2018 Annual Groundwater Monitoring and Corrective Action Report

Duck Creek GMF Pond – CCR Unit ID 203
Duck Creek Power Station
17751 North Cilco Road
Canton, Illinois 61520

Illinois Power Resources Generating, LLC

January 31, 2019

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JANUARY 31, 2019 | PROJECT #70089

2018 Annual Groundwater Monitoring and Corrective Action Report

Duck Creek GMF Pond – CCR Unit ID 203
Duck Creek Power Station
Canton, Illinois

Prepared for:

Illinois Power Resources Generating, LLC

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RACHEL A. BANOFF
Environmental Engineer

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NIKKI PAGANO, PE, PG
Senior Managing Engineer

TABLE OF CONTENTS

LIST OF FIGURES

Figure 1   Groundwater Sampling Well Location Map

LIST OF TABLES

Table 1   Statistical Background Values
Table 2   Appendix III Analytical Results

LIST OF APPENDICES

Appendix A   Alternate Source Demonstration

ACRONYMS AND ABBREVIATIONS

ASD	Alternate Source Demonstration
CCR	Coal Combustion Residuals
CFR	Code of Federal Regulations
mg/L	milligrams per liter
NRT/OBG	Natural Resource Technology, an OBG Company
OBG	O'Brien & Gere Engineers, part of Ramboll
SSI	Statistically Significant Increase
S.U.	Standard Units
TDS	Total Dissolved Solids

SECTION 1: INTRODUCTION

This report has been prepared on behalf of Illinois Power Resources Generating, LLC by O'Brien & Gere Engineers, part of Ramboll (OBG), to provide the information required by the Code of Federal Regulations (CFR) found in 40 CFR 257.90(e) for the Duck Creek GMF Pond located at Duck Creek Power Station near Canton, Illinois.

In accordance with 40 CFR § 257.90(e), the owner or operator of an existing Coal Combustion Residuals (CCR) unit must prepare an annual groundwater monitoring and corrective action report, for the preceding calendar year, that documents the status of the groundwater monitoring and corrective action program for the CCR unit, summarizes key actions completed, describes any problems encountered, discusses actions to resolve the problems, and projects key activities for the upcoming year. At a minimum, the annual report must contain the following information, to the extent available:

1. A map, aerial image, or diagram showing the CCR unit and all background (or upgradient) and downgradient monitoring wells, to include the well identification numbers, that are part of the groundwater monitoring program for the CCR unit.

2. Identification of any monitoring wells that were installed or decommissioned during the preceding year, along with a narrative description of why those actions were taken.

3. In addition to all the monitoring data obtained under §§ 257.90 through 257.98, a summary including the number of groundwater samples that were collected for analysis for each background and downgradient well, the dates the samples were collected, and whether the sample was required by the detection monitoring or assessment monitoring programs.

4. A narrative discussion of any transition between monitoring programs (e.g., the date and circumstances for transitioning from detection monitoring to assessment monitoring in addition to identifying the constituent(s) detected at a statistically significant increase over background levels).

5. Other information required to be included in the annual report as specified in §§ 257.90 through 257.98[1].

This report provides the required information for the Duck Creek GMF Pond for calendar year 2018.

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[1] For calendar year 2018, corrective action and other information required to be included in the annual report as specified in §§ 257.96 through 257.98 is not applicable.

SECTION 2: MONITORING AND CORRECTIVE ACTION PROGRAM STATUS

Detection Monitoring Program sampling event dates and parameters collected are provided in the detection monitoring program summary table below. One sample was collected from each background and downgradient well in the monitoring system during the sampling events in November 2017, June 2018, and October 2018. Resampling was conducted in January 2018 and July 2018 on a subset of the Appendix III parameters. Analytical data was evaluated after each event in accordance with the Statistical Analysis Plan, Duck Creek Power Station, Edwards Power Station, Illinois Power Resources Generating, LLC (NRT/OBG, 2017) to identify any statistically significant increases (SSIs) of Appendix III parameters over background concentrations. The dates the SSIs were evaluated are provided in the detection monitoring program summary table below.

Detection Monitoring Program Summary

Sampling Dates	Parameters Collected	SSIs	ASD Completion
November 8 and 10, 2017	Appendix III	Yes	April 9, 2018
January 17, 18, and 19, 2018	SSI parameters only	Not Applicable	Not Applicable
June 4 and 6, 2018	Appendix III	Yes	To Be Determined
July 6, 13, and 21, 2018	SSI parameters only	Not Applicable	Not Applicable
October 4, 11, 16, 17, and 20, 2018	Appendix III	To Be Determined	To Be Determined

Potential alternate sources were evaluated as outlined in the 40 CFR § 257.94(e)(2). An alternate source demonstration (ASD) was completed and certified by a qualified professional engineer. The date the ASD was completed is provided in the detection monitoring program summary table. The ASD is included in Appendix A.

Statistical background values are provided in Table 1. Analytical results from the events summarized in the detection monitoring program summary table above are included in Table 2.

The Duck Creek GMF Pond remains in the Detection Monitoring Program in accordance with 40 CFR § 257.94.

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SECTION 3: KEY ACTIONS COMPLETED IN 2018

Four groundwater monitoring events were completed in 2018 under the Detection Monitoring Program. These events occurred in January, June, July, and October, and are detailed in Section 2. One sample was collected from each background and downgradient well in the monitoring system during the sampling events in June 2018, and October 2018. Resampling was conducted in January 2018 and July 2018 on a subset of the Appendix III parameters. All samples were collected and analyzed in accordance with the Sampling and Analysis Plan (NRT/OBG, 2018). All monitoring data obtained under 40 CFR §§ 257.90 through 257.98 (as applicable) in 2018 are presented in Table 2.

G02S was added to the upgradient well network in 2018. The purpose of adding G02S was to provide data representative of the variance (range in values) in the background water quality.

The groundwater monitoring system, including the CCR unit and all background and downgradient monitoring wells, is presented in Figure 1.

SECTION 4: PROBLEMS ENCOUNTERED AND ACTIONS TO RESOLVE THE PROBLEMS

No problems were encountered with the groundwater monitoring program during 2018. Groundwater samples were collected and analyzed in accordance with the Sampling and Analysis Plan (NRT/OBG, 2018), and all data was accepted.

SECTION 5: KEY ACTIVITIES PLANNED FOR 2019

The following key activities are planned for 2019:

- Continuation of the Detection Monitoring Program with semi-annual sampling scheduled for the first and third quarters of 2019.

- Complete evaluation of analytical data from the downgradient wells, using background data to determine whether an SSI of Appendix III parameters over background concentrations has occurred.

- If an SSI is identified, potential alternate sources (i.e., a source other than the CCR unit caused the SSI or that SSI resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality) will be evaluated. If an alternate source is demonstrated to be the cause of the SSI, a written demonstration will be completed within 90 days of SSI determination and included in the annual groundwater monitoring and corrective action report for 2019.

  » If an alternate source(s) is not identified to be the cause of the SSI, the applicable requirements of 40 CFR §§ 257.94 through 257.98 (e.g., assessment monitoring) as may apply in 2019 will be met, including associated recordkeeping/notifications required by 40 CFR §§ 257.105 through 257.108.

REFERENCES

Natural Resource Technology, an OBG Company, 2017, Statistical Analysis Plan, Duck Creek Power Station, Edwards Power Station, Illinois Power Resources Generating, LLC, October 17, 2017.

Natural Resource Technology, an OBG Company, 2018, Sampling and Analysis Plan, Duck Creek GMF Pond, Duck Creek Power Station, Canton, Illinois, Project No. 2285, Revision 1, June 29, 2018.

Figures

GROUNDWATER SAMPLING WELL LOCATION MAP
DUCK CREEK GMF POND
UNIT ID: 203

2018 ANNUAL GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT
VISTRA CCR RULE GROUNDWATER MONITORING
DUCK CREEK POWER STATION
CANTON, ILLINOIS

PROJECT NO: 70089

FIGURE NO: 1

Tables

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Table 1. Statistical Background Values

2018 Annual Groundwater Monitoring and Corrective Action Report

Duck Creek Power Station

Unit ID 203 - Duck Creek GMF Pond

Parameter	Statistical Background Value
Appendix III	
Boron (mg/L)	0.07
Calcium (mg/L)	110.23
Chloride (mg/L)	20.9
Fluoride (mg/L)	0.564
pH (S.U.)	6.5 / 7.6
Sulfate (mg/L)	97
TDS (mg/L)	490

[O: KLS 8/30/18, C: RAB 8/31/18]

Notes:

mg/L = milligrams per liter

S.U. = Standard Units

TDS = Total Dissolved Solids

Table 2. Appendix III Analytical Results

2018 Annual Groundwater Monitoring and Corrective Action Report

Duck Creek Power Station

Unit ID 203 - Duck Creek GMF Pond

Sample Location	Date Sampled	B, total (mg/L)	Ca, total (mg/L)	Cl, total (mg/L)	F, total (mg/L)	pH (field) (S.U.)	SO4, total (mg/L)	TDS (mg/L)
Background / Upgradient Monitoring Wells								
G02S	11/10/2017	0.036	95	3.1	0.410	6.9	2.9	390
	1/17/2018	NA	NA	2.7	NA	6.9	NA	NA
	6/6/2018	0.042	95	2.4	0.369	6.9	<1	340
	7/6/2018	NA	NA	2.9	NA	7.0	NA	NA
	10/4/2018	0.046	97	2.7	0.285	7.1	<1	340
G50S	11/8/2017	0.012	83	5.9	0.369	7.1	22	310
	6/4/2018	0.067	87	7.3	0.301	7.1	33	320
	7/13/2018	0.018	88	NA	0.333	7.1	NA	350
	10/11/2018	0.018	97	9.6	0.264	7.2	34	340
G51S	11/8/2017	0.013	96	12	0.368	7.1	34	320
	6/4/2018	0.039	97	11	0.266	7.0	52	380
	7/13/2018	0.014	96	NA	0.310	6.9	NA	390
	10/11/2018	0.015	99	13	0.264	7.1	51	380
Downgradient Monitoring Wells								
G54S	11/8/2017	0.035	130	2.2	0.342	7.1	42	480
	1/18/2018	0.052	120	NA	NA	6.9	NA	380
	6/4/2018	0.059	130	2.3	<0.25	7.1	43	500
	7/13/2018	0.033	130	NA	0.290	7.1	NA	540
	10/16/2018	0.037	130	2.5	<0.25	7.2	44	460
G57S	11/8/2017	<0.01	120	19	0.390	7.0	51	450
	1/18/2018	NA	180	NA	<0.25	7.1	NA	370
	6/4/2018	0.027	120	19	0.280	7.2	52	500
	7/21/2018	0.024	110	NA	<0.25	7.2	NA	540
	10/17/2018	0.014	130	22	<0.25	7.3	53	470
G60S	11/8/2017	0.010	120	11	0.351	6.9	67	460
	1/19/2018	NA	100	NA	0.313	6.9	NA	520
	6/4/2018	0.035	150	11	0.316	6.9	73	490
	7/21/2018	0.022	120	NA	<0.25	7.0	NA	540
	10/17/2018	0.018	120	12	<0.25	6.9	72	440
G64S	11/8/2017	0.014	95	3.5	0.401	6.8	25	380
	1/19/2018	NA	NA	NA	0.367	6.9	NA	NA
	6/4/2018	0.029	91	3.6	0.316	6.9	25	380
	7/21/2018	0.019	83	NA	0.318	6.9	NA	390
	10/20/2018	0.021	98	3.8	0.256	6.9	28	420

[O: RAB 12/26/18, C: JQW 12/27/18][U: RAB 1/25/19]

Notes:

mg/L = milligrams per liter

NA = Not Analyzed

S.U. = Standard Units

TDS = Total Dissolved Solids

< = concentration is less than the reporting limit

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Appendix A

Alternate Source Demonstration

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April 9, 2018

This alternate source demonstration has been prepared on behalf of Illinois Power Resources Generating, LLC by O'Brien & Gere Engineers, Inc. (OBG) to provide pertinent information pursuant to 40 CFR § 257.94(e)(2) for the Duck Creek GMF Pond located at Duck Creek Power Station near Canton, Illinois.

Initial background groundwater monitoring consisting of a minimum of eight samples as required under 40 CFR § 257.94(b) was initiated in December 2015 and completed prior to October 17, 2017. The first semi-annual detection monitoring samples were collected on November 8, 2017. Evaluation of analytical data from the first detection monitoring sample for statistically significant increases (SSIs) of 40 CFR Part 257 Appendix III parameters over background concentrations was completed within 90 days of collection and analysis of the sample (January 9, 2018). That evaluation identified the following SSIs at downgradient monitoring wells:

- Boron at well G54S

- Calcium at wells G54S, G57S and G60S

- Fluoride at wells G57S, G60S and G64S

- Total dissolved solids at wells G54S, G57S and G60S

In accordance with the Statistical Analysis Plan[1], to verify the SSIs, wells G54S, G57S, G60S and G64S were resampled on January 18-19, 2018 and analyzed only for the SSI parameters at each well. Following evaluation of analytical data from the resample, the following SSIs remained:

- Boron at well G54S

- Calcium at wells G54S and G57S

- Fluoride at well G64S

- Total dissolved solids at well G60S

40 CFR § 257.94(e)(2) allows the owner or operator 90 days from the date of an SSI determination to complete a written demonstration that a source other than the CCR unit caused the SSI, or that the SSI resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality ("alternate source demonstration"). Pursuant to 40 CFR § 257.94(e)(2), the following demonstrates that sources other than the Duck Creek GMF Pond were the cause of the SSI listed above. This alternate source demonstration (ASD) was completed within 90 days of determination of the SSIs (April 9, 2018) as required by 40 CFR § 257.94(e)(2).

ALTERNATE SOURCE DEMONSTRATION: LINES OF EVIDENCE

As allowed by 40 CFR § 257.94(e)(2), this ASD demonstrates that sources other than Duck Creek GMF Pond (the CCR unit) caused the SSI. Lines of evidence (LOE) supporting this ASD include the following:

1. Incomplete background data set

2. Downgradient calcium concentrations exceeded background prior to the unit being placed into service

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[1] Natural Resource Technology, an OBG Company, 2017, Statistical Analysis Plan, Duck Creek Power Station, Illinois Power Resources Generating, LLC, October 17, 2017.

3. Proximity to historic coal mining activity

4. Concentrations of boron and sulfate, common indicators for CCR impacts to groundwater, in the downgradient wells are stable and at or below concentrations in the background wells

These lines of evidence are described and supported in greater detail below. Monitoring wells are shown on the attached Figure 1.

LOE #1: BACKGROUND DATASET IS INCOMPLETE AND IS NOT REPRESENTATIVE OF BACKGROUND

A robust background data set is a critical component of the detection monitoring program. The purpose of installing background monitoring wells is to provide data representative of the variance (range in values) in the background water quality. Comparing groundwater quality in upgradient monitoring well G02S to that in background monitoring wells, wells G50S and G51S, indicates a greater range of variability in groundwater quality upgradient (background) to the site. Table 1 summarizes the mean and variance for each parameter for the original background monitoring network (G50S and G51S), the expanded monitoring network (G02S, G50S, G51S), and the percent change in variance between the networks. Variance for boron, fluoride, sulfate, and TDS increased significantly; however, variance for calcium slightly decreased and slightly increased for chloride.

Parameter	Units	Original Background Monitoring Network G50S, G51S		Revised Background Monitoring Network G50S, G51S, G02S		Percent Change in Variance
		Mean	Variance	Mean	Variance	
Boron	mg/L	0.02	3.23E-05	0.03	6.26E-04	1,837%
Calcium	mg/L	84.88	149.98	88.50	139.13	-7%
Fluoride	mg/L	0.28	1.26E-03	0.31	4.85E-03	286%
Chloride	mg/L	9.94	27.64	7.60	29.58	7%
Sulfate	mg/L	37	393	25	563	43%
pH-Field	SU	7.15	0.03	7.01	0.06	106%
TDS	mg/L	350	1,453	374	3,946	172%

Table 1: Mean and variance of groundwater quality for the original and revised background monitoring networks

SSI determinations were made using the expanded background data set. The determinations resulted in SSIs for calcium in monitoring wells G54S, and G60S. Concentrations of boron, fluoride, and total dissolved solids in the downgradient wells are within the revised upper prediction limits (UPLs). The detection monitoring summary is provided in Attachment A.

LOE #2: CALCIUM EXCEEDED BACKGROUND PRIOR TO THE UNIT BEING PLACED INTO SERVICE

Calcium was detected above both the original and revised UPLs in downgradient well G60S prior to the GMF Pond being placed into service.

The calcium time series for well G60S from 2007-2018 is shown in Figure 2. The median observed calcium concentration is 130 milligrams per Liter mg/L, which is greater than the revised UPL of 110.23 mg/L.
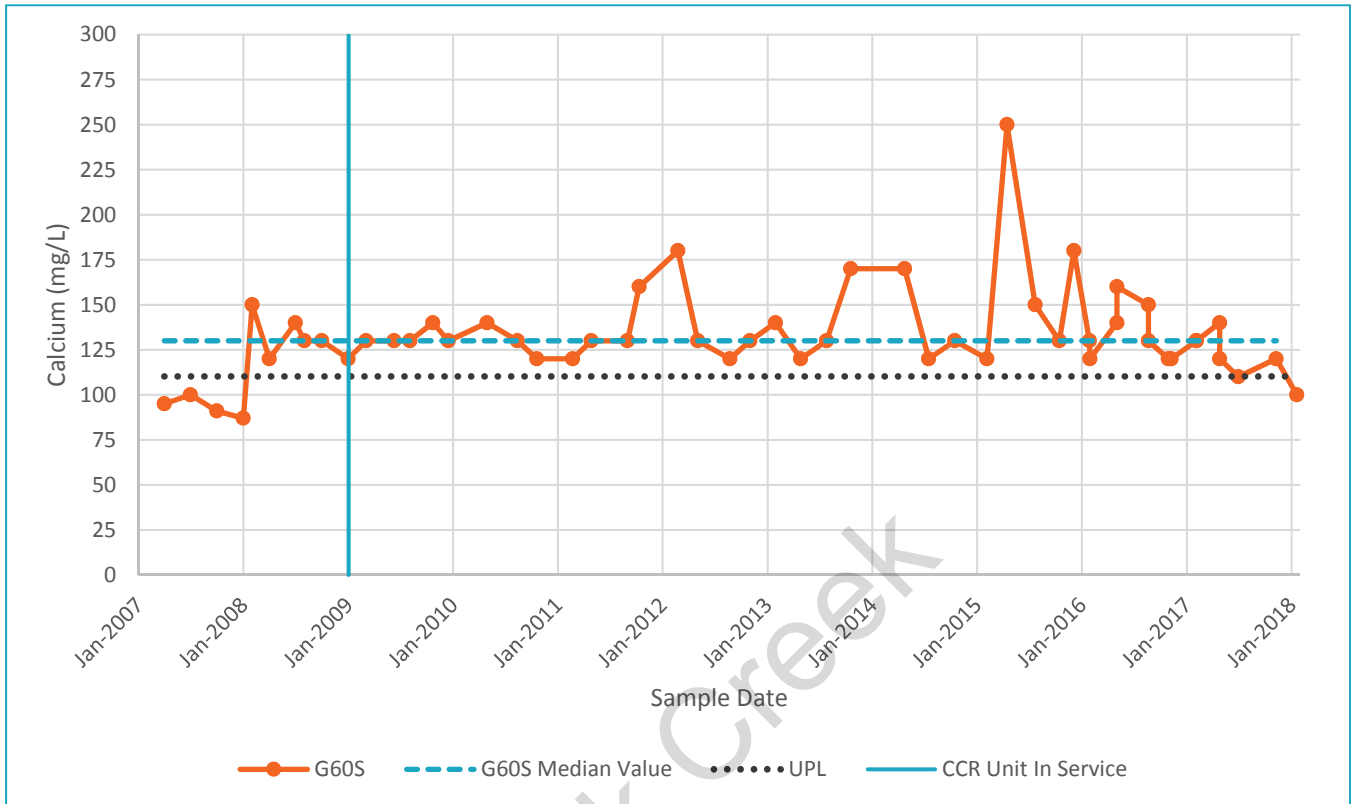
Figure 2. Calcium concentrations observed in G60S prior to and during use of the GMF Pond for CCR disposal.

Background and detection monitoring (2015-2018) calcium concentrations observed in the monitoring system are shown in Figure 3, along with the revised UPL and the median observed concentration in G60S. The calcium concentration observed in G60S during the first round of detection monitoring (120 mg/L) was above the original UPL of 108.77 mg/L. The observed concentration of 100 mg/L when resampled was below both the original and revised UPLs. Calcium concentrations observed in G54S and G57S from 2015-2018, and determined to be SSIs based upon the concentration observed on November 8, 2017, are similar to those observed in G60S from 2015-2018.
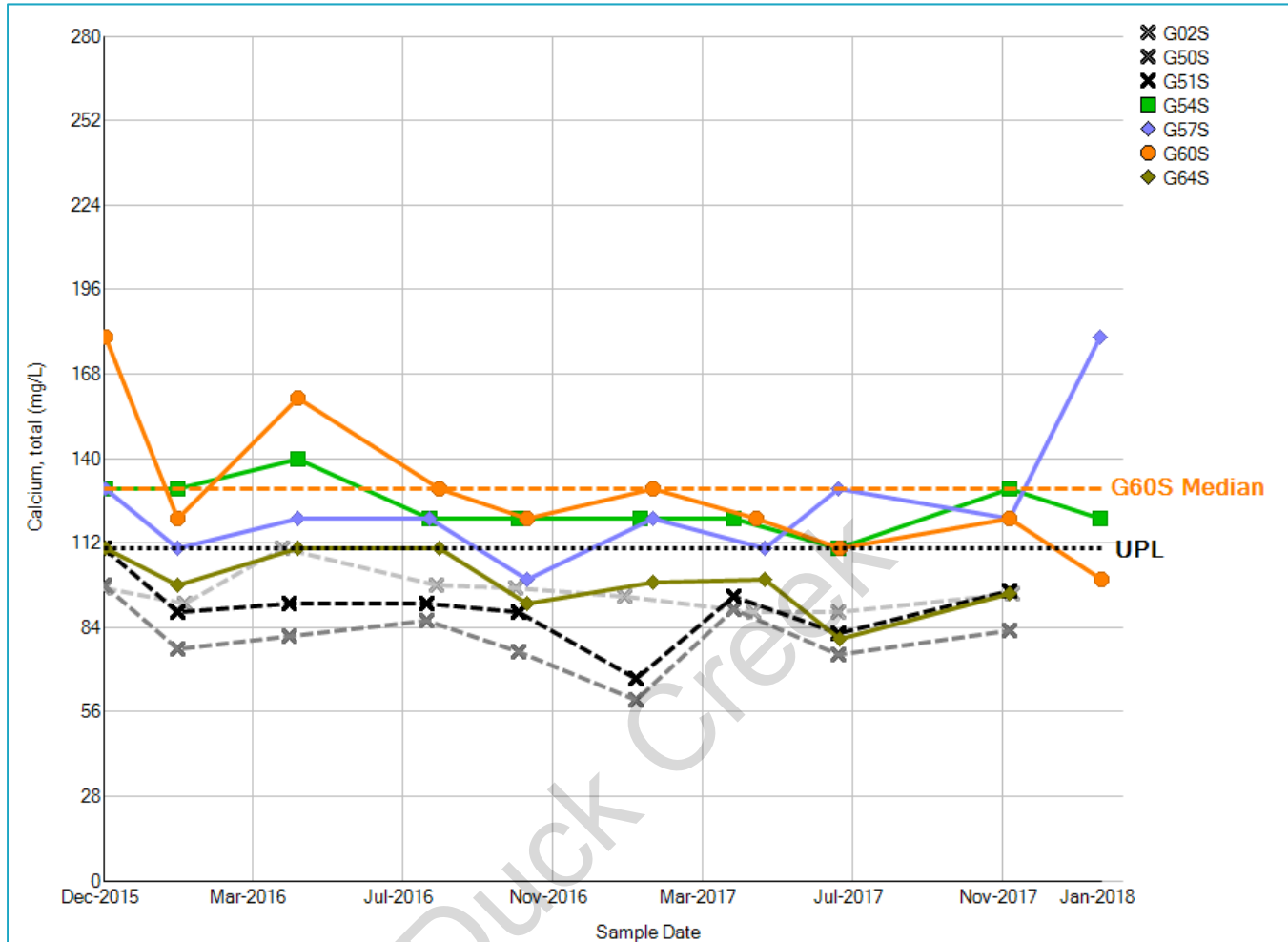
Figure 3. Calcium time series for GMF Pond monitoring system 2015-2018.

LOE #3: PROXIMITY TO HISTORIC COAL MINING ACTIVITY

The area surrounding the GMF Pond consists primarily of unmined coal and reclaimed surface mine land. The extents of the nearby mines are shown in the attached Figure 4. The coal in this area has a sulfur content greater than 2.5 lbs of sulfur per million BTUs, the highest sulfur classification used by Illinois State Geological Survey[2].

The coal varies in depth from 0 to 50 feet (ft) below ground surface (bgs). The wells associated with the monitoring system established for the Duck Creek GMF Pond pursuant to 40CFR § 257.91 are screened between 23 and 48 ft bgs. Potentiometric data indicates that groundwater flows to the southeast as shown on Figure 1. The monitoring wells are located 2,000 to 4,000 ft downgradient of the nearby mines (Figure 1).

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[2] "Illinois Coal Reserves Assessment and Database Development: Final Report", Open File Series 1997-4, Illinois State Geological Survey, Coal Section, 1997.

State of Illinois groundwater quality regulations (Illinois Administrative Code [IAC] Title 35 Part 620 Groundwater Quality) acknowledge that water quality is adversely affected in areas where coal mining activity has occurred. The groundwater standards for chloride, iron, manganese, sulfates, TDS and pH within previously mined areas are the existing concentrations.

A study of groundwater quality near surface coal mines, performed by the U.S. Geological Survey (USGS)[3], provides data on the effects of mines on groundwater quality. The study evaluated regional differences in major ion composition of groundwater in unmined and mined areas using Piper diagrams (Figure 5). Groundwater samples collected from wells downgradient of the reclaimed mine areas in the study have high concentrations of carbonate-bicarbonate anions as well as moderate concentrations of calcium cations. Groundwater samples collected from the GMF Pond monitoring wells are tightly grouped and have very high concentrations of carbonate-bicarbonate anions, similar to those from the USGS study, but with no dominant cation. Piper diagrams in Figures 5 and 6 present this graphically and Table 2 summarizes the ionic composition.

The ionic composition of water samples from the GMF Pond are significantly different than those observed in groundwater. Pond water samples are very high in magnesium with no dominant anion. The groundwater samples and the pond water samples have minimal variance as evident by the tight groupings; a mixing zone is not apparent between the pond water and groundwater samples.

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[3] "Ground-Water Quality in Unmined Areas and Near Reclaimed Surface Coal Mines in the Northern and Central Appalachian Coal Regions, Pennsylvania and West Virginia", Scientific Investigations Report 2006-5059, US Geological Survey, 2006.
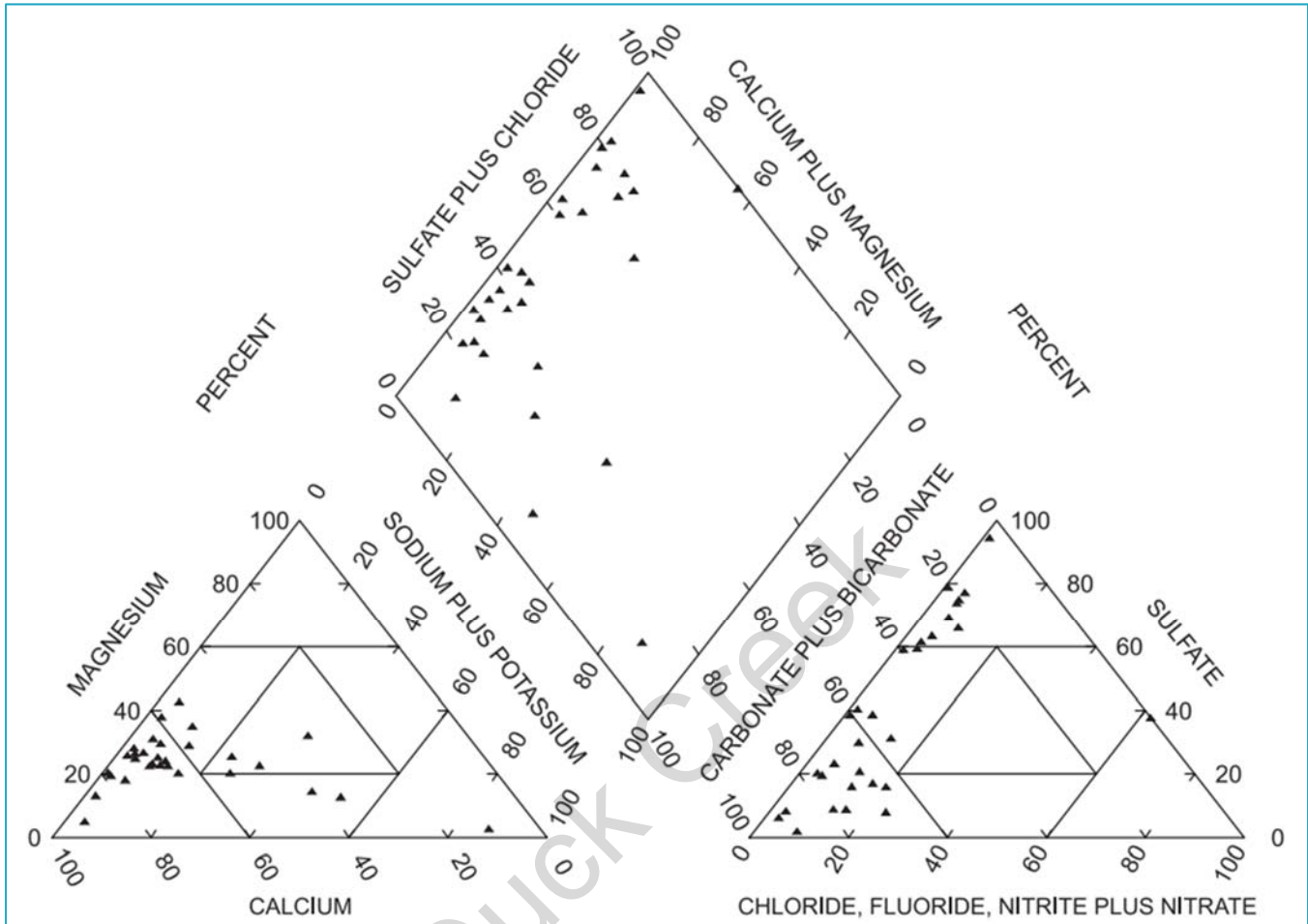
Figure 5. Piper diagram showing ionic composition of groundwater downgradient of reclaimed surface coal mines in high-sulfur coal regions (modified from USGS)
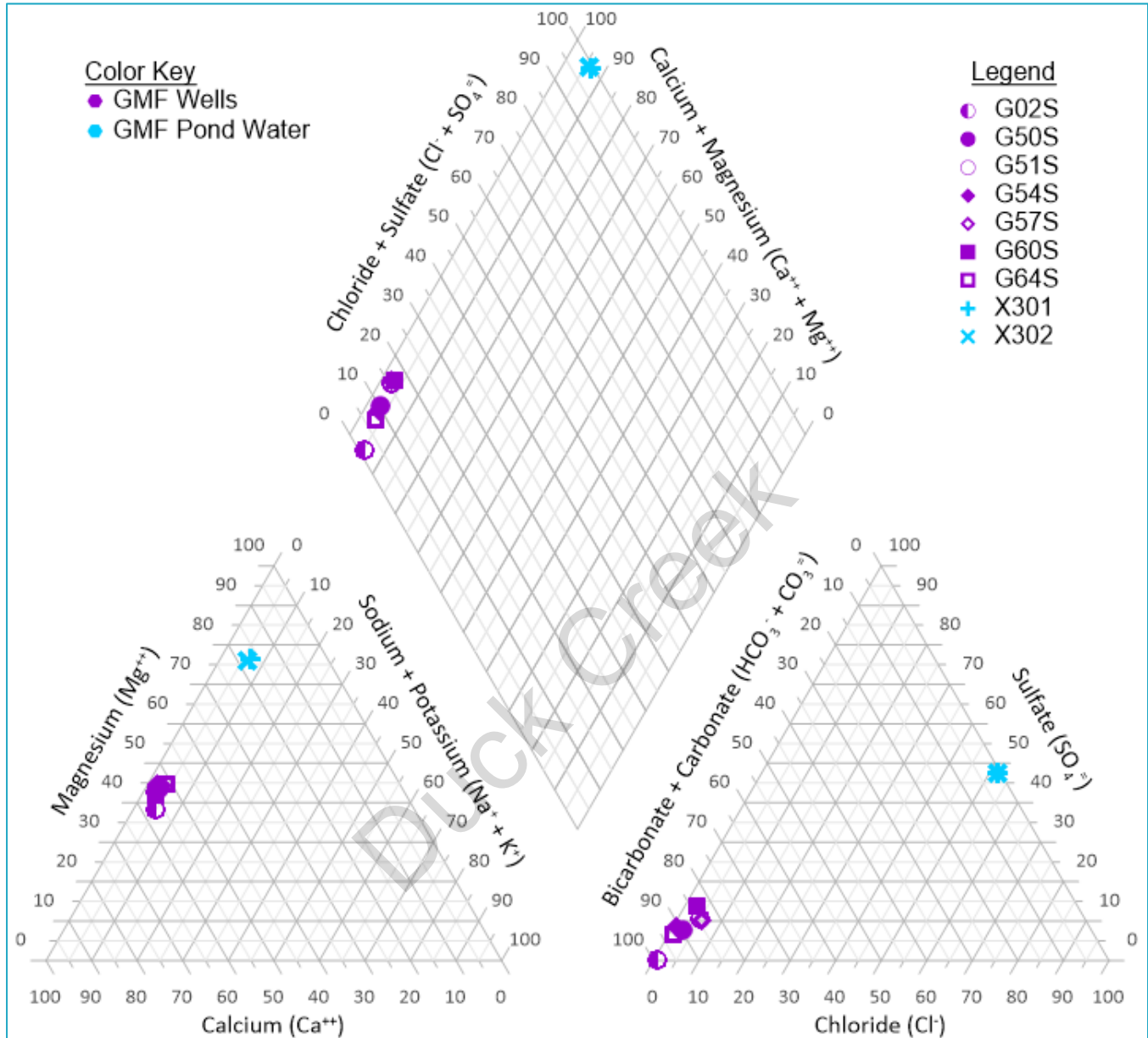
Figure 6. Piper diagram showing ionic composition of samples of groundwater and pond water associated with the Duck Creek GMF Pond

Grouping	Purple (Figure 6)	Blue (Figure 6)	Black (Figure 5)
Locations	Duck Creek GMF Pond Groundwater	Duck Creek GMF Pond Water	Groundwater from Reclaimed Surface Coal Mines Study
Dominant Cation	No dominant cation	High Magnesium	Calcium
Dominant Anion	Very High Carbonate-Bicarbonate	No dominant anion	High Carbonate-Bicarbonate

Table 2. Comparison of ionic classification of groundwater associated with the Duck Creek GMF, water from the Duck Creek GMF pond and groundwater downgradient of reclaimed surface coal mines in high-sulfur coal regions

The similar groundwater ionic classifications shown in Figure 5 and Figure 6 and summarized in Table 1, and the proximity of the historic coal mining activity, demonstrate that mining activity has affected groundwater quality at the Duck Creek GMF Pond.

LOE #4: CONCENTRATIONS OF SULFATE AND BORON, COMMON INDICATORS FOR CCR IMPACTS TO GROUNDWATER, IN THE DOWNGRADIENT WELLS ARE STABLE AND AT OR BELOW CONCENTRATIONS IN THE BACKGROUND WELLS

Boron and sulfate are common indicators of CCR impacts to groundwater due to leachability from CCR and mobility in groundwater; however, downgradient concentrations of both boron and sulfate are below their respective background UPLs. Both boron and sulfate are discussed in greater detail below.

Boron

Maximum boron concentrations measured in groundwater at downgradient wells in 2015-2017 ranged from 0.01 to 0.046 mg/L, or one and a half to seven times lower than the UPL. A time series for boron is provided in Figure 7 and boxplots are shown in Figure 8.

Figure 7. Boron time series

Figure 8. Boron boxplots

The time series and boxplots demonstrate the following observations about the wells:

- All boron concentrations in downgradient wells are substantially below the UPL of 0.07 mg/L, determined from background monitoring wells G02S, G50S, and G51S.

- The relatively level lines on the time series indicate that there is little variance in the results at each well. The minimal variance is also supported by the height of the boxplots. The upper and lower lines of the boxes are the 25th and 75th quartiles, the closer these two lines are to each other, the lower the overall variance is for that location.

Mann-Kendall trend analysis tests were performed (Attachment B) to determine if concentrations at each well were increasing, decreasing or stable (i.e., no statistically significant upward or downward trend). If the Mann-Kendall test did not identify a trend, the coefficient of variation (CV) was calculated (Attachment B) to determine if the concentrations are stable (i.e. CV less than or equal to 1), or if there if there is too much data variability to draw a conclusion.

Boron concentrations are stable in background wells G02S and G51S, and in downgradient wells G54S, G57S, and G64S. boron concentrations are decreasing in background well G50S and downgradient well G60S. Table 3 provides summary statistics, including variance and trend per well.

Monitoring Well	Boron (mg/L)				
	Minimum	Maximum	Median	Standard Deviation	Trend
G02S	0.030	0.130	0.040	0.033	stable
G50S	0.010	0.025	0.018	0.006	downward
G51S	0.010	0.020	0.010	0.005	stable
G54S	0.022	0.046	0.029	0.008	stable
G57S	0.010	0.021	0.010	0.005	stable
G60S	0.010	0.029	0.013	0.008	downward
G64S	0.010	0.036	0.016	0.009	stable

Table 3. Maximum, minimum, median, variance and trend of boron in groundwater

Sulfate

Maximum sulfate concentrations measured in groundwater at downgradient wells in 2015-2017 ranged from 25 to 68 mg/L, or one and a half to four times lower than the UPL. A time series for sulfate is provided in Figure 9 and boxplots are shown in Figure 10.
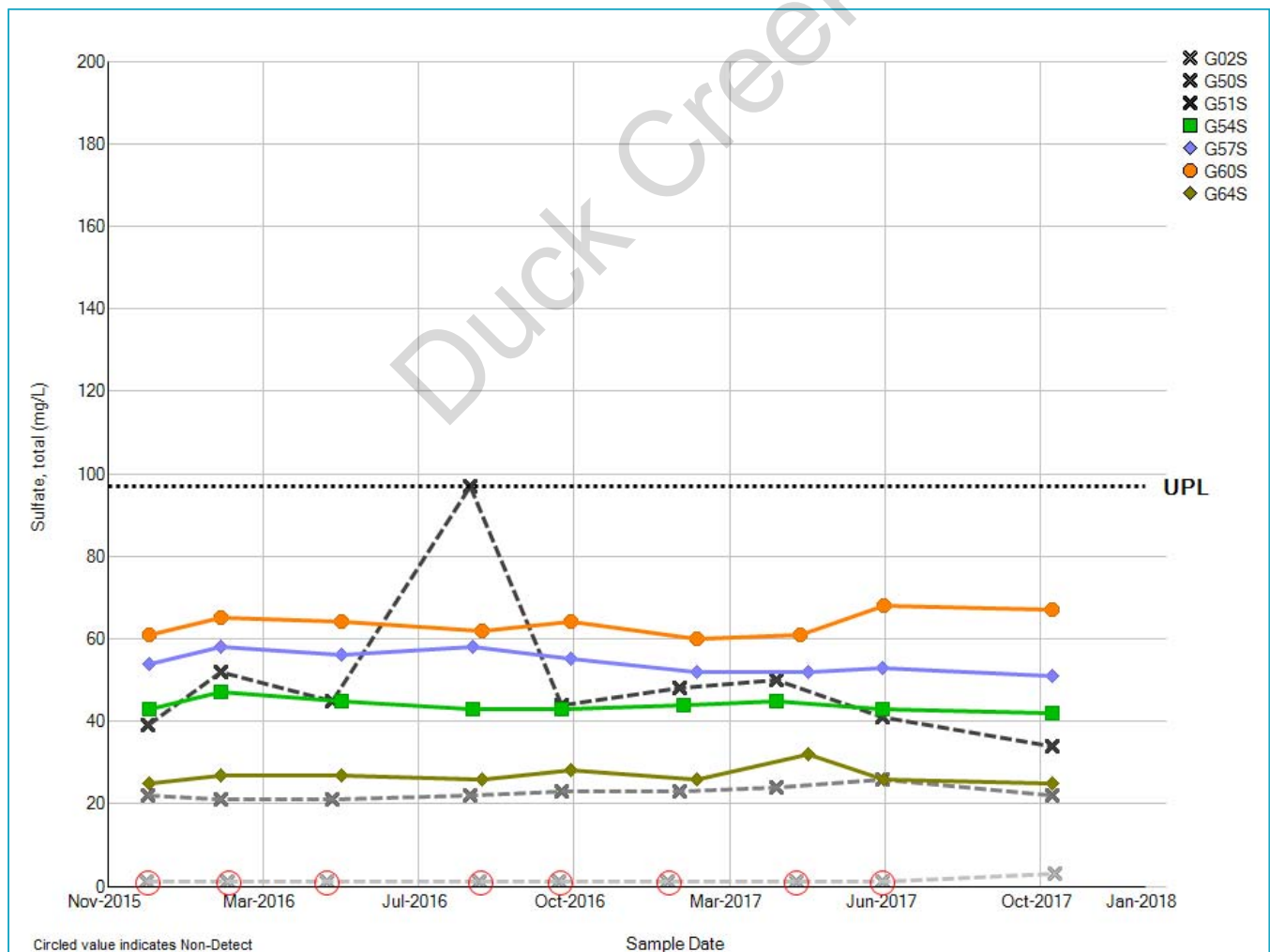
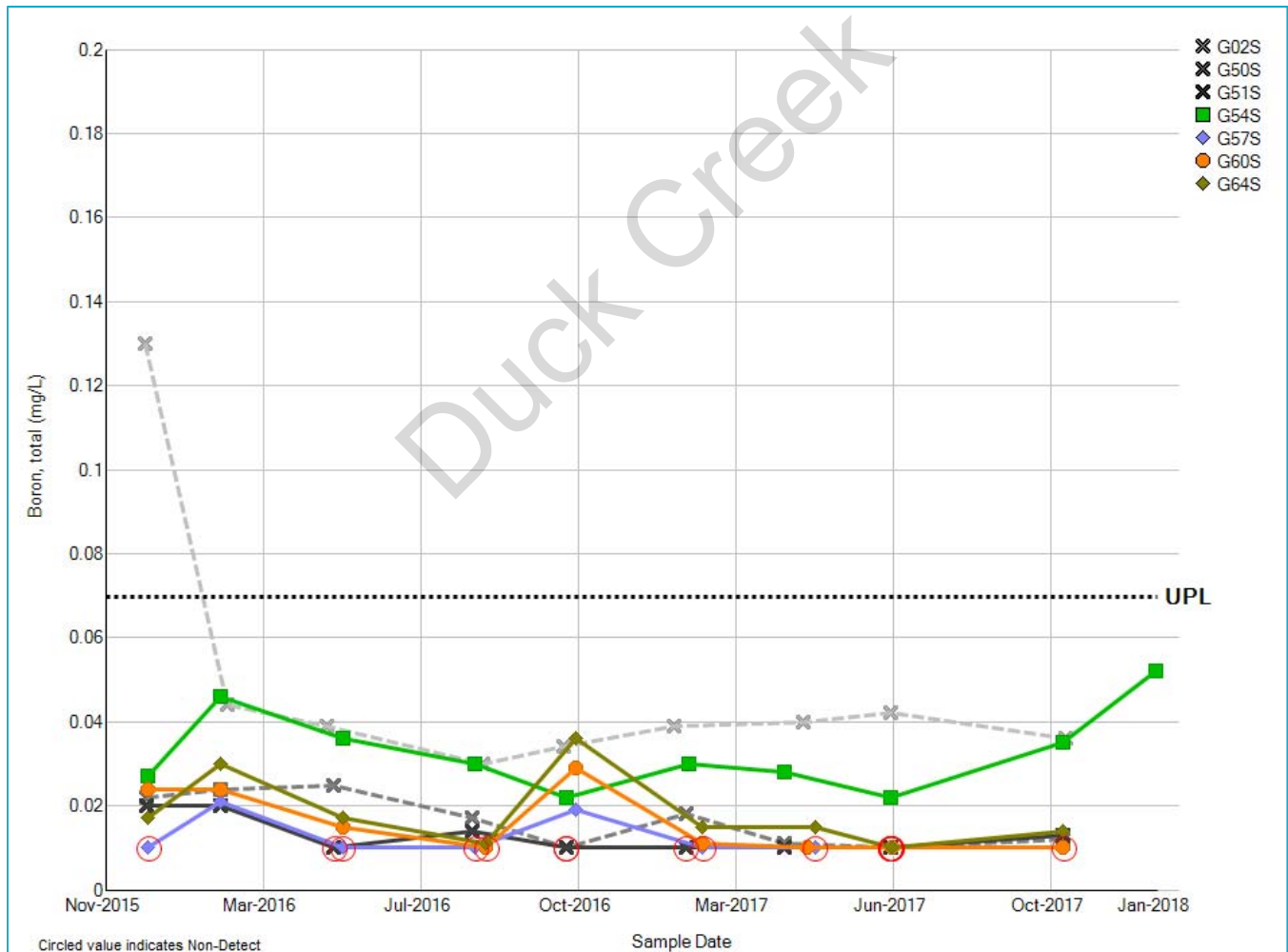

Figure 9. Sulfate time series
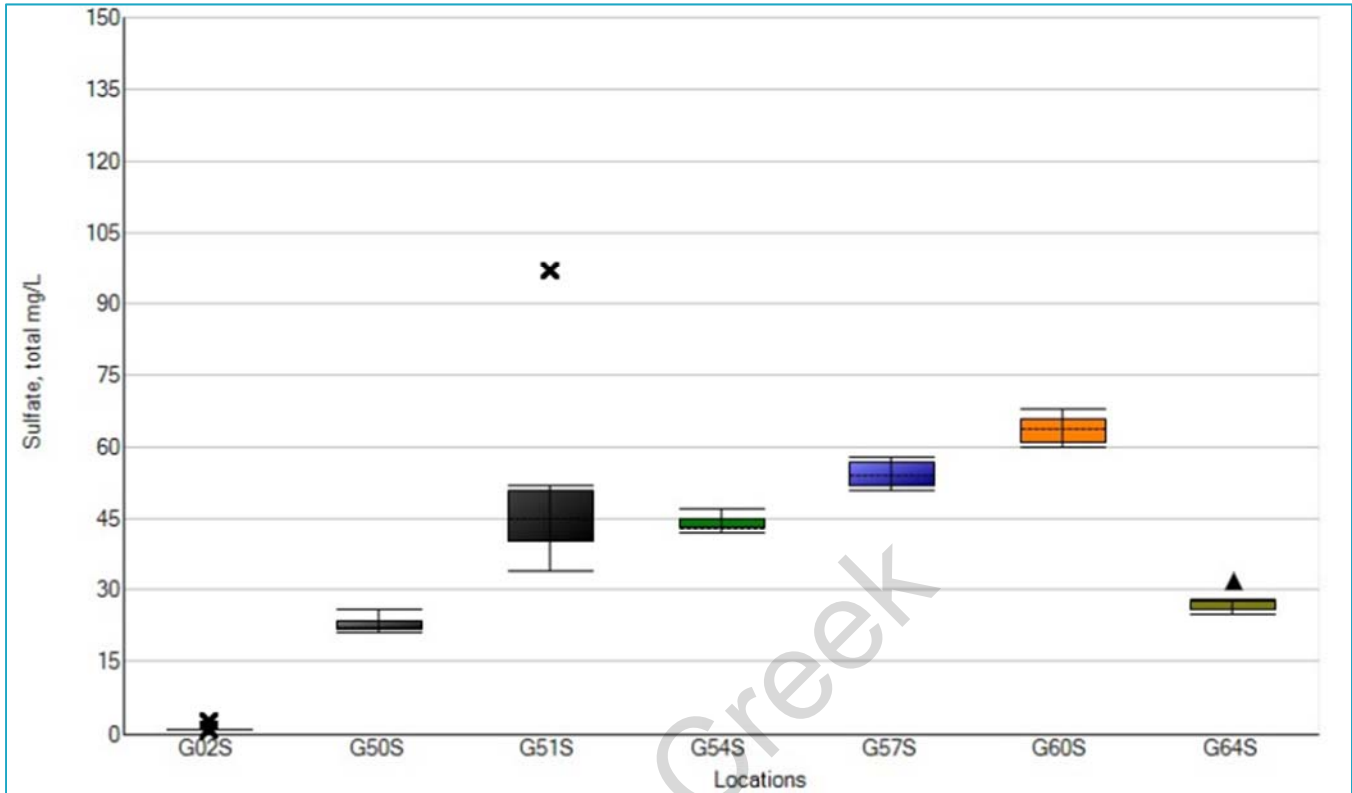
Figure 10. Sulfate boxplot
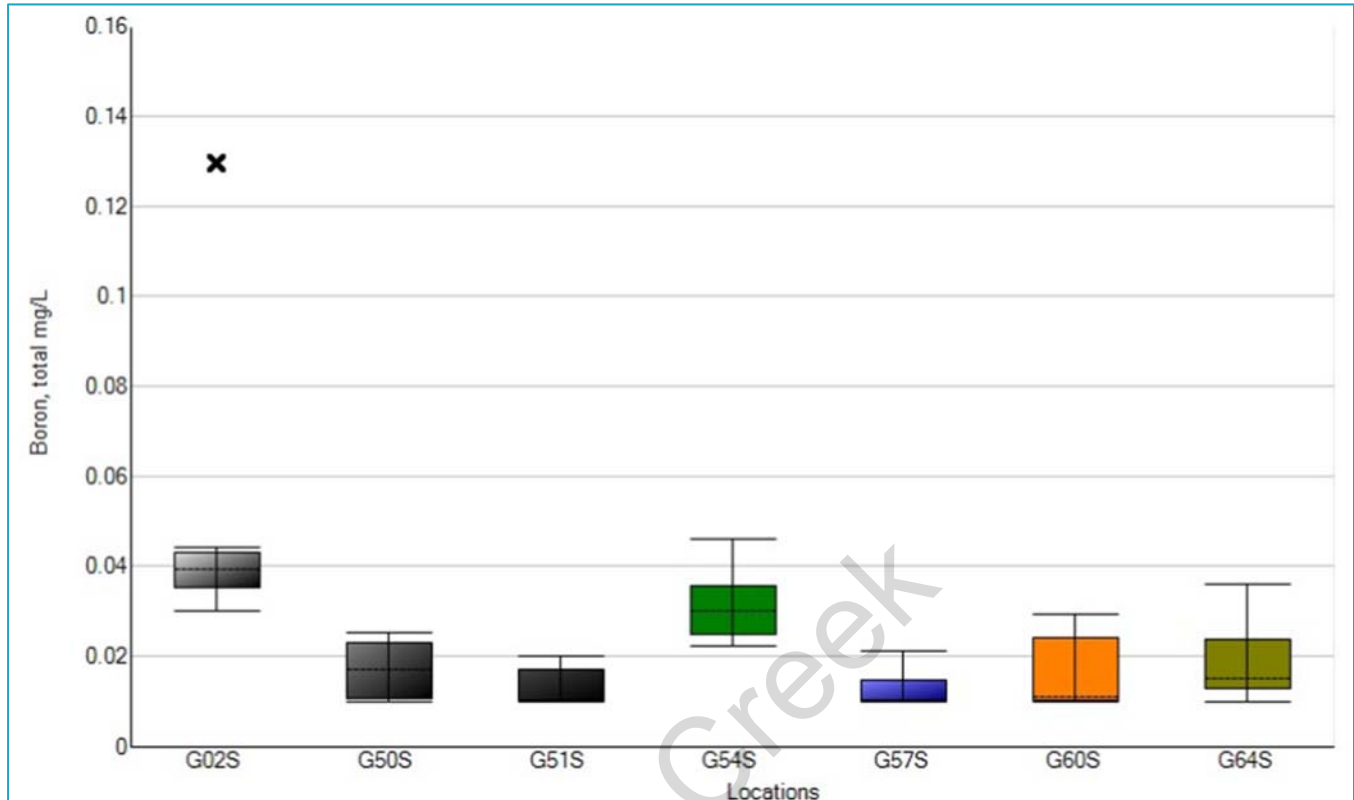
The time series and boxplots demonstrate the following observations about the wells:

- All sulfate concentrations in downgradient wells are substantially below the UPL of 97 mg/L, determined from background monitoring wells G02S, G50S and G51S.

- The relatively level lines on the time series indicate that there is little variance in the results at each well. The minimal variance is also supported by the height of the boxplots. The upper and lower lines of the boxes are the 25th and 75th quartiles, the closer these two lines are to each other, the lower the overall variance is for that location.

Mann-Kendall trend analysis tests were performed (Attachment B) to determine if concentrations at each well were increasing, decreasing or stable. If the Mann-Kendall test did not identify a trend, the coefficient of variation (CV) was calculated (Attachment B) to determine if the concentrations are stable (i.e. CV less than or equal to 1), or if there if there is too much data variability to draw a conclusion.

Sulfate concentrations are stable in background wells G02S and G51S, and downgradient wells G54S, G60S and G64S. Sulfate concentrations are increasing in background well G50S, and decreasing in downgradient well G57S. Table 4 provides summary statistics, including variance and trend per well.

| Monitoring Well | Sulfate (mg/L) | | | | |
	Minimum	Maximum	Median	Standard Deviation	Trend
G02S	1.000	1.000	1.000	0.000	stable
G50S	21.000	26.000	22.500	1.669	upward
G51S	39.000	97.000	46.500	18.701	stable
G54S	43.000	47.000	43.500	1.458	stable
G57S	52.000	58.000	54.500	2.435	downward
G60S	60.000	68.000	63.000	2.642	stable
G64S	25.000	32.000	26.500	2.167	stable
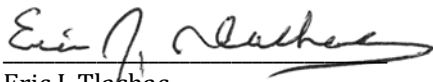
Table 4. Maximum, minimum, median and variance of sulfate in groundwater

Based on these four lines of evidence, it has been demonstrated that the boron SSI at G54S, the calcium SSIs at G54S and G57S, fluoride SSI at G64S, and total dissolved solids SSI at well G60S are not due to the Duck Creek GMF but are from an alternate anthropogenic source.

This information serves as the written alternate source demonstration prepared in accordance with 40 CFR § 257.94(e)(2) that the SSIs observed during the detection monitoring program were not due to the CCR unit but were from historic coal mining activity and other anthropogenic impacts. Therefore, an assessment monitoring program is not required and the Duck Creek GMF Pond will remain in detection monitoring.

Attachment A   Detection Monitoring Summary
Attachment B   Mann-Kendall Trend Analyses
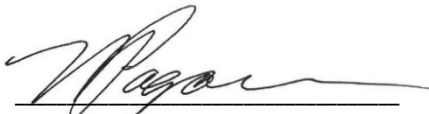
I, Eric J. Tlachac, a qualified professional engineer in good standing in the State of Illinois, certify that the information in this report is accurate as of the date of my signature below. The content of this report is not to be used for other than its intended purpose and meaning, or for extrapolations beyond the interpretations contained herein.

Eric J. Tlachac
Qualified Professional Engineer
062-063091
Illinois
O'Brien & Gere Engineers, Inc.
Date: April 9, 2018

I, Nicole M. Pagano, a professional geologist in good standing in the State of Illinois, certify that the information in this report is accurate as of the date of my signature below. The content of this report is not to be used for other than its intended purpose and meaning, or for extrapolations beyond the interpretations contained herein.

Nicole M. Pagano
Professional Geologist
196-000750
O'Brien & Gere Engineers, Inc.
Date: April 9, 2018

Figures

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
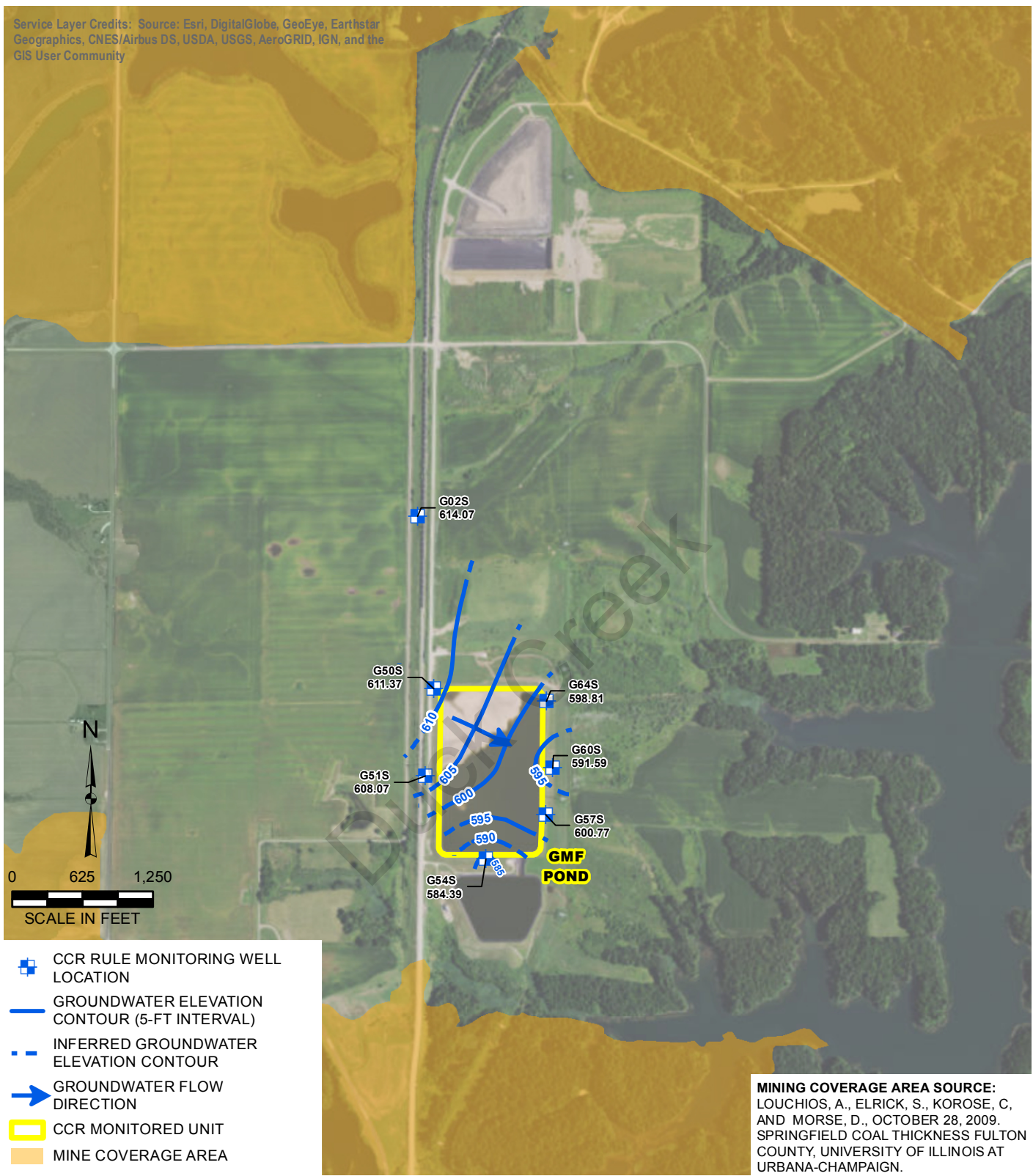
G02S
614.07

G50S
611.37

G64S
598.81

610

G60S
591.59

G51S
608.07

605

600

595

G57S
600.77

595

590

585

GMF POND

G54S
584.39

N

0   625   1,250

SCALE IN FEET

CCR RULE MONITORING WELL LOCATION

GROUNDWATER ELEVATION CONTOUR (5-FT INTERVAL)

INFERRED GROUNDWATER ELEVATION CONTOUR

GROUNDWATER FLOW DIRECTION

CCR MONITORED UNIT

MINE COVERAGE AREA

MINING COVERAGE AREA SOURCE:
LOUCHIOS, A., ELRICK, S., KOROSE, C, AND MORSE, D., OCTOBER 28, 2009. SPRINGFIELD COAL THICKNESS FULTON COUNTY, UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN.

DRAWN BY/DATE:
SDS 4/9/18
REVIEWED BY/DATE:
JJW 4/9/18
APPROVED BY/DATE:
NMP 4/9/18

DUCK CREEK GMF POND (UNIT ID: 203)
UPPERMOST AQUIFER UNIT
GROUNDWATER ELEVATION CONTOUR MAP
JUNE 28-29, 2017

ALTERNATE SOURCE DEMONSTRATION
DUCK CREEK POWER STATION
CANTON, ILLINOIS

PROJECT NO: 67719

FIGURE NO: 1

Y:\Mapping\Projects\22\2285\MXD\Alt_Source_Dem\Figure_1_DuckCreekGMFP_GWC_1706_Mining.mxd   Author: stolzsd; Date/Time: 5/11/2018, 12:02:18 PM

GMF POND

Duck Creek

N

| 0 | 1,750 | 3,500 |

SCALE IN FEET

☐ CCR MONITORED UNIT
☐ MINE COVERAGE AREA

MINING COVERAGE AREA SOURCE:
LOUCHIOS, A., ELRICK, S., KOROSE, C, AND MORSE, D., OCTOBER 28, 2009. SPRINGFIELD COAL THICKNESS FULTON COUNTY, UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN.

DRAWN BY/DATE:
SDS 4/9/18
REVIEWED BY/DATE:
EJT 4/9/18
APPROVED BY/DATE:
NMP 4/9/18

COAL MINE COVERAGE AREA
NEAR DUCK CREEK GMF POND (UNIT ID: 203)

ALTERNATE SOURCE DEMONSTRATION
DUCK CREEK POWER STATION
CANTON, ILLINOIS

PROJECT NO: 70089

FIGURE NO: 4

Y:\Mapping\Projects\221\2285\MXD\Alt_Source_Dem\Figure 4_DuckCreekGMFP_Mining.mxd   Author: stolzsd   Date/Time: 9/26/2018, 12:41:07 PM

Attachment A

Detection Monitoring Summary

Duck Creek

Detection Monitoring Summary

Location Id: **G54S**

Compliance Test: **Parametric Prediction Interval on Background**

Parameter	Sample Date	Lab Id	Re Testing	Upper Limit	Compliance Result	Exceedance	Possible SSI	Post-Hoc Trend
B, tot mg/L	11/08/2017	7111701-03	1 of 2	0.070	0.035	n		--
B, tot mg/L	01/18/2018	8012972-01	1 of 2	0.070	0.052	n		--

Location Id: **G54S**

Compliance Test: **Parametric Prediction Interval on Background**

Parameter	Sample Date	Lab Id	Re Testing	Upper Limit	Compliance Result	Exceedance	Possible SSI	Post-Hoc Trend
Ca, tot mg/L	11/08/2017	7111701-03	1 of 2	110.23	130.00	y		Downward
Ca, tot mg/L	01/18/2018	8012972-01	1 of 2	110.23	120.00	y		Downward

Location Id: **G54S**

Compliance Test: **Parametric Prediction Interval on Background**

Parameter	Sample Date	Lab Id	Re Testing	Upper Limit	Compliance Result	Exceedance	Possible SSI	Post-Hoc Trend
Cl, tot mg/L	11/08/2017	7111701-03	1 of 2	20.9	2.2	n		--

Location Id: **G54S**

Compliance Test: **Non-Parametric Prediction Interval on Background Useing largest background data value.**

Parameter	Sample Date	Lab Id	Re Testing	Upper Limit	Compliance Result	Exceedance	Possible SSI	Post-Hoc Trend

NOTE: If trend test is performed, the background slope is listed under the Upper Limit heading and the compliance slope is listed under the Compliance Result heading.

						Run Id:	4

Location Id: **G54S**

| F, tot mg/L | 11/08/2017 | 7111701-03 | 1 of 2 | 0.564 | 0.342 | n | -- |

						Run Id:	5

Location Id: **G54S**

Compliance Test: **Parametric Prediction Interval on Background**

Parameter	Sample Date	Lab Id	Re Testing	Upper Limit	Compliance Result	Exceedance	Possible SSI	Post-Hoc Trend
pH (field) STD	11/08/2017	7111701-03	1 of 2	7.53	7.05	n/n		--
pH (field) STD	01/18/2018	8012972-01	1 of 2	7.53	6.92	n/n		--

						Run Id:	6

Location Id: **G54S**

Compliance Test: **Non-Parametric Prediction Interval on Background Useing largest background data value.**

Parameter	Sample Date	Lab Id	Re Testing	Upper Limit	Compliance Result	Exceedance	Possible SSI	Post-Hoc Trend
SO4, tot mg/L	11/08/2017	7111701-03	1 of 2	97.0	42.0	n		--

						Run Id:	7

Location Id: **G54S**

Compliance Test: **Parametric Prediction Interval on Background**

Parameter	Sample Date	Lab Id	Re Testing	Upper Limit	Compliance Result	Exceedance	Possible SSI	Post-Hoc Trend
TDS mg/L	11/08/2017	7111701-03	1 of 2	490	480	n		--
TDS mg/L	01/18/2018	8012972-01	1 of 2	490	380	n		--

						Run Id:	8

NOTE: If trend test is performed, the background slope is listed under the Upper Limit heading and the compliance slope is listed under the Compliance Result heading.

Duck Creek

Detection Monitoring Summary

Run Id: 8

Location Id: **G57S**

Compliance Test: **Parametric Prediction Interval on Background**

Parameter	Sample Date	Lab Id	Re Testing	Upper Limit	Compliance Result	Exceedance	Possible SSI	Post-Hoc Trend
B, tot mg/L	11/08/2017	7111701-04	1 of 2	0.070	< 0.010	n		--

Run Id: 9

Location Id: **G57S**

Compliance Test: **Parametric Prediction Interval on Background**

Parameter	Sample Date	Lab Id	Re Testing	Upper Limit	Compliance Result	Exceedance	Possible SSI	Post-Hoc Trend
Ca, tot mg/L	11/08/2017	7111701-04	1 of 2	110.23	120.00	y		None
Ca, tot mg/L	01/18/2018	8012972-02	1 of 2	110.23	180.00	y		None

Run Id: 10

Location Id: **G57S**

Compliance Test: **Parametric Prediction Interval on Background**

Parameter	Sample Date	Lab Id	Re Testing	Upper Limit	Compliance Result	Exceedance	Possible SSI	Post-Hoc Trend
Cl, tot mg/L	11/08/2017	7111701-04	1 of 2	20.9	19.0	n		--

Run Id: 11

Location Id: **G57S**

Compliance Test: **Non-Parametric Prediction Interval on Background Useing largest background data value.**

Parameter	Sample Date	Lab Id	Re Testing	Upper Limit	Compliance Result	Exceedance	Possible SSI	Post-Hoc Trend
F, tot mg/L	11/08/2017	7111701-04	1 of 2	0.564	0.390	n		--

NOTE: If trend test is performed, the background slope is listed under the Upper Limit heading and the compliance slope is listed under the Compliance Result heading.

Run Id: 11

Location Id: G57S

Parameter	Sample Date	Lab Id	Re Testing	Result	Result	Exceedance		Post-Hoc
F, tot mg/L	01/18/2018	8012972-02	1 of 2	0.564	< 0.250	n		--

Run Id: 12

Location Id: G57S

Compliance Test: Parametric Prediction Interval on Background

Parameter	Sample Date	Lab Id	Re Testing	Upper Limit	Compliance Result	Exceedance	Possible SSI	Post-Hoc Trend
pH (field) STD	11/08/2017	7111701-04	1 of 2	7.53	7.03	n/n		--
pH (field) STD	01/18/2018	8012972-02	1 of 2	7.53	7.07	n/n		--

Run Id: 13

Location Id: G57S

Compliance Test: Non-Parametric Prediction Interval on Background Useing largest background data value.

Parameter	Sample Date	Lab Id	Re Testing	Upper Limit	Compliance Result	Exceedance	Possible SSI	Post-Hoc Trend
SO4, tot mg/L	11/08/2017	7111701-04	1 of 2	97.0	51.0	n		--

Run Id: 14

Location Id: G57S

Compliance Test: Parametric Prediction Interval on Background

Parameter	Sample Date	Lab Id	Re Testing	Upper Limit	Compliance Result	Exceedance	Possible SSI	Post-Hoc Trend
TDS mg/L	11/08/2017	7111701-04	1 of 2	490	450	n		--
TDS mg/L	01/18/2018	8012972-02	1 of 2	490	370	n		--

Run Id: 15

NOTE: If trend test is performed, the background slope is listed under the Upper Limit heading and the compliance slope is listed under the Compliance Result heading.

Run Id: 15

Location Id: **G60S**

Compliance Test: **Parametric Prediction Interval on Background**

Parameter	Sample Date	Lab Id	Re Testing	Upper Limit	Compliance Result	Exceedance	Possible SSI	Post-Hoc Trend
B, tot mg/L	11/08/2017	7111701-05	1 of 2	0.070	0.010	n		--

Run Id: 16

Location Id: **G60S**

Compliance Test: **Parametric Prediction Interval on Background**

Parameter	Sample Date	Lab Id	Re Testing	Upper Limit	Compliance Result	Exceedance	Possible SSI	Post-Hoc Trend
Ca, tot mg/L	11/08/2017	7111701-05	1 of 2	110.23	120.00	y		Downward
Ca, tot mg/L	01/19/2018	8013142-01	1 of 2	110.23	100.00	n		--

Run Id: 17

Location Id: **G60S**

Compliance Test: **Parametric Prediction Interval on Background**

Parameter	Sample Date	Lab Id	Re Testing	Upper Limit	Compliance Result	Exceedance	Possible SSI	Post-Hoc Trend
Cl, tot mg/L	11/08/2017	7111701-05	1 of 2	20.9	11.0	n		--

Run Id: 18

Location Id: **G60S**

Compliance Test: **Non-Parametric Prediction Interval on Background Useing largest background data value.**

Parameter	Sample Date	Lab Id	Re Testing	Upper Limit	Compliance Result	Exceedance	Possible SSI	Post-Hoc Trend
F, tot mg/L	11/08/2017	7111701-05	1 of 2	0.564	0.351	n		--

NOTE: If trend test is performed, the background slope is listed under the Upper Limit heading and the compliance slope is listed under the Compliance Result heading.

Duck Creek

Detection Monitoring Summary

Location Id:	**G60S**							
F, tot mg/L		01/19/2018	8013142-01	1 of 2	0.564	0.313	n	--

Location Id: **G60S**

Compliance Test: **Parametric Prediction Interval on Background**

Parameter	Sample Date	Lab Id	Re Testing	Upper Limit	Compliance Result	Exceedance	Possible SSI	Post-Hoc Trend
pH (field) STD	11/08/2017	7111701-05	1 of 2	7.53	6.89	n/n		--
pH (field) STD	01/19/2018	8013142-01	1 of 2	7.53	6.85	n/n		--

Location Id: **G60S**

Compliance Test: **Non-Parametric Prediction Interval on Background Useing largest background data value.**

Parameter	Sample Date	Lab Id	Re Testing	Upper Limit	Compliance Result	Exceedance	Possible SSI	Post-Hoc Trend
SO4, tot mg/L	11/08/2017	7111701-05	1 of 2	97.0	67.0	n		--

Location Id: **G60S**

Compliance Test: **Parametric Prediction Interval on Background**

Parameter	Sample Date	Lab Id	Re Testing	Upper Limit	Compliance Result	Exceedance	Possible SSI	Post-Hoc Trend
TDS mg/L	11/08/2017	7111701-05	1 of 2	490	460	n		--
TDS mg/L	01/19/2018	8013142-01	1 of 2	490	520	y		None

NOTE: If trend test is performed, the background slope is listed under the Upper Limit heading and the compliance slope is listed under the Compliance Result heading.

Duck Creek

Detection Monitoring Summary

Location Id: **G64S**

Compliance Test: **Parametric Prediction Interval on Background**

Parameter	Sample Date	Lab Id	Re Testing	Upper Limit	Compliance Result	Exceedance	Possible SSI	Post-Hoc Trend
B, tot mg/L	11/08/2017	7111701-06	1 of 2	0.070	0.014	n		--

Location Id: **G64S**

Compliance Test: **Parametric Prediction Interval on Background**

Parameter	Sample Date	Lab Id	Re Testing	Upper Limit	Compliance Result	Exceedance	Possible SSI	Post-Hoc Trend
Ca, tot mg/L	11/08/2017	7111701-06	1 of 2	110.23	95.00	n		--

Location Id: **G64S**

Compliance Test: **Parametric Prediction Interval on Background**

Parameter	Sample Date	Lab Id	Re Testing	Upper Limit	Compliance Result	Exceedance	Possible SSI	Post-Hoc Trend
Cl, tot mg/L	11/08/2017	7111701-06	1 of 2	20.9	3.5	n		--

Location Id: **G64S**

Compliance Test: **Non-Parametric Prediction Interval on Background Useing largest background data value.**

Parameter	Sample Date	Lab Id	Re Testing	Upper Limit	Compliance Result	Exceedance	Possible SSI	Post-Hoc Trend
F, tot mg/L	11/08/2017	7111701-06	1 of 2	0.564	0.401	n		--
F, tot mg/L	01/19/2018	8013142-02	1 of 2	0.564	0.367	n		--

NOTE: If trend test is performed, the background slope is listed under the Upper Limit heading and the compliance slope is listed under the Compliance Result heading.

Run Id: 26

Location Id: **G64S**

Compliance Test: **Parametric Prediction Interval on Background**

Parameter	Sample Date	Lab Id	Re Testing	Upper Limit	Compliance Result	Exceedance	Possible SSI	Post-Hoc Trend
pH (field) STD	11/08/2017	7111701-06	1 of 2	7.53	6.81	n/n		--
pH (field) STD	01/19/2018	8013142-02	1 of 2	7.53	6.88	n/n		--

Run Id: 27

Location Id: **G64S**

Compliance Test: **Non-Parametric Prediction Interval on Background Useing largest background data value.**

Parameter	Sample Date	Lab Id	Re Testing	Upper Limit	Compliance Result	Exceedance	Possible SSI	Post-Hoc Trend
SO4, tot mg/L	11/08/2017	7111701-06	1 of 2	97.0	25.0	n		--

Run Id: 28

Location Id: **G64S**

Compliance Test: **Parametric Prediction Interval on Background**

Parameter	Sample Date	Lab Id	Re Testing	Upper Limit	Compliance Result	Exceedance	Possible SSI	Post-Hoc Trend
TDS mg/L	11/08/2017	7111701-06	1 of 2	490	380	n		--

NOTE: If trend test is performed, the background slope is listed under the Upper Limit heading and the compliance slope is listed under the Compliance Result heading.

Attachment B

Mann-Kendall Trend Analyses

Duck Creek

Duck Creek
Mann-Kendall Trend Analysis

User Supplied Information

Location ID:	G02S	**Parameter Code:**	01022
Location Class:		**Parameter:**	B, tot
Location Type:		**Units:**	mg/L
Confidence Level:	95.00%	**Period Length:**	1 month(s)
Date Range: 12/02/2015 to 10/17/2018		**Limit Name:**	
		Averaged:	No

Trend Analysis

Trend of the least squares straight line
   Slope (fitted to data):   -0.000067   mg/L per day
   R-Squared error of fit: 0.272138

Sen's Non-parametric estimate of the slope (One-Sided Test)
   Median Slope: -0.000009   mg/L per day
   Lower Confidence Limit of Slope, M1:   -0.000070   mg/L per day
   Upper Confidence Limit of Slope, M2+1:   0.000013   mg/L per day

Non-parametric Mann-Kendall Test for Trend
   S Statistic: -0.629
   Z test: 1.645
   At the 95.0 % Confidence Level (One-Sided Test):   None

User Supplied Information

Location ID:	G50S	**Parameter Code:**	01022
Location Class:		**Parameter:**	B, tot
Location Type:		**Units:**	mg/L
Confidence Level:	95.00%	**Period Length:**	1 month(s)
Date Range: 12/02/2015 to 10/17/2018		**Limit Name:**	
		Averaged:	No

Trend Analysis

Trend of the least squares straight line
    Slope (fitted to data):   -0.000023   mg/L per day
    R-Squared error of fit: 0.532078

Sen's Non-parametric estimate of the slope (One-Sided Test)
    Median Slope: -0.000023   mg/L per day
    Lower Confidence Limit of Slope, M1:   -0.000040   mg/L per day
    Upper Confidence Limit of Slope, M2+1:   -0.000001   mg/L per day

Non-parametric Mann-Kendall Test for Trend
    S Statistic: -1.677
    Z test: 1.645
    At the 95.0 % Confidence Level (One-Sided Test):   Downward

User Supplied Information

Location ID:	G51S	**Parameter Code:**	01022
Location Class:		**Parameter:**	B, tot
Location Type:		**Units:**	mg/L
Confidence Level:	95.00%	**Period Length:**	1 month(s)
Date Range: 12/02/2015 to 10/17/2018		**Limit Name:**	
		Averaged:	No

Trend Analysis

Trend of the least squares straight line
    Slope (fitted to data):   -0.000013   mg/L per day
    R-Squared error of fit: 0.236719

Sen's Non-parametric estimate of the slope (One-Sided Test)
    Median Slope: -0.000010 mg/L per day
    Lower Confidence Limit of Slope, M1:   -0.000030 mg/L per day
    Upper Confidence Limit of Slope, M2+1:   0.000000 mg/L per day

Non-parametric Mann-Kendall Test for Trend
    S Statistic: -1.102
    Z test: 1.645
    At the 95.0 % Confidence Level (One-Sided Test):   None

User Supplied Information

Location ID:	**G54S**	**Parameter Code:**	**01022**
Location Class:		**Parameter:**	**B, tot**
Location Type:		**Units:**	**mg/L**
Confidence Level:	**95.00%**	**Period Length:**	**1 month(s)**
Date Range: 12/02/2015 to 10/17/2018		**Limit Name:**	
		Averaged:	**No**

<u>Trend Analysis</u>

Trend of the least squares straight line
    Slope (fitted to data):   0.000006   mg/L per day
    R-Squared error of fit: 0.026203

Sen's Non-parametric estimate of the slope (One-Sided Test)
    Median Slope: 0.000000   mg/L per day

    Lower Confidence Limit of Slope, M1:   -0.000026   mg/L per day

    Upper Confidence Limit of Slope, M2+1:   0.000032   mg/L per day

Non-parametric Mann-Kendall Test for Trend
    S Statistic: 0.000
    Z test: 1.645
    At the 95.0 % Confidence Level (One-Sided Test):   None

Duck Creek
Mann-Kendall Trend Analysis

User Supplied Information

Location ID:	G57S	**Parameter Code:**	01022
Location Class:		**Parameter:**	B, tot
Location Type:		**Units:**	mg/L
Confidence Level:	95.00%	**Period Length:**	1 month(s)
Date Range: 12/02/2015 to 10/17/2018		**Limit Name:**	
		Averaged:	No

<u>Trend Analysis</u>

Trend of the least squares straight line
    Slope (fitted to data):   -0.000010   mg/L per day
    R-Squared error of fit: 0.124584

Sen's Non-parametric estimate of the slope (One-Sided Test)
    Median Slope: 0.000000   mg/L per day
    Lower Confidence Limit of Slope, M1:   0.000000   mg/L per day
    Upper Confidence Limit of Slope, M2+1:   0.000000   mg/L per day

Non-parametric Mann-Kendall Test for Trend
    S Statistic: -0.869
    Z test: 1.645
    At the 95.0 % Confidence Level (One-Sided Test):   None

Duck Creek
Mann-Kendall Trend Analysis

User Supplied Information

Location ID:	G60S	**Parameter Code:**	01022
Location Class:		**Parameter:**	B, tot
Location Type:		**Units:**	mg/L
Confidence Level:	95.00%	**Period Length:**	1 month(s)
Date Range: 12/02/2015 to 10/17/2018		**Limit Name:**	
		Averaged:	No

Trend Analysis

Trend of the least squares straight line
    Slope (fitted to data):   -0.000022   mg/L per day
    R-Squared error of fit: 0.370114

Sen's Non-parametric estimate of the slope (One-Sided Test)
    Median Slope: -0.000023   mg/L per day
    Lower Confidence Limit of Slope, M1:   -0.000048   mg/L per day
    Upper Confidence Limit of Slope, M2+1:   0.000000   mg/L per day

Non-parametric Mann-Kendall Test for Trend
    S Statistic: -1.696
    Z test: 1.645
    At the 95.0 % Confidence Level (One-Sided Test):   Downward

Duck Creek
Mann-Kendall Trend Analysis

User Supplied Information

Location ID:	G64S	**Parameter Code:**	01022
Location Class:		**Parameter:**	B, tot
Location Type:		**Units:**	mg/L
Confidence Level:	95.00%	**Period Length:**	1 month(s)
Date Range: 12/02/2015 to 10/17/2018		**Limit Name:**	
		Averaged:	No

Trend Analysis

Trend of the least squares straight line
    Slope (fitted to data):   -0.000017   mg/L per day
    R-Squared error of fit: 0.181636

Sen's Non-parametric estimate of the slope (One-Sided Test)
    Median Slope: -0.000006   mg/L per day
    Lower Confidence Limit of Slope, M1:   -0.000047   mg/L per day
    Upper Confidence Limit of Slope, M2+1:   0.000000   mg/L per day

Non-parametric Mann-Kendall Test for Trend
    S Statistic: -1.581
    Z test: 1.645
    At the 95.0 % Confidence Level (One-Sided Test):   None

Duck Creek
Mann-Kendall Trend Analysis

User Supplied Information

Location ID:	**G02S**	**Parameter Code:**	**00945**
Location Class:		**Parameter:**	**SO4, tot**
Location Type:		**Units:**	**mg/L**
Confidence Level:	**95.00%**	**Period Length:**	**1 month(s)**
Date Range: 12/02/2015 to 10/17/2018		**Limit Name:**	
		Averaged:	**No**

<u>Trend Analysis</u>

Trend of the least squares straight line
   Slope (fitted to data):   0.001963   mg/L per day
   R-Squared error of fit: 0.347565

Sen's Non-parametric estimate of the slope (One-Sided Test)
   Median Slope: 0.000000   mg/L per day
   Lower Confidence Limit of Slope, M1:   0.000000   mg/L per day
   Upper Confidence Limit of Slope, M2+1:   0.000000   mg/L per day

Non-parametric Mann-Kendall Test for Trend
   S Statistic: 1.356
   Z test: 1.645
   At the 95.0 % Confidence Level (One-Sided Test):   None

Duck Creek
Mann-Kendall Trend Analysis

User Supplied Information

Location ID: **G50S**   **Parameter Code:**   **00945**
Location Class: **Parameter:**   **SO4, tot**
Location Type: **Units:**   **mg/L**
Confidence Level: **95.00%**   **Period Length:**   **1**   **month(s)**
Date Range: 12/02/2015 to 10/17/2018   **Limit Name:**
                                             Averaged: **No**

Trend Analysis

Trend of the least squares straight line
     Slope (fitted to data):   0.004013   mg/L per day
     R-Squared error of fit: 0.368771

Sen's Non-parametric estimate of the slope (One-Sided Test)
     Median Slope: 0.005769   mg/L per day
     Lower Confidence Limit of Slope, M1:   0.000000   mg/L per day
     Upper Confidence Limit of Slope, M2+1:   0.009095   mg/L per day

Non-parametric Mann-Kendall Test for Trend
     S Statistic: 1.937
     Z test: 1.645
     At the 95.0 % Confidence Level (One-Sided Test):   Upward

Duck Creek
Mann-Kendall Trend Analysis

User Supplied Information

Location ID:	**G51S**	**Parameter Code:**	**00945**
Location Class:		**Parameter:**	**SO4, tot**
Location Type:		**Units:**	**mg/L**
Confidence Level:	**95.00%**	**Period Length:**	**1 month(s)**
Date Range: 12/02/2015 to 10/17/2018		**Limit Name:**	
		Averaged:	**No**

Trend Analysis

Trend of the least squares straight line
  Slope (fitted to data):   -0.017538   mg/L per day
  R-Squared error of fit: 0.051472

Sen's Non-parametric estimate of the slope (One-Sided Test)
  Median Slope: -0.010249   mg/L per day
  Lower Confidence Limit of Slope, M1:   -0.047685   mg/L per day
  Upper Confidence Limit of Slope, M2+1:   0.020994   mg/L per day

Non-parametric Mann-Kendall Test for Trend
  S Statistic: -0.730
  Z test: 1.645
  At the 95.0 % Confidence Level (One-Sided Test):   None

Duck Creek
Mann-Kendall Trend Analysis

User Supplied Information

Location ID:	**G54S**	**Parameter Code:**	**00945**
Location Class:		**Parameter:**	**SO4, tot**
Location Type:		**Units:**	**mg/L**
Confidence Level:	**95.00%**	**Period Length:**	**1 month(s)**
Date Range: 12/02/2015 to 10/17/2018		**Limit Name:**	
		Averaged:	**No**

<u>Trend Analysis</u>

Trend of the least squares straight line
    Slope (fitted to data):   -0.003119 mg/L per day
    R-Squared error of fit: 0.234239

Sen's Non-parametric estimate of the slope (One-Sided Test)
    Median Slope: -0.002409 mg/L per day
    Lower Confidence Limit of Slope, M1:   -0.007605 mg/L per day
    Upper Confidence Limit of Slope, M2+1:   0.000000 mg/L per day

Non-parametric Mann-Kendall Test for Trend
    S Statistic: -1.102
    Z test: 1.645
    At the 95.0 % Confidence Level (One-Sided Test):   None

Duck Creek
Mann-Kendall Trend Analysis

User Supplied Information

Location ID:	**G57S**	**Parameter Code:**	**00945**
Location Class:		**Parameter:**	**SO4, tot**
Location Type:		**Units:**	**mg/L**
Confidence Level:	**95.00%**	**Period Length:**	**1 month(s)**
Date Range: 12/02/2015 to 10/17/2018		**Limit Name:**	
		Averaged:	**No**

Trend Analysis

Trend of the least squares straight line
   Slope (fitted to data):   -0.007982   mg/L per day
   R-Squared error of fit: 0.548314

Sen's Non-parametric estimate of the slope (One-Sided Test)
   Median Slope: -0.008620   mg/L per day
   Lower Confidence Limit of Slope, M1:   -0.014919   mg/L per day
   Upper Confidence Limit of Slope, M2+1:   -0.002114   mg/L per day

Non-parametric Mann-Kendall Test for Trend
   S Statistic: -2.003
   Z test: 1.645
   At the 95.0 % Confidence Level (One-Sided Test):   Downward

Duck Creek
Mann-Kendall Trend Analysis

User Supplied Information

Location ID:	**G60S**	**Parameter Code:**	**00945**
Location Class:		**Parameter:**	**SO4, tot**
Location Type:		**Units:**	**mg/L**
Confidence Level:	**95.00%**	**Period Length:**	**1 month(s)**
Date Range: 12/02/2015 to 10/17/2018		**Limit Name:**	
		Averaged:	**No**

Trend Analysis

Trend of the least squares straight line
    Slope (fitted to data):   0.004434   mg/L per day
    R-Squared error of fit: 0.145927

Sen's Non-parametric estimate of the slope (One-Sided Test)
    Median Slope: 0.004626   mg/L per day
    Lower Confidence Limit of Slope, M1:   -0.008221   mg/L per day
    Upper Confidence Limit of Slope, M2+1:   0.012320   mg/L per day

Non-parametric Mann-Kendall Test for Trend
    S Statistic: 0.527
    Z test: 1.645
    At the 95.0 % Confidence Level (One-Sided Test):   None

Duck Creek
Mann-Kendall Trend Analysis

User Supplied Information

Location ID:	**G64S**	**Parameter Code:**	**00945**
Location Class:		**Parameter:**	**SO4, tot**
Location Type:		**Units:**	**mg/L**
Confidence Level:	**95.00%**	**Period Length:**	**1 month(s)**
Date Range: 12/02/2015 to 10/17/2018		**Limit Name:**	
		Averaged:	**No**

Trend Analysis

Trend of the least squares straight line
    Slope (fitted to data):   0.001215   mg/L per day
    R-Squared error of fit: 0.018577

Sen's Non-parametric estimate of the slope (One-Sided Test)
    Median Slope: 0.000000   mg/L per day
    Lower Confidence Limit of Slope, M1:   -0.003601   mg/L per day
    Upper Confidence Limit of Slope, M2+1:   0.007853   mg/L per day

Non-parametric Mann-Kendall Test for Trend
    S Statistic: 0.000
    Z test: 1.645
    At the 95.0 % Confidence Level (One-Sided Test):   None

Duck Creek

Coefficient of Variation
Date Range: 12/02/2015 to 10/30/2017

Boron, total (mg/L)

Location	Count	Mean	Std Dev	% Non-Detects	CV
G02S	8	0.050	0.033	0.00	0.66
G50S	8	0.017	0.006	25.00	0.36
G51S	8	0.013	0.005	50.00	0.35
G54S	8	0.030	0.008	0.00	0.26
G57S	8	0.013	0.005	75.00	0.37
G60S	8	0.017	0.008	25.00	0.47
G64S	8	0.019	0.009	12.50	0.49

Sulfate, total (mg/L)

Location	Count	Mean	Std Dev	% Non-Detects	CV
G02S	8	1.000	0.000	100.00	0.00
G50S	8	22.750	1.669	0.00	0.07
G51S	8	52.000	18.701	0.00	0.36
G54S	8	44.125	1.458	0.00	0.03
G57S	8	54.750	2.435	0.00	0.04
G60S	8	63.125	2.642	0.00	0.04
G64S	8	27.125	2.167	0.00	0.08

CV=Std Dev/ Mean

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