REPORT

Coal Combustion Residual Landfill Annual Groundwater Monitoring Report - 2018 Nucla Station Ash Disposal Facility, Nucla, Colorado

Submitted to:

Tri-State Generation and Transmission Association, Inc.

P.O. Box 33695
Denver, Colorado 80233

Submitted by:

Golder Associates Inc.

44 Union Boulevard, Suite 300 Lakewood, Colorado 80228

+1 303 980-0540

18104295

January 29, 2019

Table of Contents

TABLES

FIGURES

APPENDICES

1.0 INTRODUCTION

Golder Associates Inc. (Golder) has prepared this report to describe the 2018 groundwater monitoring activities and comparative statistical analysis for the coal combustion residuals (CCR) landfill that serves the Nucla Generating Station, which is owned and operated by Tri-State Generation and Transmission Association, Inc. (Tri-State). This report was written to meet the requirements of 40 CFR 257.90(e).

1.1 Facility Information

Tri-State owns and operates the Nucla Generating Station, a 100-megawatt circulating fluidized bed coal-fired electric generating plant located near the town of Nucla, Colorado. Tri-State disposes of CCRs from the Nucla Generating Station in an existing Tri-State-owned CCR landfill, the Nucla Station Ash Disposal Facility (the Facility), which is located approximately 2.5 miles southeast of the Nucla Generating Station. Within the 81.65-acre property, the CCR disposal footprint comprises approximately 61 acres.

1.2 Purpose

The CCR rule established specific requirements for reporting of groundwater monitoring and corrective action in 40 CFR 257.90. Per part (e) of 40 CFR 257.90, no later than January 31, 2018, and annually thereafter, owners or operators of CCR units must prepare an annual groundwater monitoring and corrective action report.

2.0 GROUNDWATER MONITORING NETWORK PROGRAM STATUS

The groundwater monitoring system for the Nucla Station Ash Disposal Facility consists of five monitoring wells (MO-1, MO-2, MO-3, MO-4, and MO-5), as shown on Figure 1 (Golder 2017a).

2.1 Completed Key Actions in 2018

The following key actions were completed in 2018:

- The 2017 Annual Groundwater Monitoring Report was finalized and placed within the operating record and on Tri-State's publicly accessible CCR website.
- The second and third detection monitoring sampling events were performed.
- An alternative source demonstration (ASD) was performed as a result of a verified SSI for field pH in MO-3 (Appendix A), and it was recommended that the Facility remain in detection monitoring.

2.2 Installation and Decommissioning of Monitoring Wells

No monitoring wells were installed or decommissioned for the Nucla Station Ash Disposal Facility in 2018.

2.3 Problems and Resolutions

In July 2018, the pressure transducers used to monitor water levels in well MO-2 and MO-5 were repositioned to a shallower depth. This was in response to gradual increases in water levels within these wells resulting in a water column (and therefore pressure) above the original position of the transducers that exceeded the pressure rating of the transducers, which could result in erroneous readings.

2.4 Proposed Key Activities for 2019

The following key actions are expected to be completed in 2019:

- Detection monitoring sampling events are planned to occur in the second and fourth quarters of 2019.

3.0 GROUNDWATER MONITORING PROGRAM STATUS

Activities associated with the groundwater monitoring program are described below.

3.1 Groundwater Flow

Groundwater elevations were measured in each well prior to purging during each sampling event. Elevations are presented in Table 1 through Table 5. Groundwater elevations from the April 2018 and October 2018 sampling events are shown on Figure 1 and Figure 2, respectively. Groundwater levels in wells MO-2 and MO-5 have been slowly increasing since well installation in 2016. These increases have not resulted in changes to the understanding of the overall hydrological regime below the Facility.

The Morrison aquifer is characterized as highly heterogeneous with zones that are variably transmissive and/or subjected to variable amounts of confining pressure. This characterization is supported by the differences in groundwater levels, water column heights, and recovery times observed in the monitoring wells that have been installed to serve as the groundwater monitoring system for the Facility. Sandstone lenses in the Morrison aquifer vary considerably with respect to transmissivity (i.e., thickness and hydraulic conductivity) and horizontal extent due to the alluvial, shoreline, and lacustrine environments that deposited the Salt Wash and Brushy Basin Members of the Morrison Formation, resulting in interbedded siltstone, mudstone, claystone, and shale units. Groundwater elevation data suggest a general westerly and southerly groundwater flow direction in the Morrison aquifer in the vicinity of the Nucla Station Ash Disposal Facility. However, the heterogeneity and interbedded nature of the Morrison Formation beneath the Facility, coupled with the observation that groundwater levels in the monitoring wells continue to stabilize at the time of this report's preparation, confound the ability to precisely discern groundwater flow direction and rate.

3.2 Monitoring Data (Analytical Results)

Analytical results for the 2018 monitoring are shown in Table 1 through Table 5.

3.3 Samples Collected

Two samples were collected from wells MO-1 through MO-5 during 2018 for the detection monitoring program. These sampling events occurred in April and October 2018. Additionally, a third sample was collected from wells MO-2 and MO-3 in July 2018 for confirmatory resampling associated with the detection monitoring program.

3.4 Comparative Statistical Analysis

The comparative statistical analysis is summarized below, and the results are presented in Table 6 through Table 10. A full description of the steps taken for the comparative statistical analysis can be found in the Groundwater Monitoring Statistical Methods Certification (Golder 2017b).

3.4.1 Definitions

The following definitions are used in discussion of the comparative statistical analysis:

- SSI – is a statistically significant increase (SSI) and is defined as an analytical result that exceeds the parametric or non-parametric statistical limit established by the baseline statistical analysis.
- False-positive SSI – is defined as an analytical result that exceeds the statistical limit but can clearly be attributed to laboratory error or changes in analytical precision, or is invalidated through confirmatory resampling.

- Confirmatory resampling – is designated as the resampling event that occurs within 90 days of detecting an SSI over the statistical limit for determination of a verified SSI.
- Verified SSI – is interpreted as two consecutive SSIs (the original sample and the confirmatory resample for analytical results) for the same constituent at the same well.

3.4.2 Unverified Statistically Significant Increases

Six unverified SSIs were identified for samples collected during the October 2018 sampling event. These include calcium and field pH at MO-1, total dissolved solids (TDS) at MO-2, chloride and TDS at MO-3 and sulfate at MO-5.

Per the Groundwater Monitoring Statistical Methods Certification (Golder 2017b), a confirmatory resampling event for these unverified SSIs is scheduled to occur within 90 days of the SSI determination, during the first quarter of 2019.

3.4.3 False-positive Statistically Significant Increases

One false-positive SSI was identified during the reporting period. The TDS result for the sample collected from MO-2 during the April 2018 sampling event exceeded the non-parametric prediction limit. The TDS result for the sample collected during the July 2018 confirmatory resampling event was below the statistical limit, and therefore the April 2018 result was identified as a false-positive SSI. No further action is needed.

3.4.4 Verified Statistically Significant Increases

Field pH measurements for the samples collected from MO-3 during both 2018 detection monitoring events are verified SSIs. The initial exceedance for MO-3 field pH occurred during the April 2018 sampling event and was verified with confirmatory resampling conducted in July 2018. In September 2018, an alternative source demonstration was conducted for field pH in MO-3, and it was recommended that the Facility remain in detection monitoring (Appendix A). During the October 2018 detection motioning sampling event, the field pH measurement for the sample collected from MO-3 also exceeded the statistical limit. The September 2018 ASD indicating that the pH measurements reflect natural variability is applicable to the October 2018 measurement, and it is recommended that the Facility remain in detection monitoring.

4.0 PROGRAM TRANSITIONS

Beginning in fourth quarter of 2017, the groundwater monitoring program for the Nucla Station Ash Disposal Facility transitioned from the baseline period to detection monitoring. The Facility is currently in detection monitoring.

4.1.1 Detection Monitoring

Samples for the detection monitoring program are collected on a semi-annual basis, beginning with the sample collected in October 2017. Tri-State plans to collect semi-annual samples for the detection monitoring program in the second and fourth quarters of 2019. In 2018, an alternative source demonstration was performed for field pH in MO-3 (Appendix A), and no further actions are required.

4.1.2 Assessment Monitoring

The groundwater monitoring program for the Facility is not in assessment monitoring. Assessment monitoring has not been triggered as described in 40 CFR 257.95. As such, no alternative source demonstrations have been made under an assessment monitoring program and no actions are required.

4.1.3 Corrective Measures and Assessment

The groundwater monitoring program for the Facility does not indicate the need for corrective measures. An assessment of corrective measures, as described in 40 CFR 257.96, is not required.

5.0 RECOMMENDATIONS AND CLOSING

This report presents the groundwater monitoring activities and results for the 2018 detection monitoring program for the CCR landfill that serves the Nucla Generating Station, along with the comparative statistical analysis. The significant findings from the 2018 monitoring activities and comparative statistical analysis are as follows:

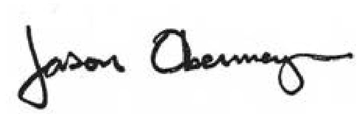
- Six unverified SSIs were identified based on the results of the October 2018 detection monitoring sampling event, and confirmatory resampling is scheduled for the first quarter of 2019.
- Field pH in MO-3 was identified as a verified SSI for both detection monitoring samples collected in 2018. An alternative source demonstration was performed in 2018 indicating that the pH measurements reflect natural variability. It is recommended that the Facility remain in detection monitoring, and no further actions are required.

As described in the Groundwater Monitoring System Certification (Golder 2017a) and the Groundwater Monitoring Statistical Methods Certification (Golder 2017b), the groundwater monitoring and analytical procedures meet the requirements of the CCR rule, and modifications to the monitoring network and sampling program are not recommended at this time.

Signature Page

Golder Associates Inc.

Sara Harkins
Senior Project Geochemist



Jason Obermeyer, PE
Associate and Senior Consultant

SH/JO/ds

6.0 REFERENCES

Golder Associates Inc., 2017a. Coal Combustion Residuals Landfill Groundwater Monitoring System Certification, Nucla Station Ash Disposal Facility. Report prepared for Tri-State Generation and Transmission Association, Inc. October 16, 2017.

Golder Associates Inc., 2017b. Coal Combustion Residuals Landfill Groundwater Statistical Method Certification, Nucla Station Ash Disposal Facility. Report prepared for Tri-State Generation and Transmission Association, Inc. October 16, 2017.

Tables

Table 1. Sample Results Summary Table – MO-1

Analytes	Units	4/24/2018 Compliance Point	10/23/2018 Compliance Point
Static Water Level Elevation	ft amsl	5715.6	5715.0
Appendix III			
Boron, Total Recoverable	mg/L	0.36	0.38
Calcium, Total Recoverable	mg/L	2.2	6.7
Chloride	mg/L	287	296
Fluoride	mg/L	1.38	1.65
pH, Field-Measured	pH units	10.9	11.8
Sulfate	mg/L	761	728
Total Dissolved Solids	mg/L	2170	1990

NOTES:
ft amsl, feet above mean sea level
mg/L, milligrams per liter

Table 2. Sample Results Summary Table – MO-2

Analytes	Units	4/25/2018 Compliance Point	7/24/2018 Confirmatory Resample	10/22/2018 Compliance Point
Static Water Level Elevation	ft amsl	5703.4	5712.2	5717.1
Appendix III				
Boron, Total Recoverable	mg/L	0.29	--	0.32
Calcium, Total Recoverable	mg/L	57.2	--	56.4
Chloride	mg/L	1950	--	2010
Fluoride	mg/L	<12.5 U	--	<12.5 U
pH, Field-Measured	pH units	8.2	--	8.1
Sulfate	mg/L	1990	--	2070
Total Dissolved Solids	mg/L	6400	6300	6460

NOTES:
--, not analyzed
ft amsl, feet above mean sea level
mg/L, milligrams per liter
Non-detects have been listed with a "<" at the practical quantitation limit
U, analyte not detected above the practical quantitation limit

Table 3. Sample Results Summary Table – MO-3

Analytes	Units	4/24/2018	7/24/2018	10/23/2018
		Compliance Point	Confirmatory Resample	Compliance Point
Static Water Level Elevation	ft amsl	5637.5	5636.7	5637.5
Appendix III				
Boron, Total Recoverable	mg/L	0.64	--	0.61
Calcium, Total Recoverable	mg/L	17.2	--	14.5
Chloride	mg/L	148	--	172
Fluoride	mg/L	2.59	--	2.94
pH, Field-Measured	pH units	8.1	8.0	8.0
Sulfate	mg/L	747	--	843
Total Dissolved Solids	mg/L	2460	--	2600

NOTES:
--, not analyzed
ft amsl, feet above mean sea level
mg/L, milligrams per liter

Table 4. Sample Results Summary Table – MO-4

Analytes	Units	4/24/2018 Compliance Point	10/23/2018 Compliance Point
Static Water Level Elevation	ft amsl	5634.9	5634.9
Appendix III			
Boron, Total Recoverable	mg/L	0.34	0.37
Calcium, Total Recoverable	mg/L	46.4	46.4
Chloride	mg/L	913	1070
Fluoride	mg/L	<12.5 U	<5 U
pH, Field-Measured	pH units	7.5	7.5
Sulfate	mg/L	1890	1900
Total Dissolved Solids	mg/L	5100	4980

NOTES:
ft amsl, feet above mean sea level
mg/L, milligrams per liter
Non-detects have been listed with a "<" at the practical quantitation limit
U, analyte not detected above the practical quantitation limit

Table 5. Sample Results Summary Table – MO-5

Analytes	Units	4/24/2018 Compliance Point	10/24/2018 Compliance Point
Static Water Level Elevation	ft amsl	5611.3	5636.6
Appendix III			
Boron, Total Recoverable	mg/L	0.4	0.4
Calcium, Total Recoverable	mg/L	27.8	22.1
Chloride	mg/L	980	1030
Fluoride	mg/L	<5 U	1.08
pH, Field-Measured	pH units	7.85	8.05
Sulfate	mg/L	1850	1960
Total Dissolved Solids	mg/L	5320	5300

NOTES:

ft amsl, feet above mean sea level

mg/L, milligrams per liter

Non-detects have been listed with a "<" at the practical quantitation limit

U, analyte not detected above the practical quantitation limit

Table 6. Statistics Summary Table – MO-1

Analytes	Units	Selected Statistical Method	Statistical Limit	April 2018		October 2018	
				Compliance Point (4/24/2018)	SSI Determination	Compliance Point (10/23/2018)	SSI Determination
Appendix III							
Boron, Total Recoverable[1]	mg/L	P-PL	0.43	0.36	No	0.38	No
Calcium, Total Recoverable[1]	mg/L	Trend[2]	--	2.2	No	6.7	Unverified
Chloride	mg/L	P-PL	341	287	No	296	No
Fluoride	mg/L	P-PL	2.8	1.38	No	1.65	No
pH, Field-Measured[3]	pH units	P-PL	9.8, 10.0	10.9 (9.8)	No	11.8 (10.1)	Unverified
Sulfate	mg/L	Trend[2]	--	761	No	728	No
Total Dissolved Solids	mg/L	Trend[2]	--	2170	No	1990	No

NOTES:
P-PL, Parametric Prediction Limit
mg/L, milligrams per liter
1. Statistical Limits were based on total analysis. Only total recoverable analyses were conducted for the compliance sampling event and have been used for comparisons.
2. Trend analysis used for the determination of SSIs.
3. A statistical limit was established using detrended data. Compliance data is detrended for comparison to statistical limit. Detrended value is shown in parentheses.

Table 7. Statistics Summary Table – MO-2

Analytes	Units	Selected Statistical Method	Statistical Limit	April 2018			October 2018	
				Compliance Point (4/25/2018)	Confirmatory Resample (7/24/2018)	SSI Determination	Compliance Point (10/22/2018)	SSI Determination
Appendix III								
Boron, Total Recoverable[1]	mg/L	P-PL	0.40	0.29	--	No	0.32	No
Calcium, Total Recoverable[1]	mg/L	P-PL	63.0	57.2	--	No	56.4	No
Chloride	mg/L	P-PL	2626	1950	--	No	2010	No
Fluoride	mg/L	NP-PL	12.5	<12.5 U	--	No	<12.5 U	No
pH, Field-Measured	pH units	P-PL	7.4, 8.9	8.2	--	No	8.1	No
Sulfate	mg/L	P-PL	2424	1990	--	No	2070	No
Total Dissolved Solids	mg/L	NP-PL	6330	6400	6300	False-Positive	6460	Unverified

NOTES:

P-PL, Parametric Prediction Limit

NP-PL, Non-parametric Prediction Limit

U, analyte not detected above the practical quantitation limit

mg/L, milligrams per liter

1. Statistical Limits were based on total analysis. Only total recoverable analyses were conducted for the compliance sampling event and have been used for comparisons.

Table 8. Statistics Summary Table – MO-3

Analytes	Units	Selected Statistical Method	Statistical Limit	April 2018			October 2018	
				Compliance Point (4/24/2018)	Confirmatory Resample (7/24/2018)	SSI Determination	Compliance Point (10/23/2018)	SSI Determination
Appendix III								
Boron, Total Recoverable[1]	mg/L	P-PL	0.75	0.64	--	No	0.61	No
Calcium, Total Recoverable[1]	mg/L	P-PL	19.6	17.2	--	No	14.5	No
Chloride	mg/L	P-PL	171	148	--	No	172	Unverified
Fluoride	mg/L	P-PL	3.50	2.59	--	No	2.94	No
pH, Field-Measured[2]	pH units	NP-PL	7.7, 7.9	8.1	8.0	Verified[2]	8.0	Verified[2]
Sulfate	mg/L	P-PL	860	747	--	No	843	No
Total Dissolved Solids	mg/L	P-PL	2587	2460	--	No	2600	Unverified

NOTES:

P-PL, Parametric Prediction Limit

NP-PL, Non-parametric Prediction Limit

mg/L, milligrams per liter

1. Statistical Limits were based on total analysis. Only total recoverable analyses were conducted for the compliance sampling event and have been used for comparisons.

2. Successful alternative source demonstration (ASD) conducted in September 2018, indicating the Facility remains in detection monitoring. This ASD is also applicable to the October 2018 sampling result.

Table 9. Statistics Summary Table – MO-4

Analytes	Units	Selected Statistical Method	Statistical Limit	April 2018		October 2018	
				Compliance Point (4/24/2018)	SSI Determination	Compliance Point (10/23/2018)	SSI Determination
Appendix III							
Boron, Total Recoverable[1]	mg/L	P-PL	0.47	0.34	No	0.37	No
Calcium, Total Recoverable[1]	mg/L	P-PL	53.3	46.4	No	46.4	No
Chloride	mg/L	P-PL	1090	913	No	1070	No
Fluoride	mg/L	NP-PL	5	<12.5 U	No	<5 U	No
pH, Field-Measured	pH units	NP-PL	7.4-7.6	7.5	No	7.5	No
Sulfate	mg/L	P-PL	2060	1890	No	1900	No
Total Dissolved Solids	mg/L	NP-PL	5210	5100	No	4980	No

NOTES:

P-PL, Parametric Prediction Limit

NP-PL, Non-parametric Prediction Limit

U, analyte not detected above the practical quantitation limit

mg/L, milligrams per liter

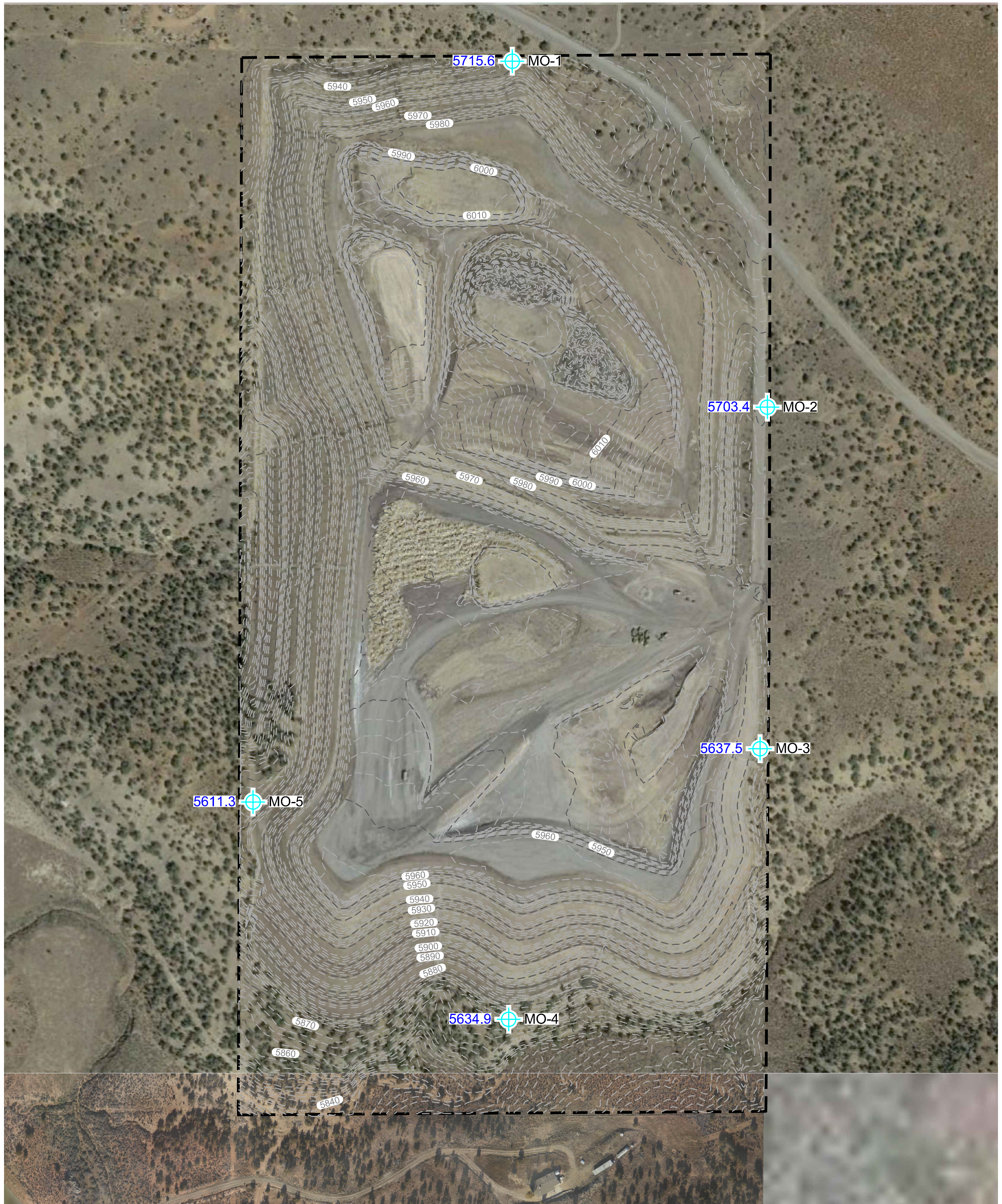
1. Statistical Limits were based on total analysis. Only total recoverable analyses were conducted for the compliance sampling event and have been used for comparisons.

Table 10. Statistics Summary Table – MO-5

Analytes	Units	Selected Statistical Method	Statistical Limit	April 2018		October 2018	
				Compliance Point (4/24/2018)	SSI Determination	Compliance Point (10/24/2018)	SSI Determination
Appendix III							
Boron, Total Recoverable[1]	mg/L	P-PL	0.51	0.4	No	0.4	No
Calcium, Total Recoverable[1]	mg/L	P-PL	54.5	27.8	No	22.1	No
Chloride	mg/L	P-PL	1309	980	No	1030	No
Fluoride	mg/L	P-PL	8.07	<5 U	No	1.08	No
pH, Field-Measured	pH units	NP-PL	7.6, 8.3	7.9	No	8.1	No
Sulfate	mg/L	P-PL	1955	1850	No	1960	Unverified
Total Dissolved Solids	mg/L	P-PL	5503	5320	No	5300	No

NOTES:
P-PL, Parametric Prediction Limit
NP-PL, Non-parametric Prediction Limit
U, analyte not detected above the practical quantitation limit
1. Statistical Limits were based on total analysis. Only total recoverable analyses were conducted for the compliance sampling event and have been used for comparisons.

Figures



LEGEND

- PROPERTY BOUNDARY
- EXISTING GROUND TOPOGRAPHY
- MO-1 MONITORING WELL
- 5715.6 GROUNDWATER ELEVATION (APRIL 2018)

0 150 300
SCALE FEET

CLIENT
TRI-STATE GENERATION AND TRANSMISSION ASSOCIATION
1100 WEST 116TH AVENUE
WESTMINSTER, COLORADO 80234

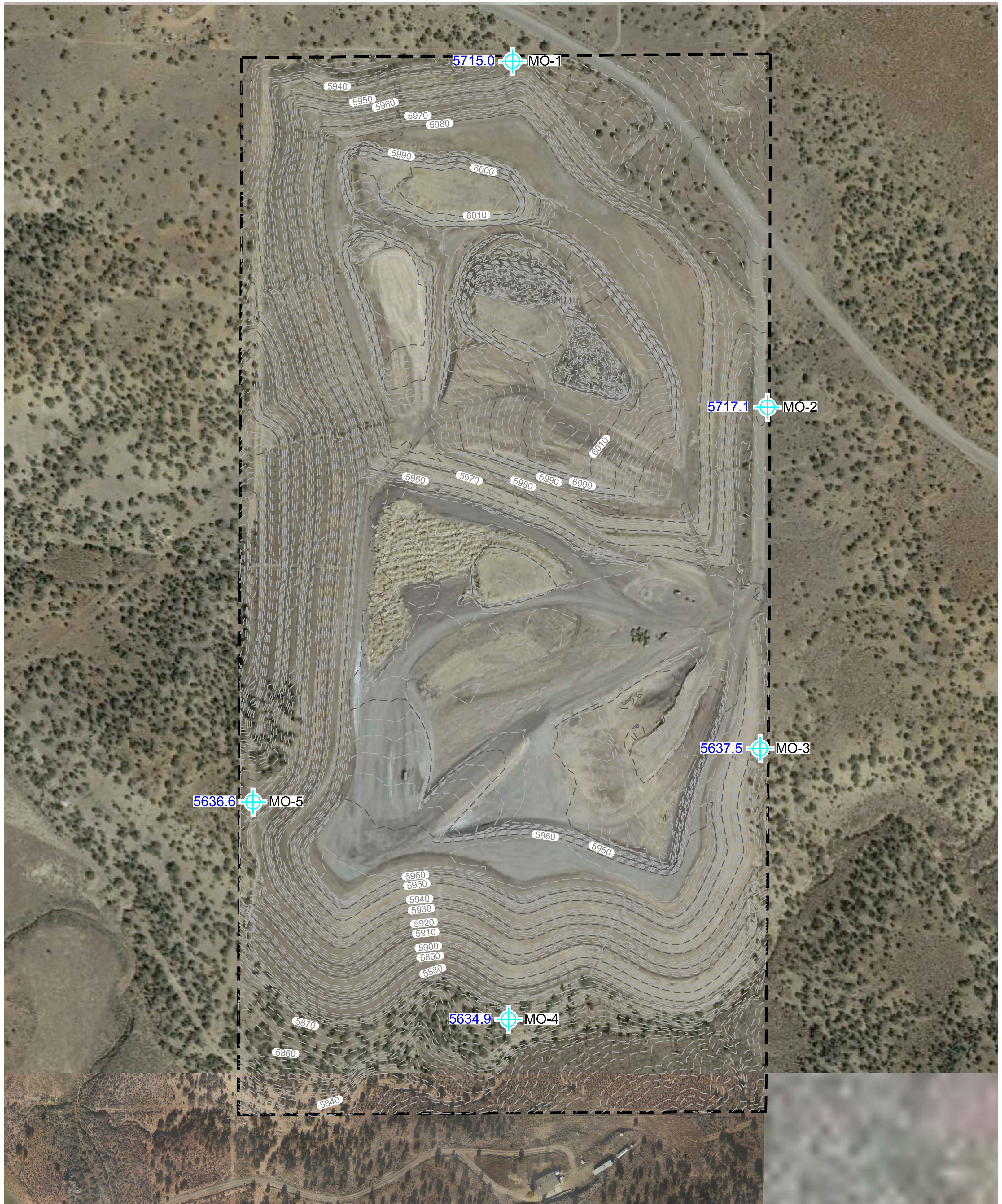
PROJECT
NUCLA STATION ASH DISPOSAL FACILITY
COAL COMBUSTION RESIDUALS LANDFILL
ANNUAL GROUNDWATER MONITORING REPORT

CONSULTANT
GOLDER

YYYY-MM-DD	2018-12-21
DESIGNED	KAC
PREPARED	KAC
REVIEWED	SAH
APPROVED	JEO

TITLE
MONITORING WELL LOCATIONS AND GROUNDWATER ELEVATIONS (APRIL 2018)

PROJECT NO.	REV.	FIGURE
18104295	0	1



LEGEND

- PROPERTY BOUNDARY
- EXISTING GROUND TOPOGRAPHY
- MO-1 MONITORING WELL
- 5715.0 GROUNDWATER ELEVATION (OCTOBER 2018)

N

0 150 300
SCALE FEET

CLIENT	PROJECT
TRI-STATE GENERATION AND TRANSMISSION ASSOCIATION 1100 WEST 116TH AVENUE WESTMINSTER, COLORADO 80234	NUCLA STATION ASH DISPOSAL FACILITY COAL COMBUSTION RESIDUALS LANDFILL ANNUAL GROUNDWATER MONITORING REPORT

CONSULTANT

GOLDER

YYYY-MM-DD	2018-12-21
DESIGNED	KAC
PREPARED	KAC
REVIEWED	SAH
APPROVED	JEO

TITLE

MONITORING WELL LOCATIONS AND GROUNDWATER ELEVATIONS (OCTOBER 2018)

PROJECT NO.	REV.	FIGURE
18104295	0	2

Path: J:\17JOBS\1779126 2017 Tri-State Nucla\CCR GW | File Name: CCR Well Locations-Aerial-Topo_October18.dwg

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D

APPENDIX A

Demonstration of Natural Variability and Analytical Uncertainty for pH at MO-3, Nucla Station Ash Disposal Facility Technical Memorandum

CERTIFICATION

Professional Engineer Certification Statement [40 CFR 257.94(e)(2)]

I hereby certify that, having reviewed the attached documentation and being familiar with the provisions of Title 40 of the Code of Federal Regulations Section 257.94 (40 CFR 257.94), this written demonstration is accurate to the best of my knowledge and has been prepared in accordance with recognized and generally accepted good engineering practices, including the consideration of applicable industry standards, and the requirements of 40 CFR 257.94(e)(2).

Golder Associates Inc.

____

Signature

September 27, 2018

Date of Certification

Jason Obermeyer, PE

Name

40294

Colorado Professional Engineer Number

TECHNICAL MEMORANDUM

DATE September 27, 2018 **Project No.** 18104295

TO Chantell Johnson
Tri-State Generation and Transmission Association, Inc.

FROM Sara Harkins

CC Jason Obermeyer and Matt Cahalan **EMAIL: Sara_Harkins@Golder.com**

DEMONSTRATION OF NATURAL VARIABILITY AND ANALYTICAL UNCERTAINTY FOR pH AT MO-3, NUCLA STATION ASH DISPOSAL FACILITY

Golder Associates Inc. (Golder) is providing this technical memorandum to support a demonstration of natural variability resulting in a statistically significant increase (SSI) for field pH at groundwater monitoring well MO-3 located at the coal combustion residuals (CCR) landfill that serves the Nucla Generating Station, which is owned and operated by Tri-State Generation and Transmission Association, Inc. (Tri-State). Tri-State disposes of CCRs from the Nucla Generating Station in an existing Tri-State-owned CCR landfill, the Nucla Station Ash Disposal Facility (the Facility), which is located approximately 2.5 miles southeast of the Nucla Generating Station. Groundwater is being monitored at the Facility to meet the requirements of the Environmental Protection Agency's (EPA) CCR Rule (40 CFR Part 257).

1.0 NUCLA STATION CCR GROUNDWATER MONITORING PROGRAM

The groundwater monitoring system for the Facility consists of five monitoring wells (MO-1, MO-2, MO-3, MO-4, and MO-5). Baseline groundwater samples were collected on an approximately monthly basis between December 13, 2016, and August 8, 2017, at each of the monitoring wells. The resulting data were used to establish intrawell baseline statistical limits for each Appendix III constituent at each well. Intrawell baseline statistical limits represent groundwater conditions in each individual well (USEPA 2009). Samples collected after baseline statistical limits were established are part of the detection monitoring program. Data from detection monitoring are compared to the statistical limits to assess possible changes in groundwater chemistry at each well. When the concentration of a given constituent exceeds the statistical limit in two consecutive sampling events, it is considered a verified SSI over the baseline concentration.

At MO-3, field pH exceeded the upper non-parametric statistical limit of 7.9 during the semi-annual compliance event in April 2018 (pH measured as 8.1) and during the confirmatory sampling event in July 2018 (pH measured as 8.0), indicating an SSI over baseline. The non-parametric limit is the highest concentration observed during the baseline period for the well. A non-parametric methodology was selected for pH at MO-3 because the baseline data were not normally or lognormally distributed, which is a requirement to implement a parametric methodology.

The following sections describe the site geology, provide comparisons to other CCR groundwater monitoring wells at the site, and explain the statistical methodology relevant to the pH measurements at MO-3. This demonstration is performed in accordance with the statistical method certification for the Facility (Golder 2017) to meet the requirements of 40 CFR 257.94(e)(2), which states that the site may remain in detection monitoring if a demonstration can be made that a source other than the regulated CCR unit caused the SSI or that the SSI was a result of an error in sampling, analysis, or statistical evaluation or natural variability in groundwater quality that was not fully captured during baseline data collection. More specifically, this technical memorandum supports the demonstration that the SSI for pH at MO-3 (April 2018 and July 2018 samples) was a result of natural variability in groundwater quality that was not fully captured during baseline data collection.

2.0 GEOLOGY AND HYDROGEOLOGY

Near-surface geology at the Nucla Station Ash Disposal Facility is generally characterized by a thin layer (0 to 15 feet thick) of unconsolidated regolith underlain by 0 to approximately 110 feet of the Dakota Sandstone, approximately 90 to 210 feet of the Burro Canyon Formation, and the Morrison Formation, which is approximately 700 to 800 feet thick regionally. The uppermost aquifer at the site is within the Morrison Formation.

The Morrison aquifer is characterized as highly heterogeneous with zones that are variably transmissive and/or subjected to variable amounts of confining pressure. This characterization is supported by the differences in groundwater levels, water column heights, and recovery times observed in the monitoring wells that have been installed to serve as the groundwater monitoring system for the Facility. Sandstone lenses in the Morrison aquifer vary considerably with respect to transmissivity (i.e., thickness and hydraulic conductivity) and horizontal extent due to the alluvial, shoreline, and lacustrine environments that deposited the Salt Wash and Brushy Basin Members of the Morrison Formation, resulting in interbedded siltstone, mudstone, claystone, and shale units. Groundwater elevation data suggest a general westerly and southerly groundwater flow direction in the Morrison aquifer in the vicinity of the Nucla Station Ash Disposal Facility. However, the heterogeneity and interbedded nature of the Morrison Formation beneath the Facility, coupled with the observation that groundwater levels in the monitoring wells continue to stabilize, confound the ability to precisely discern groundwater flow direction and hydraulic connection.

3.0 BASELINE FOR pH

Summary statistics for the pH data collected during the baseline period for the CCR monitoring wells are presented in Table 1. Summary statistics and time series graphs, presented in Table 1 and Figure 2, respectively, are useful for evaluating variability in pH measurements at MO-3 and amongst the other CCR monitoring wells. The baseline data indicate that pH varies at each monitoring well, as indicated by the standard deviation and coefficient of variation. When compared to other monitoring wells, MO-3 pH values (along with MO-4 pH values) have the smallest range, lowest standard deviation, and lowest coefficient of variation. Additionally, pH values from the April 2018 sampling event are plotted on Figure 1. This figure demonstrates that the measured pH at MO-3 is generally consistent with the pH measured at other wells in the CCR program.

Due to the time constraints associated with the implementation of the CCR Rule (40 CFR Part 257), the baseline data for the CCR program were collected on a compressed schedule, which consisted of monthly sampling between December 2016 and August 2017. We consider it likely that this compressed schedule (less than one year) did not allow for natural variations in groundwater concentrations, such as those attributable to seasonal fluctuations or other sources of natural variability, to be fully observed during the baseline data collection period.

4.0 NON-PARAMETRIC PREDICTION LIMITS AND FALSE POSITIVE RATE

The primary goal in a groundwater detection monitoring program is to identify real changes to groundwater quality if they occur, with a specific focus on increasing concentrations or changes in pH in detection monitoring data when compared to baseline data. Statistical tests are used to identify the possible presence of elevated concentrations or changes in pH, and they must have adequate statistical power to do so. Statistical power is the likelihood of detecting a change in concentrations or pH when a change is present in reality. A second critical goal is to avoid false positive errors (Type I errors), which occur when changes are incorrectly identified as being significantly different than baseline when contamination does not exist.

A site-wide false positive rate (SWFPR) is used to measure the susceptibility to false positive errors. The Unified Guidance (USEPA 2009) recommends an annual SWFPR of 10%. This SWFPR equates to a *target* per well-constituent false positive rate of 0.38% using equation 19.17 in the Unified Guidance:

$$\alpha_{w \cdot c} = 1 - (1 - \alpha)^{1/(w \cdot c)}$$

where α is the SWFPR, *w* equals the actual number of downgradient compliance wells (four in this case), and *c* is the number of monitoring constituents (seven in this case). However, based on Table 19-19 in Appendix D of the Unified Guidance the *achievable* false positive rate for a non-parametric prediction limit with a background dataset of nine measurements where two statistical evaluations are performed per year is 3.6% (much greater than the target of 0.38% noted above). The only way to reduce this false positive rate would be to increase the number of background samples, which was not feasible under the time constraints of the CCR Rule. Thus, there is a relatively high probability of falsely identifying groundwater contamination for parameters that are being tested with a non-parametric methodology at the Facility, which may have occurred during the comparative statistical analysis for pH in MO-3. Unfortunately, due to the nature of the non-parametric prediction limits, the false positive rate will remain elevated for the Facility until more sampling events are conducted. The data from future sampling events can be incorporated into an updated baseline period in accordance with the statistical methodology for the Facility (Golder 2017), which will result in either one of the following: 1) the underlying data distribution can be defined and a parametric methodology can be implemented, or 2) a non-parametric prediction limit can be constructed on a greater number of samples.

5.0 SUMMARY AND CONCLUSIONS

This demonstration details the rationale behind Golder's conclusion that the statistically significant increase in field pH at MO-3 is not an indication of groundwater impacts from the Nucla Station Ash Disposal Facility, but rather a reflection of natural variability. The lines of evidence can be summarized as follows:

- Well MO-3 pH values are generally consistent with the pH values measured for other CCR landfill monitoring wells at the Facility (Figure 1).
- Due to time constraints associated with the implementation of the CCR Rule (40 CFR Part 257), the baseline data for the CCR program were collected on a compressed schedule, which likely did not allow for natural variations in groundwater pH values to be fully observed during the baseline data collection period.
- Because of the limited number of baseline samples currently available, the selected statistical methodology to assess field pH data at MO-3, a non-parametric prediction limit, has a high false positive rate.

Based on the findings of this demonstration, Golder recommends that Tri-State continue with the detection monitoring program for the Nucla Station Ash Disposal Facility.

6.0 REFERENCES

Golder Associates Inc. (Golder), 2017. Coal Combustion Residuals Landfill Groundwater Statistical Method Certification, Nucla Station Ash Disposal Facility. October 16.

U.S. Environmental Protection Agency (USEPA), Office of Solid Waste, 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance. March.

ATTACHMENTS

Table 1 – pH Summary Statistics
Figure 1 – Monitoring Well Locations and pH Values (April 2018)
Figure 2 – pH Time Series

j:\18jobs\18104295\mo-3ph_asd_fnl_27sep18\18104295_mo-3ph_asd.27sep18.docx

Table

Table 1: pH Summary Statistics

Monitoring Well	Constituent	Date Range[1]	pH Values				
			Minimum	Mean	Maximum	Coefficient of Variation	Standard Deviation
MO-1	Field pH	2016-2017	9.5	9.9	10.2	0.03	0.27
MO-2	Field pH	2016-2017	7.8	8.2	8.4	0.03	0.22
MO-3	Field pH	2016-2017	7.7	7.8	7.9	0.01	0.08
MO-4	Field pH	2016-2017	7.4	7.5	7.6	0.01	0.08
MO-5	Field pH	2016-2017	7.6	8.0	8.3	0.03	0.25

Notes:

(1): 2016-2017 date range indicates baseline sampling period for CCR Groundwater Program.

Figures

LEGEND

- PROPERTY BOUNDARY
- EXISTING GROUND TOPOGRAPHY
- MO-1 MONITORING WELL
- 8.2 pH (APRIL 2018)
- GENERAL GROUNDWATER FLOW DIRECTION

N

0 150 300
SCALE FEET

CLIENT
TRI-STATE GENERATION AND TRANSMISSION ASSOCIATION
1100 WEST 116TH AVENUE
WESTMINSTER, COLORADO 80234

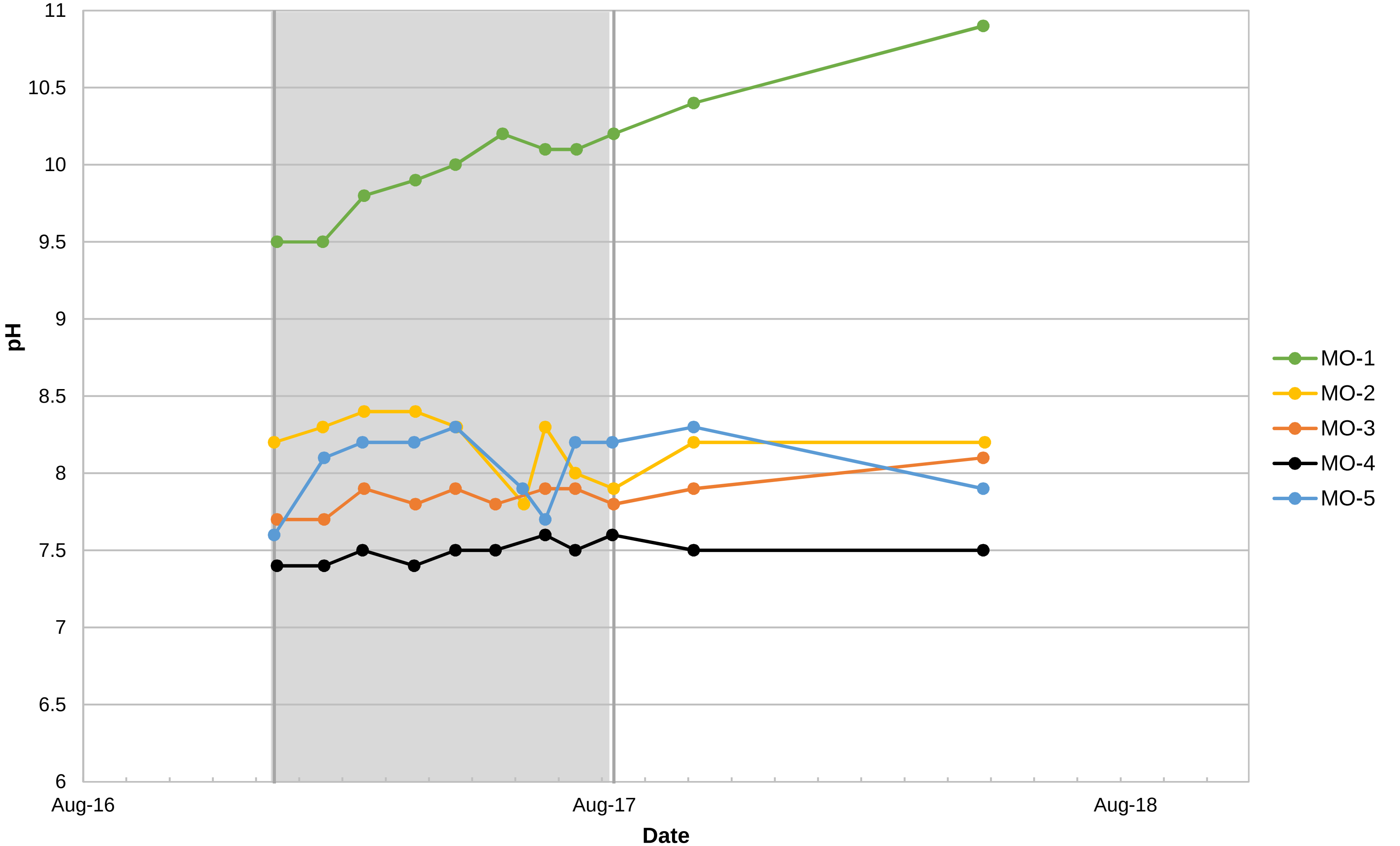
CONSULTANT
GOLDER

YYYY-MM-DD	2018-09-07
DESIGNED	KAC
PREPARED	DVS
REVIEWED	SAH
APPROVED	JEO

PROJECT
NUCLA STATION ASH DISPOSAL FACILITY
GROUNDWATER MONITORING SUPPORT

TITLE
MONITORING WELL LOCATIONS AND pH VALUES (APRIL 2018)

PROJECT NO.	REV.	FIGURE
18104295	0	1



Notes:

Gray shading indicates baseline period (December 2016 to August 2017)

Figure 2

pH Time Series

Nucla Station CCR Groundwater Program

J:\18JOBS\18104295\MO-3pH_ASD_Fnl_27Sep18\Figures\[Figure 2.xlsx]2

GOLDER

GOLDER

golder.com