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2019 Annual Groundwater Monitoring and Corrective Action Report

Date

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2019 ANNUAL GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT

COFFEEN GYPSUM MANAGEMENT FACILITY

GYPSUM STACK POND, COFFEEN POWER STATION

RAMBOLL Bright ideas. Sustainable change.

2019 ANNUAL GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT
COFFEEN GMF GYPSUM STACK POND, COFFEEN POWER STATION

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Approved by	**Eric J. Tlachac**
Description	**Annual Report in Support of the CCR Rule Groundwater Monitoring Program**

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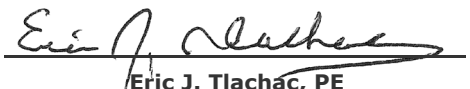

Eric J. Tlachac, PE
Managing Engineer

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ACRONYMS AND ABBREVIATIONS

ASD	Alternate Source Demonstration
CCR	Coal Combustion Residuals
GMF	Gypsum Management Facility
SAP	Sampling and Analysis Plan
SSI	Statistically Significant Increase

EXECUTIVE SUMMARY

This report has been prepared to provide the information required by Title 40 of the Code of Federal Regulations (40 C.F.R.) § 257.90(e) for the Coffeen Gypsum Management Facility (GMF) Gypsum Stack Pond located at Coffeen Power Station near Coffeen, Illinois.

Groundwater is being monitored at Coffeen GMF Gypsum Stack Pond in accordance with the Detection Monitoring Program requirements specified in 40 C.F.R. § 257.94.

No changes were made to the monitoring system in 2019 (no wells were installed or decommissioned).

The following Statistically Significant Increases (SSIs) of 40 C.F.R. Part 257 Appendix III parameter concentrations greater than background concentrations were determined during one or more sampling events in 2019:

- Calcium at well G209

Alternate Source Demonstrations (ASDs) were completed for the SSIs referenced above and Coffeen GMF Gypsum Stack Pond remains in the Detection Monitoring Program.

1. INTRODUCTION

This report has been prepared by Ramboll on behalf of Illinois Power Generating Company, to provide the information required by 40 C.F.R. § 257.90(e) for the Coffeen GMF Gypsum Stack Pond located at Coffeen Power Station near Coffeen, Illinois.

In accordance with 40 C.F.R. § 257.90(e), the owner or operator of a 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 relative to background levels).
5. Other information required to be included in the Annual Report as specified in §§ 257.90 through 257.98.

This report provides the required information for the Coffeen GMF Gypsum Stack Pond for calendar year 2019.

2. MONITORING AND CORRECTIVE ACTION PROGRAM STATUS

No changes have occurred to the monitoring program status in calendar year 2019, and Coffeen GMF Gypsum Stack Pond remains in the Detection Monitoring Program in accordance with 40 C.F.R. § 257.94.

3. KEY ACTIONS COMPLETED IN 2019

The Detection Monitoring Program is summarized in Table A. The groundwater monitoring system, including the CCR unit and all background and downgradient monitoring wells, is presented in Figure 1. No changes were made to the monitoring system in 2019 (no wells were installed or decommissioned). In general, one groundwater sample was collected from each background and downgradient well during each monitoring event.[1] All samples were collected and analyzed in accordance with the Sampling and Analysis Plan (SAP) (NRT/OBG, 2017a). All monitoring data obtained under 40 C.F.R. §§ 257.90 through 257.98 (as applicable) in 2019 are presented in Table 1. Analytical data were evaluated in accordance with the Statistical Analysis Plan (NRT/OBG, 2017b) to determine any SSIs of Appendix III parameters relative to background concentrations.

Statistical background values are provided in Table 2.

Analytical results for the November 2018 sampling event were provided in the 2018 Annual Groundwater Monitoring and Corrective Action Report.

Potential alternate sources were evaluated as outlined in the 40 C.F.R. § 257.94(e)(2). ASDs were completed and certified by a qualified professional engineer. The dates the ASDs were completed are provided in Table A. The ASDs completed in 2019 are included in Appendix A.

[1] Sampling was limited to G209 during the May 2019 sampling event to confirm Appendix III parameters initially detected at concentrations greater than statistical background values in the preceding sampling event to confirm SSIs, as allowed by the Statistical Analysis Plan.

Table A – 2018–2019 Detection Monitoring Program Summary

Sampling Date	Analytical Data Receipt Date	Parameters Collected	SSI(s)	SSI(s) Determination Date	ASD Completion Date
November 2, 2018	January 16, 2019	Appendix III	Calcium (G209)	April 15, 2019	July 15, 2019
January 16-17, 2019	April 15, 2019	Appendix III	Calcium (G209)	July 15, 2019	October 14, 2019
May 3, 2019	May 28, 2019	Appendix III Greater than Background [1]	NA	NA	NA
August 12-14, 2019	October 15, 2019	Appendix III	TBD	TBD	TBD

Notes:

NA: Not Applicable
TBD: To Be Determined
1. To confirm SSIs, as allowed by the Statistical Analysis Plan, groundwater samples were collected and analyzed for Appendix III parameters initially detected at concentrations greater than statistical background values in the preceding sampling event.

4. PROBLEMS ENCOUNTERED AND ACTIONS TO RESOLVE THE PROBLEMS

No problems were encountered with the Groundwater Monitoring Program during 2019. Groundwater samples were collected and analyzed in accordance with the SAP (NRT/OBG, 2017a), and all data were accepted.

5. KEY ACTIVITIES PLANNED FOR 2020

The following key activities are planned for 2020:

- Continuation of the Detection Monitoring Program with semi-annual sampling scheduled for the first and third quarters of 2020.
- Complete evaluation of analytical data from the downgradient wells, using background data to determine whether an SSI of Appendix III parameters detected at concentrations greater than 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 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 2020 Annual Groundwater Monitoring and Corrective Action Report.
  - If an alternate source(s) is not identified to be the cause of the SSI, the applicable requirements of 40 C.F.R. §§ 257.94 through 257.98 as may apply in 2020 (e.g., Assessment Monitoring) will be met, including associated recordkeeping/notifications required by 40 C.F.R. §§ 257.105 through 257.108.

6. REFERENCES

Natural Resource Technology, an OBG Company (NRT/OBG), 2017a. Sampling and Analysis Plan, Coffeen GMF Gypsum Stack Pond, Coffeen Power Station, Coffeen, Illinois, Project No. 2285, Revision 0, October 17, 2017.

Natural Resource Technology, an OBG Company, (NRT/OBG) 2017b. Statistical Analysis Plan, Coffeen Power Station, Newton Power Station, Illinois Power Generating Company, October 17, 2017.

TABLES

TABLE 1.
2019 ANALYTICAL RESULTS - GROUNDWATER ELEVATION AND APPENDIX III PARAMETERS
2019 ANNUAL GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT
COFFEEN POWER STATION
UNIT ID 103 - COFFEEN GMF GYPSUM STACK POND
COFFEEN, ILLINOIS
DETECTION MONITORING PROGRAM

Well Identification Number	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)	Date & Time Sampled	Depth to Groundwater (ft)[1]	Groundwater Elevation (ft NAVD88)	40 C.F.R. Part 257 Appendix III						
						Boron, total (mg/L) 6020A[2]	Calcium, total (mg/L) 6020A[2]	Chloride, total (mg/L) 9251[2]	Fluoride, total (mg/L) 9214[2]	pH (field) (S.U.) SM 4500 H+B[2]	Sulfate, total (mg/L) 9036[2]	Total Dissolved Solids (mg/L) SM 2540C[2]
Background / Upgradient Monitoring Wells												
G200	39.075139	-89.395014	1/16/2019 10:01	3.96	621.98	0.048	350	54	0.386	7.1	110	700
			5/3/2019 NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
			8/12/2019 13:07	3.90	622.04	<0.010	92	58	0.405	7.0	110	540
R201	39.075139	-89.397847	1/16/2019 11:04	4.17	622.17	<0.010	100	48	0.341	7.1	150	790
			5/3/2019 NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
			8/12/2019 14:02	3.99	622.35	<0.010	120	71	0.466	7.1	220	760
Downgradient Monitoring Wells												
G206	39.067399	-89.398548	1/17/2019 7:41	14.00	618.82	<0.010	81	27	0.458	7.1	110	480
			5/3/2019 NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
			8/14/2019 13:36	11.26	621.56	0.013	120	22	0.506	7.1	120	470
G209	39.067931	-89.396861	1/17/2019 9:48	11.11	621.80	0.011	150	68	0.426	7.1	250	860
			5/3/2019 12:16	9.82	623.09	NA	150	NA	NA	7.7	NA	NA
			8/14/2019 12:46	11.45	621.46	0.011	160	61	0.586	7.2	240	830
G212	39.068431	-89.395333	1/16/2019 13:08	11.76	621.13	<0.010	56	43	0.394	7.3	53	440
			5/3/2019 NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
			8/14/2019 9:29	12.63	620.26	<0.010	53	43	0.437	7.3	51	380
G215	39.069306	-89.393958	1/16/2019 15:18	15.03	618.03	0.097	120	61	0.379	6.9	180	800
			5/3/2019 NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
			8/14/2019 10:18	15.51	617.55	0.085	100	49	0.458	7.0	120	520
G218	39.070875	-89.393972	1/17/2019 11:29	15.90	617.21	<0.010	120	82	0.361	7.0	140	600
			5/3/2019 NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
			8/14/2019 11:12	15.25	617.86	<0.010	130	81	0.449	7.0	150	660

[O: RAB 12/9/19, C: KLT 12/10/19]

Notes:
40 C.F.R. = Title 40 of the Code of Federal Regulations
ft = foot/feet
mg/L = milligrams per liter
NA = Not Analyzed
NAVD88 = North American Vertical Datum of 1988
NS = Not Sampled
S.U. = Standard Units
< = concentration is less than the concentration shown, which corresponds to the reporting limit for the method; estimated concentrations below the reporting limit and associated qualifiers are not provided since not utilized in statistics to determine Statistically Significant Increases (SSIs) over background.
[1]All depths to groundwater were measured on the first day of the sampling event.
[2]4-digit numbers represent SW-846 analytical methods.

TABLE 2.
STATISTICAL BACKGROUND VALUES
2019 ANNUAL GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT
COFFEEN POWER STATION
UNIT ID 103 - COFFEEN GMF GYPSUM STACK POND
COFFEEN, ILLINOIS
DETECTION MONITORING PROGRAM

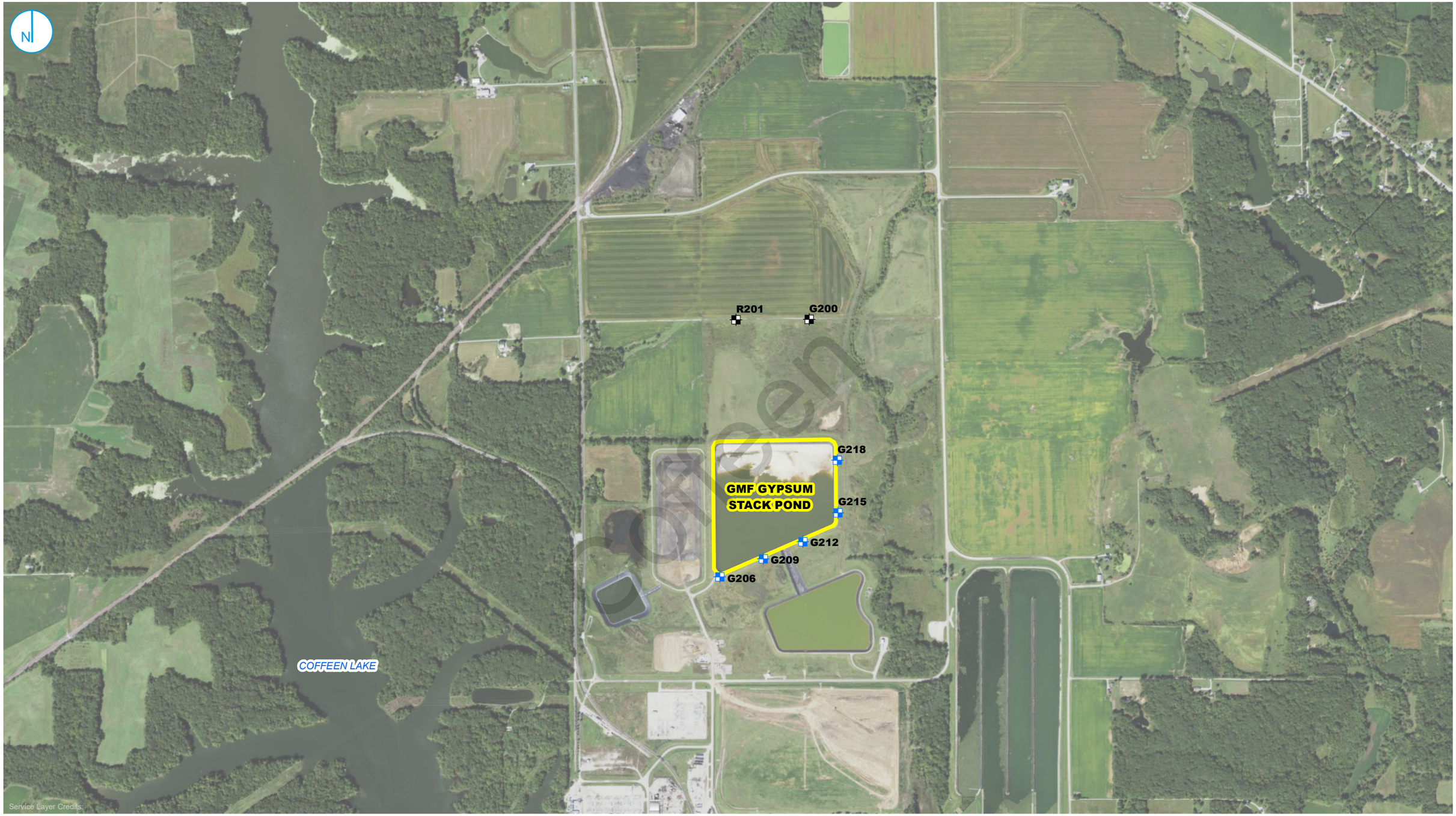
Parameter	Statistical Background Value (UPL)
40 C.F.R. Part 257 Appendix III	
Boron (mg/L)	0.39
Calcium (mg/L)	2
Chloride (mg/L)	96
Fluoride (mg/L)	0.493
pH (S.U.)	6.9 / 7.3
Sulfate (mg/L)	300
Total Dissolved Solids (mg/L)	928

[O: KLT 12/11/19, C: RAB 12/11/19]

Notes:
40 C.F.R. = Title 40 of the Code of Federal Regulations
mg/L = milligrams per liter
S.U. = Standard Units
UPL = Upper Prediction Limit

FIGURES

Y:\Mapping\Projects\22\2285\MXD\2019_AnnualGWM_CAR\Figure 1_GWS_WellLoc_CoffeenGMFGSP.mxd



PROJECT: 169000XXXX | DATED: 1/28/2020 | DESIGNER: BARTELAB

- DOWNGRADIENT MONITORING WELL LOCATION
- BACKGROUND MONITORING WELL LOCATION
- CCR MONITORED UNIT

0 500 1,000 Feet

MONITORING WELL LOCATION MAP
COFFEEN GMF GYPSUM STACK POND
UNIT ID:103

2019 ANNUAL GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT
VISTRA CCR RULE GROUNDWATER MONITORING
COFFEEN POWER STATION
COFFEEN, ILLINOIS

FIGURE 1

O'BRIEN & GERE ENGINEERS, INC.
A RAMBOLL COMPANY

RAMBOLL

APPENDIX A
ALTERNATE SOURCE DEMONSTRATIONS

40 C.F.R. § 257.94(e)(2): ALTERNATE SOURCE DEMONSTRATION
COFFEEN GMF GYPSUM STACK POND
JULY 15, 2019

July 15, 2019

Title 40 of the Code of Federal Regulations (C.F.R.) § 257.94(e)(2) allows the owner or operator of a coal combustion residuals (CCR) unit 90 days from the date of determination of statistically significant increases (SSIs) over background for groundwater constituents listed in Appendix III of 40 C.F.R. Part 257 to complete a written demonstration that a source other than the CCR unit being monitored caused the SSI(s), or that the SSI(s) resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality (alternate source demonstration [ASD]).

This ASD report has been prepared on behalf of Illinois Power Generating Company by O'Brien & Gere Engineers, Inc., part of Ramboll (OBG) to provide pertinent information pursuant to 40 C.F.R. § 257.94(e)(2) for the Coffeen Power Station Gypsum Management Facility (GMF) Gypsum Stack Pond located near Coffeen, Illinois.

The third semi-annual detection monitoring samples (Detection Monitoring Round 3 [D3]) were collected on November 2, 2018 and analytical data were received on January 16, 2019. In accordance with 40 C.F.R. § 257.93(h)(2), statistical analysis of the data to identify SSIs of 40 C.F.R. Part 257 Appendix III parameters over background concentrations was completed by April 15, 2019, within 90 days of receipt of the analytical data. The statistical determination identified the following SSIs at downgradient monitoring wells:

- pH less than the background lower prediction limit at well G215
- Calcium at well G209

Because Detection Monitoring Round 4 (D4) samples were collected on January 16 and 17, 2019, prior to SSIs referenced above being determined for D3, results from D4 were used to confirm the D3 SSIs in accordance with the Statistical Analysis Plan[1]. Following evaluation of analytical data from D4, the following SSIs were confirmed for D3:

- Calcium at well G209

Pursuant to 40 C.F.R. § 257.94(e)(2), the following demonstrates that sources other than the GMF Gypsum Stack Pond were the cause of the SSIs listed above. This ASD was completed by July 15, 2019. within 90 days of determination of the SSIs as required by 40 C.F.R. § 257.94(e)(2).

ALTERNATE SOURCE DEMONSTRATION: LINES OF EVIDENCE

Lines of evidence supporting this ASD include the following:

1. GMF Gypsum Stack Pond Composite Liner Design.
2. The ionic composition of GMF Gypsum Stack Pond water is different from the ionic composition of groundwater.
3. Calcium was present in groundwater in the vicinity of the GMF Gypsum Stack Pond prior to the unit being placed into service at concentrations that exceeded current CCR compliance background concentrations.

[1] Natural Resource Technology, an OBG Company, *Statistical Analysis Plan, Coffeen Power Station, Newton Power Station*, Illinois Power Generating Company, October 17, 2017.

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

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

The groundwater elevation contours shown on Figure 1 were measured on October 23, 2018, the first day of a combined sampling event at Coffeen Power Station for the five CCR units located there and for multiple monitoring programs required by both federal and state regulatory agencies. As noted above, groundwater sampling for D3 occurred on November 2, 2018.

LINE OF EVIDENCE #1: GMF GYPSUM STACK POND COMPOSITE LINER DESIGN

The GMF Gypsum Stack Pond is a 77-acre facility that receives blowdown from the air emission scrubbers at Coffeen Power Station and has been in operation since 2010. Construction of the GMF Gypsum Stack Pond was in accordance with Water Pollution Control Permit 2008-EA-4661 granted by the Illinois Environmental Protection Agency. The constructed GMF Gypsum Stack Pond components include the following features from top to bottom:

- 60-mil high-density polyethylene (HDPE) geomembrane liner
- 3 feet of recompacted, low-permeability soil with a maximum hydraulic conductivity of 1×10^{-7} centimeters per second (cm/s)

The Coffeen GMF Gypsum Stack Pond exceeds the design criteria for a composite liner for new CCR landfills established by 40 C.F.R. § 257.70.

LINE OF EVIDENCE #2: THE IONIC COMPOSITION OF GMF GYPSUM STACK POND WATER IS DIFFERENT FROM THE IONIC COMPOSITION OF GROUNDWATER.

Piper diagrams graphically represent ionic composition of aqueous solutions. A Piper diagram displays the position of water samples relative to their major cation and anion content, providing the information needed to identify compositional categories or groupings. Figure 2 is a Piper diagram that displays the ionic composition of groundwater samples from the background and downgradient monitoring wells associated with the GMF Gypsum Stack Pond and surface water samples collected from the GMF Gypsum Stack Pond in Quarter 3 2016 and Quarter 3 2017. The ionic compositional groupings identified are shown in the black and green ellipses on the diamond portion of the Piper diagram. These are summarized in Table 1 and discussed in more detail below.

The results can be categorized into two distinct groups. Groundwater samples from the GMF Gypsum Stack Pond background and downgradient wells (enclosed within a black ellipse) have a high percentage of carbonate-bicarbonate anions and no dominant cation. Samples of surface water in the GMF Gypsum Stack Pond (enclosed within a green ellipse) are compositionally distinct from the background and downgradient groundwater, and have a high percentage of magnesium cations and a very high percentage of sulfate anions. Based on the distinct ionic compositions, there is no evidence of mixing between the groundwater and GMF Gypsum Stack Pond surface water. The apparent lack of mixing demonstrates that there is no impact to groundwater from the GMF Gypsum Stack Pond.

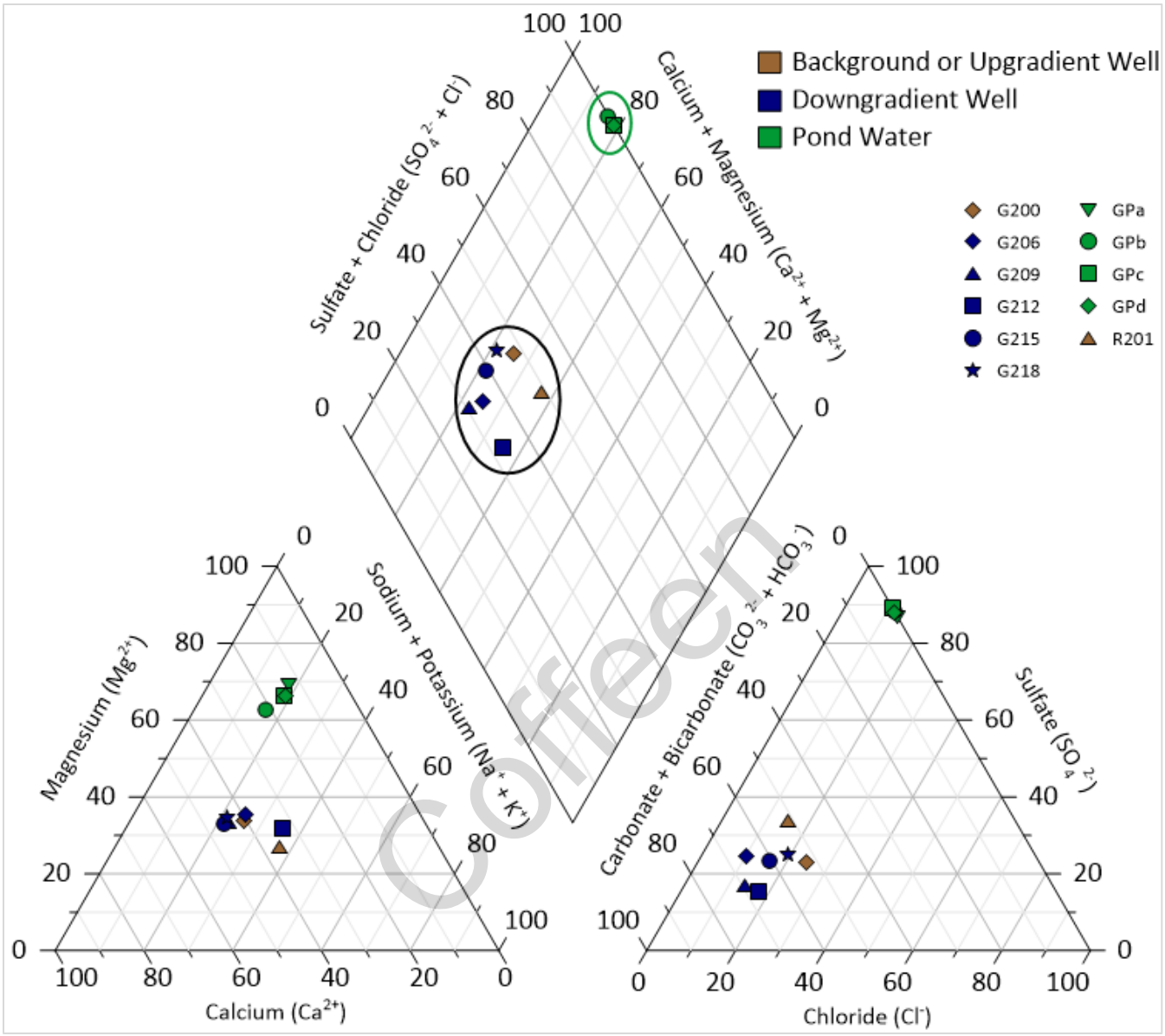


Figure 2. Piper Diagram Showing Ionic Composition of Samples of Background and Downgradient Groundwater Associated with the GMF Gypsum Stack Pond and Samples of Surface Water from the GMF Gypsum Stack Pond.

Grouping	Black	Green
Location	GMF Gypsum Stack Pond Wells Groundwater	GMF Gypsum Stack Pond Pond Water
Dominant Cation	**High Carbonate-Bicarbonate**	**High Magnesium**
Dominant Anion	No dominant anion	**Very High Sulfate**

Table 1. Summary of Ionic Classification

LINE OF EVIDENCE #3: CALCIUM WAS PRESENT IN GROUNDWATER IN THE VICINITY OF THE GMF GYPSUM STACK POND PRIOR TO THE UNIT BEING PLACED INTO SERVICE AT CONCENTRATIONS THAT EXCEEDED CURRENT CCR COMPLIANCE BACKGROUND CONCENTRATIONS

Calcium was detected in groundwater samples collected from monitoring well G205 prior to the GMF Gypsum Stack Pond being placed into service in 2010. A box plot for G205 calcium concentrations in eight samples collected from 2008-2009, is shown in Figure 3. Calcium concentrations at G205 ranged from 83 milligrams per liter (mg/L) to 160 mg/L and were most often between 87.8 mg/ L (first quartile) and 142.5 mg/L (third quartile). The calcium UPL for the GMF Gypsum Stack Pond is 143 mg/L. G205 was replaced by R205, shown on Figure 1, in 2017.

A calcium SSI at well G209 was determined at 160 mg/L during D3 and confirmed via resampling at 150 mg/L. The initial and resample concentrations are both within the range of concentrations observed at G205 from 2008-2009 before CCR was managed in the GMF Gypsum Stack Pond, indicating that the GMF Gypsum Stack Pond is not the source of calcium concentrations in this range downgradient.

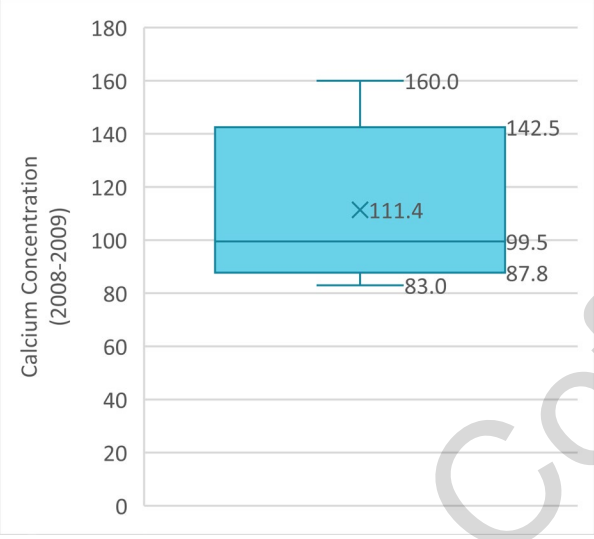


Figure 3. Box Plot of Calcium Concentrations in Downgradient Monitoring Well G205 before the GMF Gypsum Stack Pond was Placed into Service.

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

Boron and sulfate are common indicators of CCR impacts to groundwater due to their leachability from CCR and mobility in groundwater; however, downgradient concentrations of both are near or below concentrations in background wells as described below.

Boron

Boron concentrations are near or below analytical method reporting limits with the exception of background monitoring well R201 and downgradient monitoring well G215. As listed in the statistical summary provided in Attachment A (rightmost column), boron was not detected in 42 to 83 percent (%) of the samples at each downgradient well, with the exception of G215, at which boron was detected in all samples. Twenty-six (26) of 60 downgradient water samples had a detected boron concentration, 12 of which were collected from G215. Boron concentrations at G215 were below the Upper Prediction Limit (UPL) of 0.39 mg/L. Boron was also not detected in 42 to 67% of the samples at each background well. The background wells have lower percentages of non-detects than the downgradient wells, except for downgradient well G215.

Sulfate

Maximum sulfate concentrations measured in groundwater at each downgradient well between 2015 and 2019 ranged from 59 mg/L to 280 mg/L, which is lower than the UPL of 300 mg/L. A time series for sulfate is provided in Figure 4 and box plots are shown in Figure 5.

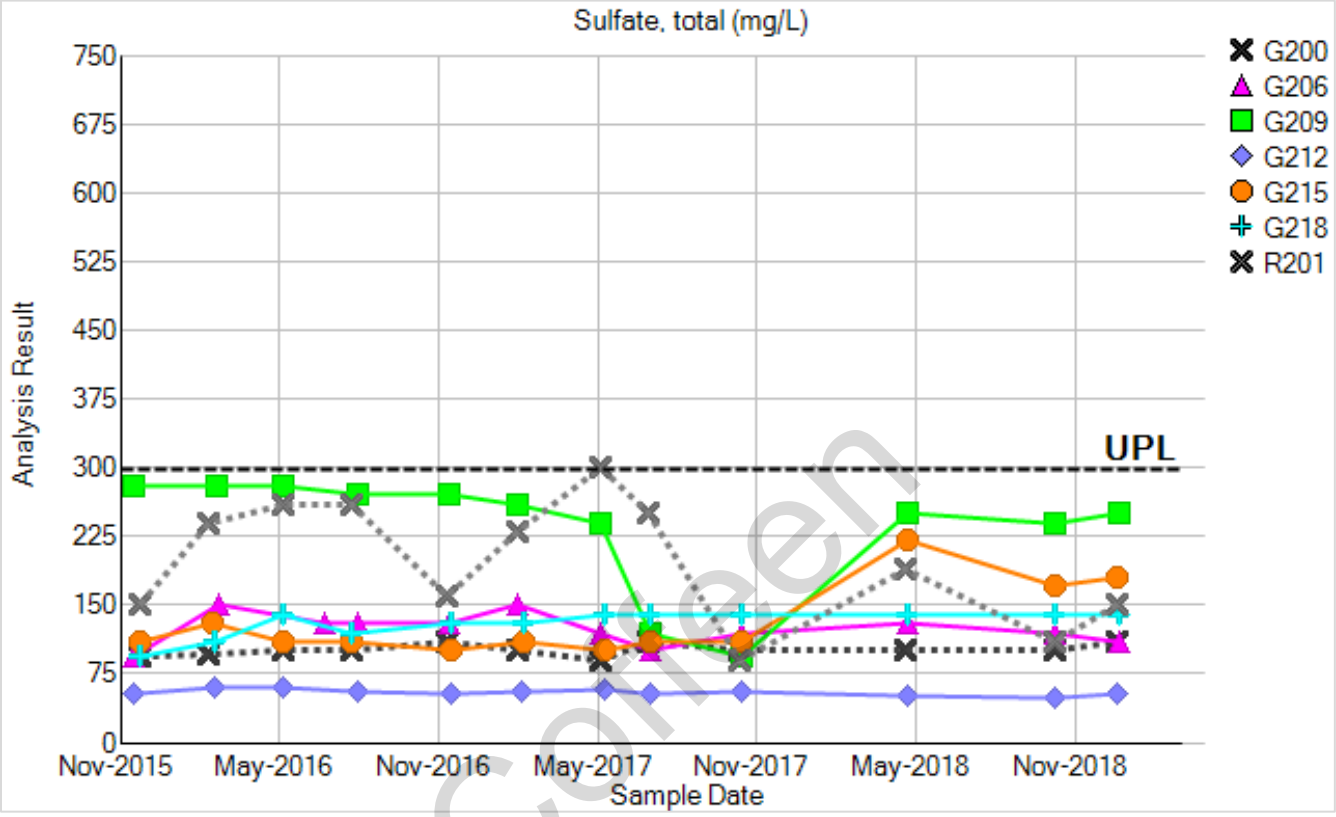


Figure 4. Sulfate Time Series.

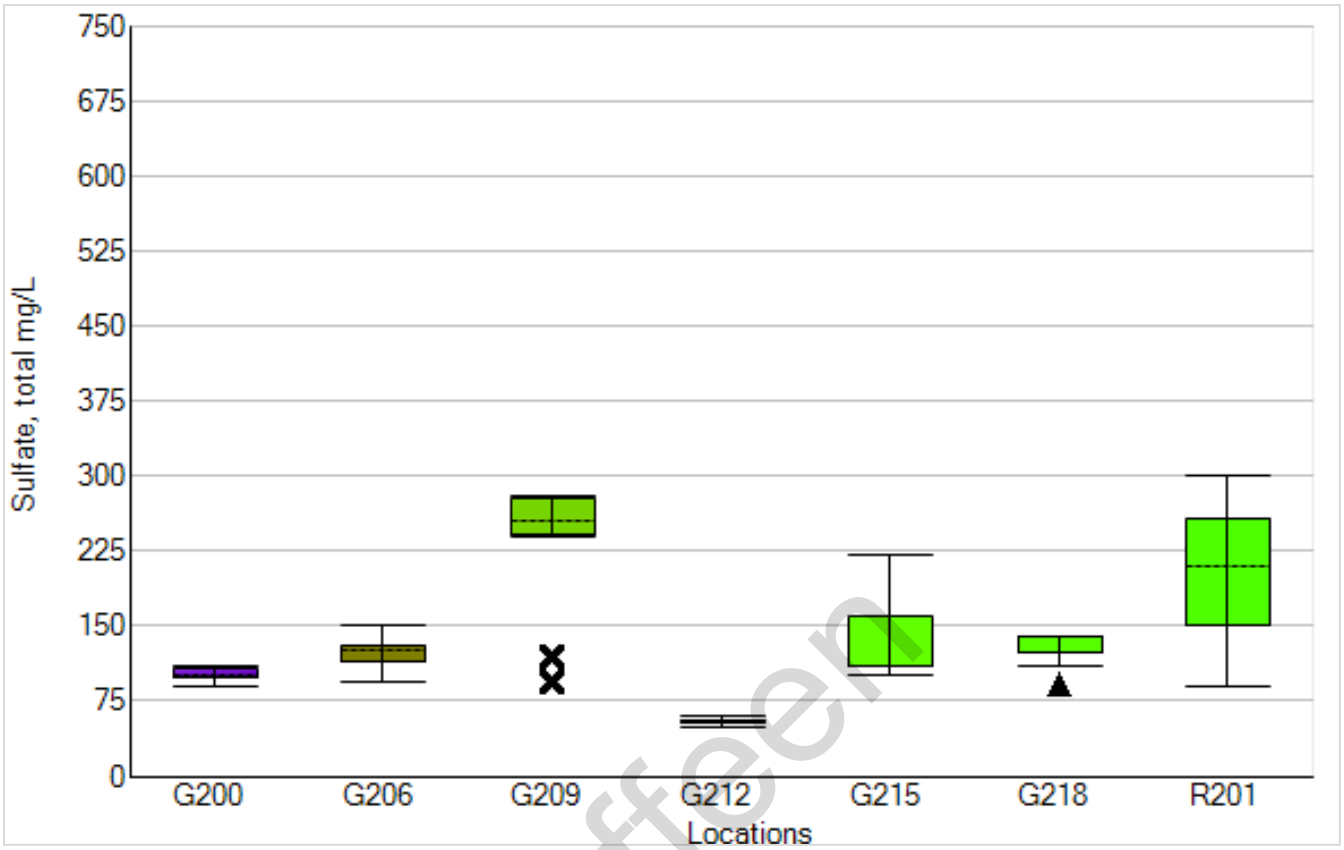


Figure 5. Sulfate Box Plots.

The time series and box plots demonstrate the following observations about the wells:

- All sulfate concentrations in downgradient wells are below the UPL of 300 mg/L, determined from background monitoring wells G200 and R201.
- There is little variability in the results at each well, with the exceptions of G209, G215, and R201, as shown 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 variability is for that location.

Mann-Kendall trend analysis tests were performed (Attachment A1) 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 A2) 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.

If a trend was identified, the CV was calculated to indicate whether data used to establish the trend are suggestive of a low or high magnitude trend. Data with a CV less than or equal to 1 suggest a low magnitude trend.

Sulfate concentrations are stable in background wells, and are stable or exhibit low magnitude trends in downgradient wells. Table 3 provides summary statistics, including variability and trend per well.

Monitoring Well	Sulfate (mg/L)					
	Minimum	Maximum	Median	Standard Deviation	Trend	CV
G200	90	110	100	6.3	stable	0.06
R201	89	300	210	67	stable	0.34
G206	95	150	125	17	stable	0.14
G209	95	280	255	62	downward	0.26
G212	49	59	54.5	2.8	downward	0.05
G215	100	220	110	39	stable	0.30
G218	94	140	140	15	upward	0.12

Table 3. Minimum, Maximum, Median, Standard Deviation, Trend, and Coefficient of Variation of Sulfate in Groundwater.

Based on these four lines of evidence, it has been demonstrated that the Coffeen GMF Gypsum Stack Pond is not the source of the Calcium SSI in G209.

This information serves as the written ASD prepared in accordance with 40 C.F.R. § 257.94(e)(2) that SSIs observed during D3 were not due to the GMF Gypsum Stack Pond, but were from naturally occurring conditions. Therefore, an assessment monitoring program is not required, and the GMF Gypsum Stack Pond will remain in detection monitoring.

Attachments

Figure 1	Coffeen GMF Gypsum Stack Pond (Unit: 103) Groundwater Elevation Contour Map October 23, 2018
Attachment A	Boron Statistical Summary for GMF Gypsum Stack Pond Monitoring Wells
Attachment B	Mann-Kendall Trend Analyses
Attachment C	Coefficient of Variation Evaluation

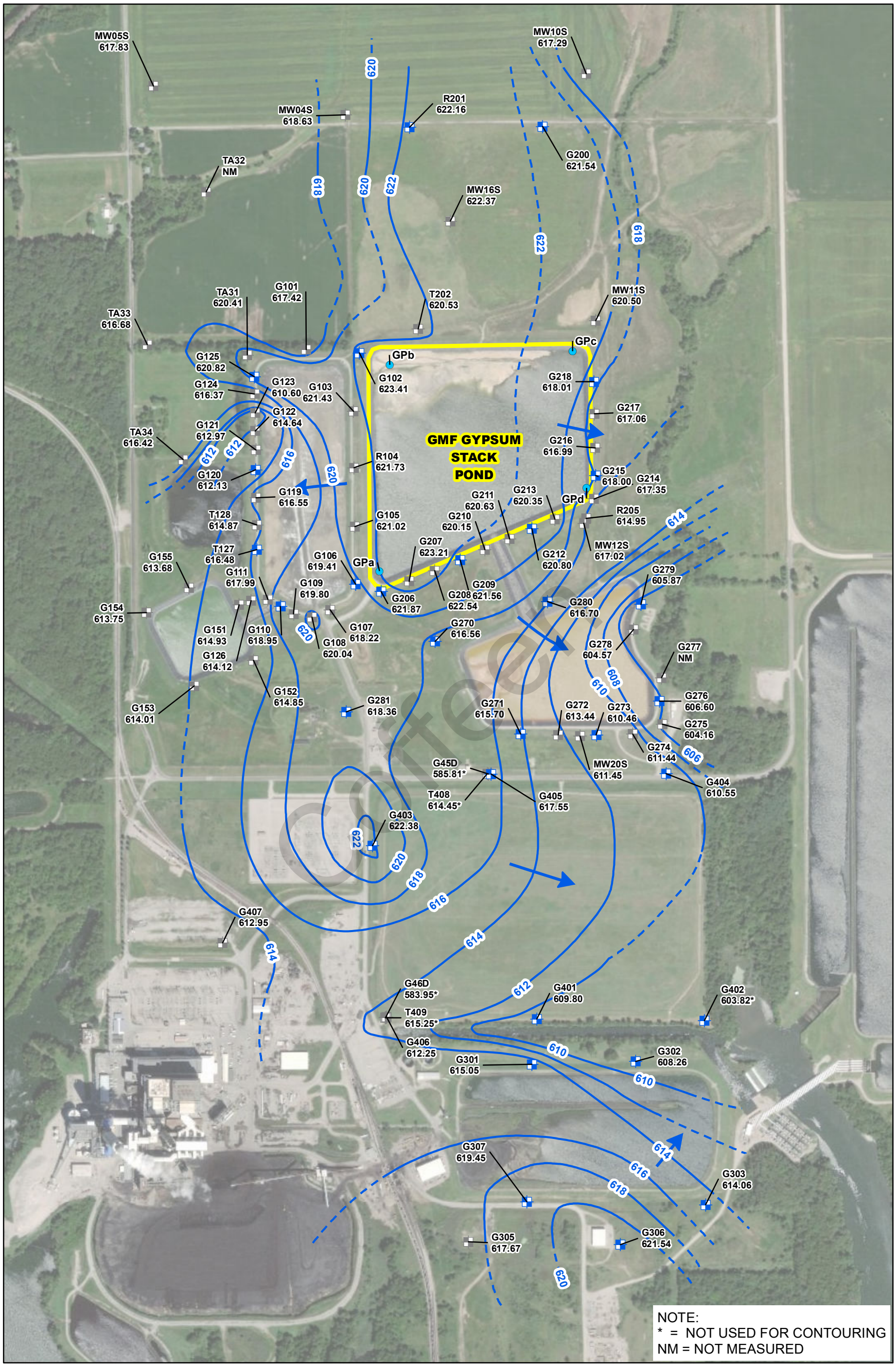
I, Eric J. Tlachac, a qualified professional engineer in good standing in the State of Illinois, certify that the information in this report is accurate as of the date of my signature below. The content of this report is not to be used for other than its intended purpose and meaning, or for extrapolations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

Eric J. Tlachac
Qualified Professional Engineer
062-063091
Illinois
O'Brien & Gere Engineers, Inc., a Ramboll Company
Date: July 15, 2019

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., a Ramboll Company
Date: July 15, 2019

Figure



NOTE:
* = NOT USED FOR CONTOURING
NM = NOT MEASURED

- CCR RULE MONITORING WELL LOCATION
- NON-CCR RULE MONITORING WELL LOCATION
- POND WATER SAMPLE LOCATION
- GROUNDWATER ELEVATION CONTOUR (2-FT CONTOUR INTERVAL, NAVD88)
- INFERRED GROUNDWATER ELEVATION CONTOUR
- GROUNDWATER FLOW DIRECTION
- CCR MONITORED UNIT

ALTERNATE SOURCE DEMONSTRATION
COFFEEN POWER STATION
COFFEEN, ILLINOIS

0 150 300 600
Feet

MONITORING WELL AND POND WATER LOCATION MAP
COFFEEN GMF GYPSUM STACK POND

N

O'BRIEN & GERE ENGINEERS, INC.

Y:\Mapping\Projects\22\2285\MXD\Alt_Source_Dem\Coffeen_GMF_GSP\Figure 1_R2018_3Q_Coffeen_GW_Contours.mxd

Attachment A

Boron Statistical Summary for GMF Gypsum Stack Pond Monitoring Wells

Attachment B

Mann-Kendall Trend Analyses

Coffeen
Mann-Kendall Trend Analysis

User Supplied Information

Location ID:	**G200**	**Parameter Code:**	**00945**
Location Class:		**Parameter:**	**SO4, tot**
Location Type:		**Units:**	**mg/L**
Confidence Level:	**95.00%**	**Period Length:**	**1 month(s)**
Date Range: 11/16/2015 to 03/31/2019		**Limit Name:**	
		Averaged:	**No**

Trend Analysis

Trend of the least squares straight line

Slope (fitted to data):	0.006122	mg/L per day
R-Squared error of fit:	0.136179	

Sen's Non-parametric estimate of the slope (One-Sided Test)

Median Slope:	0.004235	mg/L per day
Lower Confidence Limit of Slope, M1:	0.000000	mg/L per day
Upper Confidence Limit of Slope, M2+1:	0.017806	mg/L per day

Non-parametric Mann-Kendall Test for Trend

S Statistic:	1.562
Z test:	1.645
At the 95.0 % Confidence Level (One-Sided Test):	None

Coffeen
Mann-Kendall Trend Analysis

User Supplied Information

Location ID:	**G206**	**Parameter Code:**	**00945**
Location Class:		**Parameter:**	**SO4, tot**
Location Type:		**Units:**	**mg/L**
Confidence Level:	**95.00%**	**Period Length:**	**1 month(s)**
Date Range: 11/16/2015 to 03/31/2019		**Limit Name:**	
		Averaged:	**No**

Trend Analysis

Trend of the least squares straight line

Slope (fitted to data):	-0.008818	mg/L per day
R-Squared error of fit:	0.038010	

Sen's Non-parametric estimate of the slope (One-Sided Test)

Median Slope:	-0.015252	mg/L per day
Lower Confidence Limit of Slope, M1:	-0.036751	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:	-1.062
Z test:	1.645
At the 95.0 % Confidence Level (One-Sided Test):	None

Coffeen
Mann-Kendall Trend Analysis

User Supplied Information

Location ID:	**G209**	**Parameter Code:**	**00945**
Location Class:		**Parameter:**	**SO4, tot**
Location Type:		**Units:**	**mg/L**
Confidence Level:	**95.00%**	**Period Length:**	**1 month(s)**
Date Range: 11/16/2015 to 03/31/2019		**Limit Name:**	
		Averaged:	**No**

Trend Analysis

Trend of the least squares straight line		
Slope (fitted to data):	-0.058779	mg/L per day
R-Squared error of fit:	0.128210	
Sen's Non-parametric estimate of the slope (One-Sided Test)		
Median Slope:	-0.040782	mg/L per day
Lower Confidence Limit of Slope, M1:	-0.102055	mg/L per day
Upper Confidence Limit of Slope, M2+1:	-0.027282	mg/L per day
Non-parametric Mann-Kendall Test for Trend		
S Statistic:	-2.857	
Z test:	1.645	
At the 95.0 % Confidence Level (One-Sided Test):	Downward	

Coffeen
Mann-Kendall Trend Analysis

User Supplied Information

Location ID:	**G212**	**Parameter Code:**	**00945**
Location Class:		**Parameter:**	**SO4, tot**
Location Type:		**Units:**	**mg/L**
Confidence Level:	**95.00%**	**Period Length:**	**1 month(s)**
Date Range: 11/16/2015 to 03/31/2019		**Limit Name:**	
		Averaged:	**No**

Trend Analysis

Trend of the least squares straight line		
Slope (fitted to data):	-0.005245	mg/L per day
R-Squared error of fit:	0.487726	
Sen's Non-parametric estimate of the slope (One-Sided Test)		
Median Slope:	-0.004982	mg/L per day
Lower Confidence Limit of Slope, M1:	-0.009060	mg/L per day
Upper Confidence Limit of Slope, M2+1:	-0.000946	mg/L per day
Non-parametric Mann-Kendall Test for Trend		
S Statistic:	-2.160	
Z test:	1.645	
At the 95.0 % Confidence Level (One-Sided Test):	Downward	

Coffeen
Mann-Kendall Trend Analysis

User Supplied Information

Location ID:	**G215**	**Parameter Code:**	**00945**
Location Class:		**Parameter:**	**SO4, tot**
Location Type:		**Units:**	**mg/L**
Confidence Level:	**95.00%**	**Period Length:**	**1 month(s)**
Date Range: 11/16/2015 to 03/31/2019		**Limit Name:**	
		Averaged:	**No**

Trend Analysis

Trend of the least squares straight line

Slope (fitted to data):	0.070394	mg/L per day
R-Squared error of fit:	0.475847	

Sen's Non-parametric estimate of the slope (One-Sided Test)

Median Slope:	0.034863	mg/L per day
Lower Confidence Limit of Slope, M1:	0.000000	mg/L per day
Upper Confidence Limit of Slope, M2+1:	0.098961	mg/L per day

Non-parametric Mann-Kendall Test for Trend

S Statistic:	1.256
Z test:	1.645
At the 95.0 % Confidence Level (One-Sided Test):	None

Coffeen
Mann-Kendall Trend Analysis

User Supplied Information

Location ID:	**G218**	**Parameter Code:**	**00945**
Location Class:		**Parameter:**	**SO4, tot**
Location Type:		**Units:**	**mg/L**
Confidence Level:	**95.00%**	**Period Length:**	**1 month(s)**
Date Range: 11/16/2015 to 03/31/2019		**Limit Name:**	
		Averaged:	**No**

Trend Analysis

Trend of the least squares straight line

Slope (fitted to data):	0.028644	mg/L per day
R-Squared error of fit:	0.518413	

Sen's Non-parametric estimate of the slope (One-Sided Test)

Median Slope:	0.026232	mg/L per day
Lower Confidence Limit of Slope, M1:	0.000000	mg/L per day
Upper Confidence Limit of Slope, M2+1:	0.048945	mg/L per day

Non-parametric Mann-Kendall Test for Trend

S Statistic:	2.860
Z test:	1.645
At the 95.0 % Confidence Level (One-Sided Test):	Upward

Coffeen
Mann-Kendall Trend Analysis

User Supplied Information

Location ID:	**R201**	**Parameter Code:**	**00945**
Location Class:		**Parameter:**	**SO4, tot**
Location Type:		**Units:**	**mg/L**
Confidence Level:	**95.00%**	**Period Length:**	**1 month(s)**
Date Range: 11/16/2015 to 03/31/2019		**Limit Name:**	
		Averaged:	**No**

Trend Analysis

Trend of the least squares straight line

Slope (fitted to data):	-0.078691	mg/L per day
R-Squared error of fit:	0.198410	

Sen's Non-parametric estimate of the slope (One-Sided Test)

Median Slope:	-0.077109	mg/L per day
Lower Confidence Limit of Slope, M1:	-0.165212	mg/L per day
Upper Confidence Limit of Slope, M2+1:	0.054952	mg/L per day

Non-parametric Mann-Kendall Test for Trend

S Statistic:	-1.033
Z test:	1.645
At the 95.0 % Confidence Level (One-Sided Test):	None

Attachment C

Coefficient of Variation Evaluation

Coffeen

Coefficient of Variation
Date Range: 11/10/2015 to 3/31/2019

Sulfate, total (mg/L)

Location	Count	Mean	Std Dev	% Non-Detects	CV
G200	12	101	6.3	0.0	0.06
R201	12	199	67	0.0	0.34
G206	12	124	17	0.0	0.14
G209	12	236	62	0.0	0.26
G212	12	55	2.8	0.0	0.05
G215	12	130	39	0.0	0.30
G218	12	130	15	0.0	0.12

CV=Std Dev/ Mean

40 C.F.R. § 257.94(e)(2): ALTERNATE SOURCE DEMONSTRATION
COFFEEN GMF GYPSUM STACK POND
OCTOBER 14, 2019

October 14, 2019

Title 40 of the Code of Federal Regulations (C.F.R.) § 257.94(e)(2) allows the owner or operator of a Coal Combustion Residuals (CCR) unit 90 days from the date of determination of Statistically Significant Increases (SSIs) over background for groundwater constituents listed in Appendix III of 40 C.F.R. Part 257 to complete a written demonstration that a source other than the CCR unit being monitored caused the SSI(s), or that the SSI(s) resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality (Alternate Source Demonstration [ASD]).

This ASD has been prepared on behalf of Illinois Power Generating Company by O'Brien & Gere Engineers, Inc., part of Ramboll (OBG) to provide pertinent information pursuant to 40 C.F.R. § 257.94(e)(2) for the Coffeen Gypsum Management Facility (GMF) Gypsum Stack Pond, located near Coffeen, Illinois.

The fourth semi-annual detection monitoring samples (Detection Monitoring Round 4 [D4]) were collected on January 16-17, 2019 and analytical data were received on April 15, 2019. In accordance with 40 C.F.R. § 257.93(h)(2), statistical analysis of the data to identify SSIs of 40 C.F.R. Part 257 Appendix III parameters over background concentrations was completed by July 15, 2019, within 90 days of receipt of the analytical data. The statistical determination identified the following SSIs at downgradient monitoring wells:

- Calcium at well G209

In accordance with the Statistical Analysis Plan[1], to confirm the SSI, well G209 was resampled (D4R) on May 3, 2019 and analyzed only for the SSI parameter. Following evaluation of analytical data from D4R, the following SSI was confirmed:

- Calcium at well G209

Pursuant to 40 C.F.R. § 257.94(e)(2), the following demonstrates that sources other than the Coffeen GMF Gypsum Stack Pond were the cause of the SSI listed above. This ASD was completed by October 14, 2019, within 90 days of determination of the SSIs, as required by 40 C.F.R. § 257.94(e)(2).

ALTERNATE SOURCE DEMONSTRATION: LINES OF EVIDENCE

Lines of evidence supporting this ASD include the following:

1. GMF Gypsum Stack Pond Composite Liner Design.
2. The ionic composition of GMF Gypsum Stack Pond water is different from the ionic composition of groundwater.
3. Calcium was present in groundwater in the vicinity of the GMF Gypsum Stack Pond prior to the unit being placed into service at concentrations that exceeded current CCR compliance background concentrations.
4. Concentrations of boron and sulfate, common indicators for CCR impacts to groundwater, are near or below background concentrations and are stable in the downgradient wells.

These lines of evidence are described and supported in greater detail below. Monitoring well locations, pond water sample locations, and groundwater flow direction are shown on Figure 1.

[1] Natural Resource Technology, an OBG Company, 2017, *Statistical Analysis Plan, Coffeen Power Station, Newton Power Station*, Illinois Power Generating Company October 17, 2017.

The groundwater elevation contours shown on Figure 1 were measured on January 15, 2019, the first day of a combined sampling event at Coffeen Power Station for the five CCR units located there and for multiple monitoring programs required by both federal and state regulatory agencies. As noted above, groundwater sampling for D4 occurred on January 16-17, 2019.

LINE OF EVIDENCE #1: GMF GYPSUM STACK POND COMPOSITE LINER DESIGN

The GMF Gypsum Stack Pond is a 77-acre facility that has been in operation since 2010. Construction of the GMF Gypsum Stack Pond was in accordance with Water Pollution Control Permit 2008-EA-4661 granted by the Illinois Environmental Protection Agency. The GMF Gypsum Stack Pond liner includes the following components:

- 60-mil high-density polyethylene (HDPE) geomembrane liner
- Three-foot-thick layer of recompacted, low-permeability soil having a maximum hydraulic conductivity of 1×10^{-7} centimeters per second (cm/s).

The Illinois Environmental Protection Agency (IEPA)-approved Coffeen GMF Gypsum Stack Pond liner system exceeds the design criteria for a composite liner for new CCR landfills established by 40 C.F.R. § 257.70.

LINE OF EVIDENCE #2: THE IONIC COMPOSITION OF GMF GYPSUM STACK POND WATER IS DIFFERENT FROM THE IONIC COMPOSITION OF GROUNDWATER

Piper diagrams graphically represent ionic composition of aqueous solutions. A Piper diagram displays the position of water samples relative to their major cation and anion content, providing the information needed to identify compositional categories or groupings. Figure 2, below, is a Piper diagram that displays the ionic composition of groundwater samples from the background and downgradient monitoring wells associated with the GMF Gypsum Stack Pond and surface water samples collected from the GMF Gypsum Stack Pond in Quarter 3 2016 and Quarter 3 2017. The ionic compositional groupings identified are shown in the black and green ellipses on the diamond portion of the Piper diagram. These are summarized in Table 1 and discussed in more detail below.

The ionic compositions plotted on the Piper diagrams can be categorized into two distinct groups. Samples of background and downgradient groundwater from the GMF Gypsum Stack Pond wells (enclosed within a black ellipse) have high percentages of carbonate-bicarbonate anions and no dominant cation. Samples of surface water from the GMF Gypsum Stack Pond (enclosed within a green ellipse) are compositionally distinct from the background and downgradient groundwater and have high percentages of magnesium cations and high percentages of sulfate anions. The differences in ionic composition between the groundwater and Pond surface water indicates that the Pond surface water is not the source of CCR constituents detected in GMF Gypsum Stack Pond groundwater.

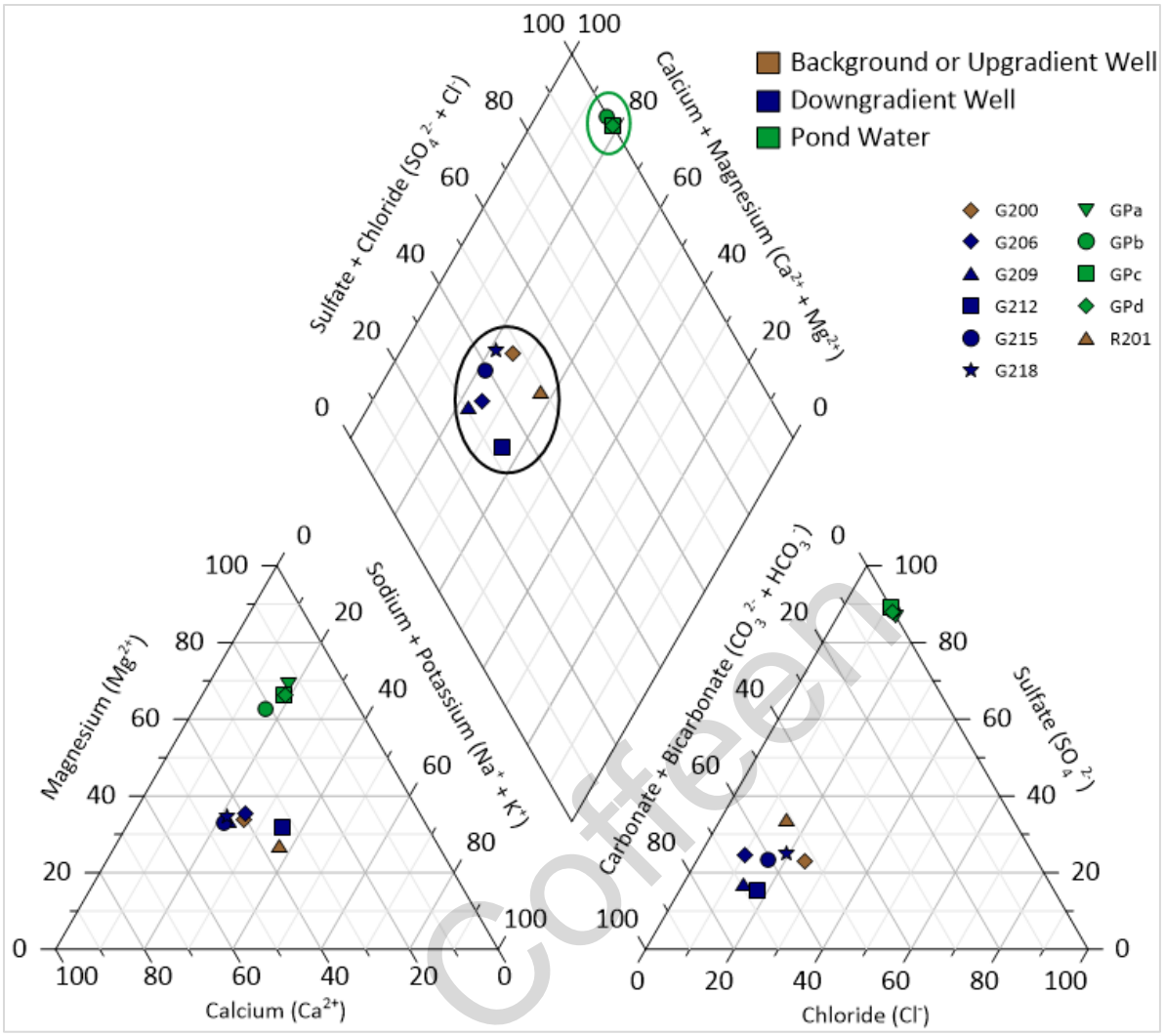


Figure 2. Piper Diagram Showing Ionic Composition of Samples of Background and Downgradient Groundwater Associated with the GMF Gypsum Stack Pond and Samples of Surface Water from the GMF Gypsum Stack Pond.

The ionic characteristics of these samples are provided in Table 1 below:

Grouping	Black	Green
Location	GMF Gypsum Stack Pond Wells Groundwater	GMF Gypsum Stack Pond Pond Water
Dominant Cation	**High Carbonate-Bicarbonate**	**High Magnesium**
Dominant Anion	No dominant anion	**High Sulfate**

Table 1. Summary of Ionic Classification.

LINE OF EVIDENCE #3: CALCIUM WAS PRESENT IN GROUNDWATER IN THE VICINITY OF THE GMF GYPSUM STACK POND PRIOR TO THE UNIT BEING PLACED INTO SERVICE AT CONCENTRATIONS THAT EXCEEDED CURRENT CCR COMPLIANCE BACKGROUND CONCENTRATIONS

Calcium was detected in groundwater samples collected from monitoring well G205 prior to the GMF Gypsum Stack Pond being placed into service in 2010. A box plot for G205 calcium concentrations measured in eight samples collected from 2008-2009 is shown in Figure 3. Calcium concentrations at G205 ranged from 83

milligrams per liter (mg/L) to 160 mg/L and were most often between 87.8 mg/ L (first quartile) and 142.5 mg/L (third quartile). G205 was replaced by R205, shown on Figure 1, in 2017.

During D4 a calcium SSI at well G209 was determined to be 150 mg/L and confirmed via resampling. The initial and resample concentrations are both within the range of concentrations observed at G205 from 2008-2009 before CCR was managed in the GMF Gypsum Stack Pond, indicating that the GMF Gypsum Stack Pond is not the source of calcium concentrations in this range downgradient.

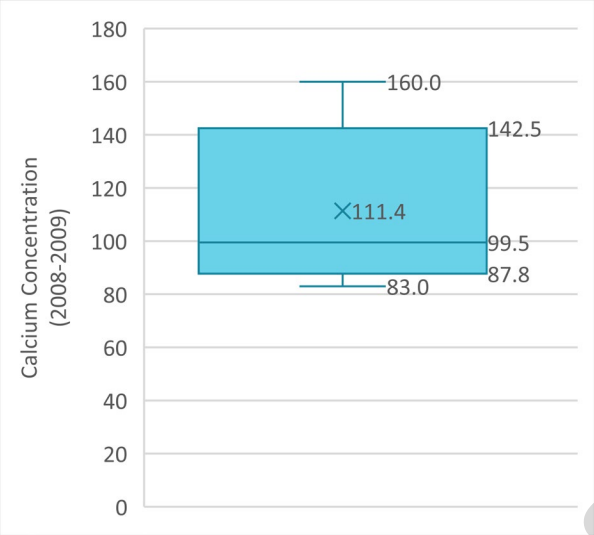


Figure 3. Box Plot of Calcium Concentrations in Monitoring Well G205 before the GMF Gypsum Stack Pond was Placed into Service.

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

Boron and sulfate are common indicators of CCR impacts to groundwater due to their leachability from CCR and mobility in groundwater; however, downgradient concentrations of both are near or below concentrations in background wells as described below.

Boron

Boron concentrations are near or below analytical method reporting limits with the exception of background monitoring well R201 and downgradient monitoring well G215. As listed in the statistical summary provided in Attachment A (rightmost column), boron was not detected in 42 to 83 percent (%) of the samples at each downgradient well, with the exception of G215, at which boron was detected in all samples. Twenty-six (26) of 60 downgradient water samples had a detected boron concentration, 12 of which were collected from G215. Boron concentrations at G215 were below the Upper Prediction Limit (UPL) of 0.39 mg/L. Boron was also not detected in 42 to 67% of the samples at each background well. The background wells have lower percentages of non-detects than the downgradient wells, except for downgradient well G215.

Sulfate

Sulfate concentrations in downgradient wells and background wells are shown on Figure 4. All sulfate concentrations in downgradient wells are below the UPL of 300 mg/L, determined from concentrations in background monitoring wells G200 and R201. Maximum sulfate concentrations measured in groundwater at each downgradient well between 2015 and 2019 ranged from 59 mg/L to 280 mg/L.

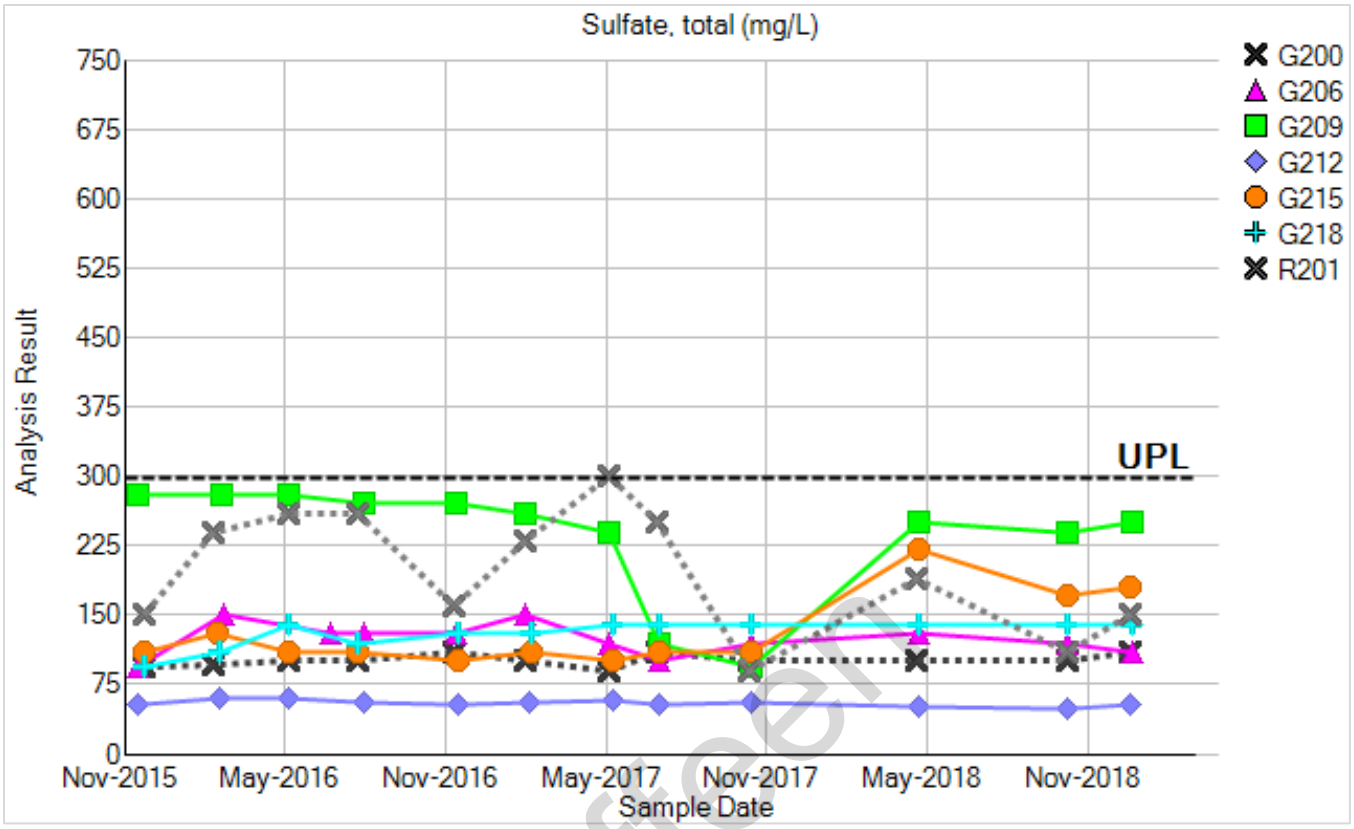


Figure 4. Sulfate Time Series.

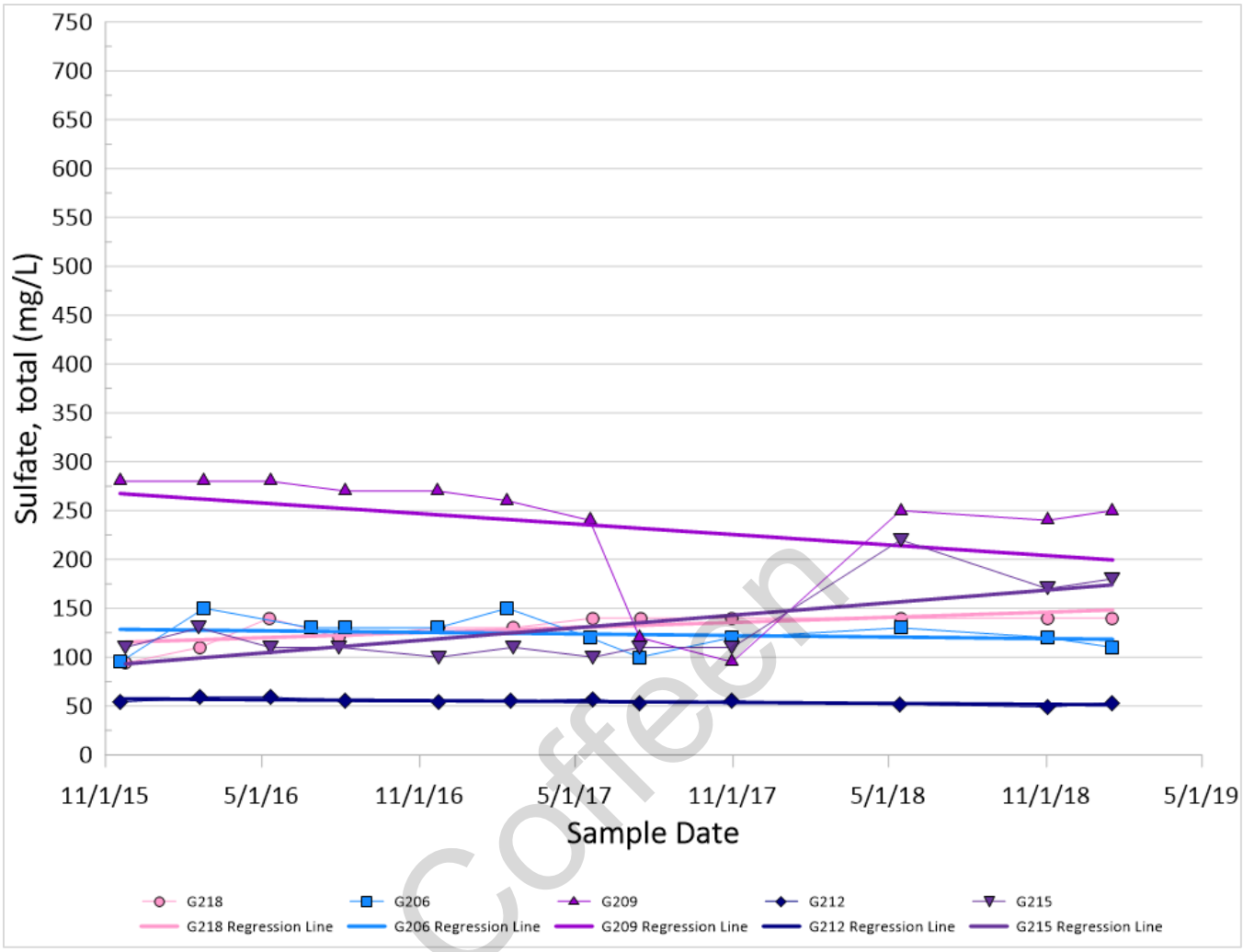


Figure 5. Downgradient Wells Sulfate Trends with Linear Regression Lines.

Sulfate is stable in downgradient wells. Linear regression lines calculated for the data at each monitoring well (straight lines as shown on Figure 5) show that concentrations from 2015 to 2019 have slight upward or downward slopes, meaning that concentrations over time may be increasing or decreasing. Mann-Kendall trend analysis tests were performed (Attachment B) to determine if sulfate concentrations at each well are 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 C) to determine if the concentrations are too variable to identify a trend (i.e., CV greater than or equal to 1). If a trend was identified, the CV was calculated to indicate whether data used to establish the trend are suggestive of a low- or high-magnitude trend. Data with a CV less than or equal to 1 suggest a low-magnitude trend.

Sulfate concentrations were stable in background wells G200 and R201, and downgradient wells G206 and G215. A statistically significant downward trend was identified in downgradient wells G209 and G212. A statistically significant upward trend was identified in downgradient monitoring well G218. Although the sulfate trend at G218 was determined to be significant based on the Mann-Kendall test, the concentrations demonstrated low variability (CV less than or equal to 1), suggesting a low-magnitude trend. Table 2 provides summary statistics, including CV and trend per well.

Concentrations of boron and sulfate near or below background levels, and the relative stability of these concentrations, support the conclusion that the Landfill is not the source of CCR constituents detected in the downgradient groundwater monitoring wells.

Monitoring Well	Sulfate (mg/L)					
	Minimum	Maximum	Median	Standard Deviation	Trend	CV
G200	90	110	100	6.3	stable	0.06
R201	89	300	210	67	stable	0.34
G206	95	150	125	17	stable	0.14
G209	95	280	255	62	downward	0.26
G212	49	59	55	2.8	downward	0.05
G215	100	220	110	39	stable	0.30
G218	94	140	140	15	upward	0.12

Table 2. Minimum, Maximum, Median, Standard Deviation, Trend, and Coefficient of Variation of Sulfate in Groundwater.

Based on these four lines of evidence, it has been demonstrated that the Coffeen GMF Gypsum Stack Pond is not the source of the calcium SSI in G209.

This information serves as the written ASD prepared in accordance with 40 C.F.R. § 257.94(e)(2) that SSIs observed during D4 were not due to the GMF Gypsum Stack Pond. Therefore, an assessment monitoring program is not required and the GMF Gypsum Stack Pond will remain in detection monitoring.

Attachments:

Figure 1	Coffeen GMF Gypsum Stack Pond (Unit: 103) Groundwater Elevation Contour Map January 15, 2019
Attachment A	Boron Statistical Summary for GMF Gypsum Stack Pond Monitoring Wells
Attachment B	Mann-Kendall Trend Analyses
Attachment C	Coefficient of Variation Evaluation

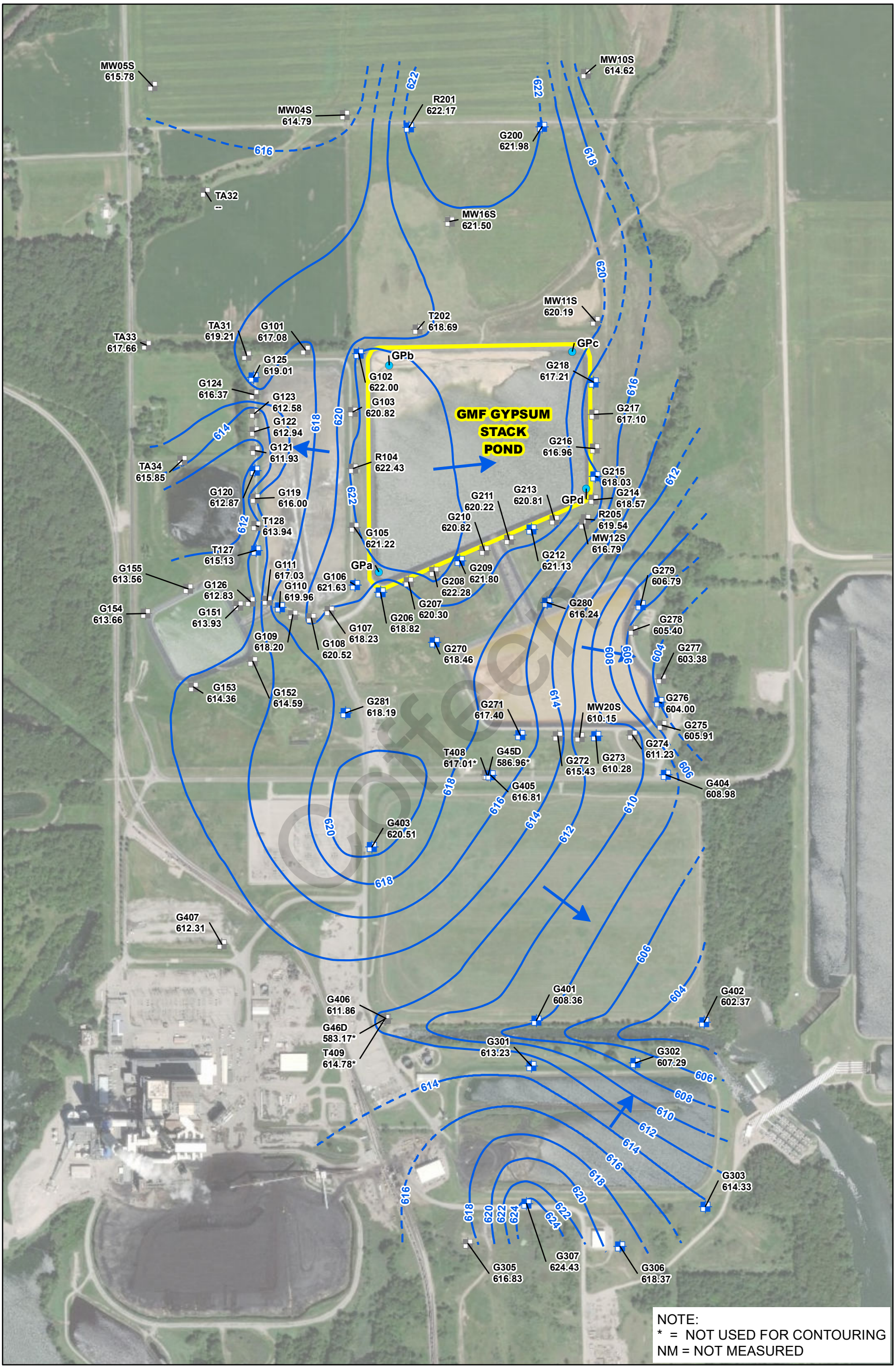
I, Eric J. Tlachac, a qualified professional engineer in good standing in the State of Illinois, certify that the information in this report is accurate as of the date of my signature below. The content of this report is not to be used for other than its intended purpose and meaning, or for extrapolations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

Eric J. Tlachac
Qualified Professional Engineer
062-063091
Illinois
O'Brien & Gere Engineers, Inc., a Ramboll Company
Date: October 14, 2019

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., a Ramboll Company
Date: October 14, 2019

Figure



NOTE:
* = NOT USED FOR CONTOURING
NM = NOT MEASURED

- CCR RULE MONITORING WELL LOCATION
- NON-CCR RULE MONITORING WELL LOCATION
- POND WATER SAMPLE LOCATION
- GROUNDWATER ELEVATION CONTOUR (2-FT CONTOUR INTERVAL, NAVD88)
- INFERRED GROUNDWATER ELEVATION CONTOUR
- GROUNDWATER FLOW DIRECTION
- CCR MONITORED UNIT

ALTERNATE SOURCE DEMONSTRATION
COFFEEN POWER STATION
COFFEEN, ILLINOIS

0 150 300 600
Feet

MONITORING WELL AND POND WATER LOCATION MAP
COFFEEN GMF GYPSUM STACK POND

N

O'BRIEN & GERE ENGINEERS, INC.

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Attachment A

Boron Statistical Summary for GMF Gypsum Stack Pond Monitoring Wells

Coffeen
Statistical Summary for Multiple Parameters (100)

User Supplied Information

Date Range: 11/16/2015 to 06/30/2019 **Option for LT Pts: x 1.00**

Locations: G200,G206,G209,G212,G215,G218,R201

Parameter **Units**

B, tot **mg/L**

Location	Class	Count	Mean	Median	Maximum	Minimum	Std Dev	Sen Slope Units/yr	Normal / Log Normal	% of Non-Detects
R201	Compliance	12	0.011	0.010	0.017	0.010	0.002	0.000	No / No	66.67
G218	Compliance	12	0.010	0.010	0.014	0.010	0.001	0.000	No / No	83.33
G215	Compliance	12	0.039	0.027	0.097	0.015	0.028	0.012	No / No	0.00
G212	Compliance	12	0.011	0.010	0.016	0.010	0.002	0.000	No / No	83.33
G209	Compliance	12	0.012	0.012	0.019	0.010	0.003	0.001	No / No	41.67
G206	Compliance	12	0.022	0.010	0.110	0.010	0.029	0.000	No / No	75.00
G200	Compliance	12	0.073	0.010	0.390	0.010	0.137	0.000	No / No	41.67

Shapiro-Wilk Normality test performed at 0.05 significance level.

Attachment B

Mann-Kendall Trend Analyses

Coffeen
Mann-Kendall Trend Analysis

User Supplied Information

Location ID:	**G200**	**Parameter Code:**	**00945**
Location Class:		**Parameter:**	**SO4, tot**
Location Type:		**Units:**	**mg/L**
Confidence Level:	**95.00%**	**Period Length:**	**1 month(s)**
Date Range: 11/16/2015 to 03/31/2019		**Limit Name:**	
		Averaged:	**No**

Trend Analysis

Trend of the least squares straight line

Slope (fitted to data):	0.006122	mg/L per day
R-Squared error of fit:	0.136179	

Sen's Non-parametric estimate of the slope (One-Sided Test)

Median Slope:	0.004235	mg/L per day
Lower Confidence Limit of Slope, M1:	0.000000	mg/L per day
Upper Confidence Limit of Slope, M2+1:	0.017806	mg/L per day

Non-parametric Mann-Kendall Test for Trend

S Statistic:	1.562
Z test:	1.645
At the 95.0 % Confidence Level (One-Sided Test):	None

Coffeen
Mann-Kendall Trend Analysis

User Supplied Information

Location ID:	**G206**	**Parameter Code:**	**00945**
Location Class:		**Parameter:**	**SO4, tot**
Location Type:		**Units:**	**mg/L**
Confidence Level:	**95.00%**	**Period Length:**	**1 month(s)**
Date Range: 11/16/2015 to 03/31/2019		**Limit Name:**	
		Averaged:	**No**

Trend Analysis

Trend of the least squares straight line

Slope (fitted to data):	-0.008818	mg/L per day
R-Squared error of fit:	0.038010	

Sen's Non-parametric estimate of the slope (One-Sided Test)

Median Slope:	-0.015252	mg/L per day
Lower Confidence Limit of Slope, M1:	-0.036751	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:	-1.062
Z test:	1.645
At the 95.0 % Confidence Level (One-Sided Test):	None

Coffeen
Mann-Kendall Trend Analysis

User Supplied Information

Location ID:	**G209**	**Parameter Code:**	**00945**
Location Class:		**Parameter:**	**SO4, tot**
Location Type:		**Units:**	**mg/L**
Confidence Level:	**95.00%**	**Period Length:**	**1 month(s)**
Date Range: 11/16/2015 to 03/31/2019		**Limit Name:**	
		Averaged:	**No**

Trend Analysis

Trend of the least squares straight line		
Slope (fitted to data):	-0.058779	mg/L per day
R-Squared error of fit:	0.128210	
Sen's Non-parametric estimate of the slope (One-Sided Test)		
Median Slope:	-0.040782	mg/L per day
Lower Confidence Limit of Slope, M1:	-0.102055	mg/L per day
Upper Confidence Limit of Slope, M2+1:	-0.027282	mg/L per day
Non-parametric Mann-Kendall Test for Trend		
S Statistic:	-2.857	
Z test:	1.645	
At the 95.0 % Confidence Level (One-Sided Test):	Downward	

Coffeen
Mann-Kendall Trend Analysis

User Supplied Information

Location ID:	**G212**	**Parameter Code:**	**00945**
Location Class:		**Parameter:**	**SO4, tot**
Location Type:		**Units:**	**mg/L**
Confidence Level:	**95.00%**	**Period Length:**	**1 month(s)**
Date Range: 11/16/2015 to 03/31/2019		**Limit Name:**	
		Averaged:	**No**

Trend Analysis

Trend of the least squares straight line		
Slope (fitted to data):	-0.005245	mg/L per day
R-Squared error of fit:	0.487726	
Sen's Non-parametric estimate of the slope (One-Sided Test)		
Median Slope:	-0.004982	mg/L per day
Lower Confidence Limit of Slope, M1:	-0.009060	mg/L per day
Upper Confidence Limit of Slope, M2+1:	-0.000946	mg/L per day
Non-parametric Mann-Kendall Test for Trend		
S Statistic:	-2.160	
Z test:	1.645	
At the 95.0 % Confidence Level (One-Sided Test):	Downward	

Coffeen
Mann-Kendall Trend Analysis

User Supplied Information

Location ID:	**G215**	**Parameter Code:**	**00945**
Location Class:		**Parameter:**	**SO4, tot**
Location Type:		**Units:**	**mg/L**
Confidence Level:	**95.00%**	**Period Length:**	**1 month(s)**
Date Range: 11/16/2015 to 03/31/2019		**Limit Name:**	
		Averaged:	**No**

Trend Analysis

Trend of the least squares straight line

Slope (fitted to data):	0.070394	mg/L per day
R-Squared error of fit:	0.475847	

Sen's Non-parametric estimate of the slope (One-Sided Test)

Median Slope:	0.034863	mg/L per day
Lower Confidence Limit of Slope, M1:	0.000000	mg/L per day
Upper Confidence Limit of Slope, M2+1:	0.098961	mg/L per day

Non-parametric Mann-Kendall Test for Trend

S Statistic:	1.256
Z test:	1.645
At the 95.0 % Confidence Level (One-Sided Test):	None

Coffeen
Mann-Kendall Trend Analysis

User Supplied Information

Location ID:	**G218**	**Parameter Code:**	**00945**
Location Class:		**Parameter:**	**SO4, tot**
Location Type:		**Units:**	**mg/L**
Confidence Level:	**95.00%**	**Period Length:**	**1 month(s)**
Date Range: 11/16/2015 to 03/31/2019		**Limit Name:**	
		Averaged:	**No**

Trend Analysis

Trend of the least squares straight line

Slope (fitted to data):	0.028644	mg/L per day
R-Squared error of fit:	0.518413	

Sen's Non-parametric estimate of the slope (One-Sided Test)

Median Slope:	0.026232	mg/L per day
Lower Confidence Limit of Slope, M1:	0.000000	mg/L per day
Upper Confidence Limit of Slope, M2+1:	0.048945	mg/L per day

Non-parametric Mann-Kendall Test for Trend

S Statistic:	2.860
Z test:	1.645
At the 95.0 % Confidence Level (One-Sided Test):	Upward

Coffeen
Mann-Kendall Trend Analysis

User Supplied Information

Location ID:	**R201**	**Parameter Code:**	**00945**
Location Class:		**Parameter:**	**SO4, tot**
Location Type:		**Units:**	**mg/L**
Confidence Level:	**95.00%**	**Period Length:**	**1 month(s)**
Date Range: 11/16/2015 to 03/31/2019		**Limit Name:**	
		Averaged:	**No**

Trend Analysis

Trend of the least squares straight line

Slope (fitted to data):	-0.078691	mg/L per day
R-Squared error of fit:	0.198410	

Sen's Non-parametric estimate of the slope (One-Sided Test)

Median Slope:	-0.077109	mg/L per day
Lower Confidence Limit of Slope, M1:	-0.165212	mg/L per day
Upper Confidence Limit of Slope, M2+1:	0.054952	mg/L per day

Non-parametric Mann-Kendall Test for Trend

S Statistic:	-1.033
Z test:	1.645
At the 95.0 % Confidence Level (One-Sided Test):	None

Attachment C

Coefficient of Variation Evaluation

Coffeen

Coefficient of Variation
Date Range: 11/10/2015 to 3/31/2019

Sulfate, total (mg/L)

Location	Count	Mean	Std Dev	% Non-Detects	CV
G200	12	101	6.3	0.0	0.06
R201	12	199	67	0.0	0.34
G206	12	124	17	0.0	0.14
G209	12	236	62	0.0	0.26
G212	12	55	2.8	0.0	0.05
G215	12	130	39	0.0	0.30
G218	12	130	15	0.0	0.12

CV=Std Dev/ Mean