DRAFT

REPORT

Final Closure Plan for Ash Pond No. 1

Coffeen Power Plant

Submitted to:

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1.0 INTRODUCTION

This Final Closure Plan has been prepared to address certain requirements of Illinois Administrative Code Title 35, Part 845, Standards for the Disposal of Coal Combustion Residuals (CCR) in Surface Impoundments (Part 845) for Illinois Power Resources Generating, LLC's (IPRG's) Ash Pond No. 1 (AP1) at the Coffeen Power Plant near Coffeen, Illinois. Specifically, this document addresses requirements pertaining to the development of a Final Closure Plan for AP1. AP1 has identification codes as follow:

- IPRG ID Number: CCR Unit ID 101
- IEPA ID Number: W1350150004-01
- IDNR Dam ID Number: IL50722

1.1 Proposed Selected Closure Method

Part 845.720 (b)(3): The final closure plan must identify the proposed selected closure method, and must include the information required in subsection (a)(1) and the closure alternatives analysis specified in Section 845.710.

IPRG evaluated closure with a final cover system (hereafter referred to as closure-in-place or CIP) (Section 845.750) and closure-by-removal of CCR (CBR) (Section 845.740). An analysis of these closure alternatives is summarized in Attachment 1. Based on the Closure Alternatives Analysis, CIP with a final cover system has been identified as the most appropriate closure method. The final cover system will physically isolate the ash (CCR) in AP1 from contact with surface water and the atmosphere and minimize the potential for release of CCR. The final cover system has been designed to minimize the post-closure infiltration of liquids into the waste.

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

2.0 FINAL CLOSURE PLAN

2.1 Narrative Closure Description

Part 845.720(a)(1)(A): A narrative description of how the CCR surface impoundment will be closed in accordance with this Part.

Closure grades and details are shown in the Drawings included as Attachment 2. The closure-in-place concept for AP1 was developed to reduce the waste footprint at closure and to achieve 10 feet of vertical separation between the top of the uppermost aquifer and the CCR material. The closed facility will have final cover slopes of 7H:1V to approximate El. 664 feet transitioning to 20H:1V (5%) slopes above that elevation to accommodate moderate settlement and promote drainage. A berm will be constructed at the east end of the consolidated footprint for stability. The location of the berm has been selected to accommodate the estimated 436,000 CY of CCR and 21,500 CY of excavated subsoil to be contained within the consolidated footprint based on the grading plan presented. The general sequencing plan for the closure-in-place method is as follows:

- Pump out ponded water [approximately 15.2 million gallons (MG)] from AP1 to the existing drainage to the north and through Outfall K20. Discharge will be managed in accordance with the NPDES permit for the site.
- A temporary water management system will be constructed within AP1, including ditches and sumps. The system will maintain AP1 in an unwatered state by collecting contact stormwater during closure construction.

Stormwater flow will be conveyed through Outfall K20 to the existing drainage to the north. Discharge will be managed in accordance with the NPDES permit for the site.

- Once the ponded water has been removed from AP1, the CCR in the consolidated footprint will be dewatered. Approximately 268,600 CY of CCR east of the consolidated footprint will be dewatered as needed to enable relocation. Free liquids in the CCR will be eliminated by removing liquid wastes or solidifying the remaining wastes. It is anticipated that after ponded water is removed approximately 14.1 MG of additional water removal will be required to dewater the CCR. The CCR will dewater to some degree by gravity, but dewatering by pumping from trenches and sumps is expected to be necessary. Liquid waste and water flowing to sumps will be managed in accordance with the NPDES permit for the site and discharged through Outfall K20.
- Any accumulated CCR within the riser structure and outlet pipes will be removed and the riser structure and outlet pipes will be decontaminated by pressure washing. Decontamination water will be routed through Outfall K20 and managed in accordance with the NPDES permit for the site. The riser structure will be demolished and disposed of in the consolidated footprint and the outlet pipes will be plugged and abandoned or removed and disposed.
- CCR will be removed from the berm footprint and relocated into the consolidated footprint. The berm will be constructed in north-south orientation at the east end of the consolidated footprint.
- The remaining CCR east of the berm will be collected and deposited west of the berm. It is anticipated that up to 1 foot of subsoil beneath the CCR may also be removed. The subsoils will be visually observed for signs of CCR. If subsoils with CCR staining are observed, they will be removed and deposited west of the berm.
- Once all CCR is contained within the consolidated footprint and appropriate grades for closure have been achieved (with grading fill used as necessary), a final cover system will be installed in accordance with Part 845.750. The final cover system will consist of (from top to bottom):
  - 24-inch-thick final protective soil layer. The soil layer will include a 6-inch-thick topsoil layer that will be revegetated with native grasses. The underlying material will consist of locally available soils from the removed embankment containment berm compacted to between 80% and 95% of the standard Proctor maximum dry density for establishment of vegetation and protection of the underlying geomembrane. Final protective soil layer material is likely to be primarily low-plasticity silt or clay based on review of site geotechnical information.
  - Nonwoven geotextile cushioning layer.
  - 40-mil linear low-density polyethylene (LLDPE) geomembrane layer.
- All areas of the closure surface will be sloped at a minimum of 1% to positively drain to the exterior of AP1. Stormwater runoff from the AP1 closure area will be removed from the top of the final cover via the construction of a free-draining stormwater management system, including berms, channels, and let-down structures, that will convey stormwater to existing surface water bodies.
- Exterior slopes of the existing western, northern, and southern containment berms used to contain the consolidated AP1 footprint will be recontoured as necessary with additional soil, sourced from the existing berms that are no longer required, to achieve minimum 3H:1V side slopes for long-term stability.

- To prevent impoundment of water in the eastern end of the current AP1 footprint after CCR removal, existing earthen embankments not required for the consolidated footprint will be removed and a channel will be excavated to allow stormwater to flow through existing NPDES Outfall K20 into the existing drainage.
- Soil fill, sourced from existing berms no longer required to contain waste in the consolidated footprint or from the on-site soil borrow area southeast of AP1, will be used as fill in low areas of the existing AP1 base grade to provide at least one foot of soil cover above the top of the uppermost aquifer and establish the final ground surface.
- The final ground surface of the eastern part of AP1 will be sloped to drain at a minimum slope of 0.5% towards the channel excavated in the northeast corner, in order to allow post-closure, non-contact stormwater to gravity flow into the existing drainage.
- Vegetation will be established on the final surface of AP1. Stormwater best management practices (BMPs) such as erosion control blankets will be used as needed to reduce erosion during vegetation establishment.
- After vegetation is established, BMPs will be removed and closure construction will be considered complete.

2.2 Decontamination of CCR Surface Impoundment

Part 845.720(a)(1)(B): If closure of the CCR surface impoundment will be accomplished through removal of CCR from the CCR surface impoundment, a description of the procedures to remove the CCR and decontaminate the CCR surface impoundment in accordance with Section 845.740.

After CCR east of the berm has been relocated to within the closure footprint, it is anticipated that up to 1 foot of subsoil beneath the CCR may also be removed. The subsoils will be visually observed for signs of CCR. If soils with signs of CCR are observed, they will be removed and deposited west of the berm.

2.3 Final Cover System Performance Standards

Part 845.720(a)(1)(C): If closure of the CCR surface impoundment will be accomplished by leaving CCR in place, a description of the final cover system, designed in accordance with Section 845.750, and the methods and procedures to be used to install the final cover. The closure plan must also discuss how the final cover system will achieve the performance standards specified in Section 845.750.

The final cover system is described in Section 2.1 and shown in the Drawings (Attachment 2). Documentation in support of the final cover system achieving the performance standards of Section 845.750 is provided in Section 4.7.

2.4 Maximum CCR Inventory Estimate

Part 845.720(a)(1)(D): An estimate of the maximum inventory of CCR ever on-site over the active life of the CCR surface impoundment.

Based on Golder's comparison (using Autodesk Civil 3D) between the existing conditions (December 2020 survey by IngenAE) and the approximate base of ash grades developed from the 1963 earthwork and grading plans, the estimated volume of CCR in AP1 is approximately 436,000 CY. No additional CCR will be placed in AP1 before it is closed.

2.5 Largest Surface Area Estimate

Part 845.720(a)(1)(E): An estimate of the largest area of the CCR surface impoundment ever requiring a final cover (see Section 845.750), at any time during the CCR surface impoundment's active life.

In the Closure Plan developed for compliance with the United States Environmental Protection Agency's (USEPA's) CCR Rule (40 CFR 257, Subpart D), the largest area of AP1 ever requiring a final cover system was estimated to be approximately 26 acres. This area represents the entire footprint of AP1. The area of the closure footprint requiring a final cover system under this Final Closure Plan is approximately 10.4 acres.

2.6 Closure Completion Schedule

Part 845.720(a)(1)(F): A schedule for completing all activities necessary to satisfy the closure criteria in this Section, including an estimate of the year in which all closure activities for the CCR surface impoundment will be completed. The schedule should provide sufficient information to describe the sequential steps that will be taken to close the CCR surface impoundment, including identification of major milestones such as coordinating with and obtaining necessary approvals and permits from other agencies, the dewatering and stabilization phases of CCR surface impoundment closure, or installation of the final cover system, and the estimated timeframes to complete each step or phase of CCR surface impoundment closure. When preparing the preliminary written closure plan, if the owner or operator of a CCR surface impoundment estimates that the time required to complete closure will exceed the timeframes specified in Section 845.760(a), the preliminary written closure plan must include the site-specific information, factors and considerations that would support any time extension sought under Section 845.760(b).

Table 1: Closure Completion Milestone Schedule

Milestone	Timeframe (Preliminary Estimates)
Final Closure Plan Submittal	August 2022
Final Design and Bid Process ■ Complete final design of the closure and select a construction contractor Agency Coordination, Approvals, and Permitting ■ Obtain state permits, as needed, for dewatering, water discharge, land disturbance, and dam modifications	8 to 12 months after Final Closure Plan Approval
Dewater and Stabilize CCR ■ Complete contractor mobilization, installation of stormwater BMPs, and unwatering of AP1 ■ Pump water from AP1 ■ Dewater and stabilize AP1	5 to 7 months after issuance of necessary permits, design completion, and bid award
Consolidate Waste Footprint ■ Demolish existing outlet structures	4 to 6 months after dewatering and CCR stabilization

Milestone	Timeframe (Preliminary Estimates)
■ Construct north-south berm ■ Relocate CCR east of berm to closure footprint	
Installation of Final Cover System ■ Prepare top of CCR for cover system installation ■ Regrade exterior embankments to 3H:1V ■ Install geomembrane ■ Install nonwoven geotextile ■ Place final protective soil	5 to 7 months after CCR relocation to closure footprint
Site Restoration ■ Place fill over top of aquifer ■ Place stormwater conveyance tack-on berms and letdown structures ■ Excavate drainage channels ■ Seed and stabilize AP1	3 to 4 months after the final cover system is complete
Timeframe to Complete Closure	Prior to April 2026

3.0 AMENDMENT OF THE FINAL CLOSURE PLAN

Part 845.720(b)(4): If a final written closure plan revision is necessary after closure activities have started for a CCR surface impoundment, the owner or operator must submit a request to modify the construction permit within 60 days following the triggering event.

IPRG will submit a written request to modify the construction permit within 60 days of a triggering event.

4.0 CLOSURE WITH A FINAL COVER SYSTEM

4.1 Minimization of Post-Closure Infiltration and Releases

Part 845.750(a): The owner or operator of a CCR surface impoundment must ensure that, at a minimum, the CCR surface impoundment is closed in a manner that will:

1) *Control, minimize or eliminate, to the maximum extent feasible, post-closure infiltration of liquids into the waste and releases of CCR, leachate, or contaminated run-off to the ground or surface waters or to the atmosphere.*

Post-closure infiltration into AP1 will be minimized by the construction of a final cover system. The final cover system will consist of (from top to bottom) the following:

- a 2-foot-thick final protective layer consisting of locally available soils compacted to between 80% and 95% of the standard Proctor maximum dry density. The uppermost 6 inches of the final protective layer will be tracked in place with a density suitable for establishment of vegetation. Soils are likely to consist primarily of low-plasticity silt or clay based on a review of site geotechnical information.
- Nonwoven geotextile cushioning layer.
- 40-mil LLDPE geomembrane.

The use of HDPE geomembrane was considered, but LLDPE geomembrane was selected because it can be installed more easily in a wider range of cold-temperature conditions. This final cover system is compliant with the Part 845 requirements, as described in Section 4.7, and will minimize the post-closure infiltration of liquids into the waste. After closure, the CCR stored in the facility will be completely covered by the final cover system, physically isolating it from contact with surface water and the atmosphere and minimizing the potential for release of CCR. This is supported by groundwater modeling, as presented in Appendix G to the Part 845 Construction Permit Application for AP1.

4.2 Preclusion of Future Impoundment

Part 845.750(a): The owner or operator of a CCR surface impoundment must ensure that, at a minimum, the CCR surface impoundment is closed in a manner that will:

2) Preclude the probability of future impoundment of water, sediment, or slurry.

The final cover system will be crowned with 7H:1V and 20H:1V slopes to direct surface water away from the facility. Beyond the final cover system, channels will direct surface water away from AP1 to existing site drainages.

4.3 Provisions for Preventing Instability, Sloughing and Movement

Part 845.750(a): The owner or operator of a CCR surface impoundment must ensure that, at a minimum, the CCR surface impoundment is closed in a manner that will:

3) Include measures that provide for major slope stability to prevent the sloughing or movement of the final cover system during the closure and post-closure care period.

An assessment of AP1 structural stability was completed as part of compliance with USEPA's CCR Rule (AECOM 2016). This assessment concluded that AP1 meets stability factor of safety requirements and does not pose a significant risk of instability.

A new earthen berm is provided in the closure design to enhance stability along the eastern end of the closure footprint. Slope stability calculations are included in Attachment 3 to demonstrate that factors of safety for static and seismic stability after closure are acceptable. The slope stability calculations also considered veneer stability to verify that the final cover system will not be susceptible to instability, sloughing, or movement during the closure and post-closure care period.

4.4 Minimize the Need for Future Maintenance

Part 845.750(a): The owner or operator of a CCR surface impoundment must ensure that, at a minimum, the CCR surface impoundment is closed in a manner that will:

4) Minimize the need for further maintenance of the CCR surface impoundment

The 5% to 14.3% design closure slopes are sufficient to adequately shed water from the facility but are flat enough to limit erosion of the final protective layer. Stormwater conveyance tack-on berms, which are sloped at 1%, direct stormwater on the final cover to a series of riprap-lined stormwater let-down structures. Minor maintenance of the final cover system (potentially including filling of low areas, reseeding, fertilizing, etcetera) will likely be necessary for several years after completion of final cover system construction, as described in the Post-closure Care Plan (Appendix J to the Part 845 Construction Permit Application for AP1). The need for long-term future maintenance is expected to be minimal after installation of the final cover system has been completed and vegetation has been established.

The channels designed to convey surface water runoff away from the closed facility have been sized to accommodate the 25-year, 24-hour storm event. The design calculations are provided in Attachment 4.

4.5 Be Completed in the Shortest Amount of Time

Part 845.750(a): The owner or operator of a CCR surface impoundment must ensure that, at a minimum, the CCR surface impoundment is closed in a manner that will:

5) Be completed in the shortest amount of time consistent with recognized and generally accepted engineering practices.

The CIP method will require significantly less material handling compared with a CBR approach. Both approaches require the removal of liquid wastes, but the CIP method will require relocation of less than 65% of the CCR present in AP1. This reduced material handling volume means that the CIP construction can be completed in approximately 25 to 36 months, compared with 36 to 56 months, or possibly more, for CBR.

4.6 Drainage and Stabilization

Part 845.750(b): Drainage and Stabilization of CCR Surface Impoundments. The owner or operator of a CCR surface impoundment or any lateral expansion of a CCR surface impoundment must meet the requirements of this subsection (b) before installing the final cover system required by subsection (c).

1) Free liquids must be eliminated by removing liquid wastes or solidifying the remaining wastes and waste residues.

2) Remaining wastes must be stabilized sufficiently to support the final cover system.

Approximately 15.2 million gallons of water will be pumped from AP1 as the initial step for facility closure. After removal of the ponded water, the CCR will still be unsuitable for supporting heavy construction traffic over much of the footprint. Careful planning will be required to safely work on the wet CCR within AP1. The planned CCR removal and relocation will rely on a series of trenches or other engineering measures to remove liquid wastes or solidify the remaining wastes. Trenches will shorten drainage routes to facilitate gravity removal of liquid wastes in the CCR in the vicinity of each trench and direct the liquid wastes to sumps. Other engineering measures may be considered to facilitate removal of liquid wastes. Sumps will be used to collect liquid wastes, which will be managed in accordance with the NPDES permit for the site. Using the process described or other engineering measures for removal of liquid wastes or solidification of the remaining wastes, the CCR remaining in place will be stabilized sufficiently to support the final cover system.

4.7 Final Cover System

Part 845.750(c): Final Cover System. If a CCR surface impoundment is closed by leaving CCR in place, the owner or operator must install a final cover system that is designed to minimize infiltration and erosion, and, at a minimum, meets the requirements of this subsection (c). The final cover system must consist of a low permeability layer and a final protective layer. The design of the final cover system must be included in the preliminary and final written closure plans required by Section 845.720 and the construction permit application for closure submitted to the Agency.

4.7.1 Low-Permeability Layer

Part 845.750(c)(1) Standards for the Low Permeability Layer. The low permeability layer must have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present, or a hydraulic conductivity no greater than 1 x 10^{-7} cm/sec, whichever is less. The low permeability layer must be constructed in accordance with the standards in either subsection (c)(1)(A) or (c)(1)(B), unless the owner or operator demonstrates that another low permeability layer construction technique or material provides equivalent or superior performance to the requirements of either subsection (c)(1)(A) or (c)(1)(B) and is approved by the Agency.

A) A compacted earth layer constructed in accordance with the following standards:

i) The minimum allowable thickness must be 0.91 meter (three feet); and

ii) The layer must be compacted to achieve a hydraulic conductivity of 1 x 10^{-7} cm/sec or less and minimize void spaces.

B) A geomembrane constructed in accordance with the following standards:

i) The geosynthetic membrane must have a minimum thickness of 40 mil (0.04 inches) and, in terms of hydraulic flux, must be equivalent or superior to a three-foot layer of soil with a hydraulic conductivity of 1 x 10^{-7} cm/sec;

ii) The geomembrane must have strength to withstand the normal stresses imposed by the waste stabilization process; and

iii) The geomembrane must be placed over a prepared base free from sharp objects and other materials that may cause damage.

The final cover system will include a 40-mil LLDPE geomembrane placed on a prepared subgrade of CCR (see the Drawings in Attachment 2). The prepared subgrade will be free of sharp objects prior to geomembrane installation. The geomembrane material will conform with the specifications of Geosynthetic Institute GRI-GM17 “Test Methods, Test Properties and Testing Frequency for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes” and will be installed per GRI-GM19a “Seam Strength and Related Properties of Thermally Bonded Homogeneous Polyolefin Geomembranes/Barriers” so that the material itself and the seams between panels will withstand the expected normal and tensile stress conditions. Furthermore, a 40-mil LLDPE geomembrane manufactured and installed to these specifications is widely accepted to be equivalent or superior to a 3-foot-thick layer of soil with a hydraulic conductivity of 1 x 10^{-7} cm/sec.

4.7.2 Final Protective Layer

Part 845.750(c)(2): Standards for the Final Protective Layer. The final protective layer must meet the following requirements, unless the owner or operator demonstrates that another final protective layer construction technique or material provides equivalent or superior performance to the requirements of this subsection (c)(2) and is approved by the Agency.

A) Cover the entire low permeability layer;

B) Be at least three feet thick, be sufficient to protect the low permeability layer from freezing, and minimize root penetration of the low permeability layer;

C) Consist of soil material capable of supporting vegetation;

D) Be placed as soon as possible after placement of the low permeability layer; and

E) Be covered with vegetation to minimize wind and water erosion.

A 2-foot-thick final protective layer will be installed for the final cover system, immediately overlaying the nonwoven geotextile cushioning layer and covering the entire low-permeability layer (see the Drawings in Attachment 2). The final protective layer will comprise locally available soils compacted to between 80% and 95% of the standard Proctor maximum dry density. The uppermost 6 inches of the final protective layer will be tracked in place to a density suitable for establishment of vegetation. This soil is expected to consist primarily of low-plasticity silt or clay based on a review of site geotechnical information. This soil is capable of supporting vegetation, will be placed as soon as possible after placement of the low-permeability layer, and will be covered with vegetation to limit wind and water erosion.

4.8 Final Cover System Settling

Part 845.750(c)(3): The disruption of the integrity of the final cover system must be minimized through a design that accommodates settling and subsidence.

The closure slopes are designed at a minimum slope of 5% to accommodate settlement while still maintaining positive drainage off the facility. Additional discussion on this subject is provided in Section 4.4.

4.9 Use of CCR in Closure

Part 845.750(d): This subsection specifies the allowable uses of CCR in the closure of CCR surface impoundments closing under Section 845.700. Notwithstanding the prohibition on further placement in Section 845.700, CCR may be placed in these surface impoundments, but only for purposes of grading and contouring in the design and construction of the final cover system, if:

1) The CCR placed was generated at the facility and is located at the facility at the time closure was initiated;

2) CCR is placed entirely above the elevation of CCR in the surface impoundment, following dewatering and stabilization (see subsection (b));

3) The CCR is placed entirely within the perimeter berms of the CCR surface impoundment; and

4) The final cover system is constructed with either:

A) A slope not steeper than 5% grade after allowance for settlement; or

B) At a steeper grade, if the Agency determines that the steeper slope is necessary, based on conditions at the site, to facilitate run-off and minimize erosion, and that side slopes are evaluated for erosion potential based on a stability analysis to evaluate possible erosion potential. The stability analysis, at a minimum, must evaluate the site geology; characterize soil shear strength; construct a slope stability model; establish groundwater and seepage conditions, if any; select loading conditions; locate critical failure surface; and iterate until minimum factor of safety is achieved.

AP1 is not closing under Section 845.700. Following dewatering of AP1, CCR currently located within AP1 (which was generated at Coffeen Power Plant) will be relocated to within the closure footprint. Closure of AP1 will comply with the requirements of Subsection 845.750(d) in the event ash from a unit other than AP1 is utilized.

Slope stability calculations are included in Attachment 3 to demonstrate that factors of safety for static and seismic stability after closure are acceptable. The slope stability calculations also considered veneer stability to verify that the final cover system will not be susceptible to instability, sloughing, or movement during the closure and post-closure care period.

5.0 CERTIFICATION

Part 845.750(c)(4): The owner or operator of the CCR surface impoundment must obtain and submit with its construction permit application for closure a written certification from a qualified professional engineer that the design of the final cover system meets the requirements of this Section.

The undersigned qualified professional engineer registered in Illinois certifies that the design of the final cover system meets the requirements of Section 845.750.

Signature Page

Golder Associates USA Inc.

I, Mark Haddock, being a registered professional engineer in good standing in the State of Illinois, certify to the best of my knowledge that this Final Closure Plan meets the requirements of Illinois Administrative Code Title 35, Part 845.

-UNCERTIFIED DRAFT-

Mark Haddock
Principal

6.0 REFERENCES

AECOM. 2016. CCR Certification Report: AP1, At Coffeen Power Station. October.

ATTACHMENT 1

Closure Alternatives Analysis

Closure Alternatives Analysis for Ash Pond No. 1 at the Coffeen Power Plant Coffeen, Illinois

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Abbreviations

AACE	Association for the Advancement of Cost Engineering
AP1	Ash Pond No. 1
BMP	Best Management Practice
CAA	Closure Alternatives Analysis
CBR	Closure-by-Removal
CCR	Coal Combustion Residual
CFR	Code of Federal Regulation
CIP	Closure-in-Place
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CY	Cubic Yard
DA	Deep Aquifer
DCU	Deep Confining Unit
EJ	Environmental Justice
FEMA	Federal Emergency Management Agency
GHG	Greenhouse Gas
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
ISGS	Illinois State Geological Survey
IPGC	Illinois Power Generating Company
LCU	Lower Confining Unit
LLDPE	Linear Low-Density Polyethylene
N_2O	Nitrous Oxide
NID	National Inventory of Dams
NO_x	Nitrogen Oxides
NPDES	National Pollutant Discharge Elimination System
PM	Particulate Matter
SFWA	State Fish and Wildlife Area
TMDL	Total Maximum Daily Load
TVA	Tennessee Valley Authority
UA	Uppermost Aquifer
UCU	Upper Confining Unit
US DOT	United States Department of Transportation
US FWS	United States Fish and Wildlife Service
VOC	Volatile Organic Compound
WPC Permit	Water Pollution Control Construction and Operating Permit

Summary of Findings

Title 35, Part 845 of the Illinois Administrative Code (IAC; IEPA, 2021a) requires the development of a Closure Alternatives Analysis (CAA) prior to undertaking closure activities at certain surface impoundments containing coal combustion residuals (CCRs) in the state of Illinois. Pursuant to requirements under IAC Section 845.710, this report presents a CAA for Ash Pond No. 1 (AP1) located on Illinois Power Generating Company's (IPGC) Coffeen Power Plant property near the City of Coffeen, Illinois. The goal of a CAA is to holistically evaluate potential closure scenarios with respect to a wide range of factors, including the efficiency, reliability, and ease of implementation of the closure scenario; its potential positive and negative short- and long-term impacts on human health and the environment; and its ability to address concerns raised by residents (IAC Part 845; IEPA, 2021a). Gradient evaluated two specific closure scenarios for AP1: Closure-in-Place (CIP) and Closure-by-Removal (CBR) with a combination of on-Site and off-Site disposal. The CIP scenario entails consolidating CCR into the western portion of AP1 and capping it with a new cover system consisting of, from bottom to top, a geomembrane layer, a geotextile cushion if needed, and 24 inches of vegetated soil. The CBR scenario entails excavating all of the CCR from AP1 and transporting a portion of the material to an on-Site landfill and the remainder of the material to an off-Site landfill for disposal. IPGC will also continue to evaluate potential opportunities for beneficial reuse of CCR excavated from AP1 as an alternative to disposal.

IAC Section 845.710(c)(2) requires CAAs to "[i]dentify whether the facility has an onsite landfill with remaining capacity that can legally accept CCR, and, if not, whether constructing an onsite landfill is possible" (IEPA, 2021a). There is an existing on-Site landfill at the Coffeen Power Plant Site with some capacity to accept CCR, but it does not have enough capacity to contain all of the material that would be removed from AP1. Furthermore, due to the planned redevelopment of the Site as a utility-scale solar energy generation and battery energy storage facility, there is not sufficient space available to expand the existing landfill.

Table S.1 summarizes the expected impacts of the CIP and CBR closure scenarios with regard to each of the factors specified under IAC Section 845.710 (IEPA, 2021a). Based on this evaluation and the additional details provided in Section 2 of this report, CIP has been identified as the most appropriate closure scenario for AP1. Key benefits of the CIP scenario relative to the CBR scenario include the more rapid redevelopment of the Site for use in utility-scale solar generation and battery energy storage and reduced impacts to workers, community members, and the environment during construction (*e.g.*, fewer construction-related accidents, lower energy demands, less air pollution and greenhouse gas [GHG] emissions, and less traffic-related impacts). This conclusion is subject to change as additional data are collected and following the completion of an upcoming public meeting, which will be held in June 2022 pursuant to requirements under IAC Section 845.710(e). Following the public meeting, a final closure decision will be made based on the considerations identified in this report, the results of additional data that are collected, and any additional considerations that arise during the public meeting. The final closure recommendation will be provided in a Final Closure Plan, which will be submitted to the Illinois Environmental Protection Agency (IEPA) as described under IAC Section 845.720(b) (IEPA, 2021a).

Table S.1 Comparison of Proposed Closure Scenarios

Evaluation Factor (Report Section; IAC Part 845 Section)	**Closure Scenario**	
	CIP	**CBR**
Closure Alternative Descriptions (Section 2.1, IAC Section 845.710(c))	AP1 would be capped in place with a new cover system consisting of, from bottom to top, a geomembrane layer, a geotextile cushion if needed, and 24 inches of vegetated soil. During the closure process, we will continue to assess off-Site CCR beneficial use opportunities. Ash consolidation and closure in place in combination with off-Site beneficial use may result in a smaller footprint for purposes of our ultimate cap design along with a reduced construction schedule.	All CCR would be excavated from AP1. Some of the CCR would be transported *via* truck to an on-Site landfill for disposal, and the remainder would be transported *via* truck to an off-Site landfill for disposal. The on-Site landfill does not have capacity for all of the CCR, nor can it be expanded due to future redevelopment plans. Expansion of the off-Site landfill may be necessary in order to accept all of the CCR and related materials from AP1. This scenario meets the requirements of IAC Section 845.710(c)(2) (IEPA, 2021a), which requires an assessment be included in the CAA of whether the Site has an on-Site landfill with available capacity or whether an on-Site landfill can be constructed.
Type and Degree of Long-Term Management, Including Monitoring, Operation, and Maintenance (Section 2.2.3, IAC Section 845.710(b)(1)(C))	Monitoring would be performed for 30 years post-closure or until GWPSs are achieved, whichever is longer. Additionally, the final cover system for AP1 would undergo 30 years of annual inspections, mowing, and maintenance.	Monitoring would be performed for 3 years post-closure or until GWPSs are achieved, whichever is longer.
Magnitude of Reduction of Existing Risks (Section 2.2.1, IAC Sections 845.710(b)(1)(A) and 845.710(b)(1)(F))	There are no current unacceptable risks to any human or ecological receptors associated with AP1. Because there are no current risks, and dissolved constituent concentrations would be expected to decline post-closure, no risks to human or ecological receptors would be expected post-closure.	There are no current unacceptable risks to any human or ecological receptors associated with AP1. Because there are no current risks, and dissolved constituent concentrations would be expected to decline post-closure, no risks to human or ecological receptors would be expected post-closure.
Likelihood of Future Releases of CCR (Section 2.2.2, IAC Sections 845.710(b)(1)(B) and 845.710(b)(1)(F))	During closure, there would be minimal risk of dike failure occurring at AP1 (*e.g.*, due to flooding or seismic activity) and minimal risk of dike overtopping during flood conditions. Post-closure, the risks of overtopping and dike failure would be even smaller than they are currently, due to the installation of a protective soil cover and new stormwater control structures. Dikes, final cover, and stormwater control features have been designed to withstand earthquakes and storm events.	During closure, there would be minimal risk of dike failure occurring at AP1 (due to, *e.g.*, flooding or seismic activity) and minimal risk of dike overtopping during flood conditions. Following excavation, there would be no risk of CCR releases due to dike failure. Changing geochemical conditions during an extended excavation can be a mechanism that results in the mobilization and increased transport in groundwater for some constituents.
Worker Risks (Section 2.2.4.1, IAC Sections 845.710(b)(1)(D) and 845.710(b)(1)(F))	An estimated 0.0019 worker fatalities and 0.29 worker injuries would be expected to occur due to on-Site activities under this closure scenario. An additional 0.0018 worker fatalities and 0.14 worker injuries would be expected to occur off-Site due to vehicle accidents during hauling, labor and equipment mobilization and demobilization, and material deliveries. In total, 0.0037 worker fatalities and 0.43 worker injuries would be expected under this closure scenario. Overall, risks to workers would likely be higher under the CBR scenario and lower under the CIP scenario. Simultaneous with closure activities, the Site would be redeveloped for use in utility-scale solar generation and battery energy storage. The simultaneous pursuit of two large construction projects may lead to traffic congestion on Site access roads, resulting in greater overall risks to workers than would result from either project alone. The CIP scenario would likely result in less traffic congestion – and, hence, a smaller increase in risks to workers – than the CBR scenario.	An estimated 0.0021 worker fatalities and 0.32 worker injuries would be expected to occur due to on-Site activities under this closure scenario. An additional 0.0044 worker fatalities and 0.30 worker injuries would be expected to occur off-Site due to vehicle accidents during hauling, labor and equipment mobilization and demobilization, and material deliveries. In total, 0.0065 worker fatalities and 0.62 worker injuries would be expected under this closure scenario. Overall, risks to workers would likely be higher under the CBR scenario and lower under the CIP scenario. Simultaneous with closure activities, the Site would be redeveloped for use in utility-scale solar generation and battery energy storage. The simultaneous pursuit of two large construction projects may lead to traffic congestion on Site access roads, resulting in greater overall risks to workers than would result from either project alone. The CIP scenario would likely result in less traffic congestion – and, hence, a smaller increase in risks to workers – than the CBR scenario.
Community Risks (Section 2.2.4.2, IAC Sections 845.710(b)(1)(D) and 845.710(b)(1)(F))		
▪ *Off-Site Impacts on Nearby Residents and EJ Communities*	Off-Site impacts on nearby residents (including accidents, traffic, noise, and air pollution) would be less under this closure scenario than under the CBR scenario because it would require less off-Site vehicle and equipment travel miles than the CBR scenario. In total, an estimated 0.0014 fatalities and 0.073 injuries would be expected to occur among community members due to off-Site activities under this scenario. No off-Site transport of CCR and/or borrow soil is required under this closure scenario. No impacts to nearby EJ communities are anticipated under this closure scenario.	Off-Site impacts on nearby residents would be greater under the CBR closure scenario than under the CIP scenario because it would require significantly more off-Site vehicle and equipment travel miles. In total, an estimated 0.0074 fatalities and 0.27 injuries would be expected to occur among community members due to off-Site activities under this scenario. With regard to traffic impacts, a haul truck would be likely to pass a location near the Site every 19 minutes on average during working hours for approximately 691 workdays over 20-30 months under this closure scenario. No impacts to nearby EJ communities are anticipated under this closure scenario.

Evaluation Factor (Report Section; IAC Part 845 Section)	Closure Scenario	
	CIP	**CBR**
▪ *Impacts on Scenic, Historical, and Recreational Value*	Due to (*e.g.*) noise and visual disturbances, construction activities may have short-term negative impacts on the recreational use of the Coffeen Lake State Fish and Wildlife Area. Because the expected duration of construction activities is shorter under this closure scenario compared to the CBR scenario, short-term impacts on the scenic and recreational value of natural areas near the Site would be less under this closure scenario than under the CBR scenario. There are no historical sites in the vicinity of the impoundment, the on-Site landfill, or the on-Site borrow soil location. Thus, no impacts on historical sites would be expected under any closure scenario.	Due to (*e.g.*) noise and visual disturbances, construction activities may have short-term negative impacts on the recreational use of the Coffeen Lake State Fish and Wildlife Area. Because the expected duration of construction activities is longer under the CBR scenario than under the CIP scenario, short-term impacts on the scenic and recreational value of natural areas near the Site would be greater under the CBR scenario than under the CIP scenario. There are no historical sites in the vicinity of the impoundment or the on-Site landfill. Thus, no impacts on historical sites would be expected under any closure scenario.
Environmental Risks (Section 2.2.4.3, IAC Sections 845.710(b)(1)(D) and 845.710(b)(1)(F))		
▪ *Impacts on Greenhouse Gas Emissions and Energy Consumption*	Total energy demands and GHG emissions would be smaller under this closure scenario than under the CBR scenario, because the total equipment and vehicle mileages required under this closure scenario would be smaller than those required under the CBR scenario. The CIP scenario would have an additional, unquantified carbon footprint due to the need to manufacture geomembranes for use in the final cover system. At the grid scale, construction of a solar facility at the Site would put energy back on the grid and reduce reliance on non-renewable energy sources. Redevelopment of the Site for solar would occur more rapidly under the CIP scenario than under the CBR scenario.	Total energy demands and GHG emissions would be greater under the CBR closure scenario than under the CIP scenario, because the total equipment and vehicle mileages required under this closure scenario would be greater than those required under the CIP scenario. If expansion of the off-Site landfill becomes necessary in order to accept all of the CCR and related materials from AP1, then the CBR scenario would have an additional, unquantified carbon footprint due to the need to manufacture geomembranes for use in the expanded landfill liner. At the grid scale, construction of a solar facility at the Site would put energy back on the grid and reduce reliance on non-renewable energy sources. Redevelopment of the Site for solar would occur more slowly under the CBR scenario than under the CIP scenario.
▪ *Impacts on Natural Resources and Habitat*	Construction may have short-term negative impacts on species located near AP1, the on-Site borrow soil location, the on-Site landfill, and the off-Site landfill. Construction may also cause a long-term shift in the habitat type atop portions of the impoundment. Short-term impacts on natural resources and habitat would be smaller under the CIP scenario than under the CBR scenario, because the overall duration of construction is shorter under the former scenario.	Construction may have short-term negative impacts on species located near AP1, the on-Site borrow soil location, the on-Site landfill, and the off-Site landfill. Construction may also cause a long-term shift in the habitat type atop portions of the impoundment. Short-term impacts on natural resources and habitat would be greater under the CBR scenario than under the CIP scenario, because the overall duration of construction is longer under the former scenario.
Time Until Groundwater Protection Standards Are Achieved (Section 2.2.5, IAC Sections 845.710(b)(1)(E) and 845.710(d)(2 and 3))	Groundwater modeling was performed to evaluate future groundwater quality in the vicinity of AP1 under each of the proposed closure scenarios (Ramboll, 2022). The groundwater modeling demonstrated that the groundwater concentrations in the monitoring wells within the UA will achieve GWPSs in 15 years with the exception of well G301 (Ramboll, 2022). The decline in post-closure groundwater concentrations at well G301 will be slower than at other locations because the well is located along the flow path of constituents that were released into the native geologic materials prior to closure. Because there will be reduced percolation of precipitation through the consolidation area within AP1 for the CIP scenario as a result of the cap, the time for concentrations to attenuate to levels below the GWPSs at well G301 is longer for the CIP scenario than for the CBR scenario.	Groundwater modeling was performed to evaluate future groundwater quality in the vicinity of AP1 under each of the proposed closure scenarios (Ramboll, 2022). The groundwater modeling demonstrated that the groundwater concentrations in the monitoring wells within the UA will achieve GWPSs in 15 years with the exception of well G301 (Ramboll, 2022). Additionally, changing geochemical conditions during an extended excavation can be a mechanism that results in the mobilization and increased transport in groundwater for some constituents. This may result in GWPS exceedance durations in excess of the model predictions.
Long-Term Reliability of the Engineering and Institutional Controls (Section 2.2.7; IAC Section 845.710(b)(1)(G))	CIP would be expected to be a reliable closure alternative over the long term.	CBR would be expected to be a reliable closure alternative over the long term.
Potential Need for Future Corrective Action (Section 2.2.8; IAC Section 845.710(b)(1)(H))	Corrective action is expected at the Site. An evaluation of potential corrective measures and corrective actions has not yet been completed, but will be conducted consistent with the requirements in IAC Section 845.660 and IAC Section 845.670.	Corrective action is expected at the Site. An evaluation of potential corrective measures and corrective actions has not yet been completed, but will be conducted consistent with the requirements in IAC Section 845.660 and IAC Section 845.670.
Effectiveness of the Alternative in Controlling Future Releases (Section 2.3; IAC Section 845.710(b)(2)(A and B))	There are no current or future risks to any human or ecological receptors associated with AP1. During closure, there would be minimal risk of dike failure occurring and minimal risk of dike overtopping during flood conditions. Post-closure, the risks of overtopping and dike failure would be even smaller than they are currently, due to the installation of a protective soil cover and new stormwater control structures. Dikes, final cover, and stormwater control features have been designed to withstand earthquakes and storm events.	There are no current or future risks to any human or ecological receptors associated with AP1. During closure, there would be minimal risk of dike failure occurring and minimal risk of dike overtopping during flood conditions. Following excavation, there would be no risk of CCR releases due to dike failure.
Ease or Difficulty of Implementing the Alternative (Section 2.4, IAC Section 845.710(b)(3))		

Evaluation Factor (Report Section; IAC Part 845 Section)	Closure Scenario	
	CIP	**CBR**
▪ *Degree of Difficulty Associated with Construction*	CIP is a reliable and standard method for managing and closing waste impoundments. Dewatering saturated CCR to construct a stabilized final cover system subgrade may present challenges during closure; however, these challenges are common to most CCR surface impoundment closures and are commonly addressed *via* surface water management and dewatering techniques.	Relative to CIP, CBR poses additional implementation difficulties due to higher earthwork volumes, higher dewatering volumes, and longer construction schedules. Hauling to an off-Site landfill would be required under the CBR scenario. Because the CCR would be hauled on public roads, it would require haul trucks with a smaller capacity (16.5 cubic yards *versus* 34 cubic yards) and would also need to be dewatered to a greater extent than would be necessary under the CIP scenario. Off-Site landfilling would additionally require the development of a disposal plan and could raise issues related to the co-disposal of CCR and other non-hazardous wastes. The off-Site landfill may also need to be expanded to receive all of the CCR generated during excavation.
▪ *Expected Operational Reliability*	Operational reliability would be expected under all closure scenarios.	Operational reliability would be expected under all closure scenarios.
▪ *Need for Permits and Approvals*	Permits required under all closure scenarios would include a modification to the existing NPDES permit; a construction permit from the IDNR Dam Safety Program to allow the embankment and spillways of AP1 to be modified as part of closure; a construction stormwater permit through IEPA; and a joint water pollution control construction and operating permit (WPC permit).	Permits required under all closure scenarios would include a modification to the existing NPDES permit; a construction permit from the IDNR Dam Safety Program to allow the embankment and spillways of AP1 to be modified as part of closure; a construction stormwater permit through IEPA; and a joint water pollution control construction and operating permit (WPC permit). Additional permits and approvals may be required under this scenario if the off-Site landfill must be expanded to receive all of the CCR from AP1.
▪ *Availability of Equipment and Specialists*	CIP and CBR rely on common construction equipment and materials and typically do not require the use of specialists. However, global supply chains have been disrupted due to the COVID-19 pandemic, resulting in shortages in the availability of construction equipment and parts. There may be delays in construction under all scenarios if supply chain resilience does not improve by the time of construction. Due to smaller earthwork volumes and a lesser need for construction equipment under the CIP scenario than under the CBR scenario, shortages may cause fewer challenges under the CIP scenario than under the CBR scenario.	CIP and CBR rely on common construction equipment and materials and typically do not require the use of specialists. However, global supply chains have been disrupted due to the COVID-19 pandemic, resulting in shortages in the availability of construction equipment and parts. There may be delays in construction under all scenarios if supply chain resilience does not improve by the time of construction. Due to higher earthwork volumes and a greater need for construction equipment under the CBR scenario than under the CIP scenario, shortages may cause greater challenges under the CBR scenario than under the CIP scenario.
▪ *Available Capacity and Location of Treatment, Storage, and Disposal Services*	Under the CIP scenario, all of the CCR currently within AP1 would be stored within the existing footprint of the impoundment. Treatment would consist of unwatering AP1 at the start of construction, performing limited dewatering to stabilize the CCR subgrade, and managing stormwater inflow. Water from unwatering and dewatering of AP1 would be discharged in accordance with the NPDES permit for the facility.	Under the CBR scenario, CCR currently within AP1 would be placed in the on-Site landfill until the on-Site landfill reaches capacity. The remaining CCR in AP1 would be hauled to the off-Site landfill. The capacity remaining at the chosen off-Site landfill in Litchfield, Illinois, would be sufficient to receive all of the CCR in AP1 that is not placed in the on-Site landfill. However, due to the relatively short period over which CCR would be received at the off-Site landfill, vertical and/or lateral expansions may become necessary. Additionally, the landfill operators may need to develop a disposal plan to account for the increased volume of material that would be received and the unique CCR waste characteristics. If expansion of the chosen off-Site landfill were found to be impractical or infeasible, then an alternative landfill located farther from the Site would need to be identified. A likely alternative to the Litchfield-Hillsboro Landfill is the Five Oaks Landfill in Taylorville, Illinois. Water from unwatering and dewatering of AP1 would be discharged in accordance with the NPDES permit for the facility.
Impact of Alternative on Waters of the State (Section 2.5, IAC Section 845.710(d)(4))	No current or future exceedances of any screening benchmarks for surface water would be expected under any closure scenario.	No current or future exceedances of any screening benchmarks for surface water would be expected under any closure scenario.
Potential Modes of Transportation Associated with CBR (Section 2.1; IAC Section 845.710(c)(1)	This factor is not relevant for CIP.	IAC Section 845.710(c)(1) requires CBR alternatives to consider multiple methods for transporting CCR off-Site, including rail, barge, and trucks. Golder evaluated the feasibility of transporting CCR to the off-Site landfill *via* rail or barge and found that neither option is viable at this Site. Truck transport has been identified as the preferred option for transport of CCR to the off-Site landfill. The local availability and use of natural gas-powered trucks, or other low-polluting trucks, will be evaluated prior to the start of construction.

Evaluation Factor (Report Section; IAC Part 845 Section)	Closure Scenario	
	CIP	**CBR**
Concerns of Residents Associated with Alternatives (Section 2.6, IAC Section 845.710(b)(4))	Despite the preference for CBR that has been expressed by nonprofits representing community interests near the Site, CIP would effectively address residents' concerns regarding potential impacts to groundwater and surface water quality at the Site. Relative to CBR, CIP also presents fewer risks to nearby residents in the form of accidents, traffic, noise, and air pollution. Moreover, under the CIP scenario, the Site could be more rapidly redeveloped for use in utility-scale solar generation and battery energy storage.	Nonprofits representing community interests near the Site have expressed a preference for CBR over CIP. However, the CBR scenario has several disadvantages with regard to potential community concerns. Relative to CIP, the CBR scenario presents greater risks to nearby residents in the form of accidents, traffic, noise, and air pollution. Moreover, under the CBR scenario, the Site could take longer to redevelop for use in utility-scale solar generation and battery energy storage.
Class 4 Cost Estimate (Section 2.7, IAC Section 845.710(d)(1))	A Class 4 cost estimate will be prepared in the Final Closure Plan consistent with AACE classification standards.	A Class 4 cost estimate will be prepared in the Final Closure Plan consistent with AACE classification standards.

Notes:

AACE = Association for the Advancement of Cost Engineering; AP1 = Ash Pond No. 1; CAA = Closure Alternatives Analysis; CBR = Closure-by-Removal; CCR = Coal Combustion Residual; CIP = Closure-in-Place; EJ = Environmental Justice; GHG = Greenhouse Gas; GWPS = Groundwater Protection Standard; IAC = Illinois Administrative Code; IDNR = Illinois Department of Natural Resources; IEPA = Illinois Environmental Protection Agency; NPDES = National Pollutant Discharge Elimination System; UA = Upper Aquifer.

1 Introduction

1.1 Site Description and History

1.1.1 Site Location and History

Illinois Power Generating Company's (IPGC) Coffeen Power Plant is an electric power generating facility with coal-fired units located approximately two miles south of the city of Coffeen, Illinois, between two lobes of Coffeen Lake. Historically, three room and pillar coal mines operated within the boundaries of the Site. From north to south, they are the Clover Leaf No. 1 Mine, which operated from 1889 to 1901; the Clover Leaf No. 4 Mine, which operated from 1906 to 1924; and the Hillsboro Mine, which operated from 1964 to 1983 (Ramboll, 2021a; ISGS and University of Illinois at Urbana-Champaign. 2011). The Coffeen Power Plant began operating in 1964 and was retired in November 2019 (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. 1 (AP1; Vistra identification [ID] No. CCR Unit 101, Illinois Environmental Protection Agency [IEPA] ID No. W1350150004-01, and National Inventory of Dams [NID] ID No. IL50722) is the subject of this report.

AP1 (Figure 1.1) is a 26.2-acre unlined surface impoundment constructed in 1964 for the management of bottom ash and other non-CCR waste generated historically by the facility (Ramboll, 2021a). It began operating in 1964 and stopped receiving sluiced ash in November 2019 (Ramboll, 2021a; AECOM, 2016a).

Initially, AP1 received CCR from the coal-fired units of the power plant, operating as a flow-through structure with outflow discharging to Coffeen Lake. AP1 primarily received bottom ash as well as low volume wastes *via* floor drains in the main power building. Later, AP1 was modified to recycle water on-Site. Reconstruction occurred from approximately 1979 to 1981 to abandon the discharge pipe to Coffeen Lake, add a recycle intake structure, and redirect flow through AP1 such that the outflow was returned to the Coffeen Power Plant for reuse as process water (Appendix B). Bottom ash was also removed for beneficial reuse from AP1 by third-party contractors (Ramboll, 2021a; Appendix B).

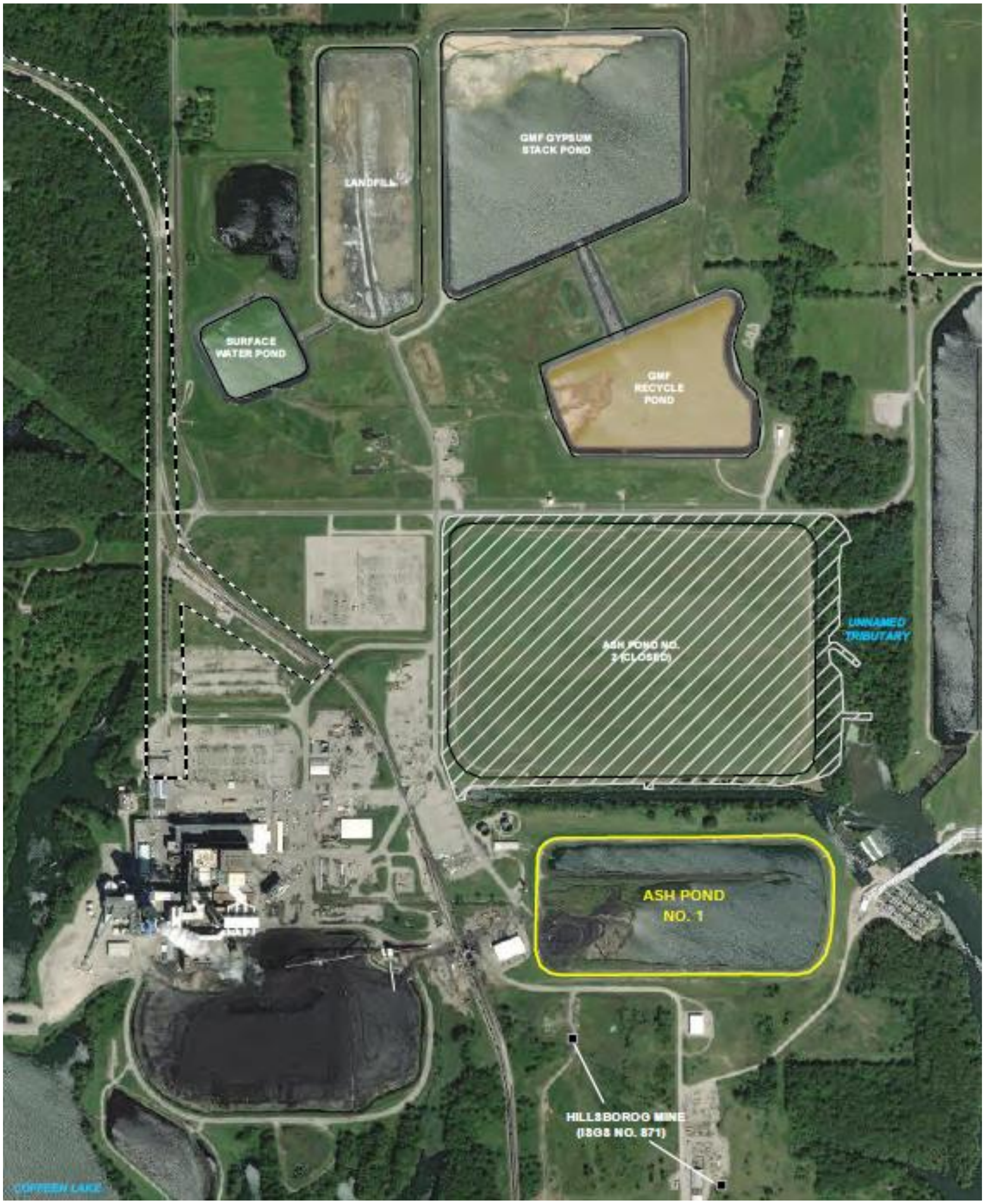

Figure 1.1 Site Location Map. GMF = Gypsum Management Facility. Adapted from Ramboll (2021a).

1.1.3 Surface Water Hydrology

Coffeen Lake has two lobes that border the Coffeen Power Plant on the west, south, and part of the eastern Site boundary. 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 (Ramboll, 2021a). The northeast corner of AP1 is located approximately 160 feet 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 760 feet northeast of AP1, and the East Fork of Shoal Creek is located approximately 4,300 feet east of AP1. Within 1,000 meters of AP1, there are several unnamed freshwater ponds and two freshwater emergent wetlands (Figure 1.2; Ramboll, 2021a). The ponds range in size from 0.2 acres to 4.8 acres. The emergent wetlands are 0.4 acre in size, located south of AP1, and 1.6 acres, located northeast of AP1 where the Unnamed Tributary enters Coffeen Lake (Figure 1.2).

The 1,100-acre Coffeen Lake was built 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 (IL EPA, 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, 2019a; 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).

Surface water samples were collected from six locations in Coffeen Lake in the vicinity of AP1 in August 2021 (Geosyntec, 2021). These data are summarized in Gradient's Human Health and Ecological Risk Assessment for the Site, which is provided as Appendix A of this report.

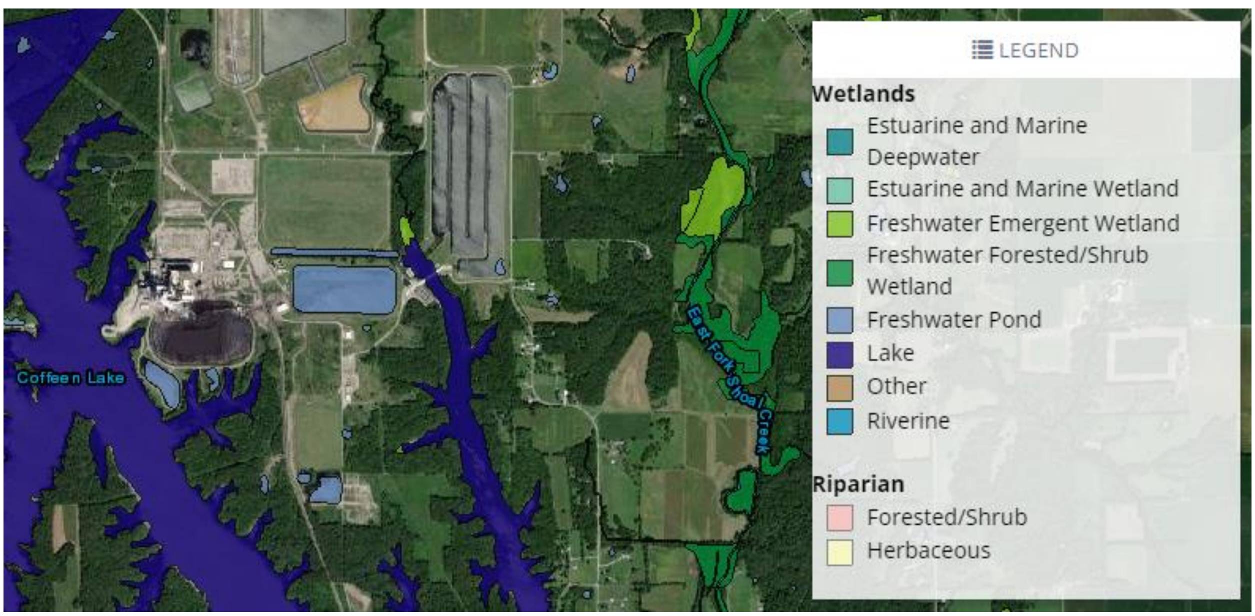

Figure 1.2 Wetlands and Surface Water Bodies in the Vicinity of the Coffeen Power Plant Ash Pond No. 1. Adapted from US FWS (2021).

1.1.4 Hydrogeology

The geology underlying the Site in the vicinity of AP1 consists of five distinct hydrostratigraphic units (Ramboll, 2021a):

- Upper Confining Unit (UCU): The UCU underlies AP1. 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 Coffeen Power

Plant except for the eastern edge of AP1 where soils were excavated during construction of the pond.

- 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 missing in several locations due to both excavation 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.
- Deep Aquifer (DA): The DA is a thin (generally less than 5-foot thick), discontinuous unit composed of sands and silty sands.
- 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 (Ramboll, 2021a).

Groundwater near AP1 flows north to northeast toward a former discharge structure and the Unnamed Tributary (Ramboll, 2021a). The "Hydrogeologic Site Characterization Report" prepared by Ramboll as part of the operating permit for AP1 includes an evaluation of groundwater data collected from AP1 monitoring wells between 2015 and 2021 (Ramboll, 2021a).

1.1.5 Site Vicinity

The Coffeen Power Plant 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 AP1 from 1906 until 1983. AP1 partially overlies the former Hillsboro Mine (Illinois State Geological Survey [ISGS] Mine No. 871), which operated from 1964 until 1983. The Clover Leaf No. 4 Mine (ISGS Mine No. 442) was located north to northwest of AP1 and operated from 1906 until 1924 (Ramboll, 2021a).

Although the area surrounding the Coffeen Power Plant 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, 1999). 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 meters of AP1 (Ramboll, 2021a).

1.2 IAC Part 845 Regulatory Review and Requirements

Title 35, Part 845 of the Illinois Administrative Code (IAC; IEPA, 2021a) requires the development of a Closure Alternatives Analysis (CAA) prior to undertaking closure activities at certain CCR-containing surface impoundments in the state of Illinois. Section 2 of this report presents a CAA for AP1 pursuant to requirements under IAC Section 845.710. The goal of a CAA is to holistically evaluate each potential closure scenario with respect to a wide range of factors, including the efficiency, reliability, and ease of implementation of the closure scenario; its potential positive and negative short- and long-term impacts on human health and the environment; and its ability to address concerns raised by residents (IEPA, 2021a). A CAA is a decision-making tool that is designed to aid in the selection of an optimal closure alternative for the impoundments at a site.

2 Closure Alternatives Analysis

2.1 Closure Alternative Descriptions (IAC Section 845.710(c))

This section of the report presents a CAA for AP1 pursuant to requirements under IAC Section 845.710 (IEPA, 2021a). The two closure scenarios evaluated in this CAA are Closure-in-Place (CIP) and Closure-by-Removal (CBR). Under the CIP scenario, the CCR would remain in place and AP1 would be capped with a new cover system. Under the CBR scenario, some of the CCR would be excavated from the impoundment and hauled to an on-Site landfill and the remainder of the CCR would be excavated from the impoundment and hauled to an off-Site landfill. IPGC will also continue to evaluate potential opportunities for beneficial reuse of CCR excavated from AP1 as an alternative to disposal.

IAC Section 845.710(c)(2) requires CAAs to, "[i]dentify whether the facility has an onsite landfill with remaining capacity that can legally accept CCR, and, if not, whether constructing an onsite landfill is possible" (IEPA, 2021a). There is an existing on-Site landfill at the Coffeen Power Plant Site with some capacity to accept CCR, but it does not have enough capacity to contain all of material that would be removed from AP1. Furthermore, due to the planned redevelopment of the Site as a utility-scale solar energy generation and battery energy storage facility, there is not sufficient space available to expand the existing landfill.

Sections 2.1.1 and 2.1.2 provide detailed descriptions of the CIP and CBR closure scenarios. These scenarios are based on closure documents and analyses provided to Gradient by Golder, which are attached to this report as Appendix B.

2.1.1 Closure-in-Place

Under the CIP scenario, AP1 would be capped in place with a final cover system. This scenario includes the following work elements (Golder Associates USA Inc., 2022; Appendix B):

- Unwatering and dewatering of the impoundment *via* pumping and passive dewatering methods. The CCR will dewater to some degree by gravity. Pumping from trenches and sumps is also expected to be necessary. Water would be pumped to the existing drainage to the north of AP1 and managed in accordance with the NPDES permit for the facility.
- Decontamination and demolition/disposal of the riser structure and outlet pipes. The riser structure will be disposed of in the consolidated footprint, and the outlet pipes will be plugged and abandoned or removed and disposed of. Decontamination water will be managed in accordance with the NPDES permit for the facility.
- Consolidation of the CCR in AP1 by excavating CCR and up to 1 foot of underlying soil from the eastern portion of AP1 into the western portion of AP1.
- Construction of a berm oriented north-south on the east end of the consolidated footprint.
- Construction of an alternative cover system consisting of a 40-mil linear low-density polyethylene (LLDPE) geomembrane layer, a nonwoven geotextile cushion, and 24 inches of

protective soil cover suitable for supporting vegetative growth. An alternative cover performance demonstration will be submitted to IEPA for approval pursuant to Section 845.750(c)(2).

- Construction of a free-draining stormwater management system, including berms, channels, and letdown structures, that will convey stormwater from the consolidated closure area to existing surface water bodies.
- Removal of existing earthen embankments not required for the consolidated footprint and excavation of a channel to allow stormwater to flow off-Site in accordance with the NPDES permit for the facility.
- Filling the low areas east of the consolidated footprint using soil sourced from existing berms that are no longer required or from the on-Site soil borrow area southeast of AP1 to provide at least 1 foot of soil cover above the top of the UA and establish the final ground surface.
- Long-term (post-closure) monitoring and maintenance, including at least 30 years of groundwater monitoring at the impoundment, or until such time as groundwater protection standards (GWPSs) are achieved. Additionally, 30 years of post-closure care would be undertaken for the final cover system, including annual cap inspections, mowing, and maintenance.

This CIP plan meets all closure requirements of IAC Part 845.750 (IEPA, 2021a). Key closure elements that address the Part 845 closure requirements are summarized below. Further details are provided in the Closure Plan (Golder Associates USA Inc., 2022).

- An alternative cover system would be installed over the CCR that remains in AP1. The cover, consisting of a 40-mil LLDPE geomembrane low-permeability layer, a geotextile cushion if needed, and 24 inches of soil, would minimize vertical infiltration of precipitation into the basin [Part 845.750(a)(1)].
- The final cover system would be gently sloped to direct surface water away from the impoundment. Beyond the final cover system, channels would direct surface water away from AP1 to existing Site drainages [Part 845.750(a)(2)].
- Impounded water would be removed from AP1 and managed in accordance with the NPDES permit for the facility [845.750(b)(1) and 845.750(b)(2)].
- Free liquids in the CCR would be eliminated by removing liquid wastes or solidifying the remaining wastes. Trenches would facilitate gravity drainage of liquid wastes in the CCR and direct the liquid wastes to sumps. Other engineering measures may be considered to facilitate removal of liquid wastes and stabilization of wastes. Sumps would be used to collect liquid wastes, which would be managed in accordance with the NPDES permit for the Site [845.750(b)(1) and 845.750(b)(2)].

Furthermore, during the closure process, we will continue to assess off-Site CCR beneficial use opportunities. Ash consolidation and closure in place in combination with off-Site beneficial use may result in a smaller footprint for purposes of our ultimate cap design along with a reduced construction schedule.

Under this scenario, approximately 305,000 cubic yards (CY) of CCR and subsoil would be relocated to the western portion of AP1 (an assumed travel distance of 2,000 feet; Appendix B). Construction of the final cover system for the impoundment and contouring east of the consolidated footprint would require an additional 109,000 CY of clean soil, which would be sourced from existing berms, and if needed, elsewhere on Site (an assumed travel distance of 2,000 feet; Appendix B). Borrow soil would be hauled on Site using trucks with an assumed capacity of 34 CY.

Under the CIP scenario, the overall expected duration of closure activities (including closure of the impoundment and site restoration) is approximately 17 to 24 months (1.4 to 2.0 years; Golder 2022). The total expected number of on-Site workdays is 503 (Appendix B). Key parameters for the CIP scenario are shown in Table 2.1.

Table 2.1 Key Parameters for the Closure-in-Place Scenario

Parameter	
Surface Area of AP1	26.2 acres
Surface Area of Final Cover System	10.4 acres
Hauled Volume of CCR and Subsoil to be Relocated	305,000 CY
Average Travel Distance for Relocation of CCR	2,000 feet
Hauled Volume of Borrow Soil	109,000 CY
Average Distance to On-Site Borrow Soil Location	2,000 feet
Duration of Construction Activities	503 days
Labor Hours	
Total On-Site Labor	25,100 hours
Total Off-Site Labor	3,980 hours
30% Contingency	8,720 hours
Total Labor Hours:	37,800 hours
Vehicle and Equipment Travel Miles	
Vehicles On-Site	8,850 miles
Equipment On-Site	37,700 miles
On-Site Haul Trucks (Unloaded + Loaded)	9,210 miles
Labor Mobilization	211,000 miles
Equipment Mobilization (Unloaded + Loaded)	43,100 miles
Off-Site Haul Trucks (Unloaded + Loaded)	0 miles
Material Deliveries (Unloaded + Loaded)	13,900 miles
Total On-Site Vehicle and Equipment Travel Miles:	55,800 miles
Total Off-Site Vehicle and Equipment Travel Miles:	268,000 miles
Total Vehicle and Equipment Travel Miles:	324,000 miles

Notes:
AP1 = Ash Pond No. 1; CCR = Coal Combustion Residual; CY = Cubic Yards.
Hauled volumes of CCR and soil are 5% greater than "in-place" volumes.
Due to rounding, totals may not match the sum of the values.
Source: Appendix B.

2.1.2 Closure-by-Removal

Under the CBR scenario, CCR would be excavated from AP1 and approximately 63% of the CCR would be transported to the on-Site landfill for disposal, and the remainder would be transported to an off-Site landfill for disposal. The on-Site landfill would be located approximately 1 mile north of AP1 along Site roads (Appendix B).

The preferred off-Site landfill for final disposal of the remaining CCR is Republic Services' Litchfield-Hillsboro Landfill in Litchfield, Illinois, which is located approximately 18 miles from the Site (Appendix B). CCR would be hauled to the off-Site landfill using haul trucks with a capacity of 16.5 CY, a smaller capacity than that of the haul trucks that would haul CCR to the on-Site landfill (34 CY) due to restrictions placed on the size of trucks that can be used on public roadways. As is described below in Section 2.4.5, it is possible that the Litchfield-Hillsboro Landfill would have to be expanded in order to accept all of the material excavated from AP1.

IAC Section 845.710(c)(1) requires CBR alternatives to consider multiple methods for transporting CCR off-Site, including rail, barge, and trucks. Golder evaluated the feasibility of transporting CCR to the off-Site landfill *via* rail or barge and found that neither option is viable at this Site (Appendix B). Transporting CCR by rail would require the construction of a new rail loading terminal on-Site and the construction of a new rail unloading terminal near the off-Site landfill. The construction of new rail terminals would require coordination with the railroad and additional permitting, which could negatively impact the project schedule. Trucks would still be needed to haul CCR to and from the terminals, and additional CCR exposures could occur during the loading and unloading of CCR into trucks and rail cars. Moreover, because there is no direct rail route from the Site to the off-Site landfill, the transport of CCR to the off-Site landfill would require 25 miles of rail transport on tracks owned by three separate rail lines.

The Coffeen Power Plant is not located near a navigable waterway, thus transportation of CCR by barge is not feasible. For these reasons, truck transport has been identified as the preferred option for transport of CCR to the off-Site landfill. Transport *via* truck would not require the construction of additional loading or unloading infrastructure and would not result in project delays due to permitting and coordination with other parties. The existing travel routes from the Site to the off-Site landfill are suitable for CCR transport *via* truck (Appendix B). The local availability and use of natural gas-powered trucks, or other low-polluting trucks, will be evaluated prior to the start of construction.

This scenario includes the following work elements (Appendix B):

- Unwatering and dewatering of the impoundment *via* pumping and passive dewatering methods. The CCR will dewater to some degree by gravity. Pumping from trenches and sumps is also expected to be necessary. Water would be pumped to the existing drainage to the north of AP1 and managed in accordance with the NPDES permit for the facility.
- Construction of temporary stormwater control structures, including ditches and sumps, to maintain AP1 in an unwatered state and convey runoff away from the impoundment.
- Excavation of approximately 311,000 CY of CCR from the impoundment and transport of these materials to the on-Site landfill.
- Excavation of the remaining CCR and up to 1 foot of subsoil (approximately 184,000 CY) from the impoundment, and transport of these materials to the off-Site landfill. Subsoils with CCR staining would be excavated with the CCR.
- Decontamination and demolition/disposal of the riser structure and outlet pipes. The riser structure will be disposed of in the offsite landfill, and the outlet pipes will be plugged and abandoned or removed and disposed. Decontamination water will be managed in accordance with the NPDES permit for the facility.
- Removal of earthen embankments and excavation of a channel to allow stormwater to flow offsite in accordance with the NPDES permit for the facility.
- Filling the low areas east of the consolidated footprint using soil sourced from existing berms to provide at least 1 foot of soil cover above the top of the UA and establish the final ground surface.
- Site restoration, including the placement of 6 inches of topsoil along the side slopes and bottom of AP1 and revegetation with native grasses.
- Monitoring for 3 years post-closure or until such time as GWPSs are achieved, whichever is longer.

Under this scenario, soil for backfilling of the impoundment and site restoration would be sourced from existing berms, and if needed, elsewhere on Site (an assumed average travel distance of approximately 2,000 feet; Appendix B). In total, 40,500 CY of clean borrow soil would be required under this scenario. A haul truck capacity of 34 CY is assumed for the on-Site transport of borrow soil (Appendix B).

The on-Site landfill currently has approximately 375,500 CY of available capacity. Thus, the on-Site landfill does not have sufficient capacity to receive all of the CCR from AP1 that is slated for disposal under this scenario. Expansion of the landfill is not viable due to the planned redevelopment of the Site as a utility-scale solar energy generation and battery energy storage facility. This scenario meets the requirements of IAC Section 845.710(c)(2) (IEPA, 2021a), which requires an assessment be included in the CAA of whether the Site has an on-Site landfill with available capacity or whether an on-Site landfill can be constructed.

Under the CBR scenario, the overall expected duration of closure activities (including closure of the impoundment and site restoration) is approximately 20 to 30 months (1.7 to 2.5 years). The total expected number of on-Site workdays is 691 (Appendix B). Key parameters for the CBR scenario are shown in Table 2.2.

Table 2.2 Key Parameters for the Closure-by-Removal Scenario

Parameter	Value
Surface Area of AP1	26.2 acres
Distance from AP1 to the On-Site Landfill	1 mile
Distance to the Off-Site Landfill	18 miles
Distance from AP1 to the On-Site Borrow Location	2,000 feet
Hauled Volume of CCR to On-Site Landfill	311,000 CY
Hauled Volume of CCR and Subsoil to Off-Site Landfill	184,000 CY
Hauled Volume of Borrow Soil	40,500 CY
Duration of Construction Activities	691 days
Labor Hours	
Total On-Site Labor	27,800 hours
Total Off-Site Labor	20,800 hours
30% Contingency	14,600 hours
Total Labor Hours:	63,100 hours
Vehicle and Equipment Travel Miles	
Vehicles On-Site	13,700 miles
Equipment On-Site	72,500 miles
On-Site Haul Trucks (Unloaded + Loaded)	19,200 miles
Labor Mobilization	387,000 miles
Equipment Mobilization (Unloaded + Loaded)	59,200 miles
Off-Site Haul Trucks (Unloaded + Loaded)	400,000 miles
Material Deliveries (Unloaded + Loaded)	7,000 miles
Total On-Site Vehicle and Equipment Travel:	105,000 miles
Total Off-Site Vehicle and Equipment Travel:	853,000 miles
Total Vehicle and Equipment Travel:	958,000 miles

Notes:
AP1 = Ash Pond No. 1; CCR = Coal Combustion Residual; CY = Cubic Yard.
Due to rounding, totals may not match the sum of the values.
Hauled volumes of CCR and soil are 5% greater than "in-place" volumes.
Source: Appendix B.

2.2 Long- and Short-Term Effectiveness of the Closure Alternative (IAC Section 845.710(b)(1))

2.2.1 Magnitude of Reduction of Existing Risks (IAC Section 845.710(b)(1)(A))

This section of the report addresses the potential risks to human and ecological receptors due to exposure to CCR-associated constituents in groundwater or surface water. Gradient has performed a Human Health and Ecological Risk Assessment for the Site (Appendix A of this report), which provides a detailed evaluation of the magnitude of existing risks to human and ecological receptors associated with AP1. This report concluded that there are no current unacceptable risks to any human or ecological receptors associated with AP1. Because there are no current risks to any human or ecological receptors, and dissolved constituent concentrations would be expected to decline post-closure, no post-closure risks would be expected under any closure scenario. Thus, there would be no current risk or future risk under any closure scenario, and the magnitude of reduction of existing risks would be the same under every closure scenario.

2.2.2 Likelihood of Future Releases of CCR (IAC Section 845.710(b)(1)(B))

This section of the report quantifies the risk of future releases of CCR that may occur during dike failure and storm-related events.

Storm-Related Releases and Dike Failure During Flood Conditions

Based on the effective Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map for the Site, AP1 is not located within the 100-year flood zone for Coffeen Lake and the Unnamed Tributary (FEMA, 1981). Engineering analyses show that the risk of overtopping occurring during flood conditions is also minimal under current conditions. Specifically, AECOM evaluated the risk of flood overtopping occurring at AP1 and found that the impoundment can adequately manage flow during peak discharge from even a 1,000-year storm event, thus preventing overtopping (AECOM, 2016b,c). Additionally, engineering analyses show that the AP1 dikes are expected to remain stable under static, seismic, and flood conditions (AECOM, 2016b,c). Prior to closure (*i.e.*, under current conditions), the risk of dike failure occurring during floods or other storm-related events is therefore minimal. Post-closure, the risks of overtopping and dike failure occurring due to floods or other storm-related events would be even smaller than they are currently. Under the CIP scenario, a new cover system would be installed, which would include 24 inches of soil and a geomembrane liner, as well as new stormwater control structures. Relative to current conditions, this cover system would provide increased protection against berm and surface erosion, groundwater infiltration, and other adverse effects that could potentially trigger a dike slope failure event. Under the CBR scenario, all of the CCR in AP1 would be excavated and relocated, eliminating the risk of a CCR release occurring post-closure. In summary, there is minimal current or future risk of sudden CCR releases occurring under any closure scenario either during or following closure.

Dike Failure Due to Seismicity

Sites in Illinois may be subject to seismic risks arising from the Wabash Valley Seismic Zone and the New Madrid Seismic Zone (IEMA, 2020). The Coffeen Power Plant property lies within a seismic impact zone (Ramboll, 2021a; Haley & Aldrich, Inc., 2018a). However, all structural components of AP1 have been designed to resist the maximum horizontal acceleration in lithified earth material for the Site. AP1 therefore meets the seismic safety requirements of 40 Code of Federal Regulations (CFR) Section 257.63(a) and IAC Section 845.330, and the overall risk of dike failure due to seismicity is expected to be low (Ramboll, 2021a; Haley & Aldrich, Inc., 2018a). Additionally, AP1 does not lie within 200 feet of an active fault or fault damage zone at which displacement has occurred within the current geological epoch (*i.e.*, within the last ~11,650 years; Haley & Aldrich, Inc., 2018b). The nearest known faults are the Crown Fault, which is located about 31 miles northwest of AP1, and the Centralia Fault zone, which is located about 35 miles southeast of AP1. These faults do not have known recent activity (Haley & Aldrich, Inc., 2018b); however, a magnitude 3.8 earthquake occurred approximately 15 miles south of AP1 in 1981, and a magnitude 3.6 earthquake occurred approximately 20 miles southeast of AP1 in 1990 (Ramboll, 2021a). Having met the seismic safety requirements, the risk of dike failure occurring during or following closure activities due to seismic activity is low at AP1.

2.2.3 Type and Degree of Long-Term Management, Including Monitoring, Operation, and Maintenance (IAC Section 845.710(b)(1)(C))

The long-term operation and management plans for AP1 and the on-Site landfill under each closure scenario are described in Section 2.1 (Closure Alternatives Descriptions). In summary, under the CIP scenario, AP1 would undergo monitoring for 30 years post-closure, or until such time as GWPSs are achieved. The post-closure care plan for the CIP scenario would additionally include annual inspections, mowing, and maintenance of the final cover system. Under the CBR scenario, AP1 would undergo monitoring for 3 years post-closure, or until such time as GWPSs are achieved.

2.2.4 Short-Term Risks to the Community or the Environment During Implementation of Closure (IAC Section 845.710(b)(1)(D))

2.2.4.1 Worker Risks

Best practices would be employed during construction in order to ensure worker safety and comply with all relevant regulations, permit requirements, and safety plans. However, it is impossible to completely eliminate the risk of accidents occurring during construction activities, both on- and off-Site. On-Site accidents include injuries and deaths arising from the use of heavy equipment and/or earthmoving operations during construction activities. Off-Site accidents include injuries and deaths due to vehicle accidents during labor and equipment mobilization/demobilization, material deliveries, and the hauling of borrow soil and CCR.

As shown in Tables 2.1 through 2.3, Golder estimates that the CIP scenario would require 25,100 on-Site labor hours and the CBR scenario would require approximately 27,800 on-Site labor hours (Appendix B). 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 US Bureau of Labor Statistics and the on-Site labor hours reported in Appendix B, we estimate that approximately 0.29 worker injuries and 0.0019 worker fatalities would occur on-Site under the CIP scenario; approximately 0.32 worker injuries and 0.0021 worker fatalities would occur on-Site under the CBR scenario (Table 2.4). The rate of on-Site worker accidents is therefore expected to be higher under the CBR scenario and lower under the CIP scenario.

Table 2.3 Expected Number of On-Site Worker Accidents Under Each Closure Scenario

Closure Scenario	Injuries	Fatalities
CIP	0.29	0.0019
CBR	0.32	0.0021

Notes:
CBR = Closure-by-Removal; CIP = Closure-in-Place.

Off-Site, a greater number of haul truck miles, labor and equipment mobilization/demobilization miles, and material delivery miles would be required under the CBR scenario than would be required under the CIP scenario (Tables 2.1 through 2.3). For example, under the CBR scenario, 400,000 haul truck miles would be required to haul CCR from the Site, and under the CIP scenario, off-Site hauling is not required (Appendix B). The United States Department of Transportation (US DOT, 2020) provides estimates of the expected number of fatalities and injuries "per vehicle mile driven" for drivers and passengers of large trucks and passenger vehicles. Table 2.5 shows the expected number of off-Site accidents under each closure scenario due to all categories of off-Site vehicle usage. For these calculations, it was assumed that labor mobilization/demobilization would rely on passenger vehicles (cars or light trucks, including pickups, vans, and sport utility vehicles) and that hauling, equipment mobilization/demobilization, and material deliveries would rely on large trucks. Based on US DOT's accident statistics and the mileage estimates in Appendix B, an estimated 0.14 worker injuries and 0.0018 worker fatalities would be expected to occur due to off-Site activities under the CIP scenario; and an estimated 0.30 worker injuries and 0.0044 worker fatalities would be expected to occur due to off-Site activities under the CBR scenario.

Table 2.4 Expected Number of Off-Site Worker Accidents Under Each Closure Scenario

Off-Site Vehicle Use Category	CIP		CBR	
	Injuries	Fatalities	Injuries	Fatalities
Hauling	0	0	0.051	0.0012
Labor Mobilization/Demobilization	0.13	0.0017	0.24	0.0030
Equipment Mobilization/Demobilization	0.0055	0.00013	0.0076	0.00017
Material Deliveries	0.0018	0.000040	0.00090	0.000020
Total:	0.14	0.0018	0.30	0.0044

Notes:
CBR = Closure-by-Removal; CIP = Closure-in-Place.

Overall, taking into account accidents occurring both on- and off-Site, 0.43 worker injuries and 0.0037 worker fatalities would be expected under the CIP scenario, and 0.62 worker injuries and 0.0065 worker fatalities would be expected under the CBR scenario. Thus, overall risks to workers would be higher under the CBR scenario and lower under the CIP scenario.

Concurrently with closure activities, a utility-scale solar facility or battery energy storage facility would be constructed on the Coffeen Power Plant Site. The simultaneous pursuit of closure-related construction and solar/energy storage facility construction may lead to traffic congestion on Site access roads, resulting in greater overall risks to workers than would result from closure or solar/energy storage redevelopment alone. Because the CIP scenario would require less hauling activity (and other forms of ingress and egress to and from the Site) than the CBR scenario and would also be completed over a shorter time period, the CIP scenario would be expected to result in less congestion on Site access roads during Site redevelopment – and, hence, a smaller increase in the risks to workers – than would occur under the CBR scenario.

In summary, risks to workers due to accidents would be expected to be greater under the CBR scenario than under the CIP scenario. Differences in worker risks between the two scenarios would largely be driven by off-Site activities.

2.2.4.2 Community Risks

Accidents

Vehicle accidents that occur off-Site can result in injuries or fatalities among community members, as well as workers. Based on the accident statistics reported by US DOT (2020) and the off-Site travel mileages reported in Appendix B, off-Site vehicle accidents could result in an estimated 0.073 injuries and 0.0014 fatalities among community members (*i.e.*, people involved in haul truck accidents that are neither haul truck drivers nor passengers, including pedestrians, drivers of other vehicles, *etc.*) under the CIP scenario (Table 2.6). Under the CBR scenario, off-Site vehicle accidents could result in an estimated 0.27 community injuries and 0.0074 community fatalities.

Table 2.5 Expected Number of Community Accidents Under Each Closure Scenario

Off-Site Vehicle Use Category	CIP		CBR	
	Injuries	Fatalities	Injuries	Fatalities
Hauling	0	0	0.15	0.0053
Labor Mobilization/Demobilization	0.052	0.00067	0.10	0.0012
Equipment Mobilization/Demobilization	0.016	0.00057	0.022	0.00079
Material Deliveries	0.0051	0.00018	0.0026	0.000093
Total:	0.073	0.0014	0.27	0.0074

Notes:
CBR = Closure-by-Removal; CIP = Closure-in-Place.

Traffic

Haul routes would be expected to use major arterial roads and highways wherever possible, which would reduce the incidence of traffic. However, the heavy use of local roads for construction operations may result in traffic near the Site and the off-Site landfill. Traffic could potentially cause travel delays on local roads and damage to local roadways. It could also cause delays in the redevelopment of the Site for use in utility-scale solar generation and battery energy storage.

Traffic may increase temporarily around the Site under all closure scenarios due to the daily arrival and departure of the workforce, equipment mobilization/demobilization, and material deliveries. However, these impacts would be expected to largely occur at the beginning or end of each workday (during the arrival/departure of the workforce), at the beginning or end of the construction period (during equipment mobilization/demobilization), and at specific times throughout the construction period (during material deliveries). These impacts would therefore likely be less disruptive to community members than the constant and steady movement of haul trucks to and from the Site due to CCR hauling. Under the CBR scenario, hauling-related construction activities would be expected to take approximately 691 workdays and require approximately 11,200 truckloads (Appendix B). Assuming 10-hour working days, a haul truck would need to pass a given location near the Site once every 19 minutes on average over 20 to 30 months under this closure scenario. Under the CIP scenario, off-Site hauling is not required.

Noise

Construction generates a great deal of noise, both in the vicinity of the Site and along haul routes. In a closure impact analysis performed by the Tennessee Valley Authority (TVA, 2015), the authors found that "[T]ypical noise levels from construction equipment used for closure are expected to be 85 dBA or less when measured at 50 ft. These types of noise levels would diminish with distance…at a rate of approximately 6 dBA per each doubling of distance and therefore would be expected to attenuate to the recommended EPA noise guideline of 55 dBA at 1,500 ft." Because there are no residences or businesses within 1,500 feet of any of the construction areas on the Site (the impoundment, the on-Site landfill, and the borrow soil location), we do not anticipate that any residences or businesses would be adversely impacted by noise pollution at the Site under any closure scenario. However, recreators and wildlife in the Coffeen Lake SFWA, which lies within 1,500 feet of AP1, could be temporarily impacted by construction noise under both scenarios. The duration of noise impacts in the vicinity of AP1 would be greater under the CBR scenario than under the CIP scenario, because the expected duration of construction is longer (17 to 24 months under the CIP scenario *vs.* 20 to 30 months under the CBR scenario).

In addition to impacts in the immediate vicinity of planned construction areas at the Site, local roads near the Site and the off-Site landfill (CBR scenario only) may also experience noise pollution due to high volumes of truck traffic. As described above (Traffic), the construction schedule for the CBR scenario requires haul trucks to pass by a given location every 19 minutes on average for 10 hours each workday for approximately 20 to 30 months. Dump trucks generate significant noise pollution, with noise levels of approximately 88 decibels or higher expected within a 50-foot radius of the truck (Exponent, 2018). This noise level is similar to the noise level of a gas-powered lawnmower or leaf blower (CDC, 2019). Decibel levels above 80 can damage hearing after 2 hours of exposure (CDC, 2019).

In addition to haul truck impacts, noise pollution may also arise from the daily arrival and departure of the workforce, equipment mobilization/demobilization, and material deliveries. These impacts would be expected to largely occur at the beginning or end of each workday (during the arrival/departure of the workforce), at the beginning or end of the construction period (during equipment mobilization/demobilization), and at specific times throughout the construction period (during material deliveries). These impacts would therefore likely be less disruptive to community members than the constant and steady movement of haul trucks to and from the Site. In summary, noise impacts are likely to be greater under the CBR scenario than under the CIP scenario due to the need for off-Site hauling.

Air Quality

Construction can adversely impact air quality. Air pollution can occur both on-Site and off-Site (*e.g.*, along haul routes), potentially impacting workers as well as community members. With regard to construction activities, two categories of air pollution are of particular concern: equipment emissions and fugitive dust. The equipment emissions of greatest concern are those found in diesel exhaust. Most construction equipment is diesel-powered, including the dump trucks that would be used to haul material to and from the Site. Diesel exhaust contains numerous air pollutants, including nitrogen oxides (NO_x), particulate matter (PM), carbon monoxide (CO), and volatile organic compounds (VOCs; Hesterberg *et al*., 2009; Mauderly and Garshick, 2009). Fugitive dust, another major air pollutant at construction sites, is generated by earthmoving operations and other soil- and CCR-handling activities. Along haul routes, an additional source of fugitive dust is road dust along unpaved dirt roads. Careful planning and the use of Best Management Practices (BMPs) such as wet suppression are used to minimize and control fugitive dust during construction activities; however, it is not possible to prevent dust generation entirely.

On-Site, emissions would be higher under the CBR scenario than under the CIP scenario, due to the greater amount of on-Site vehicle and equipment travel miles required under this scenario (55,800 total on-Site travel miles under the CIP scenario *vs.* 105,000 total on-Site travel miles under the CBR scenario; Tables 2.1 and 2.2). Off-Site, emissions would similarly be higher under the CBR scenario than under the CIP scenario due to the greater amount of off-Site vehicle and equipment travel miles required under the CBR scenario (268,000 total off-Site travel miles under the CIP scenario *vs.* 853,000 total off-Site travel miles under the CBR scenario).

Environmental Justice

The State of Illinois defines environmental justice (EJ) communities to be those communities with a minority population above twice the state average and/or a total population below twice the state poverty rate (IEPA, 2019b).

As shown in a map of EJ communities throughout the state (IEPA, 2019b), the outer perimeter of the 1-mile buffer zone for the nearest EJ community lies approximately 10 miles south of the Site near Greenville (Figure 2.1). As described above (Noise), significant noise impacts due to construction are expected to be limited to potential receptors located within 1,500 feet (0.28 miles) of the Site. Similarly, the air quality impacts of construction are expected to be limited to potential receptors located within 1,000 feet (0.19 miles) of the Site (CARB, 2005; BAAQMD, 2017). Along heavily trafficked roadways, air quality impacts are expected to be limited to potential receptors located within 600 feet of the roadway

(0.11 miles; US EPA, 2014). The EJ community near Greenville is therefore unlikely to be directly impacted by on-Site air emissions, noise pollution, or other negative impacts arising at the Site. However, they may be impacted by off-Site impacts, including labor and equipment mobilization/demobilization, and material deliveries. Off-Site impacts due to labor and equipment mobilization/demobilization and material deliveries would be expected to be diffuse (*i.e.,* to span a wide range of transport routes originating over a wide area). Additionally, these impacts would be expected to largely occur at the beginning or end of each workday (during the arrival/departure of the workforce), at the beginning or end of the construction period (during equipment mobilization/demobilization), and at specific times throughout the construction period (during material deliveries).

Off-Site hauling of CCR and excavated subsoil is evaluated in this report. Under the CBR scenario, EJ communities located along the haul route to the off-Site landfill or near the off-Site landfill itself may be negatively impacted throughout the excavation period by the air pollution, noise, traffic, and accidents generated by CCR-hauling activities. A review of the Illinois map of EJ communities reveals that the off-Site landfill is not located within the 1-mile buffer zone of an EJ community. Additionally, based on the two major haul routes suggested by Google Maps (Google, LLC, 2022), transport of CCR to the landfill will not require hauling CCR through the buffer zone of an EJ community (Figure 2.1).

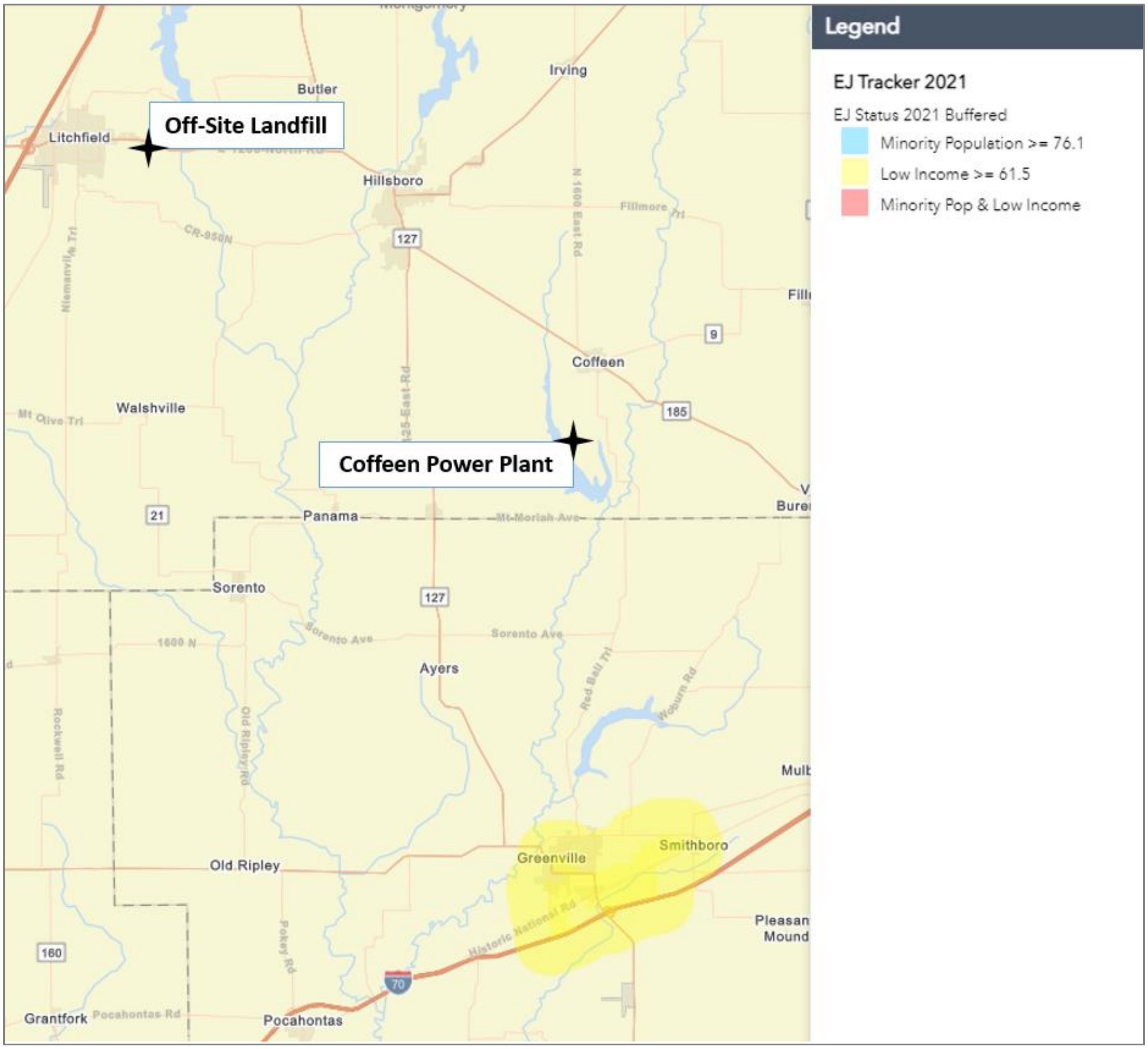

Figure 2.1 Environmental Justice Communities in the Vicinity of the Site and the Off-Site Landfill. EJ = Environmental Justice. Adapted from IEPA (2019b).

Scenic, Historical, and Recreational Value

During construction activities, negative impacts on scenic and recreational value may occur within the Coffeen Lake SFWA. Noise impacts were described above. In addition, construction activities at AP1 may be visible to recreators using these scenic and recreational areas, potentially interfering with enjoyment of the view. Negative impacts would not be expected to occur within any scenic or recreational areas located further away from the Site. The expected duration of construction activities is longer under the CBR scenario than under the CIP scenario (17 to 24 months under the CIP scenario *vs.* 20 to 30 months under the CBR scenario). It is therefore anticipated that short-term impacts on the scenic and recreational value of natural areas near the Site would be greater under the CBR scenario than under the CIP scenario.

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 meters of AP1 or the on-Site landfill (Ramboll, 2021a).

2.2.4.3 Environmental Risks

Greenhouse Gas Emissions

In addition to the air pollutants listed above in Section 2.2.4.2, construction equipment emits greenhouse gases (GHGs), including carbon dioxide (CO_2) and possibly nitrous oxide (N_2O). The potential impact of each closure scenario on GHG emissions is proportional to the potential impact of each closure scenario on other emissions from construction vehicles and equipment, as described above in Section 2.2.4.2. In summary, GHG emissions from construction equipment and vehicles would be greater under the CBR scenario than under the CIP scenario, because the total on-Site and off-Site vehicle and equipment travel miles required under the CBR scenario (958,000 total vehicle and equipment travel miles) are greater than the total required under the CIP scenario (324,000 total vehicle and equipment travel miles; Tables 2.1 and 2.2).

We did not quantify the carbon footprint of the approximately 10.4 acres of a 40-mil LLDPE geomembrane liner required for the final AP1 cover system under the CIP scenario. The carbon footprint of this geomembrane (*i.e.*, the fossil fuel emissions required to manufacture it) is an additional source of GHG emissions at the Site under the CIP scenario. The potential expansion of the off-Site landfill under the CBR scenario would have an additional, unquantified carbon footprint due to the manufacture of geomembranes used in the expanded landfill liners.

Energy Consumption

Energy consumption at a construction site is synonymous with fossil fuel consumption, because the energy to power construction vehicles and equipment comes from the burning of fossil fuels. Fossil fuel demands considered in this analysis include the burning of diesel fuel during construction activities and the carbon footprint of manufacturing geomembrane textiles. Because GHG emission impacts and energy consumption impacts both arise from the same sources at construction sites, the trends discussed above with respect to GHG emissions also apply to the evaluation of energy demands. Specifically, the energy demands of construction equipment and vehicles would be greater under the CBR scenario than under the CIP scenario. We did not quantify the energy demands of the geomembranes required for the construction of the final cover system under the CIP scenario or, potentially, the geomembranes required for expansion of the off-Site landfill under the CBR scenario.

The Coffeen Power Plant Site is slated for redevelopment as a utility-scale solar power generating facility and battery energy storage facility. At the grid scale, solar generation would add energy back onto the grid and reduce reliance on non-renewable energy sources. In the short-term, closure activities at the Site may delay and obstruct these redevelopment efforts. The magnitude of expected delays will scale with the expected duration and intensity of construction activities during closure. Because the CIP scenario requires less construction activity than the CBR scenario and would be completed over a shorter time period, the CIP scenario would be expected to result in fewer delays to redevelopment – and, hence, the more rapid realization of grid-scale energy benefits – than the CBR scenario.

Natural Resources and Habitat

During closure, major construction activities such as the excavation of the impoundment, the excavation of the borrow area, and, potentially, the expansion of the off-Site landfill may require the destruction of some existing habitat atop portions of these construction areas, resulting in negative impacts to natural resources and habitat within the footprint of these areas. Construction may also have indirect negative impacts on the natural resources and habitat in the immediate vicinity of these locations by causing alarm and escape behavior in nearby wildlife (*e.g.*, due to noise disturbances). Finally, although erosion prevention and sediment control measures will be undertaken under all closure scenarios, it is 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 adjacent to AP1 (see Section 1.1.3) due to sediment runoff during construction. Short-term impacts on natural resources and habitat would be greater under the CBR scenario than under the CIP scenario, because the overall duration of construction would be longer under the CBR scenario than under the CIP scenario (17 to 24 months under the CIP scenario *vs.* 20 to 30 months under the CBR scenario).

In addition to the short-term negative habitat impacts caused by construction activities, closure may also result in long-term shifts in the habitat types overlying the major construction locations associated with closure. This assessment does not make any value judgments regarding the relative value of the habitat types currently overlying these locations and the habitat types that could potentially overlie these locations post-closure under the various closure scenarios. For example, we did not attempt to determine whether the conversion of open water to grassland within the footprint of AP1 would constitute a positive or negative long-term change with regard to factors such as biodiversity, ecosystem services, or the preferences of recreators/sightseers.

According to the IDNR Natural Heritage Database and the United States Fish and Wildlife Service (US FWS) Environmental Conservation Online System, there are four state threatened species, five state endangered species, one federally threatened species, and one federally endangered species within Montgomery County (Ramboll, 2021a). To our knowledge, however, no threatened or endangered species have been identified at the Site. Based on the information that is currently available, we do not expect construction activities to have negative impacts on any threatened or endangered species.

2.2.5 Time Until Groundwater Protection Standards Are Achieved (IAC Sections 845.710(b)(1)(E) and 845.710(d)(2 and 3))

The time horizon over which GWPSs would be exceeded at the Site is immaterial from a risk perspective because there is no unacceptable risk associated with exceedances of a GWPS at the Site (see Section 2.2.1). Nonetheless, pursuant to requirements under IAC Section 845.710, this section of the text describes the time required to achieve GWPSs at the Site.

As described in Section 1.1.4 (Hydrogeology), water and CCR-related constituents from AP1 may migrate vertically downward until they reach the UA. Groundwater flows eastward toward the Unnamed Tributary and Coffeen Lake. The Unnamed Tributary and Coffeen Lake serve as regional sinks for shallow groundwater discharge, and shallow groundwater migration beneath or beyond the tributary or the lake is unlikely (Ramboll, 2021b,c). Groundwater flow within the UA is mostly in the horizontal direction because the UA is underlain by the low-permeability LCU (Ramboll, 2021b,c).

At the Coffeen Power Plant Site, no seasonal variation in groundwater levels has been observed. Surface water elevations in Coffeen Lake similarly do not fluctuate significantly over time, since the lake elevation is controlled by a dam. As a result, groundwater flow directions at the Site are not generally affected by seasonal variabilities (Ramboll, 2021b,c).

Groundwater modeling was performed to evaluate future groundwater quality in the vicinity of AP1 under each of the proposed closure alternatives (Ramboll, 2022). The modeling demonstrated that groundwater concentrations in the monitoring wells within the UA will achieve the GWPSs in 15 years for both the CIP and CBR scenarios, with the exception of well G301 (Ramboll, 2022). The decline in post-closure groundwater concentrations at well G301 will be slower than at other locations because the well is located along the flow path of constituents that were released into the native geologic materials prior to closure. Because there will be reduced percolation of precipitation through the consolidation area within AP1 for the CIP scenario as a result of the cap, the time for concentrations to attenuate to levels below the GWPSs at well G301 is longer for the CIP scenario than for the CBR scenario. The model predicts that GWPSs at well G301 will be achieved in approximately 59 years under the CIP scenario (Ramboll, 2022).

Additionally, changing geochemical conditions during an extended excavation associated with the CBR off-Site and CBR on-Site scenarios can be a mechanism that results in the mobilization and increased transport in groundwater for some constituents. This may result in GWPS exceedance durations in excess of the model predictions for the CBR off-Site and CBR on-Site scenarios.

2.2.6 Potential for Exposure of Humans and Environmental Receptors to Remaining Wastes, Considering the Potential Threat to Human Health and the Environment Associated with Excavation, Transportation, Re-disposal, Containment, or Changes in Groundwater Flow (IAC Section 845.710(b)(1)(F))

Section 2.2.1 evaluates potential risks to human and ecological receptors arising from the leaching of CCR-associated constituents into groundwater during closure activities and following closure of AP1. Section 2.2.2 evaluates the potential for CCR releases to occur due to dike failure or overtopping during floods or other storm-related events. In summary, there is no current or future risk to any human or ecological receptors associated with AP1. Additionally, there is minimal current or future risk of overtopping occurring at the embankments due to flood conditions at the Site. Dike failure due to, *e.g.*, seismic activity and storm-related events is also exceedingly unlikely.

Section 2.2.4 evaluates several potential risks to human health and the environment during closure activities, including risks of accidents occurring among workers; risks to nearby residents and EJ communities related to accidents, traffic, noise, and air pollution; and risks to natural resources and wildlife. The findings from this section of the text are summarized in Table S.1 (Summary of Findings).

2.2.7 Long-Term Reliability of the Engineering and Institutional Controls (IAC Section 845.710(b)(1)(G))

Post-closure, there is minimal risk of engineering or institutional failures leading to sudden releases of CCR from the impoundment under the CIP scenario. There is no post-closure risk of engineering or institutional failures under the CBR scenario (see Section 2.2.2 above). Additionally, there are no current or future unacceptable risks to any human or ecological receptors under any closure scenario (see Section 2.2.1 above). Moreover, reliable engineering and institutional controls (*e.g.*, a bottom liner, a leachate management system, and groundwater monitoring) would be implemented at the on-Site and off-Site landfills under the CBR scenario. All of the evaluated closure scenarios are therefore reliable with respect to long-term engineering and institutional controls.

2.2.8 Potential Need for Future Corrective Action Associated with the Closure (IAC Section 845.710(b)(1)(H))

Corrective action is expected at the Site. An evaluation of potential corrective measures and corrective actions has not yet been completed, but will be conducted consistent with the requirements in IAC Section 845.660 and IAC Section 845.670.

2.3 Effectiveness of the Closure Alternative in Controlling Future Releases (IAC Section 845.710(b)(2))

2.3.1 Extent to Which Containment Practices Will Reduce Further Releases (IAC Section 845.710(b)(2)(A))

The CCR in AP1 currently poses no unacceptable risks to human health or the environment (Section 2.2.1). Because current conditions do not present a risk to human health or the environment, and dissolved constituent concentrations would be expected to decline post-closure, there would also be no unacceptable risks to human health or the environment following closure, regardless of the closure scenario.

Section 2.2.2 discussed the potential for dike failure or overtopping to occur during or following closure activities, resulting in a sudden release of CCR. That analysis showed that there is minimal risk of sudden CCR releases occurring during or following closure under any closure scenario.

2.3.2 Extent to Which Treatment Technologies May Be Used (IAC Section 845.710(b)(2)(B))

Under all three closure scenarios, water generated during the dewatering and unwatering of the impoundment would be treated if necessary prior to disposal. Following treatment, water from unwatering and dewatering would be discharged in accordance with the NPDES permit for the facility.

2.4 Ease or Difficulty of Implementing Closure Alternative (IAC Section 845.710(b)(3))

2.4.1 Degree of Difficulty Associated with Constructing the Closure Alternative

CIP using a final cover system is a reliable and standard method for managing and closing impoundments that relies on common construction activities. Dewatering saturated CCR to construct a stabilized final cover system subgrade can present challenges during closure; however, these challenges are common to most CCR surface impoundment closures and are commonly addressed *via* surface water management and dewatering techniques.

Excavation and landfilling of CCR is also a reliable and standard method for closing impoundments. However, relative to CIP, CBR poses additional implementation difficulties due to higher earthwork volumes, higher dewatering volumes, and longer construction schedules. Additionally, because the CBR scenario would involve hauling CCR off-Site (*i.e.*, intrastate travel), a higher level of dewatering would be required under this scenario compared to the CIP scenario. As described in Section 2.2.4.2

(Community Risks), off-Site hauling may also have detrimental community impacts due to an increased incidence of vehicle accidents, traffic-related impacts, noise, and air pollution.

In addition to off-Site hauling, off-Site landfilling under the CBR scenario may pose particular challenges. A disposal plan would need to be developed between IPGC and the owner/operator of the third-party landfill in order to outline acceptable waste conditions upon delivery, daily waste production rates, and the expected duration of the project. Off-Site landfilling may additionally raise issues related to the co-disposal of CCR and other non-hazardous wastes. Finally, the construction schedule for excavation may be negatively impacted if, during the course of closure, it is determined that the off-Site landfill must be expanded in order to receive all of the materials excavated from AP1.

2.4.2 Expected Operational Reliability of the Closure Alternative

There is no post-closure risk of operational failures leading to sudden releases of CCR from the impoundment under the two CBR scenarios. There is minimal post-closure risk of sudden CCR releases occurring under the CIP scenario, because: (i) the final cover system will be constructed and maintained in accordance with all relevant state and federal safety regulations, and (ii) the dikes, final cover, and stormwater control features have all been designed to withstand earthquakes and storm events (see Section 2.2.2 above). Moreover, appropriate operational controls are expected to be implemented at the on-Site and off-Site landfills under the CBR scenario. As such, operational reliability would be expected under all closure scenarios.

2.4.3 Need to Coordinate with and Obtain Necessary Approvals and Permits from Other Agencies

Permits and approvals would be needed under all closure scenarios. Components of the three closure scenarios that would be expected to require a permit include:

- A modification to the existing NPDES permit through IEPA to allow the disposal of water generated from unwatering and dewatering operations to Coffeen Lake *via* the existing NPDES-permitted outfall for the Site;
- A construction permit from the IDNR, Office of Water Resources, Dam Safety Program to allow the embankment and spillways of AP1 to be modified as part of closure;
- A construction stormwater permit through IEPA, including construction stormwater controls and other BMPs such as silt fences and other measures; and
- A joint water pollution control construction and operating permit (WPC permit).

As discussed below in Section 2.4.5, under the CBR scenario, it may similarly be necessary to expand the off-Site landfill. Additional permitting may be required under this scenario for transport of the CCR and to expand the off-Site landfill. It may also be necessary to modify the operating plan for the off-Site landfill in order to accommodate the increased rate of filling of the landfill and the likely need for additional equipment and personnel to manage the receipt and disposal of the CCR.

2.4.4 Availability of Necessary Equipment and Specialists

CIP and CBR are reliable and standard methods for managing waste that rely on common construction equipment and materials and typically do not require the use of specialists, outside of typical construction labor and equipment operators. However, global supply chains have been disrupted due to the COVID-19 pandemic, resulting in shortages in the availability of construction equipment and parts. There may be some shortages in construction equipment under all scenarios, if supply chain resilience does not improve by the time of construction. Alternatively, extended downtime may be required for equipment repairs and maintenance. A national shortage of truck drivers has also developed during the COVID-19 pandemic. Due to higher earthwork volumes and a longer construction schedule under the CBR scenario than under the CIP scenario, shortages in construction equipment may cause greater challenges under this scenario than under the CIP scenario. The current shortage of truck drivers may be particularly impactful under the CBR scenario, due to the large volume of CCR to be hauled from the Site. If sufficient trucks and truck drivers are not available, the construction schedule at the impoundment may lengthen based on hauling-related delays.

The availability of critical materials such as metal, wood, and electronic chips has also been impacted by the COVID-19 pandemic. However, soil materials and geomembrane liner materials have generally been available during 2021 and early 2022 for landfill development and closure projects.

2.4.5 Available Capacity and Location of Needed Treatment, Storage, and Disposal Services

Under the CIP scenario, all of the CCR currently within AP1 would be stored within the existing footprint of AP1. Treatment would consist of unwatering AP1 at the start of construction, performing limited dewatering to stabilize the CCR subgrade, and managing stormwater inflow. Water from unwatering and dewatering of AP1 would be discharged in accordance with the NPDES permit for the facility. Under the CBR scenario, water treatment would similarly consist of unwatering and dewatering AP1 at the start of construction and discharging water from unwatering/dewatering in accordance with the NPDES permit for the facility. Due to the need for dewatering prior to CCR hauling, a higher volume of water would be expected to be generated during dewatering under the CBR scenario than under the CIP scenario.

For the CBR scenario, 495,000 CY of CCR and subsoil would be excavated from AP1 and require disposal. The existing landfill on the Coffeen Power Plant property does not have sufficient capacity to receive all of the CCR that is currently slated for landfilling under the CBR scenario. For the CBR scenario 311,000 CY of CCR would be excavated from AP1 and placed in the on-Site landfill, and the remaining 184,000 CY of CCR and subsoil would require disposal off-Site. According to the IEPA "Landfill Disposal Capacity Report" for 2020 (IEPA, 2021b), the closest nearby third-party landfill with the ability to receive and dispose of CCR from the Site is the Hillsboro-Litchfield Landfill in Litchfield, Illinois. This facility has 1,540,000 CY of remaining capacity in its current permitted footprint. It receives 83,000 CY of waste annually, and is located 18 miles from the Site by road. The Litchfield-Hillsboro Landfill therefore has sufficient capacity to receive CCR from AP1. However, closure of AP1 would increase the annual waste receipt rate at the off-Site landfill. Due to the short time frame over which CCR would be received at the landfill, vertical and/or lateral expansions may become necessary. Additionally, the landfill operators may need to develop a disposal plan to account for the increased volume of material that would be received and the unique CCR waste characteristics. Elements of this disposal plan might include increasing daily operational capacity and procedures, expediting planned airspace construction, and potentially expediting landfill expansion.

If expansion of the Litchfield-Hillsboro Landfill is impractical or infeasible, then an alternative landfill located farther from the Site would need to be identified. A likely alternative to the Litchfield-Hillsboro Landfill is the Five Oaks Landfill in Taylorville, Illinois. It has 7,050,000 CY of remaining capacity in its current permitted footprint, receives 250,000 CY of waste annually, and is located 44 miles from the Site (IEPA, 2021b).

2.5 Impact of Closure Alternative on Waters of the State (IAC Section 845.710(d)(4))

As demonstrated in Gradient's Human Health and Ecological Risk Assessment (Appendix A), both modeled and measured surface water concentrations in Coffeen Lake are all below relevant human health and ecological screening benchmarks.

Surface water concentrations of CCR-associated constituents would be expected to decline over time under all closure scenarios. Thus, no current or future exceedances of any human health or ecological screening benchmarks would be anticipated under any closure scenario.

The lined landfills that would receive the CCR excavated from the impoundment under the CBR and scenario would be managed to ensure that no surface water impacts would occur in the vicinity of the landfill. In summary, no impacts on any waters of the state would be expected under any closure scenario.

2.6 Concerns of Residents Associated with Closure Alternatives (IAC Section 845.710(b)(4))

Several nonprofits representing community interests near the Site have raised concerns regarding the potential impacts of the coal ash impoundments at this Site on groundwater and surface water quality, including Earthjustice, the Prairie Rivers Network, and the Sierra Club (Earthjustice *et al*., 2018; Sierra Club, 2014; Sierra Club and CIHCA, 2014). These parties generally prefer CBR to CIP, citing fears that allowing CCR to remain in place "allows the widespread groundwater contamination to continue indefinitely" (Earthjustice *et al*., 2018, p. 24). However, it is not the case that closing AP1 *via* CIP rather than CBR would result in undue risks to groundwater and surface water post-closure. As described in Sections 2.2.1 and 2.2.2, no current or future unacceptable risks to human or ecological receptors are associated with AP1 under any scenario. There is also minimal risk of future CCR releases occurring under any scenario. Furthermore, groundwater modeling conducted at the Site demonstrated that the groundwater concentrations in the monitoring wells within the UA will achieve GWPSs in 15 years for both the CIP and CBR scenarios, with the exception of well G301 (Section 2.2.5; Ramboll, 2022). Both closure scenarios are therefore responsive to residents' concerns regarding impacts to groundwater and surface water quality.

The CIP scenario has several advantages over the CBR scenario with regard to likely community concerns. Notably, the CIP scenario presents fewer risks to workers and nearby residents during construction in the form of accidents, traffic-related impacts, noise, and air pollution (Section 2.2.4 above). Closure would also be achieved more rapidly under the CIP scenario than under the CBR scenario, due to the shorter duration of construction activities. Finally, the Site can be more rapidly redeveloped for use in utility-scale solar generation and battery energy storage under the CIP scenario than under the CBR scenario. Redevelopment of the Site for use in solar generation and battery energy storage would bring new jobs to the community and contribute positively to Illinois' growing renewable energy portfolio.

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

A Class 4 cost estimate will be prepared in the Final Closure Plan consistent with the Association for the Advancement of Cost Engineering (AACE) Classification Standard (or a comparable classification practice as provided in the AACE Classification Standard), as required by IAC Section 845.710 (IEPA, 2021a).

2.8 Summary

Table S.1 (Summary of Findings) summarizes the expected impacts of the CIP and CBR closure scenarios with regard to each of the factors specified under IAC Section 845.710 (IEPA, 2021a). Based on this evaluation and the details provided in Section 2 above, CIP has been identified as the most appropriate closure scenario for AP1. Key benefits of the CIP scenario relative to the CBR scenario include more rapid redevelopment of the Site for use in utility-scale solar energy generation and battery energy storage and greatly reduced impacts to workers, community members, and the environment due to construction activities (*e.g.*, fewer constructed-related accidents, lower energy demands, less air pollution and GHG emissions, less traffic-related impacts, and potentially lower impacts to EJ communities). These conclusions are subject to change as additional data are collected and following the completion of an upcoming public meeting, which will be held in June 2022 pursuant to requirements under IAC Section 845.710(e). Following the public meeting, a final closure decision will be made based on the considerations identified in this report, the results of additional data that are collected, and any additional considerations that arise during the public meeting. The final closure recommendation will be provided in a Final Closure Plan, which will be submitted to IEPA as described under IAC Section 845.720(b) (IEPA, 2021a).

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Appendix A

Human Health and Ecological Risk Assessment

Draft

Human Health and Ecological Risk Assessment
Ash Pond 1
Coffeen Power Plant
Coffeen, Illinois

May 15, 2022

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Abbreviations

ADI	Acceptable Daily Intake
AP1	Ash Pond 1
BCF	Bioconcentration Factor
BCG	Biota Concentration Guide
CAA	Closure Alternatives Assessment
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
DA	Deep Aquifer
DCU	Deep Confining Unit
ESV	Ecological Screening Value
GMF	Gypsum Management Facility
GWPS	Groundwater Protection Standards
GWQS	Groundwater Quality Standards
HTC	Human Threshold Criteria
IAC	Illinois Administrative Code
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
NRWQC	National Recommended Water Quality Criteria
ORNL RAIS	Oak Ridge National Laboratory Risk Assessment Information System
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
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 1 (AP1) (Vistra Identification No. 101, Illinois Environmental Protection Agency [IEPA] ID No. W1350150004-01, and National Inventory of Dams No. IL50722). AP1 is a 23-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 AP1. This risk evaluation was performed to support the Closure Alternatives Assessment for AP1 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).

Based on the evaluation presented in this report, no unacceptable risks to human and ecological receptors resulting from CCR exposures associated with AP1 were identified. 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 when AP1 is closed. 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 AP1, Ash Pond 2, Gypsum Management Facility (GMF) Recycle Pond, GMF Gypsum Stack Pond, and the Landfill (Ramboll, 2021). AP1, the subject of this report, was constructed in 1964; it is an unlined SI that covers an area of approximately 23 acres (Ramboll, 2021). Sluicing of waste to AP1 ceased prior to November 2019 (Ramboll, 2021). 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 AP1, 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).

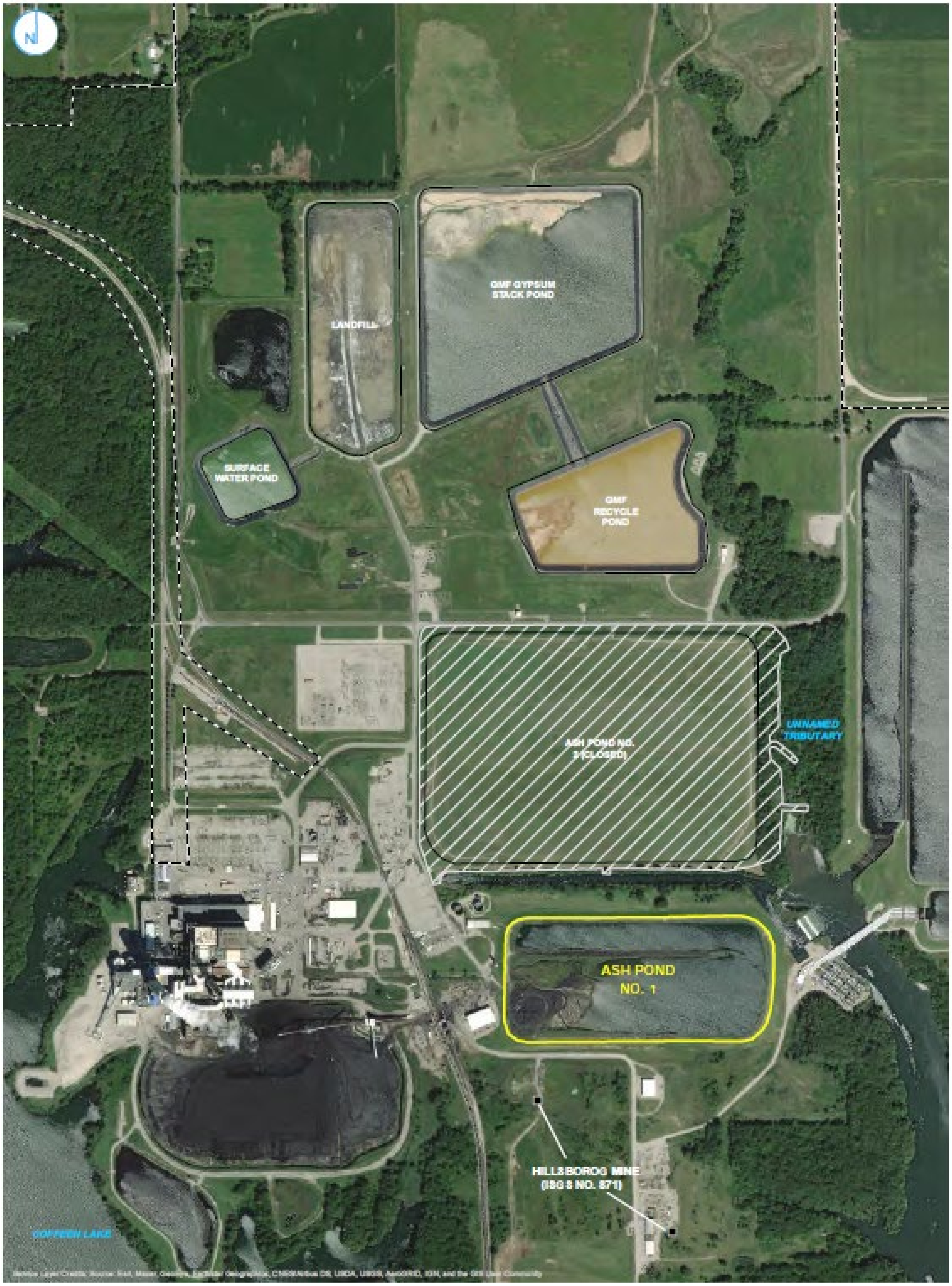

Figure 2.1 Site Location Map. Source: Ramboll (2021).

2.2 Geology/Hydrogeology

The geology underlying the CPP Site in the vicinity of AP1 primarily consists of unlithified deposits (Ramboll, 2021). The unlithified deposits were categorized into the following hydrostratigraphic units (moving downward from the ground surface): the Upper Confining Unit (UCU), which is composed of Roxana and Peoria Silts (Loess Unit); the Uppermost Aquifer (UA), which is primarily composed of sandy to gravelly silts and clays of the Hagarstown Member; the Lower Confining Unit (LCU), which is composed of the Vandalia Member, the Mulberry Grove Member, and the Smithboro Member; the Deep Aquifer (DA), which is composed of sand and sandy silts/clays of the Yarmouth Soil; and the Deep Confining Unit (DCU), which is composed of clays, silts, and sands of the Banner Formation (Ramboll, 2021).

The Hagarstown Member is separated into two units: a gravelly clay till unit on top of a sandy unit (Ramboll, 2021). The sandy unit at the base of the Hagarstown Member was identified as the UA. However, in some locations, the uppermost weathered sandy clay portion of the underlying Vandalia Member was also identified as the UA (Ramboll, 2021). The UA (*i.e.*, sandy portion of the Hagarstown Member) is generally less than 3 feet (ft) thick, but it is absent at several locations (Ramboll, 2021). The top of the UA is separated from overlying CCR materials by the low permeability Loess (*i.e.*, the UCU) and the gravelly clay till portions of the Hagarstown Member. The bottom of the UA is separated from the DA by low-permeability tills of the LCU (Ramboll, 2021). Near AP1, the UA has moderate permeability with a geometric mean horizontal hydraulic conductivity of 2×10^{-3} cm/s (Ramboll, 2021).

Groundwater within the UA flows generally from the south towards the north and northeast across AP1 and ultimately flows into a drainage ditch and the eastern branch of Coffeen Lake (Ramboll, 2021). Horizontal hydraulic gradients calculated for the UA range from 0.004 to 0.012 ft/ft, which correspond to a groundwater flow velocity ranging from 0.19 ft/day to 0.95 ft/day (Ramboll, 2021).

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 AP1 migrates and interacts with surface water and sediment in the adjacent Coffeen Lake. The CSM was developed using available hydrogeologic data specific to AP1, including information on groundwater flow and surface water characteristics (Ramboll, 2021).

CCR-related constituents may migrate vertically downward through the UCU from AP1 into the underlying groundwater of the UA. Once in groundwater, CCR-related constituents may migrate in a north/ northeasterly direction, consistent with the direction of groundwater flow, into a drainage ditch and the eastern branch of Coffeen Lake (Ramboll, 2021). 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 AP1 may mix with surface water in the eastern branch of Coffeen Lake, and dissolved constituents in groundwater may partition between the sediments and surface water in Coffeen Lake.

2.4 Groundwater Monitoring

A total of 17 wells have been used to monitor the groundwater quality near and downgradient of AP1. Of these, 13 wells are screened in the UA, 3 wells are screened in the LCU, and 1 well is screened in the DA (Table 2.1). The analyses presented in this report relied on all available data from the 17 wells collected between 2015 and 2021, which is the period subsequent to the promulgation of the Federal CCR Rule. Groundwater samples were analyzed for a suite of total metals, specified in 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 AP1 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 AP1 or that they have been identified as potential groundwater exceedances.

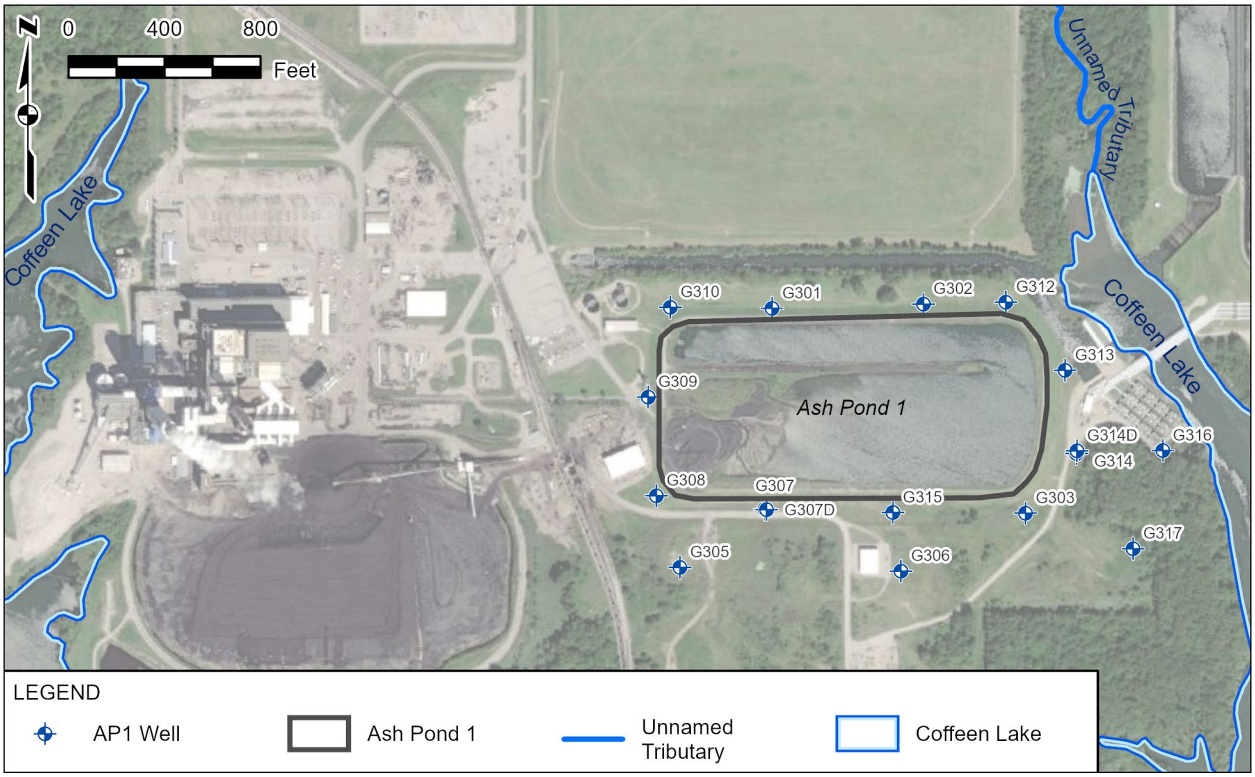

Figure 2.2 Monitoring Well Locations. Source: Ramboll (2021, Figure 3-1). AP1 = Ash Pond 1.

[1] Samples were analyzed for a longer list of inorganic constituents and general water quality parameters (chloride, fluoride, sulfate, and total dissolved solids), but these constituents were not evaluated in the risk evaluation.

Table 2.1 Groundwater Monitoring Wells Related to Coffeen Ash Pond 1

Well	Hydrogeologic Unit	Date Constructed	Screen Top Depth (ft bgs)	Screen Bottom Depth (ft bgs)	Well Depth (ft bgs)
G301	UA	9/4/2015	11.31	15.96	16.21
G302	UA	9/4/2015	13.21	17.86	18.39
G303	UA	8/26/2010	10.00	20.00	20.40
G305	UA	5/3/2016	13.44	18.27	18.50
G306	UA	5/3/2016	13.07	17.68	17.90
G307	UA	7/27/2016	12.96	17.80	18.22
G307D	LCU	1/19/2021	48.98	58.75	59.60
G308	UA	1/18/2021	10.10	14.89	15.24
G309	UA	1/21/2021	12.97	17.75	18.10
G310	UA	2/9/2021	10.24	15.03	15.38
G312	UA	1/15/2021	9.79	14.58	14.93
G313	UA	2/5/2021	6.30	11.11	11.46
G314	LCU	2/5/2021	14.56	19.58	20.02
G314D	DA	2/4/2021	39.34	49.11	49.47
G315	UA	1/14/2021	9.69	14.48	14.85
G316	LCU	2/26/2021	10.02	14.82	15.16
G317	UA	2/12/2021	30.14	34.93	35.28

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

Constituent	Samples with Constituent Detected	Samples Analyzed	Minimum Detected Value	Maximum Detected Value	Maximum Laboratory Detection Limit
Total Metals (mg/L)					
Antimony	0	152	ND	ND	0.0030
Arsenic	72	172	0.0010	0.041	0.0010
Barium	172	172	0.013	0.38	0.0010
Beryllium	2	167	0.0013	0.0029	0.0010
Boron	177	177	0.019	7.5	0.20
Cadmium	8	172	0.0011	0.027	0.0010
Chromium	31	172	0.0040	0.11	0.0040
Cobalt	81	173	0.0020	0.034	0.0020
Lead	41	172	0.0010	0.068	0.0010
Lithium	62	172	0.010	0.10	0.020
Mercury	8	152	0.00022	0.0013	0.0040
Molybdenum	111	172	0.0010	0.026	0.0010
Selenium	15	167	0.0011	0.0043	0.0010
Thallium	0	152	ND	ND	0.0010
Radionuclides (pCi/L)					
Radium-226+228	163	163	0	18	5.0
Other (mg/L)					
Chloride	171	175	1.1	180	250
Fluoride	121	175	0.25	1.4	2.5
Sulfate	175	175	5.9	2,400	500
Total Dissolved Solids	175	175	640	4,000	26

Notes:
Source: Ramboll (2021).
ND = Not Detected; 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 AP1 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 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 AP1 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.

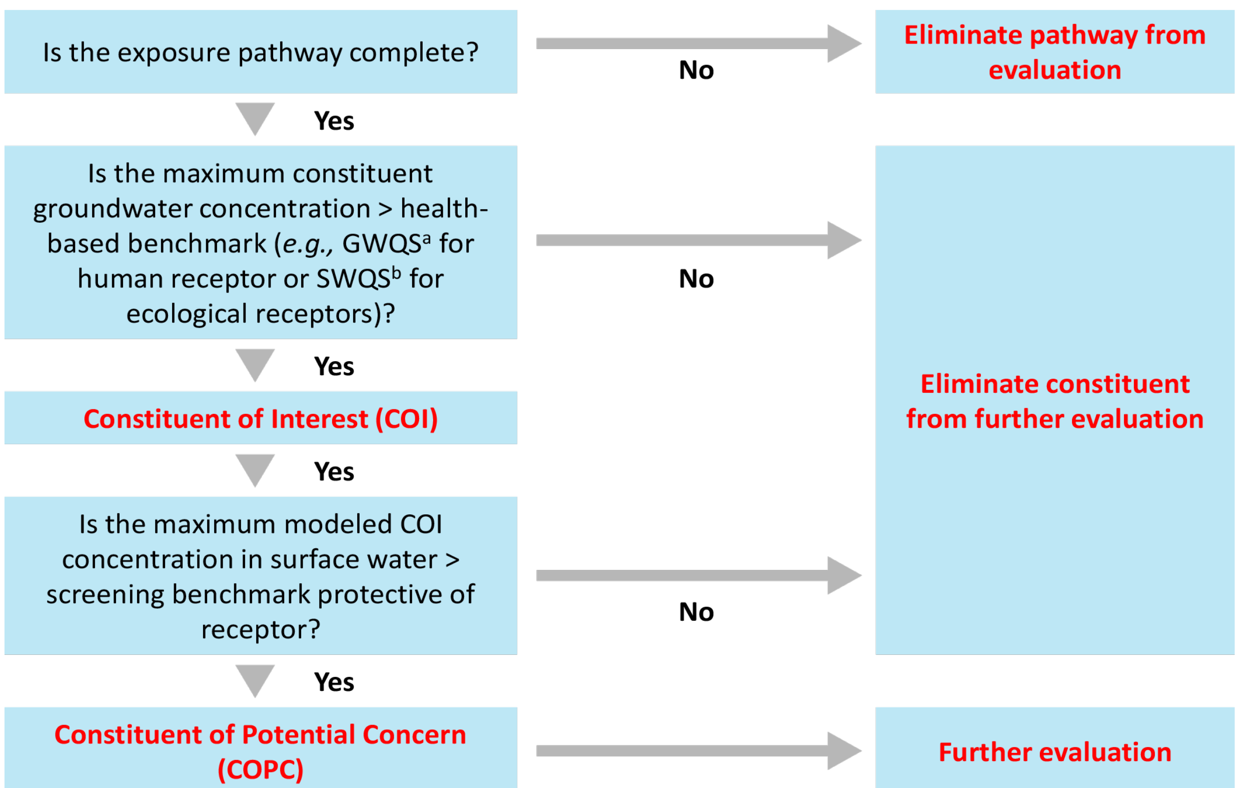

Figure 3.1 Overview of Risk Evaluation Methodology. GWQS = Groundwater Quality Standard; IEPA = Illinois Environmental Protection Agency; SWQS = Surface Water Quality Standard.
(a) The IEPA Part 845 GWPS were used to identify COIs.
(b) IEPA SWQS protective of chronic exposures to aquatic organisms were 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 AP1 has the potential to interact with surface water in Coffeen Lake. Therefore, potential AP1-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 AP1-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 AP1 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 AP1 into groundwater, surface water, sediment, and fish. The following human receptors and exposure pathways were evaluated for inclusion in the Site-specific CEM.

[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).

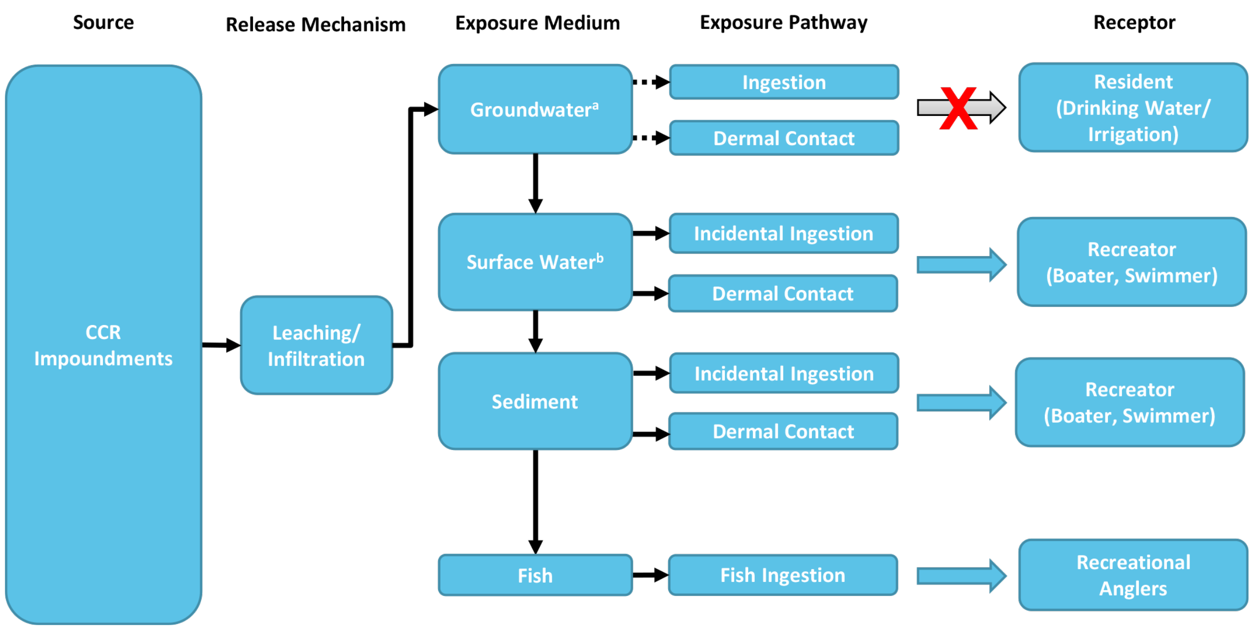

Figure 3.2 Human Conceptual Exposure Model. CCR = Coal Combustion Residuals. Dashed line/Red X = Incomplete or insignificant exposure pathway. (a) Groundwater in the vicinity of the Site is not used as a drinking water or irrigation source. (b) Surface water is not used as a drinking water source.

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 AP1. Specifically, there are no users of shallow groundwater from the UA in the vicinity of AP1; thus, no receptors can be exposed to any CCR-related constituents in groundwater originating from AP1.

Relying on state databases, Ramboll completed a water well survey in 2021 (Ramboll, 2021). A total of 12 water wells were identified within a 1,000-meter radius of the AP1 boundary during a comprehensive search of the Illinois State Geological Survey's (ISGS) Illinois Water and Related Wells (ILWATER) Map (Ramboll, 2021). These included four monitoring wells and eight farm/domestic wells (Ramboll, 2021) (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 eight farm/domestic wells are or can ever be affected by potential CCR-related constituents originating from AP1.

- **There is no off-Site migration of CCR-related constituents in groundwater**. Groundwater from the UA flows north/northeast before flowing into the eastern branch of Coffeen Lake (Ramboll, 2021). Seven of the eight farm/domestic wells within a 1,000 m radius of AP1 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 AP1. These surface water bodies are hydraulic boundaries that prevent shallow groundwater from flowing past or underneath them. 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 AP1 (Figure 3.3), there is no plausible mechanism by which the wells could be impacted by any potential constituents in groundwater associated with the AP1. There is one domestic/farm well located north of AP1 (Well ID 32 on Figure 3.3), side-gradient to AP1 and on the west side of the unnamed tributary. It is likely that this well is not in use and no longer in existence. The well, which was installed in 1981, is located near the former location of several prior residents (Figure 3.4). 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 AP1 is not a complete pathway and was not evaluated further.
- **AP1 has a limited hydraulic connection to underlying groundwater.** The LCU underlying the UA forms a hydraulic barrier between AP1 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 AP1-related impacts to deep groundwater is minimal.

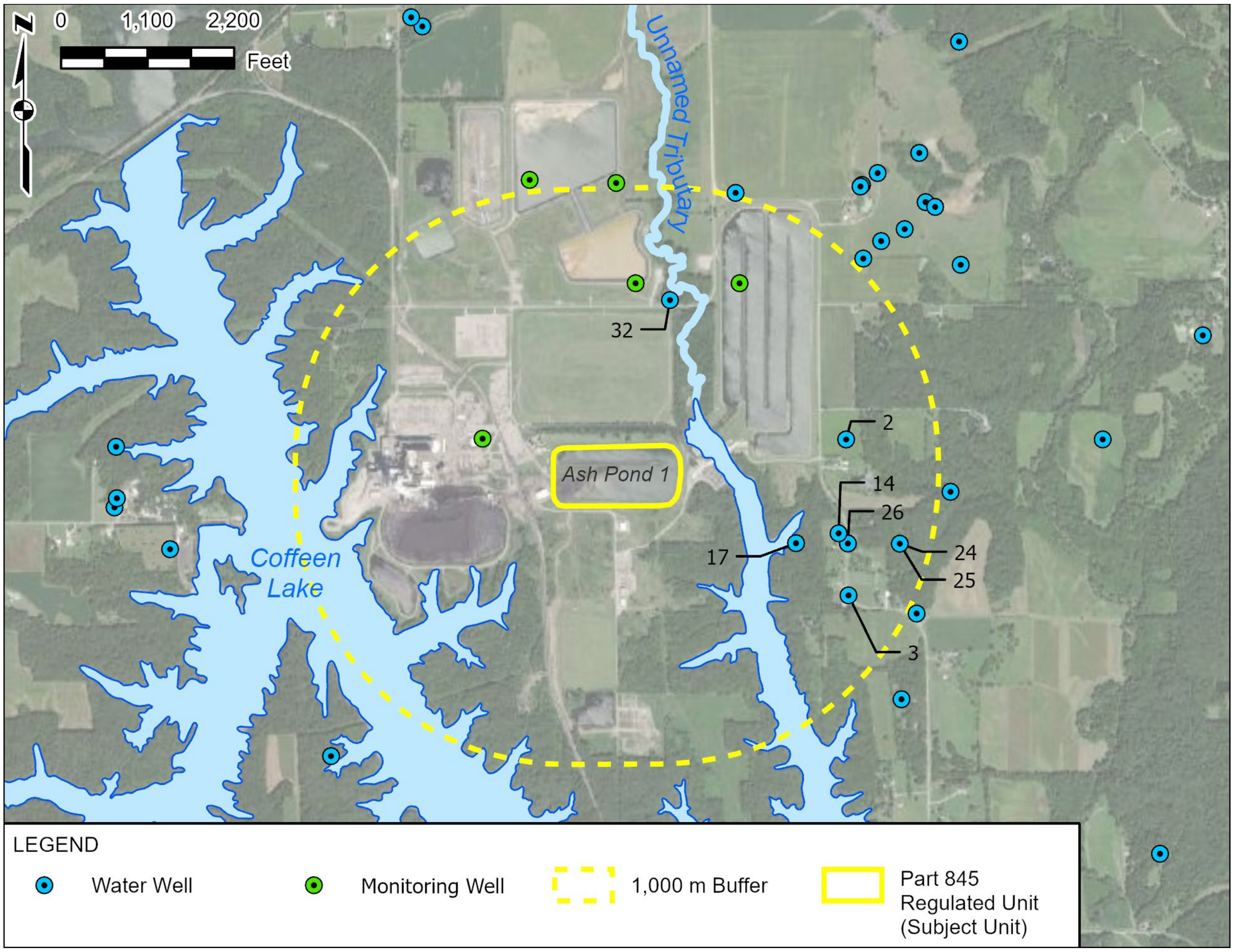

Figure 3.3 Water Wells Within 1,000 Meters of AP1. Source: Ramboll (2021).

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 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).

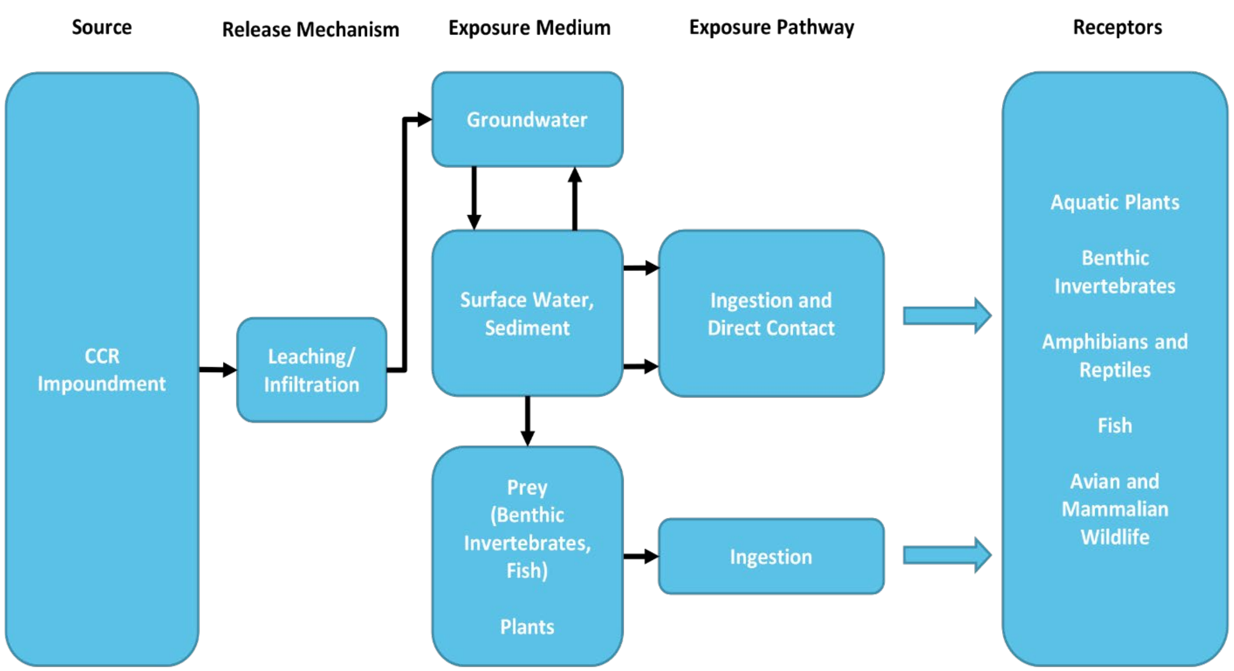

Figure 3.5 Ecological Conceptual Exposure Model. CCR = Coal Combustion Residuals.

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 AP1-associated wells, regardless of hydrostratigraphic unit. The use of groundwater data in this risk evaluation does not imply that detected constituents are associated with AP1 or that they have been identified as potential groundwater exceedances. Using this approach, eight COIs (arsenic, boron, cadmium, chromium, cobalt, lead, lithium, and radium-226+228) 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. The US EPA secondary maximum contaminant levels (MCLs) for sulfate and total dissolved solids are 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	GWPS[b]	Human Health COI[c]
Total Metals (mg/L)			
Antimony	ND	0.0060	No
Arsenic	0.041	0.010	Yes
Barium	0.38	2.0	No
Beryllium	0.0029	0.0040	No
Boron	7.5	2.0	Yes
Cadmium	0.027	0.0050	Yes
Chromium	0.11	0.10	Yes
Cobalt	0.034	0.0060	Yes
Lead	0.068	0.0075	Yes
Lithium	0.10	0.040	Yes
Mercury	0.0013	0.0020	No
Molybdenum	0.026	0.10	No
Selenium	0.0043	0.050	No
Thallium	ND	0.0020	No
Radionuclides (pCi/L)			
Radium-226+228	18	5.0	Yes
Other (mg/L)			
Chloride	180	200	No
Fluoride	1.4	4.0	No
Sulfate	2,400	400	No[d]
Total Dissolved Solids	4,000	1,200	No[d]

Notes:
COI = Constituent of Interest; GWPS = Groundwater Protection Standard; MCL = Maximum Contaminant Level; pCi/L = PicoCuries Per Liter.
Shaded = Compound identified as a COI.
(a) The constituents are those listed in the Illinois Part 845.600 GWPS (IEPA, 2021a).
(b) The Illinois Part 845.600 GWPS (IEPA, 2021a) were used to identify COIs.
(c) COIs are constituents for which the maximum concentration exceeds the groundwater standard.
(d) 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) 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 AP1-associated wells (regardless of hydrostratigraphic unit) without considering spatial or temporal representativeness for ecological receptor exposures. The use of the maximum constituent concentrations in this evaluation is designed to conservatively identify COIs that warrant further investigation. Cadmium, cobalt, lead, mercury, and radium-226+228 were identified as COIs for ecological receptors (Table 3.2).

[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	ND	0.19	US EPA R4 ESV	No
Arsenic	0.041	0.19	IEPA SWQC	No
Barium	0.38	5.0	IEPA SWQC	No
Beryllium	0.0029	0.064	US EPA R4 ESV	No
Boron	7.5	7.6	IEPA SWQC	No
Cadmium	0.027	0.0011	IEPA SWQC	Yes
Chromium	0.11	0.21	IEPA SWQC	No
Cobalt	0.034	0.019	US EPA R4 ESV	Yes
Lead	0.068	0.020	IEPA SWQC	Yes
Lithium	0.10	0.44	US EPA R4 ESV	No
Mercury	0.0013	0.0011	IEPA SWQC	Yes
Molybdenum	0.026	7.2	US EPA R4 ESV	No
Selenium	0.0043	1.0	IEPA SWQC	No
Thallium	ND	0.0060	US EPA R4 ESV	No
Radionuclides (pCi/L)				
Radium-226 + 228	18	3.0	US DOE	Yes
Other (mg/L)				
Chloride	180	500	IEPA SWQC	No
Fluoride	1.4	4.0	IEPA SWQC	No
Sulfate	2,400	NA	NA	No
Total Dissolved Solids	4,000	NA	NA	No

Notes:
AP1 = Ash Pond 1; COI = Constituent of Interest; ESV = Ecological Screening Value; GWPS = Groundwater Protection Standards; IEPA = Illinois Environmental Protection Agency; NA = Not Available; ND = Nondetect; 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 AP1, 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) from 2015 to 2021 were conservatively used to model COI concentrations in surface water and sediment. The groundwater data were measured as total metals. 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 AP1-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	613	The average thickness of the UA (*i.e.*, 3 ft or 0.9144 m) multiplied by the potential length of AP1 affected groundwater intersecting Coffeen Lake (*i.e.*, about 670 m) (Ramboll, 2021)
Hydraulic Gradient	m/m	0.0080	The average hydraulic gradient for the UA (Ramboll, 2021)
Hydraulic Conductivity of the UA	cm/s	0.0020	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 222-4807)
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:
AP1 = Ash Pond 1; 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	0.0342	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)
Total Metals				
Arsenic	0.041	1.3E+05	1.6E-06	3.8E-04
Boron	7.5	2.3E+07	2.9E-04	1.7E-03
Cadmium	0.027	8.4E+04	1.0E-06	1.4E-03
Chromium	0.11	3.4E+05	4.3E-06	1.9E-01
Cobalt	0.034	1.1E+05	1.3E-06	1.2E-03
Lead	0.068	2.1E+05	2.6E-06	2.6E-02
Lithium	0.10	3.1E+05	3.9E-06	(a)
Mercury	0.0013	4.0E+03	5.0E-08	1.8E-03
Radionuclides				
Radium-226 + 228	18	5.4E+07	6.8E-04	4.8E+00

Notes:
COI = Constituent of Concern; K_d = Equilibrium Partition Coefficient; 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.

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, 2020).[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:

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

where:

HTC	=	Human health protection criterion in picoCuries per liter (pCi/L)
TCR	=	Target cancer risk ($1{\times}10^{-5}$)
SF	=	Food ingestion slope factor (risk/pCi)
BAF	=	Bioaccumulation factor (L/kg-tissue)
F	=	Fish consumption rate (kg/day)

[4] Although recommended by US EPA (2015c), 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.

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

Screening Risk Evaluation: The maximum modeled 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	1.6E-06	NA	0.022	2.0	0.023	No	NA
Boron	2.9E-04	0.33	467	1,400	700	No	No
Cadmium	1.0E-06	NA	0.0018	1.0	0.0019	No	NA
Chromium	4.3E-06	NA	0.61	20	0.63	No	NA
Cobalt	1.3E-06	ND	0.0035	2.1	0.0035	No	No
Lead	2.6E-06	NA	0.015	0.015	0.015	No	NA
Lithium	3.9E-06	ND	4.7	14	7.0	No	No
Radionuclides (pCi/L)							
Radium-226+228	6.8E-04	NA	1,000	1,000	87,413	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 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 (mg/kg)	Recreator Sediment Screening Benchmark (mg/kg)	COPC
Total Metals (mg/kg)			
Arsenic	3.8E-04	6.8E+01	No
Boron	1.7E-03	2.7E+05	No
Cadmium	1.4E-03	1.2E+02	No
Chromium	1.9E-01	2.1E+06	No
Cobalt	1.2E-03	4.1E+02	No
Lead	2.6E-02	4.0E+02	No
Lithium	(a)	2.7E+03	NA
Radionuclides (pCi/kg)			
Radium-226+228	4.8E+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.
(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.*, cadmium, cobalt, lead, mercury, and radium-226+228).

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
- US DOE benchmarks from the guidance document, "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota" (US DOE, 2019).

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

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)						
Cadmium	1.0E-06	NA	0.0011	IEPA SWQC	No	NA
Cobalt	1.3E-06	ND	0.019	US EPA R4 ESV	No	No
Lead	2.6E-06	NA	0.020	IEPA SWQC	No	NA
Mercury	5.0E-08	NA	0.0011	IEPA SWQC	No	NA
Radionuclides (pCi/L)						
Radium-226+228	6.8E-04	NA	3.0	US DOE	No	NA

Notes:
COI = Constituent of Interest; COPC = Constituent of Potential Concern; ESV = Ecological Screening Value; IEPA = Illinois Environmental Protection Agency; NA = Not Applicable; ND = Nondetect; 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 and fluoride are not expected to sorb to sediment; therefore, risk to ecological receptors exposed to sediment was not evaluated for these constituents. The benchmarks used in this evaluation are listed in Table 3.9.

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 1% of the sediment screening benchmark. Therefore, the modeled sediment concentrations attributed to potential contributions from Site

[6] US DOE (2019) reported the biota concentration guide (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.

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	Modeled Sediment Concentration	ESV[a]	COPC	% of Benchmark
Total Metals (mg/kg)				
Cadmium	1.4E-03	0.99	No	0.14%
Cobalt	1.2E-03	50	No	0.0024%
Lead	2.6E-02	35.8	No	0.073%
Mercury	1.8E-03	0.18	No	1%
Radionuclides (pCi/kg)				
Radium-226 + 228	4.8E+00	90,000[b]	No	0.0053%

Notes:
COI = Constituent of Interest; COPC = Constituent of Potential Concern; ESV = Ecological Screening Value; 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) ESV from US DOE (2019); value converted from 90 pCi/g to 90,000 pCi/kg.

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: With the exception of mercury, the ecological COIs (*i.e.*, cadmium, cobalt, lead, and radium-226+228) were not identified as having potential bioaccumulative effects. Therefore, these COIs are not considered to pose an ecological risk *via* bioaccumulation. IEPA (2019) identifies mercury as the only metal with bioaccumulative properties. US EPA Region IV (2018) also identifies mercury (including methyl mercury) as having potential bioaccumulative effects.[7]

The modeled mercury concentration in surface water (5.1×10^{-9} mg/L) was below the mercury surface water ESV for wildlife (1.3×10^{-6} mg/L), and the modeled mercury concentration in sediment (1.9×10^{-4} mg/kg) was below the sediment ESV for wildlife (0.18 mg/kg) (US EPA Region IV, 2018). Both the modeled surface water and sediment concentrations were below benchmarks protective of receptors accounting for bioaccumulative properties. Therefore, in addition to not posing an ecological risk from direct toxicity, mercury does not pose a risk from bioaccumulation exposures.

[7] US EPA Region IV (2018) identifies selenium as having potential bioaccumulative effects. Although selenium was detected in groundwater, it was not considered an ecological COI.

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 AP1. However, it is possible that not all of the detected constituents are related specifically to AP1.
- 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 AP1 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 COI concentrations in groundwater. 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-AP1-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 AP1-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-AP1-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 90^{th} percentile exposure category for individuals" (US EPA, 2015b). 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 AP1 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 2015 to 2021 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.

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. 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, and fish). Mercury was the only ecological COI identified as having potential bioaccumulative effects. However, the modeled concentrations did not exceed benchmarks protective of bioaccumulative effects. Therefore, mercury is 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 when AP1 is closed. 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 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 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 1 (AP1) with potential CCR-related impacts and a height equal to the average saturated thickness of the UA. It was assumed that groundwater flowing through the UA may flow 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 groundwater flowing through the shallow aquifers was discharged 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)
Q	=	Groundwater flow rate (m^3/s)
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.

The cross-sectional area for the UA was 613 m^2. The length of the lake through which groundwater flows was estimated to be approximately 670 m. The height of the UA was approximately 0.91 m (Ramboll, 2021).

The hydraulic gradient was 0.008 m/m, based on the average horizontal hydraulic gradient determined for the UA (Ramboll, 2021).

The hydraulic conductivity was 0.002 cm/s, based on the geometric mean horizontal hydraulic conductivity measured for the UA (Ramboll, 2021).

Surface Water and Sediment Concentration

Groundwater flowing into the lake will be diluted in the surface water flow. Constituents transported by groundwater into the surface water migrate into the water column and the bed sediments. The surface water model Gradient used to estimate the surface water and sediment concentrations is a steady-state model described in US EPA's indirect exposure assessment methodology (US EPA, 1998), and also used in US EPA's "Human and Ecological Risk Assessment of Coal Combustion Residuals" (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:

f_{water}	=	Fraction of COI in the water column (unitless)
K_{dsw}	=	Suspended sediment-water partition coefficient (mL/g)
K_{dbs}	=	Sediment-water partition coefficient (mL/g)
TSS	=	Total suspended solids in the surface water body (mg/L), set equal to the average Coffeen Lake concentration of 3.2 mg/L (Hanson Professional Services, Inc., 2020 222-4807)
0.000001	=	Units conversion factor
d_w	=	Depth of the water column (m). The depth of the water column was estimated as 5.7 m (Austen *et al*., 1993).
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) = 5.73 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	613	m^2
Uppermost Aquifer	i	Hydraulic Gradient	0.008	m/m
Uppermost Aquifer	K	Hydraulic Conductivity	0.002	cm/s

Note:
Source: Hydraulic gradient 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				
Arsenic	2.4	2.51E+02	3.9	7.94E+03
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	-	-	-	-
Mercury	4.9	7.94E+04	5.3	2.00E+05
Radionuclides				
Radium-226+228	-	7.40E+03	-	7.40E+03
Other				
Sulfate	-	-	-	-

Notes:
Source: US EPA (2014).
Lithium 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	6	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]	0.0342	kg/m^2
M_S	Sediment Mass Per Unit Area[b]	30	kg/m^2

Notes:
Source of default values: US EPA (2014).
(a) Determined by multiplying 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 $f_{dissolved}$
Arsenic	0.442	0.558	0.955
Boron	0.9665	0.0335	0.9545
Cadmium	0.1232	0.8768	0.6772
Chromium	0.0042	0.9958	0.5697
Cobalt	0.172	0.828	0.725
Lead	0.019	0.981	0.250
Lithium	0.997	0.003	
Mercury	0.005	0.995	0.455
Radionuclides			
Radium-226+228	0.026	0.974	0.957

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				
Arsenic	4.1E-02	1.3E+05	1.6E-06	3.8E-04
Boron	7.5E+00	2.3E+07	2.9E-04	1.8E-03
Cadmium	2.7E-02	8.4E+04	1.0E-06	1.4E-03
Chromium	1.1E-01	3.4E+05	4.3E-06	1.9E-01
Cobalt	3.4E-02	1.1E+05	1.3E-06	1.2E-03
Lead	6.8E-02	2.1E+05	2.6E-06	2.6E-02
Lithium	1.0E-01	3.1E+05	3.9E-06	(a)
Mercury	1.3E-03	4.0E+03	5.0E-08	1.8E-03
Radionuclides				
Radium-226+228	1.8E+01	5.4E+07	6.8E-04	4.8E+00
Other				
Sulfate	2.4E+03	7.4E+09	9.3E-02	(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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US EPA. 2014. "Human and Ecological Risk Assessment of Coal Combustion Residuals (Final)." Office of Solid Waste and Emergency Response (OSWER), Office of Resource Conservation and Recovery, December. Accessed at http://www.regulations.gov/#!documentDetail;D=EPA-HQ-RCRA-2009-0640-11993.

Appendix B

Screening Benchmarks

Table B.1 Calculated Water Quality Standards Protective of Incidental Ingestion and Fish Consumption

Human Health COI	BCF[a] (L/kg-tissue)	Basis	MCL (mg/L)	RfD (mg/kg-day)	ADI[b] (mg/day)	Human Threshold Criteria Water & Fish (mg/L)	Water Only (mg/L)	Fish Only (mg/L)
Arsenic	44	NRWQC (2002)	0.010	0.00030	0.020	0.022	2.0	0.023
Boron	1	(c)	NC	0.20	14	467	1,400	700
Cadmium	270	US EPA, 2014	0.0050	0.00050	0.010	0.0018	1.0	0.0019
Chromium	16	NRWQC (2002)	0.10	1.5	0.20	0.61	20	0.63
Cobalt	300	ORNL (2020)	NC	0.00030	0.021	0.0035	2.1	0.0035
Lead	46	US EPA (2014)	0.015	NC	0.030	0.015	0.015	0.015
Lithium	1	(c)	NC	0.002	0.14	4.7	14	7.0
Human Health COI	**BAF (L/kg-tissue) SW-Fish**	**Basis**	**MCL (pCi/L)**	**ADI (pCi/day)**	**Food Ingestion Slope Factor[d] (risk/pCi)**	**Human Threshold Criteria Water & Fish (pCi/L)**	**Water Only (pCi/L)**	**Fish Only (pCi/L)**
Radium-226+228	4.0	ORNL (2020)	5	10	1.43E-09	1,000	1,000	87,413

Notes:

ADI = Acceptable Daily Intake; BAF = Bioaccumulation Factor; BCF = Bioconcentration Factor; MCL = Maximum Contaminant Level; NC = No Criterion Available; NRWQC = National Recommended Water Quality Criteria; ORNL = Oak Ridge National Laboratory; pCi = picocurie; Ra = Radium; RAIS = Risk Assessment Information System; RfD = Reference Dose; US EPA = United States Environmental Protection Agency.

(a) BCFs from the following hierarchy of sources:

- NRWQC (US EPA, 2002). National Recommended Water Quality Criteria: 2002. Human Health Criteria Calculation Matrix.
- US EPA (2014). Human and Ecological Risk Assessment of Coal Combustion Residuals.
- ORNL RAIS (ORNL, 2020). Risk Assessment Information System (RAIS) Toxicity Values and Chemical Parameters.

(b) ADI based on the MCL is calculated as the MCL (mg/L) multiplied by a water ingestion rate of 2 L/day. In the absence of an MCL, the ADI was calculated as the RfD (mg/kg-day) multiplied by the body weight (70 kg).

(c) BCF of 1 was used as a conservative assumption, due to lack of published BCF.

(d) Food ingestion slope factors for Ra-226+D and Ra-228+D were compared and the higher factor (Ra-228+D) was selected. The "+D" indicates that the risks from "associated short-lived radioactive decay products are also included" (US EPA, 2001).

Equations from IEPA (2019):

Consumption of Water and Fish

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

Incidental Consumption of Water Only

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

Consumption of Fish Only

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

Where:

Human Threshold Criteria (HTC)	Chemical-specific	mg/L
Acceptable Daily Intake (ADI)	Chemical-specific	mg/day
Fish Consumption Rate (F)	0.02	kg/day
Bioconcentration Factor (BCF)/ Bioaccumulation Factor (BAF)	Chemical-specific	L/kg-tissue
Water Consumption Rate (W)	0.01	L/day
Body Weight	70	kg
Target Cancer Risk (TCR)	1.0E-05	

Radium-226+228

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

Table B.2 Recreator Exposure to Sediment

COI	Relative Bioavailability (unitless)	Dermal Absorption Fraction (unitless)	Cancer				Cancer SL (mg/kg)	Non-Cancer								Recreator RSL Sediment (mg/kg)	Basis[a]
			TRV		Child + Adult			TRV		Child		Adult		Child	Adult		
			CSF $(mg/kg\text{-}day)^{-1}$	Dermal CSF $(mg/kg\text{-}day)^{-1}$	Incidental Ingestion SL (mg/kg)	Dermal Contact SL (mg/kg)		RfD (mg/kg-day)	Dermal RfD (mg/kg-day)	Incidental Ingestion SL (mg/kg)	Dermal Contact SL (mg/kg)	Incidental Ingestion SL (mg/kg)	Dermal Contact SL (mg/kg)	Non-Cancer SL (mg/kg)			
Total Metals																	
Arsenic	1	3.0E-02	1.5E+00	1.5E+00	8.1E+01	4.1E+02	6.8E+01	3.0E-04	3.0E-04	4.1E+02	4.4E+03	4.4E+03	8.0E+03	3.8E+02	2.8E+03	6.8E+01	c
Boron	1	NA	NC	NC	NC	NC	NC	2.0E-01	2.0E-01	2.7E+05	NA	2.9E+06	NA	2.7E+05	2.9E+06	2.7E+05	nc
Cadmium	1	1.0E-03	NC	NC	NC	NC	NC	1.0E-04	2.5E-06	1.4E+02	1.1E+03	1.5E+03	2.0E+03	1.2E+02	8.5E+02	1.22E+02	nc
Chromium	1	NA	NC	NC	NC	NC	NC	1.5E+00	2.0E-02	2.1E+06	NA	2.2E+07	NA	2.1E+06	2.2E+07	2.1E+06	nc
Cobalt	1	NA	NC	NC	NC	NC	NC	3.0E-04	3.0E-04	4.1E+02	NA	4.4E+03	NA	4.1E+02	4.4E+03	4.1E+02	nc
Lead	1	NA	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	4.0E+02	L
Lithium	1	NA	NC	NC	NC	NC	NC	2.0E-03	2.0E-03	2.7E+03	NA	2.9E+04	NA	2.7E+03	2.9E+04	2.7E+03	nc
Radionuclides																**Total Soil PRG (pCi/kg)**	
Radium-226+228																7.9E+03	

Notes:

ABS = Dermal Absorption Fraction; COI = Constituent of Interest; CSF = Cancer Slope Factor; NC = No Criterion Available; pCi = PicoCurie; PRG = Preliminary Remediation Goal; RfD = Reference Dose; RSL = Regional Screening Level; SL = Screening Level; TRV = Toxicity Reference Value; US EPA = United States Environmental Protection Agency.

(a) Screening benchmark defined as the lower of the Screening Levels for cancer and non-cancer. The basis of the benchmark presented as c = based on cancer endpoint, nc = based on non-cancer endpoint, or L = based on blood lead levels.

Equations for Screening Benchmark and Screening Levels:

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

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

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

Where:

Target Risk (TR)	1E-05	
Target Hazard Quotient (THQ)	1	
Reference Dose (RfD)	Chemical-specific	mg/kg-day
Dermal Absorption Fraction (ABS)	Chemical-specific	
Cancer Slope Factor (CSF)	Chemical-specific	mg/kg
Incidental Ingestions Screening Level (SL_{ing})	Chemical-specific	mg/kg
Dermal Contact Screening Level (SL_{derm})	Chemical-specific	mg/kg

Sediment – Ingestion (Chemical)

$$\text{Intake Factor (IF)} = \frac{IR \times EF \times ED \times CF}{BW \times AT} =$$

		Non-Cancer		Cancer		
Intake Factor (IF)		7.3E-07	6.8E-08	6.3E-08	2.0E-08	Basis
		Child	Adult	Child	Adult	
IR	Ingestion Rate (mg/day)	67	33	67	33	One-third of US EPA residential soil ingestion rate (Professional Judgment)
EF	Sediment Exposure Frequency (days/year)	60	60	60	60	2 days/week between April and October when air temperature > 70°F (Professional Judgment)
ED	Exposure Duration (years)	6	20	6	20	Default value for Resident (US EPA, 2021b)
CF	Conversion Factor (kg/mg)	0.000001	0.000001	0.000001	0.000001	
BW	Body Weight (kg)	15	80	15	80	Default value for Resident (US EPA, 2021b)
AT	Averaging Time (days)	2,190	7,300	25,550	25,550	Default value for Resident (US EPA, 2021b)

Sediment – Dermal Contact (Chemical)

$$\text{Intake Factor (IF)} = \frac{SA \times AF \times EF \times ED \times CF}{BW \times AT} =$$

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

Appendix B

Supporting Information for the Closure Alternatives Analysis – Ash Pond No. 1 at the Coffeen Power Plant

DRAFT

TECHNICAL MEMORANDUM

DATE April 14, 2022 **Reference No.** 21465046

TO Victor Modeer
Illinois Power Generating Company, LLC

CC David Mitchell (Illinois Power Generating Company, LLC)

FROM Michael Dreyer **EMAIL michael_dreyer@golder.com**

SUPPORTING INFORMATION FOR CLOSURE ALTERNATIVES ANALYSIS – ASH POND NO. 1 AT COFFEEN POWER STATION

Golder Associates USA Inc. (Golder), a Member of WSP, has prepared this technical memorandum for Illinois Power Generating Company, LLC (IPGC) to support the Closure Alternatives Analysis for Ash Pond No. 1 (AP1) at Coffeen Power Station. The Closure Alternatives Analysis is being completed in accordance with Illinois Administrative Code Title 35, Part 845, Standards for the Disposal of Coal Combustion Residuals (CCR) in Surface Impoundments (Part 845), by Gradient. With this technical memorandum, Golder summarizes the design basis and references used in developing the closure concepts evaluated by the Closure Alternatives Analysis.

Golder reviewed several documents related to the design, construction, and operation of AP1. Notable documents included the History of Construction (AECOM 2016a), the AP1 CCR Certification Report (AECOM 2016b), and the 2021 Periodic Certification Report for Ash Pond No. 1 (Geosyntec 2021).

1.0 INTRODUCTION AND BACKGROUND

1.1 Operational History

AP1 was constructed in 1964 and operated until the Coffeen Power Station was retired in 2019. AP1 formerly served as the primary wet impoundment basin for bottom ash produced at Coffeen Power Station and has a surface area of approximately 26.2 acres. Base grade elevations range from approximately El. 594 feet (North American Vertical Datum of 1988) to El. 620 feet. AP1 was used as a flow-through structure, where outflow was ultimately discharged to Coffeen Lake, until approximately 1979 to 1981, when AP1 was modified to facilitate recycling of water on site. The modifications included abandoning the penetrating discharge pipe in the northeast corner of the impoundment, adding a recycle intake structure in the northwest corner, removing some of the accumulated ash, flattening the interior embankment slopes using boiler slag, and regrading the remainder of the bottom ash to form a new impoundment flow.

After the facility modifications, when Coffeen Power Station was operational, outflow from AP1 flowed into the recycle intake structure (outlet pipe) and was transferred back to Coffeen Power Station for use as process water. An approximately 1,300-foot long interior dike creates an internal channel leading to the recycle intake structure. AP1 was operated as a closed-loop hydraulic system as outflow was transmitted back to Coffeen Power Station during normal operational conditions. Bottom ash was mechanically excavated from the southwest corner of AP1 for offsite beneficial use.

Sluiced bottom ash from Coffeen Power Station entered AP1 through three steel sluice pipes, which discharged along the western embankment, on the south side of the interior dike. Additional clear water inflow from Coffeen Power Station entered AP1 through two pipes, which discharged at a concrete structure approximately 120 feet north of the sluice pipes, and a 12-in. diameter ductile iron pipe located at the northwest corner of the embankment. Outflow water was transmitted back to Coffeen Power Station via a concrete riser recycle intake structure and 48-in. diameter steel recycle intake pipe located at the northwest corner of AP1, which functioned as the primary outflow pipe for AP1. The pool level was controlled by a steel spillway gate, which allowed for pool levels ranging from El. 624.5 ft to 631.0 feet. However, a berm was constructed with bottom ash around the inlet to the spillway after plant closure in 2019 to provide freeze protection for the gate while still allowing overflow during higher pool levels. A secondary 24-inch diameter pipe, which starts as a corrugated metal pipe (CMP) and transitions to steel, is connected to the 48-inch diameter steel recycle intake pipe within the embankment and was used to discharge excess flow into the process water flume during upset conditions and act as an overflow pipe (See Sheet 5, Drawing No. S-45 from AECOM 2016a).

The embankment portion of AP1 is comprised of a ring dike with a total length of approximately 4,350 ft and has a maximum height above exterior grade of 30 feet. The embankment was constructed as a homogenous earthen structure with well-compacted clayey fill. An approximately 570-foot long Hoesch 2500k steel sheet pile wall is located at the toe of the northeast corner of AP1, to separate the embankment from the plant process water flume. The process water flume was used to transmit plant cooling water back to Coffeen Lake over a series of weirs. The water level in the process water flume was surveyed to be approximately El. 600 feet in 2020, after plant closure. The sheet pile wall was installed around 2000 and driven approximately 13 feet into the foundation soils and has a maximum exposed height of 13.8 feet, for a total pile length of approximately 27 ft. Downstream dike slopes, outside of the sheet pile wall area, range from approximately 1.3H:1V (horizontal to vertical) along the southern embankment to 3H:1V and generally are covered in vegetation. Interior embankment slopes were originally constructed at 1.5H:1V out of clayey fill. Additional boiler slag material was added to the interior slopes in 1981 to flatten them to approximately 3H:1V. The embankment crest width varies from approximately 14 to 22 feet. An engineered liner system is not present beneath AP1.

The normal maximum operating water level of AP1 was El. 631.0 ft when the plant was operational, as controlled by the recycle intake structure and emergency outflow pipes. The maximum normal operating water level may be different now due to the bottom ash berm placed around the recycle intake structure. The minimum crest elevation is 635.0 ft.

1.2 Existing AP1 Liner System Information

Based on the evaluation of design drawings and available construction records, AP1 was not constructed with a liner that meets the design criteria in 40 CFR 257.71(a)(1)(i), (ii), or (iii), respectively, for a compacted soil liner, a composite liner, or an alternative composite liner. Permeability requirements were not specified for the native soils. Native soils in the area of AP1 generally consist of clay and wind-blown origin (loess), with some coarse-grained layers. The clay encountered in borings conducted in the vicinity of AP1 are generally classified as low- to medium-plasticity silty clay, sandy lean clay, or lean clay with sand (CL) often with trace amounts of gravel; or high plasticity fat clay (CH), often with trace amounts of sand. The CL and CH soils are soft to very stiff, moist to wet, and brown to gray. The coarse-grained soils encountered in the borings were classified as clayey sand (SC), silty sand (SM), or fine to coarse sand (SP), with trace amounts of gravel, loose to dense, wet, and brown to gray (AECOM, 2016b).

1.3 Type and Volume of Materials

Based on Golder's comparison (using Autodesk Civil 3D) of the existing conditions (December 2020 survey by IngenAE) and the approximate base of ash grades developed from the 1963 earthwork and grading plans, approximately 436,000 cubic yards (CY) of bottom ash are present in AP1.

Minimal information on the specific bottom ash material produced at Coffeen Power Station is available. Because the material was sluiced, the particle-size distribution of the bottom ash in AP1 is expected to be variable, becoming finer with increased distance from the deposition locations. Laboratory gradation testing was performed on two bottom ash samples collected from AP1 in 2016 at depths of 1 ft and 6 ft below ground surface (bgs). The gradation of the samples ranged from 0-2% gravel-sized particles, 88-93% sand-sized particles, and 7-10% silt and clay-sized particles (AECOM 2016b). For comparison, We Energies (2013) reports a similar gradation for bottom ash produced at Pleasant Prairie Power Plant, but with less sand-sized particles (77%) and greater amount of gravel-sized particles (10%) and silt and clay-sized particles (13%). Additionally, We Energies (2013) indicates a measured hydraulic conductivity of $4.9x10^{-3}$ cm/s for bottom ash produced at Pleasant Prairie Power Plant.

1.4 Water Levels

At the time of the December 2020 survey by IngenAE, the water level in AP1 was El. 629.2 feet. Although the water level would be expected to respond to wet or dry climate conditions, this water level is likely typical. Based on this water level, approximately 89% (388,000 CY) of the ash in AP1 is below the water level. Ash below the water level can be considered saturated. The ash above the water level forms a plateau at the southeast side of AP1 with the highest point at approximately El. 641.5 feet. Based on Golder's site observations and past history of beneficial use operations at AP1, ash above the water level is likely moist, but not saturated, and is capable of supporting light equipment traffic.

Ramboll has provided a surface corresponding to the top of the uppermost aquifer unit. Based on a comparison of this surface and the approximate base of ash grades, the base of ash appears to be below the top of the uppermost aquifer in the northeastern portion of AP1.

2.0 CLOSURE-BY-REMOVAL INFORMATION

Section 845.710(c)(1) requires the evaluation of complete removal of CCR and Section 845(d)(2) requires Closure Alternatives Analysis to identify if the Power Plant has a landfill that can accept the CCR or if constructing an on-Site landfill is feasible. Additionally, Section 845.710(c)(1) requires the evaluation of multiple modes of transportation of CCR, including rail, barge, and truck. This section includes evaluation of on-Site landfill options, potential off-Site landfills, and potential methods for transporting CCR to off-Site landfills.

2.1 Evaluation of On-Site CCR Landfill Options

There is an existing CCR landfill at the Coffeen Site, which currently has capacity for up to approximately 375,500 CY of additional material. 79,000 CY of material from the Gypsum Management Facility (GMF) Recycle Pond (RP) are planned for disposal in the on-Site landfill, which leaves approximately 296,000 CY of capacity for additional material from AP1. Therefore, the on-Site landfill does not currently have the capacity to contain all the CCR and subsoil that would be excavated from AP1 under the closure by removal scenario. However, under closure by removal, material will be disposed of in the on-Site landfill until it reaches capacity, after which material will be hauled off-Site for disposal.

Due to planned future land use of the surrounding property dedicated to renewable power generation, the landfill also cannot be expanded to sufficiently increase its capacity. Neither expansion of the existing on-site landfill nor construction of a new on-site landfill is a viable alternative at this site.

2.2 Potential Off-Site CCR Receiving Landfills

Potential off-Site landfills suitable for disposing of the approximately 140,000 CY of CCR and 35,500 CY of subsoil within AP1 that are beyond the capacity of the on-Site landfill, were evaluated using IEPA's online Illinois Disposal Capacity Report. The closest landfills to the site, by road miles, were determined to be Republic Services' Litchfield-Hillsboro Landfill (a.k.a. Litchfield Landfill) in Litchfield, Illinois and Waste Management's Five Oaks Recycling and Disposal Facility (a.k.a. Five Oaks Landfill) in Taylorville, Illinois.

The Litchfield Landfill is the preferred landfill due to its location being closer to the Coffeen Power Plant (17.9 vs. 43.5 one-way miles, respectively), thereby resulting in reduced hauling mileage. Both landfills have sufficient remaining capacity to receive the approximately 175,500 CY of CCR and subsoil, although the landfills have not yet been contacted, as of the date of this report, to confirm that they would be willing to accept the CCR. Information on both landfills is provided in Table 1 below.

Table 1: Off-Site Landfill Information

Landfill Name	Owner	Location	One-Way Distance from Site by Road (Miles)	2020 Five-Year Average Disposal Volume (in-place CY)	2020 Remaining Capacity Reported (in-place CY)
Litchfield Landfill	Republic Services	Litchfield, IL	17.9	82,620	1,535,189
Five Oaks Landfill	Waste Management	Taylorville, IL	43.5	249,664	7,051,864

2.3 Potential Off-Site CCR Transportation Methods

Section 845.710(c)(1) requires Closure-by-Removal to consider multiple methods for transporting removed CCR, including using rail, barge, and trucks. An evaluation of each method is included within this section.

2.3.1 Transportation by Rail

The Coffeen Power Plant currently has a rail spur on-Site that was historically used to receive coal shipments, which were unloaded via an unloading terminal. The terminal is not currently suitable for the loading of CCR into rail cars as it was designed and constructed for unloading, rather than loading. Additionally, the terminal was partially decommissioned by removing associated transformers and disconnecting the electrical supply after the Coffeen Power Plant was closed in 2019. In order for CCR to be hauled by rail from the Coffeen Power Plant, a new loading terminal would need to be constructed, thereby increasing the project schedule due to the need to complete design, permitting, and construction.

While the Lichfield Landfill is located within approximately 2.3 miles of an existing rail line, an existing terminal suitable for the unloading of CCR is not present. A rail unloading terminal would need to be constructed, which would increase the project schedule due to the need to coordinate with the railroad, complete design and permitting, and construct the terminal. CCR would still need to be hauled by truck from the new off-Site unloading terminal to the landfill, resulting in additional CCR handling and exposure to the surrounding environment. The Five Oaks Landfill has a rail spur on-site.

Furthermore, a direct rail route from the Coffeen Power Plant to either landfill does not exist. Hauling CCR to the Lichfield or Five Oaks Landfills would involve approximately 25 and 63 miles, respectively, of hauling by rail on tracks owned by three separate rail lines (Norfolk Southern Ry. Co., BNSF Ry. Co., and Illinois & Midland R.R. Inc.). The ability of CCR to be hauled over multiple lines and transferred from line to line is currently unknown.

Therefore, transporting CCR by rail is unlikely to be a viable option for AP1 at the Coffeen Power Plant, due to the need to design, permit, and construct additional loading and unloading infrastructure, resulting in corresponding project schedule delays, and the distance and number of rail lines which the CCR would need to be transported over.

2.3.2 Transportation by Barge

The Coffeen Power Plant is not located near a navigable waterway and, therefore, transportation of CCR by barge is not feasible.

2.3.3 Transportation by Truck

The Coffeen Power Plant is located approximately 2.9 miles from Illinois Route 185 (IL-185), which is suitable for receiving truck hauling traffic. Red Ball Trail links the Coffeen Power Plant to IL-185 and routinely receives truck traffic associated with adjacent industrial facilities and the Coffeen Power Plant. Potential travel routes between the Coffeen Power Plant and Litchfield and Five Oaks Landfills have been assumed for cost estimate purposes, although actual travel routes may vary.

Transporting CCR by truck will not require the construction of additional loading or unloading infrastructure at either the receiving landfill or the Coffeen Power Plant. CCR would be loaded into trucks using heavy equipment at AP1. CCR will then be unloaded at the receiving landfill by the truck directly. Since no construction is required, project delays related to coordination with other entities, design, and permitting are unlikely to occur. Therefore, transporting CCR by truck is a viable option for AP1 at the Coffee Power Plant.

3.0 CLOSURE DESCRIPTION NARRATIVES

Section 845.720(a)(1)(A) requires narrative description of CCR impoundment closures to be prepared. Narrative descriptions have been prepared for both closure-in-place and closure-by-removal and are included in this section.

3.1 AP1 Closure-in-Place

The closure-in-place concept for AP1 was developed to reduce the waste footprint at closure and to achieve 10 feet of vertical separation between the top of aquifer and the ash material. The proposed closure-in-place option would have final cover slopes of 7H:1V to approximate El. 664 feet transitioning to 20H:1V (5%) slopes above that elevation to accommodate moderate settlement and promote drainage. A berm will be constructed at the east end of the consolidated footprint for stability. The location of the berm has been selected to accommodate the estimated 436,000 CY of ash and 21,500 CY of excavated subsoil to be contained within the consolidated footprint based on the grading plan presented. The general sequencing plan for the closure-in-place option is as follows:

- Pump out ponded water [approximately 15.2 million gallons (MG)] from AP1 through Outfall K20 to the existing drainage to the north where it will be managed in accordance with the NPDES permit for the site.
- A temporary water management system will be constructed within AP1, including ditches and sumps. The system will maintain AP1 in an unwatered state by collecting contact stormwater during closure construction. Stormwater flow will be conveyed through Outfall K20 to the existing drainage to the north where it will be managed in accordance with the NPDES permit for the site.
- Once the ponded water has been removed from AP1, the ash in the consolidated footprint will be dewatered. Approximately 268,600 CY of ash east of the consolidated footprint will be dewatered as needed to enable relocation. It is anticipated that approximately 14.1 MG of water removal will be required to dewater the ash. The ash will dewater to some degree by gravity, but dewatering by pumping from trenches and sumps is expected to be necessary. Liquid waste and water flowing to sumps will be managed in accordance with the NPDES permit for the site and discharged through Outfall K20.
- Any accumulated ash within the riser structure and outlet pipes will be removed and the riser structure and outlet pipes will be decontaminated by pressure washing. Decontamination water will be routed through Outfall K20 and managed in accordance with the NPDES permit for the Site. The riser structure will be demolished and disposed of in the consolidated footprint and the outlet pipes will be plugged and abandoned or removed and disposed of.
- Ash will be removed from the berm footprint and relocated into the consolidated footprint. The berm will be constructed in north-south orientation at the east end of the consolidated footprint.
- The remaining ash east of the berm will be collected and deposited west of the berm. It is anticipated that up to 1 foot of subsoil beneath the ash may also be removed. The subsoils will be visually observed for signs of CCR. If subsoils with signs of CCR are observed, they will be removed and deposited west of the berm (for the purposes of conceptual design, assume 1 foot, or approximately 21,500 CY, will need to be removed).
- Compacted fill, composed of locally available soils, would be placed only as needed to achieve final cover subgrade. The compacted fill is anticipated to be compacted to a minimum of 95% of the standard Proctor maximum dry density to reduce settlement.
- Construction of an alternate final cover system, consisting of (from top to bottom):
  - 24-inch final protective soil layer. The soil layer would include a 6-inch-thick topsoil layer and be revegetated with native grasses. This layer will consist of locally available soils from the removed embankment containment berm compacted to between 80% and 95% of the standard Proctor maximum dry density for establishment of vegetation and protection of the underlying geomembrane. Protective soil layer material is likely to be primarily low-plasticity silt or clay based on review of site geotechnical information.
  - Nonwoven geotextile cushioning layer.
  - 40-mil linear low-density polyethylene (LLDPE) geomembrane layer.

- All areas of the cover system will be sloped at a minimum of 1% to positively drain to the exterior of AP1. Stormwater runoff from the AP1 closure area will be removed from the top of the final cover via the construction of a free-draining stormwater management system, including berms, channels, and letdown structures, that will convey stormwater to existing surface water bodies.
- Exterior slopes of the existing western, northern, and southern containment berms used to contain the consolidated AP1 footprint will be recontoured as necessary with additional soil, sourced from the existing berms that are no longer required, to achieve minimum 3H:1V side slopes for long-term stability.
- To prevent impoundment of water in the eastern end of the current AP1 footprint after ash removal, existing earthen embankments not required for the consolidated footprint will be removed and a channel will be excavated to allow stormwater to flow through existing NPDES Outfall K20 into the existing drainage.
- Soil fill, sourced from existing berms no longer required to contain waste in the consolidated footprint or from the on-Site soil borrow area southeast of AP1, will be used as fill in low areas of the existing AP1 base grade to provide at least one foot of soil cover above the top of the uppermost aquifer and establish the final ground surface.
- The final ground surface of the eastern part of AP1 will be sloped to drain a minimum of 0.5% towards the channel excavated in the northeast corner, in order to allow post-closure, non-contact stormwater to gravity flow into the existing drainage.
- Vegetation will be established on the final surface of AP1. Stormwater best management practices (BMPs) such as erosion control blankets will be used, as needed to reduce erosion during vegetation establishment.
- After vegetation is established, BMPs will be removed, and closure construction will be considered complete.

3.2 AP1 Closure by Removal

A narrative description of closure-by-removal activities associated with AP1 include:

- Pump out ponded water (approximately 15.2 MG) from AP1 through Outfall K20 to the existing drainage to the north where it will be managed in accordance with the NPDES permit for the site.
- A temporary water management system will be constructed within AP1, including ditches and sumps. The system will maintain AP1 in an unwatered state by collecting contact stormwater during closure construction. Stormwater flow will be conveyed through Outfall K20 to the existing drainage to the north where it will be managed in accordance with the NPDES permit for the site.
- Once the ponded water has been removed from AP1, the ash will be dewatered to enable relocation. Approximately 388,000 CY of ash is located below the current water level in AP1 and it is anticipated that approximately 20.3 MG of water removal will be required to dewater the ash. The ash will dewater to some degree by gravity, but dewatering by pumping from trenches and sumps is expected to be necessary. Liquid waste and water flowing to sumps will be managed in accordance with the NPDES permit for the site and discharged through Outfall K20.
- Ash will be removed from AP1 using mass mechanical excavation techniques.

- Approximately 296,000 CY of ash will be hauled by truck from AP1 to the on-Site CCR Landfill until the on-site CCR Landfill reaches capacity.
- The remaining ash (approximately 140,000 CY) will be loaded into over-the-road dump trucks and hauled to the off-Site receiving landfill.
- It is anticipated that up to 1 foot of subsoil (35,500 CY) beneath the ash may also be removed. The subsoils will be visually observed for signs of CCR. If subsoils with signs of CCR are observed, they will be loaded into over-the-road dump trucks and hauled to the off-Site receiving landfill.
- Any accumulated ash within the riser structure and outlet pipes will be removed and the riser structure and outlet pipes will be decontaminated by pressure washing. Decontamination water will be routed through Outfall K20 and managed in accordance with the NPDES permit for the Site. The removed ash will also be disposed of in the off-Site receiving landfill. The riser structure will be demolished and disposed of in the off-Site receiving landfill and the outlet pipes will be plugged and abandoned or removed and disposed.
- To prevent impoundment of water in the decontaminated AP1, existing earthen embankments will be removed and a channel will be excavated to allow stormwater to flow through existing NPDES Outfall K20 into the existing drainage.
- Protective cover soil, sourced from existing berms no longer required to contain CCR, will be used as fill in low areas of the existing AP1 base grade to provide at least one foot of soil cover above the top of the uppermost aquifer and establish the final ground surface.
- The final ground surface of AP1 will be sloped to drain a minimum of 0.5% towards the channel excavated in the northeast corner, in order to allow post-closure, non-contact stormwater to gravity flow into the existing drainage.
- Vegetation will be established on the final surface of AP1. Stormwater best management practices (BMPs) such as erosion control blankets will be used, as needed to reduce erosion during vegetation establishment.
- After vegetation is established, BMPs will be removed, and closure construction will be considered complete.

4.0 CONSTRUCTION SCHEDULES

Section 845.720(a)(1)(F) requires a schedule including all activities necessary to complete closure to be prepared. Schedules have been prepared for both closure-in-place and closure-by-removal and are included within this section. Schedules were prepared using estimates of task durations based on Golder’s experience, typical weather conditions at the site, and expected construction rates relative to estimated construction quantities.

4.1 AP1 Closure-in-Place

The proposed closure completion schedule for closure-in-place is provided in Table 2.

Table 2: Construction Schedule - AP1 Closure-in-Place

Milestone	Timeframe (Preliminary Estimates)
Agency Coordination, Approvals, and Permitting	8 to 12 months after Final Closure Plan Approval

Milestone	Timeframe (Preliminary Estimates)
■ Obtain state permits, as needed, for dewatering, water discharge, land disturbance, and dam modifications	
Final Design and Bid Process ■ Complete final design of the closure and select a construction contractor	8 to 14 months after Agency Coordination, Approvals, and Permitting
Dewater and Stabilize CCR, Install Final Cover System ■ Complete contractor mobilization, installation of stormwater BMPs, and unwatering of AP1 ■ Abandon outlet structures, stabilize AP1, and complete grading ■ Install the final cover system and stormwater conveyances ■ Winter weather delays are assumed between November and March of each construction year	13 to 18 months after necessary permits are issued
Site Restoration ■ Seed and stabilize AP1 ■ Complete contractor demobilization	2 to 3 months after the final cover system is complete
Timeframe to Complete Closure	31 to 47 months

4.2 AP1 Closure-by-Removal

The proposed closure completion schedule for closure-by-removal is provided in Table 3.

Table 3: Construction Schedule - AP1 Closure-by-Removal

Milestone	Timeframe (Preliminary Estimates)
Agency Coordination, Approvals, and Permitting ■ Obtain state permits, as needed, for dewatering, water discharge, land disturbance, and dam modifications	8 to 12 months after Final Closure Plan Approval
Final Design and Bid Process	8 to 14 months after Agency Coordination, Approvals, and Permitting

Milestone	Timeframe (Preliminary Estimates)
■ Complete final design of the closure and select a construction contractor	
Dewater and Excavate CCR, Decontaminate CCR Unit ■ Complete contractor mobilization, installation of stormwater BMPs, and unwatering of AP1 ■ Complete mass excavation of CCR and decontamination of AP1 ■ Winter weather delays are assumed between November and March of each construction year	16 to 24 months after necessary permits are issued
Backfill with Clean Soil ■ Regrade AP1 base grade and fill above low areas to provide at least one foot above top of uppermost aquifer. Slope to drain.	2 to 3 months after decontamination is complete
Site Restoration ■ Seed and stabilize AP1 ■ Complete contractor demobilization	2 to 3 months after backfill is complete
Timeframe to Complete Closure	36 to 56 months

5.0 MATERIAL, QUANTITY, COST, LABOR, AND MILEAGE ESTIMATES

Section 845.720(d)(1) requires that a cost estimate be prepared in accordance with the Class 4 standards of the Association for the Advancement of Cost Engineering (AACE). Cost estimates for both closure-in-place and closure-by-removal were prepared in accordance with the AACE Class 4 standards.

In addition to construction cost and quantity estimates, Golder has also prepared estimates of construction labor hours, equipment usage, haul truck mileage, daily labor mobilization vehicle mileage, material delivery mileage, and on-Site vehicle mobilization mileage.

Estimates were prepared using the following approach:

- Major construction components and line items were identified, in accordance with the narrative closure description
- Construction quantities were estimated based on volume estimates, area estimates, and proposed construction schedules

- Unit costs were estimated for each construction line item using RS Means Heavy Construction Cost Data. For line items where RS Means data was not available, unit costs were estimated based on Golder's experience.
- RS Means unit costs were developed assuming Union labor for Effingham, Illinois (located approximately 51 miles from AP1), for 2022
- Soil fill requirements beyond what is available on-Site was assumed to come from off-Site borrow sources located within 2 miles of the site, as limited borrow soil is expected to be available at the Coffeen Power Plant, due to planned future land use of the surrounding property dedicated to renewable power generation
- For line items where RS Means was used to develop the costs, the corresponding RS Means crew size, equipment description, and daily output were used to estimate the total number of man-hours and equipment hours. For line items where RS Means data was unavailable, the crew size, equipment description, and daily output were estimated based on Golder's experience.
- Daily labor mobilization miles were estimated assuming an average one-way commute of 35 miles for each individual working on-Site. The number of working days were estimated from the construction schedules.
- Estimates of haul truck mileage were based on the assumed round-trip haul distance and dump truck size. All dump trucks were assumed to be filled to capacity.
- Estimates of material delivery miles were prepared based on Golder's experience
- A contingency of 30% was applied for the construction cost estimate total, based on the level of design and quantity estimate prepared as part of this Memo

The total cost estimate for closure-in-place is **$8,889,000**, including contingency. The detailed cost estimate and labor and mileage estimates are provided in Tables 4 and 5, respectively.

The total cost estimate for closure-by-removal is **$36,689,000**, including contingency. The detailed cost estimate and labor and mileage estimates are provided in Tables 6 and 7, respectively.

6.0 REFERENCES

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APPENDIX A

Tables

AACE Class 4 Estimate
Coffeen Power Station
Closure-in-Place of Ash Pond No. 1

Item No.	Item Description	Quantity	Unit	Unit Rate (USD$/unit)	Cost (USD$)	Crew	Daily Output	Labor Hours	Equipment Hours	Notes/Assumptions/Reference
	Pre-Construction									
1	Mobilization and Demobilization (10% of Construction Subtotal)	1	LS	$ 540,500.0	$ 540,500					Typical Industry Value
	Pre-Construction Subtotal				***$ 541,000***					
	Site Preparation									
2	Mow Vegetation in limits of disturbance	87	MSF	$ 40.74	$ 3,544	B84	22	32	32	RS Means 320190191660: Mowing, mowing brush, light density, tractor with rotary mower
3	Construction Soil Erosion & Sediment Controls (Silt Fence)	5000	LF	$ 3.39	$ 16,950	B62	650	185	62	RS Means 312514161000: Synthetic erosion control, silt fence, install and remove, 3' high
4	Construction Facilities	17	MO - in use	$ 969.61	$ 16,251	-	-	-	-	
	Office Trailer	17	MO - in use	$ 258.53	$ 4,333	-	-	-	-	RS Means 015213200350: Office trailer, furnished, rent per month, 32' x 8', excl. hookups
	Storage Trailers (x2)	17	MO - in use	$ 291.92	$ 4,893	-	-	-	-	RS Means 015213201350: Storage boxes, rent per month, 40' x 8'
	Portable Toilet (x2)	17	MO - in use	$ 419.16	$ 7,025	-	-	-	-	RS Means 015433406410: Rent toilet portable chemical, incl. hourly oper. cost
5	Dust Control	120	Day	$ 2,206.88	$ 264,826	B59	0.5	1,920	1,920	RS Means 312323202510: Hauling, heavy, dust control, includes loading
6	Haul Road Maintenance	55	Day	$ 1,502.78	$ 82,653	B86A	1	440	440	RS Means 312323202600: Hauling, haul road maintenance, includes loading
	Site Preparation Subtotal				***$ 384,000***			***2,580***	***2,450***	
	Dewatering, Unwatering, and Stormwater Management									
7	Unwatering of AP1 ponded water	147	Day	$ 1,105.32	$ 162,045	Dewater	4	293	73	RS Means 312319200650: Dewatering, pumping 8 hours, attended 2 hours per day, 4" dischage pump used for 8 hours, includes 20 LF of suction hose and 100 LF of discharge hose
8	Dewatering and Stormwater Management for AP2	356	Day	$ 1,105.32	$ 393,705	Dewater	4	712	178	RS Means 312319200650: Dewatering, pumping 8 hours, attended 2 hours per day, 4" dischage pump used for 8 hours, includes 20 LF of suction hose and 100 LF of discharge hose
9	Dewatering Sumps Installation	4	EA	$ 10,000.00	$ 40,000	Sump Install	4	16	8	Unit Rate, Crew, and Daily Output based on experience. Materials include 24" corrugated HDPE pipe with geotextile wrapping, and 1 CY of gravel backfill
	Dewatering, Unwatering, and Stormwater Management Subtotal				***$ 596,000***			***1,020***	***260***	
	Ash Pond No. 1 Closure									
10	Removal and Abandonment of Riser and Outlet Structure	-	LS	-	$ 34,193	-	-	155	24	
	Demolition of Steel Walkway	800	SF	$ 13.81	$ 11,048	B21C	500	90	13	RS Means 024116330200: Bridge demolition, pedestrian, steel, 50' to 160' long, 8' to 10' wide
	Demolition of Outlet Structure	20	LF	$ 19.86	$ 397	B69	300	3	1	RS Means 024113430100: Selective demolition, box culvert, precast, 8' x 6' x 3' to 8' x 8' x 8', excludes excavation
	Plugging of Outlet Pipe	2	CY	$ 1,974.12	$ 3,948	C14A	18	22	2	RS Means 033053401040: Structural concrete, in place, column (4000 psi), square, up to 3% reinforcing by area, 36" x 36", including forms (4 uses), Grade 60 rebar, concrete (portland cement Type I), placement and finishing included
	Cleaning of Pipe Interior	1	LS	$ 3,000.00	$ 3,000	2 Clab	1	16	-	Unit Rate, Crew, and Daily Output based on experience.
	Grouting of Pipe	79	CY	$ 200.00	$ 15,800	Grout/Concrete	80	24	8	Unit Rate, Crew, and Daily Output based on experience.
11	Relocation of Ash Material and Contaminated Subgrade	290200	CY - in place	$ 8.34	$ 2,419,397	-	-	8,374	6,778	
	Excavation and Loading of Material	304710	CY - as excavated	$ 1.50	$ 457,065	B14A	3230	1,132	755	RS Means 312316435400: Excavating, large volume projects; excavation with truck loading; excavator, 4.5 CY bucket, 95% fill factor (assume 5% shrinkage factor from ground to in-place)
	Hauling of Material	304710	CY - as excavated	$ 4.06	$ 1,237,123	B34G	680	3,585	3,585	RS Means 312323206020: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld/uld., 5 MPH, cycle 4000 feet
	Spreading of Material	304710	CY - as excavated	$ 2.38	$ 725,210	B10B	1000	3,657	2,438	RS Means 312323170020: Fill, dumped material, spread, by dozer, excludes compaction
12	Excavation and Placement of Embankment Fill	28000	CY - in place	$ 8.89	$ 248,836	-	-	937	740	
	Excavation and Loading of Material	29400	CY - as excavated	$ 1.50	$ 44,100	B14A	3230	109	73	RS Means 312316435400: Excavating, large volume projects; excavation with truck loading; excavator, 4.5 CY bucket, 95% fill factor (assume 5% shrinkage factor from ground to in-place)
	Hauling of Material	29400	CY - as excavated	$ 4.06	$ 119,364	B34G	680	346	346	RS Means 312323206020: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld/uld., 5 MPH, cycle 4000 feet
	Spreading of Material	29400	CY - as excavated	$ 2.38	$ 69,972	B10B	1000	353	235	RS Means 312323170020: Fill, dumped material, spread, by dozer, excludes compaction
	Compaction of Material	28000	CY - in place	$ 0.55	$ 15,400	B10F	2600	129	86	RS Means 312323235100: Compaction; Riding, vibrating roller, 12" lifts, 4 passes (RSMeans Crew is B10Y; altered to B10F based on experience)
13	Excavation and Stockpiling of Excess Cut Material	24320	CY - in place	$ 5.84	$ 141,980	-	-	395	363	
	Excavation and Loading of Material	25536	CY - as excavated	$ 1.50	$ 38,304	B14A	3230	95	63	RS Means 312316435400: Excavating, large volume projects; excavation with truck loading; excavator, 4.5 CY bucket, 95% fill factor (assume 5% shrinkage factor from ground to in-place)
	Hauling and Dumping of Material	25536	CY - as excavated	$ 4.06	$ 103,676	B34G	680	300	300	RS Means 312323206020: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld/uld., 5 MPH, cycle 4000 feet
14	Excavation and Placement of Fill over Top of Aquifer	9600	CY - in place	$ 8.89	$ 85,315	-	-	321	255	
	Excavation and Loading of Material	10080	CY - as excavated	$ 1.50	$ 15,120	B14A	3230	37	25	RS Means 312316435400: Excavating, large volume projects; excavation with truck loading; excavator, 4.5 CY bucket, 95% fill factor (assume 5% shrinkage factor from ground to in-place)
	Hauling of Material	10080	CY - as excavated	$ 4.06	$ 40,925	B34G	680	119	119	RS Means 312323206020: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld/uld., 5 MPH, cycle 4000 feet
	Spreading of Material	10080	CY - as excavated	$ 2.38	$ 23,990	B10B	1000	121	81	RS Means 312323170020: Fill, dumped material, spread, by dozer, excludes compaction
	Compaction of Material	9600	CY - in place	$ 0.55	$ 5,280	B10F	2600	44	30	RS Means 312323235100: Compaction; Riding, vibrating roller, 12" lifts, 4 passes (RSMeans Crew is B10Y; altered to B10F based on experience)
15	Geomembrane	450900	SF - in place	$ 1.52	$ 685,368	B63B	1600	9,018	2,255	RS Means 310519531200: Pond and reservoir liners, membrane lining systems HDPE, 100,000 S.F. or more, 60 mil thick, per S.F. (multiplied unit rate by 0.5 based on experience)
16	Geotextile	450900	SF - in place	$ 0.37	$ 166,833	2 Clab	22500	321	-	RS Means 313219161550: Geotextile soil stabilization; non-woven 120 lb. tensile strength (multiplied unit rate by 4 to account for heavier geotextile based on experience)
17	Anchor Trench Installation	2400	LF	$ 2.71	$ 6,504	-	-	71	47	
	Excavation of Material	374	CY - as excavated	$ 10.05	$ 3,757	B11C	150	40	20	RS Means 312316130050: Excavating, Trench or continuous footing, common earth with no sheeting or dewatering included, 1' to 4' deep, 3/8 C.Y. excavator
	Backfilling Material	374	CY - as excavated	$ 3.14	$ 1,174	B10R	400	11	7	RS Means 312316133020: Backfill trench, F.E. Loader, wheel mtd., 1 C.Y. bucket, minimal haul
	Compaction of Material	356	CY - in place	$ 4.42	$ 1,574	A1D	140	20	20	RS Means 312323237040: Compaction, walk behind, vibrating plate 18" wide, 6" lifts, 4 passes
18	Excavation and Placement of Exterior Embankment 3:1 Fill	7100	CY - in place	$ 8.89	$ 63,098	-	-	238	188	
	Excavation and Loading of Material	7455	CY - as excavated	$ 1.50	$ 11,183	B14A	3230	28	18	RS Means 312316435400: Excavating, large volume projects; excavation with truck loading; excavator, 4.5 CY bucket, 95% fill factor (assume 5% shrinkage factor from ground to in-place)
	Hauling of Material	7455	CY - as excavated	$ 4.06	$ 30,267	B34G	680	88	88	RS Means 312323206020: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld/uld., 5 MPH, cycle 4000 feet
	Spreading of Material	7455	CY - as excavated	$ 2.38	$ 17,743	B10B	1000	89	60	RS Means 312323170020: Fill, dumped material, spread, by dozer, excludes compaction
	Compaction of Material	7100	CY - in place	$ 0.55	$ 3,905	B10F	2600	33	22	RS Means 312323235100: Compaction; Riding, vibrating roller, 12" lifts, 4 passes (RSMeans Crew is B10Y; altered to B10F based on experience)
19	Placement of Protective Cover Soil	33400	CY - in place	$ 8.68	$ 289,921	-	-	985	795	
	Excavation and Loading of Material	35070	CY - as excavated	$ 1.50	$ 52,605	B14A	5000	84	56	RS Means 312316435400: Excavating, large volume projects; excavation with truck loading; excavator, 4.5 CY bucket, 95% fill factor (assume 5% shrinkage factor from ground to in-place)
	Hauling of Material	35070	CY - as excavated	$ 4.06	$ 142,384	B34G	680	413	413	RS Means 312323206020: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld/uld., 5 MPH, cycle 4000 feet
	Spreading of Material	35070	CY - as excavated	$ 2.38	$ 83,467	B10B	1000	421	281	RS Means 312323170020: Fill, dumped material, spread, by dozer, excludes compaction
	Finish Grading of Material	49851	SY	$ 0.23	$ 11,466	B10W	8900	67	45	RS Means 312216103300: Fine grading, Finish grading slopes, gentle. Crew altered to reflect likely equipment to be used based on experience
20	Placement of Stormwater Tack-on Berms	1880	LF	$ 5.37	$ 10,089	-	-	34	28	
	Excavation and Loading of Material	1204	CY - as excavated	$ 1.50	$ 1,806	B14A	5000	3	2	RS Means 312316435400: Excavating, large volume projects; excavation with truck loading; excavator, 4.5 CY bucket, 95% fill factor (assume 5% shrinkage factor from ground to in-place)
	Hauling of Material	1204	CY - as excavated	$ 4.06	$ 4,889	B34G	680	14	14	RS Means 312323206020: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld/uld., 5 MPH, cycle 4000 feet
	Spreading of Material	1204	CY - as excavated	$ 2.38	$ 2,866	B10B	1000	14	10	RS Means 312323170020: Fill, dumped material, spread, by dozer, excludes compaction
	Finish Grading of Material	2298	SY	$ 0.23	$ 529	B10W	8900	3	2	RS Means 312216103300: Fine grading, Finish grading slopes, gentle. Crew altered to reflect likely equipment to be used based on experience
	Ash Pond No. 1 Closure Subtotal				***$ 4,152,000***			***20,850***	***11,470***	
	Site Restoration									
21	Riprap Stormwater Letdown Structures	2000	SF - in place	$ 15.43	$ 30,860	-	-	236	34	
	Geotextile	2000	SF - in place	$ 0.37	$ 740	2 Clab	22500	1	-	RS Means 313219161550: Geotextile soil stabilization; non-woven 120 lb. tensile strength (multiplied unit rate by 4 to account for heavier geotextile based on experience)
	Riprap	2000	SF - in place	$ 15.06	$ 30,120	B13	477	235	34	RS Means 313713100200: Riprap and rock lining, random, broken stone, machine placed for slope protection, 18" minimum thickness, not grouted
22	Erosion Control Blanket	37600	SF - in place	$ 0.25	$ 9,400	ECB	22500	40	13	RS Means 312514160100. Rolled erosion control mats and blankets, plastic netting, stapled, 2" x 1" mesh, 20 mil.
23	Straw Wattle Ditch Checks	2500	LF - in place	$ 3.98	$ 9,950	A2	1000	60	20	RS Means 312514160705: Compost or mulch filter sock, 9" diameter
24	Seed, Mulch, and Maintain Vegetated Surfaces	34	AC	$ 6,463.00	$ 222,327	-	-	310	310	
	Lime	1498	MSF	$ 26.88	$ 40,279	B66	700	17	17	RS Means 329113234250: Soil preparation, structural soil mixing, spread soil conditioners, ground limestone, 1#/S.Y., tractor spreader
	Fertilizer	1498	MSF	$ 13.54	$ 20,289	B66	700	17	17	RS Means 329113234150: Soil preparation, tructural soil mixing, spread soil conditioners, fertilizer, 0.2#/S.Y., tractor spreader
	Seed	1498	MSF	$ 39.20	$ 58,740	B66	52	231	231	RS Means 329219142300: Seeding athletic fields, seeding fescue, tall, 5.5 lb. per M.S.F., tractor spreader
	Mulch	1498	MSF	$ 68.75	$ 103,019	B65	530	45	45	RS Means 329113160350: Mulching, Hay, 1" deep, power mulcher, large
	Site Restoration Subtotal				***$ 273,000***			***650***	***380***	
	Engineering & Construction Support Tasks and Contingency									
25	Final Closure Design and Bid Support (5% of Construction Subtotal)	1	LS	$ 297,300.00	$ 297,300.00	-	-	-	-	Typical Industry Value
26	Engineering Support and CQA During Construction (10% of Construction Subtotal)	398	Day	$ 594,600.00	$ 594,600.00	Eng	1	3,981	1,592	Unit Rate, Crew, and Output based on experience.
	Engineering & Construction Support Tasks Subtotal				***$ 892,000***			***3,980***	***1,590***	
Construction Costs Subtotal					**$ 5,946,000**			**25,100**	**14,600**	
Project Subtotal					**$ 6,838,000**			**29,100**	**16,200**	
30% Contingency					**$ 2,051,000**			**8,700**	**4,900**	
ENGINEER'S ESTIMATE OF TOTAL CONSTRUCTION AND ENGINEERING COST AND HOURS					**$ 8,889,000**			**37,800**	**21,100**	

Notes and Assumptions:

1. LS = Lump Sum, AC = Acre, LF = Linear Foot, EA = Each, SY = Square Yard, MO = Month, YR = Year, CY = Cubic Yard, MSF = Thousand Square Feet
2. Where possible, costs were developed using RS Means 2022 Heavy Construction Costs
3. 2022 RS Means unit rates include overhead and profit and refer to standard union labor in Effingham, IL.
4. Subtotal and total costs have been rounded to the nearest $1,000. Subtotal and total hours have been rounded to the nearest 100.
5. Earthwork quantities assume that the excavation and placement of fill within construction limits will be balanced so that no off-Site fill will be required to reach the final contours. The final elevations may need to be adjusted during final design to achieve balanced quantities.

Coffeen Power Station
Closure-in-Place of Ash Pond No. 1

Crew	Labor	Daily Labor Hours	Equipment	Daily Equipment Hours	Project Total Labor Hours	Project Total Equipment Hours
B84	Operator x1	8	Rotary Mower/Tractor	8	32	32
B62	Laborer x2 Operator x1	24	Loader, Skid Steer, 30 H.P.	8	185	62
B59	Truck Driver x1	8	Truck Tractor, 220 H.P. Water Tank Trailer, 5000 Gal	8	1920	1920
B86A	Operator x1	8	Grader, 30,000 lbs	8	440	440
B14A	Operator x1 Laborer x0.5	12	Hyd. Excavator, 4.5 CY	8	1488	992
B34G	Truck Driver x1	8	Dump Truck, Off Hwy, 54 ton	8	4865	4865
B10B	Operator x1 Laborer x0.5	12	Dozer, 200 H.P.	8	4655	3105
B21C	Labor Foreman x1 Laborer x4 Operator (crane) x1 Operator (oiler) x1	56	Cutting Torches x2 Sets of Gases x2 Lattice Boom Crane, 90 ton	8	90	13
B69	Labor Foreman x1 Laborer x3 Operator (crane) x1 Operator (oiler) x1	48	Hyd. Crane, 80 ton	8	3	1
C14A	Carpenter Foreman x1 Carpenters x16 Rodmen x4 Laborers x2 Cement Finisher x1 Operator (medium) x1	200	Gas Engine Vibrator Concrete Pump (small)	16	22	2
B63B	Labor Foreman x1 Laborer x2 Operator (light) x1	32	Loader, Skid Steer, 78 H.P.	8	9018	2255
2 Clab	Laborer x2	16	None	0	338	0
B13	Labor Foreman x1 Laborer x4 Operator (crane) x1 Operator (oiler) x1	56	Hyd. Crane, 25 ton	8	235	34
A2	Laborer x2 Truck Driver x1	24	Flatbed Truck, Gas, 1.5 ton	8	60	20
B66	Operator (light) x1	8	Loader-Backhoe, 40 H.P.	8	265	265
B65	Laborer x1 Truck Driver (light) x1	16	Power Mulcher (large) Flatbed Truck, Gas, 1.5 ton	16	45	45
B11C	Laborer x1 Operator (medium) x1	16	Backhoe Loader, 48 H.P.	8	40	20
B10R	Operator (medium) x1 Laborer x0.5	12	F.E. Loader, W.M., 1 CY	8	11	7
ECB	Laborer x3	24	Tractor	8	40	13
Dewater	Laborer x1	8	8" Diesel Pump	2	1005	251
Sump Install	Laborer x1 Operator x1	16	Hyd. Excavator, 4.5 CY	8	16	8
Grout/Concrete	Laborer x2 Truck Driver x1	24	Concrete Truck	8	24	8
Eng	Engineering Staff x1.2	10	Side by Side x1	4	3981	1592
A1D	Laborer x1	8	Vibrating Plate, Gas, 18"	8	20	20
B10F	Operator (medium) x1 Laborer x0.5	12	Tandem Roller, 10 ton	8	206	138
B10W	Operator (medium) x1 Laborer x0.5	12	Dozer, 105 H.P.	8	70	47
PROJECT TOTAL					**29074**	**16155**

Notes and Assumptions:
1. Crew names in itallics were created by Golder based on experience and are not from RS Means.

Item	Quantity	Assumptions
Labor Total Hours	29,074	Per projected total in cost estimate
Duration of Onsite Construction - Days	503	Per Construction Schedule
Average Daily Crew Size	6	10 hour days
Labor Mobilization Miles	211,174	Average of 70 miles round trip per day
Vehicle Miles On-Site	8,849	1 mile round trip from gate to parking 5 miles per day for CQA tech and Construction Supervisor 10% Contingency for Site visitors (client and engineering support)
Equipment Mobilization Miles - Unloaded	21,548	Average of 300 miles one way for equipment hauling Average 1 load of equipment per working week
Equipment Mobilization Miles - Loaded	21,548	Average of 300 miles one way for equipment hauling Average 1 load of equipment per working week
Total Equipment Miles On-Site	37,710	Average of 4 of 6 crew members running equipment Assume 15 miles per piece of equipment (based on 15 minute round trip path across AP1 10 miles per day used for water truck 5 miles per day for grader
On-Site Haul Truck Miles - Unloaded	4,606	34 CY Haul Truck 4000 ft cycle
On-Site Haul Truck Miles - Loaded	4,606	34 CY Haul Truck 4000 ft cycle
Off-Site Haul Truck Miles - Unloaded	-	16.5 CY Dump Truck 4 mile cycle
Off-Site Haul Truck Miles - Loaded	-	16.5 CY Dump Truck 4 mile cycle
Material Delivery Miles - Unloaded	6,925	Same geosynthetic material source, trailer quantities, and roll sizes as Coffeen AP2 project assumed 45 extra trips for seed, fertilizer, lime, mulch, ECBs, straw wattles, and concrete
Material Delivery Miles - Loaded	6,925	Same geosynthetic material source, trailer quantities, and roll sizes as Coffeen AP2 project assumed 45 extra trips for seed, fertilizer, lime, mulch, ECBs, straw wattles, and concrete

Table 6: Material Quantity and Cost Estimate - AP1 Closure-by-Removal

AACE Class 4 Estimate
Coffeen Power Station
Closure-by-Removal of Ash Pond No. 1

Item No.	Item Description	Quantity	Unit	Unit Rate (USD$/unit)	Cost (USD$)	Crew	Daily Output	Labor Hours	Equipment Hours	Notes/Assumptions/Reference
	Pre-Construction									
1	Mobilization and Demobilization (10% of Construction Subtotal)	1	LS	$ 2,431,900.0	$ 2,432,000					Typical Industry Value
	Pre-Construction Subtotal				***$ 2,432,000***					
	Site Preparation									
2	Mow Vegetation in limits of disturbance	87	MSF	$ 40.74	$ 3,544	B84	22	32	32	RS Means 320190191660: Mowing, mowing brush, light density, tractor with rotary mower
3	Construction Soil Erosion & Sediment Controls (Silt Fence)	10000	LF	$ 3.39	$ 33,900	B62	650	369	123	RS Means 312514161000: Synthetic erosion control, silt fence, install and remove, 3' high
4	Construction Facilities	23	MO - in use	$ 969.61	$ 22,321	-	-	-	-	
	Office Trailer	23	MO - in use	$ 258.53	$ 5,951	-	-	-	-	RS Means 015213200350: Office trailer, furnished, rent per month, 32' x 8', excl. hookups
	Storage Trailers (x2)	23	MO - in use	$ 291.92	$ 6,720	-	-	-	-	RS Means 015213201350: Storage boxes, rent per month, 40' x 8'
	Portable Toilet (x2)	23	MO - in use	$ 419.16	$ 9,649	-	-	-	-	RS Means 015433406410: Rent toilet portable chemical, incl. hourly oper. cost
5	Dust Control	478	Day	$ 2,206.88	$ 1,054,889	B59	0.5	7,648	7,648	RS Means 312323202510: Hauling, heavy, dust control, includes loading
6	Haul Road Maintenance	478	Day	$ 1,502.78	$ 718,329	B86A	1	3,824	3,824	RS Means 312323202600: Hauling, haul road maintenance, includes loading
	Site Preparation Subtotal				***$ 1,833,000***			***11,870***	***11,630***	
	Dewatering, Unwatering, and Stormwater Management									
7	Unwatering, Dewatering, and Stormwater Management for AP1	147	Day	$ 1,105.32	$ 162,045	Dewater	4	293	73	RS Means 312319200650: Dewatering, pumping 8 hours, attended 2 hours per day, 4" dischage pump used for 8 hours, includes 20 LF of suction hose and 100 LF of discharge hose
8	Dewatering and Stormwater Management for AP2	544	Day	$ 1,105.32	$ 601,304	Dewater	4	1,088	272	RS Means 312319200650: Dewatering, pumping 8 hours, attended 2 hours per day, 4" dischage pump used for 8 hours, includes 20 LF of suction hose and 100 LF of discharge hose
9	Dewatering Sumps Installation	4	EA	$ 10,000.00	$ 40,000	Sump Install	4	16	8	Unit Rate, Crew, and Daily Output based on experience. Materials include 24" corrugated HDPE pipe with geotextile wrapping, and 1 CY of gravel backfill
	Dewatering, Unwatering, and Stormwater Management Subtotal				***$ 803,000***			***1,400***	***350***	
	Ash Pond No. 1 Closure									
10	Removal and Abandonment of Riser and Outlet Structure	-	LS	-	$ 34,193	-	-	155	24	
	Demolition of Steel Walkway	800	SF	$ 13.81	$ 11,048	B21C	500	90	13	RS Means 024116330200: Bridge demolition, pedestrian, steel, 50' to 160' long, 8' to 10' wide
	Demolition of Outlet Structure	20	LF	$ 19.86	$ 397	B69	300	3	1	RS Means 024113430100: Selective demolition, box culvert, precast, 8' x 6' x 3' to 8' x 8' x 8', excludes excavation
	Plugging of Outlet Pipe	2	CY	$ 1,974.12	$ 3,948	C14A	18	22	2	RS Means 033053401040: Structural concrete, in place, column (4000 psi), square, up to 3% reinforcing by area, 36" x 36", including forms (4 uses), Grade 60 rebar, concrete (portland cement Type I), placement and finishing included
	Cleaning of Pipe Interior	1	LS	$ 3,000.00	$ 3,000	2 Clab	1	16	-	Unit Rate, Crew, and Daily Output based on experience.
	Grouting of Pipe	79	CY	$ 200.00	$ 15,800	Grout/Concrete	80	24	8	Unit Rate, Crew, and Daily Output based on experience.
11	Relocation of Ash Material to On-Site CCR Landfill	296000	CY - in place	$ 11.16	$ 3,303,804	-	-	10,979	9,350	
	Excavation and Loading of Material	310800	CY - as excavated	$ 1.50	$ 466,200	B14A	3230	1,155	770	RS Means 312316435400: Excavating, large volume projects; excavation with truck loading; excavator, 4.5 CY bucket, 95% fill factor (assume 5% shrinkage factor from ground to in-place)
	Hauling of Material	310800	CY - as excavated	$ 6.75	$ 2,097,900	B34G	408	6,094	6,094	RS Means 312323206050: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld/uld., 5 MPH, cycle 2 mile
	Spreading of Material	310800	CY - as excavated	$ 2.38	$ 739,704	B10B	1000	3,730	2,486	RS Means 312323170020: Fill, dumped material, spread, by dozer, excludes compaction
12	Disposal of Remaining Ash Material/Contaminated Subsoil at Off-Site Landfill	175500	CY - in place	$ 101.52	$ 17,816,839	-	-	16,754	15,936	
	Excavation and Loading of Material	184275	CY - as excavated	$ 1.50	$ 276,413	B14A	3230	685	456	RS Means 312316435400: Excavating, large volume projects; excavation with truck loading; excavator, 4.5 CY bucket, 95% fill factor (assume 5% shrinkage factor from ground to in-place)
	Hauling of Material	184275	CY - as excavated	$ 13.11	$ 2,415,845	B34C	99	14,891	14,891	RS Means 312323203284: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 16.5 C.Y. truck, 20 min wait/ld/uld., 40 MPH, cycle 40 miles
	Finish Grading of Excavation Surface	122700	SY	$ 1.23	$ 150,921	B32C	5000	1,178	589	RS Means 312216101020: Fine grading, loam or topsoil fine grade for large area, 15,000 S.Y. or more
	Landfill Tipping Fee	189540	Ton	$ 79.00	$ 14,973,660	-	-	-	-	Unit Rate based on actual tipping fee from Republic Services Litchfield Landfill (nearest landfill to Site). Unit Rate subject to increase upon Landfill's soil classification.
13	Excavation and Placement of Fill over Top of Aquifer	9600	CY - in place	$ 8.89	$ 85,315	-	-	321	255	
	Excavation and Loading of Material	10080	CY - as excavated	$ 1.50	$ 15,120	B14A	3230	37	25	RS Means 312316435400: Excavating, large volume projects; excavation with truck loading; excavator, 4.5 CY bucket, 95% fill factor (assume 5% shrinkage factor from ground to in-place)
	Hauling of Material	10080	CY - as excavated	$ 4.06	$ 40,925	B34G	680	119	119	RS Means 312323206020: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld/uld., 5 MPH, cycle 4000 feet
	Spreading of Material	10080	CY - as excavated	$ 2.38	$ 23,990	B10B	1000	121	81	RS Means 312323170020: Fill, dumped material, spread, by dozer, excludes compaction
	Compaction of Material	9600	CY - in place	$ 0.55	$ 5,280	B10F	2600	44	30	RS Means 312323235100: Compaction; Riding, vibrating roller, 12" lifts, 4 passes (RSMeans Crew is B10Y; altered to B10F based on experience)
14	Excavation and Stockpiling of Excess Cut Material	29000	CY - in place	$ 8.34	$ 241,773	-	-	836	677	
	Excavation and Loading of Material	30450	CY - as excavated	$ 1.50	$ 45,675	B14A	3230	113	75	RS Means 312316435400: Excavating, large volume projects; excavation with truck loading; excavator, 4.5 CY bucket, 95% fill factor (assume 5% shrinkage factor from ground to in-place)
	Hauling and Dumping of Material	30450	CY - as excavated	$ 4.06	$ 123,627	B34G	680	358	358	RS Means 312323206020: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld/uld., 5 MPH, cycle 4000 feet
	Spreading of Material	30450	CY - as excavated	$ 2.38	$ 72,471	B10B	1000	365	244	RS Means 312323170020: Fill, dumped material, spread, by dozer, excludes compaction
	Ash Pond No. 1 Closure Subtotal				***$ 21,482,000***			***29,050***	***26,240***	
	Site Restoration									
15	Erosion Control Blanket	37600	SF - in place	$ 0.25	$ 9,400	ECB	22500	40	13	RS Means 312514160100. Rolled erosion control mats and blankets, plastic netting, stapled, 2" x 1" mesh, 20 mil.
16	Straw Wattle Ditch Checks	2500	LF - in place	$ 3.98	$ 9,950	A2	1000	60	20	RS Means 312514160705: Compost or mulch filter sock, 9" diameter
17	Seed, Mulch, and Maintain Vegetated Surfaces	28	AC	$ 6,463.00	$ 181,610	-	-	253	253	
	Lime	1224	MSF	$ 26.88	$ 32,902	B66	700	14	14	RS Means 329113234250: Soil preparation, structural soil mixing, spread soil conditioners, ground limestone, 1#/S.Y., tractor spreader
	Fertilizer	1224	MSF	$ 13.54	$ 16,573	B66	700	14	14	RS Means 329113234150: Soil preparation, tructural soil mixing, spread soil conditioners, fertilizer, 0.2#/S.Y., tractor spreader
	Seed	1224	MSF	$ 39.20	$ 47,982	B66	52	188	188	RS Means 329219142300: Seeding athletic fields, seeding fescue, tall, 5.5 lb. per M.S.F., tractor spreader
	Mulch	1224	MSF	$ 68.75	$ 84,152	B65	530	37	37	RS Means 329113160350: Mulching, Hay, 1" deep, power mulcher, large
	Site Restoration Subtotal				***$ 201,000***			***350***	***290***	
	Engineering & Construction Support Tasks and Contingency									
18	Final Closure Design and Bid Support (1.5% of Construction Subtotal)	1	LS	$ 401,265.00	$ 401,265.00	-	-	-	-	Typical Industry Value
19	Engineering Support and CQA During Construction (4% of Construction Subtotal)	586	Day	$ 1,070,040.00	$ 1,070,040.00	Eng	1	5,859	2,344	Unit Rate, Crew, and Output based on experience.
	Engineering & Construction Support Tasks Subtotal				***$ 1,471,000***			***5,860***	***2,340***	
Construction Costs Subtotal					**$ 26,751,000**			**42,700**	**38,500**	
Project Subtotal					**$ 28,222,000**			**48,600**	**40,800**	
30% Contingency					**$ 8,467,000**			**14,600**	**12,200**	
ENGINEER'S ESTIMATE OF TOTAL CONSTRUCTION AND ENGINEERING COST AND HOURS					**$ 36,689,000**			**63,200**	**53,000**	

Notes and Assumptions:
1. LS = Lump Sum, AC = Acre, LF = Linear Foot, EA = Each, SY = Square Yard, MO = Month, YR = Year, CY = Cubic Yard, MSF = Thousand Square Feet
2. Where possible, costs were developed using RS Means 2022 Heavy Construction Costs
3. 2022 RS Means unit rates include overhead and profit and refer to standard union labor in Effingham, IL.
4. Subtotal and total costs have been rounded to the nearest $1,000. Subtotal and total hours have been rounded to the nearest 100.
5. Earthwork quantities assume that the excavation and placement of fill within construction limits will be balanced so that no off-Site fill will be required to reach the final contours. The final elevations may need to be adjusted during final design to achieve balanced quantities.

Coffeen Power Station
Closure-by-Removal of Ash Pond No. 1

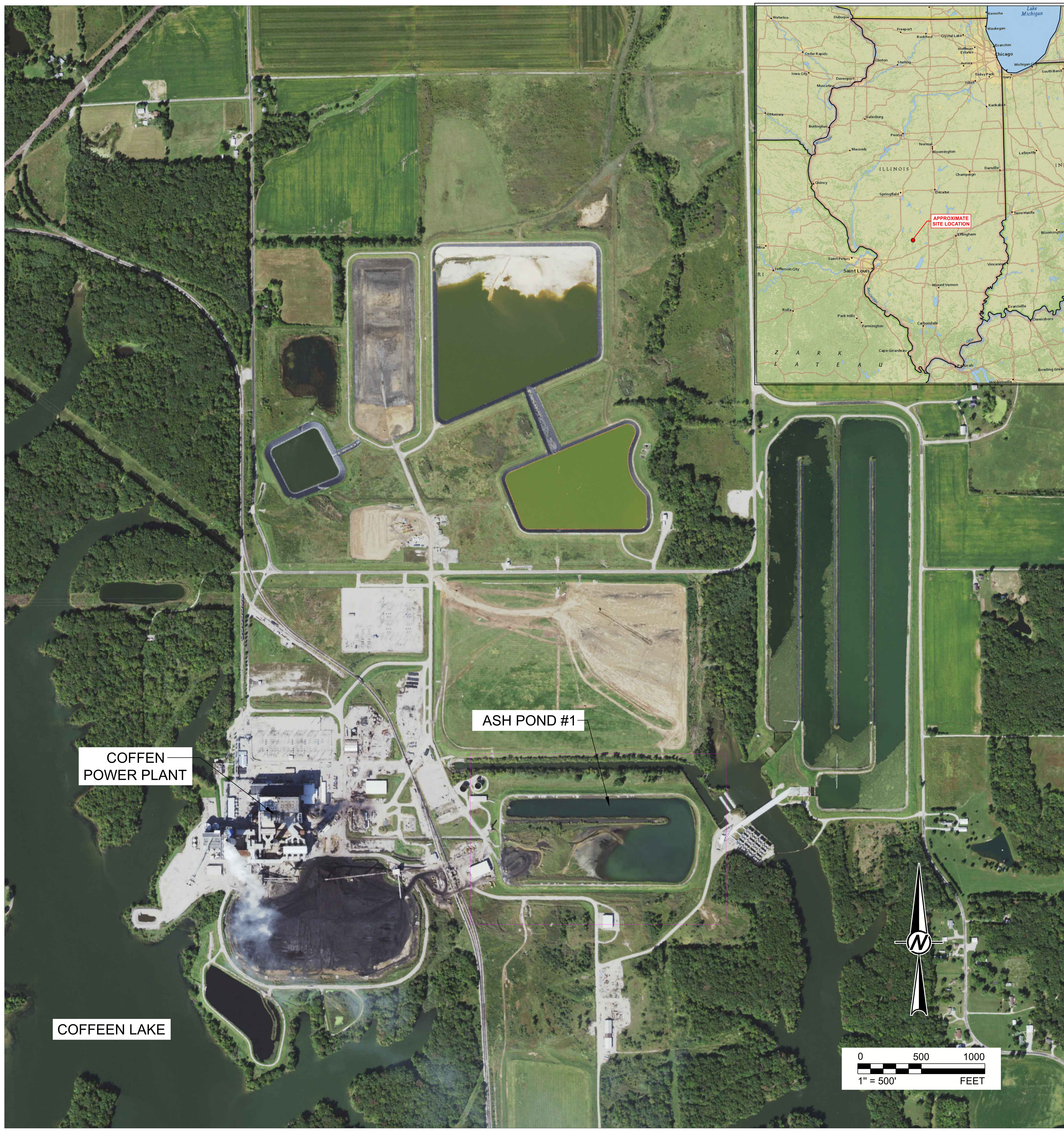
Crew	Labor	Daily Labor Hours	Equipment	Daily Equipment Hours	Project Total: Labor Hours	Project Total: Equipment Hours
B84	Operator x1	8	Rotary Mower/Tractor	8	32	32
B62	Laborer x2 Operator x1	24	Loader, Skid Steer, 30 H.P.	8	369	123
B59	Truck Driver x1	8	Truck Tractor, 220 H.P. Water Tank Trailer, 5000 Gal	8	7648	7648
B86A	Operator x1	8	Grader, 30,000 lbs	8	3824	3824
B14A	Operator x1 Laborer x0.5	12	Hyd. Excavator, 4.5 CY	8	1990	1326
B34G	Truck Driver x1	8	Dump Truck, Off Hwy, 54 ton	8	6571	6571
B10B	Operator x1 Laborer x0.5	12	Dozer, 200 H.P.	8	4216	2811
B21C	Labor Foreman x1 Laborer x4 Operator (crane) x1 Operator (oiler) x1	56	Cutting Torches x2 Sets of Gases x2 Lattice Boom Crane, 90 ton	8	90	13
B69	Labor Foreman x1 Laborer x3 Operator (crane) x1 Operator (oiler) x1	48	Hyd. Crane, 80 ton	8	3	1
C14A	Carpenter Foreman x1 Carpenters x16 Rodmen x4 Laborers x2 Cement Finisher x1 Operator (medium) x1	200	Gas Engine Vibrator Concrete Pump (small)	16	22	2
2 Clab	Laborer x2	16	None	0	16	0
A2	Laborer x2 Truck Driver x1	24	Flatbed Truck, Gas, 1.5 ton	8	60	20
B66	Operator (light) x1	8	Loader-Backhoe, 40 H.P.	8	216	216
B65	Laborer x1 Truck Driver (light) x1	16	Power Mulcher (large) Flatbed Truck, Gas, 1.5 ton	16	37	37
B32C	Labor Foreman x1 Laborer x2 Operator (medium) x3	48	Grader, 30,000 lbs Tandem Roller, 10 ton Dozer, 200 H.P.	24	1178	589
ECB	Laborer x3	24	Tractor	8	40	13
Dewater	Laborer x1	8	8" Diesel Pump	2	1381	345
Sump Install	Laborer x1 Operator x1	16	Hyd. Excavator, 4.5 CY	8	16	8
Grout/Concrete	Laborer x2 Truck Driver x1	24	Concrete Truck	8	24	8
Eng	Engineering Staff x1.2	10	Side by Side x1	4	5859	2344
B10F	Operator (medium) x1 Laborer x0.5	12	Tandem Roller, 10 ton	8	44	30
B34C	Truck Driver (heavy) x1	8	Truck Tractor, 6x4, 380 H.P. Dump Trailer, 16.5 CY	8	14891	14891
PROJECT TOTAL					**48527**	**40852**

Notes and Assumptions:
1. Crew names in itallics were created by Golder based on experience and are not from RS Means.

Item	Quantity	Assumptions
Labor Total Hours	48,527	Per projected total in cost estimate
Duration of Onsite Construction - Days	691	Per Construction Schedule
Average Daily Crew Size	8	10 hour days
Labor Mobilization Miles	386,744	Average of 70 miles round trip per day
Vehicle Miles On-Site	13,674	1 mile round trip from gate to parking 5 miles per day for CQA tech and Construction Supervisor 10% Contingency for Site visitors (client and engineering support)
Equipment Mobilization Miles - Unloaded	29,598	Average of 300 miles one way for equipment hauling Average 1 load of equipment per working week
Equipment Mobilization Miles - Loaded	29,598	Average of 300 miles one way for equipment hauling Average 1 load of equipment per working week
Total Equipment Miles On-Site	72,514	Average of 6 of 8 crew members running equipment Assume 15 miles per piece of equipment (based on 15 minute round trip path across AP1 10 miles per day used for water truck 5 miles per day for grader
On-Site Haul Truck Miles - Unloaded	9,593	34 CY Haul Truck 2 mile cycle to on-Site CCR Landfill
On-Site Haul Truck Miles - Loaded	9,593	34 CY Haul Truck 2 mile cycle to on-Site CCR Landfill
Off-Site Haul Truck Miles - Unloaded	199,911	16.5 CY Dump Truck 36 mile cycle to off-Site Landfill
Off-Site Haul Truck Miles - Loaded	199,911	16.5 CY Dump Truck 36 mile cycle to off-Site Landfill
Material Delivery Miles - Unloaded	3,500	35 extra trips for seed, fertilizer, lime, mulch, ECBs, straw wattles, and concrete
Material Delivery Miles - Loaded	3,500	35 extra trips for seed, fertilizer, lime, mulch, ECBs, straw wattles, and concrete

ATTACHMENT 2

Drawings



ILLINOIS POWER RESOURCES GENERATING, LLC
COFFEEN POWER PLANT
ASH POND NO. 1 CONSTRUCTION PERMIT APPLICATION

PREPARED BY:

GOLDER ASSOCIATES INC.
701 EMERSON ROAD, SUITE 250
CREVE COEUR, MISSOURI 63141

DRAWING LIST

NUMBER	TITLE	REVISION
1	TITLE SHEET	A
2	EXISTING CONDITIONS	A
3	ASH REGRADING AND CONTAINMENT PLAN	A
4	FINAL COVER AND STORMWATER PLAN	A
5	CROSS SECTIONS	A
6	DETAILS	A

REFERENCE(S)

1. AERIAL IMAGERY OBTAINED FROM UNITED STATES DEPARTMENT OF AGRICULTURE (USDA) NATIONAL AGRICULTURAL IMAGERY PROGRAM. IMAGERY CAPTURED 7/13/2019.

DRAFT

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
A	2022-05-06	ISSUED FOR REVIEW	ETF	ETF	MWD	JO

SEAL

CLIENT
ILLINOIS POWER RESOURCES GENERATING, LLC
COFFEEN POWER PLANT

CONSULTANT
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GOLDER ASSOCIATES USA INC.
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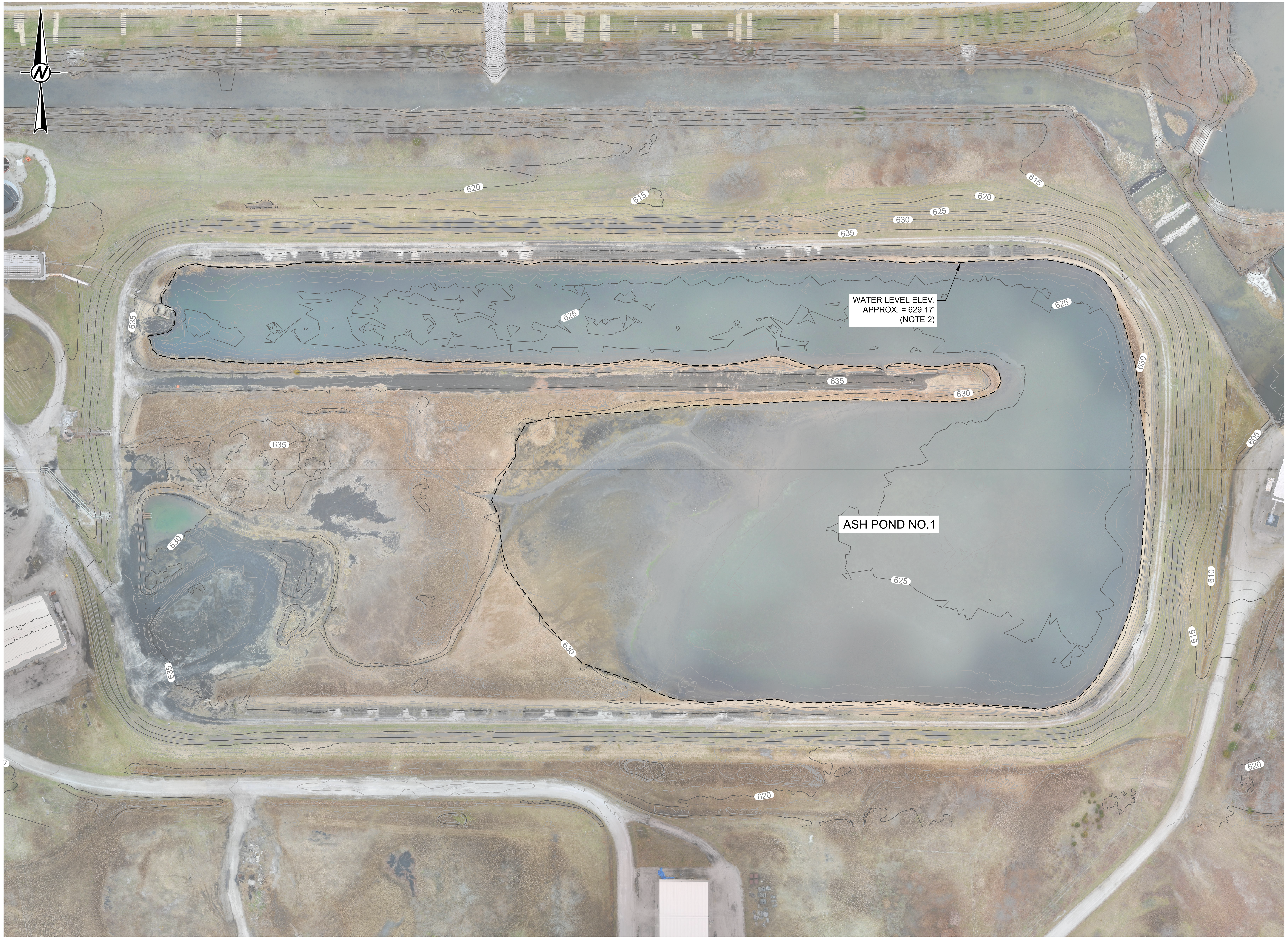
SUITE 250
CREVE COEUR, MO 63141
[+1] (314) 984 8800

PROJECT
ASH POND NO. 1 CONSTRUCTION PERMIT APPLICATION

TITLE
TITLE SHEET

PROJECT NO. 21465046 | REV. A | DRAWING 1



LEGEND

600 — EXISTING GROUND CONTOURS (SEE NOTE 1)

- - - - WATER LEVEL (SEE NOTE 2)

NOTE(S)

1. EXISTING CONTOURS ARE A COMPOSITE OF AN AERIAL SURVEY COMPLETED BY DRAGONFLY AEROSOLUTIONS DATED 12/3/2020 AND TOPOGRAPHIC/BATHYMETRIC SURVEYS COMPLETED BY INGENAE DATED 12/3/2020 & 12/4/2020.
2. WATER LEVEL LINE FROM SURVEY COMPLETED BY INGENAE DATED MARCH 24, 2021.

REFERENCE(S)

1. AERIAL IMAGERY OBTAINED FROM AERIAL SURVEY COMPLETED BY DRAGONFLY AEROSOLUTIONS DATED 12/3/2020.

NOT FOR CONSTRUCTION

DRAFT

0 100 200
1" = 100' FEET

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
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TITLE
EXISTING CONDITIONS

PROJECT NO. 21465046 | REV. A | 2 of 6 | DRAWING 2

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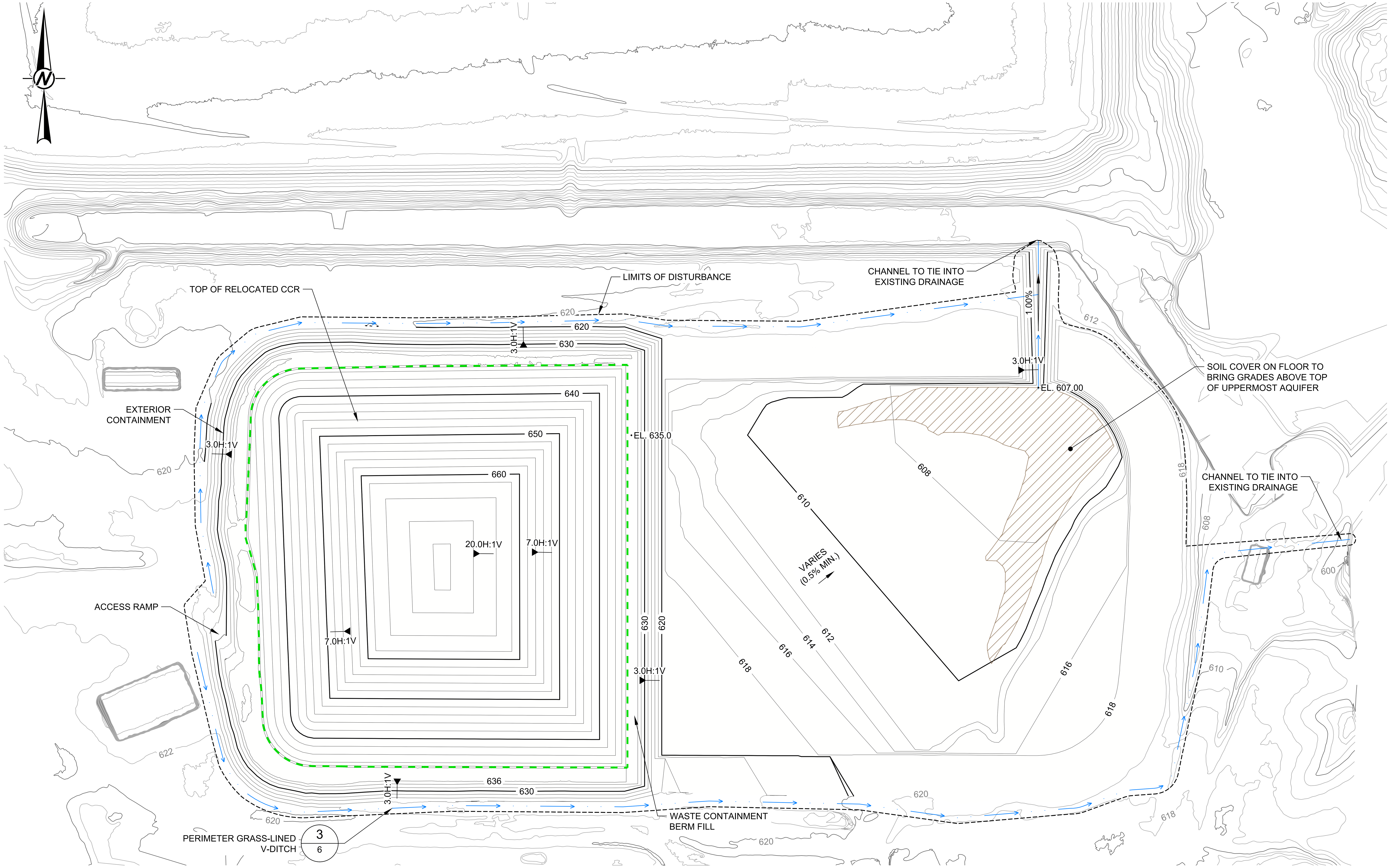

LEGEND

- 600 — AP1 CLOSURE IN PLACE GRADES (SEE NOTES 1 AND 2)
- 600 — EXISTING GROUND CONTOURS (SEE NOTE 3)
- LIMITS OF RELOCATED CCR WASTE
- PROPOSED STORMWATER FLOW PATH
- LIMITS OF DISTURBANCE

NOTE(S)

1. THE CLOSURE-IN-PLACE CONCEPT FOR ASH POND NO. 1 (AP1) INVOLVES REMOVAL OF PONDED WATER, CONSTRUCTION OF A CCR WASTE CONTAINMENT BERM, REMOVAL AND RELOCATION OF CCR WASTE AND 1 FT (MAX.) OF SUBSOIL EAST OF THE BERM TO WITHIN THE CONSOLIDATED FOOTPRINT, PLACEMENT OF SOIL COVER ON PORTIONS OF THE AP1 FLOOR EAST OF THE BERM, AND FINAL COVER CONSTRUCTION OVER THE CONSOLIDATED FOOTPRINT.
2. AP1 CLOSURE IN PLACE GRADES INCLUDE RELOCATED CCR WASTE, WASTE CONTAINMENT BERM, SOIL COVER OVER THE TOP OF THE UPPERMOST AQUIFER, AND PERIMETER GRADING AROUND AP1 EXTERIOR SIDE SLOPES.
3. EXISTING CONTOURS ARE A COMPOSITE OF AN AERIAL SURVEY COMPLETED BY DRAGONFLY AEROSOLUTIONS DATED 12/3/2020 AND TOPOGRAPHIC/BATHYMETRIC SURVEYS COMPLETED BY INGENAE DATED 12/3/2020 & 12/4/2020.

NOT FOR CONSTRUCTION

DRAFT

0 100 200
1" = 100' FEET

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
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PROJECT
ASH POND NO. 1 CONSTRUCTION PERMIT APPLICATION

TITLE
ASH REGRADING AND CONTAINMENT PLAN

PROJECT NO. 21465046 | REV. A | 3 of 6 | DRAWING 3

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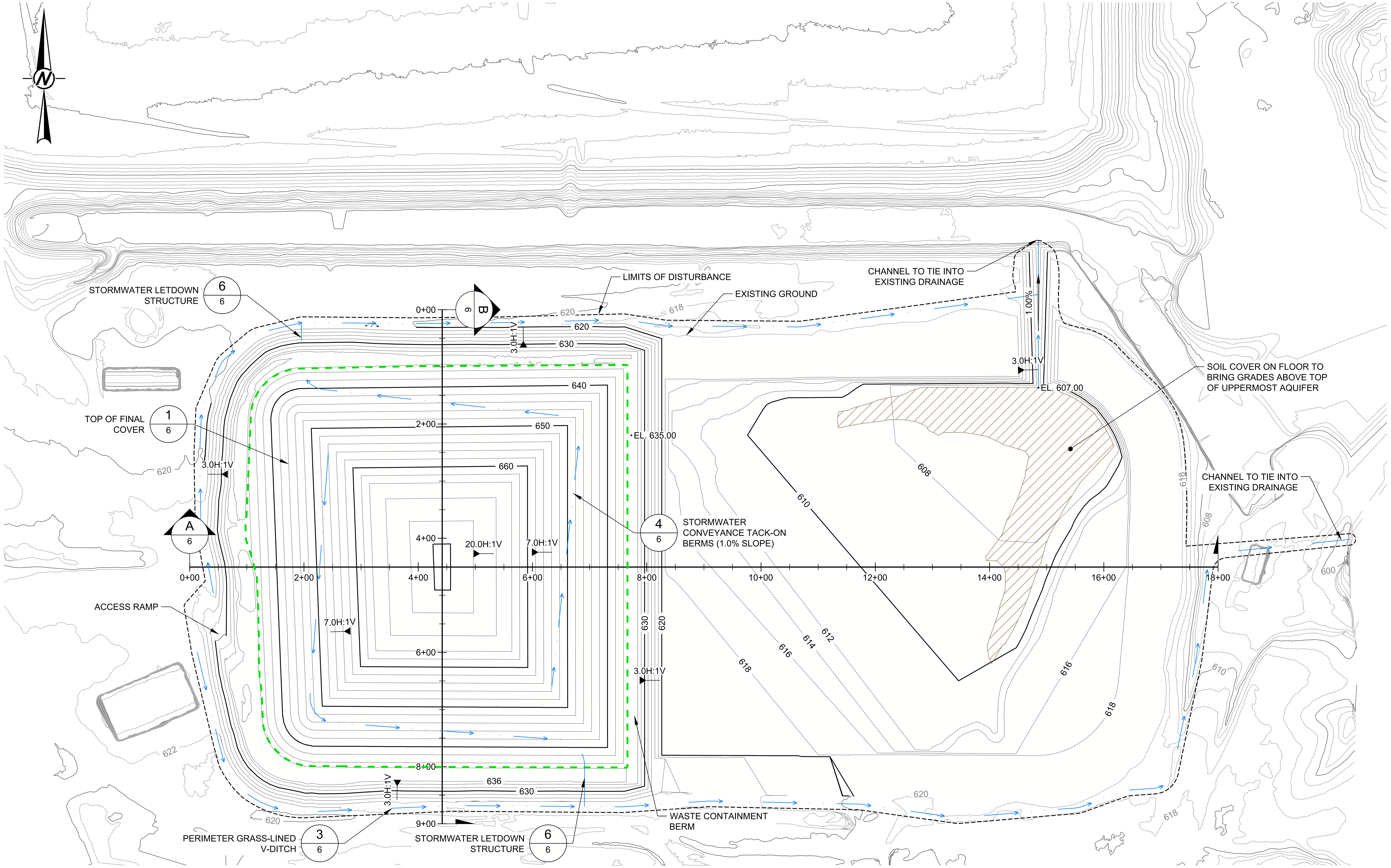

LEGEND

—— 600 ——	FINAL CLOSURE IN PLACE GRADES (SEE NOTES 1 AND 2)
—— 600 ——	EXISTING GROUND CONTOURS (SEE NOTE 3)
- - - - -	LIMIT OF RELOCATED CCR WASTE
→ · · —	PROPOSED STORMWATER FLOW PATH
- - - - -	LIMITS OF DISTURBANCE

NOTE(S)

1. THE CLOSURE-IN-PLACE CONCEPT FOR ASH POND NO. 1 (AP1) INVOLVES REMOVAL OF PONDED WATER, CONSTRUCTION OF A CCR STRUCTURAL WASTE CONTAINMENT BERM, REMOVAL AND RELOCATION OF ASH AND 1 FT (MAX.) OF SUBSOIL EAST OF THE BERM TO WITHIN THE CONSOLIDATED FOOTPRINT, PLACEMENT OF SOIL COVER ON PORTIONS OF AP1 FLOOR EAST OF THE BERM, AND FINAL COVER CONSTRUCTION.
2. FINAL GRADES INCLUDE FINAL COVER, WASTE CONTAINMENT BERM, SOIL COVER OVER TOP OF UPPERMOST AQUIFER, AND PERIMETER GRADING AROUND AP1 EXTERIOR SIDE SLOPES.
3. EXISTING CONTOURS ARE A COMPOSITE OF AN AERIAL SURVEY COMPLETED BY DRAGONFLY AEROSOLUTIONS DATED 12/3/2020, TOPOGRAPHIC/BATHYMETRIC SURVEYS COMPLETED BY INGENAE DATED 12/3/2020 & 12/4/2020.
4. THE PROPOSED STORMWATER DRAINAGE CONCEPT IS TO SHED WATER INTO EXISTING DRAINAGE CHANNELS NORTH AND EAST OF THE FACILITY. STORMWATER COLLECTED WITHIN AP1 WILL BE DIRECTED INTO AN OPEN CHANNEL THAT BREACHES THE CONSTRUCTED BERM TO CONNECT TO THE EXISTING DRAINAGE.

NOT FOR CONSTRUCTION

DRAFT

0 100 200
1" = 100' FEET

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
A	2022-05-06	ISSUED FOR REVIEW	ETF	ETF	MWD	JO

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PROJECT
ASH POND NO. 1 CONSTRUCTION PERMIT APPLICATION

TITLE
FINAL COVER AND STORMWATER PLAN

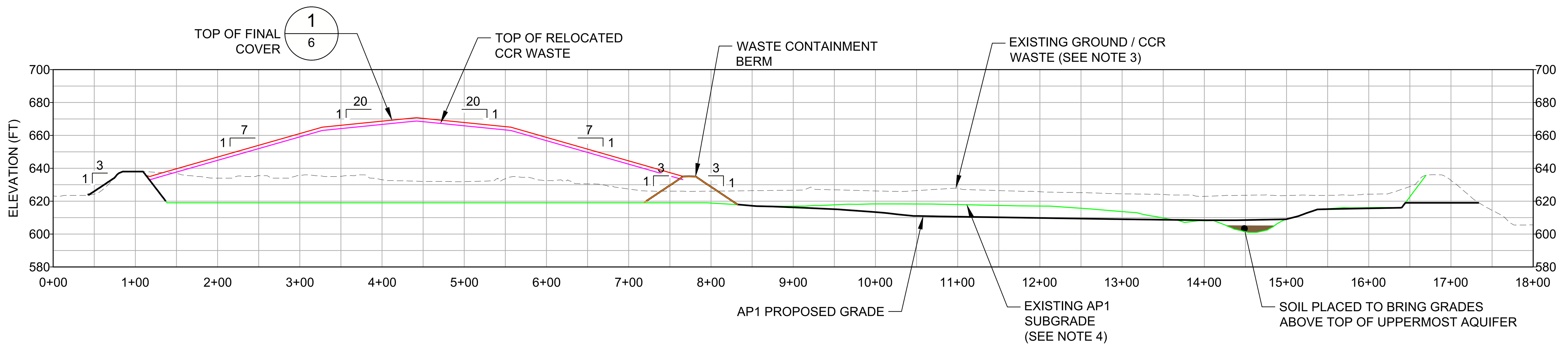
PROJECT NO. 21465046
REV. A
4 of 6
DRAWING 4

Path: C:\Users\EVForney\Golder Associates\21465046.Vistra Coffeen Part 845 Apps IL - 5 Technical Work\DRAFTING\PRODUCTION\ | File Name: CE-PROD-AP1-COVER-GRAD.dwg | Last Edited By: evforney Date: 2022-05-06 Time:4:28:48 PM | Printed By: EVForney Date: 2022-05-06 Time:4:31:27 PM

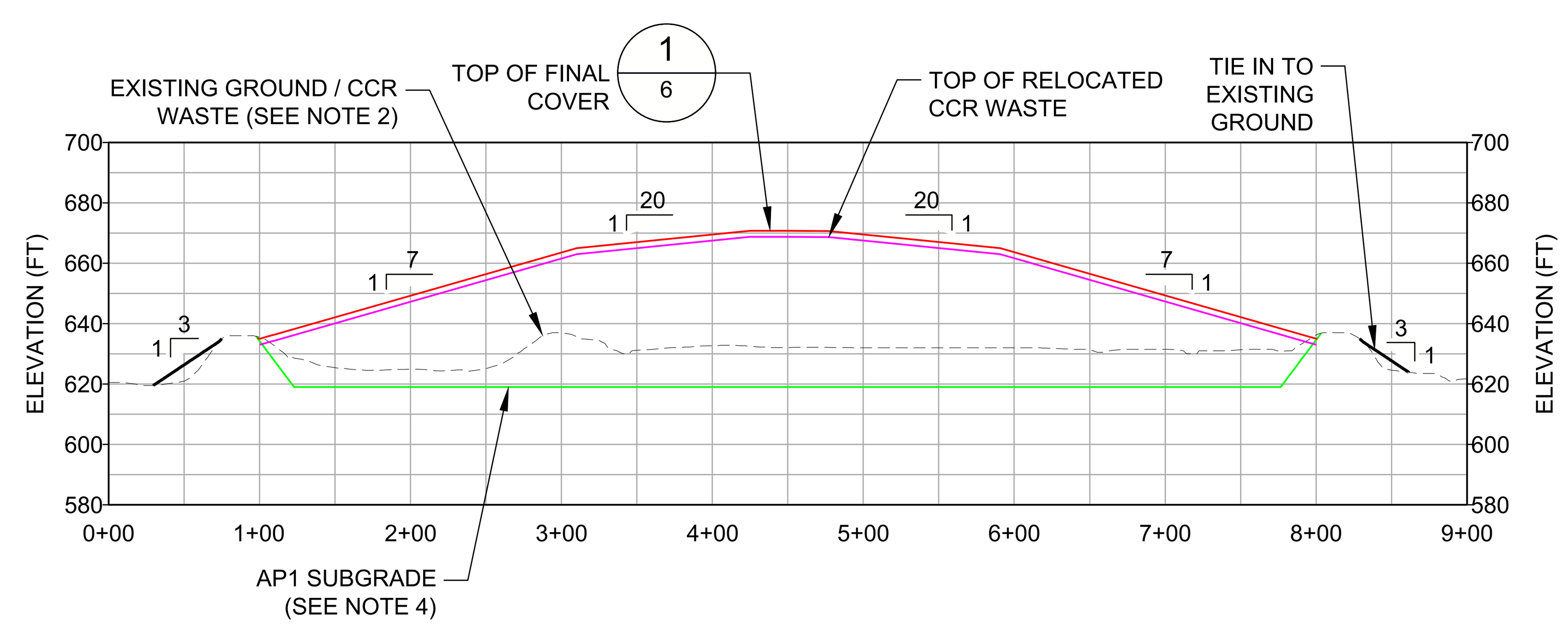
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D

NOTE(S)

1. THE CLOSURE-IN-PLACE CONCEPT FOR ASH POND NO.1 (AP1) INVOLVES REMOVAL OF PONDED WATER, CONSTRUCTION OF A WASTE CONTAINMENT BERM, REMOVAL AND RELOCATION OF CCR WASTE AND 1 FT (MAX.) OF SUBSOIL EAST OF THE BERM TO WITHIN THE CONSOLIDATED FOOTPRINT, PLACEMENT OF SOIL COVER ON PORTIONS OF AP1 FLOOR EAST OF THE BERM, AND FINAL COVER CONSTRUCTION OVER THE CONSOLIDATED FOOTPRINT.
2. AP1 BASE OF ASH GRADES WERE DEVELOPED FROM THE 1963 EARTHWORK AND GRADING PLANS.
3. EXISTING CONTOURS ARE A COMPOSITE OF AN AERIAL SURVEY COMPLETED BY DRAGONFLY AEROSOLUTIONS DATED 12/3/2020 AND TOPOGRAPHIC/BATHYMETRIC SURVEYS COMPLETED BY INGENAE DATED 12/3/2020 & 12/4/2020.



SCALE 1" = 100'
VERT. SCALE X2
A
6
SECTION A



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VERT. SCALE X2
B
6
SECTION B

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REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
A	2022-05-06	ISSUED FOR REVIEW	ETF	ETF	MWD	JO

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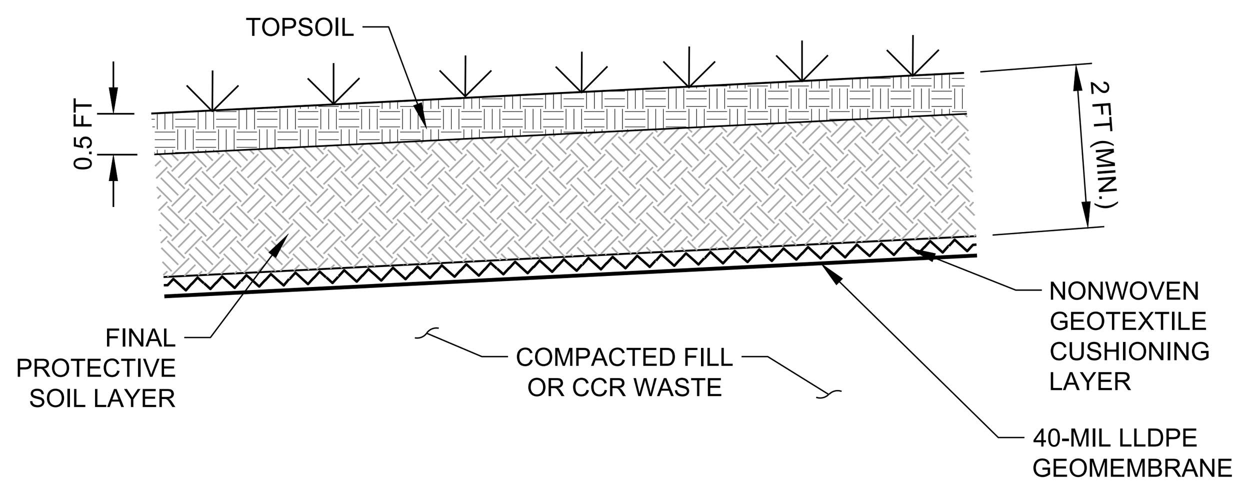
PROJECT
ASH POND NO. 1 CONSTRUCTION PERMIT APPLICATION

TITLE
CROSS SECTIONS

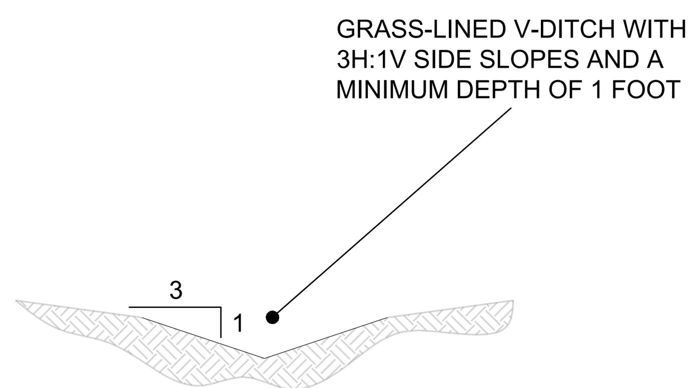
PROJECT NO. 21465046
REV. A
5 of 6
DRAWING 5

NOTE(S)
1. RR3 AND RR4 ARE ROCK MATERIALS DEFINED BY ILLINOIS DEPARTMENT OF TRANSPORTATION (IDOT).
2. PERIMETER CHANNEL SHOULD BE MIRRORED WHERE FLOW IS IN THE OPPOSITE DIRECTION.

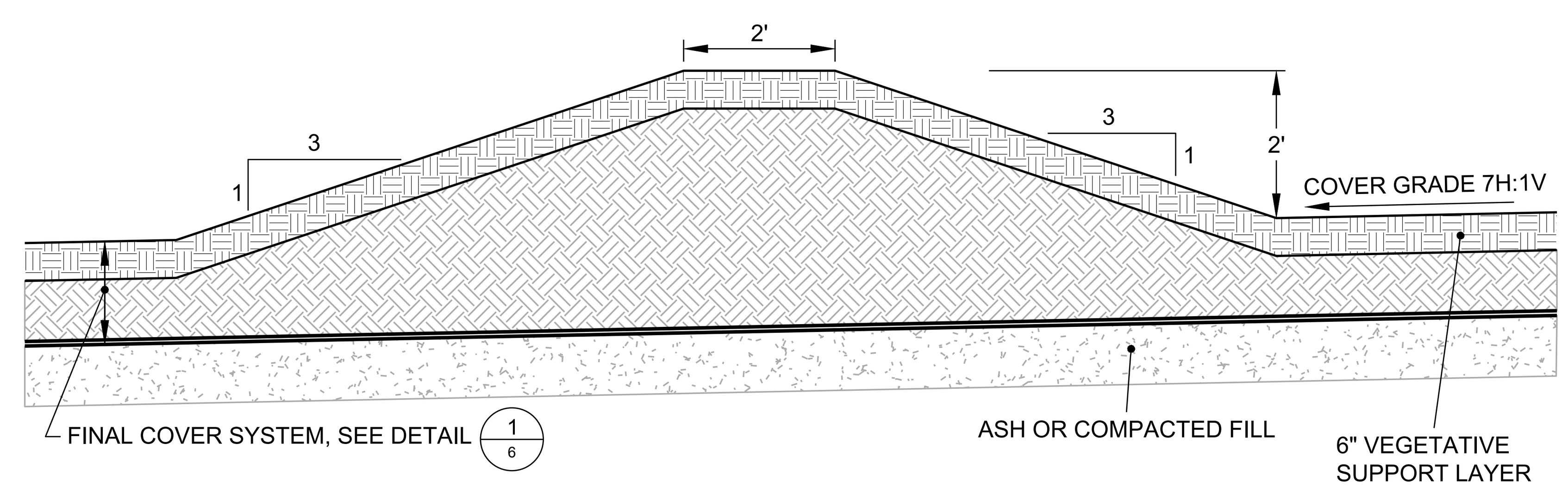


SCALE N.T.S. 1/6 **FINAL COVER DETAIL**

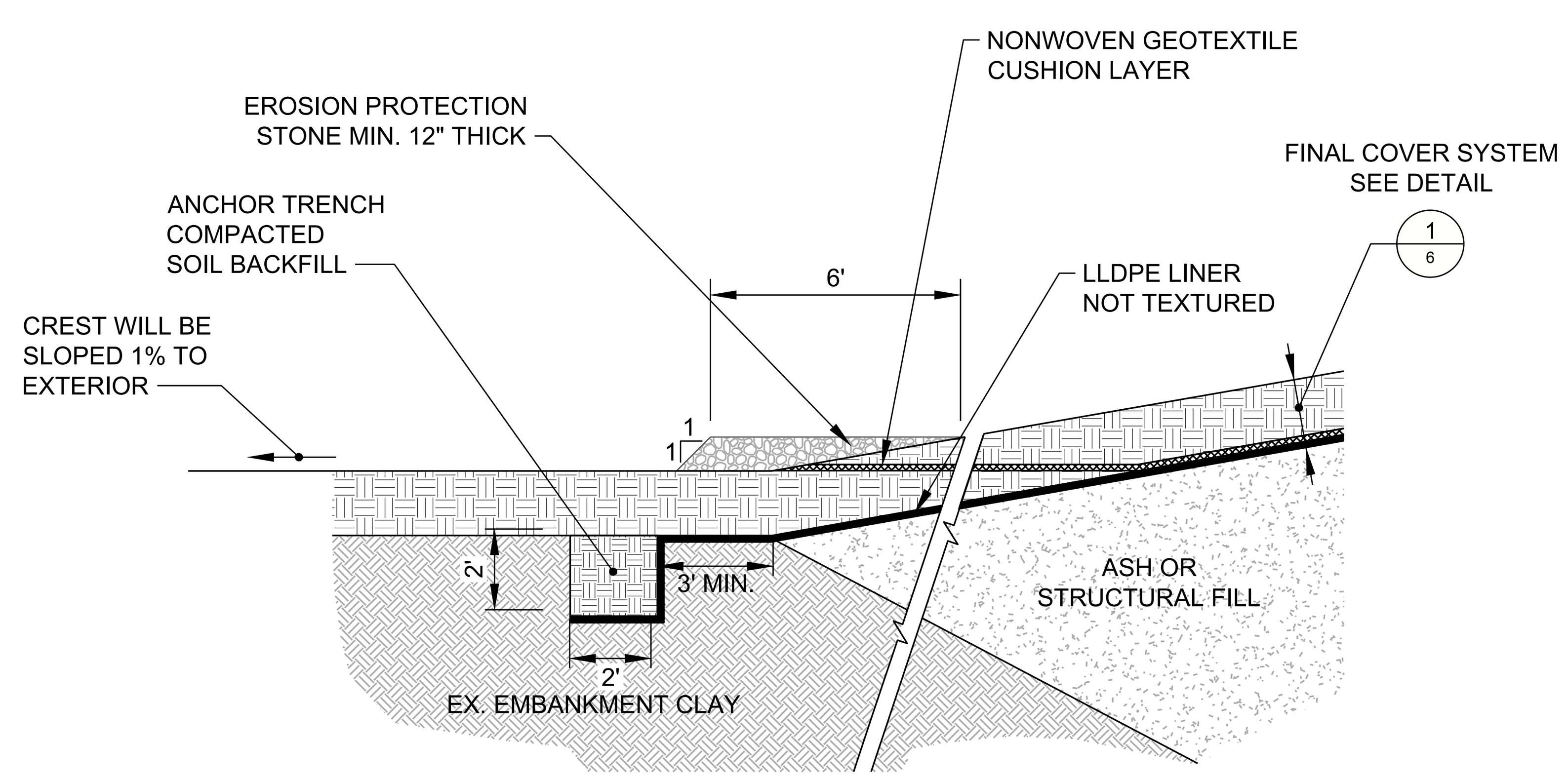
NOTE
THE FINAL PROTECTIVE SOIL LAYER WILL BE COMPOSED OF LOCALLY AVAILABLE SOILS COMPACTED TO BETWEEN 80% AND 95% OF THE STANDARD PROCTOR MAXIMUM DRY DENSITY FOR ESTABLISHMENT OF VEGETATION AND PROTECTION OF THE GEOSYNTHETICS.



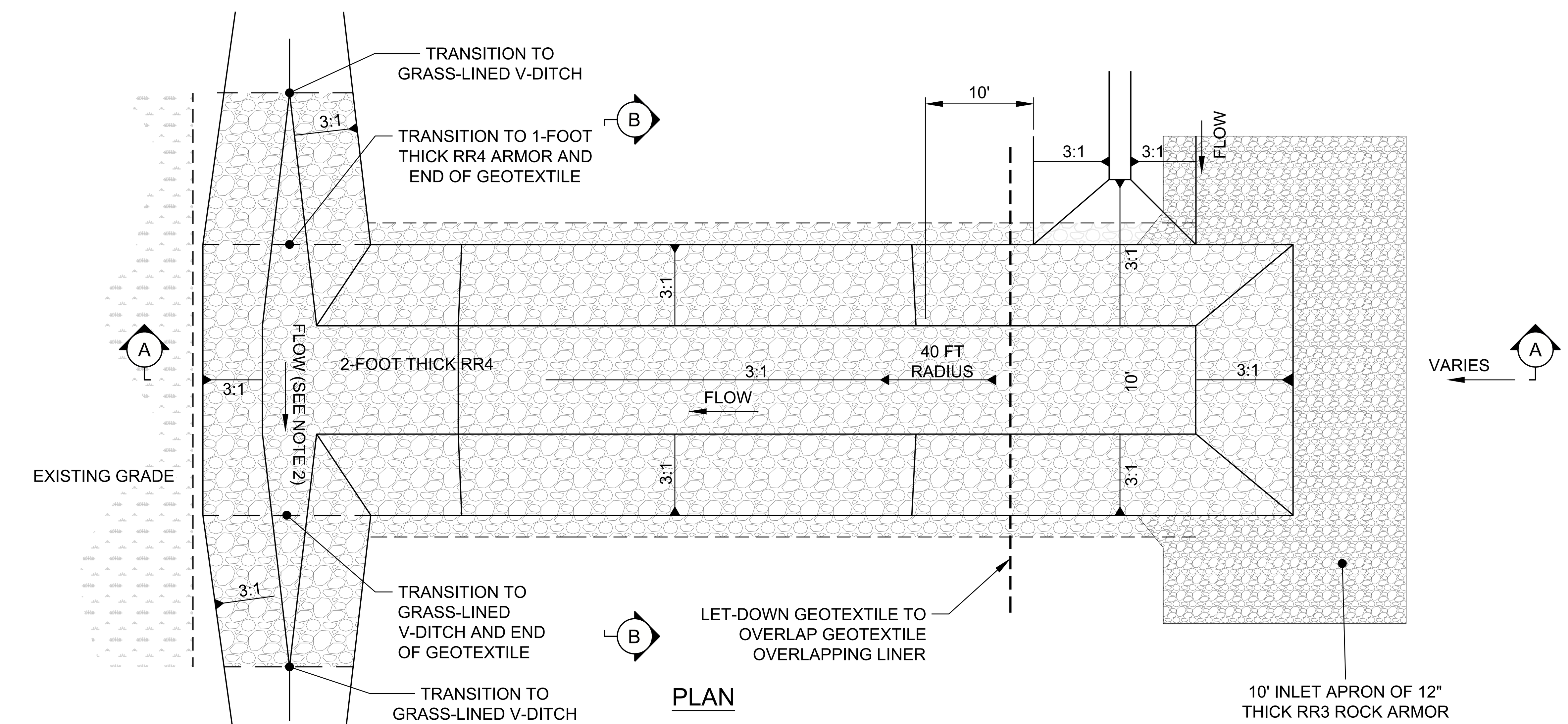
2/6 **GRASS-LINED V-DITCH (TYP)**



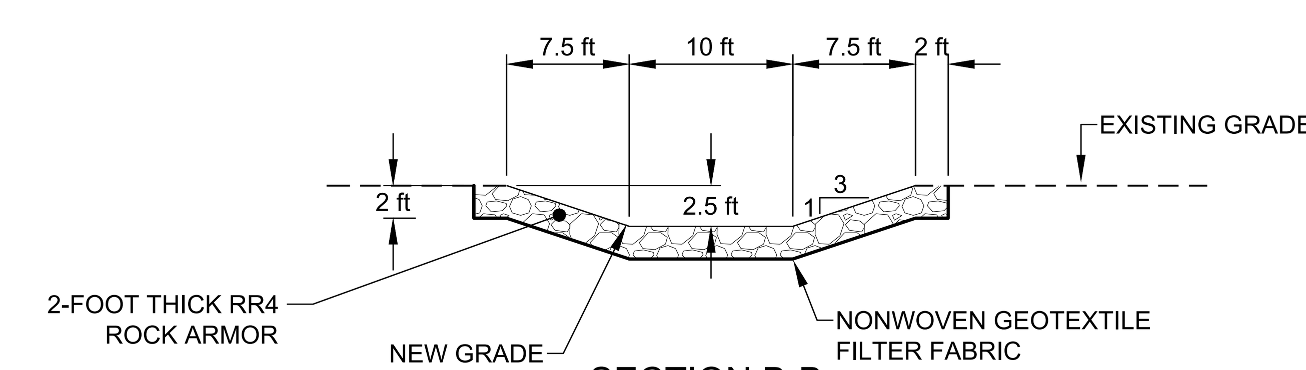
3/6 **TACK-ON BERM DETAIL (TYP)**



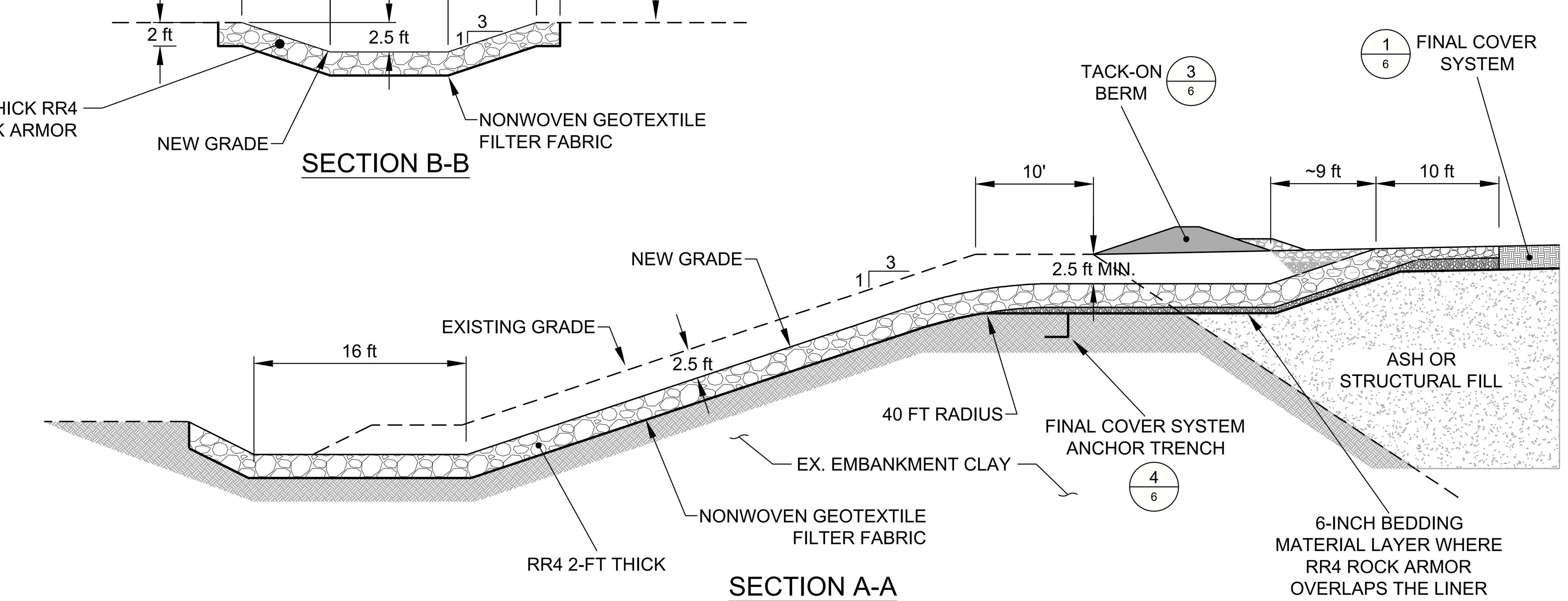
4/6 **ANCHOR TRENCH DETAIL**
NTS



PLAN



SECTION B-B



SECTION A-A

5/6 **LET-DOWN STRUCTURE DETAIL (TYP)**

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
A	2022-05-06	ISSUED FOR REVIEW	ETF	ETF	MWD	JO

SEAL

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PROJECT
ASH POND NO. 1 CONSTRUCTION PERMIT APPLICATION

TITLE
DETAILS

PROJECT NO. 21465046 | REV. A | 6 of 6 | DRAWING 6

ATTACHMENT 3

Slope Stability Calculations

CALCULATION

DATE	May 12, 2022	**Project No.** 21465046
PREPARED BY:	Elizabeth Hanna	
CHECKED BY	Michael Dreyer	
REVIEWED BY:	Jacob Sauer	**CLIENT NAME: Illinois Power Resources Generating, LLC**

SLOPE STABILITY ANALYSIS – ASH POND NO. 1

1.0 OBJECTIVE

Evaluate slope stability for Ash Pond No. 1 (AP1) closure design in terms of global stability and veneer stability for the final cover system and containment berm.

2.0 METHODOLOGY

Limit-equilibrium slope stability analyses were performed using Spencer's method of slices (Spencer 1967) in Slide2, a two-dimensional slope stability modeling software platform (Rocscience Inc. 2022). Spencer's method of slices considers both moment and force equilibrium. It is common geotechnical practice to analyze the stability of embankment slopes using limit-equilibrium methods.

2.1 Target Factors of Safety

The following target factors of safety are based on the values presented in Illinois Administrative Code Title 35, Subsection 845.460(a), as pertinent to AP1 following closure:

- Target minimum factor of safety under static long-term conditions = 1.5
- Target minimum factor of safety under seismic loading conditions = 1.0

The locally available soils that will be used for closure construction have relatively high silt and clay contents. Therefore, they are not expected to be susceptible to liquefaction.

3.0 SLOPE STABILITY ANALYSIS

3.1 Geometry

A typical cross-section through the containment berm along the east end of the closure footprint was selected for the slope stability analysis. This is identified as the critical cross-section for slope stability following closure of AP1.

The containment berm is designed with 3H-to-1V slopes and a crest width of 25 feet. The final cover system will be sloped at 7H:1V. The base of the final cover system is designed to meet the upstream edge of the containment berm crest and terminate with a 3H-to-1V slope to the crest. The final cover system will consist of the following components (from top to bottom):

- 2 feet of protective soil cover, anticipated to consist primarily of locally available low-plasticity silt or clay
- Nonwoven geotextile cushioning layer
- 40-mil textured LLDPE geomembrane

Downstream of the containment berm, the closure grades represent soil fill (locally available low-plasticity silt or clay) over the top of native soils. Previous stability analyses (AECOM 2016) determined that AP1 is underlain by a native clay layer, a relatively thin layer (approximately 3 feet) of soft native clay, and till. For simplification of the model geometry, the final cover system is represented as a layer having a thickness of 2 feet.

For slope stability analysis, the phreatic surface is modeled along the top of the native clay layer. Within the closure footprint, the CCR will be dewatered. Downstream of the containment berm, elevated groundwater is expected to present as surface water that will be managed in a stormwater channel, resulting in phreatic levels near the ground surface.

3.2 Approach and Input Parameters

The slope stability analysis uses the following approach and input parameters:

- Circular and non-circular slip surfaces are evaluated. Analysis of non-circular slip surfaces enables evaluation of veneer stability for the final cover system.
- Earthquake (seismic) loading conditions are simulated using a pseudo-static approach. Pseudo-static stability analyses apply a constant horizontal force to the system to represent the forces generated during an earthquake event, with the magnitude of the applied force typically related to the peak ground acceleration (PGA) of a specific earthquake hazard risk. A pseudo-static limit equilibrium analysis was conducted to evaluate the stability of the slope under a seismic load for the earthquake hazard representing a 2% probability of exceedance in 50 years (equaling 0.212g; i.e. a return period of 2475 years) based on the United States Geological Survey (USGS) Hazard Maps. As recommended by Hynes-Griffin and Franklin (1984), a horizontal force of ½ of the maximum PGA (EPA 1995) was used in the analysis (0.106g). In addition, the shear strength properties of the materials were reduced by 20% per the method’s requirements.
- Material properties of soils are selected based on previous stability calculations (AECOM 2016). Cohesion is neglected for conservatism.
- For conservatism, undrained strengths are applied for the ash. A vertical stress ratio (ratio of undrained strength to initial vertical effective stress) of 0.40 is used, consistent with values used in the previous stability analyses (AECOM 2016).
- Strength parameters for the geosynthetic interfaces included in the final cover system associated with the closed AP1 are evaluated from laboratory testing data published by Koerner and Narejo (2005) and summarized in Table 1.

Table 1: Characteristic Geosynthetic Interface Strengths (Koerner and Narejo 2005)

Interface	Peak Friction Angle	Peak Adhesion
Textured geomembrane against cohesive soil	18 degrees	209 psf
Textured geomembrane against granular soil	28 degrees	0 psf
NWNP geotextile against cohesive soil	30 degrees	104 psf
NWNP geotextile against textured geomembrane	25 degrees	167 psf

- The lowest geosynthetic interface strength parameters in the final cover system from Table 1 are selected for analysis. Adhesion is conservatively neglected for all geosynthetic interfaces.

A summary of material properties used in the slope stability analysis is presented in Table 2.

Table 2: Material Properties

Material	Unit Weight	Friction Angle	Cohesion or Adhesion	Vertical Stress Ratio
Embankment	135	31	0	N/A
Ash	112	N/A	N/A	0.40
Protective Cover	120	25	0	N/A
Native Clay	125	32	0	N/A
Soft Native Clay	125	30	0	N/A
Till	135	40	0	N/A

3.3 Results and Conclusions

The factor of safety for slope stability under static loading conditions is calculated as 1.8, as shown in Figure 1. The critical slip surface is surficial on the downstream face of the containment berm. The factor of safety for global stability under seismic loading conditions is calculated as 1.1, as shown in Figure 2. As with the static analysis, the critical slip surface is surficial on the downstream face of the containment berm.

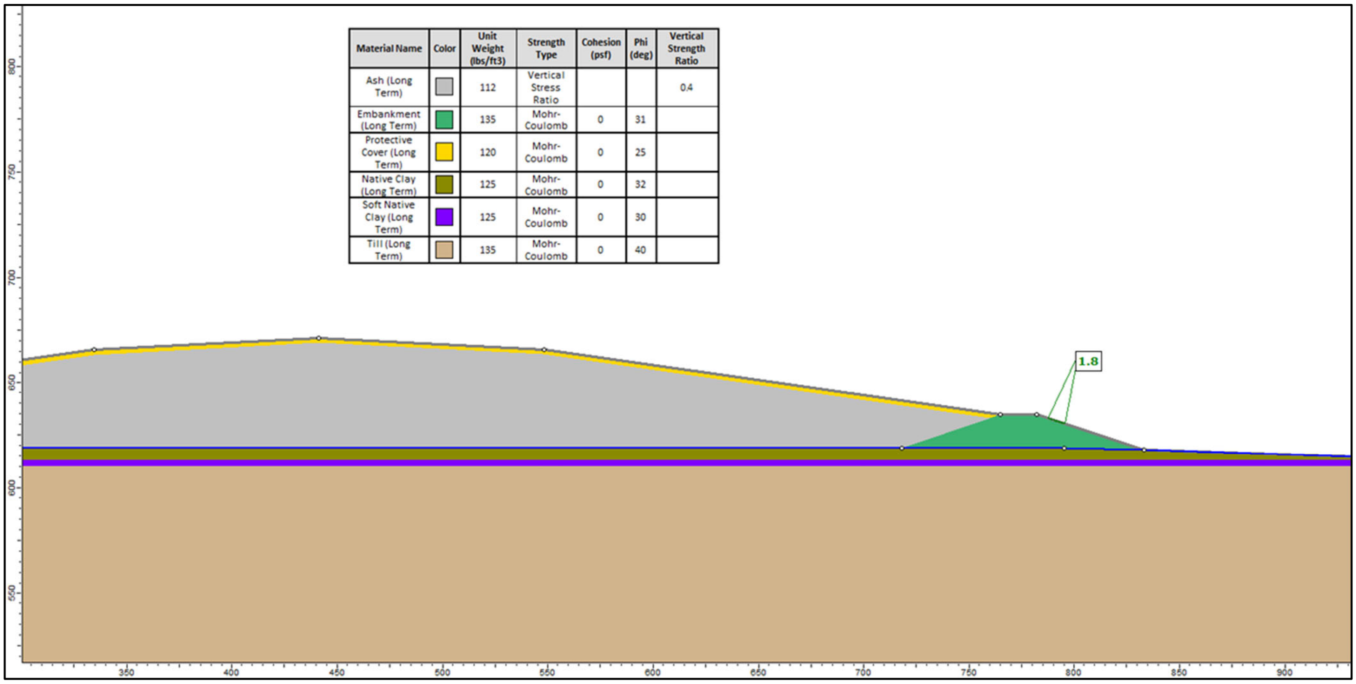

Figure 1: Analysis Result - Static Loading

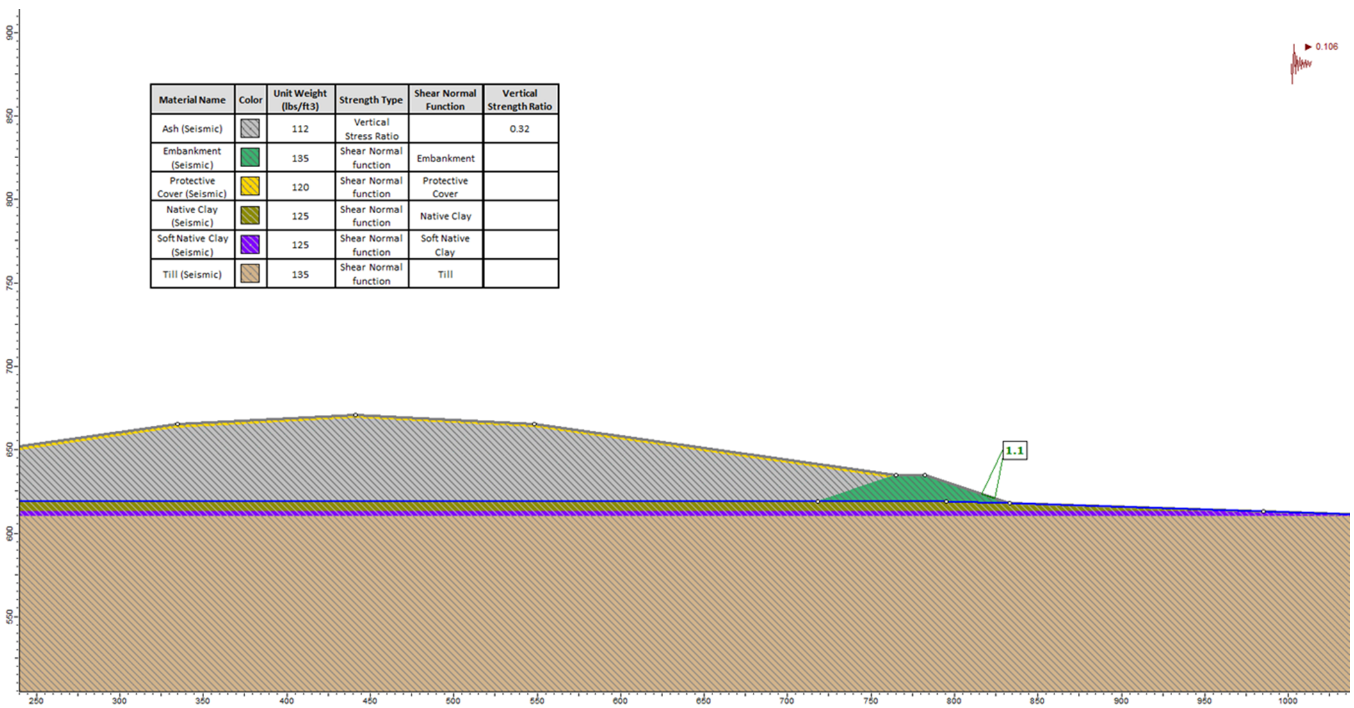

Figure 2: Analysis Result - Seismic Loading

Based on the factors of safety computed using the methods and assumptions described, the closed AP1 is expected to remain stable with an acceptable safety margin for global and veneer stability. A factor of safety greater that 1.5 was computed for static loading conditions. A factor of safety greater than 1.0 was computed for seismic loading conditions.

4.0 REFERENCES

AECOM 2016. Geotechnical Report Coffeen Power Station AP1. October 2016.

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Koerner, G.R. and Narejo, D. 2005. Direct Shear Database of Geosynthetic-to-Geosynthetic and Geosynthetic-to-Soil Interfaces. GRI Report #30, 2005.

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ATTACHMENT 4

Hydrologic Calculations

CALCULATION

DATE	May 10, 2022	**PREPARED BY**	Gustavo Guerrero, EIT
PROJECT NO.	21465046	**CHECKED BY**	DVS
CLIENT NAME	Illinois Power Resource Generating, LLC	**REVIEWED BY**	MWD

HYDROLOGY CALCULATIONS FOR CLOSURE OF ASH POND NO. 1 AT THE COFFEEN POWER PLANT

1.0 OBJECTIVE

Evaluate the hydrology (routing of stormwater runoff) after closure of Ash Pond No. 1 (AP1) at the Coffeen Power Plant. These calculations were performed to support the closure plan by determining the minimum channel dimensions.

2.0 METHODOLOGY

The areas contributing to AP1 were delineated in AutoCAD, as shown on Figure 1. The ground conditions were used to estimate a lag time using NRCS methodology (NRCS 1986). The calculations for the hydrologic parameters are included in Tables 1 and 2. The hydrologic parameters were used to model the stormwater runoff reporting to proposed channel to the north and east of the closed pond during the 25-year, 24-hour design storm event using HEC-HMS software (USACE 2021). The channels were analyzed using Manning's equation to evaluate the steady-state hydraulics.

3.0 INPUTS AND ASSUMPTIONS

Information and assumptions regarding input parameters used in the analyses include the following:

- A curve number of 58 was used to be consistent with the closed condition of Meadow and hydrologic soil group B (NRCS 1986) based on a review of the Web Soil Survey in the vicinity of AP1 (NRCS 2021).
- The design storm (25-year, 24-hour) depth from NOAA Atlas 14 (NOAA 2006) is 5.33 inches.
- Lag time was estimated using NRCS TR-55 methodology.
- Manning's number used for channel design was 0.030 for capacity and 0.035 for depth assuming a grass-lined channel.

4.0 RESULTS AND CONCLUSIONS

The HEC-HMS model results provide the estimated peak flow from the 25-year, 24-hour design storm to discharge points of interest:

- The peak flow rate at the proposed stormwater channel for AP1 is estimated as 32.2 cubic feet per second (cfs). This peak flow rate accounts for the AP1 and AP1N basins
- The peak flow rate at the proposed stormwater channel for AP1S basin is estimated as 10.0 cfs.

The output from the HEC-HMS model is shown in Table 3.

The channels were designed with dimensions as indicated in Table 4. Freeboard is shown to be at least 1 foot and at least one-half of the velocity head. The calculations indicate that the channels should function as designed.

5.0 REFERENCES

National Oceanic and Atmospheric Administration (NOAA). 2006. Precipitation-Frequency Atlas of the United States, Volume 2 Version 3.0.

Natural Resources Conservation Service (NRCS). 1986. Urban Hydrology for Small Watersheds. 2nd edition Technical Release 55). June.

Natural Resources Conservation Service (NRCS). 2021. Web Soil Survey. Available online: http://websoilsurvey.sc.egov.usda.gov/. Accessed September 22, 2021.

United States Army Corps of Engineers (USACE). 2021. Hydrologic Modeling System (HEC-HMS), Version 4.9.0. Release date: Jan 21, 2022.

TABLES

Table 1: Subbasin Summary Table

Illinois Power Resource Generating, LLC
Gypsum Management Facility Ponds
Project Number: 21465046

Date:	5/10/22
By:	GMG
Chkd:	DVS
Apprvd:	MWD

Design Storm **25 -Year Reccurence Interval**

Storm Duration (hours)	2-Year Depth (inches)	25 -Year Depth (inches)	Storm Distribution
24	3.14	5.33	II

Subbasin ID	Subbasin Area (ft^2)	Subbasin Area (acres)	Subbasin Area (sq mile)	CN = 58 Meadow HSG B (acres)	CN = 99 Open Water or Impervious (acres)	Composite SCS Curve No.	$S = \frac{1000}{CN} - 10$	Unit Runoff Q (in)	Runoff Volume (ac-ft)	Runoff Volume (ft^3)
AP-1	823,691	18.9	0.0295	18.91	0.00	CN = 58	7.24	1.35	2.13	92,984
AP-1N	389,796	8.9	0.0140	8.95	0.0	CN = 58	7.24	1.35	1.01	44,003
AP-1S	315,526	7.2	0.0113	7.24	0.0	CN = 58	7.24	1.35	0.82	35,619
		0.00	0.0000							
		0.00	0.0000							
		0.00	0.0000							
Total:	1,529,013	35.1	0.05						3.96	172,605

TABLE 2
BASIN TIME OF CONCENTRATION CALCULATIONS

Table 2: Basin Time of Concentration Calculations
Illinois Power Resource Generating, LLC
Gypsum Management Facility Ponds
Project Number: 21465046

Date:	5/10/22
By:	GMG
Chkd:	DVS
Apprvd:	MWD

Subbasin ID	Subbasin Area (sq mile)	Composite Curve Number	Total Lag (0.6*Tc) (min)	Total Travel Time (min)
Ash Pond	0.0295	58	14.5	24.1
AP-1N	0.0140	58	8.1	13.5
AP-1S	0.0113	58	8.0	13.3

Flow Segment 1

Subbasin ID	Type of Flow	Length (ft)	Slope (ft/ft)	Roughness Condition[1]		Typical Hydraulic Radius (Channel Only) (ft)	Travel Time (min)
Ash Pond	Sheet	100	0.046	G	Bermuda Grass		15.9
AP-1N	Sheet	100.0	0.080	G	Bermuda Grass		12.7
AP-1S	Sheet	100.0	0.084	G	Bermuda Grass		12.5

Flow Segment 2

Subbasin ID	Type of Flow	Length (ft)	Slope (ft/ft)	Roughness Condition[1]		Typical Hydraulic Radius (Channel Only) (ft)	Travel Time (min)
Ash Pond	Shallow	285	0.157	U	Unpaved		0.7
AP-1N	Shallow	265.0	0.123	U	Unpaved		0.8
AP-1S	Shallow	275.0	0.114	U	Unpaved		0.8

Flow Segment 3

Subbasin ID	Type of Flow	Length (ft)	Slope (ft/ft)	Roughness Condition[1]		Typical Hydraulic Radius (Channel Only) (ft)	Travel Time (min)
Ash Pond	Shallow	745	0.016	U	Unpaved		6.1
AP-1N	Channel	1900	0.006	G	Grass-lined	0.55	14.6
AP-1S	Channel	2540	0.010	G	Grass-lined	0.45	16.9

Flow Segment 3

Subbasin ID	Type of Flow	Length (ft)	Slope (ft/ft)	Roughness Condition[1]		Typical Hydraulic Radius (Channel Only) (ft)	Travel Time (min)
Ash Pond	Channel	240	0.008	G	Grass-lined	0.70	1.3
AP-1N							
AP-1S							

TABLE 3
FLOW RESULTS FROM HEC-HMS

Illinois Power Resource Generating, LLC
Gypsum Management Facility Ponds
Project Number: 21465046

Date:	5/10/22
By:	GMG
Chkd:	DVS
Apprvd:	MWD

HEC-HMS Basin Model:	GMF
HEC-HMS Met. Model:	25-yr, 24-hr
HEC-HMS Control Specs:	48-hr, 6-min

Hydrologic Element	Drainage Area (sq mile)	Peak Discharge (cfs)	Time of Peak	Total Volume (ac-ft)
Ash Pond	0.030	20.4	02May2050, 00:12	1.35
Ash Pond North	0.014	12.3	02May2050, 00:00	1.35
Ash Pond South	0.011	10	02May2050, 00:00	1.35
Ash Pond South-Sink	0.011	10	02May2050, 00:00	1.35
Ash Pond + North-Sink	0.044	32.2	02May2050, 00:06	1.35

Table 4
Channel Hydraulic Calculations

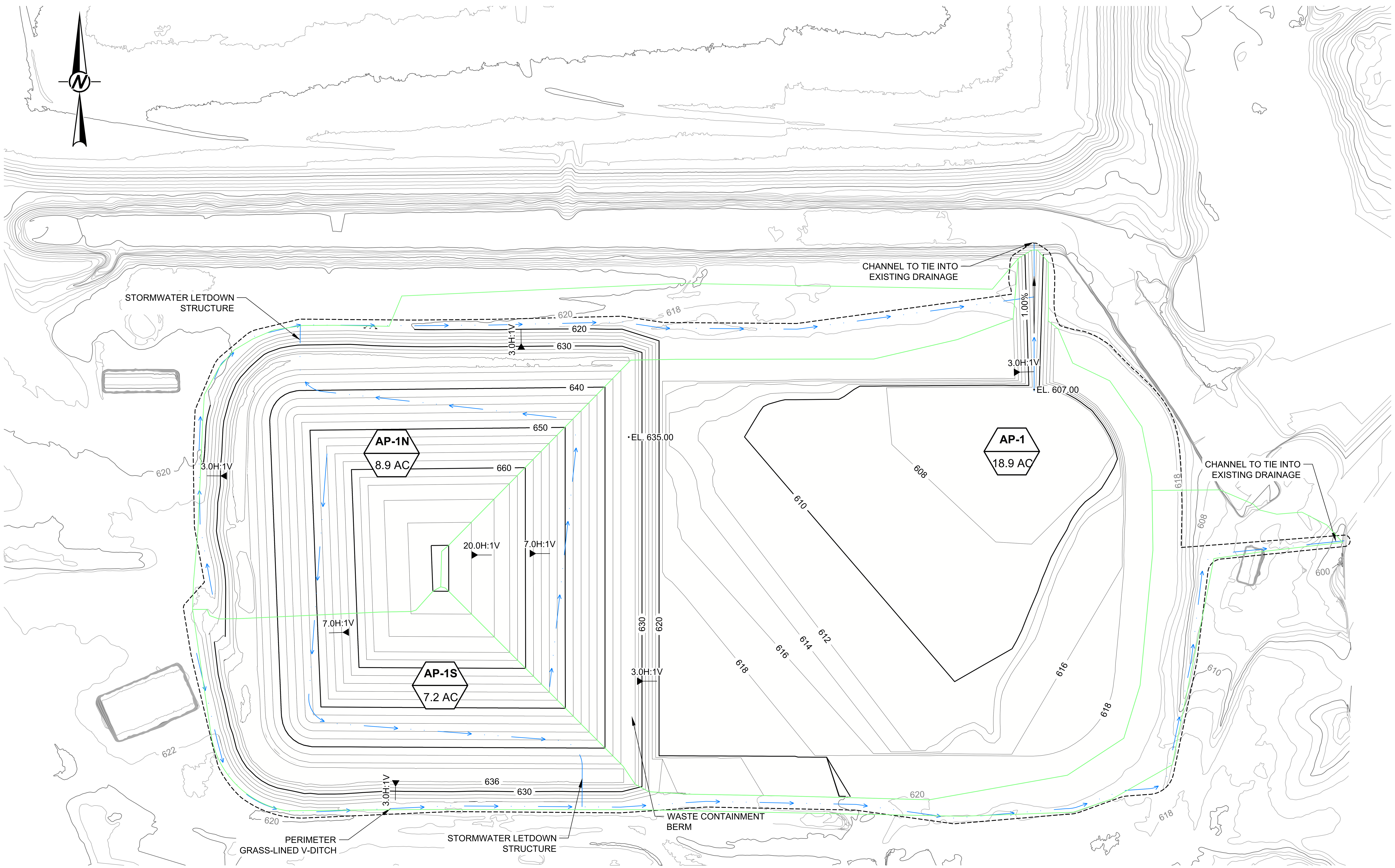
Illinois Power Resource Generating, LLC
Gypsum Management Facility Ponds
PROJECT NO.: 21465046

Date:	5/10/22
By:	GMG
Chkd:	DVS
Apprvd:	MWD

Date:	5/10/22
By:	GMG
Chkd:	DVS
Apprvd:	MJG

			Channel Design Geometry						Channel Roughness Parameters				Hydraulic Calculations							Channel Evaluations
Reach Designation	Q25 from HEC-HMS (cfs)	HEC HMS Element ID for Q	Approximate Channel Length (ft)	Bed Slope (ft/ft)	Left Side Slope (H:1V)	Right Side Slope (H:1V)	Bottom Width (ft)	Minimum Channel Depth (ft)	Design Channel Lining		Mannings 'n' for Capacity (Depth Calculation)	Mannings 'n' for Stability (Velocity Calculation)	Maximum Velocity (ft/sec)	Maximum Normal Flow Depth (ft)	Froude Number	Normal Depth Shear Stress (lb/ft^2)	Stream Power (W/m^2)	Top Width of Flow (ft)	Top Width of Channel (ft)	Available Freeboard (ft)
AP-1N Channel	12.3	Ash Pond North	1900	0.006	3.0	3.0	0	2.5	G	Grass-lined	0.035	0.030	2.7	1.32	0.59	0.47	18.26	7.9	15.0	1.2
AP-1S Channel	10.0	Ash Pond South	2540	0.010	3.0	3.0	0	2.5	G	Grass-lined	0.035	0.030	3.1	1.10	0.76	0.69	31.32	6.6	15.0	1.4
Ash Pond Channel	32.2	Ash Pond + North-Sink	240	0.008	3.0	3.0	0	12.0	G	Grass-lined	0.035	0.030	3.9	1.76	0.75	0.92	51.53	10.6	72.0	10.2

FIGURE



LEGEND

- 600 — FINAL CLOSURE IN PLACE GRADES (SEE NOTES 1 AND 2)
- 600 — EXISTING GROUND CONTOURS (SEE NOTE 3)
- PROPOSED STORMWATER FLOW PATH
- LIMITS OF DISTURBANCE
- BASIN DELINEATION
- AP-1 — BASIN ID
- X.X AC — BASIN ACREAGE

NOTE(S)

1. FINAL GRADES INCLUDE FINAL COVER, WASTE CONTAINMENT BERM, SOIL COVER OVER TOP OF UPPERMOST AQUIFER, AND PERIMETER GRADING AROUND AP1 EXTERIOR SIDE SLOPES.
2. EXISTING CONTOURS ARE A COMPOSITE OF AN AERIAL SURVEY COMPLETED BY DRAGONFLY AEROSOLUTIONS DATED 12/3/2020, TOPOGRAPHIC/BATHYMETRIC SURVEYS COMPLETED BY INGENAE DATED 12/3/2020 & 12/4/2020.
3. THE PROPOSED STORMWATER DRAINAGE CONCEPT IS TO SHED WATER INTO EXISTING DRAINAGE CHANNELS NORTH AND EAST OF THE FACILITY. STORMWATER COLLECTED WITHIN AP1 WILL BE DIRECTED INTO AN OPEN CHANNEL THAT BREACHES THE CONSTRUCTED BERM TO CONNECT TO THE EXISTING DRAINAGE.

DRAFT

0 100 200
1" = 100' FEET

WSP GOLDER

COFFEEN POWER PLANT ASH POND NO. 1

SURFACE WATER DRAINAGE BASINS

FIGURE 1

golder.com