

**REPORT ON
SELECTION OF REMEDY
NEW MADRID POWER PLANT
POND 003
MARSTON, MISSOURI**

by
Haley & Aldrich, Inc.
Cleveland, Ohio

for
Associated Electric Cooperative, Inc.
Springfield, Missouri

File No. 129342-051
March 2023



Selection of Remedy Report Certification Statement

I, Steven F. Putrich, am a professional engineer and licensed in the state of Missouri. I have reviewed this Selection of Remedy report for the Associated Electric Cooperative, Inc. New Madrid Power Plant Pond 003 coal combustion residuals surface impoundment located in Marston, Missouri. I hereby certify that this report has been prepared in general conformance with and meets the requirements of Title 40 Code of Federal Regulations (40 CFR) § 257.97 of the U. S. Environmental Protection Agency's Rule entitled "Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities." 80 Fed. Reg. 21302 (17 April 2015) (promulgating 40 CFR § 257.61); 83 Fed. Reg. 36435 (30 July 2018) (amending 40 CFR § 257.61) (the CCR Rule).

Signed: 
Certifying Engineer

Print Name: Steven F. Putrich
Missouri License No.: 2014035813
Title: Project Principal
Company: Haley & Aldrich, Inc.



Professional Engineers Seal:

I, Mark D. Nicholls, am a professional geologist and licensed in the state of Missouri. I hereby certify that this report has been prepared in general conformance with and meets the requirements of Title 40 CFR § 257.97 of the U. S. Environmental Protection Agency's Rule entitled "Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities." 80 Fed. Reg. 21302 (17 April 2015) (promulgating 40 CFR § 257.61); 83 Fed. Reg. 36435 (30 July 2018) (amending 40 CFR § 257.61) (the CCR Rule).

Signed: 
Professional Geologist

Print Name: Mark Nicholls
Missouri License No.: 20150149012
Title: Principal Hydrogeologist
Company: Haley & Aldrich, Inc.



Professional Geologist's Seal:

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1. Introduction

Associated Electric Cooperative, Inc. (AECI) retained Haley & Aldrich, Inc. (Haley & Aldrich) to prepare this Selection of Remedy Report for the coal combustion residuals (CCR) surface impoundment referred to as Pond 003 located at the AECI New Madrid Power Plant in Marston, Missouri (the Site). The selection of remedy for Pond 003 is completed according to the requirements of the U.S. Environmental Protection Agency's (USEPA) rule entitled *Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities* (CCR Rule) effective 17 April 2015, including subsequent revisions.

In accordance with Title 40, Code of Federal Regulations (40 CFR) § 257.97(b), a remedy must:

- Be protective of human health and the environment;
- Achieve the groundwater protection standard pursuant to 40 CFR § 257.95(h);
- Control the source(s) of releases so as to reduce or eliminate, to the maximum extent feasible, further releases of constituents in Appendix IV of the CCR Rule;
- Remove from the environment as much of the contaminated material that was released from the CCR unit as is feasible, taking into account factors such as avoiding inappropriate disturbance of sensitive ecosystems; and
- Comply with certain standards for management of wastes as specified in 40 CFR § 257.98(d).

In September 2019 (amended in October 2019), AECI completed the Corrective Measures Assessment (CMA) Report for Pond 003 included as Appendix A. The CMA considered a series of corrective measure alternatives, all of which were demonstrated to meet the threshold criteria listed above. The CMA Report also included the summary results of the assessment of numerous technical evaluations conducted, which include groundwater modeling, human health and ecological risk assessments, and nature and extent (N&E) of CCR constituents in groundwater assessments. The CMA compared the corrective measure alternatives to one another with respect to three of the four balancing criteria identified in the CCR Rule: long- and short-term effectiveness, source control, and implementability. The fourth balancing criteria, community concerns, is detailed in Section 2.

As required by the CCR Rule, AECI published the CMA Report to its public CCR Website and held a public meeting to discuss the results of the CMA with interested and affected parties. AECI held a public meeting on 14 November 2019¹ and accepted comments through a portal on its CCR public website. AECI received no verbal comments from the public during the public meeting and no written comments through its CCR public website portal. A copy of AECI's formal documentation of the results of the public meeting are provided in Appendix B.

¹ Prior and subsequent to the subject CCR Rule public meeting, AECI continued ongoing pursuit of N&E groundwater investigations and associated groundwater quality assessments. That work included evaluation of both the vertical and lateral extent of the areas impacted by Pond 003, groundwater modeling, and further development of the overall Site groundwater geochemical framework in support of the selection of remedy.

2. Assessment of the Fourth Balancing Criteria

The fourth balancing criteria listed under 40 CFR § 257.97(c)(4) of the CCR Rule, which are addressed herein to inform the assessment of the CMA, states:

“...the degree to which community concerns are addressed by a potential remedy(s).”

To assess the degree to which community concerns were addressed and thereby assess the fourth balancing criteria, AECl and Haley & Aldrich were available to receive and respond to comments; however, no comments were received related to the CMA. No written responses were required since no verbal or written comments were received as stated in Appendix B. With the completion of the public meeting and since no comments were received, AECl has made every effort to be responsive in addressing community concerns regarding potential remedies thereby satisfying the fourth balancing criteria set forth in 40 CFR § 257.97(c)(4).

Consistent with the approach followed in the CMA report, a graphic of the overall favorability of each remedial alternative with the addition of the fourth balancing criteria is provided below. In this graphic, green represents most favorable, yellow represents less favorable, and red represents the least favorable rating relative to the degree to which community concerns were addressed by each of the potential remedies in the CMA.

Comments or concerns were expressed on the specific remedies associated with all five alternatives in the CMA. In conclusion, green represents a favorable rating relative to the degree to which community concerns were addressed by AECl’s potential remedies.

	Alternative 1 CIP with Cap & MNA	Alternative 2 CIP with ISS, Cap, & MNA	Alternative 3 CIP with Cap & Hydraulic Containment	Alternative 4 CIP with Cap & Hydraulic Containment & Barrier Wall	Alternative 5 CBR with MNA
CATEGORY 1 Long- and Short Term Effectiveness, Protectiveness, and Certainty of Success	Green	Yellow	Yellow	Yellow	Yellow
CATEGORY 2 Effectiveness in controlling the source to reduce further releases	Yellow	Yellow	Yellow	Yellow	Green
CATEGORY 3 The ease or difficulty of implementation	Green	Red	Yellow	Yellow	Red
CATEGORY 4 Degree to which Community Concerns are Addressed by a Potential Remedy	Green	Green	Green	Green	Green

Notes:

CBR = closure by removal

CIP = closure in place

ISS = In-Situ Stabilization

MNA = monitored natural attenuation

Since no comments or information were received during the public process, the results of the CMA addressing the first three balancing criteria informed the final remedy selection. A summary of AECl’s remedial plan is provided below which will, when fully implemented and completed, achieve the corrective measures objectives in accordance with the CCR Rule requirements.

3. Corrective Measures Remedial Plan – Selection of Remedy

Based on results of the CMA and the public comment and response opportunity, AECl intends to select the following corrective action for Pond 003:

CMA Report Alternative 1 – Closure in Place with Cap and Monitored Natural Attenuation (MNA): Develop source control by ceasing receipt of CCR and non-CCR waste streams and completing closure through installation of a final cover system and employ MNA.

The selected remedy meets the standards listed in 40 CFR § 257.97(b). In making this selection, AECl considered the factors listed in 40 CFR § 257.97(c). The installation of a CCR Rule compliant final cover system in accordance with the Pond 003 Closure Plan along with MNA constitutes an appropriate remedial corrective measure for groundwater impacts.² The proposed final cover system for Pond 003 will effectively eliminate infiltration through the final cover system and into the groundwater aquifer below Pond 003 (source control), which will cut off the oxidative drivers to the aquifer that are limiting the establishment of Site-wide, sulfate-reducing conditions that are needed for molybdenum natural attenuation. Natural attenuation will reduce the limited and localized CCR-related impacts in groundwater immediately downgradient of Pond 003 and ongoing monitoring will be employed to track the progress of the combined source control and natural attenuation remedy.

The existing geochemical conditions of the Site's aquifer and the analyzed contributing factors support natural attenuation as an important part of the overall remedy for molybdenum. The geochemical conditions that will result from the implementation of closure is anticipated to stimulate the sulfate-reducing conditions necessary to enhance geochemical natural attenuation mechanisms for molybdenum. It is currently estimated that, once the oxidative drivers to the aquifer are removed post-closure in place and associated source control implementation, sufficient sulfate in groundwater and organic carbon in aquifer solids are present in the subsurface to further promote attenuation (through molybdenum secondary mineral precipitation) and support a reliable corrective measures strategy. A MNA technical summary is provided in Appendix C which includes further discussion regarding the natural attenuation mechanisms that support this remedy selection.

Additionally, risk-based screening was used to characterize whether the CCR-related constituents would potentially pose risks of concern to human and environmental receptors through the exposure pathways identified in the conceptual site model. The subject screening is performed by identifying risk-based screening levels that are applicable for the pathways under consideration and then comparing appropriate analytical data to the appropriate screening levels. **The results of the streamlined evaluation indicate that the presence of Appendix III and Appendix IV constituents and their associated levels currently detected and projected in the future in groundwater downgradient of**

² NA occurs due to naturally occurring processes within the aquifer to reduce concentrations of CCR constituents in groundwater. NA encompasses a variety of physical and chemical processes (biodegradation, sorption, dilution, chemical reactions, and evaporation), which, under the right conditions, can immobilize constituents in aquifer sediments. USEPA recognizes MNA as a corrective action component for addressing inorganics (metals) in groundwater (USEPA Directive 9283.1-36 (2015)). See Appendix C of this document entitled "MNA Technical Basis Summary in Support of Selection of Remedy" for additional information on the Site-specific application and rationale for MNA being integral to the Pond 003 selected remedy.

Pond 003 do not pose a risk to public health or the environment that are of regulatory concern. A risk evaluation summary in support of selection of remedy is provided in Appendix D.

If additional sources of contamination other than Pond 003, whether on or off Site, contribute in any way to the contaminant impacts in groundwater, AECl reserves the right to reassess, reanalyze, and/or revise the selected remedy accordingly to achieve an effective remedy for constituents contributed by Pond 003 to the uppermost aquifer. As summarized in the CMA Report, constituent concentrations are predicted to decrease over time following implementation of the selected remedy. This will allow groundwater conditions, with benefits of the planned source control and the aid of natural attenuation, to stabilize and achieve the groundwater protection standards (GWPS).

Within 90 days of selecting a remedy, in accordance with 40 CFR § 257.98(a), AECl will:

1. Establish and implement a corrective action groundwater monitoring program;
2. Implement the corrective action remedy selected; and
3. Take any interim measures necessary.

At this time, the corrective measures cited herein are deemed sufficient to meet the objectives of the CCR Rule. No additional corrective measures (including interim measures) beyond those cited herein are envisioned at this time. However, It is recognized that remedial actions are iterative in nature and AECl (as part of the long-term performance monitoring program) will periodically evaluate updated groundwater conditions and determine whether additional measures are warranted to achieve the objectives of the CCR Rule related to groundwater.

4. Plan and Action Steps for the Implementation of the Selected Remedy

AECI plans to take the following steps to implement the selected remedy:

1. Establish and implement a corrective action groundwater monitoring program that:
 - a. Meets the requirements of an assessment monitoring program under 40 CFR § 257.95;
 - b. Documents the effectiveness of the corrective action remedy; and
 - c. Demonstrates compliance with the GWPS.
2. Continue the process towards ceasing receipt of CCR and non-CCR waste streams to Pond 003.
3. Install a CCR Rule compliant final cover system that covers the extent of CCR within the Pond 003 surface impoundment to control the source of CCR-related constituents and minimize infiltration of precipitation through the Pond 003 final cover system (source control).
4. In conjunction with source control, utilize natural attenuation for treatment of groundwater concentrations above GWPS to address limited and localized CCR-related impacts. Ongoing monitoring and modeling evaluations will be utilized to document the change in concentrations of CCR constituents in groundwater as previously presented in the CMA.
5. Prepare Annual Groundwater Monitoring and Corrective Action Reports for the Site that incorporate the corrective action groundwater monitoring program to document the effectiveness of the corrective action remedy.

5. Implementation of Remedy Schedule

Under its currently estimated schedule, AECI plans to cease operation of Pond 003 by 31 May 2023, and commence closure of Pond 003 thereafter, unless future conditions dictate the need to request an extension of that date. The closure timeframe will be completed by June 2028 (plus any applicable extensions to the closure completion date) based on allowable closure timeframes provided in 40 CFR § 257.102(f)(1) and (f)(2) and based on relevant assumptions, including regulatory agency approvals and permits, engineering design, contractor availability, material supply chain availability schedule, and other logistical considerations. AECI has begun taking the following steps in support of implementing the remedy including pursuit of the following actions to date:

- AECI has continually reduced CCR and non-CCR waste streams previously discharged to Pond 003; and
- AECI has begun engineering design planning in support of the final cover system.

Estimated key milestones are provided below for the future remedial activities associated with the selected remedy. This schedule is based on best available information and assumptions, takes into account the factors listed in 40 CFR § 257.97(d), and is subject to change as additional information becomes available. The schedule may be advanced or delayed based on factors including timing of regulatory agency approvals and permits, potential issues related to COVID-19 (or other) global pandemics, contractor availability, logistical considerations, or other unforeseeable circumstances. In any event, AECI will complete remedial activities within a reasonable period of time based on these and other relevant factors:

- Establish and implement Corrective Action Groundwater Monitoring Program – June 2023;
- Cease receipt of CCR and non-CCR waste streams in Pond 003 – by June 2023;
- Commence activities associated with closure of Pond 003 – July 2023;
- Initiate installation of the final cover system – 2025;
- Complete closure construction and certification – June 2028 (unless extensions are required; any applicable extensions to the closure completion date) based on allowable closure timeframes provided in 40 CFR § 257.102(f)(1) and (f)(2); and
- Complete remedial activities – Within the 30-year post-closure care period, unless extensions are required for closure or alterations of the remedial activities dictate otherwise.

APPENDIX A
Corrective Measures Assessment

**REPORT ON
CORRECTIVE MEASURES ASSESSMENT
FOR POND 003
NEW MADRID POWER PLANT
NEW MADRID, MISSOURI**

by
Haley & Aldrich, Inc.
Cleveland, Ohio

for
Associated Electric Cooperative, Inc.
Springfield, Missouri

File No. 129342-020
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List of Acronyms and Abbreviations

Abbreviation	Definition
AECI	Associated Electric Cooperative, Inc.
CBR	Closure by Removal
CCR	Coal Combustion Residual
CIP	Closure in Place
COC	Constituent of Concern
CMA	Corrective Measures Assessment
CSM	Conceptual Site Model
FDM	Finite-Difference Method
GWPS	Groundwater Protection Standards
Gredell	Gredell Engineering Resources Inc.
Haley & Aldrich	Haley & Aldrich, Inc.
HC	Hydraulic Containment
HMOC	Hybrid Method of Characteristics
ISS	In-Situ Stabilization
Pond 003	CCR Management Unit
MDNR	Missouri Department of Natural Resources
MMOC	Modified Method of Characteristics
MNA	Monitored Natural Attenuation
MOC	Method of Characteristics
N&E	Nature and Extent
NMPP	New Madrid Power Plant
O&M	Operations and Maintenance
ONWI	Office of Nuclear Waste Isolation
RMS	Root Mean Square
RO	Reverse Osmosis
SAP	Sampling Analysis Plan
SDAP	Statistical Data Analysis Plan
SSI	Statistically Significant Increase
SSL	Statistically Significant Levels
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
UWL	Utility Waste Landfill

1. Introduction

Haley and Aldrich, Inc. (Haley & Aldrich) was retained by Associated Electric Cooperative, Inc. (AECI) to prepare this Corrective Measures Assessment (CMA) for the Coal Combustion Residual (CCR) management unit identified as Pond 003 located at the New Madrid Power Plant (NMPP). AECI has conducted detailed geologic and hydrogeologic investigations under the U. S. Environmental Protection Agency's (USEPA) rule entitled *Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities*. 80 Fed. Reg. 21302 (effective 19 October 2015) and subsequent regulatory revisions (CCR Rule).

This CMA includes a summary of the results of groundwater and site investigations at Pond 003. Groundwater impacted by Pond 003 exceeds the statistically-derived groundwater protection standards (GWPS) for molybdenum at six monitoring well locations surrounding Pond 003 based on statistical analyses completed for an assessment monitoring groundwater sampling event in September 2018. This report evaluates potential corrective measures to address these limited exceedances of the GWPS.

1.1 FACILITY DESCRIPTION/BACKGROUND

The NMPP is an active energy production facility that generates electricity through coal combustion (Figure 1-1). The CCR generated are byproducts of the combustion process and include fly ash and boiler slag material. Boiler slag, economizer ash, coal fines, and minor residual waste streams are sluiced from the power generating system to the northern end of Pond 003, where it travels south through maintained channels to the impoundment outlet. Historically, fly ash was also sluiced to this impoundment. Fly ash is now handled in a dry condition and hauled to the on-site Utility Waste Landfill (UWL). The slag is removed from Pond 003 for either beneficial use or disposal in the UWL. Site features are shown on **Figure 1-2**. Suspended economizer ash and coal fines are settled in a channel and stockpiled adjacent to the channel.

1.2 SITE CHARACTERIZATION WORK SUMMARY

Extensive subsurface investigations have occurred pursuant to the CCR Rule. In June 2009, a *Stability Evaluation of Slag Pond 1 and Ash Pond 2 Report* was prepared by Geotechnology, Inc. characterized the geology and evaluated stability of Pond 003. In October 2011, a *Hydrogeologic Characterization Report for Coal Ash Impoundment (Unlined)* was prepared by Gredell Engineering Resources, Inc. (Gredell) and characterized the geology and hydrogeology of Pond 003. In January 2012, Gredell prepared a *Well Development and Sampling Summary* that documents the development of the piezometers installed during the Stability Evaluation. In September 2015, an impoundment stability evaluation was conducted by Haley & Aldrich to further assess exterior dikes which frame the perimeter of Pond 003 as a compliance activity associated with the CCR Rule which included borings and cone penetration testing. In September 2016, Haley & Aldrich installed additional monitoring wells surrounding Pond 003 to develop the CCR groundwater monitoring network. Data from these site characterization activities were used to develop a hydrogeologic Conceptual Site Model (CSM), which included:

- Soil borings and sampling;
- Geotechnical testing;
- Well and piezometer installation;
- Slug testing; and

- Groundwater sampling.

The CSM has been further enhanced with ongoing CCR groundwater monitoring and supplemental subsurface investigation activities performed by Haley & Aldrich. Findings from these extensive and updated series of geologic and hydrogeologic investigations have been used to construct a robust CSM that supports the CMA activities discussed in this report.

1.3 GROUNDWATER MONITORING

Groundwater monitoring under the CCR Rule occurs through a phased approach to allow for a graduated response (i.e., baseline, detection, and assessment monitoring as applicable) and evaluation of steps to address groundwater quality. Haley & Aldrich prepared a Groundwater Sampling and Analysis Plan (SAP) and a Statistical Data Analysis Plan (SDAP) as required by the CCR Rule. The SAP and SDAP present the design of the groundwater monitoring system, groundwater sampling and analysis procedures, and groundwater statistical analysis methods.

Monitoring wells that make up the Pond 003 groundwater monitoring network were installed in October 2003, April 2009, and September 2016. The Pond 003 groundwater monitoring network includes three background wells (MW-16, B-123, and B-126) and nine downgradient monitoring wells (P-1 through P-5 and MW-6 through MW-9¹) located around the perimeter of Pond 003. In general, the monitoring wells are screened in the alluvial aquifer zone approximately 50 feet below ground surface.

Detection monitoring sampling events occurred in 2017 and 2018. The results of the sampling events were then compared to background/upgradient concentrations, or natural groundwater values, using statistical methods to determine whether a statistically significant increase (SSI) of constituent concentrations above background concentrations in groundwater had occurred. Results of the detection monitoring statistical analyses completed in January 2018 identified SSI concentrations of Appendix III constituents in downgradient monitoring wells relative to concentrations observed in background concentrations. At the time of this report, no alternative source was identified for the SSI constituents. Accordingly, the groundwater monitoring program transitioned to an assessment monitoring program.

During the Assessment Monitoring phase, CCR groundwater monitoring well samples were collected during May and September 2018 and subsequently analyzed for Appendix IV constituents. Appendix IV analytical results for the baseline and Assessment Monitoring events are summarized in **Table I**.

1.4 CORRECTIVE MEASURES ASSESSMENT PROCESS

The CMA process involves development of groundwater remediation technologies that will satisfy the following threshold criteria: protection of human health and the environment, attainment of GWPS, source control, constituent of concern (COC) removal and compliance with standards for waste management. Once these technologies are demonstrated to satisfy these criteria, they are then compared to one another with respect to four balancing criteria: long- and short-term effectiveness, source control, and implementability. The fourth balancing criteria involves input from the community

¹ Note that wells P-5, MW-6, and MW-7 are generally on the upgradient side of the unit with the predominant flow path being towards the east and the river, except when the river rises and causes a temporary reversal of flow to the east.

regarding the proposed remedial activities that will occur in compliance with the corrective measures plan as part of a public meeting. That meeting must be held at least 30 days prior to remedy selection by AECl.

1.5 RISK REDUCTION AND REMEDY

The CCR Rule (§257.97(b)(1) - Selection of Remedy) requires that remedies must be protective of human health and the environment. Further, §257.97(c) of the CCR Rule requires that in selecting a remedy, the owner or operator of the CCR unit must consider specific evaluation factors, including the risk reduction achieved by each of the proposed corrective measures. Each of the evaluation factors listed here from §257.97 and discussed in **Section 4** are those that consider risk to human health or the environment including:

- (c)(1)(i) Magnitude of reduction of existing risks;
- (c)(1)(ii) Magnitude of residual risks in terms of likelihood of further releases due to CCR remaining following implementation of a remedy;
- (c)(1)(iv) 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;
- (c)(1)(vi) 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, or containment;
- (d)(4) Potential risks to human health and the environment from exposure to contamination prior to completion of the remedy²;
- (d)(5)(i) Current and future uses of the aquifer;
- (d)(5)(ii) Proximity and withdrawal rate of users; and
- (d)(5)(iv) The potential damage to wildlife, crops, vegetation, and physical structures caused by exposure to CCR constituents.

² Factors (d)(4) and (d)(5) are not part of the CMA evaluation process as described in §257.97(d)(4), §257.97(d)(5)(i)(ii)(iv); rather they are factors the owner or operator must consider as part of the schedule for remedy implementation.

2. Groundwater Conceptual Site Model

To evaluate potential remedy options, the CSM was developed and evaluated based on data collected and associated with the AECI site. The CSM is summarized below.

2.1 SITE SETTING

The NMPP is located approximately two miles east of Marston, Missouri on the western bank of the Mississippi River in New Madrid County, Missouri. The site is located within the northernmost extent of the larger Mississippi Alluvial Plain and is characterized as a relatively flat alluvial plain with extensive agricultural use (Figure 1-1). Pond 003 is a surface impoundment that encompasses approximately 110 acres and is located approximately 0.3 miles southeast of the NMPP power plant site. Pond 003 has ground surface elevations varying from approximately 299 to 320 feet above mean sea level. The western boundary for Pond 003 is the Mississippi River levee which is operated and maintained by the St. Francis Levee District of Missouri and the United States Army Corps of Engineers (USACE).

2.2 GEOLOGY AND HYDROGEOLOGY

Geologic and hydrogeologic conditions beneath Pond 003 have been characterized based on information obtained during installation and testing of the monitoring wells installed around Pond 003 in 2009 and monitoring wells installed as part of the CCR groundwater monitoring network in 2016.

2.2.1 Site Geology

Pond 003 is located in the Southeastern Lowlands physiographic province. The Southeastern Lowlands is the northernmost extent of the larger Mississippi Alluvial Plain and is characterized by alluvial, fluvial, and deltaic deposits ranging in age from Cretaceous to Holocene. The plant site and Pond 003 are underlain by an unconsolidated alluvium which constitutes a regionally extensive aquifer.

In order from ground surface downward, Pond 003 is underlain by unconsolidated alluvium, the Wilcox Group, the Porters Creek Clay, and the Clayton, Owl Creek, and McNairy formations. Only the Tertiary formations (unconsolidated alluvium, Wilcox group, and Porters Creek group) are described below because they represent the uppermost and regional aquifer system.

Surficial geologic materials in the vicinity of and beneath Pond 003 include alluvium consisting of moderate to poorly sorted clay, silt, sand, and gravel of Holocene age (Miller and Vandike, 1997). The alluvium varies from approximately 250 to 300 feet thick in the vicinity of Pond 003 (Gredell Engineering Resources Inc. [Gredell], 2003). Alluvial sediments were predominantly deposited by the Mississippi and Ohio river systems. The alluvium yields substantial quantities of water to shallow wells, primarily for irrigation use, and is considered the primary local aquifer (Burns & McDonnell, 2006).

The Holocene alluvium is underlain by unconsolidated Tertiary strata. The uppermost Tertiary unit is the Wilcox Group consisting primarily of sand deposits with some interbedded clays and lignites (Burns & McDonnell, 2006). The Wilcox Group is 400 to 500 feet thick at the plant site, lying approximately 250 to 300 feet below ground surface, and stratigraphically overlies the Porters Creek Clay.

The Porters Creek Clay is approximately 650 feet in thickness in the vicinity of Pond 003. The Porters Creek Clay is composed entirely of light grey to black clay (Burns & McDonnell, 2006). The clay is a groundwater flow barrier and barrier to infiltration (Miller and Vandike, 1997). The Porters Creek Clay overlies the Clayton formation. The Clayton formation has a total thickness of approximately 30 feet near the plant site and is comprised of sand and limestone (Burns & McDonnell, 2006).

2.2.2 Site Hydrogeology and Hydrology

The water-bearing geologic formation nearest the natural ground surface at Pond 003 is alluvium consisting of moderately to poorly sorted clay, silt, sand, and gravel of Holocene age. The aquifer is used regionally for irrigation and domestic use (although no irrigation or domestic use wells exist adjacent to or downstream of Pond 003). Water levels in the uppermost aquifer are influenced by the Mississippi River stage.

Based on groundwater elevations measured between November 2016 and September 2018, the groundwater gradient in the upper aquifer unit is approximately 0.0008 to 0.003 feet per foot (feet/foot) representative of a very flat gradient. Pond 003 lies adjacent to the Mississippi River and the alluvial aquifer immediately beneath Pond 003 is unconfined and in communication with the river. Seasonal changes in river stage cause the groundwater flow direction to change and occasionally reverse. Due to the influence of the adjacent Mississippi River, the groundwater flow in the alluvial aquifer is generally to the southwest during high river stage and generally to the northeast during typical or lower river stages (Higher river stages generally occur during spring months of the year typically associated with elevated river levels in the Mississippi River). Due to the changing groundwater flow directions, monitoring wells were sited at locations to encircle Pond 003. A select number of those wells (primarily MW-16, B-123, and B-126, and during dominant groundwater flow to the northeast, wells P-5, MW-6, and MW-7) have been designated as upgradient to reflect the dominant groundwater flow towards the river for the majority of the calendar year. Monitoring Well locations are shown on **Figure 2-1**.

Hydraulic conductivity of the uppermost aquifer is based on data collected during slug testing of wells installed during development of the CCR monitoring network. The hydraulic conductivity was calculated to be 75 to 81 feet per day (approximately 3×10^{-2} cm/sec).

Because the alluvial aquifer provides a more accessible resource for groundwater production in the area, the Wilcox formation has not been developed locally as a source of groundwater. The clay and lignite present within the Wilcox formation represent lower hydraulic conductivity than the overlying alluvial aquifer. Published hydraulic conductivity values for the Wilcox formation indicate hydraulic in the range of 9 to 25 feet per day (approximately 3×10^{-3} to 9×10^{-3} cm/sec) (Office of Nuclear Waste Isolation [ONWI], 1982 and Prudic, 1991). The Wilcox formation in the vicinity of Pond 003 is estimated to be approximately 400 to 500 feet thick (Gredell, 2003).

2.3 GROUNDWATER PROTECTION STANDARDS

Haley & Aldrich completed a statistical evaluation of groundwater samples using the methods and procedures outlined in the Pond 003 Statistical Data Analysis Plan (Haley & Aldrich, 2019) to develop site-specific GWPS for each Appendix IV constituent.

Groundwater results were compared to the site-specific GWPS. Based on statistical analyses completed in January 2019, statistically significant levels (SSLs) above the GWPS are limited to six monitoring wells

(P-2, P-3, P-5, MW-7, MW-8, and MW-9) and only for one parameter (molybdenum). Monitoring well locations with SSLs are illustrated on Figure 2-2.

2.4 NATURE AND EXTENT OF GROUNDWATER IMPACTS

AECI initiated a nature and extent (N&E) investigation as required by the CCR Rule in 2019 and is currently installing a series of supplemental monitoring wells and piezometers (N&E wells) at strategic locations surrounding the impoundment. The N&E wells will be screened in two different, generalized zones of the alluvial aquifer: shallow zone at the uppermost aquifer and deep zone approximately 30 feet below the shallow zone.

Analytical results from the assessment wells indicate that molybdenum concentrations are limited in their extent. In the shallow alluvial aquifer zone, the results from monitoring wells surrounding Pond 003 indicate a dominant groundwater flow to the northeast towards the Mississippi River. The distance of the Mississippi River from the unit ranges from approximately 300 to 400 feet. N&E results will be used to supplement the evaluation of the extent of groundwater impacts, and wells are expected to be sampled in late September and October of 2019. Laboratory results will follow.

3. Risk Assessment and Exposure Evaluation

A “Groundwater Risk Evaluation” report has been prepared by Haley & Aldrich, as a supplement to this CMA document, and is presented in **Appendix A**. The purpose of the risk evaluation report is to provide the information needed to interpret and meaningfully understand the groundwater monitoring data collected and published for the NMPP under the CCR Rule. In addition, AECI has voluntarily taken the additional step of evaluating potential groundwater-to-surface water transport and exposure pathways in the risk evaluation.

The risk evaluation report was completed by developing a CSM to identify the potential for human or ecological exposure to constituents that may have been released to the environment. The CSM was used to resolve questions such as: What is the source of constituents? How can constituents be released from the source? What environmental media may be affected by constituent release? How and where do constituents travel within a medium? Is there a point where a receptor (human or ecological) could contact the constituents in the medium? If the answers to these questions are ‘Yes’, then the risk evaluation resolves the question “Are the constituent concentrations high enough to potentially exert a toxic effect?” by comparing constituent concentrations in groundwater to risk-based screening levels.

Screening levels are constituent concentrations in groundwater (and other media) that are considered to be protective of specific human exposures and ecological exposures. The USEPA and other regulatory agencies, including the Missouri Department of Natural Resources (MDNR), develop screening levels to provide a conservative estimate of the concentration to which a receptor (human or ecological) can be exposed without experiencing adverse health effects. Due to the conservative methods used to derive risk-based screening levels, it can be assumed with reasonable certainty that concentrations below screening levels will not result in adverse health effects, and that no further evaluation is necessary. Concentrations above conservative risk-based screening levels do not necessarily indicate that a potential risk exists but indicate that further evaluation may be warranted.

The results of the risk evaluation indicate that:

- Groundwater downgradient of Pond 003 is not used as a source of drinking water and is not flowing toward any groundwater supply wells. Therefore, despite some constituents in groundwater being detected at concentrations above GWPS at the waste boundary, the constituents do not pose any health risks associated with drinking water uses or exposures.
- If constituents in groundwater downgradient of the Pond 003 were assumed to flow into the Mississippi River, the concentrations in groundwater would need to be orders of magnitude higher than they are to be a potential concern to people who use the Mississippi River as a source of drinking water and for recreational purposes, and for ecological receptors that live in or use the Mississippi River.

Consequently, the risk evaluation demonstrates that there are no adverse impacts on human health or ecological receptors from groundwater uses resulting from coal ash management practices at Pond 003.

4. Corrective Measures Alternatives

4.1 CORRECTIVE MEASURES ASSESSMENT GOALS

The overall goal of this CMA is to identify and evaluate the appropriateness of potential corrective measures to prevent further releases of Appendix IV constituents above their GWPS, to remediate releases of Appendix IV constituents detected during groundwater monitoring above their GWPS that have already occurred, and to restore groundwater in the affected area to conditions that do not exceed the GWPS for these Appendix IV constituents. The corrective measures evaluation that is discussed below and subsequent sections provides an analysis of the effectiveness of five potential corrective measures in meeting the requirements and objectives of remedies as described under §257.97 (also shown graphically on **Figure 4-1**). Additional remedial alternatives were considered but were determined to not be viable for remediating groundwater at this site. This assessment also meets the requirements promulgated in §257.96 which require the assessment to evaluate:

- The performance, reliability, ease of implementation, and potential impacts of appropriate potential remedies, including safety impacts, cross-media impacts, and control of exposure to residual contamination;
- The time required to complete the remedy; and
- 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.

The criteria listed above are included in the balancing criteria considered during the corrective measures evaluation, described in **Section 5**.

4.2 GROUNDWATER MODELING

A groundwater flow and solute transport model was constructed to evaluate and compare potential corrective measures in support of the CMA for the Site. The numerical model MODFLOW-2005 (Harbaugh, 2005) was selected for the modeling effort and is a three-dimensional, finite difference groundwater flow model capable of simulating the groundwater conditions under various scenarios including pumping and changes to infiltration over time.

Model calibration is the process of refining the model representation of the hydrogeologic framework, hydraulic properties, and boundary conditions to minimize the difference between the simulated heads and fluxes to the measured data. The RMS error is the square root of the average of the squares of the residuals. The RMS adds additional weight to points where the residual is greatest. If the residuals at all points are very similar, the RMS will be close to the mean absolute error. Alternatively, a few points with high errors can add significantly to the RMS for an otherwise well calibrated model. For all three of these criteria the optimal value is zero. The numerical goals for the groundwater flow model calibration are to (1) minimize the ME and MAE errors and (2) achieve the ratio of the root mean square (RMS) error of the head residuals to the range of observed heads (i.e., normalized RMS error) to be at least less than 10 percent (Anderson and Woessner, 1992). Once the groundwater flow model was calibrated to the determined criteria, the model was set-up for solute transport.

Contaminant fate and transport modeling was conducted utilizing the three-dimensional, numerical model MT3DMS (Version 5 of MT3D) (Zheng, 1990). MT3DMS simulates advection, dispersion, adsorption and decay of dissolved constituents in groundwater using a modular structure similar to MODFLOW to permit simulation of transport components independently or jointly. MT3D interfaces directly with MODFLOW for the head solution and supports all the hydrologic and discretization features of MODFLOW. The MT3D code has a comprehensive set of solution options, including the method of characteristics (MOC), the modified method of characteristics (MMOC), a hybrid of these two methods (HMOC), and the standard finite-difference method (FDM). MT3D was originally released in 1990 as a public domain code from the USEPA and has been widely used and accepted by federal and state regulatory agencies.

For this modeling effort, the MT3DMS model utilized the flow regime from the steady-state, calibrated Site groundwater flow model presented above to simulate transport of molybdenum. The steady state model was transformed into a transient model so various CMA options could be evaluated with respect to time. The strength and locations of the potential molybdenum sources specified in the transport models were based on current dissolved-phase concentration distributions from groundwater monitoring data at the Site.

4.3 CORRECTIVE MEASURES ALTERNATIVES

Corrective measures can terminate when groundwater impacted by Pond 003 does not exceed the Appendix IV GWPS for three consecutive years of groundwater monitoring [per §257.98(c)(2)]. In accordance with §257.97, the groundwater corrective measures to be considered must meet, at a minimum, the following threshold criteria:

1. Be protective of human health and the environment;
2. Attain the GWPS;
3. Control the source(s) of releases so as to reduce or eliminate, to the maximum extent feasible, further releases of COCs to the environment;
4. Remove from the environment as much of the contaminated material that was released from the CCR unit as is feasible, considering factors such as avoiding inappropriate disturbance of sensitive ecosystems; and
5. Comply with standards (regulations) for waste management.

Each of the remedial alternatives assembled as part of this CMA meet the requirements of the threshold criteria listed above.

The remedial alternatives presented below contemplate both closure in place (CIP) (Alternatives 1 through 4) and closure by removal (CBR) (Alternative 5) of Pond 003. Both closure methods are expressly authorized under the CCR Rule. AECl has prepared a CCR Rule compliant closure plan for Pond 003 and intends to initiate closure of the unit within the allowable timeframes as stated in §257.101 of the CCR Rule.

4.3.1 Alternative 1 – Closure in Place with Capping and Monitored Natural Attenuation

Pond 003 would be closed in place with a geomembrane and soil protective cap system to reduce infiltration of precipitation to groundwater thereby isolating source material. This cap selection exceeds regulatory requirements by several orders of magnitude (conservatively, a geomembrane provides

permeabilities $<1 \times 10^{-10}$ centimeters per second (cm/sec) as compared to 1×10^{-5} cm/sec required by the CCR Rule). Over time, depletion of COCs in CCR would allow the concentration of COCs in downgradient groundwater to decline and overall groundwater concentrations of COCs to attenuate. The dissolved phase plume of molybdenum remaining above the GWPS post-closure eventually attenuates, albeit slowly due to the low hydraulic gradient (i.e., the rate at which groundwater moves in the subgrade) in the aquifer underlying Pond 003.

CIP can be completed safely, in compliance with applicable federal and state regulations, and be protective of public health and the environment. In general, CIP consists of re-grading existing CCR and installing a cap system designed to significantly reduce infiltration from precipitation, resist erosion, contain CCR materials, and prevent exposures to CCR. At Pond 003, supplemental design investigations (as required) and engineering design activities along with associated permit pursuits would precede CIP construction activities. Construction of the pond closure is estimated to take approximately 2 years to complete following initiation of closure and are expected to be completed in approximately 2026.

Monitored Natural Attenuation (MNA) is a viable remedial technology recognized by both state and federal regulators that is applicable to inorganic compounds in groundwater. The USEPA defines MNA as “the reliance on natural attenuation processes 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 (USEPA, 2015). When combined with a low-permeability cap to address the source by limiting the infiltration of precipitation into and through the CCR, MNA can reduce concentrations of molybdenum in groundwater at the Pond 003 boundary, although the time required to achieve the GWPS would be lengthy due to the low gradient and the resultant groundwater flux.

Following the installation of the cap system, AECl would implement post-closure care activities. Post-closure care includes ongoing cap maintenance and periodic inspections, along with long-term groundwater monitoring until such time that groundwater conditions return to regulatory levels. No post-closure uses are currently planned.

4.3.2 Alternative 2 – CIP with In-Situ Stabilization, Capping and Monitored Natural Attenuation

In-situ stabilization (ISS) is a technique that uses mixing of the CCR with amendments to solidify the material in place. Amendments typically include Portland Cement or other reagents and the solidification is completed in-situ using large diameter augers. CCR in Pond 003 that has the potential to periodically come into contact with a fluctuating ground water table due to Mississippi River influence would be isolated by ISS, followed by capping of the surface impoundment. Groundwater impacts would be addressed through the processes of natural attenuation. This alternative would isolate the source (through solidification and installation of a low-permeability cap) and over time, allow the concentrations of COCs in downgradient groundwater to decline and overall groundwater concentrations of COCs to attenuate.

ISS of Pond 003 is predicted to take a number of years to complete, depending on the availability and scheduling of specialized contractors and equipment. Additionally, implementation of ISS will require a

detailed design effort with bench scale testing to determine the appropriate amendment mix. Pilot testing will also be needed to verify the ability of equipment to solidify material at depth. ISS has not been commonly used to stabilize entire CCR units as part of a closure strategy, but has been used in larger industry to stabilize materials at depth. Changes to groundwater chemistry associated with the mobility of Appendix IV constituents following completion of ISS, where large volumes of cementitious amendments/reagents are added to the subsurface, are unknown and would require pilot testing. ISS and CIP construction activities are estimated to take approximately 5 years to complete following initiation of closure and are expected to be completed in approximately 2029.

Following the ISS completion and low-permeability final cap system (similar to Alternative 1) installation, AECI would implement post-closure care activities that includes long-term groundwater monitoring and periodic inspections with ongoing cap maintenance.

4.3.3 Alternative 3 – CIP with Capping and Hydraulic Containment through Groundwater Pumping and Ex-Situ Treatment

Pond 003 would be closed in place with a low-permeability cap similar to Alternative 1 to reduce infiltration and isolate source material. Pumping wells would be installed to hydraulically control the downgradient migration of molybdenum. However, pumping wells would generate effluent that would require ex-situ treatment, likely with an ion exchange or a reverse osmosis (RO) treatment system. Both treatment systems are considered advanced stage treatment technologies and require ongoing operation and maintenance and would generate a secondary waste stream – including regeneration/replacement of the ion exchange media or concentration reject water from the RO system. Approvals and permitting would be required for the construction and installation of the treatment systems and discharge of the treated groundwater.

Implementation of a large-scale hydraulic containment (HC) system will require a detailed design effort with bench scale testing to verify groundwater treatment. Pilot testing, such as pumping tests and additional groundwater modeling, will be needed to verify the hydraulic capture zone. While HC is a widely used remediation technology for contaminated industrial/commercial sites, it has not been commonly used as part of a large-scale CCR unit closure strategy. The HC system and associated ex-situ treatment would be planned to be installed during operation of the unit prior to initiation of closure. CIP construction activities are estimated to take approximately 2 years to complete following initiation of closure and are expected to be completed in approximately 2026.

Following the installation of the low-permeability cap, groundwater pumping well network, and ex-situ treatment system, AECI would implement post-closure care activities that includes operation and maintenance of the HC system, long-term groundwater sampling to monitor HC system performance, and cover system maintenance.

4.3.4 Alternative 4 – CIP with Capping and Hydraulic Containment through Groundwater Pumping and Ex-Situ Treatment and Barrier Wall

The configuration of this alternative would be identical to Alternative 3, with the addition of a low-permeability barrier wall between the pumping wells and the Mississippi River. The purpose of the wall is to reduce the flux of groundwater moving downgradient west to east from Pond 003 and minimize the intake of groundwater from the east (the Mississippi River) during groundwater pumping, therefore improving the pumping efficiency of the hydraulic containment system. Approvals and permitting would

be required for the barrier wall installation adjacent to the Mississippi River in addition to permits required for discharge of the treated groundwater.

Similar to Alternative 3, implementation of a large-scale hydraulic containment system will require a detailed design effort with bench scale testing to verify groundwater treatment. Pilot testing, such as long-duration pumping tests and additional groundwater modeling, will be needed to verify the hydraulic capture zone. A detailed design will also be required for the barrier wall, given the target depth and horizontal length of the wall. Implementation of the barrier wall and hydraulic containment system will be particularly challenging given the proximity of the Mississippi River and limited work area. Installation of the barrier wall will likely require a variety of permits with work inside the USACE flood levee and near proximity to the Mississippi River. Similar to Alternative 3, the HC system and barrier wall would be planned to be installed during operation of the unit prior to initiation of closure. CIP construction activities are estimated to take approximately 2 years to complete following initiation of closure and are expected to be completed in approximately 2026.

Once implemented, the timeline for active treatment to achieve the GWPS is expected to be potentially shorter than other alternatives due to the enhanced effects of the pumping when combined with a barrier wall.

Following the installation of the low-permeability cap, subsurface barrier wall, groundwater pumping well network, and ex-situ treatment system, AECl would implement post-closure care activities that include operation and maintenance of the hydraulic containment system, long-term groundwater sampling to monitor hydraulic containment system performance, and cap system inspection and maintenance. No ongoing maintenance would be required for the subsurface barrier wall.

4.3.5 Alternative 5 – Closure by Removal with Monitored Natural Attenuation

This alternative evaluates the removal of CCR from Pond 003 followed by natural attenuation of molybdenum in groundwater. While this alternative would eliminate the source (ponded CCR) through removal, it takes multiple years to implement during which time the impounded CCR would remain open and subject to ongoing infiltration for the duration of the removal activities. Concentrations of molybdenum in downgradient groundwater would decline via natural attenuation processes once the removal is complete.

Excavated CCR material would likely be disposed on-site, following excavation and removal from Pond 003. The existing UWL would be laterally expanded to accommodate the CCR material removed from Pond 003. Under this scenario, transportation of CCR material over public roadways would be limited to access roads along the existing Mississippi River levee system. AECl already owns and maintains a dedicated haul road from the levee access road to the UWL site. Close proximity of the UWL to Pond 003 would also decrease the duration required for closure, when compared to off-site disposal options.

Ponded CCR materials would be limited in its beneficial use applications. Historically, boiler slag at the AECl facility has been processed at its point of entry into the impoundment for screening and off-site beneficial use. Rejected portions of the boiler slag that did not meet specific criteria remain in Pond 003. Also, fly ash was sluiced and comingled with coal fines and other generated waste streams rendering that portion of the ponded ash less usable. In addition, due to chemical reactions that occurred during the placement of class C fly ash via wet sluicing and the saturated condition of the ponded ash, higher end markets like ready-mix concrete are likely limited. With additional handling and

processing (i.e., drying, screening/segregation, etc.), ponded ash can potentially be sourced for cement kiln feedstock and other supplemental beneficial use markets depending on current industry supplies, distance to target markets, competitive market price point, etc. More material characterization and market assessment is required to further evaluate beneficial use potentials for the Pond 003 CCRs.

The technical and logistical challenges of implementing a large-scale ash removal project need to be considered including the removal of CCR with excavations approximately 35-feet deep and CCR removal quantities in excess of 3.6 million cubic yards. Removal activities will be technically challenging and require a comprehensive dewatering and excavation strategy, decant water management, implementation of CCR stabilization methods and temporary staging of material for drying prior to transportation. These aspects of the removal process will affect productivity and must be considered in the planning for the overall removal process and duration. Excavation and construction safety during the removal operation is a major concern due to the use of heavy equipment (bulldozers, excavators, front end loaders, off-road trucks) and trucking/transport operations within the AECl plant site and adjacent to the Mississippi River levee system. Community impacts associated with the use of heavy equipment (equipment delivery, maintenance, etc.) and multi-year truck traffic associated with conveyance of ash removed from Pond 003 and transported to the on-site UWL are also a consideration for this alternative. Based on the volume of material, weather impacts associated with winter and wet weather months, and permitting timeframes associated with construction and operation of the UWL lateral expansions, CBR construction activities are estimated to take approximately 5 to 10 years to complete following initiation of closure and are expected to be completed in approximately 2033.

5. Comparison of Corrective Measures Alternatives

The purpose of this section is to evaluate, compare, and rank the five corrective measures alternatives relative to one another using the balancing criteria described in §257.97.

5.1 EVALUATION CRITERIA

In accordance with §257.97, remedial alternatives that satisfy the threshold criteria are then compared to four balancing (evaluation) criteria. The balancing criteria allow a comparative analysis for each corrective measure, thereby providing the basis for final corrective measure selection. The four balancing criteria include the following:

1. The long- and short-term effectiveness and protectiveness of the potential remedy(s), along with the degree of certainty that the remedy will prove successful;
2. The effectiveness of the remedy in controlling the source to reduce further releases;
3. The ease or difficulty of implementing a potential remedy; and
4. The degree to which community concerns are addressed by a potential remedy.

The fourth balancing criterion (i.e. the degree to which community concerns are addressed by a potential remedy) will be considered following a public information session to be held at least 30 days prior to remedy selection.

5.2 COMPARISON OF ALTERNATIVES

This section compares the alternatives to each other based on evaluation of the balancing criteria listed above. Each of the balancing criteria consists of several sub criteria listed in the CCR Rule which have been considered in this assessment. The goal of this analysis is to evaluate how each of the remedial alternatives are technologically feasible, relevant and readily implementable, provide adequate protection to human health and the environment, and minimizes impacts to the community.

A color-coded graphic (i.e., ribbons which are part of a comprehensive visual comparison tool (referred to as a stop light table with the comprehensive table is provided as **Table II**) is presented within each subsection below. These ribbons and associated stop light table provide a relative comparative snapshot of the favorability for each alternative against the other alternatives, where green represents favorable, yellow represents less favorable, and red represents least favorable.

5.2.1 Balancing Criteria 1 - The Long- and Short-Term Effectiveness and Protectiveness of the Potential Remedy, along with the Degree of Certainty that the Remedy Will Prove Successful

This balancing criterion takes into consideration the following sub criteria relative to the long-term and short-term effectiveness of the remedy, along with the anticipated success of the remedy.

5.2.1.1 *Magnitude of reduction of existing risks*

As summarized in **Section 3**, no unacceptable risk to human health and the environment exists with respect to Pond 003. In spite of no adverse risk being present, compliance with the CCR Rule requires the evaluation of groundwater remedial alternatives (considered in this CMA) to address SSLs of

molybdenum found in groundwater monitoring wells located at the point of compliance around Pond 003. As a result of implementing any of these remedial alternatives, other types of impacts and risks (i.e., the risk of implementing the remedies sometimes referred to as “risk of remedy”) are present to varying degrees.

The remedial alternatives that pose the lowest risk of remedy to human health and the environment are Alternatives 1 (CIP with MNA) and 3 (CIP with HC) as they are implemented on-site and involve the least amount of construction, operations and maintenance activities, the least amount of material removal/large-scale excavation and/or in-situ activities and associated impacts. Alternative 5 (CBR with MNA) has the highest potential impact due to the proximity of Pond 003 to the Mississippi River and levee system, prolonged excavation equipment usage and heavy truck traffic for an extended period of time, which increases the likelihood of roadway accidents during the estimated 5 to 10 years needed to complete material removal. Construction and material transportation will also be required to implement Alternative 2 (CIP with ISS) to support the process of solidifying the CCR. Construction of the treatment system with barrier wall and cap will be required for Alternative 4 (CIP with HC and barrier), along with the management of a generated waste stream, which poses additional risk associated with handling and treatment and the management of treatment byproducts. Comparatively, Alternative 4 (like Alternatives 1 (CIP with MNA) and 3 (CIP with HC)), pose a lesser risk than Alternatives 2 (CIP with ISS) and 5 (CBR with MNA).

	Alternative 1 CIP with Cap & MNA	Alternative 2 CIP with ISS, Cap, & MNA	Alternative 3 CIP with Cap & Hydraulic Containment	Alternative 4 CIP with Cap & Hydraulic Containment & Barrier Wall	Alternative 5 CBR with MNA
Category 1 - Subcriteria i) Magnitude of reduction of risks					

5.2.1.2 Magnitude of residual risks in terms of likelihood of further releases due to CCR remaining following implementation of a remedy

Alternative 5 (CBR with MNA) has the lowest long-term residual risk in that removal of the source material reduces the likelihood of future releases to groundwater. Following the implementation period of this alternative, the CCR material will be disposed in the on-site UWL and managed in accordance with applicable MDNR solid waste permits resulting in a low likelihood of further releases. For Alternatives 1 through 4, Pond 003 would be closed in place with the installation of a low permeability cap that would significantly reduce the infiltration of precipitation into Pond 003, however the CCR would remain in place. Alternatives 3 (CIP with HC) and 4 (CIP with HC and barrier) also provide additional mitigation measures. Due to CCR remaining in place for Alternatives 1 through 4, these alternatives are considered less favorable as compared to Alternative 5 (CBR with MNA) in terms of the likelihood of further releases following implementation.

	Alternative 1 CIP with Cap & MNA	Alternative 2 CIP with ISS, Cap, & MNA	Alternative 3 CIP with Cap & Hydraulic Containment	Alternative 4 CIP with Cap & Hydraulic Containment & Barrier Wall	Alternative 5 CBR with MNA
Category 1 - Subcriteria ii) Magnitude of residual risk in terms of likelihood of further release					

5.2.1.3 The type and degree of long-term management required, including monitoring, operation, and maintenance

Alternatives 1 (CIP with MNA), 2 (CIP with ISS), and 5 (CBR with MNA) are the most favorable alternatives with respect to this criterion because they require the least amount of long-term management and involve no mechanical systems as part of the remedy. Alternatives 1 (CIP with MNA) and 2 (CIP with ISS) will require long-term maintenance of the cover system and sampling during the MNA period. Alternative 5 (CBR with MNA) reduces long-term management at Pond 003, but the transported material will require long-term management at the on-site CCR landfill and groundwater sampling will continue to confirm natural attenuation. The remaining Alternatives 3 (CIP with HC) and 4 (CIP with HC and barrier) are least favorable because they involve more intensive systems to implement and/or maintain throughout their remediation life cycle, including operation of the pumping wells and an ex-situ treatment system.

	Alternative 1 CIP with Cap & MNA	Alternative 2 CIP with ISS, Cap, & MNA	Alternative 3 CIP with Cap & Hydraulic Containment	Alternative 4 CIP with Cap & Hydraulic Containment & Barrier Wall	Alternative 5 CBR with MNA
<i>Category 1 - Subcriteria iii)</i> Type and degree of long-term management required					

5.2.1.4 Short-term risks that might be posed to the community or the environment during implementation of such a remedy

The highest short-term impact posed to the community or environment would be during implementation of Alternative 5 (CBR with MNA), which is considered least favorable. Potential environmental impacts include noise and emissions from heavy equipment, the potential for a release during excavation and construction, and fugitive dust emissions along with associated safety concerns. Community impacts include general impacts to the community due to increased truck traffic on public roads during the entire project duration, including construction of the on-site landfill, along with an increased potential for traffic accidents and fatalities, noise, and truck emissions. In addition, construction adjacent to the Mississippi River levee system has potential to impact levee stability. As noted, Alternative 5 (CBR with MNA) will require a substantial period of time when the CCR material will be open to the environment posing risk during implementation of this remedy.

Alternatives 2 (CIP with ISS) and 4 (CIP with HC and barrier) would include truck traffic to a lesser degree for remedy construction as compared to Alternative 5. The transport of ISS and barrier wall materials to the site make these two alternatives less favorable when compared to Alternatives 1 (CIP with MNA) and 3 (CIP with HC).

For Alternatives 1 (CIP with MNA) and 3 (CIP with HC), risk to the community during implementation is considered the same and would be minimal compared to the other alternatives. Long-term sampling of the monitoring well network to verify treatment system effectiveness will pose no risk to the community.

	Alternative 1 CIP with Cap & MNA	Alternative 2 CIP with ISS, Cap, & MNA	Alternative 3 CIP with Cap & Hydraulic Containment	Alternative 4 CIP with Cap & Hydraulic Containment & Barrier Wall	Alternative 5 CBR with MNA
Category 1 - Subcriteria iv) Short term risk to community or environment during implementation					

5.2.1.5 Time until full protection is achieved

There is currently no unacceptable risk to human health and the environment associated with groundwater at Pond 003; therefore, protection is already achieved. Alternatives 1 (CIP with MNA), 4 (CIP with HC and barrier), and 5 (CBR with MNA) are anticipated to take a similar period of time until natural attenuation or active pumping and controls reduce COCs to GWPS concentrations. These three alternatives are considered comparable due to the similar timeframes for achieving GWPS associated with the low hydraulic gradient and/or reduction in flow associated with a barrier.

Alternative 5, (CBR with MNA), could take approximately 5 to 10 years or greater for construction once implementation begins. This timeframe includes the need to construct lateral expansions at the existing on-site CCR landfill. Removal construction would be followed by a period of groundwater monitoring to verify natural attenuation of the groundwater plume. The period for construction is limited mainly by the construction of the on-site CCR landfill expansions, the amount of material that can be handled per day, and the overall volume of CCR to be handled.

Alternative 3 (CIP with HC) improves the timeframe to achieve GWPS by increasing the hydraulic gradient, but the relative overall timeframe as compared to the Alternatives 1 (CIP with MNA), 4 (CIP with HC and barrier), and 5 (CBR with MNA) is not significantly improved to differentiate this alternative.

Alternative 2 (CIP with ISS) could take the longest amount of time due to the potential of reducing permeability of the upper limit of the aquifer as part of stabilization. Implementation of Alternative 2 (CIP with ISS) would require extensive engineering analysis and field testing. Assuming such studies confirm the viability of ISS technology at Pond 003 and equipment availability, field implementation could take a significant amount of time to implement. This would then be followed by a period of groundwater monitoring to verify natural attenuation of the groundwater plume.

Due to the extended time frame that will be required to achieve the GWPS for Alternatives 1 through 5, these Alternatives were given the same ranking for this balancing sub-criterion.

	Alternative 1 CIP with Cap & MNA	Alternative 2 CIP with ISS, Cap, & MNA	Alternative 3 CIP with Cap & Hydraulic Containment	Alternative 4 CIP with Cap & Hydraulic Containment & Barrier Wall	Alternative 5 CBR with MNA
Category 1 - Subcriteria v) Time until full protection is achieved					

5.2.1.6 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, or containment

Alternatives 1 (CIP with MNA), 3 (CIP with HC), and 4 (CIP with HC and barrier) all have similar, minimal potential for exposure to humans and environmental receptors during regrading and cap construction; monitoring well system installation; and installation of the barrier wall or HC system, respectively.

Alternative 1 (CIP with MNA) is the most favorable alternative since, aside from capping, no additional contact with CCR or impacted groundwater would be needed. A waste stream would be generated from the ex-situ treatment under Alternatives 3 (CIP with HC) and 4 (CIP with HC and barrier) and would need to be managed either onsite or offsite, which creates a potential for exposure/risk/impacts. Therefore, Alternatives 3 and 4 are considered less favorable when compared to Alternative 1.

Alternatives 2 (CIP with ISS) and 5 (CBR with MNA) have moderate and high potential for exposure, respectively, which makes them the least favorable remedy for this criterion. A high potential for exposure exists during the excavation and transport of the CCR if Alternative 5 (CBR with MNA) is implemented. A moderate potential to exposure exists during ISS construction (Alternative 2) if CCR needs to be disposed in the CCR landfill as part of the preliminary removal effort prior to ISS implementation.

	Alternative 1 CIP with Cap & MNA	Alternative 2 CIP with ISS, Cap, & MNA	Alternative 3 CIP with Cap & Hydraulic Containment	Alternative 4 CIP with Cap & Hydraulic Containment & Barrier Wall	Alternative 5 CBR with MNA
Category 1 - Subcriteria vi) Potential for exposure of humans and environmental receptors to remaining wastes					

5.2.1.7 Long-term reliability of the engineering and institutional controls

Alternative 5 (CBR with MNA) engineering and institutional controls would have high long-term reliability because the CCR will have been removed from Pond 003 and placed in the existing on-site CCR landfill. With the CCR no longer in place at Pond 003, no additional engineering and institutional controls are anticipated. Alternative 2 (CIP with ISS) is also expected to have a high long-term reliability because the CCR would be isolated within the ISS monolith. Alternatives 2 and 5 are considered favorable when compared to the other alternatives.

Alternatives 1 (CIP with MNA), 3 (CIP with HC), and 4 (CIP with HC and barrier) are all expected to be reliable, as capping and long-term monitoring are common methods for long-term waste management. However, for Alternative 1 (CIP with MNA) the relationship of the remaining CCR to the fluctuating levels of the Mississippi River without hydraulic controls in place could be considered a potential reduction in long-term reliability, making this alternative less favorable. Alternatives 3 and 4 include HC and ex-situ treatment which are considered proven and reliable technologies but still require bench scale and pilot testing and rely on mechanical systems to operate. Therefore, these two alternatives are considered less favorable when compared to Alternatives 2 and 5.

For Alternatives 1 through 4, which include CIP, institutional controls, such as recording of an environmental covenant restricting the use of groundwater can easily be implemented because Pond 003 is located on property owned by AECl.

	Alternative 1 CIP with Cap & MNA	Alternative 2 CIP with ISS, Cap, & MNA	Alternative 3 CIP with Cap & Hydraulic Containment	Alternative 4 CIP with Cap & Hydraulic Containment & Barrier Wall	Alternative 5 CBR with MNA
Category 1 - Subcriteria vii) Long-term reliability of engineering and institutional controls					

5.2.1.8 Potential need for replacement of the remedy

Closure in place of Pond 003 with ISS (Alternative 2) and closure by removal (Alternative 5) are both considered permanent and can be effective in appropriate circumstances. Detailed engineering assessments would need to be completed including field pilot testing to confirm the viability of such approaches for Pond 003. From the perspective of needing to replace the remedy, source removal (Alternative 5) is permanent but will take 5 to 10 years to complete once implemented. Since both remedies are permanent, Alternatives 2 (CIP with ISS) and 5 (CBR with MNA) are considered favorable.

Alternatives 1 (CIP with MNA), 3 (CIP with HC), and 4 (CIP with HC and barrier) are expected to have permanent closures with capping in place. The groundwater model results indicate that the GWPS will be achieved by all alternatives. Should long-term monitoring results indicate that the selected remedial alternative is not effective at reducing the concentration of COCs over time (or the rate of achieving the GWPS is significantly slower than the forecasted timeline), alternate and/or additional active remedial methods for groundwater may be considered in the future. This in particular applies to Alternative 1 (CIP with MNA) since no hydraulic controls would be in place making it least favorable in this criterion. A potential exists for the need to replace wells, pumping equipment, and treatment system components for Alternatives 3 (CIP with HC) and 4 (CIP with HC and barrier), which make these two alternatives less favorable when compared to Alternatives 2 (CIP with ISS) and 5 (CBR with MNA).

	Alternative 1 CIP with Cap & MNA	Alternative 2 CIP with ISS, Cap, & MNA	Alternative 3 CIP with Cap & Hydraulic Containment	Alternative 4 CIP with Cap & Hydraulic Containment & Barrier Wall	Alternative 5 CBR with MNA
Category 1 - Subcriteria viii) Potential need for replacement of the remedy					

5.2.1.9 Long- and short-term effectiveness and protectiveness criterion summary

The following graphic provides a summary of the long- and short-term effectiveness and protectiveness of the potential remedy, along with the degree of certainty that the remedy will prove successful. Alternative 1 (CIP with MNA) is the most favorable. There is an extended timeframe for all alternatives to meet the GWPS due to the low hydraulic gradient. In addition, Alternative 1 (CIP with MNA) does not include additional treatment technology aside from MNA, and therefore long-term management requirements are minimal. Alternative 1 (CIP with MNA) does not rely on mechanical systems aside from low-permeability capping. Alternatives 3 (CIP with HC) and 4 (CIP with HC and barrier) provide groundwater treatment at the waste boundary but require additional long-term operation and maintenance, generate a secondary waste stream, and rely on mechanical systems to operate. Alternative 5 (CBR with MNA) includes large-scale construction, and a lengthy implementation period, which adds the potential for exposure to humans and the environment during the construction period. Alternative 2 (CIP with ISS) also includes potential exposure to humans and environment during construction, although the construction duration is expected to be shorter than Alternative 5 (CBR with MNA).

	Alternative 1 CIP with Cap & MNA	Alternative 2 CIP with ISS, Cap, & MNA	Alternative 3 CIP with Cap & Hydraulic Containment	Alternative 4 CIP with Cap & Hydraulic Containment & Barrier Wall	Alternative 5 CBR with MNA
CATEGORY 1 Long- and Short Term Effectiveness, Protectiveness, and Certainty of Success					

5.2.2 Balancing Criteria 2 - The Effectiveness of the Remedy in Controlling the Source to Reduce Further Releases

This balancing criterion takes into consideration the ability of the remedy to control a future release, and the extensiveness of treatment technologies that will be required.

5.2.2.1 *The extent to which containment practices will reduce further releases*

For remedial Alternatives 1 through 4, installation of the low permeability cap will reduce the infiltration of precipitation into Pond 003 and decrease the flux of molybdenum to groundwater over time. Groundwater mounding, and associated outward hydraulic gradient, present at Pond 003 during operation is expected to be reduced during the final operational period and dissipate after closure. Alternatives 3 (CIP with HC) and 4 (CIP with HC and barrier) are considered favorable because active ex-situ treatment technologies will be implemented to limit further down-gradient migration of molybdenum in groundwater prior to closure.

Under Alternatives 2 (CIP with ISS) and 5 (CBR with MNA), no further releases are anticipated following removal or stabilization of the CCR material. However, the implementation of Alternative 2 (CIP with ISS) is anticipated to require multiple years to complete with MNA monitoring following completion of construction. The potential hydrogeological impacts from a large stabilization project due to alterations to the geochemical conditions from the additives and mixing process differentiate this alternative from Alternative 5 (CBR with MNA).

For Alternatives 3 (CIP with HC) and 4 (CIP with HC and barrier), additional containment or treatment practices will address COCs in groundwater migrating downgradient from Pond 003, achieving the performance criteria at the waste boundary. Alternative 1 will not have an additional containment technology beyond natural attenuation making this less favorable in terms of overall containment under this criterion.

	Alternative 1 CIP with Cap & MNA	Alternative 2 CIP with ISS, Cap, & MNA	Alternative 3 CIP with Cap & Hydraulic Containment	Alternative 4 CIP with Cap & Hydraulic Containment & Barrier Wall	Alternative 5 CBR with MNA
Category 2 - Subcriteria i) Extent to which containment practices will reduce further releases					

5.2.2.2 *The extent to which treatment technologies may be used*

No groundwater treatment technologies, other than source isolation through capping and natural attenuation, will be used for Alternatives 1 (CIP with MNA) and 5 (CBR with MNA). There would be no ongoing operation and maintenance of a treatment technology, other than periodic groundwater monitoring. Alternative 1 (CIP with MNA) relies only on low-permeability capping with long-term groundwater monitoring, while Alternative 5 relies on source removal with groundwater monitoring to confirm natural attenuation. Both alternatives are considered favorable for this criterion.

Alternative 2 (CIP with ISS) uses solidification of the CCR below the water table to address COCs in groundwater, which adds to the complexity as compared to Alternative 1 (CIP with MNA). Capping will be required following completion of ISS. Therefore, this alternative is considered less favorable when compared to Alternatives 1 and 5.

Alternatives 3 (CIP with HC) and 4 (CIP with HC and barrier) will use two additional technologies, hydraulic controls via pumping and ex-situ treatment. Alternative 4 (CIP with HC and barrier) includes an additional technology for the barrier wall. The operation of an ex-situ treatment system will create a secondary waste stream, such as concentrated reject water (RO) requiring off-site disposal, or depleted resin (ion exchange) requiring regeneration or off-site disposal. Due to additional treatment technologies required, these two alternatives are considered less favorable when compared to Alternatives 1 and 5.

	Alternative 1 CIP with Cap & MNA	Alternative 2 CIP with ISS, Cap, & MNA	Alternative 3 CIP with Cap & Hydraulic Containment	Alternative 4 CIP with Cap & Hydraulic Containment & Barrier Wall	Alternative 5 CBR with MNA
<i>Category 2 - Subcriteria ii</i> Extent to which treatment technologies may be used					

5.2.2.3 Effectiveness of the remedy in controlling the source to reduce further releases summary

The graphic below provides a summary of the effectiveness of the remedial alternatives to control the source to reduce further releases. Further releases from Alternative 5 (CBR with MNA) will not be addressed until construction is complete, but there is no further potential for release in the long-term making this the most favorable alternative. Alternatives 1 (CIP with MNA), 3 (CIP with HC), and 4 (CIP with HC and barrier) are less favorable either due to the moderate degree of effectiveness in controlling further releases or due to the amount of technologies included. Further releases under Alternative 2 (CIP with ISS) will not be addressed until construction is complete and the complexity of the stabilization makes this alternative less favorable.

	Alternative 1 CIP with Cap & MNA	Alternative 2 CIP with ISS, Cap, & MNA	Alternative 3 CIP with Cap & Hydraulic Containment	Alternative 4 CIP with Cap & Hydraulic Containment & Barrier Wall	Alternative 5 CBR with MNA
CATEGORY 2 Effectiveness in controlling the source to reduce further releases					

5.2.3 Balancing Criteria 3 - The Ease or Difficulty of Implementing a Potential Remedy

This balancing criterion takes into consideration technical and logistical challenges required to implement a remedy, including practical considerations such as equipment availability and disposal facility capacity.

5.2.3.1 Degree of difficulty associated with constructing the technology

CIP with a low permeability cap will be straightforward and can be implemented with common construction methods for Alternatives 1 (CIP with MNA), 3 (CIP with HC), and 4 (CIP with HC and barrier). Typical/Normal construction difficulties are anticipated if Alternatives 1, 3, or 4 are implemented with Alternative 4 being the most complex of these noted alternatives. Specialty equipment or contractors are not required. For Alternative 1 (CIP with MNA), no additional treatment technology is needed other than monitoring wells for groundwater monitoring. Installation of groundwater pumping wells with an ex-situ treatment system (Alternative 3) is expected to be straightforward. Alternative 4 is more complex with the addition of the barrier wall and is considered less favorable.

Alternatives 2 (CIP with ISS) and 5 (CBR with MNA) will be difficult to implement due to technical and logistical challenges. Alternative 5 will include a deep excavation and require the excavation of a substantial volume of CCR materials, dewatering, CCR stabilization, seasonal impacts to construction due to wet weather and winter weather, and transportation. In addition, the excavation of CCR materials proximate to the USACE Mississippi River levee system will require additional diligence and controls to ensure levee stability. For the CCR disposal in on-site lateral expansion of the CCR landfill for Alternative 5 (CBR with MNA), additional effort will be required for the design, permitting, approval, and construction. Under Alternative 2 (CIP with ISS), the successful completion of ISS to target depths will be technically challenging and will require field pilot testing to confirm equipment reach and stabilizing mix. Stabilization work adjacent to the levee system also has a high degree of difficulty, but overall has less material movement when compared to Alternative 5 (CBR with MNA). Alternatives 2 and 5 will both include large-scale construction, extensive permitting, specialty equipment and contractors, longer project durations, and significant technical challenges. Therefore, these Alternatives 2 and 5 are least favorable when compared to Alternatives 1, 3, and 4.

	Alternative 1 CIP with Cap & MNA	Alternative 2 CIP with ISS, Cap, & MNA	Alternative 3 CIP with Cap & Hydraulic Containment	Alternative 4 CIP with Cap & Hydraulic Containment & Barrier Wall	Alternative 5 CBR with MNA
Category 3 - Subcriteria i) Degree of difficulty associated with constructing the technology					

5.2.3.2 Expected operational reliability of the technologies

Alternative 1, (CIP with MNA) is considered the most favorable from an operational perspective because capping with MNA has a proven track record and requires limited O&M. While alternative 2 (CIP with ISS) is a proven technology and isolates the ponded material, pilot testing would be required to ensure ISS will be able to solidify CCR at depth. The potential for geochemical impact on the groundwater aquifer from the solidification amendments would need to be evaluated. Assuming successful implementation, ISS is also expected to be operationally reliable and is considered favorable. Alternative 5 (CBR with MNA) is considered a reliable alternative as all CCR material would be removed, although implementation would be challenging. Alternatives 3 (CIP with HC) and 4 (CIP with HC and barrier) are expected to be reliable but will utilize additional groundwater treatment technologies that will require significant O&M and will rely on mechanical systems to operate. Therefore, Alternatives 3 (CIP with HC) and 4 (CIP with HC and barrier) are considered less favorable.

	Alternative 1 CIP with Cap & MNA	Alternative 2 CIP with ISS, Cap, & MNA	Alternative 3 CIP with Cap & Hydraulic Containment	Alternative 4 CIP with Cap & Hydraulic Containment & Barrier Wall	Alternative 5 CBR with MNA
Category 3 - Subcriteria ii) Expected operational reliability of the technologies					

5.2.3.3 Need to coordinate with and obtain necessary approvals and permits from other agencies

Alternative 1, (CIP with MNA), is the most favorable since the implementation of the remedy is straightforward and only includes capping and MNA with minimal permitting needs. Alternatives 2 (CIP with ISS) and 4 (CIP with HC and barrier) will require extensive permitting for large-scale construction in below grade soils adjacent to the levee system) and are considered least favorable.

Alternative 5 (CBR with MNA) also will require permitting for the excavation of CCR adjacent to the levee system. The associated lateral expansion of the existing CCR landfill will require a moderate amount of regulating agency interaction, but a solid waste permit already exists for the UWL expansions. The agency will need to approve the construction efforts of the lateral expansions. This alternative is considered less favorable when compared to Alternative 1 (CIP with MNA).

Additional approval and permitting may be required for Alternative 3 (CIP with HC) for the construction and installation of treatment systems and discharge of treated groundwater, but not to the extent contemplated for Alternatives 2 (CIP with ISS) and 4 (CIP with HC and barrier).

	Alternative 1 CIP with Cap & MNA	Alternative 2 CIP with ISS, Cap, & MNA	Alternative 3 CIP with Cap & Hydraulic Containment	Alternative 4 CIP with Cap & Hydraulic Containment & Barrier Wall	Alternative 5 CBR with MNA
Category 3 - Subcriteria iii) Need to coordinate with and obtain necessary approvals and permits from other agencies					

5.2.3.4 Availability of necessary equipment and specialists

Alternative 1, (CIP with MNA), is the most favorable since specialty equipment and specialists will not be required to implement the capping or MNA remedy. Alternative 3 (CIP with HC) also consists of well understood and routine treatment systems. Alternative 4 (CIP with HC and barrier) also includes well understood and routine treatment systems but does require the availability of necessary equipment for the barrier wall construction, so this alternative is less favorable than Alternatives 1 and 3.

Alternatives 2 (CIP with ISS) and 5 (CBR with MNA) are the least favorable since both will require specialty remediation contractors to implement full removal or ISS, respectively, which will include large-scale construction dewatering and effluent management and treatment, deep excavations adjacent to the river and levee system, transportation of material for disposal, and implementation of ISS at depth (for Alternative 2 only). These two alternatives are considered the least favorable.

	Alternative 1 CIP with Cap & MNA	Alternative 2 CIP with ISS, Cap, & MNA	Alternative 3 CIP with Cap & Hydraulic Containment	Alternative 4 CIP with Cap & Hydraulic Containment & Barrier Wall	Alternative 5 CBR with MNA
Category 3 - Subcriteria iv) Availability of necessary equipment and specialists					

5.2.3.5 Available capacity and location of needed treatment, storage, and disposal services

Since Pond 003 will be closed in place for Alternatives 1 through 4, storage and disposal services for CCR material will not be needed. Temporary stockpiling of CCR during regrading and capping can be completed within the current boundaries of the CCR unit. Alternative 1 (CIP with MNA) is the most favorable alternative since no active treatment is needed. Likewise, Alternative 2 (CIP with ISS) does not require any treatment or disposal capacity. It is assumed that any excavated/relocated CCR for the ISS construction would be used in developing final grades of the closure in place. If needed, the existing CCR landfill has capacity to dispose of any necessary CCR materials. Amendments such as Portland Cement will be imported to solidify the material in-situ, with the expectation that Portland Cement will be readily available.

Both Alternatives 3 (CIP with HC) and 4 (CIP with HC and barrier) require treatment systems which do not currently exist at the facility. The ex-situ treatment system may generate a concentrated waste stream which would require onsite treatment or off-site transportation and disposal that the other alternatives would not require. With the treatment system waste stream, Alternatives 3 and 4 are considered less favorable when compared to Alternatives 1 and 2.

Alternative 5 (CBR with MNA) required an evaluation of available capacity at existing CCR landfill. The existing on-site landfill was designed and permitted to manage ongoing production at the NMPP and not ponded CCR material. For Alternative 5 (CBR with MNA), new lateral expansions of the on-site landfill would need to be designed, constructed, and approved since the existing on-site landfills were designed and permitted to manage production needs of the NMPP. Alternative 5 is considered less favorable than Alternatives 1 and 2 since it requires extensive handling, and disposal management of CCR.

	Alternative 1 CIP with Cap & MNA	Alternative 2 CIP with ISS, Cap, & MNA	Alternative 3 CIP with Cap & Hydraulic Containment	Alternative 4 CIP with Cap & Hydraulic Containment & Barrier Wall	Alternative 5 CBR with MNA
<i>Category 3 - Subcriteria v)</i> Available capacity and location of needed treatment, storage, and disposal services					

5.2.3.6 *Ease or difficulty of implementation summary*

The color ribbon below provides a summary of the ease or difficulty that will be needed to implement each alternative. Alternative 1 (CIP with MNA) is the most favorable, while Alternatives 3 and 4 are considered less favorable with moderate degrees of difficulty in implementing the remedy. Alternatives 2 and 5 have significant degrees of difficulty related to large-scale construction and permitting and are therefore considered least favorable.

	Alternative 1 CIP with Cap & MNA	Alternative 2 CIP with ISS, Cap, & MNA	Alternative 3 CIP with Cap & Hydraulic Containment	Alternative 4 CIP with Cap & Hydraulic Containment & Barrier Wall	Alternative 5 CBR with MNA
CATEGORY 3 The ease or difficulty of implementation					

6. Summary

This Corrective Measures Assessment has evaluated the following alternatives:

- Alternative 1: CIP with low permeability capping and MNA;
- Alternative 2: CIP with ISS, low permeability capping and MNA;
- Alternative 3: CIP with low permeability capping, HC of groundwater through groundwater pumping, and ex-situ groundwater treatment;
- Alternative 4: CIP with low permeability capping, HC of groundwater through groundwater pumping, ex-situ groundwater treatment, and barrier wall; and
- Alternative 5: CBR with MNA.

In accordance with §257.97, each of these alternatives has been evaluated in the context of the following threshold criteria:

- Be protective of human health and the environment;
- Attain the GWPS;
- Control the source(s) of releases so as to reduce or eliminate, to the maximum extent feasible, further releases of COCs to the environment;
- Remove from the environment as much of the contaminated material that was released from the CCR unit as is feasible, considering factors such as avoiding inappropriate disturbance of sensitive ecosystems; and
- Comply with standards (regulations) for waste management.

In addition, in accordance with §257.96, each of the alternatives has been evaluated in the context of the following balancing criteria, noting that these balancing criteria consider the sub-criteria evaluation factors of §257.97(c):

- The performance, reliability, ease of implementation, and potential impacts of appropriate potential remedies, including safety impacts, cross-media impacts, and control of exposure to residual contamination;
- The time required to complete the remedy; and
- 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.

This Corrective Measures Assessment, and the degree to which public comments are addressed, will be used to identify and select a final corrective measure for implementation at Pond 003. AECI understands that risk assessment evaluations confirm that Pond 003, even prior to closure, presents no unacceptable risk to human health or the environment. Therefore, since no adverse risk currently exists to human health and the environment, implementation of any of the remedies must consider the risk incurred during the implementation of the potential remedy activities.

In accordance with §257.98, AECI will implement a groundwater monitoring program to document the effectiveness of the selected remedial alternative. Corrective measures are considered complete when monitoring reflects groundwater downgradient of Pond 003 does not exceed Appendix IV GWPS for three consecutive years. USEPA is in the process of modifying certain CCR Rule requirements and,

depending upon the nature of such changes, assessments made herein could be modified or supplemented to reflect such future regulatory revisions.

References

1. Burns & McDonnell, 2006. Burns & McDonnell, Utility Waste Landfill Construction Permit Application for Associated Electric Cooperative, Inc., January 2006.
2. Gredell Engineering Resources, Inc., 2003. Detailed Site Investigation Work Plan, Proposed AECI New Madrid Utility Waste Landfill. 13 June.
3. Miller and Vandike, 1997. Miller, Don E., and Vandike, James E., *Missouri State Water Plan Series Volume II, Groundwater Resources of Missouri*, Missouri Department of Natural Resources Division of Geology and Land Survey, Water Resources Report No. 46., 1997.
4. Haley & Aldrich, 2019. Statistical Data Analysis Plan for Associated Electric Cooperative, Inc., April 2019.
5. NAS. 2001. Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc. Institute of Medicine. National Academy of Sciences. 2001. National Academy Press. Available at: <http://www.nap.edu/catalog/10026.html>.
6. Office of Nuclear Waste Isolation (ONWI), 1982. Gulf Coast Salt Domes Geologic Area Characterization Report Mississippi Study Area, Volume VI Technical Report.
7. USEPA. 1989. Risk Assessment Guidance for Superfund: Volume I. Human Health Evaluation Manual (Part A). Interim Final. Office of Emergency and Remedial Response. U.S. Environmental Protection Agency, Washington, D.C. EPA 540/1-89/002. Available at: <http://www.epa.gov/oswer/riskassessment/ragsa>
8. USEPA. 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities – Unified Guidance.
9. USEPA. 2015. Frequent Questions about the 2015 Coal Ash Disposal Rule. <https://www.epa.gov/coalash/frequent-questions-about-2015-coal-ash-disposal-rule>
10. USEPA. 2015a. Final Rule: Disposal of Coal Combustion Residuals (CCRs) for Electric Utilities. 80 FR 21301-21501. U.S. Environmental Protection Agency, Washington, D.C. Available at: <https://www.govinfo.gov/content/pkg/FR-2015-04-17/pdf/2015-00257.pdf>
11. USEPA. 2015b. Use of Monitored Natural Attenuation for Inorganic Contaminants in Groundwater at Superfund Sites.
12. USEPA. 2018a. USEPA Regional Screening Levels. November 2018, values for tapwater. U.S. Environmental Protection Agency. Available at: <https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables>

TABLES

TABLE I
SUMMARY OF ANALYTICAL RESULTS
 Corrective Measures Assessment
 AECl New Madrid Power Plant
 New Madrid, Missouri

Location	Sample Date	USEPA Appendix IV Constituents															
		Antimony, Total mg/l	Arsenic, Total mg/l	Barium, Total mg/l	Beryllium, Total mg/l	Cadmium, Total mg/l	Chromium, Total mg/l	Cobalt, Total mg/l	Lead, Total mg/l	Lithium, Total mg/l	Molybdenum, Total mg/l	Selenium, Total mg/l	Thallium, Total mg/l	Mercury, Total mg/l	Fluoride, Total mg/l	Radium-226 & 228 Combined pCi/L	
	<i>Site GWPS</i>	<i>0.006</i>	<i>0.010</i>	<i>2.0</i>	<i>0.004</i>	<i>0.005</i>	<i>0.100</i>	<i>0.006</i>	<i>0.015</i>	<i>0.040</i>	<i>0.100</i>	<i>0.050</i>	<i>0.002</i>	<i>0.002</i>	<i>4.0</i>	<i>5</i>	
Up Gradient	MW-16	11/2/2016	<0.0010	0.0026	0.773	<0.0010	<0.0010	<0.0010	<0.0050	<0.0010	0.026	<0.0100	<0.0010	<0.0010	<0.00020	1.22	1.85
		12/9/2016	<0.0010	0.0029	0.783	<0.0010	<0.0010	<0.0010	<0.0050	<0.0010	0.027	<0.0100	<0.0010	<0.0010	<0.00020	1.37	0.98
		1/7/2017	<0.0030	0.0027	0.800	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.033	<0.0010	<0.0010	<0.0010	<0.00020	1.10	2.34
		1/30/2017	<0.0030	0.0026	0.730	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.030	<0.0010	<0.0010	<0.0010	<0.00020	1.55	1.78
		2/21/2017	<0.0030	0.0025	0.760	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.031	<0.0010	<0.0010	<0.0010	<0.00020	1.18	1.16
		3/28/2017	<0.0030	0.0025	0.760	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.031	<0.0010	<0.0010	<0.0010	<0.00020	1.44	2.33
		4/27/2017	<0.0030	0.0025	0.760	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.030	<0.0010	<0.0010	<0.0010	<0.00020	1.38	1.84
		5/18/2017	<0.0030	0.0027	0.750	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.033	<0.0010	<0.0010	<0.0010	<0.00020	1.59	1.93
		6/24/2017	<0.0030	0.0020	0.720	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.030	<0.0010	<0.0010	<0.0010	<0.00020	1.18	1.79
		8/15/2017	<0.0030	0.0021	0.700	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.033	<0.0010	<0.0010	<0.0010	<0.00020	1.27	1.4
	5/30/2018	<0.0030	0.0020	0.72	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.025	0.0045	<0.0010	<0.0010	<0.00020	1.20	2.60	
	9/12/2018	--	0.0023	0.69	--	--	<0.0040	<0.00086	<0.0010	0.019	<0.0010	<0.0010	--	--	1.20	2.78	
	B-123	11/6/2016	<0.0010	0.0024	0.239	<0.0010	<0.0010	<0.0010	<0.0050	<0.0010	0.0276	<0.0100	<0.0010	<0.0010	<0.00020	0.52	0.97
		12/12/2016	<0.0010	0.0011	0.206	<0.0010	<0.0010	<0.0010	<0.0050	<0.0010	0.0274	<0.0100	<0.0010	<0.0010	<0.00020	0.57	0.71
		1/8/2017	<0.0030	0.0014	0.21	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.033	0.0030	<0.0010	<0.0010	<0.00020	0.446	0.641
		1/24/2017	<0.0030	0.0017	0.20	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.032	0.0035	<0.0010	<0.0010	0.00087	0.523	1.06
		2/23/2017	<0.0030	0.0023	0.22	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.031	0.0036	<0.0010	<0.0010	<0.00020	0.540	1.37
		4/25/2017	<0.0030	0.0025	0.24	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.029	0.0036	<0.0010	<0.0010	<0.00020	0.532	0.83
		5/16/2017	<0.0030	0.0020	0.21	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.030	0.0036	<0.0010	<0.0010	<0.00020	0.302	1.35
		6/21/2017	<0.0030	0.0017	0.19	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.029	0.0036	<0.0010	<0.0010	<0.00020	0.429	0.668
		8/28/2017	<0.0030	0.0020	0.20	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.029	0.0034	<0.0010	<0.0010	<0.00020	0.574	1.93
		5/30/2018	<0.0030	0.0022	0.21	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.026	0.0044	<0.0010	<0.0010	<0.00020	0.537	1.80
	9/11/2018	--	0.0040	0.27	--	--	<0.0040	<0.00086	<0.0010	0.019	0.0040	<0.0010	--	--	0.521	1.57	
	B-126	11/6/2016	<0.0010	0.0099	0.400	<0.0010	<0.0010	<0.0010	<0.0050	<0.0010	0.0159	<0.0100	<0.0010	<0.0010	<0.00020	0.39	0.70
		12/12/2016	<0.0010	0.0076	0.447	<0.0010	<0.0010	0.0013	<0.0050	<0.0010	0.0244	<0.0100	<0.0010	<0.0010	<0.00020	0.39	1.11
		1/8/2017	<0.0030	0.0063	0.250	<0.0010	<0.0010	<0.0040	0.0020	0.0011	0.016	<0.0010	<0.0010	<0.0010	<0.00020	0.376	0.342
		1/24/2017	<0.0030	0.0050	0.23	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.013	<0.0010	<0.0010	<0.0010	<0.00020	0.457	0
		2/23/2017	<0.0030	0.0067	0.28	<0.0010	<0.0010	<0.0040	0.0021	<0.0010	0.015	<0.0010	<0.0010	<0.0010	<0.00020	0.525	1.16
		4/25/2017	<0.0030	0.0084	0.21	<0.0010	<0.0010	0.0047	0.0026	0.0020	0.013	<0.0010	<0.0010	<0.0010	<0.00020	0.388	1.27
		5/16/2017	<0.0030	0.0085	0.13	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	<0.010	<0.0010	<0.0010	<0.0010	<0.00020	0.258	1.83
6/21/2017		<0.0030	0.0094	0.16	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	<0.010	<0.0010	<0.0010	<0.0010	<0.00020	0.398	0.51	
8/28/2017		<0.0030	0.0097	0.21	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.010	<0.0010	<0.0010	<0.0010	<0.00020	0.493	2.01	
5/30/2018		<0.0030	0.0086	0.24	<0.0010	<0.0010	0.0094	0.0030	0.0043	0.013	0.0014	0.0012	<0.0010	<0.00020	0.383	2.20	
9/11/2018	--	0.0052	0.31	--	--	<0.0040	0.0019	<0.0010	0.011	<0.0010	<0.0010	--	--	0.284	1.13		

TABLE I
SUMMARY OF ANALYTICAL RESULTS
 Corrective Measures Assessment
 AECl New Madrid Power Plant
 New Madrid, Missouri

Location	Sample Date	USEPA Appendix IV Constituents														
		Antimony, Total mg/l	Arsenic, Total mg/l	Barium, Total mg/l	Beryllium, Total mg/l	Cadmium, Total mg/l	Chromium, Total mg/l	Cobalt, Total mg/l	Lead, Total mg/l	Lithium, Total mg/l	Molybdenum, Total mg/l	Selenium, Total mg/l	Thallium, Total mg/l	Mercury, Total mg/l	Fluoride, Total mg/l	Radium-226 & 228 Combined pCi/L
		<i>Site GWPS</i>	<i>0.006</i>	<i>0.010</i>	<i>2.0</i>	<i>0.004</i>	<i>0.005</i>	<i>0.100</i>	<i>0.006</i>	<i>0.015</i>	<i>0.040</i>	<i>0.100</i>	<i>0.050</i>	<i>0.002</i>	<i>0.002</i>	<i>4.0</i>
MW-6	11/3/2016	<0.0010	<0.0010	0.131	<0.0010	<0.0010	<0.0010	<0.0050	<0.0010	0.0168	<0.0100	<0.0010	<0.0010	<0.00020	0.36	0.77
	11/3/2016	<0.0010	<0.0010	0.134	<0.0010	<0.0010	<0.0010	<0.0050	<0.0010	0.0173	<0.0100	<0.0010	<0.0010	<0.00020	0.36	0.74
	12/6/2016	<0.0010	0.0022	0.137	<0.0010	<0.0010	0.0022	<0.0050	<0.0010	0.0181	0.0417	<0.0010	<0.0010	<0.00020	0.32	1.56
	1/4/2017	<0.0030	0.0012	0.14	<0.0010	<0.0010	<0.0040	0.0036	<0.0010	0.023	0.046	<0.0010	<0.0010	<0.00020	0.536	1.26
	1/26/2017	<0.0030	0.0019	0.16	<0.0010	<0.0010	<0.0040	0.0033	<0.0010	0.021	0.071	<0.0010	<0.0010	<0.00020	0.564	1.92
	2/21/2017	<0.0030	0.0010	0.16	<0.0010	<0.0010	<0.0040	0.0047	<0.0010	0.021	0.034	<0.0010	<0.0010	<0.00020	0.308	1.07
	3/28/2017	<0.0030	<0.0010	0.17	<0.0010	<0.0010	<0.0040	0.0046	<0.0010	0.022	0.033	<0.0010	<0.0010	<0.00020	0.519	1.09
	4/27/2017	<0.0030	0.0016	0.18	<0.0010	<0.0010	<0.0040	0.0041	<0.0010	0.019	0.085	<0.0010	<0.0010	<0.00020	0.328	1.33
	4/27/2017	<0.0030	0.0014	0.17	<0.0010	<0.0010	<0.0040	0.0040	<0.0010	0.018	0.080	<0.0010	<0.0010	<0.00020	0.314	1.34
	5/18/2017	<0.0030	<0.0010	0.18	<0.0010	<0.0010	<0.0040	0.0050	<0.0010	0.023	0.048	<0.0010	<0.0010	<0.00020	<0.250	1.05
	6/20/2017	<0.0030	0.0012	0.16	<0.0010	<0.0010	<0.0040	0.0054	<0.0010	0.022	0.021	0.0010	<0.0010	<0.00020	0.362	2.39
8/16/2017	<0.0030	<0.0010	0.15	<0.0010	<0.0010	<0.0040	0.0060	<0.0010	0.024	0.010	<0.0010	<0.0010	<0.00020	0.316	1.65	
5/30/2018	<0.0030	<0.0010	0.16	<0.0010	<0.0010	<0.0040	0.0052	<0.0010	0.018	0.063	<0.0010	<0.0010	<0.00020	0.349	0.68	
9/11/2018	--	<0.0010	0.11	--	--	<0.0040	0.0028	<0.0010	<0.010	0.042	<0.0010	--	--	0.319	0.790	
MW-7	11/3/2016	<0.0010	0.0021	0.181	<0.0010	<0.0010	<0.0010	0.0062	<0.0010	0.0223	3.20	<0.0010	<0.0010	<0.00020	0.34	1.13
	12/6/2016	<0.0010	0.0032	0.150	<0.0010	0.0011	<0.0010	0.0098	<0.0010	0.0227	3.24	<0.0010	<0.0010	<0.00020	0.33	1.10
	1/4/2017	<0.0030	0.0045	0.11	<0.0010	0.0012	<0.0040	0.0067	<0.0010	0.031	2.8	<0.0010	<0.0010	<0.00020	0.464	1.28
	1/26/2017	<0.0030	0.0036	0.12	<0.0010	0.0016	<0.0040	0.0059	<0.0010	0.027	2.9	<0.0010	<0.0010	<0.00020	0.564	0.78
	2/22/2017	<0.0030	0.0021	0.15	<0.0010	<0.0010	<0.0040	0.0068	<0.0010	0.030	3.4	<0.0010	<0.0010	<0.00020	0.287	3.80
	3/30/2017	<0.0030	0.0018	0.15	<0.0010	<0.0010	<0.0040	0.0067	<0.0010	0.028	3.4	<0.0010	<0.0010	<0.00020	0.496	1.40
	4/26/2017	<0.0030	0.0034	0.14	<0.0010	0.0014	<0.0040	0.0051	<0.0010	0.027	3.9	<0.0010	<0.0010	<0.00020	0.277	1.73
	5/18/2017	<0.0030	0.0037	0.14	<0.0010	<0.0010	<0.0040	0.0030	<0.0010	0.034	3.9	<0.0010	<0.0010	<0.00020	<0.250	2.72
	6/20/2017	<0.0030	0.0028	0.15	<0.0010	0.0016	<0.0040	0.0070	0.0018	0.028	3.5	0.0021	0.0020	<0.00020	0.388	1.71
	8/16/2017	<0.0030	0.0020	0.17	<0.0010	<0.0010	<0.0040	0.0073	<0.0010	0.031	3.6	<0.0010	<0.0010	<0.00020	0.410	1.54
	5/30/2018	<0.0030	0.0023	0.13	<0.0010	<0.0010	<0.0040	0.0058	<0.0010	0.019	3.4	<0.0010	<0.0010	<0.00020	0.431	0.63
9/11/2018	--	0.0024	0.14	--	--	<0.0040	0.0076	<0.0010	0.014	3.0	<0.0010	--	--	0.330	1.36	
MW-8	11/4/2016	<0.0010	0.0040	0.115	<0.0010	<0.0010	<0.0010	<0.0050	<0.0010	0.0197	0.737	<0.0010	<0.0010	<0.00020	0.29	1.36
	12/7/2016	<0.0010	0.0026	0.111	<0.0010	<0.0010	<0.0010	<0.0050	<0.0010	0.0223	0.706	<0.0010	<0.0010	<0.00020	0.29	1.46
	1/5/2017	<0.0030	0.0046	0.066	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.023	0.96	<0.0010	<0.0010	<0.00020	0.366	0.56
	1/5/2017	<0.0030	0.0049	0.068	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.023	0.96	<0.0010	<0.0010	<0.00020	0.367	2.82
	1/26/2017	<0.0030	0.0045	0.085	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.022	0.87	<0.0010	<0.0010	<0.00020	0.538	0.822
	2/21/2017	<0.0030	0.0057	0.10	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.025	0.83	<0.0010	<0.0010	<0.00020	0.288	2.29
	3/30/2017	<0.0030	0.0054	0.11	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.025	0.83	<0.0010	<0.0010	<0.00020	0.475	1.35
	4/26/2017	<0.0030	0.0050	0.082	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.018	1.0	<0.0010	<0.0010	<0.00020	0.300	1.01
	5/17/2017	<0.0030	0.0062	0.098	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.022	1.2	<0.0010	<0.0010	<0.00020	0.348	1.43
	6/21/2017	<0.0030	0.0060	0.10	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.022	0.93	<0.0010	<0.0010	<0.00020	0.361	1.42
	8/16/2017	<0.0030	0.0048	0.10	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.025	1.0	<0.0010	<0.0010	<0.00020	0.376	0.91
5/30/2018	<0.0030	0.0053	0.082	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.017	0.93	<0.0010	<0.0010	<0.00020	0.343	1.07	
9/12/2018	--	0.0045	0.082	--	--	<0.0040	0.0016	<0.0010	0.012	0.86	<0.0010	--	--	0.290	0.840	

TABLE I
SUMMARY OF ANALYTICAL RESULTS
 Corrective Measures Assessment
 AECI New Madrid Power Plant
 New Madrid, Missouri


Location	Sample Date	USEPA Appendix IV Constituents															
		Antimony, Total mg/l	Arsenic, Total mg/l	Barium, Total mg/l	Beryllium, Total mg/l	Cadmium, Total mg/l	Chromium, Total mg/l	Cobalt, Total mg/l	Lead, Total mg/l	Lithium, Total mg/l	Molybdenum, Total mg/l	Selenium, Total mg/l	Thallium, Total mg/l	Mercury, Total mg/l	Fluoride, Total mg/l	Radium-226 & 228 Combined pCi/L	
	<i>Site GWPS</i>	<i>0.006</i>	<i>0.010</i>	<i>2.0</i>	<i>0.004</i>	<i>0.005</i>	<i>0.100</i>	<i>0.006</i>	<i>0.015</i>	<i>0.040</i>	<i>0.100</i>	<i>0.050</i>	<i>0.002</i>	<i>0.002</i>	<i>4.0</i>	<i>5</i>	
Down Gradient	MW-9	11/4/2016	<0.0010	<0.0010	0.0984	<0.0010	<0.0010	<0.0010	<0.0050	<0.0010	0.0258	0.312	<0.0010	<0.0010	<0.00020	0.53	3.12
		12/7/2016	<0.0010	<0.0010	0.0842	<0.0010	<0.0010	<0.0010	<0.0050	<0.0010	0.0296	0.337	0.0015	<0.0010	<0.00020	0.49	1.40
		1/5/2017	<0.0030	<0.0010	0.075	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.034	0.32	<0.0010	<0.0010	<0.00020	0.508	1.56
		1/27/2017	<0.0030	<0.0010	0.072	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.030	0.35	<0.0010	<0.0010	<0.00020	0.557	0.53
		2/21/2017	<0.0030	<0.0010	0.089	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.031	0.33	<0.0010	<0.0010	<0.00020	0.481	1.47
		3/30/2017	<0.0030	<0.0010	0.080	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.030	0.33	<0.0010	<0.0010	<0.00020	0.654	1.42
		4/26/2017	<0.0030	<0.0010	0.069	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.025	0.42	<0.0010	<0.0010	<0.00020	0.481	0.65
		5/17/2017	<0.0030	<0.0010	0.098	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.034	0.44	<0.0010	<0.0010	<0.00020	<0.250	1.30
		6/20/2017	<0.0030	<0.0010	0.092	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.029	0.36	<0.0010	<0.0010	<0.00020	0.507	0.71
		6/20/2017	<0.0030	<0.0010	0.092	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.030	0.35	<0.0010	<0.0010	<0.00020	0.528	0.46
	8/16/2017	<0.0030	<0.0010	0.097	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.035	0.35	<0.0010	<0.0010	<0.00020	0.561	0.98	
	5/30/2018	<0.0030	<0.0010	0.089	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.026	0.34	<0.0010	<0.0010	<0.00020	0.496	0.599	
	9/12/2018	--	<0.0010	0.074	--	--	<0.0040	<0.00086	<0.0010	0.021	0.34	<0.0010	--	--	0.440	0.216	
	P-1	11/5/2016	<0.0010	<0.0010	0.0533	<0.0010	<0.0010	<0.0010	<0.0050	<0.0010	0.0221	0.0194	0.0014	<0.0010	<0.00020	0.38	1.48
		12/8/2016	<0.0010	<0.0010	0.0552	<0.0010	<0.0010	<0.0010	<0.0050	<0.0010	0.0248	0.0506	<0.0010	<0.0010	<0.00020	0.44	NS
		12/8/2016	<0.0010	<0.0010	0.0534	<0.0010	<0.0010	<0.0010	<0.0050	<0.0010	0.0240	0.0378	<0.0010	<0.0010	<0.00020	0.43	NS
		1/6/2017	<0.0030	<0.0010	0.051	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.028	0.034	<0.0010	<0.0010	<0.00020	0.552	1.29
		1/28/2017	<0.0030	<0.0010	0.053	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.029	0.024	0.0062	<0.0010	<0.00020	0.516	0.75
		2/21/2017	<0.0030	<0.0010	0.065	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.029	0.013	0.0051	<0.0010	<0.00020	0.364	1.28
		3/30/2017	<0.0030	<0.0010	0.070	<0.0010	<0.0010	0.018	<0.0020	<0.0010	0.030	0.011	0.0038	<0.0010	<0.00020	0.519	1.54
		4/26/2017	0.0031	<0.0010	0.063	<0.0010	<0.0010	0.0051	<0.0020	<0.0010	0.026	0.013	0.0037	<0.0010	<0.00020	0.378	0.78
		5/17/2017	<0.0030	<0.0010	0.068	<0.0010	<0.0010	0.0071	<0.0020	<0.0010	0.031	0.015	0.0052	<0.0010	<0.00020	<0.250	1.98
		6/21/2017	<0.0030	<0.0010	0.062	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.027	0.011	0.0054	<0.0010	<0.00020	0.411	1.34
	8/16/2017	<0.0030	<0.0010	0.055	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.030	0.011	0.0033	<0.0010	<0.00020	0.416	0.63	
	5/29/2018	<0.0030	<0.0010	0.063	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.024	0.013	0.0054	<0.0010	<0.00020	0.420	0.76	
	9/12/2018	--	<0.0010	0.059	--	--	0.0071	<0.00086	<0.0010	0.020	0.023	0.0044	--	--	0.340	0.663	
	P-2	11/4/2016	<0.0010	<0.0010	0.0963	<0.0010	<0.0010	<0.0010	<0.0050	<0.0010	0.0188	0.279	0.0014	<0.0010	<0.00020	0.52	0.00
		12/7/2016	<0.0010	<0.0010	0.0888	<0.0010	<0.0010	<0.0010	<0.0050	<0.0010	0.0174	0.351	0.0010	<0.0010	<0.00020	0.61	2.05
		1/5/2017	<0.0030	<0.0010	0.076	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.020	0.35	<0.0010	<0.0010	<0.00020	0.643	0.74
		1/28/2017	<0.0030	<0.0010	0.075	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.016	0.34	0.0011	<0.0010	<0.00020	0.662	0.73
		1/28/2017	<0.0030	<0.0010	0.077	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.022	0.35	<0.0010	<0.0010	<0.00020	0.767	0.83
		2/21/2017	<0.0030	<0.0010	0.098	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.024	0.29	0.0012	<0.0010	<0.00020	0.512	1.15
		3/30/2017	<0.0030	<0.0010	0.094	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.023	0.29	0.0011	<0.0010	<0.00020	0.679	1.33
		4/26/2017	<0.0030	<0.0010	0.084	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.018	0.31	<0.0010	<0.0010	<0.00020	0.566	1.01
		5/17/2017	<0.0030	<0.0020	0.082	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.022	0.32	<0.0020	<0.0010	<0.00020	0.306	0.45
		6/20/2017	<0.0030	0.0010	0.086	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.022	0.27	0.0022	<0.0010	<0.00020	0.534	1.47
		8/17/2016	<0.0030	<0.0010	0.100	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.028	0.27	0.0014	<0.0010	<0.00020	0.520	0.52
6/1/2018		<0.0030	<0.0010	0.096	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.020	0.32	0.0015	<0.0010	<0.00020	0.544	1.04	
5/29/2018		<0.0030	<0.0010	0.095	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.019	0.32	0.0014	<0.0010	<0.00020	0.542	0.395	
9/12/2018	--	<0.0010	0.067	--	--	<0.0040	<0.00086	<0.0010	<0.010	0.32	<0.0010	--	--	0.561	0.428		

TABLE I
SUMMARY OF ANALYTICAL RESULTS
 Corrective Measures Assessment
 AECI New Madrid Power Plant
 New Madrid, Missouri

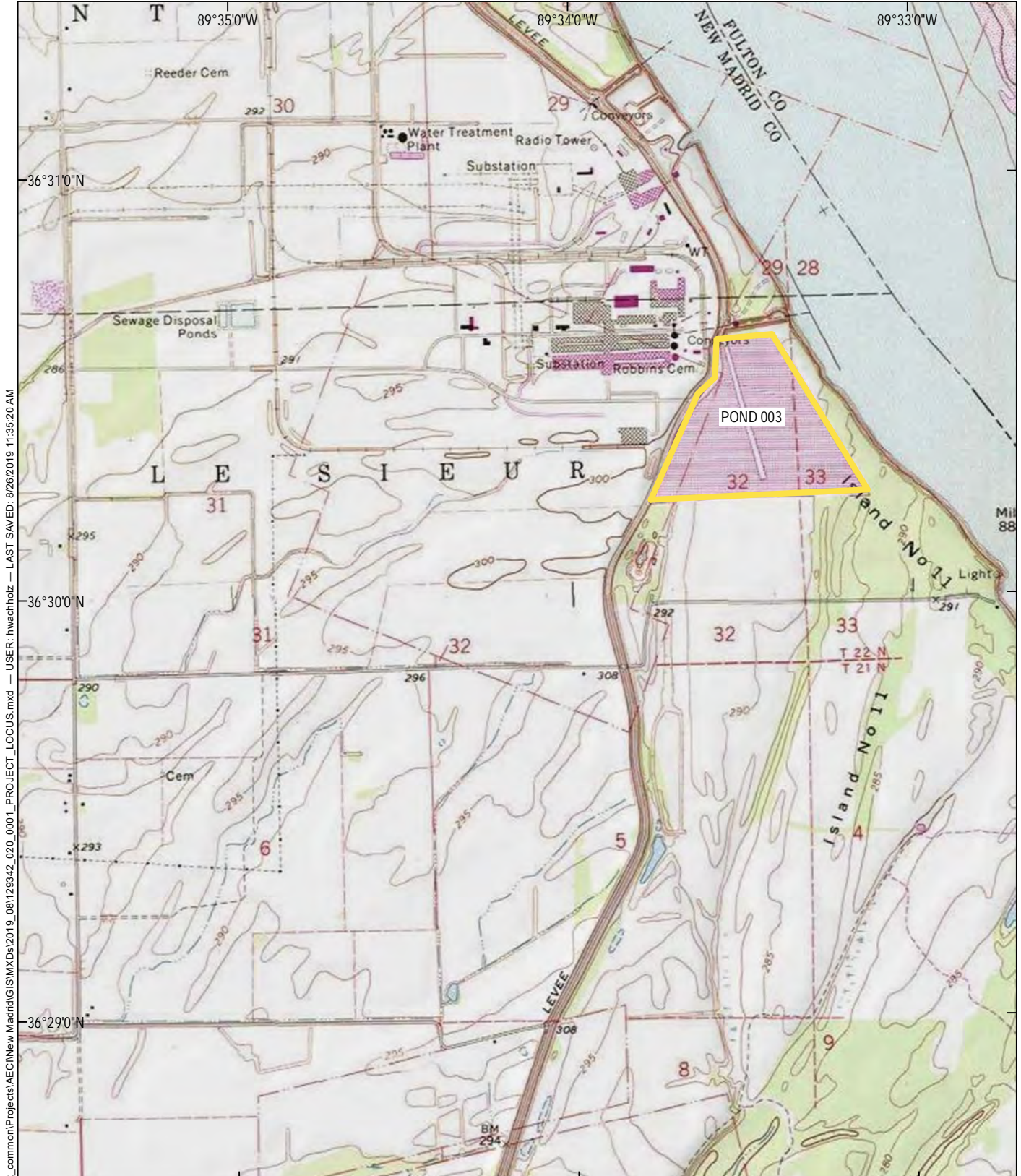
Location	Sample Date	USEPA Appendix IV Constituents															
		Antimony, Total mg/l	Arsenic, Total mg/l	Barium, Total mg/l	Beryllium, Total mg/l	Cadmium, Total mg/l	Chromium, Total mg/l	Cobalt, Total mg/l	Lead, Total mg/l	Lithium, Total mg/l	Molybdenum, Total mg/l	Selenium, Total mg/l	Thallium, Total mg/l	Mercury, Total mg/l	Fluoride, Total mg/l	Radium-226 & 228 Combined pCi/L	
	<i>Site GWPS</i>	<i>0.006</i>	<i>0.010</i>	<i>2.0</i>	<i>0.004</i>	<i>0.005</i>	<i>0.100</i>	<i>0.006</i>	<i>0.015</i>	<i>0.040</i>	<i>0.100</i>	<i>0.050</i>	<i>0.002</i>	<i>0.002</i>	<i>4.0</i>	<i>5</i>	
Down Gradient	P-3	11/4/2016	<0.0010	<0.0010	0.102	<0.0010	<0.0010	<0.0010	<0.0050	<0.0010	0.0250	1.28	0.0041	<0.0010	<0.00020	0.36	0.29
		12/7/2016	<0.0010	<0.0010	0.111	<0.0010	<0.0010	<0.0010	<0.0050	<0.0010	0.0285	1.56	0.0080	<0.0010	<0.00020	0.48	1.03
		1/5/2017	<0.0030	<0.0010	0.098	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.033	1.4	0.0046	<0.0010	<0.00020	0.481	0.72
		1/28/2017	<0.0030	<0.0010	0.10	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.027	1.3	0.0029	<0.0010	<0.00020	0.463	0.77
		2/21/2017	<0.0030	<0.0010	0.10	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.030	1.2	0.0042	<0.0010	<0.00020	0.381	1.40
		3/30/2017	<0.0030	<0.0010	0.10	<0.0010	<0.0010	<0.0040	<0.0020	0.0047	0.030	1.1	0.0048	<0.0010	<0.00020	0.591	0.30
		3/30/2017	<0.0030	<0.0010	0.10	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.030	1.1	0.0045	<0.0010	<0.00020	0.588	0.77
		4/26/2017	<0.0030	<0.0010	0.10	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.027	1.4	0.0036	<0.0010	<0.00020	0.463	0.49
		5/17/2017	<0.0030	<0.0010	0.093	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.032	1.1	0.0037	<0.0010	<0.00020	<0.250	0.86
		6/20/2017	<0.0030	<0.0010	0.095	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.029	1.0	0.0060	<0.0010	<0.00020	0.461	1.65
	8/16/2017	<0.0030	<0.0010	0.098	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.031	1.3	0.0046	<0.0010	<0.00020	0.482	1.00	
	5/29/2018	<0.0030	<0.0010	0.095	<0.0010	<0.0010	0.0048	<0.0020	0.0016	0.023	1.3	0.0054	<0.0010	<0.00020	0.560	0.604	
	9/12/2018	--	<0.0010	0.086	--	--	<0.0040	<0.00086	<0.0010	0.018	1.4	0.0057	--	--	0.426	0.125	
	P-4	11/4/2016	<0.0010	<0.0010	0.144	<0.0010	<0.0010	<0.0010	<0.0050	<0.0010	0.0379	0.0320	0.0022	<0.0010	<0.00020	0.34	0.53
		12/7/2016	<0.0010	<0.0010	0.109	<0.0010	<0.0010	<0.0010	<0.0050	<0.0010	0.0251	0.0318	0.0010	<0.0010	<0.00020	0.48	1.45
		1/5/2017	<0.0030	<0.0010	0.12	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.031	0.033	0.0018	<0.0010	<0.00020	0.568	0.89
		1/28/2017	<0.0030	<0.0010	0.11	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.029	0.031	<0.0010	<0.0010	<0.00020	0.469	0.48
		2/21/2017	<0.0030	<0.0010	0.13	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.043	0.029	0.0014	<0.0010	<0.00020	0.362	0.45
		3/30/2017	<0.0030	<0.0010	0.13	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.041	0.029	0.0019	<0.0010	<0.00020	0.543	0.11
		4/26/2017	<0.0030	<0.0010	0.12	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.032	0.030	<0.0010	<0.0010	<0.00020	0.381	0.76
5/17/2017		<0.0030	<0.0010	0.11	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.038	0.027	<0.0010	<0.0010	<0.00020	<0.250	0.98	
5/17/2017		<0.0030	<0.0020	0.12	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.038	0.029	<0.0020	<0.0010	<0.00020	<0.250	1.60	
6/20/2017		<0.0030	<0.0010	0.12	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.043	0.026	0.0019	<0.0010	<0.00020	0.380	1.09	
8/16/2017	<0.0030	<0.0010	0.14	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.050	0.030	0.0024	<0.0010	<0.00020	<0.250	0.86		
5/29/2018	<0.0030	<0.0010	0.11	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.030	0.033	0.0030	<0.0010	<0.00020	0.357	0.594		
9/12/2018	--	<0.0010	0.11	--	--	<0.0040	<0.00086	<0.0010	0.028	0.025	0.0022	--	--	0.369	0.297		

TABLE I
SUMMARY OF ANALYTICAL RESULTS
 Corrective Measures Assessment
 AECl New Madrid Power Plant
 New Madrid, Missouri

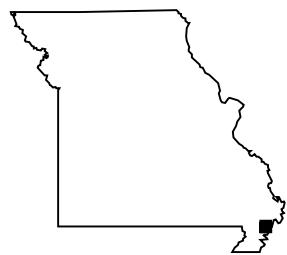
Location	Sample Date	USEPA Appendix IV Constituents															
		Antimony, Total mg/l	Arsenic, Total mg/l	Barium, Total mg/l	Beryllium, Total mg/l	Cadmium, Total mg/l	Chromium, Total mg/l	Cobalt, Total mg/l	Lead, Total mg/l	Lithium, Total mg/l	Molybdenum, Total mg/l	Selenium, Total mg/l	Thallium, Total mg/l	Mercury, Total mg/l	Fluoride, Total mg/l	Radium-226 & 228 Combined pCi/L	
	Site GWPS	0.006	0.010	2.0	0.004	0.005	0.100	0.006	0.015	0.040	0.100	0.050	0.002	0.002	4.0	5	
Down Gradient	P-5	11/3/2016	<0.0010	0.0053	0.125	<0.0010	<0.0010	<0.0010	<0.0050	<0.0010	0.0179	0.235	<0.0010	<0.0010	<0.00020	0.18	2.00
		12/6/2016	<0.0010	0.0081	0.110	<0.0010	<0.0010	<0.0010	<0.0050	<0.0010	0.0169	0.235	<0.0010	<0.0010	<0.00020	0.20	1.42
		1/4/2017	<0.0030	0.0056	0.13	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.025	0.25	<0.0010	<0.0010	<0.00020	<0.250	1.65
		1/26/2017	<0.0030	0.0068	0.14	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.024	0.23	<0.0010	<0.0010	<0.00020	0.364	0.28
		2/22/2017	<0.0030	0.011	0.15	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.024	0.27	<0.0010	<0.0010	<0.00020	<0.250	1.23
		3/30/2017	<0.0030	0.0089	0.15	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.024	0.25	<0.0010	<0.0010	<0.00020	0.438	2.06
		4/26/2017	<0.0030	0.0099	0.17	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.022	0.30	<0.0010	<0.0010	<0.00020	<0.250	1.99
		5/18/2017	<0.0030	0.0069	0.18	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.030	0.36	<0.0010	<0.0010	<0.00020	<0.250	1.30
		6/20/2017	<0.0030	0.0083	0.16	<0.0010	<0.0010	<0.0040	0.0020	<0.0010	0.026	0.26	0.0015	<0.0010	<0.00020	0.272	2.16
		8/16/2017	<0.0030	0.0064	0.13	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.024	0.23	<0.0010	<0.0010	<0.00020	<0.250	1.22
5/29/2018	<0.0030	0.0066	0.17	<0.0010	<0.0010	<0.0040	<0.0020	<0.0010	0.022	0.28	<0.0010	<0.0010	<0.00020	<0.250	1.23		
	9/11/2018	--	0.0066	0.12	--	--	<0.0040	0.0012	<0.0010	0.012	0.26	<0.0010	--	--	<0.250	2.40	

Notes:
 Bold value: Detection above laboratory reporting limit
 Statistically significant level concentration
 GWPS: Groundwater Protection Standards
 mg/L: milligram per liter
 "--" Constituent not analyzed
 NS: No Sample, sample was lost in transit.
 pCi/L: picoCurie per liter

FIGURES



GIS FILE PATH: \\haleyaldrich.com\share\phx_common\Projects\AECI\New Madrid\GIS\MXD\2019_08\12\23\42_020_0001_PROJECT_LOCUS.mxd — USER: hwaachholz — LAST SAVED: 8/26/2019 11:35:20 AM



MAP SOURCE: ESRI
 SITE COORDINATES: 36°30'23"N, 89°33'29"W

**HALEY
ALDRICH**

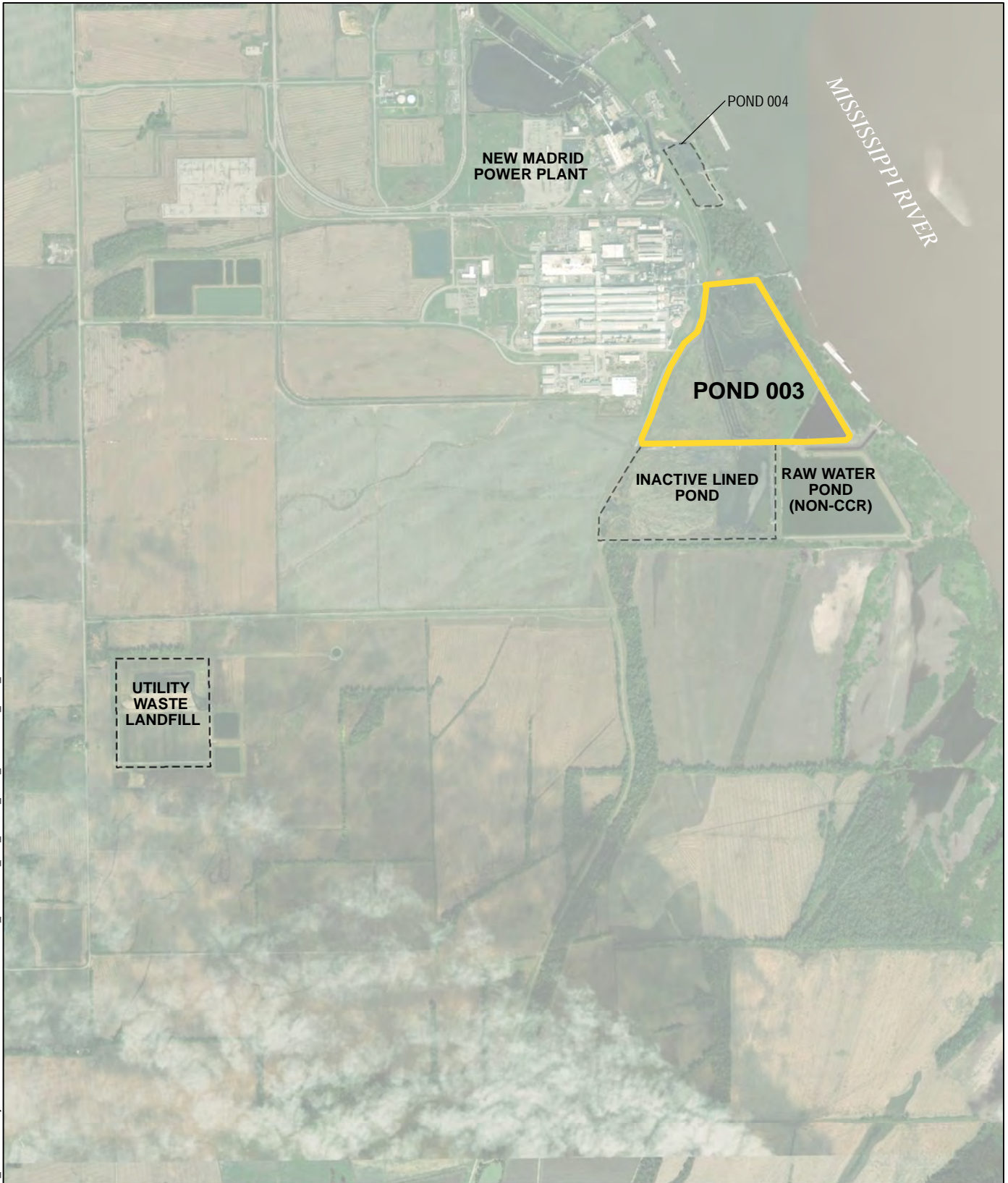
CORRECTIVE MEASURES ASSESSMENT
 ASSOCIATED ELECTRIC COOPERATIVE, INC.
 NEW MADRID POWER PLANT - POND 003
 NEW MADRID, MISSOURI

SITE LOCATION MAP

APPROXIMATE SCALE: 1 IN = 2000 FT
 SEPTEMBER 2019

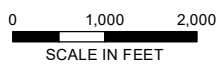
FIGURE 1-1

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NOTES

- 1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.
- 2. AERIAL IMAGERY SOURCE: ESRI, 19 MAY 2016.



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ALDRICH**

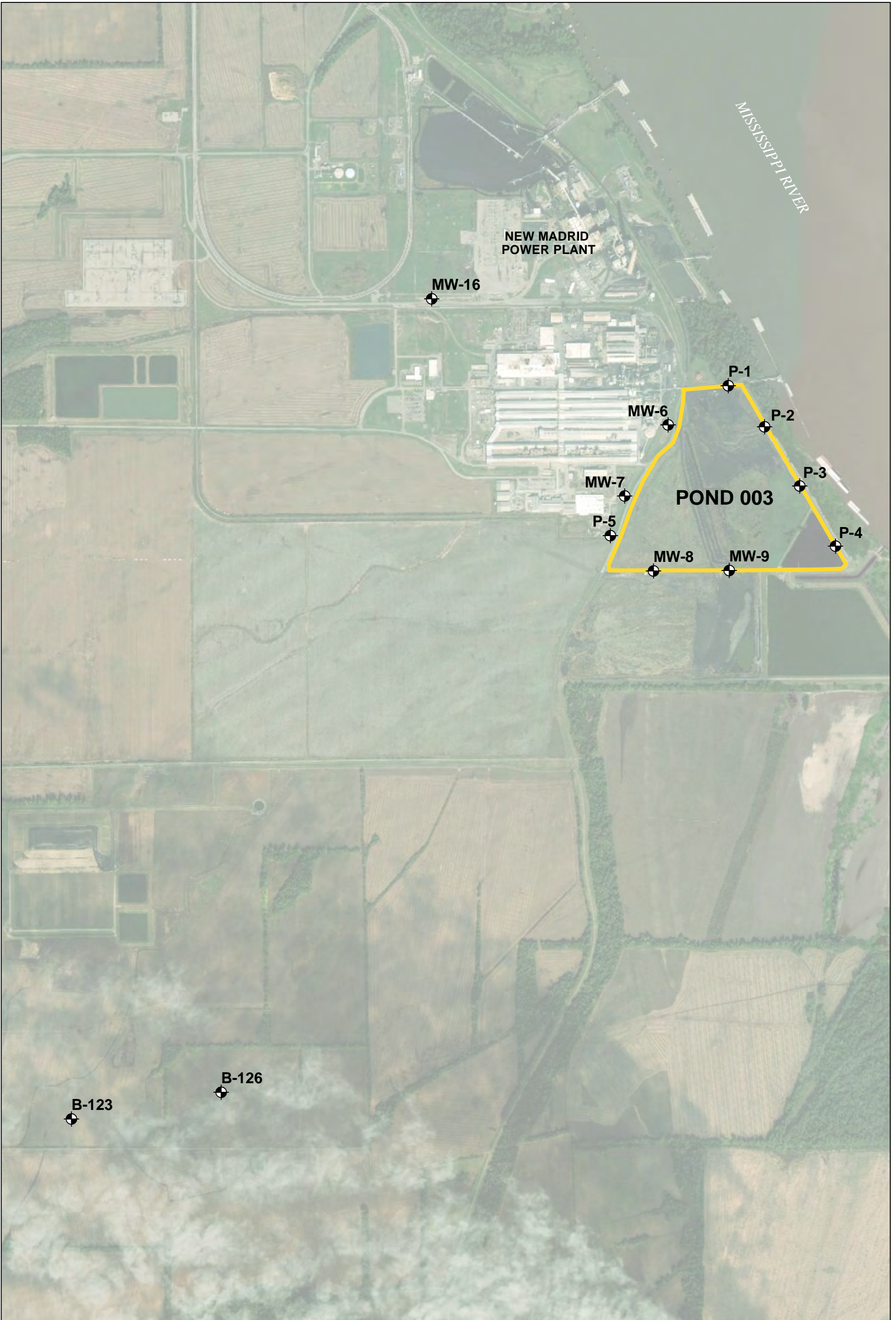
CORRECTIVE MEASURES ASSESSMENT
ASSOCIATED ELECTRIC COOPERATIVE, INC.
NEW MADRID POWER PLANT - POND 003
NEW MADRID, MISSOURI

SITE FEATURES MAP



SEPTEMBER 2019

FIGURE 1-2

GIS FILE PATH: \\haleyaldrich.com\share\phx_common\Projects\AEC\New Madrid\GIS\MXDs\2019_08\128342_020_0001_MONITORING_WELL_LOCATION.mxd — USER: hwachholz — LAST SAVED: 9/11/2019 10:09:03 AM

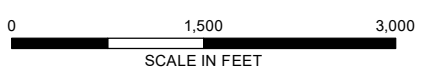


LEGEND

-  MONITORING
-  POND 003

NOTE

1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.
2. AERIAL IMAGERY SOURCE: ESRI, 19 MAY 2016.



CORRECTIVE MEASURES ASSESSMENT
ASSOCIATED ELECTRIC COOPERATIVE, INC.
NEW MADRID POWER PLANT - POND 003
NEW MADRID, MISSOURI

MONITORING WELL LOCATION MAP




SEPTEMBER 2019
SCALE: AS SHOWN

FIGURE 2-1

GIS FILE PATH: \\haleyaldrich.com\share\phtx_common\Projects\AECI\New Madrid\GIS\MXDs\2019_08\129342_020_0002-2_WELL_LOCATION_WITH_GWPS.mxd — USER: hwachholz — LAST SAVED: 8/26/2019 11:39:46 AM



LEGEND

- P-1  MONITORING WELL
- MW-8  MONITORING WELL WITH MOLYBDENUM CONCENTRATION ABOVE THE GWPS
-  UNIT BOUNDARY

NOTES

1. ALL LOCATIONS ARE APPROXIMATE
2. GWPS = GROUNDWATER PROTECTION STANDARDS
3. REFER TO TABLE I FOR GROUNDWATER ANALYTICAL RESULTS.
4. AERIAL IMAGERY SOURCE: ESRI



CORRECTIVE MEASURES ASSESSMENT
ASSOCIATED ELECTRIC COOPERATIVE, INC.
NEW MADRID POWER PLANT - POND 003
NEW MADRID, MISSOURI

MONITORING WELL LOCATIONS WITH STATISTICALLY SIGNIFICANT LEVELS ABOVE GWPS

SEPTEMBER 2019

FIGURE 2-2

FIGURE 4-1

REMEDIAL ALTERNATIVE ROADMAP

CORRECTIVE MEASURES ASSESSMENT
 ASSOCIATED ELECTRIC COOPERATIVE, INC
 NEW MADRID POWER PLANT - POND 003
 NEW MADRID, MISSOURI

Alternative Number	Remedial Alternative Description	Pond 003 Closure Description	Groundwater Remedy Components		
			A. Groundwater Remedy Approach	B. Groundwater Treatment Method	C. Post-Closure Actions
1	Closure In Place (CIP) with Capping and Monitored Natural Attenuation (MNA)	CIP with Low Permeability Cap	Natural Attenuation with Monitoring Mitigate off-site migration of groundwater with CCR constituents above GWPS through process of natural attenuation	No Active Treatment No active treatment technologies for groundwater to address CCR constituents	MNA Long-term groundwater monitoring to confirm reduction of CCR constituents
2	CIP with In-Situ Stabilization (ISS), Capping and MNA	CIP with ISS and Low Permeability Cap			
3	CIP with Capping and Hydraulic Containment through Groundwater Pumping and Ex-Situ Treatment	CIP with Low Permeability Cap	Hydraulic Containment Mitigate off-site migration of groundwater with CCR constituents above GWPS using extraction wells	Ex-Situ Treatment Treatment system (ion exchange or reverse osmosis) to remove CCR constituents from groundwater and discharge under applicable permits	Pump & Treat Long-Term Continue to operate hydraulic containment system to maintain reduction of CCR constituents in groundwater
4	CIP with Capping and Hydraulic Containment through Groundwater Pumping and Ex-Situ Treatment and Barrier Wall	CIP with Low Permeability Cap	Barrier Wall with Hydraulic Containment Mitigate off-site migration of groundwater with CCR constituents above GWPS using extraction wells and a low permeability barrier wall		
5	Closure by Removal (CBR) with MNA	CBR	Natural Attenuation with Monitoring Mitigate off-site migration of groundwater with CCR constituents above GWPS through process of natural attenuation	No Active Treatment No active treatment technologies for groundwater to address CCR constituents	MNA Long-term groundwater monitoring to confirm reduction of CCR constituents

APPENDIX A

Groundwater Risk Evaluation

**REPORT ON
GROUNDWATER RISK EVALUATION
NEW MADRID POWER PLANT
POND 003
NEW MADRID, MISSOURI**

By

Haley & Aldrich, Inc.
Greenville, South Carolina

For

Associated Electric Cooperative, Inc.
Springfield, Missouri

File No. 129342-020
August 2019



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Attachment A – Calculated Recreational Risk-Based Screening Levels

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1	Comparison of Pond 003 Complex Groundwater Monitoring Results to Groundwater Protection Standards
2	Human Health Published Screening Levels for Surface Water
3	Human Health Calculated Risk Based Screening Levels for Surface Water
4	Ecological Screening Levels for Surface Water
5	Selected Surface Water Screening Levels
6	Derivation of Risk-Based Screening Levels for Groundwater

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1	Site Location Map and Pond 003 Monitoring Well Location Map
2	Pond 003 – Groundwater Flow Direction Map – Low River Stage 3/28/2017
3	Pond 003 – Groundwater Flow Direction Map – High River Stage 5/17/2017
4	Conceptual Site Model
5	Pond 003 – DAF Calculation – Low River State 3/28/2017

List of Common Acronyms

AECI	Associated Electric Cooperative, Inc.
AWQC	Ambient Water Quality Criteria
CCR	Coal Combustion Residuals
CFR	Code of Federal Regulations
CMA	Corrective Measures Assessment
CSM	Conceptual Site Model
DAF	Dilution Attenuation Factor
Haley & Aldrich	Haley & Aldrich, Inc.
HI	Hazard Index
GWPS	Groundwater Protection Standards
MCL	Maximum Contaminant Level
MDNR	Missouri Department of Natural Resources
mg/L	Milligram per Liter
RSL	Regional Screening Level
SL	Screening Level
SSI	Statistically Significant Increase
SSL	Statistically Significant Level
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey

1. Introduction

The New Madrid Power Plant (NMPP) is a coal-fired power plant located on the Mississippi River in New Madrid, Missouri. The NMPP is an active energy production facility owned by Associated Electric Cooperative, Inc. (AECI) that generates electricity through coal combustion. The facility has been in operation since the 1970s. Pond 003 is a surface impoundment that encompasses approximately 110 acres and is located approximately 0.3 miles southeast of the NMPP plant site. **Figure 1** shows the location of the facility, and the location of Pond 003.

The U.S. Environmental Protection Agency (USEPA) issued a final rule for “Disposal of Coal Combustion Residuals from Electric Utilities” in 2015 (the CCR Rule) (USEPA, 2015). One of the requirements in the CCR Rule is that utilities monitor groundwater at coal ash management facilities, and that the data be reported publicly. NMPP is complying with the CCR Rule, and has posted the required information on their publicly-available website: <https://www.aeci.org/clean/ccr/>.

This “Groundwater Risk Evaluation” report has been prepared by Haley & Aldrich, Inc. (Haley & Aldrich), and is a companion document to the “Corrective Measures Assessment (CMA) for Pond 003 – New Madrid Power Plant.” The purpose of this risk evaluation report is to provide the information needed to interpret and meaningfully understand the groundwater monitoring data collected and published for Pond 003 under the CCR Rule.

Beyond the specific monitoring requirements of the CCR Rule, NMPP has also voluntarily taken the additional step to evaluate potential groundwater-to-surface water transport and exposure pathways through the development of risk-based groundwater screening levels that are protective of surface water in the Mississippi River. Details about the evaluation are provided below.

2. Approach

The analysis presented in this report was conducted by evaluating the environmental setting of the New Madrid Power Plant, including its location and where ash management has occurred at the facility. Information on where groundwater is located at the facility, the rate(s) of groundwater flow, the direction(s) of groundwater flow, and where waterbodies may intercept groundwater flow are reviewed and summarized here.

A conceptual model was developed based on this physical setting information, and the model was used to identify what human populations could contact groundwater and/or surface water in the area of the facility. This information was also used to identify where ecological populations could come into contact with surface water.

Human health risk assessment is a process used to estimate the chance that contact with constituents in the environment may result in harm to people. Generally, there are four components to the process (USEPA, 1989): (1) Hazard Identification/Data Evaluation, (2) Toxicity Assessment, (3) Exposure Assessment, and (4) Risk Characterization.

The USEPA and other regulatory agencies, including the Missouri Department of Natural Resources (MDNR), develop “screening levels” of constituent concentrations in groundwater (and other media)

that are considered to be protective of specific human exposures. In developing screening levels, USEPA uses a specific target risk level (component 4) combined with an assumed exposure scenario (component 3) and toxicity information from USEPA (component 2) to derive an estimate of a concentration of a constituent in an environmental medium, for example groundwater, (component 1) that is protective of a person in that exposure scenario (for example, drinking water). Similarly, ecological screening levels for surface water are developed by USEPA and MDNR to be protective of the wide range of potential aquatic ecological resources, or receptors.

Risk-based screening levels are designed to provide a conservative estimate of the concentration to which a receptor (human or ecological) can be exposed without experiencing adverse health effects. Due to the conservative methods used to derive risk-based screening levels, it can be assumed with reasonable certainty that concentrations below screening levels will not result in adverse health effects, and that no further evaluation is necessary. Concentrations above conservative risk-based screening levels do not necessarily indicate that a potential risk exists, but indicate that further evaluation may be warranted.

Human health risk-based and ecological risk-based screening levels drawn from USEPA and MDNR sources are used to determine if the concentration levels of constituents in groundwater could pose a risk to human health or the environment that warrants further evaluation.

2.1 CONCEPTUAL SITE MODEL

A conceptual site model (CSM) is used to evaluate the potential for human or ecological exposure to constituents that may have been released to the environment. Some of the questions posed during the CSM evaluation include:

What is the source? How can constituents be released from the source? What environmental media may be affected by constituent release? How and where do constituents travel within a medium? Is there a point where a receptor (human or ecological) could contact the constituents in the medium? Are the constituent concentrations high enough to potentially exert a toxic effect?

For the evaluation of the ash management operations at the NMPP, the coal ash stored in Pond 003 is the potential source. Constituents present in the coal ash can be dissolved into infiltrating water (either from precipitation or from groundwater intrusion) that flows to groundwater, and those constituents may then be present in shallow groundwater. Constituents could move with groundwater as it flows, usually in a downgradient/downhill direction.

The constituents derived from the coal ash could then be introduced to adjacent surface water bodies; here, that could be the Mississippi River. **Figure 1** shows the facility location and layout, identifies the location of Pond 003 and the adjacent surface water body, and shows the monitoring well locations. Thus, the environmental media of interest for this evaluation are:

- Groundwater on the facility; and
- Mississippi River surface water.

Pond 003 lies adjacent to the Mississippi River and the alluvial aquifer immediately beneath Pond 003 is in communication with the river. Seasonal changes in river stage cause the groundwater flow direction to change and occasionally reverse. Due to the influence of the adjacent Mississippi River, the groundwater flow in the alluvial aquifer is generally to the southwest during high river stage and generally to the northeast during low river stage. Due to the changing groundwater flow directions, monitoring wells were sited at locations to encircle Pond 003. **Figures 2 and 3** show the monitoring well networks and groundwater flow directions of the uppermost aquifer.

Groundwater downgradient of Pond 003 is not used for any purposes. An irrigation water supply well is located approximately 3500 feet to the south of Pond 003. However, that well is cross-gradient to primary groundwater flow direction and therefore would not receive groundwater discharge from Ponds 003 or 004. There are no construction activities presently occurring or planned within the uppermost aquifer in the foreseeable future. Therefore, there are no direct contact exposure pathways to groundwater downgradient of Pond 003.

The Mississippi River is not a source of drinking water in the downstream vicinity of NMPP; drinking water in New Madrid is provided by the City of New Madrid from groundwater wells. The nearest downstream water supply intake used for drinking water was identified at the Dow Chemical Plant in Iberville, Louisiana, approximately 675 miles downstream.

The Mississippi River can be used for human recreation – wading, swimming, boating, fishing and can serve as habitat for aquatic species – fish, amphibians, etc.

Thus, the potentially complete exposure pathways associated with CCR-related constituents in groundwater are:

- Direct contact with and ingestion of surface water (via migration of groundwater to surface water) during use of river water for a municipal water supply;
- Direct contact with surface water (via migration of groundwater to surface water) during recreational uses of the river; and
- Ingestion of biota (e.g., fish) that may uptake constituents that migrate from groundwater to surface water in the river.

A depiction of the conceptual site model is shown in **Figure 4**.

Based on this conceptual site model and the facility setting, samples collected from groundwater monitoring wells have been included in the evaluation. The samples have been analyzed for constituents that are commonly associated with CCR, as discussed below. However, it is recognized by the USEPA that all of these constituents can also be naturally occurring and can be found in rocks, soils, water and sediments; thus, it is necessary to understand what the naturally occurring background levels are for these constituents. The CCR Rule requires sampling and analysis of upgradient and/or background groundwater just for this reason. The sampling is detailed in the next section.

To answer the question, “Are the constituent concentrations high enough to potentially exert a toxic effect?” health risk-based screening levels from USEPA and MDNR sources are used for comparison to the data, as described in Section 5.

3. Sample Collection and Analysis

3.1 GROUNDWATER SAMPLES

Twelve (12) groundwater monitoring wells were installed to evaluate shallow alluvial groundwater at Pond 003 under the CCR Rule: nine (9) monitoring wells were installed around the perimeter of Pond 003 to assess groundwater conditions at the ash management area, and three (3) monitoring wells were installed west of the facility to assess background groundwater conditions. **Figure 1** shows the locations of the monitoring wells. Each well is identified by a unique name. MW-6 through MW-9, and P-1 through P-5 are located around the perimeter of Pond 003, and B-123, B-126, and MW-16 are the three background wells that are used to identify upgradient/background conditions in groundwater. Each groundwater monitoring well was sampled thirteen (13) times¹.

3.2 SAMPLE ANALYSIS

The CCR Rule identifies the constituents that are included for groundwater testing; these are:

Boron	Antimony	Lead
Calcium	Arsenic	Lithium
Chloride	Barium	Mercury
pH	Beryllium	Molybdenum
Sulfate	Cadmium	Selenium
TDS	Chromium	Thallium
Fluoride	Cobalt	Radium 226/228

The CCR Rule requires eight (8) rounds of groundwater sampling and analysis be conducted for all wells to provide a baseline for current conditions. CCR groundwater monitoring has been performed between November 2016 and September 2018. Groundwater samples have been collected from each of the wells in the CCR monitoring well network and analyzed for USEPA Detection (Appendix III) and Assessment (Appendix IV) Monitoring Parameters. The CCR Rule requires statistical methods be used to determine whether a statistically significant increase (SSI) above background exists for the Appendix III (first column above) constituents. Based on the SSI results from the groundwater monitoring, additional assessment monitoring has been conducted. Section 1.3 of the “Corrective Measures Assessment (CMA)” report provides more detail on the objectives of the rounds of groundwater sampling. Appendix III and IV analytical results for the baseline and Assessment Monitoring events are summarized in **Table 1**.

4. Risk-Based Screening Levels

A comprehensive set of risk-based screening levels have been compiled for this evaluation for the three types of potential exposures identified in the conceptual site model discussion above:

- Human health drinking water consumption;

¹ The CCR Rule requires eight (8) rounds of sampling events to establish baseline conditions in each well. Under the CCR Rule, further rounds are defined as “Detection” sampling.

- Human health recreational use of surface water; and
- Aquatic ecological receptors for surface water.

It is important to note that the CCR Rule limits the evaluation of groundwater monitoring data of ash management areas to groundwater protection standards (GWPS), which are Federal primary drinking water standards, also known as Maximum Contaminant Levels or MCLs (USEPA, 2018a) that are enforceable for municipal drinking water supplies, or to a comparison with site-specific background. GWPS used to evaluate potential drinking water exposures for CCR monitoring wells are shown on **Table 1**.

Table 2 provides the human health drinking water and recreational screening levels for surface water available from the MDNR and USEPA sources. **Table 3** provides site-specific risk-based screening levels (RBSLs) derived for recreational exposure to surface water. **Table 4** provides the ecological surface water screening levels from MDNR and USEPA sources.

4.1 GROUNDWATER PROTECTION STANDARDS

The GWPS is defined in the CCR Rule at §257.95 Assessment monitoring program:

(h) The owner or operator of the CCR unit must establish a groundwater protection standard for each constituent in appendix IV to this part detected in the groundwater. The groundwater protection standard shall be:

- (1) For constituents for which a maximum contaminant level (MCL) has been established under §§141.62 and 141.66 of this title, the MCL for that constituent;
- (2) For constituents for which an MCL has not been established, the background concentration for the constituent established from wells in accordance with § 257.91; or
- (3) For constituents for which the background level is higher than the MCL identified under paragraph (h)(1) of this section, the background concentration.

USEPA published Amendments to the National Minimum Criteria Finalized in 2018 (Phase One, Part One) in the Federal Register on July 30, 2018 (USEPA, 2018b). This included revising the groundwater protection standard for constituents that do not have an established drinking water standard (or MCL) at §257.95 Assessment monitoring program (h) (2):

- Cobalt – 6 ug/L (micrograms per liter)
- Lead – 15 ug/L
- Lithium – 40 ug/L
- Molybdenum – 100 ug/l

GWPS used to evaluate potential drinking water exposures for CCR monitoring wells are shown on **Table 1**.

4.2 SCREENING LEVELS FOR THE PROTECTION OF SURFACE WATER

The GWPS are specific to the evaluation of groundwater at the CCR Rule monitoring wells. This section outlines the risk-based human health and ecological surface water screening levels that are protective of surface water in the Mississippi River.

Human health screening levels for surface water are identified for two exposure settings: 1) use of surface water as a drinking water source and the consumption of fish from a surface water body, and 2) recreational uses of surface water.

4.2.1 Drinking Water Screening Levels

The human health screening levels for drinking water are from Missouri state and USEPA sources and address the drinking water exposure pathway. The Missouri State drinking water supply levels are essentially the same as the Federal primary drinking water standards, also known as Maximum Contaminant Levels or MCLs (USEPA, 2018a). The Missouri State groundwater screening levels provide some additional screening levels not included on their list of drinking water screening levels (MDNR, 2019) (**Table 2**). USEPA risk-based Regional Screening Level (RSLs) for tapwater (drinking water, or untreated groundwater used as potable water) have also been included for constituents which do not have promulgated Missouri/MCL criteria. The tapwater RSLs are based on USEPA default assumptions for residential exposure to tapwater (USEPA, 2019a). Missouri drinking water supply screening levels were used and supplemented with Federal MCLs, then the USEPA risk-based levels for tapwater (RSLs), where MDNR values were unavailable.

4.2.2 Published Recreational Screening Levels

Published human health screening levels for surface water are generally derived to be protective of the use of surface water as a drinking water source and the consumption of fish from a surface water body. The drinking water screening levels are also protective of, but highly conservative for, recreational uses of a surface water body (such as swimming or boating) because drinking water exposure is of a higher magnitude and frequency. The drinking water screening levels used to evaluate surface water, as discussed above, are protective for other recreational uses of the river such as swimming, wading, and boating. Note that this evaluation of other uses of surface water are above and beyond the requirements of the CCR Rule.

The human health screening levels for surface water are from federal and state sources and address the fish consumption pathway (where such values are available from the state) (**Table 2**). MDNR administers water quality standards for aquatic life (Missouri Code of State Regulations Division 20 Chapter 7 Table A) (MDNR, 2019). The fish consumption values for protection of human health are used for this assessment, and where unavailable the USEPA Ambient Water Quality Criteria (AWQC) for Human Health Consumption of Water and Organism are used (USEPA, 2019b).

4.2.3 Calculated Recreational Risk-Based Screening Levels

Site-specific RBSLs are essentially refined screening levels to account for receptor population characteristics and exposure pathways. As such, the site-specific RBSLs are less conservative, (i.e., more

realistic), than screening levels and are, therefore, useful for evaluating whether COPCs may have the potential to pose health risks in excess of risk thresholds. For example, whereas surface water that is used as a recreational water body for swimming could be evaluated using drinking water standards which assume that people are drinking and bathing in the water daily, site-specific RBSLs for surface water will reflect incidental ingestion and dermal contact at an exposure rate and magnitude commensurate with swimming activities.

Potential exposures to constituents in surface water could, in general, occur through ingestion and dermal contact. However, the specific nature of the potential exposures is dependent on the type of water body. Specifically:

- Incidental ingestion and dermal contact with shallow surface water (e.g., less than two feet in depth) can only occur via wading because the water is not deep enough to permit swimming. Wading exposures could potentially occur in Little Pigeon Creek.
- Incidental ingestion and dermal contact with deeper surface water (e.g., more than three feet in depth) could occur via swimming. Exposures during swimming could be potentially complete in the Mississippi River; the water in Little Pigeon Creek is not deep enough to allow for swimming.
- Dermal contact with surface water could occur during boating or fishing activities in the Mississippi River. Since these types of activities are not associated with intense exposures to water (such as is the case with swimming), incidental ingestion of surface water would be insignificant.

RBSLs derived for recreational exposures to surface water for a recreational swimmer, wader, and boater are presented in **Table 3**. The RBSLs were calculated using USEPA-derived exposure factors and equations, as well as site-specific inputs where appropriate using the USEPA RSL calculator (USEPA, 2019c). The RBSL presented is the lower of the noncancer RBSL at a target noncancer hazard index of 1 and a target cancer-based risk of 10^{-5} . The RSL calculator output, including the exposure parameters used, is provided in **Attachment A**.

4.2.4 Ecological Screening Levels

Ecological screening levels for surface water are published to provide a conservative estimate of the concentration to which an ecological receptor can be exposed without experiencing adverse effects. Due to the conservative methods used to derive published reference screening levels, it can be assumed with reasonable certainty that concentrations below screening levels will not result in any adverse effects to survival, growth and/or reproduction. Concentrations above ecological published screening levels for surface water, however, do not necessarily indicate that a potential ecological risk exists, but rather that further evaluation may be warranted.

Table 4 presents the ecological published risk-based screening levels for surface water. Some of the screening levels are based on the hardness of the water, a default hardness value of 100 mg/L has been used, in accordance with USEPA and MDNR guidance. Note that this ecological evaluation of surface water is above and beyond the requirements of the CCR Rule.

Water quality criteria are concentrations calculated from controlled laboratory tests on freshwater or marine organisms that are protective of the most sensitive organism (often zooplankton such as daphnids) for the most sensitive life stage (typically reproduction).

MDNR administers water quality standards for aquatic life protective of the most sensitive aquatic life, and therefore protective for both direct contact of surface water by aquatic life, and potential exposures to wildlife through food chain uptake (Missouri Code of State Regulations Division 20 Chapter 7 Table A) (MDNR, 2019). Where MDNR values are unavailable, the USEPA AWQC Freshwater Chronic and Acute values are used (USEPA,2019d).

4.2.5 Selected Screening Levels

Table 5 presents the selected human health and ecological screening levels (from **Tables 2 through 4**) and identifies the lowest selected screening level for surface water for the human health drinking water, human health recreational, and ecological potential exposure scenarios.

5. Results

The level of analysis and comparison to risk-based screening levels presented below is above and beyond the requirements of the CCR Rule. The analysis of the groundwater results required by the CCR Rule is presented in the “2018 Annual Groundwater Monitoring and Corrective Action Report” for NMPP Pond 003 [https://www.aeci.org/media/4268/2019-0131_nmpp-annual-report_pond-003_final-cert.pdf]. This report serves to supplement that report by providing the risk-based analysis of groundwater, so that the groundwater results can be understood in their broader environmental context.

5.1 SHALLOW ALLUVIAL AQUIFER GROUNDWATER – CCR RULE EVALUATION

AECI has filed reports and notification required by the federal CCR Rule on its website, as noted above, and additional reports will be prepared and posted on AECI’s website per the CCR Rule. The statistical analysis of the data has indicated a statistically significant increased (SSI) concentration of Appendix III constituents in downgradient monitoring wells relative to concentrations observed in upgradient monitoring wells, for samples collected from monitoring wells MW-6 through MW-9, and P-1 through P-5 (see **Figure 1**) that monitor the shallow alluvial aquifer. Analytes exhibiting an SSI are a subset of the parameters identified in Section 4 and include boron, calcium, chloride, sulfate, and TDS. These results moved the groundwater sampling into the Assessment Monitoring phase.

Based on the assessment monitoring results, concentrations of molybdenum in some wells are statistically above the GWPS. These measured concentrations are then referred to as Statistically Significant Levels (SSLs). Therefore, the Assessment of Corrective Measures phase of the CCR Rule is triggered for these Appendix IV constituents.

Groundwater data from twelve rounds of sampling of the shallow alluvial aquifer groundwater were compared to the site-specific GWPS required by the CCR Rule. **Figure 1** shows that the monitoring wells are all located at the edge of Pond 003 and, therefore, provide worst-case groundwater results. **Table 1** compares the results of all CCR monitoring well sampling rounds to the GWPS. The vast majority of the

results indicate concentration levels below the site-specific GWPS. A limited number of parameters are above the GWPS for some, but not all, sampling events.

The striking aspect of the analysis shown in **Table 1** is how few CCR monitoring well results are above a conservative GWPS based on MCLs, health-based GWPS, or background levels, given that the wells are located at the base of the ash management area, and the facility has been in operation for over 40 years. Out of the 1,575 groundwater analyses conducted, only 85 results are above the GWPS (see **Table 1**). Put another way, approximately 95% of the groundwater results for the CCR Rule monitoring wells located at the edge of Pond 003 (MW-6 through MW-9, and P-1 through P-5) are below the GWPS. Even for the very few results that may be above screening values for some of the sampling events, including the SSI and SSL results identified under the CCR Rule, there is no complete drinking water exposure pathway to groundwater. Where there is no exposure, there is no risk.

The SSI and SSL values reflect a statistical evaluation that mathematically compares the results of the various rounds of samples to background water quality and GWPS as required under the CCR rule. However, such values without further evaluation do not establish that there is an actual adverse impact to human health or the environment. The CSM process and screening analysis described in this report provide the relevant context for such groundwater monitoring results and whether Pond 003 poses a true risk to human health and the environment. As explained in the remaining sections of this report, based upon the application of risk assessment principles uniformly adopted by USEPA, no such risk exists.

6. Derivation of Risk-Based Screening Levels for Groundwater

NMPP is located on the Mississippi River – a major river system with a massive and rapid river flow. In this section, we have attempted to illustrate how the groundwater – which is a fraction of the volume and flow rate of the river – may interact with the Mississippi River under an assumed set of criteria and conditions. Such an exercise in assumptions can help put in context whether a theoretical risk to river water and its uses exists.

However, impacts to groundwater do not mean that surface waters are impaired. The degree of interface between groundwater and surface waters is variable and complex and dependent upon a variety of factors including gradient and flow rate. It is possible, however, to determine the maximum concentration level that would need to be present on-site in groundwater and still be protective of the surface water environment, assuming gradient and flow rates are such that groundwater flows into the surface water. Groundwater and surface waters flow at very different rates and volumes. The Mississippi River is the largest river system in North America and as depicted on **Table 6** and **Section 6.1**, as groundwater flows into the river, it is diluted by more than 100,000 times.

6.1 DERIVATION OF DILUTION ATTENUATION FACTOR

To estimate river surface water concentrations, a dilution attenuation factor (DAF) that accounts for groundwater flux (at the river edge (land) and river interface)² and subsequent mixing with surface

² Groundwater flux as defined by 10 CFR Part 960.2 is the rate of groundwater flow per unit area of porous media measured perpendicular to the direction of flow (in this case the Mississippi River down gradient of Pond 3).

water was calculated, and then applied to the representative groundwater concentrations.

The DAF was calculated using information for the upper most aquifer as provided in the site hydrological characterization report (Haley & Aldrich, 2017):

- Groundwater Flow ($Q_{\text{groundwater}}$): Approximately 3,114 ft³/day
- River Flow (Q_{river}): Obtained from the USGS gauging station near New Madrid (Station #07024175). The station reported an annual average flow of 4.81×10^{10} ft³/day.

Using these two values, the DAF is calculated to be 1.5×10^7 [i.e., meaning that the ratio of the volume of river flow is seven orders of magnitude greater than the flow volumes attributed to groundwater per unit area ($Q_{\text{river}} / Q_{\text{groundwater}}$)].

This calculation uses the most conservative values for groundwater flow (i.e., meaning the upper limits or reasonable maximum values of flow anticipated) because they use the maximum gradient, K values, and aquifer thicknesses, which in turn ‘maximizes’ the groundwater flux estimate. In addition, because the river stage is in direct connection with the aquifer unit, groundwater flow varies based on Low River Stage (groundwater flow toward river) and High River Stage (groundwater flow away from river). Consequently, groundwater does not migrate to the river year-round, but rather migrates to the river only during lower river stages. For the purposes of conservatism, this lower river stage (where groundwater flowing from Pond 003 to the river) was used in support of the subject risk screening. Although the calculations use conservative assumptions, the calculated dilution factor was rounded down to 100,000 as an additional measure of conservatism.

The representative surface water concentrations derived using the DAF are provided in **Table 6**. **Figure 5** provides an illustration of the DAF calculation and its relation to Pond 003.

6.2 RISK-BASED SCREENING LEVELS FOR GROUNDWATER

It is possible to calculate a protective screening level for groundwater based upon the amount of dilution that occurs under the above assumption. This calculated risk-based screening level for groundwater can be used to determine whether an on-site groundwater concentration level is protective of the river. Stated differently, at what concentration level does groundwater entering the river system pose a human health or ecological risk?

Table 6 is summarized below and shows the application of the dilution factor to calculate risk-based groundwater screening levels that are protective for surface water, for Appendix III and Appendix IV constituents with risk-based screening levels available. For each constituent, the selected human health drinking water and recreational screening levels, as well as the ecological screening levels (from **Table 5**) are presented. The lowest of the three screening levels is then identified for surface water. The dilution factor is then applied to this lowest screening level for surface water to result in the groundwater screening level that is protective for surface water, which is what is shown in the table below.

This evaluation is not limited to only those constituents for which SSIs and SSLs have been identified. The constituents listed in **Table 6** are those for which there is one or more detected groundwater result with available risk-based screening levels.

The groundwater risk-based screening levels are calculated in units of milligrams of constituent per liter of water (mg/L). One mg/L is equivalent to one million parts per million.

The table identifies the maximum groundwater concentration of each constituent detected in Pond 003 monitoring wells. The comparison between the target levels and the maximum concentrations indicates that there is a wide margin of safety between the two values. This margin is shown in the last column of the table. To illustrate, concentration levels of molybdenum would need to be more than 2,500 times higher than currently measured levels before an adverse impact in the river could occur.

CALCULATING RISK-BASED SCREENING LEVELS FOR GROUNDWATER (see Table 6)

Dilution Attenuation Factor		100,000			
Constituent	Lowest of the Human Health and Ecological Screening Levels (mg/L)	Target Groundwater Screening Level - Mississippi River (mg/L)	Maximum Groundwater Concentration (mg/L)		Ratio Between Target Groundwater Screening Level and the Maximum Groundwater Concentration
Detection Monitoring - USEPA Appendix III Constituents					
Boron	2	200,000	20	MW-7	10,000
Fluoride	4	400,000	0.679	P-2	>580,000
Assessment Monitoring - USEPA Appendix IV Constituents					
Antimony	0.006	600	0.0031	P-1	>190,000
Arsenic	0.00014	14	0.011	P-5	>1,000
Barium	2	200,000	0.181	MW-7	>1,000,000
Beryllium	0.004	400	0.001 U		NA
Cadmium	0.0007	72	0.0016	MW-7	>44,000
Chromium (Total)	0.07	7,411	0.018	P-1	>410,000
Cobalt	0.178	17,800	0.0098	MW-7	>1,000,000
Lead	0.0025	252	0.0047	P-3	>53,000
Lithium	0.04	4,000	0.05	P-4	80,000
Mercury	0.00077	77	<0.00020		NA
Molybdenum	0.1	10,000	3.9	MW-7	>2,500
Selenium	0.005	500	0.008	P-3	>62,000
Thallium	0.002	200	0.002	MW-7	100,000
Radiological (pCi/L)					
Radium-226 & 228	5	500,000	3.8	MW-7	>130,000

* Where the Groundwater Risk-Based Screening Level = Screening Level x Dilution Factor.

This means that not only do the present concentrations of constituents in groundwater at Pond 003 not pose a risk to human health or the environment, but even much higher concentrations in groundwater would not be harmful.

7. Summary

This comprehensive evaluation demonstrates that there are no adverse impacts on human health or the environment from groundwater uses resulting from coal ash management practices at the AECI NMPP.

These conclusions are supported by the analysis provided in this report, which indicates that:

- There are no uses or activities that would result in direct exposure to the groundwater that contains detections of Appendix IV constituents.
- The only potentially complete exposure pathways to constituents in groundwater are associated with migration of the groundwater to surface water in the Mississippi River; the surface water is used as a source of drinking water, for recreational uses including fishing, and as habitat for aquatic organisms. Assuming that groundwater migrates to river surface water, the calculated concentrations of groundwater constituents in river surface water are orders of magnitude lower than screening levels protective for use of the river as drinking water, consumption of fish, and protection of aquatic life.

References

1. MDNR. 2019. Rules of Department of Natural Resources Division 20 – Clean Water Commission, Chapter 7 – Water Quality. Accessed at: <https://dnr.mo.gov/env/wpp/wqstandards/>
2. USEPA. 1989. Risk Assessment Guidance for Superfund: Volume I. Human Health Evaluation Manual (Part A). Interim Final. Office of Emergency and Remedial Response. U.S. Environmental Protection Agency, Washington, D.C. EPA 540/1-89/002. Available at: <http://www.epa.gov/risk/risk-assessment-guidance-superfund-rags-part>
3. USEPA. 2015 (and subsequent changes). Final Rule: Disposal of Coal Combustion Residuals (CCRs) for Electric Utilities. 80 FR 21301-21501. U.S. Environmental Protection Agency, Washington, D.C. Available at: <http://www2.epa.gov/coalash/coal-ash-rule>
4. USEPA. 2018a. 2018 Edition of the Drinking Water Standards and Health Advisories. Office of Water. U.S. Environmental Protection Agency, Washington, DC. EPA 822-F-18-001. Available at: <https://www.epa.gov/dwstandardsregulations/2018-drinking-water-standards-and-advisory-tables>
5. USEPA. 2018b. Hazardous and Solid Waste Management System: Disposal of Coal Combustion Residuals from Electric Utilities; Amendments to the National Minimum Criteria (Phase One, Part One). Federal Register, Vol. 83, No. 146, Monday, July 30, 2018, 36435-36456. Available at: <https://www.federalregister.gov/documents/2018/07/30/2018-16262/hazardous-and-solid-waste-management-system-disposal-of-coal-combustion-residuals-from-electric>
6. USEPA. 2019a. Risk-Based Screening Levels. May 2019. Available at: <https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables>

7. USEPA. 2019b. National Recommended Water Quality Criteria - Human Health Criteria Table. Available at: <https://www.epa.gov/wqc/national-recommended-water-quality-criteria-human-health-criteria-table>
8. USEPA. 2019c. Risk-Based Screening Levels Calculator. May 2019. Available at: https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search
9. USEPA. 2019b. National Recommended Water Quality Criteria - Aquatic Life Criteria Table. Available at: <https://www.epa.gov/wqc/national-recommended-water-quality-criteria-aquatic-life-criteria-table>

TABLES

TABLE 1
COMPARISON OF AECI NEW MADRID POWER PLANT POND 003 COMPLEX GROUNDWATER MONITORING RESULTS TO SITE GROUNDWATER PROTECTION STANDARDS – NOVEMBER 2016 THROUGH SEPTEMBER 2018 SAMPLING EVENTS
AECI NEW MADRID POWER PLANT - POND 003 COMPLEX
NEW MADRID, MISSOURI

Monitoring Well ID	Date Sampled	pH field	Chloride	Fluoride	Sulfate	Solids Total Dissolved	Antimony Total	Arsenic Total	Barium Total	Beryllium Total	Boron Total	Cadmium Total	Calcium Total	Chromium Total	Cobalt Total	Lead Total	Lithium Total	Mercury Total	Molybdenum Total	Selenium Total	Thallium Total	Radium-226	Radium-228	Combined Radium		
		SU	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	pCi/L	pCi/L	pCi/L	
Up Gradient	Site GWPS (a)	NA	NA	4.0	NA	NA	0.006	0.01	2	0.004	NA	0.005	NA	0.1	0.006	0.015	0.04	0.002	0.1	0.05	0.002	NA	NA	5		
	MW-16	11/2/2016	6.82	11	1.22	118	516	<0.0010	0.0026	0.773	<0.0010	0.0425	<0.0010	157	<0.0010	<0.0050	<0.0010	0.0263	<0.00020	<0.0100	<0.0010	<0.0010	0.26	1.59	1.85	
		12/9/2016	6.89	15	1.37	107	630	<0.0010	0.0029	0.783	<0.0010	0.0431	<0.0010	154	<0.0010	<0.0050	<0.0010	0.0274	<0.00020	<0.0100	<0.0010	<0.0010	0.13	0.85	0.98	
		1/7/2017	7.58	13	1.1	120	580	<0.0030	0.0027	0.8	<0.0010	0.039	<0.0010	130	<0.0040	<0.0020	<0.0010	0.033	<0.00020	<0.0010	<0.0010	<0.0010	1.46	0.883	2.343	
		1/30/2017	7.4	11	1.55	120	570	<0.0030	0.0026	0.73	<0.0010	0.037	<0.0010	130	<0.0040	<0.0020	<0.0010	0.03	<0.00020	<0.0010	<0.0010	<0.0010	0.856	0.921	1.777	
		2/21/2017	6.91	12	1.18	95	560	<0.0030	0.0025	0.76	<0.0010	0.051	<0.0010	150	<0.0040	<0.0020	<0.0010	0.031	<0.00020	<0.0010	<0.0010	<0.0010	-0.066	1.16	1.16	
		3/28/2017	6.88	11	1.44	100	580	<0.0030	0.0025	0.76	<0.0010	0.047	<0.0010	130	<0.0040	<0.0020	<0.0010	0.031	<0.00020	<0.0010	<0.0010	<0.0010	0.702	1.63	2.332	
		4/27/2017	6.97	12	1.38	93	560	<0.0030	0.0025	0.76	<0.0010	0.06	<0.0010	150	<0.0040	<0.0020	<0.0010	0.03	<0.00020	<0.0010	<0.0010	<0.0010	0.653	1.19	1.843	
		5/18/2017	6.88	13	1.59	97	600	<0.0030	0.0027	0.75	<0.0010	0.046	<0.0010	150	<0.0040	<0.0020	<0.0010	0.033	<0.00020	<0.0010	<0.0010	<0.0010	0.814	1.12	1.934	
		6/24/2017	7.02	11	1.18	110	490	<0.0030	0.002	0.72	<0.0010	0.036	<0.0010	130	<0.0040	<0.0020	<0.0010	0.03	<0.00020	<0.0010	<0.0010	<0.0010	0.825	0.962	1.787	
		8/15/2017	6.89	10	1.27	98	500	<0.0030	0.0021	0.7	<0.0010	0.052	<0.0010	140	<0.0040	<0.0020	<0.0010	0.033	<0.00020	<0.0010	<0.0010	<0.0010	0.336	1.06	1.396	
		3/15/2018	7.03	12	1.45	84	580	<0.0030	0.002	0.72	<0.0010	0.054	<0.0010	140	<0.0040	<0.0020	<0.0010	0.025	<0.00020	0.0045	<0.0010	<0.0010	0.963	1.64	2.603	
		5/30/2018	6.99	16	1.2	73	400	--	0.0023	0.69	--	0.051	<0.0010	--	150	<0.0040	<0.00086	<0.0010	0.019	--	0.0045	<0.0010	<0.0010	2.19	0.594	2.78
	9/12/2018	6.99	16	1.2	73	400	--	0.0023	0.69	--	0.051	<0.0010	--	150	<0.0040	<0.00086	<0.0010	0.019	--	0.0045	<0.0010	<0.0010	2.19	0.594	2.78	
	B-123	11/6/2016	7.16	<5	0.52	34	394	<0.0010	0.0024	0.239	<0.0010	0.0261	<0.0010	94.3	<0.0010	<0.0050	<0.0010	0.0276	<0.00020	<0.0100	<0.0010	<0.0010	0.38	0.59	0.97	
		12/12/2016	7	<5	0.57	37	448	<0.0010	0.0011	0.206	<0.0010	0.0201	<0.0010	91	<0.0010	<0.0050	<0.0010	0.0274	<0.00020	<0.0100	<0.0010	<0.0010	0.07	0.64	0.71	
		1/8/2017	7.53	5.6	0.446	48	340	<0.0030	0.0014	0.21	<0.0010	0.031	<0.0010	89	<0.0040	<0.0020	<0.0010	0.033	<0.00020	0.003	<0.0010	<0.0010	0.156	0.485	0.641	
		1/24/2017	7.88	2.8	0.523	35	410	<0.0030	0.0017	0.2	<0.0010	0.014	<0.0010	87	<0.0040	<0.0020	<0.0010	0.032	<0.00087	0.0035	<0.0010	<0.0010	0.542	0.518	1.06	
		2/23/2017	7.22	3	0.54	36	400	<0.0030	0.0023	0.22	<0.0010	0.031	<0.0010	90	<0.0040	<0.0020	<0.0010	0.031	<0.00020	0.0036	<0.0010	<0.0010	0	1.37	1.37	
		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
		4/25/2017	7.36	3.4	0.532	36	400	<0.0030	0.0025	0.24	<0.0010	0.032	<0.0010	83	<0.0040	<0.0020	<0.0010	0.029	<0.00020	0.0036	<0.0010	<0.0010	0.429	0.398	0.827	
		5/16/2017	7.22	3.2	0.302	33	380	<0.0030	0.002	0.21	<0.0010	0.023	<0.0010	77	<0.0040	<0.0020	<0.0010	0.03	<0.00020	0.0036	<0.0010	<0.0010	0.492	0.858	1.35	
		6/21/2017	7.28	3.1	0.429	32	380	<0.0030	0.0017	0.19	<0.0010	0.029	<0.0010	78	<0.0040	<0.0020	<0.0010	0.029	<0.00020	0.0036	<0.0010	<0.0010	0	0.668	0.668	
		8/28/2017	7.24	3.5	0.574	32	360	<0.0030	0.002	0.2	<0.0010	0.03	<0.0010	82	<0.0040	<0.0020	<0.0010	0.029	<0.00020	0.0034	<0.0010	<0.0010	0.896	1.03	1.926	
		3/14/2018	7.35	3.3	0.547	32	370	<0.0030	0.0022	0.21	<0.0010	0.023	<0.0010	79	<0.0040	<0.0020	<0.0010	0.026	<0.00020	0.0044	<0.0010	<0.0010	0.671	1.13	1.801	
		5/30/2018	7.36	3.7	0.521	31	330	--	0.004	0.27	--	0.027	<0.0010	--	87	<0.0040	<0.00086	<0.0010	0.019	--	0.004	<0.0010	<0.0010	0.604	0.968	1.57
		9/11/2018	7.36	3.7	0.521	31	330	--	0.004	0.27	--	0.027	<0.0010	--	87	<0.0040	<0.00086	<0.0010	0.019	--	0.004	<0.0010	<0.0010	0.604	0.968	1.57
		B-126	11/6/2016	6.9	8	0.39	57	560	<0.0010	0.0099	0.4	<0.0010	0.0342	<0.0010	140	<0.0010	<0.0050	<0.0010	0.0159	<0.00020	<0.0100	<0.0010	<0.0010	0.7	-0.1	0.7
	12/12/2016		6.68	11	0.39	173	826	<0.0010	0.0076	0.447	<0.0010	0.0273	<0.0010	178	0.0013	<0.0050	<0.0010	0.0244	<0.00020	<0.0100	<0.0010	<0.0010	0.28	0.83	1.11	
	1/8/2017		7.49	6.4	0.376	43	240	<0.0030	0.0063	0.25	<0.0010	0.034	<0.0010	72	<0.0040	0.002	0.0011	0.016	<0.00020	<0.0010	<0.0010	<0.0010	0	0.342	0.342	
	1/24/2017		7.37	3.4	0.457	26	290	<0.0030	0.005	0.23	<0.0010	0.018	<0.0010	64	<0.0040	<0.0020	<0.0010	0.013	<0.00020	<0.0010	<0.0010	<0.0010	0	-0.189	0	
	2/23/2017		7	7.4	0.525	58	340	<0.0030	0.0067	0.28	<0.0010	0.034	<0.0010	85	<0.0040	0.0021	<0.0010	0.015	<0.00020	<0.0010	<0.0010	<0.0010	0.578	0.578	1.156	
	NS		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	4/25/2017		6.95	4.5	0.388	27	300	<0.0030	0.0084	0.21	<0.0010	0.032	<0.0010	57	0.0047	0.0026	0.002	0.013	<0.00020	<0.0010	<0.0010	<0.0010	0.441	0.826	1.267	
	5/16/2017		6.93	1.7	0.258	5.6	170	<0.0030	0.0085	0.13	<0.0010	0.022	<0.0010	35	<0.0040	<0.0020	<0.0010	<0.010	<0.00020	<0.0010	<0.0010	<0.0010	0.871	0.956	1.827	
	6/21/2017		6.91	3.2	0.398	7.6	210	<0.0030	0.0094	0.16	<0.0010	0.031	<0.0010	41	<0.0040	<0.0020	<0.0010	<0.010	<0.00020	<0.0010	<0.0010	<0.0010	0.116	0.394	0.51	
8/28/2017	6.94		4.6	0.493	20	270	<0.0030	0.0097	0.21	<0.0010	0.036	<0.0010	63	<0.0040	<0.0020	<0.0010	0.01	<0.00020	<0.0010	<0.0010	<0.0010	1	1.01	2.01		
3/14/2018	7		3.6	0.369	26	280	<0.0030	0.0086	0.24	<0.0010	0.032	<0.0010	82	0.0094	0.003	0.0043	0.013	<0.00020	0.0014	0.0012	<0.0010	0.079	2.12	2.199		
5/30/2018	7		1	0.284	11	440	--	0.0052	0.31	--	0.034	<0.0010	--	130	<0.0040	0.0019	<0.0010	0.011	--	<0.0010	<0.0010	1.01	0.116	1.126		
9/11/2018	7	1	0.284	11	440	--	0.0052	0.31	--	0.034	<0.0010	--	130	<0.0040	0.0019	<0.0010	0.011	--	<0.0010	<0.0010	1.01	0.116	1.126			
Down Gradient	MW-6	11/3/2016	6.78	<5	0.36	63	486	<0.0010	<0.0010	0.131	<0.0010	0.421	<0.0010	139	<0.0010	<0.0050	<0.0010	0.0168	<0.00020	<0.0100	<0.0010	<0.0010	0.02	0.75	0.77	
		12/6/2016	6.92	8	0.32	84	530	<0.0010	0.0022	0.137	<0.0010	0.486														

TABLE 1
 COMPARISON OF AECI NEW MADRID POWER PLANT POND 003 COMPLEX GROUNDWATER MONITORING RESULTS TO SITE GROUNDWATER PROTECTION STANDARDS – NOVEMBER 2016 THROUGH SEPTEMBER 2018 SAMPLING EVENTS
 AECI NEW MADRID POWER PLANT - POND 003 COMPLEX
 NEW MADRID, MISSOURI

Monitoring Well ID	Date Sampled	pH field	Chloride	Fluoride	Sulfate	Solids Total Dissolved	Antimony Total	Arsenic Total	Barium Total	Beryllium Total	Boron Total	Cadmium Total	Calcium Total	Chromium Total	Cobalt Total	Lead Total	Lithium Total	Mercury Total	Molybdenum Total	Selenium Total	Thallium Total	Radium-226	Radium-228	Combined Radium		
		SU	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	pCi/L	pCi/L	pCi/L	
Site GWPS (a)		NA	NA	4.0	NA	NA	0.006	0.01	2	0.004	NA	0.005	NA	0.1	0.006	0.015	0.04	0.002	0.1	0.05	0.002	NA	NA	5		
Down Gradient	MW-7	11/3/2016	6.75	7	0.34	409	1080	<0.0010	0.0021	0.181	<0.0010	19.9	<0.0010	232	<0.0010	0.0062	<0.0010	0.0223	<0.00020	3.2	<0.0010	<0.0010	0.09	1.04	1.13	
		12/6/2016	6.88	6	0.33	320	952	<0.0010	0.0032	0.15	<0.0010	18.4	0.0011	207	<0.0010	0.0098	<0.0010	0.0227	<0.00020	3.24	<0.0010	<0.0010	0.175	0.922	1.097	
		1/4/2017	7.23	7.2	0.464	360	810	<0.0030	0.0045	0.11	<0.0010	17	0.0012	120	<0.0040	0.0067	<0.0010	0.031	<0.00020	2.8	<0.0010	<0.0010	0.389	0.89	1.279	
		1/26/2017	7.62	7.9	0.564	310	720	<0.0030	0.0036	0.12	<0.0010	14	0.0016	120	<0.0040	0.0059	<0.0010	0.027	<0.00020	2.9	<0.0010	<0.0010	0.345	0.43	0.775	
		2/22/2017	6.88	7.6	0.287	380	960	<0.0030	0.0021	0.15	<0.0010	19	<0.0010	200	<0.0040	0.0068	<0.0010	0.03	<0.00020	3.4	<0.0010	<0.0010	2.97	0.829	3.799	
		3/30/2017	6.78	7.4	0.496	390	980	<0.0030	0.0018	0.15	<0.0010	17	<0.0010	180	<0.0040	0.0067	<0.0010	0.028	<0.00020	3.4	<0.0010	<0.0010	0.244	1.16	1.404	
		4/26/2017	7.02	9.3	0.277	370	900	<0.0030	0.0034	0.14	<0.0010	20	0.0014	180	<0.0040	0.0051	<0.0010	0.027	<0.00020	3.9	<0.0010	<0.0010	0.335	1.39	1.725	
		5/18/2017	6.85	10	<0.250	420	960	<0.0030	0.0037	0.14	<0.0010	20	<0.0010	170	<0.0040	0.003	<0.0010	0.034	<0.00020	3.9	<0.0010	<0.0010	0.767	1.95	2.717	
		6/20/2017	6.99	5.7	0.388	300	960	<0.0030	0.0028	0.15	<0.0010	19	0.0016	190	<0.0040	0.007	0.0018	0.028	<0.00020	3.5	0.0021	<0.0010	0.544	1.17	1.714	
	8/16/2017	7.16	6.6	0.41	290	720	<0.0030	0.002	0.17	<0.0010	16	<0.0010	210	<0.0040	0.0073	<0.0010	0.031	<0.00020	3.6	<0.0010	<0.0010	0.544	1	1.544		
	3/15/2018	7.01	9.9	0.372	340	830																				
	5/30/2018						<0.0030	0.0023	0.13	<0.0010		<0.0010		<0.0040	0.0058	<0.0010	0.019	<0.00020		3.4	<0.0010	<0.0010	0.109	0.52	0.629	
	9/11/2018	7.2	13	0.33	470	880	--	0.0024	0.14	--	19	--	200	<0.0040	0.0076	<0.0010	0.014	--	3	<0.0010	--	0.218	1.14	1.358		
	MW-8	11/4/2016	6.99	7	0.29	419	1030	<0.0010	0.004	0.115	<0.0010	17.4	<0.0010	233	<0.0010	<0.0050	<0.0010	0.0197	<0.00020	0.737	<0.0010	<0.0010	0.67	0.693	1.363	
		12/7/2016	7.09	6	0.29	443	1050	<0.0010	0.0026	0.111	<0.0010	19.8	<0.0010	235	<0.0010	<0.0050	<0.0010	0.0223	<0.00020	0.706	<0.0010	<0.0010	0.494	0.965	1.459	
		1/5/2017	7.59	12	0.366	230	570	<0.0030	0.0046	0.066	<0.0010	12	<0.0010	140	<0.0040	<0.0020	<0.0010	0.023	<0.00020	0.96	<0.0010	<0.0010	-0.137	0.563	0.563	
		1/26/2017	7.8	12	0.538	300	690	<0.0030	0.0045	0.085	<0.0010	12	<0.0010	130	<0.0040	<0.0020	<0.0010	0.022	<0.00020	0.87	<0.0010	<0.0010	-0.209	0.822	0.822	
		2/21/2017	7.11	9.6	0.288	320	840	<0.0030	0.0057	0.1	<0.0010	14	<0.0010	190	<0.0040	<0.0020	<0.0010	0.025	<0.00020	0.83	<0.0010	<0.0010	0.871	1.42	2.291	
3/30/2017		7.03	8.8	0.475	360	940	<0.0030	0.0054	0.11	<0.0010	15	<0.0010	180	<0.0040	<0.0020	<0.0010	0.025	<0.00020	0.83	<0.0010	<0.0010	0.402	0.952	1.354		
4/26/2017		7.26	11	0.3	270	660	<0.0030	0.005	0.082	<0.0010	14	<0.0010	160	<0.0040	<0.0020	<0.0010	0.018	<0.00020	1	<0.0010	<0.0010	0.0534	0.959	1.0124		
5/17/2017		7.12	9.5	0.348	300	740	<0.0030	0.0062	0.098	<0.0010	14	<0.0010	150	<0.0040	<0.0020	<0.0010	0.022	<0.00020	1.2	<0.0010	<0.0010	0.45	0.976	1.426		
6/21/2017		7.23	9.5	0.361	340	720	<0.0030	0.006	0.1	<0.0010	15	<0.0010	170	<0.0040	<0.0020	<0.0010	0.022	<0.00020	0.93	<0.0010	<0.0010	0.884	0.537	1.421		
8/16/2017		7.15	9.1	0.376	330	700	<0.0030	0.0048	0.1	<0.0010	14	<0.0010	160	<0.0040	<0.0020	<0.0010	0.025	<0.00020	1	<0.0010	<0.0010	0.239	0.674	0.913		
3/15/2018	7.32	10	0.354	180	540																					
5/30/2018						<0.0030	0.0053	0.082	<0.0010		<0.0010		<0.0040	<0.0020	<0.0010	0.017	<0.00020		0.93	<0.0010	<0.0010	0.121	0.944	1.065		
9/12/2018	7.2	10	0.29	320	700	--	0.0045	0.082	--	16	--	180	<0.0040	0.0016	<0.0010	0.012	--	0.86	<0.0010	--	0.518	0.322	0.84			
Down Gradient	MW-9	11/4/2016	7.15	17	0.53	108	534	<0.0010	<0.0010	0.0984	<0.0010	2.26	<0.0010	123	<0.0010	<0.0050	<0.0010	0.0258	<0.00020	0.312	<0.0010	<0.0010	-0.09	3.12	3.12	
		12/7/2016	7.22	16	0.49	109	476	<0.0010	<0.0010	0.0842	<0.0010	3.08	<0.0010	119	<0.0010	<0.0050	<0.0010	0.0296	<0.00020	0.337	0.0015	<0.0010	0.547	0.848	1.395	
		1/5/2017	7.55	16	0.508	110	400	<0.0030	<0.0010	0.075	<0.0010	2.8	<0.0010	82	<0.0040	<0.0020	<0.0010	0.034	<0.00020	0.32	<0.0010	<0.0010	0.275	1.28	1.555	
		1/27/2017	8.13	17	0.557	120	420	<0.0030	<0.0010	0.072	<0.0010	2.4	<0.0010	82	<0.0040	<0.0020	<0.0010	0.03	<0.00020	0.35	<0.0010	<0.0010	0.064	0.466	0.53	
		2/21/2017	7.29	17	0.481	96	500	<0.0030	<0.0010	0.089	<0.0010	2.5	<0.0010	120	<0.0040	<0.0020	<0.0010	0.031	<0.00020	0.33	<0.0010	<0.0010	0.37	1.1	1.47	
		3/30/2017	7.15	18	0.654	110	490	<0.0030	<0.0010	0.08	<0.0010	2.2	<0.0010	100	<0.0040	<0.0020	<0.0010	0.03	<0.00020	0.33	<0.0010	<0.0010	0.403	1.02	1.423	
		4/26/2017	7.5	17	0.481	97	400	<0.0030	<0.0010	0.069	<0.0010	1.9	<0.0010	90	<0.0040	<0.0020	<0.0010	0.025	<0.00020	0.42	<0.0010	<0.0010	0.32	0.334	0.654	
		5/17/2017	7.27	19	<0.250	97	480	<0.0030	<0.0010	0.098	<0.0010	2.1	<0.0010	100	<0.0040	<0.0020	<0.0010	0.034	<0.00020	0.44	<0.0010	<0.0010	0.371	0.925	1.296	
		6/20/2017	7.33	17	0.507	110	540	<0.0030	<0.0010	0.092	<0.0010	2	<0.0010	100	<0.0040	<0.0020	<0.0010	0.029	<0.00020	0.36	<0.0010	<0.0010	0.183	0.526	0.709	
	8/16/2017	7.23	16	0.561	110	430	<0.0030	<0.0010	0.097	<0.0010	2.2	<0.0010	120	<0.0040	<0.0020	<0.0010	0.035	<0.00020	0.35	<0.0010	<0.0010	0.261	0.716	0.977		
	3/15/2018	7.41	20	0.386	100	410																				
	5/30/2018						<0.0030	<0.0010	0.089	<0.0010		<0.0010		<0.0040	<0.0020	<0.0010	0.026	<0.00020		0.34	<0.0010	<0.0010	0	0.599	0.599	
	9/12/2018	7.34	20	0.44	110	470	--	<0.0010	0.074	--	2.4	--	110	<0.0040	<0.00086	<0.0010	0.021	--	0.34	<0.0010	--	0.147	0.0688	0.216		
	P-1	11/5/2016	7.05	19	0.38	178	632	<0.0010	<0.0010	0.0533	<0.0010	2.04	<0.0010	153	<0.0010	<0.0050	<0.0010	0.0221	<0.00020	0.0194	0.0014	<0.0010	-0.12	1.48	1.48	
		12/8/2016	7.25	19	0.44	170	610	<0.0010	<0.0010	0.0552	<0.0010	1.99	<0.0010	152	<0.0010	<0.0050	<0.0010	0.0248	<0.00020	0.0506	<0.0010	<0.0010	NS	NS	NS	
		1/6/2017	7.76	20	0.552	180	540	<0.0030	<0.0010	0.051	<0.0010	2	<0.0010	140	<0.0040	<0.0020	<0.0									

TABLE 1
COMPARISON OF AECI NEW MADRID POWER PLANT POND 003 COMPLEX GROUNDWATER MONITORING RESULTS TO SITE GROUNDWATER PROTECTION STANDARDS – NOVEMBER 2016 THROUGH SEPTEMBER 2018 SAMPLING EVENTS
AECI NEW MADRID POWER PLANT - POND 003 COMPLEX
NEW MADRID, MISSOURI

Monitoring Well ID	Date Sampled	pH field	Chloride	Fluoride	Sulfate	Solids Total Dissolved	Antimony Total	Arsenic Total	Barium Total	Beryllium Total	Boron Total	Cadmium Total	Calcium Total	Chromium Total	Cobalt Total	Lead Total	Lithium Total	Mercury Total	Molybdenum Total	Selenium Total	Thallium Total	Radium-226	Radium-228	Combined Radium	
		SU	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	pCi/L	pCi/L	pCi/L
	Site GWPS (a)	NA	NA	4.0	NA	NA	0.006	0.01	2	0.004	NA	0.005	NA	0.1	0.006	0.015	0.04	0.002	0.1	0.05	0.002	NA	NA	5	
Down Gradient	P-3	11/4/2016	6.91	15	0.36	138	712	<0.0010	<0.0010	0.102	<0.0010	8.83	<0.0010	179	<0.0010	<0.0050	<0.0010	0.025	<0.00020	1.28	0.0041	<0.0010	0.29	-0.06	0.29
		12/7/2016	7.03	11	0.48	155	750	<0.0010	<0.0010	0.111	<0.0010	12.8	<0.0010	191	<0.0010	<0.0050	<0.0010	0.0285	<0.00020	1.56	0.008	<0.0010	0.226	0.807	1.033
		1/5/2017	7.29	15	0.481	190	680	<0.0030	<0.0010	0.098	<0.0010	13	<0.0010	150	<0.0040	<0.0020	<0.0010	0.033	<0.00020	1.4	0.0046	<0.0010	0.0691	0.646	0.7151
		1/28/2017	7.86	13	0.463	160	610	<0.0030	<0.0010	0.1	<0.0010	11	<0.0010	140	<0.0040	<0.0020	<0.0010	0.027	<0.00020	1.3	0.0029	<0.0010	0.389	0.382	0.771
		2/21/2017	7.13	17	0.381	130	640	<0.0030	<0.0010	0.1	<0.0010	9.3	<0.0010	170	<0.0040	<0.0020	<0.0010	0.03	<0.00020	1.2	0.0042	<0.0010	0.927	0.473	1.4
		3/30/2017	6.95	14	0.591	140	700	<0.0030	<0.0010	0.1	<0.0010	8.9	<0.0010	160	<0.0040	<0.0020	<0.0010	0.03	<0.00020	1.1	0.0048	<0.0010	-0.152	0.302	0.302
		4/26/2017	7.19	14	0.463	150	660	<0.0030	<0.0010	0.1	<0.0010	12	<0.0010	190	<0.0040	<0.0020	<0.0010	0.027	<0.00020	1.4	0.0036	<0.0010	0.181	0.306	0.487
		5/17/2017	7	16	<0.250	130	640	<0.0030	<0.0010	0.093	<0.0010	7.8	<0.0010	140	<0.0040	<0.0020	<0.0010	0.032	<0.00020	1.1	0.0037	<0.0010	0.449	0.41	0.859
		6/20/2017	7.13	15	0.461	130	640	<0.0030	<0.0010	0.095	<0.0010	8.7	<0.0010	160	<0.0040	<0.0020	<0.0010	0.029	<0.00020	1	0.006	<0.0010	0.439	1.21	1.649
		8/16/2017	7.1	15	0.482	120	550	<0.0030	<0.0010	0.098	<0.0010	8.7	<0.0010	160	<0.0040	<0.0020	<0.0010	0.031	<0.00020	1.3	0.0046	<0.0010	0.274	0.729	1.003
		3/15/2018	7.32	18	0.562	120	620					6.2		140											
	5/29/2018						<0.0030	<0.0010	0.095	<0.0010		<0.0010		0.0048	<0.0020	0.0016	0.023	<0.00020	1.3	0.0054	<0.0010	0.322	0.282	0.604	
	9/12/2018	7.14	21	0.426	120	600	--	<0.0010	0.086	<0.0010	--	8.5	<0.0010	170	0.0048	<0.00086	<0.0010	0.018	--	1.4	0.0057	<0.0010	0.0702	0.0544	0.125
	P-4	11/4/2016	7.1	20	0.34	81	530	<0.0010	<0.0010	0.144	<0.0010	0.419	<0.0010	131	<0.0010	<0.0050	<0.0010	0.0379	<0.00020	0.032	0.0022	<0.0010	0.1	0.43	0.53
		12/7/2016	7.42	21	0.48	91	452	<0.0010	<0.0010	0.109	<0.0010	0.436	<0.0010	96.9	<0.0010	<0.0050	<0.0010	0.0251	<0.00020	0.0318	0.001	<0.0010	0.6	0.852	1.452
		1/5/2017	7.58	28	0.568	94	390	<0.0030	<0.0010	0.12	<0.0010	0.38	<0.0010	87	<0.0040	<0.0020	<0.0010	0.031	<0.00020	0.033	0.0018	<0.0010	-0.211	0.885	0.885
		1/28/2017	8	20	0.469	82	390	<0.0030	<0.0010	0.11	<0.0010	0.39	<0.0010	80	<0.0040	<0.0020	<0.0010	0.029	<0.00020	0.031	<0.0010	<0.0010	0.128	0.351	0.479
		2/21/2017	7.29	20	0.362	86	480	<0.0030	<0.0010	0.13	<0.0010	0.41	<0.0010	110	<0.0040	<0.0020	<0.0010	0.043	<0.00020	0.029	0.0014	<0.0010	0.0649	0.382	0.4469
		3/30/2017	7.17	19	0.543	91	520	<0.0030	<0.0010	0.13	<0.0010	0.4	<0.0010	100	<0.0040	<0.0020	<0.0010	0.041	<0.00020	0.029	0.0019	<0.0010	0.107	-0.3	0.107
		4/26/2017	7.4	19	0.381	93	440	<0.0030	<0.0010	0.12	<0.0010	0.45	<0.0010	100	<0.0040	<0.0020	<0.0010	0.032	<0.00020	0.03	<0.0010	<0.0010	0.107	0.651	0.758
		5/17/2017	7.24	21	<0.250	77	420	<0.0030	<0.0010	0.11	<0.0010	0.42	<0.0010	84	<0.0040	<0.0020	<0.0010	0.038	<0.00020	0.027	<0.0010	<0.0010	0.416	0.562	0.978
		6/20/2017	7.28	20	0.38	89	490	<0.0030	<0.0010	0.12	<0.0010	0.5	<0.0010	100	<0.0040	<0.0020	<0.0010	0.043	<0.00020	0.026	0.0019	<0.0010	0.327	0.764	1.091
		8/16/2017	7.32	20	<0.250	88	440	<0.0030	<0.0010	0.14	<0.0010	0.48	<0.0010	110	<0.0040	<0.0020	<0.0010	0.043	<0.00020	0.03	0.0024	<0.0010	0.178	0.684	0.862
		3/15/2018	7.33	20	0.324	78	420					0.45		100											
	5/29/2018						<0.0030	<0.0010	0.11	<0.0010		<0.0010		<0.0040	<0.0020	<0.0010	0.03	<0.00020	0.033	0.003	<0.0010	0.13	0.464	0.594	
	9/12/2018	6.71	23	0.369	57	460	--	<0.0010	0.11	<0.0010	--	0.43	<0.0010	120	<0.0040	<0.00086	<0.0010	0.028	--	0.025	0.0022	<0.0010	0.297	-0.0493	0.297
	P-5	11/3/2016	6.67	8	0.18	163	572	<0.0010	0.0053	0.125	<0.0010	7.98	<0.0010	123	<0.0010	<0.0050	<0.0010	0.0179	<0.00020	0.235	<0.0010	<0.0010	0.51	1.49	2
		12/6/2016	6.71	12	0.2	135	484	<0.0010	0.0081	0.11	<0.0010	6.22	<0.0010	106	<0.0010	<0.0050	<0.0010	0.0169	<0.00020	0.235	<0.0010	<0.0010	0.536	0.879	1.415
		1/4/2017	7.48	8.2	<0.250	170	550	<0.0030	0.0056	0.13	<0.0010	8.2	<0.0010	110	<0.0040	<0.0020	<0.0010	0.025	<0.00020	0.25	<0.0010	<0.0010	0.0669	1.58	1.6469
		1/26/2017	7.73	5.4	0.364	210	630	<0.0030	0.0068	0.14	<0.0010	7	<0.0010	110	<0.0040	<0.0020	<0.0010	0.024	<0.00020	0.23	<0.0010	<0.0010	0.0738	0.21	0.2838
		2/22/2017	6.78	7.3	<0.250	170	600	<0.0030	0.011	0.15	<0.0010	8.5	<0.0010	130	<0.0040	<0.0020	<0.0010	0.024	<0.00020	0.27	<0.0010	<0.0010	0.374	0.852	1.226
		3/30/2017	6.73	6.8	0.438	180	640	<0.0030	0.0089	0.15	<0.0010	7.5	<0.0010	120	<0.0040	<0.0020	<0.0010	0.024	<0.00020	0.25	<0.0010	<0.0010	0.797	1.26	2.057
		4/26/2017	6.88	6.2	<0.250	210	680	<0.0030	0.0099	0.17	<0.0010	8.7	<0.0010	140	<0.0040	<0.0020	<0.0010	0.022	<0.00020	0.3	<0.0010	<0.0010	0.808	1.18	1.988
		5/18/2017	6.8	6.7	<0.250	230	720	<0.0030	0.0069	0.18	<0.0010	9.7	<0.0010	140	<0.0040	<0.0020	<0.0010	0.03	<0.00020	0.36	<0.0010	<0.0010	0.555	0.745	1.3
		6/20/2017	6.79	5.3	0.272	260	780	<0.0030	0.0083	0.16	<0.0010	11	<0.0010	140	<0.0040	0.002	<0.0010	0.026	<0.00020	0.26	0.0015	<0.0010	0.95	1.21	2.16
8/16/2017		6.69	4.9	<0.250	180	520	<0.0030	0.0064	0.13	<0.0010	9.1	<0.0010	130	<0.0040	<0.0020	<0.0010	0.024	<0.00020	0.23	<0.0010	<0.0010	0.27	0.949	1.219	
3/15/2018		6.94	5.4	0.266	180	650					8.2		140												
5/29/2018							<0.0030	0.0066	0.17	<0.0010		<0.0010		<0.0040	<0.0020	<0.0010	0.022	<0.00020	0.28	<0.0010	<0.0010	1.02	0.213	1.233	
9/11/2018		6.13	7	<0.250	180	490	--	0.0066	0.12	<0.0010	--	9.2	<0.0010	130	<0.0040	0.0012	<0.0010	0.012	--	0.26	<0.0010	--	0.708	1.69	2.4

Notes:
 Blank cells - Constituent not included in this analysis. NA - Not Available.
 GW - Groundwater. NS - No Sample, sample was lost in transit.
 GWPS - Groundwater Protection Standard. pCi/L - picoCurie per liter.
 mg/L - milligrams per liter. su - standard units

Qualifiers:
 < - Constituent was not detected, value is the reporting limit.

(a) - Site GWPS are the USEPA Maximum Contaminant Levels (MCLs), or where unavailable, the USEPA Tapwater Regional Screening Levels (RSLs).
 USEPA 2018 Edition of the Drinking Water Standards and Health Advisories. Spring 2018.
<http://water.epa.gov/drink/contaminants/index.cfm>
 USEPA Risk-Based Screening Levels (May 2019). Values for Tap Water. Hazard Index = 1.0.
<https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables>

 Detected Concentration > Groundwater Protection Standard.

TABLE 2
HUMAN HEALTH PUBLISHED SCREENING LEVELS FOR SURFACE WATER
AECI NEW MADRID POWER PLANT - POND 003 COMPLEX
NEW MADRID, MISSOURI

Constituent	CAS RN	Human Health Published Screening Level - Drinking Water			Human Health Published Screening Level - Surface Water		Selected Published Human Health Screening Levels for Surface Water	
		Missouri Drinking Water Supply (a) (mg/L)	Missouri Groundwater (a) (mg/L)	May 2019 USEPA Tap Water RSLs (b) (mg/L)	Missouri Human Health Fish Consumption (a) (mg/L)	USEPA NRWQC Human Health Consumption of Organism Only (c) (mg/L)	Selected Screening Level - Drinking Water (d) (mg/L)	Selected Screening Level - Surface Water Consumption of Organism Only (e) (mg/L)
Detection Monitoring - USEPA Appendix III Constituents (f)								
Boron	7440-42-8	NA	2	4	NA	NA	2	NA
Fluoride	16984-48-8	4	4	0.8	NA	NA	4	NA
Assessment Monitoring - USEPA Appendix IV Constituents								
Antimony	7440-36-0	0.006	0.006	0.0078	4.3	0.64	0.006	4.3
Arsenic	7440-38-2	0.05	0.05	0.000052	NA	0.00014	0.05	0.00014
Barium	7440-39-3	2	2	3.8	NA	NA	2	NA
Beryllium	7440-41-7	0.004	0.004	0.025	NA	NA	0.004	NA
Cadmium	7440-43-9	0.005	0.005	0.0092	NA	NA	0.005	NA
Chromium	7440-47-3	0.1	0.1	22	NA	NA	0.1	NA
Cobalt	7440-48-4	NA	1	0.006	NA	NA	1	NA
Lead	7439-92-1	0.015	0.015	0.015	NA	NA	0.015	NA
Lithium	7439-93-2	NA	NA	0.04	NA	NA	0.04	NA
Mercury	7439-97-6	0.002	0.002	0.0057	NA	NA	0.002	NA
Molybdenum	7439-98-7	NA	NA	0.1	NA	NA	0.1	NA
Selenium	7782-49-2	0.05	0.05	0.1	NA	4.2	0.05	4.2
Thallium	7440-28-0	0.002	0.002	0.0002	0.0063	0.00047	0.002	0.0063
Radiological (pCi/L)								
Radium-226 & 228	7440-14-4	5 (g)	NA	NA	NA	NA	5	NA

Notes:

- CAS RN - Chemical Abstracts Service Registry Number.
mg/L - milligrams per liter.
NA - Not Available / Applicable.
NRWQC - National Recommended Water Quality Criteria.
pCi/L - picoCurie per liter.
RSL - Regional Screening Level.
USEPA - United States Environmental Protection Agency.

- (a) - 10 Missouri Code of State Regulations Division 20 Chapter 7 Table A1. Updated January 29, 2019.
<http://www.sos.mo.gov/adrules/csr/current/10csr/10c20-7a.pdf>. Missouri State Drinking Water and Groundwater Standards apply to total results, Human Health Fish Consumption values apply to dissolved results (except mercury, which applies to total results);
- (b) - USEPA Risk-Based Screening Levels (May 2019). Values for Tap Water. Hazard Index = 1.0.
<http://www2.epa.gov/risk/risk-based-screening-table-generic-tables>
- (c) - USEPA National Recommended Water Quality Criteria - Human Health Criteria Table. USEPA Office of Water and Office of Science and Technology.
<https://www.epa.gov/wqc/national-recommended-water-quality-criteria-human-health-criteria-table>
- (d) - The hierarchy for selection among the Human Health Published Screening Levels for Drinking Water is:
1) Missouri Drinking Water Supply
2) Missouri Groundwater Supply
3) USEPA RSL - Tap Water
- (e) - The hierarchy for selection among the Human Health Published Screening Values for Surface Water - Consumption of Organism Only is:
1) Missouri Human Health Fish Consumption
2) USEPA NRWQC - Consumption of Water and Organism.
- (f) - Detection Monitoring - EPA Appendix III Constituents without health risk-based screening levels are not included.
- (g) - USEPA Maximum Contaminant Level (MCL) used in the absence of a Missouri State value for radium in drinking water. USEPA, 2018. 2018 Edition of the Drinking Water Standards and Health Advisories. March. <https://www.epa.gov/dwstandardsregulations/2018-drinking-water-standards-and-advisory-tables>

TABLE 3
HUMAN HEALTH CALCULATED RISK BASED SCREENING LEVELS FOR SURFACE WATER
AECI NEW MADRID POWER PLANT - POND 003 COMPLEX
NEW MADRID, MISSOURI

Constituent	CAS RN	Human Health Calculated RBSL - Recreational Use of Surface Water (c)			Selected Human Health Calculated RBSL - Recreational Use of Surface Water (b) (mg/L)
		Current/Future Off-Site Recreational Swimmer Age-Adjusted (Ages 1 - 26) (a) (mg/L)	Current/Future Off-Site Recreational Wader Age-Adjusted (Ages 1 - 26) (a) (mg/L)	Current/Future Off-Site Recreational Boater (Adult) (a) (mg/L)	
Detection Monitoring - USEPA Appendix III Constituents (d)					
Boron	7440-42-8	114	120	11,200	114
Fluoride	16984-48-8	23.9	22.9	2,240	22.9
Assessment Monitoring - USEPA Appendix IV Constituents					
Antimony	7440-36-0	0.171	0.218	3.36	0.171
Arsenic	7440-38-2	0.0236 (e, f)	0.0389 (e, g)	2.61 (e, h)	0.0236
Barium	7440-39-3	63.7	97.1	784	63.7
Beryllium	7440-41-7	0.121	0.345	0.784	0.121
Cadmium	7440-43-9	0.134	0.225	1.4	0.134
Chromium (Total)	7440-47-3	155 (i)	386 (i)	1090 (i)	155
Cobalt	7440-48-4	0.178	0.181	42	0.178
Lead	7439-92-1	0.015 (j)	0.015 (j)	0.015 (j)	0.015
Lithium	7439-93-2	1.14	1.2	112	1.14
Mercury	7439-97-6	0.0956 (k)	0.146 (k)	1.18 (k)	0.0956
Molybdenum	7439-98-7	2.86	2.99	280	2.86
Selenium	7782-49-2	2.86	2.99	280	2.86
Thallium	7440-28-0	0.00572	0.00598	0.56	0.00572
Radiological (pCi/L)					
Radium-226 & 228	7440-14-4	NA	NA	NA	NA

Notes:

CAS RN - Chemical Abstracts Service Registry Number.

NA - Not Available.

pCi/L - picoCuries/liter.

mg/L - milligrams/liter.

RBSL - Risk-Based Screening Level.

USEPA - United States Environmental Protection Agency.

- (a) - Documentation for the receptor-specific Human Health Calculated Screening Level for Recreational Use of Surface Water is provided in Attachment B.
- (b) - The selected human health RBSL for recreational use of surface water is the minimum value from amongst the Current/Future Off-Site Recreational Swimmer, Current/Future Off-Site Recreational Wader, and Current/Future Off-Site Recreational Boater RBSLs.
- (c) - Some calculated values may be above solubility limits.
- (d) - Detection Monitoring - EPA Appendix III Constituents without health risk-based screening levels are not included.
- (e) - Arsenic RBSLs are based on the lower of the values based on a hazard index of 1 and an excess lifetime cancer risk of 1E-05.
Note that of the constituents evaluated, arsenic is the only constituent with an RSL based on potential carcinogenic effects.
- (f) - RBSL based on cancer endpoint at 1E-5 (noncancer-based RBSL is 0.647 mg/L).
- (g) - RBSL based on cancer endpoint at 1E-5 (noncancer-based RBSL is 3.04 mg/L).
- (h) - RBSL based on cancer endpoint at 1E-5 (noncancer-based RBSL is 16.8 mg/L).
- (i) - Value for chromium (III) used.
- (j) - USEPA lead action level of 0.015 mg/L for lead in drinking water (USEPA, 2018) is used as the RBSL.
- (k) - Value for mercuric chloride used.

TABLE 4
ECOLOGICAL SCREENING LEVELS FOR SURFACE WATER
AECI NEW MADRID POWER PLANT - POND 003 COMPLEX
NEW MADRID, MISSOURI

Constituent	CAS RN	Ecological Published Screening Levels - Surface Water				Selected Ecological Screening Level Acute (Dissolved) (c) (mg/L)	Selected Ecological Screening Level Chronic (Dissolved) (c) (mg/L)
		Missouri Protection of Aquatic Life Chronic (Dissolved) (a) (mg/L)	Missouri Protection of Aquatic Life Acute (Dissolved) (a) (mg/L)	USEPA NRWQC Aquatic Life Criteria CCC - Freshwater Chronic (Dissolved) (b) (mg/L)	USEPA NRWQC Aquatic Life Criteria CMC - Freshwater Acute (Dissolved) (b) (mg/L)		
Detection Monitoring - USEPA Appendix III Constituents (e)							
Boron	7440-42-8	NA	NA	NA	NA	NA	NA
Fluoride	16984-48-8	NA	NA	NA	NA	NA	NA
Assessment Monitoring - USEPA Appendix IV Constituents							
Antimony	7440-36-0	NA	NA	NA	NA	NA	NA
Arsenic	7440-38-2	0.15	0.34	0.15	0.34	0.34	0.15
Barium	7440-39-3	NA	NA	NA	NA	NA	NA
Beryllium	7440-41-7	0.005	NA	NA	NA	NA	0.005
Cadmium	7440-43-9	0.00072 (d)	0.0018 (d)	0.00072 (d)	0.0018 (d)	0.0018	0.0007
Chromium	7440-47-3	0.074 (d, e)	0.57 (d, e)	0.074 (d, e)	0.57 (d, e)	0.57	0.07
Cobalt	7440-48-4	NA	NA	NA	NA	NA	NA
Lead	7439-92-1	0.0025 (d)	0.065 (d)	0.0025 (d)	0.065 (d)	0.065	0.0025
Lithium	7439-93-2	NA	NA	NA	NA	NA	NA
Mercury	7439-97-6	0.00077	0.0014	0.00077	0.0014	0.0014	0.00077
Molybdenum	7439-98-7	NA	NA	NA	NA	NA	NA
Selenium	7782-49-2	0.005	NA	0.0031 (f)	NA	NA	0.005
Thallium	7440-28-0	NA	NA	NA	NA	NA	NA
Radiological (pCi/L)							
Radium-226 & 228	7440-14-4	NA	NA	NA	NA	NA	NA

Notes:

CAS RN - Chemical Abstracts Service Registry Number.

mg/L - milligrams per liter.

NA - Not Available / Applicable.

pCi/L - picoCurie per liter.

NRWQC - National Recommended Water Quality Criteria

CCC - Continuous Criterion Concentration

CMC - Criterion Maximum Concentration

USEPA - United States Environmental Protection Agency

- (a) - 10 Missouri Code of State Regulations Division 20 Chapter 7 Table A1. Updated January 29, 2019.
<http://www.sos.mo.gov/adrules/csr/current/10csr/10c20-7a.pdf>. Missouri State Protection of Aquatic Life Chronic values apply to dissolved results (except mercury, which applies to total results).
- (b) - USEPA Water Quality Criteria. Current Water Quality Criteria Tables. National Recommended Water Quality Criteria - Aquatic Life Criteria Table.
<http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm>
- (c) - The hierarchy for the selection of ecological screening levels is:
 1) Missouri Protection of Aquatic Life Criteria.
 2) USEPA NRWQC. Aquatic Life Criteria - Freshwater.
- (d) - Hardness dependent value for total metals adjusted for dissolved fraction. Default mean hardness value of 100 mg/L as CaCO₃ used.
- (e) - Value for trivalent chromium used.
- (f) - USEPA Office of Water. Final Criterion: Aquatic Life Ambient Water Quality Criterion for Selenium - Freshwater. 30 June 2016.
 Freshwater value for chronic (30 day) water column concentration (mg/L) of dissolved selenium in lotic (flowing) surface water. The criterion is based on fish ovary concentrations, and in lieu of that, the water column values are used.
https://www.epa.gov/sites/production/files/2016-07/documents/aquatic_life_awqc_for_selenium_freshwater_2016.pdf

TABLE 5
SELECTED SURFACE WATER SCREENING LEVELS
AECI NEW MADRID POWER PLANT - POND 003 COMPLEX
NEW MADRID, MISSOURI

Constituent	CAS RN	HH DW SL (a) (mg/L)	HH REC SL - Consumption of Organism Only (b) (mf/L)	HH Recreational Calculated RBSL (c) (mg/L)	ECO SL - Dissolved (acute) (d) (mg/L)	ECO SL - Dissolved (chronic) (d) (mg/L)
Detection Monitoring - USEPA Appendix III Constituents (e)						
Boron	7440-42-8	2	NA	114	NA	NA
Fluoride	16984-48-8	4	NA	22.9	NA	NA
Assessment Monitoring - USEPA Appendix IV Constituents						
Antimony	7440-36-0	0.006	4.3	0.171	NA	NA
Arsenic	7440-38-2	0.05	0.00014	0.236	0.34	0.15
Barium	7440-39-3	2	NA	63.7	NA	NA
Beryllium	7440-41-7	0.004	NA	0.121	NA	0.005
Cadmium	7440-43-9	0.005	NA	0.134	0.0018	0.0007
Chromium (Total)	7440-47-3	0.1	NA	155	0.57	0.07
Cobalt	7440-48-4	1	NA	0.178	NA	NA
Lead	7439-92-1	0.015	NA	0.015	0.065	0.0025
Lithium	7439-93-2	0.04	NA	1.14	NA	NA
Mercury	7439-97-6	0.002	NA	0.0956	0.0014	0.00077
Molybdenum	7439-98-7	0.1	NA	2.86	NA	NA
Selenium	7782-49-2	0.05	4.2	2.86	NA	0.005
Thallium	7440-28-0	0.002	0.0063	0.00572	NA	NA
Radiological (pCi/L)						
Radium-226 & 228	7440-14-4	5	NA	NA	NA	NA

Notes:

CAS RN - Chemical Abstracts Service Registry Number.

mg/L - milligram per liter.

ECO SL - Ecological Screening Level.

NA - Not Available.

HH DW SL - Human Health Drinking Water Screening Level.

RBSL - Risk-Based Screening Level.

HH REC SL - Human Health Recreational Use Screening Level.

(a) - Drinking Water Screening Levels selected in Table 2 using the following hierarchy:

- 1) Missouri Drinking Water Supply
- 2) Missouri Groundwater Supply
- 3) USEPA RSL - Tap Water

(b) - Human Health Surface Water Screening Levels selected in Table 2 using the following hierarchy:

- 1) Missouri Human Health Fish Consumption
- 2) USEPA NRWQC - Consumption of Water and Organism.

(c) - The Human Health Calculated Screening Levels are presented in Table 3.

The minimum calculated value for the Off-Site Recreational Boater, Wader, and Swimmer was selected.

(d) - Ecological Screening Levels selected in Table 4 using the following hierarchy:

- 1) Missouri Protection of Aquatic Life Criteria.
- 2) USEPA NRWQC. Aquatic Life Criteria - Freshwater.

(e) - Detection Monitoring - EPA Appendix III Constituents without health risk-based screening levels are not included.

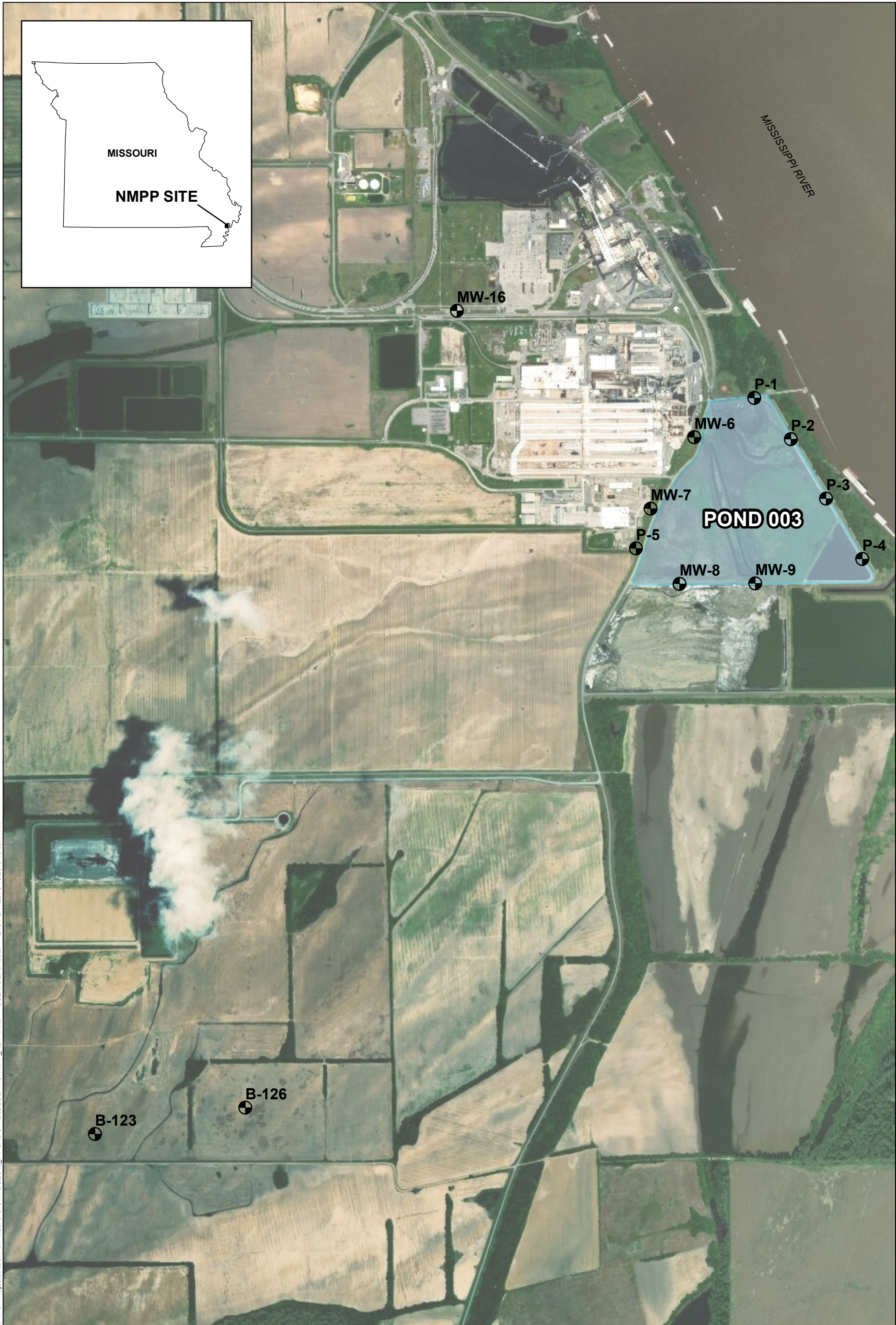
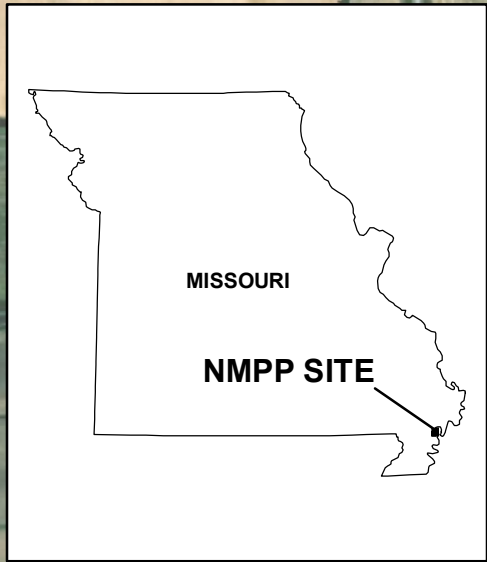
**TABLE 6
DERIVATION OF RISK-BASED TARGET SCREENING LEVELS FOR GROUNDWATER
AECI NEW MADRID POWER PLANT - POND 003 COMPLEX
NEW MADRID, MISSOURI**

Dilution Attenuation Factor (e)								100,000			
Constituent	CAS RN	HH DW SL (a) (mg/L)	HH REC SL - Consumption of Organism Only (b) (mg/L)	HH Recreational Calculated RBSL (c) (mg/L)	ECO SL - Dissolved (acute) (d) (mg/L)	ECO SL - Dissolved (chronic) (d) (mg/L)	Lowest of the Human Health and Ecological Screening Levels (mg/L)	Target Groundwater Screening Level - Mississippi River (f) (mg/L)	Maximum Groundwater Concentration (mg/L)		Ratio Between Target Groundwater Screening Level and the Maximum Groundwater Concentration
Detection Monitoring - USEPA Appendix III Constituents (g)											
Boron	7440-42-8	2	NA	114	NA	NA	2	200,000	20	MW-7	10,000
Fluoride	16984-48-8	4	NA	22.9	NA	NA	4	400,000	0.679	P-2	>580,000
Assessment Monitoring - USEPA Appendix IV Constituents											
Antimony	7440-36-0	0.006	4.3	0.171	NA	NA	0.006	600	0.0031	P-1	>190,000
Arsenic	7440-38-2	0.05	0.00014	0.0236	0.34	0.15	0.00014	14	0.011	P-5	>1,000
Barium	7440-39-3	2	NA	63.7	NA	NA	2	200,000	0.181	MW-7	>1,000,000
Beryllium	7440-41-7	0.004	NA	0.121	NA	0.005	0.004	400	0.001 U		NA
Cadmium	7440-43-9	0.005	NA	0.134	0.0018	0.0007	0.0007	72	0.0016	MW-7	>44,000
Chromium (Total)	7440-47-3	0.1	NA	155	0.57	0.07	0.07	7,411	0.018	P-1	>410,000
Cobalt	7440-48-4	1	NA	0.178	NA	NA	0.178	17,800	0.0098	MW-7	>1,000,000
Lead	7439-92-1	0.015	NA	0.015	0.065	0.0025	0.0025	252	0.0047	P-3	>53,000
Lithium	7439-93-2	0.04	NA	1.14	NA	NA	0.04	4,000	0.05	P-4	80,000
Mercury	7439-97-6	0.002	NA	0.0956	0.0014	0.00077	0.00077	77	<0.00020		NA
Molybdenum	7439-98-7	0.1	NA	2.86	NA	NA	0.1	10,000	3.9	MW-7	>2,500
Selenium	7782-49-2	0.05	4.2	2.86	NA	0.005	0.005	500	0.008	P-3	>62,000
Thallium	7440-28-0	0.002	0.0063	0.00572	NA	NA	0.002	200	0.002	MW-7	100,000
Radiological (pCi/L)											
Radium-226 & 228	7440-14-4	5	NA	NA	NA	NA	5	500,000	3.8	MW-7	>130,000



Notes:
 CAS RN - Chemical Abstracts Service Registry Number. HH REC SL - Human Health Recreational Use Screening Level.
 ECO SL - Ecological Screening Level. mg/L - milligram per liter.
 HH DW SL - Human Health Drinking Water Screening Level. NA - Not Available.

- (a) - Drinking Water Screening Levels selected in Table 2 using the following hierarchy:
 - 1) Missouri Drinking Water Supply
 - 2) Missouri Groundwater Supply
 - 3) USEPA RSL - Tap Water
- (b) - Surface Water Screening Levels selected in Table 2 using the following hierarchy:
 - 1) Missouri Human Health Fish Consumption
 - 2) USEPA NRWQC - Consumption of Water and Organism.
- (c) - The Human Health Calculated Screening Levels are presented in Table 3.
 The minimum calculated value for the Off-Site Recreational Boater, Wader, and Swimmer was selected.
- (d) - Ecological Screening Levels selected in Table 4 using the following hierarchy:
 - 1) Missouri Protection of Aquatic Life Criteria.
 - 2) USEPA NRWQC. Aquatic Life Criteria - Freshwater.
- (e) - Estimated value, see text for derivation.
- (f) - The Target Groundwater Screening Level = Minimum SL x Dilution Factor.
- (g) - Detection Monitoring - EPA Appendix III Constituents without health risk-based screening levels are not included.

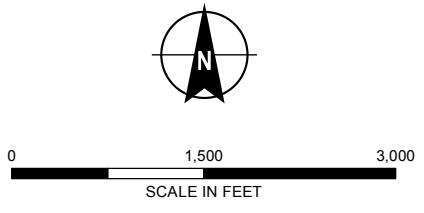
FIGURES



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- LEGEND**
-  MONITORING WELL
 -  POND 003

NOTE
 1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.
 2. AERIAL IMAGERY SOURCE: ESRI, 19 MAY 2016.



**HALEY
ALDRICH**

ASSOCIATED ELECTRIC COOPERATIVE, INC.
 NEW MADRID POWER PLANT
 MARSTON, MISSOURI

**POND 003 MONITORING WELL
 LOCATION MAP**

aeci




JANUARY 2019
 SCALE: AS SHOWN

FIGURE 1

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LEGEND

-  MONITORING WELL
-  POND 003
-  GROUNDWATER FLOW DIRECTION

NOTES

1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.
2. AERIAL IMAGERY SOURCE: ESRI, 19 MAY 2016.



ASSOCIATED ELECTRIC COOPERATIVE, INC.
NEW MADRID POWER GENERATING FACILITY
NEW MADRID COUNTY, MISSOURI

POND 003 - GROUNDWATER
FLOW DIRECTION MAP
LOW RIVER STAGE
3/28/2017






OCTOBER 2017

FIGURE 2

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LEGEND

-  MONITORING WELL
-  POND 003
-  GROUNDWATER FLOW DIRECTION

NOTES

1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.
2. AERIAL IMAGERY SOURCE: ESRI, 19 MAY 2016.



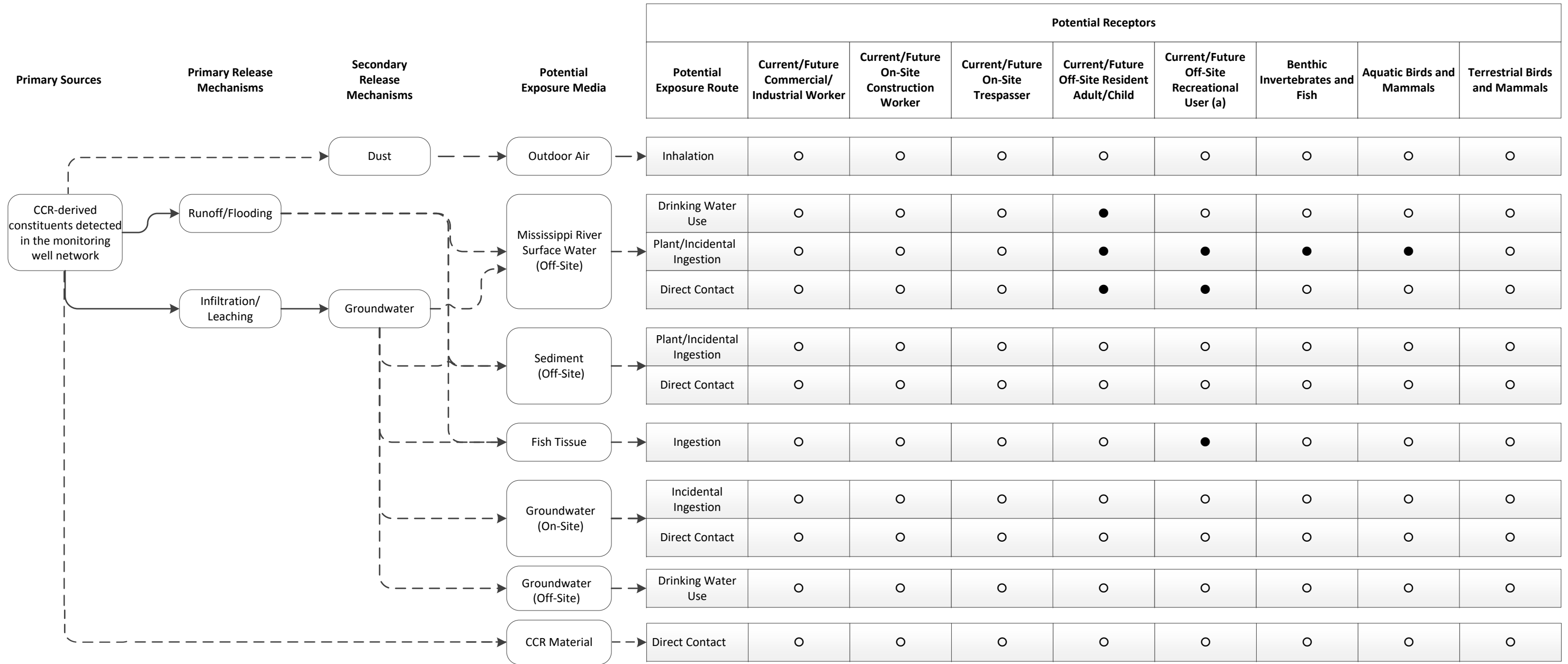
ASSOCIATED ELECTRIC COOPERATIVE, INC.
NEW MADRID POWER GENERATING FACILITY
NEW MADRID COUNTY, MISSOURI

POND 003 - GROUNDWATER
FLOW DIRECTION MAP
HIGH RIVER STAGE
5/17/2017



OCTOBER 2017

**FIGURE 4
CONCEPTUAL SITE MODEL
ASSOCIATED ELECTRIC COOPERATIVE, INC.
NEW MADRID POWER GENERATING FACILITY
NEW MADRID COUNTY, MISSOURI**



(a) Includes Current/Future Off-Site Recreational Wader, Recreational Swimmer, Recreational Boater, and Recreational Fisher.

● Pathway potentially complete and evaluated in this assessment to determine if pathway would be associated with a significant risk to human health or the environment.






○ Pathway determined to be incomplete or insignificant and therefore not further evaluated in this assessment.

→ Potential complete migration pathway.
 - - - Incomplete/insignificant migration pathway.
 CCR: Coal Combustion Residuals.

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LEGEND

-  MONITORING WELL
-  POINT OF COMPLIANCE (POC)
-  POINT OF EXPOSURE (POE)
-  DISCHARGE DIRECTION
-  POND 003

$$\text{CONCENTRATION AT POE} = \frac{\text{POC CONCENTRATION}}{Q_{\text{RIVER}} / Q_{\text{GROUNDWATER}}}$$

NOTES

1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.
2. AERIAL IMAGERY SOURCE: ESRI



ASSOCIATED ELECTRIC COOPERATIVE, INC.
NEW MADRID POWER GENERATING FACILITY
NEW MADRID COUNTY, MISSOURI

POND 003 - DAF CALCULATION
LOW RIVER STAGE
3/28/2017



MARCH 2019

ATTACHMENT A

Calculated Recreator Risk-Based Screening Levels

**TABLE A-1
HUMAN HEALTH EXPOSURE PARAMETERS FOR DERIVATION OF RISK BASED SCREENING LEVELS (RBSLs) - RECREATIONAL SURFACE WATER**

Exposure Parameter	Units	Current/Future Off-Site Recreational Swimmer				Current/Future Off-Site Recreational Wader				Current/Future Off-Site Recreational Boater Adult	
		Child (Age <6)	Adolescent (6-<16 years)	Adult	Child, Adolescent and Adult (Ages 1 - 26)	Child (Age <6)	Adolescent (6-<16 years)	Adult	Child, Adolescent and Adult (Ages 1 - 26)		
Standard Parameters											
Body Weight	BW	kg	15 USEPA, 2011 [1]	44 USEPA, 2011 [1]	80 USEPA, 2014a	NA	15 USEPA, 2011 [1]	44 USEPA, 2011 [1]	80 USEPA, 2014a	NA	80 USEPA, 2014a
Exposure Duration	ED	years	6 Ages <6	10 Ages 6 - <16	10 Balance of 26-yr exposure	26	6 Ages <6	10 Ages 6 - <16	10 Balance of 26-yr exposure	26	10 Balance of 26-yr exposure
Non-carcinogenic Averaging Time	Atnc	days	2190 ED expressed in days	3650 ED expressed in days	3650 ED expressed in days	9490 ED expressed in days	2190 ED expressed in days	3650 ED expressed in days	3650 ED expressed in days	9490 ED expressed in days	3650 ED expressed in days
Carcinogenic Averaging Time	Atc	days	25550 70 year lifetime	25550 70 year lifetime	25550 70 year lifetime	25550 70 year lifetime	25550 70 year lifetime	25550 70 year lifetime	25550 70 year lifetime	25550 70 year lifetime	25550 70 year lifetime
Incidental Ingestion of Surface Water											
Exposure Frequency	EF	days/year	45 USEPA, 2014b	45 USEPA, 2014b	45 USEPA, 2014b	45 USEPA, 2014b	45 USEPA, 2014b	45 USEPA, 2014b	45 USEPA, 2014b	45 USEPA, 2014b	NA
Water Ingestion Rate	IR	L/day	0.10 USEPA, 2014b [2]	0.10 USEPA, 2014b [2]	0.10 USEPA, 2014b [2]	NA	0.10 USEPA, 2014b [2]	0.02 USEPA, 2014b [2]	0.02 USEPA, 2014b [2]	NA	NA
Fraction Ingested	FI	unitless	1.0 Assumption	1.0 Assumption	1.0 Assumption	1.0 Assumption	1.0 Assumption	1.0 Assumption	1.0 Assumption	1.0 Assumption	NA
Age-Adjusted Water Ingestion Factor	IFWadj	L/kg	NA	NA	NA	3.39	NA	NA	NA	2.12	NA
Age-Adjusted Water Ingestion Factor-Mutagenic	IFWM	L/kg	NA	NA	NA	13.23	NA	NA	NA	10.33	NA
Dermal Exposure with Surface Water											
Exposure Frequency	EF	days/year	45 USEPA, 2014b	45 USEPA, 2014b	45 USEPA, 2014b	45 USEPA, 2014b	45 USEPA, 2014b	45 USEPA, 2014b	45 USEPA, 2014b	45 USEPA, 2014b	45 USEPA, 2014b
Exposed Skin Surface Area	SA	cm ²	6365 USEPA, 2014a	13350 USEPA, 2011 [3]	19652 USEPA, 2014a	NA	1770 USEPA, 2011 [4]	3820 USEPA, 2011 [4]	5790 USEPA, 2011 [4]	NA	5790 USEPA, 2011 [4]
Exposure Time	t-event	hr/event	2 Site-specific [5]	2 Site-specific [5]	2 Site-specific [5]	2 Site-specific [5]	2 Site-specific [5]	2 Site-specific [5]	2 Site-specific [5]	2 Site-specific [5]	2 Site-specific [5]
Events per Day	EV	event/day	1.0 Site-specific [5]	1.0 Site-specific [5]	1.0 Site-specific [5]	1.0 Site-specific [5]	1.0 Site-specific [5]	1.0 Site-specific [5]	1.0 Site-specific [5]	1.0 Site-specific [5]	1 Site-specific [5]
Age-Adjusted Dermal Contact Factor	DFWadj	events-cm ² /kg	NA	NA	NA	361647	NA	NA	NA	103497	NA
Age-Adjusted Dermal Contact Factor-Mutagenic	DFWM	events-cm ² /kg	NA	NA	NA	1131185	NA	NA	NA	319693	NA

NOTES AND ABBREVIATIONS

- USEPA, 2002 - Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OWSWER 9355.4-24
- USEPA, 2011 - Exposure Factors Handbook. USEPA/600/R-10/030. October, 2011.
- USEPA, 2014a - Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. OSWER 9200.1-120. February 6, 201.
- USEPA, 2014b - Region 4 Human Health Risk Assessment Supplemental Guidance. January 2014. Draft Final.
- [1] - Table 8-1 of USEPA (2011).
- [2] - Ingestion rate of 50 ml/hour of surface water is used for exposures to water during swimming. Intake rates for exposure to surface water during wading are 50 ml/hour for children 1-6, and 10 ml/hour for adolescents and adults. The water ingestion rate in liters/day is calculated as follows: ingestion (ml/hr) x exposure time (hr/event)/1000 (ml/L).
- [3] - Based on weighted average of mean values for 6-<16 years.
- [4] - Based on surface area of hands, forearms, lower legs, and feet.
- [5] - Assumes 2 hours per event and that on days when recreation in water occurs, all daily exposure to water is derived from locations at the Site.

Values based on a time-weighted average of child, adolescent, and adult exposure values are calculated as follows:

Water

$$IFWadj = (child\ ED\ [0-2] \times child\ EF\ [0-2] \times child\ IR\ [0-2] / child\ BW\ [0-2]) + (child\ ED\ [2-6] \times child\ EF\ [2-6] \times child\ IR\ [2-6] / child\ BW\ [2-6]) + (older\ child\ ED\ [6-16] \times older\ child\ EF\ [6-16] \times older\ child\ IR\ [6-16] / older\ child\ BW\ [6-16]) + (adult\ ED \times adult\ EF \times adult\ IR / adult\ BW)$$

$$DFWadj = (child\ EF\ [0-2] \times child\ ED\ [0-2] \times child\ SA\ [0-2] \times child\ EV\ [0-2] / child\ BW\ [0-2]) + (child\ EF\ [2-6] \times child\ ED\ [2-6] \times child\ SA\ [2-6] \times child\ EV\ [2-6] / child\ BW\ [2-6]) + (older\ child\ EF\ [6-16] \times older\ child\ ED\ [6-16] \times older\ child\ SA\ [6-16] \times older\ child\ EV\ [6-16] / older\ child\ BW\ [6-16]) + (adult\ EF \times adult\ ED \times adult\ SA \times adult\ EV / adult\ BW)$$
Water - mutagenic

$$IFWM = (child\ ED\ [0-2] \times child\ EF\ [0-2] \times child\ IR\ [0-2] \times ADAF\ [0-2] / child\ BW\ [0-2]) + (child\ ED\ [2-6] \times child\ EF\ [2-6] \times child\ IR\ [2-6] \times ADAF\ [2-6] / child\ BW\ [2-6]) + (older\ child\ ED\ [6-16] \times older\ child\ EF\ [6-16] \times older\ child\ IR\ [6-16] \times ADAF\ [6-16] / older\ child\ BW\ [6-16]) + (adult\ ED \times adult\ EF \times adult\ IR \times adult\ ADAF / adult\ BW)$$

$$DFWM = (child\ EF\ [0-2] \times child\ ED\ [0-2] \times child\ SA\ [0-2] \times child\ EV\ [0-2] \times ADAF\ [0-2] / child\ BW\ [0-2]) + (child\ EF\ [2-6] \times child\ ED\ [2-6] \times child\ SA\ [2-6] \times child\ EV\ [2-6] \times ADAF\ [2-6] / child\ BW\ [2-6]) + (older\ child\ EF\ [6-16] \times older\ child\ ED\ [6-16] \times older\ child\ SA\ [6-16] \times older\ child\ EV\ [6-16] \times ADAF\ [6-16] / older\ child\ BW\ [6-16]) + (adult\ EF \times adult\ ED \times adult\ SA \times adult\ EV \times adult\ ADAF / adult\ BW)$$

USEPA guidance for early life exposure to carcinogens (USEPA, 2005) requires that risks for potentially carcinogenic constituents that are presumed to act by a mutagenic mode of action be calculated differently than for constituents that do not act via a mutagenic mode of action.

Therefore, the age-dependent adjustment factors (ADAF) will be applied for calculations involving children under the age of 16. The ADAFs are as follows:

- Age 0 to 2 years (2 year interval from birth until 2nd birthday) – ADAF = 10
- Ages 2 to 16 years (14 year interval from 2nd birthday to 16th birthday) – ADAF = 3
- Ages 16 and up (after 16th birthday) – no adjustment - ADAF = 1

The exposure parameters for children ages <6 are applied to children 0 - 2 and 2- 6.

Site-specific

Recreator Equation Inputs for Surface Water

* Inputted values different from Recreator defaults are highlighted.

Variable	Recreator Surface Water Default Value	Form-input Value
BW ₀₋₂ (body weight) kg	15	0
BW ₂₋₆ (body weight) kg	15	0
BW ₆₋₁₆ (body weight) kg	80	0
BW ₁₆₋₃₀ (body weight) kg	80	80
BW _a (body weight - adult) kg	80	80
BW _{rec-a} (body weight - adult) kg	80	80
DFW _{rec-adj} (age-adjusted dermal factor) cm ² -event/kg	0	32568.75
DFWM _{rec-adj} (mutagenic age-adjusted dermal factor) cm ² -event/kg	0	32568.75
ED _{rec} (exposure duration - recreator) years	26	10
ED ₀₋₂ (exposure duration) years	2	0
ED ₂₋₆ (exposure duration) years	4	0
ED ₆₋₁₆ (exposure duration) years	10	0
ED ₁₆₋₃₀ (exposure duration) years	10	10
ED _{rec-a} (exposure duration - adult) years	20	10
EF _{rec-w} (exposure frequency) days/year	0	45
EF ₀₋₂ (exposure frequency) days/year	0	0
EF ₂₋₆ (exposure frequency) days/year	0	0
EF ₆₋₁₆ (exposure frequency) days/year	0	0
EF ₁₆₋₃₀ (exposure frequency) days/year	0	45
EF _{rec-a} (adult exposure frequency) days/year	0	45
ET ₀₋₂ (exposure time) hours/event	0	0
ET ₂₋₆ (exposure time) hours/event	0	0
ET ₆₋₁₆ (exposure time) hours/event	0	0
ET ₁₆₋₃₀ (exposure time) hours/event	0	2
ET _{rec-a} (adult exposure time) hours/event	0	2
EV ₀₋₂ (events) events/day	0	0
EV ₂₋₆ (events) events/day	0	0
EV ₆₋₁₆ (events) events/day	0	0
EV ₁₆₋₃₀ (events) events/day	0	1
EV _{rec-a} (adult) events/day	0	1
THQ (target hazard quotient) unitless	0.1	1
IFW _{rec-adj} (age-adjusted water intake rate) L/kg	0	0
IFWM _{rec-adj} (mutagenic age-adjusted water intake rate) L/kg	0	0
IRW ₀₋₂ (water intake rate) L/hour	0.12	0
IRW ₂₋₆ (water intake rate) L/hour	0.12	0
IRW ₆₋₁₆ (water intake rate) L/hour	0.071	0
IRW ₁₆₋₃₀ (water intake rate) L/hour	0.071	0
IRW _{rec} (water intake rate - adult) L/day	0.071	0
IRW _{rec-a} (water intake rate - adult) L/hr	0.071	0
LT (lifetime - recreator) years	70	70
SA ₀₋₂ (skin surface area) cm ²	6365	0
SA ₂₋₆ (skin surface area) cm ²	6365	0
SA ₆₋₁₆ (skin surface area) cm ²	19652	0
SA ₁₆₋₃₀ (skin surface area) cm ²	19652	5790
SA _{rec} (skin surface area - adult) cm ²	19652	5790
SA _{rec-a} (skin surface area - adult) cm ²	19652	5790
Apparent thickness of stratum corneum (cm)	0.001	0.001
TR (target risk) unitless	0.00001	0.00001

Site-specific

Recreator Regional Screening Levels (RSL) for Surface Water

Key: I = IRIS; P = PPRTV; O = OPP; A = ATSDR; C = Cal EPA; X = PPRTV Screening Level; H = HEAST; D = DWSHA; W = TEF applied; E = RPF applied; G = see user's guide; U = user provided; ca = cancer; nc = noncancer; * = where: nc SL < 100X ca SL; ** = where nc SL < 10X ca SL; SSL values are based on DAF=1; max = ceiling limit exceeded; sat = Csat exceeded.

Chemical	CAS Number	Mutagen?	Volatile?	Chemical Type	SF ₆ (mg/kg-day) ¹	SF ₀ Ref	RfD (mg/kg-day)	RfD Ref	RfC (mg/m ³)	RfC Ref	RAGSe GIABS (unitless)	K _p (cm/hr)	MW	FA (unitless)	In EPD?	DA _{event(ca)}	DA _{event(nc child)}	DA _{event(nc adult)}	Ingestion SL TR=1E-05 (ug/L)	Dermal SL TR=1E-05 (ug/L)	Carcinogenic SL TR=1E-05 (ug/L)	Ingestion SL (Child) THQ=1 (ug/L)	Dermal SL (Child) THQ=1 (ug/L)	Noncarcinogenic SL (Child) THQ=1 (ug/L)	Ingestion SL (Adult) THQ=1 (ug/L)	Dermal SL (Adult) THQ=1 (ug/L)	Noncarcinogenic SL (Adult) THQ=1 (ug/L)	Screening Level (ug/L)
Antimony (metallic)	7440-36-0	No	No	Inorganics	-		0.0004	I	-		0.1500	0.0010	121.7600	1.0000	Yes	-	-	0.0067	-	-	-	-	-	-	-	3360.0000	3360.0000	3.36E+03nc
Arsenic, Inorganic	7440-38-2	No	No	Inorganics	1.5000	I	0.0003	I	0.0000	C	1.0000	0.0010	74.9220	1.0000	Yes	0.0005	-	0.0336	-	2610.0000	2610.0000	-	-	-	-	16800.0000	16800.0000	2.61E+03ca*
Barium	7440-39-3	No	No	Inorganics	-		0.2000	I	0.0005	H	0.0700	0.0010	137.3300	1.0000	Yes	-	-	1.5690	-	-	-	-	-	-	-	784000.0000	784000.0000	7.84E+05nc
Beryllium and compounds	7440-41-7	No	No	Inorganics	-		0.0020	I	0.0000	I	0.0070	0.0010	9.0100	1.0000	Yes	-	-	0.0016	-	-	-	-	-	-	-	784.0000	784.0000	7.84E+02nc
Boron And Borates Only	7440-42-8	No	No	Inorganics	-		0.2000	I	0.0200	H	1.0000	0.0010	13.8400	1.0000	Yes	-	-	22.4141	-	-	-	-	-	-	-	11200000.0000	11200000.0000	1.12E+07nc
Cadmium (Water)	7440-43-9	No	No	Inorganics	-		0.0005	I	0.0000	A	0.0500	0.0010	112.4000	1.0000	Yes	-	-	0.0028	-	-	-	-	-	-	-	1400.0000	1400.0000	1.40E+03nc
Chromium(III), Insoluble Salts	16065-83-1	No	No	Inorganics	-		1.5000	I	-		0.0130	0.0010	52.0000	1.0000	Yes	-	-	2.1854	-	-	-	-	-	-	-	1090000.0000	1090000.0000	1.09E+06nc
Cobalt	7440-48-4	No	No	Inorganics	-		0.0003	P	0.0000	P	1.0000	0.0004	58.9300	1.0000	Yes	-	-	0.0336	-	-	-	-	-	-	-	42000.0000	42000.0000	4.20E+04nc
Fluoride	16984-48-8	No	No	Inorganics	-		0.0400	C	0.0130	C	1.0000	0.0010	38.0000	1.0000	Yes	-	-	4.4828	-	-	-	-	-	-	-	2240000.0000	2240000.0000	2.24E+06nc
Lithium	7439-93-2	No	No	Inorganics	-		0.0020	P	-		1.0000	0.0010	6.9400	1.0000	Yes	-	-	0.2241	-	-	-	-	-	-	-	112000.0000	112000.0000	1.12E+05nc
Mercuric Chloride	7487-94-7	No	No	Inorganics	-		0.0003	I	0.0003	S	0.0700	0.0010	271.5000	1.0000	Yes	-	-	0.0024	-	-	-	-	-	-	-	1180.0000	1180.0000	1.18E+03nc
Molybdenum	7439-98-7	No	No	Inorganics	-		0.0050	I	-		1.0000	0.0010	95.9400	1.0000	Yes	-	-	0.5604	-	-	-	-	-	-	-	280000.0000	280000.0000	2.80E+05nc
Selenium	7782-49-2	No	No	Inorganics	-		0.0050	I	0.0200	C	1.0000	0.0010	78.9600	1.0000	Yes	-	-	0.5604	-	-	-	-	-	-	-	280000.0000	280000.0000	2.80E+05nc
Thallium (Soluble Salts)	7440-28-0	No	No	Inorganics	-		0.0000	X	-		1.0000	0.0010	204.3800	1.0000	Yes	-	-	0.0011	-	-	-	-	-	-	-	560.0000	560.0000	5.60E+02nc

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Site-specific

Recreator Equation Inputs for Surface Water

* Inputted values different from Recreator defaults are highlighted.

Variable	Recreator Surface Water Default Value	Form-input Value
BW ₀₋₂ (body weight) kg	15	15
BW ₂₋₆ (body weight) kg	15	15
BW ₆₋₁₆ (body weight) kg	80	44
BW ₁₆₋₃₀ (body weight) kg	80	80
BW _a (body weight - adult) kg	80	62
BW _{rec-a} (body weight - adult) kg	80	62
DFW _{rec-adj} (age-adjusted dermal factor) cm ² -event/kg	0	354100.645
DFWM _{rec-adj} (mutagenic age-adjusted dermal factor) cm ² -event/kg	0	1131184.77
ED _{rec} (exposure duration - recreator) years	26	26
ED ₀₋₂ (exposure duration) years	2	2
ED ₂₋₆ (exposure duration) years	4	4
ED ₆₋₁₆ (exposure duration) years	10	10
ED ₁₆₋₃₀ (exposure duration) years	10	10
ED _{rec-a} (exposure duration - adult) years	20	20
EF _{rec-w} (exposure frequency) days/year	0	45
EF ₀₋₂ (exposure frequency) days/year	0	45
EF ₂₋₆ (exposure frequency) days/year	0	45
EF ₆₋₁₆ (exposure frequency) days/year	0	45
EF ₁₆₋₃₀ (exposure frequency) days/year	0	45
EF _{rec-a} (adult exposure frequency) days/year	0	45
ET ₀₋₂ (exposure time) hours/event	0	2
ET ₂₋₆ (exposure time) hours/event	0	2
ET ₆₋₁₆ (exposure time) hours/event	0	2
ET ₁₆₋₃₀ (exposure time) hours/event	0	2
ET _{rec-a} (adult exposure time) hours/event	0	2
EV ₀₋₂ (events) events/day	0	1
EV ₂₋₆ (events) events/day	0	1
EV ₆₋₁₆ (events) events/day	0	1
EV ₁₆₋₃₀ (events) events/day	0	1
EV _{rec-a} (adult) events/day	0	1
THQ (target hazard quotient) unitless	0.1	1
IFW _{rec-adj} (age-adjusted water intake rate) L/kg	0	6.503
IFWM _{rec-adj} (mutagenic age-adjusted water intake rate) L/kg	0	26.461
IRW ₀₋₂ (water intake rate) L/hour	0.12	0.1
IRW ₂₋₆ (water intake rate) L/hour	0.12	0.1
IRW ₆₋₁₆ (water intake rate) L/hour	0.071	0.1
IRW ₁₆₋₃₀ (water intake rate) L/hour	0.071	0.1
IRW _{rec} (water intake rate - adult) L/day	0.071	0.1
IRW _{rec-a} (water intake rate - adult) L/hr	0.071	0.1
LT (lifetime - recreator) years	70	70
SA ₀₋₂ (skin surface area) cm ²	6365	6365
SA ₂₋₆ (skin surface area) cm ²	6365	6365
SA ₆₋₁₆ (skin surface area) cm ²	19652	13350
SA ₁₆₋₃₀ (skin surface area) cm ²	19652	19652
SA _{rec} (skin surface area - adult) cm ²	19652	16501
SA _{rec-a} (skin surface area - adult) cm ²	19652	16501
Apparent thickness of stratum corneum (cm)	0.001	0.001
TR (target risk) unitless	0.000001	0.00001

Site-specific

Recreator Regional Screening Levels (RSL) for Surface Water

Key: I = IRIS; P = PPRTV; O = OPP; A = ATSDR; C = Cal EPA; X = PPRTV Screening Level; H = HEAST; D = DWSHA; W = TEF applied; E = RPF applied; G = see user's guide; U = user provided; ca = cancer; nc = noncancer; * = where: nc SL < 100X ca SL; ** = where nc SL < 10X ca SL; SSL values are based on DAF=1; max = ceiling limit exceeded; sat = Csat exceeded.

Chemical	CAS Number	Mutagen?	Volatile?	Chemical Type	SF ₆ (mg/kg-day) ¹	SF ₆ Ref	RfD (mg/kg-day)	RfD Ref	RfC (mg/m ³)	RfC Ref	RAGSe GIABS (unitless)	K _p (cm/hr)	MW	FA (unitless)	In EPD?	DA _{event(ca)}	DA _{event(nc child)}	DA _{event(nc adult)}	Ingestion SL TR=1E-05 (ug/L)	Dermal SL TR=1E-05 (ug/L)	Carcinogenic SL TR=1E-05 (ug/L)	Ingestion SL (Child) THQ=1 (ug/L)	Dermal SL (Child) THQ=1 (ug/L)	Noncarcinogenic SL (Child) THQ=1 (ug/L)	Ingestion SL (Adult) THQ=1 (ug/L)	Dermal SL (Adult) THQ=1 (ug/L)	Noncarcinogenic SL (Adult) THQ=1 (ug/L)	Screening Level (ug/L)
Antimony (metallic)	7440-36-0	No	No	Inorganics	-		0.0004	I	-		0.1500	0.0010	121.7600	1.0000	Yes	-	0.0011	0.0018	-	-	-	243.0000	573.0000	171.0000	1010.0000	914.0000	479.0000	1.71E+02nc
Arsenic, Inorganic	7440-38-2	No	No	Inorganics	1.5000	I	0.0003	I	0.0000	C	1.0000	0.0010	74.9220	1.0000	Yes	0.0000	0.0057	0.0091	26.2000	241.0000	23.6000	183.0000	2870.0000	172.0000	754.0000	4570.0000	647.0000	2.36E+01ca*
Barium	7440-39-3	No	No	Inorganics	-		0.2000	I	0.0005	H	0.0700	0.0010	137.3300	1.0000	Yes	-	0.2676	0.4267	-	-	-	122000.0000	#####	63700.0000	503000.0000	#####	150000.0000	6.37E+04nc
Beryllium and compounds	7440-41-7	No	No	Inorganics	-		0.0020	I	0.0000	I	0.0070	0.0010	9.0100	1.0000	Yes	-	0.0003	0.0004	-	-	-	1220.0000	134.0000	121.0000	5030.0000	213.0000	205.0000	1.21E+02nc
Boron And Borates Only	7440-42-8	No	No	Inorganics	-		0.2000	I	0.0200	H	1.0000	0.0010	13.8400	1.0000	Yes	-	3.8230	6.0953	-	-	-	122000.0000	#####	114000.0000	503000.0000	#####	432000.0000	1.14E+05nc
Cadmium (Water)	7440-43-9	No	No	Inorganics	-		0.0005	I	0.0000	A	0.0500	0.0010	112.4000	1.0000	Yes	-	0.0005	0.0008	-	-	-	304.0000	239.0000	134.0000	1260.0000	381.0000	292.0000	1.34E+02nc
Chromium(III), Insoluble Salt	16065-83-1	No	No	Inorganics	-		1.5000	I	-		0.0130	0.0010	52.0000	1.0000	Yes	-	0.3727	0.5943	-	-	-	913000.0000	#####	155000.0000	#####	#####	275000.0000	1.55E+05nc
Cobalt	7440-48-4	No	No	Inorganics	-		0.0003	P	0.0000	P	1.0000	0.0004	58.9300	1.0000	Yes	-	0.0057	0.0091	-	-	-	183.0000	7170.0000	178.0000	754.0000	11400.0000	708.0000	1.78E+02nc
Fluoride	16984-48-8	No	No	Inorganics	-		0.0400	C	0.0130	C	1.0000	0.0010	38.0000	1.0000	Yes	-	0.7646	1.2191	-	-	-	24300.0000	#####	22900.0000	101000.0000	#####	86300.0000	2.29E+04nc
Lithium	7439-93-2	No	No	Inorganics	-		0.0020	P	-		1.0000	0.0010	6.9400	1.0000	Yes	-	0.0382	0.0610	-	-	-	1220.0000	19100.0000	1140.0000	5030.0000	30500.0000	4320.0000	1.14E+03nc
Mercuric Chloride	7487-94-7	No	No	Inorganics	-		0.0003	I	0.0003	S	0.0700	0.0010	271.5000	1.0000	Yes	-	0.0004	0.0006	-	-	-	183.0000	201.0000	95.6000	754.0000	320.0000	225.0000	9.56E+01nc
Molybdenum	7439-98-7	No	No	Inorganics	-		0.0050	I	-		1.0000	0.0010	95.9400	1.0000	Yes	-	0.0956	0.1524	-	-	-	3040.0000	47800.0000	2860.0000	12600.0000	76200.0000	10800.0000	2.86E+03nc
Selenium	7782-49-2	No	No	Inorganics	-		0.0050	I	0.0200	C	1.0000	0.0010	78.9600	1.0000	Yes	-	0.0956	0.1524	-	-	-	3040.0000	47800.0000	2860.0000	12600.0000	76200.0000	10800.0000	2.86E+03nc
Thallium (Soluble Salts)	7440-28-0	No	No	Inorganics	-		0.0000	X	-		1.0000	0.0010	204.3800	1.0000	Yes	-	0.0002	0.0003	-	-	-	6.0800	95.6000	5.7200	25.1000	152.0000	21.6000	5.72E+00nc

Site-specific

Recreator Equation Inputs for Surface Water

* Inputted values different from Recreator defaults are highlighted.

Variable	Recreator Surface Water Default Value	Form-input Value
BW ₀₋₂ (body weight) kg	15	15
BW ₂₋₆ (body weight) kg	15	15
BW ₆₋₁₆ (body weight) kg	80	44
BW ₁₆₋₃₀ (body weight) kg	80	80
BW _a (body weight - adult) kg	80	62
BW _{rec-a} (body weight - adult) kg	80	62
DFW _{rec-adj} (age-adjusted dermal factor) cm ² -event/kg	0	101610
DFWM _{rec-adj} (mutagenic age-adjusted dermal factor) cm ² -event/kg	0	319693.295
ED _{rec} (exposure duration - recreator) years	26	26
ED ₀₋₂ (exposure duration) years	2	2
ED ₂₋₆ (exposure duration) years	4	4
ED ₆₋₁₆ (exposure duration) years	10	10
ED ₁₆₋₃₀ (exposure duration) years	10	10
ED _{rec-a} (exposure duration - adult) years	20	20
EF _{rec-w} (exposure frequency) days/year	0	45
EF ₀₋₂ (exposure frequency) days/year	0	45
EF ₂₋₆ (exposure frequency) days/year	0	45
EF ₆₋₁₆ (exposure frequency) days/year	0	45
EF ₁₆₋₃₀ (exposure frequency) days/year	0	45
EF _{rec-a} (adult exposure frequency) days/year	0	45
ET ₀₋₂ (exposure time) hours/event	0	2
ET ₂₋₆ (exposure time) hours/event	0	2
ET ₆₋₁₆ (exposure time) hours/event	0	2
ET ₁₆₋₃₀ (exposure time) hours/event	0	2
ET _{rec-a} (adult exposure time) hours/event	0	2
EV ₀₋₂ (events) events/day	0	1
EV ₂₋₆ (events) events/day	0	1
EV ₆₋₁₆ (events) events/day	0	1
EV ₁₆₋₃₀ (events) events/day	0	1
EV _{rec-a} (adult) events/day	0	1
THQ (target hazard quotient) unitless	0.1	1
IFW _{rec-adj} (age-adjusted water intake rate) L/kg	0	4.181
IFWM _{rec-adj} (mutagenic age-adjusted water intake rate) L/kg	0	20.652
IRW ₀₋₂ (water intake rate) L/hour	0.12	0.1
IRW ₂₋₆ (water intake rate) L/hour	0.12	0.1
IRW ₆₋₁₆ (water intake rate) L/hour	0.071	0.02
IRW ₁₆₋₃₀ (water intake rate) L/hour	0.071	0.02
IRW _{rec} (water intake rate - adult) L/day	0.071	0.02
IRW _{rec-a} (water intake rate - adult) L/hr	0.071	0.02
LT (lifetime - recreator) years	70	70
SA ₀₋₂ (skin surface area) cm ²	6365	1770
SA ₂₋₆ (skin surface area) cm ²	6365	1770
SA ₆₋₁₆ (skin surface area) cm ²	19652	3820
SA ₁₆₋₃₀ (skin surface area) cm ²	19652	5790
SA _{rec} (skin surface area - adult) cm ²	19652	4805
SA _{rec-a} (skin surface area - adult) cm ²	19652	4805
Apparent thickness of stratum corneum (cm)	0.001	0.001
TR (target risk) unitless	0.000001	0.00001

Site-specific

Recreator Regional Screening Levels (RSL) for Surface Water

Key: I = IRIS; P = PPRTV; O = OPP; A = ATSDR; C = Cal EPA; X = PPRTV Screening Level; H = HEAST; D = DWSHA; W = TEF applied; E = RPF applied; G = see user's guide; U = user provided; ca = cancer; nc = noncancer; * = where: nc SL < 100X ca SL; ** = where nc SL < 10X ca SL; SSL values are based on DAF=1; max = ceiling limit exceeded; sat = Csat exceeded.

Chemical	CAS Number	Mutagen?	Volatile?	Chemical Type	SF ₆ (mg/kg-day) ¹	SF ₆ Ref	RfD (mg/kg-day)	RfD Ref	RfC (mg/m ³)	RfC Ref	RAGSe GIABS (unitless)	K _p (cm/hr)	MW	FA (unitless)	In EPD?	DA _{event(ca)}	DA _{event(nc child)}	DA _{event(nc adult)}	Ingestion SL TR=1E-05 (ug/L)	Dermal SL TR=1E-05 (ug/L)	Carcinogenic SL TR=1E-05 (ug/L)	Ingestion SL (Child) THQ=1 (ug/L)	Dermal SL (Child) THQ=1 (ug/L)	Noncarcinogenic SL (Child) THQ=1 (ug/L)	Ingestion SL (Adult) THQ=1 (ug/L)	Dermal SL (Adult) THQ=1 (ug/L)	Noncarcinogenic SL (Adult) THQ=1 (ug/L)	Screening Level (ug/L)
Antimony (metallic)	7440-36-0	No	No	Inorganics	-		0.0004	I	-		0.1500	0.0010	121.7600	1.0000	Yes	-	0.0041	0.0063	-	-	-	243.0000	2060.0000	218.0000	5030.0000	3140.0000	1930.0000	2.18E+02nc
Arsenic, Inorganic	7440-38-2	No	No	Inorganics	1.5000	I	0.0003	I	0.0000	C	1.0000	0.0010	74.9220	1.0000	Yes	0.0002	0.0206	0.0314	40.7000	838.0000	38.9000	183.0000	10300.0000	179.0000	3770.0000	15700.0000	3040.0000	3.89E+01ca*
Barium	7440-39-3	No	No	Inorganics	-		0.2000	I	0.0005	H	0.0700	0.0010	137.3300	1.0000	Yes	-	0.9623	1.4652	-	-	-	122000.0000	481000.0000	97100.0000	2510000.0000	733000.0000	567000.0000	9.71E+04nc
Beryllium and compounds	7440-41-7	No	No	Inorganics	-		0.0020	I	0.0000	I	0.0070	0.0010	9.0100	1.0000	Yes	-	0.0010	0.0015	-	-	-	1220.0000	481.0000	345.0000	25100.0000	733.0000	712.0000	3.45E+02nc
Boron And Borates Only	7440-42-8	No	No	Inorganics	-		0.2000	I	0.0200	H	1.0000	0.0010	13.8400	1.0000	Yes	-	13.7476	20.9319	-	-	-	122000.0000	687000.0000	120000.0000	2510000.0000	1050000.0000	2030000.0000	1.20E+05nc
Cadmium (Water)	7440-43-9	No	No	Inorganics	-		0.0005	I	0.0000	A	0.0500	0.0010	112.4000	1.0000	Yes	-	0.0017	0.0026	-	-	-	304.0000	859.0000	225.0000	6290.0000	1310.0000	1080.0000	2.25E+02nc
Chromium(III), Insoluble Salt	16065-83-1	No	No	Inorganics	-		1.5000	I	-		0.0130	0.0010	52.0000	1.0000	Yes	-	1.3404	2.0409	-	-	-	913000.0000	670000.0000	386000.0000	1890000.0000	1020000.0000	968000.0000	3.86E+05nc
Cobalt	7440-48-4	No	No	Inorganics	-		0.0003	P	0.0000	P	1.0000	0.0004	58.9300	1.0000	Yes	-	0.0206	0.0314	-	-	-	183.0000	25800.0000	181.0000	3770.0000	39200.0000	3440.0000	1.81E+02nc
Fluoride	16984-48-8	No	No	Inorganics	-		0.0400	C	0.0130	C	1.0000	0.0010	38.0000	1.0000	Yes	-	2.7495	4.1864	-	-	-	24300.0000	1370000.0000	23900.0000	503000.0000	2090000.0000	405000.0000	2.39E+04nc
Lithium	7439-93-2	No	No	Inorganics	-		0.0020	P	-		1.0000	0.0010	6.9400	1.0000	Yes	-	0.1375	0.2093	-	-	-	1220.0000	68700.0000	1200.0000	25100.0000	105000.0000	20300.0000	1.20E+03nc
Mercuric Chloride	7487-94-7	No	No	Inorganics	-		0.0003	I	0.0003	S	0.0700	0.0010	271.5000	1.0000	Yes	-	0.0014	0.0022	-	-	-	183.0000	722.0000	146.0000	3770.0000	1100.0000	851.0000	1.46E+02nc
Molybdenum	7439-98-7	No	No	Inorganics	-		0.0050	I	-		1.0000	0.0010	95.9400	1.0000	Yes	-	0.3437	0.5233	-	-	-	3040.0000	172000.0000	2990.0000	62900.0000	262000.0000	50700.0000	2.99E+03nc
Selenium	7782-49-2	No	No	Inorganics	-		0.0050	I	0.0200	C	1.0000	0.0010	78.9600	1.0000	Yes	-	0.3437	0.5233	-	-	-	3040.0000	172000.0000	2990.0000	62900.0000	262000.0000	50700.0000	2.99E+03nc
Thallium (Soluble Salts)	7440-28-0	No	No	Inorganics	-		0.0000	X	-		1.0000	0.0010	204.3800	1.0000	Yes	-	0.0007	0.0010	-	-	-	6.0800	344.0000	5.9800	126.0000	523.0000	101.0000	5.98E+00nc

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APPENDIX B
Documentation Recording the Public Meeting



HALEY & ALDRICH, INC.
6500 Rockside Road
Suite 200
Cleveland, OH 44131
216.739.0555

MEMORANDUM

5 November 2020
File No. 129342-027

SUBJECT: Documentation Recording the Public Meeting for the Corrective Measures Assessment Pursuant to CCR Rule 40 CFR § 257.105(h)(11)
Associated Electric Cooperative, Inc.
New Madrid Power Plant – Pond 003

This document provides the record summary for the public meeting for the Corrective Measures Assessment (CMA) of coal combustion residuals surface impoundment referred to as Pond 003 at the New Madrid Power Plant completed by Associated Electric Cooperative, Inc. (AECI). AECI completed the required public meeting in accordance with 40 CFR § 257.96(e) with interested and affected parties discussing the results of the Pond 003 CMA on 14 November 2019. AECI notified the public of the public meeting initially on 8 October 2019, and several dates after, in local newspapers. The public meeting was held at the City of Marston Community Center located at 199 South Mitchell Street in Marston, Missouri between 2:00 p.m. and 4:00 p.m. The public meeting consisted of the availability of hard-copy CMA materials, poster boards summarizing the results of the CMA, and the availability of AECI and technical representatives to discuss the results of the CMA. AECI received no verbal comments from the public during the public meeting or written comments through its CCR public website portal related to the corrective measures assessment.

APPENDIX C
MNA Technical Basis Summary
in Support of Selection of Remedy

Monitored Natural Attenuation Technical Basis Summary in Support of Selection of Remedy New Madrid Power Plant Pond 003

1. Introduction/Purpose of Assessment

The purpose of this geochemical assessment is to evaluate the efficacy of monitored natural attenuation (MNA) for the treatment of elevated concentrations of molybdenum in groundwater associated with the coal combustion residuals (CCR) surface impoundment Pond 003 at the Associated Electric Cooperative, Inc. (AECI) New Madrid Power Plant (NMPP) located in Marston, Missouri (Site). The NMPP is an active energy production facility located adjacent to the Mississippi River. The CCRs generated are byproducts of the combustion process and include fly ash and boiler slag material. Pond 003 is located along the northern portion of the Site boundary (Figure 1) and is one of several closed and active CCR units; this unit is the focus of the current investigation. Pond 003 is currently under corrective measures assessment (CMA) associated with the CCR Rule, with on-going semi-annual assessment monitoring since 15 August 2018. Molybdenum is the only Appendix IV constituent which exceeds the groundwater protection standard (GWPS).

As stated in the Site CMA Report (Haley & Aldrich, Inc. [Haley & Aldrich], 2019), the preferred remedy to achieve the groundwater remedy is a combination of source control (closure in place [CIP] of Pond 003) coupled with natural attenuation (NA) and active performance monitoring to assess the effectiveness of the selected corrective measures.¹ CIP includes surface dewatering, re-grading of Pond 003, and placement of an engineered cap over the pond. CIP construction activities are anticipated to begin in 2023. In addition to molybdenum source control to groundwater, CIP is expected to directly impact subsurface geochemistry beneath the pond location. Predicted changes in geochemistry include a decrease in mobility and concentrations of molybdenum in groundwater supporting the geochemical NA capacity of the aquifer post-closure and into the future.

The U.S. Environmental Protection Agency (USEPA) technical guidance used in the assessment of MNA at Pond 003 include:

1. USEPA (2015) Use of Monitored Natural Attenuation for Inorganic Contaminants in Groundwater at Superfund Sites.
2. USEPA (1999) Use of Monitored Natural Attenuation at Superfund, Resource Conservation and Recovery Act (RCRA) Corrective Action, and Underground Storage Facilities.

The spatial and temporal data used in this MNA assessment are summarized in the report titled “Summary of Pond 003 Nature & Extent Investigation, NMPP, New Madrid, MO” (Haley & Aldrich, 2022a).

This Report summarizes the technical basis for MNA selection at Pond 003 and is organized into the three following sections:

¹ MNA occurs due to naturally occurring processes within the aquifer to reduce concentrations of CCR constituents in groundwater. MNA encompasses a variety of physical and chemical processes (biodegradation, sorption, dilution, chemical reactions, and evaporation), which, under the right conditions, can immobilize constituents in aquifer sediments. USEPA recognizes MNA as a corrective action component for addressing inorganics (metals) in groundwater (USEPA Directive 9283.1-36 [2015]).

- **Section 1: Summary of Historic Operations and Existing Geochemical Site Conditions:** This section summarizes the management history of Pond 003, identifies sources of molybdenum in groundwater, and characterizes existing site hydrogeologic and geochemical conditions that control molybdenum fate and transport in the subsurface.
- **Section 2: Anticipated Future Site Conditions.** This section summarizes the positive impacts of corrective measures (CM) will have on future Site geochemical conditions and characterize the subsequent enhancement of molybdenum NA mechanisms that will occur under this future post-closure scenario.
- **Section 3: Efficacy of MNA for Molybdenum in Groundwater.** This section provides the basis for NA during the post-closure timeframe, describes current and future MNA characterization steps, and identifies critical benchmarks to assess future NA effectiveness. Additional narrative is provided in this section which reviews a list of enhanced MNA (referred to as MNA plus) strategies for potential use in addition to conventional MNA for achieving molybdenum GWPS as necessary.

1.1 SUMMARY OF HISTORIC OPERATIONS AND EXISTING GEOCHEMICAL SITE CONDITIONS

Existing Site conditions were assessed through geochemical analysis of groundwater data collected during assessment monitoring, determination of nature and extent (N&E), and evaluation of an apparent upgradient source which is not attributed to Pond 003. Geochemical assessments performed include the following:

- Spatial analysis of select analytes (molybdenum, dissolved oxygen [DO], and redox potential [Eh]),
- Temporal analysis of molybdenum and important geochemical indicator parameters (pH, Eh, total dissolved solids [TDS], SO_4^{2-} , boron [B], and DO), molybdenum, and
- Analyte bivariate analysis, geochemical speciation assessment, redox zonation assessment, and analysis of major anions and cations (piper diagrams).

1.1.1 Historic and Current Operation and Management of Pond 003

Historic and current management strategies for Pond 003 are important because these operations have had and will continue to have a direct effect on geochemical conditions effecting molybdenum fate and transport in the subsurface. Pond 003 has been in operation since the mid-1970s. Historically, this pond received quantities of both CCR and non-CCR contact process waters, which in the past resulted in ponded hydraulic head in Pond 003 that was higher than current pond operational conditions. The ponded head of water will be removed after the implementation of CIP.

The ongoing reduction of inflow and lower ponded hydraulic head is in part due to the systematic reduction of sluiced CCR and non-CCR contact waters reporting to Pond 003 over the past 3 years. A majority of fly ash sluicing ceased to Pond 003 in the mid-1990s with only minor quantities of fly ash sluiced up to 2021. Ash management practices in recent years have changed to dry handling systems. The facility dry handled the bulk of the fly ash generated after the mid-2000s and is now fully dry handled and placed in the on-Site Utility Waste Landfill (UWL). Currently, only boiler slag and low volume non-CCR waste streams are sluiced to Pond 003, and this is planned to cease by the end of Q2 2023. Collectively, these operational changes result in a net reduction of potential molybdenum source material at Pond 003.

1.2 EXISTING SITE GEOCHEMICAL CONDITIONS

Existing Site geochemical conditions create the physiochemical framework for groundwater below Pond 003 and the surrounding area. This is limited to the characterization of molybdenum geochemistry in groundwater, which is the only constituent that occurs at concentration that is a statistically significant level above a GWPS.

1.2.1 Sources of Molybdenum to Groundwater

The sources of molybdenum in groundwater were evaluated using the following analyses:

- A review of the spatial and vertical distribution of molybdenum in groundwater as described in the AECI Pond 003 Nature & Extent (N&E) Report (Haley & Aldrich, 2022a);
- Geochemical analysis of major anions, major cations, major, minor, and trace elements in groundwater;
- Review of both the hydrogeologic Site conceptual model and groundwater flow;
- Analysis of temporal distribution of molybdenum and other important indicator parameters; and
- Investigation of potential sources upgradient, on-Site, and downgradient of Pond 003.

Groundwater quality data and geochemical analysis results from CCR compliance wells and N&E wells over the past 5 years indicate that groundwater is impacted beneath and downgradient of Pond 003. Groundwater modeling confirms that the preferred remedy (CIP coupled with MNA) is an appropriate component of the overall CM remedy to address elevated concentrations of molybdenum in groundwater. Geochemical evidence supporting the application of NA includes the occurrence of sulfate-reducing conditions in groundwater and the complimentary effects of CIP source control. Sulfate-reducing conditions support molybdenum immobilization and CIP source control will reduce oxygen-rich water infiltration from Pond 003. The combined effects of existing groundwater geochemistry and future post-closure conditions create a setting that is appropriate for implementation of NA to treat molybdenum in groundwater.

In addition to impacts to groundwater originating at Pond 003, it is apparent that an additional source of molybdenum separate from Pond 003 is present in an area that is hydraulically upgradient of Pond 003. The additional potential source is associated with an active industrial park and a metals manufacturing facility which handles or processes molybdenum compounds. Differentiation of Pond 003 from the other potential sources is supported by multiple lines of evidence including both empirical and geochemical signatures which indicate an additional upgradient source of molybdenum that is distinct from the Pond 003 potential source. Distinguishing characteristics of the upgradient source include:

- Elevated concentrations of molybdenum concentrations as high as 3.9 milligrams per liter [mg/L] in MW-7 which is located immediately downgradient of the metals manufacturing facility and upgradient of Pond 003;
- The molybdenum concentration trend in MW-7 correlates with the operational history of that industrial facility (i.e., periods of facility operation and intermittent idled operational status);
- Distinct end member differentiation from Site-derived sources based on piper-plot analysis; and
- Unique redox geochemistry, including iron reducing conditions (Fe [dissolved] >0.5 mg/L) together with depleted dissolved manganese concentrations (≤ 0.01 mg/L) and relatively higher

redox values (Eh > 0.2 V) compared to adjacent monitoring wells (MW-24S/D, MW-25S/D, and MW-26S/D).

For purposes of this technical summary, the presence of an additional upgradient source is significant, and is a potentially complicating factor for the following reasons:

1. The upgradient source appears to be of a higher concentration than Pond 003 and potentially has a greater impact on groundwater molybdenum concentrations than Pond 003. The higher upgradient contributions occur in well MW-7 (up to 3.9 mg/L) and stand in contrast to concentrations occurring in Pond 003 groundwater at edge of waste, which range from 0.072 mg/L (Table 1, MW-22S, 8/17/2022 event) to 0.93 mg/L (Table 1, MW-8, 8/15/2022 event) in both CCR compliance and N&E wells.
2. The upgradient source appears to be of a higher concentration than Pond 003 and potentially has a greater impact on groundwater molybdenum concentrations than Pond 003. The higher upgradient contributions occur in well MW-7 (up to 3.9 mg/L) and stand in contrast to concentrations occurring in Pond 003 groundwater at edge of waste, which range from 0.08 to 0.76 mg/L in both CCR compliance and N&E wells. Dissolved molybdenum concentrations in pore water underlying Pond 003 was detected at 1.9 mg/L, in a temporary monitoring point in the central area of the pond.
3. The apparent upgradient source and the potential Pond 003 sources appear to co-mingle in groundwater underlying, and downgradient of Pond 003 based on geospatial groundwater monitoring results.
4. Geochemical conditions conducive to mobilization of molybdenum in groundwater are present as a result of exposure of the pond surface to the atmosphere and ongoing sluicing into Pond 003. These conditions currently limit NA of molybdenum within, and downgradient of, NMPP property boundaries.
5. CCR material in Pond 003 will be managed in conformance with the CMA preferred remedy which is source control via Pond 003 CIP and NA of molybdenum. However, without cessation (or management/treatment) of the upgradient source, performance of Pond 003 CIP plus MNA will require continued monitoring to determine if there is a long-term need to supplement the groundwater remedy with additional MNA-plus controls such as localized point-source treatment or management of the upgradient source.

1.2.2 Site Existing Conditions

This section summarizes existing Site hydrogeologic and conditions affecting fate and transport of molybdenum at the Site. The subsurface geology and hydrogeologic conceptual Site model are documented in the reports titled *Summary of Pond 003 Nature & Extent Investigation, NMPP, New Madrid, MO* (Haley & Aldrich, 2022a), and *CCR Groundwater Characterization and Monitoring Network Description, NMPP Pond 003* (Haley & Aldrich, 2022c). Based on existing and expected future Site conditions, no unacceptable human health risk and ecological risk is anticipated as discussed in the report titled *New Madrid Power Plant, Pond 003 and 004, Preliminary Streamlined Risk Evaluation* (Haley & Aldrich, 2022b). The primary hydraulic and geochemical controls affecting the fate and transport of molybdenum in groundwater include:

- Surface water infiltration from Pond 003;
- Hydraulic effects and seasonal fluctuation of the Mississippi River; and

- Source contribution and geochemical manipulation from the upgradient source west of Pond 003.

These factors are described in detail below, with particular focus on their influence on molybdenum concentrations and NA mechanisms in groundwater.

1.2.2.1 *Summary of Spatial Molybdenum Concentrations Trend in Groundwater*

There are two potential sources contributing molybdenum to groundwater, including Pond 003 and the industrial source upgradient of Pond 003. Groundwater iso-concentration lines showing Site molybdenum concentrations (based on November 2022 sampling data) show impacts exceeding 1.1 mg/L (with historical values up to 3.9 mg/L) extend from upgradient of Pond 003 (MW-7) towards the western side of the Site to distal portions of the associated molybdenum plume located to the east of Pond 003 (MW-21S). Molybdenum concentrations along the apparent contaminant pathway between MW-7 and MW-21 decreases approximately 50 percent. This concentration reduction is evidence of existing NA mechanisms. Molybdenum NA mechanisms operating at the Site include:

- Geochemical – Localized formation of molybdenum-bearing sulfide secondary mineral precipitates resulting from sulfate reduction; and
- Hydraulic – Dilution/dispersion.

The following observations can be made based on the spatial distribution of molybdenum concentrations in groundwater at the Site.

1. Molybdenum concentrations decrease continually along the generalized direction of groundwater flow (west to east), and
2. Molybdenum concentrations approach and, in many cases, are below the GWPS (MW-19S, P4, and MW-23S) in N&E wells located outside the distal portions of the plume.

These two observations support the conclusion that NA mechanisms are currently reducing molybdenum concentrations along the groundwater flow path.

1.2.2.2 *Summary of Existing Site Geochemical Conditions*

The geochemical state and mobility of molybdenum in Site groundwater is dominated by local redox conditions due in large part to the unique thermodynamics of molybdenum and secondary mineral precipitates. Secondary mineral precipitates are insoluble molybdenum bearing minerals that form under reducing conditions. Redox processes are an important control in the chemical evolution of an aquifer, controlling the fate and transport of molybdenum in groundwater. A redox boundary, or phase boundary, marks the change in speciation of redox-sensitive elements like molybdenum, and the associated change in its mobility along the groundwater flow path of an aquifer system (Schlieker et al, 2001; Smedley and Edmunds, 2002). Under a condition characterized by oxic (i.e., oxygenated) waters, the oxidized form of Mo^{6+} is thought to be molybdate (MoO_4^{2-} ; Helz et al, 1996; Hodge et al., 1996). Soluble MoO_4^{2-} is typically found in waters that have a high Eh (redox potential) and circumneutral pH (6.5 – 7.5). In sub-oxic environments, molybdenum (VI) adsorbed on metal oxides can be released into groundwater because of reductive dissolution of manganese (Mn) and Fe in sub-oxic water (Schlieker et al., 2001). Under sulfate-reducing conditions, sulfide generated and sufficient amounts of dissolved Fe^{2+} and Mo^{4+} combine to form iron sulfides and molybdenum disulfide (molybdenite) secondary precipitates in the sediment (Crusius et al., 1996). This process occurs predominantly under

sulfate-reducing conditions, and accounts for a significant potential geochemical attenuation (i.e., in the form of secondary mineral precipitation).

Under circumneutral to slightly basic conditions (pH = 6.5 – 8.5 which occur in the majority of the underlying aquifer), molybdenum is mobile in groundwater within sub-oxic to fully oxidized geochemical redox conditions (Eh > -0.1 V). However, localized sulfate-reducing conditions are also present (as evidenced by groundwater conditions mapped in groundwater quality samples collected from MW-24S and MW-24D). Molybdenum is not mobile under sulfate-reducing redox conditions due to the precipitation of molybdenite (MoS₂) and other molybdenum/iron sulfides whose phases are thermodynamically stable under these geochemical redox conditions.

A review of all historic Site groundwater redox data (field oxidation reduction potential) measurements corrected to the Standard Hydrogen Electrode (Eh) reflects geo-spatial variability in redox state from -0.05 V (sub-oxic, iron reducing) to 0.46 V (fully oxidized).

For purposes of characterization, the groundwater impacted by molybdenum has been divided into three zones: upgradient (area surrounding MW-7), the footprint underlying Pond 003, and downgradient of Pond 003. The narrative below provides a summary of redox states for each of these distinct zones:

- **Upgradient (West of Pond 003):**
 - The apparent upgradient molybdenum source (represented by concentrations at MW-7) containing the highest concentrations occur under oxidizing redox conditions (Eh > 0.2 V) with elevated DO (>0.5 mg/L), and low dissolved manganese concentrations (below or near detection).
- **Underlying Pond 003:**
 - The geochemistry of groundwater underlying Pond 003 can be classified in two distinct geochemical regimes:
 - Area Inside the Co-Mingled Plume Core - the co-mingled molybdenum plume (illustrated as area inside the contour lines of 1 mg/L [yellow shaded area] in molybdenum iso-concentration maps [see Figure 5 of full MNA report]) appears to result from the migration from the apparent upgradient source (west of Pond 003) and potential molybdenum mass flux beneath Pond 003. Because groundwater from the apparent upgradient source is more oxidized and less iron reducing than redox conditions beneath Pond 003, comingling may result in iron oxidation along the plume core; and
 - Areas Outside the Co-Mingled Plume Core - concentrations beneath Pond 003 and outside of the plume core are primarily controlled by iron-reducing conditions as indicated by detectible dissolved iron concentrations and sub-oxic redox conditions (Eh < 0.2V).
- **Downgradient (East of Pond 003):**
 - Downgradient conditions range from fully oxic to sub-oxic manganese- and iron-reducing conditions, in part due to the influence of the oxic Mississippi River water during a high river stage period.

1.2.3 Direct Evidence for Sulfate Reduction and Molybdenum Natural Attenuation

Given the existing groundwater geochemistry conditions, the formation of sulfate-reducing conditions plays a key role in the immobilization of molybdenum in groundwater. Sulfate reduction is a biologically catalyzed oxidation-reduction geochemical process that results in the direct precipitation of metal-bearing (Mo-, and Fe-) sulfides. Sulfate reduction is a form of anaerobic respiration that uses sulfate as the terminal electron acceptor through reduction to sulfide (S^{2-}), and organic carbon as a terminal electron donor through oxidation to carbon dioxide. Sulfide is thermodynamically unstable in groundwater, and will react with metals (Fe, Mo) to form secondary mineral precipitates that act as an attenuation mechanism for molybdenum. Molybdenum-bearing secondary mineral precipitation accounts for a potentially significant geochemical attenuation mechanism for Site groundwater, these precipitates include molybdenum disulfides (molybdenite), and Fe(Mo)-sulfide complexes. Rates and dependability of sulfate reduction depend on three conditions: anaerobic conditions, sufficient sulfate concentrations in groundwater, and sufficient organic carbon concentrations in aquifer sediments. This section summarizes the evidence for sulfate reduction activities that currently exist at the Site (further discussion regarding how these conditions are predicted to be satisfied in the future Site conditions is provided in Section 1.3 of this document).

The geochemical evaluation of current redox conditions and the presence of sufficient sulfate concentrations in groundwater together with sufficient organic carbon concentrations in aquifer sediments suggests that potential for sulfate reduction exists at the Site. Evidence for sulfate reduction in Site groundwater includes:

1. Molybdenum concentration reduction along the co-mingled plume core axis: Molybdenum concentrations along the groundwater flow path reduce between the upgradient source (represented by MW-7) and the distal portion (represented by MW-21 and MW-22 series wells) of the plume by an average of 50 to 60 percent.
2. Presence of detectible sulfide concentrations: Sulfide was detected (2.0 mg/L) in wells MW-24S and MW-24D, indicating the presence of sulfate-reducing microorganisms in the Site aquifer.

1.2.4 Hydraulic and Geochemical Controls on Existing Conditions

This section summarizes several of the Site-specific hydraulic and geochemical factors that affect molybdenum fate and transport in groundwater, such as:

- Surface water infiltration from Pond 003;
- Hydraulic controls and seasonal fluctuation from the Mississippi River; and
- Molybdenum leaching from source contributions (from both Pond 003 and the industrial upgradient source from Pond 003).

Each of these factors are described in detail below, with focus on the influence of each on molybdenum concentrations and NA mechanisms in groundwater.

Pond 003 Surface Water Infiltration: Surface water infiltration from Pond 003 provides a significant source of oxygenated water to the subsurface, which acts as a driver for oxidation preventing sulfate-reducing conditions. The addition of oxygenated water to the aquifer artificially maintains stronger oxidizing conditions which are conducive to the mobilization of molybdenum in groundwater while the pond is in active operation.

Seasonal Fluctuation and Hydraulic Control of the Mississippi River: The Mississippi River stage fluctuates seasonally by as much as 30 feet throughout the year, based on the United States Geological Survey hydrologic information (United States Geological Survey, 2022). While the overall groundwater flow direction is expected toward the river, seasonal potentiometric surface maps show that the seasonal variation in stage creates a periodic reversal in groundwater flow direction. When the river stage is high, the river acts as a source of recharge to the aquifer, resulting in bank storage of oxygenated water. Although the time interval is short, the interaction of oxygenated river water with the aquifer can suspend and/or reverse reduction-driven molybdenum NA within the distal portions of the plume core. The magnitude to which this occurs, and to what extent, will be assessed with supplemental analyses that will be incorporated into future phases of the MNA Work Program.

Molybdenum Source Contributions (Upgradient Source and Pond 003): Molybdenum source contributions can be characterized as follows:

- The apparent upgradient source (non-Pond 003 source) represented by the groundwater quality data MW-7 is characterized by relatively high dissolved oxygen [DO > 0.5 mg/L], manganese (Mn)-oxidizing (below detection), Iron (Fe)-reducing (Fe [dissolved] > 0.5 mg/L), oxidizing (Eh > 0.20 V) environment. When compared to background conditions (MW-24S, and MW-25S), the conditions at MW-7 are significantly more oxidized.
- The potential source beneath Pond 003 can be observed most clearly in MW-8, which includes sub-oxic DO concentrations (DO < 0.5 mg/L), manganese (Mn)-reducing conditions (>0.5 mg/L), Iron (Fe)-reducing conditions (Fe [dissolved] > 0.5 mg/L), and sub-oxic conditions according to (Eh < 0.2 V) environment. When compared to upgradient background conditions (MW-24S and MW-25S), background conditions are more oxidizing (as evidenced by higher dissolved iron concentrations >> 0.5 mg/L in background wells).

The plume resulting from the apparent upgradient molybdenum source appears to interact with the Pond 003 source (the co-mingled plume), as indicated by yellow shaded area shown in Figure 5 of the full MNA report. The source upgradient of Pond 003 appears to be capable of contributing geochemical conditions that have the potential to inhibit the immobilization of molybdenum in groundwater.

1.3 ANTICIPATED FUTURE SITE CONDITIONS.

This section summarizes the anticipated impacts CM activities will have on future Site geochemical conditions and describes the subsequent enhancement of sulfate reduction and attenuation of molybdenum.

Section 1.2.3 provided lines of evidence that suggest sulfate reduction is present in portions of the Site aquifer, while Section 1.2.4 summarizes the existing factors (under current conditions) that can potentially limit sulfate reduction in the aquifer. This section summarizes the positive impacts CM activities will have on future Site geochemical conditions and characterize the subsequent enhancement of sulfate reduction (and subsequent natural attenuation of molybdenum) under this future scenario.

Future Site geochemistry conditions are anticipated to change based on the following factors:

- **CM Implementation:** The preferred CM remedy for Pond 003 includes CIP source reduction. CIP activities are planned to begin in 2023-2024 with re-grading of the Site to support placement of an engineered CCR Rule compliant cap.
- **Cessation/Management of the Upgradient (non-Pond 003) Source:** The upgradient source appears to contribute molybdenum,² affecting the N&E of molybdenum, and by creating geochemical contributions that are not conducive for molybdenum NA benefits. As stated earlier, without cessation, management of the upgradient source, the performance of Pond 003 CIP plus NA will require additional monitoring to determine if there is a longer-term need to supplement the overall groundwater remedy with additional MNA-plus controls (e.g., localized point-source treatment/management of the upgradient source, etc.).

Cumulative impacts from these key factors will eliminate the oxidative drivers that limit sulfate-reducing conditions needed for molybdenum NA (see Figure 17 of full MNA report). Once the oxidative drivers are removed, it is predicted that sulfate-reducing conditions will be the predominant redox state beneath and downgradient of Pond 003. Under this future regime, the kinetic rate limiting components for sulfate-reducing conditions will be the availability of the oxidizing agents (electron receptor: sulfate concentrations) and reducing agents (electron donors: organic carbon) necessary to drive the reaction.

Site groundwater data indicate that sulfate concentrations are sufficient (> 100 mg/L) to facilitate sulfate reduction in all wells where molybdenum concentrations exceed the GWPS (0.1 mg/L). Soil concentration data from samples collected within screened intervals of several Site N&E wells demonstrate an average soil total organic carbon (TOC) concentration = 0.8 percent TOC, four times higher than the average soil TOC value (0.2 percent TOC) found in the subsurface environment (USEPA, 1996). These data strongly suggest that existing characteristics are conducive for the establishment of sulfate-reducing conditions once the oxidative drivers to the aquifer are cut off. Once sulfate-reducing conditions are established in the subsurface, stronger geochemical NA of molybdenum in groundwater is expected.

1.4 EFFICACY OF MNA FOR MOLYBDENUM IN GROUNDWATER

This section describes the basis for MNA during the post-CIP implementation timeframe. This section also describes the current and future MNA characterization steps, critical benchmarks to assessing MNA in the future, and provides a list of MNA plus strategies for use as supplemental supporting remedial approaches for meeting molybdenum GWPS, if needed. Under current and expected future Site conditions, no unacceptable human health risk and ecological risk is anticipated (human and ecological risk evaluations for Pond 003 are documented in the report entitled *Summary of Pond 003 Human and Ecological Risk Evaluation, NMPP, New Madrid, MO* (Haley & Aldrich, 2022d).

² Recent upgradient concentrations in MW-7 are above 2.0 mg/L with historical concentrations as high as 3.9 mg/L, versus Pond 003 source concentrations less than 0.9 mg/L.

Groundwater molybdenum concentrations decrease by 50 percent or more along the plume core flow path between the MW-7 hotspot and distal portions of the plume. This concentration reduction is evidence of existing NA mechanisms. Based on the spatial assessment and data provided in Section 1.2.2, the NA mechanisms responsible for the concentration reductions observed along the groundwater flow path are:

1. Geochemical – molybdenum secondary mineral formation in localized areas where sulfate-reducing conditions are established; and
2. Hydraulic – dilution/dispersion.

Existing Site geochemical conditions and the contributing factors described in Section 1.2, support NA as part of the overall remedy for molybdenum with some limitations. Those limitations are in part based on current conditions such as ongoing flow to the pond, contributions from the upgradient source, and seasonal groundwater flow variations. However, it is anticipated that with implementation of closure and future management or elimination of the upgradient source, those limitations will be reduced. Following closure, it is reasonable to expect a continual improving superposition of Site conditions that will further reinforce NA conditions. Specifically, the geochemical evolution that will result from the implementation of closure is anticipated to stimulate the sulfate-reducing conditions necessary to enhance geochemical NA mechanisms for molybdenum. It is estimated that, once oxidative drivers are removed by CIP, existing sulfate in groundwater and organic carbon in aquifer solids will further promote NA through molybdenum secondary mineral precipitation, supporting reliable CM.

Data enhancements which will further support NA objectives include:

- Assessment of aquifer capability to host a sufficient population of sulfate-reducing bacteria;
- Further evaluation of organic carbon concentrations in solid aquifer soils;
- Assess longevity, reliability, and temporal nature of molybdenum-bearing sulfide secondary precipitates; and
- Assessment of the magnitude of hydraulic and geochemical influences derived from Mississippi River seasonal fluctuations.

The need to implement MNA plus can be assessed according to USEPA Adaptive Management Framework through periodically reviewing the performance of the CIP and MNA (USEPA, 2022).

Future performance monitoring will include additional NA evaluation to provide a better understanding of the capability of MNA as a site management tool after CIP and the cessation of the apparent upgradient source. Temporal molybdenum trends and geochemical evolutions will also be re-evaluated through geospatial and statistical methods during critical time intervals to confirm or revise assumptions and predictions supporting MNA.

References

1. Crusius, S., Calvert, T., Pedersen, T. and Sage, D. (1996) Rhenium and Molybdenum Enrichments in Sediments as Indicators of Oxic, Suboxic, and Sulfidic Conditions of Deposition. *Earth Planetary Sciences Letters*, 145, 65-78. [http://dx.doi.org/10.1016/S0012-821X\(96\)00204-X](http://dx.doi.org/10.1016/S0012-821X(96)00204-X).
2. Haley & Aldrich, Inc. (Haley & Aldrich), 2019. Corrective Measures Assessment for Pond 003, New Madrid Power Plant, New Madrid, Missouri. September.
3. Haley & Aldrich, 2022a. Summary of Pond 003 Nature & Extent Investigation, NMPP, New Madrid, MO.
4. Haley & Aldrich, 2022b. New Madrid Power Plant, Pond 003 and 004, Preliminary Streamlined Risk Evaluation.
5. Haley & Aldrich, 2022c. CCR Groundwater Characterization and Monitoring Network Description, NMPP Pond 003.
6. Haley & Aldrich, 2022d. Summary of Pond 003 Human and Ecological Risk Evaluation, NMPP, New Madrid, MO.
7. Helz, G.R., Miller, C.V., Charnock, J.M., Mosselmans, J.F.W., Patrick, R.A.D., Garner, C.D., and Vaughan, D.J., 1996, Mechanism of molybdenum removal from the sea and its concentration in black shales: EXAFS evidence. *Geochimica et Cosmochimica Acta*, 60(19), 3631-3642.
8. Hodge, V.F., Johannesson, K.H., Stetzenbach, K.J., 1996, Rhenium, molybdenum, and uranium in groundwater from the southern Great Basin, USA: Evidence for conservative behavior. *Geochimica et Cosmochimica Acta*, 60(17), 3197-3214.
9. Schlieker, M., Schüring, J., Hencke, J., Schulz, H.D., 2001, The influence of redox processes on trace element mobility in a sandy aquifer—an experimental approach. *Journal of Geochemical Exploration*, 73, 167-179.
10. Smedley, P.L., Edmunds, W.M., 2002, Redox Patterns and Trace-Element behavior in the East Midlands Triassic Sandstone Aquifer, U.K. *Ground Water*, 40(1), 44-58.
11. U.S. Environmental Protection Agency (USEPA), 1996. Soil Screening Guidance: Technical Background Document, EPA/540/R95/128. May.
12. USEPA, 1999. Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Facilities.
13. USEPA, 2015. Use of Monitored Natural Attenuation for Inorganic Contaminants in Groundwater at Superfund Sites.
14. USEPA, 2022. Considerations for Adaptive Management at Superfund Sites. OLEM Directive 9200.3-123. June.
15. United States Geologic Survey, 2022. National Water Information System data available on the World Wide Web (USGS Water Data for the Nation), accessed [01 August 2022], at URL [<http://waterdata.usgs.gov/nwis/>], Site Number: MS115, USGS Site Name: Mississippi River at New Madrid, MO.

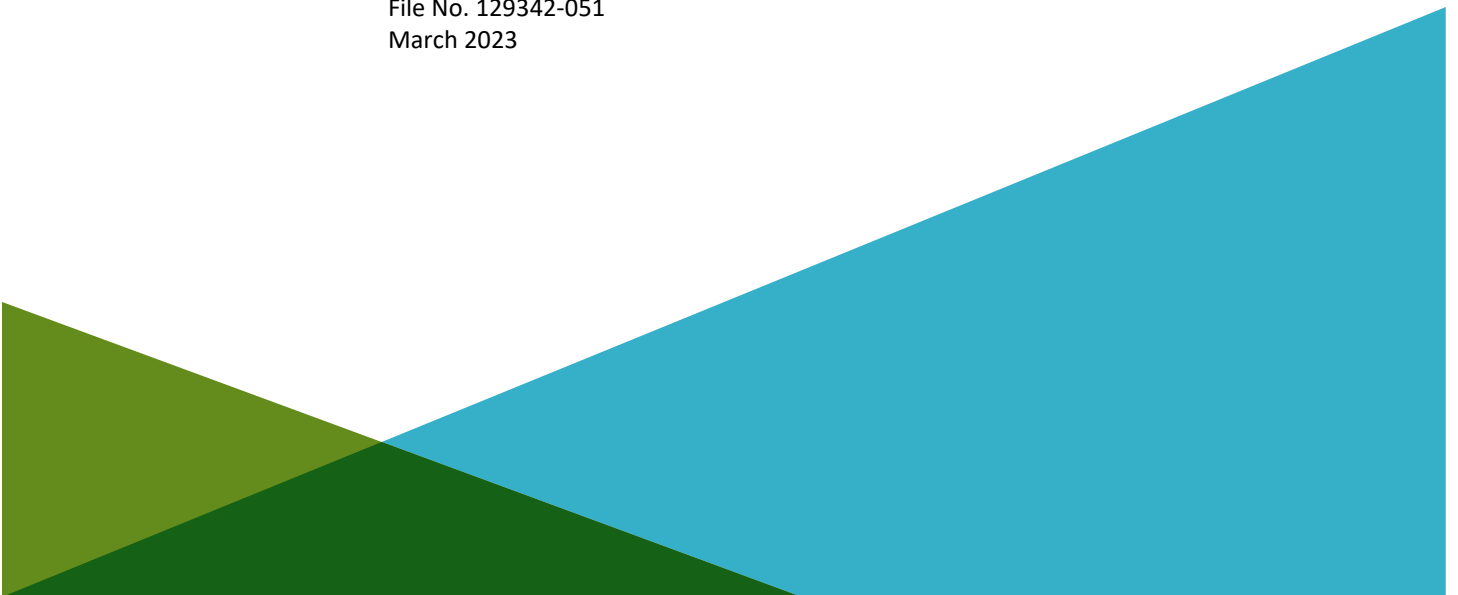
APPENDIX D
Risk Evaluation Summary
in Support of Selection of Remedy

**REPORT ON
NEW MADRID POWER PLANT
POND 003
PRELIMINARY STREAMLINED RISK EVALUATION**

by
Haley & Aldrich, Inc.
Cleveland, Ohio

for
Associated Electric Cooperative, Inc.
Springfield, Missouri

File No. 129342-051
March 2023



SIGNATURE PAGE FOR

REPORT ON

NEW MADRID POWER PLANT

POND 003

PRELIMINARY STREAMLINED RISK EVALUATION

PREPARED FOR

ASSOCIATED ELECTRIC COOPERATIVE, INC.

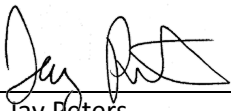
SPRINGFIELD, MISSOURI

PREPARED BY:



Steven F. Putrich, P.E.
Senior Associate – CCR Program Manager/
Engineering Principal
Haley & Aldrich, Inc.

REVIEWED AND APPROVED BY:



Jay Peters
Principal – Risk Assessment Practice Leader
Haley & Aldrich, Inc.

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1	Dilution Attenuation Factor Calculations

List of Common Acronyms

AECI	Associated Electric Cooperative, Inc.
CCR	Coal Combustion Residuals
CFR	Code of Federal Regulations
CSM	Conceptual Site Model
DAF	Dilution-Attenuation Factor
Haley & Aldrich	Haley & Aldrich, Inc.
HI	Hazard Index
MDNR	Missouri Department of Natural Resources
MRBCA	Missouri Risk-Based Corrective Action
RCRA	Resource Conservation and Recovery Act
RfC	Reference Concentration
RfD	Reference Dose
RSL	Regional Screening Level
SL	Screening Level
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey

1. Introduction

Associated Electric Cooperative, Inc. (AECI) contracted Haley & Aldrich, Inc. (Haley & Aldrich) to conduct a preliminary streamlined risk evaluation to characterize potential health and environmental risks associated with detections of monitoring parameters in the groundwater monitoring well network. This evaluation is focused on the coal combustion residuals (CCR) surface impoundment (Unit) referred to as Pond 003 at the New Madrid Power Plant (NMPP) in Marston, Missouri. Figure 1 provides the project location. **The results of this streamlined evaluation indicate that the presence of Appendix III and Appendix IV constituents in groundwater downgradient of Pond 003 do not pose a risk to public health or the environment that are of regulatory concern.** These conclusions are supported by the analysis provided in this report, which indicates that:

- There are no uses or activities that would result in direct exposure to the groundwater that contains detections of Appendix III or Appendix IV constituents.
- The only potentially complete exposure pathways to constituents in groundwater are associated with migration of the groundwater to surface water in the Mississippi River; the surface water is used as a source of drinking water, for recreational uses including fishing, and as habitat for aquatic organisms. Assuming that groundwater migrates to river surface water, the calculated concentrations of groundwater constituents in river surface water are orders of magnitude lower than screening levels protective for use of the river as drinking water, consumption of fish, and protection of aquatic life.

2. Project Background

Previously, Haley & Aldrich completed a hydrogeological characterization and designed a monitoring well network for the Pond 003 management units to comply with the requirements of the U.S. Environmental Protection Agency (USEPA) rule regulating the disposal of CCRs as solid waste under Subtitle D of the Resource Conservation and Recovery Act (RCRA), published in the Federal Register on 17 April 2015 and effective 19 October 2015 (CCR Rule; Haley & Aldrich, 2017). Figures 2 and 3 show the monitoring well networks and groundwater flow directions of the uppermost aquifer.

AECI and Haley & Aldrich then performed groundwater sampling of the well network between November 2016 and August 2022. Groundwater samples were analyzed for USEPA Detection Monitoring (Appendix III) and Assessment Monitoring (Appendix IV) parameters as stipulated in the CCR Rule, depending on the phase of the groundwater monitoring program that the Unit was regulated by.

Due to the perceived potential groundwater quality impacts from the Unit, AECI has requested the development of this streamlined risk evaluation. The purpose of the risk evaluation is to evaluate whether periodic high groundwater elevations and potential transport of detected levels of Appendix III and Appendix IV monitoring parameters in groundwater are below regulatory and health-based benchmarks for environmental media where potential exposures to human and environmental receptors may occur (i.e., the point of exposure [POE]).¹ The preliminary risk evaluation addressed in this report was completed using chemical analytical data collected as part of the AECI CCR groundwater monitoring program. That data was then used in the context of risk-based screening of the exposure pathways applicable to groundwater downgradient of the Units. The exposure pathways applicable to each Unit are described in the conceptual site model (CSM) in the following subsection.

¹ The CCR Rule requires groundwater monitoring to occur at the downgradient CCR unit waste boundary, and that location is referred to as the Point of Compliance (POC). The POE is the point of exposure where the potential exposures to human and environmental receptors may occur.

3. Conceptual Site Model

To best understand how CCR-related constituents in groundwater may affect the environment, a CSM was developed. The CSM describes the sources and potential migration pathways through which CCR-derived constituents may be transported to other environmental media (receiving media), and the human and environmental receptors that may in turn contact the receiving media. The linkage between a receiving medium and potential exposure is the exposure pathway. For an exposure pathway to be complete, the following conditions must exist (as defined by the USEPA [USEPA, 1989]):

- A source and mechanism of chemical release to the environment;
- An environmental transport medium (e.g., air, water, soil);
- A point of potential contact with the receiving medium by a receptor; and
- A receptor exposure route at the contact point (e.g., inhalation, ingestion, dermal contact).

In the context of the CSM, the CCR-derived constituents in groundwater detected in the monitoring well network represent a 'source' at the point of compliance (POC; Condition 1 above). Similarly, CCR-derived constituents could potentially migrate in groundwater downgradient of the monitoring well network and ultimately to surface water in the Mississippi River (Condition 2 above). Groundwater downgradient of the Unit could potentially be directly contacted by receptors, for example, by construction workers performing excavation activities downgradient of the impoundments (Condition 3 above). Similarly, CCR-related constituents in groundwater that migrate to the river could be contacted in surface water by recreational users of the river and aquatic life, consumed as drinking water via use of the Mississippi River as public water supply, or be up taken into fish which could be consumed by humans and wildlife (Condition 4 above). Exposure routes for constituents in water include ingestion and dermal contact (i.e., CCR-related constituents are not volatile, and therefore the inhalation exposure route is not complete).

For Pond 003, groundwater downgradient of the Unit is not used for any purposes. An irrigation water supply well is located approximately 3,500 feet to the south of Pond 003. However, that well is cross-gradient to primary groundwater flow direction and therefore would not receive groundwater discharge from Pond 003. There are no construction activities presently occurring or planned within the uppermost aquifer in the foreseeable future; therefore, there are no direct contact exposure pathways to groundwater.

Thus, the potentially complete exposure pathways associated with CCR-related constituents in groundwater are:

- Direct contact with and ingestion of surface water (via migration of groundwater to surface water) during use of river water for a municipal water supply;
- Direct contact with surface water (via migration of groundwater to surface water) during recreational uses of the river; and
- Ingestion of biota (e.g., fish) that may uptake constituents that migrate from groundwater to surface water in the river.

Figure 4 illustrates the CSM for Pond 003 and identifies potentially complete exposure pathways that are evaluated in this report. Based on the CSM, the POE is surface water in the Mississippi River.

4. Risk-Based Screening

Risk-based screening was used to characterize whether the CCR-related constituents would potentially pose risks of concern to human and environmental receptors through the exposure pathways identified in the CSM. Risk-based screening is performed by identifying risk-based screening levels that are applicable for the pathways under consideration and then comparing appropriate analytical data to the appropriate screening levels.

Risk-based screening levels represent the constituent concentrations below which risks to public health or the environment are negligible and not of regulatory concern. Risk-based screening levels are derived by regulatory agencies using conservative assumptions which address the potential toxicity of constituents and the potential for exposure to those constituents in environmental media. The goal is to reasonably over-estimate rather than underestimate toxicity and exposure, and this is done by employing default parameters defined by USEPA or other agencies in the screening level derivation, that serves as the basis for this conservative approach.

Due to the conservative methods used to derive screening levels, it can be assumed with reasonable certainty that constituent concentrations in environmental media below screening levels will not result in adverse effects to human health or the environment and, therefore, no further evaluation is necessary. Concentrations above conservative risk-based screening levels, however, do not necessarily indicate that a potential risk exists, but rather that further evaluation may be warranted. USEPA provides this description of its regional screening levels (USEPA, 2022):

“They are risk-based concentrations derived from standardized equations combining exposure information assumptions with EPA toxicity data. SLs [screening levels] are considered by the Agency to be protective for humans (including sensitive groups) over a lifetime...Generally, at sites where contaminant concentrations fall below SLs, no further action or study is warranted (under the Superfund program), so long as the exposure assumptions at a site match those considered by the SL calculations. Chemical concentrations above the SL would not automatically designate a site as ‘dirty’ or trigger a response action; however, exceeding a SL suggests that further evaluation of the potential risks by site contaminants is appropriate.”

This is expressly recognized by USEPA in their risk assessment used to support the CCR Rule-making when they discuss the toxicity values upon which the screening levels are based (USEPA, 2015; Section E.2.1):

“Reference doses (RfDs) and reference concentrations (RfCs) are used to evaluate noncancer effects from oral and inhalation exposures, respectively. RfDs and RfCs are estimates of a daily exposure to the human population (including sensitive subgroups) that is likely to be without appreciable risk of deleterious noncancer effects. However, an average lifetime exposure above the RfD (or RfC) does not imply that an adverse health effect will necessarily occur.”

Thus, risk-based screening levels are **protective** because they are concentrations at or below which we have reasonable confidence that there will be no adverse effects from exposure. However, risk-based screening levels are not **predictive** of the occurrence of adverse effects. The presence of constituent concentrations in environmental media above risk-based screening levels does not mean that harm will

occur, it only means that additional evaluation is needed to fully understand the potential for an adverse outcome.

4.1 SCREENING LEVELS

The human health screening levels used in this analysis are from Missouri state sources, or where unavailable, from federal sources.

Drinking Water Screening Levels

The Missouri Department of Natural Resources (MDNR) administers the Missouri Risk-Based Corrective Action (MRBCA) framework. The framework uses various tiers of assessment to characterize risks associated with potential exposures to chemicals in environmental media. Tier 1 risk-based target levels (RBTL) are risk-based screening levels published by MDNR in support of the MRBCA process. Tier 1 RBTLs are published for various land use/receptor exposure scenarios, including use of groundwater as a drinking water source. The Tier 1 RBTLs are derived to be protective for a carcinogenic risk of 1×10^{-5} and a non-carcinogenic hazard index (HI) of 1. The MRBCA process requires that cumulative exposure to all constituents in site media not be associated with a carcinogenic risk above 1×10^{-5} for a single chemical, a carcinogenic risk above 1×10^{-4} for all chemicals, and a HI above 1 for all chemicals that have the same toxicological endpoint.

Since Tier 1 RBTLs are not published for all chemicals that were analyzed in the groundwater samples, USEPA Regional Screening Levels (RSL) for tap water were used as screening levels for constituents that do not have a published Tier 1 RBTL. RSLs are derived to be protective for a carcinogenic risk of 1×10^{-6} and a non-carcinogenic hazard index of 1. As a conservative measure, RSLs were not adjusted to correspond to the MRBCA single chemical target risk of 1×10^{-5} .

In summary, the drinking water screening levels used in this assessment are:

- MDNR Tier 1 Target Groundwater Concentrations Protective of Domestic Use of Groundwater Pathway. Values currently published by MDNR (MDNR, 2006) and values that have been proposed by MDNR, but not yet adopted (MDNR, 2018a), are used.
- USEPA Risk-based Screening Levels, May 2022, values for tap water (for constituents for which Tier 1 RBTLs are not published), HI = 1 (USEPA, 2022)

Recreational Screening Levels

Recreational uses of surface water, for example wading, swimming, and water sports, are associated with substantially lower exposures than those associated with use of water as a source of drinking water. This is because recreational uses of water occur less frequently than uses of water as drinking water (e.g., recreational uses occur a few days per week over the warmer months of the year versus drinking water uses which are assumed to occur every day), and ingestion of water during recreational uses is only a fraction of the ingestion that occurs when using water as a source of drinking water. Therefore, screening levels for drinking water are used to conservatively represent screening levels for recreational use.

Aquatic Life Screening Levels

MDNR administers water quality standards for aquatic life (Missouri Code of State Regulations Division 20 Chapter 7 Table A; MDNR, 2022). The chronic values for protection of aquatic life are used for this

assessment. Those values are considered to be protective of the most sensitive aquatic life, and therefore protective for both direct contact of surface water by aquatic life, and potential exposures to wildlife through food chain uptake.

Fish Consumption Screening Levels

MDNR administers water quality standards for aquatic life (Missouri Code of State Regulations Division 20 Chapter 7 Table A; MDNR, 2022). The fish consumption values for protection of human health are used for this assessment.

4.2 REPRESENTATIVE CONCENTRATIONS

CCR groundwater monitoring has been performed between November 2016 and February 2022. Groundwater samples have been collected from each of the wells in the CCR monitoring well network and analyzed for USEPA Detection (Appendix III) and Assessment (Appendix IV) Monitoring parameters. To provide a conservative representation of Appendix III and IV parameter concentrations in groundwater, the maximum concentration of each Appendix III and Appendix IV parameter, among all of the rounds of sampling and all of groundwater monitoring wells associated with the Unit, was identified as the representative groundwater concentration. The maximum detected groundwater concentrations for wells associated with Pond 003 are provided in Table 1.

Groundwater analytical data are representative of concentrations that may migrate to river surface water (i.e., the POC), but they are not representative of the concentrations that would occur in surface water after groundwater mixes with surface water (i.e., the POE). Consequently, the groundwater analytical data are not representative of the constituent concentrations that receptors would potentially be exposed to in river water. To estimate river surface water concentrations, a dilution-attenuation factor (DAF) that accounts for groundwater flux (at the river edge (land) and river interface)² and subsequent mixing with surface water was calculated, and then applied to the representative groundwater concentrations.

The DAF was calculated using information for the upper most aquifer as provided in the site hydrological characterization report (Haley & Aldrich, 2017):

- Groundwater Flow ($Q_{\text{groundwater}}$): Approximately 24,000 cubic feet per day (ft^3/day)
- River Flow (Q_{river}): Obtained from the United States Geological Survey gauging station near New Madrid (Station #07024175). The station reported low flow condition (7Q10) of 1.5×10^{10} ft^3/day .

Using these two values, the DAF is calculated to be 625,000 [i.e., meaning that the ratio of the volume of river flow is seven orders of magnitude greater than the flow volumes attributed to groundwater per unit area ($Q_{\text{river}} / Q_{\text{groundwater}}$)].

This calculation uses the most conservative values for groundwater flow (i.e., meaning the upper limits or reasonable maximum values of flow anticipated) because they use the maximum gradient, K values, and aquifer thicknesses, which in turn ‘maximizes’ the groundwater flux estimate. In addition, because the river stage is in direct connection with the aquifer unit, groundwater flow varies based on low river stage (groundwater flow toward river) and high river stage (groundwater flow away from river).

² Groundwater flux as defined by Title 10 Code of Federal Regulations Part 960.2 is the rate of groundwater flow per unit area of porous media measured perpendicular to the direction of flow (in this case the Mississippi River downgradient of Ponds 003).

Consequently, groundwater does not migrate to the river year-round, but rather migrates to the river only during lower river stages. For the purposes of conservatism, this lower river stage (where groundwater flowing from Pond 003 to the river) was used in support of the subject risk screening.

The representative surface water concentrations derived using the DAF are provided in Table 2. Attachment 1 provides documentation of the DAF calculation.

4.3 RISK-BASED SCREENING RESULTS

The risk-based screening consists of a comparison of representative concentrations to the screening levels identified above. Risk-based screening was performed using representative concentrations for both groundwater and surface water.

4.3.1 Groundwater

Although there are no complete direct exposure pathways to groundwater, the groundwater representative concentrations were compared to the screening levels listed above to provide a very conservative screening of migration of groundwater to river surface water. Specifically, if constituents in groundwater are present at concentrations below the screening levels that are applicable to exposures in surface water, then clearly the constituents in groundwater are not a concern for migration to surface water. Conversely, if constituents are detected in groundwater at concentrations above screening levels applicable to exposures in surface water, then further evaluation of those constituents using representative concentrations in surface water is appropriate. In summary at the current POC:

- Drinking Water – Seven constituents were detected in groundwater associated with Pond 003 at concentrations above drinking water screening levels (arsenic, boron, cobalt, lead, lithium, molybdenum, and thallium; Table 1).
- Aquatic – Four constituents were detected in groundwater associated with Pond 003 at concentrations above aquatic life and/or fish consumption screening levels (cadmium, lead, mercury, and pH; Table 3).

These screening results indicate that all Appendix III and Appendix IV constituents, other than those listed above, are not present in groundwater at concentrations that would pose a potential concern for migration to surface water. The constituents listed above are further evaluated in Subsection 4.3.2 using representative concentrations for surface water.

4.3.2 Surface Water

Surface water concentrations were calculated for the constituents that were detected in groundwater at levels above the drinking water, aquatic life, and/or fish consumption screening levels. The calculated surface water concentrations were then compared to the screening levels to evaluate whether migration of groundwater to surface water would pose a potentially significant exposure pathway to constituents in groundwater.

The surface water concentrations were calculated by applying the DAF derived in Section 4.2 to the representative groundwater concentrations. To streamline this assessment, the highest of the representative concentrations for Pond 003 groundwater quality were used (Table 2).

As shown in Table 2, the estimated surface water concentrations are at least **four orders of magnitude lower** than even the most stringent of the drinking water, aquatic life, and fish consumption screening levels. This indicates that CCR constituents in groundwater do not pose unacceptable risks to human health or the environment at the POE because they will not migrate to surface water at concentrations that are above screening levels protective for use of the river as drinking water, consumption of fish, and protection of aquatic life.

5. Conclusions

The results of this streamlined evaluation indicate that the presence of Appendix III and Appendix IV constituents in groundwater downgradient of Pond 003 do not pose risks to public health or the environment that are of regulatory concern. These conclusions are supported by the analysis provided in this report, which indicates that:

- There are no uses or activities that would result in direct exposure to the groundwater that contains detections of Appendix III or Appendix IV constituents.
- The only potentially complete exposure pathways to constituents in groundwater are associated with migration of the groundwater to surface water in the Mississippi River; the surface water is used as a source of drinking water, for recreational uses including fishing, and as habitat for aquatic organisms. Assuming that groundwater migrates to river surface water, the calculated concentrations of groundwater constituents in river surface water are orders of magnitude lower than screening levels protective for use of the river as drinking water, consumption of fish, and protection of aquatic life.

References

1. Haley & Aldrich, Inc. 2017. CCR Groundwater Monitoring Network Description for the New Madrid Power Plant, New Madrid, Missouri. Letter to Kim Dickerson, Senior Environmental Analyst, Associated Electric Cooperative, Inc. 17 October 2017.
2. Missouri Department of Natural Resources (MDNR), 2006. Missouri Risk-Based Corrective Action Technical Guidance. Appendix B – Default Target Levels and Tier 1 Risk-Based Target Levels. Accessed June 2017. Available at: <https://dnr.mo.gov/env/hwp/mrbcadocument.htm>
3. MDNR, 2018. Draft Missouri Risk-Based Corrective Action (MRBCA).
4. MDNR, 2022. 10 Missouri Code of State Regulations Division 20 Chapter 7 Table A. Updated January 29, 2022.
5. U.S. Environmental Protection Agency (USEPA), 1989. Risk Assessment Guidance for Superfund: Volume I. Human Health Evaluation Manual (Part A). Interim Final. Office of Emergency and Remedial Response. U.S. Environmental Protection Agency, Washington, D.C. EPA 540/1-89/002. Available at: <http://www.epa.gov/risk/risk-assessment-guidance-superfund-rags-part>
6. USEPA, 2015 (and subsequent changes). Final Rule: Disposal of Coal Combustion Residuals (CCRs) for Electric Utilities. 80 FR 21301-21501. U.S. Environmental Protection Agency, Washington, D.C. Available at: <http://www2.epa.gov/coalash/coal-ash-rule>
7. USEPA, 2022. USEPA Regional Screening Levels. May 2022. U.S. Environmental Protection Agency. Available at: <http://www.epa.gov/risk/regional-screening-table>

TABLES

TABLE 1
COMPARISON OF ANALYTICAL RESULTS FOR POND 003 COMPLEX
GROUNDWATER TO DRINKING WATER SCREENING LEVELS
NEW MADRID POWER PLANT - POND 003
MARSTON, MISSOURI

Constituent	Screening Levels			Selected Screening Levels		Maximum Concentration	Maximum Concentration Exceeds Current Selected Screening Level?	Maximum Concentration Exceeds Proposed Selected Screening Level?
	Missouri Tier 1 Target Groundwater Concentrations Protective of Domestic Use of Groundwater Pathway (current) (a)	Missouri Tier 1 Risk-Based Target Level - Domestic Water Use (proposed) (b)	May 2022 USEPA Tap Water Regional Screening Levels (c)	Selected Screening Level - Current MRBCA Screening Levels (d)	Selected Screening Level - Proposed MRBCA Screening Levels (d)			
Inorganics, Total (mg/L)								
Antimony	0.006	0.006	0.0078	0.006	0.006	0.0031	No	No
Arsenic	0.01	0.01	0.000052	0.01	0.01	0.033	Yes	Yes
Barium	2	2	3.8	2	2	1	No	No
Beryllium	0.004	0.004	0.025	0.004	0.004	0.001	U	No
Boron	NA	3.99	4	4	4	33	Yes	Yes
Cadmium	0.005	0.005	0.0018	0.005	0.005	0.0016	No	No
Calcium	NA	NA	NA	NA	NA	290	No	No
Chloride	NA	NA	NA	NA	NA	62	No	No
Chromium	0.1	0.1	22	0.1	0.1	0.038	No	No
Cobalt	NA	0.006	0.006	0.006	0.006	0.013	Yes	Yes
Fluoride	4	4	0.8	4	4	1.12	No	No
Lead	0.015	0.015	0.015	0.015	0.015	0.031	Yes	Yes
Lithium	NA	0.0399	0.04	0.04	0.04	0.05	Yes	Yes
Mercury	NA	0.002	0.0057	0.0057	0.002	0.0002	U	No
Molybdenum	0.078	0.0998	0.1	0.078	0.100	3.9	Yes	Yes
Selenium	0.05	0.05	0.1	0.05	0.05	0.013	No	No
Sulfate	NA	NA	NA	NA	NA	480	No	No
Thallium	NA	0.002	0.0002	0.0002	0.002	0.002	Yes	No
Radiological (pCi/L)								
Radium-226	NA	NA	NA	NA	NA	2.97	No	No
Radium-228	NA	NA	NA	NA	NA	3.12	No	No
Radium-226 & 228 Combined	NA	NA	NA	NA	NA	3.8	No	No
Field Parameters								
Temperature (Deg C)	NA	NA	NA	NA	NA	23.07	No	No
TDS	NA	NA	NA	NA	NA	1100	No	No
pH (su)	NA	NA	NA	NA	NA	9.88	No	No

Notes:

- (a) - Missouri Risk-Based Corrective Action. 2006. Technical Guidance, Appendix B, Table B-11 "Groundwater Target Concentrations at Exposure Point". Accessed November 2018. <http://dnr.mo.gov/env/hwp/mrbc/docs/appb-6-06.pdf>
 - (b) - Draft Missouri Risk-Based Corrective Action (MRBCA). 2018. For each constituent with a Maximum Contaminant Level (MCL), the target level for the groundwater domestic use pathway is the MCL. For all other constituents, the target level is the risk-based groundwater concentration for domestic water use developed using the MRBCA models and inputs. The Tier 1 RBTLs are based on acceptable risk levels of 1 x 10⁻⁵ for carcinogenic effects and an HQ of 1.0 for non-carcinogenic effects.
 - (c) - USEPA Risk-Based Screening Levels (May 2022). Values for Tap Water. Hazard Index = 1.0; cancer risk = 1E-06. Accessed July 2022. <http://www2.epa.gov/risk/risk-based-screening-table-generic-tables>
 - (d) - The Selected Screening Value is the Missouri value (current or proposed) or the RSL where a Missouri value was not available.
- μS/cm - MicroSiemens per centimeter
Deg C = degree Celsius
MCL - Maximum Contaminant Level
mg/L - milligrams per liter
MRBCA - Missouri Risk-Based Corrective Action
NA - Not Available / Applicable
NTU - Nephelometric Turbidity Unit
pCi/L - picoCurie per liter
SU - Standard unit
TDS - Total Dissolved Solids
U - not detected, value is the maximum reporting limit

TABLE 2
ESTIMATED SURFACE WATER CONCENTRATIONS AND COMPARISON
TO DRINKING WATER AND SURFACE WATER SCREENING LEVELS
 NEW MADRID POWER PLANT - POND 003
 MARSTON, MISSOURI

Dilution Attenuation Factor (a)		625,000				
Constituent	Maximum Concentration - Pond 003	Estimated Surface Water Concentration (b)	Selected Drinking Water Screening Level - Current MRBCA Screening Levels (c)	Selected Drinking Water Screening Level - Proposed MRBCA Screening Levels (c)	Missouri Protection of Aquatic Life Chronic (d)	Missouri Human Health Fish Consumption (d)
Inorganics, Total (mg/L)						
Arsenic	0.033	5.3E-08	0.01	0.01	0.15	NA
Boron	33	5.3E-05	4	4	NA	NA
Cadmium	0.0016	2.6E-09	0.005	0.005	0.0007	NA
Cobalt	0.013	2.1E-08	0.006	0.006	NA	NA
Lead	0.031	5.0E-08	0.015	0.015	0.0025	NA
Lithium	0.05	8.0E-08	0.04	0.04	NA	NA
Molybdenum	3.9	6.2E-06	0.078	0.10	NA	NA
Selenium	0.013	2.1E-08	0.05	0.05	0.005	NA
Thallium	0.002	3.2E-09	0.0002	0.002	NA	0.0063

Notes:

- (a) See text for calculation of dilution attenuation factor.
 - (b) Estimated surface water concentration = Maximum Pond 003 Groundwater Concentration / DAF.
 - (c) - The Selected Screening Value is the Missouri value (current or proposed) or the RSL where a Missouri value was not available.
 See Table 1 for drinking water screening level sources.
 - (d) - See Table 2 for aquatic life and fish consumption screening level values.
- DAF - Dilution Attenuation Factor
 MCL - Maximum Contaminant Level
 mg/L = milligrams per liter
 MRBCA = Missouri Risk-Based Corrective Action
 NA = not applicable

TABLE 3
COMPARISON OF ANALYTICAL RESULTS FOR POND 003 COMPLEX
GROUNDWATER TO AQUATIC LIFE AND FISH CONSUMPTION SCREENING LEVELS
 NEW MADRID POWER PLANT - POND 003
 MARSTON, MISSOURI

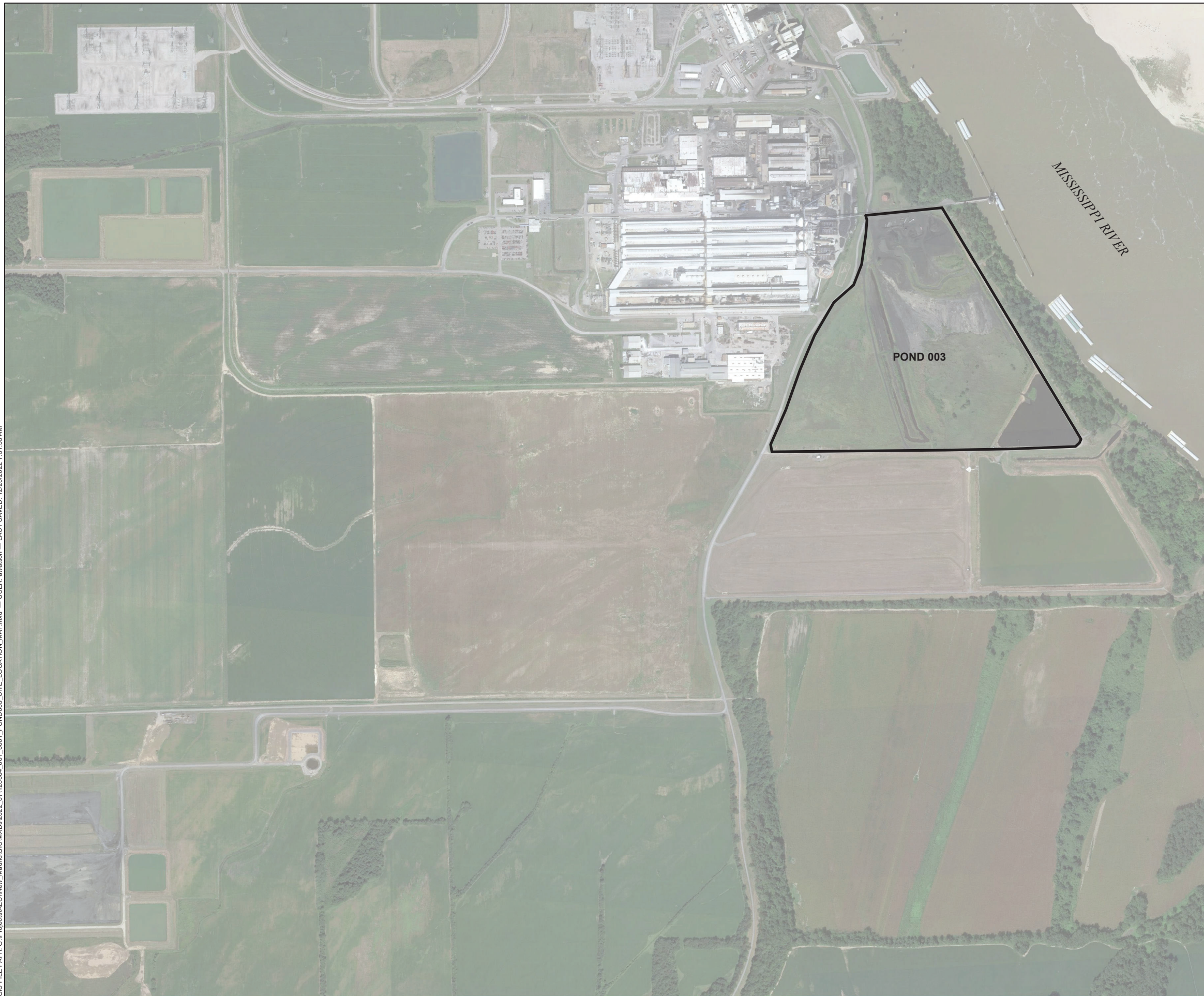
Constituent	Screening Levels		Maximum Concentration	Maximum Concentration Exceeds Protection of Aquatic Life Chronic Screening Level?	Maximum Concentration Exceeds Human Health Fish Consumption Screening Level?	
	Missouri Protection of Aquatic Life Chronic (a)	Missouri Human Health Fish Consumption (a)				
Inorganics, Total (mg/L)						
Antimony	NA		4.3	0.0031	No	No
Arsenic	0.15		NA	0.033	No	No
Barium	NA		NA	1	No	No
Beryllium	0.005		NA	0.001	U	No
Boron	NA		NA	33	No	No
Cadmium	0.0007	(c)	NA	0.0016	Yes	No
Calcium	NA		NA	290	No	No
Chloride	230		NA	62	No	No
Chromium	0.07	(b,c)	NA	0.038	No	No
Cobalt	NA		NA	0.013	No	No
Fluoride	NA		NA	1.12	No	No
Lead	0.0025	(c)	NA	0.031	Yes	No
Lithium	NA		NA	0.05	No	No
Mercury	0.00077		NA	0.0002	U	No
Molybdenum	NA		NA	3.9	No	No
Selenium	0.005		NA	0.013	Yes	No
Sulfate	NA		NA	480	No	No
Thallium	NA		0.0063	0.002	No	No
Radiological (pCi/L)						
Radium-226	NA		NA	2.97	No	No
Radium-228	NA		NA	3.12	No	No
Radium-226 & 228 Combined	NA		NA	3.8	No	No
Field Parameters						
Temperature (Deg C)	NA		NA	23.07	No	No
TDS	NA		NA	1100	No	No
pH (su)	6.5-9		NA	9.88	Yes	No

Notes:


- (a) - 10 Missouri Code of State Regulations Division 20 Chapter 7 Table A. Updated January 29, 2022.
<http://www.sos.mo.gov/adrules/csr/current/10csr/10c20-7a.pdf>. Missouri State Protection of Aquatic Life Chronic values and Human Health Fish Consumption apply to dissolved results (except mercury, which applies to total results);
- (b) - Value for trivalent chromium used.
- (c) - Hardness dependent value for total metals adjusted for dissolved fraction. Default mean hardness value of 100 mg/L as CaCO₃ used.
- µS/cm - MicroSiemens per centimeter
- Deg C = degree Celsius
- mg/L - milligrams per liter
- NA - Not Available / Applicable
- NTU - Nephelometric Turbidity Unit
- pCi/L - picoCurie per liter
- SU - Standard unit
- TDS - Total Dissolved Solids
- U - not detected, value is the maximum reporting limit

FIGURES

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LEGEND

 POND 003 BOUNDARY

NOTES

- 1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.
- 2. AERIAL IMAGERY SOURCE: GOOGLE EARTH, 6 SEPTEMBER 2021



**HALEY
ALDRICH**

ASSOCIATED ELECTRIC COOPERATIVE, INC.
NEW MADRID POWER GENERATING FACILITY
MARSTON, MISSOURI

POND 003 SITE LOCATION MAP




aeci

MARCH 2023

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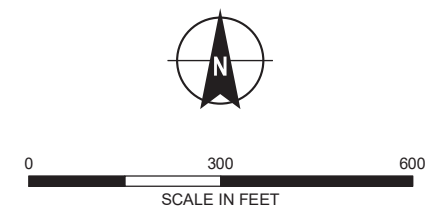


LEGEND

-  MONITORING WELL
-  APPROXIMATE GROUNDWATER FLOW DIRECTION
-  POND 003 BOUNDARY

NOTES

1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.
2. AERIAL IMAGERY SOURCE: ESRI, 21 APRIL 2021



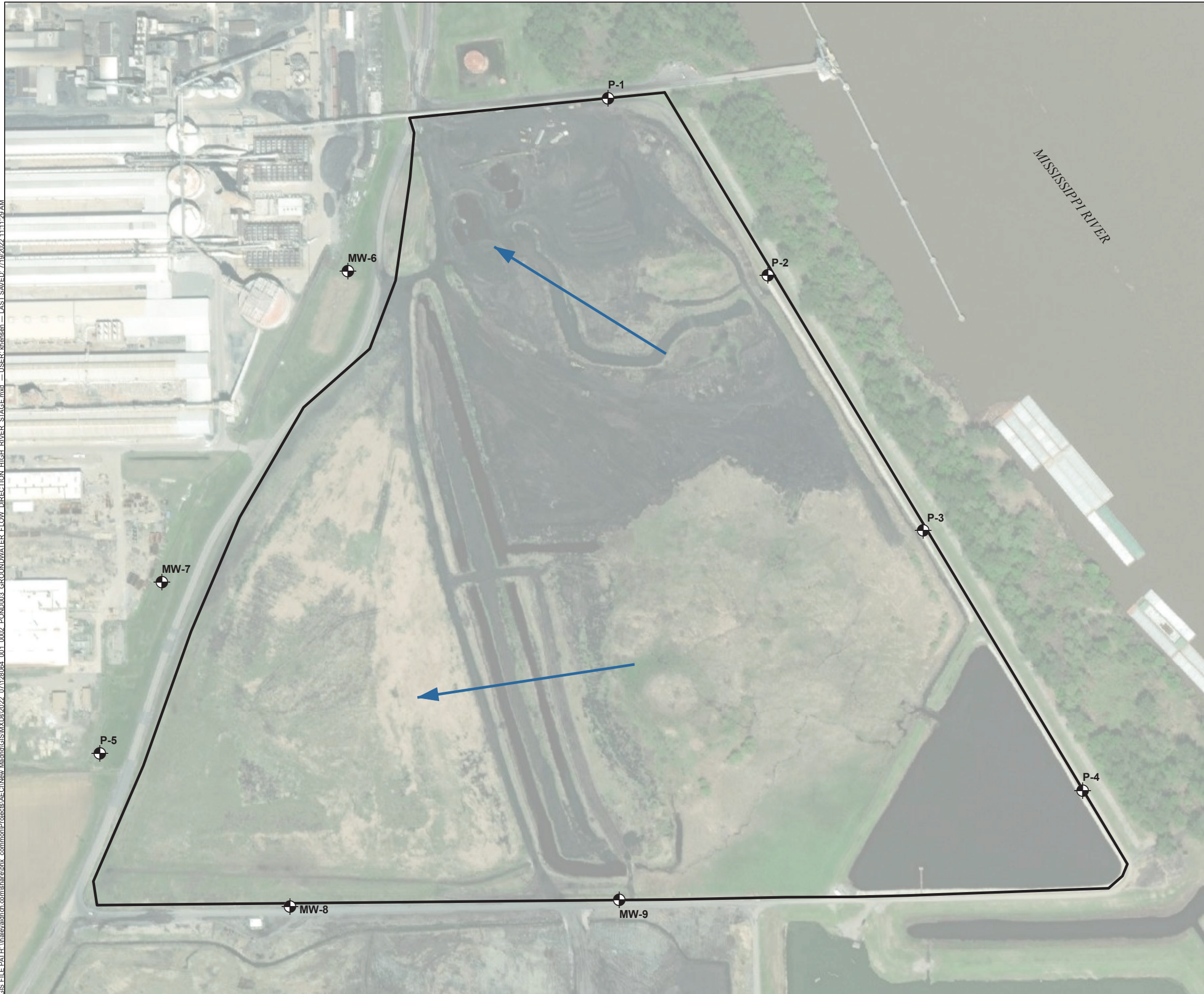
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 MARSTON, MISSOURI

**POND 003 GROUNDWATER FLOW
 DIRECTION MAP LOW RIVER STAGE**






MARCH 2023

GIS FILE PATH: \\haleyaldrich.com\share\chx_common\Projects\AECI\New_Madrid\GIS\MXDs\2022_0712\064_001_0002_POND003_GROUNDWATER_FLOW_DIRECTION_HIGH_RIVER_STAGE.mxd _USER: khansen _LAST SAVED: 7/19/2022 11:11:28AM

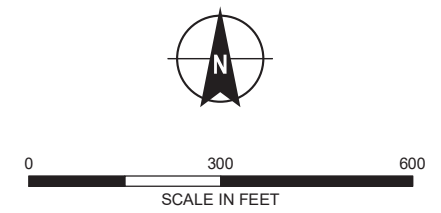


LEGEND

-  MONITORING WELL
-  APPROXIMATE GROUNDWATER FLOW DIRECTION
-  POND 003 BOUNDARY

NOTES

1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.
2. AERIAL IMAGERY SOURCE: ESRI, 21 APRIL 2019



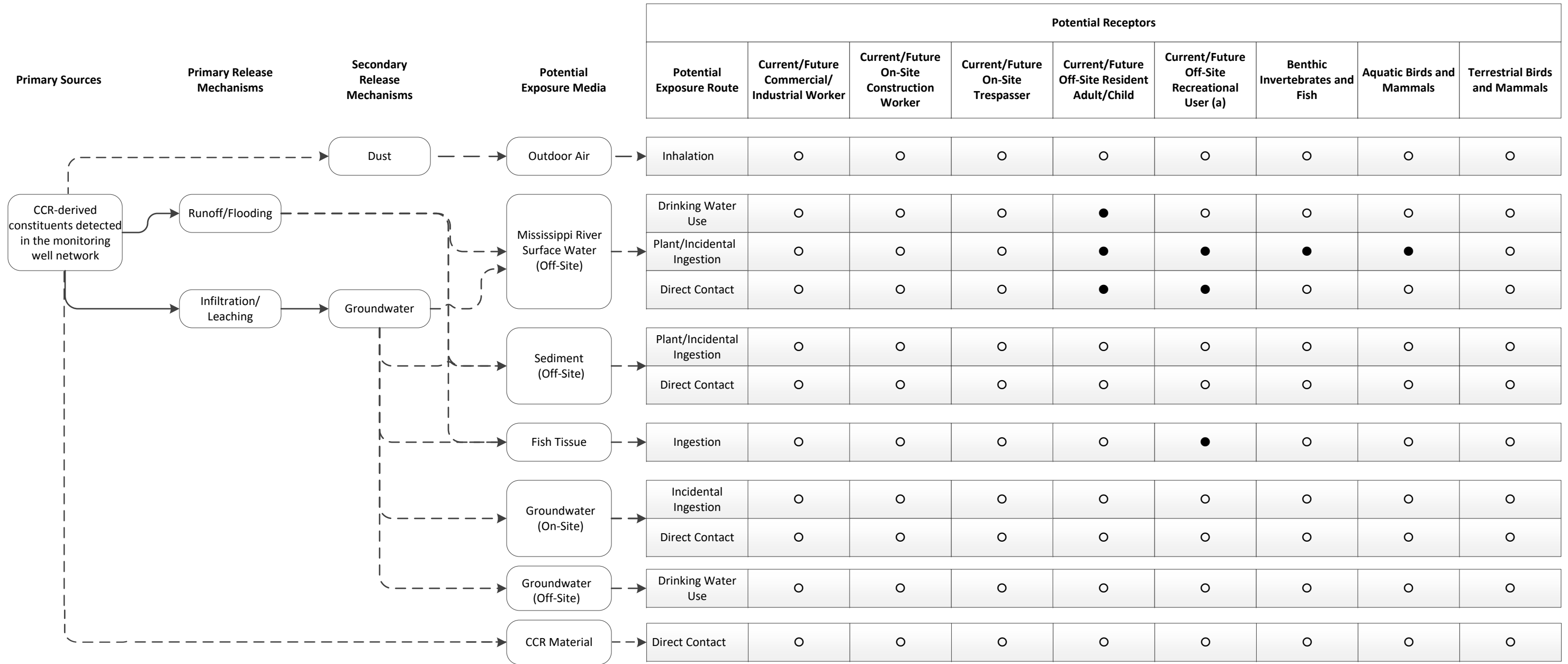
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 MARSTON, MISSOURI

POND 003 GROUNDWATER FLOW DIRECTION MAP - HIGH RIVER STAGE



MARCH 2023

**FIGURE 4
CONCEPTUAL SITE MODEL
ASSOCIATED ELECTRIC COOPERATIVE, INC.
NEW MADRID POWER GENERATING FACILITY
MARSTON, MISSOURI**



(a) Includes Current/Future Off-Site Recreational Wader, Recreational Swimmer, Recreational Boater, and Recreational Fisher.

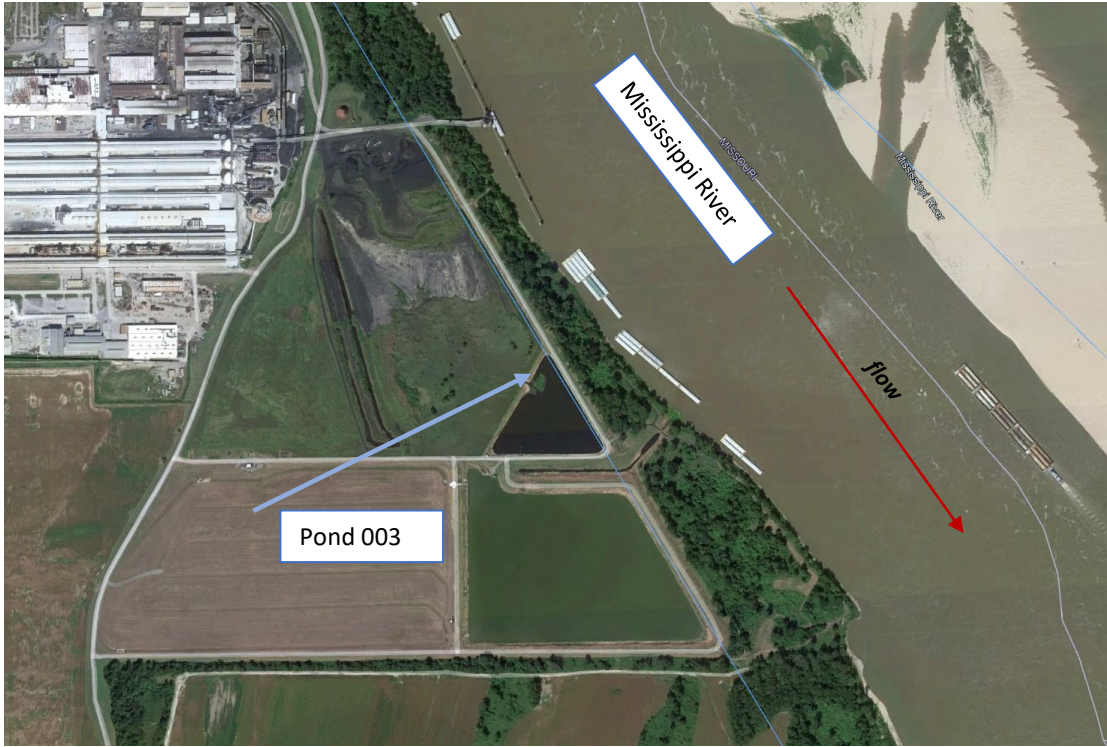
● Pathway potentially complete and evaluated in this assessment to determine if pathway would be associated with a significant risk to human health or the environment.

○ Pathway determined to be incomplete or insignificant and therefore not further evaluated in this assessment.

→ Potential complete migration pathway.
 - - - Incomplete/insignificant migration pathway.
 CCR: Coal Combustion Residuals.

ATTACHMENT 1
Dilution Attenuation Factor Calculations

Client AECI
Project New Madrid
Subject Dilution-Attenuation Factor Calculation



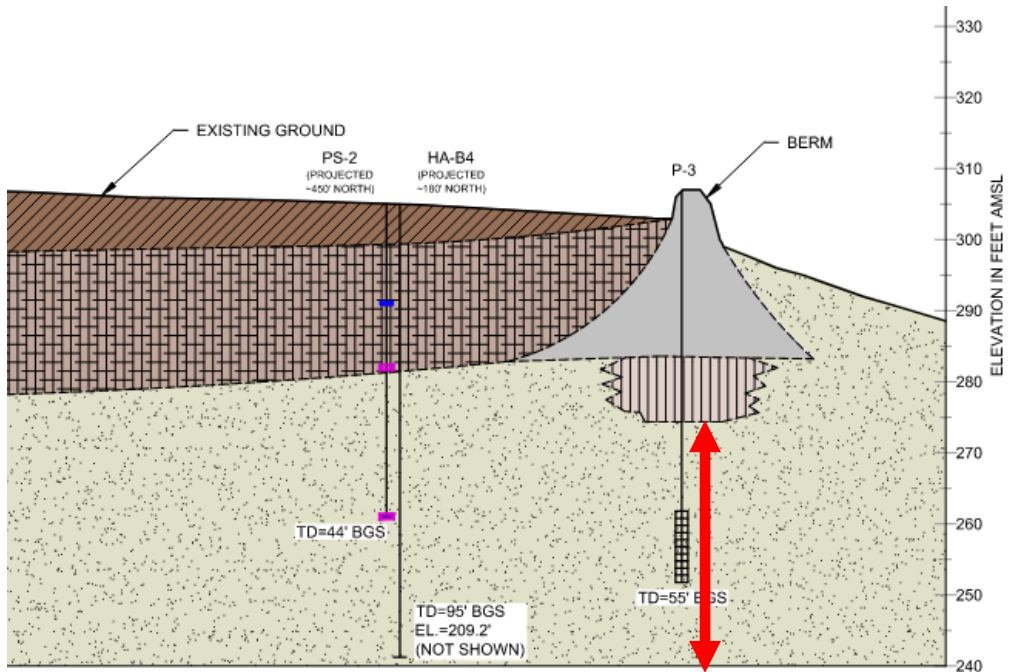
Google Earth North is top of page

Client AECI
 Project New Madrid
 Subject Dilution-Attenuation Factor Calculation

A Conceptual Model was developed for the New Madrid Pond 003 using subsurface cross section interpretations from boring logs, and surveyed elevations. Three basic subsurface units were identified: fine grained overburden, sand and gravel, and coal-combustion residuals (CCR, or "ash").

The sand and gravel is the primary flow pathway at the Site and was utilized for this calculation.

Saturated aquifer approximately 37 feet thick based on wells within the vicinity.



Client AECI
 Project New Madrid
 Subject Dilution-Attenuation Factor Calculation

River discharge calculations were obtained for the Mississippi River near the New Madrid, MO gauging station upstream of the Site. River Flow obtained from the USGS gauging station near New Madrid (Station #07024175). The station and stream statistics are maintained by the USGS.



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SUMMARY STATISTICS

	Water Year 2021		Water Years 2016 - 2021	
Annual total	187,800,000			
Annual mean	514,500		667,200	
Highest annual mean			938,000	2019
Lowest annual mean			514,500	2021
Highest daily mean	1,110,000	Apr 04	1,530,000	Mar 01, 2019
Lowest daily mean	196,000	Oct 07	167,000	Oct 05, 2017
Annual 7-day minimum	207,700	Oct 13	173,000	Oct 01, 2017
Maximum peak flow	1,120,000	Apr 04	1,530,000	Mar 01, 2019
Maximum peak stage	35.09	Apr 04	42.99 ^a	Mar 02, 2019
Annual runoff (cfsm)				
Annual runoff (inches)				
10 percent exceeds	997,000		1,120,000	
50 percent exceeds	458,000		567,000	
90 percent exceeds	262,600		318,800	

* 7Q10 rate in Cubic Feet Per Second from USGS.

^a Max gage height not associated with peak discharge

$$173,000 \text{ ft}^3/\text{Sec} \times 60 \text{ Sec}/\text{Min} \times 60 \text{ Min}/\text{Hr} \times 24 \text{ Hr}/\text{Day} = 1.5 \times 10^{10} \text{ Ft}/\text{Day}$$

Client AECI
 Project New Madrid
 Subject Dilution-Attenuation Factor Calculation

Low Flow Conditions

Groundwater Flux Calculations:

$Q = KAI$

$K = \text{Hydraulic Conductivity}$

Unit	Horizontal K (cm/sec)	Horizontal K (ft/day)
Sand and Gravel	2.9 x 10 ⁻²	81

Upper range from Haley & Aldrich 2019 CCR Groundwater Monitoring Network Description for the New Madrid Power Plant, New Madrid, Missouri

$A = \text{Area}$

Cross-section	Length (ft)	Thickness (ft)	Area (ft ²)
Full Pond	2,700	37	100,000

Upper range from Haley & Aldrich 2019 CCR Groundwater Monitoring Network Description for the New Madrid Power Plant, New Madrid, Missouri

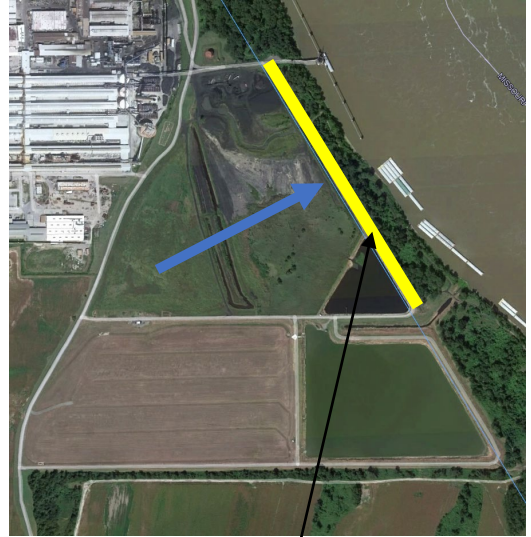
$I = \text{Gradient}$

Cross-section	Head (ft)	Distance (ft)	Gradient (ft/ft)
Full Pond			0.003

Upper range from Haley & Aldrich 2019 CCR Groundwater Monitoring Network Description for the New Madrid Power Plant, New Madrid, Missouri

$Q = \text{Groundwater Flux}$

Cross-section	Horizontal K (ft/day)	Area (ft ²)	Gradient (ft/ft)	Groundwater Flux (ft ³ /day)
Full Pond	81	100,000	0.003	24,000



Cross-sectional Area Used for Calculations. Groundwater gradient was maximum observed between November 2016 and August 2017. Arrows indicate groundwater flow direction.

Full Pond

Client AECI
 Project New Madrid
 Subject Dilution-Attenuation Factor Calculation

$$DAF = \frac{Q_R}{Q_G} \quad \text{Where: } \begin{array}{l} Q_R = \text{Discharge of Mississippi River near New Madrid, at Low-Flow conditions.} \\ Q_G = \text{Calculated Discharge from New Madrid Pond 003 to Mississippi River} \end{array}$$

DAF Under Low Flow Conditions

Cross-section	Q_G (ft ³ /day)	Q_R (ft ³ /day)	DAF
Full Pond	24,000	1.5×10^{10}	625,000