



**Second Semiannual Report on the
Progress of Remedy Selection**

**TVA Paradise Fossil Plant, Slag
Ponds CCR Units, Drakesboro,
Muhlenberg County, Kentucky**

July 15, 2020

Prepared for:

Tennessee Valley Authority
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July 15, 2020

1.0 Introduction

In accordance with 40 CFR § 257.96(a), the Tennessee Valley Authority (TVA) has prepared this second semiannual report to document progress toward remedy selection and design at Slag Ponds 2A, 2B, and Slag Stilling Pond 2C (hereinafter referred to as the Slag Ponds coal combustion residuals (CCR) Units) at the Paradise Fossil Plant (PAF) in Drakesboro, Muhlenberg County, Kentucky.

1.1 Regulatory Background

On April 17, 2015, the United States Environmental Protection Agency (U.S. EPA) published a rule that sets forth national criteria for the management of CCR produced by electric utilities. The requirements can be found in Title 40, Code of Federal Regulations (CFR) Part 257, Subpart D. The rule includes requirements for monitoring groundwater and assessing corrective measures if constituents listed in Appendix IV of the rule are detected in groundwater samples collected from downgradient monitoring wells at statistically significant levels (SSLs) greater than established groundwater protection standards (GWPS).

In January 2019, TVA completed an evaluation of whether there were SSLs over established GWPS as defined in 40 CFR § 257.95(h) for one or more Appendix IV constituents in accordance with 40 CFR § 257.95(g). At the Slag Ponds CCR Units, assessment monitoring detected an SSL greater than the GWPS for arsenic at monitoring well PAF-113. Since this time, TVA has updated the statistical analysis.

- In late-2019, TVA recalculated the statistical analysis after incorporating additional groundwater monitoring data from the second assessment monitoring event in 2019.
- In mid-2020, TVA updated the statistical analysis after incorporating results from the second assessment monitoring retest event in 2019 and the first semiannual groundwater monitoring event in 2020.

The same SSLs were observed for arsenic in PAF-113 as previously identified during the first semiannual assessment monitoring event in 2020. As of the date of this report, TVA has not completed a demonstration that a source other than the Slag Ponds CCR Units associated with well PAF-113 caused the SSL, as allowed under 40 CFR § 257.95(g)(3)(ii).

In accordance with 40 CFR § 257.96(a), TVA prepared the 2019 Assessment of Corrective Measures (ACM) Report for the Slag Ponds CCR Units at PAF, placed it in the facility operating record on July 15, 2019 and uploaded it to the TVA CCR Rule Compliance Data and Information website on August 14, 2019. The ACM Report provided an assessment of the effectiveness of potential corrective measures in achieving the criteria provided in 40 CFR § 257.96(c). Three primary strategies were evaluated to address groundwater exhibiting concentrations of arsenic above the GWPS:

- Monitored Natural Attenuation (MNA);
- Hydraulic Containment and Treatment; and,
- Enhanced In-Situ Treatment (EIST).

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Following preparation of the ACM Report, TVA began the remedy selection process. Semiannual reports are required pursuant to 40 CFR § 257.97(a) to document progress toward remedy selection and design. The CCR Rule contemplates that more investigation and consideration may be needed to evaluate and design the remedy before making the final selection. TVA placed the first Semiannual Report on the Progress of Remedy Selection into the facility operating record on January 15, 2020 pursuant to 40 CFR § 257.97(a) and § 257.105(h)(12). TVA provided notification of the availability of the semiannual report describing the progress in selecting and designing the remedy and placed it on the TVA CCR Rule Compliance Data and Information website on February 14, 2020 in accordance with 40 CFR § 257.106(h)(9) and § 257.107(h)(9). TVA will continue to review new data as it becomes available and will implement changes to the groundwater monitoring and corrective action program as necessary to maintain compliance with 40 CFR § 257.90 through § 257.98.

At least 30 days prior to final groundwater remedy selection pursuant to the CCR Rule, a public meeting will be held with interested and affected parties to discuss the results of the corrective measures assessment in accordance with 40 CFR § 257.96(e). The selected remedy must meet the requirements of 40 CFR § 257.97(b) and must consider the evaluation factors set forth in 40 CFR § 257.97(c). Once a final remedy is chosen, a final report describing the remedy and how it meets the standards set forth in 40 CFR § 257.97(b) will be prepared. The owner/operator must provide a schedule for implementing the selected remedy that considers the factors set forth in 40 CFR § 257.97(d).

1.2 Report Contents

This second semiannual progress report provides a summary of PAF site characteristics, the groundwater assessment monitoring program, the findings of the ACM process, and the current progress of selecting and designing a remedy for the statistically significant GWPS exceedance.

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2.0 Site Background and Characteristics

PAF is located in Drakesboro, Muhlenberg County, Kentucky. The Slag Ponds CCR Units are situated on the western bank of the Green River. **Figure 1** shows an overview map of PAF, including the Slag Ponds CCR Units. Construction of PAF began in 1959, and the facility's three generators were fully operational by 1970. PAF coal-fired generators 1 and 2 were retired in 2017, and the third generator was retired in February 2020. The coal combustion process at PAF resulted in the production of fly ash, boiler slag, and gypsum. The plant currently manages some of these materials in the Slag Ponds CCR Units.

Slag Ponds 2A and 2B have a combined wetted surface area of approximately 38 acres, and Slag Stilling Pond 2C has a wetted surface area of approximately 1.5 acres. The perimeter dikes of the Slag Ponds CCR Units are approximately 30-35 feet in height and were constructed using mine spoils built over alluvial deposits. The mine spoils are described as lean clay, clayey sand, or clayey gravel. The Slag Ponds CCR Units have received sluiced fly ash, bottom ash, boiler slag, plant effluent, water from the Red Water Ponds and the Coal Yard Runoff Ponds, and stormwater runoff from the plant and surrounding areas.

2.1 Conceptual Site Model Summary

The hydrogeologic conceptual site model (CSM) is one of the primary tools that can be used to support decisions on corrective measures. This section of the report provides a summary of the hydrogeologic CSM. The geology and hydrogeology of the PAF site have been characterized during implementation of multiple investigations. These investigations provide an understanding of site geology and the presence of water-bearing zones.

The subsurface geology at the Slag Ponds CCR Units consists of three main hydro-stratigraphic units, which from surface to depth, include Coal-Mine Spoils/Fill, Alluvium/Residuum, and the Carbondale Formation. The Carbondale Formation consists of interbedded layers of sandstone, siltstone, shale, and coal. It should be noted that none of these hydro-stratigraphic units meet the CCR Rule criteria for uppermost aquifer at this location; however, the mine spoils/fill and alluvium/residuum most closely meet the criteria and, for that reason, groundwater from both mine spoils/fill and alluvium/residuum wells is being monitored in accordance with 40 CFR § 257.91. A typical cross-section view of the subsurface geology is shown on **Figure 2**. The groundwater flow direction is primarily to the east, toward the Green River. **Figure 3** presents a groundwater flow direction map for PAF.

2.2 Potential Receptor Review

Most of the public water supply in Muhlenberg County is sourced from the Green River. Surface water from the Green River is withdrawn and treated by the Central City Water and Sewer System, which sells its water to the Muhlenberg County Water District for distribution to customers. The City of Drakesboro, which is located approximately 5 miles southwest of the site, provides water that is pumped from the Green River.

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3.0 Groundwater Assessment Monitoring Program

Groundwater assessment monitoring for the Slag Ponds CCR Units is conducted at PAF in accordance with 40 CFR § 257.95.

3.1 Groundwater Monitoring Well Network

In compliance with 40 CFR § 257.91, one background well (95-48A) and two upgradient wells (PAF-108 and PAF-109) were established, and four monitoring wells (95-47C, PAF-110, PAF-112, and PAF-113) were installed downgradient of the Slag Pond CCR Units and comprise the multiunit well network for Slag Ponds 2A, 2B and Slag Stilling Pond 2C. The locations of these monitoring wells are presented on **Figure 1**.

3.2 Groundwater Characterization

Groundwater assessment monitoring was conducted during 2018 and 2019, and at the time of this report, the first semiannual assessment monitoring event and retest event in 2020 had been conducted. Arsenic, an Appendix IV constituent, was detected at an SSL above the GWPS at monitoring well PAF-113. The following summarizes the Appendix IV SSLs at the PAF Slag Ponds CCR Units for 2018, 2019, and the first semiannual assessment monitoring in 2020:

- Arsenic
 - An SSL for arsenic was identified at monitoring well PAF-113;
 - The arsenic GWPS is 12.0 µg/L.

Data from existing wells have been utilized to characterize the nature and extent of any release from the Slag Ponds CCR Units as required by 40 CFR § 257.95(g)(1). An additional monitoring well (PAF-113R) was recently installed. Its data is anticipated to further refine the characterization in this area. The potential treatment zone to address the extent of arsenic above GWPS along the unit perimeter is illustrated on **Figure 4**.

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4.0 Assessment of Corrective Measures

TVA prepared the 2019 ACM Report for the Slag Ponds CCR Units and added it to the operating record on July 15, 2019. The report was posted to the TVA CCR Rule Compliance Data and Information website on August 14, 2019. The ACM Report provided an assessment of the effectiveness of potential corrective measures in achieving the criteria provided in 40 CFR § 257.96(c).

4.1 Planned Source Control Measures

The objectives of corrective measures under 40 CFR § 257.96(a) are to “prevent further releases, to remediate any releases, and to restore affected areas to original conditions.” Ultimately, in accordance with 40 CFR § 257.97(b)(3), the selected corrective measure must at a minimum “[c]ontrol the source(s) of releases so as to reduce or eliminate, to the maximum extent feasible, further releases of constituents of appendix IV to this part into the environment.”

The Preamble (80 Fed. Reg. 21302, 21406) to the CCR Rule discusses that source control measures may include modifying operational procedures. To comply with regulatory requirements and timeframes under the CCR Rule, TVA will close the Slag Ponds CCR Units in accordance with 40 CFR § 257.102.

Groundwater assessment monitoring as required by 40 CFR § 257.96(b) will continue until a remedy is selected. The monitoring will be conducted to track changes in groundwater conditions as a result of these closures and operational changes. These data will also be considered in the selection and design of a remedy in accordance with 40 CFR § 257.97.

Closure of the Slag Pond CCR Units cannot be initiated until provisions are made to re-route water that is currently discharged to the CCR units to an alternative treatment facility. Once this water is re-routed the Slag Ponds CCR Units can be completely removed from service and dewatering operations can commence. A process water basin is currently under construction with anticipated completion in 2020.

4.2 Potential Remedial Technologies

In addition to source control measures, three primary strategies were evaluated to address groundwater exhibiting concentrations of arsenic above the GWPS including:

- Monitored Natural Attenuation (MNA);
- Hydraulic Containment and Treatment; and,
- Enhanced In-Situ Treatment (EIST).

The ACM Report provides a more detailed description of these corrective measures. The effectiveness of each potential corrective measure was assessed in accordance with 40 CFR § 257.96(c) and all measures are currently considered feasible for remediating the groundwater at the Slag Ponds CCR Units.

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5.0 Selection of Remedy: Current Progress

A remedy to address the arsenic SSL in groundwater will be selected in accordance with 40 CFR § 257.97. Upon selection of a remedy, the owner or operator must prepare a final report (i.e., Remedy Selection Report) describing the selected remedy and how it meets the standards specified below pursuant to 40 CFR §257.97(b)(1)-(5). 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 units 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).

In support of the remedy selection process, additional investigation is needed and is described below.

5.1 Data Requirements for Design of Groundwater Corrective Action

Additional data requirements are needed to refine the targeted area for corrective measures, develop remedial cost estimates, and finalize the alternative for the Slag Ponds CCR Units. To address data gaps, further characterization of arsenic impacts downgradient or cross-gradient is needed in addition to investigation activities described below.

Recent activities completed and anticipated activities to further evaluate site conditions:

- A potential replacement well for monitoring well PAF-113 has been installed and developed. The replacement well (PAF-113R) will be sampled for three events over an approximately four-month period to evaluate if replacing the well contributes to lower observed sample turbidity values than those observed at existing monitoring well PAF-113. The replacement well will be evaluated for inclusion into the certified monitoring well network pending the results of the three groundwater sampling events. The locations of PAF-113 and PAF-113R are illustrated in **Figure 5**.
- Seven soil borings were installed on the northeast side of the Slag Ponds CCR Units as a screening-level investigation to refine the nature and extent of dissolved arsenic in areas east and northeast of well PAF-113. The locations of the soil borings around PAF-113 and PAF-113R are provided on **Figure 5**.
- Slug testing will be performed at the newly installed monitoring well location (PAF-113R) to further evaluate hydraulic conductivity.

Potential future activities to further evaluate MNA:

- A geochemical investigation will be conducted to evaluate groundwater and aquifer solids in areas proximal to PAF-113, PAF-113R and the surrounding soil borings at the Slag Ponds CCR Units. Arsenic can be present in multiple valence states and its chemical reactivity is affected by groundwater pH, redox potential, the presence of iron and sulfur, and other subsurface variations. The effectiveness of geochemical processes can be evaluated by collecting native soil and groundwater samples and conducting bench-scale testing to evaluate the effectiveness of MNA.

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- Groundwater Flow Modeling – Numerical modeling of groundwater flow based on expanded groundwater elevation data gained from the ongoing investigations and additional hydrogeologic characterization efforts might be used to further refine the understanding of groundwater flow direction and velocity.
- Groundwater Fate and Transport Modeling – The refined groundwater flow model might be linked to a fate and transport model to further evaluate the estimated time for natural attenuation mechanisms to reduce the arsenic concentrations to below GWPS.

Potential future activities to further evaluate hydraulic containment and treatment:

- A geochemical investigation will be conducted to evaluate groundwater and aquifer solids in areas proximal to PAF-113, PAF-113R, and the surrounding soil borings at the Slag Ponds CCR Units. The applicability and orientation of a hydraulic containment system is largely based on site-specific conditions including aquifer dimensions and conductivity, presence of confining layers, depth, gradient, characteristics of the arsenic, and presence of geochemically important minerals.
- Groundwater Flow Modeling – The numerical groundwater flow model might be used to evaluate hydraulic containment, as appropriate. A calibrated groundwater model could be used to evaluate a variety of approaches (e.g., vertical wells, horizontal wells, physical barriers) and to estimate the groundwater extraction rates necessary to contain an identified target zone. The objective of hydraulic containment modeling would be to incorporate groundwater extraction scenarios to optimize hydraulic containment of arsenic-impacted groundwater while balancing extracted groundwater treatment requirements.
- Groundwater Treatability Study - For ex-situ treatment of extracted groundwater, treatability studies would be needed to evaluate technologies for the treatment of arsenic.

Potential future activities to evaluate Enhanced In-situ Treatment:

- A geochemical investigation might be conducted to evaluate groundwater and aquifer solids in areas proximal to PAF-113 and PAF-113R at the Slag Ponds CCR Units. Removal of arsenic with multiple treatment technologies has been demonstrated in industrial wastewater applications. Potential treatment alternatives include advanced filtration, co-precipitation, redox manipulation, adsorption, and ion exchange. The most effective alternative(s) would be selected based on the geochemistry of the groundwater.
- Groundwater Treatability Study – For in-situ treatment of groundwater, bench-scale treatability studies might be conducted on representative groundwater samples prior to selecting a groundwater corrective measure for implementation to address arsenic concentrations.

5.2 Semiannual Reporting, Public Meeting, Remedy Selection and Final Report

Progress toward the selection and design of the remedy will be documented in semiannual reports in accordance with 40 CFR § 257.97(a). Semiannual reports will be placed into the facility operating record pursuant to 40 CFR § 257.105(h)(12). TVA will provide notifications of the availability of the semiannual reports describing the progress in selecting and designing the remedy and will place the reports on the TVA CCR Rule Compliance Data and Information website in accordance with 40 CFR § 257.106(h)(9) and § 257.107(h)(9) respectively 30 days after placement in the facility operating record. At least 30 days prior to selecting a remedy, a public meeting to discuss the results of the corrective measures assessment will be conducted as required by 40 CFR § 257.96(e).

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A final report will be prepared after the remedy is selected. This final report will describe the remedy and how it meets the standards specified in 40 CFR § 257.97(b) and 257.97(c). Recordkeeping requirements specified in 40 CFR § 257.105(h), notification requirements specified in 40 CFR § 257.106(h), and internet requirements specified in 40 CFR § 257.107(h) will be complied with as required by 40 CFR § 257.96(f).

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Attachments:

Figures

Figure 1 – CCR Units with Background and Downgradient Wells

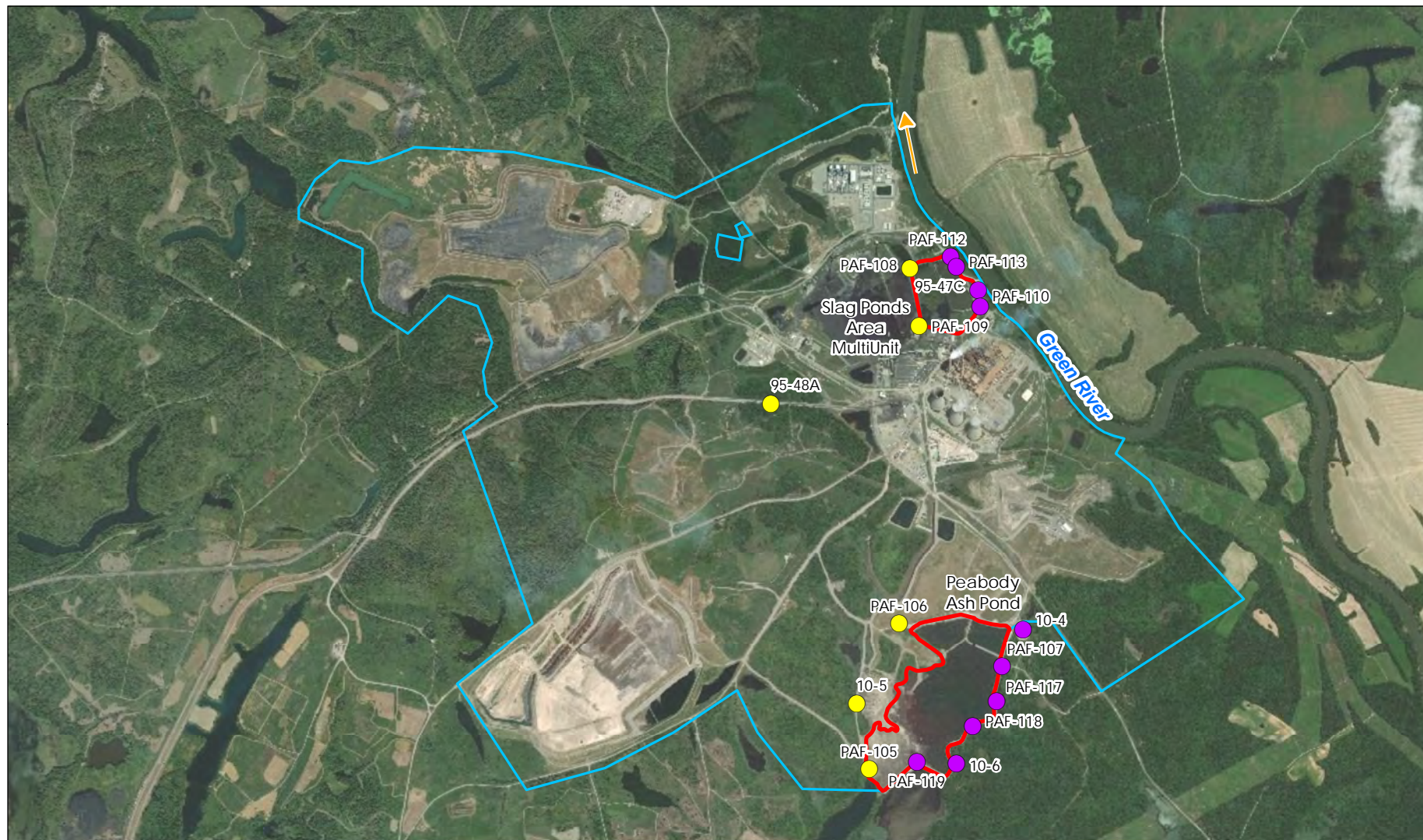
Figure 2 – Geological Cross-Section

Figure 3 – Groundwater Flow Direction

Figure 4 – Monitoring Wells and Limits of COI Impacts

Figure 5 – Geoprobe Sampling Locations

FIGURE 1
CCR UNITS WITH BACKGROUND AND
DOWNGRADIENT WELLS



- Downgradient Well
- Background or Upgradient Well
- CCR Unit Subject to CCR Rule Under § 257.96
- TVA Property Boundary



Notes

1. Coordinate System: NAD 1983 StatePlane Kentucky South FIPS 1602 Feet
2. Background: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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(At original document size of 8.5x11)
1:36,000



Project Location
Drakesboro
Muhlenberg County, KY
Client/Project
Tennessee Valley Authority
Paradise Fossil Plant
CCR Rule

Prepared by LMB on 2020-06-11
Technical Review by EP on 2020-06-11
Independent Review by JB on 2020-06-11

182603529

Figure No.

Figure 1

Title

CCR Units with Background and Downgradient Wells

FIGURE 2
GEOLOGICAL CROSS-SECTION

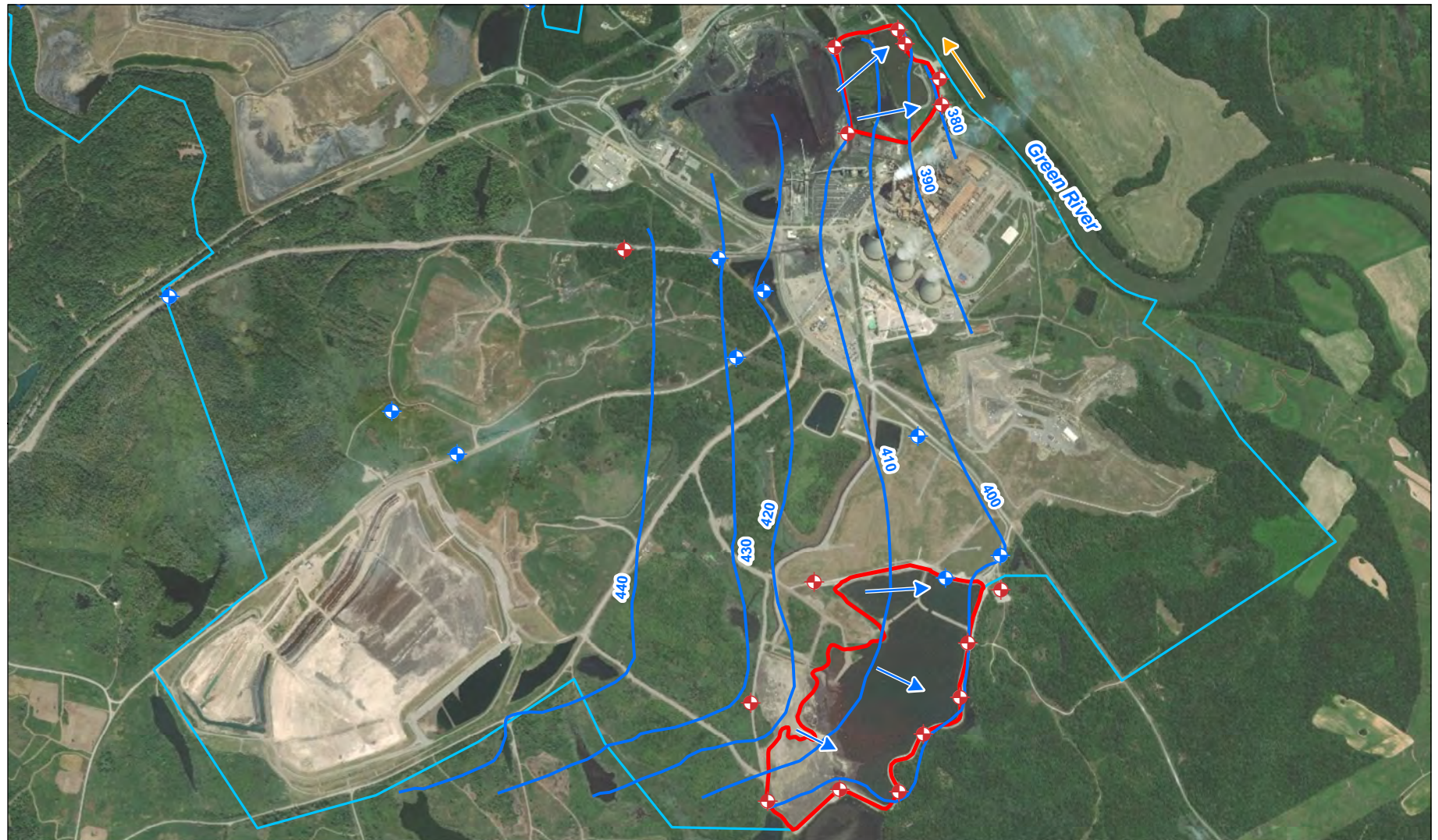


Figure No.

Figure 2



FIGURE 3
GROUNDWATER FLOW DIRECTION



- ◆ CCR Compliance Well
- ◆ CCR Observation Well
- Groundwater Flow Direction
- Groundwater Contour
- November 28, 2016 sampling event
- CCR Unit Subject to CCR Rule Under § 257.96
- TVA Property Boundary



Notes

1. Coordinate System: NAD 1983 StatePlane Kentucky South FIPS 1602 Feet
2. Background: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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(At original document size of 8.5x11)
1:24,000



Project Location
Drakesboro
Muhlenberg County, KY
Client/Project
Tennessee Valley Authority
Paradise Fossil Plant
CCR Rule

Prepared by LMB on 2020-06-11
Technical Review by EP on 2020-06-11
Independent Review by JB on 2020-06-11

182603529

Figure No.

Figure 3

Title

Groundwater Flow Direction

FIGURE 4
MONITORING WELLS AND LIMITS OF
COI IMPACTS



- Downgradient Well
- Background or Upgradient Well
- GWPS Exceedance Well
- CCR Unit Subject to CCR Rule Under § 257.96
- TVA Property Boundary
- Potential Treatment Zones (Arsenic)



Notes

1. Coordinate System: NAD 1983 StatePlane Kentucky South FIPS 1602 Feet
2. Background: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

0 700 Feet
(At original document size of 8.5x11)
1:8,400

Project Location
Drakesboro
Muhlenberg County, KY

Client/Project
Tennessee Valley Authority
Paradise Fossil Plant
CCR Rule

Prepared by LMB on 2020-06-11
Technical Review by EP on 2020-06-11
Independent Review by JB on 2020-06-11

182603529

Figure No.

Figure 4

Title
**Monitoring Wells and
Limits of COI Impacts**



FIGURE 5
GEOPROBE SAMPLING LOCATIONS



Figure
5

Title
Geoprobe Sampling Locations

Client/Project
Tennessee Valley Authority
Paradise Fossil (PAF) Plant

Project Location
Muhlenberg County, Kentucky

182603529
Prepared by SW on 2020-06-11
Technical Review by BE on 2020-06-11
Independent Review by CS on 2020-06-11

0 150 300 450 600 Feet
1:1,800 (At original document size of 22x34)

Legend

Replacement Well

Proposed Soil Boring (As-Staked)

Existing Wells

Paradise Fossil Plant Site Boundary

Slag Ponds Area CCR Unit

- Notes
1. Coordinate System: NAD 1983 StatePlane Kentucky South FIPS 1602 Feet

2. Imagery Provided by ESRI World Imagery

