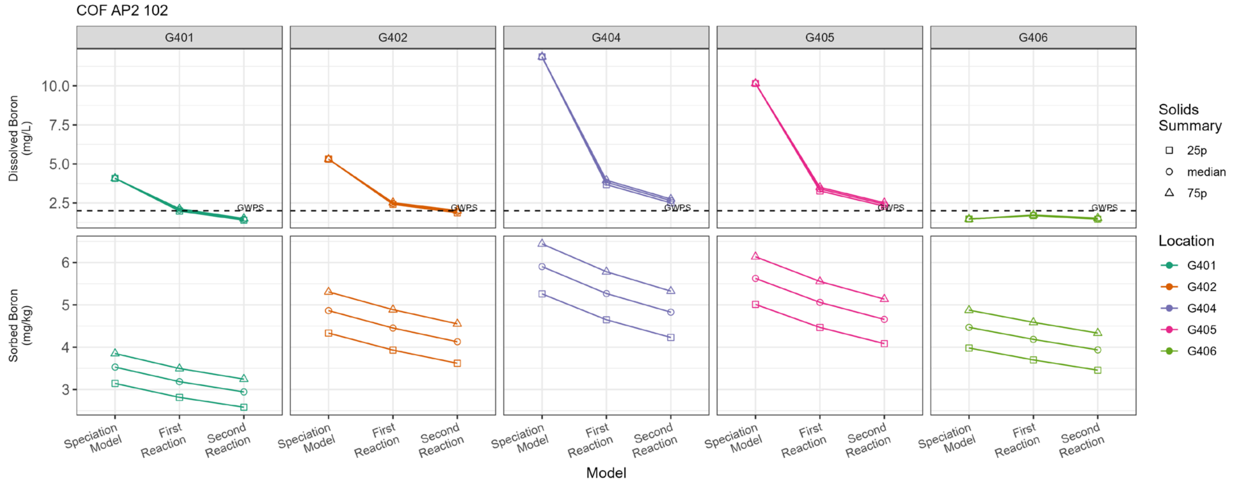


Figure 3: Percentage of Sorbed Sulfate

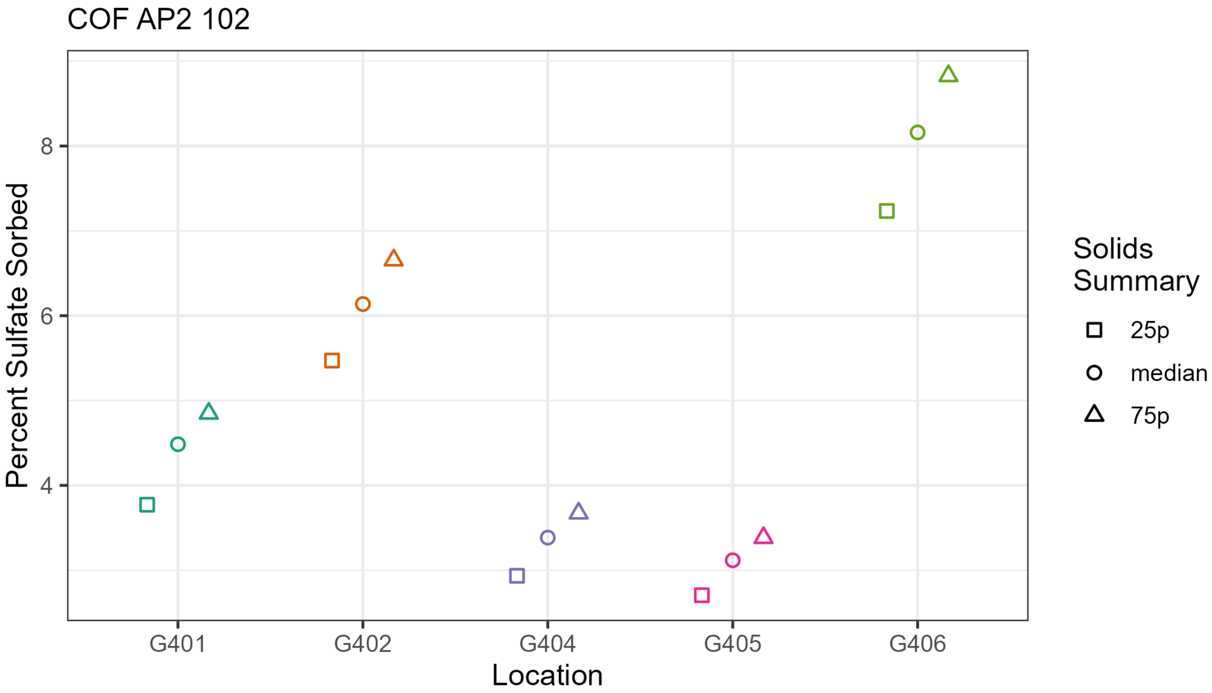


Figure 4: Modeled Sulfate Behavior

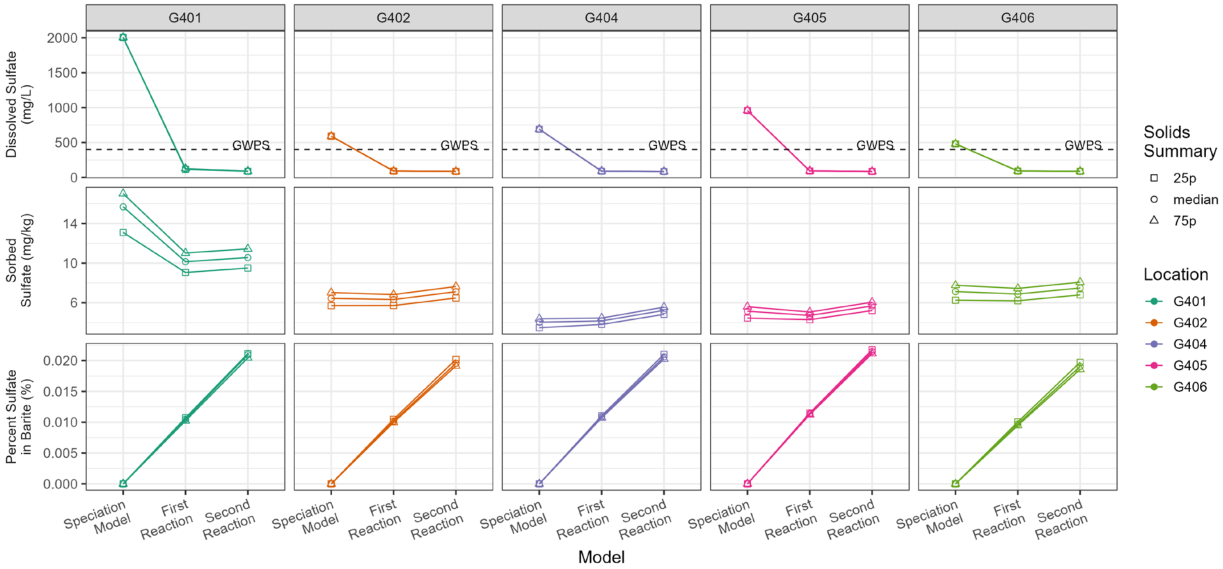
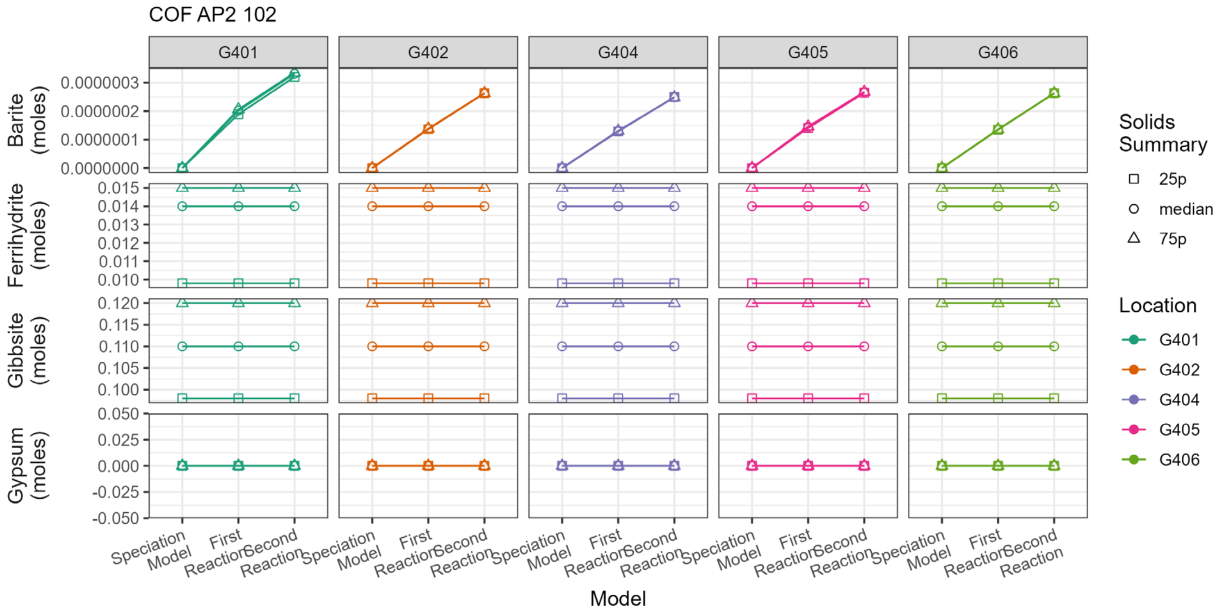


Figure 5: Modeled Sorbing Phase Behavior



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 70 to 86% of boron present in groundwater at compliance wells with boron exceedances 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 8% of aqueous boron sorbed under current conditions. These results suggest that boron sorption under current geochemical conditions is thermodynamically favorable, although the absolute amount of sorbed boron is somewhat sensitive to the amount of sorbent.

Speciation calculations for sulfate indicate that in wells with sulfate exceedances approximately 3 to 8% of sulfate present in (modeled) downgradient compliance well groundwater will sorb to mineral surfaces (**Figure 3**). Sensitivity assessments demonstrate a minor influence of variable sorbing mineral mass inputs on sulfate sorption, with the 25th percentile and 75th percentile values for mineral mass accounting for differences of up to 2% of aqueous sulfate sorbed under current conditions. These results suggest that some component of sulfate sorption is predicted under current geochemical conditions, although sulfate sorption is less favorable than boron sorption.

3.2.3 Reaction modeling

Reaction modeling results of conditions following source control demonstrate that aqueous boron and sulfate concentrations change with background groundwater interaction. Aqueous boron concentrations are predicted to decrease with each iterative reaction at all wells with boron exceedances (**Figure 2**). Some minor degree of boron desorption is predicted for all wells following each iterative reaction; however, the impact of this desorption on aqueous boron concentrations is generally offset by background groundwater containing less aqueous boron. G401 and G402 are predicted to achieve the boron GWPS after the second iterative reaction for all model scenarios. G404 and G405 are not predicted to achieve the boron GWPS after the second iterative reaction although boron concentrations continue to decrease. These results suggest that in some locations, mobilization of currently attenuated boron could result in a longer observed time to reach the GWPS compared to sulfate.

Aqueous sulfate concentrations are predicted to decrease at all wells with each iterative reaction (**Figure 4**). Some degree of sulfate desorption is predicted with background groundwater interaction in model, particularly at G401; however, the impact of this desorption on aqueous sulfate concentrations is offset by interaction with background groundwater containing less aqueous sulfate. Barite precipitation is predicted in all post-source control scenarios (**Figure 5**), which provides an additional attenuation mechanism for aqueous sulfate. All modeled wells are predicted to achieve the sulfate GWPS within one iterative reaction, indicating that mobilization of currently attenuated sulfate is unlikely to affect the time to reach the GWPS.

Boron and sulfate are predicted to sorb to ferrihydrite and gibbsite. Both minerals are predicted to be stable and exhibit minor (less than 0.01%, **Table 2**) predicted dissolution under post-source control conditions (**Figure 5**). Barite is predicted to precipitate under post-source control conditions in all model scenarios. The predicted stability of sorbing mineral phases and precipitation of barite under post-source control conditions demonstrates the continued feasibility of boron and sulfate chemical attenuation mechanisms in AP2.

These results suggest that chemical attenuation of boron and sulfate should remain feasible following source control efforts. The primary chemical attenuation mechanism for boron is anticipated to be sorption to aluminum and iron oxide mineral phases which are predicted to be stable in post-source control conditions. Chemical attenuation mechanisms for sulfate are expected to include sorption to iron and aluminum oxide minerals and precipitation of barite. These results suggest that mobilization of currently attenuated sulfate is unlikely to affect the modeled time to reach the GWPS, and that mobilization of previously attenuated boron may result in a longer observed time to reach the GWPS compared to sulfate. Chemical attenuation of sulfate is also expected to contribute to a reduction in TDS at locations G401, G402, G404, and G405. The low pH exceedance at G401 is modeled to resolve after the first iterative reaction due to the influence of more circumneutral pH groundwater migrating from background locations and its interactions with aquifer solids present in the UA.

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 and sulfate attenuation as groundwater quality returns to background conditions.

Geochemical modeling of current AP2 geochemical conditions demonstrates chemical attenuation of boron and sulfate via sorption to aquifer solids, particularly iron and aluminum oxides and (applicable to sulfate only) precipitation of barite. Modeling of anticipated future conditions predicts a minor component of desorption of boron and sulfate from solids that will be offset by interaction with background groundwater containing lower concentrations of these COCs, resulting in net aqueous concentration decreases at all wells with exceedances. Barite precipitation is predicted under future conditions, which will provide an additional attenuation mechanism for sulfate. Modeling also predicts that iron and aluminum oxide sorbing minerals phases will remain stable in post-source control conditions, and as a result this chemical attenuation mechanism will remain viable. It is expected that attenuation of sulfate will also contribute to a reduction in TDS at all wells with TDS exceedances. It is also expected that the low pH values at G401 will resolve due to interaction with neutral pH background groundwater and the buffering capacity of the carbonate minerals in the UA.

Results of the geochemical modeling suggest that mobilization of currently attenuated sulfate is unlikely to affect the modeled time to reach the GWPS, and that mobilization of previously attenuated boron may result in a longer observed time to reach the GWPS compared to sulfate. The 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
Coffeen Power Plant - Ash Pond No. 2

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 (crystalline iron oxides). Analoguous compiled sequential extraction procedure dataset (ferrihydrite and gibbsite).
	Calcite and dolomite	X-ray diffraction results
Downgradient groundwater (COC exceedance locations)	Sulfate, 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 Report
Coffeen Power Plant - Ash Pond No. 2

Parameter	Hydrostratigraphic Unit	Location	Summary Type	First Reaction Change		Second Reaction Change	
				mg/kg	%	mg/kg	%
Barite	UA	G401	25p	0.00735	NA	0.0124	69.19
			median	0.00786	NA	0.0129	64.04
			75p	0.00800	NA	0.0130	62.63
		G402	25p	0.00531	NA	0.0102	92.76
			median	0.00534	NA	0.0102	91.33
			75p	0.00538	NA	0.0102	90.20
		G404	25p	0.00500	NA	0.00970	93.74
			median	0.00506	NA	0.00967	91.11
			75p	0.00509	NA	0.00966	89.72
		G405	25p	0.00548	NA	0.0103	87.71
			median	0.00561	NA	0.0104	84.71
			75p	0.00567	NA	0.0104	83.23
		G406	25p	0.00523	NA	0.0102	95.80
			median	0.00526	NA	0.0102	94.22
			75p	0.00528	NA	0.0102	93.37
Ferrihydrite	UA	G401	25p	175	<0.01	175	<0.01
			median	249	<0.01	249	<0.01
			75p	267	<0.01	267	<0.01
		G402	25p	175	<0.01	175	<0.01
			median	249	<0.01	249	<0.01
			75p	267	<0.01	267	<0.01
		G404	25p	175	<0.01	175	<0.01
			median	249	<0.01	249	<0.01
			75p	267	<0.01	267	<0.01
		G405	25p	175	<0.01	175	<0.01
			median	249	<0.01	249	<0.01
			75p	267	<0.01	267	<0.01
		G406	25p	175	<0.01	175	<0.01
			median	249	<0.01	249	<0.01
			75p	267	<0.01	267	<0.01
Gibbsite	UA	G401	25p	1270	<0.01	1270	<0.01
			median	1430	<0.01	1430	<0.01
			75p	1560	<0.01	1560	<0.01
		G402	25p	1270	<0.01	1270	<0.01
			median	1430	<0.01	1430	<0.01
			75p	1560	<0.01	1560	<0.01
		G404	25p	1270	<0.01	1270	<0.01
			median	1430	<0.01	1430	<0.01
			75p	1560	<0.01	1560	<0.01
		G405	25p	1270	<0.01	1270	<0.01
			median	1430	<0.01	1430	<0.01
			75p	1560	<0.01	1560	<0.01
		G406	25p	1270	<0.01	1270	<0.01
			median	1430	<0.01	1430	<0.01
			75p	1560	<0.01	1560	<0.01

Notes:
% = percent
25p = 25th percentile
75p = 75th percentile
mg/kg = milligram/kilogram
UA = Uppermost Aquifer
NA = not applicable

ATTACHMENT A

Operating Permit Network Map and Potentiometric Surface (August 2023)

COMPLIANCE MONITORING WELL
BACKGROUND WELL
LEACHATE WELL
MONITORING WELL
STAFF GAGE, CCR UNIT
STAFF GAGE, RIVER

GROUNDWATER ELEVATION CONTOUR (2-FT CONTOUR INTERVAL, NAVD88)
INFERRED GROUNDWATER ELEVATION CONTOUR
GROUNDWATER FLOW DIRECTION
REGULATED UNIT (SUBJECT UNIT)
SITE FEATURE
LIMITS OF FINAL COVER
PROPERTY BOUNDARY

0 325 650 Feet

NOTES:
1. ELEVATIONS IN PARENTHESES WERE NOT USED FOR CONTOURING.
2. ELEVATIONS IN BRACKETS WERE OBTAINED OUTSIDE OF THE 24-HOUR PERIOD FROM INITIATION OF DEPTH TO GROUNDWATER MEASUREMENTS BUT WITHIN THE SAME SAMPLING EVENT.
3. ELEVATION CONTOURS SHOWN IN FEET, NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88)

POTENTIOMETRIC SURFACE MAP
AUGUST 8, 2023

2023 ANNUAL GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT
ASH POND NO. 2
COFFEEN POWER PLANT
COFFEEN, 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 COF_845_102_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_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
-saturation_indices Ferrihydrite Gibbsite Barite Calcite Dolomite(ordered) Gypsum

SOLUTION 1 #G401 (C - UA)
redox pe
units mg/l
density 1
pH 6.09
pe 3.185
temp 14.9
S(6) 2000 as SO4
B 4.07
Li 0.02185
As 0.000795
C(4) 70.7 as CO3
Cl 3.3
F 0.201
Ca 499.5
Mg 145.5
Na 71.2
K 2.53
Ba 0.0109
Si 15.6
P 0.011975
Mn 31.5
Fe 88.9
Al 0.00335
Sb 0.0002575
Be 0.0001975
Cd 0.000335
Cr 0.000875
Co 0.133
Pb 0.000205
Mo 0.000335
Se 0.000335
end

SOLUTION 2 #G402 (C - UA)
redox pe
units mg/l
density 1
```

```
pH 6.955
pe 5.335
temp 20.65
S(6) 590.5 as SO4
B 5.305
Li 0.0215
As 0.00375
C(4) 302 as CO3
Cl 3.2
F 0.2635
Ca 211
Mg 129
Na 44.95
K 1.135
Ba 0.0275
Si 13.95
P 0.024975
Mn 0.8635
Fe 0.004525
Al 0.007625
Sb 0.0002575
Be 0.0001975
Cd 0.000235
Cr 0.0034
Co 0.00295
Pb 0.00225
Mo 0.00235
Se 0.000335
end
SOLUTION 3 #G404 (C - UA)
redox pe
units mg/l
density 1
pH 6.765
pe 4.9
temp 18.35
S(6) 689 as SO4
B 11.85
Li 0.00785
As 0.0007225
C(4) 221.5 as CO3
Cl 106.5
F 0.1235
Ca 223
Mg 102.85
Na 79.8
K 0.5285
Ba 0.0305
Si 10.6
P 0.003225
Mn 2.025
Fe 0.0649
Al 0.003475
```

```
Sb 0.0006575
Be 0.0001975
Cd 0.000285
Cr 0.00175
Co 0.00177
Pb 0.000355
Mo 0.000735
Se 0.000335
end

SOLUTION 4 #G405 (C - UA)
redox pe
units mg/l
density 1
pH 6.965
pe 4.03
temp 18.95
S(6) 958 as SO4
B 10.15
Li 0.00425
As 0.000855
C(4) 169.5 as CO3
Cl 11.45
F 0.2905
Ca 251.5
Mg 110
Na 109.5
K 0.488
Ba 0.0144
Si 7.905
P 0.010475
Mn 1.085
Fe 0.1475
Al 0.005225
Sb 0.00101
Be 0.0001975
Cd 0.000235
Cr 0.000875
Co 0.000985
Pb 0.000465
Mo 0.001
Se 0.00075
end

SOLUTION 5 #G406 (C - UA)
redox pe
units mg/l
density 1
pH 6.63
pe 5.755
temp 19.05
S(6) 481 as SO4
B 1.47
Li 0.01095
As 0.0002725
```

```
C(4) 212 as CO3
Cl 3.2
F 0.267
Ca 191.5
Mg 65.35
Na 37.6
K 0.2065
Ba 0.01345
Si 12.95
P 0.008975
Mn 4.425
Fe 0.003055
Al 0.005175
Sb 0.0002575
Be 0.0001975
Cd 0.000235
Cr 0.000875
Co 0.00066
Pb 0.000205
Mo 0.000335
Se 0.000335
end

EQUILIBRIUM_PHASES 1 #G401 (C - UA) - 25p
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.098
Ferrihydrite 0 0.0098
Calcite 0 1
Dolomite(ordered) 0 2

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 #G402 (C - UA) - 25p
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.098
Ferrihydrite 0 0.0098
Calcite 0 1
Dolomite(ordered) 0 2

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 #G404 (C - UA) - 25p
Barite 0 0
```

```
Gypsum 0 0
Gibbsite 0 0.098
Ferrihydrite 0 0.0098
Calcite 0 1
Dolomite(ordered) 0 2

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 #G405 (C - UA) - 25p
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.098
Ferrihydrite 0 0.0098
Calcite 0 1
Dolomite(ordered) 0 2

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 #G406 (C - UA) - 25p
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.098
Ferrihydrite 0 0.0098
Calcite 0 1
Dolomite(ordered) 0 2

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 6.805
pe 4.95
temp 15.45
S(6) 91
B 0.0046
Li 0.0027
As 0.000485
```

```
C(4) 209
Cl 70.5 charge
F 0.305
Ca 79.25
Mg 37.3
Na 81.15
K 0.5945
Ba 0.05855
Si 7.8
P 0.0083
Mn 0.118
Fe 0.012375
Al 0.013
Sb 0.0003075
Be 0.0001975
Cd 0.000235
Cr 0.00135
Co 0.00035
Pb 0.000405
Mo 0.0007
Se 0.000335

SAVE solution 6

end

#FIRST REACTION

#G401 (C - UA) - First Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 1
USE SURFACE 1
SAVE equilibrium_phases 1
SAVE surface 1
end

#G401 (C - UA) - Second Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 1
USE SURFACE 1
SAVE equilibrium_phases 1
SAVE surface 1
end

#G402 (C - UA) - First Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 2
USE SURFACE 2
SAVE equilibrium_phases 2
SAVE surface 2
end

#G402 (C - UA) - Second Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 2
USE SURFACE 2
SAVE equilibrium_phases 2
```

```
SAVE surface 2
end

#G404 (C - UA) - First Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 3
USE SURFACE 3
SAVE equilibrium_phases 3
SAVE surface 3
end

#G404 (C - UA) - Second Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 3
USE SURFACE 3
SAVE equilibrium_phases 3
SAVE surface 3
end

#G405 (C - UA) - First Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 4
USE SURFACE 4
SAVE equilibrium_phases 4
SAVE surface 4
end

#G405 (C - UA) - Second Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 4
USE SURFACE 4
SAVE equilibrium_phases 4
SAVE surface 4
end

#G406 (C - UA) - First Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 5
USE SURFACE 5
SAVE equilibrium_phases 5
SAVE surface 5
end

#G406 (C - UA) - Second Reaction
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 COF_845_102_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_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
-saturation_indices Ferrihydrite Gibbsite Barite Calcite Dolomite(ordered) Gypsum

SOLUTION 1 #G401 (C - UA)
redox pe
units mg/l
density 1
pH 6.09
pe 3.185
temp 14.9
S(6) 2000 as SO4
B 4.07
Li 0.02185
As 0.000795
C(4) 70.7 as CO3
Cl 3.3 charge
F 0.201
Ca 499.5
Mg 145.5
Na 71.2
K 2.53
Ba 0.0109
Si 15.6
P 0.011975
Mn 31.5
Fe 88.9
Al 0.00335
Sb 0.0002575
Be 0.0001975
Cd 0.000335
Cr 0.000875
Co 0.133
Pb 0.000205
Mo 0.000335
Se 0.000335
end

SOLUTION 2 #G402 (C - UA)
redox pe
units mg/l
density 1
```

```
pH 6.955
pe 5.335
temp 20.65
S(6) 590.5 as SO4
B 5.305
Li 0.0215
As 0.00375
C(4) 302 as CO3
Cl 3.2 charge
F 0.2635
Ca 211
Mg 129
Na 44.95
K 1.135
Ba 0.0275
Si 13.95
P 0.024975
Mn 0.8635
Fe 0.004525
Al 0.007625
Sb 0.0002575
Be 0.0001975
Cd 0.000235
Cr 0.0034
Co 0.00295
Pb 0.00225
Mo 0.00235
Se 0.000335
end

SOLUTION 3 #G404 (C - UA)
redox pe
units mg/l
density 1
pH 6.765
pe 4.9
temp 18.35
S(6) 689 as SO4
B 11.85
Li 0.00785
As 0.0007225
C(4) 221.5 as CO3
Cl 106.5 charge
F 0.1235
Ca 223
Mg 102.85
Na 79.8
K 0.5285
Ba 0.0305
Si 10.6
P 0.003225
Mn 2.025
Fe 0.0649
Al 0.003475
```

```
Sb 0.0006575
Be 0.0001975
Cd 0.000285
Cr 0.00175
Co 0.00177
Pb 0.000355
Mo 0.000735
Se 0.000335
end

SOLUTION 4 #G405 (C - UA)
redox pe
units mg/l
density 1
pH 6.965
pe 4.03
temp 18.95
S(6) 958 as SO4
B 10.15
Li 0.00425
As 0.000855
C(4) 169.5 as CO3
Cl 11.45 charge
F 0.2905
Ca 251.5
Mg 110
Na 109.5
K 0.488
Ba 0.0144
Si 7.905
P 0.010475
Mn 1.085
Fe 0.1475
Al 0.005225
Sb 0.00101
Be 0.0001975
Cd 0.000235
Cr 0.000875
Co 0.000985
Pb 0.000465
Mo 0.001
Se 0.00075
end

SOLUTION 5 #G406 (C - UA)
redox pe
units mg/l
density 1
pH 6.63
pe 5.755
temp 19.05
S(6) 481 as SO4
B 1.47
Li 0.01095
As 0.0002725
```

```
C(4) 212 as CO3
Cl 3.2 charge
F 0.267
Ca 191.5
Mg 65.35
Na 37.6
K 0.2065
Ba 0.01345
Si 12.95
P 0.008975
Mn 4.425
Fe 0.003055
Al 0.005175
Sb 0.0002575
Be 0.0001975
Cd 0.000235
Cr 0.000875
Co 0.00066
Pb 0.000205
Mo 0.000335
Se 0.000335
end

EQUILIBRIUM_PHASES 1 #G401 (C - UA) - 25p
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.098
Ferrihydrite 0 0.0098
Calcite 0 1
Dolomite(ordered) 0 2

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 #G402 (C - UA) - 25p
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.098
Ferrihydrite 0 0.0098
Calcite 0 1
Dolomite(ordered) 0 2

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 #G404 (C - UA) - 25p
Barite 0 0
```

```
Gypsum 0 0
Gibbsite 0 0.098
Ferrihydrite 0 0.0098
Calcite 0 1
Dolomite(ordered) 0 2

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 #G405 (C - UA) - 25p
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.098
Ferrihydrite 0 0.0098
Calcite 0 1
Dolomite(ordered) 0 2

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 #G406 (C - UA) - 25p
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.098
Ferrihydrite 0 0.0098
Calcite 0 1
Dolomite(ordered) 0 2

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 6.805
pe 4.95
temp 15.45
S(6) 91
B 0.0046
Li 0.0027
As 0.000485
```

```
C(4) 209
Cl 70.5 charge
F 0.305
Ca 79.25
Mg 37.3
Na 81.15
K 0.5945
Ba 0.05855
Si 7.8
P 0.0083
Mn 0.118
Fe 0.012375
Al 0.013
Sb 0.0003075
Be 0.0001975
Cd 0.000235
Cr 0.00135
Co 0.00035
Pb 0.000405
Mo 0.0007
Se 0.000335

SAVE solution 6

end

#FIRST REACTION

#G401 (C - UA) - First Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 1
USE SURFACE 1
SAVE equilibrium_phases 1
SAVE surface 1
end

#G401 (C - UA) - Second Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 1
USE SURFACE 1
SAVE equilibrium_phases 1
SAVE surface 1
end

#G402 (C - UA) - First Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 2
USE SURFACE 2
SAVE equilibrium_phases 2
SAVE surface 2
end

#G402 (C - UA) - Second Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 2
USE SURFACE 2
SAVE equilibrium_phases 2
```

```
SAVE surface 2
end

#G404 (C - UA) - First Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 3
USE SURFACE 3
SAVE equilibrium_phases 3
SAVE surface 3
end

#G404 (C - UA) - Second Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 3
USE SURFACE 3
SAVE equilibrium_phases 3
SAVE surface 3
end

#G405 (C - UA) - First Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 4
USE SURFACE 4
SAVE equilibrium_phases 4
SAVE surface 4
end

#G405 (C - UA) - Second Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 4
USE SURFACE 4
SAVE equilibrium_phases 4
SAVE surface 4
end

#G406 (C - UA) - First Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 5
USE SURFACE 5
SAVE equilibrium_phases 5
SAVE surface 5
end

#G406 (C - UA) - Second Reaction
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 COF_845_102_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_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
-saturation_indices Ferrihydrite Gibbsite Barite Calcite Dolomite(ordered) Gypsum

SOLUTION 1 #G401 (C - UA)
redox pe
units mg/l
density 1
pH 6.09
pe 3.185
temp 14.9
S(6) 2000 as SO4
B 4.07
Li 0.02185
As 0.000795
C(4) 70.7 as CO3
Cl 3.3
F 0.201
Ca 499.5
Mg 145.5
Na 71.2
K 2.53
Ba 0.0109
Si 15.6
P 0.011975
Mn 31.5
Fe 88.9
Al 0.00335
Sb 0.0002575
Be 0.0001975
Cd 0.000335
Cr 0.000875
Co 0.133
Pb 0.000205
Mo 0.000335
Se 0.000335
end

SOLUTION 2 #G402 (C - UA)
redox pe
units mg/l
density 1
```

```
pH 6.955
pe 5.335
temp 20.65
S(6) 590.5 as SO4
B 5.305
Li 0.0215
As 0.00375
C(4) 302 as CO3
Cl 3.2
F 0.2635
Ca 211
Mg 129
Na 44.95
K 1.135
Ba 0.0275
Si 13.95
P 0.024975
Mn 0.8635
Fe 0.004525
Al 0.007625
Sb 0.0002575
Be 0.0001975
Cd 0.000235
Cr 0.0034
Co 0.00295
Pb 0.00225
Mo 0.00235
Se 0.000335
end
SOLUTION 3 #G404 (C - UA)
redox pe
units mg/l
density 1
pH 6.765
pe 4.9
temp 18.35
S(6) 689 as SO4
B 11.85
Li 0.00785
As 0.0007225
C(4) 221.5 as CO3
Cl 106.5
F 0.1235
Ca 223
Mg 102.85
Na 79.8
K 0.5285
Ba 0.0305
Si 10.6
P 0.003225
Mn 2.025
Fe 0.0649
Al 0.003475
```

```
Sb 0.0006575
Be 0.0001975
Cd 0.000285
Cr 0.00175
Co 0.00177
Pb 0.000355
Mo 0.000735
Se 0.000335
end

SOLUTION 4 #G405 (C - UA)
redox pe
units mg/l
density 1
pH 6.965
pe 4.03
temp 18.95
S(6) 958 as SO4
B 10.15
Li 0.00425
As 0.000855
C(4) 169.5 as CO3
Cl 11.45
F 0.2905
Ca 251.5
Mg 110
Na 109.5
K 0.488
Ba 0.0144
Si 7.905
P 0.010475
Mn 1.085
Fe 0.1475
Al 0.005225
Sb 0.00101
Be 0.0001975
Cd 0.000235
Cr 0.000875
Co 0.000985
Pb 0.000465
Mo 0.001
Se 0.00075
end

SOLUTION 5 #G406 (C - UA)
redox pe
units mg/l
density 1
pH 6.63
pe 5.755
temp 19.05
S(6) 481 as SO4
B 1.47
Li 0.01095
As 0.0002725
```

```
C(4) 212 as CO3
Cl 3.2
F 0.267
Ca 191.5
Mg 65.35
Na 37.6
K 0.2065
Ba 0.01345
Si 12.95
P 0.008975
Mn 4.425
Fe 0.003055
Al 0.005175
Sb 0.0002575
Be 0.0001975
Cd 0.000235
Cr 0.000875
Co 0.00066
Pb 0.000205
Mo 0.000335
Se 0.000335
end

EQUILIBRIUM_PHASES 1 #G401 (C - UA) - 75p
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.12
Ferrihydrite 0 0.015
Calcite 0 1
Dolomite(ordered) 0 2

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 #G402 (C - UA) - 75p
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.12
Ferrihydrite 0 0.015
Calcite 0 1
Dolomite(ordered) 0 2

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 #G404 (C - UA) - 75p
Barite 0 0
```

```
Gypsum 0 0
Gibbsite 0 0.12
Ferrihydrite 0 0.015
Calcite 0 1
Dolomite(ordered) 0 2

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 #G405 (C - UA) - 75p
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.12
Ferrihydrite 0 0.015
Calcite 0 1
Dolomite(ordered) 0 2

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 #G406 (C - UA) - 75p
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.12
Ferrihydrite 0 0.015
Calcite 0 1
Dolomite(ordered) 0 2

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 6.805
pe 4.95
temp 15.45
S(6) 91
B 0.0046
Li 0.0027
As 0.000485
```

```
C(4) 209
Cl 70.5 charge
F 0.305
Ca 79.25
Mg 37.3
Na 81.15
K 0.5945
Ba 0.05855
Si 7.8
P 0.0083
Mn 0.118
Fe 0.012375
Al 0.013
Sb 0.0003075
Be 0.0001975
Cd 0.000235
Cr 0.00135
Co 0.00035
Pb 0.000405
Mo 0.0007
Se 0.000335

SAVE solution 6

end

#FIRST REACTION

#G401 (C - UA) - First Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 1
USE SURFACE 1
SAVE equilibrium_phases 1
SAVE surface 1
end

#G401 (C - UA) - Second Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 1
USE SURFACE 1
SAVE equilibrium_phases 1
SAVE surface 1
end

#G402 (C - UA) - First Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 2
USE SURFACE 2
SAVE equilibrium_phases 2
SAVE surface 2
end

#G402 (C - UA) - Second Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 2
USE SURFACE 2
SAVE equilibrium_phases 2
```

```
SAVE surface 2
end

#G404 (C - UA) - First Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 3
USE SURFACE 3
SAVE equilibrium_phases 3
SAVE surface 3
end

#G404 (C - UA) - Second Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 3
USE SURFACE 3
SAVE equilibrium_phases 3
SAVE surface 3
end

#G405 (C - UA) - First Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 4
USE SURFACE 4
SAVE equilibrium_phases 4
SAVE surface 4
end

#G405 (C - UA) - Second Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 4
USE SURFACE 4
SAVE equilibrium_phases 4
SAVE surface 4
end

#G406 (C - UA) - First Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 5
USE SURFACE 5
SAVE equilibrium_phases 5
SAVE surface 5
end

#G406 (C - UA) - Second Reaction
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 COF_845_102_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_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
-saturation_indices Ferrihydrite Gibbsite Barite Calcite Dolomite(ordered) Gypsum

SOLUTION 1 #G401 (C - UA)
redox pe
units mg/l
density 1
pH 6.09
pe 3.185
temp 14.9
S(6) 2000 as SO4
B 4.07
Li 0.02185
As 0.000795
C(4) 70.7 as CO3
Cl 3.3 charge
F 0.201
Ca 499.5
Mg 145.5
Na 71.2
K 2.53
Ba 0.0109
Si 15.6
P 0.011975
Mn 31.5
Fe 88.9
Al 0.00335
Sb 0.0002575
Be 0.0001975
Cd 0.000335
Cr 0.000875
Co 0.133
Pb 0.000205
Mo 0.000335
Se 0.000335
end

SOLUTION 2 #G402 (C - UA)
redox pe
units mg/l
density 1
```

```
pH 6.955
pe 5.335
temp 20.65
S(6) 590.5 as SO4
B 5.305
Li 0.0215
As 0.00375
C(4) 302 as CO3
Cl 3.2 charge
F 0.2635
Ca 211
Mg 129
Na 44.95
K 1.135
Ba 0.0275
Si 13.95
P 0.024975
Mn 0.8635
Fe 0.004525
Al 0.007625
Sb 0.0002575
Be 0.0001975
Cd 0.000235
Cr 0.0034
Co 0.00295
Pb 0.00225
Mo 0.00235
Se 0.000335
end

SOLUTION 3 #G404 (C - UA)
redox pe
units mg/l
density 1
pH 6.765
pe 4.9
temp 18.35
S(6) 689 as SO4
B 11.85
Li 0.00785
As 0.0007225
C(4) 221.5 as CO3
Cl 106.5 charge
F 0.1235
Ca 223
Mg 102.85
Na 79.8
K 0.5285
Ba 0.0305
Si 10.6
P 0.003225
Mn 2.025
Fe 0.0649
Al 0.003475
```

```
Sb 0.0006575
Be 0.0001975
Cd 0.000285
Cr 0.00175
Co 0.00177
Pb 0.000355
Mo 0.000735
Se 0.000335
end

SOLUTION 4 #G405 (C - UA)
redox pe
units mg/l
density 1
pH 6.965
pe 4.03
temp 18.95
S(6) 958 as SO4
B 10.15
Li 0.00425
As 0.000855
C(4) 169.5 as CO3
Cl 11.45 charge
F 0.2905
Ca 251.5
Mg 110
Na 109.5
K 0.488
Ba 0.0144
Si 7.905
P 0.010475
Mn 1.085
Fe 0.1475
Al 0.005225
Sb 0.00101
Be 0.0001975
Cd 0.000235
Cr 0.000875
Co 0.000985
Pb 0.000465
Mo 0.001
Se 0.00075
end

SOLUTION 5 #G406 (C - UA)
redox pe
units mg/l
density 1
pH 6.63
pe 5.755
temp 19.05
S(6) 481 as SO4
B 1.47
Li 0.01095
As 0.0002725
```

```
C(4) 212 as CO3
Cl 3.2 charge
F 0.267
Ca 191.5
Mg 65.35
Na 37.6
K 0.2065
Ba 0.01345
Si 12.95
P 0.008975
Mn 4.425
Fe 0.003055
Al 0.005175
Sb 0.0002575
Be 0.0001975
Cd 0.000235
Cr 0.000875
Co 0.00066
Pb 0.000205
Mo 0.000335
Se 0.000335
end

EQUILIBRIUM_PHASES 1 #G401 (C - UA) - 75p
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.12
Ferrihydrite 0 0.015
Calcite 0 1
Dolomite(ordered) 0 2

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 #G402 (C - UA) - 75p
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.12
Ferrihydrite 0 0.015
Calcite 0 1
Dolomite(ordered) 0 2

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 #G404 (C - UA) - 75p
Barite 0 0
```

```
Gypsum 0 0
Gibbsite 0 0.12
Ferrihydrite 0 0.015
Calcite 0 1
Dolomite(ordered) 0 2

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 #G405 (C - UA) - 75p
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.12
Ferrihydrite 0 0.015
Calcite 0 1
Dolomite(ordered) 0 2

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 #G406 (C - UA) - 75p
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.12
Ferrihydrite 0 0.015
Calcite 0 1
Dolomite(ordered) 0 2

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 6.805
pe 4.95
temp 15.45
S(6) 91
B 0.0046
Li 0.0027
As 0.000485
```

```
C(4) 209
Cl 70.5 charge
F 0.305
Ca 79.25
Mg 37.3
Na 81.15
K 0.5945
Ba 0.05855
Si 7.8
P 0.0083
Mn 0.118
Fe 0.012375
Al 0.013
Sb 0.0003075
Be 0.0001975
Cd 0.000235
Cr 0.00135
Co 0.00035
Pb 0.000405
Mo 0.0007
Se 0.000335

SAVE solution 6

end

#FIRST REACTION

#G401 (C - UA) - First Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 1
USE SURFACE 1
SAVE equilibrium_phases 1
SAVE surface 1
end

#G401 (C - UA) - Second Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 1
USE SURFACE 1
SAVE equilibrium_phases 1
SAVE surface 1
end

#G402 (C - UA) - First Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 2
USE SURFACE 2
SAVE equilibrium_phases 2
SAVE surface 2
end

#G402 (C - UA) - Second Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 2
USE SURFACE 2
SAVE equilibrium_phases 2
```

```
SAVE surface 2
end

#G404 (C - UA) - First Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 3
USE SURFACE 3
SAVE equilibrium_phases 3
SAVE surface 3
end

#G404 (C - UA) - Second Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 3
USE SURFACE 3
SAVE equilibrium_phases 3
SAVE surface 3
end

#G405 (C - UA) - First Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 4
USE SURFACE 4
SAVE equilibrium_phases 4
SAVE surface 4
end

#G405 (C - UA) - Second Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 4
USE SURFACE 4
SAVE equilibrium_phases 4
SAVE surface 4
end

#G406 (C - UA) - First Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 5
USE SURFACE 5
SAVE equilibrium_phases 5
SAVE surface 5
end

#G406 (C - UA) - Second Reaction
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 COF_845_102_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_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
-saturation_indices Ferrihydrite Gibbsite Barite Calcite Dolomite(ordered) Gypsum

SOLUTION 1 #G401 (C - UA)
redox pe
units mg/l
density 1
pH 6.09
pe 3.185
temp 14.9
S(6) 2000 as SO4
B 4.07
Li 0.02185
As 0.000795
C(4) 70.7 as CO3
Cl 3.3
F 0.201
Ca 499.5
Mg 145.5
Na 71.2
K 2.53
Ba 0.0109
Si 15.6
P 0.011975
Mn 31.5
Fe 88.9
Al 0.00335
Sb 0.0002575
Be 0.0001975
Cd 0.000335
Cr 0.000875
Co 0.133
Pb 0.000205
Mo 0.000335
Se 0.000335
end

SOLUTION 2 #G402 (C - UA)
redox pe
units mg/l
density 1
```

```
pH 6.955
pe 5.335
temp 20.65
S(6) 590.5 as SO4
B 5.305
Li 0.0215
As 0.00375
C(4) 302 as CO3
Cl 3.2
F 0.2635
Ca 211
Mg 129
Na 44.95
K 1.135
Ba 0.0275
Si 13.95
P 0.024975
Mn 0.8635
Fe 0.004525
Al 0.007625
Sb 0.0002575
Be 0.0001975
Cd 0.000235
Cr 0.0034
Co 0.00295
Pb 0.00225
Mo 0.00235
Se 0.000335
end

SOLUTION 3 #G404 (C - UA)
redox pe
units mg/l
density 1
pH 6.765
pe 4.9
temp 18.35
S(6) 689 as SO4
B 11.85
Li 0.00785
As 0.0007225
C(4) 221.5 as CO3
Cl 106.5
F 0.1235
Ca 223
Mg 102.85
Na 79.8
K 0.5285
Ba 0.0305
Si 10.6
P 0.003225
Mn 2.025
Fe 0.0649
Al 0.003475
```

```
Sb 0.0006575
Be 0.0001975
Cd 0.000285
Cr 0.00175
Co 0.00177
Pb 0.000355
Mo 0.000735
Se 0.000335
end

SOLUTION 4 #G405 (C - UA)
redox pe
units mg/l
density 1
pH 6.965
pe 4.03
temp 18.95
S(6) 958 as SO4
B 10.15
Li 0.00425
As 0.000855
C(4) 169.5 as CO3
Cl 11.45
F 0.2905
Ca 251.5
Mg 110
Na 109.5
K 0.488
Ba 0.0144
Si 7.905
P 0.010475
Mn 1.085
Fe 0.1475
Al 0.005225
Sb 0.00101
Be 0.0001975
Cd 0.000235
Cr 0.000875
Co 0.000985
Pb 0.000465
Mo 0.001
Se 0.00075
end

SOLUTION 5 #G406 (C - UA)
redox pe
units mg/l
density 1
pH 6.63
pe 5.755
temp 19.05
S(6) 481 as SO4
B 1.47
Li 0.01095
As 0.0002725
```

```
C(4) 212 as CO3
Cl 3.2
F 0.267
Ca 191.5
Mg 65.35
Na 37.6
K 0.2065
Ba 0.01345
Si 12.95
P 0.008975
Mn 4.425
Fe 0.003055
Al 0.005175
Sb 0.0002575
Be 0.0001975
Cd 0.000235
Cr 0.000875
Co 0.00066
Pb 0.000205
Mo 0.000335
Se 0.000335
end

EQUILIBRIUM_PHASES 1 #G401 (C - UA) - median
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.11
Ferrihydrite 0 0.014
Calcite 0 1
Dolomite(ordered) 0 2

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 #G402 (C - UA) - median
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.11
Ferrihydrite 0 0.014
Calcite 0 1
Dolomite(ordered) 0 2

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 #G404 (C - UA) - median
Barite 0 0
```

```
Gypsum 0 0
Gibbsite 0 0.11
Ferrihydrite 0 0.014
Calcite 0 1
Dolomite(ordered) 0 2

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 #G405 (C - UA) - median
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.11
Ferrihydrite 0 0.014
Calcite 0 1
Dolomite(ordered) 0 2

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 #G406 (C - UA) - median
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.11
Ferrihydrite 0 0.014
Calcite 0 1
Dolomite(ordered) 0 2

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 6.805
pe 4.95
temp 15.45
S(6) 91
B 0.0046
Li 0.0027
As 0.000485
```

```
C(4) 209
Cl 70.5 charge
F 0.305
Ca 79.25
Mg 37.3
Na 81.15
K 0.5945
Ba 0.05855
Si 7.8
P 0.0083
Mn 0.118
Fe 0.012375
Al 0.013
Sb 0.0003075
Be 0.0001975
Cd 0.000235
Cr 0.00135
Co 0.00035
Pb 0.000405
Mo 0.0007
Se 0.000335

SAVE solution 6

end

#FIRST REACTION

#G401 (C - UA) - First Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 1
USE SURFACE 1
SAVE equilibrium_phases 1
SAVE surface 1
end

#G401 (C - UA) - Second Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 1
USE SURFACE 1
SAVE equilibrium_phases 1
SAVE surface 1
end

#G402 (C - UA) - First Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 2
USE SURFACE 2
SAVE equilibrium_phases 2
SAVE surface 2
end

#G402 (C - UA) - Second Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 2
USE SURFACE 2
SAVE equilibrium_phases 2
```

```
SAVE surface 2
end

#G404 (C - UA) - First Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 3
USE SURFACE 3
SAVE equilibrium_phases 3
SAVE surface 3
end

#G404 (C - UA) - Second Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 3
USE SURFACE 3
SAVE equilibrium_phases 3
SAVE surface 3
end

#G405 (C - UA) - First Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 4
USE SURFACE 4
SAVE equilibrium_phases 4
SAVE surface 4
end

#G405 (C - UA) - Second Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 4
USE SURFACE 4
SAVE equilibrium_phases 4
SAVE surface 4
end

#G406 (C - UA) - First Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 5
USE SURFACE 5
SAVE equilibrium_phases 5
SAVE surface 5
end

#G406 (C - UA) - Second Reaction
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 COF_845_102_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_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
-saturation_indices Ferrihydrite Gibbsite Barite Calcite Dolomite(ordered) Gypsum

SOLUTION 1 #G401 (C - UA)
redox pe
units mg/l
density 1
pH 6.09
pe 3.185
temp 14.9
S(6) 2000 as SO4
B 4.07
Li 0.02185
As 0.000795
C(4) 70.7 as CO3
Cl 3.3 charge
F 0.201
Ca 499.5
Mg 145.5
Na 71.2
K 2.53
Ba 0.0109
Si 15.6
P 0.011975
Mn 31.5
Fe 88.9
Al 0.00335
Sb 0.0002575
Be 0.0001975
Cd 0.000335
Cr 0.000875
Co 0.133
Pb 0.000205
Mo 0.000335
Se 0.000335
end

SOLUTION 2 #G402 (C - UA)
redox pe
units mg/l
density 1
```

```
pH 6.955
pe 5.335
temp 20.65
S(6) 590.5 as SO4
B 5.305
Li 0.0215
As 0.00375
C(4) 302 as CO3
Cl 3.2 charge
F 0.2635
Ca 211
Mg 129
Na 44.95
K 1.135
Ba 0.0275
Si 13.95
P 0.024975
Mn 0.8635
Fe 0.004525
Al 0.007625
Sb 0.0002575
Be 0.0001975
Cd 0.000235
Cr 0.0034
Co 0.00295
Pb 0.00225
Mo 0.00235
Se 0.000335
end
SOLUTION 3 #G404 (C - UA)
redox pe
units mg/l
density 1
pH 6.765
pe 4.9
temp 18.35
S(6) 689 as SO4
B 11.85
Li 0.00785
As 0.0007225
C(4) 221.5 as CO3
Cl 106.5 charge
F 0.1235
Ca 223
Mg 102.85
Na 79.8
K 0.5285
Ba 0.0305
Si 10.6
P 0.003225
Mn 2.025
Fe 0.0649
Al 0.003475
```

```
Sb 0.0006575
Be 0.0001975
Cd 0.000285
Cr 0.00175
Co 0.00177
Pb 0.000355
Mo 0.000735
Se 0.000335
end

SOLUTION 4 #G405 (C - UA)
redox pe
units mg/l
density 1
pH 6.965
pe 4.03
temp 18.95
S(6) 958 as SO4
B 10.15
Li 0.00425
As 0.000855
C(4) 169.5 as CO3
Cl 11.45 charge
F 0.2905
Ca 251.5
Mg 110
Na 109.5
K 0.488
Ba 0.0144
Si 7.905
P 0.010475
Mn 1.085
Fe 0.1475
Al 0.005225
Sb 0.00101
Be 0.0001975
Cd 0.000235
Cr 0.000875
Co 0.000985
Pb 0.000465
Mo 0.001
Se 0.00075
end

SOLUTION 5 #G406 (C - UA)
redox pe
units mg/l
density 1
pH 6.63
pe 5.755
temp 19.05
S(6) 481 as SO4
B 1.47
Li 0.01095
As 0.0002725
```

```
C(4) 212 as CO3
Cl 3.2 charge
F 0.267
Ca 191.5
Mg 65.35
Na 37.6
K 0.2065
Ba 0.01345
Si 12.95
P 0.008975
Mn 4.425
Fe 0.003055
Al 0.005175
Sb 0.0002575
Be 0.0001975
Cd 0.000235
Cr 0.000875
Co 0.00066
Pb 0.000205
Mo 0.000335
Se 0.000335
end

EQUILIBRIUM_PHASES 1 #G401 (C - UA) - median
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.11
Ferrihydrite 0 0.014
Calcite 0 1
Dolomite(ordered) 0 2

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 #G402 (C - UA) - median
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.11
Ferrihydrite 0 0.014
Calcite 0 1
Dolomite(ordered) 0 2

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 #G404 (C - UA) - median
Barite 0 0
```

```
Gypsum 0 0
Gibbsite 0 0.11
Ferrihydrite 0 0.014
Calcite 0 1
Dolomite(ordered) 0 2

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 #G405 (C - UA) - median
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.11
Ferrihydrite 0 0.014
Calcite 0 1
Dolomite(ordered) 0 2

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 #G406 (C - UA) - median
Barite 0 0
Gypsum 0 0
Gibbsite 0 0.11
Ferrihydrite 0 0.014
Calcite 0 1
Dolomite(ordered) 0 2

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 6.805
pe 4.95
temp 15.45
S(6) 91
B 0.0046
Li 0.0027
As 0.000485
```

```
C(4) 209
Cl 70.5 charge
F 0.305
Ca 79.25
Mg 37.3
Na 81.15
K 0.5945
Ba 0.05855
Si 7.8
P 0.0083
Mn 0.118
Fe 0.012375
Al 0.013
Sb 0.0003075
Be 0.0001975
Cd 0.000235
Cr 0.00135
Co 0.00035
Pb 0.000405
Mo 0.0007
Se 0.000335

SAVE solution 6

end

#FIRST REACTION

#G401 (C - UA) - First Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 1
USE SURFACE 1
SAVE equilibrium_phases 1
SAVE surface 1
end

#G401 (C - UA) - Second Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 1
USE SURFACE 1
SAVE equilibrium_phases 1
SAVE surface 1
end

#G402 (C - UA) - First Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 2
USE SURFACE 2
SAVE equilibrium_phases 2
SAVE surface 2
end

#G402 (C - UA) - Second Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 2
USE SURFACE 2
SAVE equilibrium_phases 2
```

```
SAVE surface 2
end

#G404 (C - UA) - First Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 3
USE SURFACE 3
SAVE equilibrium_phases 3
SAVE surface 3
end

#G404 (C - UA) - Second Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 3
USE SURFACE 3
SAVE equilibrium_phases 3
SAVE surface 3
end

#G405 (C - UA) - First Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 4
USE SURFACE 4
SAVE equilibrium_phases 4
SAVE surface 4
end

#G405 (C - UA) - Second Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 4
USE SURFACE 4
SAVE equilibrium_phases 4
SAVE surface 4
end

#G406 (C - UA) - First Reaction
USE SOLUTION 6
USE EQUILIBRIUM_PHASES 5
USE SURFACE 5
SAVE equilibrium_phases 5
SAVE surface 5
end

#G406 (C - UA) - Second Reaction
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 appendix to the Groundwater Polishing Report for the Coffeen Power Plant (CPP) Ash Pond No. 2 (AP2) Unit 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 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 and 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 on Coffeen AP2 samples. The dataset constraints necessitated alternative means of deriving oxide inputs.

Because SEP analyses were not completed on any CPP AP2 samples, model input concentrations for ferrihydrite and gibbsite were derived using site-specific total metals and the proportion of total metals as crystalline metal oxides or amorphous metal oxides compiled from SEP datasets consisting of samples collected from similar geologic systems at various power generating facilities across Illinois. Much of the Coffeen AP2 uppermost aquifer (UA) consists of the Hagarstown Member, so the analogous dataset for the UA is comprised of samples collected from various power generating facilities across Illinois specifically within the Hagarstown Member. The geologic similarity (regional geology, similar lithologies and depositional environments, similar mineral assemblages) between the samples comprising this dataset and the CPP AP2 subsurface make this dataset appropriate for estimating the amount and distribution of sorbing solid phases in the absence of a

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[1] The Nature and Extent Report was previously submitted to IEPA on June 12, 2024, and provided with relevant updates as Appendix D of the CAAA to which this report is attached.

complete site-specific dataset. SEP data for iron and aluminum is available for 3 Hagarstown Member solid phase samples collected from a different power generating unit.

Total solid-phase iron was measured in three AP2 UA solids samples at concentrations ranging from 14,000 milligrams per kilogram (mg/kg) to 22,000 mg/kg. Six AP2 UA solid samples were analyzed for mineralogy via X-ray diffraction analysis. X-ray diffraction analysis identified multiple minerals containing iron in their crystal structures, only one of which is an iron oxide mineral (magnetite). The crystalline iron component for the UA was determined by applying a proportion of 0.0006 (representative of 0.06 weight % - the average magnetite component of AP2 UA samples) to the median total iron value from UA samples.

The amorphous ferrihydrite component for the UA was based on the 25th percentile of amorphous ferrihydrite distribution in the analogous compiled SEP dataset.

The gibbsite component of the models was determined using the average mass of aluminum associated with the oxide fraction from the compiled SEP dataset described above.

In thermodynamic modeling, the amount of sorbing phase present is typically the dominant control on the concentration of constituents sorbed under a given pH. 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[2] is represented by the hydrous ferric oxide (HFO) thermodynamic dataset 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:

---

[2] 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.

ϕ = porosity (water volume in cubic centimeters [cm^3] / total volume in cm^3)

ρ = density of the solid (grams [g]/cm^3)

Porosity and density represent the median of measurements each hydrostratigraphic unit as reported in the Hydrogeologic Characterization Report[3].

Moles of ferrihydrite and gibbsite were determined using metal concentrations as described above, the molar mass of iron or aluminum, and the mass of solid phase in the model:

$$Moles\ of\ Metal\ Oxide = \frac{mg\ Fe\ or\ Al}{kg\ solid} \times \frac{g}{1000\ mg} \times \frac{moles\ Fe\ or\ Al}{g\ Fe\ or\ Al} \times kg\ Solid\ Mass\ in\ Model$$

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 were included as mineral phases in the model because carbonate mineral formation and dissolution are often major controls on groundwater pH. Calcite is a common carbonate mineral and was detected at levels of greater than 1% by weight in X-ray diffraction analysis and are therefore considered to be present in excess within the aquifer. Dolomite was not detected in AP2 UA XRD samples and was therefore not added to the initial model input. Therefore, the mass fractions reported in the X-ray diffraction are used as model inputs for the UA. Both calcite and dolomite were allowed to precipitate in the reaction phase of the model.

Barite and gypsum are common sulfate minerals that have the potential to form under ambient environmental conditions. Neither mineral was detected in X-ray diffraction results at well locations containing exceedances of GWPSs. Therefore, barite and gypsum did not have initial concentrations in the model but were allowed to precipitate or dissolve 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

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[3] 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.

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.
- Remaining constituents regulated under 35 IAC § 845.600[4]: 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[5] 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:

---

[4] 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.

[5] https://static.horiba.com/fileadmin/Horiba/Products/Process_and_Environmental/Water_Pollution/Instruction_Manuals/U-50/U-50_Manual.pdf

$$\frac{mg\ CO_3^{2-}}{L} = \frac{mg\ CaCO_3}{L} \times \frac{mole\ CaCO_3}{100.1\ mg\ CaCO_3} \times \frac{1\ mole\ CO_3^{2-}}{1\ mole\ CaCO_3} \times \frac{60\ mg\ CO_3^{2-}}{mole\ CO_3^{2-}}$$

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 all three background locations measured in Quarter 2 and Quarter 3, 2023.

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.

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ATTACHMENT D

Complete Geochemical Modeling Outputs

Attachment D. PHREEQC modeling output

Groundwater Polishing Report
Ash Pond No. 2
Coffeen Power Plant
Coffeen, IL

Location	Location Description	Model	Charge Balance	Solids Summary
G401	C - UA	Initial Soln	TRUE	25p
G402	C - UA	Initial Soln	TRUE	25p
G404	C - UA	Initial Soln	TRUE	25p
G405	C - UA	Initial Soln	TRUE	25p
G406	C - UA	Initial Soln	TRUE	25p
G401	C - UA	Speciation Model	TRUE	25p
G402	C - UA	Speciation Model	TRUE	25p
G404	C - UA	Speciation Model	TRUE	25p
G405	C - UA	Speciation Model	TRUE	25p
G406	C - UA	Speciation Model	TRUE	25p
G401	C - UA	First Reaction	TRUE	25p
G401	C - UA	Second Reaction	TRUE	25p
G402	C - UA	First Reaction	TRUE	25p
G402	C - UA	Second Reaction	TRUE	25p
G404	C - UA	First Reaction	TRUE	25p
G404	C - UA	Second Reaction	TRUE	25p
G405	C - UA	First Reaction	TRUE	25p
G405	C - UA	Second Reaction	TRUE	25p
G406	C - UA	First Reaction	TRUE	25p
G406	C - UA	Second Reaction	TRUE	25p
G401	C - UA	Initial Soln	TRUE	75p
G402	C - UA	Initial Soln	TRUE	75p
G404	C - UA	Initial Soln	TRUE	75p
G405	C - UA	Initial Soln	TRUE	75p
G406	C - UA	Initial Soln	TRUE	75p
G401	C - UA	Speciation Model	TRUE	75p
G402	C - UA	Speciation Model	TRUE	75p
G404	C - UA	Speciation Model	TRUE	75p
G405	C - UA	Speciation Model	TRUE	75p
G406	C - UA	Speciation Model	TRUE	75p
G401	C - UA	First Reaction	TRUE	75p
G401	C - UA	Second Reaction	TRUE	75p
G402	C - UA	First Reaction	TRUE	75p
G402	C - UA	Second Reaction	TRUE	75p
G404	C - UA	First Reaction	TRUE	75p
G404	C - UA	Second Reaction	TRUE	75p
G405	C - UA	First Reaction	TRUE	75p
G405	C - UA	Second Reaction	TRUE	75p
G406	C - UA	First Reaction	TRUE	75p
G406	C - UA	Second Reaction	TRUE	75p
G401	C - UA	Initial Soln	TRUE	median
G402	C - UA	Initial Soln	TRUE	median
G404	C - UA	Initial Soln	TRUE	median

G405	C - UA	Initial Soln	TRUE	median
G406	C - UA	Initial Soln	TRUE	median
G401	C - UA	Speciation Model	TRUE	median
G402	C - UA	Speciation Model	TRUE	median
G404	C - UA	Speciation Model	TRUE	median
G405	C - UA	Speciation Model	TRUE	median
G406	C - UA	Speciation Model	TRUE	median
G401	C - UA	First Reaction	TRUE	median
G401	C - UA	Second Reaction	TRUE	median
G402	C - UA	First Reaction	TRUE	median
G402	C - UA	Second Reaction	TRUE	median
G404	C - UA	First Reaction	TRUE	median
G404	C - UA	Second Reaction	TRUE	median
G405	C - UA	First Reaction	TRUE	median
G405	C - UA	Second Reaction	TRUE	median
G406	C - UA	First Reaction	TRUE	median
G406	C - UA	Second Reaction	TRUE	median
G401	C - UA	Initial Soln	FALSE	25p
G402	C - UA	Initial Soln	FALSE	25p
G404	C - UA	Initial Soln	FALSE	25p
G405	C - UA	Initial Soln	FALSE	25p
G406	C - UA	Initial Soln	FALSE	25p
G401	C - UA	Speciation Model	FALSE	25p
G402	C - UA	Speciation Model	FALSE	25p
G404	C - UA	Speciation Model	FALSE	25p
G405	C - UA	Speciation Model	FALSE	25p
G406	C - UA	Speciation Model	FALSE	25p
G401	C - UA	First Reaction	FALSE	25p
G401	C - UA	Second Reaction	FALSE	25p
G402	C - UA	First Reaction	FALSE	25p
G402	C - UA	Second Reaction	FALSE	25p
G404	C - UA	First Reaction	FALSE	25p
G404	C - UA	Second Reaction	FALSE	25p
G405	C - UA	First Reaction	FALSE	25p
G405	C - UA	Second Reaction	FALSE	25p
G406	C - UA	First Reaction	FALSE	25p
G406	C - UA	Second Reaction	FALSE	25p
G401	C - UA	Initial Soln	FALSE	75p
G402	C - UA	Initial Soln	FALSE	75p
G404	C - UA	Initial Soln	FALSE	75p
G405	C - UA	Initial Soln	FALSE	75p
G406	C - UA	Initial Soln	FALSE	75p
G401	C - UA	Speciation Model	FALSE	75p
G402	C - UA	Speciation Model	FALSE	75p
G404	C - UA	Speciation Model	FALSE	75p
G405	C - UA	Speciation Model	FALSE	75p
G406	C - UA	Speciation Model	FALSE	75p
G401	C - UA	First Reaction	FALSE	75p
G401	C - UA	Second Reaction	FALSE	75p
G402	C - UA	First Reaction	FALSE	75p

G402	C - UA	Second Reaction	FALSE	75p
G404	C - UA	First Reaction	FALSE	75p
G404	C - UA	Second Reaction	FALSE	75p
G405	C - UA	First Reaction	FALSE	75p
G405	C - UA	Second Reaction	FALSE	75p
G406	C - UA	First Reaction	FALSE	75p
G406	C - UA	Second Reaction	FALSE	75p
G401	C - UA	Initial Soln	FALSE	median
G402	C - UA	Initial Soln	FALSE	median
G404	C - UA	Initial Soln	FALSE	median
G405	C - UA	Initial Soln	FALSE	median
G406	C - UA	Initial Soln	FALSE	median
G401	C - UA	Speciation Model	FALSE	median
G402	C - UA	Speciation Model	FALSE	median
G404	C - UA	Speciation Model	FALSE	median
G405	C - UA	Speciation Model	FALSE	median
G406	C - UA	Speciation Model	FALSE	median
G401	C - UA	First Reaction	FALSE	median
G401	C - UA	Second Reaction	FALSE	median
G402	C - UA	First Reaction	FALSE	median
G402	C - UA	Second Reaction	FALSE	median
G404	C - UA	First Reaction	FALSE	median
G404	C - UA	Second Reaction	FALSE	median
G405	C - UA	First Reaction	FALSE	median
G405	C - UA	Second Reaction	FALSE	median
G406	C - UA	First Reaction	FALSE	median
G406	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)
6.09	3.18	-1.86e-16	-3.06e-13	0.0209
6.96	5.33	6.32e-17	1.65e-13	0.00615
6.76	4.90	3.95e-12	1.05e-08	0.00718
6.96	4.03	2.68e-18	6.48e-15	0.00999
6.63	5.75	2.11e-16	7.58e-13	0.00501
6.09	3.18	-1.72e-16	-2.83e-13	0.0209
6.96	5.33	7.53e-17	1.97e-13	0.00615
6.76	4.90	3.95e-12	1.05e-08	0.00718
6.96	4.03	-2.53e-18	-6.12e-15	0.00999
6.63	5.75	2.23e-16	8.01e-13	0.00501
7.34	-4.93e-01	-1.62e-04	-6.76e-01	0.00120
7.39	-4.62e-01	-4.21e-06	-1.86e-02	0.000920
7.35	3.59	-9.48e-05	-4.08e-01	0.000947
7.39	3.36	-1.66e-07	-7.33e-04	0.000900
7.33	2.55	-8.16e-05	-3.49e-01	0.000927
7.38	2.57	6.31e-07	0.00278	0.000884
7.36	1.72	-1.22e-04	-5.27e-01	0.000958
7.39	1.79	2.42e-07	0.00107	0.000890
7.33	3.56	-1.02e-04	-4.35e-01	0.000952
7.38	3.34	-2.70e-06	-1.19e-02	0.000910
6.09	3.18	-1.86e-16	-3.06e-13	0.0209
6.96	5.33	6.32e-17	1.65e-13	0.00615
6.76	4.90	3.95e-12	1.05e-08	0.00718
6.96	4.03	2.68e-18	6.48e-15	0.00999
6.63	5.75	2.11e-16	7.58e-13	0.00501
6.09	3.18	-1.72e-16	-2.83e-13	0.0209
6.96	5.33	7.53e-17	1.97e-13	0.00615
6.76	4.90	3.95e-12	1.05e-08	0.00718
6.96	4.03	-2.53e-18	-6.12e-15	0.00999
6.63	5.75	2.23e-16	8.01e-13	0.00501
7.32	-4.69e-01	-1.59e-04	-6.49e-01	0.00132
7.38	-4.72e-01	-1.00e-05	-4.39e-02	0.000922
7.33	3.67	-1.07e-04	-4.54e-01	0.000960
7.38	3.42	-1.50e-06	-6.59e-03	0.000897
7.31	2.57	-8.49e-05	-3.58e-01	0.000943
7.37	2.57	-6.00e-07	-2.63e-03	0.000879
7.35	1.72	-1.36e-04	-5.84e-01	0.000981
7.38	1.77	-1.07e-06	-4.71e-03	0.000886
7.30	3.64	-1.09e-04	-4.56e-01	0.000968
7.37	3.40	-5.18e-06	-2.26e-02	0.000909
6.09	3.18	-1.86e-16	-3.06e-13	0.0209
6.96	5.33	6.32e-17	1.65e-13	0.00615
6.76	4.90	3.95e-12	1.05e-08	0.00718

6.96	4.03	2.68e-18	6.48e-15	0.00999
6.63	5.75	2.11e-16	7.58e-13	0.00501
6.09	3.18	-1.72e-16	-2.83e-13	0.0209
6.96	5.33	7.53e-17	1.97e-13	0.00615
6.76	4.90	3.95e-12	1.05e-08	0.00718
6.96	4.03	-2.53e-18	-6.12e-15	0.00999
6.63	5.75	2.23e-16	8.01e-13	0.00501
7.32	-4.66e-01	-1.43e-04	-5.87e-01	0.00129
7.38	-4.61e-01	-8.05e-06	-3.53e-02	0.000922
7.33	3.64	-9.69e-05	-4.14e-01	0.000955
7.38	3.40	-8.80e-07	-3.87e-03	0.000898
7.32	2.58	-7.64e-05	-3.23e-01	0.000939
7.37	2.58	-7.61e-08	-3.34e-04	0.000881
7.35	1.73	-1.24e-04	-5.32e-01	0.000974
7.38	1.78	-4.58e-07	-2.02e-03	0.000888
7.31	3.62	-9.90e-05	-4.15e-01	0.000963
7.37	3.38	-4.20e-06	-1.83e-02	0.000909
6.09	3.18	0.00221	3.78	0.0209
6.96	5.33	0.00661	21.1	0.00615
6.76	4.90	0.00304	8.79	0.00718
6.96	4.03	0.00380	10.2	0.00999
6.63	5.75	0.00422	18.0	0.00501
6.09	3.18	0.00221	3.78	0.0209
6.96	5.33	0.00661	21.1	0.00615
6.76	4.90	0.00304	8.79	0.00718
6.96	4.03	0.00380	10.2	0.00999
6.63	5.75	0.00422	18.0	0.00501
7.34	-4.97e-01	-1.59e-04	-6.62e-01	0.00120
7.39	-4.66e-01	-4.14e-06	-1.82e-02	0.000920
7.35	3.58	-8.19e-05	-3.53e-01	0.000943
7.39	3.36	4.77e-08	0.000211	0.000900
7.33	2.54	-7.68e-05	-3.29e-01	0.000925
7.38	2.57	7.30e-07	0.00322	0.000884
7.36	1.71	-1.15e-04	-4.99e-01	0.000955
7.39	1.78	3.60e-07	0.00159	0.000890
7.33	3.55	-9.05e-05	-3.85e-01	0.000948
7.38	3.33	-2.52e-06	-1.11e-02	0.000910
6.09	3.18	0.00221	3.78	0.0209
6.96	5.33	0.00661	21.1	0.00615
6.76	4.90	0.00304	8.79	0.00718
6.96	4.03	0.00380	10.2	0.00999
6.63	5.75	0.00422	18.0	0.00501
6.09	3.18	0.00221	3.78	0.0209
6.96	5.33	0.00661	21.1	0.00615
6.76	4.90	0.00304	8.79	0.00718
6.96	4.03	0.00380	10.2	0.00999
6.63	5.75	0.00422	18.0	0.00501
7.32	-4.74e-01	-1.55e-04	-6.34e-01	0.00132
7.38	-4.76e-01	-9.93e-06	-4.34e-02	0.000922
7.33	3.66	-9.15e-05	-3.90e-01	0.000955

7.38	3.42	-1.20e-06	-5.28e-03	0.000897
7.31	2.56	-7.96e-05	-3.36e-01	0.000941
7.37	2.56	-4.64e-07	-2.03e-03	0.000878
7.35	1.71	-1.29e-04	-5.52e-01	0.000978
7.38	1.76	-9.08e-07	-4.00e-03	0.000886
7.30	3.63	-9.54e-05	-3.99e-01	0.000963
7.37	3.39	-4.92e-06	-2.15e-02	0.000909
6.09	3.18	0.00221	3.78	0.0209
6.96	5.33	0.00661	21.1	0.00615
6.76	4.90	0.00304	8.79	0.00718
6.96	4.03	0.00380	10.2	0.00999
6.63	5.75	0.00422	18.0	0.00501
6.09	3.18	0.00221	3.78	0.0209
6.96	5.33	0.00661	21.1	0.00615
6.76	4.90	0.00304	8.79	0.00718
6.96	4.03	0.00380	10.2	0.00999
6.63	5.75	0.00422	18.0	0.00501
7.32	-4.70e-01	-1.40e-04	-5.74e-01	0.00129
7.38	-4.65e-01	-7.96e-06	-3.49e-02	0.000922
7.33	3.64	-8.32e-05	-3.55e-01	0.000950
7.38	3.40	-6.23e-07	-2.74e-03	0.000898
7.32	2.57	-7.16e-05	-3.03e-01	0.000937
7.37	2.57	4.09e-08	0.000179	0.000881
7.35	1.72	-1.17e-04	-5.03e-01	0.000972
7.38	1.77	-3.20e-07	-1.41e-03	0.000888
7.31	3.61	-8.65e-05	-3.63e-01	0.000959
7.37	3.38	-3.98e-06	-1.74e-02	0.000910

B	Li	As	C(4)	Cl
0.000378	3.16e-06	1.06e-08	0.00118	0.00230
0.000491	3.10e-06	5.01e-08	0.00504	0.00670
0.00110	1.13e-06	9.66e-09	0.00370	0.00605
0.000940	6.13e-07	1.14e-08	0.00283	0.00413
0.000136	1.58e-06	3.64e-09	0.00354	0.00431
0.000378	3.16e-06	1.06e-08	0.00118	0.00230
0.000491	3.10e-06	5.01e-08	0.00504	0.00670
0.00110	1.13e-06	9.66e-09	0.00370	0.00605
0.000940	6.13e-07	1.14e-08	0.00283	0.00413
0.000136	1.58e-06	3.64e-09	0.00354	0.00431
0.000183	3.89e-07	7.23e-09	0.00463	0.00608
0.000130	3.89e-07	5.58e-09	0.00429	0.00608
0.000224	3.89e-07	2.61e-08	0.00462	0.00608
0.000173	3.89e-07	2.48e-08	0.00427	0.00608
0.000340	3.89e-07	6.79e-09	0.00475	0.00608
0.000232	3.89e-07	6.65e-09	0.00435	0.00608
0.000303	3.89e-07	1.09e-08	0.00452	0.00608
0.000213	3.89e-07	1.12e-08	0.00427	0.00608
0.000157	3.89e-07	2.68e-09	0.00482	0.00608
0.000135	3.89e-07	2.47e-09	0.00433	0.00608
0.000378	3.16e-06	1.06e-08	0.00118	0.00230
0.000491	3.10e-06	5.01e-08	0.00504	0.00670
0.00110	1.13e-06	9.66e-09	0.00370	0.00605
0.000940	6.13e-07	1.14e-08	0.00283	0.00413
0.000136	1.58e-06	3.64e-09	0.00354	0.00431
0.000378	3.16e-06	1.06e-08	0.00118	0.00230
0.000491	3.10e-06	5.01e-08	0.00504	0.00670
0.00110	1.13e-06	9.66e-09	0.00370	0.00605
0.000940	6.13e-07	1.14e-08	0.00283	0.00413
0.000136	1.58e-06	3.64e-09	0.00354	0.00431
0.000197	3.89e-07	7.71e-09	0.00477	0.00608
0.000139	3.89e-07	5.64e-09	0.00438	0.00608
0.000234	3.89e-07	2.70e-08	0.00477	0.00608
0.000186	3.89e-07	2.39e-08	0.00435	0.00608
0.000366	3.89e-07	6.94e-09	0.00493	0.00608
0.000255	3.89e-07	6.20e-09	0.00444	0.00608
0.000324	3.89e-07	1.08e-08	0.00462	0.00608
0.000233	3.89e-07	1.05e-08	0.00433	0.00608
0.000160	3.89e-07	2.81e-09	0.00503	0.00608
0.000142	3.89e-07	2.34e-09	0.00444	0.00608
0.000378	3.16e-06	1.06e-08	0.00118	0.00230
0.000491	3.10e-06	5.01e-08	0.00504	0.00670
0.00110	1.13e-06	9.66e-09	0.00370	0.00605

0.000940	6.13e-07	1.14e-08	0.00283	0.00413
0.000136	1.58e-06	3.64e-09	0.00354	0.00431
0.000378	3.16e-06	1.06e-08	0.00118	0.00230
0.000491	3.10e-06	5.01e-08	0.00504	0.00670
0.00110	1.13e-06	9.66e-09	0.00370	0.00605
0.000940	6.13e-07	1.14e-08	0.00283	0.00413
0.000136	1.58e-06	3.64e-09	0.00354	0.00431
0.000191	3.89e-07	7.49e-09	0.00474	0.00608
0.000135	3.89e-07	5.53e-09	0.00436	0.00608
0.000229	3.89e-07	2.68e-08	0.00474	0.00608
0.000181	3.89e-07	2.40e-08	0.00433	0.00608
0.000354	3.89e-07	6.89e-09	0.00490	0.00608
0.000245	3.89e-07	6.25e-09	0.00442	0.00608
0.000315	3.89e-07	1.08e-08	0.00460	0.00608
0.000224	3.89e-07	1.06e-08	0.00432	0.00608
0.000158	3.89e-07	2.78e-09	0.00499	0.00608
0.000139	3.89e-07	2.35e-09	0.00441	0.00608
0.000378	3.16e-06	1.06e-08	0.00118	9.34e-05
0.000491	3.10e-06	5.01e-08	0.00504	9.04e-05
0.00110	1.13e-06	9.66e-09	0.00370	0.00301
0.000940	6.13e-07	1.14e-08	0.00283	0.000323
0.000136	1.58e-06	3.64e-09	0.00354	9.04e-05
0.000378	3.16e-06	1.06e-08	0.00118	9.34e-05
0.000491	3.10e-06	5.01e-08	0.00504	9.04e-05
0.00110	1.13e-06	9.66e-09	0.00370	0.00301
0.000940	6.13e-07	1.14e-08	0.00283	0.000323
0.000136	1.58e-06	3.64e-09	0.00354	9.04e-05
0.000183	3.89e-07	7.31e-09	0.00463	0.00608
0.000129	3.89e-07	5.64e-09	0.00429	0.00608
0.000222	3.89e-07	2.73e-08	0.00461	0.00608
0.000173	3.89e-07	2.59e-08	0.00427	0.00608
0.000341	3.89e-07	6.93e-09	0.00475	0.00608
0.000232	3.89e-07	6.79e-09	0.00435	0.00608
0.000303	3.89e-07	1.11e-08	0.00451	0.00608
0.000213	3.89e-07	1.15e-08	0.00427	0.00608
0.000156	3.89e-07	2.76e-09	0.00481	0.00608
0.000134	3.89e-07	2.55e-09	0.00433	0.00608
0.000378	3.16e-06	1.06e-08	0.00118	9.34e-05
0.000491	3.10e-06	5.01e-08	0.00504	9.04e-05
0.00110	1.13e-06	9.66e-09	0.00370	0.00301
0.000940	6.13e-07	1.14e-08	0.00283	0.000323
0.000136	1.58e-06	3.64e-09	0.00354	9.04e-05
0.000378	3.16e-06	1.06e-08	0.00118	9.34e-05
0.000491	3.10e-06	5.01e-08	0.00504	9.04e-05
0.00110	1.13e-06	9.66e-09	0.00370	0.00301
0.000940	6.13e-07	1.14e-08	0.00283	0.000323
0.000136	1.58e-06	3.64e-09	0.00354	9.04e-05
0.000197	3.89e-07	7.80e-09	0.00477	0.00608
0.000139	3.89e-07	5.70e-09	0.00438	0.00608
0.000232	3.89e-07	2.82e-08	0.00477	0.00608

0.000186	3.89e-07	2.50e-08	0.00435	0.00608
0.000366	3.89e-07	7.08e-09	0.00493	0.00608
0.000255	3.89e-07	6.33e-09	0.00444	0.00608
0.000324	3.89e-07	1.11e-08	0.00461	0.00608
0.000233	3.89e-07	1.08e-08	0.00433	0.00608
0.000159	3.89e-07	2.89e-09	0.00503	0.00608
0.000141	3.89e-07	2.41e-09	0.00444	0.00608
0.000378	3.16e-06	1.06e-08	0.00118	9.34e-05
0.000491	3.10e-06	5.01e-08	0.00504	9.04e-05
0.00110	1.13e-06	9.66e-09	0.00370	0.00301
0.000940	6.13e-07	1.14e-08	0.00283	0.000323
0.000136	1.58e-06	3.64e-09	0.00354	9.04e-05
0.000378	3.16e-06	1.06e-08	0.00118	9.34e-05
0.000491	3.10e-06	5.01e-08	0.00504	9.04e-05
0.00110	1.13e-06	9.66e-09	0.00370	0.00301
0.000940	6.13e-07	1.14e-08	0.00283	0.000323
0.000136	1.58e-06	3.64e-09	0.00354	9.04e-05
0.000191	3.89e-07	7.59e-09	0.00474	0.00608
0.000135	3.89e-07	5.59e-09	0.00436	0.00608
0.000227	3.89e-07	2.80e-08	0.00474	0.00608
0.000180	3.89e-07	2.51e-08	0.00433	0.00608
0.000355	3.89e-07	7.02e-09	0.00490	0.00608
0.000245	3.89e-07	6.37e-09	0.00442	0.00608
0.000315	3.89e-07	1.11e-08	0.00459	0.00608
0.000224	3.89e-07	1.09e-08	0.00432	0.00608
0.000157	3.89e-07	2.86e-09	0.00498	0.00608
0.000138	3.89e-07	2.42e-09	0.00441	0.00608

F	Ca	Mg	Na	K
1.06e-05	0.0125	0.00600	0.00311	6.49e-05
1.39e-05	0.00527	0.00531	0.00196	2.91e-05
6.51e-06	0.00557	0.00424	0.00348	1.35e-05
1.53e-05	0.00629	0.00453	0.00477	1.25e-05
1.41e-05	0.00478	0.00269	0.00164	5.29e-06
1.06e-05	0.0125	0.00600	0.00311	6.49e-05
1.39e-05	0.00527	0.00531	0.00196	2.91e-05
6.51e-06	0.00557	0.00424	0.00348	1.35e-05
1.53e-05	0.00629	0.00453	0.00477	1.25e-05
1.41e-05	0.00478	0.00269	0.00164	5.29e-06
1.62e-05	0.00224	0.00222	0.00353	1.52e-05
1.60e-05	0.00207	0.00206	0.00353	1.52e-05
1.60e-05	0.00215	0.00213	0.00353	1.52e-05
1.61e-05	0.00208	0.00206	0.00353	1.52e-05
1.60e-05	0.00217	0.00216	0.00353	1.52e-05
1.61e-05	0.00208	0.00207	0.00353	1.52e-05
1.60e-05	0.00213	0.00211	0.00353	1.52e-05
1.60e-05	0.00207	0.00206	0.00353	1.52e-05
1.63e-05	0.00218	0.00217	0.00353	1.52e-05
1.61e-05	0.00209	0.00208	0.00353	1.52e-05
1.06e-05	0.0125	0.00600	0.00311	6.49e-05
1.39e-05	0.00527	0.00531	0.00196	2.91e-05
6.51e-06	0.00557	0.00424	0.00348	1.35e-05
1.53e-05	0.00629	0.00453	0.00477	1.25e-05
1.41e-05	0.00478	0.00269	0.00164	5.29e-06
1.06e-05	0.0125	0.00600	0.00311	6.49e-05
1.39e-05	0.00527	0.00531	0.00196	2.91e-05
6.51e-06	0.00557	0.00424	0.00348	1.35e-05
1.53e-05	0.00629	0.00453	0.00477	1.25e-05
1.41e-05	0.00478	0.00269	0.00164	5.29e-06
1.63e-05	0.00232	0.00230	0.00353	1.52e-05
1.60e-05	0.00209	0.00208	0.00353	1.52e-05
1.60e-05	0.00218	0.00217	0.00353	1.52e-05
1.61e-05	0.00209	0.00208	0.00353	1.52e-05
1.60e-05	0.00221	0.00220	0.00353	1.52e-05
1.60e-05	0.00210	0.00209	0.00353	1.52e-05
1.60e-05	0.00215	0.00214	0.00353	1.52e-05
1.60e-05	0.00208	0.00207	0.00353	1.52e-05
1.64e-05	0.00223	0.00222	0.00353	1.52e-05
1.61e-05	0.00211	0.00210	0.00353	1.52e-05
1.06e-05	0.0125	0.00600	0.00311	6.49e-05
1.39e-05	0.00527	0.00531	0.00196	2.91e-05
6.51e-06	0.00557	0.00424	0.00348	1.35e-05

1.53e-05	0.00629	0.00453	0.00477	1.25e-05
1.41e-05	0.00478	0.00269	0.00164	5.29e-06
1.06e-05	0.0125	0.00600	0.00311	6.49e-05
1.39e-05	0.00527	0.00531	0.00196	2.91e-05
6.51e-06	0.00557	0.00424	0.00348	1.35e-05
1.53e-05	0.00629	0.00453	0.00477	1.25e-05
1.41e-05	0.00478	0.00269	0.00164	5.29e-06
1.63e-05	0.00231	0.00229	0.00353	1.52e-05
1.60e-05	0.00209	0.00208	0.00353	1.52e-05
1.60e-05	0.00218	0.00216	0.00353	1.52e-05
1.61e-05	0.00209	0.00208	0.00353	1.52e-05
1.60e-05	0.00220	0.00219	0.00353	1.52e-05
1.60e-05	0.00210	0.00209	0.00353	1.52e-05
1.60e-05	0.00215	0.00214	0.00353	1.52e-05
1.60e-05	0.00208	0.00207	0.00353	1.52e-05
1.64e-05	0.00222	0.00221	0.00353	1.52e-05
1.61e-05	0.00211	0.00209	0.00353	1.52e-05
1.06e-05	0.0125	0.00600	0.00311	6.49e-05
1.39e-05	0.00527	0.00531	0.00196	2.91e-05
6.51e-06	0.00557	0.00424	0.00348	1.35e-05
1.53e-05	0.00629	0.00453	0.00477	1.25e-05
1.41e-05	0.00478	0.00269	0.00164	5.29e-06
1.06e-05	0.0125	0.00600	0.00311	6.49e-05
1.39e-05	0.00527	0.00531	0.00196	2.91e-05
6.51e-06	0.00557	0.00424	0.00348	1.35e-05
1.53e-05	0.00629	0.00453	0.00477	1.25e-05
1.41e-05	0.00478	0.00269	0.00164	5.29e-06
1.62e-05	0.00224	0.00222	0.00353	1.52e-05
1.60e-05	0.00207	0.00206	0.00353	1.52e-05
1.60e-05	0.00215	0.00213	0.00353	1.52e-05
1.61e-05	0.00208	0.00206	0.00353	1.52e-05
1.60e-05	0.00217	0.00216	0.00353	1.52e-05
1.61e-05	0.00208	0.00207	0.00353	1.52e-05
1.60e-05	0.00213	0.00211	0.00353	1.52e-05
1.60e-05	0.00207	0.00206	0.00353	1.52e-05
1.63e-05	0.00218	0.00217	0.00353	1.52e-05
1.61e-05	0.00209	0.00208	0.00353	1.52e-05
1.06e-05	0.0125	0.00600	0.00311	6.49e-05
1.39e-05	0.00527	0.00531	0.00196	2.91e-05
6.51e-06	0.00557	0.00424	0.00348	1.35e-05
1.53e-05	0.00629	0.00453	0.00477	1.25e-05
1.41e-05	0.00478	0.00269	0.00164	5.29e-06
1.06e-05	0.0125	0.00600	0.00311	6.49e-05
1.39e-05	0.00527	0.00531	0.00196	2.91e-05
6.51e-06	0.00557	0.00424	0.00348	1.35e-05
1.53e-05	0.00629	0.00453	0.00477	1.25e-05
1.41e-05	0.00478	0.00269	0.00164	5.29e-06
1.63e-05	0.00232	0.00230	0.00353	1.52e-05
1.60e-05	0.00209	0.00208	0.00353	1.52e-05
1.60e-05	0.00218	0.00217	0.00353	1.52e-05

1.61e-05	0.00209	0.00208	0.00353	1.52e-05
1.60e-05	0.00221	0.00220	0.00353	1.52e-05
1.60e-05	0.00210	0.00209	0.00353	1.52e-05
1.60e-05	0.00215	0.00214	0.00353	1.52e-05
1.60e-05	0.00208	0.00207	0.00353	1.52e-05
1.64e-05	0.00223	0.00222	0.00353	1.52e-05
1.61e-05	0.00211	0.00210	0.00353	1.52e-05
1.06e-05	0.0125	0.00600	0.00311	6.49e-05
1.39e-05	0.00527	0.00531	0.00196	2.91e-05
6.51e-06	0.00557	0.00424	0.00348	1.35e-05
1.53e-05	0.00629	0.00453	0.00477	1.25e-05
1.41e-05	0.00478	0.00269	0.00164	5.29e-06
1.06e-05	0.0125	0.00600	0.00311	6.49e-05
1.39e-05	0.00527	0.00531	0.00196	2.91e-05
6.51e-06	0.00557	0.00424	0.00348	1.35e-05
1.53e-05	0.00629	0.00453	0.00477	1.25e-05
1.41e-05	0.00478	0.00269	0.00164	5.29e-06
1.63e-05	0.00231	0.00229	0.00353	1.52e-05
1.60e-05	0.00209	0.00208	0.00353	1.52e-05
1.60e-05	0.00218	0.00216	0.00353	1.52e-05
1.61e-05	0.00209	0.00208	0.00353	1.52e-05
1.60e-05	0.00220	0.00219	0.00353	1.52e-05
1.60e-05	0.00210	0.00209	0.00353	1.52e-05
1.60e-05	0.00215	0.00214	0.00353	1.52e-05
1.60e-05	0.00208	0.00207	0.00353	1.52e-05
1.64e-05	0.00222	0.00221	0.00353	1.52e-05
1.61e-05	0.00211	0.00209	0.00353	1.52e-05

Ba	Si	P	Mn	Fe
7.96e-08	0.000260	3.88e-07	0.000575	0.00160
2.01e-07	0.000232	8.07e-07	1.57e-05	8.11e-08
2.22e-07	0.000177	1.04e-07	3.69e-05	1.16e-06
1.05e-07	0.000132	3.39e-07	1.98e-05	2.65e-06
9.80e-08	0.000216	2.90e-07	8.06e-05	5.48e-08
7.96e-08	0.000260	3.88e-07	0.000575	0.00160
2.01e-07	0.000232	8.07e-07	1.57e-05	8.11e-08
2.22e-07	0.000177	1.04e-07	3.69e-05	1.16e-06
1.05e-07	0.000132	3.39e-07	1.98e-05	2.65e-06
9.80e-08	0.000216	2.90e-07	8.06e-05	5.48e-08
2.34e-07	9.49e-05	1.54e-06	6.04e-06	4.70e-05
2.94e-07	9.24e-05	1.54e-06	2.72e-06	3.03e-05
2.90e-07	0.000108	8.84e-07	2.56e-06	9.27e-09
3.00e-07	0.000104	8.92e-07	2.07e-06	9.71e-09
2.97e-07	8.58e-05	1.98e-07	2.59e-06	4.92e-08
3.06e-07	8.49e-05	2.10e-07	2.00e-06	3.48e-08
2.85e-07	9.66e-05	6.21e-07	2.43e-06	2.50e-07
3.03e-07	9.79e-05	6.49e-07	2.00e-06	1.75e-07
2.91e-07	8.90e-05	7.07e-07	1.56e-05	1.04e-08
2.97e-07	8.55e-05	7.19e-07	6.52e-06	1.03e-08
7.96e-08	0.000260	3.88e-07	0.000575	0.00160
2.01e-07	0.000232	8.07e-07	1.57e-05	8.11e-08
2.22e-07	0.000177	1.04e-07	3.69e-05	1.16e-06
1.05e-07	0.000132	3.39e-07	1.98e-05	2.65e-06
9.80e-08	0.000216	2.90e-07	8.06e-05	5.48e-08
7.96e-08	0.000260	3.88e-07	0.000575	0.00160
2.01e-07	0.000232	8.07e-07	1.57e-05	8.11e-08
2.22e-07	0.000177	1.04e-07	3.69e-05	1.16e-06
1.05e-07	0.000132	3.39e-07	1.98e-05	2.65e-06
9.80e-08	0.000216	2.90e-07	8.06e-05	5.48e-08
2.16e-07	9.67e-05	1.54e-06	6.86e-06	5.23e-05
2.95e-07	8.90e-05	1.50e-06	2.93e-06	3.35e-05
2.88e-07	0.000111	8.85e-07	2.68e-06	9.30e-09
3.02e-07	0.000101	8.72e-07	2.10e-06	9.47e-09
2.95e-07	8.72e-05	1.95e-07	2.74e-06	5.40e-08
3.09e-07	8.04e-05	1.97e-07	2.02e-06	3.75e-08
2.80e-07	9.67e-05	6.12e-07	2.54e-06	2.72e-07
3.05e-07	9.37e-05	6.24e-07	2.02e-06	1.91e-07
2.89e-07	9.15e-05	7.08e-07	1.77e-05	1.07e-08
2.99e-07	8.15e-05	6.90e-07	7.68e-06	1.02e-08
7.96e-08	0.000260	3.88e-07	0.000575	0.00160
2.01e-07	0.000232	8.07e-07	1.57e-05	8.11e-08
2.22e-07	0.000177	1.04e-07	3.69e-05	1.16e-06

1.05e-07	0.000132	3.39e-07	1.98e-05	2.65e-06
9.80e-08	0.000216	2.90e-07	8.06e-05	5.48e-08
7.96e-08	0.000260	3.88e-07	0.000575	0.00160
2.01e-07	0.000232	8.07e-07	1.57e-05	8.11e-08
2.22e-07	0.000177	1.04e-07	3.69e-05	1.16e-06
1.05e-07	0.000132	3.39e-07	1.98e-05	2.65e-06
9.80e-08	0.000216	2.90e-07	8.06e-05	5.48e-08
2.20e-07	9.62e-05	1.54e-06	6.50e-06	5.04e-05
2.95e-07	8.93e-05	1.51e-06	2.82e-06	3.22e-05
2.89e-07	0.000110	8.84e-07	2.63e-06	9.36e-09
3.01e-07	0.000101	8.74e-07	2.09e-06	9.61e-09
2.96e-07	8.67e-05	1.95e-07	2.68e-06	5.23e-08
3.08e-07	8.09e-05	1.99e-07	2.01e-06	3.64e-08
2.82e-07	9.64e-05	6.13e-07	2.50e-06	2.63e-07
3.04e-07	9.42e-05	6.28e-07	2.01e-06	1.84e-07
2.90e-07	9.08e-05	7.06e-07	1.68e-05	1.07e-08
2.99e-07	8.19e-05	6.93e-07	7.14e-06	1.03e-08
7.96e-08	0.000260	3.88e-07	0.000575	0.00160
2.01e-07	0.000232	8.07e-07	1.57e-05	8.11e-08
2.22e-07	0.000177	1.04e-07	3.69e-05	1.16e-06
1.05e-07	0.000132	3.39e-07	1.98e-05	2.65e-06
9.80e-08	0.000216	2.90e-07	8.06e-05	5.48e-08
7.96e-08	0.000260	3.88e-07	0.000575	0.00160
2.01e-07	0.000232	8.07e-07	1.57e-05	8.11e-08
2.22e-07	0.000177	1.04e-07	3.69e-05	1.16e-06
1.05e-07	0.000132	3.39e-07	1.98e-05	2.65e-06
9.80e-08	0.000216	2.90e-07	8.06e-05	5.48e-08
2.34e-07	9.48e-05	1.54e-06	6.08e-06	4.74e-05
2.94e-07	9.23e-05	1.54e-06	2.73e-06	3.06e-05
2.91e-07	0.000108	8.87e-07	2.61e-06	9.29e-09
3.00e-07	0.000103	8.96e-07	2.09e-06	9.73e-09
2.98e-07	8.57e-05	1.99e-07	2.62e-06	5.00e-08
3.06e-07	8.48e-05	2.10e-07	2.01e-06	3.53e-08
2.86e-07	9.64e-05	6.23e-07	2.46e-06	2.55e-07
3.03e-07	9.78e-05	6.52e-07	2.01e-06	1.79e-07
2.92e-07	8.88e-05	7.12e-07	1.60e-05	1.04e-08
2.97e-07	8.54e-05	7.24e-07	6.69e-06	1.03e-08
7.96e-08	0.000260	3.88e-07	0.000575	0.00160
2.01e-07	0.000232	8.07e-07	1.57e-05	8.11e-08
2.22e-07	0.000177	1.04e-07	3.69e-05	1.16e-06
1.05e-07	0.000132	3.39e-07	1.98e-05	2.65e-06
9.80e-08	0.000216	2.90e-07	8.06e-05	5.48e-08
7.96e-08	0.000260	3.88e-07	0.000575	0.00160
2.01e-07	0.000232	8.07e-07	1.57e-05	8.11e-08
2.22e-07	0.000177	1.04e-07	3.69e-05	1.16e-06
1.05e-07	0.000132	3.39e-07	1.98e-05	2.65e-06
9.80e-08	0.000216	2.90e-07	8.06e-05	5.48e-08
2.16e-07	9.66e-05	1.54e-06	6.91e-06	5.29e-05
2.95e-07	8.89e-05	1.50e-06	2.93e-06	3.38e-05
2.90e-07	0.000110	8.88e-07	2.74e-06	9.32e-09

3.02e-07	0.000101	8.76e-07	2.12e-06	9.49e-09
2.96e-07	8.70e-05	1.96e-07	2.78e-06	5.49e-08
3.09e-07	8.03e-05	1.98e-07	2.03e-06	3.81e-08
2.81e-07	9.65e-05	6.14e-07	2.57e-06	2.78e-07
3.05e-07	9.36e-05	6.27e-07	2.03e-06	1.95e-07
2.90e-07	9.13e-05	7.12e-07	1.83e-05	1.07e-08
2.99e-07	8.14e-05	6.94e-07	7.90e-06	1.02e-08
7.96e-08	0.000260	3.88e-07	0.000575	0.00160
2.01e-07	0.000232	8.07e-07	1.57e-05	8.11e-08
2.22e-07	0.000177	1.04e-07	3.69e-05	1.16e-06
1.05e-07	0.000132	3.39e-07	1.98e-05	2.65e-06
9.80e-08	0.000216	2.90e-07	8.06e-05	5.48e-08
7.96e-08	0.000260	3.88e-07	0.000575	0.00160
2.01e-07	0.000232	8.07e-07	1.57e-05	8.11e-08
2.22e-07	0.000177	1.04e-07	3.69e-05	1.16e-06
1.05e-07	0.000132	3.39e-07	1.98e-05	2.65e-06
9.80e-08	0.000216	2.90e-07	8.06e-05	5.48e-08
2.20e-07	9.61e-05	1.54e-06	6.55e-06	5.09e-05
2.95e-07	8.93e-05	1.51e-06	2.83e-06	3.24e-05
2.90e-07	0.000110	8.87e-07	2.68e-06	9.38e-09
3.01e-07	0.000101	8.78e-07	2.10e-06	9.63e-09
2.96e-07	8.66e-05	1.96e-07	2.71e-06	5.31e-08
3.08e-07	8.08e-05	1.99e-07	2.02e-06	3.70e-08
2.82e-07	9.63e-05	6.15e-07	2.53e-06	2.69e-07
3.04e-07	9.40e-05	6.30e-07	2.02e-06	1.88e-07
2.91e-07	9.06e-05	7.11e-07	1.74e-05	1.07e-08
2.99e-07	8.18e-05	6.98e-07	7.33e-06	1.03e-08

Al	Sb	Be	Cd	Cr
1.25e-07	2.12e-09	2.20e-08	2.99e-09	1.69e-08
2.83e-07	2.12e-09	2.19e-08	2.09e-09	6.55e-08
1.29e-07	5.41e-09	2.19e-08	2.54e-09	3.37e-08
1.94e-07	8.31e-09	2.20e-08	2.09e-09	1.69e-08
1.92e-07	2.12e-09	2.19e-08	2.09e-09	1.68e-08
1.25e-07	2.12e-09	2.20e-08	2.99e-09	1.69e-08
2.83e-07	2.12e-09	2.19e-08	2.09e-09	6.55e-08
1.29e-07	5.41e-09	2.19e-08	2.54e-09	3.37e-08
1.94e-07	8.31e-09	2.20e-08	2.09e-09	1.69e-08
1.92e-07	2.12e-09	2.19e-08	2.09e-09	1.68e-08
4.94e-08	2.53e-09	2.04e-09	1.34e-10	5.94e-10
5.31e-08	2.53e-09	1.87e-09	1.02e-10	5.50e-10
5.00e-08	2.53e-09	7.92e-09	5.13e-10	2.60e-08
5.31e-08	2.53e-09	7.23e-09	3.97e-10	2.31e-08
4.89e-08	2.53e-09	6.51e-09	3.02e-10	8.00e-09
5.24e-08	2.53e-09	5.84e-09	2.09e-10	7.14e-09
5.09e-08	2.53e-09	1.13e-08	3.95e-10	7.39e-09
5.31e-08	2.53e-09	1.06e-08	2.90e-10	6.83e-09
4.84e-08	2.53e-09	4.50e-09	1.11e-09	3.51e-09
5.25e-08	2.53e-09	4.00e-09	9.18e-10	3.17e-09
1.25e-07	2.12e-09	2.20e-08	2.99e-09	1.69e-08
2.83e-07	2.12e-09	2.19e-08	2.09e-09	6.55e-08
1.29e-07	5.41e-09	2.19e-08	2.54e-09	3.37e-08
1.94e-07	8.31e-09	2.20e-08	2.09e-09	1.69e-08
1.92e-07	2.12e-09	2.19e-08	2.09e-09	1.68e-08
1.25e-07	2.12e-09	2.20e-08	2.99e-09	1.69e-08
2.83e-07	2.12e-09	2.19e-08	2.09e-09	6.55e-08
1.29e-07	5.41e-09	2.19e-08	2.54e-09	3.37e-08
1.94e-07	8.31e-09	2.20e-08	2.09e-09	1.69e-08
1.92e-07	2.12e-09	2.19e-08	2.09e-09	1.68e-08
4.80e-08	2.53e-09	2.13e-09	1.43e-10	6.17e-10
5.22e-08	2.53e-09	1.90e-09	1.07e-10	5.53e-10
4.87e-08	2.53e-09	8.27e-09	5.48e-10	2.71e-08
5.23e-08	2.53e-09	7.36e-09	4.25e-10	2.38e-08
4.75e-08	2.53e-09	6.85e-09	3.33e-10	8.42e-09
5.15e-08	2.53e-09	5.98e-09	2.27e-10	7.30e-09
5.00e-08	2.53e-09	1.17e-08	4.26e-10	7.64e-09
5.26e-08	2.53e-09	1.07e-08	3.12e-10	6.93e-09
4.68e-08	2.53e-09	4.76e-09	1.17e-09	3.67e-09
5.15e-08	2.53e-09	4.10e-09	9.66e-10	3.22e-09
1.25e-07	2.12e-09	2.20e-08	2.99e-09	1.69e-08
2.83e-07	2.12e-09	2.19e-08	2.09e-09	6.55e-08
1.29e-07	5.41e-09	2.19e-08	2.54e-09	3.37e-08

1.94e-07	8.31e-09	2.20e-08	2.09e-09	1.69e-08
1.92e-07	2.12e-09	2.19e-08	2.09e-09	1.68e-08
1.25e-07	2.12e-09	2.20e-08	2.99e-09	1.69e-08
2.83e-07	2.12e-09	2.19e-08	2.09e-09	6.55e-08
1.29e-07	5.41e-09	2.19e-08	2.54e-09	3.37e-08
1.94e-07	8.31e-09	2.20e-08	2.09e-09	1.69e-08
1.92e-07	2.12e-09	2.19e-08	2.09e-09	1.68e-08
4.82e-08	2.53e-09	2.11e-09	1.40e-10	6.12e-10
5.24e-08	2.53e-09	1.89e-09	1.04e-10	5.52e-10
4.89e-08	2.53e-09	8.21e-09	5.36e-10	2.68e-08
5.25e-08	2.53e-09	7.33e-09	4.13e-10	2.35e-08
4.77e-08	2.53e-09	6.79e-09	3.22e-10	8.33e-09
5.17e-08	2.53e-09	5.95e-09	2.20e-10	7.25e-09
5.01e-08	2.53e-09	1.16e-08	4.14e-10	7.58e-09
5.27e-08	2.53e-09	1.07e-08	3.03e-10	6.90e-09
4.71e-08	2.53e-09	4.71e-09	1.15e-09	3.63e-09
5.17e-08	2.53e-09	4.08e-09	9.48e-10	3.20e-09
1.25e-07	2.12e-09	2.20e-08	2.99e-09	1.69e-08
2.83e-07	2.12e-09	2.19e-08	2.09e-09	6.55e-08
1.29e-07	5.41e-09	2.19e-08	2.54e-09	3.37e-08
1.94e-07	8.31e-09	2.20e-08	2.09e-09	1.69e-08
1.92e-07	2.12e-09	2.19e-08	2.09e-09	1.68e-08
1.25e-07	2.12e-09	2.20e-08	2.99e-09	1.69e-08
2.83e-07	2.12e-09	2.19e-08	2.09e-09	6.55e-08
1.29e-07	5.41e-09	2.19e-08	2.54e-09	3.37e-08
1.94e-07	8.31e-09	2.20e-08	2.09e-09	1.69e-08
1.92e-07	2.12e-09	2.19e-08	2.09e-09	1.68e-08
4.95e-08	2.53e-09	2.04e-09	1.41e-10	5.99e-10
5.31e-08	2.53e-09	1.87e-09	1.07e-10	5.54e-10
5.00e-08	2.53e-09	7.90e-09	6.64e-10	2.64e-08
5.31e-08	2.53e-09	7.22e-09	5.12e-10	2.35e-08
4.89e-08	2.53e-09	6.50e-09	3.40e-10	8.05e-09
5.24e-08	2.53e-09	5.83e-09	2.34e-10	7.19e-09
5.09e-08	2.53e-09	1.13e-08	4.53e-10	7.44e-09
5.31e-08	2.53e-09	1.06e-08	3.32e-10	6.87e-09
4.84e-08	2.53e-09	4.49e-09	1.34e-09	3.56e-09
5.25e-08	2.53e-09	3.99e-09	1.10e-09	3.22e-09
1.25e-07	2.12e-09	2.20e-08	2.99e-09	1.69e-08
2.83e-07	2.12e-09	2.19e-08	2.09e-09	6.55e-08
1.29e-07	5.41e-09	2.19e-08	2.54e-09	3.37e-08
1.94e-07	8.31e-09	2.20e-08	2.09e-09	1.69e-08
1.92e-07	2.12e-09	2.19e-08	2.09e-09	1.68e-08
1.25e-07	2.12e-09	2.20e-08	2.99e-09	1.69e-08
2.83e-07	2.12e-09	2.19e-08	2.09e-09	6.55e-08
1.29e-07	5.41e-09	2.19e-08	2.54e-09	3.37e-08
1.94e-07	8.31e-09	2.20e-08	2.09e-09	1.69e-08
1.92e-07	2.12e-09	2.19e-08	2.09e-09	1.68e-08
4.80e-08	2.53e-09	2.13e-09	1.52e-10	6.22e-10
5.22e-08	2.53e-09	1.90e-09	1.12e-10	5.58e-10
4.87e-08	2.53e-09	8.25e-09	7.10e-10	2.75e-08

5.24e-08	2.53e-09	7.35e-09	5.48e-10	2.41e-08
4.75e-08	2.53e-09	6.85e-09	3.75e-10	8.47e-09
5.15e-08	2.53e-09	5.97e-09	2.54e-10	7.35e-09
5.00e-08	2.53e-09	1.17e-08	4.89e-10	7.68e-09
5.26e-08	2.53e-09	1.07e-08	3.58e-10	6.98e-09
4.69e-08	2.53e-09	4.75e-09	1.41e-09	3.72e-09
5.15e-08	2.53e-09	4.09e-09	1.16e-09	3.27e-09
1.25e-07	2.12e-09	2.20e-08	2.99e-09	1.69e-08
2.83e-07	2.12e-09	2.19e-08	2.09e-09	6.55e-08
1.29e-07	5.41e-09	2.19e-08	2.54e-09	3.37e-08
1.94e-07	8.31e-09	2.20e-08	2.09e-09	1.69e-08
1.92e-07	2.12e-09	2.19e-08	2.09e-09	1.68e-08
1.25e-07	2.12e-09	2.20e-08	2.99e-09	1.69e-08
2.83e-07	2.12e-09	2.19e-08	2.09e-09	6.55e-08
1.29e-07	5.41e-09	2.19e-08	2.54e-09	3.37e-08
1.94e-07	8.31e-09	2.20e-08	2.09e-09	1.69e-08
1.92e-07	2.12e-09	2.19e-08	2.09e-09	1.68e-08
4.82e-08	2.53e-09	2.11e-09	1.48e-10	6.17e-10
5.24e-08	2.53e-09	1.89e-09	1.10e-10	5.56e-10
4.89e-08	2.53e-09	8.18e-09	6.94e-10	2.72e-08
5.25e-08	2.53e-09	7.32e-09	5.34e-10	2.39e-08
4.77e-08	2.53e-09	6.78e-09	3.62e-10	8.38e-09
5.17e-08	2.53e-09	5.94e-09	2.46e-10	7.30e-09
5.01e-08	2.53e-09	1.16e-08	4.76e-10	7.63e-09
5.27e-08	2.53e-09	1.07e-08	3.47e-10	6.95e-09
4.71e-08	2.53e-09	4.70e-09	1.39e-09	3.68e-09
5.17e-08	2.53e-09	4.07e-09	1.14e-09	3.25e-09

Co	Pb	Mo	Se	Hfo_s
2.26e-06	9.92e-10	3.50e-09	4.26e-09	0
5.01e-08	1.09e-08	2.45e-08	4.25e-09	0
3.01e-08	1.72e-09	7.67e-09	4.25e-09	0
1.67e-08	2.25e-09	1.04e-08	9.51e-09	0
1.12e-08	9.90e-10	3.50e-09	4.25e-09	0
2.26e-06	9.92e-10	3.50e-09	4.26e-09	4.90e-05
5.01e-08	1.09e-08	2.45e-08	4.25e-09	4.90e-05
3.01e-08	1.72e-09	7.67e-09	4.25e-09	4.90e-05
1.67e-08	2.25e-09	1.04e-08	9.51e-09	4.90e-05
1.12e-08	9.90e-10	3.50e-09	4.25e-09	4.90e-05
8.37e-08	1.37e-10	9.23e-09	3.58e-08	4.90e-05
5.64e-08	1.01e-10	7.42e-09	4.27e-09	4.90e-05
1.16e-08	4.90e-09	8.87e-09	3.06e-09	4.90e-05
8.69e-09	3.77e-09	7.42e-09	3.12e-09	4.90e-05
3.39e-09	5.30e-10	8.27e-09	3.92e-09	4.90e-05
2.23e-09	3.59e-10	7.42e-09	3.91e-09	4.90e-05
2.86e-09	1.04e-09	8.54e-09	9.98e-09	4.90e-05
2.04e-09	7.57e-10	7.45e-09	9.53e-09	4.90e-05
5.71e-09	1.45e-09	7.66e-09	4.16e-09	4.90e-05
4.64e-09	1.21e-09	7.35e-09	4.00e-09	4.90e-05
2.26e-06	9.92e-10	3.50e-09	4.26e-09	0
5.01e-08	1.09e-08	2.45e-08	4.25e-09	0
3.01e-08	1.72e-09	7.67e-09	4.25e-09	0
1.67e-08	2.25e-09	1.04e-08	9.51e-09	0
1.12e-08	9.90e-10	3.50e-09	4.25e-09	0
2.26e-06	9.92e-10	3.50e-09	4.26e-09	7.50e-05
5.01e-08	1.09e-08	2.45e-08	4.25e-09	7.50e-05
3.01e-08	1.72e-09	7.67e-09	4.25e-09	7.50e-05
1.67e-08	2.25e-09	1.04e-08	9.51e-09	7.50e-05
1.12e-08	9.90e-10	3.50e-09	4.25e-09	7.50e-05
9.26e-08	1.42e-10	1.02e-08	5.25e-08	7.50e-05
6.17e-08	1.05e-10	7.54e-09	4.31e-09	7.50e-05
1.25e-08	5.21e-09	9.61e-09	3.06e-09	7.50e-05
9.39e-09	4.05e-09	7.53e-09	2.95e-09	7.50e-05
3.78e-09	5.81e-10	8.71e-09	3.97e-09	7.50e-05
2.47e-09	3.94e-10	7.49e-09	3.72e-09	7.50e-05
3.11e-09	1.12e-09	9.09e-09	1.02e-08	7.50e-05
2.22e-09	8.21e-10	7.56e-09	9.57e-09	7.50e-05
6.07e-09	1.51e-09	7.83e-09	4.27e-09	7.50e-05
4.92e-09	1.27e-09	7.35e-09	3.85e-09	7.50e-05
2.26e-06	9.92e-10	3.50e-09	4.26e-09	0
5.01e-08	1.09e-08	2.45e-08	4.25e-09	0
3.01e-08	1.72e-09	7.67e-09	4.25e-09	0

1.67e-08	2.25e-09	1.04e-08	9.51e-09	0
1.12e-08	9.90e-10	3.50e-09	4.25e-09	0
2.26e-06	9.92e-10	3.50e-09	4.26e-09	7.00e-05
5.01e-08	1.09e-08	2.45e-08	4.25e-09	7.00e-05
3.01e-08	1.72e-09	7.67e-09	4.25e-09	7.00e-05
1.67e-08	2.25e-09	1.04e-08	9.51e-09	7.00e-05
1.12e-08	9.90e-10	3.50e-09	4.25e-09	7.00e-05
8.94e-08	1.38e-10	9.99e-09	4.93e-08	7.00e-05
5.95e-08	1.02e-10	7.51e-09	4.31e-09	7.00e-05
1.21e-08	5.09e-09	9.47e-09	3.05e-09	7.00e-05
9.11e-09	3.93e-09	7.51e-09	2.97e-09	7.00e-05
3.64e-09	5.61e-10	8.62e-09	3.95e-09	7.00e-05
2.37e-09	3.79e-10	7.48e-09	3.74e-09	7.00e-05
3.02e-09	1.09e-09	8.99e-09	1.01e-08	7.00e-05
2.15e-09	7.95e-10	7.54e-09	9.56e-09	7.00e-05
5.96e-09	1.49e-09	7.79e-09	4.24e-09	7.00e-05
4.82e-09	1.24e-09	7.35e-09	3.86e-09	7.00e-05
2.26e-06	9.92e-10	3.50e-09	4.26e-09	0
5.01e-08	1.09e-08	2.45e-08	4.25e-09	0
3.01e-08	1.72e-09	7.67e-09	4.25e-09	0
1.67e-08	2.25e-09	1.04e-08	9.51e-09	0
1.12e-08	9.90e-10	3.50e-09	4.25e-09	0
2.26e-06	9.92e-10	3.50e-09	4.26e-09	4.90e-05
5.01e-08	1.09e-08	2.45e-08	4.25e-09	4.90e-05
3.01e-08	1.72e-09	7.67e-09	4.25e-09	4.90e-05
1.67e-08	2.25e-09	1.04e-08	9.51e-09	4.90e-05
1.12e-08	9.90e-10	3.50e-09	4.25e-09	4.90e-05
8.47e-08	1.39e-10	9.25e-09	3.59e-08	4.90e-05
5.71e-08	1.03e-10	7.42e-09	4.27e-09	4.90e-05
1.21e-08	5.07e-09	8.93e-09	3.10e-09	4.90e-05
9.13e-09	3.91e-09	7.42e-09	3.16e-09	4.90e-05
3.50e-09	5.46e-10	8.30e-09	3.95e-09	4.90e-05
2.30e-09	3.70e-10	7.43e-09	3.93e-09	4.90e-05
2.96e-09	1.07e-09	8.57e-09	1.01e-08	4.90e-05
2.11e-09	7.80e-10	7.45e-09	9.62e-09	4.90e-05
5.91e-09	1.51e-09	7.69e-09	4.21e-09	4.90e-05
4.81e-09	1.26e-09	7.35e-09	4.04e-09	4.90e-05
2.26e-06	9.92e-10	3.50e-09	4.26e-09	0
5.01e-08	1.09e-08	2.45e-08	4.25e-09	0
3.01e-08	1.72e-09	7.67e-09	4.25e-09	0
1.67e-08	2.25e-09	1.04e-08	9.51e-09	0
1.12e-08	9.90e-10	3.50e-09	4.25e-09	0
2.26e-06	9.92e-10	3.50e-09	4.26e-09	7.50e-05
5.01e-08	1.09e-08	2.45e-08	4.25e-09	7.50e-05
3.01e-08	1.72e-09	7.67e-09	4.25e-09	7.50e-05
1.67e-08	2.25e-09	1.04e-08	9.51e-09	7.50e-05
1.12e-08	9.90e-10	3.50e-09	4.25e-09	7.50e-05
9.37e-08	1.44e-10	1.02e-08	5.27e-08	7.50e-05
6.24e-08	1.07e-10	7.54e-09	4.31e-09	7.50e-05
1.31e-08	5.39e-09	9.71e-09	3.10e-09	7.50e-05

9.86e-09	4.19e-09	7.54e-09	2.99e-09	7.50e-05
3.90e-09	5.99e-10	8.74e-09	3.99e-09	7.50e-05
2.54e-09	4.06e-10	7.50e-09	3.75e-09	7.50e-05
3.22e-09	1.16e-09	9.14e-09	1.03e-08	7.50e-05
2.30e-09	8.46e-10	7.57e-09	9.66e-09	7.50e-05
6.28e-09	1.57e-09	7.86e-09	4.32e-09	7.50e-05
5.09e-09	1.31e-09	7.35e-09	3.89e-09	7.50e-05
2.26e-06	9.92e-10	3.50e-09	4.26e-09	0
5.01e-08	1.09e-08	2.45e-08	4.25e-09	0
3.01e-08	1.72e-09	7.67e-09	4.25e-09	0
1.67e-08	2.25e-09	1.04e-08	9.51e-09	0
1.12e-08	9.90e-10	3.50e-09	4.25e-09	0
2.26e-06	9.92e-10	3.50e-09	4.26e-09	7.00e-05
5.01e-08	1.09e-08	2.45e-08	4.25e-09	7.00e-05
3.01e-08	1.72e-09	7.67e-09	4.25e-09	7.00e-05
1.67e-08	2.25e-09	1.04e-08	9.51e-09	7.00e-05
1.12e-08	9.90e-10	3.50e-09	4.25e-09	7.00e-05
9.05e-08	1.40e-10	1.00e-08	4.95e-08	7.00e-05
6.02e-08	1.03e-10	7.51e-09	4.31e-09	7.00e-05
1.28e-08	5.27e-09	9.56e-09	3.09e-09	7.00e-05
9.57e-09	4.07e-09	7.51e-09	3.01e-09	7.00e-05
3.76e-09	5.78e-10	8.66e-09	3.98e-09	7.00e-05
2.45e-09	3.90e-10	7.48e-09	3.77e-09	7.00e-05
3.12e-09	1.12e-09	9.03e-09	1.02e-08	7.00e-05
2.22e-09	8.18e-10	7.54e-09	9.65e-09	7.00e-05
6.17e-09	1.54e-09	7.83e-09	4.29e-09	7.00e-05
4.99e-09	1.29e-09	7.35e-09	3.90e-09	7.00e-05

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
0.00196	0.00323	0.000103	0.000384	7.02e-05
0.00196	0.00323	9.11e-05	9.21e-05	5.62e-06
0.00196	0.00323	0.000109	0.000119	1.66e-05
0.00196	0.00323	0.000138	0.000107	2.25e-05
0.00196	0.00323	9.63e-05	0.000135	1.27e-05
0.00196	0.00323	0.000199	0.000159	8.54e-07
0.00196	0.00323	0.000210	0.000157	6.49e-07
0.00196	0.00323	0.000164	0.000102	9.06e-07
0.00196	0.00323	0.000173	0.000102	8.47e-07
0.00196	0.00323	0.000185	0.000108	1.18e-06
0.00196	0.00323	0.000195	0.000109	1.08e-06
0.00196	0.00323	0.000162	8.27e-05	1.26e-06
0.00196	0.00323	0.000166	8.29e-05	1.10e-06
0.00196	0.00323	0.000188	0.000127	9.69e-07
0.00196	0.00323	0.000203	0.000127	9.15e-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
0.00300	0.00396	0.000158	0.000588	0.000108
0.00300	0.00396	0.000139	0.000141	8.61e-06
0.00300	0.00396	0.000166	0.000181	2.54e-05
0.00300	0.00396	0.000211	0.000164	3.45e-05
0.00300	0.00396	0.000147	0.000207	1.95e-05
0.00300	0.00396	0.000297	0.000245	1.44e-06
0.00300	0.00396	0.000323	0.000241	1.04e-06
0.00300	0.00396	0.000244	0.000155	1.41e-06
0.00300	0.00396	0.000266	0.000156	1.34e-06
0.00300	0.00396	0.000274	0.000165	1.86e-06
0.00300	0.00396	0.000300	0.000167	1.75e-06
0.00300	0.00396	0.000245	0.000126	2.02e-06
0.00300	0.00396	0.000257	0.000127	1.78e-06
0.00300	0.00396	0.000278	0.000193	1.50e-06
0.00300	0.00396	0.000311	0.000194	1.48e-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
0.00280	0.00363	0.000147	0.000548	0.000100
0.00280	0.00363	0.000130	0.000132	8.04e-06
0.00280	0.00363	0.000155	0.000169	2.37e-05
0.00280	0.00363	0.000197	0.000153	3.22e-05
0.00280	0.00363	0.000138	0.000193	1.82e-05
0.00280	0.00363	0.000279	0.000229	1.32e-06
0.00280	0.00363	0.000301	0.000225	9.65e-07
0.00280	0.00363	0.000229	0.000145	1.31e-06
0.00280	0.00363	0.000248	0.000146	1.25e-06
0.00280	0.00363	0.000258	0.000154	1.73e-06
0.00280	0.00363	0.000281	0.000156	1.63e-06
0.00280	0.00363	0.000229	0.000118	1.87e-06
0.00280	0.00363	0.000239	0.000119	1.65e-06
0.00280	0.00363	0.000261	0.000181	1.40e-06
0.00280	0.00363	0.000291	0.000181	1.38e-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
0.00196	0.00323	0.000103	0.000384	7.05e-05
0.00196	0.00323	9.08e-05	9.16e-05	5.72e-06
0.00196	0.00323	0.000108	0.000118	1.68e-05
0.00196	0.00323	0.000138	0.000107	2.28e-05
0.00196	0.00323	9.61e-05	0.000134	1.30e-05
0.00196	0.00323	0.000199	0.000159	8.55e-07
0.00196	0.00323	0.000210	0.000157	6.50e-07
0.00196	0.00323	0.000164	0.000102	9.01e-07
0.00196	0.00323	0.000173	0.000102	8.45e-07
0.00196	0.00323	0.000185	0.000108	1.18e-06
0.00196	0.00323	0.000195	0.000109	1.08e-06
0.00196	0.00323	0.000162	8.28e-05	1.26e-06
0.00196	0.00323	0.000166	8.30e-05	1.10e-06
0.00196	0.00323	0.000189	0.000127	9.66e-07
0.00196	0.00323	0.000203	0.000127	9.15e-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
0.00300	0.00396	0.000158	0.000587	0.000108
0.00300	0.00396	0.000139	0.000140	8.76e-06
0.00300	0.00396	0.000166	0.000181	2.57e-05
0.00300	0.00396	0.000211	0.000163	3.48e-05
0.00300	0.00396	0.000147	0.000206	1.98e-05
0.00300	0.00396	0.000297	0.000245	1.44e-06
0.00300	0.00396	0.000323	0.000241	1.04e-06
0.00300	0.00396	0.000245	0.000155	1.40e-06

0.00300	0.00396	0.000266	0.000156	1.34e-06
0.00300	0.00396	0.000274	0.000165	1.86e-06
0.00300	0.00396	0.000301	0.000167	1.75e-06
0.00300	0.00396	0.000245	0.000126	2.01e-06
0.00300	0.00396	0.000257	0.000127	1.78e-06
0.00300	0.00396	0.000278	0.000194	1.50e-06
0.00300	0.00396	0.000312	0.000194	1.48e-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
0.00280	0.00363	0.000147	0.000548	0.000101
0.00280	0.00363	0.000130	0.000131	8.17e-06
0.00280	0.00363	0.000155	0.000169	2.40e-05
0.00280	0.00363	0.000197	0.000153	3.25e-05
0.00280	0.00363	0.000137	0.000192	1.85e-05
0.00280	0.00363	0.000279	0.000229	1.32e-06
0.00280	0.00363	0.000301	0.000225	9.66e-07
0.00280	0.00363	0.000230	0.000145	1.30e-06
0.00280	0.00363	0.000248	0.000146	1.25e-06
0.00280	0.00363	0.000258	0.000154	1.73e-06
0.00280	0.00363	0.000281	0.000156	1.63e-06
0.00280	0.00363	0.000230	0.000118	1.86e-06
0.00280	0.00363	0.000239	0.000119	1.65e-06
0.00280	0.00363	0.000262	0.000181	1.40e-06
0.00280	0.00363	0.000291	0.000181	1.38e-06

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
0.000131	0.000519	8.58e-05	0.000465	2.12e-05
2.85e-06	0.000406	0.000248	0.000606	0.000102
9.09e-06	0.000368	0.000208	0.000712	0.000111
8.77e-06	0.000349	0.000278	0.000486	0.000106
8.95e-06	0.000398	0.000175	0.000780	9.44e-05
3.43e-07	0.000361	0.000278	0.000529	0.000112
2.43e-07	0.000370	0.000306	0.000468	0.000107
2.81e-07	0.000338	0.000337	0.000428	0.000117
2.49e-07	0.000342	0.000360	0.000385	0.000111
3.48e-07	0.000302	0.000318	0.000511	0.000148
3.01e-07	0.000316	0.000349	0.000448	0.000136
3.23e-07	0.000299	0.000361	0.000403	0.000134
2.77e-07	0.000310	0.000382	0.000368	0.000125
3.27e-07	0.000320	0.000293	0.000536	0.000135
2.86e-07	0.000331	0.000327	0.000463	0.000126
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0.000201	0.000794	0.000131	0.000711	3.24e-05
4.37e-06	0.000622	0.000379	0.000927	0.000156
1.39e-05	0.000563	0.000318	0.00109	0.000170
1.34e-05	0.000535	0.000425	0.000744	0.000163
1.37e-05	0.000609	0.000267	0.00119	0.000144
5.95e-07	0.000548	0.000410	0.000847	0.000174
3.90e-07	0.000548	0.000451	0.000750	0.000170
4.47e-07	0.000517	0.000502	0.000683	0.000183
3.96e-07	0.000511	0.000537	0.000612	0.000177
5.62e-07	0.000456	0.000468	0.000821	0.000232
4.87e-07	0.000461	0.000513	0.000722	0.000221
5.22e-07	0.000452	0.000541	0.000638	0.000211
4.42e-07	0.000458	0.000570	0.000584	0.000200
5.25e-07	0.000485	0.000430	0.000865	0.000211
4.64e-07	0.000484	0.000479	0.000747	0.000204
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0

0	0	0	0	0
0	0	0	0	0
0.000187	0.000741	0.000123	0.000664	3.03e-05
4.08e-06	0.000580	0.000354	0.000865	0.000145
1.30e-05	0.000526	0.000297	0.00102	0.000158
1.25e-05	0.000499	0.000397	0.000694	0.000152
1.28e-05	0.000568	0.000250	0.00111	0.000135
5.42e-07	0.000512	0.000385	0.000784	0.000162
3.62e-07	0.000514	0.000424	0.000694	0.000158
4.14e-07	0.000482	0.000471	0.000633	0.000170
3.68e-07	0.000479	0.000503	0.000567	0.000164
5.20e-07	0.000426	0.000440	0.000760	0.000216
4.52e-07	0.000433	0.000482	0.000668	0.000205
4.82e-07	0.000422	0.000507	0.000592	0.000196
4.11e-07	0.000430	0.000535	0.000542	0.000186
4.86e-07	0.000453	0.000404	0.000800	0.000196
4.30e-07	0.000455	0.000450	0.000691	0.000188
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0.000132	0.000518	8.58e-05	0.000465	2.12e-05
2.89e-06	0.000404	0.000247	0.000607	0.000102
9.17e-06	0.000367	0.000208	0.000713	0.000111
8.84e-06	0.000349	0.000278	0.000486	0.000107
9.08e-06	0.000397	0.000175	0.000781	9.49e-05
3.42e-07	0.000361	0.000278	0.000529	0.000112
2.43e-07	0.000370	0.000306	0.000468	0.000107
2.80e-07	0.000338	0.000336	0.000428	0.000117
2.49e-07	0.000342	0.000359	0.000385	0.000111
3.48e-07	0.000302	0.000317	0.000511	0.000148
3.01e-07	0.000316	0.000349	0.000448	0.000136
3.22e-07	0.000299	0.000361	0.000403	0.000134
2.77e-07	0.000310	0.000382	0.000368	0.000125
3.26e-07	0.000320	0.000293	0.000535	0.000135
2.86e-07	0.000330	0.000327	0.000463	0.000126
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0.000202	0.000793	0.000131	0.000711	3.25e-05
4.43e-06	0.000619	0.000379	0.000929	0.000156
1.40e-05	0.000562	0.000318	0.00109	0.000170
1.35e-05	0.000534	0.000425	0.000744	0.000163
1.39e-05	0.000607	0.000268	0.00120	0.000145
5.95e-07	0.000548	0.000410	0.000847	0.000174
3.90e-07	0.000547	0.000451	0.000750	0.000170
4.45e-07	0.000516	0.000501	0.000683	0.000183

3.96e-07	0.000511	0.000535	0.000612	0.000177
5.60e-07	0.000456	0.000468	0.000821	0.000232
4.87e-07	0.000461	0.000512	0.000723	0.000221
5.20e-07	0.000451	0.000540	0.000638	0.000210
4.42e-07	0.000458	0.000570	0.000584	0.000200
5.23e-07	0.000485	0.000429	0.000865	0.000211
4.64e-07	0.000484	0.000478	0.000748	0.000204
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0.000188	0.000740	0.000123	0.000664	3.03e-05
4.13e-06	0.000578	0.000353	0.000867	0.000146
1.31e-05	0.000525	0.000297	0.00102	0.000159
1.26e-05	0.000498	0.000396	0.000695	0.000152
1.30e-05	0.000567	0.000250	0.00112	0.000136
5.42e-07	0.000512	0.000385	0.000784	0.000163
3.62e-07	0.000513	0.000424	0.000695	0.000158
4.12e-07	0.000481	0.000470	0.000633	0.000170
3.68e-07	0.000478	0.000502	0.000567	0.000164
5.18e-07	0.000426	0.000439	0.000760	0.000216
4.52e-07	0.000433	0.000481	0.000668	0.000205
4.80e-07	0.000422	0.000506	0.000592	0.000196
4.11e-07	0.000430	0.000534	0.000542	0.000186
4.84e-07	0.000452	0.000404	0.000800	0.000196
4.30e-07	0.000454	0.000450	0.000691	0.000188

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
4.87e-06	4.35e-05	6.61e-06	1.90e-08	4.17e-07
1.04e-05	2.52e-05	1.04e-06	6.01e-09	3.58e-08
2.75e-06	7.19e-06	3.20e-07	1.64e-08	1.05e-07
1.08e-05	2.02e-05	6.38e-07	1.64e-08	7.50e-08
7.10e-06	2.39e-05	1.37e-06	2.83e-08	2.34e-07
1.80e-05	3.46e-05	1.13e-06	6.41e-08	3.02e-07
1.85e-05	3.30e-05	1.00e-06	5.91e-08	2.59e-07
1.43e-05	2.12e-05	5.34e-07	5.60e-09	2.04e-08
1.45e-05	2.04e-05	4.88e-07	5.38e-09	1.86e-08
4.23e-06	5.95e-06	1.42e-07	1.97e-08	6.81e-08
4.38e-06	5.87e-06	1.33e-07	1.80e-08	5.92e-08
1.39e-05	1.70e-05	3.54e-07	2.00e-08	6.02e-08
1.39e-05	1.67e-05	3.39e-07	1.87e-08	5.51e-08
1.20e-05	1.94e-05	5.32e-07	2.94e-08	1.17e-07
1.24e-05	1.86e-05	4.72e-07	2.65e-08	9.75e-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
7.46e-06	6.66e-05	1.01e-05	2.91e-08	6.38e-07
1.59e-05	3.86e-05	1.59e-06	9.19e-09	5.47e-08
4.20e-06	1.10e-05	4.90e-07	2.51e-08	1.61e-07
1.66e-05	3.09e-05	9.76e-07	2.51e-08	1.15e-07
1.09e-05	3.66e-05	2.09e-06	4.33e-08	3.58e-07
2.72e-05	5.39e-05	1.81e-06	1.01e-07	4.91e-07
2.87e-05	5.15e-05	1.57e-06	9.56e-08	4.21e-07
2.16e-05	3.29e-05	8.51e-07	8.80e-09	3.29e-08
2.24e-05	3.16e-05	7.57e-07	8.50e-09	2.94e-08
6.37e-06	9.18e-06	2.25e-07	3.11e-08	1.10e-07
6.71e-06	8.93e-06	2.02e-07	2.94e-08	9.58e-08
2.13e-05	2.63e-05	5.51e-07	3.15e-08	9.54e-08
2.16e-05	2.56e-05	5.18e-07	3.00e-08	8.76e-08
1.81e-05	3.02e-05	8.57e-07	4.68e-08	1.92e-07
1.92e-05	2.88e-05	7.31e-07	4.33e-08	1.59e-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
6.96e-06	6.22e-05	9.44e-06	2.71e-08	5.95e-07
1.48e-05	3.60e-05	1.48e-06	8.58e-09	5.11e-08
3.92e-06	1.03e-05	4.57e-07	2.34e-08	1.51e-07
1.55e-05	2.88e-05	9.11e-07	2.34e-08	1.07e-07
1.01e-05	3.42e-05	1.95e-06	4.04e-08	3.34e-07
2.55e-05	5.02e-05	1.68e-06	9.39e-08	4.53e-07
2.67e-05	4.79e-05	1.46e-06	8.85e-08	3.89e-07
2.02e-05	3.07e-05	7.88e-07	8.20e-09	3.05e-08
2.09e-05	2.95e-05	7.04e-07	7.93e-09	2.74e-08
5.96e-06	8.55e-06	2.08e-07	2.89e-08	1.02e-07
6.27e-06	8.34e-06	1.88e-07	2.72e-08	8.87e-08
1.99e-05	2.45e-05	5.12e-07	2.93e-08	8.86e-08
2.01e-05	2.39e-05	4.83e-07	2.78e-08	8.13e-08
1.69e-05	2.81e-05	7.92e-07	4.35e-08	1.77e-07
1.79e-05	2.68e-05	6.80e-07	4.01e-08	1.47e-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
4.88e-06	4.35e-05	6.60e-06	1.89e-08	4.15e-07
1.04e-05	2.52e-05	1.04e-06	5.97e-09	3.54e-08
2.76e-06	7.21e-06	3.20e-07	1.64e-08	1.05e-07
1.09e-05	2.02e-05	6.38e-07	1.64e-08	7.47e-08
7.18e-06	2.41e-05	1.37e-06	2.83e-08	2.33e-07
1.81e-05	3.46e-05	1.13e-06	6.39e-08	3.01e-07
1.85e-05	3.30e-05	1.00e-06	5.89e-08	2.58e-07
1.43e-05	2.13e-05	5.36e-07	5.49e-09	2.00e-08
1.45e-05	2.05e-05	4.90e-07	5.28e-09	1.83e-08
4.24e-06	5.97e-06	1.43e-07	1.96e-08	6.76e-08
4.40e-06	5.89e-06	1.34e-07	1.79e-08	5.88e-08
1.40e-05	1.71e-05	3.55e-07	1.99e-08	5.98e-08
1.40e-05	1.67e-05	3.41e-07	1.86e-08	5.48e-08
1.21e-05	1.95e-05	5.35e-07	2.90e-08	1.15e-07
1.25e-05	1.87e-05	4.76e-07	2.62e-08	9.62e-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
7.46e-06	6.67e-05	1.01e-05	2.90e-08	6.35e-07
1.60e-05	3.86e-05	1.59e-06	9.13e-09	5.42e-08
4.22e-06	1.10e-05	4.90e-07	2.50e-08	1.61e-07
1.67e-05	3.10e-05	9.77e-07	2.51e-08	1.14e-07
1.10e-05	3.68e-05	2.10e-06	4.33e-08	3.56e-07
2.73e-05	5.39e-05	1.81e-06	1.01e-07	4.89e-07
2.87e-05	5.15e-05	1.57e-06	9.53e-08	4.20e-07
2.17e-05	3.30e-05	8.55e-07	8.63e-09	3.23e-08

2.25e-05	3.17e-05	7.61e-07	8.34e-09	2.89e-08
6.39e-06	9.21e-06	2.26e-07	3.09e-08	1.09e-07
6.73e-06	8.96e-06	2.02e-07	2.92e-08	9.53e-08
2.13e-05	2.64e-05	5.54e-07	3.13e-08	9.49e-08
2.16e-05	2.57e-05	5.20e-07	2.98e-08	8.71e-08
1.82e-05	3.04e-05	8.62e-07	4.62e-08	1.90e-07
1.94e-05	2.90e-05	7.36e-07	4.28e-08	1.57e-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
6.97e-06	6.22e-05	9.44e-06	2.70e-08	5.93e-07
1.49e-05	3.61e-05	1.48e-06	8.52e-09	5.06e-08
3.94e-06	1.03e-05	4.57e-07	2.34e-08	1.50e-07
1.56e-05	2.89e-05	9.12e-07	2.34e-08	1.07e-07
1.03e-05	3.44e-05	1.96e-06	4.04e-08	3.32e-07
2.55e-05	5.02e-05	1.67e-06	9.37e-08	4.52e-07
2.68e-05	4.79e-05	1.46e-06	8.83e-08	3.88e-07
2.03e-05	3.08e-05	7.92e-07	8.05e-09	2.99e-08
2.10e-05	2.96e-05	7.08e-07	7.78e-09	2.69e-08
5.98e-06	8.58e-06	2.09e-07	2.88e-08	1.01e-07
6.29e-06	8.36e-06	1.89e-07	2.70e-08	8.81e-08
1.99e-05	2.46e-05	5.14e-07	2.91e-08	8.81e-08
2.02e-05	2.40e-05	4.85e-07	2.77e-08	8.08e-08
1.71e-05	2.83e-05	7.97e-07	4.30e-08	1.75e-07
1.81e-05	2.70e-05	6.85e-07	3.96e-08	1.45e-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
3.90e-08	1.47e-10	5.92e-09	4.65e-07	7.69e-08
1.49e-09	1.10e-11	6.13e-11	2.40e-08	1.46e-08
1.06e-09	7.38e-11	4.73e-11	5.45e-08	3.08e-08
3.11e-09	8.37e-11	9.84e-11	5.39e-08	4.29e-08
7.17e-09	1.64e-11	4.10e-10	1.19e-07	5.24e-08
1.97e-08	8.62e-11	6.43e-10	2.06e-07	1.59e-07
1.83e-08	6.22e-11	5.56e-10	2.05e-07	1.70e-07
1.01e-09	7.22e-12	2.54e-11	1.61e-08	1.61e-08
9.86e-10	5.99e-12	2.36e-11	1.65e-08	1.74e-08
7.93e-10	3.46e-11	1.90e-11	4.03e-08	4.23e-08
7.74e-10	2.46e-11	1.76e-11	4.17e-08	4.61e-08
2.54e-09	3.03e-11	5.28e-11	4.46e-08	5.39e-08
2.50e-09	2.18e-11	5.08e-11	4.64e-08	5.73e-08
4.22e-09	2.66e-11	1.16e-10	6.97e-08	6.38e-08
3.92e-09	2.38e-11	9.96e-11	6.97e-08	6.89e-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
5.97e-08	2.25e-10	9.06e-09	7.11e-07	1.18e-07
2.28e-09	1.69e-11	9.38e-11	3.67e-08	2.24e-08
1.63e-09	1.13e-10	7.24e-11	8.34e-08	4.71e-08
4.77e-09	1.28e-10	1.51e-10	8.25e-08	6.56e-08
1.10e-08	2.52e-11	6.28e-10	1.83e-07	8.02e-08
3.12e-08	1.40e-10	1.05e-09	3.18e-07	2.37e-07
2.89e-08	1.04e-10	8.81e-10	3.07e-07	2.53e-07
1.58e-09	1.13e-11	4.09e-11	2.49e-08	2.42e-08
1.52e-09	9.82e-12	3.64e-11	2.46e-08	2.58e-08
1.23e-09	5.56e-11	3.01e-11	6.12e-08	6.27e-08
1.18e-09	4.20e-11	2.68e-11	6.12e-08	6.80e-08
3.93e-09	4.91e-11	8.24e-11	6.75e-08	8.09e-08
3.84e-09	3.69e-11	7.76e-11	6.87e-08	8.55e-08
6.70e-09	4.08e-11	1.90e-10	1.08e-07	9.53e-08
6.12e-09	3.88e-11	1.56e-10	1.03e-07	1.02e-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
5.57e-08	2.10e-10	8.46e-09	6.64e-07	1.10e-07
2.12e-09	1.58e-11	8.75e-11	3.43e-08	2.09e-08
1.52e-09	1.05e-10	6.76e-11	7.78e-08	4.39e-08
4.45e-09	1.20e-10	1.41e-10	7.70e-08	6.12e-08
1.02e-08	2.35e-11	5.86e-10	1.71e-07	7.49e-08
2.90e-08	1.27e-10	9.68e-10	2.96e-07	2.23e-07
2.69e-08	9.39e-11	8.17e-10	2.88e-07	2.38e-07
1.48e-09	1.04e-11	3.80e-11	2.32e-08	2.27e-08
1.42e-09	8.93e-12	3.40e-11	2.31e-08	2.43e-08
1.15e-09	5.06e-11	2.79e-11	5.71e-08	5.89e-08
1.11e-09	3.76e-11	2.50e-11	5.75e-08	6.39e-08
3.66e-09	4.46e-11	7.66e-11	6.32e-08	7.58e-08
3.59e-09	3.32e-11	7.24e-11	6.45e-08	8.02e-08
6.22e-09	3.78e-11	1.75e-10	1.00e-07	8.95e-08
5.71e-09	3.55e-11	1.45e-10	9.68e-08	9.59e-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
3.89e-08	1.47e-10	5.90e-09	4.63e-07	7.66e-08
1.47e-09	1.09e-11	6.05e-11	2.36e-08	1.44e-08
1.06e-09	7.33e-11	4.71e-11	5.41e-08	3.06e-08
3.11e-09	8.31e-11	9.81e-11	5.36e-08	4.26e-08
7.17e-09	1.63e-11	4.08e-10	1.18e-07	5.21e-08
1.97e-08	8.59e-11	6.41e-10	2.05e-07	1.58e-07
1.82e-08	6.19e-11	5.54e-10	2.04e-07	1.69e-07
9.95e-10	7.06e-12	2.51e-11	1.58e-08	1.57e-08
9.73e-10	5.87e-12	2.33e-11	1.62e-08	1.70e-08
7.91e-10	3.44e-11	1.89e-11	4.00e-08	4.20e-08
7.72e-10	2.45e-11	1.76e-11	4.14e-08	4.58e-08
2.54e-09	3.01e-11	5.27e-11	4.43e-08	5.35e-08
2.49e-09	2.17e-11	5.08e-11	4.61e-08	5.69e-08
4.20e-09	2.61e-11	1.15e-10	6.87e-08	6.30e-08
3.90e-09	2.34e-11	9.90e-11	6.88e-08	6.80e-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
5.95e-08	2.24e-10	9.02e-09	7.08e-07	1.17e-07
2.26e-09	1.66e-11	9.27e-11	3.62e-08	2.21e-08
1.63e-09	1.12e-10	7.21e-11	8.28e-08	4.69e-08
4.76e-09	1.27e-10	1.50e-10	8.20e-08	6.53e-08
1.10e-08	2.49e-11	6.25e-10	1.81e-07	7.98e-08
3.11e-08	1.40e-10	1.05e-09	3.16e-07	2.36e-07
2.88e-08	1.04e-10	8.78e-10	3.06e-07	2.52e-07
1.56e-09	1.11e-11	4.03e-11	2.44e-08	2.37e-08

1.50e-09	9.61e-12	3.59e-11	2.41e-08	2.53e-08
1.23e-09	5.54e-11	3.01e-11	6.07e-08	6.23e-08
1.18e-09	4.18e-11	2.67e-11	6.08e-08	6.75e-08
3.92e-09	4.88e-11	8.23e-11	6.71e-08	8.03e-08
3.84e-09	3.67e-11	7.75e-11	6.83e-08	8.49e-08
6.66e-09	4.00e-11	1.89e-10	1.06e-07	9.41e-08
6.09e-09	3.81e-11	1.55e-10	1.02e-07	1.01e-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
5.55e-08	2.09e-10	8.42e-09	6.61e-07	1.09e-07
2.11e-09	1.55e-11	8.65e-11	3.37e-08	2.06e-08
1.52e-09	1.05e-10	6.73e-11	7.73e-08	4.37e-08
4.44e-09	1.19e-10	1.40e-10	7.65e-08	6.09e-08
1.02e-08	2.33e-11	5.83e-10	1.69e-07	7.45e-08
2.89e-08	1.27e-10	9.64e-10	2.95e-07	2.22e-07
2.68e-08	9.35e-11	8.14e-10	2.87e-07	2.37e-07
1.45e-09	1.02e-11	3.74e-11	2.28e-08	2.22e-08
1.40e-09	8.75e-12	3.36e-11	2.27e-08	2.38e-08
1.14e-09	5.03e-11	2.78e-11	5.67e-08	5.85e-08
1.10e-09	3.74e-11	2.49e-11	5.71e-08	6.35e-08
3.65e-09	4.44e-11	7.65e-11	6.27e-08	7.53e-08
3.58e-09	3.30e-11	7.23e-11	6.41e-08	7.97e-08
6.19e-09	3.71e-11	1.74e-10	9.90e-08	8.83e-08
5.67e-09	3.48e-11	1.44e-10	9.55e-08	9.46e-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
6.29e-08	1.18e-07	5.80e-13	0.000617	0.00175
3.32e-10	1.68e-10	3.68e-14	0.000348	0.00241
2.46e-09	1.35e-09	3.42e-14	0.000191	0.00292
3.48e-09	1.35e-09	3.00e-14	0.000246	0.00278
3.81e-09	2.68e-09	1.40e-13	0.000369	0.00221
4.88e-10	1.95e-10	1.30e-14	0.000565	0.00156
3.60e-10	1.35e-10	1.20e-14	0.000593	0.00143
4.32e-11	1.34e-11	9.66e-15	0.000356	0.00218
4.10e-11	1.21e-11	1.00e-14	0.000404	0.00201
1.58e-10	4.64e-11	7.10e-15	0.000236	0.00258
1.42e-10	3.97e-11	8.15e-15	0.000300	0.00235
1.89e-10	4.82e-11	7.50e-15	0.000266	0.00248
1.66e-10	4.15e-11	8.55e-15	0.000324	0.00227
2.11e-10	7.12e-11	1.22e-14	0.000386	0.00206
1.93e-10	6.03e-11	1.16e-14	0.000423	0.00192
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
9.63e-08	1.80e-07	7.10e-13	0.000755	0.00214
5.08e-10	2.58e-10	4.51e-14	0.000426	0.00295
3.76e-09	2.06e-09	4.18e-14	0.000234	0.00358
5.32e-09	2.07e-09	3.68e-14	0.000302	0.00341
5.83e-09	4.11e-09	1.71e-13	0.000452	0.00271
8.33e-10	3.45e-10	1.68e-14	0.000687	0.00194
5.84e-10	2.19e-10	1.46e-14	0.000713	0.00180
6.76e-11	2.15e-11	1.21e-14	0.000425	0.00271
6.46e-11	1.90e-11	1.20e-14	0.000475	0.00253
2.50e-10	7.53e-11	8.69e-15	0.000276	0.00321
2.33e-10	6.46e-11	9.55e-15	0.000345	0.00296
3.02e-10	7.80e-11	9.11e-15	0.000314	0.00309
2.67e-10	6.63e-11	1.00e-14	0.000376	0.00285
3.34e-10	1.16e-10	1.57e-14	0.000463	0.00255
3.16e-10	9.88e-11	1.42e-14	0.000502	0.00241
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0

0	0	0	0	0
0	0	0	0	0
8.99e-08	1.68e-07	6.50e-13	0.000692	0.00196
4.74e-10	2.41e-10	4.13e-14	0.000390	0.00270
3.51e-09	1.92e-09	3.83e-14	0.000215	0.00328
4.97e-09	1.93e-09	3.37e-14	0.000277	0.00312
5.45e-09	3.83e-09	1.57e-13	0.000414	0.00248
7.62e-10	3.13e-10	1.54e-14	0.000632	0.00177
5.41e-10	2.03e-10	1.35e-14	0.000659	0.00164
6.30e-11	1.99e-11	1.11e-14	0.000393	0.00247
6.04e-11	1.78e-11	1.11e-14	0.000443	0.00229
2.32e-10	6.96e-11	8.07e-15	0.000258	0.00293
2.16e-10	6.00e-11	8.97e-15	0.000325	0.00268
2.80e-10	7.20e-11	8.45e-15	0.000292	0.00281
2.48e-10	6.16e-11	9.38e-15	0.000353	0.00259
3.10e-10	1.08e-10	1.43e-14	0.000428	0.00232
2.93e-10	9.15e-11	1.31e-14	0.000466	0.00219
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
6.30e-08	1.18e-07	5.80e-13	0.000617	0.00174
3.34e-10	1.69e-10	3.69e-14	0.000346	0.00240
2.47e-09	1.35e-09	3.41e-14	0.000189	0.00292
3.50e-09	1.36e-09	3.00e-14	0.000244	0.00278
3.86e-09	2.70e-09	1.40e-13	0.000367	0.00220
4.86e-10	1.95e-10	1.29e-14	0.000566	0.00156
3.59e-10	1.34e-10	1.20e-14	0.000594	0.00143
4.21e-11	1.31e-11	9.68e-15	0.000359	0.00218
4.02e-11	1.18e-11	1.01e-14	0.000406	0.00200
1.56e-10	4.60e-11	7.08e-15	0.000236	0.00258
1.41e-10	3.95e-11	8.15e-15	0.000300	0.00235
1.87e-10	4.78e-11	7.49e-15	0.000267	0.00248
1.64e-10	4.12e-11	8.55e-15	0.000325	0.00227
2.08e-10	7.00e-11	1.23e-14	0.000388	0.00205
1.90e-10	5.95e-11	1.16e-14	0.000425	0.00191
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
9.64e-08	1.80e-07	7.10e-13	0.000755	0.00213
5.11e-10	2.58e-10	4.52e-14	0.000424	0.00294
3.78e-09	2.07e-09	4.17e-14	0.000232	0.00358
5.35e-09	2.08e-09	3.67e-14	0.000299	0.00341
5.91e-09	4.14e-09	1.72e-13	0.000450	0.00270
8.31e-10	3.44e-10	1.68e-14	0.000689	0.00194
5.82e-10	2.18e-10	1.46e-14	0.000715	0.00180
6.60e-11	2.10e-11	1.21e-14	0.000428	0.00270

6.34e-11	1.87e-11	1.20e-14	0.000479	0.00252
2.48e-10	7.47e-11	8.67e-15	0.000276	0.00321
2.31e-10	6.42e-11	9.55e-15	0.000345	0.00296
2.99e-10	7.73e-11	9.10e-15	0.000314	0.00308
2.65e-10	6.59e-11	1.00e-14	0.000376	0.00285
3.28e-10	1.15e-10	1.57e-14	0.000466	0.00254
3.12e-10	9.75e-11	1.42e-14	0.000505	0.00240
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
8.99e-08	1.68e-07	6.51e-13	0.000692	0.00196
4.77e-10	2.41e-10	4.14e-14	0.000388	0.00269
3.53e-09	1.93e-09	3.82e-14	0.000212	0.00328
5.00e-09	1.94e-09	3.37e-14	0.000274	0.00312
5.51e-09	3.86e-09	1.57e-13	0.000412	0.00247
7.60e-10	3.12e-10	1.54e-14	0.000634	0.00177
5.40e-10	2.02e-10	1.35e-14	0.000660	0.00163
6.15e-11	1.95e-11	1.11e-14	0.000396	0.00246
5.92e-11	1.75e-11	1.12e-14	0.000446	0.00228
2.30e-10	6.91e-11	8.05e-15	0.000258	0.00293
2.14e-10	5.96e-11	8.97e-15	0.000325	0.00268
2.77e-10	7.14e-11	8.44e-15	0.000293	0.00281
2.46e-10	6.12e-11	9.38e-15	0.000353	0.00259
3.05e-10	1.06e-10	1.43e-14	0.000430	0.00232
2.89e-10	9.03e-11	1.31e-14	0.000468	0.00218

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
8.70e-12	0.00980	0	0.0980	0
1.06e-10	0.00980	0	0.0980	0
7.66e-11	0.00980	0	0.0980	0
1.07e-10	0.00980	0	0.0980	0
2.73e-11	0.00980	0	0.0980	0
3.19e-10	0.00980	7.81e-07	0.0980	4.33e-07
3.32e-10	0.00980	3.97e-08	0.0980	4.29e-07
3.76e-10	0.00980	1.60e-07	0.0980	4.32e-07
3.79e-10	0.00980	1.61e-07	0.0980	4.29e-07
4.02e-10	0.00980	1.60e-07	0.0980	4.33e-07
4.05e-10	0.00980	1.60e-07	0.0980	4.30e-07
4.12e-10	0.00980	1.60e-07	0.0980	4.31e-07
4.02e-10	0.00980	1.61e-07	0.0980	4.29e-07
3.03e-10	0.00980	1.60e-07	0.0980	4.34e-07
3.28e-10	0.00980	1.61e-07	0.0980	4.30e-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
1.06e-11	0.0150	0	0.120	0
1.30e-10	0.0150	0	0.120	0
9.38e-11	0.0150	0	0.120	0
1.31e-10	0.0150	0	0.120	0
3.34e-11	0.0150	0	0.120	0
3.70e-10	0.0150	1.14e-06	0.120	4.34e-07
4.13e-10	0.0150	-4.89e-08	0.120	4.30e-07
4.47e-10	0.0150	1.60e-07	0.120	4.33e-07
4.69e-10	0.0150	1.60e-07	0.120	4.30e-07
4.77e-10	0.0150	1.60e-07	0.120	4.35e-07
4.99e-10	0.0150	1.60e-07	0.120	4.31e-07
4.97e-10	0.0150	1.60e-07	0.120	4.32e-07
5.02e-10	0.0150	1.60e-07	0.120	4.29e-07
3.52e-10	0.0150	1.60e-07	0.120	4.35e-07
3.99e-10	0.0150	1.60e-07	0.120	4.31e-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
9.76e-12	0.0140	0	0.110	0
1.19e-10	0.0140	0	0.110	0
8.60e-11	0.0140	0	0.110	0
1.20e-10	0.0140	0	0.110	0
3.06e-11	0.0140	0	0.110	0
3.41e-10	0.0140	1.05e-06	0.110	4.34e-07
3.74e-10	0.0140	-2.88e-08	0.110	4.30e-07
4.11e-10	0.0140	1.60e-07	0.110	4.33e-07
4.26e-10	0.0140	1.61e-07	0.110	4.30e-07
4.37e-10	0.0140	1.60e-07	0.110	4.34e-07
4.54e-10	0.0140	1.60e-07	0.110	4.30e-07
4.55e-10	0.0140	1.60e-07	0.110	4.32e-07
4.55e-10	0.0140	1.61e-07	0.110	4.29e-07
3.25e-10	0.0140	1.60e-07	0.110	4.35e-07
3.64e-10	0.0140	1.60e-07	0.110	4.30e-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
8.67e-12	0.00980	0	0.0980	0
1.05e-10	0.00980	0	0.0980	0
7.58e-11	0.00980	0	0.0980	0
1.06e-10	0.00980	0	0.0980	0
2.70e-11	0.00980	0	0.0980	0
3.19e-10	0.00980	7.91e-07	0.0980	4.33e-07
3.32e-10	0.00980	3.61e-08	0.0980	4.29e-07
3.77e-10	0.00980	1.60e-07	0.0980	4.32e-07
3.78e-10	0.00980	1.61e-07	0.0980	4.29e-07
4.03e-10	0.00980	1.60e-07	0.0980	4.33e-07
4.05e-10	0.00980	1.60e-07	0.0980	4.30e-07
4.13e-10	0.00980	1.60e-07	0.0980	4.31e-07
4.03e-10	0.00980	1.61e-07	0.0980	4.29e-07
3.03e-10	0.00980	1.60e-07	0.0980	4.34e-07
3.27e-10	0.00980	1.61e-07	0.0980	4.30e-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
1.06e-11	0.0150	0	0.120	0
1.29e-10	0.0150	0	0.120	0
9.29e-11	0.0150	0	0.120	0
1.30e-10	0.0150	0	0.120	0
3.30e-11	0.0150	0	0.120	0
3.70e-10	0.0150	1.15e-06	0.120	4.34e-07
4.13e-10	0.0150	-5.46e-08	0.120	4.30e-07
4.48e-10	0.0150	1.60e-07	0.120	4.33e-07

4.69e-10	0.0150	1.60e-07	0.120	4.30e-07
4.78e-10	0.0150	1.60e-07	0.120	4.35e-07
5.00e-10	0.0150	1.60e-07	0.120	4.31e-07
4.98e-10	0.0150	1.60e-07	0.120	4.32e-07
5.02e-10	0.0150	1.60e-07	0.120	4.29e-07
3.52e-10	0.0150	1.60e-07	0.120	4.35e-07
3.98e-10	0.0150	1.60e-07	0.120	4.31e-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
9.73e-12	0.0140	0	0.110	0
1.18e-10	0.0140	0	0.110	0
8.51e-11	0.0140	0	0.110	0
1.19e-10	0.0140	0	0.110	0
3.03e-11	0.0140	0	0.110	0
3.41e-10	0.0140	1.06e-06	0.110	4.34e-07
3.73e-10	0.0140	-3.40e-08	0.110	4.30e-07
4.11e-10	0.0140	1.60e-07	0.110	4.33e-07
4.26e-10	0.0140	1.61e-07	0.110	4.30e-07
4.38e-10	0.0140	1.60e-07	0.110	4.34e-07
4.54e-10	0.0140	1.60e-07	0.110	4.30e-07
4.56e-10	0.0140	1.60e-07	0.110	4.32e-07
4.55e-10	0.0140	1.61e-07	0.110	4.29e-07
3.25e-10	0.0140	1.60e-07	0.110	4.35e-07
3.63e-10	0.0140	1.60e-07	0.110	4.30e-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	1.00	0	2.00
0	0	1.00	0	2.00
0	0	1.00	0	2.00
0	0	1.00	0	2.00
0	0	1.00	0	2.00
1.89e-07	1.89e-07	1.00	0.000757	2.00
3.20e-07	1.31e-07	1.00	0.000544	2.00
1.37e-07	1.37e-07	1.00	0.000626	2.00
2.63e-07	1.27e-07	1.00	0.000542	2.00
1.29e-07	1.29e-07	1.00	0.000716	2.00
2.49e-07	1.21e-07	1.00	0.000577	2.00
1.41e-07	1.41e-07	1.00	0.000678	2.00
2.64e-07	1.24e-07	1.00	0.000558	2.00
1.34e-07	1.34e-07	1.00	0.000709	2.00
2.63e-07	1.29e-07	1.00	0.000537	2.00
0	0	0	0	0
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0	0	1.00	0	2.00
0	0	1.00	0	2.00
0	0	1.00	0	2.00
0	0	1.00	0	2.00
2.06e-07	2.06e-07	1.00	0.000830	2.00
3.35e-07	1.29e-07	1.00	0.000564	2.00
1.38e-07	1.38e-07	1.00	0.000655	2.00
2.63e-07	1.25e-07	1.00	0.000561	2.00
1.31e-07	1.31e-07	1.00	0.000761	2.00
2.48e-07	1.17e-07	1.00	0.000601	2.00
1.46e-07	1.46e-07	1.00	0.000716	2.00
2.67e-07	1.21e-07	1.00	0.000574	2.00
1.36e-07	1.36e-07	1.00	0.000762	2.00
2.63e-07	1.27e-07	1.00	0.000559	2.00
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0

0	0	0	0	0
0	0	0	0	0
0	0	1.00	0	2.00
0	0	1.00	0	2.00
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0	0	1.00	0	2.00
2.02e-07	2.02e-07	1.00	0.000809	2.00
3.31e-07	1.29e-07	1.00	0.000558	2.00
1.37e-07	1.37e-07	1.00	0.000647	2.00
2.63e-07	1.25e-07	1.00	0.000555	2.00
1.30e-07	1.30e-07	1.00	0.000747	2.00
2.49e-07	1.19e-07	1.00	0.000593	2.00
1.44e-07	1.44e-07	1.00	0.000703	2.00
2.66e-07	1.22e-07	1.00	0.000568	2.00
1.35e-07	1.35e-07	1.00	0.000745	2.00
2.63e-07	1.27e-07	1.00	0.000553	2.00
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	1.00	0	2.00
0	0	1.00	0	2.00
0	0	1.00	0	2.00
0	0	1.00	0	2.00
0	0	1.00	0	2.00
1.89e-07	1.89e-07	1.00	0.000756	2.00
3.20e-07	1.31e-07	1.00	0.000544	2.00
1.35e-07	1.35e-07	1.00	0.000620	2.00
2.62e-07	1.27e-07	1.00	0.000542	2.00
1.28e-07	1.28e-07	1.00	0.000714	2.00
2.49e-07	1.21e-07	1.00	0.000577	2.00
1.40e-07	1.40e-07	1.00	0.000675	2.00
2.64e-07	1.24e-07	1.00	0.000558	2.00
1.33e-07	1.33e-07	1.00	0.000703	2.00
2.62e-07	1.29e-07	1.00	0.000536	2.00
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0	0	0	0	0
0	0	0	0	0
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0	0	0	0	0
0	0	1.00	0	2.00
0	0	1.00	0	2.00
0	0	1.00	0	2.00
0	0	1.00	0	2.00
0	0	1.00	0	2.00
2.06e-07	2.06e-07	1.00	0.000829	2.00
3.35e-07	1.29e-07	1.00	0.000564	2.00
1.37e-07	1.37e-07	1.00	0.000647	2.00

2.61e-07	1.25e-07	1.00	0.000560	2.00
1.30e-07	1.30e-07	1.00	0.000759	2.00
2.48e-07	1.17e-07	1.00	0.000601	2.00
1.45e-07	1.45e-07	1.00	0.000712	2.00
2.66e-07	1.21e-07	1.00	0.000574	2.00
1.35e-07	1.35e-07	1.00	0.000755	2.00
2.61e-07	1.27e-07	1.00	0.000559	2.00
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	1.00	0	2.00
0	0	1.00	0	2.00
0	0	1.00	0	2.00
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0	0	1.00	0	2.00
2.02e-07	2.02e-07	1.00	0.000808	2.00
3.31e-07	1.29e-07	1.00	0.000558	2.00
1.36e-07	1.36e-07	1.00	0.000640	2.00
2.61e-07	1.25e-07	1.00	0.000555	2.00
1.29e-07	1.29e-07	1.00	0.000745	2.00
2.48e-07	1.19e-07	1.00	0.000593	2.00
1.44e-07	1.44e-07	1.00	0.000700	2.00
2.66e-07	1.22e-07	1.00	0.000568	2.00
1.34e-07	1.34e-07	1.00	0.000739	2.00
2.61e-07	1.27e-07	1.00	0.000553	2.00

d_Dolomite(ordered)	Gypsum	d_Gypsum	si_Ferrihydrite	si_Gibbsite
0	0	0	1.08	-3.06e-01
0	0	0	0.958	0.892
0	0	0	1.67	0.644
0	0	0	2.00	0.745
0	0	0	0.390	0.792
0	0	0	1.08	-3.06e-01
0	0	0	0.958	0.892
0	0	0	1.67	0.644
0	0	0	2.00	0.745
0	0	0	0.390	0.792
-1.03e-03	0	0	0	0
-6.40e-04	0	0	0	0
-7.99e-04	0	0	0	0
-6.40e-04	0	0	0	0
-9.11e-04	0	0	0	0
-6.83e-04	0	0	0	0
-8.28e-04	0	0	0	0
-6.50e-04	0	0	0	0
-9.19e-04	0	0	0	0
-6.49e-04	0	0	0	0
0	0	0	1.08	-3.06e-01
0	0	0	0.958	0.892
0	0	0	1.67	0.644
0	0	0	2.00	0.745
0	0	0	0.390	0.792
0	0	0	1.08	-3.06e-01
0	0	0	0.958	0.892
0	0	0	1.67	0.644
0	0	0	2.00	0.745
0	0	0	0.390	0.792
-1.20e-03	0	0	0	0
-6.78e-04	0	0	0	0
-8.64e-04	0	0	0	0
-6.73e-04	0	0	0	0
-1.00e-03	0	0	0	0
-7.25e-04	0	0	0	0
-8.95e-04	0	0	0	0
-6.77e-04	0	0	0	0
-1.02e-03	0	0	0	0
-6.93e-04	0	0	0	0
0	0	0	1.08	-3.06e-01
0	0	0	0.958	0.892
0	0	0	1.67	0.644

0	0	0	2.00	0.745
0	0	0	0.390	0.792
0	0	0	1.08	-3.06e-01
0	0	0	0.958	0.892
0	0	0	1.67	0.644
0	0	0	2.00	0.745
0	0	0	0.390	0.792
-1.16e-03	0	0	0	0
-6.69e-04	0	0	0	0
-8.50e-04	0	0	0	0
-6.65e-04	0	0	0	0
-9.79e-04	0	0	0	0
-7.14e-04	0	0	0	0
-8.78e-04	0	0	0	0
-6.69e-04	0	0	0	0
-9.98e-04	0	0	0	0
-6.83e-04	0	0	0	0
0	0	0	1.08	-3.05e-01
0	0	0	0.962	0.894
0	0	0	1.67	0.645
0	0	0	2.00	0.746
0	0	0	0.393	0.794
0	0	0	1.08	-3.05e-01
0	0	0	0.962	0.894
0	0	0	1.67	0.645
0	0	0	2.00	0.746
0	0	0	0.393	0.794
-1.03e-03	0	0	0	0
-6.40e-04	0	0	0	0
-7.93e-04	0	0	0	0
-6.40e-04	0	0	0	0
-9.09e-04	0	0	0	0
-6.83e-04	0	0	0	0
-8.25e-04	0	0	0	0
-6.50e-04	0	0	0	0
-9.13e-04	0	0	0	0
-6.48e-04	0	0	0	0
0	0	0	1.08	-3.05e-01
0	0	0	0.962	0.894
0	0	0	1.67	0.645
0	0	0	2.00	0.746
0	0	0	0.393	0.794
0	0	0	1.08	-3.05e-01
0	0	0	0.962	0.894
0	0	0	1.67	0.645
0	0	0	2.00	0.746
0	0	0	0.393	0.794
-1.20e-03	0	0	0	0
-6.78e-04	0	0	0	0
-8.56e-04	0	0	0	0

-6.73e-04	0	0	0	0
-9.99e-04	0	0	0	0
-7.25e-04	0	0	0	0
-8.92e-04	0	0	0	0
-6.77e-04	0	0	0	0
-1.02e-03	0	0	0	0
-6.92e-04	0	0	0	0
0	0	0	1.08	-3.05e-01
0	0	0	0.962	0.894
0	0	0	1.67	0.645
0	0	0	2.00	0.746
0	0	0	0.393	0.794
0	0	0	1.08	-3.05e-01
0	0	0	0.962	0.894
0	0	0	1.67	0.645
0	0	0	2.00	0.746
0	0	0	0.393	0.794
-1.16e-03	0	0	0	0
-6.69e-04	0	0	0	0
-8.43e-04	0	0	0	0
-6.65e-04	0	0	0	0
-9.77e-04	0	0	0	0
-7.14e-04	0	0	0	0
-8.75e-04	0	0	0	0
-6.69e-04	0	0	0	0
-9.92e-04	0	0	0	0
-6.82e-04	0	0	0	0

si_Barite	si_Calcite	si_Dolomite(ordered)	si_Gypsum
0.453	-1.81e+00	-3.92e+00	-4.99e-02
0.388	-1.02e-01	-1.09e-01	-7.21e-01
0.550	-4.83e-01	-1.03e+00	-6.24e-01
0.334	-3.42e-01	-7.54e-01	-4.83e-01
0.0996	-6.77e-01	-1.54e+00	-7.58e-01
0.453	-1.81e+00	-3.92e+00	-4.99e-02
0.388	-1.02e-01	-1.09e-01	-7.21e-01
0.550	-4.83e-01	-1.03e+00	-6.24e-01
0.334	-3.42e-01	-7.54e-01	-4.83e-01
0.0996	-6.77e-01	-1.54e+00	-7.58e-01
0	0	0	-1.55e+00
0	0	0	-1.68e+00
0	0	0	-1.66e+00
0	0	0	-1.69e+00
0	0	0	-1.67e+00
0	0	0	-1.69e+00
0	0	0	-1.66e+00
0	0	0	-1.69e+00
0	0	0	-1.65e+00
0	0	0	-1.68e+00
0.453	-1.81e+00	-3.92e+00	-4.99e-02
0.388	-1.02e-01	-1.09e-01	-7.21e-01
0.550	-4.83e-01	-1.03e+00	-6.24e-01
0.334	-3.42e-01	-7.54e-01	-4.83e-01
0.0996	-6.77e-01	-1.54e+00	-7.58e-01
0.453	-1.81e+00	-3.92e+00	-4.99e-02
0.388	-1.02e-01	-1.09e-01	-7.21e-01
0.550	-4.83e-01	-1.03e+00	-6.24e-01
0.334	-3.42e-01	-7.54e-01	-4.83e-01
0.0996	-6.77e-01	-1.54e+00	-7.58e-01
0	0	0	-1.50e+00
0	0	0	-1.68e+00
0	0	0	-1.65e+00
0	0	0	-1.69e+00
0	0	0	-1.65e+00
0	0	0	-1.70e+00
0	0	0	-1.64e+00
0	0	0	-1.69e+00
0	0	0	-1.64e+00
0	0	0	-1.68e+00
0.453	-1.81e+00	-3.92e+00	-4.99e-02
0.388	-1.02e-01	-1.09e-01	-7.21e-01
0.550	-4.83e-01	-1.03e+00	-6.24e-01

0.334	-3.42e-01	-7.54e-01	-4.83e-01
0.0996	-6.77e-01	-1.54e+00	-7.58e-01
0.453	-1.81e+00	-3.92e+00	-4.99e-02
0.388	-1.02e-01	-1.09e-01	-7.21e-01
0.550	-4.83e-01	-1.03e+00	-6.24e-01
0.334	-3.42e-01	-7.54e-01	-4.83e-01
0.0996	-6.77e-01	-1.54e+00	-7.58e-01
0	0	0	-1.52e+00
0	0	0	-1.68e+00
0	0	0	-1.65e+00
0	0	0	-1.69e+00
0	0	0	-1.66e+00
0	0	0	-1.69e+00
0	0	0	-1.65e+00
0	0	0	-1.69e+00
0	0	0	-1.64e+00
0	0	0	-1.68e+00
0.457	-1.80e+00	-3.91e+00	-4.73e-02
0.406	-9.06e-02	-8.64e-02	-7.06e-01
0.559	-4.79e-01	-1.02e+00	-6.17e-01
0.344	-3.37e-01	-7.44e-01	-4.75e-01
0.115	-6.68e-01	-1.52e+00	-7.46e-01
0.457	-1.80e+00	-3.91e+00	-4.73e-02
0.406	-9.06e-02	-8.64e-02	-7.06e-01
0.559	-4.79e-01	-1.02e+00	-6.17e-01
0.344	-3.37e-01	-7.44e-01	-4.75e-01
0.115	-6.68e-01	-1.52e+00	-7.46e-01
0	0	0	-1.55e+00
0	0	0	-1.68e+00
0	0	0	-1.66e+00
0	0	0	-1.69e+00
0	0	0	-1.67e+00
0	0	0	-1.69e+00
0	0	0	-1.66e+00
0	0	0	-1.69e+00
0	0	0	-1.66e+00
0	0	0	-1.68e+00
0.457	-1.80e+00	-3.91e+00	-4.73e-02
0.406	-9.06e-02	-8.64e-02	-7.06e-01
0.559	-4.79e-01	-1.02e+00	-6.17e-01
0.344	-3.37e-01	-7.44e-01	-4.75e-01
0.115	-6.68e-01	-1.52e+00	-7.46e-01
0.457	-1.80e+00	-3.91e+00	-4.73e-02
0.406	-9.06e-02	-8.64e-02	-7.06e-01
0.559	-4.79e-01	-1.02e+00	-6.17e-01
0.344	-3.37e-01	-7.44e-01	-4.75e-01
0.115	-6.68e-01	-1.52e+00	-7.46e-01
0	0	0	-1.51e+00
0	0	0	-1.68e+00
0	0	0	-1.65e+00

0	0	0	-1.69e+00
0	0	0	-1.66e+00
0	0	0	-1.70e+00
0	0	0	-1.65e+00
0	0	0	-1.69e+00
0	0	0	-1.64e+00
0	0	0	-1.68e+00
0.457	-1.80e+00	-3.91e+00	-4.73e-02
0.406	-9.06e-02	-8.64e-02	-7.06e-01
0.559	-4.79e-01	-1.02e+00	-6.17e-01
0.344	-3.37e-01	-7.44e-01	-4.75e-01
0.115	-6.68e-01	-1.52e+00	-7.46e-01
0.457	-1.80e+00	-3.91e+00	-4.73e-02
0.406	-9.06e-02	-8.64e-02	-7.06e-01
0.559	-4.79e-01	-1.02e+00	-6.17e-01
0.344	-3.37e-01	-7.44e-01	-4.75e-01
0.115	-6.68e-01	-1.52e+00	-7.46e-01
0	0	0	-1.52e+00
0	0	0	-1.68e+00
0	0	0	-1.65e+00
0	0	0	-1.69e+00
0	0	0	-1.66e+00
0	0	0	-1.69e+00
0	0	0	-1.65e+00
0	0	0	-1.69e+00
0	0	0	-1.65e+00
0	0	0	-1.68e+00

APPENDIX B

DRAWINGS AND MATERIAL SPECIFICATIONS FOR SELECTED REMEDY

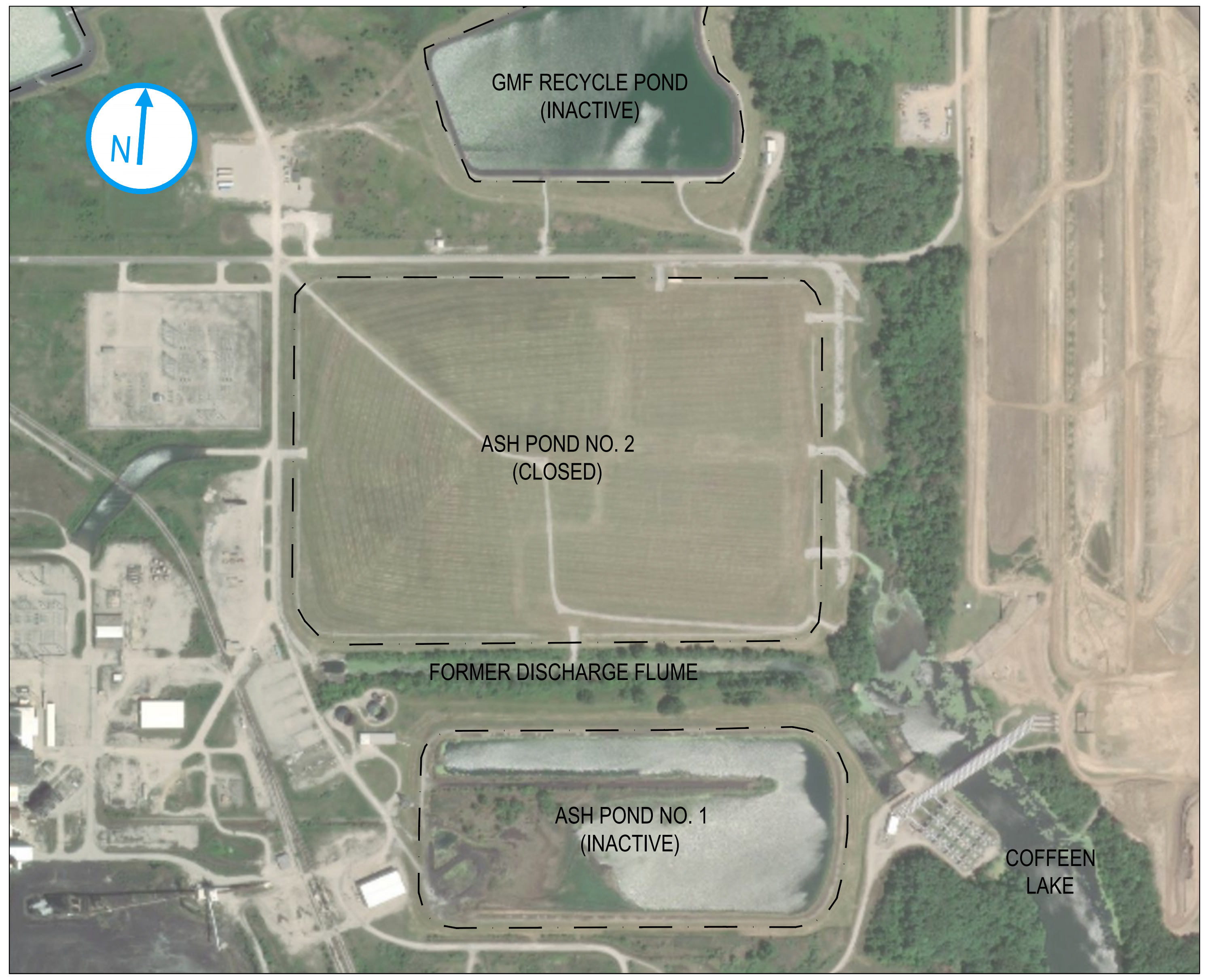
SAVED: 3/5/25 5:03 PM

CORRECTIVE ACTION PERMIT-LEVEL DESIGN

Coffeen Ash Pond No. 2

Coffeen Power Plant, Coffeen, IL

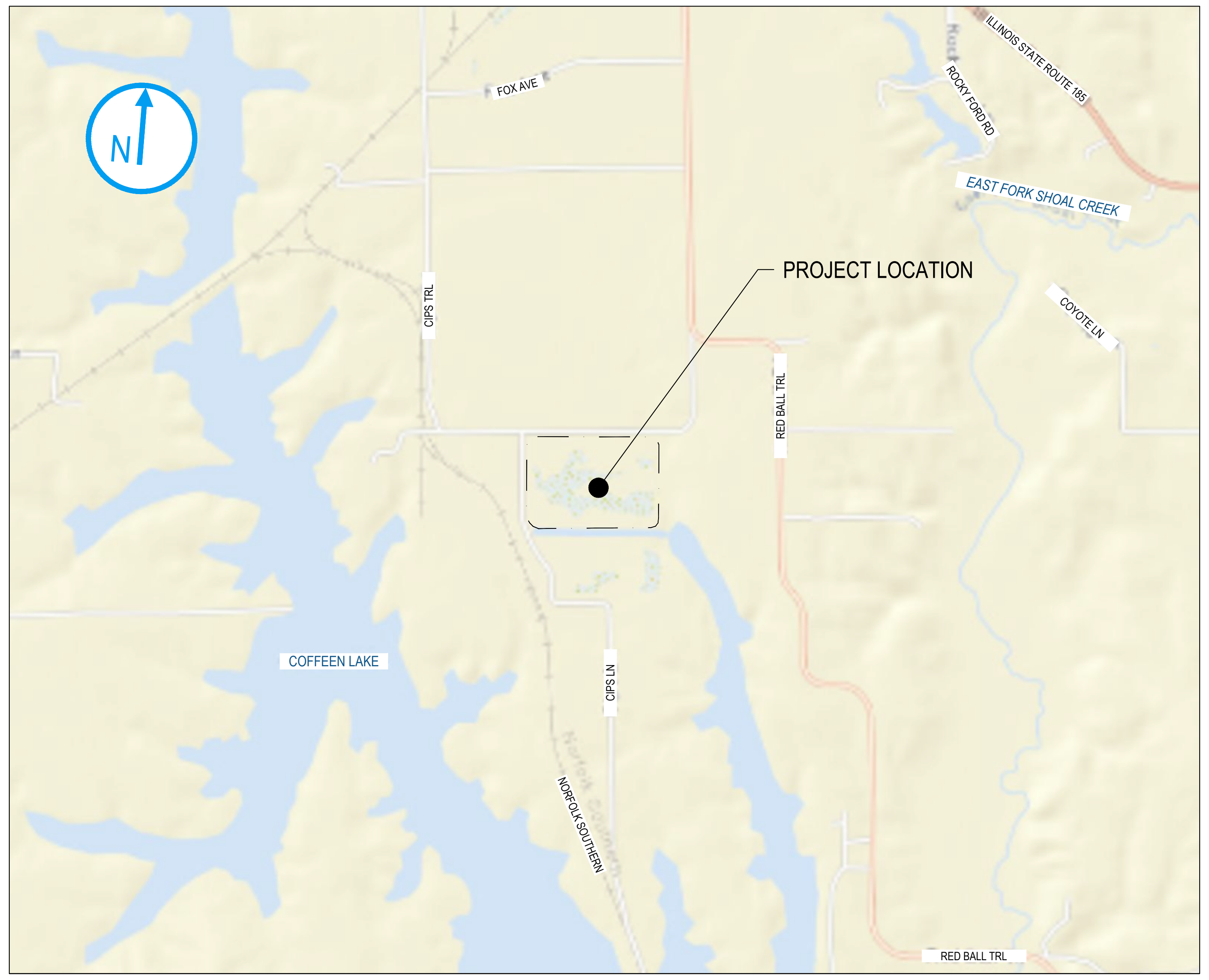
HORIZONTAL GROUNDWATER EXTRACTION (GWE) WELL



AERIAL IMAGERY: ESRI WORLD IMAGERY

LOCATION MAP

500' 0 500'
SCALE: 1"=500'



SOURCE: ESRI WORLD STREET MAP

VICINITY MAP

2000' 0 2000'
SCALE: 1"=2000'

SHEET INDEX

General	
G-000	Cover
Civil	
C-101	Overall Site Plan
C-201	Enlarged Plan and Profile
C-401	Air Compressor Extraction Pump Shed Schematic

Illinois Power Generating Company
Coffeen Power Plant
134 Cips Lane, Coffeen, IL 62017
April 2025

RAMBOLL

RAMBOLL AMERICAS ENGINEERING SOLUTIONS, INC.

PERMIT-LEVEL
DESIGN
NOT FOR
CONSTRUCTION
DATE: ----

1940110241-001

C:\DC\ACCDOCS\RAMBOLL GRUPPEN AS\RUS-1940106781-004 VISTRA - COFFEEN AP2\PROJECT FILES\4 DELIVERY\40 WIP\401 CIVIL\DRAWINGS\G-000_COF-AP2.DWG

SAVED: 3/7/25 10:36 AM
C:\DC\ACCDOCS\RAMBOLL GRUPPEN AS\RUS-1940106781-004 VISTRA - COFFEEN AP2\PROJECT FILES\4 DELIVERY\40 WIP\401 CIVIL\DRAWINGS\C-101_COF-AP2.DWG

NOTES:
1. EXISTING GRADING REPRESENTED PER COFFEEN POWER PLANT ASH POND NO. 2 CLOSURE AS-BUILT DRAWINGS COMPLETED BY GOLDER, NOVEMBER 2020.
2. HORIZONTAL DATUM: ILLINOIS STATE PLANE (NAD83, IN US FEET).
VERTICAL DATUM: NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88, IN US FEET).

OVERALL SITE PLAN

100' 0 100'
SCALE: 1"=100'

PERMIT-LEVEL DESIGN
NOT FOR CONSTRUCTION

DATE: ----

NO.	REV DATE	REVISION	INT.

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.

Project Details
ILLINOIS POWER GENERATING COMPANY
Coffeen Ash Pond No. 2
Coffeen Power Plant
134 Cips Lane, Coffeen, IL 62017

Location:

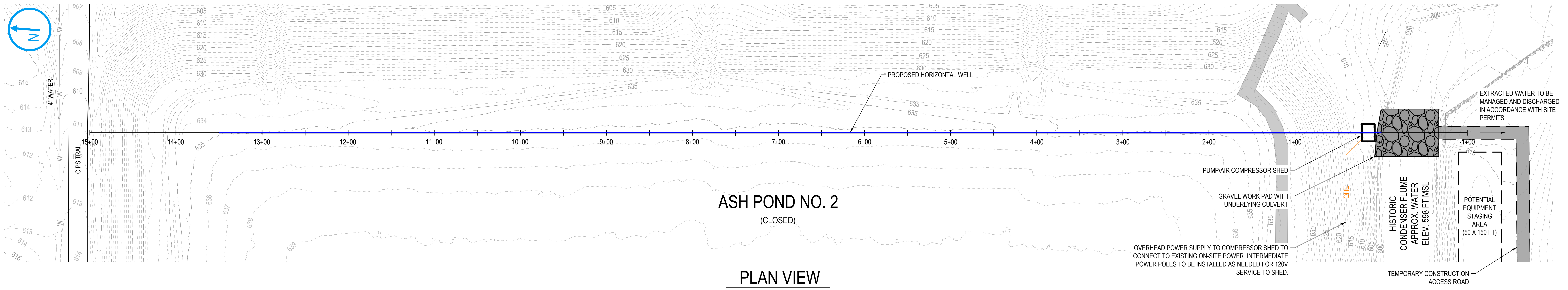
Drawing Title
OVERALL SITE PLAN

Designer / Professional Engineer Responsible: J. BOND

RAMBOLL
RAMBOLL AMERICAS ENGINEERING SOLUTIONS, INC.
234 W. Florida St,
Milwaukee, WI 53204
414-837-3607

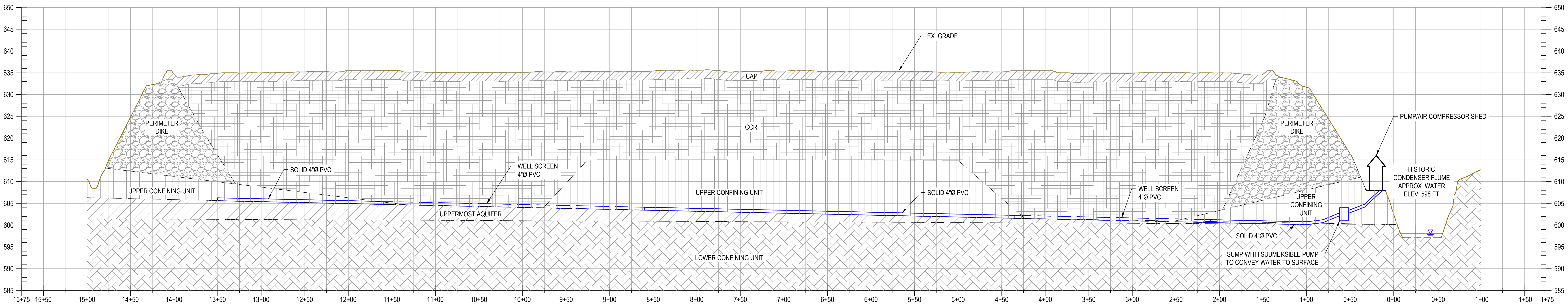
Project Number **1940110241-001**	Designed by K. NOHR	Drawn by B. LEMMON	Checked by S. SLAGLE-GARRETT	Approved by J. BOND	Date April 2025	
Project Status Corrective Action Permit-Level Design	Drawing Number **C-101**			Scale AS NOTED	Sc x	Rev. x

SAVED: 3/10/25 12:36 AM



PLAN VIEW

60' 0 60'
SCALE: 1"=60'



PROFILE STATION 0+00 TO 13+50

60' 0 60'
SCALE HORZ. 1" = 60'

12' 0 12'
SCALE: VERT. 1"=12'

NOTE: HORIZONTAL WELL FEATURES DRAWN NOT TO SCALE.
LITHOLOGIC CONTACTS ARE APPROXIMATE.

LEGEND

EXISTING

— — 360 — —	MAJOR CONTOUR
- - - 358 - - -	MINOR CONTOUR
— · — · —	APPROXIMATE SITE BOUNDARY
▭	WETLANDS
▭	BODY OF WATER (LAKE, POND, RAVINE, ETC.)
▨	GRAVEL ACCESS ROAD
—x—x—	FENCE
········	GUARDRAIL
—o— S —	SEWER - GRAVITY, AND MANHOLE
— » — » —	SEWER - FORCEMAIN
⊢ — ⊣	STORMDRAIN, AND CULVERT
— W —	WATERMAIN
— UE —	UNDERGROUND ELECTRICAL
— OHE —	OVERHEAD ELECTRICAL
Ø	UTILITY POLE
☼	LIGHT POLE

PROPOSED

⌐ ─ ─ ¬	STAGING AREA
▭	STRUCTURE
▩	GRAVEL WORK PAD
▬ ▬ ▬	TEMPORARY CONSTRUCTION ACCESS ROAD
— OHE —	OVERHEAD ELECTRICAL
———	HORIZONTAL WELL

NOTES:

1. ALL SUBSURFACE MATERIAL INTERFACES ARE APPROXIMATE AND WILL BE VERIFIED VIA FUTURE SUBSURFACE INVESTIGATION PROGRAMS.
2. THE HORIZONTAL WELL ALIGNMENT, INCLUDING ELEVATIONS AND SCREENED INTERVALS, IS APPROXIMATE AND WILL ALSO BE ADJUSTED BASED ON FUTURE SUBSURFACE INVESTIGATION PROGRAMS.

NO.	REV DATE	REVISION	INT.

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PERMIT-LEVEL
DESIGN
NOT FOR
CONSTRUCTION

DATE: ----

Project Details
ILLINOIS POWER GENERATING COMPANY
Coffeen Ash Pond No. 2
Coffeen Power Plant
134 Cips Lane, Coffeen, IL 62017

Location:

Drawing Title
ENLARGED PLAN AND PROFILE

Designer / Professional Engineer Responsible:
J. BOND

RAMBOLL
RAMBOLL AMERICAS ENGINEERING SOLUTIONS, INC.
234 W. Florida St,
Milwaukee, WI 53204
414-837-3607

Project Number	Designed by	Drawn by	Checked by	Approved by	Date
1940110241-001	K. NOHR	B. LEMMON	S. SLAGLE-GARRETT	J. BOND	April 2025

Project Status	Drawing Number	Scale	Sc	Rev.
Corrective Action Permit-Level Design	**C-201**	AS NOTED	x	x

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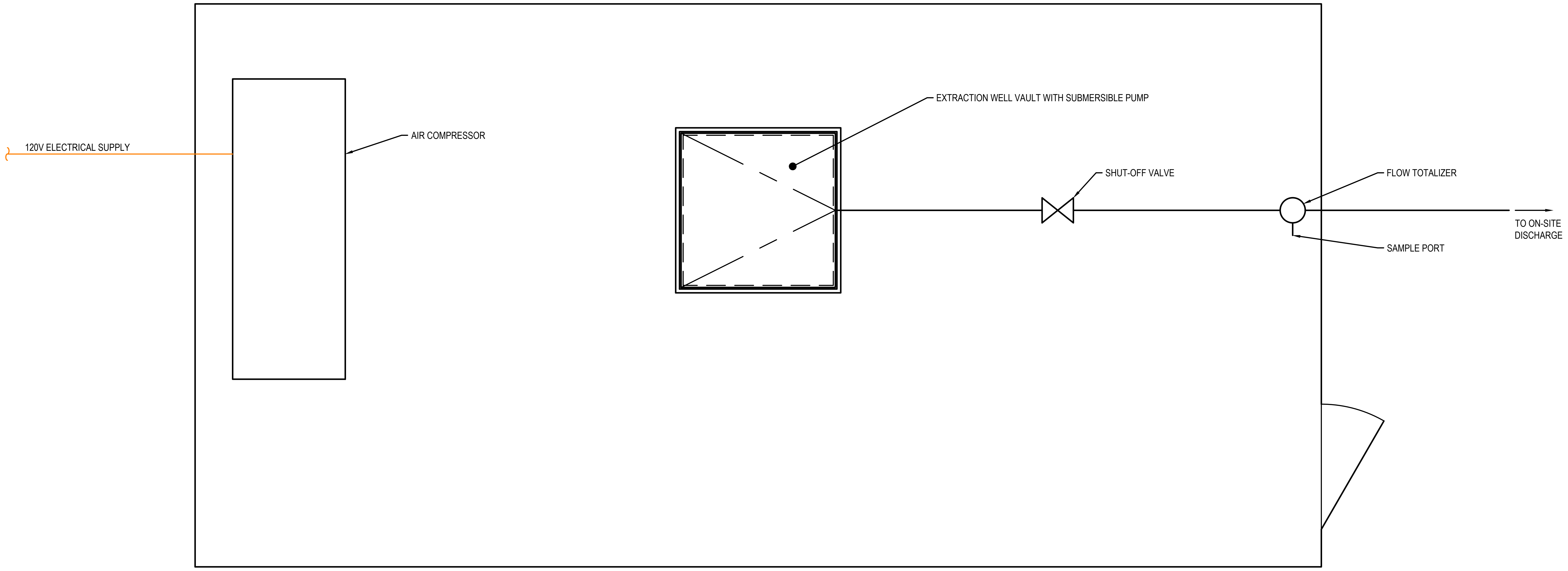
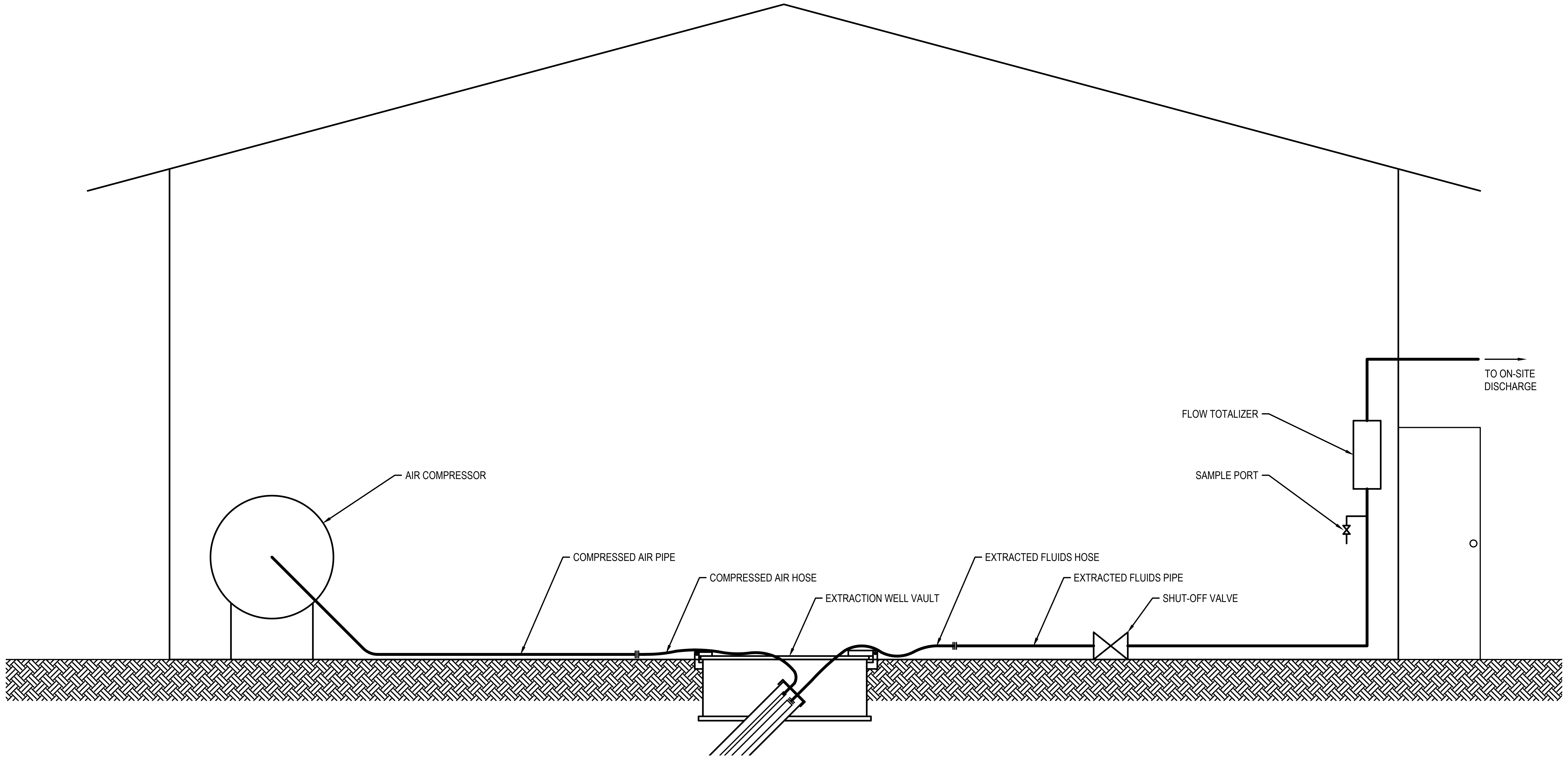


TOP PLAN



FRONT ELEVATION

AIR COMPRESSOR/EXTRACTION PUMP SHED SCHEMATIC

NOT TO SCALE

PERMIT-LEVEL DESIGN NOT FOR CONSTRUCTION

DATE: ----

NO.	REV DATE	REVISION	INT.

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Project Details
ILLINOIS POWER GENERATING COMPANY
Coffeen Ash Pond No. 2
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134 Cips Lane, Coffeen, IL 62017

Drawing Title
AIR COMPRESSOR/ EXTRACTION PUMP SHED SCHEMATIC

RAMBOLL
RAMBOLL AMERICAS ENGINEERING SOLUTIONS, INC.
234 W. Florida St, Milwaukee, WI 53204
414-837-3607

Location:

Designer / Professional Engineer Responsible: J. BOND

Project Number: **1940110241-001**
Designed by: K. NOHR
Drawn by: B. LEMMON
Checked by: S. SLAGLE-GARRETT
Approved by: J. BOND
Date: April 2025

Project Status: Corrective Action Permit-Level Design
Drawing Number: **C-401**
Scale: AS NOTED
Sc: x
Rev.: x