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REPORT ON

CORRECTIVE MEASURES ASSESSMENT HARDING STREET GENERATING STATION INDIANAPOLIS, INDIANA

by
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for
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File No. 133274-005
September 2019
AMENDED 11 October 2019

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List of Acronyms and Abbreviations

Abbreviation	Definition
Ash Pond System	Middle Ponds, Former Pond 2, and Former Pond 4
ATC	ATC Group Services LLC
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
ft	Feet
GMP	Groundwater Monitoring Plan
gpm	Gallons Per Minute
GWPS	Groundwater Protection Standards
Haley & Aldrich	Haley & Aldrich, Inc.
HC	Hydraulic Containment
HSGS	Harding Street Generating Station
IDNR	Indiana Department of Natural Resources
IPL	Indianapolis Power & Light Company
MCL	Maximum Contaminant Level
Middle Ponds	Ash Ponds 1, 2A, 2B, and 3
MNA	Monitored Natural Attenuation
msl	Mean Sea Level
N&E	Nature and Extent
O&M	Operations and Maintenance
RO	Reverse Osmosis
Site	Harding Street 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 Indianapolis Power & Light Company (IPL) to prepare this Corrective Measures Assessment (CMA) for the Coal Combustion Residual (CCR) units Ash Ponds 1, 2A, 2B, and 3 (herein referred to as the "Middle Ponds"), former Pond 2 and former Pond 4[1] that together comprise what is herein referred to as the "Ash Pond System" located at the Harding Street Generating Station (HSGS 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.

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). 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-hardingstreet.com/Home/default.aspx.

1.1 FACILITY DESCRIPTION/BACKGROUND

IPL owns and operates the HSGS, which is located on the southwest side of Indianapolis, Indiana, in Marion County. The Site is bounded to the north by light industrial property, to the east/southeast by light industrial and residential property, to the west and northwest by the White River, and to the south by Hanson Aggregate (an active quarry) (**Figure 1-1**).

The HSGS began operations in 1931 and currently has no coal-fired electric generating units. Prior to the full conversion of all the coal-fired units to natural gas in early 2016, Harding Street Units 5, 6, and 7 operated as coal-fired units with a combined nameplate capacity of approximately 673 MW. Historically, the HSGS treated fly ash, bottom ash, flue gas desulfurization by-products, low volume, non-chemical metal cleaning wastes, and stormwater streams generated by these units through sedimentation, neutralization, and flocculation. The Ash Pond System illustrated on **Figure 1-2** encompasses approximately 79 acres.

1.2 GROUNDWATER MONITORING

Groundwater monitoring under the CCR Rule occurs through a phased approach to allow for a graduated response (i.e., detection and assessment monitoring as applicable) and evaluation of steps to address groundwater quality associated with a CCR unit. Weaver Consultants Group prepared a Groundwater Monitoring Plan (GMP) as required by the CCR Rule. The GMP presents the design of the groundwater monitoring system, groundwater sampling and analysis procedures, and groundwater statistical analysis methods.

[1] Former Pond 2 and former Pond 4 are not subject to the CCR Rule, but due to the multi-unit groundwater system, have been included as part of this CMA.

The CCR groundwater monitoring network includes eight initial background wells and 17 downgradient monitoring wells which are located around the perimeter of the Ash Pond System. Monitoring well locations are shown on **Figure 1-3.** Nested monitoring wells were installed in the alluvial deposits (sand and gravel aquifer zone) below the base of the Ash Pond System. Monitoring wells designated MW-XS are screened in the upper part of the saturated zone; wells designated MW-XI are screened in the middle part of the saturated zone; and wells designated MW-XD are screened in the lower part of the saturated zone. Below is a list of the CCR monitoring well network:

Background (Upgradient)		Downgradient	
Shallow	**Intermediate and Deep**	**Shallow**	**Intermediate and Deep**
MW-15S	MW-15I	MW-1S	MW-1D
	MW-15D	MW-2S	MW-2D
		MW-3S	MW-3D
		MW-4S	MW-7D
		MW-5S	MW-9I
		MW-6S	MW-9D
		MW-7S	MW-10D
		MW-8S	MW-11D
		MW-9S	MW-12D
		MW-10S	MW-13D
		MW-11S	MW-14D
		MW-12S	
		MW-13S	

Monitoring wells were installed between September 2015 and February 2016 to support compliance with the CCR Rule. Monitoring wells MW-1S, MW-1D, MW-2S, MW-2D, MW-3S, MW-3D, MW-4S, and MW-8S initially represented upgradient/background wells. Due to a concern raised by the Indiana Department of Environmental Management (IDEM) regarding the configuration of the originally established upgradient wells, IPL agreed to install three new upgradient wells (MW-15S, MW-15I, and MW-15D) further away from the Ash Pond System in the northeast corner of the Site. These new wells replaced MW-1S, MW-1D, MW-2S, MW-2D, MW3S, MW-3D, and MW-4S as upgradient wells; however, the original upgradient wells will continue to be utilized for groundwater monitoring purposes as downgradient wells within the system. Background monitoring sampling is still ongoing for the new upgradient well nest (MW-15) in accordance with §257.93(d).

Detection monitoring sampling events occurred in 2016 and 2017. The results of the sampling events were then compared to background (initial upgradient wells) concentrations using statistical methods to determine whether statistically significant increases (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. There were no alternative sources identified for 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 antimony, arsenic, lithium, and molybdenum were present in groundwater at SSLs above the GWPS.

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;
> > (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 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, the conceptual site model (CSM) was developed and evaluated based on data collected and associated with the IPL site. The CSM is summarized below.

2.1 SITE SETTING

The HSGS is located on the southwest side of Indianapolis, Indiana at 3700 S. Harding Street. The Site is bounded to the north by light industrial property, to the east/southeast by light industrial and residential property, to the west and northwest by the White River, and to the south by Hanson Aggregate (an active quarry). Lick Creek flows through the Site between the generating station and the Ash Pond System and flows west into the White River.

The Site is located within the White River Valley on the banks of the White River. The HSGS is composed of broad, flat to rolling, alluvial plain of the White River underlain by sedimentary bedrock. The alluvial plane consists of uplands to the west and east that form valley boundaries for surface water drainage. The ground surface elevation of the HSGS is approximately 673 feet (ft) above mean sea level (msl) with the uplands rising to 750 ft msl to the east and 725 ft msl to the west. Bedrock elevations in the vicinity of the site occur at approximately 629 to 605 ft msl, or approximately 44 to 78 ft below ground surface.

2.2 GEOLOGY AND HYDROGEOLOGY

The HSGS is located within the New Castle Till Plains and Drainageways, which is part of the Central Till Plain Region of Indiana. The source of surface material that comprises the uppermost aquifer is till of eastern, or Huron-Erie Lobe origin deposited during the Pleistocene Epoch. Most of the landforms in the northern part of the White River basin were produced by these glacial events. The natural soils in this area consists mainly of outwash including fine-grained clays and silts overlying sands and gravels associated with the White River. Bedrock beneath the facility is comprised of Devonian and Mississippian age New Albany Shale underlain by Silurian and Devonian age carbonates[3].

The uppermost aquifer of the region reflects the geology, with the high conductivity alluvial plain bounded by upland areas to the east and west. The bottom of the uppermost aquifer is defined by the low conductivity New Albany Shale bedrock. Domestic wells screened within the New Albany Shale typically yield 1 to 5 gallons per minute (gpm), thus the new Albany Shale is not considered a significant aquifer. Groundwater flow within the alluvial sand and gravel aquifer typically yields 500 to 2,000 gpm and range from 50 to 100 ft thick per the Indiana Department of Natural Resources (IDNR, 2002). Multiple *in situ* hydraulic conductivity tests completed in the alluvial aquifer at the HSGS site indicate that the hydraulic conductivity of the uppermost aquifer is $> 1 \times 10^{-2}$ centimeters per second (cm/sec).

In the northern portion of the site, north of Lick Creek, the potentiometric surface flow is towards the White River with a gradient of 0.002 to 0.005 ft. South of Lick Creek, along the southern portion of the Site the flow is primarily controlled by groundwater discharge into the Hanson Quarry. While there are areas along the southern property boundary that appear to be affected by the mining operation to the south, the presence of the alluvial aquifer in this area is currently under investigation as part of ongoing

[3] Geotechnical Data Report: Proposed Wastewater Treatment Plant, IPL Harding Street Generating Station, Indianapolis, Indiana (Cardno ATC Group Services LLC (ATC) 2013)

N&E efforts. The local groundwater flow direction in the vicinity of all units is discussed further in **Section 2.4**.

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 micrograms per liter (ug/L)
- 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 considered to be site-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). Statistically significant levels above the GWPS were determined and are limited to antimony at two monitoring well locations; arsenic at 12 monitoring well locations; lithium at 15 monitoring well locations; and molybdenum at 14 monitoring well locations. Monitoring well locations with SSLs above the GWPS are illustrated on **Figure 2-1**.

2.4 NATURE AND EXTENT OF GROUNDWATER IMPACTS

As outlined in **Section 1.2** of this CMA, statistically significant levels of antimony, arsenic, lithium, and molybdenum were identified in the assessment monitoring results. As a result, IPL initiated an N&E investigation as required by the CCR Rule in 2019. Seven nested piezometers were installed (three within the limits of former Pond 2 and four within the limits of the Middle Ponds). The piezometers are screened in the ash and in the upper alluvial plain aquifer to provide information on the hydraulic connection between the ash and underlying aquifer. Based on a review of the existing water level data from nested piezometers, there appears to be some weak connection between the ash and the underlying aquifer.

Two staff gauges were installed (one in Lick Creek and one in the White River) along with two nearby shallow piezometers, and re-development of one historical monitoring well (M-4 located downgradient of former Pond 2). These were used as N&E monitoring equipment. The existing CCR monitoring wells, along with these new staff gauges and piezometers were utilized to better define groundwater flow direction. These data confirmed that groundwater in the alluvial plain aquifer generally flows southwest towards the active quarry. N&E piezometers, staff gauges, and monitoring well locations are shown in **Figure 1-3.** Future additional N&E analytical results, which may include N&E work at the Hanson Aggregate site, 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 Ash Pond System 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.

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 Ash Pond System 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 southwest toward the active quarry, with a small component 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 Ash Pond System will be limited in extent by the direction of groundwater flow (southwest toward the quarry and river) and will not impact surrounding areas to the east and north.

There are no on-site users of shallow groundwater at the HSGS. Water for plant operations is obtained from the White River, and potable water is provided by the municipal water utility. The IDNR Division of Water Well Records database lists 57 wells within a ½ mile radius of the Ash Pond System. Only eight of the 57 wells are located downgradient of the Ash Pond System, the rest of the wells are to the north and east of the Ash Pond System (upgradient) and, therefore, would not be impacted by groundwater from the Ash Pond System. There is one well (well number 270704) located northwest of the Ash Pond System across the White River. This well is classified as an IPL test well in the IDNR database. This well is located at the Southside Landfill and is not in use by IPL. Of the eight wells identified as downgradient of the Ash Pond System, five are owned by American Aggregates Corporation (Hanson Aggregates) and classified as test wells in the IDNR database, two are classified as industrial, and one is classified as a residential well. The residential well located downgradient of the Ash Pond System in the IDNR Water Well Records (well number 184105) is mapped in the IDNR database as being in the Hanson Aggregates quarry based on the geographic coordinates entered in the well record. However, the physical address listed in the well records places it outside of the half-mile radius from HSGS's Ash Pond System, in a residential area to the northwest and across the White River from the Ash Pond System. The river prevents wells on the far side from being impacted by the Ash Pond System.

Further investigation of the nature and extent of the presence of SSL constituents in groundwater is being conducted by IPL; this CSM will be updated as needed with the results of that investigation.

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 (85%) are below GWPS (i.e., below drinking water standards).

Groundwater is not used as a source of drinking water at HSGS. Construction workers at HSGS performing intrusive excavation activities in the future could potentially contact groundwater during a short-term construction/excavation event. As discussed in **Section 2.4** there may be N&E work at Hanson (quarry). If nature and extent evaluations in the quarry identify CCR-related constituents in seep water within the quarry, then workers in the adjacent quarry could potentially contact CCR constituents in groundwater seeps during quarry operations, similar to a construction worker. The nature of this contact with groundwater would be incidental (e.g., getting groundwater on the hands and arms). Risk-based screening levels for groundwater were developed to be protective of incidental contact by construction workers, and for non-drinking water potable uses by quarry workers. All monitoring well analytical results are below both sets of screening levels. Therefore, there is no unacceptable health risk for construction workers or quarry workers.

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 310 (a unitless value). When the SW-DAF is applied to the lowest conservative risk-based screening level for surface water, the results indicate that groundwater concentrations at the Ash Pond System would need to be higher before groundwater movement into the river could hypothetically cause a CCR-related constituent in White River surface water to be above human health or ecological screening levels.

Based on currently available information, there is no impact of the Ash Pond System on drinking water, nor on the White River.

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 seven 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 appropriate 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 include an evaluation of:

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

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

4.2 GROUNDWATER FATE AND TRANSPORT MODELING

Groundwater at the Site was modeled utilizing Groundwater Vista Version 7 for flow and solute transport. The model was constructed, calibrated, and subsequent simulations run to evaluate remedy alternatives for Appendix IV constituents above the GWPS. Site-specific parameters (i.e., groundwater elevations and hydraulic conductivity) were utilized for model preparation. MODFLOW 2005, a finite difference three-dimensional solver, was utilized for groundwater flow estimation. Modeled groundwater elevations were compared to observed values from the on-site well network 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 Ash Pond System 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.

The remedial alternatives presented below contemplate close in-place (CIP) (Alternatives 1 through 4), hybrid[4] closure by removal (CBR) (Alternatives 5 and 6) and CBR (Alternative 7) of the Ash Pond System. All three of these closure methods are expressly authorized under the CCR Rule. IPL has prepared a CCR Rule compliant Ash Pond Closure Plan for the Ash Pond System that is subject to change based on the selected remedy. Once selected, IPL intends to initiate closure of the unit as part of the remedy within the allowable timeframes as stated in §257.101 of the CCR Rule.

4.3.1 Alternative 1 – CIP with Capping (All Units); Hydraulic Containment through Groundwater Pumping with Ex-Situ Treatment (Middle Ponds & Pond 2); Pond 4 Monitored Natural Attenuation

All Units would be closed in place with a geomembrane and soil protective cap system for Alternative 1 to reduce infiltration of precipitation to groundwater thereby isolating source material. This cap design would exceed regulatory requirements as compared to 1×10^{-5} cm/sec required by the CCR Rule.

Pumping wells would be installed downgradient along the southern property boundary of the Middle Ponds and along the southern and western side of Pond 2 to hydraulically control the migration of those constituents downgradient. However, pumping wells would generate effluent that would require ex-situ treatment, likely with an ion exchange or a reverse osmosis (RO) treatment system. Both treatment systems are considered advanced stage treatment technologies and require ongoing operation and maintenance (O&M) and would generate a secondary waste stream, including but not limited to regeneration/replacement of the ion exchange media or concentration reject water from the RO system. Approvals and permitting would be required for the construction and installation of the closure/capping of the Ash Pond system, treatment systems, and discharge of the treated groundwater.

[4] Hybrid closure by removal for this CMA is defined in Section 4.3.5 and includes CCR removal from the Middle Ponds and Ponds 2 only.

CIP can be completed safely, in compliance with applicable federal and state regulations, and be protective of public health and the environment. In general, CIP consists of re-grading existing CCR and installing a cap system designed to significantly reduce infiltration from precipitation, resist erosion, contain CCR materials, and prevent exposures to CCR. This CIP alternative would require mounding of the remaining CCR within all Units, or require importation of borrow soil, in order to create a surface with adequate slope to prevent the ponding of stormwater. CIP construction activities are estimated to take approximately four to five years to complete following initiation of closure. This excludes the timeframe to complete any permitting.

Implementation of a large-scale hydraulic containment (HC) system would require a detailed design effort with bench-scale testing to verify groundwater treatment. Pilot testing, such as pumping tests and additional groundwater modeling, would be needed to verify the hydraulic capture zone. Pumping system effluent would be directed to a new ion exchange or RO treatment system to be installed on-site. While HC is a widely used remediation technology for contaminated industrial/commercial sites, it has not been commonly used as part of a large-scale CCR unit closure strategy. The HC system would be planned to be installed during CIP closure activities.

For Pond 4, 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 the Pond 4 boundary.

Following the installation of the low-permeability cap and the ex-situ treatment system, IPL would implement post-closure care activities that include operation of the HC system, long-term groundwater sampling to monitor HC system performance, and cap system maintenance. Upon completion of capping, Once the concentrations of Appendix IV constituents would decline and attenuate to the GWPS and operation of the HC system would cease. IPL would maintain the groundwater monitoring system and continue to monitor the groundwater pursuant to §§257.90 through 257.98.

4.3.2 Alternative 2 – CIP with Capping and Hydraulic Containment through Groundwater Pumping with Ex-Situ Treatment (All Units)

Alternative 2 is effectively the same as Alternative 1 with the exception that, in this case, all Units, including Pond 4, would be treated via HC and ex-situ treatment. Pumping wells for this alternative would be added along the downgradient western and southern edge of Pond 4 resulting in more and potentially larger sized piping, and a higher rate and volume of water to be treated, therefore requiring a potentially larger ex-situ treatment system over that of Alternative 1IPL would maintain the groundwater monitoring system and continue to monitor the groundwater pursuant to §§257.90 through 257.98.

4.3.3 Alternative 3 – CIP with Capping (All Units); Hydraulic Containment through Groundwater Pumping with Ex-Situ Treatment and Barrier Wall (Middle Ponds & Pond 2); Pond 4 MNA

Alternative 3 is identical to Alternative 1 but also includes addition of a sub-surface barrier wall adjacent and downgradient of Pond 2 and the Middle Ponds. The purpose of the wall is to reduce the flux of groundwater moving downgradient northeast to southwest from the Ash Pond System and minimize the intake of groundwater from the south and west during groundwater pumping, therefore improving the pumping efficiency (and decreasing the size) of the HC system. Approvals and permitting would be required for the construction and installation of the closure/capping of the Ash Pond System, barrier wall, treatment systems, and discharge of the treated groundwater. In this alternative, the barrier wall and HC system would not extend across the downgradient side of Pond 4.

The alternative involves construction of a low-permeability barrier wall and long-term pumping of groundwater to hydraulically control downgradient migration of Appendix IV constituents in groundwater, with treatment of pumping system effluent in an onsite ion exchange, RO, or other treatment system. This alternative would rely on a combination of a full-depth barrier wall extending through the alluvial aquifer, and groundwater pumping wells upgradient of the barrier wall to control the groundwater hydraulic head upgradient of the barrier wall as well as control the downgradient migration of Appendix IV constituents in groundwater.

Similar to Alternatives 1 and 2, implementation of a large-scale HC system would require a detailed design effort with bench-scale testing to verify groundwater treatment. Pilot testing, such as long-duration pumping tests and additional groundwater modeling, would be needed to verify the hydraulic capture zone. A detailed design would also be required for the barrier wall, given the target depth and horizontal length of the wall. Implementation of the barrier wall and HC system would be challenging given the limited work area along the south property line.

No ongoing/post-closure O&M would be required for the subsurface barrier wall. The other HC, ex-situ treatment, final cover, and post-closure elements described in Alternative 1 would apply for this alternative. 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 – CIP with Capping and Hydraulic Containment through Groundwater Pumping with Ex-situ Treatment with Barrier Wall (All Units)

Alternative 4 is effectively the same as Alternative 3 with the exception that, in this case, the barrier wall, HC, and ex-situ treatment systems would also extend across the downgradient western and southern edge of Pond 4. The addition of HC along Pond 4 would increase the resulting total pumping rate and volume to be treated over that of Alternative 3 but is expected to be less than Alternative 2 due to the addition of the sub-surface barrier wall.

No ongoing/post-closure O&M would be required for the subsurface barrier wall. The other HC, ex-situ treatment, final cover and post-closure elements described in Alternative 1 would apply for this alternative. 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 – Hybrid CBR with Monitored Natural Attenuation; Pond 4 CIP with MNA

This alternative evaluates the removal of CCR from Pond 2 and the Middle Ponds (see Hybrid CBR description below) while CCR in Pond 4 would be closed in place followed by natural attenuation of Appendix IV constituents in groundwater.

Hybrid CBR for this alternative is anticipated to consist of the following:

1. CCR removal from the Middle Ponds and placement in Pond 4;
2. Backfilling of the Middle Ponds footprint with clean fill to 2-ft above the seasonal high groundwater table;
3. Installation of a new perimeter dike around the perimeter of the Middle Ponds and Pond 4;
4. Removal of CCR from Pond 2 and placement within the newly constructed perimeter dike over the footprint of Pond 4 and Middle Ponds; and
5. Installation of a low permeability cap over the Pond 4 and Middle Ponds area.

This alternative would include the movement of approximately 2.1 million cubic yards (CY) of CCR from Pond 2 and approximately 0.5 million CY from the Middle Ponds. An additional 250,000+/- CY of clean fill would be imported from an on-site or off-site borrow source to raise the grade within the Middle Ponds area above the seasonal high groundwater table.

Technical and logistical challenges of implementing a large-scale CCR removal project need to be considered. Closing Pond 4 in place for this alternative (and Alternative 6) does reduce the overall volume of material to be moved by approximately 40% from that of full removal as with Alternative 7. Removal activities require dewatering and temporary staging/stockpiling of material for drying prior to transportation, which may affect productivity and extend the timeframe to complete removal. During periods of rain and inclement weather, the removal schedule 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.

Potential community impacts, safety concerns, and challenges do exist with the CBR alternative although the on-site disposal associated with this alternative, if available, could serve to significantly reduce those risks. The hybrid CBR activities constitute a large-scale construction project and, as such, presents inherent construction risks. The risk of transportation-related injuries on public roads is eliminated as is the need for roadway improvements associated with impacts from heavy truck traffic, thereby eliminating road construction disruptions and/or delays. Fossil fuel consumption and vehicle emissions would result from the removal action but would be minimized due to the limited on-site transport distance.

Following removal of the CCR, concentrations of Appendix IV constituents in downgradient groundwater would decline via natural attenuation processes. Upon completion of the hybrid CBR approach, IPL would maintain the groundwater monitoring system and continue to monitor the groundwater pursuant to §§257.90 through 257.98.

4.3.6 Alternative 6 – Hybrid CBR of Middle Ponds & Pond 2 with MNA, Pond 4 CIP with Full Perimeter Barrier Wall and MNA

Alternative 6 is similar to Alternative 5 but also includes addition of a perimeter sub-surface barrier wall (or ring wall) that would be installed around the perimeter of Pond 4. Installation of a perimeter barrier wall would necessitate additional construction equipment and materials to install and could potentially lengthen the time for installation of the remedy over that of Alternative 5 but could potentially be installed simultaneously during movement of the Middle Ponds material over to Pond 4. Therefore, the time to complete this alternative would be expected to be similar to that of Alternative 5. All other technical and logistical challenges, community impacts, and safety concerns would be similar to that of Alternative 5. No ongoing/post-closure O&M would be required for the subsurface barrier wall. IPL would maintain the groundwater monitoring system and continue to monitor the groundwater pursuant to §§257.90 through 257.98.

4.3.7 Alternative 7 – CBR with MNA (All Units)

This alternative evaluates the removal of CCR from all units followed by natural attenuation of Appendix IV constituents in groundwater. While this alternative would eliminate (through removal) the source the Ash Pond System would remain open to the environs and the ponded ash would be subject to ongoing infiltration for the duration of the removal activities.

There are several potential community impacts, safety concerns, and challenges associated with the CBR alternative. Given the magnitude of the total estimated truck trips (>250,000 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 traveling 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 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.

Technical and logistical challenges of implementing a large-scale CCR removal project also need to be considered. Removal activities require dewatering and temporary staging/stockpiling of material for drying prior to transportation, which may affect productivity and extend the timeframe to complete removal. During periods of rain and inclement weather, the removal schedule 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.

Following removal of the CCR, concentrations of Appendix IV constituents in downgradient groundwater would decline via natural attenuation processes. Upon completion of CBR, 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 and compare the seven corrective measures alternatives using the balancing criteria described in §257.97(c).

5.1 EVALUATION CRITERIA

In accordance with §257.97, remedial alternatives[5] that satisfy the threshold criteria are then compared to four balancing (evaluation) criteria. The balancing criteria allow a comparative analysis for each corrective measure, thereby providing the basis for final corrective measure selection. The four balancing criteria include the following (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.

[5] 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**, based on currently available information the Ash Pond System at HSGS does not pose a risk to human health or the environment. Therefore, based on currently available information the remedial alternatives considered are not necessary to reduce an assumed risk posed by the Appendix IV constituents, antimony, arsenic, 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.

Alternative 1, which includes closure in place with HC and MNA, and Alternative 2, which includes a greater degree of HC, are considered favorable because CCR remains in place without the need for material handling, dewatering, and transportation to an off-site landfill, or the large scale construction of a subsurface barrier wall. With respect to the magnitude of reduction of existing risk, Alternatives 1 and 2 are considered favorable since installation of groundwater recovery systems and the O&M of ex-situ treatment systems are considered favorable relative to Alternatives 3 and 4 which include construction of subsurface barriers, and Alternatives 5 and 6 which contemplate partial removal of the CCR. Alternative 7, which includes full removal of the Ash Pond System, is considered least favorable with respect to this criterion due to the risks associated with material handling, dewatering, and transportation to an off-site landfill throughout the duration of the long-term construction project.

	Alternative 1 CIP All Units with Cap and Hydraulic Containment with Ex-Situ Treatment with Pond 4 MNA	**Alternative 2** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment - All Units	**Alternative 3** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment with Barrier Wall with Pond 4 MNA	**Alternative 4** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment with Barrier Wall - All Units	**Alternative 5** Hybrid Closure by Removal (CBR) with MNA with Pond 4 CIP with MNA	**Alternative 6** Hybrid Closure by Removal (CBR) of Pond 2 & Middle Ponds with MNA with Pond 4 CIP with Full Perimeter Wall with MNA	**Alternative 7** Closure by Removal (CBR) with MNA - All Units
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 CIP or partial CIP, the uncertainty associated with CCR materials remaining in the environment represents a slightly higher potential risk; therefore, Alternatives 1 through 6 are considered less favorable with respect to this criterion. Since Alternative 7 includes full CBR, this alternative is considered favorable.

	Alternative 1 CIP All Units with Cap and Hydraulic Containment with Ex-Situ Treatment with Pond 4 MNA	**Alternative 2** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment - All Units	**Alternative 3** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment with Barrier Wall with Pond 4 MNA	**Alternative 4** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment with Barrier Wall - All Units	**Alternative 5** Hybrid Closure by Removal (CBR) with MNA with Pond 4 CIP with MNA	**Alternative 6** Hybrid Closure by Removal (CBR) of Pond 2 & Middle Ponds with MNA with Pond 4 CIP with Full Perimeter Wall with MNA	**Alternative 7** Closure by Removal (CBR) with MNA - All Units
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 5, 6, and 7 are the most favorable alternatives with respect to this criterion because long-term management is limited to MNA which involves no mechanical systems as part of the remedy.

Alternatives 1 and 3 are less favorable since both alternatives include HC systems, which will require O&M until the GWPS is achieved. Alternatives 2 and 4 are considered the least favorable since these two alternatives also include larger scale HC systems and therefore the long-term management requirements will be higher relative to the other alternatives.

	Alternative 1 CIP All Units with Cap and Hydraulic Containment with Ex-Situ Treatment with Pond 4 MNA	**Alternative 2** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment - All Units	**Alternative 3** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment with Barrier Wall with Pond 4 MNA	**Alternative 4** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment with Barrier Wall - All Units	**Alternative 5** Hybrid Closure by Removal (CBR) with MNA with Pond 4 CIP with MNA	**Alternative 6** Hybrid Closure by Removal (CBR) of Pond 2 & Middle Ponds with MNA with Pond 4 CIP with Full Perimeter Wall with MNA	**Alternative 7** Closure by Removal (CBR) with MNA - All Units
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 7 includes transportation of the CCR material over public roadways for off-site disposal, this alternative is considered the least favorable. Alternatives 5 and 6 are considered less favorable when compared to Alternatives 1 through 4 since these alternatives also include hybrid CBR with or without a full perimeter wall with associated risks to the environment during the construction and on-site disposal of CCR. Alternatives 1 through 4 are generally limited to the transportation of capping materials or barrier wall material onto the site as part of the remedy and are considered favorable relative to short-term risk to the community or environment.

	Alternative 1 CIP All Units with Cap and Hydraulic Containment with Ex-Situ Treatment with Pond 4 MNA	**Alternative 2** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment - All Units	**Alternative 3** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment with Barrier Wall with Pond 4 MNA	**Alternative 4** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment with Barrier Wall - All Units	**Alternative 5** Hybrid Closure by Removal (CBR) with MNA with Pond 4 CIP with MNA	**Alternative 6** Hybrid Closure by Removal (CBR) of Pond 2 & Middle Ponds with MNA with Pond 4 CIP with Full Perimeter Wall with MNA	**Alternative 7** Closure by Removal (CBR) with MNA - All Units
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 antimony, arsenic, 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 most favorable for Alternatives 5 through 7 which include removal or isolation coupled with MNA to achieve the GWPS. Alternatives 1 and 2 rely on capping, HC, and MNA to achieve the GWPS and are less favorable with timeframes comparably longer than Alternatives 5 through 7. Similarly, Alternatives 3 and 4 rely on capping, HC, a subsurface barrier wall, and MNA to achieve the GWPS and are least favorable due to the longer timeframe to achieve GWPS when compared to the other alternatives.

	Alternative 1 CIP All Units with Cap and Hydraulic Containment with Ex-Situ Treatment with Pond 4 MNA	**Alternative 2** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment - All Units	**Alternative 3** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment with Barrier Wall with Pond 4 MNA	**Alternative 4** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment with Barrier Wall - All Units	**Alternative 5** Hybrid Closure by Removal (CBR) with MNA with Pond 4 CIP with MNA	**Alternative 6** Hybrid Closure by Removal (CBR) of Pond 2 & Middle Ponds with MNA with Pond 4 CIP with Full Perimeter Wall with MNA	**Alternative 7** Closure by Removal (CBR) with MNA - All Units
Category 1 - Subcriteria v) Time until full protection is achieved							

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

Because the extent of groundwater impacted by the Ash Pond System is limited to the alluvial aquifer, Alternative 1 has the lowest potential for exposure to human and environmental receptors and is considered most favorable with respect to this criterion. Alternative 1 assumes that the ash ponds will be capped, and the HC and treatment system will be limited in size since the Pond 4 remedy will utilize MNA. Alternative 2 assumes that HC will be used as part of the remedy from all ash ponds, which will require a larger HC system with greater O&M requirements and a larger secondary waste stream. Therefore, Alternative 2 is considered less favorable when compared to Alternative 1. In addition to a HC system, Alternatives 3 and 4 include a subsurface barrier wall to further impede the flow of groundwater. The barrier wall installation will require large-scale construction which creates a potential for exposure and these two alternatives are therefore considered less favorable. Alternatives 5 and 6 include partial removal of CCR as part of the remedy, which creates a potential for exposure during construction and are therefore considered less favorable. Alternative 7, which includes complete excavation, transportation, and off-site 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 CIP All Units with Cap and Hydraulic Containment with Ex-Situ Treatment with Pond 4 MNA	**Alternative 2** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment - All Units	**Alternative 3** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment with Barrier Wall with Pond 4 MNA	**Alternative 4** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment with Barrier Wall - All Units	**Alternative 5** Hybrid Closure by Removal (CBR) with MNA with Pond 4 CIP with MNA	**Alternative 6** Hybrid Closure by Removal (CBR) of Pond 2 & Middle Ponds with MNA with Pond 4 CIP with Full Perimeter Wall with MNA	**Alternative 7** Closure by Removal (CBR) with MNA - All Units
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

Alternatives 5 through 7 include partial or full removal of the CCR, or CCR isolation with a perimeter wall, and are expected to have high long-term reliability and are considered most favorable with respect to this criterion. Alternatives 1 through 4, which incorporate CIP, are also considered reliable even though they require the long-term maintenance of the cap and cover system. Alternatives 1 through 4 also include HC systems which 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. Therefore, Alternatives 1 through 4 are considered less reliable when compared to Alternatives 5 through 7.

	Alternative 1 CIP All Units with Cap and Hydraulic Containment with Ex-Situ Treatment with Pond 4 MNA	**Alternative 2** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment - All Units	**Alternative 3** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment with Barrier Wall with Pond 4 MNA	**Alternative 4** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment with Barrier Wall - All Units	**Alternative 5** Hybrid Closure by Removal (CBR) with MNA with Pond 4 CIP with MNA	**Alternative 6** Hybrid Closure by Removal (CBR) of Pond 2 & Middle Ponds with MNA with Pond 4 CIP with Full Perimeter Wall with MNA	**Alternative 7** Closure by Removal (CBR) with MNA - All Units
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 through 7, which incorporate CCR removal or isolation with MNA, are considered the remedies with the lowest likelihood of requiring replacement because source removal or isolation is permanent and natural processes will remedy groundwater. Alternative 1, which includes closure in-place with MNA for Pond 4, is considered the least favorable since it relies on the operation of the mechanical system (HC) for the other ponds and relies on a cap and cover system to reduce infiltration and control the source and natural processes to reduce the concentrations of Appendix IV constituents in groundwater downgradient from Pond 4. Should monitoring results indicate that the selected remedial alternative is not effective at reducing the concentration of Appendix IV constituents over time, alternate or additional active remedial methods for groundwater may be considered in the future. Alternative 3 is similar but also includes a barrier wall down-gradient of Pond 2 and the Middle Ponds so it is slightly less unfavorable. Alternatives 2 and 4, which rely on the operation of the mechanical systems (HC), with or without a subsurface barrier wall, are considered more likely to require replacement and are considered less favorable than Alternatives 5 through 7.

	Alternative 1 CIP All Units with Cap and Hydraulic Containment with Ex-Situ Treatment with Pond 4 MNA	**Alternative 2** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment - All Units	**Alternative 3** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment with Barrier Wall with Pond 4 MNA	**Alternative 4** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment with Barrier Wall - All Units	**Alternative 5** Hybrid Closure by Removal (CBR) with MNA with Pond 4 CIP with MNA	**Alternative 6** Hybrid Closure by Removal (CBR) of Pond 2 & Middle Ponds with MNA with Pond 4 CIP with Full Perimeter Wall with MNA	**Alternative 7** Closure by Removal (CBR) with MNA - All Units
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 5 and 6, which include CCR removal or isolation with a perimeter wall, are considered the most favorable, while Alternatives 1 through 3, which include HC, are considered less favorable since this alternative, while effective, would produce a secondary waste stream that would need to be handled and disposed, which creates a potential for exposure. Alternative 4, which includes a barrier wall and HC system with ex-situ treatment for the entire Ash Pond System, is considered the least favorable.

	Alternative 1 CIP All Units with Cap and Hydraulic Containment with Ex-Situ Treatment with Pond 4 MNA	**Alternative 2** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment - All Units	**Alternative 3** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment with Barrier Wall with Pond 4 MNA	**Alternative 4** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment with Barrier Wall - All Units	**Alternative 5** Hybrid Closure by Removal (CBR) with MNA with Pond 4 CIP with MNA	**Alternative 6** Hybrid Closure by Removal (CBR) of Pond 2 & Middle Ponds with MNA with Pond 4 CIP with Full Perimeter Wall with MNA	**Alternative 7** Closure by Removal (CBR) with MNA - All Units
CATEGORY 1 Long- and Short Term Effectiveness, Protectiveness, and Certainty of Success							

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

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

5.2.2.1 The extent to which containment practices will reduce further releases

Alternatives 5 through 7 are considered favorable since these alternatives include CCR removal or CCR isolation with a full perimeter wall. These three alternatives are considered highly effective at reducing further releases because they include source removal or isolation. Alternatives 1 through 4 are considered less favorable in this sub-category because source material remains in place and rely on HC systems or MNA to address the migration of antimony, arsenic, lithium, and molybdenum in groundwater.

	Alternative 1 CIP All Units with Cap and Hydraulic Containment with Ex-Situ Treatment with Pond 4 MNA	**Alternative 2** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment - All Units	**Alternative 3** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment with Barrier Wall with Pond 4 MNA	**Alternative 4** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment with Barrier Wall - All Units	**Alternative 5** Hybrid Closure by Removal (CBR) with MNA with Pond 4 CIP with MNA	**Alternative 6** Hybrid Closure by Removal (CBR) of Pond 2 & Middle Ponds with MNA with Pond 4 CIP with Full Perimeter Wall with MNA	**Alternative 7** Closure by Removal (CBR) with MNA - All Units
Category 2 - Subcriteria i) Extent to which containment practices will reduce further releases							

5.2.2.2 The extent to which treatment technologies may be used

With respect to Alternatives 5 through 7, no groundwater treatment technologies other than natural attenuation will be used and are considered the most favorable with respect to this criterion. Alternatives 1 through 4 rely on pumping wells and an ex-situ treatment system and are 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 1 CIP All Units with Cap and Hydraulic Containment with Ex-Situ Treatment with Pond 4 MNA	**Alternative 2** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment - All Units	**Alternative 3** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment with Barrier Wall with Pond 4 MNA	**Alternative 4** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment with Barrier Wall - All Units	**Alternative 5** Hybrid Closure by Removal (CBR) with MNA with Pond 4 CIP with MNA	**Alternative 6** Hybrid Closure by Removal (CBR) of Pond 2 & Middle Ponds with MNA with Pond 4 CIP with Full Perimeter Wall with MNA	**Alternative 7** Closure by Removal (CBR) with MNA - All Units
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. Alternatives 5 through 7, which include source removal or isolation, are considered the most favorable while Alternatives 1 through 4 are considered less favorable since these alternatives rely on mechanical systems to control the migration of Appendix IV constituents.

	Alternative 1 CIP All Units with Cap and Hydraulic Containment with Ex-Situ Treatment with Pond 4 MNA	**Alternative 2** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment - All Units	**Alternative 3** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment with Barrier Wall with Pond 4 MNA	**Alternative 4** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment with Barrier Wall - All Units	**Alternative 5** Hybrid Closure by Removal (CBR) with MNA with Pond 4 CIP with MNA	**Alternative 6** Hybrid Closure by Removal (CBR) of Pond 2 & Middle Ponds with MNA with Pond 4 CIP with Full Perimeter Wall with MNA	**Alternative 7** Closure by Removal (CBR) with MNA - All Units
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 1 is considered most favorable since the concepts and technologies are proven and can be implemented in a reasonable timeframe. Relative to the other alternatives that include HC, the pumping system is smaller scale and the Pond 4 remedy relies on MNA to remedy groundwater. Alternatives 2 through 4 are considered less favorable since the HC systems are larger scale or include a subsurface barrier wall to maintain hydraulic control. Alternative 5 is also less favorable since this scenario includes source removal as a component of the remedy and will require large-scale construction. Alternatives 6 and 7 are considered the least favorable since these scenarios include full removal of the CCR (Alternative 7) or partial removal of the CCR with a full perimeter wall for CCR isolation. Relative to the other alternatives, Alternatives 6 and 7 will involve large-scale construction project to fully remove CCR from the Ash Pond System and/or installation of a deep, fully encompassing perimeter wall as part of the groundwater remedy.

	Alternative 1 CIP All Units with Cap and Hydraulic Containment with Ex-Situ Treatment with Pond 4 MNA	**Alternative 2** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment - All Units	**Alternative 3** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment with Barrier Wall with Pond 4 MNA	**Alternative 4** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment with Barrier Wall - All Units	**Alternative 5** Hybrid Closure by Removal (CBR) with MNA with Pond 4 CIP with MNA	**Alternative 6** Hybrid Closure by Removal (CBR) of Pond 2 & Middle Ponds with MNA with Pond 4 CIP with Full Perimeter Wall with MNA	**Alternative 7** Closure by Removal (CBR) with MNA - All Units
Category 3 - Subcriteria i) Degree of difficulty associated with constructing the technology							

5.2.3.2 Expected operational reliability of the technologies

Alternatives 5 through 7 are considered the most favorable from an operational perspective because removal or isolation of the source followed by MNA has a proven track record and only requires long-term monitoring following implementation. While Alternatives 1 through 4, which include HC, are also expected to be reliable, these alternatives will utilize additional groundwater treatment technologies which will require treatability studies and O&M and therefore are considered less favorable when compared to the other alternatives.

	Alternative 1 CIP All Units with Cap and Hydraulic Containment with Ex-Situ Treatment with Pond 4 MNA	**Alternative 2** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment - All Units	**Alternative 3** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment with Barrier Wall with Pond 4 MNA	**Alternative 4** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment with Barrier Wall - All Units	**Alternative 5** Hybrid Closure by Removal (CBR) with MNA with Pond 4 CIP with MNA	**Alternative 6** Hybrid Closure by Removal (CBR) of Pond 2 & Middle Ponds with MNA with Pond 4 CIP with Full Perimeter Wall with MNA	**Alternative 7** Closure by Removal (CBR) with MNA - All Units
Category 3 - Subcriteria ii) Expected operational reliability of the technologies							

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

While Alternatives 1 and 2 will require additional permitting and approvals for treatability testing, field scale pilot testing, groundwater discharge, groundwater treatment, and/or disposal of secondary waste streams, these two alternatives are considered the most favorable when compared to the other alternatives. Additional approvals and permits will be required for Alternatives 3 and 4 since these two scenarios include a subsurface barrier wall in addition to a HC and treatment system. Alternatives 5 through 7 are considered the least favorable since these scenarios will require extensive permitting and approvals (highly complex permits may be necessary to obtain waterway, floodway and waste management approvals and permits) for the removal of the CCR or installation of a full perimeter wall contemplated under Alternative 6.

	Alternative 1 CIP All Units with Cap and Hydraulic Containment with Ex-Situ Treatment with Pond 4 MNA	**Alternative 2** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment - All Units	**Alternative 3** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment with Barrier Wall with Pond 4 MNA	**Alternative 4** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment with Barrier Wall - All Units	**Alternative 5** Hybrid Closure by Removal (CBR) with MNA with Pond 4 CIP with MNA	**Alternative 6** Hybrid Closure by Removal (CBR) of Pond 2 & Middle Ponds with MNA with Pond 4 CIP with Full Perimeter Wall with MNA	**Alternative 7** Closure by Removal (CBR) with MNA - All Units
Category 3 - Subcriteria iii) Need to coordinate with and obtain necessary approvals and permits from other agencies							

5.2.3.4 *Availability of necessary equipment and specialists*

Alternatives 1 and 2 are the most favorable since specialty equipment and specialists will not be required to implement the MNA remedy and the size of the construction project is relatively small. Both alternatives will require equipment for drilling, recovery well installation, construction of groundwater conveyance systems, and treatment system but these are readily available. Alternatives 3 and 4 are less favorable since specialized equipment and contractors will be required for the barrier wall installation. Alternatives 5 through 7 are considered the least favorable since specialized equipment and contractors will be needed for the large-scale construction project associated with CCR removal and construction of a full perimeter wall contemplated under Alternative 6.

	Alternative 1 CIP All Units with Cap and Hydraulic Containment with Ex-Situ Treatment with Pond 4 MNA	**Alternative 2** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment - All Units	**Alternative 3** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment with Barrier Wall with Pond 4 MNA	**Alternative 4** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment with Barrier Wall - All Units	**Alternative 5** Hybrid Closure by Removal (CBR) with MNA with Pond 4 CIP with MNA	**Alternative 6** Hybrid Closure by Removal (CBR) of Pond 2 & Middle Ponds with MNA with Pond 4 CIP with Full Perimeter Wall with MNA	**Alternative 7** Closure by Removal (CBR) with MNA - All Units
Category 3 - Subcriteria iv) Availability of necessary equipment and specialists							

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

Alternatives 5 and 6 are considered the most favorable since the removed CCR will be placed elsewhere on the Ash Pond System as part of the hybrid closure. No off-site disposal will be needed. Alternatives 1 through 4 are considered less favorable since these scenarios include HC with groundwater treatment. The ex-situ treatment system may generate a concentrated waste stream which would require off-site transportation and disposal. Alternative 7 is considered the least favorable since this alternative will require adequate capacity, storage, and disposal services at an off-site facility.

	Alternative 1 CIP All Units with Cap and Hydraulic Containment with Ex-Situ Treatment with Pond 4 MNA	**Alternative 2** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment - All Units	**Alternative 3** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment with Barrier Wall with Pond 4 MNA	**Alternative 4** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment with Barrier Wall - All Units	**Alternative 5** Hybrid Closure by Removal (CBR) with MNA with Pond 4 CIP with MNA	**Alternative 6** Hybrid Closure by Removal (CBR) of Pond 2 & Middle Ponds with MNA with Pond 4 CIP with Full Perimeter Wall with MNA	**Alternative 7** Closure by Removal (CBR) with MNA - All Units
Category 3 - Subcriteria v) Available capacity and location of needed treatment, storage, and disposal services							

5.2.3.6 *Ease or difficulty of implementation summary*

The graphic below provides a summary of the ease or difficulty that will be needed to implement each alternative. Alternative 1 is considered the most favorable while Alternatives 2 through 4 which include a barrier wall component are considered less favorable. Alternative 5 is also considered less favorable since this alternative includes partial removal of the CCR and associated large-scale construction. Due to the construction of a full perimeter wall to isolate CCR under Alternative 6, and large-scale construction for full removal and disposal requirements under Alternative 7, these two alternatives are considered the least favorable.

	Alternative 1 CIP All Units with Cap and Hydraulic Containment with Ex-Situ Treatment with Pond 4 MNA	**Alternative 2** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment - All Units	**Alternative 3** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment with Barrier Wall with Pond 4 MNA	**Alternative 4** CIP with Cap and Hydraulic Containment with Ex-Situ Treatment with Barrier Wall - All Units	**Alternative 5** Hybrid Closure by Removal (CBR) with MNA with Pond 4 CIP with MNA	**Alternative 6** Hybrid Closure by Removal (CBR) of Pond 2 & Middle Ponds with MNA with Pond 4 CIP with Full Perimeter Wall with MNA	**Alternative 7** Closure by Removal (CBR) with MNA - All Units
CATEGORY 3 Ease of implementation							

6. Summary

This Corrective Measures Assessment has evaluated the following alternatives:

- Alternative 1: CIP with Capping (All Units); HC through Groundwater Pumping with Ex-Situ Treatment (Middle Ponds & Pond 2); Pond 4 Monitored Natural Attenuation (MNA);
- Alternative 2: CIP with Capping and HC through Groundwater Pumping with Ex-Situ Treatment (All Units);
- Alternative 3: CIP with Capping (All Units); HC through Groundwater Pumping with Ex-Situ Treatment and Barrier Wall (Middle Ponds and Pond 2); Pond 4 MNA;
- Alternative 4: CIP with Capping and HC through Groundwater Pumping with Ex-Situ Treatment with Barrier All (All Units);
- Alternative 5: Hybrid CBR with Monitored Natural Attenuation; Pond 4 CIP with MNA;
- Alternative 6: Hybrid CBR of Middle Ponds and Pond 2 with MNA, Pond 4 CIP with Full Perimeter Barrier Wall with MNA; and
- Alternative 7: CBR with MNA (All Units).

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

- Be protective of human health and the environment;
- Attain the GWPS 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 constituent s 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 HSGS 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 HSGS CCR website.

References

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

2. ATC. 2018. 2017 CCR Annual Groundwater Monitoring and Corrective Action Report, IPL Ash Pond System Monitoring Program, Harding Street Generating Station, Indianapolis, Indiana.

3. Sargent & Lundy. 2016. CCR Surface Impoundment Closure Plan. IPL Harding Street Generating Station.

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

5. USEPA. 2015a. Final Rule: Disposal of Coal Combustion Residuals (CCRs) for Electric Utilities. 80 CFR 21301-21501. U.S. Environmental Protection Agency, Washington, D.C. Available at: https://www.govinfo.gov/content/pkg/FR-2015-04-17/pdf/2015-00257.pdf

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

7. 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

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TABLES

TABLE I
REMEDIAL ALTERNATIVE ROADMAP
ASH POND SYSTEM
HARDING STREET GENERATING STATION - INDIANAPOLIS, INDIANA

Alternative Number	Remedial Alternative Description	Pond Closure Description			Groundwater Remedy Components		
		Pond 2	Middle Ponds (1, 2A, 2B, and 3)	Pond 4	A. Groundwater Remedy Approach	B. Groundwater Treatment Method	C. Post-Closure Actions
1	**Closure in Place (CIP) with Capping (All Units); Hydraulic Containment through Groundwater Pumping with Ex-Situ Treatment (Middle Ponds & Pond 2); Pond 4 Monitored Natural Attenuation (MNA)**	**CIP with Hydraulic Containment (HC)**	**CIP with HC**	**CIP with MNA**	**Hydraulic Containment (Pond 2 and Middle Ponds)** Mitigate off-site migration of groundwater with CCR constituents above GWPS using extraction wells. Potentially consolidate CCR on-site **Natural Attenuation with Monitoring (Pond 4)** Mitigate off-site migration of groundwater with CCR constituents above GWPS through process of natural attenuation	**Ex-Situ Treatment (Pond 2 and Middle Ponds)** Treatment system (ion exchange or reverse osmosis) to remove CCR constituents from groundwater and discharge under applicable permits **No Active Treatment (Pond 4)** No active treatment technologies for groundwater to address CCR constituents	**Pump & Treat Long-Term (Pond 2 and Middle Ponds)** Continue to operate hydraulic containment system to maintain reduction of CCR constituents in groundwater **MNA (Pond 4)** Long-term groundwater monitoring to confirm reduction of CCR constituents
2	**CIP with Capping and Hydraulic Containment through Groundwater Pumping with Ex-Situ Treatment (All Units)**	**CIP with HC**			**Hydraulic Containment** Mitigate off-site migration of groundwater with CCR constituents above GWPS using extraction wells. Potentially consolidate CCR on-site	**Ex-Situ Treatment** Treatment system (ion exchange or reverse osmosis) to remove CCR constituents from groundwater and discharge under applicable permits	**Pump & Treat Long-Term** Continue to operate hydraulic containment system to maintain reduction of CCR constituents in groundwater
3	**CIP with Capping (All Units); Hydraulic Containment through Groundwater Pumping with Ex-Situ Treatment and Barrier Wall (Middle Ponds & Pond 2); Pond 4 MNA**	**CIP with HC & Barrier Wall**	**CIP with HC & Barrier Wall**	**CIP with MNA**	**Hydraulic Containment with Barrier Wall (Pond 2 and Middle Ponds)** Mitigate off-site migration of groundwater with CCR constituents above GWPS using extraction wells and a subsurface low-permeability barrier wall. Potentially consolidate CCR on-site **Natural Attenuation with Monitoring (Pond 4)** Mitigate off-site migration of groundwater with CCR constituents above GWPS through process of natural attenuation	**Ex-Situ Treatment (Pond 2 and Middle Ponds)** Treatment system (ion exchange or reverse osmosis) to remove CCR constituents from groundwater and discharge under applicable permits **No Active Treatment (Pond 4)** No active treatment technologies for groundwater to address CCR constituents	**Pump & Treat Long-Term (Pond 2 and Middle Ponds)** Continue to operate hydraulic containment system to maintain reduction of CCR constituents in groundwater **MNA (Pond 4)** Long-term groundwater monitoring to confirm reduction of CCR constituents
4	**CIP with Capping and Hydraulic Containment through Groundwater Pumping with Ex-Situ Treatment and Barrier Wall (All Units)**	**CIP with HC & Barrier Wall**			**Hydraulic Containment with Barrier Wall** Mitigate off-site migration of groundwater with CCR constituents above GWPS using extraction wells and a subsurface low-permeability barrier wall. Potentially consolidate CCR on-site	**Ex-Situ Treatment** Treatment system (ion exchange or reverse osmosis) to remove CCR constituents from groundwater and discharge under applicable permits	**Pump & Treat Long-Term** Continue to operate hydraulic containment system to maintain reduction of CCR constituents in groundwater
5	**Hybrid Closure by Removal (CBR) with MNA; Pond 4 CIP with MNA**	**CBR** *(Move material to other pond footprints)*	**CBR** *(Move material to other pond footprints)*	**CIP with MNA**	**Natural Attenuation with Monitoring** Mitigate off-site migration of groundwater with CCR constituents above GWPS through process of natural attenuation	**No Active Treatment** No active treatment technologies for groundwater to address CCR constituents	**MNA** Long-term groundwater monitoring to confirm reduction of CCR constituents
6	**Hybrid CBR of Middle Ponds & Pond 2 with MNA, Pond 4 CIP with Full Perimeter Wall with MNA**	**CBR** *(Move material to other pond footprints)*	**CBR** *(Move material to other pond footprints)*	**CIP with MNA & Ring Wall** *(minor pumping on interior)*	**Natural Attenuation with Monitoring** Mitigate off-site migration of groundwater with CCR constituents above GWPS through process of natural attenuation	**No Active Treatment** No active treatment technologies for groundwater to address CCR constituents	**MNA** Long-term groundwater monitoring to confirm reduction of CCR constituents
7	**CBR with MNA (All Units)**	**CBR** ***(Remove CCR from units for BU or off-site disposal)***			**Natural Attenuation with Monitoring** Mitigate off-site migration of groundwater with CCR constituents above GWPS through process of natural attenuation	**No Active Treatment** No active treatment technologies for groundwater to address CCR constituents	**MNA** Long-term groundwater monitoring to confirm reduction of CCR constituents

Notes: Results of this remedial alternative list is subject to change based on further evaluation of closure alternative evaluations being performed by H&A.
The role of the mining property situated down-gradient of the HSS units is subject to further/ongoing Nature and extent evaluation.
List of RA's is subject to change depending on whether AES prefers to include/incorporate exempt units (Pond 2 & Pond 4) into CMA vs. limit to only Ponds 1, 2A, 2B & 3.
List of RA's is subject to change depending on whether AES prefers to incorporate IDEM lateral infiltration requirements or keep CCR Rule CMA RA's independent of IDEM.

TABLE II

SUMMARY OF CORRECTIVE MEASURES

ASH POND SYSTEM

HARDING STREET GENERATING STATION - INDIANAPOLIS, INDIANA

Alternative Number	Remedial Alternative Description[1]	THRESHOLD CRITERIA					BALANCING CRITERIA																	
								Sub-Category 1									Sub-Cat. 2			Sub-Category 3				
								1	2	3	4	5	6	7	8		1	2		1	2	3	4	5
		Be protective of human health and the environment	Attain the groundwater protective standard	Control the source of releases so as to reduce or eliminate, to the maximum extent feasible, further releases of Appendix IV constituents into the environment	Remove from the environment as much of the contaminated material that was released from the CCR unit as is feasible, taking into account factors such as avoiding inappropriate disturbance of sensitive ecosystems	Management of waste to comply with all applicable RCRA requirements	**CATEGORY 1** Long- and Short-Term Effectiveness, Protectiveness, and Certainty of Success that the remedy will prove successful	*Magnitude of reduction of existing risks*	*Magnitude of residual risks in terms of likelihood of further releases due to CCR remaining following implementation of a remedy*	*Type and degree of long-term management required including monitoring, operation and maintenance*	*Short-term risk to community or environment during implementation of remedy*	*Time until full protection is achieved*	*Potential for exposure of humans and environmental receptors to remaining wastes, considering the potential threat to human health and the environment associated with excavation, transportation, re-disposal, or containment*	*Long-term reliability of engineering and institutional controls*	*Potential need for replacement of the remedy*	**CATEGORY 2** Effectiveness in controlling the source to reduce further releases	*Extent to which containment practices will reduce further releases*	*Extent to which treatment technologies may be used*	**CATEGORY 3** The ease or difficulty of implementation	*Degree of difficulty associated with constructing the technology*	*Expected operational reliability of the technologies*	*Need to coordinate with and obtain necessary approvals and permits from other agencies*	*Availability of necessary equipment and specialists*	*Available capacity and location of needed treatment, storage, and disposal services*
1	Closure in Place (CIP) with Capping (All Units); Hydraulic Containment through Groundwater Pumping with Ex-Situ Treatment (Middle Ponds & Pond 2); Pond 4 Monitored Natural Attenuation (MNA)	✓	✓	✓	✓	✓																		
2	CIP with Capping and Hydraulic Containment through Groundwater Pumping with Ex-Situ Treatment (All Units)	✓	✓	✓	✓	✓																		
3	CIP with Capping (All Units); Hydraulic Containment through Groundwater Pumping with Ex-Situ Treatment and Barrier Wall (Middle Ponds & Pond 2); Pond 4 MNA	✓	✓	✓	✓	✓																		
4	CIP with Capping and Hydraulic Containment through Groundwater Pumping with Ex-Situ Treatment and Barrier Wall (All Units)	✓	✓	✓	✓	✓																		

TABLE II

SUMMARY OF CORRECTIVE MEASURES

ASH POND SYSTEM

HARDING STREET GENERATING STATION - INDIANAPOLIS, INDIANA

Alternative Number	Remedial Alternative Description[1]	THRESHOLD CRITERIA					BALANCING CRITERIA																	
							CATEGORY 1 Long- and Short-Term Effectiveness, Protectiveness, and Certainty of Success that the remedy will prove successful	Sub-Category 1								CATEGORY 2 Effectiveness in controlling the source to reduce further releases	Sub-Cat. 2		CATEGORY 3 The ease or difficulty of implementation	Sub-Category 3				
								1	2	3	4	5	6	7	8		1	2		1	2	3	4	5
		Be protective of human health and the environment	Attain the groundwater protective standard	Control the source of releases so as to reduce or eliminate, to the maximum extent feasible, further releases of Appendix IV constituents into the environment	Remove from the environment as much of the contaminated material that was released from the CCR unit as is feasible, taking into account factors such as avoiding inappropriate disturbance of sensitive ecosystems	Management of waste to comply with all applicable RCRA requirements		*Magnitude of reduction of existing risks*	*Magnitude of residual risks in terms of likelihood of further releases due to CCR remaining following implementation of a remedy*	*Type and degree of long-term management required including monitoring, operation and maintenance*	*Short-term risk to community or environment during implementation of remedy*	*Time until full protection is achieved*	*Potential for exposure of humans and environmental receptors to remaining wastes, considering the potential threat to human health and the environment associated with excavation, transportation, re-disposal, or containment*	*Long-term reliability of engineering and institutional controls*	*Potential need for replacement of the remedy*		*Extent to which containment practices will reduce further releases*	*Extent to which treatment technologies may be used*		*Degree of difficulty associated with constructing the technology*	*Expected operational reliability of the technologies*	*Need to coordinate with and obtain necessary approvals and permits from other agencies*	*Availability of necessary equipment and specialists*	*Available capacity and location of needed treatment, storage, and disposal services*
5	**Hybrid Closure by Removal (CBR) with MNA; Pond 4 CIP with MNA**	✓	✓	✓	✓	✓	Green	Yellow	Yellow	Green	Yellow	Green	Yellow	Green	Green	Green	Green	Green	Yellow	Yellow	Green	Red	Red	Green
6	**Hybrid CBR of Middle Ponds & Pond 2 with MNA, Pond 4 CIP with Full Perimeter Wall with MNA**	✓	✓	✓	✓	✓	Green	Yellow	Yellow	Green	Yellow	Green	Yellow	Green	Green	Green	Green	Green	Red	Red	Green	Red	Red	Green
7	**CBR with MNA (All Units)**	✓	✓	✓	✓	✓	Yellow	Red	Green	Green	Red	Green	Red	Green	Green	Green	Green	Green	Red	Red	Green	Red	Red	Red

COLOR LEGEND

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

[1]Other remedial alternatives, such as closure in place with monitored natural attenuation (MNA), were 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.

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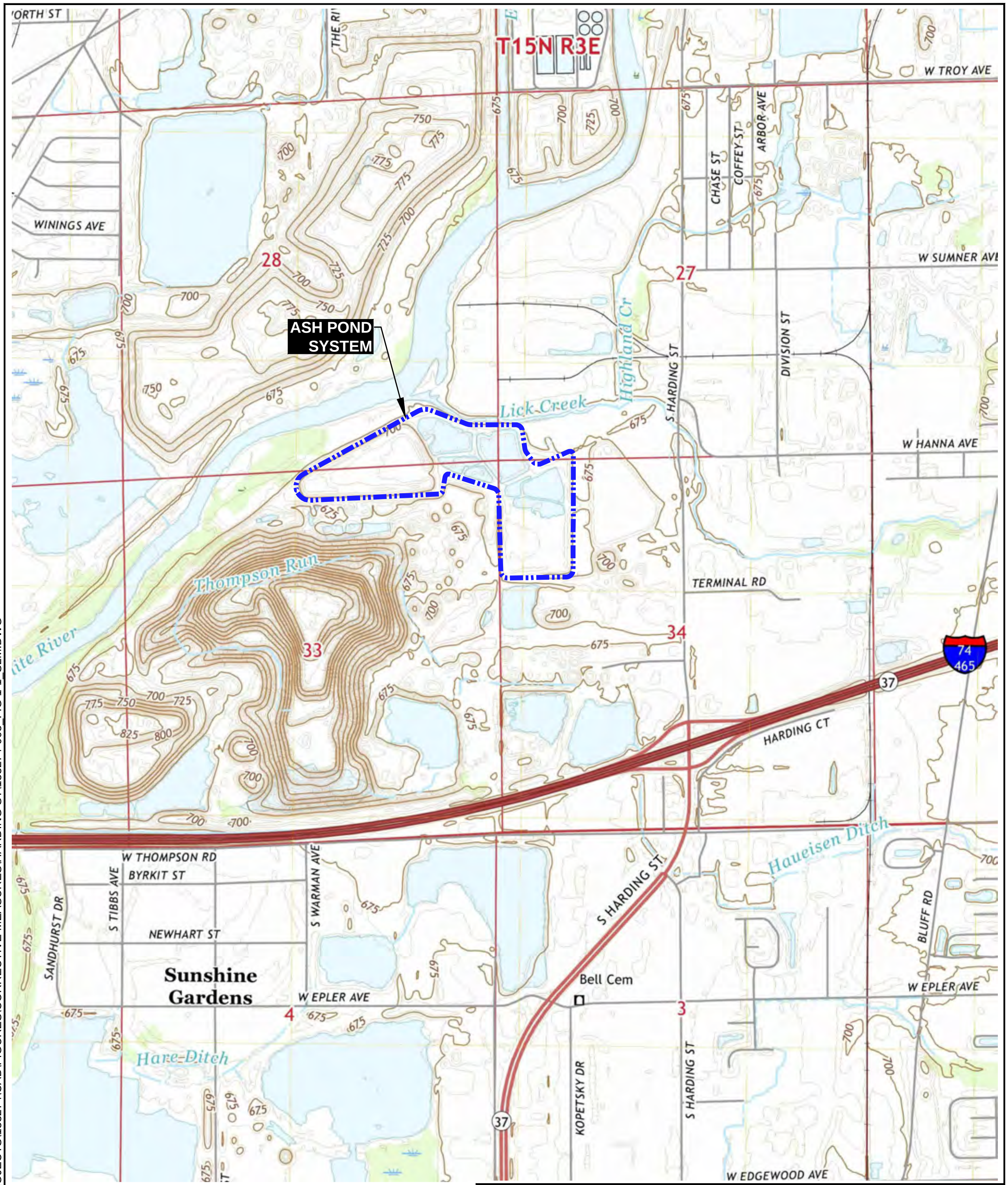
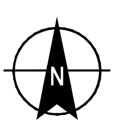
FIGURES



MAP SOURCE: USGS
QUADRANGELS: MAYWOOD, IN 2019



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CORRECTIVE MEASURES ASSESSMENT
ASH POND SYSTEM
HARDING STREET GENERATING STATION
INDIANAPOLIS, INDIANA

SITE LOCATION MAP

APPROXIMATE SCALE: 1IN = 2000 FT
OCTOBER 2019

FIGURE 1-1

VARI, KATALIN Printed: 9/30/2019 1:47 PM Layout: FIGURE 1-1
\\HALEYALDRICH.COM\SHARE\CF\PROJECTS\133274\CAD\FIGURES\CORRECTIVE MEASURES\HARDING ST\133274-005_FIG 1-1_SLM.DWG

LEGEND

- APPROXIMATE LIMITS OF PROPERTY
- APPROXIMATE LIMITS OF ASH POND SYSTEM
- APPROXIMATE BOUNDARY OF ASH POND

NOTES

1. AERIAL IMAGE FROM GOOGLE EARTH, DATED 2018.
2. ALL BOUNDARIES AND LOCATIONS ARE APPROXIMATE.

N

0 500 1000

SCALE IN FEET

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CORRECTIVE MEASURES ASSESSMENT
ASH POND SYSTEM
HARDING STREET GENERATING STATION
INDIANAPOLIS, INDIANA

SITE FEATURES

SCALE: AS SHOWN
OCTOBER 2019

FIGURE 1-2

VARI, KATALIN Saved: 9/30/2019 4:54 PM Layout: FIGURE 1-2
\\HALEYALDRICH.COM\SHARE\CF\PROJECTS\133274\CAD\FIGURES\CORRECTIVE MEASURES\HARDING ST\133274-005_FIG 1-2_SITE.DWG

LEGEND

- APPROXIMATE LIMITS OF PROPERTY
- APPROXIMATE LIMITS OF ASH POND SYSTEM
- APPROXIMATE BOUNDARY OF ASH POND
- M-3 / P-2 / PZ-1 — PIEZOMETER LOCATION
- MW-2 — CCR MONITORING WELL LOCATION
- P1 PZ-1S / P1 PZ-1D — NATURE AND EXTENT PIEZOMETER LOCATION
- SG-1 — NATURE AND EXTENT STAFF GAUGE LOCATION
- M-4 — NATURE AND EXTENT MONITORING WELL LOCATION

NOTES

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

N

0 500 1000
SCALE IN FEET

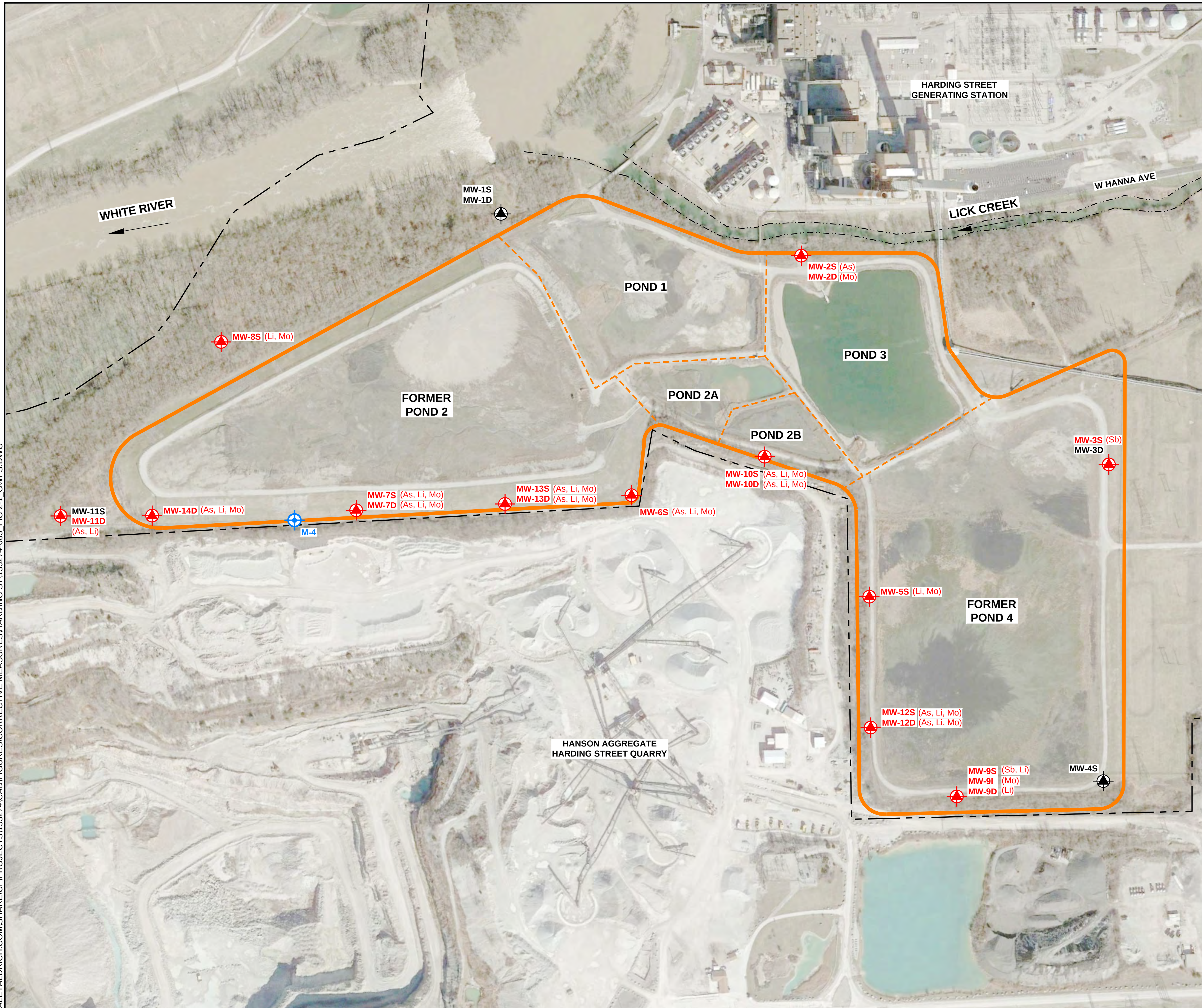
HALEY ALDRICH

CORRECTIVE MEASURES ASSESSMENT
ASH POND SYSTEM
HARDING STREET GENERATING STATION
INDIANAPOLIS, INDIANA

CCR MONITORING WELL AND NATURE AND EXTENT MONITORING EQUIPMENT LOCATIONS

SCALE: AS SHOWN
OCTOBER 2019

FIGURE 1-3



LEGEND

APPROXIMATE LIMITS OF PROPERTY

APPROXIMATE LIMITS OF ASH POND SYSTEM

APPROXIMATE BOUNDARY OF ASH POND

MW-3 CCR MONITORING WELL WITH NO SSL

MW-4 NATURE AND EXTENT MONITORING WELL

MW-8S CCR MONITORING WELL WITH REPORTED SSL

As = ARSENIC

Sb = ANTIMONY

Li = LITHIUM

Mo = MOLYBDENUM

NOTES

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

N

0 400 800

SCALE IN FEET

HALEY ALDRICH

CORRECTIVE MEASURES ASSESSMENT
ASH POND SYSTEM
HARDING STREET GENERATING STATION
INDIANAPOLIS, INDIANA

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

SCALE: AS SHOWN
OCTOBER 2019

FIGURE 2-1