Environmental Assessment Report

Johnsonville Fossil Plant

New Johnsonville, Tennessee

Tennessee Valley Authority

Title and Approval Page

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Prepared By:	Tennessee Valley Authority
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Revision Log

Revision	Date	Description
0	September 6, 2023	Submittal to TDEC
1	February 12, 2024	Addresses November 14, 2023 TDEC Review Comments and Issued for TDEC

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Executive Summary

On August 6, 2015, the Tennessee Department of Environment and Conservation (TDEC) issued Commissioner's Order No. OGC15-0177 (TDEC Order) to Tennessee Valley Authority (TVA) to establish a process for investigating, assessing, and remediating unacceptable risks from management of coal combustion residuals (CCR) at TVA coal-fired plants in the State of Tennessee. TVA began construction of the Johnsonville Fossil (JOF) Plant in 1949 and commenced power generation operations in 1951. The JOF Plant coal-fired units have been inactive since 2017. There are four CCR management units[1] at the JOF Plant included in the TDEC Order: Ash Disposal Area 1, DuPont Road Dredge Cell, South Rail Loop Area 4, and Active Ash Pond 2. The former Coal Yard is also included in the TDEC Order, therefore, when discussing overall site findings herein the former Coal Yard is included.

In accordance with the TDEC Order, TVA and Stantec Consulting Services Inc. (Stantec), on behalf of TVA, prepared an Environmental Investigation Plan (EIP) for the JOF Plant to obtain and provide information requested by TDEC. As specified in the TDEC Order, the objective of the EIP was to "identify the extent of soil, surface water, and groundwater contamination by CCR" from onsite management of CCR material in impoundments and landfills. In addition, per TDEC's information requests, the EIP included assessment of CCR management unit structural stability and integrity.

Between 2019 and 2021, TVA and Stantec conducted the TDEC Order environmental investigations (EI) for the JOF Plant CCR management units. The EI included characterization of the site hydrogeology and investigations of CCR material, groundwater, background soils, seeps, surface streams, sediments, and ecology, as well as a Water Use Survey, which is ongoing. EI activities were implemented in accordance with the approved Sampling and Analysis Plans and Quality Assurance Project Plans, including TVA- and TDEC-approved programmatic and project-specific changes made following approval of the EIP. Based on a comprehensive quality assurance review, the EI data are usable and meet the objectives of the TDEC Order.

The EI data were evaluated along with information collected as part of previous investigations and other ongoing regulatory monitoring programs conducted between the 1970s and 2023 The objectives of the TDEC Order are similar to these other programs, including TDEC landfill permit requirements (Chapter 0400-11-01) and the United States Environmental Protection Agency CCR Rule (Title 40, Code of Federal Regulations Part 257, Subpart D) that cover certain CCR management units. Collectively, these data provide a broad-based characterization of the CCR management units to meet the objectives of the EIP. Geotechnical data were used for CCR management unit stability and integrity evaluations. Environmental sample data were used to characterize the extent of potential impacts and were compared to constituent-specific TDEC-approved levels to identify CCR constituents that require further evaluation in the next phase of the TDEC Order, the Corrective Action/Risk Assessment (CARA) Plan.

This Environmental Assessment Report (EAR) describes the extent of surface stream water, sediment, and groundwater contamination from the JOF Plant CCR management units, and provides the information, data, and evaluations used to make those assessments. As described herein, more than 97% of the environmental sample results from over 1,800 samples were below the approved levels. The EI data indicate impacts to limited onsite groundwater areas, and that the CCR management units have had minimal, if any, potential impacts to sediment and surface stream water quality, and ecological communities in the Tennessee River. The EI data will be used to evaluate the basis and methods for CCR management unit closure in the CARA Plan, including an evaluation of the performance of existing closure methods; modifications to closure methodology will be identified, as needed, in the CARA Plan.

[1] The term "CCR management unit" is used in this document generally and is not intended to be a designation under federal or state regulations.

The following are the overall assessment findings based on data as presented in this EAR:

- Surface stream water quality is within ranges protective of human health and aquatic life in the Tennessee River
- Sediment quality is within ranges protective of aquatic life in the Tennessee River adjacent to and downstream of the CCR management units. Additional evaluation of potential risks associated with sediments in the Boat Harbor and Intake Channel is warranted in the CARA Plan to determine if corrective actions are needed
- The EI data indicate that ecological communities are healthy in the Tennessee River adjacent to and downstream of the CCR management units
- The CCR management units have adequate structural stability, and slopes are stable under current static and seismic loading conditions
- For the seep investigation, three areas of interest (AOIs) were identified during the EI. One AOI has been mitigated under a TDEC approved plan. The remaining two AOIs are currently being monitored and will be further evaluated in the CARA Plan.
- Most TDEC Appendix I and CCR Rule Appendix IV CCR constituent concentrations in onsite groundwater are below TDEC-approved groundwater screening levels (GSLs), and groundwater impacts are limited to onsite areas along the perimeter of the CCR management units. However, additional assessments will be included in the CARA Plan to evaluate the need for corrective action for targeted onsite groundwater remediation at locations where statistically significant concentrations of CCR constituents above GSLs exist.
- Drainage improvements or potential corrective actions are expected to reduce concentrations of CCR constituents to below GSLs in groundwater at downgradient monitoring locations for Active Ash Pond 2, Ash Disposal Area 1, and the Former Coal Yard
- The groundwater flow direction within the uppermost aquifer beneath the CCR management units and former Coal Yard is generally to the west-southwest toward the Tennessee River. Groundwater flow in the vicinity of the CCR management units is bounded to the west by the Tennessee River. A higher elevation ridge to the east of the plant and a watershed boundary along the southern border are topographic divides for groundwater flow.

Exhibit ES-1 shows overall findings of the investigation and the locations where the environmental assessments concluded that no further evaluation is needed. It also shows where further evaluation is needed in the CARA Plan for sediment results, AOIs, and onsite groundwater. Onsite groundwater impacts may require further evaluation regardless of the CCR management unit closure method, and groundwater remediation can be accomplished along with closure in place or closure by removal. TVA continues to evaluate ways to beneficially use CCR material in a manner consistent with regulatory requirements while maximizing value to the Tennessee Valley.

The next step is to complete the Water Use Survey; these results will be included in the JOF Plant EAR Revision 1. Upon TDEC approval of the EAR, and in accordance with the TDEC Order, TVA will further evaluate these findings and prepare a CARA Plan for submittal to TDEC. The CARA Plan, which will be subject to a public review and comment process, will evaluate whether unacceptable risks related to management of CCR material exist at the JOF Plant. The CARA Plan will also specify the actions TVA plans to take at the TDEC Order CCR management units and the basis of those actions. It will also incorporate other operational changes planned or in progress by TVA, including details for CCR beneficial use operations, modification of the TDEC Order CCR management units as needed to meet regulatory standards, and long-term closure and monitoring.

Exhibit No.

ES-1

Title

Summary of Environmental Assessment Report Findings Johnsonville Fossil Plant

Client/Project

Tennessee Valley Authority
Johnsonville Fossil (JOF) Plant TDEC Order

Project Location | 175568286

New Johnsonville, Tennessee | Prepared by KB on 2023-08-18

CCR Management Unit | Former Stilling Pond | Former Coal Yard

Key Findings

The ecological communities are healthy in the Kentucky Lake/Tennessee River adjacent to and downstream of the CCR management units based on the results of the environmental assessment and other monitoring efforts.

Nearly all of the environmental sample results were below the approved levels.

The health of the aquatic life is a key indicator of the health of the Kentucky Lake/Tennessee River. This means that TVA is managing its CCR units in a way that's protective of the environment.

Investigation and Monitoring Findings

These symbols summarize the findings of the investigation and monitoring:

- No action is needed.
- Further evaluation is required in this area.
- Corrective action is being evaluated for onsite groundwater along the perimeter of the unit in this area.

Next Steps

With TDEC acceptance of the environmental assessment, TVA will further evaluate certain areas for potential corrective action and will conduct a water use survey to better understand groundwater conditions around the Johnsonville Fossil Plant.

TVA will use the findings from the environmental assessment to prepare and submit a corrective action plan to TDEC. This plan, which will be released for public review and comment, will specify measures TVA plans to take to address unacceptable risks.

TVA's efforts will continue until regulators are satisfied, and monitoring of groundwater will continue for many years.

Stantec TVA

Acronyms and Abbreviations

AOI	Area of Interest
ATL	Alternate Thermal Limit
bgs	Below Ground Surface
BIP	Balanced Indigenous Population
BTV	Background Threshold Value
CARA	Corrective Action/Risk Assessment
CBR	Critical Body Residue
CCR	Coal Combustion Residuals
CCR Parameters	CCR Constituents listed in 40 CFR 257, Appendices III and IV, and the five inorganic constituents listed in Appendix I of Tennessee Rule 0400-11-01-.04
CCR Rule	USEPA Final Rule on Disposal of Coal Combustion Residuals from Electric Utilities
CFR	Code of Federal Regulations
CSM	Conceptual Site Model
CWA	Clean Water Act
°F	Degrees Fahrenheit
DMP	Data Management Plan
DSWM	TDEC Division of Solid Waste Management
EAR	Environmental Assessment Report
EDA	Exploratory Data Analysis
EI	Environmental Investigation
EIP	Environmental Investigation Plan
EnvStds	Environmental Standards, Inc.
ESV	Ecological Screening Value
EWC	Ewers Water Consultants, Inc.
EXD	Exploratory Drilling
feet amsl	Feet Above Mean Sea Level
GEL	GEL Laboratories, LLC
GSL	Groundwater Screening Level
GWPS	Groundwater Protection Standard(s)
HBI	Hilsenhoff Biotic Index
LOAEL	Lowest Observed Adverse Effect Level
JOF Plant	Johnsonville Fossil Plant
MQA	Material Quantity Assessment
NOAA	National Oceanic & Atmospheric Administration
NOAEL	No Observed Adverse Effect Level
NPDES	National Pollutant Discharge Elimination System
PACE	Pace Analytical® Services, LLC
%	Percent
PLM	Polarized Light Microscopy
QA	Quality Assurance

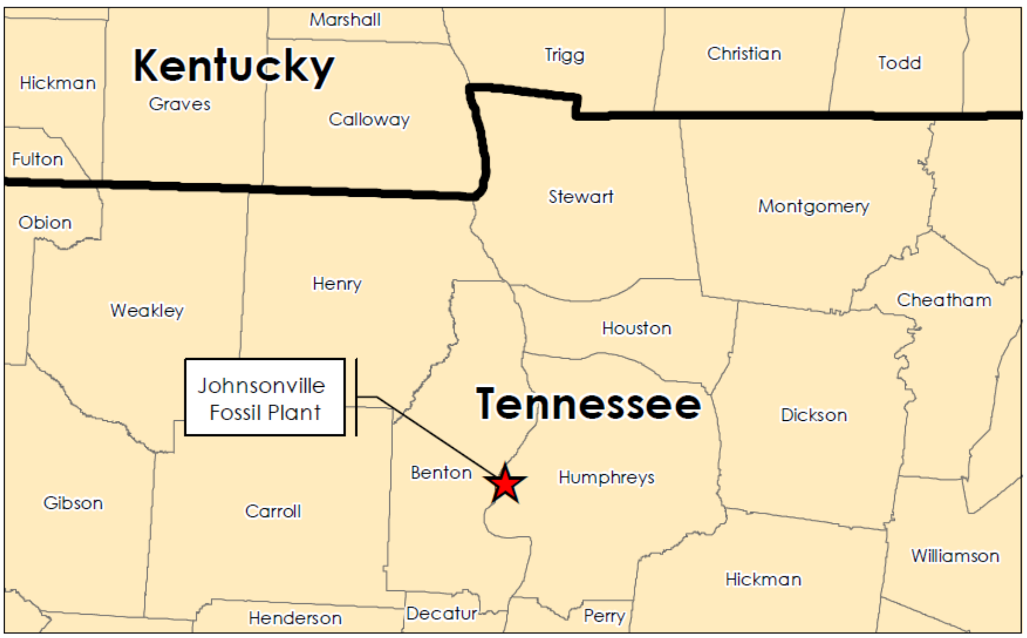
Acronyms and Abbreviations

QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
QC	Quality Control
RBI	Reservoir Benthic Index
RCRA	Resource Conservation and Recovery Act
RFAI	Reservoir Fish Assemblage Index
RJ Lee	RJ Lee Group
SAP	Sampling and Analysis Plan
SAR	Sampling and Analysis Report
SPLP	Synthetic Precipitation Leaching Procedure
SSLs	Statistically Significant Levels
Stantec	Stantec Consulting Services Inc.
TDEC	Tennessee Department of Environment and Conservation
TDEC Order	Commissioner’s Order OGC15-0177
TestAmerica	Eurofins Environment Testing America
TN	Tennessee
TOC	Total Organic Carbon
TRM	Tennessee River Mile
TVA	Tennessee Valley Authority
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UTLs	Upper Tolerance Limits

Chapter 1 Introduction

The Tennessee Valley Authority (TVA) and Stantec Consulting Services Inc. (Stantec), on behalf of TVA, prepared this Environmental Assessment Report (EAR) to provide an evaluation of the environmental conditions at the Johnsonville Fossil Plant (JOF Plant) in New Johnsonville, Tennessee, that may have been related to management of coal combustion residuals (CCR) in onsite impoundments and landfills. The JOF Plant is a decommissioned TVA coal-fired power plant in Humphrey's County, located on the eastern side of Kentucky Lake (Tennessee River) in the north-central portion of Tennessee (see below and Exhibit 1-1).

JOF Plant Location



1.1 Background, Scope, and Objectives

On August 6, 2015, the Tennessee Department of Environment and Conservation (TDEC) issued Commissioner's Order No. OGC15-0177 (TDEC Order) to TVA (TDEC 2015, in Appendix A.1). The four CCR management units[2] at the JOF Plant included in the TDEC Order are: Ash Disposal Area 1, DuPont Road Dredge Cell, South Rail Loop Area 4, and Active Ash Pond 2 (see below). The former Coal Yard is also included in the TDEC Order, therefore, when discussing overall site findings herein the former Coal Yard is generally included.

[2] The term "CCR management unit" is used in this document generally and is not intended to be a designation under federal or state regulations.

JOF CCR Management Units

In accordance with the TDEC Order, TVA prepared an Environmental Investigation Plan (EIP) for the JOF Plant (TVA 2018) to obtain and provide information requested by TDEC. Following public review and comment on the draft, the EIP was approved by TDEC on December 10, 2018, and TVA implemented the activities between 2019 and 2021 in accordance with the approved EIP. As specified in the TDEC Order, the objective of the EIP was to "identify the extent of soil, surface water, and ground water contamination by CCR" from onsite management of CCR material in impoundments and landfills. In addition, per TDEC's information requests, the EIP included assessment of CCR management unit structural stability and integrity.

The EIP included characterization of the site hydrogeology and investigations of CCR material, groundwater, background soils, seeps, surface streams, sediments, and ecology at and near the JOF Plant CCR management units to supplement historical data. This EAR presents the results of those investigations and an evaluation of recent and historical data to provide conceptual site models (CSMs) for the CCR management units and overall findings for environmental media at the JOF Plant. CSMs describe sources of CCR constituents, pathways by which they can move, and environment media potentially impacted if they are released. As required by the TDEC Order, this EAR will be revised to address TDEC comments until TDEC determines that the extent of CCR contamination has been defined.

1.2 Regulatory Framework

The onsite management of CCR material at the JOF Plant is subject to the following regulatory programs relevant to this investigation. Data from these programs were considered in the development of the EAR.

1.2.1 CCR Rule

The USEPA CCR Rule sets forth national criteria for the management of CCR, was published on April 17, 2015, and can be found in Title 40, Code of Federal Regulations (40 CFR) Part 257, Subpart D (CCR Rule). The rule includes criteria for monitoring groundwater and assessing corrective measures if constituents listed in Appendix IV of the CCR Rule are detected in samples collected from downgradient groundwater monitoring wells at statistically significant levels (SSLs) greater than established groundwater protection standards (GWPS). Groundwater monitoring results and assessment of corrective measures are reported as required by the CCR Rule. TVA's CCR Rule Compliance Data and Information website is available for the public to view CCR Rule-required documents, including groundwater monitoring reports for the JOF Plant CCR management units, at the following location: Johnsonville Fossil Plant (tva.com).

Additional CCR Rule criteria include closure and post-closure plans, design (including structural stability), location demonstrations, and operating criteria demonstrations which are certified by a qualified professional engineer.

The one CCR management unit at the JOF Plant that is included in the TDEC Order and is also subject to the CCR Rule is Active Ash Pond 2.

1.2.2 State Programs

In addition to the TDEC Order and CCR Rule, TDEC has issued permits to TVA for ongoing CCR management and wastewater discharges from the JOF Plant CCR management units. Current permits include:

- TDEC Rule 0400-11-01-.04 Division of Solid Waste Management (DSWM) - Class II Landfill Permit No. IDL 43-102-0082 for the DuPont Road Dredge Cell
- National Pollutant Discharge Elimination System (NPDES) Permit No. TN0082023. Permitted wastewater and stormwater discharges are to the Kentucky Lake (Tennessee River) at mile 99 via Outfall 001.

The DSWM regulatory requirements govern CCR management and monitoring of groundwater for the TDEC permitted landfill (consisting of the DuPont Road Dredge Cell). Records are maintained for groundwater monitoring well sample results and groundwater elevations throughout the life of the unit, including the post-closure care period. Groundwater monitoring results are reported to TDEC at the intervals specified in the permit.

Under the NPDES permit, outfall monitoring results are recorded and submitted monthly to TDEC's Division of Water Resources. Raw water intake samples are collected annually and submitted in the Discharge Monitoring Report following the sampling event. Whole effluent toxicity testing is conducted annually. An alternative thermal limit was approved for the permit as a result of biological monitoring data showing that a thermal variance is justified in the near-field area of the plant's final discharge to the Kentucky Lake (Tennessee River) via Outfall 001.

1.3 Environmental Investigation Overview

The following provides an overview of the environmental investigation (EI) activities conducted in accordance with the EIP that are reported in this EAR. The evaluation of existing data from previous studies conducted at the JOF Plant served as the foundation to support the TDEC Order EI.

1.3.1 TDEC Order

The TDEC Order was issued to establish a process for investigating, assessing, and remediating unacceptable risks from management of CCR material at TVA coal-fired plants in the State of Tennessee. The TDEC Order also established a process whereby TDEC would oversee TVA's implementation of the United States Environmental Protection Agency (USEPA) CCR Rule for coordination and compliance with Tennessee's solid waste management program. Information about the USEPA CCR Rule is provided in Section 1.2.2.

Upon TDEC approval of the EAR, TVA will prepare and submit a Corrective Action/Risk Assessment (CARA) Plan to TDEC. The CARA Plan, which will be subject to a public review and comment process, will specify the actions TVA plans to take to mitigate unacceptable risks at the JOF Plant CCR management units, including the basis of those actions. The information provided in this EAR will support TVA's preparation of the CARA Plan and TDEC's decision-making process regarding the actions to be taken at the JOF Plant CCR management units pursuant to the TDEC Order.

1.3.2 Investigation Activities

In December 2018, Revision 4 of the EIP was approved by TDEC (Appendix A.2), which details the proposed EI to be conducted by TVA to provide additional information requested by TDEC. The EIP is comprised of desktop studies, Sampling and Analysis Plans (SAPs), a Quality Assurance Project Plan (QAPP), a Data Management Plan (DMP), a proposed schedule of investigative activities, and responses to TDEC information requests and public comments.

Environmental media samples collected as part of the EI, or other ongoing environmental programs being conducted at the plant, were analyzed for CCR parameters listed in the CCR Rule, Appendices III and IV. Five additional inorganic parameters listed in Appendix I of Tennessee (TN) Rule 0400-11-01-.04 that are not included in the CCR Rule Appendices III and IV were analyzed to maintain continuity with TDEC environmental programs.

CCR Parameters
CCR Rule Appendix III Parameters
Boron
Calcium
Chloride
Fluoride[1] (also Appendix IV)
pH
Sulfate
Total Dissolved Solids
CCR Rule Appendix IV Parameters
Antimony
Arsenic
Barium
Beryllium
Cadmium
Chromium
Cobalt
Lead
Lithium
Mercury
Molybdenum
Radium-226+228
Selenium
Thallium
Additional TDEC Appendix I Parameters
Copper
Nickel
Silver
Vanadium
Zinc

Notes: [1]Fluoride is both a CCR Rule Appendix III and CCR Rule Appendix IV CCR parameter. In this table, and in the results figures and tables for this report, fluoride has been grouped with the Appendix III CCR parameters only to avoid duplication. Only TDEC Appendix I and CCR Rule Appendix IV constituents are subject to potential corrective measures

The combined CCR Rule Appendices III and IV parameters and TDEC Appendix I inorganic parameters are referenced collectively herein as “CCR Parameters.” As specified in the SAPs, additional parameter analyses were also performed based on the specific needs of the investigation. Where applicable, additional analyses are described in Chapters 3 through 7 below.

As documented in this EAR, the EI was implemented in accordance with the SAPs, which were updated with TVA- and TDEC-approved programmatic and project-specific changes made after approval of the EIP. EI results are summarized in the executive summary and section by section in this report, with details of each investigation provided in technical evaluation summaries and associated sampling and analysis reports (SARs) included as appendices. The purpose of the SARs was to document the work completed during the investigations and present the information and data collected to meet the objectives of the SAPs. The SARs were prepared and submitted to TDEC for review following completion of the SAP scopes of work. If TDEC provided comments after their initial reviews of the SARs, the comments were addressed, and the SARs were updated and re-submitted to TDEC for final acceptance. After each of the SARs was accepted by

TDEC, those EI results, along with historical data collected under other State and/or CCR programs, were evaluated and are presented in this EAR.

The investigations and subsequent assessments completed pursuant to the EIP SAPs at the JOF Plant CCR management units are listed below:

- Background Soil Investigation
- Exploratory Drilling
- CCR Material Characteristics Investigation
- Material Quantity Assessment
- Hydrogeological Investigation
- Groundwater Investigation
- Dye Trace Study
- Seep Investigation
- Surface Stream Investigation
- Sediment and Benthic Investigation
- Fish Tissue Investigation.

1.3.2.1 Screening Levels

Sampling results obtained during these investigations are evaluated in this EAR by comparing concentrations of CCR Parameters to TDEC-approved screening levels (Tables 1-1 through1-5 and Appendix A.2). The purpose of this comparison is to identify CCR Parameters in environmental media that require further assessment in the CARA Plan. The screening levels are generic (not specific to an individual person or ecological receptor) and are protective of human and ecological health. Most screening levels are not regulatory standards and are conservatively based on published health studies. Concentrations above the screening level do not necessarily mean that an adverse health effect is occurring, but rather, that further evaluation is required in the CARA Plan to determine if an unacceptable risk exists, and if corrective action is required.

Groundwater screening levels (GSLs) and surface water screening levels are based on published human health risk-based values considering these media as potential potable water sources (Tables 1-1 and 1-2). Surface water, sediment, and mayfly and fish tissue screening levels are based on published ecological risk-based values drawn from regulatory guidance and published studies (Tables 1-2 through 1-5). In cases where there is more than one applicable screening level for an environmental medium (e.g., surface water), the lowest value, or both values, are compared to the analytical results.

The statistical evaluation conducted for groundwater analytical results in this EAR was for investigatory purposes to characterize the extent of CCR impacts as required by the TDEC Order (Appendix E.3). It was not conducted for compliance with the CCR Rule or TDEC permitted landfill monitoring programs. Reports for compliance with the CCR Rule can be found on TVA's CCR Rule Compliance Data and Information website. Groundwater monitoring reports for the TDEC permitted landfill monitoring program are submitted to TDEC within 60 days of sampling events.

1.3.2.2 Hydrogeological Terms

For purposes of this EAR, the following hydrogeological terms as they are defined below are used throughout this document.

- Pore water - subsurface water that occurs in pore spaces in CCR material
- Groundwater - subsurface water that occurs in pore spaces in unconsolidated or geologic materials (e.g., soil, bedrock)
- Aquifer - a geologic formation capable of yielding usable quantities of groundwater
- Unconfined aquifer – an aquifer in which the water table forms the upper boundary
- Confined aquifer - an aquifer present between two aquitard when the water level in a well is observed to be above the top of the aquifer due to the confining pressure (see graphic below)
- Aquitard – a geologic formation comprised of less permeable geologic materials that transmit groundwater more slowly than the aquifer
- Saturated – Unconsolidated or geologic materials (e.g., soil, bedrock) or CCR material where all of the pore space is filled with water. The use of the term "saturated" in reference to CCR material does not imply that the pore water is readily separable from the CCR material.
- Moisture content - the measure of the amount of water contained within unconsolidated or geologic materials (e.g., soil, bedrock) or CCR material. Moisture content of saturated material can be variable because the characteristics of the material determine the amount of pore space available for water to fill.
- Phreatic surface - the surface of pore water at which pressure is atmospheric and below which CCR material may be saturated with pore water. Pore water levels are measured at locations where temporary wells or piezometers were installed within CCR material. The measured pore water levels are used to infer pore water levels between the wells and piezometers to develop the phreatic surface.
- Uppermost aquifer – the geologic formation nearest the natural ground surface that is an aquifer, as well as lower aquifers that are hydraulically interconnected with this aquifer within the facility's property boundary
- Water table – the surface of groundwater at which pressure is atmospheric and below the geologic materials (e.g., soil or bedrock) may be saturated with groundwater. The measured groundwater levels are used to infer groundwater levels between the wells and piezometers to develop the water table surface. Groundwater levels are measured at locations where wells or piezometers were installed at depths near the depth of the water table surface.
- Piezometric surface - the surface of groundwater defined by the level to which groundwater will rise in a well completed in a confined aquifer.

Groundwater level measurements in a confined aquifer represent the water pressure not the actual level of groundwater. Groundwater in a confined aquifer is not in contact with the CCR material inside the CCR management unit because the groundwater is physically separated by the overlying confining layer. Groundwater pressure measurements are used to estimate directions of groundwater movement.

Pore Water

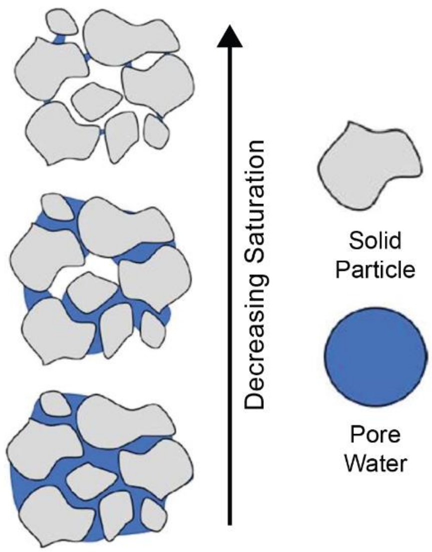
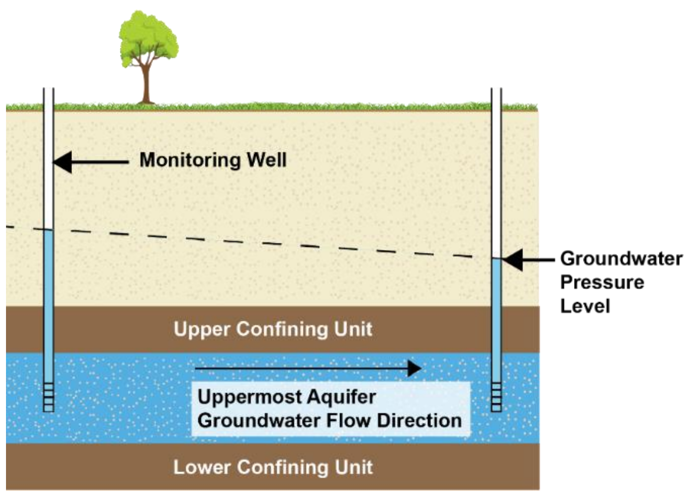


Figure Reference: Benson, C., *Water Flow in Coal Combustion Products and Drainage of Free Water*, Report No. 3002021963, Electric Power Research Institute, Palo Alto, CA.

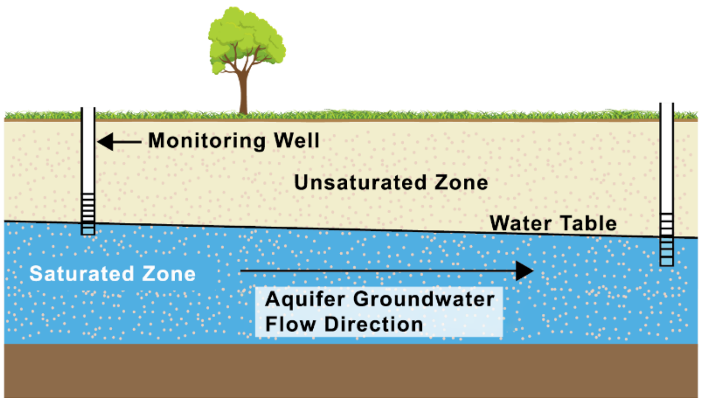
This figure depicts how subsurface water occurs in the pore spaces in CCR material (referred to as "pore water" in this EAR), and how saturation varies within the CCR material. The phreatic surface is the surface of pore water at which pressure is atmospheric and below which CCR material is saturated with pore water.

Confined Aquifer



Groundwater is subsurface water that occurs in pore spaces in soil or bedrock. Groundwater level measurements taken in a well screened in a confined aquifer represent the water pressure in the confined aquifer not the actual level of groundwater. Groundwater in a confined aquifer is not in contact with the CCR material inside the CCR management unit because the groundwater is physically separated by the overlying confining layer. Groundwater pressure measurements are used to estimate directions of groundwater movement. Groundwater generally flows much more slowly than water in a surface stream or river.

Unconfined Aquifer



Groundwater is subsurface water that occurs in pore spaces in soil or bedrock. Groundwater level measurements taken in a well screened near the water table in an unconfined aquifer represent the water level in the aquifer. Groundwater level measurements are used to estimate directions of groundwater movement. Groundwater generally flows much more slowly than water in a surface stream or river.

1.3.3 Data Management and Quality Assessment

For the EI, laboratory analytical testing was conducted by the following laboratories:

- GEL Laboratories, LLC (GEL) in Charleston, South Carolina
- Eurofins Environment Testing America Inc. (formerly known as TestAmerica and referenced herein as TestAmerica), in Nashville, Tennessee; Pittsburgh, Pennsylvania; and St. Louis, Missouri
- RJ Lee Group (RJ Lee) in Monroeville, Pennsylvania
- Pace Analytical Services, LLC (Pace) in Green Bay, Wisconsin.

In addition, quantitative analysis of benthic invertebrate community samples was performed by Pennington and Associates, Inc. in Cookeville, Tennessee (Appendix J.3). Geotechnical laboratory testing and data review was performed by Stantec in Lexington and Louisville, Kentucky. Dye Trace Study laboratory testing was performed by Ewers Water Consultants, Inc. (EWC), Richmond, Kentucky,

Data management was performed by Environmental Standards, Inc. (EnvStds). Field data and laboratory analytical data collected under the EI were managed in a database in accordance with the DMP for the TDEC Order (EnvStds 2018a). The DMP was developed for data collected under the TDEC Order. Consolidated management of data related to the TDEC Order allowed for environmental data associated with the investigation to be appropriately maintained and accessible to data end users. The DMP provided a basis for supporting technical data management with an emphasis on completeness, data usability, and defensibility of the data.

To support the EI, a Quality Assurance (QA) program was implemented to verify that environmental data used for decision-making were reliable. The overall QA objective for field activities, laboratory analyses, and data assessment was to produce data of sufficient and known quality to support program-specific objectives and produce high-quality, legally-defensible data. This objective was met by following the QAPP (EnvStds 2018b), included as Appendix C of the EIP.

The QAPP was followed for investigation data quality assessment, where data quality refers to the level of reliability associated with a dataset or data point. The QAPP describes QA procedures and Quality Control (QC) measures applied to EI activities, describes the generation and use of environmental data associated with the investigation, is applicable to sampling and monitoring programs associated with EI activities, and provides quantitative objectives for analytical data generated under the investigation activities.

Data collected during the EI were evaluated for usability by conducting a QA review, per the QAPP. As part of TVA's commitment to generate representative and reliable data, oversight of field activities, field documentation review, centralized data management, and data validation or verification of laboratory analytical was performed by EnvStds. In addition, TDEC and TDEC's contractor, Civil & Environmental Consultants, Inc., were periodically onsite to observe field activities and collect confirmation samples during the investigations. Based on the QA review performed by EnvStds, the EI data collected are considered usable for reporting and evaluation in this EAR and meet the objectives of the TDEC Order. Further documentation of the QA program implemented during the EI is provided in the *Data Quality Summary Report for the Tennessee Valley Authority Johnsonville Fossil Plant Environmental Investigation* prepared by EnvStds following completion of the EI (EnvStds 2023).

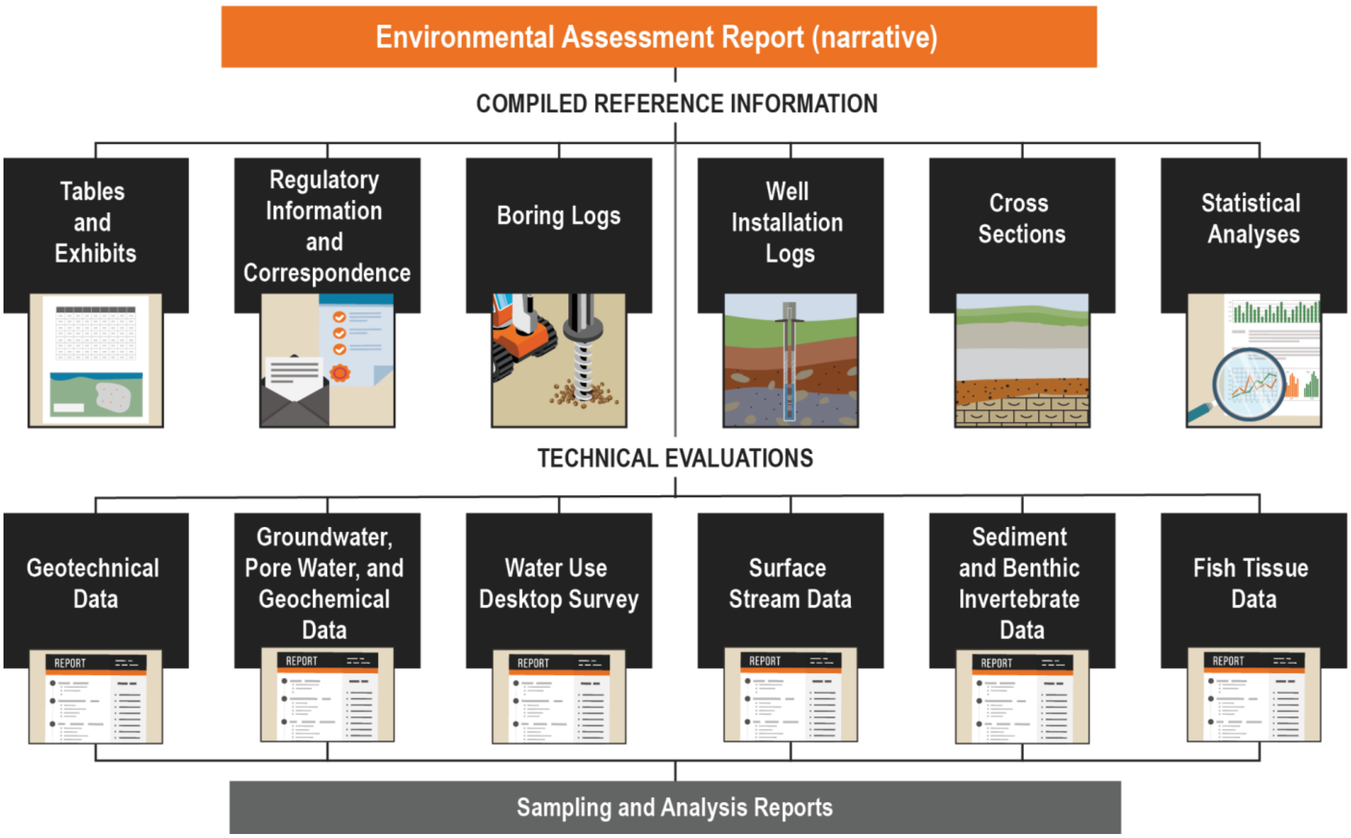
1.4 Key Milestones

A chronology of key milestones and events related to the TDEC Order and implementation of the EIP that occurred following approval of the EIP is provided below. This JOF Plant EAR Revision 0 has been prepared to provide information to TDEC prior to TVA finishing the Water Use Survey. This approach was approved by TDEC to allow initiation of the Water Use Survey.

Date	Event
December 12, 2018	TDEC approval of JOF Plant EIP Revision 4
March 14, 2019	Kickoff meeting held with TVA and TDEC to discuss implementation of EIP
April 8, 2019	Phase 1 EI field activities commence
February 5, 2021	Phase 1 EI field activities substantially complete (excluding Phase 2 Sampling and Water Use Survey)
August 24, 2020	Initial SAR submitted to TDEC
August 17, 2021	Phase 2 field activities commenced
Pending	Last SAR accepted by TDEC
September 6, 2023	Submittal of JOF Plant EAR Revision 0 to TDEC
Pending	Initiation of Water Use Survey (following TDEC approval of approach)

1.5 Report Organization

This EAR is based on EI data and results from other ongoing environmental programs obtained for the JOF Plant CCR management units through 2022. To facilitate discussion of the interrelationships of the data collected during the EI, the EAR presents evaluation of findings organized in the following principal investigation components: background soils, CCR materials, hydrogeology, seeps, and ecology. Chapters 3 through 8 herein provide a summary of each investigation's scope and presents the evaluation of those data, along with relevant historical or other environmental program data. The summary of findings presented in Chapters 3 through 8 are supported by detailed technical information and analyses presented in appendices as diagrammed below. Details of technical evaluations and information supporting those evaluations are included in appendices organized by subject matter. Field investigation activities sampling results are provided in SARs associated with each subject matter. The structure of the overall document is provided in the diagram below.



This EAR is organized as follows:

- **Executive Summary**: Describes the principal elements and findings of the environmental investigations presented in the EAR
- **Chapter 1 – Introduction:** Describes the background and purpose of the investigation, regulatory framework, an overview of the EI, public and agency involvement, and EAR organization
- **Chapter 2 – Site History and Physical Characteristics:** Presents the operational history, land use, and physical characteristics of the JOF Plant
- **Chapter 3 – Background Soil Investigation:** Summarizes the results of background soil investigation conducted for the JOF Plant
- **Chapter 4 – CCR Material Investigations:** Summarizes the CCR management unit geotechnical investigation results, including exploratory drilling, slope stability, structural integrity, and structural stability (bedrock) evaluations, findings from evaluations of pore water and CCR material characteristics investigation results, and provides information regarding CCR material characteristics and quantities
- **Chapter 5 – Hydrogeological Investigations:** Describes hydrogeologic conditions based on data from historical groundwater sampling and EI activities, and findings from geochemical evaluations of groundwater, pore water, and dye trace study results. Additionally, the desktop findings of the water use survey are presented
- **Chapter 6 – Seep Investigation:** Summarizes the results of the seep investigation
- **Chapter 7 – Surface Streams, Sediment, and Ecological Investigations:** Describes the historical activities and EI results and evaluation of the surface water, sediment, benthic macroinvertebrate community, and mayfly and fish tissue data
- **Chapter 8 – TDEC Order Investigation Summary and Conceptual Site Models:** Presents the JOF Plant CSMs describing the nature and extent of CCR material contained in the CCR management units, and a summary of the associated impacts (if any) to groundwater, soil, seeps, surface stream water, and ecology
- **Chapter 9 – Conclusions and Next Steps:** Presents a summary of, and conclusions based on, the EI conducted at the JOF Plant CCR management units and next steps for activities related to the TDEC Order
- **Chapter 10 – References:** List of documents referenced in the EAR
- **Tables and Exhibits:** Presented following the main text of this report, and are numbered according to the chapter that they are first presented in
- **Appendices:** Includes regulatory information, technical data (i.e., boring logs, well installation logs, cross sections), data and statistical analyses, technical evaluations, and SARs for each investigation. Technical evaluations and supporting information have been grouped into the investigation components described in the main report (e.g., background soils, CCR material, hydrogeology, seeps, surface stream water, sediment, and ecology).

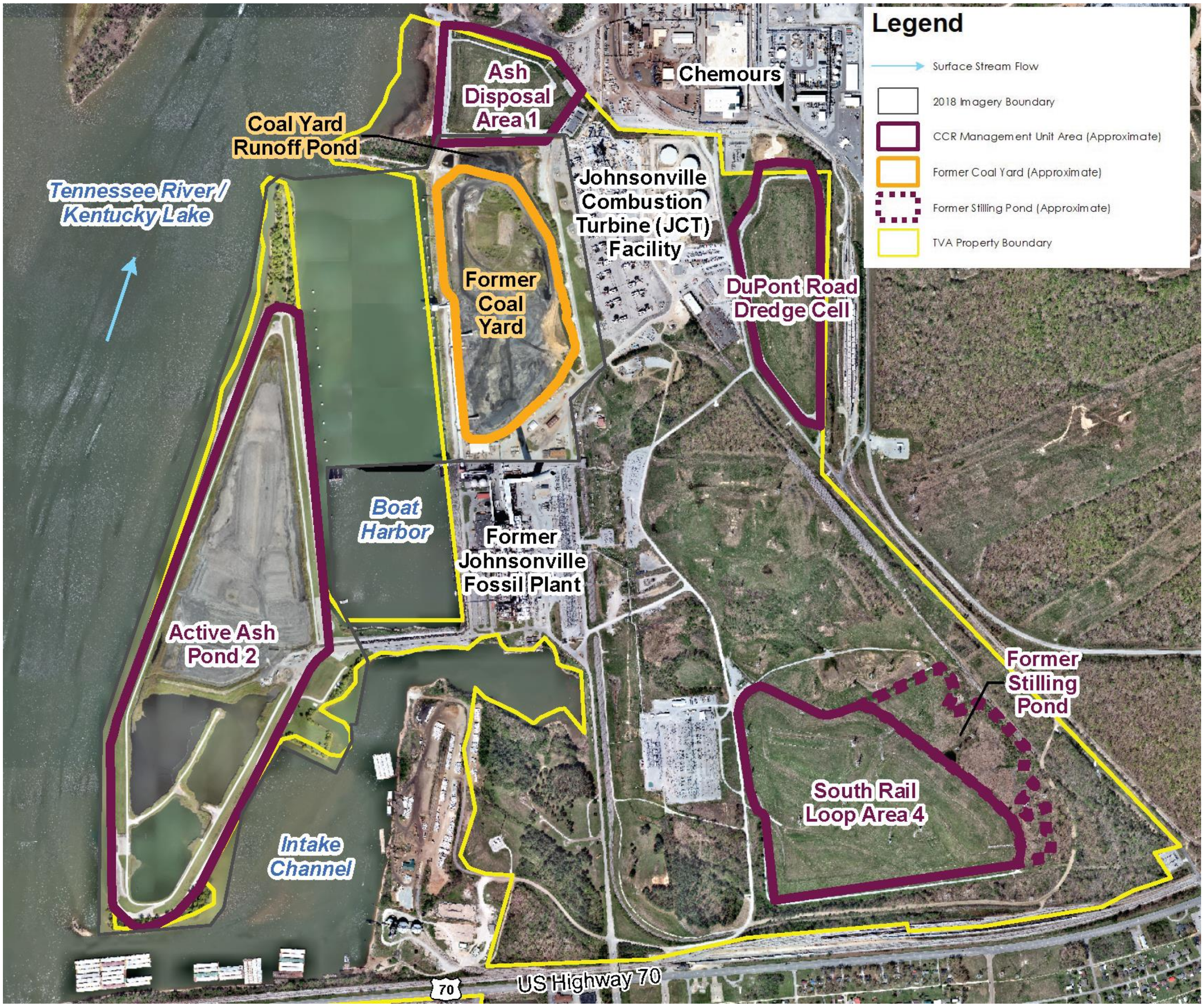
Chapter 2 Site History and Physical Characteristics

2.1 Site Operations

TVA began construction of the JOF Plant in 1949 and commenced power generation operations in 1951. The JOF Plant coal-fired units have been inactive since 2017. Power generation at the Johnsonville Plant was replaced by 20 natural gas combustion turbine units. It is now known as the Johnsonville Combustion Turbine facility (TVA 2023).

The JOF Plant CCR management units are shown below and on Exhibit 2-1 and include: Ash Disposal Area 1, DuPont Road Dredge Cell, South Rail Loop Area 4, and Active Ash Pond 2. The Coal Yard is also shown below and on Exhibit 2-1. Previously closed CCR management units were closed in accordance with applicable regulations in effect at the time of closure. The total area of the CCR management units is approximately 225 acres. The total area of the Coal Yard is approximately 38 acres.

JOF Plant Features



2.2 CCR Management Unit History and Land Use

CCR was first sluiced to Ash Disposal Area 1. CCR was also placed in what is now the north end of the Coal Yard in the first few years of operation of the JOF Plant. Sluicing to Ash Disposal Area 1 continued until 1970. CCR was sluiced to Active Ash Pond 2 from 1970 to 2017 when TVA ceased coal-fired power generation at the JOF Plant. CCR was periodically dredged from Active Ash Pond 2 and stacked in the South Rail Loop Area and DuPont Road Dredge Cell.

2.2.1 Ash Disposal Area 1

Ash Disposal Area 1 was originally part of a larger CCR unit composed of three sub-units: Ponds A, B, and C (refer to Exhibit 2-2; TVA 1949 and 1954a). A portion of Pond A, and the entirety of Ponds B and C are on the adjacent Chemours (formerly DuPont) property (TVA 1988). The portion of Pond A on TVA property is now referred to as Ash Disposal Area 1. Ponds A, B, and C were constructed in the early 1950s and began receiving sluiced CCR in 1952. The initial earth dike for the original unit was constructed using hydraulic fill sourced from the excavation of the boat harbor; the top elevation varied from 359 to 365 feet above mean sea level (amsl) (TVA 1954a and TVA 1954b). In 1952, TVA sold the land containing Ponds B and C, and a portion of Pond A to Chemours (formally DuPont), while retaining the right to continue CCR operations until 1986 (TVA 2018). The initial perimeter dike was raised by site personnel using the "heaviest available ash" to reduce the risk of overtopping (TVA 1967 and 1968a). TVA ceased sluicing CCR to the ponds in 1970, Pond C became the sole responsibility of DuPont under a formal agreement in 1972 (TVA 1998), and Ponds A and B were closed and capped in 1976 with an earth and vegetative cover (TVA 1976a). Additional earth fill was added to the exterior slopes of Ponds A and B in 1978 (TVA 1988). DuPont installed a fence and gate across the closed Pond A in 1977 (TVA 1988), assuming responsibility for Pond B and the portion of Pond A on their property.

In 2015, the original cover soil was stripped, and a new engineered cover system was installed at Ash Disposal Area 1. The subgrade was regraded using general fill, and a final cover system was installed consisting of a 12-inch vegetative cover and a 24-inch compacted clay cap (Stantec 2015a). In conjunction with the construction of the new cover system, a drainage culvert along the north side of the unit and a rock buttress along the west side (i.e., lake side) of the unit were constructed (Stantec 2015b and 2015c). The rock buttress consisted of (from top to bottom) 18 inches of riprap, six inches of No. 57 stone, geocomposite, geomembrane, another geocomposite, and river gravel varying in thickness to bring the subgrade to the desired grade.

2.2.2 DuPont Road Dredge Cell

The DuPont Road Dredge Cell (Exhibit 2-2) was constructed in the early 1990s and began receiving CCR dredged from Active Ash Pond 2 in 1992 (TVA 1993). The DuPont Road Dredge Cell was regulated as a Class II-industrial waste facility per TDEC Solid Waste Disposal Permit #IDL 43-102-0082. Initial activities involved the construction of a perimeter dike to an elevation of approximately 414 feet amsl and placement of a three-foot thick compacted soil bottom liner, both using clay soils excavated from within the footprint of the CCR unit. When the elevation of sluiced CCR approached the top of the clay perimeter dike, CCR was excavated to construct a second perimeter dike to an elevation of approximately 430 feet amsl inside the first clay perimeter dike (TVA 1999a).

The unit stopped receiving CCR by March 1994 (TVA 1994). Beginning in early 2000, another 430,000 cubic yards of CCR from Active Ash Pond 2 were stacked in the DuPont Road Dredge Cell (TVA 2000 and 2002). The unit ceased receiving CCR in March 2001 and was closed in late 2001 (TVA 2001a). Closure included final grading and construction of a compacted clay cap and vegetative cover (TVA 2001b).

In 2010 TVA began a cap improvement project at the DuPont Road Dredge Cell. The existing vegetative cover was removed and a new cap system, consisting of topsoil and vegetative cover overlying a geocomposite and geomembrane, was installed on the existing compacted clay cap. The outboard slopes of sections of the perimeter clay dike greater than 14-feet tall were armored with a Tennessee Department of Transportation Type I geotextile and three feet of riprap. The cap system improvements consisted of two phases, the first involved the placement of smooth and textured Linear Low-Density Polyethylene (LLDPE) geomembranes overlain with single- and double-sided geocomposites, respectively. The smooth geomembrane was placed on the flatter, center portion of the cell and the textured geomembrane was placed on a small portion of the steeper, side slopes of the cell. The second phase consisted of the construction of an anchor trench for the Phase 2 textured LLDPE geomembrane placed on the remaining side slopes of the cell, and a double-sided geocomposite overlying the geomembrane. Following the completion of each phase, an 18-inch vegetative cover and six inches of topsoil were placed. The cap improvements for the DuPont Road Dredge Cell were completed in April 2012 (Stantec 2012).

2.2.3 South Rail Loop Area 4

TVA completed the construction of South Rail Loop Area 4 in 1982 to receive dredged CCR from Active Ash Pond 2. The South Rail Loop Area 4 consists of three subunits: Area 1, Area 2, and Area 3 (refer to Exhibit 2-2).

Initially at South Rail Loop Area 4, a single dredge cell was constructed in the western portion of the unit footprint, with perimeter dikes on three sides of the unit tying into higher ground to the east (TVA 1996a and 1996b). In 1981, the perimeter dikes for the unit were completed. The south and west perimeter dikes were raised by plant personnel using unspecified fill (TVA 1982). The dredge cell was divided in two by clay dikes: Area 1 to the north and Area 2 to the southwest. The unit received CCR dredged from Active Ash Pond 2 beginning in 1981 until 1985 (TVA 1986). The CCR was primarily sluiced to Area 2 until 1983 after which the CCR was dry stacked using draglines (TVA 1983a).

Interim closure of Area 2 occurred in 1986 when the area was capped with compacted earth (TVA 1993). In 1988, Area 3 was constructed as a new dredge cell east of Area 2, via pit excavation and dike construction (TVA 1988). By mid-1989, the dredge cell at Area 3 was filled to approximately 75 percent of the estimated total capacity of 600,000 cubic yards (TVA 1989). Some of the CCR within the dredge cell at Area 3 was moved to Area 2 in mid-1993. Area 1 and Area 3 began receiving CCR again in 1993 (TVA 1993, TVA 1994, Law Engineering and Tribble and Richardson 1996, TVA 1999b). In 1993, dry stacking resumed at Area 2 over the interim cover (TVA 1997a). Placement at Area 2 was complete by November 1993. Area 2 was closed using a cover system which consisted of (from top to bottom) a one-foot-thick vegetative cover and a one-foot-thick compacted clay cover. The Area 2 cover system was constructed between March 1994 and July 1994 (Beaver 1994).

In 1996, Area 3 was converted from a dredge cell to a rim-ditch operation, and an additional 700,000 cubic yards of CCR was dredged from Active Ash Pond 2 and sluiced to this area (TVA 1995 and 1996c). Sluicing to Area 3 ceased in 1997 and an interim six-inch cover soil layer was placed (TVA 1997b). Additional CCR was placed over the interim cover to bring the area to grade prior to the placement of the final cover system (TVA 1999b). Area 1 received CCR until 1999 (Law Engineering and Tribble and Richardson 1996, TVA 1999b). Area 1 and Area 3 were closed using a cover system composed of (from top to bottom) a 20-inch vegetative cover, geocomposite, and textured geomembrane (TVA 2002). The South Rail Loop Area 4 was formally approved for closure in 2005 (TDEC 2005).

CCR was observed in EI boring JOF-B09 which indicates that CCR is also present east of South Rail Loop Area 4 in the adjacent area designated as the former Stilling Pond in Exhibits 2-1 and 2-2.

2.2.4 Active Ash Pond 2

The Tennessee River was impounded in 1944 by the construction of Kentucky Dam (refer to Exhibit 2-2; TVA 1968b and TVA 1997c). Active Ash Pond 2 is an impoundment formed by the construction of hydraulic fill dikes starting in 1950. CCR was sluiced to Active Ash Pond 2 from 1970 to 2017 when TVA ceased coal-fired power generation at the JOF Plant. Sluiced CCR was routed through settling ponds within Active Ash Pond 2 to allow particles to settle out prior to discharging to the Tennessee River through a National Pollutant Discharge Elimination System-permitted outfall. TVA raised the Active Ash Pond dikes with soil fill from elevation 378 to 390 feet amsl in 1978 (TVA 1997c). CCR was periodically dredged from Active Ash Pond 2 and placed in South Rail Loop Area 4 and the DuPont Road Dredge Cell during the 1980s and 1990s (Stantec 2010a). TVA stopped sluicing to Active Ash Pond 2 in 2017 when the coal-fired units were shut down.

2.2.5 Former Coal Yard

The former Coal Yard is located in the central portion of the JOF Plant reservation (refer to Exhibit 2-2). When the JOF Plant opened, the original Coal Yard footprint covered approximately half the area it does today. During the first few years of JOF Plant operation, CCR was utilized in the north end of the Coal Yard to fill low ground above the Tennessee River floodplain. Additionally, in the early 1990's, a stabilized surface was constructed in the southern half of the Coal Yard to support heavy equipment operation and coal piles using CCR material as beneficial use (Stantec 2016).

2.3 Ownership and Surrounding Land Use

The site is owned and operated by TVA, a corporate agency of the United States, and is located along the eastern side of Kentucky Lake (Tennessee River) and almost entirely within the city limits of New Johnsonville (Exhibit 2-1).

Land use surrounding the JOF Plant is primarily agriculture and rural residential areas.

Public water is provided by the New Johnsonville Water Department located in the city of New Johnsonville (Robinson & Brooks 2010 and USGS 2019). The New Johnsonville Water Department obtains its water supply from the Tennessee River at river mile marker 101.8R located approximately one mile south (upstream) of the JOF Plant and provides potable water to New Johnsonville and the entire area within ½-mile of the JOF Plant (Vann 2019).

The City of Camden's potable water supply system does not service the Survey Area or areas east of the Tennessee River; however, the water system also obtains water from the Tennessee River with the water intake located within the Survey Area near where Interstate Highway 70 crosses the River.

Additional information about these public water supplies is provided in Appendix H.10.

2.4 Physical Characteristics

2.4.1 Regional and Site Physiography

The JOF Plant is located within the Interior Low Plateaus Physiographic Province, immediately to the east of the Coastal Plain Physiographic Province (Fenneman 1938). More specifically, the JOF Plant is located within the Western Highland Rim division of the Interior Low Plateaus Physiographic Province. Extensive areas of the Western Highland Rim are deeply incised by numerous large and small streams. (USFS 1994).

The 1936 Johnsonville quadrangle map shows the area prior to construction of the Kentucky Lake Reservoir; however, this quadrangle does not show topography. The 1950 Johnsonville quadrangle map shows topography, but TVA and DuPont site features are already present (TVA 2016); therefore, the original topography is unavailable.

The site comprises a partially dissected river terrace, with a series of valleys and gullies traversing the area. This has resulted in a gently rolling terrain with the tops of the low hills at elevations around 410 feet amsl and valley floors ranging from elevations of 350 to 390 feet amsl (TVA 1948).

The figure below provides a current aerial photograph overlain on the topography of and near the JOF Plant. The plant is located in a topographically low area between higher elevation ridges to the northeast and the Tennessee River on the west.

JOF Physiographic Features

2.4.2 Regional Geology, Hydrogeology and Surface Water Hydrology

Much of the Interior Low Plateaus Physiographic Province is underlain by limestone aquifers in Mississippian rocks, called the Highland Rim aquifer system in Tennessee (USGS 1994). The Mississippian aquifers are usually covered by unconsolidated material, which primarily consists of weathered material, or residuum, of clay, silt, sand, and pebble-sized particles of limestone or chert, derived mostly from weathering of the underlying bedrock. Where thick and saturated, the chert rubble constitutes a productive local aquifer. Where present in the area, the Mississippian-age Fort Payne limestone is a productive aquifer. The older Chattanooga Shale primarily services as a confining unit. Below the Chattanooga Shale lies the Camden Formation, which is the principal aquifer in the region.

As summarized in groundwater monitoring reports, shallow groundwater movement at the JOF Plant generally follows topography, with groundwater flowing westward or southwestward toward the Tennessee River. The shallow aquifer underlying the JOF Plant is not utilized as a source for drinking water (TVA 2016).

2.4.2.1 Geology

The lithology in the general vicinity of the JOF Plant consists of almost completely horizontal beds of Paleozoic shale, chert and limestone. According to the Geologic Map of the Johnsonville Quadrangle, Tennessee (TDEC 2017), the JOF Plant is immediately underlain by alluvium that consist of poorly sorted, unconsolidated gravel, sand, silt, and clay which may be up to 70-feet thick. Beneath the alluvial deposits, drilling activities appeared to have encountered the Fort Payne Formation along the eastern portion of the JOF Plant and the Camden Formation within the western portion of the JOF Plant. The Chattanooga Shale lies immediately beneath the Fort Payne Formation, but in portions of the JOF Plant area, the Chattanooga Shale is the uppermost bedrock formation.

The major fault pattern in the region is comprised of series of northwest striking, southwest dipping thrust faults. The major faults are associated with the northwest branch of the Nashville Dome (Kellberg 1948).

A map showing the geologic units for the JOF Plant is provided in Exhibit 2-3.

2.4.2.2 Surface Water Hydrology

The JOF Plant is located within the Lower Tennessee River Basin, which includes roughly 160 river miles in Tennessee. Within the Lower Tennessee River Basin, the JOF Plant is situated near the south end of the Kentucky Lake Watershed, which is approximately 1,460 square miles and includes parts of nine counties with more than 100,000 lake acres. In accordance with the TVA Kentucky Operating Guide (TVA 2020), normal river water elevation of Kentucky Lake (Tennessee River) ranges between 354 and 359 feet amsl (winter and summer pool elevations, respectively). The 100-year and 500-year flood elevations are approximately 375 feet amsl (FEMA 2009).

The Highland Rim Section of the Interior Low Plateau also has a moderate density of small to medium intermittent and perennial streams and associated rivers, most with moderate volume of water at low velocity (USFS 1994) (Exhibit 2-4).

2.4.2.3 Regional Hydrogeology

Groundwater in the Highland Rim aquifer system occurs primarily in secondary porosity such as solution openings, joints, and faults (USGS 1986). The secondary porosity stores and transmits most of the water that moves through the limestone; it then discharges to streams, springs, and wells. Little water passes through the blocks of limestone between the bedding planes and fractures (USGS 1995). The older Chattanooga Shale is the lower confining layer for the Highland Rim aquifer system. Below the Chattanooga Shale lies the Camden Formation. Mississippian aquifers are usually covered by unconsolidated material, which primarily consists of weathered material, or residuum, clay, silt, sand, and pebble-sized particles of limestone or chert, derived mostly from weathering of the underlying bedrock. Where thick and saturated, this chert rubble constitutes a productive local aquifer. The unconsolidated materials can store large quantities of water that subsequently percolate slowly downward to recharge aquifers in the underlying consolidated rock (USGS 1995). But at the JOF Plant, limestone was rarely encountered in borings. Limestone encountered in borings during the Exploratory Drilling SAR did not show obvious signs of significant dissolution.

2.4.3 Local Climate

Locally near the JOF Plant, the average monthly high temperature at weather station USC00401352, Camden, Tennessee (National Oceanic & Atmospheric Administration 2021) located approximately ten miles northwest of the JOF Plant, ranges between 49 degrees Fahrenheit (°F) in January to 90°F in July, and the average monthly low ranges between 28°F in January to 70°F in July. Average annual precipitation at this location is 51.6 inches, with May being the wettest month, averaging 5.4 inches, and September being the driest month, averaging 3.4 inches.

2.4.4 Cultural and Historical Resources

Historically, land in Humphreys County was used as hunting grounds and settlements for Woodlands and Mississippian tribes. Pioneer settlement began in the area around 1800, and the county was formed in 1809. Settled areas were primarily used for agricultural purposes, most importantly corn. In addition to growing crops, the area was known for raising livestock and iron operations (Tennessee Historical Society 2017; USDA 1946).

The landscape of Humphreys County began to change following the Civil War into the early 20th century. Peanuts, rather than corn, became the biggest crop in the area, producing one-third of the state's peanuts in the early 1900s. The timber industry also flourished in the less fertile areas of the county (Tennessee Historical Society 2017).

In 1933, President Franklin Delano Roosevelt signed the TVA Act, changing the economy of Humphreys County from agriculture to industrialization. Between 1938 and 1942, TVA purchased most of the fertile land in the area to create the Kentucky Lake and Dam. Along the new body of water, industry flourished. A chemical plant, a manganese factory, and an aluminum reduction plant were all open by the early 1950s. Today Humphreys County boasts recreational attractions and wetland areas created on the Kentucky Lake (Tennessee Historical Society 2017).

Chapter 3 Background Soil Investigation

Constituents in CCR material are also present in naturally occurring soil. To evaluate potential contributions of CCR Parameters in naturally occurring soil to other environmental media, such as surface water or groundwater, TVA reviewed information from historical studies and completed a background soil investigation as part of the EI. EI field activities were performed in general accordance with the following documents: *Background Soil SAP* (Stantec 2018a)*, Hydrogeological Investigation SAP* (Stantec 2018b)*,* and the *QAPP* (EnvStds 2018b) including TVA- and TDEC-approved programmatic and project-specific changes made after approval of the EIP.

The following sections summarize historical studies and EI activities and present overall investigation and statistical evaluation findings for background soils based on data obtained during the EI. Additional information regarding the background soil statistical analyses and the EI are provided in Appendices E.1 and F.1, respectively.

3.1 Previous Studies and Assessments

As part of the development of the EIP, historical background soil data were reviewed to evaluate the need for additional data. In 2010, TVA installed three groundwater monitoring wells in support of the Utility Solid Waste Activities Group at Active Ash Pond 2. Five saturated soil samples were collected from within the screened interval of monitoring wells 10-AP1, 10-AP2, and 10-AP3 and analyzed for 16 naturally occurring metals (Stantec 2011). Two soil samples were collected from the 10-AP1 boring between 34.5 and 41.0 feet below ground surface (bgs), two samples were collected at 10-AP2 between 30.0 and 36.5 feet bgs, and one sample was collected at 10-AP3 between 35.0 and 36.5 feet bgs using recovered soil from standard penetration tests (Stantec 2011). Soil was examined for natural concretions or nodules that may contribute to groundwater metals concentrations (Stantec 2011). In February 2016, Stantec conducted site activities to install one potential background monitoring well, JOF-101, and collect two composite soil samples from the screened interval for analytical testing of naturally occurring metals and other constituents. The analytical suite included most CCR Parameters; however, sulfate was not included because the soil sample analysis predated the defined objectives of the EI. The well installation and soil sampling activities are further detailed in the *Geotechnical Field Services for Well Installations and Closures* report dated February 23, 2017 (Stantec 2017). These historical data were reviewed in conjunction with the background soils data collected for the EI described in Chapter 3.4 below.

3.2 TDEC Order Investigation Activities

The objective of the TDEC Order background soil investigation was to characterize background soils on TVA property near the JOF Plant CCR management units by sampling locations where naturally occurring, in-place, native soils are present and unaffected by CCR material. A total of 67 samples were collected from 12 background soil borings and from within the screened interval of three background well borings. For the background soil borings, the sampling team typically collected approximately two-foot grab samples from the mid-point of each five-foot soil run based on recovery. These sampling locations are depicted on Exhibit 3-1.

Background soil borings were advanced and sampled using a direct push technology rig. Background well borings were advanced and sampled using a hollow stem auger drill rig. The average depth of the background soil borings was approximately 19.4 feet bgs. Samples were analyzed for CCR Parameters. Surficial soil samples were collected from each background soil boring location and analyzed for the presence of ash (percent [%] ash) to evaluate the presence or absence of CCR material. Soil samples were also tested for pH in the field.

3.3 Lithology

Boring logs for the background soil borings and background monitoring well borings are provided in Appendix B.1. Review of the background soil boring logs, the Geologic Map of the Johnsonville Quadrangle (Tennessee Geological Survey, 1964, revised 2017) indicated that the borings and monitoring wells were installed in three different geologic units. These units and the associated borings are summarized in Table 3-1.

3.4 Background Soil Investigation Results Summary

Field and lithologic data were reviewed for each EI boring location to evaluate whether collected samples accurately represent unsaturated background conditions. 12 samples were excluded from the statistical evaluation because they were collected from a saturated interval. Additionally, soil samples collected as part of the previous 2010 sampling activities were excluded from the evaluation because these samples were collected from a saturated soil zone.

The EI background soils data collected from unsaturated intervals in native soils were statistically evaluated for potential outliers and anomalous data, dataset comparison parameters, and overall data variability. Multiple potential outliers were identified and flagged in the dataset. However, given the heterogeneity of naturally occurring inorganic compounds in soils, statistical outliers were not removed prior to statistical analysis.

Background threshold values (BTVs) are estimates of constituent concentrations in samples collected from unimpacted naturally occurring soils. Specifically, 95% one-sided Upper Tolerance Limits (UTLs) with 95% coverage (95% UTLs) were used to calculate BTVs, representing that there is a 95% confidence on average that 95% of the data are below the UTL and no more than 5% of the data are expected to exceed the UTL. UTLs were calculated at three depth intervals: 0 to 0.5 feet below ground surface feet bgs, 0.5 to less than or equal to 10 feet bgs and greater than 10 feet bgs. In addition, a UTL was calculated for each CCR Parameter using results collected from the three depth intervals combined. The results of these calculations are summarized in the *Statistical Analysis of Background Soil Data* in Appendix E.1, with BTVs provided in Attachment E.1-A.

Chapter 4 CCR Material Investigations

To evaluate the extent, structural stability, characteristics, and quantities of CCR material in the management units, TVA reviewed information from historical studies, and performed investigations as part of the EI. EI field activities were performed in general accordance with the following documents: *Exploratory Drilling (EXD) SAP* and *Addendum to Exploratory Drilling SAP* (Stantec 2018c, Stantec 2021), *CCR Material Characteristics SAP* (Stantec 2018d), *Material Quantity SAP* (Stantec 2018e), and the *QAPP* (EnvStds 2018b), including TVA- and TDEC-approved programmatic and project-specific changes that were made after approval of the EIP. Field work included drilling 16 borings, installing 10 piezometers and 15 temporary wells, and collecting 134 CCR material samples and 15 pore water samples.

The following sections summarize the geotechnical stability evaluation findings, CCR material characteristic results, and CCR material quantity estimates based on the data obtained during previous investigations and the EI at the CCR management units at the JOF Plant. Additional details regarding these investigations are provided in Appendix G.

4.1 Geotechnical Investigation

The purpose of the geotechnical investigation component of the EI was to further characterize and evaluate subsurface conditions for four CCR management units at the JOF Plant, including Ash Disposal Area 1, Active Ash Pond 2, DuPont Road Dredge Cell, South Rail Loop Area 4, as well as one other area that is not a CCR management unit (Coal Yard). For this investigation, TVA reviewed information from previous representative studies and assessments, completed an exploratory drilling field program, and conducted evaluations for slope stability, structural integrity and structural stability (bedrock).

The following sections summarize the previous studies and present overall geotechnical investigation and evaluation findings based on data obtained during previous studies and the EI for the JOF Plant CCR management units.

4.1.1 Exploratory Drilling

4.1.1.1 Previous Representative Studies and Assessments

Through the various information requests, as well as TDEC comments on the EIP, a need was identified for an evaluation of existing geotechnical data (borings, piezometric data, laboratory data, material parameters, analyses, etc.). The *Evaluation of Existing Geotechnical Data* (Appendix H of the EIP) was prepared to review the existing data and evaluate its adequacy with respect to responding to the various TDEC information requests. Evaluating the adequacy of existing data, in accordance with the QAPP, depends on both the type of data and its intended use. Where applicable, existing geotechnical data were used to support the subjects addressed throughout the EAR.

4.1.1.2 TDEC Order Investigation Activities

Exploratory Drilling (EXD) field work was conducted in two phases (Phase 1 and Phase 2) and consisted of four primary activities – drilling and sampling, installing temporary wells, installing piezometers, and cross-hole seismic testing. The primary objective of the Phase 1 EXD was to perform borings, install temporary wells, and install piezometers to further characterize subsurface conditions at Ash Disposal Area 1, Active Ash Pond 2, DuPont Road Dredge Cell, South Rail Loop Area 4, and the Coal Yard. The primary objective of the Phase 2 EXD was to perform borings, advance cone penetration test (CPT) soundings, and conduct cross-hole seismic testing to further characterize subsurface conditions at Ash Disposal Area 1 and South Rail Loop Area 4.

Boring and CPT layouts are shown on Exhibits 4-1 through 4-5. For additional details on the EXD activities, refer to Appendices G.1 and G.2 (*Technical Evaluation of Geotechnical Data* and the *JOF EXD SAR*, respectively).

4.1.1.3 Results and Discussion

At each boring location in Ash Disposal Area 1 and Active Ash Pond 2, the uppermost foundation soil was predominantly lean to fat clay or silty clay, with a single occurrence each of clayey gravel and silty sand. At each boring location in the DuPont Road Dredge Cell, the uppermost soil beneath the CCR material was lean clay fill or clayey sand fill. At each boring location at the South Rail Loop Area 4, the uppermost foundation soil ranged from lean clay to clayey sand and gravel to well and poorly graded gravel with sand, silt, or clay. At each boring location in the Coal Yard the uppermost foundation soil ranged from lean clay to silty sand to silty gravel. This is generally consistent with historical borings across the CCR management units. At one boring location adjacent to South Rail Loop Area 4, CCR was encountered beyond the limits of the closed unit footprint.

At the South Rail Loop Area 4, three temporary wells were planned to be screened in CCR. The purpose was to allow for CCR pore water sampling within the sluiced CCR. However, upon reaching the planned termination criteria, the water level in one of these boring (JOF-TW14) was found to have insufficient depth of water to facilitate CCR pore water sampling. Therefore, a temporary well was not installed in JOF-TW14.

4.1.2 Slope Stability

The load cases evaluated in the stability analyses are based on conventional practice and appropriate industry standards for landfills and surface water impoundments, as applicable, and are noted below:

- Static, long-term (i.e., normal operation conditions) global stability
- Static, long-term veneer (i.e., final cover) stability
- Seismic, pseudostatic global stability
- Seismic, pseudostatic veneer stability
- Seismic, post-earthquake global stability (includes a preceding liquefaction triggering assessment).

As described in the JOF Plant EIP, including the *Evaluation of Existing Geotechnical Data* (EIP Appendix H), the existing data are sufficient to establish appropriate shear strengths and stability results for certain static and seismic load cases. The summaries of existing geotechnical data demonstrate that existing data are representative and suitable to support the stability analyses. Supplemental geotechnical data were collected, per the EXD SAP, to support the new or updated stability analyses described in the EIP and the Stability SAP. The scope of the EIP and the Stability SAP did not require stability analyses of the former Coal Yard, because CCR material was not placed for disposal purposes; CCR was placed as structural fill. For the JOF Plant, historical stability analyses were adequate to address:

1) the Active Ash Pond 2 static and seismic global slope stability analyses for the current geometry
2) the DuPont Road Dredge Cell static global slope stability analyses for the current, closed geometry.

For the JOF Plant, the Stability SAP was necessary to address:

1) the Ash Disposal Area 1 static and seismic slope stability analyses for the current, closed geometry

2) the DuPont Road Dredge Cell static veneer, seismic global, and seismic veneer slope stability analyses for the current, closed geometry

3) the South Rail Loop Area 4 static and seismic slope stability analyses for the current, closed geometry

4.1.2.1 Results and Discussion

The static and seismic stability results for the JOF Plant CCR management units are summarized and compared to criteria in Appendix G.1. For additional details on the analyses required under the Stability SAP, refer to the *Static Stability SAR* and *Seismic Stability SAR* provided as Appendix G.3 and Appendix G.4, respectively. The global stability and the veneer stability for each analyzed section meets the established FS criteria for the static (except one veneer stability case that was still accepted by TDEC, as described in Appendix G.1) and seismic load cases.

4.1.3 Structural Integrity

"Structural integrity" considers structural potential failure modes that could lead to a release of CCR material, other than slope stability and structural stability of bedrock.

For the JOF Plant CCR management units, the EIP summarized historical reports that would be leveraged to address structural integrity, and those are referenced in Appendix G.1. There was no SAP specifically required under the TDEC Order program to address this subject.

4.1.3.1 Results and Discussion

Based on the historical report information, no significant deficiencies were identified with respect to structural integrity of the CCR management units. In addition, TVA further promotes structural integrity of the CCR management units by performing routine inspections and other compliance activities, in accordance with TVA policies, state regulations and federal regulations.

4.1.4 Structural Stability (Bedrock)

"Structural stability (bedrock)" considers stability of bedrock below fill areas—that is, evaluating the bedrock with respect to voids/cavities and faults/joints of significant lateral or vertical extent that could be large enough to lead to loss of structural support and potential release of the overlying CCR material.

For the JOF Plant CCR management units, the EIP, including the *Evaluation of Existing Geotechnical Data* (EIP Appendix H), summarized historical reports that would be leveraged to address structural stability of the bedrock. In addition, the EXD SAR includes new information specifically required under the TDEC Order program to address this subject.

4.1.4.1 Results and Discussion

The CCR management units at the JOF Plant are underlain by the Ridgetop Formation (of the Fort Payne Formation), Chattanooga Shale, and the Camden Formation. Locally, the bedrock is primarily shale or limestone. No voids were noted in the rock cores. Based upon the site-specific geologic mapping, rock core borings, and CCR management unit performance, there is no evidence of voids/cavities that could lead to loss of structural support and potential release of the overlying CCR materials.

4.2 CCR Material Characteristics

TVA reviewed information from historical studies and completed a CCR material characteristics investigation as part of the EI to characterize leachability of CCR constituents within four CCR management units at the JOF Plant: Ash Disposal Area 1, Active Ash Pond 2, DuPont Road Dredge Cell, and the South Rail Loop Area 4. Additionally, the Coal Yard was included in the CCR material characteristics investigation. EI field activities were performed in general accordance with the following documents: *CCR Material Characteristics SAP* (Stantec 2018d), *Exploratory Drilling (EXD) SAP* (Stantec 2018c), and the *QAPP* (EnvStds 2018b), including TVA- and TDEC-approved programmatic and project-specific changes made after approval of the EIP.

The following sections summarize historical studies and EI CCR material characterization activities, and present overall investigation and statistical evaluation findings. Additional information regarding the CCR material and pore water statistical analyses and the investigation are provided in Appendix E.2 and G.5, respectively. Further evaluation of the CCR material and pore water results is provided in Appendix G.1. Additional evaluation of the hydrogeologic conditions at the JOF Plant is provided in Chapter 5.1 and Appendix H.1.

4.2.1 Previous Studies and Assessments

Historical studies conducted by TVA did not include collecting CCR management unit pore water samples for laboratory analysis. Therefore, a more comprehensive investigation was conducted as part of the EI which included collection and analyses of pore water, as summarized in Chapter 4.2.2.

4.2.2 TDEC Order Investigation Activities

The objective of the TDEC Order CCR material characteristics investigation was to assess the presence of constituents in and their susceptibility to leach from CCR material by collecting pore water and CCR material samples (saturated and unsaturated) from within Ash Disposal Area 1, Active Ash Pond 2, DuPont Road Dredge Cell, and South Rail Loop Area 4. Additionally, the Coal Yard was included in the CCR material characteristics investigation. 134 CCR material samples were collected from 16 temporary well borings, though only 15 temporary wells were installed. These were analyzed for CCR Parameters (defined in Chapter 1.3) and additional parameters of interest for the CCR material characteristics investigation. The additional parameters of interest and analyses included total organic carbon (TOC), iron and manganese. TVA also performed Synthetic Precipitation Leaching Procedure (SPLP) analyses for metals and radiological parameters. During sampling, CCR material present at each boring was visually characterized using the Unified Soil Classification System, which classifies material by grain size distribution followed by the material's textural properties.

Following temporary well installation and development, pore water levels were measured prior to sampling, hydraulic conductivity testing was performed, and pore water samples were collected from each well. The temporary well locations are depicted on Exhibit 4-6.

4.2.3 CCR Material Characteristics Evaluation

This section presents a summary of the evaluation of the CCR material and pore water analytical results to assess the presence of constituents in and their susceptibility to leach from CCR material. In addition, SPLP analysis of CCR material was conducted to assess whether SPLP can be used to predict pore water concentrations.

4.2.4 Total Metals and SPLP Evaluation Results

Statistical evaluations were conducted to evaluate whether the total concentrations of metals in CCR material could be used as a reliable predictor of leachable concentrations as represented by SPLP concentrations. The evaluations included comparison of total metals concentrations in CCR material to SPLP concentrations. The results indicated that the total concentrations of metals in CCR material are not a reliable predictor of the magnitude of the potentially leached concentrations using SPLP. Additional discussion of the evaluations is provided in Appendices E.2 and G.1.

TVA also compared pore water results to SPLP results for the CCR material to evaluate whether SPLP could be used as a predictor of pore water concentrations. CCR constituent concentrations were generally higher in pore water samples than in SPLP results. These findings indicate that SPLP analysis of CCR material is not a good predictor of pore water concentrations. The results indicate that direct measurement of pore water concentrations is the most accurate method of characterizing potential leachability of CCR constituents from CCR material, but geochemical modeling is needed to predict the concentrations of constituents in groundwater. Additional discussion of the evaluations is provided in Appendices E.2 and G.1.

4.2.5 Pore Water Phreatic Surface

TVA measured pore water levels in the temporary wells on a monthly frequency for six months. In addition, the wells were gauged during bi-monthly EI groundwater sampling events. This information was combined with available information from other instruments to develop phreatic surface maps for Active Ash Pond 2, the DuPont Road Dredge Cell, South Rail Loop Area 4, and the northern portion of the Coal Yard. A phreatic surface map was not developed for Ash Disposal Area 1 because this CCR management unit has only two pore water data points, which is not sufficient to provide a representative contour map. The phreatic surface is the surface of pore water at which pressure is atmospheric and below which CCR material may be saturated with pore water. The use of the term “saturated” or references to the moisture content of CCR material does not imply that the pore water is readily separable from the CCR material. Saturated CCR material can have a range of moisture contents based on the characteristics of the material. Exhibit 4-6 provides a representative phreatic surface elevation contour map for Event #5 conducted in August 2020. Table G.1-4 (Appendix G.1) provides a summary of the pore water gauging data for the August 2020 Sampling event. The data for other gauging events can be found in Table 4.1 and Appendices H.3, H.4, H.5, H.6, and H.8.

Previously closed CCR management units were closed in accordance with applicable regulations in effect at the time of closure. The pore water levels reported herein may not represent steady-state conditions.

4.2.6 Pore Water Quality Evaluation

This section provides a summary of the analytical results for pore water samples collected from temporary wells installed as part of the EI. Pore water samples were collected during three sampling events. The first sampling event was conducted as part of the EI in February 2020. The second and third sampling events were conducted as part of other investigative activities in March/April 2021 and May 2021.

The pore water characterization evaluation was based on a comparison of pore water concentrations to groundwater concentrations and GSLs across the JOF Plant. GSLs are not directly applicable to pore water. Comparing pore water concentrations to GSLs is used to identify CCR constituents that have some potential to impact groundwater downgradient of CCR management units. Pore water concentrations were compared to GSLs for constituents listed in Appendix I of TDEC Rule 0400-11-01-.04 (TDEC Appendix I) and in Appendix IV of the CCR Rule because these constituents are subject to potential corrective measures. Eleven TDEC Appendix I or CCR Rule Appendix IV constituents (antimony, arsenic, beryllium, cadmium, cobalt, lithium, molybdenum, nickel, selenium, thallium, and vanadium) had reported concentrations in one or more pore water samples above a GSL. Of these, five constituents (arsenic, cobalt, lithium, molybdenum, nickel) had statistically significant concentrations in groundwater above a GSL.

The figure below summarizes reported pore water and groundwater analytical results and their comparisons to GSLs. The locations of temporary pore water wells are shown as symbols with an orange outer ring; groundwater well symbols have a blue outer ring. The colored slices in each symbol indicate CCR constituents detected above a GSL in each temporary pore water well. The number of colored sections within each slice represents the magnitude of the reported concentrations relative to the GSL. The legend provides further explanation of the colors and rings.

Pore Water Quality (with Groundwater)

There is a distinct difference between pore water and groundwater quality. As this figure illustrates, many constituents detected above a GSL in pore water samples were below the applicable GSLs in groundwater samples from the same areas.

4.2.7 CCR Material Characteristics Summary

Sample location selection, collection methodology, analyses, and quality assurance/quality control (QA/QC) completed for the investigation are provided in the *CCR Material Characteristics SAR* included in Appendix G.5.

The CCR material and pore water data collected during the EI are evaluated, along with historical data and data collected from other programs.

The following are the key findings of the JOF Plant CCR material characteristics investigation:

- The total concentrations of metals in CCR material are not a reliable predictor of the magnitude of the potentially leached concentrations represented by SPLP results, and SPLP analysis was not a good predictor of pore water concentrations. The results indicate that direct measurement of pore water concentrations is the most accurate way of characterizing potential leachability of CCR constituents from CCR material, but geochemical modeling is needed to predict the concentrations of constituents in groundwater.

- The downward trend in pore water levels in the DuPont Road Dredge Cell suggests that the cap is performing as expected and has effectively eliminated infiltration into the CCR material.

- The pore water levels reported herein may not represent steady-state conditions or correspond to a closed condition if the CCR management units were to be closed with CCR material in place. The phreatic surfaces in Ash Disposal Area 1, the former Coal Yard, and Active Ash Pond 2 would be expected to decrease in elevation if decanting or modifications to stormwater drainage or the existing soil cap or cover systems were to be implemented.

- There is a distinct difference between pore water and groundwater quality.

4.3 CCR Material Quantity Assessment

TVA completed a Material Quantity Assessment (MQA) to estimate CCR material quantities and other properties in support of fulfilling the requirements for the TDEC Order. MQA activities were performed in general accordance with the Material Quantity SAP (Stantec 2018e). The following sections summarize historical studies and EI activities, and present overall evaluation findings for material quantity based on data obtained during previous studies and the EI for the JOF CCR management units. Additionally, the former Coal Yard was included in the MQA.

4.3.1 Previous Studies and Assessments

Previous material quantity assessments were completed by TriAD Environmental Consultants, Inc. (TriAD) of Nashville, Tennessee, as part of their Historical Ash Volume Calculations (TriAD 2017 a, b, c, d). The Historical Ash Volume Calculations by TriAD were completed for Ash Disposal Area 1, DuPont Road Dredge Cell, South Rail Loop Area 4, and Active Ash Pond 2. The TriAD historical ash volume calculations are provided in Appendix G.6.

4.3.2 TDEC Order Investigation Activities

The objectives of the MQA, conducted pursuant to the Material Quantity SAP, were to describe CCR management unit geometry, CCR material quantity, phreatic surface elevations, and subsurface conditions for the following CCR management units at the JOF Plant for the units subject to the TDEC Order: Ash Disposal Area 1, DuPont Road Dredge

Cell, South Rail Loop Area 4, and Active Ash Pond 2 (MQA Study Area). The former Coal Yard is also included in the TDEC Order MQA Study Area.

Three-dimensional models of the MQA Study Area were developed using data from existing borings installed under different environmental or geotechnical programs, as well as pre-construction topographic information, historical drawings, and survey information for the MQA Study Area. The existing information was supplemented with data from borings drilled per the EXD SAP. The three-dimensional model of the former Coal Yard was developed using existing boring data located in the northern portion of the former Coal Yard. The three-dimensional models include an area east and adjacent to South Rail Loop Area 4 designated as the former Stilling Pond. For additional details regarding the development of the models, refer to the MQA SAR (Appendix G.7).

The three-dimensional models were analyzed using AutoDesk® AutoCAD® Civil 3D surface volumes to estimate CCR material volumes. Pore water level and pore water pressure measurements recorded in the temporary wells and piezometers per the Material Quantity, CCR Material Characteristics and Groundwater Investigation SAPs and summarized in Table 4-1, were compared to the three-dimensional models to estimate the quantity of CCR material below the phreatic surface in the CCR management units. Specifically, pore water level and pore water pressure measurements from Groundwater Investigation Event #5 shown on Exhibit 4-6 (Appendix H.7) were used to estimate the quantity of CCR material below the phreatic surface in the former Coal Yard, Ash Disposal Area 1, DuPont Road Dredge Cell, South Rail Loop Area 4, and Active Ash Pond 2.

4.3.3 Material Quantity Assessment Results

4.3.3.1 Cross Sections

Cross sections developed using the three-dimensional models are provided in Appendix D. As shown on Exhibit D-1, Section A-A’ is a cross section of Ash Disposal Area 1, Section B-B’ is a cross section of the DuPont Road Dredge Cell, Section C-C’ is a cross section of South Rail Loop Area 4, Section D-D’ is a cross section of the Active Ash Pond 2, and Section E-E’ is a cross section of the former Coal Yard. The cross sections profile the CCR management units from the groundline based on a 2019 aerial survey to below the top of rock surface.

4.3.3.2 CCR Material Limits and Thickness

Exhibit 4-7 shows estimated limits and thickness ranges of CCR material within the MQA Study Area. The Ash Disposal Area 1 CCR limits shown on Exhibit 4-7 and Section A-A’ correspond to the crest of the dike and the approximate cap limits. The DuPont Road Dredge Cell CCR limits shown on Exhibit 4-7 and Section B-B’ correspond to the crest of the starter dikes. The South Rail Loop Area 4 and former Stilling Pond CCR limits shown on Exhibit 4-7 and Section C-C’ correspond to the crest of the starter dike and intersection of the existing ground surface and original ground surface. The Active Ash Pond 2 CCR limits shown on Exhibit 4-7 and Section D-D’ correspond to the crest of the starter dikes. The former Coal Yard CCR limits shown on Exhibit 4-7 and Section E-E’ are based on boring data. Estimated CCR material thickness ranges from 0 to 90 feet.

4.3.3.3 CCR Material Volumes

CCR material volumes summarized in Table 4-2 were estimated using the three-dimensional models and AutoDesk® AutoCAD® Civil 3D volume surfaces. The volumes were also compared to the pore water elevation contours shown on Exhibit 4-6 to estimate the volume of CCR material below the phreatic surface. As explained in Chapter 1.3.1, the phreatic surface is the surface of pore water at which pressure is atmospheric and below which CCR material may be saturated with pore water. The use of the term "saturated" and/or references to the moisture content of CCR material does not imply that the pore water is readily separable from the CCR material. Saturated CCR material can have a range of moisture contents based on the characteristics of the material.

The total acreage of the CCR limits is approximately 260 acres. The estimated total volume of CCR material is approximately 11 million cubic yards. Approximately 45% of the estimated total volume of CCR material is below the estimated phreatic surface.

Ash Disposal Area 1, DuPont Road Dredge Cell, and South Rail Loop Area 4 (except for the former Stilling Pond) were previously closed in accordance with applicable regulations in effect at the time of closure. The pore water levels reported herein may not represent steady-state conditions.

It should be noted that the volumes reported herein for the former Coal Yard, Active Ash Pond 2, and former Stilling Pond do not correspond to a closed condition and the phreatic surface would be expected to decrease after decanting of Active Ash Pond 2 and capping of CCR management units, the former Coal Yard, and former Stilling Pond, if these areas were to be closed with CCR material in place. Multiple methods are regularly utilized to sufficiently stabilize saturated CCR material to facilitate safe construction and support of a final cover system.

4.3.3.4 Comparison to Previous MQA

TriAD previously computed material quantity volumes for Ash Disposal Area 1, DuPont Road Dredge Cell, South Rail Loop Area 4, and Active Ash Pond 2, as discussed in Chapter 4.3.1. TriAD's estimated total aerial extent and volume of CCR material were approximately 189 acres and 10.1 million cubic yards, respectively. A comparison of the two volumetric models indicates that the EI CCR material volume estimates are approximately 9% to 19% higher for South Rail Loop Area 4 and Ash Disposal Area 1, respectively. These differences are likely because the EI volumetric models included the former Stilling Pond adjacent to South Rail Loop Area 4 as well as areas between the west and south dikes at Ash Disposal Area No.1; these areas were not included in the Triad models.

4.3.3.5 Secondary Volume Estimates and Verification Method

The CCR material quantity analyses completed in AutoDesk® AutoCAD® Civil 3D were verified with the Trimble Terramodel 3D™ software package (Terramodel). The top and bottom of the CCR material surfaces were imported into Terramodel to perform secondary CCR material volume estimates. The Terramodel analyses confirmed the Civil 3D volumes with a deviation of less than 2%. Terramodel CCR material volume estimate summaries are provided in Appendix G.6.

4.4 CCR MATERIAL INVESTIGATIONS SUMMARY

CCR material investigations provided geotechnical and analytical data to evaluate the extent, structural stability, characteristics, and material quantities in the CCR management units. CCR material characteristics data were also further evaluated in the hydrogeological evaluations. Primary investigation findings are:

- The global stability and the veneer stability for each analyzed section meets the established factor of safety criteria for the static (except one veneer stability case that was still accepted by TDEC, as described in Appendix G.1) and seismic load cases

- The CCR management units have adequate structural integrity, and there is no evidence of voids/cavities in bedrock that could lead to loss of structural support and potential release of overlying CCR material
- CCR material and pore water have been characterized as specified in the EIP, and CCR material and phreatic surfaces have been estimated for each of the CCR management units and the Coal Yard. CCR material and estimated thickness ranges are depicted in plan view on Exhibit 4-7 and in cross-sections in Appendix D.
- Estimated CCR material volumes and areas for the CCR management units and the former Coal Yard are provided in Table 4-2. The total area of the CCR material within the CCR management units and the former Coal Yard is approximately 260 acres, and the estimated total volume is approximately 11 million cubic yards. Approximately 45% of the estimated total volume of CCR material within the CCR management units and the former Coal Yard is below the estimated phreatic surface. It should be noted that the volumes reported herein for the former Coal Yard, Active Ash Pond 2, and former Stilling Pond do not correspond to a closed condition and the phreatic surface would be expected to decrease following decanting of Active Ash Pond 2 and after capping of CCR management units, the former Coal Yard, and former Stilling Pond, if these areas were to be closed with CCR material in place. Multiple methods are regularly utilized to sufficiently stabilize saturated CCR material to facilitate safe construction and support of a final cover system.

Chapter 5 Hydrogeological Investigations

To evaluate hydrogeological conditions and to characterize groundwater quality, TVA reviewed information from previous studies, integrated data and findings from previous and other ongoing environmental programs and conducted hydrogeological and groundwater investigations as part of the EI (see Appendix H.1 for information included in the evaluation). EI field activities were conducted in general accordance with the following documents: *Hydrogeological Investigation SAP* (Stantec 2018b), *Groundwater Investigation SAP* (Stantec 2018f)*, Dye Trace Study SAP (Stantec 2018g),* and the *QAPP* (EnvStds 2018b), including TVA- and TDEC-approved programmatic and project-specific changes that were made after approval of the EIP*.* Field work included installing permanent wells and borings to collect samples of groundwater for analysis of CCR Parameters and geochemistry evaluation parameters. Additionally, as part of the EI, a water use desktop survey was performed in general accordance with the *Water Use Survey SAP* (Stantec 2018h)*.*

The following sections summarize findings based on evaluation of the information collected from implementation of the EI and data collected under other TDEC permitted landfill and CCR Rule programs at and near the JOF Plant CCR management units. Additional details regarding these investigations and evaluations are provided in Appendices E.3 and H.1 through H.10.

5.1 Groundwater and Hydrogeological Investigations

The purpose of the groundwater and hydrogeological investigations was to further characterize and evaluate subsurface conditions in proximity to four CCR management units at the JOF Plant, including Ash Disposal Area 1, Active Ash Pond 2, DuPont Road Dredge Cell, and South Rail Loop Area 4. Additionally, the former Coal Yard was included in the groundwater and hydrogeological investigation. A dye trace study was also conducted at Active Ash Pond 2 to evaluate if preferential hydrogeologic pathways are present between Active Ash Pond 2 and the underlying alluvial aquifer and the surrounding surface water. For this investigation, TVA reviewed information from previous representative studies and assessments, completed field sampling programs, and conducted evaluations related to geology, hydrogeology, and groundwater quality as part of the EI.

5.1.1 Previous Studies and Assessments

Exploratory drilling at the JOF Plant began in 1948 to evaluate the suitability for the foundation for a proposed power plant. Since that time, several exploratory drilling and hydrogeological investigations have been conducted. Groundwater monitoring has been conducted at the JOF Plant since approximately 1980. Monitoring well networks were previously installed to evaluate groundwater conditions as part of the TDEC permitted landfill and CCR Rule groundwater monitoring programs. Appendix H.1 provides summaries of informative studies related to the hydrogeology of the JOF Plant.

Groundwater data from the TDEC permitted landfill and CCR Rule programs follow quality assurance programs similar to that developed for the TDEC Order. Data from these historical and ongoing groundwater monitoring programs applicable to the TDEC Order CCR management units are included in the evaluation summarized below.

5.1.2 TDEC Order Investigation Activities

The objectives of the TDEC Order groundwater and hydrogeological investigations were to characterize groundwater quality and evaluate groundwater flow conditions in the vicinity of the JOF Plant CCR management units. Well installation and sample location selection, sample collection methodology, sample analyses, and QA/QC completed for the investigations are provided in the *Hydrogeological Investigation SAR* (Appendix H.2) and the *Groundwater Investigation SARs* for the six sampling events (Appendices H.3 through H.8). Exhibit 5-1 shows the locations of wells and the piezometer installed as part of the EI.

Proposed monitoring well JOF-108 was intended to be a third downgradient monitoring location for Ash Disposal Area 1; however, due to the presence of CCR material encountered in the five soil borings advanced near the proposed location, as well as shallow refusal in three of these borings, monitoring well JOF-108 was not installed following approval by TDEC. Additional details associated with the presence of CCR material at these soil boring locations is provided in Chapter 5.1.3.1.

Upgradient wells (JOF-109 and JOF-112) and background well (JOF-119) were installed to provide groundwater samples that have not been affected by the CCR management units or the former Coal Yard and to be representative of upgradient or background conditions in the unconsolidated materials. Downgradient wells (JOF-110, JOF-111, and JOF-118) were installed in unconsolidated materials downgradient of the CCR management units and wells (JOF-113, JOF-114, and JOF-117) were installed in unconsolidated materials downgradient of the former Coal Yard to provide additional locations to evaluate groundwater levels and quality.

5.1.3 Hydrogeological Investigation Results

Several soil boring and well and piezometer installation projects at and in the vicinity of the JOF Plant CCR management units and the former Coal Yard yielded information about the geology, groundwater elevations, groundwater flow direction, and groundwater quality. This section provides an evaluation of the hydrogeological setting of JOF Plant CCR management units and former Coal Yard. Details of the evaluations are provided in Appendix H.1.

5.1.3.1 Well Construction and Presence of CCR Material

As mentioned in Chapter 5.1.2, CCR material was encountered in the initial boring advanced for the installation of monitoring well JOF-108. The location of the soil boring was moved four times (JOF-108 Offset A through JOF-108 Offset D) to find a location to install a well where CCR material was not observed. However, because CCR material was encountered throughout most of the intervals in the four additional soil borings, a suitable location south of Ash Disposal Area 1 could not be located and monitoring well JOF-108 was not installed following approval by TDEC.

CCR material was also encountered in the initial soil boring (JOF-110 Pre) advanced for the installation of monitoring well JOF-110 and the initial soil boring (JOF-111 Pre) advanced for the installation of monitoring well JOF-111. Additional soil borings for well JOF-110 (JOF-110 Alt 1 and JOF-110) and JOF-111 (JOF-111 Offset A, JOF-111 Offset B, JOF-111 Offset C, JOF-111A, and JOF-111B) were advanced to find locations not affected by CCR material to install each well. Because CCR material was encountered within the upper portions of each of the soil borings, double-cased monitoring wells were constructed through the CCR material in borings JOF-110 and JOF-111 to provide locations to evaluate groundwater flow and quality in these areas.

5.1.3.2 Lithology and Hydrostratigraphic Units

Chapter 2.4 provides a discussion of the regional geologic setting for the JOF Plant. This chapter provides a discussion of the site-specific lithology and hydrostratigraphic units of the JOF Plant. Use of the terminology “fill material” in the following discussions excludes CCR material. A discussion of CCR material is provided in Chapter 4.

The unconsolidated materials consist primarily of fill, residuum, and alluvium overlying bedrock. Residuum is the material that remains after bedrock has weathered to a point that it is no longer considered rock. Residuum commonly consists of clay or silt but can have layers of coarser materials such as sand and gravel. Alluvium refers to native materials that are deposited by moving water. The alluvium can be differentiated into clay, silt, sand, and gravel which generally exhibit a coarsening downward sequence. The fill is composed of aggregate or reworked native deposits ranging in thickness from a few feet to over 45 feet at the former Coal Yard. The unconsolidated materials range in thickness from a few feet to over 70 feet, with the thickest extent encountered in the vicinity of Active Ash Pond 2.

The unconsolidated materials overlie Mississippian and Devonian-aged sedimentary bedrock formations. The Fort Payne Formation ranges from 100 to 200 feet in thickness and is comprised of a cherty limestone or calcareous sandstone that underlies the alluvial deposits in the eastern part of the JOF Plant and pinches out near the river (Kellberg 1948). The Chattanooga Shale consists of grayish-black, fissile, carbonaceous shale with a thickness of seven to 75-feet at the site. The Chattanooga Shale is underlain by the Camden Formation. The Camden Formation is composed of hard, dense, brittle, light-gray, chert layers separated by softer gritty clay along bedding planes with a thickness of more than 100 feet. It is extremely fractured and fresh quarry faces break down rapidly.

The following figures show three-dimensional representations of the various geological deposits and CCR material. The first figure shows a lithologic model, including the locations of the CCR management units and the former Coal Yard and a representation of the extent of CCR material at the JOF Plant. The second figure shows the extent of the unconsolidated materials consisting primarily of silts and clays colored orange. The third figure shows the extent of unconsolidated materials consisting primarily of sand and gravel colored light yellow. The fourth figure shows the bedrock surface colored gray. The dikes surrounding the CCR management units are shown in the brighter yellow color.

JOF Plant CCR and Unconsolidated Materials

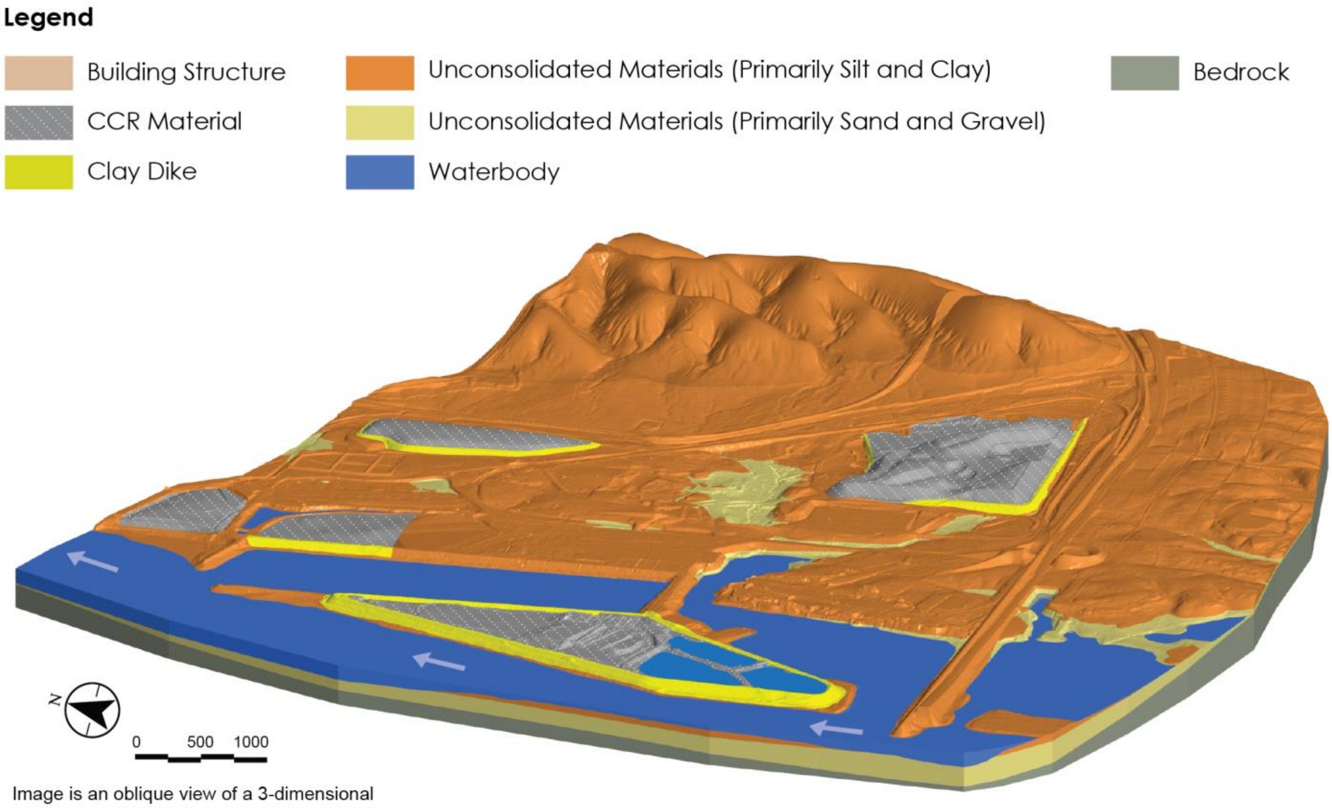


Image is an oblique view of a 3-dimensional model at 2.5X vertical exaggeration. The scale above is valid only in the horizontal direction.

JOF Plant Unconsolidated Materials (Primarily Silts and Clays)

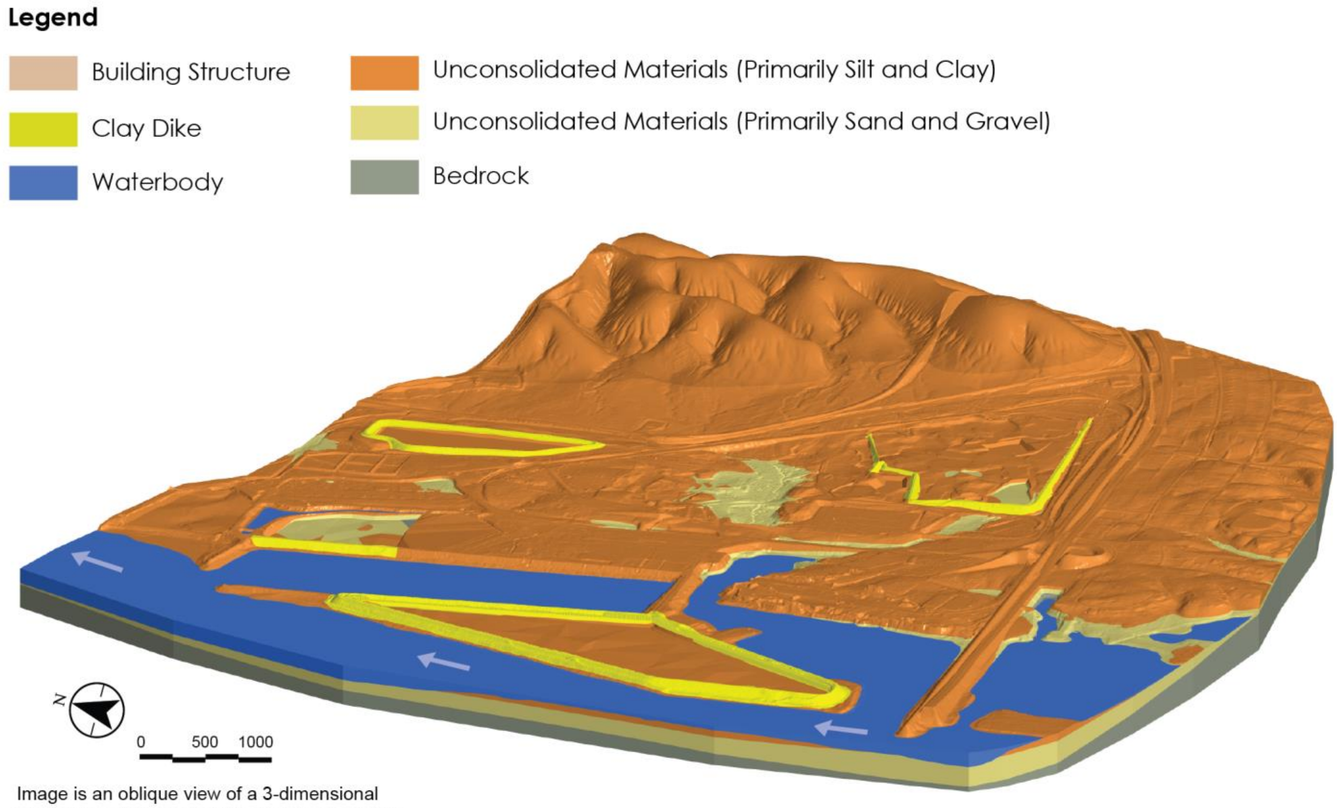


Image is an oblique view of a 3-dimensional model at 2.5X vertical exaggeration. The scale above is valid only in the horizontal direction.

JOF Plant Unconsolidated Materials (Primarily Sand and Gravel)

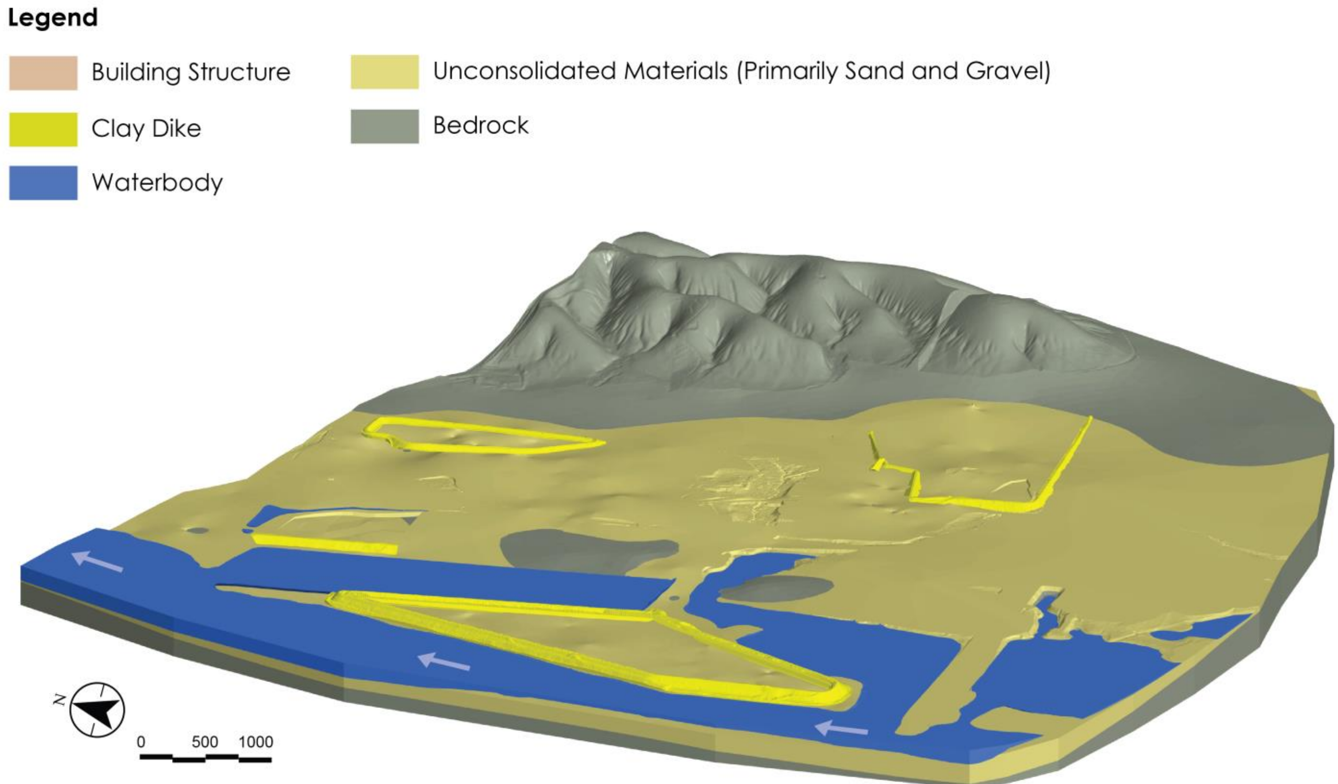


Image is an oblique view of a 3-dimensional model at 2.5X vertical exaggeration. The scale above is valid only in the horizontal direction.

JOF Plant Bedrock Surface

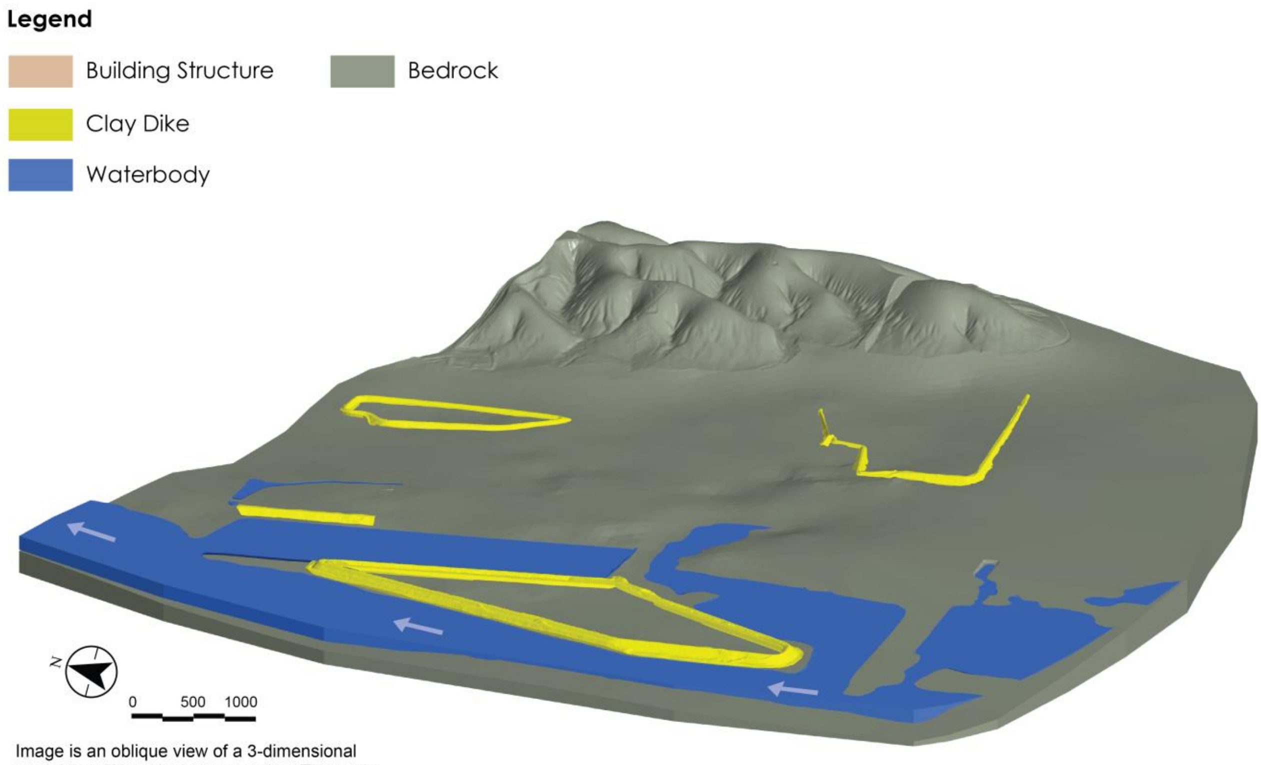


Image is an oblique view of a 3-dimensional model at 2.5X vertical exaggeration. The scale above is valid only in the horizontal direction.

Representative cross sections, showing the underlying lithologic units and CCR material are provided in Appendix D. Exhibit D-1 is a transect location map for the cross-sections. Exhibit D-2 depicts the profiles across Ash Disposal Area 1 and the DuPont Road Dredge Cell. Exhibit D-3 depicts the profile across South Rail Loop Area 4. Exhibit D-4 depicts the profiles across Active Ash Pond 2 and the former Coal Yard.

Hydrostratigraphic units are geological formations that have been defined to characterize the hydrogeology of the JOF Plant to understand where and how groundwater is flowing. In saturated geological formations that have higher permeability than adjacent formations, groundwater flows in a mostly horizontal direction. In saturated geological formations that have lower permeability than adjacent formations, groundwater flows in a more vertical direction. The more permeable geological formations capable of yielding useable quantities of groundwater are called aquifers. Aquifers are targeted for development as water sources by property owners. The less permeable geological formations are called aquitards.

The hydraulic characteristics of aquifers are used to classify them. If an aquifer is located between two aquitards, then the aquifer is called a confined aquifer. Groundwater can flow through aquitards into underlying aquifers, but the rate of flow is commonly much slower than the rate of flow within the aquifer. Aquifers can be considered confined even if they are not completely covered by an aquitard. For example, the Memphis aquifer in western Tennessee is a confined aquifer, yet it is known that the aquitard above the Memphis aquifer is thin or absent in some areas (USGS 1990).

In a confined aquifer, measured groundwater levels rise above the top of the aquifer. The difference between the measured groundwater levels within the aquifer and the top of the aquifer is called the pressure head. For confined aquifers, groundwater is not encountered in the interval shown as pressure head above the top of the aquifer because it is bounded by an upper aquitard, which also physically separates the groundwater from the geologic unit located above the upper aquitard. If an aquifer's boundary forms the water table, then the aquifer is called an unconfined aquifer.

In state and federal regulations, the term uppermost aquifer is used. This is the aquifer closest to ground surface. Regulations are designed to protect the groundwater in the uppermost aquifer because it could be used by property owners as a source of water. The term uppermost aquifer is used in this report.

5.1.3.3 Uppermost Aquifer and Groundwater Flow

This section provides a discussion of how groundwater flows at the JOF Plant. Groundwater flow occurs because gravity moves groundwater from areas of higher groundwater elevations to areas of lower elevations along flow paths that are generally perpendicular to groundwater elevation contours. Physiographic and hydrogeological features affect how groundwater flows. Hydrogeological barriers (i.e., rivers and surface streams) and divides (i.e., ridges that form watershed boundaries) bound the extent of groundwater flow. Groundwater flows toward, but not across, hydrogeological barriers and away from hydrogeological divides.

Based on the geology and hydraulic conductivities measured in the vicinity of Ash Disposal Area 1, the DuPont Road Dredge Cell, and South Rail Loop Area 4 CCR management units, the primarily sand and gravel interval in the unconsolidated materials above bedrock is defined as the uppermost aquifer and is under unconfined conditions.

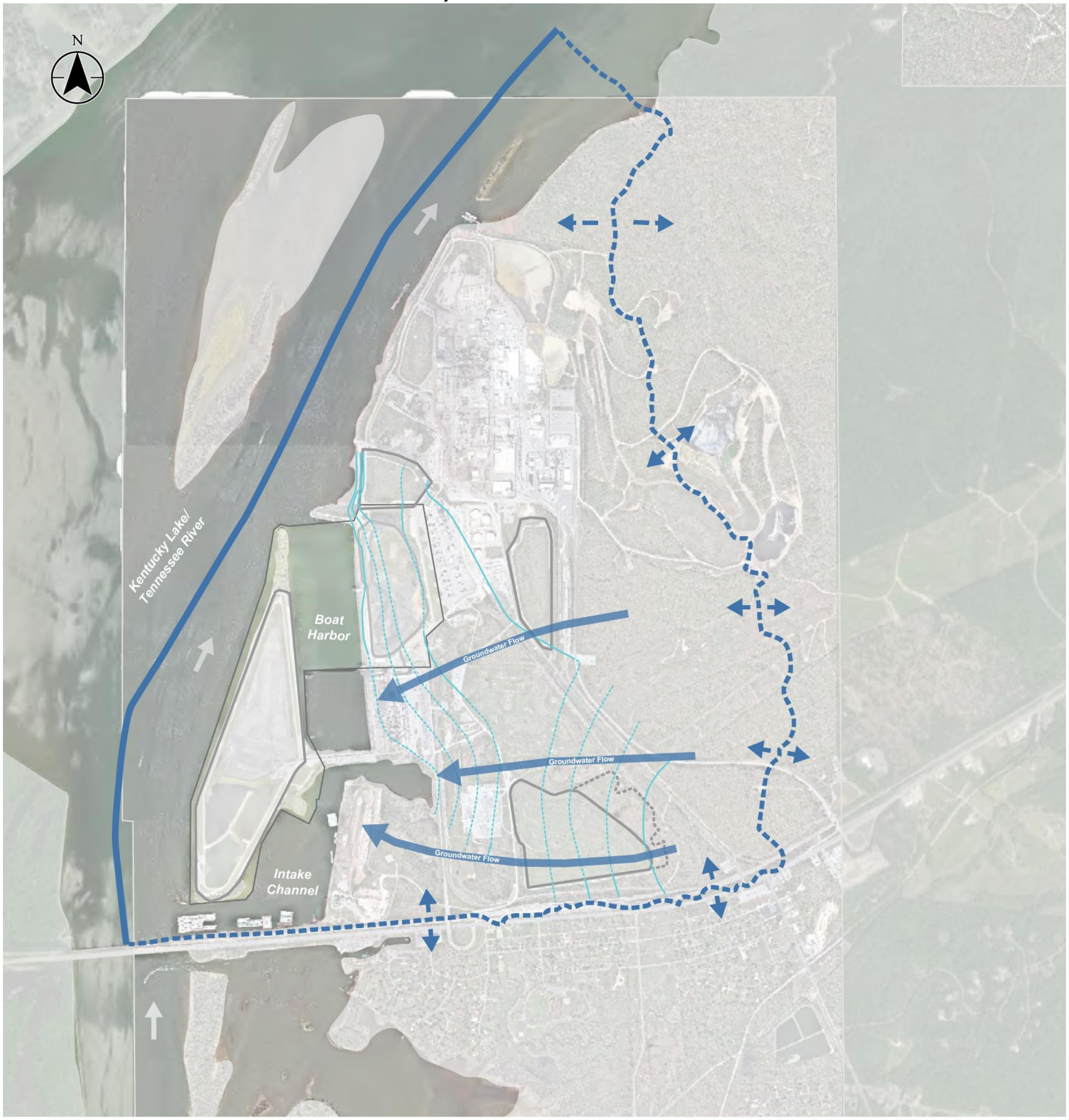
Based on the geology and hydraulic conductivities of geologic materials measured in the vicinity of the former Coal Yard, the primarily sand and gravel interval and the upper, highly fractured part of the Camden Chert are considered to be the uppermost aquifer, which is under unconfined conditions.

Based on the geology and hydraulic conductivities measured in the vicinity of Active Ash Pond 2, the primarily sand and gravel interval in the unconsolidated materials above bedrock is considered to be the uppermost aquifer. The uppermost aquifer is overlain by less permeable clay that is defined as an aquitard; therefore, the uppermost aquifer is a confined aquifer. Groundwater in a confined aquifer is not in contact with the CCR material inside the CCR management units where the aquitard is present because the aquitard physically separates them. Appendix H.1 provides additional details regarding the characterization of the uppermost aquifer and the distribution and thickness of the aquitard.

During the EI, groundwater levels were measured within the uppermost aquifer prior to the six groundwater sampling events to evaluate the direction and rate of groundwater flow in the uppermost aquifer. Surface water elevations were measured at the Tennessee River because the elevations of surface streams affect groundwater flow.

The available data indicated that groundwater generally flows west toward the Tennessee River. Calculated groundwater flow rates ranged from approximately five feet/year to 163 feet/year, which is generally much slower than water flow in surface streams or rivers. Flow rates in surface streams or rivers generally are measured in feet per second (USGS 1999). Exhibit 5-1 is a representative groundwater contour map. Physiographic features that affect groundwater flow in the vicinity of the JOF Plant include the steep topography of ridge to the east and the Tennessee River to the west of the CCR management units and former Coal Yard. In the vicinity of the CCR management units and the former Coal Yard, groundwater flow is bounded to the west by the Tennessee River. Groundwater flow directions, boundaries, and topographic divides are shown in the following figure. Additional discussion of the hydrogeology and groundwater flow is provided in Appendix H.1.

Groundwater Flow Directions, Boundaries and Divides



Legend

- Interpolated Groundwater Contour
- Groundwater Contour (5 ft interval; elevations are in ft amsl)
- Surface stream that bounds groundwater flow
- Hydrogeological Divide
- Generalized groundwater flow direction
- CCR Unit Area (Approximate)
- Former Stilling Pond (Approximate)
- Former Coal Yard (Approximate)

Notes: Groundwater contours included to illustrate general groundwater flow directions. See Exhibit 5-1, Groundwater Elevation Contour Map Event #5 (August 10-11, 2020), for actual groundwater elevations and groundwater contours.

5.1.3.4 Dye Trace Study

As a subtask to the groundwater and hydrogeologic investigations, a dye trace study was conducted to evaluate if preferential hydrogeologic pathways are present between the Active Ash Pond 2 and the underlying alluvial aquifer and surrounding surface water (Kentucky Lake/Tennessee River). EI field activities were performed in general accordance with the following documents: *Dye Trace Study SAP* (Stantec 2018g), *Quality Assurance Management Plan* (EWC 2020).

The approach and scope of the dye trace study consisted of four phases: bench study, background study, dye injections, and post-injection sampling and analysis. To conduct the dye injections, five borings were advanced along the centerline of Active Ash Pond 2 to depths just above the base of the CCR management unit. Two separate dyes were used to investigate potential differences in flow within the southern and northern parts of Active Ash Pond 2. Surface water and groundwater monitoring locations around the periphery of Active Ash Pond 2 were sampled for six months at weekly and biweekly intervals. These sampling locations are depicted on Exhibit 5-2.

The dye from the injections was not detected in surface water and only detected at one groundwater monitoring location (JOF-104). The results of the dye trace study showed a connection between Active Ash Pond 2 and monitoring well JOF-104, but no other positive results were reported. Based on this information, no preferential transport pathways between Active Ash Pond 2 and the Tennessee River were observed during the dye trace study. The results of these sampling activities are summarized in the *SAR for Active Ash Pond 2 Dye Trace Study* in Appendix H.9.

5.1.3.5 Groundwater / Surface Water / Pore Water Relationship

TVA measured pore water levels within the temporary wells monthly for six months. In addition, the wells were gauged during bi-monthly groundwater sampling events. This information was combined with available information from other instruments to develop maps of the phreatic surfaces for the former Coal Yard, the DuPont Road Dredge Cell, South Rail Loop Area 4, and Active Ash Pond 2 at the time of gauging. A phreatic surface map was not developed for Ash Disposal Area 1 because this CCR management unit has only two pore water data points, which are not sufficient to provide a representative contour map. The phreatic surface is the surface of pore water at which pressure is atmospheric and below which CCR material may be saturated with pore water. The use of the term “saturated” or references to the moisture content of CCR material does not imply that the pore water is readily separable from the CCR material. Saturated CCR material can have a range of moisture contents based on the characteristics of the material. In addition, some of the other instruments that measure pore water, groundwater, and surface stream levels have been automated to provide time-series data, which have been plotted to evaluate the relationships of the elevations of pore water, groundwater, and surface streams. Detailed discussion of these relationships is provided below and in Appendix H.1.

Generally, the available groundwater level data indicated that pore water levels were higher than groundwater levels in the uppermost aquifers in the vicinity of the CCR management units and the former Coal Yard. This suggests that the low permeabilities of the perimeter dikes impede lateral and vertical flow of pore water out of the CCR management units and former Coal Yard. Available information indicates that pore water levels are not causing a reversal of the groundwater flow direction along the upgradient edge of these CCR management units or the former Coal Yard (sometimes referred to as mounding).

Groundwater, pore water, and surface stream level fluctuations were compared to each other to evaluate the correlations of changes in water levels between the three media. Pore water levels within the CCR management units and the former Coal Yard and groundwater levels within the uppermost aquifers responded differently to Tennessee River stage fluctuations and precipitation events. For Ash Disposal Area 1, there was a subdued correlation of fluctuations in groundwater and pore water elevations with the Tennessee River stage. In addition, both groundwater and pore water elevations showed decreases that correlated with the lowering of the water level within the Coal Yard Runoff Pond. For the former Coal Yard, there is a subdued correlation of fluctuations in groundwater and pore water elevations with the Tennessee River stage, except for well JOF-112. Well JOF-112 showed a decrease in groundwater elevations that correlated with the lowering of the water level within the Coal Yard Runoff Pond.

For the DuPont Road Dredge Cell, the fluctuations in groundwater elevations correlated with seasonal precipitation patterns. There has been a downward trend in the pore water elevations surface since the geosynthetic caps were installed. Pore water elevations did not correlate with the Tennessee River stage or precipitation. For South Rail Loop Area 4, the fluctuations in groundwater, except for well B-6R which were stable, and pore water elevations correlated with seasonal precipitation patterns.

For Active Ash Pond 2, the fluctuations in groundwater elevations correlated with the Tennessee River stage. Pore water elevations did not correlate with the Tennessee River stage or seasonal precipitation patterns. The fluctuations in pore water elevations are interpreted to be affected by precipitation events and operation of the pool levels within the CCR management unit.

The pore water levels reported herein may not represent steady-state conditions. The low permeability of the geosynthetic caps is expected to result in the continued decrease in pore water levels in the DuPont Road Dredge Cell and South Rail Loop Area 4. The pore water levels within Ash Disposal Area 1, the former Coal Yard, and Active Ash Pond 2 would be expected to decrease in elevation if stormwater drainage or cap modifications were to be implemented. The low permeability of the perimeter dikes limits lateral flow into or out of the CCR management units.

5.1.3.6 Groundwater Quality Evaluation

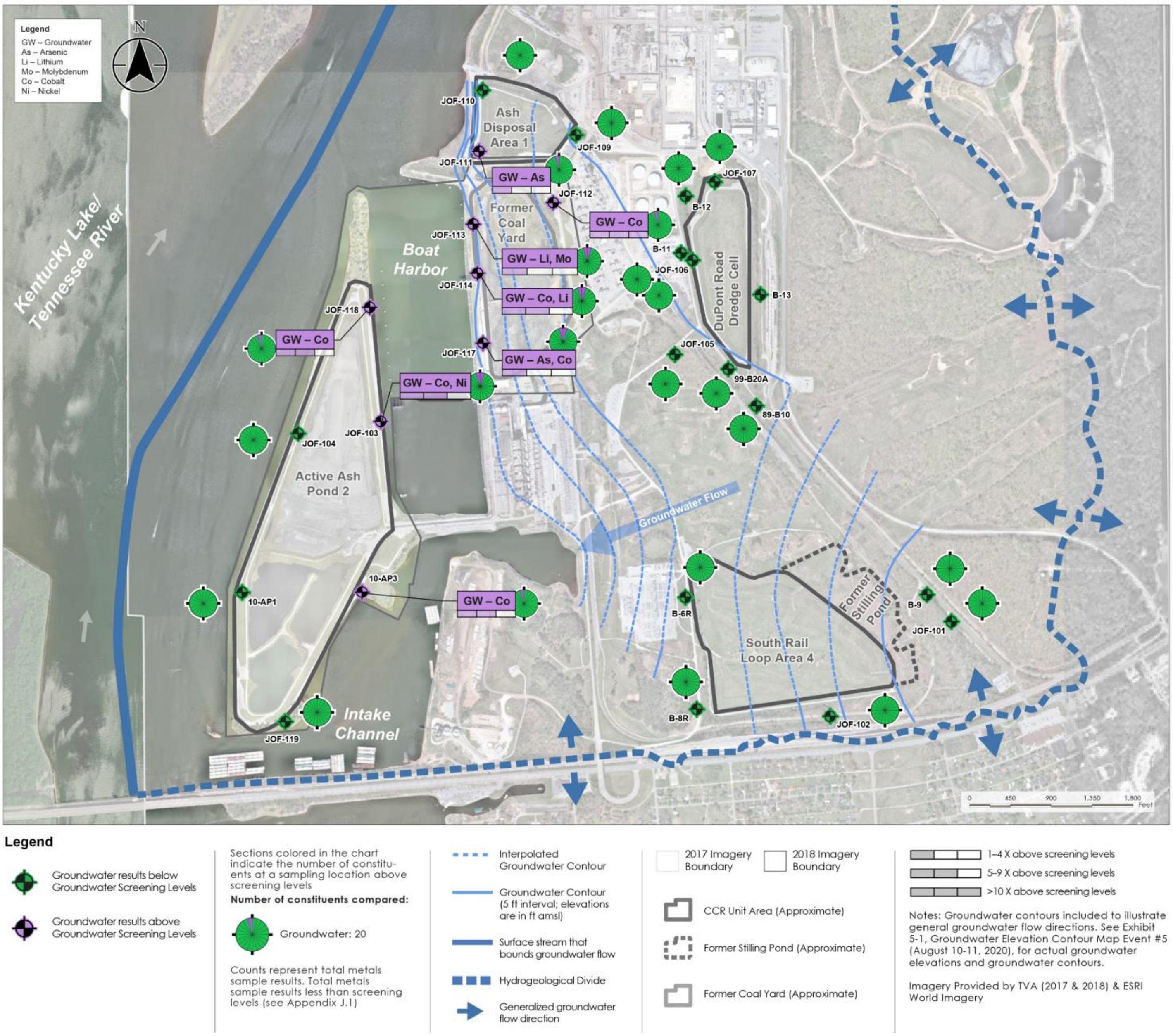
This section provides a discussion of the analytical results for groundwater samples collected from monitoring wells installed as part of the EI and previously installed wells monitored as part of the TDEC permitted landfill and CCR Rule groundwater monitoring programs. The groundwater quality evaluation is based on a statistical evaluation of constituents listed in Appendix I of TDEC Rule 0400-11-01-.04 (TDEC Appendix I) and Appendices III and IV of the CCR Rule. The analytical results were compared to GSLs approved by TDEC (see Table 1-1 and Appendix A.2). The statistical evaluation of groundwater analytical data is provided in Appendix E.3. Additional discussion of the results of the statistical evaluation are provided in Appendix H.1.

The dataset compiled for statistical analysis includes available analytical data for groundwater samples collected between March 2015 and February 2023, although the specific start date and frequency of sampling may vary between wells based on date of well installation and the applicable monitoring program. This time period was selected because it includes data that met the requirements of the data quality objectives for the TDEC Order program.

Downgradient of the CCR management units, four CCR Rule Appendix IV CCR constituents (some of which are also TDEC Appendix I constituents) had statistically significant concentrations in onsite groundwater above a GSL in seven downgradient wells that require further evaluation in the CARA Plan to determine the need for corrective action that will be based on statistically significant concentrations above an established GWPS. These constituents include arsenic (JOF-111 and JOF-117), cobalt (10-AP3, JOF-103, JOF-114, JOF-117, and JOF-118), lithium (JOF-113 and JOF-114), and molybdenum (JOF-113). One CCR Rule Appendix IV constituent (cobalt) had a statistically significant concentration in onsite groundwater above a GSL in one upgradient well (JOF-112). One additional TDEC Appendix I constituent (nickel) had a statistically significant concentration in onsite groundwater above a GSL in one well (JOF-103). Four wells had only one constituent with a statistically significant concentration greater than a GSL, and four wells had two constituents with statistically significant concentrations above a GSL. The groundwater impacts described above are limited to onsite areas along the perimeter of the CCR management units.

The following figure shows the results of the statistical evaluation of CCR Rule Appendix IV and TDEC Appendix I constituents. Each monitoring well is represented by a symbol that is divided into 20 slices within a circle. The slices are colored green for each of the 20 CCR constituents that was detected at concentrations below the GSLs. Slices colored purple represent constituents that were detected above GSLs. The small boxes provide the constituents that were detected above the GSL. The bars below the boxes provide a gauge for how much the concentrations were above the GSL. See the legend in the figure for further explanation of the symbols. Additional discussion of the results of the statistical evaluation are provided in Appendix H.1.

Groundwater Findings Near the JOF Plant CCR Management Units



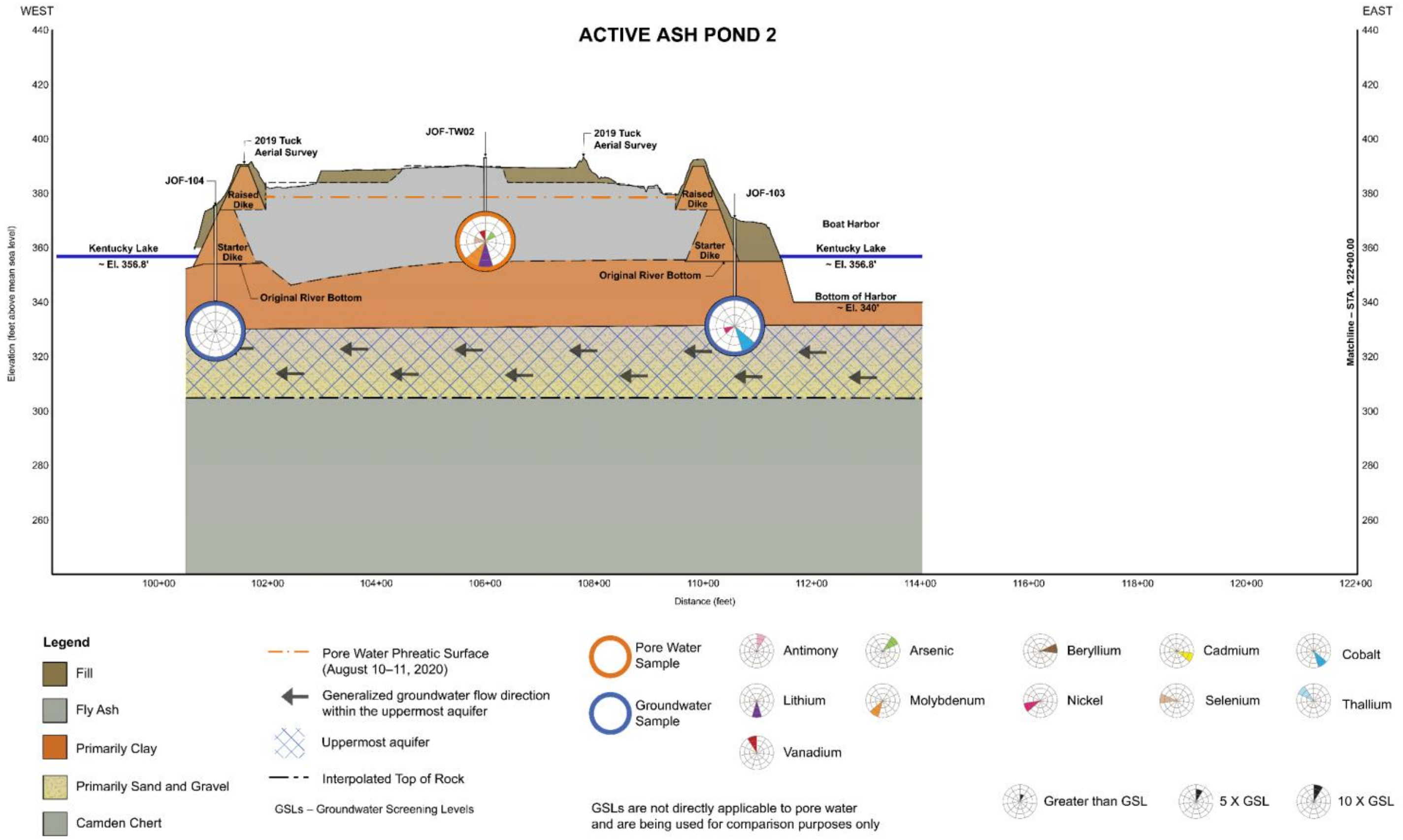
The figure shows that most constituents were detected below the GSLs. Eight wells had constituents with statistically significant concentrations above a GSL.

In addition, the quality of pore water was compared to groundwater quality. The following two figures illustrate the difference between pore water quality (symbol with orange outer ring) measured within the CCR management units and groundwater quality (symbol with blue outer ring) measured at the edge of the CCR management units. The first figure is a plan view showing the differences in water quality by comparison of the colors within the symbols. The CCR constituents detected are represented by different colors, as shown in the legend. The relative concentration of the constituent detected compared to the GSLs is represented by the number of colored sections within each slice.

The second figure is a cross section through Active Ash Pond 2 that also shows the same differences in water quality. These two figures show that generally the constituents detected in downgradient groundwater along the edge of the CCR management units are different than those detected in pore water within the CCR management units or that they were detected at lower concentrations. This can be explained by geochemical reactions that can occur as water flows through natural geological materials. In addition, cobalt was detected in the upgradient well of the former Coal Yard.

Pore Water and Groundwater Concentration Comparison

Cross Section View of Pore Water and Groundwater Comparison



5.2 Geochemical Evaluation of Groundwater Data

Groundwater quality is affected by numerous geochemical processes during groundwater flow through geological materials. The distinct difference between the chemical characteristics of pore water within the CCR material, presented in Chapter 4, and the characteristics of groundwater quality downgradient of the CCR management units and former Coal Yard at the JOF Plant is difficult to explain without the aid of geochemistry. It is well documented in the literature that certain CCR constituents that are detected in pore water (typically at higher concentrations than in groundwater) can be affected by geochemical processes that occur between constituents dissolved in groundwater and geological materials through which it flows. The effects of these geochemical processes, which often result in the attenuation of CCR constituents (i.e., reduced concentrations) can explain observed differences between the characteristics of pore water and groundwater. The extent of the interactions between dissolved constituents in groundwater and geological materials ranges from limited interaction for constituents such as boron, chloride, and sulfate, to strong interactions for constituents such as arsenic and cobalt.

Observations of groundwater and pore water chemistry can indicate the extent to which geochemical processes chemically change groundwater and influence groundwater quality at the JOF Plant. Boron, chloride, and sulfate commonly occur in high concentrations in pore water and are minimally attenuated by geochemical processes. Thus, they can be used to infer locations in the groundwater monitoring program where there is an influence from pore water. In contrast, those CCR constituents most likely to be influenced by interactions between geological materials and groundwater (e.g., arsenic, lithium, and molybdenum) typically show concentrations in groundwater monitoring wells that are much different than those observed in pore water, indicating that groundwater is being chemically changed relative to pore water by some physical or geochemical process (or a combination of both) occurring as it flows through geological materials.

Understanding the geochemistry of geological materials is important in interpreting the processes influencing current conditions of groundwater chemistry at the JOF Plant and evaluating effects of activities, such as drainage modifications or groundwater remediation, on the evolution of groundwater quality. Further evaluation of the geochemical processes acting in the upgradient system at the JOF Plant to influence groundwater quality will be included in the CARA Plan during assessments of remedies, where needed.

5.3 Water Use Survey

The objectives of the EI water use survey are to identify and sample usable private water supply wells and surface water sources potentially being used for domestic purposes within 0.5-mile of the boundary of the JOF Plant, herein referred to as the Survey Area as outlined in the EIP and shown in the figure below. For this study, TVA defined a usable water well to be one that will house a pump (even if a pump is not currently present) and does not contain an obstruction or defective construction that would prevent the insertion or operation of a pump. A detailed discussion of the water use survey is provided in Appendix H.10.

This EAR provides the results of the initial desktop survey phase of the water use survey intended to identify usable water wells and springs within the Survey Area.

5.3.1 Desktop Survey

The first step of the water use survey was a desktop survey (the Survey) to identify usable private wells and springs. This included a review of registered well information obtained from TDEC, historical hydrogeologic reports, aerial photographs, and contacting public water supply providers in the vicinity of the JOF Plant. The goal of the Survey was to identify potential and known wells or springs within the Survey Area.

5.3.1.1 Desktop Survey Results

Based on the results of the Survey, four parcels were identified in the Survey Area that may have up to five potentially usable wells used for domestic or business purposes. No springs were identified in the Survey Area.

5.3.1.2 Usable Water Well and/or Spring Identification

In addition to conducting the Survey, the JOF Water Use Survey SAP outlines a process to identify offsite areas where groundwater has the potential to be affected by the JOF Plant CCR management units or former Coal Yard using results of investigative activities required as part of the EI. This process includes consideration of geologic and hydrogeologic conditions (i.e., hydraulic barriers [rivers/streams], topography, groundwater flow direction, and watershed boundaries).

As shown in the figure below, the JOF Plant is adjacent to the eastern shore of the Tennessee River. A key characteristic of the setting is that the JOF Plant is situated in a low-lying area along the Tennessee River with a higher elevation ridge to the east of the plant and a watershed boundary along the southern border. Mimicking topography, groundwater flows west/southwest across the JOF Plant area towards the Tennessee River. In general, groundwater elevation contours follow surface topography, and groundwater flows from areas of higher elevation towards Tennessee River.

Based on the geologic and hydrogeologic conditions present at and in the vicinity of the JOF Plant, parcels containing a well or spring located west of the JOF Plant would have the greatest likelihood of being downgradient of the JOF Plant CCR management units or the former Coal Yard. Potable water wells screened in overburden or bedrock located east, north, and south of the JOF Plant CCR management units would have a low likelihood of being impacted from groundwater associated with JOF Plant CCR management units or former Coal Yard based on the current groundwater flow pattern.

Hydrogeological Investigations

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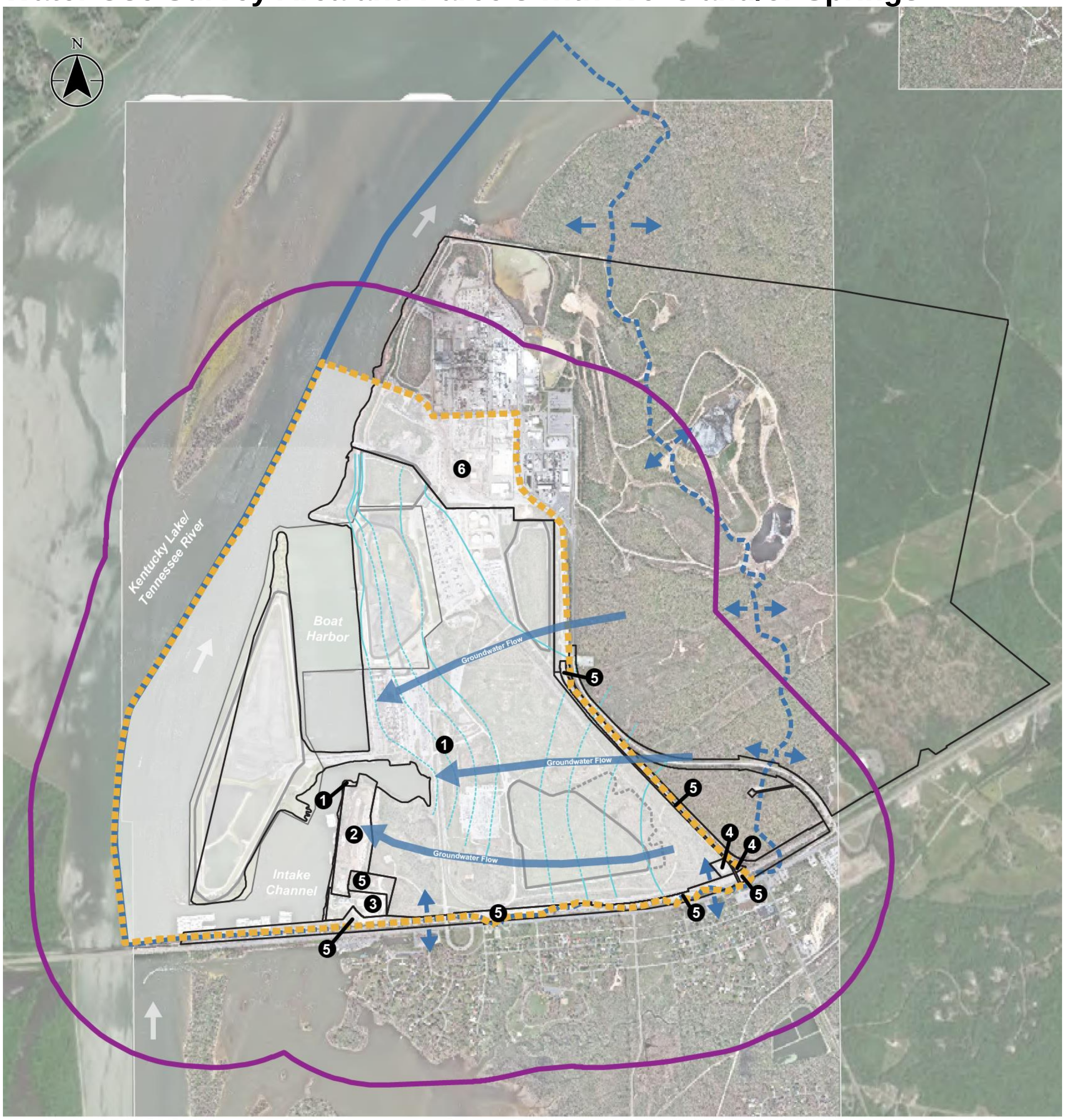
Water Use Survey Area and Parcels with Wells and/or Springs



Legend

- Interpolated Groundwater Contour
- Groundwater Contour (5 ft interval; elevations are in ft amsl)
- Surface stream that bounds groundwater flow
- Hydrogeological Divide
- Generalized groundwater flow direction
- CCR Unit Area (Approximate)
- Former Stilling Pond (Approximate)
- Former Coal Yard (Approximate)
- WUS Survey Area
- Water Use Survey Area of Interest
- Parcel Identified for Water Use Survey
- # Parcel Identifier

Notes: Groundwater contours included to illustrate general groundwater flow directions. See Exhibit 5-1, Groundwater Elevation Contour Map Event #5 (August 10-11, 2020), for actual groundwater elevations and groundwater contours.

Considering the geologic and hydrogeologic conditions present at and in the vicinity of the JOF Plant resulted in an Area of Interest within the Survey Area. This Area of Interest, shown in the figure above, contains six parcels that have the potential of being impacted by CCR management operations. Planned efforts to contact parcel owners in this area will determine if additional wells or springs are present. These efforts will be initiated upon TDEC's concurrence with the approach and parcels identified. Results of the updated Water Use Survey will be reported in EAR Revision 1.

5.4 Hydrogeological Investigation Summary

The objectives of the TDEC Order hydrogeological and groundwater investigations were to characterize the hydrogeology and groundwater quality and evaluate groundwater flow conditions in the vicinity of the JOF Plant CCR management units. The key findings of the JOF Plant hydrogeological and groundwater investigations are summarized below:

- TVA evaluated analytical results for groundwater in support of the EAR based on data collected under three groundwater monitoring programs (some of which overlap), including the EI, CCR Rule, and TDEC permitted landfill monitoring programs. Monitoring well locations and CCR constituents that will require further evaluation in the CARA Plan are provided below.

Summary of Findings Requiring Further Evaluation in the CARA Plan	
CCR Management Unit	**Groundwater**
Ash Disposal Area 1	Arsenic (Well JOF-111)
Active Ash Pond 2	Cobalt (Wells 10-AP3, JOF-103 and JOF-118) Nickel (Well JOF-103)
Former Coal Yard*	Arsenic (Well JOF-117) Cobalt (Wells JOF-112, JOF-114 and JOF-117) Lithium (Wells JOF-113 and JOF-114) Molybdenum (Well JOF-113)
South Rail Loop Area 4	None
DuPont Road Dredge Cell	None

*Not a CCR management unit

- Drainage improvements or potential corrective actions are expected to reduce concentrations of CCR constituents to below GSLs in groundwater at downgradient monitoring locations for Active Ash Pond 2, Ash Disposal Area 1, and the former Coal Yard

- Pore water within the CCR material has specific chemical characteristics that are different from the characteristics of groundwater downgradient of the CCR management units. Certain CCR constituents that have been detected in pore water are affected by geochemical processes during groundwater flow through geological materials. The effect of these geochemical processes, which can result in the attenuation of CCR constituents and reduced dissolved groundwater concentrations, can explain the observed differences between the characteristics of pore water and groundwater quality.

- The pore water levels reported herein may not represent steady-state conditions. The low permeability of the geosynthetic caps is expected to result in the continued decrease in pore water levels in the DuPont Road Dredge Cell and South Rail Loop Area 4. The pore water levels within Ash Disposal Area 1, the former Coal Yard, and Active Ash Pond 2 would be expected to decrease in elevation if stormwater drainage or cap modifications were to be implemented. The low permeability of the perimeter dikes limits lateral flow into or out of the CCR management units. The results of the dye trace study support this conclusion for Active Ash Pond 2 because it indicated that there are no preferential transport pathways between the CCR management unit and the Tennessee River. The use of the term “saturated” or references to the moisture content of CCR material does not imply that the pore water is readily separable from the CCR material.

- The coarse-grained unconsolidated materials, and Camden Chert beneath the former Coal Yard, are considered to be the uppermost aquifer and are under unconfined conditions, except in the vicinity of Active Ash Pond 2. The uppermost aquifer in the vicinity of Active Ash Pond 2 is the coarse-grained unconsolidated materials and is considered confined because it is overlain by fine-grained unconsolidated materials that act as an aquitard.

- The groundwater flow direction within the uppermost aquifer beneath the CCR management units and former Coal Yard is generally to the west-southwest toward the Tennessee River. Groundwater flow in the vicinity of the CCR management units is bounded to the west by the Tennessee River. A higher elevation ridge to the east of the plant and a watershed boundary along the southern border are topographic divides for groundwater flow.

TVA will continue to monitor the trends of arsenic, cobalt, lithium, molybdenum, and nickel and conduct further evaluation in the CARA Plan to determine if corrective actions are needed. The influence of geochemical processes on groundwater quality will be further evaluated in the CARA Plan as part of the assessment of remedies, where needed.

Chapter 6 Seep Investigation

To evaluate potentially active seeps and collect data to assess potential seepage to surface water streams adjacent to the JOF Plant CCR management units, TVA reviewed historical seep management information and conducted a seep investigation as part of the TDEC Order EI. A summary of the historical seep information for the JOF Plant CCR management units is presented in Chapter 6.1. Because historical seep management at the CCR management units did not include collecting soil or surface water for analysis, samples of these media were obtained and analyzed for the EI as described in Chapter 6.2. The overall evaluation of the EI seep investigation results, including relevant historical data, are presented in Chapter 6.3. Additional information regarding the investigation field activities and sampling results is provided in the *Seep SAR* (Appendix I.1).

6.1 Historical Information

This section provides a brief summary of the available historical information that formed the basis of scope of the EI seep investigation. A detailed compilation of historical seep locations, remedial actions, and monitoring actions is presented in the EIP (Appendix T).

TVA has conducted annual CCR management unit dike inspections since 1967. TVA historically performed visual inspections of the dikes and toe areas in accordance with NPDES Permit No. TN0005444. (Note: The property is currently addressed as part of NPDES permit No. TNR05318 for the Johnsonville Combustion Turbines Plant). Historical reports and inspections identified seeps, evaluated potential impacts, and documented remedial activities as summarized in the EIP. Historically, TVA addressed wet areas and potential seepage areas in a conservative manner to anticipate possible structural concerns at the CCR management units. Identified wet areas were classified as seeps unless observational evidence suggested an alternative water source such as poor drainage or precipitation. 22 historical seeps were included in the EI and are identified on Exhibits 6-1 and 6-2.

Historical Seep Nos. 1D, 4A, 4B, 4C, 5, 6 and 13 are not located adjacent to surface water and were not included in the EI. Historical Seep Nos. 5A and 5B were located along the dike of Dupont Road Dredge Cell and were included in the EI. Historical Seep Nos.1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, and 13 were located adjacent to the Intake Channel, the Boat Harbor or the Kentucky Lake/Tennessee River and were included in the EIP (Appendix I.1).

6.2 TDEC Order Investigation Activities

The primary objectives of the TDEC Order EI seep investigation at the JOF Plant CCR management units were to identify and collect information regarding the potential presence of active seepage, and if identified, evaluate the data obtained to assess potential movement of groundwater or pore water with dissolved CCR constituents into adjacent surface water streams. Seep investigation field activities and statistical evaluation of the data collected were performed in general accordance with the *Seep SAP* (Stantec 2018i) and the *QAPP* (EnvStds 2018b), including TVA- and TDEC-approved programmatic and project-specific changes made following approval of the EIP. Sample location selection, collection methodology, analyses, and QA/QC completed for the investigation are provided in the *Seep SAR* included in Appendix I.1.

The seep investigation consisted of inspecting accessible areas by foot or vehicle; investigating inaccessible areas (i.e., structural mitigation areas covered by riprap) by boat; observing exposed shoreline in areas where historical seep locations could only be accessed by boat; measuring field parameters in surface water in areas monitored by boat; collecting soil and water samples associated with potentially active seeps, referred to herein as areas of interest (AOIs); and conducting weekly inspections at applicable AOIs.

6.3 Seep Investigation Results Summary

Based on the investigation findings, three AOIs were identified at the JOF Plant. Further detail is presented below.

Visual Inspections

During the visual walkdown inspection conducted by TVA and TDEC on September 24, 2019, no signs of wetness were noted at Historical Seep Nos. 1, 3, 4, 5, 5A, 5B, 6, 7, 8, 9, 11, 12, and 13. However, two AOIs were identified (Exhibits 6-1 and 6-2):

- AOI01 – Identified as a red coloration of riprap downslope of riprap near Historical Seep No. 2, northeast of Active Ash Pond 2 and adjacent to the Boat Harbor; no signs of visible active flow, standing water or wetness were noted
- AOI02 – Identified as a red coloration and clear flowing water from the base of the riprap to the water downslope of riprap in proximity to Historical Seeps Nos. 1A, 1B, and 1C southwest of Ash Disposal Area 1 and adjacent to the Kentucky Lake/Tennessee River.

A third AOI was visually identified by TVA on September 25, 2019 by boat:

- AOI03 – Identified near Historical Seep No. 4, at the west end of the causeway leading to Active Ash Pond 2 and adjacent to the Boat Harbor based on the presence of active flow and red coloration.

Inaccessible Area Inspections

Four historical seeps were identified in areas adjacent to Kentucky Lake/Tennessee River and the Boat Harbor banks for additional investigation by boat during the September 2019 inspection. Field measurements of water quality parameters including pH, specific conductance, dissolved oxygen, and temperature were conducted at 182 locations adjacent to and at intermediate locations between the historical seeps from September 24 through September 26, 2019. The measurements were generally conducted in areas that were covered with riprap and accessible by boat. A statistical analysis of the results was performed to evaluate whether there were statistically significant differences between areas adjacent to and upstream of potential seep locations. As detailed in Appendix E.4, the statistical results indicated that there were no adjacent locations where the four measured water quality parameters indicated statistically significant differences when compared with upstream locations. Based on the statistical analysis of water quality parameter measurements, no additional AOIs were identified in inaccessible (i.e., riprap-covered) areas for further investigation or data collection in the EI, nor is there a need for further evaluation of these results in the CARA Plan.

AOI Monitoring and Sampling

Based on the results of the site inspections, the three AOIs were monitored visually on an approximately weekly basis at AOI01 and AOI03 from November 2019 through March 2020, and at AOI02 from October 2019 through March 2020. When AOI01 was exposed, standing water was generally present in one area with no flow. If standing water was observed, an iridescent sheen and reddish-brown coloration were usually present. When AOI02 was exposed, standing water was usually present in one to three areas with no flow. An iridescent sheen and reddish-brown coloration also were observed. Consistent flow (approximately one gallon per minute) was observed at AOI03. Based on weekly observations, conditions did not appear to be associated with precipitation.

Surficial soil and water samples were collected at AOI01 on October 1, 2020, at AOI02 on April 9, 2020, and at AOI03 on February 5, 2021 for analysis of CCR parameters. Sample collection and analysis information and data results are provided in Appendix I.

Supplemental Actions and Investigations

AOI01, AOI02, and AOI03 were subsequently inspected visually for 21 monthly events between August 2021 and April 2023. In addition, the Coal Yard Runoff Pond was drawn down beginning on September 1, 2021, and water levels were measured in select proximal groundwater monitoring wells during this same period to evaluate the effectiveness of the drawdown. Water levels decreased up to approximately four feet in select wells. Soil and water samples were also collected at AOI03 and analyzed for CCR parameters as part of five quarterly sampling events conducted October 2021 through October 2022. A water recovery and treatment system was approved by TDEC and installed to capture flow at AOI03 in early 2023 and no further action is planned. The results of the supplemental actions and investigations at AOI1 and AOI2 will be further evaluated and documented in the CARA Plan.

Chapter 7 Surface Streams, Sediment, and Ecological Investigations

To characterize environmental conditions and evaluate potential impacts to surface streams, sediments, and associated ecological receptors in the vicinity of the JOF Plant, TVA reviewed information from historical studies, and performed surface water, sediment, benthic macroinvertebrate community, mayfly tissue, and fish tissue investigations as part of the EI. EI field activities were performed in general accordance with the following documents: *Surface Stream SAP* (Stantec 2018j), *Benthic SAP* (Stantec 2018k), *Fish Tissue SAP* (Stantec 2018l), and the *QAPP* (EnvStds 2018b), including TVA- and TDEC-approved programmatic and project-specific changes made after approval of the EIP. As described below, the scopes of these investigations varied, but environmental media generally were sampled upstream, adjacent, and downstream of the JOF Plant CCR management units.

The following sections summarize historical and EI activities, and present overall investigation and evaluation findings for surface stream water, sediment, benthic invertebrate community, mayfly tissue, and fish tissue based on data obtained during previous studies and the EI. Statistical analyses of the surface stream water, sediment, mayfly tissue, and fish tissue data are provided in Appendices E.5 through E.8, respectively. A detailed technical evaluation of these results and associated SARs are provided in Appendices J.1 through J.6.

7.1 Previous Studies and Assessments

7.1.1 Surface Stream Studies and Ongoing Monitoring Activities

Biological community monitoring of the Tennessee River in the vicinity of the JOF Plant was performed in autumn of 2010 and in summer and autumn 2011. To accompany the biological data, general water quality parameters were measured in-situ, including temperature, conductivity, dissolved oxygen, and pH. The studies found that upstream and downstream aquatic communities near the JOF Plant were ecologically similar. TVA concluded that the JOF Plant thermal effluent was not adversely affecting downstream biological communities, and that water quality was satisfactory for aquatic life use. Outside of TDEC Order investigation activities, there are no current or ongoing surface water monitoring programs at the JOF Plant.

7.1.2 Sediment and Benthic Invertebrate Studies

TVA collected sediment samples from 1990 to 2015 from two established locations in the Tennessee River, at Tennessee River Mile (TRM) 23.0 and 85.0. These samples were collected downstream from the JOF Plant (TRM 99.0) (TVA 2017). From 1993 to 2015, sediment samples also were collected from a location in the Big Sandy River Embayment, more than 30 miles downstream from the JOF Plant. In 2003 and 2006, sediment samples were collected from seven additional embayments located upstream and downstream from the JOF Plant, the nearest of which is the Birdsong Creek Embayment located approximately five miles upstream (TVA 2017). Sediment samples were analyzed for multiple parameters including some CCR Parameters (arsenic, cadmium, calcium, chromium, copper, lead, mercury, nickel, selenium, and zinc).

TVA has conducted biological assessments by periodically monitoring aquatic communities (fish and benthic invertebrates) to evaluate their status upstream and downstream of the JOF Plant as detailed in Appendix J.3. In 2010 and 2011, benthic invertebrate assessments were conducted to determine if Clean Water Act (CWA) Section 316(a) alternate thermal limits (ATLs) established for the JOF Plant thermal discharge were protective of a Balanced Indigenous Population (BIP) of aquatic life (TVA 2011 and 2012).

The 2010 and 2011 JOF Plant benthic sample results showed overall similarities between the upstream and downstream benthic sample locations — in numbers of species, mean densities, and relative compositions of functional feeding groups. Generally, the benthic invertebrate community structure demonstrates that an abundant and diverse community is present both downstream and upstream of the JOF Plant (TVA 2011 and 2012).

Mayfly collections during previous studies were limited to those incorporated into the Reservoir Benthic Index (RBI) sampling conducted as part of the above referenced activities in 2010 and 2011.

7.1.3 Fish Community and Fish Tissue Studies

As noted above, TVA has conducted biological assessments by periodically monitoring aquatic communities (fish and benthic invertebrates) to evaluate their status upstream and downstream of the JOF Plant. Historical fish population assessments were completed in the mid-1970s, 1980s, and annually during 2001-2003, 2005, and 2007-2019, as detailed in Appendix J.5. Since 2008, assessments have been conducted annually in accordance with the JOF Plant NPDES Permit. Additionally, sport fish surveys, fish impingement monitoring and entrainment studies were conducted, with one historical study including the collection and analysis of fish tissue. Conclusions based on previous fish population assessments and tissue studies near the JOF Plant are as follows:

Fish Population Monitoring. The initial CWA Section 316(a) study concluded that JOF Plant operations had little or no measurable impact on Kentucky Reservoir fish populations (TVA 1974). Subsequent cove rotenone studies supported these initial conclusions and found that fish populations near the JOF Plant were similar to those in other areas of the Kentucky Reservoir (TVA 1981). In addition, Reservoir Fish Assemblage Index (RFAI) results for the 2001 to 2011 fish community monitoring concluded that the river met BIP criteria at upstream and downstream locations. RFAI scores at the downstream locations showed that fish communities were similar to the upstream control site. Based on these results, TVA concluded the JOF Plant thermal effluent was not adversely affecting downstream fish communities (TVA 2011, 2012). This was supported by TDEC's confirmation of TVA’s position that a BIP exists in the Tennessee River adjacent to the JOF Plant in the facility’s NPDES permit (TN0005444) (TDEC 2011, pp 10 & 16 NOD).

Fish Impingement Monitoring. Initial 1970s impingement studies and comparisons to standing stock data supported the conclusion that impingement rates would not be expected to adversely affect population (TVA 1976b). During its 2005 to 2007 impingement monitoring, TVA measured lower impingement rates than the previous studies, supporting the conclusion that JOF Plant operations had no adverse impact on local fish communities (TVA 2007).

Fish Entrainment Studies. The 1975 entrainment study indicated no significant adverse environmental impact to the Kentucky Reservoir fisheries resources due to JOF Plant operations (TVA 1976c).

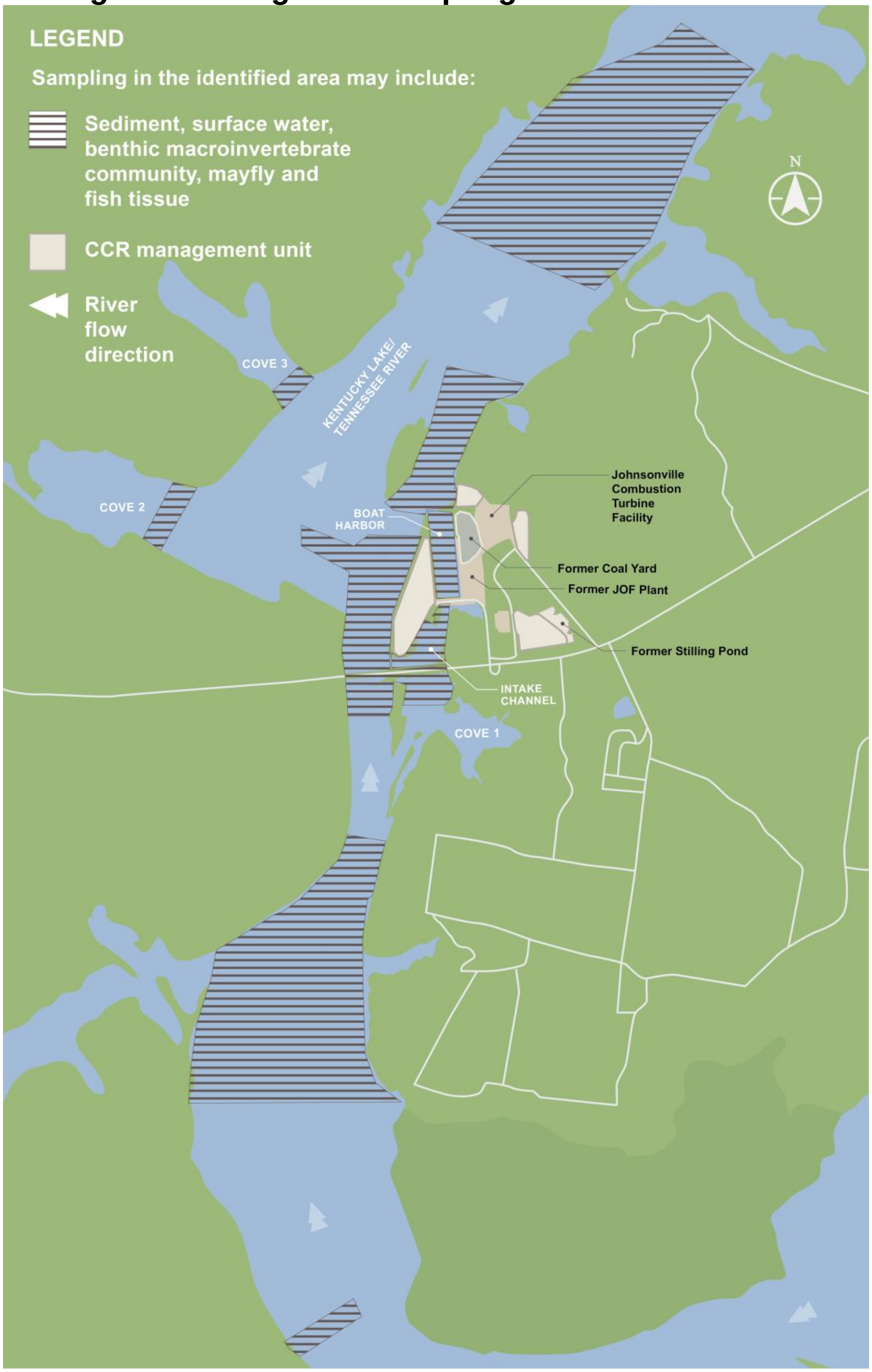
Fish Tissue Collection. TVA (1983b) found that mercury concentrations in fish tissue collected from the Pickwick and Kentucky Reservoirs peaked in 1972-1973 and steadily decreased thereafter; no fish tissue results exceeded the federal guideline concentration in 1979, the final year of the monitoring study. Beginning in 1988, fish tissue contaminant concentrations measured during screening-level sampling were typically either below detectable levels or below levels that would require issuance of fish consumption advisories. No fish consumption advisories specific to the mainstream Tennessee River within the Kentucky Reservoir (i.e., excluding statewide advisories) were issued.

7.2 TDEC Order Investigation Activities

The objectives of the ecological investigations were to characterize water quality, sediment chemistry, benthic macroinvertebrate community composition, mayfly tissue, and fish tissue in the vicinity of the JOF Plant and to provide information to evaluate if CCR material and/or dissolved CCR constituents have moved from the CCR management units, potentially impacting these environmental media. In addition, sediment, mayfly, and fish tissue data were collected to evaluate potential bioaccumulation impacts.

The EI field activities were performed in 2019 and 2021 in general accordance with the *Surface Stream SAP, Benthic SAP, Fish Tissue SAP,* and the *QAPP*, including TVA- and TDEC-approved programmatic and project-specific changes made following approval of the EIP. Surface stream and sediment samples were collected from transects located upstream, adjacent, and downstream of the CCR management units in the Tennessee River (including three coves) and at representative locations within the Intake Channel and Boat Harbor adjacent to the CCR management units. Mayfly (*Hexagenia*) and fish tissue samples were respectively collected in sampling areas and reaches located in similar areas as the surface stream and sediment transects within the Tennessee River, Intake Channel, and Boat Harbor (see below).

Ecological Investigation Sampling Transects and Reaches



In summary:

- A total of 175 primary surface stream samples were collected during EI activities, 111 from transects located in the Tennessee River (including three separate coves), 21 from transects in the Intake Channel, and 43 from transects in the Boat Harbor. Technical evaluation of these sampling results is presented in the *Technical Evaluation of Surface Stream Data* (Appendix J.1), and investigation sampling information is provided in the *Surface Stream SAR* (Appendix J.2).

- A total of 41 shallow sediment samples and 36 deeper sediment samples were collected during EI activities 39 from transects located in the Tennessee River (including three separate coves), 16 from transects located in the Intake Channel, and 22 from transects located in the Boat Harbor (Exhibit 7-1). Technical evaluation of these sampling results is presented in the *Technical Evaluation of Sediment and Benthic Invertebrate Data* (Appendix J.3), and investigation sampling information is provided in the *Benthic SAR* (Appendix J.4).

- A total of 20 composite mayfly tissue samples were collected during EI activities from individual reaches (12 in the Tennessee River, four in the Intake Channel, and four in the Boat Harbor) (Exhibit 7-2). Technical evaluation of these sampling results is presented in Appendix J.3, and investigation sampling information is provided in Appendix J.4.

- Five targeted fish species consisting of bluegill, redear sunfish, largemouth bass, channel catfish, and shad were targeted for EI sampling in sampling reaches located in the Tennessee River, the Intake Channel, and the Boat Harbor (Exhibit 7-3). The fish were resected and composited to provide a total of 74 fish tissue samples (42 in the Tennessee River, 16 in the Intake Channel and 16 in the Boat Harbor) comprised of muscle, liver, and ovary tissue samples for the gamefish, and whole fish for the shad. Technical evaluation of these sampling results is presented in the *Technical Evaluation of Fish Community and Fish Tissue Data* (Appendix J.5), and investigation sampling information is provided in the *Fish Tissue SAR* (Appendix J.6).

- A total of 20 composite benthic macroinvertebrate community samples were collected from 14 transects located in the Tennessee River, three transects in the Intake Channel, and three transects in the Boat Harbor. The five samples collected along each transect were processed individually by the laboratory and individual sample taxa lists (and counts) were composited to generate a comprehensive taxa list for each sampled stream segment. Technical evaluation of these sampling results is presented in Appendix J.3, and investigation sampling methods are provided in Appendix J.4.

7.3 Supplemental Ecological Investigation Activities

During the 2019 sampling and analysis of biota and sediments collected from the Boat Harbor as part of implementation of the JOF Plant EIP, a bluegill (*Lepomis macrochirus*) composite liver sample was reported to have an atypically higher copper concentration than observed at the other locations. In addition, several sediment samples collected from the Boat Harbor also had comparatively elevated copper concentrations, as did the sample of non-depurated mayfly nymphs collected from the Boat Harbor, although copper concentrations reported for both mayfly nymphs and adults were below the applicable screening levels (i.e., the "no observed adverse effect" level [NOAEL]) for Critical Body Residues (CBR). Based on the 2019 results, further investigation of copper concentrations in biota and sediments from the JOF Boat Harbor and Intake Channel was conducted. The *Fish Tissue and Benthic Sampling and Analysis Plans Addendum I* (Stantec 2021) was prepared to describe the collection and testing of additional composited bluegill tissue samples, composited mayfly nymph samples, and sediment samples to support further evaluation of copper concentrations in biota and sediments in the Boat Harbor.

The supplemental sampling described in the *Fish Tissue and Benthic SAPs Addendum I* was conducted in June and July 2021. Three bluegill fish tissue liver samples were taken from the Tennessee River (upstream reach), the Intake Channel and the Boat Harbor. In accordance with the Addendum, the collected composite mayfly samples and sediment samples were retained pending the results of the fish tissue samples as the ultimate line of evidence that might demonstrate potential impacts. Because the total copper concentrations measured from the fish tissue samples collected in July 2021 were not determined to be elevated, the mayfly samples and sediment samples were not analyzed. The investigation sampling information is provided in the *Fish Tissue and Benthic SAR Addendum* (Appendix J.7).

7.4 Results and Discussion

The following summarizes the results of the surface stream water, sediment, benthic macroinvertebrate community, mayfly tissue, and fish tissue investigations for the JOF Plant CCR management units. Sampling results for these media are presented in Exhibits 7-1 through 7-3.

Sampling data obtained during these investigations were evaluated by comparing measured concentrations to TDEC-approved screening levels for the EAR (Tables 1-2 through 1-5 and Appendix A.2). As described in Chapter 1.3.1, most screening levels are not regulatory standards, and are used to identify CCR Parameters in environmental media that require further evaluation in the CARA Plan to determine if an unacceptable risk exists and corrective action is required. In this section and the supporting technical evaluation appendices, screening values are used to evaluate potential impacts related to measured CCR Parameter concentrations. Screening values are conservative and protective of human and ecological health. Because they are conservative, sampling results above these levels do not necessarily indicate there are impacts to aquatic organisms or the environment, but rather, that the results require further evaluation in the CARA Plan.

Surface water screening levels for human health, which are based on use of surface water as a drinking water supply source, are applied only to surface stream results for the Tennessee River, as it is the only potable surface water source potentially affected by the JOF Plant CCR management units. Ecological screening levels, based on published studies of CCR Parameters health effects on ecological receptors, are applied to surface stream, sediment, mayfly tissue, and fish tissue results.

The ecological data evaluation approach utilized a two-step process. First, an exploratory data analysis (EDA) identified CCR Parameters present at concentrations higher than the EAR Ecological Screening Values (ESVs) (Tables 1-2 and 1-3 and Appendix A.2) in surface stream water and sediment samples. Second, when CCR Parameters were detected above surface water and sediment ESVs, fish and mayfly tissue concentrations for those constituents were compared to TDEC-approved CBR values. Due to their potential for bioaccumulation effects, mercury and selenium were evaluated in fish and mayfly tissue samples even if these constituents were not detected above ESVs in surface stream water and sediment samples.

7.4.1 Surface Stream, Sediment, Mayfly and Fish Tissues Analyses

7.4.1.1 Tennessee River

CCR Parameter concentrations in surface stream samples from the Tennessee River were below human health screening levels and consistently below acute and chronic ESVs (see Appendix J.1, Table J.1-1).

None of the polarized light microscopy (PLM) results for sediment samples from the Tennessee River were above 8% ash, below the 20% ash threshold that would trigger Phase 2 supplemental sampling. Beryllium was detected at a concentration above its chronic ESV (1.15 times above the ESV) in one sediment sample collected from a location upstream of the JOF Plant CCR Management Units. Selenium was detected at a concentration above its chronic ESV (1.1 times above the ESV) in one sediment sample collected from a location upstream of the JOF Plant CCR Management Units (see below and Exhibit 7-2). None of the CCR Parameter concentrations in the remaining sediment samples collected from the Tennessee River were above their respective ESVs.

In addition, the following CCR Parameters were detected at concentrations above their chronic ESVs in sediment samples collected from coves (which are considered representative of control conditions for comparison to results from the Boat Harbor and Intake Channel) along the Tennessee River (see below and Exhibit 7-2):

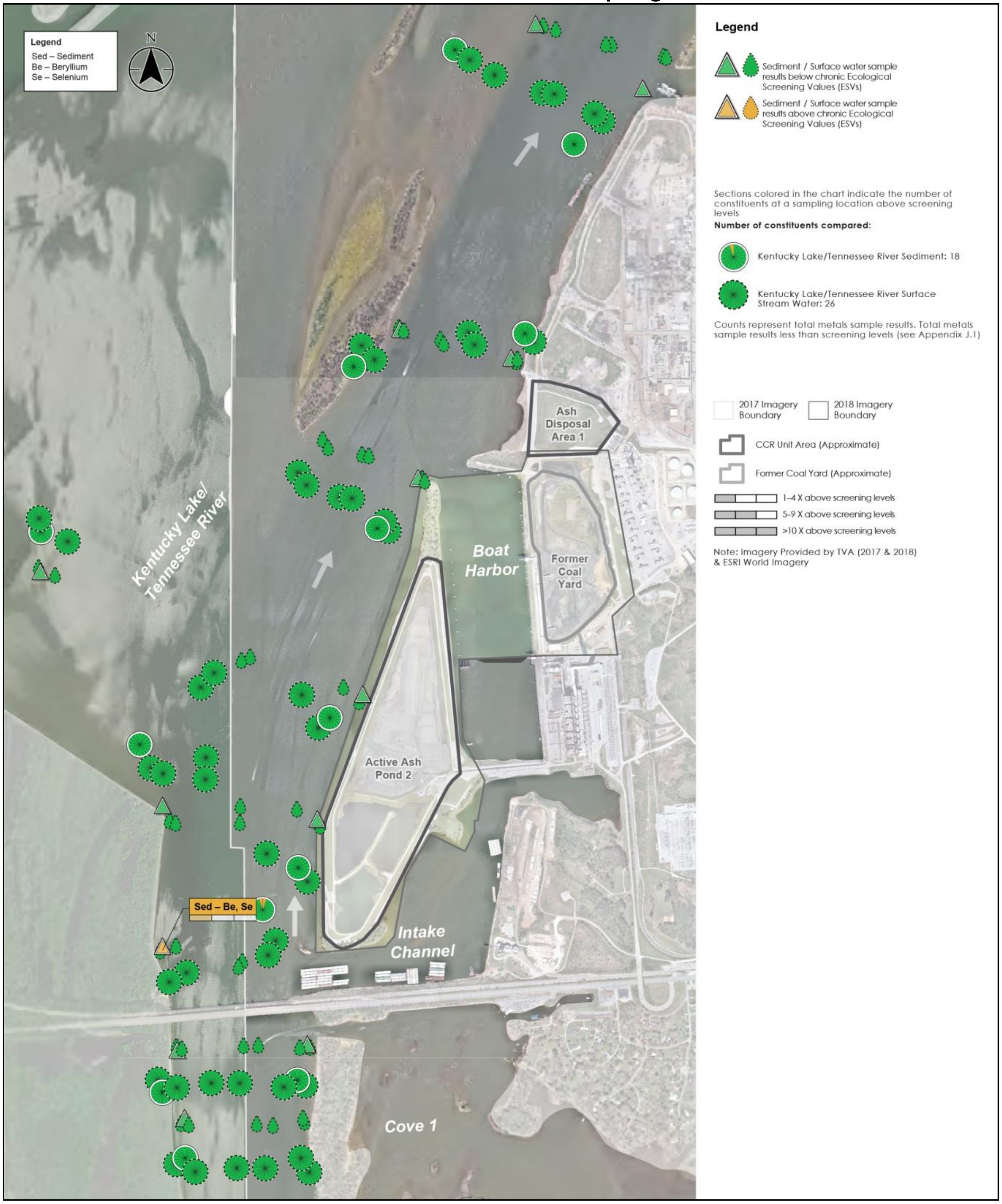
- Arsenic, barium and beryllium were detected at concentrations above their respective chronic ESVs in one or more sample collected from transect CV01 in a cove on the east side of the Tennessee River upstream from the Plant
- Arsenic, beryllium, and selenium were detected at concentrations above their respective chronic ESVs in one or more sample collected from transect CV02 in a cove on the west side of the Tennessee River
- Beryllium, nickel, and selenium were detected at concentrations above their respective chronic ESVs in one or more sample collected from transect CV03 in a cove on the west side of the Tennessee River.

Selenium concentrations in mayfly tissue samples were detected above CBR values but showed very little variability in results upstream, adjacent, and downstream of the JOF Plant CCR management units (Exhibit 7-3).

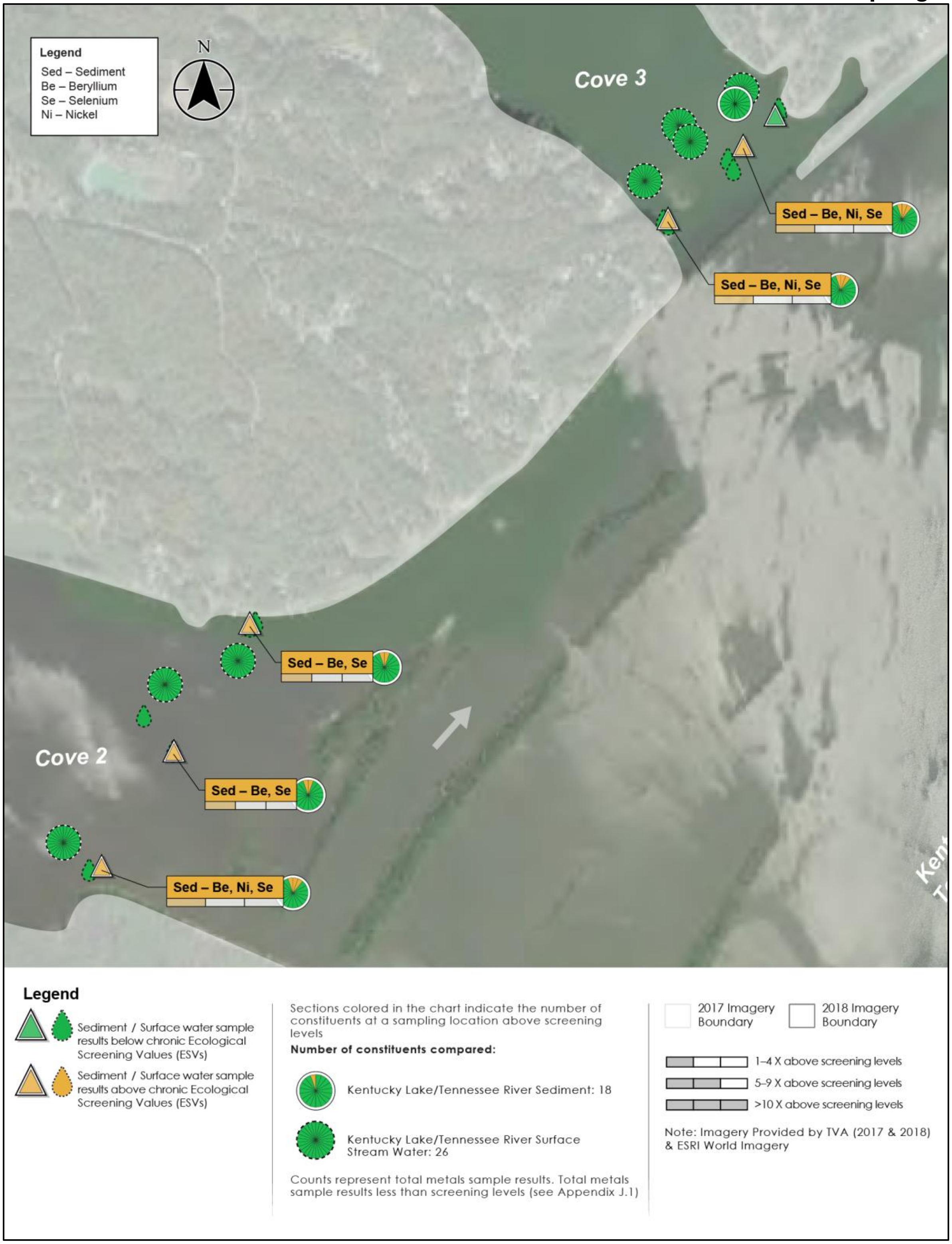
Gamefish (bluegill, channel catfish, largemouth, and redear sunfish) muscle and liver tissues had mercury concentrations higher than either the chronic or acute CBR values, and selenium concentrations in liver tissues were higher than the chronic CBR value (Exhibit 7-4). Selenium concentrations were below the CBR values in gamefish muscle and ovary tissues. However, across the upstream, adjacent and downstream locations, similar results suggest no potential impacts from the JOF Plant CCR management units on gamefish muscle and liver tissue concentrations of mercury and selenium.

For whole-fish tissue samples, mercury concentrations were higher than the chronic CBR value for samples collected upstream, adjacent, and downstream of the JOF Plant, suggesting no potential impacts from the JOF Plant CCR management units on whole-fish tissue concentrations of mercury. All whole-fish beryllium and selenium concentrations were below the chronic CBR value.

Tennessee River Sediment and Surface Stream Sampling Locations



Tennessee River Cove 2 and Cove 3 Sediment and Surface Stream Sampling Locations



7.4.1.2 Intake Channel

None of the PLM results for sediment samples from the Intake Channel were above the 20% ash threshold, and none of the CCR Parameter concentrations in surface stream water were above their respective ESVs. The Phase 1 EDA identified no sediment results for the CCR Parameters at concentrations above their respective acute ESVs. Arsenic, beryllium, and selenium concentrations in sediment were above their respective chronic ESVs for one location in the Intake Channel as shown in the graphic below and on Exhibit 7-2. Concentrations of the remaining CCR Parameters were below their respective chronic and acute ESVs in sediment samples from the Boat Harbor.

Beryllium was detected in sediment at concentrations slightly above its chronic ESV at one location in the Intake Channel, however there are no applicable CBR values for beryllium for comparison to mayfly tissue sample results. However, beryllium concentrations were below the CBR values for the tested whole fish samples.

None of the Intake Channel composite mayfly sample concentrations were above the NOAEL or Lowest Observed Adverse Effect Level (LOAEL) for mercury. Below is a summary of the constituents and sample locations with results above NOAELs/LOAELs in the Intake Channel adjacent to the JOF Plant CCR management units:

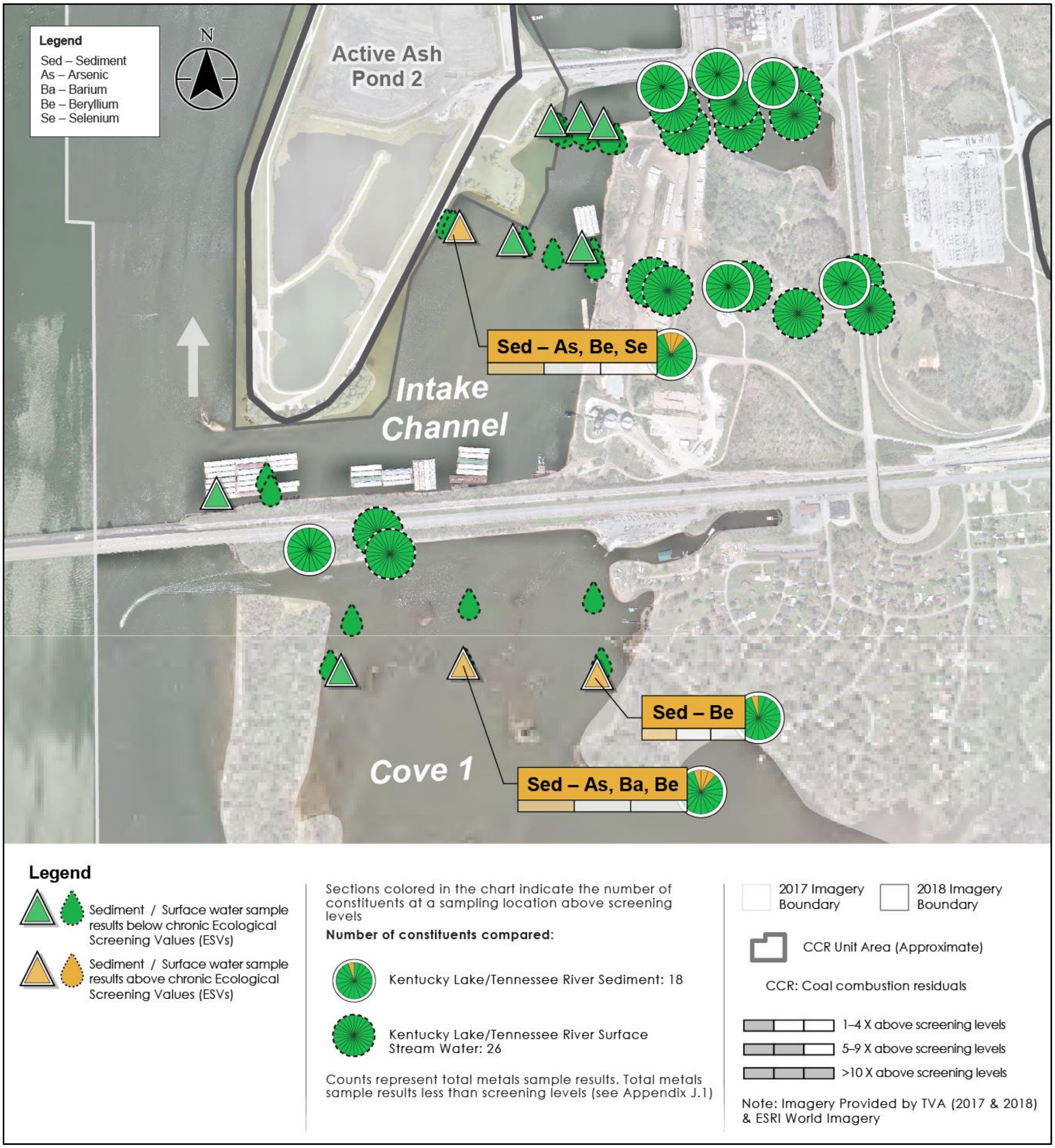
- Arsenic concentrations in the depurated mayfly nymph composite tissue sample and male and female adult mayfly composite tissue sample were above the NOAEL for arsenic. The arsenic concentration in the non-depurated mayfly nymph composite tissue sample was above both the NOAEL and LOAEL.

- The selenium concentration in the depurated mayfly nymph composite tissue sample was above the NOAEL for selenium. Selenium concentrations in the non-depurated mayfly nymph composite tissue sample and the male and female adult mayfly composite tissue sample were above both the NOAEL and LOAEL.

Half of the gamefish muscle and liver tissue samples had arsenic concentrations higher than the chronic CBR value, and three of four muscle tissue samples had mercury concentrations higher than the chronic CBR value. For gamefish liver tissues, selenium concentrations were higher than the chronic CBR value, and mercury concentrations higher than the acute CBR value. Whole-fish shad tissue samples exhibited arsenic and mercury concentrations higher than the chronic CBR values.

Arsenic and selenium concentrations were below the NOAEL in gamefish ovary tissues and selenium concentrations were below the NOAEL in gamefish muscle tissues. Beryllium and selenium concentrations were below the NOAEL in whole-fish tissues. Similar to the Boat Harbor sampling reach, there are no specific upstream or downstream segments within the Intake Channel for comparison.

Intake Channel Sediment and Surface Stream Sampling Locations



7.4.1.3 Boat Harbor

CCR Parameter concentrations in surface stream samples from the Boat Harbor were consistently below acute and chronic ESVs.

None of the PLM results for sediment samples from the Boat Harbor were above 8% ash, below the 20% ash threshold that would have triggered Phase 2 supplemental sampling. Arsenic, beryllium, copper, mercury, and selenium concentrations in sediment were above their respective chronic ESVs at one or more locations in the Boat Harbor, but not above their respective acute ESVs as shown in the graphic below and on Exhibit 7-2. Concentrations of the remaining CCR Parameters were below their respective chronic and acute ESVs in sediment samples from the Boat Harbor.

Although beryllium was detected in sediment at one location at a concentration slightly above its chronic ESV (1.2 times higher), there are no applicable CBR values for beryllium for comparison to mayfly tissue sample results.

Copper and mercury concentrations were below CBR values in the mayfly tissue samples collected from the sampling locations in the Boat Harbor. Below is a summary of the constituents and sample locations with results above NOAELs/LOAELs in the Boat Harbor:

- Arsenic concentrations in the depurated mayfly nymph composite tissue sample and male and female adult mayfly composite tissue sample were above the NOAEL for arsenic. The arsenic concentration in the non-depurated mayfly nymph composite tissue sample was above both the NOAEL and LOAEL.

- The selenium concentration in the depurated mayfly nymph composite tissue sample was above the NOAEL for selenium. Selenium concentrations in the non-depurated mayfly nymph composite tissue sample and the male and female adult mayfly composite tissue sample were above both the NOAEL and LOAEL.

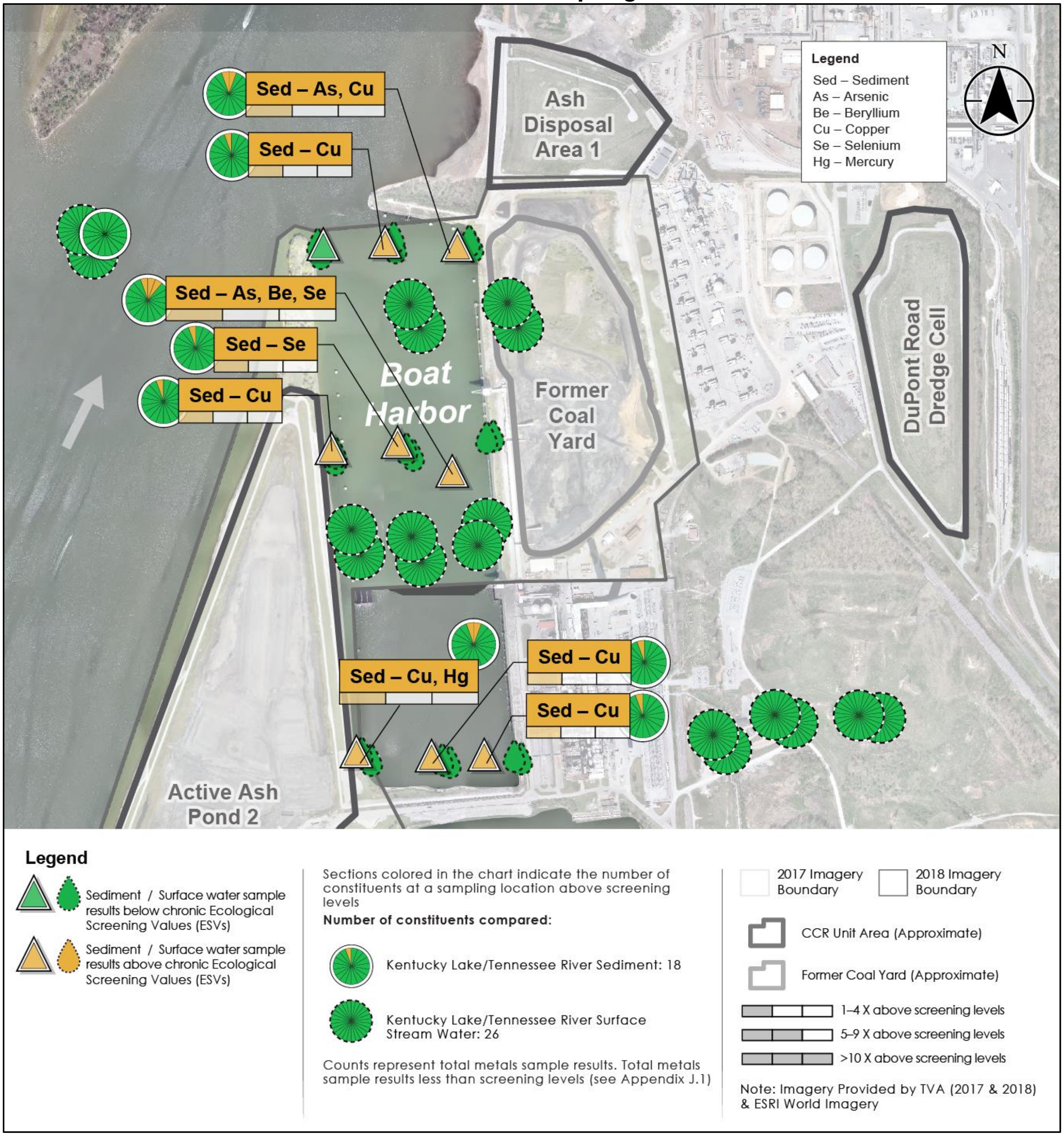
Three of four gamefish muscle tissue samples had arsenic concentrations higher than the chronic CBR value, and only one sample exhibited mercury concentrations higher than the chronic CBR value. Gamefish liver tissues had selenium concentrations higher than the chronic CBR value, and mercury concentrations higher than the acute CBR value. Of the four gamefish liver tissue samples, a single sample had arsenic and copper concentrations higher than their respective chronic CBR values. For whole-fish tissue samples, arsenic, mercury, and copper concentrations were higher than their respective chronic CBR values.

Selenium and copper concentrations were found to be below their respective CBR values in gamefish muscle tissues, as were arsenic and selenium concentrations in the ovary tissues. Beryllium and selenium concentrations were found to be below their respective CBR values in whole-fish tissues. Due to its aspect as a cove, the Boat harbor has no specific upstream or downstream segments for comparison.

Results of the supplemental sampling event conducted in July 2021 demonstrated that the three samples collected within the Intake Channel and Boat Harbor had concentrations below the chronic CBR value for copper. Because the results showed concentrations lower than the chronic CBR value for copper, comparative analyses were not conducted on the samples and the sediment and benthic invertebrate samples were not analyzed.

Based on the above evaluation, arsenic, beryllium, copper, mercury, and selenium in sediment will be further evaluated in the CARA Plan.

Boat Harbor Sediment and Surface Stream Sampling Locations



7.4.2 Benthic Macroinvertebrate Community Analysis

Benthic macroinvertebrate community sampling was conducted in the Tennessee River and its adjacent coves in the vicinity of the JOF Plant, the Intake Channel, and the Boat Harbor using a ponar dredge sampler. The Tennessee River was sampled at eleven transect locations (See Appendix J.3, Exhibit J.3-2): three upstream control locations, five adjacent to the JOF Plant (TR02 through TR06), and three downstream of the JOF Plant (TR07, TR08, and TR11). The Intake Channel and Boat Harbor were each sampled at three transect locations adjacent to the JOF Plant (BH01 through BH03 and IC01 through IC03, respectively). One transect was sampled at the mouth of each of three coves inflowing to the Tennessee River (CV01, CV02, and CV03). These cove sampling locations are representative of control conditions for comparison to results from the Intake Channel and Boat Harbor, as they share similar qualitative habitat characteristics that may affect benthic community composition, and by extension, metric outcomes.

The benthic community taxa lists and counts were composited by transect to capture a comprehensive cross section of the existing benthic communities in each representative segment of these waterbodies. Community metrics were then evaluated as indicators of biological integrity, including the Reservoir Biotic Index (RBI), Total Taxa Richness (TTR), and the Hilsenhoff Biotic Index (HBI), as described below. Appendix J.3 contains more detailed discussion of the metric analysis summarized herein and contains the full suite of calculations in Benthic Community Summary Sheets (Attachment J.3-A).

Generally, the benthic macroinvertebrate community metrics were corroborative and demonstrated spatially consistent relationships among indicators. The RBI results for the Tennessee River, the Intake Channel, and the Boat Harbor, representative of overall biological integrity, generally showed similar total scores in comparison to their respective unimpacted control locations (and frequently had higher RBI scores than controls). Historical data were also consistent with the 2019 EI results, demonstrating little change in biological integrity since 2010. The RBI multi-metric does not reflect potential impacts associated with JOF Plant CCR management units.

In the Tennessee River, three transect locations adjacent to the CCR management units had the highest richness (TTR) within the study area (TR03, TR04, and TR05), including upstream control locations. The remaining adjacent and downstream transects in the Tennessee River supported benthic communities with similar richness to the upstream controls. The Intake Channel and Boat Harbor had similar TTR ranges to each other and were also within the ranges of richness values calculated for the three control cove transects. Although average TTR values in the Intake Channel and Boat Harbor were lower than average Tennessee River TTR, this relationship was expected as a likely reflection of the physical habitat differences apparent during the survey. While the Intake Channel and Boat harbor are characterized by slow-flowing backwater conditions, the Tennessee River has free-flowing riverine conditions that satisfy the colonization, survival, and reproductive requirements of different taxa. The consistency between potential impact areas and their respective controls do not suggest that potential impacts from the JOF Plant CCR management units have occurred, nor do they demonstrate degradation of the benthic community in adjacent and downstream waters from other potential stressors.

Results of the HBI provides corroborative evidence for the findings of the RBI and TTR metric analyses. Similar to RBI and TTR indicators, the HBI results further demonstrated that the healthiest benthic communities in the study area are located in areas adjacent to the JOF Plant, corresponding to the highest level of community stress sensitivity. In the Tennessee River, the Intake Channel, and the Boat Harbor, HBI scores were aligned with the results calculated for their respective controls and frequently reflected higher environmental stress levels at the control locations than adjacent and downstream of the plant. HBI results provide no evidence suggesting potential impacts associated with the JOF Plant CCR management units.

In summary, benthic communities within adjacent and downstream areas of the Tennessee River, the Intake Channel, and the Boat Harbor appear to be at least as healthy, rich, and sensitive as their respective control locations unimpacted by CCR from the Plant. The benthic community data do not reflect any impacts from the CCR management Units.

7.5 Surface Streams, Sediment, and Ecological Investigation Summary

The evaluation of EI surface stream, sediment, benthic macroinvertebrate community, mayfly tissue, and fish tissue sampling results indicates that potential impacts to water quality and aquatic life are predominantly limited within the Intake Channel, the Boat Harbor, and the three Coves off the Tennessee River as summarized below.

- Surface stream water quality in the Tennessee River, Intake Channel, and Boat Harbor is within ranges protective of human health and aquatic life. Sampling results were below chronic ESVs (Table 1-2) and indicate no potential water quality impacts from the CCR management units.

- Ash was either not detected or detected at very low levels (i.e., between 1% and 8%), with very little variation in results among sample locations. CCR Parameter concentrations in sediment samples from the Tennessee River were below chronic ESVs, except for beryllium and selenium concentrations in a single sediment sample (TR03) from an upstream control location (Exhibit 7-2). These results indicate that sediment quality in the Tennessee River adjacent and downstream of the JOF Plant are within ranges that are protective of aquatic life. Sediment sampling results above chronic ESVs were identified for mercury at the BH01 location in the Boat Harbor, for barium at the CV01 location in a cove on the east side of the Tennessee River upstream from the JOF Plant, and for nickel at two CV03 locations in a cove on the west side of the Tennessee River. Sediment sampling results above chronic ESVs for copper were identified for several locations in the Boat Harbor. Sediment sampling results above chronic ESVs were identified for arsenic, beryllium, and/or selenium at several locations within the Intake Channel, Boat Harbor, and all three coves (which are representative of control conditions for comparison to results from the Intake Channel and Boat Harbor, as they share similar habitat characteristics).

- The adjacent and downstream mayfly and fish tissue sampling results for the Tennessee River were similar to upstream control locations (Exhibits 7-3 and 7-4, respectively). These results do not indicate potential impacts or bioaccumulation effects within these populations related to the JOF Plant CCR management units.

- The adjacent and downstream benthic communities appear to be at least as healthy, rich, and sensitive as upstream control locations unimpacted by CCR from the Plant, and collectively, the benthic community data reflect no potential impacts from the CCR management units.

Overall, the EI sample results in conjunction with historical benthic community and fish population data demonstrate healthy and consistent ecological communities within the investigation area and indicate that the JOF Plant CCR management units have had minimal, if any, potential impacts to sediment and surface stream water quality or ecological communities of the Tennessee River.

Based on the EI findings, further evaluation of the CCR Parameters detected in sediment samples above ESVs will be completed in the CARA Plan.

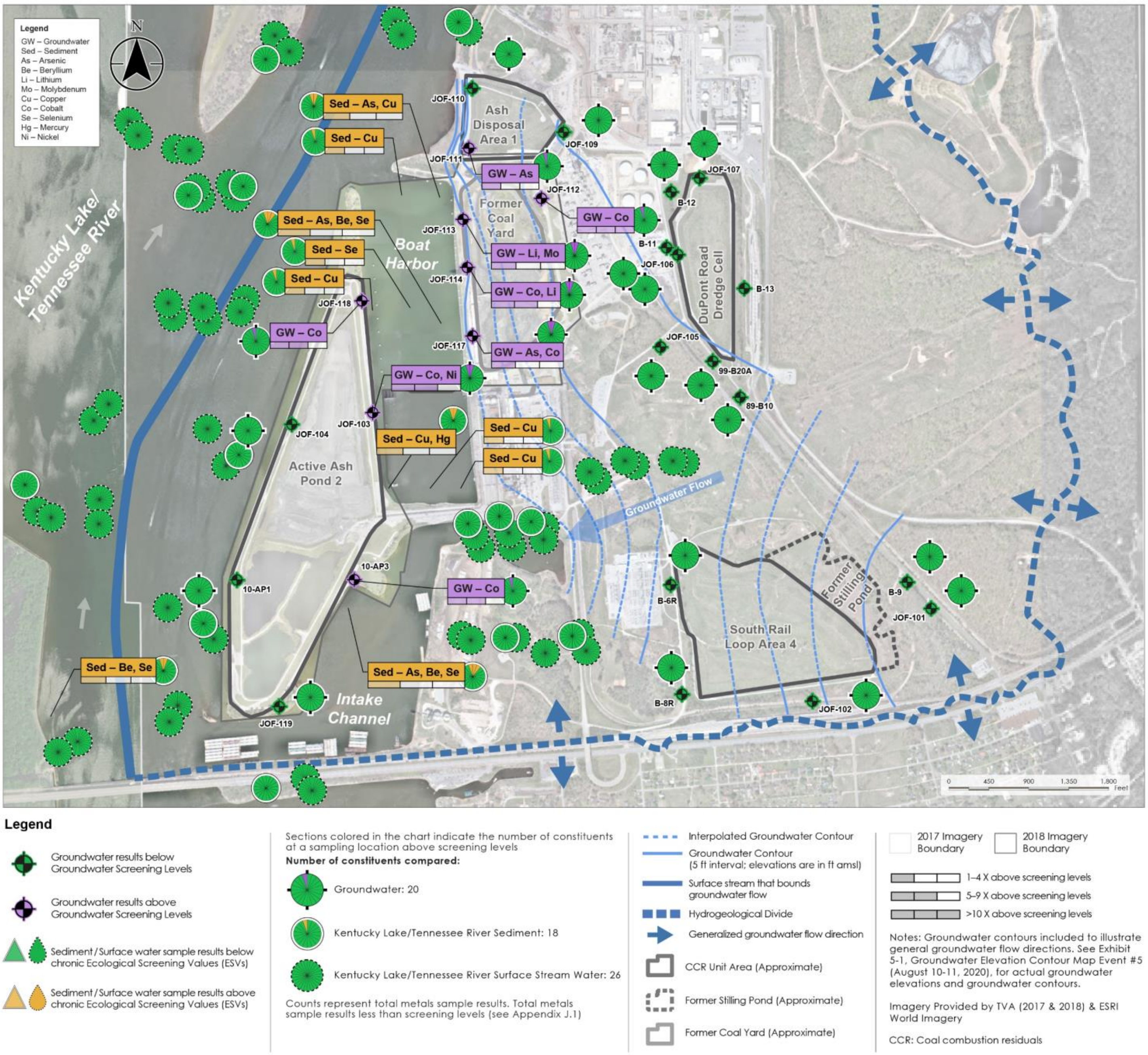
Chapter 8 TDEC Order Investigation Summary and Conceptual Site Models

This section summarizes the assessment of CCR material, structural stability and integrity of the CCR management units and the former Coal Yard, and extent of CCR Parameters within environmental media investigated during the EI at the JOF Plant. CSMs for the CCR management units and the former Coal Yard and overall findings are also presented based on the EI and associated historical and ongoing program results. CSMs describe sources of CCR constituents, pathways by which they can move, and environment media potentially impacted if they are released.

Analytical results were compared to TDEC-approved EAR screening levels to identify areas that require further evaluation. Most screening levels are not regulatory standards and are conservatively based on published health studies. Concentrations above the screening level do not necessarily mean that an adverse health effect is occurring, but rather, that further evaluation is required in the CARA Plan to determine if an unacceptable risk exists, and if corrective action is required. CCR management units were evaluated for potential slope stability impacts, which were defined as those areas having analysis results (i.e., factors of safety) that do not meet TDEC-approved criteria for one or more load cases. This section provides a summary of potential impacts identified during the EI that will be further evaluated in the CARA Plan.

Several EI findings are common among the CCR management units and the former Coal Yard and are discussed in Chapter 8.1. Specific EI findings and CSMs for each CCR management unit and the former Coal Yard are described in Chapters 8.2 through 8.6 and presented on Exhibits 8-1 through 8-5. These exhibits depict findings discussed in this EAR on a representative cross-section of subsurface conditions for each unit. Results of the EI are presented for the overall investigation area on Exhibit 8-6 and near the CCR management units and former Coal Yard as shown on the figure below and on Exhibit 8-7.

Overall Findings Near JOF Plant CCR Management Units



8.1 Common Findings

The common EI findings for the JOF Plant CCR management units are as follows:

Structural Stability and Integrity: The global slope stability and the veneer slope stability for each of the CCR management units that were evaluated meets the established factor of safety criteria for the static (except one veneer stability case for South Rail Loop Area 4 that was still accepted by TDEC, as described in Appendix G.1) and seismic load cases. The CCR management units have adequate structural integrity, and there is no evidence of voids/cavities in bedrock that could lead to loss of structural support and potential release of overlying CCR material.

Hydrogeology: The coarse-grained unconsolidated materials, and Camden Chert beneath the former Coal Yard, are considered to be the uppermost aquifer and are under unconfined conditions, except in the vicinity of Active Ash Pond 2. The uppermost aquifer in the vicinity of Active Ash Pond 2 is the coarse-grained unconsolidated materials and is considered confined and are overlain by fine-grained unconsolidated materials that act as an aquitard.

The horizontal groundwater flow direction within the uppermost aquifer beneath the CCR management units and former Coal Yard is generally to the west-southwest toward the Tennessee River. Groundwater flow in the vicinity of the CCR management units and the former Coal Yard is bounded to the west by the Tennessee River. A higher elevation ridge to the east of the plant and a watershed boundary along the southern border are topographic divides for groundwater flow.

The pore water levels reported herein may not represent steady-state conditions. The low permeability of the existing geosynthetic caps is expected to result in the continued decrease in pore water levels in the DuPont Road Dredge Cell and South Rail Loop Area 4. The pore water levels within Ash Disposal Area 1, the former Coal Yard, and Active Ash Pond 2 would be expected to decrease in elevation if stormwater drainage or cap modifications were to be implemented. The low permeabilities of the perimeter dikes limit lateral and vertical flow into or out of the CCR management units and the former Coal Yard. The results of the dye trace study support this conclusion because it indicated that there are no preferential transport pathways between Active Ash Pond 2 and the Tennessee River. The use of the term “saturated” or references to the moisture content of CCR material does not imply that the pore water is readily separable from the CCR material.

Pore water within the CCR material has specific chemical characteristics that are different from the characteristics of groundwater downgradient of the CCR management units and the former Coal Yard. Certain CCR constituents that have been detected in pore water are affected by geochemical processes during groundwater flow through geological materials. The effect of these geochemical processes, which can result in the attenuation of CCR constituents and reduced dissolved groundwater concentrations, can explain the observed differences between the characteristics of pore water and groundwater quality.

Surface Streams: Surface stream water quality results in the Tennessee River, Intake Channel and Boat Harbor were within ranges protective of human health and aquatic life. Sampling results were below chronic ESVs and indicate no potential water quality impacts from the CCR management units.

Sediment: Most CCR Parameter concentrations in sediment samples collected from the Tennessee River, Intake Channel, coves, and Boat Harbor were below chronic ESVs, except for limited occurrences. Arsenic, beryllium, and selenium were identified above chronic ESVs at one sample location within the Intake Channel and arsenic, barium, beryllium, or selenium at seven sample locations in the coves. Within the Boat Harbor, arsenic, beryllium, copper, mercury, and selenium were identified above chronic ESVs at eight sample locations.

Bioaccumulation: Mayfly and fish tissue results are similar upstream, adjacent, and downstream of the CCR management units, with some results (mercury in fish tissue and arsenic and selenium in fish and mayfly tissues) above the CBRs.

Benthic Communities: The adjacent and downstream benthic communities in the Tennessee River appear to be similarly healthy, rich, and sensitive as upstream control locations unimpacted by CCR from the Plant, and collectively, the benthic community data suggest no potential impacts from the CCR management units.

Seeps: Three AOIs were identified during the EI. One AOI (AOI03) has been mitigated under a TDEC approved plan.

8.2 Ash Disposal Area 1

A summary of EI evaluation findings and a CSM for Ash Disposal Area 1 is provided on Exhibit 8-1 in cross-sectional view and on Exhibit 8-7 in plan view. These exhibits also illustrate surrounding units and water bodies for Ash Disposal Area 1.

CCR material in this unit is stacked bottom ash and fly ash above sluiced bottom ash and fly ash, and the estimated total volume of CCR material is about 730,000 cubic yards.

Only one TDEC Appendix I and CCR Rule Appendix IV CCR constituent concentration in onsite groundwater was above a GSL. The primary constituent of interest in groundwater for Ash Disposal Area 1 is arsenic at well JOF-111.

The results of the EI and other ongoing ecological monitoring programs indicate operations at this CCR management unit have not impacted downstream surface stream water quality, benthic macroinvertebrate communities, or mayfly and fish tissues and populations in the Tennessee River.

One AOI (AOI02) was identified during the EI and is currently being monitored for further evaluation.

In summary, potential impacts associated with the Ash Disposal Area 1 CCR management unit based on EI sampling results are limited to arsenic in onsite groundwater at one monitoring well. Additionally, one AOI (AOI02) is currently being monitored. This constituent and AOI will be further evaluated in the CARA Plan to determine if unacceptable risks exist and corrective actions are needed.

8.3 DuPont Road Dredge Cell

A summary of EI findings and a CSM for the DuPont Road Dredge Cell is provided on Exhibit 8-2 in cross-sectional view and on Exhibit 8-7 in plan view. These exhibits also illustrate surrounding units for the DuPont Road Dredge Cell.

CCR material is stacked fly ash and bottom ash above sluiced fly ash and bottom ash, with an estimated total volume of CCR of about 1.1 million cubic yards.

TDEC Appendix I and CCR Rule Appendix IV CCR constituent concentrations in onsite groundwater are below GSLs at the DuPont Road Dredge Cell.

The Dupont Road Dredge Cell is located upgradient of Ash Disposal Area 1 and the former Coal Yard; therefore, evaluations of potential impacts of this unit on surface streams and sediments are included in the discussions for Ash Disposal Area 1 and the former Coal Yard.

8.4 South Rail Loop Area 4

A summary of EI findings and a CSM for the South Rail Loop Area 4 is provided on Exhibit 8-3 in cross-sectional view and on Exhibit 8-7 in plan view. These exhibits also illustrate surrounding units for the South Rail Loop Area 4.

CCR material is stacked ash and sluiced ash, with an estimated total volume of about 4 million cubic yards.

TDEC Appendix I and CCR Rule Appendix IV CCR constituent concentrations in onsite groundwater are below GSLs at South Rail Loop Area 4.

The South Rail Loop Area 4 is located upgradient of Active Ash Pond 2; therefore, evaluations of potential impacts of this unit on surface streams and sediments are included in the discussions for Active Ash Pond 2.

8.5 Active Ash Pond 2

A summary of EI findings and a CSM for Active Ash Pond 2 is provided on Exhibit 8-4 in cross-sectional view and on Exhibit 8-7 in plan view. These exhibits also illustrate surrounding units and water bodies for the Active Ash Pond 2.

CCR material is sluiced bottom ash and sluiced fly ash with an estimated total volume of about 4.5 million cubic yards.

Most TDEC Appendix I and CCR Rule Appendix IV CCR constituent concentrations in onsite groundwater are below GSLs. The primary constituents of interest in groundwater for Active Ash Pond 2 are cobalt and nickel at three monitoring wells, including 10-AP3, JOF-103, and JOF-118. Concentrations of cobalt and nickel were below the ESVs in sediment and surface stream water samples in the Tennessee River, the Intake Channel and the Boat Harbor, which serve as hydraulic boundaries for groundwater flow.

None of the PLM results for sediment samples from the Tennessee River were above 8% ash, well below the 20% ash threshold that would have triggered Phase 2 supplemental sampling. Beryllium and selenium were detected at one location in sediment upstream to this CCR management unit in the Tennessee River, at concentrations slightly above their respective chronic ESVs (1.38 mg/kg and 2.14 mg/kg). Arsenic, beryllium and selenium were detected in one sediment sample in the Intake Channel above their ESVs and arsenic, beryllium, copper, mercury, and selenium were detected in sediments in the Boat Harbor above ESVs. However, these constituents were not detected in groundwater samples above the GSL in wells at Active Ash Pond 2.

The results of the EI and other ongoing ecological monitoring programs indicate operations at this CCR management unit have not impacted adjacent or downstream surface stream water quality, benthic macroinvertebrate communities, or mayfly and fish tissues and populations in the Tennessee River, Intake Channel, and the Boat Harbor.

Two AOIs (AOI01 and AOI03) were identified during the EI. One AOI (AOI03) has been mitigated under a TDEC approved plan and the remaining AOI (AOI01) is currently being monitored for further evaluation.

In summary, potential impacts associated with the Active Ash Pond 2 CCR management unit based on EI sampling results are limited to cobalt and nickel in onsite groundwater at three monitoring wells and arsenic, beryllium, and selenium in sediment at one sample locations in the Intake Channel and arsenic, beryllium, copper, mercury, and selenium in sediment at eight sample locations in the Boat Harbor. Additionally, one AOI (AOI01) is currently being monitored. These constituents and AOI will be further evaluated in the CARA Plan to determine if unacceptable risks exist and corrective actions are needed.

8.6 Former Coal Yard

A summary of EI evaluation findings and a CSM for the former Coal Yard is provided on Exhibit 8-5 in cross-sectional view, and on Exhibit 8-6 in plan view. These exhibits also illustrate surrounding units and water bodies for the former Coal Yard.

The scope of the EIP and the Stability SAP did not require stability analyses or structural integrity evaluations of the former Coal Yard, because CCR material was not placed for disposal purposes; CCR material was placed as structural fill. CCR material is sluiced fly ash and bottom ash, with an estimated total volume of about 551,000 cubic yards.

Most TDEC Appendix I and CCR Rule Appendix IV CCR constituent concentrations in onsite groundwater are below GSLs. The primary constituents of interest in groundwater for the former Coal Yard are arsenic, cobalt, lithium, and molybdenum at four monitoring wells. The concentrations of cobalt, lithium and molybdenum were below the ESVs in sediment and surface water samples in the Boat Harbor and the Tennessee River, which serve as hydraulic boundaries for groundwater flow.

None of the PLM results for sediment samples from the Boat Harbor were above 8% ash. Arsenic, beryllium, copper, mercury, and selenium were detected in sediment adjacent to this CCR management unit in the Boat Harbor at concentrations above their respective chronic ESVs.

The results of the EI and other ongoing ecological monitoring programs indicate operations at this CCR management unit have not impacted adjacent or downstream surface stream water quality, benthic macroinvertebrate communities, or mayfly and fish tissues and populations in the Boat Harbor or the Tennessee River.

In summary, potential impacts associated with the former Coal Yard are limited to arsenic, cobalt, lithium, and molybdenum in onsite groundwater at four monitoring wells and arsenic, beryllium, copper, mercury, and selenium in sediment at eight samples locations in the in the Boat Harbor. These constituents will be further evaluated in the CARA Plan to determine if unacceptable risks exist and corrective actions are needed.

Chapter 9 Conclusions and Next Steps

9.1 Conclusions

In accordance with the TDEC Order, TVA prepared an EIP for the JOF Plant CCR management units to obtain and provide information requested by TDEC. As specified in the TDEC Order, the objective of the EIP was to “identify the extent of soil, surface water, and groundwater contamination by CCR” from onsite management of CCR material in impoundments and landfills. In addition, per TDEC’s information requests, the EIP included assessment of CCR management unit structural stability and integrity. Between 2019 and 2021, TVA and Stantec implemented EI activities in accordance with the approved EIP. The EI included characterization of the site hydrogeology and investigations of CCR material, groundwater, background soils, seeps, surface streams, sediments, and ecology, as well as the Water Use Survey, which is ongoing.

This EAR presents the results of those investigations, describes the extent of surface stream water, sediment, and groundwater contamination from the JOF Plant CCR management units, and provides the information, data, and evaluations used to make those assessments. Geotechnical analysis findings and environmental sampling results above TDEC approved screening levels in specific media will be further evaluated in the CARA Plan to determine whether unacceptable risks exist that require corrective action. As required by the TDEC Order, this EAR will be revised to address TDEC comments until the objective of the EIP is met.

In summary, more than 97% of the compared environmental sample results from over 1,800 samples were below screening levels. Most screening levels are not regulatory standards and are conservatively based on published health studies. The EI data indicate impacts to limited onsite groundwater areas and that the CCR management units have had minimal, if any, potential impacts to sediment and surface stream water quality, and ecological communities in the Tennessee River. The following are overall assessment findings for the investigation based on data as presented in this EAR:

- Surface stream water quality is within ranges protective of human health and aquatic life in the Tennessee River
- Sediment quality is within ranges protective of aquatic life in the Tennessee River adjacent to and downstream of the CCR management units. Additional evaluation of potential risks associated with sediments in the Boat Harbor and Intake Channel is warranted in the CARA Plan to determine if corrective actions are needed
- The EI data indicate that ecological communities are healthy in the Tennessee River adjacent to and downstream of the CCR management units
- The CCR management units have adequate structural stability, and slopes are stable under current static and seismic loading conditions
- For the seep investigation, three AOIs were identified during the EI. One AOI has been mitigated under a TDEC approved plan. The remaining two AOIs are currently being monitored and will be further evaluated in the CARA Plan.

- Most TDEC Appendix I and CCR Rule Appendix IV CCR constituent concentrations in onsite groundwater are below TDEC-approved GSLs, and groundwater impacts are limited to onsite areas along the perimeter of the CCR management units and the former Coal Yard. However, additional assessments will be included in the CARA Plan to evaluate the need for corrective action for targeted onsite groundwater remediation at locations where statistically significant concentrations of CCR constituents above GSLs exist.

- Drainage improvements or potential corrective actions are expected to reduce concentrations of CCR constituents to below GSLs in groundwater at downgradient monitoring locations for Active Ash Pond 2, Ash Disposal Area 1, and the former Coal Yard

- The groundwater flow direction within the uppermost aquifer beneath the CCR management units and former Coal Yard is generally to the west-southwest toward the Tennessee River. Groundwater flow in the vicinity of the CCR management units and former Coal Yard is bounded to the west by the Tennessee River. A higher elevation ridge to the east of the plant and a watershed boundary along the southern border are topographic divides for groundwater flow.

The following summary provides the specific findings requiring further evaluation in the CARA Plan.

Summary of Findings Requiring Further Evaluation in the CARA Plan				
CCR Management Unit	**Stability**	**Groundwater**	**Seeps**	**Surface Stream, Sediment, Ecology**
Ash Disposal Area 1	None	Arsenic (Well JOF-111)	AOI02	None
Active Ash Pond 2	None	Cobalt (Wells 10-AP3, JOF-103 and JOF-118) Nickel (Well JOF-103)	AOI01	Arsenic, beryllium, copper, mercury, and selenium in Boat Harbor sediments Arsenic, beryllium, and selenium in Intake Channel sediments
Former Coal Yard*	Not applicable	Arsenic (Well JOF-117) Cobalt (Wells JOF-112, JOF-114 and JOF-117) Lithium (Wells JOF-113 and JOF-114) Molybdenum (Well JOF-113)	None	Arsenic, beryllium, copper, mercury, and selenium in Boat Harbor sediments
South Rail Loop Area 4	None	None	None	None
DuPont Road Dredge Cell	None	None	None	None

*Not a CCR management unit

9.2 Next Steps

This EAR will be revised to include the results of the Water Use Survey.

Upon approval of the EAR, TVA will prepare and submit a CARA Plan to TDEC in accordance with the TDEC Order. The CARA Plan, which will be subject to a public review and comment process, will evaluate whether unacceptable risks related to management of CCR material exist at the JOF Plant. The EI data will be used to evaluate the basis and methods for TDEC Order CCR management unit closure in the CARA Plan, including an evaluation of the performance of existing closure methods; modifications to closure methodology will be identified, as needed, in the CARA Plan. The CARA Plan will also specify the actions TVA plans to take at the CCR management units and the former Coal Yard and the basis of those actions. It will also incorporate other operational changes planned or in progress by TVA, including details for CCR material beneficial use operations, modification of the CCR management units and former Coal Yard as needed to meet regulatory standards and long-term closure and monitoring. TVA continues to evaluate additional ways to beneficially use CCR material in a manner consistent with regulatory requirements while maximizing value to the Tennessee Valley.

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TABLES

Table 1-1. Human Health Screening Levels for Groundwater
Environmental Assessment Report

CCR Parameters	Groundwater Screening Levels (µg/L)	Source
CCR Rule Appendix III Constituents :		
Boron	4,000	RSL
Calcium	--	--
Chloride	250,000	SMCL
Fluoride	4,000	MCL
pH	6.5-8.5 S.U.	SMCL
Sulfate	250,000	SMCL
Total Dissolved Solids	500,000	SMCL
CCR Rule Appendix IV Constituents :		
Antimony	6	MCL
Arsenic	10	MCL
Barium	2,000	MCL
Beryllium	4	MCL
Cadmium	5	MCL
Chromium (total)	100	MCL
Cobalt	6	CCR Rule GWPS
Fluoride	4,000	MCL
Lead	15	CCR Rule GWPS
Lithium	40	CCR Rule GWPS
Mercury	2	MCL
Molybdenum	100	CCR Rule GWPS
Radium-226 & 228	5 pCi/L	MCL
Selenium	50	MCL
Thallium	2	MCL
TDEC Appendix I Constituents :		
Copper	1,300	MCLG
Nickel	100	TN MCL
Silver	100	TN SMCL
Vanadium	86	RSL
Zinc	5,000	SMCL

Notes:
MCL: USEPA maximum contaminant level
MCLG: Maximum contaminant level goal
pCi/L: picocuries per liter
SMCL: USEPA secondary maximum contaminant level
S. U.: Standard Unit
RSL: USEPA regional screening level (November 2018)
TN MCL: maximum contaminant level promulgated by State of Tennessee
TN SMCL: secondary maximum contaminant level promulgated by State of Tennessee
ug/L: micrograms per liter

Table 1-2. Human Health and Ecological Site Specific Screening Levels for Surface Water Environmental Assessment Report[1]

CCR Parameters	Johnsonville Fossil Plant						
	Human Health Surface Water Screening Levels		Ecological Surface Water Screening Levels				
			Tennessee River (Hardness = 60 mg/L)				
	(µg/L)	Source	Total Chronic (µg/L)	Total Acute (µg/L)	Dissolved Chronic (µg/L)	Dissolved Acute (µg/L)	
CCR Rule Appendix III Constituents :							
Boron	4,000	RSL	7,200	34,000	NA	NA	a
Calcium	--	--	116,000	NA	NA	NA	a
Chloride	250,000	SMCL	230,000	860,000	NA	NA	a
Fluoride	4,000	MCL	2,700	9,800	NA	NA	a
pH	6 - 9 S.U.	TN DWS	6.5 - 9	NA	NA	NA	b
Sulfate	250,000	SMCL	NA	NA	NA	NA	
Total Dissolved Solids	500,000	TN DWS/SMCL	NA	NA	NA	NA	
CCR Rule Appendix IV Constituents :							
Antimony	6	TN DWS/MCL	190	900	NA	NA	a
Arsenic	10	TN DWS/MCL	150	340	150	340	a
Barium	2,000	TN DWS/MCL	220	2,000	NA	NA	a
Beryllium	4	TN DWS/MCL	11	93	NA	NA	a
Cadmium*	5	TN DWS/MCL	0.526	1.16	0.489	1.12	b
Chromium*	100	TN DWS/MCL	56.7	1187	48.8	375	b
Cobalt	6	RSL	19	120	NA	NA	a
Fluoride	4,000	MCL	2,700	9,800	NA	NA	a
Lead*	5	TN DWS	1.66	42.6	1.44	36.9	b
Lithium	40	RSL	440	910	NA	NA	a
Mercury	2	TN DWS/MCL	0.77	1.4	0.77	1.4	a
Molybdenum	100	RSL	800	7,200	NA	NA	a
Radium-226 & 228	5 pCi/L	MCL	3 pCi/L	3 pCi/L	NA	NA	c
Selenium	50	TN DWS/MCL	3.1	20	NA	NA	b
Thallium	2	TN DWS/MCL	6	54	NA	NA	a
TDEC Appendix I Constituents :							
Copper*	1,300	MCL	6.03	8.65	5.79	8.31	b
Nickel*	100	TN DWS	33.9	305	33.8	304	b
Silver*	94	RSL	NA	1.57	NA	1.34	b
Vanadium	86	RSL	27	79	NA	NA	a
Zinc*	2,000	HAL	77.7	77.7	76.6	76.0	b

Notes:

[1] The proposed screening level for evaluation of surface water in the EAR is the lowest (most conservative) of the available values for each parameter.

* The freshwater screening values are hardness dependent.

mg/L: milligrams per liter

pCi/L: picocuries per liter

ug/L: micrograms per liter

NA: not applicable

SMCL: USEPA secondary maximum contaminant level

MCL: USEPA maximum contaminant level

MCLG: Maximum contaminant level goal

TN DWS: Tennessee Drinking Water Standards

TN MCL: maximum contaminant level promulgated by State of Tennessee

RSL: USEPA regional screening level (November 2018)

a USEPA Region 4 Surface Water Screening Values for Hazardous Waste Sites (March 2018 Revision).

b Tennessee Department of Environment and Consevation (TDEC), 2019. Chapter 0400-40-03, General Water Quality Criteria.

c U.S. Department of Energy (DOE), 2019. DOE Standard (DOE-STD-1153-2019), A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota.
Biota Concentration Guides for water of 4 pCi/L for Radium-226 and 3 pCi/L for Radium-228.

Red highlight denotes bioaccumulative constituent (USEPA Region 4 Ecological Risk Assessment Supplemental Guidance, March 2018 Update).

Table 1-3. Ecological Screening Levels for Freshwater Sediment
Environmental Assessment Report

CCR Parameters	Freshwater Sediment Screening Values Chronic (mg/kg-dw)		Freshwater Sediment Screening Values Acute (mg/kg-dw)		Sediment Quality Assessment Guidelines[a] TEC (mg/kg)	Sediment Quality Assessment Guidelines[a] PEC (mg/kg)
CCR Rule Appendix III Constituents :						
Percent Ash	20%	b	40%	c	NA	NA
Boron	NA		NA		NA	NA
Calcium	NA		NA		NA	NA
Chloride	NA		NA		NA	NA
Fluoride	NA		NA		NA	NA
pH	NA		NA		NA	NA
Sulfate	NA		NA		NA	NA
Total Dissolved Solids	NA		NA		NA	NA
CCR Rule Appendix IV Constituents :						
Antimony	2		25	e	NA	NA
Arsenic	9.8		33	e	9.8	33
Barium	240		22925	f	NA	NA
Beryllium	1.2		42	f	NA	NA
Cadmium	1		5	e	1	5
Chromium	43.4		111	e	43	110
Cobalt	50		NA	e	50	NA
Fluoride	NA		NA		NA	NA
Lead	35.8		128	e	36	130
Lithium	NA		NA		NA	NA
Mercury	0.18		1.1	e	0.18	1.1
Molybdenum	38		69760	f	NA	NA
Radium-226 & 228	90 pCi/g		90 pCi/g	d	NA	NA
Selenium	2	g	2.9	e	NA	NA
Thallium	1.2		10	f	NA	NA
TDEC Appendix I Constituents :						
Copper	31.6		149	e	32	150
Nickel	22.7		48.6	e	23	49
Silver	1		2.2	e	NA	NA
Vanadium	66		564	f	NA	NA
Zinc	121		459	e	120	460

NA - Not Available

a MacDonald, et al., 2003. Development and Evaluation of Numerical Sediment Quality Assessment Guidelines for Florida Inland Waters.
TEC - Threshold Effect Concentration, PEC - Probable Effect Concentration.

b Environmental Investigation Plans (EIP) for TVA fossil plants under the TDEC Consent Order.

c Arcadis, 2012. Kingston Ash Recovery Project Non-Time Critical Removal Action River System Baseline Ecological Risk Assessment (BERA).

d U.S. Department of Energy (DOE), 2019. DOE Standard (DOE-STD-1153-2019), A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota.
Biota Concentration Guides for sediment of 100 pCi/g for Radium-226 and 90 pCi/g for Radium-228.

e USEPA Region 4 Sediment Screening Values for Hazardous Waste Sites (March 2018 Revision).

f National Institute for Public Health and the Environment (RIVM), 2005. Environmental Risk Limits for Nine Trace Elements.
The Maximum Permissible Concentration (MPC) is used for the chronic value and the Serious Risk Addition (SRA_{eco}) is used for the acute value.

g Lemly, A.D., 2002. Selenium Assessment in Aquatic Ecosystems

Red highlight denotes bioaccumulative constituent (USEPA Region 4 Ecological Risk Assessment Supplemental Guidance (March 2018 Update).

Table 1-4. Screening Levels for Mayfly Tissue Critical Body Residues
Environmental Assessment Report

CCR Parameters	Mayfly Tissue Critical Body Residue NOAEL (mg/kg-ww)	LOAEL (mg/kg-ww)	
CCR Rule Appendix III Constituents :			
Boron	NA	NA	
Calcium	NA	NA	
Chloride	NA	NA	
Fluoride	NA	NA	
pH	NA	NA	
Sulfate	NA	NA	
Total Dissolved Solids	NA	NA	
CCR Rule Appendix IV Constituents :			
Antimony	NA	NA	
Arsenic	0.0249	0.249	a
Barium	NA	NA	
Beryllium	NA	NA	
Cadmium	15.6	156	a
Chromium (total)	0.144	1.44	a
Cobalt	0.1061	1.061	
Fluoride	NA	NA	
Lead	269	2690	a
Lithium	NA	NA	
Mercury	2.7	27	a
Molybdenum	NA	NA	
Radium-226 & 228	NA	NA	
Selenium	0.051	0.51	a
Thallium	1.206	12.06	a
TDEC Appendix I Constituents :			
Copper	26	260	a
Nickel	0.115	1.15	a
Silver	0.23	2.3	a
Vanadium	0.604	6.04	a
Zinc	382	3820	a

Notes:

a Arcadis, 2012. Kingston Ash Recovery Project Non-Time Critical Removal Action River System Baseline Ecological Risk Assessment (BERA).

Toxicity values were selected from the U.S. Army Corps of Engineers/ USEPA Environmental Residue-Effects Database (ERED).

LOAEL - Lowest Observed Adverse Effect Level

NOAEL - No Observed Adverse Effect Level

mg/kg-dw - milligrams per kilogram, dry weight

mg/kg-ww - milligrams per kilogram, wet weight

Red highlight denotes bioaccumulative constituent (USEPA Region 4 Ecological Risk Assessment Supplemental Guidance (March 2018 Update).

Table 1-5. Screening Levels for Fish Tissue Critical Body Residues
Environmental Assessment Report

CCR Parameters	Whole Body Fish Tissue Critical Body Residue NOAEL (mg/kg-ww)	LOAEL (mg/kg-ww)		Liver Tissue Critical Body Residue NOAEL (mg/kg-ww)	LOAEL (mg/kg-ww)		Muscle Tissue Critical Body Residue NOAEL (mg/kg-ww)	LOAEL (mg/kg-ww)		Ovary Tissue Critical Body Residue NOAEL (mg/kg-ww)	LOAEL (mg/kg-ww)	
CCR Rule Appendix III Constituents :												
Boron	NA	NA		NA	NA		NA	NA		NA	NA	
Calcium	NA	NA		NA	NA		NA	NA		NA	NA	
Chloride	NA	NA		NA	NA		NA	NA		NA	NA	
Fluoride	NA	NA		NA	NA		NA	NA		NA	NA	
pH	NA	NA		NA	NA		NA	NA		NA	NA	
Sulfate	NA	NA		NA	NA		NA	NA		NA	NA	
Total Dissolved Solids	NA	NA		NA	NA		NA	NA		NA	NA	
CCR Rule Appendix IV Constituents :												
Antimony	NA	NA		NA	NA		NA	NA		NA	NA	
Arsenic	0.04	0.4	a	0.569	5.69	a	0.076	0.76	a	8.4	84	a
Barium	NA	NA		NA	NA		NA	NA		NA	NA	
Beryllium	5.13	51.3	a	NA	NA		NA	NA		NA	NA	
Cadmium	0.0019	0.019	a	0.0000137	0.000137	a	0.03	0.12	a	NA	NA	
Chromium (total)	0.128	1.28	a	0.042	0.42	a	NA	NA		NA	NA	
Cobalt	NA	NA		NA	NA		NA	NA		NA	NA	
Fluoride	NA	NA		NA	NA		NA	NA		NA	NA	
Lead	0.0278	0.278	a	0.0393	0.393	a	2.3	23	a	NA	NA	
Lithium	NA	NA		NA	NA		NA	NA		NA	NA	
Mercury	0.006	0.06	a	0.0009	0.009	a	0.08	0.8	a	NA	NA	
Molybdenum	NA	NA		NA	NA		NA	NA		NA	NA	
Radium-226 & 228	NA	NA		NA	NA		NA	NA		NA	NA	
Selenium	8.5	8.5	b	0.524	5.24	a	11.3	11.3	b	15.1	15.1	b
Thallium	0.027	0.27	a	NA	NA		NA	NA		NA	NA	
TDEC Appendix I Constituents :												
Copper	0.196	1.96	a	6.52	65.2	a	3.4	34	a	NA	NA	
Nickel	11.81	118.1	a	8.22	82.2	a	11.81	118.1	a	NA	NA	
Silver	0.0114	0.114	a	19	190	a	NA	NA		NA	NA	
Vanadium	0.68	2.7	a	0.03	0.3	a	NA	NA		NA	NA	
Zinc	0.45	4.5	a	3.4	34	a	NA	NA		NA	NA	

Notes:

a Arcadis, 2012. Kingston Ash Recovery Project Non-Time Critical Removal Action River System Baseline Ecological Risk Assessment (BERA).
Toxicity values were selected from the U.S. Army Corps of Engineers/USEPA Environmental Residue-Effects Database (ERED).

b USEPA, 2016. Chronic Ambient Water Quality Criterion for Selenium. Fish tissue concentrations expressed as mg/kg-dry weight.

LOAEL – Lowest Observed Adverse Effect Level

NOAEL - No Observed Adverse Effect Level

mg/kg-dw - milligrams per kilogram, dry weight

mg/kg-ww - milligrams per kilogram, wet weight

Red highlight denotes bioaccumulative constituent (USEPA Region 4 Ecological Risk Assessment Supplemental Guidance (March 2018 Update).

Table 3-1 - Lithologic Summary
Johnsonville Fossil Plant
January - February 2019

Geologic Unit	Boring IDs	Depth Range	Group Name and Particle-size Range	Color Range	Additional Observations
Alluvial/Fluvial Deposits	ALL	Ground surface to between 8.8 and *46.5 feet bgs.	Silty lean clay and fat clays that grade into silt clayey sands or poorly graded gravels.	Generally yellowish brown to brown and strong brown. Pinkish white to pale brown in JOF-BG06.	Generally low to medium plasticity, fat clay with high plasticity was noted in JOF-BG01, JOF-BG06, and JOF-BG09.
Fort Payne Formation	JOF-BG01, JOF-BG02, JOF-BG03, JOF-BG04, JOF-BG05, JOF-BG06, JOF-BG07	Ground surface to between 9.3 and 41.0 feet bgs.	JOF-BG01 ranges from silty sand and grades to a lean clay and fat clay. Others generally consist of lean clay and silty lean clay grading to a fat clay with gravel or silty clayey sand. Boring JOF-BG02 grades to a poorly graded gravel at 20.0 feet bgs, and JOF-BG03 grades to a well graded gravel at 17.0 feet bgs. All borings terminate on a very fine grained, brownish sandstone.	Generally yellowish brown to brown and strong brown. Pinkish white to pale brown in JOF-BG06	Generally low to medium plasticity, medium to high plasticity was noted in JOF-BG02, JOF-BG03, JOF-BG06, and JOF-BG07; high plasticity was noted in JOF-BG01 and JOF-BG06.
Chattanooga Shale	JOF-BG10	Ground surface to 14.5 feet bgs.	Clayey silt generally from ground surface to 5.0 feet bgs, grading to a very stiff dark brown lean clay until auger refusal on dark black brown, moderately hard, thinly bedded shale.	Strong brown to dark brown	Generally low plasticity to medium plasticity.
Camden Formation	JOF-BG08, **JOF-BG09, JOF-BG12, JOF-112	Ground surface to between 8.8 and 30.0 feet bgs	Soil varies in each boring; JOF-BG08 ranges from lean clay to 8.5 feet bgs, clayey-silt to 12.5 feet bgs, clayey sand to 15.0 feet bgs, grading to a poorly graded gravel; BG09 consists of fat clay; JOF-BG12 consists of silty gravels to 9.0 fet bgs, grading to a silty sand to 13.5 feet bgs; JOF-112 consists of sandy lean clays to 12.5 feet bgs, grading to a poorly graded gravel. JOF-BG08, JOF-BG12, and JOF-112 terminate on a white to light gray hard limestone.	Reddish brown to brown and strong brown	Generally ranges from non-plastic to low plasticity. JOF-112 grades to a non-plastic at 12.5 feet bgs to refusal at 30.9 feet bgs. High plasticity was noted throughout in JOF-BG09.

*Bedrock was not encountered in boring JOF-109.

**JOF-BG09: Bedrock at refusal was not described. However, based in the location in relation to boring JOF-BG12 (Camden Formation), it is anticipated that the bedrock underlying JOF-BG09 is the Camden Formation.

Notes:

bgs - below ground surface

ID - identification

TABLE 4-1 – Pore Water Level Measurements
Johnsonville Fossil Plant
June-November 2020

Temporary Well / Piezometer ID	Top of Casing Elevation	Piezometer Sensor Elevation	Pore Water Elevation (ft msl)					
	ft msl	ft bgs	6/8/2020	7/9/2020	8/10/2020	9/8/2020	10/12/2020	11/9/2020
Temporary Wells								
JOF-TW01	396.33	n/a	382.71	381.99	380.98	382.48	379.72	380.30
JOF-TW02	397.38	n/a	380.02	379.28	378.64	380.39	373.07	378.64
JOF-TW03	409.49	n/a	396.62	378.38	378.21	379.40	376.91	377.95
JOF-TW04	394.25	n/a	382.68	382.56	382.51	382.74	382.43	382.57
JOF-TW05	393.44	n/a	382.06	382.27	382.39	382.43	382.43	382.48
JOF-TW06	395.13	n/a	372.32	372.27	372.23	372.32	371.88	372.08
JOF-TW07	402.92	n/a	373.69	373.73	373.78	373.64	373.49	373.71
JOF-TW08	387.22	n/a	377.38	378.05	378.04	378.98	376.12	377.32
JOF-TW09	387.52	n/a	372.48	372.16	371.82	371.38	369.84	370.12
JOF-TW10	384.92	n/a	376.22	375.90	375.62	375.48	374.32	374.78
JOF-TW11	440.13	n/a	402.02	401.93	401.95	401.84	401.86	401.84
JOF-TW12	444.17	n/a	401.86	401.87	401.27	401.23	401.51	401.31
JOF-TW13	441.39	n/a	402.66	402.56	402.54	402.28	402.27	401.91
JOF-TW15	451.71	n/a	386.45	385.98	385.87	385.85	385.53	385.48
JOF-TW16	473.81	n/a	393.06	392.18	392.07	392.05	391.58	391.33
Piezometers								
JOF-E-2A-PZ5	n/a	370.9	383.1	383.2	383.3	383.3	383.0	383.3
JOF_PZEC	n/a	365.4	382.9	382.9	382.6	382.6	382.6	382.6
JOF_PZFC	n/a	364.8	384.5	384.5	383.1	383.1	383.0	383.1
JOF_PZGC	n/a	364.8	377.7	377.8	378.7	378.9	379.0	378.7
JOF_PZHC	n/a	365.8	382.2	382.2	382.4	382.4	382.3	382.4
JOF_PZIC	n/a	360.1	381.8	381.7	381.7	381.8	381.7	381.9
JOF_PZJC	n/a	365.0	381.6	382.0	381.5	383.5	379.4	382.5
JOF_PZKC	n/a	365.5	380.3	380.1	379.9	NM	NM	381.3
JOF_PZLC	n/a	365.5	380.0	379.8	379.0	381.1	377.6	380.4
JOF_PZMC	n/a	366.1	375.4	375.0	376.7	378.9	375.0	377.4
P-8	n/a	394.5	400.0	400.0	400.1	400.2	400.0	400.2
P-9	n/a	393.8	395.6	395.6	395.7	395.7	395.4	395.8
P-10	n/a	391.0	401.6	401.5	401.6	401.5	401.0	401.0

Notes:

bgs	below ground surface
ft	feet
ID	identification
msl	mean sea level
n/a	not applicable
NM	not measured

1. Top of casing elevations were obtained boring logs, well details, and well survey data.
2. For piezometers, pore water elevations and piezometer data were obtained from geotechnical instrumentation database. Data from vibrating wire piezometers were averaged for the measurement date. For consistency in reporting for the TDEC Order, historical piezometer IDs were modified (if necessary) to include 'VWPZ' to indicate a vibrating wire piezometer.
3. Depth to pore water in piezometers and pore water elevations at all locations are calculated values. Accuracy of piezometer data is to 0.1 ft.
4. Pore water levels were not measured in select piezometers as noted above because the sensors were not recording data.

Table 4-2 -Estimated CCR Material Areas, Depths, and Volumes
Johnsonville Fossil Plant

CCR Unit/Facility	CCR Material Above Phreatic Surface (CY)	CCR Material Below Phreatic Surface (CY)	Total (CY)	Minimum CCR Depth (FT)	Maximum CCR Depth (FT)	CCR Unit/Facility Area (Acres)
Active Ash Pond 2	519,040	3,950,180	4,469,220	0	56	107
Ash Disposal Area 1	418,190	310,190	728,380	0	42	19
Former Coal Yard	106,020	444,630	550,650	0	28	38
DuPont Road Dredge Cell	897,270	161,330	1,058,600	0	45	25
South Rail Loop Area 4 and Former Stilling Pond	4,139,460	96,270	4,235,730	0	90	74
Study Area Units Total	**6,079,980**	**4,962,600**	**11,042,580**	**Not Applicable**	**Not Applicable**	**263**

Notes:

1. CCR – coal combustion residuals
2. CY – cubic yards
3. The volumes reported herein for the former Coal Yard, Active Ash Pond 2, and former Stilling Pond do not correspond to a closed condition and the phreatic surface would be expected to decrease following decanting of Active Ash Pond 2 and after capping of CCR management units, the former Coal Yard, and former Stilling Pond, if these areas were
4. For details regarding the development of the three-dimensional models of the CCR management units, refer to the MQA SAR

(Appendix G.7).

5. For details regarding water level measurements used to estimate the phreatic surface elevation, refer to Chapter 4.3.3.3.
6. The former Coal Yard is not a CCR Unit.

Stantec

EXHIBITS

Exhibit No.
1-1

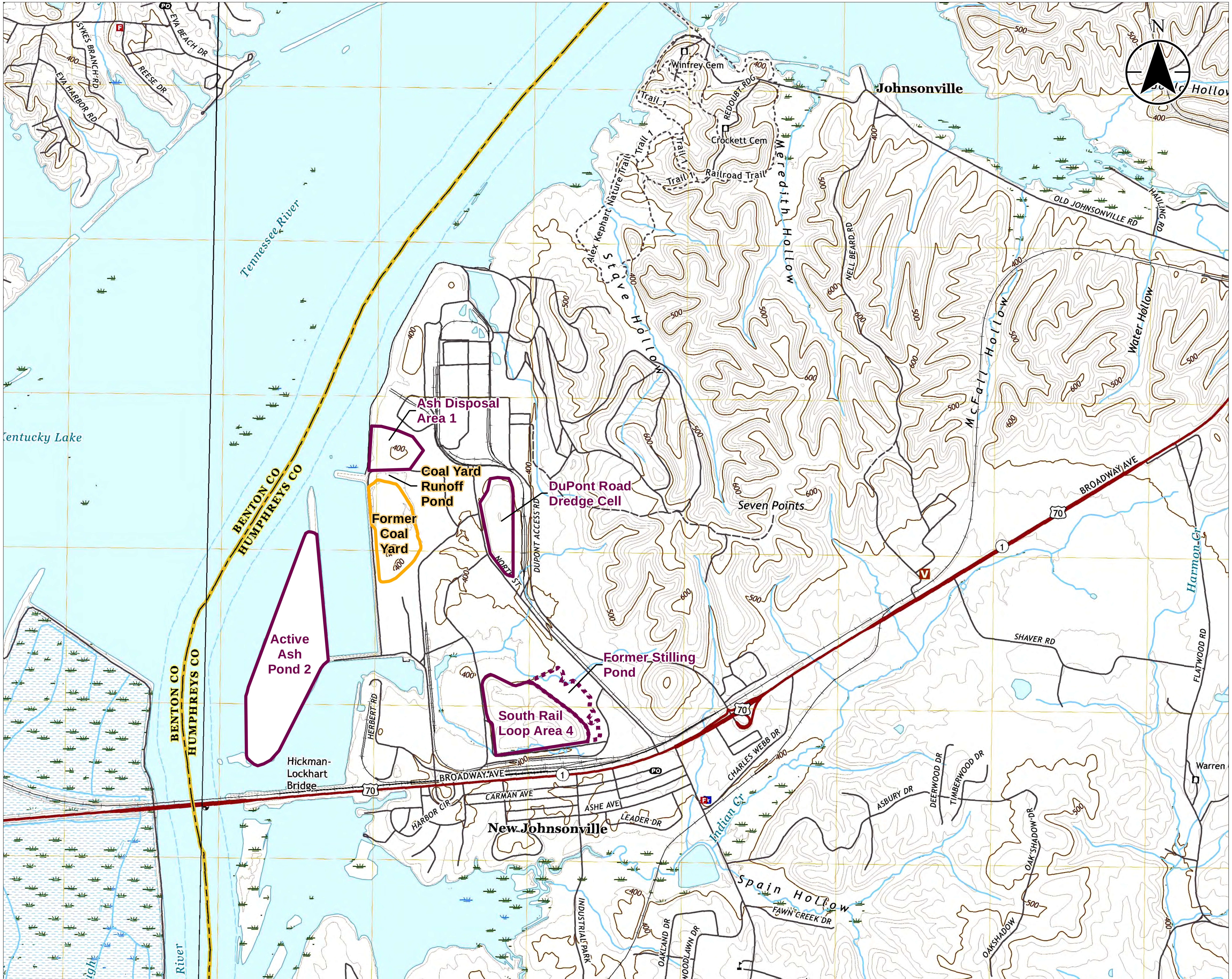
Title
Location Plan and Topographic Map

Client/Project
Tennessee Valley Authority
Johnsonville Fossil (JOF) Plant TDEC Order

Project Location
New Johnsonville, Tennessee

175568286
Prepared by DMB on 2023-08-15
Technical Review by EM on 2023-08-15

0 1,000 2,000 3,000 4,000 Feet
1:12,000 (At original document size of 22x34)



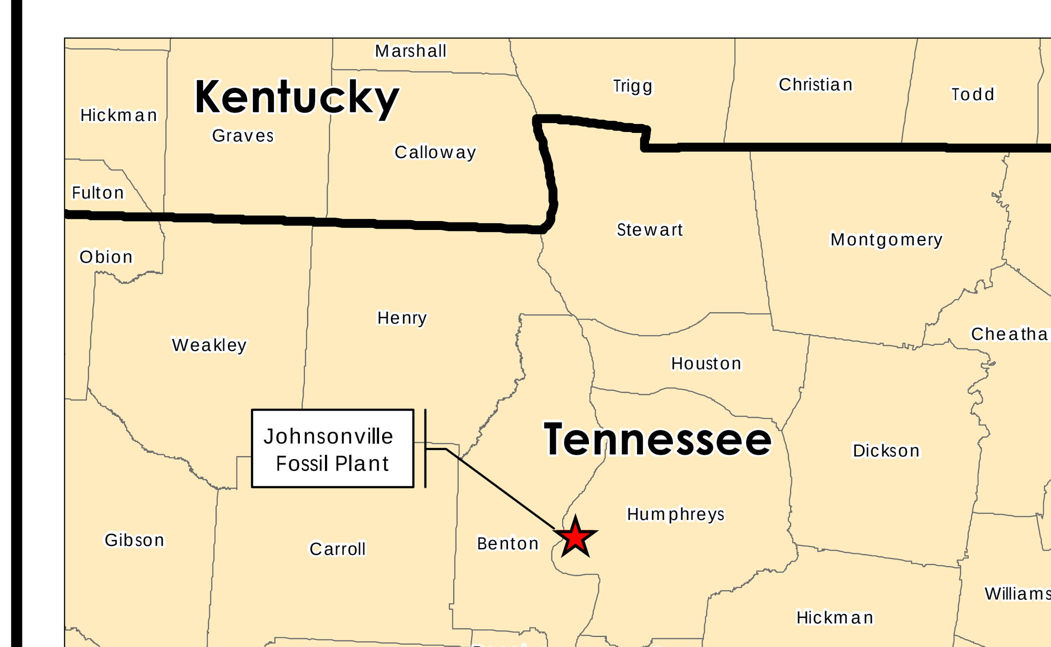
Legend

- CCR Management Unit Area (Approximate)
- Former Coal Yard (Approximate)
- Former Stilling Pond (Approximate)

CCR = Coal Combustion Residuals

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Topographic Mapping corresponds to the Camden Quadrangle (Edition 2019, Scale 1:24,000) and the Johnsonville Quadrangle (Edition 2019, Scale 1:24,000)



Stantec TVA

Exhibit No.

2-1

Title

JOF Plant Overview

Client/Project

Tennessee Valley Authority
Johnsonville Fossil (JOF) Plant TDEC Order

Project Location

New Johnsonville, Tennessee

175568286
Prepared by DMB on 2023-08-21
Technical Review by JW on 2023-08-21

0 400 800 1,200 1,600 Feet

1:4,800 (At original document size of 22x34)

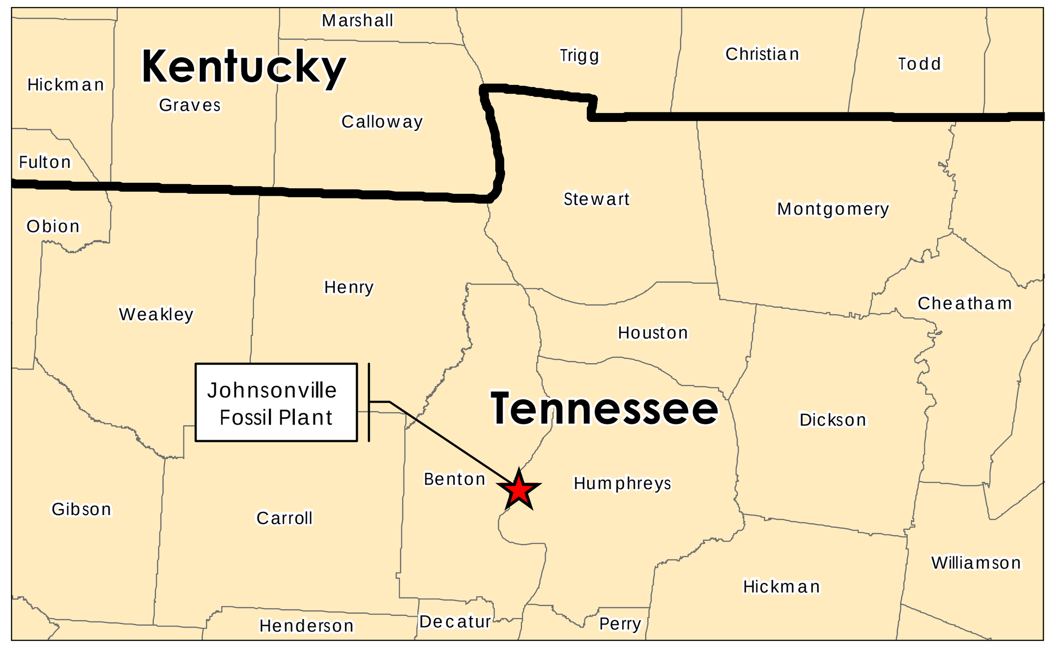
Legend

- 2018 Imagery Boundary
- CCR Management Unit Area (Approximate)
- Former Coal Yard (Approximate)
- Former Stilling Pond (Approximate)
- TVA Property Boundary

CCR = Coal Combustion Residuals

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by TVA (2017 and 2018-09-18)



U:\TVA-EIP\175568286_JOF_Phase2\gis\mxd\EAR\2-1_JOF_PlantOverview.mxd Revised: 2023-08-21 By: mbough

Exhibit No.

2-2

Title

Dike Construction History

Client/Project

Tennessee Valley Authority
Johnsonville Fossil (JOF) Plant TDEC Order

Project Location

New Johnsonville, Tennessee

175568286
Prepared by DMB on 2023-08-21
Technical Review by EM on 2023-08-21

0 600 1,200 1,800 2,400 Feet

1:7,200 (At original document size of 22x34)

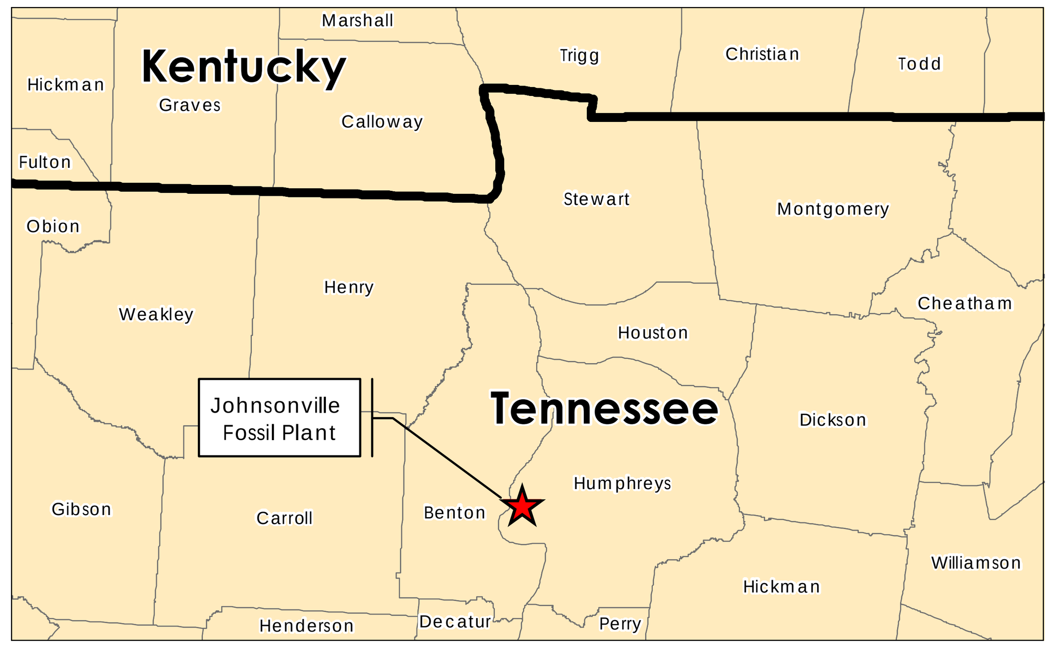
Legend

- Cross Section Location
- Active Ash Pond 2 Dike (Approximate)
- Coal Yard Dike (Approximate)
- DuPont Road Dredge Cell Berm (Approximate)
- South Rail Loop Dike (Approximate)
- West Dike (Approximate)
- Property Line (Approximate)
- 2017 Imagery Boundary
- 2018 Imagery Boundary
- CCR Management Unit Area (Approximate)
- Former Coal Yard (Approximate)
- Former Stilling Pond (Approximate)
- Historical CCR Management Area (Approximate)

CCR = Coal Combustion Residuals

Notes

1. Coordinate System: NAD 1927 StatePlane Tennessee FIPS 4100
2. Imagery Provided by TVA (2017 & 2018) and Esri World Imagery



U:\TVA-EP\175568286_JOF_Phase2\gis\mxd\EAR\2-2_DikeConstructionHistory.mxd Revised: 2023-08-21 By: mbough

Exhibit No.

2-3

Title

Geologic Map

Client/Project

Tennessee Valley Authority
Johnsonville Fossil (JOF) Plant TDEC Order

Project Location 175568286

New Johnsonville, Tennessee

Prepared by DMB on 2023-08-21
Technical Review by MD on 2023-08-21

0 400 800 1,200 1,600 Feet

1:4,800 (At original document size of 22x34)

Legend

- Approximate Location of Inferred Thrust Fault (1948)
- 2017 Imagery Boundary
- 2018 Imagery Boundary
- CCR Management Unit Area (Approximate)
- Former Coal Yard (Approximate)
- Former Stilling Pond (Approximate)
- TVA Property Boundary

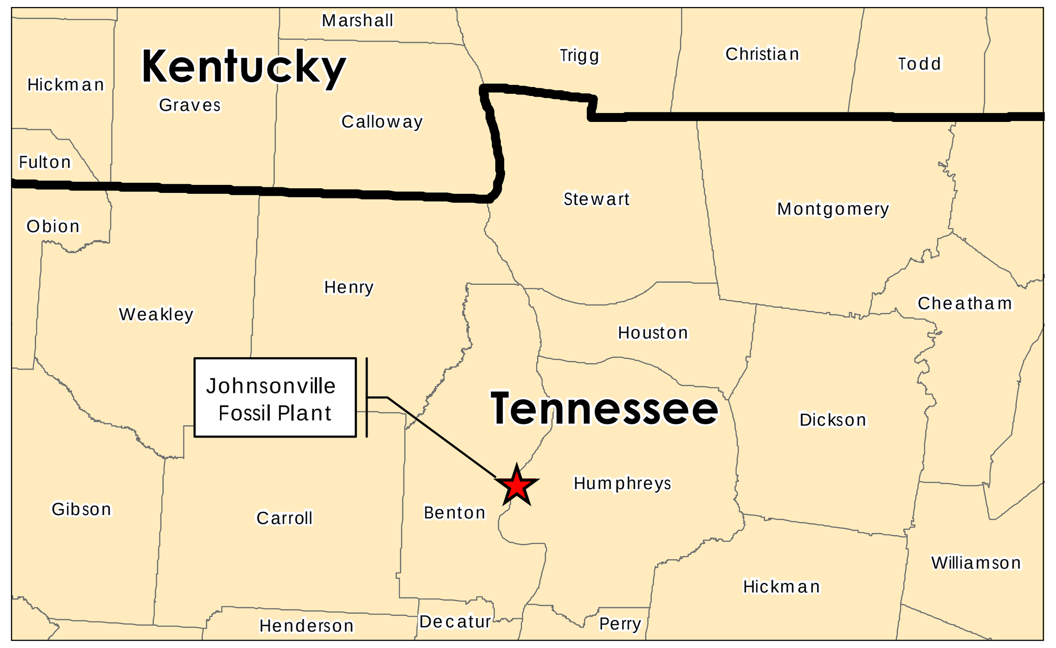
Geologic Formations

- D - Devonian Formations, includes Pegram Formation, Camden Formation, Harriman Formation, Flat Gap Limestone, and Ross Formation
- Mfp - Fort Payne Formation or Fort Payne Formation and Chattanooga Shale
- Msw - St. Louis Limestone and Warsaw Limestone
- Qal - Alluvial deposits

CCR = Coal Combustion Residuals

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by TVA (2017 and 2018-09-18) and Esri World Imagery
3. Geologic Data downloaded from https://mrdata.usgs.gov/geology/state/state.php?state=TN
4. Location of fault obtained from Kellberg, 1948



Stantec TVA

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Exhibit No.
2-4

Title
Historic Stream Alignments

Client/Project
Tennessee Valley Authority
Johnsonville Fossil (JOF) Plant TDEC Order

Project Location
New Johnsonville, Tennessee

175568286
Prepared by DMB on 2023-08-16
Technical Review by EM on 2023-08-16

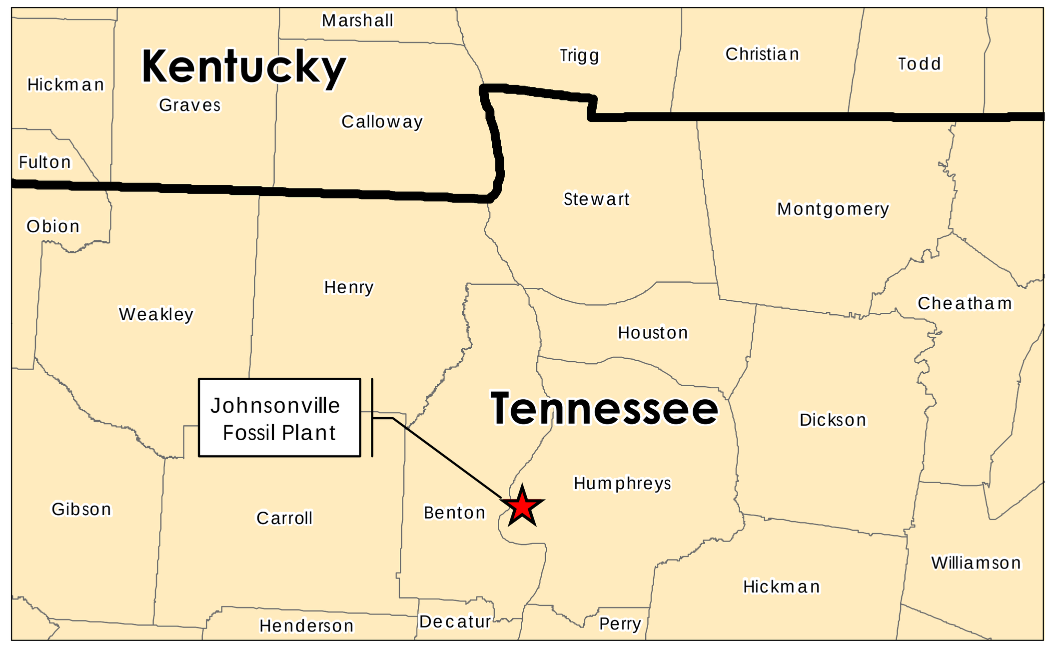
0 400 800 1,200 1,600 Feet
1:4,800 (At original document size of 22x34)

Legend

- Historic Stream (Approximate)
- 2018 Imagery Boundary
- CCR Management Unit Area (Approximate)
- Former Coal Yard (Approximate)
- Former Stilling Pond (Approximate)

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by TVA (2017 & 2018) and Esri World Imagery
3. Historic Streams obtained from topographic map USGS, Johnsonville Quadrangle, 1936



Stantec

TVA

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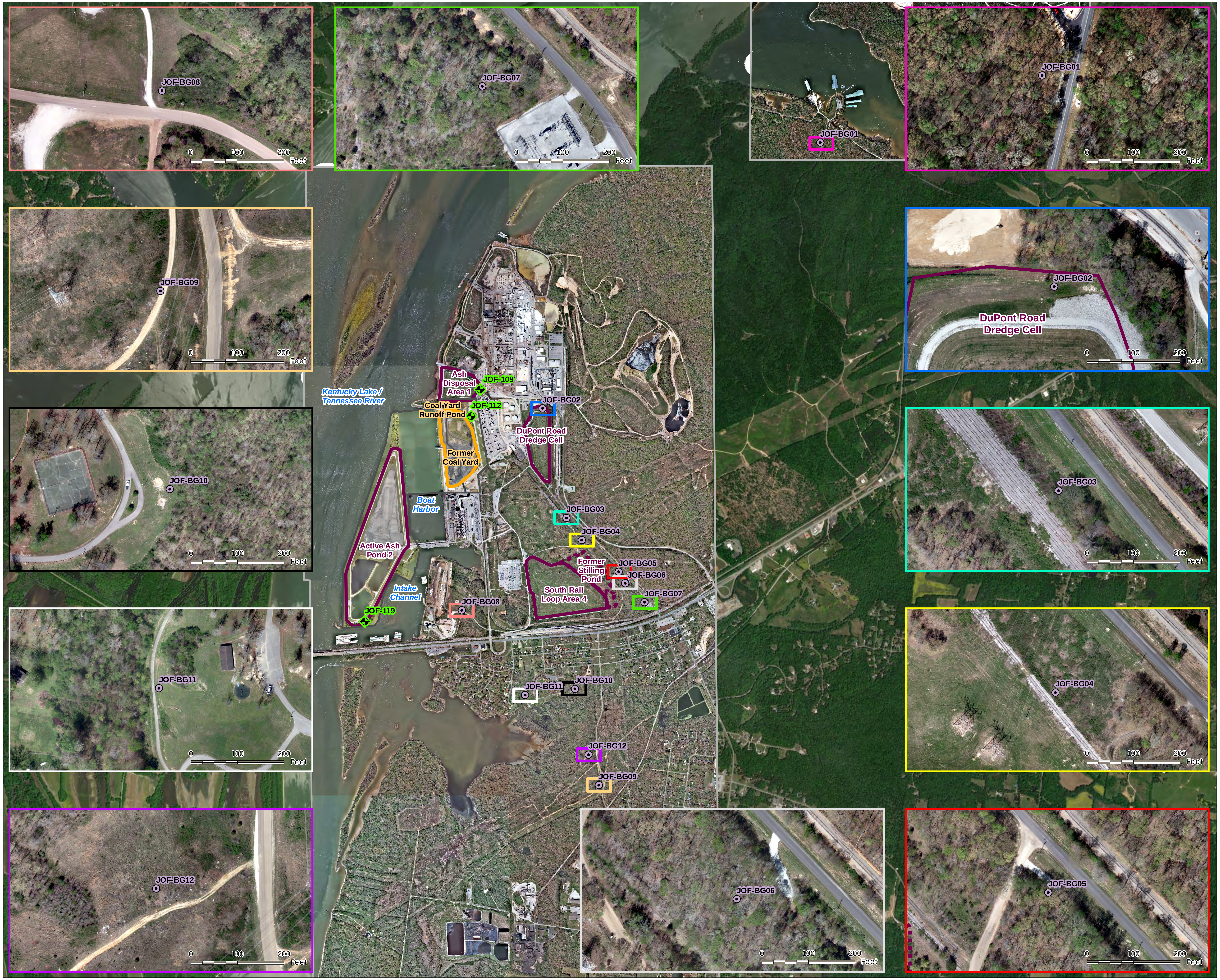


Exhibit No.

3-1

Title

Background Soil Boring and Well Location Map

Client/Project

Tennessee Valley Authority
Johnsonville Fossil Plant (JOF) TDEC Order

Project Location

New Johnsonville, Tennessee

175568286

Prepared by DMB on 2023-08-16
Technical Review by RN on 2023-08-16

0 1,300 2,600 3,900 5,200 Feet

1:15,600 (At original document size of 22x34)

Legend

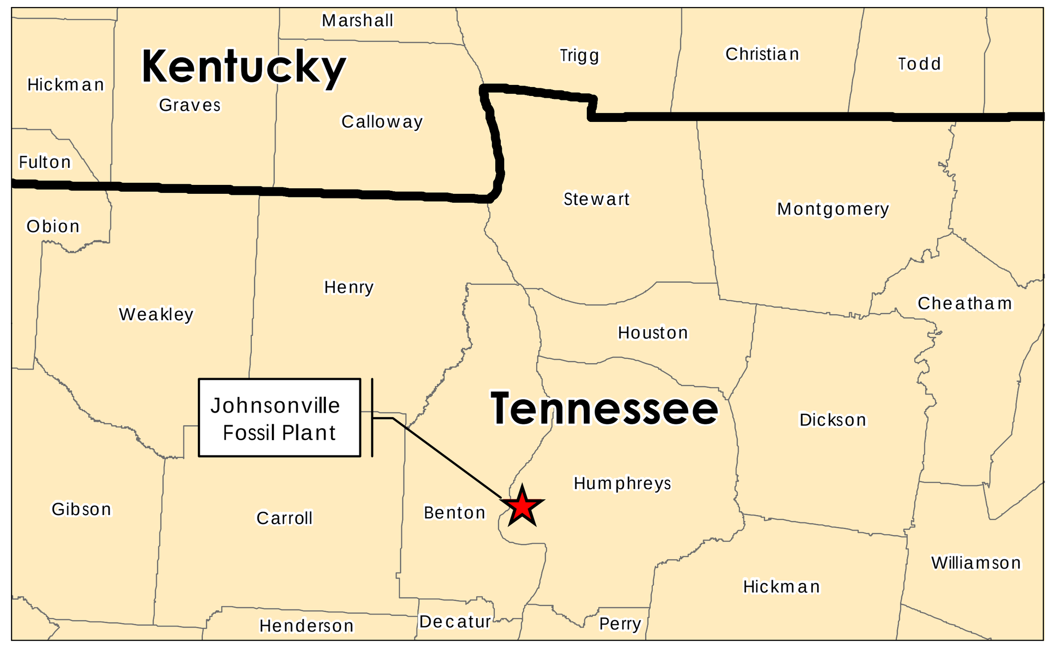
- Background Soil Boring
- Background Monitoring Well
- 2017 Imagery Boundary
- 2018 Imagery Boundary
- CCR Management Unit Area (Approximate)
- Former Coal Yard (Approximate)
- Former Stilling Pond (Approximate)

CCR = Coal Combustion Residuals

N

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by TVA (2017 & 2018) and Esri World Imagery
3. Each inset outline color correlates with the same color extent shown in the main figure.



Stantec TVA

Exhibit No.

4-1

Title

Phase 1 Boring Locations Ash Disposal Area 1, Former Coal Yard, & DuPont Road Dredge Cell

Client/Project

Tennessee Valley Authority
Johnsonville Fossil (JOF) Plant TDEC Order

Project Location

New Johnsonville, Tennessee

175568286
Prepared by DMB on 2023-08-16
Technical Review by RB on 2023-08-16

0 200 400 600 800 Feet

1:2,400 (At original document size of 22x34)

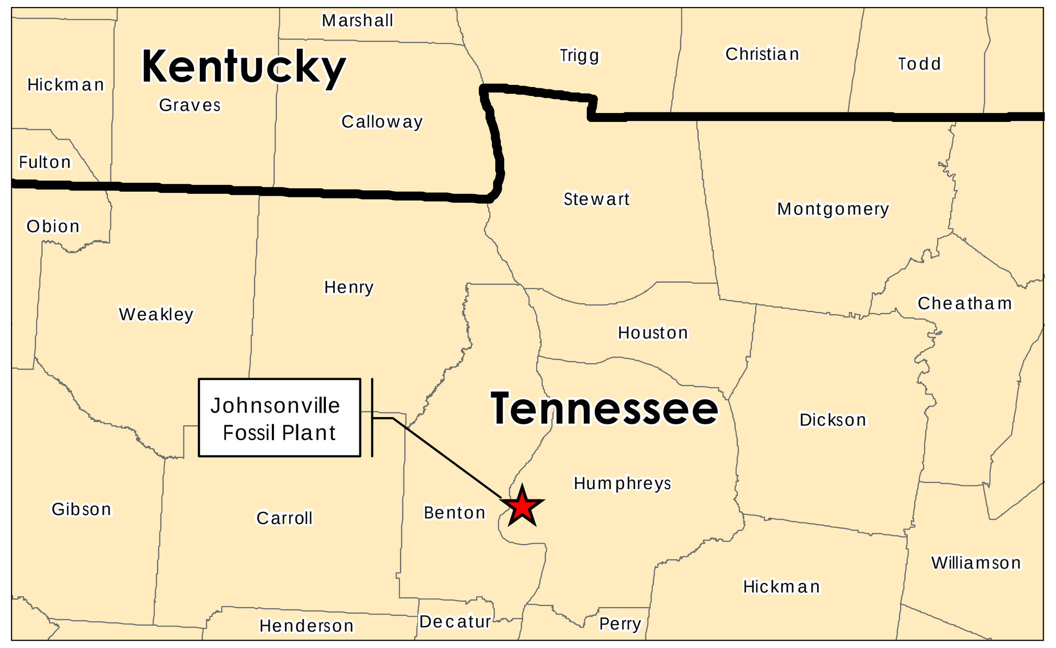
Legend

- Geotechnical Boring
- Geotechnical Boring with Vibrating Wire Piezometer
- Temporary Well
- 2018 Imagery Boundary
- CCR Management Unit Area (Approximate)
- Former Coal Yard (Approximate)
- TVA Property Boundary

CCR = Coal Combustion Residuals

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by TVA (2017 & 2018)
3. Boring locations were surveyed on November 13, 2019. Temporary well locations were surveyed on March 23, 2020. Surveying activities were performed by DDS Engineering, PLLC.



Stantec TVA

Exhibit No.
4-2

Title
Phase 1 Boring Locations
Active Ash Pond 2

Client/Project
Tennessee Valley Authority
Johnsonville Fossil (JOF) Plant TDEC Order

Project Location
New Johnsonville, Tennessee

175568286
Prepared by DMB on 2023-08-16
Technical Review by RB on 2023-08-16

0 300 600 900 1,200 Feet
1:3,600 (At original document size of 22x34)

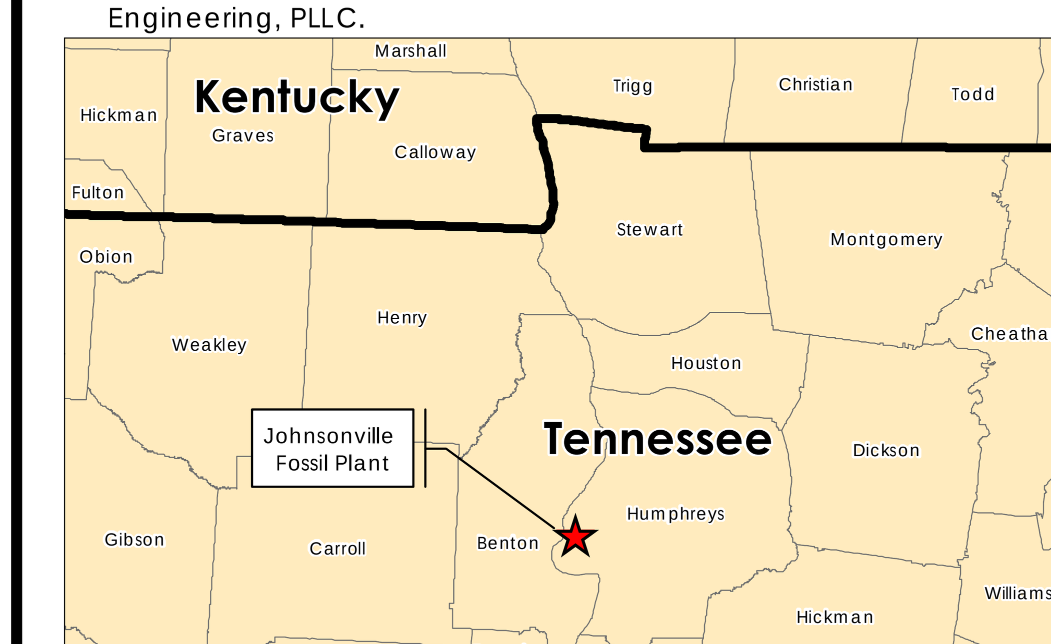
Legend

- Temporary Well
- 2017 Imagery Boundary
- 2018 Imagery Boundary
- CCR Management Unit Area (Approximate)
- Former Coal Yard (Approximate)
- TVA Property Boundary

CCR = Coal Combustion Residuals

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by TVA (2017 & 2018) and Esri World Imagery
3. Temporary well locations were surveyed on March 25, 2020 by DDS Engineering, PLLC.



Stantec
TVA

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Exhibit No.

4-3

Title

Phase 1 Boring Locations South Rail Loop Area 4 and Former Stilling Pond

Client/Project

Tennessee Valley Authority
Johnsonville Fossil (JOF) Plant TDEC Order

Project Location

New Johnsonville, Tennessee

175568286
Prepared by DMB on 2023-08-16
Technical Review by RB on 2023-08-16

0 200 400 600 800 Feet

1:2,400 (At original document size of 22x34)

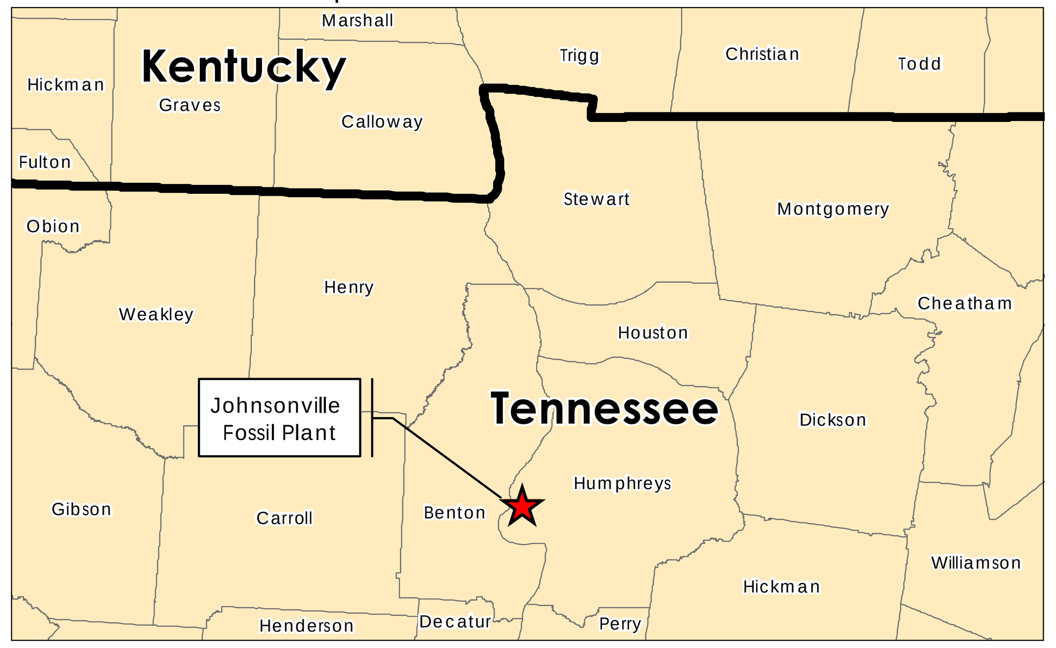
Legend

- Geotechnical Boring
- Geotechnical Boring with Vibrating Wire Piezometer
- Temporary Well
- CCR Management Unit Area (Approximate)
- Former Stilling Pond (Approximate)
- TVA Property Boundary

CCR = Coal Combustion Residuals

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by TVA (2017)
3. Boring locations were surveyed on November 12 and 13, 2019 and March 24, 2020. Temporary well locations were surveyed on November 12, 2019. Surveying activities were performed by DDS Engineering, PLLC.
4. Temporary Well JOF-TW14 was not installed because the boring had insufficient depth of water in CCR to warrant installation.



Stantec TVA

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Exhibit No.

4-4

Title

Phase 2 Boring Locations
Ash Disposal Area 1

Client/Project

Tennessee Valley Authority
Johnsonville Fossil (JOF) Plant TDEC Order

Project Location

New Johnsonville, Tennessee

175568286

Prepared by DMB on 2023-08-16
Technical Review by RB on 2023-08-16

0 100 200 300 400 Feet

1:1,200 (At original document size of 22x34)

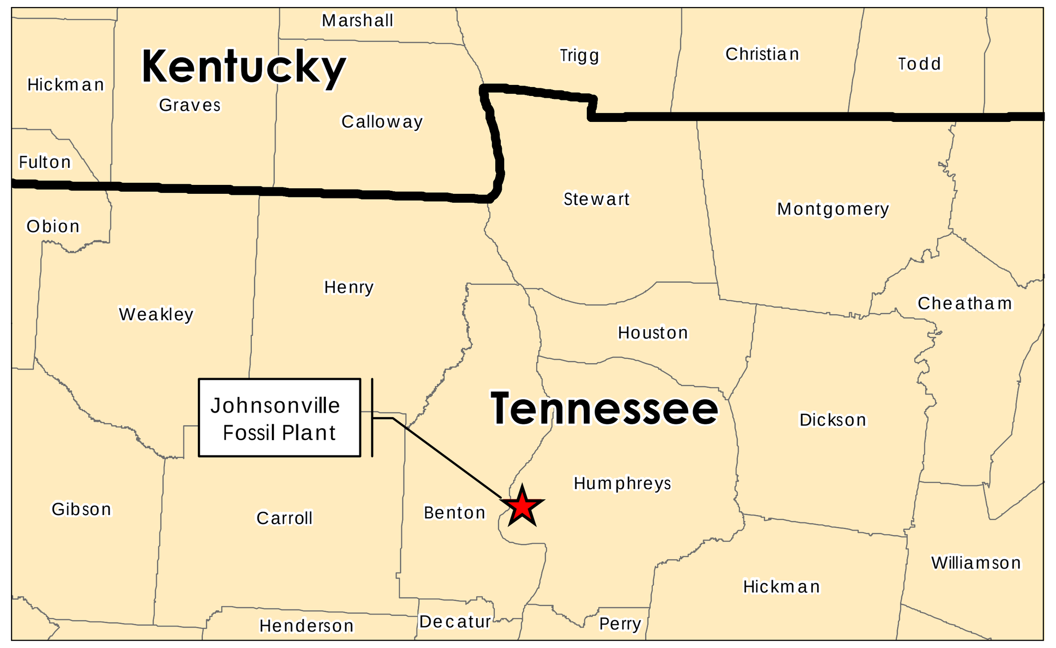
Legend

- Geotechnical Boring
- Cone Penetration Test
- 2018 Imagery Boundary
- CCR Management Unit Area (Approximate)
- Former Coal Yard (Approximate)
- TVA Property Boundary

CCR = Coal Combustion Residuals

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by TVA (2017 & 2018)
3. Boring and Cone Penetration Test locations were surveyed on November 10, 2021. Surveying activities were performed by TVA.



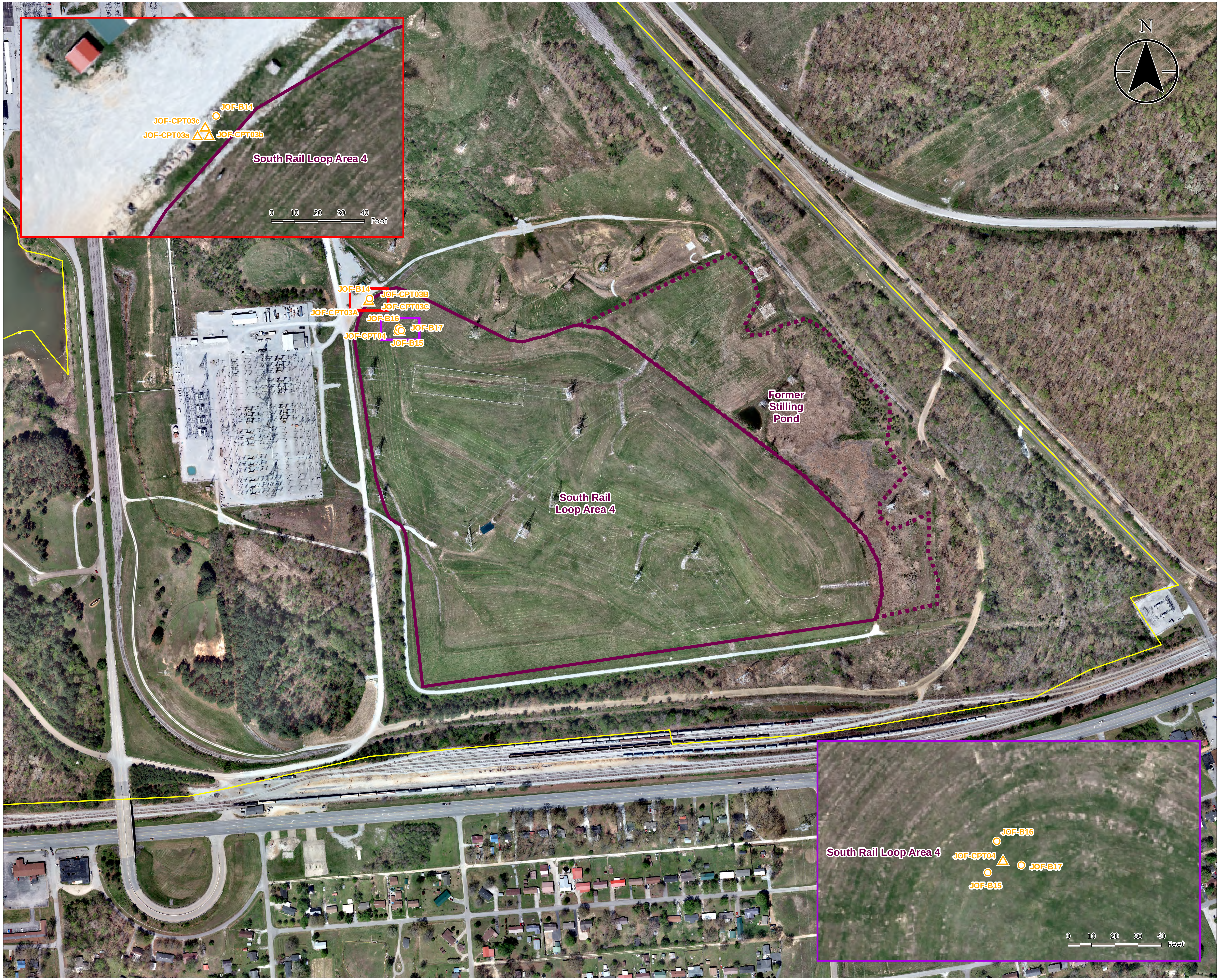


Exhibit No.

4-5

Title

Phase 2 Boring Locations South Rail Loop Area 4 and Former Stilling Pond

Client/Project

Tennessee Valley Authority
Johnsonville Fossil (JOF) Plant TDEC Order

Project Location: New Johnsonville, Tennessee

175568286
Prepared by DMB on 2023-08-16
Technical Review by RB on 2023-08-16

0 200 400 600 800 Feet

1:2,400 (At original document size of 22x34)

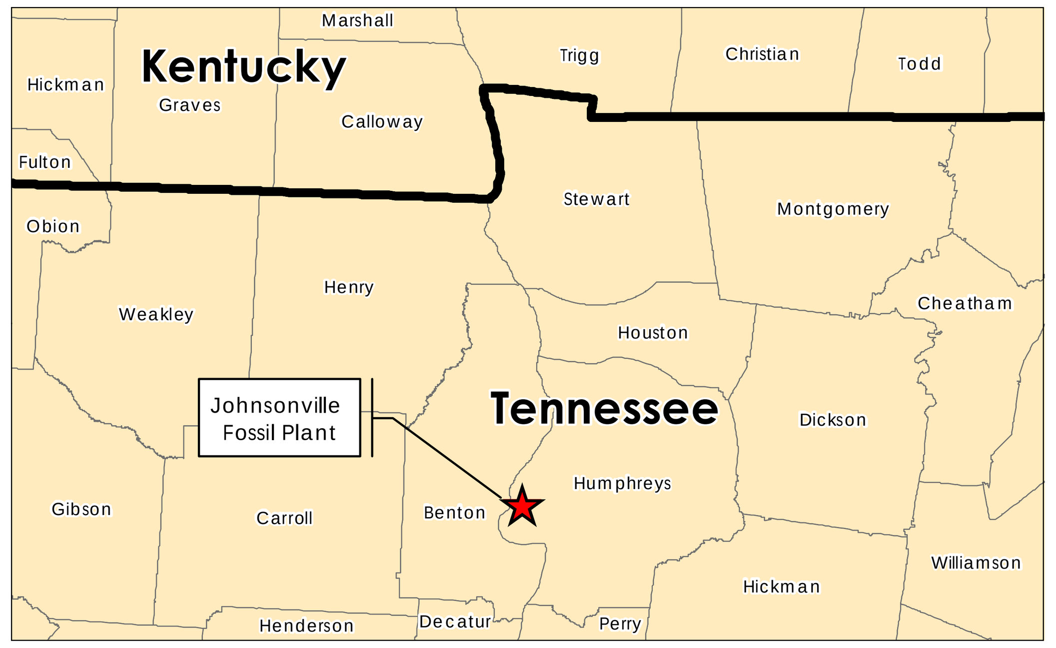
Legend

- Geotechnical Boring
- Cone Penetration Test
- CCR Management Unit Area (Approximate)
- Former Stilling Pond (Approximate)
- TVA Property Boundary

CCR = Coal Combustion Residuals

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by TVA (2017)
3. Boring and Cone Penetration Test locations were surveyed on November 10, 2021. Surveying activities were performed by TVA.



Stantec TVA

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Exhibit No.

4-6

Title

Pore Water Elevation Contour Map, Event #5 (August 10, 2020)

Client/Project

Tennessee Valley Authority
Johnsonville Fossil (JOF) Plant TDEC Order

Project Location 175568286

New Johnsonville, Tennessee

Prepared by DMB on 2023-08-16
Technical Review by MD on 2023-08-16

0 450 900 1,350 1,800 Feet

1:5,400 (At original document size of 22x34)

Legend

- Groundwater Investigation Monitoring Well groundwater elevation in feet above mean sea level (ft amsl); value not used for contouring
- Other Monitoring Well groundwater elevation in ft amsl; value not used for contouring
- Piezometer, groundwater label in blue text, pore water label in yellow highlighted black text; elevation in ft amsl (e.g., JOF-E-2A-PZ2) (e.g., JOF-E-2A-PZ5)
- Piezometer in CCR pore water elevation in ft amsl
- Temporary well in CCR pore water elevation in ft amsl
- Tennessee River/Kentucky Lake Gauging Station surface water elevation in ft amsl
- Surface Stream Flow
- Interpolated Pore water Contour (5 ft interval; elevations are in ft amsl)
- Pore water Contour (5 ft interval; elevations are in ft amsl)
- 2017 Imagery Boundary
- 2018 Imagery Boundary
- CCR Management Unit Area (Approximate)
- Former Coal Yard (Approximate)
- Former Stilling Pond (Approximate)

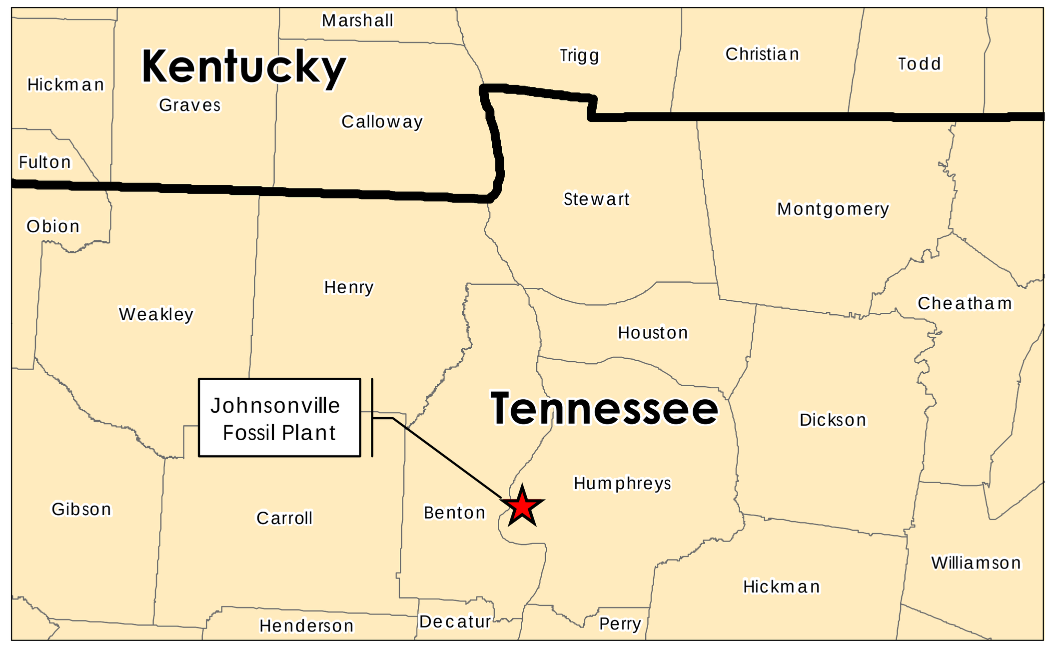
CCR: Coal combustion residuals

*Groundwater elevation displayed but not used as input for contouring due to factors such as well construction or being screened in a different hydrogeologic unit.

**Nested VWPZ sensors monitoring pore water and groundwater elevations in the same borehole, and the location is shown by a single symbol.

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by TVA (2017 & 2018) and Esri World Imagery
3. Pore water contours were created using manual adjustment and Surfer Version 16.1.350 (December 13, 2018)



Stantec TVA

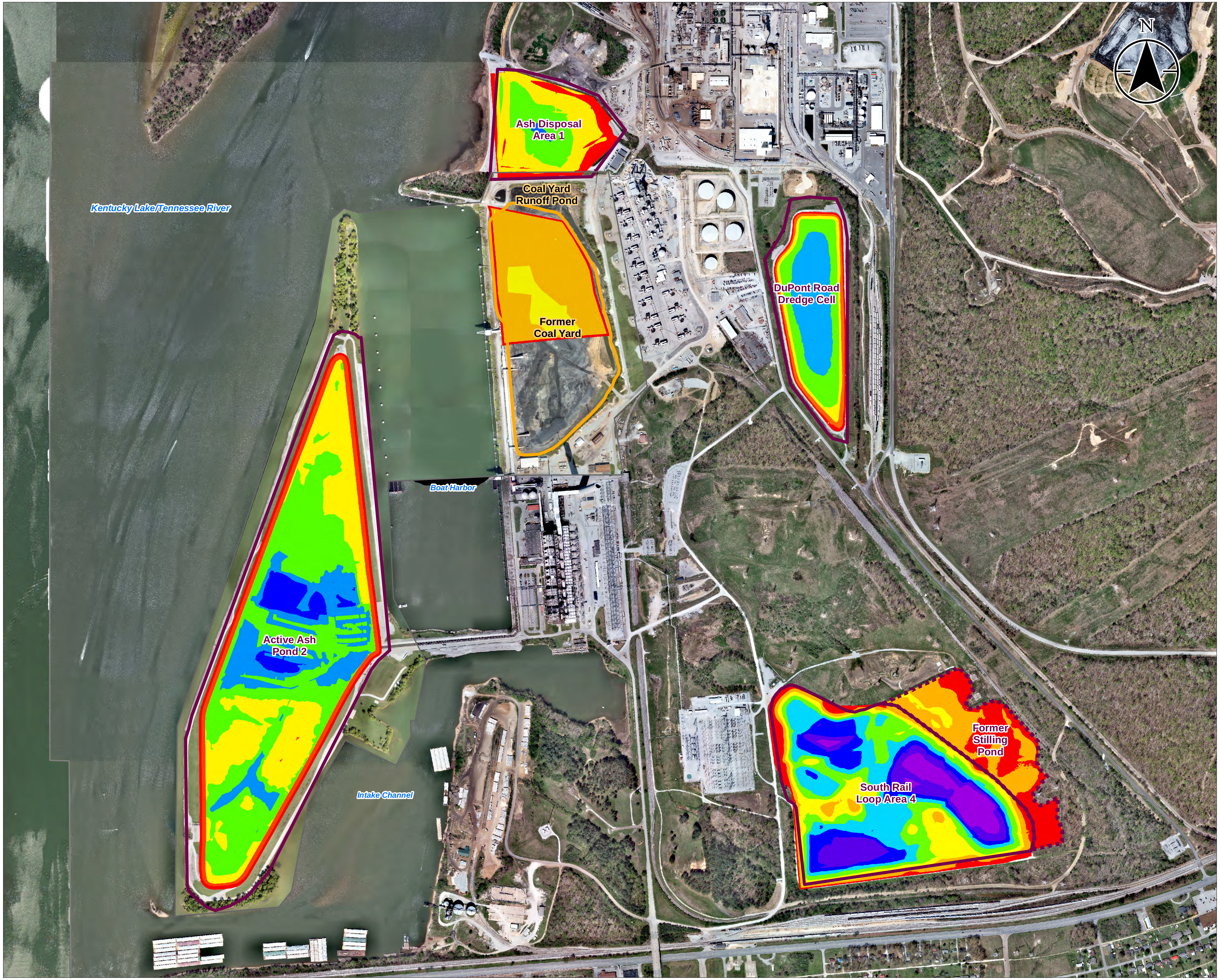


Exhibit No.
4-7

Title
Material Quantity Assessment Study Area Estimated Limits and Depths of CCR Material

Client/Project
Tennessee Valley Authority
Johnsonville Fossil (JOF) Plant TDEC Order

Project Location
New Johnsonville, Tennessee

175568286
Prepared by DMB on 2023-08-16
Technical Review by EM on 2023-08-16

0 400 800 1,200 1,600 Feet
1:4,800 (At original document size of 22x34)

Legend

- 2017 Imagery Boundary
- 2018 Imagery Boundary
- CCR Management Unit Area (Approximate)
- Former Coal Yard (Approximate)
- Former Stilling Pond (Approximate)

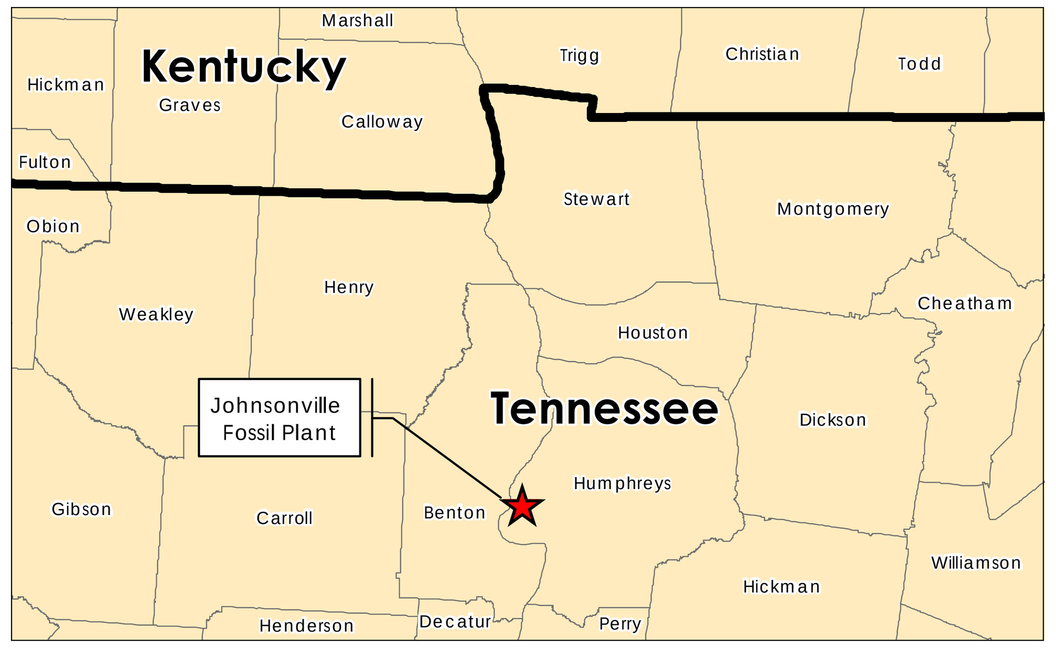
CCR = Coal Combustion Residuals

SUMMARY TABLE

NUMBER	MIN. DEPTH (FT)	MAX. DEPTH (FT)	AREA (AC)	COLOR
1	0.00	10.00	21	
2	10.00	20.00	41	
3	20.00	30.00	47	
4	30.00	40.00	56	
5	40.00	50.00	35	
6	50.00	60.00	12	
7	60.00	70.00	7	
8	70.00	90.00	4	

Notes

1. Coordinate System: NAD 1927 StatePlane Tennessee FIPS 4100
2. Imagery Provided by TVA (2017 & 2018) and Esri World Imagery



Stantec TVA

Exhibit No.

5-1

Title

Groundwater Elevation Contour Map, Event #5 (August 10-11, 2020)

Client/Project

Tennessee Valley Authority
Johnsonville Fossil (JOF) Plant TDEC Order

Project Location

New Johnsonville, Tennessee

175568286
Prepared by DMB on 2023-08-17
Technical Review by MD on 2023-08-17

0 450 900 1,350 1,800 Feet

1:5,400 (At original document size of 22x34)

Legend

- Groundwater Investigation Monitoring Well groundwater elevation in feet above mean sea level (ft amsl)
- Other Monitoring Well groundwater elevation in ft amsl
- Piezometer, groundwater label in blue text, pore water label in yellow highlighted black text; elevation in ft amsl (e.g., JOF-E-2A-PZ2) (e.g., JOF-E-2A-PZ5)
- Piezometer in CCR pore water elevation in ft amsl; value not used for contouring
- Temporary well in CCR pore water elevation in ft amsl; value not used for contouring
- Tennessee River/Kentucky Lake Gauging Station surface water elevation in ft amsl
- Surface Stream Flow
- Interpolated Groundwater Contour (5 ft interval; elevations are in ft amsl)
- Groundwater Contour (5 ft interval; elevations are in ft amsl)
- 2017 Imagery Boundary
- 2018 Imagery Boundary
- CCR Management Unit Area (Approximate)
- Former Coal Yard (Approximate)
- Former Stilling Pond (Approximate)

CCR: Coal combustion residuals

*Groundwater and pore water elevation displayed but not used as input for contouring due to factors such as well construction or being screened in a different hydrogeologic unit.

**Nested VWPZ sensors monitoring pore water and groundwater elevations in the same borehole, and the location is shown by a single symbol.

***The JOF_PZET and JOF_PZFT groundwater elevations are approximately 3-4 feet below the trend established in other piezometers within the Active Ash Pond 2. The groundwater elevation is displayed but not used for contouring.

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by TVA (2017 & 2018) and Esri World Imagery
3. Groundwater contours were created using Surfer Version 16.1.350 (December 13, 2018) and manual adjustment

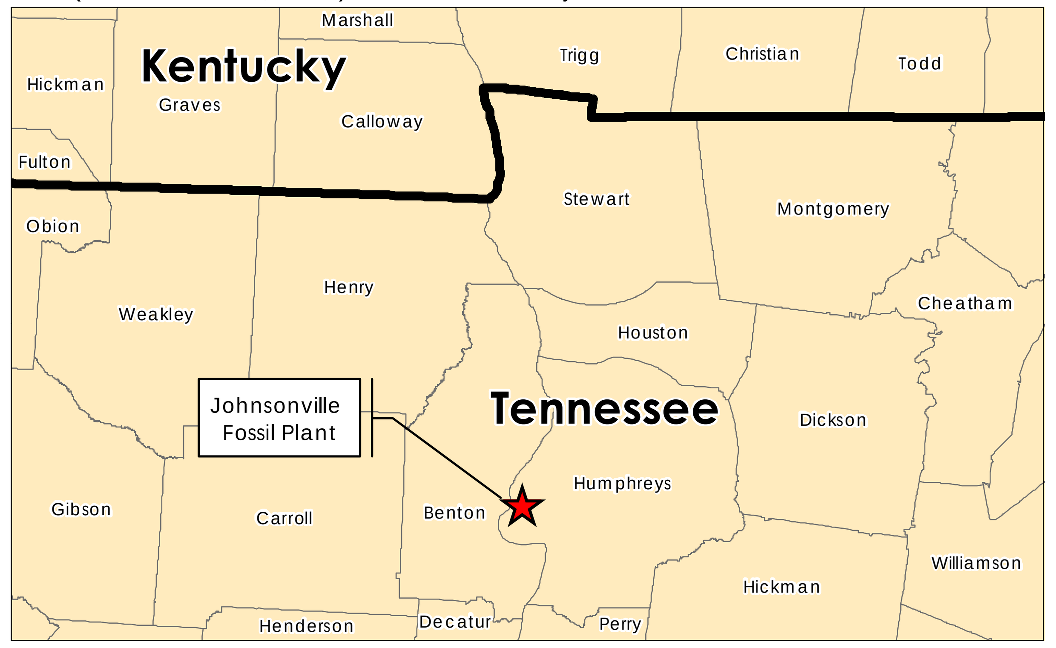


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Exhibit No.

5-2

Title

Dye Trace Study Locations

Client/Project

Tennessee Valley Authority
Johnsonville Fossil (JOF) Plant TDEC Order

Project Location

New Johnsonville, Tennessee

175568286

Prepared by DMB on 2023-08-16
Technical Review by KC on 2023-08-16

0 400 800 1,200 1,600 Feet

1:4,800 (At original document size of 22x34)

Legend

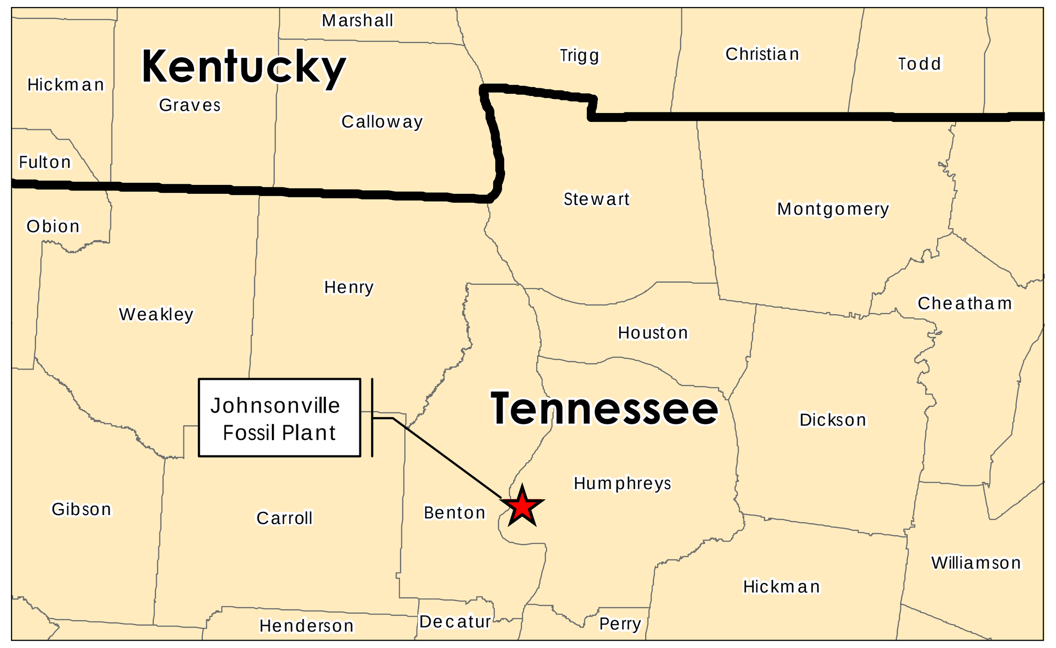
- CCR Well Monitoring Location
- Boring Location to Collect Samples for Bench Study
- Surface Water Upgradient Monitoring Location
- Dye Injection Boring Location
- Surface Water Monitoring Location
- Monitoring Well
- Existing Piezometer Open Standpipe
- 2017 Imagery Boundary
- 2018 Imagery Boundary
- CCR Management Unit Area (Approximate)
- Former Coal Yard (Approximate)
- Former Stilling Pond (Approximate)
- TVA Property Boundary

CCR = Coal Combustion Residuals

Injected Dyes:
IP-1 and IP-2 Sulpho Rhodamine-B
IP-3, IP-4, and IP-5 fluorescein

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by TVA (2017 & 2018) and Esri World Imagery



Stantec TVA

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Exhibit No.
6-1

Title
Seep Investigation - Water Quality Parameter Measurement Locations – North Detail

Client/Project
Tennessee Valley Authority
Johnsonville Fossil (JOF) Plant TDEC Order

Project Location
New Johnsonville, Tennessee

175568286
Prepared by DMB on 2023-08-16
Technical Review by HW on 2023-08-16

1:1,200 (At original document size of 22x34)

Legend

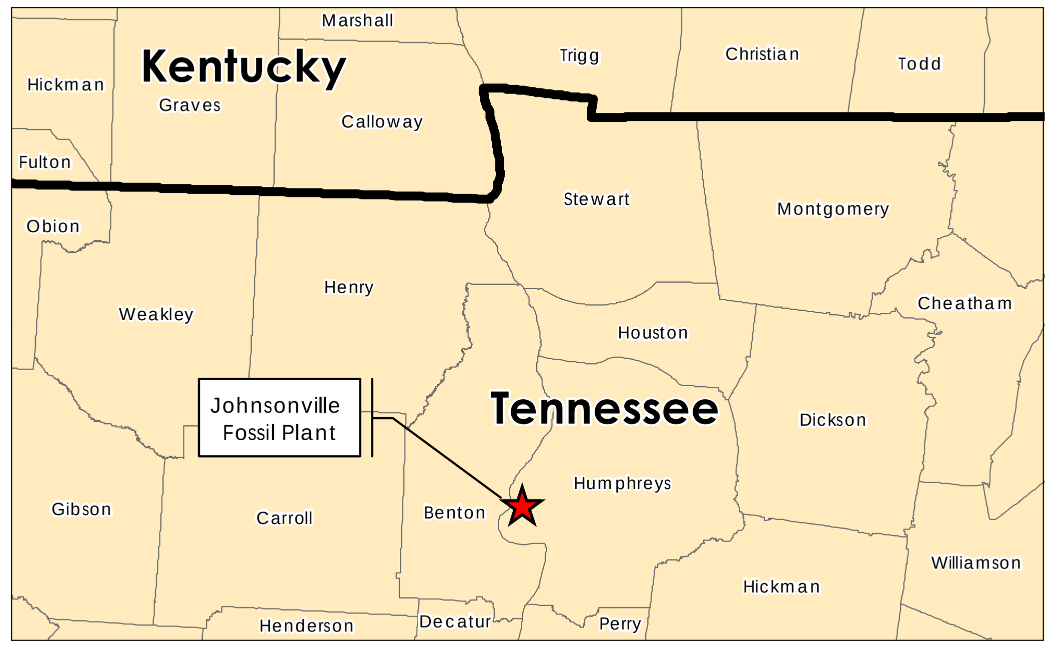
Measurement Locations

- Intermediate Area (IA)
- Historical Seep (HS)
- Area of Interest (AOI) Location
- 2018 Imagery Boundary
- CCR Management Unit Area (Approximate)
- Former Coal Yard (Approximate)

CCR = Coal Combustion Residuals

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by TVA (2017 & 2018)



Stantec TVA

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Exhibit No.

6-2

Title

Seep Investigation - Water Quality Parameter Measurement Locations – South Detail

Client/Project

Tennessee Valley Authority
Johnsonville Fossil (JOF) Plant TDEC Order

Project Location

New Johnsonville, Tennessee

175568286

Prepared by DMB on 2023-08-16
Technical Review by HW on 2023-08-16

0 300 600 900 1,200 Feet

1:3,600 (At original document size of 22x34)

Legend

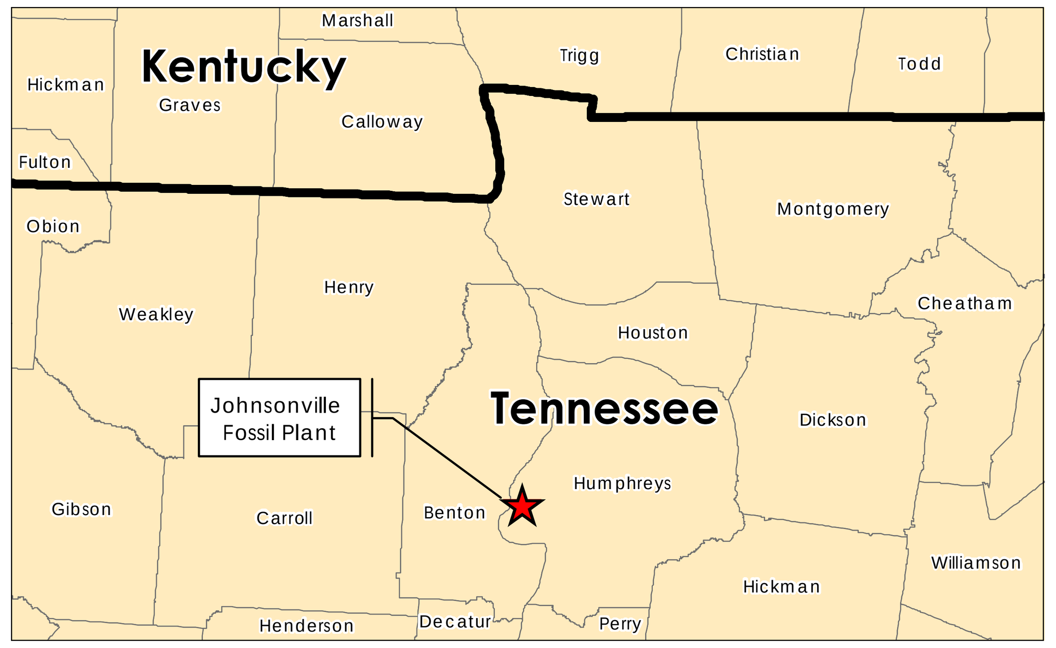
Measurement Locations

- Adjacent (A)
- Downstream (D)
- Upstream (U)
- Intermediate Area (IA)
- Historical Seep (HS)
- Area of Interest (AOI) Location
- Historical Seep 4C
- Historical Seep 5B
- 2017 Imagery Boundary
- 2018 Imagery Boundary
- CCR Management Unit Area (Approximate)
- Former Coal Yard (Approximate)

CCR = Coal Combustion Residuals

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by TVA (2017 & 2018) and Esri World Imagery



Stantec TVA

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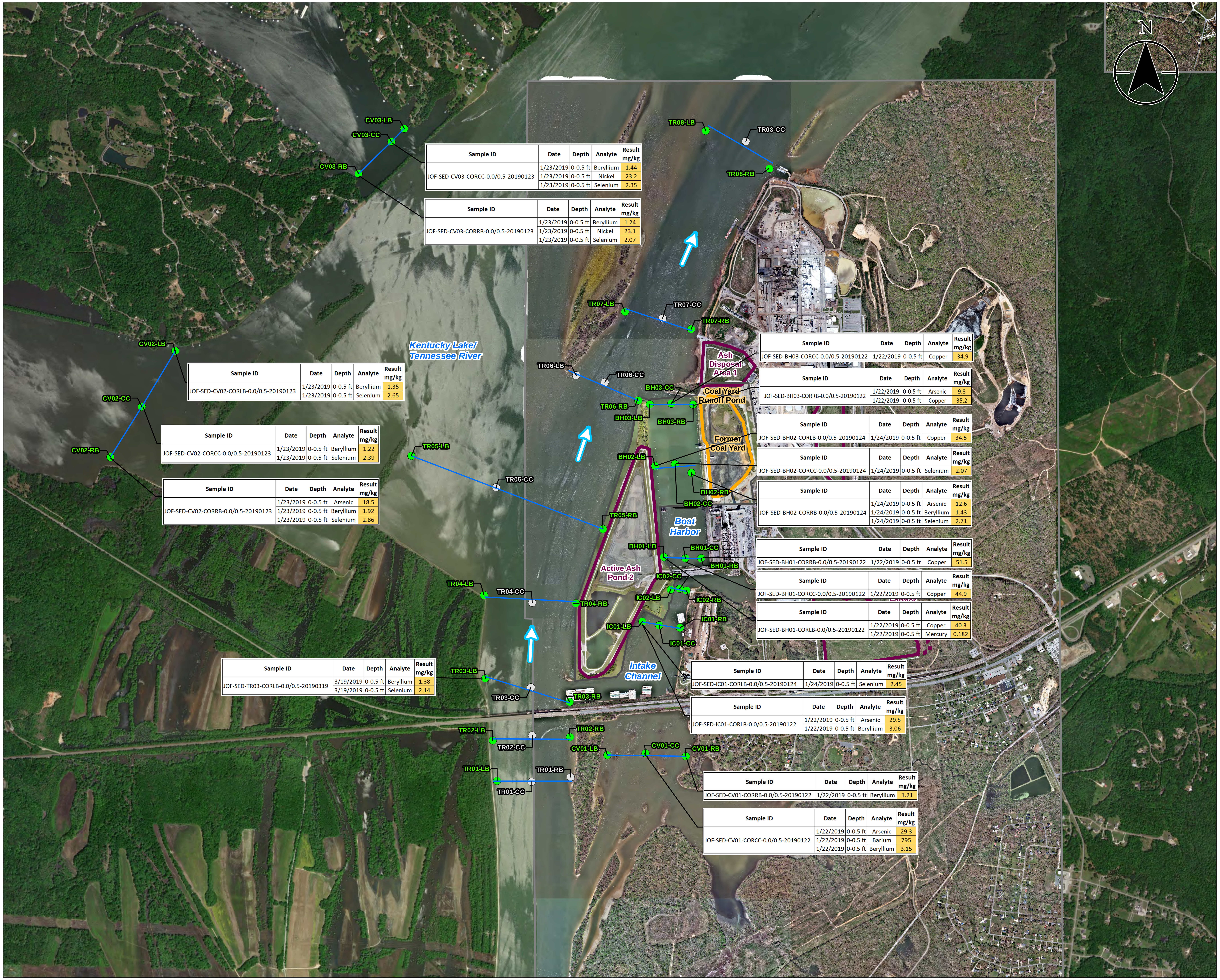


Sample ID	Date	Depth	Analyte	Result mg/kg
JOF-SED-CV03-CORCC-0.0/0.5-20190123	1/23/2019	0-0.5 ft	Beryllium	1.44
	1/23/2019	0-0.5 ft	Nickel	23.2
	1/23/2019	0-0.5 ft	Selenium	2.35

Sample ID	Date	Depth	Analyte	Result mg/kg
JOF-SED-CV03-CORRB-0.0/0.5-20190123	1/23/2019	0-0.5 ft	Beryllium	1.24
	1/23/2019	0-0.5 ft	Nickel	23.1
	1/23/2019	0-0.5 ft	Selenium	2.07

Sample ID	Date	Depth	Analyte	Result mg/kg
JOF-SED-CV02-CORLB-0.0/0.5-20190123	1/23/2019	0-0.5 ft	Beryllium	1.35
	1/23/2019	0-0.5 ft	Selenium	2.65

Sample ID	Date	Depth	Analyte	Result mg/kg
JOF-SED-CV02-CORCC-0.0/0.5-20190123	1/23/2019	0-0.5 ft	Beryllium	1.22
	1/23/2019	0-0.5 ft	Selenium	2.39

Sample ID	Date	Depth	Analyte	Result mg/kg
JOF-SED-CV02-CORRB-0.0/0.5-20190123	1/23/2019	0-0.5 ft	Arsenic	18.5
	1/23/2019	0-0.5 ft	Beryllium	1.92
	1/23/2019	0-0.5 ft	Selenium	2.86

Sample ID	Date	Depth	Analyte	Result mg/kg
JOF-SED-TR03-CORLB-0.0/0.5-20190319	3/19/2019	0-0.5 ft	Beryllium	1.38
	3/19/2019	0-0.5 ft	Selenium	2.14

Sample ID	Date	Depth	Analyte	Result mg/kg
JOF-SED-BH03-CORCC-0.0/0.5-20190122	1/22/2019	0-0.5 ft	Copper	34.9

Sample ID	Date	Depth	Analyte	Result mg/kg
JOF-SED-BH03-CORRB-0.0/0.5-20190122	1/22/2019	0-0.5 ft	Arsenic	9.8
	1/22/2019	0-0.5 ft	Copper	35.2

Sample ID	Date	Depth	Analyte	Result mg/kg
JOF-SED-BH02-CORLB-0.0/0.5-20190124	1/24/2019	0-0.5 ft	Copper	34.5

Sample ID	Date	Depth	Analyte	Result mg/kg
JOF-SED-BH02-CORCC-0.0/0.5-20190124	1/24/2019	0-0.5 ft	Selenium	2.07

Sample ID	Date	Depth	Analyte	Result mg/kg
JOF-SED-BH02-CORRB-0.0/0.5-20190124	1/24/2019	0-0.5 ft	Arsenic	12.6
	1/24/2019	0-0.5 ft	Beryllium	1.43
	1/24/2019	0-0.5 ft	Selenium	2.71

Sample ID	Date	Depth	Analyte	Result mg/kg
JOF-SED-BH01-CORRB-0.0/0.5-20190122	1/22/2019	0-0.5 ft	Copper	51.5

Sample ID	Date	Depth	Analyte	Result mg/kg
JOF-SED-BH01-CORCC-0.0/0.5-20190122	1/22/2019	0-0.5 ft	Copper	44.9

Sample ID	Date	Depth	Analyte	Result mg/kg
JOF-SED-BH01-CORLB-0.0/0.5-20190122	1/22/2019	0-0.5 ft	Copper	40.3
	1/22/2019	0-0.5 ft	Mercury	0.182

Sample ID	Date	Depth	Analyte	Result mg/kg
JOF-SED-IC01-CORLB-0.0/0.5-20190124	1/24/2019	0-0.5 ft	Selenium	2.45

Sample ID	Date	Depth	Analyte	Result mg/kg
JOF-SED-IC01-CORLB-0.0/0.5-20190122	1/22/2019	0-0.5 ft	Arsenic	29.5
	1/22/2019	0-0.5 ft	Beryllium	3.06

Sample ID	Date	Depth	Analyte	Result mg/kg
JOF-SED-CV01-CORRB-0.0/0.5-20190122	1/22/2019	0-0.5 ft	Beryllium	1.21

Sample ID	Date	Depth	Analyte	Result mg/kg
JOF-SED-CV01-CORCC-0.0/0.5-20190122	1/22/2019	0-0.5 ft	Arsenic	29.3
	1/22/2019	0-0.5 ft	Barium	795
	1/22/2019	0-0.5 ft	Beryllium	3.15

Exhibit No.

7-1

Title

Sediment Sampling Results Above Ecological Screening Values

Client/Project

Tennessee Valley Authority
Johnsonville Fossil (JOF) Plant TDEC Order

Project Location

New Johnsonville, Tennessee

175568286
Prepared by MB on 2023-08-17
Technical Review by JC on 2023-08-17

0 1,000 2,000 3,000 4,000 Feet

1:12,000 (At original document size of 22x34)

Legend

- Sediment Sampling Locations - Collected
- Sediment Sampling Locations - Attempted: Insufficient Sediment for Sampling
- Sediment Sampling Location Transects
- Surface Stream Flow
- 2017 Imagery Boundary
- 2018 Imagery Boundary
- CCR Management Unit Area (Approximate)
- Former Coal Yard (Approximate)
- Former Stilling Pond (Approximate)

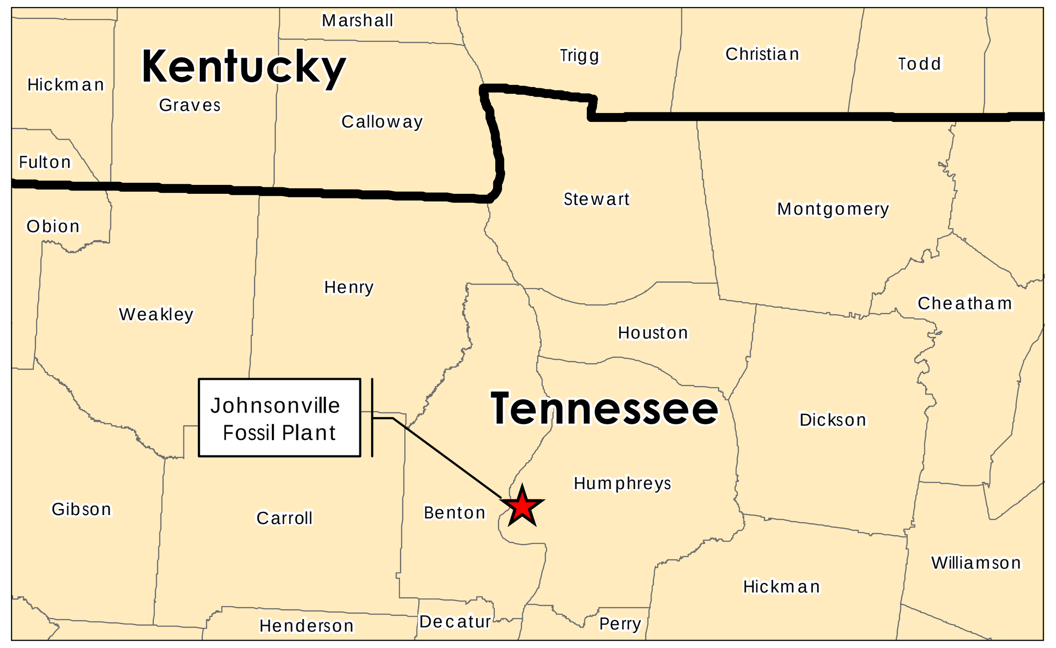
Abbreviations:
CC - Center Channel
RB- Right Bank
LB- Left Bank
mg/kg - milligrams per kilogram
ESV - Ecological Screening Level
CCR - Coal combustion residuals

Concentration > Chronic ESV
Concentration > Acute ESV

Chronic Ecological Screening Values	
Arsenic	9.8 mg/kg
Beryllium	1.2 mg/kg
Copper	31.6 mg/kg
Mercury	0.18 mg/kg
Selenium	2 mg/kg

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by TVA (2017 & 2018) and Esri World Imagery



Stantec TVA

Exhibit No.
7-2

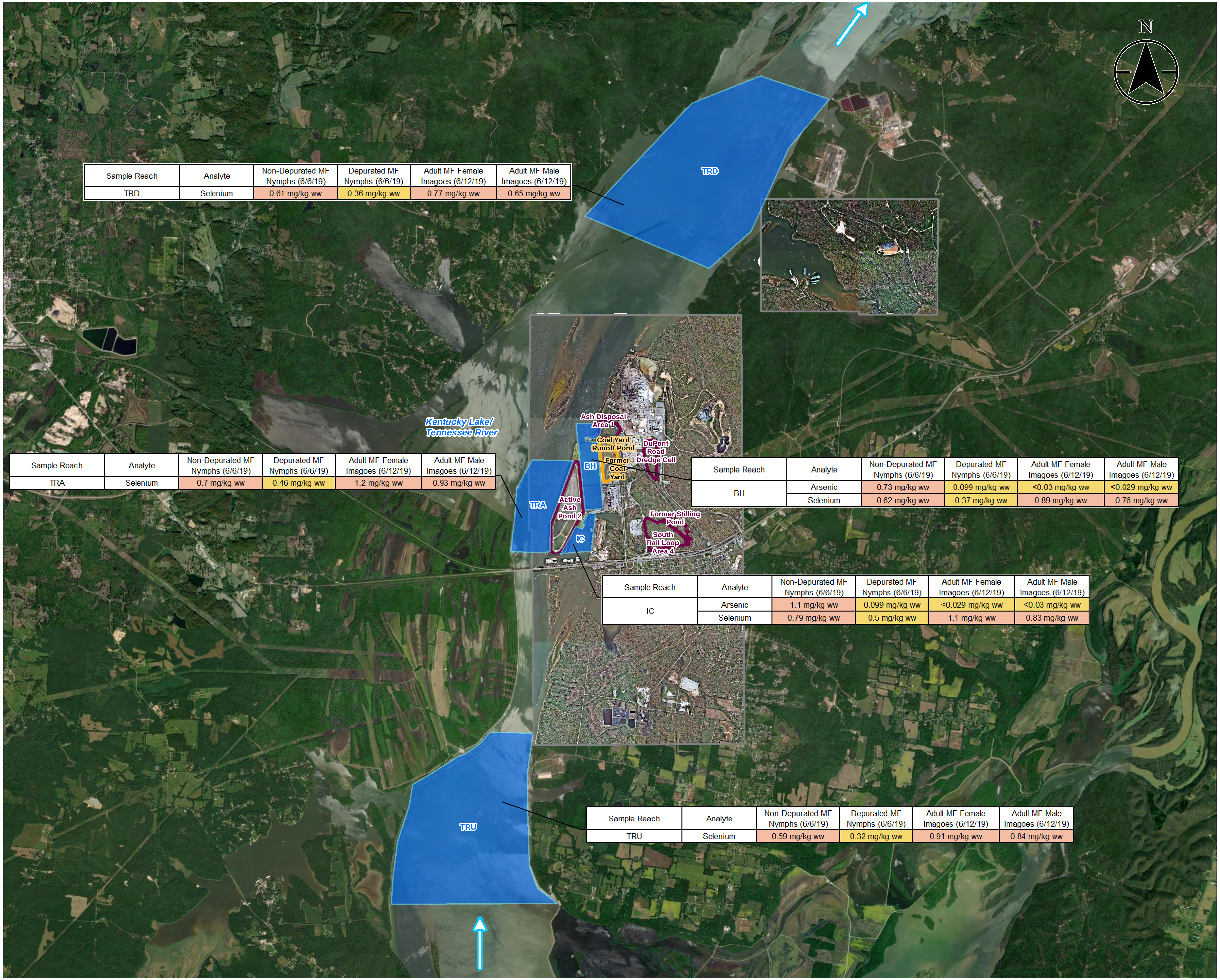
Title
Mayfly Sampling Results Above Critical Body Residue Values

Client/Project
Tennessee Valley Authority
Johnsonville Fossil (JOF) Plant TDEC Order

Project Location
New Johnsonville, Tennessee

175568286
Prepared by DMB on 2023-08-16
Technical Review by BL on 2023-08-16

0 2,500 5,000 7,500 10,000 Feet
1:30,000 (At original document size of 22x34)



Sample Reach	Analyte	Non-Depurated MF Nymphs (6/6/19)	Depurated MF Nymphs (6/6/19)	Adult MF Female Imagoes (6/12/19)	Adult MF Male Imagoes (6/12/19)
TRD	Selenium	0.61 mg/kg ww	0.36 mg/kg ww	0.77 mg/kg ww	0.65 mg/kg ww

Sample Reach	Analyte	Non-Depurated MF Nymphs (6/6/19)	Depurated MF Nymphs (6/6/19)	Adult MF Female Imagoes (6/12/19)	Adult MF Male Imagoes (6/12/19)
TRA	Selenium	0.7 mg/kg ww	0.46 mg/kg ww	1.2 mg/kg ww	0.93 mg/kg ww

Sample Reach	Analyte	Non-Depurated MF Nymphs (6/6/19)	Depurated MF Nymphs (6/6/19)	Adult MF Female Imagoes (6/12/19)	Adult MF Male Imagoes (6/12/19)
BH	Arsenic	0.73 mg/kg ww	0.099 mg/kg ww	<0.03 mg/kg ww	<0.029 mg/kg ww
	Selenium	0.62 mg/kg ww	0.37 mg/kg ww	0.89 mg/kg ww	0.76 mg/kg ww

Sample Reach	Analyte	Non-Depurated MF Nymphs (6/6/19)	Depurated MF Nymphs (6/6/19)	Adult MF Female Imagoes (6/12/19)	Adult MF Male Imagoes (6/12/19)
IC	Arsenic	1.1 mg/kg ww	0.099 mg/kg ww	<0.029 mg/kg ww	<0.03 mg/kg ww
	Selenium	0.79 mg/kg ww	0.5 mg/kg ww	1.1 mg/kg ww	0.83 mg/kg ww

Sample Reach	Analyte	Non-Depurated MF Nymphs (6/6/19)	Depurated MF Nymphs (6/6/19)	Adult MF Female Imagoes (6/12/19)	Adult MF Male Imagoes (6/12/19)
TRU	Selenium	0.59 mg/kg ww	0.32 mg/kg ww	0.91 mg/kg ww	0.84 mg/kg ww

Legend

Mayfly Sampling Locations
TRU – Tennessee River Upstream
TRA – Tennessee River Adjacent
TRD – Tennessee River Downstream
IC – Intake Channel
BH – Boat Harbor

Surface Stream Flow
2017 Imagery Boundary
2018 Imagery Boundary
CCR Management Unit Area (Approximate)
Former Coal Yard (Approximate)
Former Stilling Pond (Approximate)

Concentration > CBR NOAEL
Concentration > CBR LOAEL

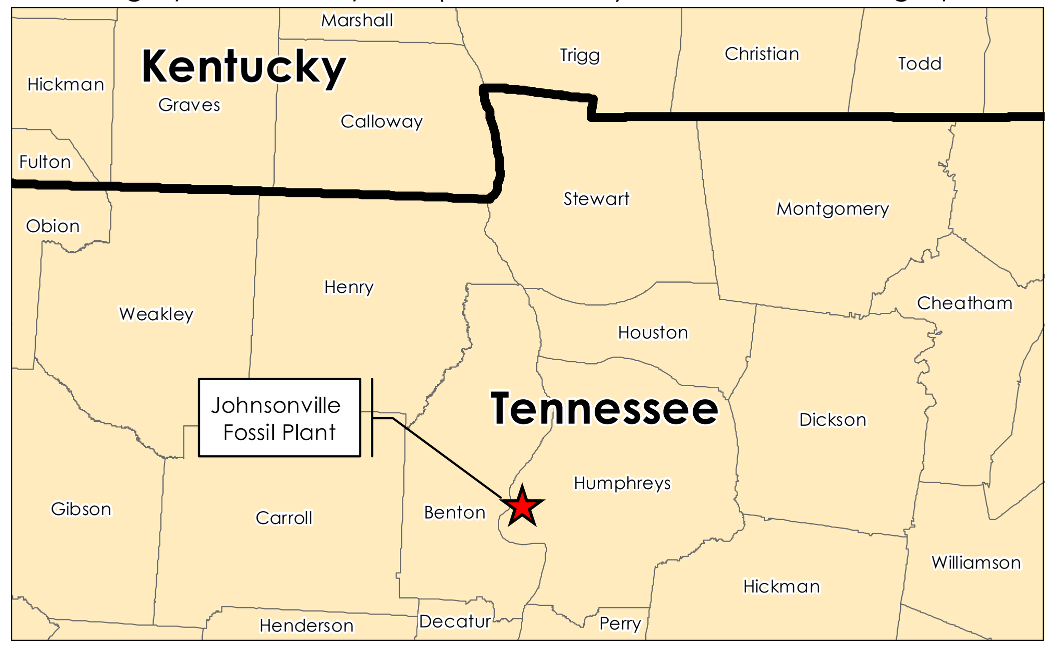
Abbreviations:

mg/kg ww	Milligrams per kilogram wet weight
CCR	Coal combustion residuals
CBR	Critical body residue
NOAEL	No observed adverse effect level
LOAEL	Lowest observed adverse effect level
MF	Mayflies

	Critical Body Residue	
	NOAEL	LOAEL
	(mg/kg - ww)	(mg/kg - ww)
Arsenic	0.0249	0.249
Selenium	0.051	0.51

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by TVA (2017 & 2018) and Esri World Imagery



Stantec TVA

U:\TVA-EIP\175568286_JOF_Phase2\gis\mxd\EAR\7-2_Mayfly_Sampling_ResultsAboveCBRV.mxd Revised: 2023-08-16 By: mbough

Exhibit No.
7-3

Title

Fish Tissue Sampling Results Equal to or Above Critical Body Residue Values

Client/Project

Tennessee Valley Authority
Johnsonville Fossil (JOF) Plant TDEC Order

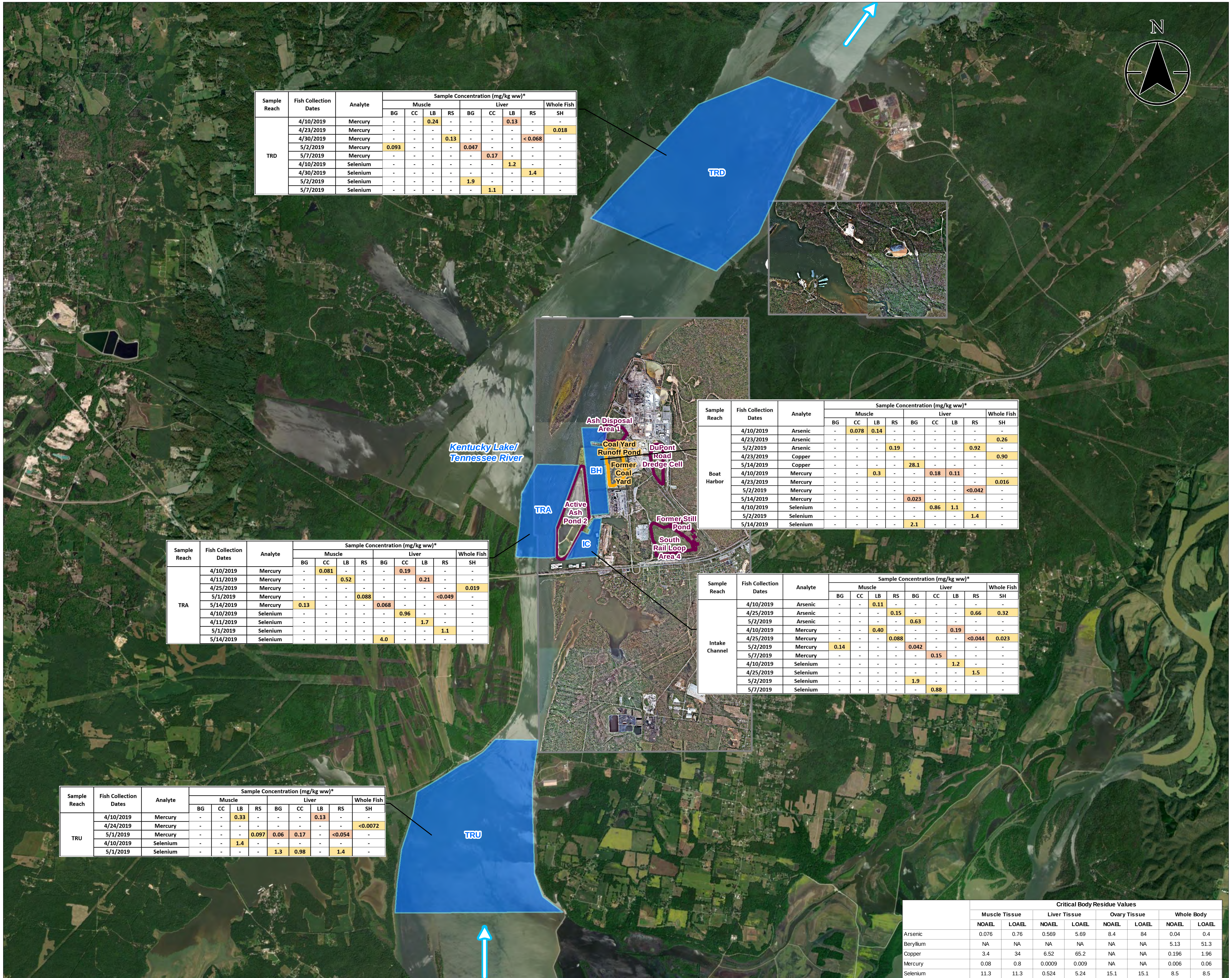
Project Location

New Johnsonville, Tennessee

175568286
Prepared by MB on 2023-08-16
Technical Review by JS on 2023-08-16

0 2,500 5,000 7,500 10,000 Feet

1:30,000 (At original document size of 22x34)



Sample Reach	Fish Collection Dates	Analyte	Sample Concentration (mg/kg ww)*								
			Muscle				Liver				Whole Fish
			BG	CC	LB	RS	BG	CC	LB	RS	SH
TRD	4/10/2019	Mercury	-	-	0.24	-	-	-	0.13	-	-
	4/23/2019	Mercury	-	-	-	-	-	-	-	-	0.018
	4/30/2019	Mercury	-	-	-	0.13	-	-	-	< 0.068	-
	5/2/2019	Mercury	0.093	-	-	-	0.047	-	-	-	-
	5/7/2019	Mercury	-	-	-	-	-	0.17	-	-	-
	4/10/2019	Selenium	-	-	-	-	-	-	1.2	-	-
	4/30/2019	Selenium	-	-	-	-	-	-	-	1.4	-
	5/2/2019	Selenium	-	-	-	-	1.9	-	-	-	-
	5/7/2019	Selenium	-	-	-	-	-	1.1	-	-	-

Sample Reach	Fish Collection Dates	Analyte	Sample Concentration (mg/kg ww)*								
			Muscle				Liver				Whole Fish
			BG	CC	LB	RS	BG	CC	LB	RS	SH
Boat Harbor	4/10/2019	Arsenic	-	0.078	0.14	-	-	-	-	-	-
	4/23/2019	Arsenic	-	-	-	-	-	-	-	-	0.26
	5/2/2019	Arsenic	-	-	-	0.19	-	-	-	0.92	-
	4/23/2019	Copper	-	-	-	-	-	-	-	-	0.90
	5/14/2019	Copper	-	-	-	-	28.1	-	-	-	-
	4/10/2019	Mercury	-	-	0.3	-	-	0.18	0.11	-	-
	4/23/2019	Mercury	-	-	-	-	-	-	-	-	0.016
	5/2/2019	Mercury	-	-	-	-	-	-	-	<0.042	-
	5/14/2019	Mercury	-	-	-	-	0.023	-	-	-	-
	4/10/2019	Selenium	-	-	-	-	-	0.86	1.1	-	-
	5/2/2019	Selenium	-	-	-	-	-	-	-	1.4	-
	5/14/2019	Selenium	-	-	-	-	2.1	-	-	-	-

Sample Reach	Fish Collection Dates	Analyte	Sample Concentration (mg/kg ww)*								
			Muscle				Liver				Whole Fish
			BG	CC	LB	RS	BG	CC	LB	RS	SH
TRA	4/10/2019	Mercury	-	0.081	-	-	-	0.19	-	-	-
	4/11/2019	Mercury	-	-	0.52	-	-	-	0.21	-	-
	4/25/2019	Mercury	-	-	-	-	-	-	-	-	0.019
	5/1/2019	Mercury	-	-	-	0.088	-	-	-	<0.049	-
	5/14/2019	Mercury	0.13	-	-	-	0.068	-	-	-	-
	4/10/2019	Selenium	-	-	-	-	-	0.96	-	-	-
	4/11/2019	Selenium	-	-	-	-	-	-	1.7	-	-
	5/1/2019	Selenium	-	-	-	-	-	-	-	1.1	-
	5/14/2019	Selenium	-	-	-	-	4.0	-	-	-	-

Sample Reach	Fish Collection Dates	Analyte	Sample Concentration (mg/kg ww)*								
			Muscle				Liver				Whole Fish
			BG	CC	LB	RS	BG	CC	LB	RS	SH
Intake Channel	4/10/2019	Arsenic	-	-	0.11	-	-	-	-	-	-
	4/25/2019	Arsenic	-	-	-	0.15	-	-	-	0.66	0.32
	5/2/2019	Arsenic	-	-	-	-	0.63	-	-	-	-
	4/10/2019	Mercury	-	-	0.40	-	-	-	0.19	-	-
	4/25/2019	Mercury	-	-	-	0.088	-	-	-	<0.044	0.023
	5/2/2019	Mercury	0.14	-	-	-	0.042	-	-	-	-
	5/7/2019	Mercury	-	-	-	-	-	0.15	-	-	-
	4/10/2019	Selenium	-	-	-	-	-	-	1.2	-	-
	4/25/2019	Selenium	-	-	-	-	-	-	-	1.5	-
	5/2/2019	Selenium	-	-	-	-	1.9	-	-	-	-
	5/7/2019	Selenium	-	-	-	-	-	0.88	-	-	-

Sample Reach	Fish Collection Dates	Analyte	Sample Concentration (mg/kg ww)*								
			Muscle				Liver				Whole Fish
			BG	CC	LB	RS	BG	CC	LB	RS	SH
TRU	4/10/2019	Mercury	-	-	0.33	-	-	-	0.13	-	-
	4/24/2019	Mercury	-	-	-	-	-	-	-	-	<0.0072
	5/1/2019	Mercury	-	-	-	0.097	0.06	0.17	-	<0.054	-
	4/10/2019	Selenium	-	-	1.4	-	-	-	-	-	-
	5/1/2019	Selenium	-	-	-	-	1.3	0.98	-	1.4	-

	Critical Body Residue Values							
	Muscle Tissue		Liver Tissue		Ovary Tissue		Whole Body	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Arsenic	0.076	0.76	0.569	5.69	8.4	84	0.04	0.4
Beryllium	NA	NA	NA	NA	NA	NA	5.13	51.3
Copper	3.4	34	6.52	65.2	NA	NA	0.196	1.96
Mercury	0.08	0.8	0.0009	0.009	NA	NA	0.006	0.06
Selenium	11.3	11.3	0.524	5.24	15.1	15.1	8.5	8.5

Legend

Fish Sampling Location
TRU – Tennessee River Upstream
TRA – Tennessee River Adjacent
TRD – Tennessee River Downstream
IC – Intake Channel
BH – Boat Harbor

Surface Stream Flow

2017 Imagery Boundary

2018 Imagery Boundary

CCR Management Unit Area (Approximate)

Former Coal Yard (Approximate)

Former Stilling Pond (Approximate)

Abbreviations:

BG Bluegill
CC Channel Catfish
LB Largemouth Bass
RS Redear Sunfish
SH Shad

Concentration > CBR NOAEL
Concentration > CBR LOAEL

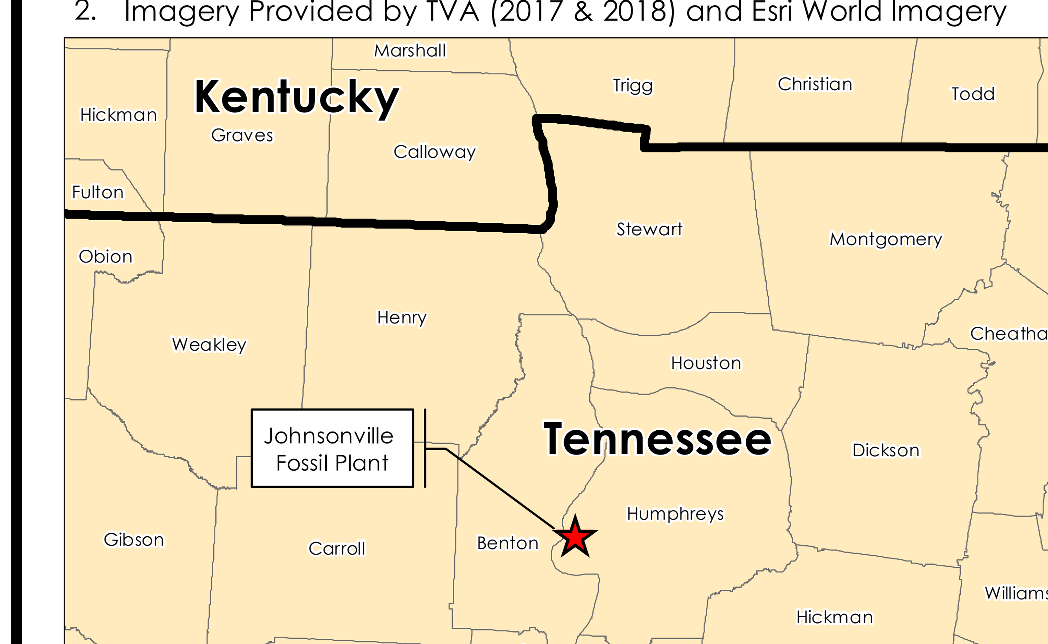
TR = Tennessee River
U = Upstream
A = Adjacent
D = Downstream
IC = Intake Channel
BH = Boat Harbor

CCR - Coal combustion residuals
CBR - Critical Body Residue
NOAEL - No Observed Adverse Effects Value
LOAEL - Lowest Observed Adverse Effects Value

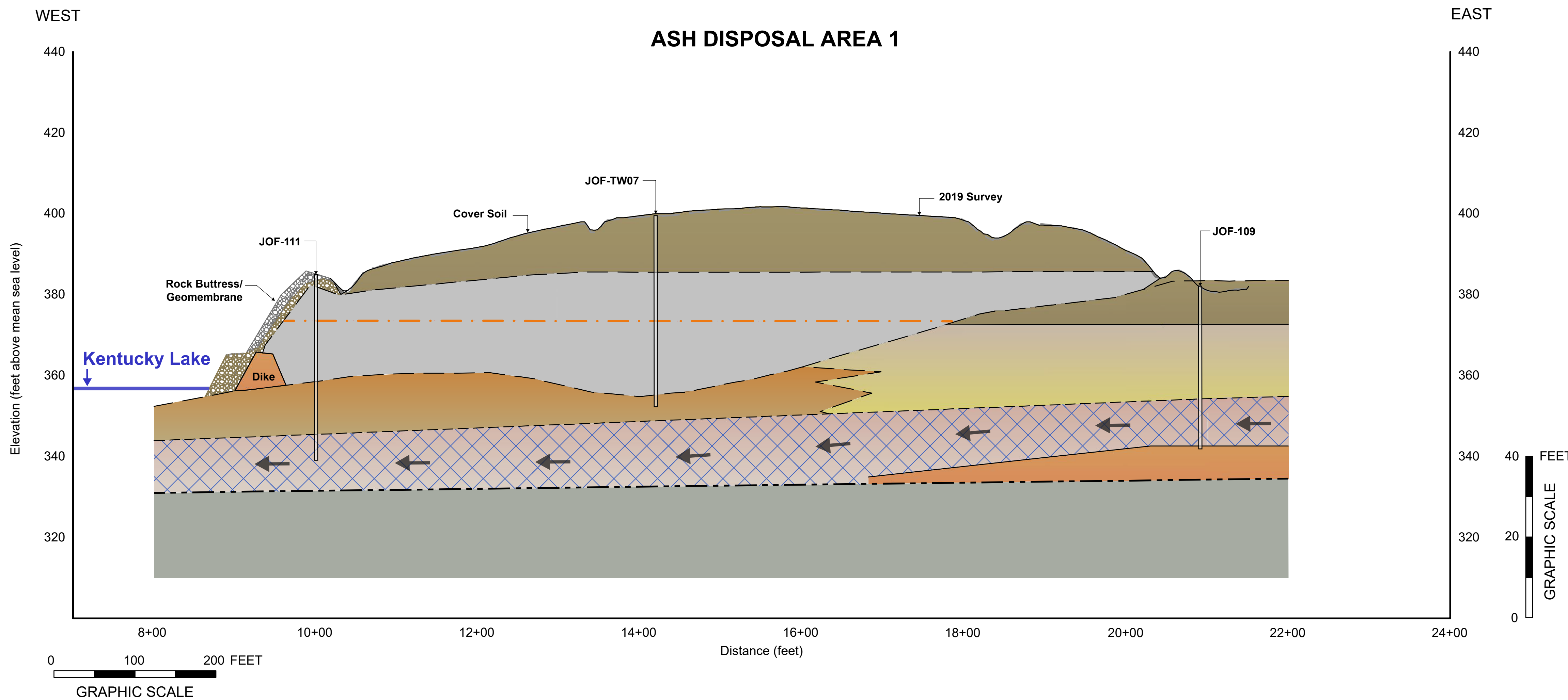
* Selenium concentrations reported as mg/kg wet weight (ww) for liver tissue and mg/kg dry weight for whole body, muscle, and ovary samples to permit direct comparison to the selenium CBRs for these tissues.

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Provided by TVA (2017 & 2018) and Esri World Imagery



Stantec
TVA



1 CCR Material

- CCR material in this unit is stacked bottom ash and fly ash above sluiced bottom ash and fly ash, with an estimated total volume of ~ 730,000 cubic yards.
- The global slope stability and the veneer slope stability meet the established factor of safety criteria for the static and seismic load cases.
- The structural integrity of the CCR management unit is adequate and there is no evidence of voids/cavities in bedrock that could lead to loss of structural support and potential release of overlying CCR material.

2 Groundwater Quality

- The pore water levels reported herein may not represent steady-state conditions. The continued presence of pore water might be caused by infiltration of precipitation into the CCR material. The pore water levels would be expected to decrease in elevation if stormwater drainage or cap modifications were to be implemented. The low permeability of the perimeter dikes and foundation soils limits lateral flow into or out of the CCR management units.
- Groundwater concentrations for most TDEC Appendix I and CCR Rule Appendix IV CCR constituents were below GSLs. Arsenic in well JOF-111 was detected above the GSL. This constituent will be further evaluated and addressed in the CARA Plan to determine if corrective actions are needed.

3 Potential Seeps

- One AOI (AOI02) was identified during the EI and is currently being monitored and will be further evaluated in the CARA Plan.

4 Surface Stream, Sediment and Ecology

- CCR Parameter concentrations in surface stream and sediment samples from the Tennessee River collected adjacent to and downstream of the CCR management unit were below ESVs.
- Based on the results of the EI and other ongoing ecological monitoring programs, operations at this CCR management unit have not impacted adjacent sediment and surface stream water quality, benthic macroinvertebrate communities, or mayfly and fish tissues and populations in the Tennessee River.

Legend

- Fill
- CCR
- Primarily Clayey Gravel
- Primarily Clay
- Primarily Silty Clay
- Primarily Sand and Gravel
- Limestone (Possible Fort Payne Formation)
- Pore Water Phreatic Surface (August 10–11, 2020)
- Uppermost aquifer
- Interpolated Top of Rock
- Generalized groundwater flow direction within the uppermost aquifer

The purpose of the arrows is to show the inferred generally horizontal groundwater flow direction within the uppermost aquifer. They are not intended to illustrate the flow between unconsolidated materials and bedrock.

Notes:

Cross section transect line is shown on Exhibit D-1.

AOI – Area of Interest
CARA – Corrective Action/Risk Assessment
CCR – Coal Combustion Residuals
EI – Environmental Investigation
ESV – Ecological Screening Value
GSLs – Groundwater Screening Levels

Stantec

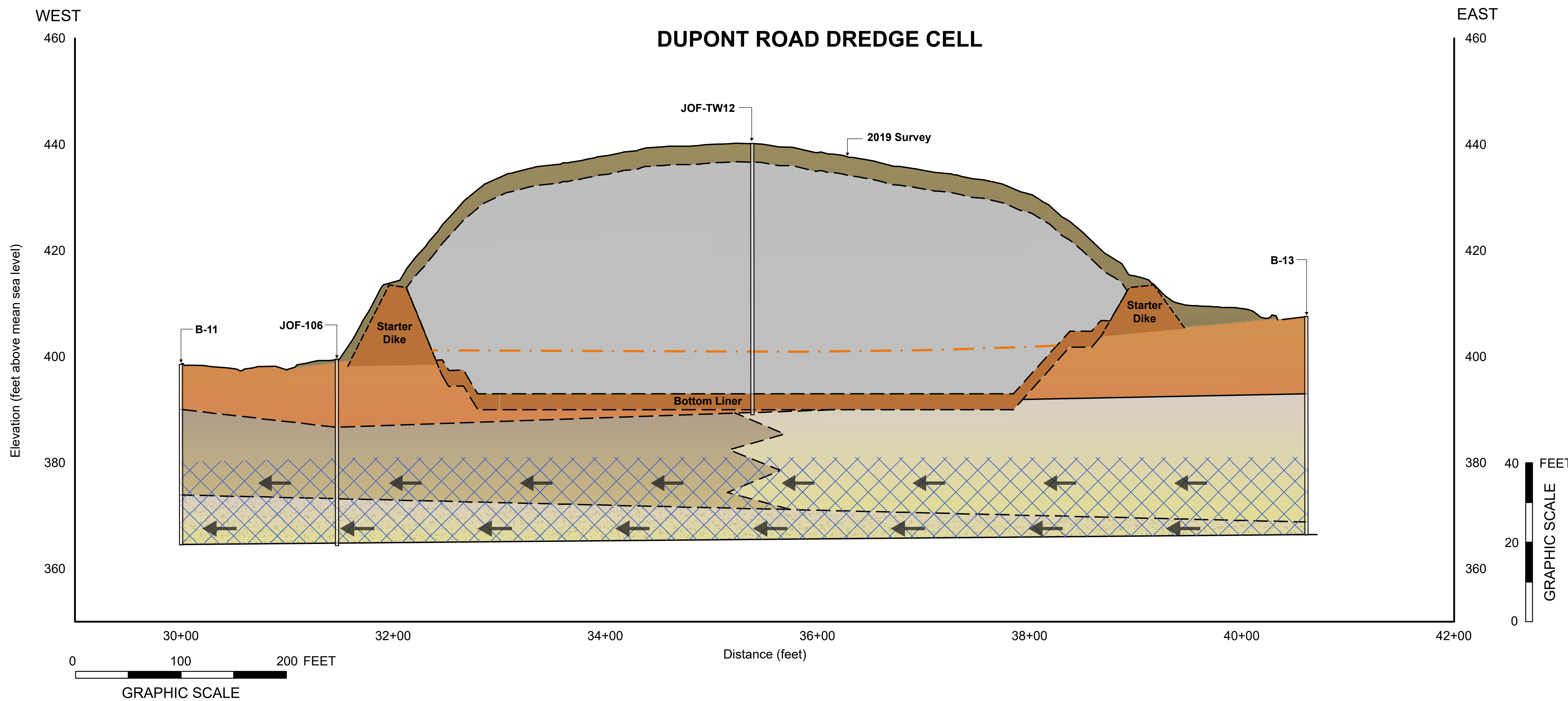
Exhibit No.
8-1

Title
ASH DISPOSAL AREA 1 CROSS-SECTION A-A' CONCEPTUAL SITE MODEL

Client/Project
Tennessee Valley Authority
Johnsonville Fossil (JOF) Plant TDEC Order

Project Location
New Johnsonville, Tennessee

175568286
Prepared by KB on 2023-12-20



1 CCR Material

- CCR material is stacked fly ash and bottom ash above sluiced fly ash and bottom ash, with an estimated total volume of ~ 1.1 million cubic yards.
- The global slope stability and the veneer slope stability meet the established factor of safety criteria for the static and seismic load cases.
- The structural integrity of the CCR management unit is adequate and there is no evidence of voids/cavities in bedrock that could lead to loss of structural support and potential release of overlying CCR material.

2 Groundwater Quality

- The pore water levels reported herein may not represent steady-state conditions. The low permeability of the geosynthetic cap is expected to result in the continued decrease in pore water levels. The low permeability of the perimeter dikes and foundation soils limits lateral flow into or out of the CCR management units.
- Groundwater concentrations for TDEC Appendix I and CCR Rule Appendix IV CCR constituent concentrations are below GSLs.

3 Potential Seeps

- No AOIs were identified during the EI.

4 Surface Stream, Sediment and Ecology

- Potential impacts for these media are evaluated as part of the Ash Disposal Area 1 and the former Coal Yard.

Legend

- Soil and Geosynthetic Cap
- Fly Ash and Bottom Ash
- Primarily Clay
- Bottom Liner/Starter Dike
- Primarily Clayey Gravel
- Primarily Gravelly Clay
- Sand
- Pore Water Phreatic Surface (August 10–11, 2020)
- Uppermost aquifer
- Generalized groundwater flow direction within the uppermost aquifer

The purpose of the arrows is to show the inferred generally horizontal groundwater flow direction within the uppermost aquifer. They are not intended to illustrate the flow between unconsolidated materials and bedrock.

Notes:

Cross section transect line is shown on Exhibit D-1.

AOI – Area of Interest
CARA – Corrective Action/Risk Assessment
CCR – Coal Combustion Residuals
EI – Environmental Investigation
ESV – Ecological Screening Value
GSLs – Groundwater Screening Levels

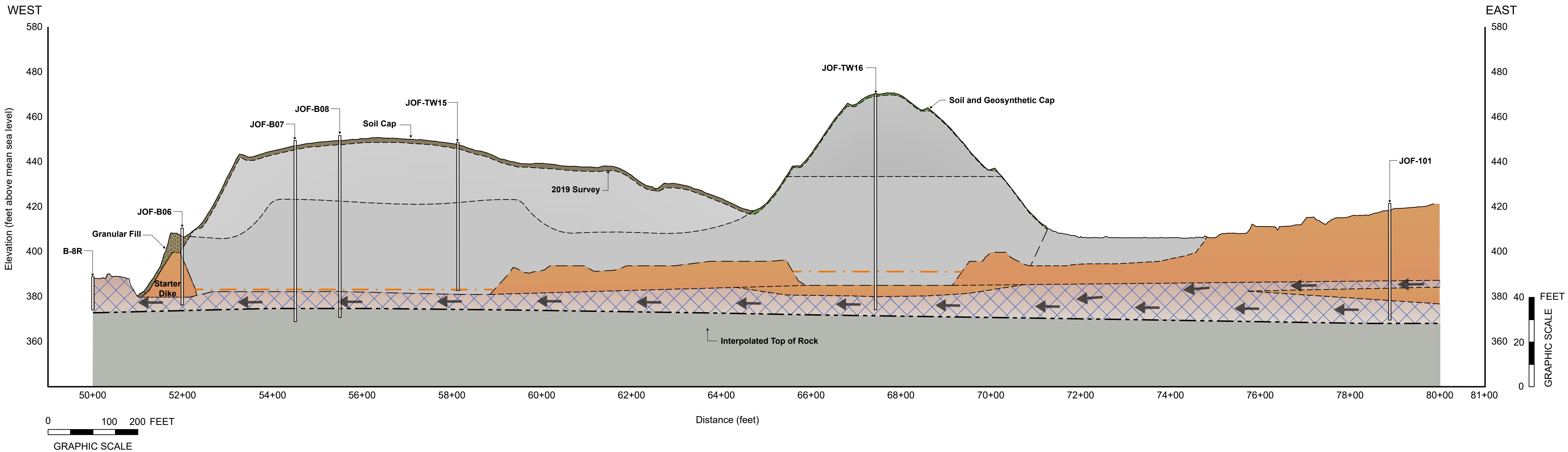
Exhibit No.
8-2

Title
DUPONT ROAD DREDGE CELL
CROSS-SECTION B-B' CONCEPTUAL SITE MODEL

Client/Project
Tennessee Valley Authority
Johnsonville Fossil (JOF) Plant TDEC Order

Project Location
New Johnsonville, Tennessee
175568286
Prepared by KB on 2023-12-20

SOUTH RAIL LOOP AREA 4



1 CCR Material

- CCR material is stacked ash and sluiced ash with an estimated total volume of ~ 4 million cubic yards.
- The global slope stability and the veneer slope stability meet the established factor of safety criteria for the static and seismic load cases except one veneer stability case that was still accepted by TDEC.
- The structural integrity of the CCR management unit is adequate and there is no evidence of voids/cavities in bedrock that could lead to loss of structural support and potential release of overlying CCR material.

2 Groundwater Quality

- The pore water levels reported herein may not represent steady-state conditions. The low permeability of the geosynthetic cap is expected to result in the continued decrease in pore water levels. The low permeability of the perimeter dikes and foundation soils limits lateral flow into or out of the CCR management units
- Groundwater concentrations for TDEC Appendix I and CCR Rule Appendix IV CCR constituent concentrations are below GSLs.

3 Potential Seeps

- No AOIs were identified during the EI.

4 Surface Stream, Sediment and Ecology

- Potential impacts for these media are evaluated as part of Active Ash Pond 2.

Legend

- Soil Cap
- Soil and Geosynthetic Cap
- Upper Ash
- Lower Ash
- Primarily Clay
- Primarily Sand and Gravel
- Chattanooga Shale Formation
- Pore Water Phreatic Surface (August 10–11, 2020)
- Uppermost aquifer
- Interpolated Top of Rock
- Generalized groundwater flow direction within the uppermost aquifer

The purpose of the arrows is to show the inferred generally horizontal groundwater flow direction within the uppermost aquifer. They are not intended to illustrate the flow between unconsolidated materials and bedrock.

Notes:

Cross section transect line is shown on Exhibit D-1.

AOI – Area of Interest
CARA – Corrective Action/Risk Assessment
CCR – Coal Combustion Residuals
EI – Environmental Investigation
ESV – Ecological Screening Value
GSLs – Groundwater Screening Levels

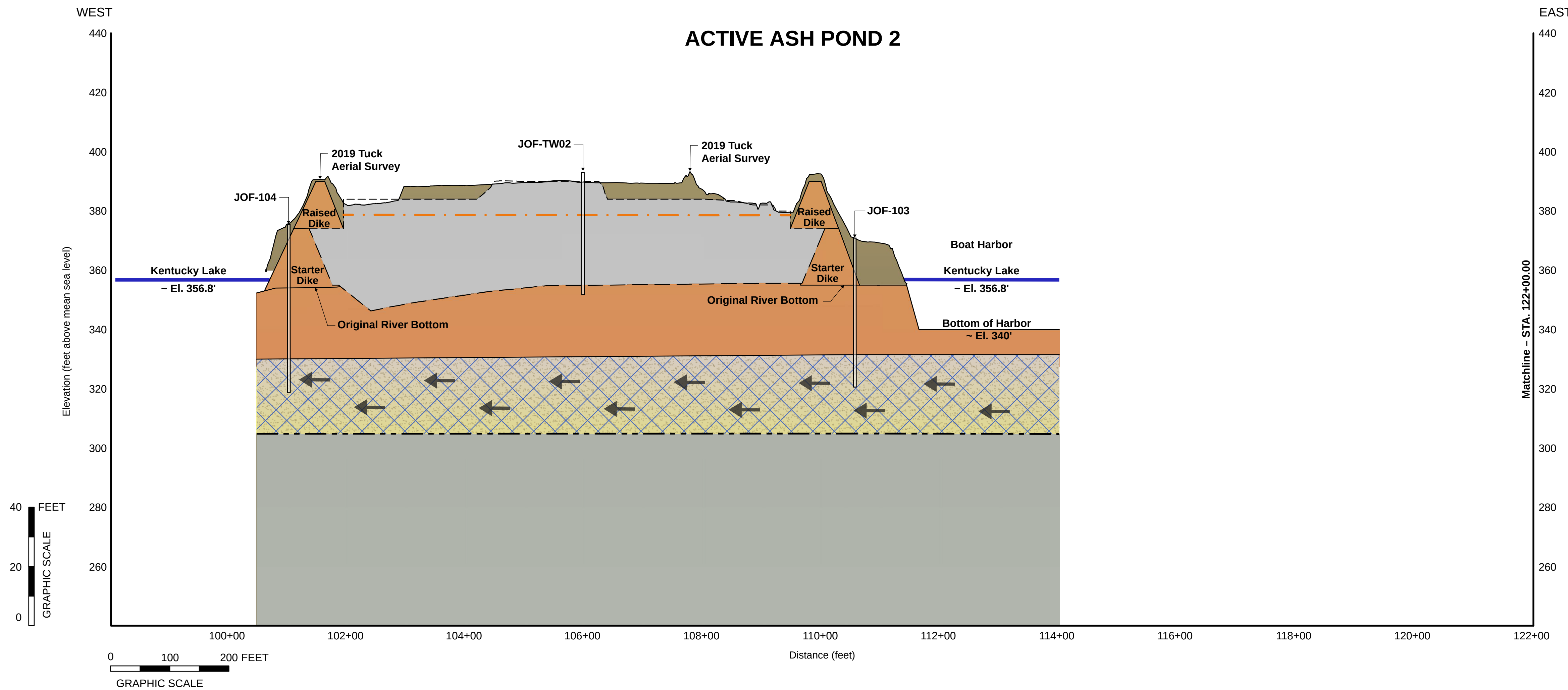
Stantec

Exhibit No.
8-3

Title
SOUTH RAIL LOOP AREA 4 CROSS-SECTION C-C' CONCEPTUAL SITE MODEL

Client/Project
Tennessee Valley Authority
Johnsonville Fossil (JOF) Plant TDEC Order

Project Location
New Johnsonville, Tennessee
175568286
Prepared by KB on 2023-08-25



1 CCR Material

- CCR material is sluiced bottom ash and sluiced fly ash, with an estimated total volume of ~ 4.5 million cubic yards.
- The global slope stability and the veneer slope stability meet the established factor of safety criteria for the static and seismic load cases.
- The structural integrity of the CCR management unit is adequate and there is no evidence of voids/cavities in bedrock that could lead to loss of structural support and potential release of overlying CCR material.

2 Groundwater Quality

- The pore water levels reported herein may not represent steady-state conditions. The pore water levels would be expected to decrease in elevation if stormwater drainage or a cap system were installed. The low permeability of the perimeter dikes and foundation soils limits lateral flow into or out of the CCR management units. The results of the dye trace study support this conclusion because it indicated that there are no preferential transport pathways between Active Ash Pond 2 and the Tennessee River.
- Groundwater concentrations for most TDEC Appendix I and CCR Rule Appendix IV CCR constituents were below GSLs. Cobalt in wells 10-AP3, JOF-103, and JOF-118 and nickel in well JOF-103 were detected above GSLs. These constituents will be further evaluated and addressed in the CARA Plan to determine if corrective actions are needed.

3 Potential Seeps

- Two AOIs were identified during the EI. One AOI (AOI03) has been mitigated under a TDEC approved plan. The remaining AOI (AOI01) is currently being monitored and will be further evaluated in the CARA Plan.

4 Surface Stream, Sediment and Ecology

- Beryllium and selenium sediment results were above chronic ESVs at one sample location in the Tennessee River. Arsenic, beryllium, and selenium sediment results were above ESVs in the Intake Channel and arsenic, beryllium, copper, mercury, and selenium sediment results were above ESVs in the Boat Harbor. These metals were not above GSLs in groundwater samples at this unit.
- These constituents will be further evaluated and addressed in the CARA Plan to determine if corrective actions are needed.

Legend

- Fill
- Fly Ash
- Primarily Clay
- Primarily Sand and Gravel
- Camden Chert
- Pore Water Phreatic Surface (August 10–11, 2020)
- Uppermost aquifer
- Interpolated Top of Rock
- Generalized groundwater flow direction within the uppermost aquifer

The purpose of the arrows is to show the inferred generally horizontal groundwater flow direction within the uppermost aquifer. They are not intended to illustrate the flow between unconsolidated materials and bedrock.

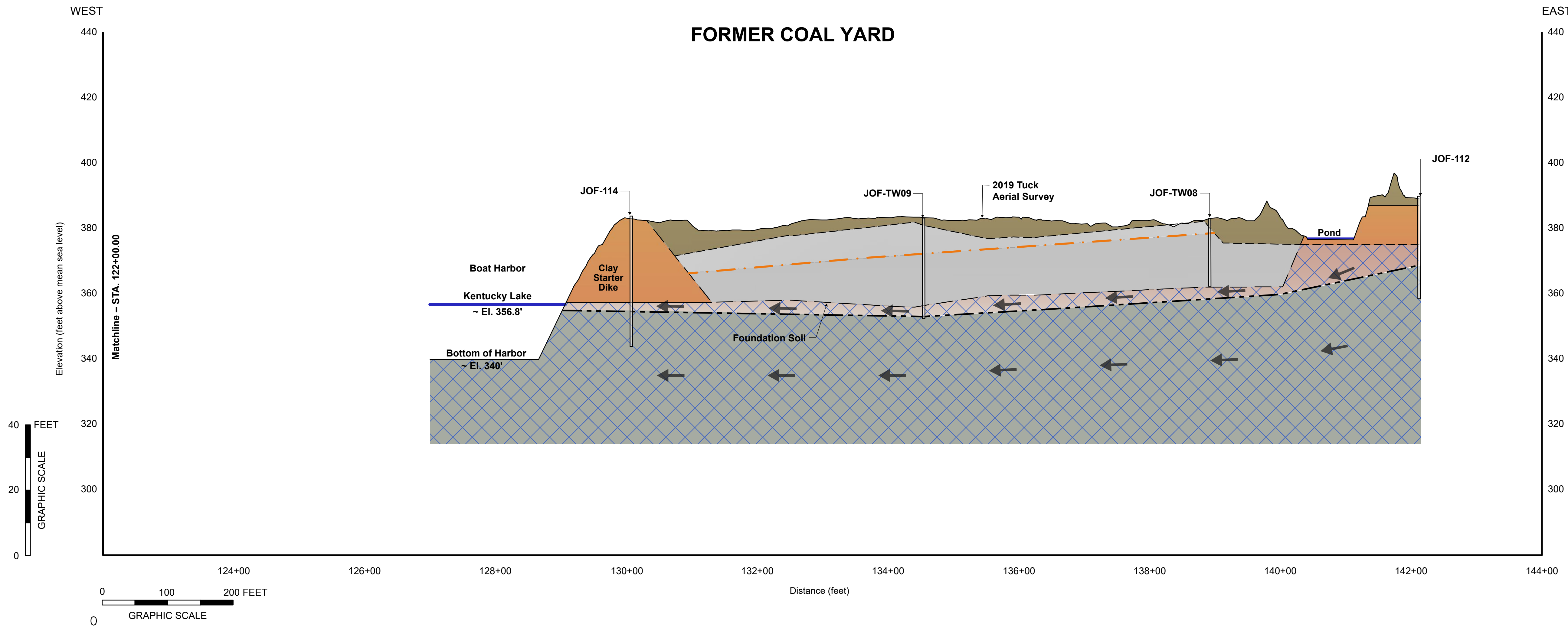
Notes:

Cross section transect line is shown on Exhibit D-1.

AOI – Area of Interest
CARA – Corrective Action/Risk Assessment
CCR – Coal Combustion Residuals
EI – Environmental Investigation
ESV – Ecological Screening Value
GSLs – Groundwater Screening Levels

Stantec TVA

Exhibit No.
8-4
Title
ACTIVE ASH POND 2 CROSS-SECTION D-D' CONCEPTUAL SITE MODEL
Client/Project
Tennessee Valley Authority
Johnsonville Fossil (JOF) Plant TDEC Order
Project Location 175568286
New Johnsonville, Tennessee
Prepared by KB on 2023-08-15



1 CCR Material

- CCR material is sluiced fly ash and bottom ash with an estimated total volume of ~ 551,000 cubic yards.

2 Groundwater Quality

- The pore water levels reported herein may not represent steady-state conditions. The pore water levels would be expected to decrease in elevation if stormwater drainage or cap modifications were to be implemented. The low permeability of the perimeter dikes limits lateral flow into or out of the CCR management units.
- Groundwater concentrations for most TDEC Appendix I and CCR Rule Appendix IV CCR constituents are below GSLs. Arsenic in well JOF-117, cobalt in wells JOF-112, JOF-114 and JOF-117, lithium in wells JOF-113 and JOF-114, and molybdenum in well JOF-113 were detected above GSLs. These constituents will be further evaluated and addressed in the CARA Plan to determine if corrective actions are needed.

3 Potential Seeps

- No AOIs were identified during the EI.

4 Surface Stream, Sediment and Ecology

- Arsenic, beryllium, copper, mercury, and selenium sediment results were above chronic ESVs in the Boat Harbor.
- These constituents will be further evaluated and addressed in the CARA Plan to determine if corrective actions are needed.

Legend

- Fill
- Upper Ash
- Lower Ash
- Primarily Clay
- Primarily Sand and Gravel
- Camden Chert
- Pore Water Phreatic Surface (August 10–11, 2020)
- Uppermost aquifer
- Interpolated Top of Rock
- Generalized groundwater flow direction within the uppermost aquifer

The purpose of the arrows is to show the inferred generally horizontal groundwater flow direction within the uppermost aquifer. They are not intended to illustrate the flow between unconsolidated materials and bedrock.

Notes:

Cross section transect line is shown on Exhibit D-1.

AOI – Area of Interest
CARA – Corrective Action/Risk Assessment
CCR – Coal Combustion Residuals
EI – Environmental Investigation
ESV – Ecological Screening Value
GSLs – Groundwater Screening Levels

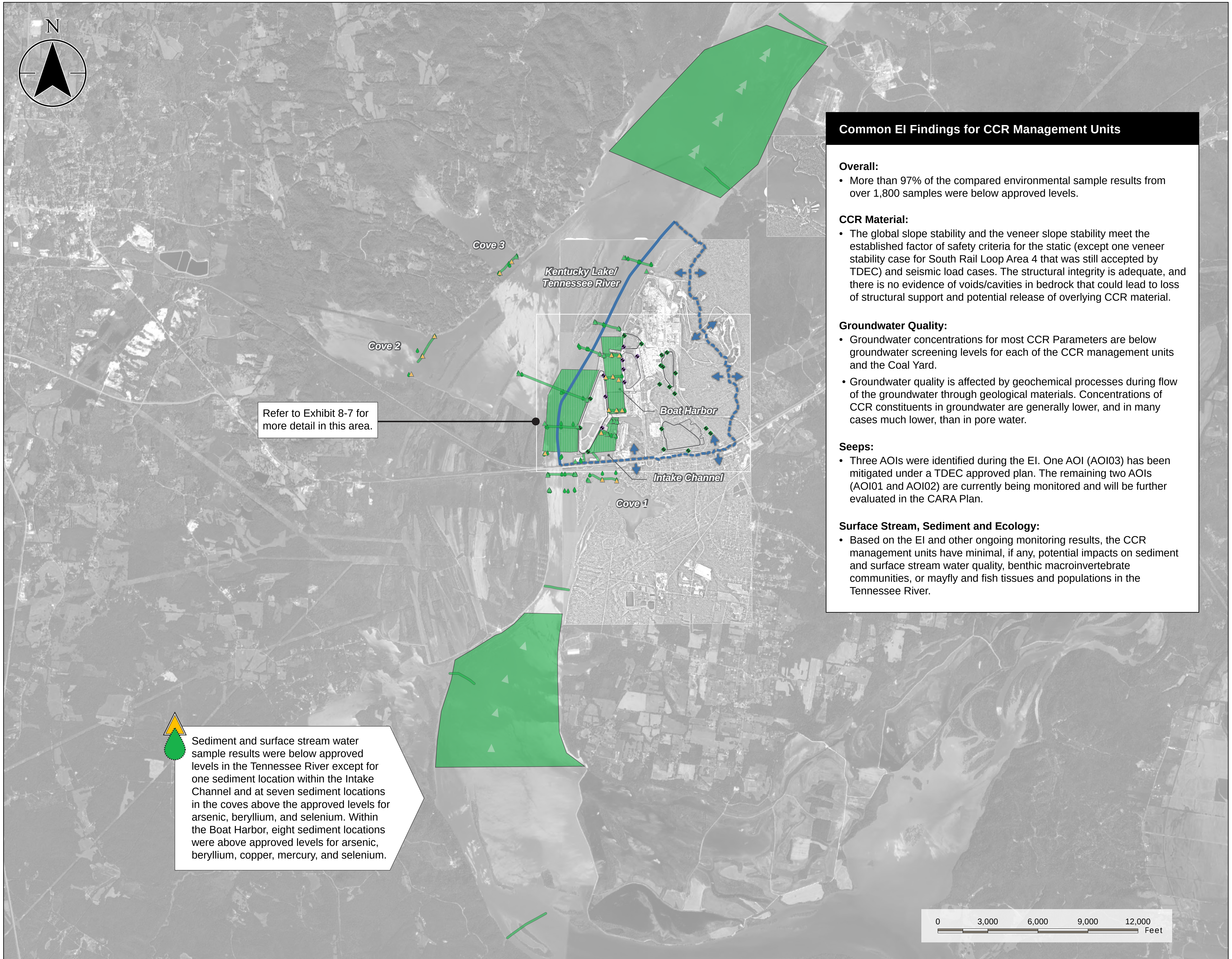
Stantec TVA

Exhibit No.
8-5

Title
FORMER COAL YARD CROSS-SECTION
E-E' CONCEPTUAL SITE MODEL

Client/Project
Tennessee Valley Authority
Johnsonville Fossil (JOF) Plant TDEC Order

Project Location 175568286
New Johnsonville, Tennessee
Prepared by KB on 2024-01-17



Common EI Findings for CCR Management Units

Overall:

- More than 97% of the compared environmental sample results from over 1,800 samples were below approved levels.

CCR Material:

- The global slope stability and the veneer slope stability meet the established factor of safety criteria for the static (except one veneer stability case for South Rail Loop Area 4 that was still accepted by TDEC) and seismic load cases. The structural integrity is adequate, and there is no evidence of voids/cavities in bedrock that could lead to loss of structural support and potential release of overlying CCR material.

Groundwater Quality:

- Groundwater concentrations for most CCR Parameters are below groundwater screening levels for each of the CCR management units and the Coal Yard.
- Groundwater quality is affected by geochemical processes during flow of the groundwater through geological materials. Concentrations of CCR constituents in groundwater are generally lower, and in many cases much lower, than in pore water.

Seeps:

- Three AOIs were identified during the EI. One AOI (AOI03) has been mitigated under a TDEC approved plan. The remaining two AOIs (AOI01 and AOI02) are currently being monitored and will be further evaluated in the CARA Plan.

Surface Stream, Sediment and Ecology:

- Based on the EI and other ongoing monitoring results, the CCR management units have minimal, if any, potential impacts on sediment and surface stream water quality, benthic macroinvertebrate communities, or mayfly and fish tissues and populations in the Tennessee River.

Exhibit No.

8-6

Title

Overall Investigation Area Findings

Client/Project

Tennessee Valley Authority
Johnsonville Fossil (JOF) Plant TDEC Order

Project Location | 175568286
New Johnsonville, Tennessee | Prepared by KB on 2023-08-24

Legend

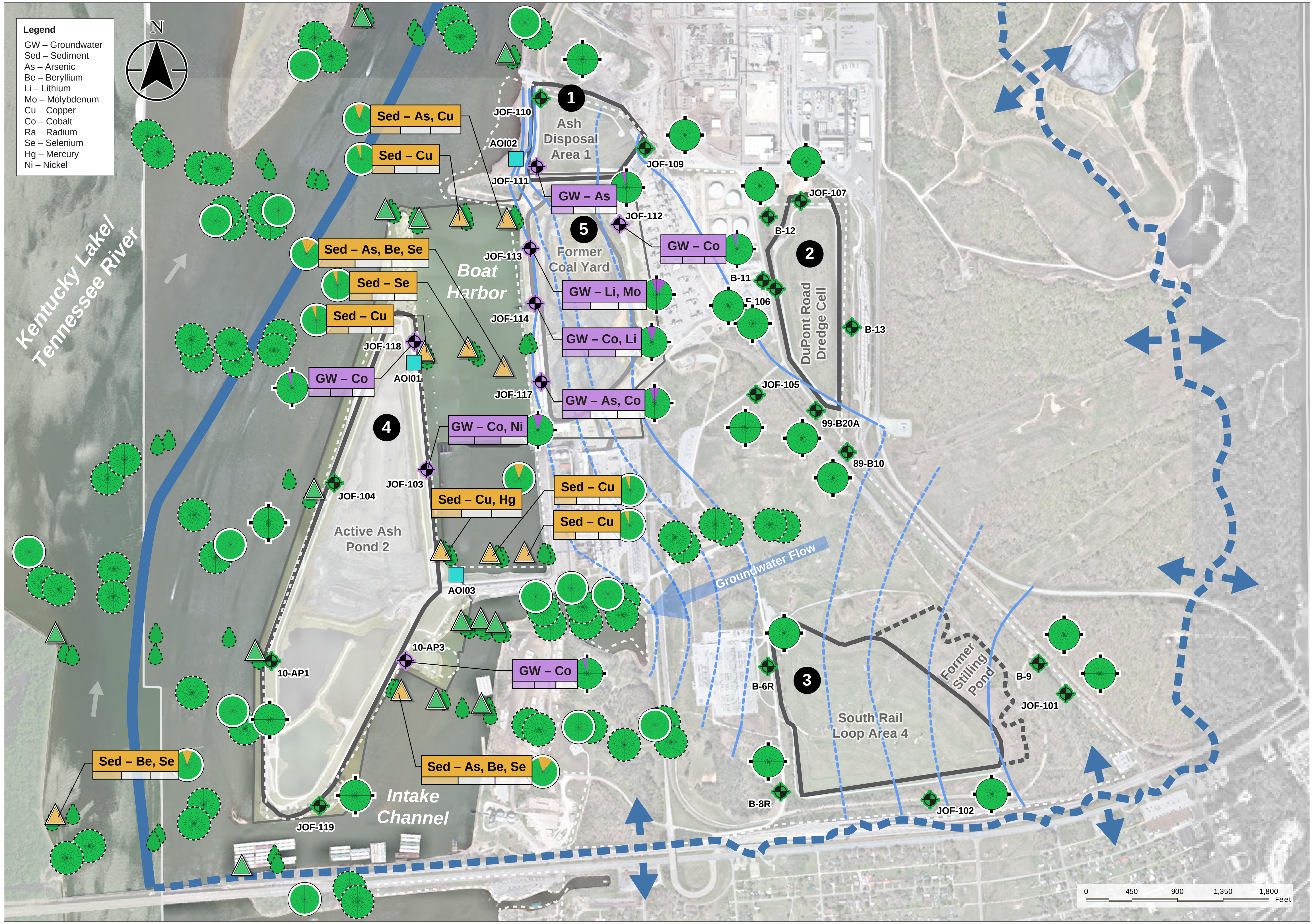
- Groundwater results below Groundwater Screening Levels
- Groundwater results above Groundwater Screening Levels
- Sediment sample results below chronic Ecological Screening Values
- Sediment sample results above chronic Ecological Screening Values
- Surface water sample results below chronic Ecological Screening Values
- Surface water sample results above chronic Ecological Screening Values
- Benthic macroinvertebrate community sampling transect (See Surface Stream, Sediment and Ecology note on exhibit)
- Upstream mayfly and fish tissue sampling (See Surface Stream, Sediment and Ecology note on exhibit)
- Adjacent mayfly and fish tissue sampling (See Surface Stream, Sediment and Ecology note on exhibit)
- Downstream mayfly and fish tissue sampling (See Surface Stream, Sediment and Ecology note on exhibit)
- Surface stream that bounds groundwater flow
- Hydrogeological Divide
- Generalized groundwater flow direction
- 2017 Imagery Boundary
- 2018 Imagery Boundary
- CCR Unit Area (Approximate)
- Former Stilling Pond (Approximate)
- Former Coal Yard (Approximate)

Abbreviations:

AOI: Area of Interest
CCR: Coal combustion residuals
EI: Environmental Investigation

Imagery Provided by TVA (2017 & 2018) & ESRI World Imagery

Stantec TVA



Potential groundwater, surface stream water and sediment impacts described below will be further evaluated in the CARA Plan

1 Ash Disposal Area 1

CCR Material:

- CCR material in this unit is stacked bottom ash and fly ash above sluiced bottom ash and fly ash, with an estimated total volume of 730,000 cubic yards.

Groundwater Quality:

- Arsenic (well JOF-111) was detected above the GSL.

Potential Seeps:

- One AOI (AOI02) was identified during the EI and is currently being monitored and will be further evaluated in the CARA Plan.

Surface Stream, Sediment and Ecology:

- CCR Parameter concentrations in sediment samples collected from the Holston River adjacent to the CCR management unit were below chronic ESVs.

2 DuPont Road Dredge Cell

CCR Material:

- CCR material is stacked fly ash and bottom ash above sluiced fly ash and bottom ash, with an estimated total volume of ~ 1.1 million cubic yards.

Groundwater Quality:

- Groundwater concentrations for TDEC Appendix I and CCR Rule Appendix IV CCR constituent concentrations are below GSLs.

Surface Stream, Sediment and Ecology:

- Potential impacts for these media are evaluated as part of Ash Disposal Area 1 and the former Coal Yard.

3 South Rail Loop Area 4

CCR Material:

- CCR material is stacked ash and sluiced ash with an estimated total volume of ~ 4 million cubic yards.

Groundwater Quality:

- Groundwater concentrations for TDEC Appendix I and CCR Rule Appendix IV CCR constituent concentrations are below GSLs.

Surface Stream, Sediment and Ecology:

- Potential impacts for these media are evaluated as part of Active Ash Pond 2.

4 Active Ash Pond 2

CCR Material:

- CCR material is sluiced bottom ash and sluiced fly ash, with an estimated total volume of ~ 4.5 million cubic yards.

Groundwater Quality:

- Cobalt (wells 10-AP3, JOF-103, and JOF-118) and nickel (well JOF-103) were detected above GSLs.

Potential Seeps:

- Two AOIs were identified during the EI. One AOI (AOI03) has been mitigated under a TDEC approved plan. The remaining AOI (AOI01) is currently being monitored and will be further evaluated in the CARA Plan.

Surface Stream, Sediment and Ecology:

- Beryllium and selenium sediment results were above chronic ESVs at one sample location in the Tennessee River. Arsenic, beryllium, and selenium sediment results were above ESVs in the Intake Channel and arsenic, beryllium, copper, mercury, and selenium sediment results were aboveESVs in the Boat Harbor. These metals were not above GSLs in groundwater samples at this unit.

5 Former Coal Yard

CCR Material:

- CCR material is sluiced fly ash and bottom ash with an estimated total volume of ~ 551,000 cubic yards.

Groundwater Quality:

- Arsenic (well JOF-117), cobalt (wells JOF-112, JOF-114 and JOF-117), lithium (wells JOF-113 and JOF-114), and molybdenum (well JOF-113) were detected above GSLs.

Surface Stream, Sediment and Ecology:

- Arsenic, beryllium, copper, mercury, and selenium sediment results were above chronic ESVs in the Boat Harbor.

Legend

- Groundwater results below Groundwater Screening Levels
- Groundwater results above Groundwater Screening Levels
- Sediment / Surface water sample results below chronic Ecological Screening Values (ESVs)
- Sediment / Surface water sample results above chronic Ecological Screening Values (ESVs)
- Area of Interest (AOI)

Sections colored in the chart indicate the number of constituents at a sampling location above screening levels

Number of constituents compared:

- Groundwater: 20
- Kentucky Lake/Tennessee River Sediment: 18
- Kentucky Lake/Tennessee River Surface Stream Water: 26

Counts represent total metals sample results. Total metals sample results less than screening levels (see Appendix J.1)

- Interpolated Groundwater Contour
- Groundwater Contour (5 ft interval; elevations are in ft amsl)
- Surface stream that bounds groundwater flow
- Hydrogeological Divide
- Generalized groundwater flow direction
- 2017 Imagery Boundary
- 2018 Imagery Boundary
- TVA Property Boundary
- CCR Unit Area (Approximate)
- Former Stilling Pond (Approximate)
- Former Coal Yard (Approximate)

CCR: Coal combustion residuals

- 1–4 X above screening levels
- 5–9 X above screening levels
- >10 X above screening levels

Notes: Groundwater contours included to illustrate general groundwater flow directions. See Exhibit 5-1, Groundwater Elevation Contour Map Event #5 (August 10-11, 2020), for actual groundwater elevations and groundwater contours.

Imagery Provided by TVA (2017 & 2018) & ESRI World Imagery

Stantec TVA

Exhibit No.
8-7

Title
Overall Findings Near JOF Plant CCR Management Units

Client/Project
Tennessee Valley Authority
Johnsonville Fossil (JOF) Plant TDEC Order

Project Location 175568286
New Johnsonville, Tennessee
Prepared by KB on 2023-08-21