Centralia Landfill

Groundwater Monitoring Data
Statistical Evaluation

Prepared for
Lewis County Solid Waste Utility

Prepared By
Puget Sound Environmental PLLC

PN 7722.500.010.010.001

LEWIS COUNTY
Washington's First County
est. 1845

PUGET SOUND
ENVIRONMENTAL PLLC

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Introduction and Background

This statistical evaluation was prepared by Puget Sound Environmental PLLC on behalf of Lewis County Solid Waste Utility (Lewis County). The groundwater data summarized herein was collected by Lewis County during routine compliance monitoring at the Centralia Landfill (Landfill) in Chehalis, WA. The data was collected as part of the ongoing compliance monitoring program being conducted to satisfy Model Toxics Control Act (MTCA) requirements. The Landfill location, monitoring network, and flow direction for the upper and lower aquifers are presented on Figure 1 through Figure 6.

The Landfill is a closed municipal solid waste landfill that operated between 1958 and 1994. A closure system including a cap, landfill gas controls, and the environmental monitoring network were implemented as part of a MTCA cleanup action. Cleanup activities were determined necessary and were completed at the landfill in accordance with Consent Decree C91-5100 executed in 2001 between the Washington State Department of Ecology (Ecology), Lewis County, the City of Chehalis, the City of Centralia, the City of Morton, the City of Mossyrock, the Town of Pe Ell, and the City of Vader. Elements of the cleanup generally included closure activities typical in the solid waste industry intended to contain the waste in place, prevent generation of leachate, protect groundwater and surface water quality, and control landfill gas (LFG).

The monitoring is conducted throughout the year and the resulting data is uploaded annually to the Washington State Department of Ecology (Ecology) Environment Information Management (EIM) database and summarized annually in monitoring reports. The statistical evaluation summarized herein is required once per five years. In addition to the required steps, further data evaluation has been conducted which indicates small changes to the monitoring program may be warranted based on the many successful years of monitoring that show generally predictable conditions and confirm protectiveness of the cleanup actions.

As noted in the Washington Administrative Code (WAC) 173-340-350, the data collection process *"should remain flexible and streamlined when possible to avoid the collection and evaluation of unnecessary information so that the cleanup can proceed in a timely manner."* This refers specifically to the remedial investigation and feasibility study portion of the MTCA process, but the intent is clearly appropriate for cleanup implementation and the subject monitoring program as well.

Summary

This report presents the required statistical evaluation of groundwater monitoring parameters with comparison to cleanup levels (CULs) pursuant to MTCA requirements. The evaluation is conducted once per 5 years to determine if the cleanup action has achieved the numerical CULs. In addition to the required evaluation, this report includes further statistical evaluation of monitored parameters which do not have associated CULs to evaluate whether changes to the monitoring parameter list are warranted.

Existing Monitoring Program

Monitoring Wells	Monitoring Parameters	Monitoring Frequency
Upper Aquifer: *MW-1S (background)* *MW-3S (background)* *MW-4S (background)* MW-2S B-2S MW-CNE-1S B-1S MW-5S B-1SU (shallow) B-2SU (shallow) MW-2SU (shallow) **Lower Aquifer:** *MW-1D (background)* MW-2D MW-3D B-6DR B-8DR MW-CNE-1D	Alkalinity Ammonia **Arsenic, Dissolved** Calcium, Dissolved Total Organic Carbon (TOC) Chemical Oxygen Demand (COD) **Chloride** Hardness **Iron, Dissolved** Magnesium, Dissolved **Manganese, Dissolved** **Mercury, Dissolved** **Nitrate+Nitrite as N** Potassium, Dissolved Sodium, Dissolved **Total Dissolved Solids** **Sulfate** Zinc, Dissolved	The County tests groundwater from each of the listed 17 monitoring wells, for each parameter, twice per year.

Monitoring wells shown in regular text are compliance monitoring wells.
Monitoring wells shown in italics and marked (background) provide background groundwater quality.
*Monitoring parameters shown in **bold** have regulatory compliance limits.*
Monitoring parameters in regular text are geochemical or leachate indicator parameters.

Based on the statistical evaluations presented herein, minor changes to the existing monitoring program appear warranted and include a reduction in the number of wells, reduction in the monitoring parameters, and for the background monitoring wells and parameters with no regulatory CULs, a reduction in monitoring frequency. No changes are warranted or recommended for field-collected parameters.

Statistical Determination of Compliance with Cleanup Levels

This evaluation includes calculating the upper limit of the mean concentration with 95 percent confidence (95UCL) to determine if water quality meets the required criteria. To demonstrate compliance with MTCA CULs using statistics, the following 3 criteria must be met:

1. The 95UCL must be below the numerical CUL,
2. No single sample result can be more than twice the value of the CUL, and
3. No more than 10 percent of the individual results can exceed the CUL.

As noted in the Compliance Monitoring Plan[1] (CMP), because the 95UCL calculations require a significant effort, the 2nd and 3rd criteria listed above are applied first. So that this screening reflects current conditions, the 2nd and 3rd criteria are based on the most recent 8 samples. If more than one of the most recent 8 samples is in exceedance of the CUL, the parameter is determined out of compliance for the associated well. The following tables summarize this screening:

Criterion 2 – No single sample in previous 8 sampling events greater than 2x CUL

Aquifer	Arsenic	Iron	Manganese	Mercury	Nitrate + Nitrite	TDS	Sulfate	Zinc
Upper	Fail	Fail	Fail	Pass	Fail	Fail	Pass	Pass
Lower	Fail	Fail	Fail	Pass	Fail	Fail	Pass	Pass

Criterion 3 – Less than 10% exceedance of CUL in previous 8 sampling events

Aquifer	Arsenic	Iron	Manganese	Mercury	Nitrate + Nitrite	TDS	Sulfate	Zinc
Upper	Fail	Fail	Fail	Pass	Pass	Pass	Pass	Pass
Lower	Fail	Fail	Fail	Pass	Pass	Pass	Pass	Pass

Based on the screening above, the 95UCL was calculated for the parameters which met each criterion at every compliance monitoring well: mercury, sulfate, and zinc. The 95UCL calculation uses the entire available dataset from 2009 through 2021. The tables below present statistical summaries for these parameters, including number of samples, frequency of detection (FOD), data distribution, comparison values (CULs), and the 95UCL calculated using Land's approach, as follows:

$$\mathrm{UCL} = \exp\left(\bar{y} + 0.5 s_y^2 + s_y H_{1-\alpha} / \sqrt{n-1}\right)$$

[1] Pacific Groundwater Group, *Centralia Landfill 2020 Compliance Monitoring Plan*, July 2020.

Criterion 1 - Mercury:

Parameter	Location	Number of Samples	Frequency of Detection	Distribution	Comparison Value (mg/L)	Maximum Detection[a]	95 UCL
Upper Aquifer Mercury	Background	69	13%	Lognormal	-	-	0.0003
	B-1S	23	22%	Lognormal	0.002	0.00004	-
	B-1SU	24	21%	Lognormal		0.00003	
	B-2S	23	17%	Lognormal		0.0000013	
	B-2SU	24	21%	Lognormal		0.0000082	
	MW-2S	24	21%	Lognormal		0.0000036	
	MW-2SU	24	21%	Lognormal		0.000001	
	MW-5S	25	24%	Lognormal		0.00003	
	MW-CNE-1S	24	25%	Lognormal		0.00000233	
Lower Aquifer Mercury	Background	24	21%	Lognormal	-	-	0.0003
	B-6DR	24	21%	Lognormal	0.002	0.00003	-
	B-8DR	24	13%	Lognormal		0.0000011	
	MW-2D	24	17%	Lognormal		0.0000006	
	MW-3D	24	21%	Lognormal		0.0000024	
	MW-CNE-1D	24	21%	Lognormal		0.0000007	
	PASS / FAIL:	**Pass - Mercury meets cleanup standards being below the CUL at all points of compliance.**					

Criterion 1 - Sulfate:

Parameter	Location	Number of Samples	Frequency of Detection	Distribution	Comparison Value (mg/L)	Maximum Detection[a]	95 UCL
Upper Aquifer Sulfate	Background	81	99%	Lognormal	-	-	23.59
	B-1S	25	48%	Lognormal	250	2.138	-
	B-1SU	26	58%	Lognormal		-	1.85
	B-2S	26	88%	Lognormal			5.44
	B-2SU	27	100%	Lognormal			5.76
	MW-2S	27	93%	Lognormal			4.52
	MW-2SU	27	93%	Lognormal			10.33
	MW-5S	27	100%	Lognormal			4.85
	MW-CNE-1S	26	69%	Lognormal			1.72
Lower Aquifer Sulfate	Background	26	35%	Lognormal	-	-	0.89
	B-6DR	27	56%	Lognormal	250	-	2.33
	B-8DR	27	100%	Lognormal		-	23.54
	MW-2D	26	31%	Lognormal		3.73	-
	MW-3D	26	27%	Lognormal		1.59	
	MW-CNE-1D	25	32%	Lognormal		17	
	PASS / FAIL:	**Pass - Sulfate meets cleanup standards being below the CUL at all points of compliance.**					

Criterion 1 - Zinc:

Parameter	Location	Number of Samples	Frequency of Detection	Distribution	Comparison Value (mg/L)	Maximum Detection[a]	95 UCL
Upper Aquifer Zinc	Background	78	60%	Lognormal	-	-	0.0055
	B-1S	24	50%	Lognormal	5	-	0.0043
	B-1SU	26	42%	Lognormal		0.0171	-
	B-2S	24	54%	Lognormal		-	0.0071
	B-2SU	26	69%	Lognormal			0.0050
	MW-2S	25	56%	Lognormal			0.0089
	MW-2SU	25	64%	Lognormal			0.0070
	MW-5S	26	81%	Lognormal			0.0142
	MW-CNE-1S	26	69%	Lognormal			0.0073
Lower Aquifer Zinc	Background	26	50%	Lognormal	-	-	0.0148
	B-6DR	25	32%	Lognormal	5	0.005	-
	B-8DR	25	28%	Lognormal		0.0043	
	MW-2D	25	36%	Lognormal		0.005	
	MW-3D	26	38%	Lognormal		0.01	
	MW-CNE-1D	25	32%	Lognormal		0.005	
	PASS / FAIL:	**Pass - Zinc meets cleanup standards being below the CUL at all points of compliance.**					

Notes:

- Statistical summary output, distribution assessment by probability plot, and 95UCL calculations by Land's method are provided in Attachments A, B, and C
- The laboratory reporting limit was used for non-detects as a conservative measure
- When FOD was less than 50 percent, or when data has neither normal or lognormal distribution, the maximum detection in the last 8 sampling events serves as the 95UCL

Section Summary

Based on the screening evaluation and 95UCL calculations, the cleanup action implemented at the site has achieved partial sufficiency toward attainment of cleanup standards with respect to mercury, sulfate, and zinc in groundwater at each compliance well at the site. Based on these results, we propose these three parameters should be removed from the parameter list moving forward, beginning in 2023. The final section of this report presents a table summarizing these recommended changes, as well as recommendations discussed in the following sections.

Monitoring Well Network Adjustment

The county currently conducts monitoring of groundwater elevation and chemistry twice per year at each of these 17 monitoring wells:

Upper Aquifer	***Lower Aquifer***
MW-1S (Background Well)	MW-1D (Background Well)
MW-3S (Background Well)	B-6DR
MW-4S (Background Well)	B-8DR
B-1S	MW-2D
B-1SU	MW-3D
B-2S	MW-CNE-1D
B-2SU	
MW-2S	
MW-2SU	
MW-5S	
MW-CNE-1S	

This is a rather large number of monitoring wells for a project of this size. While it was necessary earlier in the monitoring program to understand hydrogeologic conditions including contaminant distribution, fate, and transport, some of the wells are now extraneous and/or redundant. Adequate coverage can be more efficiently provided by a smaller number of wells now that a significant dataset has been established and groundwater quality conditions are relatively stable. Based on review of the CMP, monitoring reports, and the physical layout of the monitoring wells, 4 monitoring wells have been identified as candidates for removal from the list above.

1. MW-4S (Background Well)
    - The upper aquifer background water quality is well represented by 2 other background wells (MW-1S and MW-3S). MW-4S is redundant and located in a less ideal position for providing true background conditions than the other 2. For these reasons it is recommended that MW-4 is omitted from chemical sampling, but retained for groundwater elevation monitoring.

2. MW-3D
    - This well has been regularly monitored by the County but was omitted from the CMP, likely due to redundancy. It is recommended that MW-3D is omitted from further chemical sampling but retained for groundwater elevation monitoring.

3. B-1S
    - This well is outfitted with a pump that has not operated reliably, introducing a challenge to collecting representative groundwater samples, and is in need of repair or replacement. Due to the adequate coverage of the upper aquifer in this are by B-1SU, B-2SU, and MW-6S, it does not appear warranted to expend budget to repair or replace the pump. It is recommended that the well is omitted from chemical sampling, but retained for groundwater elevation monitoring.

4. B-2S
    - Similar to B-1S, this well is outfitted with a pump that has not operated reliably and may need replacement. Due to the adequate coverage of the upper aquifer in this direction by B-1SU, B-2SU, MFW-5S, and MW-6S, it is recommended that the well is omitted from chemical sampling but retained for groundwater elevation monitoring.

Figure 2 provides a site layout and shows the locations of monitoring wells. The final section of this report presents a table summarizing the recommended changes.

Monitoring Frequency Adjustment

During routine groundwater monitoring, the County tests samples for the parameters with CULs and also some without CULs. The monitored parameters that do not have associated regulatory limits are included in the monitoring program to evaluate general geochemistry and leachate indicators. This helps to assess whether groundwater is impacted by the landfill – an important function of the monitoring program. However, because waste is no longer being placed at this landfill and the monitoring has confirmed the cover system constructed at this site is functioning as designed, it is anticipated that groundwater quality will slowly improve over the coming years. It appears warranted to revisit the frequency of monitoring for the parameters without CULs.

As part of this evaluation, the data for parameters without CULs were evaluated by Welch's T-Test to observe for statistical differences between upgradient and downgradient concentrations, and the data were evaluated by Mann-Kendall to observe for upward trends in the data. These evaluations confirmed that *most* parameters at *many* locations are similar to background conditions and are relatively stable. However, the tests do not reach this conclusion for all parameter at all locations, and as such, continued monitoring is appropriate to observe for changing conditions and to determine when downgradient quality will be statistically the same as background. Monitoring for parameters that do have CULs is anticipated to continue on a biannual basis into the foreseeable future, and the County seeks to update other portions of the monitoring program to be more sustainable, by monitoring for parameters without associated numerical cleanup levels on an annual basis.

Similarly, because background groundwater quality conditions are now well-established, the County seeks to reduce monitoring at background wells to annual basis, which is not anticipated to degrade the quality or effectiveness of the monitoring program. To summarize, based on these considerations, the County requests that the monitoring program is adjusted as follows:

- **Wet season** *(To occur in the future strictly between October 1 and April 30)*
    - Test at all locations upgradient and downgradient
    - Test for all parameters including those with and without CULs
- **Dry season** *(To occur in the future strictly between May 1 and September 30)*
    - Test only the compliance monitoring wells (skip the background wells)
    - Test only the parameters with compliance limits CULs (skip the others)

Summary and Recommendations

Based on the consistency of monitoring results conducted since 2009, consistent 5-year reviews from Ecology, and the discussions presented above, small changes to the monitoring program appear warranted. The changes recommended herein include:

1. Remove 3 parameters from the program based on statistical attainment of the CUL
2. Reduce chemical monitoring from 17 wells to 13
3. Reduce the frequency of monitoring for select parameters and select wells to annual

The following table summarizes the updated monitoring program with these changes. Groundwater elevation data will be collected at all wells during both wet and dry seasons.

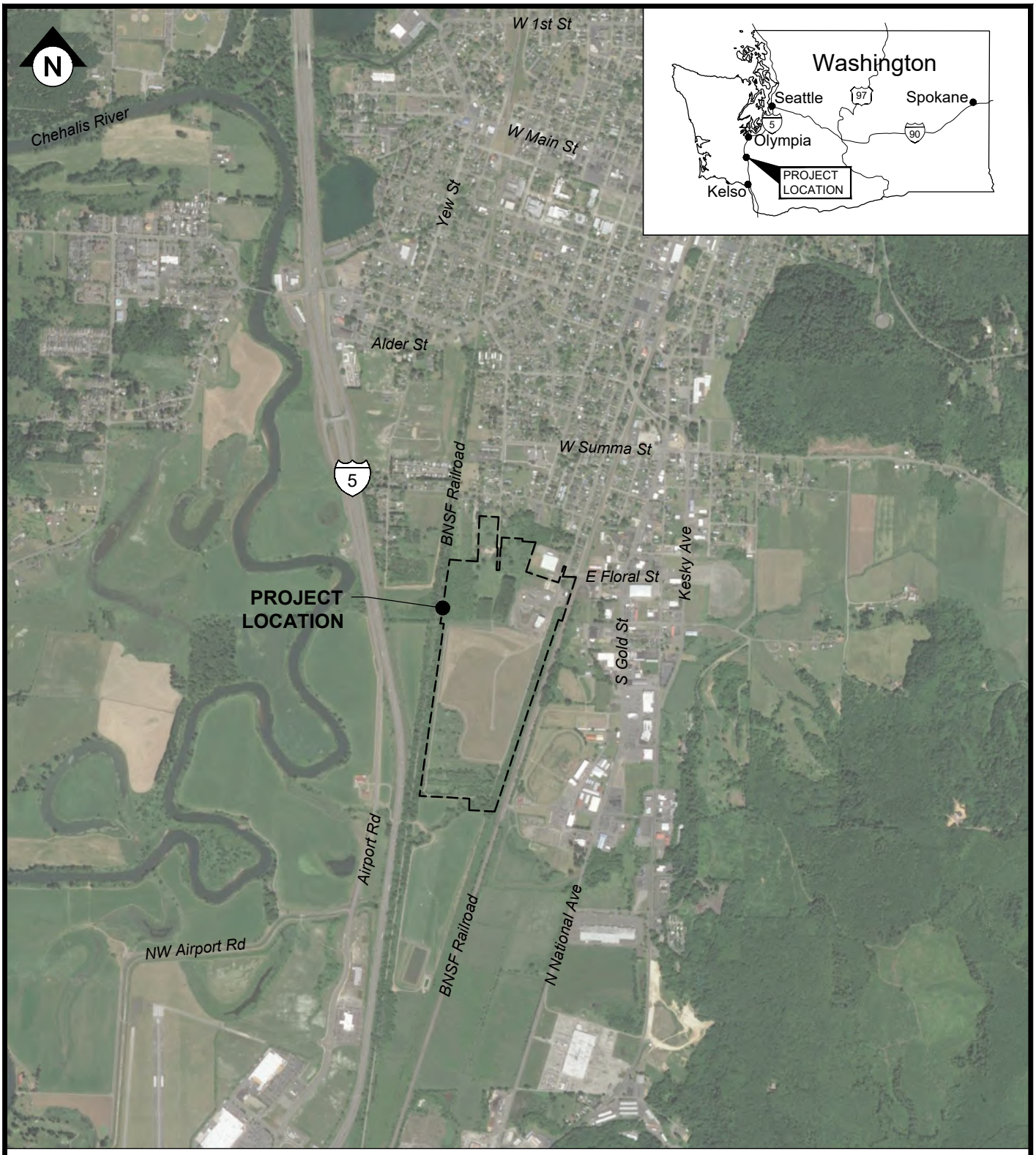
Recommended Program Update:

Season	Monitoring Wells	Monitoring Parameters
Wet Season (Oct. through Apr.)	**Upper Aquifer:** MW-1S (background) MW-3S (background) MW-2S MW-CNE-1S MW-5S B-1SU (shallow) B-2SU (shallow) MW-2SU (shallow) **Lower Aquifer:** MW-1D (background) MW-2D B-6DR B-8DR MW-CNE-1D	Alkalinity, Carb as CaCO3 Ammonia as N, Total Arsenic, Dissolved Calcium, Dissolved Carbon, Total Organic Chemical Oxygen Demand (COD) Chloride Hardness Iron, Dissolved Magnesium, Dissolved Manganese, Dissolved Nitrate+Nitrite as N Potassium, Dissolved Sodium, Dissolved Solids, Total Dissolved
Dry Season (May through Sep.)	**Upper Aquifer:** MW-2S MW-CNE-1S MW-5S B-1SU (shallow) B-2SU (shallow) MW-2SU (shallow) **Lower Aquifer:** MW-2D B-6DR B-8DR MW-CNE-1D	Arsenic, Dissolved Chloride Iron, Dissolved Manganese, Dissolved Nitrate+Nitrite as N Solids, Total Dissolved

Use of this Report

This report has been prepared on behalf of Lewis County Solid Waste Utility by Puget Sound Environmental PLLC. This report is intended for specific application to the Centralia Landfill project. No other parties, except with regulatory authority over the project, is entitled to rely on the information, conclusions, and recommendations included in this document without the express written consent of Puget Sound Environmental, PLLC. The reuse of the content of this report for any other project, without prior review and authorization by Puget Sound Environmental PLLC shall be at the user's sole risk. Puget Sound Environmental PLLC warrants that within the limitations of scope, schedule, and budget, the services described herein have been provided in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions as this project. No other warranty is made expressly or implied.

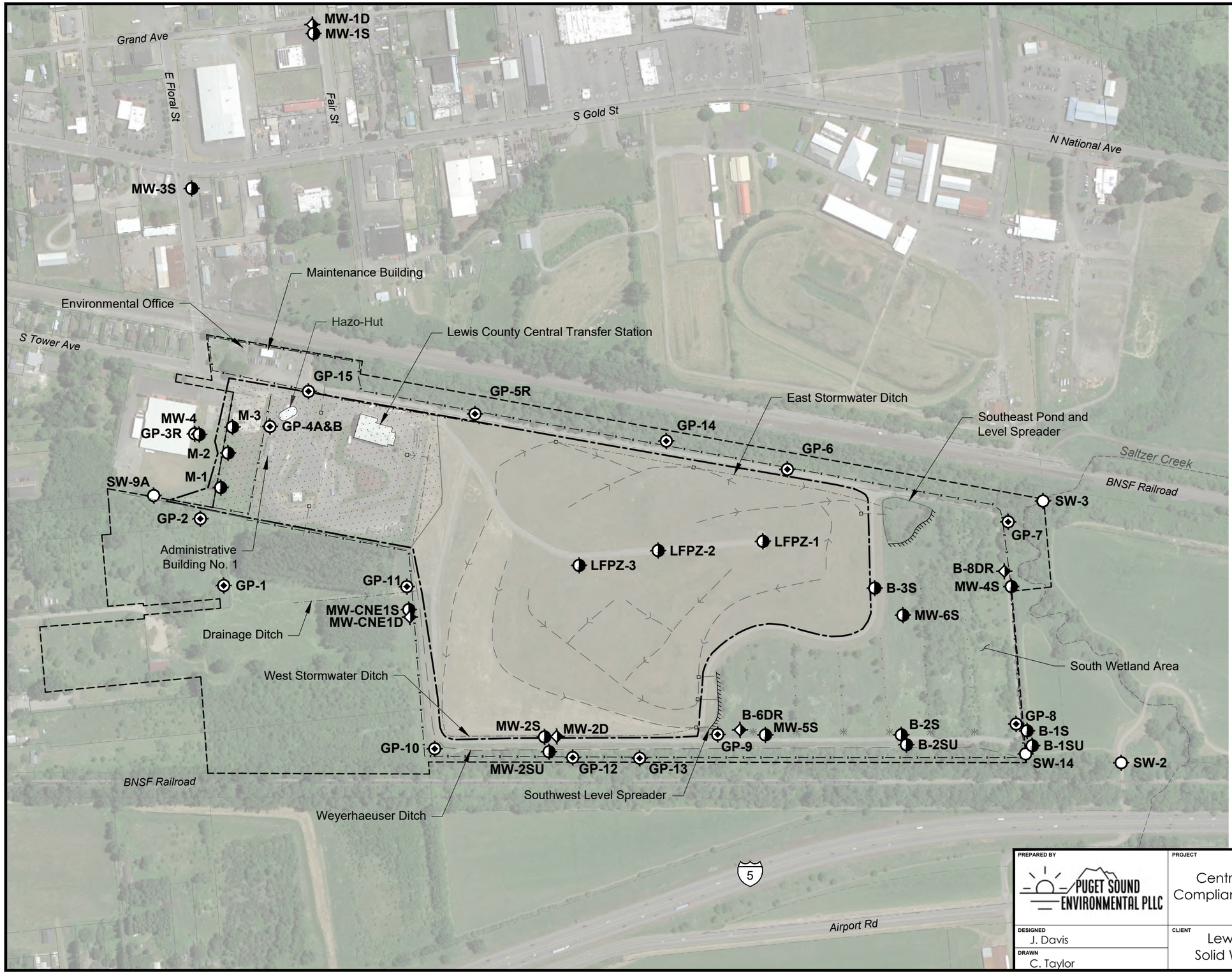
Figures



0 2,000 4,000

Scale in Feet

PREPARED BY: PUGET SOUND ENVIRONMENTAL PLLC	PROJECT: Centralia Landfill Compliance Monitoring	SHEET TITLE: **Vicinity Map**
DESIGNED: J. Davis	CLIENT: Lewis County Solid Waste Utility	
DRAWN: C. Taylor		DATE: July 2022 / FIGURE: 1



LEGEND

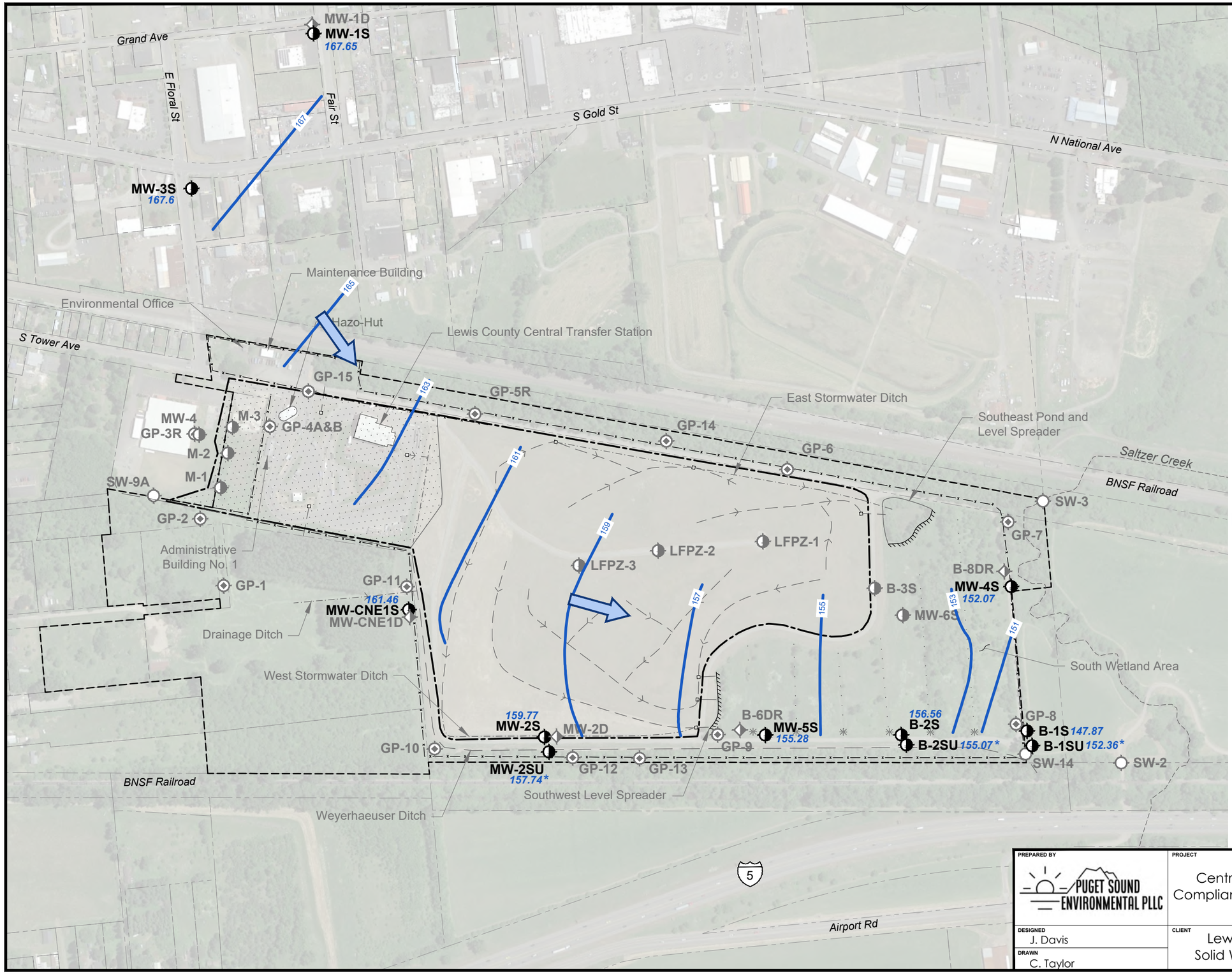
- Landfill Gas Probe
- Surface Water Monitoring Well
- Upper Unit Groundwater Monitoring Well
- Lower Unit Groundwater Monitoring Well
- Project Boundary
- Edge of Refuse
- Runoff Control Berm
- Ditch on Top of Final Cover System
- Fence
- Stormwater Catch Basin
- Culverts with Side Gates
- Stormwater Swales
- Stormwater Level Spreader
- Closed Northend Landfill
- Tax Parcel

N

0 400 800

Scale in Feet

PREPARED BY: PUGET SOUND ENVIRONMENTAL PLLC	PROJECT: Centralia Landfill Compliance Monitoring	SHEET TITLE: **Monitoring Locations**
DESIGNED: J. Davis	CLIENT: Lewis County Solid Waste Utility	
DRAWN: C. Taylor		DATE: July 2022 / FIGURE: **2**



LEGEND

- Landfill Gas Probe
- Surface Water Monitoring Well
- Upper Unit Groundwater Monitoring Well
- Lower Unit Groundwater Monitoring Well
- Project Boundary
- Edge of Refuse
- Runoff Control Berm
- Ditch on Top of Final Cover System
- Fence
- Stormwater Catch Basin
- Culverts with Side Gates
- Stormwater Swales
- Stormwater Level Spreader
- Closed Northend Landfill
- Tax Parcel
- 152.07 Measured Groundwater Elevation
- 155 Approximate Groundwater Elevation Contour
- Approximate Groundwater Flow Direction

NOTE

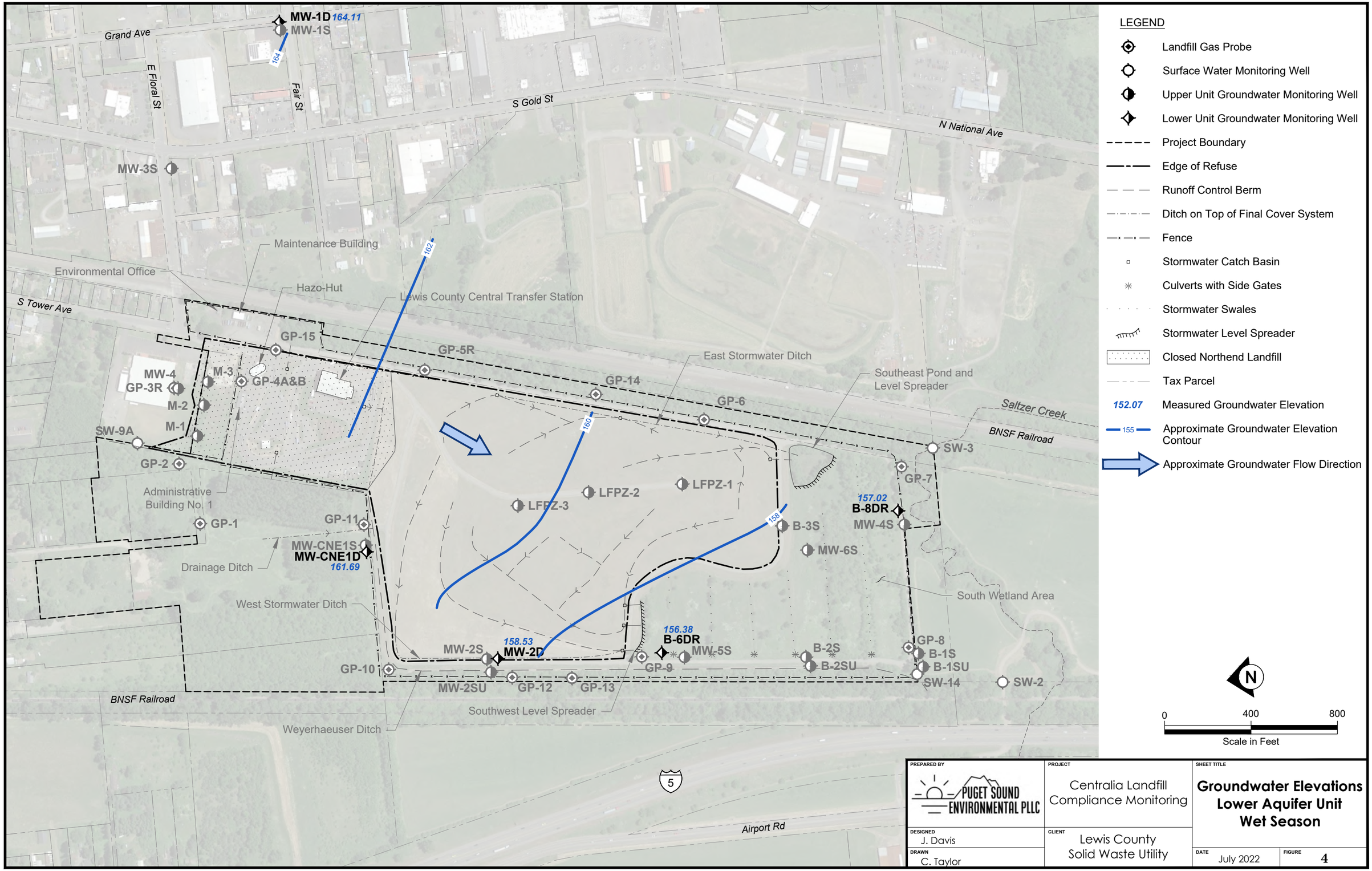
* Elevations for Shallow Upper Unit wells shown for reference but omitted from contours.

N

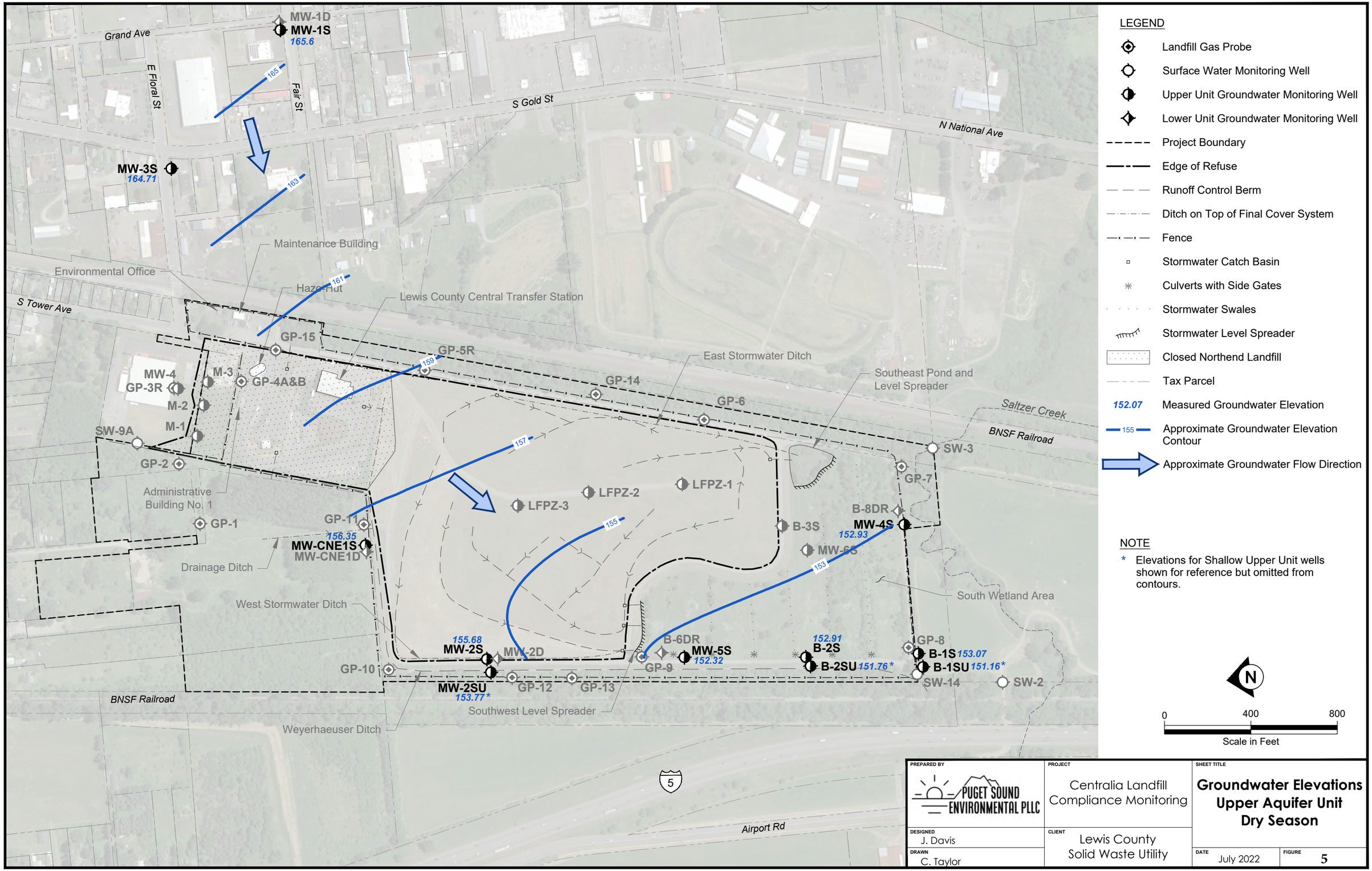
0 400 800

Scale in Feet

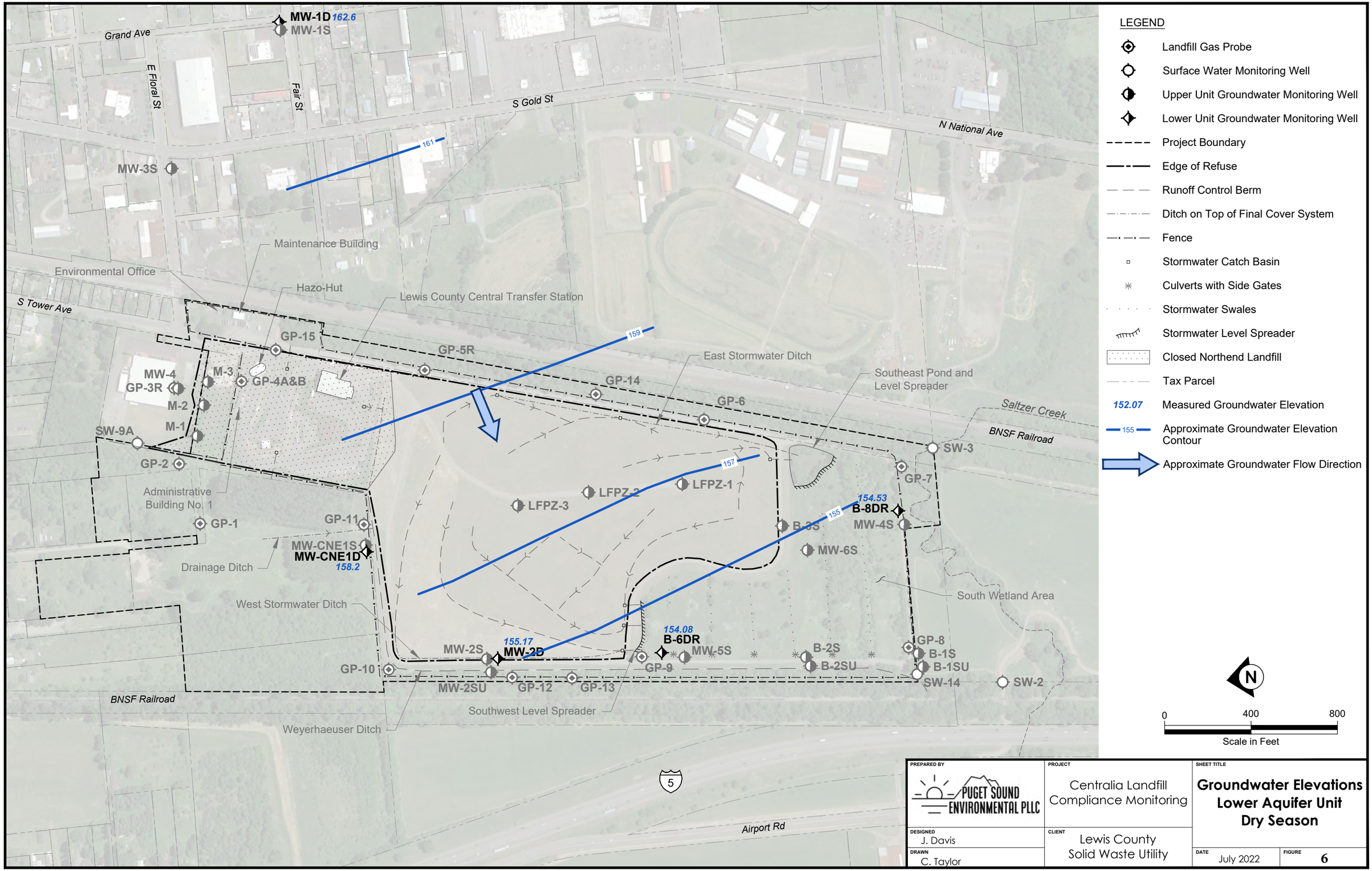
PREPARED BY: PUGET SOUND ENVIRONMENTAL PLLC	PROJECT: Centralia Landfill Compliance Monitoring	SHEET TITLE: **Groundwater Elevations Upper Aquifer Unit Wet Season**
DESIGNED: J. Davis	CLIENT: Lewis County Solid Waste Utility	
DRAWN: C. Taylor		DATE: July 2022 / FIGURE: 3



PREPARED BY: PUGET SOUND ENVIRONMENTAL PLLC	PROJECT: Centralia Landfill Compliance Monitoring	SHEET TITLE: **Groundwater Elevations Lower Aquifer Unit Wet Season**	
DESIGNED: J. Davis	CLIENT: Lewis County Solid Waste Utility		
DRAWN: C. Taylor		DATE: July 2022	FIGURE: 4



PREPARED BY: PUGET SOUND ENVIRONMENTAL PLLC	PROJECT: Centralia Landfill Compliance Monitoring	SHEET TITLE: **Groundwater Elevations Upper Aquifer Unit Dry Season**	
DESIGNED: J. Davis	CLIENT: Lewis County Solid Waste Utility		
DRAWN: C. Taylor		DATE: July 2022	FIGURE: 5



PREPARED BY: PUGET SOUND ENVIRONMENTAL PLLC	PROJECT: Centralia Landfill Compliance Monitoring	SHEET TITLE: **Groundwater Elevations Lower Aquifer Unit Dry Season**	
DESIGNED: J. Davis	CLIENT: Lewis County Solid Waste Utility		
DRAWN: C. Taylor		DATE: July 2022	FIGURE: 6

Attachment A

Basic Statistics

Parameter: Mercury

Original Data (Not Transformed)

Non-Detects Replaced with Detection Limit

Total Measurements	407
Total Non-Detects	327 (80.344%)
Pooled Mean	7.39604e-05
Pooled Std Dev	0.000118481
Compliance Meas.	311
Compliance Mean	7.59958e-05
Compliance Std Dev	0.000131546
Background Meas.	96
Background Mean	6.73667e-05
Background Std Dev	5.8892e-05

Background Locations

There are 4 background location

Location	Meas.	Non-Detects	% ND	Total
MW-1D	24	19	79.1667	0.0015993
MW-1S	24	20	83.3333	0.0015894
MW-3S	24	20	83.3333	0.001689
MW-4S	24	20	83.3333	0.0015895

Location	Mean	Std Dev	Std Err	Rank Sum	Rank Mean
MW-1D	6.66375e-05	5.80822e-05	0	4889	203.708
MW-1S	6.6225e-05	5.83866e-05	0	4702	195.917
MW-3S	7.0375e-05	6.42012e-05	0	4744	197.667
MW-4S	6.62292e-05	5.83818e-05	0	4714	196.417

Compliance Locations

There are 13 compliance location

Location	Obs.	Non-Detects	% ND	Total
B-1S	23	18	78.2609	0.0015096
B-1SU	24	19	79.1667	0.0016024
B-2S	23	19	82.6087	0.0014903
B-2SU	24	19	79.1667	0.001697
B-6DR	24	19	79.1667	0.0035036
B-8DR	24	21	87.5	0.0015896
MW-2D	24	20	83.3333	0.0015891
MW-2S	24	19	79.1667	0.0016923
MW-2SU	24	19	79.1667	0.0016896
MW-3D	24	19	79.1667	0.0016913
MW-5S	25	19	76	0.0017997
MW-CNE-1D	24	19	79.1667	0.0016893
MW-CNE-1S	24	18	75	0.0020909

Location	Mean	Std Dev	Dif From Bkg	Std Err	Rank Sum	Rank Mean
B-1S	6.56348e-05	5.86914e-05	-1.73188e-06	2.77116e-05	4755	206.739
B-1SU	6.67667e-05	5.79313e-05	-6e-07	2.72418e-05	4943	205.958
B-2S	6.47957e-05	5.91999e-05	-2.57101e-06	2.77116e-05	4576	198.957
B-2SU	7.07083e-05	6.38408e-05	3.34167e-06	2.72418e-05	4972	207.167
B-6DR	0.000145983	0.00041925	7.86167e-05	2.72418e-05	4966	206.917

B-8DR	6.62333e-05	5.83769e-05	-1.13333e-06	2.72418e-05	4561	190.042
MW-2D	6.62125e-05	5.84013e-05	-1.15417e-06	2.72418e-05	4709	196.208
MW-2S	7.05125e-05	6.40479e-05	3.14583e-06	2.72418e-05	4977	207.375
MW-2SU	7.04e-05	6.41728e-05	3.03333e-06	2.72418e-05	4967	206.958
MW-3D	7.04708e-05	6.40934e-05	3.10417e-06	2.72418e-05	4992	208
MW-5S	7.1988e-05	6.27856e-05	4.62133e-06	2.68024e-05	5348	213.92
MW-CNE-1D	7.03875e-05	6.4187e-05	3.02083e-06	2.72418e-05	4976	207.333
MW-CNE-1S	8.71208e-05	0.000100327	1.97542e-05	2.72418e-05	5237	218.208

Analysis of Variance Statistics

SS Wells	1.42299e-07
SS Total	5.69928e-06

Kruskal-Wallis Statistics

Non-Detect Rank	164
Background Rank Sum	19049
Background Rank Mean	198.427
H Statistic	1.36207
H Adjusted for Ties	2.82958

Basic Statistics

Parameter: Sulfate

Original Data (Not Transformed)

Non-Detects Replaced with Detection Limit

Total Measurements	449
Total Non-Detects	123 (27.3942%)
Pooled Mean	5.45734
Pooled Std Dev	8.51486
Compliance Meas.	342
Compliance Mean	3.45554
Compliance Std Dev	6.37572
Background Meas.	107
Background Mean	11.8556
Background Std Dev	11.0184

Background Locations

There are 4 background location

Location	Meas.	Non-Detects	% ND	Total
MW-1D	26	17	65.3846	13.3759
MW-1S	27	0	0	544.76
MW-3S	27	1	3.7037	487.601
MW-4S	27	0	0	222.816

Location	Mean	Std Dev	Std Err	Rank Sum	Rank Mean
MW-1D	0.514458	0.663446	0	2622	100.846
MW-1S	20.1763	12.8771	0	10600	392.593
MW-3S	18.0593	7.37684	0	10599	392.556
MW-4S	8.25244	4.50881	0	9216	341.333

Compliance Locations

There are 13 compliance location

Location	Obs.	Non-Detects	% ND	Total
B-1S	25	13	52	21.2439
B-1SU	26	11	42.3077	24.33
B-2S	26	3	11.5385	69.23
B-2SU	27	0	0	112.406
B-6DR	27	12	44.4444	32.908
B-8DR	27	0	0	557.29
MW-2D	26	18	69.2308	17.4559
MW-2S	27	2	7.40741	65.82
MW-2SU	27	2	7.40741	116.427
MW-3D	26	19	73.0769	11.5019
MW-5S	27	0	0	101.077
MW-CNE-1D	25	17	68	29.8829
MW-CNE-1S	26	8	30.7692	22.221

Location	Mean	Std Dev	Dif From Bkg	Std Err	Rank Sum	Rank Mean
B-1S	0.849756	0.996426	-11.0059	1.11392	3151	126.04
B-1SU	0.935769	1.03522	-10.9199	1.09641	3649	140.346
B-2S	2.66269	2.57996	-9.19294	1.09641	5945	228.654
B-2SU	4.16319	1.89798	-7.69245	1.07996	7910	292.963
B-6DR	1.21881	2.22659	-10.6368	1.07996	3845	142.407

B-8DR	20.6404	8.27445	8.78474	1.07996	11072	410.074
MW-2D	0.671381	1.0444	-11.1843	1.09641	2675	102.885
MW-2S	2.43778	2.0622	-9.41786	1.07996	6367	235.815
MW-2SU	4.31211	8.43194	-7.54352	1.07996	6538	242.148
MW-3D	0.442381	0.459395	-11.4133	1.09641	2419	93.0385
MW-5S	3.74359	2.00331	-8.11204	1.07996	7638	282.889
MW-CNE-1D	1.19532	3.34347	-10.6603	1.11392	2739	109.56
MW-CNE-1S	0.854654	0.720384	-11.001	1.09641	4040	155.385

Analysis of Variance Statistics

SS Wells	21618.6
SS Total	32481.3

Kruskal-Wallis Statistics

Non-Detect Rank	62
Background Rank Sum	33037
Background Rank Mean	308.757
H Statistic	226.7
H Adjusted for Ties	231.458

Basic Statistics

Parameter: Zinc

Original Data (Not Transformed)

Non-Detects Replaced with Detection Limit

Total Measurements	432
Total Non-Detects	207 (47.9167%)
Pooled Mean	0.00476706
Pooled Std Dev	0.0188402
Compliance Meas.	328
Compliance Mean	0.00400892
Compliance Std Dev	0.00872389
Background Meas.	104
Background Mean	0.0071581
Background Std Dev	0.0351578

Background Locations

There are 4 background location

Location	Meas.	Non-Detects	% ND	Total
MW-1D	26	13	50	0.453021
MW-1S	25	14	56	0.06905
MW-3S	26	12	46.1538	0.091963
MW-4S	27	5	18.5185	0.130408

Location	Mean	Std Dev	Std Err	Rank Sum	Rank Mean
MW-1D	0.0174239	0.0700142	0	5602	215.462
MW-1S	0.002762	0.00318457	0	4700	188
MW-3S	0.00353704	0.0031368	0	5862	225.462
MW-4S	0.00482993	0.00466448	0	7524	278.667

Compliance Locations

There are 13 compliance location

Location	Obs.	Non-Detects	% ND	Total
B-1S	24	12	50	0.06841
B-1SU	26	15	57.6923	0.08111
B-2S	24	11	45.8333	0.1052
B-2SU	26	8	30.7692	0.08844
B-6DR	25	17	68	0.04791
B-8DR	25	18	72	0.05091
MW-2D	25	16	64	0.12982
MW-2S	25	11	44	0.152295
MW-2SU	25	9	36	0.103514
MW-3D	26	16	61.5385	0.06316
MW-5S	26	5	19.2308	0.248892
MW-CNE-1D	25	17	68	0.0491
MW-CNE-1S	26	8	30.7692	0.126166

Location	Mean	Std Dev	Dif From Bkg	Std Err	Rank Sum	Rank Mean
B-1S	0.00285042	0.0022459	-0.00430768	0.00426323	5013	208.875
B-1SU	0.00311962	0.00368884	-0.00403848	0.00412786	5160	198.462
B-2S	0.00438333	0.00553626	-0.00277476	0.00426323	5508	229.5
B-2SU	0.00340154	0.00285109	-0.00375656	0.00412786	6356	244.462
B-6DR	0.0019164	0.00148303	-0.0052417	0.00419338	4091	163.64

B-8DR	0.0020364	0.00181782	-0.0051217	0.00419338	4070	162.8
MW-2D	0.0051928	0.0121385	-0.0019653	0.00419338	4579	183.16
MW-2S	0.0060918	0.0131608	-0.0010663	0.00419338	5634	225.36
MW-2SU	0.00414056	0.0034717	-0.00301754	0.00419338	6361	254.44
MW-3D	0.00242923	0.00244994	-0.00472887	0.00412786	4726	181.769
MW-5S	0.00957277	0.0224904	0.00241467	0.00412786	7665	294.808
MW-CNE-1D	0.001964	0.00170022	-0.0051941	0.00419338	4103	164.12
MW-CNE-1S	0.00485254	0.00673415	-0.00230556	0.00412786	6574	252.846

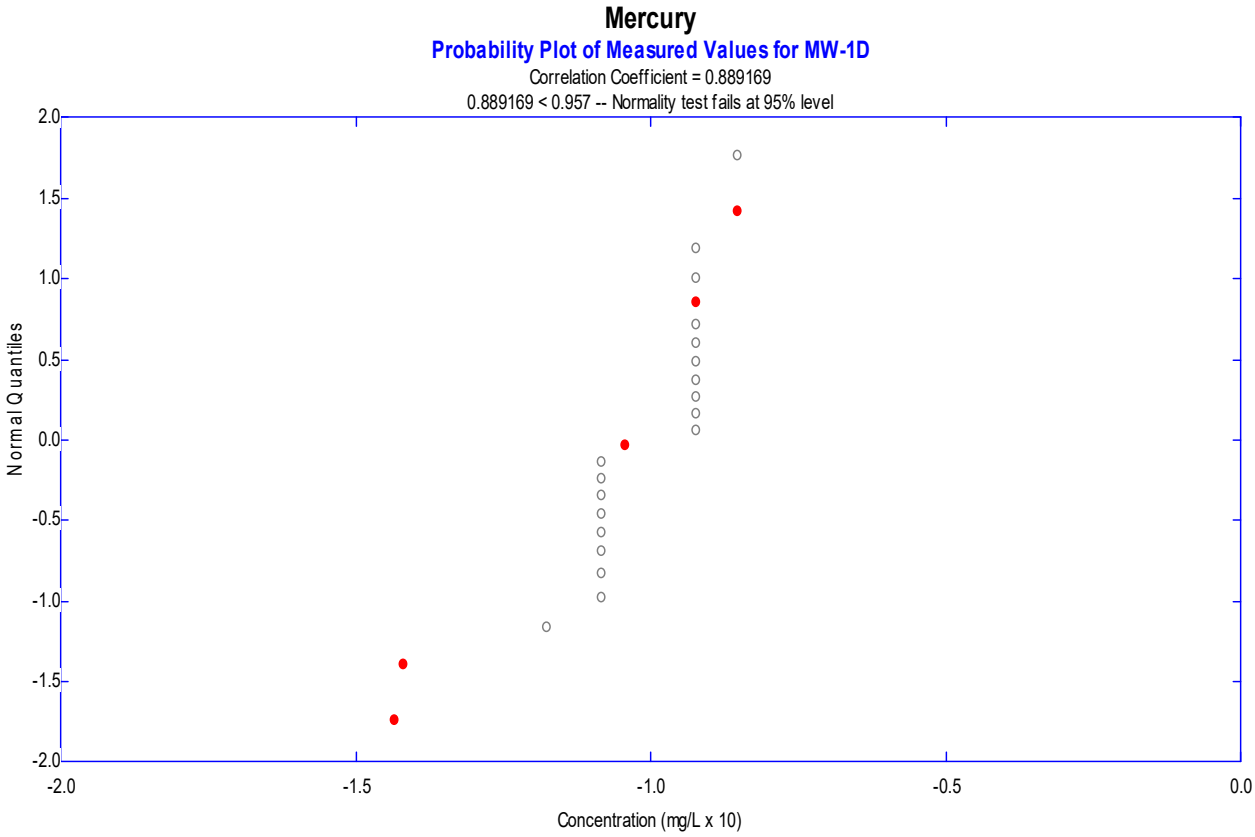
Analysis of Variance Statistics

SS Wells	0.00590274
SS Total	0.152985

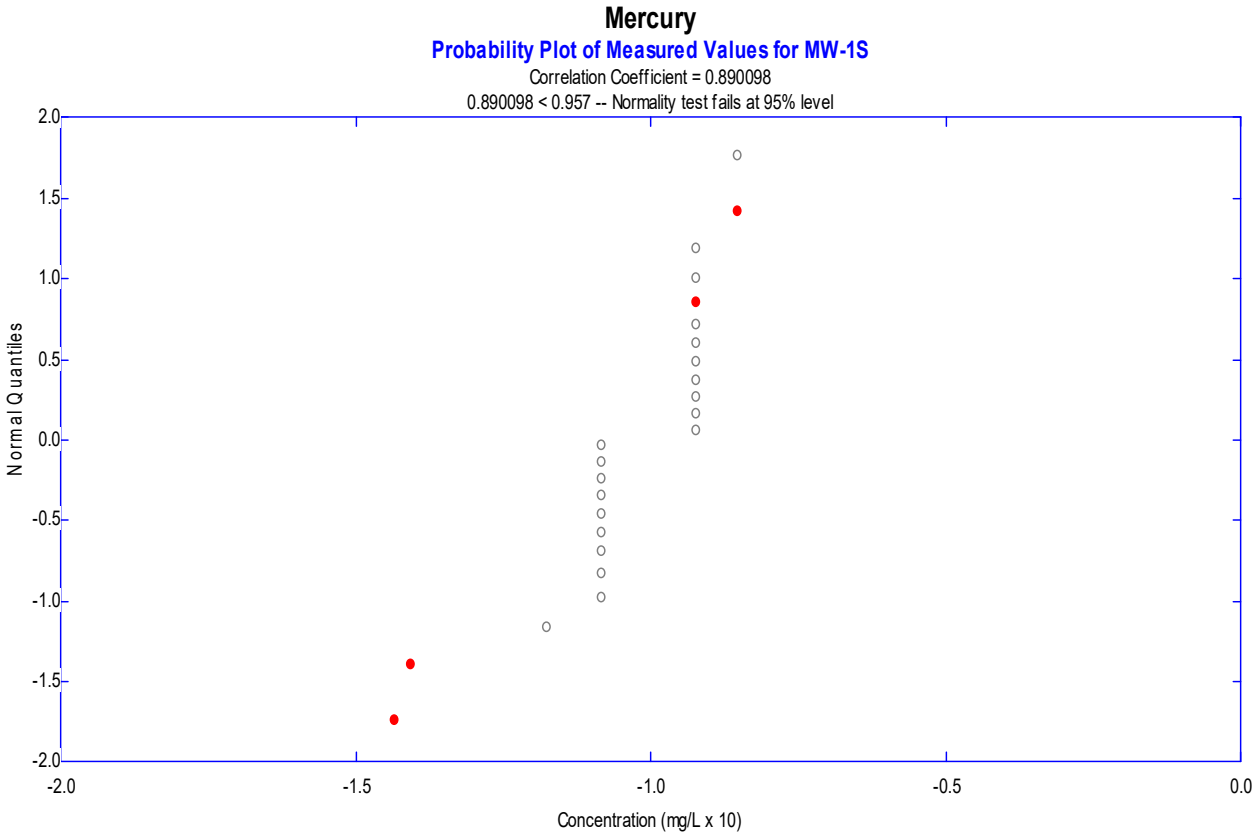
Kruskal-Wallis Statistics

Non-Detect Rank	104
Background Rank Sum	23688
Background Rank Mean	227.769
H Statistic	35.2108
H Adjusted for Ties	39.5634

Attachment B



Log-transformed results pass the CMP requirement for correlation coefficient > 0.85. Non-detected concentrations presented at full laboratory reporting limit as conservative measure. These censored results presented with open circle and detections presented red.



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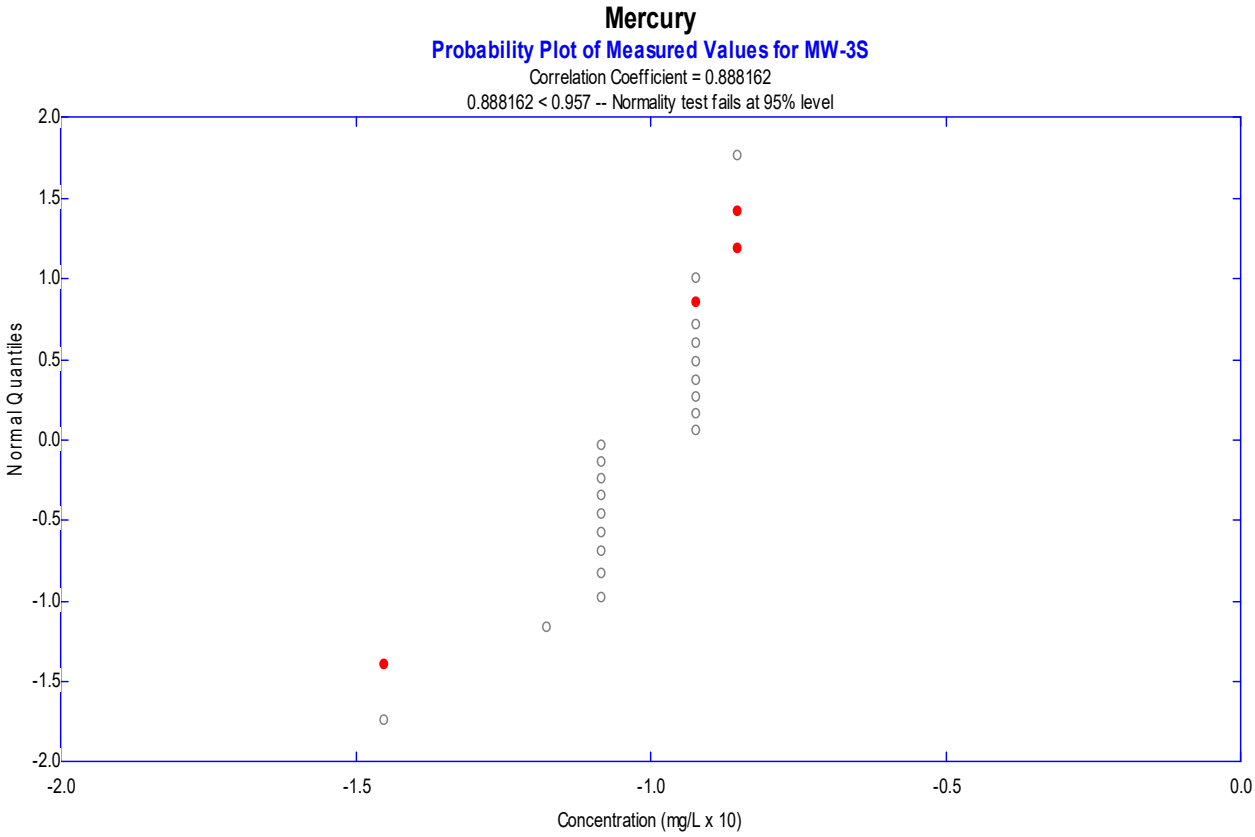

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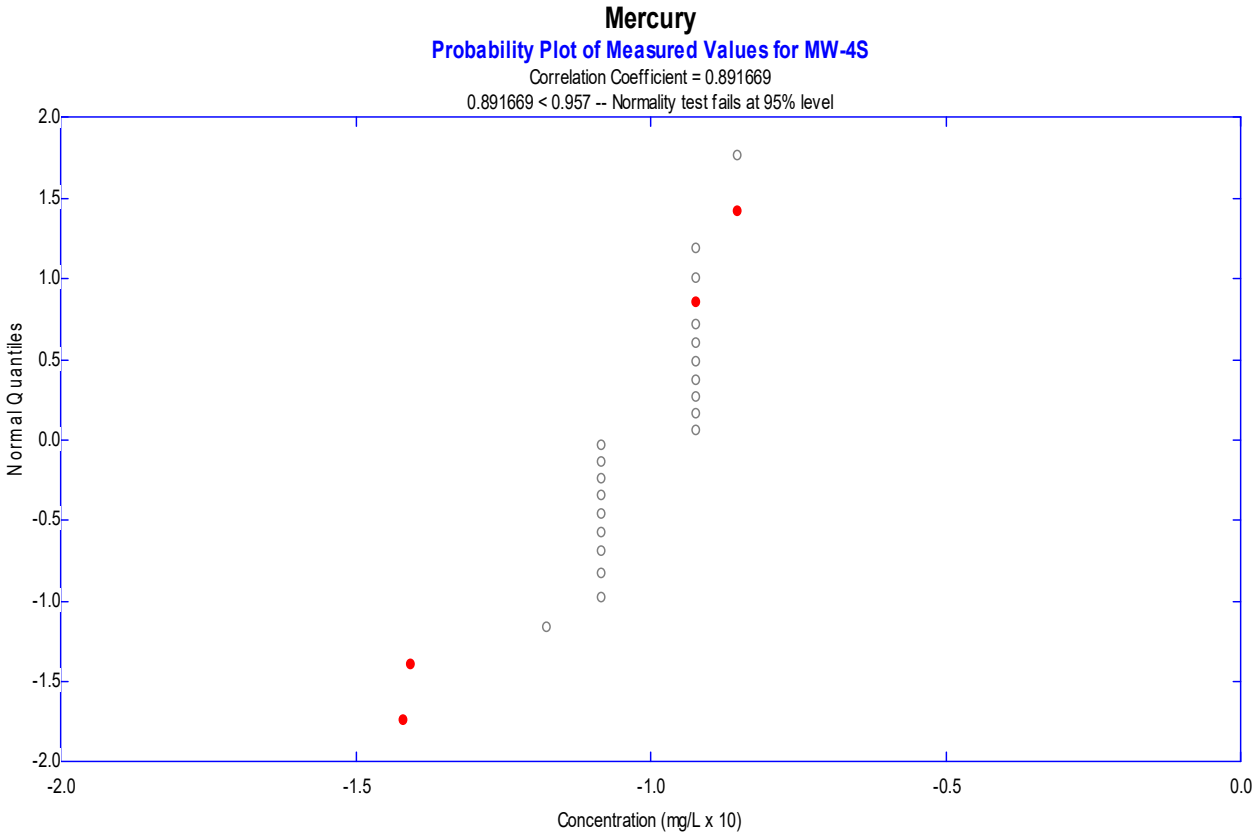

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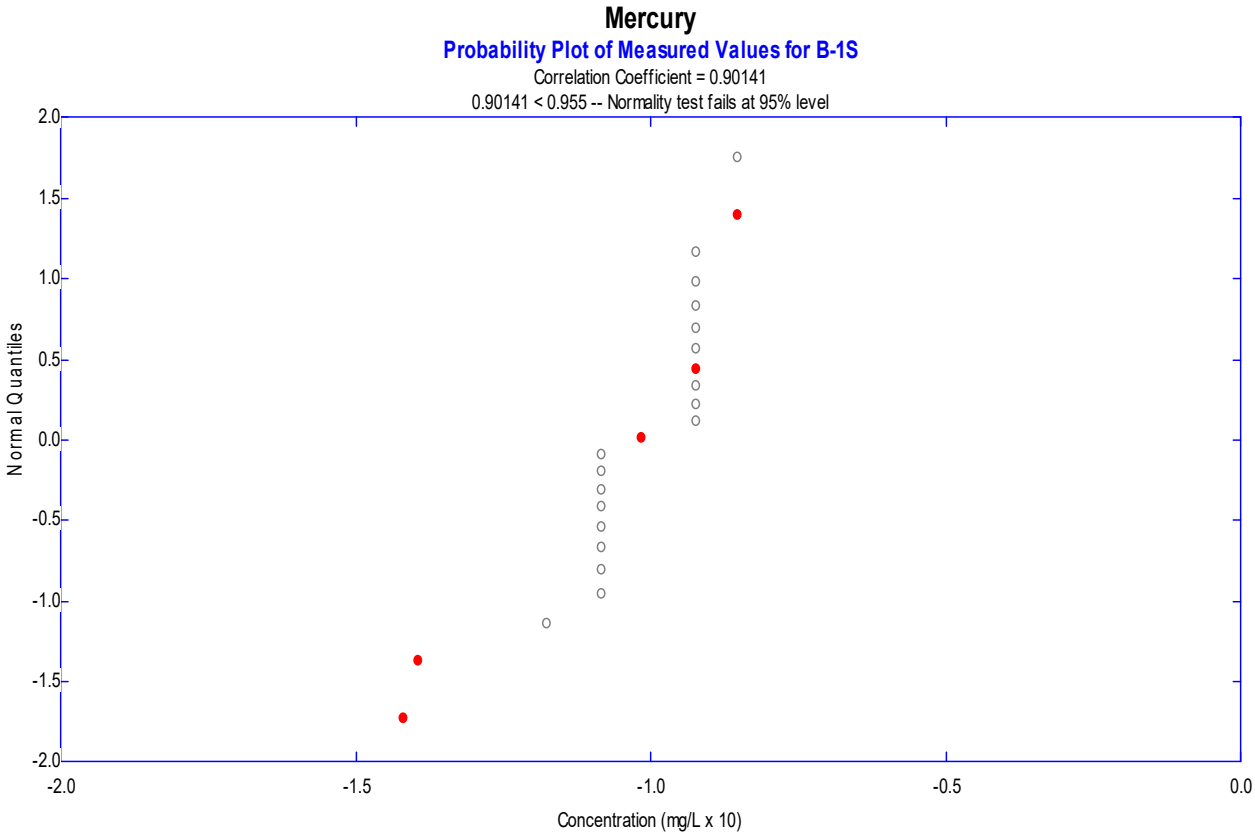

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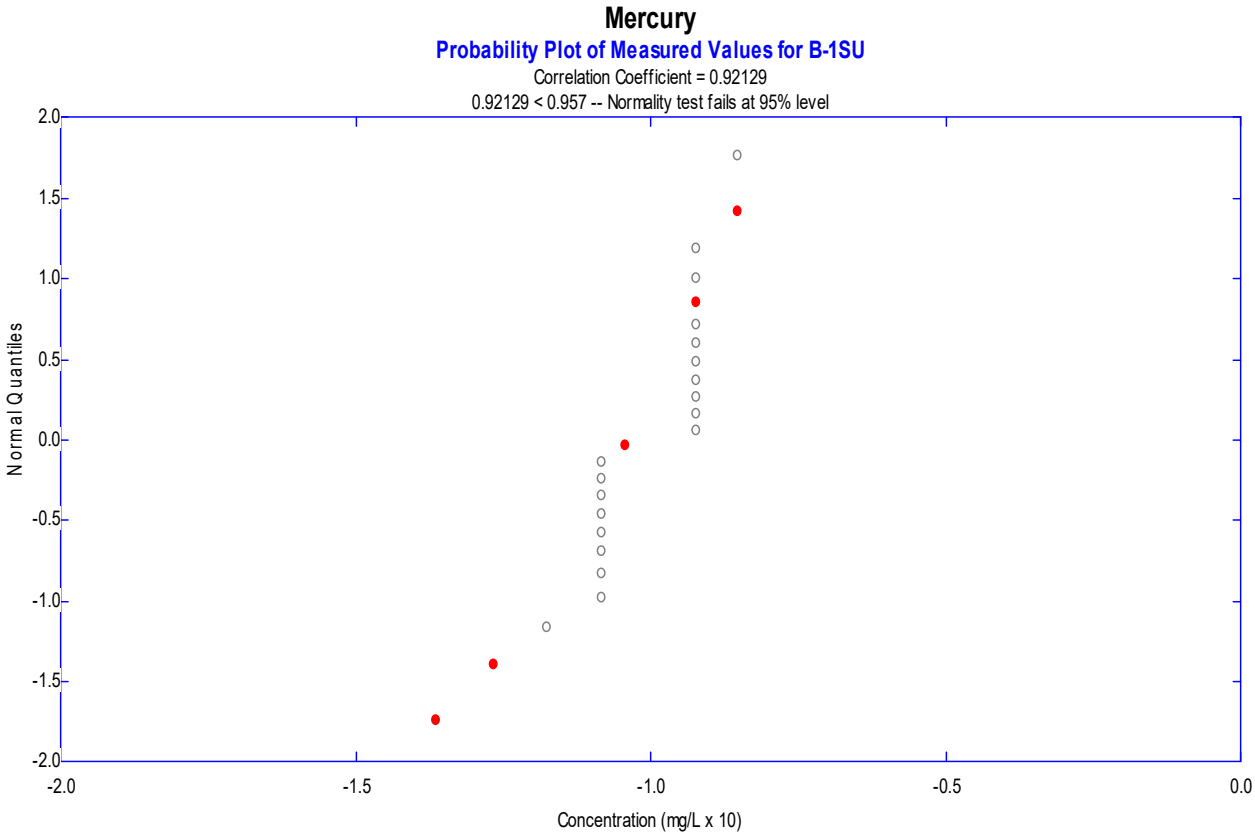

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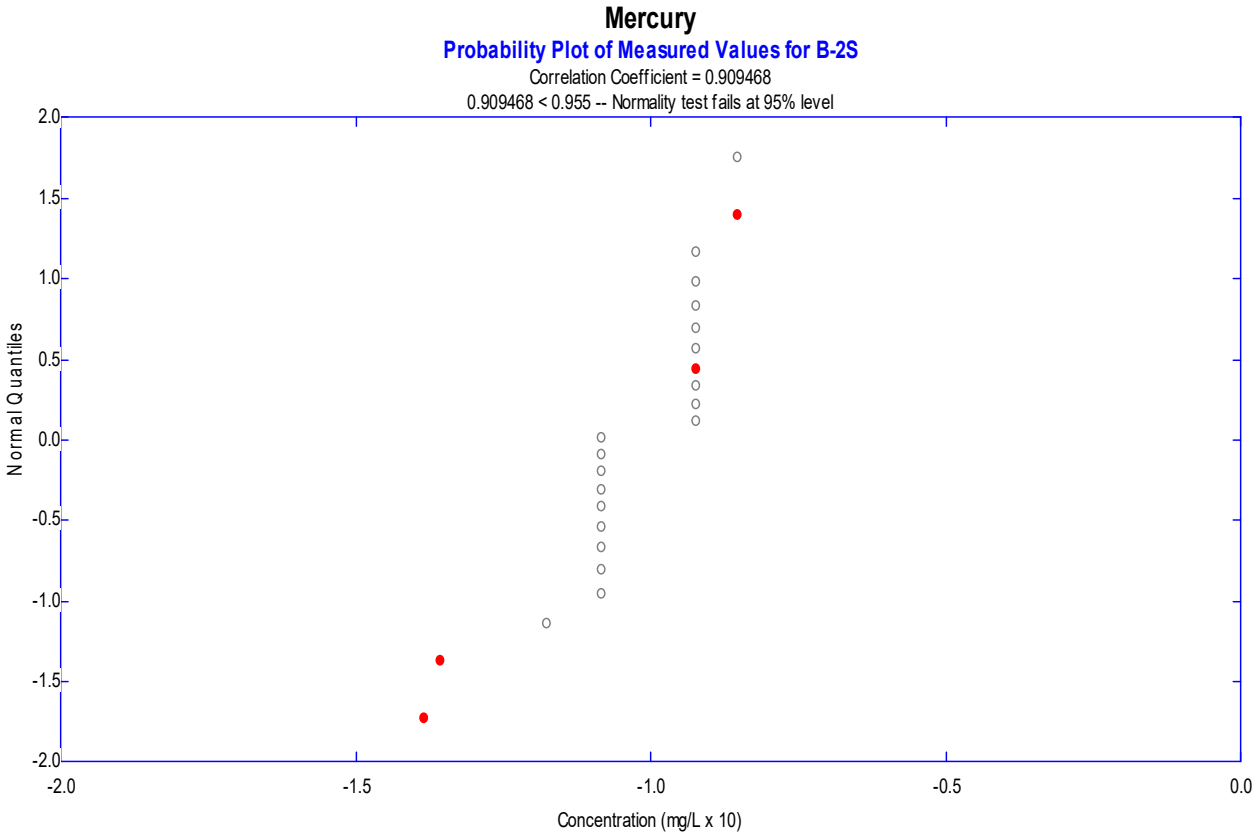

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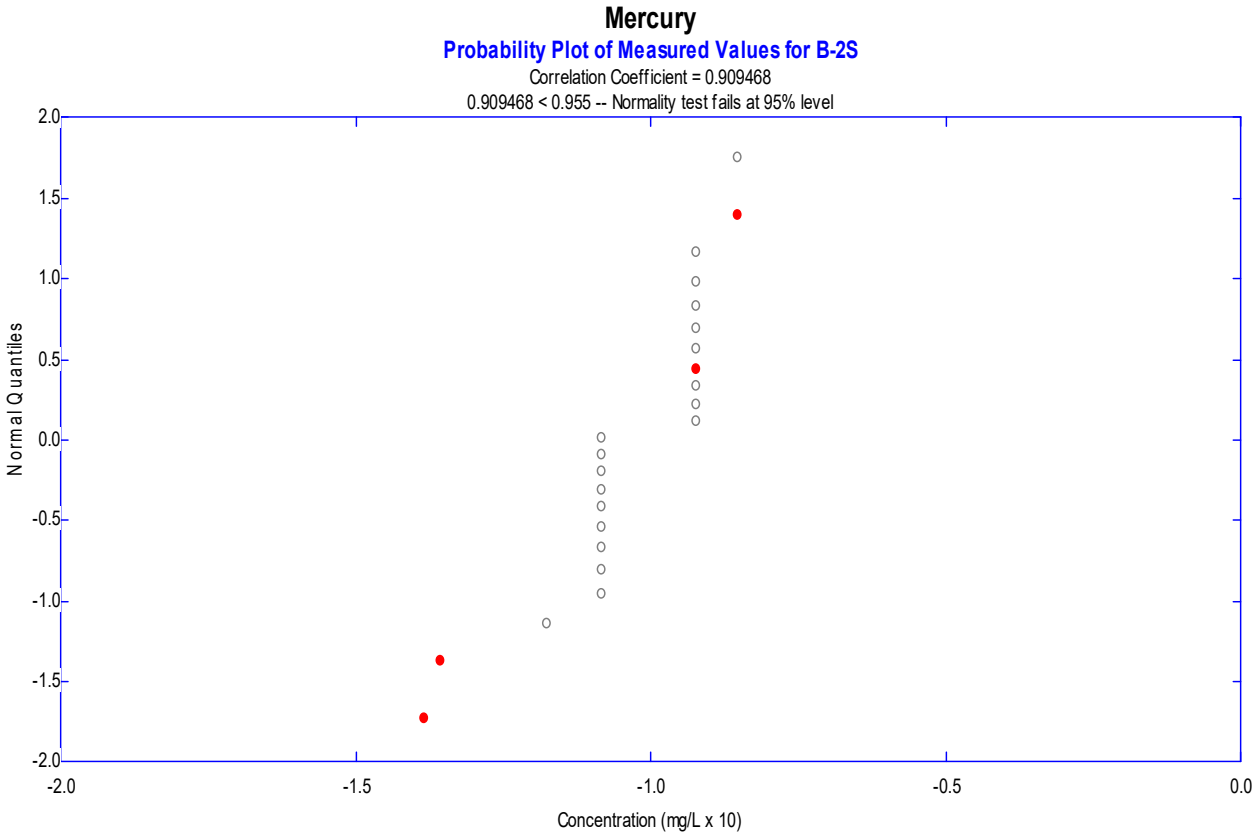

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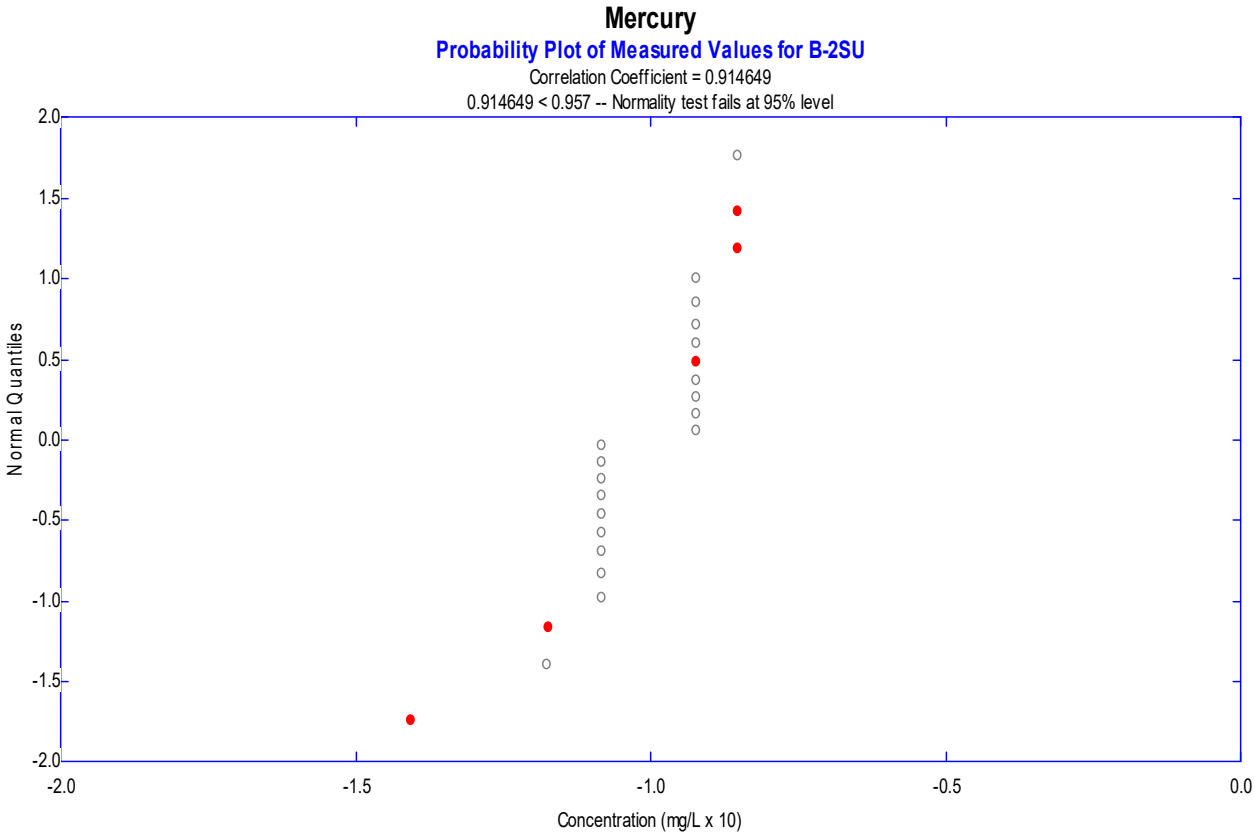

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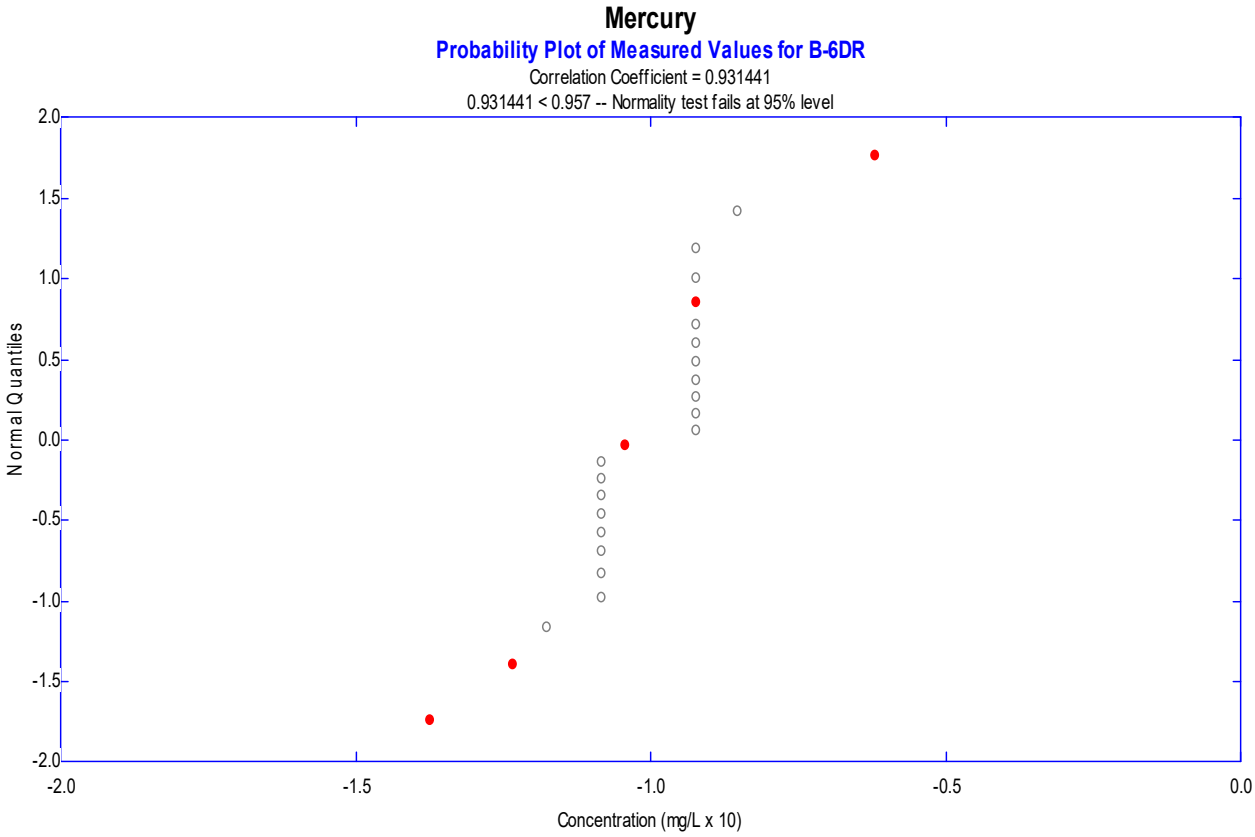

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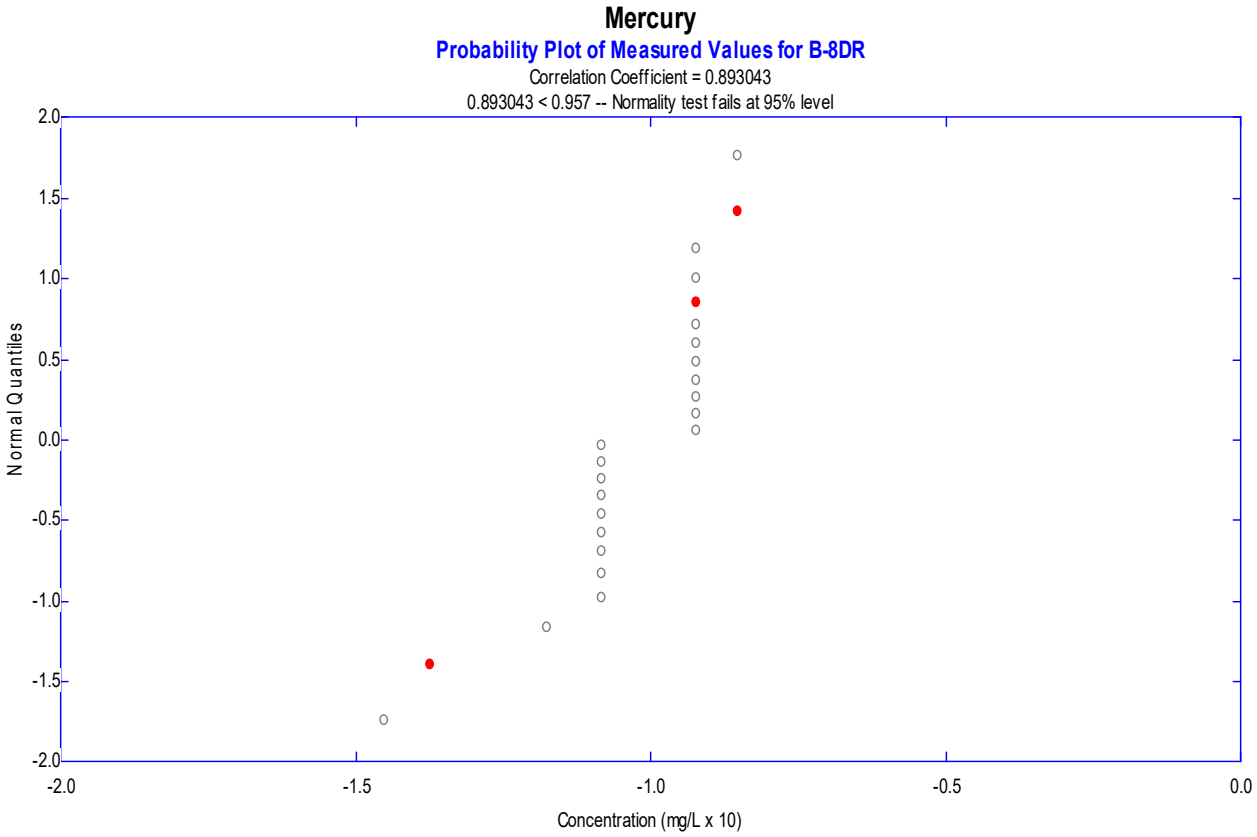

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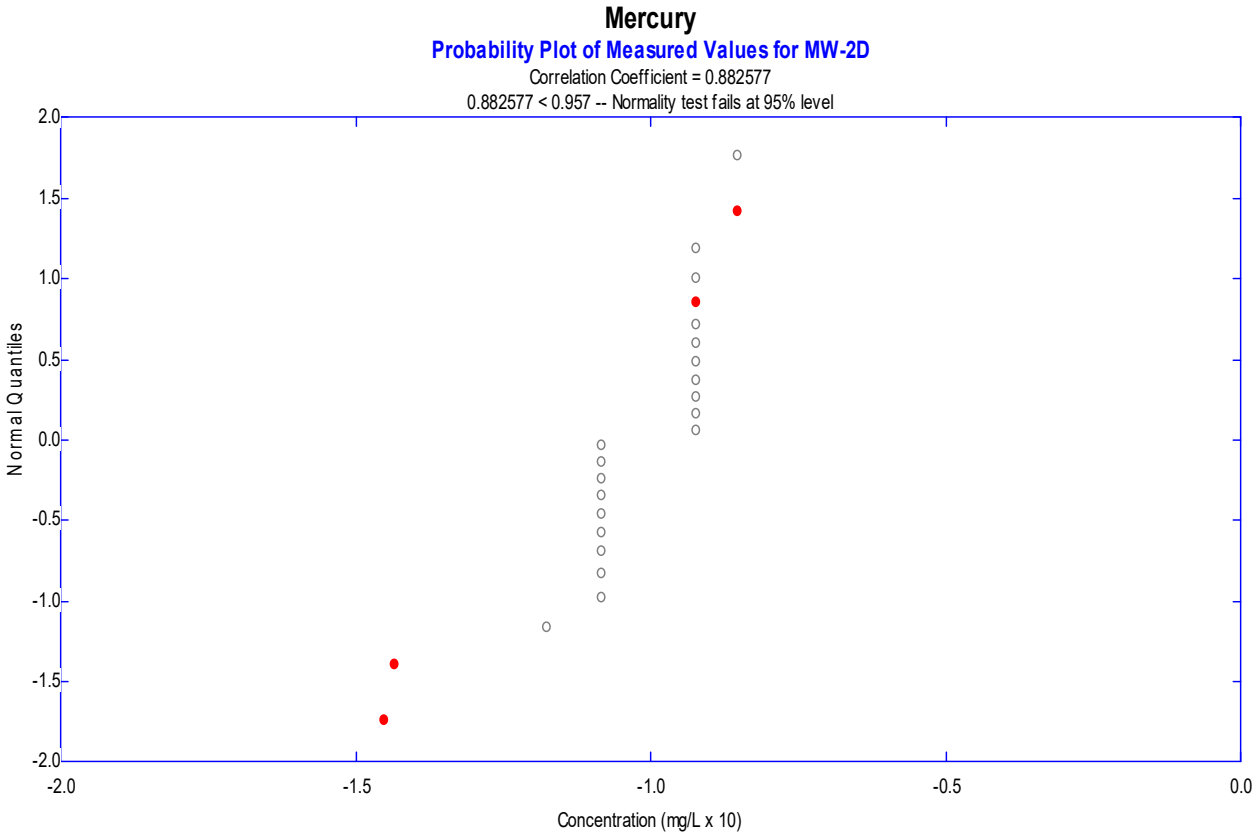

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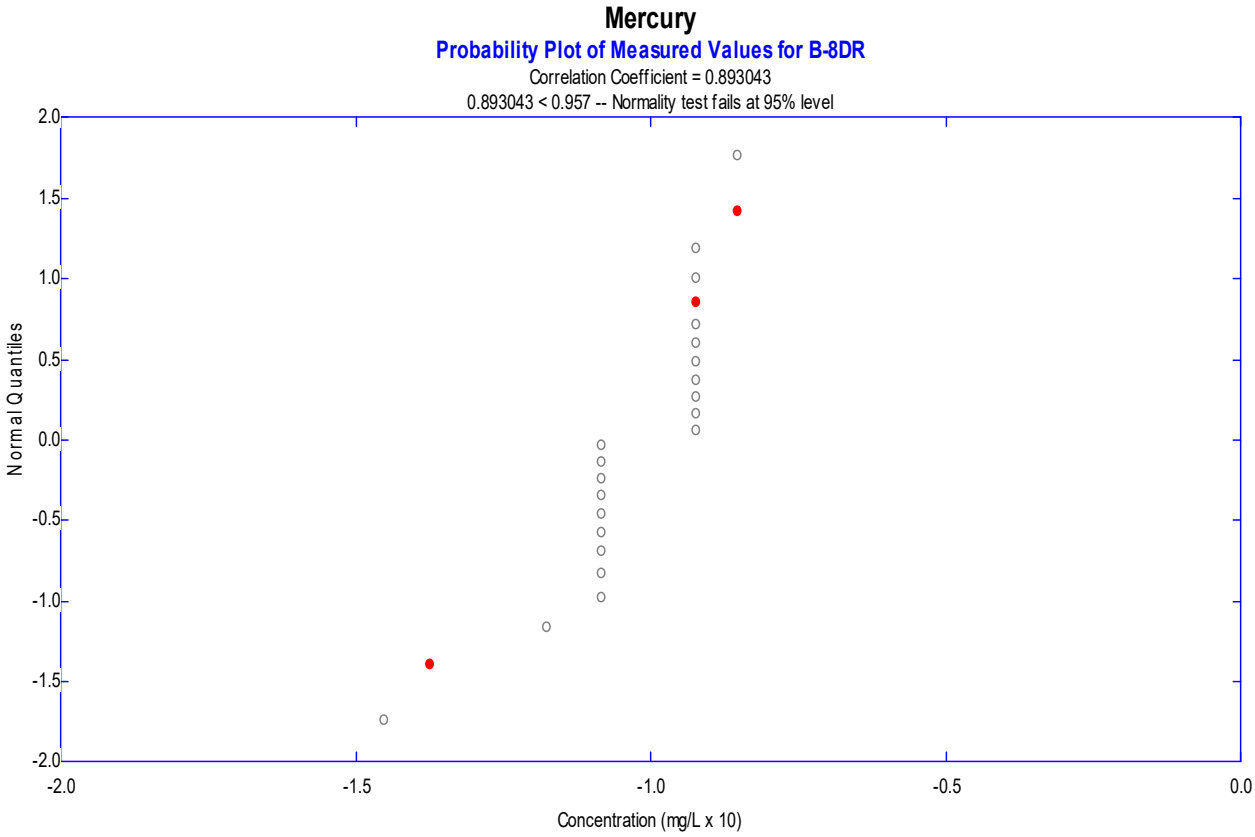

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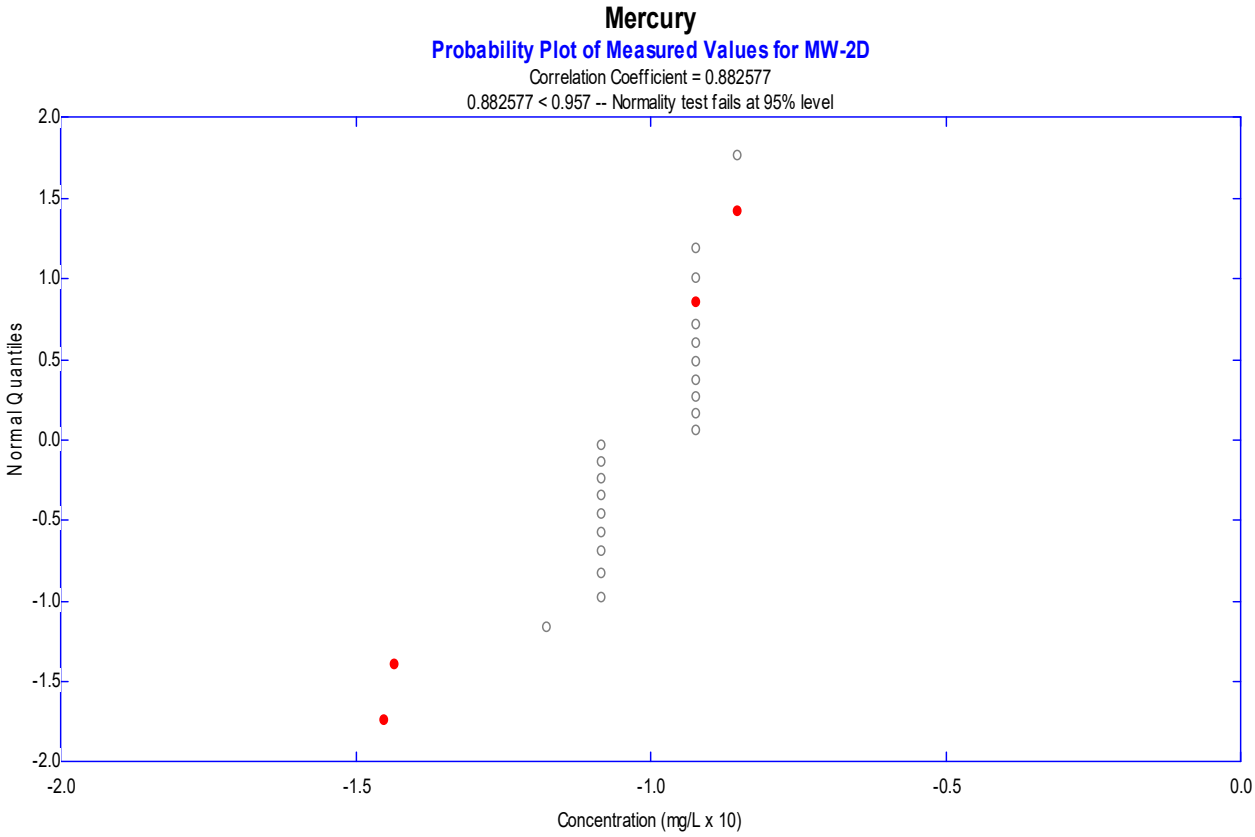

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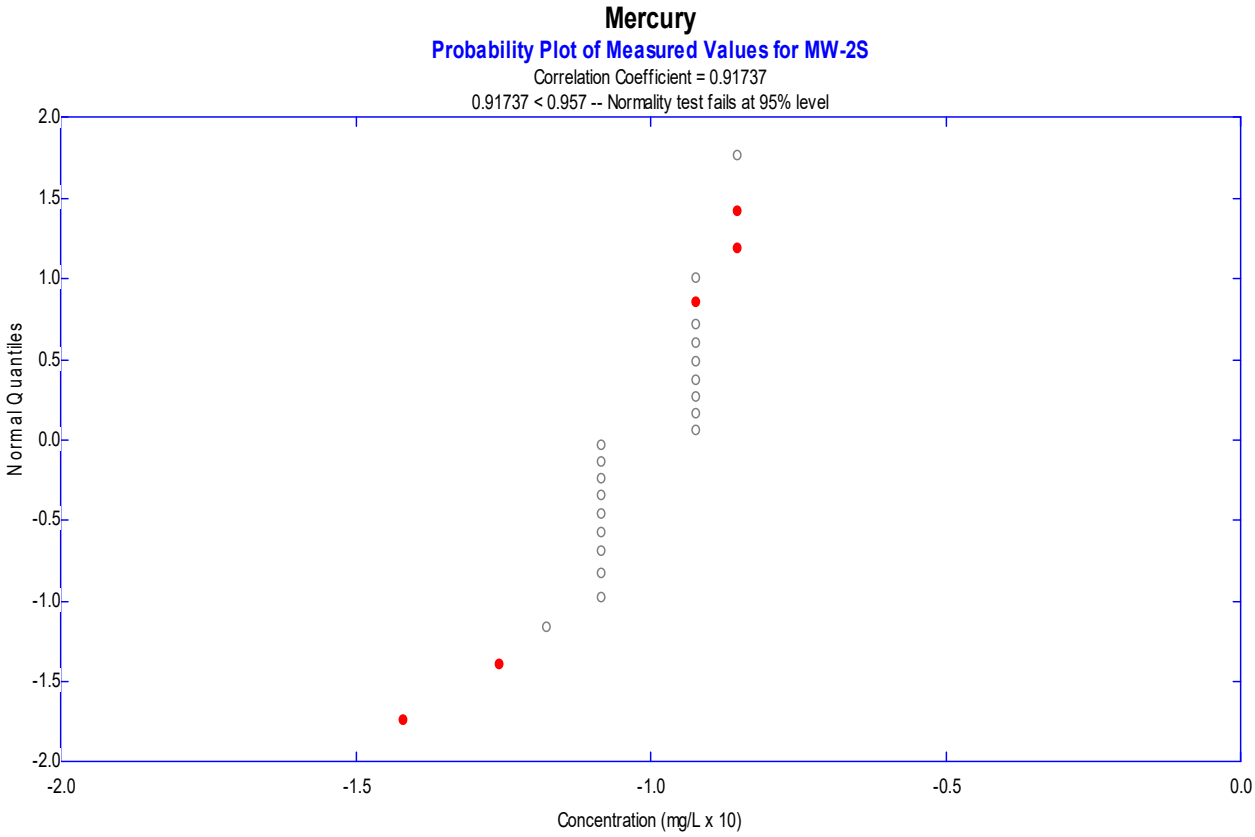

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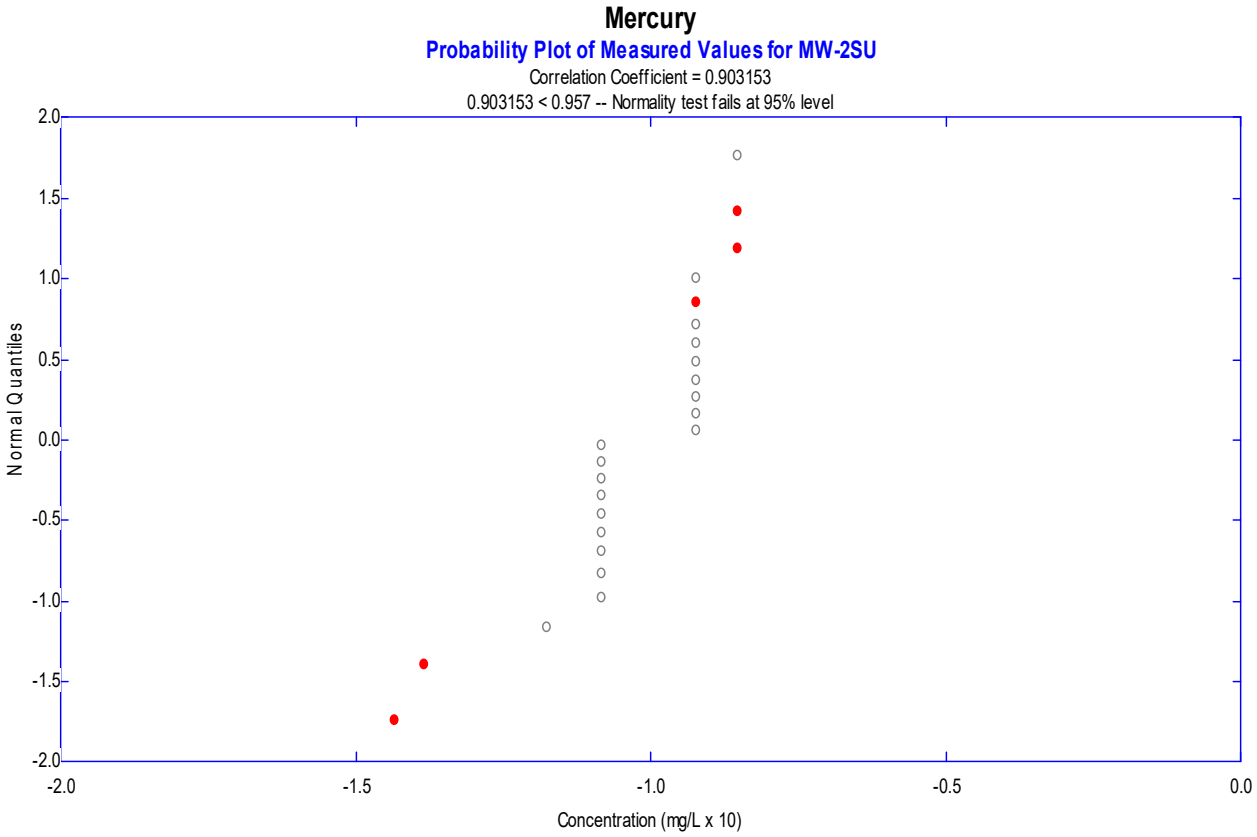

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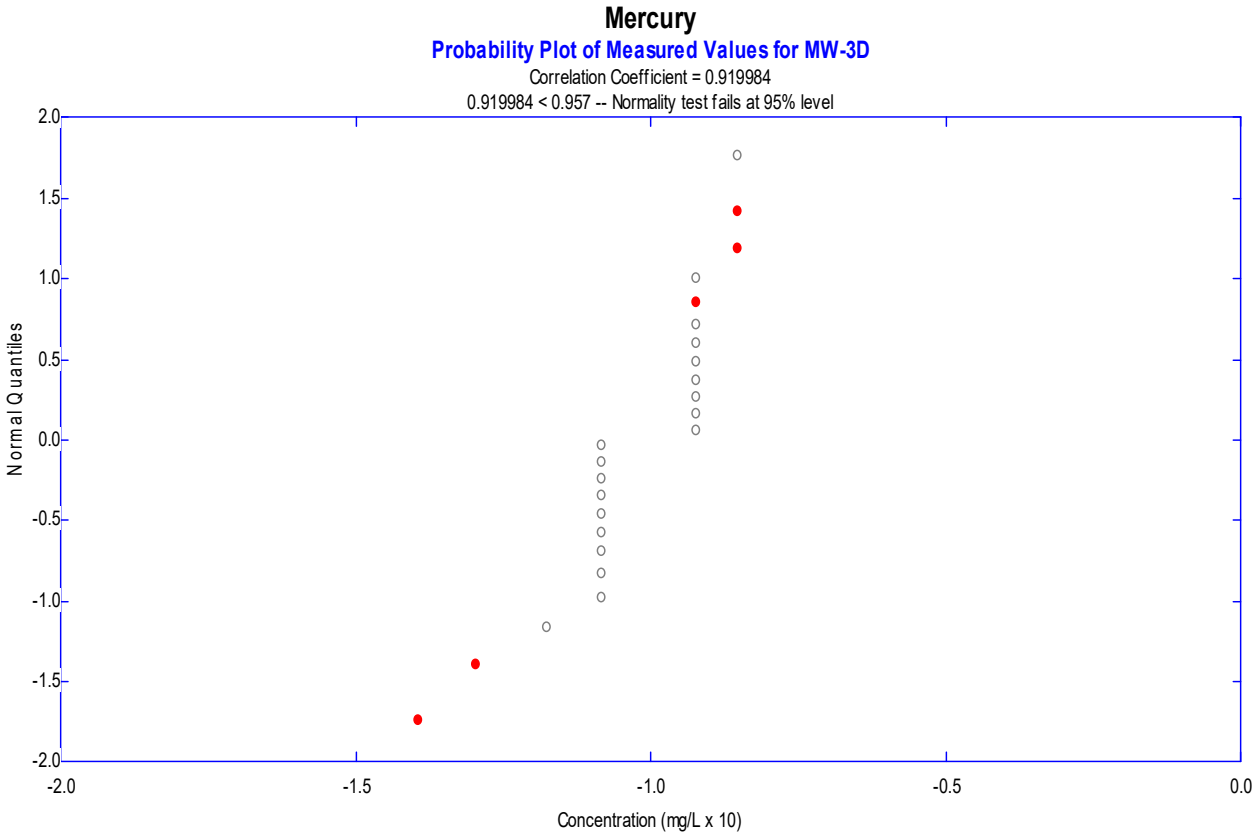

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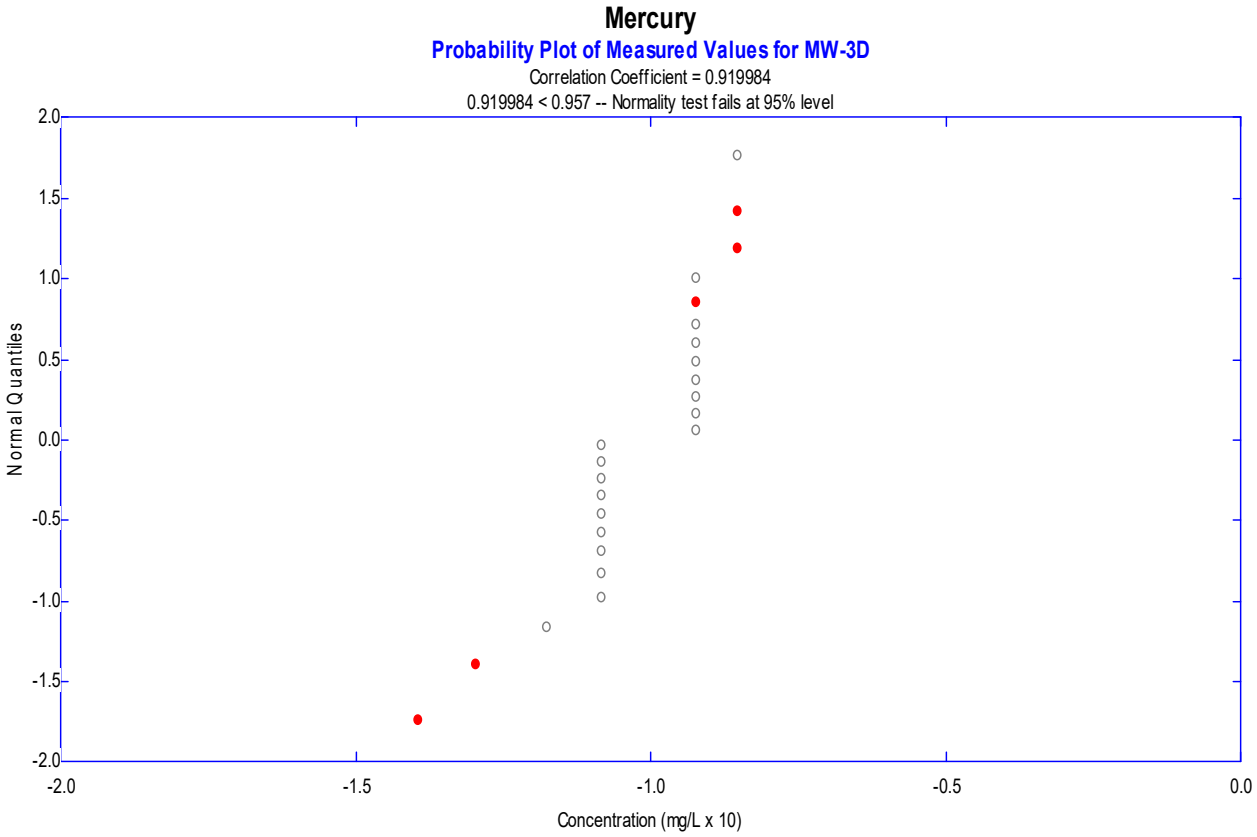

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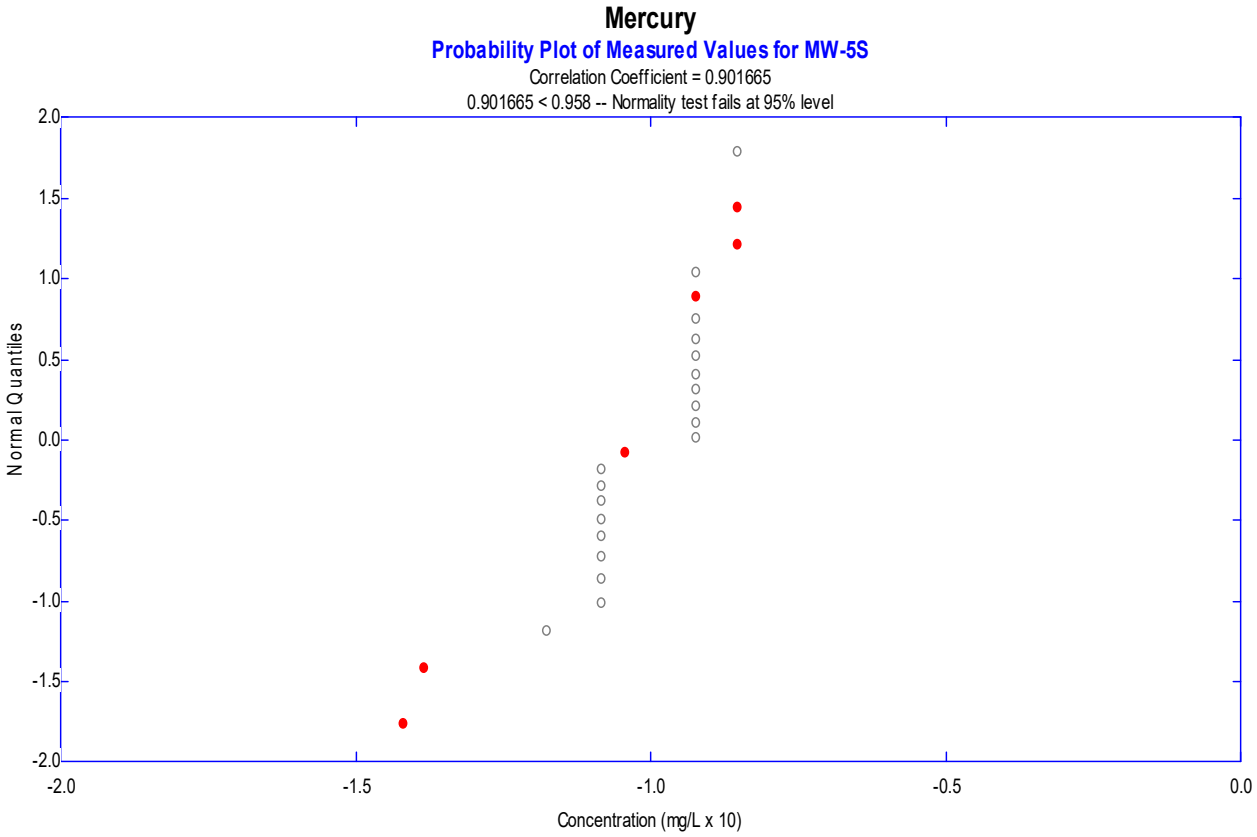

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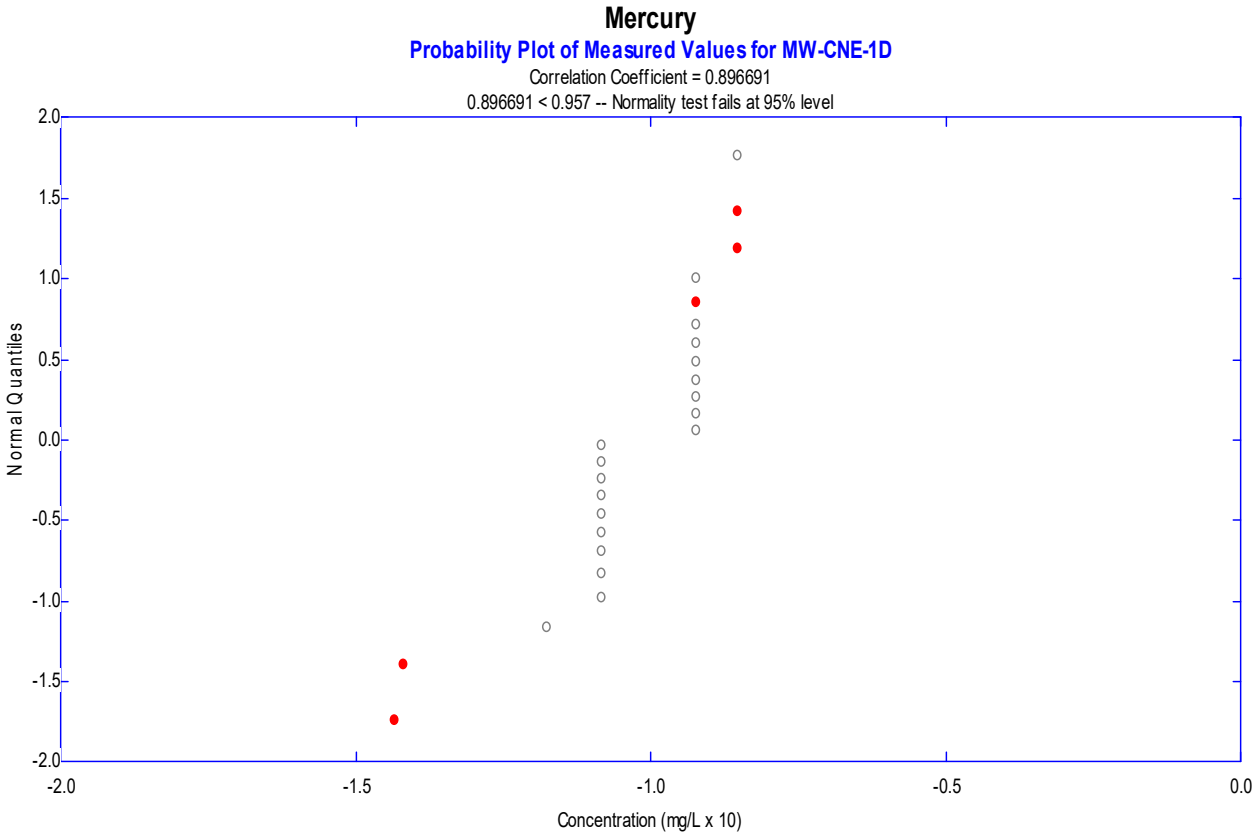

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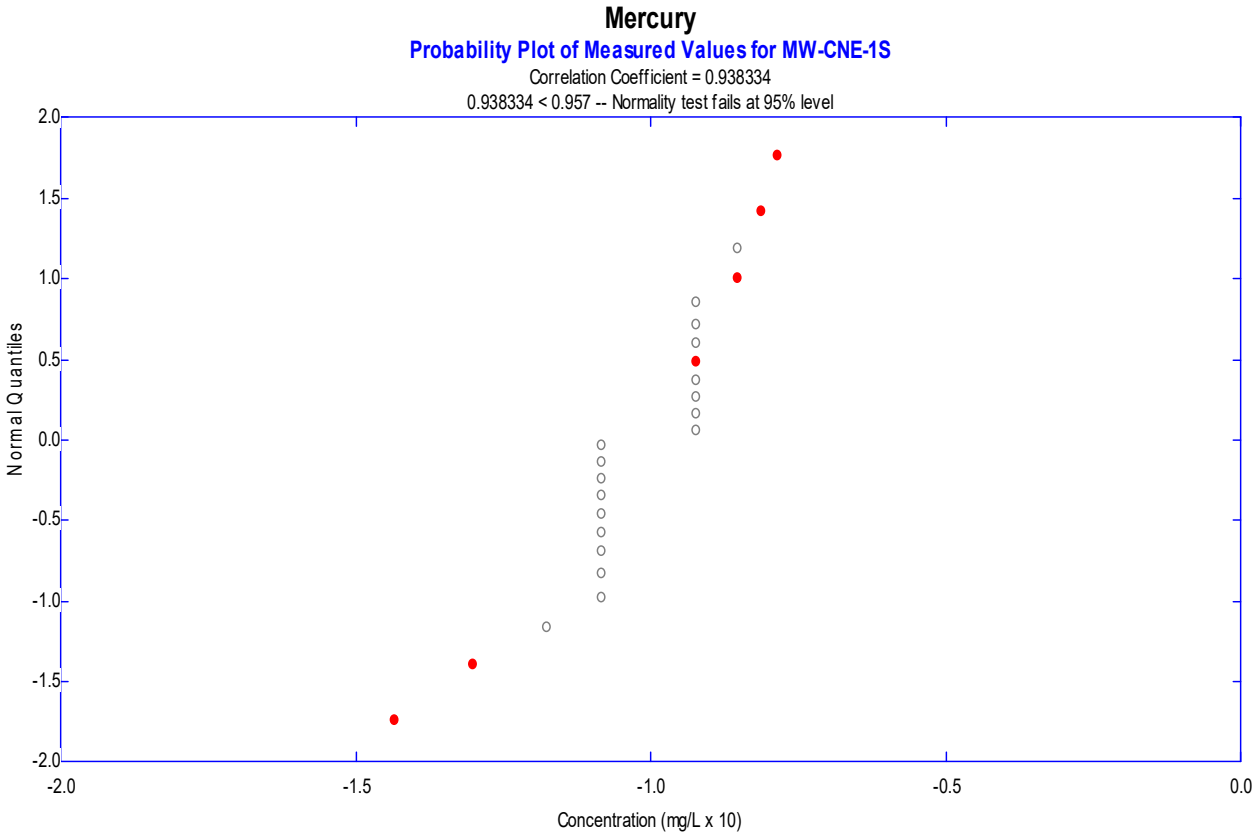

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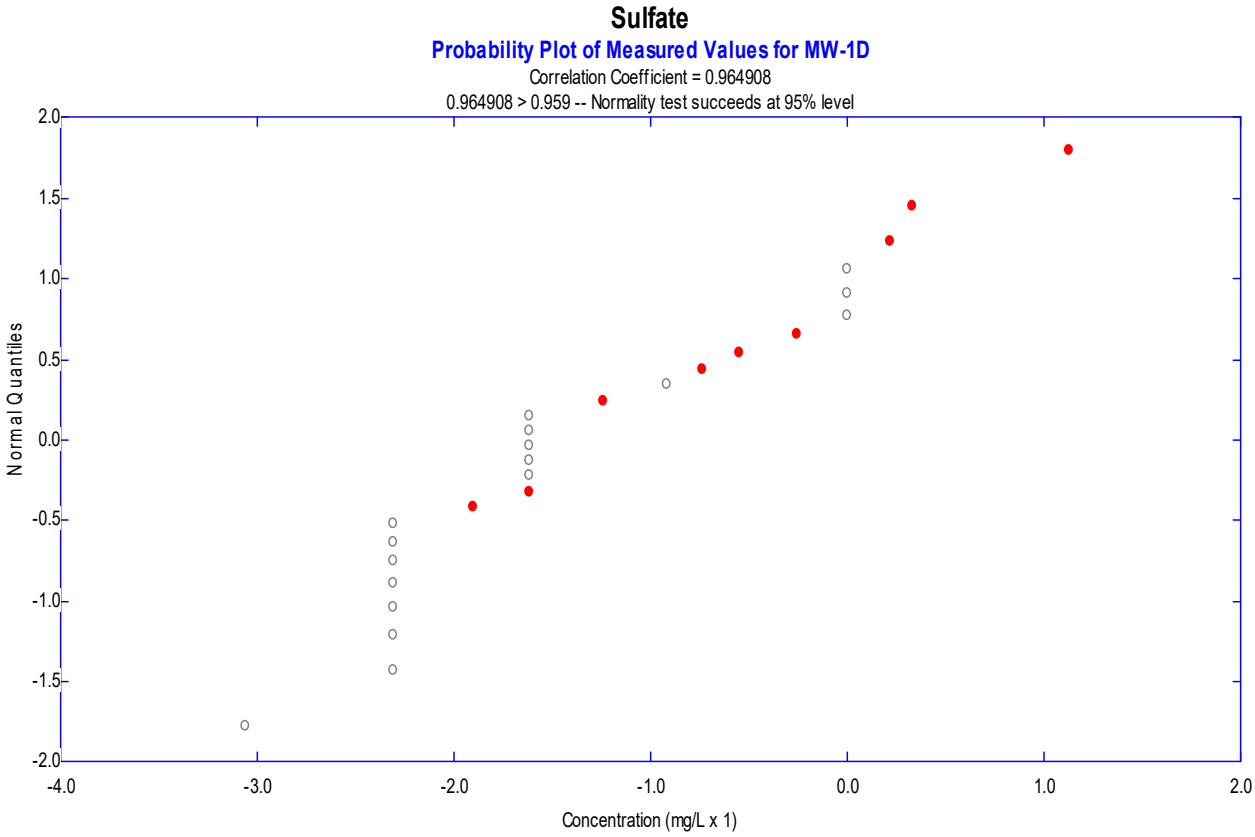

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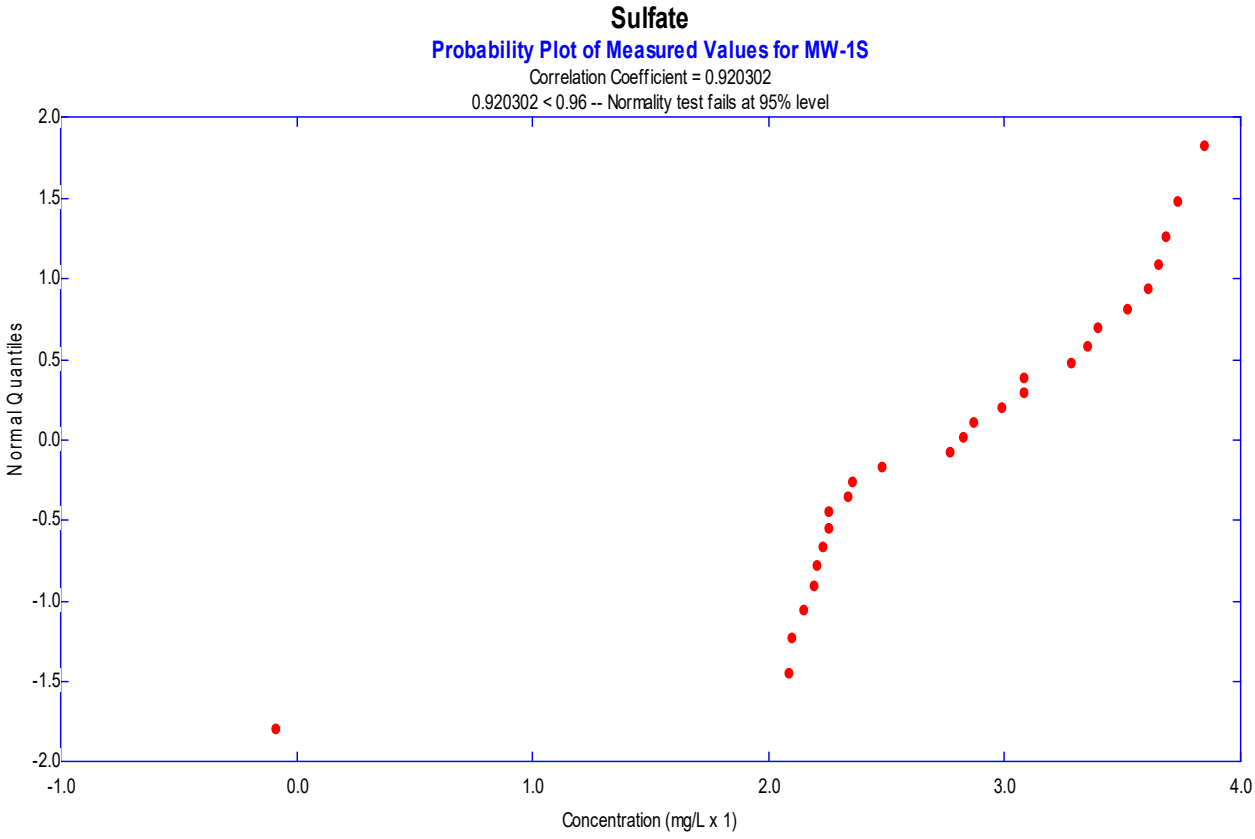

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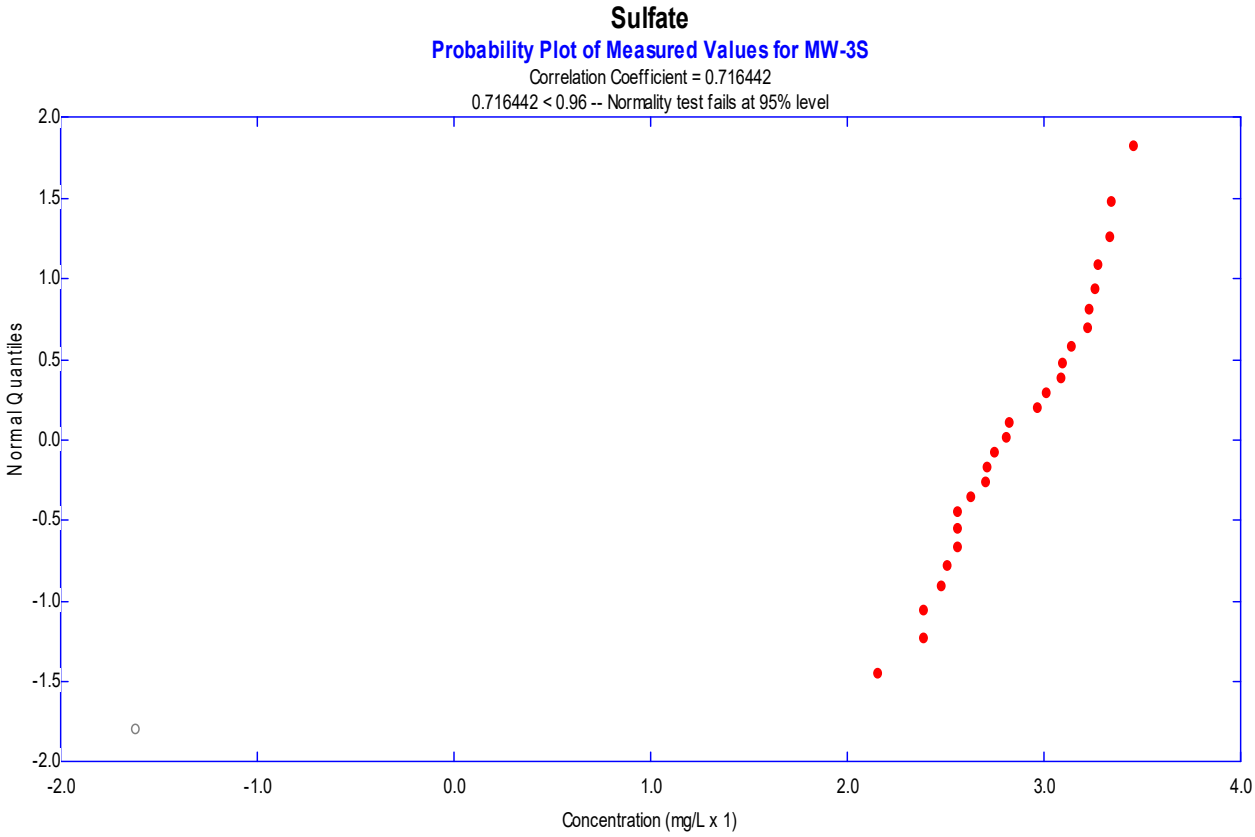

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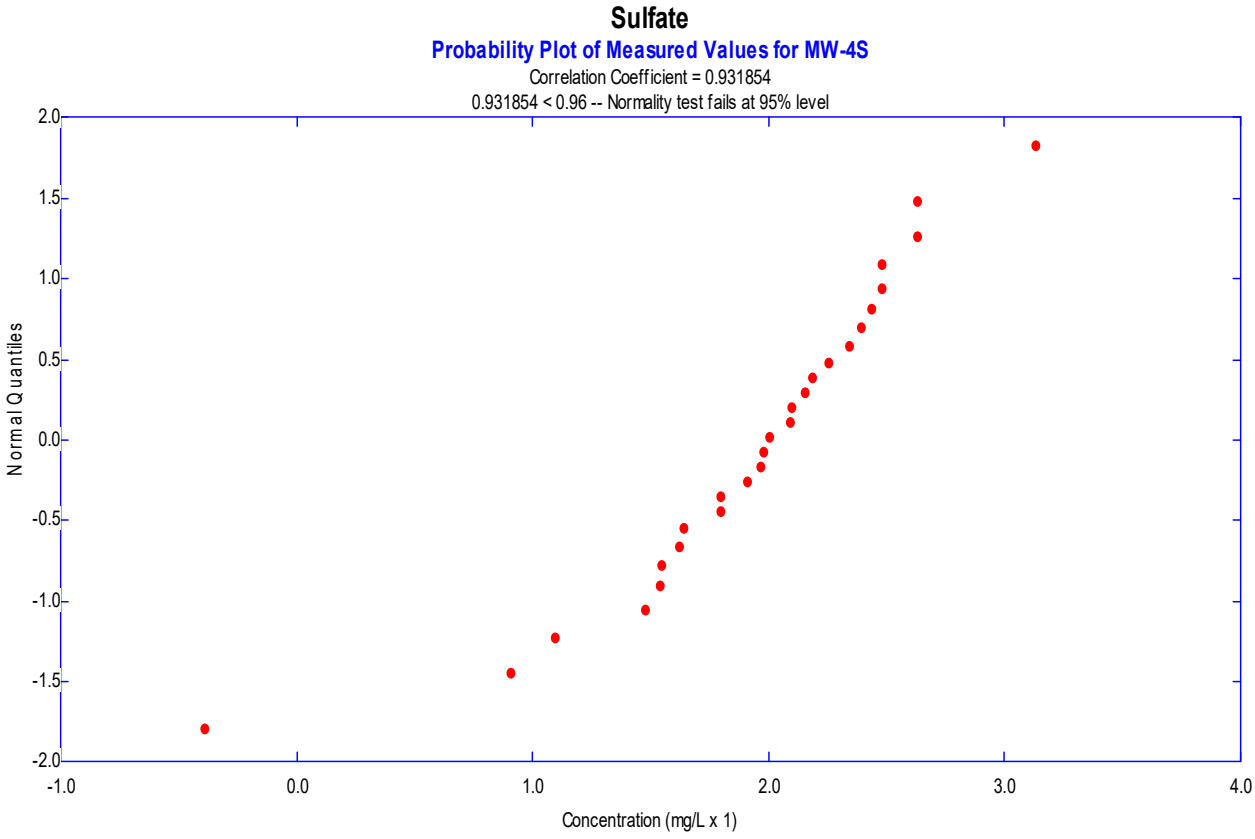

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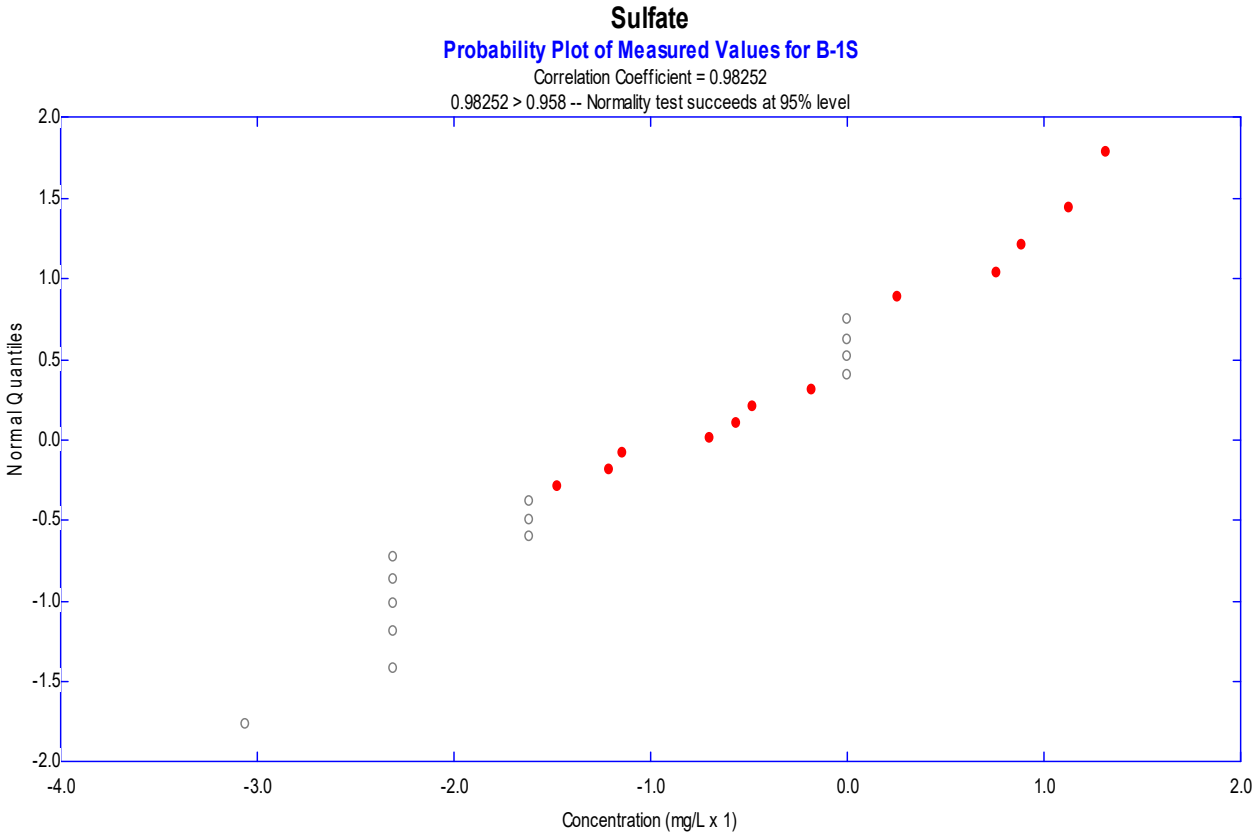

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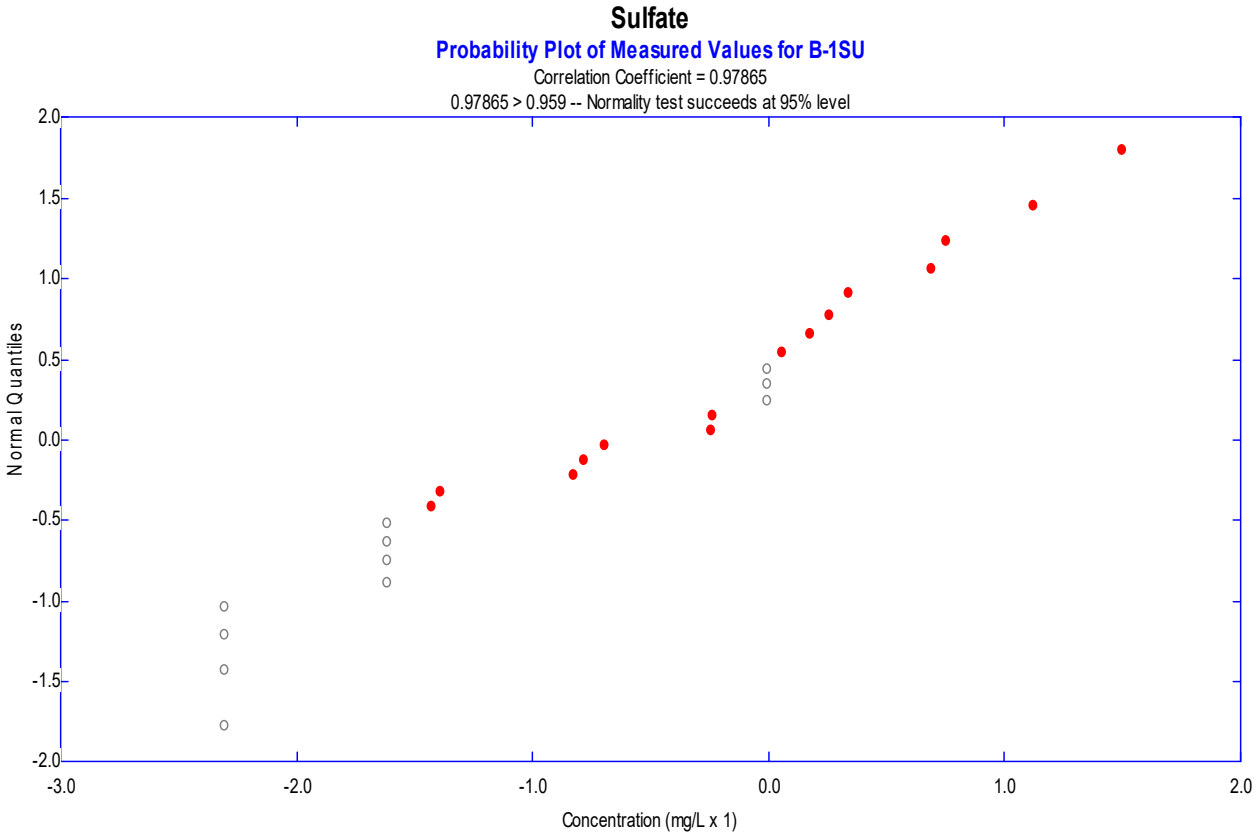

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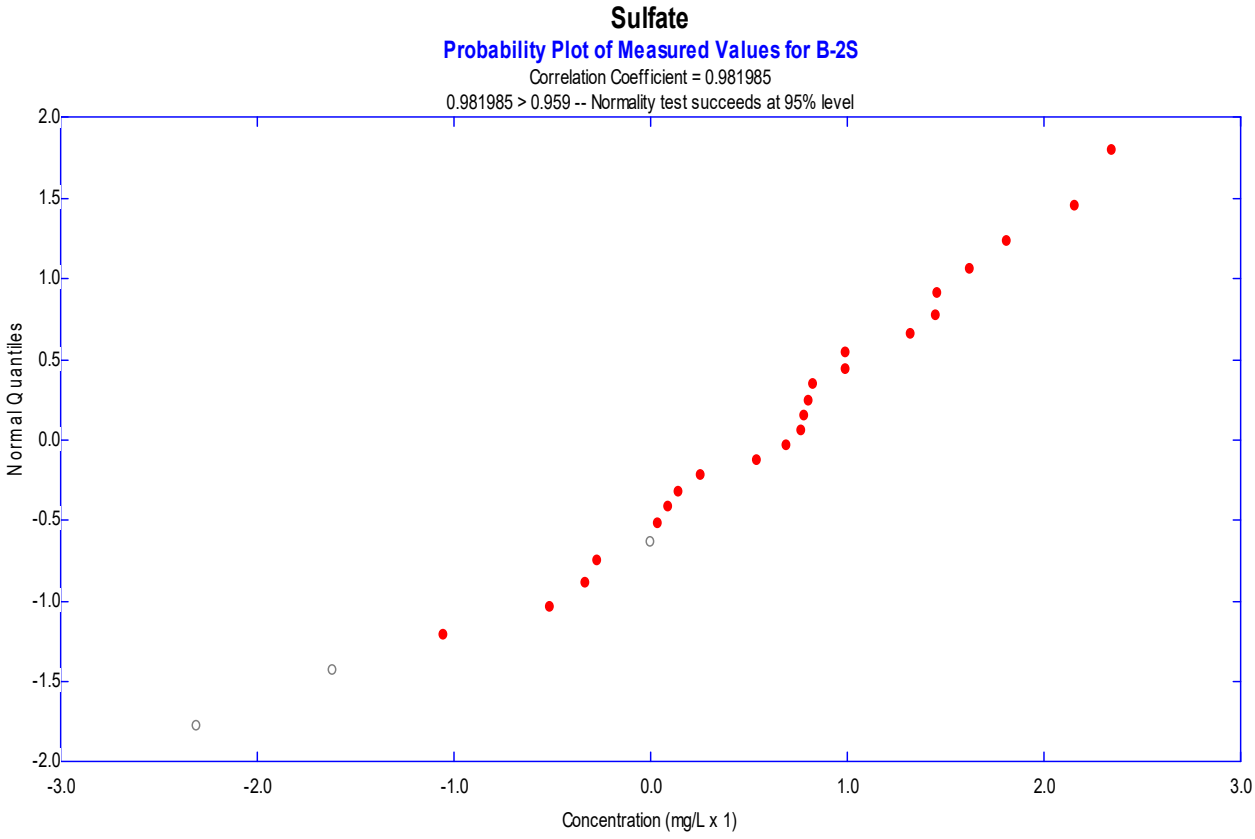

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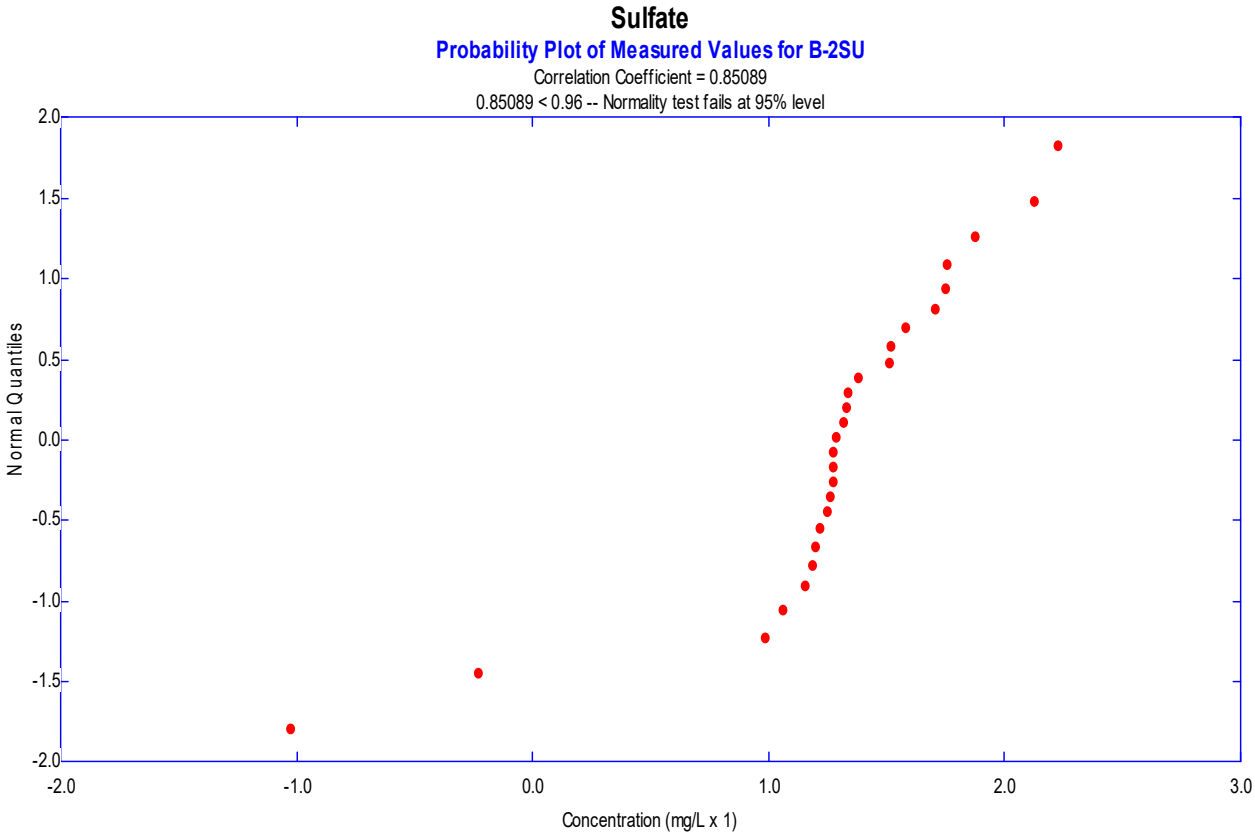

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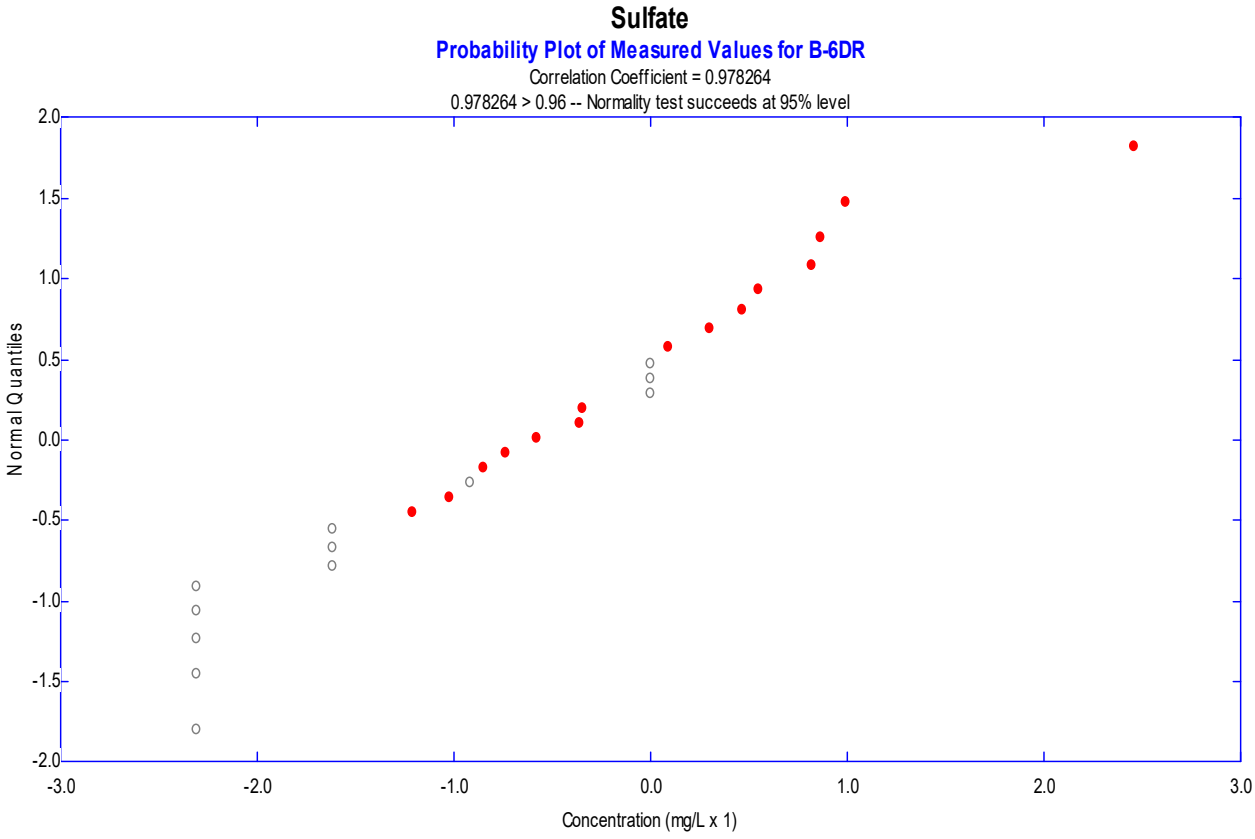

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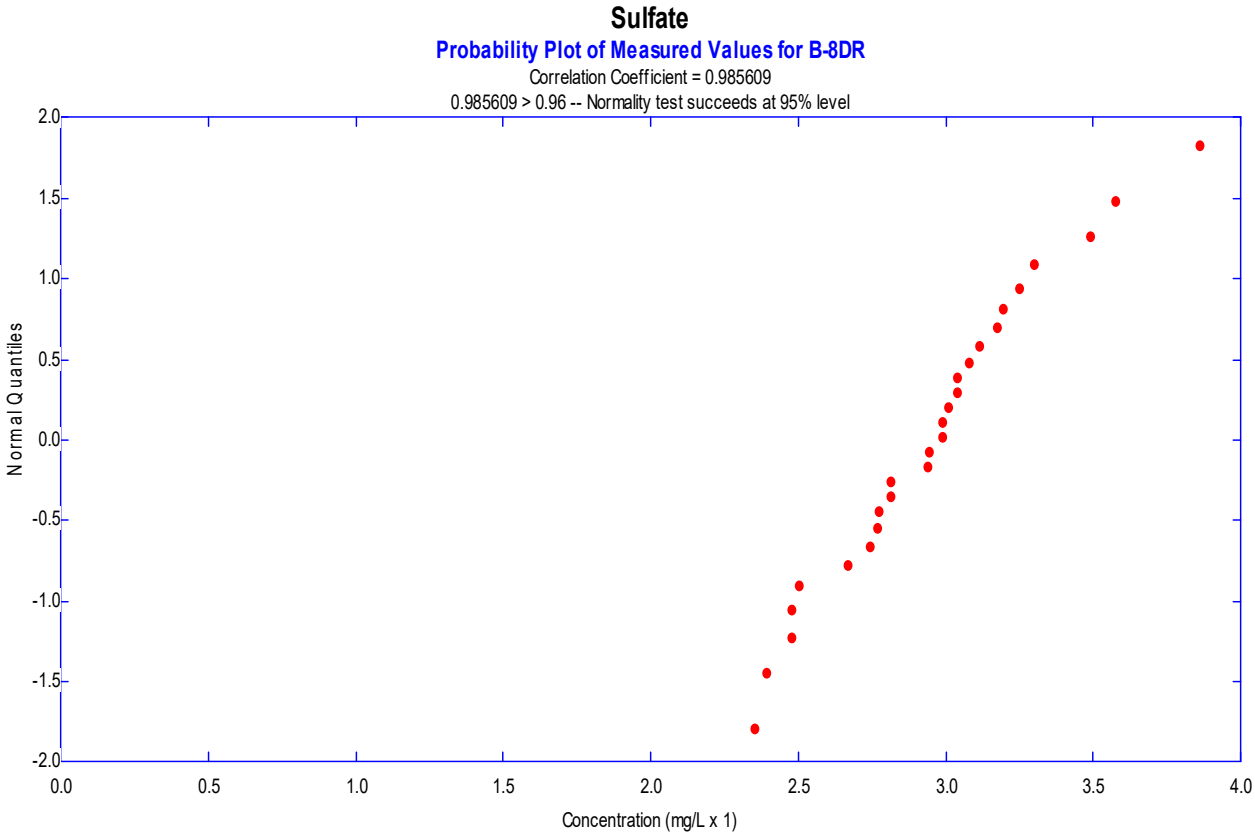

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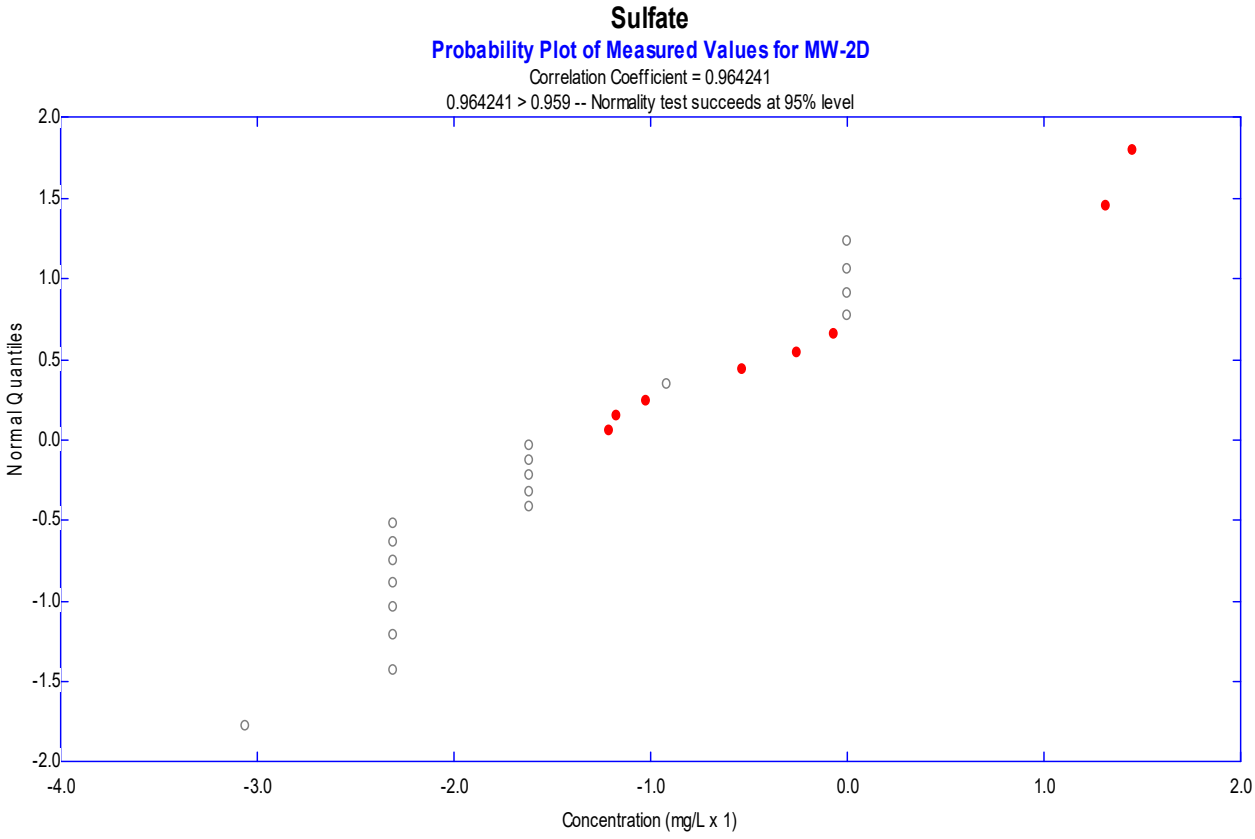

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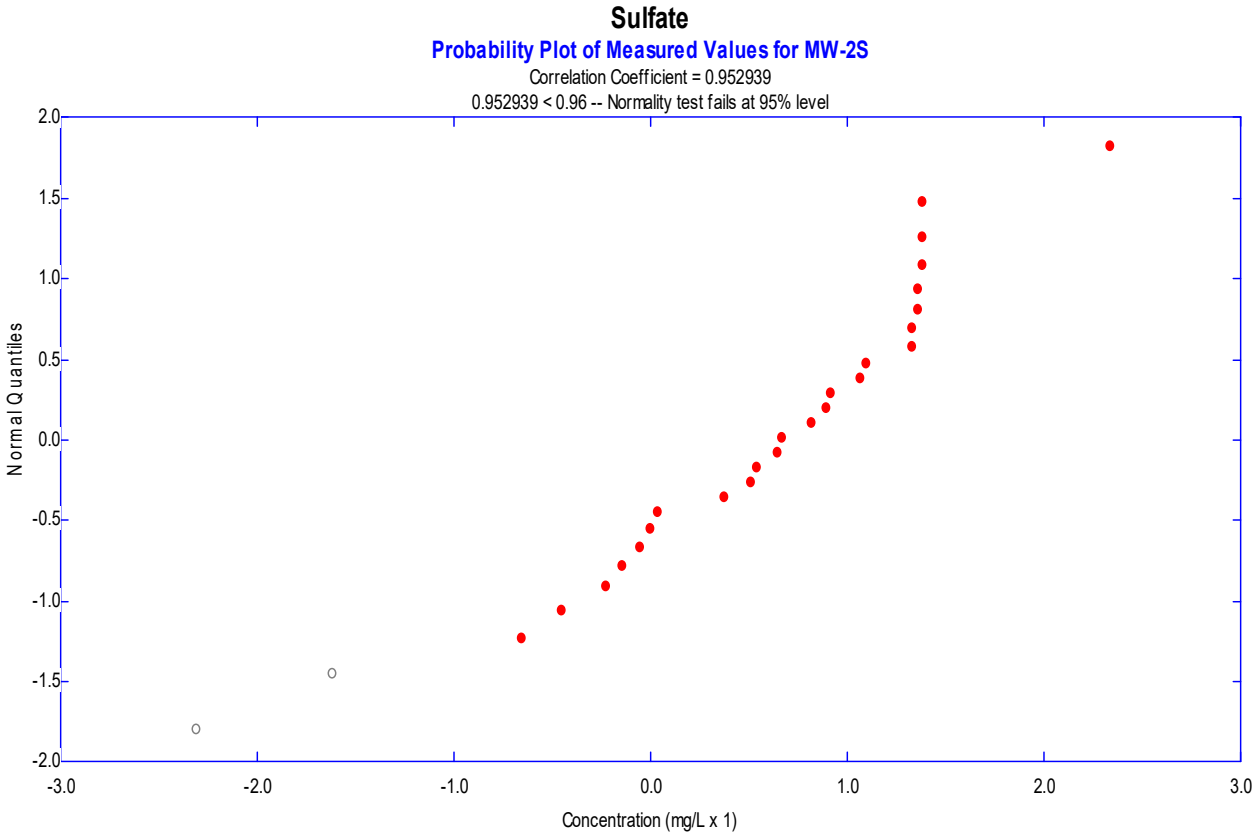

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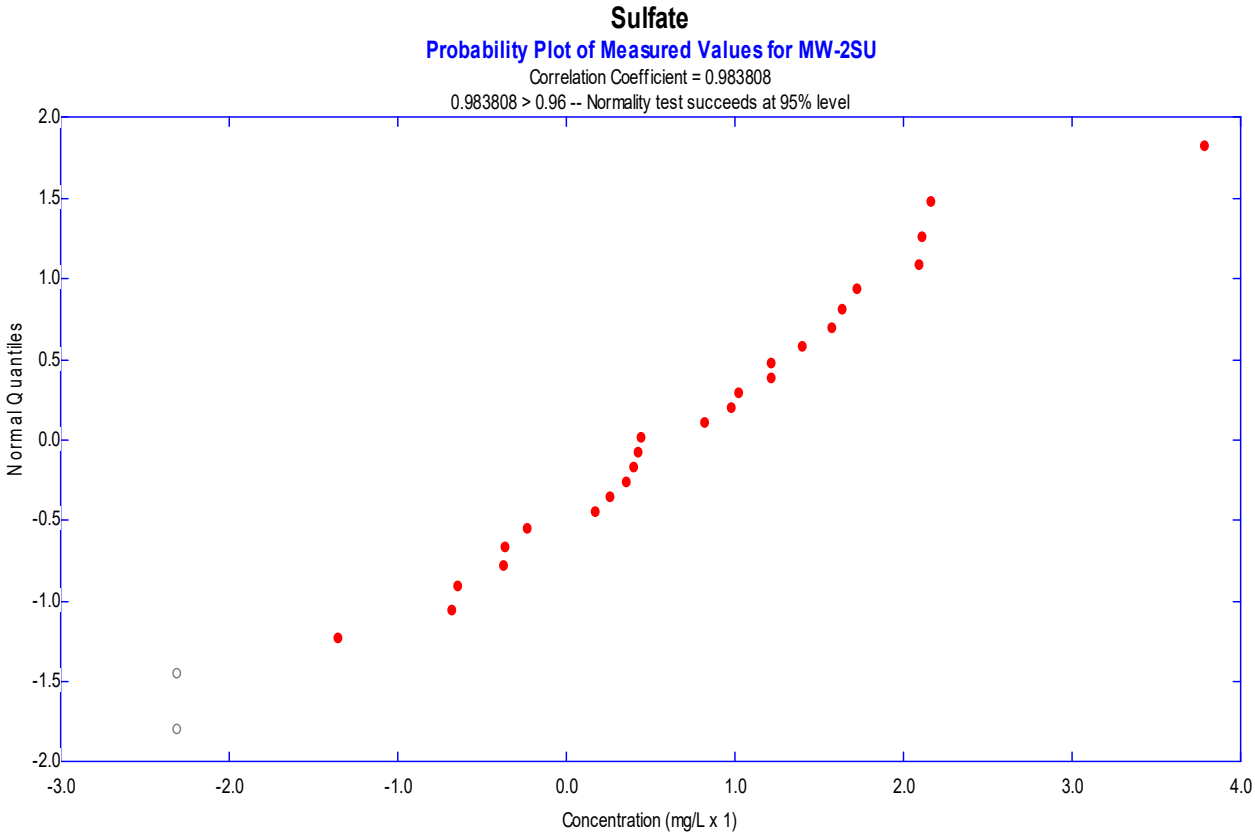

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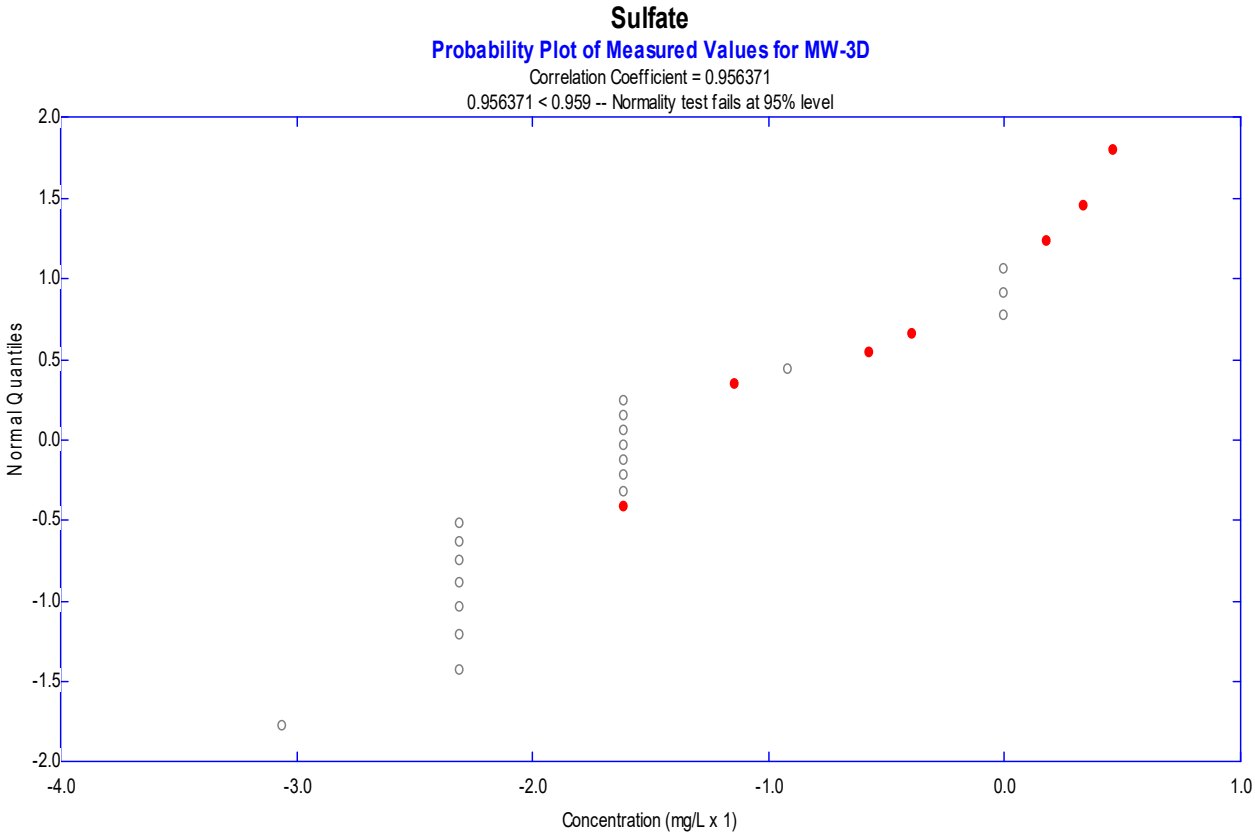

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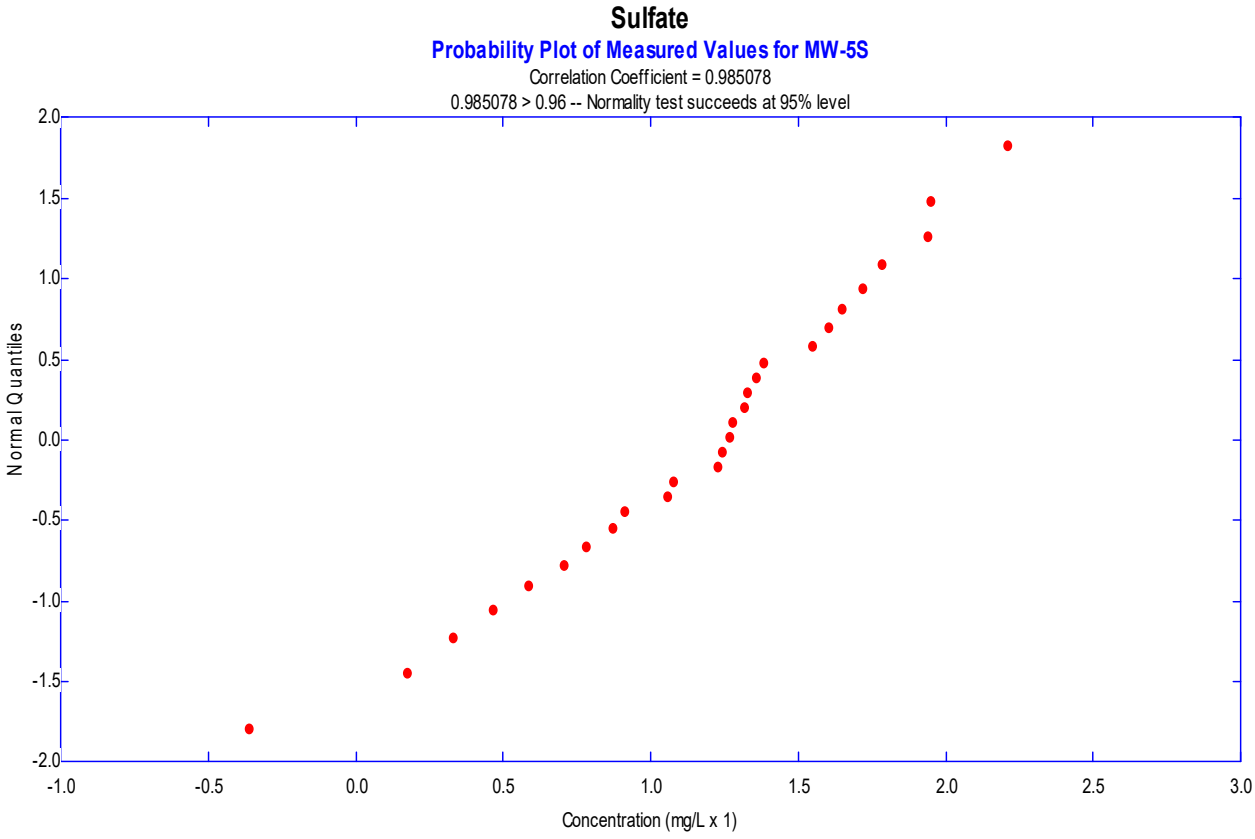

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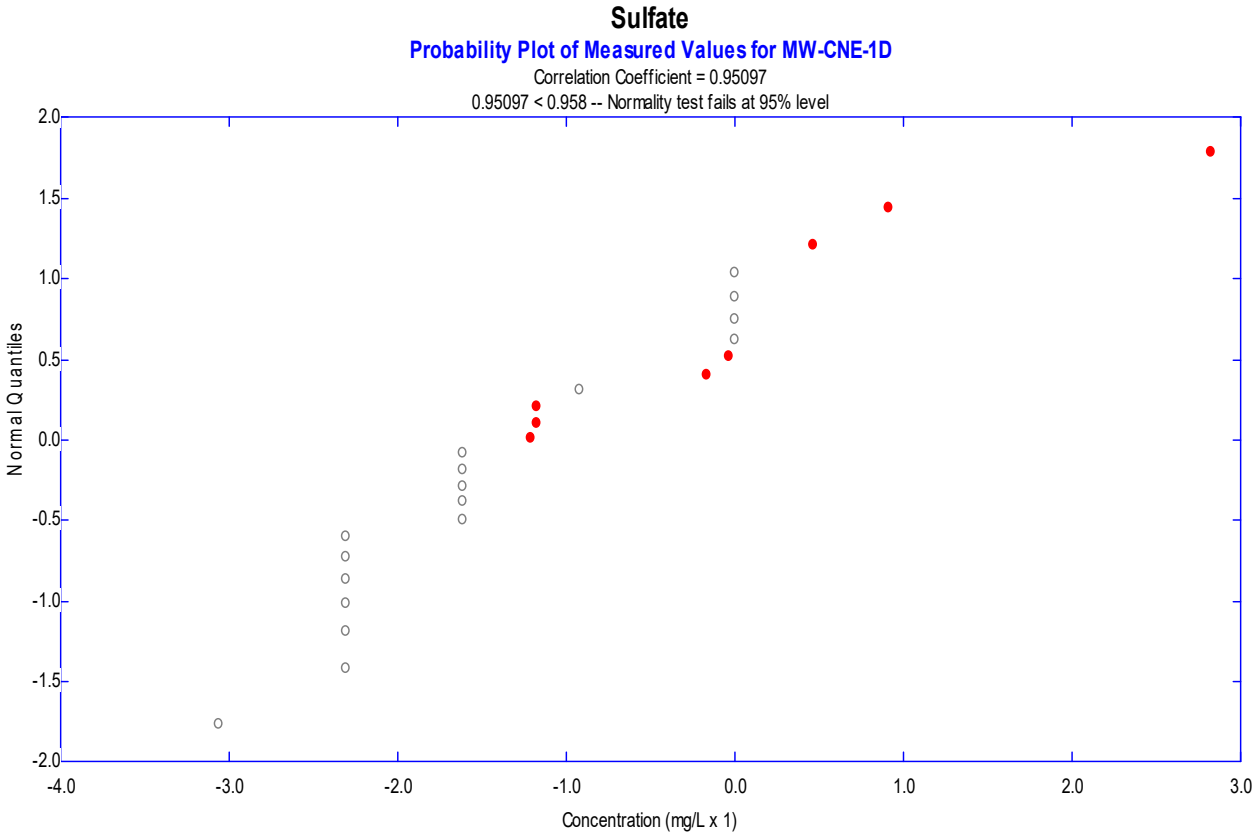

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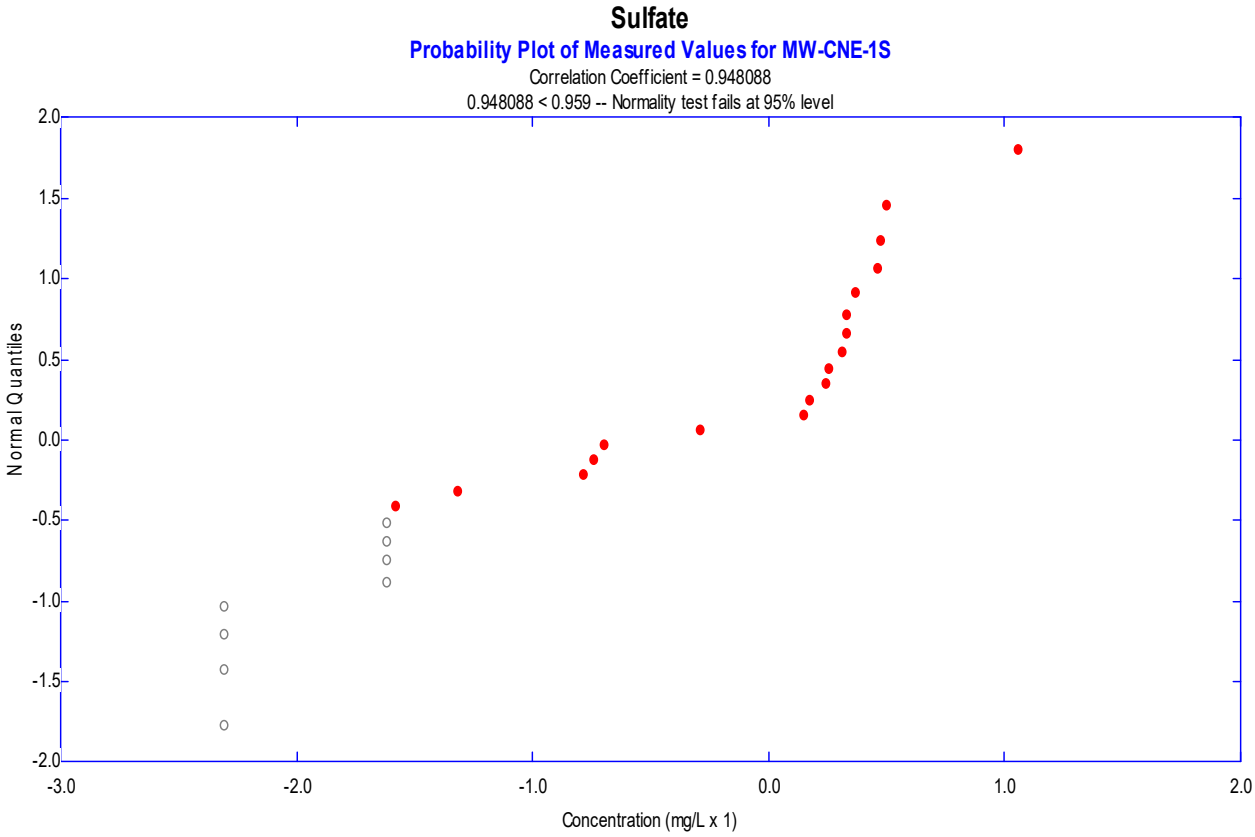

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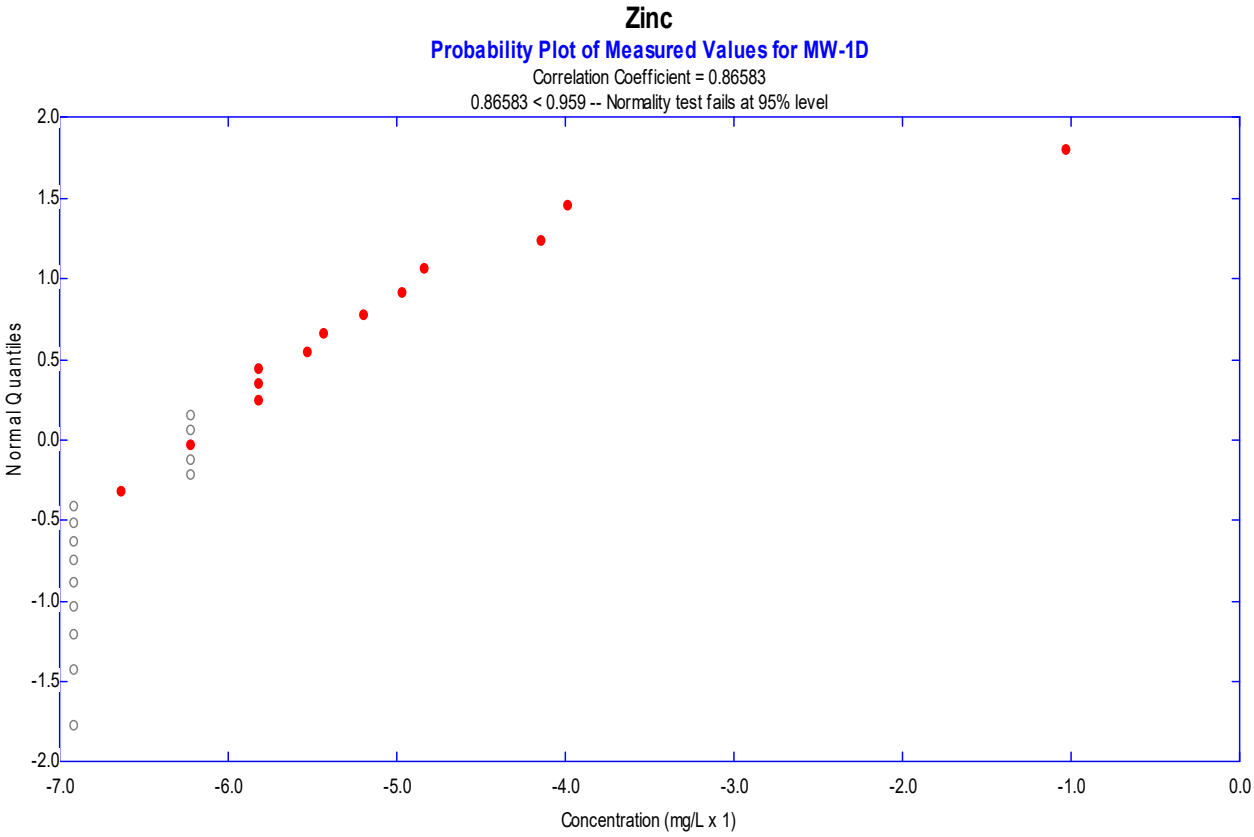

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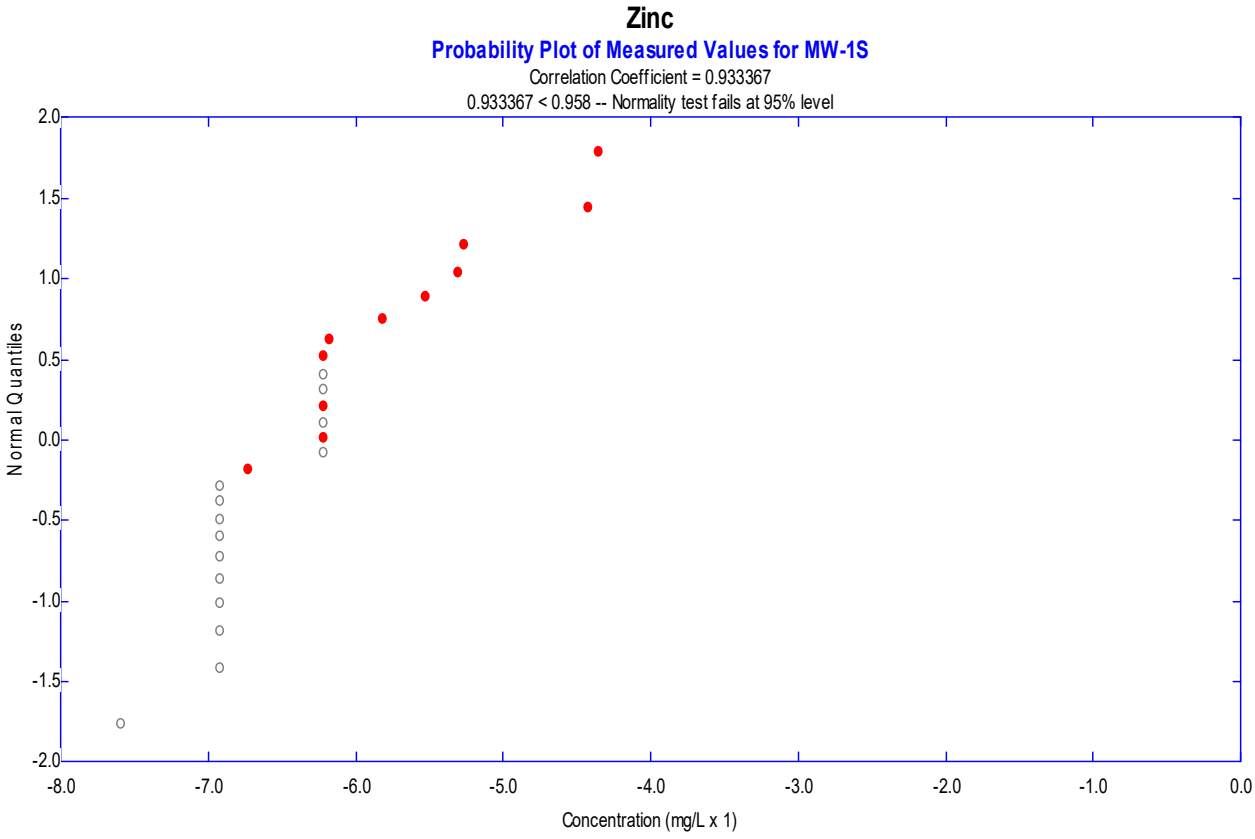

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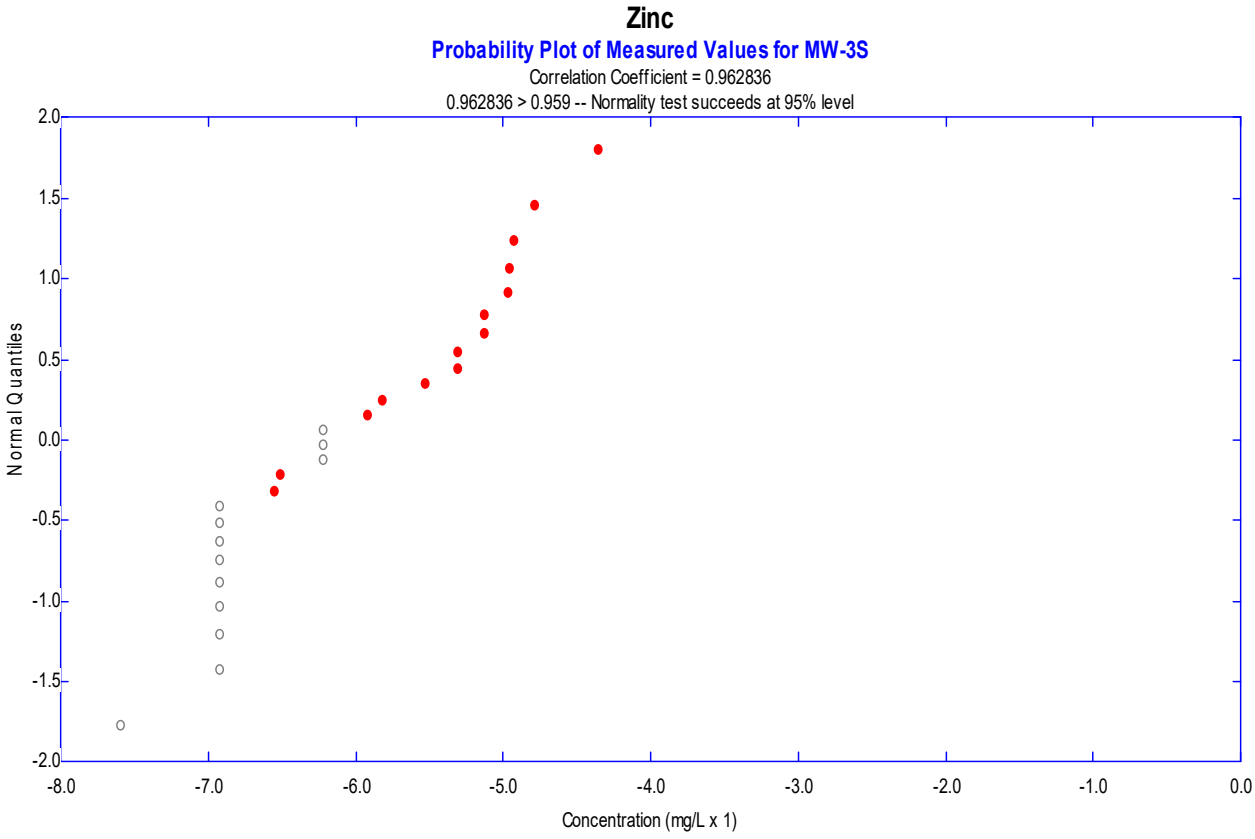

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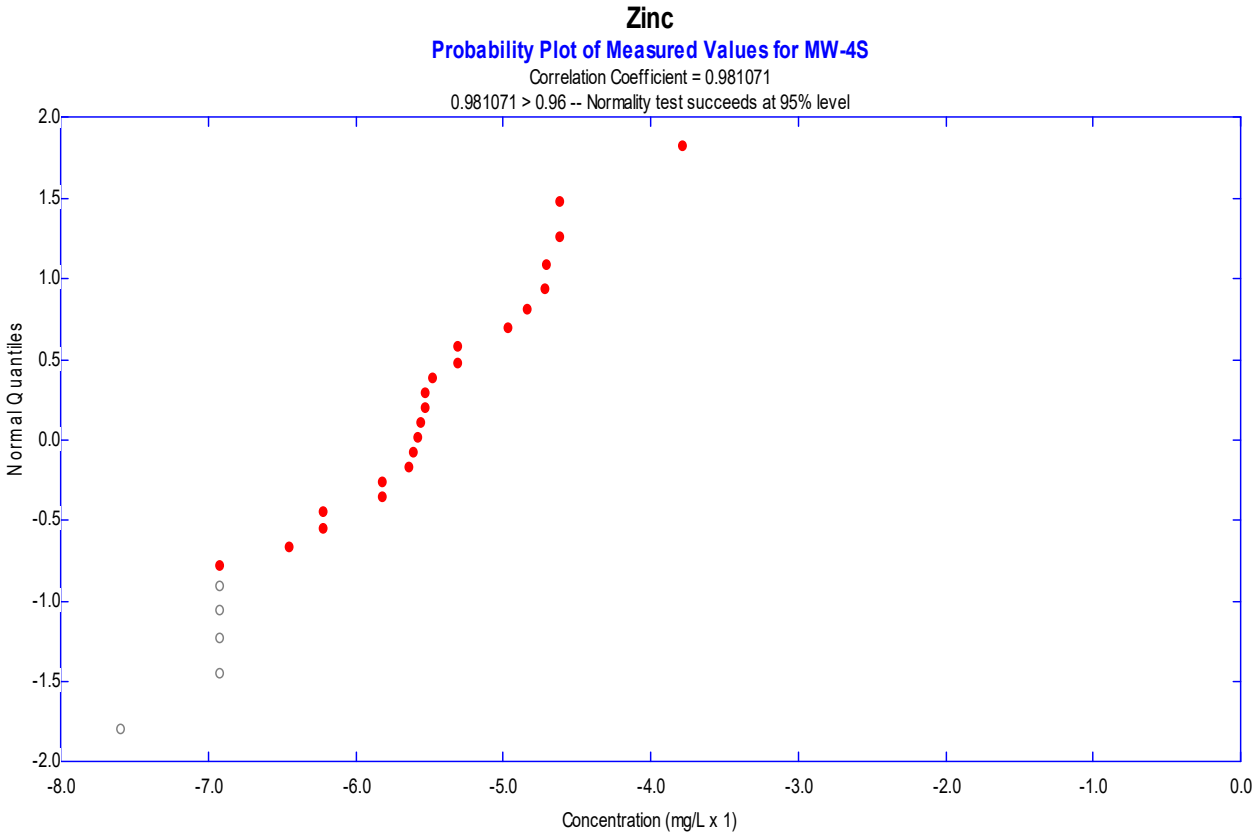

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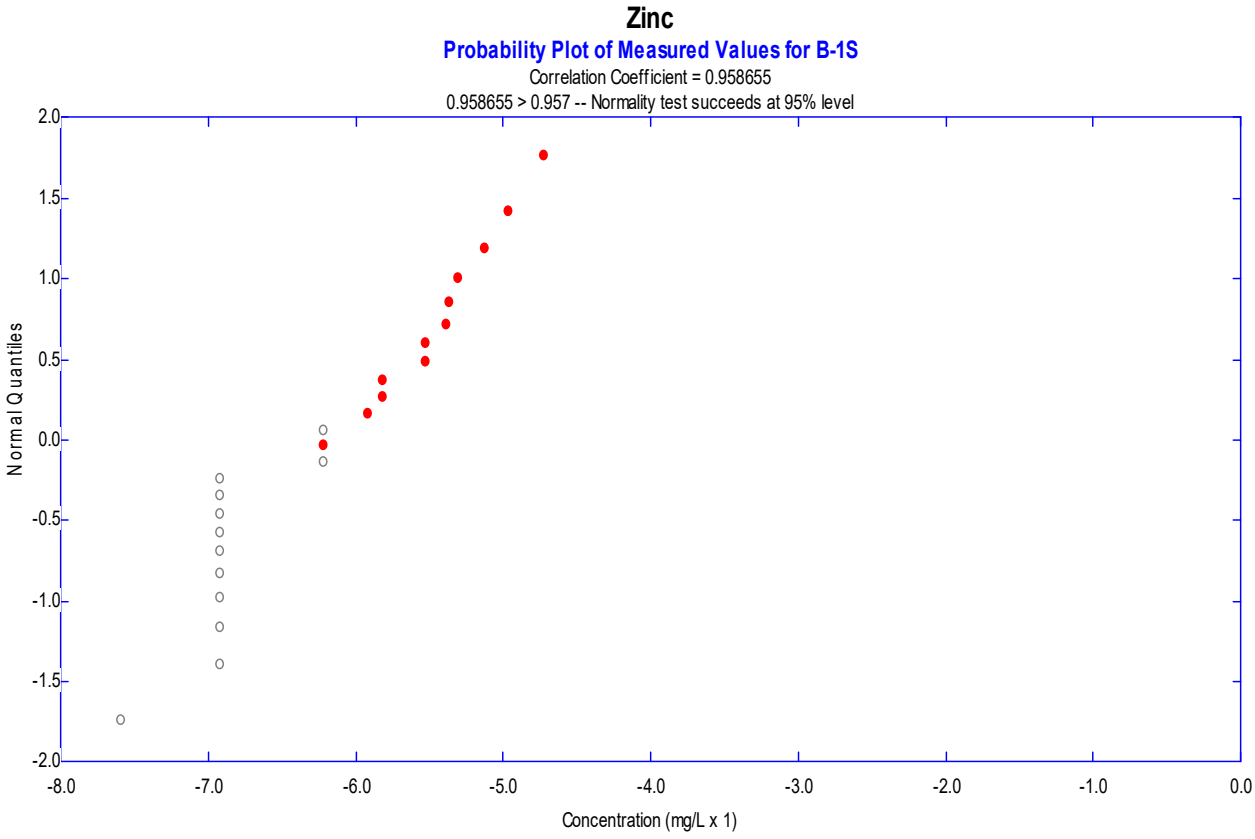

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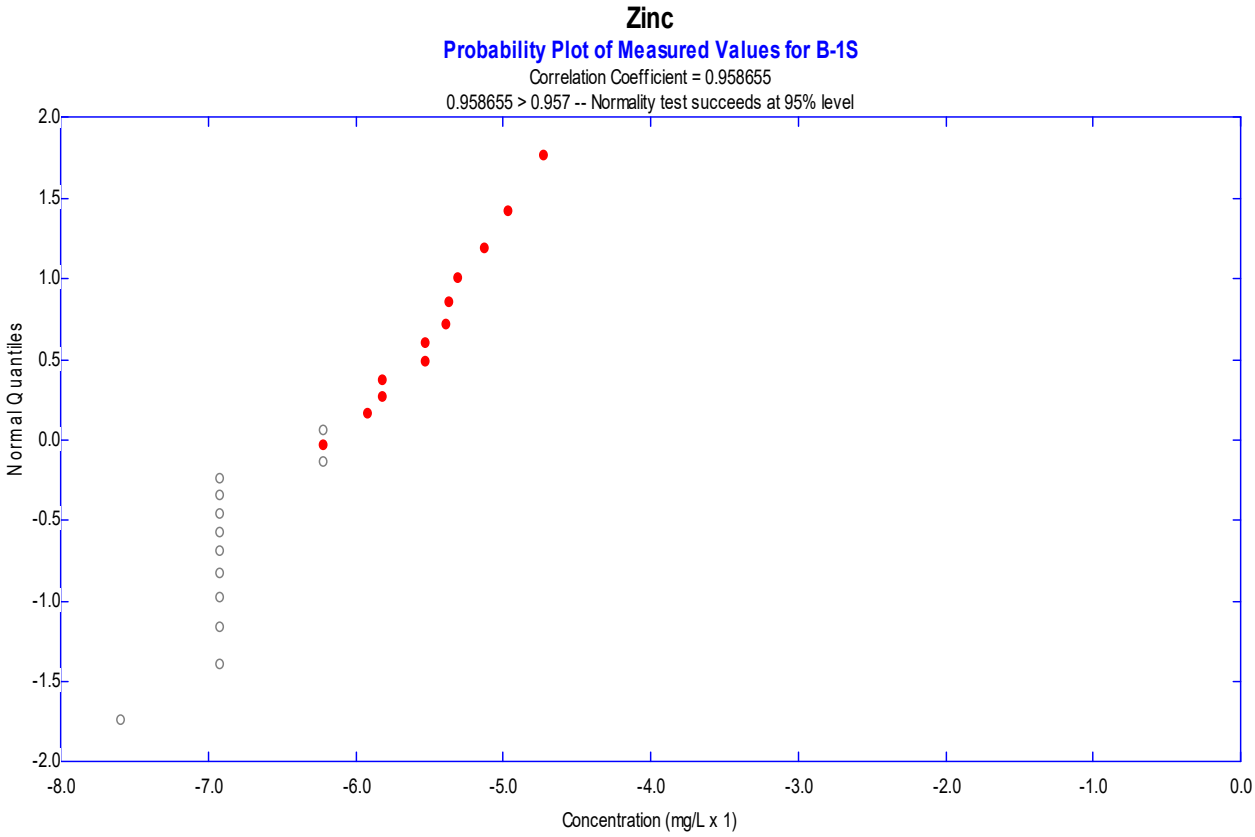

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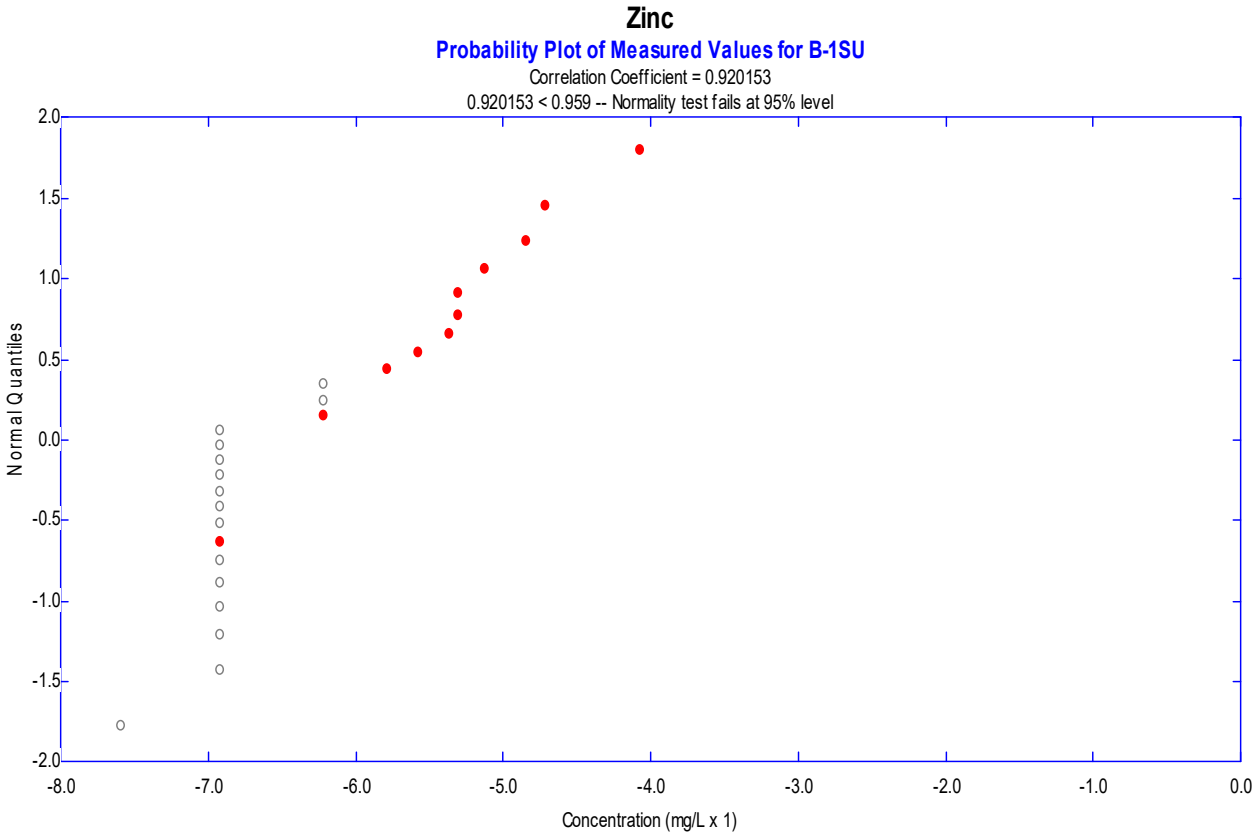

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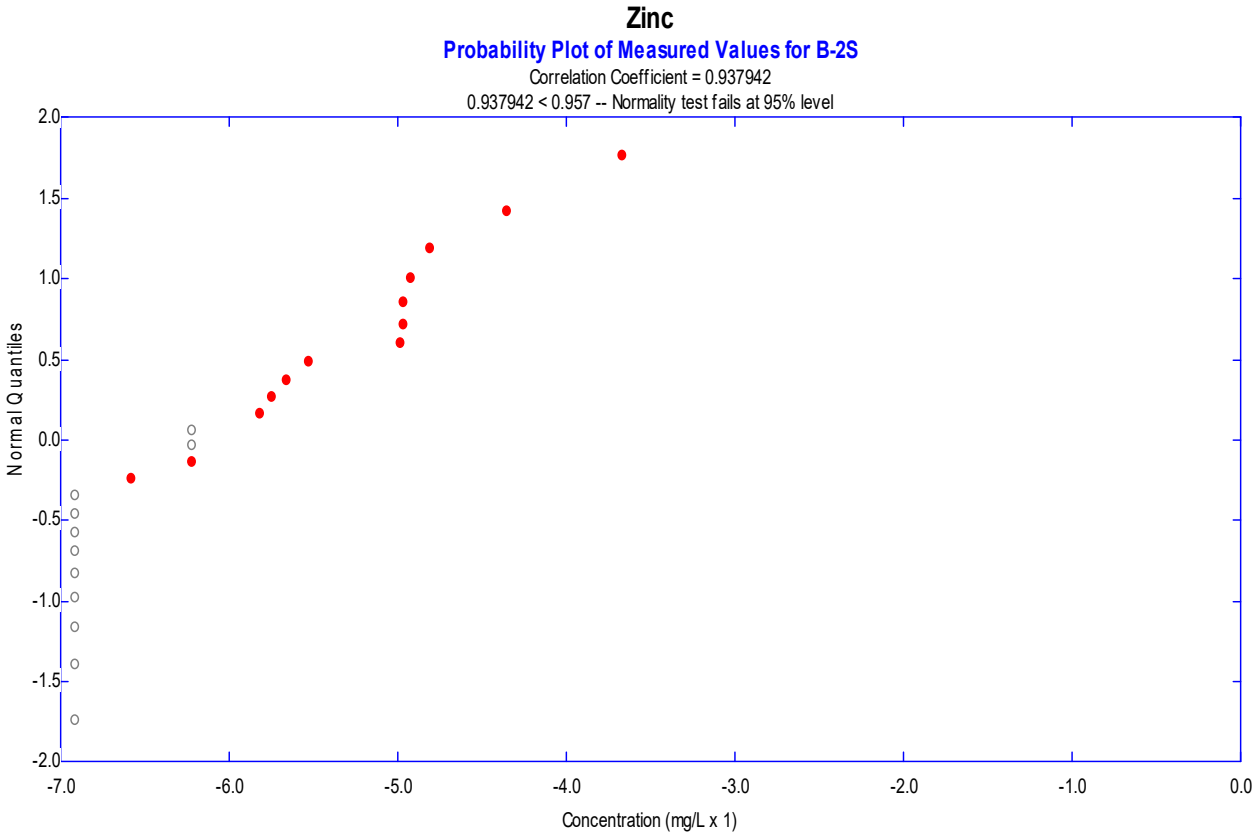

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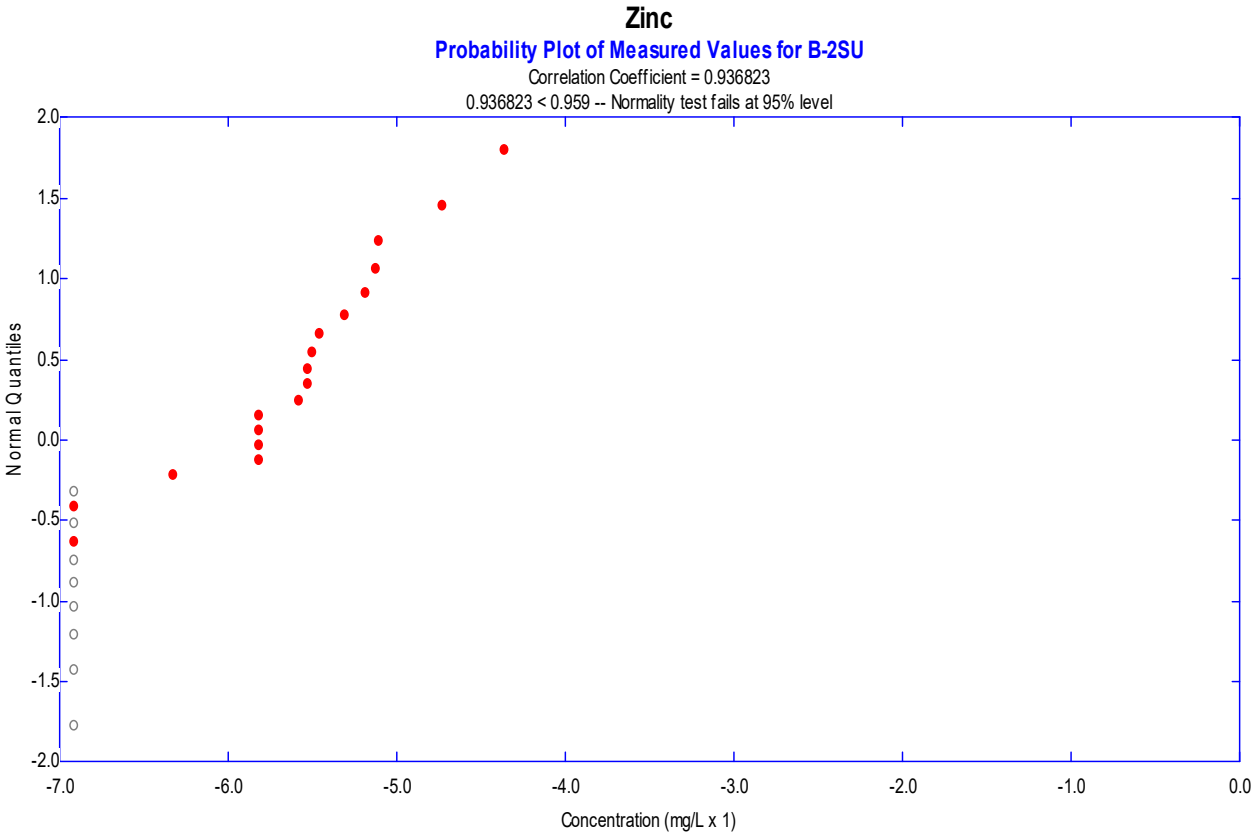

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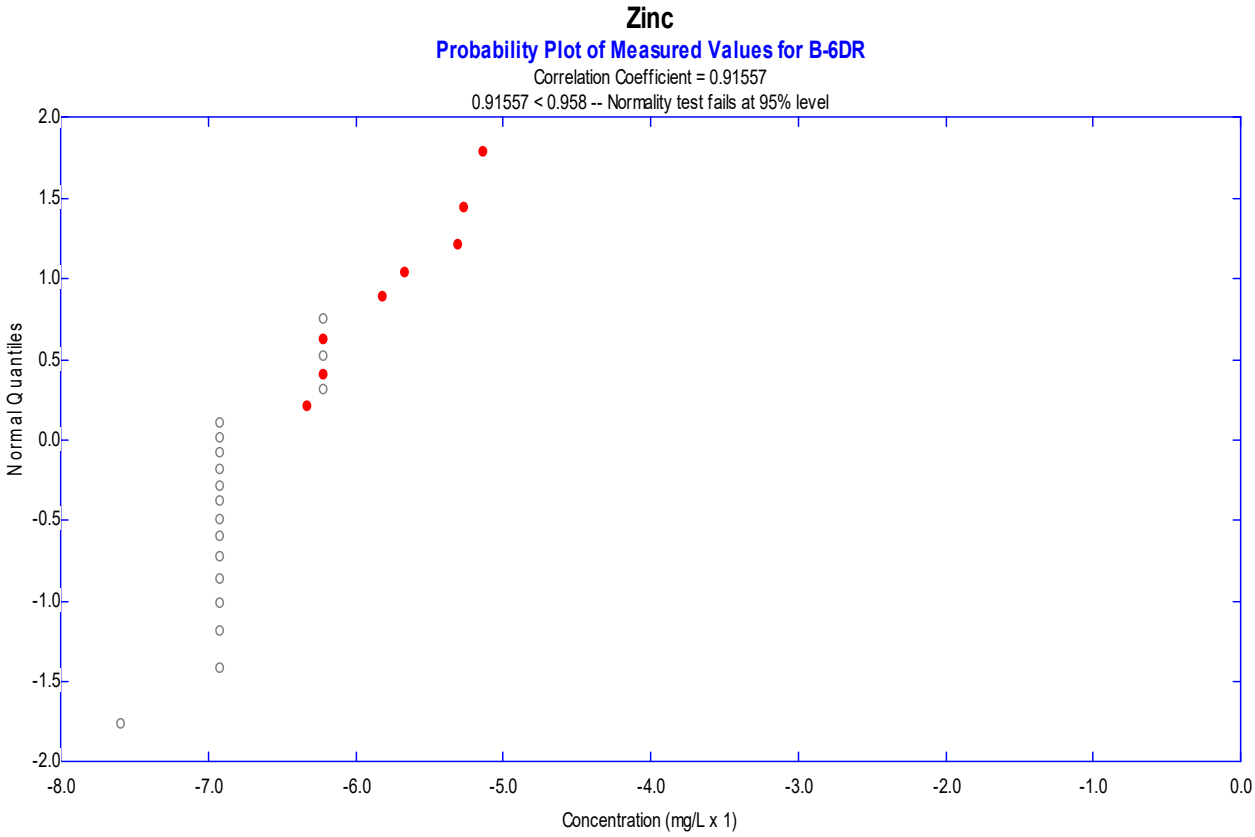

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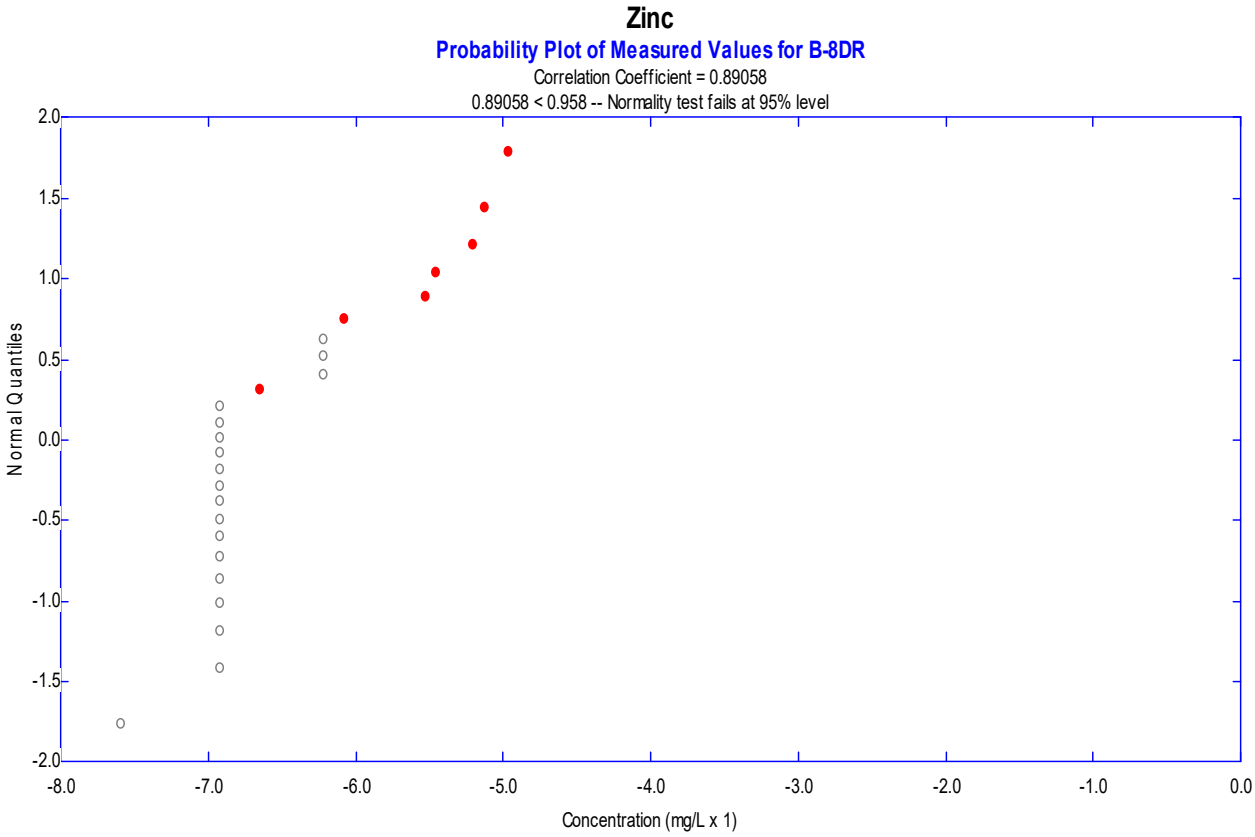

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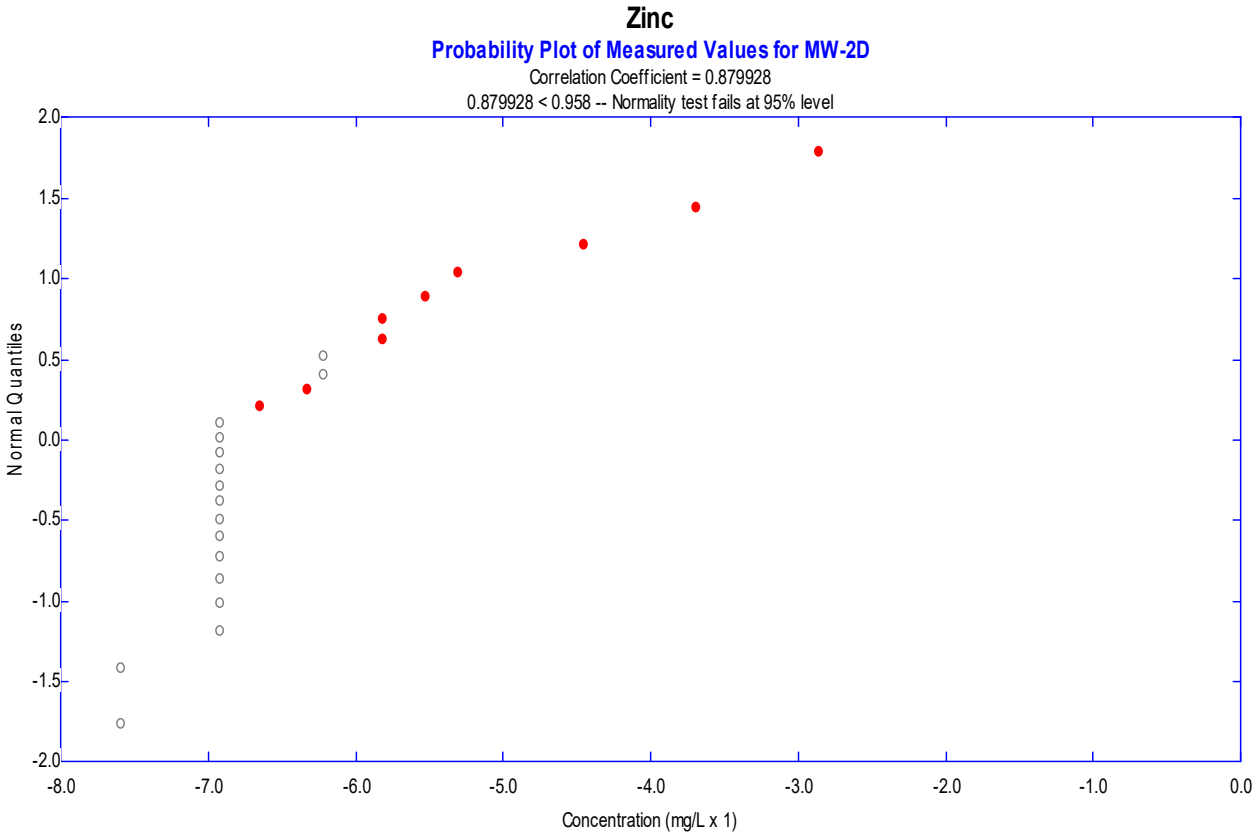

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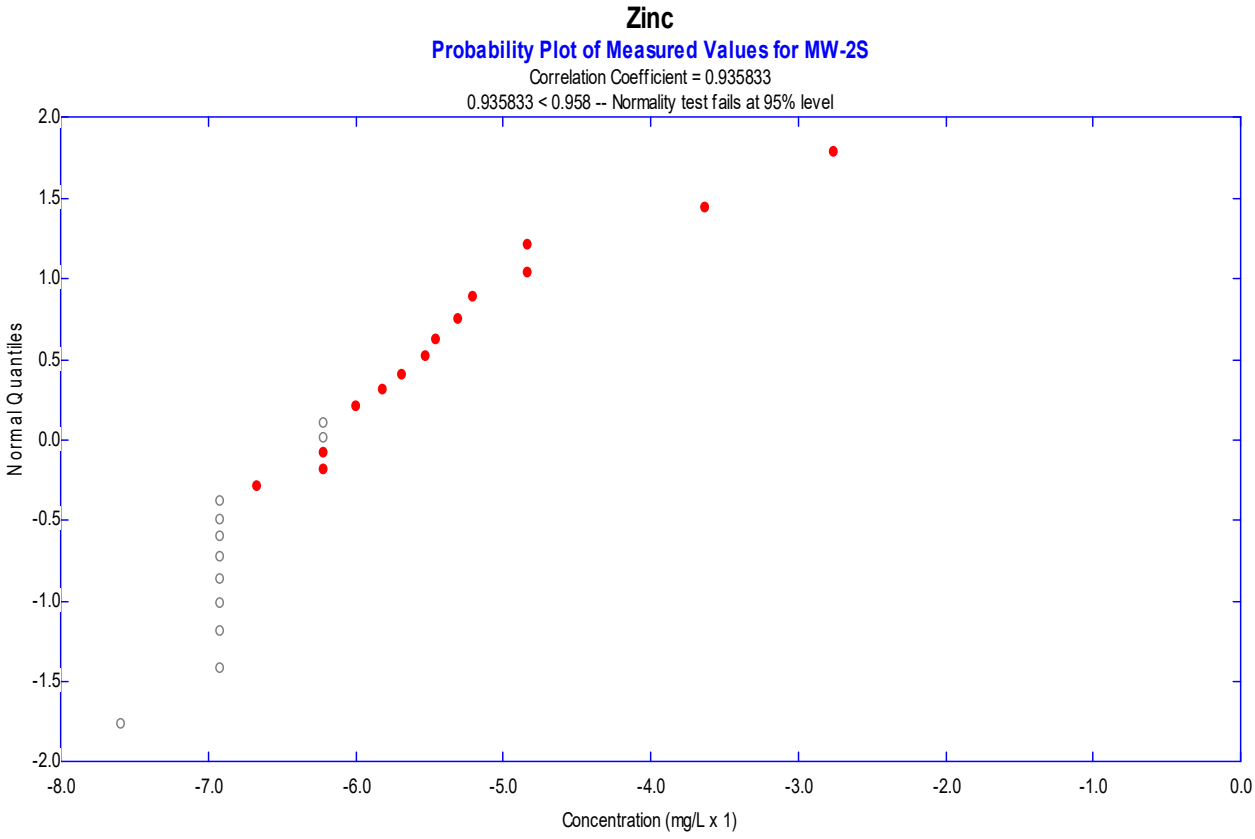

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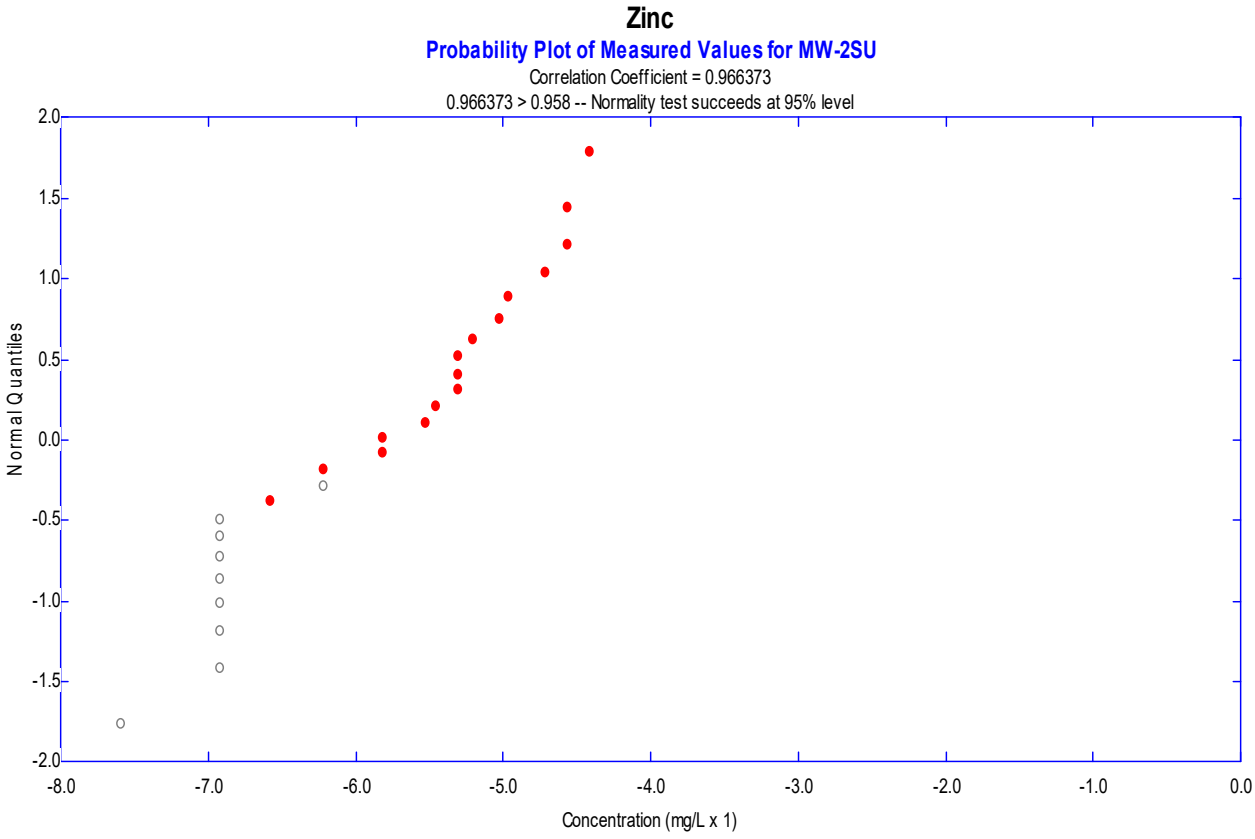

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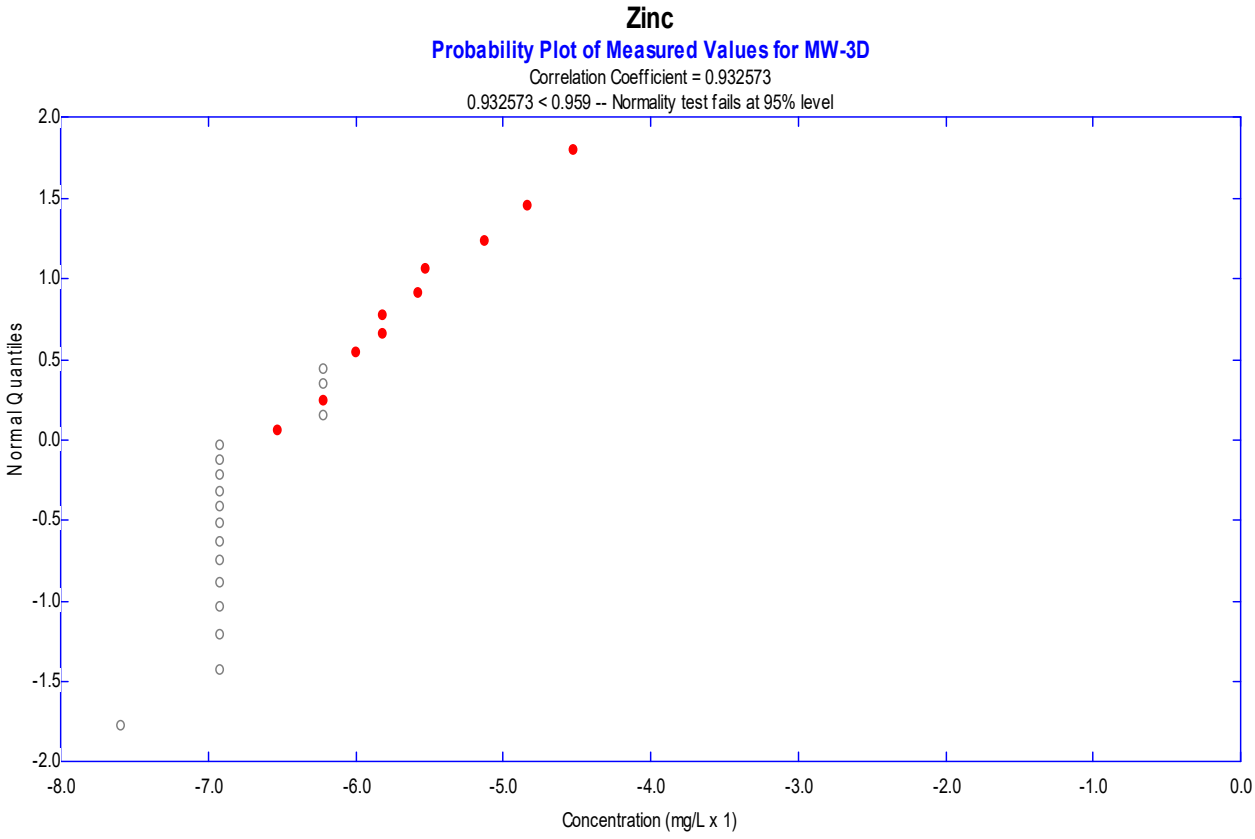

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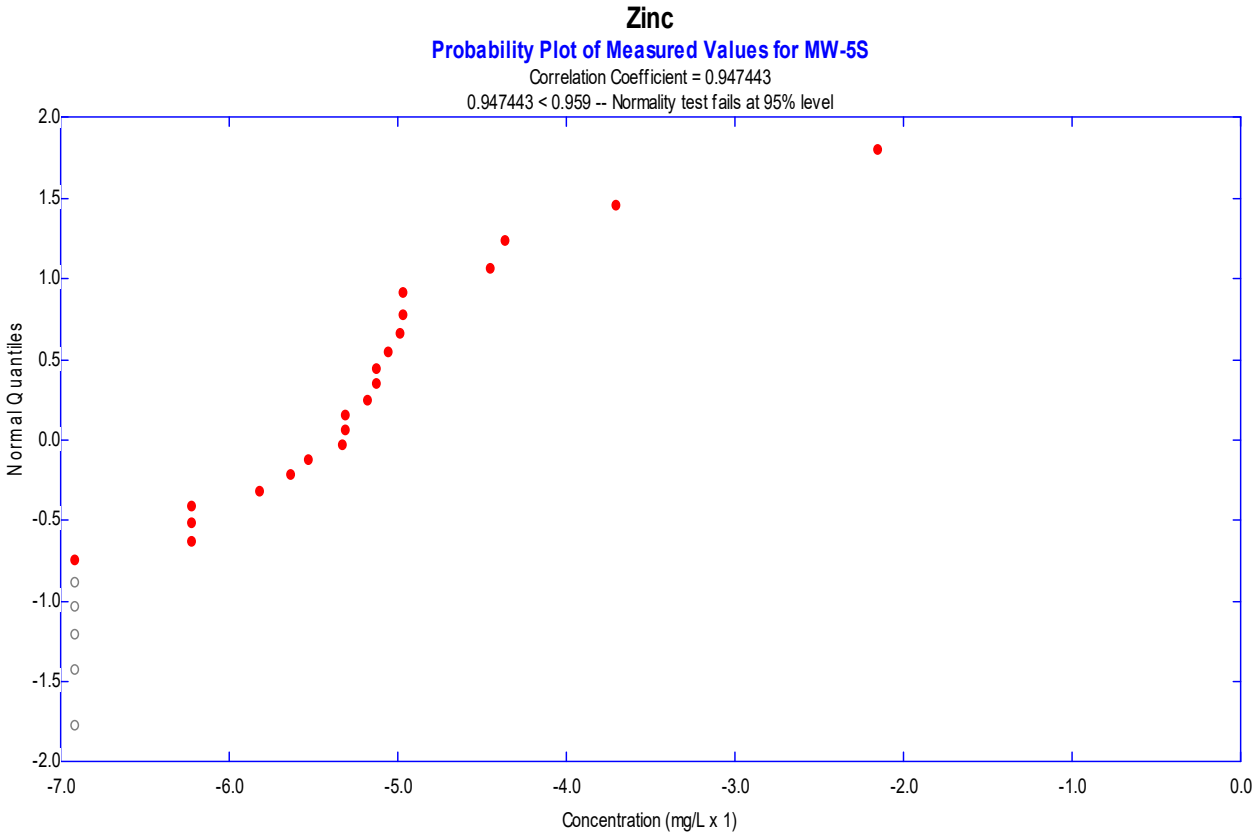

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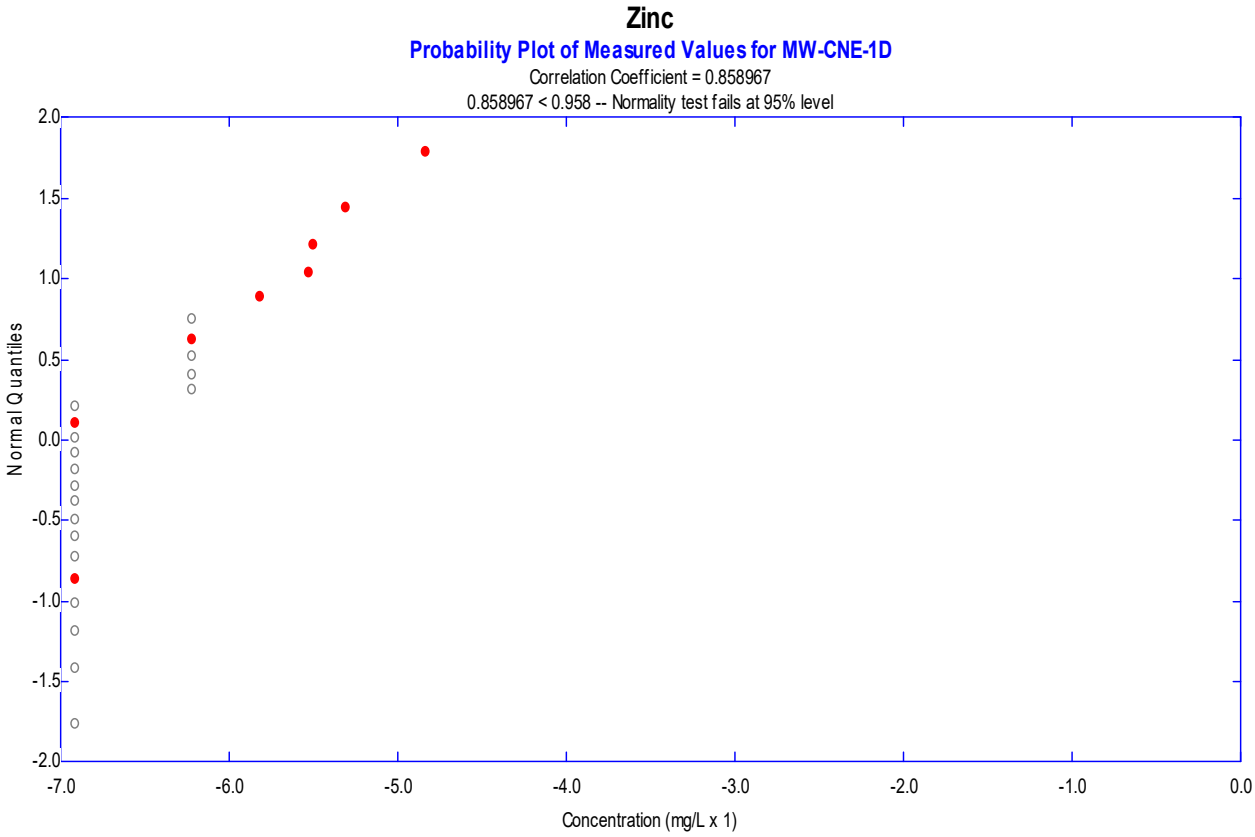

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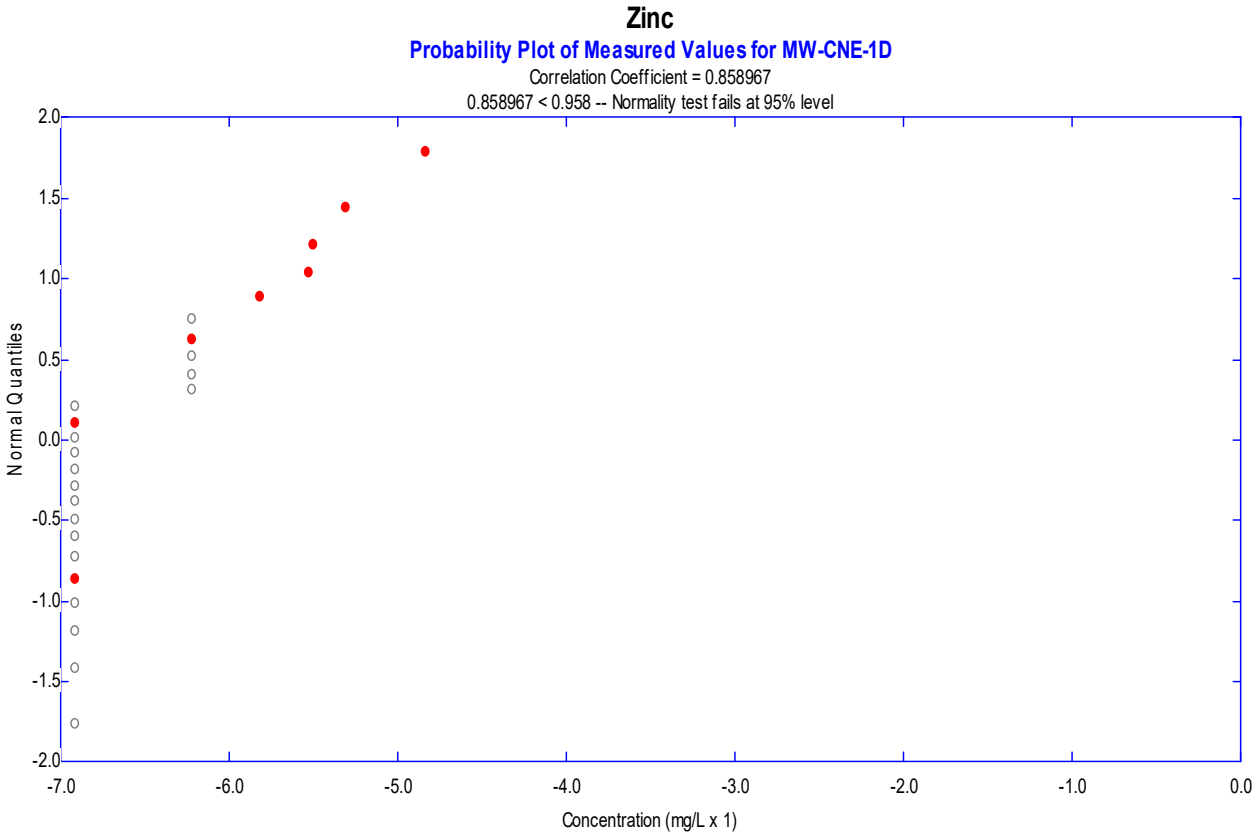

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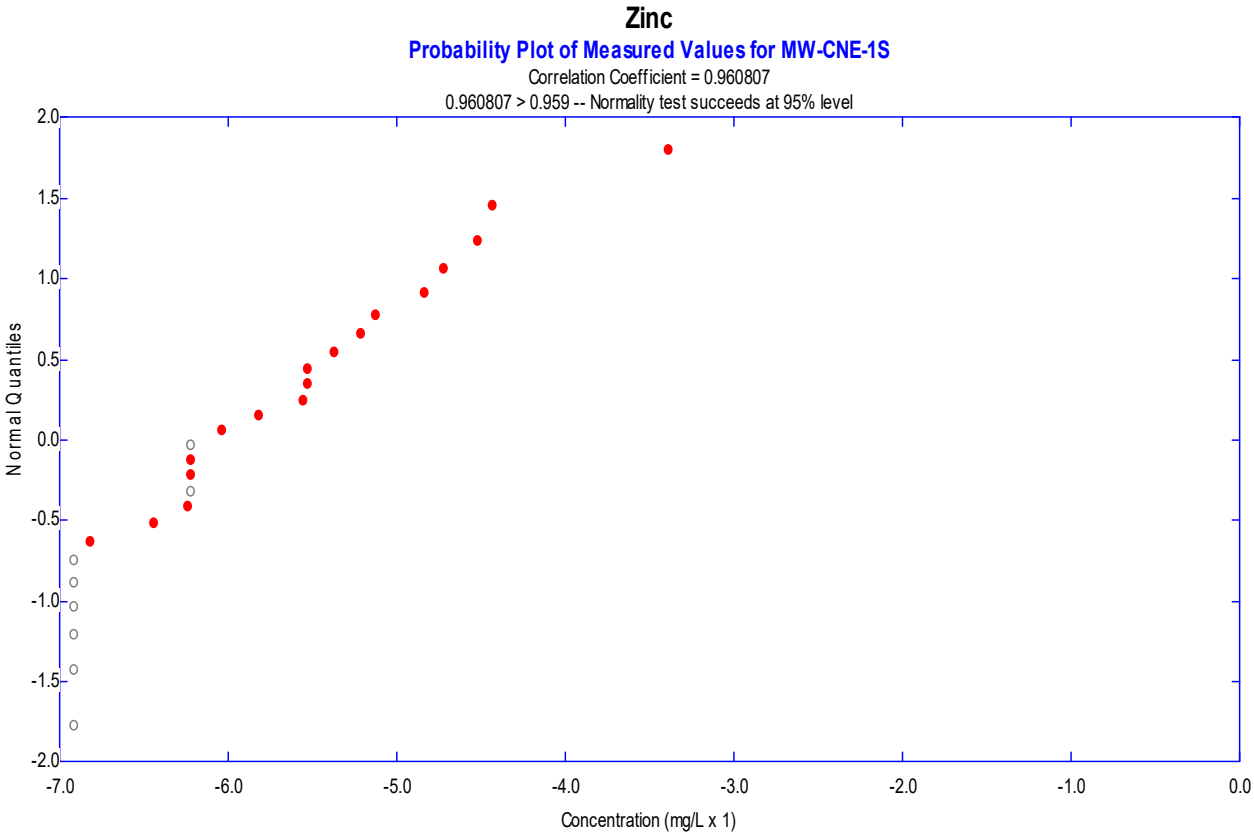

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Attachment C

Land's Confidence Interval Individual Well UCL Calculation

Parameter: Mercury

Natural Logarithm Transformation

Non-Detects Replaced with Detection Limit

95% Confidence Upward Test

Background Wells

Well ID	Samples	Mean	Std Dev	H	UCL
MW-1D	24	-10.2644	1.52717	3.28358	-8.05263
MW-1S	24	-10.2757	1.51656	3.26687	-8.09266
MW-3S	24	-10.274	1.61682	3.42472	-7.81236
MW-4S	24	-10.2693	1.49888	3.23913	-8.1336

Compliance Wells

Well ID	Samples	Mean	Std Dev	H	UCL
B-1S	23	-10.2801	1.49836	3.26172	-8.11555
B-1SU	24	-10.1722	1.29747	2.93813	-8.53557
B-2S	23	-10.2787	1.42172	3.14571	-8.31456
B-2SU	24	-10.1379	1.31965	2.97128	-8.44953
B-6DR	24	-10.0636	1.48591	3.21975	-7.96205
B-8DR	24	-10.27	1.50525	3.24907	-8.11736
MW-2D	24	-10.2953	1.56938	3.35003	-7.96755
MW-2S	24	-10.1777	1.38852	3.0742	-8.32368
MW-2SU	24	-10.2375	1.52075	3.27347	-8.04317
MW-3D	24	-10.1842	1.39055	3.07724	-8.32508
MW-5S	25	-10.1741	1.48045	3.18856	-8.11462
MW-CNE-1D	24	-10.2524	1.55851	3.33292	-7.9548
MW-CNE-1S	24	-10.1282	1.5318	3.29087	-7.90385

Unused Wells

Well ID	Samples	Mean	Std Dev	H	UCL

Land's Confidence Interval Individual Well UCL Calculation

Parameter: Sulfate

Natural Logarithm Transformation

Non-Detects Replaced with Detection Limit

95% Confidence Upward Test

Background Wells

Well ID	Samples	Mean	Std Dev	H	UCL
MW-1D	26	-1.2586	1.07971	2.60079	-0.114099
MW-1S	27	2.75561	0.822867	2.27025	3.46053
MW-3S	27	2.70425	0.931233	2.39647	3.57552
MW-4S	27	1.94007	0.673729	2.11196	2.44608

Compliance Wells

Well ID	Samples	Mean	Std Dev	H	UCL
B-1S	25	-0.830328	1.23884	2.83338	0.653537
B-1SU	26	-0.62706	1.13072	2.66945	0.615886
B-2S	26	0.504513	1.10347	2.63278	1.69438
B-2SU	27	1.28707	0.63813	2.07722	1.75063
B-6DR	27	-0.583916	1.23009	2.78496	0.84449
B-8DR	27	2.96068	0.363496	1.85129	3.15872
MW-2D	26	-1.13854	1.17699	2.73173	0.197151
MW-2S	27	0.521614	1.00062	2.48022	1.50895
MW-2SU	27	0.583926	1.37475	2.99065	2.33521
MW-3D	26	-1.31089	1.0098	2.50669	-0.294787
MW-5S	27	1.169	0.591672	2.03271	1.57991
MW-CNE-1D	25	-1.01431	1.33151	2.96884	0.67905
MW-CNE-1S	26	-0.626451	1.09105	2.61606	0.539598

Unused Wells

Well ID	Samples	Mean	Std Dev	H	UCL

Land's Confidence Interval Individual Well UCL Calculation

Parameter: Zinc

Natural Logarithm Transformation

Non-Detects Replaced with Detection Limit

95% Confidence Upward Test

Background Wells

Well ID	Samples	Mean	Std Dev	H	UCL
MW-1D	26	-5.85994	1.32151	2.93413	-4.21124
MW-1S	25	-6.27179	0.803544	2.26919	-5.57675
MW-3S	26	-6.02128	0.898274	2.36899	-5.19223
MW-4S	27	-5.71283	0.916023	2.37812	-4.86606

Compliance Wells

Well ID	Samples	Mean	Std Dev	H	UCL
B-1S	24	-6.15876	0.801216	2.27696	-5.45738
B-1SU	26	-6.23338	0.918229	2.39333	-5.37228
B-2S	24	-5.94761	0.98427	2.50183	-4.94975
B-2SU	26	-5.99874	0.819154	2.27681	-5.29022
B-6DR	25	-6.47717	0.639051	2.09421	-5.9998
B-8DR	25	-6.47621	0.70575	2.1617	-5.91575
MW-2D	25	-6.27489	1.15638	2.7209	-4.96403
MW-2S	25	-5.9736	1.12676	2.68049	-4.7223
MW-2SU	25	-5.87328	0.944431	2.43847	-4.95721
MW-3D	26	-6.34708	0.762625	2.21413	-5.71858
MW-5S	26	-5.49832	1.13209	2.6713	-4.25267
MW-CNE-1D	25	-6.46573	0.630863	2.08599	-5.99812
MW-CNE-1S	26	-5.83655	0.947979	2.42977	-4.92654

Unused Wells

Well ID	Samples	Mean	Std Dev	H	UCL