Second Semiannual Report on the Progress of Remedy Selection

TVA Paradise Fossil Plant, Peabody Ash Pond, Drakesboro, Muhlenberg County, Kentucky

July 15, 2020

Prepared for:

Tennessee Valley Authority
Chattanooga, Tennessee

Prepared by:

Stantec Consulting Services Inc.

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1.0 Introduction

In accordance with 40 CFR § 257.97(a), the Tennessee Valley Authority (TVA) has prepared this second semiannual report to document progress toward remedy selection and design at the Peabody Ash Pond (hereinafter referred to as the coal combustion residuals (CCR) Unit) 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 CCR Unit, assessment monitoring in 2018 detected an SSL greater than the GWPS for arsenic at monitoring well PAF-119. 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 second assessment monitoring retest event from 2019 and the first semiannual assessment monitoring event in 2020.

The same SSL was observed for arsenic in PAF-119 as previously identified during the first semiannual assessment monitoring in 2020. As of the date of this report, TVA has not completed a demonstration that a source other than the CCR Unit associated with well PAF-119 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 CCR Unit 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).

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 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.

2.0 Site Background and Characteristics

PAF is located in Drakesboro, Muhlenberg County, Kentucky. The CCR Unit is located along the northern bank of Jacobs Creek. **Figure 1** shows an overview map of PAF including the Peabody Ash Pond CCR Unit. 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 these materials on site; however, the Peabody Ash Pond CCR Unit no longer receives sluiced fly ash as of July 1, 2019.

The PAF CCR Unit is an active, unlined CCR surface impoundment that is approximately 120 acres in size. Surface mining operations were conducted in the area of the CCR Unit between 1974 and 1991. The strip-mining operations left earth-fill dikes along the southern and eastern sides of the CCR Unit. In 1997, the dikes were raised to their current elevation and are 12- to 20-feet in height (AECOM, 2016a – Initial Static Safety Assessment). The original embankment fill materials generally consist of mine spoils that are characterized as silty clay with variable quantities of silt, sand, coal and rock fragments. The raised dike of the CCR Unit consists of clay with some rock fragments. The CCR Unit primarily has received sluiced fly ash, but also has received decant waters from the Gypsum Disposal Area Stilling Ponds and other non-CCR waste streams (AECOM, 2016b – History of Construction).

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 through historical investigations since construction of the CCR Unit. These investigations provide an understanding of site geology and the presence of water-bearing zones. The subsurface geology at the CCR Unit 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 consists of interbedded layers of sandstone, siltstone, shale, and coal. It should be noted that none of these hydro-stratigraphic units strictly meet the CCR Rule criteria for upper-most aquifer at this location; however, the mine spoils/fill unit is most closely aligned with the criteria for water quality, quantity and depth and is therefore 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 at the CCR Unit is primarily east to east-southeast, towards Jacob's Creek. **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.

3.0 Groundwater Assessment Monitoring Program

Groundwater assessment monitoring for the CCR Unit 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 three upgradient wells (10-5, PAF-105, PAF-106) were established and six monitoring wells (10-4, 10-6, PAF-107, PAF-117, PAF-118, and PAF-119) were installed downgradient of the CCR Unit. 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-119. The following summarizes the Appendix IV SSLs at the PAF CCR Unit for 2018, 2019, and the first semiannual assessment monitoring in 2020:

- Arsenic
    - SSLs for arsenic were identified at monitoring well PAF-119; and,
    - The arsenic GWPS is 15.4 μg/L.

Data from existing wells have been utilized to characterize the nature and extent of any release from the CCR Unit as required by 40 CFR § 257.95(g)(1). An additional monitoring well (PAF-119R) has been installed and its data is helping to further refine this characterization. The potential treatment zone to address the extent of arsenic above GWPS along the unit perimeter is illustrated on **Figure 4**.

4.0 Assessment of Corrective Measures

TVA prepared the 2019 ACM Report for the CCR Unit 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 [from the CCR Unit], 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 achieve TVA's commitment to comply with regulatory requirements and timeframes under the CCR Rule, TVA will close the CCR Unit 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 the closure and operational changes. These data will also be considered in the selection and design of a remedy in accordance with 40 CFR § 257.97.

The CCR Unit cannot be closed until provisions are made to re-route water that is currently discharged to the CCR Unit. Once this water is re-routed, the CCR Unit can be completely removed from service and dewatering operations can commence. A process water basin is currently under construction with an 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 are currently considered feasible for remediating the groundwater at the CCR Unit.

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 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).

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 Peabody Ash Pond. To address data gaps, further characterization of arsenic impacts downgradient or cross-gradient of the CCR Unit are needed in addition investigations activities described below.

Recent activities completed to further evaluate site conditions:

- A potential replacement well for monitoring well PAF-119 has been installed and developed. The replacement well (PAF-119R) will be sampled for three events over an approximately four-month period to evaluate if screening the well at a shallower depth, (a screened depth that does not straddle a zone of weathered bedrock[1]), contributes to lower dissolved arsenic concentrations than those observed at existing monitoring well PAF-119. 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-119 and PAF-119R are illustrated in **Figure 5**.

- Four soil borings were installed on the southeast side of the Peabody Ash Pond as a screening-level investigation to refine the nature and extent of dissolved arsenic in areas east and southwest of wells PAF-119 and PAF-119R. The locations of the soil borings around PAF-119 and PAF-119R are provided on **Figure 5**.

- Slug testing will be performed at the newly installed monitoring well location (PAF-119R) 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-119, PAF-119R and the surrounding soil borings at the Peabody Ash Pond. 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.

[1] The weathered bedrock unit at PAF-119 consists of shale and coal that have the potential to have elevated naturally occurring levels of arsenic.

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.

- 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-119, PAF-119R, and the surrounding soil borings at the Peabody Ash Pond CCR Unit. 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 might 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-119 and PAF-119R at the Peabody Ash Pond CCR Unit. Removal of arsenic with multiple treatment technologies have 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). 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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July 15, 2020

References:

AECOM. (2016a). *Initial Static Safety Assessment, Existing Surface Impoundment - Peabody Ash Pond, EPA Final CCR Rule, TVA Paradise Fossil Plant, Drakesboro, Kentucky.* October 7, 2016.

AECOM. (2016b). *History of Construction for Coal Combustion Residuals, Existing Surface Impoundment – Peabody Ash Pond. Paradise Fossil Plant, Drakesboro, Kentucky*. October 12, 2016.

Attachments:

Figures

Figure 1 – CCR Unit with Background and Downgradient Wells

Figure 2 – Geologic Cross-Section

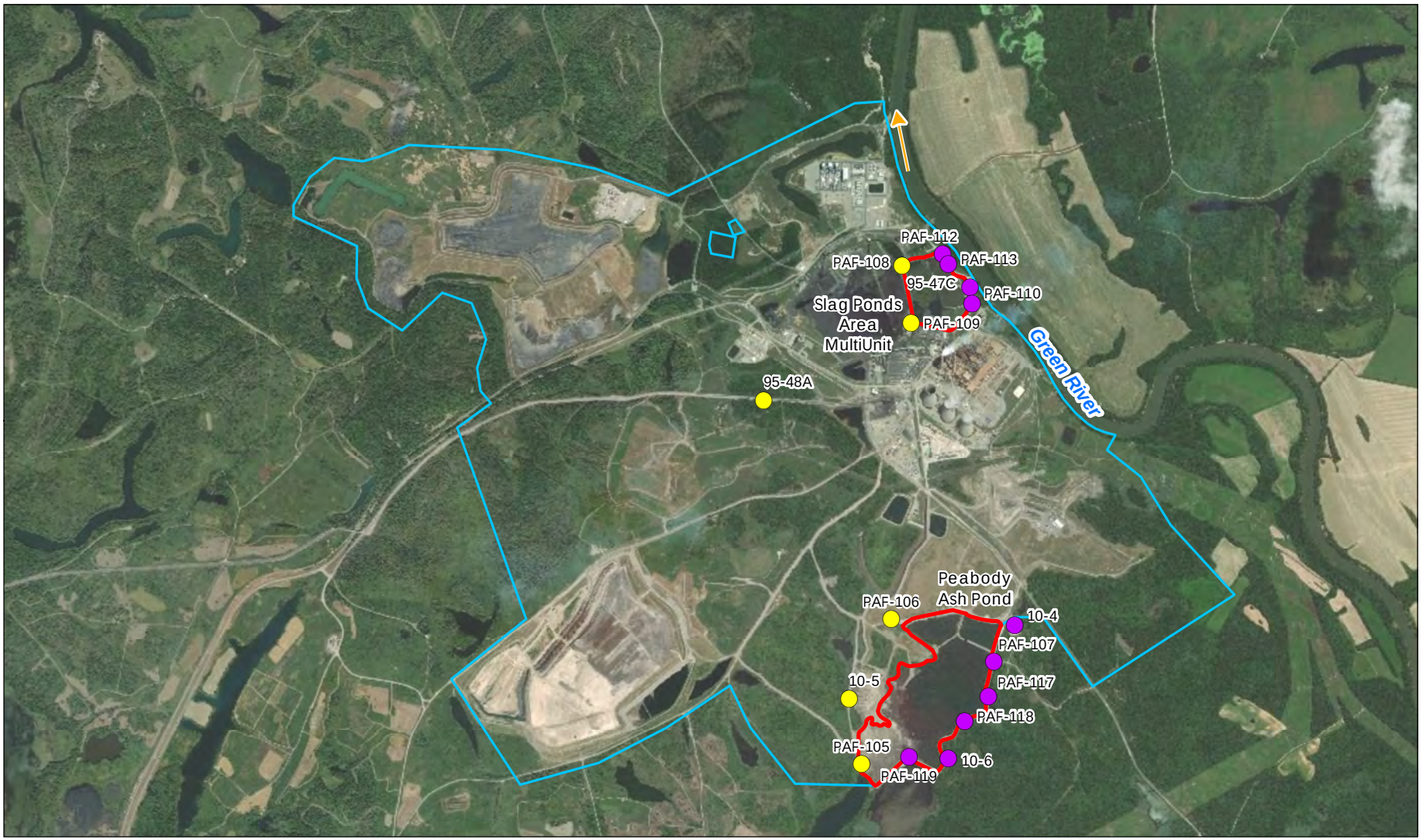
Figure 3 – Groundwater Flow Direction

Figure 4 – Monitoring Wells and Limits of COI Impacts

Figure 5 – Geoprobe Sampling Locations

FIGURE 1

CCR UNIT WITH BACKGROUND AND DOWNGRADIENT WELLS



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

N

0 1,500 3,000 Feet

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

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

Project Location
Drakesboro
Muhlenberg County, KY

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

Client/Project
Tennessee Valley Authority
Paradise Fossil Plant
CCR Rule

182603529

Figure No.
Figure 1

Title
CCR Units with Background and Downgradient Wells

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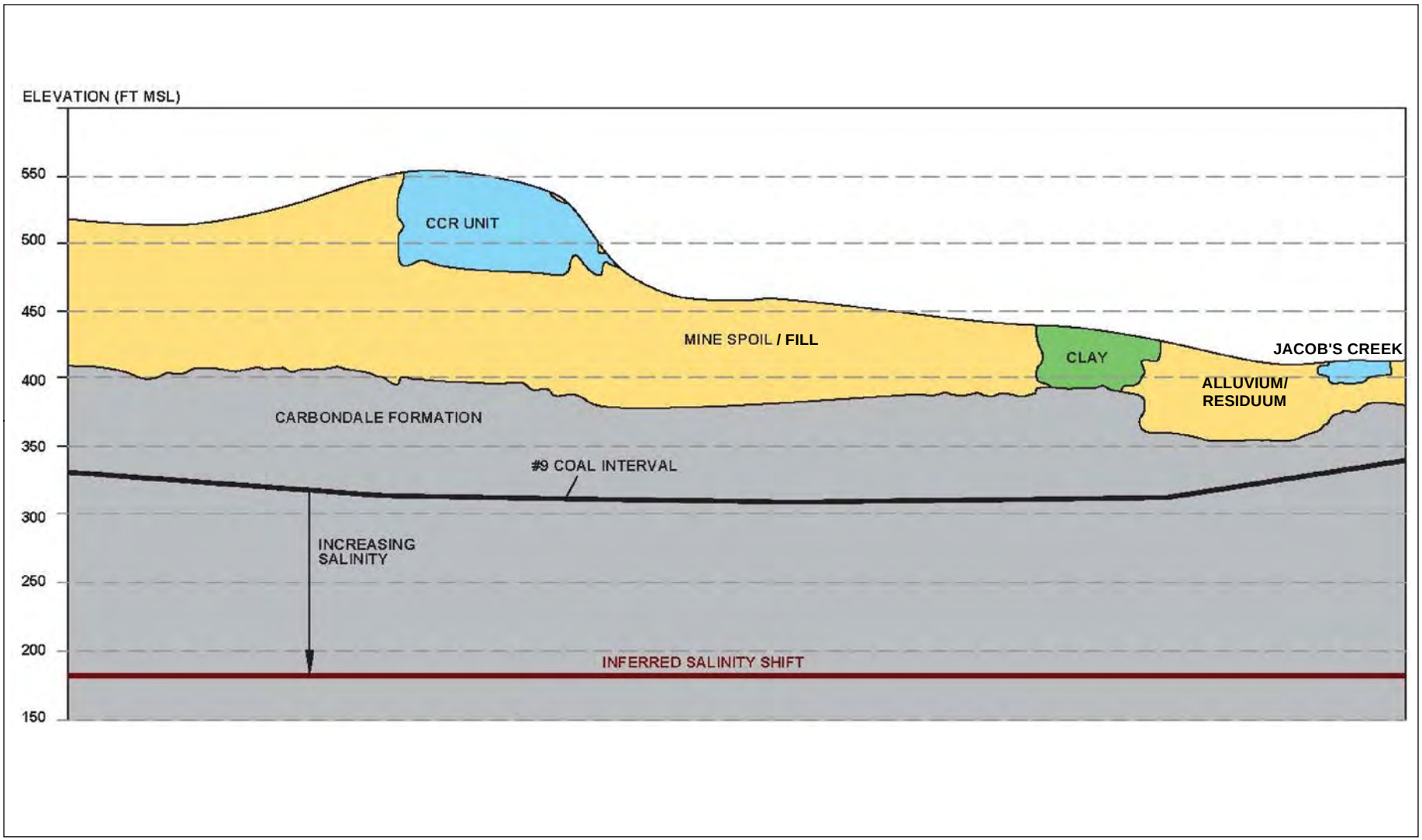
FIGURE 2
GEOLOGIC CROSS-SECTION



Project Location
Drakesboro
Muhlenberg County, KY

Prepared by LMB on 2020-07-06
Technical Review by EP on 2020-07-06
Independent Review by JB on 2020-07-06

Client/Project
Tennessee Valley Authority
Paradise Fossil Plant
CCR Rule

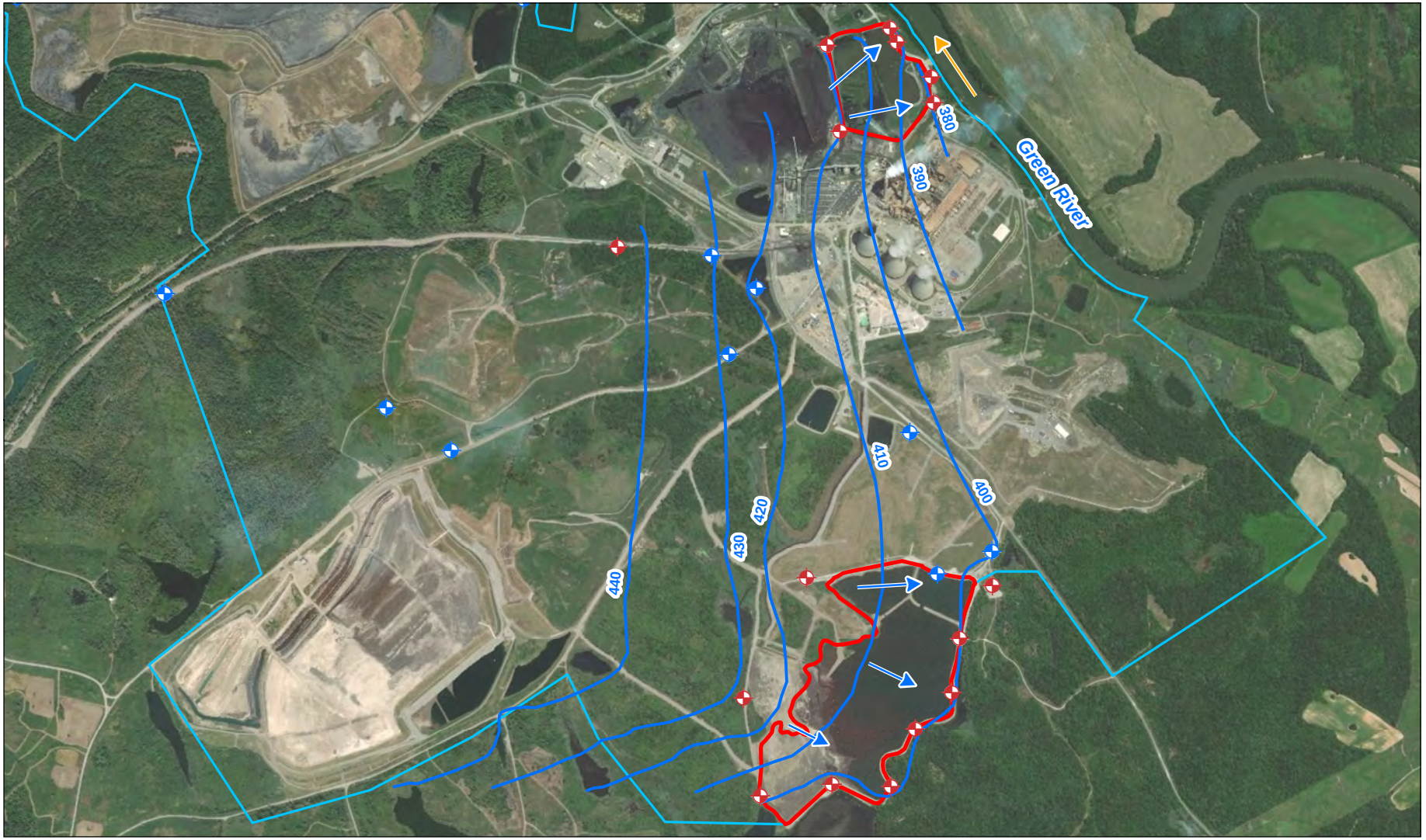
182603529

Figure No.
Figure 2

Title
Geologic Cross-Section

U:\182603529\gis\mxd\SemiannualPeabody_Ash_Pond\TVA_SAR_PAF_Figure2.mxd Revised: 2020-07-06 By: lblackman

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

N

0 1,000 2,000 Feet
(At original document size of 8.5x11)
1:24,000

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

TVA

Project Location
Drakesboro
Muhlenberg County, KY

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

Client/Project
Tennessee Valley Authority
Paradise Fossil Plant
CCR Rule

182603529

Figure No.
Figure 3

Title
Groundwater Flow Direction

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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 Zone (Arsenic)

N

0 1,000 Feet

(At original document size of 8.5x11)
1:12,000

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

Project Location
Drakesboro
Muhlenberg County, KY

Prepared by LMB on 2020-06-12
Technical Review by EP on 2020-06-12
Independent Review by JB on 2020-06-12

Client/Project
Tennessee Valley Authority
Paradise Fossil Plant
CCR Rule

182603529

Figure No.
Figure 4

Title
Monitoring Wells and Limits of COI Impacts

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FIGURE 5
GEOPROBE SAMPLING LOCATIONS

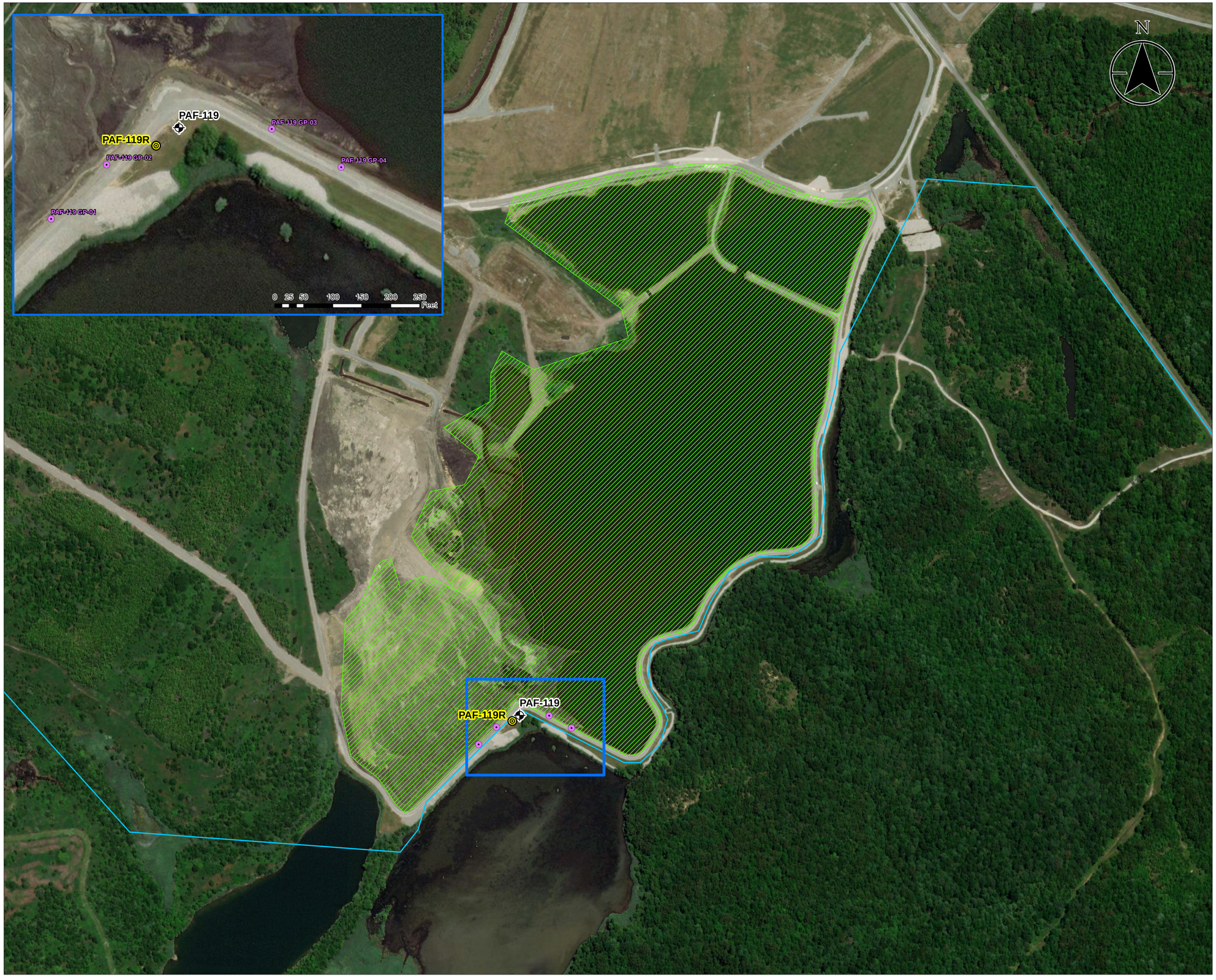

Figure
5

Title
Geoprobe Sampling Locations

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

Project Location
Muhlenberg County, Kentucky

182603529
Prepared by SW on 2020-06-12
Technical Review by BE on 2020-06-12
Independent Review by CS on 2020-06-12

0 150 300 450 600 Feet
1:3,000 (At original document size of 22x34)

Legend

- Replacement Well
- Soil Boring
- Existing Wells
- Paradise Fossil Plant Site Boundary
- Peabody Ash Pond CCR Unit

Notes
1. Coordinate System: NAD 1983 StatePlane Kentucky South FIPS 1602 Feet
2. Imagery Provided by ESRI World Imagery