APPENDIX E –
STATISTICAL ANALYSES

APPENDIX E.1

STATISTICAL ANALYSIS OF BACKGROUND SOIL DATA

Appendix E.1 – Statistical Analysis of Background Soil Data

TDEC Commissioner's Order:
Environmental Assessment Report
Kingston Fossil Plant
Harriman, Tennessee

March 12, 2024

Prepared for:

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APPENDIX E.1 – STATISTICAL ANALYSIS OF BACKGROUND SOIL DATA

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Sign-off Sheet

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Abbreviations

BGS	Background Soil
BTVs	Background Threshold Values
CASRN	Chemical Abstracts Service Registry Number
CCR	Coal Combustion Residuals
CCR Parameter	Constituents listed in Appendices III and IV of 40 CFR 257 and five inorganic constituents included in Appendix I of Tennessee Rule 0400-11-01-.04
CCR Rule	Title 40, Code of Federal Regulations, Part 257
EAR	Environmental Assessment Report
EI	Environmental Investigation
ft bgs	Feet Below Ground Surface
IQR	Interquartile Range
KIF Plant	Kingston Fossil Plant
NA	Not Available
%	Percent
SAR	Sampling and Analysis Report
Stantec	Stantec Consulting Services Inc.
TDEC	Tennessee Department of Environment and Conservation
TVA	Tennessee Valley Authority
UTLs	Upper Tolerance Limits

1.0 INTRODUCTION

Stantec Consulting Services Inc. (Stantec) prepared this statistical analysis report on behalf of the Tennessee Valley Authority (TVA) to summarize the statistical analyses performed on background soil (BGS) data to support evaluations conducted for the Environmental Assessment Report (EAR) at the Kingston Fossil Plant (KIF Plant) located in Harriman, Tennessee. The BGS samples were collected as part of the Tennessee Department of Environment and Conservation (TDEC) Order Environmental Investigation (EI) between March 2019 and February 2020 in the vicinity of the KIF Plant from locations where naturally occurring, *in situ*, native soils unaffected by Coal Combustion Residual (CCR) materials were present. Further details regarding the BGS sampling program and results are available in the *KIF Plant Background Soil Investigation Sampling and Analysis Report* (SAR) (Appendix F.1), including the BGS investigation boring locations (Exhibit A.2), and a list of the BGS investigation borings and associated soil samples and analyses (Table B.1).

21 samples were excluded from the statistical analysis datasets for being collected in the saturated zone. The Constituents listed in Appendices III and IV of 40 CFR 257 and five inorganic constituents included in Appendix I of Tennessee Rule 0400-11-01-.04 (CCR Parameters) included in the analysis are presented below in Table E.1-1.

Table E.1-1 – CCR Parameters Evaluated in Statistical Analysis

Parameter	CASRN
CCR Rule Appendix III Parameters	
Boron	7440-42-8
Calcium	7440-70-2
Chloride	16887-00-6
Fluoride[1] (also Appendix IV)	16984-48-8
pH	NA
Sulfate	14808-79-8
TDS	NA
CCR Rule Appendix IV Parameters	
Antimony	7440-36-0
Arsenic	7440-38-2
Barium	7440-39-3
Beryllium	7440-41-7
Cadmium	7440-43-9
Chromium	7440-47-3
Cobalt	7440-48-4
Lead	7439-92-1
Lithium	7439-93-2
Mercury	7439-97-6
Molybdenum	7439-98-7
Radium-226+228	13982-63-3/ 15262-20-1
Selenium	7782-49-2
Thallium	7440-28-0
TDEC Appendix I Parameters	
Copper	7440-50-8
Nickel	7440-02-0
Silver	7440-22-4
Vanadium	7440-62-2
Zinc	7440-66-6
Other	
% Ash	NA

Notes: CASRN - Chemical Abstracts Service Registry Number; CCR Rule - Title 40, Code of Federal Regulations, Part 257; NA - Not available; % - Percent
[1]Fluoride is both a CCR Rule Appendix III and CCR Rule Appendix IV parameter. In this table, and in the results presented herein, fluoride has been grouped with the Appendix III parameters only to avoid duplication.

The following sections present the methods and results from general exploratory data analysis using summary statistics, data plots, outlier screening methods and the calculation of Background Threshold Values (BTVs).

2.0 METHODS

The statistical evaluation for the BGS data collected at the KIF Plant for the EI was conducted in two parts: 1) exploratory data analysis and 2) calculation of site-specific BTVs. The analyses relied on available background soil data collected as part of the BGS EI. Quality assurance and quality control samples (e.g. field duplicates) were excluded from the statistical analysis.

2.1 EXPLORATORY DATA ANALYSIS

Exploratory data analysis is the initial step of statistical analysis. It utilizes simple summary statistics (e.g. mean, median, standard deviation and percentiles) and graphical representations to identify important characteristics of an analytical dataset, such as the center of the data (mean, median), variation, distribution, spatial patterns, presence of outliers, and randomness.

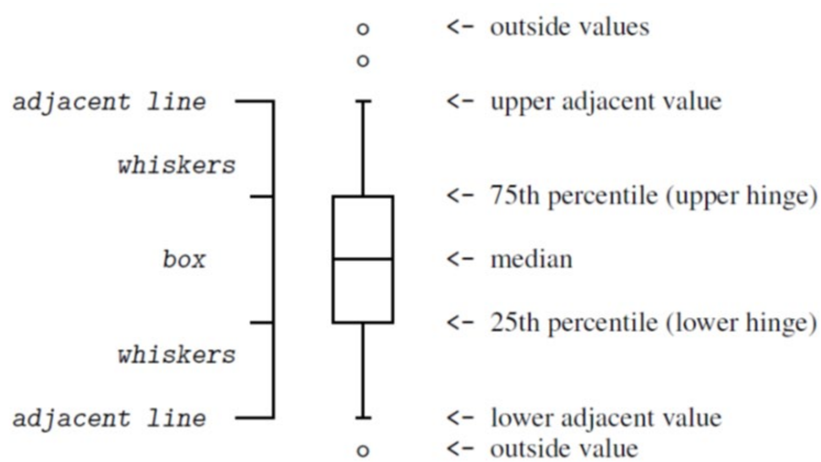
For the EI, surficial soil samples were typically collected at depths ranging from 0.0 to approximately 0.5 feet below ground surface (ft bgs). In addition to the CCR parameters (Table E.1-1), these samples were analyzed for the presence of CCR Material (% Ash). Along with surficial samples, the field sampling personnel collected approximately two feet of soil from each five-foot soil run (one foot in both directions from the midpoint of the five-foot interval) for the total depth of the boring. For the statistical analysis, soil depths were aggregated into the following depth intervals: surficial (0 to approximately 0.5 ft bgs), approximately 0.5 to less than or equal to 10 ft bgs, and greater than 10 ft bgs.

2.1.1 Summary Statistics

Summary statistics were calculated for each CCR Parameter grouped by depth interval and the entire set of BGS samples (including all depth intervals and boring locations). Summary statistics include information such as the total numbers of available samples, the frequencies of detection, ranges of reporting limits, minimum and maximum detected concentrations, mean concentrations, standard deviations, median concentrations and the 95th percentile concentrations. A summary statistics table is presented in Attachment E.1-A.

2.1.2 Exploratory Data Plots

Exploratory data plots (box plots) were constructed to support a visual review of the data. Box plots identify the center of the data, distribution, variability, and to visually identify potential outliers. The diagram below graphically depicts the basics of the construction of the box plots (StataCorp LLC 2017).



The box portion of the plot is the interquartile range (IQR), which represents the middle 50% of data, with the bottom of the box being the 25th percentile and the top of the box being the 75th percentile. The line inside the box is the median concentration. The top of the upper "whisker" represents the first observed concentration above the 75th percentile, whereas the bottom of the lower "whisker" represents the first observed concentration below the 25th percentile (upper adjacent value and lower adjacent value, respectively). Values that lie outside of the adjacent values represent outside concentrations (i.e. concentrations at the upper and lower ends of the distribution of the data). The method detection limit was used as the reported value in order to construct the box plot when analytical results were reported as non-detects.

Two sets of side-by-side box plots were constructed for the BGS CCR Parameter data: 1) results by depth interval and 2) results by BGS boring location. These box plots were useful in identifying differences in CCR Parameter concentrations between depth intervals and between boring locations and were especially useful for visually identifying potential outliers. Box plots for CCR Parameters aggregated by depth interval and by boring location are provided in Attachment E.1-B.

2.1.3 Outlier Screening

Outliers are data points that are abnormally high or low as compared to the rest of the measurements and may represent anomalous data or data errors, but may also represent natural variation of CCR Parameter concentrations in environmental systems. Screening for outliers is a critical step because outliers can bias statistical estimates, statistical testing results, and inferences. The size of the datasets for each depth interval (a minimum of 10 samples) were sufficiently large to capture natural variation commonly seen in environmental datasets.

Outlier values were initially screened visually using the side-by-side box plots. If suspected visual outliers were identified, then Tukey's procedure was used to identify extreme outliers (Tukey 1977). This method relies on the IQR, which is defined as the 75th percentile value minus the 25th percentile value.

Values were identified as potential outliers as follows:

- **Lower extreme outliers** are less than the 25th percentile minus 3 x IQR
- **Upper extreme outliers** are greater than the 75th percentile plus 3 x IQR.

Finally, when the potential outlier(s) were identified visually and by Tukey's procedure, then statistical testing for outliers (Dixon or Rosner's Test) was conducted to determine if the data points were statistically significant outliers.

Following confirmation of the outliers as statistically significant, a desktop evaluation was conducted to verify that the data points were not errors (e.g., laboratory or transcriptional error). Field forms, data validation reports, and other variables in the dataset that could influence analytical results were also evaluated. If a verifiable error was discovered, the outlier was removed and, if possible, replaced with a corrected value.

In the absence of a verifiable error, additional lines of evidence were reviewed to determine final outlier disposition (e.g., frequency of detection, spatial and temporal variability). If an outlier was identified as suitable for removal from further statistical analysis, a clear and defensible rationale based on multiple lines of evidence was provided. In addition, values that were identified as outliers and removed from further evaluation in the present statistical analysis were retained in the historical database and will be reevaluated for inclusion or exclusion in future statistical analyses of this dataset. The results of the outlier screening for the CUF Plant CCR material dataset are provided in Section 3.1.

2.2 ESTIMATES OF BACKGROUND CONDITIONS

BTVs were calculated as conservative estimates of CCR Parameter concentrations in BGS. Specifically, 95% upper tolerance limits (UTLs) with 95% coverage were calculated for each parameter at each soil depth interval defined for the statistical datasets and with all depths combined to establish conservative estimates of background soil concentrations. The UTL represents the upper bound of a pre-specified proportion of the underlying data population with a specified level of confidence. For example, for a "95% UTL with 95% coverage", there is 95% confidence that, on average, 95% of the data are below the UTL. The upper one-sided UTL is commonly used in environmental monitoring and is constructed using background data (Ofungwu 2014). In the case of pH, 95% tolerance intervals with 95% coverage were calculated to bound the range of pH values. BTVs aggregated by soil depth interval and with all depths combined are presented in Attachment E.1-A.

2.2.1 Tests for Normality of Background Data

Prior to the calculation of UTLs, the data were evaluated for normality. Parametric methods to establish background conditions (UTLs) can be applied to data that are normally distributed or to data that fit another defined statistical distribution (e.g. gamma distribution), or to data that can be transformed to normal using mathematical transformations (e.g. lognormal transformation). Testing data for normality was done using formal statistical methods, known as goodness-of-fit-testing (e.g. Shapiro-Wilk or Lilliefors tests). If the data did not fit a defined statistical distribution or could not be transformed to normal, then non-parametric methods were used.

2.2.2 Parametric UTLs

Parametric UTLs were used when the background data were normally distributed, gamma distributed, or transformed using the lognormal transformation. A background sample size or dataset consisting of at least eight observations was required to generate an adequate tolerance limit.

The calculation of the UTL is straightforward:

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

Where:

$\overline{x}$ = mean CCR parameter concentration in the background dataset

s = standard deviation of CCR parameter in the background dataset

τ = multiplier based on size of dataset, confidence (95%) and desired coverage (95%).

2.2.3 Non-parametric UTLs

When the background data do not fit the normal or gamma distribution or cannot be normalized via the lognormal transformation, non-parametric UTLs were used. The non-parametric UTL is an order statistic, typically the maximum or the second largest observed concentration in the background dataset. Unlike parametric methods, the desired coverage and confidence interval cannot be pre-specified for non-parametric tolerance limits. In the case of non-parametric methods, the level of confidence increases with increasing sample size. If non-parametric methods were used, the approximate level of confidence was reported.

UTLs, especially non-parametric UTLs, are sensitive to outliers and are biased high in the presence of outliers. For this initial analysis, no suspect outliers were removed from the data set. If the UTLs presented in this report are going to be used to inform corrective actions, then additional analysis to account for the presence of outliers is warranted.

3.0 RESULTS AND DISCUSSION

3.1 SUMMARY STATISTICS, EXPLORATORY DATA PLOTS, AND OUTLIER SCREENING

Summary statistics for each CCR Parameter are provided in Attachment E.1-A, with results aggregated by depth interval and with all depths combined. Summary statistics are sorted by CCR Parameter type (i.e., CCR Rule Appendix III Parameters, CCR Rule Appendix IV Parameters, TDEC Appendix I Parameters, and Other). Box plots for each CCR Parameter aggregated by depth and boring location are provided in Attachment E.1-B.

The number of values identified as potential outliers using Tukey's procedure for each depth interval and with all depths combined is identified in Attachment E.1-A. For these potential outliers, no definitive reasons were identified for the outlier values and the values identified were assumed to be representative of natural conditions and natural variation within native soil. These values were flagged as statistical outliers in the dataset and retained for subsequent calculations and analysis if needed for future evaluations (see columns labelled "Number of Statistical Outliers" and "Number of Outliers Removed" in Attachment E.1-A).

3.2 ESTIMATES OF BACKGROUND CONDITIONS

BTVs for the BGS investigation at the KIF Plant were calculated using UTLs (and Tolerance Intervals in the case of pH). The resulting BTV concentrations and the statistical distribution and methods used to calculate the UTLs are identified for each CCR Parameter aggregated by depth interval and with all depths combined in Attachment E.1-A.

4.0 REFERENCES

Ofungwu, J. (2014), Statistical Applications for Environmental Analysis and Risk Assessment. Hoboken, New Jersey: John Wiley and Sons, Inc.

StataCorp. (2017), Stata Graphics Reference Manual Stata: Release 15. Statistical Software. College Station, TX: StataCorp LLC.

Tukey, J.W. (1977), Exploratory data analysis. Reading, Massachusetts: Addison-Wesley, 1977.

ATTACHMENT E.1-A
SUMMARY STATISTICS TABLES

Summary Statistics - Background Soil Investigation
Kingston Fossil Plant - Harriman, Tennessee

Parameter	Soil Depth	Frequency of Detection	Range of Reporting Limits	% Non Detect	Statistics using Detected Data Only		Statistics using all Detects & Non-Detects									
					Minimum Detect	Maximum Detect	Mean	Standard Deviation	25^{th} Percentile	50^{th} Percentile	75^{th} Percentile	95^{th} Percentile	Number of Statistical Outliers	Number of Outliers Removed	Background Threshold Value	Statistical Distribution & Method
Percent Ash																
Ash	Surficial	11/12	(1 - 1)	8.3%	1	5	2.67	1.31	1.75	2.50	4.00	4.45	0	0	NA	NA
CCR Rule Appendix IV Parameters																
Boron	Surficial	10/14	(1.53 - 1.85)	28.6%	1.68	9.51	3.36	2.37	1.73	2.58	3.41	8.01	2	0	11.0	95% WH Approximate Gamma UTL 95% Coverage
	0.5' to 10' bgs	12/20	(1.6 - 1.81)	40.0%	1.84	7.99	2.88	1.82	1.68	1.98	3.42	6.72			7.23	95% UTL (Normal) 95% Coverage
	>10' bgs	10/19	(1.54 - 1.74)	47.4%	1.83	12.9	3.17	2.76	1.64	1.83	3.40	8.16			10.2	95% WH Approximate Gamma UTL 95% Coverage
	All Depth	32/53	(1.53 - 1.85)	39.6%	1.68	12.9	3.10	2.35	1.68	2.06	3.52	7.77			8.32	95% KM UTL (Lognormal) 95% Coverage
Calcium	Surficial	14/14	--	0.0%	260	15,400	3,390	5,000	654	1,040	3,690	14,600	4	0	22,100	95% WH Approximate Gamma UTL 95% Coverage
	0.5' to 10' bgs	20/20	--	0.0%	35.6	13,500	1,280	2,990	62.9	232	973	3,080			17,500	95% (Lognormal) 95% Coverage
	>10' bgs	19/19	--	0.0%	23.1	1,000	186	243	36.5	67.6	235	628			1,520	95% (Lognormal) 95% Coverage
	All Depth	53/53	--	0.0%	23.1	15,400	1,450	3,340	66.6	260	906	8,020			10,900	95% (Lognormal) 95% Coverage
Chloride	Surficial	2/14	(4.37 - 5.62)	85.7%	4.37	6.34	4.51	0.507	4.54	4.70	5.12	5.87	8	0	6.34	95% UTL (NP-51.2%) 95% Coverage
	0.5' to 10' bgs	4/20	(4.11 - 5.25)	80.0%	6.83	15.6	5.44	3.06	4.59	4.77	5.18	12.2			15.6	95% UTL (NP-64.2%) 95% Coverage
	>10' bgs	6/19	(4.48 - 5.67)	68.4%	6.78	19.3	7.03	4.51	4.53	4.89	7.30	16.8			19.3	95% UTL (NP-62.3%) 95% Coverage
	All Depth	12/53	(4.11 - 5.67)	77.4%	4.37	19.3	5.66	3.49	4.53	4.76	5.28	14.0			16.5	95% UTL (NP-75%) 95% Coverage
Fluoride	Surficial	10/14	(0.792 - 0.831)	28.6%	0.869	3.76	1.77	1.01	0.841	1.35	2.56	3.54	9	0	4.40	95% UTL (Normal) 95% Coverage
	0.5' to 10' bgs	5/20	(0.761 - 0.903)	75.0%	1.15	3.17	1.13	0.736	0.807	0.824	0.965	2.75			3.17	95% UTL (NP-64.2%) 95% Coverage
	>10' bgs	1/19	(0.715 - 1.11)	94.7%	4.40	4.40	0.91	0.823	0.793	0.833	0.944	1.44			4.40	95% UTL (NP-62.3%) 95% Coverage
	All Depth	16/53	(0.715 - 1.11)	69.8%	0.869	4.40	1.20	0.922	0.800	0.840	1.15	3.27			3.76	95% UTL (NP-75%) 95% Coverage
pH (lab)	Surficial	14/14	--	0.0%	5.4	7.8	6.6	0.88	5.8	6.7	7.4	7.7	0	0	(4.0-9.1)	95% Tolerance Interval (Normal) 95% Coverage
	0.5' to 10' bgs	20/20	--	0.0%	4.6	8.1	5.7	1.1	5.1	5.4	6.3	8.1			(4.6-8.1)	95% Tolerance Interval (NP-64.2%) 95% Coverage
	>10' bgs	19/19	--	0.0%	4.6	7.2	5.2	0.56	5.0	5.2	5.4	5.8			(3.7-6.8)	95% Tolerance Interval (Lognormal) 95% Coverage
	All Depth	53/53	--	0.0%	4.6	8.1	5.8	1.0	5.1	5.4	6.5	7.7			(4.6-8.1)	95% Tolerance Interval (NP-75%) 95% Coverage
pH (field)	Surficial	14/14	--	0.0%	5.20	7.49	6.35	0.789	5.70	6.05	6.92	7.47	0	0	(4.09-8.60)	95% Tolerance Interval (Normal) 95% Coverage
	0.5' to 10' bgs	20/20	--	0.0%	4.02	7.86	5.47	1.05	4.75	5.12	5.96	7.76			(2.53-8.40)	95% Tolerance Interval (Gamma) 95% Coverage
	>10' bgs	19/19	--	0.0%	4.07	6.79	5.01	0.619	4.73	5.02	5.22	5.75			(3.40-6.63)	95% Tolerance Interval (Normal) 95% Coverage
	All Depth	53/53	--	0.0%	4.02	7.86	5.54	0.986	4.87	5.25	5.89	7.47			(3.20-7.87)	95% Tolerance Interval (Lognormal) 95% Coverage
Sulfate	Surficial	13/14	(9.83 - 9.83)	7.1%	8.35	30.1	19.0	7.90	10.7	19.1	27.1	29.5	1	0	39.6	95% UTL (Normal) 95% Coverage
	0.5' to 10' bgs	13/20	(7.86 - 8.53)	35.0%	14.3	213	31.7	43.9	8.31	22.0	32.9	63.2			131	95% WH Approximate Gamma UTL 95% Coverage
	>10' bgs	4/19	(7.14 - 11.1)	79.0%	12.6	25.6	9.73	5.45	7.92	8.56	11.1	21.3			25.6	95% UTL (NP-62.3%) 95% Coverage
	All Depth	30/53	(7.14 - 11.1)	43.4%	8.35	213	20.4	29.1	8.32	12.6	25.4	43.6			64.7	95% KM UTL (Lognormal) 95% Coverage
CCR Rule Appendix IV Parameters																
Antimony	Surficial	13/14	(0.0783 - 0.0783)	7.1%	0.0868	0.353	0.199	0.0864	0.135	0.203	0.270	0.329	0	0	0.425	95% UTL (Normal) 95% Coverage
	0.5' to 10' bgs	14/20	(0.0721 - 0.0824)	30.0%	0.0727	0.345	0.161	0.0937	0.0810	0.139	0.219	0.338			0.386	95% UTL (Normal) 95% Coverage
	>10' bgs	15/19	(0.0719 - 0.0829)	21.1%	0.0775	0.502	0.185	0.127	0.0871	0.123	0.221	0.419			0.493	95% UTL (Normal) 95% Coverage
	All Depth	42/53	(0.0719 - 0.0829)	20.8%	0.0727	0.502	0.180	0.107	0.0847	0.139	0.230	0.370			0.397	95% UTL (Normal) 95% Coverage
Arsenic	Surficial	14/14	--	0.0%	2.42	11.9	5.76	2.62	3.87	5.56	6.32	10.2	2	0	12.6	95% UTL (Normal) 95% Coverage
	0.5' to 10' bgs	20/20	--	0.0%	1.59	9.16	4.80	1.94	3.08	4.79	6.14	7.40			9.44	95% UTL (Normal) 95% Coverage
	>10' bgs	19/19	--	0.0%	2.32	40.4	8.82	11.5	3.01	4.95	7.79	40.0			40.4	95% UTL (NP-62.3%) 95% Coverage
	All Depth	53/53	--	0.0%	1.59	40.4	6.49	7.20	3.08	4.97	6.30	12.3			40.0	95% UTL (NP-75%) 95% Coverage
Barium	Surficial	14/14	--	0.0%	25.6	199	93.2	49.8	50.9	90.6	120	170	0	0	223	95% UTL (Normal) 95% Coverage
	0.5' to 10' bgs	20/20	--	0.0%	16.3	251	82.7	70.6	26.2	57.1	142	191			333	95% WH Approximate Gamma UTL 95% Coverage
	>10' bgs	19/19	--	0.0%	10.0	156	49.8	42.9	18.1	24.8	75.6	133			280	95% (Lognormal) 95% Coverage
	All Depth	53/53	--	0.0%	10.0	251	73.7	58.5	24.8	58.0	107	188			308	95% (Lognormal) 95% Coverage
Beryllium	Surficial	14/14	--	0.0%	0.152	1.11	0.652	0.365	0.290	0.627	1.01	1.08	0	0	1.61	95% UTL (Normal) 95% Coverage
	0.5' to 10' bgs	20/20	--	0.0%	0.109	1.14	0.559	0.375	0.204	0.473	0.953	1.11			1.94	95% WH Approximate Gamma UTL 95% Coverage
	>10' bgs	19/19	--	0.0%	0.105	2.51	0.664	0.685	0.163	0.301	1.01	1.72			3.1	95% WH Approximate Gamma UTL 95% Coverage
	All Depth	53/53	--	0.0%	0.105	2.51	0.621	0.499	0.202	0.451	0.987	1.45			1.63	95% UTL (NP-75%) 95% Coverage
Cadmium	Surficial	13/14	(0.0211 - 0.0211)	7.1%	0.0232	0.188	0.0681	0.0465	0.0375	0.0527	0.0783	0.152	4	0	0.19	95% UTL (Normal) 95% Coverage
	0.5' to 10' bgs	5/20	(0.0198 - 0.0228)	75.0%	0.0234	0.128	0.0291	0.0245	0.0205	0.0213	0.0230	0.0552			0.0877	95% UTL (Normal) 95% Coverage
	>10' bgs	6/19	(0.0194 - 0.0228)	68.4%	0.0243	0.273	0.0485	0.0637	0.0206	0.0215	0.0288	0.164			0.203	95% UTL (Normal) 95% Coverage
	All Depth	24/53	(0.0194 - 0.0228)	54.7%	0.0232	0.273	0.0462	0.0500	0.0207	0.0227	0.0478	0.141			0.143	95% WH Approximate Gamma UTL 95% Coverage

Summary Statistics - Background Soil Investigation
Kingston Fossil Plant - Harriman, Tennessee

Parameter	Soil Depth	Frequency of Detection	Range of Reporting Limits	% Non Detect	Statistics using Detected Data Only		Statistics using all Detects & Non-Detects									
					Minimum Detect	Maximum Detect	Mean	Standard Deviation	25th Percentile	50th Percentile	75th Percentile	95th Percentile	Number of Statistical Outliers	Number of Outliers Removed	Background Threshold Value	Statistical Distribution & Method
Chromium	Surficial	14/14	--	0.0%	6.85	38.1	21.0	9.42	14.3	17.7	29.8	34.7	0	0	45.6	95% UTL (Normal) 95% Coverage
	0.5' to 10' bgs	20/20	--	0.0%	8.55	41.1	21.1	8.99	14.6	19.4	26.1	39.7			42.7	95% UTL (Normal) 95% Coverage
	>10' bgs	19/19	--	0.0%	5.17	30.5	14.9	8.31	8.42	12.0	21.1	29.0			42.0	95% WH Approximate Gamma UTL 95% Coverage
	All Depth	53/53	--	0.0%	5.17	41.1	18.9	9.19	12.0	16.2	25.4	34.9			42.4	95% WH Approximate Gamma UTL 95% Coverage
Cobalt	Surficial	14/14	--	0.0%	1.70	27.3	12.1	7.81	6.34	11.1	18.9	22.6	0	0	32.5	95% UTL (Normal) 95% Coverage
	0.5' to 10' bgs	20/20	--	0.0%	1.33	30.6	11.5	8.80	2.05	11.2	15.3	28.2			32.6	95% UTL (Normal) 95% Coverage
	>10' bgs	19/19	--	0.0%	1.24	50.2	11.8	12.5	2.76	7.45	15.4	34.0			55.9	95% WH Approximate Gamma UTL 95% Coverage
	All Depth	53/53	--	0.0%	1.24	50.2	11.8	9.88	2.80	9.44	16.5	29.1			40.2	95% WH Approximate Gamma UTL 95% Coverage
Fluoride	Surficial	10/14	(0.792 - 0.831)	28.6%	0.869	3.76	1.77	1.01	0.841	1.35	2.56	3.54	9	0	4.40	95% UTL (Normal) 95% Coverage
	0.5' to 10' bgs	5/20	(0.761 - 0.903)	75.0%	1.15	3.17	1.13	0.736	0.807	0.824	0.965	2.75			3.17	95% UTL (NP-64.2%) 95% Coverage
	>10' bgs	1/19	(0.715 - 1.11)	94.7%	4.40	4.40	0.909	0.823	0.793	0.833	0.944	1.44			4.40	95% UTL (NP-62.3%) 95% Coverage
	All Depth	16/53	(0.715 - 1.11)	69.8%	0.869	4.40	1.20	0.922	0.800	0.840	1.15	3.27			3.76	95% UTL (NP-75%) 95% Coverage
Lead	Surficial	14/14	--	0.0%	7.73	49.6	18.0	11.1	11.1	14.1	19.9	36.7	3	0	47.1	95% UTL (Normal) 95% Coverage
	0.5' to 10' bgs	20/20	--	0.0%	5.42	25.4	14.0	5.48	10.2	13.3	16.3	23.6			27.1	95% UTL (Normal) 95% Coverage
	>10' bgs	19/19	--	0.0%	3.23	61.8	17.0	15.5	7.99	11.1	19.3	47.9			63.6	95% WH Approximate Gamma UTL 95% Coverage
	All Depth	53/53	--	0.0%	3.23	61.8	16.1	11.3	9.62	12.7	18.5	40.8			40.5	95% WH Approximate Gamma UTL 95% Coverage
Lithium	Surficial	14/14	--	0.0%	3.86	23.2	11.6	6.78	6.52	8.61	17.5	21.3	0	0	29.3	95% UTL (Normal) 95% Coverage
	0.5' to 10' bgs	20/20	--	0.0%	4.77	28.5	12.8	6.52	8.76	10.7	13.8	25.2			31.7	95% WH Approximate Gamma UTL 95% Coverage
	>10' bgs	19/19	--	0.0%	2.88	26.4	9.76	7.10	4.31	6.30	14.9	24.1			41.2	95% (Lognormal) 95% Coverage
	All Depth	53/53	--	0.0%	2.88	28.5	11.4	6.80	5.79	9.40	15.1	24.3			28.8	95% WH Approximate Gamma UTL 95% Coverage
Mercury	Surficial	11/14	(0.0257 - 0.0722)	21.4%	0.0175	0.174	0.0532	0.0384	0.0387	0.0548	0.0651	0.111	0	0	0.178	95% WH Approximate Gamma UTL 95% Coverage
	0.5' to 10' bgs	13/20	(0.0155 - 0.0483)	35.0%	0.0165	0.188	0.0654	0.0556	0.0289	0.0461	0.0900	0.187			0.199	95% UTL (Normal) 95% Coverage
	>10' bgs	16/19	(0.0162 - 0.0275)	15.8%	0.0172	0.149	0.0600	0.0416	0.0275	0.0483	0.0834	0.139			0.161	95% UTL (Normal) 95% Coverage
	All Depth	40/53	(0.0155 - 0.0722)	24.5%	0.0165	0.188	0.0601	0.0469	0.0275	0.0483	0.0765	0.159			0.179	95% WH Approximate Gamma UTL 95% Coverage
Molybdenum	Surficial	14/14	--	0.0%	0.235	2.35	0.848	0.575	0.520	0.744	1.06	1.80	2	0	2.35	95% UTL (Normal) 95% Coverage
	0.5' to 10' bgs	18/20	(0.19 - 0.214)	10.0%	0.284	1.30	0.624	0.321	0.383	0.630	0.706	1.22			1.39	95% UTL (Normal) 95% Coverage
	>10' bgs	15/19	(0.189 - 0.583)	21.1%	0.253	5.84	0.938	1.37	0.331	0.427	0.655	3.57			5.84	95% UTL (NP-62.3%) 95% Coverage
	All Depth	47/53	(0.189 - 0.583)	11.3%	0.235	5.84	0.796	0.899	0.343	0.568	0.886	2.07			2.55	95% KM UTL (Lognormal) 95% Coverage
Radium-226+228	Surficial	14/14	--	0.0%	1.181	3.09	2.31	0.659	1.67	2.51	2.84	2.94	0	0	4.03	95% UTL (Normal) 95% Coverage
	0.5' to 10' bgs	20/20	--	0.0%	1.618	3.56	2.58	0.585	2.07	2.80	2.94	3.34			3.98	95% UTL (Normal) 95% Coverage
	>10' bgs	19/19	--	0.0%	0.696	4.26	2.49	1.09	1.65	2.17	3.12	4.22			5.14	95% UTL (Normal) 95% Coverage
	All Depth	53/53	--	0.0%	0.696	4.26	2.48	0.810	1.70	2.59	2.95	4.02			4.13	95% UTL (Normal) 95% Coverage
Selenium	Surficial	14/14	--	0.0%	0.389	1.60	0.854	0.363	0.619	0.744	1.02	1.47	0	0	1.80	95% UTL (Normal) 95% Coverage
	0.5' to 10' bgs	20/20	--	0.0%	0.244	1.63	0.704	0.311	0.470	0.699	0.866	0.977			1.45	95% UTL (Normal) 95% Coverage
	>10' bgs	19/19	--	0.0%	0.162	1.34	0.674	0.395	0.336	0.485	0.984	1.33			2.05	95% WH Approximate Gamma UTL 95% Coverage
	All Depth	53/53	--	0.0%	0.162	1.63	0.732	0.358	0.450	0.704	0.893	1.36			1.46	95% UTL (Normal) 95% Coverage
Thallium	Surficial	14/14	--	0.0%	0.124	0.453	0.248	0.0994	0.187	0.219	0.273	0.443	2	0	0.508	95% UTL (Normal) 95% Coverage
	0.5' to 10' bgs	20/20	--	0.0%	0.127	0.417	0.230	0.0717	0.186	0.218	0.255	0.356			0.402	95% UTL (Normal) 95% Coverage
	>10' bgs	19/19	--	0.0%	0.0542	1.01	0.245	0.238	0.108	0.170	0.255	0.702			0.926	95% WH Approximate Gamma UTL 95% Coverage
	All Depth	53/53	--	0.0%	0.0542	1.01	0.240	0.155	0.164	0.200	0.259	0.458			0.621	95% (Lognormal) 95% Coverage

Summary Statistics - Background Soil Investigation
Kingston Fossil Plant - Harriman, Tennessee

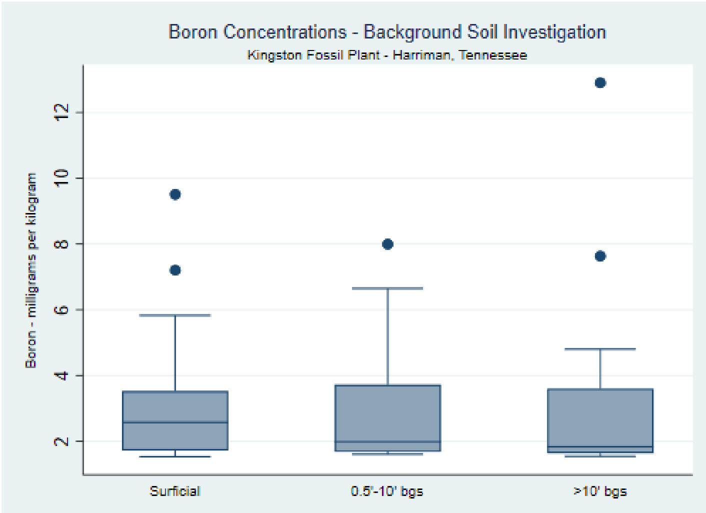
Parameter	Soil Depth	Frequency of Detection	Range of Reporting Limits	% Non Detect	Statistics using Detected Data Only		Statistics using all Detects & Non-Detects									
					Minimum Detect	Maximum Detect	Mean	Standard Deviation	25th Percentile	50th Percentile	75th Percentile	95th Percentile	Number of Statistical Outliers	Number of Outliers Removed	Background Threshold Value	Statistical Distribution & Method
TDEC Appendix I Parameters																
Copper	Surficial	14/14	--	0.0%	2.89	28.0	13.5	8.88	7.24	8.83	20.5	27.6	1	0	48.3	95% WH Approximate Gamma UTL 95% Coverage
	0.5' to 10' bgs	20/20	--	0.0%	4.49	36.7	13.9	7.43	9.81	11.5	15.8	25.7			34.7	95% WH Approximate Gamma UTL 95% Coverage
	>10' bgs	19/19	--	0.0%	3.39	60.4	15.6	14.2	5.95	8.58	24.0	32.6			61.2	95% WH Approximate Gamma UTL 95% Coverage
	All Depth	53/53	--	0.0%	2.89	60.4	14.4	10.5	7.47	10.3	20.6	28.8			45.5	95% (Lognormal) 95% Coverage
Nickel	Surficial	14/14	--	0.0%	3.41	38.4	15.7	12.6	5.61	8.31	26.1	36.6	0	0	67.4	95% WH Approximate Gamma UTL 95% Coverage
	0.5' to 10' bgs	20/20	--	0.0%	3.40	37.8	13.3	11.3	4.98	8.63	19.1	33.5			49.9	95% WH Approximate Gamma UTL 95% Coverage
	>10' bgs	19/19	--	0.0%	2.25	47.4	13.1	13.7	3.22	4.98	20.7	34.7			47.4	95% UTL (NP-62.3%) 95% Coverage
	All Depth	53/53	--	0.0%	2.25	47.4	13.9	12.3	4.48	7.77	21.1	36.5			38.4	95% UTL (NP-75%) 95% Coverage
Silver	Surficial	2/14	(0.0304 - 0.039)	85.7%	0.0641	0.102	0.0379	0.0198	0.0333	0.0343	0.0378	0.0774	2	0	0.102	95% UTL (NP-51.2%) 95% Coverage
	0.5' to 10' bgs	0/20	(0.0304 - 0.0362)	100.0%	--	--	--	--	0.0322	0.0332	0.0346	0.0359			0.0362	95% UTL (NP-64.2%) 95% Coverage
	>10' bgs	0/19	(0.0308 - 0.0445)	100.0%	--	--	--	--	0.0326	0.0337	0.0362	0.0434			0.0445	95% UTL (NP-62.3%) 95% Coverage
	All Depth	2/53	(0.0304 - 0.0445)	96.2%	0.0641	0.102	0.0324	0.0107	0.0325	0.0335	0.0355	0.0438			0.0641	95% UTL (NP-75%) 95% Coverage
Vanadium	Surficial	14/14	--	0.0%	12.9	32.7	25.1	5.72	21.0	25.9	28.3	32.7	0	0	40.1	95% UTL (Normal) 95% Coverage
	0.5' to 10' bgs	20/20	--	0.0%	15.2	33.6	24.7	4.38	22.2	24.2	27.1	31.5			35.2	95% UTL (Normal) 95% Coverage
	>10' bgs	19/19	--	0.0%	6.84	42.0	20.9	9.59	13.2	20.5	27.9	34.0			44.1	95% UTL (Normal) 95% Coverage
	All Depth	53/53	--	0.0%	6.84	42.0	23.4	7.13	19.9	23.8	28.0	32.9			38	95% UTL (Normal) 95% Coverage
Zinc	Surficial	14/14	--	0.0%	15.4	75.9	45.0	19.9	26.3	45.2	58.1	73.8	2	0	97.1	95% UTL (Normal) 95% Coverage
	0.5' to 10' bgs	20/20	--	0.0%	12.5	64.4	30.8	13.6	22.4	26.5	36.4	58.0			69.6	95% WH Approximate Gamma UTL 95% Coverage
	>10' bgs	19/19	--	0.0%	8.06	170	44.7	46.1	15.1	27.8	52.6	141			190	95% WH Approximate Gamma UTL 95% Coverage
	All Depth	53/53	--	0.0%	8.06	170	39.5	30.8	22.0	29.3	48.8	87.9			121	95% (Lognormal) 95% Coverage

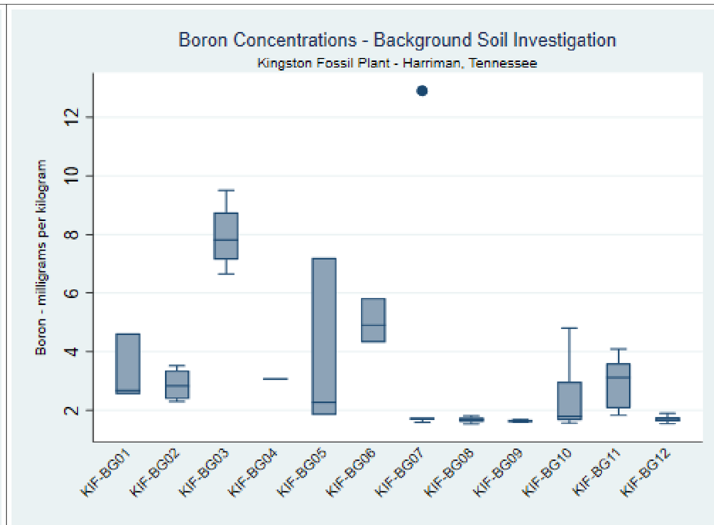
Notes:
CCR Rule - Title 40, Code of Federal Regulations, Part 257
bgs - below ground surface
KM - Kaplan-Meier, For Parameters with non-detects reported at the method detection limit, the mean, standard deviation, and background threshold values were calculated using Kaplan-Meier methods
'--" - Not Applicable
NP-% - Non-parametric method and associated confidence level of the estimate
TDEC - Tennessee Department of Environment and Conservation
UTL - Upper Tolerance Limit
WH - Background Threshold Limits based on the gamma distribution utilize Wilson Hiferty (WH) estimates
% - Percent

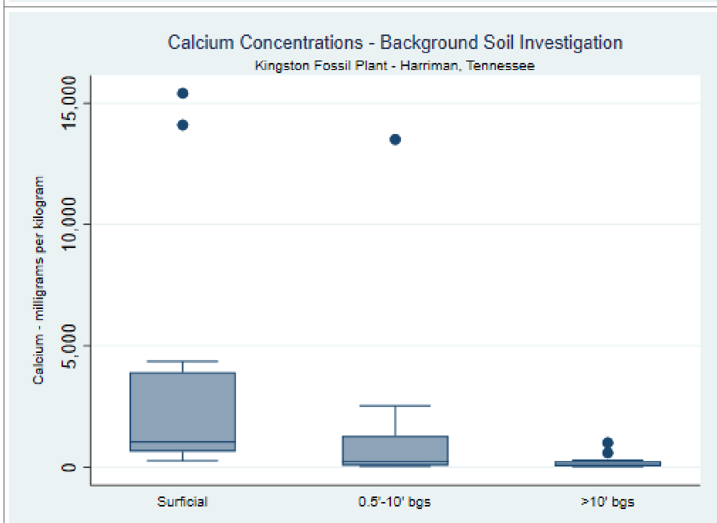
Except for Ash, pH & Radium 226 + 228, all units milligrams per kilogram (mg/kg)
Units for Ash are percent (%)
Units for pH are Standard Units (S.U.)
Units for Radium 226+228 are picocuries per gram (pCi/g)
All non-detects reported at the laboratory reporting limit
Surficial soil samples were collected in the 0 to 0.5 feet below ground surface (bgs) soil depth interval

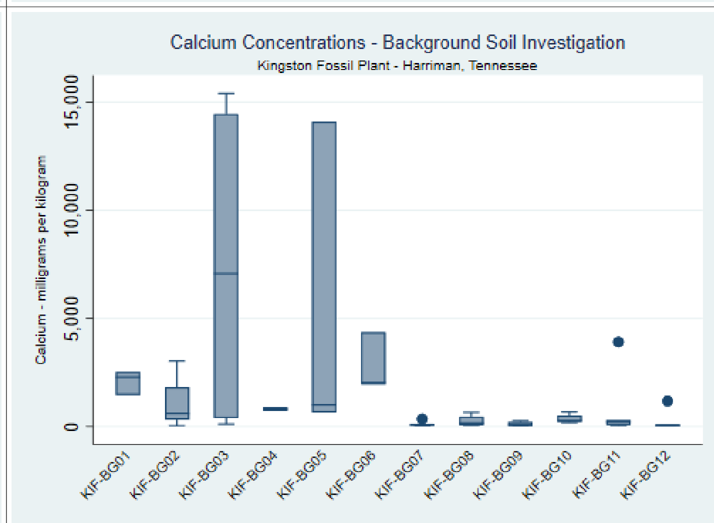
ATTACHMENT E.1-B
BOX PLOTS

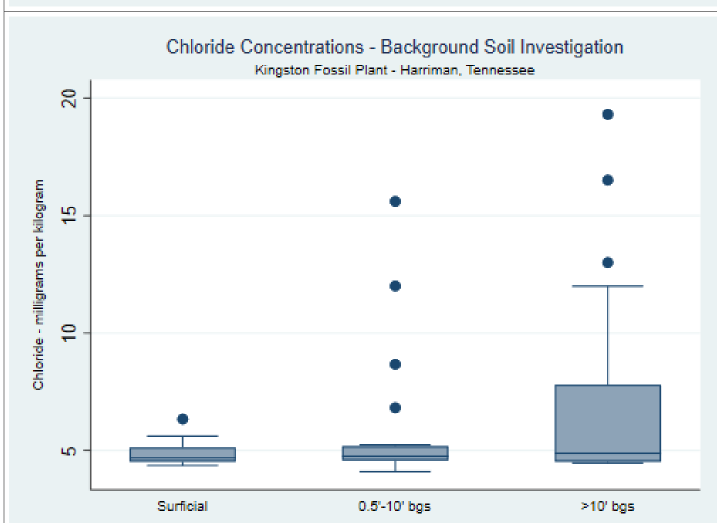
Box Plots
CCR Rule Appendix III Parameters
Background Soil Investigation
Kingston Fossil Plant - Harriman, Tennessee

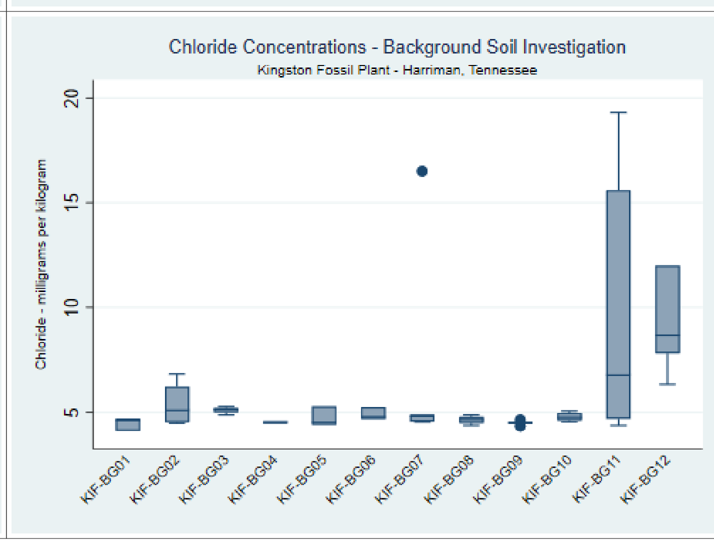


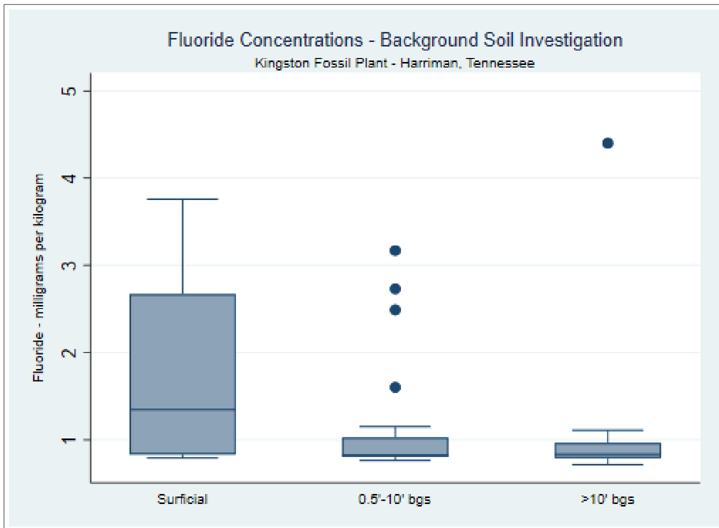


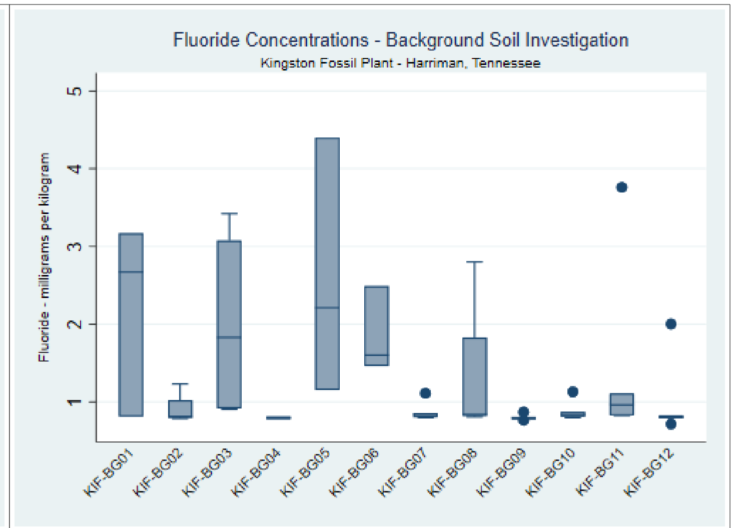


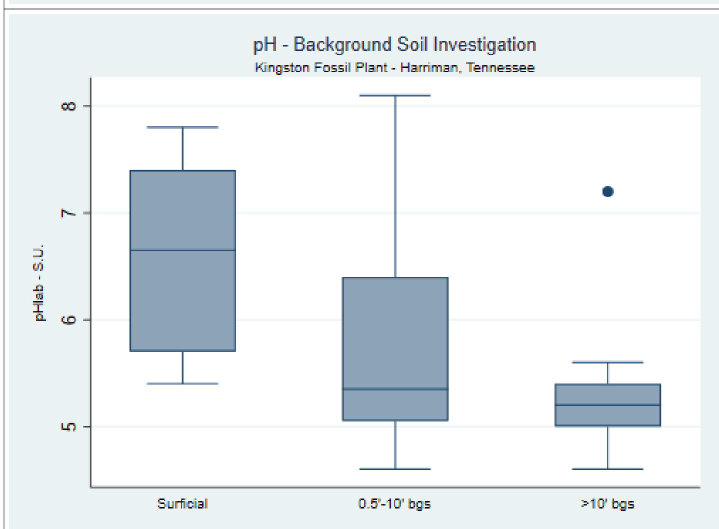


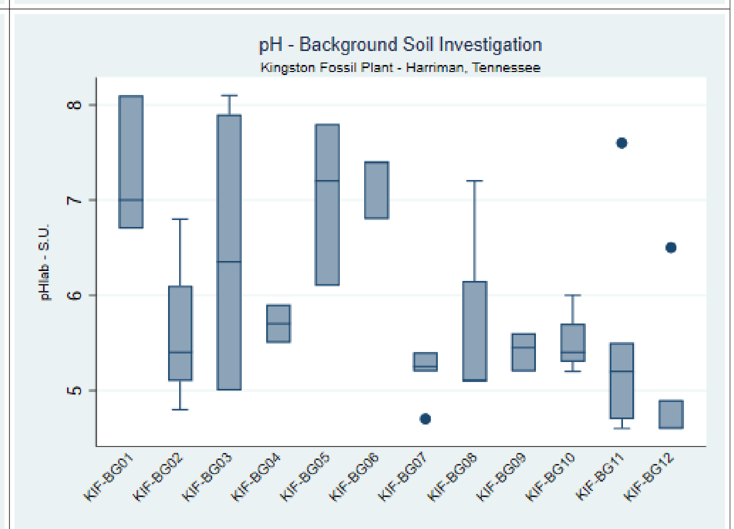


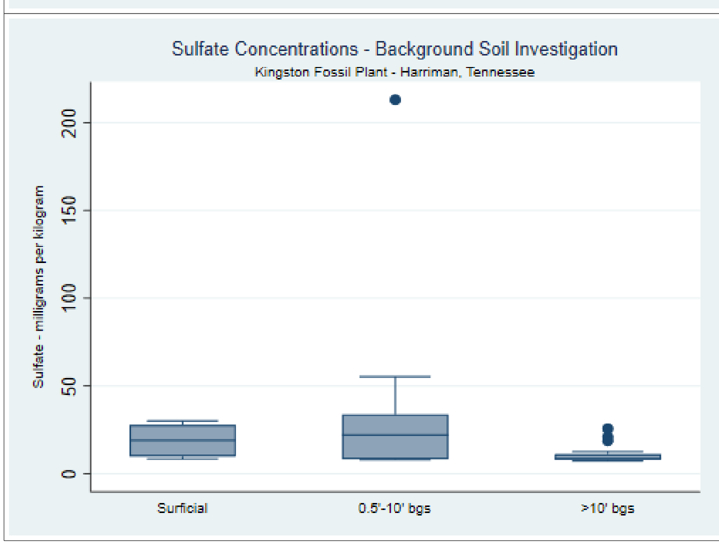


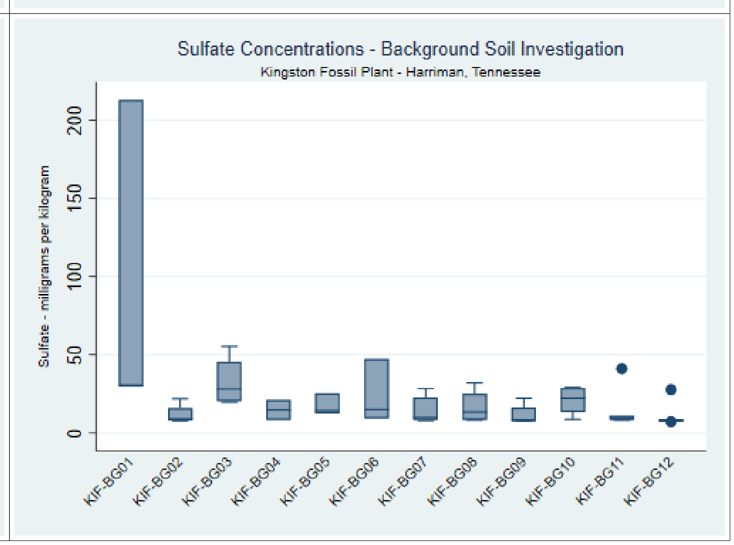

Fluoride Concentrations - Background Soil Investigation
Kingston Fossil Plant - Harriman, Tennessee
Fluoride - milligrams per kilogram
1
2
3
4
5
Surficial
0.5'-10' bgs
>10' bgs


Fluoride Concentrations - Background Soil Investigation
Kingston Fossil Plant - Harriman, Tennessee
Fluoride - milligrams per kilogram
1
2
3
4
5
KIF-BG01
KIF-BG02
KIF-BG03
KIF-BG04
KIF-BG05
KIF-BG06
KIF-BG07
KIF-BG08
KIF-BG09
KIF-BG10
KIF-BG11
KIF-BG12

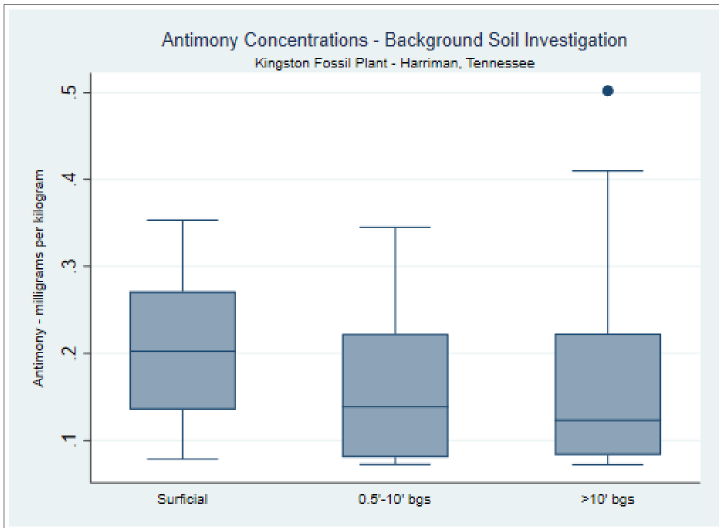

pH - Background Soil Investigation
Kingston Fossil Plant - Harriman, Tennessee
pHlab - S.U.
5
6
7
8
Surficial
0.5'-10' bgs
>10' bgs

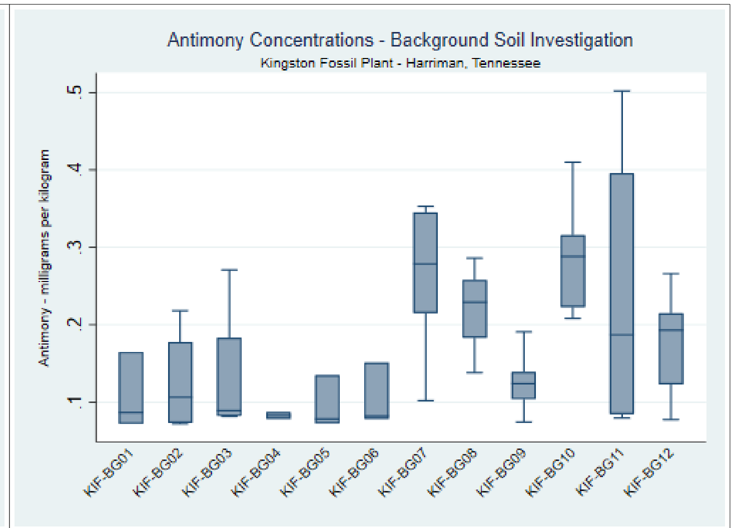

pH - Background Soil Investigation
Kingston Fossil Plant - Harriman, Tennessee
pHlab - S.U.
5
6
7
8
KIF-BG01
KIF-BG02
KIF-BG03
KIF-BG04
KIF-BG05
KIF-BG06
KIF-BG07
KIF-BG08
KIF-BG09
KIF-BG10
KIF-BG11
KIF-BG12

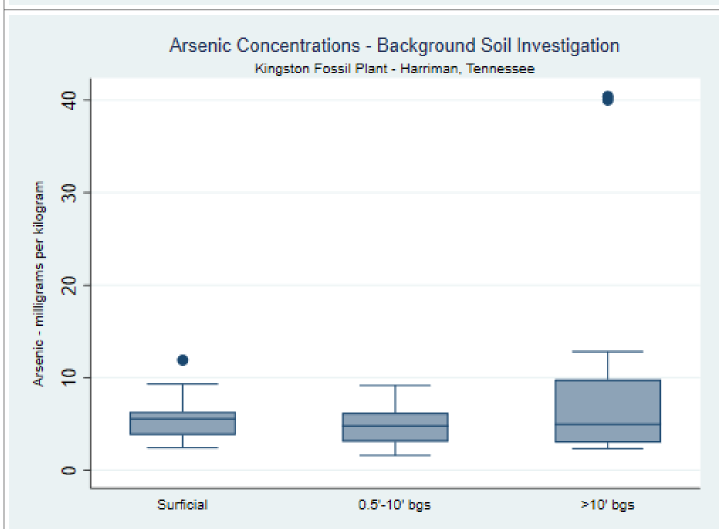

Sulfate Concentrations - Background Soil Investigation
Kingston Fossil Plant - Harriman, Tennessee
Sulfate - milligrams per kilogram
0
50
100
150
200
Surficial
0.5'-10' bgs
>10' bgs

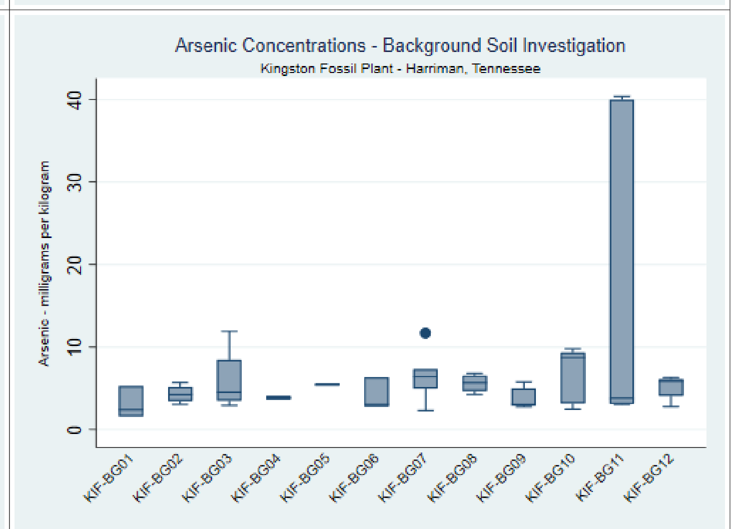

Sulfate Concentrations - Background Soil Investigation
Kingston Fossil Plant - Harriman, Tennessee
Sulfate - milligrams per kilogram
0
50
100
150
200
KIF-BG01
KIF-BG02
KIF-BG03
KIF-BG04
KIF-BG05
KIF-BG06
KIF-BG07
KIF-BG08
KIF-BG09
KIF-BG10
KIF-BG11
KIF-BG12

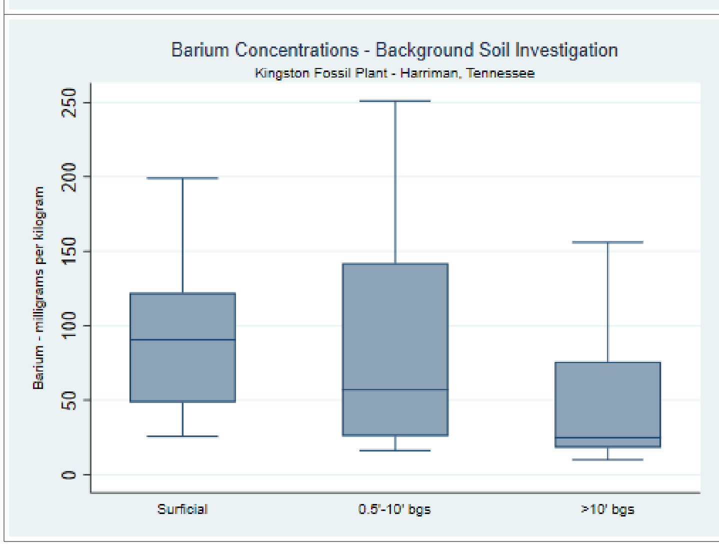
Box Plots
CCR Rule Appendix IV Parameters
Background Soil Investigation
Kingston Fossil Plant - Harriman, Tennessee

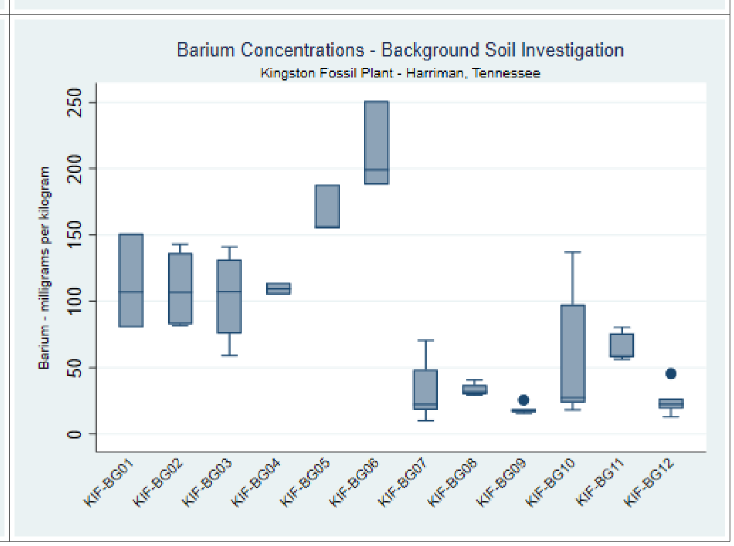


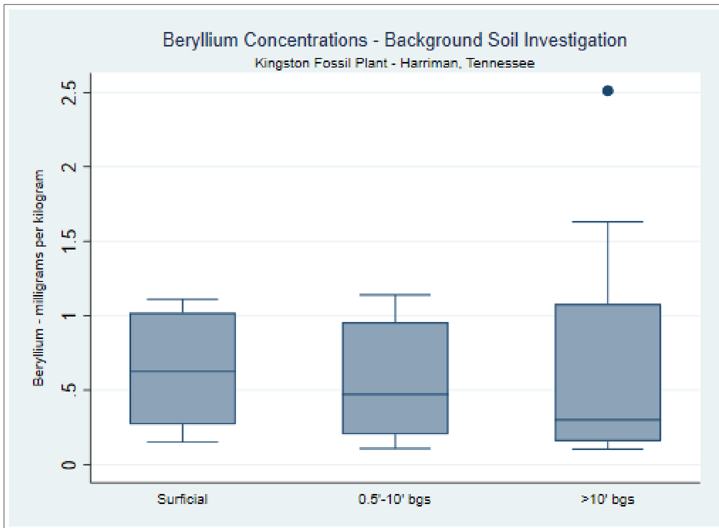


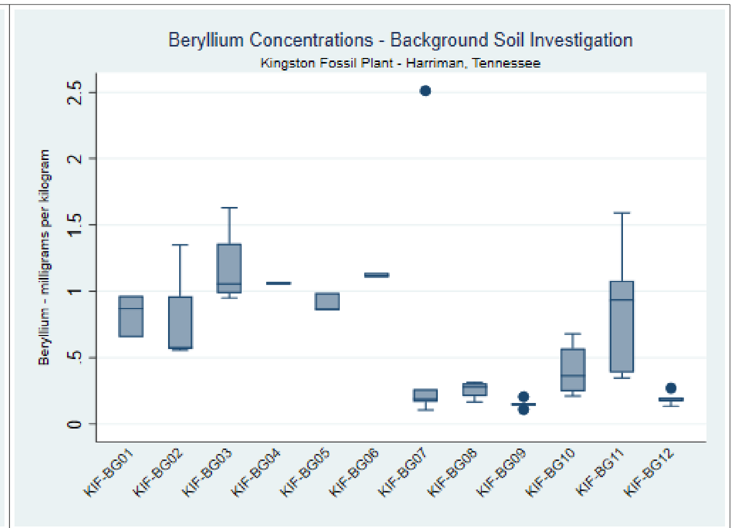


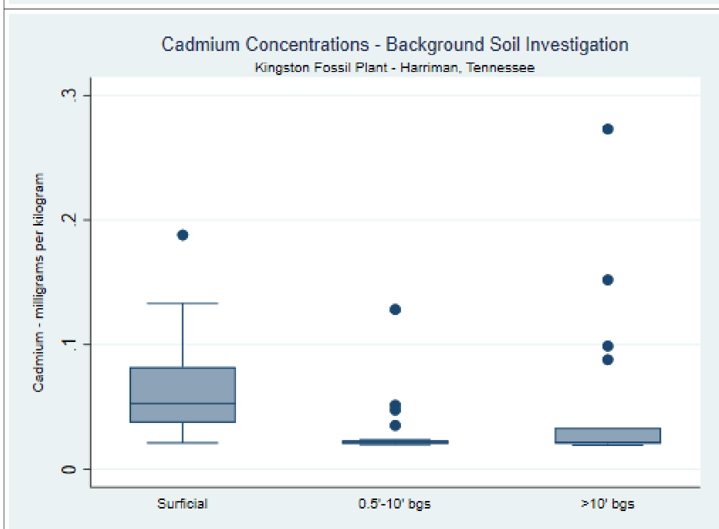


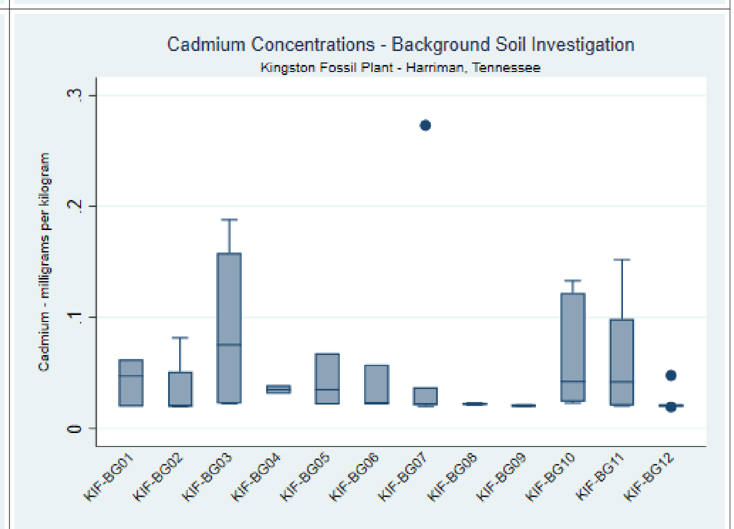


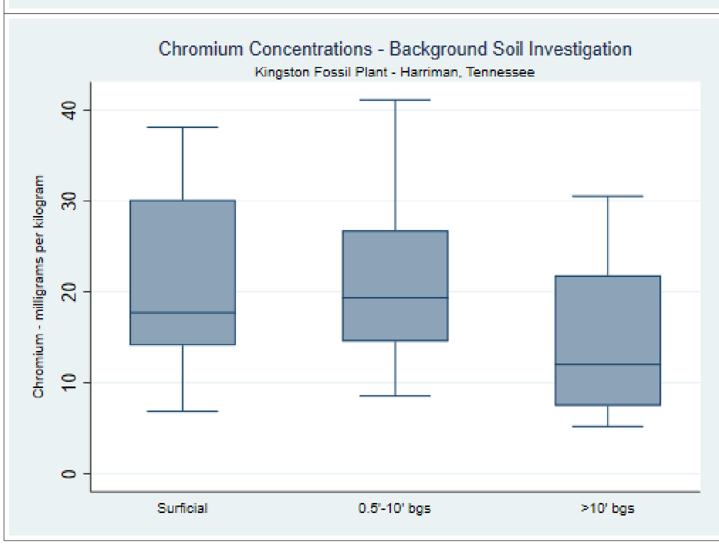


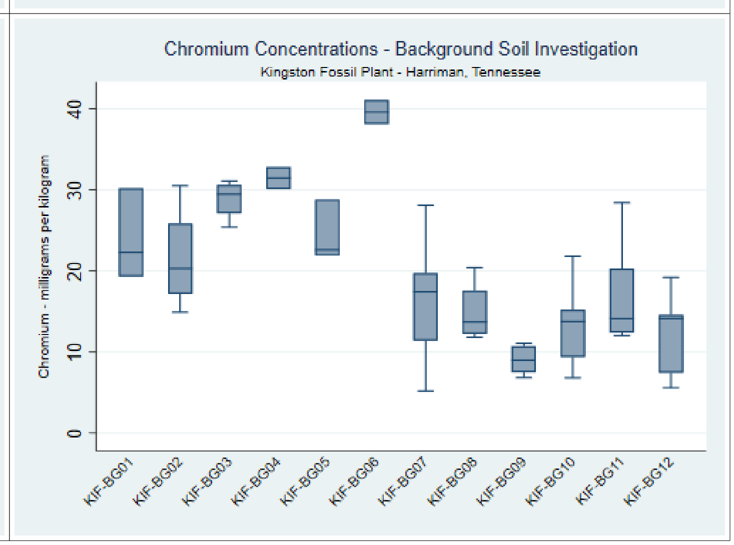

Beryllium Concentrations - Background Soil Investigation
Kingston Fossil Plant - Harriman, Tennessee
Beryllium - milligrams per kilogram
0
.5
1
1.5
2
2.5
Surficial
0.5'-10' bgs
>10' bgs

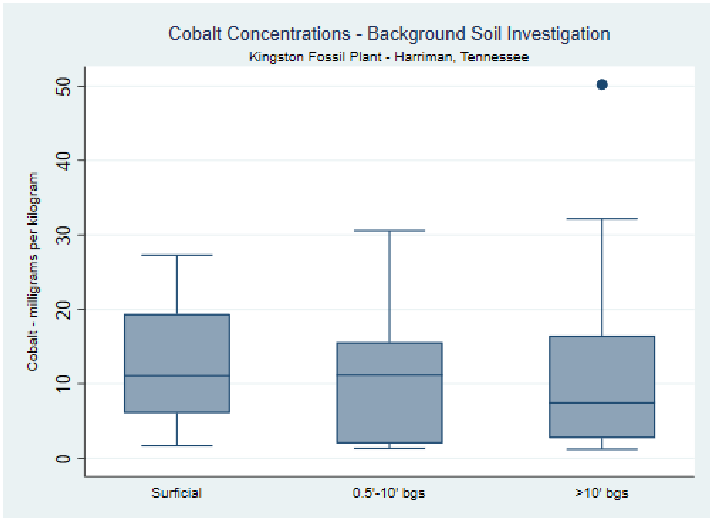

Beryllium Concentrations - Background Soil Investigation
Kingston Fossil Plant - Harriman, Tennessee
Beryllium - milligrams per kilogram
0
.5
1
1.5
2
2.5
KIF-BG01
KIF-BG02
KIF-BG03
KIF-BG04
KIF-BG05
KIF-BG06
KIF-BG07
KIF-BG08
KIF-BG09
KIF-BG10
KIF-BG11
KIF-BG12


Cadmium Concentrations - Background Soil Investigation
Kingston Fossil Plant - Harriman, Tennessee
Cadmium - milligrams per kilogram
0
.1
.2
.3
Surficial
0.5'-10' bgs
>10' bgs

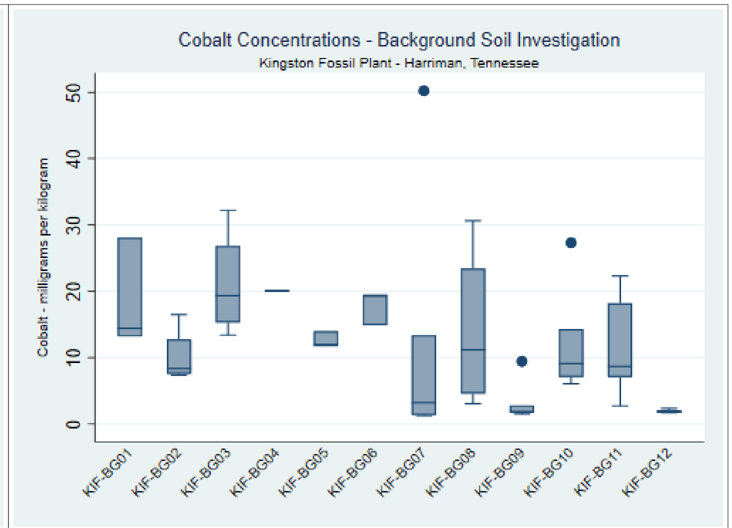

Cadmium Concentrations - Background Soil Investigation
Kingston Fossil Plant - Harriman, Tennessee
Cadmium - milligrams per kilogram
0
.1
.2
.3
KIF-BG01
KIF-BG02
KIF-BG03
KIF-BG04
KIF-BG05
KIF-BG06
KIF-BG07
KIF-BG08
KIF-BG09
KIF-BG10
KIF-BG11
KIF-BG12


Chromium Concentrations - Background Soil Investigation
Kingston Fossil Plant - Harriman, Tennessee
Chromium - milligrams per kilogram
0
10
20
30
40
Surficial
0.5'-10' bgs
>10' bgs

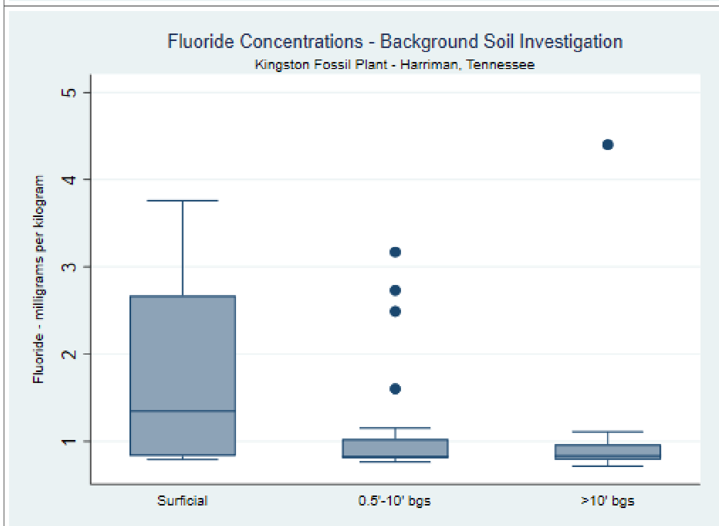

Chromium Concentrations - Background Soil Investigation
Kingston Fossil Plant - Harriman, Tennessee
Chromium - milligrams per kilogram
0
10
20
30
40
KIF-BG01
KIF-BG02
KIF-BG03
KIF-BG04
KIF-BG05
KIF-BG06
KIF-BG07
KIF-BG08
KIF-BG09
KIF-BG10
KIF-BG11
KIF-BG12



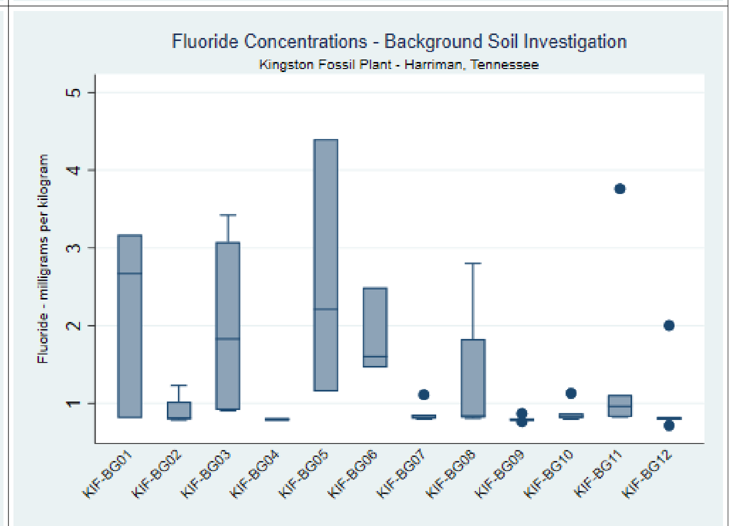
Cobalt Concentrations - Background Soil Investigation
Kingston Fossil Plant - Harriman, Tennessee
Cobalt - milligrams per kilogram
0
10
20
30
40
50
Surficial
0.5'-10' bgs
>10' bgs



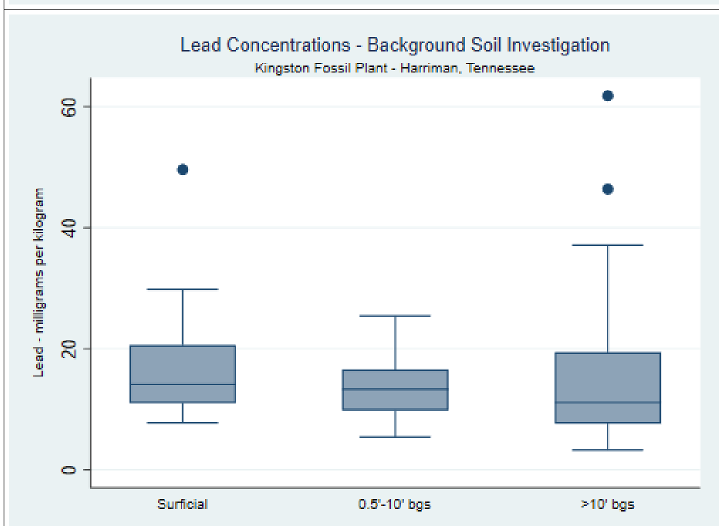
Cobalt Concentrations - Background Soil Investigation
Kingston Fossil Plant - Harriman, Tennessee
Cobalt - milligrams per kilogram
0
10
20
30
40
50
KIF-BG01
KIF-BG02
KIF-BG03
KIF-BG04
KIF-BG05
KIF-BG06
KIF-BG07
KIF-BG08
KIF-BG09
KIF-BG10
KIF-BG11
KIF-BG12



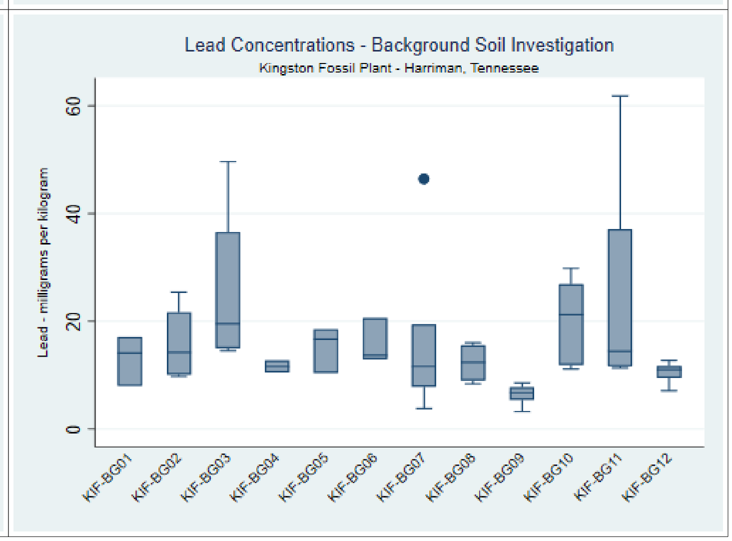
Fluoride Concentrations - Background Soil Investigation
Kingston Fossil Plant - Harriman, Tennessee
Fluoride - milligrams per kilogram
1
2
3
4
5
Surficial
0.5'-10' bgs
>10' bgs



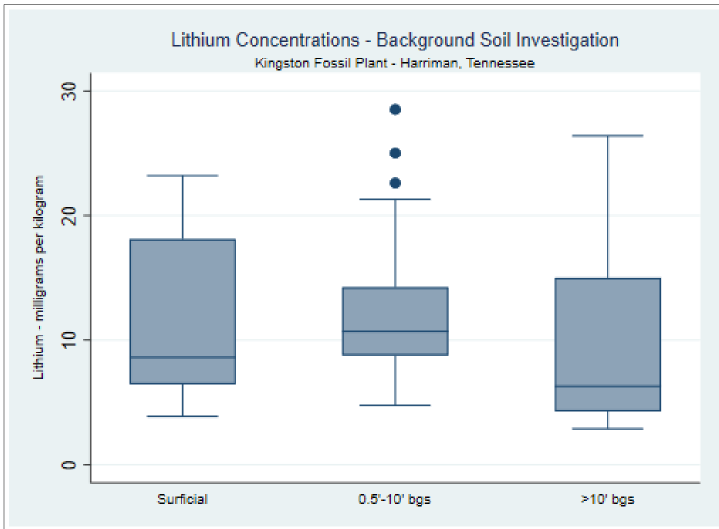
Fluoride Concentrations - Background Soil Investigation
Kingston Fossil Plant - Harriman, Tennessee
Fluoride - milligrams per kilogram
1
2
3
4
5
KIF-BG01
KIF-BG02
KIF-BG03
KIF-BG04
KIF-BG05
KIF-BG06
KIF-BG07
KIF-BG08
KIF-BG09
KIF-BG10
KIF-BG11
KIF-BG12

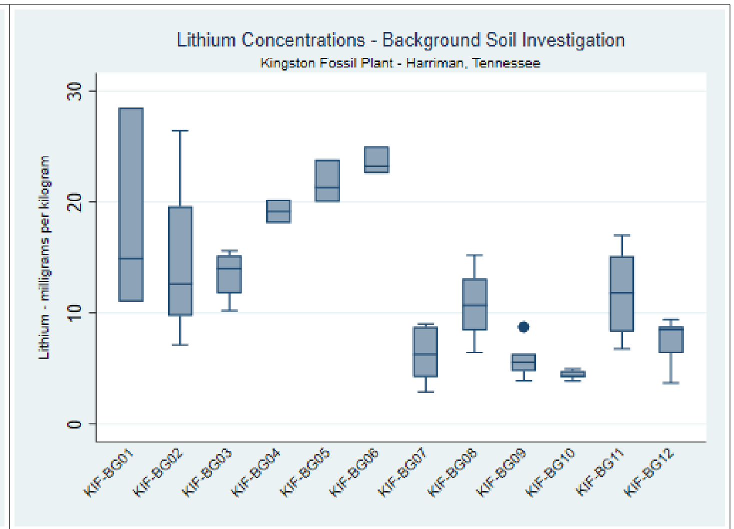


Lead Concentrations - Background Soil Investigation
Kingston Fossil Plant - Harriman, Tennessee
Lead - milligrams per kilogram
0
20
40
60
Surficial
0.5'-10' bgs
>10' bgs



Lead Concentrations - Background Soil Investigation
Kingston Fossil Plant - Harriman, Tennessee
Lead - milligrams per kilogram
0
20
40
60
KIF-BG01
KIF-BG02
KIF-BG03
KIF-BG04
KIF-BG05
KIF-BG06
KIF-BG07
KIF-BG08
KIF-BG09
KIF-BG10
KIF-BG11
KIF-BG12


Lithium Concentrations - Background Soil Investigation
Kingston Fossil Plant - Harriman, Tennessee
Lithium - milligrams per kilogram
0
10
20
30
Surficial
0.5'-10' bgs
>10' bgs


Lithium Concentrations - Background Soil Investigation
Kingston Fossil Plant - Harriman, Tennessee
Lithium - milligrams per kilogram
0
10
20
30
KIF-BG01
KIF-BG02
KIF-BG03
KIF-BG04
KIF-BG05
KIF-BG06
KIF-BG07
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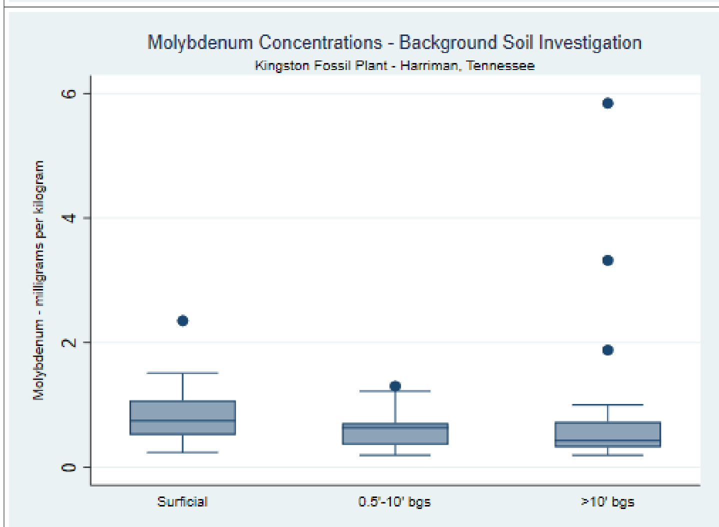
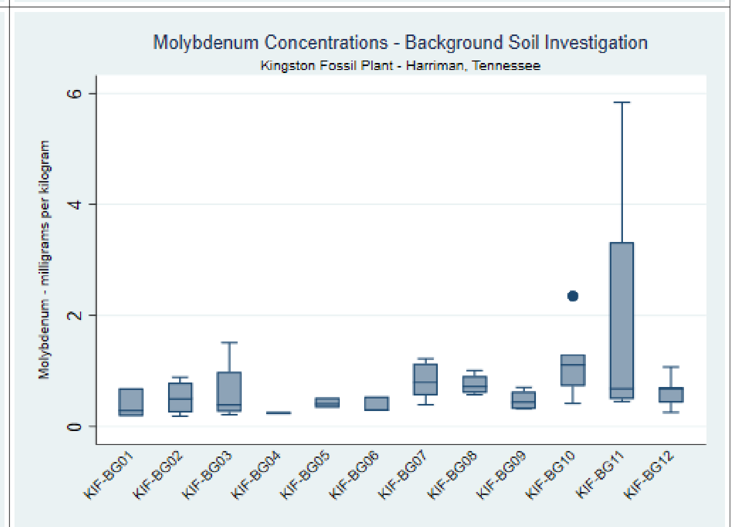
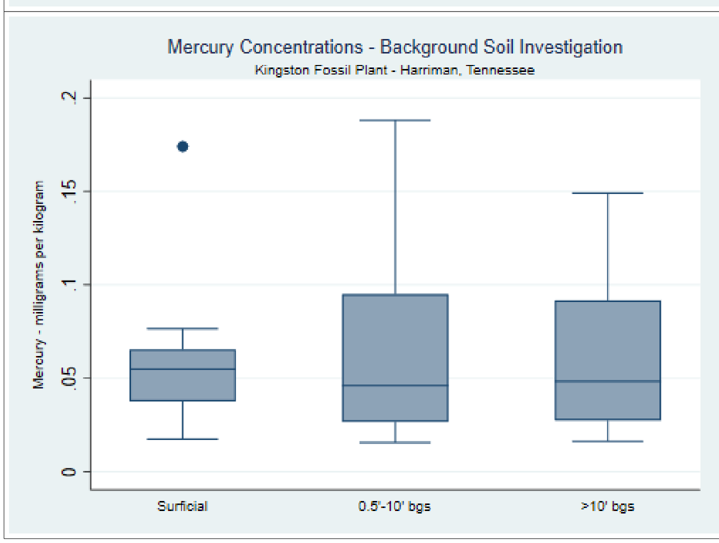
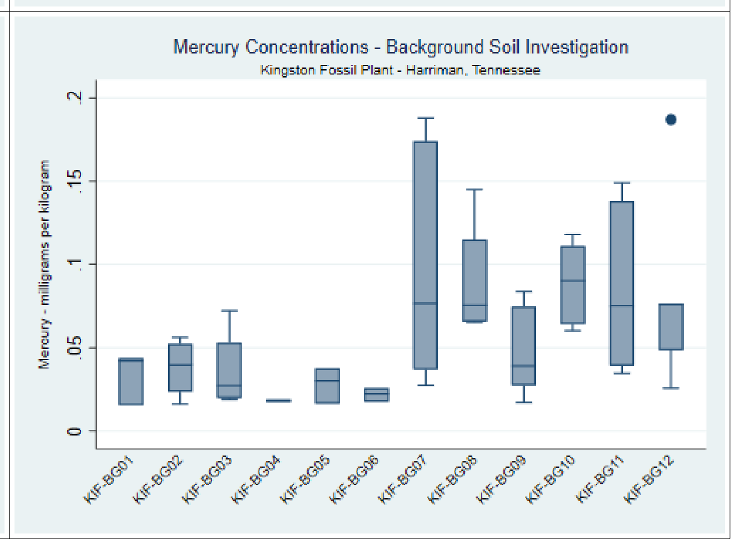
KIF-BG10
KIF-BG11
KIF-BG12


Molybdenum Concentrations - Background Soil Investigation
Kingston Fossil Plant - Harriman, Tennessee
Molybdenum - milligrams per kilogram
0
2
4
6
Surficial
0.5'-10' bgs
>10' bgs


Molybdenum Concentrations - Background Soil Investigation
Kingston Fossil Plant - Harriman, Tennessee
Molybdenum - milligrams per kilogram
0
2
4
6
KIF-BG01
KIF-BG02
KIF-BG03
KIF-BG04
KIF-BG05
KIF-BG06
KIF-BG07
KIF-BG08
KIF-BG09
KIF-BG10
KIF-BG11
KIF-BG12


Mercury Concentrations - Background Soil Investigation
Kingston Fossil Plant - Harriman, Tennessee
Mercury - milligrams per kilogram
0
.05
.1
.15
.2
Surficial
0.5'-10' bgs
>10' bgs


Mercury Concentrations - Background Soil Investigation
Kingston Fossil Plant - Harriman, Tennessee
Mercury - milligrams per kilogram
0
.05
.1
.15
.2
KIF-BG01
KIF-BG02
KIF-BG03
KIF-BG04
KIF-BG05
KIF-BG06
KIF-BG07
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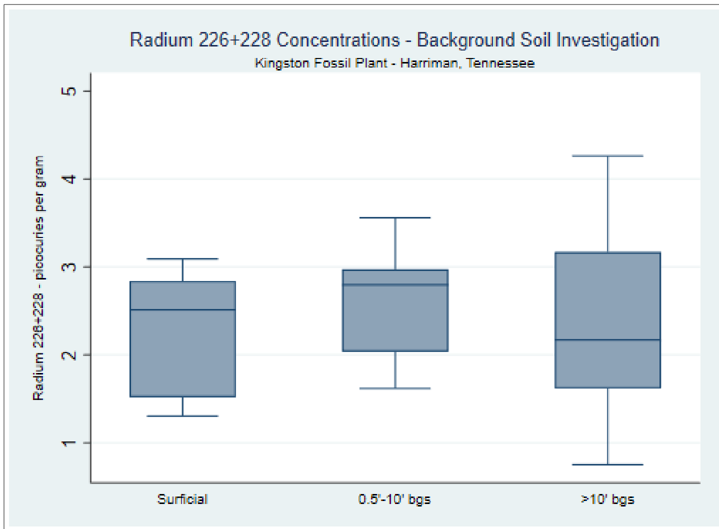
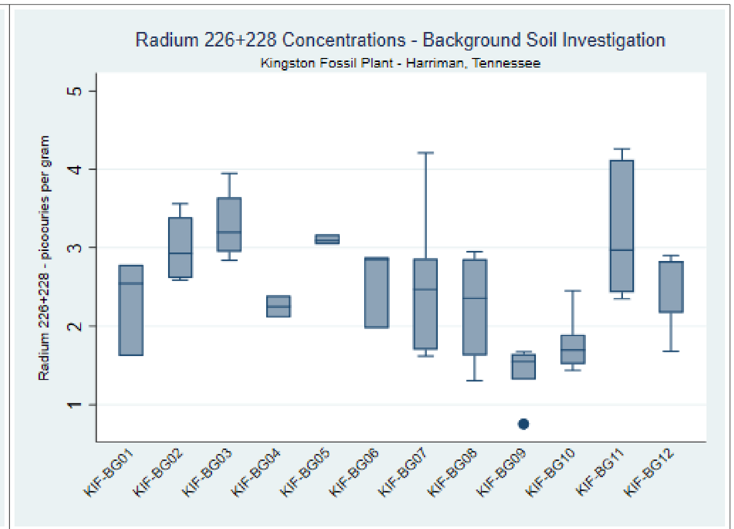
KIF-BG09
KIF-BG10
KIF-BG11
KIF-BG12


Radium 226+228 Concentrations - Background Soil Investigation
Kingston Fossil Plant - Harriman, Tennessee
Radium 226+228 - picocuries per gram
1
2
3
4
5
Surficial
0.5'-10' bgs
>10' bgs


Radium 226+228 Concentrations - Background Soil Investigation
Kingston Fossil Plant - Harriman, Tennessee
Radium 226+228 - picocuries per gram
1
2
3
4
5
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KIF-BG02
KIF-BG03
KIF-BG04
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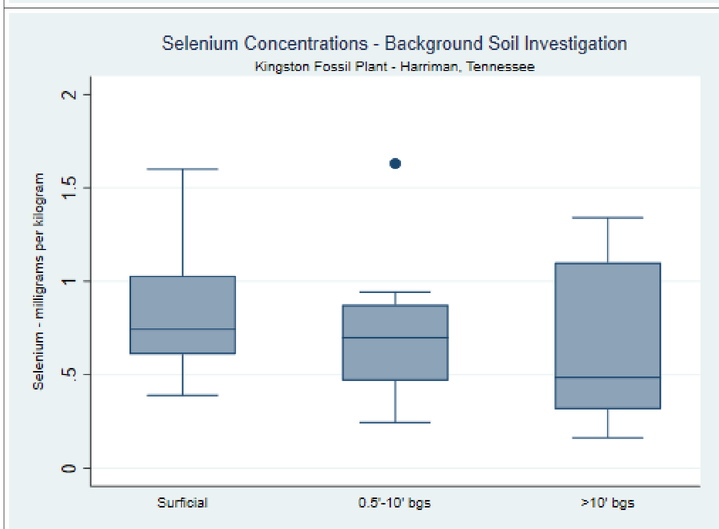
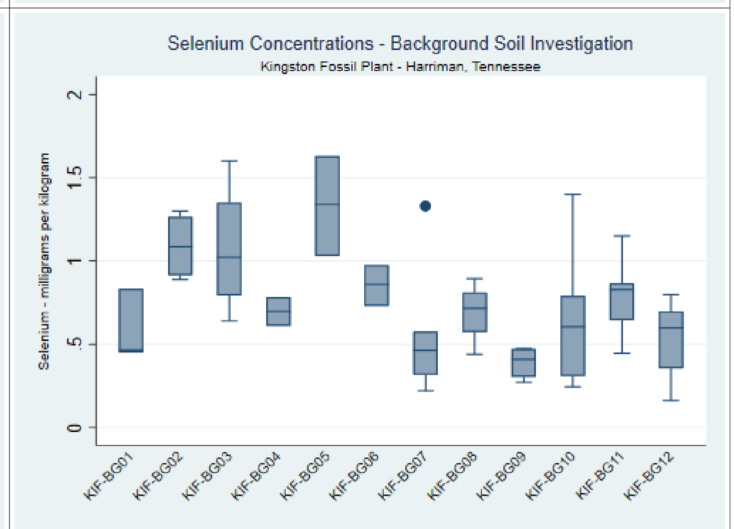
KIF-BG09
KIF-BG10
KIF-BG11
KIF-BG12


Selenium Concentrations - Background Soil Investigation
Kingston Fossil Plant - Harriman, Tennessee
Selenium - milligrams per kilogram
0
.5
1
1.5
2
Surficial
0.5'-10' bgs
>10' bgs


Selenium Concentrations - Background Soil Investigation
Kingston Fossil Plant - Harriman, Tennessee
Selenium - milligrams per kilogram
0
.5
1
1.5
2
KIF-BG01
KIF-BG02
KIF-BG03
KIF-BG04
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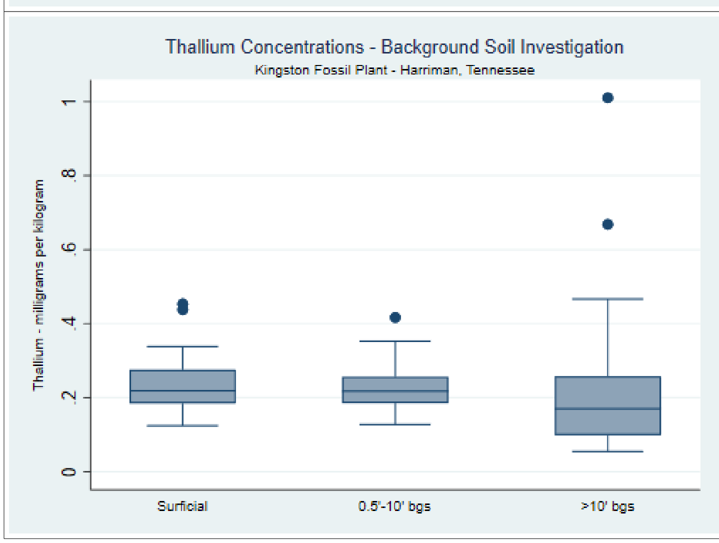
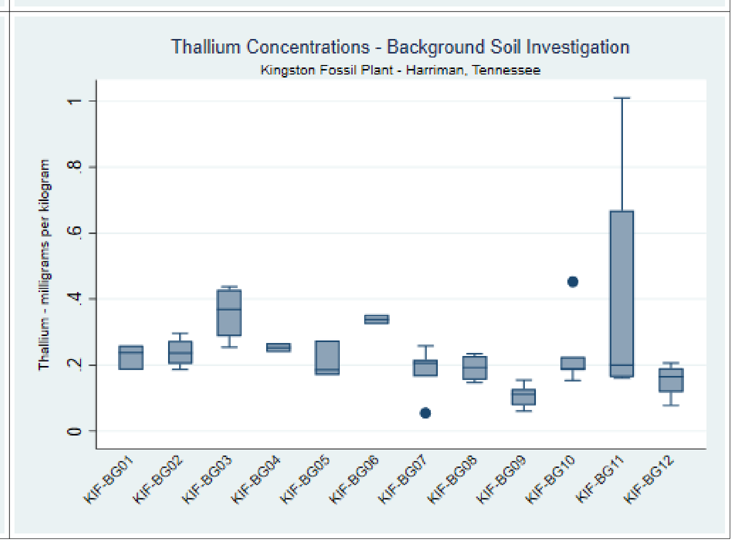
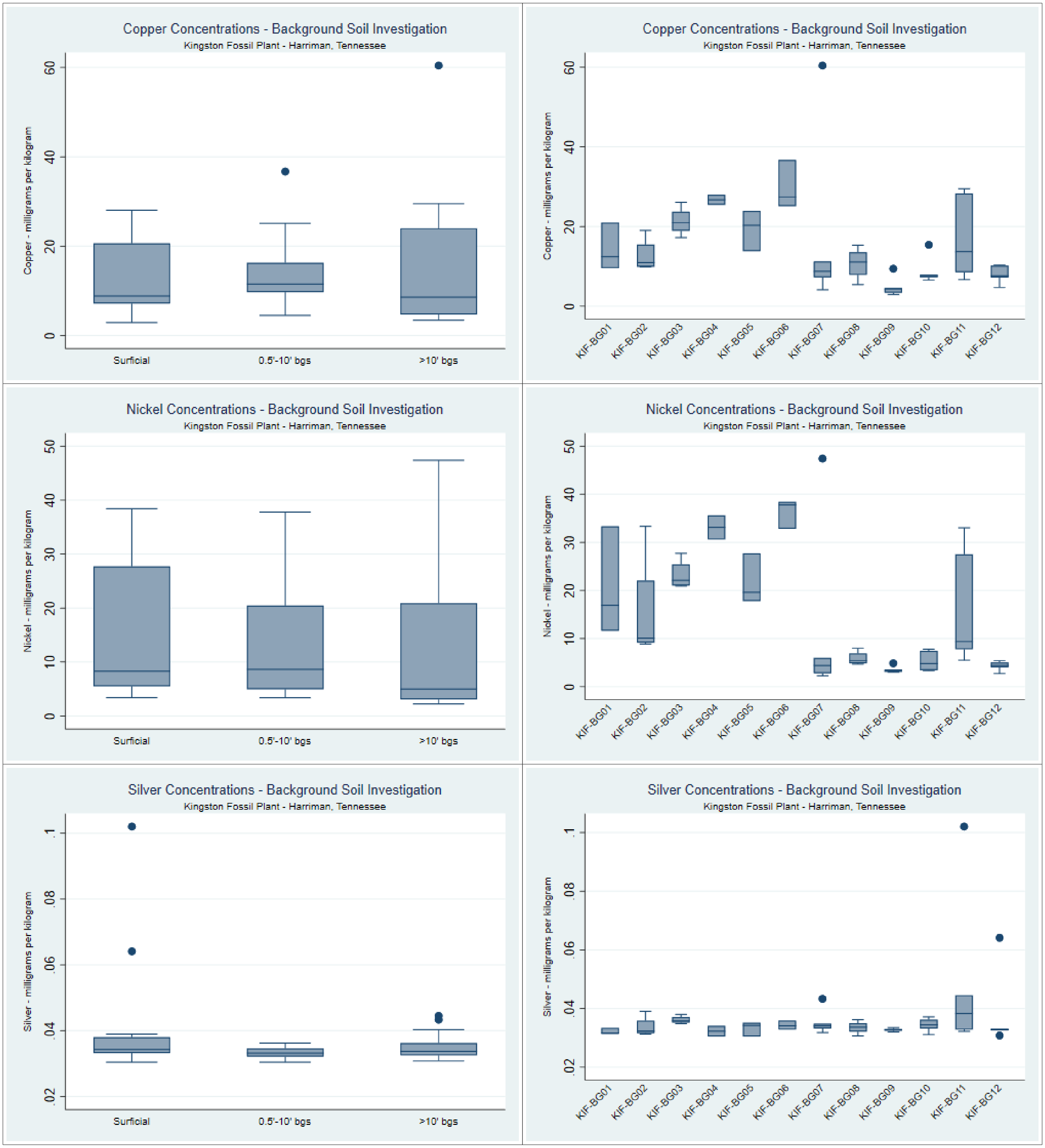
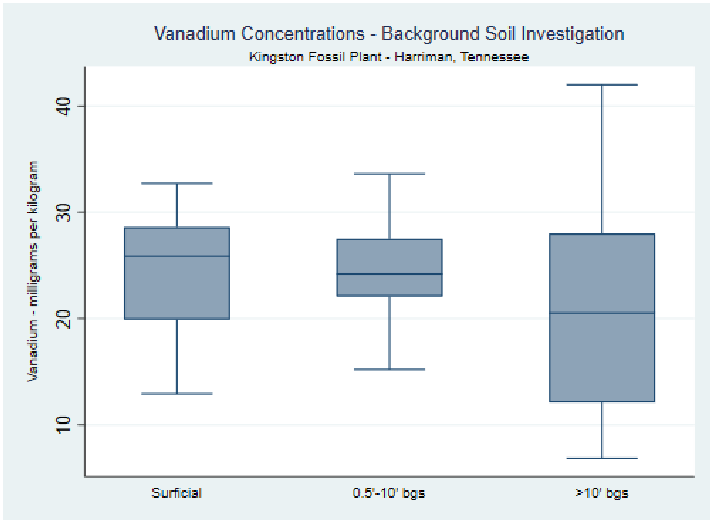
KIF-BG06
KIF-BG07
KIF-BG08
KIF-BG09
KIF-BG10
KIF-BG11
KIF-BG12


Thallium Concentrations - Background Soil Investigation
Kingston Fossil Plant - Harriman, Tennessee
Thallium - milligrams per kilogram
0
.2
.4
.6
.8
1
Surficial
0.5'-10' bgs
>10' bgs

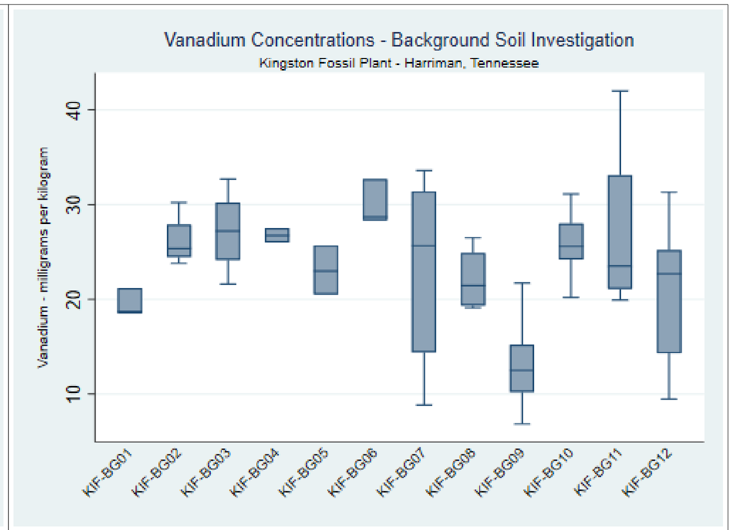

Thallium Concentrations - Background Soil Investigation
Kingston Fossil Plant - Harriman, Tennessee
Thallium - milligrams per kilogram
0
.2
.4
.6
.8
1
KIF-BG01
KIF-BG02
KIF-BG03
KIF-BG04
KIF-BG05
KIF-BG06
KIF-BG07
KIF-BG08
KIF-BG09
KIF-BG10
KIF-BG11
KIF-BG12

Box Plots
TDEC Appendix I Parameters
Background Soil Investigation
Kingston Fossil Plant - Harriman, Tennessee

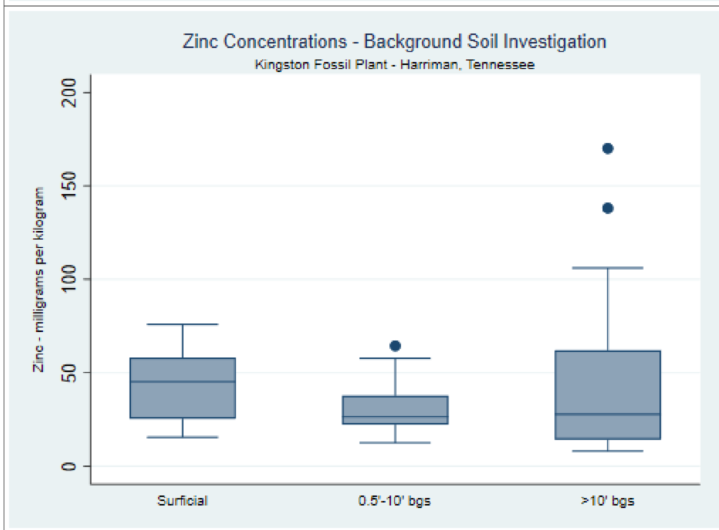




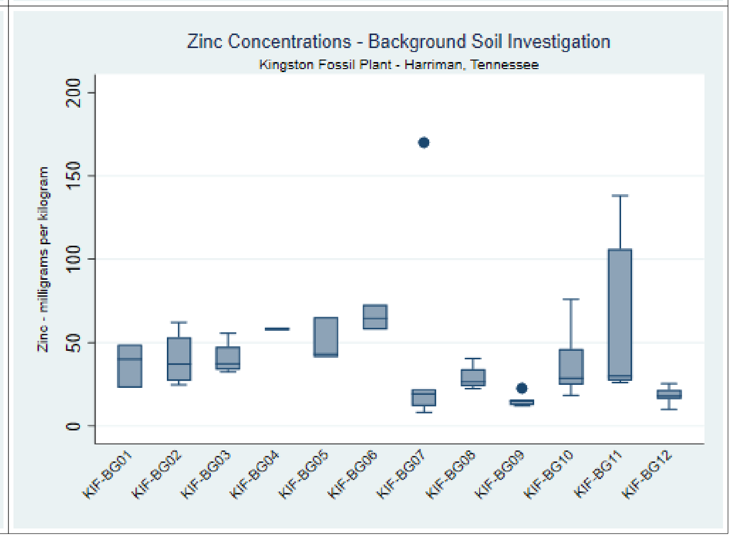
Vanadium Concentrations - Background Soil Investigation
Kingston Fossil Plant - Harriman, Tennessee
Vanadium - milligrams per kilogram
10
20
30
40
Surficial
0.5'-10' bgs
>10' bgs



Vanadium Concentrations - Background Soil Investigation
Kingston Fossil Plant - Harriman, Tennessee
Vanadium - milligrams per kilogram
10
20
30
40
KIF-BG01
KIF-BG02
KIF-BG03
KIF-BG04
KIF-BG05
KIF-BG06
KIF-BG07
KIF-BG08
KIF-BG09
KIF-BG10
KIF-BG11
KIF-BG12



Zinc Concentrations - Background Soil Investigation
Kingston Fossil Plant - Harriman, Tennessee
Zinc - milligrams per kilogram
0
50
100
150
200
Surficial
0.5'-10' bgs
>10' bgs



Zinc Concentrations - Background Soil Investigation
Kingston Fossil Plant - Harriman, Tennessee
Zinc - milligrams per kilogram
0
50
100
150
200
KIF-BG01
KIF-BG02
KIF-BG03
KIF-BG04
KIF-BG05
KIF-BG06
KIF-BG07
KIF-BG08
KIF-BG09
KIF-BG10
KIF-BG11
KIF-BG12

APPENDIX E.2

STATISTICAL ANALYSIS OF CCR MATERIAL CHARACTERISTICS DATA

Stantec

Appendix E.2 - Statistical Analysis of CCR Material Characteristics Data

TDEC Commissioner's Order:
Environmental Assessment Report
Kingston Fossil Plant
Harriman, Tennessee

March 12, 2024

Prepared for:

Tennessee Valley Authority
Chattanooga, Tennessee

TVA TENNESSEE VALLEY AUTHORITY

Prepared by:

Stantec Consulting Services Inc.
Lexington, Kentucky

REVISION LOG

Revision	Description	Date
0	EAR Submittal to TDEC	May 30, 2023
1	Addresses August 16, 2023 TDEC Review Comments and Issued for TDEC	November 14, 2023
2	Addresses January 12, 2024 TDEC Review Comments and Issued for TDEC	March 12, 2024

Sign-off Sheet

This document entitled Appendix E.2 - Statistical Analysis of CCR Material Characteristics Data was prepared by Stantec Consulting Services Inc. (“Stantec”) for the account of Tennessee Valley Authority (the “Client”). Any reliance on this document by any third party is strictly prohibited. The material in it reflects Stantec’s professional judgment in light of the scope, schedule and other limitations stated in the document and in the contract between Stantec and the Client. The opinions in the document are based on conditions and information existing at the time the document was published and do not consider any subsequent changes. In preparing the document, Stantec did not verify information supplied to it by others. Any use which a third party makes of this document is the responsibility of such third party. Such third party agrees that Stantec shall not be responsible for costs or damages of any kind, if any, suffered by it or any other third party as a result of decisions made or actions taken based on this document.

Prepared by ______________________

Chris La Londe, Senior Risk Assessor

Reviewed by ______________________

Melissa Whitfield Aslund, PhD, Environmental Scientist

Approved by ______________________

Rebekah Brooks, PG, Senior Principal Hydrogeologist

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2.1.3 Outlier Screening 4
2.2 REGRESSION ANALYSIS 5

3.0 RESULTS AND DISCUSSION **5**
3.1 SUMMARY STATISTICS, EXPLORATORY DATA PLOTS, AND OUTLIER SCREENING 5
3.2 REGRESSION ANALYSIS 5

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Table E.2-2 – CCR Parameters Evaluated in Statistical Analysis 2

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Attachment E.2-B Box Plots – CCR Material

Attachment E.2-C Box Plots – Pore Water Outlier Analysis

Attachment E.2-D Scatter Plots and Regression

Abbreviations

CASRN	Chemical Abstracts Service Registry Number
CCR	Coal Combustion Residuals
CCR Parameters	Constituents listed in Appendices III and IV of 40 CFR 257 and five inorganic constituents included in Appendix I of Tennessee Rule 0400-11-01-.04
CCR Rule	Title 40, Code of Federal Regulations, Part 257
EAR	Environmental Assessment Report
IQR	Interquartile Range
KIF Plant	Kingston Fossil Plant
NA	Not Available
NTUs	Nephelometric Turbidity Units
%	Percent
SPLP	Synthetic Precipitate Leaching Procedure
Stantec	Stantec Consulting Services Inc.
TDEC	Tennessee Department of Environment and Conservation
TVA	Tennessee Valley Authority

March 12, 2024

1.0 INTRODUCTION

Stantec Consulting Services Inc. (Stantec) prepared this appendix on behalf of the Tennessee Valley Authority (TVA) to document the statistical analyses performed on data collected to characterize coal combustion residual (CCR) material in support of evaluations conducted for the Environmental Assessment Report (EAR) at the Kingston Fossil Plant (KIF Plant) located in Harriman, Tennessee. The CCR material characterization samples were collected between November 2018 and December 2019 within the TDEC Order CCR management units[1] at the KIF Plant, which include the Interim Ash Staging Area, Sluice Trench and Area East of Sluice Trench, and Stilling Pond . Further details regarding the CCR material sampling and laboratory data are presented in the KIF Plant *CCR Material Characteristics Sampling and Analysis Report* (Appendix J.2). Additional samples collected in November 2017 from the Stilling Pond were incorporated into this evaluation.

For the Environmental Investigation, CCR material and pore water samples were collected for characterization related to the leachability of constituents listed in Appendices III and IV of 40 CFR 257 and five additional inorganic constituents included in Appendix I of Tennessee Rule 0400-11-01-.04 (CCR Parameters) from material within two KIF Plant TDEC Order CCR management units: the Interim Ash Staging Area and Sluice Trench and Area East of Sluice Trench. Additional samples collected in November 2017 from locations in the Stilling Pond were included into this evaluation. The Synthetic Precipitate Leaching Procedure (SPLP) was used to characterize leachability of CCR Parameters in CCR material. Temporary well/boring locations and the number of samples collected in each KIF Plant TDEC Order CCR management unit are presented in Table E.2-1. Table E.2-2 presents the list of CCR parameters evaluated in this statistical evaluation.

Table E.2-1 – CCR Material Characteristics Sample Locations - KIF Plant

KIF Plant TDEC Order CCR Management Unit	Temporary Well/Boring Location	Number of Samples	
		CCR Material/SPLP	Pore Water
Interim Ash Staging Area	KIF-TW01; KIF-TW02; KIF-TW03; KIF-B01; KIF-B02; KIF-B03	33	3
Sluice Trench and Area East of Sluice Trench	KIF-TW04; KIF-TW05; KIF-B04	17	2
Stilling Pond	GP-17-101; GP-17-102; GP-17-103	3	3

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

Table E.2-2 – CCR Parameters Evaluated in Statistical Analysis

CCR Parameter	CASRN
CCR Rule Appendix III Parameters	
Boron	7440-42-8
Calcium	7440-70-2
Chloride	16887-00-6
Fluoride[1] (also Appendix IV)	16984-48-8
pH	NA
Sulfate	14808-79-8
Total Dissolved Solids	NA
CCR Rule Appendix IV Parameters	
Antimony	7440-36-0
Arsenic	7440-38-2
Barium	7440-39-3
Beryllium	7440-41-7
Cadmium	7440-43-9
Chromium	7440-47-3
Cobalt	7440-48-4
Lead	7439-92-1
Lithium	7439-93-2
Mercury	7439-97-6
Molybdenum	7439-98-7
Radium-226+228	13982-63-3 / 15262-20-1
Selenium	7782-49-2
Thallium	7440-28-0
Additional TDEC Appendix I Parameters	
Copper	7440-50-8
Nickel	7440-02-0
Silver	7440-22-4
Vanadium	7440-62-2
Zinc	7440-66-6
Other	
Iron	7439-89-6
Manganese	7439-96-5
Total Organic Carbon	NA

Notes: CASRN: Chemical Abstracts Service Registry Number; CCR Rule - Title 40, Code of Federal Regulations, Part 257; NA – Not Available; TDEC - Tennessee Department of Environment and Conservation
[1]Fluoride is both a CCR Rule Appendix III and CCR Rule Appendix IV CCR parameter. In this table, and in the results figures and tables for this report, fluoride has been grouped with the Appendix III CCR parameters only to avoid duplication.

The following sections present the methods and results used to evaluate the CCR material and pore water data, including: 1) general exploratory data analysis (summary statistics, data plots and outlier screening), 2) a regression analysis to evaluate correlation between SPLP results to CCR Parameter concentrations in CCR material, and 3) a comparison of SPLP results to pore water concentrations.

2.0 METHODS

The statistical evaluation was conducted in three parts: 1) exploratory data analysis, 2) regression analysis, and 3) comparison of SPLP results to CCR Parameter concentrations in pore water.

2.1 EXPLORATORY DATA ANALYSIS

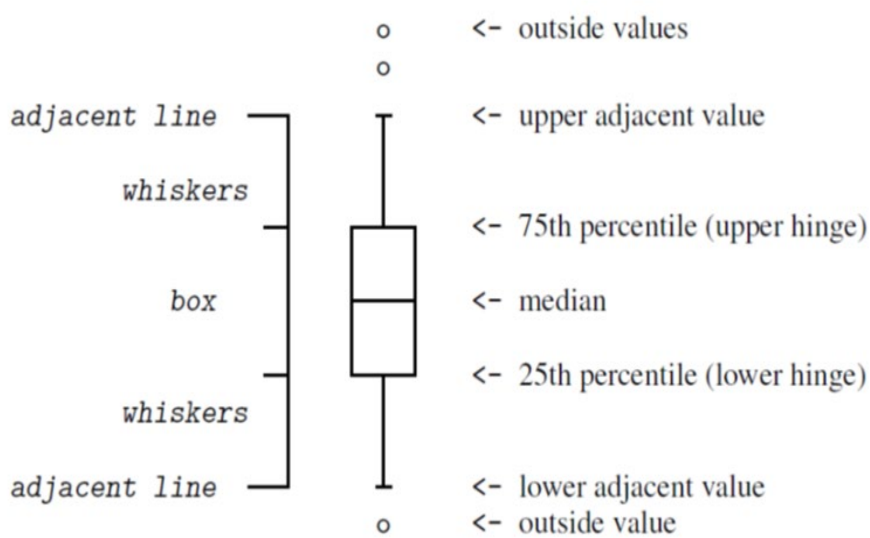
Exploratory data analysis is the initial step of statistical analysis. It utilizes simple summary statistics (e.g. mean, median, standard deviation and percentiles) and graphical representations to identify characteristics of an analytical dataset, such as the center of the data (mean, median), variation, distribution, patterns, presence of outliers, and randomness.

2.1.1 Summary Statistics

Summary statistics were calculated for CCR material, SPLP, and pore water for each CCR Parameter grouped by KIF Plant TDEC Order CCR management unit. Summary statistics include information such as the total numbers of available samples, the frequencies of detection, ranges of reporting limits, minimum and maximum detected concentrations, mean concentrations, standard deviations, median concentrations, and the 95th percentile concentrations. Summary statistics were calculated for total metal and dissolved metal concentrations in pore water. Summary statistics tables are presented in Attachment E.2-A.

2.1.2 Exploratory Data Plots

Box plots were constructed of CCR Parameter concentrations in CCR material to support a visual review of the data. Box plots were used to identify the center of the data, distribution, variability, and to visually identify potential outliers. The diagram below graphically depicts the basics of the construction of the box plots (StataCorp LLC 2017).



The box portion of the plot is the interquartile range (IQR), which represents the middle 50 percent (%) of data, with the bottom of the box being the 25th percentile and the top of the box being the 75th percentile. The line inside the box is the median concentration. The top of the upper “whisker” represents the first observed concentration above the 75th percentile, whereas the bottom of the lower “whisker” represents the first observed concentration below the 25th percentile (upper adjacent value and lower adjacent value, respectively). Values that lie outside of the adjacent values represent outside (potential outliers) concentrations (i.e. concentrations at the upper and lower ends of the distribution of the data). The method detection limit was used as the reported value in order to construct the box plot when analytical results were reported as non-detects.

Side-by-side box plots were constructed for the CCR material and pore water data and aggregated by temporary well/boring location and KIF Plant TDEC Order CCR management unit. These box plots were useful in identifying differences in CCR Parameter concentrations between each KIF Plant TDEC Order CCR management unit and are especially useful for visually identifying potential outliers. Box plots are presented in Attachment E.2-B for CCR material results and E.2-C for pore water results.

2.1.3 Outlier Screening

Outliers are data points that are abnormally high or low as compared to other measurements and may represent anomalous data or data errors. Outliers may also represent natural variation of CCR Parameter concentrations in environmental systems. Screening for outliers is a critical step because outliers can bias statistical estimates, statistical testing results, and inferences.

Outlier values were initially screened visually using side-by-side box plots. If suspected visual outliers were identified, then Tukey's procedure was used to identify extreme outliers (Tukey 1977). This method relies on the 25th and 75th percentiles of the data (IQR), which is defined as the 75th percentile value minus the 25th percentile value. Values were identified as potential outliers as follows:

- **Lower extreme outliers** are less than the 25th percentile minus 3 x IQR
- **Upper extreme outliers** are greater than the 75th percentile plus 3 x IQR.

Finally, when the potential outlier(s) were identified visually and by Tukey's procedure, then statistical testing for outliers (Dixon or Rosner's Test) was conducted to determine if the data points were statistically significant outliers.

Following confirmation of the outliers as statistically significant, a desktop evaluation was conducted to verify that the data points were not errors (e.g., laboratory or transcriptional error). Field forms, data validation reports, and other variables in the dataset that could influence analytical results were also evaluated. If a verifiable error was discovered, the outlier was removed and, if possible, replaced with a corrected value.

In the absence of a verifiable error, additional lines of evidence were reviewed to determine final outlier disposition (e.g., frequency of detection, spatial and temporal variability). If an outlier was identified as suitable for removal from further statistical analysis, a clear and defensible rationale based on multiple lines of evidence was provided. In addition, values that were identified as outliers and removed from further evaluation in the present statistical analysis were retained in the historical database and will be reevaluated for inclusion or exclusion in future statistical analyses of this dataset. The results of the outlier screening for the KIF Plant CCR material dataset are provided in Section 3.1.

2.2 REGRESSION ANALYSIS

The linear relationship between the concentrations of CCR Parameters in SPLP results and concentrations in CCR material was evaluated using regression analysis. Scatter plots were constructed to compare SPLP and CCR material results for the CCR Parameters. Using linear regression, the Pearson's correlation coefficient was estimated, and a regression line was fit to the data and added to the scatter plots. As part of the analysis, the SPLP results for the CCR Parameters were compared to the range of pore water concentrations observed in the respective KIF Plant TDEC Order CCR management units. Analyses were conducted on data where CCR parameters were detected in greater than 50% of the samples in both the SPLP and CCR material datasets. Scatter plots, regression results, and range of pore water concentrations are presented in Attachment E.2-D.

3.0 RESULTS AND DISCUSSION

3.1 SUMMARY STATISTICS, EXPLORATORY DATA PLOTS, AND OUTLIER SCREENING

Summary statistics tables are presented in Attachment E.2-A, and box plots are presented in Attachments E.2-B for CCR material and E.2-C for pore water.

No outliers were identified in the CCR material or SPLP datasets.

Anomalously high CCR parameter concentrations were observed in the pore water sample collected from well GP-17-102, thus the pore water dataset was subsequently screened using outlier screening methods described above for CCR Appendix IV and TDEC Appendix I parameters. Pore water box plots aggregated by KIF Plant TDEC Order CCR management unit are presented as Attachment E.2-C. Multiple CCR parameter concentrations were identified as potential statistical outliers. Turbidity measurements were also anomalously high in sample GP-17-102 (616.3 nephelometric turbidity units [NTUs]), compared to turbidity measurements across the KIF Plant TDEC Order CCR management unit areas, which ranged from 1.17 to 99 NTUs. Using the outlier screening methods described above, turbidity in sample GP-17-102 was found to be a statistically significant outlier. A box plot for turbidity is provided in Attachment E.2-C. Since turbidity was an outlier and could be the cause of other anomalously high CCR parameter concentrations observed in sample GP-17-102, sample results from GP-17-102 were excluded from further statistical analyses.

3.2 REGRESSION ANALYSIS

The purpose of the regression analysis was to evaluate whether the total concentrations of metals in CCR material could be used as a reliable predictor of leachable concentrations as represented by SPLP concentrations. Scatter plots, regression results, and range of pore water concentrations are presented in Attachment E.2-D. The correlation coefficient is a numerical measure that measures the strength of association between two variables (in this case, between total concentration and SPLP results for CCR material), with values ranging from zero to one. A high correlation coefficient (closer to one) demonstrates a strong relationship between the two variables, whereas a low correlation coefficient (closer to zero) demonstrates a weak relationship. The slope of the regression line indicates the direction of correlation. A positive slope indicates that SPLP concentrations increased as CCR Parameter concentrations in CCR material increased. Conversely, a negative slope indicates that as CCR Parameter concentrations in CCR material increased, the SPLP concentrations decreased.

The statistical relationships between SPLP concentrations and CCR material concentrations were inconsistent and highly variable. One would expect SPLP concentrations to increase with increasing CCR parameter concentrations in CCR material (e.g. regression line with a positive slope). However, this relationship was inconsistent between different CCR parameters and between KIF Plant TDEC Order CCR management units (e.g. boron). In some cases, even when there was a statistically significant correlation (e.g., vanadium), the wide range of variability around the regression line limits the predictive value of the relationship. The results indicate that the total concentrations of metals in CCR material are not a reliable predictor of the magnitude of the potentially leached concentrations measured using SPLP.

In addition, the CCR parameter concentrations in SPLP generally underestimated CCR parameter concentrations measured in pore water.

The results indicate that direct measurement of pore water concentrations is the most accurate way of characterizing potential leachability from CCR materials.

4.0 REFERENCES

StataCorp LLC. (2017). Stata Graphics Reference Manual Stata: Release 15. Statistical Software. College Station, Texas: StataCorp LLC.

Tukey, J.W. (1977). Exploratory Data Analysis. Reading, Massachusetts: Addison-Wesley. 1977.

ATTACHMENT E.2–A
SUMMARY STATISTICS

Summary Statistics - CCR Material Characteristics Kingston Fossil Plant - Harriman, Tennessee											
Parameter	CCR Management Unit	Frequency of Detection	Range of Reporting Limits	% Non Detect	Statistics using Detected Data Only		Statistics using Detects & Non-Detects			
					Minimum Detect	Maximum Detect	Mean	Standard Deviation	50th Percentile	95th Percentile
CCR Rule Appendix III Parameters										
Boron	Interim Ash Staging Area	33/33	--	0%	9.67	57.6	29.0	13.59	26.4	50.7
	Sluice Trench and Ballfield East of Sluice Trench	17/17	--	0%	3.92	211	62.0	70.62	31.7	202.2
	Interim Ash Staging Area	3/3	--	0%	28.3	58.7	39.3	16.83	31	55.93
Calcium	Interim Ash Staging Area	33/33	--	0%	1,060	24,500	5,828	5,914	3,680	19,480
	Sluice Trench and Ballfield East of Sluice Trench	17/17	--	0%	770	51,100	13,495	15,054	4,530	36,300
	Interim Ash Staging Area	3/3	--	0%	2,250	6,400	3,753	2,299	2,610	6,021
Chloride	Interim Ash Staging Area	23/33	(4.62-5.79)	30.3%	5.48	104	10.19	16.78	6.83	13.52
	Sluice Trench and Ballfield East of Sluice Trench	2/17	(5.07-10.2)	88.2%	6.04	9.88	5.484	1.177	6.07	9.944
	Interim Ash Staging Area	1/3	(3.79-3.86)	66.7%	4.36	4.36	3.98	0.269	3.86	4.31
Fluoride	Interim Ash Staging Area	17/33	(0.756-1.05)	48.5%	1.13	4.29	1.671	1.163	1.13	3.752
	Sluice Trench and Ballfield East of Sluice Trench	7/17	(0.848-1.37)	58.8%	1.07	2.37	1.10	0.403	1.07	1.794
	Interim Ash Staging Area	3/3	--	0.0%	1.15	6.13	3.44	2.515	3.03	5.82
pH (lab)	Interim Ash Staging Area	33/33	--	0%	4.90	8.70	7.345	0.896	7.60	8.30
	Sluice Trench and Ballfield East of Sluice Trench	17/17	--	0%	3.90	11.0	8.165	2.166	8.20	10.92
	Interim Ash Staging Area	3/3	--	0%	7.80	8.0	7.9	0.1	7.90	7.99
Sulfate	Interim Ash Staging Area	33/33	--	0%	111	16,400	1,157	2,788	531	2,252
	Sluice Trench and Ballfield East of Sluice Trench	17/17	--	0%	49.7	1,460	434	434	258	1,196
	Interim Ash Staging Area	3/3	--	0%	31.9	94	65	31	70	91
CCR Rule Appendix IV Parameters										
Antimony	Interim Ash Staging Area	33/33	--	0%	0.292	1.15	0.659	0.281	0.623	1.108
	Sluice Trench and Ballfield East of Sluice Trench	17/17	--	0%	0.225	2.01	0.808	0.616	0.538	1.866
	Stilling Pond	3/3	--	0%	0.432	0.926	0.761	0.285	0.924	0.926
Arsenic	Interim Ash Staging Area	33/33	--	0%	18.1	119	49.12	24.09	43.6	92.6
	Sluice Trench and Ballfield East of Sluice Trench	17/17	--	0%	15.9	115	38.82	24.0	33.5	77.64
	Stilling Pond	3/3	--	0%	32.6	80.8	60.5	25.0	68.1	79.53
Barium	Interim Ash Staging Area	33/33	--	0%	105	428	248	95.56	243	410.2
	Sluice Trench and Ballfield East of Sluice Trench	17/17	--	0%	79.7	1520	475.6	515	218	1448
	Stilling Pond	3/3	--	0%	137	225	185	44.54	193	221.8
Beryllium	Interim Ash Staging Area	33/33	--	0%	0.596	3.86	1.673	0.822	1.50	3.116
	Sluice Trench and Ballfield East of Sluice Trench	17/17	--	0%	0.321	5.49	2.249	1.823	1.54	5.434
	Stilling Pond	3/3	--	0%	1.28	2.44	1.853	0.58	1.84	2.38
Cadmium	Interim Ash Staging Area	33/33	--	0%	0.0664	0.879	0.262	0.179	0.230	0.554
	Sluice Trench and Ballfield East of Sluice Trench	17/17	--	0%	0.0520	0.594	0.233	0.204	0.153	0.580
	Stilling Pond	3/3	--	0%	0.2460	0.571	0.413	0.163	0.423	0.556

Summary Statistics - CCR Material Characteristics Kingston Fossil Plant - Harriman, Tennessee											
Parameter	CCR Management Unit	Frequency of Detection	Range of Reporting Limits	% Non Detect	Statistics using Detected Data Only		Statistics using Detects & Non-Detects			
					Minimum Detect	Maximum Detect	Mean	Standard Deviation	50^{th} Percentile	95^{th} Percentile
Chromium	Interim Ash Staging Area	33/33	--	0%	8.78	35.3	21.29	7.778	19.3	34.0
	Sluice Trench and Ballfield East of Sluice Trench	17/17	--	0%	8.73	41.0	23.63	11.0	22.7	38.84
	Stilling Pond	3/3	--	0%	13.5	20.3	17.87	3.8	19.8	20.25
Cobalt	Interim Ash Staging Area	33/33	--	0%	3.88	35.6	9.018	5.819	7.48	14.9
	Sluice Trench and Ballfield East of Sluice Trench	17/17	--	0%	3.15	22.1	10.88	6.257	8.76	21.22
	Stilling Pond	3/3	--	0%	4.42	7.97	6.097	1.783	5.9	7.763
Fluoride	Interim Ash Staging Area	17/33	(0.756-1.05)	48.5%	1.13	4.29	1.671	1.163	1.13	3.752
	Sluice Trench and Ballfield East of Sluice Trench	7/17	(0.848-1.37)	58.8%	1.07	2.37	1.10	0.403	1.07	1.794
	Stilling Pond	3/3	--	0.0%	1.15	6.13	3.44	2.515	3.03	5.82
Lead	Interim Ash Staging Area	33/33	--	0%	2.83	27.4	11.77	6.993	9.62	24.3
	Sluice Trench and Ballfield East of Sluice Trench	17/17	--	0%	2.82	27.4	11.79	8.949	8.12	26.6
	Stilling Pond	3/3	--	0%	11.6	19.9	16.37	4.285	17.6	19.67
Lithium	Interim Ash Staging Area	33/33	--	0%	10.2	38.8	20.0	8.60	17.7	36.0
	Sluice Trench and Ballfield East of Sluice Trench	17/17	--	0%	5.75	23.1	14.56	5.831	13.1	22.94
	Stilling Pond	3/3	--	0%	15.4	25.2	20.1	4.912	19.7	24.65
Mercury	Interim Ash Staging Area	31/33	(0.0148-0.0305)	6.06%	0.0307	1.22	0.125	0.212	0.0786	0.305
	Sluice Trench and Ballfield East of Sluice Trench	17/17	--	0%	0.0351	0.611	0.166	0.153	0.120	0.489
	Stilling Pond	3/3	--	0%	0.0451	0.101	0.0682	0.0292	0.058	0.0967
Molybdenum	Interim Ash Staging Area	33/33	--	0%	1.82	9.31	3.538	1.891	2.91	8.078
	Sluice Trench and Ballfield East of Sluice Trench	17/17	--	0%	0.990	6.84	4.20	1.894	3.74	6.688
	Stilling Pond	3/3	--	0%	1.880	16	8.05	7.228	6.26	15.03
Radium-226+228	Interim Ash Staging Area	33/33	--	0%	2.95	8.52	6.38	1.37	6.62	8.18
	Sluice Trench and Ballfield East of Sluice Trench	17/17	--	0%	2.87	7.61	5.55	1.41	5.57	7.49
	Stilling Pond	3/3	--	0%	6.57	7.78	7.113	0.61	6.99	7.701
Selenium	Interim Ash Staging Area	33/33	--	0%	1.00	8.88	2.967	1.764	2.51	6.434
	Sluice Trench and Ballfield East of Sluice Trench	17/17	--	0%	1.32	13.5	4.046	2.917	3.45	7.60
	Stilling Pond	3/3	--	0%	1.91	4.21	3.367	1.267	3.98	4.19
Thallium	Interim Ash Staging Area	33/33	--	0%	0.395	7.31	1.208	1.172	1.03	1.838
	Sluice Trench and Ballfield East of Sluice Trench	17/17	--	0%	0.353	1.75	1.027	0.368	1.05	1.694
	Stilling Pond	3/3	--	0%	1.05	1.51	1.24	0.24	1.16	1.475

Summary Statistics - CCR Material Characteristics Kingston Fossil Plant - Harriman, Tennessee										
Parameter	CCR Management Unit	Frequency of Detection	Range of Reporting Limits	% Non Detect	Statistics using Detected Data Only		Statistics using Detects & Non-Detects			
					Minimum Detect	Maximum Detect	Mean	Standard Deviation	50th Percentile	95th Percentile
TDEC Appendix I Parameters										
Copper	Interim Ash Staging Area	33/33	--	0%	13.4	47.7	28.27	9.73	26.1	42.44
	Sluice Trench and Ballfield East of Sluice Trench	17/17	--	0%	12.3	79.3	35.41	24.23	25.2	77.3
	Stilling Pond	3/3	--	0%	19.3	36.9	28.2	8.802	28.4	36.05
Nickel	Interim Ash Staging Area	33/33	--	0%	10.3	37.5	20.67	7.285	18.5	32.8
	Sluice Trench and Ballfield East of Sluice Trench	17/17	--	0%	10.2	40.0	22.93	10.38	20.0	39.28
	Stilling Pond	3/3	--	0%	11.1	18.3	14.87	3.612	15.2	17.99
Silver	Interim Ash Staging Area	25/33	(0.0324-0.0424)	24.2%	0.0235	0.116	0.0559	0.0277	0.0443	0.107
	Sluice Trench and Ballfield East of Sluice Trench	9/17	(0.0376-0.333)	47.1%	0.0202	0.355	0.0737	0.0955	0.122	0.337
	Stilling Pond	3/3	--	0.0%	0.0447	0.0663	0.0591	0.0124	0.0662	0.0663
Vanadium	Interim Ash Staging Area	33/33	--	0%	15.5	76.7	42.23	17.28	38.0	73.32
	Sluice Trench and Ballfield East of Sluice Trench	17/17	--	0%	11.1	121	54.25	38.58	38.3	119.4
	Stilling Pond	3/3	--	0%	25.1	46.1	37.07	10.8	40	45.49
Zinc	Interim Ash Staging Area	33/33	--	0%	10.8	43.2	25.56	10.86	23.1	41.74
	Sluice Trench and Ballfield East of Sluice Trench	17/17	--	0%	5.43	61.5	27.69	18.32	23.0	58.14
	Stilling Pond	3/3	--	0%	18.1	37	27.33	9.457	26.9	35.99
Additional Parameters										
Iron	Interim Ash Staging Area	33/33	--	0%	9,950	110,000	34,959	21,896	30,700	68,240
	Sluice Trench and Ballfield East of Sluice Trench	17/17	--	0%	8,810	107,000	38,042	25,389	38,800	74,280
	Stilling Pond	3/3	--	0%	10,400	14,000	11,967	1,845	11,500	13,750
Manganese	Interim Ash Staging Area	33/33	--	0%	37.9	242	85.76	44.6	73.6	164.2
	Sluice Trench and Ballfield East of Sluice Trench	17/17	--	0%	26.1	216	97.88	52.66	88.2	188
	Stilling Pond	3/3	--	0%	39.9	153	81.43	62.24	51.4	142.8
TOC	Interim Ash Staging Area	33/33	--	0%	6,810	45,600	23,231	10,529	22,500	41,880
	Sluice Trench and Ballfield East of Sluice Trench	17/17	--	0%	11,400	93,900	36,900	22,927	31,800	81,900
	Stilling Pond	3/3	--	0%	17,900	19,800	19,133	1,069	19,700	19,790

Notes:

CCR Rule - Title 40, Code of Federal Regulations, Part 257

TDEC - Tennessee Department of Environment and Conservation

% - percent

"--" - Not Applicable

TOC - Total Organic Carbon

Except for pH & Radium 226 + 228, all units are milligrams per kilogram (mg/kg).

Units for pH are Standard Units (S.U.).

Units for Radium 226+228 are picocuries per gram (pCi/g).

All non-detects reported at the method detection limit.

For Parameters with non-detects reported at the method detection limit, the mean and standard deviation were calculated using Kaplan-Meier methods (KM)

Summary Statistics - CCR Material Characteristics - Synthetic Precipitate Leaching Procedure (SPLP) Kingston Fossil Plant - Harriman, Tennessee										
Parameter	CCR Management Unit	Frequency of Detection	Range of Reporting Limits	% Non Detect	Statistics using Detected Data Only		Statistics using Detects & Non-Detects			
					Minimum Detect	Maximum Detect	Mean	Standard Deviation	50th Percentile	95th Percentile
CCR Rule Appendix III Parameters										
Boron	Interim Ash Staging Area	30/33	(62.5 - 76.6)	9.09%	45.1	1,020	422.3	393.1	160	987.8
	Sluice Trench and Ballfield East of Sluice Trench	12/17	(38.6 - 291)	29.4%	40.0	1,180	305.7	419.5	111	1,156
	Stilling Pond	3/3	--	0.0%	360.0	598	474.7	119.2	466	585
Calcium	Interim Ash Staging Area	33/33	--	0%	4,580	385,000	26,818	64,925	13,400	37,340
	Sluice Trench and Ballfield East of Sluice Trench	17/17	--	0%	3,570	42,000	20,640	13,646	17,100	38,880
	Stilling Pond	3/3	--	0%	8,000	21,700	13,500	7,238	10,800	20,610
CCR Rule Appendix IV Parameters										
Antimony	Interim Ash Staging Area	24/33	(0.378 - 1.12)	27.3%	0.460	6.19	1.246	1.391	0.847	4.376
	Sluice Trench and Ballfield East of Sluice Trench	7/17	(0.879 - 1.75)	58.8%	1.18	5.67	1.627	1.235	1.35	3.502
	Stilling Pond	3/3	--	0.0%	4.56	12.6	7.5	4.434	5.34	11.87
Arsenic	Interim Ash Staging Area	33/33	--	0%	0.917	143	26.0	33.0	15.3	93.3
	Sluice Trench and Ballfield East of Sluice Trench	17/17	--	0%	0.351	40.7	12.72	11.53	6.53	34.06
	Stilling Pond	3/3	--	0%	90.4	190	124.8	56.52	93.9	180.4
Barium	Interim Ash Staging Area	33/33	--	0%	10.4	199	72.47	39.38	73.5	129.8
	Sluice Trench and Ballfield East of Sluice Trench	17/17	--	0%	6.55	377	105.8	102.1	87.5	283.4
	Stilling Pond	3/3	--	0%	160	327	222.7	90.96	181	312.4
Beryllium	Interim Ash Staging Area	4/33	(0.057 - 0.182)	87.9%	0.202	0.433	0.0864	0.0857	0.155	0.268
	Sluice Trench and Ballfield East of Sluice Trench	5/17	(0.057 - 0.155)	70.6%	0.0600	3.31	0.346	0.808	0.155	1.806
	Stilling Pond	0/3	(0.131 - 0.131)	100.0%	--	--	--	--	0.131	0.131
Cadmium	Interim Ash Staging Area	4/33	(0.125 - 0.125)	87.9%	0.133	0.396	0.145	0.0646	0.125	0.295
	Sluice Trench and Ballfield East of Sluice Trench	3/17	(0.125 - 0.125)	82.4%	0.192	1.88	0.288	0.456	0.125	1.232
	Stilling Pond	2/3	(0.0781 - 0.0781)	33.3%	0.086	0.089	0.0844	0.0046	0.086	0.0887
Chromium	Interim Ash Staging Area	10/33	(0.631 - 1.53)	69.7%	0.804	6.88	1.20	1.159	1.53	2.684
	Sluice Trench and Ballfield East of Sluice Trench	15/17	(1.53 - 1.53)	11.8%	1.06	22.7	4.344	5.60	1.95	14.14
	Stilling Pond	0/3	(1.17 - 2.9)	100.0%	--	--	--	--	2.46	2.856
Cobalt	Interim Ash Staging Area	17/33	(0.075 - 0.075)	48.5%	0.091	12.2	1.20	2.465	0.091	5.79
	Sluice Trench and Ballfield East of Sluice Trench	5/17	(0.075 - 0.245)	70.6%	0.100	54.5	4.854	13.15	0.100	24.66
	Stilling Pond	3/3	--	0.0%	0.116	0.513	0.284	0.205	0.223	0.484
Lead	Interim Ash Staging Area	9/33	(0.094 - 0.128)	72.7%	0.130	1.09	0.157	0.183	0.128	0.406
	Sluice Trench and Ballfield East of Sluice Trench	3/17	(0.094 - 0.516)	82.4%	0.161	6.62	0.54	1.537	0.128	2.172
	Stilling Pond	2/3	(0.318 - 0.318)	33.3%	0.964	1.17	0.817	0.363	0.964	1.149
Lithium	Interim Ash Staging Area	29/33	(2.56 - 3.14)	12.1%	3.15	19.9	9.565	5.044	9.22	17.0
	Sluice Trench and Ballfield East of Sluice Trench	15/17	(2.56 - 3.14)	11.8%	3.13	30.7	7.057	6.725	4.54	16.94
	Stilling Pond	3/3	--	0.0%	4.95	7.7	6.083	1.437	5.6	7.49

Summary Statistics - CCR Material Characteristics - Synthetic Precipitate Leaching Procedure (SPLP) Kingston Fossil Plant - Harriman, Tennessee											
Parameter	**CCR Management Unit**	**Frequency of Detection**	**Range of Reporting Limits**	**% Non Detect**	**Statistics using Detected Data Only**		**Statistics using Detects & Non-Detects**			
					Minimum Detect	**Maximum Detect**	**Mean**	**Standard Deviation**	**50th Percentile**	**95th Percentile**
Mercury	Interim Ash Staging Area	1/33	(0.101 - 0.101)	97.0%	0.114	0.114	0.101	0.00223	0.101	0.101
	Sluice Trench and Ballfield East of Sluice Trench	0/17	(0.1 - 0.101)	100%	--	--	--	--	0.101	0.101
	Stilling Pond	0/3	(0.0653 - 0.0653)	100%	--	--	--	--	0.0653	0.0653
Molybdenum	Interim Ash Staging Area	30/33	(0.61 - 0.61)	9.09%	0.759	203	26.69	44.19	9.97	134.2
	Sluice Trench and Ballfield East of Sluice Trench	11/17	(0.474 - 3.81)	35.3%	1.34	49.2	10.79	12.7	6.11	29.36
	Stilling Pond	3/3	--	0.0%	25.3	88	60.87	32.19	69.3	86.13
Radium-226+228	Interim Ash Staging Area	11/33	(0.0233 - 0.59)	66.7%	0.0645	0.594	0.128	0.151	0.207	0.534
	Sluice Trench and Ballfield East of Sluice Trench	9/17	(0 - 0.338)	47.1%	0.245	1.062	0.348	0.354	0.338	0.824
	Stilling Pond	0/0	--	--	--	--	--	--	--	--
Selenium	Interim Ash Staging Area	26/33	(2.62 - 2.62)	21.2%	1.28	10.6	5.092	3.049	3.97	10.3
	Sluice Trench and Ballfield East of Sluice Trench	17/17	--	0%	1.04	42.3	11.0	12.14	6.71	36.46
	Stilling Pond	3/3	--	0%	13	32.2	21.4	9.835	18.9	30.87
Thallium	Interim Ash Staging Area	15/33	(0.063 - 0.148)	54.6%	0.152	1.23	0.221	0.259	0.148	0.751
	Sluice Trench and Ballfield East of Sluice Trench	4/17	(0.063 - 0.148)	76.5%	0.174	4.45	0.527	1.20	0.128	3.30
	Stilling Pond	1/3	(0.0531 - 0.0531)	66.7%	0.09	0.09	0.0654	0.02	0.0531	0.09
TDEC Appendix I Parameters										
Copper	Interim Ash Staging Area	14/33	(0.627 - 1.3)	57.6%	0.685	9.03	1.60	2.02	0.962	6.658
	Sluice Trench and Ballfield East of Sluice Trench	7/17	(0.627 - 9.17)	58.8%	5.97	21.7	6.491	7.545	5.99	19.86
	Stilling Pond	2/3	(1.04 - 1.04)	33.3%	2.61	2.69	2.113	0.76	2.61	2.682
Nickel	Interim Ash Staging Area	16/33	(0.312 - 1.32)	51.5%	0.382	23.3	2.863	4.707	1.02	10.3
	Sluice Trench and Ballfield East of Sluice Trench	12/17	(0.312 - 0.573)	29.4%	0.467	111	11.52	27.63	0.866	62.76
	Stilling Pond	3/3	--	0.0%	0.643	2.35	1.311	0.912	0.941	2.209
Silver	Interim Ash Staging Area	4/33	(0.121 - 0.177)	87.9%	0.128	0.215	0.127	0.0193	0.121	0.177
	Sluice Trench and Ballfield East of Sluice Trench	0/17	(0.121 - 0.177)	100%	--	--	--	--	0.121	0.177
	Stilling Pond	0/3	(0.2 - 0.2)	100%	--	--	--	--	0.2	0.2
Vanadium	Interim Ash Staging Area	26/33	(0.899 - 0.899)	21.2%	1.03	100	13.09	19.76	5.62	42.22
	Sluice Trench and Ballfield East of Sluice Trench	17/17	--	0%	0.926	187	42.05	54.46	12.8	135.8
	Stilling Pond	3/3	--	0%	48	96.3	69.1	24.72	63	92.97
Zinc	Interim Ash Staging Area	10/33	(2.42 - 3.22)	69.7%	3.65	26.1	4.285	5.449	3.22	13.21
	Sluice Trench and Ballfield East of Sluice Trench	7/17	(2.42 - 6.29)	58.8%	3.66	69.3	12.29	20.0	5.29	60.74
	Stilling Pond	3/3	--	0.0%	49.6	137	86.53	45.2	73	130.6

Summary Statistics - CCR Material Characteristics - Synthetic Precipitate Leaching Procedure (SPLP) Kingston Fossil Plant - Harriman, Tennessee										
Parameter	**CCR Management Unit**	**Frequency of Detection**	**Range of Reporting Limits**	**% Non Detect**	**Statistics using Detected Data Only**		**Statistics using Detects & Non-Detects**			
					Minimum Detect	**Maximum Detect**	**Mean**	**Standard Deviation**	**50^{th} Percentile**	**95^{th} Percentile**
Additional Parameters										
Iron	Interim Ash Staging Area	17/33	(14.1 - 19.5)	48.5%	14.8	8,940	426	1,572	19.5	1,714
	Sluice Trench and Ballfield East of Sluice Trench	10/17	(14.1 - 19.5)	41.2%	15.7	21,700	2,417	6,464	19.5	19,060
	Stilling Pond	3/3	--	0.0%	107	606	365	250	382	584
Manganese	Interim Ash Staging Area	31/33	(1.35 - 1.35)	6.06%	1.47	2,090	121	388.9	9.13	601.4
	Sluice Trench and Ballfield East of Sluice Trench	12/17	(1.35 - 1.35)	29.4%	1.43	138	17.46	34.0	2.88	70.16
	Stilling Pond	3/3	--	0.0%	4.62	20.2	10.76	8.3	7.45	18.93

Notes:
CCR Rule - Title 40, Code of Federal Regulations, Part 257
TDEC - Tennessee Department of Environment and Conservation
% - percent
"--" - Not Applicable

Except for pH & Radium 226 + 228, all units are micrograms per liter (µg/L).
Units for pH are Standard Units (S.U.).
Units for Radium 226+228 are picocuries per liter (pCi/L).
All non-detects reported at the method detection limit.
For Parameters with non-detects reported at the method detection limit, the mean and standard deviation were calculated using Kaplan-Meier methods (KM).

Summary Statistics - CCR Material Characteristics - Pore Water - Total Metals Kingston Fossil Plant - Harriman, Tennessee										
Parameter	CCR Management Unit	Frequency of Detection	Range of Reporting Limits	% Non Detect	Statistics using Detected Data Only		Statistics using Detects & Non-Detects			
					Minimum Detect	Maximum Detect	Mean	Standard Deviation	50th Percentile	95th Percentile
CCR Rule Appendix III Parameters										
Boron	Interim Ash Staging Area	3/3	--	0%	797	3,830	2,646	1,622	3,310	3,778
	Sluice Trench and Ballfield East of Sluice Trench	2/2	--	0%	2,160	2,600	2,380	311	2,380	2,578
	Stilling Pond	2/2	--	0%	1,080	11,000	6,040	7,014	6,040	10,504
Calcium	Interim Ash Staging Area	3/3	--	0%	174,000	521,000	349,667	173,541	354,000	504,300
	Sluice Trench and Ballfield East of Sluice Trench	2/2	--	0%	136,000	288,000	212,000	107,480	212,000	280,400
	Stilling Pond	2/2	--	0%	85,700	189,000	137,350	73,044	137,350	183,835
Chloride	Interim Ash Staging Area	3/3	--	0%	9,400	34,200	18,833	13,422	12,900	32,070
	Sluice Trench and Ballfield East of Sluice Trench	2/2	--	0%	6,990	12,200	9,595	3,684	9,595	11,940
	Stilling Pond	0/0	--	--	--	--	--	--	--	--
Fluoride	Interim Ash Staging Area	3/3	--	0%	268	463	351	100.7	322	448.9
	Sluice Trench and Ballfield East of Sluice Trench	2/2	--	0%	192	325	258.5	94.05	258.5	318.4
	Stilling Pond	0/0	--	--	--	--	--	--	--	--
pH (field)	Interim Ash Staging Area	3/3	--	0%	6.84	6.93	6.873	0.0493	6.85	6.922
	Sluice Trench and Ballfield East of Sluice Trench	2/2	--	0%	6.53	8.86	7.695	1.648	7.695	8.744
	Stilling Pond	2/2	--	0%	6.73	7.16	6.945	0.304	6.945	7.044
Sulfate	Interim Ash Staging Area	3/3	--	0%	376,000	1,420,000	887,333	522,327	866,000	1,364,600
	Sluice Trench and Ballfield East of Sluice Trench	2/2	--	0%	300,000	902,000	601,000	425,678	601,000	871,900
	Stilling Pond	0/0	--	--	--	--	--	--	--	--
TDS	Interim Ash Staging Area	3/3	--	0%	850,000	2,580,000	1,703,333	865,236	1,680,000	2,490,000
	Sluice Trench and Ballfield East of Sluice Trench	2/2	--	0%	659,000	1,670,000	1,164,500	714,885	1,164,500	1,619,450
	Stilling Pond	2/2	--	0%	345,000	882,000	613,500	379,716	613,500	855,150
CCR Rule Appendix IV Parameters										
Antimony	Interim Ash Staging Area	0/3	(0.378 - 0.378)	100%	--	--	--	--	0.378	0.378
	Sluice Trench and Ballfield East of Sluice Trench	1/2	(0.378 - 0.378)	50.0%	0.707	0.707	0.543	0.165	0.543	0.691
	Stilling Pond	0/2	(2.1 - 4.25)	100.0%	--	--	--	--	3.175	4.143
Arsenic	Interim Ash Staging Area	3/3	--	0%	229	382	304	76.54	301	373.9
	Sluice Trench and Ballfield East of Sluice Trench	2/2	--	0%	79.4	365	222.2	201.9	222.2	350.7
	Stilling Pond	2/2	--	0%	676	1770	1223	773.6	1223	1715
Barium	Interim Ash Staging Area	3/3	--	0%	36.2	76.2	50.5	22.3	39.1	72.49
	Sluice Trench and Ballfield East of Sluice Trench	2/2	--	0%	32.0	242	137	148.5	137	231.5
	Stilling Pond	2/2	--	0%	216.0	265	240.5	34.65	240.5	262.6
Beryllium	Interim Ash Staging Area	0/3	(0.155 - 0.155)	100%	--	--	--	--	0.155	0.155
	Sluice Trench and Ballfield East of Sluice Trench	0/2	(0.155 - 0.155)	100%	--	--	--	--	0.155	0.155
	Stilling Pond	1/2	(0.131 - 0.131)	50%	0.346	0.346	0.239	0.108	0.239	0.335
Cadmium	Interim Ash Staging Area	1/3	(0.125 - 0.125)	66.7%	0.127	0.127	0.126	0.000943	0.125	0.127
	Sluice Trench and Ballfield East of Sluice Trench	0/2	(0.125 - 0.125)	100%	--	--	--	--	0.125	0.125
	Stilling Pond	1/2	(0.0781 - 0.0781)	50%	0.589	0.59	0.334	0.255	0.334	0.563

Summary Statistics - CCR Material Characteristics - Pore Water - Total Metals Kingston Fossil Plant - Harriman, Tennessee										
Parameter	CCR Management Unit	Frequency of Detection	Range of Reporting Limits	% Non Detect	Statistics using Detected Data Only		Statistics using Detects & Non-Detects			
					Minimum Detect	Maximum Detect	Mean	Standard Deviation	50^{th} Percentile	95^{th} Percentile
Chromium	Interim Ash Staging Area	0/3	(2.79 - 4.74)	100%	--	--	--	--	4.13	4.679
	Sluice Trench and Ballfield East of Sluice Trench	0/2	(1.96 - 3.72)	100%	--	--	--	--	2.84	3.632
	Stilling Pond	0/2	(2.05 - 4.73)	100%	--	--	--	--	3.39	4.596
Cobalt	Interim Ash Staging Area	3/3	--	0%	0.393	3.10	1.39	1.489	0.673	2.86
	Sluice Trench and Ballfield East of Sluice Trench	2/2	--	0%	0.257	0.350	0.304	0.0658	0.304	0.345
	Stilling Pond	2/2	--	0%	1.39	2.190	1.79	0.566	1.79	2.150
Fluoride	Interim Ash Staging Area	3/3	--	0%	268	463	351	100.7	322	448.9
	Sluice Trench and Ballfield East of Sluice Trench	2/2	--	0%	192	325	258.5	94.05	258.5	318.4
	Stilling Pond	0/0	--	--	--	--	--	--	--	--
Lead	Interim Ash Staging Area	1/3	(0.128 - 0.128)	66.7%	0.671	0.671	0.309	0.256	0.128	0.617
	Sluice Trench and Ballfield East of Sluice Trench	1/2	(0.128 - 0.128)	50.0%	0.135	0.135	0.132	0.00350	0.132	0.135
	Stilling Pond	2/2	--	0.0%	1.21	4.51	2.86	2.33300	2.86	4.345
Lithium	Interim Ash Staging Area	3/3	--	0%	192	528	335.7	173.2	287	503.9
	Sluice Trench and Ballfield East of Sluice Trench	2/2	--	0%	47.8	308	177.9	184	177.9	295
	Stilling Pond	1/2	(14.5 - 14.5)	50%	159	159	86.75	72.25	86.75	151.8
Mercury	Interim Ash Staging Area	0/3	(0.101 - 0.101)	100%	--	--	--	--	0.101	0.101
	Sluice Trench and Ballfield East of Sluice Trench	0/2	(0.101 - 0.101)	100%	--	--	--	--	0.101	0.101
	Stilling Pond	0/2	(0.0653 - 0.0653)	100%	--	--	--	--	0.0653	0.0653
Molybdenum	Interim Ash Staging Area	3/3	--	0%	120	450	320.3	176	391	444.1
	Sluice Trench and Ballfield East of Sluice Trench	2/2	--	0%	193	195	194	1.414	194	194.9
	Stilling Pond	2/2	--	0%	74.2	3310	1692	2288	1692	3148
Radium-226+228	Interim Ash Staging Area	2/2	--	0.0%	0.359	0.620	0.49	0.185	0.490	0.607
	Sluice Trench and Ballfield East of Sluice Trench	2/2	--	0%	0.257	0.544	0.401	0.203	0.401	0.530
	Stilling Pond	0/0	--	--	--	--	--	--	--	--
Selenium	Interim Ash Staging Area	0/3	(2.62 - 2.62)	100%	--	--	--	--	2.62	2.62
	Sluice Trench and Ballfield East of Sluice Trench	0/2	(2.62 - 2.62)	100%	--	--	--	--	2.62	2.62
	Stilling Pond	1/2	(1.27 - 1.27)	50%	1.38	1.38	1.325	0.055	1.325	1.375
Thallium	Interim Ash Staging Area	2/3	(0.128 - 0.128)	33.3%	0.149	0.491	0.256	0.166	0.149	0.457
	Sluice Trench and Ballfield East of Sluice Trench	0/2	(0.128 - 0.128)	100%	--	--	--	--	0.128	0.128
	Stilling Pond	2/2	--	0%	0.198	0.768	0.483	0.403	0.483	0.74
TDEC Appendix I Parameters										
Copper	Interim Ash Staging Area	3/3	--	0%	0.758	1.60	1.136	0.428	1.05	1.545
	Sluice Trench and Ballfield East of Sluice Trench	1/2	(0.627 - 0.627)	50.0%	0.667	0.667	0.647	0.0200	0.647	0.67
	Stilling Pond	1/2	(3.45 - 3.45)	50.0%	8.49	8.49	5.97	2.5200	5.97	8.24
Nickel	Interim Ash Staging Area	3/3	--	0%	0.998	3.91	2.44	1.456	2.42	3.761
	Sluice Trench and Ballfield East of Sluice Trench	2/2	--	0%	0.866	1.94	1.40	0.759	1.40	1.886
	Stilling Pond	2/2	--	0%	2.66	6.46	4.56	2.687	4.56	6.27
Silver	Interim Ash Staging Area	0/3	(0.121 - 0.121)	100%	--	--	--	--	0.121	0.121
	Sluice Trench and Ballfield East of Sluice Trench	0/2	(0.121 - 0.121)	100%	--	--	--	--	0.121	0.121
	Stilling Pond	0/2	(0.2 - 0.2)	100%	--	--	--	--	0.2	0.2

Summary Statistics - CCR Material Characteristics - Pore Water - Total Metals Kingston Fossil Plant - Harriman, Tennessee										
Parameter	CCR Management Unit	Frequency of Detection	Range of Reporting Limits	% Non Detect	Statistics using Detected Data Only		Statistics using Detects & Non-Detects			
					Minimum Detect	Maximum Detect	Mean	Standard Deviation	50th Percentile	95th Percentile
Vanadium	Interim Ash Staging Area	0/3	(1.73 - 3.9)	100%	--	--	--	--	2.59	3.769
	Sluice Trench and Ballfield East of Sluice Trench	0/2	(2.37 - 13.4)	100%	--	--	--	--	7.885	12.85
	Stilling Pond	2/2	--	0%	6.03	14.8	10.42	6.201	10.42	14.36
Zinc	Interim Ash Staging Area	3/3	--	0%	5.41	10.3	7.407	2.57	6.51	9.921
	Sluice Trench and Ballfield East of Sluice Trench	1/2	(3.22 - 3.22)	50.0%	45.3	45.3	24.26	21.0	24.26	43.2
	Stilling Pond	2/2	--	0.0%	5.37	12.1	8.735	4.8	8.735	11.76
Additional Water Quality Parameters										
Iron	Interim Ash Staging Area	3/3	--	0%	36,700	73,300	51,167	19,467	43,500	70,320
	Sluice Trench and Ballfield East of Sluice Trench	2/2	--	0%	608	108,000	54,304	75,938	54,304	102,630
	Stilling Pond	2/2	--	0%	2,370	5,410	3,890	2,150	3,890	5,258
Manganese	Interim Ash Staging Area	3/3	--	0%	1,750	5,820	3,537	2,080	3,040	5,542
	Sluice Trench and Ballfield East of Sluice Trench	2/2	--	0%	151	2,410	1,281	1,597	1,281	2,297
	Stilling Pond	2/2	--	0%	322	851	587	374	587	825
TOC	Interim Ash Staging Area	3/3	--	0%	916	2,120	1,344	673	996	2,008
	Sluice Trench and Ballfield East of Sluice Trench	2/2	--	0%	1,190	4,290	2,740	2,192	2,740	4,135
	Stilling Pond	2/2	--	0%	2,070	3,810	2,940	1,230	2,940	3,723

Notes:

CCR Rule - Title 40, Code of Federal Regulations, Part 257

TDEC - Tennessee Department of Environment and Conservation

% - percent

"--" : Not Applicable

TDS - Total Dissolved Solids

TOC - Total Organic Carbon

Sample results collected from GP-17-102 at the Stilling Pond were excluded from the analysis due to elevated Turbidity (616.3 Nephelometric Turbidity Units).

Except for pH & Radium 226 + 228, all units micrograms per liter (µg/L).

Units for pH are Standard Units (S.U.).

Units for Radium 226+228 are picocuries per liter (pCi/L).

All non-detects reported at the laboratory detection limit.

For Parameters with non-detects reported at the method detection limit, the mean and standard deviation were calculated using Kaplan-Meier methods (KM).

Summary Statistics - CCR Material Characteristics - Pore Water - Dissolved Metals Kingston Fossil Plant - Harriman, Tennessee										
Parameter	CCR Management Unit	Frequency of Detection	Range of Reporting Limits	% Non Detect	Statistics using Detected Data Only		Statistics using Detects & Non-Detects			
					Minimum Detect	Maximum Detect	Mean	Standard Deviation	50th Percentile	95th Percentile
CCR Rule Appendix III Parameters										
Boron	Interim Ash Staging Area	3/3	--	0%	762	3,550	2,534	1,540	3,290	3,524
	Sluice Trench and Ballfield East of Sluice Trench	2/2	--	0%	2,080	2,610	2,345	375	2,345	2,584
	Stilling Pond	2/2	--	0%	1,170	10,000	5,585	6,244	5,585	9,559
Calcium	Interim Ash Staging Area	3/3	--	0%	163,000	517,000	343,333	177,094	350,000	500,300
	Sluice Trench and Ballfield East of Sluice Trench	2/2	--	0%	134,000	298,000	216,000	115,966	216,000	289,800
	Stilling Pond	2/2	--	0%	75,300	185,000	130,150	77,570	130,150	179,515
CCR Rule Appendix IV Parameters										
Antimony	Interim Ash Staging Area	0/3	(0.378 - 0.378)	100%	--	--	--	--	0.378	0.378
	Sluice Trench and Ballfield East of Sluice Trench	1/2	(0.378 - 0.378)	50.0%	0.681	0.681	0.530	0.152	0.530	0.666
	Stilling Pond	1/2	(1.84 - 1.84)	50.0%	4.05	4.05	2.945	1.105	2.945	3.94
Arsenic	Interim Ash Staging Area	3/3	--	0%	180	372	280	96.25	288	363.6
	Sluice Trench and Ballfield East of Sluice Trench	2/2	--	0%	78.4	349	214	191.3	213.7	335.5
	Stilling Pond	2/2	--	0%	598.0	1820	1209	864.1	1209	1759
Barium	Interim Ash Staging Area	3/3	--	0%	34.4	60.5	44.07	14.31	37.3	58.18
	Sluice Trench and Ballfield East of Sluice Trench	2/2	--	0%	31.1	240	135.6	147.7	135.6	229.6
	Stilling Pond	2/2	--	0%	219	231	225	8.485	225	230.4
Beryllium	Interim Ash Staging Area	0/3	(0.155 - 0.155)	100%	--	--	--	--	0.155	0.155
	Sluice Trench and Ballfield East of Sluice Trench	0/2	(0.155 - 0.155)	100%	--	--	--	--	0.155	0.155
	Stilling Pond	1/2	(0.131 - 0.131)	50%	0.391	0.391	0.261	0.13	0.261	0.378
Cadmium	Interim Ash Staging Area	0/3	(0.125 - 0.125)	100%	--	--	--	--	0.125	0.125
	Sluice Trench and Ballfield East of Sluice Trench	0/2	(0.125 - 0.125)	100%	--	--	--	--	0.125	0.125
	Stilling Pond	2/2	--	0%	0.171	0.566	0.369	0.28	0.369	0.546
Chromium	Interim Ash Staging Area	0/3	(2.24 - 3.53)	100%	--	--	--	--	3.13	3.49
	Sluice Trench and Ballfield East of Sluice Trench	0/2	(1.53 - 2.96)	100%	--	--	--	--	2.245	2.89
	Stilling Pond	1/2	(0.85 - 0.85)	50%	5.76	5.76	3.305	2.455	3.305	5.52
Cobalt	Interim Ash Staging Area	3/3	--	0%	0.369	2.88	1.228	1.431	0.436	2.636
	Sluice Trench and Ballfield East of Sluice Trench	2/2	--	0%	0.243	0.313	0.278	0.0495	0.278	0.310
	Stilling Pond	2/2	--	0%	0.658	2.79	1.724	1.508	1.724	2.683
Lead	Interim Ash Staging Area	0/3	(0.128 - 0.128)	100%	--	--	--	--	0.128	0.128
	Sluice Trench and Ballfield East of Sluice Trench	0/2	(0.128 - 0.128)	100%	--	--	--	--	0.128	0.128
	Stilling Pond	1/2	(0.318 - 0.318)	50%	4.6	4.6	2.459	2.141	2.459	4.386
Lithium	Interim Ash Staging Area	3/3	--	0%	181	555	338.7	193.8	280	527.5
	Sluice Trench and Ballfield East of Sluice Trench	2/2	--	0%	48.6	317	182.8	189.8	182.8	303.6
	Stilling Pond	2/2	--	0%	19.7	173	96.35	108.4	96.35	165.3

Summary Statistics - CCR Material Characteristics - Pore Water - Dissolved Metals Kingston Fossil Plant - Harriman, Tennessee										
Parameter	**CCR Management Unit**	**Frequency of Detection**	**Range of Reporting Limits**	**% Non Detect**	**Statistics using Detected Data Only**		**Statistics using Detects & Non-Detects**			
					Minimum Detect	**Maximum Detect**	**Mean**	**Standard Deviation**	**50th Percentile**	**95th Percentile**
Mercury	Interim Ash Staging Area	0/3	(0.101 - 0.101)	100%	--	--	--	--	0.101	0.101
	Sluice Trench and Ballfield East of Sluice Trench	0/2	(0.101 - 0.101)	100%	--	--	--	--	0.101	0.101
	Stilling Pond	0/2	(0.0653 - 0.0653)	100%	--	--	--	--	0.0653	0.0653
Molybdenum	Interim Ash Staging Area	3/3	--	0%	115	443	314.3	175	385	437.2
	Sluice Trench and Ballfield East of Sluice Trench	2/2	--	0%	195	196	195.5	0.707	195.5	196
	Stilling Pond	2/2	--	0%	67.5	3520	1794	2441	1794	3347
Selenium	Interim Ash Staging Area	0/3	(2.62 - 2.62)	100%	--	--	--	--	2.62	2.62
	Sluice Trench and Ballfield East of Sluice Trench	0/2	(2.62 - 2.62)	100%	--	--	--	--	2.62	2.62
	Stilling Pond	0/2	(1.27 - 1.27)	100%	--	--	--	--	1.27	1.27
Thallium	Interim Ash Staging Area	1/3	(0.128 - 0.128)	66.7%	0.442	0.442	0.233	0.148	0.128	0.411
	Sluice Trench and Ballfield East of Sluice Trench	0/2	(0.128 - 0.128)	100%	--	--	--	--	0.128	0.128
	Stilling Pond	2/2	--	0%	0.399	0.425	0.412	0.0184	0.412	0.424
TDEC Appendix I Parameters										
Copper	Interim Ash Staging Area	1/3	(0.627 - 0.627)	66.7%	0.905	0.905	0.720	0.131	0.627	0.877
	Sluice Trench and Ballfield East of Sluice Trench	0/2	(0.627 - 0.627)	100%	--	--	--	--	0.627	0.63
	Stilling Pond	1/2	(1.04 - 1.04)	50%	10.1	10.1	5.57	4.53	5.57	9.65
Nickel	Interim Ash Staging Area	1/3	(0.809 - 1.68)	66.7%	3.96	3.96	1.859	1.485	1.68	3.732
	Sluice Trench and Ballfield East of Sluice Trench	1/2	(0.912 - 0.912)	50.0%	1.90	1.90	1.406	0.494	1.406	1.85
	Stilling Pond	2/2	--	0.0%	1.89	6.10	3.995	2.977	3.995	5.89
Silver	Interim Ash Staging Area	0/3	(0.121 - 0.121)	100%	--	--	--	--	0.121	0.121
	Sluice Trench and Ballfield East of Sluice Trench	0/2	(0.121 - 0.121)	100%	--	--	--	--	0.121	0.121
	Stilling Pond	0/2	(0.2 - 0.2)	100%	--	--	--	--	0.2	0.2
Vanadium	Interim Ash Staging Area	0/3	(1.4 - 2.12)	100%	--	--	--	--	1.87	2.10
	Sluice Trench and Ballfield East of Sluice Trench	1/2	(1.64 - 1.64)	50.0%	11.3	11.3	6.47	4.83	6.47	10.82
	Stilling Pond	1/2	(4.45 - 4.45)	50.0%	16.6	16.6	10.53	6.075	10.53	15.99
Zinc	Interim Ash Staging Area	3/3	--	0%	4.41	9.65	6.677	2.691	5.97	9.282
	Sluice Trench and Ballfield East of Sluice Trench	1/2	(3.22 - 3.22)	50.0%	44.7	44.7	24.0	20.74	24.0	42.63
	Stilling Pond	1/2	(2.65 - 2.65)	50.0%	9.86	9.86	6.3	3.605	6.3	9.5

Summary Statistics - CCR Material Characteristics - Pore Water - Dissolved Metals Kingston Fossil Plant - Harriman, Tennessee										
Parameter	CCR Management Unit	Frequency of Detection	Range of Reporting Limits	% Non Detect	Statistics using Detected Data Only		Statistics using Detects & Non-Detects			
					Minimum Detect	Maximum Detect	Mean	Standard Deviation	50th Percentile	95th Percentile
Additional Water Quality Parameters										
Iron	Interim Ash Staging Area	3/3	--	0%	31,900	73,300	49,333	21,459	42,800	70,250
	Sluice Trench and Ballfield East of Sluice Trench	2/2	--	0%	188	107,000	53,594	75,527	53,594	101,659
	Stilling Pond	2/2	--	0%	3,190	3,370	3,280	127	3,280	3,361
Manganese	Interim Ash Staging Area	3/3	--	0%	1,680	5,770	3,473	2,091	2,970	5,490
	Sluice Trench and Ballfield East of Sluice Trench	2/2	--	0%	155	2,430	1,293	1,609	1,293	2,316
	Stilling Pond	2/2	--	0%	272	748	510	337	510	724

Notes:

CCR Rule - Title 40, Code of Federal Regulations, Part 257

TDEC - Tennessee Department of Environment and Conservation

% - percent

"--" : Not Applicable

Sample results collected from GP-17-102 at the Stilling Pond were excluded from the analysis due to elevated Turbidity (616.3 Nephelometric Turbidity Units).

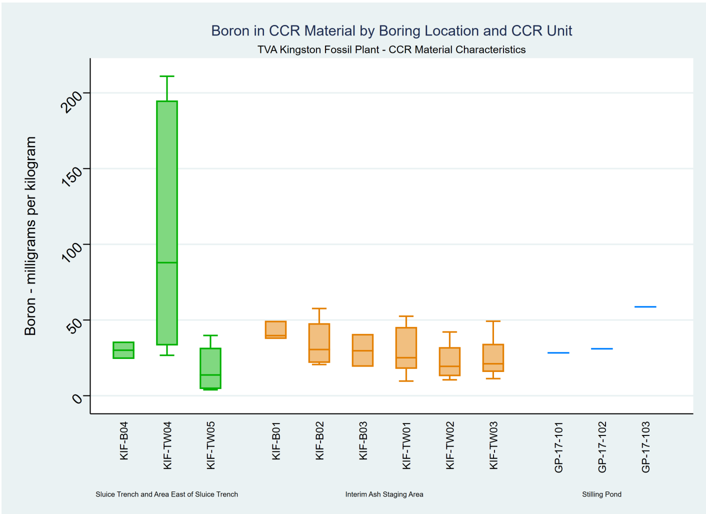
All units in micrograms per liter (µg/L)

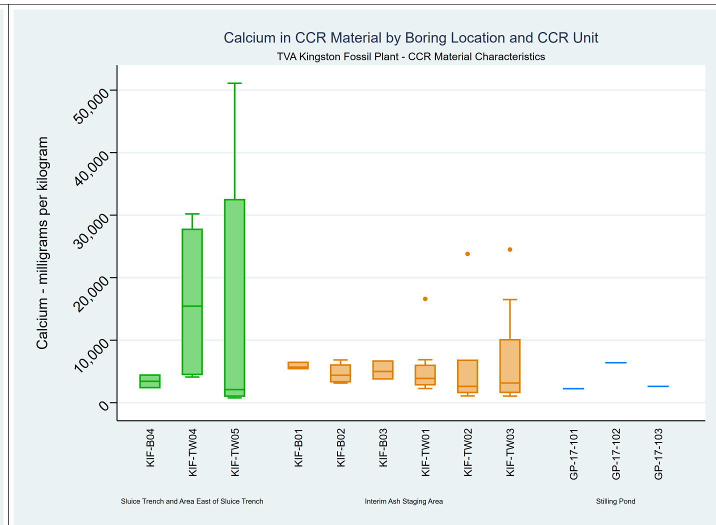
All non-detects reported at the laboratory detection limit

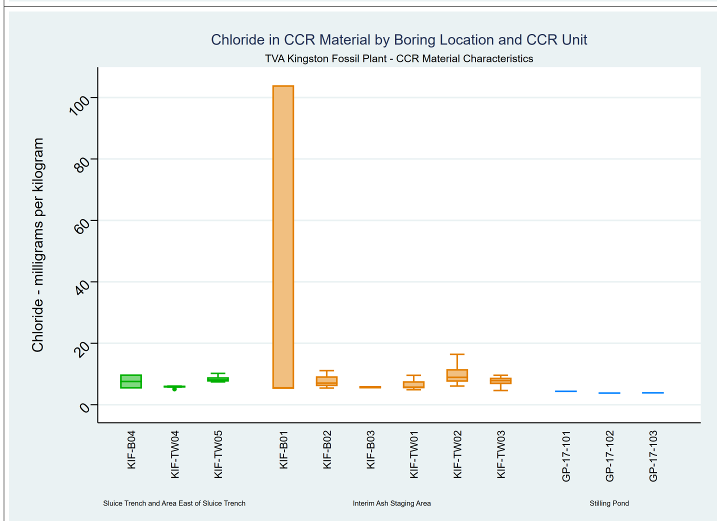
For Parameters with non-detects reported at the method detection limit, the mean and standard deviation were calculated using Kaplan-Meier methods (KM).

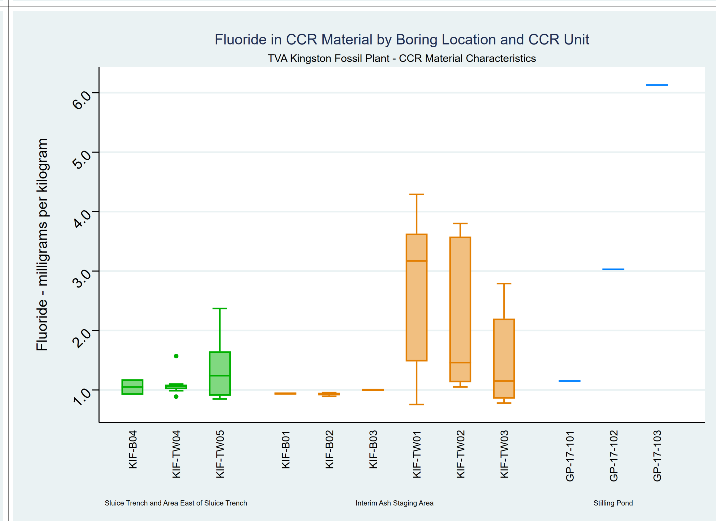
ATTACHMENT E.2-B
BOX PLOTS – CCR MATERIAL

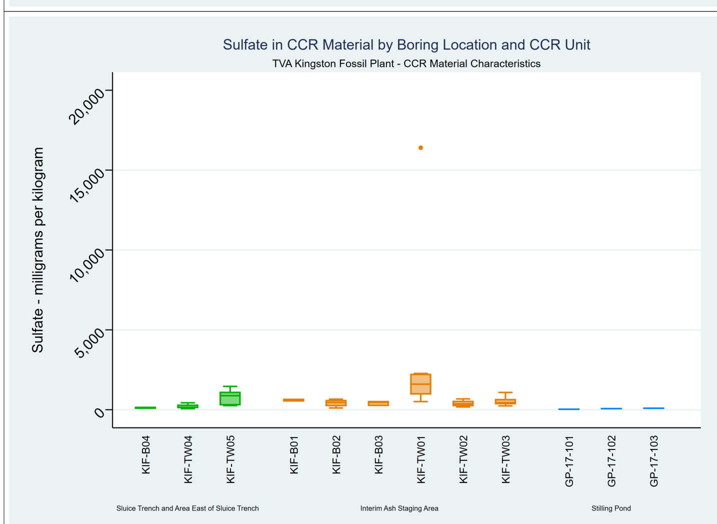
Box Plots
CCR Rule Appendix III Parameters
CCR Material Characteristics Investigation
Kingston Fossil Plant - Harriman, Tennessee

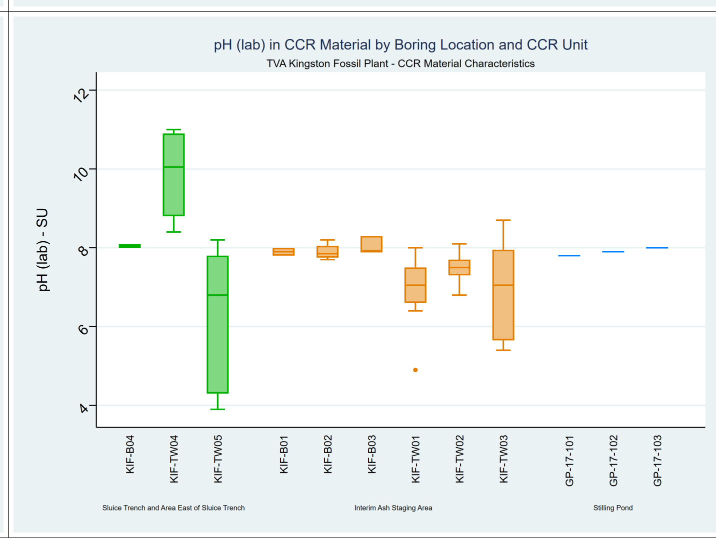




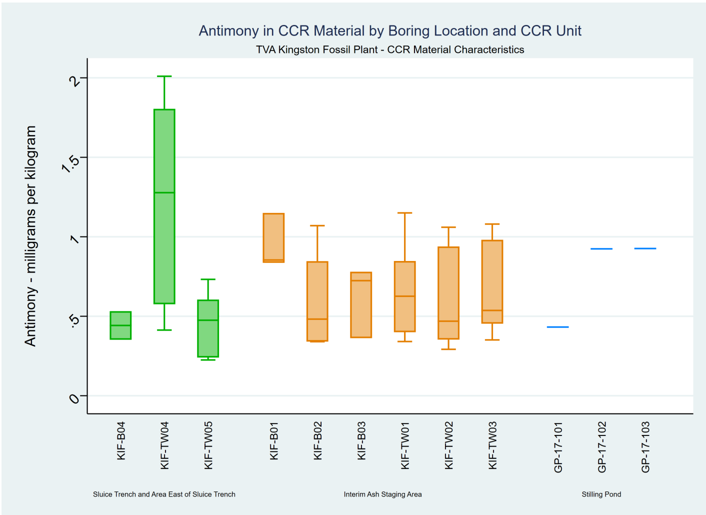


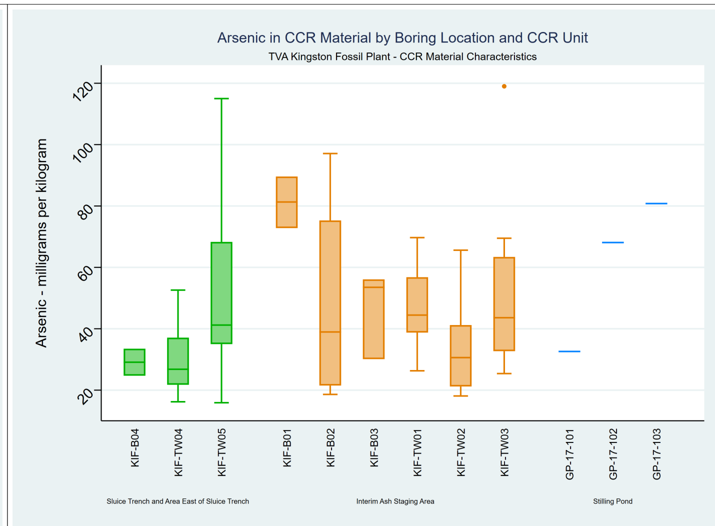


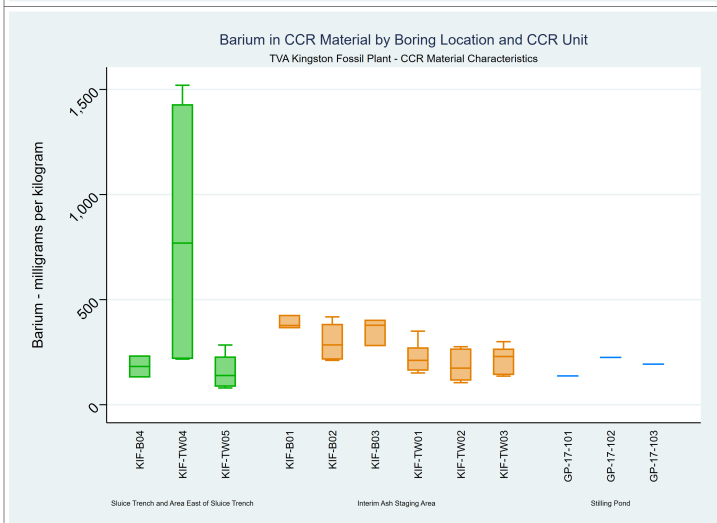


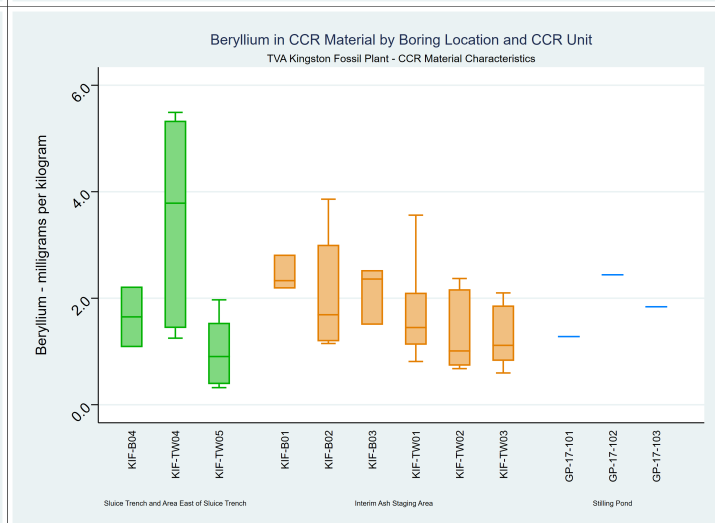


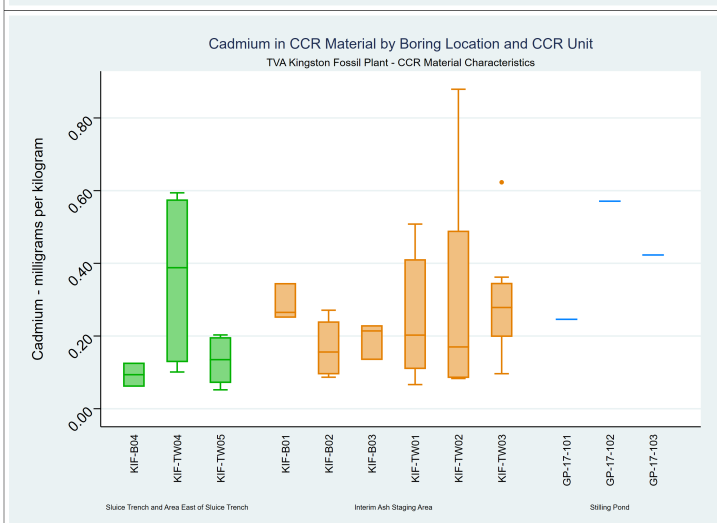
Box Plots
CCR Rule Appendix IV Parameters
CCR Material Characteristics Investigation
Kingston Fossil Plant - Harriman, Tennessee

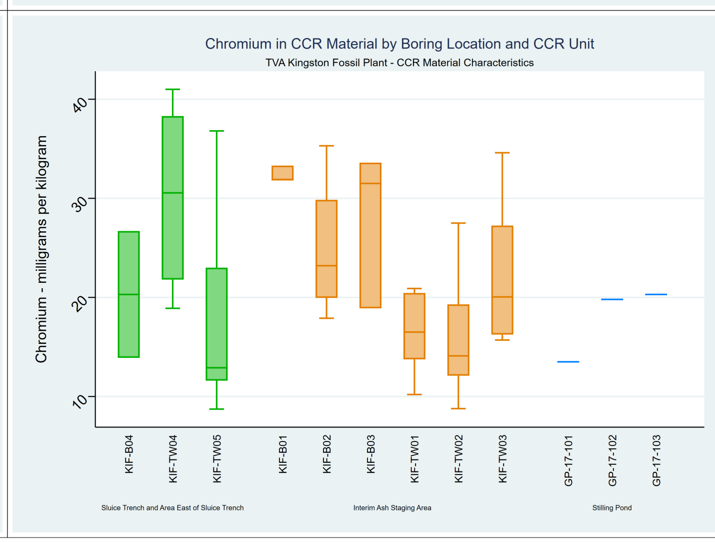


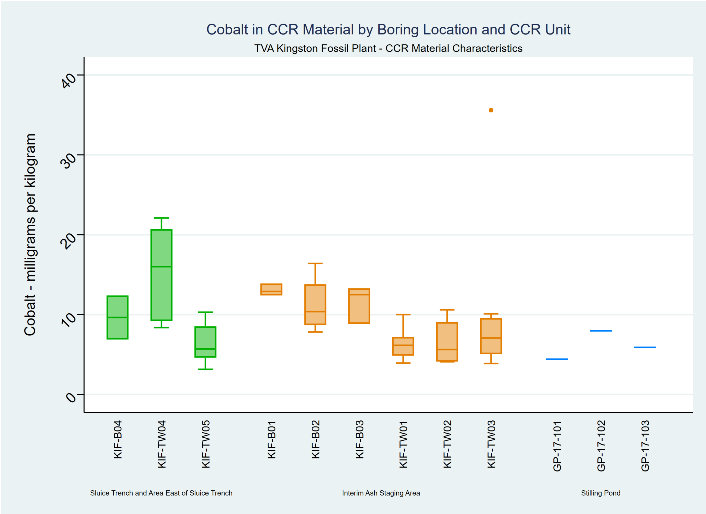




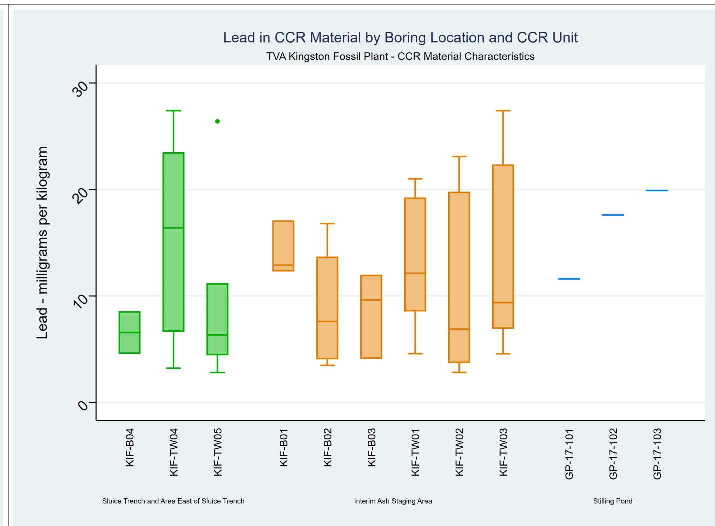




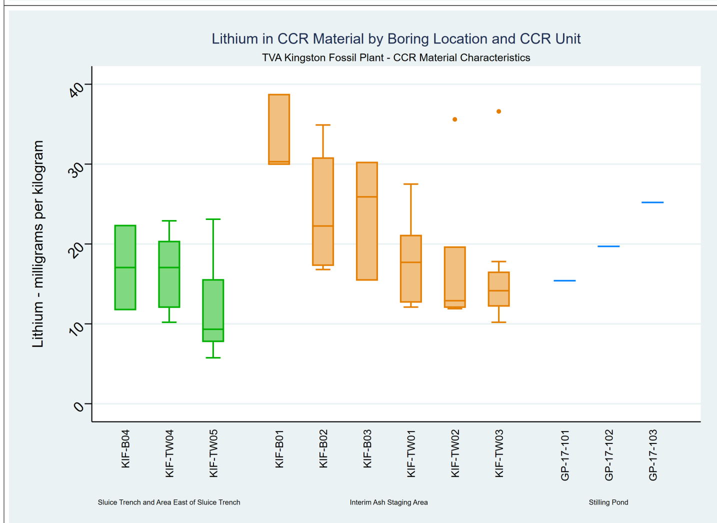




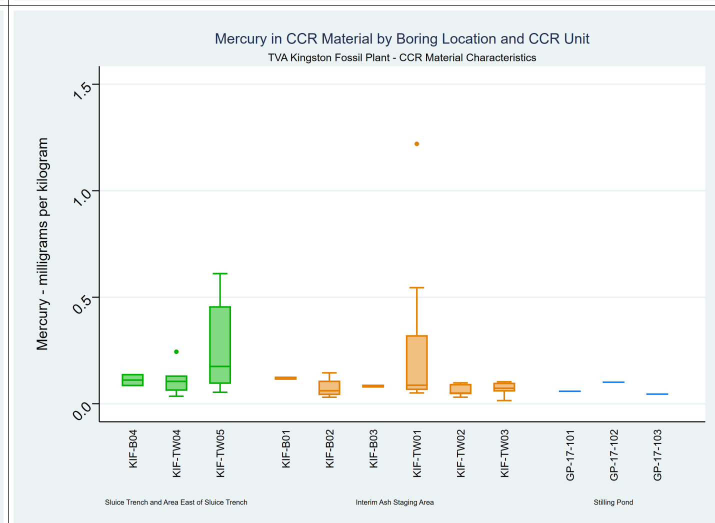
Cobalt in CCR Material by Boring Location and CCR Unit
TVA Kingston Fossil Plant - CCR Material Characteristics
Cobalt - milligrams per kilogram
0
10
20
30
40
KIF-B04
KIF-TW04
KIF-TW05
KIF-B01
KIF-B02
KIF-B03
KIF-TW01
KIF-TW02
KIF-TW03
GP-17-101
GP-17-102
GP-17-103
Sluice Trench and Area East of Sluice Trench
Interim Ash Staging Area
Stilling Pond



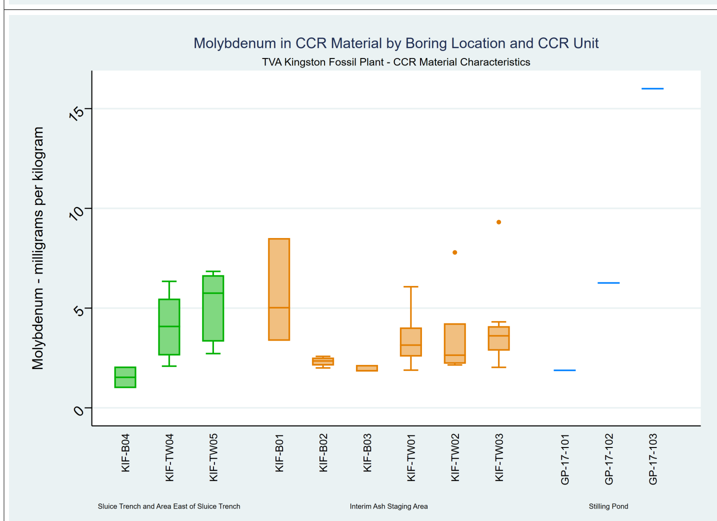
Lead in CCR Material by Boring Location and CCR Unit
TVA Kingston Fossil Plant - CCR Material Characteristics
Lead - milligrams per kilogram
0
10
20
30
KIF-B04
KIF-TW04
KIF-TW05
KIF-B01
KIF-B02
KIF-B03
KIF-TW01
KIF-TW02
KIF-TW03
GP-17-101
GP-17-102
GP-17-103
Sluice Trench and Area East of Sluice Trench
Interim Ash Staging Area
Stilling Pond



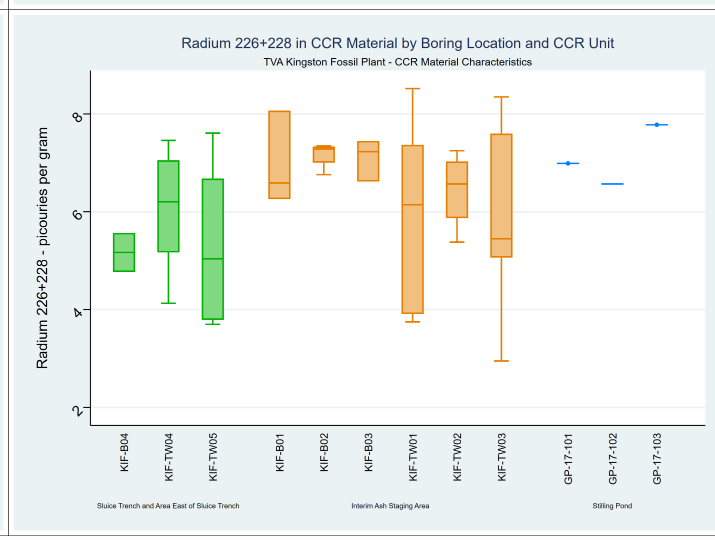
Lithium in CCR Material by Boring Location and CCR Unit
TVA Kingston Fossil Plant - CCR Material Characteristics
Lithium - milligrams per kilogram
0
10
20
30
40
KIF-B04
KIF-TW04
KIF-TW05
KIF-B01
KIF-B02
KIF-B03
KIF-TW01
KIF-TW02
KIF-TW03
GP-17-101
GP-17-102
GP-17-103
Sluice Trench and Area East of Sluice Trench
Interim Ash Staging Area
Stilling Pond



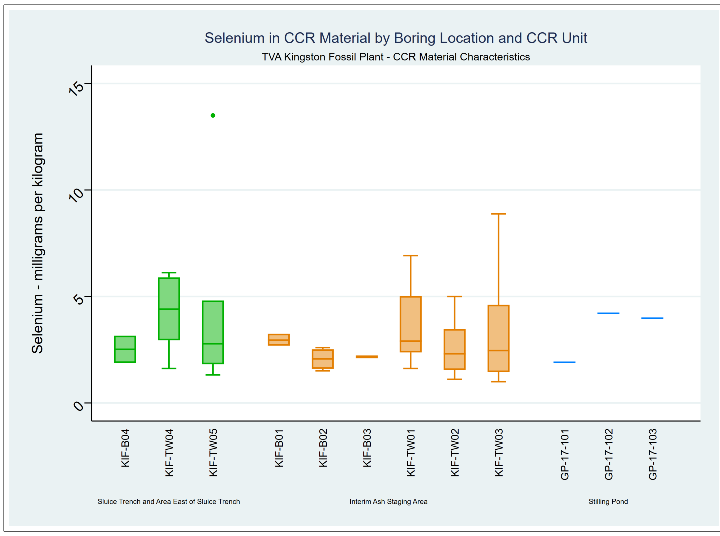
Mercury in CCR Material by Boring Location and CCR Unit
TVA Kingston Fossil Plant - CCR Material Characteristics
Mercury - milligrams per kilogram
0.0
0.5
1.0
1.5
KIF-B04
KIF-TW04
KIF-TW05
KIF-B01
KIF-B02
KIF-B03
KIF-TW01
KIF-TW02
KIF-TW03
GP-17-101
GP-17-102
GP-17-103
Sluice Trench and Area East of Sluice Trench
Interim Ash Staging Area
Stilling Pond

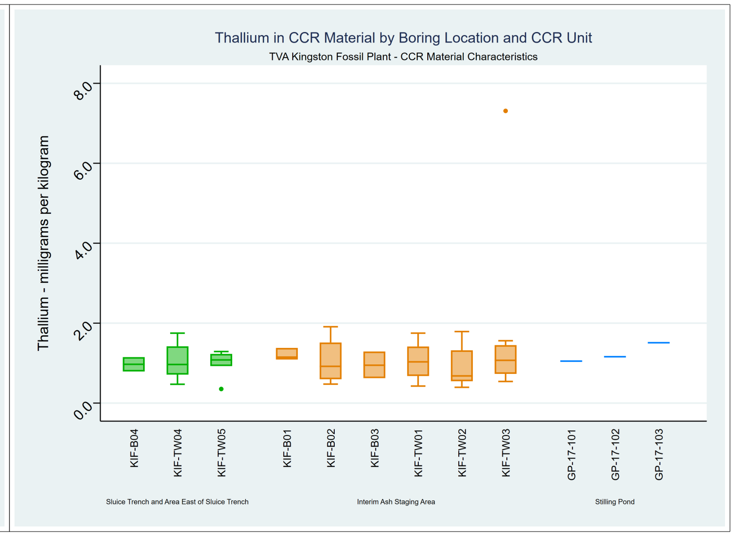


Molybdenum in CCR Material by Boring Location and CCR Unit
TVA Kingston Fossil Plant - CCR Material Characteristics
Molybdenum - milligrams per kilogram
0
5
10
15
KIF-B04
KIF-TW04
KIF-TW05
KIF-B01
KIF-B02
KIF-B03
KIF-TW01
KIF-TW02
KIF-TW03
GP-17-101
GP-17-102
GP-17-103
Sluice Trench and Area East of Sluice Trench
Interim Ash Staging Area
Stilling Pond

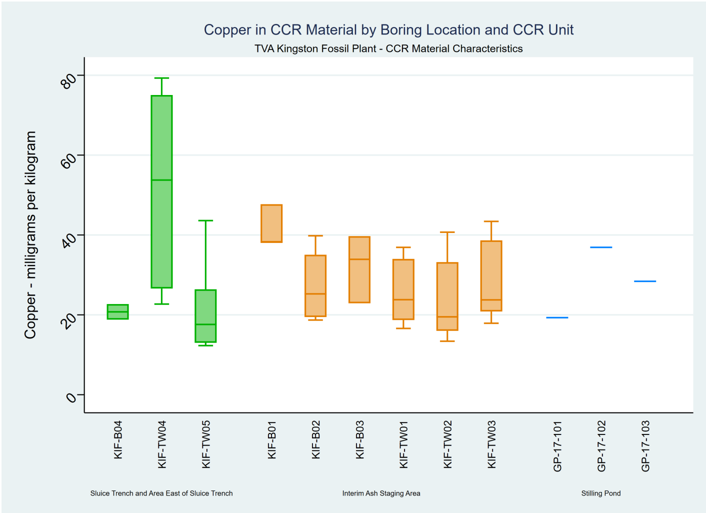


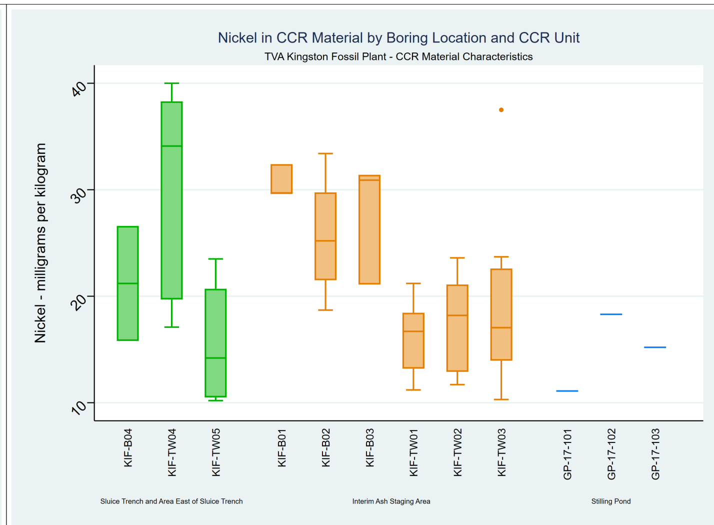
Radium 226+228 in CCR Material by Boring Location and CCR Unit
TVA Kingston Fossil Plant - CCR Material Characteristics
Radium 226+228 - picouries per gram
2
4
6
8
KIF-B04
KIF-TW04
KIF-TW05
KIF-B01
KIF-B02
KIF-B03
KIF-TW01
KIF-TW02
KIF-TW03
GP-17-101
GP-17-102
GP-17-103
Sluice Trench and Area East of Sluice Trench
Interim Ash Staging Area
Stilling Pond

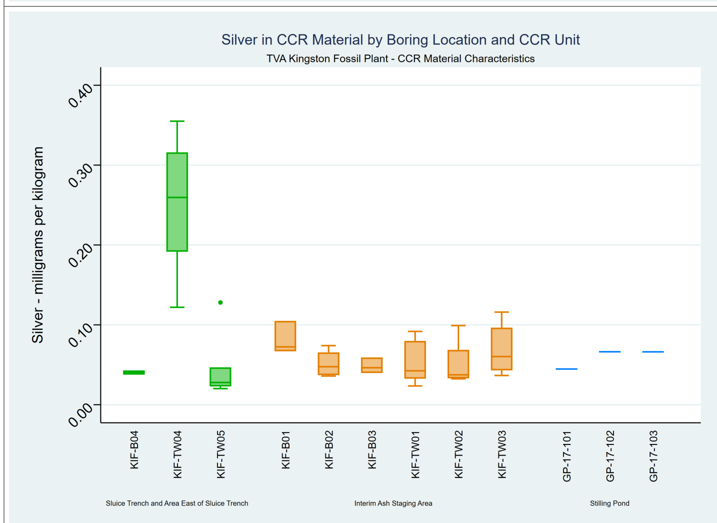

Selenium in CCR Material by Boring Location and CCR Unit
TVA Kingston Fossil Plant - CCR Material Characteristics
Selenium - milligrams per kilogram
0
5
10
15
KIF-B04
KIF-TW04
KIF-TW05
KIF-B01
KIF-B02
KIF-B03
KIF-TW01
KIF-TW02
KIF-TW03
GP-17-101
GP-17-102
GP-17-103
Sluice Trench and Area East of Sluice Trench
Interim Ash Staging Area
Stilling Pond

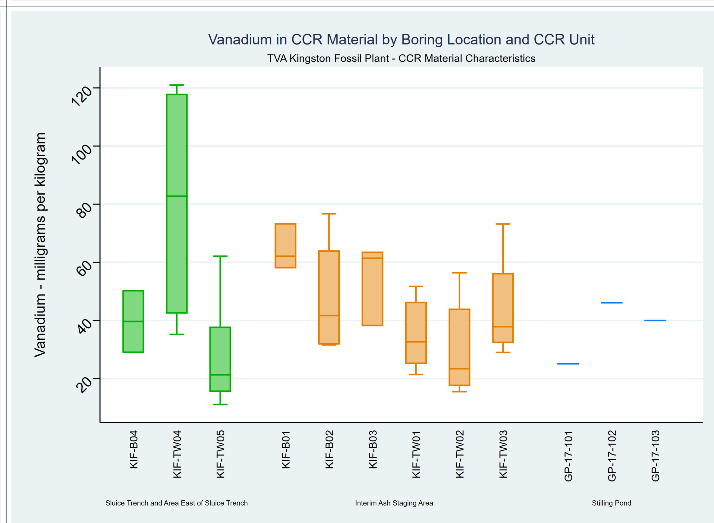

Thallium in CCR Material by Boring Location and CCR Unit
TVA Kingston Fossil Plant - CCR Material Characteristics
Thallium - milligrams per kilogram
0.0
2.0
4.0
6.0
8.0
KIF-B04
KIF-TW04
KIF-TW05
KIF-B01
KIF-B02
KIF-B03
KIF-TW01
KIF-TW02
KIF-TW03
GP-17-101
GP-17-102
GP-17-103
Sluice Trench and Area East of Sluice Trench
Interim Ash Staging Area
Stilling Pond

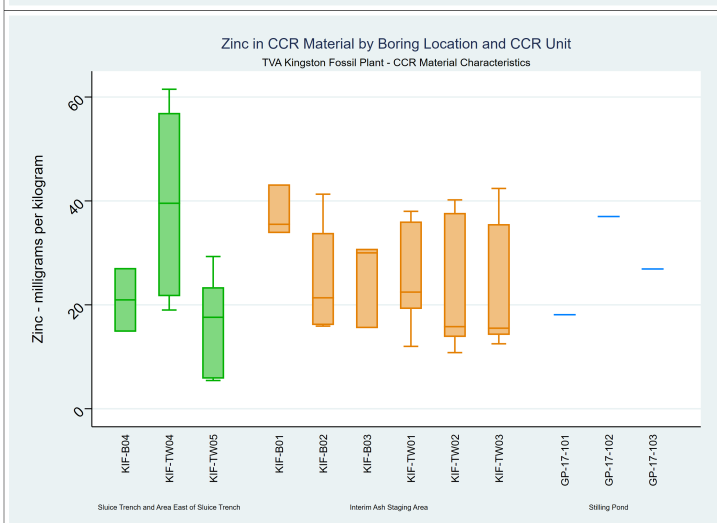
Box Plots
TDEC Appendix I Parameters
CCR Material Characteristics Investigation
Kingston Fossil Plant - Harriman, Tennessee











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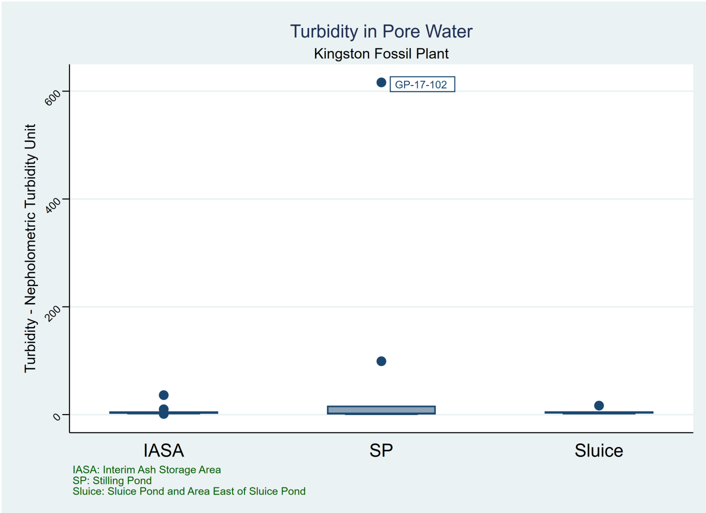
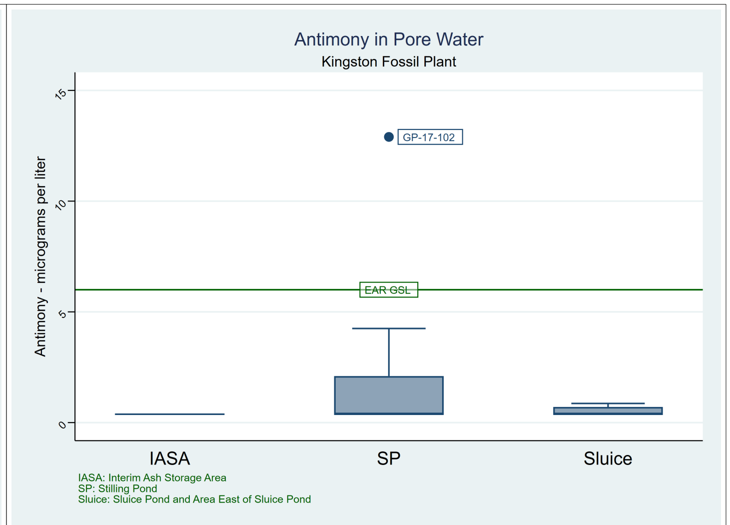
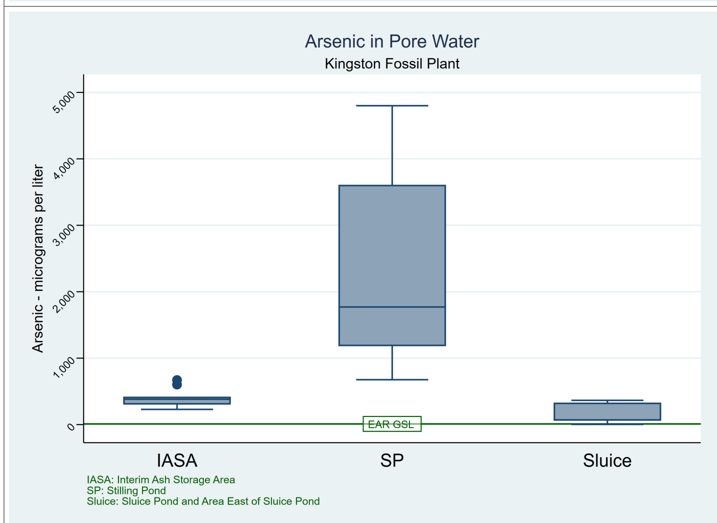
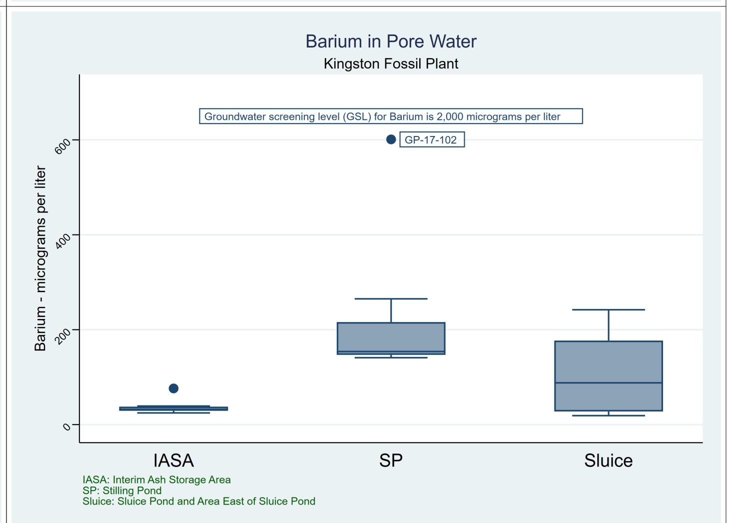
ATTACHMENT E.2-C
BOX PLOTS – PORE WATER OUTLIER ANALYSIS

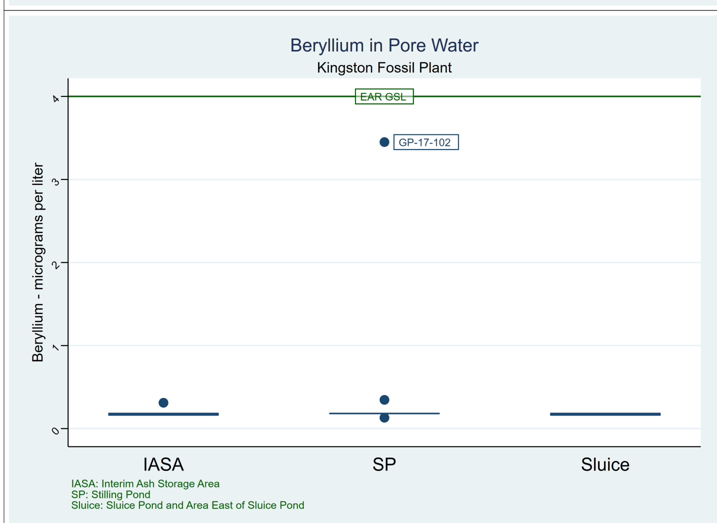
Box Plots - Pore Water Outlier Analysis
CCR Rule Appendix IV Parameters
Pore Water Investigation
Kingston Fossil Plant - Harriman, Tennessee

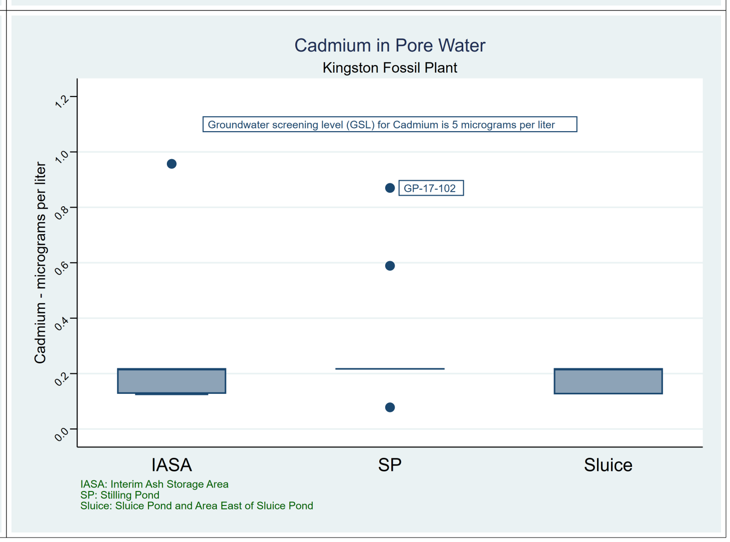


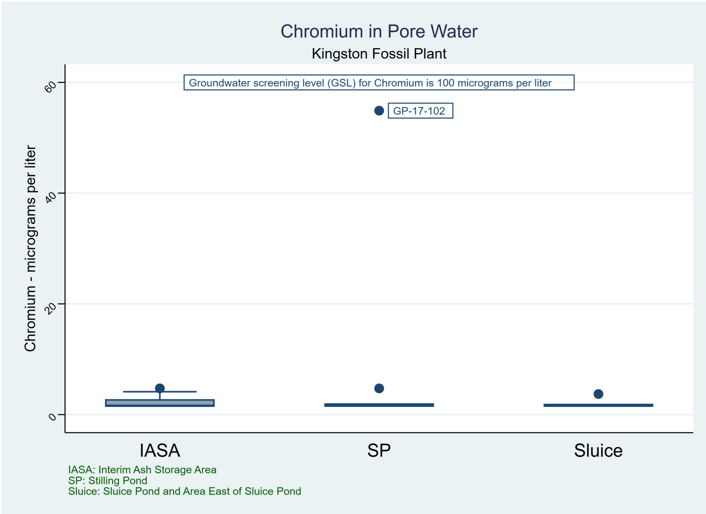


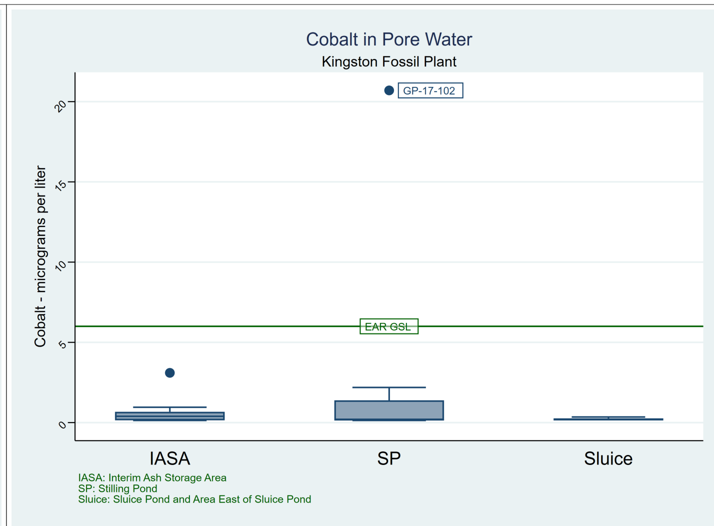


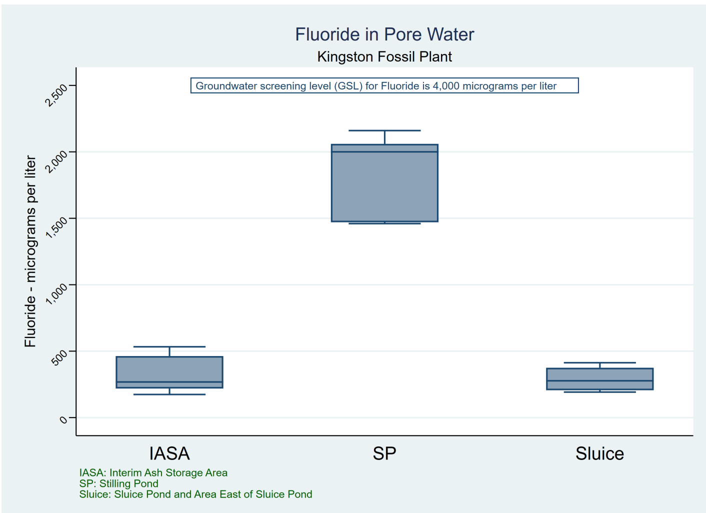


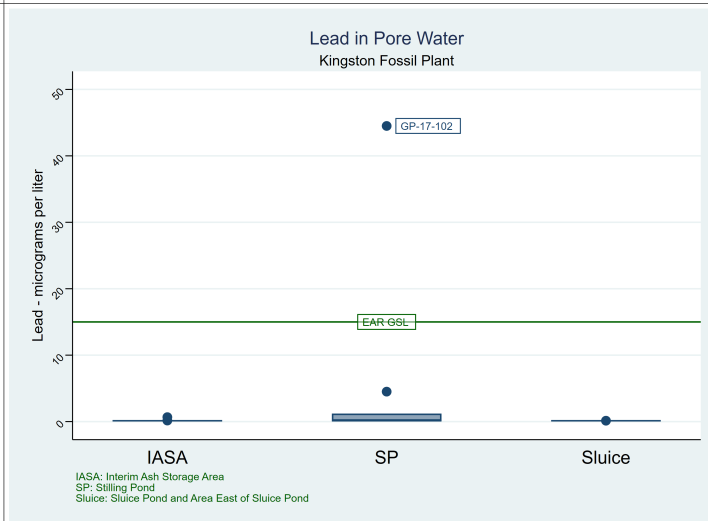


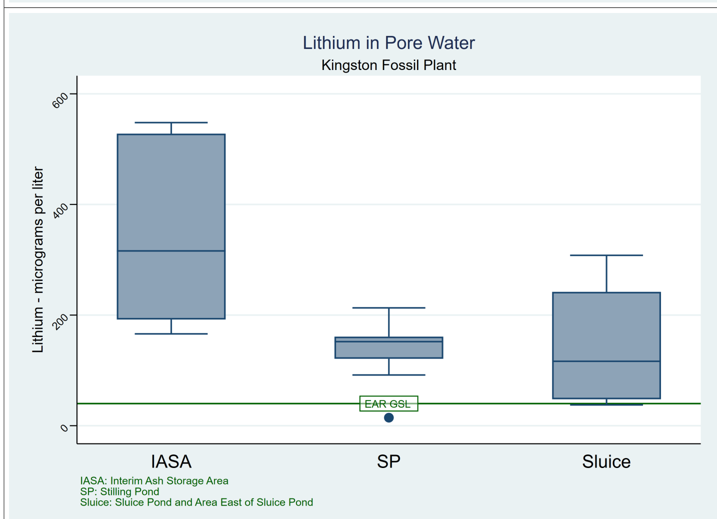


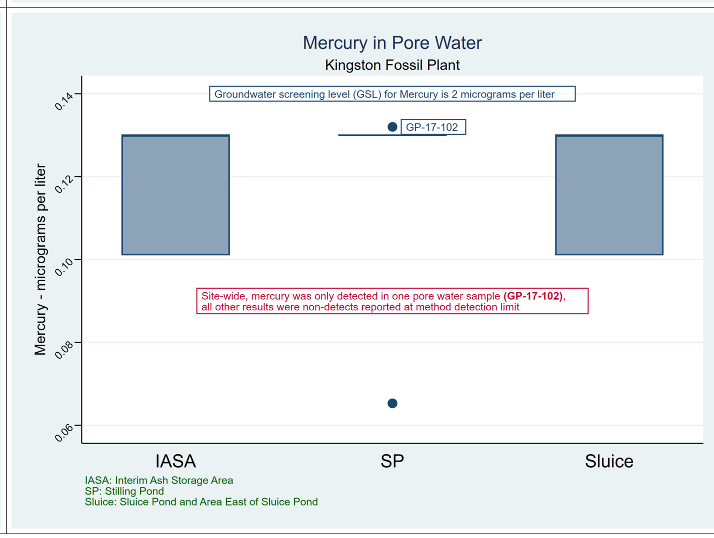

Chromium in Pore Water
Kingston Fossil Plant
Groundwater screening level (GSL) for Chromium is 100 micrograms per liter
GP-17-102
Chromium - micrograms per liter
0
20
40
60
IASA
SP
Sluice
IASA: Interim Ash Storage Area
SP: Stilling Pond
Sluice: Sluice Pond and Area East of Sluice Pond

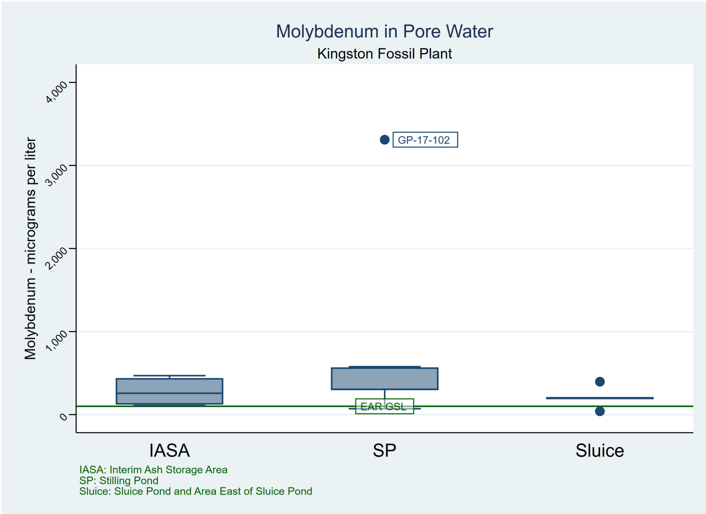

Cobalt in Pore Water
Kingston Fossil Plant
GP-17-102
EAR GSL
Cobalt - micrograms per liter
0
5
10
15
20
IASA
SP
Sluice
IASA: Interim Ash Storage Area
SP: Stilling Pond
Sluice: Sluice Pond and Area East of Sluice Pond


Fluoride in Pore Water
Kingston Fossil Plant
Groundwater screening level (GSL) for Fluoride is 4,000 micrograms per liter
Fluoride - micrograms per liter
0
500
1,000
1,500
2,000
2,500
IASA
SP
Sluice
IASA: Interim Ash Storage Area
SP: Stilling Pond
Sluice: Sluice Pond and Area East of Sluice Pond

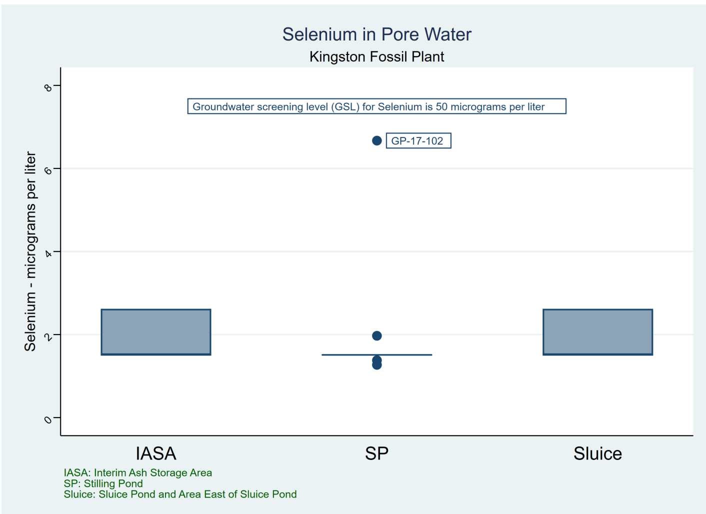

Lead in Pore Water
Kingston Fossil Plant
GP-17-102
EAR GSL
Lead - micrograms per liter
0
10
20
30
40
50
IASA
SP
Sluice
IASA: Interim Ash Storage Area
SP: Stilling Pond
Sluice: Sluice Pond and Area East of Sluice Pond

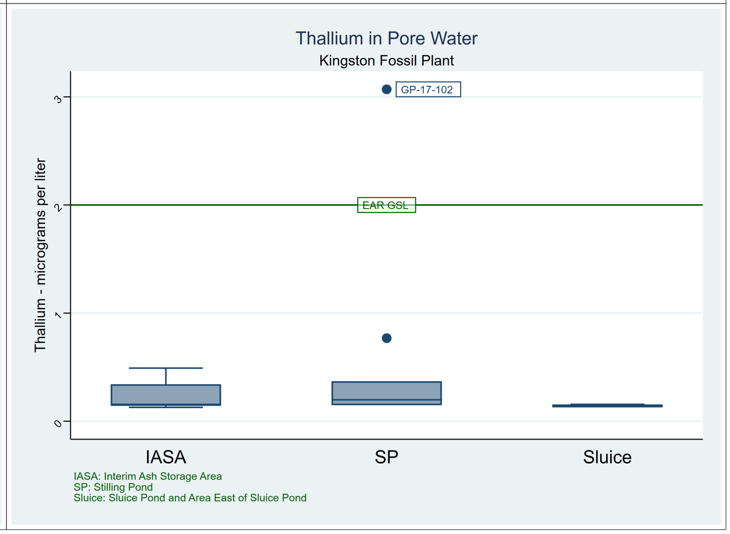

Lithium in Pore Water
Kingston Fossil Plant
EAR GSL
Lithium - micrograms per liter
0
200
400
600
IASA
SP
Sluice
IASA: Interim Ash Storage Area
SP: Stilling Pond
Sluice: Sluice Pond and Area East of Sluice Pond


Mercury in Pore Water
Kingston Fossil Plant
Groundwater screening level (GSL) for Mercury is 2 micrograms per liter
GP-17-102
Site-wide, mercury was only detected in one pore water sample (GP-17-102),
all other results were non-detects reported at method detection limit
Mercury - micrograms per liter
0.06
0.08
0.10
0.12
0.14
IASA
SP
Sluice
IASA: Interim Ash Storage Area
SP: Stilling Pond
Sluice: Sluice Pond and Area East of Sluice Pond

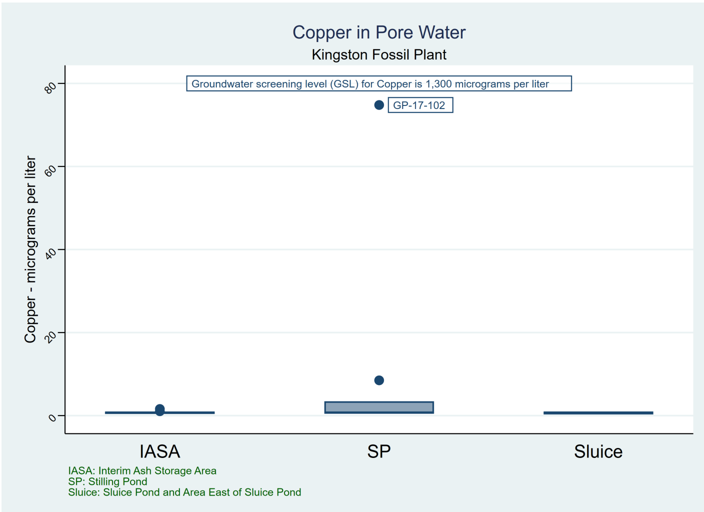


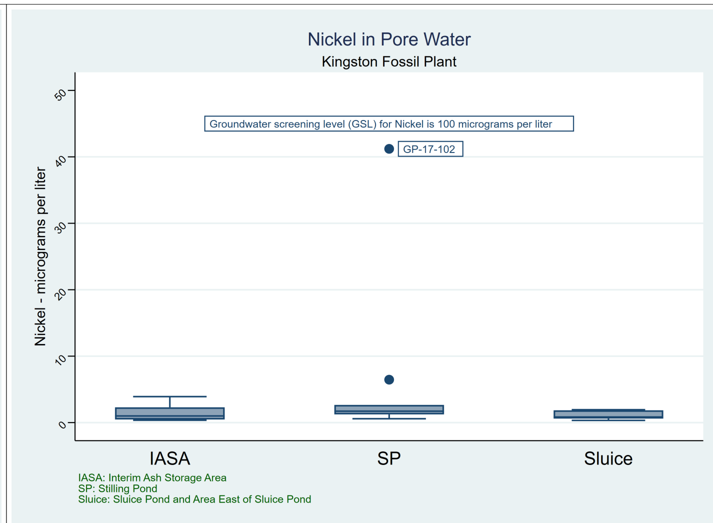
Results for Radium 226+228 were not Reported for GP-17-101, GP-17-102, or GP-17-103



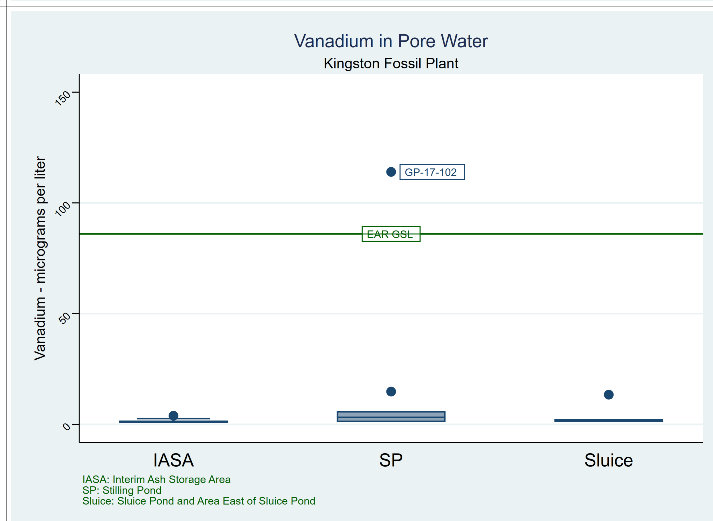


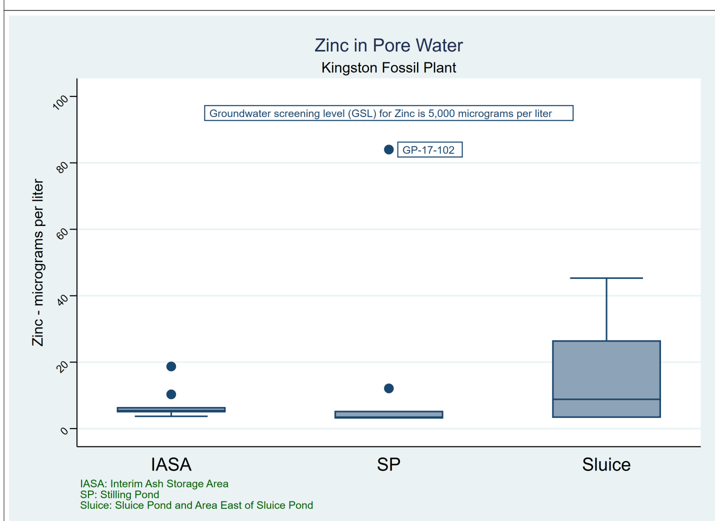
Box Plots - Pore Water Outlier Analysis
TDEC Appendix I Parameters
Pore Water Investigation
Kingston Fossil Plant - Harriman, Tennessee





Silver was not detected above the method detection limit in any pore water sample





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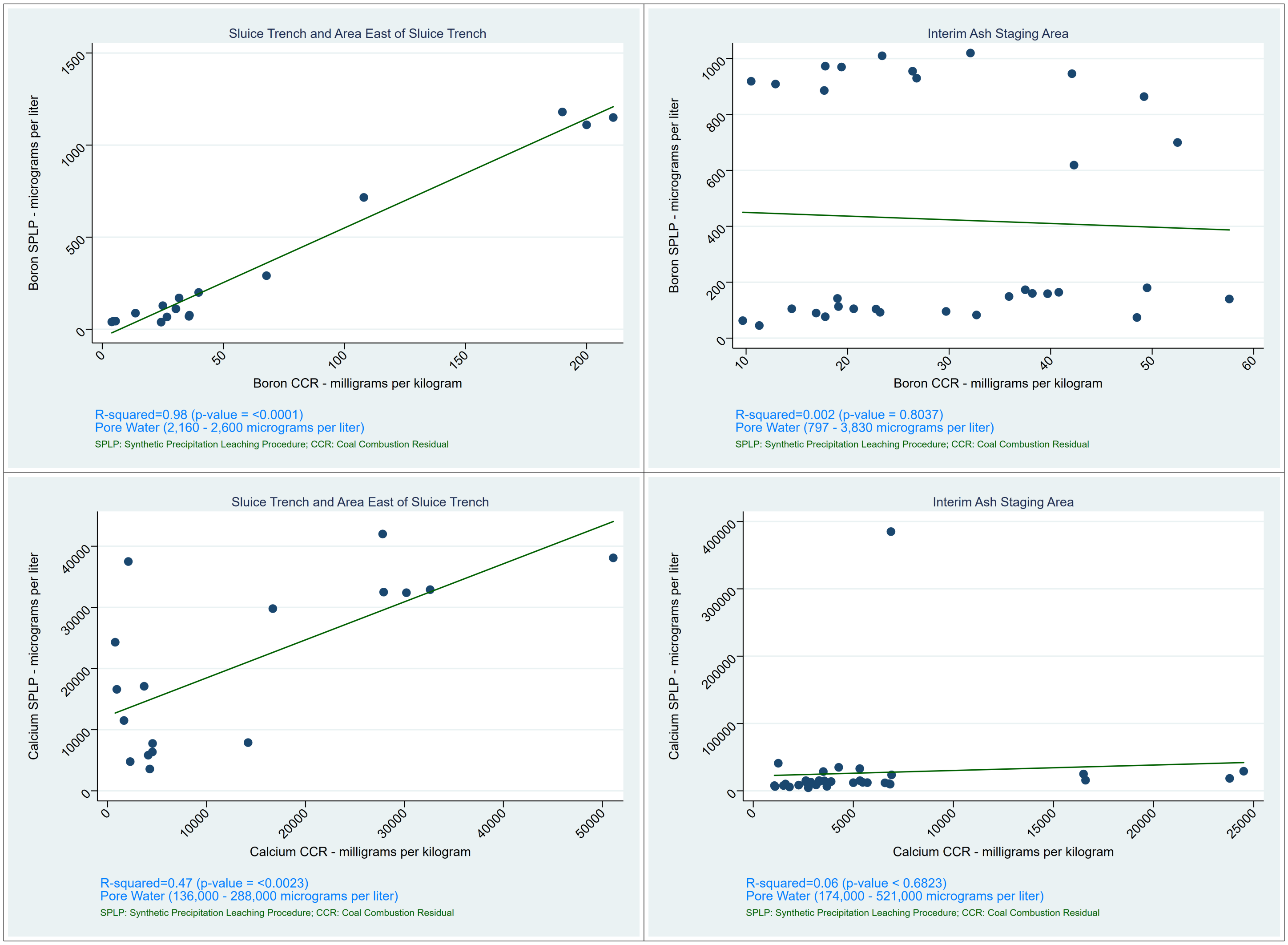
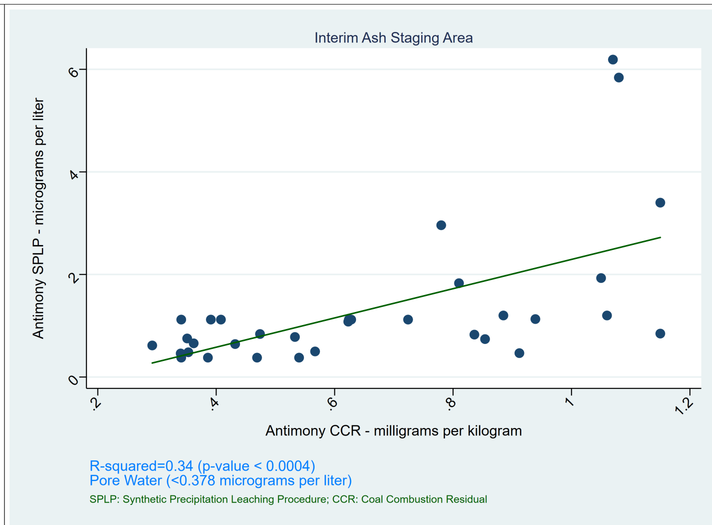
ATTACHMENT E.2-D
SCATTER PLOTS AND REGRESSION

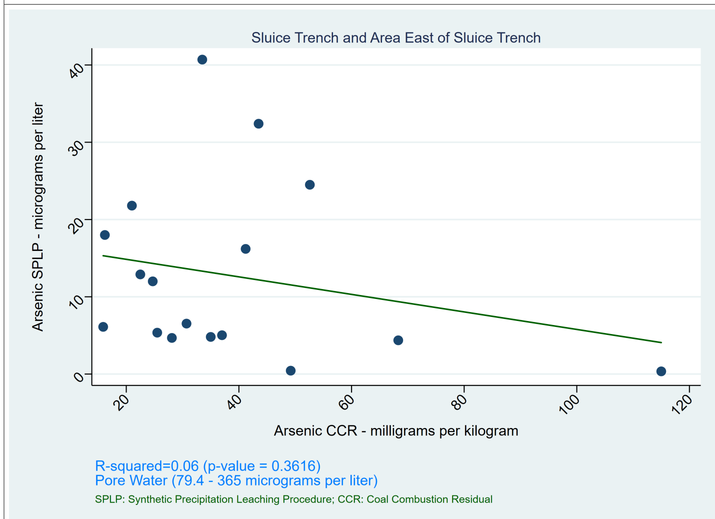
Scatter Plots (SPLP and CCR Material)
CCR Rule Appendix III Parameters
CCR Material Characteristics Investigation
Kingston Fossil Plant - Harriman, Tennessee

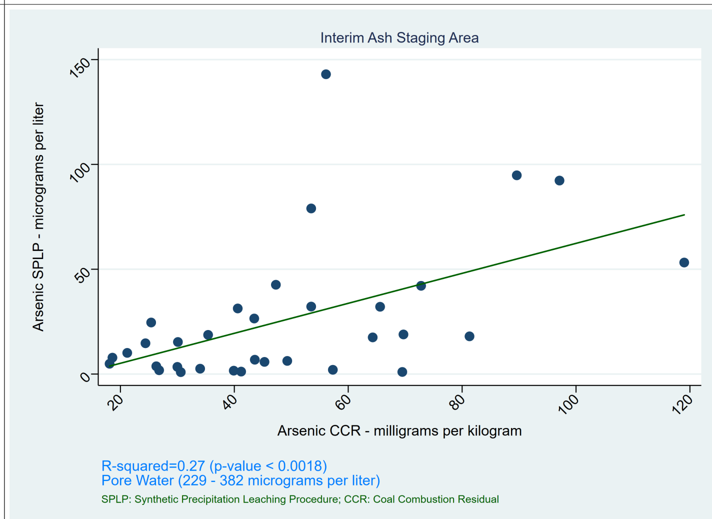


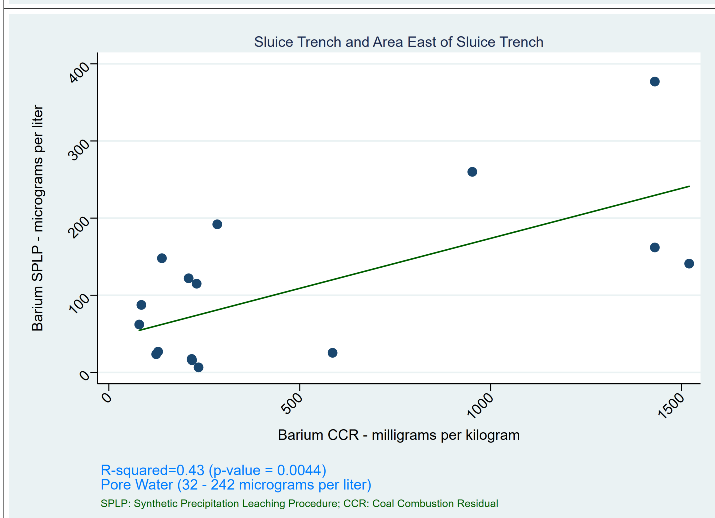
Scatter Plots (SPLP and CCR Material)
CCR Rule Appendix IV Parameters
CCR Material Characteristics Investigation
Kingston Fossil Plant - Harriman, Tennessee

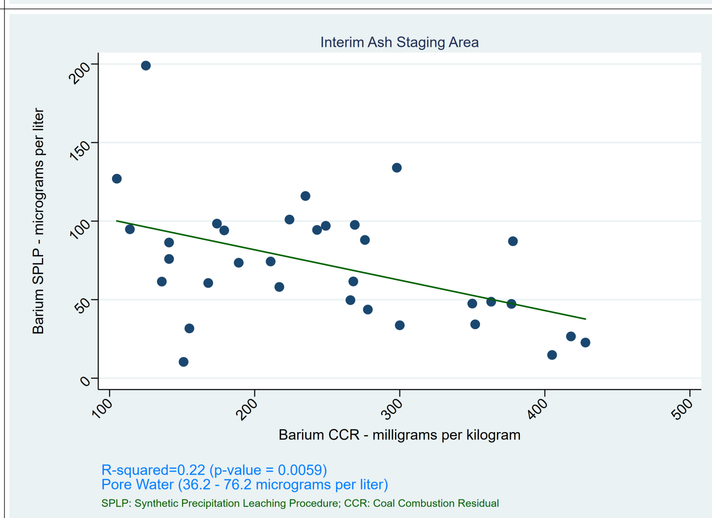
Antimony/Sluice Trench and Area East of Sluice Trench, Insufficient Data, > 50% non-Detects in SPLP or CCR Material Data Sets





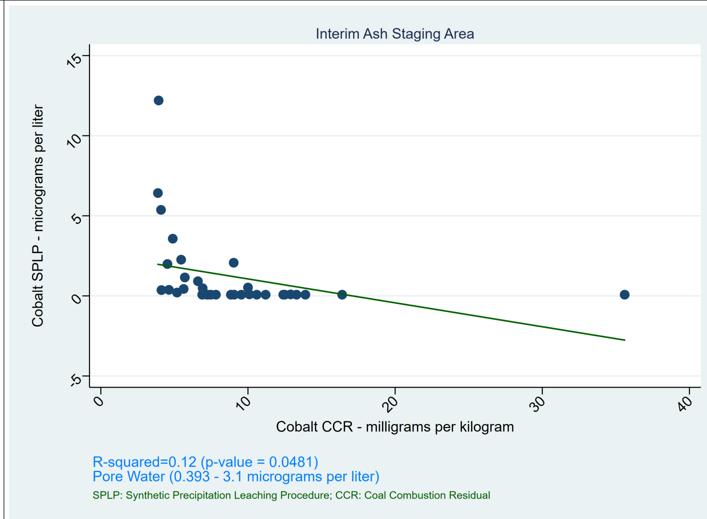
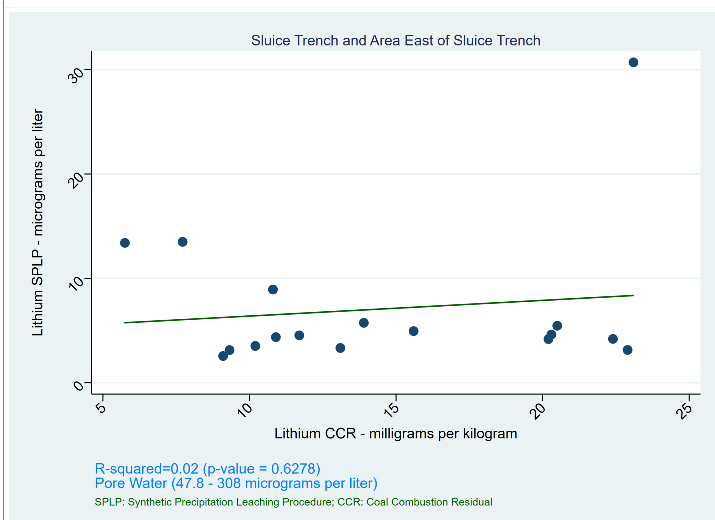
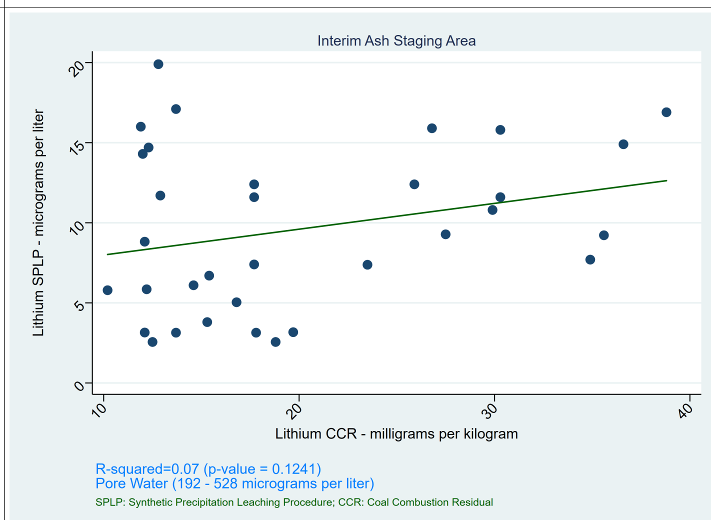






Beryllium/Sluice Trench and Area East of Sluice Trench, Insufficient Data, > 50% non-Detects in SPLP or CCR Material Data Sets

Beryllium/Interim Ash Staging Area, Insufficient Data, > 50% non-Detects in SPLP or CCR Material Data Sets

<table>
<tr><td>Cadmium/Sluice Trench and Area East of Sluice Trench, Insufficient Data, > 50% non-Detects in SPLP or CCR Material Data Sets</td><td>Cadmium/Interim Ash Staging Area, Insufficient Data, > 50% non-Detects in SPLP or CCR Material Data Sets</td></tr>
<tr><td>Chromium/Sluice Trench and Area East of Sluice Trench, Insufficient Data, > 50% non-Detects in SPLP or CCR Material Data Sets</td><td>Chromium/Interim Ash Staging Area, Insufficient Data, > 50% non-Detects in SPLP or CCR Material Data Sets</td></tr>
<tr><td>Cobalt/Sluice Trench and Area East of Sluice Trench, Insufficient Data, > 50% non-Detects in SPLP or CCR Material Data Sets</td><td>
</td></tr>
<tr><td>Lead/Sluice Trench and Area East of Sluice Trench, Insufficient Data, > 50% non-Detects in SPLP or CCR Material Data Sets</td><td>Lead/Interim Ash Staging Area, Insufficient Data, > 50% non-Detects in SPLP or CCR Material Data Sets</td></tr>
<tr><td>
</td><td>
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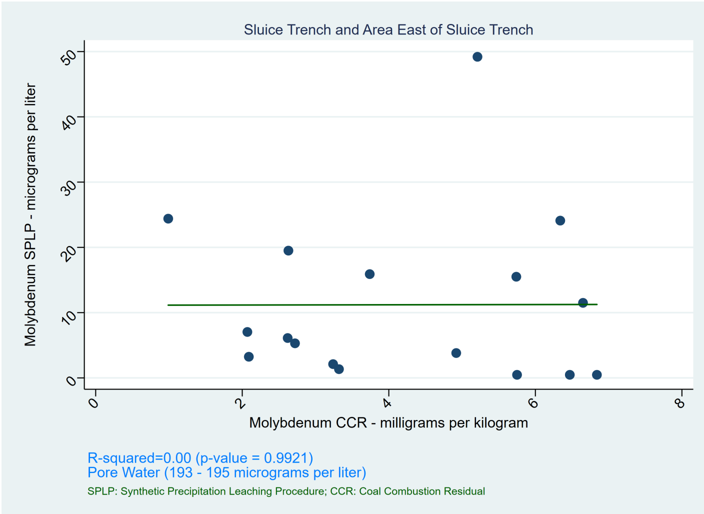
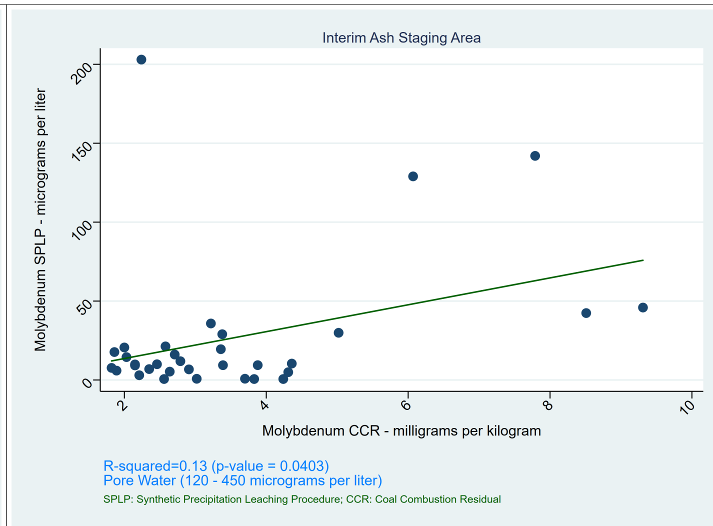
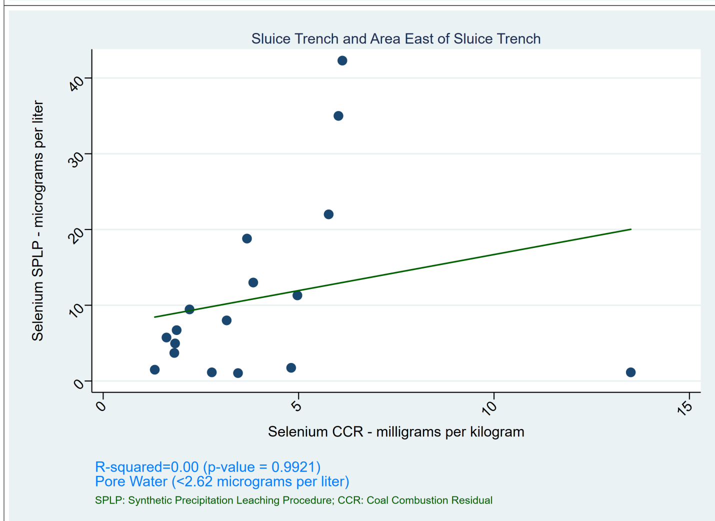
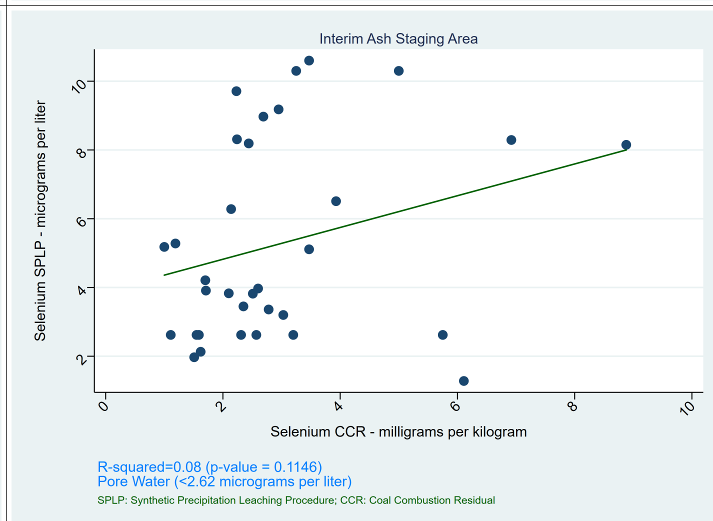
<tr><td>Mercury/Sluice Trench and Area East of Sluice Trench, Insufficient Data, > 50% non-Detects in SPLP or CCR Material Data Sets</td><td>Mercury/Interim Ash Staging Area, Insufficient Data, > 50% non-Detects in SPLP or CCR Material Data Sets</td></tr>
</table>









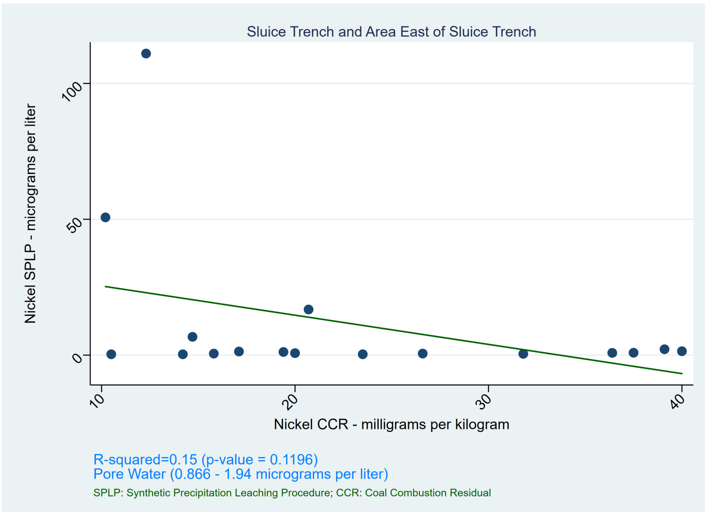
Thallium/Sluice Trench and Area East of Sluice Trench, Insufficient Data, > 50% non-Detects in SPLP or CCR Material Data Sets

Thallium/Interim Ash Staging Area, Insufficient Data, > 50% non-Detects in SPLP or CCR Material Data Sets

Scatter Plots (SPLP and CCR Material)
TDEC Appendix I Parameters
CCR Material Characteristics Investigation
Kingston Fossil Plant - Harriman, Tennessee

Copper/Sluice Trench and Area East of Sluice Trench, Insufficient Data, > 50% non-Detects in SPLP or CCR Material Data Sets

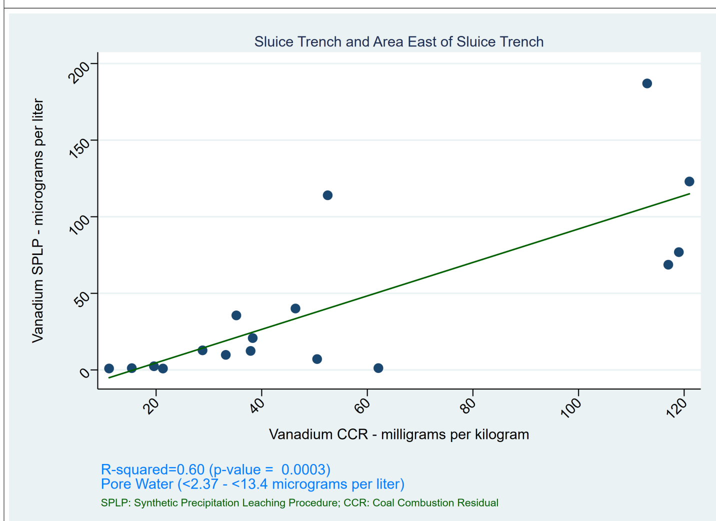
Copper/Interim Ash Staging Area, Insufficient Data, > 50% non-Detects in SPLP or CCR Material Data Sets

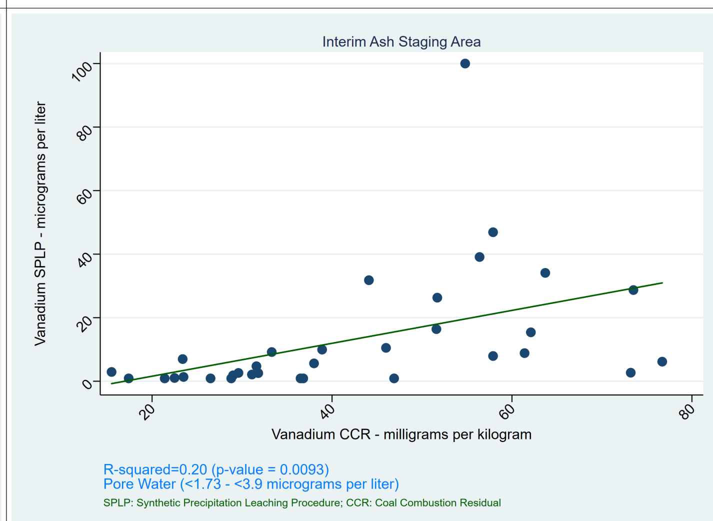


Nickel/Interim Ash Staging Area, Insufficient Data, > 50% non-Detects in SPLP or CCR Material Data Sets

Silver/Sluice Trench and Area East of Sluice Trench, Insufficient Data, > 50% non-Detects in SPLP or CCR Material Data Sets

Silver/Interim Ash Staging Area, Insufficient Data, > 50% non-Detects in SPLP or CCR Material Data Sets





Zinc/Sluice Trench and Area East of Sluice Trench, Insufficient Data, > 50% non-Detects in SPLP or CCR Material Data Sets

Zinc/Interim Ash Staging Area, Insufficient Data, > 50% non-Detects in SPLP or CCR Material Data Sets

APPENDIX E.3

STATISTICAL ANALYSIS OF GROUNDWATER ANALYTICAL RESULTS

Appendix E.3 - Statistical Analysis of Groundwater Analytical Results

TDEC Commissioner's Order:
Environmental Assessment Report
Kingston Fossil Plant
Harriman, Tennessee

March 12, 2024

Prepared for:

Tennessee Valley Authority
Chattanooga, Tennessee

Prepared by:

Stantec Consulting Services Inc.
Lexington, Kentucky

APPENDIX E.3 - STATISTICAL ANALYSIS OF GROUNDWATER ANALYTICAL RESULTS

REVISION LOG

Revision	Description	Date
0	EAR Submittal to TDEC	May 30, 2023
1	Addresses August 16, 2023 TDEC Review Comments and Issued for TDEC	November 14, 2023
2	Addresses January 12, 2024 TDEC Review Comments and Issued for TDEC	March 12, 2024

Sign-off Sheet

This document entitled Appendix E.3 - Statistical Analysis of Groundwater Analytical Results was prepared by Stantec Consulting Services Inc. (“Stantec”) for the account of Tennessee Valley Authority (the “Client”). Any reliance on this document by any third party is strictly prohibited. The material in it reflects Stantec’s professional judgment in light of the scope, schedule and other limitations stated in the document and in the contract between Stantec and the Client. The opinions in the document are based on conditions and information existing at the time the document was published and do not consider any subsequent changes. In preparing the document, Stantec did not verify information supplied to it by others. Any use which a third party makes of this document is the responsibility of such third party. Such third party agrees that Stantec shall not be responsible for costs or damages of any kind, if any, suffered by it or any other third party as a result of decisions made or actions taken based on this document.

Prepared by ______________________

Melissa Whitfield Aslund, PhD, Environmental Scientist

Reviewed by ______________________

Chris LaLonde, Senior Risk Assessor

Approved by ______________________

Rebekah Brooks, PG, Senior Principal Hydrogeologist

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ATTACHMENT E.3-E	LINEAR REGRESSION RESULTS

Abbreviations

CASRN	Chemical Abstracts Service Registry Number
CCR	Coal Combustion Residuals
CCR Parameters	Constituents listed in Appendices III and IV of Title 40, Code of Federal Regulations, Part 257 and five inorganic constituents included in Appendix I of Tennessee Rule 0400-11-01-.04
CCR Rule	Title 40, Code of Federal Regulations, Part 257
CFR	Code of Federal Regulations
EAR	Environmental Assessment Report
EI	Environmental Investigation
GSLs	Groundwater Screening Levels
KIF Plant	Kingston Fossil Plant
µg/L	Micrograms Per Liter
NA	Not Available
%	Percent
Stantec	Stantec Consulting Services Inc.
TDEC	Tennessee Department of Environment and Conservation
TDS	Total Dissolved Solids
TVA	Tennessee Valley Authority
Unified Guidance	Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities: Unified Guidance
USEPA	United States Environmental Protection Agency

March 12, 2024

1.0 INTRODUCTION

Stantec Consulting Services Inc. (Stantec) prepared this appendix on behalf of the Tennessee Valley Authority (TVA) to summarize the statistical analyses performed on groundwater quality data to support evaluations conducted for the Environmental Assessment Report (EAR) at the Kingston Fossil Plant (KIF Plant) located in Harriman, Tennessee. These statistical analyses include an evaluation of groundwater quality data collected at the KIF Plant for the Tennessee Department of Environment and Conservation (TDEC) Order Environmental Investigation (EI), in compliance with the Title 40, Code of Federal Regulations (CFR) Part 257 (Coal Combustion Residuals [CCR Rule]) monitoring program, and the TDEC permitted landfill groundwater monitoring program. The statistical analysis in this appendix focused on the parameters listed in Appendices III and IV of Title 40 CFR 257 and five additional inorganic constituents included in Appendix I of Tennessee Rule 0400-11-01-.04 (CCR Parameters) (see Table E.3-1). The wells included in this statistical analysis are listed in Table E.3-2.

The dataset compiled for statistical analysis includes available analytical data for groundwater samples collected between June 2009 and December 2022, although the specific start date and frequency of sampling may vary between wells based on date of well installation and the applicable monitoring program. This time period was selected because it includes the data that met the data quality objectives of the EI. The complete groundwater quality results for the dataset compiled for statistical analysis are reported in Appendix H.1.

Table E.3-1 – CCR Parameters Evaluated in Statistical Analysis

Parameter	CASRN
CCR Rule Appendix III Parameters	
Boron	7440-42-8
Calcium	7440-70-2
Chloride	16887-00-6
Fluoride[1] (also Appendix IV)	16984-48-8
pH	NA
Sulfate	14808-79-8
TDS	NA
CCR Rule Appendix IV Parameters	
Antimony	7440-36-0
Arsenic	7440-38-2
Barium	7440-39-3
Beryllium	7440-41-7
Cadmium	7440-43-9
Chromium	7440-47-3
Cobalt	7440-48-4
Lead	7439-92-1
Lithium	7439-93-2
Mercury	7439-97-6
Molybdenum	7439-98-7
Radium-226+228	13982-63-3/ 15262-20-1
Selenium	7782-49-2
Thallium	7440-28-0
Additional TDEC Appendix I Parameters	
Copper	7440-50-8
Nickel	7440-02-0
Silver	7440-22-4
Vanadium	7440-62-2
Zinc	7440-66-6

Notes: CASRN - Chemical Abstracts Service Registry Number; CCR – Coal Combustion Residuals; NA - Not available; TDS - Total dissolved solids

[1]Fluoride is both a CCR Rule Appendix III and CCR Rule Appendix IV constituent. In this table and in the results figures and tables for this report, fluoride has been grouped with the Appendix III constituents only to avoid duplication.

Table E.3-2 - Groundwater Monitoring Wells and Parameters Included in Statistical Analysis

Well Location	Well	Program			Parameters Included in Statistical Analysis		
		EI Wells	TDEC Permitted Landfill Wells	CCR Rule Wells	CCR Rule Appendix III	CCR Rule Appendix IV	TDEC Appendix I
Background	AD-1	-	X	X	X	X	X
	GW-2	X	-	-	X	X	X
Stilling Pond	6AR	-	X	X	X	X	X
	KIF-103	X	-	X	X	X	X
	KIF-104	X	-	X	X	X	X
Sluice Trench and Area East of Sluice Trench, Interim Ash Staging Area	AD-2	-	X	X	X	X	X
	AD-3	-	X	X	X	X	X
	KIF-105	X	-	X	X	X	X
	KIF-106	X	-	X	X	X	X
	KIF-109	-	-	X	X	X	X

Notes
For each well, the program to which the well belongs as well as the parameters evaluated in this statistical analysis are identified with an ‘X’ and highlighted gray. Programs or parameters that are not applicable to that well are indicated with a dash (-).

2.0 METHODS

2.1 EXPLORATORY DATA ANALYSIS

The initial step of statistical analysis was the exploratory data analysis. The process of the exploratory data analysis utilizes simple summary statistics (e.g., mean, median, standard deviation and percentiles) and graphical representations to identify important characteristics of an analytical dataset, such as the center of the data (i.e., mean, median), variation, distribution, patterns, presence of outliers and randomness.

Summary statistics were calculated for each well-constituent pair. These summary statistics include information such as total number of available samples, frequency of detection, and maximum detected values and detected concentrations for each well-constituent pair. Exploratory data plots for each well-constituent pair (i.e., box plots and time series plots) were also constructed to support a visual review of the data and identify potential outliers.

Outliers are data points that are abnormally high or low as compared to other measurements and may represent anomalous data or data errors. Outliers may also represent natural variation of concentrations in environmental systems. Therefore, where potential outliers were visually identified in box plots or time-series plots, secondary statistical screening was completed using Tukey's procedure to identify extreme outliers (Tukey 1977) followed by statistical testing for outliers (Dixon or Rosner's test, α=0.05). Following confirmation of the outliers as statistically significant, a desktop evaluation was conducted to verify that the data points were not errors (e.g., laboratory or transcriptional error). Field forms, data validation reports, and other variables in the dataset that could influence analytical results were also evaluated. If a verifiable error was discovered, the outlier was removed and, if possible, replaced with a corrected value.

In the absence of a verifiable error, additional lines of evidence were reviewed to determine final outlier disposition (e.g., frequency of detection, spatial and temporal variability). If an outlier was identified as suitable for removal from further statistical analysis, a clear and defensible rationale based on multiple lines of evidence was provided. In addition, values that were identified as outliers and removed from further evaluation in the present statistical analysis were retained in the historical database and will be reevaluated for inclusion or exclusion in future statistical analyses of this dataset.

2.2 COMPARISON OF GROUNDWATER QUALITY DATA TO GROUNDWATER SCREENING LEVELS

The United States Environmental Protection Agency (USEPA) document "*Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities: Unified Guidance*" (USEPA 2009; hereafter referred to as the Unified Guidance) describes statistical methods for comparing groundwater concentrations to fixed standards such as the TDEC-approved groundwater screening levels (GSLs) identified in Appendix A.2. In the Unified Guidance, a confidence interval approach is recommended for comparing groundwater monitoring data to a fixed numerical limit. If the underlying population is stable (i.e., no trend is present), then the Unified Guidance indicates that comparison to a fixed standard can be made based on a confidence interval around the mean. However, the Unified Guidance indicates that "*where the data exhibit a trend over time the interval will incorporate not only the natural variability in the underlying population, but also additional variation induced by the trend itself. The net result is a confidence interval that can be much wider than expected for a given confidence level and sample size (n).*" Therefore, in the presence of a statistically significant trend, the Unified Guidance recommends constructing a confidence band around a trend line, where the comparison is made to the fixed standard based on the confidence band as of the most recent evaluated sampling event, rather than a static confidence interval around the mean.

For the groundwater data reviewed herein, these approaches were applied to identify well-constituent pairs where the available data indicate a statistically significant concentration above or equal to the GSL for constituents other than pH, or statistically significant values outside the GSL range for pH. For this dataset, the null hypothesis was that the groundwater concentrations were less than the GSL for constituents other than pH and that levels were within the GSL range for pH. In accordance with the methods described in the Unified Guidance, constituent concentrations were determined to represent a statistically significant concentration above or equal to a GSL for constituents other than pH, only when there were sufficient data to support statistical confidence band or interval evaluation and the applicable lower confidence band or interval was greater than or equal to the GSL as of the most recent sampling event included in the statistical analysis. For pH, which has both an upper and lower GSL, a statistical difference was identified if there were sufficient data to support statistical analysis, and either the applicable lower confidence band or interval was greater than or equal to the upper GSL or the applicable upper confidence band or interval was less than or equal to the lower GSL as of the most recent sampling event included in the statistical analysis. Whether comparison should be made using a confidence band or confidence interval was determined for each well-constituent pair based on the results of a linear regression trend analysis for each well-constituent pair. If no significant linear trend was detected ($p \geq 0.05$ for the regression slope), comparison to the GSLs was completed based on a static confidence interval around the mean. If a statistically significant linear trend was present ($p < 0.05$ for the regression slope), comparison to the GSLs was completed based on a confidence band around the linear regression trend line at the most recent evaluated sampling event. In both cases, the confidence band or intervals were constructed with 98 percent (%) confidence, which correspond to a lower confidence limit with 99% confidence.

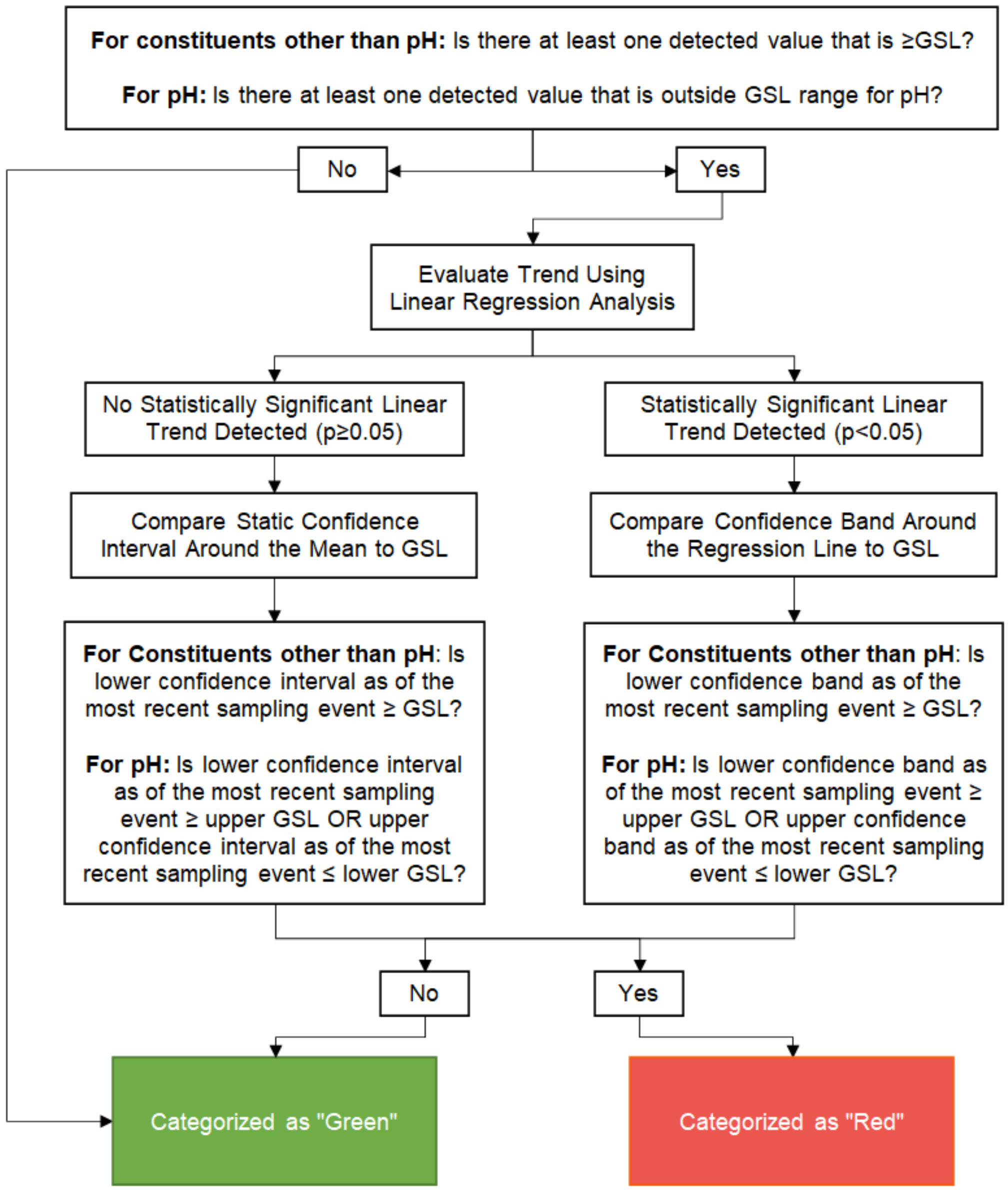
Additional details regarding the methods used to compare groundwater quality data to groundwater screening levels are provided below. As described below, the approach adopted for this comparison was dependent on the number of samples available and the proportion of detected concentrations for each well-constituent pair.

2.2.1 Linear Regression Trend Analysis and Confidence Interval/ Confidence Band Evaluation

For well-constituent pairs with five or more samples and at least four detected values, groundwater quality data were compared to GSLs using a linear regression trend analysis and confidence interval/ confidence band evaluation summarized in **Figure E.3-1** (below) and described in more detail in this section.

First, data were screened to identify if there were reported individual values greater than or equal to the GSL for constituents other than pH or outside the GSL range for pH. In the absence of such a value, well-constituent pairs were classified as 'Green'. If such a value was observed, then linear regression analysis was completed to identify well-constituent pairs with a statistically significant linear trend ($p<0.05$) over the analyzed time period. As noted above, if no statistically significant linear trend was detected ($p\geq0.05$), a static confidence interval around the mean was used for comparison to the GSLs. If a statistically significant linear trend was present ($p<0.05$), a confidence band around the linear regression trend line at the most recent evaluated sampling event was used for comparison to the GSLs. In both cases, 98% confidence intervals were constructed, which correspond to a lower confidence limit with 99% confidence. Non-detect values were conservatively represented at the reported detection limit.

The resulting confidence intervals and confidence bands were then compared to the GSL for the analyzed well-constituent pairs as of the most recent sampling event included in the statistical analysis. For constituents other than pH, well-constituent pairs were classified as 'Red', indicating a statistically significant concentration above or equal to the GSL at a 99% confidence level only if the applicable lower confidence band or interval was greater than or equal to the GSL as of the most recent sampling event included in the statistical analysis (see examples in **Figure E.3-2** below). For pH, well-constituent pairs were classified as 'Red', indicating a statistically significant difference from the GSL range at a 99% confidence level, if the applicable lower confidence band or interval was greater than or equal to the upper GSL or if the applicable upper confidence interval was less than or equal to the lower GSL as of the most recent sampling event included in the statistical analysis (see examples in **Figure E.3-3** below). The remaining well-constituent pairs with five or more samples and at least four detected values that were not classified as 'Red' using the linear regression trend analysis and confidence interval/ confidence band evaluation described above were classified as 'Green'. The 'Green' category indicates that as of the most recent sampling event included in the analysis, constituent levels were not statistically significantly greater than or equal to the GSL (for constituents other than pH) and not statistically greater than or equal to the upper GSL or less than or equal to the lower GSL for pH at a 99% confidence level.



Note: GSL = TDEC-approved Groundwater Screening Level (see Appendix A.2)

Figure E.3-1 – Flow chart summarizing linear regression trend analysis and confidence interval/ confidence band evaluation

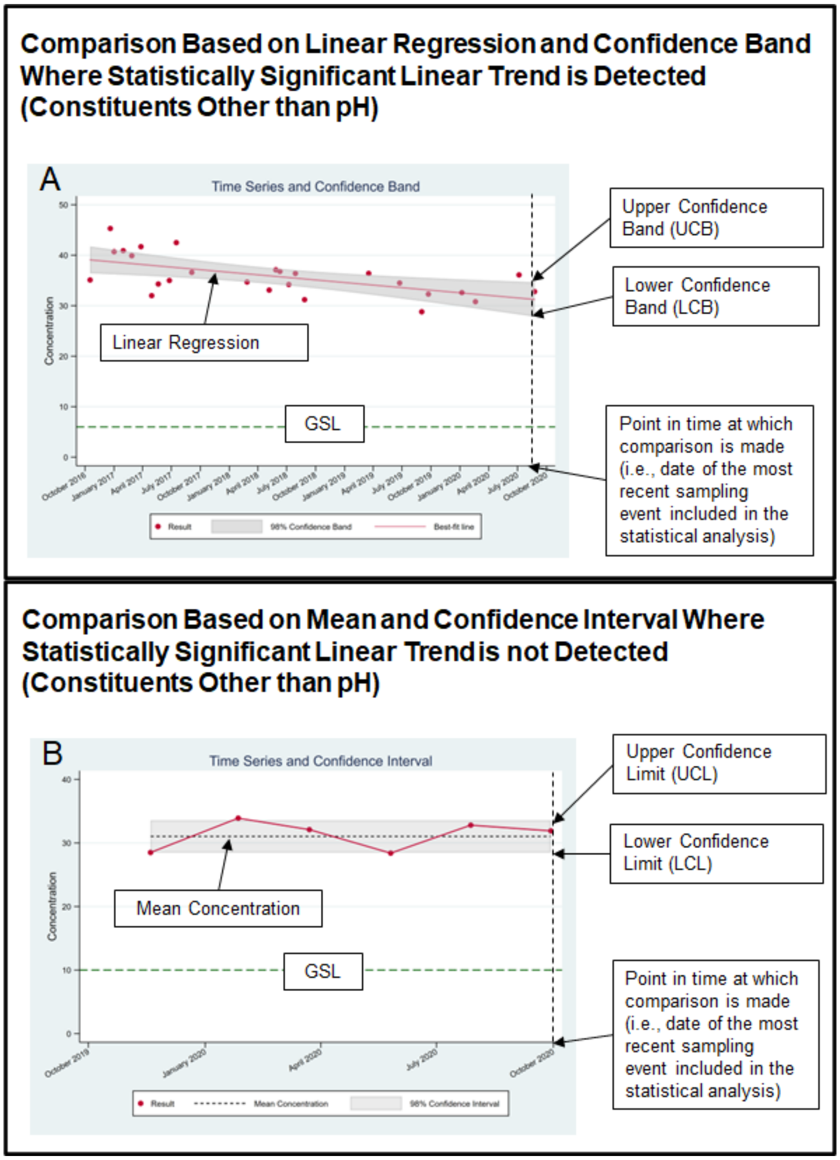


Figure E.3-2 – Examples of well-constituent pairs classified as 'Red' for constituents other than pH (A) in the presence of a statistically significant linear trend ($p<0.05$) and (B) in the absence of a statistically significant linear trend ($p \geq 0.05$)

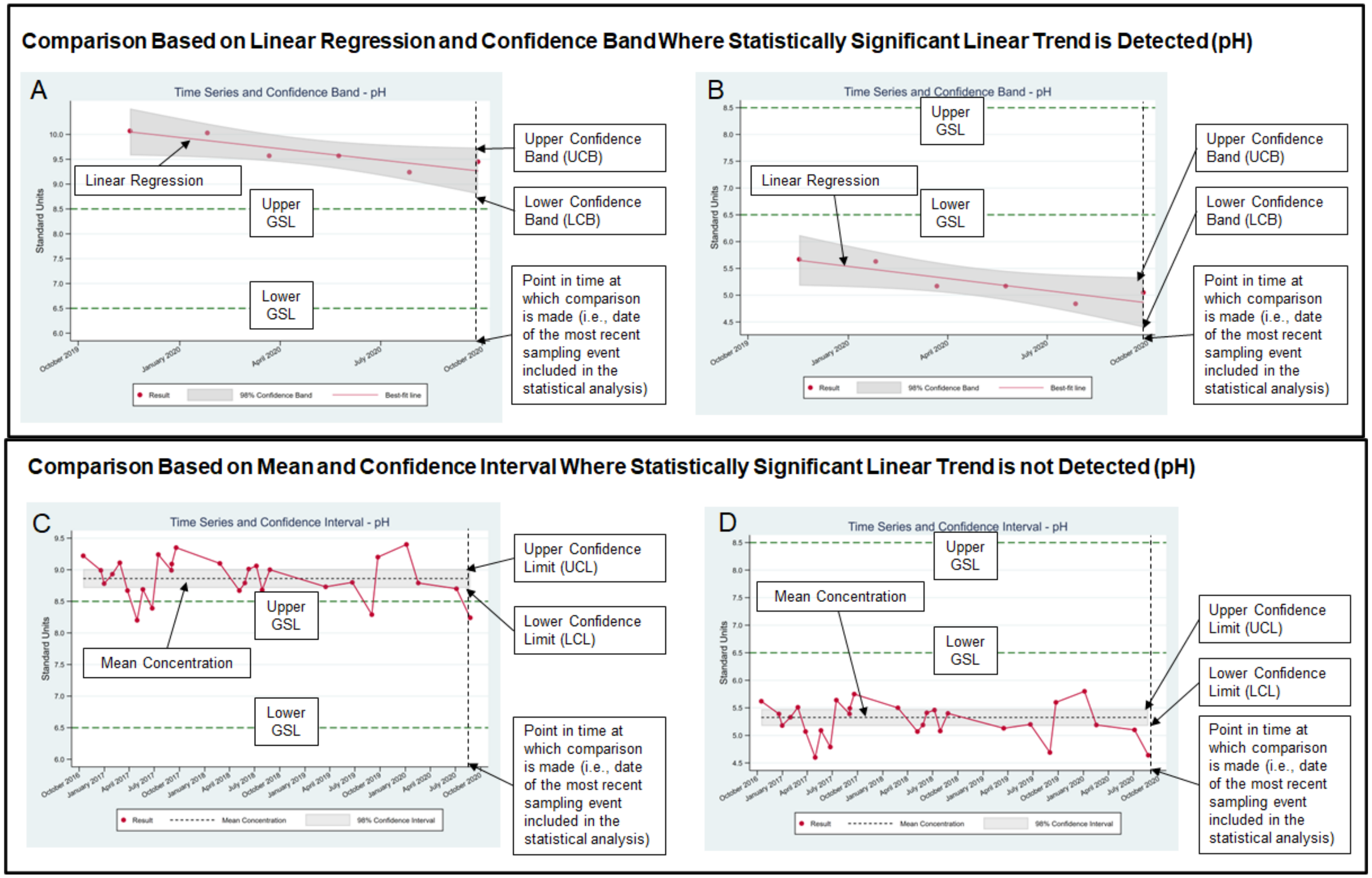


Figure E.3-3 - Examples of well-constituent pairs classified as 'Red' for pH (A, B) in the presence of a statistically significant linear trend ($p<0.05$) and (C, D) in the absence of a statistically significant linear trend ($p\geq0.05$)

2.2.2 Evaluation for Well-Constituent Pairs Using Point-by-Point Method

Well-constituent pairs with less than five samples in the dataset or less than four detected results were not well suited to a linear regression trend analysis and confidence band or interval evaluation. Therefore, an alternate evaluation was completed for these well-constituent pairs based on a point-by-point comparison of the reported concentration for each sample to the applicable GSL. In this approach, well-constituent pairs were classified as 'Green*,' if there were no detected values that were greater than or equal to the GSL for constituents other than pH, or there were no detected values outside the GSL range for pH. However, if there was a limited dataset (i.e., less than five samples in the dataset or less than four detected results), and at least one value was greater than or equal to the GSL for constituents other than pH or there were detected values outside the GSL range for pH, this triggered further data review and an alternate evaluation of that well-constituent pair. For these well-constituent pairs, the available data were reviewed and alternate statistical approaches were considered (e.g., completing a statistical evaluation resulting in a 'Red' or 'Green' classification as described in Section 2.2.1 using the limited dataset). If such an alternate evaluation was required, then this was clearly identified and additional rationale provided in the applicable sub-sections of Section 3.0.

3.0 RESULTS AND DISCUSSION

3.1 EXPLORATORY DATA ANALYSIS

Summary statistics for each evaluated well-constituent pair are provided in Attachment E.3-A**,** with results grouped by well and sorted by constituent type. Exploratory data analysis plots for each well-constituent pair (i.e., box plots and time-series plots) are provided in Attachments E.3-B and E.3-C. These plots were reviewed to identify potential outliers and provide a qualitative evaluation of data distribution. The plots also provide a preliminary comparison of the results from individual sampling events to the applicable GSLs. Based on this evaluation, five outliers that were sufficiently abnormal to justify their removal from further statistical analysis were identified. These outliers and their rationale for removal are summarized below:

- For total dissolved solids at well AD-1, a value of 1,500,000 micrograms per Liter (µg/L) was reported for a sample collected in June 2016. In comparison, the values of the 66 additional samples for AD-1 collected before or after that event between June 2009 and December 2022 ranged from 196,000 to 376,000 µg/L (i.e., approximately 4 to 8 times lower than the identified outlier). Furthermore, the increased total dissolved solids result from the June 2016 sampling event was not supported by a concurrent increase in specific conductance (417 µS/cm in June 2016, where subsequent events ranged from 361 to 590 µS/cm, with the exception of one sampling event in February 2019, which had a specific conductance value of 7 µS/cm). Given that no similarly high TDS concentrations have been observed in 13 years of sampling at this well, the TDS concentration of 1,500,000 µg/L observed for a sample collected at well AD-1 in June 2016 was excluded from additional statistical analysis.

- For total dissolved solids at well GW-2, a value of 4,950,000 µg/L was reported for a sample collected in December 2019. In comparison, the values of the remaining five samples for GW-2 collected both before and after that event between June 2019 and April 2020 ranged from 10,000 to 70,000 µg/L (i.e., approximately 70 to 500 times lower than the identified outlier). Furthermore, the increased total dissolved solids result from the December 2019 sampling event was not supported by a concurrent increase in specific conductance (95.4 µS/cm in December 2019, where previous and subsequent events ranged from 58-141 µS/cm).
- For zinc at AD-2 and AD-3, concentrations of 12,500 µg/L and 6,570 µg/L, respectively, were observed for samples collected in September 2018. In comparison, the values of the 136 additional samples for AD-2 and AD-3 collected before or after that event between June 2009 and November 2022 ranged from 1.83 µg/L to <50 µg/L, with the next highest detected concentration equal to 35.3 µg/L (i.e., at least 190 times lower than the identified outliers). Furthermore, the increased zinc results from the September 2018 sampling events at AD-2 and AD-3 were not correlated with an increase in sample turbidity (turbidity at AD-2 was 5.11 NTU in September 2018 and ranged from 0.78 – 60.8 NTU for other sampling events and turbidity at AD-3 was 3.15 NTU in September 2018 and ranged from 0.21 – 4.21 NTU for other sampling events). Given that no similarly high zinc concentrations have been observed in 13 years of sampling at these wells, the zinc concentrations of 12,500 µg/L and 6,570 µg/L from AD-2 and AD-3 from September 2018 were excluded from additional statistical analysis.
- For sulfate at 6AR, a concentration of 18,900 µg/L was reported for a sample collected in September 2009. In comparison, sulfate concentrations for the additional 55 samples collected since that sampling event between 2010 and 2022 were more than ten times higher than the identified outlier, with the next highest reported sulfate concentration having a value of 212,000 µg/L in December 2011. Because no similarly low sulfate concentrations have been observed at 6AR in 13 subsequent years of sampling, the sulfate concentration of 18,900 µg/L for 6AR from September 2009 was excluded from additional statistical analysis.

As such, statistical analysis for total dissolved solids at AD-1 and GW-2, for zinc at AD-2 and AD-3, and for sulfate at 6AR was carried out with the identified outliers removed. There were no other potential outliers removed from further statistical analysis.

3.2 COMPARISON OF GROUNDWATER QUALITY DATA TO APPROVED GROUNDWATER SCREENING LEVELS

A summary of the results comparing groundwater quality data to GSLs is provided in Table E.3-3. The confidence bands or confidence intervals generated to support this comparison are provided in Attachment E.3-D, and the statistical results of these regression analyses are reported in Attachment E.3-E. Further discussion is provided below.

For most well-constituent pairs that were evaluated by linear regression, no statistically significant trend over time was observed based on the linear regression analyses. Comparison to the GSLs for these well-constituent pairs was completed based on a static confidence interval around the mean as shown in

Attachment E.3-D. However, there were three well-constituent pairs where a statistically significant decreasing trend was detected and fifteen well-constituent pairs where a statistically significant increasing trend was detected, as indicated in Attachment E.3-E. Comparison to the GSLs for these well-constituent pairs was completed based on a confidence band around the trend line as shown in Attachment E.3-D.

Table E.3-3 – Summary of Statistically Significant Concentrations/Values

Parameter	Background		Stilling Pond			Sluice Trench and Area East of Sluice Trench, Interim Ash Staging Area				
	AD-1	GW-2	6AR	KIF-103	KIF-104	AD-2	AD-3	KIF-105	KIF-106	KIF-109
CCR Rule Appendix III Parameters										
Boron	Green	Green*	Green	Green	Green	Green	Green	Green	Green	Green
Chloride	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Fluoride[1] (also Appendix IV)	Green	Green*	Green	Green	Green	Green	Green	Green	Green	Green
pH (field)	Green	Red	Red	Red	Red	Red	Green	Red	Green	Red
Sulfate	Green	Green	Red	Green	Red	Red	Red	Red	Red	Green
Total Dissolved Solids	Green	Green	Green	Green	Red	Red	Red	Red	Red	Green
CCR Rule Appendix IV Parameters										
Antimony	Green*	Green*	Green	Green*	Green	Green*	Green*	Green*	Green*	Green*
Arsenic	Green	Green*	Green	Green	Green	Green	Green	Green	Green	Green
Barium	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Beryllium	Green*	Green*	Green	Green*	Green*	Green	Green*	Green	Green*	Green*
Cadmium	Green*	Green*	Green	Green*	Green*	Green*	Green*	Green	Green*	Green*
Chromium	Green	Green*	Green	Green*	Green*	Green	Green	Green*	Green*	Green*
Cobalt	Green	Green*	Red	Red	Red	Red	Green	Red	Green	Green
Lead	Green*	Green*	Green	Green*	Green*	Green	Green*	Green	Green*	Green*
Lithium	Green	Green*	Green*	Green*	Green	Green	Green	Green	Green	Green
Mercury	Green*	Green*	Green*	Green*	Green*	Green*	Green*	Green*	Green*	Green*
Molybdenum	Green	Green*	Green*	Green*	Green	Green	Green	Green*	Green	Green*
Radium-226+228	Green	Green*	Green	Green	Green	Green	Green	Green	Green*	Green
Selenium	Green*	Green*	Green*	Green*	Green*	Green	Green*	Green*	Green*	Green*
Thallium	Green	Green*	Green	Green*	Green*	Green	Green	Green	Green*	Green*
Additional TDEC Appendix I Parameters										
Copper	Green	Green*	Green*	Green*	Green	Green*	Green	Green*	Green*	Green*
Nickel	Green*	Green*	Green	Green	Green	Green	Green	Green	Green	Green
Silver	Green*	Green*	Green*	Green*	Green*	Green*	Green*	Green*	Green*	Green*
Vanadium	Green*	Green*	Green*	Green*	Green	Green*	Green*	Green*	Green*	Green*
Zinc	Green*	Green*	Green	Green	Green	Green	Green	Green	Green	Green

Notes:
Green - No statistically significant concentration greater than or equal to the GSL for constituents other than pH and no statistically significant difference outside the GSL range for pH.
Green* - Limited dataset (sample size <5 or <4 detected values), but none of the available results are greater than or equal to the GSL or outside the GSL range for pH.
Red - Statistically significant concentration greater than or equal to the GSL for constituents other than pH or a statistically significant difference outside the GSL range for pH.
Bold colors are used to represent CCR Rule Appendix IV Parameter and TDEC Appendix I Parameter results; subdued colors represent CCR Rule Appendix III Parameter results.
[1]Fluoride is both a CCR Rule Appendix III and CCR Rule Appendix IV constituent. In this table, fluoride has been grouped only with the Appendix III constituents to avoid duplication of results.

In total, 16 well-constituent pairs were identified with CCR Parameters at statistically significant concentrations greater than or equal to the GSL for constituents other than pH. There were also seven wells where statistically significant difference from the GSL range for pH were observed. The well-constituent pairs with statistically significant concentrations greater than or equal to the GSL or outside the GSL range for pH (i.e., categorized as 'Red' in Table E.3-3) are summarized in Table E.3-4.

Table E.3-4 – Summary of Statistically Significant Concentrations Greater than the GSL

Well	Appendix III			Appendix IV
	pH (field)	Sulfate	Total Dissolved Solids	Cobalt
GW-2	X	-	-	-
6AR	X	X	-	X
KIF-103	X	-	-	X
KIF-104	X	X	X	X
AD-2	X	X	X	X
AD-3	-	X	X	-
KIF-105	X	X	X	X
KIF-106	-	X	X	-
KIF-109	X	-	-	-

Notes
Well-constituent pairs with CCR Parameters at statistically significant concentrations greater than or equal to the GSL for constituents other than pH or outside the GSL range for pH are identified with an 'X' and highlighted gray.
Dash (-) indicates the absence of a statistically significant concentration greater than or equal to the GSL or outside the GSL range for pH for that well-constituent pair.

4.0 REFERENCES

Tukey, J.W. (1977). *Exploratory Data Analysis*. Reading, Massachusetts: Addison-Wesley. 1977.

United States Environmental Protection Agency (USEPA). (2009). *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities: Unified Guidance*. EPA 530/R-09-007, 884 pp.

ATTACHMENT E.3-A
SUMMARY STATISTICS

Summary Statistics - Groundwater Investigation									
Kingston Fossil Plant - Harriman, Tennessee									
Parameter	Frequency of Detection	Range of Reporting Limits	% Non Detect	Statistics using Detected Data Only		Statistics using Detects & Non-Detects			
				Minimum Detect	Maximum Detect	Mean	Standard Deviation	50th Percentile	95th Percentile
Well: AD-1									
CCR Rule Appendix III Parameters									
Boron	50/70	(0.7 - 1,000)	28.6%	106	227	129.2	37.11	136.5	1,000
Calcium	70/70	--	0.0%	2,790	18,100	7,084	3,583	5,960	13,855
Chloride	59/69	(1,550 - 5,100)	14.5%	1,190	6,730	1,660	664.8	1,590	2,654
Fluoride[1] (also Appendix IV)	66/71	(100 - 257)	7.0%	28.4	707	244.5	84.56	244	325.5
pH	43/43	--	0.0%	6.81	9.15	8.494	0.406	8.6	8.869
Sulfate	68/69	(1,000 - 1,000)	1.4%	19,000	83,400	25,896	8,618	24,400	30,840
TDS	68/68	--	0.0%	196,000	376,000	255,544	21,868	253,000	289,200
CCR Rule Appendix IV Parameters									
Antimony	3/72	(0.303 - 2)	95.8%	0.361	0.695	0.317	0.0639	0.378	2
Arsenic	50/72	(0.0743 - 2)	30.6%	0.36	2.46	0.573	0.284	0.586	2
Barium	71/72	(200 - 200)	1.4%	43.9	115	70.59	18.93	66.9	109.7
Beryllium	0/72	(0.057 - 2)	100.0%	--	--	--	--	0.33	2
Cadmium	0/72	(0.125 - 1)	100.0%	--	--	--	--	0.33	1
Chromium	15/72	(0.09 - 3.31)	79.2%	0.331	2.9	0.341	0.419	1.53	2.078
Cobalt	4/72	(0.0246 - 2)	94.4%	0.093	0.707	0.0525	0.0966	0.33	2
Lead	3/72	(0.0603 - 2)	95.8%	0.303	1.74	0.104	0.225	0.33	2
Lithium	31/44	(0.794 - 50)	29.5%	15.2	25.5	18.18	5.555	20.65	50
Mercury	0/72	(0.0392 - 1.5)	100.0%	--	--	--	--	0.15	0.2
Molybdenum	26/70	(0.474 - 5)	62.9%	0.34	2.72	0.518	0.3	0.61	2
Radium-226+228	10/48	(0 - 2)	79.2%	0.182	1.56	0.172	0.345	0.326	1.2
Selenium	0/72	(0.316 - 5)	100.0%	--	--	--	--	1.162	2.62
Thallium	4/72	(0.0239 - 2)	94.4%	0.322	0.5	0.0622	0.115	0.472	2
TDEC Appendix I Parameters									
Copper	22/72	(0.33 - 5)	69.4%	0.36	9.54	0.746	1.177	0.649	2.339
Nickel	10/72	(0.243 - 5)	86.1%	0.33	1.49	0.305	0.184	0.336	2
Silver	0/72	(0.0878 - 2)	100.0%	--	--	--	--	0.33	2
Vanadium	4/72	(0.1 - 5.22)	94.4%	0.59	0.919	0.375	0.298	1	4
Zinc	4/72	(1.83 - 50)	94.4%	3.58	9.18	2.23	1.282	8.3	25
Well: GW-2									
CCR Rule Appendix III Parameters									
Boron	3/6	(70.6 - 273)	50.0%	77.3	367	142.2	107.1	157	343.5
Calcium	6/6	--	0.0%	5,160	15,900	10,222	4,432	10,300	15,500
Chloride	5/6	(1,840 - 1,840)	16.7%	1,240	1,610	1,454	130.9	1,505	1,783
Fluoride[1] (also Appendix IV)	3/6	(41.6 - 71.5)	50.0%	36.4	68	46.67	12.36	52.55	70.63
pH	6/6	--	0.0%	5.28	6.11	5.84	0.308	5.93	6.1
Sulfate	6/6	--	0.0%	12,300	35,200	22,050	9,000	20,350	33,900
Total Dissolved Solids[2]	4/5	(10,000 - 10,000)	20.0%	38,000	70,000	48,400	22,033	60,000	68,800
CCR Rule Appendix IV Parameters									
Antimony	0/6	(0.378 - 1.07)	100.0%	--	--	--	--	0.378	0.897
Arsenic	2/6	(0.313 - 0.574)	66.7%	0.338	0.377	0.331	0.025	0.331	0.525
Barium	6/6	--	0.0%	19.9	49.3	33.45	12.19	32.8	48.3
Beryllium	1/6	(0.182 - 0.182)	83.3%	0.267	0.267	0.196	0.0317	0.182	0.246
Cadmium	0/6	(0.125 - 0.217)	100.0%	--	--	--	--	0.125	0.217
Chromium	0/6	(1.53 - 4.19)	100.0%	--	--	--	--	2.04	4.165
Cobalt	2/6	(0.075 - 0.134)	66.7%	0.076	0.082	0.077	0.00292	0.079	0.134
Lead	0/6	(0.128 - 0.128)	100.0%	--	--	--	--	0.128	0.128
Lithium	1/6	(3.39 - 3.39)	83.3%	3.65	3.65	3.433	0.0969	3.39	3.585
Mercury	0/6	(0.101 - 0.13)	100.0%	--	--	--	--	0.101	0.123
Molybdenum	0/6	(0.61 - 0.61)	100.0%	--	--	--	--	0.61	0.61
Radium-226+228	0/6	(0.00721 - 0.736)	100.0%	--	--	--	--	0.449	0.702
Selenium	0/6	(1.51 - 2.62)	100.0%	--	--	--	--	1.51	2.343
Thallium	0/6	(0.128 - 0.41)	100.0%	--	--	--	--	0.148	0.345
TDEC Appendix I Parameters									
Copper	0/6	(0.627 - 0.775)	100.0%	--	--	--	--	0.627	0.738
Nickel	2/6	(0.312 - 0.336)	66.7%	0.377	0.885	0.418	0.21	0.336	0.758
Silver	0/6	(0.121 - 0.177)	100.0%	--	--	--	--	0.177	0.177
Vanadium	1/6	(0.991 - 2.34)	83.3%	1.66	1.66	1.125	0.268	1.201	2.17
Zinc	2/6	(3.22 - 3.22)	66.7%	3.24	56.7	12.14	19.93	3.22	43.34

Summary Statistics - Groundwater Investigation									
Kingston Fossil Plant - Harriman, Tennessee									
Parameter	Frequency of Detection	Range of Reporting Limits	% Non Detect	Statistics using Detected Data Only		Statistics using Detects & Non-Detects			
				Minimum Detect	Maximum Detect	Mean	Standard Deviation	50th Percentile	95th Percentile
Well: 6AR									
CCR Rule Appendix III Parameters									
Boron	45/56	(2.49 - 1,000)	19.6%	465	723	585	104	618	1,000
Calcium	56/56	--	0.0%	41,000	66,600	54,368	6,363	54,700	65,100
Chloride	56/56	--	0.0%	4,020	10,100	6,918	1,347	7,275	8,610
Fluoride[1] (also Appendix IV)	26/57	(26 - 500)	54.4%	26.8	243	50.37	41.24	66	199.8
pH	41/41	--	0.0%	4.52	5.84	5.028	0.306	5.02	5.54
Sulfate	55/55	--	0.0%	212,000	327,000	263,345	28,054	267,000	306,800
TDS	56/56	--	0.0%	328,000	550,000	434,161	48,261	445,500	502,750
CCR Rule Appendix IV Parameters									
Antimony	8/57	(0.303 - 2)	86.0%	0.432	2.93	0.477	0.552	0.378	2.04
Arsenic	30/57	(0.0743 - 2)	47.4%	0.338	3.24	0.499	0.491	0.549	2
Barium	55/57	(50 - 200)	3.5%	20.2	43.2	24.8	4.51	22.9	36.4
Beryllium	49/62	(0.064 - 2)	21.0%	0.195	0.977	0.619	0.177	0.695	2
Cadmium	62/62	--	0.0%	0.147	35.7	2.99	4.55	2.25	5.9
Chromium	5/57	(0.09 - 2.86)	91.2%	0.34	2.12	0.249	0.378	1.53	2
Cobalt	62/62	--	0.0%	84.1	165	117.9	17.23	118	140
Lead	14/57	(0.0603 - 2)	75.4%	0.131	0.427	0.127	0.0863	0.226	2
Lithium	2/43	(0.794 - 50)	95.3%	0.855	0.867	0.813	0.0304	3.39	50
Mercury	0/57	(0.0392 - 0.2)	100.0%	--	--	--	--	0.13	0.2
Molybdenum	0/56	(0.33 - 5)	100.0%	--	--	--	--	0.61	2
Radium-226+228	10/46	(0 - 2)	78.3%	0.174	2.304	0.206	0.437	0.321	1.212
Selenium	2/57	(0.316 - 5)	96.5%	0.401	1.32	0.368	0.209	1.51	2.62
Thallium	6/57	(0.0239 - 2)	89.5%	0.073	0.724	0.101	0.148	0.472	2
TDEC Appendix I Parameters									
Copper	7/57	(0.33 - 4.12)	87.7%	0.34	2.75	0.421	0.333	0.627	2
Nickel	62/62	--	0.0%	30.4	65.8	45.52	6.678	44.1	54.9
Silver	1/57	(0.0878 - 2)	98.2%	0.315	0.315	0.0949	0.0395	0.223	2
Vanadium	4/57	(0.1 - 4)	93.0%	0.973	2.55	0.252	0.447	0.991	4
Zinc	57/57	--	0.0%	25.5	73.9	41.28	9.192	39.6	55.82
Well: KIF-103									
CCR Rule Appendix III Parameters									
Boron	27/27	--	0.0%	742	1,140	941.6	91.47	933	1,071
Calcium	27/27	--	0.0%	25,000	56,900	36,007	7,884	34,700	50,930
Chloride	27/27	--	0.0%	4,930	9,350	6,349	946.3	6,400	7,395
Fluoride[1] (also Appendix IV)	16/27	(26.3 - 154)	40.7%	27.7	71.6	39.62	12.23	43.4	92.88
pH	26/26	--	0.0%	5.55	6.31	5.962	0.16	5.965	6.165
Sulfate	27/27	--	0.0%	56,600	102,000	82,615	10,823	82,600	98,450
TDS	27/27	--	0.0%	190,000	340,000	259,704	38,013	254,000	323,000
CCR Rule Appendix IV Parameters									
Antimony	1/27	(0.378 - 1.12)	96.3%	0.524	0.524	0.384	0.0281	0.378	0.519
Arsenic	25/27	(1.16 - 3.12)	7.4%	0.441	8.33	2.756	1.646	2.93	4.653
Barium	27/27	--	0.0%	32.9	62.3	43.83	6.356	43.9	54.19
Beryllium	0/27	(0.057 - 0.274)	100.0%	--	--	--	--	0.182	0.274
Cadmium	0/27	(0.125 - 0.217)	100.0%	--	--	--	--	0.125	0.217
Chromium	0/27	(1.32 - 3.16)	100.0%	--	--	--	--	1.53	1.991
Cobalt	27/27	--	0.0%	29.9	71.4	60.05	8.974	62.5	70.17
Lead	2/27	(0.094 - 0.167)	92.6%	0.617	1.12	0.151	0.214	0.128	0.482
Lithium	1/27	(0.831 - 3.39)	96.3%	0.864	0.864	0.839	0.0143	3.14	3.39
Mercury	0/27	(0.101 - 0.13)	100.0%	--	--	--	--	0.101	0.13
Molybdenum	0/27	(0.474 - 2.7)	100.0%	--	--	--	--	0.61	0.61
Radium-226+228	6/27	(0 - 1.082)	77.8%	0.241	1.291	0.164	0.283	0.347	1.038
Selenium	0/27	(0.739 - 2.62)	100.0%	--	--	--	--	1.51	2.62
Thallium	3/27	(0.063 - 0.472)	88.9%	0.16	0.227	0.0816	0.0488	0.148	0.472
TDEC Appendix I Parameters									
Copper	0/27	(0.627 - 11.1)	100.0%	--	--	--	--	0.627	1.252
Nickel	24/27	(2.06 - 4.1)	11.1%	0.86	3.29	2.524	0.557	2.66	3.275
Silver	3/27	(0.121 - 0.223)	88.9%	0.128	0.284	0.132	0.0361	0.177	0.223
Vanadium	0/27	(0.776 - 1.3)	100.0%	--	--	--	--	0.899	1.074
Zinc	18/27	(2.88 - 9.29)	33.3%	3.28	9.13	4.16	1.495	3.85	8.653

Summary Statistics - Groundwater Investigation									
Kingston Fossil Plant - Harriman, Tennessee									
Parameter	Frequency of Detection	Range of Reporting Limits	% Non Detect	Statistics using Detected Data Only		Statistics using Detects & Non-Detects			
				Minimum Detect	Maximum Detect	Mean	Standard Deviation	50th Percentile	95th Percentile
Well: KIF-104									
CCR Rule Appendix III Parameters									
Boron	27/27	--	0.0%	780	1,990	1,536	313	1,590	1,881
Calcium	27/27	--	0.0%	133,000	197,000	166,185	16,692	167,000	193,400
Chloride	27/27	--	0.0%	6,420	20,100	10,938	3,248	10,600	18,720
Fluoride[1] (also Appendix IV)	19/27	(64.5 - 134)	29.6%	30.5	218	89.84	46.13	92.8	168.5
pH	25/25	--	0.0%	5.88	6.9	6.186	0.189	6.19	6.4
Sulfate	27/27	--	0.0%	397,000	812,000	552,815	92,690	552,000	705,200
TDS	27/27	--	0.0%	870,000	1,280,000	1,043,185	96,736	1,030,000	1,218,000
CCR Rule Appendix IV Parameters									
Antimony	5/27	(0.378 - 1.13)	81.5%	0.481	1.36	0.456	0.214	0.378	1.127
Arsenic	27/27	--	0.0%	3.59	13.8	8.191	2.676	8.57	11.58
Barium	27/27	--	0.0%	60.2	192	123.5	34.92	119	183.2
Beryllium	2/27	(0.057 - 0.274)	92.6%	0.267	0.427	0.0799	0.0805	0.182	0.274
Cadmium	0/27	(0.125 - 0.217)	100.0%	--	--	--	--	0.125	0.217
Chromium	2/27	(0.754 - 3.25)	92.6%	1.74	2.01	0.858	0.328	1.53	3.219
Cobalt	27/27	--	0.0%	1.08	26.3	12.5	5.197	10.8	23.18
Lead	3/27	(0.094 - 0.167)	88.9%	0.128	0.27	0.107	0.0403	0.128	0.204
Lithium	14/27	(0.831 - 9.35)	48.1%	1.07	23.9	4.08	4.623	3.39	9.035
Mercury	0/27	(0.101 - 0.13)	100.0%	--	--	--	--	0.101	0.13
Molybdenum	21/27	(0.61 - 3.94)	22.2%	0.679	3.83	1.578	1.074	1.04	3.824
Radium-226+228	17/27	(0.124 - 1.931)	37.0%	0.337	1.616	0.716	0.426	0.758	1.603
Selenium	1/27	(0.739 - 2.62)	96.3%	2.13	2.13	0.816	0.319	1.51	2.62
Thallium	0/27	(0.063 - 0.754)	100.0%	--	--	--	--	0.148	0.472
TDEC Appendix I Parameters									
Copper	4/27	(0.627 - 1.3)	85.2%	0.76	1.14	0.68	0.13	0.627	1.14
Nickel	21/27	(0.517 - 4.16)	22.2%	0.446	2.77	1.424	0.7	1.54	2.755
Silver	1/27	(0.121 - 0.49)	96.3%	0.441	0.441	0.133	0.0615	0.177	0.376
Vanadium	5/27	(0.776 - 1.47)	81.5%	0.909	1.19	0.843	0.118	0.991	1.33
Zinc	19/27	(3.22 - 10.1)	29.6%	3.27	10.5	4.586	1.711	4.34	9.899
Well: AD-2									
CCR Rule Appendix III Parameters									
Boron	58/67	(1,000 - 1,000)	13.4%	358	1,360	847	252.1	908	1,291
Calcium	67/67	--	0.0%	25,700	182,000	102,809	47,498	97,300	173,000
Chloride	66/66	--	0.0%	4,910	21,200	10,535	4,076	9,250	18,950
Fluoride[1] (also Appendix IV)	38/68	(64.7 - 130)	44.1%	39.6	162	79.34	29.21	100	137.2
pH	40/40	--	0.0%	5.42	6.27	5.839	0.14	5.84	6.04
Sulfate	66/66	--	0.0%	69,600	534,000	314,456	141,045	351,000	509,000
TDS	67/67	--	0.0%	28,000	878,000	507,582	219,191	567,000	844,300
CCR Rule Appendix IV Parameters									
Antimony	3/69	(0.303 - 2)	95.7%	0.38	0.774	0.316	0.0659	0.378	2
Arsenic	58/69	(0.0743 - 2)	15.9%	0.512	29.7	2.825	3.863	2	9.304
Barium	66/69	(31.8 - 200)	4.3%	22.4	48.6	34.58	6.612	33.5	46.9
Beryllium	23/69	(0.064 - 2)	66.7%	0.124	0.436	0.219	0.0937	0.33	2
Cadmium	0/69	(0.125 - 1)	100.0%	--	--	--	--	0.33	1
Chromium	9/69	(0.09 - 2.3)	87.0%	0.33	4.63	0.385	0.776	1.53	2.26
Cobalt	69/69	--	0.0%	3.72	18.7	10.38	4.12	10.6	17.02
Lead	30/69	(0.0603 - 2)	56.5%	0.208	1.32	0.32	0.225	0.33	2
Lithium	29/43	(0.794 - 50)	32.6%	9.71	15.4	12.02	2.647	13.4	50
Mercury	0/69	(0.0392 - 1.5)	100.0%	--	--	--	--	0.15	0.2
Molybdenum	54/67	(0.33 - 5)	19.4%	0.42	9.76	1.96	1.818	1.57	5.59
Radium-226+228	12/44	(0 - 1.273)	72.7%	0.0839	1.132	0.207	0.331	0.45	1.081
Selenium	5/69	(0.316 - 5)	92.8%	0.401	1.66	0.394	0.24	1.51	2.62
Thallium	11/69	(0.0239 - 2)	84.1%	0.068	0.752	0.132	0.164	0.472	2
TDEC Appendix I Parameters									
Copper	6/69	(0.33 - 5)	91.3%	0.703	5.91	0.514	0.752	0.627	2
Nickel	64/69	(2 - 5.86)	7.2%	1.96	7.84	4.262	1.501	4.45	6.608
Silver	0/69	(0.0878 - 2)	100.0%	--	--	--	--	0.33	2
Vanadium	3/69	(0.1 - 4.96)	95.7%	0.97	3.64	0.229	0.514	1	4
Zinc[2]	29/68	(1.83 - 50)	57.4%	6.17	35.3	7.897	4.342	8.3	25

Summary Statistics - Groundwater Investigation									
Kingston Fossil Plant - Harriman, Tennessee									
Parameter	Frequency of Detection	Range of Reporting Limits	% Non Detect	Statistics using Detected Data Only		Statistics using Detects & Non-Detects			
				Minimum Detect	Maximum Detect	Mean	Standard Deviation	50th Percentile	95th Percentile
Well: AD-3									
CCR Rule Appendix III Parameters									
Boron	63/67	(379 - 1,000)	6.0%	361	1,870	1,036	444.6	1,000	1,768
Calcium	67/67	--	0.0%	120,000	432,000	281,075	102,086	315,000	395,800
Chloride	61/67	(1,000 - 20,000)	9.0%	1,710	8,660	5,167	2,392	5,960	8,444
Fluoride[1] (also Appendix IV)	56/69	(72.3 - 2,000)	18.8%	51.5	426	163.4	76.72	146	308.6
pH	42/42	--	0.0%	6.27	7.3	6.657	0.218	6.675	7.071
Sulfate	66/67	(1,000 - 1,000)	1.5%	186,000	1,130,000	601,687	294,215	696,000	961,700
TDS	67/67	--	0.0%	247,000	1,870,000	1,161,970	462,685	1,310,000	1,757,000
CCR Rule Appendix IV Parameters									
Antimony	1/69	(0.303 - 2)	98.6%	0.345	0.345	0.305	0.00839	0.378	2
Arsenic	12/69	(0.0743 - 2)	82.6%	0.34	2.57	0.211	0.397	0.33	2
Barium	67/69	(19.5 - 200)	2.9%	12.5	57.9	26.88	9.835	24.7	47.94
Beryllium	1/69	(0.064 - 2)	98.6%	0.205	0.205	0.0696	0.0276	0.33	2
Cadmium	0/69	(0.125 - 1)	100.0%	--	--	--	--	0.33	1
Chromium	5/69	(0.09 - 4.1)	92.8%	0.333	5.64	0.261	0.765	1.53	2.18
Cobalt	73/73	--	0.0%	2.35	8.57	5.268	1.852	5.32	8.136
Lead	1/69	(0.0603 - 2)	98.6%	0.183	0.183	0.0641	0.0213	0.33	2
Lithium	28/43	(0.794 - 50)	34.9%	4.92	22.1	9.691	3.829	11.4	50
Mercury	0/69	(0.0392 - 1.5)	100.0%	--	--	--	--	0.15	0.2
Molybdenum	6/67	(0.33 - 5)	91.0%	0.36	0.769	0.356	0.0732	0.61	2
Radium-226+228	10/48	(0 - 2)	79.2%	0.096	1.691	0.168	0.33	0.42	1.061
Selenium	0/69	(0.316 - 5)	100.0%	--	--	--	--	1.51	2.62
Thallium	6/69	(0.0239 - 2)	91.3%	0.179	0.941	0.0891	0.199	0.472	2
TDEC Appendix I Parameters									
Copper	6/69	(0.33 - 5)	91.3%	0.53	14.4	0.575	1.681	0.627	2
Nickel	59/69	(1.33 - 5)	14.5%	0.97	7.78	2.424	1.114	2.59	4.366
Silver	0/69	(0.0878 - 2)	100.0%	--	--	--	--	0.33	2
Vanadium	3/69	(0.1 - 4)	95.7%	1.21	2.56	0.185	0.385	1	4
Zinc[2]	9/68	(1.83 - 50)	86.8%	3.29	15.4	2.733	2.352	8.3	25
Well: KIF-105									
CCR Rule Appendix III Parameters									
Boron	27/27	--	0.0%	1,650	2,250	1,848	145.9	1,820	2,105
Calcium	27/27	--	0.0%	155,000	203,000	176,481	9,776	176,000	187,700
Chloride	27/27	--	0.0%	6,760	25,500	11,190	5,442	8,720	23,410
Fluoride[1] (also Appendix IV)	18/27	(26.3 - 132)	33.3%	38.8	123	54.52	18.84	58.3	118.8
pH	26/26	--	0.0%	5.16	5.78	5.563	0.174	5.615	5.77
Sulfate	27/27	--	0.0%	503,000	601,000	545,481	26,471	546,000	591,000
TDS	27/27	--	0.0%	781,000	919,000	847,185	33,185	840,000	902,600
CCR Rule Appendix IV Parameters									
Antimony	1/27	(0.378 - 1.12)	96.3%	0.83	0.83	0.396	0.0886	0.378	1.033
Arsenic	22/27	(0.466 - 1.17)	18.5%	0.35	1.21	0.596	0.212	0.623	1.134
Barium	25/27	(18.1 - 18.6)	7.4%	17.5	23	19.33	1.412	19.1	22.32
Beryllium	8/27	(0.155 - 1.15)	70.4%	0.057	0.473	0.123	0.0992	0.182	0.414
Cadmium	27/27	--	0.0%	0.387	2.38	1.026	0.546	0.751	1.936
Chromium	0/27	(1.17 - 3.77)	100.0%	--	--	--	--	1.53	2.64
Cobalt	27/27	--	0.0%	16.5	33.9	21.17	5.57	18.5	31.35
Lead	19/27	(0.128 - 0.225)	29.6%	0.132	0.325	0.19	0.0671	0.17	0.314
Lithium	8/27	(2.56 - 3.39)	70.4%	2.6	7.44	3.034	0.922	3.39	3.638
Mercury	0/27	(0.101 - 0.13)	100.0%	--	--	--	--	0.101	0.13
Molybdenum	0/27	(0.474 - 1.05)	100.0%	--	--	--	--	0.61	0.61
Radium-226+228	8/27	(0.215 - 1.398)	70.4%	0.429	1.748	0.449	0.373	0.56	1.37
Selenium	1/27	(0.739 - 2.62)	96.3%	0.883	0.883	0.763	0.0537	1.51	2.62
Thallium	19/27	(0.128 - 0.472)	29.6%	0.159	0.975	0.26	0.168	0.232	0.493
TDEC Appendix I Parameters									
Copper	0/27	(0.627 - 4.33)	100.0%	--	--	--	--	0.627	1.3
Nickel	27/27	--	0.0%	16.1	33.6	20.84	5.544	18.8	32.39
Silver	0/27	(0.121 - 0.223)	100.0%	--	--	--	--	0.177	0.223
Vanadium	1/27	(0.776 - 2.43)	96.3%	1.09	1.09	0.792	0.0684	0.991	2.103
Zinc	24/27	(13.5 - 17.5)	11.1%	12.5	38	19.03	8.294	14.9	36.93

Summary Statistics - Groundwater Investigation									
Kingston Fossil Plant - Harriman, Tennessee									
Parameter	Frequency of Detection	Range of Reporting Limits	% Non Detect	Statistics using Detected Data Only		Statistics using Detects & Non-Detects			
				Minimum Detect	Maximum Detect	Mean	Standard Deviation	50^{th} Percentile	95^{th} Percentile
Well: KIF-106									
CCR Rule Appendix III Parameters									
Boron	26/27	(345 - 345)	3.7%	248	414	324.5	42.37	315	382.2
Calcium	27/27	--	0.0%	71,200	202,000	116,281	47,052	86,800	195,800
Chloride	27/27	--	0.0%	7,160	36,000	16,348	9,858	9,200	34,260
Fluoride[1] (also Appendix IV)	23/27	(120 - 149)	14.8%	68.2	202	144.6	40.14	157	192.7
pH	28/28	--	0.0%	6.48	6.94	6.667	0.102	6.65	6.823
Sulfate	27/27	--	0.0%	85,000	446,000	204,789	135,221	106,000	418,700
TDS	27/27	--	0.0%	283,000	883,000	489,630	219,962	329,000	837,800
CCR Rule Appendix IV Parameters									
Antimony	0/27	(0.378 - 1.12)	100.0%	--	--	--	--	0.378	0.984
Arsenic	23/27	(0.904 - 2.66)	14.8%	0.668	4.28	1.694	1.249	1.05	4.154
Barium	27/27	--	0.0%	34.2	65.8	48.35	7.929	48.1	58.89
Beryllium	1/27	(0.057 - 0.274)	96.3%	0.206	0.206	0.0635	0.0304	0.182	0.274
Cadmium	1/27	(0.125 - 0.217)	96.3%	0.159	0.159	0.127	0.00848	0.125	0.217
Chromium	2/27	(1.17 - 4.48)	92.6%	1.64	1.99	1.228	0.191	1.53	2.481
Cobalt	27/27	--	0.0%	2.3	3.68	3.088	0.322	3.17	3.432
Lead	3/27	(0.094 - 0.309)	88.9%	0.132	0.187	0.103	0.0251	0.128	0.22
Lithium	24/27	(3.33 - 6.97)	11.1%	3.44	14.9	7.043	3.507	5.64	14.15
Mercury	0/27	(0.101 - 0.13)	100.0%	--	--	--	--	0.101	0.13
Molybdenum	11/27	(0.474 - 0.61)	59.3%	2.08	5.27	1.742	1.68	0.61	4.954
Radium-226+228	3/27	(0.0143 - 1.357)	88.9%	0.427	1.541	0.125	0.319	0.407	1.235
Selenium	0/27	(0.739 - 2.62)	100.0%	--	--	--	--	1.51	2.62
Thallium	2/27	(0.063 - 0.472)	92.6%	0.161	0.199	0.0747	0.0356	0.148	0.472
TDEC Appendix I Parameters									
Copper	1/27	(0.627 - 1.3)	96.3%	0.699	0.699	0.631	0.0157	0.627	1.252
Nickel	24/27	(1.36 - 1.93)	11.1%	1.01	2.11	1.566	0.249	1.57	1.979
Silver	0/27	(0.121 - 0.223)	100.0%	--	--	--	--	0.177	0.223
Vanadium	0/27	(0.776 - 4.96)	100.0%	--	--	--	--	0.991	2.33
Zinc	8/27	(2.42 - 3.53)	70.4%	2.48	48.1	5.055	8.805	3.22	12.2

Summary Statistics - Groundwater Investigation									
Kingston Fossil Plant - Harriman, Tennessee									
Parameter	Frequency of Detection	Range of Reporting Limits	% Non Detect	Statistics using Detected Data Only		Statistics using Detects & Non-Detects			
				Minimum Detect	Maximum Detect	Mean	Standard Deviation	50th Percentile	95th Percentile
Well: KIF-109									
CCR Rule Appendix III Parameters									
Boron	6/13	(38.6 - 116)	53.8%	45.3	939	138.1	244	60.1	579
Calcium	13/13	--	0.0%	49,100	120,000	61,985	19,743	53,500	96,780
Chloride	13/13	--	0.0%	4,570	8,810	5,896	1,127	5,990	7,664
Fluoride[1] (also Appendix IV)	9/13	(26 - 64.8)	30.8%	26.8	67.5	39.9	13.22	46.7	65.88
pH	12/12	--	0.0%	5.81	6.33	6.003	0.126	5.99	6.187
Sulfate	13/13	--	0.0%	112,000	395,000	187,000	97,444	136,000	385,400
TDS	13/13	--	0.0%	350,000	721,000	484,923	118,309	444,000	709,000
CCR Rule Appendix IV Parameters									
Antimony	0/13	(0.378 - 0.506)	100.0%	--	--	--	--	0.378	0.506
Arsenic	13/13	--	0.0%	1.47	2.82	2.388	0.349	2.43	2.766
Barium	13/13	--	0.0%	127	162	153	9.983	156	161.4
Beryllium	0/13	(0.182 - 0.274)	100.0%	--	--	--	--	0.182	0.274
Cadmium	0/13	(0.217 - 0.217)	100.0%	--	--	--	--	0.217	0.217
Chromium	0/13	(1.53 - 1.53)	100.0%	--	--	--	--	1.53	1.53
Cobalt	13/13	--	0.0%	1.8	13.9	4.122	3.239	2.92	9.22
Lead	0/13	(0.128 - 0.167)	100.0%	--	--	--	--	0.128	0.167
Lithium	5/13	(3.39 - 3.39)	61.5%	0.934	5.2	1.548	1.069	3.39	4.114
Mercury	0/13	(0.13 - 0.13)	100.0%	--	--	--	--	0.13	0.13
Molybdenum	1/13	(0.61 - 0.61)	92.3%	0.67	0.67	0.615	0.016	0.61	0.634
Radium-226+228	6/13	(0.246 - 1.687)	53.8%	0.828	1.652	0.826	0.56	1.05	1.666
Selenium	0/13	(0.739 - 1.51)	100.0%	--	--	--	--	1.51	1.51
Thallium	1/13	(0.148 - 0.472)	92.3%	0.341	0.341	0.169	0.0607	0.148	0.472
TDEC Appendix I Parameters									
Copper	1/13	(0.627 - 1.14)	92.3%	10.1	10.1	1.356	2.524	0.627	4.724
Nickel	12/13	(1.63 - 1.63)	7.7%	0.959	13.1	2.64	3.136	1.49	7.772
Silver	0/13	(0.177 - 0.223)	100.0%	--	--	--	--	0.177	0.223
Vanadium	0/13	(0.776 - 0.991)	100.0%	--	--	--	--	0.991	0.991
Zinc	7/13	(2.88 - 5.3)	46.2%	3.31	8.6	4.269	1.734	4.08	7.202

Notes:

CCR Rule - Title 40, Code of Federal Regulations, Part 257

"-- " : Not Applicable

TDEC - Tennessee Department of Environment and Conservation

Except for Radium-226 + 228, and pH, all units micrograms per liter (µg/L).

Units for Radium 226+228 are picocuries per liter (pCi/L).

Units for pH are standard units (SU).

Mean and Standard Deviation are Kaplan Meier (KM) Mean and Standard Deviation for data with reported non-detect values.

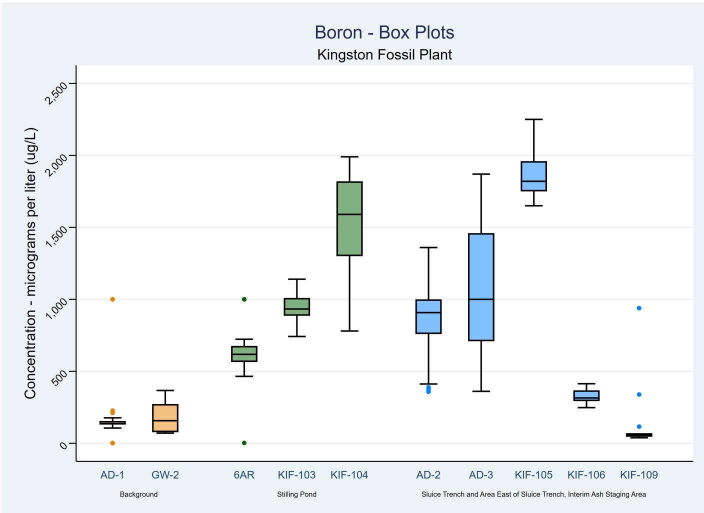
All non-detects reported at the laboratory reporting limit

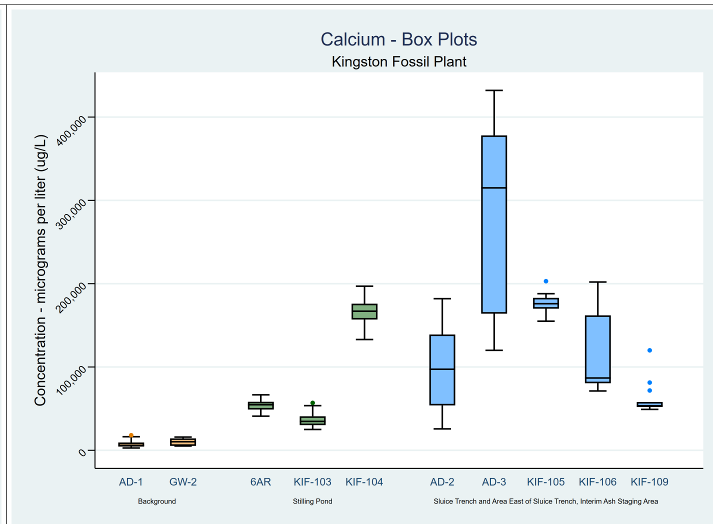
[1]Fluoride is both a CCR Rule Appendix III and CCR Rule Appendix IV constituent. In this table, fluoride has been grouped with the Appendix III constituents only to avoid duplication of results.

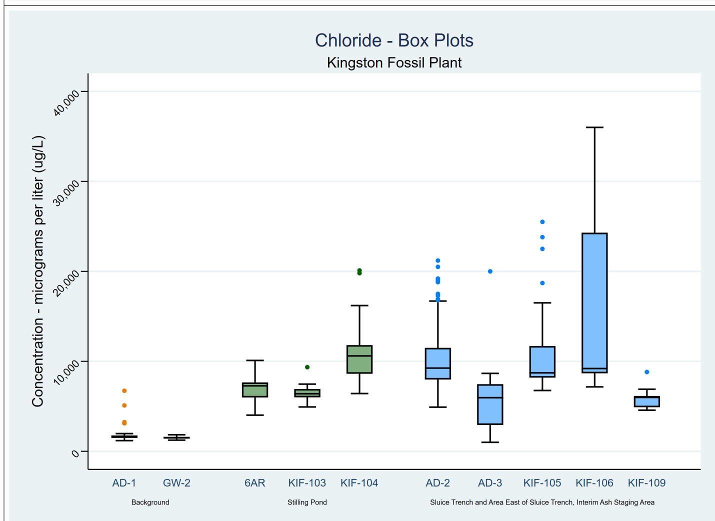
[2]Summary statistics shown here calculated with identified outlier removed (see Section 3.1 for list of identified outliers)

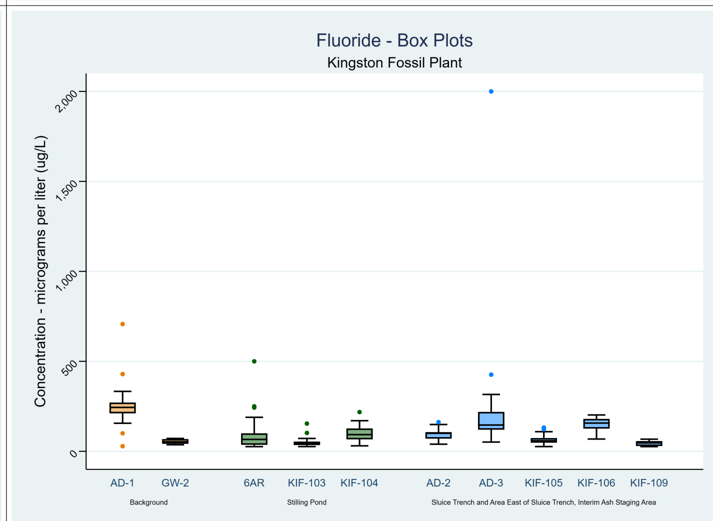
ATTACHMENT E.3-B
BOX PLOTS

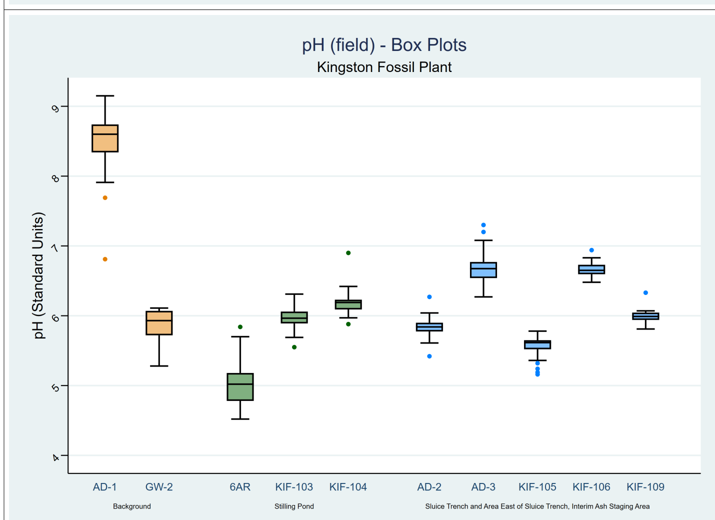
Box Plots
CCR Rule Appendix III Parameters
Kingston Fossil Plant - Harriman, Tennessee

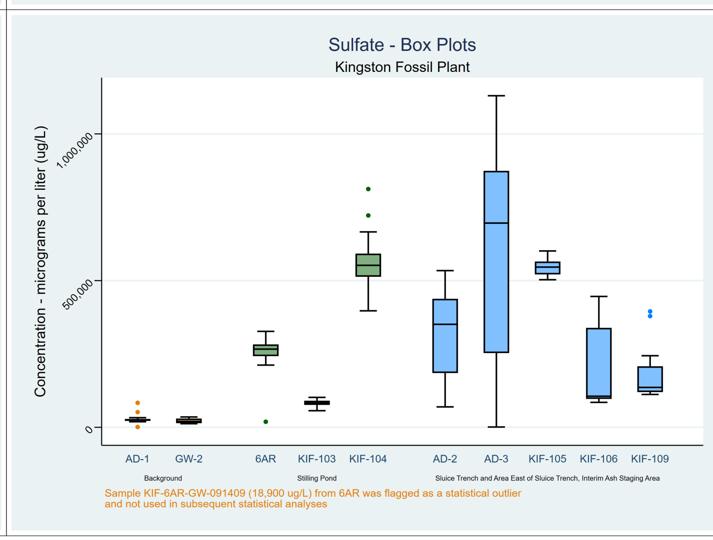


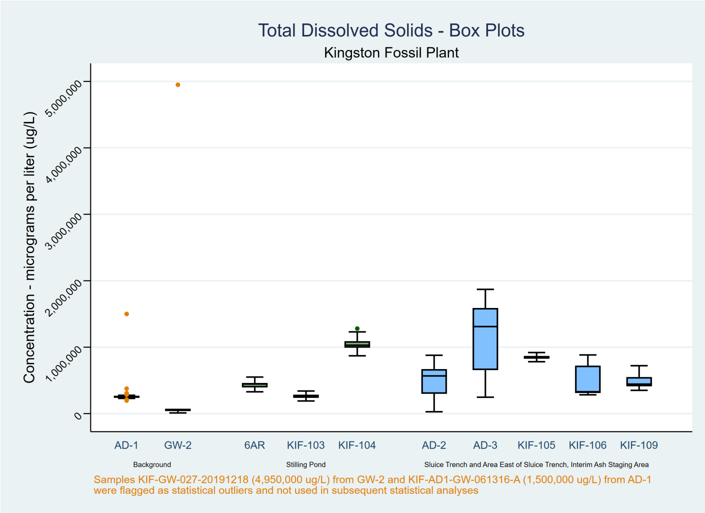












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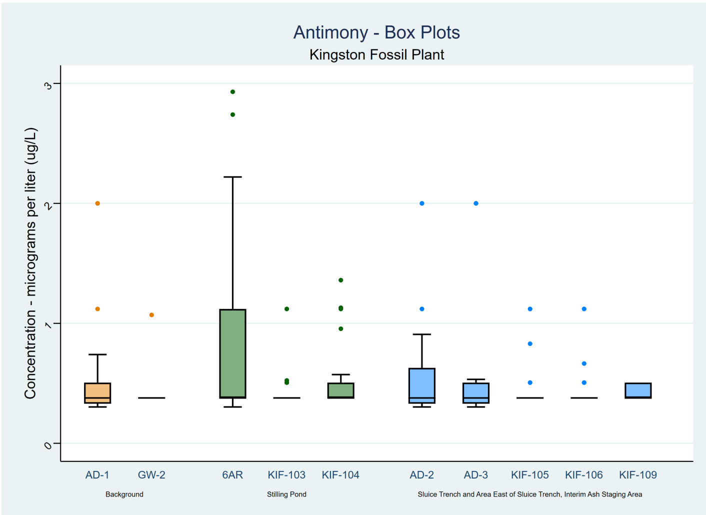
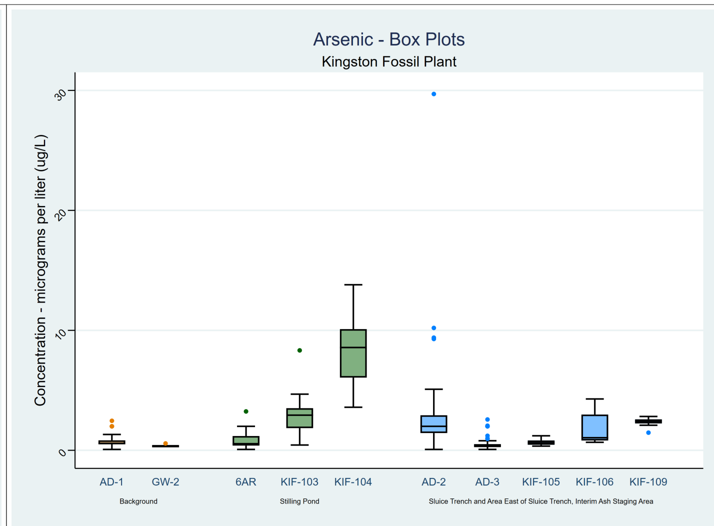
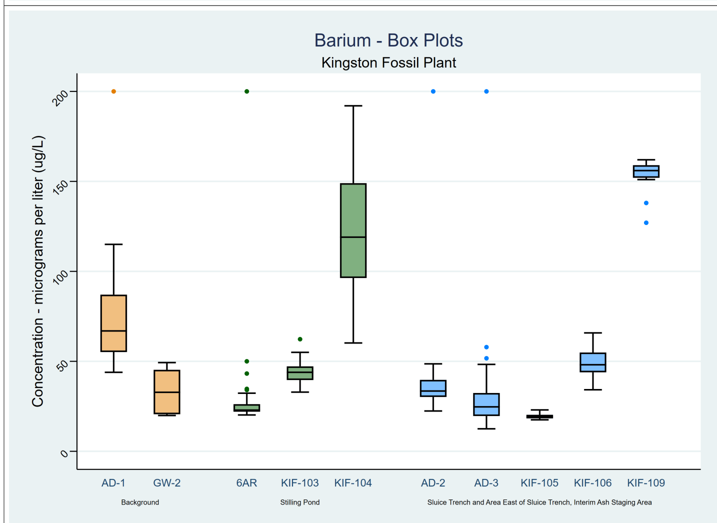
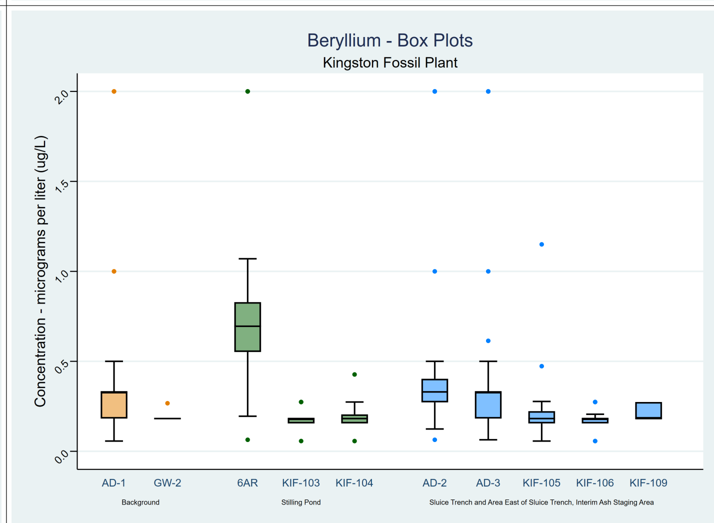
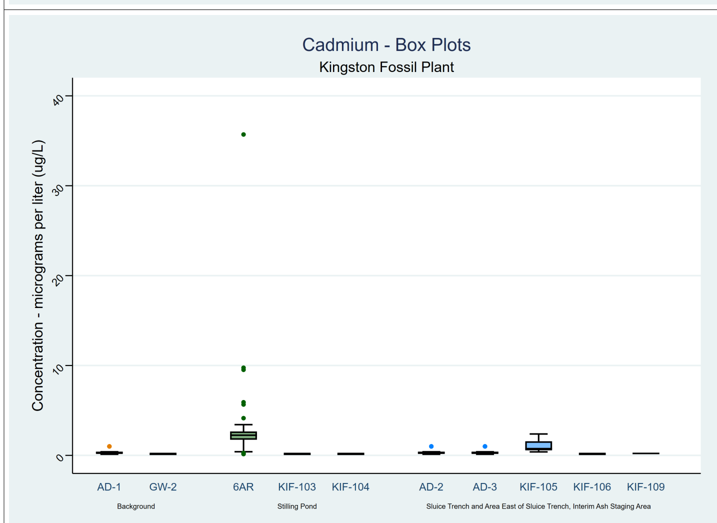
Box Plots
CCR Rule Appendix IV Parameters
Kingston Fossil Plant - Harriman, Tennessee

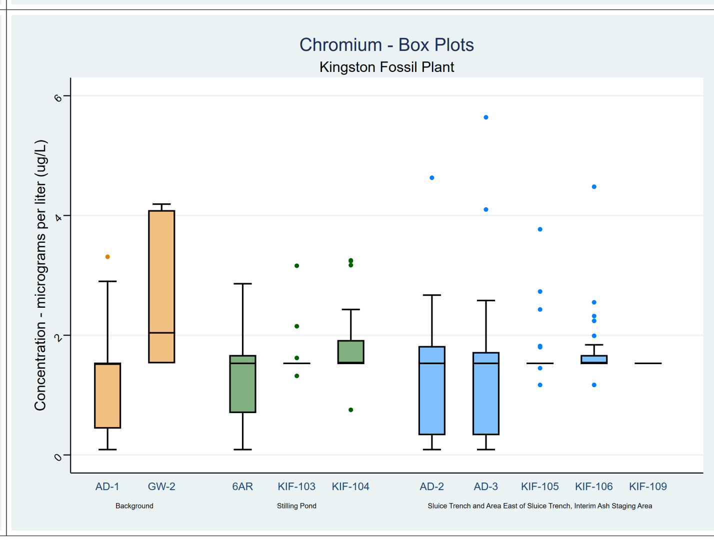


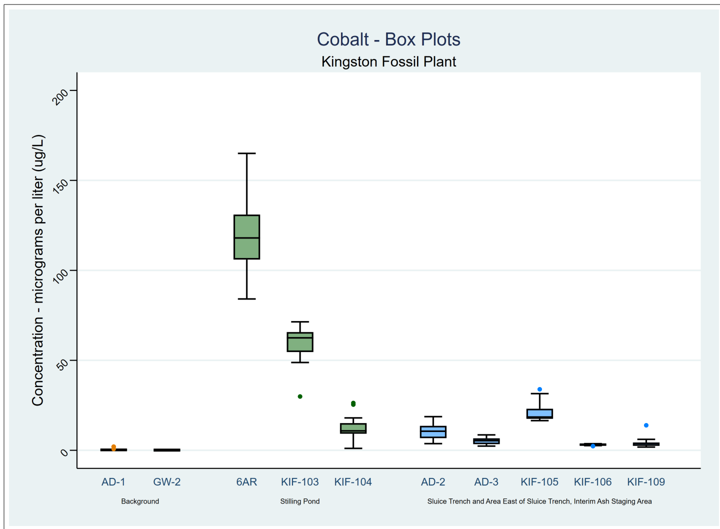


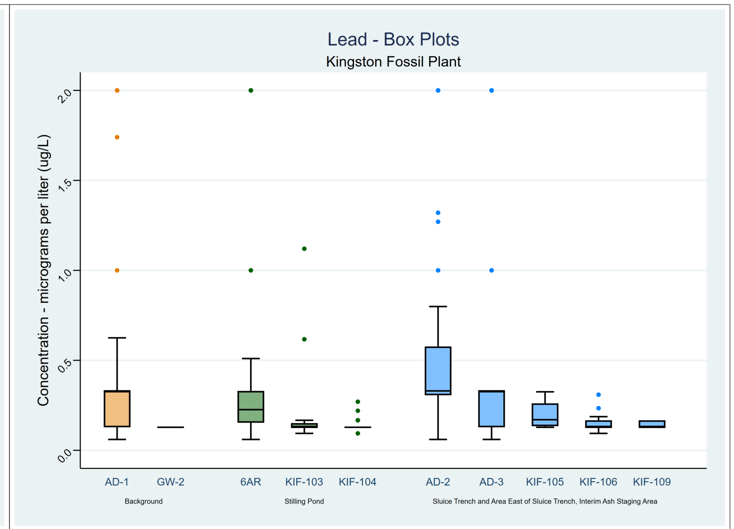


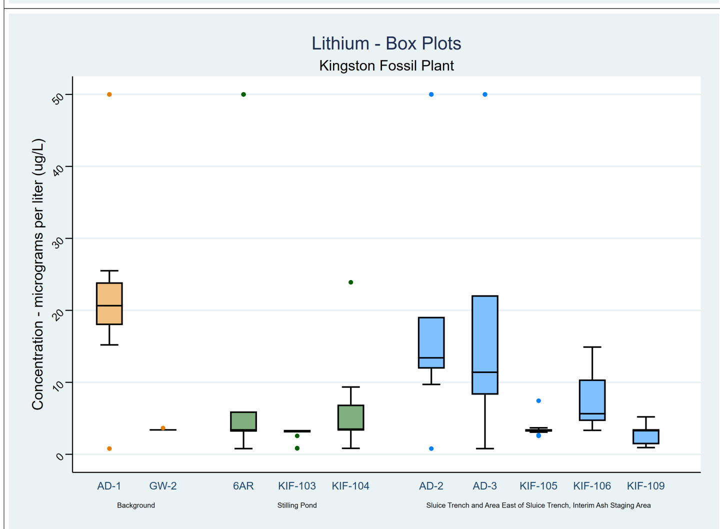


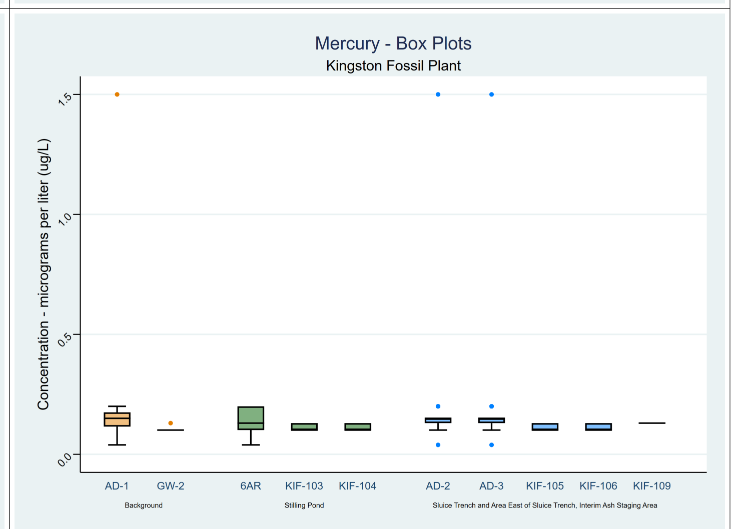


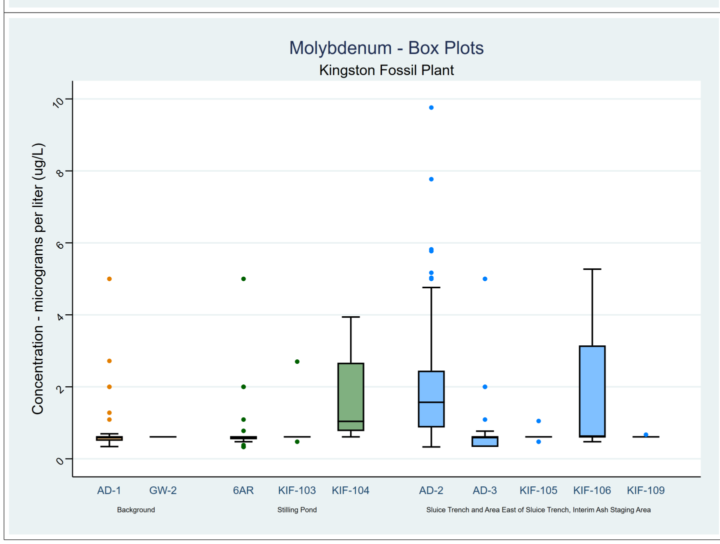


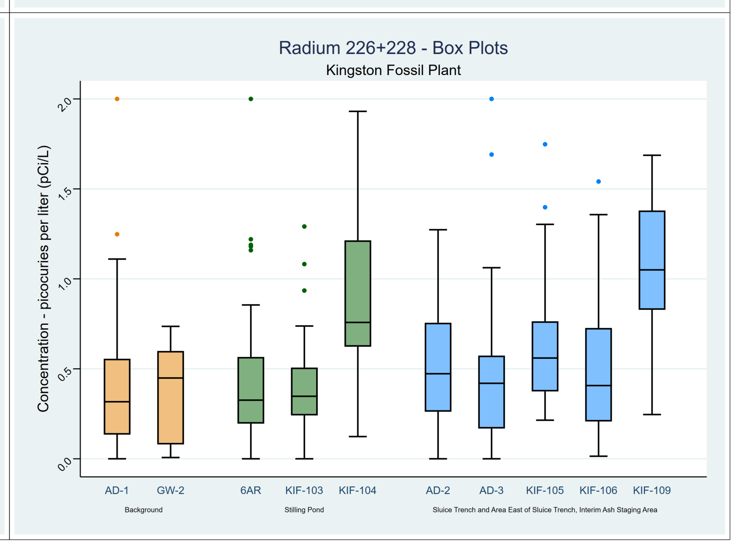

Cobalt - Box Plots
Kingston Fossil Plant
Concentration - micrograms per liter (ug/L)
0
50
100
150
200
AD-1
GW-2
6AR
KIF-103
KIF-104
AD-2
AD-3
KIF-105
KIF-106
KIF-109
Background
Stilling Pond
Sluice Trench and Area East of Sluice Trench, Interim Ash Staging Area

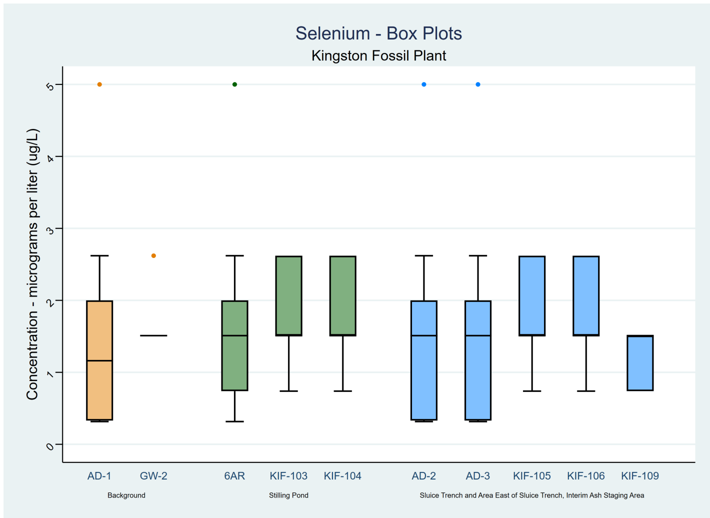

Lead - Box Plots
Kingston Fossil Plant
Concentration - micrograms per liter (ug/L)
0.0
0.5
1.0
1.5
2.0
AD-1
GW-2
6AR
KIF-103
KIF-104
AD-2
AD-3
KIF-105
KIF-106
KIF-109
Background
Stilling Pond
Sluice Trench and Area East of Sluice Trench, Interim Ash Staging Area

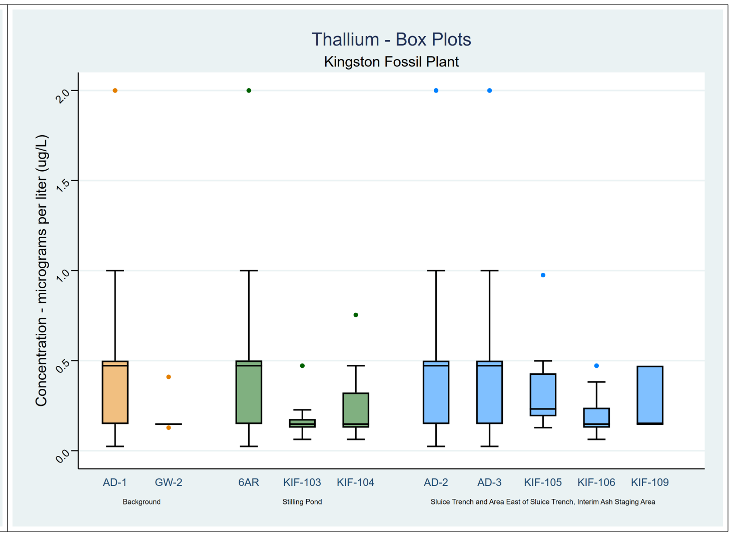

Lithium - Box Plots
Kingston Fossil Plant
Concentration - micrograms per liter (ug/L)
0
10
20
30
40
50
AD-1
GW-2
6AR
KIF-103
KIF-104
AD-2
AD-3
KIF-105
KIF-106
KIF-109
Background
Stilling Pond
Sluice Trench and Area East of Sluice Trench, Interim Ash Staging Area


Mercury - Box Plots
Kingston Fossil Plant
Concentration - micrograms per liter (ug/L)
0.0
0.5
1.0
1.5
AD-1
GW-2
6AR
KIF-103
KIF-104
AD-2
AD-3
KIF-105
KIF-106
KIF-109
Background
Stilling Pond
Sluice Trench and Area East of Sluice Trench, Interim Ash Staging Area

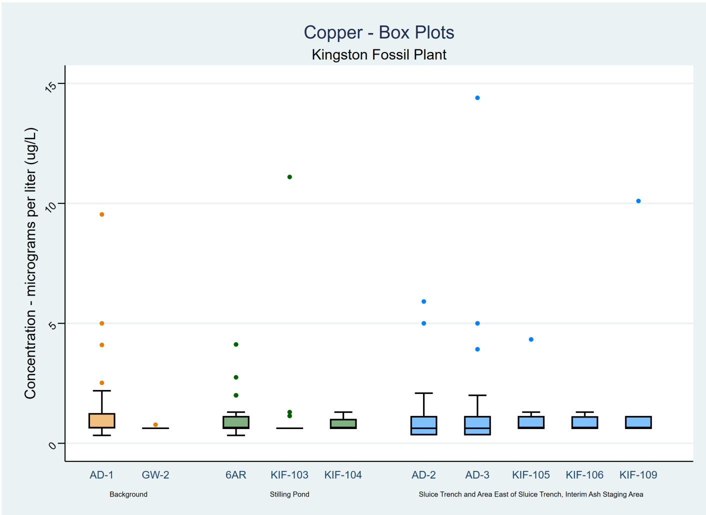

Molybdenum - Box Plots
Kingston Fossil Plant
Concentration - micrograms per liter (ug/L)
0
2
4
6
8
10
AD-1
GW-2
6AR
KIF-103
KIF-104
AD-2
AD-3
KIF-105
KIF-106
KIF-109
Background
Stilling Pond
Sluice Trench and Area East of Sluice Trench, Interim Ash Staging Area

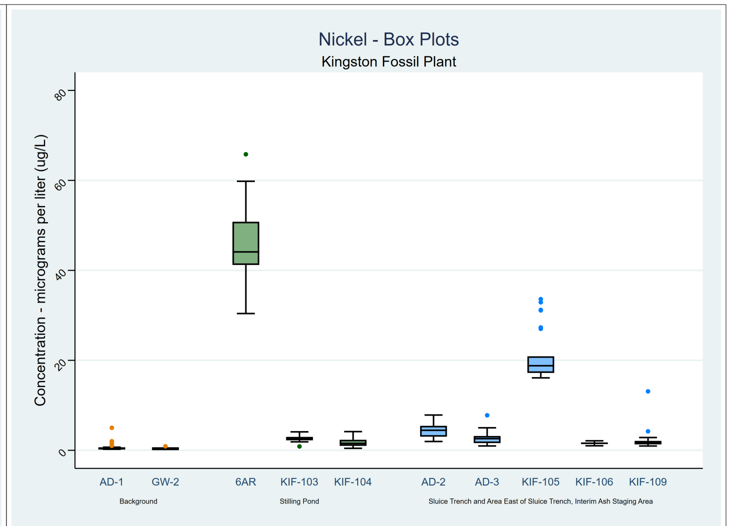

Radium 226+228 - Box Plots
Kingston Fossil Plant
Concentration - picocuries per liter (pCi/L)
0.0
0.5
1.0
1.5
2.0
AD-1
GW-2
6AR
KIF-103
KIF-104
AD-2
AD-3
KIF-105
KIF-106
KIF-109
Background
Stilling Pond
Sluice Trench and Area East of Sluice Trench, Interim Ash Staging Area

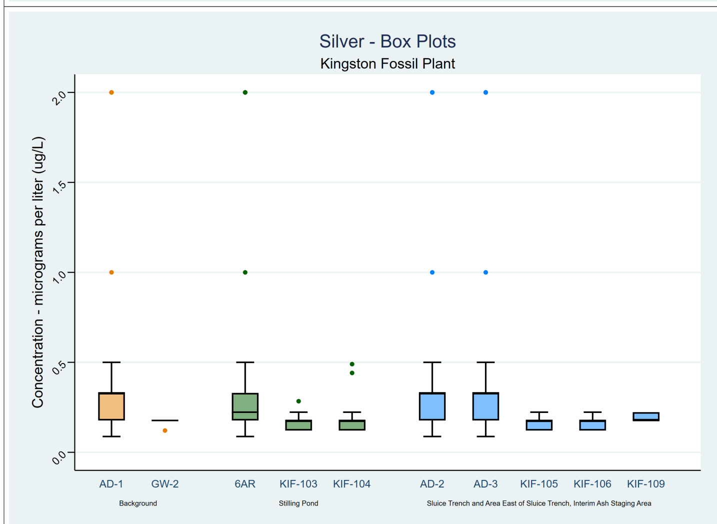

Selenium - Box Plots
Kingston Fossil Plant
Concentration - micrograms per liter (ug/L)
0
1
2
3
4
5
AD-1
GW-2
6AR
KIF-103
KIF-104
AD-2
AD-3
KIF-105
KIF-106
KIF-109
Background
Stilling Pond
Sluice Trench and Area East of Sluice Trench, Interim Ash Staging Area

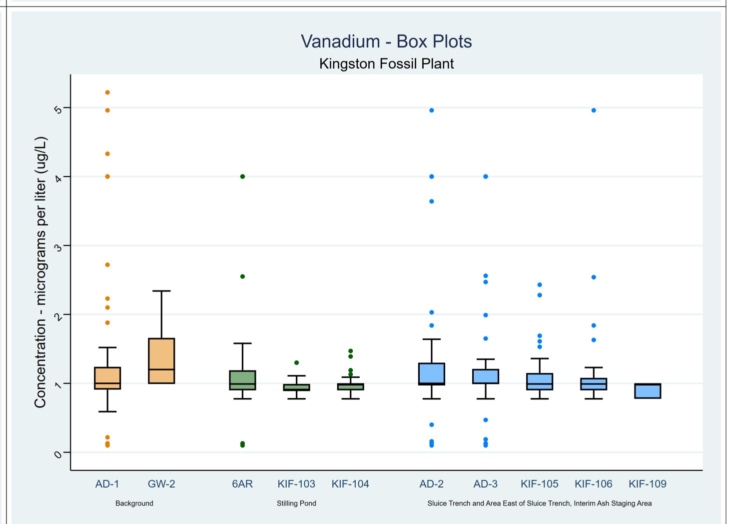

Thallium - Box Plots
Kingston Fossil Plant
Concentration - micrograms per liter (ug/L)
0.0
0.5
1.0
1.5
2.0
AD-1
GW-2
6AR
KIF-103
KIF-104
AD-2
AD-3
KIF-105
KIF-106
KIF-109
Background
Stilling Pond
Sluice Trench and Area East of Sluice Trench, Interim Ash Staging Area

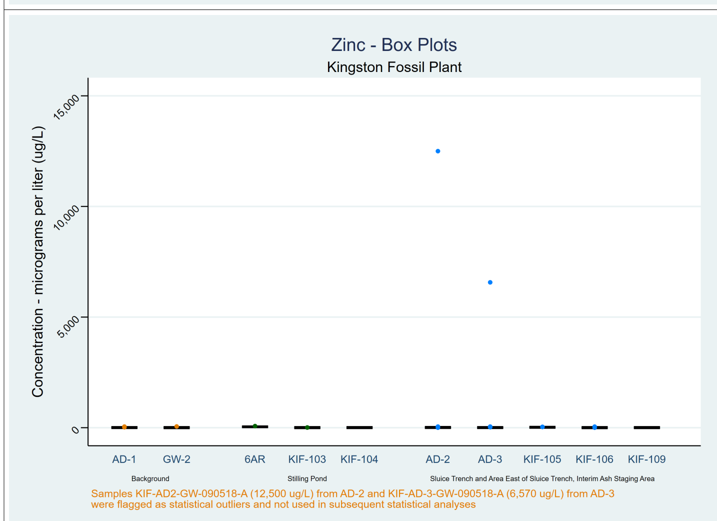
Box Plots
TDEC Appendix I Parameters
Kingston Fossil Plant - Harriman, Tennessee











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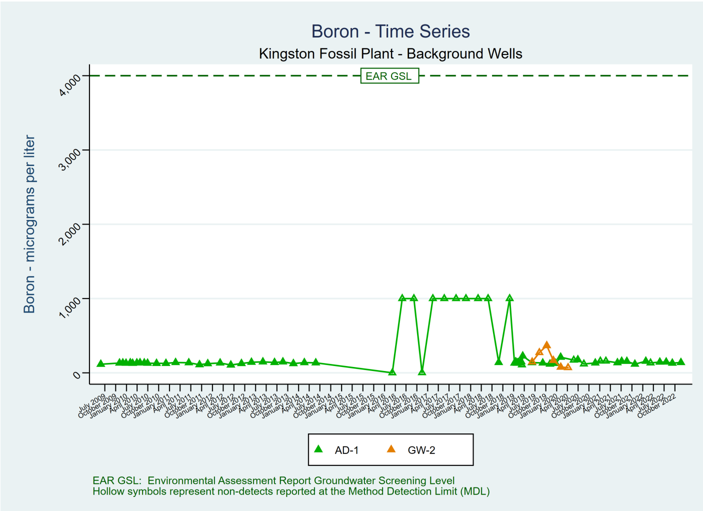
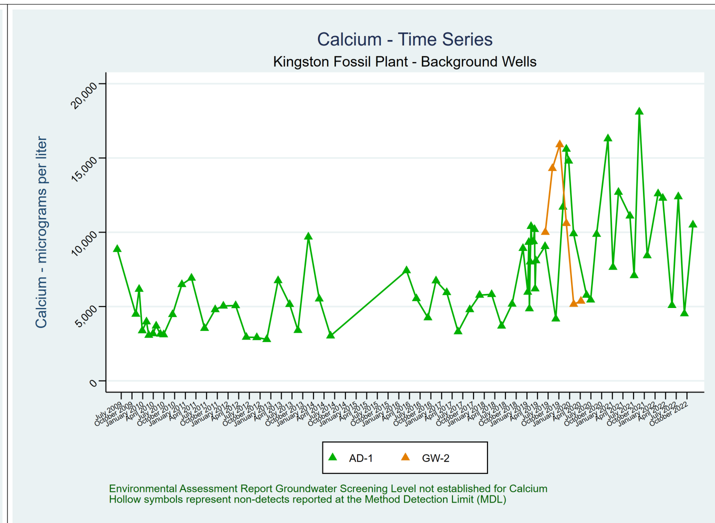
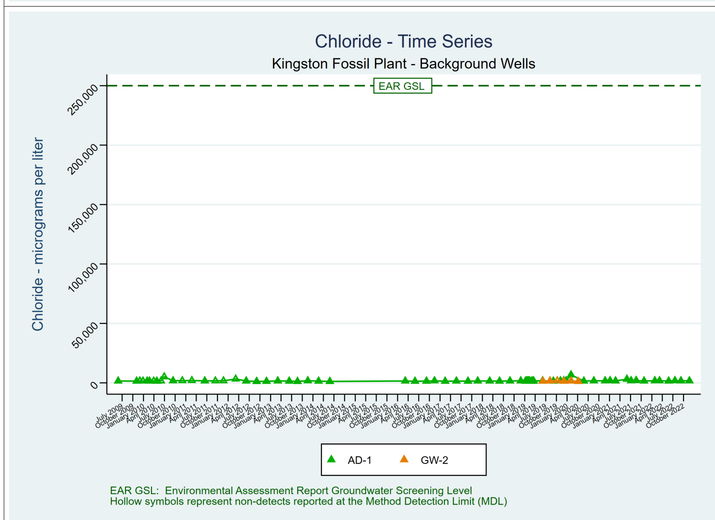
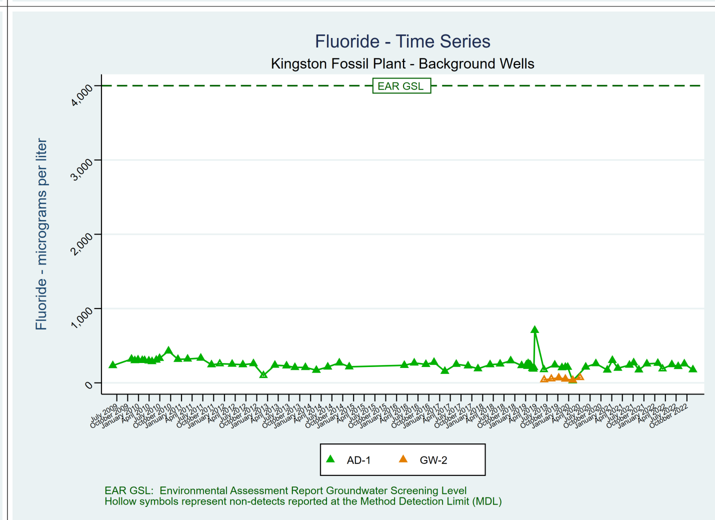
ATTACHMENT E.3-C
TIME SERIES PLOTS

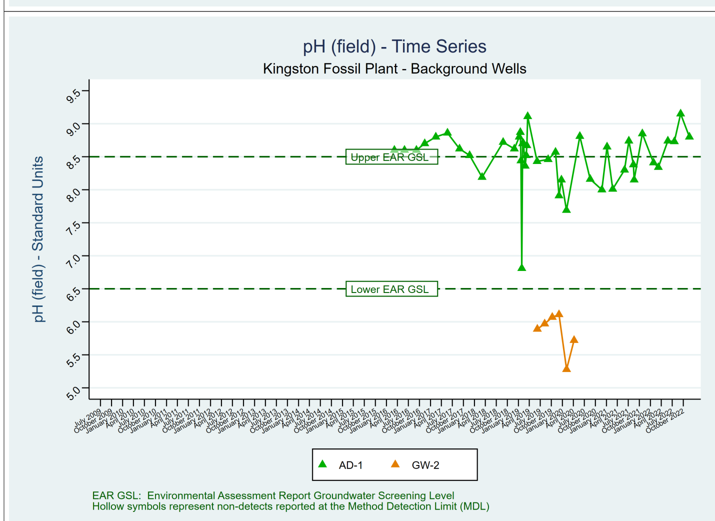
Time Series Plots
Background Wells
CCR Rule Appendix III Parameters
Kingston Fossil Plant - Harriman, Tennessee

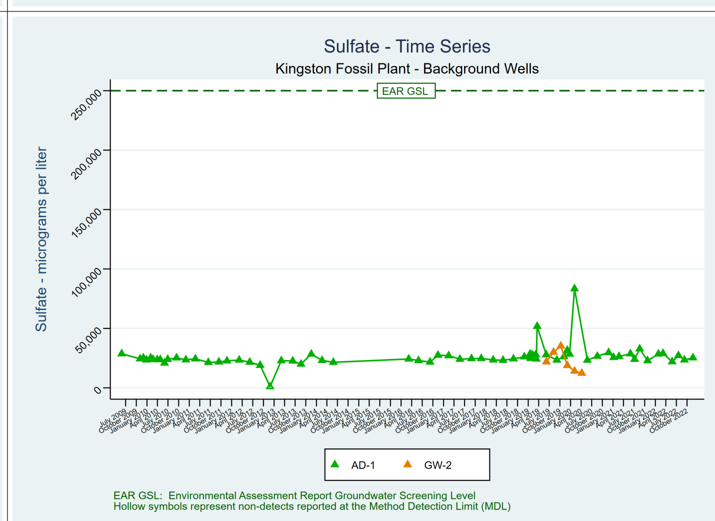


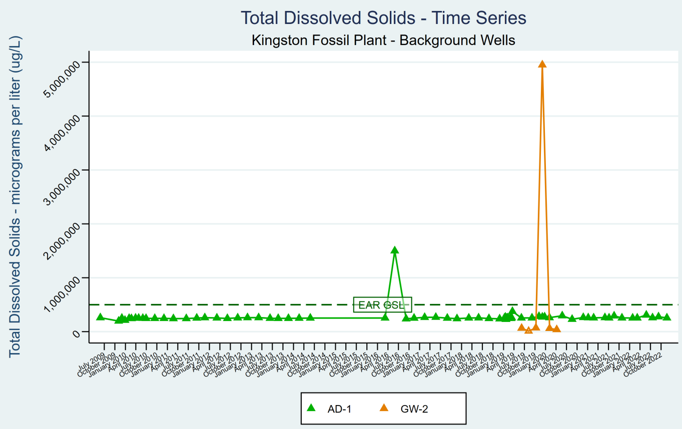












Samples KIF-GW-027-20191218 (4,950,000 ug/L) from GW-2 and KIF-AD1-GW-061316-A (1,500,000 ug/L) from AD-1 were flagged as statistical outliers and not used in subsequent statistical analyses

EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)

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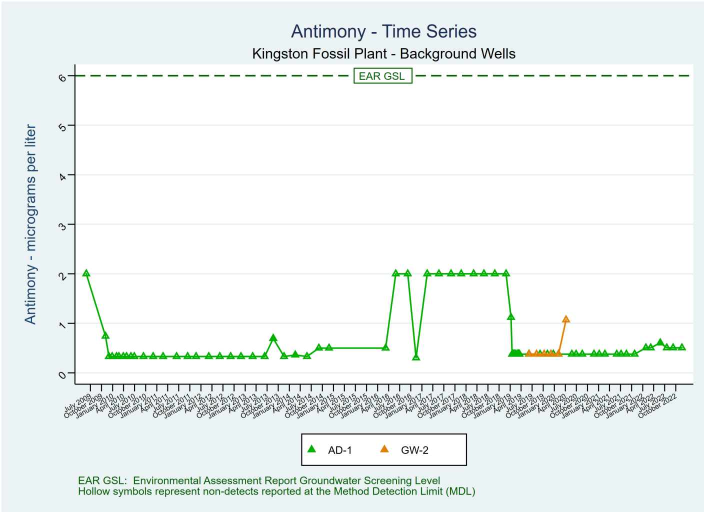
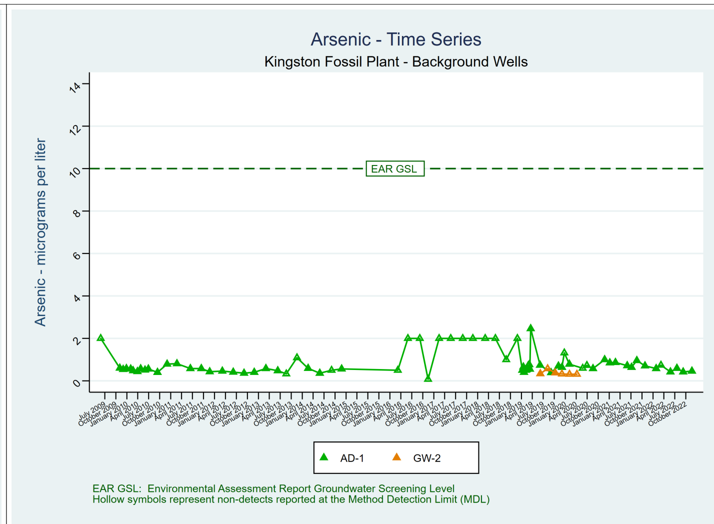
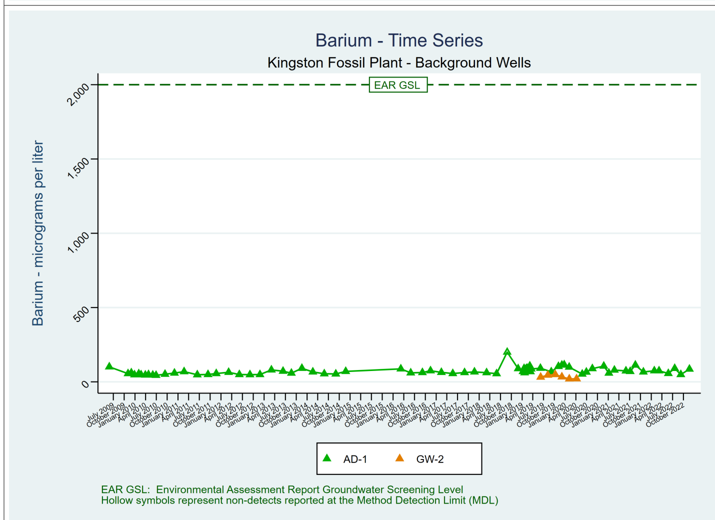
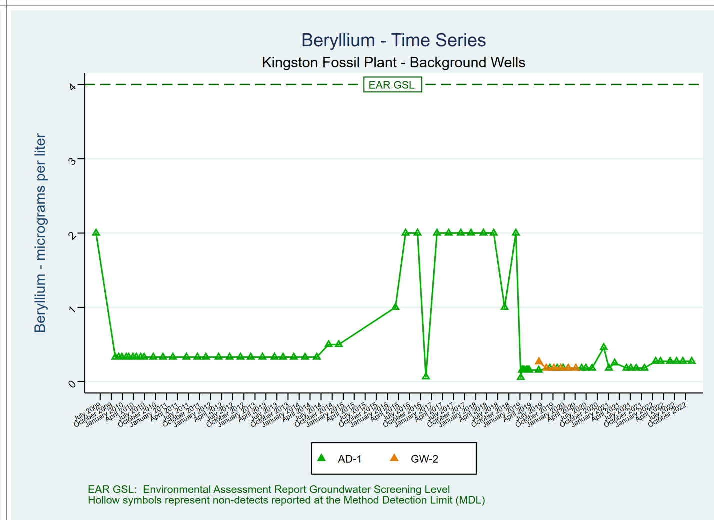
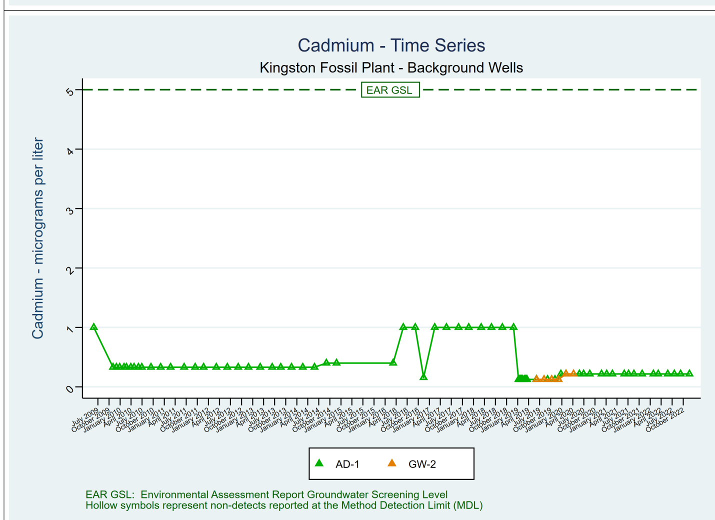
Time Series Plots
Background Wells
CCR Rule Appendix IV Parameters
Kingston Fossil Plant - Harriman, Tennessee

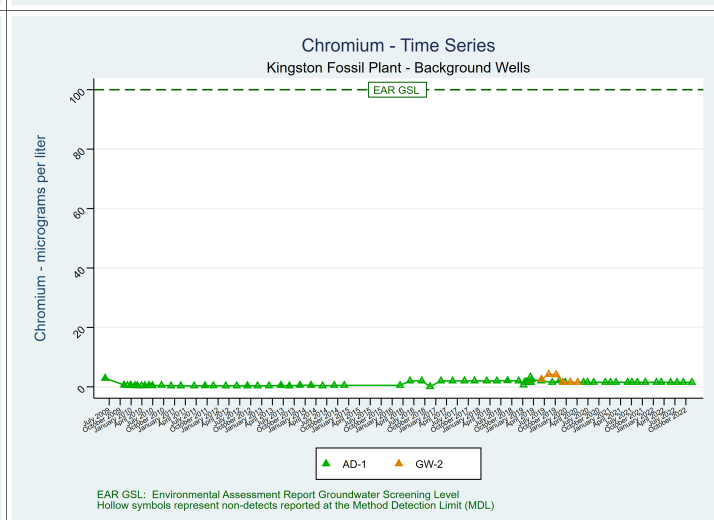


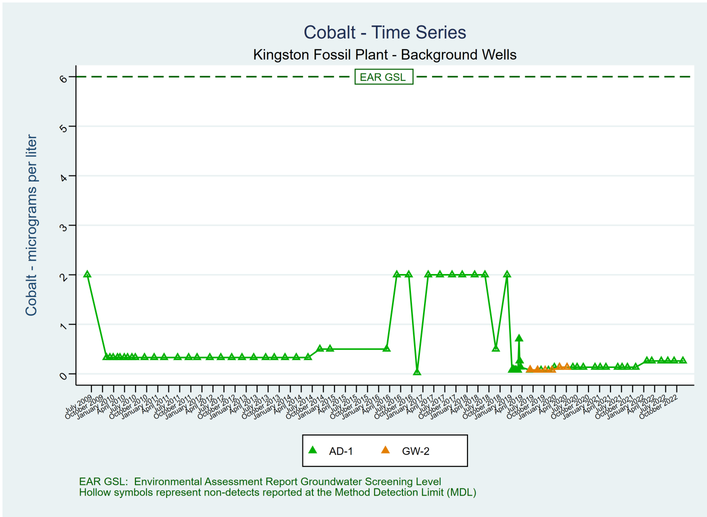


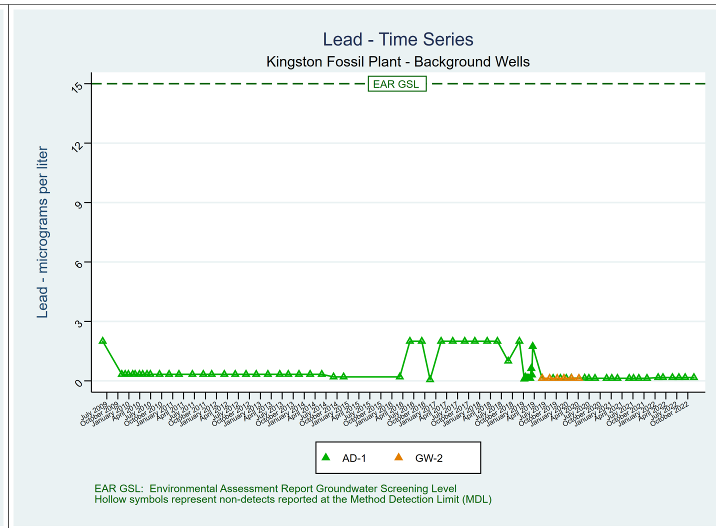


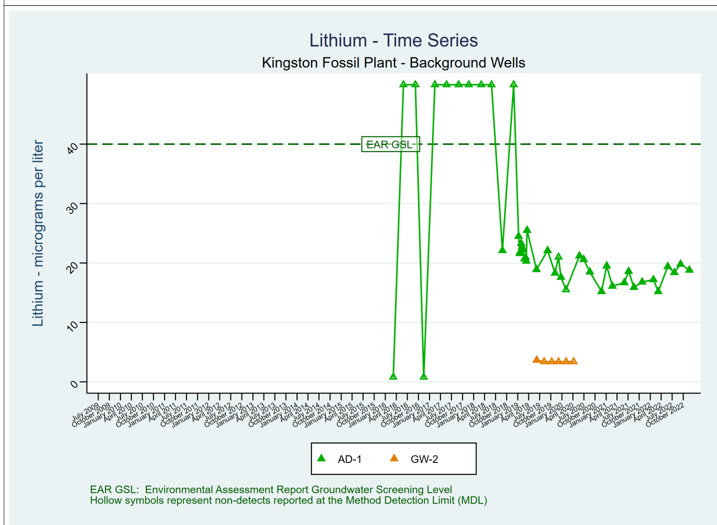


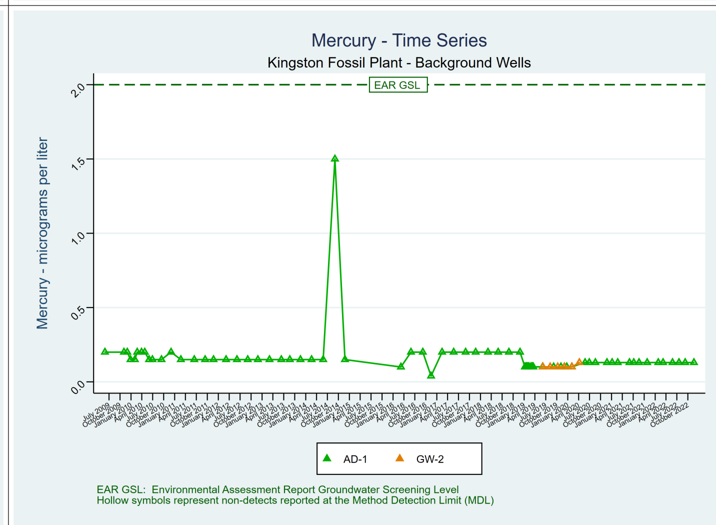


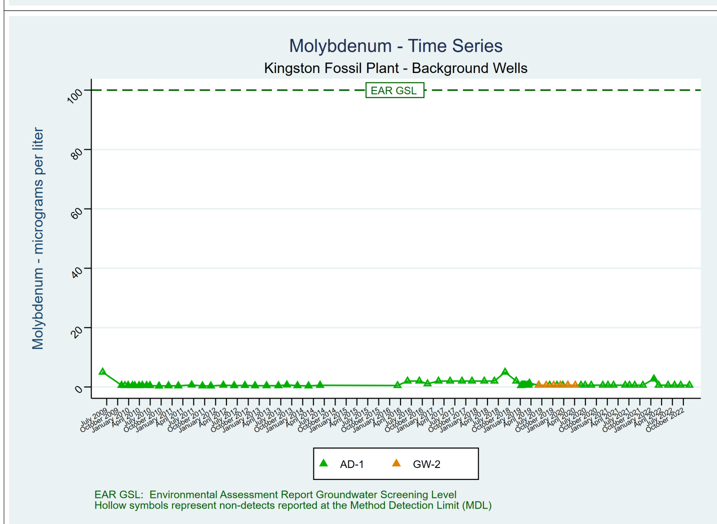


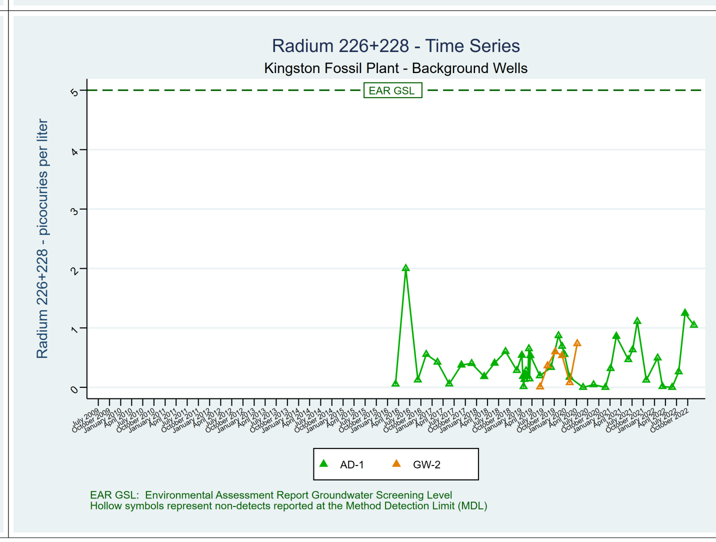

Cobalt - Time Series
Kingston Fossil Plant - Background Wells
Cobalt - micrograms per liter
EAR GSL
AD-1
GW-2
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)

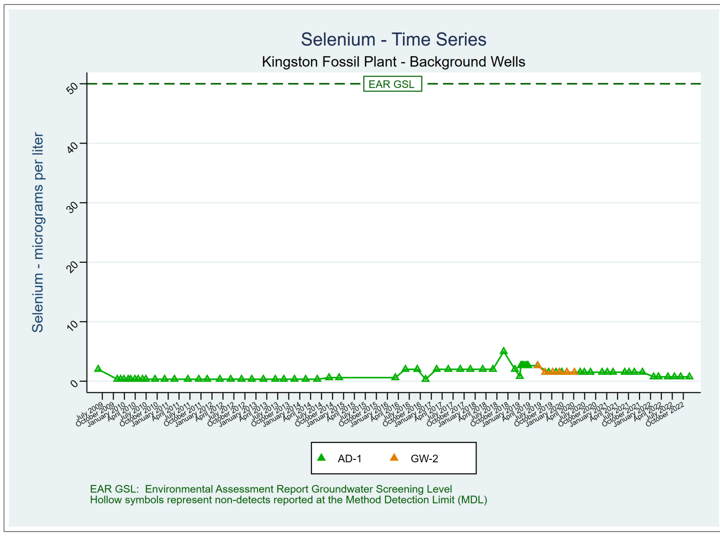

Lead - Time Series
Kingston Fossil Plant - Background Wells
Lead - micrograms per liter
EAR GSL
AD-1
GW-2
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)

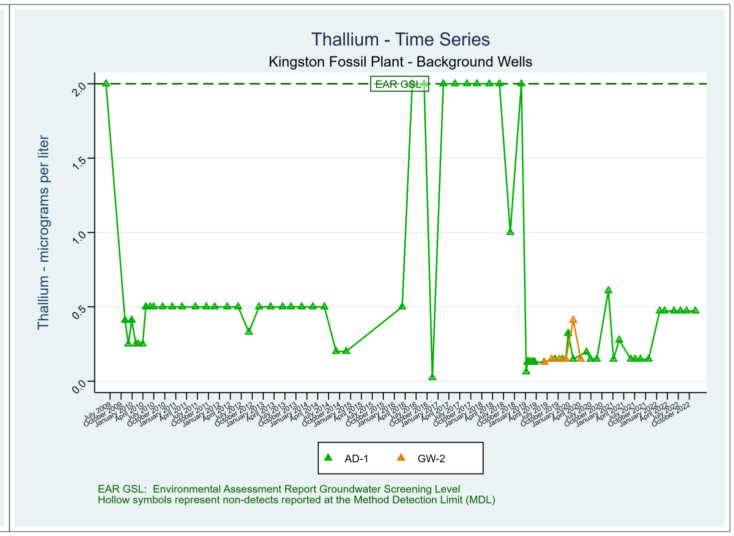

Lithium - Time Series
Kingston Fossil Plant - Background Wells
Lithium - micrograms per liter
EAR GSL
AD-1
GW-2
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)


Mercury - Time Series
Kingston Fossil Plant - Background Wells
Mercury - micrograms per liter
EAR GSL
AD-1
GW-2
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)

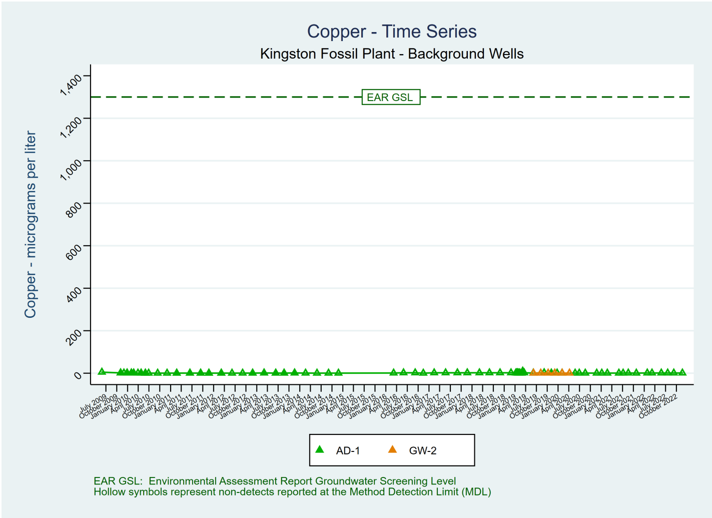

Molybdenum - Time Series
Kingston Fossil Plant - Background Wells
Molybdenum - micrograms per liter
EAR GSL
AD-1
GW-2
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)

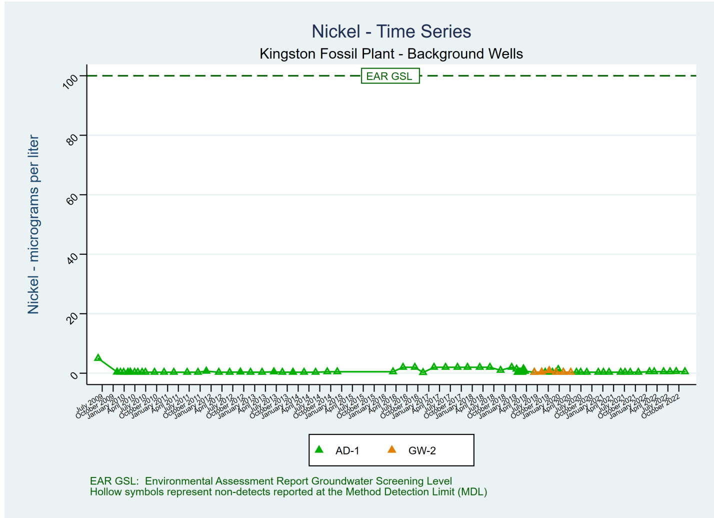

Radium 226+228 - Time Series
Kingston Fossil Plant - Background Wells
Radium 226+228 - picocuries per liter
EAR GSL
AD-1
GW-2
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)

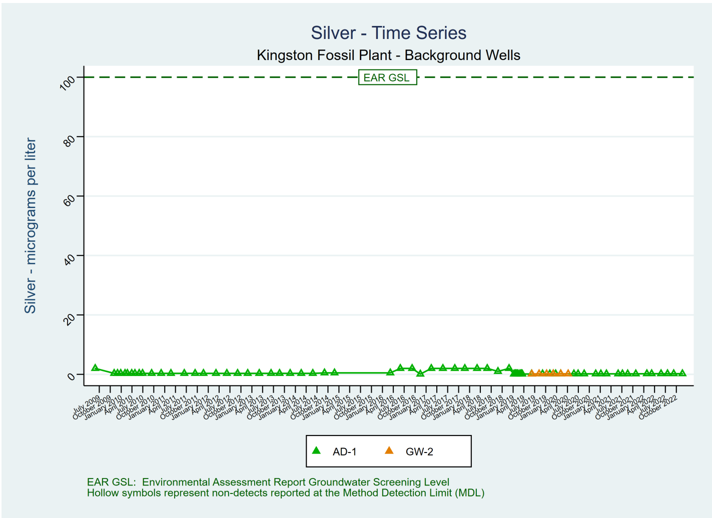

Selenium - Time Series
Kingston Fossil Plant - Background Wells
EAR GSL
Selenium - micrograms per liter
AD-1
GW-2
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)

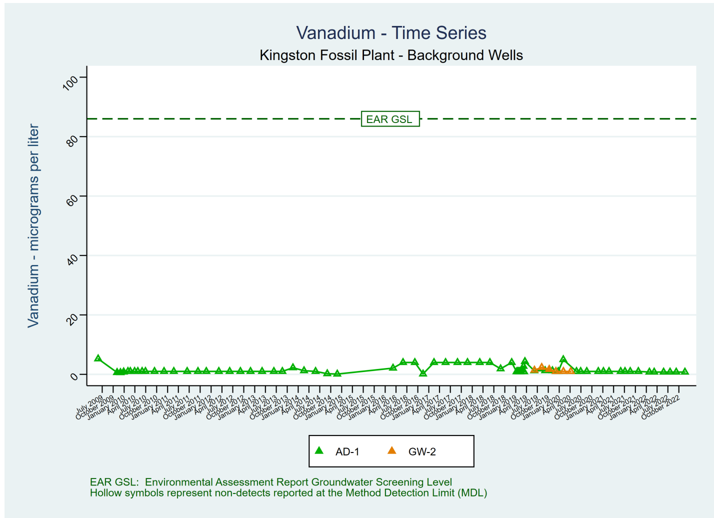

Thallium - Time Series
Kingston Fossil Plant - Background Wells
EAR GSL
Thallium - micrograms per liter
AD-1
GW-2
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)

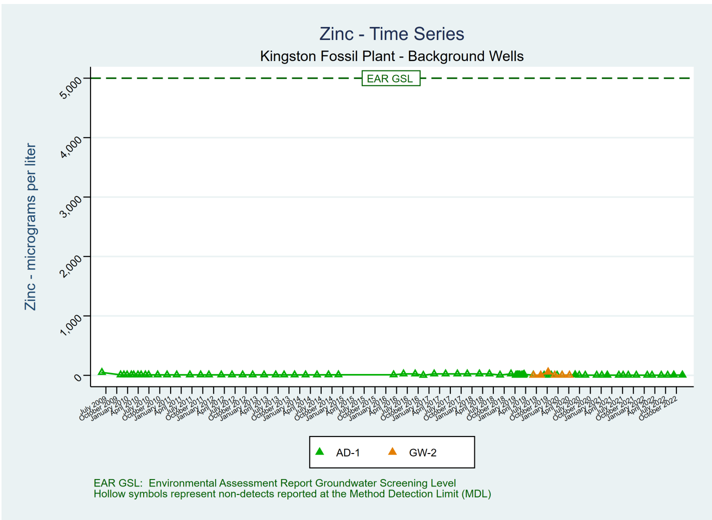
Time Series Plots
Background Wells
TDEC Appendix I Parameters
Kingston Fossil Plant - Harriman, Tennessee











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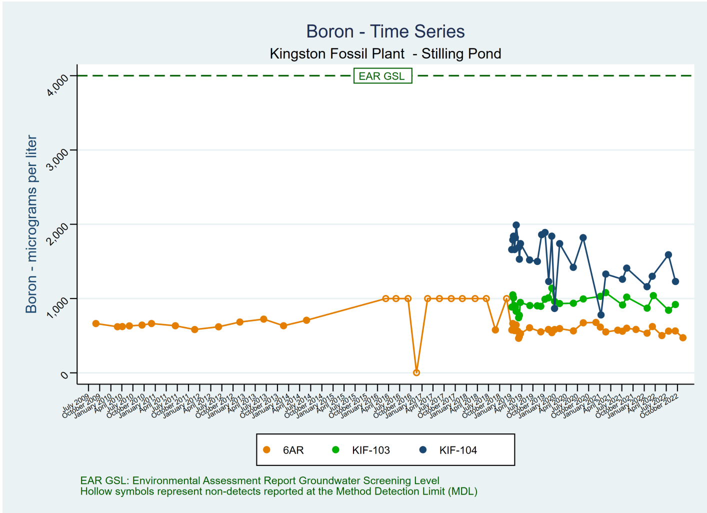
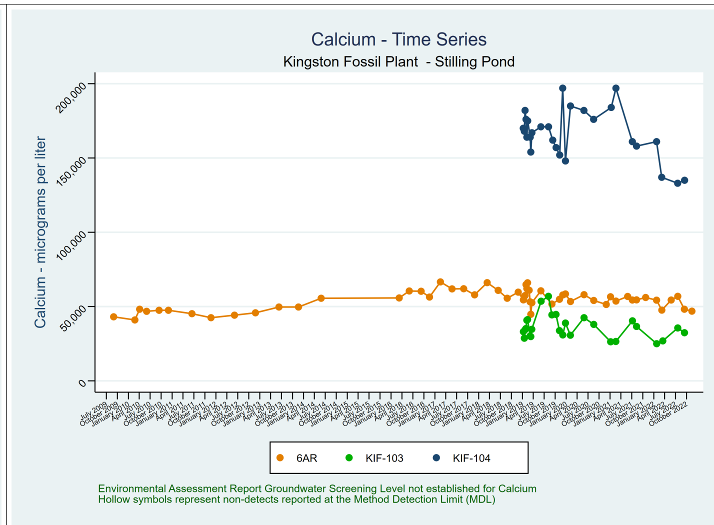
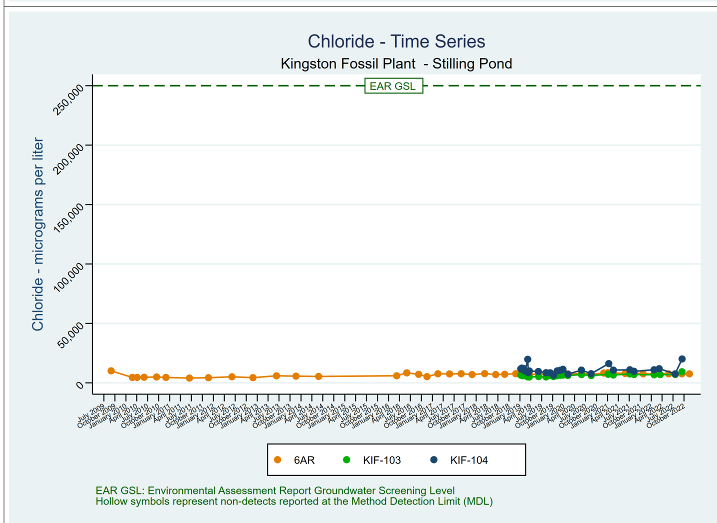
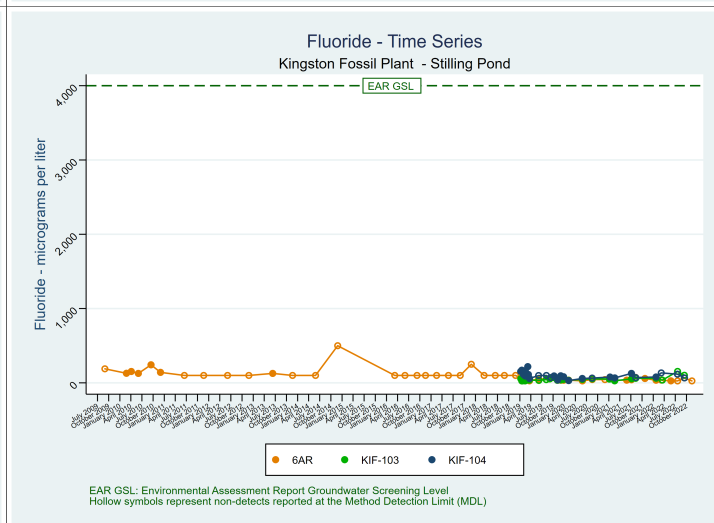
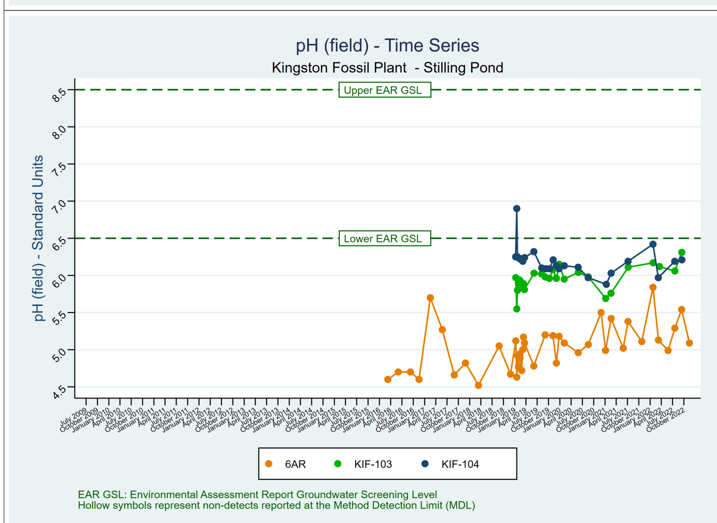
Time Series Plots
Stilling Pond Wells
CCR Rule Appendix III Parameters
Kingston Fossil Plant - Harriman, Tennessee

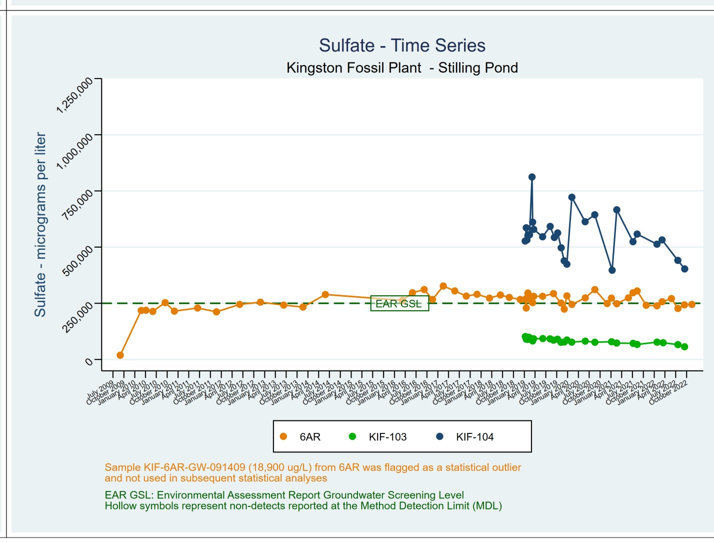


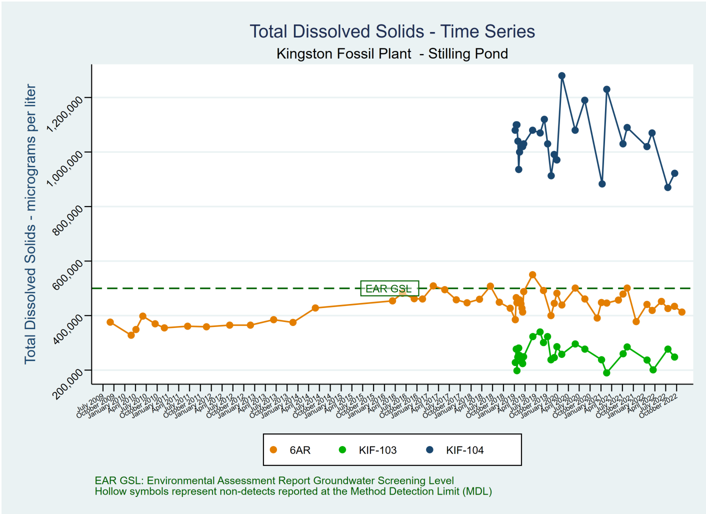












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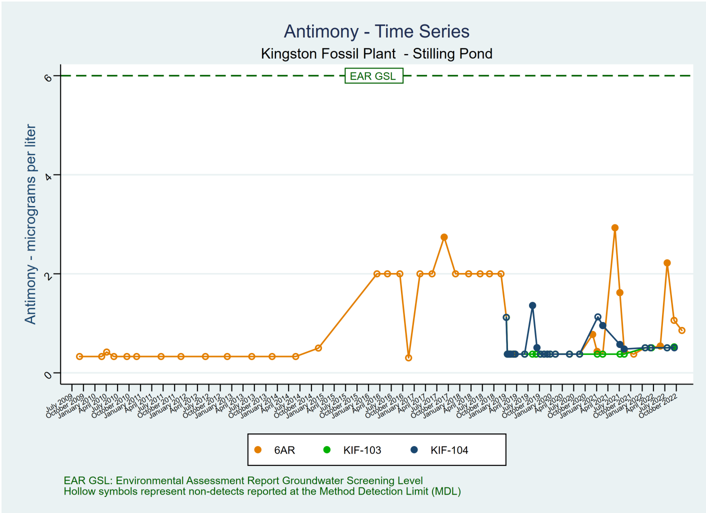
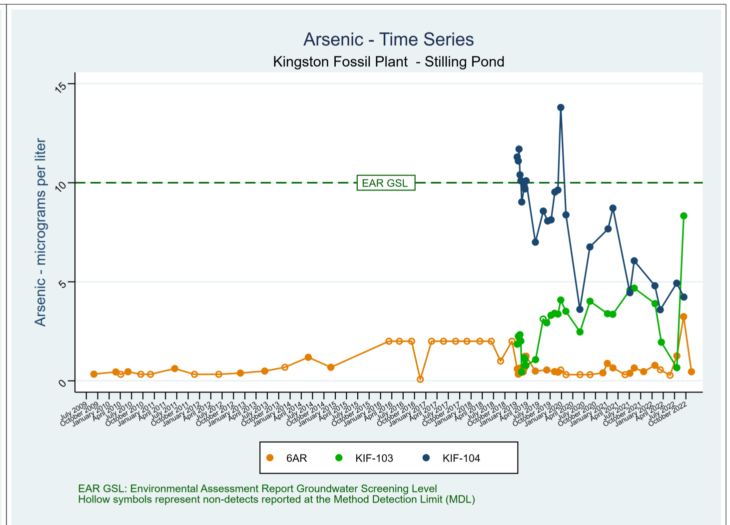
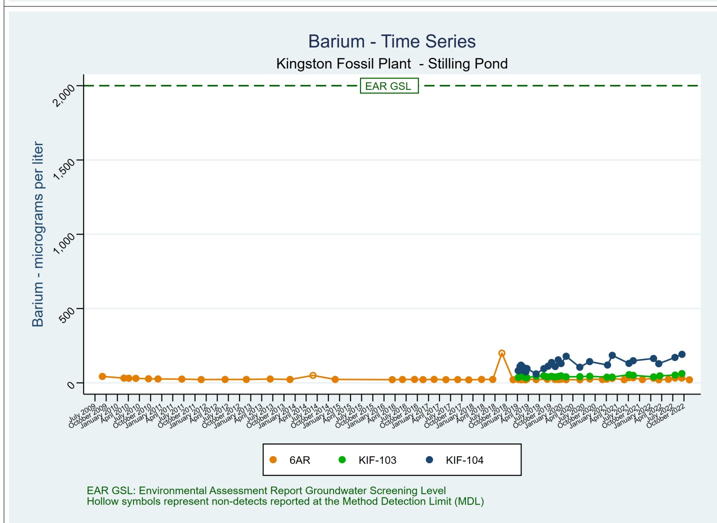
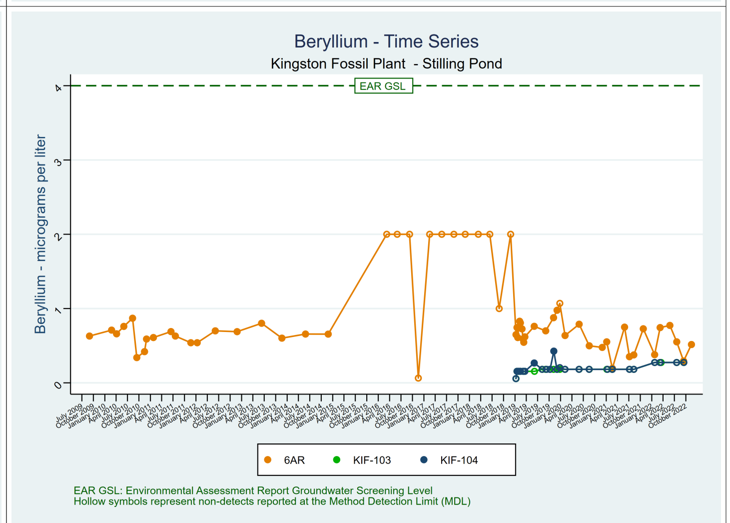
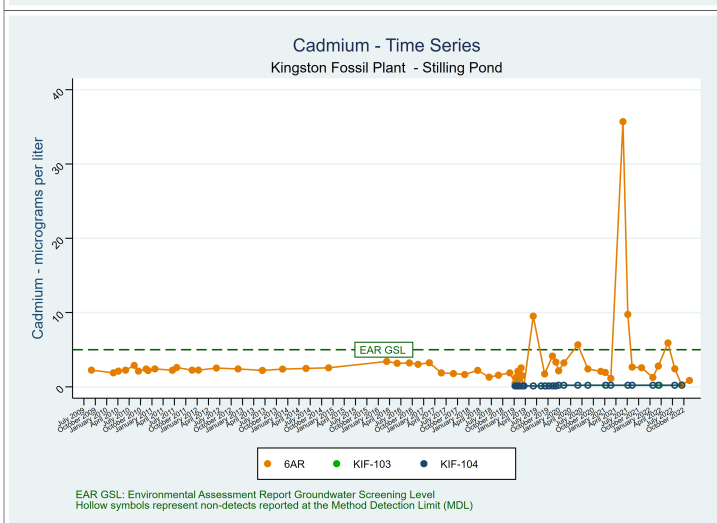
Time Series Plots
Stilling Pond Wells
CCR Rule Appendix IV Parameters
Kingston Fossil Plant - Harriman, Tennessee

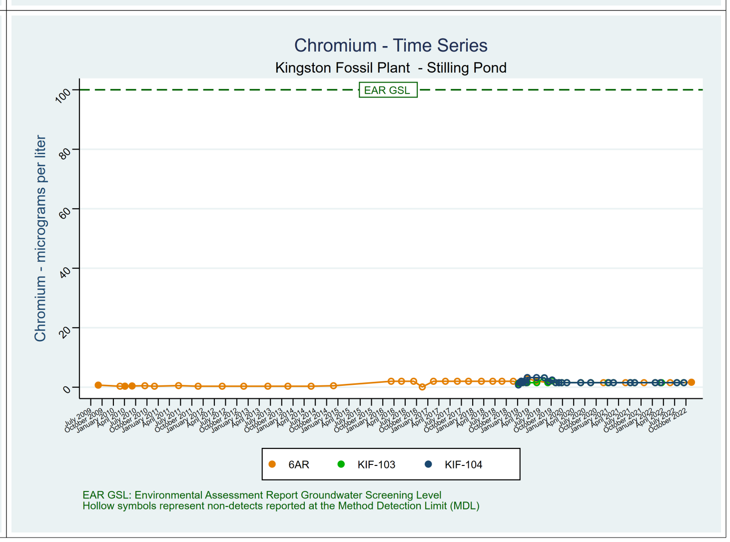


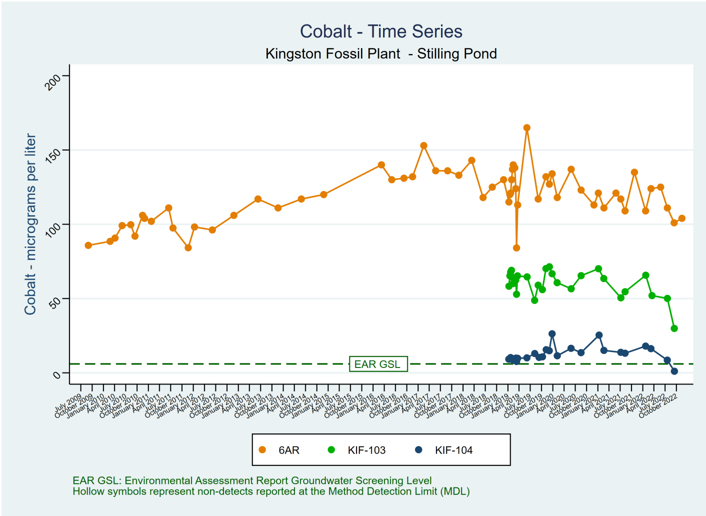


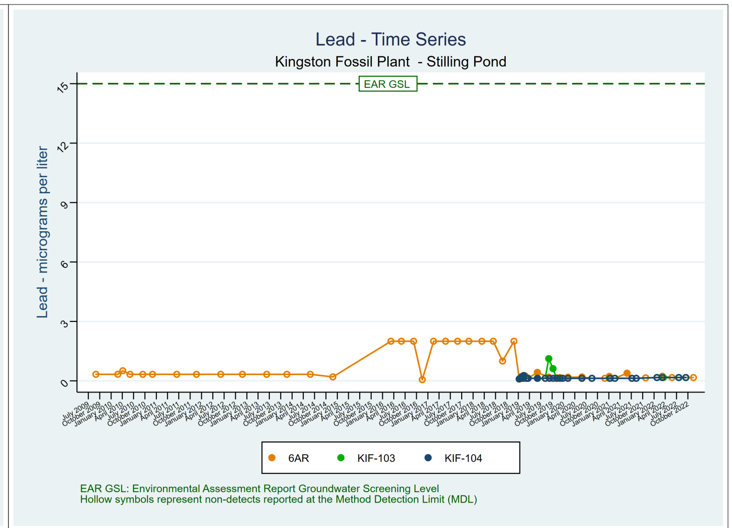


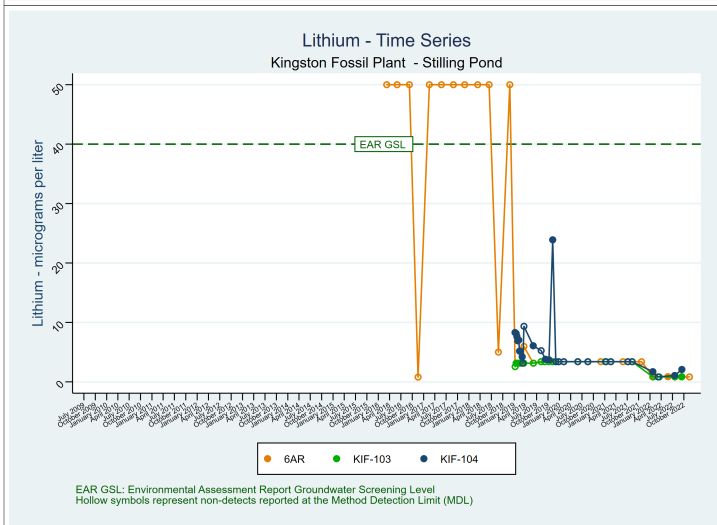


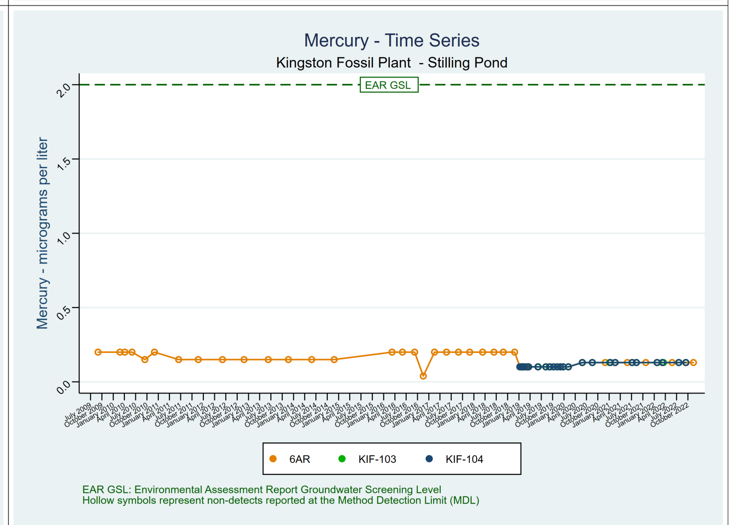


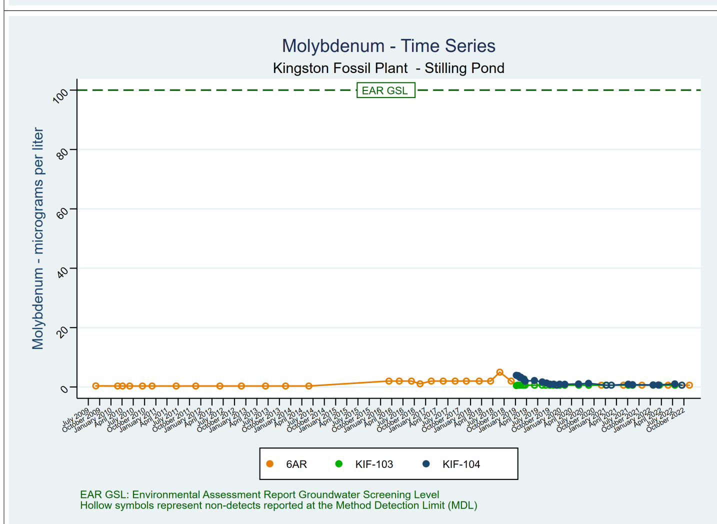


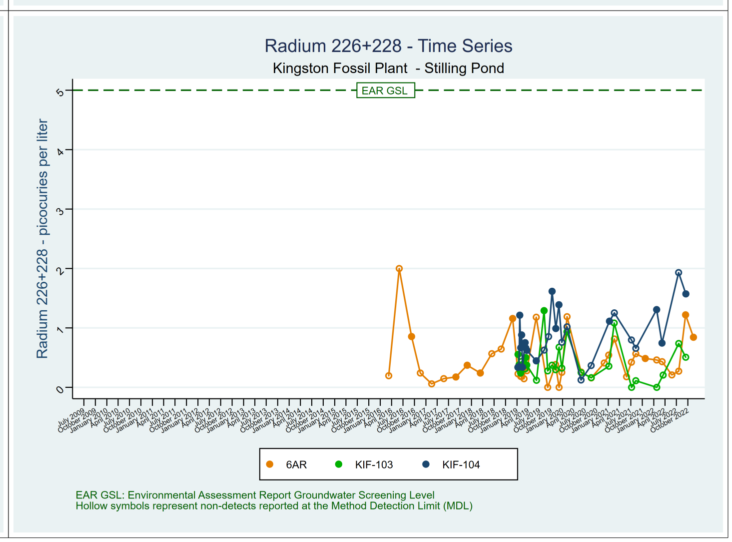

Cobalt - Time Series
Kingston Fossil Plant - Stilling Pond
Cobalt - micrograms per liter
0
50
100
150
200
EAR GSL
6AR
KIF-103
KIF-104
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)

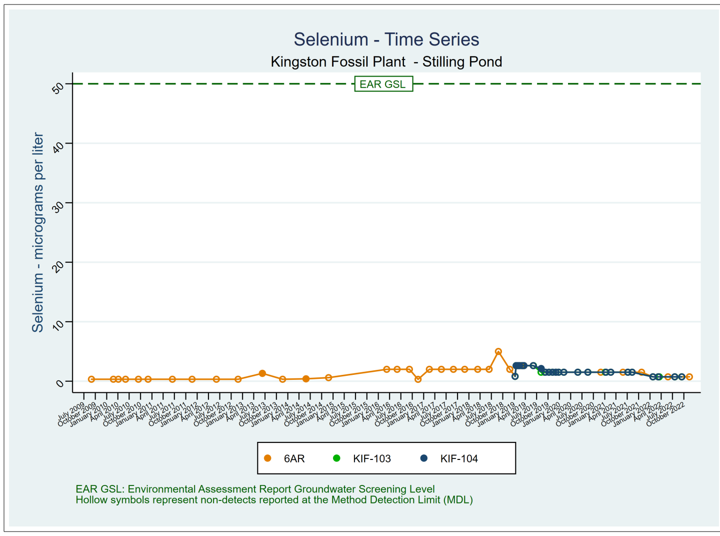

Lead - Time Series
Kingston Fossil Plant - Stilling Pond
Lead - micrograms per liter
0
3
6
9
12
15
EAR GSL
6AR
KIF-103
KIF-104
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)

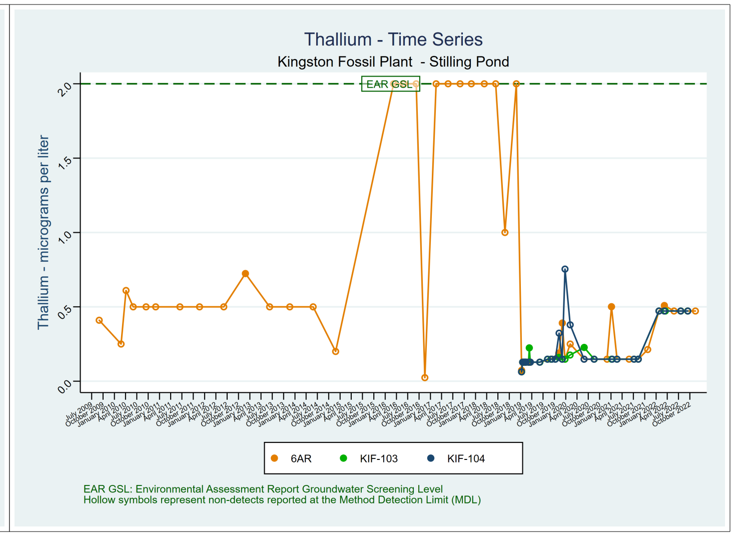

Lithium - Time Series
Kingston Fossil Plant - Stilling Pond
Lithium - micrograms per liter
0
10
20
30
40
50
EAR GSL
6AR
KIF-103
KIF-104
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)


Mercury - Time Series
Kingston Fossil Plant - Stilling Pond
Mercury - micrograms per liter
0.0
0.5
1.0
1.5
2.0
EAR GSL
6AR
KIF-103
KIF-104
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)

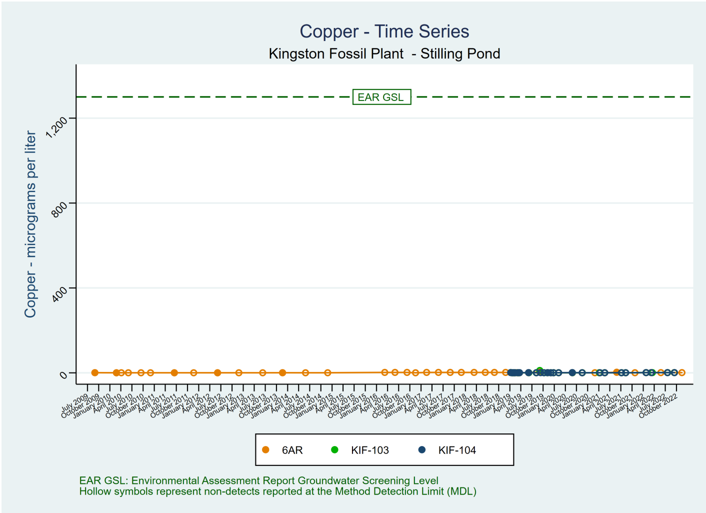

Molybdenum - Time Series
Kingston Fossil Plant - Stilling Pond
Molybdenum - micrograms per liter
0
20
40
60
80
100
EAR GSL
6AR
KIF-103
KIF-104
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)

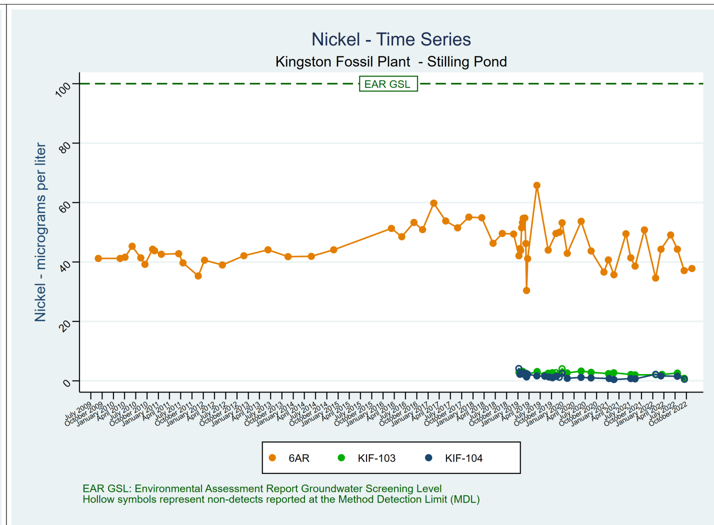

Radium 226+228 - Time Series
Kingston Fossil Plant - Stilling Pond
Radium 226+228 - picocuries per liter
0
1
2
3
4
5
EAR GSL
6AR
KIF-103
KIF-104
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)

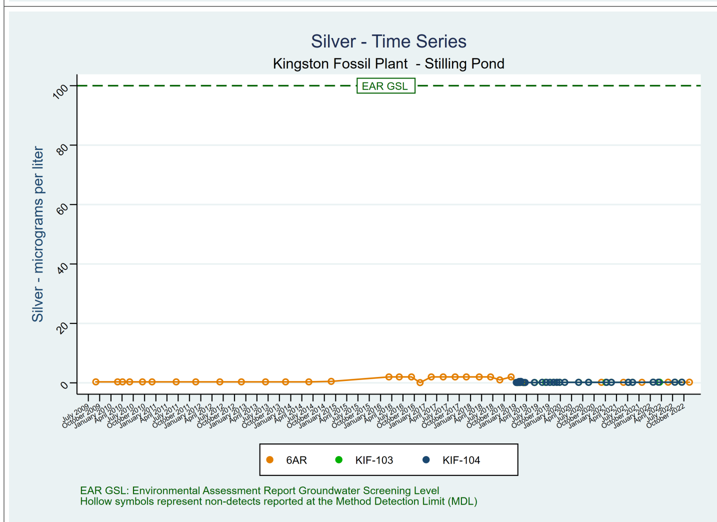

Selenium - Time Series
Kingston Fossil Plant - Stilling Pond
Selenium - micrograms per liter
EAR GSL
6AR
KIF-103
KIF-104
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)

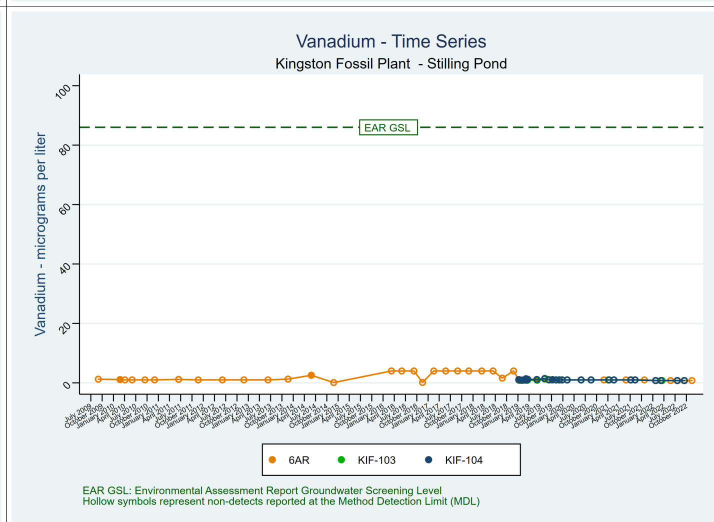

Thallium - Time Series
Kingston Fossil Plant - Stilling Pond
Thallium - micrograms per liter
EAR GSL
6AR
KIF-103
KIF-104
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)

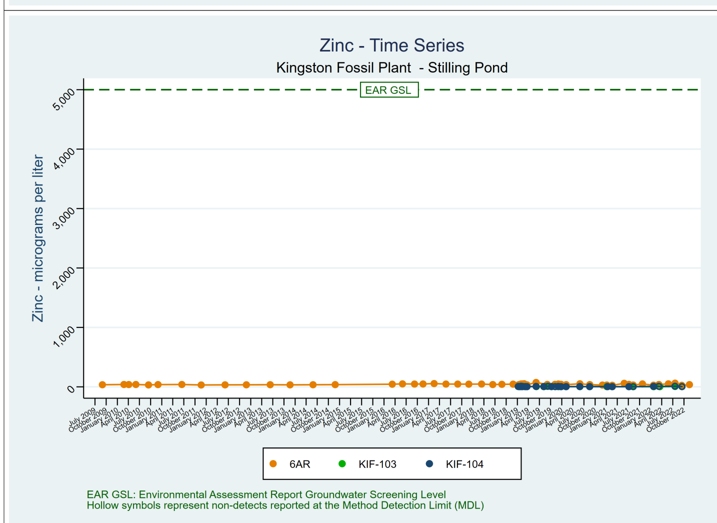
Time Series Plots
Stilling Pond Wells
TDEC Appendix I Parameters
Kingston Fossil Plant - Harriman, Tennessee











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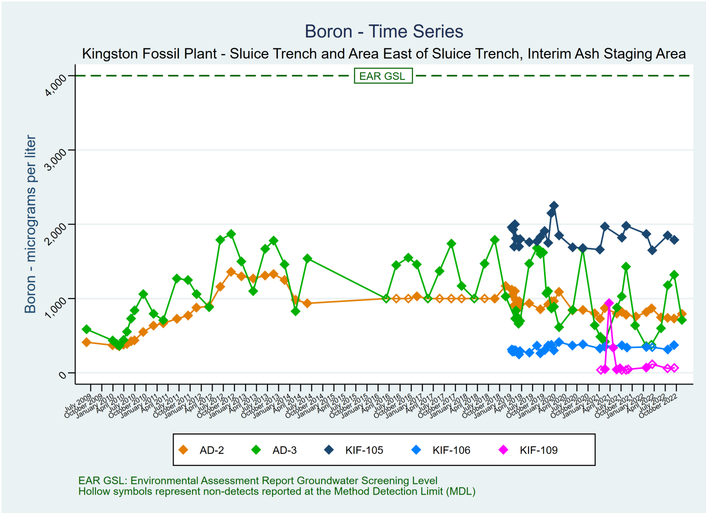
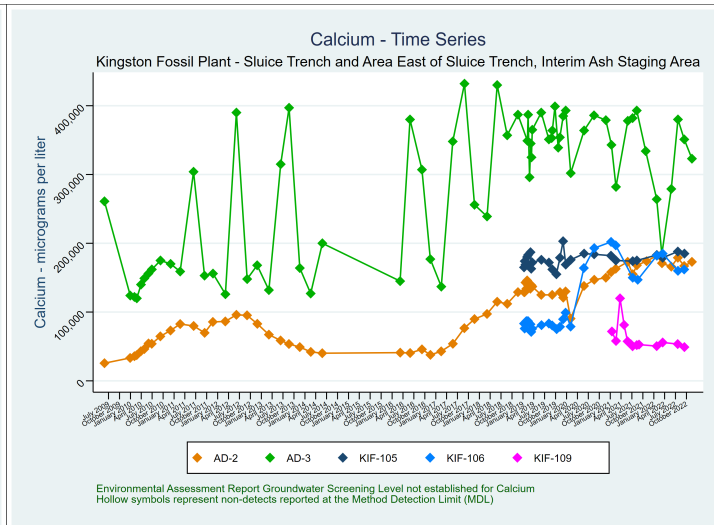
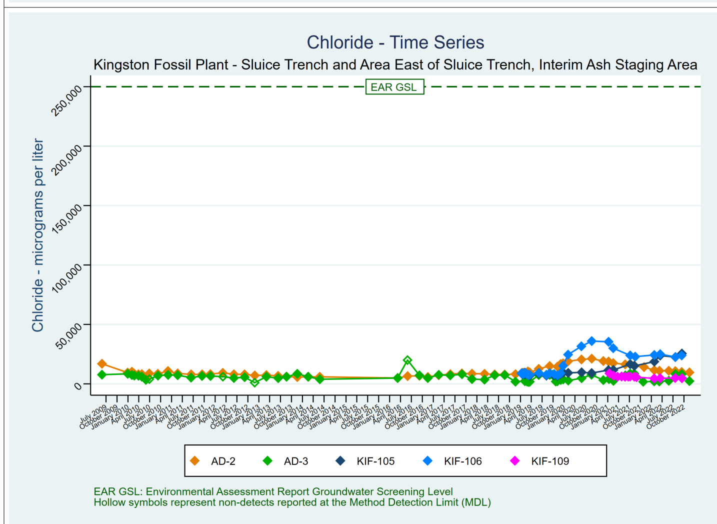
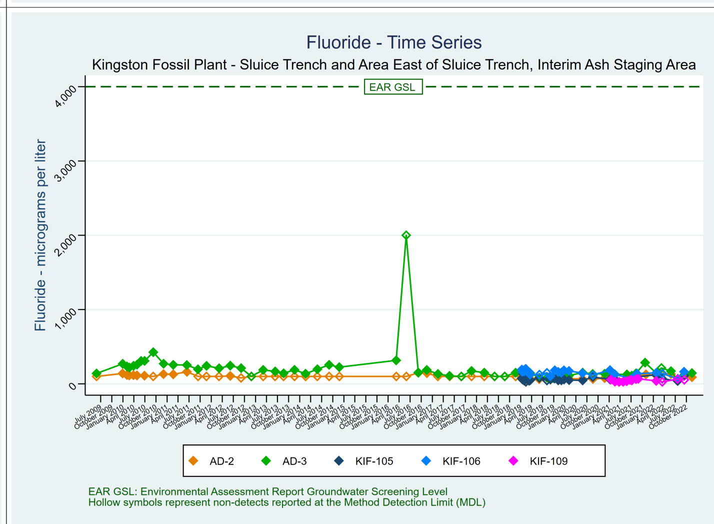
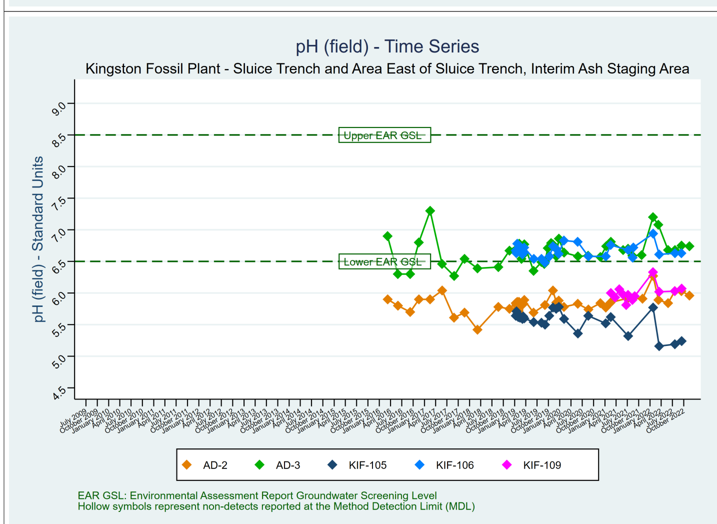
Time Series Plots
Sluice Trench and Area East of Sluice Trench, Interim Ash Staging Area Wells
CCR Rule Appendix III Parameters
Kingston Fossil Plant - Harriman, Tennessee

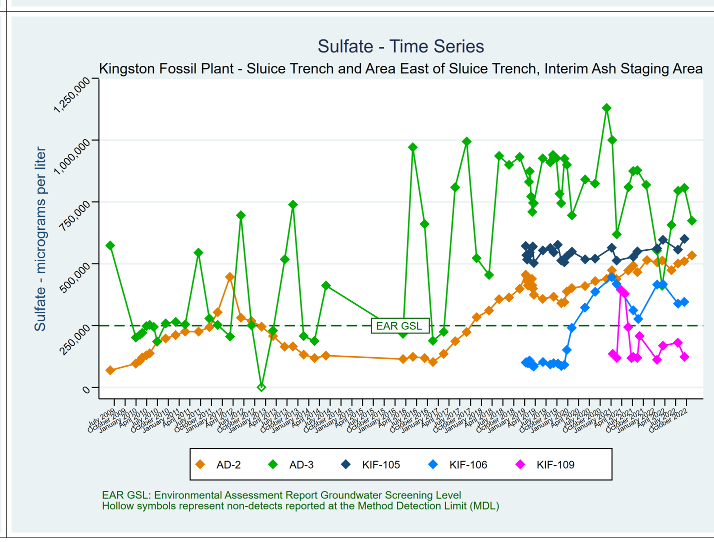


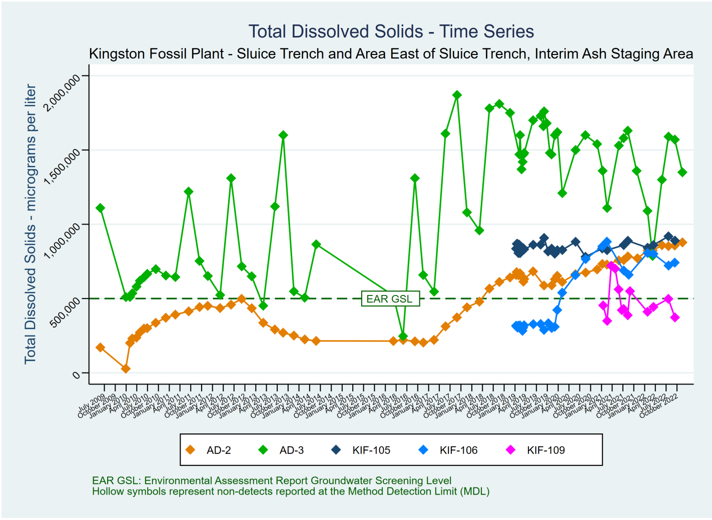












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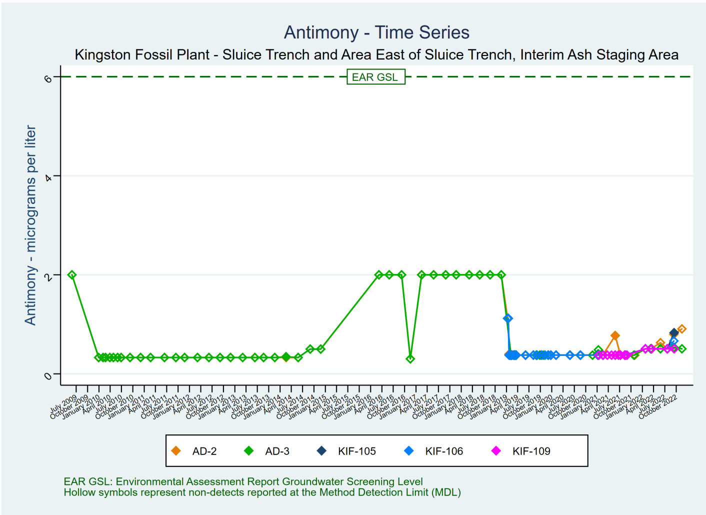
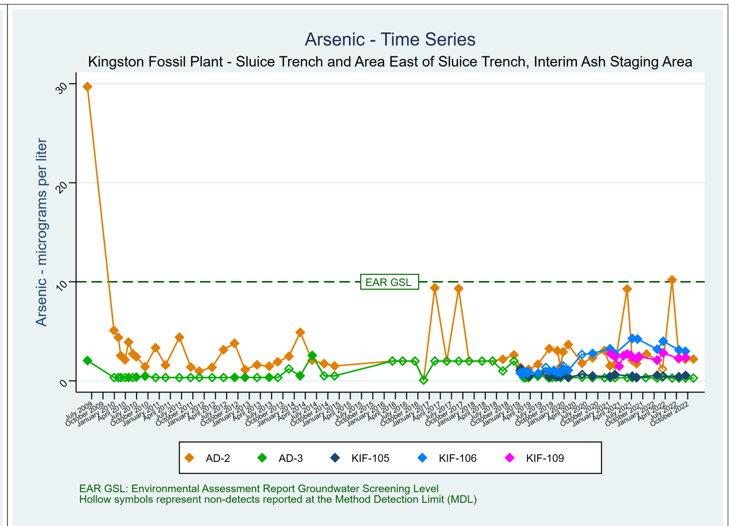
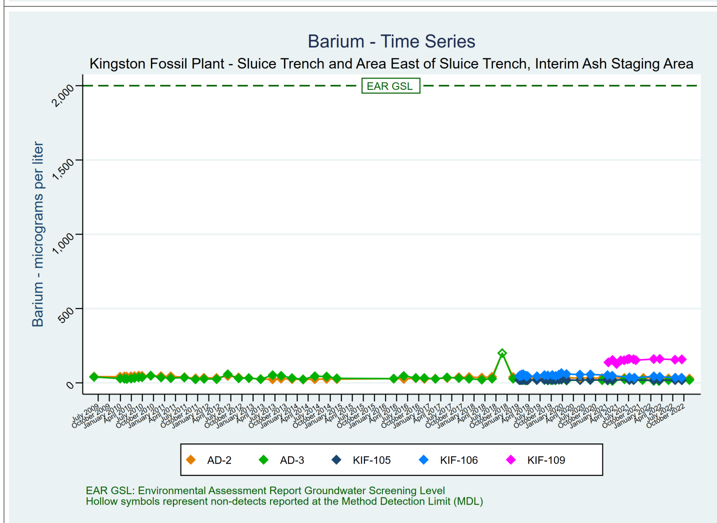
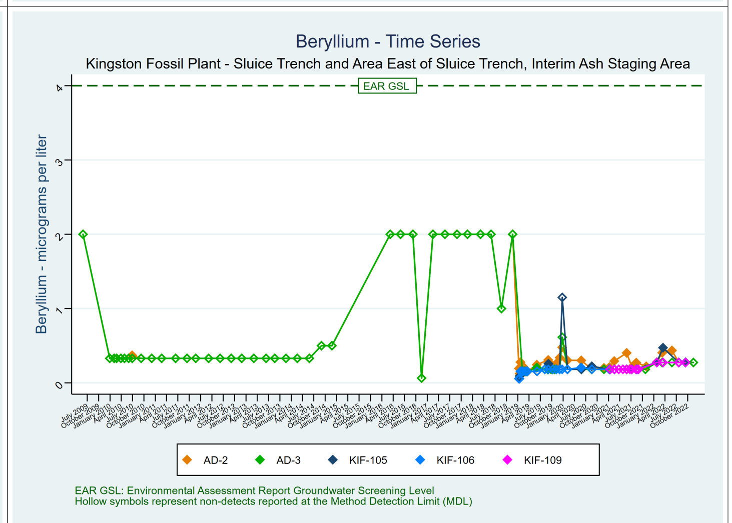
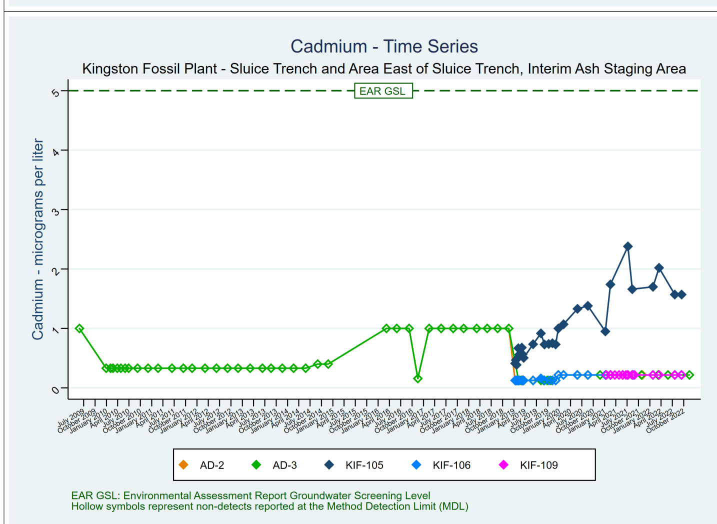
Time Series Plots
Sluice Trench and Area East of Sluice Trench, Interim Ash Staging Area Wells
CCR Rule Appendix IV Parameters
Kingston Fossil Plant - Harriman, Tennessee

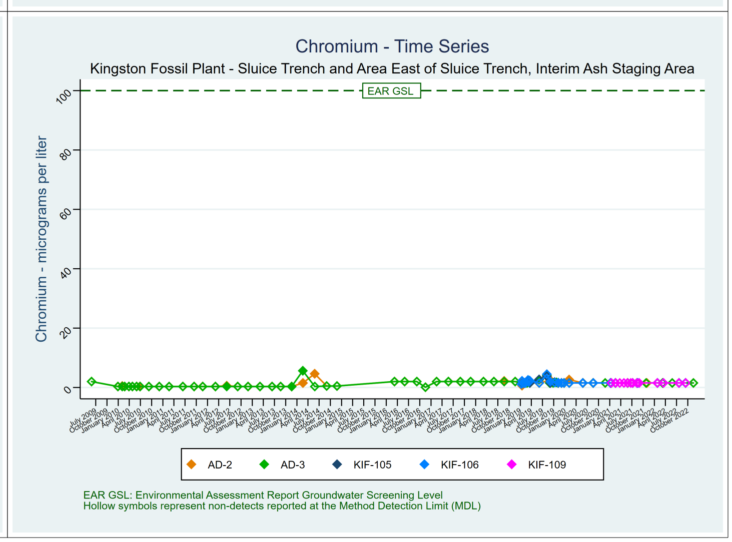


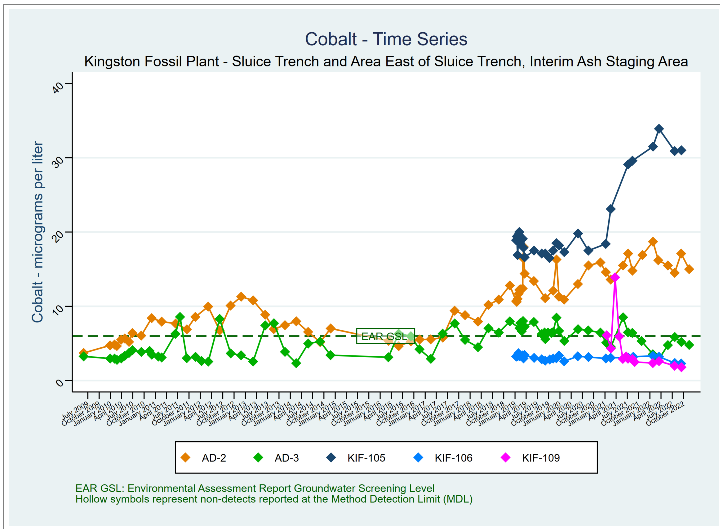


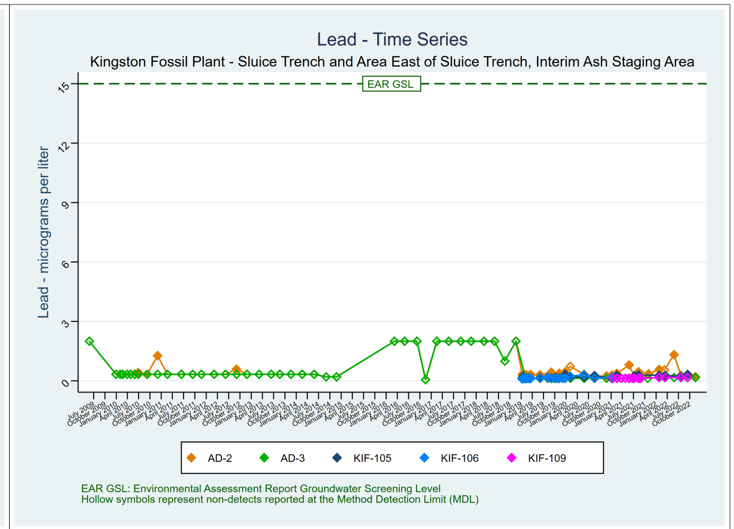


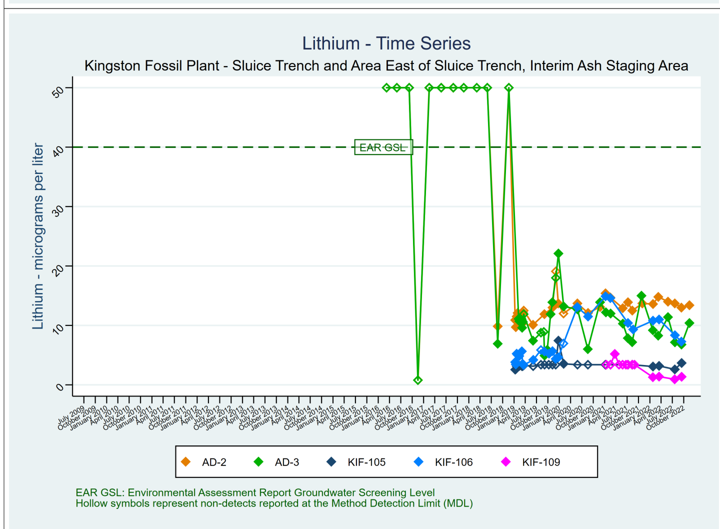


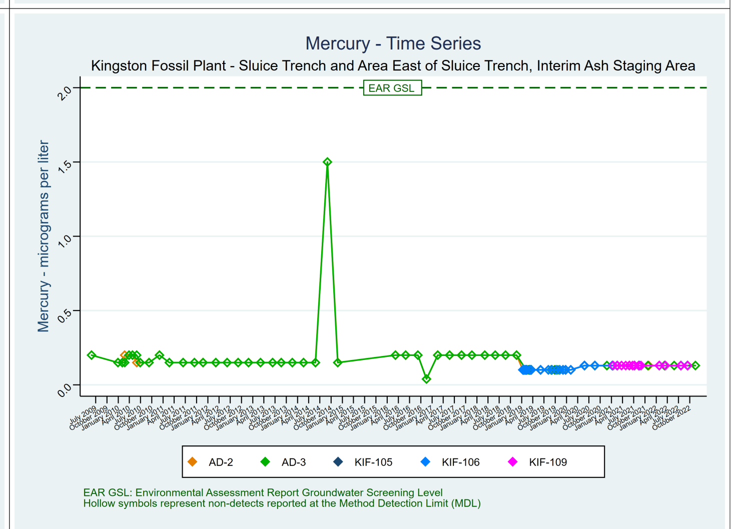


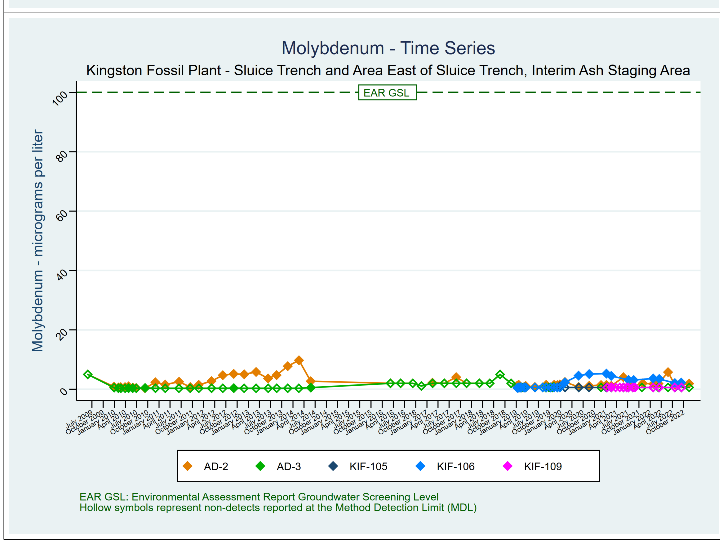


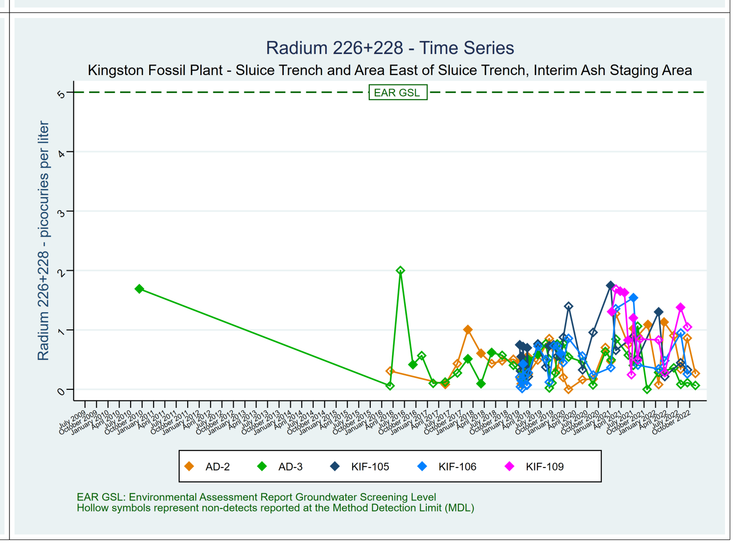

Cobalt - Time Series
Kingston Fossil Plant - Sluice Trench and Area East of Sluice Trench, Interim Ash Staging Area
Cobalt - micrograms per liter
0
10
20
30
40
EAR GSL
AD-2
AD-3
KIF-105
KIF-106
KIF-109
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)

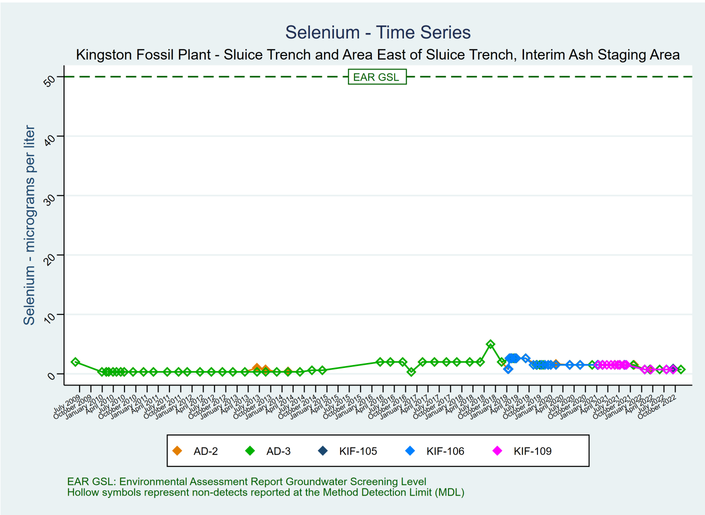

Lead - Time Series
Kingston Fossil Plant - Sluice Trench and Area East of Sluice Trench, Interim Ash Staging Area
Lead - micrograms per liter
0
3
6
9
12
15
EAR GSL
AD-2
AD-3
KIF-105
KIF-106
KIF-109
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)

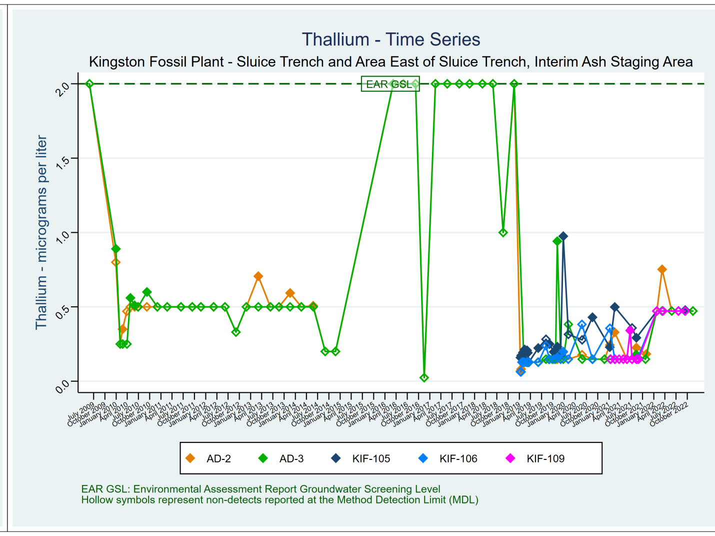

Lithium - Time Series
Kingston Fossil Plant - Sluice Trench and Area East of Sluice Trench, Interim Ash Staging Area
Lithium - micrograms per liter
0
10
20
30
40
50
EAR GSL
AD-2
AD-3
KIF-105
KIF-106
KIF-109
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)


Mercury - Time Series
Kingston Fossil Plant - Sluice Trench and Area East of Sluice Trench, Interim Ash Staging Area
Mercury - micrograms per liter
0.0
0.5
1.0
1.5
2.0
EAR GSL
AD-2
AD-3
KIF-105
KIF-106
KIF-109
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)

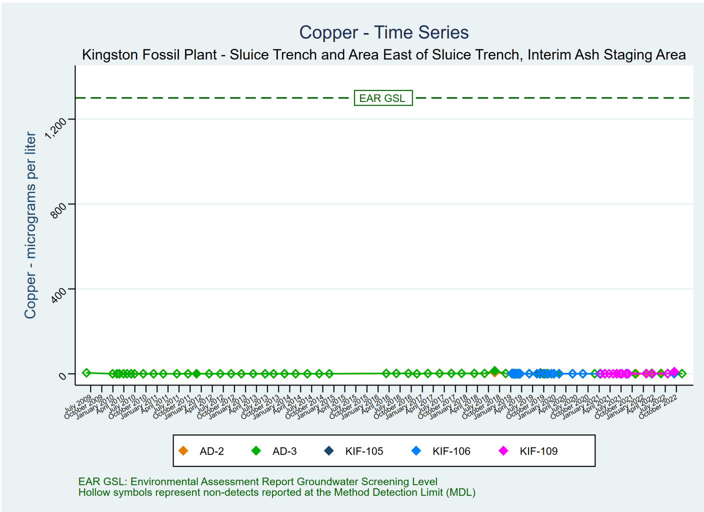

Molybdenum - Time Series
Kingston Fossil Plant - Sluice Trench and Area East of Sluice Trench, Interim Ash Staging Area
Molybdenum - micrograms per liter
0
20
40
60
80
100
EAR GSL
AD-2
AD-3
KIF-105
KIF-106
KIF-109
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)

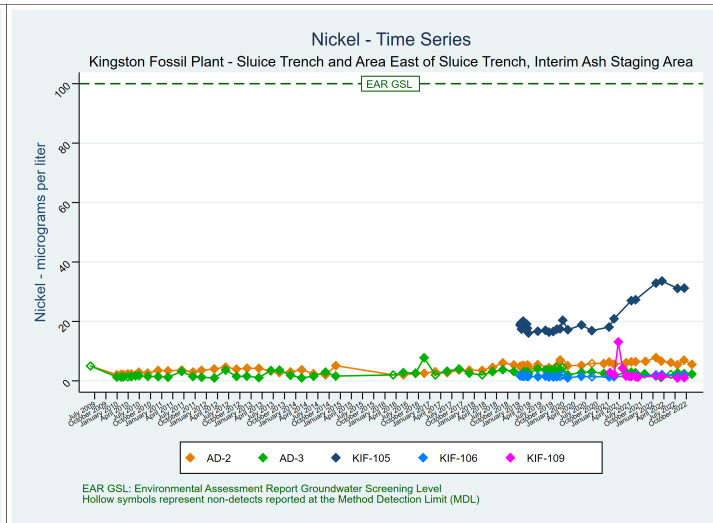

Radium 226+228 - Time Series
Kingston Fossil Plant - Sluice Trench and Area East of Sluice Trench, Interim Ash Staging Area
Radium 226+228 - picocuries per liter
0
1
2
3
4
5
EAR GSL
AD-2
AD-3
KIF-105
KIF-106
KIF-109
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)

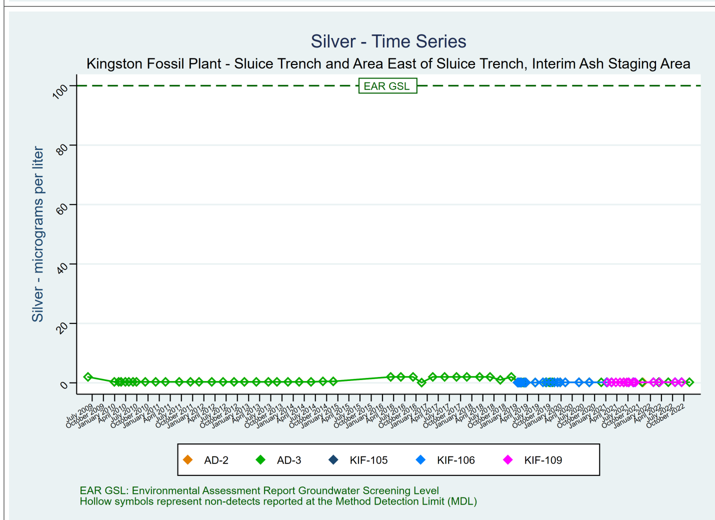

Selenium - Time Series
Kingston Fossil Plant - Sluice Trench and Area East of Sluice Trench, Interim Ash Staging Area
EAR GSL
Selenium - micrograms per liter
0
10
20
30
40
50
AD-2
AD-3
KIF-105
KIF-106
KIF-109
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)

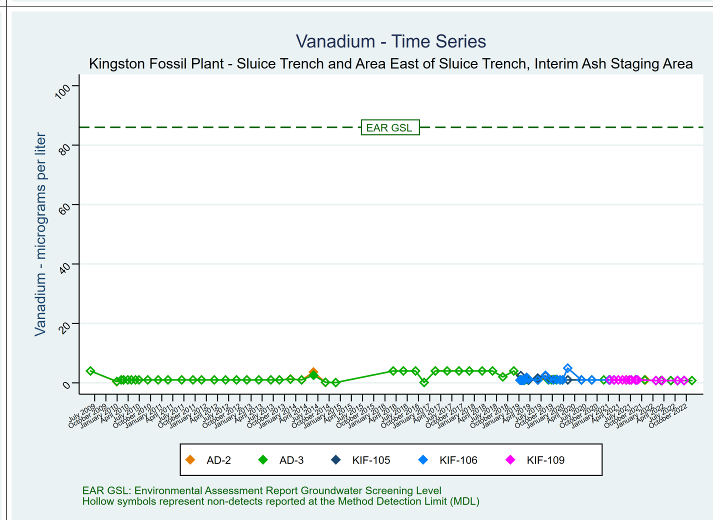

Thallium - Time Series
Kingston Fossil Plant - Sluice Trench and Area East of Sluice Trench, Interim Ash Staging Area
EAR GSL
Thallium - micrograms per liter
0.0
0.5
1.0
1.5
2.0
AD-2
AD-3
KIF-105
KIF-106
KIF-109
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)

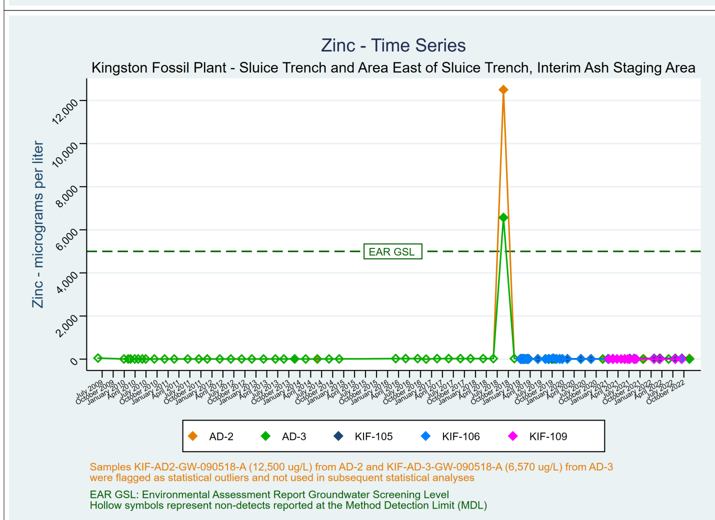
Time Series Plots
Sluice Trench and Area East of Sluice Trench, Interim Ash Staging Area Wells
TDEC Appendix I Parameters
Kingston Fossil Plant - Harriman, Tennessee











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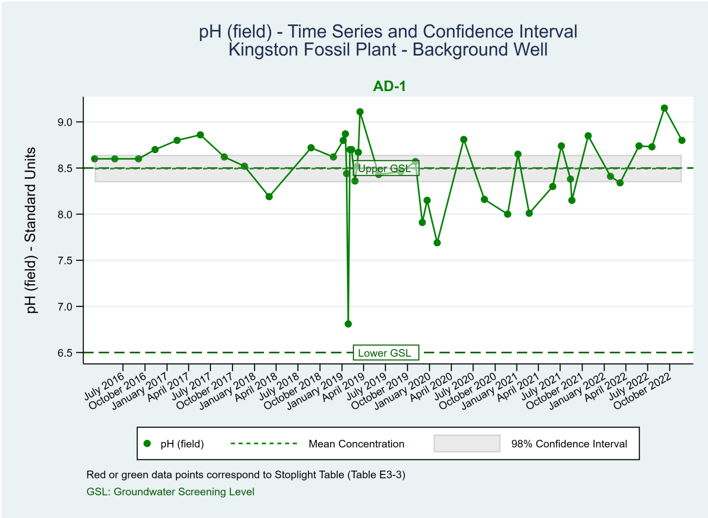
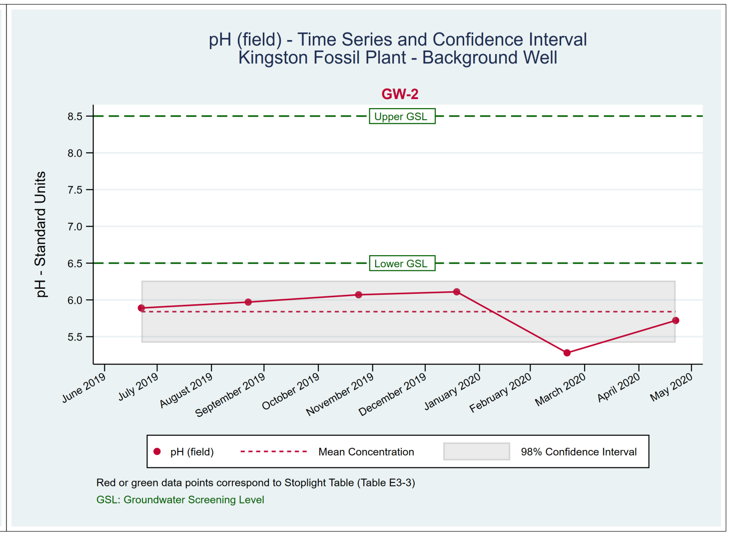
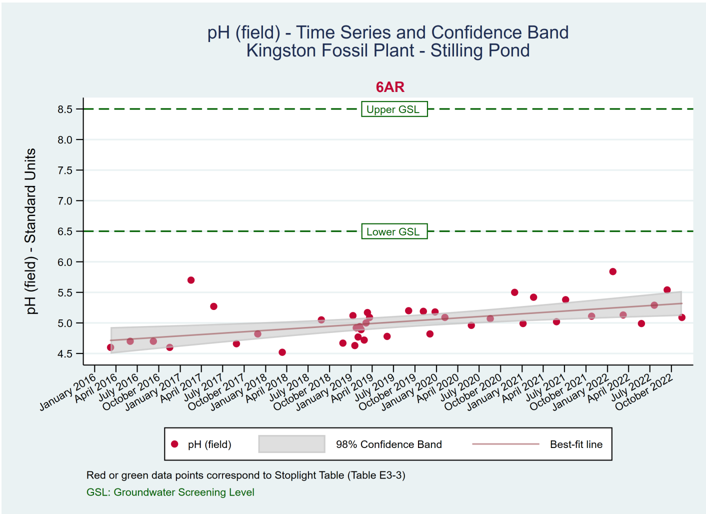
ATTACHMENT E.3-D
LINEAR REGRESSION PLOTS

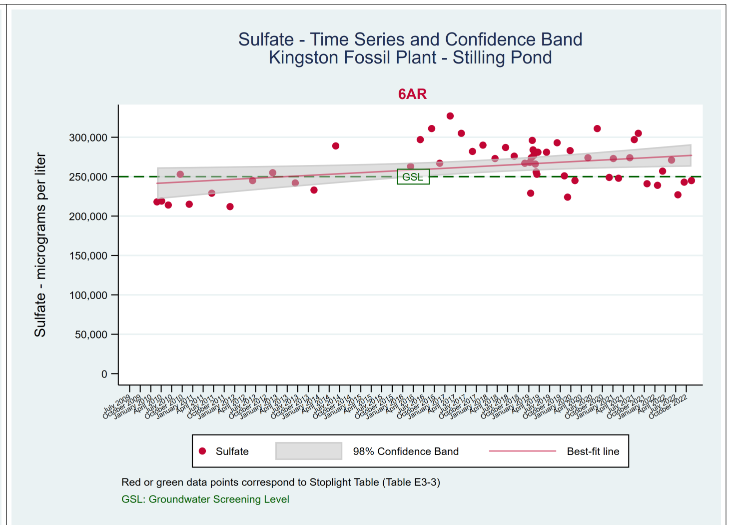
Regression Plots
Background Wells
CCR Rule Appendix III Parameters
Kingston Fossil Plant - Harriman, Tennessee

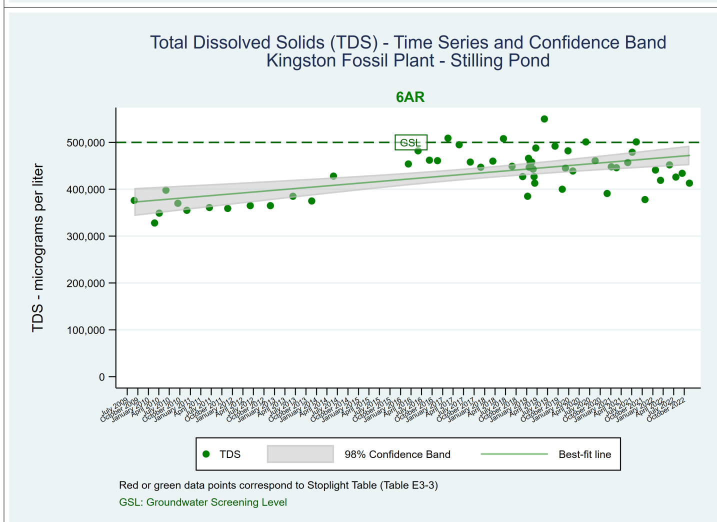


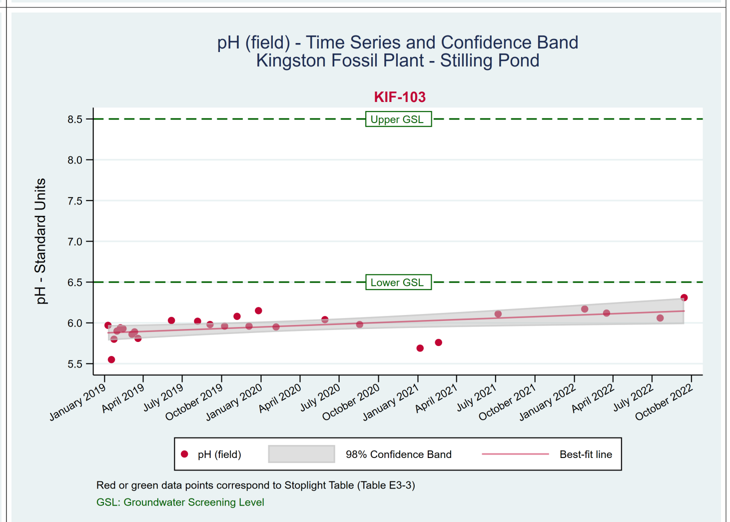


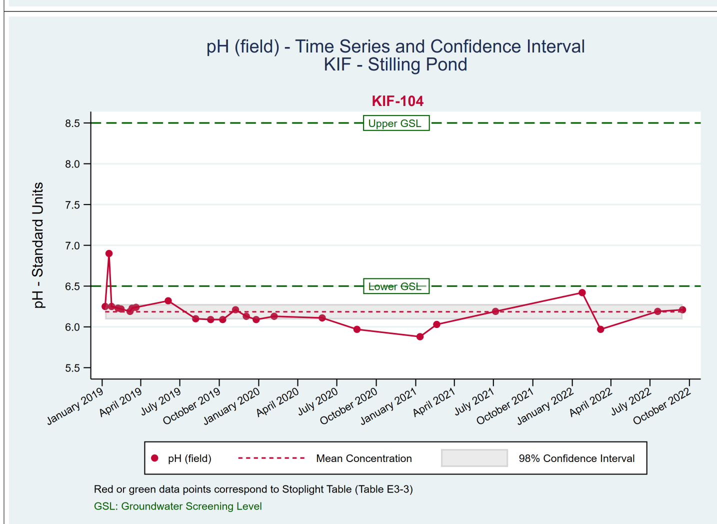
Regression Plots
Stilling Pond Wells
CCR Rule Appendix III Parameters
Kingston Fossil Plant - Harriman, Tennessee

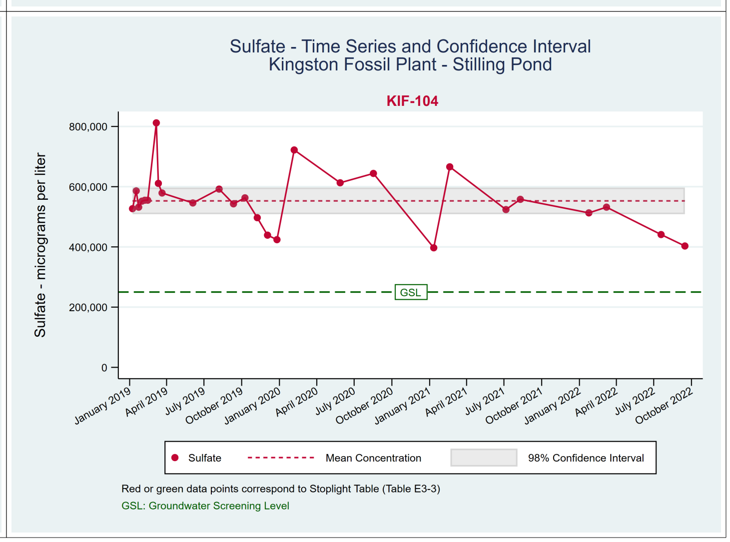


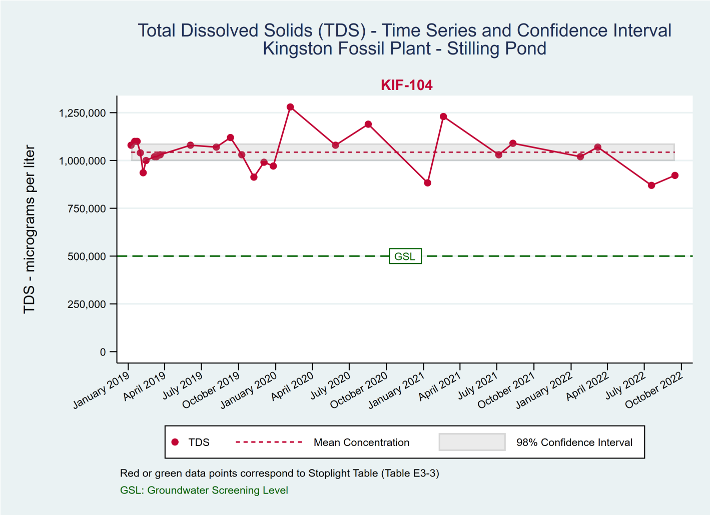












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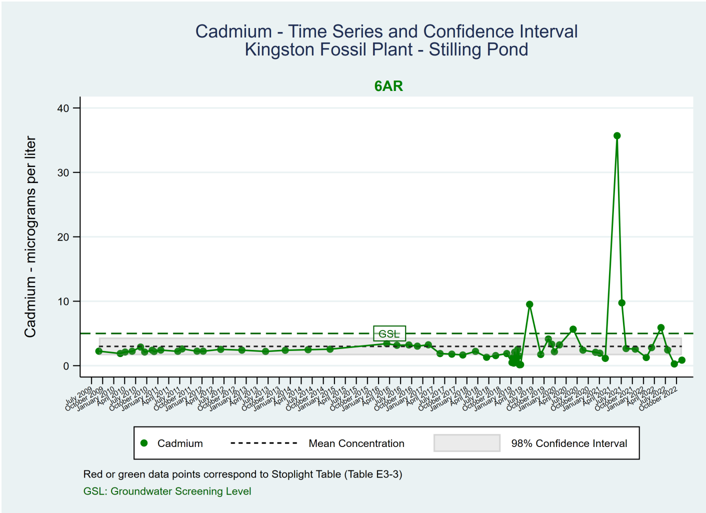
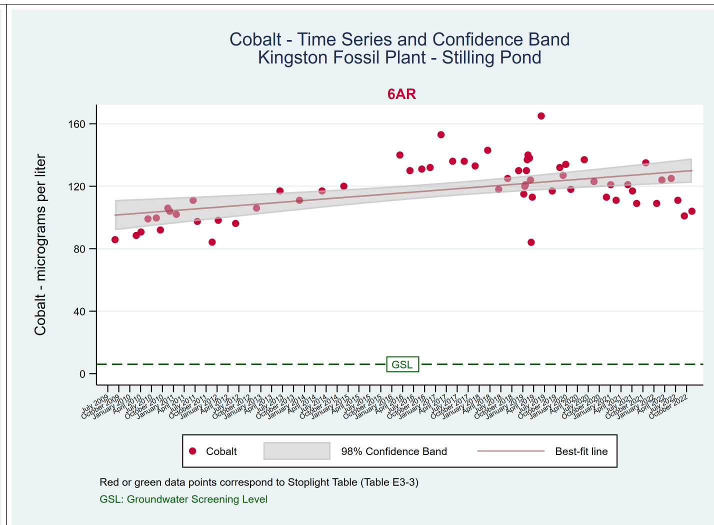
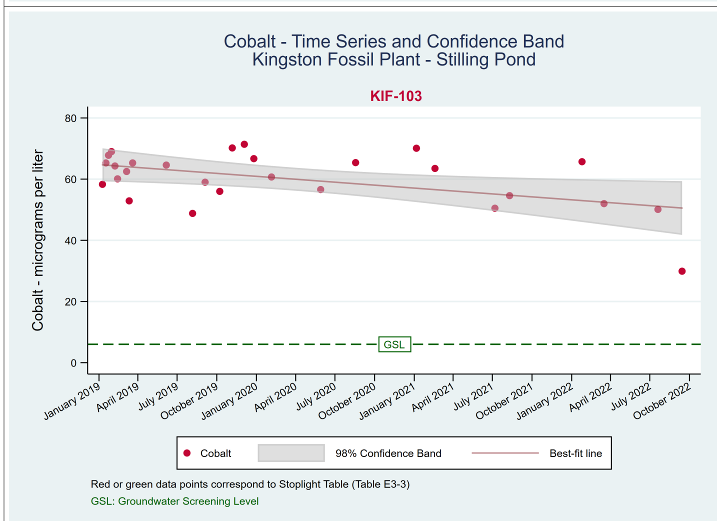
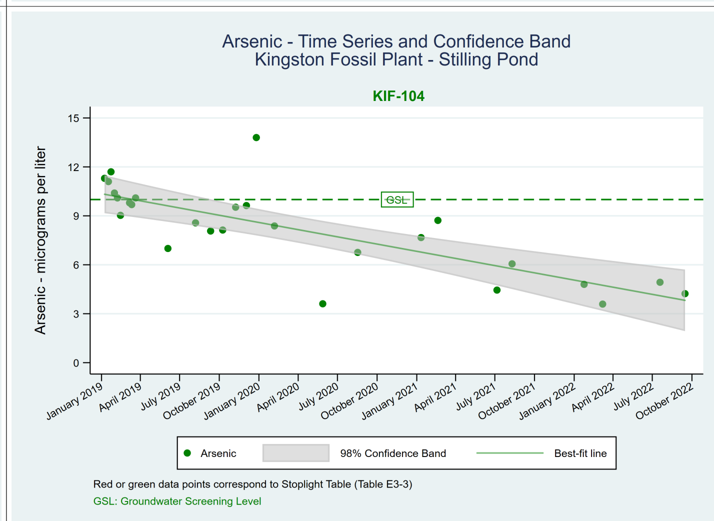
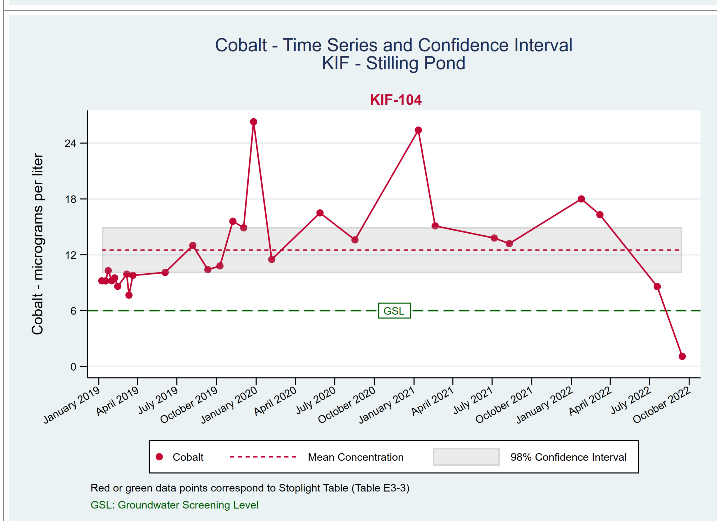
Regression Plots
Stilling Pond Wells
CCR Rule Appendix IV Parameters
Kingston Fossil Plant - Harriman, Tennessee











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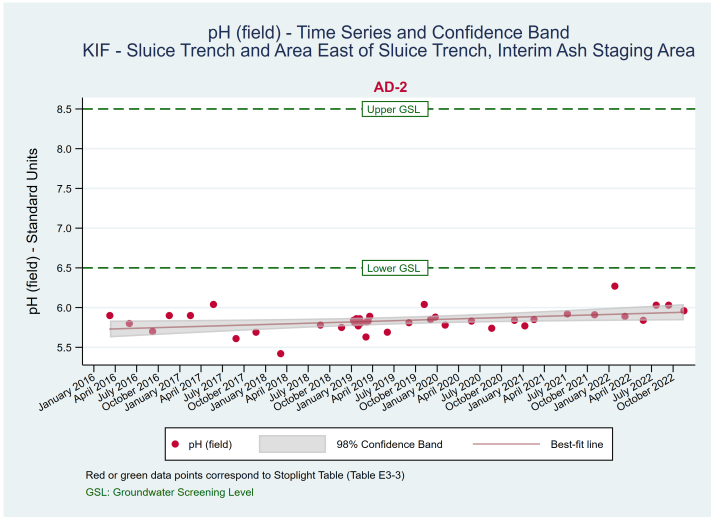
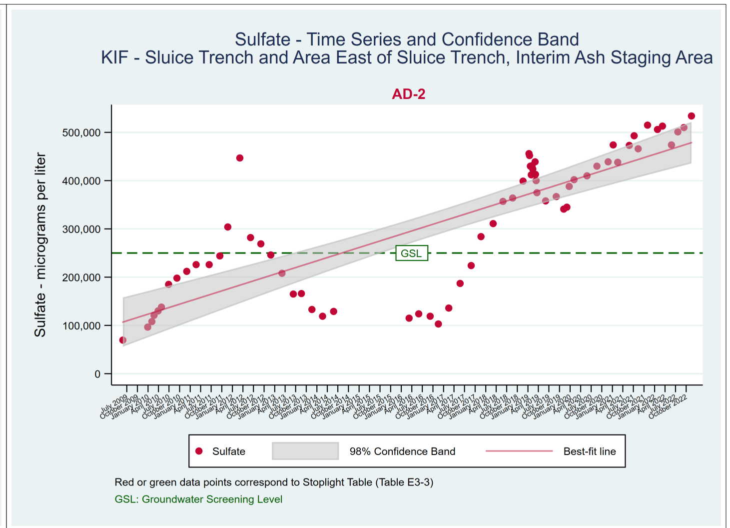
Regression Plots

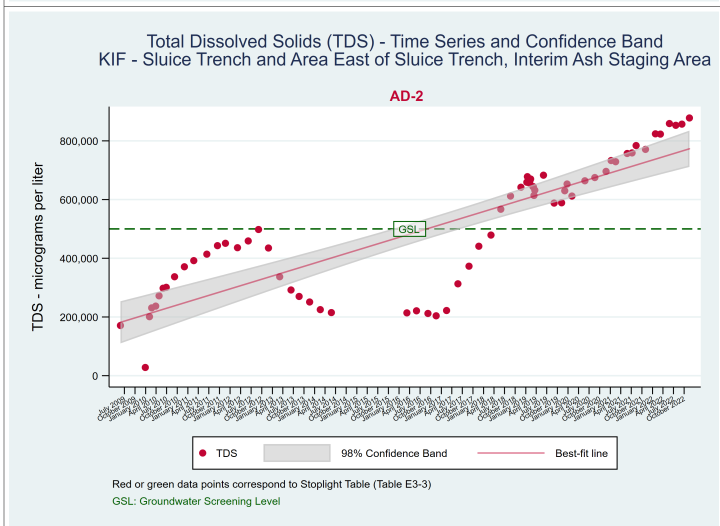
Sluice Trench and Area East of Sluice Trench, Interim Ash Staging Area Wells

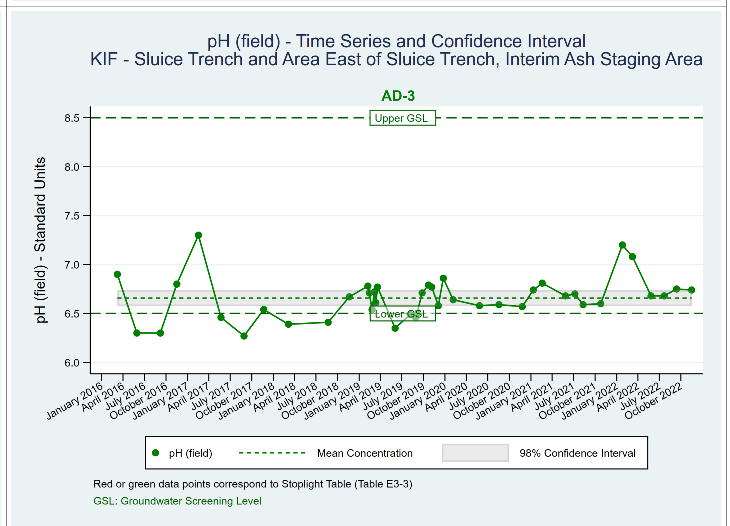
CCR Rule Appendix III Parameters

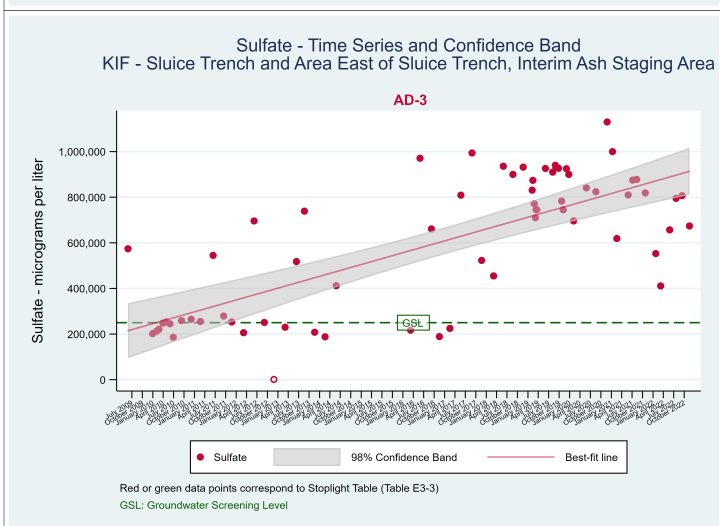
Kingston Fossil Plant - Harriman, Tennessee

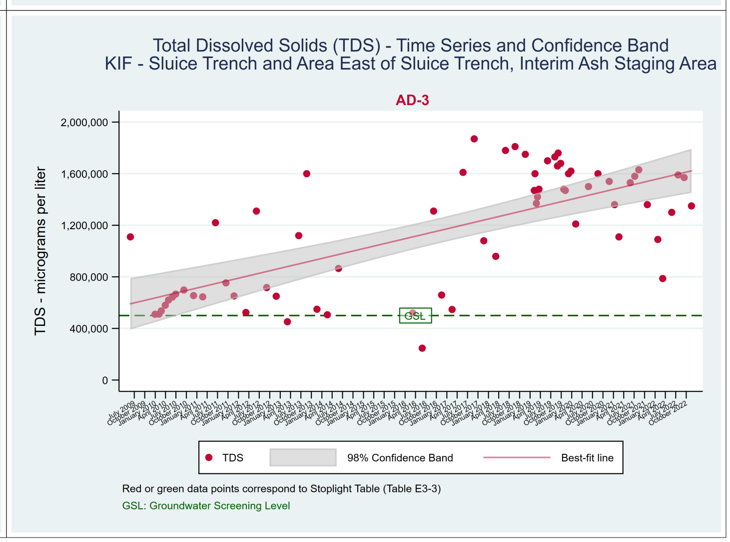


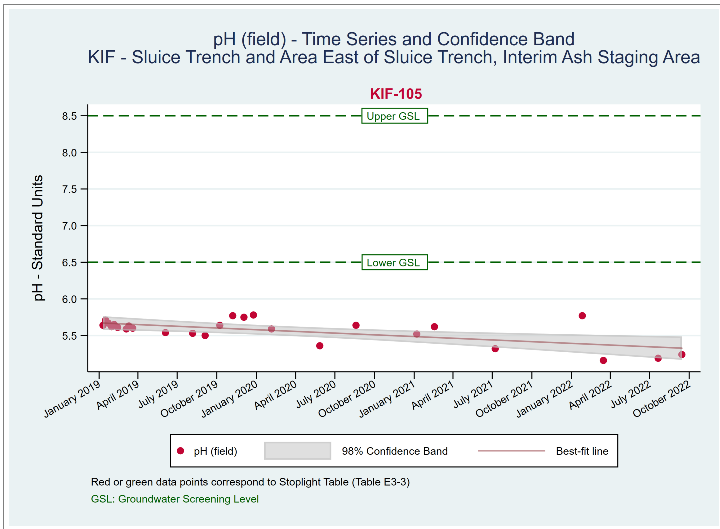


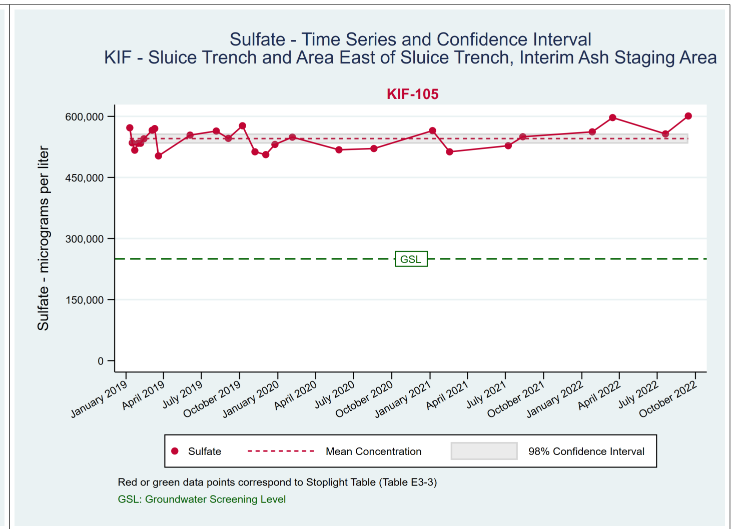


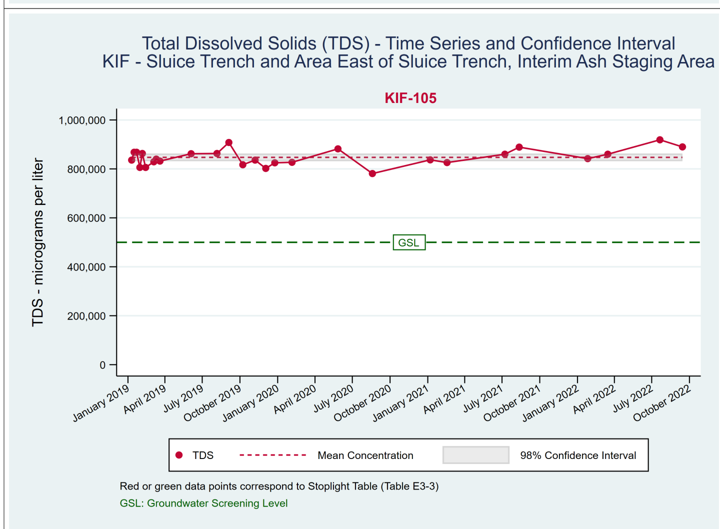


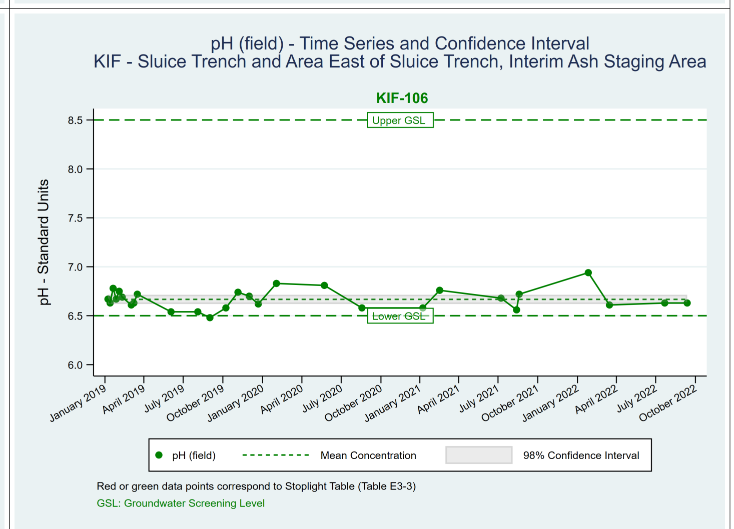





pH (field) - Time Series and Confidence Band
KIF - Sluice Trench and Area East of Sluice Trench, Interim Ash Staging Area
KIF-105
pH - Standard Units
Upper GSL
Lower GSL
pH (field)
98% Confidence Band
Best-fit line
Red or green data points correspond to Stoplight Table (Table E3-3)
GSL: Groundwater Screening Level


Sulfate - Time Series and Confidence Interval
KIF - Sluice Trench and Area East of Sluice Trench, Interim Ash Staging Area
KIF-105
Sulfate - micrograms per liter
GSL
Sulfate
Mean Concentration
98% Confidence Interval
Red or green data points correspond to Stoplight Table (Table E3-3)
GSL: Groundwater Screening Level


Total Dissolved Solids (TDS) - Time Series and Confidence Interval
KIF - Sluice Trench and Area East of Sluice Trench, Interim Ash Staging Area
KIF-105
TDS - micrograms per liter
GSL
TDS
Mean Concentration
98% Confidence Interval
Red or green data points correspond to Stoplight Table (Table E3-3)
GSL: Groundwater Screening Level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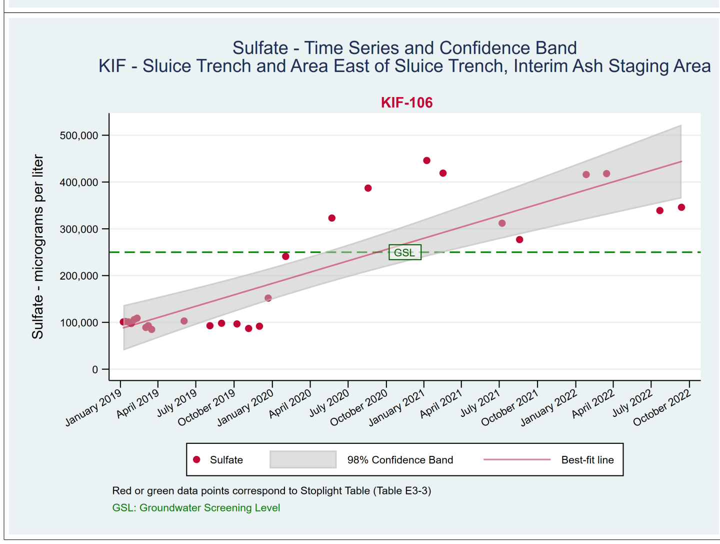
KIF-106
pH - Standard Units
Upper GSL
Lower GSL
pH (field)
Mean Concentration
98% Confidence Interval
Red or green data points correspond to Stoplight Table (Table E3-3)
GSL: Groundwater Screening Level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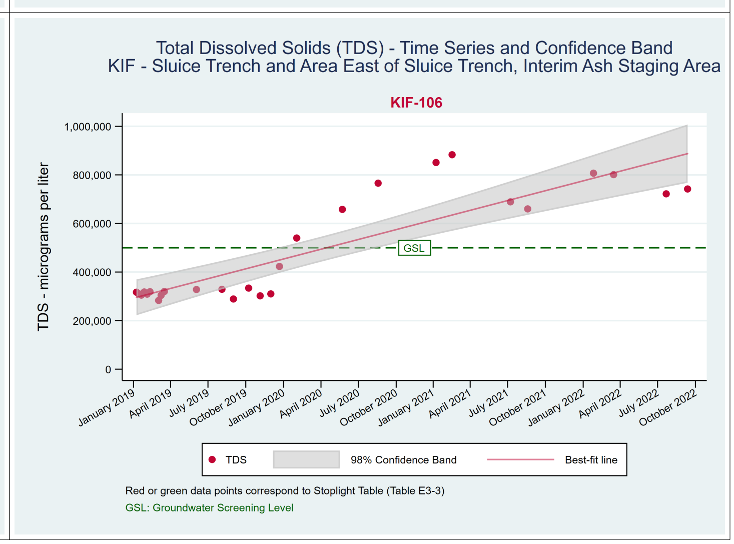
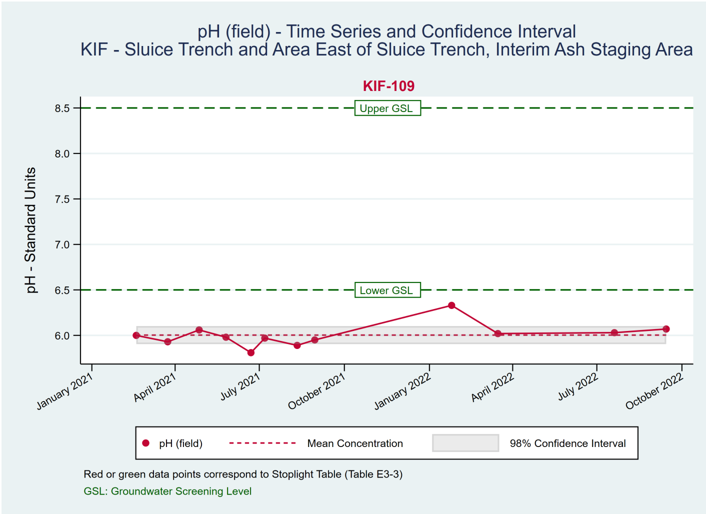
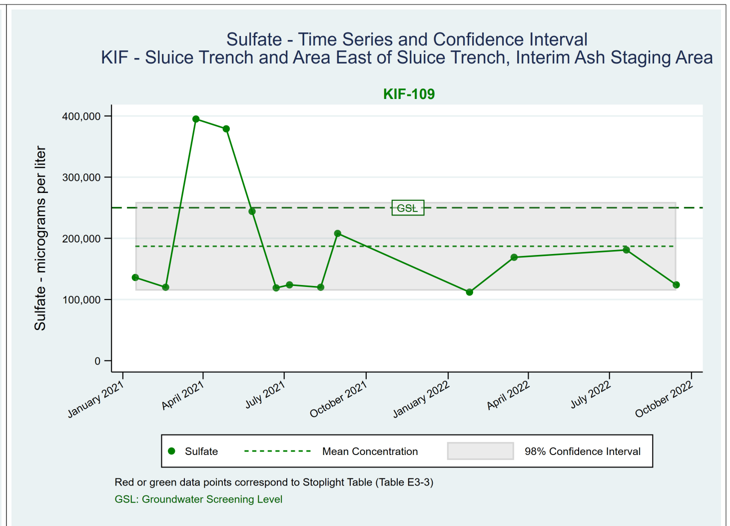
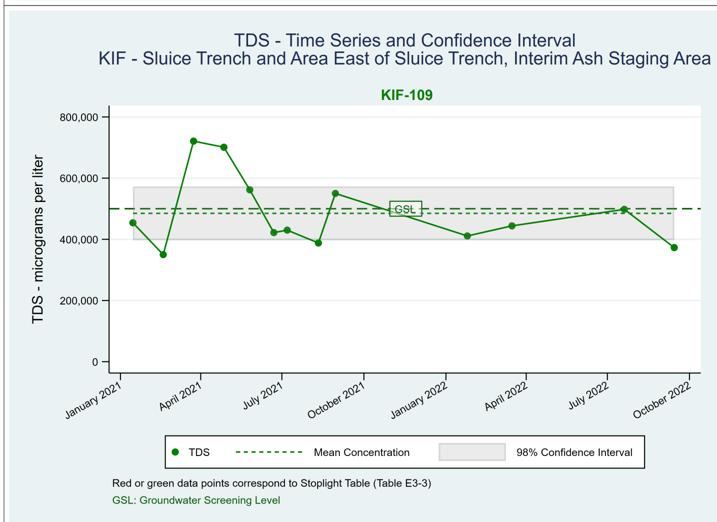
KIF - Sluice Trench and Area East of Sluice Trench, Interim Ash Staging Area
KIF-106
Sulfate - micrograms per liter
GSL
Sulfate
98% Confidence Band
Best-fit line
Red or green data points correspond to Stoplight Table (Table E3-3)
GSL: Groundwater Screening Level


Total Dissolved Solids (TDS) - Time Series and Confidence Band
KIF - Sluice Trench and Area East of Sluice Trench, Interim Ash Staging Area
KIF-106
TDS - micrograms per liter
GSL
TDS
98% Confidence Band
Best-fit line
Red or green data points correspond to Stoplight Table (Table E3-3)
GSL: Groundwater Screening Level







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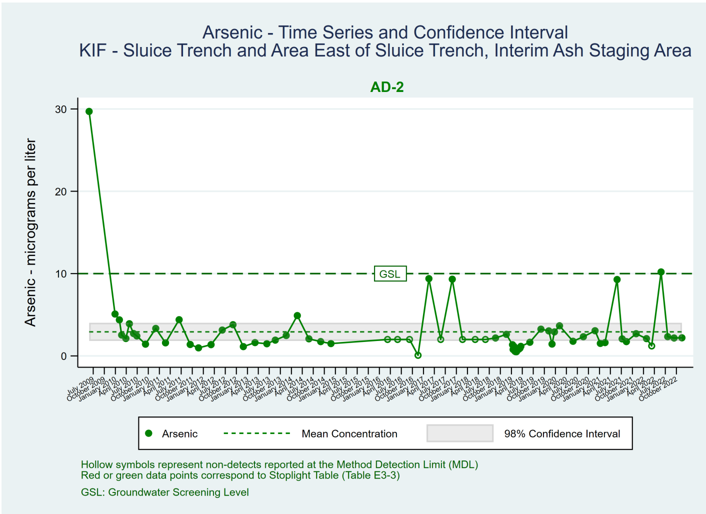
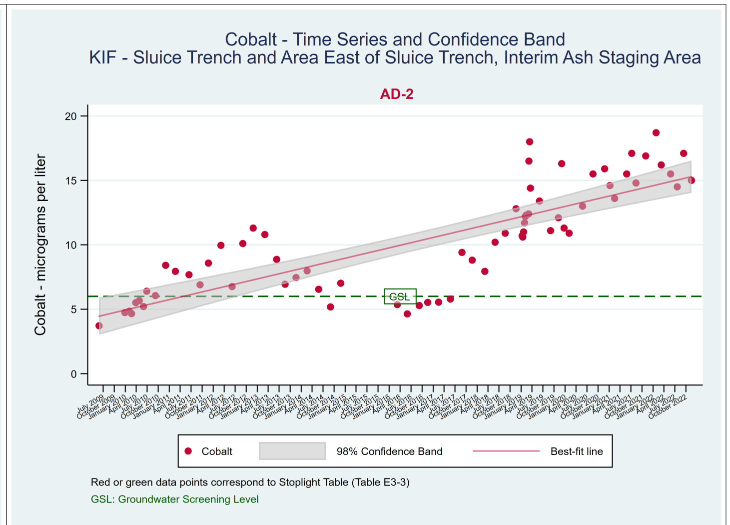
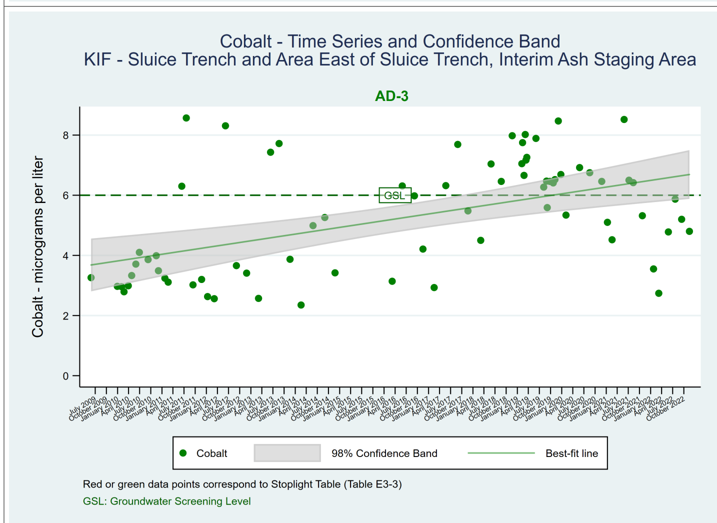
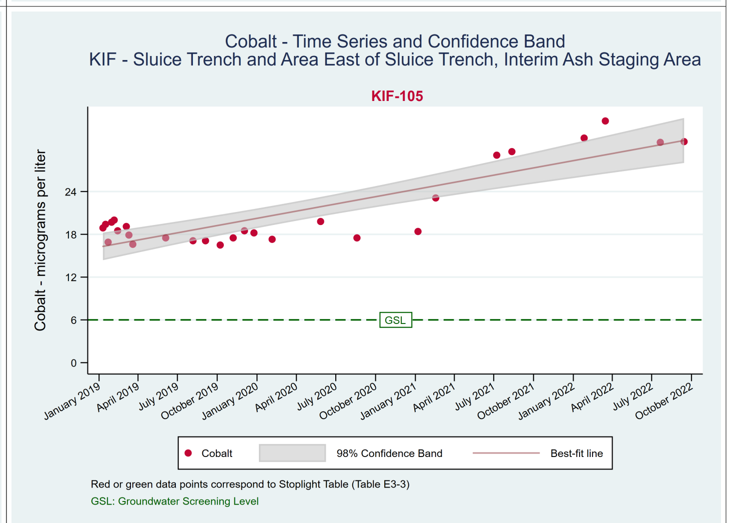
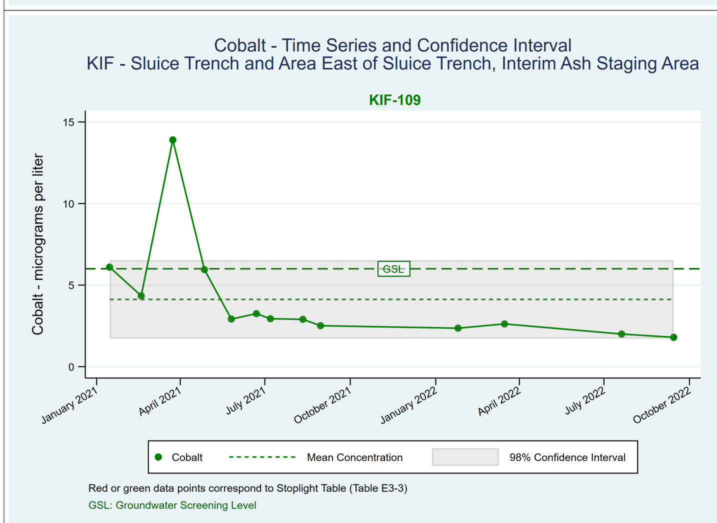
Regression Plots
Sluice Trench and Area East of Sluice Trench, Interim Ash Staging Area Wells
CCR Rule Appendix IV Parameters
Kingston Fossil Plant - Harriman, Tennessee











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ATTACHMENT E.3-E
LINEAR REGRESSION RESULTS

Attachment E.3-E - Linear Regression Results
Groundwater Investigation - Kingston Fossil Plant - Harriman, Tennessee

Well	Constituent Type	Constituent	p-value	Trend summary[1]
AD-1	CCR Rule Appendix III Parameters	pH	0.7739	No trend detected
GW-2	CCR Rule Appendix III Parameters	pH	0.3113	No trend detected
6AR	CCR Rule Appendix III Parameters	pH	0.0003	Increasing
		Sulfate	0.0063	Increasing
		Total Dissolved Solids	<0.0001	Increasing
	CCR Rule Appendix IV Parameters	Cadmium	0.2433	No trend detected
		Cobalt	<0.0001	Increasing
KIF-103	CCR Rule Appendix III Parameters	pH	0.0047	Increasing
	CCR Rule Appendix IV Parameters	Cobalt	0.0065	Decreasing
KIF-104	CCR Rule Appendix III Parameters	pH	0.1734	No trend detected
		Sulfate	0.0614	No trend detected
		Total Dissolved Solids	0.395	No trend detected
	CCR Rule Appendix IV Parameters	Arsenic	<0.0001	Decreasing
		Cobalt	0.3969	No trend detected
AD-2	CCR Rule Appendix III Parameters	pH	0.0086	Increasing
		Sulfate	<0.0001	Increasing
		Total Dissolved Solids	<0.0001	Increasing
	CCR Rule Appendix IV Parameters	Arsenic	0.1271	No trend detected
		Cobalt	<0.0001	Increasing
AD-3	CCR Rule Appendix III Parameters	pH	0.072	No trend detected
		Sulfate	<0.0001	Increasing
		Total Dissolved Solids	<0.0001	Increasing
	CCR Rule Appendix IV Parameters	Cobalt	<0.0001	Increasing
KIF-105	CCR Rule Appendix III Parameters	pH	0.0005	Decreasing
		Sulfate	0.08	No trend detected
		Total Dissolved Solids	0.0579	No trend detected
	CCR Rule Appendix IV Parameters	Cobalt	<0.0001	Increasing
KIF-106	CCR Rule Appendix III Parameters	pH	0.6825	No trend detected
		Sulfate	<0.0001	Increasing
		Total Dissolved Solids	<0.0001	Increasing
KIF-109	CCR Rule Appendix III Parameters	pH	0.1758	No trend detected
		Sulfate	0.3135	No trend detected
		Total Dissolved Solids	0.2954	No trend detected
	CCR Rule Appendix IV Parameters	Cobalt	0.0535	No trend detected

Notes:

CCR Rule - Title 40, Code of Federal Regulations, Part 257

1. Trend evaluated using linear regression. Regression considered significant when $p<0.05$.

2. Fluoride is both a CCR Rule Appendix III and CCR Rule Appendix IV constituent. In this table, fluoride has been grouped with the Appendix III constituents only to avoid duplication of results.

APPENDIX E.4

STATISTICAL ANALYSIS OF WATER QUALITY PARAMETERS

Originally Published as Appendix D of the Seep Sampling and Analysis Report

Stantec

Appendix D – Statistical Analysis of Water Quality Parameters

Kingston Fossil Plant
Seep Investigation

June 17, 2020

Prepared for:

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Chattanooga, Tennessee

Prepared by:

Stantec Consulting Services Inc.
Lexington, Kentucky

Revision Record

Revision	Description	Author		Quality Check		Independent Review	
0	Initial draft	Chris LaLonde	10/10/2019	Melissa Aslund	10/18/2019	Carole Farr	3/26/2020

Sign-off Sheet

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Abbreviations

AOC	Area of Concern
AOI	Area of Interest
CCR	Coal Combustion Residuals
DO	Dissolved Oxygen
KIF	Kingston Fossil Plant
M/AOC#2	Historic seep M/AOC#3
SAP	Sampling and Analysis Plan
SAR	Sampling and Analysis Report
Stantec	Stantec Consulting Services Inc.
USEPA	United States Environmental Protection Agency
UTL	Upper Tolerance Level

June 17, 2020

1.0 INTRODUCTION

A statistical analysis of water quality parameter data collected in Emory River adjacent to the Kingston Fossil Plant (KIF Plant) was conducted as part of the seep investigation. The statistical analysis was used to evaluate whether there are statistically significant differences between monitoring results collected "adjacent to" and "upstream of" historical seep/Areas of Concern (AOC) locations and between intermediate and upstream control areas. This appendix to the KIF Plant seep investigation sampling and analysis report (SAR) presents the statistical approach and methods used for this analysis and the analysis results.

2.0 OBJECTIVE

The objective of the statistical analysis is to identify statistically significant differences between water quality parameter results measured "adjacent" to inaccessible historical seep/AOC locations and results measured "upstream" of those locations. As described in Section 3.2.1 of this SAR, four historical seep/AOC locations were identified and targeted for monitoring at the KIF Plant for the seep investigation.

An Area of Interest (AOI) is identified when statistically significant evidence indicates that: 1) water quality parameter results collected "adjacent" to historical seep/AOC locations are different than water quality parameter results collected "upstream" of historical seep locations/AOC for all four parameters, or 2) intermediate areas differ significantly from upstream control areas for all four parameters.

3.0 DATASETS

In accordance with the Seep Sampling and Analysis Plan (SAP), datasets were generated consisting of water quality parameter measurements for each of the four field parameters for each historical seepage location/AOC identified by Tennessee Valley Authority for evaluation. The data used in the statistical analysis were obtained in spreadsheet format from the "*Seep Investigation/ Surface Stream Field Parameter Measurement Forms"*, which were prepared in real time as the field investigation was being conducted. Statistical datasets were established based on proximity to individual or combined historical seep/AOC locations. A summary of the measurement location identifications and the number of measurements is provided in Table D.1.

In addition to the measurements associated with each of the four historical seep/AOC locations, measurements were also collected in intermediate areas between these locations. The distance between these measurements was typically 200 feet. Overall, this resulted in the collection of a total of 17 intermediate measurements, collected over five intermediate areas (Exhibit A.1; Appendix A).

Finally, data were also collected from two "upstream control areas" and placed into two groups for evaluation: UC24 (measurements collected on April 24, 2019) includes upstream control locations KIF-UC-98 through KIF-UC-117, and UC25 (measurements collected on April 25, 2019) includes upstream control measurement locations KIF-UC-153 through KIF-UC-172 (Exhibit A.1; Appendix A). A total of 20 measurements were collected from each "upstream control area". The distance between these measurements was approximately five feet.

Measurements collected from the intermediate areas were combined by location and compared statistically to measurements collected from the upstream control areas to identify statistically significant differences between each of the four parameters.

4.0 STATISTICAL ANALYSIS METHODS

In accordance with the Seep SAP, the following statistical analysis methods were used to evaluate the water quality parameter measurement results:

- Formal hypothesis testing was used to identify statistically significant differences between adjacent and upstream monitoring data for historic seep/AOC locations by comparison of mean parameter concentrations between the datasets; and
- Formal hypothesis testing was used to identify statistically significant differences between intermediate area data and control area data for intermediate area locations. Tolerance interval methods were utilized to assess differences between monitoring data collected in intermediate areas compared to control area(s).

The statistical analysis was conducted in three phases: 1) exploratory data analysis/outlier screening, 2) testing of statistical assumptions, and 3) formal hypothesis testing. These phases are discussed below. Analyses were conducted using United States Environmental Protection Agency (USEPA) ProUCL (version 5.1.002) and STATA Statistics and Data Analysis (version 15.1).

4.1 EXPLORATORY DATA ANALYSIS/OUTLIER SCREENING

Initially, the monitoring data associated with historical seep areas were plotted on time-series graphs and in box plots. Time-series graphs allow for the identification of trends, outliers, and to visually identify differences between water quality parameter measurements that were collected in a downstream to upstream direction. Box plots allow for the identification of outliers and provide a basic sense of the potential underlying statistical distributions. The time-series and box plots are presented in Attachment D.1. In addition to graphical analysis, descriptive statistics were calculated for each water quality parameter for each historical seep/AOC location, intermediate areas, and upstream control areas. A summary of the descriptive statistics is presented in Attachment D.2.

Following the calculation of descriptive statistics, the data was screened for possible outliers. Outliers are data points that are abnormally high or low as compared to the rest of the measurements and may represent anomalous data and/or data errors. Outliers may also represent natural variation of constituent concentrations in environmental systems. During the seep investigation, water quality parameters were measured at intermediate area locations, upstream control locations and downstream, adjacent and upstream of historical seeps/AOC locations. Utilizing the complete set of data to screen for the presence of outliers allowed for evaluation of potential spatial variation in the natural ecosystem. Screening for outliers is a critical step as outliers can bias the statistical testing results.

Outliers are identified graphically using side by side box plots and time-series graphs (Attachment D.1). Suspect visual outliers were further analyzed to determine if they are extreme outliers. The Tukey's procedure (Tukey, 1977) as outlined in the USEPA document*: "Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities. Unified Guidance"* (USEPA 2009) – (Unified Guidance) was used to identify extreme outliers. The Tukey's procedure is briefly outlined below:

***Lower extreme outlier*:** The value is less than: 25^{th} percentile – (3 x interquartile range)

or

Upper extreme outlier: The value is greater than: 75^{th} percentile + (3 x interquartile range)

where:

Interquartile Range = 75^{th} percentile value – 25^{th} percentile value

If an outlier was identified visually and considered extreme (Tukey's procedure), then formal statistical testing (Dixon's and/or Rosner tests) was conducted to confirm that the data point is a statistically significant outlier. Utilizing the procedures outlined above, no outliers were identified or removed from the analytical dataset.

4.2 TEST OF STATISTICAL ASSUMPTIONS

In environmental applications, formal hypothesis testing is commonly used to compare mean values between two "populations". In the case of the investigation of historical seep/AOCs locations at the KIF Plant, the populations can be defined as monitoring results collected ***adjacent*** to the historical seep/AOC and monitoring results collected immediately ***upstream*** of the historical seep/AOC location. In the case of the investigation of intermediate areas, the population can be defined as monitoring results collected in the ***intermediate areas*** and monitoring results collected in the ***upstream control areas***.

Two sample t-tests were used to identify statistically significant differences between monitoring data collected adjacent to historical seeps/AOCs and data collected immediately upstream. As with most statistical tests, t-tests must meet statistical assumptions in order to produce reliable statistical conclusions. T-tests have two statistical assumptions: 1) the data "fit" or can be transformed to fit the normal distribution, and 2) the variance of each population being compared are equal (homoscedasticity).

The assumption of normality was tested visually using Normal Q-Q plots and statistically using the Shapiro-Wilks Test (alpha 0.01). Data for each parameter in adjacent and upstream measurements were normally distributed. Normal Q-Q plots are presented in Attachment D.3. The assumption of homoscedasticity was tested using the F-Test for the Equality of Two-Variances. In instances where variances were not equal, the Satterthwaite's degrees of freedom were used to adjust for unequal variances. The results of the evaluation of normality and equality of variances between the upstream and adjacent measurement locations are presented in Table D.2.

4.3 FORMAL HYPOTHESIS TESTING

The objective of formal hypothesis testing is to determine whether mean water quality parameter monitoring results for the "adjacent" datasets are statistically different than the results for the "upstream" datasets. Hypothesis tests are standard statistical methods used to decide between two competing alternatives based on available data. Uncertainties arise when sample statistics are used as estimates of "true" but unknown population parameters (mean, standard deviation). Hypothesis testing provides the framework for managing these uncertainties and controlling potential decision errors (Ofungwu, 2014).

Hypothesis tests are set up based on two competing alternatives. The null hypothesis (H_o) represents baseline conditions or conditions of no effects/differences. The null hypothesis can be represented mathematically as:

H_o: Mean Adjacent – Mean Upstream = 0; or Mean Adjacent = Mean Upstream

The alternative hypothesis is simply the opposite of the null hypothesis and can be written as:

H_a: Mean Adjacent – Mean Upstream ≠ 0

If there is an *a priori* idea that a parameter's mean may be greater than or less than the upstream mean the alternative hypothesis can be written as:

H_a: Mean Adjacent – Mean Upstream < 0 or Mean Adjacent – Mean Upstream > 0

The former alternative hypothesis is considered a two-sided test (e.g., it is unknown if the difference will be higher or lower and therefore, need to account for both possibilities). The later alternative hypotheses are considered a one-sided test (e.g., there is *a priori* knowledge of the direction of change – the parameter measurement is expected to be higher or lower when comparing adjacent to upstream monitoring data).

Appropriate hypothesis tests were established prior to examining the data. Two-sided tests were used to evaluate pH and temperature as there is no *a priori* knowledge that these parameters are expected to be higher or lower when comparing adjacent to upstream monitoring data. However, one-sided tests were used to evaluate specific conductance and DO based on the following assumptions: 1) the specific conductance would be expected to be higher adjacent to an active seep as opposed to upstream due to expected higher concentrations of metals in water emanating from a Coal Combustion Residuals (CCR) unit and 2) the DO would be expected to be lower adjacent to an active seep in a similar area as opposed to DO in a surface stream.

The null and alternative hypotheses for the seep investigation are presented below:

- Specific Conductance (SC - microSiemens/centimeter)
  - H_o: Mean $SC_{Adjacent}$ - Mean $SC_{Upstream} = 0$
  - H_a: Mean $SC_{Adjacent}$ – Mean $SC_{Upstream} > 0$
- pH (Standard Units)
  - H_o: Mean $pH_{Adjacent}$ – Mean $pH_{Upstream} = 0$
  - H_a: Mean $pH_{Adjacent}$ – Mean $pH_{Upstream} \neq 0$
- Temperature (Temp – degrees Celsius)
  - H_o: Mean $Temp_{Adjacent}$ – Mean $Temp_{Upstream} = 0$
  - H_a: Mean $Temp_{Adjacent}$ – Mean $Temp_{Upstream} \neq 0$
- DO (milligrams/Liter)
  - H_o: Mean $DO_{Adjacent}$ – Mean $DO_{Upstream} = 0$
  - H_a: Mean $DO_{Adjacent}$ – Mean $DO_{Upstream} < 0$

Statistical hypothesis tests produce a p-value (probability value). The p-value represents the probability that the mean of the adjacent measurements is equal to the mean of the upstream measurements. If the p-value of a statistical test is ***small** (i.e., below the significance level)*, the normal procedure is to reject the null (Ho), accept the alternative (Ha), and conclude there is a ***statistically significant difference between adjacent and upstream monitoring results that is unlikely to have occurred by chance.***

The statistician establishes the “significance level” (α), which is typically set between 0.01 and 0.10. This can be thought of as an acceptable false positive rate (e.g., rejecting the null when the null is true, which is equivalent to finding a statistically significant difference between adjacent and upstream monitoring data, when in fact one does not exist).

The significance level for a single test needs to be adjusted in situations where multiple hypothesis tests are going to be conducted at a site. Conducting multiple statistical tests on a site increases the chances of getting a significant result simply by chance (e.g. false positive statistical test result). For example, 16 statistical tests were conducted at the KIF Plant to identify differences in adjacent and upstream water quality parameter monitoring data for the seep investigation; if alpha is set at 0.1 and the multiple testing is ignored, then the cumulative error rate can be calculated:

Cumulative error rate = $1-(1-0.1)^{16}$ = 81% chance of making false positive error

The Bonferroni correction was utilized to adjust the significance level to control the site-wide false positive rate described above. This method simply divides the desired overall significance level (0.10) by the number of hypothesis tests conducted site-wide (4 parameters x 4 historic seeps/AOCs = 16 tests). For the KIF Plant, the adjustment yields an individual test significance level of 0.1/16 tests = 0.00625. Therefore, to reject the null and determine that there is a statistically significant difference between adjacent and upstream monitoring results that is unlikely to have occurred by chance, the p-value of the test needs to be less than 0.00625.

All data followed the normal distribution parametric T-tests utilized. In the case where variances were not equal between adjacent and upstream measurements, the Satterthwaite two-sample T-test was used to account for unequal variances.

4.4 TOLERANCE INTERVALS

Tolerance limits consist of two values expected to contain a pre-specified proportion of the underlying data population with a specified level of confidence. For example, for a 95% tolerance interval with a 95% confidence level, there is 95% confidence that, on average, 95% of the data population is contained within the interval. The one-sided Upper Tolerance Level (UTL) is commonly used in environmental monitoring and is constructed using background data (Ofungwu, 2014).

The calculation of the UTL is straightforward:

$$UTL = \bar{x} + \tau s$$

Where:

- $\bar{x}$ = mean constituent concentration in background dataset
- s = standard deviation of constituent in background dataset
- τ = tau multiplier - based on size of dataset, confidence (95%) and desired coverage (95%)

Two sets of tolerance intervals were calculated for each parameter using data collected from control area UC24 (n=20) and UC25 (n=20), respectively. Prior to calculating tolerance intervals, the data were tested for normality and for outliers using methods described previously. All control area datasets were free of outliers and were normally distributed.

The statistical null hypothesis (H_o) is that mean parameter measurements collected from intermediate areas lie within the tolerance interval, and the alternate hypothesis (H_a) is that the mean parameter measurements are outside of the tolerance interval. In order to test these hypotheses, 95% confidence intervals around the mean parameter measurements from the intermediate area data were estimated and compared to the upstream control area tolerance intervals. Prior to calculating confidence intervals, the intermediate area monitoring data were pooled and tested for normality and for outliers using methods described previously. The intermediate area dataset was free of outliers and was normally distributed.

Confidence intervals were calculated based on the following equation:

$$Confidence\ Interval = \overline{x} +/- t_{1-\propto/2,n-1} * s/\sqrt{n}$$

Where,

$\overline{x}$ = mean parameter measurement in intermediate area

s = standard deviation of parameter measurement in intermediate area

n = number of measurements in intermediate area dataset

$t_{(1-\propto/2,n-1)}$ = two tailed t value, with n-1 degrees of freedom (where α = 0.05)

Statistically significant differences were identified if the confidence interval calculated using the intermediate area dataset falls outside of the applicable upstream control area tolerance interval.

5.0 STATISTICAL ANALYSIS RESULTS

The following sections describe the results of 1) the hypothesis testing comparing the water quality parameter results between the adjacent and upstream measurements at each of the four historical seep/AOC locations, and 2) the interval testing comparing the water quality parameter results from intermediate areas to two upstream control areas.

5.1 HYPOTHESIS TESTING RESULTS: ADJACENT AND UPSTREAM MEASUREMENT COMPARISONS AT HISTORIC SEEP/AOC LOCATIONS

A historic seep/AOC is considered an AOI when the mean values of all four water quality parameters (DO, pH, specific conductance and temperature) are found to be statistically different when comparing adjacent to upstream monitoring data. For pH and temperature, the difference between upstream and adjacent measurements may be either positive or negative. However, it is expected that an active seep would increase specific conductance (due to higher concentrations of metals in water emanating from a CCR unit) and decrease DO (as seep water from a similar area would have decreased DO relative to a surface stream). Therefore, only significant increases in specific conductance and significant decreases in DO in the adjacent areas, relative to the upstream areas were evaluated. Table D.3 provides a summary of the hypothesis testing, including the p-values obtained using procedures described in preceding sections to identify significant differences between adjacent and upstream water quality parameter monitoring data at the four identified historical seep/AOC locations. None of the evaluated historical seep locations/AOCs were observed to have statistically significant values across all four prescribed parameters. Therefore, no AOIs were identified for further investigation or data collection.

5.2 INTERVAL TESTING RESULTS: INTERMEDIATE AREA COMPARISON TO UPSTREAM CONTROL AREAS

Water quality parameter monitoring results collected from intermediate areas were evaluated against monitoring data collected from upstream control location groups (UC24 and UC25) to identify any AOIs. A visual comparison of the upstream control data suggests that there is a difference between water quality parameter readings between the two upstream control locations. Box plots comparing the distributions of the two upstream control areas are presented in Attachment D.1. The visual observations were confirmed using hypothesis testing; all four parameters were statistically significantly different when comparing UC24 to UC25. The differences are possibly due to physical location (i.e., UC25 is further north and located 'around the bend' of the river from investigated historical seep/AOC locations except for historic seep M/AOC#3 (M/AOC#3)).

To account for potential differences between upstream control locations, water quality parameter readings for intermediate areas north of M/AOC#3 were compared to the results from UC25; all other intermediate area readings were compared to the results from UC24. For an intermediate area to be considered an AOI, the mean values of all four water quality parameters (DO, pH, specific conductance and temperature) are required to be statistically different when monitoring data collected from intermediate areas are compared to data collected in the upstream control areas. Table D.4 presents a summary of the interval testing results used to identify significant differences between intermediate areas and upstream control location monitoring data. This analysis did not identify any additional AOIs for further investigation.

6.0 REFERENCES

Ofungwu, J., 2014. *Statistical Applications for Environmental Analysis and Risk Assessment*. Hoboken, New Jersey: John Wiley and Sons, Inc.

Tukey, J.W., 1977. *Exploratory Data Analysis*. Reading, Massachusetts: Addison-Wesely, 1977

U.S. Environmental Protection Agency, 2009. *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance*.

TABLES

TABLE D.1 – Summary of Water Quality Parameter Measurement Locations
Kingston Fossil Plant
April 2019

Historical Seep / AOC Locations	Measurement Location IDs	Number of Measurements		
		Downstream	Adjacent	Upstream
L/AOC#2	KIF-LAOC2-D-2 through KIF-LAOC2-U-30	10	8	11
HSK	KIF-HSK-D-35 through KIF-HSK-U-63	10	9	10
HSCluster-(C,R)	KIF-HSCR-D-69 through KIF-HSCR-U-96	10	8	10
M/AOC#3,HSD	KIF-MAOC3HSD-D-119 through KIF-MAOC3HSD-U-147	10	9	10

Notes:

1. Historic Seep (HS) and Area of Concern (AOC) locations and measurement location identications (IDs) are shown on Exhibits A.1 through A.3.

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TABLE D.2 – Tests of Normality and Equality of Variances between Adjacent and Upstream Monitoring Results
Kingston Fossil Plant
April 2019

	Historical Seep/AOC Location			
Monitoring Parameters	**L/AOC#2**	**HSK**	**HS Cluster-(C,R)**	**M/AOC#3,HSD**
Number of Samples (Adjacent / Upstream)	8 / 11	9 / 10	8 / 10	9 / 10
Dissolved Oxygen	Normal / =	Normal / =	Normal / ≠	Normal / ≠
pH	Normal / ≠	Normal / =	Normal / =	Normal / ≠
Specific Conductance	Normal / =	Normal / =	Normal / =	Normal / =
Temperature	Normal / =	Normal / ≠	Normal / =	Normal / =

Notes:

=	Variances are equal when comparing adjacent and upstream data sets
≠	Variances are not equal when comparing adjacent and upstream data sets
AOC	Historical Area of Concern
HS	Historical Seep
Normal	Data Sets (adjacent and upstream) are normally distributed (alpha=0.01)

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TABLE D.3 – Summary of Statistical Hypothesis Testing
Kingston Fossil Plant
April 2019

Historical Seep/ AOC Location	Number of Samples	p-value DO	p-value pH	p-value Specific Conductance	p-value Temperature
	Adjacent / Upstream	mg/L	SU	uS/cm	DEG C
L/AOC#2	8 / 11	0.9911	0.0699	0.1115	*0.0043*
HSK	9 / 10	0.0968	*0.0024*	0.1032	*0.0032*
HS Cluster-(C,R)	8 / 10	0.8677	0.3919	0.1039	*0.0026*
M/AOC#3, HSD	9 / 10	0.9926	*0.0000*	0.6558	*0.0004*

Notes:

AOC	Historical Area of Concern
DEG C	degrees Celsius
DO	Dissolved Oxygen
HS	Historical Seep
mg/L	milligrams per Liter
SU	Standard Units
SWFPR	site-wide false positive rate
uS/cm	microSiemens per centimeter

1. The p-value represents the probability that the mean of the adjacent measurements is equal to the mean of the upstream measurements. If a p-value is small (i.e., below the significance level), it is indicative that there is a statistically significant difference between adjacent and upstream monitoring results that is unlikely to have occurred by chance.

2. Adjusted Significance Level (SWFPR/No. of Statistical Tests): 0.10/16 = 0.00625

3. Shaded values indicate a statistically significant difference between measurements at relative locations to historical seeps/AOCs (p-value is below adjusted significance level, reject null hypothesis).

TABLE D.4 – Summary of Intermediate Area Statistical Testing
Kingston Fossil Plant
April 2019

Parameter	Confidence Interval Intermediate Area 1 [(a)]	Tolerance Interval		Confidence Interval Intermediate Area 2 [(b)]	Tolerance Interval	
		UC 25	Significant?		UC 24	Significant?
Dissolved Oxygen	(7.482 - 8.51)	(7.164 - 9.11)	No	(7.961 - 8.657)	(7.209 - 8.375)	No
pH	*(7.718 - 7.89)*	*(7.278 - 7.514)*	*Yes*	(6.813 - 7.149)	(7.071 - 7.251)	No
Specific Conductance	*(57.68 - 62.88)*	*(48.17 - 52.19)*	*Yes*	*(51.03 - 56.87)*	*(46.24 - 47.8)*	*Yes*
Temperature	(19.34 - 19.82)	(18.77 - 19.65)	No	(15.02 - 16.18)	(15.97 - 18.47)	No

Notes:

%	percent
UC	Upstream Control

[(a)] Confidence Interval: 95% confidence interval from intermediate areas north of M/AOC#3.

[(b)] Confidence Interval: 95% confidence interval from intermediate areas south of M/AOC#3.

1. Tolerance Interval: 95% tolerance interval with 95% coverage.
2. Shaded values are statistically significant differences if the confidence interval calculated using the intermediate area data set falls outside of the tolerance interval.

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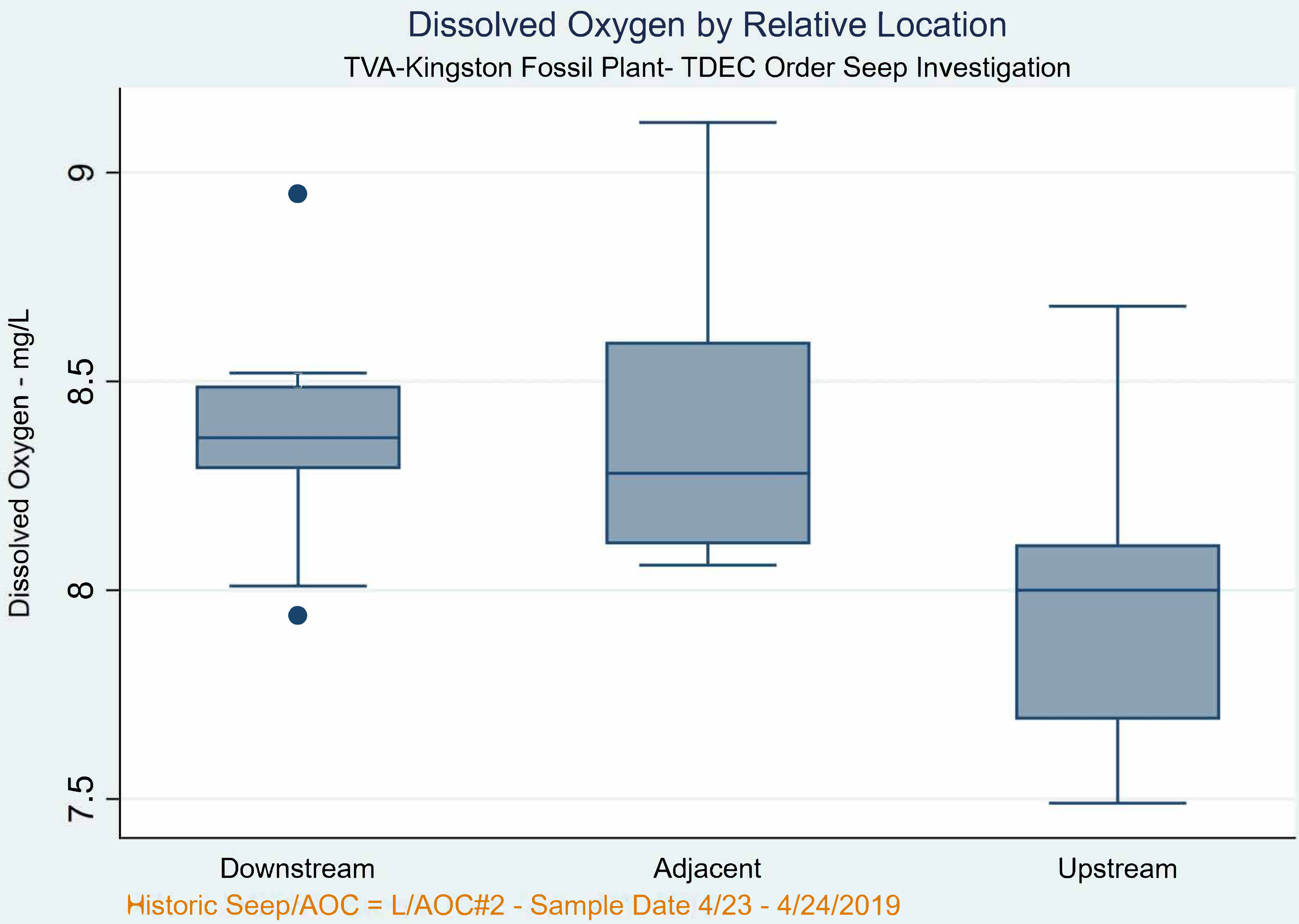
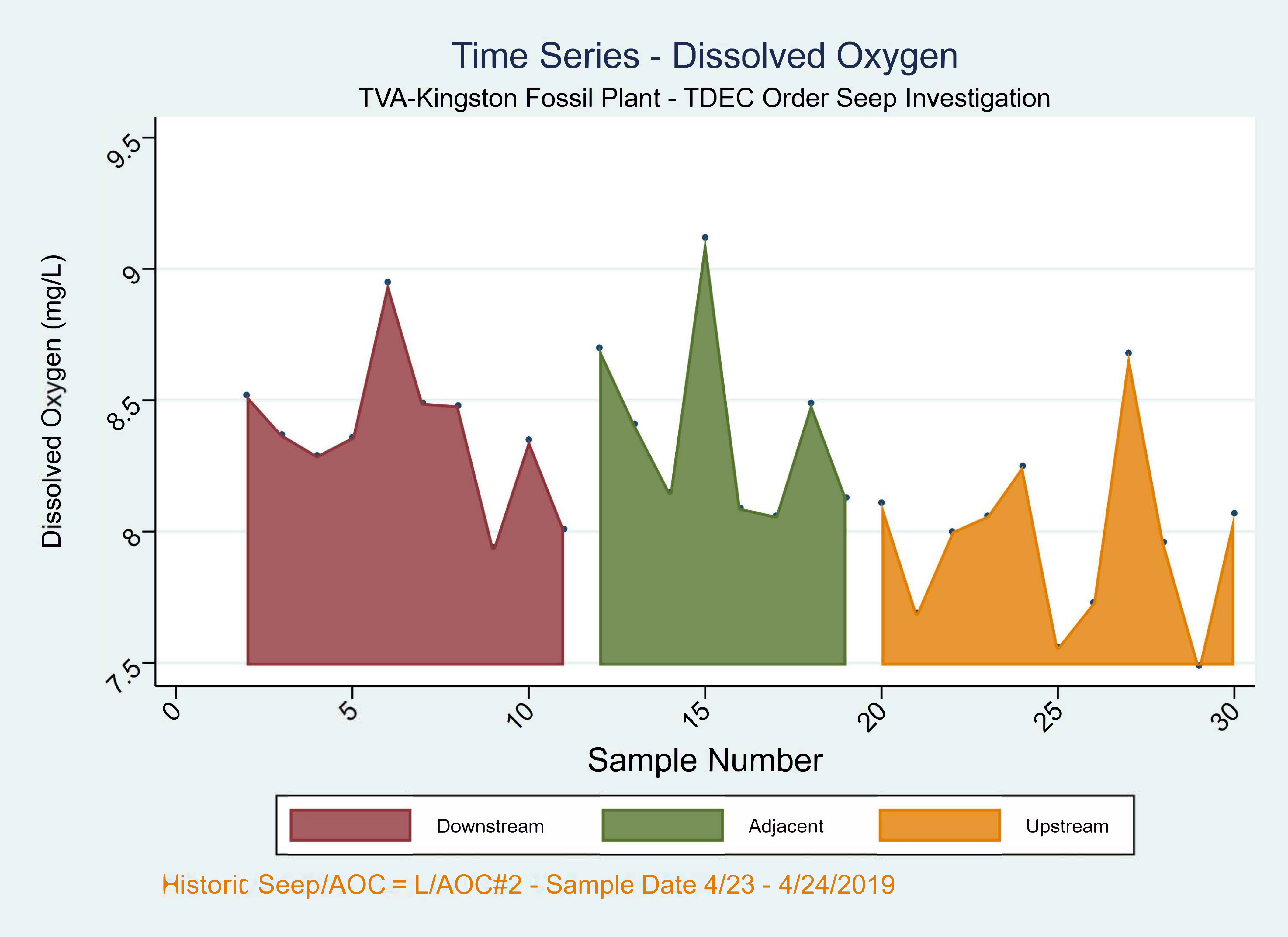
ATTACHMENTS

ATTACHMENT D.1

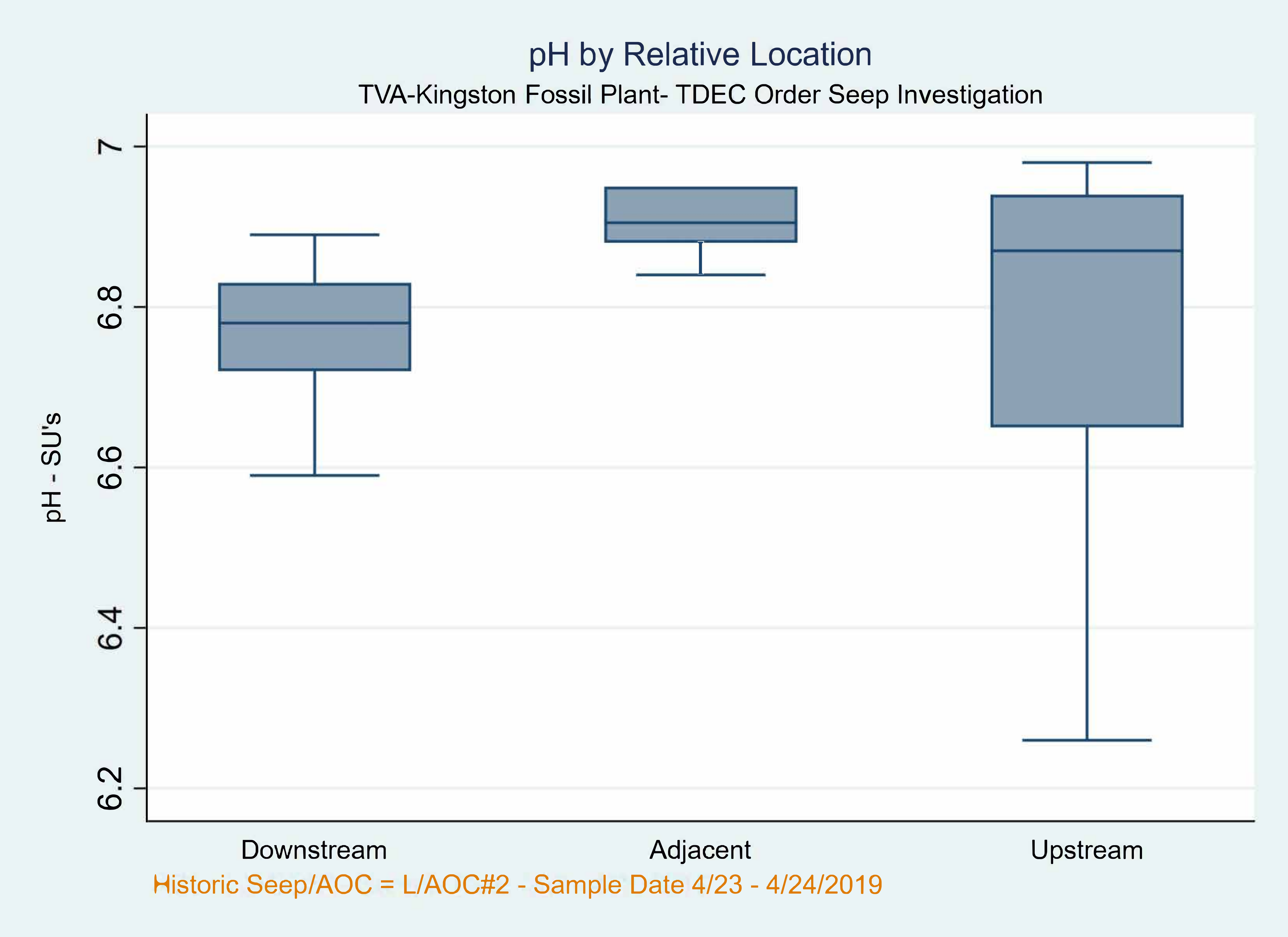
Time-Series and Box Plots

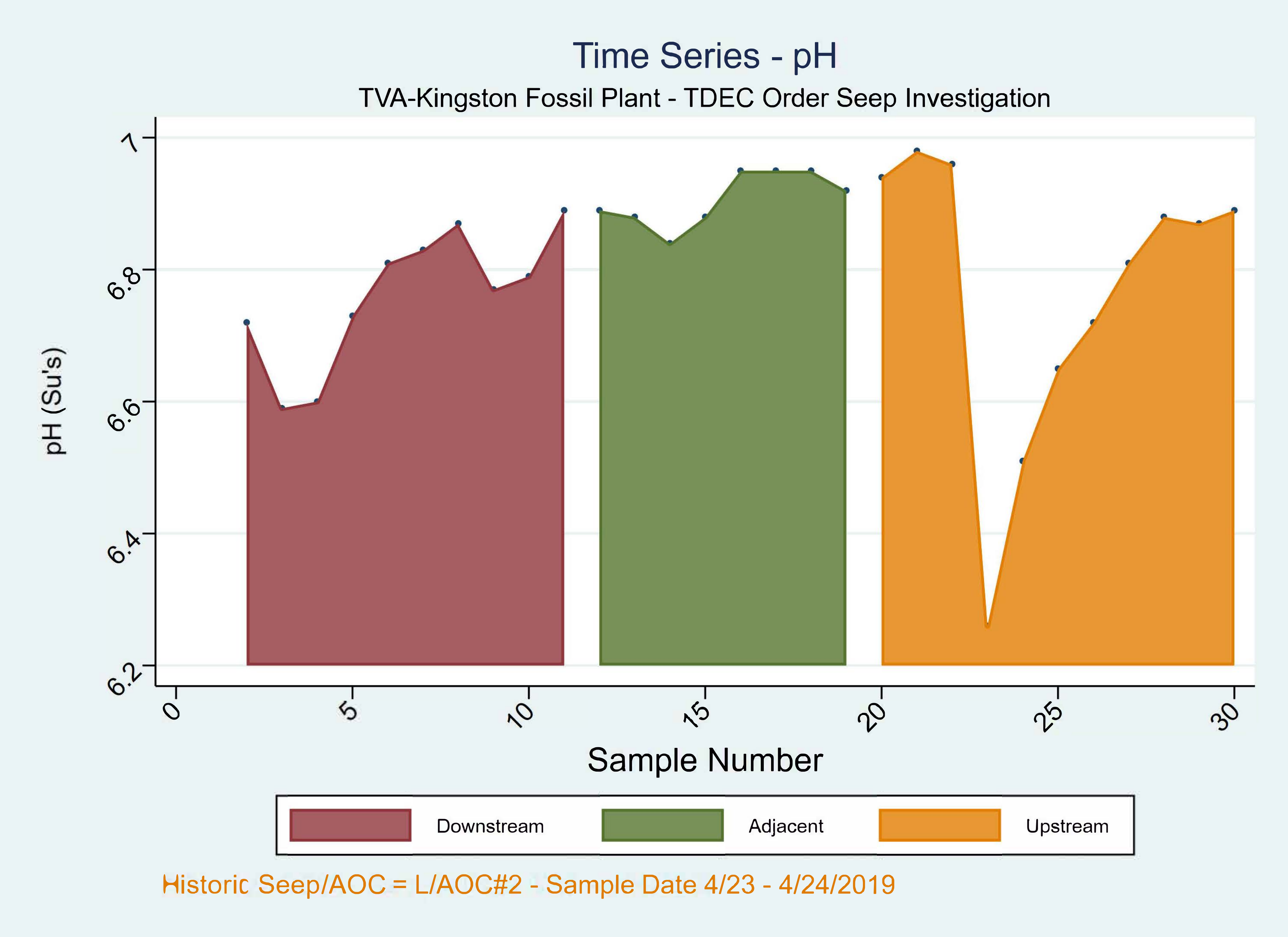


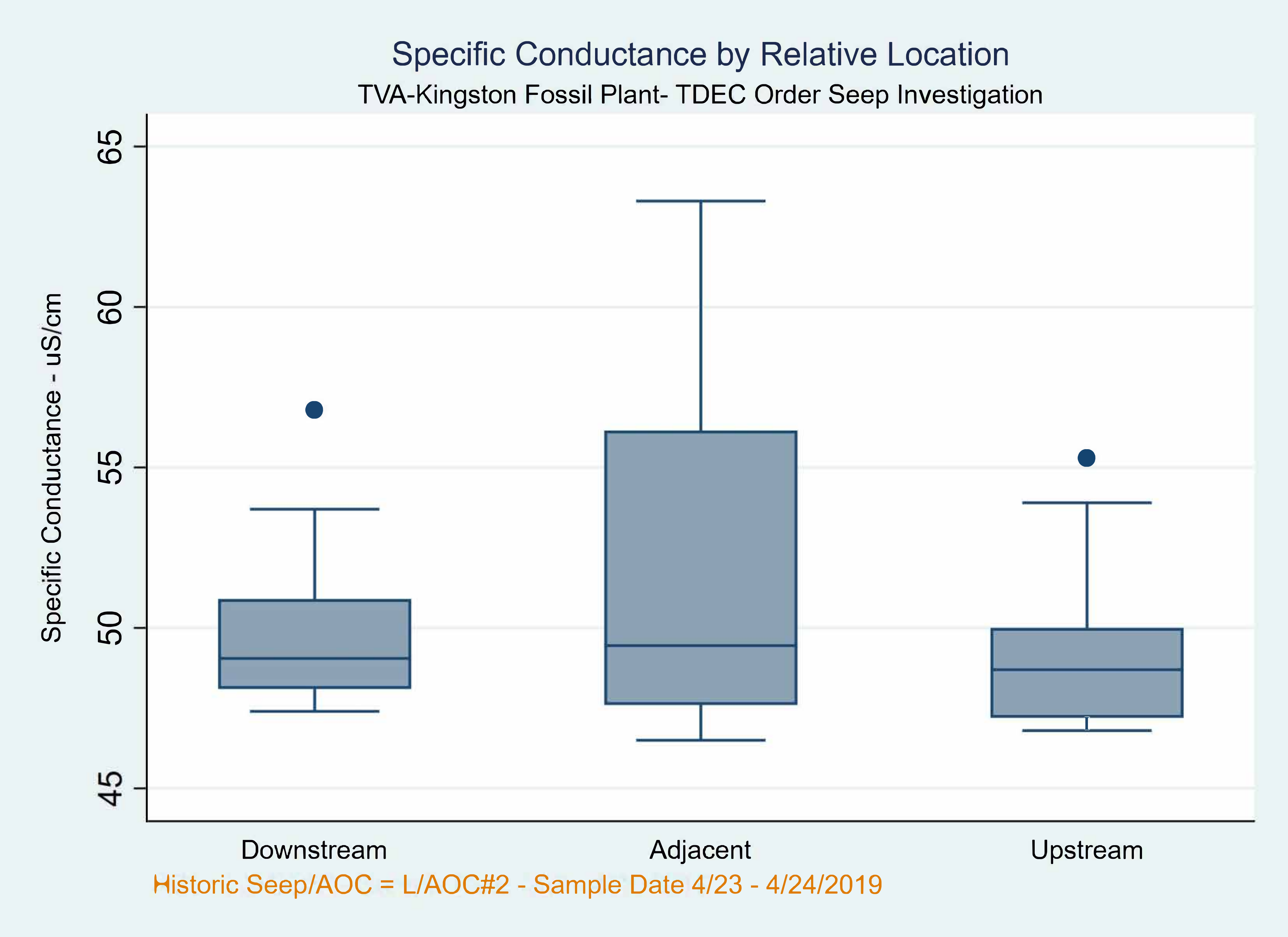
Dissolved Oxygen by Relative Location
TVA-Kingston Fossil Plant- TDEC Order Seep Investigation
Dissolved Oxygen - mg/L
9
8.5
8
7.5
Downstream
Adjacent
Upstream
Historic Seep/AOC = L/AOC#2 - Sample Date 4/23 - 4/24/2019

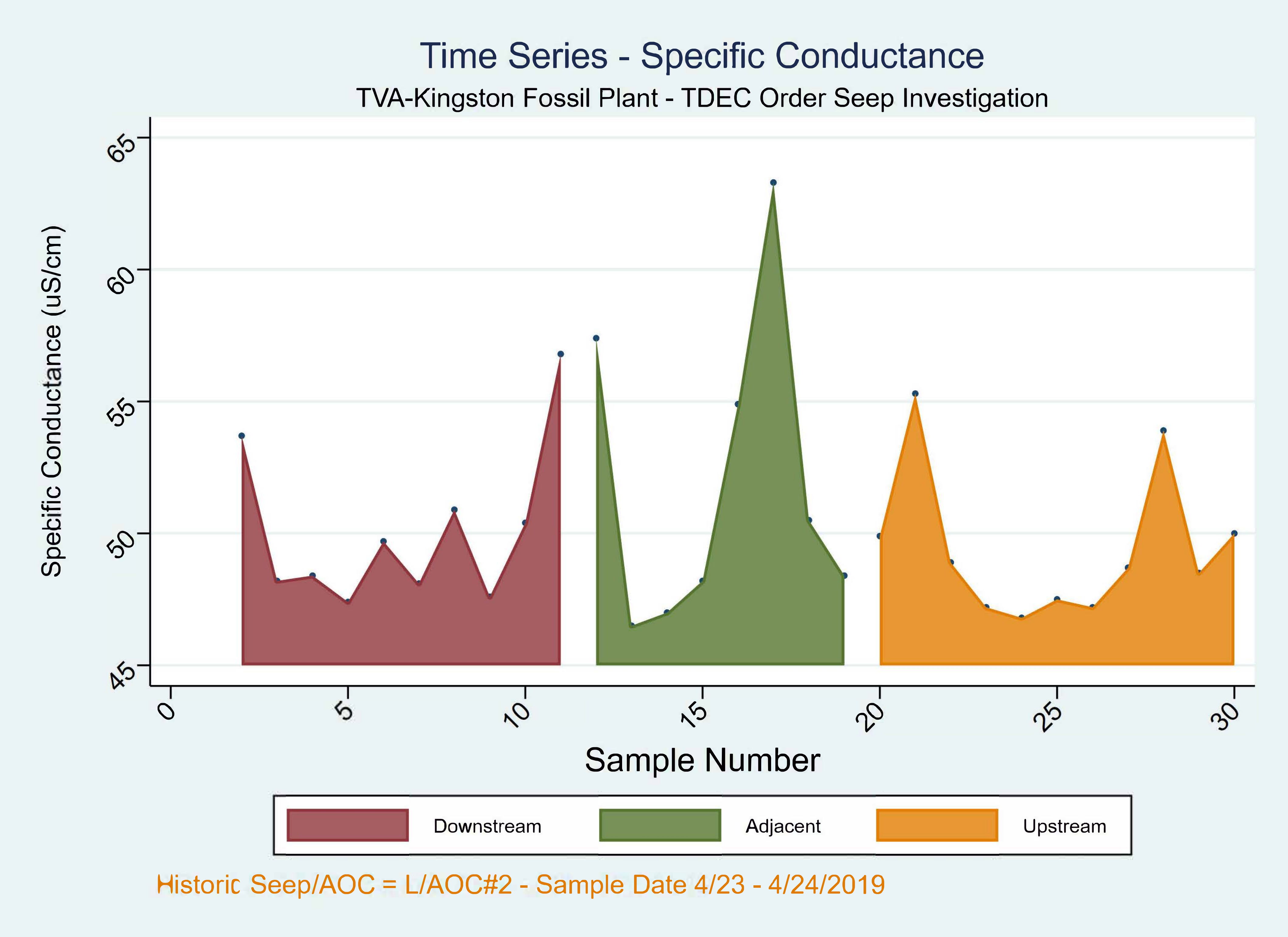


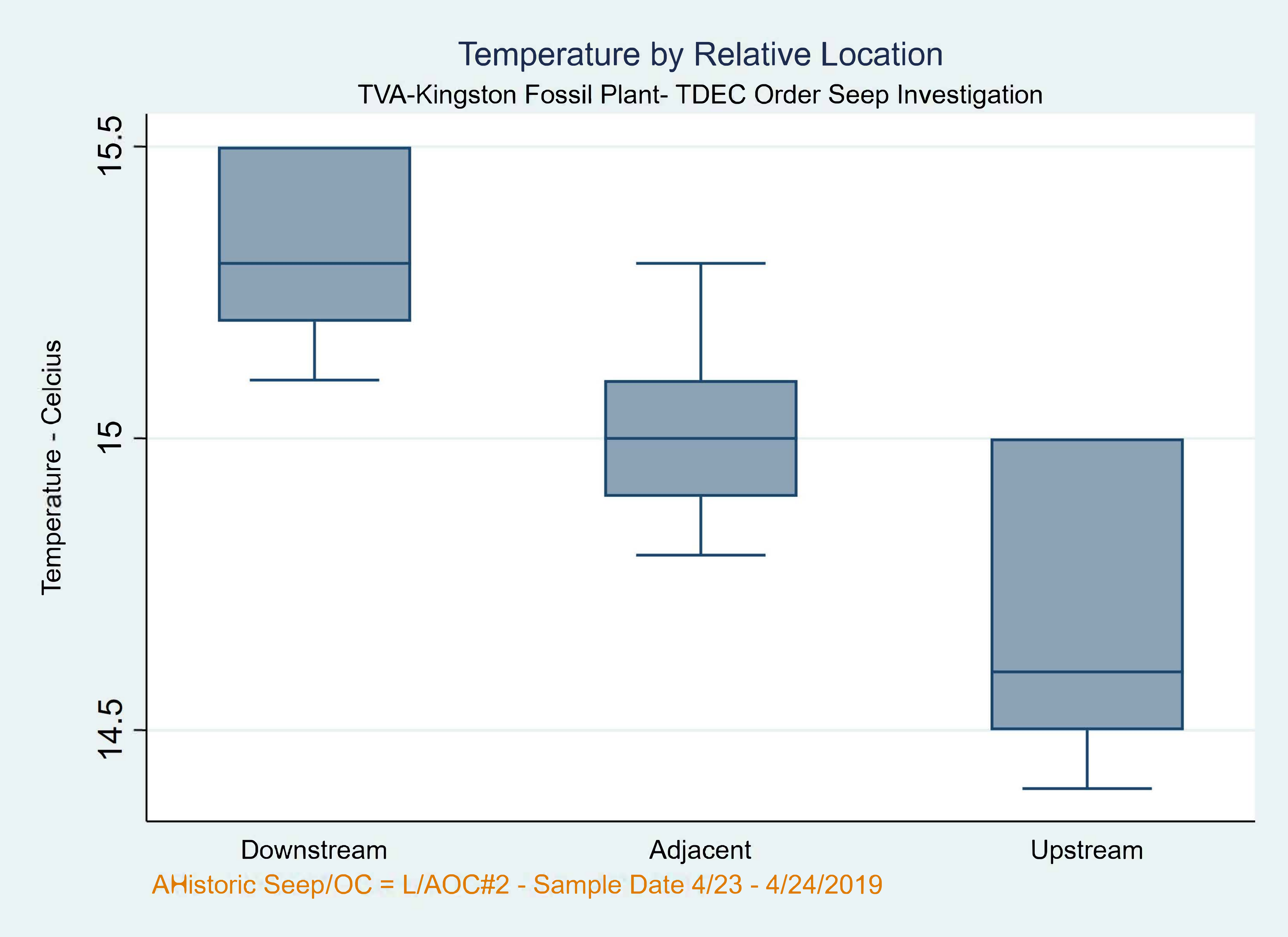
Time Series - Dissolved Oxygen
TVA-Kingston Fossil Plant - TDEC Order Seep Investigation
Dissolved Oxygen (mg/L)
9.5
9
8.5
8
7.5
0
5
10
15
20
25
30
Sample Number
Downstream
Adjacent
Upstream
Historic Seep/AOC = L/AOC#2 - Sample Date 4/23 - 4/24/2019

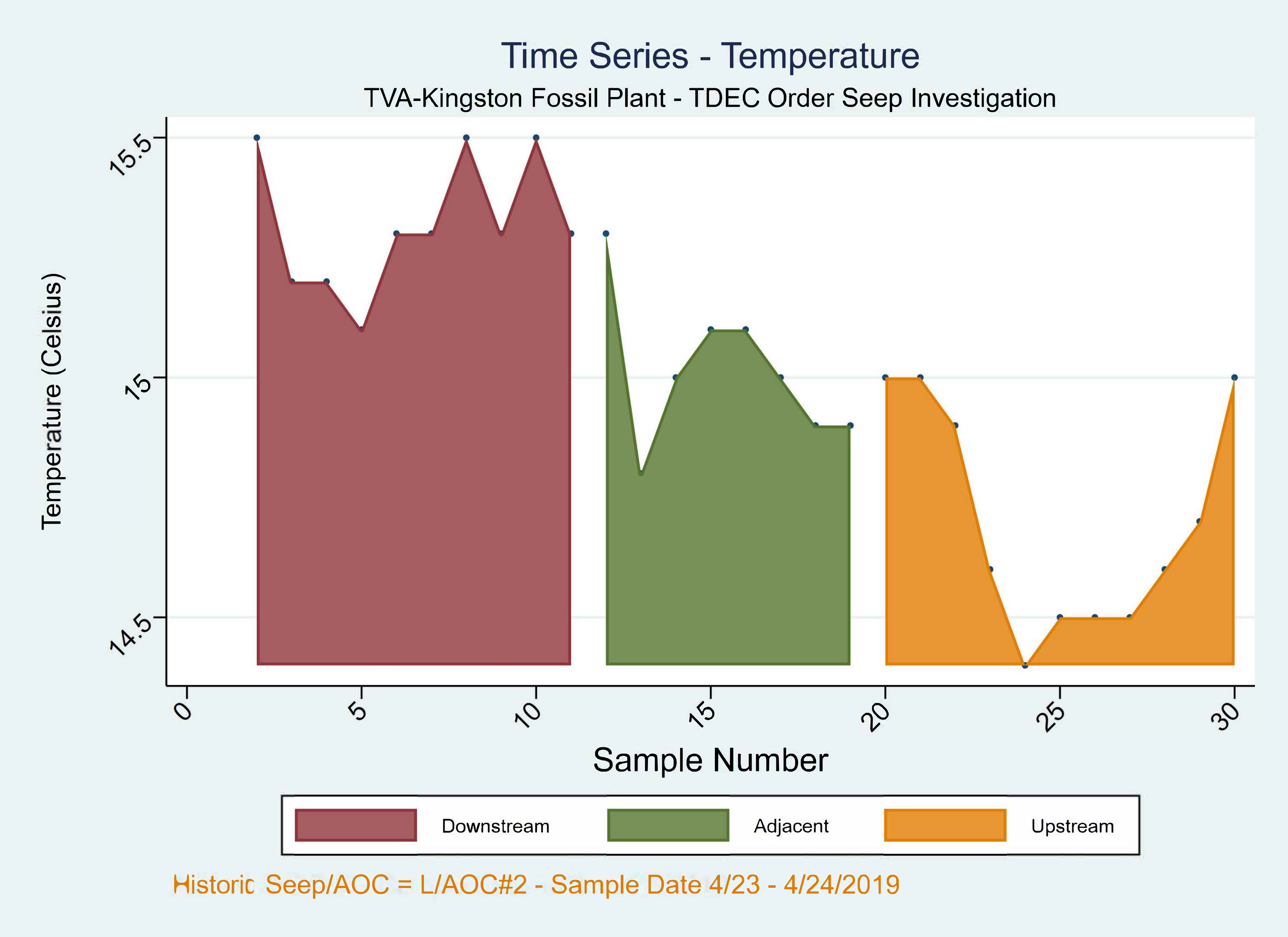

pH by Relative Location
TVA-Kingston Fossil Plant- TDEC Order Seep Investigation
pH - SU's
7
6.8
6.6
6.4
6.2
Downstream
Adjacent
Upstream
Historic Seep/AOC = L/AOC#2 - Sample Date 4/23 - 4/24/2019

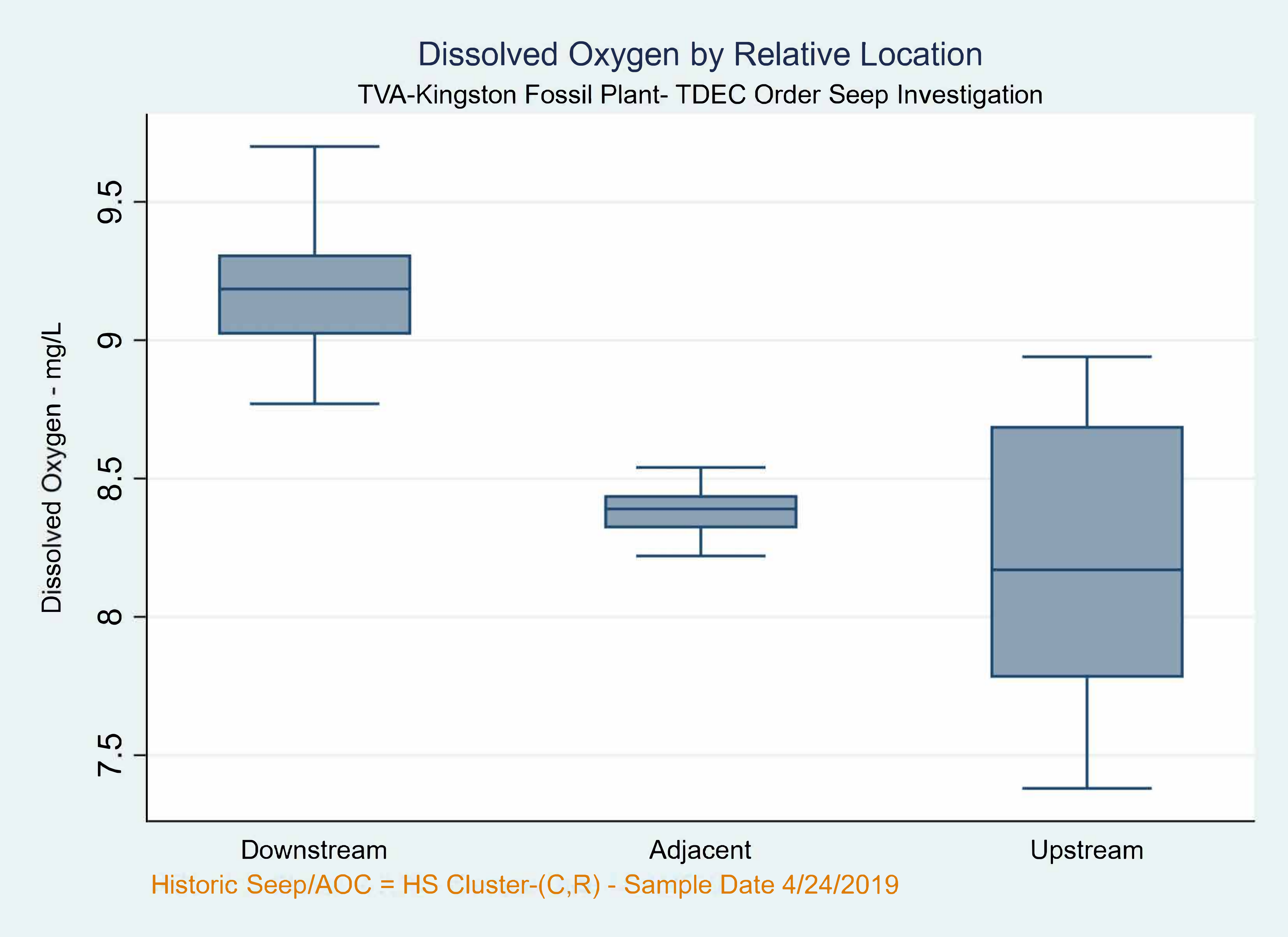

Time Series - pH
TVA-Kingston Fossil Plant - TDEC Order Seep Investigation
pH (Su's)
7
6.8
6.6
6.4
6.2
0
5
10
15
20
25
30
Sample Number
Downstream
Adjacent
Upstream
Historic Seep/AOC = L/AOC#2 - Sample Date 4/23 - 4/24/2019

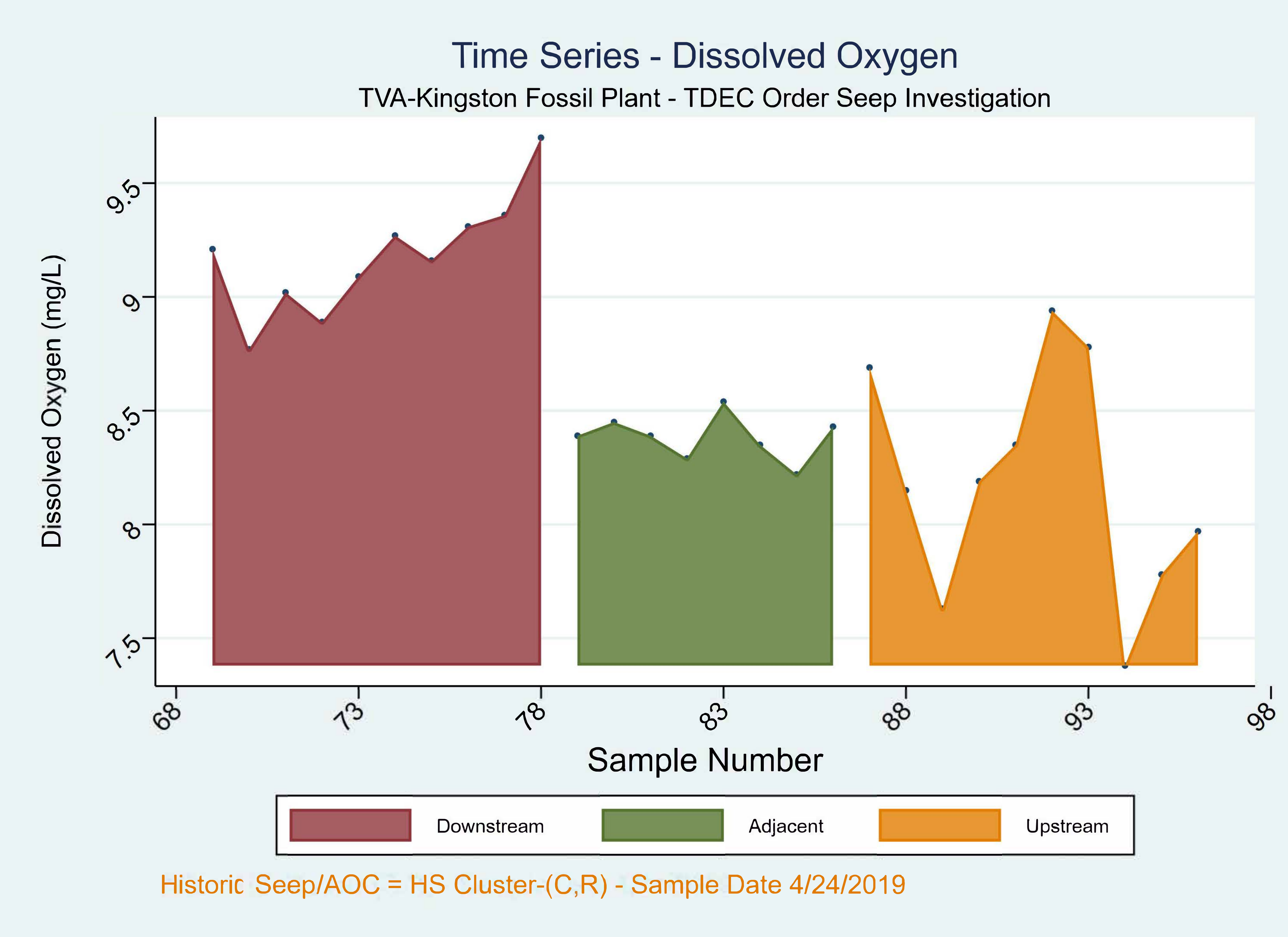

Specific Conductance by Relative Location
TVA-Kingston Fossil Plant- TDEC Order Seep Investigation
Specific Conductance - uS/cm
65
60
55
50
45
Downstream
Adjacent
Upstream
Historic Seep/AOC = L/AOC#2 - Sample Date 4/23 - 4/24/2019

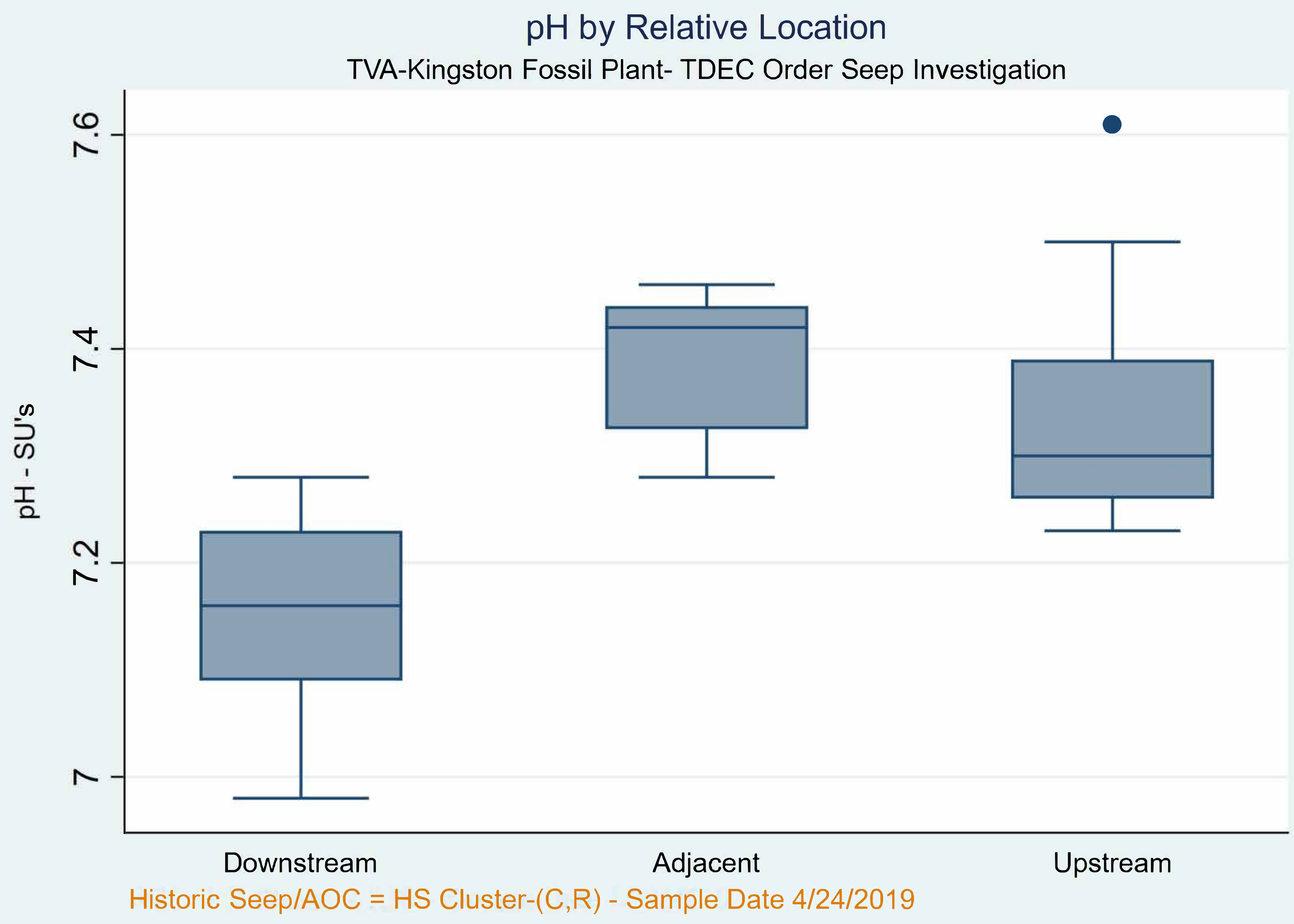

Time Series - Specific Conductance
TVA-Kingston Fossil Plant - TDEC Order Seep Investigation
Specific Conductance (uS/cm)
65
60
55
50
45
0
5
10
15
20
25
30
Sample Number
Downstream
Adjacent
Upstream
Historic Seep/AOC = L/AOC#2 - Sample Date 4/23 - 4/24/2019


Temperature by Relative Location
TVA-Kingston Fossil Plant- TDEC Order Seep Investigation
Temperature - Celcius
15.5
15
14.5
Downstream
Adjacent
Upstream
AHistoric Seep/OC = L/AOC#2 - Sample Date 4/23 - 4/24/2019

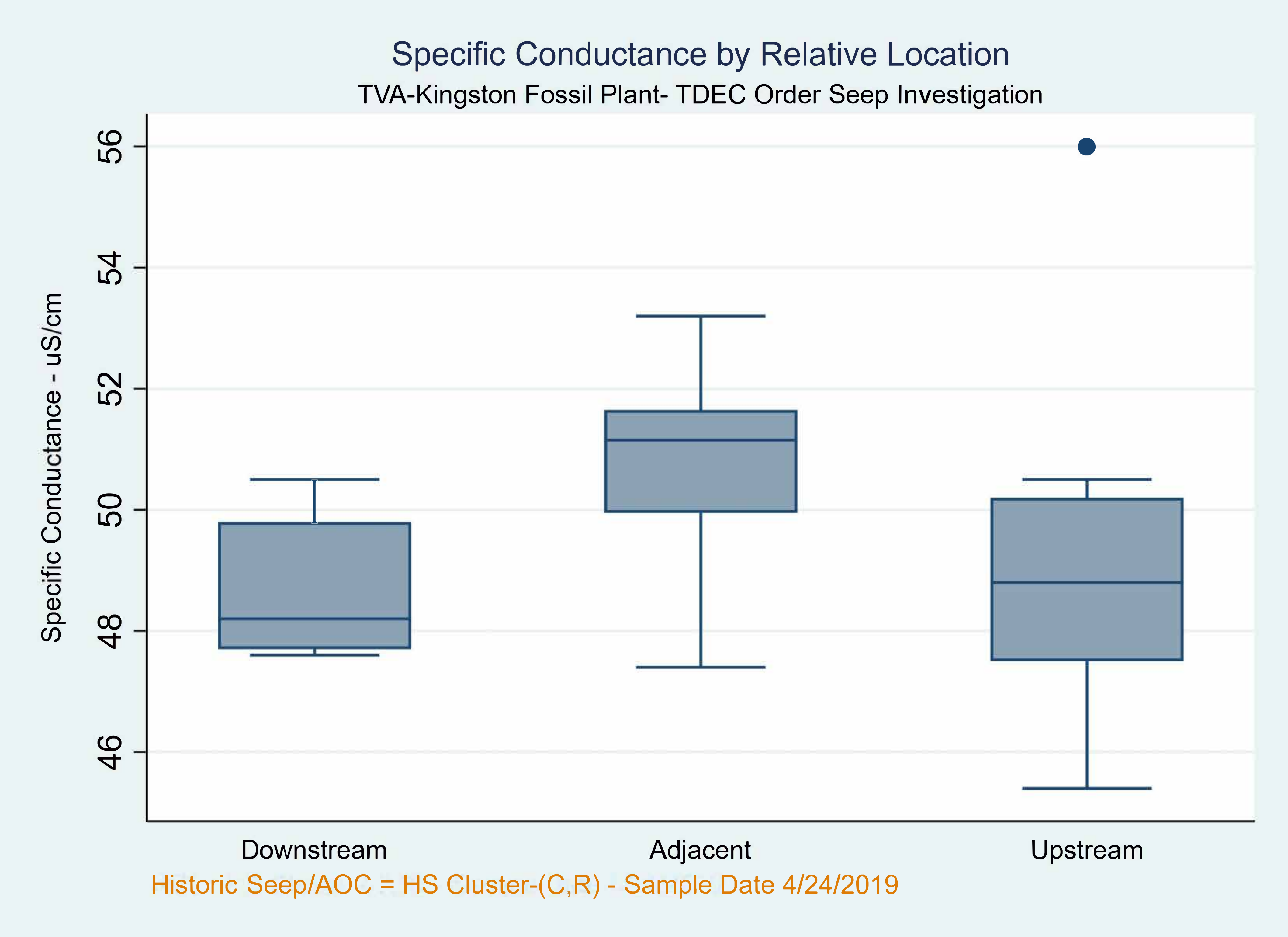

Time Series - Temperature
TVA-Kingston Fossil Plant - TDEC Order Seep Investigation
Temperature (Celsius)
15.5
15
14.5
0
5
10
15
20
25
30
Sample Number
Downstream
Adjacent
Upstream
Historic Seep/AOC = L/AOC#2 - Sample Date 4/23 - 4/24/2019


Dissolved Oxygen by Relative Location
TVA-Kingston Fossil Plant- TDEC Order Seep Investigation
Dissolved Oxygen - mg/L
9.5
9
8.5
8
7.5
Downstream
Adjacent
Upstream
Historic Seep/AOC = HS Cluster-(C,R) - Sample Date 4/24/2019

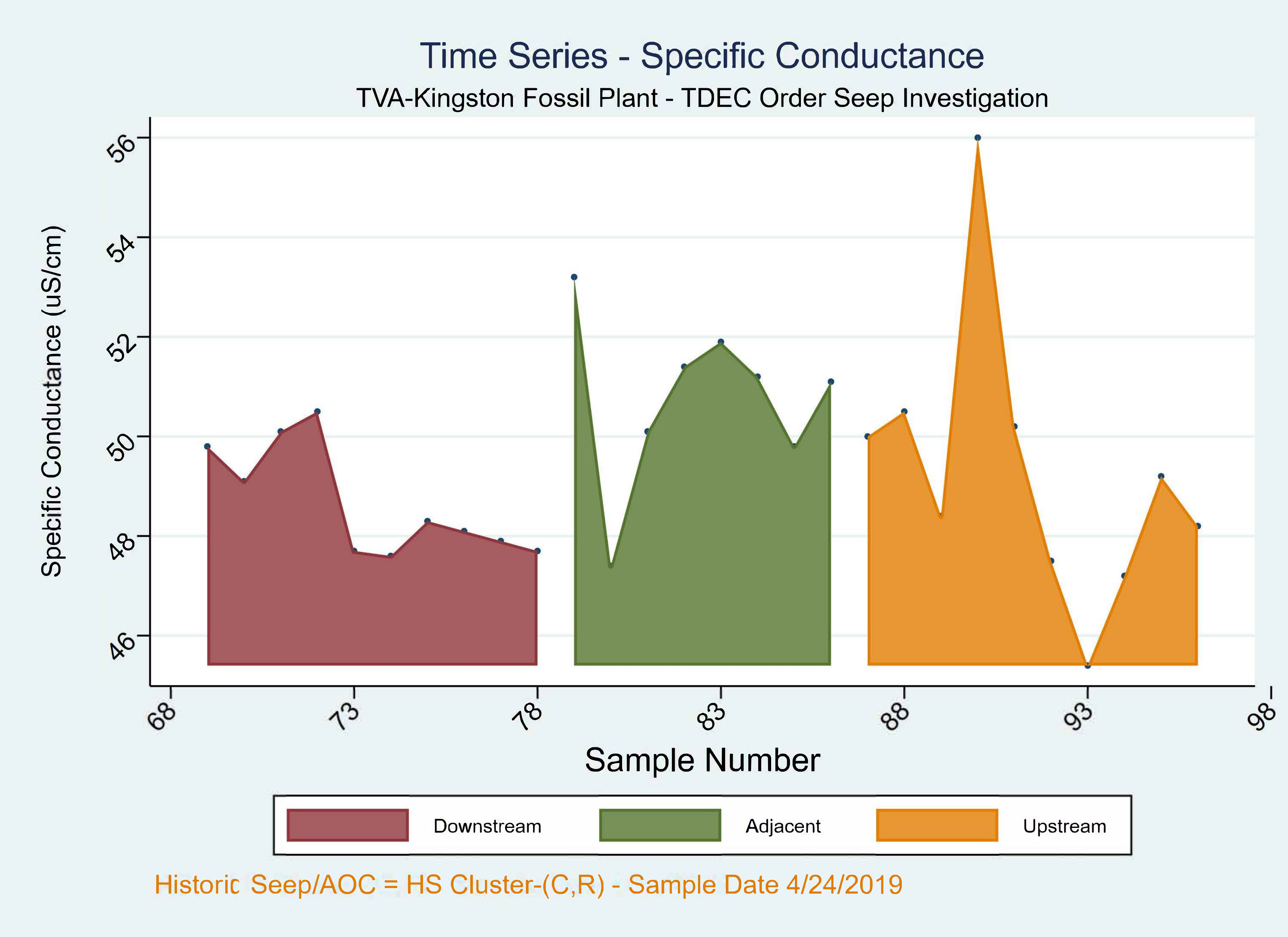

Time Series - Dissolved Oxygen
TVA-Kingston Fossil Plant - TDEC Order Seep Investigation
Dissolved Oxygen (mg/L)
9.5
9
8.5
8
7.5
68
73
78
83
88
93
98
Sample Number
Downstream
Adjacent
Upstream
Historic Seep/AOC = HS Cluster-(C,R) - Sample Date 4/24/2019


pH by Relative Location
TVA-Kingston Fossil Plant- TDEC Order Seep Investigation
pH - SU's
7.6
7.4
7.2
7
Downstream
Adjacent
Upstream
Historic Seep/AOC = HS Cluster-(C,R) - Sample Date 4/24/2019

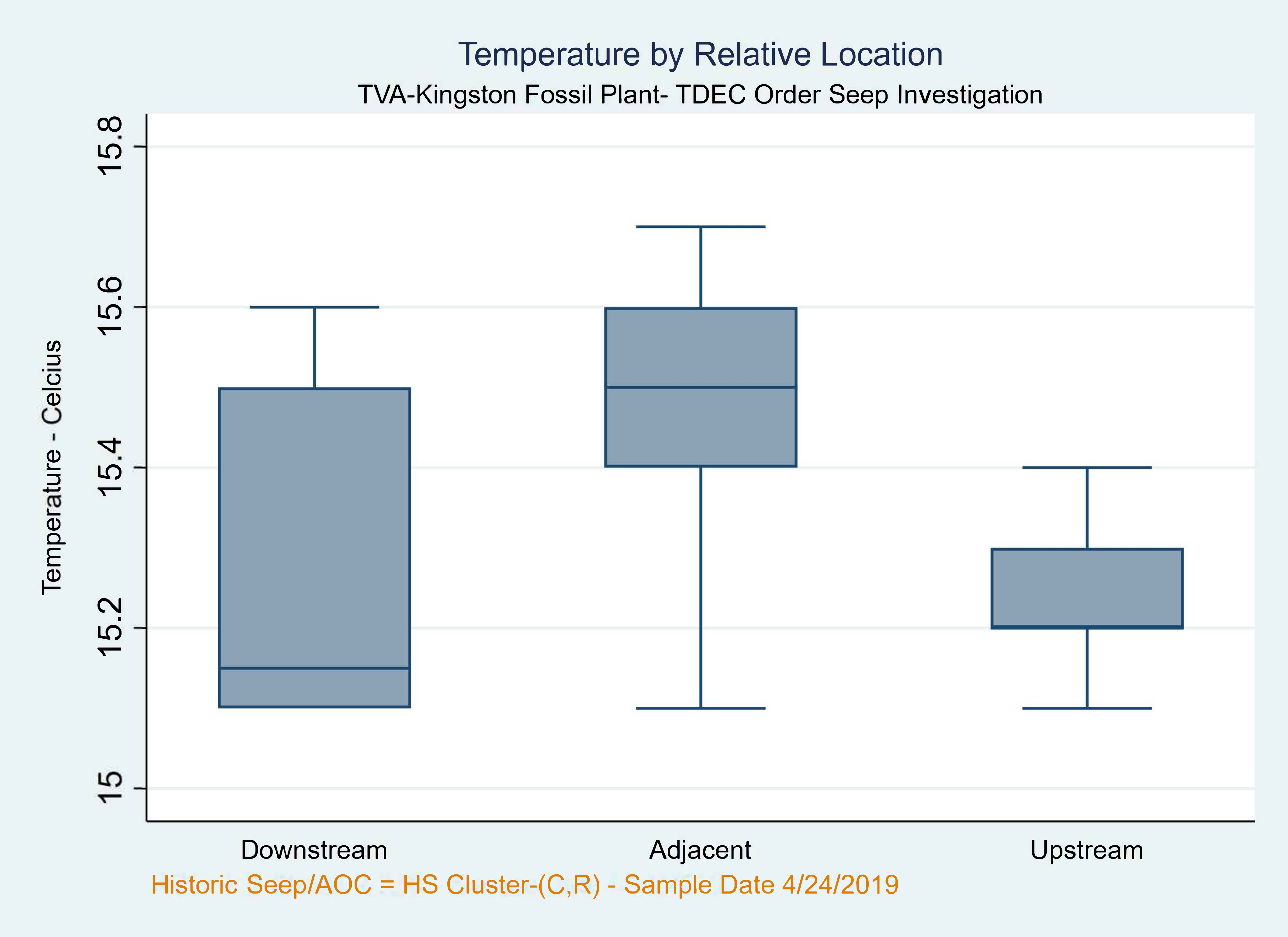

Time Series - pH
TVA-Kingston Fossil Plant - TDEC Order Seep Investigation
pH (Su's)
7.6
7.4
7.2
7
68
73
78
83
88
93
98
Sample Number
Downstream
Adjacent
Upstream
Historic Seep/AOC – HS Cluster-(C,R) - Sample Date 4/24/2019

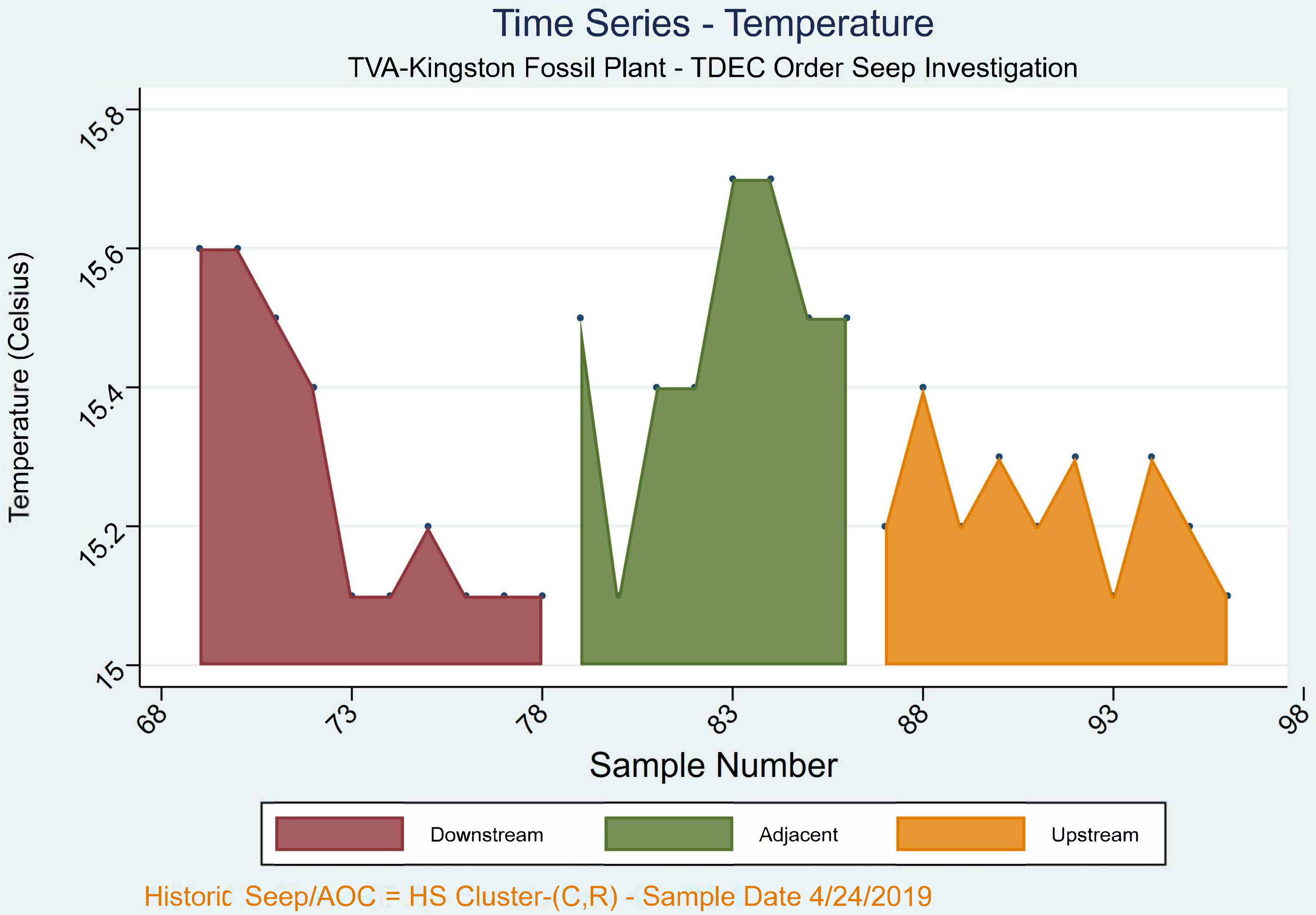


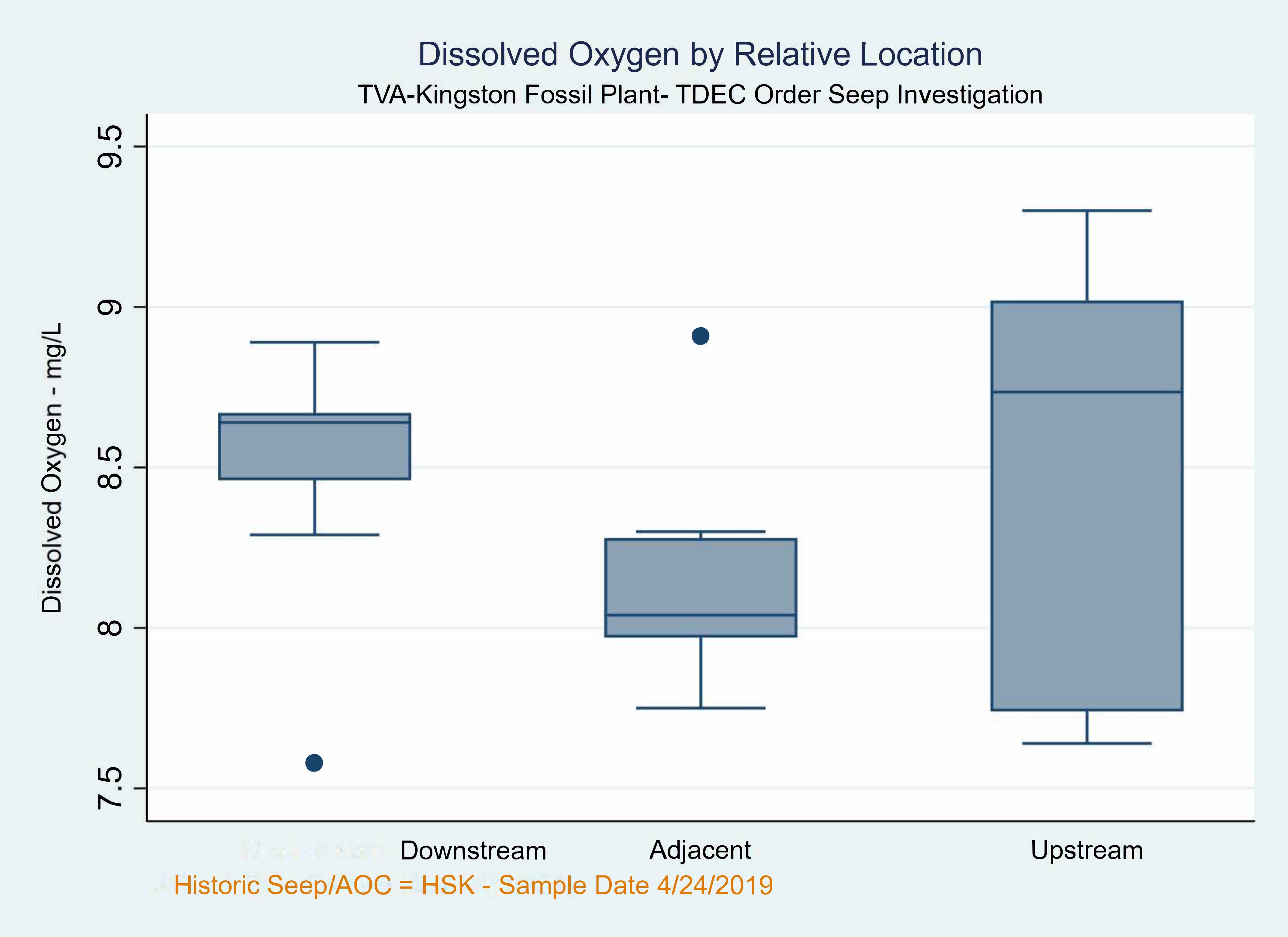
Specific Conductance by Relative Location
TVA-Kingston Fossil Plant- TDEC Order Seep Investigation
Specific Conductance - uS/cm
56
54
52
50
48
46
Downstream
Adjacent
Upstream
Historic Seep/AOC = HS Cluster-(C,R) - Sample Date 4/24/2019

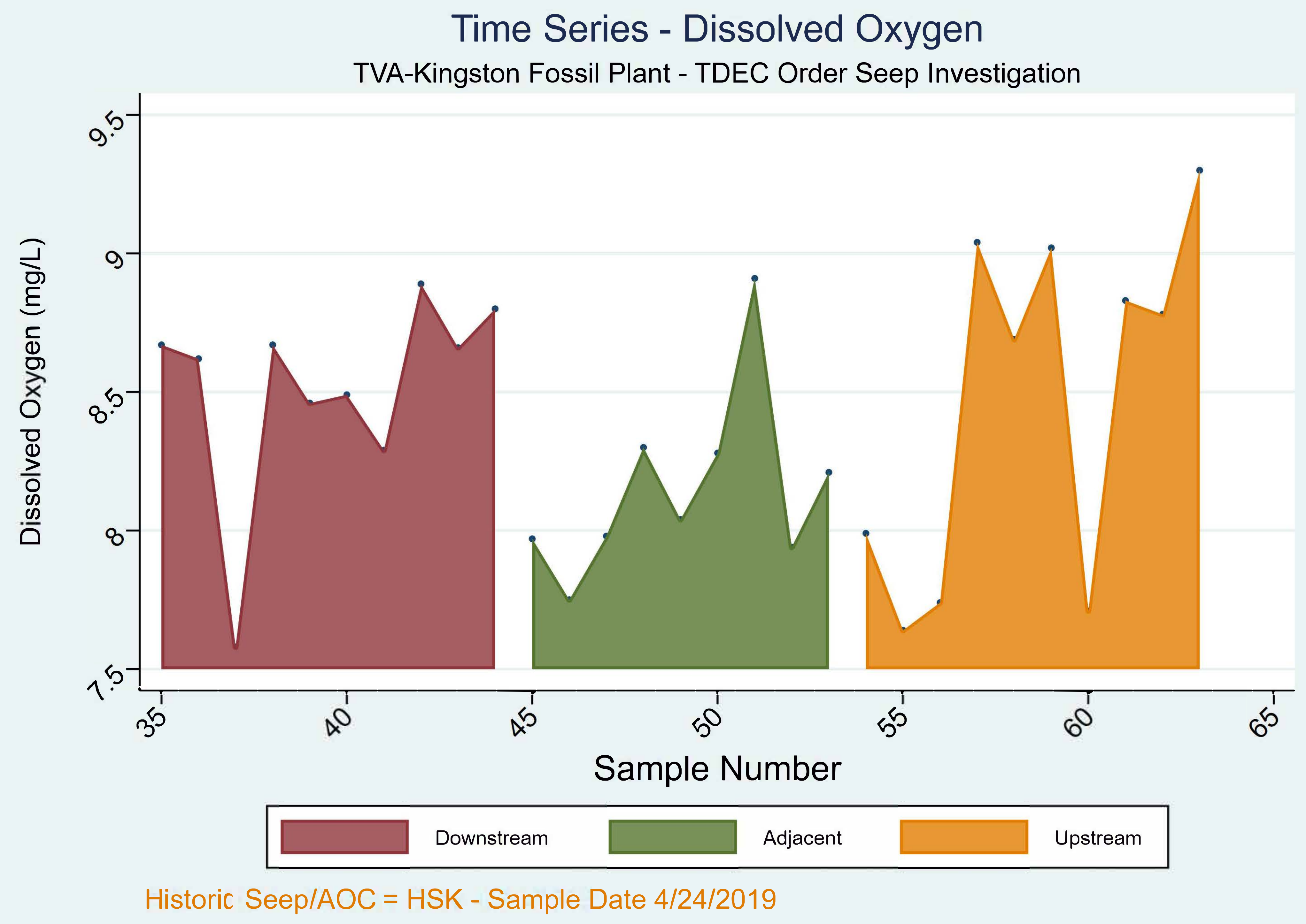


Time Series - Specific Conductance
TVA-Kingston Fossil Plant - TDEC Order Seep Investigation
Specific Conductance (uS/cm)
56
54
52
50
48
46
68
73
78
83
88
93
98
Sample Number
Downstream
Adjacent
Upstream
Historic Seep/AOC = HS Cluster-(C,R) - Sample Date 4/24/2019

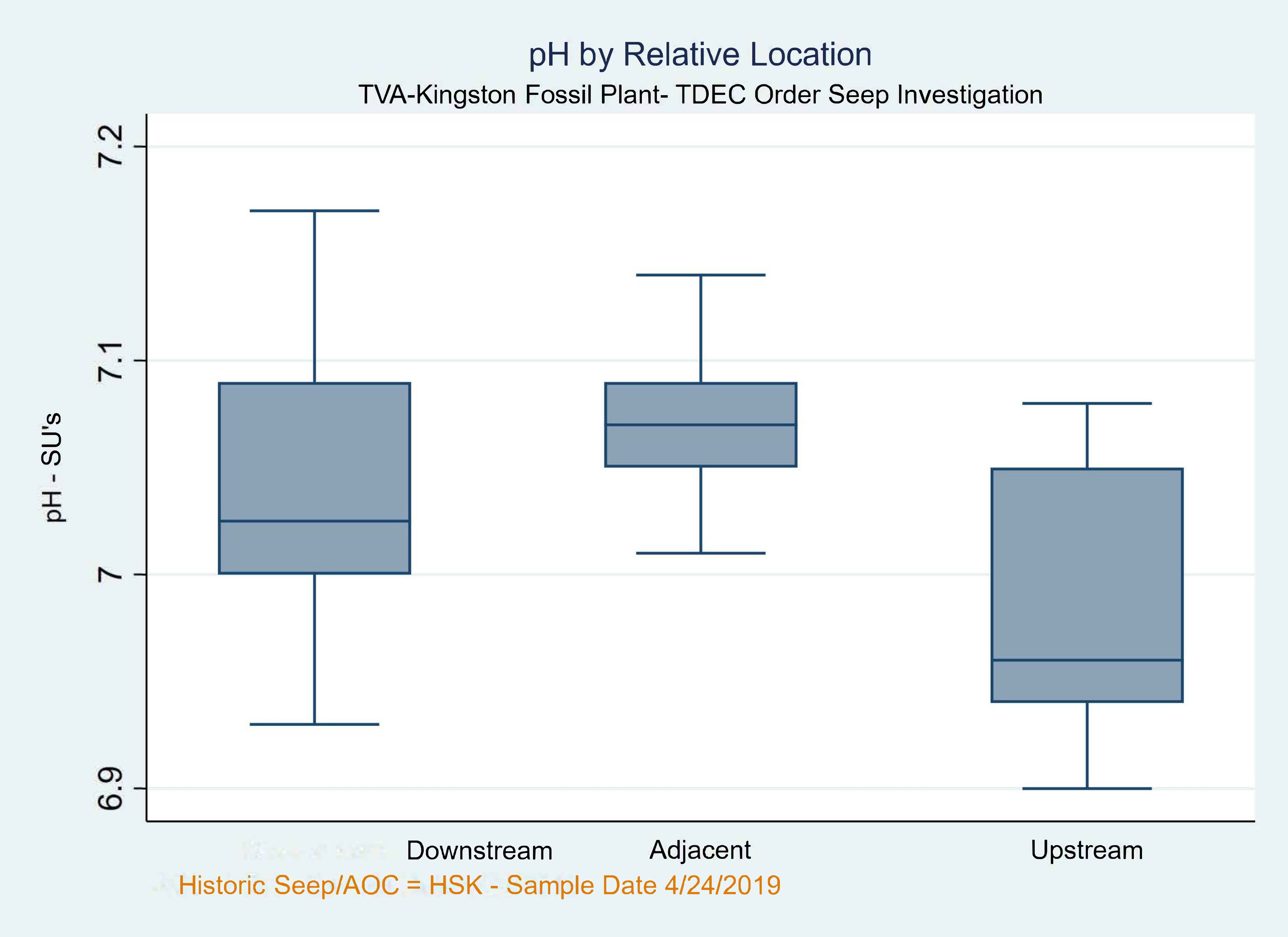

Temperature by Relative Location
TVA-Kingston Fossil Plant- TDEC Order Seep Investigation
Temperature - Celcius
15.8
15.6
15.4
15.2
15
Downstream
Adjacent
Upstream
Historic Seep/AOC = HS Cluster-(C,R) - Sample Date 4/24/2019

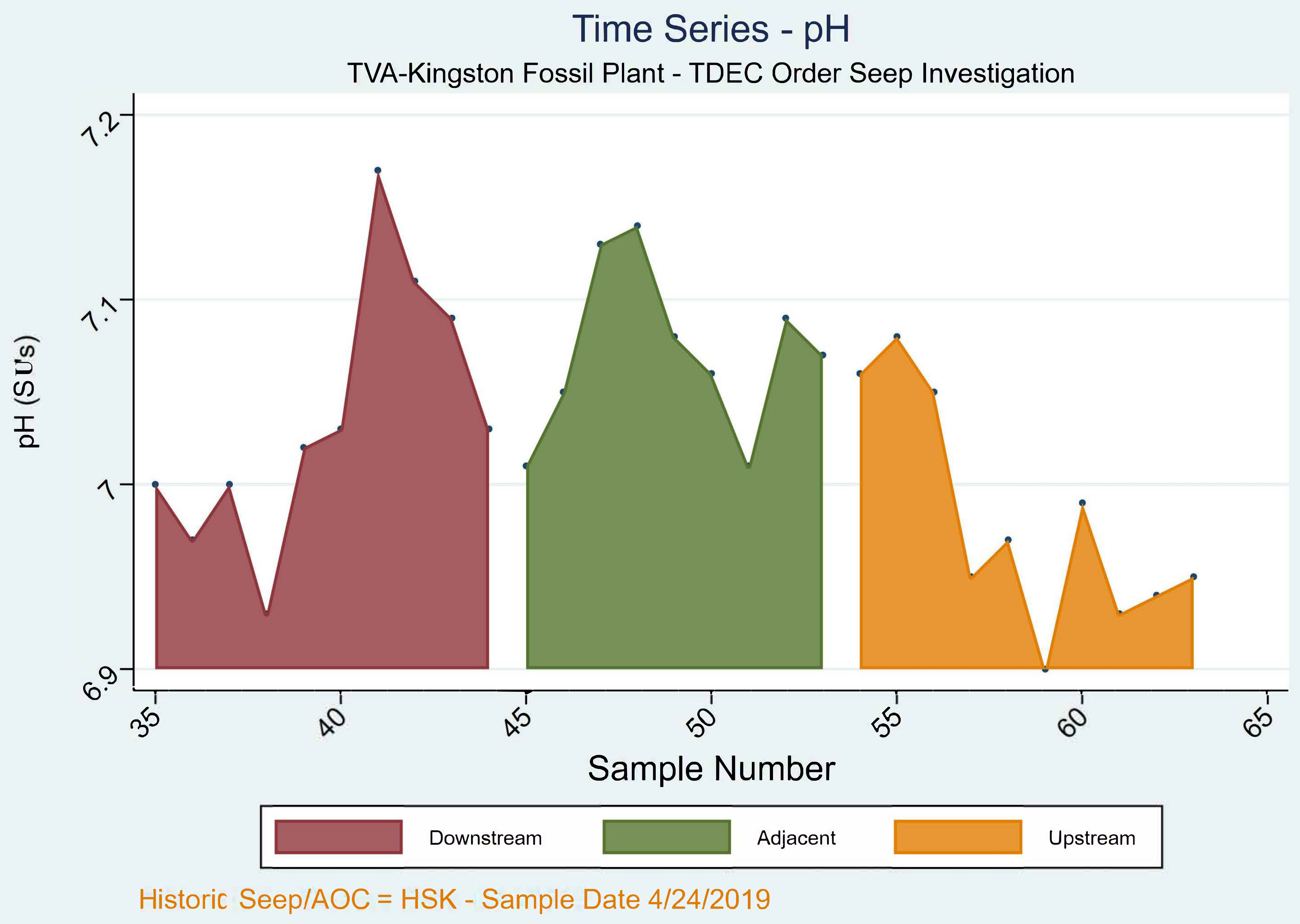

Time Series - Temperature
TVA-Kingston Fossil Plant - TDEC Order Seep Investigation
Temperature (Celsius)
15.8
15.6
15.4
15.2
15
68
73
78
83
88
93
98
Sample Number
Downstream
Adjacent
Upstream
Historic Seep/AOC = HS Cluster-(C,R) - Sample Date 4/24/2019


Dissolved Oxygen by Relative Location
TVA-Kingston Fossil Plant- TDEC Order Seep Investigation
Dissolved Oxygen - mg/L
9.5
9
8.5
8
7.5
Downstream
Adjacent
Upstream
Historic Seep/AOC = HSK - Sample Date 4/24/2019

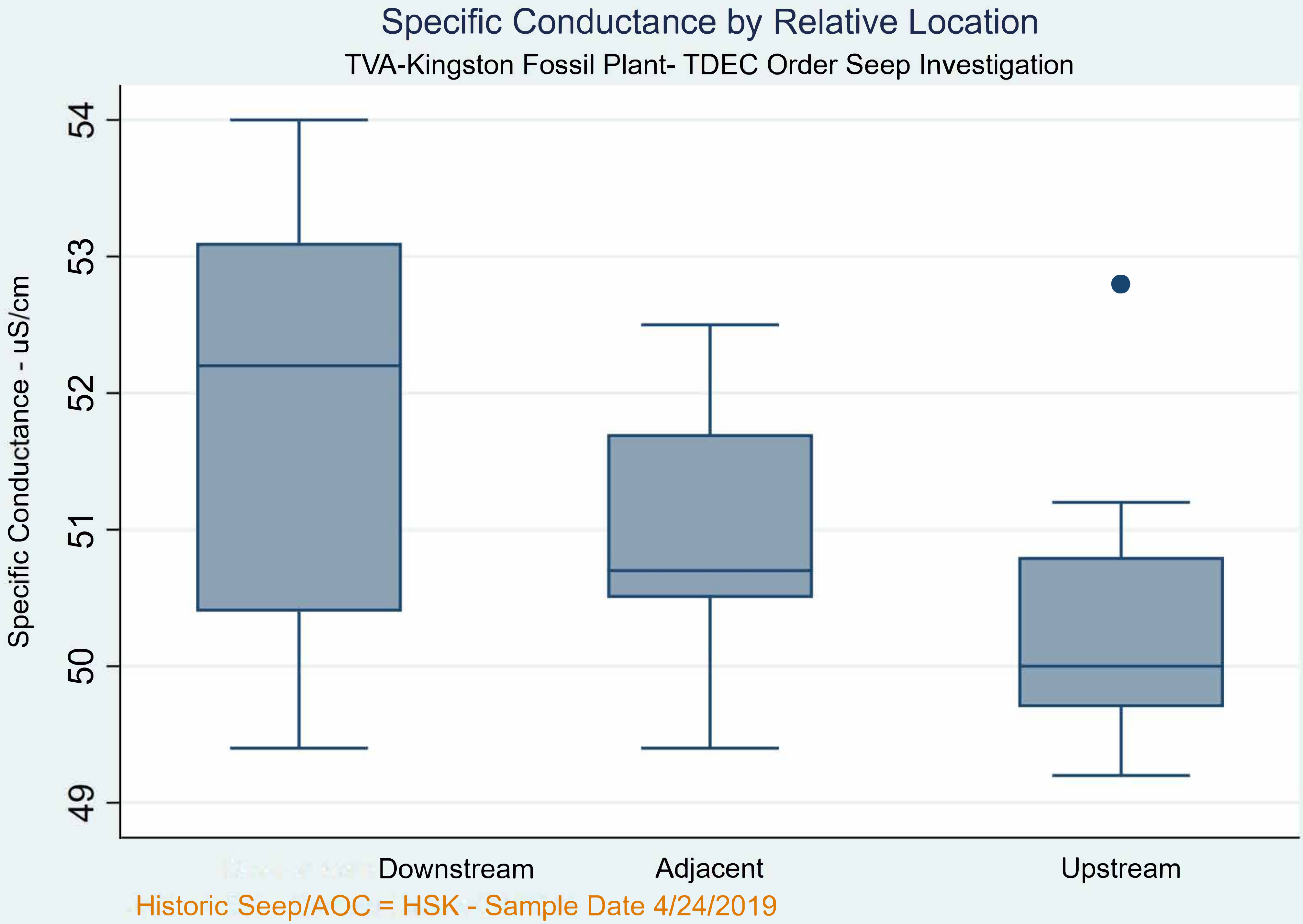


Time Series - Dissolved Oxygen
TVA-Kingston Fossil Plant - TDEC Order Seep Investigation
Dissolved Oxygen (mg/L)
9.5
9
8.5
8
7.5
35
40
45
50
55
60
65
Sample Number
Downstream
Adjacent
Upstream
Historic Seep/AOC = HSK - Sample Date 4/24/2019

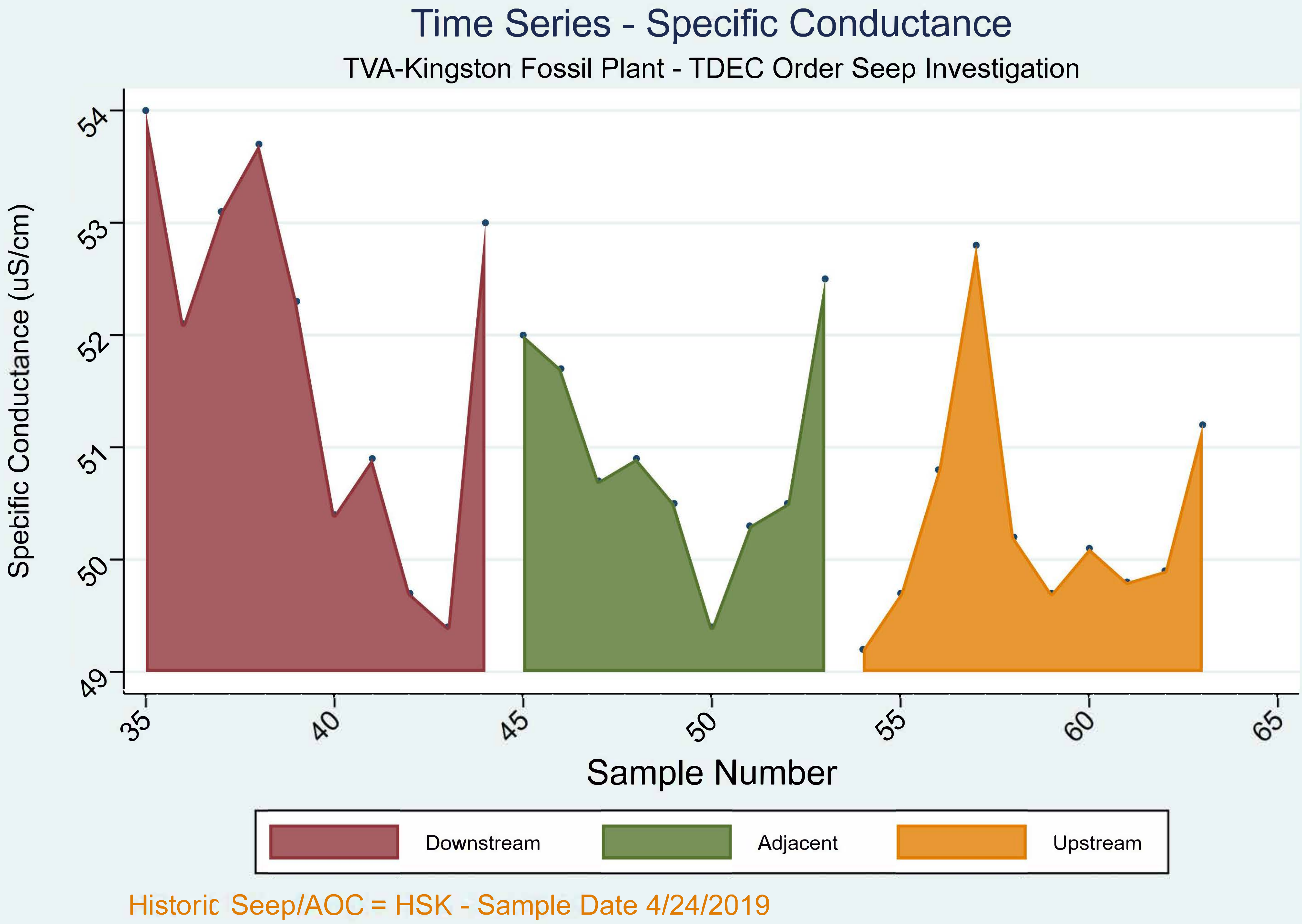

pH by Relative Location
TVA-Kingston Fossil Plant- TDEC Order Seep Investigation
pH - SU's
7.2
7.1
7
6.9
Downstream
Adjacent
Upstream
Historic Seep/AOC = HSK - Sample Date 4/24/2019

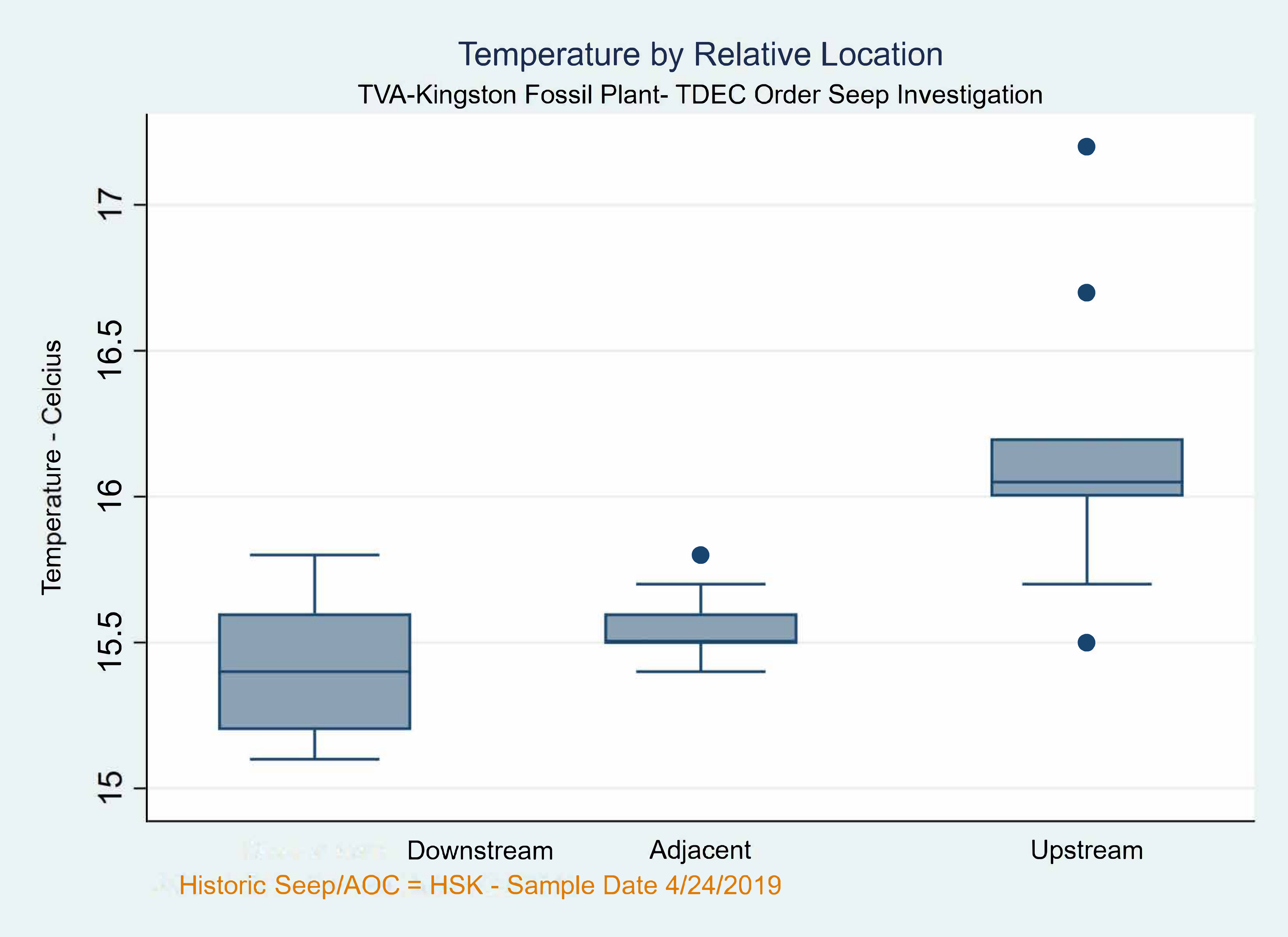


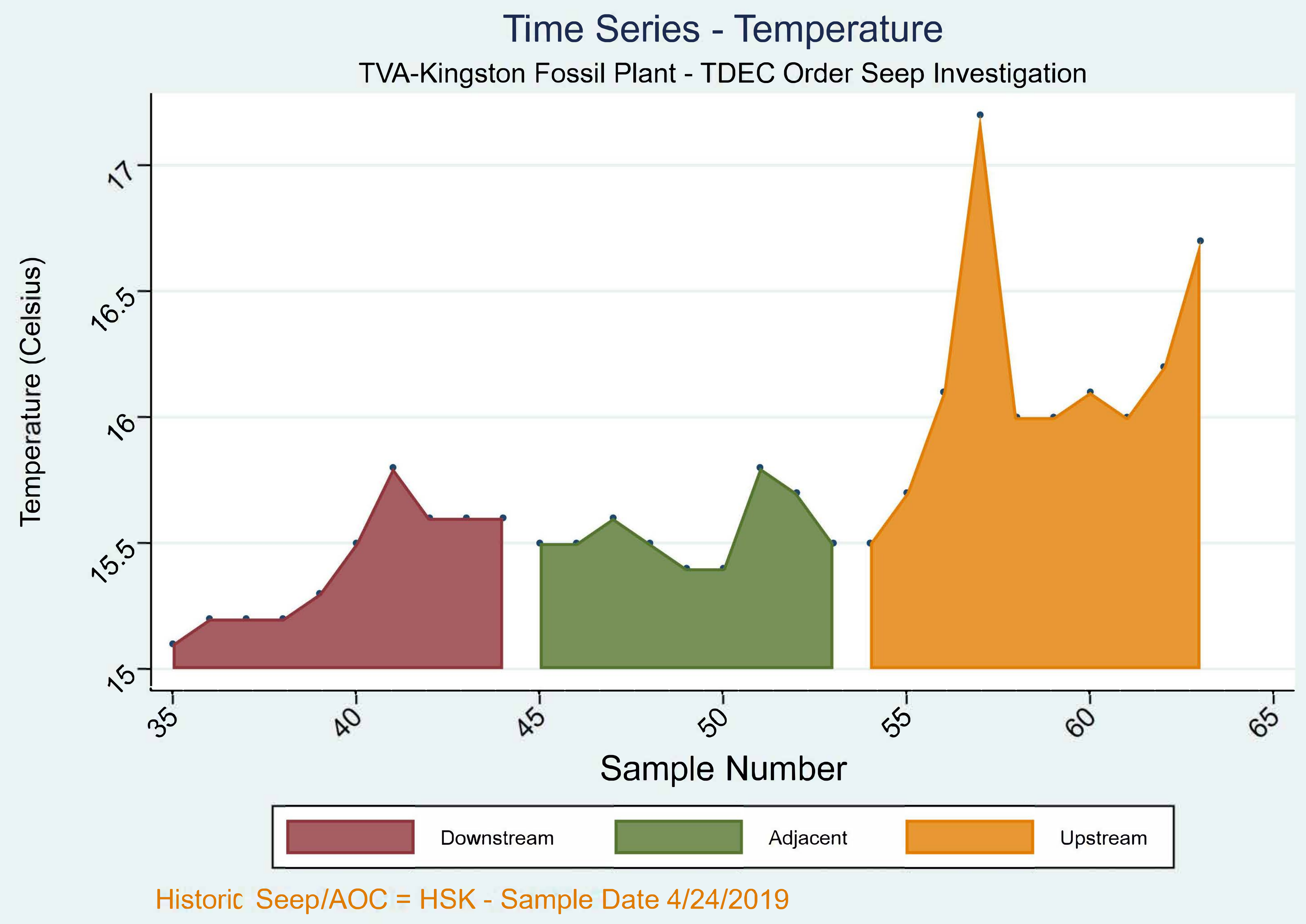
Time Series - pH
TVA-Kingston Fossil Plant - TDEC Order Seep Investigation
pH (SUs)
7.2
7.1
7
6.9
35
40
45
50
55
60
65
Sample Number
Downstream
Adjacent
Upstream
Historic Seep/AOC = HSK - Sample Date 4/24/2019



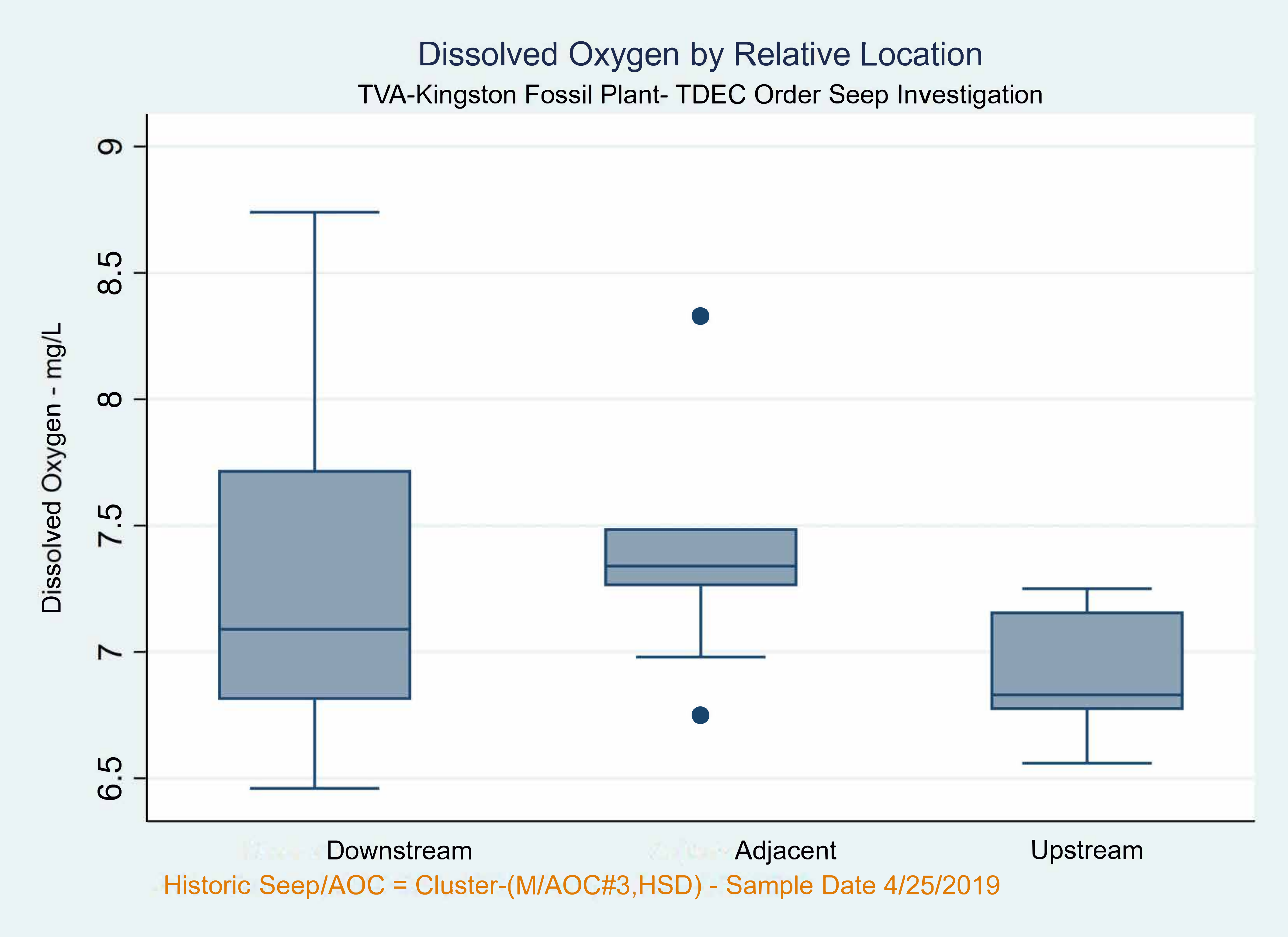
Specific Conductance by Relative Location
TVA-Kingston Fossil Plant- TDEC Order Seep Investigation
Specific Conductance - uS/cm
54
53
52
51
50
49
Downstream
Adjacent
Upstream
Historic Seep/AOC = HSK - Sample Date 4/24/2019

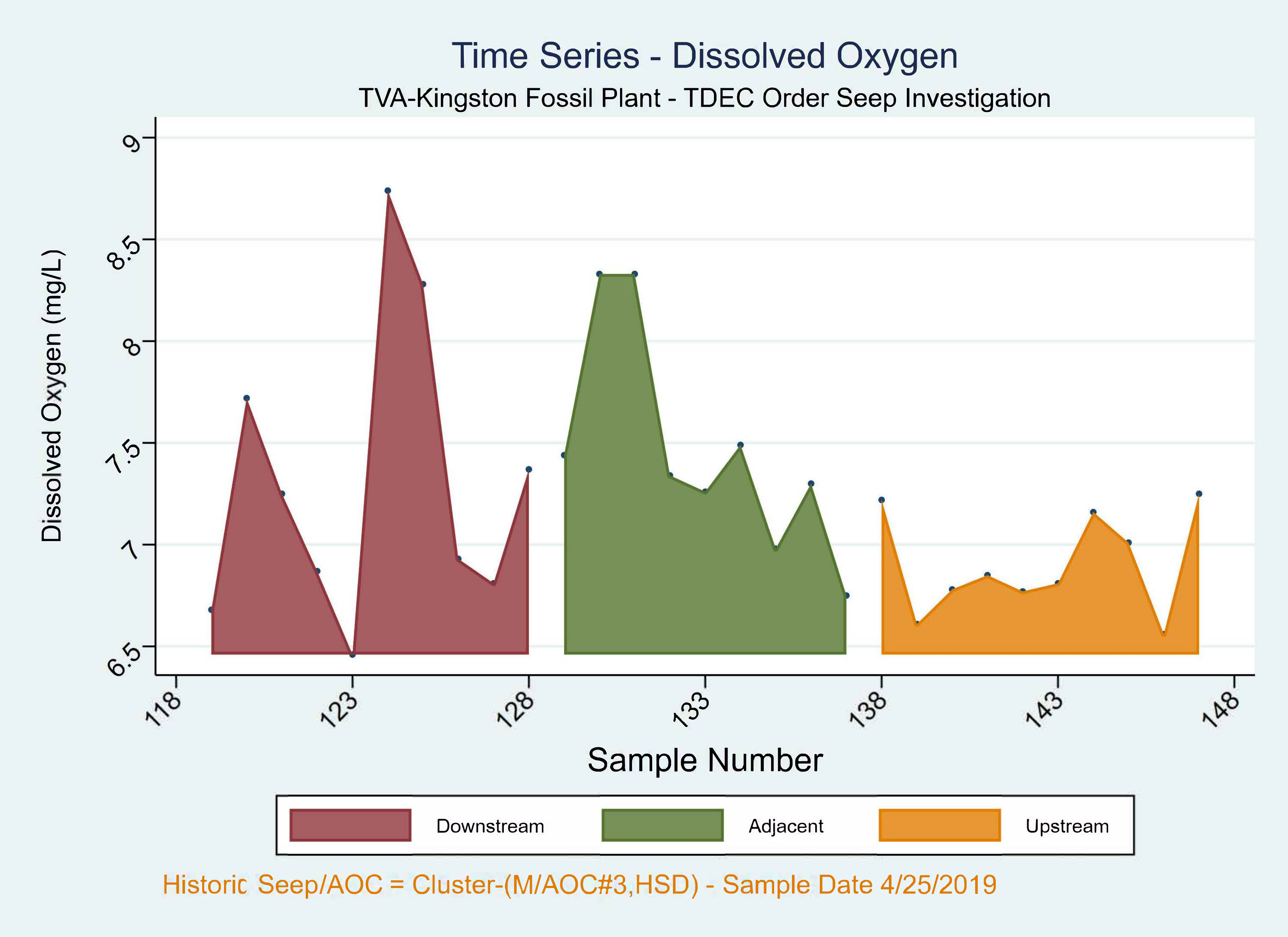

Time Series - Specific Conductance
TVA-Kingston Fossil Plant - TDEC Order Seep Investigation
Specific Conductance (uS/cm)
54
53
52
51
50
49
35
40
45
50
55
60
65
Sample Number
Downstream
Adjacent
Upstream
Historic Seep/AOC = HSK - Sample Date 4/24/2019


Temperature by Relative Location
TVA-Kingston Fossil Plant- TDEC Order Seep Investigation
Temperature - Celcius
17
16.5
16
15.5
15
Downstream
Adjacent
Upstream
Historic Seep/AOC = HSK - Sample Date 4/24/2019

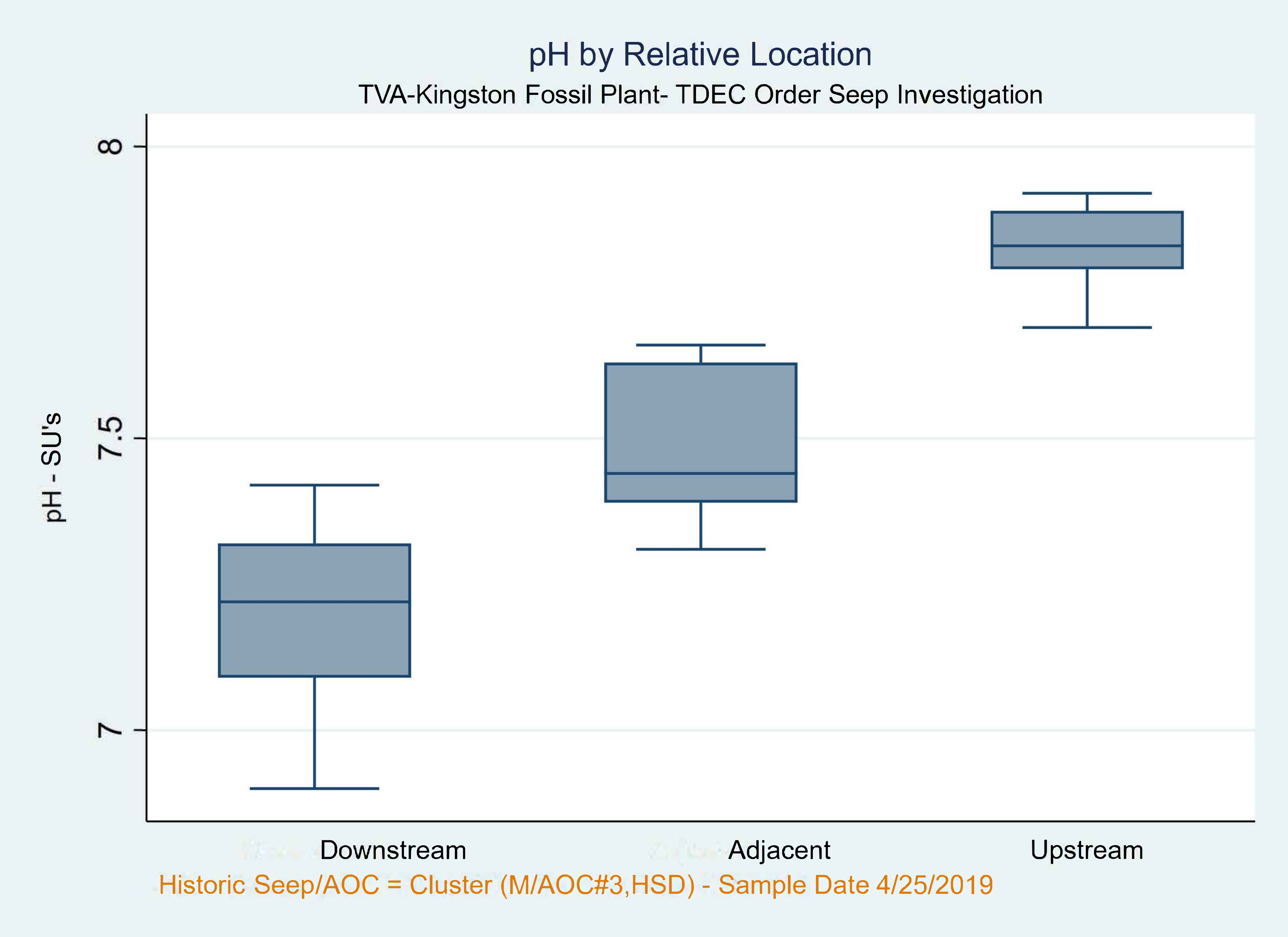


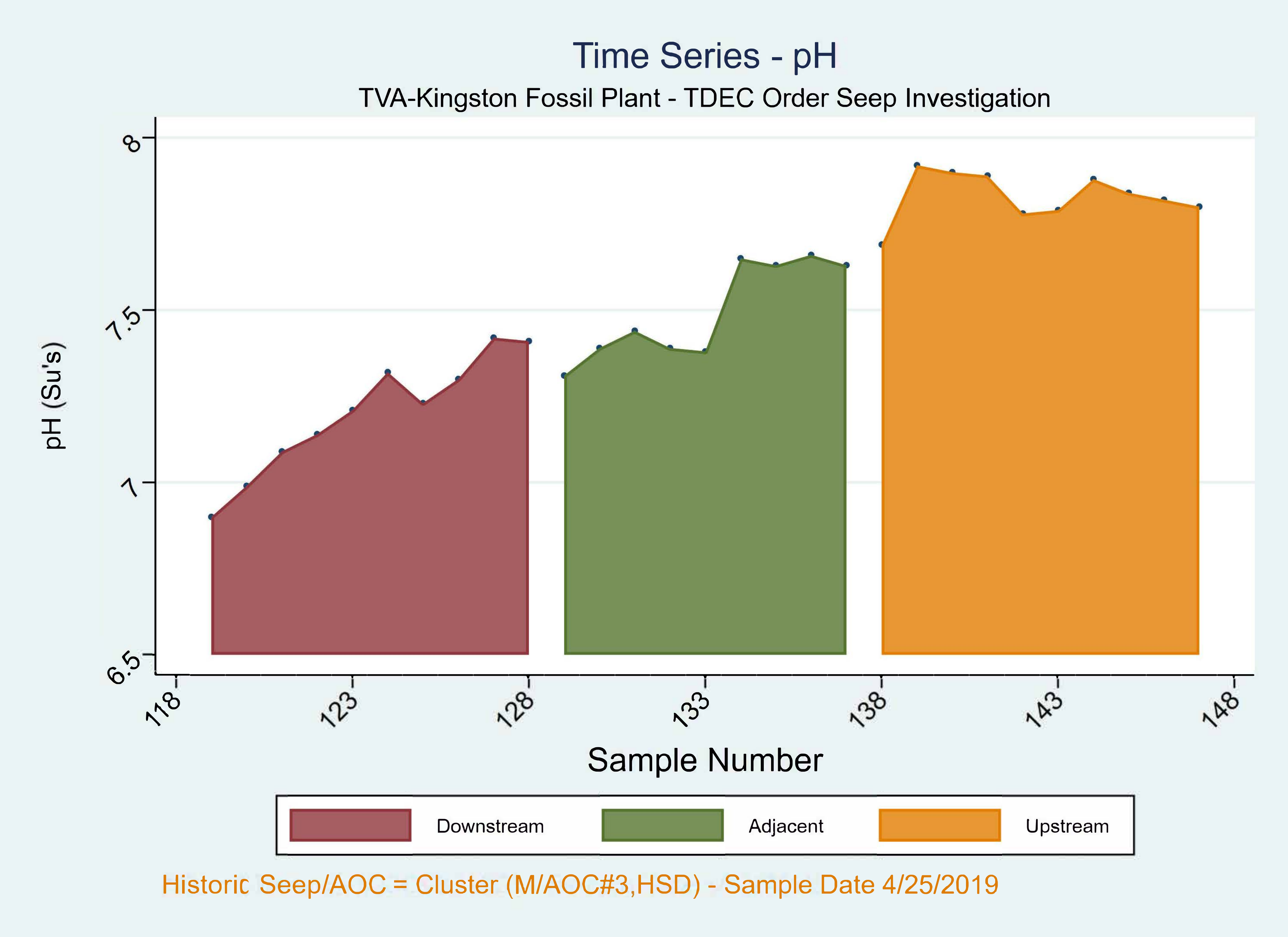
Time Series - Temperature
TVA-Kingston Fossil Plant - TDEC Order Seep Investigation
Temperature (Celsius)
17
16.5
16
15.5
15
35
40
45
50
55
60
65
Sample Number
Downstream
Adjacent
Upstream
Historic Seep/AOC = HSK - Sample Date 4/24/2019


Dissolved Oxygen by Relative Location
TVA-Kingston Fossil Plant- TDEC Order Seep Investigation
Dissolved Oxygen - mg/L
9
8.5
8
7.5
7
6.5
Downstream
Adjacent
Upstream
Historic Seep/AOC = Cluster-(M/AOC#3,HSD) - Sample Date 4/25/2019

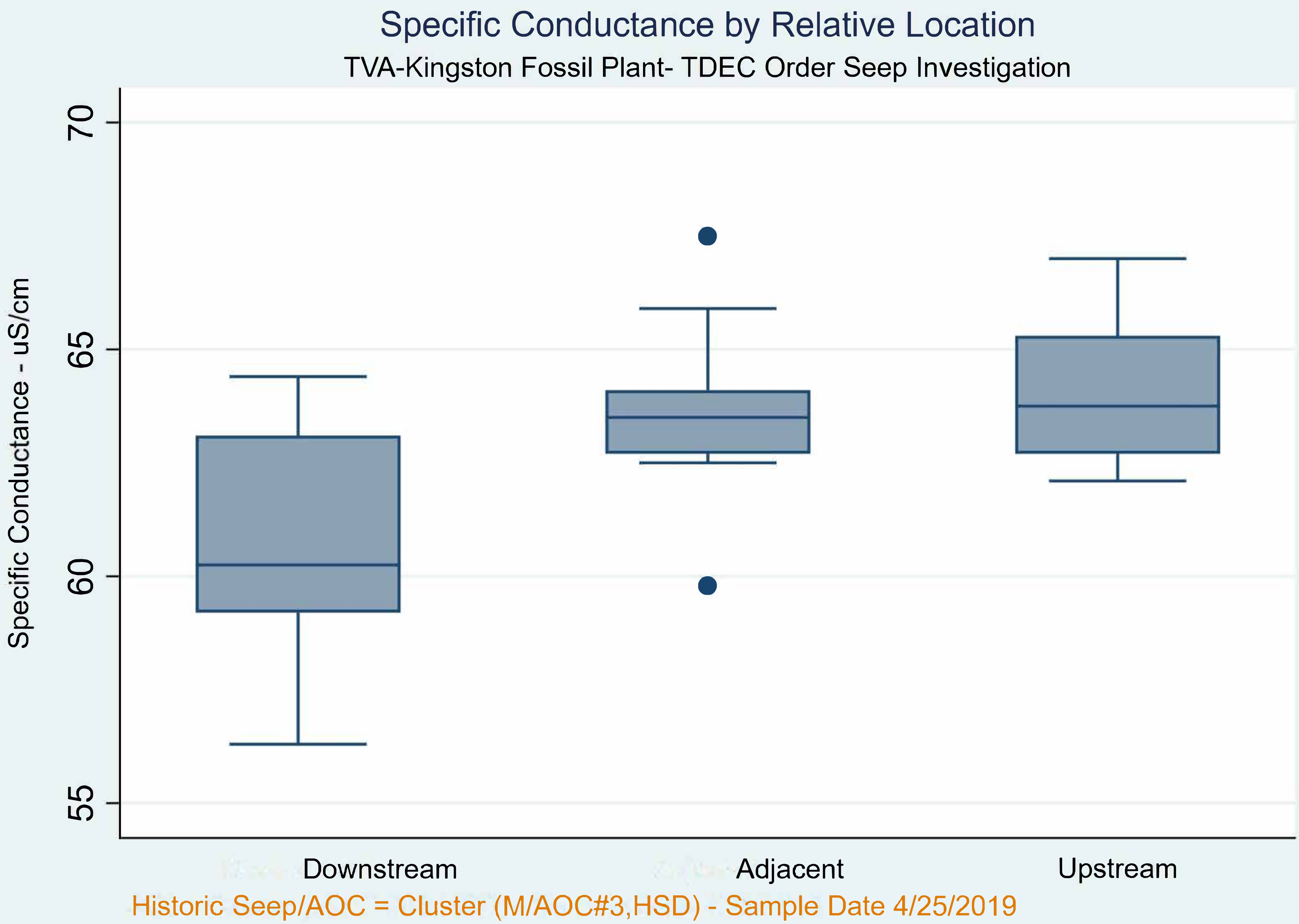


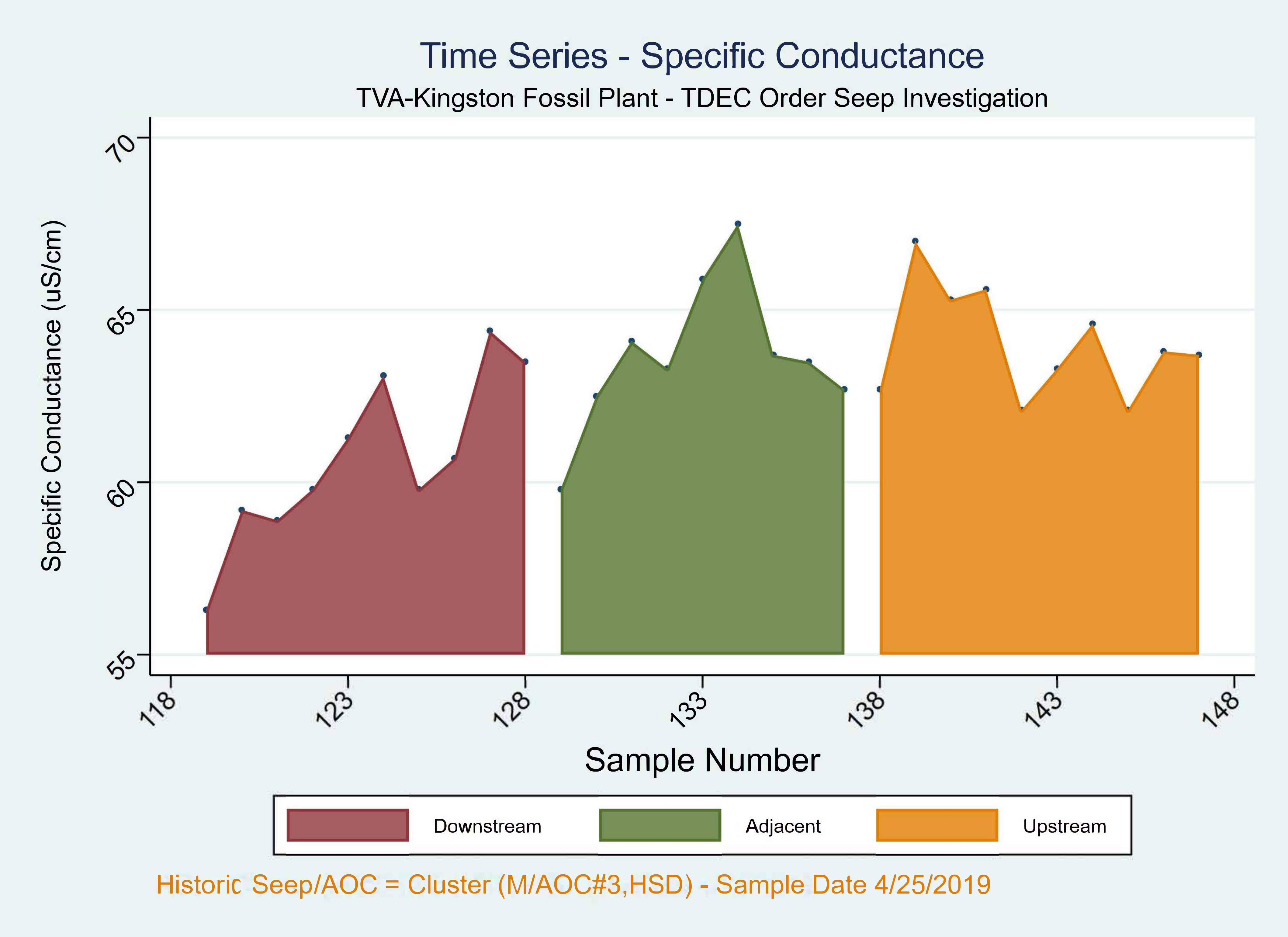
Time Series - Dissolved Oxygen
TVA-Kingston Fossil Plant - TDEC Order Seep Investigation
Dissolved Oxygen (mg/L)
9
8.5
8
7.5
7
6.5
118
123
128
133
138
143
148
Sample Number
Downstream
Adjacent
Upstream
Historic Seep/AOC = Cluster-(M/AOC#3,HSD) - Sample Date 4/25/2019

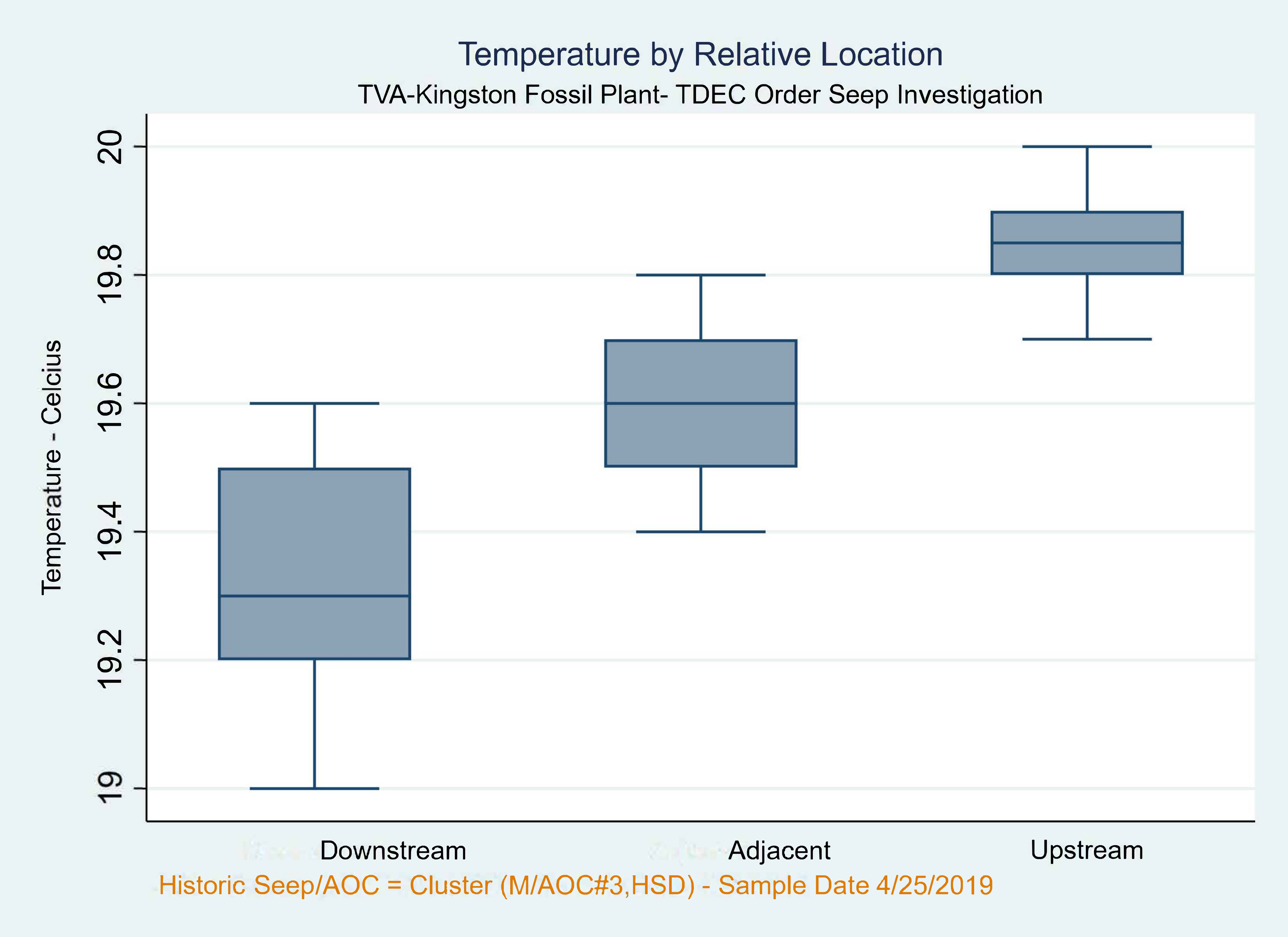

pH by Relative Location
TVA-Kingston Fossil Plant- TDEC Order Seep Investigation
pH - SU's
8
7.5
7
Downstream
Adjacent
Upstream
Historic Seep/AOC = Cluster (M/AOC#3,HSD) - Sample Date 4/25/2019



Time Series - pH
TVA-Kingston Fossil Plant - TDEC Order Seep Investigation
pH (Su's)
8
7.5
7
6.5
118
123
128
133
138
143
148
Sample Number
Downstream
Adjacent
Upstream
Historic Seep/AOC = Cluster (M/AOC#3,HSD) - Sample Date 4/25/2019


Specific Conductance by Relative Location
TVA-Kingston Fossil Plant- TDEC Order Seep Investigation
Specific Conductance - uS/cm
70
65
60
55
Downstream
Adjacent
Upstream
Historic Seep/AOC = Cluster (M/AOC#3,HSD) - Sample Date 4/25/2019


Time Series - Specific Conductance
TVA-Kingston Fossil Plant - TDEC Order Seep Investigation
Specific Conductance (uS/cm)
70
65
60
55
118
123
128
133
138
143
148
Sample Number
Downstream
Adjacent
Upstream
Historic Seep/AOC = Cluster (M/AOC#3,HSD) - Sample Date 4/25/2019


Temperature by Relative Location
TVA-Kingston Fossil Plant- TDEC Order Seep Investigation
Temperature - Celcius
20
19.8
19.6
19.4
19.2
19
Downstream
Adjacent
Upstream
Historic Seep/AOC = Cluster (M/AOC#3,HSD) - Sample Date 4/25/2019

Time Series - Temperature
TVA-Kingston Fossil Plant - TDEC Order Seep Investigation
Temperature (Celsius)
20
19.8
19.6
19.4
19.2
19
118
123
128
133
138
143
148
Sample Number
Downstream
Adjacent
Upstream
Historic Seep/AOC = Cluster (M/AOC#3,HSD) - Sample Date 4/25/2019

ATTACHMENT D.2

Summary of Descriptive Statistics

KIF Seep Investigation –Summary Statistics for Areas of Concern (AOCs)

Kingston Fossil Plant - Seep Investigation - Summary Statistics Dissolved Oxygen - milligrams per liter (mg/L)								
Historical Seep/ AOC Location	**Relative Location to AOC**	**Number of Samples**	**Minimum**	**Maximum**	**Mean**	**Standard Deviation**	**Median**	**95th Percentile**
L/AOC#2	Downstream	10	7.94	8.95	8.38	0.28	8.37	8.95
	Adjacent	8	8.06	9.12	8.39	0.37	8.28	9.12
	Upstream	11	7.49	8.68	7.96	0.34	8.00	8.68
HS Cluster-(C,R)	Downstream	10	8.77	9.70	9.18	0.26	9.19	9.70
	Adjacent	8	8.22	8.54	8.38	0.10	8.39	8.54
	Upstream	10	7.38	8.94	8.19	0.51	8.17	8.94
HSK	Downstream	10	7.58	8.89	8.51	0.37	8.64	8.89
	Adjacent	9	7.75	8.91	8.15	0.34	8.04	8.91
	Upstream	10	7.64	9.30	8.47	0.63	8.74	9.30
M/AOC#3,HSD	Downstream	10	6.46	8.74	7.31	0.74	7.09	8.74
	Adjacent	9	6.75	8.33	7.47	0.54	7.34	8.33
	Upstream	10	6.56	7.25	6.90	0.25	6.83	7.25
Control (4/24/2019)		20	7.22	8.29	7.79	0.24	7.80	8.17
Control (4/25/2019)		20	7.27	8.68	8.14	0.41	8.22	8.67
Intermediate Areas		17	7.01	9.21	8.21	0.65	8.09	9.21

KIF Seep Investigation –Summary Statistics for Areas of Concern (AOCs)

Kingston Fossil Plant - Seep Investigation - Summary Statistics pH (Standard Units)								
Historical Seep/ AOC Location	**Relative Location to AOC**	**Number of Samples**	**Minimum**	**Maximum**	**Mean**	**Standard Deviation**	**Median**	**95th Percentile**
L/AOC#2	Downstream	10	6.59	6.89	6.76	0.10	6.78	6.89
	Adjacent	8	6.84	6.95	6.91	0.04	6.91	6.95
	Upstream	11	6.26	6.98	6.77	0.22	6.87	6.98
HS Cluster-(C,R)	Downstream	10	6.98	7.28	7.16	0.09	7.16	7.28
	Adjacent	8	7.28	7.46	7.39	0.07	7.42	7.46
	Upstream	10	7.23	7.61	7.35	0.12	7.30	7.61
HSK	Downstream	10	6.93	7.17	7.04	0.07	7.03	7.17
	Adjacent	9	7.01	7.14	7.07	0.05	7.07	7.14
	Upstream	10	6.90	7.08	6.98	0.06	6.96	7.08
M/AOC#3,HSD	Downstream	10	6.90	7.42	7.20	0.17	7.22	7.42
	Adjacent	9	7.31	7.66	7.50	0.14	7.44	7.66
	Upstream	10	7.69	7.92	7.83	0.07	7.83	7.92
Control (4/24/2019)		20	7.10	7.24	7.16	0.04	7.15	7.23
Control (4/25/2019)		20	7.29	7.48	7.40	0.05	7.40	7.47
Intermediate Areas		17	6.29	7.88	7.22	0.47	7.23	7.88

KIF Seep Investigation –Summary Statistics for Areas of Concern (AOCs)

Kingston Fossil Plant - Seep Investigation - Summary Statistics Specific Conductance - microsiemens per centimeter (µS/cm)								
Historical Seep/ AOC Location	**Relative Location to AOC**	**Number of Samples**	**Minimum**	**Maximum**	**Mean**	**Standard Deviation**	**Median**	**95th Percentile**
L/AOC#2	Downstream	10	47.4	56.8	50.1	3.03	49.1	56.8
	Adjacent	8	46.5	63.3	52.0	5.98	49.5	63.3
	Upstream	11	46.8	55.3	49.4	2.78	48.7	55.3
HS Cluster-(C,R)	Downstream	10	47.6	50.5	48.7	1.10	48.2	50.5
	Adjacent	8	47.4	53.2	50.8	1.72	51.2	53.2
	Upstream	10	45.4	56.0	49.3	2.84	48.8	56.0
HSK	Downstream	10	49.4	54.0	51.9	1.66	52.2	54.0
	Adjacent	9	49.4	52.5	50.9	0.96	50.7	52.5
	Upstream	10	49.2	52.8	50.3	1.04	50.0	52.8
M/AOC#3,HSD	Downstream	10	56.3	64.4	60.7	2.45	60.3	64.4
	Adjacent	9	59.8	67.5	63.7	2.16	63.5	67.5
	Upstream	10	62.1	67.0	64.0	1.60	63.8	67.0
Control (4/24/2019)		20	46.5	47.7	47.0	0.33	47.1	47.6
Control (4/25/2019)		20	48.7	52.3	50.2	0.84	50.1	52.0
Intermediate Areas		17	46.3	64.4	55.8	5.70	56.9	64.4

KIF Seep Investigation –Summary Statistics for Areas of Concern (AOCs)

Kingston Fossil Plant - Seep Investigation - Summary Statistics Temperature (Celsius)								
Historical Seep/ AOC Location	**Relative Location to AOC**	**Number of Samples**	**Minimum**	**Maximum**	**Mean**	**Standard Deviation**	**Median**	**95th Percentile**
L/AOC #2	Downstream	10	15.1	15.5	15.3	0.14	15.3	15.5
	Adjacent	8	14.8	15.3	15.0	0.16	15.0	15.3
	Upstream	11	14.4	15.0	14.7	0.23	14.6	15.0
HS Cluster-(C,R)	Downstream	10	15.1	15.6	15.3	0.22	15.2	15.6
	Adjacent	8	15.1	15.7	15.5	0.19	15.5	15.7
	Upstream	10	15.1	15.4	15.2	0.09	15.2	15.4
HSK	Downstream	10	15.1	15.8	15.4	0.24	15.4	15.8
	Adjacent	9	15.4	15.8	15.5	0.13	15.5	15.8
	Upstream	10	15.5	17.2	16.2	0.48	16.1	17.2
M/AOC#3,HSD	Downstream	10	19.0	19.6	19.3	0.19	19.3	19.6
	Adjacent	9	19.4	19.8	19.6	0.14	19.6	19.8
	Upstream	10	19.7	20.0	19.8	0.10	19.9	20.0
Control (4/24/2019)		20	16.5	18.4	17.2	0.49	17.2	18.2
Control (4/25/2019)		20	18.8	19.5	19.2	0.17	19.2	19.5
Intermediate Areas		17	14.9	19.8	16.8	2.09	15.6	19.8

p-Values by Areas of Concern (AOCs)

Kingston Fossil Plant Seep Investigation - Summary of Hypothesis Testing						
Historical Seep/AOC Location	**Relative Location to Historical Seep**	**Number of Samples**	**Dissolved Oxygen (mg/L)**	**pH (Standard Units)**	**Specific Conductance (µS/cm)**	**Temperature (Celsius)**
			p-value	**p-value**	**p-value**	**p-value**
L/AOC#2	Adjacent v Upstream	8/11	0.9894	0.0699	0.1426	**0.0027**
HSK	Adjacent v Upstream	9/10	0.0921	**0.0022**	0.1023	**0.0032**
HS Cluster-(C,R)	Adjacent v Upstream	8/10	0.8677	0.3658	0.0928	0.0081
M/AOC#3,HSD	Adjacent v Upstream	9/10	0.9926	**0.0000**	0.6530	**0.0008**

Adjusted Significance Level (SWFPR/#Statistical Tests): 0.10/16 = 0.00625

Bold and Highlight indicate that p-value is below adjusted significance level, reject null and conclude statistically significant difference.

(mg/L = milligrams per liter

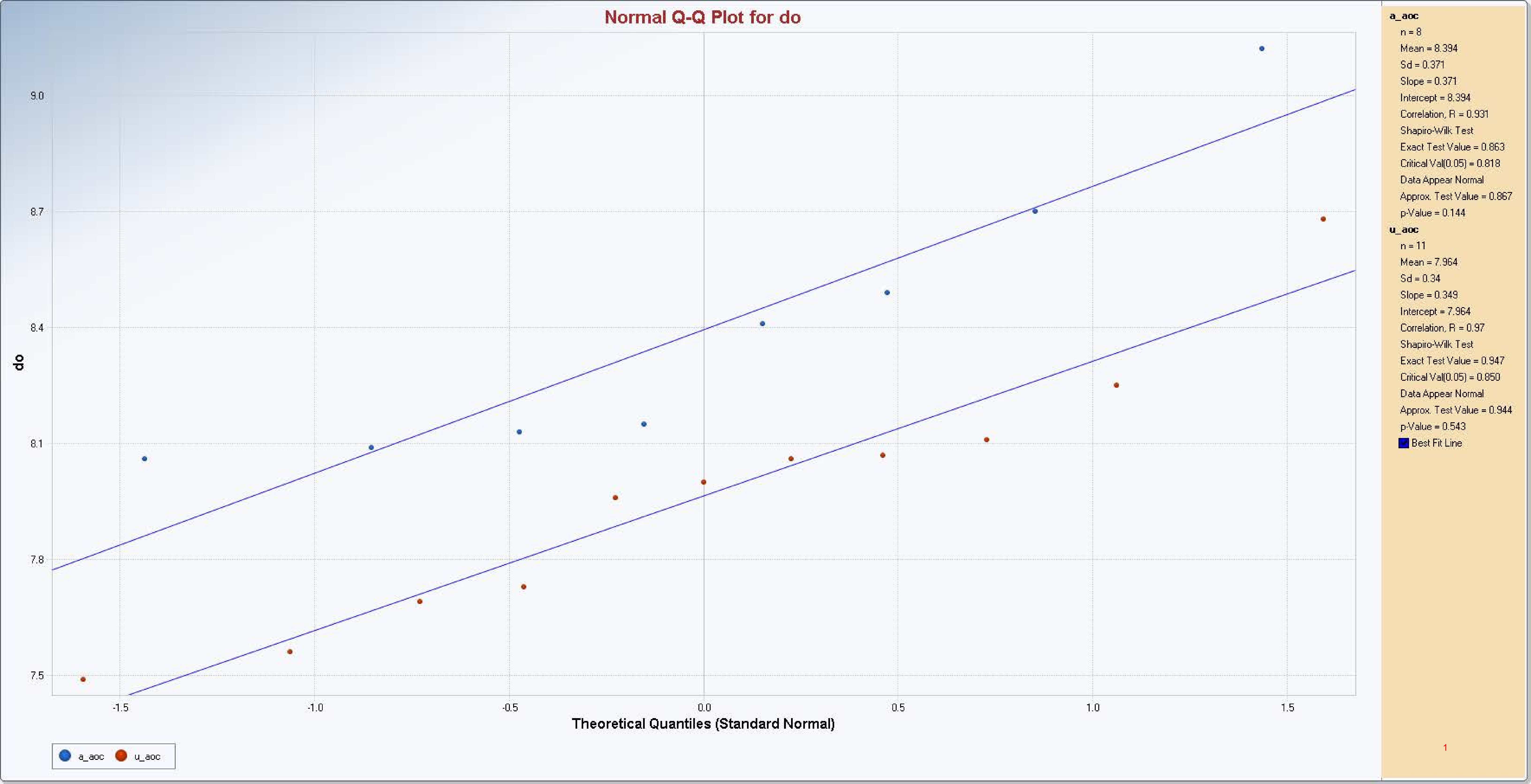
µS/cm = microsiemens per centimeter

AOC = Area of Concern

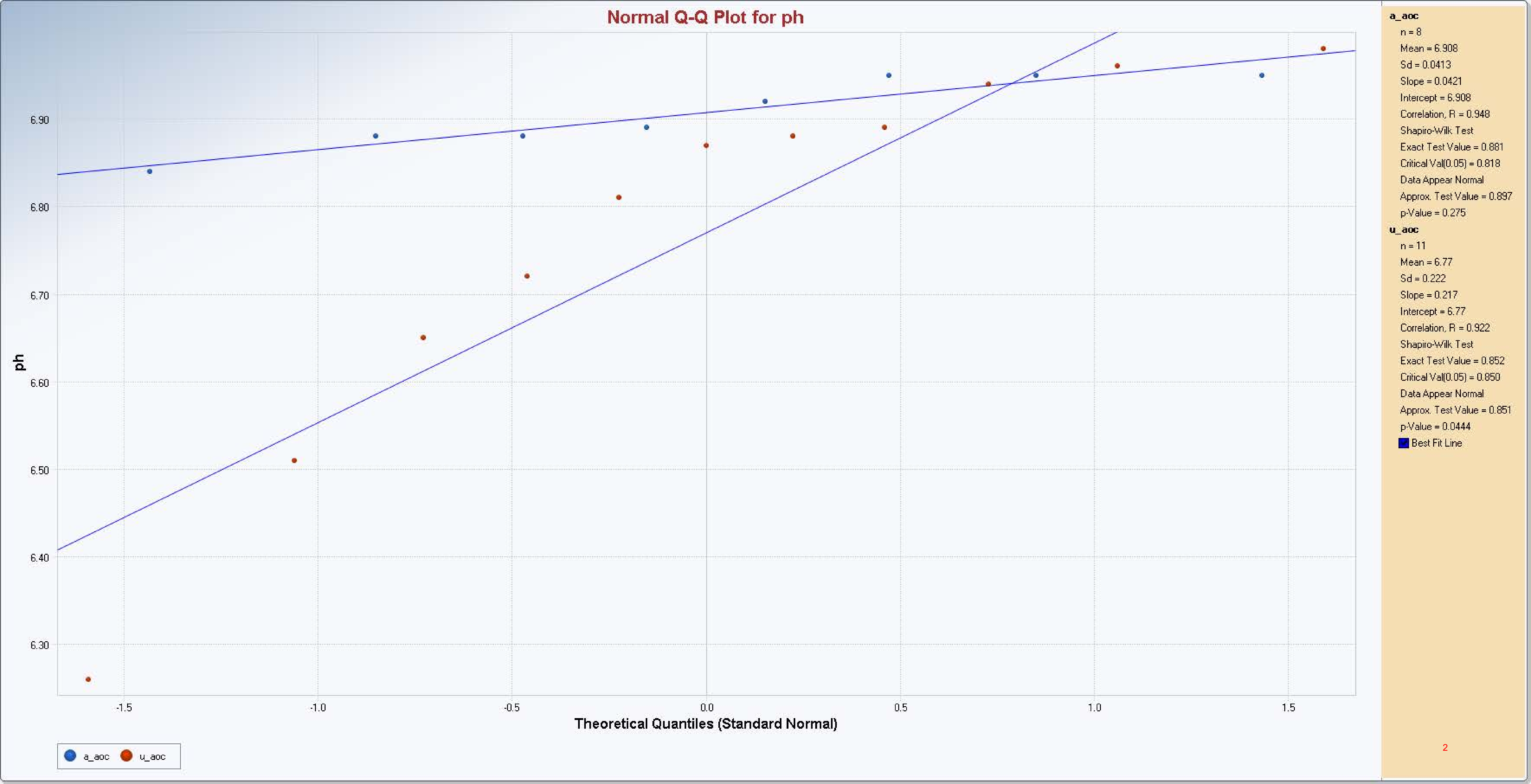
ATTACHMENT D.3

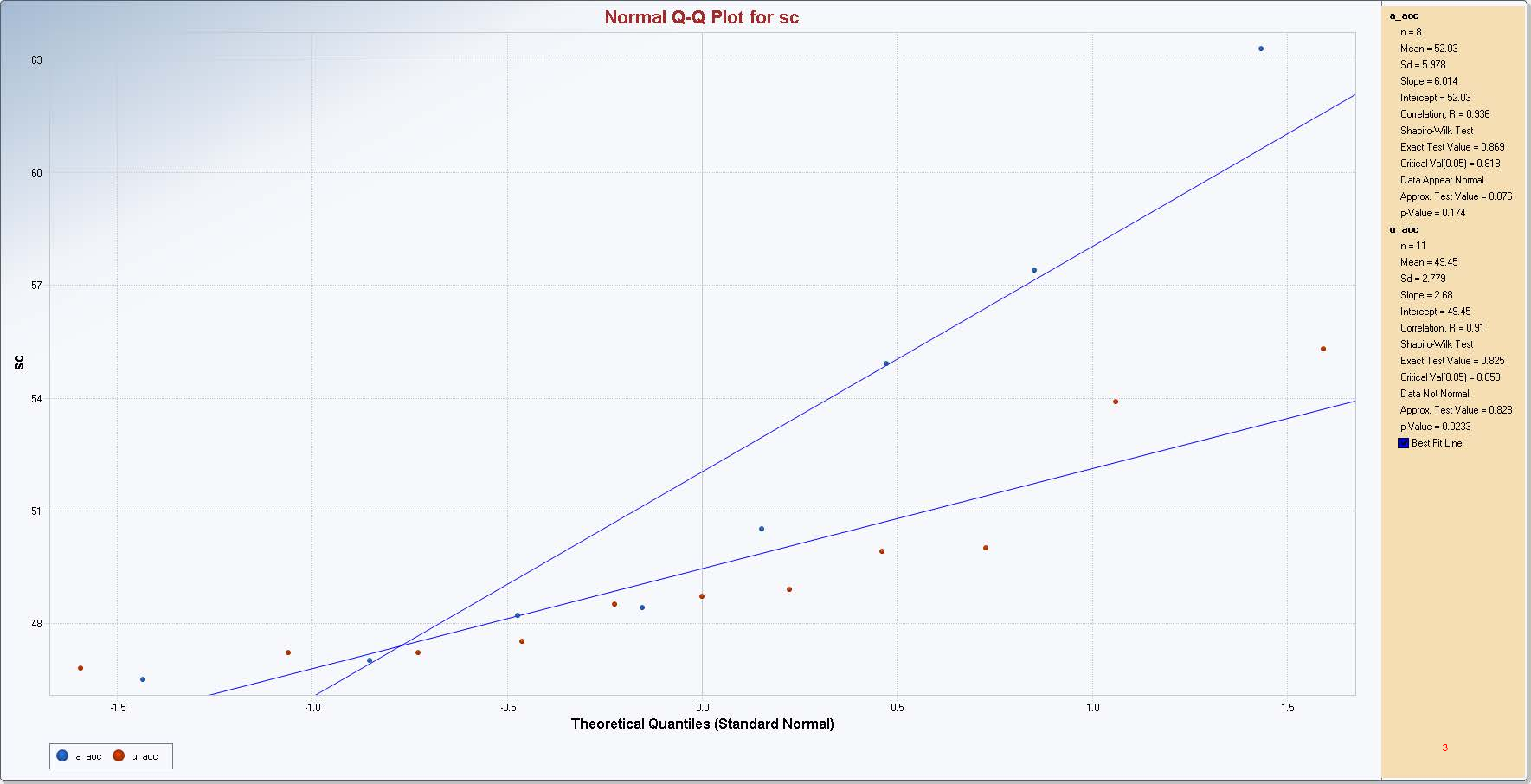
Normal Q-Q Plots

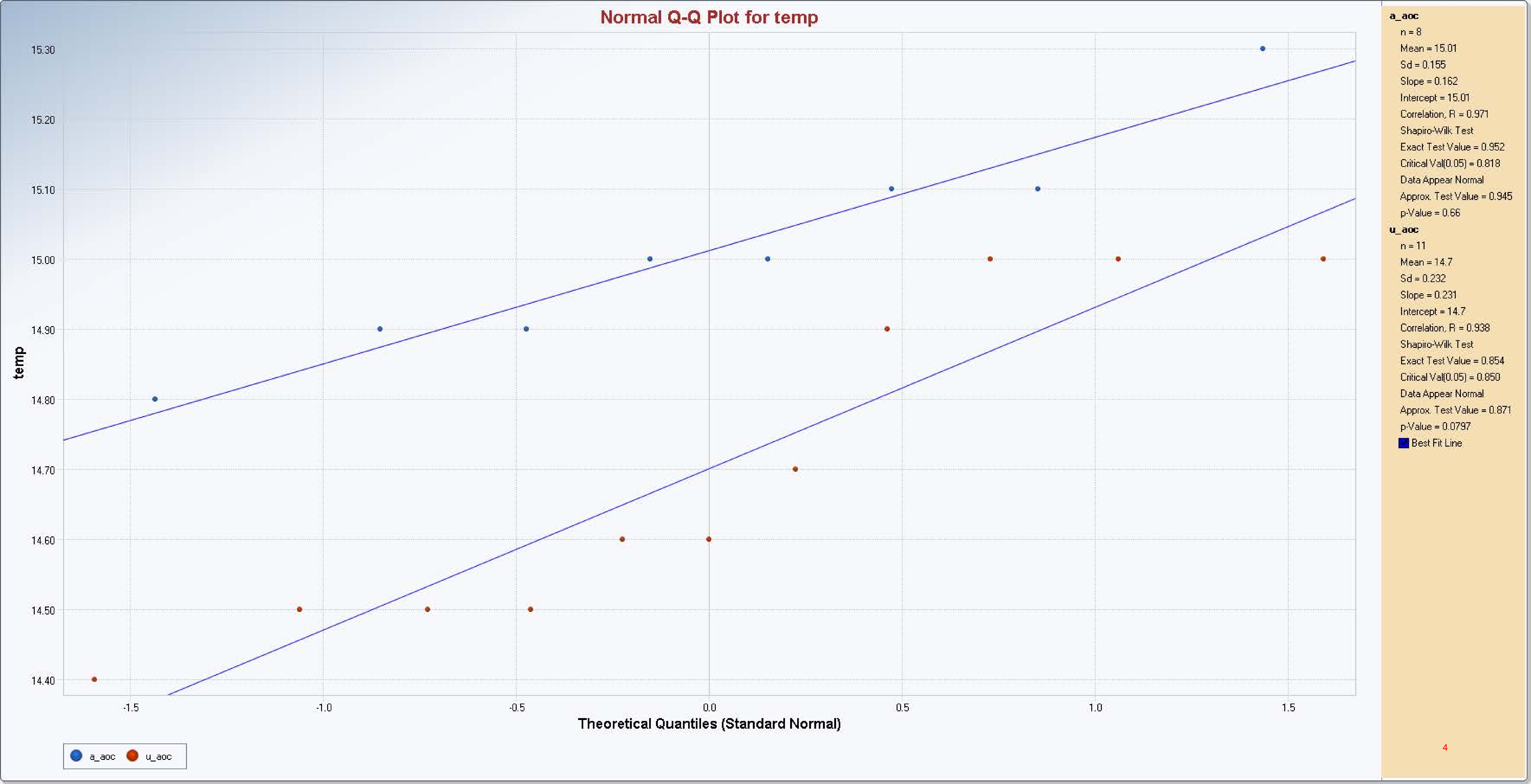
Key to Normal Quantile – Quantile (Q-Q Plots)		
Parameter Abbreviations	**Parameter**	**Units**
do	Dissolved Oxygen	milligrams per liter (mg/L)
ph	pH	standard units (SU's)
sc	Specific Conductance	microsiemens per centimeter (µS/cm)
temp	Temperature	Celsius (°C)
Additional Abbreviations		
"a_"	Measurements collected adjacent to Historic Seep or Area of Concern	
"u_"	Measurements collected upstream of Historic Seep or Area of Concern	

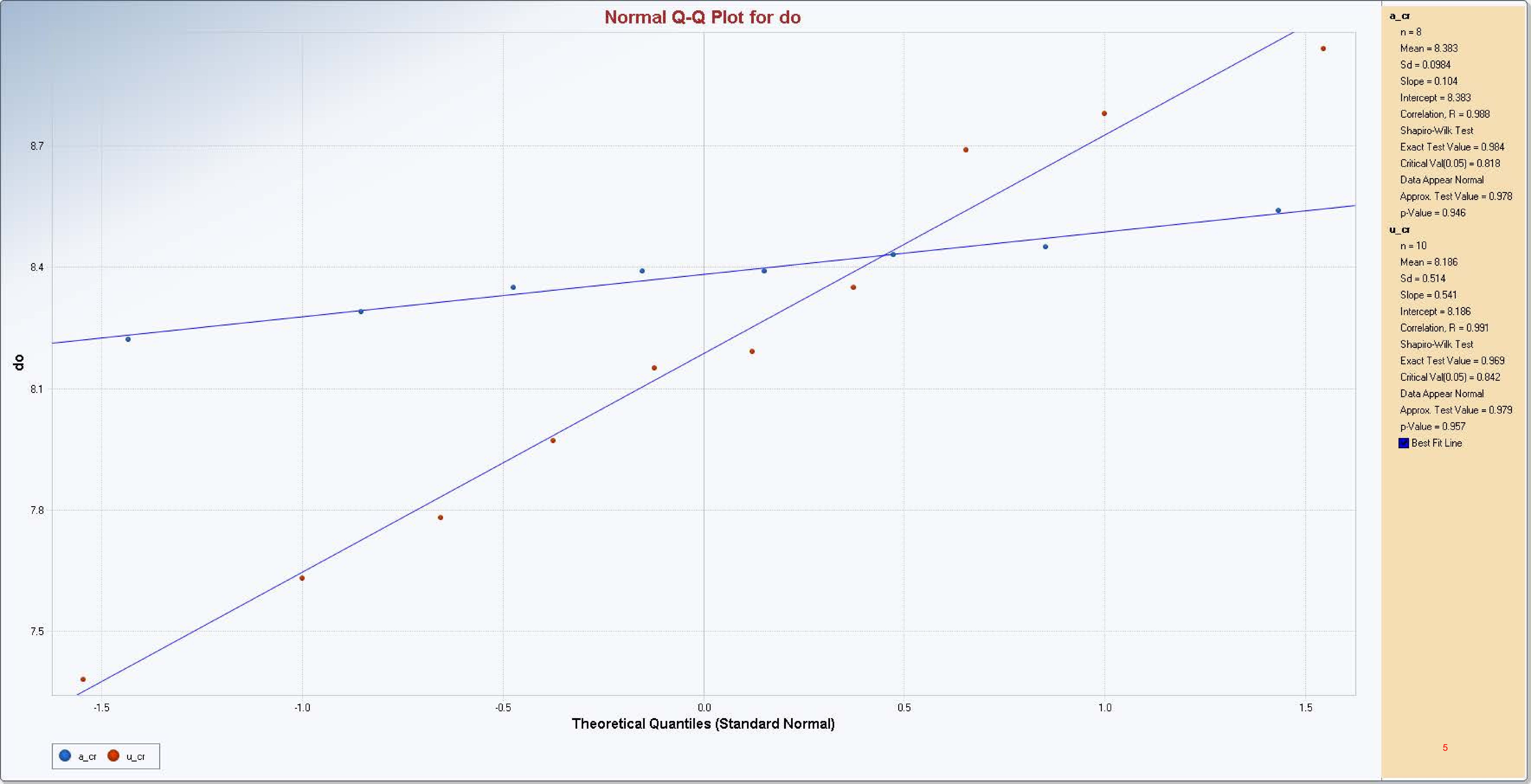


Normal Q-Q Plot for do
9.0
8.7
8.4
8.1
7.8
7.5
do
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
Theoretical Quantiles (Standard Normal)
a_aoc
u_aoc
a_aoc
n = 8
Mean = 8.394
Sd = 0.371
Slope = 0.371
Intercept = 8.394
Correlation, R = 0.931
Shapiro-Wilk Test
Exact Test Value = 0.863
Critical Val(0.05) = 0.818
Data Appear Normal
Approx. Test Value = 0.867
p-Value = 0.144
u_aoc
n = 11
Mean = 7.964
Sd = 0.34
Slope = 0.349
Intercept = 7.964
Correlation, R = 0.97
Shapiro-Wilk Test
Exact Test Value = 0.947
Critical Val(0.05) = 0.850
Data Appear Normal
Approx. Test Value = 0.944
p-Value = 0.543
Best Fit Line
1

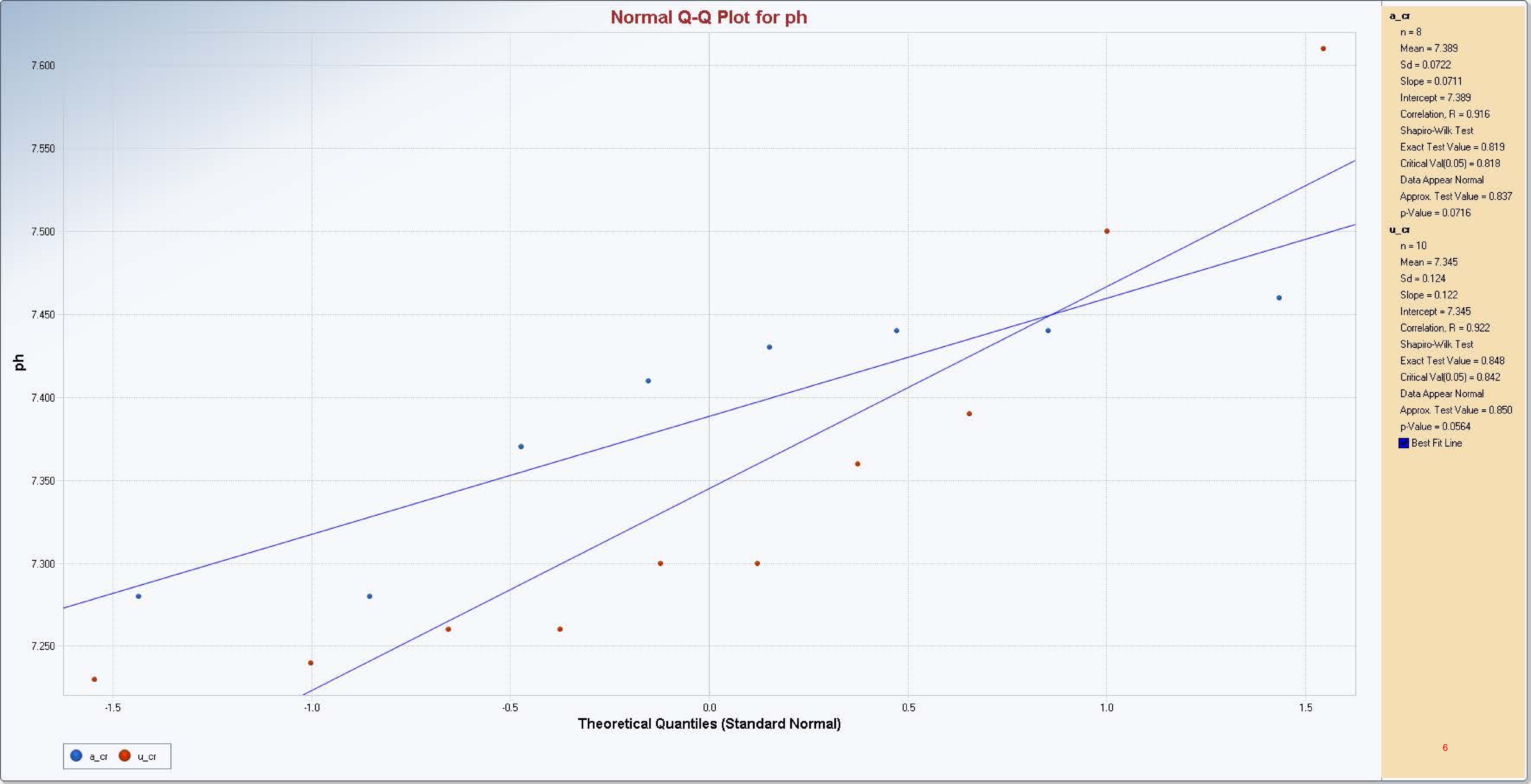

Normal Q-Q Plot for ph
ph
6.90
6.80
6.70
6.60
6.50
6.40
6.30
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
Theoretical Quantiles (Standard Normal)
a_aoc
u_aoc
a_aoc
n = 8
Mean = 6.908
Sd = 0.0413
Slope = 0.0421
Intercept = 6.908
Correlation, R = 0.948
Shapiro-Wilk Test
Exact Test Value = 0.881
Critical Val(0.05) = 0.818
Data Appear Normal
Approx. Test Value = 0.897
p-Value = 0.275
u_aoc
n = 11
Mean = 6.77
Sd = 0.222
Slope = 0.217
Intercept = 6.77
Correlation, R = 0.922
Shapiro-Wilk Test
Exact Test Value = 0.852
Critical Val(0.05) = 0.850
Data Appear Normal
Approx. Test Value = 0.851
p-Value = 0.0444
Best Fit Line
2

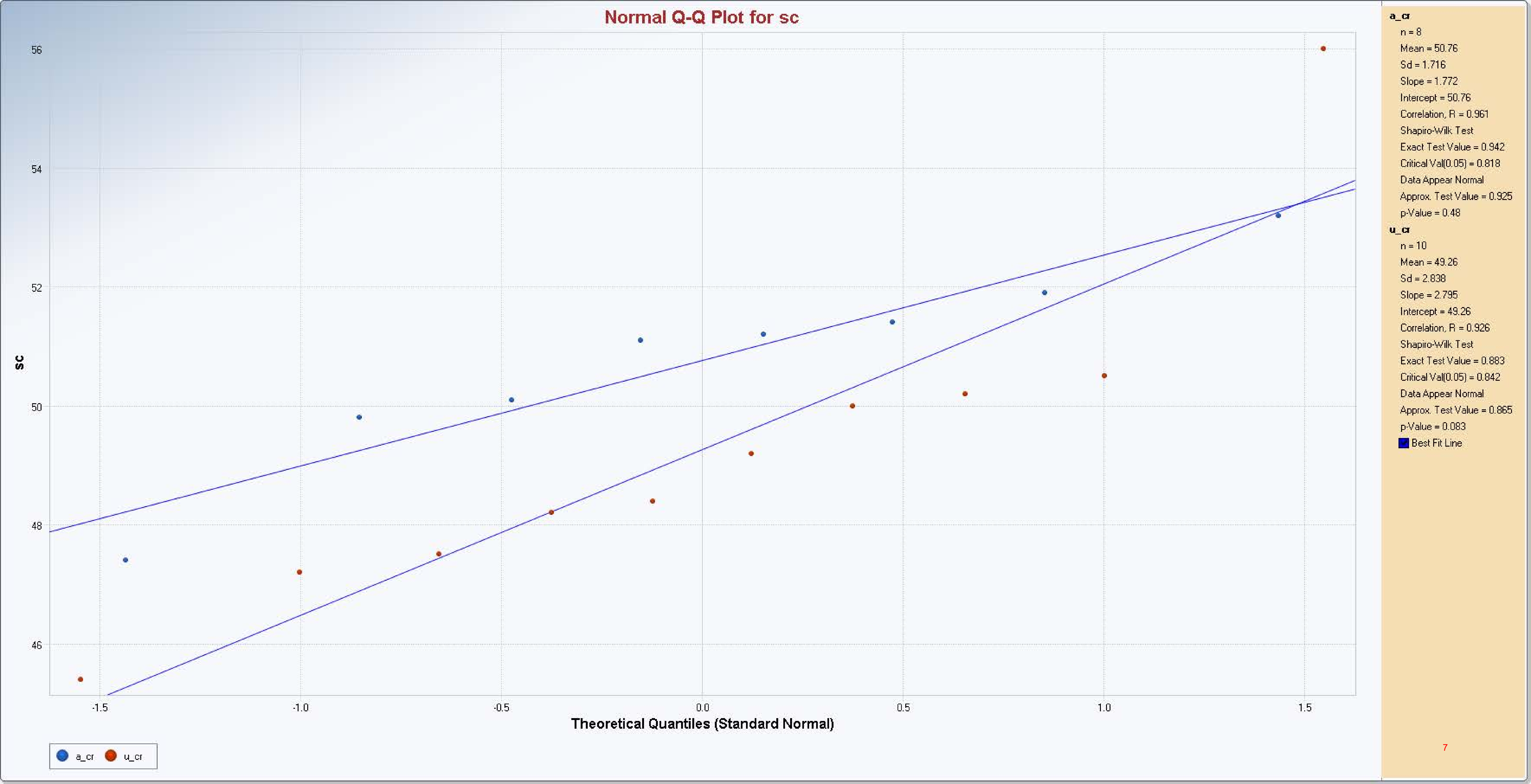

Normal Q-Q Plot for sc
sc
63
60
57
54
51
48
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
Theoretical Quantiles (Standard Normal)
a_aoc
u_aoc
a_aoc
n = 8
Mean = 52.03
Sd = 5.978
Slope = 6.014
Intercept = 52.03
Correlation, R = 0.936
Shapiro-Wilk Test
Exact Test Value = 0.869
Critical Val(0.05) = 0.818
Data Appear Normal
Approx. Test Value = 0.876
p-Value = 0.174
u_aoc
n = 11
Mean = 49.45
Sd = 2.779
Slope = 2.68
Intercept = 49.45
Correlation, R = 0.91
Shapiro-Wilk Test
Exact Test Value = 0.825
Critical Val(0.05) = 0.850
Data Not Normal
Approx. Test Value = 0.828
p-Value = 0.0233
Best Fit Line
3

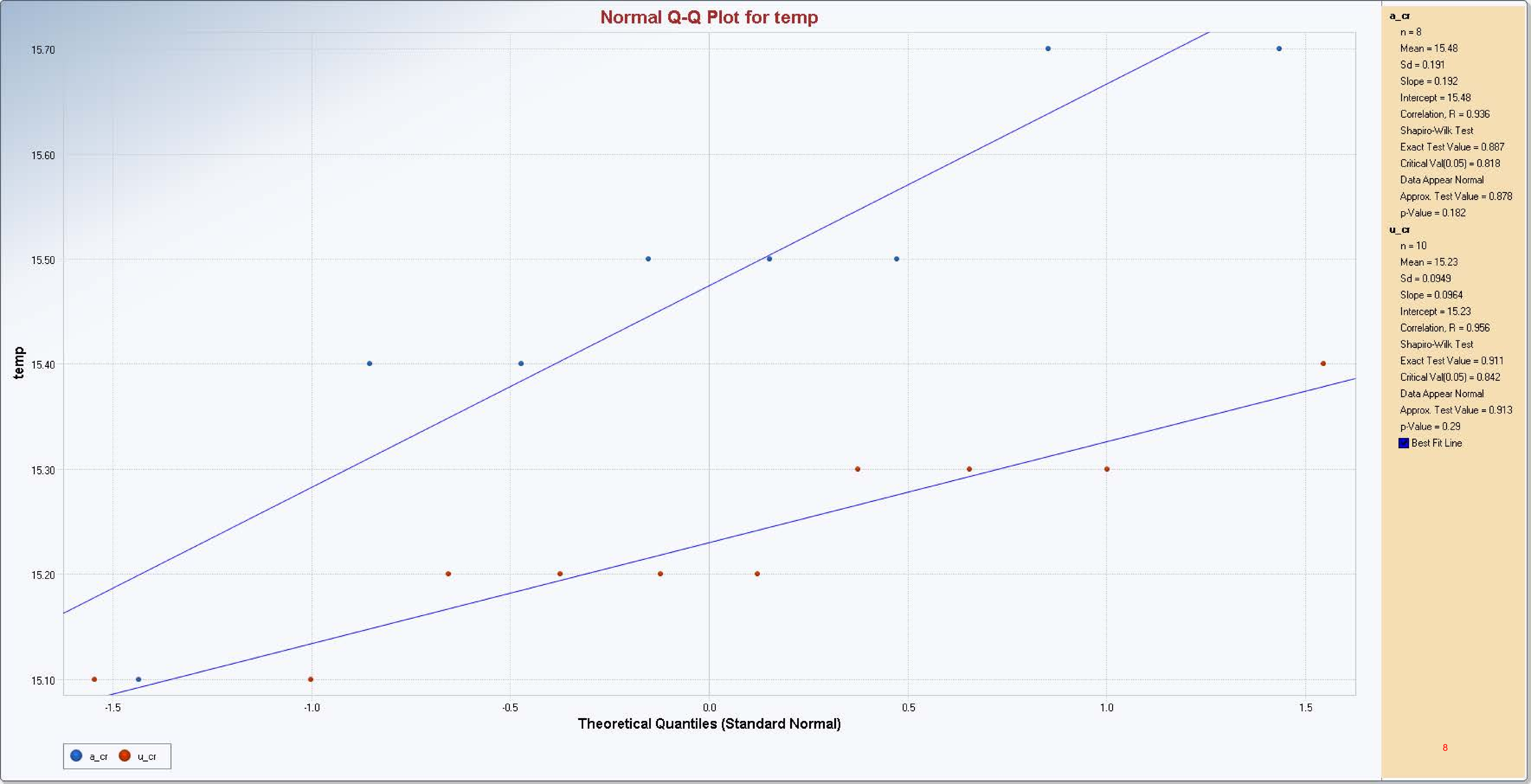

Normal Q-Q Plot for temp
temp
15.30
15.20
15.10
15.00
14.90
14.80
14.70
14.60
14.50
14.40
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
Theoretical Quantiles (Standard Normal)
a_aoc
u_aoc
a_aoc
n = 8
Mean = 15.01
Sd = 0.155
Slope = 0.162
Intercept = 15.01
Correlation, R = 0.971
Shapiro-Wilk Test
Exact Test Value = 0.952
Critical Val(0.05) = 0.818
Data Appear Normal
Approx. Test Value = 0.945
p-Value = 0.66
u_aoc
n = 11
Mean = 14.7
Sd = 0.232
Slope = 0.231
Intercept = 14.7
Correlation, R = 0.938
Shapiro-Wilk Test
Exact Test Value = 0.854
Critical Val(0.05) = 0.850
Data Appear Normal
Approx. Test Value = 0.871
p-Value = 0.0797
Best Fit Line
4



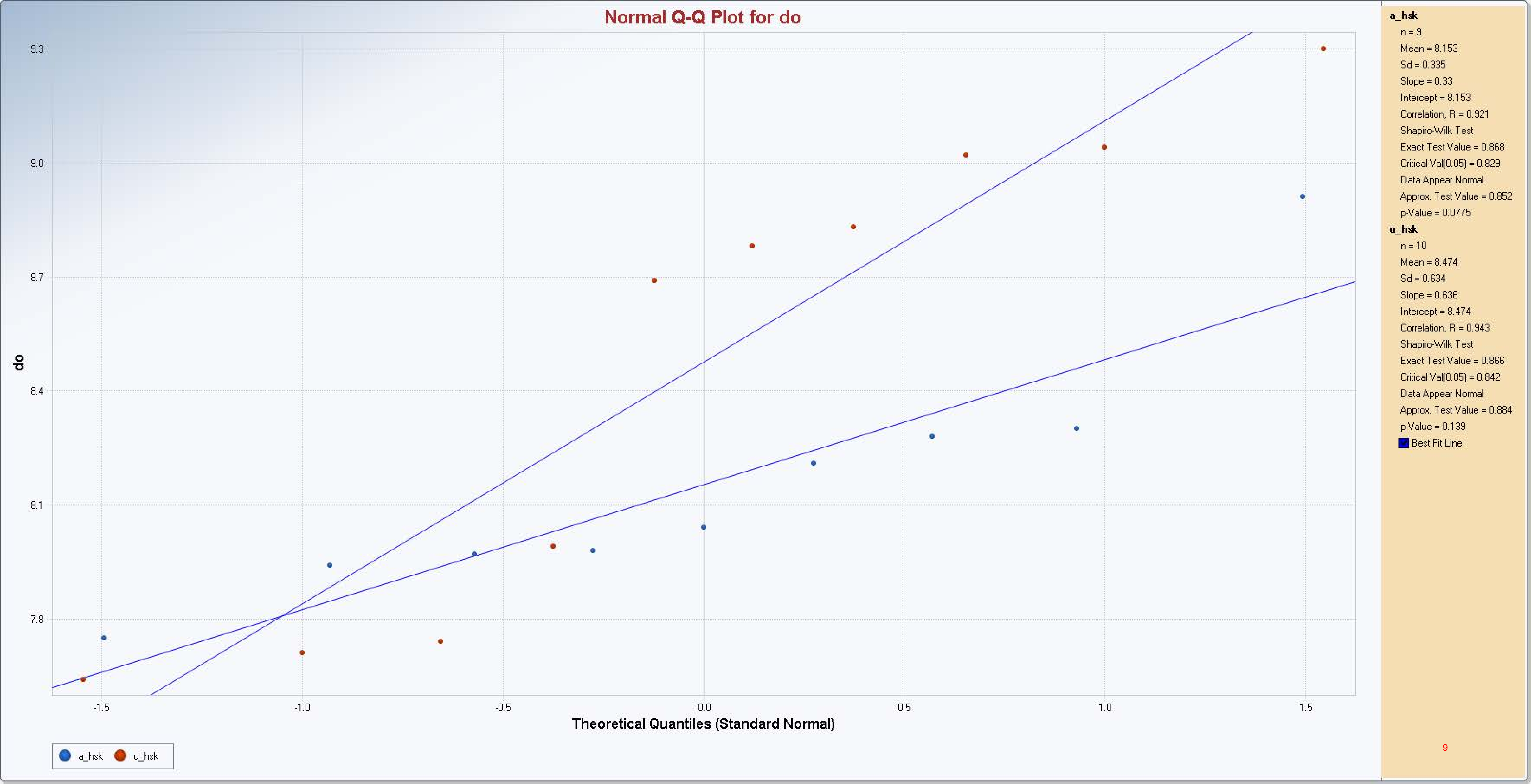
Normal Q-Q Plot for do
8.7
8.4
8.1
7.8
7.5
do
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
Theoretical Quantiles (Standard Normal)
a_cr
u_cr
a_cr
n = 8
Mean = 8.383
Sd = 0.0984
Slope = 0.104
Intercept = 8.383
Correlation, R = 0.988
Shapiro-Wilk Test
Exact Test Value = 0.984
Critical Val(0.05) = 0.818
Data Appear Normal
Approx. Test Value = 0.978
p-Value = 0.946
u_cr
n = 10
Mean = 8.186
Sd = 0.514
Slope = 0.541
Intercept = 8.186
Correlation, R = 0.991
Shapiro-Wilk Test
Exact Test Value = 0.969
Critical Val(0.05) = 0.842
Data Appear Normal
Approx. Test Value = 0.979
p-Value = 0.957
Best Fit Line
5

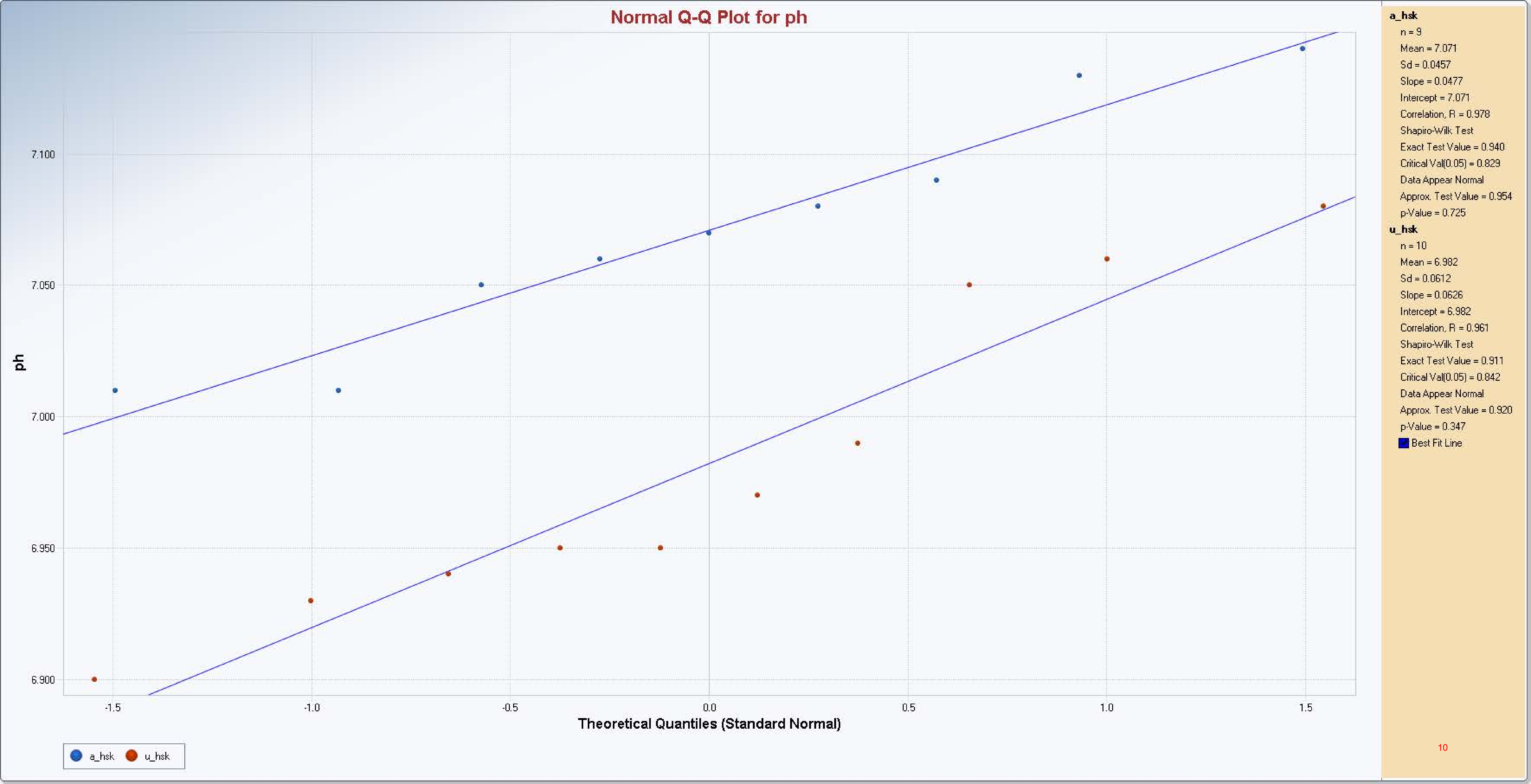

Normal Q-Q Plot for ph
ph
Theoretical Quantiles (Standard Normal)
7.600
7.550
7.500
7.450
7.400
7.350
7.300
7.250
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
a_cr
u_cr
a_cr
n = 8
Mean = 7.389
Sd = 0.0722
Slope = 0.0711
Intercept = 7.389
Correlation, R = 0.916
Shapiro-Wilk Test
Exact Test Value = 0.819
Critical Val(0.05) = 0.818
Data Appear Normal
Approx. Test Value = 0.837
p-Value = 0.0716
u_cr
n = 10
Mean = 7.345
Sd = 0.124
Slope = 0.122
Intercept = 7.345
Correlation, R = 0.922
Shapiro-Wilk Test
Exact Test Value = 0.848
Critical Val(0.05) = 0.842
Data Appear Normal
Approx. Test Value = 0.850
p-Value = 0.0564
Best Fit Line
6


Normal Q-Q Plot for sc
56
54
52
50
48
46
sc
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
Theoretical Quantiles (Standard Normal)
a_cr
u_cr
a_cr
n = 8
Mean = 50.76
Sd = 1.716
Slope = 1.772
Intercept = 50.76
Correlation, R = 0.961
Shapiro-Wilk Test
Exact Test Value = 0.942
Critical Val(0.05) = 0.818
Data Appear Normal
Approx. Test Value = 0.925
p-Value = 0.48
u_cr
n = 10
Mean = 49.26
Sd = 2.838
Slope = 2.795
Intercept = 49.26
Correlation, R = 0.926
Shapiro-Wilk Test
Exact Test Value = 0.883
Critical Val(0.05) = 0.842
Data Appear Normal
Approx. Test Value = 0.865
p-Value = 0.083
Best Fit Line

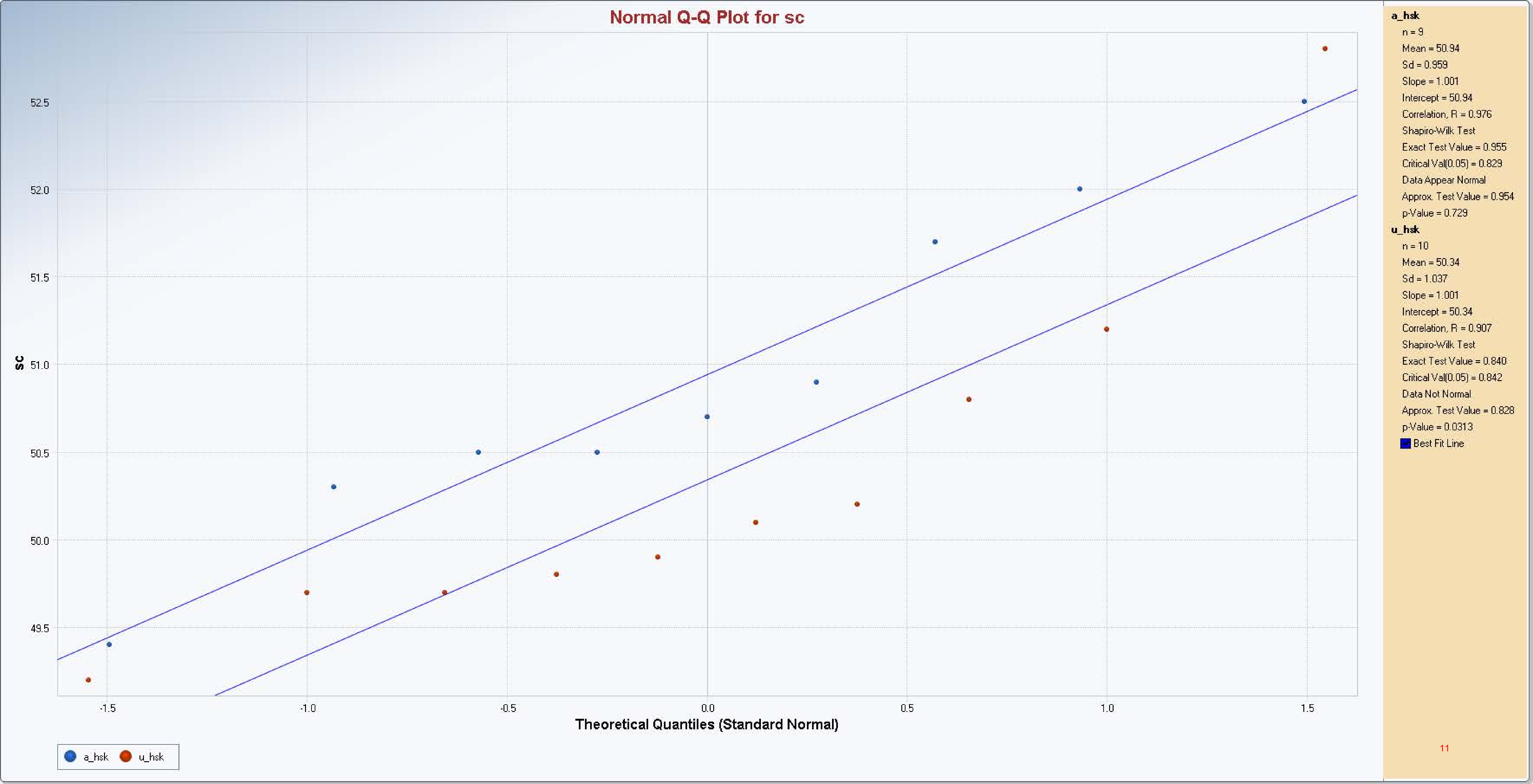


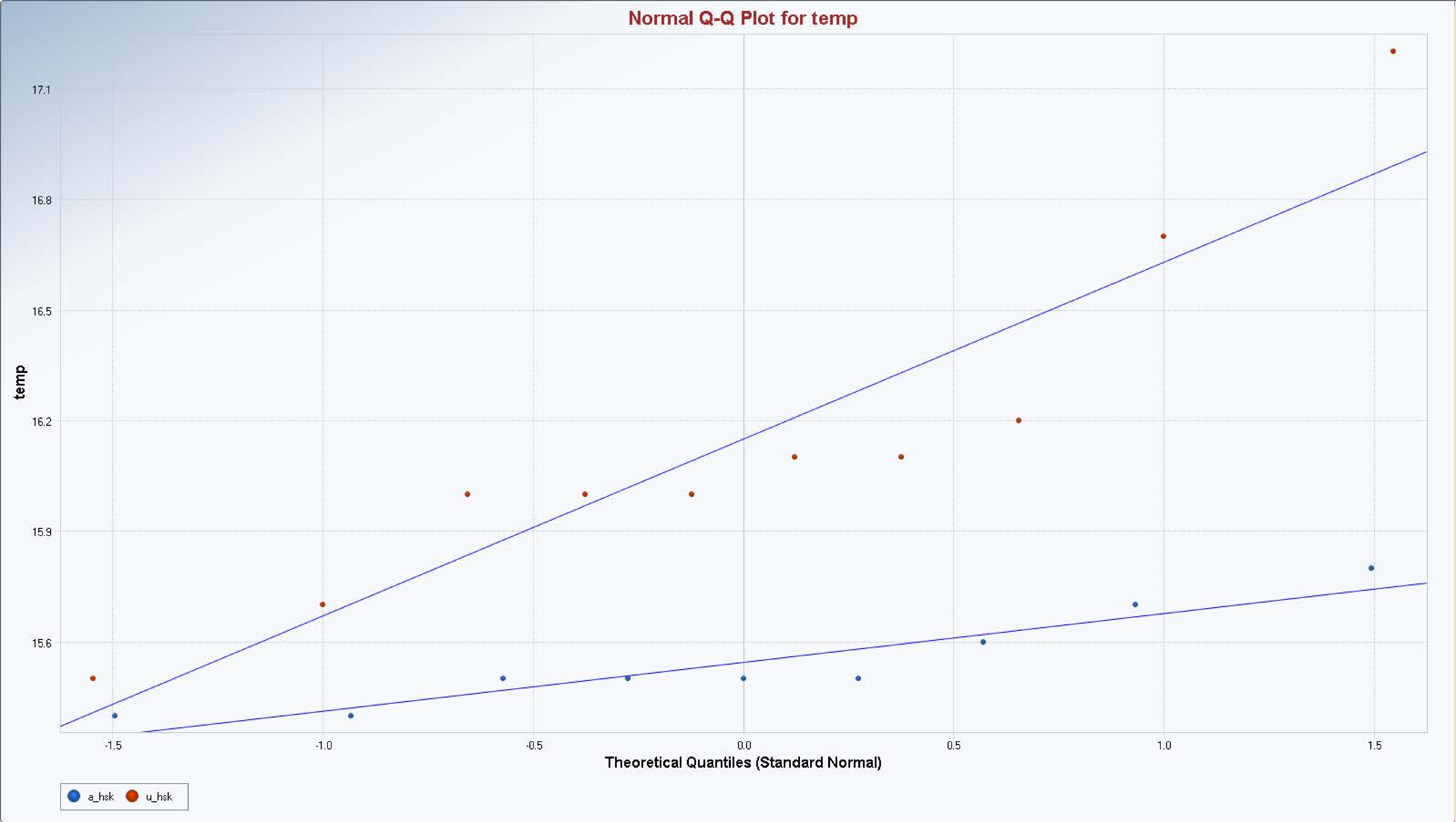
Normal Q-Q Plot for temp
temp
15.70
15.60
15.50
15.40
15.30
15.20
15.10
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
Theoretical Quantiles (Standard Normal)
a_cr
u_cr
a_cr
n = 8
Mean = 15.48
Sd = 0.191
Slope = 0.192
Intercept = 15.48
Correlation, R = 0.936
Shapiro-Wilk Test
Exact Test Value = 0.887
Critical Val(0.05) = 0.818
Data Appear Normal
Approx. Test Value = 0.878
p-Value = 0.182
u_cr
n = 10
Mean = 15.23
Sd = 0.0949
Slope = 0.0964
Intercept = 15.23
Correlation, R = 0.956
Shapiro-Wilk Test
Exact Test Value = 0.911
Critical Val(0.05) = 0.842
Data Appear Normal
Approx. Test Value = 0.913
p-Value = 0.29
Best Fit Line
8


Normal Q-Q Plot for do
do
9.3
9.0
8.7
8.4
8.1
7.8
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
Theoretical Quantiles (Standard Normal)
a_hsk
u_hsk
a_hsk
n = 9
Mean = 8.153
Sd = 0.335
Slope = 0.33
Intercept = 8.153
Correlation, R = 0.921
Shapiro-Wilk Test
Exact Test Value = 0.868
Critical Val(0.05) = 0.829
Data Appear Normal
Approx. Test Value = 0.852
p-Value = 0.0775
u_hsk
n = 10
Mean = 8.474
Sd = 0.634
Slope = 0.636
Intercept = 8.474
Correlation, R = 0.943
Shapiro-Wilk Test
Exact Test Value = 0.866
Critical Val(0.05) = 0.842
Data Appear Normal
Approx. Test Value = 0.884
p-Value = 0.139
Best Fit Line
9



Normal Q-Q Plot for ph
7.100
7.050
7.000
6.950
6.900
ph
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
Theoretical Quantiles (Standard Normal)
a_hsk
u_hsk
a_hsk
n = 9
Mean = 7.071
Sd = 0.0457
Slope = 0.0477
Intercept = 7.071
Correlation, R = 0.978
Shapiro-Wilk Test
Exact Test Value = 0.940
Critical Val(0.05) = 0.829
Data Appear Normal
Approx. Test Value = 0.954
p-Value = 0.725
u_hsk
n = 10
Mean = 6.982
Sd = 0.0612
Slope = 0.0626
Intercept = 6.982
Correlation, R = 0.961
Shapiro-Wilk Test
Exact Test Value = 0.911
Critical Val(0.05) = 0.842
Data Appear Normal
Approx. Test Value = 0.920
p-Value = 0.347
Best Fit Line
10


Normal Q-Q Plot for sc
sc
52.5
52.0
51.5
51.0
50.5
50.0
49.5
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
Theoretical Quantiles (Standard Normal)
a_hsk
u_hsk
a_hsk
n = 9
Mean = 50.94
Sd = 0.959
Slope = 1.001
Intercept = 50.94
Correlation, R = 0.976
Shapiro-Wilk Test
Exact Test Value = 0.955
Critical Val(0.05) = 0.829
Data Appear Normal
Approx. Test Value = 0.954
p-Value = 0.729
u_hsk
n = 10
Mean = 50.34
Sd = 1.037
Slope = 1.001
Intercept = 50.34
Correlation, R = 0.907
Shapiro-Wilk Test
Exact Test Value = 0.840
Critical Val(0.05) = 0.842
Data Not Normal
Approx. Test Value = 0.828
p-Value = 0.0313
Best Fit Line

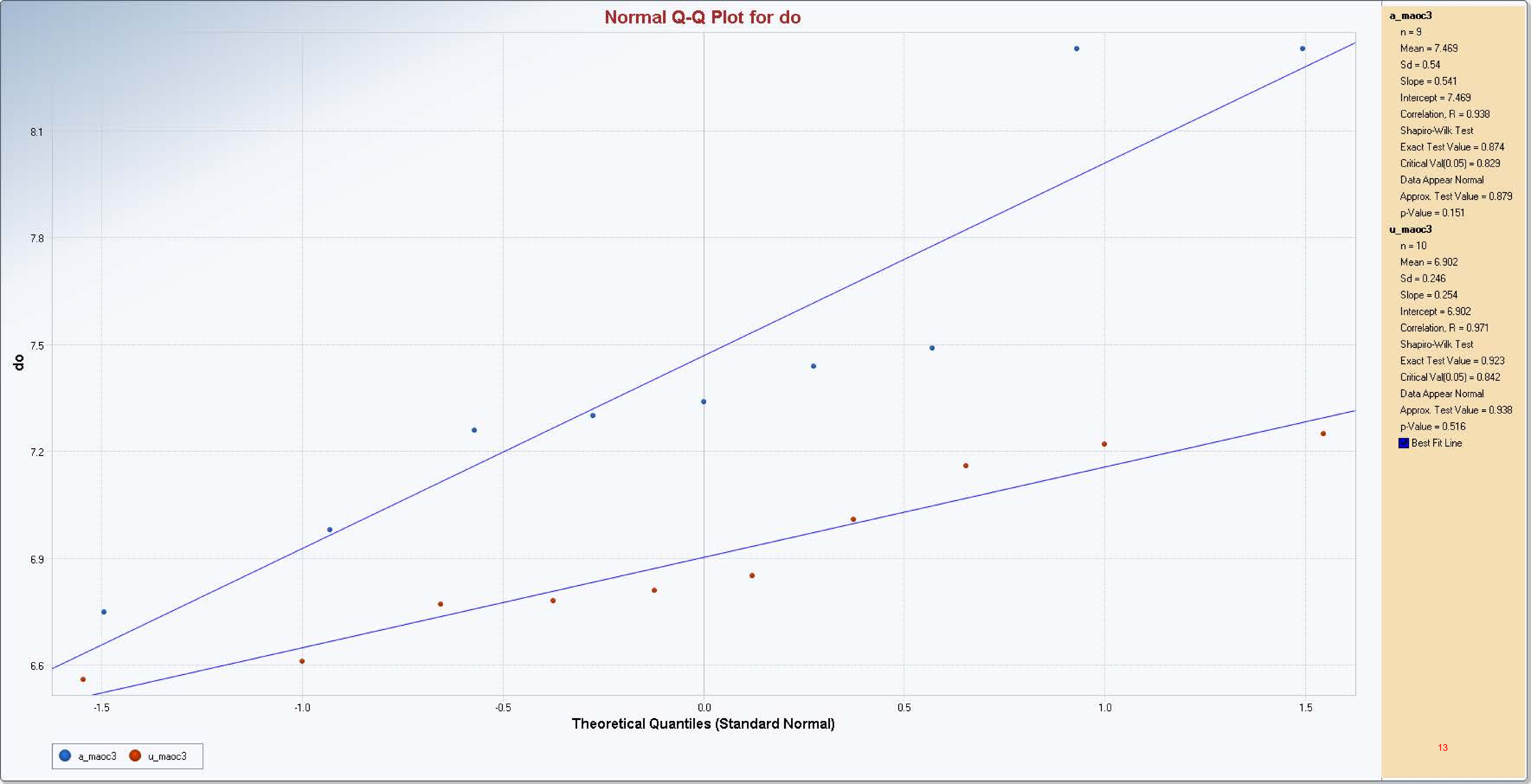


a_hsk

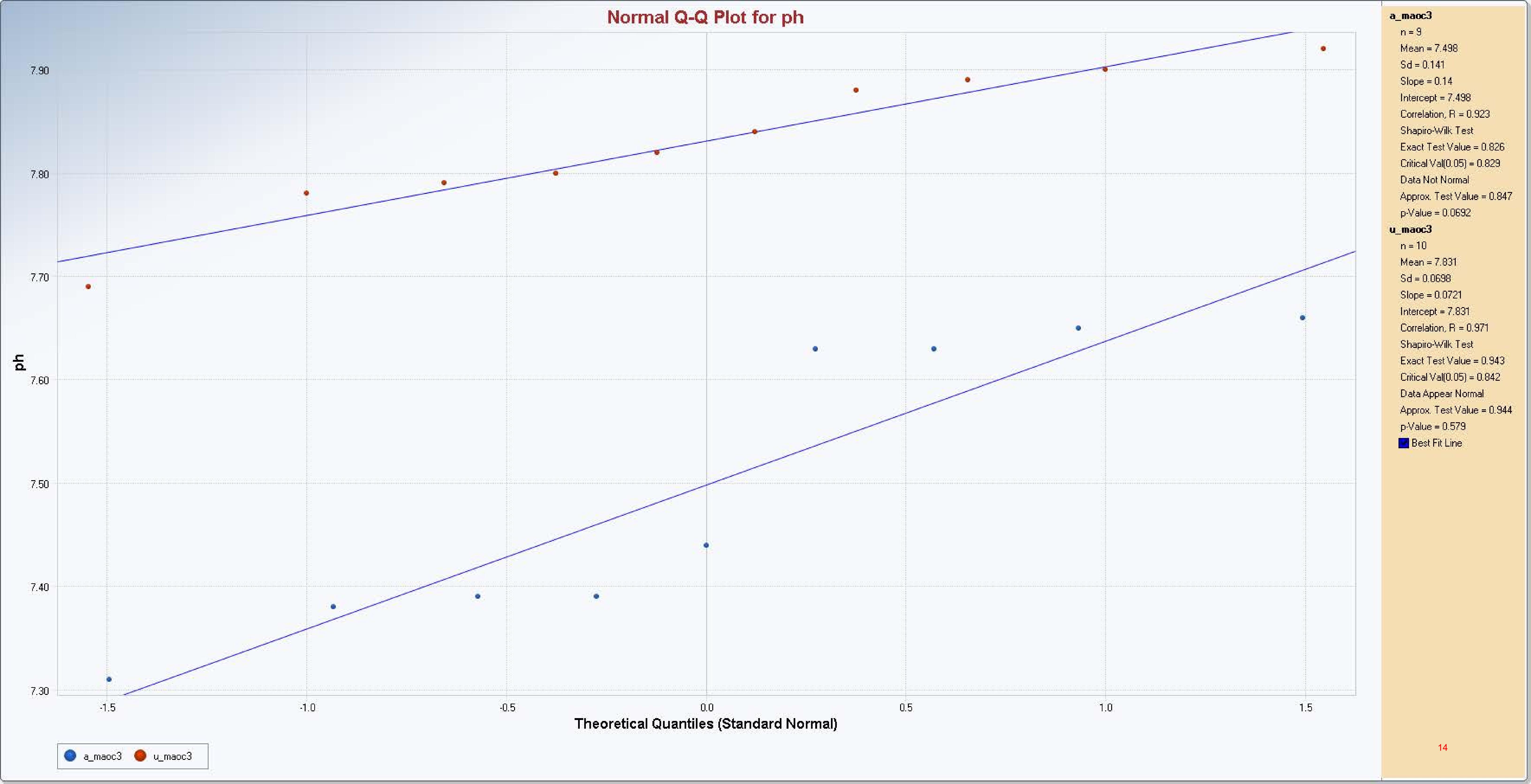
n = 9
Mean = 15.54
Sd = 0.133
Slope = 0.133
Intercept = 15.54
Correlation, R = 0.936
Shapiro-Wilk Test
Exact Test Value = 0.874
Critical Val(0.05) = 0.829
Data Appear Normal
Approx. Test Value = 0.876
p-Value = 0.141

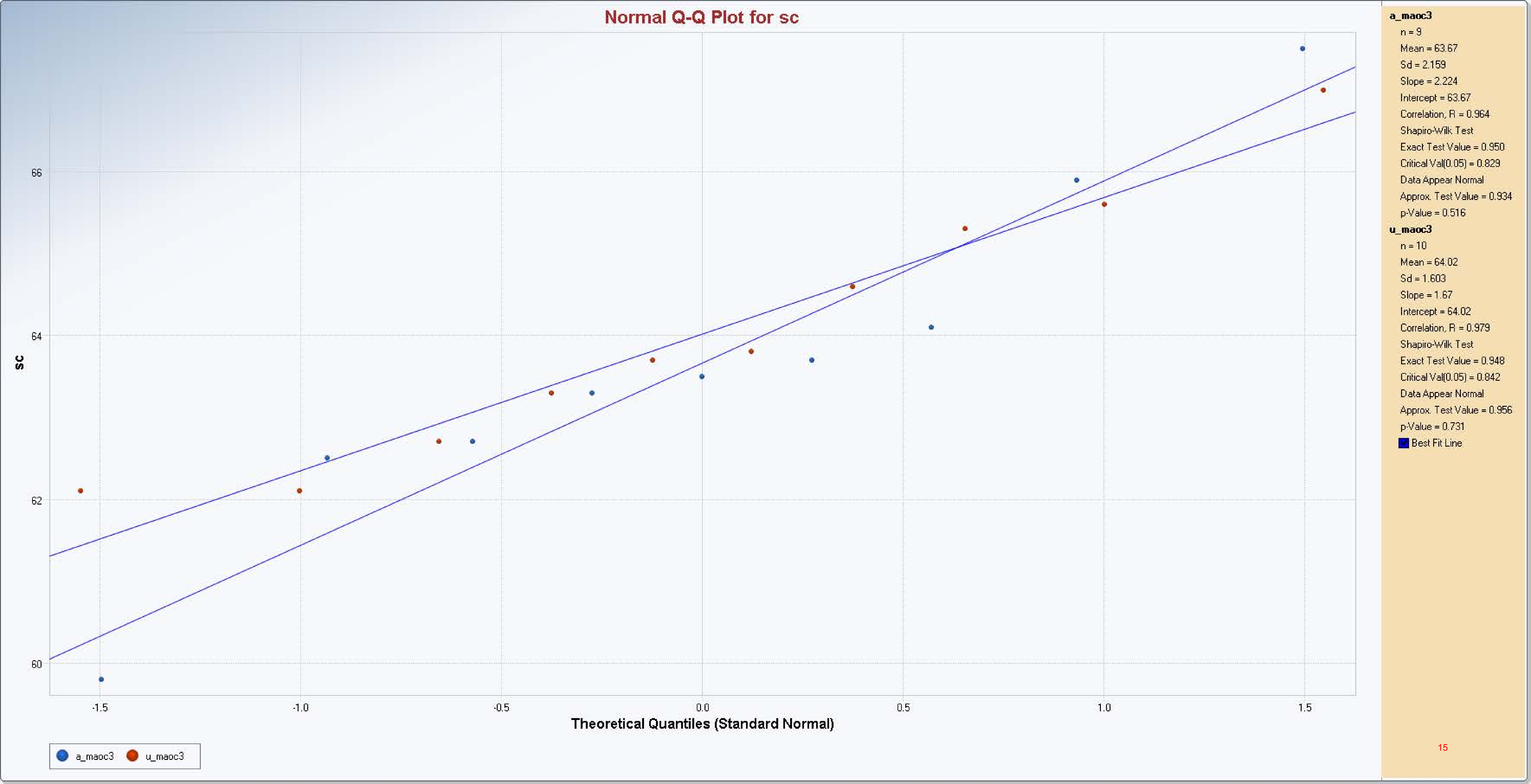
u_hsk

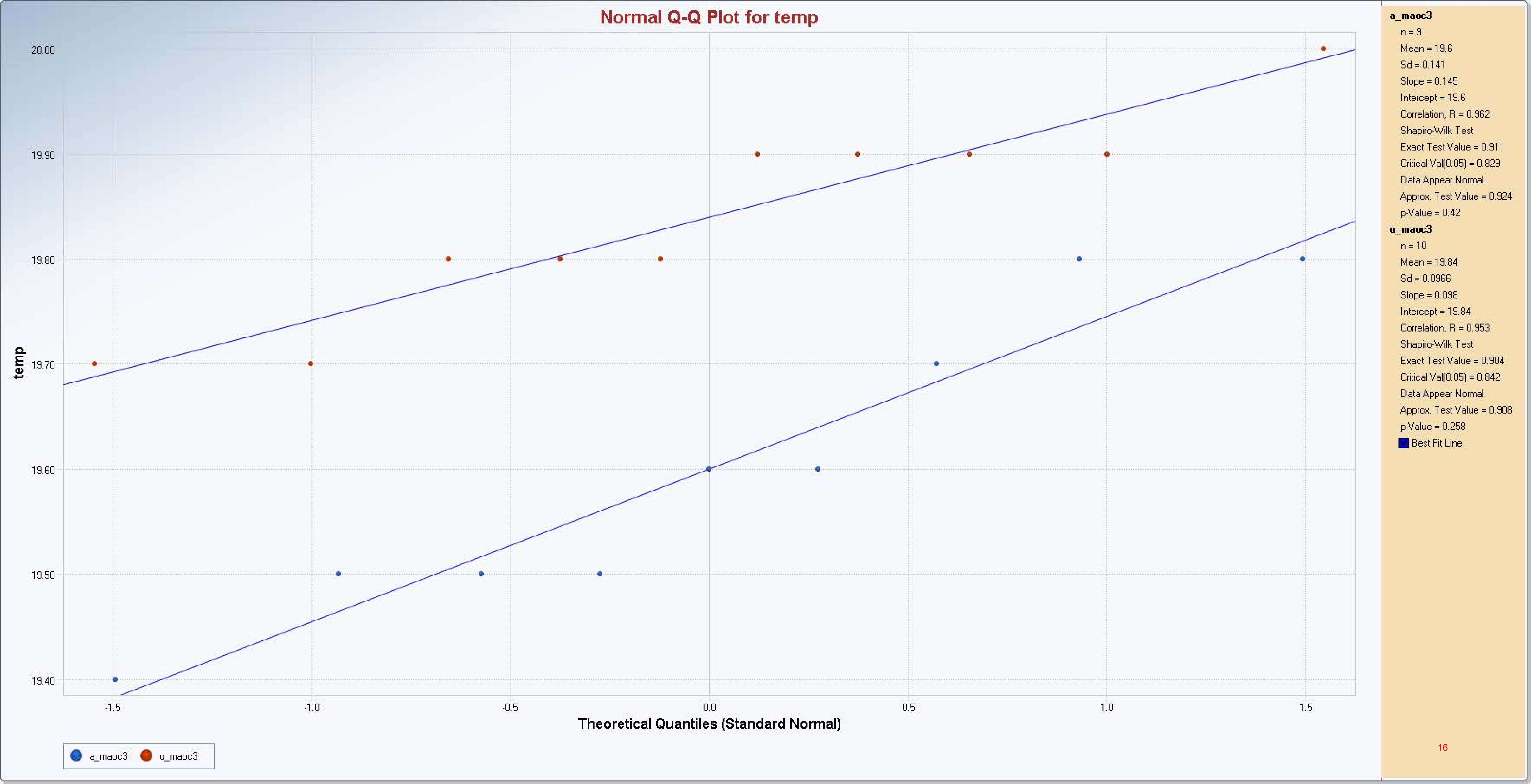
n = 10
Mean = 16.15
Sd = 0.484
Slope = 0.479
Intercept = 16.15
Correlation, R = 0.931
Shapiro-Wilk Test
Exact Test Value = 0.884
Critical Val(0.05) = 0.842
Data Appear Normal
Approx. Test Value = 0.872
p-Value = 0.1
Best Fit Line



Normal Q-Q Plot for do
do
Theoretical Quantiles (Standard Normal)
8.1
7.8
7.5
7.2
6.9
6.6
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
a_maoc3
u_maoc3
a_maoc3
n = 9
Mean = 7.469
Sd = 0.54
Slope = 0.541
Intercept = 7.469
Correlation, R = 0.938
Shapiro-Wilk Test
Exact Test Value = 0.874
Critical Val(0.05) = 0.829
Data Appear Normal
Approx. Test Value = 0.879
p-Value = 0.151
u_maoc3
n = 10
Mean = 6.902
Sd = 0.246
Slope = 0.254
Intercept = 6.902
Correlation, R = 0.971
Shapiro-Wilk Test
Exact Test Value = 0.923
Critical Val(0.05) = 0.842
Data Appear Normal
Approx. Test Value = 0.938
p-Value = 0.516
Best Fit Line
13


Normal Q-Q Plot for ph
ph
Theoretical Quantiles (Standard Normal)
7.90
7.80
7.70
7.60
7.50
7.40
7.30
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
a_maoc3
u_maoc3
a_maoc3
n = 9
Mean = 7.498
Sd = 0.141
Slope = 0.14
Intercept = 7.498
Correlation, R = 0.923
Shapiro-Wilk Test
Exact Test Value = 0.826
Critical Val(0.05) = 0.829
Data Not Normal
Approx. Test Value = 0.847
p-Value = 0.0692
u_maoc3
n = 10
Mean = 7.831
Sd = 0.0698
Slope = 0.0721
Intercept = 7.831
Correlation, R = 0.971
Shapiro-Wilk Test
Exact Test Value = 0.943
Critical Val(0.05) = 0.842
Data Appear Normal
Approx. Test Value = 0.944
p-Value = 0.579
Best Fit Line
14


Normal Q-Q Plot for sc
sc
66
64
62
60
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
Theoretical Quantiles (Standard Normal)
a_maoc3
u_maoc3
a_maoc3
n = 9
Mean = 63.67
Sd = 2.159
Slope = 2.224
Intercept = 63.67
Correlation, R = 0.964
Shapiro-Wilk Test
Exact Test Value = 0.950
Critical Val(0.05) = 0.829
Data Appear Normal
Approx. Test Value = 0.934
p-Value = 0.516
u_maoc3
n = 10
Mean = 64.02
Sd = 1.603
Slope = 1.67
Intercept = 64.02
Correlation, R = 0.979
Shapiro-Wilk Test
Exact Test Value = 0.948
Critical Val(0.05) = 0.842
Data Appear Normal
Approx. Test Value = 0.956
p-Value = 0.731
Best Fit Line
15


Normal Q-Q Plot for temp
20.00
19.90
19.80
19.70
19.60
19.50
19.40
temp
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
Theoretical Quantiles (Standard Normal)
a_maoc3
u_maoc3
a_maoc3
n = 9
Mean = 19.6
Sd = 0.141
Slope = 0.145
Intercept = 19.6
Correlation, R = 0.962
Shapiro-Wilk Test
Exact Test Value = 0.911
Critical Val(0.05) = 0.829
Data Appear Normal
Approx. Test Value = 0.924
p-Value = 0.42
u_maoc3
n = 10
Mean = 19.84
Sd = 0.0966
Slope = 0.098
Intercept = 19.84
Correlation, R = 0.953
Shapiro-Wilk Test
Exact Test Value = 0.904
Critical Val(0.05) = 0.842
Data Appear Normal
Approx. Test Value = 0.908
p-Value = 0.258
Best Fit Line
16