2018 Annual Groundwater Monitoring and Corrective Action Report

Tennessee Valley Authority
Cumberland Fossil Plant Stilling Pond (Including Retention Pond) CCR Unit

Prepared for:
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January 31, 2019

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January 31, 2019

Reference: 2018 Annual Groundwater Monitoring and Corrective Action Report
TVA Cumberland Fossil Plant Stilling Pond (Including Retention Pond) 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 Stilling Pond (including retention pond) CCR Unit at the Tennessee Valley Authority (TVA) Cumberland Fossil Plant (CUF). In 2017, TVA established a groundwater monitoring network and program at the CUF Stilling Pond (including retention pond) 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:

- Conducted a statistical analysis of the 2017 detection monitoring groundwater sampling data was performed 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).

- Performed 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).

- Established an assessment monitoring program in accordance with 40 CFR 257.94(e)(1) because the Appendix III alternate source demonstration was unable to establish that the SSIs were the result of another source or the result of an error.

- Placed notification of the establishment of the assessment monitoring program in the facility operating record in accordance with 40 CFR 257.94(e)(3) and 257.105(h)(5); provided notification to the State of Tennessee in accordance with 40 CFR 257.106(h)(4); and placed notification on the CCR Compliance Data and Information website https://www.tva.gov/Environment/Environmental-Stewardship/Coal-Combustion-Residuals in accordance with 40 CFR 257.107(h)(4).

- Sampled and analyzed groundwater in the certified monitoring network for Appendix IV constituents in accordance with 40 CFR 257.95(b).

- Sampled wells in the certified monitoring network and analyzed samples for CCR constituents (Appendix III and Appendix IV constituents) in accordance with 40 CFR 257.95(d)(1). The sampling results were placed in the operating record as required by 40 CFR 257.95(d)(1) and 257.105(h)(6). Additionally, these results are included in Table 1 of this 2018 Annual Report in accordance with 257.95(d)(3).

- Established groundwater protection standards in accordance with 40 CFR 257.95(d)(2) and included the standards in this 2018 Annual Report in accordance with 257.95(d)(3).

- Performed field and desktop site characterization investigations to improve the CUF Conceptual Site Model (CSM).
- 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 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:

- Complete an evaluation of whether one or more Appendix IV constituents are detected at statistically significant levels (SSLs) above the established groundwater protection standards in accordance with 40 CFR 257.95(g).
- Perform an alternate source demonstration for the SSLs over groundwater protection standards (Appendix IV constituents) in accordance with 40 CFR 257.95(g)(3)(ii).
- Initiate characterization of the nature and extent of the release in accordance with 40 CFR 257.95(g)(1) if the Appendix IV alternate source demonstration performed under 40 CFR 257.95(g)(3)(ii) is not successful.
- Notification of the exceedances of established groundwater protection standards will be placed in the facility operating record in accordance with 40 CFR 257.95(g) and 257.105(h)(8); will be provided to the State of Tennessee in accordance with 40 CFR 257.106(h)(6); and will be placed on the CCR Compliance Data and Information website (https://www.tva.gov/Environment/Environmental-Stewardship/Coal-Combustion-Residuals) in accordance with 40 CFR 257.107(h)(6).
- All persons who own the land or reside on the land that directly overlies any part of the plume of contamination if contaminants have migrated off-site will be notified in accordance with 40 CFR 257.95(g)(2) if the Appendix IV alternate source demonstration performed under 40 CFR 257.95(g)(3)(ii) is not successful.
- Initiate Assessment of Corrective Measures in accordance with 40 CFR 257.95(g)(3)(i) and 40 CFR 257.96.
- Perform further field and desktop site characterization investigations to improve the CUF CSM.
- Continue semi-annual assessment monitoring at the certified groundwater monitoring network consistent with 40 CFR 257.95.
- 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

The Retention Pond/Stilling Pond Unit is located north of the Dry Fly Ash Stack, east of Wells Creek and south of the Cumberland River. The Unit includes an internal divider dike which separates the Retention Pond to the south and the Stilling Pond to the north. The Unit is considered an active CCR surface impoundment and is used for detention of stormwater, CCRs, and process water. Effluent from the Unit discharges to the Cumberland River under a National Pollutant Discharge Elimination System (NPDES) permit.

The monitoring well network for the CUF Stilling Pond (including retention pond) CCR Unit consists of two background wells (CUF-201 and CUF-202) and four downgradient wells (CUF-205, CUF-206, CUF-207, and CUF-208). The downgradient wells are installed at the waste boundary. Figure 1 is an aerial photograph that shows the Stilling Pond (including retention pond) and the groundwater monitoring well locations. The monitoring well network was designed for a single CCR Unit (Stilling Pond [including retention pond]).

No monitoring wells in the CCR network 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 in 2016-2017 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.

Assessment monitoring groundwater sampling was conducted between May and October 2018 and the results are summarized in Table 1. A summary of groundwater sample locations, well designations, analytes sampled, sampling dates and monitoring program status is provided in Table 2.

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 Cumberland River surface water elevations are summarized in Table 3. Groundwater flow directions were determined for each sampling event, and a generalized depiction of groundwater flow direction is illustrated on Figure 2. The uppermost aquifer at the CUF Stilling Pond (including retention pond) CCR Unit consists of a sand and gravel formation (i.e., alluvial deposits).

Testing for hydraulic conductivity at the background or downgradient groundwater monitoring wells, as summarized in Table 4, was determined by a 2018 hydrogeologic evaluation (Terracon, 2018). Testing data indicates the uppermost aquifer has a geometric mean hydraulic conductivity of 9.5 x 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 slug testing (9.5 x 10^{-4} cm/sec);
- horizontal hydraulic gradients measured during the implementation of the groundwater sampling and analysis program, ranging from 0.0031 to 0.0049 feet per foot (ft/ft); and,
- an effective porosity ranging between 24% and 28% (Law Engineering, 1992).

The average linear flow velocity in the uppermost aquifer ranges from approximately 11 to 20 feet per year.

STATISTICAL ANALYSIS OF GROUNDWATER DATA

The groundwater monitoring data for the assessment 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 Compliance Data and Information website. Groundwater protection standards were established in accordance with 40 CFR 257.95(h), as the larger of published regulatory limits or screening criteria (e.g., maximum contaminant levels (MCLs)) and upper tolerance limits (UTLs) derived from background. Maximum contaminant levels may or may not be considered the appropriate groundwater protection standard depending on background well concentrations for each Appendix IV[1] constituent[2]. The 2018 Statistical Analysis Report is included in Appendix A and covers the two CCR Units for CUF.

The sampling results used to identify potential groundwater protection standards exceedances were obtained during five distinct monitoring events that were performed between May and August of 2018[3]. Comparisons were made against a fixed groundwater protection standard via a confidence interval or confidence interval band. No retesting was conducted and none of the

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

2 USEPA has published MCLs or alternate regulatory limits for each of the Appendix IV constituents. Consequently, in most cases the groundwater protection standard is equal to the MCL. However, there may be cases where background levels of a constituent exceed the MCL. In these instances, an alternate groundwater protection standard must be derived from on-site background levels. On July 30, 2018, EPA provided alternate regulatory limits (i.e., that could be used as potential groundwater protection standards) for four of the Appendix IV chemical Constituents of Interest (COIs) for which the agency has not assigned MCLs to date. If site-specific background levels are lower, these may be used in place of background levels under 257.95(h)(2). Specifically, those alternate COIs include threshold values at the following health-based levels: 1.) Cobalt - 6 µg/L; 2.) Lithium - 40 µg/L; 3.) Molybdenum – 100 µg/L; and, 4.) Lead - 15 µg/L.

3 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 critical information about groundwater variability, can be gained from more frequent sampling.

individual compliance point measurements were directly compared against the groundwater protection standard. All of the Appendix IV monitoring data collected both in Year-One and Year-Two were used to construct the confidence interval bands. Cross-sections of each confidence interval band were then compared to the groundwater protection standard for the most recent assessment monitoring event in each case for the purpose of identifying any SSLs. A well-constituent pair is considered out of compliance only if its average constituent levels, as estimated via the confidence interval cross-section, currently exceed the groundwater protection standard. During Assessment Monitoring, one arsenic-related SSL was recorded at well CUF-206.

NARRATIVE DISCUSSION OF ANY TRANSITION BETWEEN MONITORING PROGRAMS

In January 2018, 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 initial round of detection monitoring indicated SSIs of Appendix III CCR constituents at the downgradient monitoring wells. TVA performed error checking and 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). TVA also performed investigations to determine whether a source other than the CCR materials contained within the CUF Stilling Pond (including retention pond) Area was the cause of the SSI. The alternate source demonstration study did not demonstrate that the SSI was a result of error or another source. An Assessment Monitoring Program was established and implemented as specified in 40 CFR 257.95. Notification of the assessment monitoring program was provided to the State of Tennessee and placed on the CCR Compliance Data and Information website (https://www.tva.gov/Environment/Environmental-Stewardship/Coal-Combustion-Residuals) in accordance with 40 CFR 257.106(h)(4) and 40 CFR 257.107(h)(4), respectively.

In accordance with assessment monitoring program requirements, groundwater in wells in the certified monitoring network was sampled and analyzed for Appendix IV constituents in accordance with 40 CFR 257.95(b) within 90 days of triggering assessment monitoring. Subsequent sampling and analysis of all wells in the certified monitoring network for Appendix III and IV constituents occurred in accordance with 40 CFR 257.95(d)(1). Appendix III and IV constituent concentrations were placed in the facility operating record in accordance with 40 CFR 257.105(h)(6) and are summarized in Table 1. Groundwater protection standards were established in accordance with 40 CFR 257.95(d)(2) and are summarized in Table 5. In January 2019, an evaluation of whether there are SSLs over established groundwater protection standards for one or more Appendix IV constituents was completed in accordance with 40 CFR 257.95(g). Although not required to be included in this 2018 Annual Report, during Assessment Monitoring, one arsenic-related SSL was recorded at monitoring well CUF-206. 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.

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

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.

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References:

Law Engineering, 1992. Report of Hydrogeologic Evaluation, Proposed Dry Fly Ash and Gypsum Disposal Facility, TVA Cumberland Fossil Plant, Cumberland City, Tennessee, Law Project No. 574-01442.04. Prepared for Tennessee Valley Authority. July 3.

Terracon, 2018. Aquifer Testing and Equipment Blank Results. TVA CCR Rule – Cumberland Fossil Plant (CUF). Terracon Consultants, Inc. December 12, 2018.

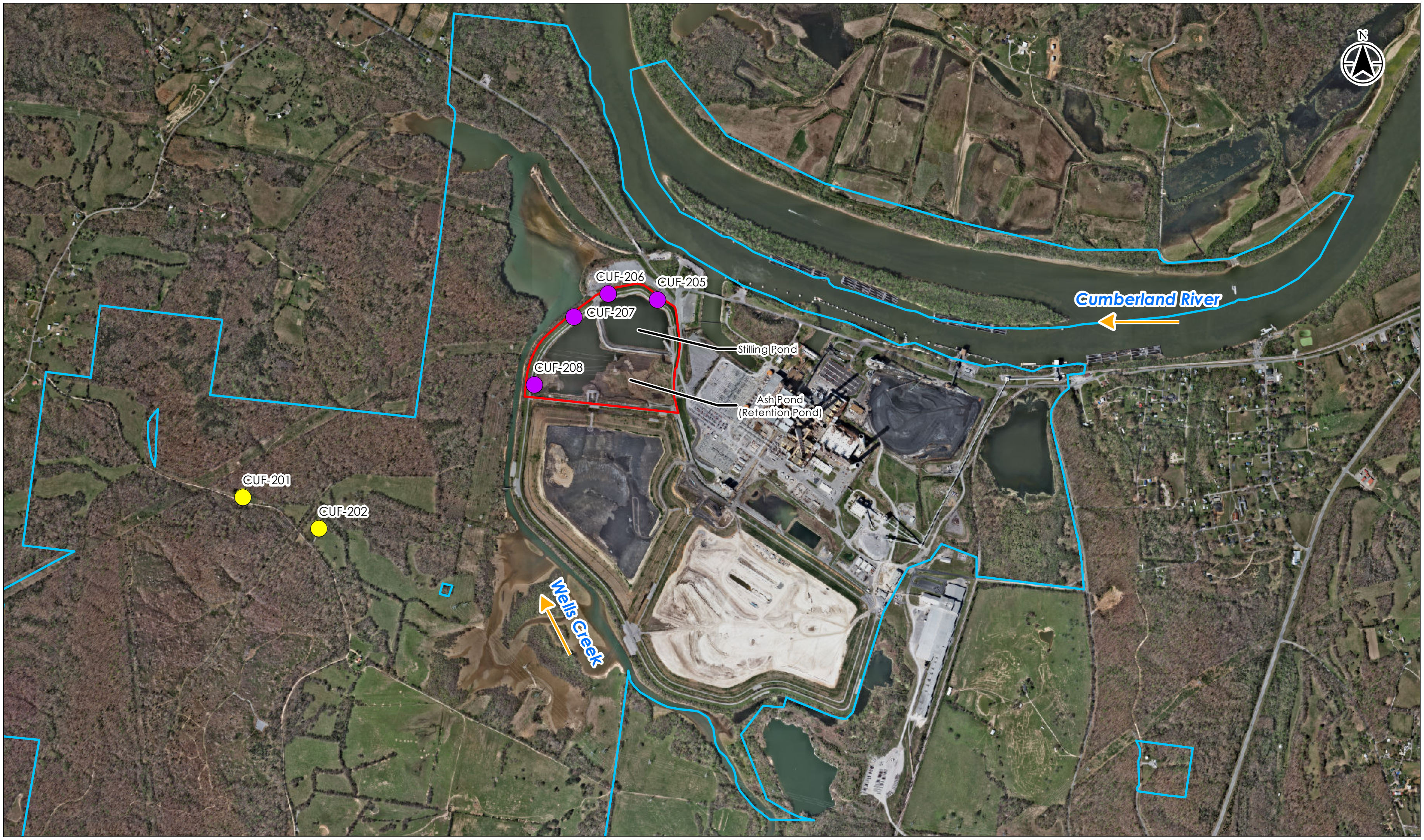
Attachments:

Figure 1 – Map with CCR Unit Background and Downgradient Wells
Figure 2 – Generalized Groundwater Flow Direction Map

Table 1 – Assessment Monitoring Groundwater Sampling Results
Table 2 – Groundwater Sampling Summary
Table 3 – Groundwater and Surface Water Elevation Summary
Table 4 – Hydraulic Conductivity Data Summary
Table 5 – Groundwater Protection Standards

Appendix A – 2018 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 (Flown April 8, 2017)

Project Location 182603174
Cumberland City
Stewart County,
Tennessee

Prepared by WSW on 2018-05-07
Technical Review by MD on 2018-05-07
Independent Review by JK on 2018-05-07

Client/Project
Tennessee Valley Authority
Cumberland Fossil Plant
CCR Rule

Figure No.
1

Title
Map with CCR Unit Background and Downgradient Wells

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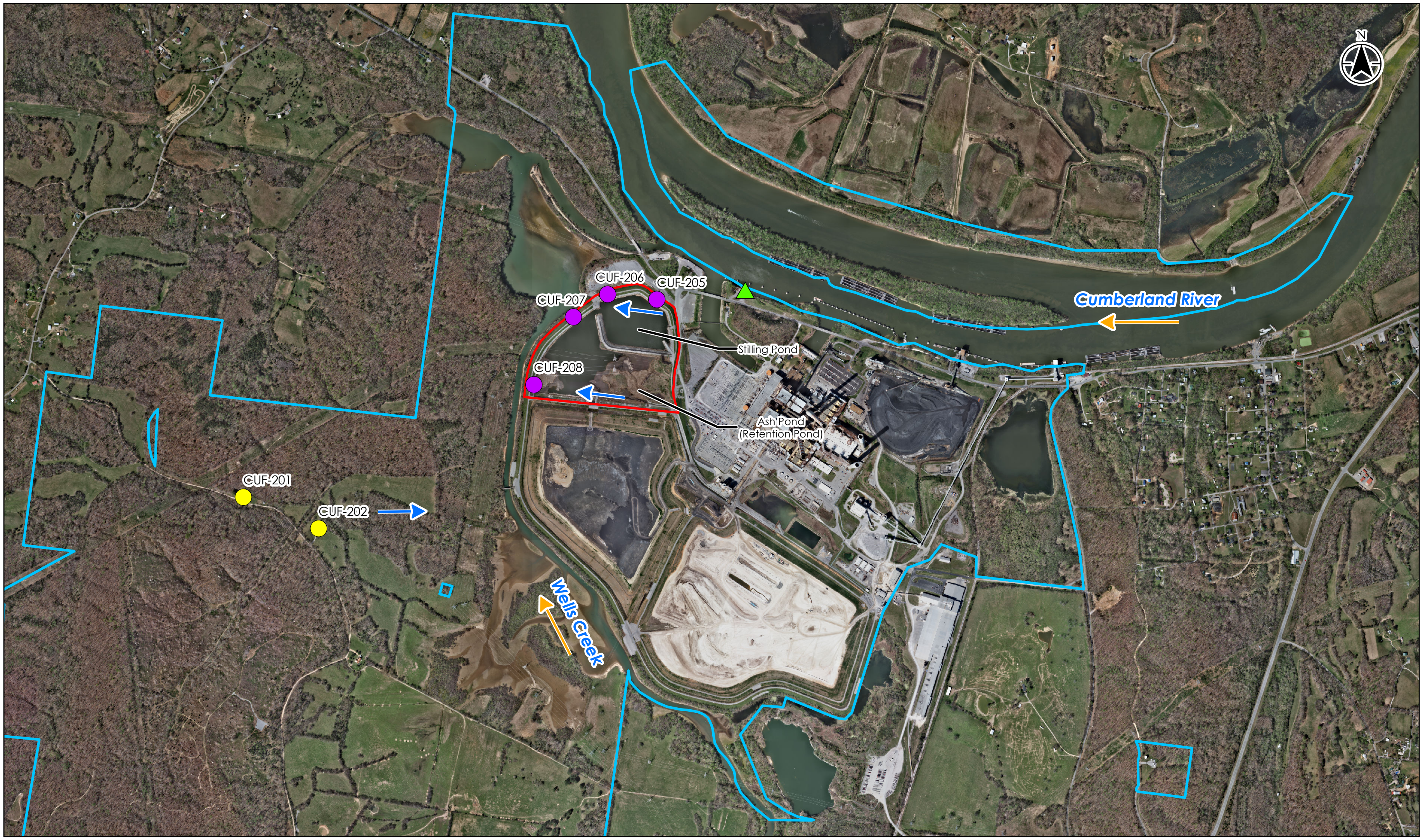

Staff Gauge
Background Well
Downgradient Well
Groundwater Flow Direction
CCR Unit Subject to CCR Rule
TVA Property Boundary

Groundwater flow directions are based on 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 (Flown April 8, 2017)

Stantec

TVA

Project Location 182603174
Cumberland City
Stewart County,
Tennessee

Prepared by CMB on 2019-01-14
Technical Review by WSW on 2019-01-14
Independent Review by MD on 2019-01-14

Client/Project
Tennessee Valley Authority
Cumberland Fossil Plant
CCR Rule

Figure No.
2

Title
Generalized Groundwater Flow Direction Map

TABLES

Table 1 - Assessment Monitoring Groundwater Sampling Results

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

Monitoring Well		**CUF-201**													
Sample Date		**30-May-18**		**19-Jun-18**		**10-Jul-18**		**31-Jul-18**		**20-Aug-18**		**10-Sep-18**		**02-Oct-18**	
Sample Round		**1**		**2**		**3**		**4**		**5**		**6**		**7**	
Well Designation		**Background**		**Background**		**Background**		**Background**		**Background**		**Background**		**Background**	
Analyte	Units	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q
Total Metals															
Antimony	mg/L	< 0.00112	U	0.00128	J	< 0.00112	U	< 0.00112	U	< 0.00112	U	< 0.00112	U	< 0.00112	U
Arsenic	mg/L	0.00141		0.00394		0.00491		0.00442		0.00455		0.00410		0.00432	
Barium	mg/L	0.0208		0.0205		0.0233		0.0263		0.0256		0.0251		0.0257	
Beryllium	mg/L	< 0.0000570	U	< 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	< 0.0330	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
Calcium	mg/L	23.4		25.9		25.3		25.5		25.0		23.9		23.4	
Chromium	mg/L	< 0.000631	U	< 0.00187	U*	< 0.00109	U*	< 0.00136	U*	< 0.00115	U*	< 0.00175	U*	< 0.00194	U*
Cobalt	mg/L	0.000423	J	0.000639		0.000675		0.000650		0.000546		0.000537		0.000490	J
Lead	mg/L	< 0.0000940	U	< 0.0000940	U	< 0.0000940	U	< 0.0000940	U	< 0.0000940	U	< 0.0000940	U	< 0.0000940	U
Lithium	mg/L	< 0.00373	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
Molybdenum	mg/L	< 0.00164	U*	0.00148	J	0.00194	J	0.00241	J	0.00226	J	0.00233	J	0.00230	J
Selenium	mg/L	< 0.000813	U	< 0.000813	U	< 0.000813	U	< 0.000813	U	< 0.000813	U	< 0.000813	U	< 0.000813	U
Thallium	mg/L	< 0.0000630	U	< 0.0000630	U	< 0.0000630	U	< 0.0000630	U	< 0.0000630	U	< 0.0000630	U	< 0.0000630	U
Radium 226 + Radium 228	pCi/L	0.0547	U	0.218	U	0.260	U*	0.602	U*	0.343	U*	0.385	U*	0.419	U*
Anions															
Chloride	mg/L	1.50		1.06	J	0.984	J	1.41		1.65		1.07		1.53	
Fluoride	mg/L	0.140		0.114		0.130		0.0940	J	0.0978	J	0.128		< 0.180	U*
Sulfate	mg/L	1.55		1.26	J	1.14		1.47		1.68		0.980	J	< 1.45	U*
General Chemistry															
Total Dissolved Solids	mg/L	98.0		105		99.0		114		101		101		110	
Field pH															
pH (field)	SU	7.12		7.12		7.01		7.01		7.08		6.80		6.66	

Notes:

NA - Not Available

Q - Data Qualifier

U* - This result should be considered not detected because it was detected in an associated field or laboratory blank at a similar concentration

UJ - Analyte not detected, but the reporting limit may or may not be higher due to a bias identified during data validation

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

U - Concentration not detected

mg/L - milligrams per liter

pCi/L - picoCurie per liter

SU - Standard Unit

Monitoring Well		CUF-202													
Sample Date		30-May-18		19-Jun-18		10-Jul-18		31-Jul-18		21-Aug-18		10-Sep-18		02-Oct-18	
Sample Round		1		2		3		4		5		6		7	
Well Designation		Background		Background		Background		Background		Background		Background		Background	
Analyte	Units	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
Arsenic	mg/L	< 0.000323	U	< 0.000499	U*	0.000371	J	0.000328	J	0.000425	J	0.000392	J	< 0.000323	U
Barium	mg/L	0.0199		0.0122		0.0155		0.0215		0.0198		0.0210		0.0220	
Beryllium	mg/L	< 0.0000570	U	< 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	< 0.0327	U*	< 0.0303	U	< 0.0303	U	< 0.0303	U
Cadmium	mg/L	< 0.000125	U	0.000125	J	0.000215	J	0.000247	J	0.000164	J	0.000161	J	0.000210	J
Calcium	mg/L	60.1		66.9		60.7		63.9		58.3		61.2		58.2	
Chromium	mg/L	< 0.000631	U	< 0.00171	U*	< 0.000947	U*	< 0.00171	U*	< 0.00158	U*	< 0.00191	U*	< 0.00146	U*
Cobalt	mg/L	0.0000780	J	0.000103	J	0.000176	J	0.000154	J	0.000114	J	0.000134	J	0.000131	J
Lead	mg/L	< 0.0000940	U	< 0.0000940	U	< 0.0000940	U	< 0.0000940	U	< 0.0000940	U	< 0.0000940	U	< 0.0000940	U
Lithium	mg/L	< 0.00474	U*	0.00302	J	0.00280	J	0.00354	J	0.00299	J	0.00372	J	0.00333	J
Mercury	mg/L	< 0.0000653	U	< 0.0000653	U	< 0.0000653	U	< 0.0000653	U	< 0.0000653	U	< 0.0000653	U	< 0.0000653	U
Molybdenum	mg/L	< 0.00506	U*	0.00893		0.00722		0.00758		0.00624		0.00690		0.00657	
Selenium	mg/L	< 0.000813	U	< 0.000813	U	< 0.000813	U	< 0.000813	U	< 0.000813	U	< 0.000813	U	< 0.000813	U
Thallium	mg/L	< 0.0000630	U	0.000830	J	0.00113		0.00102		0.000941	J	0.000868	J	0.000941	J
Radium 226 + Radium 228	pCi/L	0.281	U	0.210	U	0.280	U*	0.531	U*	0.369	U*	0.289	U*	0.448	U*
Anions															
Chloride	mg/L	1.28		0.978	J	0.819	J	1.42		1.52		0.989	J	1.43	
Fluoride	mg/L	0.222		0.184		0.164		0.178		0.161		0.187		0.214	
Sulfate	mg/L	15.6		12.5	J	11.9		16.8		17.3		12.7		16.9	
General Chemistry															
Total Dissolved Solids	mg/L	219		223		218		229		211		220		237	
Field pH															
pH (field)	SU	7.47		7.42		7.43		7.43		7.33		7.32		7.22	

Notes:

NA - Not Available

Q - Data Qualifier

U* - This result should be considered not detected because it was detected in an associated field or laboratory blank at a similar concentration

UJ - Analyte not detected, but the reporting limit may or may not be higher due to a bias identified during data validation

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

U - Concentration not detected

mg/L - milligrams per liter

pCi/L - picoCurie per liter

SU - Standard Unit

Monitoring Well		CUF-205													
Sample Date		30-May-18		19-Jun-18		11-Jul-18		01-Aug-18		21-Aug-18		12-Sep-18		02-Oct-18	
Sample Round		1		2		3		4		5		6		7	
Well Designation		Downgradient		Downgradient		Downgradient		Downgradient		Downgradient		Downgradient		Downgradient	
Analyte	Units	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
Arsenic	mg/L	0.000386	J	< 0.000639	U*	0.000570	J	0.000667	J	0.000617	J	0.000398	J	0.000480	J
Barium	mg/L	0.0772		0.0796		0.0823		0.0901		0.0910		0.0861		0.0802	
Beryllium	mg/L	< 0.0000570	U*	< 0.0000570	U	< 0.0000570	U	< 0.0000570	U	< 0.0000570	U	< 0.0000570	U	< 0.0000570	U
Boron	mg/L	0.158		0.137		0.130		0.146		0.122		0.138		0.129	
Cadmium	mg/L	0.000224	J	0.000317	J	0.000212	J	0.000211	J	0.000222	J	0.000174	J	0.000171	J
Calcium	mg/L	130		133		127		131		132		125		124	
Chromium	mg/L	< 0.000631	U	< 0.00174	U*	< 0.00113	U*	< 0.00141	U*	< 0.00152	U*	< 0.00106	U*	< 0.00170	U*
Cobalt	mg/L	0.000469	J	0.000512		0.000572		0.00131		0.00156		0.000983		0.000558	
Lead	mg/L	< 0.0000940	U	< 0.0000940	U	< 0.0000940	U	< 0.0000940	U	< 0.0000940	U	< 0.0000940	U	< 0.0000940	U
Lithium	mg/L	< 0.00382	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	UJ	< 0.0000653	U	< 0.0000653	U	< 0.0000653	U	< 0.0000653	U
Molybdenum	mg/L	< 0.000827	U*	0.000956	J	0.000955	J	0.00107	J	0.00122	J	0.000985	J	0.000903	J
Selenium	mg/L	< 0.000813	U	< 0.000813	U	< 0.000813	U	< 0.000813	U	< 0.000813	U	< 0.000813	U	< 0.000813	U
Thallium	mg/L	< 0.0000630	U	< 0.0000630	U	< 0.0000630	U	< 0.0000630	U	< 0.0000630	U	< 0.0000630	U	< 0.0000630	U
Radium 226 + Radium 228	pCi/L	0.337	J	0.558	U	0.414	U*	0.925	U*	1.11	J	0.681	U*	0.344	U*
Anions															
Chloride	mg/L	5.13		3.59	J	4.03		5.62		5.75		3.81		5.42	
Fluoride	mg/L	0.122		0.119		0.0898	J	0.107		0.0591	J	0.0820	J	< 0.156	U*
Sulfate	mg/L	152		135	J	155		163		168		140		152	
General Chemistry															
Total Dissolved Solids	mg/L	476		477		510		510		500		503		500	
Field pH															
pH (field)	SU	6.91		6.96		6.88		6.81		6.98		6.72		6.87	

Notes:

NA - Not Available

Q - Data Qualifier

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UJ - Analyte not detected, but the reporting limit may or may not be higher due to a bias identified during data validation

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

U - Concentration not detected

mg/L - milligrams per liter

pCi/L - picoCurie per liter

SU - Standard Unit

Monitoring Well		CUF-206													
Sample Date		29-May-18		20-Jun-18		11-Jul-18		01-Aug-18		21-Aug-18		11-Sep-18		03-Oct-18	
Sample Round		1		2		3		4		5		6		7	
Well Designation		Downgradient		Downgradient		Downgradient		Downgradient		Downgradient		Downgradient		Downgradient	
Analyte	Units	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
Arsenic	mg/L	0.00993		0.0104		0.0131		0.0121		0.00965		0.0100		0.00934	
Barium	mg/L	0.0985		0.101		0.103		0.0983		0.0931		0.102		0.0970	
Beryllium	mg/L	< 0.0000570	U	< 0.0000570	U	< 0.0000570	U	< 0.0000570	U	< 0.0000570	U	< 0.0000570	U	< 0.0000570	U
Boron	mg/L	20.6		21.4		19.6		20.2		12.5		19.8		18.5	
Cadmium	mg/L	< 0.000125	U	< 0.000125	U	< 0.000125	U	< 0.000125	U	< 0.000125	U	< 0.000125	U	< 0.000125	U
Calcium	mg/L	551		592		566		548		530		546		543	
Chromium	mg/L	< 0.000631	U	< 0.00166	U*	< 0.00147	U*	< 0.00145	U*	< 0.00210	U*	< 0.00219	U*	< 0.000631	U
Cobalt	mg/L	0.000493	J	0.000644		0.000614		0.000647		0.000590		0.000761		0.000578	
Lead	mg/L	< 0.0000940	U	< 0.0000940	U	< 0.0000940	U	< 0.0000940	U	< 0.0000940	U	0.000204	J	< 0.0000940	U
Lithium	mg/L	< 0.00256	U	< 0.00256	U	0.00257	J	< 0.00256	U	0.00719		< 0.00256	U	< 0.00256	U
Mercury	mg/L	< 0.0000653	U	< 0.0000653	U	< 0.0000653	UJ	< 0.0000653	U	< 0.0000653	U	< 0.0000653	U	< 0.0000653	U
Molybdenum	mg/L	< 0.000951	U*	0.000787	J	0.000786	J	0.000796	J	0.000797	J	0.00135	J	0.000800	J
Selenium	mg/L	< 0.000813	U	< 0.000813	U	< 0.000813	U	< 0.000813	U	< 0.000813	U	< 0.000813	U	< 0.000813	U
Thallium	mg/L	< 0.0000630	U	< 0.0000630	U	< 0.0000630	U	< 0.0000630	U	< 0.0000630	U	< 0.0000630	U	< 0.0000630	U
Radium 226 + Radium 228	pCi/L	1.41	J	1.18	J	0.927	J	1.49	J	1.71		1.61		1.88	
Anions															
Chloride	mg/L	663		557		480		659		640		521		516	
Fluoride	mg/L	< 0.0658	U	< 0.132	U	< 0.132	U	< 0.0658	U	< 0.0658	U	< 0.132	U	< 0.132	U
Sulfate	mg/L	1060		888		765		1030		1040		817		878	
General Chemistry															
Total Dissolved Solids	mg/L	2800		2850		2900		3240		3010		2970		2900	
Field pH															
pH (field)	SU	6.52		6.60		6.66		6.61		6.65		6.53		6.50	

Notes:

NA - Not Available

Q - Data Qualifier

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UJ - Analyte not detected, but the reporting limit may or may not be higher due to a bias identified during data validation

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

U - Concentration not detected

mg/L - milligrams per liter

pCi/L - picoCurie per liter

SU - Standard Unit

Table 1 - Assessment Monitoring Groundwater Sampling Results

Monitoring Well		CUF-207													
Sample Date		31-May-18		20-Jun-18		11-Jul-18		01-Aug-18		22-Aug-18		11-Sep-18		03-Oct-18	
Sample Round		1		2		3		4		5		6		7	
Well Designation		Downgradient		Downgradient		Downgradient		Downgradient		Downgradient		Downgradient		Downgradient	
Analyte	Units	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	< 0.00260	U*
Arsenic	mg/L	0.000673	J	< 0.00119	U*	0.000973	J	0.00117		0.00125		< 0.000951	U*	0.000851	J
Barium	mg/L	0.0558		0.0590		0.0561		0.0570		0.0510		0.0588		0.0571	
Beryllium	mg/L	< 0.0000570	U	< 0.0000570	U	< 0.0000570	U	< 0.0000570	U	< 0.0000570	U	< 0.0000570	U	< 0.0000570	U
Boron	mg/L	25.6		27.3		25.8		26.0		24.3		26.7		23.3	
Cadmium	mg/L	< 0.000125	U	< 0.000125	U	< 0.000125	U	< 0.000125	U	< 0.000125	U	< 0.000125	U	< 0.000125	U
Calcium	mg/L	468		494		448		462		446		458		442	
Chromium	mg/L	< 0.000631	U	< 0.00168	U*	< 0.000919	U*	< 0.00128	U*	< 0.00206	U*	< 0.00124	U*	< 0.00128	U*
Cobalt	mg/L	0.000289	J	0.000385	J	0.000356	J	0.000368	J	< 0.000339	U*	0.000350	J	0.000352	J
Lead	mg/L	< 0.0000940	U	< 0.0000940	U	< 0.0000940	U	< 0.0000940	U	< 0.0000940	U	< 0.0000940	U	< 0.0000940	U
Lithium	mg/L	< 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	UJ	< 0.0000653	U	< 0.0000653	U	< 0.0000653	U	< 0.0000653	U
Molybdenum	mg/L	0.0211		0.0205		0.0187		0.0194		0.0202		0.0204		0.0191	
Selenium	mg/L	< 0.000813	U	< 0.000813	U	< 0.000813	U	< 0.000813	U	< 0.000813	U	< 0.000813	U	< 0.000813	U
Thallium	mg/L	< 0.0000630	U	< 0.0000630	U	< 0.0000630	U	< 0.0000630	U	< 0.0000630	U	< 0.0000630	U	< 0.0000630	U
Radium 226 + Radium 228	pCi/L	1.11	U*	0.689	J	0.891		0.972	U*	0.928	U*	0.809	J	0.975	
Anions															
Chloride	mg/L	626		478		475		608		613		488		498	
Fluoride	mg/L	0.201	J	0.202	J	0.142	J	0.120	J	0.503		0.144	J	0.182	J
Sulfate	mg/L	1110		867		844		1070		1110		850		946	
General Chemistry															
Total Dissolved Solids	mg/L	3020		2760		2710		2870		2850		3060		3050	
Field pH															
pH (field)	SU	6.74		6.78		6.82		6.85		6.74		6.73		6.73	

Notes:

NA - Not Available

Q - Data Qualifier

U* - This result should be considered not detected because it was detected in an associated field or laboratory blank at a similar concentration

UJ - Analyte not detected, but the reporting limit may or may not be higher due to a bias identified during data validation

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

U - Concentration not detected

mg/L - milligrams per liter

pCi/L - picoCurie per liter

SU - Standard Unit

Table 1 - Assessment Monitoring Groundwater Sampling Results

Monitoring Well		CUF-208													
Sample Date		31-May-18		20-Jun-18		12-Jul-18		01-Aug-18		22-Aug-18		11-Sep-18		03-Oct-18	
Sample Round		1		2		3		4		5		6		7	
Well Designation		Downgradient		Downgradient		Downgradient		Downgradient		Downgradient		Downgradient		Downgradient	
Analyte	Units	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	< 0.00199	U*
Arsenic	mg/L	0.00311		0.00310		0.00314		0.00366		0.00358		0.00308		0.00276	
Barium	mg/L	0.0324		0.0335		0.0324		0.0354		0.0304		0.0362		0.0358	
Beryllium	mg/L	< 0.0000570	U	< 0.0000570	U	< 0.0000570	U	< 0.0000570	U	< 0.0000570	U	< 0.0000570	U	< 0.0000570	U
Boron	mg/L	12.2		11.8		10.4		10.2		10.1		10.0		9.24	
Cadmium	mg/L	< 0.000125	U	< 0.000125	U	< 0.000125	U	< 0.000125	U	< 0.000125	U	< 0.000125	U	< 0.000125	U
Calcium	mg/L	715		706		672		682		598		625		623	
Chromium	mg/L	< 0.000631	U	< 0.00158	U*	< 0.00133	U*	< 0.00138	U*	< 0.00195	U*	< 0.00153	U*	< 0.00103	U*
Cobalt	mg/L	0.00465		0.00497		0.00548		0.00523		0.00471		0.00496		0.00473	
Lead	mg/L	< 0.0000940	U	< 0.0000940	U	< 0.0000940	U	< 0.0000940	U	< 0.0000940	U	< 0.0000940	U	< 0.0000940	U
Lithium	mg/L	< 0.00280	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
Molybdenum	mg/L	0.00255	J	0.00232	J	0.00222	J	0.00234	J	0.00300	J	0.00361	J	0.00327	J
Selenium	mg/L	< 0.000813	U	< 0.000813	U	< 0.000813	U	< 0.000813	U	< 0.000813	U	< 0.000813	U	< 0.000813	U
Thallium	mg/L	< 0.0000630	U	< 0.0000630	U	< 0.0000630	U	< 0.0000630	U	< 0.0000630	U	< 0.0000630	U	< 0.0000630	U
Radium 226 + Radium 228	pCi/L	0.478	U*	0.465	U*	0.552	U*	0.351	U*	0.407	U*	0.404	U*	0.395	U*
Anions															
Chloride	mg/L	675		527		529		639		577		511		514	
Fluoride	mg/L	0.0786	J	< 0.132	U	< 0.132	U	< 0.0658	U	0.525		< 0.132	U	< 0.132	U
Sulfate	mg/L	1110		877		851		991		887		777		866	
General Chemistry															
Total Dissolved Solids	mg/L	3210		3130		3020		3110		2970		3110		3190	
Field pH															
pH (field)	SU	6.71		6.70		6.65		6.72		6.77		6.70		6.71	

Notes:

NA - Not Available

Q - Data Qualifier

U* - This result should be considered not detected because it was detected in an associated field or laboratory blank at a similar concentration

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

U - Concentration not detected

mg/L - milligrams per liter

pCi/L - picoCurie per liter

SU - Standard Unit

Well ID	Well Designation	Number of Samples Collected	May 29-31, 2018	June 19-20, 2018	July 10-12, 2018	July 31-August 1, 2018	August 20-22, 2018	September 10-12, 2018	October 2-3, 2018	Assessment Monitoring Program
CUF-201	Background	7	X	X	X	X	X	X	X	Assessment Monitoring - 257.95(a); 257.95(b); 257.95(d)(1) - Appendix III and Appendix IV Constituents
CUF-202	Background	7	X	X	X	X	X	X	X	Assessment Monitoring - 257.95(a); 257.95(b); 257.95(d)(1) - Appendix III and Appendix IV Constituents
CUF-205	Downgradient	7	X	X	X	X	X	X	X	Assessment Monitoring - 257.95(a); 257.95(b); 257.95(d)(1) - Appendix III and Appendix IV Constituents
CUF-206	Downgradient	7	X	X	X	X	X	X	X	Assessment Monitoring - 257.95(a); 257.95(b); 257.95(d)(1) - Appendix III and Appendix IV Constituents
CUF-207	Downgradient	7	X	X	X	X	X	X	X	Assessment Monitoring - 257.95(a); 257.95(b); 257.95(d)(1) - Appendix III and Appendix IV Constituents
CUF-208	Downgradient	7	X	X	X	X	X	X	X	Assessment Monitoring - 257.95(a); 257.95(b); 257.95(d)(1) - Appendix III and Appendix IV Constituents

Notes:

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

Table 3
Groundwater and Surface Water Elevation Summary

Groundwater Elevation Collection Date		29-May-18	18-Jun-18	10-Jul-18	31-Jul-18	20-Aug-18	10-Sep-18	01-Oct-18
Monitoring Well	**Units**							
CUF-201	ft-MSL	388.72	388.64	388.41	388.27	388.10	388.23	388.26
CUF-202	ft-MSL	378.16	377.04	377.08	377.29	376.69	377.87	378.32
CUF-205	ft-MSL	366.72	366.55	365.72	364.52	363.47	366.33	367.83
CUF-206	ft-MSL	364.90	364.53	362.89	361.97	361.42	360.81	361.84
CUF-207	ft-MSL	365.25	364.80	363.03	362.11	361.61	360.98	361.90
CUF-208	ft-MSL	361.93	361.72	360.57	359.52	359.30	358.84	359.82
Cumberland River	ft-MSL	359.37	NA	NA	357.27	356.96	355.67	357.21

NA - Surface water elevation data not available from iSite Central System from 6/15/18 to 6/20/18 and from 6/29/18 to 7/18/18.

Table 4 - Hydraulic Conductivity Data Summary

Well ID	Well Designation	Slug Test Hydraulic Conductivity (cm/sec)
CUF-201	Background	5.9E-05
CUF-202	Background	2.948E-05
CUF-205	Downgradient	2.779E-03
CUF-206	Downgradient	6.224E-02
CUF-207	Downgradient	5.353E-03
CUF-208	Downgradient	4.586E-04
Geometric Mean of Hydraulic Conductivity (cm/sec)		**9.5E-04**

Notes:

cm/sec - centimeters per second

Table 5 - Groundwater Protection Standards

Chemical Name	Unit	GWPS / BTV*
Antimony	mg/L	0.006
Arsenic	mg/L	0.01
Barium	mg/L	2
Beryllium	mg/L	0.004
Boron	mg/L	0.0318*
Cadmium	mg/L	0.005
Calcium	mg/L	75.5*
Chloride	mg/L	2.01*
Chromium	mg/L	0.1
Cobalt	mg/L	0.006
Fluoride	mg/L	4
Lead	mg/L	0.015
Lithium	mg/L	0.04
Mercury	mg/L	0.002
Molybdenum	mg/L	0.1
pH (field)	SU	6.24 - 8.13*
Radium 226 + Radium 228	pCi/L	5
Selenium	mg/L	0.05
Sulfate	mg/L	17.6*
Thallium	mg/L	0.002
Total Dissolved Solids	mg/L	230*

Notes:

GWPS - Groundwater Protection Standard

* - BTV - Background Threshold Values for Appendix III Constituents (2017)

mg/L - milligrams per liter

SU - standard units

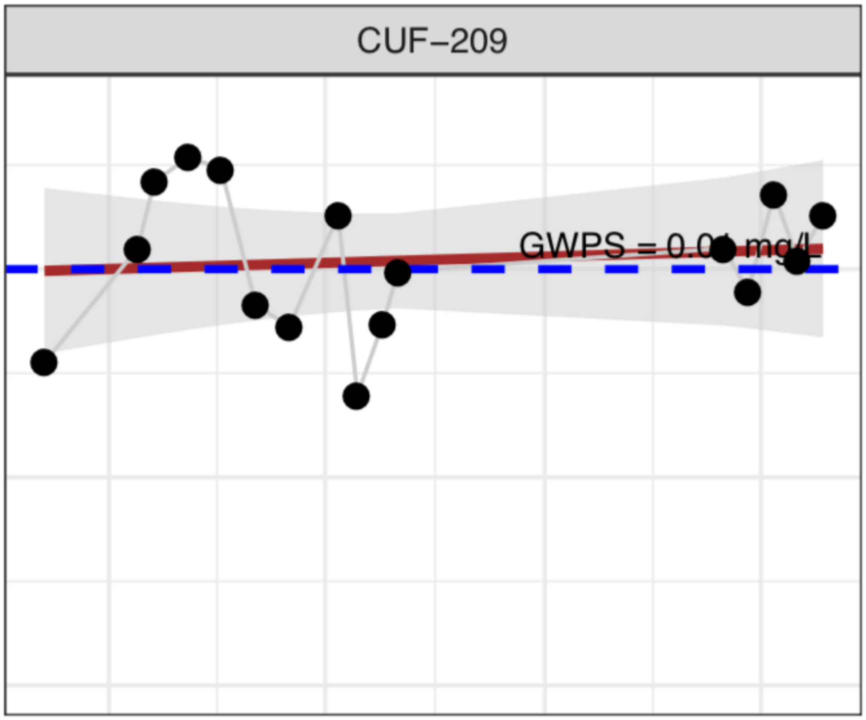
pCi/L - picocuries per liter

N/A - not applicable

APPENDIX A
STATISTICAL ANALYSIS REPORT

STATISTICAL ANALYSIS REPORT FOR CUMBERLAND FOSSIL PLANT

2018



1/15/2019

Contents

Tables

1 Introduction

This report summarizes the statistical analysis performed on groundwater quality constituents monitored during Year-Two of the Coal Combustion Residuals (CCR) Rule's Ground Water Quality Monitoring (GWQM) Program for the Multi-Unit Area and the Stilling Pond and Retention Pond at the Tennessee Valley Authority (TVA) Cumberland Fossil Plant (CUF). During the first year of the establishment of TVA's CCR-Rule GWQM Program, all thirteen of the CCR-Units that are located at nine of TVA's fossil plants were monitored for the Appendix III and Appendix IV constituents to establish baseline conditions at each site.

The United States Environmental Protection Agency (USEPA) required all Owners and/or Operators of fossil plants to establish the baseline groundwater-quality conditions using only eight sampling events, collected roughly over a period of one year. As a follow-up to the establishment of baseline groundwater-quality conditions, USEPA also required the subsequent performance of at least a single sampling event, under a monitoring phase known as 'Detection Monitoring,' to collect samples for chemical-laboratory analysis of Appendix III constituents.

Although most Appendix III constituents are naturally occurring chemicals in groundwater, USEPA requires analysis of these constituents to determine if a CCR Unit shows signs of contributing contamination to a 'usable aquifer.' It should be noted that the definition of 'usable aquifer' is undefined with respect to its quantity and/or quality by the authors of the CCR Rule and, as such, it is left up to the purview of the Owners and/or Operators' commissioned geo-hydrological professional(s), who must be State-level registered and actively licensed Professional Engineer(s) (PE), with demonstrable competency in the subject areas of groundwater resources evaluations, requiring a thorough understanding of hydrogeological criteria and methodologies.

Summarizing the Year-One results, selected values of the analytical Appendix III constituents observed during the Detection Monitoring Event exceeded the established Upper Prediction Limits established from the baseline data at all CCR-Rule monitored units. The CCR Rule allows for potential sources of error or alternative sources of the exceedances to be determined via an 'Alternate Source Demonstration' (ASD). However, largely due to the presence of boron (a constituent with no MCL and producing no identifiable toxicological risk at the levels observed), along with USEPA's imposed fast-track deadlines, there was insufficient time to perform statistical retesting or to properly study the problems to understand the potential alternative sources for the reported exceedances during the first year of the CCR-Rule GWQM Program. Consequently, out of TVA's thirteen CCR units monitored and assessed during Year-One of the Program, only three of the units were exempt from the requirements to switch into a phase of the CCR Rule known as 'Assessment Monitoring' in order to monitor for the list of Appendix IV constituents shown on the right-hand column of **Table 2**.

As part of this year's efforts (i.e., Year-Two), the baseline datasets for Year-One and those results obtained during Year-Two of the CCR-Rule GWQM Program were evaluated in order to establish statistically-derived Groundwater Protection Standards (GWPS) for each of the CCR Units located at six of TVA's fossil plant sites. As presented in USEPA's Unified Guidance document on the statistical analysis of groundwater monitoring data (2009), confidence-interval (CI) bands are a recommended technique for performing statistical comparisons against GWPS. In particular, trends at downgradient wells in analytical concentrations from laboratory analysis of Constituents of Interest (COI) can be plotted and used to estimate CI bands, which in turn can be compared against relevant GWPS. A statistically significant level (SSL) is found if and only if the lower limit of the CI band exceeds the GWPS for the most recent Assessment Monitoring sampling event.

As also required by the United States Environmental Protection Agency's (USEPA's) Coal Combustion Residuals (CCR) Rule section describing the Assessment Monitoring Program (§257.95), test results for the Year-Two Assessment Monitoring events were compared to the GWPS for determination of all exceedances. Additional description of how the GWPS for each COI and each CCR Unit were established is provided in subsequent sections of this report.

At the CUF plant's CCR Unit, the sampling results used to identify potential GWPS exceedances were obtained during a minimum of five distinct monitoring events that were performed between May of 2018 and August of 2018 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.

For those wells at which exceedances of GWPS 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 as to the reasons for such exceedances (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 IV 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 networks — one for Stilling and Retention Pond and one for the Multi-Unit area — as Certified by a Professional Engineer at the firm of AECOM or other, are 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) 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.

Table 1. CCR Rule Monitoring Well Networks

Background	Downgradient (Stilling Pond)		Downgradient (Multi-Unit)	
CUF-201 CUF-202	CUF-205 CUF-206	CUF-207 CUF-208	CUF-209 CUF-211	93-2R CUF-212 93-3

Groundwater samples collected as part of the CCR Rule monitoring program were analyzed for constituents listed in Appendix IV of the CCR Rule. Only non-filtered sample results were utilized for the statistical analysis of Appendix IV 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 IV constituents, filtered samples were also collected to better understand and/or dispel the potential source(s) of falsely-named GWPS exceedances. A summary of constituents included in the data analysis is provided in **Table 2.**

Table 2. CCR Rule Monitored Constituents

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

2 Statistical Analysis

The basic steps in the Assessment Monitoring analysis for Year-Two data included the following:

1) Developing groundwater protection standards (GWPS) for each Appendix IV constituent, using published MCLs and/or water quality limits, along with baseline data from upgradient and background well locations at each CCR site;
2) Computing trends and associated confidence interval (CI) bands for each well location and Appendix IV constituent (i.e., each well-constituent pair); and
3) Comparing each CI band against its respective GWPS to assess whether an exceedance 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 4**. 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.

2.1 Developing Groundwater Protection Standards (GWPS)

USEPA has published Maximum Contaminant Limits (MCL) or alternate regulatory limits for each of the Appendix IV constituents. Consequently, in most cases the groundwater protection standard (GWPS) is equal to the MCL. However, there may be cases where background levels of a constituent exceed the MCL. In these instances, an alternate GWPS must be derived from on-site background levels.

On July 17, 2018, EPA unofficially promulgated alternate regulatory limits (i.e., potential GWPS) for four of the Appendix IV chemical Constituents of Interest (COIs) for which the agency has not assigned MCLs to date. In the absence of MCLs or site-specific GWPS, those may be used in place of background levels under 257.95(h)(2). Specifically, those alternate COIs include threshold values at the following health-based levels:

1. Cobalt - 6 µg/L
2. Lithium - 40 µg/L
3. Molybdenum – 100 µg/L
4. Lead - 15 µg/L.

According to the promulgated CCR Rule (80 Federal Register 21302, 21405, April 17, 2015):

"For each appendix IV constituent that is detected, a groundwater protection standard must be set. The groundwater protection standards must be the MCL or the background concentration level for the detected constituent, whichever is higher. If there is no MCL promulgated for a detected constituent, then the groundwater protection standard must be set at background."

The CCR Rule is also consistent with EPA's Unified Guidance for the statistical analysis of groundwater monitoring data, which states:

"But a number of situations arise where a GWPS must be based on a background limit. The Part 264 regulations presume such a standard as one of the options under §264.94(a); an ACL may also be determined from background under §264.94(b).

"More recent Part 258 rules specify a background GWPS where a promulgated or risk-based standard is not available or if the historical background is greater than an MCL [§258.55(h)(2) & (3)]." (USEPA, Unified Guidance, 2009, p. 7-20).

Based on these rules and guidance, TVA has established GWPS across its CCR program using the following decision logic:

1. For each Appendix IV parameter where a GWPS must be established, a comparison is made between the promulgated regulatory limit and a site-specific limit computed from background data.
2. If the background-based limit is larger than the promulgated limit, the GWPS is set to the background limit. But if the promulgated limit is larger, the GWPS is set to the published value.

In cases where a background limit must be computed, USEPA's Unified Guidance recommends different strategies for computing a background-based GWPS (USEPA, Unified Guidance, 2009, Section 7.5). One of these strategies — a 95% confidence, 95% coverage upper tolerance limit (UTL) on background — was selected and used to compute the UTL on site-specific background data for each Appendix IV parameter. Then these UTLs were compared against the promulgated regulatory limits to determine the site-specific GWPS.

For the Cumberland Fossil Plant (CUF), **Table 3, included below,** lists the calculated UTLs and final GWPS established for these particular CCR Units. Note that for all the constituents, the background-based UTL was smaller than the MCL or proposed alternate regulatory limit. Also, the same set of GWPS were used at both CCR units, since the two units shared a common set of background wells.

Table 3. CUF Groundwater Protection Standards (GWPS)

COI	N	ND.PCT	MODEL	COV	CONF	UTL	UNITS	MCL	GWPS
Antimony	32	96.9	NP	0.95	0.8063	0.0020	mg/L	0.006	0.006
Arsenic	32	31.2	NP	0.95	0.8063	0.0051	mg/L	0.01	0.01
Barium	32	0	NORMAL	0.95	0.9500	0.0377	mg/L	2	2
Beryllium	32	100	NP	0.95	0.8063	0.0010	mg/L	0.004	0.004
Cadmium	32	71.9	NP	0.95	0.8063	0.0010	mg/L	0.005	0.005
Chromium	32	100	NP	0.95	0.8063	0.0020	mg/L	0.1	0.1
Cobalt*	32	9.4	Log	0.95	0.9500	0.0026	mg/L	0.006	0.006
Fluoride	34	11.8	NORMAL	0.95	0.9500	0.2532	mg/L	4	4
Lead	32	100	NP	0.95	0.8063	0.0010	mg/L	0.015	0.015

COI	N	ND.PCT	MODEL	COV	CONF	UTL	UNITS	MCL	GWPS
Lithium*	32	68.8	Cube Root	0.95	0.9500	0.0040	mg/L	0.04	0.04
Mercury	32	100	NP	0.95	0.8063	0.0002	mg/L	0.002	0.002
Molybdenum*	32	6.2	Log	0.95	0.9500	0.0135	mg/L	0.1	0.1
Rad226+228	31	0	NORMAL	0.95	0.9500	1.0584	pCi/L	5	5
Selenium	32	100	NP	0.95	0.8063	0.0050	mg/L	0.05	0.05
Thallium	32	62.5	Cube	0.95	0.9500	0.0012	mg/L	0.002	0.002

* No potential Health Effects provided for these Constituents of Interests (COI) - See Appendix “C”

To compute each upper tolerance limit (UTL), the following steps were taken:

1) All baseline data - those from designated up-gradient or background wells collected up through from the Program’s first sampling event through August of 2018 were grouped and checked for possible outliers.

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. In a boxplot, the length of the box is the range of the central 50% of the sorted measurements. Tukey’s original outlier rule states that any observation more than 1.5 box lengths above or below the edges of the boxplot classifies as a possible outlier. For stable, symmetric data distributions, Tukey’s rule often works well.

Groundwater data is often skewed instead of symmetric, and may exhibit shorter (i.e., localized) or longer-term (non-linear) trends. Because of this reality, a modified version of Tukey’s rule is generally needed to avoid classifying too many possible outliers. The modification consists of two parts: a) a possible outlier is only flagged if flagged both on the nominal scale of measurement as well as on the log-scale (i.e., when each observation is first mathematically transformed by taking a logarithm); and b) an outlier is only flagged if more than 3 box lengths above the edges of the boxplot. Together, these modifications better account for data skewness and localized trends in the background observations.

If any possible outliers are flagged, they are visually compared against observations at other well locations. If similar patterns or measurement ranges are common, the suspect values are kept in the data. If not, the suspected outliers are formally assessed using Rosner’s outlier test. Any confirmed outliers are excluded from the UTL computations.

At CUF, no likely outliers among the background data were flagged.

2) The grouped baseline data were also analyzed to determine whether they could be fit to a known statistical model. If so, a parametric UTL was computed; if not, a nonparametric UTL 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. Models tested ranged from the tenth root to the tenth power and included the null transformation (power = 1), which assumes the data are normally distributed without transformation, the logarithm, which models the lognormal distribution, and the cube root, which closely mimics the gamma distribution.

The transformation which most nearly normalized the data was then formally tested using Filliben's probability plot correlation coefficient test. Filliben's test checks for normality of the transformed measurements by computing the correlation between the data and matched quantiles (i.e., z-scores) from a standard normal distribution. The process is exactly parallel to fitting a line on a normal probability plot of the (transformed) data. The closer to a linear fit, the higher the correlation; the further from a linear fit, the smaller the correlation. Filliben's test formally assesses the strength of the correlation to determine whether it is high enough to declare that the data are consistent with a normal distributional model.

Filliben's test yields a p-value measuring the statistical significance of the result. A p-value no less than 0.01 was judged as sufficient to assume normality of the (transformed) observations, while data with a Filliben's test p-value less than 0.01 were judged significantly non-normal. Datasets passing Filliben's test were assumed to have a parametric model corresponding to the transformation employed, e.g., data tested on the log-scale were assumed consistent with the lognormal distribution; data tested on the square root scale were assumed consistent with the square-root normal distribution, and so on.

Datasets which could not be sufficiently normalized, thus failing Filliben's test, were analyzed by nonparametric means. In many instances, this may occur when the data includes a large fraction of non-detects. **Table 3** lists a shorthand for the statistical model utilized for each Constituent of Interest (COI) under the Model column (e.g., NP stands for nonparametric, Cube Root is the cube root transformation, Log stands for the logarithm, implying a lognormal model, NORMAL represents the null transformation, implying a normal model, etc.)

3) The final statistical model for each COI was used to compute an upper tolerance limit (UTL) with 95% coverage and 95% confidence.

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

$$UTL = \overline{x} + \kappa s$$

where $\overline{x}$ 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, as well as the desired coverage and confidence levels. If the data have been transformed, the final UTL is derived by back-transforming the scaled UTL, 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 UTL is selected as one of the largest of the sample values, typically the maximum. Because there is no multiplier as in the parametric case, the confidence level associated with a nonparametric UTL is computed 'after the fact,' based on the sample size and desired coverage level: the smaller the sample size, the lower the confidence; the bigger the sample size, the higher the confidence level.

For the CUF site, **Table 3** illustrates a fundamental tradeoff. Nonparametric UTLs do not assume a known statistical model, but for a baseline sample size of, say, 32, the cost is that the achieved confidence level is somewhat lower than the target of 95%. The net effect of a lower confidence level is akin to a poor archer. A good archer will aim and hit the target a high percentage of the time, while a poor archer will often miss. The target in this analogy is the desired coverage level. One might ask: Will the UTL exceed 95% of the population of groundwater measurements as targeted? A low confidence suggests that the target will often be missed, meaning that a more accurate UTL would be larger than the one computed from the available sample data. Unfortunately, without a statistical model, and especially with a large percentage of non-detects, little improvement is possible in the UTL estimates unless a larger sample size is employed.

Table 4. Descriptive Summary Statistics of Background Data

Constituent	Units	N	No. of NDs	Minimum	Maximum	Mean	Median
Antimony	mg/L	32	31	0.0006	0.0020	0.0006	0.0013
Arsenic	mg/L	32	14	0.0003	0.0031	0.0012	0.0010
Barium	mg/L	32	0	0.0206	0.0852	0.0471	0.0422
Beryllium	mg/L	32	32	0.0010	0.0010	0.0005	0.0010
Cadmium	mg/L	32	16	0.0001	0.0010	0.0003	0.0003
Chromium	mg/L	32	19	0.0005	0.0025	0.0007	0.0006
Cobalt	mg/L	32	13	0.0001	0.0011	0.0003	0.0003
Lead	mg/L	32	4	0.0306	0.2880	0.1295	0.0880
Lithium	mg/L	32	25	0.0001	0.0010	0.0002	0.0002
Mercury	mg/L	32	20	0.0022	0.0099	0.0040	0.0038
Molybdenum	mg/L	32	32	0.0002	0.0002	0.0001	0.0002
Radium 226 + 228	pCi/L	32	3	0.0006	0.0955	0.0413	0.0379
Selenium	mg/L	30	0	0.0190	2.5300	0.8943	0.8175
Thallium	mg/L	32	31	0.0024	0.0050	0.0024	0.0037

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.

2.2 Computing Trend Lines and Confidence Interval Bands

USEPA's Unified Guidance recommends comparing some type of confidence interval (CI) against a groundwater protection standard (GWPS) in order to assess whether or not the limit has been exceeded with statistical significance. If the entire interval exceeds the GWPS, a statistically significant level (SSL) is identified. If none of the interval, or only part, exceeds the GWPS, no SSL is recorded.

The rationale behind this procedure is predicated on the following:

1) A confidence interval is typically designed to 'contain' or 'capture' a specific target or feature of the underlying groundwater population, usually the mean or median measurement value. An interval rather than a point estimate is utilized because that is the only way to ensure the target is captured with a high degree of statistical confidence.

2) When a confidence interval is entirely on one side or the other of a fixed numerical limit, the confidence is high that the desired population target is also to that side of the limit.

3) Because the target may exist anywhere in the range represented by the confidence interval, an interval that 'straddles' the fixed limit is not guaranteed to be either above or below the GWPS, and certainly not with high or known statistical confidence.

USEPA's logic ensures that a correct decision about the occurrence of an SSL can be made with high statistical assurance.

Since groundwater data are collected over time, and not all at once, some or most of the variation in the measurements may be due to a trend. To better account for this possibility, USEPA also recommends a variation on the confidence interval method known as a confidence interval band around a trend line. In this case, a (linear) trend line is first fit to the data, then a confidence band is constructed around the trend line. The confidence interval band can be compared against a GWPS in much the same fashion as a confidence interval, only now a comparison can be made at different points in time by comparing the 'cross-section' of the band for a given sampling date. If the interval represented by the confidence band cross-section fully exceeds the GWPS, an SSL is identified for that sampling event.

At TVA's CCR sites, including CUF, CI bands were constructed (as described below) for each well-constituent pair using all data collected through August of 2018. Cross-sections of each band were then compared to the GWPS for the most recent Assessment Monitoring event in each case for the purpose of identifying any SSLs. Note that in cases where the data are obviously trending, the CI band technique provides a much more powerful and accurate means of judging exceedances above GWPS. Ignoring a trend typically makes a standard confidence interval much too wide and uncertain to be of much use, due to the extra variation imparted by the trend. For data that are more stable, both methods will tend to give similar results.

2.2.1 Trend Lines Using Linear Regression

Unless there are extreme outliers and/or curvature in the data, linear regression provides a standard and well-tested method for estimating the linear portion of a trend. The slope of the regression line points to the magnitude and direction of the trend. There is also a standard method for computing a confidence band around a linear regression trend line. For instance, equations [21.24] and [21.25] of Section 21.3 in the Unified Guidance can be compactly written as follows:

$$CB_{1-\alpha} = \hat{x}_0 \pm \sqrt{2s_e^2 \cdot F_{1-\alpha,2,n-2} \cdot \left[\frac{1}{n} + \frac{\left(t_0 - \overline{t}\right)^2}{\left(n-1\right)s_t^2} \right]}$$

where CB = confidence band, $\hat{x}_0$ is the regression line estimate at time t_0, s_e^2 is the mean squared error of the regression line, *F* is a quantile from the F-distribution with 2 and n–2 degrees of freedom, and $\overline{t}$ and s_t^2 represent the mean and standard deviation of the sampling dates.

For well-constituent pairs with no non-detects, linear regression and the formula above were used to construct each confidence band with 98% overall confidence, corresponding to a lower confidence limit with 99% confidence. When non-detects are present, the same formulas apply but an adjustment must be made for the censored measurements. The strategy adopted for TVA's CCR sites involves the following steps:

1) Each non-detect is assumed to follow a triangle distribution centered at half the (sample-specific) reporting limit, and with limits extending from zero to the reporting limit. Then an imputation for each non-detect is randomly drawn from this distribution;
2) The combined set of detected values and imputed non-detects are used to estimate a linear regression trend line and associated confidence band with 98% statistical confidence;
3) Steps (1) and (2) are repeated 500 times, each time with a different set of random imputations, leading to 500 potentially different trend lines and confidence bands;
4) The 500 sets of trends lines and bands are averaged point-wise (i.e., at each time along a sequence of dates spanning the time range of the data) to compute the final trend and confidence band estimates.

By repeating this sequence of steps a large number of times (500), the uncertainty associated with the non-detects can be reasonably captured within the final CI band estimate.

2.2.2 Outliers

Prior to constructing any of the confidence interval (CI) bands, the data at each well-constituent pair were examined for possible outliers. As with the grouped background data, visual examination was done with time series plots and the modified Tukey's boxplot rule was utilized for initial screening. For the CUF site, no observations were flagged as potential outliers in the Stilling Pond network, but two potential outliers were identified in the Multi-Unit area network. Of these, one observation was confirmed as an outlier by Rosner's test: a value of 0.0575 for Radium 226+228 at well location CUF-209. This value was excluded from subsequent statistical calculations.

2.3 Comparing Confidence Interval Bands Against GWPS

To assess whether any SSLs occurred during the 2018 Assessment Monitoring at TVA's CCR sites, the confidence interval (CI) bands described in **Section 2.2** were compared against the constituent-specific groundwater protection standards (GWPS) described in **Section 2.1**. Of note, an SSL was identified if and only if the CI band fully exceeded the GWPS at the *most recent* sampling event.

To clarify the importance of this last statement, consider the difference in statistical approach between Detection Monitoring and Assessment Monitoring. When utilizing prediction limits in Detection Monitoring, at least two sampling events per year must be collected and evaluated to determine whether there are any SSIs above background levels. Each prediction limit is derived from the baseline or background data, then each new compliance point value is compared against its respective prediction limit. If the newest compliance value exceeds the limit, a potential SSI is flagged, to be confirmed or disconfirmed via additional resampling and retesting.

The statistical approach in Assessment Monitoring is different. Comparisons are made against a fixed GWPS via a confidence interval or confidence interval band. No retesting is conducted and none of the individual compliance point measurements are directly compared against the GWPS. Instead, multiple compliance observations must be used to construct each confidence interval or CI band, necessarily at least four and preferably 8 to 10 or more. Consequently, all the Assessment Monitoring data collected both in Year-One and Year-Two were used to construct the CI bands. Furthermore, a well-constituent pair is considered out of compliance only if its constituent levels currently exceed the GWPS. This is best assessed by considering the cross-section of the CI band associated with the most recent sampling event. A summary of the SSLs is displayed in **Table 5** of **Section 3**.

3 Summary of Statistical Analysis

To facilitate an ‘at-a-glance’ summary of the statistical comparison results, **Tables 5 and 6** are ‘traffic light’ matrices, showing for each CCR network a compact representation of each well location matched against each constituent in Appendix IV. This summary is useful in planning for mitigation actions. Green cells indicate that no SSL was observed in 2018. Red cells indicate the opposite: an SSL was flagged during the most recent sampling events. Yellow cells are warnings which indicate that a well-constituent pair should be closely watched. These cases have increasing trends and a CI band whose lower limit is at least 65% of the GWPS. Often, the CI band cross-section straddles the GWPS in yellow cells.

At the CUF Multi-Unit site (Table 5), one cobalt-related SSL during year-two of the Program was recorded at well CUF-212 and for lithium at well 93-3. Warning flags (yellow) were raised for arsenic at CUF-209 and CUF-211, for cobalt at well CUF-211. At the Stilling and Retention Pond network (Table 6), one arsenic-related SSL was found at well CUF-206, but no additional warning flags. In summary, a total of three SSLs and three warnings were identified across the Program network wells that are located near to the CUF plant’s CCR Units during the year-two monitoring phase.

Table 5. CUF Plant's Multi-Unit GW Monitoring Network - Traffic Light Matrix Based on Comparative Analysis of Statistical Analysis Results versus Groundwater Protection Standards (GWPS)

ITEM No.	TRAFFIC LIGHT MATRIX							
	Constituent of Interest	GROUNDWATER QUALITY MONITORING WELL LOCATIONS						
		CUF-201	CUF-202	CUF-209	CUF-211	93-2R	CUF-212	93-3
1.	Antimony	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
2.	Arsenic	GREEN	GREEN	YELLOW	YELLOW	GREEN	GREEN	GREEN
3.	Barium	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
4.	Beryllium	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
5.	Cadmium	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
6.	Chromium	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
7.	Cobalt	GREEN	GREEN	GREEN	YELLOW	GREEN	RED	GREEN
8.	Fluoride	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
9.	Lead	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
10.	Lithium	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	RED
11.	Mercury	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
12.	Molybdenum	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
13.	Rad226+228	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
14.	Selenium	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
15.	Thallium	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN

COLOR-CODING KEY:	
(green)	Monitored data for the specific COI are deemed to fall below GWPS
(yellow)	Monitored data are deemed to fall below GWPS, but an internal warning is issued to TVA staff that CI band lower limit is at least 65% of the GWPS.
(red)	Monitored data for the specific COI are deemed to exceed GWPS

Table 6. CUF Plant's Stilling and Retention Pond - Traffic Light Matrix Based on Comparative Analysis of Statistical Analysis Results versus Groundwater Protection Standards (GWPS)

ITEM No.	TRAFFIC LIGHT MATRIX						
	Constituent of Interest	GROUNDWATER QUALITY MONITORING WELL LOCATIONS					
		CUF-201	CUF-202	CUF-205	CUF-206	CUF-207	CUF-208
16.	Antimony	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
17.	Arsenic	GREEN	GREEN	GREEN	RED	GREEN	GREEN
18.	Barium	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
19.	Beryllium	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
20.	Cadmium	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
21.	Chromium	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
22.	Cobalt	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
23.	Fluoride	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
24.	Lead	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
25.	Lithium	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
26.	Mercury	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
27.	Molybdenum	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
28.	Rad226+228	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
29.	Selenium	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
30.	Thallium	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN

COLOR-CODING KEY:	
(green)	Monitored data for the specific COI are deemed to fall below GWPS
(yellow)	Monitored data are deemed to fall below GWPS, but an internal warning is issued to TVA staff that CI band lower limit is at least 65% of the GWPS.
(red)	Monitored data for the specific COI are deemed to exceed GWPS

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 20460