2018 Annual Groundwater Monitoring and Corrective Action Report

Tennessee Valley Authority
Kingston Fossil Plant Peninsula
Disposal Area CCR Unit

Prepared for:
Tennessee Valley Authority
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January 31, 2019

Reference: 2018 Annual Groundwater Monitoring Report
TVA Kingston Fossil Plant Peninsula Disposal Area CCR Unit

In accordance with 40 CFR 257.90(e) of the Federal Coal Combustion Residuals (CCR) Rule (CCR Rule), this 2018 Annual Groundwater Monitoring and Corrective Action Report (2018 Annual Report) documents 2018 groundwater monitoring activities at the Peninsula Disposal Area CCR Unit at the Tennessee Valley Authority (TVA) Kingston Fossil Plant (KIF). In 2017, TVA established a groundwater monitoring network and program at the KIF Peninsula Disposal Area CCR Unit in accordance with 40 CFR 257.90. The groundwater monitoring network was certified by a qualified Professional Engineer as required by 40 CFR 257.91(f). During 2018, TVA performed the following groundwater monitoring activities:

- Baseline monitoring continued for well G-7A to obtain a minimum of eight independent baseline samples pursuant to 40 CFR 257.94(b).[1]
- Conducted a statistical analysis of the 2017 detection monitoring groundwater sampling data in accordance with 40 CFR 257.93(h), and it was concluded that there were statistically significant increases (SSIs) over background levels for certain Appendix III constituents. The results were included in Table 1 of the 2017 Annual Groundwater Monitoring and Corrective Action Report, which was placed on the CCR Compliance Data and Information website (https://www.tva.gov/Environment/Environmental-Stewardship/Coal-Combustion-Residuals
- Performed an alternate source demonstration for the SSIs over background levels of Appendix III constituents in accordance with 40 CFR 257.94(e)(2); investigated whether the SSI 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); and, in accordance with 40 CFR 257.94(e)(2), the Appendix III alternate source demonstration was successfully completed, was certified by a qualified professional engineer, and is included as Appendix A to this 2018 Annual Report.
- Continued under the detection monitoring program and performed eight[2] groundwater sampling events of the certified monitoring network in accordance with 40 CFR 257.94.
- Sampled and analyzed for the detection monitoring program between May and October 2018 in accordance with the CCR Rule [40 CFR 257.93 and 257.94(a)].
- Performed further field and desktop site characterization investigations to improve the KIF Conceptual Site Model (CSM).

[1] Monitoring well G-7A was found to be damaged during an inspection but was certified into the CCR program as a future CCR monitoring well. Additional sampling was performed in 2018 to supplement the baseline following repair of the well.

[2] Five sampling events were conducted for monitoring well G-1B.

- Continued TVA's third-party Quality Assurance Program to evaluate and improve groundwater analytical data using best practices concerning field methods and validation techniques, as well as the application of the most 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 second-year phase of the TVA groundwater quality monitoring program and therefore, no further action has been recommended except for the planned key activities for 2019 that are outlined below.

The projected key activities for 2019 are:

- Perform further field and desktop site characterization investigations to improve the KIF CSM.
- Continue semi-annual detection monitoring of the certified groundwater monitoring network consistent with 40 CFR 257.94.
- 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 the most 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 WELL NETWORK

Initial construction of the approximately 52-acre Phase I portion of the Peninsula Disposal Area was completed in 2009. The Phase I area was originally designed as a surface impoundment for gypsum slurry generated from the flue gas desulfurization (FGD) process. However, a failure of the clay liner occurred in December 2010, operation ceased, and mitigation occurred, including over-excavation of the suspected areas. TVA modified the disposal approach by dewatering the FGD gypsum and constructing the CCR unit as a dry landfill with a composite clay/geomembrane liner and leachate collection system. The Phase 1 portion of the Peninsula Disposal Area was subdivided into Phase IA (west) and Phase IB (east) areas and separated by a divider dike. Each of the Phase 1 areas are approximately 25-acres in size. Construction of the Phase 1A area was completed in December of 2011, and the Phase 1B area was completed in September 2014.

The monitoring well network for the KIF Peninsula Disposal Area CCR Unit consists of two background wells (G-1B and KIF-101) and six downgradient wells (G-3A, G-3B, G-5A, G-5B, G-7A, and G-7B)[3]. The downgradient wells are installed at the waste boundary. Figure 1 is an aerial photograph that shows the groundwater monitoring well locations. The monitoring well network was designed for a single CCR Unit (Peninsula Disposal Area). Monitoring wells G-8B, G-9B, and G-10B are currently included as background wells in the system; however, they will be located downgradient from a future landfill expansion. Until that expansion, these wells represent background conditions and are not included in the CCR monitoring well network or in the statistical analysis for KIF.

No monitoring wells were installed or decommissioned during the 2018 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 Compliance Data and Information website https://www.tva.gov/Environment/Environmental-Stewardship/Coal-Combustion-Residuals.

GROUNDWATER SAMPLING AND LABORATORY ANALYTICAL TESTING

A groundwater sampling and analysis program was developed and includes procedures and techniques for: sample collection; sample preservation and shipment; analytical procedures; chain-of-custody control; and, quality assurance and quality control (QA/QC) required by 40 CFR 257.93(a). 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 semi-annual detection monitoring was completed in compliance with 40 CFR 257.94. Groundwater sampling was conducted between May and October 2018[4] and the results are summarized in Tables 1A and 1B for the residuum and bedrock saturated zones, respectively. Baseline groundwater samples for well G-7A were obtained between May and October 2018 and results for G-7A 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 and Emory River surface water elevations are summarized in Table 4. Groundwater flow directions were determined for each sampling event, and a generalized depiction of groundwater flow direction is illustrated on Figures 2A and 2B for the residuum and bedrock saturated zones, respectively. In general, groundwater flow at the KIF Peninsula Disposal Area CCR Unit is influenced by the confluence of the Emory River and the Clinch River to the southeast of the site. The primary groundwater flow direction from the CCR unit is to the south towards the Clinch River in both the residuum and bedrock saturated zones.

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[3] Monitoring wells with A in the suffix, or no suffix are screened in unconsolidated overburden/residuum consisting of clay and silt. Monitoring wells with a B in the suffix are screened in the Knox Group bedrock aquifer.

[4] The CCR rule requires a minimum of two semi-annual sampling events per well once the required background data has been obtained. Groundwater aquifers can be quite complex, with significant changes and heterogeneity over both time and space. Two events per well per year is sometimes inadequate to reasonably characterize groundwater quality. Much greater flexibility in statistical approach, as well as critical information about groundwater variability, can be gained from more frequent sampling.

Testing for hydraulic conductivity in the uppermost aquifer (residuum) at the background or downgradient monitoring wells, as summarized in Table 5, was determined by a recent hydrogeological evaluation (Terracon, 2019). Testing data indicates the uppermost saturated zone has a geometric mean hydraulic conductivity of 1.17 x 10^{-3} 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;
- horizontal hydraulic gradients measured during the implementation of the groundwater sampling and analysis program, ranging from 0.0012 to 0.0053 feet per foot (ft/ft); and,
- an effective porosity of 27% (TVA, 2005).

The average linear flow velocity in the uppermost aquifer (residuum) ranges from approximately 5.4 to 23.8 feet per year.

Hydraulic conductivity testing was performed in the bedrock aquifer (Knox Group Dolomite), and the results are summarized in Table 5 (Terracon, 2019). Testing data indicates the bedrock aquifer has a geometric mean hydraulic conductivity of 7.05 x 10^{-5} centimeters per second (cm/sec). Linear groundwater flow velocity was calculated for the bedrock aquifer using:

- the geometric mean hydraulic conductivity calculated from hydraulic testing;
- horizontal hydraulic gradients measured during the implementation of the groundwater sampling and analysis program, ranging from 0.0012 to 0.0036 feet per foot (ft/ft); and,
- an effective porosity of 17% (TVA, 2005).

The average linear flow velocity in the bedrock aquifer ranges from approximately 0.5 to 1.5 feet per year.

STATISTICAL ANALYSIS OF GROUNDWATER DATA

The groundwater monitoring data was 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 Compliance Data and Information website. Background groundwater quality was established for the background monitoring wells.

Baseline and detection monitoring data sets for Year-One (2017) and those results obtained during Year-Two (2018) of the CCR Rule Groundwater Quality Monitoring Program were evaluated in order to establish upper prediction limits (UPLs) on upgradient background data, and then to compare Year-Two compliance measurements against these statistical limits to assess any statistically significant increases (SSIs) above background. To assess whether any SSIs occurred during the 2018 Detection Monitoring, the routine sampling events from sampling rounds 1 and 5 at each well-constituent pair were compared against their respective prediction limits. Under a 1-of-2 retesting strategy, sampling rounds 3 and 7 were reserved as possible resamples. This enabled at least a month's lag time between any of the routine and resample measurements. A summary of the detection monitoring statistical evaluation is provided in Tables 6A and 6B for the residuum and bedrock saturated zones, respectively. The Statistical Analysis Report is provided as Appendix B.

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[5] as required by 40 CFR 257.93(h). The groundwater analytical results from the 2018 rounds of detection monitoring indicated similar SSIs of Appendix III CCR constituents at the downgradient monitoring wells screened in residuum with the following exceptions: 1.) monitoring wells G-5A and G-7A had SSIs for pH that were not previously observed; 2.) monitoring well G-5A no longer has an SSI for chloride; and, 3.) monitoring well G-3A no longer has an SSI for pH. The groundwater analytical results from the 2018 rounds of detection monitoring indicated similar SSIs of Appendix III CCR constituents at the downgradient monitoring wells screened in bedrock with the following exceptions: 1.) monitoring well G-3B had an SSI for chloride that was not previously observed; 2.) monitoring well G-5B no longer has an SSI for fluoride; and, 3.) monitoring well G-7B no longer has an SSI for chloride. 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 KIF Peninsula Disposal Area were the cause of any verified SSI over background as specified in 40 CFR 257.94(e)(2). The alternate source demonstration study determined that the SSIs were a result of another source and not attributable to the Peninsula Disposal Area. Alternate source demonstration documentation is provided in Appendix A. The alternate source demonstration was re-evaluated and supports that the SSIs for pH at monitoring wells G-5A and G-7A and the SSI for chloride at monitoring well G-3B were also attributable to another source and not the Peninsula Disposal Area. 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.

LIMITATIONS

This document entitled 2018 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.

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

2018 ANNUAL GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT
TVA Kingston Fossil Plant Peninsula Disposal Area CCR Unit
January 31, 2019

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References:

Benziger and Kellberg 1951. Preliminary Geological Investigations for Eastern Area Steam Plant. Division of Water Control Planning, Geologic Branch, Tennessee Valley Authority, Knoxville, Tennessee

Terracon, 2019. Aquifer Testing and Equipment Blank Results. TVA CCR Rule – Kingston Fossil Plant (KIF). Terracon Consultants, Inc. January, 2019.

TVA, Kingston Fossil Plant, 2005. Peninsular Site, Hydrogeological Evaluation of Coal-Combustion Byproduct Disposal Facility WR2005-1-36-133. October 2005.

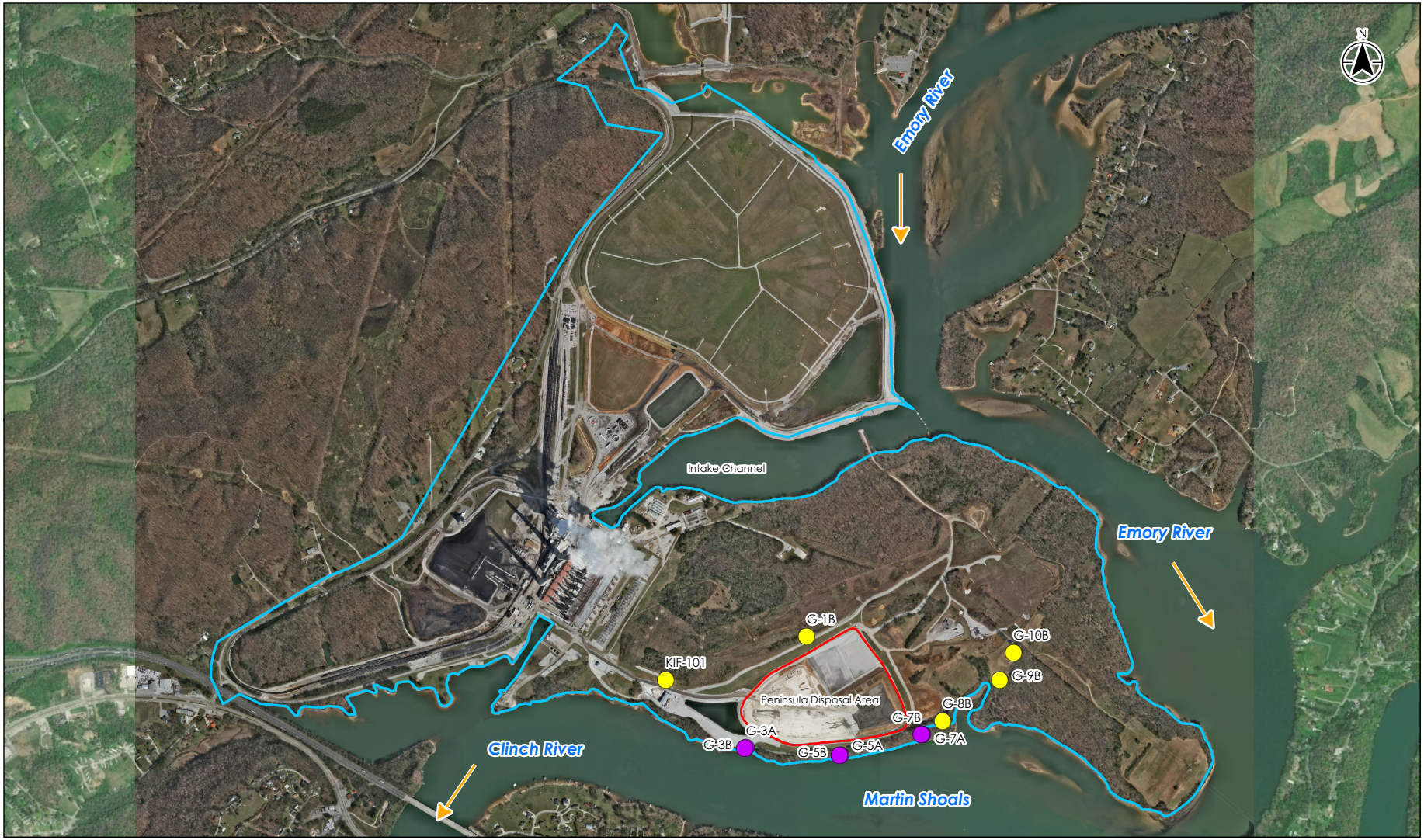
Attachments:

Figure 1 – Map with CCR Unit Background and Downgradient Wells
Figure 2A – Generalized Groundwater Flow Direction Map – Residuum
Figure 2B – Generalized Groundwater Flow Direction Map - Bedrock

Table 1A – Detection Monitoring Groundwater Sampling Results – Residuum
Table 1B – Detection Monitoring Groundwater Sampling Results - Bedrock
Table 2 – Baseline Groundwater Sampling Results
Table 3 – Groundwater Sampling Summary
Table 4 – Groundwater and Surface Water Elevation Summary
Table 5 – Hydraulic Conductivity Data Summary
Table 6A – Detection Monitoring Statistical Evaluation – Residuum
Table 6B – Detection Monitoring Statistical Evaluation - Bedrock

Appendix A – Alternate Source Demonstration Documentation
Appendix B – Statistical Analysis Report

FIGURES



Background Well

Downgradient Well

CCR Unit Subject to CCR Rule

TVA Property Boundary

0 1,000 2,000 Feet

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

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Source: Tucker Mapping Solutions, INC (2017-03-16) and Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Stantec

TVA

Project Location	182603174
City of Kingston Roane County, Tennessee	Prepared by CMB on 2018-11-19 Technical Review by WSW on 2018-11-19 Independent Review by JK on 2018-11-19

Client/Project

Tennessee Valley Authority
Kingston Fossil Plant
CCR Rule

Figure No.

1

Title

Map with CCR Unit Background and Downgradient Wells

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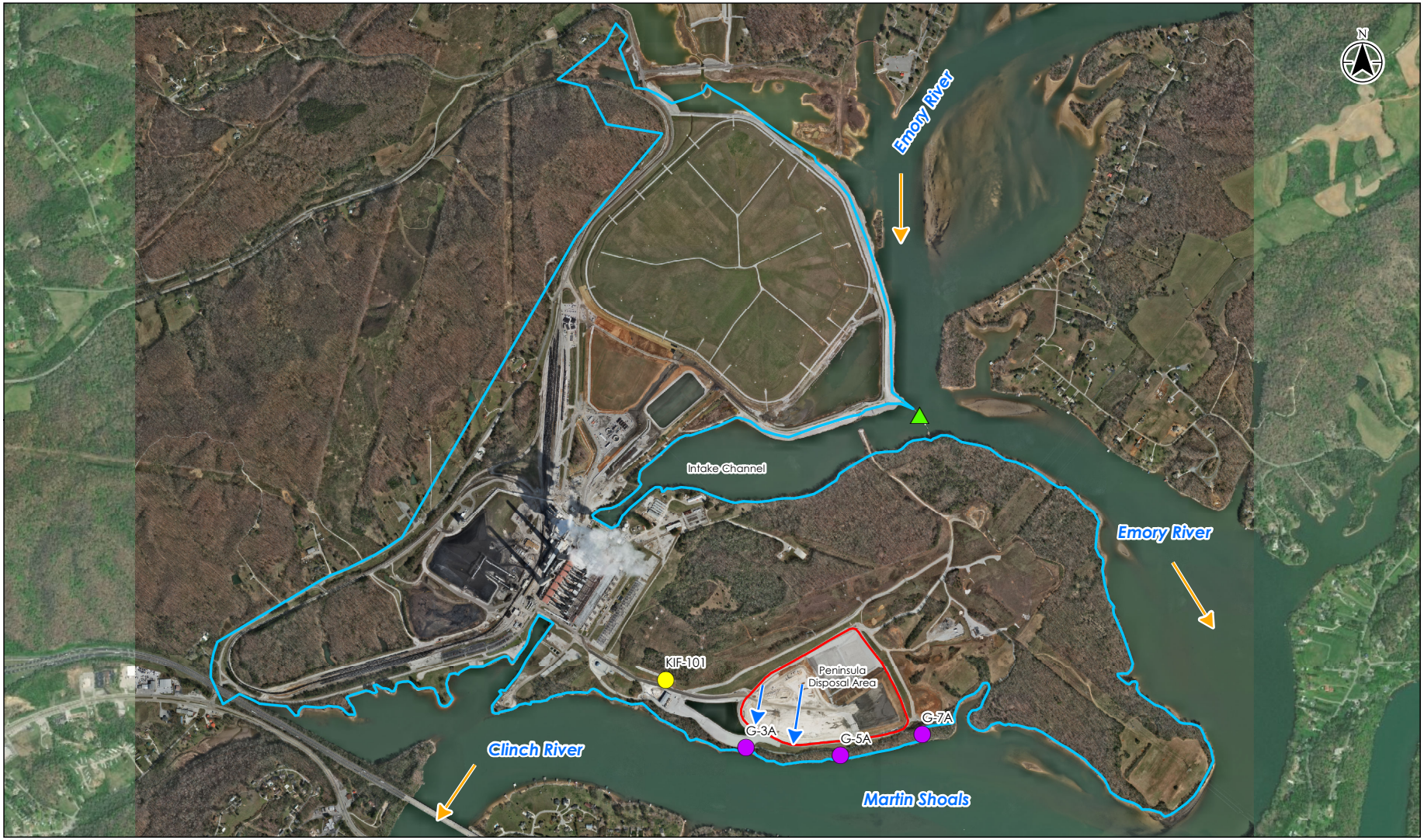

Staff Gauge
Background Well
Downgradient Well
Groundwater Flow Direction
CCR Unit Subject to CCR Rule
TVA Property Boundary

Groundwater flow directions are based on Emory River elevations and groundwater elevations from CCR and Non-CCR monitoring wells.

0 1,000 2,000 Feet

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

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Source: Tucker Mapping Solutions, INC (2017-03-16) and Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Stantec

TVA

Project Location 182603174

City of Kingston
Roane County,
Tennessee

Prepared by CMB on 2018-12-12
Technical Review by WSW on 2018-12-12
Independent Review by MD on 2018-12-12

Client/Project
Tennessee Valley Authority
Kingston Fossil Plant
CCR Rule

Figure No.
2A

Title
Generalized Groundwater Flow Direction Map - Residuum

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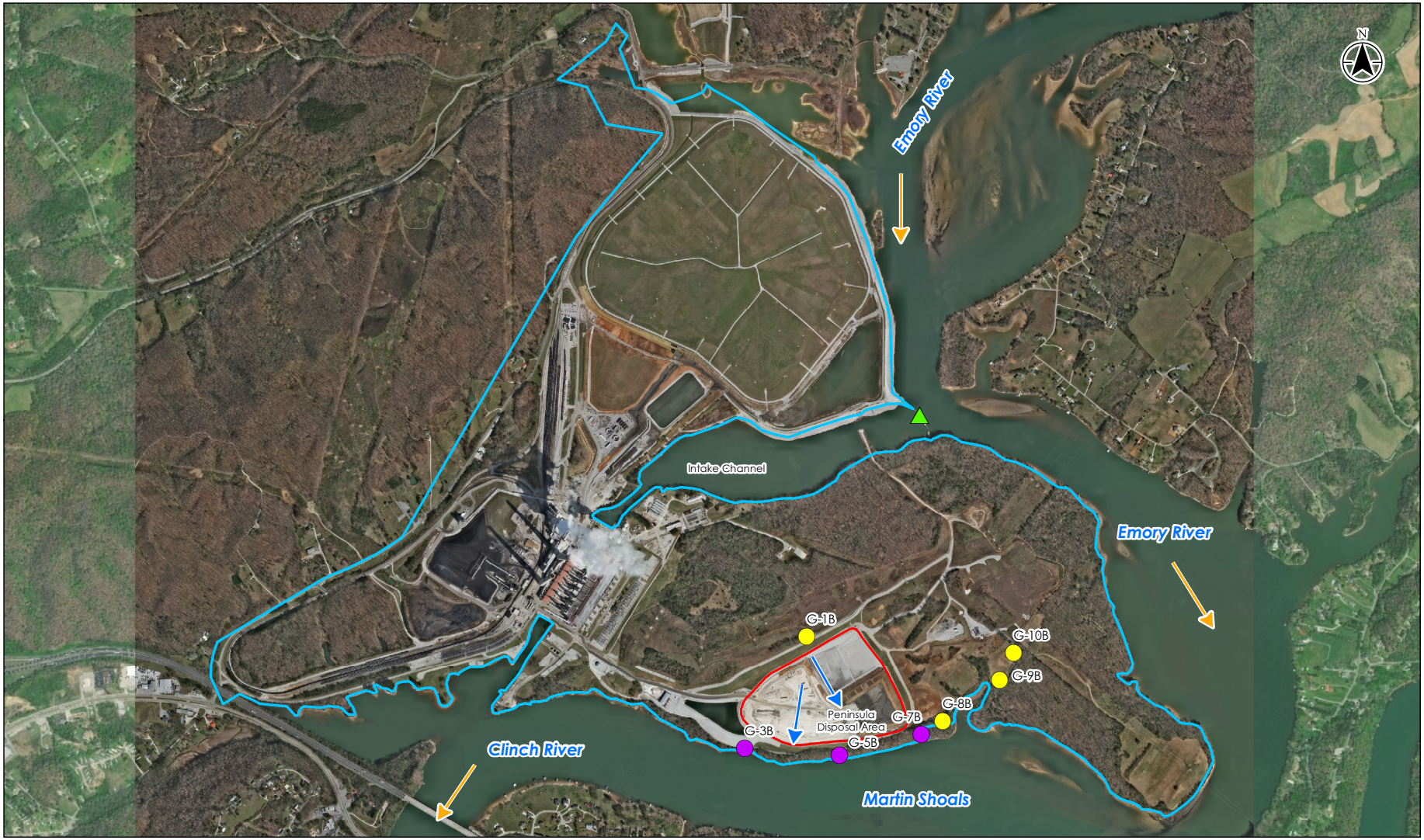

Staff Gauge

Background Well

Downgradient Well

Groundwater Flow Direction

CCR Unit Subject to CCR Rule

TVA Property Boundary

Groundwater flow directions are based on Emory River elevations and groundwater elevations from CCR and Non-CCR monitoring wells.

0 1,000 2,000 Feet

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

Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Source: Tucker Mapping Solutions, INC (2017-03-16) and Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Stantec

TVA

Project Location 182603174

City of Kingston
Roane County,
Tennessee

Prepared by CMB on 2018-12-12
Technical Review by WSW on 2018-12-12
Independent Review by MD on 2018-12-12

Client/Project
Tennessee Valley Authority
Kingston Fossil Plant
CCR Rule

Figure No.
2B

Title
Generalized Groundwater Flow Direction Map - Bedrock

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TABLES

Table 1A
Detection Monitoring
Groundwater Sampling
Results - Residuum

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

Monitoring Well		G-3A															
Sample Date		25-May-18		07-Jun-18		02-Jul-18		19-Jul-18		09-Aug-18		29-Aug-18		19-Sep-18		10-Oct-18	
Sample Round		1		2		3		4		5		6		7		8	
Well Designation		Downgradient		Downgradient		Downgradient		Downgradient		Downgradient		Downgradient		Downgradient		Downgradient	
Analyte	Units	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q
Total Metals																	
Boron	mg/L	< 0.0303	U	< 0.0303	U	< 0.0303	U	< 0.0303	U	< 0.0303	U	< 0.0303	U	< 0.0303	U	< 0.0303	U
Calcium	mg/L	37.1		35.3		30.4		38.4		31.3		40.2		39.8		37.7	
Anions																	
Chloride	mg/L	2.03		1.99		1.80		2.11		1.17		1.26		1.31		2.91	
Fluoride	mg/L	0.0270	J	0.0384	J	0.0268	J	0.0300	J	< 0.0263	U	0.0340	J	< 0.0263	U	0.0308	J
Sulfate	mg/L	18.6		23.5		23.6		21.5		22.5		21.9		23.0		19.1	
General Chemistry																	
Total Dissolved Solids	mg/L	210		222		159		201		179		210	J	210		189	
Field pH																	
pH (field)	SU	5.93		6.67		6.16		6.67		6.43		6.79		6.99		6.33	

Notes:
Q - Data Qualifier
J - Quantitation is approximate due to limitations identified during data validation
U - Concentration not detected
mg/L - milligrams per liter
SU - Standard Unit

DETECTION MONITORING

Table 1A
Detection Monitoring
Groundwater Sampling
Results - Residuum

Monitoring Well		G-5A															
Sample Date		25-May-18		07-Jun-18		29-Jun-18		18-Jul-18		09-Aug-18		28-Aug-18		18-Sep-18		09-Oct-18	
Sample Round		1		2		3		4		5		6		7		8	
Well Designation		Downgradient		Downgradient		Downgradient		Downgradient		Downgradient		Downgradient		Downgradient		Downgradient	
Analyte	Units	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q
Total Metals																	
Boron	mg/L	0.156		0.146		0.130		0.125		0.126		0.116		0.140		0.137	
Calcium	mg/L	66.4		64.6		68.6		64.5		59.3		60.4		59.1		58.7	
Anions																	
Chloride	mg/L	8.99		11.1		10.7	J	11.5		8.02		7.36		7.81		7.83	
Fluoride	mg/L	0.157		0.189		0.172	J	0.156		0.162		0.174		0.146		0.155	
Sulfate	mg/L	20.2		23.2		23.6	J	24.3		20.6		20.2		22.4		21.9	
General Chemistry																	
Total Dissolved Solids	mg/L	297		331		293		292		294		285		267		270	
Field pH																	
pH (field)	SU	6.43		6.96		6.96		6.95		7.00		7.09		8.10		7.51	

Notes:
Q - Data Qualifier
J - Quantitation is approximate due to limitations identified during data validation
U - Concentration not detected
mg/L - milligrams per liter
SU - Standard Unit

DETECTION MONITORING

Table 1A
Detection Monitoring
Groundwater Sampling
Results - Residuum

Monitoring Well		KIF-101															
Sample Date		21-May-18		04-Jun-18		26-Jun-18		16-Jul-18		06-Aug-18		27-Aug-18		17-Sep-18		08-Oct-18	
Sample Round		1		2		3		4		5		6		7		8	
Well Designation		Background		Background		Background		Background		Background		Background		Background		Background	
Analyte	Units	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q
Total Metals																	
Boron	mg/L	< 0.0303	U	< 0.0303	U	< 0.0303	U	< 0.0303	U	< 0.0303	U	< 0.0303	U	0.0373	J	< 0.0303	U
Calcium	mg/L	96.4		87.8		101		98.4		97.9		102		96.9		91.2	
Anions																	
Chloride	mg/L	4.73		6.31		6.39		6.66		4.76		4.94		4.72		4.04	
Fluoride	mg/L	0.0473	J	0.0702	J	0.0593	J	0.0780	J	< 0.0494	U*	0.0761	J	0.0471	J	< 0.0482	U*
Sulfate	mg/L	97.2		113		107		114		92.4		102		115		112	
General Chemistry																	
Total Dissolved Solids	mg/L	453		417		441		430		440		449		453		126	
Field pH																	
pH (field)	SU	6.14		5.88		6.78		6.72		6.41		6.84		7.04		6.65	

Notes:
Q - Data Qualifier
J - Quantitation is approximate due to limitations identified during data validation
U - Concentration not detected
mg/L - milligrams per liter
SU - Standard Unit

DETECTION MONITORING

Table 1B
Detection Monitoring
Groundwater Sampling
Results - Bedrock

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

Monitoring Well		G-1B									
Sample Date		22-May-18		04-Jun-18		26-Jun-18		07-Aug-18		27-Aug-18	
Sample Round		1		2		3		5		6	
Well Designation		Background		Background		Background		Background		Background	
Analyte	Units	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q
Total Metals											
Boron	mg/L	< 0.0303	U	< 0.0303	U	< 0.0303	U	< 0.0303	U	< 0.0303	U
Calcium	mg/L	46.6		42.5		46.0		43.2		44.8	
Anions											
Chloride	mg/L	1.12		1.55		1.49		1.17		1.42	
Fluoride	mg/L	< 0.0263	U	0.0290	J	< 0.0263	U	< 0.0263	U	0.0301	J
Sulfate	mg/L	0.792	J	0.783	J	1.14		0.683	J	0.698	J
General Chemistry											
Total Dissolved Solids	mg/L	231		222		215		215		194	
Field pH											
pH (field)	SU	6.74		6.68		7.43		7.36		7.61	

Notes:

Q - Data Qualifier

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

U - Concentration not detected

mg/L - milligrams per liter

SU - Standard Unit

DETECTION MONITORING

Table 1B
Detection Monitoring
Groundwater Sampling
Results - Bedrock

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

Monitoring Well		G-3B															
Sample Date		25-May-18		07-Jun-18		02-Jul-18		19-Jul-18		09-Aug-18		29-Aug-18		19-Sep-18		10-Oct-18	
Sample Round		1		2		3		4		5		6		7		8	
Well Designation		Downgradient		Downgradient		Downgradient		Downgradient		Downgradient		Downgradient		Downgradient		Downgradient	
Analyte	Units	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q
Total Metals																	
Boron	mg/L	< 0.0303	U	< 0.0303	U	< 0.0303	U	< 0.0303	U	< 0.0303	U	< 0.0303	U	< 0.0303	U	< 0.0303	U
Calcium	mg/L	43.7		42.0		44.3		45.4		40.7		44.9		42.6		44.6	
Anions																	
Chloride	mg/L	1.98		2.30		2.23		2.88		1.73		1.67		1.68		2.55	
Fluoride	mg/L	0.0486	J	0.0583	J	0.0486	J	0.0829	J	0.0422	J	0.0508	J	0.0364	J	0.0624	J
Sulfate	mg/L	28.2		26.2		25.1		30.1		23.6		22.6		26.8		26.6	
General Chemistry																	
Total Dissolved Solids	mg/L	243		271		242		254		250		243	J	226		222	
Field pH																	
pH (field)	SU	6.17		7.44		7.70		7.55		7.51		7.53		7.68		7.56	

Notes:

Q - Data Qualifier

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

U - Concentration not detected

mg/L - milligrams per liter

SU - Standard Unit

DETECTION MONITORING

Table 1B
Detection Monitoring
Groundwater Sampling
Results - Bedrock

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

Monitoring Well		G-5B															
Sample Date		25-May-18		07-Jun-18		29-Jun-18		18-Jul-18		09-Aug-18		28-Aug-18		18-Sep-18		09-Oct-18	
Sample Round		1		2		3		4		5		6		7		8	
Well Designation		Downgradient		Downgradient		Downgradient		Downgradient		Downgradient		Downgradient		Downgradient		Downgradient	
Analyte	Units	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q
Total Metals																	
Boron	mg/L	0.347		0.319		0.298		0.277		0.294		0.267		0.318		0.285	
Calcium	mg/L	113		106		107		102		98.5		103		105		95.6	
Anions																	
Chloride	mg/L	87.9		112		82.2		109		96.9		105		91.0		83.7	
Fluoride	mg/L	0.124		0.111		0.133		0.113		0.0640	J	0.0979	J	0.0773	J	0.0708	J
Sulfate	mg/L	134		163		118		155		130		130		133		118	
General Chemistry																	
Total Dissolved Solids	mg/L	580		659		578		578		641		588		554		532	
Field pH																	
pH (field)	SU	6.70		7.27		7.38		7.29		7.33		7.37		7.98		7.46	

Notes:

Q - Data Qualifier

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

U - Concentration not detected

mg/L - milligrams per liter

SU - Standard Unit

DETECTION MONITORING

Table 1B
Detection Monitoring
Groundwater Sampling
Results - Bedrock

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

Monitoring Well		G-7B															
Sample Date		24-May-18		06-Jun-18		29-Jun-18		18-Jul-18		08-Aug-18		28-Aug-18		18-Sep-18		09-Oct-18	
Sample Round		1		2		3		4		5		6		7		8	
Well Designation		Downgradient		Downgradient		Downgradient		Downgradient		Downgradient		Downgradient		Downgradient		Downgradient	
Analyte	Units	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q
Total Metals																	
Boron	mg/L	< 0.0303	U	< 0.0303	U	< 0.0303	U	< 0.0303	U	< 0.0303	U	< 0.0303	U	< 0.0303	U	< 0.0303	U
Calcium	mg/L	32.0		28.0		29.2		29.1		29.5		31.8		29.5		31.6	
Anions																	
Chloride	mg/L	1.72		2.52		2.65	J	2.89		1.97		2.08		1.88		1.91	
Fluoride	mg/L	< 0.0263	U	< 0.0263	U	0.0305	J	< 0.0263	U	< 0.0263	U	0.0292	J	< 0.0263	U	< 0.0263	U
Sulfate	mg/L	2.51		3.90		3.69	J	3.33		2.09		2.49		2.28		1.88	
General Chemistry																	
Total Dissolved Solids	mg/L	199		247		217		221		225		244		214		207	
Field pH																	
pH (field)	SU	6.98		7.77		7.82		7.83		7.84		7.89		8.21		7.99	

Notes:

Q - Data Qualifier

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

U - Concentration not detected

mg/L - milligrams per liter

SU - Standard Unit

DETECTION MONITORING

Table 1B
Detection Monitoring
Groundwater Sampling
Results - Bedrock

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

Monitoring Well		G-8B															
Sample Date		24-May-18		06-Jun-18		29-Jun-18		17-Jul-18		08-Aug-18		28-Aug-18		18-Sep-18		09-Oct-18	
Sample Round		1		2		3		4		5		6		7		8	
Well Designation		Background		Background		Background		Background		Background		Background		Background		Background	
Analyte	Units	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q
Total Metals																	
Boron	mg/L	< 0.0303	U	< 0.0303	U	< 0.0303	U	< 0.0303	U	< 0.0303	U	< 0.0303	U	< 0.0303	U	< 0.0303	U
Calcium	mg/L	37.4		38.5		39.4		39.2		36.3		36.2		35.8		35.8	
Anions																	
Chloride	mg/L	1.12		1.96		1.54	J	1.70		1.10		1.04		1.01		1.48	
Fluoride	mg/L	< 0.0263	U	0.177		0.0414	J	0.0354	J	< 0.0263	U	0.0295	J	< 0.0263	U	< 0.0263	U
Sulfate	mg/L	3.41		4.08		4.49	J	4.93		3.47		2.93		3.49		4.78	
General Chemistry																	
Total Dissolved Solids	mg/L	193		199		172		176		182		168		186		134	
Field pH																	
pH (field)	SU	6.72		7.37		7.26		7.32		7.41		7.49		7.73		7.84	

Notes:

Q - Data Qualifier

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

U - Concentration not detected

mg/L - milligrams per liter

SU - Standard Unit

DETECTION MONITORING

Table 1B
Detection Monitoring
Groundwater Sampling
Results - Bedrock

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

Monitoring Well		G-9B															
Sample Date		23-May-18		05-Jun-18		28-Jun-18		17-Jul-18		07-Aug-18		28-Aug-18		17-Sep-18		08-Oct-18	
Sample Round		1		2		3		4		5		6		7		8	
Well Designation		Background		Background		Background		Background		Background		Background		Background		Background	
Analyte	Units	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q
Total Metals																	
Boron	mg/L	< 0.0303	U	< 0.0303	U	< 0.0303	U	< 0.0303	U	< 0.0303	U	< 0.0303	U	< 0.0303	U	< 0.0303	U
Calcium	mg/L	46.2		41.3		51.9		44.1		47.8		49.4		52.3		50.2	
Anions																	
Chloride	mg/L	1.18		1.70		1.75		2.00	J	1.39		1.53		1.25		1.84	
Fluoride	mg/L	0.0367	J	0.0478	J	< 0.0263	U	0.0491	J	< 0.0371	U*	0.0585	J	0.0311	J	< 0.0494	U*
Sulfate	mg/L	50.1		55.5		52.3		48.7	J	47.4		47.3		49.6		49.0	
General Chemistry																	
Total Dissolved Solids	mg/L	257		258		250		249	J	258		270		272		238	
Field pH																	
pH (field)	SU	5.92		6.45		6.68		6.78		6.63		6.93		7.49		7.21	

Notes:

Q - Data Qualifier

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

U - Concentration not detected

mg/L - milligrams per liter

SU - Standard Unit

DETECTION MONITORING

Table 1B
Detection Monitoring
Groundwater Sampling
Results - Bedrock

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

Monitoring Well		G-10B															
Sample Date		23-May-18		06-Jun-18		28-Jun-18		17-Jul-18		07-Aug-18		27-Aug-18		17-Sep-18		08-Oct-18	
Sample Round		1		2		3		4		5		6		7		8	
Well Designation		Background		Background		Background		Background		Background		Background		Background		Background	
Analyte	Units	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q
Total Metals																	
Boron	mg/L	< 0.0303	U	< 0.0303	U	< 0.0303	U	< 0.0303	U	< 0.0303	U	< 0.0303	U	< 0.0303	U	< 0.0303	U
Calcium	mg/L	25.0		26.3		26.5		24.9		23.2		25.2		23.6		23.5	
Anions																	
Chloride	mg/L	1.03		1.41		1.48		1.61		1.10		1.47		1.06		1.70	
Fluoride	mg/L	< 0.0263	U	< 0.0263	U	< 0.0263	U	< 0.0263	U	< 0.0263	U	< 0.0263	U	< 0.0263	U	< 0.0263	U
Sulfate	mg/L	2.04		2.45		2.56		3.32		2.12		2.16		2.34		2.49	
General Chemistry																	
Total Dissolved Solids	mg/L	124		146		110		121		134		111		114		85.0	
Field pH																	
pH (field)	SU	7.49		7.96		7.82		7.95		7.85		8.12		8.63		7.87	

Notes:

Q - Data Qualifier

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

U - Concentration not detected

mg/L - milligrams per liter

SU - Standard Unit

DETECTION MONITORING

Table 2
Baseline Groundwater Sampling Results - Residuum

Monitoring Well		G-7A															
Sample Date		24-May-18		06-Jun-18		29-Jun-18		18-Jul-18		09-Aug-18		28-Aug-18		18-Sep-18		09-Oct-18	
Sample Round		1		2		3		4		5		6		7		8	
Well Designation		Downgradient		Downgradient		Downgradient		Downgradient		Downgradient		Downgradient		Downgradient		Downgradient	
Analyte	Units	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q
Total Metals																	
Antimony	mg/L	< 0.00112	U	< 0.00112	U	< 0.00112	U	< 0.00112	U	< 0.00112	U	< 0.00112	U	< 0.00112	U	< 0.00112	U
Arsenic	mg/L	< 0.00151	U*	< 0.00170	U*	< 0.000975	U*	< 0.000953	U*	0.000996	J	< 0.00147	U*	0.00102		0.000916	J
Barium	mg/L	0.0147		0.0157		0.0169		0.0155		0.0164		0.0184		0.0174		0.0158	
Beryllium	mg/L	< 0.0000570	U	0.0000590	J	< 0.0000570	U	< 0.0000570	U	< 0.0000570	U	< 0.0000570	U	< 0.0000570	U	< 0.0000570	U
Boron	mg/L	< 0.0303	U	< 0.0303	U	< 0.0303	U	< 0.0303	U	< 0.0303	U	< 0.0303	U	< 0.0303	U	< 0.0303	U
Cadmium	mg/L	< 0.000125	U	< 0.000125	U	< 0.000125	U	< 0.000125	U	< 0.000125	U	< 0.000125	U	< 0.000125	U	< 0.000125	U
Calcium	mg/L	41.8		46.8		47.0		43.9		42.7		46.5		44.6		42.5	
Chromium	mg/L	< 0.00188	U*	< 0.00306	U*	< 0.00155	U*	< 0.000710	U*	< 0.00261	U*	< 0.00285	U*	< 0.00172	U*	< 0.00149	U*
Cobalt	mg/L	< 0.0000750	U	< 0.0000760	U*	< 0.0000750	U	< 0.0000750	U	< 0.0000750	U	< 0.0000750	U	< 0.0000750	U	< 0.0000750	U
Lead	mg/L	0.000323	J	< 0.000117	U*	0.000125	J	< 0.000123	U*	< 0.0000940	U	< 0.000109	U*	0.000139	J	0.000133	J
Lithium	mg/L	< 0.00256	U	< 0.00256	U	< 0.00256	U	< 0.00256	U	< 0.00256	U	< 0.00256	U	< 0.00256	U	< 0.00256	U
Mercury	mg/L	< 0.0000653	U	< 0.0000653	U	< 0.0000653	U	< 0.0000653	U	< 0.0000653	U	< 0.0000653	U	< 0.0000653	U	< 0.0000653	U
Molybdenum	mg/L	< 0.000474	U	< 0.000693	U*	0.000485	J	0.000571	J	0.000519	J	0.000634	J	0.000613	J	< 0.000474	U
Selenium	mg/L	< 0.000813	U	< 0.000813	U	< 0.000813	U	< 0.000813	U	< 0.000813	U	< 0.000813	U	< 0.000813	U	< 0.000813	U
Thallium	mg/L	0.0000720	J	0.0000680	J	0.0000850	J	< 0.0000630	U	0.0000640	J	0.0000770	J	0.0000910	J	0.0000840	J
Radium 226 + Radium 228	pCi/L	0.527	J	0.0840	J	0.723	U*	0.602	U*	0.727	U*	0.499	U*	0.490	U*	0.408	U*
Anions																	
Chloride	mg/L	2.00		2.69		2.77	J	3.01		2.07		1.86		1.91		2.78	
Fluoride	mg/L	< 0.0263	U	< 0.0263	U	0.0599	J	0.0413	J	0.0280	J	0.0348	J	< 0.0263	U	< 0.0263	U
Sulfate	mg/L	9.22		10.9		11.5	J	11.8		9.39		8.69		10.0		11.9	
General Chemistry																	
Total Dissolved Solids	mg/L	236		231		221		221		237		219		229		170	
Field pH																	
pH (field)	SU	6.36		7.37		7.11		7.30		7.32		7.48		8.28		7.38	

Notes:
Q - Data Qualifier
U* - Result should be considered "not-detected" because it was detected in a rinsate blank or laboratory blank at a similar level
J - Quantitation is approximate due to limitations identified during data validation
UJ - Analyte not detected, but the reporting limit may or may not be higher due to a bias identified during data validation
U - Analyte not detected
mg/L - milligrams per liter
pCi/L - picoCurie per liter
SU - Standard Unit

BASELINE MONITORING

Table 3 - Groundwater Sampling Summary

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

Well ID	Well Designation	Number of Sampling Events Conducted	May 21-25, 2018	June 4-7, 2018	June 26 - July 2, 2018	July 16-19, 2018	August 6-9, 2018	August 27-29, 2018	September 17-19, 2018	October 8-10, 2018	Groundwater Monitoring Program
G-1B	Background	5	X	X	X		X	X			Detection Monitoring - 257.94(a); 257.94(b) - Appendix III Constituents
G-3A	Downgradient	8	X	X	X	X	X	X	X	X	Detection Monitoring - 257.94(a); 257.94(b) - Appendix III Constituents
G-3B	Downgradient	8	X	X	X	X	X	X	X	X	Detection Monitoring - 257.94(a); 257.94(b) - Appendix III Constituents
G-5A	Downgradient	8	X	X	X	X	X	X	X	X	Detection Monitoring - 257.94(a); 257.94(b) - Appendix III Constituents
G-5B	Downgradient	8	X	X	X	X	X	X	X	X	Detection Monitoring - 257.94(a); 257.94(b) - Appendix III Constituents
G-7A	Downgradient	8	X	X	X	X	X	X	X	X	Baseline Monitoring - 257.94(b) - Appendix III and IV Constituents
G-7B	Downgradient	8	X	X	X	X	X	X	X	X	Detection Monitoring - 257.94(a); 257.94(b) - Appendix III Constituents
G-8B	Background	8	X	X	X	X	X	X	X	X	Detection Monitoring - 257.94(a); 257.94(b) - Appendix III Constituents
G-9B	Background	8	X	X	X	X	X	X	X	X	Detection Monitoring - 257.94(a); 257.94(b) - Appendix III Constituents
G-10B	Background	8	X	X	X	X	X	X	X	X	Detection Monitoring - 257.94(a); 257.94(b) - Appendix III Constituents
KIF-101	Background	8	X	X	X	X	X	X	X	X	Detection Monitoring - 257.94(a); 257.94(b) - Appendix III Constituents

Notes:

Baseline groundater samples analyzed for Appendix III and Appendix IV constituents - G-7A

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

Appendix IV Constituents - antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, fluoride, lead, lithium, mercury, molybdenum, selenium, thallium, radium 226 and radium 228 combined

Table 4
Groundwater and Surface Water Elevation Summary

Groundwater Elevation Collection Date		21-May-18	04-Jun-18	26-Jun-18	16-Jul-18	06-Aug-18	27-Aug-18	17-Sep-18	08-Oct-18
Monitoring Well	**Units**	**Residuum**							
G-3A	ft-MSL	741.13	741.87	739.95	740.71	741.46	740.90	739.87	740.66
G-5A	ft-MSL	740.99	741.77	740.96	740.68	741.36	740.80	739.74	740.52
G-7A	ft-MSL	741.19	741.84	741.03	741.04	741.46	740.90	739.92	740.70
KIF-101	ft-MSL	741.27	741.87	741.11	740.78	741.52	740.91	739.91	740.70
Monitoring Well	**Units**	**Bedrock - Knox Group**							
G-1B	ft-MSL	746.56	745.21	743.60	nm	744.32	743.75	nm	nm
G-3B	ft-MSL	741.03	741.75	742.06	740.57	741.34	740.77	739.73	740.51
G-5B	ft-MSL	741.00	741.76	740.96	740.59	741.36	740.78	739.70	740.49
G-7B	ft-MSL	741.24	741.89	740.08	740.49	741.50	740.94	739.97	740.74
G-8B	ft-MSL	741.06	741.66	740.35	740.61	741.31	740.74	739.82	740.57
G-9B	ft-MSL	742.62	743.06	740.40	741.17	740.45	740.12	739.53	741.95
G-10B	ft-MSL	742.58	742.31	741.13	741.33	741.53	741.06	740.40	741.82
		Surface Water							
Emory River	ft-MSL	741.11	741.61	740.68	740.59	741.21	740.63	739.68	740.21

Notes:

nm - Not Measured

Table 5 Hydraulic Conductivity Data Summary

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

Well ID	Formation	Well Position	Slug Test Hydraulic Conductivity (cm/sec)
G-3A	Residuum	Downgradient	5.32E-04
G-5A	Residuum	Downgradient	6.04E-04
G-7A	Residuum	Downgradient	1.33E-03
KIF-101	Residuum	Background	4.33E-03
Geometric Mean of Hydraulic Conductivity (cm/sec)*			**1.17E-03**
G-1B	Knox Group Bedrock	Background	6.58E-03
G-3B	Knox Group Bedrock	Downgradient	6.01E-06
G-5B	Knox Group Bedrock	Downgradient	6.49E-06
G-7B	Knox Group Bedrock	Downgradient	9.63E-05
G-8B	Knox Group Bedrock	Background	NA
G-9B	Knox Group Bedrock	Background	NA
G-10B	Knox Group Bedrock	Background	NA
Geometric Mean of Hydraulic Conductivity (cm/sec)*			**7.05E-05**

Notes:

cm/sec - centimeters per second

NA - Not Available

* - Residuum and bedrock geometric mean hydraulic conductivities based on slug test values

Source for Hydrogeological Evaluation Included in the Text:*Kingston Fossil Plant - Penisular Site, Hydrogeological Evaluation of Coal-Combustion Byproduct Disposal Facility, WR2005-1-36-133*, October 2005

Table 6A - Detection Monitoring Statistical Evaluation - Residuum

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

Constituent	Boron	Calcium	Chloride	Fluoride	pH	Sulfate	TDS
Unit	mg/L	mg/L	mg/L	mg/L	SU	mg/L	mg/L
UPL	0.037	123.192	8.992	0.1	6.02-6.99	193.298	526.64
Well ID	2018 Detection Monitoring Round 1 on May 21-25, 2018 (Resample Results on June 26-July 2, 2018)						
G-3A	<0.0303 (<0.0303)	37.1 (30.4)	2.03 (1.80)	0.0270 (0.0268)	5.93 (6.16)	18.6 (23.6)	210 (159)
G-5A	**0.156** **(0.130)**	66.4 (68.6)	8.99 (10.7)	**0.157** **(0.172)**	6.43 (6.96)	20.2 (23.6)	297 (293)
G-7A	<0.0303 (<0.0303)	41.8 (47.0)	2.00 (2.77)	<0.0263 (0.0599)	6.36 **(7.11)**	9.22 (11.5)	236 (221)
KIF-101	<0.0303 (<0.0303)	96.4 (101)	4.73 (6.39)	0.0473 (0.0593)	6.14 (6.78)	97.2 (107)	453 (441)
Well ID	2018 Detection Monitoring Round 2 Results on August 6-9, 2018 (Resample Results on September 17-19, 2018)						
G-3A	<0.0303 (<0.0303)	31.3 (39.8)	1.17 (1.31)	<0.0263 (<0.0263)	6.43 (6.99)	22.5 (23.0)	179 (210)
G-5A	**0.126** **(0.140)**	59.3 (59.1)	8.02 (7.81)	**0.162** **(0.146)**	**7.00** **(8.10)**	20.6 (22.4)	294 (267)
G-7A	<0.0303 (<0.0303)	42.7 (44.6)	2.07 (1.91)	0.0280 (<0.0263)	**7.32** **(8.28)**	9.39 (10.0)	237 (229)
KIF-101	<0.0303 (0.0373)	97.9 (96.9)	4.76 (4.72)	<0.0494 (0.0471)	6.41 (7.04)	92.4 (115)	440 (453)

Notes:

Bold and underlined concentration indicates an SSI over background

SSI - Statistically Significant Increase

UPL - Upper Prediction Limit

TDS - Total Dissolved Solids

mg/L - milligrams per liter

SU - Standard Units

Well KIF-101 is the background monitoring well

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

Parenthesized values represent resample results

Table 6B - Detection Monitoring Statistical Evaluation - Bedrock

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

Constituent	Boron	Calcium	Chloride	Fluoride	pH	Sulfate	TDS
Unit	mg/L	mg/L	mg/L	mg/L	SU	mg/L	mg/L
UPL	0.024	52.214	1.920	0.177	6.38-8.17	55.5	279.70
Well ID	2018 Detection Monitoring Round 1 on May 22-25, 2018 (Resample Results on June 26-July 2, 2018)						
G-3B	<0.0303 (<0.0303)	43.7 (44.3)	**1.98 (2.23)**	0.0486 (0.0486)	6.17 (7.70)	28.2 (25.1)	243 (242)
G-5B	**0.347 (0.298)**	**113 (107)**	**87.9 (82.2)**	0.124 (0.133)	6.70 (7.38)	**134 (118)**	**580 (578)**
G-7B	<0.0303 (<0.0303)	32.0 (29.2)	1.72 (2.65)	<0.0263 (0.0305)	6.98 (7.82)	2.51 (3.69)	199 (217)
G-1B	<0.0303 (<0.0303)	46.6 (46.0)	1.12 (1.49)	<0.0263 (<0.0263)	6.74 (7.43)	0.792 (1.14)	231 (215)
Well ID	2018 Detection Monitoring Round 2 Results on August 7-9, 2018 (Resample Results on September 18-19, 2018)						
G-3B	<0.0303 (<0.0303)	40.7 (42.6)	1.73 (1.68)	0.0422 (0.0364)	7.51 (7.68)	23.6 (26.8)	250 (226)
G-5B	**0.294 (0.318)**	**98.5 (105)**	**96.9 (91.0)**	0.0640 (0.0773)	7.33 (7.98)	**130 (133)**	**641 (554)**
G-7B	<0.0303 (<0.0303)	29.5 (29.5)	1.97 (1.88)	<0.0263 (<0.0263)	7.82 (8.21)	2.09 (2.28)	225 (214)
G-1B	<0.0303	43.2	1.17	<0.0263	7.36	0.683	215

Notes:

Bold and underlined concentration indicates an SSI over background

SSI - Statistically Significant Increase

UPL - Upper Prediction Limit

TDS - Total Dissolved Solids

mg/L - milligrams per liter

SU - Standard Units

Well G-1B is the background monitoring well

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

Parenthesized values represent resample results

APPENDIX A
ALTERNATE SOURCE DEMONSTRATION DOCUMENTATION

NOTICE OF SUCCESSFUL ALTERNATE SOURCE DEMONSTRATION

KINGSTON FOSSIL PLANT

PENINSULA DISPOSAL AREA

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 Kingston 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 Peninsula Disposal Area.

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 Peninsula Disposal Area located within the boundaries of the Kingston Fossil Plant's Reservation.

DATE: 4/13/18

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

SUCCESSFUL ALTERNATE SOURCE DEMONSTRATION EXECUTIVE SUMMARY

KINGSTON FOSSIL PLANT

PENINSULA DISPOSAL AREA

A successful Alternate Source Demonstration (ASD) was conducted on behalf of the Tennessee Valley Authority (TVA) for Kingston Fossil (KIF) 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 Peninsula Disposal Area unit.

The ASD determined that the potential SSIs identified in the Peninsula Disposal Area Detection Monitoring program are not related to a release from the regulated CCR unit, but rather were attributable to the 2010 failure of a clay liner and associated release of CCR materials. The conclusion that the potential SSIs are due to sources other than the Peninsula Disposal Area is supported by the following lines of evidence:

- The Appendix III constituents with potential SSIs had been detected in downgradient monitoring wells prior to the construction of the Peninsula Disposal Area in 2011 and start of operation in 2012.
- During 2010, failure of the clay liner for a former gypsum pond was observed.
- After mitigation of the former gypsum pond clay liner failure, the Peninsula Disposal Area was constructed over the location of the former gypsum pond. The Peninsula Disposal Area was constructed with a geomembrane liner and leachate collection system.
- Groundwater monitoring data in downgradient monitoring wells exhibited a sharp increase in concentrations of Appendix III constituents that peaked in the year following the failure of the clay liner and have since declined substantially. This pattern of constituent concentrations is consistent with the release that has been mitigated and inconsistent with an ongoing release from the Peninsula Disposal Area.

The constituents that caused the apparent SSIs were detected prior to the placement of CCR in the new Peninsula Disposal Area's lined landfill and their pattern of detection is inconsistent with a release from the regulated CCR unit.

SUMMARY

Based on completion of the successful ASD for the Peninsula Disposal Area, and in accordance with 40 C.F.R. 257.94(e)(2), the site will remain in detection monitoring as of April 15, 2018.

APPENDIX B
STATISTICAL ANALYSIS REPORT

STATISTICAL ANALYSIS REPORT FOR KINGSTON FOSSIL PLANT

2018

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1/14/2019

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2.2 Background Statistical Models and Prediction Limits 5
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1 Introduction

This report summarizes the statistical analysis performed on groundwater quality constituents monitored during the Coal Combustion Residuals (CCR) Rule's 2018 Annual Groundwater Monitoring (GWM) Program for the Peninsula Disposal Area at the Tennessee Valley Authority (TVA) Kingston Fossil Plant (KIF). The 2018 Annual GWM Program is the second year of the program. Statistically significant increases (SSIs) were present in several parameters based on the 2017 annual groundwater sampling results. An Alternate Source Determination (ASD) was made and the Unit remains in Detection Monitoring.

At the KIF plant's CCR Units, the sampling results used to identify potential SSIs were developed based on data obtained from a minimum of seven distinct monitoring events performed between May and September of 2018 by 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.

The current CCR Rule groundwater monitoring networks, as Certified by a Professional Engineer from AECOM, is presented in **Table 1**.

Table 1. CCR Rule Monitoring Well Networks

CCR Site Network	Background	Downgradient
Residuum	KIF-101	G-3A G-5A G-7A
Knox Group	G-1B G-8B G-9B G-10B	G-3B G-5B G-7B

The 'R' Statistical Analysis package (www.r-project.org) in conjunction with R-Studio (www.rstudio.com) (both popular public domain software products) and other analytical tools 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.

Groundwater samples collected as part of the CCR Rule monitoring program were analyzed for constituents listed in Appendix III of the CCR Rule. Only non-filtered sample results were utilized for the statistical analysis of Appendix III constituents. As high turbidity measurements during the purging of wells (e.g., values above 5 NTUs) have the propensity to increase the concentrations of Appendix III constituents, filtered samples were also collected to better understand and/or dispel the potential source(s) of falsely-identified SSIs. A summary of constituents included in the data analysis is provided in the first column of Table 2.

Table 2. CCR Rule Monitored Constituents

Appendix III Constituents (Detection Monitoring)	Appendix IV Constituents (Assessment Monitoring)
Boron	Antimony
Calcium	Arsenic
Chloride	Barium
Fluoride	Beryllium
pH (field)	Cadmium
Sulfate	Chromium
Total Dissolved Solids (TDS)	Cobalt
	Fluoride
	Lead
	Lithium
	Mercury
	Molybdenum
	Radium 226 + 228
	Selenium
	Thallium

2 Statistical Analysis

The basic steps in the Detection Monitoring analysis for the 2018 data included the following:

1) Calculating the site testing configuration, and determining the statistical power associated with interwell parametric and nonparametric prediction limits under possible retesting schemes;
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 the 2018 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 or background data were examined initially, and recapped with descriptive statistics, as shown in **Table 3**. To handle any non-detects in these calculations, non-detect values 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.

Table 3A. Summary of Background Dataset Descriptive Statistics, Residuum

Constituent	Units	N	No. of NDs	Minimum	Maximum	Mean	Median
Boron	mg/L	32	31	0.0006	0.0020	0.0006	0.0013
Calcium	mg/L	32	14	0.0003	0.0031	0.0012	0.0010
Chloride	mg/L	32	0	0.0206	0.0852	0.0471	0.0422
Fluoride	mg/L	32	32	0.0010	0.0010	0.0005	0.0010
pH	mg/L	32	16	0.0001	0.0010	0.0003	0.0003
Sulfate	mg/L	32	19	0.0005	0.0025	0.0007	0.0006
TDS	mg/L	32	13	0.0001	0.0011	0.0003	0.0003

Table 3B. Summary of Background Dataset Descriptive Statistics, Knox Group

Constituent	Units	N	No. of NDs	Minimum	Maximum	Mean	Median
Boron	mg/L	32	31	0.0006	0.0020	0.0006	0.0013
Calcium	mg/L	32	14	0.0003	0.0031	0.0012	0.0010
Chloride	mg/L	32	0	0.0206	0.0852	0.0471	0.0422
Fluoride	mg/L	32	32	0.0010	0.0010	0.0005	0.0010
pH	mg/L	32	16	0.0001	0.0010	0.0003	0.0003
Sulfate	mg/L	32	19	0.0005	0.0025	0.0007	0.0006
TDS	mg/L	32	13	0.0001	0.0011	0.0003	0.0003

Notes:
1. ND = not detected above the laboratory reporting limit.
2. All computations involving non-detects handled using the Kaplan-Meier adjustment. In the case of 100% NDs, mean is computed by substituting half the reporting limit for each ND.

2.1 Site Testing Configuration and Statistical Power

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 or more resamples — depending on the appropriate value of m — is (are) compared against the UPL or prediction interval. If any of the resamples falls within the bounds of prediction limit/interval, the test passes. If all the resamples exceed the bounds of the limit/interval, an SSI is confirmed for that well and constituent.

To determine the appropriate value of m for use in retesting, four different retesting strategies were assessed by computing the statistical power associated with possible prediction limits under a 1-of-1, 1-of-2, 1-of-3, and 1-of-4 approach (note that a 1-of-1 approach implies the lack of any retesting). Each of the prediction limits was computed under the constraint that the annual site-wide false positive rate (SWFPR) be no more than 10%, thus accounting for the available background sample size for each Appendix III constituent (n=23 for the Residuum network, n=63 for the Knox Group), along with the number of downgradient compliance wells (3), the number of constituents to be tested (7), and the number of statistical evaluations per year (2).

2.2 Background Statistical Models and Prediction Limits

To compute each upper threshold limit (UTL) (or prediction interval for pH), the following steps were taken:

1) <u>All baseline data</u> — those from designated upgradient or background wells — collected from the Program's first sampling event through September of 2018 were grouped and checked for possible outliers.

At KIF, one possible outlier was flagged for pH at well KIF-101, a significant dip during the second sampling event of 2018 in June 2018. However, the unusual change in pH was matched to various degrees on the same or closely-timed sampling events at each downgradient well, including those in the Knox Group network. Since nearly the same pattern was observed across-the-board for sampling events taken at this time, it was judged better to keep all the data 'as is,' rather than removing similar values at the compliance wells.

2) The grouped baseline data were also analyzed to determine whether they could be fit to a known statistical model. If so, a parametric UPL or prediction interval was computed; if not, a nonparametric UPL or interval was constructed.

To fit potential statistical models, a series of normalizing mathematical transformations was applied to each baseline dataset. These transformations are known as power transformations, since they raise each observation to a mathematical power. The goal is to find, if possible, a transformation that normalizes the data on the transformed scale.

3) The final statistical model for each COI was used to compute an upper prediction limit (UPL) or prediction interval associated with a 1-of-2 retesting scheme, and such that the limit or interval met EPA's twin performance criteria of controlling the site-wide false positive rate and having sufficient statistical power.

When a parametric model is appropriate, on the normalized scale, a UPL is computed using the standard normal theory equation (and similarly for a two-sided prediction interval):

$$UPL = \bar{x} + \kappa s$$

where $\bar{x}$ and s represent the mean and standard deviation of the (transformed) observations, and κ is a multiplier which depends on the number of baseline measurements, desired confidence level, retesting strategy, and network configuration (number of downgradient wells, number of constituents, and number of annual evaluations). If the data have been transformed, the final UPL or prediction interval is derived by back-transforming the scaled UPL or interval bounds, e.g., for a log transformation, the result is exponentiated; for a square-root transformation, the result is squared, etc.

For nonparametric models, the normal theory equation does not apply. Instead, the UPL is selected as one of the largest of the sample values, typically the maximum, while the LPL (if applicable) is selected as one of the smallest values (usually the minimum). Because there is no multiplier as in the parametric case, the confidence level associated with a nonparametric UPL is computed 'after the fact,' based on the sample size, desired confidence level, retesting strategy, etc.: the smaller the sample size, the lower the confidence; the bigger the sample size, the higher the confidence level.

For the KIF, **Table 4, included below,** lists the calculated UPLs (and LPL for pH) established for these particular CCR Units.

Table 4A. KIF Residuum Interwell Prediction Limits

COI	N	ND.PCT	MODEL	1-of-m	FPR	UNITS	LPL	UPL
Boron	23	47.8	Log	2	0.0149	mg/L	0	0.037
Calcium	23	0	Square	2	0.0149	mg/L	0	123.192
Chloride	23	0	Log	2	0.0149	mg/L	0	8.992
Fluoride	23	13	Log	2	0.0149	mg/L	0	0.1
pH	24	0	Eighth Power	2	0.0075	SU	6.02	6.99
Sulfate	23	0	Log	2	0.0149	mg/L	0	193.298

COI	N	ND.PCT	MODEL	1-of-m	FPR	UNITS	LPL	UPL
TDS	23	0	Cube	2	0.0149	mg/L	0	526.64

Table 4B. KIF Knox Group Interwell Prediction LImits

COI	N	ND.PCT	MODEL	1-of-m	FPR	UNITS	LPL	UPL
Boron	63	74.6	NP	2	0.0149	mg/L	0	0.024
Calcium	63	1.6	Square	2	0.0149	mg/L	0	52.214
Chloride	63	1.6	Square	2	0.0149	mg/L	0	1.920
Fluoride	63	65.1	NP	2	0.0149	mg/L	0	0.177
pH	63	0	Square	2	0.0075	SU	6.38	8.17
Sulfate	63	1.6	NP	2	0.0149	mg/L	0	55.5
TDS	63	0	Normal	2	0.0149	mg/L	0	279.70

2.3 Comparing Compliance Data Against Prediction Limits

To assess whether any SSIs occurred during the 2018 Detection Monitoring at TVA's KIF CCR units, the routine sampling events from sampling rounds 1 and 5 at each COI-well pair were compared against their respective prediction limits. Under a 1-of-2 retesting strategy, sampling rounds 3 and 7 were reserved as possible resamples. This enabled at least a month's lag time between any of the routine and resample measurements.

If either routine observation (sampling rounds 1 and 5) exceeded the upper prediction limit (UPL), or for pH, was outside the bounds of the prediction interval on either side, a potential SSI was flagged. Then the reserved resample associated with the routine event (sampling rounds 3 and 7) was compared against the same limit or interval. Only if the routine observation and its resample both were outside the bounds of the prediction limit/interval was a confirmed SSI identified.

3 Summary of Statistical Analysis

To facilitate an ‘at-a-glance’ summary of the statistical comparison results, Tables 5A and 5B are ‘traffic light’ matrices, 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 in 2018. Red cells indicate that: an SSI was flagged during one or both of the semi-annual evaluation events.

At the KIF Residuum CCR network (Table 5A), Detection Monitoring SSIs during the 2018 annual sampling were recorded for boron, fluoride, and pH at downgradient well G-5A, and for pH at well G-7A. At the Knox Group CCR network (Table 5B), SSIs were recorded for boron, calcium, chloride, sulfate, and TDS at well G-5B, and for chloride at well G-3B. In summary, a total of seven SSIs were identified at Program network wells that are located near the KIF plant’s Residuum CCR Unit during the 2018 Detection Monitoring phase, along with a total of 11 SSIs at the KIF plant’s Knox Group CCR Unit.

Table 5A. Traffic Light Matrix Based on Comparative Analysis of Statistical Analysis Results versus Prediction Limits, KIF Residuum

ITEM No.	TRAFFIC LIGHT MATRIX			
	Constituent of Interest	GROUNDWATER QUALITY MONITORING WELL LOCATIONS		
		G-3A	G-5A	G-7A
1.	Boron	GREEN	RED	GREEN
2.	Calcium	GREEN	GREEN	GREEN
3.	Chloride	GREEN	GREEN	GREEN
4.	Fluoride	GREEN	RED	GREEN
5.	pH	GREEN	RED	RED
6.	Sulfate	GREEN	GREEN	GREEN
7.	TDS	GREEN	GREEN	GREEN

COLOR-CODING KEY:	
	Monitored data for the specific COI are deemed to fall within prediction limit bounds
	Monitored data for the specific COI are deemed to exceed prediction limit bounds

Table 5B. Traffic Light Matrix Based on Comparative Analysis of Statistical Analysis Results versus Prediction Limits, KIF Knox Group

ITEM No.	TRAFFIC LIGHT MATRIX			
	Constituent of Interest	GROUNDWATER QUALITY MONITORING WELL LOCATIONS		
		G-3B	G-5B	G-7B
1.	Boron	GREEN	RED	GREEN
2.	Calcium	GREEN	RED	GREEN
3.	Chloride	RED	RED	GREEN
4.	Fluoride	GREEN	GREEN	GREEN
5.	pH	GREEN	GREEN	GREEN
6.	Sulfate	GREEN	RED	GREEN
7.	TDS	GREEN	RED	GREEN

COLOR-CODING KEY:	
	Monitored data for the specific COI are deemed to fall within prediction limit bounds
	Monitored data for the specific COI are deemed to exceed prediction limit bounds

4 References

1) US Environmental Protection Agency (2009) *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance* - Office of Resource Conservation and Recovery EPA 530/R-09-007

2) US Environmental Protection Agency (2007) *Framework for Metals Risk Assessment* EPA 120/R-07/001 Office of the Science Advisor Risk Assessment Forum, Washington, DC 2046