First Semi-Annual 2023 Groundwater Sampling Report

Sand Management Site

Boone, Iowa

August 2024

Prepared by

1631 NW 30th Court
Ankeny, Iowa 50023

SEE-001-024-391

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Groundwater Sampling Report
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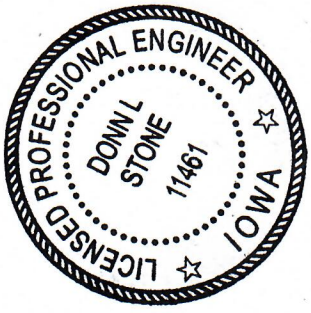
BESSER
Trusted Since 1904

August 2024



I hereby certify that this engineering document was prepared by me or under my direct personal supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Iowa.

Donn L Stone, P.E. — Date: 20 Aug 24

License Number: 11461
My license renewal date is December 31, 2024

First Semi-Annual 2024
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1.0 INTRODUCTION

Besser Quinn owns a facility known as the Besser Quinn Sand Management Site. This site has received used foundry sand since 2000. The site is under closure procedures and is operating under DNR ID #08-BUD-08-99 as prepared by the Iowa Department of Natural Resource. The BUD requires groundwater monitoring for four quarters of a year and thence semi-annually. This report presents the findings of a sampling event during June 2023 to perform chemical analysis consistent with the BUD. The former chemical analyses were associated with the chemical analyses required for sand being deposited at the site. The semi-annual sampling program will continue with the next sampling event anticipated in November or December 2024.

1.1 OWNER INFORMATION

Besser Quinn Machine and Foundry
Division of the Besser International Pipe Machinery Corporation
1518 12th Street
Boone, Iowa 50036

Besser-Quinn Vice President - Pipe and Precast
Brian Christle - 515-432-3553

1.2 SITE LOCATION INFORMATION

The Quinn Quarry Reclamation site is located along Boone County Road E-41, which was formerly USA Highway 30. The street address of the site is 1159 216th Drive. Figure 1 notes the location of the Besser Quinn Sand Management Site.

1.3 HISTORIC DISSCUSSION

The initial development of the site required the determination of depth to groundwater and the collection of groundwater samples for chemical analysis. To accomplish these tasks, three groundwater wells were installed. Groundwater was found near 30' of depth and quality control samples did not note the presence of chemical at unacceptable concentrations.

2.0 SUBSURFACE CONDITIONS AND MONITORING WELLS

Monitoring wells were installed in 2000 as a function of the initial siting of the management site. In late 2018, the initial wells were checked and two of the wells were determined to be non-functionable. Two replacements wells were installed adjacent to the two non-functional wells. Monitoring of the three functional wells did not present a defined groundwater flow direction and IDNR requested two additional wells to assist in defining the groundwater flow direction. After the completion of the fourth and fifth wells, IDNR geologic staff reviewed satellite images and suggested that the management site was sighted on a narrow peninsula of glacial till surrounded by alluvium. Based on this observation, this location of the site could potentially have groundwater flow in several directions which could change with time.

Historic groundwater measurements note inconsistent trends in elevations, with some monitoring wells noting higher elevations than the previous sampling event, while the others were noted as lower than the previous sampling event. The groundwater sampling was delayed for this sampling event as the area has been subjected to a drought. The groundwater in the monitoring wells present at the previous sampling event was low and made obtaining a good sample difficult. The area received several rainfalls of more than an inch during the spring of 2024. The depth to groundwater was checked, noting slight change in elevation. By mid-summer the groundwater elevation had increased in most of the wells. The inconsistency of the groundwater surface between sampling events and between wells further demonstrates the disconnection of the wells from each other. Table 1 presents the current groundwater elevations compared the to the previous sampling event measurements.

Table 1
Groundwater Depth
August 2024

Monitoring well	Depth to water	Height of Riser	Well Screen	Surface Elevation	Groundwater Elevation August 2024	Previous Elevation December 2023
QN	16.18	2.60	26’-36’	909.82	893.64	887.34
QNE	30.57	3.33	18'-50'	919.14	888.57	887.37
QNW	46.57	3.04	18'-50'	922.01	875.44	874.95
QS	41.54	3.13	18'-50'	916.18	874.64	874.43
QE	40.21	2.72	24’-34’	915.76	875.55	875.61
QW	dry	3.05	34’-44’	912.19		

3.0 REVIEW OF GROUNDWATER ANALYSIS

Groundwater samples are typically obtained on two semi-annual occasions with the most recent event taking place on December 1, 2023. The samples were subjected to the analysis outlined in the BUD. Table 2 presents some of the concentration of detected materials in the groundwater samples. The full analysis is in the appendix. The BUD lists certain VOC compounds for analysis, further the BUD states that the groundwater analysis need not be performed on the VOC compounds if there are not found to be present in the sand being placed at the site. Per the most recent sand analysis, no VOCs were noted as present.

Table 2
Historic Groundwater Analysis, ppm
March, June, September & December 2020, June 2021 & December 2021, June 2022
March 2023, June 2023, December 2023, August 2024

Monitoring well	Manganese Total Metal	Molybdenum Total Metal	Barium Total Metal	Boron Total Metal	Cobalt Total Metal	Nickel Total Metal
QN – Mar. 2020	1.15	0.358	0.205	0.544	0.0039	0.019
QN – Jun 2020	0.945	0.265	0.089	0.479	0.0035	0.020
QN-Sept. 2020	0.857	0.246	0.079	0.481	0.0029	0.017
QN – Dec. 2020	1.10	0.250	0.104	0.520	0.0039	0.016
QN – June 2021	0.955	0.223	0.122	0.661	0.0034	0.013
QN – Dec. 2021	0.614	0.184	0.126	0.634	0.0025	0.017
QN – June 2022	0.333	0.024	0.056	0.124	0.0008	0020
QN – Dec. 2022	0.922	0.134	0.043	0.523	0.0059	0.025
QN – March 2023	0.782	0.124	0.0445	0.654	0.0027	0.016
QN – June 2023	0.689	0.115	0.0881	0.603	0.0061	0.0121
QN – Dec. 2023	0.691	0.090	0.0594	0.488	0.0025	0.169
QN – Aug. 2024	5.81	0.0147	0.0486	0.0374	0.0041	0.0094
QNE – Mar. 2020	1.46	0.115	0.149	1.15	0.0038	0.016
QNE – Jun 2020	0.616	0.021	0.104	0.476	0.0019	0.018
QNE-Sept. 2020	0.698	0.023	0.094	0.0752	0.0011	0.015
QNE – Dec. 2020	0.604	0.023	0.097	0.739	0.0013	0.012
QNE – June 2021	0.397	0.020	0.096	0.749	0.0006	ND
QNE – Dec. 2021	0.431	0.020	0.097	0.730	0.0007	ND
QNE – June 2022	0.313	0.018	0.100	0.608	0.0005	ND
QNE – Dec. 2022	0.399	0.014	0.096	0.632	0.0043	ND
QNE – Mar2023	0.639	0.0129	0.0907	0.671	0.0011	0.0053
QNE – June 2023	0.347	0.0117	0.100	0.620	0.0062	0.0044
QNE – Dec. 2023	0.555	0.0127	0.0992	0.625	0.0027	0.0066
QNE –Aug. 2024	0.042	0.0121	0.109	0.660	0.0009	0.0052

QNW -Mar. 2020	1.04	ND	0.226	0.174	0.0033	ND
QNW – Jun. 2020	0.302	ND	0.170	ND	0.0074	0.010
QNW-Sept. 2020	0.056	ND	0.245	0.198	0.0004	ND
QNW- Dec. 2020	0.045	ND	0.287	0.247	0.0004	ND
QNW – June 2021	0.701	ND	0.260	0.163	0.0033	ND
QNW- Dec. 2021	0.714	ND	0.309	0.0277	0.0067	ND
QNW – June 2022	5.24	0.018	1.82	0.122	0.0804	0.100
QNW – Dec. 2022	9.88	0.020	1.40	0.296	0.0581	0.091
QNW -Mar 2023	0.105	ND	0.195	0.147	0.0007	0.0040
QNW– June 2023	0.512	ND	0.249	0.138	0.0030	0.0056
QNW – Dec. 2023	49.9	0.155	9.41	1.29	0.727	1.37
QNW – Aug. 2024	4.42	0.0077	0.314	0.211	0.0087	0.0181
QS – Mar. 2020	16.6	0.02	2.99	0.162	0.227	0.338
QS – Jun. 2020	0.658	ND	0.256	ND	0.0103	0.021
QS-Sept. 2020	0.419	ND	0.250	ND	0.0064	0.015
QS – Dec. 2020	1.08	ND	0.384	ND	0.0135	0.025
QS – June 2021	0.429	ND	0.261	0.114	0.007	0.012
QS – Dec. 2021	0.078	ND	0.202	ND	0.0038	ND
QS – June 2022	20.0	0.022	3.89	0.139	0.226	0.336
QS – Dec. 2022	12.0	0.014	2.68	0.135	0.192	0.229
QS – Mar 2023	ND	ND	0.188	ND	ND	ND
QS – June 2023	2.42	ND	0.719	0.106	0.0357	0.0456
QS – Dec. 2023	22.5	0.0670	22.5	ND	1.62	1.89
QS – Aug. 2024	No Sample	No Sample	No Sample	No Sample	No Sample	No Sample
QE – Mar. 2020	1.29	ND	0.120	0.293	0.0048	0.011
QE – Jun. 2020	1.02	ND	0.114	0.185	0.002	ND
QE-Sept. 2020	0.808	ND	0.063	0.524	0.0004	ND
QE – Dec. 2020	0.776	0.010	0.052	0.523	0.0042	0.015
QE – June 2021	2.07	ND	0.0065	0.504	0.0017	ND
QE – Dec. 2021	3.01	ND	0.077	0.489	0.0024	0.015
QE – June 2022	0.719	ND	0.069	ND	0.0023	ND
QE – Dec 2022	1.5	0.019	0.152	0.645	0.0293	0.043
QE – Mar 2023	1.39	0.0041	0.637	0.167	0.0066	0.0157
QE – June 2023	3.03	0.0040	0.0778	0.385	0.0076	0.0116
QE – Dec 2023	1.48	0.0076	0.0716	0.629	0.0085	0.0248
QE – Aug 2024	2.86	0.0071	0.0659	0.0577	0.0058	0.0130
QW – Mar. 2020	0.082	ND	0.176	ND	0.0012	ND
QW – Jun. 2020	0.024	ND	0.151	ND	0.0004	ND
QW-Sept. 2020	0.023	ND	0.156	ND	0.0004	ND

QW – Dec. 2020	0.049	ND	0.170	ND	0.0009	ND
QW – June 2021	0.504	ND	0.284	ND	0.0082	0.016
QW – Dec. 2021	0.059	ND	0.189	ND	0.0013	ND
QW – June 2022	2.02	ND	0.628	ND	0.0308	0.053
QW – Dec. 2022	Dry	Dry	Dry	Dry	Dry	Dry
QW – Mar 2023	Dry	Dry	Dry	Dry	Dry	Dry
QW – June 2023	Dry	Dry	Dry	Dry	Dry	Dry
QW – Dec. 2023	Dry	Dry	Dry	Dry	Dry	Dry
QW – Aug. 2024	Dry	Dry	Dry	Dry	Dry	Dry

Table 2 notes that selected metals exhibit concentrations fairly consistent between June 2020, and June 2023. Again, for the August 2024 sampling, MW QW was noted as dry and no groundwater sample was obtained. A slow flow pump was used to collect a sample for MW QS, however there was not enough groundwater available to collect a sample.

The most previous sampling event disrupted the sediment in the QE, QNE, QNW and QS wells and influenced the metal analysis. The August 2024 sampling was performed without disrupting the sediment. For the most part metal concentrations dropped with the recent sampling with the reduction in sediment. However, MW QN and MW QNW exhibited a significant higher manganese concentrations than the historic sampling events.. WM QE also noted a higher manganese concentration, which is somewhat consistent with past sampling events.

Table 3 presented below compares the ground water to the State of Iowa non-protected groundwater standard. Table 3 notes manganese concentrations exceeded the State of Iowa non-protected groundwater standard in MW QN. No other exceedances were noted.

Table 3
Groundwater Analysis to Non-Protected Groundwater Std., ppm
December 2023

Monitoring well	Manganese Total Metal	Molybdenum Total Metal	Barium Total Metal	Boron Total Metal	Cobalt Total Metal	Nickel Total Metal
Non-Protected GW standard	4.9	0.2	10	30	0.01	0.7
QN –Aug. 2024	5.81	0.0147	0.0486	0.0374	0.0041	0.0094
QNE – Aug. 2024	0.042	0.0121	0.109	0.660	0.0009	0.0052
QNW – Aug. 2024	4.42	0.0077	0.314	0.211	0.0087	0.0181
QS – Aug. 2024	No Sample	No Sample	No Sample	No Sample	No Sample	No Sample
QE –Aug. 2024	2.86	0.0071	0.0659	0.0577	0.0058	0.0130
QW – Aug. 2024	Dry	Dry	Dry	Dry	Dry	Dry

Table 4
Groundwater Analysis to Protected Groundwater Std., ppm
December 2023

Monitoring well	Manganese Total Metal	Molybdenum Total Metal	Barium Total Metal	Boron Total Metal	Cobalt Total Metal	Nickel Total Metal
Protected GW standard	0.3	0.04	2.0	6.0	0.0021	0.1
QN –June 2023	5.81	0.0147	0.0486	0.0374	0.0041	0.0094
QNE – June 2023	0.042	0.0121	0.109	0.660	0.0009	0.0052
QNW – June 2023	4.42	0.0077	0.314	0.211	0.0087	0.0181
QS – June 2023	No Sample	No Sample	No Sample	No Sample	No Sample	No Sample
QE –June 2023	2.86	0.0071	0.0659	0.0577	0.0058	0.0130
QW – June 2023	Dry	Dry	Dry	Dry	Dry	Dry

Table 4 notes that the only metal exceeding the Protected Groundwater Standard is manganese in QN, QNW and QE. In the past other metals were noting as exceeding this standard.

A statistical analysis of the groundwater surface and metal concentration trends was performed by Otter Creek Environmental Services, L.L.C., Elgin, Illinois. A copy of the report is included in the Appendix.

4.0 SUMMARY

This sampling report presents data from the first semi-annual groundwater sampling event for 2024. The current concentrations, for the most part, are consistent with the previous sampling events and analysis. Future sampling events will be undertaken to develop site averages for chemical parameters.

Based on the comparison to the Iowa state wide groundwater standards, the concentrations noted with this sampling event notes several metals as non-compliant with the standard. Sampling and reporting will continue until the life of the BUD is complete.

Appendix A

Chemical Analysis

Groundwater Sampling Field Sheet

Disposal Site Name: Besser Quinn Permit No.:

Well/Piezometer: MW QNW Weather: foggy- misty, 64 F

Date: 13 August 2024 Sampler Name: Donn Stone

Monitoring Well Details

Construction Data

Borehole Diameter (in): 6 Depth to Tope of Screen (ft): 18'

Casing Diameter (in): 2 Casing Material: 2' PVC

Top of Casing Elevation (ft. MSL): 925.05 Ground Surface Elevation (ft. MSL): 922.01

Field Observations

Locked: ☒ Yes ☐ No

	Before Purging	After Purging	Before Sampling
Depth to Water Level (ft.):			46.57
Water Elevation (ft. MSL):			875.44

Screen Submerged? (Depth to Water Level < Depth to Top of Screen) ☐ Yes ■ No

	Start	End
Purge Date/Time		

Well Conditions Commentary: well cover and casing in good repair

Sampling Equipment (check one)

☐ Pump ☐ Interval Sampler

☒ Bailer ☐ Other (specify):

Equipment Name & Description: 2' PVC bailer, plastic rope

Pump Types (check one)

☐ Submersible ☐ Peristaltic ☐ Bladder ☐ Inertial Lift Pump ☐ Other (specify):

Method (check one)

☐ Low Flow ☐ No Purge ☐ Purge

Options (check one)

☒ Dedicated ☐ Disposable ☐ Portable

Decontamination Method: washed and sanitized in office, wrapped in plastic until opened in field

Field Analysis

							Final Reading
Date/Time	12:16						
Depth to Water (ft)	46.57						
Volume Purged ( )							
Temp (°C)	60 F						
Sp. Cond (umhos/cm)	1860						
pH	6.9						
DO (mg/l)							
ORP (mV)							
Turbidity (NTU)							

Equipment Depth: Flow Rate: Volume Removed: Volume Sampled:

Odor? ☐ Yes ☒ No Color? ☐ Yes ☒ No

Comments: slight turbidity at end of sampling

Groundwater Sampling Field Sheet

Disposal Site Name: Besser Quinn Permit No.:

Well/Piezometer: MW QNE Weather: foggy- misty, 64 F

Date: 13 August 2024 Sampler Name: Donn Stone

Monitoring Well Details

Construction Data

Borehole Diameter (in): 6 Depth to Tope of Screen (ft): 18'

Casing Diameter (in): 2 Casing Material: 2' PVC

Top of Casing Elevation (ft. MSL): 922.47 Ground Surface Elevation (ft. MSL): 919.14

Field Observations

Locked: ☒ Yes ☐ No

	Before Purging	After Purging	Before Sampling
Depth to Water Level (ft.):			30.57
Water Elevation (ft. MSL):			888.57

Screen Submerged? (Depth to Water Level < Depth to Top of Screen) ☐ Yes ■ No

	Start	End
Purge Date/Time		

Well Conditions Commentary: well cover and casing in good repair

Sampling Equipment (check one)

☐ Pump ☐ Interval Sampler

☒ Bailer ☐ Other (specify):

Equipment Name & Description: 2' PVC bailer, plastic rope

Pump Types (check one)

☐ Submersible ☐ Peristaltic ☐ Bladder ☐ Inertial Lift Pump ☐ Other (specify):

Method (check one)

☐ Low Flow ☐ No Purge ☐ Purge

Options (check one)

☒ Dedicated ☐ Disposable ☐ Portable

Decontamination Method: washed and sanitized in office, wrapped in plastic until opened in field

Field Analysis

							Final Reading
Date/Time	10:06						
Depth to Water (ft)	30.57						
Volume Purged ( )							
Temp (°C)	60 F						
Sp. Cond (umhos/cm)	1200						
pH	6.9						
DO (mg/l)							
ORP (mV)							
Turbidity (NTU)							

Equipment Depth: Flow Rate: Volume Removed: Volume Sampled:

Odor? ☐ Yes ☒ No Color? ☐ Yes ☒ No

Comments: increasing silt with depth, slight turbidty

Groundwater Sampling Field Sheet

Disposal Site Name: Besser Quinn Permit No.:

Well/Piezometer: MW QN Weather: foggy- misty, 64 F

Date: 13 August 2024 Sampler Name: Donn Stone

Monitoring Well Details

Construction Data

Borehole Diameter (in): 6 Depth to Tope of Screen (ft): 26'

Casing Diameter (in): 2 Casing Material: 2' PVC

Top of Casing Elevation (ft. MSL): 912.42 Ground Surface Elevation (ft. MSL): 909.82

Field Observations

Locked: ☒ Yes ☐ No

	Before Purging	After Purging	Before Sampling
Depth to Water Level (ft.):			16.18
Water Elevation (ft. MSL):			893.64

Screen Submerged? (Depth to Water Level < Depth to Top of Screen) ■ Yes ☐ No

	Start	End
Purge Date/Time		

Well Conditions Commentary: well cover and casing in good repair

Sampling Equipment (check one)

☐ Pump ☐ Interval Sampler

☒ Bailer ☐ Other (specify):

Equipment Name & Description: 2' PVC bailer, plastic rope

Pump Types (check one)

☐ Submersible ☐ Peristaltic ☐ Bladder ☐ Inertial Lift Pump ☐ Other (specify):

Method (check one)

☐ Low Flow ☐ No Purge ☐ Purge

Options (check one)

☒ Dedicated ☐ Disposable ☐ Portable

Decontamination Method: washed and sanitized in office, wrapped in plastic until opened in field

Field Analysis

							Final Reading
Date/Time	10:46						
Depth to Water (ft)	16.18						
Volume Purged ( )							
Temp (°C)	60 F						
Sp. Cond (umhos/cm)	3190						
pH	6.6						
DO (mg/l)							
ORP (mV)							
Turbidity (NTU)							

Equipment Depth: Flow Rate: Volume Removed: Volume Sampled:

Odor? ☒ Yes ☐ No Color? ☐ Yes ☒ No

Comments: slight septic odor, no turbidity

Groundwater Sampling Field Sheet

Disposal Site Name: Besser Quinn Permit No.:

Well/Piezometer: MW QE Weather: foggy- misty, 64 F

Date: 13 August 2024 Sampler Name: Donn Stone

Monitoring Well Details

Construction Data

Borehole Diameter (in): 6 Depth to Tope of Screen (ft): 24'

Casing Diameter (in): 2 Casing Material: 2' PVC

Top of Casing Elevation (ft. MSL): 918.48 Ground Surface Elevation (ft. MSL): 915.76

Field Observations

Locked: ☒ Yes ☐ No

	Before Purging	After Purging	Before Sampling
Depth to Water Level (ft.):			40.21
Water Elevation (ft. MSL):			875.55

Screen Submerged? (Depth to Water Level < Depth to Top of Screen) ☐ Yes ☒ No

	Start	End
Purge Date/Time		

Well Conditions Commentary: well cover and casing in good repari

Sampling Equipment (check one)

☐ Pump ☐ Interval Sampler

☒ Bailer ☐ Other (specify):

Equipment Name & Description: 2' PVC bailer, plastic rope

Pump Types (check one)

☐ Submersible ☐ Peristaltic ☐ Bladder ☐ Inertial Lift Pump ☐ Other (specify):

Method (check one)

☐ Low Flow ☐ No Purge ☐ Purge

Options (check one)

☒ Dedicated ☐ Disposable ☐ Portable

Decontamination Method: washed and sanitized in office, wrapped in plastic until opened in field

Field Analysis

							Final Reading
Date/Time	11:30						
Depth to Water (ft)	40.21						
Volume Purged ( )							
Temp (°C)	59						
Sp. Cond (umhos/cm)	3200						
pH	6.9						
DO (mg/l)							
ORP (mV)							
Turbidity (NTU)							

Equipment Depth: Flow Rate: Volume Removed: Volume Sampled:

Odor? ☐ Yes ☒ No Color? ☐ Yes ☒ No

Comments: slight if any turbidity,

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CERTIFICATE OF ANALYSIS

1HH1175

Stone Environmental Engineering

Donn Stone
1631 NW 30th Court
Ankeny, IA 50021

Project Name: SEE 001

Project / PO Number: SEE 001
Received: 08/14/2024
Reported: 08/29/2024

Analytical Testing Parameters

Client Sample ID: QN
Sample Matrix: Aqueous
Lab Sample ID: 1HH1175-01
Collected By: DLS
Collection Date: 08/12/2024 10:46

Determination of Carbonyl Compounds	Result	RL	Units	DF	Note	Prepared	Analyzed	Analyst
EPA 8315								
Formaldehyde	<20.0	20.0	ug/L	1		08/15/24 1422	08/17/24 1511	PDS

Determination of Conventional Chemistry Parameters	Result	RL	Units	DF	Note	Prepared	Analyzed	Analyst
EPA 410.4								
COD, total	<20	20	mg/L	1		08/19/24 1143	08/19/24 1246	CES
EPA 420.1								
Phenols, total	<0.035	0.035	mg/L	1		08/28/24 0839	08/28/24 1604	KKJ
EPA 9020								
Total Organic Halogens (TOX)	**0.092**	0.010	mg/L	1	**TX1**	08/27/24 0000	08/28/24 1440	LNH
TIMBERLINE								
Nitrogen, Ammonia	**0.61**	0.10	mg/L	1		08/26/24 1253	08/26/24 1554	JAC
USGS I-3765-85								
Total Suspended Solids (TSS)	**87**	1	mg/L	1		08/15/24 1624	08/16/24 0910	RDH

Determination of Inorganic Anions	Result	RL	Units	DF	Note	Prepared	Analyzed	Analyst
EPA 9056								
Fluoride	**0.1**	0.1	mg/L	1		08/26/24 0000	08/27/24 0203	MID
Chloride	**99.3**	10.0	mg/L	10		08/26/24 0000	08/26/24 1428	MID
Sulfate	**1010**	10.0	mg/L	10		08/26/24 0000	08/26/24 1428	MID

Determination of Total Metals	Result	RL	Units	DF	Note	Prepared	Analyzed	Analyst
EPA 3005A/EPA 6020A								
Antimony, total	<0.0020	0.0020	mg/L	4		08/15/24 1613	08/19/24 2017	RVV
Arsenic, total	**0.0092**	0.0040	mg/L	4		08/15/24 1613	08/19/24 2017	RVV
Barium, total	**0.0486**	0.0040	mg/L	4		08/15/24 1613	08/19/24 2017	RVV
Beryllium, total	<0.0040	0.0040	mg/L	4		08/15/24 1613	08/19/24 2017	RVV
Cadmium, total	<0.0008	0.0008	mg/L	4		08/15/24 1613	08/19/24 2017	RVV
Chromium, total	<0.0080	0.0080	mg/L	4		08/15/24 1613	08/19/24 2017	RVV
Cobalt, total	**0.0041**	0.0004	mg/L	4		08/15/24 1613	08/19/24 2017	RVV
Copper, total	<0.0040	0.0040	mg/L	4		08/15/24 1613	08/19/24 2017	RVV
Lead, total	<0.0040	0.0040	mg/L	4		08/15/24 1613	08/19/24 2017	RVV
Manganese, total	**5.81**	0.100	mg/L	100		08/15/24 1613	08/20/24 1209	RVV
Molybdenum, total	**0.0147**	0.0040	mg/L	4		08/15/24 1613	08/19/24 2017	RVV
Nickel, total	**0.0094**	0.0040	mg/L	4		08/15/24 1613	08/19/24 2017	RVV

Client Sample ID:	QN		
Sample Matrix:	Aqueous	**Collected By:**	DLS
Lab Sample ID:	1HH1175-01	**Collection Date:**	08/12/2024 10:46

Determination of Total Metals	Result	RL	Units	DF	Note	Prepared	Analyzed	Analyst
Selenium, total	<0.0040	0.0040	mg/L	4		08/15/24 1613	08/19/24 2017	RVV
Silver, total	<0.0040	0.0040	mg/L	4		08/15/24 1613	08/19/24 2017	RVV
Thallium, total	<0.0020	0.0020	mg/L	4		08/15/24 1613	08/19/24 2017	RVV
Vanadium, total	<0.0200	0.0200	mg/L	4		08/15/24 1613	08/19/24 2017	RVV
Zinc, total	<0.0200	0.0200	mg/L	4		08/15/24 1613	08/19/24 2017	RVV
EPA 3010A/EPA 6010B								
Aluminum, total	**0.125**	0.050	mg/L	1		08/16/24 0732	08/20/24 0018	JAR
Boron, total	**0.374**	0.100	mg/L	1		08/16/24 0732	08/21/24 0343	JAR
Iron, total	**15.7**	0.100	mg/L	1		08/16/24 0732	08/20/24 0018	JAR
Magnesium, total	**164**	0.100	mg/L	1		08/16/24 0732	08/20/24 0018	JAR
EPA 7470A								
Mercury, total	<0.00050	0.00050	mg/L	1		08/16/24 1502	08/20/24 1056	JAR

CERTIFICATE OF ANALYSIS

1HH1175

Client Sample ID:	QNE		
Sample Matrix:	Aqueous	**Collected By:**	DLS
Lab Sample ID:	1HH1175-02	**Collection Date:**	08/12/2024 10:06

Determination of Carbonyl Compounds	Result	RL	Units	DF	Note	Prepared	Analyzed	Analyst
EPA 8315								
Formaldehyde	<10.0	10.0	ug/L	1		08/15/24 1422	08/17/24 1530	PDS

Determination of Conventional Chemistry Parameters	Result	RL	Units	DF	Note	Prepared	Analyzed	Analyst
EPA 410.4								
COD, total	<20	20	mg/L	1		08/19/24 1143	08/19/24 1246	CES
EPA 420.1								
Phenols, total	<0.035	0.035	mg/L	1		08/28/24 0839	08/28/24 1604	KKJ
EPA 9020								
Total Organic Halogens (TOX)	<0.010	0.010	mg/L	1		08/27/24 0000	08/28/24 1440	LNH
TIMBERLINE								
Nitrogen, Ammonia	**1.52**	0.10	mg/L	1		08/26/24 1253	08/26/24 1556	JAC
USGS I-3765-85								
Total Suspended Solids (TSS)	**6**	1	mg/L	1		08/15/24 1624	08/16/24 0910	RDH

Determination of Inorganic Anions	Result	RL	Units	DF	Note	Prepared	Analyzed	Analyst
EPA 9056								
Fluoride	**0.1**	0.1	mg/L	1		08/26/24 0000	08/27/24 0225	MID
Chloride	**6.5**	1.0	mg/L	1		08/26/24 0000	08/27/24 0225	MID
Sulfate	**233**	10.0	mg/L	10		08/26/24 0000	08/26/24 1451	MID

Determination of Total Metals	Result	RL	Units	DF	Note	Prepared	Analyzed	Analyst
EPA 3005A/EPA 6020A								
Antimony, total	<0.0020	0.0020	mg/L	4		08/15/24 1613	08/19/24 2023	RVV
Arsenic, total	<0.0040	0.0040	mg/L	4		08/15/24 1613	08/19/24 2023	RVV
Barium, total	**0.109**	0.0040	mg/L	4		08/15/24 1613	08/19/24 2023	RVV
Beryllium, total	<0.0040	0.0040	mg/L	4		08/15/24 1613	08/19/24 2023	RVV
Cadmium, total	<0.0008	0.0008	mg/L	4		08/15/24 1613	08/19/24 2023	RVV
Chromium, total	<0.0080	0.0080	mg/L	4		08/15/24 1613	08/19/24 2023	RVV
Cobalt, total	**0.0009**	0.0004	mg/L	4		08/15/24 1613	08/19/24 2023	RVV
Copper, total	**0.0052**	0.0040	mg/L	4		08/15/24 1613	08/19/24 2023	RVV
Lead, total	<0.0040	0.0040	mg/L	4		08/15/24 1613	08/19/24 2023	RVV
Manganese, total	**0.402**	0.0040	mg/L	4		08/15/24 1613	08/19/24 2023	RVV
Molybdenum, total	**0.0121**	0.0040	mg/L	4		08/15/24 1613	08/19/24 2023	RVV
Nickel, total	**0.0052**	0.0040	mg/L	4		08/15/24 1613	08/19/24 2023	RVV
Selenium, total	<0.0040	0.0040	mg/L	4		08/15/24 1613	08/19/24 2023	RVV
Silver, total	<0.0040	0.0040	mg/L	4		08/15/24 1613	08/19/24 2023	RVV
Thallium, total	<0.0020	0.0020	mg/L	4		08/15/24 1613	08/19/24 2023	RVV
Vanadium, total	<0.0200	0.0200	mg/L	4		08/15/24 1613	08/19/24 2023	RVV
Zinc, total	<0.0200	0.0200	mg/L	4		08/15/24 1613	08/19/24 2023	RVV
EPA 3010A/EPA 6010B								

CERTIFICATE OF ANALYSIS

1HH1175

Client Sample ID:	QNE		
Sample Matrix:	Aqueous	**Collected By:**	DLS
Lab Sample ID:	1HH1175-02	**Collection Date:**	08/12/2024 10:06

Determination of Total Metals	Result	RL	Units	DF	Note	Prepared	Analyzed	Analyst
Aluminum, total	**0.092**	0.050	mg/L	1		08/16/24 0732	08/20/24 0027	JAR
Boron, total	**0.660**	0.100	mg/L	1		08/16/24 0732	08/21/24 0352	JAR
Iron, total	**0.161**	0.100	mg/L	1		08/16/24 0732	08/20/24 0027	JAR
Magnesium, total	**62.2**	0.100	mg/L	1		08/16/24 0732	08/20/24 0027	JAR
EPA 7470A								
Mercury, total	<0.00050	0.00050	mg/L	1		08/16/24 1502	08/20/24 1058	JAR

Client Sample ID:	QE		
Sample Matrix:	Aqueous	**Collected By:**	DLS
Lab Sample ID:	1HH1175-03	**Collection Date:**	08/12/2024 11:30

Determination of Carbonyl Compounds	Result	RL	Units	DF	Note	Prepared	Analyzed	Analyst
EPA 8315								
Formaldehyde	<20.0	20.0	ug/L	1		08/15/24 1422	08/17/24 1549	PDS

Determination of Conventional Chemistry Parameters	Result	RL	Units	DF	Note	Prepared	Analyzed	Analyst
EPA 410.4								
COD, total	**21**	20	mg/L	1		08/19/24 1143	08/19/24 1246	CES
EPA 420.1								
Phenols, total	<0.035	0.035	mg/L	1		08/28/24 0839	08/28/24 1604	KKJ
EPA 9020								
Total Organic Halogens (TOX)	**0.032**	0.010	mg/L	1	**TX1, TX2**	08/27/24 0000	08/28/24 1440	LNH
TIMBERLINE								
Nitrogen, Ammonia	**1.74**	0.10	mg/L	1		08/26/24 1253	08/26/24 1559	JAC
USGS I-3765-85								
Total Suspended Solids (TSS)	**852**	1	mg/L	1		08/15/24 1624	08/16/24 0910	RDH

Determination of Inorganic Anions	Result	RL	Units	DF	Note	Prepared	Analyzed	Analyst
EPA 9056								
Fluoride	<0.1	0.1	mg/L	1		08/26/24 0000	08/27/24 0248	MID
Chloride	**15.2**	1.0	mg/L	1		08/26/24 0000	08/27/24 0248	MID
Sulfate	**901**	10.0	mg/L	10		08/26/24 0000	08/26/24 1513	MID

Determination of Total Metals	Result	RL	Units	DF	Note	Prepared	Analyzed	Analyst
EPA 3005A/EPA 6020A								
Antimony, total	<0.0020	0.0020	mg/L	4		08/15/24 1613	08/19/24 2029	RVV
Arsenic, total	**0.0099**	0.0040	mg/L	4		08/15/24 1613	08/19/24 2029	RVV
Barium, total	**0.0659**	0.0040	mg/L	4		08/15/24 1613	08/19/24 2029	RVV
Beryllium, total	<0.0040	0.0040	mg/L	4		08/15/24 1613	08/19/24 2029	RVV
Cadmium, total	<0.0008	0.0008	mg/L	4		08/15/24 1613	08/19/24 2029	RVV
Chromium, total	<0.0080	0.0080	mg/L	4		08/15/24 1613	08/19/24 2029	RVV
Cobalt, total	**0.0058**	0.0004	mg/L	4		08/15/24 1613	08/19/24 2029	RVV
Copper, total	<0.0040	0.0040	mg/L	4		08/15/24 1613	08/19/24 2029	RVV
Lead, total	<0.0040	0.0040	mg/L	4		08/15/24 1613	08/19/24 2029	RVV
Manganese, total	**2.86**	0.100	mg/L	100		08/15/24 1613	08/20/24 1209	RVV
Molybdenum, total	**0.0071**	0.0040	mg/L	4		08/15/24 1613	08/19/24 2029	RVV
Nickel, total	**0.0130**	0.0040	mg/L	4		08/15/24 1613	08/19/24 2029	RVV
Selenium, total	<0.0040	0.0040	mg/L	4		08/15/24 1613	08/19/24 2029	RVV
Silver, total	<0.0040	0.0040	mg/L	4		08/15/24 1613	08/19/24 2029	RVV
Thallium, total	<0.0020	0.0020	mg/L	4		08/15/24 1613	08/19/24 2029	RVV
Vanadium, total	<0.0200	0.0200	mg/L	4		08/15/24 1613	08/19/24 2029	RVV
Zinc, total	<0.0200	0.0200	mg/L	4		08/15/24 1613	08/19/24 2029	RVV
EPA 3010A/EPA 6010B								

Client Sample ID:	QE		
Sample Matrix:	Aqueous	**Collected By:**	DLS
Lab Sample ID:	1HH1175-03	**Collection Date:**	08/12/2024 11:30

Determination of Total Metals	Result	RL	Units	DF	Note	Prepared	Analyzed	Analyst
Aluminum, total	**0.078**	0.050	mg/L	1		08/16/24 0732	08/20/24 0033	JAR
Boron, total	**0.577**	0.100	mg/L	1		08/16/24 0732	08/21/24 0358	JAR
Iron, total	**12.3**	0.100	mg/L	1		08/16/24 0732	08/20/24 0033	JAR
Magnesium, total	**140**	0.100	mg/L	1		08/16/24 0732	08/20/24 0033	JAR
EPA 7470A								
Mercury, total	<0.00050	0.00050	mg/L	1		08/16/24 1502	08/20/24 1101	JAR

CERTIFICATE OF ANALYSIS

1HH1175

Client Sample ID:	QNW		
Sample Matrix:	Aqueous	**Collected By:**	DLS
Lab Sample ID:	1HH1175-04	**Collection Date:**	08/12/2024 12:16

Determination of Carbonyl Compounds	Result	RL	Units	DF	Note	Prepared	Analyzed	Analyst
EPA 8315								
Formaldehyde	<10.0	10.0	ug/L	1		08/15/24 1422	08/17/24 1608	PDS

Determination of Conventional Chemistry Parameters	Result	RL	Units	DF	Note	Prepared	Analyzed	Analyst
EPA 410.4								
COD, total	<20	20	mg/L	1		08/19/24 1143	08/19/24 1246	CES
EPA 420.1								
Phenols, total	**0.053**	0.035	mg/L	1		08/26/24 0847	08/26/24 1714	KKJ
EPA 9020								
Total Organic Halogens (TOX)	**0.133**	0.010	mg/L	1	**TX1**	08/27/24 0000	08/28/24 1440	LNH
TIMBERLINE								
Nitrogen, Ammonia	**0.11**	0.10	mg/L	1		08/26/24 1253	08/26/24 1601	JAC
USGS I-3765-85								
Total Suspended Solids (TSS)	**626**	1	mg/L	1		08/15/24 1624	08/16/24 0910	RDH

Determination of Inorganic Anions	Result	RL	Units	DF	Note	Prepared	Analyzed	Analyst
EPA 9056								
Fluoride	**0.1**	0.1	mg/L	1		08/26/24 0000	08/27/24 0310	MID
Chloride	**241**	10.0	mg/L	10		08/26/24 0000	08/26/24 1536	MID
Sulfate	**134**	10.0	mg/L	10		08/26/24 0000	08/26/24 1536	MID

Determination of Total Metals	Result	RL	Units	DF	Note	Prepared	Analyzed	Analyst
EPA 3005A/EPA 6020A								
Antimony, total	<0.0020	0.0020	mg/L	4		08/15/24 1613	08/19/24 2035	RVV
Arsenic, total	**0.0063**	0.0040	mg/L	4		08/15/24 1613	08/19/24 2035	RVV
Barium, total	**0.314**	0.0040	mg/L	4		08/15/24 1613	08/19/24 2035	RVV
Beryllium, total	<0.0040	0.0040	mg/L	4		08/15/24 1613	08/19/24 2035	RVV
Cadmium, total	<0.0008	0.0008	mg/L	4		08/15/24 1613	08/19/24 2035	RVV
Chromium, total	<0.0080	0.0080	mg/L	4		08/15/24 1613	08/19/24 2035	RVV
Cobalt, total	**0.0087**	0.0004	mg/L	4		08/15/24 1613	08/19/24 2035	RVV
Copper, total	**0.0071**	0.0040	mg/L	4		08/15/24 1613	08/19/24 2035	RVV
Lead, total	**0.0042**	0.0040	mg/L	4		08/15/24 1613	08/19/24 2035	RVV
Manganese, total	**4.42**	0.100	mg/L	100		08/15/24 1613	08/20/24 1209	RVV
Molybdenum, total	**0.0077**	0.0040	mg/L	4		08/15/24 1613	08/19/24 2035	RVV
Nickel, total	**0.0181**	0.0040	mg/L	4		08/15/24 1613	08/19/24 2035	RVV
Selenium, total	<0.0040	0.0040	mg/L	4		08/15/24 1613	08/19/24 2035	RVV
Silver, total	<0.0040	0.0040	mg/L	4		08/15/24 1613	08/19/24 2035	RVV
Thallium, total	<0.0020	0.0020	mg/L	4		08/15/24 1613	08/19/24 2035	RVV
Vanadium, total	<0.0200	0.0200	mg/L	4		08/15/24 1613	08/19/24 2035	RVV
Zinc, total	<0.0200	0.0200	mg/L	4		08/15/24 1613	08/19/24 2035	RVV
EPA 3010A/EPA 6010B								

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Microbac Laboratories, Inc., Newton

CERTIFICATE OF ANALYSIS

1HH1175

Client Sample ID:	QNW		
Sample Matrix:	Aqueous	**Collected By:**	DLS
Lab Sample ID:	1HH1175-04	**Collection Date:**	08/12/2024 12:16

Determination of Total Metals	Result	RL	Units	DF	Note	Prepared	Analyzed	Analyst
Aluminum, total	**2.46**	0.050	mg/L	1		08/16/24 0732	08/20/24 0042	JAR
Boron, total	**0.211**	0.100	mg/L	1		08/16/24 0732	08/21/24 0409	JAR
Iron, total	**13.8**	0.100	mg/L	1		08/16/24 0732	08/20/24 0042	JAR
Magnesium, total	**68.3**	0.100	mg/L	1		08/16/24 0732	08/20/24 0042	JAR
EPA 7470A								
Mercury, total	<0.00050	0.00050	mg/L	1		08/16/24 1502	08/20/24 1103	JAR

Definitions

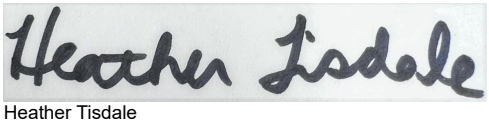
RL: Reporting Limit

TX1: Repeated analysis of this sample consistently exceeded greater than 10% breakthrough to the second column.

TX2: The RPD value for the sample duplicates are outside of acceptance limits due to matrix interference. The reported value is an average of all test measurements.

Report Comments

Reviewed and Approved By:



Heather Tisdale

Customer Relationship Specialist

heather.tisdale@microbac.com

08/29/24 12:30

CHAIN OF CUSTODY RECORD

MICROBAC®
600 East 17th Stre
Newton, IA 50208
641-792-8451

1 H H 1 1 7 5

Stone Environmental Engineering
PM: Heather Tisdale

SITE INFORMATION

Sampler:

Project: SEE 001

REPORT TO

Donn Stone
Stone Environmental Engineering
1631 NW 30th Court
Ankeny, IA 50021

INVOICE TO

Donn Stone
Stone Environmental Engineering
1631 NW 30th Court
Ankeny, IA 50021

SPECIAL INSTRUCTIONS

None pH & CONDUCTIVITY — REPORT SEPERATELY

Turn Around Time
☒ Standard ☐ RUSH, need by ___/___/___

LAB USE ONLY

Work Order 1HH1175
Temperature 2.1
Turn-Cooler: No

- ☐ Custody Seal
- ☒ Containers Intact
- ☒ COC/Labels Agree
- ☐ Preservation Confirmed
- ☒ Received on Ice

Number	Sample Identification / Client ID	Matrix	Sample Type	Date	Time	Number of Containers	Analyses	Lab Sample Number
-001	GW-	Aqueous	GRAB	8/12	10:46	7	8315@Formaldehyde, 9020-100, ag-t-6020, al-t-6010, as-t-6020, ba-t-6020, be-t-6020, b-t-6010, cd-t-6020, cl-9056-w, cod-t-410.4, cond-2510, co-t-6020, cr-t-6020, cu-t-6020, f-9056, fe-t-6010, hg-t-7470, mg-t-6010, mn-t-6020, mo-t-6020, nh3-timberline, ni-t-6020, pb-t-6020, ph-4500, phenol-t-420.1, sb-t-6020, se-t-6020, so4-9056-w, tl-t-6020, tss-i-3765-85, v-t-6020, zn-t-6020	01

Relinquished By: [signature] Date/Time: 13 Aug 0700

Received By: ___ Date/Time: ___

Relinquished By: [signature] Date/Time: 8/14/2024 2:38 PM

Received for Lab By: [signature] Date/Time: ___

Remarks:

Original - Lab Copy Yellow - Sampler Copy

CHAIN OF C

MICROBAC®
600 East 17th Street S
Newton, IA 50208
641-792-8451

1HH1175

Stone Environmental Engineering
PM: Heather Tisdale

SITE INFORMATION
Sampler:
Project: SEE 001

REPORT TO
Donn Stone
Stone Environmental Engineering
1631 NW 30th Court
Ankeny, IA 50021

INVOICE TO
Donn Stone
Stone Environmental Engineering
1631 NW 30th Court
Ankeny, IA 50021

SPECIAL INSTRUCTIONS
None X pH & conductivity
Turn Around Time
☑ Standard ☐ RUSH, need by ___/___/___

LAB USE ONLY
Work Order 1HH1175
Temperature 2.1
Turn-Cooler: No

- Custody Seal
- Containers Intact
- COC/Labels Agree
- Preservation Confirmed
- Received on Ice

Number	Sample Identification / Client ID	Matrix	Sample Type	Date	Time	Number of Containers	Analyses	Lab Sample Number
-002	QNE	Aqueous	GRAB	8/12	10:00	7	8315@Formaldehyde, 9020-100, ag-t-6020, al-t-6010, as-t-6020, ba-t-6020, be-t-6020, b-t-6010, cd-t-6020, cl-9056-w, cod-t-410.4, cond-2510, co-t-6020, cr-t-6020, cu-t-6020, f-9056, fe-t-6010, hg-t-7470, mg-t-6010, mn-t-6020, mo-t-6020, nh3-timberline, ni-t-6020, pb-t-6020, ph-4500, phenol-t-420.1, sb-t-6020, se-t-6020, so4-9056-w, tl-t-6020, tss-i-3765-85, v-t-6020, zn-t-6020	02

Relinquished By — Date/Time: 13 Aug 0700
Received By — Date/Time:
Relinquished By — Date/Time: 5/14/2024 2:30 PM
Received for Lab By — Date/Time:

Remarks:

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CHAIN OF CUS[illegible]RECORD

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600 East 17th Street Sou
Newton, IA 50208
641-792-8451

1HH1175
Stone Environmental Engineering
PM: Heather Tisdale

SITE INFORMATION
Sampler:
Project: SEE 001

REPORT TO
Donn Stone
Stone Environmental Engineering
1631 NW 30th Court
Ankeny, IA 50021

INVOICE TO
Donn Stone
Stone Environmental Engineering
1631 NW 30th Court
Ankeny, IA 50021

SPECIAL INSTRUCTIONS
None / PH; CONDUCTIVITY
REPORT SODIALITY
Turn Around Time
☐ Standard ☐ RUSH, need by ___/___/___

LAB USE ONLY
Work Order 1HH1175
Temperature 2.1
Turn-Cooler: No

- ☐ Custody Seal
- ☒ Containers Intact
- ☒ COC/Labels Agree
- ☐ Preservation Confirmed
- ☑ Received on Ice

Number	Sample Identification / Client ID	Matrix	Sample Type	Date	Time	Number of Containers	Analyses	Lab Sample Number
-003	QE	Aqueous	GRAB	8/12	11:30	7	8315@Formaldehyde, ag-t-6020, as-t-6020, be-t-6020, cd-t-6020, cod-t-410.4, co-t-6020, cu-t-6020, fe-t-6010, mg-t-6010, mo-t-6020, ni-t-6020, ph-4500, sb-t-6020, so4-9056-w, tss-t-3765-85, zn-t-6020, 9020-100, al-t-6010, ba-t-6020, b-t-6010, cl-9056-w, cond-2510, cr-t-6020, f-9056, hg-t-7470, mn-t-6020, nh3-timberline, pb-t-6020, phenol-t-420.1, se-t-6020, tl-t-6020, v-t-6020	03

Relinquished By — Date/Time: 13 Aug 0700
Received By — Date/Time:
Relinquished By — Date/Time:
Received for Lab By — Date/Time: 8/14/2024 2:39 JW

Remarks:

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CHAIN OF

MICROBAC®

600 East 17th Stree
Newton, IA 50208
641-792-8451

1 H H 1 1 7 5

Stone Environmental Engineering
PM: Heather Tisdale

SITE INFORMATION

Sampler:

Project: SEE 001

REPORT TO

Donn Stone
Stone Environmental Engineering
1631 NW 30th Court
Ankeny, IA 50021

TO

Donn Stone
Stone Environmental Engineering
1631 NW 30th Court
Ankeny, IA 50021

SPECIAL INSTRUCTIONS

Note pH, Conductivity Report Seperately

Turn Around Time

☒ Standard ☐ RUSH, need by ___/___/___

LAB USE ONLY

Work Order 1HH1175

Temperature 2.1

Turn-Cooler: No

☒ Custody Seal
☒ Containers Intact
☒ COC/Labels Agree
☐ Preservation Confirmed
☑ Received on Ice

Number	Sample Identification / Client ID	Matrix	Sample Type	Date	Time	Number of Containers	Analyses	Lab Sample Number
-004	QNW	Aqueous	GRAB	8/12	12:16	7	8315@Formaldehyde, ag-t-6020, as-t-6020, be-t-6020, cd-t-6020, cod-t-410.4, co-t-6020, cu-t-6020, fe-t-6010, mg-t-6010, mo-t-6020, ni-t-6020, ph-4500, sb-t-6020, so4-9056-w, tss-i-3765-85, zn-t-6020, 9020-100, al-t-6010, ba-t-6020, b-t-6010, cl-9056-w, cond-2510, cr-t-6020, f-9056, hg-t-7470, mn-t-6020, nh3-timberline, pb-t-6020, phenol-t-420.1, se-t-6020, tl-t-6020, v-t-6020	04

Relinquished By: [signature] Date/Time: 13 Aug 16 0700

Received By: Date/Time:

Relinquished By: [signature] Date/Time: 8/14/2024 2:39 PM

Received for Lab By: Date/Time:

Remarks:

Original - Lab Copy Yellow - Sampler Copy

Results of the Ground Water Statistics

for Besser Quinn Quarry

First Semi-Annual Monitoring Event in 2024

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INTRODUCTION

This report contains the results of the statistical analyses used to evaluate the ground water data obtained during the first semi-annual monitoring event in 2024 at Besser Quinn Quarry. The ground water at Besser Quinn Quarry is monitored by wells QE, QN, QNE, QNW, QS, and QW. These monitoring wells were sampled on August 12, 2024 and analyzed for the parameters required by permit. No sample was obtained at QS; well QW was reported to be dry.

The statistical plan is designed to detect a release from the facility at the earliest indication so that it is protective of human health and the environment. Both interwell and intrawell methodologies are described and then applied to the Besser Quinn Quarry data. The statistical plan conforms with IAC 567, Chapter 113.10, USEPA Guidance document ("*Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Unified Guidance"*, March 2009), and the American Society for Testing and Materials (ASTM) standard D6312-98, *Developing Appropriate Statistical Approaches for Ground-Water Detection Monitoring Programs*.

Ground Water Monitoring Program

The groundwater monitoring network for Besser Quinn Quarry includes wells QE, QN, QNE, QNW, QS, and QW. Each of the groundwater monitoring wells is to be sampled at least semiannually and analyzed for the detection monitoring parameters listed below.

Detection monitoring constituents for Besser Quinn Quarry
Barium, Total
Boron, Total
Cobalt, Total
Manganese, Total
Molybdenum, Total
Nickel, Total

The ground water data obtained during the first semi-annual monitoring event in 2024 are summarized in Attachment A. The historical ground water data obtained from 2019 through the first semi-annual monitoring event in 2024 are summarized in Attachment B.

STATISTICAL METHODOLOGIES FOR DETECTION MONITORING

IAC 567, Chapter 113.10(4) provides several options for statistically evaluating the ground water data at those wells that monitor the open cells or contiguous MSWLF units. The preferred methods for comparing ground water data are using either prediction limits or using control charts. Both of these methods were applied to the Besser Quinn Quarry data using the DUMPStat® statistical program. DUMPStat® is a program for the statistical analysis of groundwater monitoring data using methods described in "Statistical Methods for Groundwater Monitoring" by Dr. Robert D. Gibbons. The DUMPStat program is completely consistent with all USEPA regulations and guidance and the ASTM D6312-98 guidance. Ground water statistics are to be done on the constituents listed.

Interwell Statistics: Upgradient versus Downgradient Comparisons

Interwell statistics are appropriate when the upgradient and downgradient wells monitor the same ground water formation and there is similar variability in the upgradient and downgradient zones. Site prediction limits are determined by pooling the historical ground water data from hydraulically upgradient wells. This statistical method compares the current downgradient determinations to site prediction limits and checks for exceedances. The type of prediction limit utilized (e.g., parametric or nonparametric) is based on the detection frequency and the data distribution of each parameter in the background data. The distribution of the background data is tested for normality using the Shapiro-Wilk test (Gibbons, 1994 and USEPA 1992). If the constituent is normally distributed, a normal prediction limit is used. If normality is rejected by the Shapiro-Wilk test, the background data is transformed by taking the natural logarithm. The Shapiro-Wilk test is then reapplied on the transformed data. If it is not rejected, lognormal prediction limits are used. If after transforming the data, normality is still rejected, nonparametric prediction limits are used for that analyte. The nonparametric prediction limit is the largest determination in the background measurements. For constituents where the background detection frequency is greater than 0% but less than 50%, nonparametric prediction limits will be used. If the detection frequency is 0% after thirteen samples have been collected, the practical quantitation limit (PQL) becomes the nonparametric prediction limit.

Results of the Interwell Statistics

The background data used in this statistical analysis includes the ground water data collected from ground water wells QE, QN, and QNE during the period from 2020 through the current data. A summary of the background data from monitoring wells QE, QN, and QNE is listed in Attachment C, Table 1 "Upgradient Data". This statistical method compares the current downgradient determinations to site prediction limits and checks for exceedances.

Table 2 "Most Current Downgradient Monitoring Data", summarizes the current data from downgradient well QNW compared to the site prediction limits. Prediction limit exceedances are flagged with asterisks. For the most current data, the site prediction limit exceedances detected are summarized in the table below.

Prediction Limit Exceedances at Besser Quinn Quarry during the First Semi-Annual Monitoring Event in 2024

Well	Parameter	Result	Prediction Limit	Prediction Limit Type	Verified/ Awaiting verification
QNW	Barium, mg/L	0.314	0.2050	Nonparametric	Verified
	Manganese, mg/L	4.42	3.8243	Lognormal	Verified

The detection frequencies of the parameters in the up and down gradient monitoring wells are summarized in Table 3. Table 4 summarizes the results of the Shapiro-Wilk test. Table 5 is a summary of the statistics and prediction limits determined. Time series graphs of each of the parameters at each well with the corresponding prediction limits are attached.

A statistical power curve indicates the expected false assessments for the site as a whole. The false positive rate for interwell analyses is the percentage of failures when the upgradient versus downgradient true mean difference equals zero. False negative rate indicates the chance of missing contamination at a single well

for a single constituent. The statistical power is a function of the number of wells included, the number of constituents compared, the detection frequencies, and the data distributions involved. For interwell analysis, the site-wide false positive rate is 1% and the test becomes sensitive to 5 standard deviation unit increases over background.

Intrawell statistics

Intrawell statistics are appropriate for facilities where the upgradient wells do not accurately characterize the natural ground water conditions downgradient from the facility. This may be due to different hydrogeological conditions where the wells are screened, having too few upgradient wells to account for the spatial variability, or the site exhibiting no definable hydraulic gradient. Intrawell statistics compare new measurements to the historical data at each ground water monitoring well independently. It is recommended that at least eight background samples be obtained prior to performing the statistics.

The most useful technique for intrawell comparisons is the combined Shewhart-CUSUM control chart. This control chart procedure is useful because it will detect releases both in terms of the constituent concentration and cumulative increases. This method is also extremely sensitive to sudden and gradual releases. A requirement for constructing these control charts is that the parameter is detected at a frequency greater than or equal to 25%, otherwise the data variance is not properly defined.

The combined Shewhart-CUSUM control chart assumes that the data are independent and normally distributed with a fixed mean and a constant variance. Independent data is much more critical than the normality assumption. To achieve independence, it is recommended that data are collected no more frequently than quarterly to account for seasonal variation. The combined Shewhart-CUSUM control chart is extremely robust to deviations from normality. Because the control charts do not use a specific multiplier based on a normal distribution, it is more conservative to assume normality.

It is recommended that at least eight rounds of data be available to provide a reliable estimate of the mean and standard deviation of the parameter concentration, although the control charts will be generated with as few as four data points. Having only four data points may produce greater uncertainty in the mean and standard deviation of the background data, leading to higher control limits, thus having a potentially high false negative rate.

Many groundwater monitoring parameters are not detected at a frequency great enough to generate the combined Shewhart-CUSUM control charts. For constituents that are detected less than 25% of the time at a particular well, the data should be plotted as a time series until a sufficient number of data points are available to provide a 99% confidence nonparametric prediction limit. Thirteen independent measurements (with 1 resample) are necessary to achieve a 99% confidence (1% false positive rate) nonparametric prediction limit. Eight independent measurements (for pass 1 of 2 resamples) are necessary to achieve a 99% confidence nonparametric prediction limit. The nonparametric prediction limit is the largest determination out of the data set collected for that well and parameter. If the detection frequency is 0% after thirteen samples have been collected, the practical quantitation limit (PQL) becomes the nonparametric prediction limit.

In developing the statistical background, the historical data must be thoroughly screened for anomalous data due to sampling error, analytical error, or simply by chance alone. An erroneous data point, if not removed prior to the mean and variance computations, would yield a larger control limit thus increasing the false negative rate. The DUMPStat® program screens for outliers using the Dixon test. Anomalous data will still be plotted on the graphs (with a unique symbol) but will not be included in the calculations.

The verification resample plan is an integral function of the statistical plan to reduce the probability that anomalous data obtained after the background has been established, is indicative of a release.

The background data for each well and constituent is tested for existing trends using Sen's nonparametric estimate of trend. If contamination exists prior to completing the background, the control limits could be potentially high and this control chart method would not be able to detect an increasing trend unless the increase is severe.

Results of the Intrawell Statistics

The monitoring constituents at wells QE, QN, QNE, QNW, and QS were evaluated using the combined Shewhart-CUSUM control chart method. The previous background included the four rounds of data obtained from March 2020 through December 2020. Since a minimum of eight rounds of data is recommended, the background was updated to include data obtained from March 2020 through December 2022.

A summary of the intrawell statistics is included in Attachment D, Table 1 "Summary Statistics and Intermediate Computations for Combined Shewhart-CUSUM Control Charts." The control charts or time series graphs follow the summary table. For the most current data, the control limit exceedances detected are summarized in the table below. No increasing trends were detected in the background data.

Control Limit Exceedances During the First Semi-Annual Monitoring Event in 2024

Well	Parameter	Result	CUSUM value	Control Limit	Control Limit Type	Verified/ Awaiting Verification
QN	Manganese, mg/L	5.81	5.5427	2.5968	Normal	Awaiting verification

A control chart factor was selected to provide a balance of the site-wide false positive and false negative rates. A statistical power curve indicates the expected false assessments for the site as a whole. The site-wide false positive rate is 5% and the test becomes sensitive to 4 standard deviation units over background.

Attachment A

Ground Water Data

Table 1

Analytical Data Summary for 8/12/2024

Constituents	Units	QE	QN	QNE	QNW
Barium, Total	mg/L	.0659	.0486	.1090	.3140
Boron, Total	mg/L	.577	.374	.660	.211
Cobalt, Total	mg/L	.0058	.0041	.0009	.0087
Manganese, Total	mg/L	2.860	5.810	.402	4.420
Molybdenum, Total	mg/L	.0071	.0147	.0121	.0077
Nickel, Total	mg/L	.0130	.0094	.0052	.0181

* - The displayed value is the arithmetic mean of multiple database matches.

Table 1

Analytical Data Summary for 8/12/2024

Constituents	Units	QE	QN	QNE	QNW
Aluminum	mg/L	.078	.125	.092	2.460
Ammonia	mg/L	1.74	.61	1.52	.11
Antimony, total	mg/L	<.002	<.002	<.002	<.002
Arsenic, total	mg/L	.0099	.0092	<.0040	.0063
Barium, Total	mg/L	.0659	.0486	.1090	.3140
Beryllium, total	mg/L	<.004	<.004	<.004	<.004
Boron, Total	mg/L	.577	.374	.660	.211
Cadmium, total	mg/L	<.0008	<.0008	<.0008	<.0008
Chloride	mg/L	15.2	99.3	6.5	241.0
Chromium, total	mg/L	<.008	<.008	<.008	<.008
Cobalt, Total	mg/L	.0058	.0041	.0009	.0087
COD	mg/L	21	<20	<20	<20
Copper, total	mg/L	<.0040	<.0040	.0052	.0071
Fluoride	mg/L	<.1	.1	.1	.1
Formaldehyde	ug/L	<20	<20	<10	<10
Iron	mg/L	12.300	15.700	.161	13.800
Lead, total	mg/L	<.0040	<.0040	<.0040	.0042
Magnesium	mg/L	140.0	164.0	62.2	68.3
Manganese, Total	mg/L	2.860	5.810	.402	4.420
Mercury, total	mg/L	<.0005	<.0005	<.0005	<.0005
Molybdenum, Total	mg/L	.0071	.0147	.0121	.0077
Nickel, Total	mg/L	.0130	.0094	.0052	.0181
Phenols	mg/L	<.035	<.035	<.035	.053
Selenium, total	mg/L	<.004	<.004	<.004	<.004
Silver, total	mg/L	<.004	<.004	<.004	<.004
Sulfate	mg/L	901	1010	233	134
Thallium, total	mg/L	<.002	<.002	<.002	<.002
TOX	mg/L	.032	.092	<.010	.133
TSS	mg/L	852	87	6	626
Vanadium, total	mg/L	<.02	<.02	<.02	<.02
Zinc, total	mg/L	<.020	<.020	<.020	<.002

* - The displayed value is the arithmetic mean of multiple database matches.

Attachment B

Historical Ground Water Data

Table 1

Analytical Data Summary for QE

Constituents	Units	3/1/2020	6/15/2020	9/1/2020	12/9/2020	6/10/2021	12/9/2021	6/21/2022	12/6/2022	3/22/2023	6/19/2023	12/1/2023	8/12/2024
Barium, Total	mg/L	.1200	.1140	.0630	.0520	.0065	.0770	.0690	.1520	.0637	.0778	.0716	.0659
Boron, Total	mg/L	.293	.185	.524	.523	.504	.489	<.100	.645	.167	.385	.629	.577
Cobalt, Total	mg/L	.0048	.0020	.0004	.0042	.0017	.0024	.0023	.0293	.0066	.0076	.0085	.0058
Manganese, Total	mg/L	1.290	1.020	.808	.776	2.070	3.010	.719	1.500	1.390	3.030	1.480	2.860
Molybdenum, Total	mg/L	<.0100	<.0100	<.0100	.0100	<.0100	<.0100	<.0100	.0190	.0041	.0040	.0076	.0071
Nickel, Total	mg/L	.0110	<.0100	<.0100	.0150	<.0100	.0150	<.0100	.0430	.0157	.0116	.0248	.0130

* - The displayed value is the arithmetic mean of multiple database matches.

Table 2

Analytical Data Summary for QN

Constituents	Units	3/1/2020	6/15/2020	9/1/2020	12/9/2020	6/10/2021	12/9/2021	6/21/2022	12/6/2022	3/22/2023	6/19/2023	12/1/2023	8/12/2024
Barium, Total	mg/L	.2050	.0890	.0790	.1040	.1220	.1260	.0560	.0430	.0445	.0881	.0594	.0486
Boron, Total	mg/L	.544	.479	.481	.520	.661	.634	.124	.523	.654	.603	.488	.374
Cobalt, Total	mg/L	.0039	.0035	.0029	.0039	.0034	.0025	.0008	.0059	.0027	.0061	.0025	.0041
Manganese, Total	mg/L	1.150	.945	.857	1.100	.955	.614	.333	.922	.782	.689	.691	5.810
Molybdenum, Total	mg/L	.3580	.2650	.2460	.2500	.2230	.1840	.0240	.1340	.1240	.1150	.0900	.0147
Nickel, Total	mg/L	.0190	.0200	.0170	.0160	.0130	.0170	.0200	.0250	.0106	.0121	.0169	.0094

* - The displayed value is the arithmetic mean of multiple database matches.

Table 3

Analytical Data Summary for QNE

Constituents	Units	3/1/2020	6/15/2020	9/1/2020	12/9/2020	6/10/2021	12/9/2021	6/21/2022	12/6/2022	3/22/2023	6/19/2023	12/1/2023	8/12/2024
Barium, Total	mg/L	.1490	.1040	.0940	.0970	.0960	.0970	.1000	.0960	.0907	.1000	.0992	.1090
Boron, Total	mg/L	1.1500	.4760	.0752	.7390	.7490	.7300	.6080	.6320	.6710	.6200	.6250	.6600
Cobalt, Total	mg/L	.0038	.0019	.0011	.0013	.0006	.0007	.0005	.0043	.0011	.0062	.0027	.0009
Manganese, Total	mg/L	1.460	.616	.698	.604	.397	.431	.313	.399	.639	.347	.555	.402
Molybdenum, Total	mg/L	.1150	.0210	.0230	.0230	.0200	.0200	.0180	.0140	.0129	.0117	.0127	.0121
Nickel, Total	mg/L	.0160	.0180	.0150	.0120	<.0100	<.0100	<.0100	<.0100	.0053	.0044	.0066	.0052

* - The displayed value is the arithmetic mean of multiple database matches.

Table 4

Analytical Data Summary for QNW

Constituents	Units	3/1/2020	6/15/2020	9/1/2020	12/9/2020	6/10/2021	12/9/2021	6/21/2022	12/6/2022	3/22/2023	6/19/2023	12/1/2023	8/12/2024
Barium, Total	mg/L	.226	.170	.245	.287	.260	.309	1.820	1.400	.195	.249	9.410	.314
Boron, Total	mg/L	.174	<.010	.198	.247	.163	.277	.122	.296	.147	.138	1.290	.211
Cobalt, Total	mg/L	.0033	.0074	.0004	.0004	.0033	.0067	.0804	.0581	.0007	.0030	.7270	.0087
Manganese, Total	mg/L	1.040	.302	.056	.045	.701	.714	5.240	9.880	.105	.512	49.900	4.420
Molybdenum, Total	mg/L	<.0100	<.0100	<.0100	<.0100	<.0100	<.0100	.0180	.0200	<.0040	<.0040	.1550	.0077
Nickel, Total	mg/L	<.0100	.0100	<.0100	<.0100	<.0100	<.0100	.1000	.0910	.0040	.0056	1.3700	.0181

* - The displayed value is the arithmetic mean of multiple database matches.

Table 5

Analytical Data Summary for QS

Constituents	Units	3/1/2020	6/15/2020	9/1/2020	12/9/2020	6/10/2021	12/9/2021	6/21/2022	12/6/2022	3/22/2023	6/19/2023	12/1/2023
Barium, Total	mg/L	2.990	.256	.250	.384	.261	.202	3.890	2.680	.188	.719	22.500
Boron, Total	mg/L	.162	<.010	<.010	<.010	.114	<.100	.139	.135	<.100	.106	<1.000
Cobalt, Total	mg/L	.2270	.0103	.0064	.0135	.0070	.0038	.2260	.1920	<.0004	.0357	1.6200
Manganese, Total	mg/L	16.600	.658	.419	1.080	.429	.078	20.000	12.000	<.004	2.420	93.100
Molybdenum, Total	mg/L	.020	<.010	<.010	<.010	<.010	<.010	.022	.014	<.004	<.004	.067
Nickel, Total	mg/L	.3380	.0210	.0150	.0250	.0120	<.0100	.3360	.2290	<.0040	.0456	1.8900

* - The displayed value is the arithmetic mean of multiple database matches.

Table 6

Analytical Data Summary for QW

Constituents	Units	3/1/2020	6/15/2020	9/1/2020	12/9/2020	6/10/2021	12/9/2021	6/21/2022
Barium, Total	mg/L	.176	.151	.156	.170	.284	.189	.628
Boron, Total	mg/L	<.01	<.01	<.01	<.01	<.01	<.10	<.10
Cobalt, Total	mg/L	.0012	.0004	.0004	.0009	.0082	.0013	.0308
Manganese, Total	mg/L	.082	.024	.023	.049	.504	.059	2.020
Molybdenum, Total	mg/L	<.01	<.01	<.01	<.01	<.01	<.01	<.01
Nickel, Total	mg/L	<.010	<.010	<.010	<.010	.016	<.010	.053

* - The displayed value is the arithmetic mean of multiple database matches.

Attachment C

Summary Tables and Graphs for the Interwell Comparisons

Table 1

Upgradient Data

Constituent	Units	Well	Date		Result	Adjusted	
Barium, Total	mg/L	QE	03/01/2020		0.1200		
Barium, Total	mg/L	QE	06/15/2020		0.1140		
Barium, Total	mg/L	QE	09/01/2020		0.0630		
Barium, Total	mg/L	QE	12/09/2020		0.0520		
Barium, Total	mg/L	QE	06/10/2021		0.0065		*
Barium, Total	mg/L	QE	12/09/2021		0.0770		
Barium, Total	mg/L	QE	06/21/2022		0.0690		
Barium, Total	mg/L	QE	12/06/2022		0.1520		
Barium, Total	mg/L	QE	03/22/2023		0.0637		
Barium, Total	mg/L	QE	06/19/2023		0.0778		
Barium, Total	mg/L	QE	12/01/2023		0.0716		
Barium, Total	mg/L	QE	08/12/2024		0.0659		
Boron, Total	mg/L	QE	03/01/2020		0.2930		
Boron, Total	mg/L	QE	06/15/2020		0.1850		
Boron, Total	mg/L	QE	09/01/2020		0.5240		
Boron, Total	mg/L	QE	12/09/2020		0.5230		
Boron, Total	mg/L	QE	06/10/2021		0.5040		
Boron, Total	mg/L	QE	12/09/2021		0.4890		
Boron, Total	mg/L	QE	06/21/2022	ND	0.1000		
Boron, Total	mg/L	QE	12/06/2022		0.6450		
Boron, Total	mg/L	QE	03/22/2023		0.1670		
Boron, Total	mg/L	QE	06/19/2023		0.3850		
Boron, Total	mg/L	QE	12/01/2023		0.6290		
Boron, Total	mg/L	QE	08/12/2024		0.5770		
Cobalt, Total	mg/L	QE	03/01/2020		0.0048		
Cobalt, Total	mg/L	QE	06/15/2020		0.0020		
Cobalt, Total	mg/L	QE	09/01/2020		0.0004		
Cobalt, Total	mg/L	QE	12/09/2020		0.0042		
Cobalt, Total	mg/L	QE	06/10/2021		0.0017		
Cobalt, Total	mg/L	QE	12/09/2021		0.0024		
Cobalt, Total	mg/L	QE	06/21/2022		0.0023		
Cobalt, Total	mg/L	QE	12/06/2022		0.0293		
Cobalt, Total	mg/L	QE	03/22/2023		0.0066		
Cobalt, Total	mg/L	QE	06/19/2023		0.0076		
Cobalt, Total	mg/L	QE	12/01/2023		0.0085		
Cobalt, Total	mg/L	QE	08/12/2024		0.0058		
Manganese, Total	mg/L	QE	03/01/2020		1.2900		
Manganese, Total	mg/L	QE	06/15/2020		1.0200		
Manganese, Total	mg/L	QE	09/01/2020		0.8080		
Manganese, Total	mg/L	QE	12/09/2020		0.7760		
Manganese, Total	mg/L	QE	06/10/2021		2.0700		
Manganese, Total	mg/L	QE	12/09/2021		3.0100		
Manganese, Total	mg/L	QE	06/21/2022		0.7190		
Manganese, Total	mg/L	QE	12/06/2022		1.5000		
Manganese, Total	mg/L	QE	03/22/2023		1.3900		
Manganese, Total	mg/L	QE	06/19/2023		3.0300		
Manganese, Total	mg/L	QE	12/01/2023		1.4800		
Manganese, Total	mg/L	QE	08/12/2024		2.8600		
Molybdenum, Total	mg/L	QE	03/01/2020	ND	0.0100		
Molybdenum, Total	mg/L	QE	06/15/2020	ND	0.0100		
Molybdenum, Total	mg/L	QE	09/01/2020	ND	0.0100		
Molybdenum, Total	mg/L	QE	12/09/2020		0.0100		
Molybdenum, Total	mg/L	QE	06/10/2021	ND	0.0100		
Molybdenum, Total	mg/L	QE	12/09/2021	ND	0.0100		
Molybdenum, Total	mg/L	QE	06/21/2022	ND	0.0100		
Molybdenum, Total	mg/L	QE	12/06/2022		0.0190		
Molybdenum, Total	mg/L	QE	03/22/2023		0.0041		
Molybdenum, Total	mg/L	QE	06/19/2023		0.0040		
Molybdenum, Total	mg/L	QE	12/01/2023		0.0076		
Molybdenum, Total	mg/L	QE	08/12/2024		0.0071		
Nickel, Total	mg/L	QE	03/01/2020		0.0110		
Nickel, Total	mg/L	QE	06/15/2020	ND	0.0100		
Nickel, Total	mg/L	QE	09/01/2020	ND	0.0100		
Nickel, Total	mg/L	QE	12/09/2020		0.0150		
Nickel, Total	mg/L	QE	06/10/2021	ND	0.0100		
Nickel, Total	mg/L	QE	12/09/2021		0.0150		
Nickel, Total	mg/L	QE	06/21/2022	ND	0.0100		
Nickel, Total	mg/L	QE	12/06/2022		0.0430		*
Nickel, Total	mg/L	QE	03/22/2023		0.0157		
Nickel, Total	mg/L	QE	06/19/2023		0.0116		
Nickel, Total	mg/L	QE	12/01/2023		0.0248		
Nickel, Total	mg/L	QE	08/12/2024		0.0130		
Barium, Total	mg/L	QN	03/01/2020		0.2050		
Barium, Total	mg/L	QN	06/15/2020		0.0890		

* - Outlier for that well and constituent.
** - ND value replaced with median RL.
*** - ND value replaced with manual RL.
ND = Not detected, Result = detection limit.

Table 1

Upgradient Data

Constituent	Units	Well	Date		Result	Adjusted	
Barium, Total	mg/L	QN	09/01/2020		0.0790		
Barium, Total	mg/L	QN	12/09/2020		0.1040		
Barium, Total	mg/L	QN	06/10/2021		0.1220		
Barium, Total	mg/L	QN	12/09/2021		0.1260		
Barium, Total	mg/L	QN	06/21/2022		0.0560		
Barium, Total	mg/L	QN	12/06/2022		0.0430		
Barium, Total	mg/L	QN	03/22/2023		0.0445		
Barium, Total	mg/L	QN	06/19/2023		0.0881		
Barium, Total	mg/L	QN	12/01/2023		0.0594		
Barium, Total	mg/L	QN	08/12/2024		0.0486		
Boron, Total	mg/L	QN	03/01/2020		0.5440		
Boron, Total	mg/L	QN	06/15/2020		0.4790		
Boron, Total	mg/L	QN	09/01/2020		0.4810		
Boron, Total	mg/L	QN	12/09/2020		0.5200		
Boron, Total	mg/L	QN	06/10/2021		0.6610		
Boron, Total	mg/L	QN	12/09/2021		0.6340		
Boron, Total	mg/L	QN	06/21/2022		0.1240		*
Boron, Total	mg/L	QN	12/06/2022		0.5230		
Boron, Total	mg/L	QN	03/22/2023		0.6540		
Boron, Total	mg/L	QN	06/19/2023		0.6030		
Boron, Total	mg/L	QN	12/01/2023		0.4880		
Boron, Total	mg/L	QN	08/12/2024		0.3740		
Cobalt, Total	mg/L	QN	03/01/2020		0.0039		
Cobalt, Total	mg/L	QN	06/15/2020		0.0035		
Cobalt, Total	mg/L	QN	09/01/2020		0.0029		
Cobalt, Total	mg/L	QN	12/09/2020		0.0039		
Cobalt, Total	mg/L	QN	06/10/2021		0.0034		
Cobalt, Total	mg/L	QN	12/09/2021		0.0025		
Cobalt, Total	mg/L	QN	06/21/2022		0.0008		
Cobalt, Total	mg/L	QN	12/06/2022		0.0059		
Cobalt, Total	mg/L	QN	03/22/2023		0.0027		
Cobalt, Total	mg/L	QN	06/19/2023		0.0061		
Cobalt, Total	mg/L	QN	12/01/2023		0.0025		
Cobalt, Total	mg/L	QN	08/12/2024		0.0041		
Manganese, Total	mg/L	QN	03/01/2020		1.1500		
Manganese, Total	mg/L	QN	06/15/2020		0.9450		
Manganese, Total	mg/L	QN	09/01/2020		0.8570		
Manganese, Total	mg/L	QN	12/09/2020		1.1000		
Manganese, Total	mg/L	QN	06/10/2021		0.9550		
Manganese, Total	mg/L	QN	12/09/2021		0.6140		
Manganese, Total	mg/L	QN	06/21/2022		0.3330		
Manganese, Total	mg/L	QN	12/06/2022		0.9220		
Manganese, Total	mg/L	QN	03/22/2023		0.7820		
Manganese, Total	mg/L	QN	06/19/2023		0.6890		
Manganese, Total	mg/L	QN	12/01/2023		0.6910		
Manganese, Total	mg/L	QN	08/12/2024		5.8100		*
Molybdenum, Total	mg/L	QN	03/01/2020		0.3580		
Molybdenum, Total	mg/L	QN	06/15/2020		0.2650		
Molybdenum, Total	mg/L	QN	09/01/2020		0.2460		
Molybdenum, Total	mg/L	QN	12/09/2020		0.2500		
Molybdenum, Total	mg/L	QN	06/10/2021		0.2230		
Molybdenum, Total	mg/L	QN	12/09/2021		0.1840		
Molybdenum, Total	mg/L	QN	06/21/2022		0.0240		
Molybdenum, Total	mg/L	QN	12/06/2022		0.1340		
Molybdenum, Total	mg/L	QN	03/22/2023		0.1240		
Molybdenum, Total	mg/L	QN	06/19/2023		0.1150		
Molybdenum, Total	mg/L	QN	12/01/2023		0.0900		
Molybdenum, Total	mg/L	QN	08/12/2024		0.0147		
Nickel, Total	mg/L	QN	03/01/2020		0.0190		
Nickel, Total	mg/L	QN	06/15/2020		0.0200		
Nickel, Total	mg/L	QN	09/01/2020		0.0170		
Nickel, Total	mg/L	QN	12/09/2020		0.0160		
Nickel, Total	mg/L	QN	06/10/2021		0.0130		
Nickel, Total	mg/L	QN	12/09/2021		0.0170		
Nickel, Total	mg/L	QN	06/21/2022		0.0200		
Nickel, Total	mg/L	QN	12/06/2022		0.0250		
Nickel, Total	mg/L	QN	03/22/2023		0.0106		
Nickel, Total	mg/L	QN	06/19/2023		0.0121		
Nickel, Total	mg/L	QN	12/01/2023		0.0169		
Nickel, Total	mg/L	QN	08/12/2024		0.0094		
Barium, Total	mg/L	QNE	03/01/2020		0.1490		
Barium, Total	mg/L	QNE	06/15/2020		0.1040		
Barium, Total	mg/L	QNE	09/01/2020		0.0940		
Barium, Total	mg/L	QNE	12/09/2020		0.0970		

* - Outlier for that well and constituent.
** - ND value replaced with median RL.
*** - ND value replaced with manual RL.
ND = Not detected, Result = detection limit.

Table 1

Upgradient Data

Constituent	Units	Well	Date		Result	Adjusted	
Barium, Total	mg/L	QNE	06/10/2021		0.0960		
Barium, Total	mg/L	QNE	12/09/2021		0.0970		
Barium, Total	mg/L	QNE	06/21/2022		0.1000		
Barium, Total	mg/L	QNE	12/06/2022		0.0960		
Barium, Total	mg/L	QNE	03/22/2023		0.0907		
Barium, Total	mg/L	QNE	06/19/2023		0.1000		
Barium, Total	mg/L	QNE	12/01/2023		0.0992		
Barium, Total	mg/L	QNE	08/12/2024		0.1090		
Boron, Total	mg/L	QNE	03/01/2020		1.1500		
Boron, Total	mg/L	QNE	06/15/2020		0.4760		
Boron, Total	mg/L	QNE	09/01/2020		0.0752		*
Boron, Total	mg/L	QNE	12/09/2020		0.7390		
Boron, Total	mg/L	QNE	06/10/2021		0.7490		
Boron, Total	mg/L	QNE	12/09/2021		0.7300		
Boron, Total	mg/L	QNE	06/21/2022		0.6080		
Boron, Total	mg/L	QNE	12/06/2022		0.6320		
Boron, Total	mg/L	QNE	03/22/2023		0.6710		
Boron, Total	mg/L	QNE	06/19/2023		0.6200		
Boron, Total	mg/L	QNE	12/01/2023		0.6250		
Boron, Total	mg/L	QNE	08/12/2024		0.6600		
Cobalt, Total	mg/L	QNE	03/01/2020		0.0038		
Cobalt, Total	mg/L	QNE	06/15/2020		0.0019		
Cobalt, Total	mg/L	QNE	09/01/2020		0.0011		
Cobalt, Total	mg/L	QNE	12/09/2020		0.0013		
Cobalt, Total	mg/L	QNE	06/10/2021		0.0006		
Cobalt, Total	mg/L	QNE	12/09/2021		0.0007		
Cobalt, Total	mg/L	QNE	06/21/2022		0.0005		
Cobalt, Total	mg/L	QNE	12/06/2022		0.0043		
Cobalt, Total	mg/L	QNE	03/22/2023		0.0011		
Cobalt, Total	mg/L	QNE	06/19/2023		0.0062		
Cobalt, Total	mg/L	QNE	12/01/2023		0.0027		
Cobalt, Total	mg/L	QNE	08/12/2024		0.0009		
Manganese, Total	mg/L	QNE	03/01/2020		1.4600		
Manganese, Total	mg/L	QNE	06/15/2020		0.6160		
Manganese, Total	mg/L	QNE	09/01/2020		0.6980		
Manganese, Total	mg/L	QNE	12/09/2020		0.6040		
Manganese, Total	mg/L	QNE	06/10/2021		0.3970		
Manganese, Total	mg/L	QNE	12/09/2021		0.4310		
Manganese, Total	mg/L	QNE	06/21/2022		0.3130		
Manganese, Total	mg/L	QNE	12/06/2022		0.3990		
Manganese, Total	mg/L	QNE	03/22/2023		0.6390		
Manganese, Total	mg/L	QNE	06/19/2023		0.3470		
Manganese, Total	mg/L	QNE	12/01/2023		0.5550		
Manganese, Total	mg/L	QNE	08/12/2024		0.4020		
Molybdenum, Total	mg/L	QNE	03/01/2020		0.1150		*
Molybdenum, Total	mg/L	QNE	06/15/2020		0.0210		
Molybdenum, Total	mg/L	QNE	09/01/2020		0.0230		
Molybdenum, Total	mg/L	QNE	12/09/2020		0.0230		
Molybdenum, Total	mg/L	QNE	06/10/2021		0.0200		
Molybdenum, Total	mg/L	QNE	12/09/2021		0.0200		
Molybdenum, Total	mg/L	QNE	06/21/2022		0.0180		
Molybdenum, Total	mg/L	QNE	12/06/2022		0.0140		
Molybdenum, Total	mg/L	QNE	03/22/2023		0.0129		
Molybdenum, Total	mg/L	QNE	06/19/2023		0.0117		
Molybdenum, Total	mg/L	QNE	12/01/2023		0.0127		
Molybdenum, Total	mg/L	QNE	08/12/2024		0.0121		
Nickel, Total	mg/L	QNE	03/01/2020		0.0160		
Nickel, Total	mg/L	QNE	06/15/2020		0.0180		
Nickel, Total	mg/L	QNE	09/01/2020		0.0150		
Nickel, Total	mg/L	QNE	12/09/2020		0.0120		
Nickel, Total	mg/L	QNE	06/10/2021	ND	0.0100		
Nickel, Total	mg/L	QNE	12/09/2021	ND	0.0100		
Nickel, Total	mg/L	QNE	06/21/2022	ND	0.0100		
Nickel, Total	mg/L	QNE	12/06/2022	ND	0.0100		
Nickel, Total	mg/L	QNE	03/22/2023		0.0053		
Nickel, Total	mg/L	QNE	06/19/2023		0.0044		
Nickel, Total	mg/L	QNE	12/01/2023		0.0066		
Nickel, Total	mg/L	QNE	08/12/2024		0.0052		

* - Outlier for that well and constituent.
** - ND value replaced with median RL.
*** - ND value replaced with manual RL.
ND = Not detected, Result = detection limit.

Table 2

Most Current Downgradient Monitoring Data

Constituent	Units	Well	Date	Result		Pred. Limit
Barium, Total	mg/L	QNW	08/12/2024	0.3140	***	0.2050
Boron, Total	mg/L	QNW	08/12/2024	0.2110	**	1.0374
Cobalt, Total	mg/L	QNW	08/12/2024	0.0087	**	0.0249
Manganese, Total	mg/L	QNW	08/12/2024	4.4200	***	3.8243
Molybdenum, Total	mg/L	QNW	08/12/2024	0.0077		0.3047
Nickel, Total	mg/L	QNW	08/12/2024	0.0181	**	0.0300

* - Current value failed - awaiting verification.
** - Current value passed - previous exceedance not verified.
*** - Current value failed - exceedance verified.
**** - Current value passed - awaiting one more verification.
***** - Insufficient background data to compute prediction limit.
ND = Not Detected, Result = detection limit.

Table 3

Detection Frequencies in Upgradient and Downgradient Wells

Constituent	Upgradient Detect	Upgradient N	Upgradient Proportion	Downgradient Detect	Downgradient N	Downgradient Proportion
Barium, Total	35	35	1.000	12	12	1.000
Boron, Total	33	34	0.971	11	12	0.917
Cobalt, Total	36	36	1.000	12	12	1.000
Manganese, Total	35	35	1.000	12	12	1.000
Molybdenum, Total	29	35	0.829	4	12	0.333
Nickel, Total	27	35	0.771	7	12	0.583

N = Total number of measurements in all wells.
Detect = Total number of detections in all wells.
Proportion = Detect/N.

Table 4

Shapiro-Wilk Multiple Group Test of Normality

Constituent	Detect	N	Detect Freq	G raw	G log	G cbrt	G sqrt	G sqr	G cub	Crit Value	Dist Form	Model Type
Barium, Total	35	35	1.000	4.486	2.610					2.326	non-norm	nonpar
Boron, Total	33	34	0.971	2.062	2.200					2.326	normal	normal
Cobalt, Total	36	36	1.000	3.537	0.696					2.326	lognor	lognor
Manganese, Total	35	35	1.000	2.520	1.979					2.326	lognor	lognor
Molybdenum, Total	29	35	0.829	1.107	1.905					2.326	normal	normal
Nickel, Total	27	35	0.771	1.206	0.900					2.326	normal	normal

* - Distribution override for that constituent.
Fit to distribution is confirmed if G <= critical value.
Model type may not match distributional form when detection frequency < 50%.

Table 5

Summary Statistics and Prediction Limits

Constituent	Units	Detect	N	Mean	SD	alpha	Factor	Pred Limit	Type	Conf
Barium, Total	mg/L	35	35					0.2050	nonpar	0.99
Boron, Total	mg/L	33	34	0.5454	0.1984	0.0100	2.4803	1.0374	normal	
Cobalt, Total	mg/L	36	36	-5.9325	0.9060	0.0100	2.4712	0.0249	lognor	
Manganese, Total	mg/L	35	35	-0.1688	0.6100	0.0100	2.4756	3.8243	lognor	
Molybdenum, Total	mg/L	29	35	0.0648	0.0969	0.0100	2.4756	0.3047	normal	
Nickel, Total	mg/L	27	35	0.0110	0.0077	0.0100	2.4756	0.0300	normal	

Conf = confidence level for passing initial test or one verification resample at all downgradient wells for a single constituent (nonparametric test only).
* - Insufficient Data.
** - Calculated limit raised to Manual Reporting Limit.
*** - Nonparametric limit based on ND value.
For transformed data, mean and SD in transformed units and prediction limit in original units.
All sample sizes and statistics are based on outlier free data.
For nonparametric limits, median reporting limits are substituted for extreme reporting limit values.

Table 6

Dixon's Test Outliers
1% Significance Level

Constituent	Units	Well	Date	Result	ND Qualifier	Date Range	N	Critical Value
Barium, Total	mg/L	QE	06/10/2021	0.0065		03/01/2020-08/12/2024	12	0.6425
Nickel, Total	mg/L	QE	12/06/2022	0.0430		03/01/2020-08/12/2024	12	0.6425
Boron, Total	mg/L	QN	06/21/2022	0.1240		03/01/2020-08/12/2024	12	0.6425
Manganese, Total	mg/L	QN	08/12/2024	5.8100		03/01/2020-08/12/2024	12	0.6425
Boron, Total	mg/L	QNE	09/01/2020	0.0752		03/01/2020-08/12/2024	12	0.6425
Molybdenum, Total	mg/L	QNE	03/01/2020	0.1150		03/01/2020-08/12/2024	12	0.6425

N = Total number of independent measurements in background at each well.
Date Range = Dates of the first and last measurements included in background at each well.
Critical Value depends on the significance level and on N-1 when the two most extreme values are tested or N for the most extreme value.

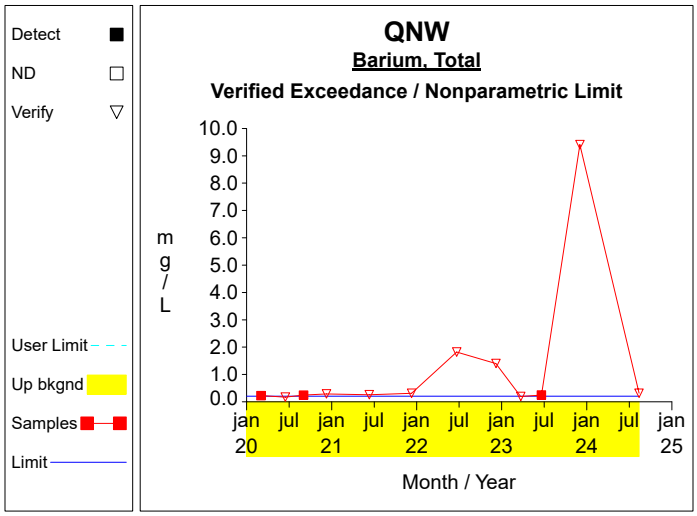
Table 8

Historical Downgradient Data for Constituent-Well Combinations that Failed the Current Statistical Evaluation or are in Verification Resampling Mode

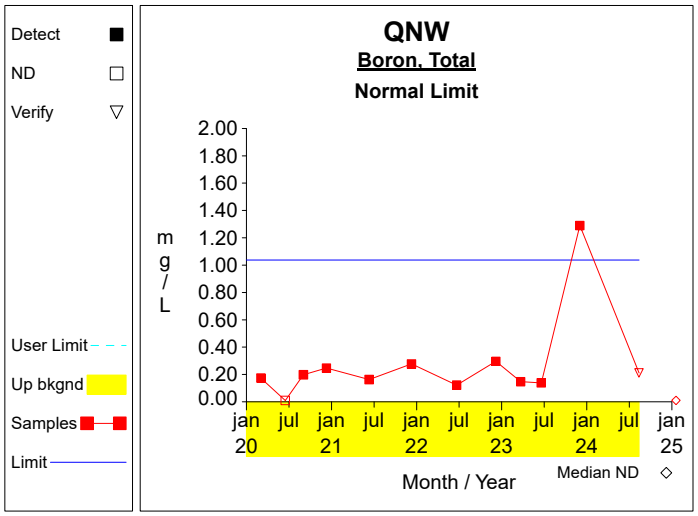
Constituent	Units	Well	Date		Result		Pred. Limit
Barium, Total	mg/L	QNW	03/01/2020		0.2260	*	0.2050
Barium, Total	mg/L	QNW	06/15/2020		0.1700		0.2050
Barium, Total	mg/L	QNW	09/01/2020		0.2450	*	0.2050
Barium, Total	mg/L	QNW	12/09/2020		0.2870	*	0.2050
Barium, Total	mg/L	QNW	06/10/2021		0.2600	*	0.2050
Barium, Total	mg/L	QNW	12/09/2021		0.3090	*	0.2050
Barium, Total	mg/L	QNW	06/21/2022		1.8200	*	0.2050
Barium, Total	mg/L	QNW	12/06/2022		1.4000	*	0.2050
Barium, Total	mg/L	QNW	03/22/2023		0.1950		0.2050
Barium, Total	mg/L	QNW	06/19/2023		0.2490	*	0.2050
Barium, Total	mg/L	QNW	12/01/2023		9.4100	*	0.2050
Barium, Total	mg/L	QNW	08/12/2024		0.3140	*	0.2050
Boron, Total	mg/L	QNW	03/01/2020		0.1740		1.0374
Boron, Total	mg/L	QNW	06/15/2020	ND	0.0100		1.0374
Boron, Total	mg/L	QNW	09/01/2020		0.1980		1.0374
Boron, Total	mg/L	QNW	12/09/2020		0.2470		1.0374
Boron, Total	mg/L	QNW	06/10/2021		0.1630		1.0374
Boron, Total	mg/L	QNW	12/09/2021		0.2770		1.0374
Boron, Total	mg/L	QNW	06/21/2022		0.1220		1.0374
Boron, Total	mg/L	QNW	12/06/2022		0.2960		1.0374
Boron, Total	mg/L	QNW	03/22/2023		0.1470		1.0374
Boron, Total	mg/L	QNW	06/19/2023		0.1380		1.0374
Boron, Total	mg/L	QNW	12/01/2023		1.2900	*	1.0374
Boron, Total	mg/L	QNW	08/12/2024		0.2110		1.0374
Cobalt, Total	mg/L	QNW	03/01/2020		0.0033		0.0249
Cobalt, Total	mg/L	QNW	06/15/2020		0.0074		0.0249
Cobalt, Total	mg/L	QNW	09/01/2020		0.0004		0.0249
Cobalt, Total	mg/L	QNW	12/09/2020		0.0004		0.0249
Cobalt, Total	mg/L	QNW	06/10/2021		0.0033		0.0249
Cobalt, Total	mg/L	QNW	12/09/2021		0.0067		0.0249
Cobalt, Total	mg/L	QNW	06/21/2022		0.0804	*	0.0249
Cobalt, Total	mg/L	QNW	12/06/2022		0.0581	*	0.0249
Cobalt, Total	mg/L	QNW	03/22/2023		0.0007		0.0249
Cobalt, Total	mg/L	QNW	06/19/2023		0.0030		0.0249
Cobalt, Total	mg/L	QNW	12/01/2023		0.7270	*	0.0249
Cobalt, Total	mg/L	QNW	08/12/2024		0.0087		0.0249
Manganese, Total	mg/L	QNW	03/01/2020		1.0400		3.8243
Manganese, Total	mg/L	QNW	06/15/2020		0.3020		3.8243
Manganese, Total	mg/L	QNW	09/01/2020		0.0560		3.8243
Manganese, Total	mg/L	QNW	12/09/2020		0.0450		3.8243
Manganese, Total	mg/L	QNW	06/10/2021		0.7010		3.8243
Manganese, Total	mg/L	QNW	12/09/2021		0.7140		3.8243
Manganese, Total	mg/L	QNW	06/21/2022		5.2400	*	3.8243
Manganese, Total	mg/L	QNW	12/06/2022		9.8800	*	3.8243
Manganese, Total	mg/L	QNW	03/22/2023		0.1050		3.8243
Manganese, Total	mg/L	QNW	06/19/2023		0.5120		3.8243
Manganese, Total	mg/L	QNW	12/01/2023		49.9000	*	3.8243
Manganese, Total	mg/L	QNW	08/12/2024		4.4200	*	3.8243
Nickel, Total	mg/L	QNW	03/01/2020	ND	0.0100		0.0300
Nickel, Total	mg/L	QNW	06/15/2020		0.0100		0.0300
Nickel, Total	mg/L	QNW	09/01/2020	ND	0.0100		0.0300
Nickel, Total	mg/L	QNW	12/09/2020	ND	0.0100		0.0300
Nickel, Total	mg/L	QNW	06/10/2021	ND	0.0100		0.0300
Nickel, Total	mg/L	QNW	12/09/2021	ND	0.0100		0.0300
Nickel, Total	mg/L	QNW	06/21/2022		0.1000	*	0.0300
Nickel, Total	mg/L	QNW	12/06/2022		0.0910	*	0.0300
Nickel, Total	mg/L	QNW	03/22/2023		0.0040		0.0300
Nickel, Total	mg/L	QNW	06/19/2023		0.0056		0.0300
Nickel, Total	mg/L	QNW	12/01/2023		1.3700	*	0.0300
Nickel, Total	mg/L	QNW	08/12/2024		0.0181		0.0300

* - Significantly increased over background.
** - Detect at limit for 100% NDs in background (NPPL only).
*** - Manual exclusion.
ND = Not Detected, Result = detection limit.

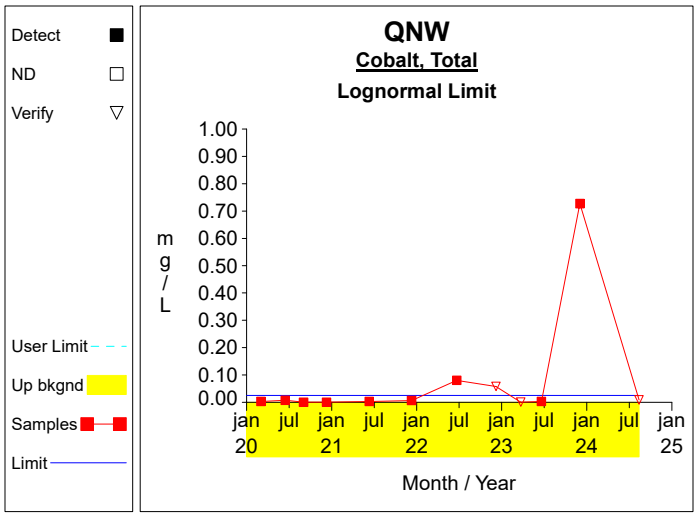
Up vs. Down Prediction Limits



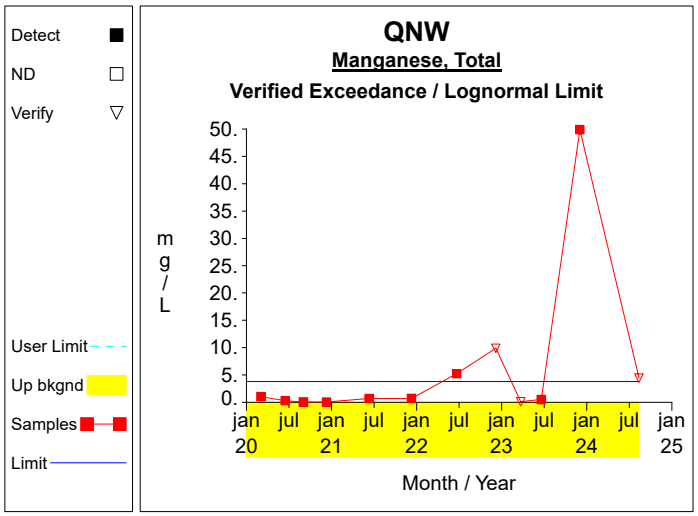
Graph 1



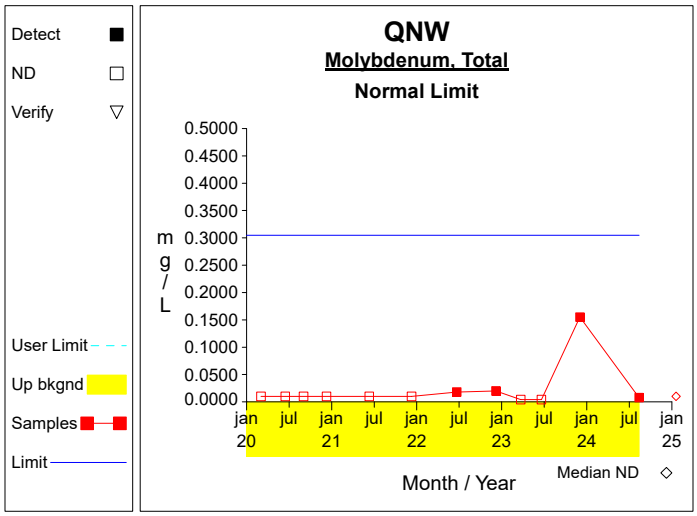
Graph 2



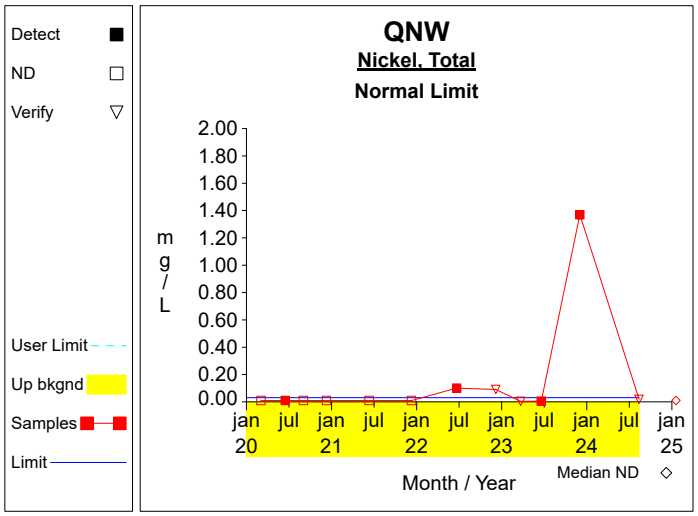
Graph 3



Graph 4



Graph 5

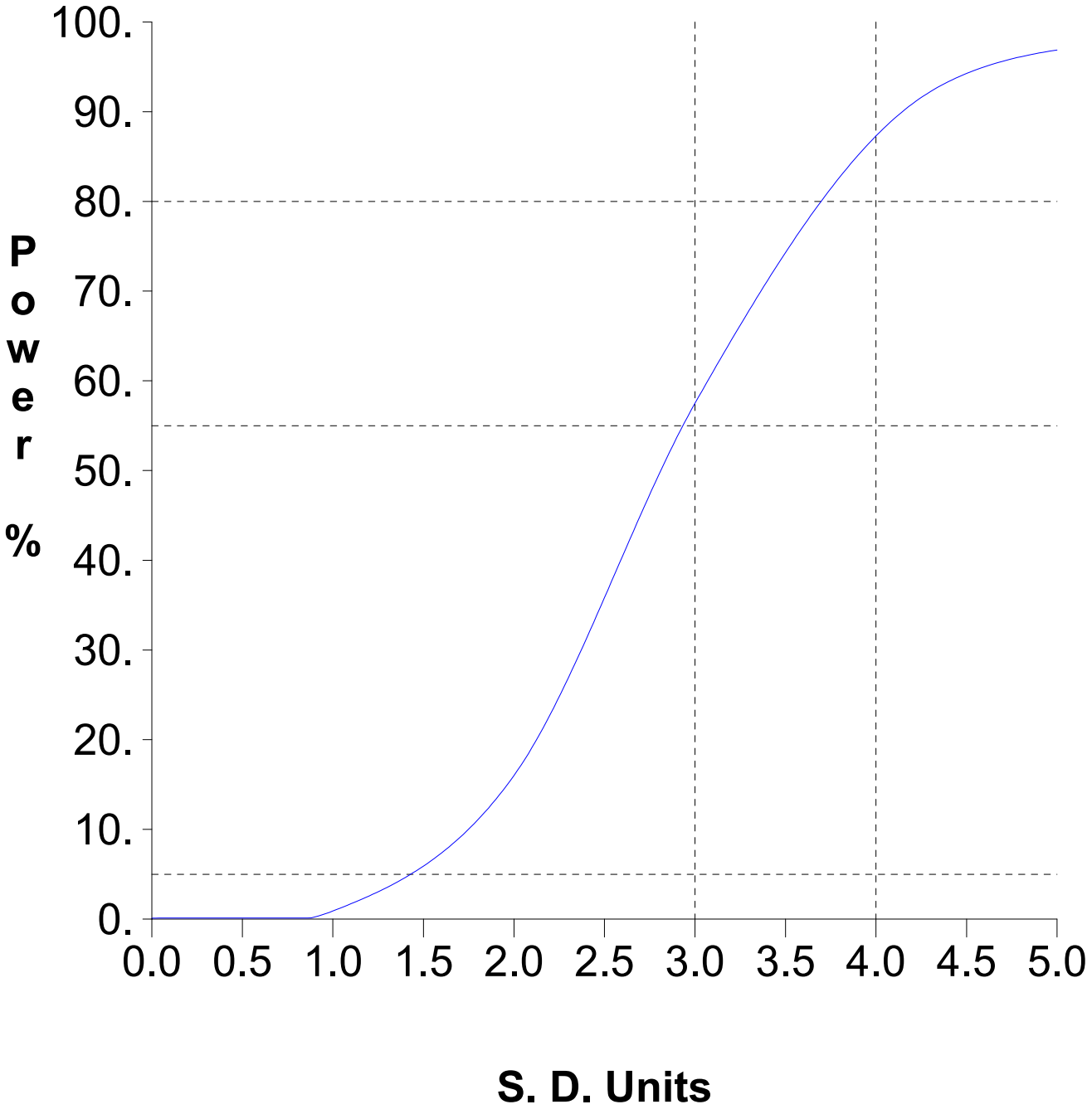


Graph 6

Prepared by: Otter Creek Environmental

False Positive and False Negative Rates for Current

Upgradient vs. Downgradient Monitoring Program



Worksheet 1 - Upgradient vs. Downgradient Comparisons
Barium, Total (mg/L)
Nonparametric Prediction Limit

Step	Equation	Description
1	PL = max(X) = **0.205**	Compute nonparametric prediction limit as largest background measurement.
2	Conf = **0.99**	Confidence level is based on N, K and resampling strategy (see Gibbons 1994).

Worksheet 1 - Upgradient vs. Downgradient Comparisons
Boron, Total (mg/L)
Normal Prediction Limit

Step	Equation	Description
1	$\overline{X}_1$ = **sum[X_1]** / **N_1** = **18.542** / **33** = **0.562**	Compute mean of N_1 detected measurements.
2	S_1 = ((**sum[X_1^2]**-**sum[X_1]**^{2}/**N_1**) / (**N_1**-1))^{½} = ((**11.41**-**343.806**/**33**) / (**33**-1))^{½} = **0.176**	Compute sd of N_1 detected measurements.
3	$\overline{X}$ = (1 - **N_0**/**N**) $\overline{\mathbf{X}}_1$ = (1 - **1**/**34**) **0.562** = **0.545**	Use Aitchison's method to adjust mean for presence of nondetects.
4	S = [(1 - **N_0**/**N**) * **S_1^2** + (**N_0**/**N**) (1 - (**N_0**-1)/(**N**-1)) $\overline{\mathbf{X}}_1^2$]^{½} = [(1 - **1**/**34**) * **0.176**^{2} + (**1**/**34**) (1 - (**1**-1)/(**34**-1)) **0.562**^{2}]^{½} = **0.198**	Use Aitchison's method to adjust sd for presence of nondetects.
5	alpha = min[(1-.95$^{1/\mathbf{K}}$)^{½}, .01] = min[(1-.95$^{1/\mathbf{6}}$)^{½}, .01] = **0.01**	Adjusted per comparison false positive rate. Pass initial or 1 resample.
6	PL = $\overline{\mathbf{X}}$ + **tS**(1+1/**N**)^{½} = **0.545** + (**2.445***0.198)(1+1/**34**)^{½} = **1.037**	One-sided normal prediction limit (t is Student's t on N-1 degrees of freedom and 1-alpha confidence level).

Worksheet 1 - Upgradient vs. Downgradient Comparisons
Cobalt, Total (mg/L)
Lognormal Prediction Limit

Step	Equation	Description
1	$Y = \log_e(X)$	Transform to natural logarithmic scale.
2	$\overline{Y}$ = **sum[Y]** / **N** = **-213.569** / **36** = **-5.932**	Compute mean on a natural log scale.
3	$S_Y = ((\mathbf{sum[Y^2]} - \mathbf{sum[Y]}^2/\mathbf{N}) / (\mathbf{N}-1))^{1/2}$ $= ((\mathbf{1295.714} - \mathbf{45611.517}/\mathbf{36}) / (\mathbf{36}-1))^{1/2}$ = **0.906**	Compute sd on a natural log scale.
4	alpha = min[$(1-.95^{1/\mathbf{K}})^{1/2}$, .01] = min[$(1-.95^{1/\mathbf{6}})^{1/2}$, .01] = **0.01**	Adjusted per comparison false positive rate. Pass initial or 1 resample.
5	$PL = \exp[\overline{\mathbf{Y}} + \mathbf{tS_Y}(1+1/\mathbf{N})^{1/2}]$ = exp[**-5.932** + (**2.438*****0.906**)$(1+1/\mathbf{36})^{1/2}$] = **0.025**	One-sided lognormal prediction limit (t is Student's t on N-1 degrees of freedom and 1-alpha confidence level).

Worksheet 1 - Upgradient vs. Downgradient Comparisons
Manganese, Total (mg/L)
Lognormal Prediction Limit

Step	Equation	Description
1	$Y = \log_e(X)$	Transform to natural logarithmic scale.
2	$\overline{Y}$ = **sum[Y]** / **N** = **-5.907** / **35** = **-0.169**	Compute mean on a natural log scale.
3	$S_Y = ((\mathbf{sum[Y^2]} - \mathbf{sum[Y]}^2/\mathbf{N}) / (\mathbf{N}-1))^{1/2}$ $= ((\mathbf{13.649} - \mathbf{34.893}/\mathbf{35}) / (\mathbf{35}-1))^{1/2}$ = **0.61**	Compute sd on a natural log scale.
4	alpha = min[$(1-.95^{1/\mathbf{K}})^{1/2}$, .01] = min[$(1-.95^{1/\mathbf{6}})^{1/2}$, .01] = **0.01**	Adjusted per comparison false positive rate. Pass initial or 1 resample.
5	PL = $\exp[\overline{\mathbf{Y}} + \mathbf{tS_Y}(1+1/\mathbf{N})^{1/2}]$ = exp[**-0.169** + (**2.441*****0.61**)$(1+1/\mathbf{35})^{1/2}$] = **3.824**	One-sided lognormal prediction limit (t is Student's t on N-1 degrees of freedom and 1-alpha confidence level).

Worksheet 1 - Upgradient vs. Downgradient Comparisons
Molybdenum, Total (mg/L)
Normal Prediction Limit

Step	Equation	Description
1	$\overline{X}_1 = \mathbf{sum[X_1]} / \mathbf{N_1}$ $= \mathbf{2.268} / \mathbf{29}$ $= \mathbf{0.078}$	Compute mean of N_1 detected measurements.
2	$S_1 = ((\mathbf{sum[X_1^2]} - \mathbf{sum[X_1]}^2/\mathbf{N_1}) / (\mathbf{N_1}-1))^{½}$ $= ((\mathbf{0.464}-\mathbf{5.143}/\mathbf{29}) / (\mathbf{29}-1))^{½}$ $= \mathbf{0.101}$	Compute sd of N_1 detected measurements.
3	$\overline{X} = (1 - \mathbf{N_0}/\mathbf{N}) \overline{\mathbf{X}}_1$ $= (1 - \mathbf{6}/\mathbf{35})\ \mathbf{0.078}$ $= \mathbf{0.065}$	Use Aitchison's method to adjust mean for presence of nondetects.
4	$S = [(1 - \mathbf{N_0}/\mathbf{N}) * \mathbf{S_1}^2 +$ $(\mathbf{N_0}/\mathbf{N}) (1 - (\mathbf{N_0}-1)/(\mathbf{N}-1)) \overline{\mathbf{X}}_1^2]^{½}$ $= [(1 - \mathbf{6}/\mathbf{35}) * \mathbf{0.101}^2 +$ $(\mathbf{6}/\mathbf{35}) (1 - (\mathbf{6}-1)/(\mathbf{35}-1)) \mathbf{0.078}^2]^{½}$ $= \mathbf{0.097}$	Use Aitchison's method to adjust sd for presence of nondetects.
5	$\text{alpha} = \min[(1-.95^{1/\mathbf{K}})^{½}, .01]$ $= \min[(1-.95^{1/\mathbf{6}})^{½}, .01]$ $= \mathbf{0.01}$	Adjusted per comparison false positive rate. Pass initial or 1 resample.
6	$PL = \overline{\mathbf{X}} + \mathbf{tS}(1+1/\mathbf{N})^{½}$ $= \mathbf{0.065}$ $+ (\mathbf{2.441}*\mathbf{0.097})(1+1/\mathbf{35})^{½}$ $= \mathbf{0.305}$	One-sided normal prediction limit (t is Student's t on N-1 degrees of freedom and 1-alpha confidence level).

Worksheet 1 - Upgradient vs. Downgradient Comparisons
Nickel, Total (mg/L)
Normal Prediction Limit

Step	Equation	Description
1	$\overline{X}_1 = \mathbf{sum[X_1]} / \mathbf{N_1}$ $= \mathbf{0.385} / \mathbf{27}$ $= \mathbf{0.014}$	Compute mean of N_1 detected measurements.
2	$S_1 = ((\mathbf{sum[X_1^2]} - \mathbf{sum[X_1]}^2/\mathbf{N_1}) / (\mathbf{N_1}-1))^{½}$ $= ((\mathbf{0.006}-\mathbf{0.148}/\mathbf{27}) / (\mathbf{27}-1))^{½}$ $= \mathbf{0.005}$	Compute sd of N_1 detected measurements.
3	$\overline{X} = (1 - \mathbf{N_0}/\mathbf{N}) \overline{\mathbf{X}}_\mathbf{1}$ $= (1 - \mathbf{8}/\mathbf{35}) \mathbf{0.014}$ $= \mathbf{0.011}$	Use Aitchison's method to adjust mean for presence of nondetects.
4	$S = [(1 - \mathbf{N_0}/\mathbf{N}) * \mathbf{S_1}^2 +$ $(\mathbf{N_0}/\mathbf{N}) (1 - (\mathbf{N_0}-1)/(\mathbf{N}-1)) \overline{\mathbf{X}}_\mathbf{1}^2]^{½}$ $= [(1 - \mathbf{8}/\mathbf{35}) * \mathbf{0.005}^2 +$ $(\mathbf{8}/\mathbf{35}) (1 - (\mathbf{8}-1)/(\mathbf{35}-1)) \mathbf{0.014}^2]^{½}$ $= \mathbf{0.008}$	Use Aitchison's method to adjust sd for presence of nondetects.
5	$\text{alpha} = \min[(1-.95^{1/\mathbf{K}})^{½}, .01]$ $= \min[(1-.95^{1/\mathbf{6}})^{½}, .01]$ $= \mathbf{0.01}$	Adjusted per comparison false positive rate. Pass initial or 1 resample.
6	$PL = \overline{\mathbf{X}} + \mathbf{tS}(1+1/\mathbf{N})^{½}$ $= \mathbf{0.011}$ $+ (\mathbf{2.441}*\mathbf{0.008})(1+1/\mathbf{35})^{½}$ $= \mathbf{0.03}$	One-sided normal prediction limit (t is Student's t on N-1 degrees of freedom and 1-alpha confidence level).

Attachment D

Summary Tables and Graphs for the Intrawell Comparisons

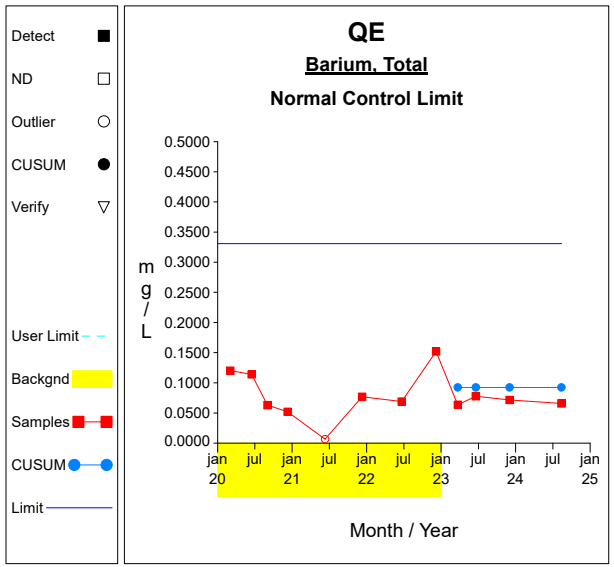
Table 1

Summary Statistics and Intermediate Computations for Combined Shewhart-CUSUM Control Charts

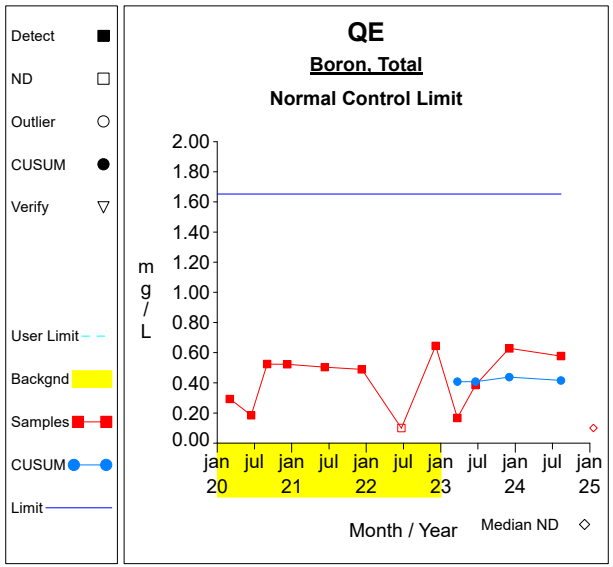
Constituent	Units	Well	N(back)	N(mon)	N(tot)	Mean	SD	R(i-1)	R(i)	S(i-1)	S(i)	Limit	Type	Conf	
Barium, Total	mg/L	QE	7	4	12	0.0924	0.0367	0.0716	0.0659	0.0924	0.0924	0.3307	normal		
Boron, Total	mg/L	QE	8	4	12	0.4079	0.1914	0.6290	0.5770	0.4376	0.4153	1.6520	normal		
Cobalt, Total	mg/L	QE	8	4	12	0.0059	0.0096	0.0085	0.0058	0.0059	0.0059	0.0680	normal		
Manganese, Total	mg/L	QE	8	4	12	1.3991	0.7938	1.4800	2.8600	1.5232	2.1903	6.5590	normal		
Molybdenum, Total	mg/L	QE	8	4	12	0.0111	0.0032	0.0076	0.0071	0.0111	0.0111	0.0318	normal		
Nickel, Total	mg/L	QE	7	4	12	0.0116	0.0024	0.0248	0.0130	0.0224	0.0215	0.0270	normal		
Barium, Total	mg/L	QN	8	4	12	0.1030	0.0505	0.0594	0.0486	0.1030	0.1030	0.4315	normal		
Boron, Total	mg/L	QN	7	4	12	0.5489	0.0717	0.4880	0.3740	0.5489	0.5489	1.0148	normal		
Cobalt, Total	mg/L	QN	7	4	12	0.0037	0.0011	0.0025	0.0041	0.0037	0.0037	0.0108	normal		
Manganese, Total	mg/L	QN	8	4	12	0.8595	0.2673	0.6910	5.8100	0.8595	5.5427	2.5968	normal		
Molybdenum, Total	mg/L	QN	7	4	12	0.2371	0.0699	0.0900	0.0147	0.2371	0.2371	0.6913	normal		
Nickel, Total	mg/L	QN	8	4	12	0.0184	0.0035	0.0169	0.0094	0.0184	0.0184	0.0414	normal		
Barium, Total	mg/L	QNE	8	4	12	0.1041	0.0184	0.0992	0.1090	0.1041	0.1041	0.2236	normal		
Boron, Total	mg/L	QNE	7	4	12	0.7263	0.2105	0.6250	0.6600	0.7263	0.7263	2.0942	normal		
Cobalt, Total	mg/L	QNE	8	4	12	0.0018	0.0015	0.0027	0.0009	0.0042	0.0018	0.0114	normal		
Manganese, Total	mg/L	QNE	8	4	12	0.6148	0.3665	0.5550	0.4020	0.6148	0.6148	2.9970	normal		
Molybdenum, Total	mg/L	QNE	7	4	12	0.0199	0.0031	0.0127	0.0121	0.0199	0.0199	0.0402	normal		
Nickel, Total	mg/L	QNE	8	4	12	0.0126	0.0032	0.0066	0.0052	0.0126	0.0126	0.0337	normal		
Barium, Total	mg/L	QNW	6	4	12	0.2495	0.0489	9.4100	0.3140	9.3611	0.2651	0.5673	normal		
Boron, Total	mg/L	QNW	7	4	12	0.2110	0.0641	1.2900	0.2110	1.2259	0.2110	0.6275	normal		
Cobalt, Total	mg/L	QNW	8	4	12	0.0200	0.0311	0.7270	0.0087	0.6959	0.0200	0.2220	normal		
Manganese, Total	mg/L	QNW	8	4	12	2.2473	3.5224	49.9000	4.4200	46.3776	2.2473	25.1427	normal		
Molybdenum, Total	mg/L	QNW	8	4	12	0.0123	0.0042	0.1550	0.0077	0.1508	0.0123	0.0396	normal		
Nickel, Total	mg/L	QNW	6	4	12								nonpar *		**

N(back) and N(mon) = Non-outlier measurements in the background and monitoring periods.
N(tot) = All independent measurements for that constituent and well.
For transformed data, mean and SD in transformed units and control limit in original units.
Conf = confidence level for passing initial test or one verification resample (nonparametric test only).
* - Insufficient Data.
** - Detection Frequency < 25%.
*** - Zero Variance.

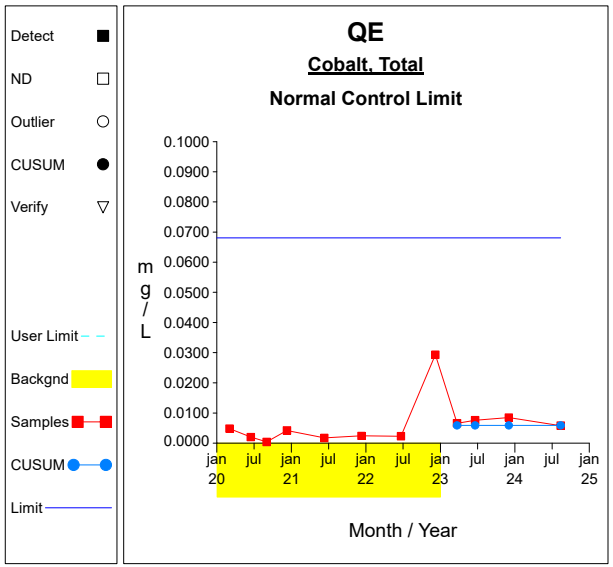
Intra-Well Control Charts / Prediction Limits



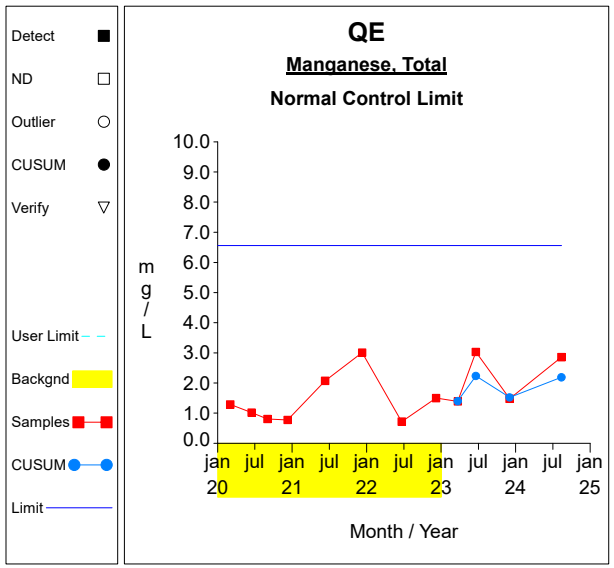
Graph 1



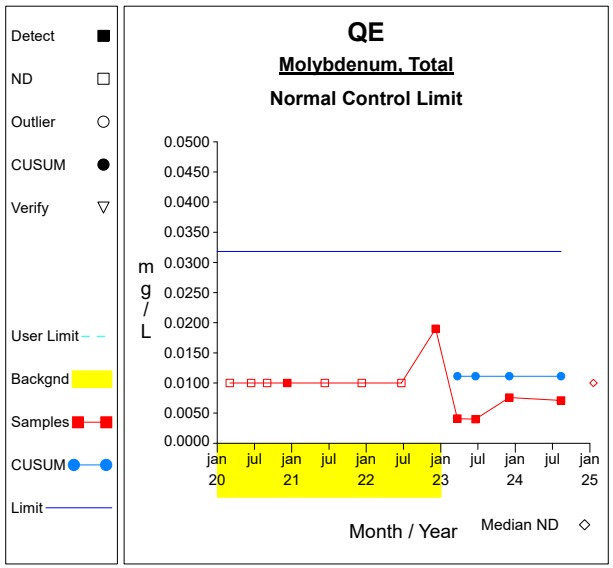
Graph 2



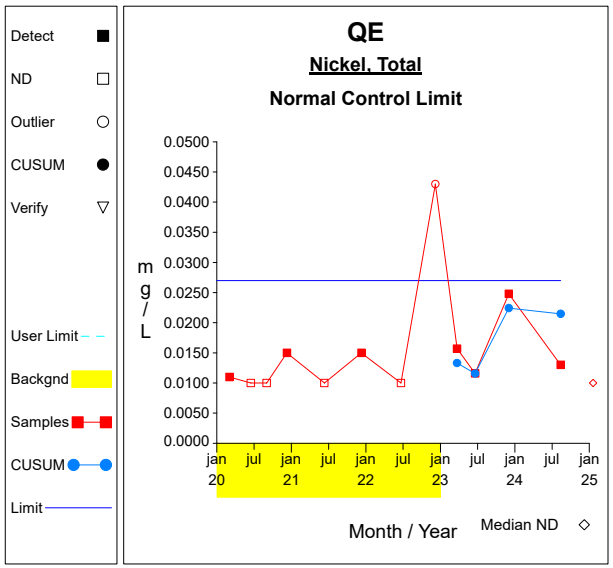
Graph 3



Graph 4



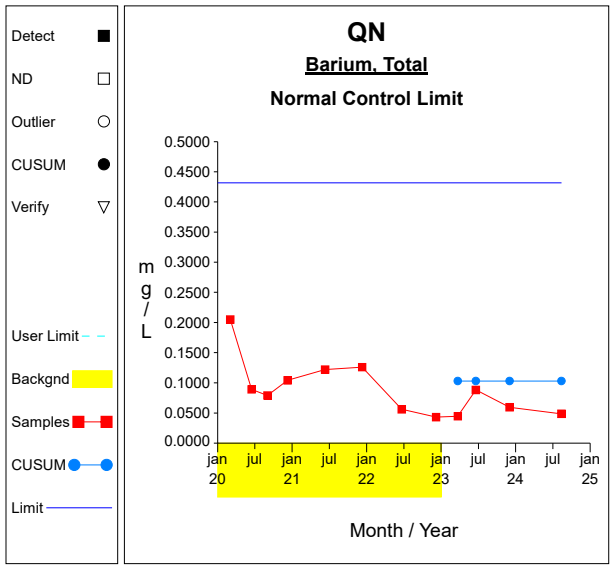
Graph 5



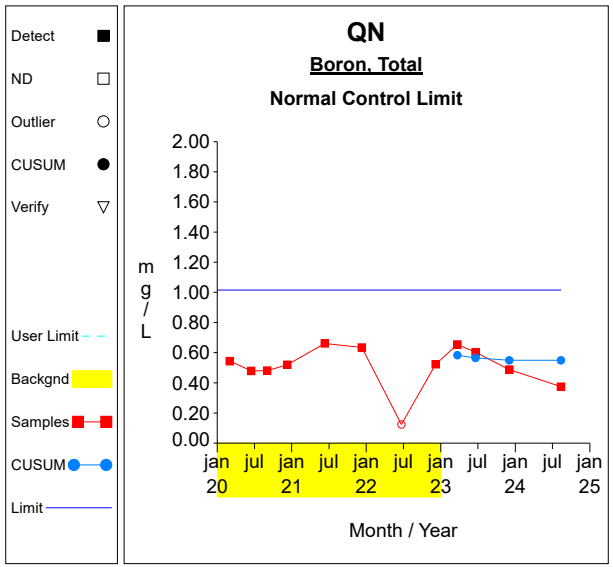
Graph 6

Prepared by: Otter Creek Environmental

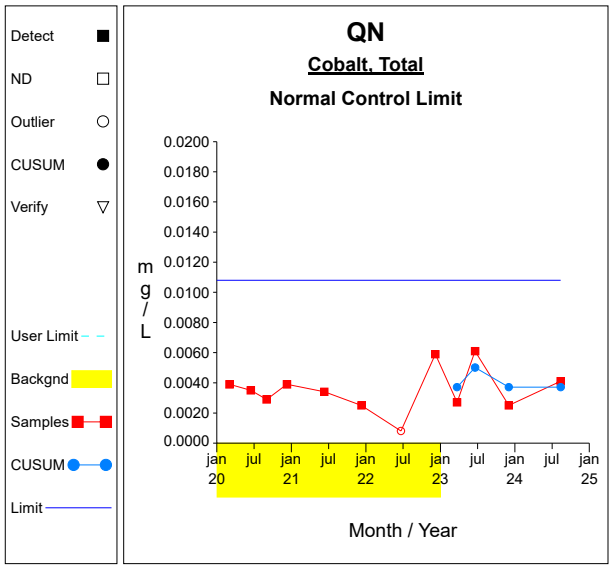
Intra-Well Control Charts / Prediction Limits



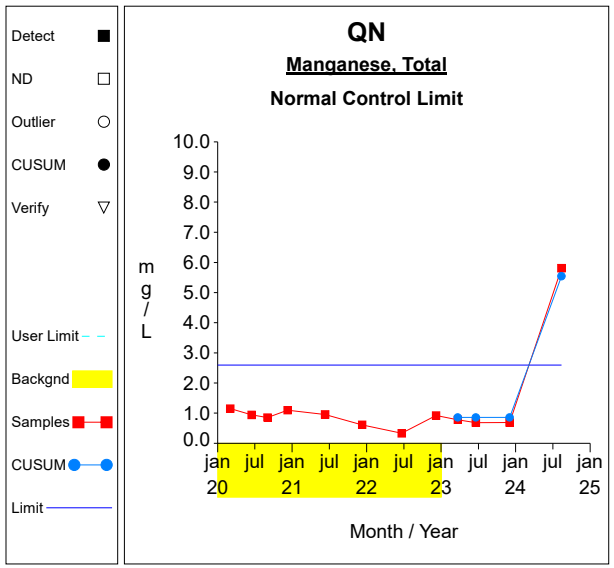
Graph 7



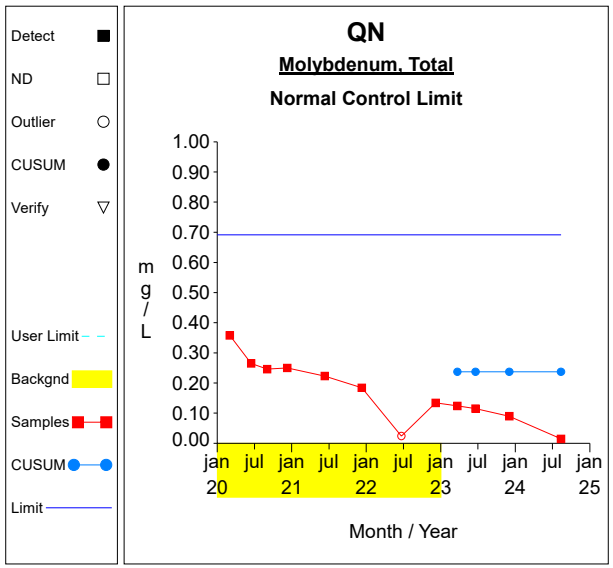
Graph 8



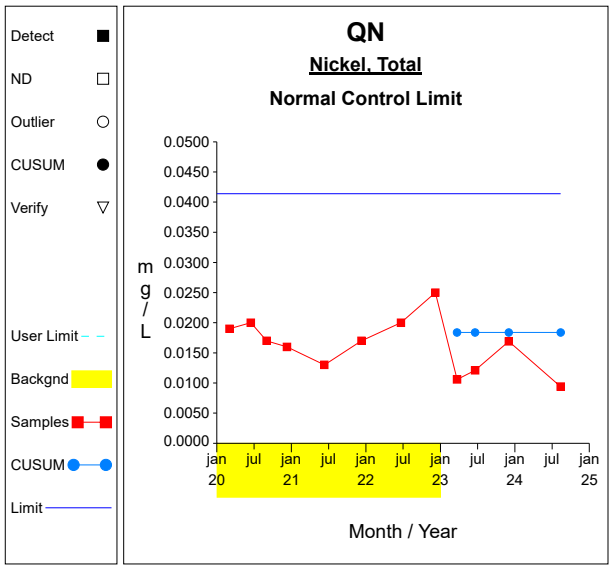
Graph 9



Graph 10



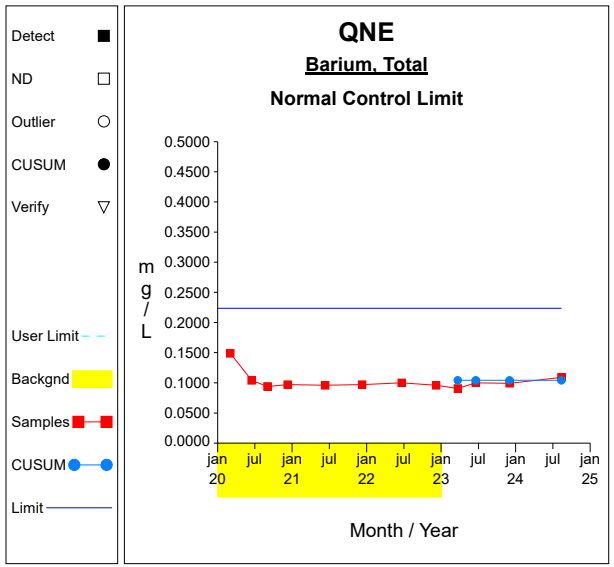
Graph 11



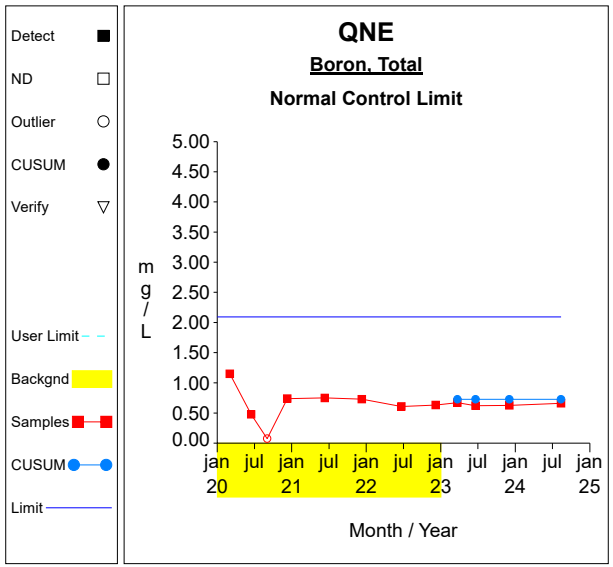
Graph 12

Prepared by: Otter Creek Environmental

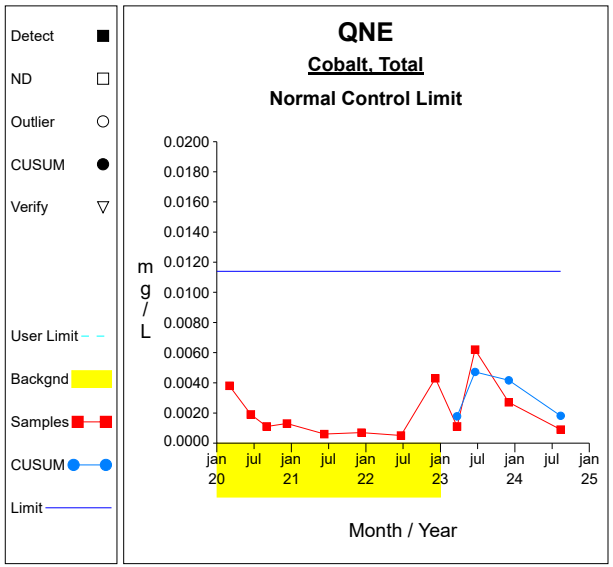
Intra-Well Control Charts / Prediction Limits



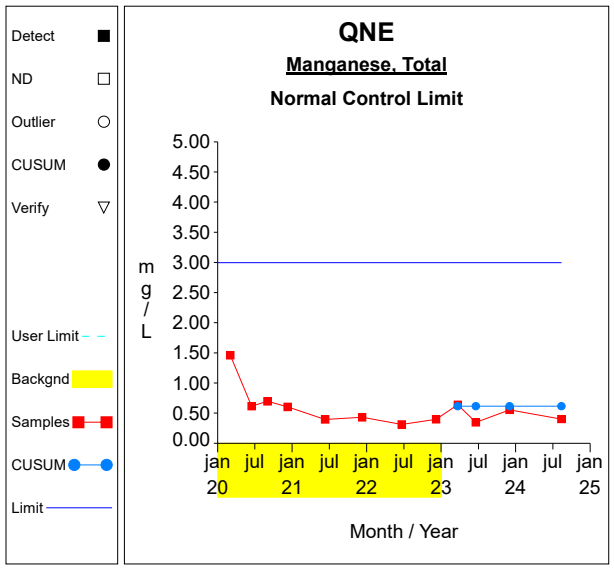
Graph 13



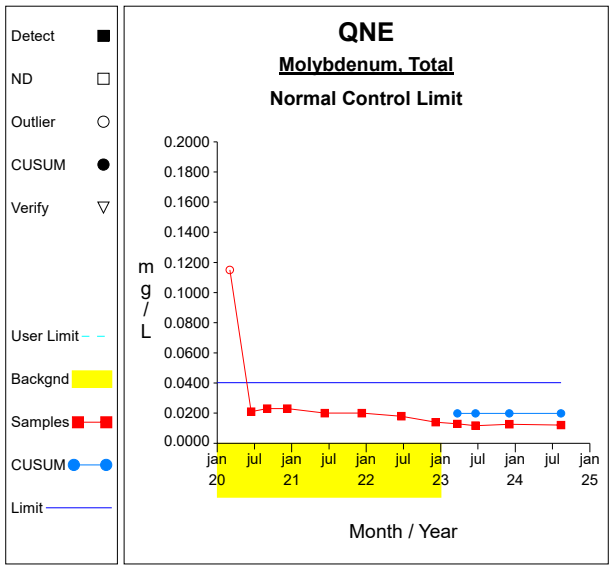
Graph 14



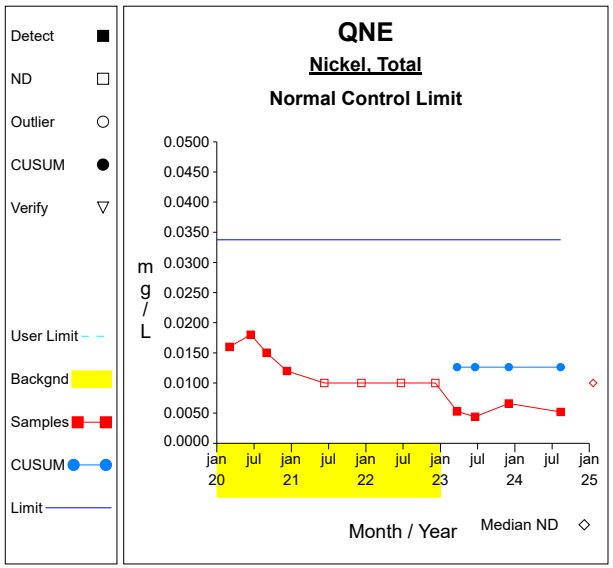
Graph 15



Graph 16



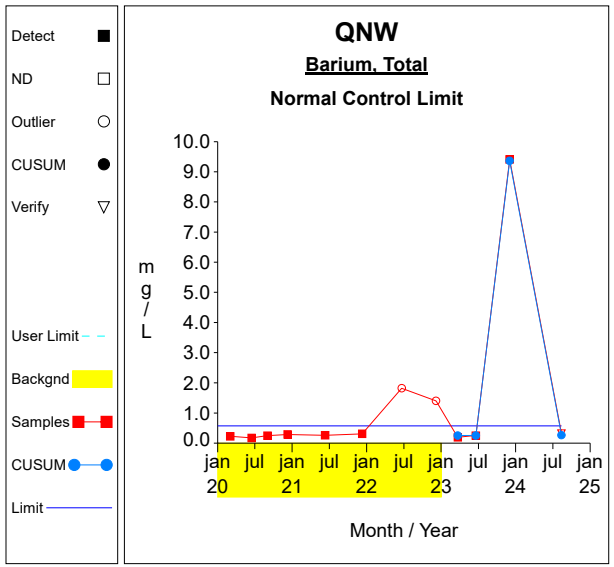
Graph 17



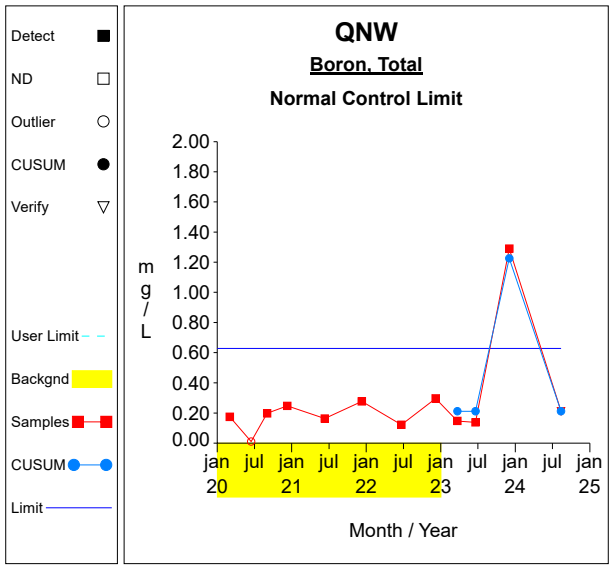
Graph 18

Prepared by: Otter Creek Environmental

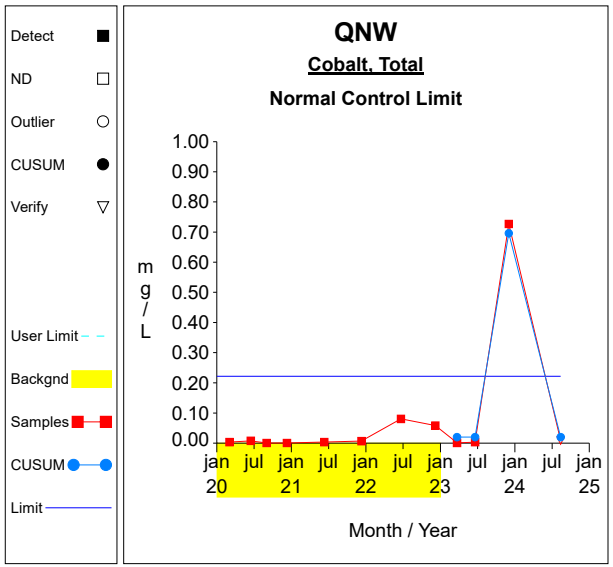
Intra-Well Control Charts / Prediction Limits



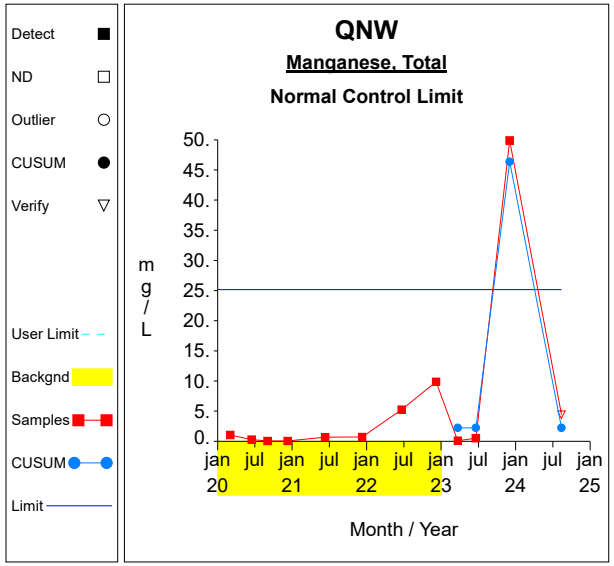
Graph 19



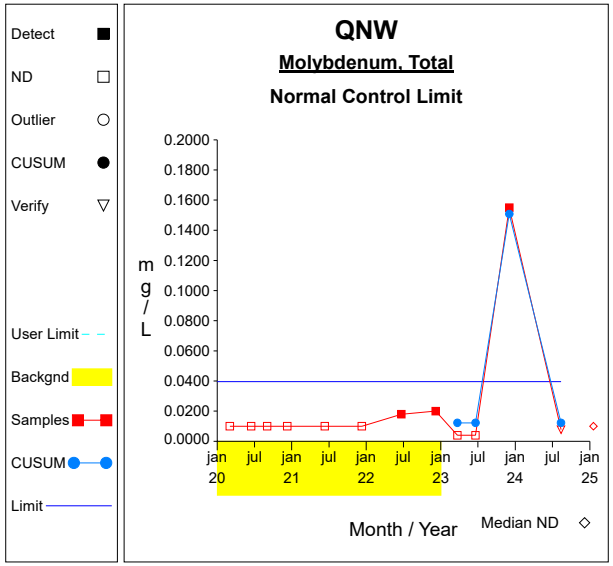
Graph 20



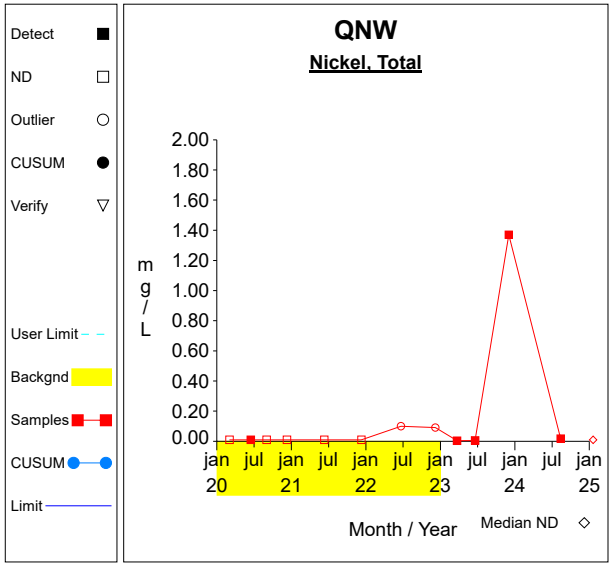
Graph 21



Graph 22



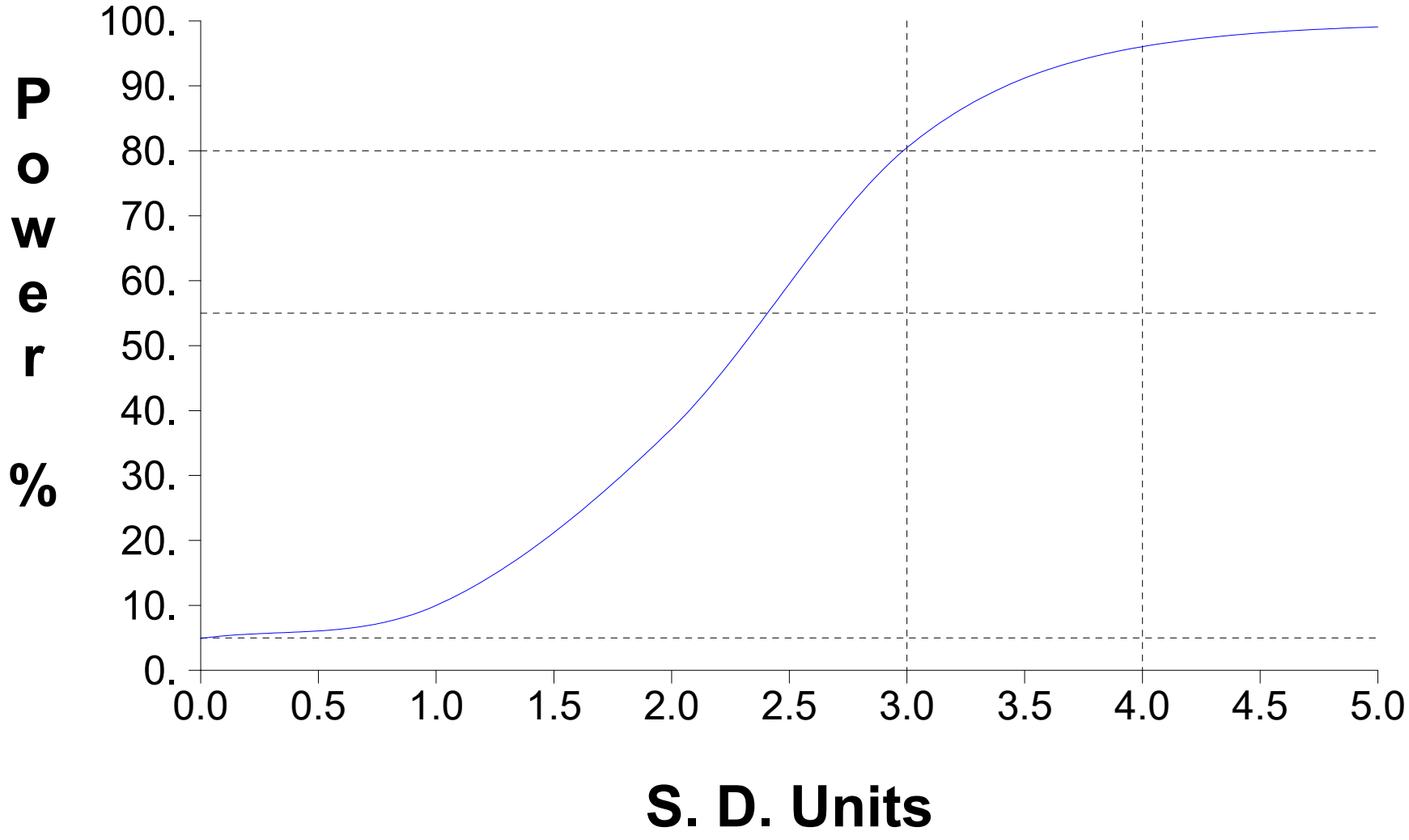
Graph 23



Graph 24

Prepared by: Otter Creek Environmental

False Positive and False Negative Rates for Current Intra-Well Control Charts Monitoring Program



Worksheet 2 - Intra-Well Control Charts / Prediction Limits
Barium, Total (mg/L) at QE
Normal Control Limit

Step	Equation	Description
1	$\overline{X}$ = **sum[X]** / **N** = **0.647** / **7** = **0.092**	Compute background mean.
2	S = ((**sum[X^2]** - **sum[X]**^{2}/**N**) / (**N**-1))^{½} = ((**0.068** - **0.419/7**) / (**7**-1))^{½} = **0.037**	Compute background sd.
3	SCL = $\overline{\mathbf{X}}$ + **F** * **S** = **0.092** + **6.5** * **0.037** = **0.331**	Compute combined Shewhart-CUSUM normal control limit.
4	N' = **N** * (**N**-1) / 2 = **7** * (**7**-1) / 2 = **21**	Number of sample pairs during trend detection period.
5	S = **-0.015**	Sen's estimator of trend.
6	var(S) = **44.333**	Variance estimate for slope.
7	M_1(S) = (**N'** - $\mathbf{Z}_{.99}$ * **var(S)**^{½}) / 2 = (**21** - **2.326** * **44.333**^{½}) / 2 = **2.756**	Ordinal position for one-sided lower confidence limit for slope. The LCL is the M_1^{th} largest slope estimate. When M_1 is not an integer, interpolation is used.
8	LCL(S) = **-0.117**	One-sided lower confidence limit for slope.

Worksheet 2 - Intra-Well Control Charts / Prediction Limits
Boron, Total (mg/L) at QE
Normal Control Limit

Step	Equation	Description
1	$\overline{X}$ = **sum[X]** / **N** = **3.263** / **8** = **0.408**	Compute background mean.
2	S = ((**sum[X^2]** - **sum[X]**^{2}/**N**) / (**N**-1))^{½} = ((**1.587** - **10.647**/**8**) / (**8**-1))^{½} = **0.191**	Compute background sd.
3	SCL = $\overline{\mathbf{X}}$ + **F** * **S** = **0.408** + **6.5** * **0.191** = **1.652**	Compute combined Shewhart-CUSUM normal control limit.
4	N' = **N** * (**N**-1) / 2 = **8** * (**8**-1) / 2 = **28**	Number of sample pairs during trend detection period.
5	S = **0.057**	Sen's estimator of trend.
6	var(S) = **65.333**	Variance estimate for slope.
7	M_1(S) = (**N'** - **Z**$_{.99}$ * **var(S)**^{½}) / 2 = (**28** - **2.326** * **65.333**^{½}) / 2 = **4.6**	Ordinal position for one-sided lower confidence limit for slope. The LCL is the M_1^{th} largest slope estimate. When M_1 is not an integer, interpolation is used.
8	LCL(S) = **-0.252**	One-sided lower confidence limit for slope.

Worksheet 2 - Intra-Well Control Charts / Prediction Limits
Cobalt, Total (mg/L) at QE
Normal Control Limit

Step	Equation	Description
1	$\overline{X}$ = **sum[X]** / **N** = **0.047** / **8** = **0.006**	Compute background mean.
2	S = ((**sum[X^2]** - **sum[X]**^{2}/**N**) / (**N**-1))^{½} = ((**9.17**x**10**$^{-4}$ - **0.002**/**8**) / (**8**-1))^{½} = **0.01**	Compute background sd.
3	SCL = $\overline{\mathbf{X}}$ + **F** * **S** = **0.006** + **6.5** * **0.01** = **0.068**	Compute combined Shewhart-CUSUM normal control limit.
4	N' = **N** * (**N**-1) / 2 = **8** * (**8**-1) / 2 = **28**	Number of sample pairs during trend detection period.
5	S = **4.26**x**10**$^{-4}$	Sen's estimator of trend.
6	var(S) = **65.333**	Variance estimate for slope.
7	M_1(S) = (**N'** - **Z**$_{.99}$ * **var(S)**^{½}) / 2 = (**28** - **2.326** * **65.333**^{½}) / 2 = **4.6**	Ordinal position for one-sided lower confidence limit for slope. The LCL is the M_1^{th} largest slope estimate. When M_1 is not an integer, interpolation is used.
8	LCL(S) = **-0.003**	One-sided lower confidence limit for slope.

Worksheet 2 - Intra-Well Control Charts / Prediction Limits
Manganese, Total (mg/L) at QE
Normal Control Limit

Step	Equation	Description
1	$\overline{X}$ = **sum[X]** / **N** = **11.193** / **8** = **1.399**	Compute background mean.
2	S = ((**sum[X^2]** - **sum[X]**^{2}/**N**) / (**N**-1))^{½} = ((**20.072** - **125.283**/**8**) / (**8**-1))^{½} = **0.794**	Compute background sd.
3	SCL = $\overline{\mathbf{X}}$ + **F** * **S** = **1.399** + **6.5** * **0.794** = **6.559**	Compute combined Shewhart-CUSUM normal control limit.
4	N' = **N** * (**N**-1) / 2 = **8** * (**8**-1) / 2 = **28**	Number of sample pairs during trend detection period.
5	S = **0.019**	Sen's estimator of trend.
6	var(S) = **65.333**	Variance estimate for slope.
7	M_1(S) = (**N'** - **Z**$_{.99}$ * **var(S)**^{½}) / 2 = (**28** - **2.326** * **65.333**^{½}) / 2 = **4.6**	Ordinal position for one-sided lower confidence limit for slope. The LCL is the M_1^{th} largest slope estimate. When M_1 is not an integer, interpolation is used.
8	LCL(S) = **-0.973**	One-sided lower confidence limit for slope.

Worksheet 2 - Intra-Well Control Charts / Prediction Limits
Molybdenum, Total (mg/L) at QE
Normal Control Limit

Step	Equation	Description
1	$\overline{X}$ = **sum[X]** / **N** = **0.089** / **8** = **0.011**	Compute background mean.
2	S = ((**sum[X^2]** - **sum[X]**^{2}/**N**) / (**N**-1))^{½} = ((**0.001** - **0.008**/**8**) / (**8**-1))^{½} = **0.003**	Compute background sd.
3	SCL = $\overline{\mathbf{X}}$ + **F** * **S** = **0.011** + **6.5** * **0.003** = **0.032**	Compute combined Shewhart-CUSUM normal control limit.
4	N' = **N** * (**N**-1) / 2 = **8** * (**8**-1) / 2 = **28**	Number of sample pairs during trend detection period.
5	S = **0.0**	Sen's estimator of trend.
6	var(S) = **21.0**	Variance estimate for slope.
7	M_1(S) = (**N'** - **Z**$_{.99}$ * **var(S)**^{½}) / 2 = (**28** - **2.326** * **21.0**^{½}) / 2 = **8.67**	Ordinal position for one-sided lower confidence limit for slope. The LCL is the M_1^{th} largest slope estimate. When M_1 is not an integer, interpolation is used.
8	LCL(S) = **0.0**	One-sided lower confidence limit for slope.

Worksheet 2 - Intra-Well Control Charts / Prediction Limits
Nickel, Total (mg/L) at QE
Normal Control Limit

Step	Equation	Description
1	$\overline{X}$ = **sum[X]** / **N** = **0.081** / **7** = **0.012**	Compute background mean.
2	S = ((**sum[X^2]** - **sum[X]**^{2}/**N**) / (**N**-1))^{½} = ((**9.71**x**10**$^{-4}$ - **0.007**/**7**) / (**7**-1))^{½} = **0.002**	Compute background sd.
3	SCL = $\overline{\mathbf{X}}$ + **F** * **S** = **0.012** + **6.5** * **0.002** = **0.027**	Compute combined Shewhart-CUSUM normal control limit.
4	N' = **N** * (**N**-1) / 2 = **7** * (**7**-1) / 2 = **21**	Number of sample pairs during trend detection period.
5	S = **0.0**	Sen's estimator of trend.
6	var(S) = **34.667**	Variance estimate for slope.
7	M_1(S) = (**N'** - **Z**$_{.99}$ * **var(S)**^{½}) / 2 = (**21** - **2.326** * **34.667**^{½}) / 2 = **3.652**	Ordinal position for one-sided lower confidence limit for slope. The LCL is the M_1^{th} largest slope estimate. When M_1 is not an integer, interpolation is used.
8	LCL(S) = **-0.003**	One-sided lower confidence limit for slope.

Worksheet 2 - Intra-Well Control Charts / Prediction Limits
Barium, Total (mg/L) at QN
Normal Control Limit

Step	Equation	Description
1	$\overline{X}$ = **sum[X]** / **N** = **0.824** / **8** = **0.103**	Compute background mean.
2	S = ((**sum[X^2]** - **sum[X]**^{2}/**N**) / (**N**-1))^{½} = ((**0.103** - **0.679**/**8**) / (**8**-1))^{½} = **0.051**	Compute background sd.
3	SCL = $\overline{\mathbf{X}}$ + **F** * **S** = **0.103** + **6.5** * **0.051** = **0.431**	Compute combined Shewhart-CUSUM normal control limit.
4	N' = **N** * (**N**-1) / 2 = **8** * (**8**-1) / 2 = **28**	Number of sample pairs during trend detection period.
5	S = **-0.029**	Sen's estimator of trend.
6	var(S) = **65.333**	Variance estimate for slope.
7	M_1(S) = (**N'** - **Z**$_{.99}$ * **var(S)**^{½}) / 2 = (**28** - **2.326** * **65.333**^{½}) / 2 = **4.6**	Ordinal position for one-sided lower confidence limit for slope. The LCL is the M_1^{th} largest slope estimate. When M_1 is not an integer, interpolation is used.
8	LCL(S) = **-0.102**	One-sided lower confidence limit for slope.

Worksheet 2 - Intra-Well Control Charts / Prediction Limits
Boron, Total (mg/L) at QN
Normal Control Limit

Step	Equation	Description
1	$\overline{X}$ = **sum[X]** / **N** = **3.842** / **7** = **0.549**	Compute background mean.
2	S = ((**sum[X^2]** - **sum[X]**^{2}/**N**) / (**N**-1))^{½} = ((**2.14** - **14.761**/**7**) / (**7**-1))^{½} = **0.072**	Compute background sd.
3	SCL = $\overline{\mathbf{X}}$ + **F** * **S** = **0.549** + **6.5** * **0.072** = **1.015**	Compute combined Shewhart-CUSUM normal control limit.
4	N' = **N** * (**N**-1) / 2 = **7** * (**7**-1) / 2 = **21**	Number of sample pairs during trend detection period.
5	S = **0.019**	Sen's estimator of trend.
6	var(S) = **44.333**	Variance estimate for slope.
7	M_1(S) = (**N'** - **Z**$_{.99}$ * **var(S)**^{½}) / 2 = (**21** - **2.326** * **44.333**^{½}) / 2 = **2.756**	Ordinal position for one-sided lower confidence limit for slope. The LCL is the M_1^{th} largest slope estimate. When M_1 is not an integer, interpolation is used.
8	LCL(S) = **-0.115**	One-sided lower confidence limit for slope.

Worksheet 2 - Intra-Well Control Charts / Prediction Limits
Cobalt, Total (mg/L) at QN
Normal Control Limit

Step	Equation	Description
1	$\overline{X}$ = **sum[X]** / **N** = **0.026** / **7** = **0.004**	Compute background mean.
2	S = ((**sum[X^2]** - **sum[X]**^{2}/**N**) / (**N**-1))^{½} = ((**1.04**x**10**$^{-4}$ - **6.76**x**10**$^{-4}$/**7**) / (**7**-1))^{½} = **0.001**	Compute background sd.
3	SCL = $\overline{\mathbf{X}}$ + **F** * **S** = **0.004** + **6.5** * **0.001** = **0.011**	Compute combined Shewhart-CUSUM normal control limit.
4	N' = **N** * (**N**-1) / 2 = **7** * (**7**-1) / 2 = **21**	Number of sample pairs during trend detection period.
5	S = **-1.02**x**10**$^{-4}$	Sen's estimator of trend.
6	var(S) = **43.333**	Variance estimate for slope.
7	M_1(S) = (**N'** - **Z**$_{.99}$ * **var(S)**^{½}) / 2 = (**21** - **2.326** * **43.333**^{½}) / 2 = **2.844**	Ordinal position for one-sided lower confidence limit for slope. The LCL is the M_1^{th} largest slope estimate. When M_1 is not an integer, interpolation is used.
8	LCL(S) = **-0.002**	One-sided lower confidence limit for slope.

Worksheet 2 - Intra-Well Control Charts / Prediction Limits
Manganese, Total (mg/L) at QN
Normal Control Limit

Step	Equation	Description
1	$\overline{X}$ = **sum[X]** / **N** = **6.876** / **8** = **0.86**	Compute background mean.
2	S = ((**sum[X^2]** - **sum[X]**^{2}/**N**) / (**N**-1))^{½} = ((**6.41** - **47.279**/**8**) / (**8**-1))^{½} = **0.267**	Compute background sd.
3	SCL = $\overline{\mathbf{X}}$ + **F** * **S** = **0.86** + **6.5** * **0.267** = **2.597**	Compute combined Shewhart-CUSUM normal control limit.
4	N' = **N** * (**N**-1) / 2 = **8** * (**8**-1) / 2 = **28**	Number of sample pairs during trend detection period.
5	S = **-0.207**	Sen's estimator of trend.
6	var(S) = **65.333**	Variance estimate for slope.
7	M_1(S) = (**N'** - **Z**$_{.99}$ * **var(S)**^{½}) / 2 = (**28** - **2.326** * **65.333**^{½}) / 2 = **4.6**	Ordinal position for one-sided lower confidence limit for slope. The LCL is the M_1^{th} largest slope estimate. When M_1 is not an integer, interpolation is used.
8	LCL(S) = **-0.55**	One-sided lower confidence limit for slope.

Worksheet 2 - Intra-Well Control Charts / Prediction Limits
Molybdenum, Total (mg/L) at QN
Normal Control Limit

Step	Equation	Description
1	$\overline{X}$ = **sum[X]** / **N** = **1.66** / **7** = **0.237**	Compute background mean.
2	S = ((**sum[X^2]** - **sum[X]**^{2}/**N**) / (**N**-1))^{½} = ((**0.423** - **2.756**/**7**) / (**7**-1))^{½} = **0.07**	Compute background sd.
3	SCL = $\overline{\mathbf{X}}$ + **F** * **S** = **0.237** + **6.5** * **0.07** = **0.691**	Compute combined Shewhart-CUSUM normal control limit.
4	N' = **N** * (**N**-1) / 2 = **7** * (**7**-1) / 2 = **21**	Number of sample pairs during trend detection period.
5	S = **-0.058**	Sen's estimator of trend.
6	var(S) = **44.333**	Variance estimate for slope.
7	M_1(S) = (**N'** - **Z**$_{.99}$ * **var(S)**^{½}) / 2 = (**21** - **2.326** * **44.333**^{½}) / 2 = **2.756**	Ordinal position for one-sided lower confidence limit for slope. The LCL is the M_1^{th} largest slope estimate. When M_1 is not an integer, interpolation is used.
8	LCL(S) = **-0.16**	One-sided lower confidence limit for slope.

Worksheet 2 - Intra-Well Control Charts / Prediction Limits
Nickel, Total (mg/L) at QN
Normal Control Limit

Step	Equation	Description
1	$\overline{X}$ = **sum[X]** / **N** = **0.147** / **8** = **0.018**	Compute background mean.
2	S = ((**sum[X^2]** - **sum[X]**^{2}/**N**) / (**N**-1))^{½} = ((**0.003** - **0.022**/**8**) / (**8**-1))^{½} = **0.004**	Compute background sd.
3	SCL = $\overline{\mathbf{X}}$ + **F** * **S** = **0.018** + **6.5** * **0.004** = **0.041**	Compute combined Shewhart-CUSUM normal control limit.
4	N' = **N** * (**N**-1) / 2 = **8** * (**8**-1) / 2 = **28**	Number of sample pairs during trend detection period.
5	S = **7.17**x**10**$^{-4}$	Sen's estimator of trend.
6	var(S) = **63.333**	Variance estimate for slope.
7	M_1(S) = (**N'** - **Z**$_{.99}$ * **var(S)**^{½}) / 2 = (**28** - **2.326** * **63.333**^{½}) / 2 = **4.745**	Ordinal position for one-sided lower confidence limit for slope. The LCL is the M_1^{th} largest slope estimate. When M_1 is not an integer, interpolation is used.
8	LCL(S) = **-0.005**	One-sided lower confidence limit for slope.

Worksheet 2 - Intra-Well Control Charts / Prediction Limits
Barium, Total (mg/L) at QNE
Normal Control Limit

Step	Equation	Description
1	$\overline{X}$ = **sum[X]** / **N** = **0.833** / **8** = **0.104**	Compute background mean.
2	S = ((**sum[X^2]** - **sum[X]**^{2}/**N**) / (**N**-1))^{½} = ((**0.089** - **0.694**/**8**) / (**8**-1))^{½} = **0.018**	Compute background sd.
3	SCL = $\overline{\mathbf{X}}$ + **F** * **S** = **0.104** + **6.5** * **0.018** = **0.224**	Compute combined Shewhart-CUSUM normal control limit.
4	N' = **N** * (**N**-1) / 2 = **8** * (**8**-1) / 2 = **28**	Number of sample pairs during trend detection period.
5	S = **-0.002**	Sen's estimator of trend.
6	var(S) = **63.333**	Variance estimate for slope.
7	M_1(S) = (**N'** - **Z**$_{.99}$ * **var(S)**^{½}) / 2 = (**28** - **2.326** * **63.333**^{½}) / 2 = **4.745**	Ordinal position for one-sided lower confidence limit for slope. The LCL is the M_1^{th} largest slope estimate. When M_1 is not an integer, interpolation is used.
8	LCL(S) = **-0.043**	One-sided lower confidence limit for slope.

Worksheet 2 - Intra-Well Control Charts / Prediction Limits
Boron, Total (mg/L) at QNE
Normal Control Limit

Step	Equation	Description
1	$\overline{X}$ = **sum[X]** / **N** = **5.084** / **7** = **0.726**	Compute background mean.
2	S = ((**sum[X^2]** - **sum[X]**^{2}/**N**) / (**N**-1))^{½} = ((**3.958** - **25.847**/**7**) / (**7**-1))^{½} = **0.21**	Compute background sd.
3	SCL = $\overline{\mathbf{X}}$ + **F** * **S** = **0.726** + **6.5** * **0.21** = **2.094**	Compute combined Shewhart-CUSUM normal control limit.
4	N' = **N** * (**N**-1) / 2 = **7** * (**7**-1) / 2 = **21**	Number of sample pairs during trend detection period.
5	S = **-0.079**	Sen's estimator of trend.
6	var(S) = **44.333**	Variance estimate for slope.
7	M_1(S) = (**N'** - **Z**$_{.99}$ * **var(S)**^{½}) / 2 = (**21** - **2.326** * **44.333**^{½}) / 2 = **2.756**	Ordinal position for one-sided lower confidence limit for slope. The LCL is the M_1^{th} largest slope estimate. When M_1 is not an integer, interpolation is used.
8	LCL(S) = **-0.367**	One-sided lower confidence limit for slope.

Worksheet 2 - Intra-Well Control Charts / Prediction Limits
Cobalt, Total (mg/L) at QNE
Normal Control Limit

Step	Equation	Description
1	$\overline{X}$ = **sum[X]** / **N** = **0.014** / **8** = **0.002**	Compute background mean.
2	S = ((**sum[X^2]** - **sum[X]**^{2}/**N**) / (**N**-1))^{½} = ((**4.05**x**10**$^{-5}$ - **2.02**x**10**$^{-4}$/**8**) / (**8**-1))^{½} = **0.001**	Compute background sd.
3	SCL = $\overline{\mathbf{X}}$ + **F** * **S** = **0.002** + **6.5** * **0.001** = **0.011**	Compute combined Shewhart-CUSUM normal control limit.
4	N' = **N** * (**N**-1) / 2 = **8** * (**8**-1) / 2 = **28**	Number of sample pairs during trend detection period.
5	S = **-5.61**x**10**$^{-4}$	Sen's estimator of trend.
6	var(S) = **65.333**	Variance estimate for slope.
7	M_1(S) = (**N'** - **Z**$_{.99}$ * **var(S)**^{½}) / 2 = (**28** - **2.326** * **65.333**^{½}) / 2 = **4.6**	Ordinal position for one-sided lower confidence limit for slope. The LCL is the M_1^{th} largest slope estimate. When M_1 is not an integer, interpolation is used.
8	LCL(S) = **-0.003**	One-sided lower confidence limit for slope.

Worksheet 2 - Intra-Well Control Charts / Prediction Limits
Manganese, Total (mg/L) at QNE
Normal Control Limit

Step	Equation	Description
1	$\overline{X}$ = **sum[X]** / **N** = **4.918** / **8** = **0.615**	Compute background mean.
2	S = ((**sum[X^2]** - **sum[X]**^{2}/**N**) / (**N**-1))^{½} = ((**3.964** - **24.187**/**8**) / (**8**-1))^{½} = **0.367**	Compute background sd.
3	SCL = $\overline{\mathbf{X}}$ + **F** * **S** = **0.615** + **6.5** * **0.367** = **2.997**	Compute combined Shewhart-CUSUM normal control limit.
4	N' = **N** * (**N**-1) / 2 = **8** * (**8**-1) / 2 = **28**	Number of sample pairs during trend detection period.
5	S = **-0.2**	Sen's estimator of trend.
6	var(S) = **65.333**	Variance estimate for slope.
7	M_1(S) = (**N'** - **Z**$_{.99}$ * **var(S)**^{½}) / 2 = (**28** - **2.326** * **65.333**^{½}) / 2 = **4.6**	Ordinal position for one-sided lower confidence limit for slope. The LCL is the M_1^{th} largest slope estimate. When M_1 is not an integer, interpolation is used.
8	LCL(S) = **-0.682**	One-sided lower confidence limit for slope.

Worksheet 2 - Intra-Well Control Charts / Prediction Limits
Molybdenum, Total (mg/L) at QNE
Normal Control Limit

Step	Equation	Description
1	$\overline{X}$ = **sum[X]** / **N** = **0.139** / **7** = **0.02**	Compute background mean.
2	S = ((**sum[X^2]** - **sum[X]**^{2}/**N**) / (**N**-1))^{½} = ((**0.003** - **0.019**/**7**) / (**7**-1))^{½} = **0.003**	Compute background sd.
3	SCL = $\overline{\mathbf{X}}$ + **F** * **S** = **0.02** + **6.5** * **0.003** = **0.04**	Compute combined Shewhart-CUSUM normal control limit.
4	N' = **N** * (**N**-1) / 2 = **7** * (**7**-1) / 2 = **21**	Number of sample pairs during trend detection period.
5	S = **-0.003**	Sen's estimator of trend.
6	var(S) = **42.333**	Variance estimate for slope.
7	M_1(S) = (**N'** - **Z**$_{.99}$ * **var(S)**^{½}) / 2 = (**21** - **2.326** * **42.333**^{½}) / 2 = **2.933**	Ordinal position for one-sided lower confidence limit for slope. The LCL is the M_1^{th} largest slope estimate. When M_1 is not an integer, interpolation is used.
8	LCL(S) = **-0.006**	One-sided lower confidence limit for slope.

Worksheet 2 - Intra-Well Control Charts / Prediction Limits
Nickel, Total (mg/L) at QNE
Normal Control Limit

Step	Equation	Description
1	$\overline{X}$ = **sum[X]** / **N** = **0.101** / **8** = **0.013**	Compute background mean.
2	S = ((**sum[X^2]** - **sum[X]**^{2}/**N**) / (**N**-1))^{½} = ((**0.001** - **0.01**/**8**) / (**8**-1))^{½} = **0.003**	Compute background sd.
3	SCL = $\overline{\mathbf{X}}$ + **F** * **S** = **0.013** + **6.5** * **0.003** = **0.034**	Compute combined Shewhart-CUSUM normal control limit.
4	N' = **N** * (**N**-1) / 2 = **8** * (**8**-1) / 2 = **28**	Number of sample pairs during trend detection period.
5	S = **-0.003**	Sen's estimator of trend.
6	var(S) = **56.667**	Variance estimate for slope.
7	M_1(S) = (**N'** - **Z**$_{.99}$ * **var(S)**^{½}) / 2 = (**28** - **2.326** * **56.667**^{½}) / 2 = **5.245**	Ordinal position for one-sided lower confidence limit for slope. The LCL is the M_1^{th} largest slope estimate. When M_1 is not an integer, interpolation is used.
8	LCL(S) = **-0.006**	One-sided lower confidence limit for slope.

Worksheet 2 - Intra-Well Control Charts / Prediction Limits
Barium, Total (mg/L) at QNW
Normal Control Limit

Step	Equation	Description
1	$\overline{X}$ = **sum[X]** / **N** = **1.497** / **6** = **0.25**	Compute background mean.
2	S = ((**sum[X^2]** - **sum[X]**^{2}/**N**) / (**N**-1))^{½} = ((**0.385** - **2.241**/**6**) / (**6**-1))^{½} = **0.049**	Compute background sd.
3	SCL = $\overline{\mathbf{X}}$ + **F** * **S** = **0.25** + **6.5** * **0.049** = **0.567**	Compute combined Shewhart-CUSUM normal control limit.
4	N' = **N** * (**N**-1) / 2 = **6** * (**6**-1) / 2 = **15**	Number of sample pairs during trend detection period.
5	S = **0.05**	Sen's estimator of trend.
6	var(S) = **28.333**	Variance estimate for slope.
7	M_1(S) = (**N'** - **Z**$_{.99}$ * **var(S)**^{½}) / 2 = (**15** - **2.326** * **28.333**^{½}) / 2 = **1.309**	Ordinal position for one-sided lower confidence limit for slope. The LCL is the M_1^{th} largest slope estimate. When M_1 is not an integer, interpolation is used.
8	LCL(S) = **-0.15**	One-sided lower confidence limit for slope.

Worksheet 2 - Intra-Well Control Charts / Prediction Limits
Boron, Total (mg/L) at QNW
Normal Control Limit

Step	Equation	Description
1	$\overline{X}$ = **sum[X]** / **N** = **1.477** / **7** = **0.211**	Compute background mean.
2	S = ((**sum[X^2]** - **sum[X]**^{2}/**N**) / (**N**-1))^{½} = ((**0.336** - **2.182**/**7**) / (**7**-1))^{½} = **0.064**	Compute background sd.
3	SCL = $\overline{\mathbf{X}}$ + **F** * **S** = **0.211** + **6.5** * **0.064** = **0.628**	Compute combined Shewhart-CUSUM normal control limit.
4	N' = **N** * (**N**-1) / 2 = **7** * (**7**-1) / 2 = **21**	Number of sample pairs during trend detection period.
5	S = **0.03**	Sen's estimator of trend.
6	var(S) = **44.333**	Variance estimate for slope.
7	M_1(S) = (**N'** - **Z**$_{.99}$ * **var(S)**^{½}) / 2 = (**21** - **2.326** * **44.333**^{½}) / 2 = **2.756**	Ordinal position for one-sided lower confidence limit for slope. The LCL is the M_1^{th} largest slope estimate. When M_1 is not an integer, interpolation is used.
8	LCL(S) = **-0.103**	One-sided lower confidence limit for slope.

Worksheet 2 - Intra-Well Control Charts / Prediction Limits
Cobalt, Total (mg/L) at QNW
Normal Control Limit

Step	Equation	Description
1	$\overline{X}$ = **sum[X]** / **N** = **0.16** / **8** = **0.02**	Compute background mean.
2	S = ((**sum[X^2]** - **sum[X]**^{2}/**N**) / (**N**-1))^{½} = ((**0.01** - **0.026**/**8**) / (**8**-1))^{½} = **0.031**	Compute background sd.
3	SCL = $\overline{\mathbf{X}}$ + **F** * **S** = **0.02** + **6.5** * **0.031** = **0.222**	Compute combined Shewhart-CUSUM normal control limit.
4	N' = **N** * (**N**-1) / 2 = **8** * (**8**-1) / 2 = **28**	Number of sample pairs during trend detection period.
5	S = **0.007**	Sen's estimator of trend.
6	var(S) = **63.333**	Variance estimate for slope.
7	M_1(S) = (**N'** - **Z**$_{.99}$ * **var(S)**^{½}) / 2 = (**28** - **2.326** * **63.333**^{½}) / 2 = **4.745**	Ordinal position for one-sided lower confidence limit for slope. The LCL is the M_1^{th} largest slope estimate. When M_1 is not an integer, interpolation is used.
8	LCL(S) = **-0.005**	One-sided lower confidence limit for slope.

Worksheet 2 - Intra-Well Control Charts / Prediction Limits
Manganese, Total (mg/L) at QNW
Normal Control Limit

Step	Equation	Description
1	$\overline{X}$ = **sum[X]** / **N** = **17.978** / **8** = **2.247**	Compute background mean.
2	S = ((**sum[X^2]** - **sum[X]**^{2}/**N**) / (**N**-1))^{½} = ((**127.251** - **323.208**/**8**) / (**8**-1))^{½} = **3.522**	Compute background sd.
3	SCL = $\overline{\mathbf{X}}$ + **F** * **S** = **2.247** + **6.5** * **3.522** = **25.143**	Compute combined Shewhart-CUSUM normal control limit.
4	N' = **N** * (**N**-1) / 2 = **8** * (**8**-1) / 2 = **28**	Number of sample pairs during trend detection period.
5	S = **1.072**	Sen's estimator of trend.
6	var(S) = **65.333**	Variance estimate for slope.
7	M_1(S) = (**N'** - **Z**$_{.99}$ * **var(S)**^{½}) / 2 = (**28** - **2.326** * **65.333**^{½}) / 2 = **4.6**	Ordinal position for one-sided lower confidence limit for slope. The LCL is the M_1^{th} largest slope estimate. When M_1 is not an integer, interpolation is used.
8	LCL(S) = **-0.781**	One-sided lower confidence limit for slope.

Worksheet 2 - Intra-Well Control Charts / Prediction Limits
Molybdenum, Total (mg/L) at QNW
Normal Control Limit

Step	Equation	Description
1	$\overline{X}$ = **sum[X]** / **N** = **0.098** / **8** = **0.012**	Compute background mean.
2	S = ((**sum[X^2]** - **sum[X]**^{2}/**N**) / (**N**-1))^{½} = ((**0.001** - **0.01**/**8**) / (**8**-1))^{½} = **0.004**	Compute background sd.
3	SCL = $\overline{\mathbf{X}}$ + **F** * **S** = **0.012** + **6.5** * **0.004** = **0.04**	Compute combined Shewhart-CUSUM normal control limit.
4	N' = **N** * (**N**-1) / 2 = **8** * (**8**-1) / 2 = **28**	Number of sample pairs during trend detection period.
5	S = **0.0**	Sen's estimator of trend.
6	var(S) = **37.0**	Variance estimate for slope.
7	M_1(S) = (**N'** - **Z**$_{.99}$ * **var(S)**^{½}) / 2 = (**28** - **2.326** * **37.0**^{½}) / 2 = **6.926**	Ordinal position for one-sided lower confidence limit for slope. The LCL is the M_1^{th} largest slope estimate. When M_1 is not an integer, interpolation is used.
8	LCL(S) = **0.0**	One-sided lower confidence limit for slope.

Worksheet 2 - Intra-Well Control Charts / Prediction Limits
Nickel, Total (mg/L) at QNW

Insufficient data to perform analysis

Table 2

Analytical Data and CUSUM Summary

Constituent	Units	Well	Date	Background	Result		Outlier	CUSUM	Adjusted	
Barium, Total	mg/L	QE	03/01/2020	yes	0.1200					
Barium, Total	mg/L	QE	06/15/2020	yes	0.1140					
Barium, Total	mg/L	QE	09/01/2020	yes	0.0630					
Barium, Total	mg/L	QE	12/09/2020	yes	0.0520					
Barium, Total	mg/L	QE	06/10/2021	yes	0.0065		yes			*
Barium, Total	mg/L	QE	12/09/2021	yes	0.0770					
Barium, Total	mg/L	QE	06/21/2022	yes	0.0690					
Barium, Total	mg/L	QE	12/06/2022	yes	0.1520					
Barium, Total	mg/L	QE	03/22/2023		0.0637			0.0924		
Barium, Total	mg/L	QE	06/19/2023		0.0778			0.0924		
Barium, Total	mg/L	QE	12/01/2023		0.0716			0.0924		
Barium, Total	mg/L	QE	08/12/2024		0.0659			0.0924		
Boron, Total	mg/L	QE	03/01/2020	yes	0.2930					
Boron, Total	mg/L	QE	06/15/2020	yes	0.1850					
Boron, Total	mg/L	QE	09/01/2020	yes	0.5240					
Boron, Total	mg/L	QE	12/09/2020	yes	0.5230					
Boron, Total	mg/L	QE	06/10/2021	yes	0.5040					
Boron, Total	mg/L	QE	12/09/2021	yes	0.4890					
Boron, Total	mg/L	QE	06/21/2022	yes	0.1000	ND				
Boron, Total	mg/L	QE	12/06/2022	yes	0.6450					
Boron, Total	mg/L	QE	03/22/2023		0.1670			0.4079		
Boron, Total	mg/L	QE	06/19/2023		0.3850			0.4079		
Boron, Total	mg/L	QE	12/01/2023		0.6290			0.4376		
Boron, Total	mg/L	QE	08/12/2024		0.5770			0.4153		
Cobalt, Total	mg/L	QE	03/01/2020	yes	0.0048					
Cobalt, Total	mg/L	QE	06/15/2020	yes	0.0020					
Cobalt, Total	mg/L	QE	09/01/2020	yes	0.0004					
Cobalt, Total	mg/L	QE	12/09/2020	yes	0.0042					
Cobalt, Total	mg/L	QE	06/10/2021	yes	0.0017					
Cobalt, Total	mg/L	QE	12/09/2021	yes	0.0024					
Cobalt, Total	mg/L	QE	06/21/2022	yes	0.0023					
Cobalt, Total	mg/L	QE	12/06/2022	yes	0.0293					
Cobalt, Total	mg/L	QE	03/22/2023		0.0066			0.0059		
Cobalt, Total	mg/L	QE	06/19/2023		0.0076			0.0059		
Cobalt, Total	mg/L	QE	12/01/2023		0.0085			0.0059		
Cobalt, Total	mg/L	QE	08/12/2024		0.0058			0.0059		
Manganese, Total	mg/L	QE	03/01/2020	yes	1.2900					
Manganese, Total	mg/L	QE	06/15/2020	yes	1.0200					
Manganese, Total	mg/L	QE	09/01/2020	yes	0.8080					
Manganese, Total	mg/L	QE	12/09/2020	yes	0.7760					
Manganese, Total	mg/L	QE	06/10/2021	yes	2.0700					
Manganese, Total	mg/L	QE	12/09/2021	yes	3.0100					
Manganese, Total	mg/L	QE	06/21/2022	yes	0.7190					
Manganese, Total	mg/L	QE	12/06/2022	yes	1.5000					
Manganese, Total	mg/L	QE	03/22/2023		1.3900			1.3991		
Manganese, Total	mg/L	QE	06/19/2023		3.0300			2.2362		
Manganese, Total	mg/L	QE	12/01/2023		1.4800			1.5232		
Manganese, Total	mg/L	QE	08/12/2024		2.8600			2.1903		
Molybdenum, Total	mg/L	QE	03/01/2020	yes	0.0100	ND				
Molybdenum, Total	mg/L	QE	06/15/2020	yes	0.0100	ND				

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**** - ND value replaced with manual RL.
ND = Not detected, Result = detection limit.

Table 2

Analytical Data and CUSUM Summary

Constituent	Units	Well	Date	Background	Result		Outlier	CUSUM	Adjusted	
Molybdenum, Total	mg/L	QE	09/01/2020	yes	0.0100	ND				
Molybdenum, Total	mg/L	QE	12/09/2020	yes	0.0100					
Molybdenum, Total	mg/L	QE	06/10/2021	yes	0.0100	ND				
Molybdenum, Total	mg/L	QE	12/09/2021	yes	0.0100	ND				
Molybdenum, Total	mg/L	QE	06/21/2022	yes	0.0100	ND				
Molybdenum, Total	mg/L	QE	12/06/2022	yes	0.0190					
Molybdenum, Total	mg/L	QE	03/22/2023		0.0041			0.0111		
Molybdenum, Total	mg/L	QE	06/19/2023		0.0040			0.0111		
Molybdenum, Total	mg/L	QE	12/01/2023		0.0076			0.0111		
Molybdenum, Total	mg/L	QE	08/12/2024		0.0071			0.0111		
Nickel, Total	mg/L	QE	03/01/2020	yes	0.0110					
Nickel, Total	mg/L	QE	06/15/2020	yes	0.0100	ND				
Nickel, Total	mg/L	QE	09/01/2020	yes	0.0100	ND				
Nickel, Total	mg/L	QE	12/09/2020	yes	0.0150					
Nickel, Total	mg/L	QE	06/10/2021	yes	0.0100	ND				
Nickel, Total	mg/L	QE	12/09/2021	yes	0.0150					
Nickel, Total	mg/L	QE	06/21/2022	yes	0.0100	ND				
Nickel, Total	mg/L	QE	12/06/2022	yes	0.0430		yes			*
Nickel, Total	mg/L	QE	03/22/2023		0.0157			0.0133		
Nickel, Total	mg/L	QE	06/19/2023		0.0116			0.0116		
Nickel, Total	mg/L	QE	12/01/2023		0.0248			0.0224		
Nickel, Total	mg/L	QE	08/12/2024		0.0130			0.0215		
Barium, Total	mg/L	QN	03/01/2020	yes	0.2050					
Barium, Total	mg/L	QN	06/15/2020	yes	0.0890					
Barium, Total	mg/L	QN	09/01/2020	yes	0.0790					
Barium, Total	mg/L	QN	12/09/2020	yes	0.1040					
Barium, Total	mg/L	QN	06/10/2021	yes	0.1220					
Barium, Total	mg/L	QN	12/09/2021	yes	0.1260					
Barium, Total	mg/L	QN	06/21/2022	yes	0.0560					
Barium, Total	mg/L	QN	12/06/2022	yes	0.0430					
Barium, Total	mg/L	QN	03/22/2023		0.0445			0.1030		
Barium, Total	mg/L	QN	06/19/2023		0.0881			0.1030		
Barium, Total	mg/L	QN	12/01/2023		0.0594			0.1030		
Barium, Total	mg/L	QN	08/12/2024		0.0486			0.1030		
Boron, Total	mg/L	QN	03/01/2020	yes	0.5440					
Boron, Total	mg/L	QN	06/15/2020	yes	0.4790					
Boron, Total	mg/L	QN	09/01/2020	yes	0.4810					
Boron, Total	mg/L	QN	12/09/2020	yes	0.5200					
Boron, Total	mg/L	QN	06/10/2021	yes	0.6610					
Boron, Total	mg/L	QN	12/09/2021	yes	0.6340					
Boron, Total	mg/L	QN	06/21/2022	yes	0.1240		yes			*
Boron, Total	mg/L	QN	12/06/2022	yes	0.5230					
Boron, Total	mg/L	QN	03/22/2023		0.6540			0.5823		
Boron, Total	mg/L	QN	06/19/2023		0.6030			0.5648		
Boron, Total	mg/L	QN	12/01/2023		0.4880			0.5489		
Boron, Total	mg/L	QN	08/12/2024		0.3740			0.5489		
Cobalt, Total	mg/L	QN	03/01/2020	yes	0.0039					
Cobalt, Total	mg/L	QN	06/15/2020	yes	0.0035					
Cobalt, Total	mg/L	QN	09/01/2020	yes	0.0029					
Cobalt, Total	mg/L	QN	12/09/2020	yes	0.0039					

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**** - ND value replaced with manual RL.
ND = Not detected, Result = detection limit.

Table 2

Analytical Data and CUSUM Summary

Constituent	Units	Well	Date	Background	Result		Outlier	CUSUM	Adjusted	
Cobalt, Total	mg/L	QN	06/10/2021	yes	0.0034					
Cobalt, Total	mg/L	QN	12/09/2021	yes	0.0025					
Cobalt, Total	mg/L	QN	06/21/2022	yes	0.0008		yes			*
Cobalt, Total	mg/L	QN	12/06/2022	yes	0.0059					
Cobalt, Total	mg/L	QN	03/22/2023		0.0027			0.0037		
Cobalt, Total	mg/L	QN	06/19/2023		0.0061			0.0050		
Cobalt, Total	mg/L	QN	12/01/2023		0.0025			0.0037		
Cobalt, Total	mg/L	QN	08/12/2024		0.0041			0.0037		
Manganese, Total	mg/L	QN	03/01/2020	yes	1.1500					
Manganese, Total	mg/L	QN	06/15/2020	yes	0.9450					
Manganese, Total	mg/L	QN	09/01/2020	yes	0.8570					
Manganese, Total	mg/L	QN	12/09/2020	yes	1.1000					
Manganese, Total	mg/L	QN	06/10/2021	yes	0.9550					
Manganese, Total	mg/L	QN	12/09/2021	yes	0.6140					
Manganese, Total	mg/L	QN	06/21/2022	yes	0.3330					
Manganese, Total	mg/L	QN	12/06/2022	yes	0.9220					
Manganese, Total	mg/L	QN	03/22/2023		0.7820			0.8595		
Manganese, Total	mg/L	QN	06/19/2023		0.6890			0.8595		
Manganese, Total	mg/L	QN	12/01/2023		0.6910			0.8595		
Manganese, Total	mg/L	QN	08/12/2024		5.8100			5.5427		**
Molybdenum, Total	mg/L	QN	03/01/2020	yes	0.3580					
Molybdenum, Total	mg/L	QN	06/15/2020	yes	0.2650					
Molybdenum, Total	mg/L	QN	09/01/2020	yes	0.2460					
Molybdenum, Total	mg/L	QN	12/09/2020	yes	0.2500					
Molybdenum, Total	mg/L	QN	06/10/2021	yes	0.2230					
Molybdenum, Total	mg/L	QN	12/09/2021	yes	0.1840					
Molybdenum, Total	mg/L	QN	06/21/2022	yes	0.0240		yes			*
Molybdenum, Total	mg/L	QN	12/06/2022	yes	0.1340					
Molybdenum, Total	mg/L	QN	03/22/2023		0.1240			0.2371		
Molybdenum, Total	mg/L	QN	06/19/2023		0.1150			0.2371		
Molybdenum, Total	mg/L	QN	12/01/2023		0.0900			0.2371		
Molybdenum, Total	mg/L	QN	08/12/2024		0.0147			0.2371		
Nickel, Total	mg/L	QN	03/01/2020	yes	0.0190					
Nickel, Total	mg/L	QN	06/15/2020	yes	0.0200					
Nickel, Total	mg/L	QN	09/01/2020	yes	0.0170					
Nickel, Total	mg/L	QN	12/09/2020	yes	0.0160					
Nickel, Total	mg/L	QN	06/10/2021	yes	0.0130					
Nickel, Total	mg/L	QN	12/09/2021	yes	0.0170					
Nickel, Total	mg/L	QN	06/21/2022	yes	0.0200					
Nickel, Total	mg/L	QN	12/06/2022	yes	0.0250					
Nickel, Total	mg/L	QN	03/22/2023		0.0106			0.0184		
Nickel, Total	mg/L	QN	06/19/2023		0.0121			0.0184		
Nickel, Total	mg/L	QN	12/01/2023		0.0169			0.0184		
Nickel, Total	mg/L	QN	08/12/2024		0.0094			0.0184		
Barium, Total	mg/L	QNE	03/01/2020	yes	0.1490					
Barium, Total	mg/L	QNE	06/15/2020	yes	0.1040					
Barium, Total	mg/L	QNE	09/01/2020	yes	0.0940					
Barium, Total	mg/L	QNE	12/09/2020	yes	0.0970					
Barium, Total	mg/L	QNE	06/10/2021	yes	0.0960					
Barium, Total	mg/L	QNE	12/09/2021	yes	0.0970					

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**** - ND value replaced with manual RL.
ND = Not detected, Result = detection limit.

Table 2

Analytical Data and CUSUM Summary

Constituent	Units	Well	Date	Background	Result		Outlier	CUSUM	Adjusted	
Barium, Total	mg/L	QNE	06/21/2022	yes	0.1000					
Barium, Total	mg/L	QNE	12/06/2022	yes	0.0960					
Barium, Total	mg/L	QNE	03/22/2023		0.0907			0.1041		
Barium, Total	mg/L	QNE	06/19/2023		0.1000			0.1041		
Barium, Total	mg/L	QNE	12/01/2023		0.0992			0.1041		
Barium, Total	mg/L	QNE	08/12/2024		0.1090			0.1041		
Boron, Total	mg/L	QNE	03/01/2020	yes	1.1500					
Boron, Total	mg/L	QNE	06/15/2020	yes	0.4760					
Boron, Total	mg/L	QNE	09/01/2020	yes	0.0752		yes			*
Boron, Total	mg/L	QNE	12/09/2020	yes	0.7390					
Boron, Total	mg/L	QNE	06/10/2021	yes	0.7490					
Boron, Total	mg/L	QNE	12/09/2021	yes	0.7300					
Boron, Total	mg/L	QNE	06/21/2022	yes	0.6080					
Boron, Total	mg/L	QNE	12/06/2022	yes	0.6320					
Boron, Total	mg/L	QNE	03/22/2023		0.6710			0.7263		
Boron, Total	mg/L	QNE	06/19/2023		0.6200			0.7263		
Boron, Total	mg/L	QNE	12/01/2023		0.6250			0.7263		
Boron, Total	mg/L	QNE	08/12/2024		0.6600			0.7263		
Cobalt, Total	mg/L	QNE	03/01/2020	yes	0.0038					
Cobalt, Total	mg/L	QNE	06/15/2020	yes	0.0019					
Cobalt, Total	mg/L	QNE	09/01/2020	yes	0.0011					
Cobalt, Total	mg/L	QNE	12/09/2020	yes	0.0013					
Cobalt, Total	mg/L	QNE	06/10/2021	yes	0.0006					
Cobalt, Total	mg/L	QNE	12/09/2021	yes	0.0007					
Cobalt, Total	mg/L	QNE	06/21/2022	yes	0.0005					
Cobalt, Total	mg/L	QNE	12/06/2022	yes	0.0043					
Cobalt, Total	mg/L	QNE	03/22/2023		0.0011			0.0018		
Cobalt, Total	mg/L	QNE	06/19/2023		0.0062			0.0047		
Cobalt, Total	mg/L	QNE	12/01/2023		0.0027			0.0042		
Cobalt, Total	mg/L	QNE	08/12/2024		0.0009			0.0018		
Manganese, Total	mg/L	QNE	03/01/2020	yes	1.4600					
Manganese, Total	mg/L	QNE	06/15/2020	yes	0.6160					
Manganese, Total	mg/L	QNE	09/01/2020	yes	0.6980					
Manganese, Total	mg/L	QNE	12/09/2020	yes	0.6040					
Manganese, Total	mg/L	QNE	06/10/2021	yes	0.3970					
Manganese, Total	mg/L	QNE	12/09/2021	yes	0.4310					
Manganese, Total	mg/L	QNE	06/21/2022	yes	0.3130					
Manganese, Total	mg/L	QNE	12/06/2022	yes	0.3990					
Manganese, Total	mg/L	QNE	03/22/2023		0.6390			0.6148		
Manganese, Total	mg/L	QNE	06/19/2023		0.3470			0.6148		
Manganese, Total	mg/L	QNE	12/01/2023		0.5550			0.6148		
Manganese, Total	mg/L	QNE	08/12/2024		0.4020			0.6148		
Molybdenum, Total	mg/L	QNE	03/01/2020	yes	0.1150		yes			*
Molybdenum, Total	mg/L	QNE	06/15/2020	yes	0.0210					
Molybdenum, Total	mg/L	QNE	09/01/2020	yes	0.0230					
Molybdenum, Total	mg/L	QNE	12/09/2020	yes	0.0230					
Molybdenum, Total	mg/L	QNE	06/10/2021	yes	0.0200					
Molybdenum, Total	mg/L	QNE	12/09/2021	yes	0.0200					
Molybdenum, Total	mg/L	QNE	06/21/2022	yes	0.0180					
Molybdenum, Total	mg/L	QNE	12/06/2022	yes	0.0140					

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**** - ND value replaced with manual RL.
ND = Not detected, Result = detection limit.

Table 2

Analytical Data and CUSUM Summary

Constituent	Units	Well	Date	Background	Result		Outlier	CUSUM	Adjusted	
Molybdenum, Total	mg/L	QNE	03/22/2023		0.0129			0.0199		
Molybdenum, Total	mg/L	QNE	06/19/2023		0.0117			0.0199		
Molybdenum, Total	mg/L	QNE	12/01/2023		0.0127			0.0199		
Molybdenum, Total	mg/L	QNE	08/12/2024		0.0121			0.0199		
Nickel, Total	mg/L	QNE	03/01/2020	yes	0.0160					
Nickel, Total	mg/L	QNE	06/15/2020	yes	0.0180					
Nickel, Total	mg/L	QNE	09/01/2020	yes	0.0150					
Nickel, Total	mg/L	QNE	12/09/2020	yes	0.0120					
Nickel, Total	mg/L	QNE	06/10/2021	yes	0.0100	ND				
Nickel, Total	mg/L	QNE	12/09/2021	yes	0.0100	ND				
Nickel, Total	mg/L	QNE	06/21/2022	yes	0.0100	ND				
Nickel, Total	mg/L	QNE	12/06/2022	yes	0.0100	ND				
Nickel, Total	mg/L	QNE	03/22/2023		0.0053			0.0126		
Nickel, Total	mg/L	QNE	06/19/2023		0.0044			0.0126		
Nickel, Total	mg/L	QNE	12/01/2023		0.0066			0.0126		
Nickel, Total	mg/L	QNE	08/12/2024		0.0052			0.0126		
Barium, Total	mg/L	QNW	03/01/2020	yes	0.2260					
Barium, Total	mg/L	QNW	06/15/2020	yes	0.1700					
Barium, Total	mg/L	QNW	09/01/2020	yes	0.2450					
Barium, Total	mg/L	QNW	12/09/2020	yes	0.2870					
Barium, Total	mg/L	QNW	06/10/2021	yes	0.2600					
Barium, Total	mg/L	QNW	12/09/2021	yes	0.3090					
Barium, Total	mg/L	QNW	06/21/2022	yes	1.8200		yes			*
Barium, Total	mg/L	QNW	12/06/2022	yes	1.4000		yes			*
Barium, Total	mg/L	QNW	03/22/2023		0.1950			0.2495		
Barium, Total	mg/L	QNW	06/19/2023		0.2490			0.2495		
Barium, Total	mg/L	QNW	12/01/2023		9.4100			9.3611		**
Barium, Total	mg/L	QNW	08/12/2024		0.3140			0.2651		
Boron, Total	mg/L	QNW	03/01/2020	yes	0.1740					
Boron, Total	mg/L	QNW	06/15/2020	yes	0.0100	ND	yes			*
Boron, Total	mg/L	QNW	09/01/2020	yes	0.1980					
Boron, Total	mg/L	QNW	12/09/2020	yes	0.2470					
Boron, Total	mg/L	QNW	06/10/2021	yes	0.1630					
Boron, Total	mg/L	QNW	12/09/2021	yes	0.2770					
Boron, Total	mg/L	QNW	06/21/2022	yes	0.1220					
Boron, Total	mg/L	QNW	12/06/2022	yes	0.2960					
Boron, Total	mg/L	QNW	03/22/2023		0.1470			0.2110		
Boron, Total	mg/L	QNW	06/19/2023		0.1380			0.2110		
Boron, Total	mg/L	QNW	12/01/2023		1.2900			1.2259		**
Boron, Total	mg/L	QNW	08/12/2024		0.2110			0.2110		
Cobalt, Total	mg/L	QNW	03/01/2020	yes	0.0033					
Cobalt, Total	mg/L	QNW	06/15/2020	yes	0.0074					
Cobalt, Total	mg/L	QNW	09/01/2020	yes	0.0004					
Cobalt, Total	mg/L	QNW	12/09/2020	yes	0.0004					
Cobalt, Total	mg/L	QNW	06/10/2021	yes	0.0033					
Cobalt, Total	mg/L	QNW	12/09/2021	yes	0.0067					
Cobalt, Total	mg/L	QNW	06/21/2022	yes	0.0804					
Cobalt, Total	mg/L	QNW	12/06/2022	yes	0.0581					
Cobalt, Total	mg/L	QNW	03/22/2023		0.0007			0.0200		
Cobalt, Total	mg/L	QNW	06/19/2023		0.0030			0.0200		

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Table 2

Analytical Data and CUSUM Summary

Constituent	Units	Well	Date	Background	Result		Outlier	CUSUM	Adjusted	
Cobalt, Total	mg/L	QNW	12/01/2023		0.7270			0.6959		**
Cobalt, Total	mg/L	QNW	08/12/2024		0.0087			0.0200		
Manganese, Total	mg/L	QNW	03/01/2020	yes	1.0400					
Manganese, Total	mg/L	QNW	06/15/2020	yes	0.3020					
Manganese, Total	mg/L	QNW	09/01/2020	yes	0.0560					
Manganese, Total	mg/L	QNW	12/09/2020	yes	0.0450					
Manganese, Total	mg/L	QNW	06/10/2021	yes	0.7010					
Manganese, Total	mg/L	QNW	12/09/2021	yes	0.7140					
Manganese, Total	mg/L	QNW	06/21/2022	yes	5.2400					
Manganese, Total	mg/L	QNW	12/06/2022	yes	9.8800					
Manganese, Total	mg/L	QNW	03/22/2023		0.1050			2.2473		
Manganese, Total	mg/L	QNW	06/19/2023		0.5120			2.2473		
Manganese, Total	mg/L	QNW	12/01/2023		49.9000			46.3776		**
Manganese, Total	mg/L	QNW	08/12/2024		4.4200			2.2473		
Molybdenum, Total	mg/L	QNW	03/01/2020	yes	0.0100	ND				
Molybdenum, Total	mg/L	QNW	06/15/2020	yes	0.0100	ND				
Molybdenum, Total	mg/L	QNW	09/01/2020	yes	0.0100	ND				
Molybdenum, Total	mg/L	QNW	12/09/2020	yes	0.0100	ND				
Molybdenum, Total	mg/L	QNW	06/10/2021	yes	0.0100	ND				
Molybdenum, Total	mg/L	QNW	12/09/2021	yes	0.0100	ND				
Molybdenum, Total	mg/L	QNW	06/21/2022	yes	0.0180					
Molybdenum, Total	mg/L	QNW	12/06/2022	yes	0.0200					
Molybdenum, Total	mg/L	QNW	03/22/2023		0.0040	ND		0.0123		
Molybdenum, Total	mg/L	QNW	06/19/2023		0.0040	ND		0.0123		
Molybdenum, Total	mg/L	QNW	12/01/2023		0.1550			0.1508		**
Molybdenum, Total	mg/L	QNW	08/12/2024		0.0077			0.0123		
Nickel, Total	mg/L	QNW	03/01/2020	yes	0.0100	ND				
Nickel, Total	mg/L	QNW	06/15/2020	yes	0.0100					
Nickel, Total	mg/L	QNW	09/01/2020	yes	0.0100	ND				
Nickel, Total	mg/L	QNW	12/09/2020	yes	0.0100	ND				
Nickel, Total	mg/L	QNW	06/10/2021	yes	0.0100	ND				
Nickel, Total	mg/L	QNW	12/09/2021	yes	0.0100	ND				
Nickel, Total	mg/L	QNW	06/21/2022	yes	0.1000		yes			*
Nickel, Total	mg/L	QNW	12/06/2022	yes	0.0910		yes			*
Nickel, Total	mg/L	QNW	03/22/2023		0.0040					
Nickel, Total	mg/L	QNW	06/19/2023		0.0056					
Nickel, Total	mg/L	QNW	12/01/2023		1.3700					
Nickel, Total	mg/L	QNW	08/12/2024		0.0181					

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ND = Not detected, Result = detection limit.

Table 4

Dixon's Test Outliers
1% Significance Level

Constituent	Units	Well	Date	Result	ND Qualifier	Date Range	N	Critical Value
Barium, Total	mg/L	QE	06/10/2021	0.0065		03/01/2020-12/06/2022	8	0.6808
Nickel, Total	mg/L	QE	12/06/2022	0.0430		03/01/2020-12/06/2022	8	0.6808
Boron, Total	mg/L	QN	06/21/2022	0.1240		03/01/2020-12/06/2022	8	0.6808
Cobalt, Total	mg/L	QN	06/21/2022	0.0008		03/01/2020-12/06/2022	8	0.6808
Molybdenum, Total	mg/L	QN	06/21/2022	0.0240		03/01/2020-12/06/2022	8	0.6808
Boron, Total	mg/L	QNE	09/01/2020	0.0752		03/01/2020-12/06/2022	8	0.6808
Molybdenum, Total	mg/L	QNE	03/01/2020	0.1150		03/01/2020-12/06/2022	8	0.6808
Barium, Total	mg/L	QNW	06/21/2022	1.8200		03/01/2020-12/06/2022	8	0.6371
Barium, Total	mg/L	QNW	12/06/2022	1.4000		03/01/2020-12/06/2022	8	0.6371
Boron, Total	mg/L	QNW	06/15/2020	0.0100	< 0.0100	03/01/2020-12/06/2022	8	0.6808
Nickel, Total	mg/L	QNW	06/21/2022	0.1000		03/01/2020-12/06/2022	8	0.6371
Nickel, Total	mg/L	QNW	12/06/2022	0.0910		03/01/2020-12/06/2022	8	0.6371

N = Total number of independent measurements in background at each well.
Date Range = Dates of the first and last measurements included in background at each well.
Critical Value depends on the significance level and on N-1 when the two most extreme values are tested or N for the most extreme value.