Corrective Measures Assessment

Old West Ash Pond (Pond No. 1 and Pond No. 3) and Polishing Pond
Hennepin Power Station
13498 East 800th Street
Hennepin, Illinois

Dynegy Midwest Generation, LLC

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EXECUTIVE SUMMARY

The Old West Ash Pond (Pond No. 1 and Pond No. 3) and Old West Polishing Pond (OWPP) (hereafter collectively referred to as the OWAP) at the Hennepin Power Station (HPS) is a coal combustion residuals (CCR) multi-unit comprised of three inactive surface impoundments. The OWAP is located near the City of Hennepin, in Putnam County, Illinois as shown on Figure 1.

A Closure and Post Closure Care Plan (Closure Plan; Geosyntec, 2017) consisting of a corrective action process for the OWAP was submitted to the Illinois Environmental Protection Agency (IEPA). The Closure Plan is consistent with the written closure plan required by 40 C.F.R. § 257.102. IEPA approved the Closure Plan on June 19, 2018 (IEPA, 2018a). The approved Closure Plan summarized the planned closure and corrective measures of the OWAP, which include dewatering the CCR, if needed, mechanical excavation of material from the OWPP for use as structural fill in the OWAP, grading within the OWAP, constructing an alternative cover system consisting of geomembrane and vegetated cover soils in direct contact with the graded CCR, establishment of a vegetative cover, and monitored natural attenuation (MNA). Closure of the OWPP consists of removal of CCR and dike soils in the OWPP and consolidation of these materials into the OWAP. The closure construction activities have begun and will be completed by November 2020 as indicated in the approved Closure Plan. After closure activities are complete, post-closure activities, which include groundwater monitoring and maintenance of the final cover system, will occur.

The new cover system exceeds the requirements of 40 C.F.R. § 257.102, will significantly minimize water infiltration into the closed CCR multi-unit (the primary source of CCR constituents in groundwater), and allow surface water to drain off the cover system. This will reduce generation of potentially impacted water and the extent of groundwater impacts from the OWAP in the Uppermost Aquifer by natural attenuation. The approved cover system will limit the migration of potentially impacted groundwater, control surface water on the cover system and surrounding the OWAP, and will reduce contaminant transport off-site, both spatially and temporally. Groundwater modeling results of post-closure OWAP indicate construction of the cover system and MNA will result in declining contaminant concentrations within months after cover construction (NRT/OBG, 2017a).

Statistically significant levels (SSLs) of total arsenic, lithium, and molybdenum were identified at the OWAP during groundwater monitoring required by 40 C.F.R. § 257.90. There are no existing off-site water wells, potable or non-potable, that are likely to be impacted by groundwater from the HPS property. **There are no impairments to groundwater usage on the HPS property or surrounding properties caused by the OWAP.**

Impacts of groundwater with elevated concentrations of CCR constituents from beneath the closed OWAP on nearby surface waters are not expected. Concentrations of sulfate and boron in the Illinois River, adjacent to HPS, were calculated in the Hydrogeologic Site Characterization Report (NRT/OBG, 2017b) to be less than laboratory detection methods. Boron is a common indicator parameter for the presence of CCR impacts in groundwater, in part because it is more mobile than other contaminants potentially associated with CCR. The fate and transport of lithium in the groundwater is expected to be similar to that of boron, because both are mobile in groundwater and relatively unaffected by sorption to organic matter or iron hydroxides in the aquifer. Since molybdenum has a higher sorption potential (which reduces mobility in groundwater) than boron (EPRI, 2012), the percentage of molybdenum released from the OWAP that potentially discharges to surface water is anticipated to be less than the percentage of boron that potentially discharges to surface waters. Arsenic is mobile under reducing conditions, but it takes longer to flush through the system than boron. As such, no adverse effects to surface water are expected.

This Corrective Measures Assessment (CMA) was prepared to address the requirements of 40 C.F.R. § 257.96. The following potential corrective measures were identified based upon site-specific conditions:

- IEPA-Approved Alternative 1) Closure in Place (CIP) (Alternative Cover System) and MNA
- Alternative 2) Closure by Removal (CBR) and MNA

  - Alternative 2A) On-site CCR disposal and MNA
  - Alternative 2B) Off-site CCR disposal and MNA
- Alternative 3) Closure in Place (Alternative Cover System) with groundwater cutoff wall, hydraulic gradient control system, and MNA

These alternatives were evaluated with respect to the following remedy selection evaluation factors in 40 C.F.R. § 257.97 and their associated considerations.

LONG- AND SHORT-TERM EFFECTIVENESS, PROTECTIVENESS AND CERTAINTY

Closure in Place (CIP) alternatives (IEPA-Approved Alternative 1 and Alternative 3) are more effective and protective than Closure by Removal (CBR) alternatives (Alternatives 2A and 2B). This is primarily due to: 1) the relatively short timeframe for permitting and constructing a CIP alternative, relative to the long implementation timeframe for CBR (approximately 8 to 13 years, depending on permitting), during which time groundwater would continue to be impacted from CCR remaining on-site, and 2) the increased potential for human health and environmental impacts during excavation and transport of CCR during removal activities, particularly off-site disposal (Alternative 2B).

SOURCE CONTROL

Groundwater modeling for IEPA-Approved Alternative 1 indicates that, although the secondary source of groundwater impacts (underlying saturated soils that have been in contact with CCR-impacted groundwater) will remain in place, concentrations will begin to decline within months after cover system construction is complete.

Adding a groundwater cutoff wall and hydraulic gradient control system to IEPA-Approved Alternative 1 (*i.e.*, Alternative 3) may enhance the secondary source control effectiveness, but also increases the implementation timeframe relative to IEPA-Approved Alternative 1 due to the need to design and permit the groundwater cutoff wall and hydraulic gradient control system. The potentially reduced time to meet GWPS relative to IEPA-Approved Alternative 1 is expected be offset by the time required to design and permit the Alternative 3 groundwater cutoff wall and hydraulic gradient control system. The ability of Alternative 3 to effectively reduce groundwater concentrations and attain GWPS will have a high dependence upon the ability to key the groundwater cutoff wall into a low-permeability geologic unit beneath the OWAP (presumably bedrock).

The CBR alternatives (Alternatives 2A and 2B) may achieve long-term source control, but present short-term environmental risk associated with implementation. The primary source of groundwater impacts (CCR) would remain in place during implementation, allowing transport of arsenic, lithium, and molybdenum into the groundwater throughout the extended permitting and implementation timeframe (8 to 13 years, depending on permitting requirements). Human and environmental receptors would also be exposed to CCR over this timeframe and the secondary source of groundwater impacts would remain after remedy implementation.

IMPLEMENTABILITY

IEPA-Approved Alternative 1 is currently under construction. Alternative 3 would require detailed site investigation and design activities prior to implementation. CBR alternatives (2A and 2B) would entail significant difficulty in permitting, construction, and transportation, which would delay potential benefits associated with this remedy.

IEPA-Approved Alternative 1 provides performance that is as good, or better than, the other alternatives for each of the evaluation factors considered. A public meeting will be held in accordance with 40 C.F.R. § 257.96(e). Following receipt of public input, a corrective measure will be selected and documented in the remedy selection report required by 40 C.F.R. § 257.97(a).

1 INTRODUCTION

O'Brien & Gere Engineers, Inc, part of Ramboll (OBG), has prepared this Corrective Measures Assessment (CMA) for the Old West Ash Pond (Pond No. 1 and Pond No. 3) and Old West Polishing Pond (OWPP), coal combustion residuals (CCR) Multi-Unit ID 804 (hereafter collectively referred to as the OWAP), located at Hennepin Power Station (HPS), near the Village of Hennepin, in Putnam County, Illinois. This CMA report complies with the requirements of Title 40 of the Code of Federal Regulations (C.F.R.) § 257, Subpart D Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments (CCR Rule). Under the CCR Rule, owners and operators of existing CCR surface impoundments (SIs) must initiate a CMA in accordance with 40 C.F.R. § 257.96 when one or more Appendix IV constituents are detected at statistically significant levels (SSLs) above groundwater protection standards (GWPS), and the owner or operator has not demonstrated that a source other than the CCR unit has caused the SSLs. This CMA is responsive to the 40 C.F.R. § 257.96 and § 257.97 requirements for assessing potential corrective measures to address the exceedance of the GWPS for lithium, molybdenum and arsenic.

1.1 SITE DESCRIPTION AND HISTORY

The OWAP is located in the northeast quarter of Section 27, Township 33 North, Range 2 West, Putnam County, Illinois (Figure 1) less than 200 feet south of the Illinois River, approximately one-half mile east of the Big Bend, where the river shifts course from predominantly west to predominantly south. It is comprised of three inactive surface impoundments: the Old West Ash Pond, which includes Pond No. 1 (9.3 acres) at the eastern end of the impoundment, containing primarily bottom ash and slag, and Pond No. 3 (16.4 acres) in the central portion of the impoundment, containing mixed coal ash; and the Old West Polishing (Secondary) Pond (4.7 acres) located at the western end of the impoundment (Figure 2). It is bordered to the southeast by agricultural fields, to the southwest and west by low-lying floodplain within the Donnelley Wildlife Management Area (Donnelley WMA), administered by the Illinois Department of Natural Resources (IDNR), and to the east by the coal pile and power-generating facility. These three inactive impoundments are considered a single CCR unit (multi-unit) for groundwater monitoring required by the CCR Rule.

The HPS has two coal-fired generating units constructed in 1953 and 1959 with a total capacity of 280 megawatts (MW). Dynegy Midwest Generation, LLC (DMG), operated the OWAP from 1952 until late 1996, when it was removed from service. All coal ash disposed at the OWAP is derived from Illinois coal.

In January 2018, DMG submitted the Closure and Post-Closure Care Plan for the OWAP (Closure Plan, Geosyntec, 2017) to the Illinois Environmental Protection Agency (IEPA). The Closure Plan set forth corrective measures and sought approval to close the OWAP by dewatering the CCR, if needed, mechanical excavation of material from the OWPP for use as structural fill in the OWAP, grading within the OWAP, constructing an alternative soil and geosynthetic cover system in direct contact with the graded CCR, establishment of a vegetative cover, and monitored natural attenuation (MNA). Closure of the OWPP consists of removal of CCR and dike soils in the OWPP and consolidation of these materials into the OWAP. The final cover system for the OWAP will significantly minimize water infiltration into the closed CCR multi-unit; and allow drainage of water off of, and out of, the closed CCR mult-unit. The final cover system will include a 40-mil linear low-density polyethylene (LLDPE) geomembrane liner, a geo-composite drainage layer, 1.5-ft soil cover, and 0.5-ft vegetated erosion soil layer. In accordance with the CCR Rule, the final cover system must have a permeability less than or equal to $1\text{x}10^{-5}$ cm/sec or the permeability of the foundation soils or liner beneath the CCR, whichever is less. The OWAP is partially underlain by silt and clay soils with a permeability on the order of $1\text{x}10^{-6}$ to $1\text{x}10^{-7}$ cm/sec. The final cover system will have a permeability of approximately $4\text{x}10^{-13}$ cm/sec which is over 5 to 6 orders of magnitude lower than that required. The Closure Plan included provisions for performing maintenance of the final cover system and groundwater monitoring to assess natural attenuation. If a statistically significant increasing trend is observed to continue over a period of two or more years, and a subsequent hydrogeologic site investigation demonstrates that such exceedances are due to a release from the OWAP and corrective actions are necessary and appropriate to mitigate the release, a corrective action plan will be proposed as a modification to the post-closure care plan. The IEPA subsequently approved the Closure Plan on June 19, 2018 (IEPA, 2018a).

1.2 CORRECTIVE MEASURES ASSESSMENT OBJECTIVES AND METHODOLOGY

The objective of this CMA is to document the assessment of potential corrective measures considered for impacted groundwater associated with OWAP at the HPS. The CMA evaluates the effectiveness of potential corrective measures (including the IEPA-approved Closure Plan) in meeting requirements and objectives of the remedy, as described under 40 C.F.R. § 257.96(c), by addressing the following:

- The performance, reliability, ease of implementation, and potential impacts of appropriate potential remedies, including safety impacts, cross-media impacts, and control of exposure to any residual contamination.
- The time required to begin and complete the remedy.
- The institutional requirements, such as state or local permit requirements, or other environmental or public health requirements that may substantially affect implementation of the remedy(s).

The CMA provides a systematic, rational method for evaluating potential corrective measure alternatives. The assessment process evaluates potential corrective measures against a set of general performance standards (threshold criteria) that act as filters to screen out alternatives that do not meet minimum standards for protectiveness. Alternatives that meet the performance standards are then evaluated against a series of evaluation factors and considerations (balancing criteria) to evaluate the relative effectiveness of each alternative. The performance standards are requirements that must be met to ensure a successful remedy, whereas the evaluation factors and considerations provide flexibility and guidance to aid decision-making to best meet the performance standards. Corrective measures will likely not effectively address each and every evaluation factor and consideration; rather, they are compared against one another to inform a rational selection of a corrective measure for the OWAP.

The following performance standards, per 40 C.F.R. § 257.97, were used to screen potential corrective measures for the OWAP (threshold criteria) to ensure they are met by the selected alternative:

- Be protective of human health and the environment.
- Attain the groundwater protection standards per 40 C.F.R. § 257.95(h).
- Provide source control to reduce or eliminate, to the maximum extent feasible, further releases of Appendix IV constituents.
- Remove from the environment as much of the contaminated material as feasible.
- Comply with waste management standards per 40 C.F.R. § 257.98(d).

40 C.F.R. § 259.102 specifically allows either Closure by Removal (CBR) or Closure in Place (CIP) approaches to site closure. Site-specific considerations regarding the OWAP Conceptual Site Model (CSM, Section 2) were used to evaluate potential corrective measures. The following potential corrective measures were considered during CMA process:

- IEPA-Approved Alternative 1) Closure in Place (Alternative Cover System) and MNA
- Alternative 2) Closure by Removal and MNA,
  - Alternative 2A) On-site CCR disposal and MNA
  - Alternative 2B) Off-site CCR disposal and MNA
- Alternative 3) Closure in Place (Alternative Cover System) with groundwater cutoff wall, hydraulic gradient control, and MNA

Each of these corrective measure alternatives meets the threshold criteria and were comparatively evaluated, per the 40 C.F.R. § 257.97 remedy selection evaluation factors and considerations, which implicitly encompass the requirements and objectives included under 40 C.F.R. § 257.96(c) and summarized above. Other alternatives were considered but not retained for further analysis because they are technically infeasible given the site-specific geologic and hydrogeologic setting and/or chemical characteristics of the groundwater impacts identified at the OWAP, as described below.

The highly transmissive, but heterogeneous, Uppermost Aquifer, and nature, extent, and detected concentrations of groundwater contaminants constrained the selection of potentially applicable engineering controls. Specifically, the effectiveness of a pump and treat system to hydraulically contain and capture the arsenic, lithium, and molybdenum plumes, with their limited areal extents in close proximity to the Illinois River in an aquifer with relatively high conductivity, was weighed against the practicability of the alternatives that were considered. The lack of vertical overlap of their occurrences (arsenic plume occurs approximately 50 ft below ground surface [bgs], whereas lithium and molybdenum are shallower at approximately 25 ft bgs), would make designing an effective groundwater extraction system difficult. The proximity of the plumes to the Illinois River also presents challenges for plume capture and containment, which would require removal and treatment of high volumes of water. Because pump and treat would yield little net benefit, at much greater energy demands, pump wear and tear, and aquifer stresses, compared to a groundwater cutoff wall with hydraulic gradient control (*e.g.*, Alternative 3), construction of a pump and treat system was not retained for further analysis in this CMA.

In a similar manner, in-situ solidification/stabilization (ISS) was considered but not retained for analysis, based on practical considerations. ISS is a treatment technology which consists of encapsulating waste within a cured monolith having increased compressive strength and reduced hydraulic conductivity. Hazards can be reduced by both converting waste constituents into less soluble and mobile forms and isolating waste from groundwater, thus facilitating groundwater remediation and reduction of leaching to groundwater. The timeframe to implement ISS, including bench-scale and pilot-scale testing to support the detailed design, is longer than other alternatives and would delay source control relative to other alternatives. In addition, the effects on groundwater chemistry associated with the addition of large volumes of Portland cement and other amendments to the subsurface would require detailed evaluation. Implementation would also require specialized contractors and equipment.

2 CONCEPTUAL SITE MODEL

The currently defined extent of the release of CCR constituents to the environment does not threaten public health. There are currently no impairments to groundwater usage on the HPS property or surrounding properties associated with constituents from the OWAP. CCR dewatering and the alternative cover system will reduce generation of potentially-impacted water and migration from the OWAP, and minimize CCR constituents entering the environment, as described in the Groundwater Model Report (NRT/OBG, 2017a). Calculated low concentrations of CCR indicator parameters in surface water near the OWAP are evidence that current conditions are protective of surface water receptors.

2.1 GEOLOGY AND HYDROGEOLOGY

The geology and hydrogeology described in the Hydrogeologic Site Characterization Report (NRT/OBG, 2017b) are summarized below and define the conceptual site model for the OWAP; cross-sections are provided in the Hydrogeologic Site Characterization Report:

- Fill - CCRs consisting primarily of fly ash with lesser amounts of bottom ash and slag. This layer also includes the constructed fill berms around the ash ponds, which contain variable admixtures of CCRs and re-worked native silt, clay, and sand.
- Alluvial fine-grained silts and clays, classified as Cahokia Alluvium.
- Alluvial fine to medium sands, also Cahokia Alluvium.
- Sand and gravel with boulders deposited by glacial meltwaters and classified as the Henry Formation.

The river-laid deposits are classified as Cahokia Alluvium. The Henry Formation sands and gravels make up the upper and lower terraces, and fill the valley beneath the alluvium. The Cahokia (lower hydraulic conductivity) and Henry Formations (high hydraulic conductivity) together form the Uppermost Aquifer from the water table down to the top of bedrock.

The stratigraphy of unlithified materials underlying the Henry Formation is uncertain, but it is assumed, based on nearby borings at the power plant, East Ash Pond System, and vicinity, that the Henry Formation most likely sits directly on top of bedrock near the OWAP. However, based on the identification of till approximately ½ mile south of the impoundment, it is possible that till of the Wedron or Glasford Formation, or an older sand formation, the Sankoty Sand, lies between the Henry Formation and bedrock.

The uppermost bedrock near the HPS, including the OWAP, is the Pennsylvanian Carbondale Formation, which consists of shale with thin limestone, sandstone, and coal beds. Three deeper borings around the perimeter of the East Ash Pond System indicate the presence of shale bedrock between elevations 400 and 410 ft above the site datum (NAVD88), approximately 50-60 ft below ground surface (bgs) at the OWAP. Water well logs at the power plant indicate shale bedrock at an elevation of roughly 350 ft above NAVD88 (approximately 90 ft bgs at the OWAP).

The OWAP lies over both glacial deposits (Henry Formation) and alluvium (Cahokia Alluvium). Specifically, Pond No. 1, lies on top of lower terrace glacial sand and gravel deposits, and the eastern portion of Pond No. 3 overlies alluvial sand, whereas the western portion of Pond No. 3 and the OWPP overlay silty clay alluvial channel fill deposits.

The groundwater monitoring well network is shown on Figure 2. The Illinois River is the local and regional groundwater discharge area under normal river stage; the primary directions of groundwater flow are north and northwest. River stage is usually lowest during the months of August through October. The river basin experiences annual spring flooding during the months of March, April, May, and sometimes June, and lesser flooding occasionally occurs during autumn. River stage during high precipitation and/or flood events seasonally rises above adjacent groundwater elevations and low-lying areas of the floodplain. Horizontal hydraulic gradients from the OWAP to off-site areas range from 0.001 foot per foot (ft/ft) during Illinois River flood stage to about 0.005 ft/ft during normal river stage, yielding a groundwater velocity ranging from

0.1 ft/day to 1.1 ft/day. During normal river stage, a slight groundwater mound occurs within the OWAP with radial flow north toward the river, as well as flow to the southwest that eventually discharges into the river west of the OWAP.

A groundwater flow and transport model was developed for the OWAP to evaluate the effect that cover system construction and MNA would have on surrounding groundwater quality. Boron was modeled to simulate migration of CCR impacts in groundwater. Boron is a common indicator parameter for the presence of CCR impacts in groundwater, in part because it is more mobile than other contaminants potentially associated with CCR. Therefore, boron was modeled to document the impact of the proposed cover system for closure of the OWAP and MNA. The results were presented in the Groundwater Model Report (NRT/OBG, 2017a). The transport and fate of lithium in the groundwater is expected to be similar to boron, because both are mobile in groundwater and relatively unaffected by sorption to organic matter or iron hydroxides in the aquifer (EPRI, 2012). Molybdenum has the potential to be sorbed onto iron hydroxides or organic matter in the aquifer materials, depending on the geochemical conditions but is typically mobile (EPRI, 2012). The presence of fine-grained material underlying the western portion of the OWAP provides increased sorption potential. This may increase the length of time required for molybdenum to reach GWPS, as it may desorb from the aquifer materials as dissolved concentrations decline. Arsenic mobility is subject to precipitation, co-precipitation, and dissolution reactions with pH and oxidation-reduction conditions strongly influencing which reactions occur (EPRI, 2012). Therefore, arsenic has the potential for an increased length of time required to reach GWPS during corrective action compared to boron, as arsenic may precipitate out of solution and/or dissolve back in depending on oxidation-reduction conditions.

Modeling results indicate that boron concentrations are predicted to begin declining within months after cover construction, ultimately meeting groundwater quality standards in 50 years after cover completion in areas where sand and gravel underlies the OWAP, and within 200 years in areas where silty clay underlies the OWAP.

A hydrostatic model was also developed for the OWAP to evaluate the hydrostatic conditions following construction of the proposed cover system (NRT/OBG, 2017c). Results indicate hydrostatic equilibrium can be attained for the system and hydraulic head beneath the proposed cover system is expected to decrease to near-zero level at equilibrium seven years after completion of cover construction.

2.2 POTABLE WATER WELL INVENTORY

A comprehensive water well survey conducted by NRT and Kelron (2009a) for a 2,500-foot radius around the entire HPS property boundary, inclusive of the OWAP, concluded that there are no existing off-site water wells, potable or non-potable, likely to be impacted by groundwater from the HPS property. There were only two wells located outside of the Hennepin Power Station property boundary and within 2,500 feet of the OWAP. The two wells, constructed in 1844 and 1922 to depths of 30 and 17 feet bgs, respectively, according to State of Illinois records, have been verified and were most likely abandoned decades ago. There are no homes, farms, or other potential users present at these two locations. There are also no public water supply (PWS), community water supply (CWS), or non-CWS wells or wellhead protection areas (WHPAs) within 2,500 feet of the OWAP.

Within the plant property boundary, there are four wells owned by DMG, all of which are non-potable and non-contact industrial wells.

2.3 GROUNDWATER QUALITY

Groundwater monitoring per 40 C.F.R. § 257.90 commenced in December 2015. Monitoring wells around the OWAP were installed beginning in 1982, and additional wells and piezometers were installed throughout the 1990s; the most recent monitoring wells were installed in 2015 to establish the groundwater monitoring system required by the CCR Rule and in 2019 to define the extent of CCR impacts. Monitoring includes groundwater elevation measurements and collection of water quality samples from background monitoring wells 32 and 34, and downgradient wells 21, 22, 22D, 23, 24, 35, 49, and 50 (Figure 2). Detection monitoring, per 40 C.F.R. § 257.90, was initiated in December 2017; statistically significant increases (SSIs) of Appendix III parameters over background concentrations were detected in November 2017. Alternate source evaluations were inconclusive for one or more of the SSIs. Therefore, in accordance with 40 C.F.R. § 257.94(e)(2), an Assessment Monitoring Program was established for the OWAP on April 9, 2018. Assessment Monitoring results identified statistically significant levels (SSLs) of the Appendix IV parameters arsenic, lithium, and molybdenum. Arsenic over the GWPS of 0.01 milligrams per Liter (mg/L) was detected in downgradient monitoring well MW-24, at concentrations from 0.0263 mg/L to 0.0380 mg/L. Lithium over the GWPS of 0.04 mg/L was detected in downgradient monitoring well MW-22, at concentrations from 0.0527 mg/L to 0.0764 mg/L. Molybdenum over the GWPS of 0.1 mg/L was detected in downgradient monitoring well MW-22, at concentrations from 0.1610 mg/L to 0.2060 mg/L. No other SSLs have been identified for OWAP.

2.4 IMPACTED GROUNDWATER DISCHARGE TO SURFACE WATER

Boron and sulfate surface water concentrations were calculated from known groundwater concentrations to assess the potential impact to surface water due to groundwater below the OWAP discharging to the Illinois River. The calculations were presented in the Hydrogeologic Site Characterization Report (NRT/OBG, 2017b) and indicated that groundwater discharge to the Illinois River could potentially increase concentrations of boron by 0.0034 mg/L and sulfate by 0.19 mg/L. Both calculated concentrations are below their respective detection limits reported by the laboratory, indicating that changes in concentration would not likely be detected and impacts would be negligible.

3 CORRECTIVE MEASURES ALTERNATIVE DESCRIPTIONS

The corrective measure alternatives described below meet the threshold criteria summarized in Section 1.2 and are capable of mitigating groundwater impacts from the OWAP.

3.1 IEPA-APPROVED ALTERNATIVE 1: CLOSURE IN PLACE (ALTERNATIVE COVER SYSTEM) WITH MNA

IEPA-Approved Alternative 1: Design of the CIP (alternative cover system) has been completed, the Closure Plan has been approved by IEPA (IEPA, 2018a), and construction has begun. This alternative includes dewatering the CCR, installation of a sheet pile wall between the OWAP and OWPP, mechanical excavation of OWPP material for use as structural fill in the OWAP, placement of an alternative soil and geosynthetic cover system in direct contact with the graded CCR and existing soil cover material, and MNA. Closure of the OWPP consists of removal of CCR and dike soils in the OWPP and consolidation of these materials into the OWAP. The alternative cover system for the OWAP will be constructed in direct contact with the compacted CCR subgrade and will consist of, from bottom to top, a 40-mil linear low-density polyethylene (LLDPE) geomembrane liner, a geo-composite drainage layer, 1.5 feet (ft) of cover soil, and 0.5-ft erosion soil layer capable of supporting native vegetative growth. The new cover system will significantly minimize water infiltration into the closed CCR multi-unit (primary source of CCR constituents in groundwater) and allow surface water to drain off the cover system, thus reducing the generation of potentially-impacted water and reducing the extent of arsenic, lithium, and molybdenum impact in the Uppermost Aquifer. Stormwater runoff from the final cover system will be directed off of and away from the new final cover system through construction of eight interior stormwater channels.

Both federal and state regulators have long recognized that MNA can be an acceptable component of a remedial action, when it can achieve remedial action objectives in a reasonable timeframe. In 1999, the USEPA published a final policy directive (USEPA, 1999) for use of MNA for groundwater remediation and described the process as follows:

- The reliance on natural attenuation processes (within the context of a carefully controlled and monitored site cleanup approach) to achieve site-specific remediation objectives within a time frame that is reasonable compared to that offered by other more active methods. “The ‘natural attenuation processes’ that are at work in such a remediation approach include a variety of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater. These in-situ processes include biodegradation; dispersion; dilution; sorption; volatilization; radioactive decay; and chemical or biological stabilization, transformation, or destruction of contaminants.”

It is important to note that USEPA has stated that source control (such as the approved OWAP cover system) was the most effective means of ensuring the timely attainment of remediation objectives (USEPA, 1999). Natural attenuation processes will constitute a “finishing step” after effective source control at the OWAP by means of a cover system (IEPA-Approved Alternative 1 Alternative Cover System), and ongoing groundwater monitoring will document the attenuation and long-term effectiveness of the source control. Based on the groundwater prediction model (NRT/OBG, 2017a), concentrations of CCR constituents will begin to decline and the extent of groundwater impacts will begin to reduce within months after cover placement.

IEPA-Approved Alternative 1 includes, but is not limited to, the following primary project components:

- Removal of free water and grading the CCR to allow cover system construction.
- Installation of a sheet pile wall at the splitter dike between the OWAP and OWPP, for support and seepage control during CBR of the OWPP. The sheet pile wall will not be removed after construction.
- Mechanical excavation of material from the OWPP for use as structural fill in the OWAP, including retained CCR and dike soils.
- Removal of existing NPDES Outfall 005 at the OWPP.
- Abandonment of the 24-inch corrugated metal pipe connecting the OWAP to the OWPP.

- Installation of a riprap buttress in front of the splitter dike sheet pile wall for stability.
- Relocating and/or reshaping the existing CCR and cover material within OWAP to achieve acceptable grades for closure. Borrow soil will be used to supplement fill volume, if necessary, to reach final design grades.
- Placement of an alternative soil and geosynthetic cover system. In accordance with the CCR Rule, final cover systems must have a permeability less than or equal to $1x10^{-5}$ cm/sec or the permeability of the foundation soils or liner beneath the CCR, whichever is less. The OWAP is partially underlain by silt and clay soils with a permeability on the order of $1x10^{-6}$ to $1x10^{-7}$ cm/sec. The alternative geosynthetic cover system with a permeability of approximately $4x10^{-13}$ cm/sec is well below that of the foundation soils.
- Establishing and maintaining native vegetative growth on the OWAP final cover, to minimize erosion.
- Constructing a stormwater management system consisting of eight interior stormwater channels that will direct stormwater off of and away from the new final cover system.
- Placement of riprap erosion protection along limited areas of the OWAP north dike.
- Monitoring attenuation processes in groundwater to demonstrate that the extent of groundwater impact is decreasing in size and concentration following closure. In accordance with the IEPA-approved groundwater monitoring plan, if a statistically significant increasing trend is observed to continue over a period of two or more years, and a subsequent hydrogeologic site investigation demonstrates that such exceedances are due to a release from OWAP, and corrective actions are necessary and appropriate to mitigate the release, a corrective action plan will be proposed as a modification to the post-closure care plan.
- Ongoing inspection and maintenance of the cover system, groundwater monitoring, and stormwater system; and property management, per the approved Closure Plan.

IEPA-Approved Alternative 1 addresses the primary source of CCR constituents in groundwater by minimizing surface water infiltration and reducing generation of potentially-impacted water. The secondary source of groundwater impacts (underlying saturated soils that have been in contact with CCR-impacted groundwater) will be addressed by monitoring natural attenuation processes. Construction has begun and will be completed by November 2020. Potential impacts to public health and safety for IEPA-Approved Alternative 1 are much lower than Alternatives 2A and 2B, because there is significantly less CCR handling associated with Alternative 1. During the 1- to 2-year construction period, there could be some increase in off-site traffic due to the increased need for on-site workers. IEPA-Approved Alternative 1 is expected to achieve compliance with GWPS more quickly than Alternatives 2A and 2B, because source control measures will be implemented more rapidly. Boron concentrations in most wells will meet the groundwater protection standards in 50 years upon cover system completion.

3.2 ALTERNATIVE 2: CLOSURE BY REMOVAL WITH MNA

Alternative 2, Closure by Removal (CBR), would include removal of all CCR from the OWAP, moisture conditioning the CCR as needed to facilitate excavating, loading, and transporting CCR to either an on-site or off-site landfill, backfilling the excavation, and groundwater monitoring.

Alternative 2 would require transporting more than 50,400 loads of materials (630,000 CY of CCR, assuming 12.5 CY per load) to either an on-site or off-site location for disposal. This would result in increased risk to the public, particularly for the off-site disposal alternative, increased greenhouse gas emissions and carbon footprint, and increased potential for fugitive dust exposure. The existing on-site landfill does not have adequate capacity and the regulatory approval process for a new on-site landfill would take multiple levels of approval, including environmental permits and local authorization. Opposition to such projects and regulatory approvals would take 5 to10 years before construction could commence. Transporting ash to an off-site landfill also presents concerns about available landfill capacity and community impacts, safety concerns, and project duration. Given the volume of ash, it is expected to take approximately 3 years (assuming 60 trucks per day, 5 days per week) to remove the ash and transport it to an off-site landfill.

This alternative would address the primary source of groundwater impacts by removing the CCR (primary source of groundwater impacts), but the secondary source of groundwater impacts would not begin to diminish until the primary source is removed, approximately 3 years after removal begins.

Over the long term, Alternative 2 would attain GWPS by removing the primary source and through MNA of the secondary source. In the short term, continued release of CCR constituents to the groundwater would occur from the CCR during removal activities, extending the time during which groundwater concentrations are above GWPS.

3.2.1 Alternative 2A – Disposal in On-Site Landfill and MNA

HPS has a permitted on-site landfill located east of the plant that is active but not currently accepting CCR and has inadequate capacity for most of the material from the OWAP. There may be adequate usable space available to site a new landfill on the property to the south of the OWAP (Figure 1). Disposal of excavated CCR in an on-site landfill would require siting, permitting, design, and construction. It is anticipated that several new permits would be required to allow siting and construction of an on-site landfill, including a modification of an existing NPDES permit, fugitive dust, and a solid waste disposal permit from the IEPA Bureau of Land. Permitting requirements for an on-site landfill are estimated to extend the overall timeframe for remedy implementation by an additional 5 to 10 years before CCR removal from the OWAP could begin, resulting in a total implementation timeframe of 8 to 13 years. If any component of siting or permitting is found to be not feasible, then this alternative would no longer be an option.

3.2.2 Alternative 2B – Disposal in Off-Site Landfill and MNA

Disposal of CCR in an off-site landfill would result in significantly increased potential for impacts to the surrounding community, including potential safety concerns related to the volume of material to be transported (630,000 CY) and the distance to an existing, permitted, Subtitle D landfill that accepts CCR. Adequate off-site disposal capacity is potentially available within 60 miles of the HPS (IEPA, 2018b), but coordination with the landfill operator would be required to confirm disposal options. Complete removal of CCR would require material hauling for approximately 3 years, consisting of approximately 60 daily round-trip truck hauls, 5 days per week, from the site to the landfill, with potential for increased injuries and possible fatalities from traffic accidents. Transportation of the excavated CCR would require design and construction of on-site access roads and may require upgrades to existing public roads to withstand the increased haul truck traffic for the duration of excavation activities. Coordination with the Illinois Department of Transportation may be required to evaluate existing road capacities, improvement strategies, and permitting with unknown schedule implications.

3.3 ALTERNATIVE 3: CLOSURE IN PLACE (ALTERNATIVE COVER SYSTEM) WITH CUTOFF WALL, HYDRAULIC GRADIENT CONTROL, AND MNA

Alternative 3 would include all components of IEPA-Approved Alternative 1, and a groundwater hydraulic control system that would be designed and constructed to contain groundwater impacted by arsenic, lithium, and molybdenum in the Uppermost Aquifer. Similar to IEPA-Approved Alternative 1, Alternative 3 would significantly minimize infiltration into the closed CCR multi-unit (the primary source of CCR constituents in groundwater) and allow surface water to drain off the cover system, thus reducing the generation of potentially-impacted water and reducing the extent of groundwater impact. In addition, a low-permeability cutoff wall would be constructed around the OWAP and keyed into bedrock. A system of groundwater extraction wells would be placed within the cutoff wall to establish an inward gradient and capture groundwater within the footprint of the OWAP. Extracted groundwater would be managed in accordance with a modification to the existing NPDES permit, including treatment prior to discharge, if necessary.

Alternative 3 would include the following primary project components:

- Removal of free water and grading of CCR to allow cover system construction.
- Installation of a sheet pile wall at the splitter dike between the OWAP and OWPP for support and seepage control during Closure by Removal of the OWPP. The sheet pile wall will not be removed after construction.
- Mechanical excavation of material from the OWPP for use as structural fill in the OWAP, including retained CCR and dike soils.
- Removal of existing NPDES Outfall 005 at the OWPP.
- Installation of a riprap buttress in front of the splitter dike sheet pile wall for stability.
- Abandonment of the 24-inch corrugated metal pipe connecting the OWAP to the OWPP.
- Relocating and/or reshaping the existing CCR and cover material within OWAP, to achieve acceptable grades for closure. Borrow soil will be used to supplement fill volume, if necessary, to reach final design grades.
- Placement of an alternative soil and geosynthetic cover system. In accordance with the CCR Rule, final cover systems must have a permeability less than or equal to $1x10^{-5}$ cm/sec or the permeability of the foundation soils or liner beneath the CCR, whichever is less. The OWAP is partially underlain by silt and clay soils with a permeability on the order of $1x10^{-6}$ to $1x10^{-7}$ cm/sec. The alternative geosynthetic cover system with a permeability of approximately $4x10^{-13}$ cm/sec is well below that of the foundation soils.
- Establishing and maintaining native vegetative growth on the OWAP final cover, to minimize erosion.
- Constructing a stormwater management system consisting of eight interior stormwater channels that will direct stormwater off of and away from the new final cover system.
- Placement of riprap erosion protection along limited areas of the OWAP north dike.
- Designing and constructing a low-permeability cutoff wall keyed into bedrock and surrounding the OWAP and a system of groundwater extraction wells within the footprint of the OWAP to establish an inward gradient.
- Monitoring attenuation processes in groundwater to demonstrate that the extent of groundwater impact is decreasing in size and concentration following closure.
- Ongoing inspection and maintenance of the cover system and hydraulic gradient control system, groundwater monitoring to demonstrate that the extent of groundwater impact is decreasing in size and concentration following closure, and stormwater and property management.

The design of a cutoff wall and groundwater extraction system will require additional site characterization and may result in a high density of wells and borings that may extend 100 ft or more below ground surface to identify a unit into which to key the cutoff wall (presumed to be bedrock).

In addition to the source control provided by Alternative 1, Alternative 3 would also contain the secondary source (saturated soils containing CCR constituents) located beneath the footprint of the OWAP. Alternative 3 would require completion of detailed design for the cutoff wall and hydraulic gradient control system. Construction could be completed in less than 5 years; ongoing groundwater extraction for hydraulic gradient control would be required as part of regular operation and maintenance. Potential impacts to the public health and safety posed by implementation would be similar to IEPA-Approved Alternative 1 and would be significantly less than that posed by the Alternatives 2A and 2B, because all work would be completed on site. There would be some increases in off-site traffic due to increased need for on-site workers. Alternative 3 would achieve compliance with GWPS more quickly than Alternative 2 because of the relatively short construction timeframe.

4 COMPARISON OF CORRECTIVE MEASURES ALTERNATIVES

4.1 EVALUATION FACTORS AND CONSIDERATIONS

The corrective measures alternatives described in the previous section meet the threshold criteria presented in Section 1.3 and were compared to each other relative to the following remedy selection evaluation factors identified in 40 C.F.R. § 257.97:

- Long and short-term effectiveness, protectiveness and certainty
- Source control effectiveness.
- Implementability

These factors and associated considerations are presented in Table 1, along with qualitative comparisons of the ability of each alternative to address each consideration. The goal is to understand which alternative will protect human health and the environment (including consideration of potential impacts associated with implementation), provide source control to minimize the risk of future releases, and be permitted, constructed, and operated easily and reliably. The corrective measures and qualitative comparison presented on Table 1 are discussed relative to each of the specific considerations in the following report sections.

4.2 LONG- AND SHORT-TERM EFFECTIVENESS, PROTECTIVENESS, AND CERTAINTY

The first evaluation factor addresses the potential for alternatives to effectively and reliably protect human health and the environment from impacts related to CCR management and/or disposal at the OWAP. This evaluation factor is focused on the ability of alternatives to address existing impacts on site and off site, both short-term (during the implementation phase) and long-term (after implementation of the alternative), along with the degree of certainty that the alternatives will remain protective of human health and the environment.

In general, CIP alternatives (IEPA-Approved Alternative 1 and Alternative 3) are more effective and protective than CBR alternatives (Alternatives 2A and 2B). This is primarily due to: 1) the relatively short timeframe for permitting and constructing a CIP alternative, relative to the long implementation timeframe for CBR (approximately 8 to 13 years, depending on permitting), during which time groundwater would continue to be impacted from CCR remaining on site; and 2) the increased potential for human health and environmental impacts during excavation and transport of CCR during removal activities, particularly off-site disposal (Alternative 2B).

4.2.1 Magnitude of Reduction of Existing Risks

As discussed in Section 2, there are no threats to human health or the environment associated with the release of CCR constituents from the OWAP. No private or public groundwater users were identified during the potable well survey. Impacts of groundwater with elevated concentrations of CCR constituents from beneath the closed OWAP on nearby surface waters are not expected.

All alternatives will require some amount of on-site construction or off-site transport and disposal of CCR. These activities will introduce risks with different impacts on different community and environmental receptors over different timeframes. IEPA-Approved Alternative 1 and Alternative 3 represent the lowest risk (highest risk reduction) to the surrounding community because corrective measure activities would be limited to the HPS property. There would be some additional construction worker traffic, the possibility of community exposure to fugitive dust emissions, and the increased potential for safety and noise impacts during the comparatively short construction period (2 to 3 years for IEPA-Approved Alternative 1 and 7 to 8 years for Alternative 3 [including permitting]). There would be similar impacts from Alternative 2A, but the impacts would continue for a longer time (approximately 8 to 13 years, depending on permitting) and there would be increased direct-contact impacts because the CCR would be exposed over the removal implementation timeframe.

Risks to community and environmental receptors would be greatest (lowest risk reduction) for Alternative 2B due to the extended implementation schedule required for the large volume of CCR to be excavated, transported off-site, and disposed (estimated 60 trucks per day, 5 days per week for 3 years), and the increased potential for safety and noise impacts, exposure to fugitive dust during transport, and increases in greenhouse gas emissions and carbon footprint. Alternative 2A would have somewhat less risk (somewhat greater risk reduction) because the corrective measures would be constrained to the site, but implementation timeframes would be greater than Alternative 2B with the addition of permitting for a new on-site landfill.

4.2.2 Magnitude of Residual Risks, Likelihood of Further CCR Releases Following Implementation

All alternatives present the same level of residual risk and likelihood of further CCR releases because the secondary source is not addressed by the alternatives. Groundwater modeling performed for IEPA-Approved Alternative 1 indicated that the concentrations of boron, and, by extension, lithium and molybdenum, potentially attributable to the OWAP will begin to decline, and the extent of groundwater impacts will begin to reduce within months after cover placement, resulting in a relatively low potential for future CCR releases after construction. IEPA Approved Alternative 1 would reduce the potential for ongoing release within 7 years of cover construction as hydrostatic equilibrium would be achieved within that timeframe.

Although the Alternative 3 cutoff wall and hydraulic gradient control system may result in reducing the residual risks more quickly after construction than IEPA-Approved Alternative 1, the delay in implementation related to system design and permitting is expected to offset the improved performance relative to Alternative 1. In addition, the degree of risk reduction associated with Alternative 3 will be dependent on effectively keying the slurry cutoff wall into a low-permeability geologic unit at depth below the OWAP.

Alternatives 2A and 2B would have a higher potential for further CCR releases because the primary source of groundwater impacts would remain in place throughout the extended siting, permitting, and implementation timeframe (8-13 years depending on permitting requirements). During that time period, transport of contaminants into the groundwater would continue. In addition, the secondary source of groundwater impacts would remain in place after CCR removal and disposal in either an on-site or an off-site landfill. Alternatives 2A and 2B have the lowest long-term residual risk resulting from source removal. Alternatives 2A and 2B also have a higher potential for further CCR releases due to the extensive transportation and CCR-handling processes necessary to move the CCR to a landfill.

4.2.3 Type and Degree of Long-Term Management Required, Including Monitoring, O&M

All alternatives would require some degree of long-term management. IEPA-Approved Alternative 1 will have the simplest long-term maintenance because there are no active systems requiring monitoring or maintenance to ensure performance. Maintenance of the cover and erosion control systems would be performed in accordance with the approved Closure Plan. Furthermore, a Post-Closure Care Plan for IEPA-Approved Alternative 1 has been approved by IEPA that includes provisions for monitoring and maintenance for a post-closure period anticipated to continue for 30 years. The post-closure period may extend beyond 30 years if additional groundwater monitoring results indicate the necessity.

Alternative 2B would require ongoing coordination with landfill and transportation operators during the approximately 3-year implementation period. Alternatives 2A and 2B would require operation and maintenance in conformance with Subtitle D requirements, including long-term groundwater monitoring. Alternative 3 would also require long-term management, including routine operation and maintenance, and regular replacement of materials and parts, to ensure hydraulic gradient control system performance.

4.2.4 Short-Term Risks to the Community or the Environment During Implementation

The least short-term risk to the community or the environment is posed by IEPA-Approved Alternative 1 and Alternative 3. The majority of the work would be completed on site for both alternatives, limiting exposure primarily to workers during on-site construction activities. Alternative 2A would have somewhat greater potential for short-term risk to the community, relative to Alternatives 1 and 3, because of the longer timeframe required for CCR excavation, and the associated increased potential for community exposure from fugitive dust emissions during on-site work, and the increased potential for safety and noise impacts.

Risks to community and environmental receptors would be greatest for Alternative 2B due to the extended implementation schedule required for the large volume of CCR to be excavated, transported, and disposed off site, and the increased potential for safety and noise impacts, exposure to fugitive dust during transport, and increases in greenhouse gas emissions and carbon footprint.

4.2.5 Time Until Full Protection is Achieved

Source control and natural attenuation are capable of reducing CCR constituent concentrations in groundwater to or below GWPS over time.

All alternatives under consideration would address the primary source of groundwater impacts and would ultimately attain GWPS. IEPA-Approved Alternative 1 provides the shortest time to attain GWPS. Groundwater modeling performed for IEPA-Approved Alternative 1 indicated that concentrations of boron, and, by extension, lithium and molybdenum, potentially attributable to the OWAP will begin to decline and the extent of groundwater impacts will begin to reduce within months after cover placement. The time-frame within which arsenic would achieve GWPS is dependent upon oxidation-reduction conditions following cover placement.

Alternative 3 will rapidly reduce the migration of groundwater from below the OWAP; however, the potentially shorter time to meet GWPS after the remedy is complete is expected to be offset by the increased implementation timeframe. Construction of the cover system would be completed in 1 to 2 years, resulting in declining contaminant concentrations and reduction in the extent of groundwater impacts within months after cover construction. However, detailed site characterization, design, and permitting required for construction of the groundwater cutoff wall and hydraulic gradient control system for Alternative 3 would likely extend remedy implementation of that alternative by another 2 to 5 years.

Alternatives 2A and 2B are expected to require the longest time to attain GWPS because the primary source of groundwater impacts would remain in place during implementation, allowing transport of contaminants into the groundwater throughout the extended permitting and implementation timeframe (8 to 13 years, depending on permitting requirements) and the secondary source of groundwater impacts would remain after remedy implementation. Subsequent natural attenuation would allow attainment of the GWPS, although the timeframe would be longer than for IEPA-Approved Alternative 1 and Alternative 3. In addition, if any component of siting or permitting for Alternative 2A is found to be not feasible, then the alternative would be no longer be an option and another alternative would need to be developed thereby extending the time until full protection is achieved by the period of time spent developing Alternative 2A.

4.2.6 Potential for Exposure of Human and Environmental Receptors to Remaining Wastes

IEPA-Approved Alternative 1 and Alternative 3 have the lowest potential for exposure to remaining waste. The approved Closure Plan construction activities will be completed within 1 to 2 years and potential exposures would be limited to on-site workers during construction. The cover will serve as a barrier to remaining waste and will prevent future potential exposures. Alternative 2A would have more potential for on-site worker exposure than IEPA-Approved Alternative 1 and Alternative 3 because CCR excavation would increase both the accessibility of the CCR and the timeframe over which exposures could occur. Alternative 2B would have the highest potential for human and environmental receptor exposure because of the long implementation timeframe and the off-site transport of CCR, which would result in long-term potential for exposure to off-site human and environmental receptors.

4.2.7 Long Term Reliability of the Engineering and Institutional Controls

IEPA-Approved Alternative 1 has been designed and approved by IEPA and will provide a high degree of reliability. Alternative 3 would also have a high degree of reliability because Alternative 3 would have a similar cover system design, and the hydraulic gradient control system would be managed by defined, routine operation and maintenance procedures. Landfilling, as presented in Alternatives 2A and 2B, is an accepted method for long-term waste management and engineered landfills (on- or off-site) would be designed and constructed using mandatory design standards and performance criteria to ensure long-term reliability.

4.2.8 Potential Need for Replacement of the Remedy

There is limited potential for any of the remedies under consideration to require replacement with other remedies. Each of the potential remedies are accepted waste management techniques and have well-defined operation and maintenance procedures. IEPA-Approved Alternative 1 will not have any active systems that would require maintenance or parts replacement; each of the other alternatives would require ongoing operation and maintenance procedures and parts replacement over time.

4.3 SOURCE CONTROL EFFECTIVENESS

The second evaluation factor addresses the source control effectiveness of the alternatives and the extent to which treatment technologies could be used to enhance the source control measures. Addressing the source of contaminants is a critical factor in improving groundwater quality by eliminating contaminant transport and attaining GWPS.

Groundwater modeling for IEPA-Approved Alternative 1 indicates that, although the secondary source of groundwater impacts (underlying saturated soils that have been in contact with CCR-impacted groundwater) will remain in place, concentrations will begin to decline, and the extent of groundwater impacts will begin to reduce, within months after cover construction.

Adding a groundwater cutoff wall and hydraulic gradient control system to IEPA-Approved Alternative 1 (*i.e.*, Alternative 3) may enhance the overall source control effectiveness, but would increase the implementation timeframe. The potentially reduced time to meet GWPS under IEPA-Approved Alternative 1 is expected to be offset by the time required to design and permit the Alternative 3 groundwater cutoff wall and hydraulic gradient control system.

The CBR alternatives (Alternatives 2A and 2B) may achieve long-term source control, but present short-term environmental risk associated with implementation. The primary source of groundwater impacts (CCR) would remain in place during implementation, allowing transport of arsenic, lithium, and molybdenum into the groundwater throughout the extended permitting and implementation timeframe (8 to 13 years, depending on permitting requirements). Human and environmental receptors would also be exposed to CCR over this timeframe and the secondary source of groundwater impacts would remain after remedy implementation.

4.3.1 Extent to Which Containment Practices Will Reduce Further Releases

All potential corrective measures would address the primary source of CCR constituents in groundwater; Alternative 3 would also limit the discharge of groundwater in the Uppermost Aquifer that comes into contact with secondary source material. Groundwater modeling for IEPA-Approved Alternative 1 indicated that concentrations of boron, and, by extension, lithium and molybdenum, potentially attributable to the OWAP will begin to decline and the extent of groundwater impacts will begin to reduce within months after cover placement, thus significantly reducing future releases. Alternative 3 would be expected to provide a similar, or possibly higher, level of source control effectiveness with the addition of a groundwater cutoff wall and hydraulic gradient control system. However, the ability of the groundwater cutoff wall and hydraulic gradient control system to effectively reduce groundwater concentrations and attain GWPS will have a high dependence upon the ability to key the cutoff wall into a low-permeability geologic unit beneath the OWAP (presumably bedrock).

Alternatives 2A and 2B would be less effective in controlling future releases in the short-term because the secondary source of groundwater impacts will remain in place after excavation and disposal of CCR in either an on-site or an off-site landfill.

4.3.2 Extent to Which Treatment Technologies May be Used

No groundwater treatment technologies, other than natural attenuation, would be implemented with these alternatives. Groundwater extracted to maintain gradient control under Alternative 3 could be treated to meet applicable discharge requirements, if necessary. Treatment technologies are not expected to be necessary for the corrective measure alternatives evaluated. However, if groundwater data demonstrates that attenuation is not occurring as expected, treatment technologies will be reconsidered.

4.4 IMPLEMENTABILITY

The third evaluation factor addresses the ease and operational reliability of implementing the alternatives and includes consideration of permitting requirements and availability of resources to implement the remedy.

IEPA-Approved Alternative 1 has been approved by IEPA and is, thus, the most easily implementable alternative. Alternative 3 would require detailed site investigation and design activities prior to implementation. CBR alternatives (2A and 2B) would entail significant difficulty in permitting, construction, and transportation.

4.4.1 Degree of Difficulty Associated with Constructing the Technology

IEPA-Approved Alternative 1 will be the most easily-implemented alternative because it will employ relatively common construction activities and is required to be completed by November 2020. Alternative 3 would require a somewhat higher degree of difficulty due to the need to design and construct an effective hydraulic gradient control system in a heterogeneous aquifer, in addition to the alternative cover system. Alternative 2B could likely be implemented without permitting a new off-site landfill because adequate disposal capacity is potentially available at one existing off-site landfill within 60 miles from the HPS (IEPA, 2018b), but this would need to be coordinated with the landfill operator(s). Alternative 2B would require approximately 60 trucks per day, 5 days per week over a 3-year period to dispose of the 630,000 CY of CCR that would be excavated from the OWAP. The siting, permitting, design, and construction of an on-site landfill (Alternative 2A) represents the highest degree of difficulty. Permitting a new on-site landfill if possible, introduces significant uncertainty and could add 5 to 10 years to the estimated 3 years required for CCR excavation and removal that would be required to implement Alternative 2A, resulting in a total implementation timeframe of 8 to 13 years.

4.4.2 Expected Operational Reliability of Technologies

IEPA-Approved Alternative 1 is an accepted containment technology with high operational reliability. Disposal of waste in an engineered landfill, either on site or off site (Alternative 2A and Alternative 2B), is an accepted waste management procedure with a high degree of operational reliability. CCR disposal would occur in a permitted facility that would have defined and regulated operational procedures and performance criteria. The addition of an active engineering control system (gradient control), heterogeneity within the Uppermost Aquifer, and uncertainty of the depth to a key-in unit for the groundwater cutoff wall would result in Alternative 3 being somewhat less reliable than Alternatives 1 and 2.

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

The Closure Plan for IEPA-Approved Alternative 1 has been approved by IEPA; therefore, no additional approvals are required. Alternative 3 would require design and permitting for the groundwater cutoff wall and hydraulic gradient control system. Alternative 2B may require permitting for transportation and/or disposal of CCR at an off-site landfill and significant coordination with the landfill operator and CCR transporters to manage disposal options. Alternative 2A would require significant permitting processes for siting and constructing a new on-site Subtitle D landfill that could extend the implementation schedule and introduce significant uncertainty into the remedy implementation. All corrective measures would require updates to the existing site NPDES permit.

4.4.4 Availability of Necessary Equipment and Specialists

Landfilling is a standard waste management method for which equipment and specialists are readily available. Similarly, the earthwork and capping activities that would be required for IEPA-Approved Alternative 1 and Alternative 3 are routine construction activities for which equipment and workforce would be readily available. The hydraulic gradient control system and groundwater cutoff wall associated with Alternative 3 may require specialized equipment; however, there are several nationally-known contractors who specialize in groundwater remediation and cutoff wall construction, so the availability of equipment and specialists would not pose an obstacle for implementation.

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

IEPA-Approved Alternative 1 would not require treatment, storage, and disposal services. Alternative 3 would require modification of the existing NPDES permit for discharge of groundwater extracted for hydraulic gradient control. Adequate disposal capacity is likely available at off-site landfills within 60 miles from the HPS (IEPA, 2018b) to allow implementation of Alternative 2B, although coordination with the landfill operator(s) and CCR transporters would be required. Available disposal capacity for Alternative 2A is possible, as unused acreage is available on site; however, there may be physical constraints related to siting and constructing an additional new on-site landfill (*e.g.*, aquifer susceptibility).

5 SUMMARY

This Corrective Measures Assessment was prepared to address the requirements of 40 C.F.R. § 257.96. The following corrective measure alternatives were identified based upon site-specific conditions:

- IEPA-Approved Alternative 1) Closure in Place (Alternative Cover System) and MNA
- Alternative 2) Closure by Removal
  - Alternative 2A) On-site CCR disposal and MNA
  - Alternative 2B) Off-site CCR disposal and MNA
- Alternative 3) Closure in Place (Alternative Cover System) with groundwater cutoff wall, hydraulic gradient control system, and MNA

These alternatives were evaluated with respect to the following remedy selection evaluation factors in 40 C.F.R. § 257.97 and their associated considerations.

5.1 LONG- AND SHORT-TERM EFFECTIVENESS, PROTECTIVENESS, AND CERTAINTY

In general, CIP alternatives (IEPA-Approved Alternative 1 and Alternative 3) are more effective and protective than CBR alternatives (Alternatives 2A and 2B). This is primarily due to: 1) the relatively short timeframe for permitting and constructing a CIP alternative, relative to the long implementation timeframe for CBR (approximately 8 to 13 years, depending on permitting), during which time groundwater would continue to be impacted from CCR remaining on site; and 2) the increased potential for human health and environmental impacts during excavation and transport of CCR during removal activities, particularly off-site disposal (Alternative 2B).

5.2 SOURCE CONTROL

Groundwater modeling for IEPA-Approved Alternative 1 indicates that, although the secondary source of groundwater impacts (underlying saturated soils that have been in contact with CCR-impacted groundwater) will remain in place, concentrations will begin to decline and the extent of groundwater impacts will begin to reduce within months after cover construction.

Adding a groundwater cutoff wall and hydraulic gradient control system to IEPA-Approved Alternative 1 (*i.e.*, Alternative 3) may enhance the overall source control effectiveness, but would increase the implementation timeframe. The potentially reduced time to meet GWPS relative to IEPA-Approved Alternative 1 is expected be offset by the time required to design and permit the Alternative 3 groundwater cutoff wall and hydraulic gradient control system. The ability of Alternative 3 to effectively reduce groundwater concentrations and attain GWPS will have a high dependence upon the ability to key the groundwater cutoff wall into a low-permeability geologic unit beneath the OWAP (presumably bedrock)

The CBR alternatives (Alternatives 2A and 2B) may achieve long-term source control, but present short-term environmental risk associated with implementation. The primary source of groundwater impacts (CCR) would remain in place during implementation, allowing transport of arsenic, lithium, and molybdenum into the groundwater throughout the extended permitting and implementation timeframe (8 to 13 years, depending on permitting requirements). Human and environmental receptors would also be exposed to CCR over this timeframe and the secondary source of groundwater impacts would remain after remedy implementation.

5.3 IMPLEMENTABILITY

IEPA-Approved Alternative 1 is currently under construction and is the most easily implementable alternative. Alternative 3 would require detailed site investigation and design activities prior to implementation. CBR alternatives (2A and 2B) would entail significant difficulty in permitting, construction, and transportation which would delay potential benefits associated with this remedy.

IEPA-Approved Alternative 1 provides performance that is as good, or better than, the other alternatives for each of the evaluation factors considered. A public meeting will be held in accordance with 40 C.F.R. § 257.96(e). Following receipt of public input, a corrective measure will be selected and documented in the remedy selection report required by 40 C.F.R. § 257.97(a).

6 REFERENCES

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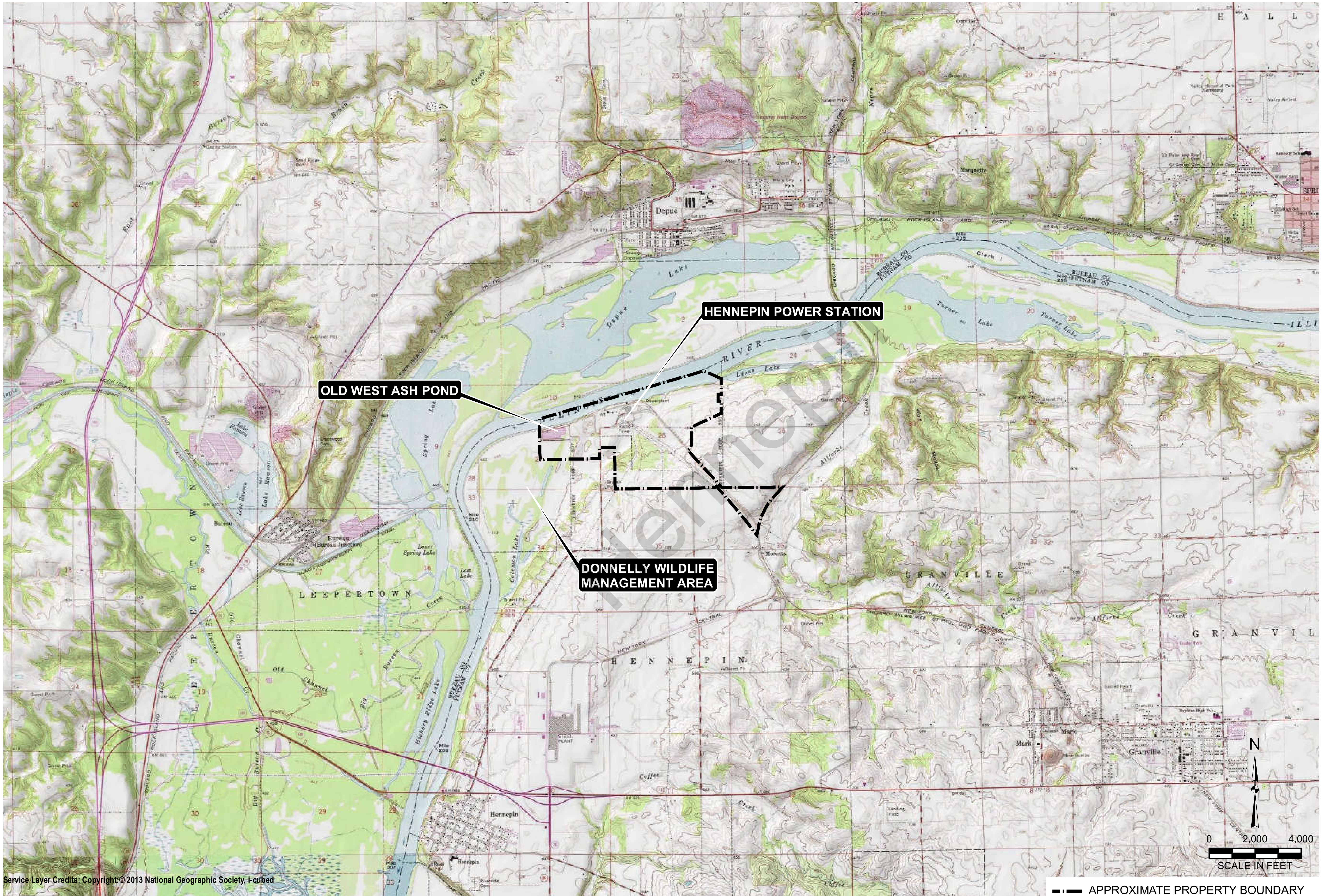
Tables

Table 1 - Corrective Measures Assessment Matrix
Old West Ash Pond (Pond No. 1 and Pond No. 3) and Polishing Pond
Hennepin Power Station
September 5, 2019

Evaluation Factors	Considerations	Rating That Indicates Best Performance[1]	IEPA-Approved Alternative 1 Closure in Place Alternative Cover System[2]	Alternative 2 Closure by Removal: 2A On-Site Landfill (New Construction)	Alternative 2 Closure by Removal: 2B Off-Site Landfill	Alternative 3 Closure in Place Alternative Cover System with Cut-off Wall and Gradient Control
Long and short-term effectiveness, protectiveness and certainty	Magnitude of reduction of existing risks	High	High. Risks to the community or environmental receptors is minimal because cover system construction does not include significant excavation, transportation or re-disposal and would be limited to on-site activities. Some small increase in short term risk to workers during consolidation of CCR and construction of cover.	Medium. Risks to the community or environmental receptors is medium because although excavation, transportation or re-disposal of CCR would be limited to the HPS property, the implementation timeframe is long, thus extending potential exposures to workers during construction, potential fugitive dust and noise impact to community members.	Low. Increased risks to the community and the environment during excavation, transport and re-disposal of CCR in an off-site landfill due to potential increased number of receptors during transport. Excavation and transport of CCR would require 3 years to complete assuming 60 trucks per day to transport CCR to off-site landfill.	High. Risks to the community or environmental receptors is low because cover and groundwater extraction system construction does not include significant excavation, transportation or re-disposal and would be limited to on-site activities. Some small increase in short term risk to workers during construction of cover.
	Magnitude of residual risks in terms of likelihood of further releases due to CCR remaining following implementation of remedy	Low	Medium. Groundwater modeling indicates that hydrostatic equilibrium will be achieved approximately 7 years after cover construction, reducing the potential for further CCR releases. Intermittent high river events will periodically saturate primary source materials but will not affect long-term concentrations.	Medium. Removal of primary source reduces the potential for further releases from primary source (CCR) due to placement in an engineered landfill. Secondary source (underlying saturated soils) remains.	Medium. Removal of primary source significantly reduces the potential for further releases from primary source (CCR) due to placement in an engineered landfill. Secondary source (underlying saturated soils) remains.	Medium. Construction of the cover will reduce infiltration into primary source, and gradient control may address groundwater that comes into contact with the secondary source, but design and construction will delay this process and effectiveness of gradient control is uncertain due to aquifer heterogeneity and uncertain depth of a unit to key the cut off wall into.
	Type and degree of long term management required, including monitoring, O&M	Low	Low. The approved alternative cover system does not include any active operational systems, minimal maintenance is required to ensure cover performance and the approved Post-Closure Care Plan includes procedures for groundwater monitoring, cover monitoring and maintenance.	Medium. Landfills are required to implement routine operation & maintenance activities, including groundwater monitoring.	Medium. Landfills are required to implement routine operation & maintenance activities, including groundwater monitoring.	Medium. Operation of gradient control system will include routine equipment maintenance and regular materials & parts replacement. Groundwater monitoring will be required to verify performance.
	Short term risks that might be posed to the community or the environment during implementation of such a remedy, including potential threats to human health and the environment associated with excavation, transportation, and re-disposal of contaminant	Low	Low. Short term risks to the community or environmental receptors is low because CIP does not include significant excavation, transportation or re-disposal. Some small increase in short term risk to workers during construction of cover.	Medium. Limited short term risk to the community and some increased short term environmental risk during excavation and on-site transport of CCR due to increased potential for limited exposure to CCR during on-site excavation, transport and re-disposal.	High. Increased short term risks to the community and the environment during excavation, transport and re-disposal of CCR in an off-site landfill due to potential increased number of receptors during transport. Excavation and transport of CCR would require approximately 3 years to complete assuming 60 trucks per day to transport CCR to off-site landfill.	Low. Short term risks to the community or environmental receptors is low because gradient control system construction does not include significant excavation, transportation or re-disposal. Some small increase in short term risk to workers during construction of cover.
	Time until full protection is achieved	Low	Low. Source control using an alternative cover system will be completed in 1 to 2 years. Groundwater modeling indicates that contaminant concentrations will begin to decline and the plume will begin to retreat within months after cover construction, reducing the time to attain GWPS.	High. Complete source removal would ultimately result in compliance with GWPS by source removal, flushing and attenuation. Long implementation timeframe for permitting and CCR excavation (8 to 13 years) would result in longest time to meet GWPS.	High. Complete source removal would ultimately result in compliance with GWPS by source removal, flushing and attenuation. Long implementation timeframe for permitting and CCR excavation (8 to 13 years) would result is longest time to meet GWPS.	Medium. Source control using an alternative cover system could be completed in 1 to 2 years, resulting in declining contaminant concentrations and plume retreat within months after cover construction. Detailed site characterization, design and permitting would be required for constructing the groundwater gradient control system and would likely extend remedy implementation by 2 to 5 years. Cutoff wall and gradient control will rapidly reduce the migration of groundwater from below the OWAP; however, potentially reduced time to meet GWPS may be offset by the increased implementation timeframe.
	Potential for exposure of human and environmental receptors to remaining wastes, considering the potential threat to human health and the environment associated with excavation, transportation, re-disposal	Low	Low. Potential for exposure to human or environmental receptors is low because CIP does not include significant excavation, transportation or re-disposal. Some small increase in potential exposure to workers during construction of cover.	Medium. Some limited potential for exposure of human and environmental receptors to CCR during relocation to on-site landfill.	High. Potential for exposure to human and environmental receptors to CCR during relocation due to long duration off-site transportation of CCR to landfill. Excavation and transport of CCR would require approximately 3 years to complete assuming 60 trucks per day to transport CCR to off-site landfill.	Low. Potential for exposure to human or environmental receptors is low because gradient control does not include significant excavation, transportation or re-disposal. Some small increase in potential exposure to workers during construction of cover.
	Long term reliability of the engineering and institutional controls	High	High. Approved alternative cover system has been designed in accordance with applicable requirements and approved by IEPA.	High. Engineered landfills are designed and constructed using mandatory design standards and performance criteria and have long term operations and monitoring.	High. Engineered landfills are designed and constructed using mandatory design standards and performance criteria and have long term operations and monitoring.	High. Gradient control system will be managed by defined, routine operation and maintenance procedures similar to landfills.
	Potential need for replacement of the remedy	Low	Low. Cover will not need replacement, approved post-closure care plan includes procedures for cover system monitoring and maintenance.	Medium. Landfill cover would not need replacement, leachate collection system would require maintenance and parts replacement over time.	Medium. Landfill cap would not need replacement, leachate collection system would require maintenance and parts replacement over time.	Medium. Cover system would not need replacement, regular maintenance would be required to maintain cover performance. Gradient control system could require maintenance and parts replacement over time.
Source control effectiveness	Extent to which containment practices will reduce further releases	High	Medium. Remaining saturated CCR may act as a source for continued groundwater releases. However, groundwater modeling indicates that contaminant concentrations will begin to decline and the plume will begin to retreat within months after cover construction.	Medium. Future releases will be mitigated by removal of CCR and re-disposal in an engineered landfill, but secondary source will remain in place.	Medium. Future releases will be mitigated by removal of CCR and re-disposal in an engineered landfill, but secondary source will remain in place.	Medium. Cut-off wall and hydraulic control system will address the primary source, but effectiveness will depend upon ability to key cutoff wall into a low-permeability geologic unit beneath AP2 (presumably bedrock).
	Extent to which treatment technologies may be used	Low	Low. Use of treatment technologies is not necessary.	Low. Use of treatment technologies is not necessary.	Low. Use of treatment technologies is not necessary.	Low. Use of treatment technologies is not necessary.
Implementability	Degree of difficulty associated with constructing the technology	Low	Low. Cover construction could be completed within 1 to 2 years and the required earthwork would not be difficult.	High. The existing on-site landfill does not have adequate capacity for disposal of the 630,000 CY of CCR in the OWAP. A new on-site landfill would require siting, permitting, design and construction prior to implementing closure activities. Limited space available for on-site landfill.	Medium. There is adequate off-site landfill capacity for the CCR that would be excavated from OWAP. Excavation and transport of CCR would require approximately 3 years to complete assuming 60 trucks per day to transport CCR to off-site landfill.	Medium. Gradient control system effectiveness is a function of degree of heterogeneity of the uppermost aquifer. Cover construction could be completed quickly and the required construction would not be difficult.
	Expected operational reliability of technologies	High	High. Alternative cover system design and post-closure care plan approved by IEPA.	High. Engineered landfilling is an accepted waste management technology subject to defined operating procedures and performance criteria.	High. Engineered landfilling is an accepted waste management technology subject to defined operating procedures and performance criteria.	Medium. The cover has good reliability characteristics, similar to the landfill alternative, and the gradient control system is an active engineering control that will be managed by routine monitoring and maintenance. Reliability will also be affected by heterogeneity of the Uppermost Aquifer.
	Need to coordinate with and obtain necessary approvals and permits from other agencies	Low/None	None. The IEPA has approved the closure plan for construction of a alternative cover system and long-term inspection, maintenance and monitoring.	High. Siting, design and construction of a new on-site landfill will require permitting through the IEPA Bureau of Land and construction would require a modification to the existing NPDES permit.	Medium. Excavation, transport and disposal in an existing landfill may require permits for transportation and/or disposal and a modification to the existing NPDES permit would be required.	Medium. Cover and gradient control system design will require design review and approval by IEPA and modification to existing NPDES permit.
	Availability of necessary equipment and specialists	High	High. Earthwork and cover construction are routine construction activities.	High. Earthwork and landfill construction are routine construction activities.	High. Earthwork and landfill construction are routine construction activities.	Medium. Cover construction and gradient control system are routine construction activities; specialty contractors may be required for slurry wall and groundwater control system construction.
	Available capacity and location of needed treatment, storage and disposal services	High/None	None. No treatment, storage or disposal services required for cover system construction.	Low. The existing on-site landfill does not have sufficient capacity for the 630,000 million CY of CCR that would be removed under this alternative. Permitting and construction for a new on-site landfill is estimated to extend the overall timeframe for remedy implementation by an additional 5 to 10 years before CCR excavation could begin.	Medium. There is adequate off-site landfill capacity for the CCR that would be excavated from OWAP. Excavation and transport of CCR would require approximately 3 years to complete assuming 60 trucks per day to transport CCR to off-site landfill.	Medium. No treatment, storage or disposal services required for cover construction; extracted groundwater would be disposed of via existing NPDES outfall.

Notes: 1 The rating for each consideration is a representation of relative performance between alternatives. In some instances, a rating of high indicates best performance relative to the specific consideration, while in other instances a rating of low indicates best performance relative to the consideration. The rating shown in this column defines which rating indicates best performance.
2 Closure Plan approved by IEPA June 19, 2018

Figures



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REVIEWED BY/DATE:
FA 8/7/19
APPROVED BY/DATE:
SLG 8/7/19

SITE LOCATION MAP

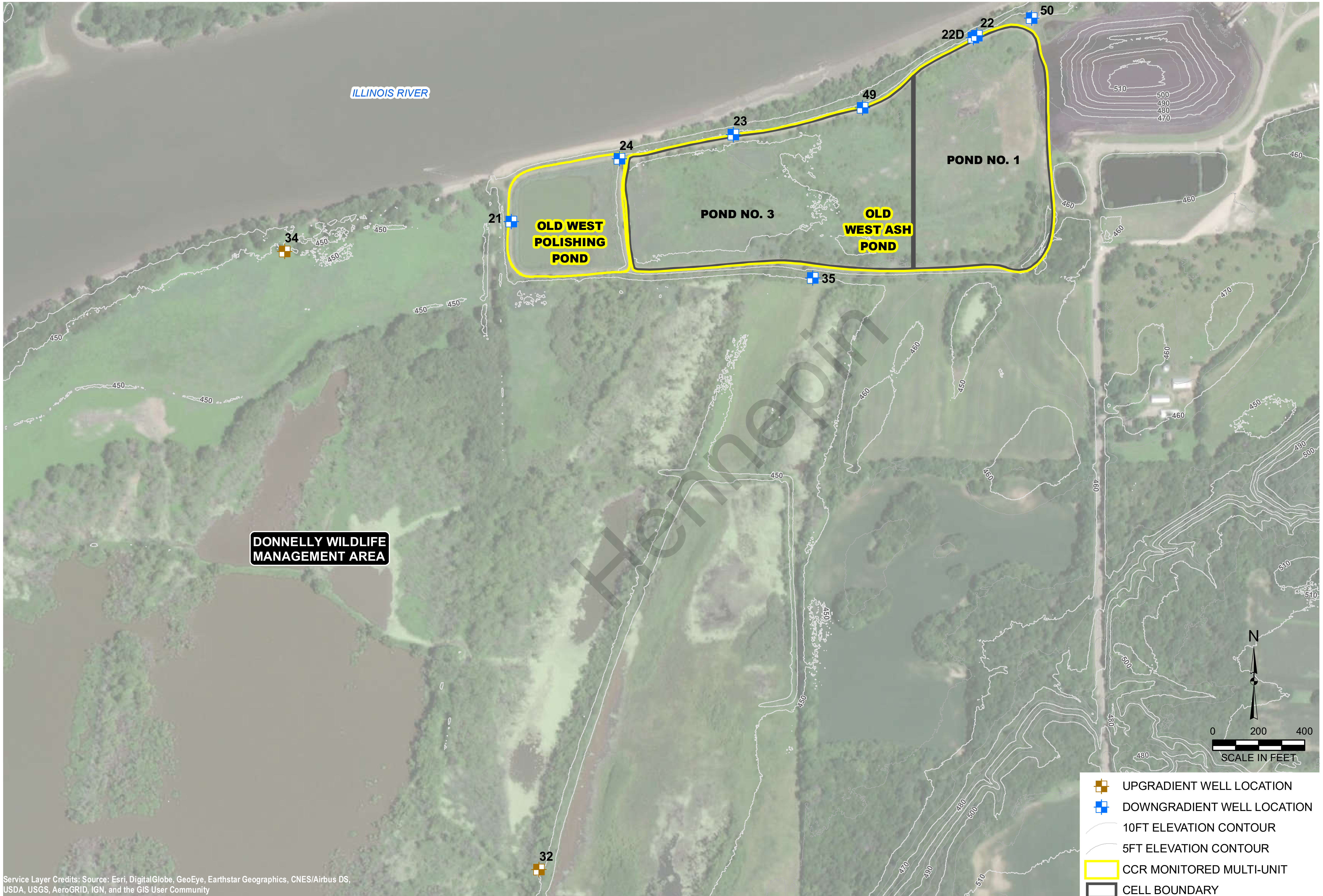
CORRECTIVE MEASURES ASSESSMENT
OLD WEST ASH POND (POND NO. 1 AND POND NO. 3) AND POLISHING POND
HENNEPIN POWER STATION
HENNEPIN, ILLINOIS

PROJECT NO: 72857

FIGURE NO: 1

OBG Part of Ramboll

\\server27-01Y Drive\Mapping\Projects\22\2285_Hennepin West\MXD\CMA\Figure 1_Site Location Map.mxd Author: STOLZSD; Date/Time: 9/3/2019, 5:33:15 PM



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APPROVED BY/DATE: SLG 8/7/19

CCR GROUNDWATER MONITORING SYSTEM

CORRECTIVE MEASURES ASSESSMENT
OLD WEST ASH POND (POND NO. 1 AND POND NO. 3) AND POLISHING POND
HENNEPIN POWER STATION
HENNEPIN, ILLINOIS

PROJECT NO: 72857

FIGURE NO: 2

OBG Part of Ramboll

OBG

Part of Ramboll