2022 Annual Groundwater Monitoring and Corrective Action Report

Tennessee Valley Authority
Bull Run Fossil Plant Dry Fly Ash Stack Lateral Expansion CCR Unit

Prepared for:
Tennessee Valley Authority
1101 Market Street
Chattanooga, TN 37402

Prepared by:
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January 31, 2023

2022 ANNUAL GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT

TVA Bull Run Fossil Plant Dry Fly Ash Stack Lateral Expansion CCR Unit

January 31, 2023

In accordance with 40 CFR § 257.90(e) of the Disposal of Coal Combustion Residuals from Electric Utilities final rule (CCR Rule), this 2022 Annual Groundwater Monitoring and Corrective Action Report (2022 Annual Report) documents 2022 groundwater monitoring activities at the Dry Fly Ash Stack (DFAS) Lateral Expansion CCR Unit at the Tennessee Valley Authority (TVA) Bull Run Fossil Plant (BRF). In 2017, TVA established a groundwater monitoring system and program at the BRF DFAS Lateral Expansion CCR Unit in accordance with 40 CFR § 257.90. The groundwater monitoring system was certified by a qualified Professional Engineer as required by 40 CFR § 257.91(f).

OVERVIEW

An overview of the current status of groundwater monitoring and corrective action program for the DFAS Lateral Expansion CCR Unit is provided below in accordance with 40 CFR § 257.90(e)(6).

- At the start and end of the current 2022 annual reporting period, the DFAS Lateral Expansion CCR Unit was operating under the detection monitoring program in 40 CFR § 257.94.

- Constituents listed in Appendix III with statistically significant increases (SSIs) over background and the names of the monitoring wells are summarized in Table 1.

- During the 2018 detection monitoring sampling, a statistically significant increase (SSI) over background levels for one or more constituents listed in Appendix III to this part pursuant to 40 CFR § 257.94(e) was observed for boron, calcium, sulfate and total dissolved solids (TDS) in monitoring wells BRF-107 and well J. In addition, SSIs were observed for boron, fluoride, sulfate and TDS at monitoring well MW-3H/P-3. An assessment monitoring program was not initiated for the DFAS Lateral Expansion because a successful Appendix III alternate source demonstration (ASD) was completed in April 2018. The ASD is provided as Appendix D of this report in accordance with 40 CFR § 257.94(e)(2).

- During the 2020 detection monitoring events, the same SSIs of Appendix III CCR constituents at the downgradient monitoring wells were identified as in 2018 and 2019 with one exception. The SSI for TDS at monitoring well MW-3H/P-3 was not observed in 2020. The alternate source demonstration was re-evaluated in 2020 and continues to support that the SSIs are attributable to another source and not the DFAS Lateral Expansion CCR Unit.

- During the 2021 detection monitoring events, the same SSIs of Appendix III CCR constituents at the downgradient monitoring wells were identified as in 2020 with one exception. An SSI was observed for pH at monitoring well MW-3H/P-3. The alternate source demonstration was re-evaluated in 2021 and continues to support that the SSIs are attributable to another source and not the DFAS Lateral Expansion CCR Unit.

- During the 2022 detection monitoring events, the same SSIs of Appendix III CCR constituents at the downgradient monitoring wells were identified as in 2021 with one exception. An SSI was not observed for pH at monitoring well MW-3H/P-3. The alternate source demonstration was re-evaluated in 2022 and continues to support that the SSIs are attributable to another source and not the DFAS Lateral Expansion CCR Unit.

2022 AND PROJECTED 2023 GROUNDWATER MONITORING ACTIVITIES

During 2022, TVA performed the following groundwater monitoring activities:

- Conducted a statistical analysis of the 2021 detection monitoring groundwater sampling data in accordance with 40 CFR § 257.93(h) in January 2022, and it was concluded that there were SSIs over background levels for certain Appendix III constituents. The results were included in Table 7 of the 2021 Annual Groundwater Monitoring and Corrective Action Report, which was placed on the CCR Rule Compliance Data and Information website (https://www.tva.com/environment/environmental-stewardship/coal-combustion-residuals/bull-run).

- Continued under the detection monitoring program and performed two semiannual groundwater sampling events and two retest events between January and August 2022 of the certified monitoring system in accordance with 40 CFR § 257.94.
- Statistical analyses of the 2022 detection monitoring results were performed in accordance with the CCR Rule 40 CFR § 257.93(h). TVA has provided the determination of any statistically significant increases (SSIs) over background for both semiannual detection monitoring events as shown on Table 1.
- Performed further site characterization to improve the BRF Conceptual Site Model (CSM).
- Continued TVA's third-party Quality Assurance Program to evaluate groundwater analytical data using best practices concerning field methods and validation techniques, as well as the application of appropriate statistical methods.
- Reviewed new data as it became available to maintain compliance with 40 CFR § 257.90 through 257.98.
- Complied with recordkeeping requirements as specified in 40 CFR § 257.105(h), notification requirements specified in 40 CFR § 257.106(h) and internet requirements specified in 40 CFR § 257.107(h).

No problems were encountered during the 2022 TVA groundwater quality monitoring program, and therefore, no additional actions have been recommended except for the planned key activities for 2023 that are outlined below.

The projected key activities for 2023 are:

- Perform further site characterization to improve the BRF CSM.
- Continue semiannual detection monitoring at the certified groundwater monitoring system consistent with 40 CFR § 257.94.
- Evaluate whether one or more Appendix III constituents are detected at SSIs above established background concentrations in accordance with 40 CFR § 257.93(h).
- Continue TVA's third-party Quality Assurance Program to evaluate groundwater analytical data using best practices concerning field methods and validation techniques, as well as the application of appropriate statistical methods.
- Review new data as it becomes available and implement changes to the groundwater monitoring program as necessary to maintain compliance with 40 CFR § 257.90 through 257.98.
- Comply with recordkeeping requirements as specified in 40 CFR § 257.105(h), notification requirements specified in 40 CFR § 257.106(h) and internet requirements specified in 40 CFR § 257.107(h).

GROUNDWATER MONITORING SYSTEM

The DFAS area is located to the northeast of the main plant and coal yard and is comprised of multiple phased landfills built in sequence. The DFAS Phase I and II areas were permitted together as a Class II Landfill and went into operation in 1983 (permit No. IDL 01-103-0080). Construction of the Phase I area cap was completed in 1992. The Phase II area stacking began in 1989, overlapping the Phase I area, and continued through 2015. Construction began on the lined DFAS Lateral Expansion in 2012 and placement of ash within the unit began in 2015 and is currently ongoing, which classifies it as the only active landfill at the BRF site per the CCR Rule.[1]

The groundwater monitoring system for the BRF DFAS Lateral Expansion CCR Unit consists of two background wells (I and MWC) and three downgradient wells (BRF-107, J, and MW-3H/P-3). The downgradient wells are installed at the waste boundary. Figure 1 is an aerial photograph that shows the DFAS Lateral Expansion and the groundwater monitoring well locations. The groundwater monitoring system was designed for a single CCR Unit (DFAS Lateral Expansion).

No monitoring wells in the certified monitoring system were installed or decommissioned during the 2022 reporting period. The certification of the groundwater monitoring system required under 40 CFR § 257.91(f) is included in the facility operating record and on the CCR Rule Compliance Data and Information website:

https://www.tva.com/environment/environmental-stewardship/coal-combustion-residuals/bull-run.

GROUNDWATER SAMPLING AND LABORATORY ANALYTICAL TESTING

A groundwater sampling and analysis program was developed and includes, as required by 40 CFR § 257.93(a), procedures and techniques for sample collection, sample preservation and shipment, analytical procedures, chain-of-custody control, and quality assurance and quality control (QA/QC). The groundwater monitoring program includes sampling and analysis procedures designed to provide monitoring results that are an accurate representation of groundwater quality at background and downgradient wells.

The semiannual detection monitoring was completed in compliance with 40 CFR § 257.94. Groundwater sampling was conducted between January and August 2022 and the results are summarized in Table 2. A summary of groundwater sample locations, well designations, analytes sampled, sampling dates, and monitoring program status is provided in Table 3.

Groundwater elevations were measured in each monitoring well immediately prior to purging during each sampling event as required by 40 CFR § 257.93(c). Groundwater elevations for monitoring wells in the certified monitoring system and Clinch River surface water elevations are summarized in Table 4.[2] Groundwater flow directions were estimated for each sampling event, and a depiction of groundwater flow direction for the August 2022 event[3] is illustrated on Figure 2. The regional groundwater directional flow at

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[1] With oversight from the Tennessee Department of Environment and Conservation (TDEC), TVA has been conducting environmental investigations of the CCR management units at BRF, including the Dry Fly Ash Stack Phase I, Phase II, and Lateral Expansion units, in accordance with TDEC Commissioner's Order, OGC 15-0177 (TDEC Order). The TDEC Order sets forth the process for TVA to investigate the CCR management units, provide an assessment of the data to TDEC, and present proposed corrective measures and remedies, including for groundwater, to TDEC for approval.

[2] Groundwater elevations were collected at additional monitoring wells during each sampling event and are summarized in Table A-1 in Appendix A.

[3] Groundwater flow direction maps for the January, February, July, and August 2022 sampling events are included in Appendix B.

BRF is influenced by the Clinch River to the west/southwest of the site and then locally by Worthington Branch that runs to the south of the DFAS Lateral Expansion at the base of Bull Run Ridge. Worthington Branch flows west-southwest, discharging to the Clinch River. The primary groundwater flow direction is to the west/southwest toward the Clinch River. Locally, groundwater flows south beneath the DFAS Lateral Expansion towards Worthington Branch.

The uppermost aquifer at the BRF DFAS Lateral Expansion CCR Unit consists of a thin layer of residuum underlain by fractured Chickamauga Limestone. Groundwater occurrence is variable and controlled by a series of interconnected bedrock fractures shallower than 300 feet (AECOM, 2015).

Hydraulic conductivity values at the background or downgradient groundwater monitoring wells, as summarized in Table 5, are estimated in a 2018 hydrogeologic evaluation (Terracon, 2019). Testing data indicated the uppermost saturated zone has a geometric mean hydraulic conductivity of 3.2×10^{-4} centimeters per second (cm/sec). Linear groundwater flow velocity was calculated for the uppermost aquifer using:

- The geometric mean hydraulic conductivity calculated from hydraulic testing (3.2×10^{-4} cm/sec)
- Horizontal hydraulic gradients calculated during the implementation of the groundwater sampling and analysis program, ranging from 0.0326 to 0.0338 feet per foot (ft/ft), and
- An effective porosity of approximately 1% (AECOM, 2015).

The average linear flow velocity in the uppermost aquifer ranges from approximately 1,077 to 1,114 feet per year. The rate and direction of groundwater flow in the bedrock for each groundwater sampling event is summarized in Table 6 in accordance with 40 CFR § 257.93(c).

STATISTICAL ANALYSIS OF GROUNDWATER DATA

The groundwater monitoring data for the 2022 detection monitoring events were evaluated using statistical procedures as required by 40 CFR § 257.93(f) through 257.93(h). The statistical method certification is included in the facility operating record and the CCR Rule Compliance Data and Information website. Background groundwater quality was established for the background monitoring wells MWC and Well I.

Baseline and detection monitoring data sets for 2017 through 2022 of the CCR Rule Groundwater Quality Monitoring Program were evaluated in order to establish upper prediction limits (UPLs) on background data, and then to compare 2022 compliance measurements against these statistical limits to assess any SSIs above background. To assess whether any SSIs occurred during the 2022 Detection Monitoring, the routine sampling events from sampling rounds 1 and 3 at each well-constituent pair were compared against their respective UPL. Under a 1-of-2 retesting strategy, sampling rounds 2 and 4 were included as retest events. A summary of the detection monitoring statistical evaluation is provided in Table 7. The 2022 Statistical Analysis Report is provided as Appendix C.

NARRATIVE DISCUSSION OF ANY TRANSITION BETWEEN MONITORING PROGRAMS

TVA evaluated the groundwater monitoring data for SSIs over background levels for the constituents listed in Appendix III[4] as required by 40 CFR § 257.93(h). The groundwater analytical results from the 2022 rounds of detection monitoring indicated identical SSIs of Appendix III CCR constituents at the downgradient monitoring wells compared to the 2021 monitoring results with one exception. An SSI for pH at monitoring well MW-3H/P-3 was not observed in 2022. TVA performed confirmation of the SSIs via retesting procedures and error checking and investigated whether the SSIs over background resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality as specified in 40 CFR § 257.94(e)(2).

Following the 2017 groundwater data collection, TVA performed investigations to determine whether a source other than the CCR materials contained in the BRF DFAS Lateral Expansion CCR Unit was the cause of any verified SSI over background as specified in 40 CFR § 257.94(e)(2). The Appendix III alternate source demonstration study was completed in April 2018, certified by a qualified professional engineer, and determined that the SSIs were a result of another source and not attributable to the DFAS Lateral Expansion CCR Unit. Alternate source demonstration documentation is provided in Appendix D. The alternate source demonstration was re-evaluated in 2022 and continues to support that the SSIs are attributable to another source and not the DFAS Lateral Expansion CCR Unit. Additionally, as part of the permitting and groundwater monitoring requirements of this CCR landfill for the State of Tennessee, the leachate collection system for the lined landfill is monitored for Appendix III/Appendix IV constituents. This leachate data will be used as needed as a line of evidence to evaluate if Appendix III/Appendix IV constituent trends change in the downgradient monitoring wells. TVA will continue to review new data as it becomes available and implement changes to the groundwater monitoring program as necessary to maintain compliance with 40 CFR § 257.90 through 257.98.

[4] Appendix III CCR Constituents: boron, calcium, chloride, fluoride, pH, sulfate, and total dissolved solids (TDS).

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January 31, 2023

LIMITATIONS

This document entitled 2022 Annual Groundwater Monitoring and Corrective Action Report was prepared by Stantec Consulting Services Inc. (“Stantec”) for the Tennessee Valley Authority (the “Client”). The material in it reflects Stantec’s professional judgment in light of the scope, schedule and other limitations stated in the document. The opinions in the document are based on conditions and information existing at the time the document was published and do not take into account any subsequent changes. In preparing the document, Stantec relied upon data and information supplied to it by the client.

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2022 ANNUAL GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT

TVA Bull Run Fossil Plant Dry Fly Ash Stack Lateral Expansion CCR Unit

January 31, 2023

References:

AECOM, 2015. Part II Permit Application Hydrogeologic Site Investigation CCP Proposal Landfill. June 12, 2015.

Terracon, 2019. Aquifer Testing and Equipment Blank Results. TVA CCR Rule – Bull Run Fossil Plant (BRF). Terracon Consultants, Inc. January 15, 2019.

Attachments:

Figure 1 – CCR Unit with Background and Downgradient Wells

Figure 2 – Dry Fly Ash Stack Potentiometric Map – August 22, 2022

Table 1 - Summary of Appendix III Constituent Statistically Significant Increases

Table 2 – Detection Monitoring Groundwater Sampling Results

Table 3 – Groundwater Sampling Summary

Table 4 – Groundwater and Surface Water Elevation Summary

Table 5 – Hydraulic Conductivity Data Summary

Table 6 – Rate and Direction of Groundwater Flow Summary

Table 7 – Detection Monitoring Statistical Evaluation

Appendix A – Groundwater and Surface Water Elevation Summary - Additional Monitoring Wells

Appendix B – Potentiometric Maps

Appendix C – 2022 Statistical Analysis Report

Appendix D – Alternate Source Demonstration Documentation

FIGURES

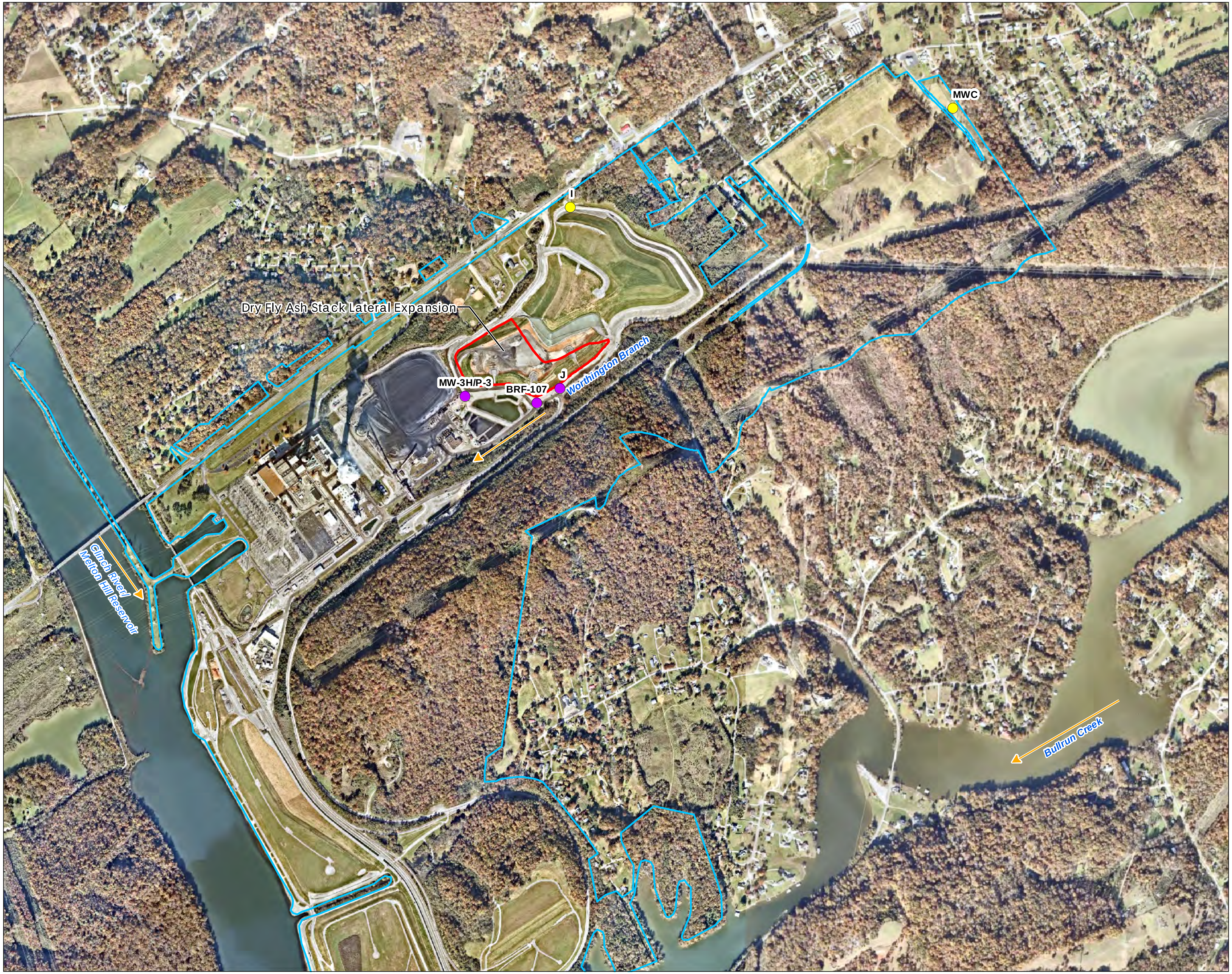

Figure No.

1

Title

CCR Units with Background and Downgradient Wells

Client/Project

182603748

Tennessee Valley Authority
Bull Run Fossil (BRF) Plant

Project Location

Claxton
Anderson County, Tennessee

Prepared by DMB on 2023-01-09
TR by KM on 2023-01-09
IR by MD on 2023-01-09

N

0 1,000 Feet
(At original document size of 11x17)
1:12,000

Legend

- Downgradient Well
- Background Well
- Surface Water Flow Direction
- CCR Unit Subject to CCR Rule
- TVA Property Boundary (Approximate)

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Source: NearMap (2021-11-09)

TVA

U:\TVA-E\P175568274_BRF_Phase2\gis\mxd\2022_Annual_GWBRF_Fig1_DFAS_CCRUnits_Background_and_DowngradientWells.mxd Revised: 2023-01-09 By: mbough

Figure No.
2

Title
Dry Fly Ash Stack Potentiometric Map August 22, 2022

Client/Project 182603748
Tennessee Valley Authority
Bull Run Fossil (BRF) Plant

Project Location
Claxton
Anderson County, Tennessee

Prepared by DMB on 2023-01-05
TR by MP on 2023-01-05
IR by MD on 2023-01-05

N

0 300 Feet
(At original document size of 11x17)
1:3,600

Legend
- CCR Network Well; Certified CCR Network Well
- Non-CCR Network Well
- Potentiometric Contour 8/22/2022 (ft amsl)
- Inferred Potentiometric Contour 8/22/2022 (ft amsl)
- Groundwater Flow Direction
- CCR Management Unit Area (Approximate)
- TVA Property Boundary (Approximate)

Notes
1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Source: NearMap (2021-11-09)
3. Clinch River was 793.82 ft amsl on August 22, 2022.

TVA

U:\TVA-EIP\175568274_BRF_Phase2\gis\mxd\2022_Annual_GW\BRF_Fig8-4_DFAS_PotentiometricEvent20220822.mxd Revised: 2023-01-05 By: mbough

TABLES

Table 1
Summary of Appendix III
Constituent Statistically Significant
Increases

Constituent	MW-3H/P-3	BRF-107	J
Boron	X	X	X
Calcium		X	X
Chloride			
Fluoride	X		
pH			
Sulfate	X	X	X
TDS		X	X

Notes:

X - Statistically Significant Increase

TDS - Total Dissolved Solids

Monitoring Well			**BRF-107**							
Sample Date			**06-Jan-22**		**23-Feb-22**		**12-Jul-22**		**24-Aug-22**	
Sample Round			**1**		**1 - Retest**		**2**		**2 - Retest**	
Well Designation			**Downgradient**		**Downgradient**		**Downgradient**		**Downgradient**	
Analyte	Units	Analytical Method	Result	Q	Result	Q	Result	Q	Result	Q
Total Metals										
Boron	ug/L	SW846 6020A/B	562		547		502		515	
Calcium	mg/L	SW846 6020A/B	197		200		218		199	
Anions										
Chloride	mg/L	EPA 300.0/SW846 9056	7.49	J	8.26		7.51		7.39	
Fluoride	mg/L	EPA 300.0/SW846 9056	< 0.0701	U*	0.0586	J	0.0524	J	< 0.103	U*
Sulfate	mg/L	EPA 300.0/SW846 9056	322	J	257		232		241	
General Chemistry										
Total Dissolved Solids	mg/L	SM 2540C	741		735		759		783	
Field Parameters										
Temperature, Water (C)	DEG_C	FIELD MEASURE	13.0		16.6		18.6		20.7	
Turbidity, field	NTU	FIELD MEASURE	0.17		0.06		0.51		0.07	
ORP	mV	FIELD MEASURE	123.7		10.8		33.4		97.0	
Specific Cond. (Field)	mS/cm	FIELD MEASURE	0.96		1.06		0.96		1.061	
Dissolved Oxygen	mg/L	FIELD MEASURE	0.49		0.46		2.62		0.29	
pH (field)	pH Units	FIELD MEASURE	6.85		6.82		6.83		6.81	

Notes:

Metals Analysis performed at Eurofins Analytical Laboratories switched from Method SW 846 6020A to SW 846 6020B on 6/4/2022.

Q - Data Qualifier

U* - Result should be considered "not-detected" because it was detected in a rinsate blank or laboratory blank at similar level

J - Quantitation is approximate due to limitations identified during data validation

U - Analyte not detected

ug/L - micrograms per liter
mg/L - milligrams per liter
pCi/L - picoCurie per liter
DEG_C - degrees Celsius

NTU - Nephelometric Turbidity Units
mV - millivolts
mS/cm - milliseimens per centimeter
SU - Standard Unit

Monitoring Well			**I**							
Sample Date			**04-Jan-22**		**24-Feb-22**		**13-Jul-22**		**25-Aug-22**	
Sample Round			**1**		**1 - Retest**		**2**		**2 - Retest**	
Well Designation			**Background**		**Background**		**Background**		**Background**	
Analyte	Units	Analytical Method	Result	Q	Result	Q	Result	Q	Result	Q
Total Metals										
Boron	ug/L	SW846 6020A/B	< 59.1	U*	87.6		74.5	J	< 76.8	U*
Calcium	mg/L	SW846 6020A/B	85.2		79.3		85.7		84.3	
Anions										
Chloride	mg/L	EPA 300.0/SW846 9056	24.2		24.6		24.5		25.6	
Fluoride	mg/L	EPA 300.0/SW846 9056	< 0.0799	U*	0.0668	J	< 0.0589	U*	< 0.0933	U*
Sulfate	mg/L	EPA 300.0/SW846 9056	4.93		4.79		< 4.42	U*	4.64	
General Chemistry										
Total Dissolved Solids	mg/L	SM 2540C	372		342		336		341	
Field Parameters										
Temperature, Water (C)	DEG_C	FIELD MEASURE	13.7		12.9		22.9		27.7	J
Turbidity, field	NTU	FIELD MEASURE	0.24		0.16		0.65		0.32	
ORP	mV	FIELD MEASURE	63.1		158.3		31.2		71.9	
Specific Cond. (Field)	mS/cm	FIELD MEASURE	0.542		0.592		0.55		0.608	
Dissolved Oxygen	mg/L	FIELD MEASURE	0.53		0.96		3.83		0.36	
pH (field)	pH Units	FIELD MEASURE	7.40		7.27		7.20		7.25	

Notes:

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Table 2
Detection Monitoring Groundwater
Sampling Results

CCR Annual Groundwater Monitoring and
Corrective Action Report
TVA Bull Run Fossil Plant

Monitoring Well			J							
Sample Date			05-Jan-22		22-Feb-22		13-Jul-22		25-Aug-22	
Sample Round			1		1 - Retest		2		2 - Retest	
Well Designation			Downgradient		Downgradient		Downgradient		Downgradient	
Analyte	Units	Analytical Method	Result	Q	Result	Q	Result	Q	Result	Q
Total Metals										
Boron	ug/L	SW846 6020A/B	2170		1970		2090		1890	
Calcium	mg/L	SW846 6020A/B	361		331		369		365	
Anions										
Chloride	mg/L	EPA 300.0/SW846 9056	13.4		14.0		11.5		12.7	
Fluoride	mg/L	EPA 300.0/SW846 9056	< 0.0710	U*	< 0.0724	U*	< 0.0521	U*	< 0.0873	U*
Sulfate	mg/L	EPA 300.0/SW846 9056	807		909		839		817	
General Chemistry										
Total Dissolved Solids	mg/L	SM 2540C	1490		1500		1590		1610	
Field Parameters										
Temperature, Water (C)	DEG_C	FIELD MEASURE	15.0		16.6		18.1		19.6	J
Turbidity, field	NTU	FIELD MEASURE	0.20		0.21		0.13		0.06	
ORP	mV	FIELD MEASURE	137.2		36.9		44.2		75.2	
Specific Cond. (Field)	mS/cm	FIELD MEASURE	1.67		1.79		1.64		1.788	
Dissolved Oxygen	mg/L	FIELD MEASURE	0.89		0.21		0.40		0.13	
pH (field)	pH Units	FIELD MEASURE	6.97		6.97		6.84		6.94	

Notes:

Metals Analysis performed at Eurofins Analytical Laboratories switched from Method SW 846 6020A to SW 846 6020B on 6/4/2022.

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mS/cm - milliseimens per centimeter

SU - Standard Unit

Monitoring Well			**MW-3H/P-3**							
Sample Date			**06-Jan-22**		**23-Feb-22**		**13-Jul-22**		**26-Aug-22**	
Sample Round			**1**		**1 - Retest**		**2**		**2 - Retest**	
Well Designation			**Downgradient**		**Downgradient**		**Downgradient**		**Downgradient**	
Analyte	Units	Analytical Method	Result	Q	Result	Q	Result	Q	Result	Q
Total Metals										
Boron	ug/L	SW846 6020A/B	618		646		616		674	
Calcium	mg/L	SW846 6020A/B	41.4		43.3		43.1		46.5	
Anions										
Chloride	mg/L	EPA 300.0/SW846 9056	10.1	J	11.0		9.41		10.5	
Fluoride	mg/L	EPA 300.0/SW846 9056	0.525	J	0.520		0.504		0.482	
Sulfate	mg/L	EPA 300.0/SW846 9056	56.0	J	65.9		63.2		59.9	
General Chemistry										
Total Dissolved Solids	mg/L	SM 2540C	407		399		401		410	
Field Parameters										
Temperature, Water (C)	DEG_C	FIELD MEASURE	12.3		16.5		21.5		22.2	
Turbidity, field	NTU	FIELD MEASURE	0.27		0.57		0.31		0.71	
ORP	mV	FIELD MEASURE	-138.6		-50.4		-97.2		-76.2	
Specific Cond. (Field)	mS/cm	FIELD MEASURE	0.609		0.68		0.62		0.684	
Dissolved Oxygen	mg/L	FIELD MEASURE	0.20		2.15		1.44		0.25	
pH (field)	pH Units	FIELD MEASURE	7.65		7.67		7.57		7.60	

Notes:

Metals Analysis performed at Eurofins Analytical Laboratories switched from Method SW 846 6020A to SW 846 6020B on 6/4/2022.

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mV - millivolts

mS/cm - milliseimens per centimeter

SU - Standard Unit

Table 2
Detection Monitoring Groundwater Sampling Results

Monitoring Well			**MWC**							
Sample Date			**04-Jan-22**		**23-Feb-22**		**12-Jul-22**		**26-Aug-22**	
Sample Round			**1**		**1 - Retest**		**2**		**2 - Retest**	
Well Designation			**Background**		**Background**		**Background**		**Background**	
Analyte	Units	Analytical Method	Result	Q	Result	Q	Result	Q	Result	Q
Total Metals										
Boron	ug/L	SW846 6020A/B	< 216	U*	160		181		< 241	U*
Calcium	mg/L	SW846 6020A/B	112		102		99.0		103	
Anions										
Chloride	mg/L	EPA 300.0/SW846 9056	4.88		5.61		4.70		4.74	
Fluoride	mg/L	EPA 300.0/SW846 9056	< 0.172	U*	0.158		0.123		0.135	
Sulfate	mg/L	EPA 300.0/SW846 9056	28.0		37.3		14.9		20.5	
General Chemistry										
Total Dissolved Solids	mg/L	SM 2540C	420		406		369		382	
Field Parameters										
Temperature, Water (C)	DEG_C	FIELD MEASURE	11.3		14.2		20.9		23.7	
Turbidity, field	NTU	FIELD MEASURE	0.35		0.12		1.76		0.62	
ORP	mV	FIELD MEASURE	128.0		160.7		-35.6		-83.6	
Specific Cond. (Field)	mS/cm	FIELD MEASURE	0.628		0.70		0.60		0.687	
Dissolved Oxygen	mg/L	FIELD MEASURE	2.67		1.93		1.02		0.38	
pH (field)	pH Units	FIELD MEASURE	7.33		7.16		7.13		7.10	

Notes:

Metals Analysis performed at Eurofins Analytical Laboratories switched from Method SW 846 6020A to SW 846 6020B on 6/4/2022.

Q - Data Qualifier

U* - Result should be considered "not-detected" because it was detected in a rinsate blank or laboratory blank at similar level

J - Quantitation is approximate due to limitations identified during data validation

U - Analyte not detected

ug/L - micrograms per liter
mg/L - milligrams per liter
pCi/L - picoCurie per liter
DEG_C - degrees Celsius

NTU - Nephelometric Turbidity Units
mV - millivolts
mS/cm - milliseimens per centimeter
SU - Standard Unit

Table 3
Groundwater Sampling Summary

CCR Annual Groundwater Monitoring and Corrective Action Report - TVA Bull Run Fossil Plant

Well ID	Well Designation	Number of Sampling Events Conducted	January 4-6, 2022	February 22-24, 2022	July 12-13, 2022	August 24-26, 2022	Groundwater Monitoring Program
Sample Round			1	1 - Retest	2	2 - Retest	
BRF-107	Downgradient	4	X	X	X	X	Detection Monitoring - 257.94(a); 257.94(b) - Appendix III Constituents
I	Background	4	X	X	X	X	Detection Monitoring - 257.94(a); 257.94(b) - Appendix III Constituents
J	Downgradient	4	X	X	X	X	Detection Monitoring - 257.94(a); 257.94(b) - Appendix III Constituents
MW-3H/ P-3	Downgradient	4	X	X	X	X	Detection Monitoring - 257.94(a); 257.94(b) - Appendix III Constituents
MWC	Background	4	X	X	X	X	Detection Monitoring - 257.94(a); 257.94(b) - Appendix III Constituents

Notes:

Appendix III Constituents - boron, calcium, chloride, fluoride, pH, sulfate, total dissolved solids (TDS)

Table 4
Groundwater and Surface Water Elevation Summary

Groundwater Elevation Collection Date			03-Jan-22		15-Feb-22		11-Jul-22		22-Aug-22	
Monitoring Well	**Units**	**TOC Elevation**	**Depth to Water**	**GW/SW Elevation**	**Depth to Water**	**GW/SW Elevation**	**Depth to Water**	**GW/SW Elevation**	**Depth to Water**	**GW/SW Elevation**
BRF-107	ft-MSL	825.55	14.29	811.26	14.47	811.08	14.08	811.47	14.10	811.45
I	ft-MSL	876.57	3.94	872.63	4.97	871.60	5.18	871.39	5.18	871.39
J	ft-MSL	834.39	20.90	813.49	21.62	812.77	21.27	813.12	20.87	813.52
MWC**	ft-MSL	865.24	6.78	858.46	6.72*	858.52*	7.22	858.02	7.35	857.89
MW-3H/P-3	ft-MSL	834.27	13.92	820.35	14.02	820.25	13.68	820.59	13.49	820.78
		Surface Water								
Clinch River	ft-MSL	NA	NA	794.13	NA	793.56	NA	794.28	NA	793.82

Notes:

*Measurement collected on 2/14/2022

** Background monitoring well MWC groundwater elevations were not used in production of potentiometric maps included in Figure 2 and Appendix B.

ft-MSL - Feet above mean sea level

GW/SW - Groundwater / Surface Water

NA - Not applicable

Well ID	Well Designation	Slug Test Hydraulic Conductivity (cm/sec)	Pumping Test Hydraulic Conductivity (cm/sec)
BRF-107	Downgradient	2.5E-04	NA
I	Background	NA	4.8E-05
J	Downgradient	NA	NA
MW-3H/ P-3	Downgradient	NA	1.2E-04
MWC	Background	4.1E-04	NA
Geometric Mean of Hydraulic Conductivity (cm/sec)		**3.2E-04**	**7.6E-05**

Notes:

cm/sec - centimeters per second

NA - not available

Groundwater Elevation Collection Date	**3-Jan-22**	**15-Feb-22**	**11-Jul-22**	**22-Aug-22**
Sample Round	**1**	**1 - Retest**	**2**	**2 - Retest**
Horizontal Gradient	0.0338	0.0330	0.0327	0.0326
Hydraulic Conductivity (cm/sec)	3.2E-04	3.2E-04	3.2E-04	3.2E-04
Effective Porosity	1%	1%	1%	1%
Flow Direction (cardinal)	South-Southeast	South-Southeast	South-Southeast	South-Southeast
Linear Velocity (ft/yr)	1114	1088	1079	1077

Notes:

cm/sec - centimeters per second

ft/yr - feet per year

Constituent		**Boron**	**Calcium**	**Chloride**	**Fluoride**	**pH**	**Sulfate**	**TDS**
Unit		**µg/L**	**mg/L**	**mg/L**	**mg/L**	**SU**	**mg/L**	**mg/L**
2022 UPL		**202**	**115**	**27.2**	**0.172**	**6.73** – 7.88**	**33.9**	**424**
Well ID	**Date**							
BRF-107	1/6/2022	**<u>562</u>**	**<u>197</u>**	7.49 J	< 0.0701	6.85	**<u>322 J</u>**	**<u>741</u>**
	2/23/2022	**<u>(547)</u>**	**<u>(200)</u>**	(8.26)	(0.0586 J)	(6.82)	**<u>(257)</u>**	**<u>(735)</u>**
	7/12/2022	**<u>502</u>**	**<u>218</u>**	7.51	0.0524 J	6.83	**<u>232</u>**	**<u>759</u>**
	8/24/2022	**<u>(515)</u>**	**<u>(199)</u>**	(7.39)	(< 0.103)	(6.81)	**<u>(241)</u>**	**<u>(783)</u>**
J	1/5/2022	**<u>2170</u>**	**<u>361</u>**	13.4	< 0.071	6.97	**<u>807</u>**	**<u>1490</u>**
	2/22/2022	**<u>(1970)</u>**	**<u>(331)</u>**	(14)	(< 0.0724)	(6.97)	**<u>(909)</u>**	**<u>(1500)</u>**
	7/13/2022	**<u>2090</u>**	**<u>369</u>**	11.5	< 0.0521	6.84	**<u>839</u>**	**<u>1590</u>**
	8/25/2022	**<u>(1890)</u>**	**<u>(365)</u>**	(12.7)	(< 0.0873)	(6.94)	**<u>(817)</u>**	**<u>(1610)</u>**
MW-3H/P-3	1/6/2022	**<u>618</u>**	41.4	10.1 J	**<u>0.525 J</u>**	7.65	**<u>56 J</u>**	407
	2/23/2022	**<u>(646)</u>**	(43.3)	(11)	**<u>(0.52)</u>**	(7.67)	**<u>(65.9)</u>**	(399)
	7/13/2022	**<u>616</u>**	43.1	9.41	**<u>0.504</u>**	7.57	**<u>63.2</u>**	401
	8/26/2022	**<u>(674)</u>**	(46.5)	(10.5)	**<u>(0.482)</u>**	(7.60)	**<u>(59.9)</u>**	(410)
I	1/4/2022	< 59.1	85.2	24.2	< 0.0799	7.40	4.93	372
	2/24/2022	(87.6)	(79.3)	(24.6)	(0.0668 J)	(7.27)	(4.79)	(342)
	7/13/2022	74.5 J	85.7	24.5	< 0.0589	7.20	< 4.42	336
	8/25/2022	< 76.8	(84.3)	(25.6)	(< 0.0933)	(7.25)	(4.64)	(341)
MWC	1/4/2022	< 216	112	4.88	< 0.172	7.33	28.0	420
	2/23/2022	(160)	(102)	(5.61)	(0.158)	(7.16)	(37.3)	(406)
	7/12/2022	181	99.0	4.7	0.123	7.13	14.9	369
	8/26/2022	< 241	(103)	(4.74)	(0.135)	(7.10)	(20.5)	(382)

Notes:

<u>Bold and underlined concentration</u> indicates a statistically significant increase (SSI) over background where both the original sample and retest sample exceed the UPL or, for pH, are outside the prediction interval

TDS - Total Dissolved Solids

µg/L - micrograms per liter

mg/L - milligrams per liter

SU - Standard Units

UPL - Upper Prediction Limit

** indicates the lower bound of the range is the lower prediction limit (LPL). The upper bound is the UPL.

"<": analyte was not detected and the Method Detection Limit (MDL) is presented

Parenthesized values represent retest results

Wells I and MWC are background monitoring wells

APPENDIX A
GROUNDWATER AND SURFACE WATER ELEVATION SUMMARY – ADDITIONAL MONITORING WELLS

Table A-1
Groundwater and Surface Water Elevation Summary - Additional Monitoring Wells

Groundwater Elevation Collection Date			03-Jan-22		15-Feb-22			11-Jul-22		22-Aug-22	
Monitoring Well	**Units**	**TOC Elevation**	**Depth to Water**	**GW/SW Elevation**	**Depth to Water**	**GW/SW Elevation**	**TOC Elevation**	**Depth to Water**	**GW/SW Elevation**	**Depth to Water**	**GW/SW Elevation**
F45R	ft-MSL	835.35	14.40	820.95	15.60	819.75	835.35	14.95	820.40	15.29	820.06
BRF-115	ft-MSL	836.20	15.74	820.80	16.98	819.56	840.56	16.99	823.57	17.81	822.75
BRF-116	ft-MSL	840.56	18.51	822.14	19.21	821.35	836.54	18.90	817.64	19.19	817.35
H	ft-MSL	855.46	9.31	846.15	11.74	843.72	855.46	12.15	843.31	12.14	843.32
		Surface Water									
Clinch River	ft-MSL	NA	NA	794.13	NA	793.56	NA	NA	794.28	NA	793.82

Notes:

ft-MSL - Feet above mean sea level

GW/SW - Groundwater / Surface Water

NA - Not applicable

APPENDIX B
POTENTIOMETRIC MAPS

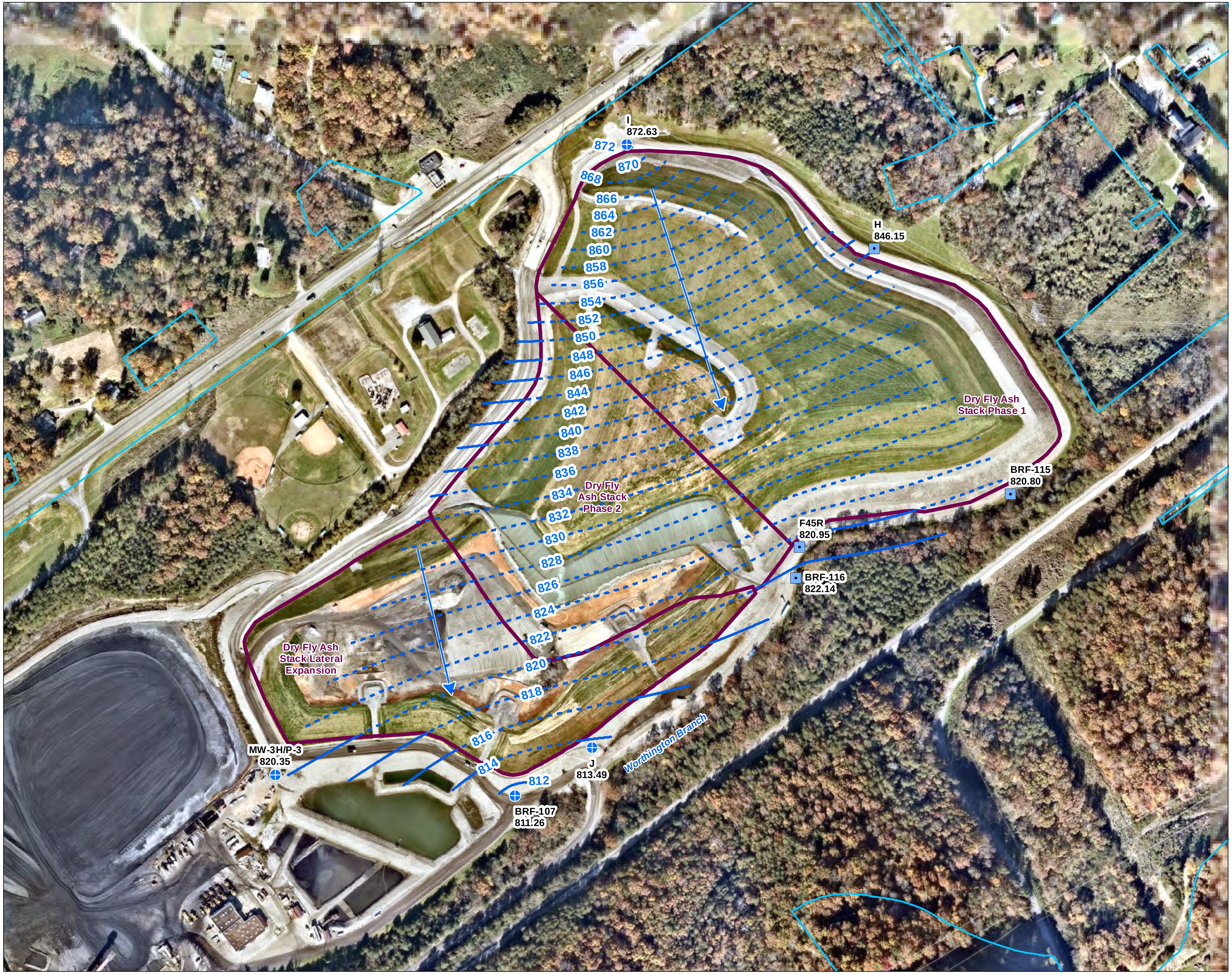

Figure No.

B-1

Title

Dry Fly Ash Stack
Potentiometric Map January 3, 2022

Client/Project 182603748

Tennessee Valley Authority
Bull Run Fossil (BRF) Plant

Project Location

Claxton
Anderson County, Tennessee

Prepared by DMB on 2023-01-05
TR by MP on 2023-01-05
IR by MD on 2023-01-05

N

0 300 Feet

(At original document size of 11x17)
1:3,600

Legend

- CCR Network Well; Certified CCR Network Well
- Non-CCR Network Well
- Potentiometric Contour 1/3/2022 (ft amsl)
- Inferred Potentiometric Contour 1/3/2022 (ft amsl)
- Groundwater Flow Direction
- CCR Management Unit Area (Approximate)
- TVA Property Boundary (Approximate)

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Source: NearMap (2021-11-09)
3. Clinch River was 794.13 ft amsl on January 3, 2022.

TVA

U:\TVA-EIP\175568274_BRF_Phase2\gis\mxd\2022_Annual_GW\BRF_Fig8-1_DFAS_PotentiometricEvent20220103.mxd Revised: 2023-01-05 By: mbough

Figure No.
B-2

Title
Dry Fly Ash Stack
Potentiometric Map February 15, 2022

Client/Project
182603748
Tennessee Valley Authority
Bull Run Fossil (BRF) Plant

Project Location
Claxton
Anderson County, Tennessee

Prepared by DMB on 2023-01-05
TR by MP on 2023-01-05
IR by MD on 2023-01-05

N

0 300
Feet
(At original document size of 11x17)
1:3,600

Legend

- CCR Network Well; Certified CCR Network Well
- Non-CCR Network Well
- Potentiometric Contour 2/15/2022 (ft amsl)
- Inferred Potentiometric Contour 2/15/2022 (ft amsl)
- Groundwater Flow Direction
- CCR Management Unit Area (Approximate)
- TVA Property Boundary (Approximate)

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Source: NearMap (2021-11-09)
3. Clinch River was 793.56 ft amsl on February 15, 2022.

TVA

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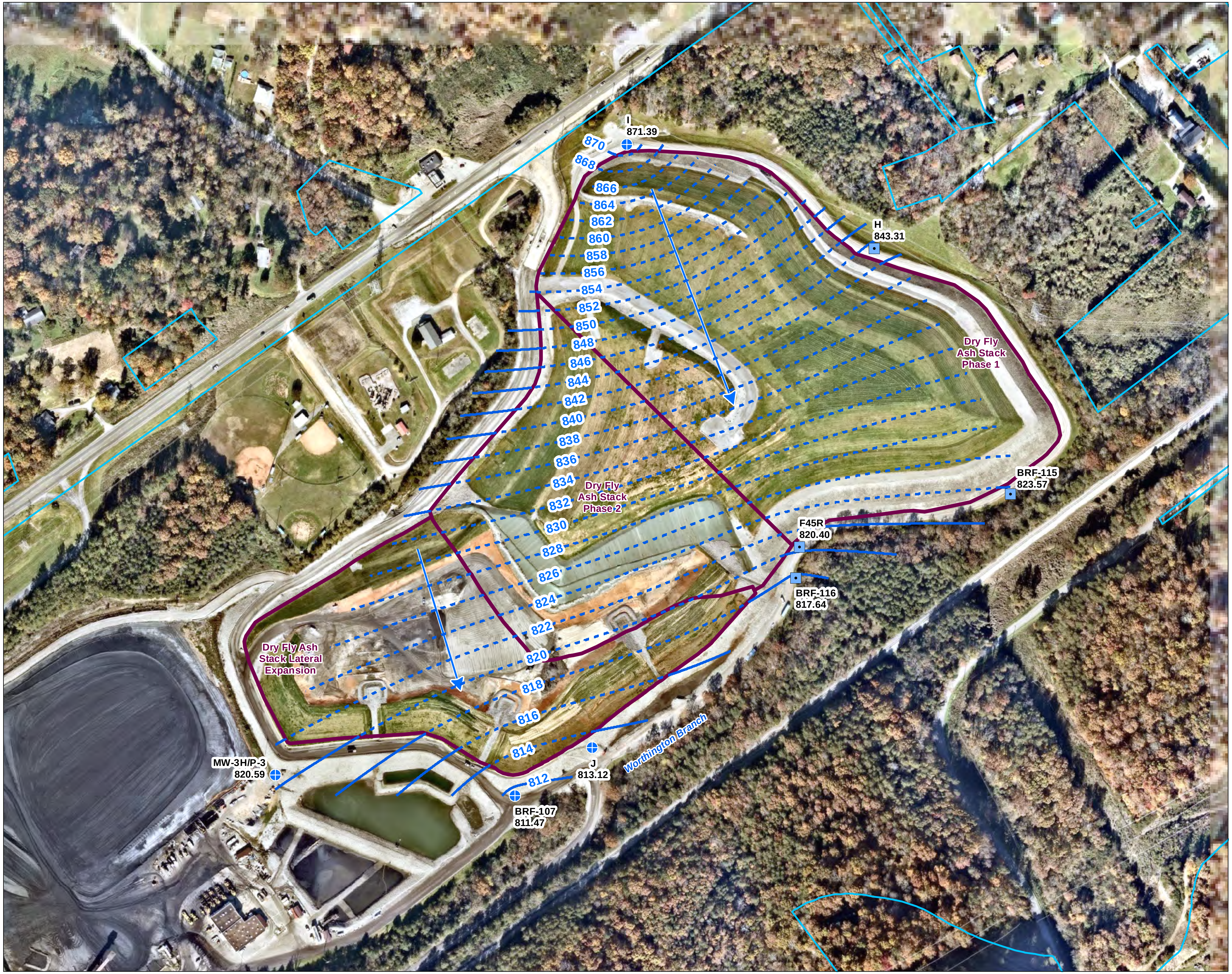

Figure No.

B-3

Title

Dry Fly Ash Stack
Potentiometric Map July 11, 2022

Client/Project 182603748

Tennessee Valley Authority
Bull Run Fossil (BRF) Plant

Project Location
Claxton
Anderson County, Tennessee

Prepared by DMB on 2023-01-05
TR by MP on 2023-01-05
IR by MD on 2023-01-05

N

0 300 Feet
(At original document size of 11x17)
1:3,600

Legend

- CCR Network Well; Certified CCR Network Well
- Non-CCR Network Well
- Potentiometric Contour 7/11/2022 (ft amsl)
- Inferred Potentiometric Contour 7/11/2022 (ft amsl)
- Groundwater Flow Direction
- CCR Management Unit Area (Approximate)
- TVA Property Boundary (Approximate)

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Source: NearMap (2021-11-09)
3. Clinch River was 794.28 ft amsl on July 11, 2022.

TVA

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Figure No.
B-4

Title
Dry Fly Ash Stack Potentiometric Map August 22, 2022

Client/Project
182603748
Tennessee Valley Authority
Bull Run Fossil (BRF) Plant

Project Location
Claxton
Anderson County, Tennessee

Prepared by DMB on 2023-01-05
TR by MP on 2023-01-05
IR by MD on 2023-01-05

N

0 — 300 Feet
(At original document size of 11x17)
1:3,600

Legend
- CCR Network Well; Certified CCR Network Well
- Non-CCR Network Well
- Potentiometric Contour 8/22/2022 (ft amsl)
- Inferred Potentiometric Contour 8/22/2022 (ft amsl)
- Groundwater Flow Direction
- CCR Management Unit Area (Approximate)
- TVA Property Boundary (Approximate)

Notes
1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Source: NearMap (2021-11-09)
3. Clinch River was 793.82 ft amsl on August 22, 2022.

TVA

U:\TVA-EIP\175568274_BRF_Phase2\gis\mxd\2022_Annual_GW\BRF_FigB-4_DFAS_PotentiometricEvent20220822.mxd Revised: 2023-01-05 By: mbough

APPENDIX C
2022 STATISTICAL ANALYSIS REPORT

Statistical Analysis Report for Bullrun Fossil Plant

2022 CCR Program, Annual Update

Kirk Cameron, Ph.D., MacStat Consulting, Ltd.

2023-01-06

Contents

1 Introduction

This report summarizes the statistical analysis performed on groundwater quality constituents monitored during 2022 of the Coal Combustion Residuals (CCR) Rule's Ground Water Quality Monitoring (GWQM) Program at the Tennessee Valley Authority (TVA) Bullrun Fossil Plant (BRF).

The CCR unit at BRF is currently in Detection Monitoring during 2022 sampling, necessitating continued monitoring of the Appendix III constituents listed in the left-hand column of **Table 2**. As part of this year's efforts (i.e., 2022), the baseline datasets collected since Year-One of the CCR-Rule GWQM Program were evaluated in order to establish updated prediction limits on upgradient background data, and then to compare 2022 compliance measurements against these statistical limits to assess any statistically significant increases (SSI) above background. Summaries of the prediction limit results are provided in subsequent sections of this report.

At the BRF plant's CCR Unit, the sampling results used to identify potential SSIs were obtained during a minimum of four distinct monitoring events that were collected between November of 2022 and August of 2022 by the firm of Terracon, with Laboratory Analysis performed by Test America Laboratories (located at Pittsburg, PA, and St Louis, MO), and Quality Assurance Controls by Environmental Standards, Inc., all under direct contracts to TVA.

At the BRF network, the sampling results used to compute the background statistics were obtained from a set of designated background wells (I, MWC) using data collected from November 2016 until August 2022. Groundwater samples were analyzed for 7 distinct constituents as required under Appendix 3 of the CCR Rule (listed in **Table 2**). Only non-filtered sample results were utilized for the statistical analysis.

For those wells at which SSIs occurred, TVA requested the construction of 'Traffic Light' matrices to facilitate an at-a-glance identification of such exceedances and to promote intra-company follow-up assessments of the possible causes (e.g., other identifiable chemicals used on site or by others located in the vicinity of the plants) and to plan for mitigation actions, whenever warranted. Sample analytical results of CCR-Rule Appendix III constituents obtained from each of the monitoring wells and events were used to perform the statistical analysis and generate the graphs shown in this report. The current CCR Rule groundwater monitoring network, as Certified by a Professional Engineer at the firm of AECOM or other, is presented in **Table 1**.

The 'R' Statistical Analysis package (www.r-project.org) in conjunction with R-Studio (www.rstudio.com), both popular public domain software products, were used in the production of the statistical values and graphs. ProUCL data dumps from TVA's EQuIS Professional and Enterprise Database were used to populate the R-based statistical analyses.

Table 1: CCR Rule Monitoring Network

Background	Downgradient
I	MW-3H/P-3
MWC	BRF-107
	J

For this year's efforts, the baseline datasets of the CCR-Rule GWQM Program were augmented with routine monitoring samples in order to update the background database. The background data were then utilized to develop statistically-derived prediction limits. Finally, data from the compliance wells were statistically compared to the prediction limits to determine whether any statistical limits were exceeded, thus causing a statistically significant exceedance (SSI).

Table 2: CCR Rule Monitored Constituents

Appendix III	Appendix IV
Boron	Antimony
Calcium	Arsenic
Chloride	Barium
Fluoride	Beryllium
Sulfate	Cadmium
pH	Chromium
TDS	Cobalt
	Fluoride
	Lead
	Lithium
	Mercury
	Molybdenum
	Rad226+228
	Selenium
	Thallium

2 Statistical Analysis

At the BRF CCR network, the sampling results used to compute the background statistics were obtained only from designated background wells using historical data that were first screened for possible trends or shifts in concentration levels over time. Any early data exhibiting a substantially different pattern or average concentration level than more recent data were excluded from the calculations. The cutoff date used for selecting background data was determined on a constituent by constituent basis, but was designed to include as much data as possible reflecting current groundwater conditions.

Groundwater samples were analyzed for a total of 21 distinct constituents, as required for the CCR monitoring program. Fluoride is monitored under both Appendices. Results for the 7 Appendix III parameters are presented in this report.

The basic steps in the Detection Monitoring analysis of the 2022 data included the following:

1. Implementing an effective prediction limit statistical approach;
2. Assessing best-fitting statistical models for each background dataset, including identification of any statistical outliers, then computing interwell prediction limits; and
3. Comparing each prediction limit against 2022 compliance data, including resamples if necessary, to assess whether an SSI occurred.

To accomplish these steps, the data were first summarized and modeled. The baseline/background data were initially examined. Any non-detects were treated as statistically 'left-censored,' with the censoring limit equal to the reporting limit (RL). Then the Kaplan-Meier adjustment method (USEPA 2009) was employed to derive estimated summary statistics that account for the presence of non-detects.

2.1 Statistical Approach

TVA has established a statistical testing approach within its CCR detection monitoring program using the following decision logic:

1. For each Appendix III parameter and compliance well location, a comparison is made between each routinely collected sample and a site-specific upper prediction limit (UPL) computed from upgradient background data (or for pH, against a site-specific prediction interval).
2. If the routine observation exceeds the upper prediction limit (or for pH, is lower than the lower prediction limit), a potential SSI is identified. If the routine observation is within the bounds of the UPL or prediction interval, the test passes.
3. In the event of a potential SSI, one resample is compared against the UPL or prediction interval. If the resample falls within the bounds of prediction limit/interval, the test passes. If instead the resample exceeds the bounds of the limit/interval, an SSI is confirmed for that well and constituent.

2.2 Background Statistical Models and Prediction Limits

Beginning with this year's annual report, certain technical improvements were implemented when computing each prediction limit (UPL) or prediction interval:

1. All baseline data from designated upgradient or background wells collected through August 2022 were grouped and initially screened for possible outliers. This outlier screening was performed visually on time series plots of the data, as well as systematically via a modified version of Tukey's boxplot rule.

Unlike previous analyses, apparent outliers were not formally tested or removed from the data analysis, unless a nonparametric data model was indicated. Instead, as described in Step 2 below, any possible outliers from parametric data models were *down-weighted* in the statistical calculations, in order to minimize the impact of such values on the prediction limit/interval estimates.

In case of a nonparametric model, any outliers that were flagged were visually compared against observations at other well locations. If similar patterns or measurement ranges were seen, the suspect values were kept in the data. If not, the suspected outliers were excluded from the prediction limit/interval computations. At the BRF CCR network, 2 possible nonparametric outliers were flagged in the grouped background data.

This newer strategy for handling outliers entails key benefits. The process of flagging outliers always involves a mixture of art (i.e., professional judgment) and statistical science. In some cases, disputes can arise among stakeholders as to whether specific values ought to be treated as outliers and/or eliminated from statistical analysis. This can especially be true when there is no known physical cause of the apparent outliers (e.g., laboratory or sampling error). Down-weighting done in an objective manner does not exclude any data, yet minimizes the impact of true outliers.

2. The grouped baseline data were analyzed to determine whether they could be fit to a known statistical model. If so, a quasi-parametric bootstrap-t prediction limit/interval was computed; if not, a nonparametric prediction limit/interval was constructed. Datasets which could not be sufficiently normalized were therefore analyzed by nonparametric means. In the nonparametric case, any apparent outliers were carefully reviewed to determine if they should be removed

from the analysis. Note that formal outlier testing is not possible when the underlying data model is unknown. Outlier removal in this setting comes down to professional judgment and statistical experience.

To account for possible outliers in each dataset fit to a known statistical model (i.e., parametric cases), a probability plot of the background dataset was constructed matching the observed data values against quantiles from a standard normal distribution (i.e., z-scores). Then a *robust* regression line was fit to the probability plot, to capture the dominant pattern in the bulk of the data while minimizing the impact (or influence) on the estimated line of any extreme or outlying values. Using this robust regression line, the distance between each observed value and the regression line fit was calculated and used to generate a statistical weighting of each data point. Values farther off the line were assigned smaller weights via a standard weighting function, while those closest to the line received the highest weights. These weights (w_i) were subsequently used in computing each prediction limit/interval.

To account for non-normal data, a range of possible mathematical transformations was applied to each background dataset, in order to identify the statistical model that maximized the robust correlation between pairs on the probability plot. The statistical weights described above were ultimately computed using the best-fitting statistical model.

3. The best-fitting statistical model for each COI was used to compute a prediction limit or interval.

When a parametric model is appropriate, on the normalized scale, a prediction interval is computed using the standard normal theory equation:

$$PL = \bar{x} \pm \kappa s$$

where $\bar{x}$ and s represent the mean and standard deviation of the (transformed) observations, and κ is a prediction limit multiplier. If the data have been transformed, the final prediction limit/interval is derived by back-transforming the scaled limit/interval. The prediction limit multiplier is computed as function of several inputs, including the background sample size, the targeted site-wide false positive risk (SWFPR), the configuration of the monitoring network (i.e., number of wells and number of COIs per well), and the retesting strategy implemented at the site (e.g., 1-of-2, etc.).

To account for possible outliers and the statistical weighting described above, a slightly different strategy was implemented to compute an estimate of the prediction limit multiplier, $\hat{\kappa}$. Specifically, a large number of *bootstrap* samples were drawn from the observed data (each bootstrap sample representing a random resampling of the original data, with each sample element being selected at random *with replacement*). For each bootstrap sample, weighted estimates of the mean and standard deviation were computed to form the following ratio:

$$\left(\frac{x_i - \bar{x}_w}{s_w}\right)$$

where x_i is a random value drawn from the background data. Then an upper percentile of these ratios led to an estimate of the appropriate prediction limit multiplier, $\hat{\kappa}$. Finally, the bootstrap-t prediction interval was computed as:

$$PL = \bar{x}_w \pm \hat{\kappa} s_w$$

The PLs computed under this methodology utilize all the data, including any possible extreme values, are reasonably robust (i.e., minimally impacted) in the presence of actual outliers, but are *quasi-parametric* — instead of nonparametric — despite the use of the bootstrap technique. This last characteristic implies that the bootstrap-t will result in an accurate PL only when the bulk of the background data can be closely fit to a known statistical model. In cases where an adequate statistical model cannot be identified, a nonparametric PL must be computed instead.

The probability plot correlations mentioned earlier were utilized in testing this method on a large series of datasets to derive an empirical cutoff value of 0.95 for deciding when the bootstrap-t could be applied. Further, the bootstrap-t does not work well when the dataset is *multi-modal* (i.e., it has multiple peaks or 'humps'), for instance when multiple background wells are grouped together but have rather different average concentration levels (perhaps due to a heterogenous aquifer). If a test for unimodality (i.e., single peak like the normal distribution) passed, then correlations of 0.95 and above led to use of the bootstrap-t, while multi-modality or correlations below this cutoff led to calculation of a nonparametric prediction limit/interval. Note that for nonparametric models, the prediction limit is selected as one of the largest of the sample values, often the maximum.

For the BRF CCR network, **Table 3** lists the calculated UPLs (and LPL for pH) established for this particular Unit.

Table 3: BRF Interwell Prediction Limits

COI	N	ND.Pct	Model	1-of-m	FPR	Units	LPL	UPL
Boron	62	36	TBOOT-Log	2	0.0149	ug/L	NA	202
Calcium	62	0	TBOOT-Log	2	0.0149	mg/L	NA	115
Chloride	62	0	NP	2	0.0088	mg/L	NA	27.2
Fluoride	62	19	TBOOT-Log	2	0.0149	mg/L	NA	0.172
pH	62	0	TBOOT-Log	2	0.0149	SU	6.73	7.88
Sulfate	62	1.6	NP	2	0.0088	mg/L	NA	33.9
TDS	62	0	TBOOT-Log	2	0.0149	mg/L	NA	424

2.3 Comparing Compliance Data Against Prediction Limits

To assess whether any SSIs occurred during 2022 Detection Monitoring at TVA's BRF CCR site, the routine sampling event from sampling rounds 1 and 3 at each COI-well pair were compared against their respective prediction limit. Under a 1-of-2 retesting strategy, sampling rounds 2 and 4 were reserved as possible resamples. This enabled sufficient lag time between any of the routine and resample measurements to assume approximate statistical independence.

If the routine observations (sampling rounds 1 and 3) exceeded the upper prediction limit (UPL), or for pH, were outside the bounds of the prediction interval on either side, a potential SSI was flagged. Then the reserved resamples associated with the routine events (sampling rounds 2 and 4) were compared against the same limit or interval. Only if the routine observation and its associated resample both were outside the bounds of the prediction limit/interval was a confirmed SSI identified.

Table 4 is a summary of the 2022 statistical tests at the BRF CCR unit where a confirmed SSI occurred.

Table 4: Confirmed 2022 Prediction Limit SSIs at BRF CCR Site

COI	Well	Date	Result	Units	Stage	LPL	UPL	SSI
Boron	MW-3H/P-3	2022-01-06	618	ug/L	Sample	NA	202	YES
Boron	MW-3H/P-3	2022-02-23	646	ug/L	Resample	NA	202	YES
Boron	MW-3H/P-3	2022-07-13	616	ug/L	Sample	NA	202	YES
Boron	MW-3H/P-3	2022-08-26	674	ug/L	Resample	NA	202	YES
Boron	BRF-107	2022-01-06	562	ug/L	Sample	NA	202	YES
Boron	BRF-107	2022-02-23	547	ug/L	Resample	NA	202	YES
Boron	BRF-107	2022-07-12	502	ug/L	Sample	NA	202	YES
Boron	BRF-107	2022-08-24	515	ug/L	Resample	NA	202	YES
Boron	J	2022-01-05	2170	ug/L	Sample	NA	202	YES
Boron	J	2022-02-22	1970	ug/L	Resample	NA	202	YES
Boron	J	2022-07-13	2090	ug/L	Sample	NA	202	YES
Boron	J	2022-08-25	1890	ug/L	Resample	NA	202	YES
Calcium	BRF-107	2022-01-06	197	mg/L	Sample	NA	115	YES
Calcium	BRF-107	2022-02-23	200	mg/L	Resample	NA	115	YES
Calcium	BRF-107	2022-07-12	218	mg/L	Sample	NA	115	YES
Calcium	BRF-107	2022-08-24	199	mg/L	Resample	NA	115	YES
Calcium	J	2022-01-05	361	mg/L	Sample	NA	115	YES
Calcium	J	2022-02-22	331	mg/L	Resample	NA	115	YES
Calcium	J	2022-07-13	369	mg/L	Sample	NA	115	YES
Calcium	J	2022-08-25	365	mg/L	Resample	NA	115	YES
Fluoride	MW-3H/P-3	2022-01-06	0.525	mg/L	Sample	NA	0.172	YES
Fluoride	MW-3H/P-3	2022-02-23	0.52	mg/L	Resample	NA	0.172	YES
Fluoride	MW-3H/P-3	2022-07-13	0.504	mg/L	Sample	NA	0.172	YES
Fluoride	MW-3H/P-3	2022-08-26	0.482	mg/L	Resample	NA	0.172	YES
Sulfate	MW-3H/P-3	2022-01-06	56	mg/L	Sample	NA	33.9	YES
Sulfate	MW-3H/P-3	2022-02-23	65.9	mg/L	Resample	NA	33.9	YES
Sulfate	MW-3H/P-3	2022-07-13	63.2	mg/L	Sample	NA	33.9	YES
Sulfate	MW-3H/P-3	2022-08-26	59.9	mg/L	Resample	NA	33.9	YES
Sulfate	BRF-107	2022-01-06	322	mg/L	Sample	NA	33.9	YES
Sulfate	BRF-107	2022-02-23	257	mg/L	Resample	NA	33.9	YES
Sulfate	BRF-107	2022-07-12	232	mg/L	Sample	NA	33.9	YES
Sulfate	BRF-107	2022-08-24	241	mg/L	Resample	NA	33.9	YES
Sulfate	J	2022-01-05	807	mg/L	Sample	NA	33.9	YES
Sulfate	J	2022-02-22	909	mg/L	Resample	NA	33.9	YES
Sulfate	J	2022-07-13	839	mg/L	Sample	NA	33.9	YES
Sulfate	J	2022-08-25	817	mg/L	Resample	NA	33.9	YES
TDS	BRF-107	2022-01-06	741	mg/L	Sample	NA	424	YES
TDS	BRF-107	2022-02-23	735	mg/L	Resample	NA	424	YES
TDS	BRF-107	2022-07-12	759	mg/L	Sample	NA	424	YES
TDS	BRF-107	2022-08-24	783	mg/L	Resample	NA	424	YES
TDS	J	2022-01-05	1490	mg/L	Sample	NA	424	YES
TDS	J	2022-02-22	1500	mg/L	Resample	NA	424	YES
TDS	J	2022-07-13	1590	mg/L	Sample	NA	424	YES
TDS	J	2022-08-25	1610	mg/L	Resample	NA	424	YES

3 Summary of Statistical Analysis

To facilitate an 'at-a-glance' summary of the statistical comparison results, **Table 5** is a 'traffic light' matrix, showing a compact representation of each well location matched against each constituent in Appendix III. This summary is useful in planning for mitigation actions. Green cells indicate that no SSI was observed during the first semi-annual evaluation of 2022. Red cells indicate the opposite: an SSI was flagged during the first semi-annual evaluation.

At the BRF CCR network, a total of 22 Detection Monitoring SSIs were identified at Program network wells during the 2022 annual evaluation.

Table 5: Traffic Light Matrix for BRF CCR Site

	Well Locations		
COI	**MW-3H/P-3**	**BRF-107**	**J**
Boron	RED	RED	RED
Calcium	GRN	RED	RED
Chloride	GRN	GRN	GRN
Fluoride	RED	GRN	GRN
pH	GRN	GRN	GRN
Sulfate	RED	RED	RED
TDS	GRN	RED	RED

Color-Coding Key:

RED = Results outside prediction limit bounds;

GRN = Results within prediction limit bounds

4 References

USEPA. 2009. "Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities: Unified Guidance." USEPA: Office of Resource Conservation & Recovery.

APPENDIX D
ALTERNATE SOURCE DEMONSTRATION DOCUMENTATION

NOTICE OF SUCCESSFUL ALTERNATE SOURCE DEMONSTRATION

BULL RUN FOSSIL PLANT

DRY FLY ASH STACK LATERAL EXPANSION

In accordance with the provisions of 40 C.F.R. 257.94(e)(2), Tennessee Valley Authority (TVA) commissioned an Alternate Source Demonstration (ASD) study for the above-named CCR unit located within the Bull Run Fossil plant's reservation. The study provided successful proof that the ASD of Appendix III constituents measured were due to sources other than the CCR unit named above. As required by 40 C.F.R. 257.94(e)(2), TVA will include the demonstration, as certified by the qualified Professional Engineer (PE) named below, in its "Annual Groundwater Monitoring and Corrective Action Report". TVA will continue its detection monitoring program for the Dry Fly Ash Stack Lateral Expansion.

QUALIFIED PROFESSIONAL ENGINEER CERTIFICATION

I, Stephen H. Bickel, being a Professional Engineer in good standing in the State of Tennessee do hereby certify, to the best of my knowledge, information, and belief, that the information contained in this certification is prepared in accordance with the accepted practice of engineering; that the information contained herein is accurate as of the date of my signature below; and that the successful Alternate Source Demonstration (ASD) as described above meets the requirements of 40 CFR § 257.94(e)(2). Opinions relating to this ASD, environmental, geologic, and hydrogeologic conditions or other conclusions are based on available data; actual conditions may vary from those encountered at the times and locations where data are obtained, despite the use of due care.

SIGNATURE: ______________________

PRINTED NAME: Stephen Bickel, PE

ADDRESS: 10509 Timberwood Circle, Suite 100, Louisville, KY 40223

TELEPHONE: (502) 212-5075

Attachments:

ASD for CCR Unit Dry Fly Ash Stack Lateral Expansion located within the boundaries of the Bull Run Fossil Plant's Reservation.

DATE: 4/13/2018

STEPHEN H. BICKEL
REGISTERED ENGINEER
AGRICULTURE
COMMERCE
No. 113134
STATE OF TENNESSEE

SUCCESSFUL ALTERNATE SOURCE DEMONSTRATION EXECUTIVE SUMMARY

BULL RUN FOSSIL PLANT

DRY FLY ASH STACK LATERAL EXPANSION

A successful Alternate Source Demonstration (ASD) was conducted on behalf of the Tennessee Valley Authority (TVA) for Bull Run Fossil (BRF) Plant in accordance with 40 C.F.R. 257.94(e)(2) of the Coal Combustion Residuals (CCR) rule. This ASD was conducted in response to the identification of potential statistically significant increases (SSIs) during sampling conducted under the Detection Monitoring program [40 C.F.R. 257.94] in connection with the regulated Dry Fly Ash Stack Lateral Expansion unit.

The ASD determined that the potential SSIs identified in the Dry Fly Ash Stack Lateral Expansion Detection Monitoring program were attributable to pre-existing groundwater conditions that long preceded the construction of the regulated CCR unit. The conclusion that the potential SSIs are due to sources other than the Dry Fly Ash Stack Lateral Expansion is supported by the following lines of evidence:

- The Appendix III constituents with potential SSIs had been detected in downgradient Well J beginning in 1991, more than 20 years prior to the construction of Dry Fly Ash Stack Lateral Expansion in 2012.
- The magnitude of historical concentrations of the Appendix III constituents from the 1991-2011 time period in downgradient Well J are comparable to current concentrations (2011 to present).
- The newly-engineered landfill was constructed with a geomembrane liner and leachate collection system. Construction began in 2012.
- The presence of constituents that caused the potential SSIs cannot be attributed to the Dry Fly Ash Stack Lateral Expansion because they were documented to exist prior to the placement of CCR materials into this unit.

SUMMARY

Based on completion of the successful ASD for the Dry Fly Ash Stack Lateral Expansion, and in accordance with 40 C.F.R. 257.94(e)(2), the site will remain in detection monitoring as of April 15, 2018.