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**REPORT ON**

# CORRECTIVE MEASURES ASSESSMENT PETERSBURG GENERATING STATION PETERSBURG, INDIANA

by
Haley & Aldrich, Inc.
Cleveland, Ohio

for
Indianapolis Power & Light Company
Indianapolis, Indiana

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## List of Acronyms and Abbreviations

| Abbreviation | Definition |
|---|---|
| Ash Pond System or AP | Ash Ponds A, A’, B, C and D |
| ATC | ATC Group Services LLC |
| ASD | Alternate Source Demonstration |
| bgs | Below Ground Surface |
| CBR | Closure by Removal |
| CCR | Coal Combustion Residual |
| CIP | Closure in Place |
| cm/sec | Centimeters per Second |
| CMA | Corrective Measures Assessment |
| CSM | Conceptual Site Model |
| CY | Cubic Yard |
| GWPS | Groundwater Protection Standards |
| Haley & Aldrich | Haley & Aldrich, Inc. |
| IDEM | Indiana Department of Environmental Management |
| IDNR | Indiana Department of Natural Resources |
| IPL | Indianapolis Power & Light Company |
| ISS | *In Situ* Stabilization |
| Landfill or LF | Type III Restricted Waste Landfill |
| MCL | Maximum Contaminant Level |
| MNA | Monitored Natural Attenuation |
| msl | Mean Sea Level |
| N&E | Nature and Extent |
| NPDES | National Pollution Discharge Elimination System |
| PGS | Petersburg Generating Station |
| RO | Reverse Osmosis |
| SAP | Sampling Analysis Plan |
| Site | Petersburg Generating Station |
| SSI | Statistically Significant Increase |
| SSL | Statistically Significant Levels |
| SW-DAF | Surface Water Dilution and Attenuation Factor |
| ug/L | Micrograms per Liter |
| USEPA | United States Environmental Protection Agency |

# 1. Introduction

Haley and Aldrich, Inc. (Haley & Aldrich) was retained by the Indianapolis Power & Light Company (IPL) to prepare this Corrective Measures Assessment (CMA) for the Coal Combustion Residual (CCR) units that are comprised of Ash Ponds A, A', B, C, and D[1] (herein referred to as the Ash Pond System or AP), and Type III Restricted Waste Landfill (herein referred to as the Landfill or LF) located at the Petersburg Generating Station (PGS or "Site"). IPL has conducted detailed geologic and hydrogeologic investigations under the U.S. Environmental Protection Agency's (USEPA) rule entitled *Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities*. 80 Fed. Reg. 21302 (effective 19 October 2015) and subsequent regulatory revisions (CCR Rule). These investigations have included ongoing groundwater monitoring and Nature and Extent (N&E) investigations associated with §257.95 of the CCR Rule.

A summary of the historical groundwater monitoring results for the CCR Rule Appendix III and Appendix IV constituents including relevant statistics can be found in the facility's annual groundwater monitoring and corrective action reports located at: http://ccr-.petersburg.com/Home/default.aspx.

This CMA report evaluates potential corrective measures to remediate groundwater for the constituents present in groundwater at statistically signification levels (SSLs) above the Groundwater Protection Standards (GWPS) at both the AP and LF. These evaluations identified SSL above GWPS for arsenic, cadmium, cobalt, lithium, and molybdenum in groundwater at seven monitoring well locations downgradient of the AP and LF. A source other than the AP and LF were identified for arsenic, cadmium and cobalt; therefore, this CMA is being prepared to address lithium and molybdenum in groundwater. An Alternate Source Demonstration (ASD) for arsenic and an ASD for cadmium and cobalt has been certified by a qualified professional. Documentation supporting each successful ASD, along with the professional engineer's certification, will be provided in the January 2020 Annual Groundwater Monitoring and Corrective Action Reports as required by 40 CFR §257.95(g)(3)(ii).

## 1.1 FACILITY DESCRIPTION/BACKGROUND

IPL owns and operates the PGS, which is located approximately four miles northeast of the town of Petersburg in Pike County, Indiana. The facility is bounded to the north and west by the east fork of the White River and to the south and east by woods and farmland. Lick Creek enters the Site from the south and flows beneath the generating station before discharging to the White River **(Figure 1-1)**.

The Ash Pond System covers approximately 152 acres and consists of five impoundments (Ponds A, A', B, C, and D) that were constructed with natural soil liners. The AP has received coal ash, a combination of fly ash and bottom ash in addition to various other NPDES regulated wastewater streams that was produced at the PGS. Ponds A and A' are inactive and closure was initiated in 2018; Ponds B and D have been closed in place in accordance with the Indiana Department of Environmental Management (IDEM) approved Closure Plan; Pond C is in the closure process as an in-place closure. The AP is bordered to the south by the Petersburg Generating Station and to the east by the Indiana Southern Railroad. Site features are illustrated on **Figure 1-2**.

[1] Ponds B and D are not subject to the CCR Rule but have been included as part of this CMA since they are part of a multi-unit groundwater monitoring network.

The LF is located east of the AP and encompasses a total area of approximately 124 acres inside the currently permitted Solid Waste Boundary. Approximately 80 acres of the current LF were permitted by IDEM in 1983 while the remaining 43.6 acres were permitted as an expansion to the LF in 1996 and an expansion revision approved by IDEM in 2018. To date, none of the expansion area has been constructed and partial closure certification from IDEM has been received for approximately 32 acres on the west side of the original LF footprint. An interim soil cover was placed over the active portions of the LF in 2017. The LF operates under IDEM Permit Number FP63-2.

## 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 associated with a CCR unit. ATC Group Services LLC (ATC) prepared a Sampling and Analysis Plan (SAP) as required by the CCR Rule for the AP and the LF. The SAP presents the design of the groundwater monitoring network, groundwater sampling and analysis procedures, and groundwater statistical analysis methods. The AP and LF each have their own groundwater monitoring programs that are described in the following sections.

### 1.2.1 Ash Pond System

Monitoring wells were installed in 2014 to support compliance with the IDEM-approved AP closure plan and are now used for CCR compliance purposes. The CCR groundwater monitoring network includes three background wells (MW-2 (2R), MW-3, and MW-4C) that are located east of the AP (west of the LF) and fourteen downgradient monitoring wells located around the perimeter of the AP. Monitoring well locations are shown on **Figure 1-3.** Monitoring wells were installed in the unconsolidated deposits overlying bedrock. Monitoring wells designated AP-X or AP-XB are screened in the upper part of the saturated zone; wells designated AP-XI are screened in the middle part of the saturated zone; and wells designated AP-XA are screened in the lower part of the saturated zone. Below is a list detailing the CCR monitoring well network:

| Background (Upgradient) | Downgradient | | |
|---|---|---|---|
| **Shallow** | **Shallow** | **Intermediate** | **Deep** |
| MW-2 (2R)<br>MW-3<br>MW-4C | AP-1 (1R)<br>AP-2BO<br>AP-3<br>AP-4B<br>AP-5<br>AP-6B<br>AP-7<br>AP-8 | AP-4I | AP-2A<br>AP-3A<br>AP-4A<br>AP-5A<br>AP-6A |

Detection monitoring sampling events occurred in 2016 and 2017. The results of the sampling events were then compared to background (upgradient) concentrations using statistical methods to determine whether SSIs of constituent concentrations above background concentrations in groundwater had occurred. Results of the detection monitoring statistical analyses completed in January 2018 identified SSI concentrations of Appendix III constituents in downgradient monitoring wells relative to concentrations observed in background monitoring wells. A successful alternative source demonstration was not completed for the SSI constituents. Accordingly, the groundwater monitoring program transitioned to an assessment monitoring program.

During the assessment monitoring phase, CCR groundwater monitoring well samples were collected during May and September 2018 and subsequently analyzed for the Appendix III and Appendix IV constituents as required by 40 CFR §257.95(b) and 40 CFR §257.95(d)(1). 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 SSL results indicated that cadmium, cobalt, and molybdenum were present in groundwater at SSLs above the GWPS.

A source other than the AP was identified for cadmium and cobalt; therefore, in accordance with 40 CFR §257.95(g)(3)(ii), a field investigation was initiated to demonstrate that this source other than the AP caused the cadmium and cobalt contamination. Based on the investigative activities performed, the source of the cadmium and cobalt contamination at AP-8 is due to historical surface and underground coal mining activities conducted in this area of the Site. As a result, a successful ASD report for cadmium and cobalt was completed and certified as accurate by a qualified professional engineer and will be provided in the January 2020 Annual Groundwater Monitoring and Corrective Action Report.

### 1.2.2 Landfill

Monitoring wells were installed in 2017 to support compliance with the CCR Rule and to supplement existing wells that had been installed in 1986. The CCR groundwater monitoring network includes background well MW-1 that is located southeast of the LF and seven downgradient monitoring wells (MW-2R, MW-3, MW-4C, MW-10, MW-11, MW-12, and MW-13) located around the perimeter of the LF and screened in the unconsolidated deposits and weathered bedrock. Monitoring well locations are shown on **Figure 1-3.** Below is a list detailing the CCR monitoring well network:

| Background (Upgradient) | Downgradient |
|---|---|
| MW-1 | MW-2 (2R)<br>MW-3<br>MW-4C<br>MW-10<br>MW-11<br>MW-12<br>MW-13 |

Detection monitoring sampling events occurred in 2016 and 2017. The results of the sampling events were then compared to background (upgradient) concentrations using statistical methods to determine whether SSIs of Appendix III constituent concentrations above background concentrations in groundwater had occurred. Results of the detection monitoring statistical analyses completed in January 2018 identified SSI concentrations of Appendix III constituents in downgradient monitoring wells relative to concentrations observed in background concentrations. A successful alternative source demonstration was not completed for the SSI constituents. Accordingly, the groundwater monitoring program transitioned to an assessment monitoring program.

During the assessment monitoring phase, CCR groundwater monitoring well samples were collected during May and September 2018 and subsequently analyzed for the Appendix III and Appendix IV constituents as required by 40 CFR §257.95(b) and 40 CFR §257.95(d)(1). 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 SSL results indicated that, arsenic, lithium, and molybdenum were present in groundwater at SSLs above the GWPS.

A source other than the LF was identified for arsenic; therefore, in accordance with 40 CFR §257.95(g)(3)(ii), a field investigation was initiated to demonstrate that this source other than the LF caused the arsenic contamination. Based on the investigative activities performed, the source of the arsenic contamination at MW-10 is due to the presence of naturally-occurring sources of arsenic and the reducing geochemical conditions near the well from the historic surface mining activities conducted in this area of the Site. As a result, a successful ASD report for arsenic was completed and certified as accurate by a qualified professional engineer and will be provided in the January 2020 Annual Groundwater Monitoring and Corrective Action Report.

### 1.3 CORRECTIVE MEASURES ASSESSMENT PROCESS

The CMA must include an analysis of the effectiveness of potential corrective measure in meeting all of the requirements and objectives of the remedy per 40 CFR §257.96(c). Each remedy must meet the following threshold criteria as stated in the CCR Rule:

> §257.97 Selection of remedy [Threshold Criteria]
> (b) Remedies must:
>
> > (1) Be protective of human health and the environment;
> > (2) Attain the groundwater protection standard as specified pursuant to §257.95(h);
> > (3) 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;
> > (4) Remove from the environment as much of the contaminated material that was released from the CCR unit as is feasible, taking into account factors such as avoiding inappropriate disturbance of sensitive ecosystems; and
> > (5) Comply with standards for management of wastes as specified in §257.98(d).

Once these technologies are demonstrated to meet these threshold criteria, they are then compared to one another with respect to the following balancing criteria as stated in the CCR Rule:

> §257.97 Selection of remedy [Balancing Criteria]
> (c) In selecting a remedy that meets the standards of paragraph (b) of this section, the owner or operator of the CCR unit shall consider the following evaluation factors:
>
> > (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 based on consideration of the following:
> >
> > > (i) Magnitude of reduction of existing risks;
> > > (ii) Magnitude of residual risks in terms of likelihood of further releases due to CCR remaining following implementation of a remedy;

(iii) The type and degree of long-term management required, including monitoring, operation, and maintenance;
(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;
(v) Time until full protection is achieved;
(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;
(vii) Long-term reliability of the engineering and institutional controls; and
(viii) Potential need for replacement of the remedy.

(2) The effectiveness of the remedy in controlling the source to reduce further releases based on consideration of the following factors:

(i) The extent to which containment practices will reduce further releases; and
(ii) The extent to which treatment technologies may be used.

(3) The ease or difficulty of implementing a potential remedy(s) based on consideration of the following types of factors:

(i) Degree of difficulty associated with constructing the technology;
(ii) Expected operational reliability of the technologies;
(iii) Need to coordinate with and obtain necessary approvals and permits from other agencies;
(iv) Availability of necessary equipment and specialists; and
(v) Available capacity and location of needed treatment, storage, and disposal services.

(4) The degree to which community concerns are addressed by a potential remedy(s).

The fourth balancing criterion involves input from the community regarding the proposed remedial alternatives. This criterion will be addressed by presenting the alternatives at a public meeting and soliciting comments. That meeting will be held at least 30 days prior to remedy selection by IPL.

### 1.4 RISK REDUCTION AND REMEDY

As presented above, 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 balancing criteria listed here from §257.97(c) and discussed in **Section 5** 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; and

- (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 factored into 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.

**Section 3** presents a summary of the groundwater risk evaluation that provides the basis for evaluating these risk-based balancing criteria factors in **Section 5**.

### 1.5 CMA AMENDMENTS

As additional information becomes available in the future, including future groundwater monitoring results or other site-specific or general information, or technological developments, this CMA is subject to change. Nature and Extent evaluations are still underway for the Site and may influence the information in this report including the potential corrective measures and the analysis of the potential corrective measures. To the extent material changes to the CMA become necessary, such revised versions of the CMA will be posted to the facility CCR public website.

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

# 2. Groundwater Conceptual Site Model

To evaluate potential remedy options, a conceptual site model (CSM) was developed and evaluated based on data collected and associated with the Site. The CSM is summarized below.

## 2.1 SITE SETTING

The Site is located at 6925 N. State Road in Washington Township, Pike County, near Petersburg, Indiana. The Site is bounded to the north and west by the east fork of the White River, and by agricultural lands to the east and south.

The Site is located in the Wabash Lowland Subregion of the Southern Hills and Lowlands physiographic region of southwest Indiana on the banks of the east fork of the White River. The Wabash Lowland Sub-region is characterized by low-relief and rolling hills forming uplands along and between dominant bedrock drainage channels of the present-day Wabash, Eel, White, and East Fork White Rivers. The ground surface elevation of the Site ranges from approximately 500 feet above mean sea level (msl) on the east to about 430 feet above msl on the west.

## 2.2 GEOLOGY AND HYDROGEOLOGY

The Site is south of the area of Indiana affected by the last major Wisconsin glacial ice sheets but lies north and within the part of Indiana affected by earlier Pleistocene continental glacial episodes. A review of previously conducted sub-surface explorations indicates that the upland area is comprised of varying thickness of unconsolidated deposits of medium- to fine-grained sand, sandy silt, silt, and clayey silt with underlying Pennsylvanian bedrock. Sub-surface explorations completed in the areas adjacent and west of the LF in the vicinity of the AP indicate the presence of thicker Quaternary granular deposits in bedrock valleys. These unconsolidated deposits are generally fine to coarse outwash sands with finer grained silts and clays near the ground surface.

The AP is constructed in the White River floodplain. Most of the footprint overlies unconsolidated valley fill deposits that consist of roughly 10 to 15 feet of relatively fine-grained loamy alluvium on top of outwash sand and gravel. The outwash sand and gravel are up to 60 feet thick depending on the elevation of the buried bedrock erosional surface. The eastern side of the AP is roughly aligned with the former eastern edge of the floodplain.

The LF is located within the upland area adjacent to White River floodplain and the AP is located along the eastern edge of the floodplain. The unconsolidated sediments in the vicinity of the LF are characterized as silt, clayey silt, loam, silt loam, clay loam, sandy loam, and sandy clay, while the granular material consists of sand and loamy sand. Some of the deeper sandy loam and sand units may in part represent a highly weathered bedrock zone above more intact bedrock. The weathered bedrock is identified between approximately 22.5 feet and 36 feet below ground surface (bgs). More resistant bedrock is present between approximately 63 and 93 feet bgs. The sediments in the vicinity of the AP are general outwash fine to coarse sand with finer grained silts and clays near the surface with thicker granular deposits in bedrock valleys.

Bedrock in the Site area is Pennsylvanian age sandstone, limestone, shale, and coal of the Carbondale Group. Two formations, the Petersburg and Dugger Formations, underlie the unconsolidated outwash, floodplain, and wind-blown deposits. The top of the Petersburg Formation includes Springfield Coal. The Petersburg formation ranges from 40 to 120 feet thick and includes shale, sandstone, and coal. The Dugger formation overlies the Petersburg Formation and consists of limestone, coal, sandstone, and shale.

Following the completion of a three-month transducer survey, and pump down test of the drainage ditch separating the AP and the LF, it was determined that groundwater flow in the uppermost aquifer is dominantly west toward the White River, with groundwater contours generally trending parallel to the shoreline. A review of the groundwater elevations over this time period and the resulting elevations from pumping down the ditch, indicates that groundwater passing under the LF is weakly connected to the alluvial deposits underlying the AP, ultimately flowing west toward the White River. The alluvial deposits underlying the AP appear to be hydraulically connected to the White River. The finer-grained unconsolidated deposits that overly the coarser-grained deposits, and immediately underlie the AP, appear to be leaky. The underlying coarser grained alluvial deposits and ultimately the White River hydraulically control the entire unconsolidated groundwater flow system.

Hydraulic conductivity values are consistent with the expected values for wells screened in outwash sands and range from $1 \times 10^{-2}$ to $9 \times 10^{-2}$ cm/sec (centimeters per second). Lower hydraulic conductivities were measured in finer-grained, unconsolidated soils consisting of sandy loam, loam, silty clay, sandy clay, sand, and sandy loam. The hydraulic conductivities from slug tests range from $1 \times 10^{-4}$ cm/sec to $1 \times 10^{-3}$ cm/sec.

## 2.3 GROUNDWATER PROTECTION STANDARDS

The GWPS are 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 30 July 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

Because the GWPS is the higher of the MCL and the background concentration, and background concentrations are specific to each ash management area, the GWPS are unit-specific.
ATC completed a statistical evaluation of groundwater sample results for the AP and LF that meets the performance standard of §257.93. Unit-specific GWPS for each Appendix IV constituent were developed pursuant to 40 CFR §257.95(h). For the Ash Pond, SSLs above the GWPS are limited to cadmium and cobalt at monitoring well location AP-8; molybdenum at monitoring well location AP-2A, and molybdenum at monitoring well location AP-3A. For the LF, SSLs above the GWPS are limited to arsenic at monitoring well location MW-10; lithium at monitoring well location MW-2R, MW-3, and MW-4C; and molybdenum at monitoring well location MW-3. Monitoring well locations with SSLs above the GWPS are illustrated on **Figure 2-1**.

Following development of GWPS and establishment of SSLs, field investigations were initiated to demonstrate in accordance with 40 CFR §257.95(g)(3)(ii) that a source other than the AP and LF caused the arsenic SSL at MW-10 and the cadmium and cobalt SSLs at AP-8. A successful ASD report for each of these constituents was completed and certified as accurate by a qualified professional engineer.

## 2.4 NATURE AND EXTENT OF GROUNDWATER IMPACTS

As outlined in **Section 1.2** of this CMA, assessment monitoring results identified SSLs of cadmium, cobalt, and molybdenum for the Ash Pond and arsenic, lithium, and molybdenum for the LF. As a result, IPL initiated a nature and extent (N&E) investigation as required by the CCR Rule in 2019**.** Five N&E monitoring wells (N&E wells) (AP-9A, AP-10A, MW-19A, MW-19B, and MW-19I) were installed downgradient of the Ash Pond to provide horizontal and vertical delineation of molybdenum detected in samples collected from AP-2A and AP-3A. As noted in the previous section, a successful ASD report was completed and certified as accurate by a qualified professional engineer to address the cadmium and cobalt SSLs that were detected in AP-8.

A nested pair of piezometers (AP-PZ-1 screened in the ash and P-4 2019 screened in the alluvial deposits) were installed within the limits of Pond A to provided information on the hydraulic connection between the alluvial deposits underlying the AP and the White River. A third piezometer (AP-11A) was also installed north of the AP to better define groundwater flow direction. N&E piezometers and monitoring well locations are shown in **Figure 1-3.**

Three N&E wells (MW-14 through MW-16) were installed downgradient of the LF to delineate the horizontal extent of lithium and molybdenum detected in samples collected from monitoring wells (MW-2R, MW-3 and MW-4C) and to better inform seasonal high water level conditions related to Pond A. An ASD is pending to address the arsenic SSL that was detected in the groundwater samples from monitoring well MW-10. Two additional N&E monitoring points (MW-17 and MW-18) were installed on the northwest (downgradient side) of the LF. These wells are currently providing additional control points further define groundwater flow direction.

The N&E evaluation is ongoing. Future N&E analytical results will be used to supplement and enhance the evaluation of the extent of groundwater impacts and assessment of corrective measures.

# 3. Risk Assessment and Exposure Evaluation

A groundwater risk evaluation was performed by Haley & Aldrich, based on currently available information, the purpose of which is to provide the context needed to interpret and meaningfully understand the groundwater monitoring data collected and published for the AP and LF under the CCR Rule. In addition, IPL proactively took an additional step of evaluating potential groundwater-to-surface water transport and exposure pathways in the risk evaluation. N&E work and associated evaluations are still underway for the Site and may result in changes to this section of the report.

The risk evaluation was initiated by developing a CSM to identify the potential for human or ecological exposure to constituents that may have been released to the environment. Constituents present in the AP or LF can be dissolved into infiltrating water (from precipitation) and those constituents may move through the subsurface and could then be present in shallow groundwater. Constituents could move with groundwater as it flows, usually in a downgradient/downhill direction. The general direction of groundwater flow at the Site is to the west toward the White River.

Groundwater moves slowly through the rock and soils beneath the ground. Like surface water, it also moves from areas of high elevation to areas of low elevation and can move into adjacent surface water. Potential release of constituents to groundwater from the AP or LF will be limited in extent by the direction of groundwater flow (west toward the river) and will not impact surrounding upgradient areas to the east and south.

There are no on-site users of shallow groundwater at PGS. The Indiana Department of Natural Resources (IDNR) Division of Water Well Records database lists seven wells within a half mile radius of the AP and LF (IDNR, 2019). Five of these wells are downgradient of the AP and LF; all of these wells are owned by IPL and are no longer in use at PGS. Water for plant operations is obtained from the White River and potable water is provided by the municipal water utility. The review of the IDNR database did not identify any downgradient wells that are not associated with PGS operations. Two residential wells were identified within a ½ mile radius of the LF; these wells are located to the east (upgradient) of the AP and LF near State Road 57 and, therefore, would not be impacted by groundwater from either the AP or LF. The White River is downgradient of the Ash Pond System; groundwater will not flow beyond the river; therefore, the wells on the other side of the river are not considered to be downgradient.

To answer the question, “Are the constituent concentrations high enough to potentially exert a toxic effect?” health risk-based screening levels were used for comparison to the data. Of the groundwater data collected, the majority (94%) are below GWPS (i.e., below drinking water standards). There is no direct exposure to groundwater at or downgradient of the AP and LF by human or ecological receptors.

In addition, a surface water dilution and attenuation factor (SW-DAF) was derived for groundwater that may flow to the White River; the conservatively calculated SW-DAF is 3,200 (a unitless value). When the SW-DAF is applied to the lowest conservative risk-based screening level for surface water (including screening levels for both human health and ecological receptors) the results indicate that groundwater concentrations at the APs or LF could be much higher before groundwater could hypothetically cause a CCR-related constituent in White River surface water to be above a screening level protective of recreational use of the river and ecological receptors.

This evaluation demonstrates that the impacts of the AP and LF are limited. There is no known impact on drinking water (there are no downgradient users of groundwater as drinking water) and there is no evidence of impact to human health or the environment. There is no exposure to CCR-derived constituents detected in groundwater at the PGS facility, either via groundwater use or surface water. Even for the very few results that may be above screening values for some of the groundwater sampling events, there is no complete drinking water exposure pathway to groundwater. Where there is no exposure, there is no risk.

Therefore, because no adverse risk currently exists, any of the remedies considered in this CMA are all protective of human health and the environment, and implementation of any of the remedial alternatives will not result in a meaningful reduction in risk to groundwater-related exposures or risk.

# 4. Corrective Measures Alternatives

## 4.1 CORRECTIVE MEASURES ASSESSMENT GOALS

As noted in §257.96(a), within 90 days of detecting Appendix IV SSLs, “the owner or operator must initiate an assessment of corrective measures to prevent further releases, to remediate any releases and to restore affected area to original conditions.” The corrective measures evaluation that is discussed below and in subsequent sections provides an analysis of the effectiveness of five potential corrective measures in meeting the requirements and objectives of remedies as described under §257.97 (also shown in **Table I**). 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(c) for the balancing criteria (provided in more detail in **Section 1.3**) which includes 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 any residual contamination;
- The time required to begin and 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(s).

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

As described in **Section 2.2**, the LF is located immediately upgradient from the AP. Groundwater passing beneath the LF flows approximately east to west to the alluvial deposits beneath the AP. Since the LF and AP are in very close proximity, and groundwater beneath both units is hydrogeologically continuous, this CMA has been prepared for both the LF and the AP.

## 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 to achieve a calibration of less than 10% 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 predict that concentrations of SSL constituents decrease to the GWPS over time in the down-gradient monitoring locations for each of the remedial alternatives. The simulation outcomes are incorporated into the Balancing Criterion 1 sub-category discussions **(Section 5.2.1).**

## 4.3 CORRECTIVE MEASURES ALTERNATIVES

Corrective measures (remedies) are considered complete when groundwater impacted by the AP and LF does not exceed the Appendix IV GWPS for three consecutive years of groundwater monitoring pursuant to §257.98(c)(2). In accordance with §257.97(b), for the groundwater remedies to be considered, they must meet, at a minimum, the following threshold criteria (provided in more detail in **Section 1.3**):

1. Be protective of human health and the environment;
2. Attain the GWPS as specified pursuant to §257.95(h);
3. 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;
4. Remove from the environment as much of the contaminated material that was released from the CCR unit as is feasible, taking into account factors such as avoiding inappropriate disturbance of sensitive ecosystems; and
5. Comply with standards (regulations) for management of waste as specified in §257.98(d).

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

IPL has prepared a CCR Rule compliant ash pond closure plan for the AP and LF that is subject to change based on the selected remedy. Once selected, IPL intends to initiate closure of the units within the allowable timeframes as stated in §257.101 of the CCR Rule. The remedial alternatives presented below contemplate both closure in place (CIP) (Alternatives 1 through 4) and closure by removal (CBR) (Alternative 5) for the AP. All alternatives contemplate closure of the LF with capping.

### 4.3.1 Alternative 1 – Ash Pond Closure in Place with *In Situ* Stabilization and Capping, Cap Type III Landfill and Monitored Natural Attenuation

The AP would be closed in place with a cover that is constructed of a geomembrane and soil protective cap system to reduce infiltration of surface water to groundwater thereby isolating source material. This cap design would exceed regulatory requirements as compared to 1 x 10-5 cm/sec required by the CCR Rule but meet the expectations of the IDEM for purposes of CIP. The western one-third (approximately) of the LF has been closed in place with a low permeability cap. The remainder of the LF would also be addressed by installing a CCR Rule and IDEM compliant low permeability soil or geomembrane and soil protective cap system compliant with IDEM requirements and the CCR Rule to reduce the infiltration of precipitation to groundwater.

Prior to capping, CCR material below the water table would be isolated using targeted *in situ* stabilization (ISS). ISS is a technique that uses mixing of the CCR with amendments to solidify the material in place. Amendments typically include Portland Cement and the stabilization 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. Over time, the limited infiltration and solidified CCR would allow the concentration of constituents present in downgradient groundwater above GWPS and attributed to the AP to decline.

The LF would be addressed by installing a low-permeability cap to reduce the infiltration of precipitation to groundwater. Similar to the AP, limiting the infiltration of precipitation to groundwater would allow the downgradient concentrations of Appendix IV constituents to decline via natural attenuation.

CIP can be completed safely, in compliance with applicable federal and state regulations, and be protective of public health and the environment. In general, CIP consists of installing a cap/cover designed to significantly reduce infiltration from surface water or rainwater, resist erosion, contain CCR materials, and prevent exposures to CCR.

ISS is a technology that has been applied to a variety of sites for the remediation of soil and isolation of source material. As a technology, ISS has been accepted by state and federal regulators and a variety of guidance documents on ISS implementation are available.

Monitored natural attenuation (MNA) is a viable remedial technology recognized by both state and federal regulators that is applicable to inorganic compounds in groundwater. The USEPA defines MNA as “the reliance on natural attenuation processes to achieve site-specific remediation objectives within a time frame that is reasonable compared to that offered by other more active methods.” The “natural attenuation processes” that are at work in such a remediation approach include a variety of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater. These *in situ* processes include biodegradation, dispersion, dilution, sorption, volatilization, radioactive decay, and chemical or biological stabilization, transformation, or destruction of contaminants (USEPA, 2015). When combined with a low-permeability cap to address the source by limiting the infiltration of precipitation into and through the CCR, MNA can reduce concentrations of Appendix IV constituents in groundwater at and beyond the AP boundary.

Following completion of ISS and the installation of the AP and LF cap systems, IPL would implement post-closure care activities. Post-closure care includes cap system maintenance the continuation of groundwater monitoring pursuant to §§257.90 through 257.98.

### 4.3.2 Alternative 2 – Ash Pond CIP with Capping, Cap Type III Landfill, and Hydraulic Containment through Groundwater Pumping with Ex-situ Treatment

The AP would be closed in place with a cover that is constructed of a geomembrane and soil protective cap system to reduce infiltration of precipitation to groundwater thereby isolating source material.

Appendix IV constituents detected at the boundary of the AP at concentrations above the GWPS would be addressed with hydraulic containment through groundwater pumping to hydraulically control the migration of those constituents downgradient. Appendix IV constituents already present in groundwater downgradient from the pumping wells would be addressed through processes of natural attenuation. Pumping well effluent would be treated ex-situ, likely with an ion exchange or a reverse osmosis (RO) treatment system. The treatment system would have ongoing operations and maintenance and would generate a secondary waste stream – including but not limited to the regeneration/replacement of the ion exchange media or accumulation of reject water from the RO system. Verification that the effluent could be discharged under the current National Pollution Discharge Elimination System (NPDES) permit or application for and approval of a NPDES permit modification would be required.

Following the installation of the low-permeability caps (LF and AP) and the ex-situ treatment system, IPL would implement post-closure care activities that includes operation of the pumping wells and ex-situ treatment system, long-term groundwater sampling to monitor hydraulic containment system performance, and cap system maintenance. The groundwater pumping system would prevent further downgradient migration of groundwater from the units. The Appendix IV constituents present in groundwater downgradient of the units would be remediated through the processes of natural attenuation. Once concentrations of Appendix IV constituents decrease to the GWPS, operation of the hydraulic containment system could cease. IPL would maintain the groundwater monitoring system and continue to monitor the groundwater pursuant to §§257.90 through 257.98.

### 4.3.3 Alternative 3 – Ash Pond CIP with Capping, Cap Type III Landfill, and Hydraulic Containment through Groundwater Pumping with Ex-situ Treatment and Barrier Wall

The AP and LF would be closed in place as described in **Section 4.3.2** to reduce infiltration of precipitation to groundwater. Appendix IV constituents detected at the boundary of the AP at concentrations above the GWPS would be addressed with hydraulic containment through groundwater pumping to hydraulically control the migration of those constituents downgradient. Pumping well effluent would be treated ex-situ, likely with an ion exchange or an RO treatment system.

To improve efficiency of the pumping wells, a low permeability subsurface barrier wall would be installed to the west of the pumping wells, between the AP and the White River. The low permeability barrier wall would limit the amount of groundwater entering the pumping wells from the west, therefore allowing the pumping wells to operate at a lower pumping rate to achieve hydraulic containment. Appendix IV constituents already present in groundwater downgradient from the barrier wall would be addressed through processes of natural attenuation.

The LF would be addressed by installing a low-permeability cap to reduce the infiltration of precipitation to groundwater. The limited infiltration of precipitation to groundwater would allow the downgradient concentrations of Appendix IV constituents to decline via processes of natural attenuation.

Following the installation of the low-permeability caps (LF and AP) and barrier wall, IPL would implement post-closure care activities that includes continued operation of the pumping wells and treatment system, long-term groundwater sampling to monitor hydraulic control system performance, and cap system maintenance. Once concentrations of Appendix IV constituents downgradient of the barrier wall decrease to the GWPS, operation of the hydraulic containment system would cease. IPL would maintain the groundwater monitoring system and continue to monitor the groundwater pursuant to §§257.90 through 257.98.

### 4.3.4 Alternative 4 – Ash Pond CIP with Capping and Full Perimeter Wall, Cap Type III Landfill, and Limited Groundwater Pumping (pressure relief) with Ex-situ Treatment

The AP and LF would be closed in place as described in **Section 4.3.3** to reduce infiltration of precipitation to groundwater. In addition to the low-permeability cap, the AP would be surrounded by a low-permeability perimeter wall to isolate the CCR from further interaction with groundwater. Pumping wells would operate in alluvial soils beneath the AP and within the perimeter wall to control groundwater elevation within the walled area and create a slight inward hydraulic gradient. Pumping well effluent would be treated ex-situ, likely with an ion exchange or an RO treatment system. Appendix

IV constituents already present in groundwater outside of the perimeter wall would be addressed through processes of natural attenuation.

The LF would be addressed by installing a low-permeability or geomembrane and soil protective cap system to reduce the infiltration of precipitation to groundwater. The limited infiltration of precipitation to groundwater would allow the downgradient concentrations of Appendix IV constituents to decline via processes of natural attenuation, potentially supplemented with a gravity drain or other drainage features/controls on the western side of the LF.

Following the installation of the low-permeability caps (LF and AP), IPL would implement post-closure care activities that includes continued operation of the pumping wells and treatment system, long-term groundwater sampling to monitor remediation performance, and cap system maintenance. Once concentrations of Appendix IV constituents decrease to the GWPS, operation of the groundwater pumping system would cease. IPL would maintain the groundwater monitoring system and continue to monitor the groundwater pursuant to §§257.90 through 257.98.

#### 4.3.5 Alternative 5 – Ash Pond Closure by Removal, Cap Type III Landfill, and MNA

This alternative evaluates the removal of CCR from the AP and capping of the LF followed by natural attenuation of Appendix IV constituents in groundwater. Following AP and LF closure completion, concentrations of Appendix IV constituents in downgradient groundwater would decline via natural attenuation processes.

The location of CCR disposal is currently uncertain. Additional LF capacity, or a new LF, may be established on-site for AP CCR disposal. Alternatively, the CCR may be disposed off-site at an MSW landfill. Removal activities would likely 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 would 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 Site.

There are several potential community impacts, safety concerns and challenges associated with the off-site disposal CBR alternative. Given the magnitude of the total estimated truck trips (>350,000 trips) along with the combined travel distance required to transport the CCR to one or more landfills, there are increased exposures to transportation-related incidents. In addition, due to the volume and duration of loaded trucks travelling on public roads, it is anticipated that improvements to these roads may be necessary before or during large-scale removal of CCR. This could result in additional traffic flow disruptions and congestion due to road construction activities and delay in implementation or completion of this alternative. Fossil fuel consumption and vehicle emissions from transporting the CCR to a regional landfill are also significant in order to complete the off-site CBR alternative.

Following AP removal and LF capping, groundwater would be addressed through MNA which is a viable remedial technology that can reduce concentrations of Appendix IV constituents in groundwater at the AP boundary. Upon completion of AP CBR and LF capping, IPL would maintain the groundwater monitoring system and continue to monitor the groundwater pursuant to §§257.90 through 257.98.

# 5. Comparison of Corrective Measures Alternatives

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

## 5.1 EVALUATION CRITERIA

In accordance with §257.97, remedial alternatives[3] 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 informing the final corrective measure selection. The four balancing criteria include the following (provided in more detail in **Section 1.3**):

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(s); and
4. The degree to which community concerns are addressed by a potential remedy(s).

The degree to which community concerns are addressed by the potential remedies will be considered following a public meeting to discuss the results of the corrective measures assessment with interested and affected parties and will be held at least 30 days prior to remedy selection in accordance with §257.96(e).

## 5.2 COMPARISON OF ALTERNATIVES

This section compares the alternatives to each other based on evaluation of the balancing criteria listed above. Each of the balancing criteria consists of several sub-criteria listed in the CCR Rule (provided in detail in **Section 1.3**) which have been considered in this assessment. The goal of this analysis is to evaluate the alternatives based on whether each is technologically feasible, relevant and readily implementable, provides adequate protection to human health and the environment, and minimizes impacts to the community as compared to other alternatives.

A color-coded graphic which is part of a comprehensive visual comparison tool (see **Table II**) 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.

[3] The terms "corrective measures alternatives" and "remedial alternatives" are used interchangeably within this report to represent potential remedies for satisfying the requirements of §257.97 of the CCR Rule.

#### 5.2.1.1 *Magnitude of reduction of existing risks*

As summarized by the risk evaluation in **Section 3**, the Ash Pond System and Landfill at PGS do not pose a risk to human health or the environment. Therefore, the remedial alternatives considered are not necessary to reduce an assumed risk posed by the Appendix IV constituents, lithium and molybdenum, in groundwater because no such adverse risk exists. However, other types of impacts may be posed by the various remedial alternatives considered herein.

With respect to the magnitude of reduction of existing risk, Alternatives 2 and 3 are considered favorable since installation of groundwater recovery systems and the operation and maintenance of ex-situ treatment systems are considered favorable relative to the remaining three alternatives which all include large-scale construction. Alternatives 1 and 4 include ISS or full perimeter wall construction, respectively, which create risks associated with material handling and transportation of construction materials to the Site. Alternatives 1 and 4 are therefore considered less favorable. Alternative 5 is considered least favorable with respect to this criterion due to the risks associated with material handling, dewatering, and transportation to the off-site landfill throughout the duration of the long-term Ash Pond System removal project.

| | **Alternative 1** Ash Pond CIP with In-Situ Stabilization and Capping, Cap Landfill and MNA | **Alternative 2** Ash Pond CIP with Capping, Cap Landfill, and HC through Groundwater Pumping with Ex-Situ Treatment | **Alternative 3** Ash Pond CIP with Capping, Cap Landfill, HC through Groundwater Pumping with Ex-Situ Treatment and Barrier Wall | **Alternative 4** Ash Pond CIP with Capping and Full Perimeter Wall, Cap Landfill and Limited Groundwater Pumping with Ex-Situ Treatment | **Alternative 5** Ash Pond Closure by Removal, Cap Landfill, and MNA |
|---|---|---|---|---|---|
| *Category 1 - Subcriteria i)* Magnitude of reduction of risks | | | | | |

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

Following implementation of a remedy, all alternatives will initially achieve an equal magnitude of residual risks in terms of likelihood of further releases due to CCR remaining because full implementation of all the remedies will result in meeting the GWPS as a threshold criterion. However, for those alternatives that include Ash Pond System CIP, the uncertainty associated with CCR materials remaining in the environment represents a slightly higher potential risk, therefore these alternatives are considered less favorable with respect to this criterion. With respect to the LF, all alternatives are equivalent since the Landfill will be CIP.

| | **Alternative 1** Ash Pond CIP with In-Situ Stabilization and Capping, Cap Landfill and MNA | **Alternative 2** Ash Pond CIP with Capping, Cap Landfill, and HC through Groundwater Pumping with Ex-Situ Treatment | **Alternative 3** Ash Pond CIP with Capping, Cap Landfill, HC through Groundwater Pumping with Ex-Situ Treatment and Barrier Wall | **Alternative 4** Ash Pond CIP with Capping and Full Perimeter Wall, Cap Landfill and Limited Groundwater Pumping with Ex-Situ Treatment | **Alternative 5** Ash Pond Closure by Removal, Cap Landfill, and MNA |
|---|---|---|---|---|---|
| *Category 1 - Subcriteria ii)* Magnitude of residual risk in terms of likelihood of further release | | | | | |

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

Alternatives 1 and 5 are favorable alternatives with respect to this sub-criterion because CIP with isolation of the Ash Pond System through ISS (Alternative 1) or removal (Alternative 5) with MNA requires the least amount of long-term management and involve no mechanical systems as part of the remedy. Alternative 4 is also considered favorable since this CIP alternative includes isolation (perimeter wall) of the Ash Pond System with only limited groundwater pumping to maintain an inward hydraulic gradient across the wall. Alternatives 2 and 3 are less favorable since both alternatives include larger-scale hydraulic containment systems which will require operation and maintenance until the GWPS is achieved. For the Landfill, long-term inspection and maintenance of the cap will be equivalent for all alternatives.

| | **Alternative 1** Ash Pond CIP with In-Situ Stabilization and Capping, Cap Landfill and MNA | **Alternative 2** Ash Pond CIP with Capping, Cap Landfill, and HC through Groundwater Pumping with Ex-Situ Treatment | **Alternative 3** Ash Pond CIP with Capping, Cap Landfill, HC through Groundwater Pumping with Ex-Situ Treatment and Barrier Wall | **Alternative 4** Ash Pond CIP with Capping and Full Perimeter Wall, Cap Landfill and Limited Groundwater Pumping with Ex-Situ Treatment | **Alternative 5** Ash Pond Closure by Removal, Cap Landfill, and MNA |
|---|---|---|---|---|---|
| *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 of the remedies, along with truck emissions and noise. Because Alternative 5 includes transportation of the CCR material over public roadways for off-site disposal, this alternative is considered the least favorable. Alternatives 3 and 4 are considered less favorable when compared to Alternative 2 since the remedial approach includes a subsurface barrier wall or perimeter wall, which will include transportation of construction materials onto the Site via public roadways. Similarly, Alternative 1 is considered unfavorable since ISS will include transportation of construction materials and amendments onto the Site via public roadways. Alternatives 2 is generally limited to the transportation of Ash Pond System capping materials and hydraulic containment equipment onto the Site as part of the remedy and is considered the most favorable relative to short-term risk to the community or environment. For the Landfill, implementation of the CIP with capping will be equivalent for all alternatives.

| | **Alternative 1** Ash Pond CIP with In-Situ Stabilization and Capping, Cap Landfill and MNA | **Alternative 2** Ash Pond CIP with Capping, Cap Landfill, and HC through Groundwater Pumping with Ex-Situ Treatment | **Alternative 3** Ash Pond CIP with Capping, Cap Landfill, HC through Groundwater Pumping with Ex-Situ Treatment and Barrier Wall | **Alternative 4** Ash Pond CIP with Capping and Full Perimeter Wall, Cap Landfill and Limited Groundwater Pumping with Ex-Situ Treatment | **Alternative 5** Ash Pond Closure by Removal, Cap Landfill, and MNA |
|---|---|---|---|---|---|
| *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 lithium and molybdenum associated with the Ash Pond System; therefore, protection is already achieved. The timeframes to achieve GWPS were evaluated using a predictive model as described in **Section 4.2**. Based upon predictive modeling the timeframes to achieve GWPS are long-term for all alternatives, therefore each of the five alternatives are ranked equally for this sub-criterion.

| | **Alternative 1** Ash Pond CIP with In-Situ Stabilization and Capping, Cap Landfill and MNA | **Alternative 2** Ash Pond CIP with Capping, Cap Landfill, and HC through Groundwater Pumping with Ex-Situ Treatment | **Alternative 3** Ash Pond CIP with Capping, Cap Landfill, HC through Groundwater Pumping with Ex-Situ Treatment and Barrier Wall | **Alternative 4** Ash Pond CIP with Capping and Full Perimeter Wall, Cap Landfill and Limited Groundwater Pumping with Ex-Situ Treatment | **Alternative 5** Ash Pond Closure by Removal, Cap Landfill, and MNA |
|---|---|---|---|---|---|
| *Category 1 - Subcriteria v)* Time until full protection is achieved | | | | | |

#### 5.2.1.6 Potential for exposure of humans and environmental receptors to remaining wastes, considering the potential threat to human health and the environment associated with excavation, transportation, re-disposal, or containment

Because the downgradient extent of groundwater impacted by the Ash Pond System and Landfill is limited to the alluvial aquifer, Alternative 2 has the lowest potential for exposure to human and environmental receptors and is considered most favorable with respect to this criterion since capping and operation of the hydraulic containment system has the least potential for exposure. Alternatives 3 and 4 are considered less favorable since they include construction of a subsurface barrier wall or perimeter wall, respectively, which increases the potential for exposure during construction. Similarly, Alternative 1 is considered less favorable since this scenario includes ISS of the CCR, which increases the potential for exposure during construction. Alternative 5, which includes excavation, transportation, and disposal of CCR material has the highest potential risk for exposure to humans and environmental receptors due to construction and transportation and is therefore considered least favorable with respect to this criterion.

| | **Alternative 1** Ash Pond CIP with In-Situ Stabilization and Capping, Cap Landfill and MNA | **Alternative 2** Ash Pond CIP with Capping, Cap Landfill, and HC through Groundwater Pumping with Ex-Situ Treatment | **Alternative 3** Ash Pond CIP with Capping, Cap Landfill, HC through Groundwater Pumping with Ex-Situ Treatment and Barrier Wall | **Alternative 4** Ash Pond CIP with Capping and Full Perimeter Wall, Cap Landfill and Limited Groundwater Pumping with Ex-Situ Treatment | **Alternative 5** Ash Pond Closure by Removal, Cap Landfill, and MNA |
|---|---|---|---|---|---|
| *Category 1 - Subcriteria vi)* Potential for exposure of humans and environmental receptors to remaining wastes | | | | | |

#### 5.2.1.7 Long-term reliability of the engineering and institutional controls

All alternatives include long-term maintenance of the LF cap and cover system, which is considered reliable. Alternatives 1, 4, and 5 include isolation or removal of the Ash Pond System CCR and are expected to have high long-term reliability and are considered most favorable with respect to this criterion. Hydraulic containment systems (Alternatives 2 and 3) 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 and are therefore considered less reliable.

| | **Alternative 1** Ash Pond CIP with In-Situ Stabilization and Capping, Cap Landfill and MNA | **Alternative 2** Ash Pond CIP with Capping, Cap Landfill, and HC through Groundwater Pumping with Ex-Situ Treatment | **Alternative 3** Ash Pond CIP with Capping, Cap Landfill, HC through Groundwater Pumping with Ex-Situ Treatment and Barrier Wall | **Alternative 4** Ash Pond CIP with Capping and Full Perimeter Wall, Cap Landfill and Limited Groundwater Pumping with Ex-Situ Treatment | **Alternative 5** Ash Pond Closure by Removal, Cap Landfill, and MNA |
|---|---|---|---|---|---|
| *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 LF capping and CBR with MNA for the Ash Pond System, is considered the remedy with a low likelihood of requiring replacement because source removal is permanent and natural processes will remedy groundwater. Alternatives 1 and 4 include isolation of the Ash Pond System CCR through ISS or a perimeter wall, respectively, along with landfill capping which are expected to be permanent with a low likelihood of needing replacement. From the perspective of needing to replace the remedy, the alternatives that rely on operating mechanical systems (Alternatives 2 and 3) are considered more likely to require replacement and are, therefore, also considered less favorable than the alternatives which include LF capping and Ash Pond System isolation or removal.

| | **Alternative 1** Ash Pond CIP with In-Situ Stabilization and Capping, Cap Landfill and MNA | **Alternative 2** Ash Pond CIP with Capping, Cap Landfill, and HC through Groundwater Pumping with Ex-Situ Treatment | **Alternative 3** Ash Pond CIP with Capping, Cap Landfill, HC through Groundwater Pumping with Ex-Situ Treatment and Barrier Wall | **Alternative 4** Ash Pond CIP with Capping and Full Perimeter Wall, Cap Landfill and Limited Groundwater Pumping with Ex-Situ Treatment | **Alternative 5** Ash Pond Closure by Removal, Cap Landfill, and MNA |
|---|---|---|---|---|---|
| *Category 1 - Subcriteria viii)* Potential need for replacement of the remedy | | | | | |

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

The following graphic provides a summary of the long- and short-term effectiveness and protectiveness of the potential remedy, along with the degree of certainty that the remedy will prove successful. Alternatives 1 through 4, which include CIP with hydraulic containment or isolation for the Ash Pond System and CIP with capping for the Landfill, are considered equally less favorable due to sub-criterion considerations. Containment or isolation practices are proven and known to successfully contain releases, although isolation will require substantial construction efforts and hydraulic containment will require ongoing operation and maintenance. For Alternatives 1 through 4, CCR remains in place within the Ash Pond System, which leaves the potential for a further release following the implementation of the remedy. Alternative 5, which includes CBR with MNA for the Ash Pond System and CIP with capping for the Landfill, is considered the least favorable. Removal of the CCR from the Ash Pond System will require large-scale construction with transportation of CCR over public roadways, which creates potential impacts to the community. Ash Pond System removal activities also create a greater potential for exposure to humans and the environment during construction relative to Alternatives 1 through 4 which include closure in place.

| | **Alternative 1**<br>Ash Pond CIP with In-Situ Stabilization and Capping, Cap Landfill and MNA | **Alternative 2**<br>Ash Pond CIP with Capping, Cap Landfill, and HC through Groundwater Pumping with Ex-Situ Treatment | **Alternative 3**<br>Ash Pond CIP with Capping, Cap Landfill, HC through Groundwater Pumping with Ex-Situ Treatment and Barrier Wall | **Alternative 4**<br>Ash Pond CIP with Capping and Full Perimeter Wall, Cap Landfill and Limited Groundwater Pumping with Ex-Situ Treatment | **Alternative 5**<br>Ash Pond Closure by Removal, Cap Landfill, and MNA |
|---|---|---|---|---|---|
| **CATEGORY 1**<br>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 extensiveness of treatment technologies that will be required.

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

Alternatives 2 and 3 are considered favorable in this sub-category because source material remains in place, but hydraulic containment systems are effective at reducing further releases. Alternative 4 is also considered favorable since the full perimeter wall around the Ash Pond System will be effective at reducing a further release. Alternatives 1 and 5 which include ISS or removal of the Ash Pond System, respectively, will be effective longer-term, but releases will continue to occur during the construction period which will be lengthy. Therefore, Alternatives 1 and 5 are considered less favorable when compared to Alternatives 2 through 4. All alternatives assume capping of the Landfill which is expected to reduce further releases by limiting infiltration of precipitation.

| | **Alternative 1**<br>Ash Pond CIP with In-Situ Stabilization and Capping, Cap Landfill and MNA | **Alternative 2**<br>Ash Pond CIP with Capping, Cap Landfill, and HC through Groundwater Pumping with Ex-Situ Treatment | **Alternative 3**<br>Ash Pond CIP with Capping, Cap Landfill, HC through Groundwater Pumping with Ex-Situ Treatment and Barrier Wall | **Alternative 4**<br>Ash Pond CIP with Capping and Full Perimeter Wall, Cap Landfill and Limited Groundwater Pumping with Ex-Situ Treatment | **Alternative 5**<br>Ash Pond Closure by Removal, Cap Landfill, and MNA |
|---|---|---|---|---|---|
| *Category 2 - Subcriteria i)*<br>Extent to which containment practices will reduce further releases | | | | | |

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

With respect to Alternatives 1 and 5, no groundwater treatment technologies other than natural attenuation will be used and are considered the most favorable with respect to this criterion. Alternative 4 will rely on a full perimeter wall for the Ash Pond System along with limited groundwater pumping system to maintain an inward hydraulic gradient and is considered less favorable when compared to Alternatives 1 and 5. Alternative 2 will rely on pumping wells and an ex-situ treatment system and is considered less favorable. The 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 3 will rely on pumping wells, an ex-situ treatment system, and a barrier wall downgradient from the Ash Pond System and is considered the least favorable.

| | **Alternative 1** Ash Pond CIP with In-Situ Stabilization and Capping, Cap Landfill and MNA | **Alternative 2** Ash Pond CIP with Capping, Cap Landfill, and HC through Groundwater Pumping with Ex-Situ Treatment | **Alternative 3** Ash Pond CIP with Capping, Cap Landfill, HC through Groundwater Pumping with Ex-Situ Treatment and Barrier Wall | **Alternative 4** Ash Pond CIP with Capping and Full Perimeter Wall, Cap Landfill and Limited Groundwater Pumping with Ex-Situ Treatment | **Alternative 5** Ash Pond Closure by Removal, Cap Landfill, and MNA |
|---|---|---|---|---|---|
| *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. For all alternatives, Landfill CIP with capping is considered effective and therefore equivalent. For the Ash Pond System, Alternative 3 is considered the least favorable since this alternative will require the greatest number and scale of treatment technologies (capping, barrier wall, hydraulic containment system, and ex-situ treatment system) to reduce further releases. Alternatives 2 and 4 are considered less favorable since they will require a greater number of treatment technologies relative to Alternatives 1 and 5. Alternatives 1 and 5 are also considered less favorable since ISS or removal will be effective at reducing further releases long-term, but releases will be on-going during the lengthy construction period.

| | **Alternative 1** Ash Pond CIP with In-Situ Stabilization and Capping, Cap Landfill and MNA | **Alternative 2** Ash Pond CIP with Capping, Cap Landfill, and HC through Groundwater Pumping with Ex-Situ Treatment | **Alternative 3** Ash Pond CIP with Capping, Cap Landfill, HC through Groundwater Pumping with Ex-Situ Treatment and Barrier Wall | **Alternative 4** Ash Pond CIP with Capping and Full Perimeter Wall, Cap Landfill and Limited Groundwater Pumping with Ex-Situ Treatment | **Alternative 5** Ash Pond Closure by Removal, Cap Landfill, and MNA |
|---|---|---|---|---|---|
| **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 technical and logistical challenges required to implement a remedy, including practical considerations such as equipment availability and disposal facility capacity.

### *5.2.3.1 Degree of difficulty associated with constructing the technology*

Alternatives 2 is considered most favorable since the concepts and technologies are proven and can be implemented in a reasonable timeframe. Alternative 3 and 4 are considered less favorable since the subsurface barrier wall or perimeter wall will increase the complexity of implementation. Alternatives 1 and 5 will involve large-scale construction projects to isolate or remove CCR from the Ash Pond System and are therefore considered the least favorable. All alternatives assume CIP with capping for the Landfill, which can be readily implemented.

| | Alternative 1<br>Ash Pond CIP with In-Situ Stabilization and Capping, Cap Landfill and MNA | Alternative 2<br>Ash Pond CIP with Capping, Cap Landfill, and HC through Groundwater Pumping with Ex-Situ Treatment | Alternative 3<br>Ash Pond CIP with Capping, Cap Landfill, HC through Groundwater Pumping with Ex-Situ Treatment and Barrier Wall | Alternative 4<br>Ash Pond CIP with Capping and Full Perimeter Wall, Cap Landfill and Limited Groundwater Pumping with Ex-Situ Treatment | Alternative 5<br>Ash Pond Closure by Removal, Cap Landfill, and MNA |
|---|---|---|---|---|---|
| *Category 3 - Subcriteria i)*<br>Degree of difficulty associated with constructing the technology | | | | | |

### 5.2.3.2 *Expected operational reliability of the technologies*

For the Landfill, all alternatives assume CIP with capping which is considered reliable. Alternatives 1, 4 and 5 are considered favorable from an operational perspective because isolation or removal of the Ash Pond System followed by MNA only requires long-term monitoring following implementation. Alternative 3 includes a barrier wall which is expected to improve the efficiency of the HC system, but will still require operations and maintenance which makes this alternative less reliable when compared to Alternatives 1, 4, and 5. Alternative 2 includes hydraulic containment, which is expected to be reliable, but this alternative will utilize additional groundwater treatment technologies which will require treatability studies and operations and maintenance and therefore is considered least favorable when compared to the other alternatives.

| | Alternative 1<br>Ash Pond CIP with In-Situ Stabilization and Capping, Cap Landfill and MNA | Alternative 2<br>Ash Pond CIP with Capping, Cap Landfill, and HC through Groundwater Pumping with Ex-Situ Treatment | Alternative 3<br>Ash Pond CIP with Capping, Cap Landfill, HC through Groundwater Pumping with Ex-Situ Treatment and Barrier Wall | Alternative 4<br>Ash Pond CIP with Capping and Full Perimeter Wall, Cap Landfill and Limited Groundwater Pumping with Ex-Situ Treatment | Alternative 5<br>Ash Pond Closure by Removal, Cap Landfill, and MNA |
|---|---|---|---|---|---|
| *Category 3 - Subcriteria ii)*<br>Expected operational reliability of the technologies | | | | | |

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

For the Landfill, all alternatives assume CIP with capping and equal favorability. For the Ash Pond System, Alternative 1 will require approvals and permits for implementation of the ISS, which is considered less favorable. Alternatives 2 and 3 will require additional permitting and approvals for treatability testing, field scale pilot testing, groundwater discharge, groundwater treatment, and/or disposal of secondary waste streams and are also considered less favorable. Alternative 4 is considered less favorable since approvals and permits will be required for construction of the full perimeter wall within the floodway and the smaller-scale pumping system which will maintain an inward hydraulic gradient. Alternative 5 is considered the least favorable since more complex permits will be required for the large-scale removal of the Ash Pond System and off-site transportation and disposal of the CCR.

| | Alternative 1<br>Ash Pond CIP with In-Situ Stabilization and Capping, Cap Landfill and MNA | Alternative 2<br>Ash Pond CIP with Capping, Cap Landfill, and HC through Groundwater Pumping with Ex-Situ Treatment | Alternative 3<br>Ash Pond CIP with Capping, Cap Landfill, HC through Groundwater Pumping with Ex-Situ Treatment and Barrier Wall | Alternative 4<br>Ash Pond CIP with Capping and Full Perimeter Wall, Cap Landfill and Limited Groundwater Pumping with Ex-Situ Treatment | Alternative 5<br>Ash Pond Closure by Removal, Cap Landfill, and MNA |
|---|---|---|---|---|---|
| *Category 3 - Subcriteria iii)*<br>Need to coordinate with and obtain necessary approvals and permits from other agencies | | | | | |

#### 5.2.3.4 *Availability of necessary equipment and specialists*

For the Landfill, all alternatives are considered equivalent since CIP with capping will not require specialists or specialized equipment. For the Ash Pond System, Alternative 2 will require equipment for drilling, recovery well installation, construction of groundwater conveyance systems, and treatment system but these are readily available. Therefore, Alternative 2 is considered most favorable when compared to the other alternatives. Alternatives 1, 3, and 4 are least favorable since specialized equipment and contractors will be required for the ISS (Alternative 1), installation of the barrier wall (Alternative 3) and installation of the full perimeter wall. (Alternative 4). Alternative 5 is less favorable since it will require equipment for the large-scale construction project, but implementation is expected to be straightforward without the needs for specialists.

| | **Alternative 1** Ash Pond CIP with In-Situ Stabilization and Capping, Cap Landfill and MNA | **Alternative 2** Ash Pond CIP with Capping, Cap Landfill, and HC through Groundwater Pumping with Ex-Situ Treatment | **Alternative 3** Ash Pond CIP with Capping, Cap Landfill, HC through Groundwater Pumping with Ex-Situ Treatment and Barrier Wall | **Alternative 4** Ash Pond CIP with Capping and Full Perimeter Wall, Cap Landfill and Limited Groundwater Pumping with Ex-Situ Treatment | **Alternative 5** Ash Pond Closure by Removal, Cap Landfill, and MNA |
|---|---|---|---|---|---|
| *Category 3 - Subcriteria iv)* Availability of necessary equipment and specialists | | | | | |

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

Alternative 1 is considered the most favorable since treatment, storage, and disposal will not be needed. Isolating the CCR in place will not require off-site disposal and will not generate a waste stream. Alternative 5, which includes closure by removal, requires adequate capacity, storage, and disposal services. Due to the relatively large size of the Ash Pond System (approximately 5.7 million cubic yards) and off-site disposal, this alternative is considered the least favorable. For Alternatives 2 and 3 which include hydraulic containment with groundwater treatment, the ex-situ treatment system may generate a concentrated waste stream which would require off-site transportation and disposal that Alternative 1 would not require and are therefore considered less favorable. For Alternative 4, a pumping system with ex-situ treatment would operate and may generate a concentrated waste stream, although a smaller volume than Alternatives 2 and 3 is anticipated. Spoils generated during the installation of the full perimeter wall may also require off-site disposal, which makes Alternative 4 less favorable when compared to Alternative 1.

| | **Alternative 1** Ash Pond CIP with In-Situ Stabilization and Capping, Cap Landfill and MNA | **Alternative 2** Ash Pond CIP with Capping, Cap Landfill, and HC through Groundwater Pumping with Ex-Situ Treatment | **Alternative 3** Ash Pond CIP with Capping, Cap Landfill, HC through Groundwater Pumping with Ex-Situ Treatment and Barrier Wall | **Alternative 4** Ash Pond CIP with Capping and Full Perimeter Wall, Cap Landfill and Limited Groundwater Pumping with Ex-Situ Treatment | **Alternative 5** Ash Pond Closure by Removal, Cap Landfill, and MNA |
|---|---|---|---|---|---|
| *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. For all alternatives, Landfill CIP with capping is considered readily implementable and therefore equivalent. For the Ash Pond System, Alternatives 2 and 3 which include a hydraulic containment component, and Alternative 4 which includes a full perimeter wall with limited groundwater pumping, are considered less favorable. Due to the large-scale construction for Ash Pond System removal and disposal requirements, Alternative 5 (CBR with MNA) is considered the least favorable, as is Alternative 1 which will require specialized contractors and equipment to implement and will require large-scale construction.

| | **Alternative 1** Ash Pond CIP with In-Situ Stabilization and Capping, Cap Landfill and MNA | **Alternative 2** Ash Pond CIP with Capping, Cap Landfill, and HC through Groundwater Pumping with Ex-Situ Treatment | **Alternative 3** Ash Pond CIP with Capping, Cap Landfill, HC through Groundwater Pumping with Ex-Situ Treatment and Barrier Wall | **Alternative 4** Ash Pond CIP with Capping and Full Perimeter Wall, Cap Landfill and Limited Groundwater Pumping with Ex-Situ Treatment | **Alternative 5** Ash Pond Closure by Removal, Cap Landfill, and MNA |
|---|---|---|---|---|---|
| **CATEGORY 3** Ease of implementation | | | | | |



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# 6. Summary

This Corrective Measures Assessment has evaluated the following alternatives:

- Alternative 1: Ash Pond CIP with *In Situ* Stabilization and capping, Cap Type III Landfill and MNA;
- Alternative 2: Ash Pond CIP with capping, Cap Type III Landfill, and hydraulic containment through groundwater pumping with ex-situ treatment;
- Alternative 3: Ash Pond CIP with capping, Cap Type III Landfill, and hydraulic containment through groundwater pumping with ex-situ treatment and barrier wall;
- Alternative 4: Ash Pond CIP with capping, Cap Type III Landfill, and hydraulic containment through limited groundwater pumping (pressure relief) with ex-situ treatment and perimeter wall; and
- Alternative 5: Ash Pond CBR, Cap Type III Landfill, and MNA.

In accordance with §257.97(b), each of these alternatives has been confirmed to meet the following threshold criteria:

- Be protective of human health and the environment;
- Attain the GWPS 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; and
- Comply with standards for management of wastes as specified in §257.98(d).

In addition, in accordance with §257.96(c), 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(s); and
- The degree to which community concerns are addressed by a potential remedy(s).

This Corrective Measures Assessment, the input received during the public meeting, and any additional information, including N&E investigative work results will be used to select a remedy (corrective measure) for implementation at the Site in accordance with the CCR Rule. §257.97(a) requires that a semi-annual report be prepared to document progress toward remedy selection and design. Once a remedy is selected, a final remedy selection report must be prepared to document details of the selected remedy and how the selected remedy meets §257.97(b) requirements. The final selected remedy report will also be certified by a professional engineer and posted to the PGS CCR website.

# References


1. ATC. 2019. 2018 CCR Annual Groundwater Monitoring and Corrective Action Report, IPL Petersburg Generating Station Ash Pond System, Petersburg, Indiana.

2. ATC. 2019. 2018 CCR Annual Groundwater Monitoring and Corrective Action Report, IPL Petersburg Generating Station RWS Type III Landfill, Petersburg, Indiana.

3. ATC. 2018. 2017 CCR Annual Groundwater Monitoring and Corrective Action Report, IPL Petersburg Generating Station Ash Pond System, Petersburg, Indiana.

4. ATC. 2018. 2017 CCR Annual Groundwater Monitoring and Corrective Action Report, IPL Petersburg Generating Station RWS Type III Landfill, Petersburg, Indiana.

5. ATC. 2016. Closure Plan Modification No. 1, IPL Petersburg Generating Station Type III RWS Landfill.

6. Cardno ATC 2014. Proposed Closure and Post-Closure Plans, Ash Pond System Petersburg Generating Station Ash Pond System, Petersburg, Indiana.

7. USEPA. 2015. Frequent Questions about the 2015 Coal Ash Disposal Rule. https://www.epa.gov/coalash/frequent-questions-about-2015-coal-ash-disposal-rule

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10. USEPA. 2018a. USEPA Regional Screening Levels. November 2018, values for tap water. U.S. Environmental Protection Agency. Available at: https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables


\\haleyaldrich.com\share\CF\Projects\133274\002 - Petersburg CMA\CMA Report\Ash Pond_Landfill\Enhancement Period\Text\Final\2019_1011 IPL Petersburg CMA Final Draft.docx

# TABLES

**TABLE I**
**REMEDIAL ALTERNATIVE ROADMAP**
MULTI-UNIT ASH POND AND TYPE III LANDFILL
PETERSBURG GENERATING STATION - PETERSBURG, INDIANA

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

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**TABLE II**

**SUMMARY OF CORRECTIVE MEASURES**

CORRECTIVE MEASURES ASSESSMENT

MULTI-UNIT ASH POND AND TYPE III LANDFILL

PETERSBURG GENERATING STATION - PETERSBURG, INDIANA

| Alternative Number | Remedial Alternative Description | THRESHOLD CRITERIA: Be protective of human health and the environment | THRESHOLD CRITERIA: Attain the groundwater protective standard | THRESHOLD CRITERIA: 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 | THRESHOLD CRITERIA: 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 | THRESHOLD CRITERIA: Management of waste to comply with all applicable RCRA requirements | BALANCING CRITERIA: 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 | Sub-Category 1: 2 Magnitude of residual risks in terms of likelihood of further releases due to CCR remaining following implementation of a remedy | Sub-Category 1: 3 Type and degree of long-term management required including monitoring, operation and maintenance | Sub-Category 1: 4 Short-term risk to community or environment during implementation of remedy | Sub-Category 1: 5 Time until full protection is achieved | Sub-Category 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 | Sub-Category 1: 7 Long-term reliability of engineering and institutional controls | Sub-Category 1: 8 Potential need for replacement of the remedy | CATEGORY 2 Effectiveness in controlling the source to reduce further releases | Sub-Cat. 2: 1 Extent to which containment practices will reduce further releases | Sub-Cat. 2: 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 | Sub-Category 3: 2 Expected operational reliability of the technologies | Sub-Category 3: 3 Need to coordinate with and obtain necessary approvals and permits from other agencies | Sub-Category 3: 4 Availability of necessary equipment and specialists | Sub-Category 3: 5 Available capacity and location of needed treatment, storage, and disposal services |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Ash Pond Closure in Place (CIP) with In-Situ Stabilization (ISS) and Capping, Cap Type III Landfill, and Monitored Natural Attenuation (MNA) | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | | | | | | | | | | | | | | |
| 2 | Ash Pond CIP with Capping, Cap Type III Landfill, and Hydraulic Containment through Groundwater Pumping with Ex-Situ Treatment | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | | | | | | | | | | | | | | |
| 3 | Ash Pond CIP with Capping, Cap Type III Landfill, and Hydraulic Containment through Groundwater Pumping with Ex-Situ Treatment and Barrier Wall | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | | | | | | | | | | | | | | |
| 4 | Ash Pond CIP with Capping and Full Perimeter Wall, Cap Type III Landfill, and Limited Groundwater Pumping (pressure relief) with Ex-Situ Treatment | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | | | | | | | | | | | | | | |
| 5 | Ash Pond Closure by Removal (CBR), Cap Type III Landfill, and MNA | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | | | | | | | | | | | | | | |

**COLOR LEGEND**

Most favorable when compared to other alternatives

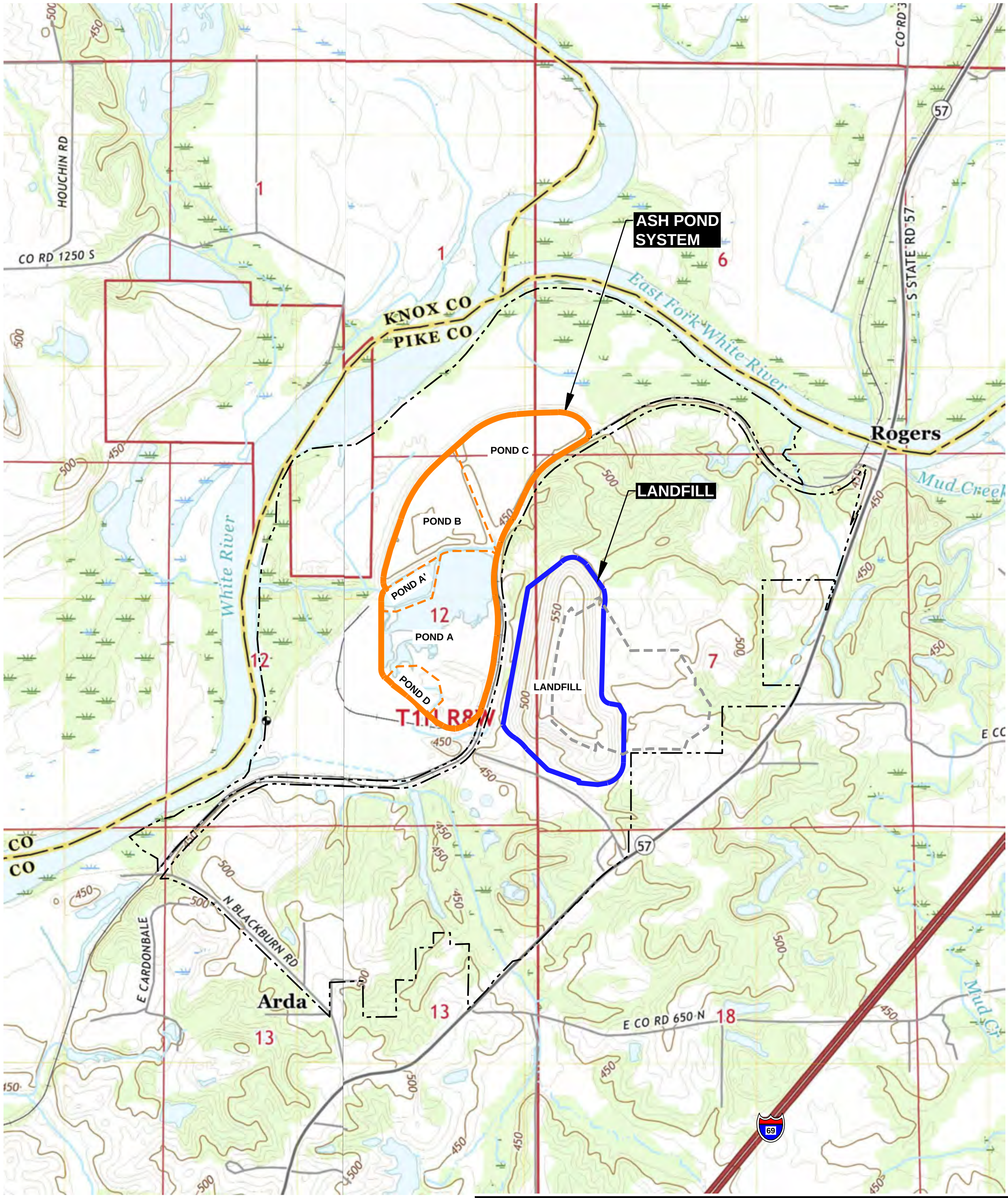
Less favorable when compared to other alternatives

Least favorable when compared to other alternatives

[1] Closure in place with monitored natural attenuation (MNA) was evaluated as a potential remedial alternative, but did not pass the threshold criteria due to an inability to attain the Groundwater Protective Standard.

Note: For context, this a relative comparison of remedial options for this site. Site conditions, weather, and site-specific considerations are made in this table. This is not a comparison to all options at all sites.

**FIGURES**




MAP SOURCE: USGS
QUADRANGELS: SANDY HOOK, IN 2019
MONROE CITY, IN 2019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CORRECTIVE MEASURES ASSESSMENT
PETERSBURG GENERATING STATION
PETERSBURG, INDIANA

SITE LOCATION MAP

APPROXIMATE SCALE: 1IN = 2000 FT
OCTOBER 2019

FIGURE 1-1

VARI, KATALIN Printed: 10/4/2019 6:20 PM Layout: FIGURE 1-1
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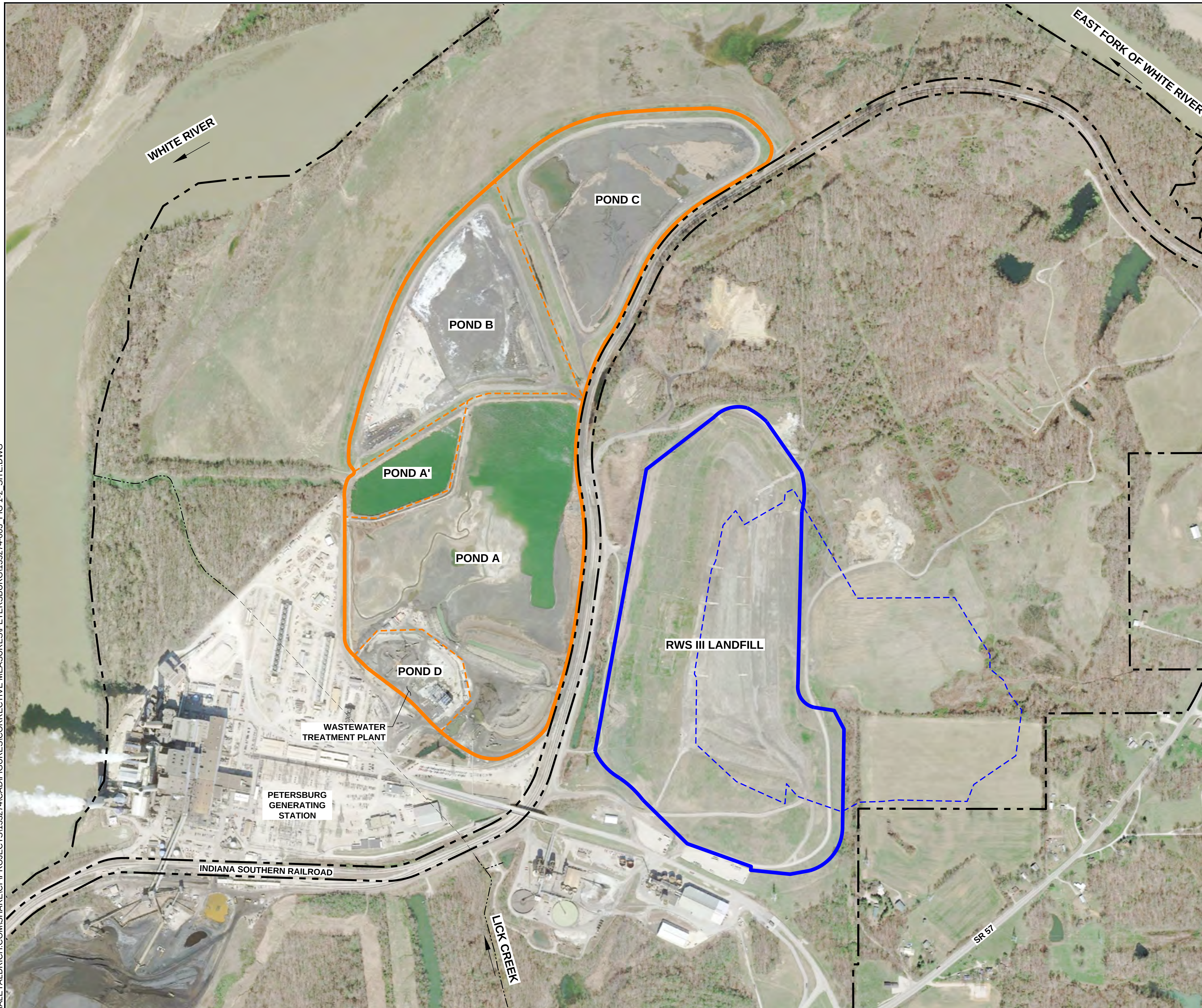


**LEGEND**

- APPROXIMATE PROPERTY BOUNDARY
- APPROXIMATE LIMITS OF ASH POND SYSTEM
- APPROXIMATE BOUNDARY OF ASH POND
- APPROXIMATE LIMITS OF LANDFILL
- APPROXIMATE PERMITTED LANDFILL EXPANSION BOUNDARY

**NOTES**

1. ALL BOUNDARIES AND LOCATIONS ARE APPROXIMATE.
2. AERIAL IMAGE FROM GOOGLE EARTH.

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0 700 1400

SCALE IN FEET

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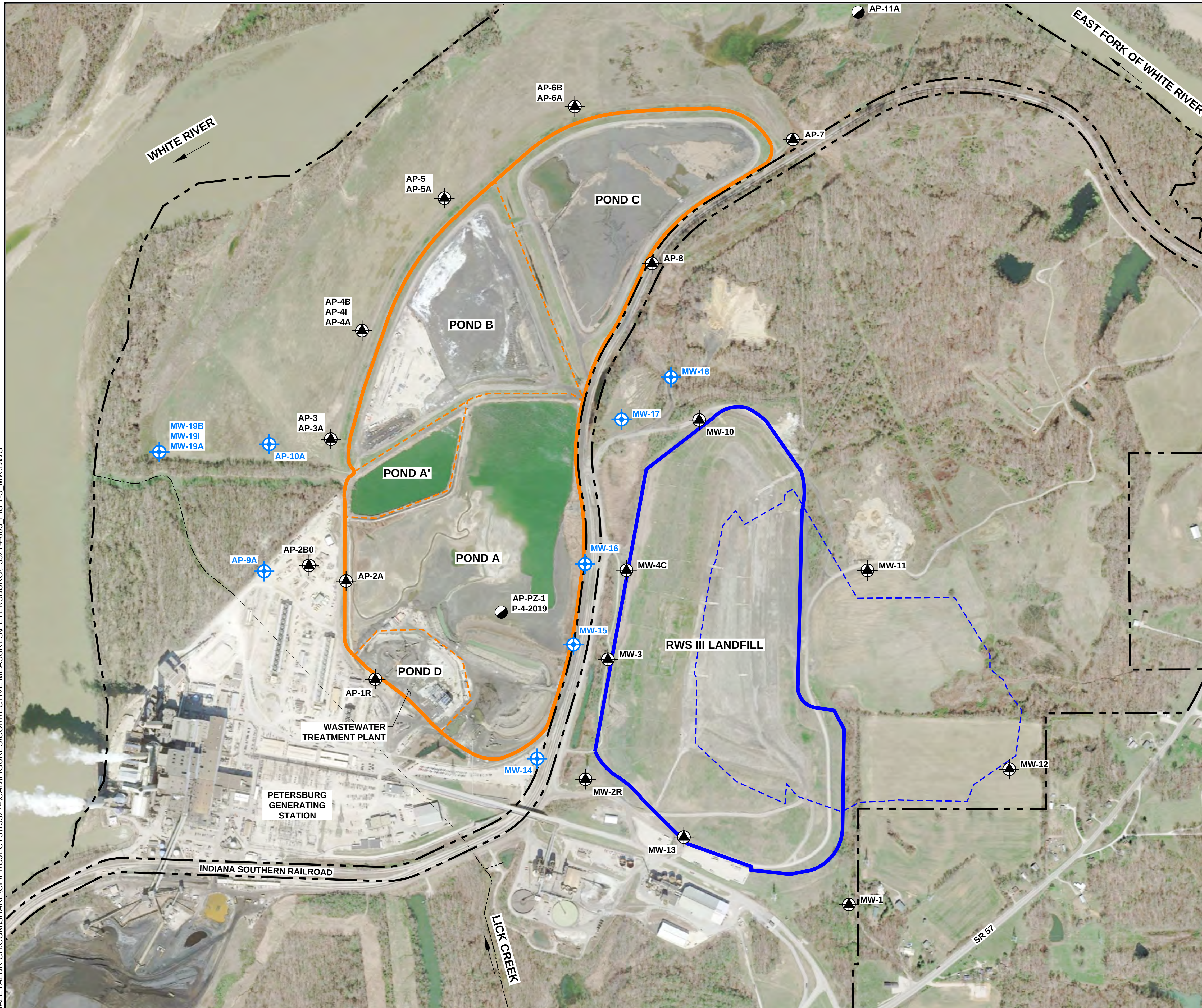
CORRECTIVE MEASURES ASSESSMENT
PETERSBURG GENERATING STATION
PETERSBURG, INDIANA

SITE FEATURES

SCALE: AS SHOWN
OCTOBER 2019

FIGURE 1-2

VARI, KATALIN Saved: 9/30/2019 3:49 PM Layout: FIGURE 1-2
\\HALEYALDRICH.COM\SHARE\CF\PROJECTS\133274\CAD\FIGURES\CORRECTIVE MEASURES\PETERSBURG\133274-003_FIG 1-2_SITE.DWG




## LEGEND

- APPROXIMATE PROPERTY BOUNDARY
- APPROXIMATE LIMITS OF ASH POND SYSTEM
- APPROXIMATE BOUNDARY OF ASH POND
- APPROXIMATE LIMITS OF LANDFILL
- APPROXIMATE PERMITTED LANDFILL EXPANSION BOUNDARY
- AP-7 CCR MONITORING WELL LOCATION
- AP-PZ-1 PIEZOMETER LOCATION
- MW-14 NATURE AND EXTENT MONITORING WELL

## NOTES

1. ALL BOUNDARIES AND LOCATIONS ARE APPROXIMATE.
2. AERIAL IMAGE FROM GOOGLE EARTH.
3. MONITORING WELL LOCATIONS OBTAINED FROM FIGURE 2 2018 CCR ANNUAL GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT (ATC, JANUARY 2019).
4. WELL DESIGNATION:
   - B = SHALLOW WELL
   - I = INTERMEDIATE WELL
   - A = DEEP WELL
5. CCR = COAL COMBUSTION RESIDUALS

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0 700 1400
SCALE IN FEET

HALEY ALDRICH

CORRECTIVE MEASURES ASSESSMENT
PETERSBURG GENERATING STATION
PETERSBURG, INDIANA

# CCR AND NATURE AND EXTENT MONITORING WELL LOCATIONS

SCALE: AS SHOWN
OCTOBER 2019

FIGURE 1-3

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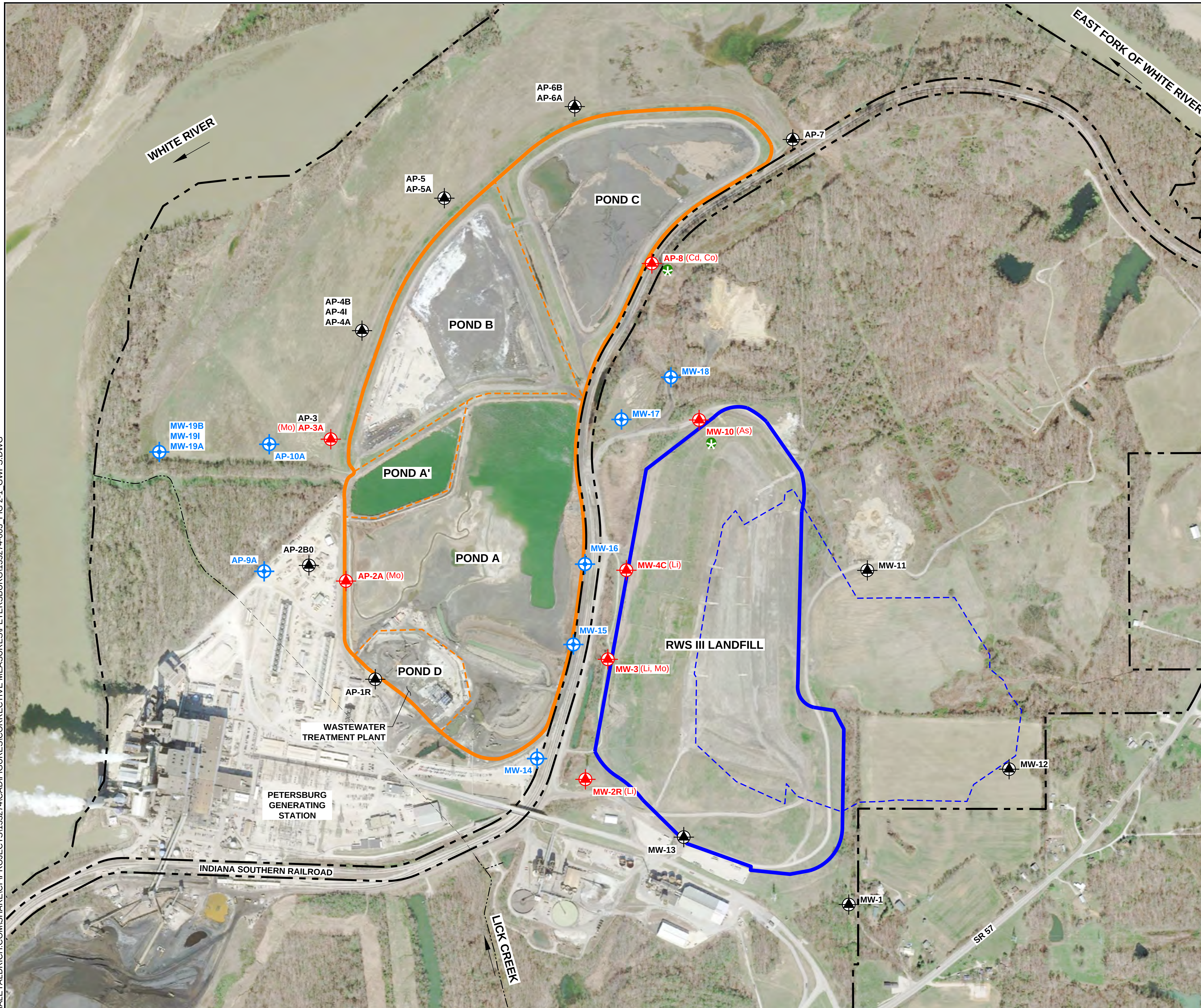


## LEGEND

- APPROXIMATE PROPERTY BOUNDARY
- APPROXIMATE LIMITS OF ASH POND SYSTEM
- APPROXIMATE BOUNDARY OF ASH POND
- APPROXIMATE LIMITS OF LANDFILL
- APPROXIMATE PERMITTED LANDFILL EXPANSION BOUNDARY
- AP-7 CCR MONITORING WELL WITH NO SSL
- MW-14 NATURE AND EXTENT MONITORING WELL
- MW-3 CCR MONITORING WELL WITH REPORTED SSL
  - As = ARSENIC
  - Cb = CADMIUM
  - Co = COBALT
  - Li = LITHIUM
  - Mo = MOLYBDENUM
- SUCCESSFUL ALTERNATIVE SOURCE DEMONSTRATION COMPLETED

## NOTES

1. ALL BOUNDARIES AND LOCATIONS ARE APPROXIMATE.
2. AERIAL IMAGE FROM GOOGLE EARTH.
3. MONITORING WELL LOCATIONS OBTAINED FROM FIGURE 2 2018 CCR ANNUAL GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT (ATC, JANUARY 2019).
4. WELL DESIGNATION:
   - B = SHALLOW WELL
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   - A = DEEP WELL
5. CCR = COAL COMBUSTION RESIDUALS
6. SSL = STATISTICALLY SIGNIFICANT LEVEL

N

0 700 1400

SCALE IN FEET

HALEY ALDRICH

CORRECTIVE MEASURES ASSESSMENT
PETERSBURG GENERATING STATION
PETERSBURG, INDIANA

# CCR MONITORING WELL LOCATIONS WITH STATISTICALLY SIGNIFICANT LEVELS ABOVE GROUNDWATER PROTECTION STANDARDS

SCALE: AS SHOWN
OCTOBER 2019

FIGURE 2-1

VARI, KATALIN Saved: 10/4/2019 6:14 PM Layout: FIGURE 2-1
\\HALEYALDRICH.COM\SHARE\CF\PROJECTS\133274\CAD\FIGURES\CORRECTIVE MEASURES\PETERSBURG\133274-003_FIG 2-1_GWPS.DWG