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REPORT ON

CORRECTIVE MEASURES ASSESSMENT
F.B. CULLEY GENERATING STATION
NEWBURGH, INDIANA

by
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for
Southern Indiana Gas and Electric Company
Evansville, Indiana

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Overview

Southern Indiana Gas and Electric Company (SIGECO) retained Haley & Aldrich, Inc. (Haley & Aldrich) to prepare this Corrective Measures Assessment (CMA) for the Coal Combustion Residual (CCR) management unit, referred to as the East Ash Pond (EAP), located at F.B. Culley Generating Station (FBC) in Newburgh, Indiana. FBC is a coal-fired power plant located on the Ohio River in Warrick County, Indiana. The CMA was completed in accordance with requirements stated in 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 (Apr. 17, 2015) (promulgating 40 CFR §257.61); 83 Fed. Reg. 36435 (July 30, 2018) (amending 40 CFR §257.61) (CCR Rule).

SIGECO implemented groundwater monitoring under the CCR Rule through a phased approach to allow for a graduated response and evaluation of steps to address groundwater quality. Assessment monitoring completed in 2018 evaluated the presence and concentration of Appendix IV constituents in groundwater specified in the CCR Rule. Of the 23 CCR parameters evaluated, only one Appendix IV constituent, molybdenum, exceeds the Groundwater Protection Standards (GWPS) established for the EAP.

In performing this CMA, Haley & Aldrich considered the following: presence and distribution of molybdenum, EAP configuration, hydrogeologic setting, and the results of the risk evaluation. Within the EAP, CCR is managed in an impoundment at depths that range from zero (0) feet to approximately 60 feet. The alluvial aquifer beneath the EAP is approximately 80 feet in thickness. Although flow within the alluvial aquifer is directly controlled by the river stages of the Ohio River, groundwater flow is generally from the upland area north of the EAP toward the Ohio River.

To provide a comprehensive CMA, the evaluation described herein included surface impoundment closure options and groundwater remediation alternatives that were combined to constitute comprehensive groundwater remedies, including:

- Alternative 1: Monitored Natural Attenuation (MNA) with In-Situ Solidification (ISS) and Closure in Place (CIP);
- Alternative 2: Hydraulic Containment using pumping with no treatment of the extracted groundwater prior to discharge (hereafter referred to as “Hydraulic Containment with No Treatment”), ISS and CIP;
- Alternative 3: Hydraulic Containment using pumping with treatment of the extracted groundwater prior to discharge (hereafter referred to as “Hydraulic Containment with Treatment”), ISS and CIP;
- Alternative 4: In-Situ Groundwater Treatment, ISS and CIP;
- Alternative 5: MNA with Closure by Removal (CBR);
- Alternative 6: Hydraulic Containment with No Treatment and CBR;
- Alternative 7: Hydraulic Containment with Treatment and CBR; and
- Alternative 8: In-Situ Groundwater Treatment and CBR.

These eight alternatives were developed to meet the threshold criteria provided in the CCR rule at § 257.97 as discussed in **Section 4**, which are:

- Be protective of human health and the environment;

- Attain the groundwater protection standard as specified pursuant to §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 to this part into the environment;
- 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;
- Comply with standards for management of wastes as specified in §257.98(d).

The alternatives were then compared to three of the four balancing criteria stated in the CCR Rule at §257.97. The four balancing criteria consider:

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.

Balancing criteria four, which considers community concerns, will be evaluated following a public information session to be conducted at least 30 days prior to remedy selection by SIGECO.

The following observations are made regarding closure scenarios and groundwater remedial alternatives for the EAP and are described more fully in this report:

- **Cap Integrity and Hydrogeologic Conditions:** All CIP alternatives assumed the installation of a cap and cover system that meets or exceeds the performance criteria set forth in the CCR Rule and is referred to in this CMA as a "low permeability cap." Vertical infiltration via precipitation would be virtually eliminated following installation of the geomembrane cover system. Ash in contact with groundwater would be addressed via remedies that would control, minimize or eliminate the post-closure infiltration of liquids[1].

- **No Risk:** Risk assessment evaluations confirm that the EAP, even prior to closure, presents no **unacceptable risk** to human health or the environment. In fact, concentration levels of molybdenum would need to be **more than 1,000 times higher** than currently measured levels in groundwater before an adverse impact to human health or the environment to a receptor in the Ohio River (the only affected receptor) would occur. Therefore, because no adverse risk currently exists, implementation of any of the remedies considered herein will not result in a meaningful reduction in risk to groundwater-related exposures.

- **Excavation Timeframe:** Because the EAP is relatively small (approximately 378,000 cubic yards), the timeframes associated with excavation and off-site disposal of CCR material are comparable to the timeframes anticipated for capping with ISS. As a result, the logistical challenges – including excavation, transportation, and disposal, and the short-term risks to the community are not significantly different for the CIP and CBR remedy components.

[1] For purposes of this document, the representative remedy that would achieve this requirement is in-situ solidification (ISS). We note that subsurface barrier walls are also appropriate under this remedy and could be used interchangably to describe this remedy component.

In accordance with §257.98, SIGECO 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 the EAP 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. See *Federal Register (March 15, 2018; 83 FR 11584*).

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List of Acronyms and Abbreviations

Abbreviation	Definition
ASD	Alternate Source Demonstration
CBR	Closure by Removal
CCR	Coal Combustion Residual
CIP	Closure in Place
COC	Constituent of Concern
CMA	Corrective Measures Assessment
CSM	Conceptual Site Model
EAP	East Ash Pond CCR Management Unit
FBC	F.B. Culley Generating Station
GMP	Groundwater Monitoring Plan
GWPS	Groundwater Protection Standards
Haley & Aldrich	Haley & Aldrich, Inc.
ISS	In-Situ Solidification
MNA	Monitorned Natural Attenuation
msl	Mean Sea Level
N&E	Nature and Extent
SIGECO	Southern Indiana Gas and Electric Company
SSI	Statistically Significant Increase
SSL	Statistically Significant Level
USEPA	United States Environmental Protection Agency

1. Introduction

Haley & Aldrich, Inc. (Haley & Aldrich) was retained by Southern Indiana Gas and Electric Company (SIGECO) to prepare this Corrective Measures Assessment (CMA) for the Coal Combustion Residual (CCR) management unit (East Ash Pond [EAP]) located at the F.B. Culley Generating Station (FBC), herein referred to as the "Site", in Warrick County, Indiana. SIGECO has conducted detailed geologic and hydrogeologic investigations under the U.S. Environmental Protection Agency (USEPA) rule entitled *Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities*. 80 Fed. Reg. 21302 (Apr. 17, 2015) (promulgating 40 CFR §257.61); 83 Fed. Reg. 36435 (July 30, 2018) (amending 40 CFR §257.61) (CCR Rule). These investigations were, in part, related to the groundwater monitoring and corrective action requirements in the CCR Rule.

This CMA includes a summary of the groundwater monitoring results for Appendix IV constituents, a summary of the evaluation of the Appendix III constituents for statistically significant increases (SSI) compared to background, and a comparison of the Appendix IV constituents detected in assessment monitoring to the Groundwater Protection Standards (GWPS). These evaluations identified statistically significant levels (SSL) of molybdenum in groundwater downgradient of the EAP. This report evaluates potential corrective measures to remediate groundwater for the exceedance of the GWPS.

1.1 FACILITY DESCRIPTION/BACKGROUND

The Site is located adjacent the northern bank of the Ohio River west of the confluence of the Ohio River and Little Pigeon Creek approximately three miles east of the town of Newburgh. The Site varies in ground surface elevations from 359 to 430-feet above mean sea level (msl). The higher elevations are to the north of the Site, north of the Ohio River floodplain. In general, surface topography across the site slopes to the south towards the Ohio River **(Figure 1-1)**. Surface water runoff occurs via sheet flow to low lying areas which eventually lead to the Ohio River and Little Pigeon Creek.

The Site began operations in 1953. FBC is an active energy production facility that generates electricity through the combustion of Illinois Basin coal. The coal combustion residuals are products of the combustion process and include bottom ash, fly ash, and flue gas desulfurization sludge. CCR is currently managed through beneficial re-use and on the Site in a 10-acre impoundment known as the EAP. Site features are shown on **Figure 1-2**. Approximately 378,000 cubic yards of CCR material is currently stored in the EAP. SIGECO owns the land and operates the station for supplying electric power to industrial, commercial, and residential customers in its service territory.

1.2 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 and Aldrich prepared a *Groundwater Monitoring Plan* (GMP) as required by the CCR Rule. The GMP presents the design of the groundwater monitoring system, groundwater sampling and analysis procedures, and groundwater statistical analysis methods.

Monitoring wells were installed in December 2015, March 2016 and February 2017. The monitoring well network includes three background wells (CCR-AP-1R, CCR-AP-7 and CCR-AP-9) and seven downgradient monitoring wells (CCR-AP-2, CCR-AP-3, CCR-AP-4, CCR-AP-5, CCR-AP-6, CCR-AP-8) located around the perimeter of the EAP. Monitoring well locations are shown in **Figure 1-3**.

Detection monitoring events occurred in 2016 and 2017. The results of the sampling events were then compared to background using statistical methods to determine if Appendix III constituents are present at concentrations above background, called SSIs downgradient of the EAP. The result of the statistical analysis identified SSIs were calculated thereby triggering Assessment Monitoring and respective notification of the same.

During the Assessment Monitoring phase, CCR groundwater samples were collected from the CCR monitoring well network in June, and August 2018 and subsequently analyzed for the Appendix III and Appendix IV constituents as required by 40 CFR §257.95(b) and 40 CFR §257.95(d)(1). Appendix IV analytical results are summarized in Table I. Concurrent with the second assessment sampling round, and as required by 40 CFR §257.95(h), GWPS were established for the detected Appendix IV constituents. The assessment monitoring sampling results were compared to the GWPS to determine if SSLs of Appendix IV constituents were present downgradient of the EAP. The results of this evaluation indicated that arsenic and molybdenum were present in groundwater at statistically significant levels above the GWPS. Appendix IV analytical results are summarized in **Table IA**.

As a result of this determination and in accordance with 40 CFR §257.95(g)(3) a field investigation was initiated to demonstrate that a source other than the EAP caused the arsenic and molybdenum contamination. However, due to an extended period of time where the Ohio River was at flood stage, the proposed sampling locations associated with the alternate source demonstration (ASD) for arsenic could not be accessed and the ASD could not be completed prior to the April 15, 2019 deadline to initiate an assessment of corrective measures. The sampling and analysis conducted to evaluate the potential for the naturally occurring coal seam, identified in the boring for CCR-AP-5, to be an alternate source for molybdenum was completed. The molybdenum ASD showed that the naturally occurring coal was a contributing source of molybdenum but the CCR material in the EAP was the primary source. Consequently, both molybdenum and arsenic were carried forward into the assessment of corrective measures while SIGECO continued to pursue the alternate source demonstration for arsenic. Field work for the arsenic ASD was completed on June 12, 2019 and the analytical results were received on July 23, 2019. Soil and groundwater sampling results confirmed that arsenic was naturally occurring in the fine grained, organic rich, alluvial soil and documented the geochemical conditions required to mobilize arsenic through the process of reductive dissolution. As a result, it was determined that the alternate source for arsenic in downgradient groundwater wells from the EAP is the naturally occurring fine-grained alluvium soils, and therefore the corrective measures assessment that follows is focused solely on molybdenum.

1.3 CORRECTIVE MEASURES ASSESSMENT PROCESS

The CMA process involves development of groundwater remediation technologies that will result in meeting the following threshold criteria: protection of human health and the environment, attainment of GWPS, source control, constituent removal, and compliance with standards for waste management. Once these technologies are demonstrated to meet these criteria, they are then compared to one another with respect to the following balancing criteria: long- and short-term effectiveness, source control, and ease or difficulty of implementation. Input from the community on such proposed measures will occur as part of a public meeting to be conducted at least 30 days prior to remedy selection by SIGECO.

1.4 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 following evaluation factors listed here from §257.97 and discussed in **Section 4** are those that are directly related to human health and environmental risk:

- (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;

The following are additional factors related to risk that are considered when developing the schedule for implementing and completing remedial activities once a remedy is selected (§257.97(d)):

- (d)(4) Potential risks to human health and the environment from exposure to contamination prior to completion of the remedy[2];
- (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

The Site geology and hydrogeology was initially described in the *Groundwater Monitoring Plan* prepared by Haley & Aldrich in October 2017. The Conceptual Site Model (CSM) presented in this section of the CMA has been updated to reflect information gathered to comply with the CCR Rule.

2.1 SITE SETTING

The Site is located on the northern bank of the Ohio River, at the confluence of the Ohio River and Little Pigeon Creek, approximately three miles east of the town of Newburgh. The Site varies in elevation with ground surface elevations varying from 430 to 359-feet above msl. Higher elevations are north of the Ash Pond with surface topography sloping to the west and south towards the Ohio River. Surface water runoff occurs via sheet flow into low lying areas towards the Ohio River and Little Pigeon Creek.

2.2 GEOLOGY AND HYDROGEOLOGY

The EAP is located within the Ohio River valley which contains naturally occurring alluvial (stream) and loess (windblown) deposits derived indirectly from continental ice sheets. These sediments were transported in meltwater heavily loaded with entrained sediments that accumulated on top of the Pennsylvanian age shale, limestone and sandstone bedrock. Westerly winds simultaneously deposited silty sediments in the upland areas adjacent to the stream valley. As a result, base levels of the valley floor increased in elevation and created natural levees and terraces. These natural levees produced slackwater lakes which deposited thick sequences of silt and clay adjacent to the river channel. When the ice sheets retreated, the sediment load in the Ohio River diminished and lowered base levels. Consequently, the river incised the slackwater lake sediments, sculpted fluvial terraces, and deposited sand and gravel stream alluvium.

Soil types described in boring logs from monitoring wells installed around the EAP, as well as boring logs generated from geotechnical explorations conducted by AECOM through the EAP indicate that the uppermost aquifer is comprised of a layered sequence of unconsolidated deposits consisting primarily of silts and clay associated with the slackwater lakes overlying sand and gravel alluvium. This unconsolidated overburden overlies Pennsylvanian age shale.

Bedrock around FBC belongs to the Carbondale Group. The Group consists of Pennsylvanian age sandstone, limestone, shale and coal. The Group ranges from 260 to 470 feet thick but on average is approximately 300 feet thick. The Carbondale Group includes laterally persistent limestone units and four of Indiana's commercially important coal seams. Laterally continuous shale beds are associated with the coal formations. Bedrock beneath the EAP dips to the south and south west toward the Ohio River. In the upland area to the northeast of the EAP, the top of bedrock is represented by sandstone. The sandstone unit is not present along the Ohio River where the bedrock is more deeply eroded, and the top of bedrock is represented by gray shale.

The Site is located in the vicinity of the Wabash Valley and New Madrid seismic zones. The largest earthquake recorded (magnitude 5.2) proximal to the Site occurred in April 18, 2008 approximately fifty miles northwest of the facility.
Hydrogeologic units are defined based on their ability to transmit groundwater or serve as confining units between zones of groundwater. In the vicinity of the EAP, the uppermost aquifer occurs within

unconsolidated Ohio River alluvial deposits consisting of silt and clay with discontinuous interbedded layers of sand. To the north of the Ash Pond the uppermost aquifer occurs in the shale and sandstone bedrock units. Recharge to the surficial aquifer occurs through direct surface infiltration.

Piezometric data recorded from the monitoring wells installed on-site shows that the configuration of the uppermost aquifer is primarily controlled by surface topography with some influence from the underlying weathered bedrock. Groundwater flow in the immediate vicinity of the Ash Pond is radial with an overall flow direction from the upland areas north of the Ash Pond to the south toward the Ohio River and Little Pigeon Creek. Groundwater elevations vary seasonally but the groundwater flow patterns remain consistent.

Groundwater flow velocity in the uppermost aquifer beneath the EAP was estimated using site-specific hydraulic conductivity, measured hydraulic gradients, and an assumed effective porosity of 25 percent. Hydraulic conductivity varied from 1.3E-3 cm/sec adjacent to the northern boundary of the Ash Pond to 5.5E-5 cm/sec in the upland area north of the Ash Pond. The hydraulic gradient north of the Ash Pond is 0.06 feet/foot. South of the Ash Pond the hydraulic gradient steepens to 0.1 feet/foot down to the Ohio River. Using the site-specific hydraulic conductivity and hydraulic gradients, and assuming an effective porosity of 25 percent the groundwater flow north of the Ash Pond is estimated to be 325 feet/year. To the south of the Ash Pond groundwater flow is estimated to be 25 feet/year.

2.3 GROUNDWATER PROTECTION STANDARDS

Haley and Aldrich completed a statistical evaluation of groundwater samples using the methods and procedures outlined in the Groundwater Monitoring Plan's *Statistical Analysis Plan* (Haley and Aldrich 2017) to develop site-specific GWPS for each Appendix IV constituent.

Groundwater results were compared to the site-specific GWPS. Exceedances above the GWPS are limited to three monitoring wells (CCR-AP-5, CCR-AP-6I, and CCR-AP-8I) for molybdenum only. Monitoring well locations with SSLs above the GWPS are illustrated on **Figure 2-1**.

2.4 NATURE AND EXTENT OF GROUNDWATER IMPACTS

As outlined in Section 1.2 of this CMA, a successful ASD for arsenic was determined and therefore the corrective measures assessment is focused solely on molybdenum. However, because of the compressed schedule in the Rule and concern over the availability of drillers, SIGECO decided to initiate an evaluation of the nature and extent of molybdenum and arsenic prior to determining the presence of an SSL and prior to the conclusion of the alternate source demonstration, which is the reasoning for installing new monitoring wells along the south side of the EAP. Prior to the successful ASD for arsenic, molybdenum was limited to the shallow aquifer at monitoring well CCR-AP-5 and arsenic was limited to the shallow wells installed in the fine-grained soil south and west of the EAP. Haley & Aldrich initiated an investigation to define the horizontal and vertical nature and extent (N&E) of Appendix IV SSLs as required by the CCR Rule in November 2018 by installing five new monitoring wells (CCR-AP-10, CCR-AP-11, CCR-AP-5I, CCR-AP-6I, and CCR-AP-8I). Monitoring wells CCR-AP-10 and CCR-AP-11 were installed to horizontally delineate molybdenum detected in samples collected from CCR-AP-5 and CCR-AP-5I was installed to vertically delineate molybdenum. Monitoring wells CCR-AP-6I and CCR-AP-8I were installed to vertically delineate arsenic detected along the south side of the EAP. The location of the new monitoring wells is shown on **Figure 1-3**.

Groundwater sampling results from the monitoring wells installed to horizontally and vertically delineate molybdenum detected in samples collected from CCR-AP-5 showed that the extent of molybdenum was limited to the vicinity of CCR-AP-5. Molybdenum was not detected in these newly installed wells at concentrations above GWPSs. However, molybdenum was identified at concentrations above GWPS in groundwater samples collected from the wells installed along the southern berm of the EAP to vertically delineate arsenic . Horizontally, the molybdenum plume is delineated by the Ohio River and vertically the molybdenum plume is defined by the top of the shale bedrock recognizing that the shale bedrock will impede the vertical movement of groundwater. Additional refinement of the groundwater conditions may be considered in the future to support design and construction of groundwater remedies, as necessary. Appendix IV analytical results for the nature and extent monitoring wells are summarized in **Table 1B**.

3. Risk Assessment and Exposure Evaluation

A "Groundwater Risk Evaluation" report has been prepared by Haley & Aldrich, as a companion 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 FBC EAP under the CCR Rule. In addition, SIGECO 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: Is there a source? Are constituents released from the source? Are environmental media (soil, groundwater, surface water, sediments and air) affected by the constituent release? Do constituents travel within and between media? 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 have 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 Indiana Department of Environmental Management, 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 is understood 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 the EAP is not used as a source of drinking water and is not flowing toward any groundwater supply wells. Therefore, despite one constituent in groundwater being detected at statistically significant levels above GWPS, the constituent does not pose any health risks associated with drinking water uses or exposures.

- If constituents in groundwater downgradient of the EAP were assumed to flow into the Ohio 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 Ohio River as a source of drinking water and for recreational purposes, and for ecological receptors that live in or use the Ohio 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 the F.B Culley Generating Station East Ash Pond.

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 to groundwater 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 where Appendix IV constituents are present at concentrations below the GWPS. The corrective measures evaluation that is discussed below and subsequent sections provides an analysis of the effectiveness of eight 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. By meeting these requirements. this assessment also meets the requirements promulgated in §257.96 which include an evaluation of:

- 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 FATE AND TRANSPORT MODELING

Groundwater at the Site was modeled utilizing Groundwater Vista Version 7 for flow and solute transport. The model was constructed, calibrated, and subsequent simulations run to evaluate remedy alternatives for Appendix IV constituents above the GWPS. Site-specific parameters (i.e. groundwater elevations and hydraulic conductivity) were utilized for model preparation. MODFLOW 2005, a finite difference three-dimensional solver, was utilized for groundwater flow estimation. Modeled groundwater elevations were compared to observed values from the on-site well network (February 2019) to achieve a calibration of less than 10 percent scaled root mean squared of measured water levels. Once groundwater flow was calibrated in the model, solute transport was completed using MT3DMS, a three-dimensional solute transport modeling program. Parameters affecting transport such as advection, diffusion, dispersion, and adsorption are utilized within the MT3DMS package to estimate solute transport within the model domain.

The calibrated flow models were used to simulate the different remediation alternatives and the effects they have on groundwater quality through time. These simulations are incorporated into the discussion on remediation alternatives provided below.

4.3 CORRECTIVE MEASURES ALTERNATIVES

Corrective measures are considered complete when groundwater impacted by the EAP does not exceed the Appendix IV GWPS for three consecutive years of groundwater monitoring. In accordance with §257.97, the groundwater corrective measures being 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 corrective measures assembled in this CMA meet the requirements of the threshold criteria listed above.

The corrective measures alternatives presented below contemplate both closure in place (CIP) (Alternatives 1 through 4) and closure by removal (CBR) (Alternatives 5 through 8) of the EAP. Both closure methods are expressly authorized under the CCR Rule.

4.3.1 Alternative 1 – Monitored Natural Attenuation (MNA) with In-Situ Solidification (ISS) and Closure in Place

The EAP would be closed in place with a cap system that will reduce infiltration of surface water to groundwater thereby isolating source material. This cap selection would meet or exceed the performance criteria set forth in 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. CCR material below the water table would be isolated using targeted in-situ soil solidification (ISS). In-situ soil solidification is a technique that uses mixing of the CCR with amendments to solidify the material in place. Amendments typically include Portland Cement and the solidification is completed in-situ using large diameter augers. CCR located beneath the water table 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 (MNA).

Closure-in-place (CIP) with MNA 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 installing a cap/cover designed to significantly reduce infiltration from surface water or rainwater, resist erosion, contain CCR materials, and prevent exposures to CCR. CIP at the EAP will require mounding of the remaining CCRs within the pond, or importation of borrow soil, in order to create a surface with adequate slope to construct a cap and prevent the mounding and ponding of stormwater. This could require extensive excavation and transferring of the material within the pond. Excavation and construction safety during closure is a concern due to heavy equipment (e.g., bulldozers, excavators, front end loaders, and off-road trucks) and dump truck operation within the active FBC site. Additionally, the stormwater runoff will need to be managed, requiring additional time to design and potentially construct a stormwater runoff pond. As previously stated, CCR material below the water table would be isolated using targeted ISS. At the EAP, CIP construction activities are roughly anticipated to take approximately 12 to 18 months.

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 may 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 and targeted ISS 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 boundary of the EAP.

Following the installation of the cap system, SIGECO would implement post-closure care activities. Post-closure care includes cap system maintenance and long-term groundwater monitoring until such time that groundwater conditions return to below GWPS.

4.3.2 Alternative 2 – Hydraulic Containment with No Treatment, ISS and CIP

Using this alternative, the EAP would be closed in-place as described in Section 4.3.1 to reduce infiltration of surface water to groundwater and isolate the CCR material below the water table. Molybdenum in groundwater would be addressed with hydraulic containment through groundwater pumping to hydraulically control the migration of those constituents downgradient. Pumping would be undertaken in the alluvial aquifer and the pumping well effluent is assumed to be discharged directly to surface water under existing or future discharge permits. Under this alternative no treatment would be used prior to discharge. Verification that the effluent could be discharged under current permits or application for and approval of a new permit would be required.

Implementation of a large-scale hydraulic containment system will require a detailed and lengthy design effort. Pilot testing, such as pumping tests and additional groundwater modeling will be needed to verify the hydraulic capture zone.

The pumping well effluent would be discharged directly to a receiving water body (i.e. the Ohio River) in accordance with a National Pollutant Discharge Elimination System (NPDES) Permit. No treatment would be used prior to discharge. The construction of water discharge piping from the EAP to the receiving water body will require engineering design, permitting, and site construction. For the effluent to be discharged to a receiving water body, the existing FBC NPDES Permit may need to be modified or a new permit issued. Either option would likely require effluent testing or modeling to support a permit application. The anticipated timeline for permitting and construction of this option is one year.

Following the installation of the groundwater pumping well network, SIGECO would implement post-closure care activities that includes operation and maintenance of the hydraulic containment system, long-term groundwater sampling to monitor hydraulic control system performance, and cap and cover system maintenance.

4.3.3 Alternative 3 – Hydraulic Containment with Treatment, ISS and CIP

The EAP would be closed in-place as described in Section 4.3.1 to reduce infiltration of surface water to groundwater. Molybdenum detected at the boundary of the unit at concentrations above the GWPS would be addressed with hydraulic containment through groundwater pumping to hydraulically control the migration of those constituents downgradient. Pumping would be limited to the uppermost aquifer. Pumping well effluent would be treated ex-situ, likely with an ion exchange or a reverse osmosis (RO) treatment system. Both systems would have ongoing operation and maintenance and would generate a secondary waste stream – including regeneration/replacement of the ion exchange media or accumulation of reject water from the RO system.

The design and construction of an ion exchange or RO system would require additional development of a treatment system enclosure, equipment and space that adds complexity to this alternative. As noted in the previous option, implementation of a large-scale hydraulic containment system would require a detailed and lengthy design effort. Pilot testing, such as pumping tests and additional groundwater modeling, will be needed to verify the hydraulic capture zone. The timeline for engineering , procurement, permit modification and construction of this option is estimated to be 1 to 2 years.

Following the installation of the low-permeability cap, groundwater pumping well network, and ex-situ treatment system, SIGECO would implement post-closure care activities that includes operation and maintenance of the hydraulic containment system, long-term groundwater sampling to monitor hydraulic containment system performance, and cover system maintenance. Over time, concentrations of molybdenum would decrease to less than the GWPS and operation of the hydraulic containment system would cease.

4.3.4 Alternative 4 – In-Situ Treatment, ISS and CIP

The EAP would be closed in-place as described in Section 4.3.1 to reduce infiltration of surface water to groundwater. Molybdenum would be addressed through in-situ addition of groundwater treatment amendments downgradient of the EAP with the objective of accelerating the time required to achieve the GWPS within the treatment zone. Approvals and permitting would be required for the construction and installation of the treatment system and injection/application of amendments to the subsurface.

Implementation of an in-situ treatment system will require a detailed lengthy design effort with additional bench scale testing to verify groundwater treatment. The bench scale testing will evaluate the efficacy of treating molybdenum in-situ, while factoring in potential changes in groundwater geochemistry which may adversely affect the stability of other CCR-related constituents.

Following the installation of the in-situ treatment system, SIGECO would implement post-closure care activities that include periodic amendment injections or periodic replenishment of the treatment reagents within the treatment zone or reactive barrier, long-term groundwater sampling to monitor treatment system performance, and cover system maintenance. Over time concentrations of molybdenum would decrease to values less than the GWPS and in-situ treatment would cease.

4.3.5 Alternative 5 – MNA with Closure by Removal

This alternative evaluates the removal of CCR from the EAP at FBC followed by natural attenuation of molybdenum in groundwater. Because the EAP is relatively small (approximately 378,000 cubic yards), excavation and off-site disposal is expected to take less than 2-years to complete. As with Alternative 1, concentrations of molybdenum in downgradient groundwater would decline via natural attenuation processes.

Due to the relatively small size of the EAP, potential community impacts, safety concerns, and construction challenges associated with the CBR alternative are not anticipated to be significantly different than CIP with ISS. Technical and logistical challenges of implementing an ash removal project have already been addressed by SIGECO through their ongoing closure activities associated with the West Ash Pond. Removal activities require dewatering and temporary staging/stockpiling of material for drying prior to transportation, which may affect productivity and extend the timeframe to complete removal. During periods of rain and inclement weather, the removal schedule will be negatively impacted. Excavation and construction safety during the removal duration is another concern due to heavy equipment (e.g., bulldozers, excavators, front end loaders, and off-road trucks) and dump truck operation within the active FBC site.

Groundwater would be addressed through MNA. 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). MNA can reduce concentrations of molybdenum in groundwater at the boundary of the EAP. Long-term, SIGECO would implement post-closure care activities that includes groundwater sampling.

4.3.6 Alternative 6 – Hydraulic Containment with No Treatment and CBR

Similar to Alternative 5, the EAP would be closed by removal; however, under this alternative molybdenum in groundwater would be addressed with hydraulic containment through groundwater pumping to hydraulically control the migration of those constituents downgradient. Pumping would be undertaken in the alluvial aquifer. Under this alternative the pumping well effluent would be discharged directly to surface water under existing or future discharge permits. No treatment would be used prior to discharge. Verification that the effluent could be discharged under current permits or application for and approval of a new permit would be required.

Implementation of a large-scale hydraulic containment system would require a detailed and lengthy design effort. Pilot testing, such as pumping tests and additional groundwater modeling will be needed to verify the hydraulic capture zone.

The pumping well effluent would be discharged directly to a receiving water body (i.e. the Ohio River) in accordance with a National Pollutant Discharge Elimination System (NPDES) Permit. No treatment

would be used prior to discharge. The construction of a transport system from the EAP to the receiving water body would require engineering design, permitting, and site construction. For the effluent to be discharged to a receiving water body, the existing FBC NPDES Permit may need to be modified or a new permit issued. Either option will require effluent testing or modeling to support a permit application. The anticipated timeline for permitting and construction of this option is one year.
Following the installation of the groundwater pumping well network, SIGECO would implement post-closure care activities that includes operation and maintenance of the hydraulic containment system, long-term groundwater sampling to monitor hydraulic control system performance, and cap and cover system maintenance.

4.3.7 Alternative 7 – Hydraulic Containment with Treatment and CBR

Similar to Alternative 5, the EAP would be closed by removal; however, under this alternative molybdenum detected at the boundary of the unit at concentrations above the GWPS would be addressed with hydraulic containment through groundwater pumping to hydraulically control the migration of those constituents downgradient. Pumping would be limited to the uppermost aquifer. Pumping well effluent would be treated ex-situ, likely with an ion exchange or a reverse osmosis (RO) treatment system. Both systems would have ongoing operation and maintenance and would generate a secondary waste stream – including regeneration/replacement of the ion exchange media or accumulation of reject water from the RO system.

The design and construction of an ion exchange or RO system would require additional development of a treatment system enclosure, equipment and space that adds complexity to this alternative. As noted in the previous option, implementation of a large-scale hydraulic containment system would require a detailed and lengthy design effort. Pilot testing, such as pumping tests and additional groundwater modeling, will be needed to verify the hydraulic capture zone.

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

4.3.8 Alternative 8 – In-Situ Treatment and CBR

Similar to Alternative 5, the EAP would be closed by removal; however, under this alternative molybdenum would be addressed through in-situ addition of groundwater treatment amendments downgradient of the EAP with the objective of accelerating the time required to achieve the GWPS within the treatment zone. Approvals and permitting would be required for the construction and installation of the treatment system and injection/application of amendments to the subsurface.

Implementation of an in-situ treatment system will require a detailed lengthy design effort with additional bench scale testing to verify groundwater treatment. The bench scale testing will evaluate the efficacy of treating molybdenum in-situ, while factoring in potential changes in groundwater geochemistry which may adversely affect the stability of other CCR-related constituents.

Following the installation of the in-situ treatment system, SIGECO would implement post-closure care activities that include periodic amendment injections or periodic replenishment of the treatment reagents within the treatment zone or reactive barrier, long-term groundwater sampling to monitor treatment system performance, and cover system maintenance.

5. Comparison of Corrective Measures Alternatives

The purpose of this section is to evaluate, compare, and rank the eight corrective measures alternatives 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.

Public input and feedback will be considered following a public information session to be conducted at least 30 days prior to remedy selection by SIGECO.

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 Rule which have been considered in this assessment. The goal of this analysis is to identify the alternative that is technologically feasible, relevant and readily implementable, provides adequate protection to human health and the environment, and minimizes impacts to the community.

A color-coded graphic which is part of a comprehensive visual comparison tool (see **Table 2**) is presented within each subsection below. These graphics provide a visual snapshot of the favorability of each alternative compared to the other alternatives, where green represents “most favorable”, yellow represents “less favorable”, and red represents “least favorable”.

5.2.1 Balancing Criterion 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 indicated by the N&E evaluation and the most recent groundwater sampling results, and the risk evaluation presented in Section 3, no unacceptable risk to human health and the environment exists with respect to the FBC EAP. Therefore, none of the remedial alternatives are necessary to reduce risks because no such unacceptable risk to molybdenum currently exists. However, other types of impacts may be posed by the various remedial alternatives considered herein. Alternatives 5 through 8 which all include closure by removal are considered the most favorable options because the source is completely removed from the environment. Alternatives 1 through 4 are considered less favorable because the source is left in place. Alternatives 3 and 7, which incorporate hydraulic containment and ex--situ treatment have the highest potential remediation risk due to the installation of pumping wells, construction of treatment systems, long-term operation and maintenance, and the generation of secondary waste streams.

	Alternative 1 MNA with ISS and CIP	**Alternative 2** HC with No Treatment, ISS and CIP	**Alternative 3** HC with Treatment, ISS and CIP	**Alternative 4** In-Situ Treatment, ISS and CIP
Category 1 - Subcriteria i) Magnitude of reduction of risks				

	Alternative 5 MNA with CBR	**Alternative 6** HC with No Treatment and CBR	**Alternative 7** HC with Treatment and CBR	**Alternative 8** In-Situ Treatment and CBR
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

All alternatives have equal magnitude of residual risks in terms of likelihood of further releases due to CCR remaining because full implementation of all of the remedies will result in meeting the GWPS (as a proxy for risk).

	Alternative 1 MNA with ISS and CIP	**Alternative 2** HC with No Treatment, ISS and CIP	**Alternative 3** HC with Treatment, ISS and CIP	**Alternative 4** In-Situ Treatment, ISS and CIP
Category 1 - Subcriteria ii) Magnitude of residual risk in terms of likelihood of further release				

	Alternative 5 MNA with CBR	**Alternative 6** HC with No Treatment and CBR	**Alternative 7** HC with Treatment and CBR	**Alternative 8** In-Situ Treatment and CBR
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

Alternative 5 (CBR with MNA) is the most favorable alternative with respect to this criterion because it requires the least amount of long-term management and involves no mechanical systems as part of the remedy. Alternative 1 (CIP with capping and MNA) is slightly less favorable because it requires maintenance of a cap and cover system. The remaining alternatives, which all include hydraulic containment or in-situ treatment require long-term O&M, and those alternatives that contain ex-situ treatment (Alternatives 3 and 7) are the least favorable due to the O&M of groundwater treatment systems and the generation of secondary waste streams.

	Alternative 1 MNA with ISS and CIP	**Alternative 2** HC with No Treatment, ISS and CIP	**Alternative 3** HC with Treatment, ISS and CIP	**Alternative 4** In-Situ Treatment, ISS and CIP
Category 1 - Subcriteria iii) Type and degree of long-term management required				

	Alternative 5 MNA with CBR	**Alternative 6** HC with No Treatment and CBR	**Alternative 7** HC with Treatment and CBR	**Alternative 8** In-Situ Treatment and CBR
Category 1 - Subcriteria iii) 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

Community impacts include general impacts to the community due to increased truck traffic on public roads during construction and operation of the remedies, along with generation of secondary waste streams with transportation and off-site disposal of waste streams. Because the volume of material that would need to be imported to cap and cover the EAP is not significantly different than the volume of CCR material in the EAP that would be excavated and disposed off-site the short-term risks associated with CIP and CBR are considered to be similar with little difference in truck traffic for all options.

	Alternative 1 MNA with ISS and CIP	**Alternative 2** HC with No Treatment, ISS and CIP	**Alternative 3** HC with Treatment, ISS and CIP	**Alternative 4** In-Situ Treatment, ISS and CIP
Category 1 - Subcriteria iv) Short term risk to community or environment during implementation				

	Alternative 5 MNA with CBR	**Alternative 6** HC with No Treatment and CBR	**Alternative 7** HC with Treatment and CBR	**Alternative 8** In-Situ Treatment and CBR
Category 1 - Subcriteria iv) Short term risk to community or environment during implementation				

5.2.1.5 Time until full protection is achieved

As previously stated, there is currently no unacceptable exposure to groundwater impacted by molybdenum associated with the EAP; therefore, protection is already achieved. The timeframes to achieve GWPS were evaluated using a predictive model as described above. Based upon predictive modeling, Alternatives 2, 3, 4, 6, 7 and 8, which include a groundwater pumping or in-situ remediation component are predicted to achieve the GWPS in the shortest amount of time. Closure by removal with MNA (Alternative 5) and closure in place (Alternative 1) with MNA are predicted to take slightly more time to achieve GWPS due to the longer period of time required for MNA to reduce molybdenum concentrations and are therefore less favorable.

	Alternative 1 MNA with ISS and CIP	**Alternative 2** HC with No Treatment, ISS and CIP	**Alternative 3** HC with Treatment, ISS and CIP	**Alternative 4** In-Situ Treatment, ISS and CIP
Category 1 - Subcriteria v) Time until full protection is achieved				

	Alternative 5 MNA with CBR	**Alternative 6** HC with No Treatment and CBR	**Alternative 7** HC with Treatment and CBR	**Alternative 8** In-Situ Treatment and CBR
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

Because the extent of groundwater impacted by the EAP is limited to the alluvial aquifer, Alternative 1 (CIP with MNA) has the lowest potential for exposure to human and environmental receptors and is considered most favorable with respect to this criteria. Alternative 4 which relies on in-situ treatment is slightly less favorable because it involves the construction of reactive barriers or injection systems however exposures to remaining wastes during construction are still quite low. Alternatives 5 through 8, which include excavation, transportation, and disposal of CCR material with off-site disposal have a potential risk for exposure to humans and environmental receptors due to construction and transportation. Alternative 7 that include hydraulic containment with ex-situ treatment also has a potential risk associated with the generation and management of secondary waste streams and is considered least favorable.

	Alternative 1 MNA with ISS and CIP	**Alternative 2** HC with No Treatment, ISS and CIP	**Alternative 3** HC with Treatment, ISS and CIP	**Alternative 4** In-Situ Treatment, ISS and CIP
Category 1 - Subcriteria vi) Potential for exposure of humans and environmental receptors to remaining wastes				

	Alternative 5 MNA with CBR	**Alternative 6** HC with No Treatment and CBR	**Alternative 7** HC with Treatment and CBR	**Alternative 8** In-Situ Treatment and CBR
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) is expected to have high long-term reliability and is considered most favorable with respect to this criteria. Alternative 1 (CIP with MNA) is considered slightly less reliable due to the long-term maintenance of the cap and cover system, however, is still quite reliable. Hydraulic containment (Alternatives 2, 3, 6 and 7) are considered reliable, proven technologies and would have high long-term reliability, but require field pilot studies and bench scale testing and rely on mechanical systems (groundwater pumping and/or treatment systems) to operate and maintain.

Alternatives 4 and 8 are considered least favorable with respect to this criteria because the treatment technology is unproven.

	Alternative 1 MNA with ISS and CIP	**Alternative 2** HC with No Treatment, ISS and CIP	**Alternative 3** HC with Treatment, ISS and CIP	**Alternative 4** In-Situ Treatment, ISS and CIP
Category 1 - Subcriteria vii) Long-term reliability of engineering and institutional controls				

	Alternative 5 MNA with CBR	**Alternative 6** HC with No Treatment and CBR	**Alternative 7** HC with Treatment and CBR	**Alternative 8** In-Situ Treatment and CBR
Category 1 - Subcriteria vii) Long-term reliability of engineering and institutional controls				

5.2.1.8 Potential need for replacement of the remedy

Alternative 5, which incorporates closure by removal with MNA is considered the remedy with the lowest likelihood of requiring replacement because source removal is permanent and natural processes will remedy groundwater. Alternative 1, which includes closure in-place with MNA is considered slightly less favorable since it relies on ISS and the cap and cover system to reduce infiltration and control the source and natural processes to reduce the concentrations of molybdenum in groundwater. Should monitoring results indicate that the selected remedial alternative is not effective at reducing the concentration of molybdenum over time, alternate and/or additional active remedial methods for groundwater may be considered in the future. From the perspective of needing to replace the remedy, the alternatives that rely on operating systems (Alternatives 2, 3, 4, 6, 7, and 8) are considered more likely to require replacement, with alternatives 4 and 8 being the most likely to be replaced due to the unproven nature of the in-situ treatment technology.

	Alternative 1 MNA with ISS and CIP	**Alternative 2** HC with No Treatment, ISS and CIP	**Alternative 3** HC with Treatment, ISS and CIP	**Alternative 4** In-Situ Treatment, ISS and CIP
Category 1 - Subcriteria viii) Potential need for replacement of the remedy				

	Alternative 5 MNA with CBR	**Alternative 6** HC with No Treatment and CBR	**Alternative 7** HC with Treatment and CBR	**Alternative 8** In-Situ Treatment and CBR
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 MNA with ISS and CIP	**Alternative 2** HC with No Treatment, ISS and CIP	**Alternative 3** HC with Treatment, ISS and CIP	**Alternative 4** In-Situ Treatment, ISS and CIP
CATEGORY 1 Long- and Short Term Effectiveness, Protectiveness, and Certainty of Success				

	Alternative 5 MNA with CBR	**Alternative 6** HC with No Treatment and CBR	**Alternative 7** HC with Treatment and CBR	**Alternative 8** In-Situ Treatment and CBR
CATEGORY 1 Long- and Short Term Effectiveness, Protectiveness, and Certainty of Success				

5.2.2 Balancing Criterion 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 degree of complexity of treatment technologies that would be required.

5.2.2.1 The extent to which containment practices will reduce further releases

Although Alternatives 5 through 8 do not include containment as part of the remedy, they are considered highly effective at reducing further releases because they all include source removal.

Alternatives 1 through 4 are considered less favorable in this sub-category because source material remains in place. Despite this ranking, the containment practices in Alternatives 1 through 4 are proven and are known to successfully contain releases.

	Alternative 1 MNA with ISS and CIP	**Alternative 2** HC with No Treatment, ISS and CIP	**Alternative 3** HC with Treatment, ISS and CIP	**Alternative 4** In-Situ Treatment, ISS and CIP
Category 2 - Subcriteria i) Extent to which containment practices will reduce further releases				

	Alternative 5 MNA with CBR	**Alternative 6** HC with No Treatment and CBR	**Alternative 7** HC with Treatment and CBR	**Alternative 8** In-Situ Treatment and CBR
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

In-situ groundwater treatment technologies have been identified that could successfully treat molybdenum in groundwater, but these in-situ treatment technologies are not proven and would require extensive treatability testing and field scale pilot testing and as a result are considered least favorable with respect to this comparative analysis. With respect to Alternatives 1 and 5, no groundwater treatment technologies, other than natural attenuation will be used. Alternatives 2 and 6 will rely on one technology (hydraulic containment) to address groundwater with the effluent being directly discharge elsewhere on the property. For Alternatives 3 and 7, which include hydraulic containment with ex-situ treatment, two technologies, hydraulic containment and ex-situ treatment, will be utilized. The operation of an ex-situ treatment system will create a secondary waste stream, such as concentrated reject water (from RO) requiring off-site disposal, or depleted resin (from ion exchange), requiring regeneration or off-site disposal.

	Alternative 1 MNA with ISS and CIP	**Alternative 2** HC with No Treatment, ISS and CIP	**Alternative 3** HC with Treatment, ISS and CIP	**Alternative 4** In-Situ Treatment, ISS and CIP
Category 2 - Subcriteria ii) Extent to which treatment technologies may be used				

	Alternative 5 MNA with CBR	**Alternative 6** HC with No Treatment and CBR	**Alternative 7** HC with Treatment and CBR	**Alternative 8** In-Situ Treatment and CBR
Category 2 - Subcriteria ii) 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.

	Alternative 1 MNA with ISS and CIP	**Alternative 2** HC with No Treatment, ISS and CIP	**Alternative 3** HC with Treatment, ISS and CIP	**Alternative 4** In-Situ Treatment, ISS and CIP
CATEGORY 2 Effectiveness in controlling the source to reduce further releases				

	Alternative 5 MNA with CBR	**Alternative 6** HC with No Treatment and CBR	**Alternative 7** HC with Treatment and CBR	**Alternative 8** In-Situ Treatment and CBR
CATEGORY 2 Effectiveness in controlling the source to reduce further releases				

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

This balancing criterion takes into consideration the following technical and logistical challenges required to implement a remedy:

1. Degree of difficulty associated with constructing the technology;
2. Expected operational reliability of the technologies;
3. Need to coordinate with and obtain necessary approvals and permits from other agencies;
4. Availability of necessary equipment and specialists; and
5. Available capacity and location of needed treatment, storage, and disposal services.

5.2.3.1 *Degree of difficulty associated with constructing the technology*

For Alternatives 1 and 5 (CIP and CBR with MNA), the concept is already proven and can be implemented in a reasonable timeframe (less than two years). Alternative 1 is considered slightly less favorable due to the need for targeted ISS to address CCR material below the water table. Alternatives 4 and 8, which rely on in-situ treatment that will require extensive treatability testing and field scale pilot testing are slightly more difficult to construct than Alternatives 1 and 5.

Alternatives 2, 3, 6, and 7, which all incorporate hydraulic containment, will be more difficult to construct and will require additional treatability testing, field scale pilot studies, and permitting, with Alternatives 3 and 7 being the most difficult due to the O&M of ex-situ treatment systems.

	Alternative 1 MNA with ISS and CIP	**Alternative 2** HC with No Treatment, ISS and CIP	**Alternative 3** HC with Treatment, ISS and CIP	**Alternative 4** In-Situ Treatment, ISS and CIP
Category 3 - Subcriteria i) Degree of difficulty associated with constructing the technology				

	Alternative 5 MNA with CBR	**Alternative 6** HC with No Treatment and CBR	**Alternative 7** HC with Treatment and CBR	**Alternative 8** In-Situ Treatment and CBR
Category 3 - Subcriteria i) Degree of difficulty associated with constructing the technology				

5.2.3.2 *Expected operational reliability of the technologies*

Alternative 5 (CBR with MNA) is considered the most favorable from an operational perspective because removal of the source followed by MNA has a proven track record and only requires long-term monitoring following implementation. Alternative 1 (CIP with MNA) is considered slightly less favorable because it relies on construction and long-term maintenance of the cap and cover system to control the source. While Alternatives 2, 3, 6, and 7, which include hydraulic containment, are also expected to be reliable, these alternatives will utilize additional groundwater treatment technologies which will require treatability studies and operations and maintenance and therefore are considered the less favorable when compared to the other alternatives. The in-situ treatment alternatives (Alternatives 4 and 8) are considered least favorable with respect to this criteria due to the less-proven nature of this technology.

	Alternative 1 MNA with ISS and CIP	**Alternative 2** HC with No Treatment, ISS and CIP	**Alternative 3** HC with Treatment, ISS and CIP	**Alternative 4** In-Situ Treatment, ISS and CIP
Category 3 - Subcriteria ii) Expected operational reliability of the technologies				

	Alternative 5 MNA with CBR	**Alternative 6** HC with No Treatment and CBR	**Alternative 7** HC with Treatment and CBR	**Alternative 8** In-Situ Treatment and CBR
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 5 (CBR with MNA) is the most favorable since the implementation of the remedy is straightforward, generally consistent with other construction at the facility (that has been successfully permitted) and only includes MNA. The remaining alternatives will require additional permitting and approvals for treatability testing, field scale pilot testing, groundwater discharge, groundwater treatment, and/or disposal of secondary waste streams. Alternatives 1 through 4, which all include CIP with ISS, are considered the least favorable due to CCR materials remaining beneath the water table, which may require more extensive approvals and permitting.

	Alternative 1 MNA with ISS and CIP	**Alternative 2** HC with No Treatment, ISS and CIP	**Alternative 3** HC with Treatment, ISS and CIP	**Alternative 4** In-Situ Treatment, ISS and CIP
Category 3 - Subcriteria iii) Need to coordinate with and obtain necessary approvals and permits from other agencies				

	Alternative 5 MNA with CBR	**Alternative 6** HC with No Treatment and CBR	**Alternative 7** HC with Treatment and CBR	**Alternative 8** In-Situ Treatment and CBR
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 5 (CBR with MNA) is the most favorable since specialty equipment and specialists will not be required to implement the MNA remedy and the size of the construction project is relatively small. Alternatives 1 through 4 require some specialized equipment to undertake ISS. Alternatives 2 and 6 will require equipment for drilling, recovery well installation, and construction of groundwater conveyance systems and are less favorable than Alternatives 1 and 5 but equipment required should not present a great challenge. Alternatives 3 and 7 which include an ex-situ treatment component are less favorable since they will require construction, operation, and maintenance of ex-situ treatment systems. Alternatives 4 and 8, which incorporate in-situ groundwater treatment, will require extensive treatability testing, field scale pilot testing, and specialty laboratory and contractor support and are therefore considered least favorable.

	Alternative 1 MNA with ISS and CIP	**Alternative 2** HC with No Treatment, ISS and CIP	**Alternative 3** HC with Treatment, ISS and CIP	**Alternative 4** In-Situ Treatment, ISS and CIP
Category 3 - Subcriteria iv) Availability of necessary equipment and specialists				

	Alternative 5 MNA with CBR	**Alternative 6** HC with No Treatment and CBR	**Alternative 7** HC with Treatment and CBR	**Alternative 8** In-Situ Treatment and CBR
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*

Alternatives 5 through 8, which include closure by removal, require adequate capacity, storage, and disposal service for off-site receiving facilities. The relatively small size of the EAP should not adversely impact closure by removal with respect to this criteria.

Except for Alternatives 3 and 7, which include hydraulic containment with ex-situ treatment the remaining alternatives would not generate a waste stream and therefore would not require treatment, storage, or disposal services. For Alternatives 3 and 7, the ex-situ treatment system may generate a concentrated waste stream which would require off-site transportation and disposal that the other alternatives would not require and are therefore considered the least favorable.

	Alternative 1 MNA with ISS and CIP	**Alternative 2** HC with No Treatment, ISS and CIP	**Alternative 3** HC with Treatment, ISS and CIP	**Alternative 4** In-Situ Treatment, ISS and CIP
Category 3 - Subcriteria v) Available capacity and location of needed treatment, storage, and disposal services				

	Alternative 5 MNA with CBR	**Alternative 6** HC with No Treatment and CBR	**Alternative 7** HC with Treatment and CBR	**Alternative 8** In-Situ Treatment and CBR
Category 3 - Subcriteria v) Available capacity and location of needed treatment, storage, and disposal services				

5.2.3.6 *Ease or difficulty of implementation summary*

The graphic below provides a summary of the ease or difficulty that will be needed to implement each alternative. Alternative 1 (CIP with capping and MNA) and Alternative 4 (CBR with MNA) are considered the most favorable, while the remaining alternatives that include a hydraulic containment component or in-situ treatment are considered less favorable.

	Alternative 1 MNA with ISS and CIP	**Alternative 2** HC with No Treatment, ISS and CIP	**Alternative 3** HC with Treatment, ISS and CIP	**Alternative 4** In-Situ Treatment, ISS and CIP
CATEGORY 3 Ease of implementation				

	Alternative 5 MNA with CBR	**Alternative 6** HC with No Treatment and CBR	**Alternative 7** HC with Treatment and CBR	**Alternative 8** In-Situ Treatment and CBR
CATEGORY 3 Ease of implementation				

6. Summary

This Corrective Measures Assessment has evaluated the following alternatives:

- Alternative 1: MNA with ISS and CIP;
- Alternative 2: Hydraulic Containment with No Treatment, ISS and CIP;
- Alternative 3: Hydraulic Containment with Treatment, ISS and CIP;
- Alternative 4: In-Situ Groundwater Treatment, ISS and CIP;
- Alternative 5: MNA with CBR;
- Alternative 6: Hydraulic Containment with No Treatment and CBR;
- Alternative 7: Hydraulic Containment with Treatment and CBR; and
- Alternative 8: In-Situ Treatment Groundwater Treatment and CBR.

In accordance with §257.97, each of these alternatives has been confirmed to meet 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:

- 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;
- The effectiveness of the remedy in controlling the source to reduce further releases;
- The ease or difficulty of implementing a potential remedy; and
- The degree to which community concerns are addressed by a potential remedy.

This Corrective Measures Assessment, and the input received during the public comment period, will be used to identify and select a final corrective measure for implementation at the EAP.

References

1. 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

2. USEPA. 2015b. Use of Monitored Natural Attenuation for Inorganic Contaminants in Groundwater at Superfund Sites.

3. 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

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TABLES

TABLE 1A
ASSESSMENT MONITORING GROUNDWATER ANALYTICAL RESULTS - APPENDIX IV CONSTITUENTS
CORRECTIVE MEASURES ASSESSMENT
F.B. CULLEY GENERATING STATION - EAST ASH POND

Location Name	Groundwater	CCR-AP-2	CCR-AP-2	CCR-AP-2	CCR-AP-2	CCR-AP-2	CCR-AP-2	CCR-AP-2	CCR-AP-2	CCR-AP-2	CCR-AP-2	CCR-AP-2	CCR-AP-2	CCR-AP-2	CCR-AP-3	CCR-AP-3	CCR-AP-3
Sample Name	Protection	CCR-AP-2-20160610	CCR-AP-2-20160812	CCR-AP-2-20161028	CCR-AP-2-20161207	CCR-AP-2-20170208	CCR-AP-2-20170406	CCR-AP-2-20170607	CCR-AP-2-20170928	CCR-AP-2-20171117	CCR-AP-2-20180611	CCR-AP-2-20180828	CCR-AP-2-20181115	CCR-AP-2-20190528	CCR-AP-3-20160610	CCR-AP-3-20160815	CCR-AP-3-20161028
Sample Date	Standard	06/10/2016	08/12/2016	10/28/2016	12/07/2016	02/08/2017	04/06/2017	06/07/2017	09/28/2017	11/17/2017	06/11/2018	08/28/2018	11/15/2018	05/28/2019	06/10/2016	08/15/2016	10/28/2016
Appendix IV Constituents (mg/L)																	
Antimony, Total	0.006	**0.002**	0.002 U	0.002 U	**0.00024 J**	0.002 U	0.002 U	0.002 U	**0.0017 J**	0.01 U	0.002 U	0.02 U	0.002 U	**0.0011 J**	0.002 U	0.002 U	0.002 U
Arsenic, Total	0.01	**0.0018**	**0.0016**	**0.0044**	**0.003**	**0.0035**	**0.0018**	**0.0066**	**0.017**	**0.0066**	**0.013**	**0.021**	**0.0012**	**0.032**	**0.058**	**0.072**	**0.071**
Barium, Total	2	**0.055**	**0.038**	**0.09**	**0.14**	**0.12**	**0.052**	**0.27**	**0.44**	**0.17**	**0.27**	**0.52**	**0.043 B**	**0.26**	**0.41**	**0.38**	**0.4**
Beryllium, Total	0.004	**0.00014 J**	**0.00015 J**	**0.00066 J**	**0.00056 J**	**0.00038 J**	**0.00032 J**	**0.00099 J**	**0.0027**	**0.0012 J**	**0.0021**	**0.002 J**	0.001 U	**0.0021**	0.001 U	0.001 U	0.001 U
Cadmium, Total	0.005	**0.00055 J**	**0.00023 J**	**0.00053 J**	**0.00048 J**	**0.00038 J**	**0.00011 J**	**0.00078 J**	**0.00073 J**	0.005 U	**0.00089 J**	0.01 U	**0.00015 J**	**0.0023**	0.001 U	0.001 U	0.001 U
Chromium, Total	0.1	**0.0035**	**0.003**	**0.013**	**0.011**	**0.0084**	**0.0037**	**0.025**	**0.056**	**0.021**	**0.042**	**0.082**	**0.0019 J**	**0.052**	**0.0021**	**0.0018 J**	**0.002**
Cobalt, Total	0.006	**0.0073**	**0.0096**	**0.016 J**	**0.012**	**0.014**	**0.011**	**0.021**	**0.038**	**0.018**	**0.023**	**0.029**	**0.0084**	**0.026**	**0.0094**	**0.008**	**0.0076 J**
Fluoride	4	**0.16 J+**	**0.28**	**0.23**	**0.3 J+**	**0.26 J+**	**0.29**	**0.3 J**	**0.28**	**0.11**	**0.28**	**0.25**	**0.32**	**0.4 J+**	0.1 U	**0.93**	**0.31**
Lead, Total	0.015	**0.0023**	**0.0028**	**0.0096 J**	**0.006**	**0.0057**	**0.0026 J+**	**0.016**	**0.051**	**0.012**	**0.03**	**0.035**	**0.00053 J**	**0.038**	**0.00041 J**	**0.00039 J**	0.001 UJ
Lithium, Total	0.04	0.05 U	0.05 U	**0.017 J**	0.05 U	**0.01 J**	0.05 U	**0.023 J**	**0.023 J**	0.25 U	**0.033**	**0.057**	0.005 U	**0.031**	0.05 U	0.05 U	0.05 U
Mercury, Total	0.002	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	-	0.0002 U	**0.00038**	0.0002 U	0.0002 U	0.0002 U
Molybdenum, Total	0.1	**0.0018 J**	**0.00099 J**	**0.0014 J**	**0.0015 J**	**0.0017 J**	**0.00094 J**	**0.0024 J**	**0.0051**	**0.004 J**	**0.003 J**	**0.0056 J**	**0.00091 J**	**0.0078**	**0.011**	**0.014**	**0.014**
Selenium, Total	0.05	**0.00044 J**	**0.00076 J**	**0.0013 J**	0.005 U	0.005 U	0.005 UJ	0.005 U	**0.0044 J**	0.025 U	**0.0026 J**	0.05 U	0.005 U	**0.0065**	**0.0015 J**	**0.00062 J**	**0.0018 J**
Thallium, Total	0.002	**0.000048 J**	**0.000048 J**	**0.00014 J**	**0.00016 J**	**0.00017 J**	0.001 U	**0.00026 J**	**0.00068 J**	**0.00079 J**	**0.00048 J**	**0.00099 J**	0.001 U	**0.0009 J**	0.001 U	0.001 U	0.001 U
Radiological (pCi/L)																	
Radium-226	NA	**0.222 J ± 0.145**	**1.22 ± 0.355**	**0.731 ± 0.526**	**2.01 ± 1.16**	**0.672 ± 0.334**	**1.03 ± 0.385**	**0.894 ± 0.361**	**0.730 ± 0.327**	**0.266 ± 0.151**	**0.597 ± 0.32**	R	-	**2.57 ± 0.584**	**0.657 J ± 0.201**	**0.865 ± 0.232**	**1.15 ± 0.477**
Radium-228	NA	0.542 U ± 0.572	1.09 U ± 1.02	0.648 U ± 0.534	0.707 U ± 1.12	**1.00 ± 0.596**	**1.44 ± 0.934**	**2.40 ± 1.07**	1.18 U ± 1.06	0.585 U ± 0.5	0.294 U ± 0.337	**0.880 ± 0.51**	-	2.81 U ± 1.93	**1.10 ± 0.581**	0.784 U ± 0.583	**0.819 ± 0.347**
Radium-226 & 228	5	0.764 U ± 0.59	**2.32 ± 1.08**	**1.38 J ± 0.75**	**2.72 J ± 1.61**	**1.68 ± 0.684**	**2.47 J ± 1.01**	**3.29 ± 1.13**	**1.91 J+ ± 1.11**	**0.850 J+ ± 0.522**	**0.891 J ± 0.465**	R	-	**5.38 J ± 2.02**	**1.75 ± 0.615**	**1.65 ± 0.627**	**1.97 ± 0.589**

ABBREVIATIONS AND NOTES:

Statistically significant level (SSL) concentration.
CCR: Coal Combustion Residuals.
mg/L: milligram per liter.
pCi/L: picoCurie per liter.
su: standard units.
USEPA: United States Environmenta.l Protection Agency
J: Value is estimated
J-: Value is estimated, biased low
J+: Value is estimated, biased high
R: Rejected during validation
U: Not detected, value is the laboratory reporting limit

- USEPA. 2016. Final Rule: Disposal of Coal Combustion Residuals from Electric Utilities. July 26. 40 CFR Part 257. https://www.epa.gov/coalash/coal-ash-rule

TABLE 1A
ASSESSMENT MONITORING GROUNDWATER ANALYTICAL RESULTS - APPENDIX IV CONSTITUENTS
CORRECTIVE MEASURES ASSESSMENT
F.B. CULLEY GENERATING STATION - EAST ASH POND

Location Name Sample Name Sample Date	Groundwater Protection Standard	CCR-AP-3 CCR-AP-3-20161207 12/07/2016	CCR-AP-3 CCR-AP-3-20170208 02/08/2017	CCR-AP-3 CCR-AP-3-20170406 04/06/2017	CCR-AP-3 CCR-AP-3-20170607 06/07/2017	CCR-AP-3 CCR-AP-3-20170928 09/28/2017	CCR-AP-3 CCR-AP-3-20171117 11/17/2017	CCR-AP-3 CCR-AP-3-20180611 06/11/2018
Appendix IV Constituents (mg/L)								
Antimony, Total	0.006	**0.00031 J**	0.002 U	0.002 U	0.002 U	**0.00058 J**	0.002 U	0.002 U
Arsenic, Total	0.01	**0.068**	**0.086**	**0.08**	**0.077**	**0.066**	**0.067**	**0.08**
Barium, Total	2	**0.43**	**0.46**	**0.42**	**0.44**	**0.39**	**0.4**	**0.47**
Beryllium, Total	0.004	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
Cadmium, Total	0.005	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
Chromium, Total	0.1	**0.0023**	**0.002**	**0.0021**	0.002 U	0.002 U	**0.0021**	**0.0041 J+**
Cobalt, Total	0.006	**0.007**	**0.0072**	**0.0063**	**0.0062**	**0.0057**	**0.0056**	**0.0052**
Fluoride	4	**0.5**	**0.39**	**0.57**	**0.55**	**0.45**	**0.14**	**0.56**
Lead, Total	0.015	**0.00066 J**	**0.00035 J**	**0.00048 J+**	0.001 U	**0.00098 J**	**0.00051 J**	**0.00092 J**
Lithium, Total	0.04	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.005 U
Mercury, Total	0.002	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U
Molybdenum, Total	0.1	**0.014**	**0.013**	**0.011**	**0.012**	**0.01**	**0.011**	**0.0099**
Selenium, Total	0.05	**0.0019 J**	**0.002 J**	**0.0018 J-**	**0.0018 J**	**0.0016 J**	**0.0017 J**	**0.0023 J**
Thallium, Total	0.002	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	**0.0001 J**	0.001 U
Radiological (pCi/L)								
Radium-226	NA	**0.789 ± 0.398**	0.373 U ± 0.293	**0.450 ± 0.144**	**0.582 ± 0.158**	**0.411 ± 0.136**	**0.626 ± 0.162**	**0.475 ± 0.329**
Radium-228	NA	**0.932 ± 0.48**	0.489 U ± 0.614	**0.644 ± 0.344**	**1.25 ± 0.427**	R	R	0.292 U ± 0.375
Radium-226 & 228	5	**1.72 ± 0.623**	0.862 U ± 0.68	**1.09 ± 0.373**	**1.83 ± 0.456**	R	R	**0.768 J ± 0.499**

Location Name Sample Name Sample Date	CCR-AP-3 CCR-AP-3-20180828 08/28/2018	CCR-AP-3 CCR-AP-3-20181116 11/16/2018	CCR-AP-3R CCR-AP-3R-20190528 05/28/2019	CCR-AP-4 CCR-AP-4-20160610 06/10/2016	CCR-AP-4 CCR-AP-4-20160812 08/12/2016	CCR-AP-4 CCR-AP-4-20161028 10/28/2016	CCR-AP-4 CCR-AP-4-20161207 12/07/2016	CCR-AP-4 CCR-AP-4-20170208 02/08/2017	CCR-AP-4 CCR-AP-4-20170406 04/06/2017
Appendix IV Constituents (mg/L)									
Antimony, Total	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U	**0.0004 J**	0.002 U	0.002 U
Arsenic, Total	**0.071**	**0.076**	**0.077**	**0.036**	**0.065**	**0.05**	**0.045**	**0.086**	**0.086**
Barium, Total	**0.43**	**0.45**	**0.44**	**0.52**	**0.75**	**0.63**	**0.61**	**0.64**	**0.63**
Beryllium, Total	0.001 U	0.001 U	0.001 U	**0.00049 J**	**0.00033 J**	**0.00025 J**	**0.00046 J**	**0.00014 J**	**0.00015 J**
Cadmium, Total	0.001 U	0.001 U	0.001 U	**0.00018 J**	**0.00018 J**	0.001 U	**0.00023 J**	0.001 U	0.001 U
Chromium, Total	**0.0041 J+**	**0.0029**	0.002 U	**0.012**	**0.0081**	**0.0037**	**0.014**	**0.0026**	**0.0028**
Cobalt, Total	**0.0046**	**0.0055**	**0.0054**	**0.0078**	**0.0071**	**0.0045 J**	**0.0086**	**0.0039**	**0.0045**
Fluoride	**0.33**	**0.37**	**0.53 J+**	**0.29 J+**	**0.43**	**0.3**	**0.49**	**0.32 J+**	**0.36**
Lead, Total	**0.00078 J**	**0.00018 J**	**0.00033 J**	**0.0099**	**0.0063**	**0.0057 J**	**0.011**	**0.0018**	**0.0018 J+**
Lithium, Total	0.005 U	0.005 U	0.005 U	**0.01 J**	**0.0096 J**	**0.014 J**	**0.0098 J**	0.05 U	0.05 U
Mercury, Total	-	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0004 U	0.0002 U	0.0002 U	0.0002 U
Molybdenum, Total	**0.0096**	**0.01**	**0.0099**	**0.0022 J**	**0.0025 J**	**0.0011 J**	**0.002 J**	**0.00093 J**	**0.00092 J**
Selenium, Total	**0.0021 J**	**0.0021 J**	0.005 U	**0.0018 J**	**0.0016 J**	**0.0011 J**	**0.00098 J**	0.005 U	0.005 UJ
Thallium, Total	0.001 U	0.001 U	0.001 U	**0.000084 J**	**0.000061 J**	**0.00011 J**	**0.00015 J**	**0.000063 J**	0.001 U
Radiological (pCi/L)									
Radium-226	R	-	**0.404 ± 0.159**	**1.07 J ± 0.261**	**1.53 ± 0.429**	**1.54 ± 0.683**	**2.11 ± 1.11**	**0.984 ± 0.383**	**0.789 ± 0.227**
Radium-228	**0.946 ± 0.416**	-	**1.83 ± 1.11**	0.417 U ± 0.723	1.37 U ± 1.43	**0.864 ± 0.448**	**2.17 ± 1.34**	**1.03 ± 0.62**	0.370 U ± 0.488
Radium-226 & 228	**1.70 J+ ± 0.463**	-	**2.24 ± 1.12**	**1.49 ± 0.769**	**2.90 ± 1.49**	**2.40 ± 0.816**	**4.28 ± 1.74**	**2.01 ± 0.728**	**1.16 J ± 0.538**

ABBREVIATIONS AND NOTES:

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CCR: Coal Combustion Residuals.
mg/L: milligram per liter.
pCi/L: picoCurie per liter.
su: standard units.
USEPA: United States Environmenta.l Protection Agency
J: Value is estimated
J-: Value is estimated, biased low
J+: Value is estimated, biased high
R: Rejected during validation
U: Not detected, value is the laboratory reporting limit

- USEPA. 2016. Final Rule: Disposal of Coal Combustion Residuals from Electric Utilities. July 26. 40 CFR Part 257. https://www.epa.gov/coalash/coal-ash-rule

TABLE 1A
ASSESSMENT MONITORING GROUNDWATER ANALYTICAL RESULTS - APPENDIX IV CONSTITUENTS
CORRECTIVE MEASURES ASSESSMENT
F.B. CULLEY GENERATING STATION - EAST ASH POND

Location Name	Groundwater	CCR-AP-4	CCR-AP-4	CCR-AP-4	CCR-AP-4	CCR-AP-4	CCR-AP-4	CCR-AP-4R
Sample Name	Protection	CCR-AP-4-20170608	CCR-AP-4-20170929	CCR-AP-4-20171117	CCR-AP-4-20180611	CCR-AP-4-20180828	CCR-AP-4-20181115	CCR-AP-4R-20190528
Sample Date	Standard	06/08/2017	09/29/2017	11/17/2017	06/11/2018	08/28/2018	11/15/2018	05/28/2019
Appendix IV Constituents (mg/L)								
Antimony, Total	0.006	0.002 U	**0.00066 J**	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U
Arsenic, Total	0.01	**0.086**	**0.081**	**0.083**	**0.027**	**0.11**	**0.088**	**0.11**
Barium, Total	2	**0.66**	**0.58**	**0.57**	**0.45**	**0.78**	**0.58**	**0.66**
Beryllium, Total	0.004	**0.00026 J**	**0.00017 J**	**0.00028 J**	0.001 U	**0.00084 J**	**0.00018 J**	0.001 U
Cadmium, Total	0.005	**0.00014 J**	**0.00016 J**	0.001 U	0.001 U	**0.00048 J**	0.001 U	0.001 U
Chromium, Total	0.1	**0.0066**	**0.0076**	**0.01**	R	**0.028**	**0.0062**	0.0034 U
Cobalt, Total	0.006	**0.0068**	**0.0055**	**0.0064**	**0.002**	**0.013**	**0.003**	**0.0031**
Fluoride	4	**0.46**	**0.35**	**0.35**	**0.41**	**0.29**	**0.34**	**0.37 J+**
Lead, Total	0.015	**0.0045**	**0.0048**	**0.0046**	**0.00052 J**	**0.021**	**0.0029**	**0.0043**
Lithium, Total	0.04	0.05 U	0.05 U	0.05 U	**0.0029 J**	**0.019**	**0.0062**	**0.0041 J**
Mercury, Total	0.002	0.0002 U	0.0002 U	0.0002 U	0.0002 U	-	0.0002 U	0.0002 U
Molybdenum, Total	0.1	**0.0014 J**	**0.0016 J**	**0.0022 J**	**0.0012 J**	**0.0033 J**	**0.00076 J**	**0.0011 J**
Selenium, Total	0.05	0.005 U	0.005 U	0.005 U	**0.0009 J**	**0.0016 J**	**0.0011 J**	0.005 U
Thallium, Total	0.002	**0.000061 J**	0.001 U	**0.00012 J**	0.001 U	**0.00026 J**	0.001 U	0.001 U
Radiological (pCi/L)								
Radium-226	NA	**1.60 ± 0.408**	**1.26 ± 0.397**	**1.15 ± 0.266**	**0.830 ± 0.366**	**2.47 ± 0.635**	-	**0.846 ± 0.224**
Radium-228	NA	**2.00 ± 0.818**	R	R	0.458 U ± 0.313	1.06 U ± 0.934	-	**1.54 ± 0.735**
Radium-226 & 228	5	**3.60 ± 0.914**	R	R	**1.29 J ± 0.482**	**3.53 J ± 1.13**	-	**2.38 ± 0.768**

Location Name	CCR-AP-5	CCR-AP-5	CCR-AP-5	CCR-AP-5	CCR-AP-5	CCR-AP-5	CCR-AP-5	CCR-AP-5	CCR-AP-5	CCR-AP-5
Sample Name	CCR-AP-5-20160610	BLIND DUPLICATE-20160610	CCR-AP-5-20160812	DUP-20160812	CCR-AP-5-20161028	DUP-20161028	CCR-AP-5-20161207	DUP-20161207	CCR-AP-5-20170208	
Sample Date	06/10/2016	06/10/2016	08/12/2016	08/12/2016	10/28/2016	10/28/2016	12/07/2016	12/07/2016	02/08/2017	
Appendix IV Constituents (mg/L)										
Antimony, Total	0.02 U	0.02 U	0.002 U	0.002 U	0.002 U	0.002 U	**0.000058 J**	0.002 U	0.002 U	
Arsenic, Total	0.01 U	0.01 U	**0.00059 J**	**0.00078 J**	**0.00065 J**	**0.0008 J**	**0.00073 J**	**0.00073 J**	**0.0015**	
Barium, Total	**0.032 J**	**0.039 J**	**0.03**	**0.03**	**0.034**	**0.034**	**0.036**	**0.036**	**0.046**	
Beryllium, Total	0.01 U	0.01 U	0.001 U	0.001 U	0.001 U	0.001 U	**0.00096 J**	**0.00077 J**	**0.00019 J**	
Cadmium, Total	0.01 U	0.01 U	**0.00016 J**	**0.00019 J**	**0.00015 J**	**0.00016 J**	0.001 U	**0.00016 J**	**0.0012**	
Chromium, Total	0.02 U	0.02 U	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U	
Cobalt, Total	**0.0069**	**0.0081**	**0.0063**	**0.0061**	**0.0065 J**	**0.0066 J**	**0.0061**	**0.0058**	**0.007**	
Fluoride	**0.58**	**0.5**	**0.99**	**0.92**	**1.1**	**1.1**	**1.3**	**1.3**	**0.98**	
Lead, Total	0.01 U	0.01 U	0.001 U	0.001 U	0.001 UJ	0.001 UJ	0.001 U	0.001 U	0.001 U	
Lithium, Total	**0.14**	**0.14**	**0.13**	**0.13**	**0.15**	**0.15**	**0.13**	**0.13**	**0.15**	
Mercury, Total	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	
Molybdenum, Total	**0.38**	**0.45**	**0.37**	**0.37**	**0.41**	**0.42**	**0.39**	**0.38**	**0.39**	
Selenium, Total	0.05 U	0.05 U	0.005 U	0.005 U	0.005 U	**0.0007 J**	0.005 U	0.005 U	0.005 U	
Thallium, Total	0.01 U	0.01 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	**0.000065 J**	
Radiological (pCi/L)										
Radium-226	**0.224 J ± 0.0858**	**0.176 J ± 0.0741**	0.106 U ± 0.0753	**0.230 ± 0.0858**	0.449 U ± 0.338	0.398 U ± 0.331	0.0176 U ± 0.286	**0.683 ± 0.42**	0.0782 U ± 0.217	
Radium-228	**0.550 ± 0.3**	**0.634 ± 0.33**	**0.523 ± 0.33**	**0.748 J ± 0.388**	0.462 U ± 0.35	**0.557 ± 0.349**	**0.714 ± 0.438**	0.618 U ± 0.487	0.562 U ± 0.517	
Radium-226 & 228	**0.774 ± 0.313**	**0.810 ± 0.338**	**0.629 ± 0.338**	**0.978 J ± 0.397**	**0.911 ± 0.486**	**0.955 J ± 0.481**	**0.732 J ± 0.524**	**1.30 J ± 0.643**	0.640 U ± 0.561	

ABBREVIATIONS AND NOTES:

Statistically significant level (SSL) concentration.
CCR: Coal Combustion Residuals.
mg/L: milligram per liter.
pCi/L: picoCurie per liter.
su: standard units.
USEPA: United States Environmenta.l Protection Agency
J: Value is estimated
J-: Value is estimated, biased low
J+: Value is estimated, biased high
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TABLE 1A
ASSESSMENT MONITORING GROUNDWATER ANALYTICAL RESULTS - APPENDIX IV CONSTITUENTS
CORRECTIVE MEASURES ASSESSMENT
F.B. CULLEY GENERATING STATION - EAST ASH POND

Location Name Sample Name Sample Date	Groundwater Protection Standard	CCR-AP-5 DUP-20170208 02/08/2017	CCR-AP-5 CCR-AP-5-20170407 04/07/2017	CCR-AP-5 DUP-20170407 04/07/2017	CCR-AP-5 CCR-AP-5-20170608 06/08/2017	CCR-AP-5 DUP1-20170608 06/08/2017	CCR-AP-5 CCR-AP-5-20170928 09/28/2017	CCR-AP-5 DUP1-20170928 09/28/2017
Appendix IV Constituents (mg/L)								
Antimony, Total	0.006	0.002 U	0.002 U	**0.00082 J**	0.002 U	0.002 U	0.002 U	0.002 U
Arsenic, Total	0.01	**0.0018**	**0.00039 J**	**0.00047 J**	**0.00042 J**	**0.00038 J**	**0.00084 J**	**0.0009 J**
Barium, Total	2	**0.048**	**0.034**	**0.035**	**0.036**	**0.035**	**0.041**	**0.041**
Beryllium, Total	0.004	**0.00014 J**	**0.00058 J**	**0.00068 J**	**0.00017 J**	**0.00017 J**	**0.00047 J**	**0.00046 J**
Cadmium, Total	0.005	**0.001**	**0.0004 J**	**0.00042 J**	**0.00037 J**	**0.00044 J**	**0.00075 J**	**0.00081 J**
Chromium, Total	0.1	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U
Cobalt, Total	0.006	**0.0066**	**0.0063**	**0.0064**	**0.0053**	**0.0054**	**0.0041**	**0.0047**
Fluoride	4	**1.2**	**0.96**	**1**	**1.1**	**1.1**	**0.76 J**	**0.49 J**
Lead, Total	0.015	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
Lithium, Total	0.04	**0.15**	**0.15**	**0.14**	**0.11**	**0.11**	**0.099**	**0.099**
Mercury, Total	0.002	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U
Molybdenum, Total	0.1	**0.39**	**0.33**	**0.33**	**0.3**	**0.3**	**0.21**	**0.22**
Selenium, Total	0.05	0.005 U	0.005 UJ	0.005 UJ	0.005 U	0.005 U	0.005 U	0.005 U
Thallium, Total	0.002	**0.000056 J**	0.001 U	0.001 U	0.001 U	**0.000056 J**	**0.00016 J**	**0.00017 J**
Radiological (pCi/L)								
Radium-226	NA	-0.0195 U ± 0.206	**0.186 ± 0.0813**	**0.123 ± 0.0744**	**0.193 ± 0.0924**	**0.143 ± 0.0878**	**0.184 ± 0.0749**	**0.150 ± 0.0692**
Radium-228	NA	0.452 U ± 0.496	0.209 U ± 0.227	0.0557 U ± 0.211	**1.01 ± 0.357**	**0.578 ± 0.317**	R	-0.0776 UJ ± 0.182
Radium-226 & 228	5	0.452 U ± 0.537	**0.396 J ± 0.241**	0.179 UJ ± 0.224	**1.21 ± 0.369**	**0.721 ± 0.329**	R	0.15 UJ ± 0.195

Location Name Sample Name Sample Date	CCR-AP-5 CCR-AP-5-20171117 11/17/2017	CCR-AP-5 DUP-20171117 11/17/2017	CCR-AP-5 CCR-AP-5-20180611 06/11/2018	CCR-AP-5 BLIND DUPLICATE-20180611 06/11/2018	CCR-AP-5 CCR-AP-5-20180828 08/28/2018	CCR-AP-5 BLIND DUP-20180828 08/28/2018	CCR-AP-5 CCR-AP-5-20181115 11/15/2018	CCR-AP-5 CCR-AP-5-20181217 12/17/2018	CCR-AP-5 CCR-AP-5-20190528 05/28/2019
Appendix IV Constituents (mg/L)									
Antimony, Total	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U
Arsenic, Total	**0.00039 J**	**0.0005 J**	R	R	0.001 U	**0.00082 J**	**0.0027**	**0.0014**	**0.0011**
Barium, Total	**0.038**	**0.04**	**0.068**	**0.073**	**0.033**	**0.034**	**0.05**	**0.08**	**0.04**
Beryllium, Total	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	**0.000081 J**	0.001 U	0.001 U
Cadmium, Total	**0.00035 J**	**0.00036 J**	**0.00057 J**	**0.0006 J**	**0.00024 J**	**0.00027 J**	**0.00023 J**	**0.00077 J**	**0.00051 J**
Chromium, Total	0.002 U	0.002 U	0.0014 U	R	0.002 U	0.0033 U	**0.0041**	**0.00067 J**	0.0027 U
Cobalt, Total	**0.0046**	**0.0049**	**0.0028**	**0.0033**	**0.0028**	**0.0036**	**0.00052**	**0.00071**	**0.0031**
Fluoride	**1**	**0.9**	**1.4**	**1.5**	**1.3**	**1.3**	**1.4**	**1.1**	**1.2 J+**
Lead, Total	0.001 U	0.001 U	**0.000099 J**	**0.000096 J**	0.001 U	0.001 U	**0.0016**	**0.00021 J**	**0.0011**
Lithium, Total	**0.12**	**0.12**	**0.11**	**0.096**	**0.094**	**0.098**	**0.0085**	**0.067**	**0.087**
Mercury, Total	0.0002 U	0.0002 U	0.0002 U	0.0002 U	-	-	0.0002 U	0.0002 U	0.0002 U
Molybdenum, Total	**0.24**	**0.25**	**0.39**	**0.42**	**0.37**	**0.38**	**0.0094**	**0.25**	**0.38**
Selenium, Total	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	**0.0017 J**	**0.001 J**	0.005 U
Thallium, Total	**0.00018 J**	**0.00023 J**	0.001 U	**0.000076 J**	0.001 U	0.001 U	**0.000066 J**	**0.000073 J**	0.001 U
Radiological (pCi/L)									
Radium-226	**0.250 ± 0.0868**	**0.294 ± 0.0941**	**0.261 ± 0.167**	**0.231 ± 0.168**	R	R	-	-	**0.107 ± 0.0722**
Radium-228	0.234 U ± 0.238	R	0.213 U ± 0.216	**0.605 ± 0.274**	0.252 U ± 0.311	0.130 U ± 0.253	-	-	0.257 U ± 0.341
Radium-226 & 228	**0.483 J+ ± 0.253**	R	**0.474 J ± 0.273**	**0.836 ± 0.321**	R	R	-	-	0.364 UJ ± 0.349

ABBREVIATIONS AND NOTES:

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TABLE 1A
ASSESSMENT MONITORING GROUNDWATER ANALYTICAL RESULTS - APPENDIX IV CONSTITUENTS
CORRECTIVE MEASURES ASSESSMENT
F.B. CULLEY GENERATING STATION - EAST ASH POND

Location Name	Groundwater	CCR-AP-5	CCR-AP-6	CCR-AP-6	CCR-AP-6	CCR-AP-6	CCR-AP-6	CCR-AP-6	CCR-AP-6	CCR-AP-6	CCR-AP-6	CCR-AP-6	CCR-AP-6	CCR-AP-6	CCR-AP-6	CCR-AP-8
Sample Name	Protection	BLIND DUPLICATE-20190528	CCR-AP-6-20160610	CCR-AP-6-20160812	CCR-AP-6-20161028	CCR-AP-6-20161207	CCR-AP-6-20170208	CCR-AP-6-20170406	CCR-AP-6-20170607	CCR-AP-6-20170929	CCR-AP-6-20171117	CCR-AP-6-20180611	CCR-AP-6-20180828	CCR-AP-6-20181117	CCR-AP-6-20190528	CCR-AP8-20170309
Sample Date	Standard	05/28/2019	06/10/2016	08/12/2016	10/28/2016	12/07/2016	02/08/2017	04/06/2017	06/07/2017	09/29/2017	11/17/2017	06/11/2018	08/28/2018	11/17/2018	05/28/2019	03/09/2017
Appendix IV Constituents (mg/L)																
Antimony, Total	0.006	0.002 U	0.002 U	0.002 U	0.002 U	**0.00048 J**	**0.00047 J**	0.002 U	**0.00059 J**	**0.0014 J**	0.01 U	**0.0012 J**	0.002 U	0.002 U	**0.00083 J**	**0.0018 J**
Arsenic, Total	0.01	**0.0013**	**0.04**	**0.059**	**0.06**	**0.067**	**0.11**	**0.11**	**0.096**	**0.089**	**0.081**	**0.12**	**0.1**	**0.11**	**0.11**	**0.044**
Barium, Total	2	**0.042**	**0.51**	**0.58**	**0.55**	**0.62**	**0.61**	**0.64**	**0.6**	**0.55**	**0.49**	**0.69**	**0.64**	**0.58**	**0.69**	**0.57**
Beryllium, Total	0.004	0.001 U	0.001 U	**0.00026 J**	**0.00011 J**	**0.00036 J**	**0.00025 J**	**0.00024 J**	**0.00042 J**	**0.00039 J**	0.005 U	**0.00065 J**	**0.00046 J**	**0.000083 J**	**0.00069 J**	0.001 U
Cadmium, Total	0.005	**0.00053 J**	0.001 U	**0.00016 J**	0.001 U	**0.00029 J**	**0.00027 J**	**0.00019 J**	**0.00024 J**	**0.00052 J**	**0.00039 J**	**0.00051 J**	**0.0005 J**	0.001 U	**0.0006 J**	0.001 U
Chromium, Total	0.1	0.0028 U	**0.0031**	**0.0092**	**0.005**	**0.015**	**0.011**	**0.0098**	**0.014**	**0.02**	**0.014**	**0.029**	**0.031**	**0.0048**	**0.028**	**0.0012 J**
Cobalt, Total	0.006	**0.0031**	**0.0042**	**0.0095**	**0.0075 J**	**0.01**	**0.009**	**0.0069**	**0.011**	**0.012**	**0.0087**	**0.014**	**0.013**	**0.0044**	**0.018**	**0.015**
Fluoride	4	**1.3 J+**	**0.43**	**0.67**	**0.42**	**0.62**	**0.5**	**0.45**	**0.63**	**0.55**	**0.24**	**0.6**	**0.42**	**0.44**	**0.67 J+**	**0.13**
Lead, Total	0.015	**0.0017**	**0.0021**	**0.0071**	**0.0035 J**	**0.01**	**0.0079**	**0.0074 J+**	**0.0096**	**0.014**	**0.011**	**0.02**	**0.02**	**0.0022**	**0.024**	**0.00058 J**
Lithium, Total	0.04	**0.086**	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	**0.011 J**	0.05 U	0.25 U	**0.016**	**0.014**	**0.0035 J**	**0.014**	0.05 U
Mercury, Total	0.002	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	-	0.0002 U	0.0002 U	0.0002 U
Molybdenum, Total	0.1	**0.38**	**0.02**	**0.018**	**0.021**	**0.024**	**0.03**	**0.024**	**0.026**	**0.033**	**0.027**	**0.033**	**0.031**	**0.027**	**0.028**	**0.014**
Selenium, Total	0.05	0.005 U	**0.001 J**	**0.0014 J**	**0.0015 J**	**0.0014 J**	0.005 U	**0.0018 J-**	**0.0014 J**	**0.0023 J**	0.025 U	**0.0023 J**	**0.0019 J**	**0.0016 J**	0.005 U	0.005 U
Thallium, Total	0.002	0.001 U	0.001 U	**0.000047 J**	0.001 U	**0.0001 J**	**0.000063 J**	0.001 U	**0.00009 J**	**0.00013 J**	0.005 U	**0.00022 J**	**0.0002 J**	0.001 U	**0.00018 J**	0.001 U
Radiological (pCi/L)																
Radium-226	NA	**0.146 ± 0.0812**	**0.652 J ± 0.142**	**1.32 ± 0.278**	**1.38 ± 0.686**	-0.236 U ± 0.919	**0.929 ± 0.371**	**0.730 ± 0.221**	**2.33 ± 0.648**	**0.815 ± 0.227**	**0.695 ± 0.171**	**1.15 ± 0.384**	**1.71 J ± 0.551**	-	**6.34 J- ± 1.43**	**0.893 ± 0.233**
Radium-228	NA	0.435 U ± 0.42	**0.543 ± 0.293**	0.811 U ± 0.725	0.663 U ± 0.532	1.58 U ± 1.55	0.755 U ± 0.581	0.455 U ± 0.438	**3.61 ± 1.47**	R	R	**1.12 ± 0.415**	0.929 U ± 1.02	-	3.90 UJ ± 4.41	1.07 U ± 1.02
Radium-226 & 228	5	0.581 UJ ± 0.428	**1.20 ± 0.325**	**2.13 ± 0.776**	**2.05 J ± 0.868**	1.58 U ± 1.8	**1.68 J ± 0.69**	**1.19 J ± 0.49**	**5.93 ± 1.6**	R	R	**2.27 ± 0.565**	**2.64 J ± 1.16**	-	**10.2 J- ± 4.64**	**1.96 J ± 1.04**

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CORRECTIVE MEASURES ASSESSMENT
F.B. CULLEY GENERATING STATION - EAST ASH POND

Location Name Sample Name Sample Date	Groundwater Protection Standard	CCR-AP-8 CCR-AP-8-20170406 04/06/2017	CCR-AP-8 CCR-AP-8-20170426 04/26/2017	CCR-AP-8 CCR-AP-8-20170530 05/30/2017	CCR-AP-8 CCR-AP-8-20170607 06/07/2017	CCR-AP-8 CCR-AP-8-20170725 07/25/2017	CCR-AP-8 CCR-AP-8-20170815 08/15/2017	CCR-AP-8 CCR-AP-8-20170928 09/28/2017	CCR-AP-8 CCR-AP-8-20171117 11/17/2017	CCR-AP-8 CCR-AP-8-20180611 06/11/2018	CCR-AP-8 CCR-AP-8-20180828 08/28/2018	CCR-AP-8 CCR-AP-8-20181116 11/16/2018	CCR-AP-8 CCR-AP-8-20190528 05/28/2019
Appendix IV Constituents (mg/L)													
Antimony, Total	0.006	**0.00066 J**	**0.001 J**	**0.00082 J**	**0.0011 J**	0.002 U	**0.0014 J**	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U	**0.00046 J**
Arsenic, Total	0.01	**0.052**	**0.07**	**0.06**	**0.076**	**0.087**	**0.095**	**0.087**	**0.083**	**0.11**	**0.096**	**0.1**	**0.1**
Barium, Total	2	**0.59**	**0.59**	**0.58**	**0.6**	**0.67**	**0.64**	**0.56**	**0.53**	**0.68**	**0.58**	**0.58**	**0.49**
Beryllium, Total	0.004	0.001 U	0.001 U	0.001 U	0.001 U	**0.0002 J**	**0.00039 J**	0.001 U	0.001 U	**0.00022 J**	**0.00016 J**	0.001 U	0.001 U
Cadmium, Total	0.005	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	**0.00016 J**	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
Chromium, Total	0.1	**0.0022**	**0.0019 J**	**0.0028**	R	**0.0041**	**0.012**	**0.0021 J+**	**0.0021**	**0.0069 J+**	**0.0068 J+**	**0.0024**	0.0034 U
Cobalt, Total	0.006	**0.012**	**0.011**	**0.011**	**0.011**	**0.012**	**0.017**	**0.0098**	**0.0082**	**0.0086**	**0.0077**	**0.0059**	**0.0044**
Fluoride	4	**0.35**	**0.28**	**0.24**	**0.21 J**	**0.24 J**	**0.26**	**0.34**	**0.4**	**0.41**	**0.21**	**0.25**	**0.51 J+**
Lead, Total	0.015	**0.0011 J+**	**0.00081 J**	**0.0022**	**0.001**	**0.0025**	**0.0076**	**0.0011**	**0.0011**	**0.0033**	**0.0021**	**0.0005 J**	**0.0012**
Lithium, Total	0.04	0.05 U	**0.014 J**	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	**0.0057**	**0.0052**	0.005 U	**0.0031 J**
Mercury, Total	0.002	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	-	0.0002 U	0.0002 U
Molybdenum, Total	0.1	**0.015**	**0.014**	**0.013**	**0.014**	**0.014**	**0.015**	**0.012**	**0.012**	**0.013**	**0.012**	**0.0095**	**0.0099**
Selenium, Total	0.05	**0.0017 J-**	**0.0015 J**	**0.0017 J**	**0.0017 J**	**0.0015 J**	**0.0022 J**	**0.002 J**	0.005 U	**0.0021 J**	**0.0018 J**	**0.0019 J**	0.005 U
Thallium, Total	0.002	0.001 U	0.001 U	0.001 U	**0.000068 J**	**0.000058 J**	**0.00015 J**	0.001 U	**0.00029 J**	**0.000083 J**	0.001 U	0.001 U	0.001 U
Radiological (pCi/L)													
Radium-226	NA	**1.34 ± 0.31**	**0.883 ± 0.196**	**0.720 ± 0.162**	**0.721 J ± 0.211**	**0.704 ± 0.201**	**0.513 ± 0.143**	**0.529 ± 0.153**	**0.640 ± 0.164**	**0.544 ± 0.277**	R	-	**0.443 ± 0.148**
Radium-228	NA	**0.677 ± 0.435**	**0.778 ± 0.372**	**0.457 ± 0.284**	**1.60 J ± 0.556**	0.889 U ± 0.726	0.316 U ± 0.305	R	R	**0.502 ± 0.319**	0.367 U ± 0.309	-	0.0635 UJ ± 0.848
Radium-226 & 228	5	**2.01 ± 0.534**	**1.66 ± 0.421**	**1.18 ± 0.327**	**2.32 J ± 0.594**	**1.59 J ± 0.754**	**0.829 J ± 0.337**	R	R	**1.05 ± 0.422**	R	-	0.506 UJ ± 0.861

ABBREVIATIONS AND NOTES:

Statistically significant level (SSL) concentration.
CCR: Coal Combustion Residuals.
mg/L: milligram per liter.
pCi/L: picoCurie per liter.
su: standard units.
USEPA: United States Environmenta.l Protection Agency
J: Value is estimated
J-: Value is estimated, biased low
J+: Value is estimated, biased high
R: Rejected during validation
U: Not detected, value is the laboratory reporting limit

- USEPA. 2016. Final Rule: Disposal of Coal Combustion Residuals from Electric Utilities. July 26. 40 CFR Part 257. https://www.epa.gov/coalash/coal-ash-rule

TABLE 1B
NATURE AND EXTENT GROUNDWATER ANALYTICAL RESULTS - APPENDIX IV CONSTITUENTS
CORRECTIVE MEASURES ASSESSMENT
F.B. CULLEY GENERATING STATION - EAST ASH POND

Location Name	Groundwater	CCR-AP-5I	CCR-AP-5I	CCR-AP-6I	CCR-AP-6I	CCR-AP-6I	CCR-AP-8I	CCR-AP-8I	CCR-AP-8I	CCR-AP-11	CCR-AP-11
Sample Name	Protection	CCR-AP-5I-20190213	CCR-AP-5I-20190612	CCR-AP-6I-20181117	CCR-AP-6I-20190212	CCR-AP-6I-20190612	CCR-AP-8I-20181117	CCR-AP-8I-20190212	CCR-AP-8I-20190612	CCR-AP-11-20190213	CCR-AP-11-20190612
Sample Date	Standard	02/13/2019	06/12/2019	11/17/2018	02/12/2019	06/12/2019	11/17/2018	02/12/2019	06/12/2019	02/13/2019	06/13/2019
Appendix IV Constituents (mg/L)											
Antimony, Total	0.006	**0.00075 J**	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U
Arsenic, Total	0.01	**0.0007 J**	**0.00072 J**	**0.0037**	**0.0048**	**0.0028**	**0.004**	**0.00099 J**	**0.0051**	**0.0026**	**0.047**
Barium, Total	2	**0.037**	**0.085**	**0.11**	**0.052**	**0.28**	**0.3**	**0.21**	**0.063**	**0.092**	**0.34**
Beryllium, Total	0.004	0.001 U	0.001 U	0.001 U	0.001 U	**0.00019 J**	**0.000078 J**	0.001 U	**0.00018 J**	0.001 U	**0.00017 J**
Cadmium, Total	0.005	0.001 U	0.001 U	**0.00015 J**	**0.00019 J**	0.001 U	0.001 U	**0.00022 J**	**0.00022 J**	0.001 U	0.001 U
Chromium, Total	0.1	0.002 U	0.002 U	**0.002**	0.002 U	0.0026 U	**0.0029**	0.002 U	0.0033 U	0.002 U	0.0032 U
Cobalt, Total	0.006	**0.00064**	**0.00048 J**	**0.0017**	**0.0019**	**0.00062 J+**	**0.0016**	**0.00014 J**	**0.0031**	**0.0016**	**0.025**
Fluoride	4	**0.34**	**0.31**	**0.13**	**0.16 J**	**0.19 J+**	**0.26**	**0.27**	**0.12 J+**	**0.97**	**0.32**
Lead, Total	0.015	0.001 U	**0.00023 J**	**0.00084 J**	**0.0003 J**	0.001 U	**0.001**	0.001 U	0.001 U	**0.00018 J**	0.001 U
Lithium, Total	0.04	**0.03**	**0.035**	**0.043**	**0.055**	**0.33**	**0.44**	**0.37**	**0.047**	**0.0077**	**0.004 J**
Mercury, Total	0.002	-	0.0002 U	0.0002 U	-	0.0002 U	0.0002 U	-	0.0002 U	-	0.0002 U
Molybdenum, Total	0.1	**0.0054**	**0.0017 J**	**0.63**	**0.75**	**0.34**	**0.36**	**0.67**	**0.86**	**0.0049 J**	**0.0011 J**
Selenium, Total	0.05	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U
Thallium, Total	0.002	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	**0.00013 J**	0.001 U	0.001 U
Radiological (pCi/L)											
Radium-226	NA	**0.274 ± 0.188**	**0.85 ± 0.36**	-	**0.203 ± 0.0906**	**1.31 ± 0.47**	-	**1.25 ± 0.222**	**0.46 ± 0.24**	**0.283 ± 0.171**	**0.56 ± 0.29**
Radium-228	NA	0.189 U ± 0.213	0.40 U ± 0.36	-	**0.460 ± 0.246**	**1.76 ± 0.58**	-	**1.87 ± 0.412**	**0.88 ± 0.42**	0.0228 U ± 0.24	0.60 U ± 0.39
Radium-226 & 228	5	**0.463 ± 0.284**	**1.25 J ± 0.509**	-	**0.664 ± 0.262**	**3.07 ± 0.747**	-	**3.12 ± 0.468**	**1.34 ± 0.484**	0.305 U ± 0.295	**1.16 J ± 0.486**

ABBREVIATIONS AND NOTES:

Statistically significant level (SSL) concentration.
CCR: Coal Combustion Residuals.
mg/L: milligram per liter.
pCi/L: picoCurie per liter.
su: standard units.
USEPA: United States Environmenta.l Protection Agency
J: Value is estimated
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J+: Value is estimated, biased high
R: Rejected during validation
U: Not detected, value is the laboratory reporting limit

- USEPA. 2016. Final Rule: Disposal of Coal Combustion Residuals from Electric Utilities. July 26. 40 CFR Part 257. https://www.epa.gov/coalash/coal-ash-rule

TABLE 2

SUMMARY OF CORRECTIVE MEASURES

CORRECTIVE MEASURES ASSESSMENT

F.B. CULLEY GENERATING STATION - EAST ASH POND

Alternative Number	Remedial Alternative Description	THRESHOLD CRITERIA					BALANCING CRITERIA																		
								Sub-Category 1									Sub-Cat. 2			Sub-Category 3				
								1	2	3	4	5	6	7	8		1	2		1	2	3	4	5
		Be protective of human health and the environment	Attain the groundwater protective standard	Control the source of releases so as to reduce or eliminate, to the maximum extent feasible, further releases of Appendix IV constituents into the environment	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	Management of waste to comply with all applicable RCRA requirements	CATEGORY 1 Long- and Short-Term Effectiveness, Protectiveness, and Certainty of Success that the remedy will prove successful	*Magnitude of reduction of existing risks*	*Magnitude of residual risks in terms of likelihood of further releases due to CCR remaining following implementation of a remedy*	*Type and degree of long-term management required including monitoring, operation and maintenance*	*Short-term risk to community or environment during implementation of remedy*	*Time until full protection is achieved*	*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*	*Long-term reliability of engineering and institutional controls*	*Potential need for replacement of the remedy*	CATEGORY 2 Effectiveness in controlling the source to reduce further releases	*Extent to which containment practices will reduce further releases*	*Extent to which treatment technologies may be used*	CATEGORY 3 The ease or difficulty of implementation	*Degree of difficulty associated with constructing the technology*	*Expected operational reliability of the technologies*	*Need to coordinate with and obtain necessary approvals and permits from other agencies*	*Availability of necessary equipment and specialists*	*Available capacity and location of needed treatment, storage, and disposal services*
1	Monitored Natural Attenuation (MNA) with In-Situ Solidification (ISS) and Closure in Place (CIP)	✓	✓	✓	✓	✓																		
2	Hydraulic Containment with No Treatment, ISS and CIP	✓	✓	✓	✓	✓																		
3	Hydraulic Containment with Treatment, ISS and CIP	✓	✓	✓	✓	✓																		
4	In-Situ Treatment, ISS and CIP	✓	✓	✓	✓	✓																		

TABLE 2

SUMMARY OF CORRECTIVE MEASURES

CORRECTIVE MEASURES ASSESSMENT

F.B. CULLEY GENERATING STATION - EAST ASH POND

Alternative Number	Remedial Alternative Description	THRESHOLD CRITERIA: Be protective of human health and the environment	Attain the groundwater protective standard	Control the source of releases so as to reduce or eliminate, to the maximum extent feasible, further releases of Appendix IV constituents into the environment	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	Management of waste to comply with all applicable RCRA requirements
5	MNA with Closure by Removal (CBR)	✓	✓	✓	✓	✓
6	Hydraulic Containment with No Treatment and CBR	✓	✓	✓	✓	✓
7	Hydraulic Containment with Treatment and CBR	✓	✓	✓	✓	✓
8	In-Situ Treatment and CBR	✓	✓	✓	✓	✓

BALANCING CRITERIA

Alternative Number	CATEGORY 1: Long- and Short-Term Effectiveness, Protectiveness, and Certainty of Success that the remedy will prove successful	Sub-Category 1 – 1: Magnitude of reduction of existing risks	2: Magnitude of residual risks in terms of likelihood of further releases due to CCR remaining following implementation of a remedy	3: Type and degree of long-term management required including monitoring, operation and maintenance	4: Short-term risk to community or environment during implementation of remedy	5: Time until full protection is achieved	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	7: Long-term reliability of engineering and institutional controls	8: Potential need for replacement of the remedy
5	Green	Green	Green	Green	Yellow	Yellow	Yellow	Green	Green
6	Yellow	Green	Green	Yellow	Yellow	Green	Yellow	Yellow	Yellow
7	Red	Yellow	Green	Red	Yellow	Green	Red	Yellow	Yellow
8	Red	Green	Green	Yellow	Yellow	Green	Yellow	Red	Red

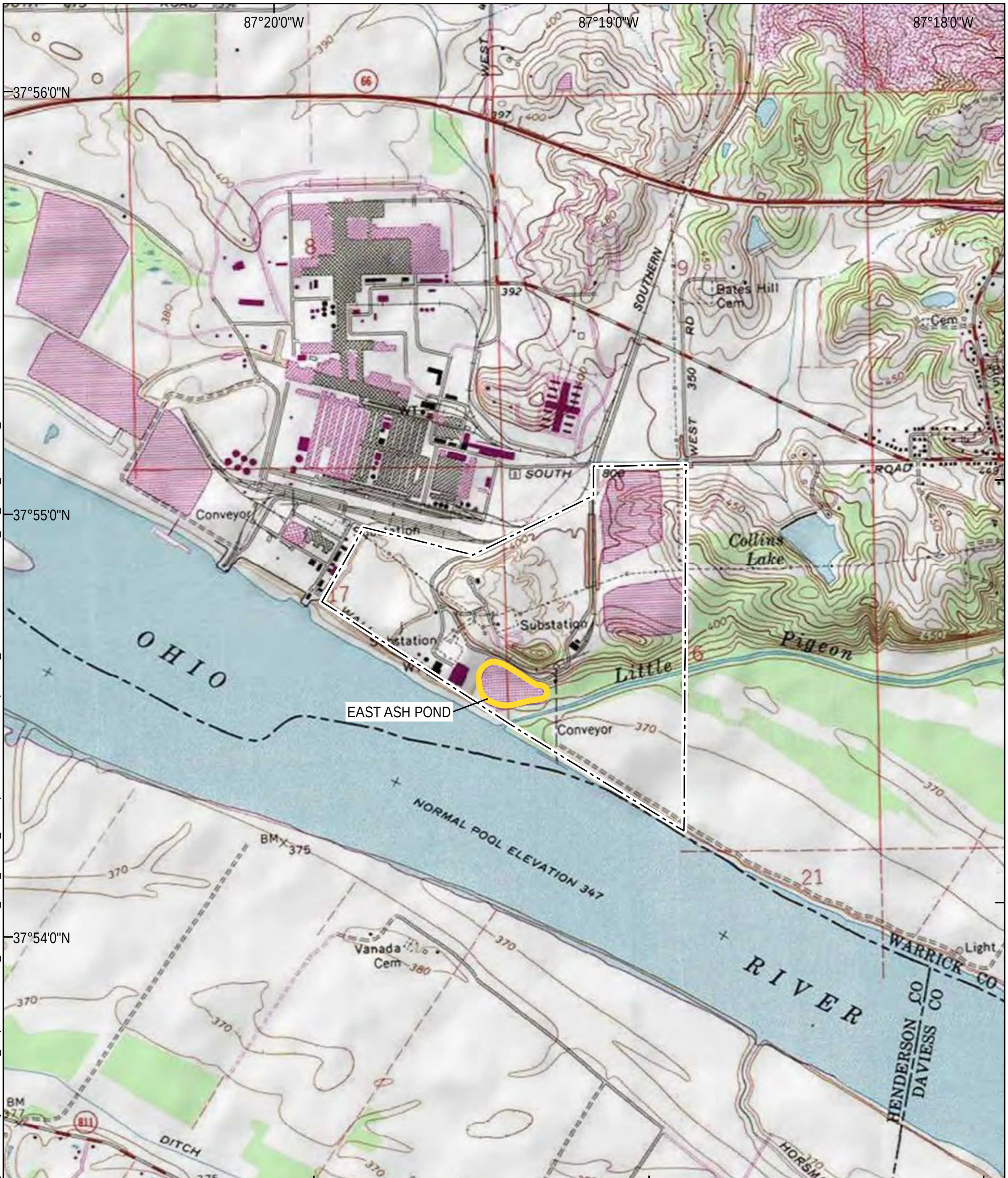
Alternative Number	CATEGORY 2: Effectiveness in controlling the source to reduce further releases	Sub-Cat. 2 – 1: Extent to which containment practices will reduce further releases	2: Extent to which treatment technologies may be used	CATEGORY 3: The ease or difficulty of implementation	Sub-Category 3 – 1: Degree of difficulty associated with constructing the technology	2: Expected operational reliability of the technologies	3: Need to coordinate with and obtain necessary approvals and permits from other agencies	4: Availability of necessary equipment and specialists	5: Available capacity and location of needed treatment, storage, and disposal services
5	Green	Green	Green	Green	Green	Green	Green	Green	Green
6	Yellow	Green	Yellow	Yellow	Red	Yellow	Yellow	Yellow	Green
7	Yellow	Green	Yellow	Yellow	Red	Yellow	Yellow	Yellow	Yellow
8	Red	Green	Red	Red	Yellow	Red	Red	Red	Green

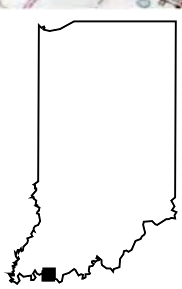
COLOR LEGEND

- Green: Most favorable when compared to other alternatives
- Yellow: Less favorable when compared to other alternatives
- Red: Least favorable when compared to other alternatives

HALEY ALDRICH

FIGURES





MAP SOURCE: ESRI
SITE COORDINATES: 36°30'28"N, 89°33'37"W

HALEY ALDRICH

CORRECTIVE MEASURE ASSESSMENT
SOUTHERN INDIANA GAS AND ELECTRIC COMPANY
F.B. CULLEY GENERATING STATION
NEWBURGH, INDIANA

SITE LOCATION MAP

APPROXIMATE SCALE: 1 IN = 2000 FT
SEPTEMBER 2019

FIGURE 1-1

GIS FILE PATH: \\haleyaldrich.com\share\boi_common\Projects\Vectren_Corporation\42796_Evansville_CCR_GWMP_Development\Global\GIS\Maps\2019_08\F.B. CULLEY\129420_001_0000_PROJECT_LOCUS.mxd — USER: hwachholz — LAST SAVED: 8/28/2019 10:06:45 AM

LEGEND

- EAST ASH POND BOUNDARY
- WEST ASH POND BOUNDARY
- APPROXIMATE PROPERTY BOUNDARY

NOTES

1. ALL LOCATIONS ARE APPROXIMATE
2. CCR COAL COMBUSTION RESIDUALS
3. AERIAL IMAGERY SOURCE: ESRI

0 350 700
SCALE IN FEET

HALEY ALDRICH

CORRECTIVE MEASURES ASSESSMENT
SOUTHERN INDIANA GAS AND ELECTRIC COMPANY
F.B. CULLEY GENERATING STATION
NEWBURGH, INDIANA

SITE FEATURES MAP

SEPTEMBER 2019

FIGURE 1-2

GIS FILE PATH: \\haleyaldrich.com\share\boi_common\Projects\Vectren_Corporation\42796_Evansville_CCR_GWMP_Development\Global\GIS\Maps\2019_08\F.B. CULLEY\129420_001_0001-2_SITE_FEATURES_MAP.mxd — USER: hwachholz — LAST SAVED: 8/23/2019 12:14:28 PM

LEGEND

CCR-AP-11 — MONITORING WELL

CCR-AP-6I — NATURE AND EXTENT MONITORING WELL

APPROXIMATE UNIT BOUNDARY

APPROXIMATE PROPERTY BOUNDARY

NOTES

1. ALL LOCATIONS ARE APPROXIMATE
2. CCR COAL COMBUSTION RESIDUALS
3. AERIAL IMAGERY SOURCE: ESRI

N

0 220 440

SCALE IN FEET

HALEY ALDRICH

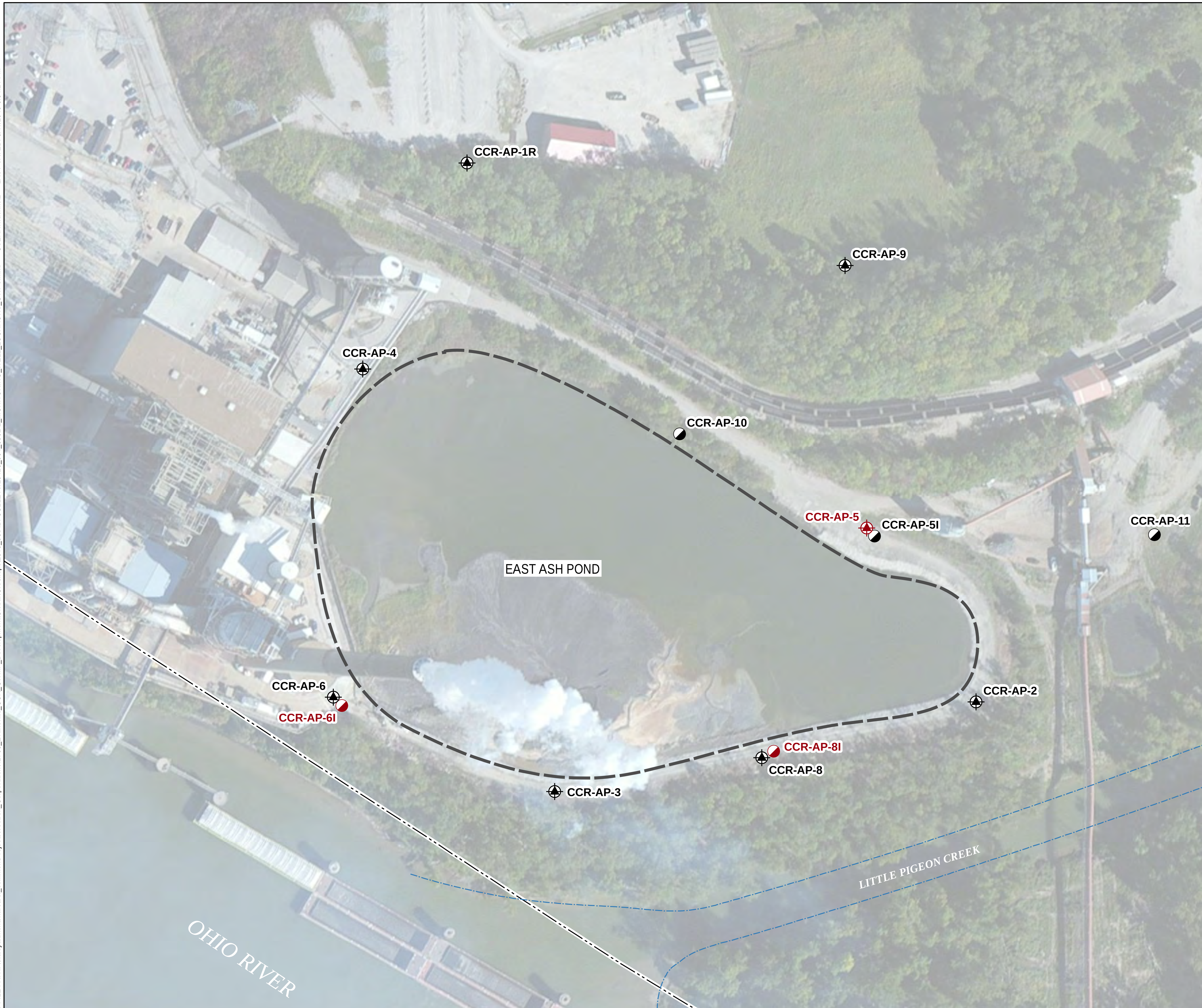
CORRECTIVE MEASURES ASSESSMENT
SOUTHERN INDIANA GAS AND ELECTRIC COMPANY
F.B. CULLEY GENERATING STATION
NEWBURGH, INDIANA

GROUNDWATER MONITORING WELL LOCATIONS

SEPTEMBER 2019

FIGURE 1-3

GIS FILE PATH: \\haleyaldrich\share\bol_common\Projects\Vectren_Corporation\42796_Evansville_CCR_GWMP_Development\Global\GIS\Maps\2019_08\F.B. CULLEY\129420_001_0002-1_MONITORING_WELL_LOCATIONS.mxd — USER: hwachholz — LAST SAVED: 9/11/2019 3:37:14 PM



LEGEND

CCR-AP-11 — MONITORING WELL WITH NO CONSTITUENTS ABOVE GWPS

CCR-AP-5I — NATURE AND EXTENT MONITORING WELL

CCR-AP-5 — MONITORING WELL WITH MOLYBDENUM CONCENTRATION ABOVE THE GWPS

APPROXIMATE UNIT BOUNDARY

APPROXIMATE PROPERTY BOUNDARY

NOTES

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

N

0 150 300

SCALE IN FEET

HALEY ALDRICH

CORRECTIVE MEASURES ASSESSMENT
SOUTHERN INDIANA GAS AND ELECTRIC COMPANY
F.B. CULLEY GENERATING STATION
NEWBURGH, INDIANA

MONITORING WELL LOCATIONS WITH STATISTICALLY SIGNIFICANT LEVELS ABOVE GWPS

SEPTEMBER 2019

FIGURE 2-1

GIS FILE PATH: \\haleyaldrich\share\bi_common\Projects\Vectren_Corporation\42796_Evansville_CCR_GWMP_Development\Global\GIS\Maps\2019_08\F.B. CULLEY\129420_001_0002-2_MONITORING_WELL_LOCATIONS_GWPS.mxd — USER: hwachholz — LAST SAVED: 9/11/2019 3:34:21 PM

FIGURE 4-1
REMEDIAL ALTERNATIVE ROADMAP
CORRECTIVE MEASURES ASSESSMENT
SOUTHERN INDIANA GAS AND ELECTRIC COMPANY
F.B. CULLEY GENERATING STATION - EAST ASH POND
NEWBURGH, INDIANA

Alternative Number	Remedial Alternative Description	Ash Pond Closure Method	Interim Measure Options for Groundwater	Post-Closure Options for Groundwater
1	**Monitored Natural Attenuation (MNA) with In-Situ Solidification (ISS) and Closure in Place (CIP)**	**Closure in Place with ISS (or equivalent - e.g., Fully Encapsulated Slurry Wall) and Cap**	**MNA**	**MNA** Post-closure groundwater monitoring to confirm reduction of CCR constituents following completion of ISS and capping
2	**Hydraulic Containment with No Treatment, ISS and CIP**		**Hydraulic Containment with No Treatment*** Mitigate off-site migration of groundwater with CCR constituents above GWPS using extraction wells, direct discharge of effluent	
3	**Hydraulic Containment with Treatment, ISS and CIP**		**Hydraulic Containment with Ex-Situ Treatment** Mitigate off-site migration of groundwater with CCR constituents above Groundwater Protection Standards (GWPS) using extraction wells, ex-situ treatment of effluent prior to discharge	
4	**In-Situ Treatment, ISS and CIP**		**In-Situ Treatment** Subsurface treatment to reduce CCR constituents in groundwater	
5	**MNA with Closure by Removal (CBR)**	**Closure by Removal**	**MNA**	**MNA** Post-closure groundwater monitoring to confirm reduction of CCR constituents following removal
6	**Hydraulic Containment with No Treatment and CBR**		**Hydraulic Containment with No Treatment** Mitigate off-site migration of groundwater with CCR constituents above GWPS using extraction wells, direct discharge of effluent	
7	**Hydraulic Containment with Treatment and CBR**		**Hydraulic Containment with Ex-Situ Treatment** Mitigate off-site migration of groundwater with CCR constituents above GWPS using extraction wells, ex-situ treatment of effluent prior to discharge	
8	**In-Situ Treatment and CBR**		**In-Situ Treatment** Subsurface treatment to reduce CCR constituents in groundwater	

* To be determined based on ELG/NPDES permit updates

APPENDIX A

Groundwater Risk Evaluation

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REPORT ON

GROUNDWATER RISK EVALUATION
F.B. CULLEY GENERATING STATION
NEWBURGH, INDIANA

by
Haley & Aldrich, Inc.
Cleveland, Ohio

for
Southern Indiana Gas and Electric Company
Evansville, Indiana

File No. 129420-020
September 2019

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1	SITE FEATURES
2	PRIVATE WELL LOCATIONS WITHIN A HALF-MILE RADIUS OF FACILITY BOUNDARY
3	CONCEPTUAL SITE MODEL

List of Acronyms

AAC	Acute Aquatic Criterion
ASD	Alternate Source Demonstration
AWQC	Ambient Water Quality Criteria
CAC	Chronic Aquatic Criterion
CCR	Coal Combustion Residual
CMA	Corrective Measures Assessment
CSM	Conceptual Site Model
CWA	Clean Water Act
EAP	East Ash Pond
FBC	F.B. Culley Generating Station
GWPS	Groundwater Protection Standards
IDEM	Indiana Department of Environmental Management
IWPCD	Indiana Water Pollution Control Division
MCL	Maximum Contaminant Level
mg/L	Milligram per Liter
NRWQC	National Recommended Water Quality Criteria
ORSANCO	Ohio River Valley Water Sanitation Commission
RSL	Regional Screening Level
SIGECO	Southern Indiana Gas and Electric Company
SSI	Statistically Significant Increase
SSL	Statistically Significant Level
ug/L	Microgram per Liter
USEPA	United States Environmental Protection Agency

1. Introduction

The F.B. Culley Generating Station (FBC) is a coal-fired power plant (the Site) located on the Ohio River in Warrick County, Indiana. The facility is located adjacent to the northern bank of the Ohio River and Little Pigeon Creek approximately three miles east of the town of Newburgh, Indiana. The facility has been in operation since 1953, and coal combustion residuals (CCR) are currently managed on the Site in a 10-acre impoundment known as the East Ash Pond (EAP), commissioned around 1971. Southern Indiana Gas and Electric Company (SIGECO) currently owns the land and operates the station for supplying electric power to industrial, commercial, and residential customers in its service territory. **Figure 1** shows the location of the facility, and the location of the EAP.

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. SIGECO is complying with the CCR Rule, and has posted the required information on their publicly-available website: *https://www.vectren.com/reporting/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 the F.B. Culley Generating Station – East Ash Pond, Newburgh, Indiana." 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 the FBC under the CCR Rule.

Beyond the specific monitoring requirements of the CCR Rule, SIGECO 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 Ohio River and Little Pigeon Creek. Details about the evaluation are provided below.

2. Approach

The analysis presented in this report was conducted by evaluating the environmental setting of the FBC, 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 Indiana Department of Environmental Management (IDEM), 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 IDEM 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 IDEM 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 FBC, the coal ash stored in the EAP 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 Ohio River and/or Little Pigeon Creek. **Figure 1** shows the facility location and layout, identifies direction of groundwater flow, and identifies the adjacent surface water bodies. Thus, the environmental media of interest for this evaluation are:

- Groundwater on the facility;
- Ohio River surface water; and
- Little Pigeon Creek surface water.

Groundwater flow in the immediate vicinity of the EAP is radial with an overall flow direction from the upland areas north of the EAP to the south toward the Ohio River, as shown in **Figure 1**. Groundwater elevations vary seasonally but the direction of groundwater flow patterns remain consistent.

There are no on-site users of shallow groundwater adjacent to the EAP. There are approximately 28 private wells recorded within a half-mile radius of the facility, and all are located either west or upgradient of the facility (see **Figure 2**), meaning that groundwater does not flow from the EAP toward those wells. One well (number 233831 on **Figure 2)**, owned by Yankeetown Dock Corp., is located to the east of the EAP. This well is on the opposite side of Little Pigeon Creek from the Site and is not downgradient to the EAP.

There are three water wells on facility property that are used to supply water to the FBC. These wells are located upgradient and west of the EAP (see **Figure 2**).

Thus, there are no downgradient users of the groundwater. Consequently, there are no complete drinking water exposure pathways to groundwater downgradient of the EAP.

The Ohio River is a supply source for drinking water and the nearest public water supply intake is located approximately 18.4 miles downstream near the City of Evansville, Indiana. Little Pigeon Creek flows into the Ohio River, except during periods of low precipitation, when the creek is dry. The creek is not used as a source of drinking water.

The Ohio River can be used for human recreation – wading, swimming, boating, fishing. Little Pigeon Creek can also be used recreationally, though its small size and periodic drying would limit its recreational use mostly to wading.

Both the creek and the river serve as habitat for aquatic species – fish, amphibians, etc.

A depiction of the conceptual site model is shown in **Figure 3**.

Figure 1 shows the groundwater sample locations. 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 is 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 IDEM sources are used for comparison to the data, as described in Section 5.

3. Sample Collection and Analysis

3.1 GROUNDWATER SAMPLES

The CCR Rule requires that groundwater monitoring occur at one (1) upgradient location and three (3) downgradient locations. For the EAP evaluation, nine (9) groundwater monitoring wells were installed to evaluate shallow alluvial groundwater: six (6) monitoring wells were installed around the perimeter of the EAP to assess groundwater conditions at the ash management area, and three (3) monitoring wells were installed just north 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. CCR-AP-2 through CCR-AP-6 and CCR-AP-8 are located around the perimeter of the EAP, and CCR-AP-1R, CCR-AP-7, and CCR-AP-9 are the three background wells that are used to identify upgradient/background conditions in groundwater. Each groundwater monitoring well was sampled eleven (11) times[1].

3.2 SAMPLE ANALYSIS

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

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

The CCR Rule requires eight (8) rounds of groundwater sampling and analysis be conducted for all wells to provide a baseline for current conditions. At this facility, nine rounds of groundwater samples were collected through November 2017, and were analyzed for all constituents. Assessment Monitoring samples in June and August 2018 were analyzed for constituents in the last two columns above (these are the Appendix IV constituents under the CCR Rule – the remaining are referred to as Appendix III constituents). The CCR Rule requires statistical methods be used to determine whether a statistically significant increase (SSI) above background exists for the first column (Appendix III) constituents, a condition that triggers conducting Assessment Monitoring. Based on the SSI results from the groundwater monitoring, 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**.

[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.

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

It is important to note that the CCR Rule requires that the downgradient monitoring wells be located at the edge of the ash management area. Moreover, the CCR Rule limits the evaluation of groundwater monitoring data from 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, whether or not that groundwater is used as a source of drinking water, or to Regional Screening Levels (RSLs) for those constituents that do not have an established MCL, or finally to a comparison with site-specific background. GWPS used to evaluate potential drinking water exposures for CCR monitoring wells are shown on **Table 1**.

To augment this evaluation, **Table 2** provides the risk-based human health drinking water and recreational screening levels for surface water available from the IDEM 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 IDEM 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. Based on the CSM presented in **Section 2.1** and **Figure 3**, this section outlines the risk-based human health and ecological surface water screening levels that are protective of surface water in the Ohio River.

Human health screening levels for surface water are identified for the following exposure settings: 1) use of surface water as a drinking water source, 2) the consumption of fish from a surface water body, and 3) recreational uses of surface water.

4.2.1 Drinking Water Screening Levels

The human health screening levels for drinking water are from IDEM and USEPA sources and address the drinking water exposure pathway. The IDEM criteria for drinking water class groundwater are the same as the Federal primary drinking water standards, also known as Maximum Contaminant Levels or MCLs. USEPA risk-based Regional Screening Levels (RSLs) (USEPA, 2019a) for tapwater (drinking water, or untreated groundwater used as potable water) have also been included for constituents which do not have promulgated IDEM/MCL criteria. The tapwater RSLs are based on USEPA default assumptions for residential exposure to tapwater. These sources, in the order in which they are to be used, are:

- USEPA Office of Water, Health Advisory Program. 2018 Edition of the Drinking Water Standards and Health Advisories. (USEPA, 2018a)

- USEPA. Regional Screening Levels (RSLs), May 2019. Values for tapwater. (USEPA, 2019a)

- Indiana Administrative Code Title 327 - Water Pollution Control Division. 327 IAC 2-11-6(a)(1). Health protective goals for select inorganic contaminants in untreated groundwater used as drinking water. (IWPCD, 2019a)

Screening levels for human health drinking water are provided in **Table 2**.

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. Values that address use of surface water as drinking water are the values for drinking water provided in **Table 2**. Values that address the fish consumption pathway are the federal and state values for surface water.

Where the surface water body is not within the Great Lakes System, is on the Ohio River, and is a source of public drinking water, these screening level sources, in the order in which they are to be used, are:

- Ohio River Valley Water Sanitation Commission (ORSANCO) Pollution Control Standards for Discharges to the Ohio River. 2019 Revision. Chapter 3 Water Quality Criteria - Human Health. Human health protection criteria are protective of drinking water, recreational, and fish consumption uses. (ORSANCO, 2019)
- USEPA Ambient Water Quality Criteria (AWQC) for Human Health Consumption of Organisms. (USEPA, 2019b)
- Indiana Administrative Code Title 327 - Water Pollution Control Division. Active Projects. Proposed revisions to Indiana's Aquatic Life and Human Health Ambient Water Quality Criteria for metals. Revisions are proposed to reflect updates to National Recommended Water Quality Criteria (NRWQC) at Section 304(a) of the Clean Water Act (CWA). The proposed revisions are to 327 IAC 2-1-6 Minimum Surface Water Quality Standards for metals in Indiana waters not within the Great Lakes System, for consumption of organisms. (IN.gov, 2019; 2017)
- Indiana Administrative Code Title 327 - Water Pollution Control Division. Article 2. Water Quality Standards. Rule 1. Water Quality Standards Applicable to All State Waters Except Waters Within the Great Lakes System. 327 IAC 2-1-6 Minimum Surface Water Quality Standards (current/ promulgated surface water quality standards), for consumption or organisms. (IWPCD, 2019b)

If values from the above surface water sources are not published for a given constituent, then the selected drinking water screening level from Section 4.2.1 is used.

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 more realistic than screening levels and, therefore, are useful for evaluating whether constituents 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 Ohio 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 Ohio 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 the RBSL calculated for a target cancer-based risk of 10^{-4}. 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 at or below screening levels will not result in any adverse effects to survival, growth and/or reproduction. Concentrations above published ecological 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 published ecological 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 IDEM 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). The following criteria are used to evaluate the levels of metals in off-site surface water, in the order in which they were used:

- Ohio River Valley Water Sanitation Commission (ORSANCO) Pollution Control Standards for Discharges to the Ohio River. 2019 Revision. Chapter 3 Water Quality Criteria - Aquatic life. Aquatic Life criteria are protective of maintaining fish and other aquatic life. (ORSANCO, 2019).
- USEPA AWQC Freshwater Chronic and Acute. (USEPA, 2019d)
- Planned Revisions to Metals Criteria for the Protection of Aquatic Life and Human Health. IDEM Aquatic Life Criterion Applicable to All State Waters Except Waters of the State Within the Great Lakes System; acute aquatic criterion (AAC) and chronic aquatic criterion (CAC). (IN.gov, 2019; 2017).
- Current (promulgated) IDEM Aquatic Life Criterion Applicable to All State Waters Except Waters of the State Within the Great Lakes System; AAC and CAC. Indiana Administrative Code Title 327 Water Pollution Control Division. (IWPCD, 2019b)
- USEPA Region 5 Resource Conservation and Recovery Act (RCRA) Ecological Screening Levels, Archive Document. (USEPA, 2003)

4.2.5 Selected Screening Levels

Table 5 presents the selected human health and ecological screening levels (from **Tables 1 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 2019 "Annual Groundwater Monitoring and Corrective Action Report" for FBC East Ash Pond [*https://www.vectren.com/assets/downloads/planning/ccr/Culley%20East%20Ash%20Pond%20Annual%20Ground%20Water%20Report%202019.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

SIGECO 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 SIGECO's website per the CCR Rule. The statistical analysis of the data has indicated an SSI for samples collected from monitoring wells CCR-AP-3, CCR-AP-4, CCR-AP-5, CCR-AP- 6, and CCR-AP-8 (see **Figure 1**) that monitor the shallow alluvial aquifer. Analytes exhibiting an SSI are a subset of the parameters identified in Section 4: arsenic and molybdenum. The Appendix III statistical analysis results, followed by an unsuccessful Alternate Source Demonstration, moved the groundwater sampling into the Assessment Monitoring phase.

Groundwater data from eleven 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 the EAP and, therefore, provide worst-case groundwater results. Based on the assessment monitoring results, concentrations of only two (2) constituents, arsenic and molybdenum, of the 15 Appendix IV constituents analyzed in the downgradient 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. An arsenic alternative source demonstration (ASD) determined that the alternate source for arsenic in downgradient groundwater wells from the EAP is the naturally occurring fine-grained alluvium soils and, therefore, the corrective measures assessment is focused solely on molybdenum.

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 immediately adjacent to the base of the ash management area, and the facility has been in operation for over 60 years. Out of the 912 groundwater analyses conducted, only 128 results are above the GWPS (see **Table 1**). Put another way, approximately 86% of the groundwater results for the

CCR Rule monitoring wells located at the edge of the EAP (CCR-AP-2 through CCR-AP-6 and CCR-AP-8) 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 results identified under the CCR Rule, there is no complete drinking water exposure pathway to groundwater. Without the complete drinking water exposure pathway, the risk is negated.

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 the EAP 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

FBC is located on the Ohio River – a major river system with a massive and rapid river flow. This section illustrates how the groundwater – which is a fraction of the volume and flow rate of the river – may interact with the Ohio River under an assumed set of criteria and conditions (see **Attachment B**). Such an exercise in assumptions can help put in context whether a theoretical risk to river water and its uses exists. Because of the intermittent dry nature of the creek, a DAF for Little Pigeon Creek was not calculated.

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 Ohio River is a large river system in North America and as depicted on **Table 6** and **Attachment B**, and as groundwater flows into the river, it is diluted by more than 18,000 times.

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 human and ecological uses of surface water, as shown in the table below.

This evaluation is not limited to only those constituents for which SSIs or 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 part per million.

The table identifies the maximum groundwater concentration of each constituent detected in the EAP 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 arsenic and molybdenum would need to be more than 1,500 and more than 4,000 times higher, respectively, 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 for Ohio River		**18,000**			
Constituents	**Lowest of the Human Health and Ecological Screening Levels (mg/L)**	**Target Groundwater Screening Level - Ohio River (mg/L)***	**Maximum Groundwater Concentration (mg/L)**		**Ratio Between Target Groundwater Screening Level and the Maximum Groundwater Concentration**
Detection Monitoring - EPA Appendix III Constituents					
Boron	4	72,000	68	CCR-AP-5	>1,000
Fluoride	1	18,000	1.4	CCR-AP-5	>12,000
Assessment Monitoring - EPA Appendix IV Constituents					
Antimony	0.0056	101	0.002	CCR-AP-2	>50,000
Arsenic	0.000175	180	0.12	CCR-AP-6	>1,500
Barium	0.22	3,960	0.78	CCR-AP-4	>5,000
Beryllium	0.000068	21	0.0027	CCR-AP-2	>7,500
Cadmium	0.00025	4	0.0012	CCR-AP-5	>3,500
Chromium (Total)	0.074	1,334	0.082	CCR-AP-2	>16,000
Cobalt	0.006	108	0.038	CCR-AP-2	>2,500
Lead	0.0025	45	0.051	CCR-AP-2	>800
Lithium	0.04	720	0.15	CCR-AP-5	>4,500
Mercury	0.000012	0.2	0.2 U		NA
Molybdenum	0.1	1,800	0.41	CCR-AP-5	>4,000
Selenium	0.0031	56	0.0044	CCR-AP-2	>12,00
Thallium	0.00024	4	0.00099	CCP-AP-2	>4,000
Radiological Constituent		**(pCi/L)**	**(pCi/L)**		**(pCi/L)**
Radium	4	72,000	5.93 ± 1.6	CCP-AP-6	>9,500

*** 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 the EAP 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 ecological receptors from constituents present in groundwater resulting from coal ash management practices at the East Ash Pond at the F.B Culley Generating Station.

8. References

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TABLES

TABLE 1
COMPARISON OF EAST ASH POND GROUNDWATER MONITORING RESULTS TO SITE GROUNDWATER PROTECTION STANDARDS –
JUNE 2016 THROUGH AUGUST 2018 SAMPLING EVENTS
SOUTHERN INDIANA GAS AND ELECTRIC COMPANY
F.B. CULLEY GENERATING STATION
NEWBURGH, INDIANA

Monitoring Well ID		Date Sampled	pH (lab)	Chloride	Fluoride	Sulfate	Total Dissolved Solids	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	Radium-226 & 228
			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	pCi/L	pCi/L	pCi/L
Site GWPS (a)			NA	NA	4	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	NA
Upgradient	CCR-AP-1	06/10/2016	7.74 J	19	0.81	180 J-	740	0.002 U	0.0045	0.077	0.00053 J	0.51	0.001 U	53	0.011	**0.0081**	0.0074	**0.045 J**	0.0002 U	0.015	0.00071 J	0.000082 J	0.607 J ± 0.204	0.344 U ± 0.659	0.950 U ± 0.69
		08/12/2016	8.1 J	18	0.48	180	760	0.002 U	0.0067	0.12	0.00074 J	0.54	0.001 U	51	0.02	**0.014**	0.013	**0.053**	0.0002 U	0.013	0.0014 J	0.00012 J	3.13 ± 0.594	3.20 ± 1.39	6.32 ± 1.51
		10/28/2016	7.6 J	19 J+	0.5	110 J+	740	0.002 U	0.0024	0.05	0.00011 J	0.65	0.001 U	50 J-	0.0019 J	0.0015 J	0.0011 J	0.035 J	0.0002 U	0.006	0.005 U	0.001 U	0.353 U ± 0.558	0.509 U ± 0.505	0.862 U ± 0.753
		12/07/2016	7.7 J	19	0.55	130	710	0.00072 J	0.0036	0.081	0.00049 J	0.68 J+	0.001 U	44	0.0092	0.005	0.0057	0.035 J	0.0002 U	0.0047 J	0.00045 J	0.000079 J	1.75 U ± 1.31	0.340 U ± 1.48	2.09 U ± 1.98
		02/08/2017	7.5 J	18	0.53	140	750	0.00077 J	0.0068	0.11	0.00058 J	0.69 J+	0.000081 J	42 J-	0.012	**0.0083**	0.0083	**0.043 J**	0.0002 U	0.0073	0.005 U	0.00033 J	2.99 ± 0.678	3.58 ± 0.962	6.56 ± 1.18
		04/06/2017	7.8 J	17	0.57	150	730	0.00055 J	**0.012**	0.16	0.0014	0.62	0.00018 J	55 J+	0.03	**0.017**	**0.02 J+**	**0.063**	0.0002 U	0.0067	0.0014 J-	0.001 U	2.28 ± 0.58	4.45 ± 1.35	6.73 J ± 1.47
		06/07/2017	7.7 J	18	0.58	150	840	0.00053 J	0.008	0.11	0.00073 J	0.72 J+	0.001 U	55	0.015	**0.0088**	0.0093	**0.049 J**	0.0002 U	0.0073	0.005 U	0.00012 J	1.74 ± 0.489	3.25 ± 1.09	5.00 ± 1.19
		09/28/2017	7.7 J	18	0.49	160	770	0.0025	0.0055	0.086	0.00035 J	0.44	0.001 U	48	0.01	0.0059	0.0068	0.036 J	0.0002 U	0.008	0.005 U	0.000088 J	1.94 ± 0.553	4.52 ± 1.43	6.46 ± 1.53
		11/17/2017	7.9 J	18	0.48	170 J-	770	0.01 U	0.0075	0.15	0.0013 J	0.82 J+	0.005 U	57	0.021	**0.013**	0.014	**0.059 J**	0.0002 U	0.013 J	0.025 U	0.0014 J	3.33 ± 0.689	R	R
		06/11/2018	-	-	0.47	-	-	0.02 U	**0.029**	0.55	**0.0056 J**	-	0.01 U	-	**0.12**	**0.047**	**0.063**	**0.17**	0.0002 U	0.01 J	0.05 U	0.001 J	2.01 ± 0.674	2.14 ± 0.626	4.15 ± 0.92
		08/28/2018	7.8 J	11	0.47	150	820	0.02 U	**0.023**	0.47	0.0033 J	0.61 J	0.01 U	47	**0.13**	**0.036**	**0.049**	**0.13**	-	0.0077 J	0.05 U	0.00094 J	2.42 ± 0.633	2.65 ± 1.05	5.07 ± 1.23
	CCR-AP-7	06/10/2016	7.37 J	31	R	93 J-	590	0.002 U	0.0025	0.1	0.001 U	0.034 J+	0.001 U	86	0.00048 J	0.0012	0.00062 J	0.01 J	0.0002 U	0.0082	0.00035 J	0.001 U	0.330 J ± 0.0973	0.166 U ± 0.267	0.496 ± 0.284
		08/12/2016	7.9 J	26	0.24	73	580	0.002 U	0.0048	0.12	0.001 U	0.034 U	0.001 U	88	0.00047 J	0.0023	0.00099 J	0.011 J	0.0002 U	0.0054	0.005 U	0.001 U	0.390 ± 0.118	0.625 J ± 0.344	1.02 J ± 0.363
		10/28/2016	7.1 J	25 J+	0.25	66 J+	530	0.002 U	0.0084	0.16	0.00017 J	0.02 J+	0.001 U	120 J-	0.0026	0.0053 J	0.0082 J	0.02 J	0.0002 U	0.0044 J	0.00073 J	0.00008 J	1.28 ± 0.664	0.434 U ± 0.433	1.72 J ± 0.792
		12/07/2016	7.4 J	26	0.37 J+	96	620	0.00016 J	0.0083	0.14	0.00012 J	0.071 U	0.001 U	99	0.0039	0.0037	0.0036	0.012 J	0.0002 U	0.0088	0.005 U	0.000066 J	0.439 U ± 0.399	0.558 U ± 0.451	0.997 ± 0.602
		02/08/2017	7.4 J	25	0.28 J+	110	630	0.00062 J	**0.018**	0.19	0.00075 J	0.034 U	0.00032 J	150 J-	0.019	**0.015**	**0.02**	0.039 J	0.0002 U	0.013	0.005 U	0.00061 J	0.744 ± 0.22	0.365 U ± 0.252	1.11 J ± 0.335
		04/06/2017	7.3 J	27	0.29	110	640	0.002 U	0.008	0.15	0.00022 J	0.08 U	0.00014 J	110 J+	0.0048	0.0054	0.0087 J+	0.019 J	0.0002 U	0.0058	0.005 UJ	0.001 U	0.719 ± 0.182	0.830 ± 0.427	1.55 ± 0.464
		06/07/2017	7.3 J	28	0.34	100	620	0.002 U	0.0075	0.15	0.00015 J	0.15 U	0.001 U	100	0.0039 J+	0.0032	0.0041	0.019 J	0.0002 U	0.0069	0.005 U	0.000088 J	0.398 ± 0.129	0.895 ± 0.413	1.29 ± 0.433
		09/28/2017	7.3 J	29	0.19	82	570	0.002 U	0.0058	0.12	0.001 U	0.056 J	0.001 U	94	0.002 U	0.00054	0.001 U	0.01 J	0.0002 U	0.0036 J	0.005 U	0.001 U	0.308 ± 0.095	R	R
		11/17/2017	7.2 J	31	0.25	77 J-	550	0.002 U	0.0034	0.11	0.001 U	0.091 U	0.001 U	96	0.002 U	0.0003 J	0.001 U	0.012 J	0.0002 U	0.0028 J	0.005 U	0.001 U	0.312 ± 0.0954	R	R
		06/11/2018	-	-	0.31	-	-	0.002 U	0.0071	0.14	0.001 U	-	0.001 U	-	0.0014 U	0.00065	0.00041 J	0.011	0.0002 U	0.0025 J	0.005 U	0.001 U	0.480 ± 0.216	0.0986 U ± 0.257	0.579 J ± 0.336
		08/28/2018	7.5 J	27	0.31	70	580	0.002 U	0.0064	0.14	0.000067 J	0.08 U	0.001 U	100	0.0061 J+	0.0014	0.0014	0.013	-	0.0026 J	0.005 U	0.001 U	R	0.307 U ± 0.231	R
	CCR-AP-9	03/09/2017	7.5 J	23	0.14	130	550	0.0044	0.0031	0.13	0.00017 J	0.2	0.000079 J	92	0.0042	**0.0062**	0.0025	0.03 J	0.0002 U	0.011	0.0058	0.001 U	R	0.401 U ± 0.915	0.934 UJ ± 0.938
		04/07/2017	7.4 J	21	0.36	120	610	0.0014 J	0.006	0.23	0.00053 J	0.23	0.000095 J	110 J+	0.0088	**0.012**	0.0073 J+	0.033 J	0.0002 U	0.0097	0.005 UJ	0.001 U	1.62 ± 0.47	1.61 ± 0.989	3.23 J ± 1.1
		04/26/2017	7.5 J	21	0.35	120	590	0.0012 J	0.008	0.23	0.00066 J	0.26 J+	0.00011 J	110	0.012	**0.013**	0.0069	0.04 J	0.0002 U	0.0071	0.005 U	0.000098 J	1.91 ± 0.393	2.11 ± 0.815	4.02 ± 0.905
		05/30/2017	7.7 J	19	0.33	110	600	0.0011 J	0.01	0.27	0.00092 J	0.26	0.00015 J	120	0.014	**0.013**	0.012	0.04 J	0.0002 U	0.0065	0.005 U	0.00018 J	0.614 ± 0.173	0.619 U ± 0.412	1.23 J ± 0.447
		06/08/2017	7.6 J	20	0.42	110	600	0.0014 J	0.0077	0.21	0.00047 J	0.29 U	0.00011 J	120	0.0088	**0.0096**	0.0056	0.034 J	0.0002 U	0.0059	0.005 U	0.0001 J	1.43 ± 0.332	2.06 ± 0.67	3.49 ± 0.747
		07/25/2017	7.4 J	19	0.3	90	650	0.002 U	0.01	0.28	0.0011	0.25	0.00022 J	130	0.02	**0.014**	0.011	**0.048 J**	0.0002 U	0.0059	0.005 U	0.00016 J	0.962 ± 0.286	0.644 ± 0.422	1.61 ± 0.51
		08/15/2017	7.5 J	18	0.33	110	600	0.00078 J	0.0087	0.24	0.00073 J	0.22	0.00014 J	130	0.013	**0.016**	0.0098	0.036 J	0.0002 U	0.0027 J	0.0014 J	0.00011 J	1.68 ± 0.304	R	R
		09/28/2017	7.5 J	17	0.3	120	620	0.002 U	0.0058	0.21	0.00017 J	0.29	0.001 U	110	0.0067	**0.0072**	0.0033	0.029 J	0.0002 U	0.0043 J	0.005 U	0.001 U	2.05 ± 0.533	1.47 U ± 0.995	3.52 J+ ± 1.13
		11/17/2017	7.4 J	16	0.36	120 J-	620	**0.0079 J+**	0.0088	0.29	0.00095 J	0.34 U	0.005 U	130	0.019	**0.015**	0.0098	**0.05 J**	0.0002 U	0.0069 J	0.025 U	0.00062 J	1.38 ± 0.3	R	R
		06/11/2018	-	-	0.37	-	-	0.0012 J	0.0091	0.32	0.001	-	0.00017 J	-	0.025	**0.013**	0.011	**0.048**	0.0002 U	0.0048 J	0.0011 J	0.00021 J	1.18 ± 0.397	0.108 U ± 0.374	1.29 J ± 0.545
		08/28/2018	7.2 J	9.3	0.34	99	650	0.02 U	**0.032**	0.72	**0.0041 J**	0.34 J	0.01 U	190	**0.15**	**0.047**	**0.041**	**0.12**	-	0.012 J	0.0099 J	0.00098 J	1.35 J ± 0.32	1.25 ± 0.619	2.60 J ± 0.697
Downgradient	CCR-AP-2	06/10/2016	7.26 J	72	0.16 J+	530 J-	1700	0.002	0.0018	0.055	0.00014 J	15	0.00055 J	200	0.0035	**0.0073**	0.0023	0.05 U	0.0002 U	0.0018 J	0.00044 J	0.000048 J	0.222 J ± 0.145	0.542 U ± 0.572	0.764 U ± 0.59
		08/12/2016	7.4 J	73	0.28	730	1700	0.002 U	0.0016	0.038	0.00015 J	12	0.00023 J	230	0.003	**0.0096**	0.0028	0.05 U	0.0002 U	0.00099 J	0.00076 J	0.000048 J	1.22 ± 0.355	1.09 U ± 1.02	2.32 ± 1.08
		10/28/2016	6.7 J	73 J+	0.23	540 J+	1600	0.002 U	0.0044	0.09	0.00066 J	11	0.00053 J	220 J-	0.013	**0.016 J**	0.0096 J	0.017 J	0.0002 U	0.0014 J	0.0013 J	0.00014 J	0.731 ± 0.526	0.648 U ± 0.534	1.38 J ± 0.75
		12/07/2016	6.8 J	75	0.3 J+	680	1600	0.00024 J	0.003	0.14	0.00056 J	12	0.00048 J	240	0.011	**0.012**	0.006	0.05 U	0.0002 U	0.0015 J	0.005 U	0.00016 J	2.01 ± 1.16	0.707 U ± 1.12	2.72 J ± 1.61
		02/08/2017	7 J	83	0.26 J+	570	1500	0.002 U	0.0035	0.12	0.00038 J	12	0.00038 J	260 J-	0.0084	**0.014**	0.0057	0.01 J	0.0002 U	0.0017 J	0.005 U	0.00017 J	0.672 ± 0.334	1.00 ± 0.596	1.68 ± 0.684
		04/06/2017	6.8 J	89	0.29	600	1600	0.002 U	0.0018	0.052	0.00032 J	12	0.00011 J	240 J+	0.0037	**0.011**	0.0026 J+	0.05 U	0.0002 U	0.00094 J	0.005 UJ	0.001 U	1.03 ± 0.385	1.44 ± 0.934	2.47 J ± 1.01
		06/07/2017	6.8 J	81	0.3 J	510	1600	0.002 U	0.0066	0.27	0.00099 J	12	0.00078 J	240	0.025	**0.021**	**0.016**	0.023 J	0.0002 U	0.0024 J	0.005 U	0.00026 J	0.894 ± 0.361	2.40 ± 1.07	3.29 ± 1.13
		09/28/2017	6.9 J	110	0.28	610	1700	0.0017 J	**0.017**	0.44	0.0027	7.8	0.00073 J	220	0.056	**0.038**	**0.051**	0.023 J	0.0002 U	0.0051	0.0044 J	0.00068 J	0.730 ± 0.327	1.18 U ± 1.06	1.91 J+ ± 1.11
		11/17/2017	7 J	120	0.11	680 J-	1600	0.01 U	0.0066	0.17	0.0012 J	14	0.005 U	260	0.021	**0.018**	0.012	0.25 U	0.0002 U	0.004 J	0.025 U	0.00079 J	0.266 ± 0.151	0.585 U ± 0.5	0.850 J+ ± 0.522
		06/11/2018	-	-	0.28	-	-	0.002 U	**0.013**	0.27	0.0021	-	0.00089 J	-	0.042	**0.023**	**0.03**	0.033	0.0002 U	0.003 J	0.0026 J	0.00048 J	0.597 ± 0.32	0.294 U ± 0.337	0.891 J ± 0.465
		08/28/2018	6.9 J	150	0.25	510	1500	0.02 U	**0.021**	0.52	0.002 J	9.6	0.01 U	220	0.082	**0.029**	**0.035**	**0.057**	-	0.0056 J	0.05 U	0.00099 J	R	0.880 ± 0.51	R
	CCR-AP-3	06/10/2016	7.17 J	26	0.1 U	1.3 J-	1000	0.002 U	**0.058**	0.41	0.001 U	0.18	0.001 U	160	0.0021	**0.0094**	0.00041 J	0.05 U	0.0002 U	0.011	0.0015 J	0.001 U	0.657 J ± 0.201	1.10 ± 0.581	1.75 ± 0.615
		08/15/2016	7.6 J	26	0.93	R	1000	0.002 U	**0.072**	0.38	0.001 U	0.15 J+	0.001 U	170	0.0018 J	**0.008**	0.00039 J	0.05 U	0.0002 U	0.014	0.00062 J	0.001 U	0.865 ± 0.232	0.784 U ± 0.583	1.65 ± 0.627
		10/28/2016	7 J	27 J+	0.31	1.1 J+	1000	0.002 U	**0.071**	0.4	0.001 U	0.16	0.001 U	190 J-	0.002	**0.0076 J**	0.001 UJ	0.05 U	0.0002 U	0.014	0.0018 J	0.001 U	1.15 ± 0.477	0.819 ± 0.347	1.97 ± 0.589
		12/07/2016	7.2 J	26	0.5	1 U	970	0.00031 J	**0.068**	0.43	0.001 U	0.17 J+	0.001 U	190	0.0023	**0.007**	0.00066 J	0.05 U	0.0002 U	0.014	0.0019 J	0.001 U	0.789 ± 0.398	0.932 ± 0.48	1.72 ± 0.623
		02/08/2017	7.2 J	23	0.39	0.67 J	1000	0.002 U	**0.086**	0.46	0.001 U	0.18 J+	0.001 U	190 J-	0.002	**0.0072**	0.00035 J	0.05 U	0.0002 U	0.013	0.002 J	0.001 U	0.373 U ± 0.293	0.489 U ± 0.614	0.862 U ± 0.68
		04/06/2017	7.1 J	25	0.57	1 U	1000	0.002 U	**0.08**	0.42	0.001 U	0.2	0.001 U	180 J+	0.0021	**0.0063**	0.00048 J+	0.05 U	0.0002 U	0.011	0.0018 J-	0.001 U	0.450 ± 0.144	0.644 ± 0.344	1.09 ± 0.373
		06/07/2017	7.2 J	25	0.55	0.56 J	1200	0.002 U	**0.077**	0.44	0.001 U	0.27 U	0.001 U	200	0.002 U	**0.0062**	0.001 U	0.05 U	0.0002 U	0.012	0.0018 J	0.001 U	0.582 ± 0.158	1.25 ± 0.427	1.83 ± 0.456
		09/28/2017	7.1 J	25	0.45	0.48 J	1000	0.00058 J	**0.066**	0.39	0.001 U	0.12	0.001 U	180	0.002 U	0.0057	0.00098 J	0.05 U	0.0002 U	0.01	0.0016 J	0.001 U	0.411 ± 0.136	R	R
		11/17/2017	7.4 J	25	0.14	0.82 J-	970	0.002 U	**0.067**	0.4	0.001 U	0.19 U	0.001 U	190	0.0021	0.0056	0.00051 J	0.05 U	0.0002 U	0.011	0.0017 J	0.0001 J	0.626 ± 0.162	R	R
		06/11/2018	-	-	0.56	-	-	0.002 U	**0.08**	0.47	0.001 U	-	0.001 U	-	0.0041 J+	0.0052	0.00092 J	0.005 U	0.0002 U	0.0099	0.0023 J	0.001 U	0.475 ± 0.329	0.292 U ± 0.375	0.768 J ± 0.499
		08/28/2018	7.3 J	12	0.33	1 U	1000	0.002 U	**0.071**	0.43	0.001 U	0.14	0.001 U	180	0.0041 J+	0.0046	0.00078 J	0.005 U	-	0.0096	0.0021 J	0.001 U	R	0.946 ± 0.416	1.70 J+ ± 0.463
	CCR-AP-4	06/10/2016	6.95 J	25	0.29 J+	20 J-	1000	0.002 U	**0.036**	0.52	0.00049 J	0.16	0.00018 J	160	0.012	**0.0078**	0.0099	0.01 J	0.0002 U	0.0022 J	0.0018 J	0.000084 J	1.07 J ± 0.261	0.417 U ± 0.723	1.49 ± 0.769
		08/12/2016	7.3 J	24	0.43	R	1000	0.002 U	**0.065**	0.75	0.00033 J	0.16 J+	0.00018 J	190	0.0081	**0.0071**	0.0063	0.0096 J	0.0002 U	0.0025 J	0.0016 J	0.000061 J	1.53 ± 0.429	1.37 U ± 1.43	2.90 ± 1.49
		10/28/2016	6.7 J	85 J+	0.3	15 J+	890	0.002 U	**0.05**	0.63	0.00025 J	0.18	0.001 U	170 J-	0.0037	0.0045 J	0.0057 J	0.014 J	0.0004 U	0.0011 J	0.0011 J	0.00011 J	1.54 ± 0.683	0.864 ± 0.448	2.40 ± 0.816
		12/07/2016	7 J	70	0.49	3.9 J+	880	0.0004 J	**0.045**	0.61	0.00046 J	0.16 J+	0.00023 J	160	0.014	**0.0086**	0.011	0.0098 J	0.0002 U	0.002 J	0.00098 J	0.00015 J	2.11 ± 1.11	2.17 ± 1.34	4.28 ± 1.74
		02/08/2017	6.9 J	49	0.32 J+	1 U	900	0.002 U	**0.086**	0.64	0.00014 J	0.14 U	0.001 U	180 J-	0.0026	0.0039	0.0018	0.05 U	0.0002 U	0.00093 J	0.005 U	0.000063 J	0.984 ± 0.383	1.03 ± 0.62	2.01 ± 0.728
		04/06/2017	6.7 J	48	0.36	1 U	960	0.002 U	**0.086**	0.63	0.00015 J	0.17	0.001 U	180 J+	0.0028	0.0045	0.0018 J+	0.05 U	0.0002 U	0.00092 J	0.005 UJ	0.001 U	0.789 ± 0.227	0.370 U ± 0.488	1.16 J ± 0.538
		06/08/2017	6.7 J	46	0.46	0.64 J	1000	0.002 U	**0.086**	0.66	0.00026 J	0.18 U	0.00014 J	190	0.0066	**0.0068**	0.0045	0.05 U	0.0002 U	0.0014 J	0.005 U	0.000061 J	1.60 ± 0.408	2.00 ± 0.818	3.60 ± 0.914
		09/29/2017	6.8 J	41	0.35	0.63 J	980	0.00066 J	**0.081**	0.58	0.00017 J	0.085	0.00016 J	170	0.0076	0.0055	0.0048	0.05 U	0.0002 U	0.0016 J	0.005 U	0.001 U	1.26 ± 0.397	R	R
		11/17/2017	7.1 J	40	0.35	1.1 J-	910	0.002 U	**0.083**	0.57	0.00028 J	0.14 U	0.001 U	180	0.01	**0.0064**	0.0046	0.05 U	0.0002 U	0.0022 J	0.005 U	0.00012 J	1.15 ± 0.266	R	R
		06/11/2018	-	-	0.41	-	-	0.002 U	**0.027**	0.45	0.001 U	-	0.001 U	-	R	0.002	0.00052 J	0.0029 J	0.0002 U	0.0012 J	0.0009 J	0.001 U	0.830 ± 0.366	0.458 U ± 0.313	1.29 J ± 0.482
		08/28/2018	6.8 J	16	0.29	2.6	950	0.002 U	**0.11**	0.78	0.00084 J	0.1	0.00048 J	190	0.028	**0.013**	**0.021**	0.019	-	0.0033 J	0.0016 J	0.00026 J	2.47 ± 0.635	1.06 U ± 0.934	3.53 J ± 1.13

TABLE 1
COMPARISON OF EAST ASH POND GROUNDWATER MONITORING RESULTS TO SITE GROUNDWATER PROTECTION STANDARDS –
JUNE 2016 THROUGH AUGUST 2018 SAMPLING EVENTS
SOUTHERN INDIANA GAS AND ELECTRIC COMPANY
F.B. CULLEY GENERATING STATION
NEWBURGH, INDIANA

Monitoring Well ID		Date Sampled	pH (lab)	Chloride	Fluoride	Sulfate	Total Dissolved Solids	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	Radium-226 & 228
			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	pCi/L	pCi/L	pCi/L
Site GWPS (a)			NA	NA	4	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	NA
Downgradient	CCR-AP-5	06/10/2016	7.09 J	880	0.58	2.5 UJ	4600	0.02 U	0.01 U	0.032 J	0.01 U	53	0.01 U	520	0.02 U	**0.0069**	0.01 U	**0.14**	0.0002 U	**0.38**	0.05 U	0.01 U	0.224 J ± 0.0858	0.550 ± 0.3	0.774 ± 0.313
		08/12/2016	7.4 J	750	0.99	1500	4400	0.002 U	0.00059 J	0.03	0.001 U	54	0.00016 J	480	0.002 U	**0.0063**	0.001 U	**0.13**	0.0002 U	**0.37**	0.005 U	0.001 U	0.106 U ± 0.0753	0.523 ± 0.33	0.629 ± 0.338
		10/28/2016	7 J	860 J+	1.1	1600 J+	4000	0.002 U	0.00065 J	0.034	0.001 U	68	0.00015 J	550 J-	0.002 U	**0.0065 J**	0.001 UJ	**0.15**	0.0002 U	**0.41**	0.005 U	0.001 U	0.449 U ± 0.338	0.462 U ± 0.35	0.911 ± 0.486
		12/07/2016	7 J	860	1.3	1700	4200	0.000058 J	0.00073 J	0.036	0.00096 J	64	0.001 U	570	0.002 U	**0.0061**	0.001 U	**0.13**	0.0002 U	**0.39**	0.005 U	0.001 U	0.0176 U ± 0.286	0.714 ± 0.438	0.732 J ± 0.524
		02/08/2017	7.2 J	780	0.98	1500	4000	0.002 U	0.0015	0.046	0.00019 J	59	0.0012	580 J-	0.002 U	**0.007**	0.001 U	**0.15**	0.0002 U	**0.39**	0.005 U	0.000065 J	0.0782 U ± 0.217	0.562 U ± 0.517	0.640 U ± 0.561
		04/07/2017	7 J	880	0.96	1900	4200	0.002 U	0.00039 J	0.034	0.00058 J	56	0.0004 J	550 J+	0.002 U	**0.0063**	0.001 U	**0.15**	0.0002 U	**0.33**	0.005 UJ	0.001 U	0.186 ± 0.0813	0.209 U ± 0.227	0.396 J ± 0.241
		06/08/2017	7.1 J	560	1.1	1400	4200	0.002 U	0.00042 J	0.036	0.00017 J	58	0.00037 J	510	0.002 U	0.0053	0.001 U	**0.11**	0.0002 U	**0.3**	0.005 U	0.001 U	0.193 ± 0.0924	1.01 ± 0.357	1.21 ± 0.369
		09/28/2017	7 J	640	0.76 J	1400	3300	0.002 U	0.00084 J	0.041	0.00047 J	33	0.00075 J	470	0.002 U	0.0041	0.001 U	**0.099**	0.0002 U	**0.21**	0.005 U	0.00016 J	0.184 ± 0.0749	R	R
		11/17/2017	7 J	770	1	1600 J-	3500	0.002 U	0.00039 J	0.038	0.001 U	52	0.00035 J	510	0.002 U	0.0046	0.001 U	**0.12**	0.0002 U	**0.24**	0.005 U	0.00018 J	0.250 ± 0.0868	0.234 U ± 0.238	0.483 J+ ± 0.253
		06/11/2018	-	-	1.4	-	-	0.002 U	R	0.068	0.001 U	-	0.00057 J	-	0.0014 U	0.0028	0.000099 J	**0.11**	0.0002 U	**0.39**	0.005 U	0.001 U	0.261 ± 0.167	0.213 U ± 0.216	0.474 J ± 0.273
		08/28/2018	7.2 J	340	1.3	1200	2700	0.002 U	0.001 U	0.033	0.001 U	41	0.00024 J	320	0.002 U	0.0028	0.001 U	**0.094**	-	**0.37**	0.005 U	0.001 U	R	0.252 U ± 0.311	R
	CCR-AP-6	06/10/2016	7.35 J	40	0.43	0.57 J-	1100	0.002 U	**0.04**	0.51	0.001 U	1.1	0.001 U	180	0.0031	0.0042	0.0021	0.05 U	0.0002 U	0.02	0.001 J	0.001 U	0.652 J ± 0.142	0.543 ± 0.293	1.20 ± 0.325
		08/12/2016	7.8 J	39	0.67	R	1100	0.002 U	**0.059**	0.58	0.00026 J	0.83	0.00016 J	190	0.0092	**0.0095**	0.0071	0.05 U	0.0002 U	0.018	0.0014 J	0.000047 J	1.32 ± 0.278	0.811 U ± 0.725	2.13 ± 0.776
		10/28/2016	7.2 J	38 J+	0.42	0.98 J+	1000	0.002 U	**0.06**	0.55	0.00011 J	0.74	0.001 U	190 J-	0.005	**0.0075 J**	0.0035 J	0.05 U	0.0002 U	0.021	0.0015 J	0.001 U	1.38 ± 0.686	0.663 U ± 0.532	2.05 J ± 0.868
		12/07/2016	7.3 J	36	0.62	1 U	1000	0.00048 J	**0.067**	0.62	0.00036 J	0.79 J+	0.00029 J	190	0.015	**0.01**	0.01	0.05 U	0.0002 U	0.024	0.0014 J	0.0001 J	-0.236 U ± 0.919	1.58 U ± 1.55	1.58 U ± 1.8
		02/08/2017	7.4 J	42	0.5	0.67 J	1000	0.00047 J	**0.11**	0.61	0.00025 J	0.89 J+	0.00027 J	200 J-	0.011	**0.009**	0.0079	0.05 U	0.0002 U	0.03	0.005 U	0.000063 J	0.929 ± 0.371	0.755 U ± 0.581	1.68 J ± 0.69
		04/06/2017	7.2 J	46	0.45	0.5 J	1100	0.002 U	**0.11**	0.64	0.00024 J	2.2	0.00019 J	210 J+	0.0098	**0.0069**	0.0074 J+	0.05 U	0.0002 U	0.024	0.0018 J-	0.001 U	0.730 ± 0.221	0.455 U ± 0.438	1.19 J ± 0.49
		06/07/2017	7.3 J	40	0.63	1.1	1200	0.00059 J	**0.096**	0.6	0.00042 J	1.3 J+	0.00024 J	200	0.014	**0.011**	0.0096	0.011 J	0.0002 U	0.026	0.0014 J	0.00009 J	2.33 ± 0.648	3.61 ± 1.47	5.93 ± 1.6
		09/29/2017	7.3 J	38	0.55	0.71 J	1100	0.0014 J	**0.089**	0.55	0.00039 J	0.44	0.00052 J	180	0.02	**0.012**	0.014	0.05 U	0.0002 U	0.033	0.0023 J	0.00013 J	0.815 ± 0.227	R	R
		11/17/2017	7.6 J	42	0.24	0.74 J-	1000	0.01 U	**0.081**	0.49	0.005 U	2.1 J+	0.00039 J	180	0.014	**0.0087**	0.011	0.25 U	0.0002 U	0.027	0.025 U	0.005 U	0.695 ± 0.171	R	R
		06/11/2018	-	-	0.6	-	-	0.0012 J	**0.12**	0.69	0.00065 J	-	0.00051 J	-	0.029	**0.014**	**0.02**	0.016	0.0002 U	0.033	0.0023 J	0.00022 J	1.15 ± 0.384	1.12 ± 0.415	2.27 ± 0.565
		08/28/2018	7.4 J	19	0.42	1.1	1000	0.002 U	**0.1**	0.64	0.00046 J	0.51	0.0005 J	190	0.031	**0.013**	**0.02**	0.014	-	0.031	0.0019 J	0.0002 J	1.71 J ± 0.551	0.929 U ± 1.02	2.64 J ± 1.16
	CCR-AP-8	03/09/2017	7.2 J	21	0.13	37	1400	0.0018 J	**0.044**	0.57	0.001 U	0.037 J	0.001 U	300	0.0012 J	**0.015**	0.00058 J	0.05 U	0.0002 U	0.014	0.005 U	0.001 U	0.893 ± 0.233	1.07 U ± 1.02	1.96 J ± 1.04
		04/06/2017	6.9 J	19	0.35	16	1400	0.00066 J	**0.052**	0.59	0.001 U	0.08 U	0.001 U	320 J+	0.0022	**0.012**	0.0011 J+	0.05 U	0.0002 U	0.015	0.0017 J-	0.001 U	1.34 ± 0.31	0.677 ± 0.435	2.01 ± 0.534
		04/26/2017	7 J	18	0.28	1.6	1400	0.001 J	**0.07**	0.59	0.001 U	0.08 U	0.001 U	320	0.0019 J	**0.011**	0.00081 J	0.014 J	0.0002 U	0.014	0.0015 J	0.001 U	0.883 ± 0.196	0.778 ± 0.372	1.66 ± 0.421
		05/30/2017	7.3 J	17	0.24	6.2	1500	0.00082 J	**0.06**	0.58	0.001 U	0.034 J	0.001 U	340	0.0028	**0.011**	0.0022	0.05 U	0.0002 U	0.013	0.0017 J	0.001 U	0.720 ± 0.162	0.457 ± 0.284	1.18 ± 0.327
		06/07/2017	7 J	13	0.21 J	4 J	1500	0.0011 J	**0.076**	0.6	0.001 U	0.08 U	0.001 U	330	R	**0.011**	0.001	0.05 U	0.0002 U	0.014	0.0017 J	0.000068 J	0.721 J ± 0.211	1.60 J ± 0.556	2.32 J ± 0.594
		07/25/2017	7 J	17	0.24 J	3.8	1500	0.002 U	**0.087**	0.67	0.0002 J	0.08 U	0.001 U	350	0.0041	**0.012**	0.0025	0.05 U	0.0002 U	0.014	0.0015 J	0.000058 J	0.704 ± 0.201	0.889 U ± 0.726	1.59 J ± 0.754
		08/15/2017	7.3 J	16	0.26	5	1400	0.0014 J	**0.095**	0.64	0.00039 J	0.08 U	0.00016 J	340	0.012	**0.017**	0.0076	0.05 U	0.0002 U	0.015	0.0022 J	0.00015 J	0.513 ± 0.143	0.316 U ± 0.305	0.829 J ± 0.337
		09/28/2017	7 J	17	0.34	2.3	1400	0.002 U	**0.087**	0.56	0.001 U	0.025 J	0.001 U	320	0.0021 J+	**0.0098**	0.0011	0.05 U	0.0002 U	0.012	0.002 J	0.001 U	0.529 ± 0.153	R	R
		11/17/2017	7 J	16	0.4	1.9 J-	1300	0.002 U	**0.083**	0.53	0.001 U	0.043 U	0.001 U	300	0.0021	**0.0082**	0.0011	0.05 U	0.0002 U	0.012	0.005 U	0.00029 J	0.640 ± 0.164	R	R
		06/11/2018	-	-	0.41	-	-	0.002 U	**0.11**	0.68	0.00022 J	-	0.001 U	-	0.0069 J+	**0.0086**	0.0033	0.0057	0.0002 U	0.013	0.0021 J	0.000083 J	0.544 ± 0.277	0.502 ± 0.319	1.05 ± 0.422
		08/28/2018	7 J	6	0.21	1.3	1300	0.002 U	**0.096**	0.58	0.00016 J	0.08 U	0.001 U	280	0.0068 J+	**0.0077**	0.0021	0.0052	-	0.012	0.0018 J	0.001 U	R	0.367 U ± 0.309	R

Notes:

Blank cells - Constituent not included in this analysis.
GW - Groundwater.
GWPS - Groundwater Protection Standard.

mg/L - milligrams per liter.
NA - Not Available.
pCi/L - picoCurie per liter.
su - Standard Units

Qualifiers:
J: Value is estimated
J-: Value is estimated, biased low
J+: Value is estimated, biased high
R: Rejected during validation
U: Not detected, value is the laboratory reporting limit

(a) - Site GWPS provided in the 2018 Transmittal of Groundwater Protection Standards - F.B. Culley Station – East Ash Pond (Haley & Aldrich, 2018).

Detected Concentration > Groundwater Protection Standard. (shown in bold)

TABLE 2
HUMAN HEALTH PUBLISHED SCREENING LEVELS FOR SURFACE WATER
SOUTHERN INDIANA GAS AND ELECTRIC COMPANY
F.B. CULLEY GENERATING STATION
NEWBURGH, INDIANA

		Human Health Published Screening Level - Drinking Water			Human Health Published Screening Level - Surface Water				Selected Published Human Health Screening Levels for Surface Water	
Constituent	CAS RN	USEPA MCL (a) (mg/L)	USEPA RSL Tap Water (b) (mg/L)	IDEM Criteria for Drinking Water Class Groundwater (c) (mg/L)	ORSANCO Human Health Water Quality Standards (d) (mg/L)	USEPA NRWQC Consumption of Organism Only (e) (mg/L)	IDEM CCC HLSC Consumption of Organism Only (proposed) (f)(g) (mg/L)	IDEM CCC HLSC Consumption of Organism Only (current) (h) (mg/L)	Selected Screening Level - Drinking Water (i) (mg/L)	Selected Screening Level - Surface Water Consumption of Organism Only (j) (mg/L)
Detection Monitoring - USEPA Appendix III Constituents (r)										
Boron	7440-42-8	NA	4	NA	NA	NA	NA	NA	4	NA
Fluoride	16984-48-8	4	0.8	4	1	NA	NA	NA	4	1
Assessment Monitoring - USEPA Appendix IV Constituents										
Antimony	7440-36-0	0.006	0.0078	0.006	0.0056	0.64	0.64	45	0.006	0.0056
Arsenic	7440-38-2	0.01	0.000052	0.01	0.01	0.0014 (m, n)	NP	0.000175 (l)	0.01	0.01
Barium	7440-39-3	2	3.8	2	1	NA	NA	NA	2	1
Beryllium	7440-41-7	0.004	0.025	0.004	NA	NA	NP	0.00117	0.004	0.00117
Cadmium	7440-43-9	0.005	0.0092	0.005	NA	NA	NP	NA	0.005	NA
Chromium (Total)	7440-47-3	0.1	22 (k)	0.1	NA (k)	NA (k)	NP (k)	3433 (k)	0.1	3433
Cobalt	7440-48-4	NA	0.006	NA	NA	NA	NA	NA	0.006	NA
Lead	7439-92-1	0.015 (o)	0.015 (o)	0.015 (o)	NA	NA	NP	NA	0.015	NA
Lithium	7439-93-2	NA	0.04	NA	NA	NA	NA	NA	0.04	NA
Mercury	7439-97-6	0.002 (p)	0.0057 (q)	0.002 (p)	0.000012	NA	0.00015	0.00015	0.002	0.000012
Molybdenum	7439-98-7	NA	0.1	NA	NA	NA	NA	NA	0.1	NA
Selenium	7782-49-2	0.05	0.1	0.05	0.17	4.2	4.2	NA	0.05	0.17
Thallium	7440-28-0	0.002	0.0002	0.002	0.00024	0.00047	0.048	0.048	0.002	0.00024
Radiological (pCi/L)										
Radium-226 & 228	7440-14-4	5	NA	5	4	NA	NA	NA	5	4

Notes:

CAS RN - Chemical Abstracts Service Registry Number.
CCC HLSC - Continuous Criterion Concentration. Human Life-Cycle Safe Concentration.
IDEM - Indiana Department of Environmental Management.
MCL - Maximum Contaminant Level.
mg/L - milligrams/liter.
NA - Not Available.
NP - (NRWQC) Not Proposed. Criteria to be deleted.
NRWQC - National Recommended Water Quality Criteria.
ORSANCO - Ohio River Valley Water Sanitation Commission.
pCi/L - picoCuries/liter.
RSL - Regional Screening Level.
USEPA - United States Environmental Protection Agency.

(a) - 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
(b) - USEPA, 2019. Regional Screening Levels (May 2019). Values for Tap Water, Hazard Index = 1.0. TR = 1E-06.
https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables

TABLE 2
HUMAN HEALTH PUBLISHED SCREENING LEVELS FOR SURFACE WATER
SOUTHERN INDIANA GAS AND ELECTRIC COMPANY
F.B. CULLEY GENERATING STATION
NEWBURGH, INDIANA

(c) - IDEM Water Quality Standards. Title 327 of the Indiana Administrative Code (IAC). Article 2. Water Quality Standards. Rule 11. Ground Water Quality Standards.
Part 327 IAC 2-11-6. Criteria for Drinking Water Class Ground Water.
http://www.in.gov/legislative/iac/T03270/A00020.PDF?

(d) - Ohio River Valley Water Sanitation Commission (ORSANCO) Pollution Control Standards for Discharges to the Ohio River. 2019 Revision.
Chapter 3 Water Quality Criteria - Human Health. Human health protection criteria are protective of drinking water, recreational, and fish consumption uses
http://www.orsanco.org/wp-content/uploads/2019/06/Final-Standards-Doc-2019-Revision.pdf

(e) - USEPA National Recommended Water Quality Criteria - Human Health Criteria Table.
USEPA NRWQC - Human Health Criterion for the Consumption of Organism Only apply to total concentrations.
https://www.epa.gov/wqc/national-recommended-water-quality-criteria-human-health-criteria-table

(f) - IDEM (IN.gov). Water Quality in Indiana. Water Quality Standards.
http://www.in.gov/idem/cleanwater/2329.htm

(g) - IDEM (IN.gov). Water Quality in Indiana. Water Quality Standards. Active Projects - Planned Revisions to Metals Criteria for the Protection of Aquatic Life and Human Health.
Second Notice of Tables of Rulemaking. IDEM is providing notice of its intent to revise Indiana's Aquatic Life and Human Health Ambient Water Quality Criteria (WQC) for metals (total recoverable).
Proposed revisions reflect updates to USEPA NRWQC at Section 304(a) of the Clean Water Act.
https://www.in.gov/idem/cleanwater/files/wqs_rulemaking_tables_second_notice.pdf

(h) - IDEM Water Quality Standards. Title 327 of the IAC. Article 2. Water Quality Standards. Rule 1. Water Quality Standards Applicable to All State Waters Except Waters of the State Within the Great Lakes
Part 327 IAC 2-1-6 Minimum Surface Water Quality Standards. Table 6-1. Surface Water Quality Standards for metals apply to total recoverable concentrations.
For carcinogenic substances, criteria are to protect human health from unacceptable cancer risk of greater than one (1) additional occurrence of cancer per one hundred thousand (100,000) populatio
http://www.in.gov/legislative/iac/T03270/A00020.PDF?

(i) - The hierarchy for selection among the Human Health Published Screening Levels for Drinking Water is:
1) USEPA MCL
2) USEPA RSL - Tap Water
3) IDEM Criteria for Drinking Water Class Groundwater

(j) - The hierarchy for selection among the Human Health Published Screening Values for Surface Water - Consumption of Organism Only is:
1) ORSANCO Human Health Water Quality Standards
2) USEPA NRWQC - Consumption of Organism Only.
3) IDEM CCC HLSC - Consumption of Organism Only (proposed).
4) IDEM CCC HLSC - Consumption of Organism Only (current).

(k) - Value for chromium (III).
(l) - Value for inorganic arsenic as arsenite, As(III). Value derived from nonthreshold cancer risk
(m) - Value for inorganic arsenic only.
(n) - This criterion adjusted to a carcinogenicity of 1E-05 risk.
(o) - Lead Action Level. This is a drinking water treatment action level applicable to regulated Community and Non-Transient Non-Community public water systems.
http://www.in.gov/idem/files/factsheet_owq_pws_lead_copper.pdf
https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=60001N8P.txt
(p) - Value for inorganic mercury.
(q) - Value for mercuric chloride.
(r) - Detection Monitoring - EPA Appendix III Constituents without health risk-based screening levels are not included.

TABLE 3
HUMAN HEALTH CALCULATED RISK BASED SCREENING LEVELS FOR SURFACE WATER
SOUTHERN INDIANA GAS AND ELECTRIC COMPANY
F.B. CULLEY GENERATING STATION
NEWBURGH, INDIANA

Constituent	CAS RN	Human Health Calculated RBSL - Recreational Use of Surface Water (c): 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)		Selected Human Health Calculated RBSL - Recreational Use of Surface Water (b) (mg/L)
Detection Monitoring - USEPA Appendix III Constituents (d)								
Boron	7440-42-8	114		120		11,200		114
Fluoride	16984-48-8	23.9		23.9		2,240		23.9
Assessment Monitoring - USEPA Appendix IV Constituents								
Antimony	7440-36-0	0.171		0.218		3.36		0.171
Arsenic	7440-38-2	0.236	(e, f)	0.389	(e, g)	16.8	(e, h)	0.236
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 - micrograms/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-4 (noncancer-based RBSL is 0.647 mg/L).
(g) - RBSL based on cancer endpoint at 1E-4 (noncancer-based RBSL is 3 mg/L).
(h) - RBSL based on noncancer endpoint (cancer-based RBSL at 1E-4 is 26.1 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
SOUTHERN INDIANA GAS AND ELECTRIC COMPANY
F.B. CULLEY GENERATING STATION
NEWBURGH, INDIANA

		Ecological Published Screening Levels - Surface Water																					
		ORSANCO Aquatic Life Criteria CMC - Freshwater (acute) (a) (mg/L)		ORSANCO Aquatic Life Criteria CCC - Freshwater (chronic) (a) (mg/L)		USEPA NRWQC Aquatic Life Criteria CMC - Freshwater (acute) (b) (mg/L)		USEPA NRWQC Aquatic Life Criteria CCC - Freshwater (chronic) (b) (mg/L)		USEPA Region 5 Ecological Screening Values (freshwater - chronic) (c) (mg/L)		IDEM AAC Aquatic Life Criterion (acute) (proposed) (d)(e) (mg/L)		IDEM CAC Aquatic Life Criterion (chronic) (proposed) (d)(e) (mg/L)		IDEM AAC Aquatic Life Criterion (acute) (current) (f) (mg/L)		IDEM CAC Aquatic Life Criterion (chronic) (current) (f) (mg/L)		Selected Ecological Screening Level (acute) (g) (mg/L)		Selected Ecological Screening Level (chronic) (g) (mg/L)	
Constituent	CAS RN	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Detection Monitoring - USEPA Appendix III Constituents (m)																							
Boron	7440-42-8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluoride	16984-48-8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Assessment Monitoring - USEPA Appendix IV Constituents																							
Antimony	7440-36-0	NA	NA	NA	NA	NA	NA	NA	NA	0.08	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.08	NA
Arsenic	7440-38-2	0.34 (i)	0.34 (i)	0.15 (i)	0.15 (i)	0.34 (i)	0.34 (i)	0.15 (i)	0.15 (i)	0.148	NA	0.34	0.34 (j)	0.15	0.15 (j)	0.36	0.36 (j)	0.19	0.19 (j)	0.34	0.34	0.15	0.15
Barium	7440-39-3	NA	NA	NA	NA	NA	NA	NA	NA	0.22 (h)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.22	NA
Beryllium	7440-41-7	NA	NA	NA	NA	NA	NA	NA	NA	0.0036	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.0036	NA
Cadmium	7440-43-9	0.0021 (k)	0.0020 (k)	0.00027 (k)	0.00025 (k)	0.0019 (k)	0.0018 (k)	0.00079 (k)	0.00072 (k)	0.00015 (h)	NA	0.0019 (k)	0.0018 (k)	0.00079 (k)	0.00072 (k)	0.0039 (k)	0.0037 (k)	0.0011 (k)	0.0010 (k)	0.0021	0.0020	0.00027	0.00025
Chromium (Total)	7440-47-3	1.8 (n)	0.57 (n)	0.086 (n)	0.074 (n)	1.8 (n)	0.57 (n)	0.086 (n)	0.074 (n)	0.042 h, n	NA	1.8 (n)	0.57 (n)	0.086 (n)	0.074 (n)	1.7 (n)	0.55 (n)	0.21 (n)	0.18 (n)	1.8	0.57	0.086	0.074
Cobalt	7440-48-4	NA	NA	NA	NA	NA	NA	NA	NA	0.024	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.024	NA
Lead	7439-92-1	0.082 (k)	0.065 (k)	0.0032 (k)	0.0025 (k)	0.082 (k)	0.065 (k)	0.0032 (k)	0.0025 (k)	0.00117 (h)	NA	0.12 (k)	0.10 (k)	0.010 (k)	0.0079 (k)	0.082 (k)	0.065 (k)	0.0032 (k)	0.0025 (k)	0.082	0.065	0.0032	0.0025
Lithium	7439-93-2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	7439-97-6	0.0017 (l)	0.0014 (l)	0.00091 (l)	0.00077 (l)	0.0016 (l)	0.0014 (l)	0.00091 (l)	0.00077 (l)	0.0000013	NA	0.0024	NA	0.000012	NA	0.0024	NA	0.000012	NA	0.0017	0.0014	0.00091	0.00077
Molybdenum	7439-98-7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	7782-49-2	NA	NA	0.005	NA	NA	NA	NA	0.0031 (o)	0.005	NA	NA	NA	NA	0.0031 (o)	0.13	NA	0.035	NA	0.13	NA	0.005	0.0031
Thallium	7440-28-0	NA	NA	NA	NA	NA	NA	NA	NA	0.01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.01	NA
Radiological (pCi/L)																							
Radium-226 & 22	7440-14-4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:

AAC - Acute Aquatic Criterion

CAC - Chronic Aquatic Criterion

CAS RN - Chemical Abstracts Service Registry Number.

CCC - Continuous Criterion Concentration

CMC - Criterion Maximum Concentration

IDEM - Indiana Department of Environmental Management

mg/L - micrograms/liter.

NA - Not Available

NRWQC - National Recommended Water Quality Criteria

ORSANCO - Ohio River Valley Water Sanitation Commission

pCi/L - picoCuries/liter.

USEPA - United States Environmental Protection Agency

TABLE 4
ECOLOGICAL SCREENING LEVELS FOR SURFACE WATER
SOUTHERN INDIANA GAS AND ELECTRIC COMPANY
F.B. CULLEY GENERATING STATION
NEWBURGH, INDIANA

Notes:

(a) - Ohio River Valley Water Sanitation Commission (ORSANCO) Pollution Control Standards for Discharges to the Ohio River. 2019 Revision.
Chapter 3 Water Quality Criteria - Aquatic life. Aquatic Life criteria are protective of maintaining fish and other aquatic life.
http://www.orsanco.org/wp-content/uploads/2019/06/Final-Standards-Doc-2019-Revision.pdf

(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) - USEPA Archive Document. USEPA Region 5 Resource Conservation and Recovery Act (RCRA) - Ecological Screening Values. August 22, 2003.
https://archive.epa.gov/region5/waste/cars/web/pdf/ecological-screening-levels-200308.pdf

(d) - IDEM (IN.gov). Water Quality in Indiana. Water Quality Standards. Active Projects - Planned Revisions to Metals Criteria for the Protection of Aquatic Life and Human Health.
Second Notice of Tables of Rulemaking. IDEM is providing notice of its intent to revise Indiana's Aquatic Life and Human Health Ambient Water Quality Criteria (WQC) for metals (total recoverable).
Aquatic Life Criteria Tables 1, 2, and 4. The screening levels for hardness-dependent metals are calculated for a default hardness value of 100 mg/L CaCO3.
Proposed revisions reflect updates to USEPA NRWQC at Section 304(a) of the Clean Water Act.
https://www.in.gov/idem/cleanwater/files/wqs_rulemaking_tables_second_notice.pdf

(e) - IDEM (IN.gov). Water Quality in Indiana. Water Quality Standards.
http://www.in.gov/idem/cleanwater/2329.htm

(f) - IDEM Water Quality Standards. Title 327 of the IAC. Article 2. Water Quality Standards. Rule 1. Water Quality Standards Applicable to All State Waters Except Waters of the State Within the Great Lakes System.
Part 327 IAC 2-1-6 Minimum Surface Water Quality Standards. Tables 6-1, 6-2, and 6-3. Surface Water Quality Standards for metals apply to total recoverable concentrations.
The screening levels for hardness-based metals are calculated for a default hardness value of 100 mg/L $CaCO_3$.
http://www.in.gov/legislative/iac/T03270/A00020.PDF?

(g) - The hierarchy for the selection of ecological screening levels is:
1) ORSANCO Aquatic Life Criterion.
2) USEPA NRWQC. Aquatic Life Criteria - Freshwater.
3) USEPA Region 5. Freshwater Screening Values.
4) IDEM Aquatic Life Criterion (proposed).
5) IDEM Aquatic Life Criterion (current).

(h) - USEPA Region 5, RCRA Ecological Screening Levels (archive 2003-08-22) for hardness-dependent metal, freshwater - chronic criteria. Value displayed corresponds to a soft water total hardness of 50 mg/L as $CaCO_3$.

(i) - Value for inorganic arsenic only.

(j) - Value for inorganic arsenic as arsenite, As(III).

(k) - Criterion expressed as a function of total hardness (mg/L). Value displayed is the site-specific total hardness of 100 mg/L.

(l) - Aquatic Life Criterion for metallic mercury (CAS RN 7439-97-6) and/or methylmercury (CAS RN 22967-92-6).

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

(n) - Value for chromium (III).

(o) - 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
SOUTHERN INDIANA GAS AND ELECTRIC COMPANY
F.B. CULLEY GENERATING STATION
NEWBURGH, INDIANA

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 - Total (acute) (d) (mg/L)	ECO SL - Dissolved (acute) (d) (mg/L)	ECO SL - Total (chronic) (d) (mg/L)	ECO SL - Dissolved (chronic) (d) (mg/L)
Detection Monitoring - USEPA Appendix III Constituents (e)								
Boron	7440-42-8	4	NA	114	NA	NA	NA	NA
Fluoride	16984-48-8	4	1	23.9	NA	NA	NA	NA
Assessment Monitoring - USEPA Appendix IV Constituents								
Antimony	7440-36-0	0.006	0.0056	0.171	NA	NA	0.08	NA
Arsenic	7440-38-2	0.01	0.01	0.236	0.34	0.34	0.15	0.15
Barium	7440-39-3	2	1	63.7	NA	NA	0.22	NA
Beryllium	7440-41-7	0.004	0.00117	0.121	NA	NA	0.0036	NA
Cadmium	7440-43-9	0.005	NA	0.134	0.0021	0.0020	0.00027	0.00025
Chromium (Total)	7440-47-3	0.1	3433	155	1.8	0.57	0.086	0.074
Cobalt	7440-48-4	0.006	NA	0.178	NA	NA	0.024	NA
Lead	7439-92-1	0.015	NA	0.015	0.082	0.065	0.0032	0.0025
Lithium	7439-93-2	0.04	NA	1.14	NA	NA	NA	NA
Mercury	7439-97-6	0.002	0.000012	0.0956	0.0017	0.0014	0.00091	0.00077
Molybdenum	7439-98-7	0.1	NA	2.86	NA	NA	NA	NA
Selenium	7782-49-2	0.05	0.17	2.86	0.13	NA	0.005	0.0031
Thallium	7440-28-0	0.002	0.00024	0.00572	NA	NA	0.01	NA
Radiological (pCi/L)								
Radium-226 & 228	7440-14-4	5	4	NA	NA	NA	NA	NA

Notes:

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

(a) - Drinking Water Screening Levels selected in Table 2 using the following hierarchy:
1) USEPA MCL
2) USEPA RSL - Tap Water
3) IDEM Criteria for Drinking Water Class Groundwater

(b) - Human Health Published Screening Values for Surface Water - Consumption of Organism Only selected in Table 2 using the following hierarchy:
1) ORSANCO Human Health Water Quality Standards
2) USEPA NRWQC - Consumption of Organism Only.
3) IDEM CCC HLSC - Consumption of Organism Only (proposed).
4) IDEM CCC HLSC - Consumption of Organism Only (current).

(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) ORSANCO Aquatic Life Criterion.
2) USEPA NRWQC. Aquatic Life Criteria - Freshwater.
3) USEPA Region 5. Freshwater Screening Values.
4) IDEM Aquatic Life Criterion (proposed).
5) IDEM Aquatic Life Criterion (current).

(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
SOUTHERN INDIANA GAS AND ELECTRIC COMPANY
F.B. CULLEY GENERATING STATION
NEWBURGH, INDIANA

										Dilution Attenuation Factor - Ohio River (e)	18,000			
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 - Total (acute) (d) (mg/L)**	**ECO SL - Dissolved (acute) (d) (mg/L)**	**ECO SL - Total (chronic) (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 - Ohio 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	4	NA	114	NA	NA	NA	NA	4		72,000	68	CCR-AP-5	>1,000
Fluoride	16984-48-8	4	1	23.9	NA	NA	NA	NA	1		18,000	1.4	CCR-AP-5	>12,000
Assessment Monitoring - USEPA Appendix IV Constituents														
Antimony	7440-36-0	0.006	0.0056	0.171	NA	NA	0.08	NA	0.0056		101	0.002	CCR-AP-2	>50,000
Arsenic	7440-38-2	0.01	0.01	0.236	0.34	0.34	0.15	0.15	0.01		180	0.12	CCR-AP-6	>1,500
Barium	7440-39-3	2	1	63.7	NA	NA	0.22	NA	0.22		3,960	0.78	CCR-AP-4	>5,000
Beryllium	7440-41-7	0.004	0.00117	0.121	NA	NA	0.0036	NA	0.00117		21	0.0027	CCR-AP-2	>7,500
Cadmium	7440-43-9	0.005	NA	0.134	0.0021	0.0020	0.00027	0.00025	0.00025		4	0.0012	CCR-AP-5	>3,500
Chromium (Total)	7440-47-3	0.1	3433	155	1.8	0.57	0.086	0.074	0.074		1,334	0.082	CCR-AP-2	>16,000
Cobalt	7440-48-4	0.006	NA	0.178	NA	NA	0.024	NA	0.006		108	0.038	CCR-AP-2	>2,500
Lead	7439-92-1	0.015	NA	0.015	0.082	0.065	0.0032	0.0025	0.0025		45	0.051	CCR-AP-2	>800
Lithium	7439-93-2	0.04	NA	1.14	NA	NA	NA	NA	0.04		720	0.15	CCR-AP-5	>4,500
Mercury	7439-97-6	0.002	0.000012	0.0956	0.0017	0.0014	0.00091	0.00077	0.000012		0.2	0.2 U		NA
Molybdenum	7439-98-7	0.1	NA	2.86	NA	NA	NA	NA	0.1		1,800	0.41	CCR-AP-5	>4,000
Selenium	7782-49-2	0.05	0.17	2.86	0.13	NA	0.005	0.0031	0.0031		56	0.0044	CCR-AP-2	>12,000
Thallium	7440-28-0	0.002	0.00024	0.00572	NA	NA	0.01	NA	0.00024		4	0.00099	CCP-AP-2	>4,000
Radiological (pCi/L)														
Radium-226 & 228	7440-14-4	5	4	NA	NA	NA	NA	NA	4		72,000	5.93 ± 1.6	CCP-AP-6	>9,500

Notes:

CAS RN - Chemical Abstracts Service Registry Num
ECO SL - Ecological Screening Level.
HH DW SL - Human Health Drinking Water Screeni
HH REC SL - Human Health Recreational Use Screening Level.
mg/L - milligram per liter.
NA - Not Available.
RBSL - Risk-Based Screening Level.

TABLE 6
DERIVATION OF RISK-BASED TARGET SCREENING LEVELS FOR GROUNDWATER
SOUTHERN INDIANA GAS AND ELECTRIC COMPANY
F.B. CULLEY GENERATING STATION
NEWBURGH, INDIANA

(a) - Drinking Water Screening Levels selected in Table 2 using the following hierarchy:
1) USEPA MCL
2) USEPA RSL - Tap Water
3) IDEM Criteria for Drinking Water Class Groundwater

(b) - Human Health Published Screening Values for Surface Water - Consumption of Organism Only selected in Table 2 using the following hierarchy:
1) ORSANCO Human Health Water Quality Standards
2) USEPA NRWQC - Consumption of Organism Only.
3) IDEM CCC HLSC - Consumption of Organism Only (proposed).
4) IDEM CCC HLSC - Consumption of Organism Only (current).

(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) ORSANCO Aquatic Life Criterion.
2) USEPA NRWQC. Aquatic Life Criteria - Freshwater.
3) USEPA Region 5. Freshwater Screening Values.
4) IDEM Aquatic Life Criterion (proposed).
5) IDEM Aquatic Life Criterion (current).

(e) - Estimated value, see DAF calculation documents 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

GIS FILE PATH: \\haleyaldrich.com\share\boi_common\Projects\Vectren_Corporation\42796_Evansville_CCR_GWMP_Development\Global\GIS\Maps\2017_12\42796_000_000MB_FB_CULLEY_GROUNDWATER_CONTOURS.mxd — USER: ajospe — LAST SAVED: 12/12/2017 5:26:45 PM

LEGEND

UPGRADIENT MONITORING WELL

DOWNGRADIENT MONITORING WELL

POTENTIOMETRIC FLOW LINE, DASHED WHERE

NOTES

1. AERIAL IMAGERY SOURCE: ESRI
2. LOCATIONS DERIVED FROM THREE I DESIGN DATA.
3. GROUNDWATER ELEVATIONS MEASURED 6 APRIL 2017

N

0 500

SCALE IN FEET

HALEY ALDRICH

VECTREN CORPORATION
F.B. CULLEY GENERATING STATION
3711 DARLINGTON ROAD
NEWBURGH, INDIANA

SITE FEATURES

JANUARY 2018

FIGURE 1

FIGURE 2
PRIVATE WELL LOCATIONS WITHIN A HALF-MILE RADIUS OF FACILITY BOUNDARY SOUTHERN INDIANA GAS AND ELECTRIC COMPANY
F.B. CULLEY GENERATING STATION, NEWBURGH, IN

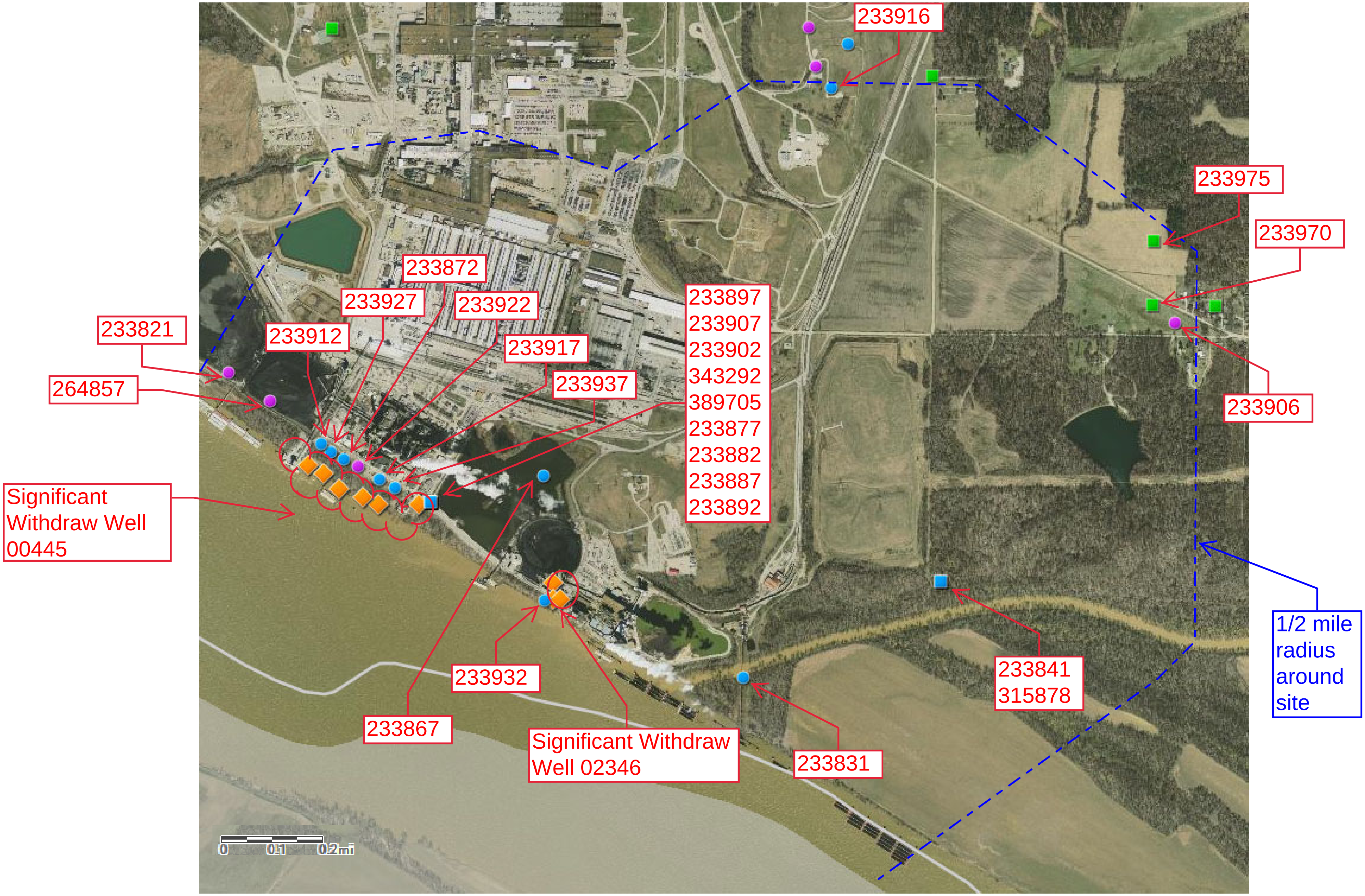
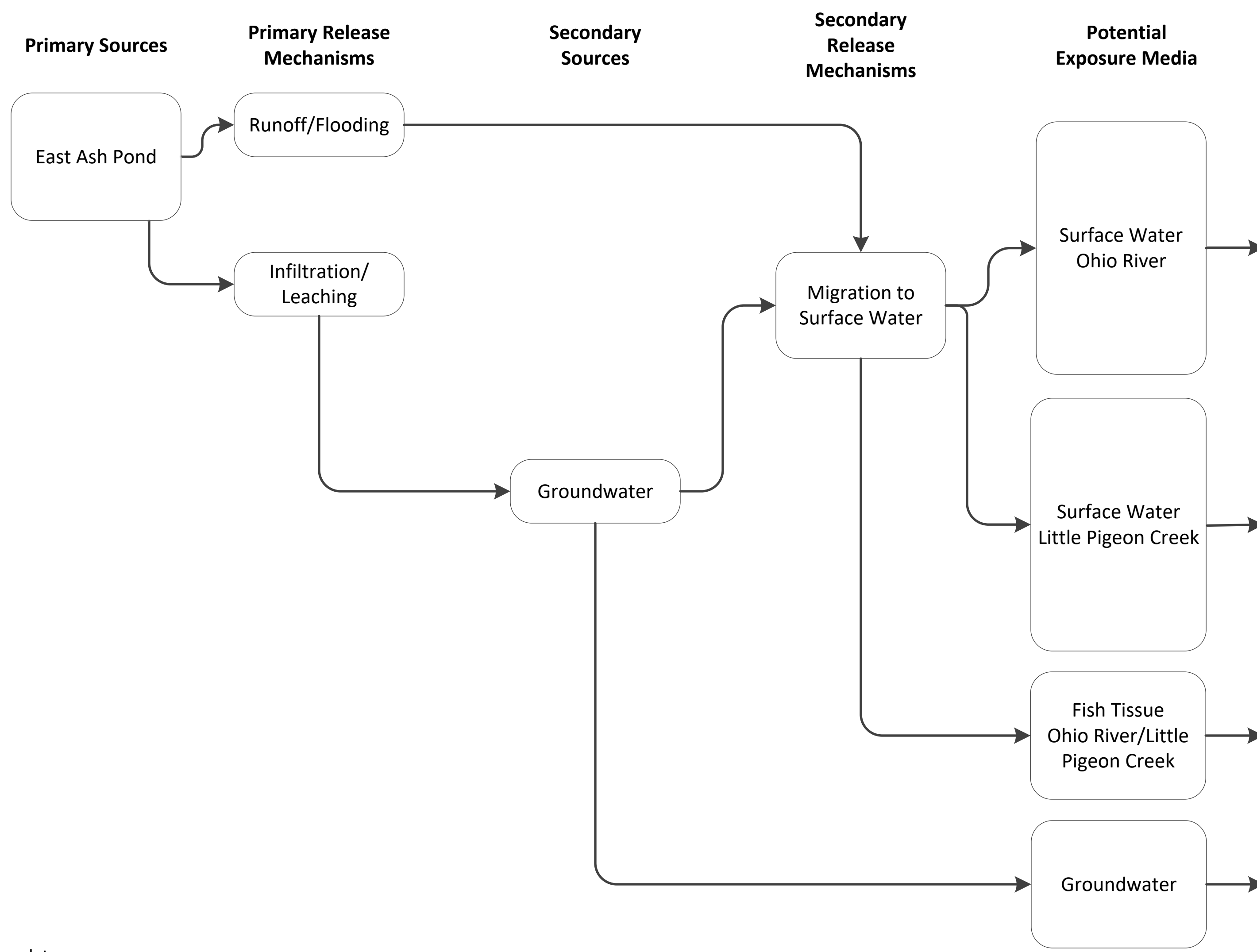


FIGURE 3
CONCEPTUAL SITE MODEL
SOUTHERN INDIANA GAS & ELECTRIC COMPANY
F.B. CULLEY GENERATING STATION, NEWBURGH, IN



	Potential Human Health Receptors					Potential Ecological Receptors
Potential Exposure Route	**Current/Future Off-Site Resident Adult/Child**	**Current/Future Off-Site Recreational Swimmer**	**Current/Future Off-Site Recreational Wader**	**Current/Future Off-Site Recreational Boater**	**Current/Future Off-Site Recreational Fisher**	**Aquatic Receptors**
Drinking Water Use	⊙ (a)	○	○	○	○	NA
Incidental Ingestion	○	⊙	⊙	⊙	⊙	NA
Dermal Contact	○	⊙	⊙	⊙	⊙	NA
Aquatic Exposure	NA	NA	NA	NA	NA	⊙
Drinking Water Use	○ (b)	○	○	○	○	NA
Incidental Ingestion	○	○ (c)	⊙	○ (c)	○ (c)	NA
Dermal Contact	○	○ (c)	⊙	○ (c)	○ (c)	NA
Aquatic Exposure	NA	NA	NA	NA	NA	⊙
Ingestion	○	○	○	○	⊙	NA
Aquatic Exposure	NA	NA	NA	NA	NA	⊙
Drinking Water Use	○ (d)	○	○	○	○	NA
Aquatic Exposure	NA	NA	NA	NA	NA	○ (e)

Notes:

- ● Pathway potentially complete
- ⊙ Pathway potentially complete – pathway evaluated in this risk assessment; results indicate no risk to human health or the environment.
- ○ Pathway evaluated and found incomplete; results indicate no risk to human health or the environment.

(a) The Ohio River is used as a source of drinking water; the nearest downstream drinking water intake is 18.4 miles downstream at the City of Evansville, Indiana.
(b) Little Pigeon Creek is not used as a source of drinking water.
(c) The size of Little Pigeon Creek precludes swimming, fishing and boating activities.
(d) The shallow alluvial aquifer in the vicinity of the East Ash Pond is not used for drinking water purposes.
(e) Ecological Receptors are not exposed to groundwater.

NA – Not Applicable.

ATTACHMENT A

Calculated Recreational 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
			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)	Adult
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	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	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] x child EF [0-2] x child IR [0-2] / child BW [0-2]) + (child ED [2-6] x child EF [2-6] x child IR [2-6] / child BW [2-6]) + (older child ED [6-16] x older child EF [6-16] x older child IR [6-16] / older child BW [6-16]) + (adult ED x adult EF x adult IR / adult BW)
DFWadj = (child EF [0-2] x child ED [0-2] x child SA [0-2] x child EV [0-2] / child BW [0-2]) + (child EF [2-6] x child ED [2-6] x child SA [2-6] x child EV [2-6] / child BW [2-6]) + (older child EF [6-16] x older child ED [6-16] x older child SA [6-16] x older child EV [6-16] / older child BW [6-16]) + (adult EF x adult ED x adult SA x adult EV / adult BW)
Water - mutagenic
IFWM = (child ED [0-2] x child EF [0-2] x child IR [0-2] x ADAF [0-2] / child BW [0-2]) + (child ED [2-6] x child EF [2-6] x child IR [2-6] x ADAF [2-6] / child BW [2-6]) + (older child ED [6-16] x child EF [6-16] x older child IR [6-16] x ADAF [6-16] / older child BW [6-16]) + (adult ED x adult EF x adult IR x adult ADAF / adult BW)
DFWM = (child EF [0-2] x child ED [0-2] x child SA [0-2] x child EV [0-2] x ADAF [0-2] / child BW [0-2]) + (child EF [2-6] x child ED [2-6] x child SA [2-6] x child EV [2-6] x ADAF [2-6] / child BW [2-6]) + (older child EF [6-16] x older child ED [6-16] x older child SA [6-16] x older child EV [6-16] x ADAF [6-16] / older child BW [6-16]) + (adult EF x adult ED x adult SA x adult EV x 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.

Current/Future Off-Site Recreational Boater

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	0.000001	0.0001

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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_o(mg/kg-day)$^{-1}$	SF_o 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	-	26100.0000	26100.0000	-	-	-	-	16800.0000	16800.0000	1.68E+04nc
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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Current/Future Off-Site Recreational Swimmer

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	0.0001

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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_o(mg/kg-day)$^{-1}$	SF_o 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	262.0000	2410.0000	236.0000	183.0000	2870.0000	172.0000	754.0000	4570.0000	647.0000	2.36E+02ca**
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	134000.0000	63700.0000	503000.0000	213000.0000	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	1910000.0000	114000.0000	503000.0000	3050000.0000	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 Salts	16065-83-1	No	No	Inorganics	-		1.5000	I	-		0.0130	0.0010	52.0000	1.0000	Yes	-	0.3727	0.5943	-	-	-	913000.0000	186000.0000	155000.0000	3770000.0000	297000.0000	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	382000.0000	22900.0000	101000.0000	610000.0000	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

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Current/Future Off-Site Recreational Wader

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	0.0001

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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_o(mg/kg-day)$^{-1}$	SF_o 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	407.0000	8380.0000	389.0000	183.0000	10300.0000	179.0000	3770.0000	15700.0000	3040.0000	3.89E+02ca*
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	6870000.0000	120000.0000	2510000.0000	10500000.0000	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	18900000.0000	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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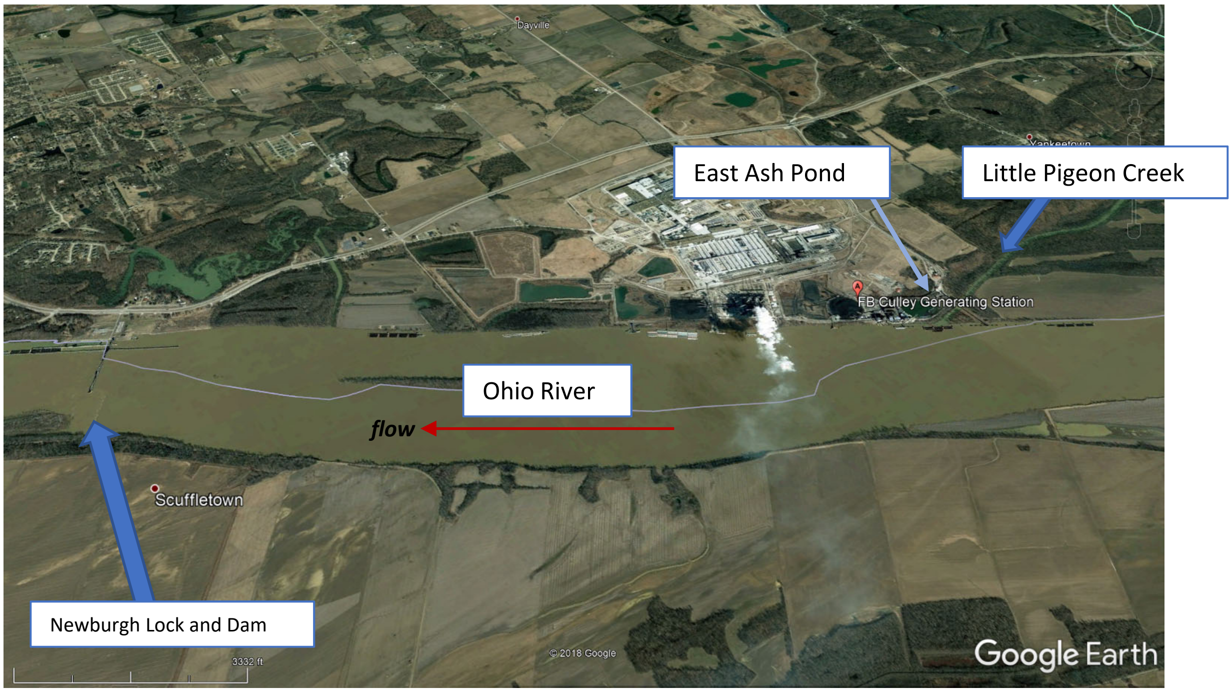
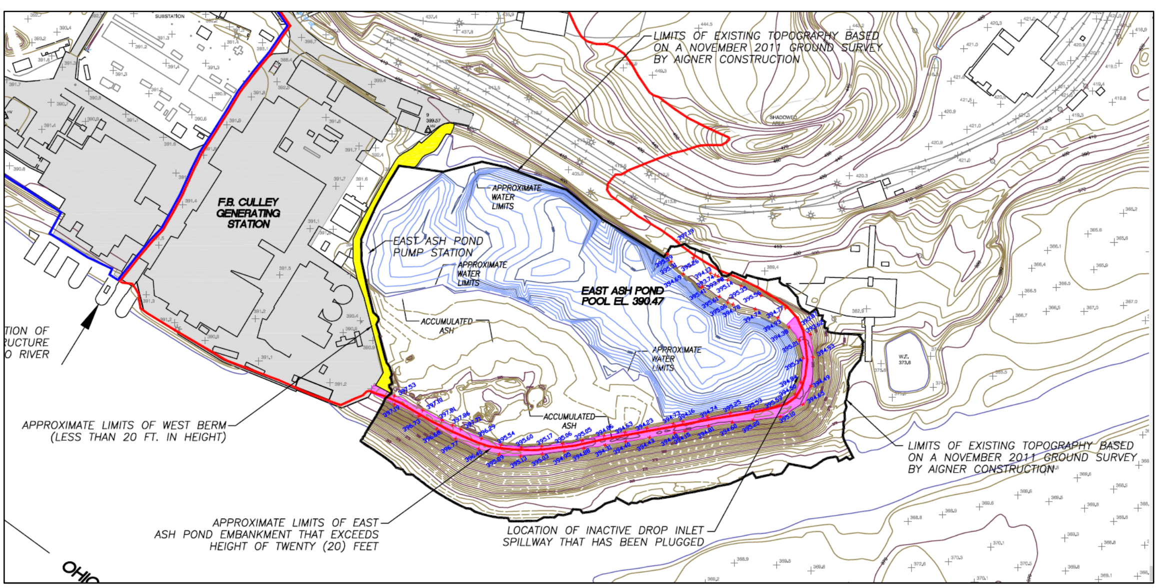
ATTACHMENT B

East Ash Pond Dilution Attenuation Factor Calculations

HALEY ALDRICH	CALCULATIONS		
Client	Vectren	File No.	129420-017
Project	F.B. Culley Generation Station East Ash Pond	Sheet	1 of 5
Subject	Dilution-Attenuation Factor Calculation	Date	26 July 2019
		Computed By	J.P. Brandenburg
		Checked By	Jacob Chu



Google Earth Perspective View, Facing North



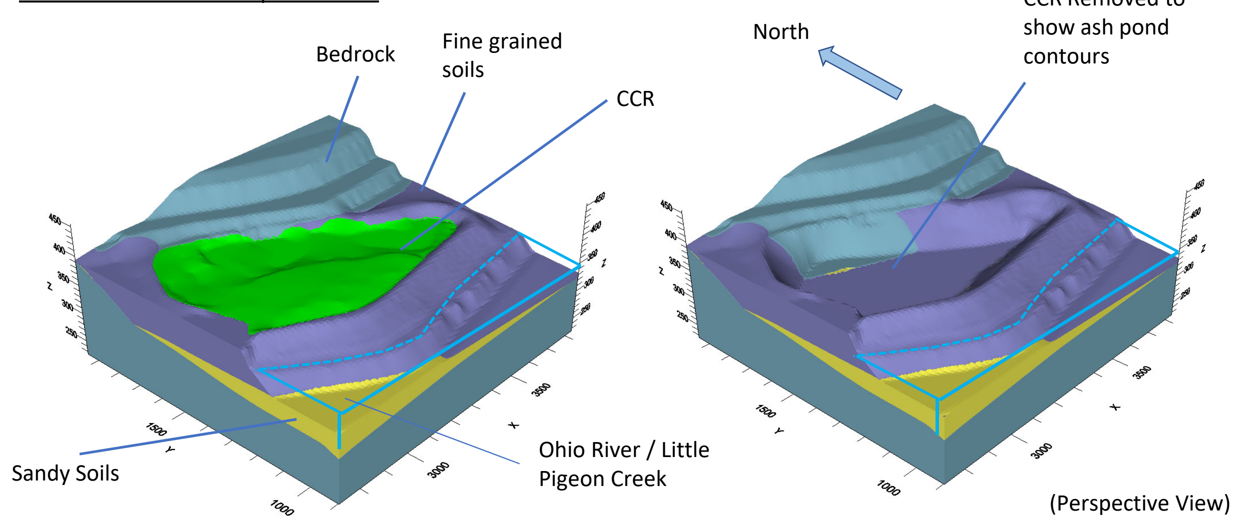
From ATC Group Services, East Ash Pond Visual Site Inspection Report, 2015

HALEY ALDRICH	CALCULATIONS	File No.	129420-017
Client	Vectren	Sheet	2 of 5
Project	F.B. Culley Generation Station East Ash Pond	Date	26 July 2019
Subject	Dilution-Attenuation Factor Calculation	Computed By	J.P. Brandenburg
		Checked By	Jacob Chu

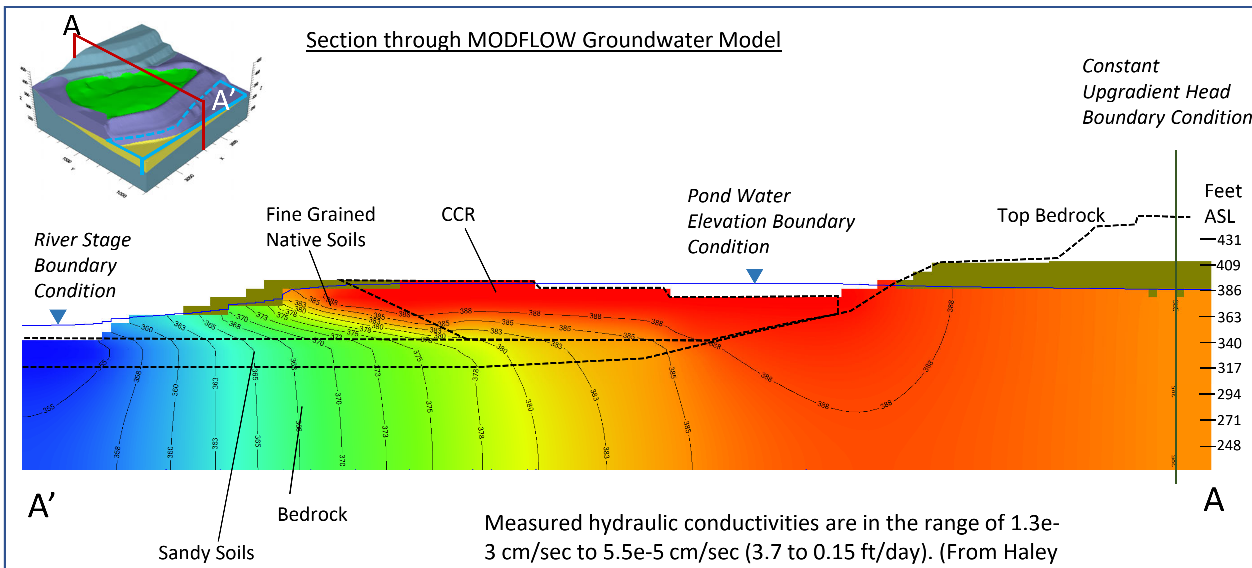
A 3D Conceptual Model was constructed for the East Ash Pond using subsurface cross sections interpreted from boring logs by Haley & Aldrich, and surveyed elevations from the 2015 East Pond Ash Inspection by ATC Group Services. Four basic subsurface units were identified: bedrock, fine grained soils, sandy soils, and coal-combustion residuals (CCR, or "ash").

The 3D Conceptual Model was then used to construct a MODFLOW-2005 Groundwater Model. Properties assigned to each of the four units were mapped to a regular (undeformed) 8-foot grid. Three boundary conditions are assigned: a river boundary condition representing the Ohio River and Little Pigeon Creek, a constant head boundary condition representing water ponded in the East Ash Pond, and a constant upgradient head. A water balance budget zone is assigned to the grid layer beneath the CCR.

East Ash Pond: 3D Conceptual Model



Section through MODFLOW Groundwater Model



Measured hydraulic conductivities are in the range of 1.3e-3 cm/sec to 5.5e-5 cm/sec (3.7 to 0.15 ft/day). (From Haley & Aldrich "Report on Groundwater Monitoring Program," 2017, October)

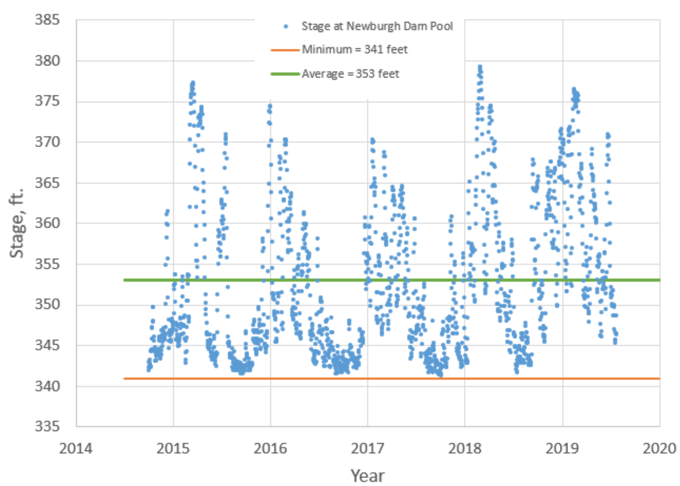
CALCULATIONS

HALEY ALDRICH

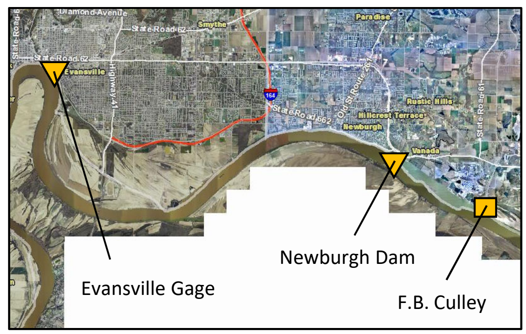
Client	Vectren	File No.	129420-017
Project	F.B. Culley Generation Station East Ash Pond	Sheet	3 of 5
Subject	Dilution-Attenuation Factor Calculation	Date	26 July 2019
		Computed By	J.P. Brandenburg
		Checked By	Jacob Chu

Based on gaging data, water surface elevation (stage) of the Newburgh Dam Pool ranges from 341 to 379 feet above the NGVD29 vertical datum. The average stage is 353 feet.

Discontinuous discharge data is available at the Evansville Gage (USGS 03322000; below the Newburgh Dam) from 1940-1996. Although minimum instantaneous flow was approximately 100,000 cfs after the dam was completed in 1975, flow durations will depend on operation of the Dam and Locks and are not presently known. The pre-1975 minimum of approximately 10,000 cfs is used as a most conservative assumption of low flow conditions on the Ohio River. This may be improved to less conservative values if information can be obtained from the Army Corps of Engineers hydrologic model or dam release data.

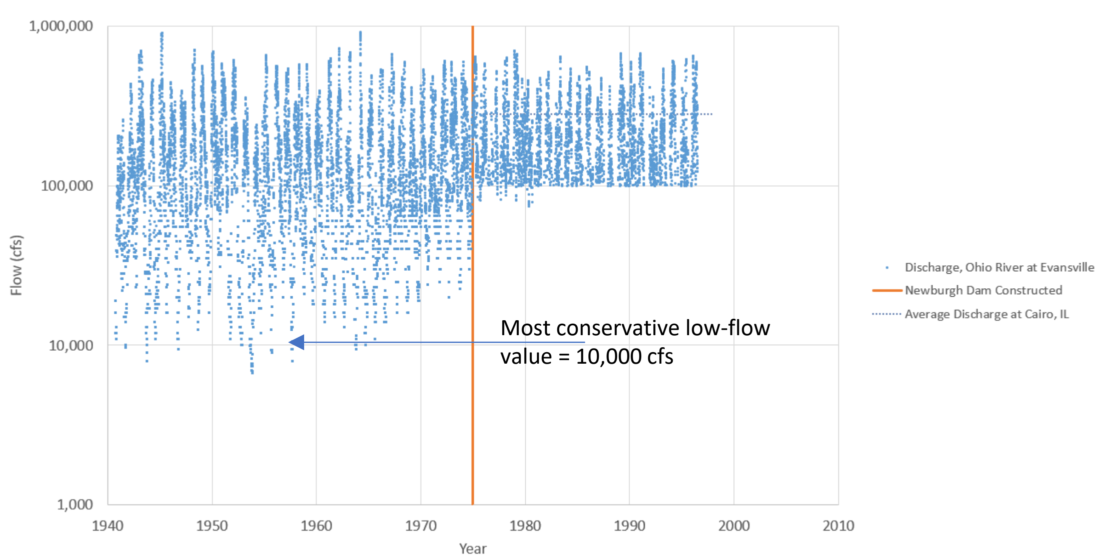


https://waterdata.usgs.gov/nwis/inventory/?site_no=03304300



https://maps.indiana.edu/previewMaps/Hydrology/Monitoring_Streamflow_Gauges.html

Datum = 329.18 feet NGVD29



https://waterdata.usgs.gov/nwis/inventory/?site_no=03322000

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CALCULATIONS

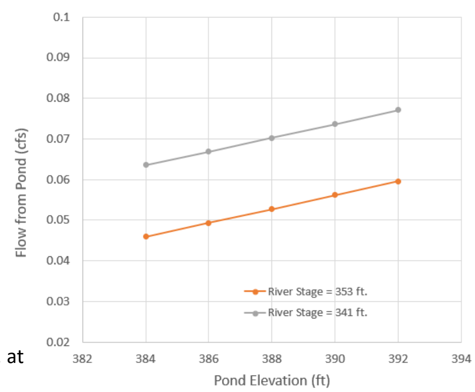
HALEY ALDRICH

Client	Vectren
Project	F.B. Culley Generation Station East Ash Pond
Subject	Dilution-Attenuation Factor Calculation
File No.	129420-017
Sheet	4 of 5
Date	26 July 2019
Computed By	J.P. Brandenburg
Checked By	Jacob Chu

Scenario 1

•Typical measured values for site hydraulic conductivities (K), most conservative value for discharge of Ohio River

Unit	Horizontal K (ft/day)	Vertical K (ft/day)
CCR	0.1	0.1
Fine grained soils	0.15	0.015
Sandy soils	3	0.3
Bedrock	0.1	0.1



$$DAF = \frac{Q_R}{Q_G}$$ Where: $Q_R =$ Discharge of Ohio River at East Ash Pond, at Low-Flow conditions.

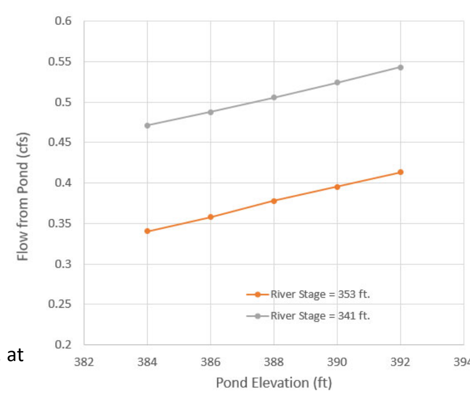
$Q_G =$ Model Discharge from East Ash Pond to Ohio River

Pond Elevation (feet)	River Stage (feet)	Qg (cfs)	Qr (cfs)	DAF
384	353	0.046	10,000	**210,000**
392	353	0.060	10,000	**160,000**
384	341	0.064	10,000	**150,000**
392	341	0.077	10,000	**130,000**

Scenario 2

•Conservative (very high) values for site hydraulic conductivities (K), most conservative value for discharge of Ohio River

Unit	Horizontal K (ft/day)	Vertical K (ft/day)
CCR	1	1
Fine grained soils	10	1
Sandy soils	10	1
Bedrock	0.1	0.1



$$DAF = \frac{Q_R}{Q_G}$$ Where: $Q_R =$ Discharge of Ohio River at East Ash Pond, at Low-Flow conditions.

$Q_G =$ Model Discharge from East Ash Pond to Ohio River

Pond Elevation (feet)	River Stage (feet)	Qg (cfs)	Qr (cfs)	DAF
384	353	0.34	10,000	**29,000**
392	353	0.41	10,000	**24,000**
384	341	0.47	10,000	**21,000**
392	341	0.54	10,000	**18,000**

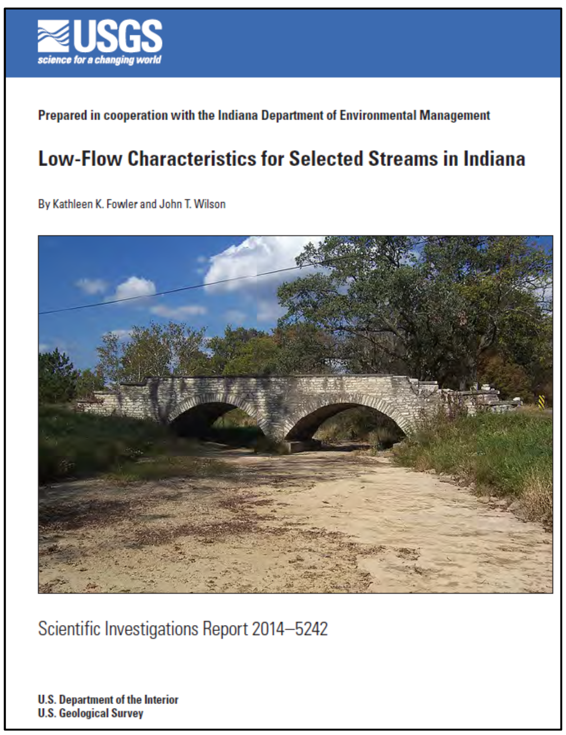
CALCULATIONS

Client	Vectren	File No.	129420-017
Project	F.B. Culley Generation Station East Ash Pond	Sheet	5 of 5
Subject	Dilution-Attenuation Factor Calculation	Date	26 July 2019
		Computed By	J.P. Brandenburg
		Checked By	Jacob Chu

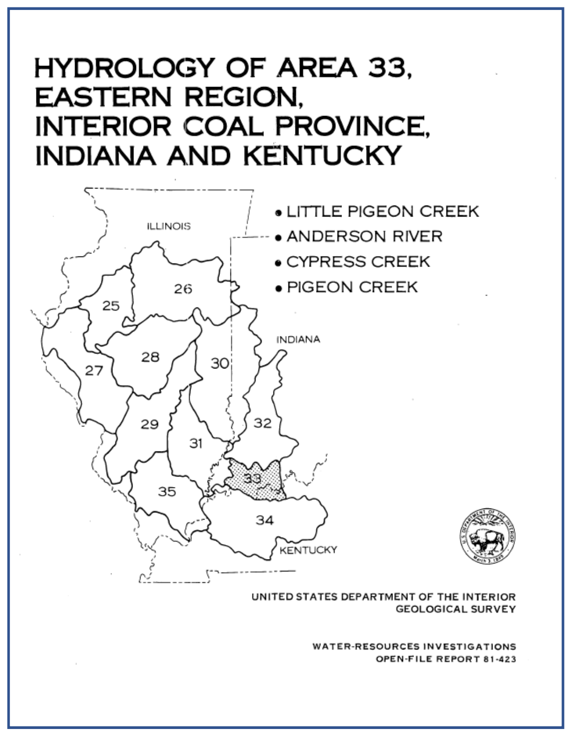
The confluence of Little Pigeon Creek and the Ohio River is adjacent to the east side of the East Ash Pond. The lowest reach of the Creek runs parallel to the Ohio River.

As reported by the USGS, higher reaches of the Creek have weak aquifer support and are dry during periods of low precipitation (7Q10 flow is zero). Flow in the terminal reach of the Creek is controlled by fluctuations of the Newburgh Dam pool.

Relevant Publications:



https://pubs.usgs.gov/sir/2014/5242/



https://pubs.usgs.gov/of/1981/0423/report.pdf