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UCOR-4715

Preliminary Determination of Background Groundwater Concentrations for the U.S. Department of Energy Oak Ridge Reservation Oak Ridge, Tennessee

This document is approved for public release per review by:

Teresa D. Fancher 8/6/15

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Preliminary Determination of Background Groundwater Concentrations for the U.S. Department of Energy Oak Ridge Reservation Oak Ridge, Tennessee

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Prepared for the
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USQD Review Determination	☐ USQD ☐ UCD ☒ CAT X ☐ Exempt (Select Criteria below.) USQD/UCD/CAT X No.: USQD-MS-CX-REPORTS-1074 R5
Exemption Criteria	☐ (1) Non-Intent Change ☐ (2) DOE-Approved Document ☐ (3) Clearly no impact on Nuclear Facilities ☐ (4) Chief Financial Officer, Internal Audit, Labor Relations, Legal, Public Affairs, or Project Controls Organization Document
USQD Preparer:	Name: [signature] Date: 8/6/15
Exhibit L Mandatory Contractor Document	☒ No ☐ Yes (Requires review by the Proforma Change Control Board.)
PCCB Reviewer:	Not required NAME & ORGANIZATION — Date

Reviewed by: Holly Clancy — 8/17/15
Holly Clancy, Oak Ridge Reservation Groundwater Program Document Lead
Restoration Services, Inc.
Date

Concurred By: [signature] — 8/17/15
Lynn Sims, Water Resources Restoration Program Manager
Restoration Services, Inc.
Date

Approved By: [signature] — 8/17/15
Curt Walker, Environmental Stewardship Manager
Restoration Services, Inc.
Date

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REVISION LOG		
Revision Number	Description of Changes	Pages Affected

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ACRONYMS

CAS	Chemical Abstracts Service
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
DOE	U.S. Department of Energy
DQO	data quality objective
EPA	U.S. Environmental Protection Agency
ETTP	East Tennessee Technology Park
HQ	hazard quotient
KM	Kaplan-Meier
LANL	Los Alamos National Laboratory
MCL	maximum contaminant level
NAWQA	National Water-Quality Assessment
OREIS	Oak Ridge Environmental Information System
ORR	Oak Ridge Reservation
PCA	principal components analysis
PEMS	Project Environmental Measurement System
PRG	preliminary remediation goal
QA/QC	Quality Assurance/Quality Control
RI/FS	Remedial Investigation/Feasibility Study
RSL	Regional Screening Level
TDEC	Tennessee Department of Environment and Conservation
TIC	tentatively identified compound
TR	target risk
UCOR	URS | CH2M Oak Ridge LLC
UCL	upper confidence limit
USGS	U.S. Geological Survey
UTL	upper tolerance limit
Y-12	Y-12 National Security Complex

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1. INTRODUCTION

There is considerable uncertainty associated with assessing background groundwater characteristics on and around the Oak Ridge Reservation (ORR). The absence of background concentration levels for naturally-occurring substances and for substances resulting from human activities presents difficulties in differentiating groundwater containing elevated concentrations potentially due to ORR-related impacts.

U.S. Environmental Protection Agency (EPA) guidance defines background as:

> *Substances or locations that are not influenced by the releases from a site and are usually described as naturally occurring or anthropogenic: (1) Naturally occurring substances present in the environment in forms that have not been influenced by human activity. (2) Anthropogenic substances are natural and human-made substances present in the environment as a result of human activities (not specifically related to the CERCLA site in question).* (EPA 540-R-01-003).

Most guidance documents and research papers on methods to determine natural or anthropogenic background concentrations primarily employ environmental sample collection and statistical data analysis techniques. However, geochemical evaluations may also be used to identify potentially contaminated samples and naturally occurring metals (Thorbjornsen and Myers 2007).

While it may be convenient to think of the background concentration as a single value, the concentration of a chemical in groundwater will naturally vary both spatially and temporally resulting in a range of concentrations. This variation has been well documented in numerous formal studies (e.g. USGS 1993, USGS 1997) and primarily results from the difference in chemicals found in different subsurface rock and soil types. The laboratory analytical process introduces additional variability. Because of both natural and introduced variability, background can best be understood as a distribution[1], prompting the question: "Is the distribution of concentrations consistent with the distribution of concentrations in background?" (GSMC-1).

The need for defining a range and distribution of background groundwater concentration levels to help delineate areas of potential off-site groundwater contamination was identified during the recent data quality objectives (DQO) process for the Off-site Groundwater Assessment (DOE/OR/01-2649&D1). This report describes the process used to determine preliminary background concentrations for the ORR and adjacent area using available data and makes recommendations for use of these distributions in evaluating groundwater.

[1]A data distribution is the nature or shape of the spread of data over a range of values (such as bell-shaped, uniform, or skewed). (Triola 2009)

2. PREVIOUS STUDIES AND CURRENT STUDY

2.1 ORR STUDIES

The need for background groundwater concentrations on the ORR has been recognized in the past and has been the subject of previous studies. Two formally documented efforts are described below.

- Y-12 National Security Complex (Y-12) study. Background concentrations for inorganics were developed for the Y-12 Plant in 1996 (Y/ER-234) using data from a large selection of wells throughout the Plant site and a combination of statistical cluster analysis and conventional cumulative probability distribution graphing. The objective of the study was to develop a methodology for setting groundwater reference concentrations using all site groundwater data instead of only results of sampling groundwater wells upgradient of known groundwater contamination. The outcome was the development of background concentrations for inorganics by ORR hydrogeologic unit (i.e., Knox Aquifer vs. ORR Aquitards) for the Y-12 Plant area. Past uses of this background dataset include evaluation of monitoring results at the Y-12 Plant (Y/ER-205) and groundwater data in Union Valley (DOE/OR/02-1545&D2).

- East Tennessee Technology Park (ETTP) study. The Sitewide Remedial Investigation/Feasibility Study (RI/FS) for ETTP prepared in 2007 (DOE/OR/01-2279&D3) developed background concentrations for many analytes found in groundwater at the ETTP. Groundwater background values for ETTP were derived using existing groundwater data and new data collected during the RI. Eleven monitoring wells were identified as representing the background well network for the site. The background monitoring wells included five bedrock and six unconsolidated zone wells. Analytical data for samples collected from the five bedrock and six unconsolidated zone wells were combined to derive the groundwater background values for ETTP because the bedrock and unconsolidated zones are interconnected and all 11 wells were found to have similar water chemistry. The mean concentration of each analyte in the combined dataset was calculated. One-half the quantitation limit was used in calculating the mean for analytes that were not detected. The background value for each analyte was established as twice the mean or the highest concentration detected for that analyte, whichever was lower. Background groundwater concentrations were developed for inorganics, herbicides and pesticides, and selected organic compounds. The derived background concentrations were used for screening the available groundwater data used in the ETTP RI/FS. Regulators withheld approval of groundwater sections of the RI/FS pending performance of a groundwater treatability study.

Despite previous efforts, no universally acceptable background concentrations have been established for groundwater on and around the ORR.

2.2 STUDIES OUTSIDE THE ORR

Other studies conducted outside the ORR to develop background concentrations for groundwater include the following:

- U.S. Geological Survey (USGS) studies. The USGS has conducted several nationwide studies of background groundwater quality under their National Water-Quality Assessment (NAWQA) Program. These studies have looked at public water supply wells and domestic water wells nationwide to develop ranges of background concentrations based on regional aquifer characteristics. Some of these background concentrations are compared with ORR-specific data in this study and applicable USGS NAWQA reports are listed in the References.

- U.S. Department of Energy (DOE) Los Alamos National Laboratory (LANL) study. A recent study was prepared at LANL to establish background groundwater concentrations for the site. The study (LA-UR-10-4827) developed background groundwater concentrations for inorganics and radionuclides for use at LANL. This study included one of the most detailed efforts to define background for fall-out radionuclides.

2.3 CURRENT STUDY

As with the Y-12 study, the current study evaluates existing available groundwater data to develop a dataset of background concentrations. Both newly collected data and existing data were used in the previous ETTP background study. Unlike both previous ORR studies, the current study, in an effort to determine background concentrations for ORR and the adjacent area, includes evaluation of results from years of off-site sampling conducted by the Tennessee Department of Environment and Conservation (TDEC). The TDEC results were recently obtained and compiled for use in planning the Off-site Groundwater Assessment project.

Chapter 3 describes the process used to evaluate available data. Chapter 4 further describes the evaluation steps. Chapter 5 contains conclusions and recommendations for using the resulting estimated background concentrations. References are listed in Chapter 6. Appendices A and B contain output from two of the interim process steps. Appendix C contains output from the final background dataset.

3. DESCRIPTION OF PROCESS

The general process to determine background concentrations included identifying available data and performing initial data review and cleanup followed by a series of iterative steps of data analysis and filtering (removal) of data that may not be representative of uncontaminated groundwater or appropriate for the final dataset. Table 1 provides a summary description of each step, corresponding changes in the size of the interim datasets after completion of each step, and output contained in this report.

Table 1. Steps to develop background dataset for ORR area groundwater

	Step No.	Step name	Output in this report
Initial data identification, review, and cleanup		Available data (353 locations, 145,426 observations)	
	1	Identify available data • from OREIS (114 locations, 125,739 observations) • from TDEC (239 locations, 19,687 observations)	Original data files (Appendix D, on CD): *OREIS original data set.xlsx* *TDEC original data set.xlsx*
	2	Perform initial data review and cleanup to produce first dataset	
Data analysis and filtering of interim datasets		First dataset (341 locations, 123,240 observations)	
	3	Perform first data analysis	
	4	First data filter	
		Second dataset (242 locations, 23, 682 observations)	
	5	Perform second data analysis	• Summary statistics (Appendix A, Table A.1) Probability plots (Appendix A, Figures A.1 – A.15)
	6	Second data filter	
		Third dataset (84 locations, 7,865 observations)	
	7	Perform third data analysis	
	8	Third data filter	
		Fourth dataset (77 locations, 2,855 locations)	
	9	Perform fourth data analysis	• Summary statistics (Appendix B, Table B.1) • Probability plots (Appendix B, Figures B.1 – B.27). Evaluation of possible additional outliers (Appendix B, Tables B.2 and B.3, Figure B.28)
	10	Fourth data filter	
Analysis of final dataset		Final dataset (74 locations, 2,759 observations)	
	11	Perform data analysis on final dataset • from OREIS (0 locations, 0 observations) • from TDEC (74 locations, 2,759 observations)	Final dataset (Appendix D, on CD): *ORR GW background final data set.xlsx* • Summary statistics (Table 2). • Comparison of medians, percentiles and UTLs to USGS data (Table 3). • Probability plots (Appendix C, Figures C.1 through C.27) • Box plot comparison with USGS data (Appendix C, Figures C.28 through C.46)

CD = compact disk
GW = groundwater
ORR = Oak Ridge Reservation
OREIS = Oak Ridge Environmental Information System
TDEC = Tennessee Department of Environment and Conservation
USGS = U.S. Geological Survey
UTL = upper tolerance limit

The process began with identifying data from 353 locations (Step 1) and ended with 74 locations in the final dataset (Step 11). As illustrated in Figure 1, the red dots are locations eliminated during the evaluation process and the blue dots are the 74 locations remaining in the final dataset.

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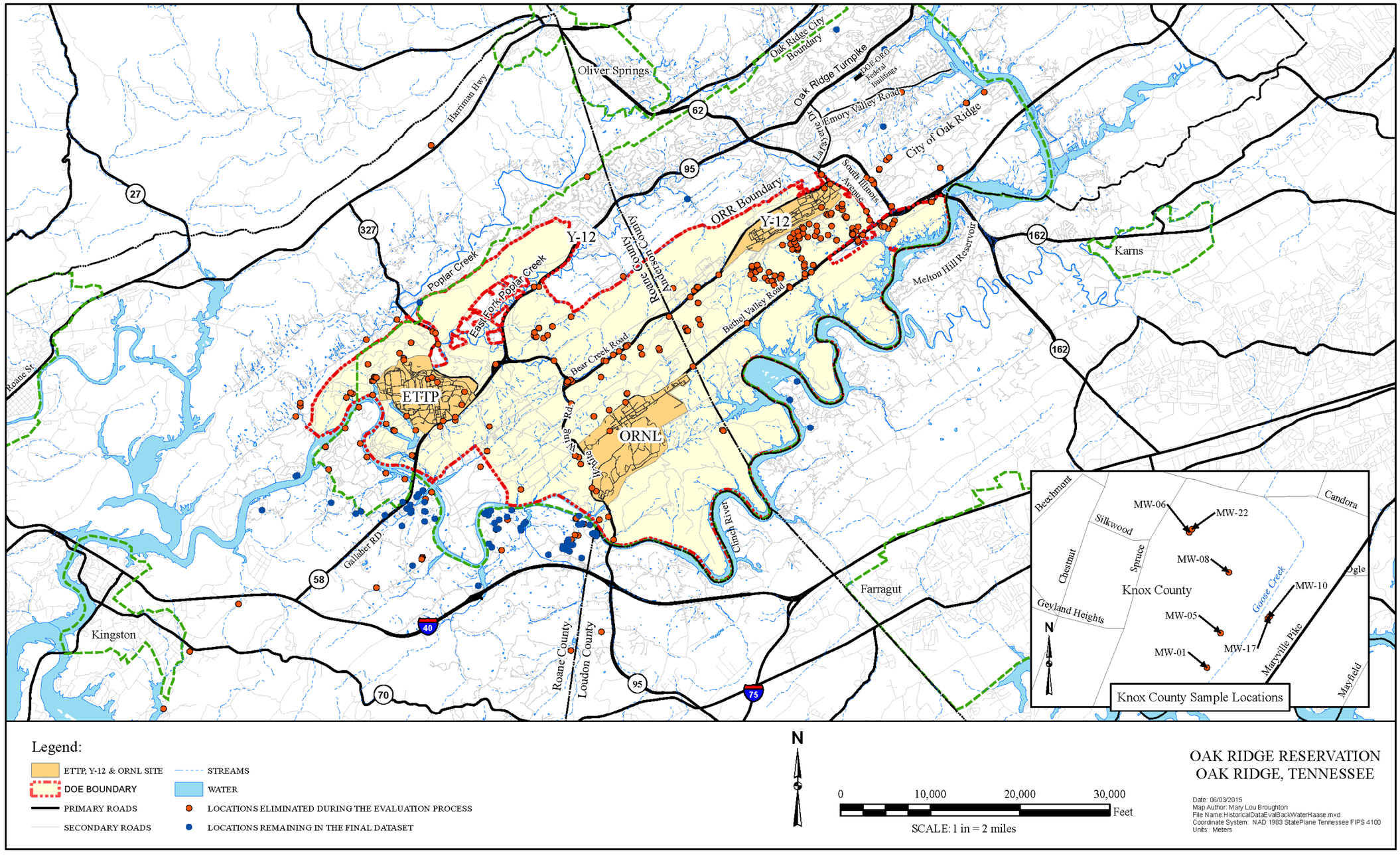

Figure 1. Locations evaluated to develop background dataset for ORR groundwater.

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4. DESCRIPTION OF STEPS

The steps listed in Table 1 that were used to develop a background dataset for ORR groundwater are further described below.

4.1 INITIAL DATA IDENTIFICATION, REVIEW, AND CLEANUP (STEPS 1 AND 2)

4.1.1 Step 1. Identify available data

Groundwater monitoring has been conducted on the ORR for several decades. Much of the groundwater data collected since the early-1990s were placed in the Oak Ridge Environmental Information System (OREIS). In addition, TDEC has collected data within and around the ORR for a similar time period. Groundwater data from OREIS[2] and off-site groundwater sample results provided by TDEC were evaluated for this study. The data identified consisted of 114 locations and 125,739 observations from OREIS and 239 locations and 19,687 observations from TDEC. An electronic copy of these original data files is provided in Appendix D.

4.1.2 Step 2. Perform initial data review and cleanup

Before conducting formal statistical evaluations, a review of the data was performed. This review included reviewing data quality and examining the data for general patterns and characteristics. For example, quantitation or detection limits commonly begin to lower in historical datasets as laboratory analytical technology improves, resulting in poor identification of low concentration levels early in the data record. The progressive lowering of quantitation or detection limits can mistakenly appear to be a decreasing concentration trend in a time series plot if the non-detects have been replaced with some fraction of the quantitation or detection limit (for example, historically one-half the detection limit has been used).

General aspects of the initial evaluation included:

- Convert analytes to consistent names and Chemical Abstracts Service (CAS) numbers.
- Standardize station names and analyte units of measure.
- Evaluate results for appropriate data validation flags.
- Reduce data by keeping one concentration per station, analyte and date collected. Process duplicates and replicates by keeping largest detected concentration for a given station, analyte and date collected.
- Delete tentatively identified compounds (TICs), surface water and quality assurance/quality control (QA/QC) data.
- Review consistency of quantitation limits over time to determine if changes in limits might impact the statistical analysis of the dataset.

[2]Subsequent to downloading data from OREIS, a determination was made that some off-site data may contain sensitive or legally privileged information that is not approved for public release. As a result, some data used in this study that was previously available in OREIS is now stored in the Project Environmental Measurements System (PEMS) database that is not available to the public.

- Determine if non-detect results were reported to quantitation limits or detection limits, and the difference in measurement uncertainty based on which reporting method was used.

- Evaluate the reported Rad Error (estimated uncertainty in the measurement) to determine detect or non-detect for radiological results that did not have a qualifier indicated.

4.2 DATA ANALYSIS AND DATA FILTERING OF INTERIM DATASETS (STEPS 3 THROUGH 10)

Following initial data review and cleanup, a series of alternating steps of data analysis (Steps 3, 5, 7, and 9 in Table 1), including statistical analysis, and filtering (removal) of data from interim datasets (Steps 4, 6, 8, and 10 in Table 1), was performed as summarized below.

4.2.1 Data Analysis

Data analysis of interim datasets included calculation of summary statistics, comparison of data to screening criteria, and preparation of normal probability plots for select constituents. These probability plots are used to identify analyte results on the high end of the distribution that may represent results from impacted wells, and thus were used to eliminate potentially impacted wells from the dataset. Efforts were taken to err on the side of eliminating a well if it was suspected of having been impacted.

4.2.1.1 Calculation of summary statistics

Summary statistics, including confidence and tolerance limits, were calculated for groundwater analytes to represent the upper bound estimate of the background population. In addition to calculating central tendency statistics (mean, median), statistics included:

- Upper confidence limit (UCL) – Upper confidence limits for the mean are upper bound estimates for the mean with specified confidence. Interval estimates are often desirable because the estimate of the mean varies from sample to sample. Instead of a single estimate for the mean, a one-sided confidence interval generates an upper limit for the mean. The interval estimate gives an indication of how much uncertainty there is in our estimate of the true mean. The narrower the interval, the more precise is our estimate. Confidence limits are expressed in terms of a confidence coefficient. Although the choice of confidence coefficient is somewhat arbitrary, the 90% and 95% intervals were selected for the ORR dataset.

- Upper tolerance limit (UTL) – A tolerance limit establishes the values in which a fixed proportion of a population is bound. A UTL95/95 represents the upper limit of a tolerance interval in which at least 95% of the observations from the background population will be less than or equal to the value, with a 95% confidence. A UTL95/95 is designed to provide simultaneous coverage of 95% of all observations. Approximately 5% of background samples are expected to exceed a UTL95/95 with 95% confidence.

Summary statistics from analysis of two interim datasets (second and fourth datasets) are contained in Table A.1 in Appendix A and Table B.1 in Appendix B, respectively. The UTL with 95% confidence and 95% coverage (UTL95/95) is shown where it can be calculated. The well with the maximum detected concentration is also shown. Other summary statistics include the minimum and maximum detection limits, minimum, mean, median, maximum and standard deviation of both detects and non-detects, minimum, mean, maximum and standard deviation of detected concentrations, distribution (normal, lognormal, gamma or nonparametric), UCL on the mean with 90% confidence and UCL on the mean with 95% confidence.

Use of concentrations from each independent sample vs. use of median concentrations. For analysis of the second dataset (Appendix A), concentrations from all dates collected within a well were treated as independent samples. Therefore, a well that was sampled 10 times would have 10 concentrations of a given analyte represented in the dataset, while another well that was sampled only once has only one concentration in the dataset for that analyte.

For subsequent datasets, in order to eliminate bias in the summary statistics towards wells that were sampled more frequently than other wells, the median unfiltered concentration (along with its detection status) was calculated for each constituent and well. This approach was also used in the 1996 background groundwater study at Y-12 (Y/ER-234). Using only one concentration per well ignores any temporal variability for wells that were sampled multiple times. It also eliminates spatially biasing the final summary statistics since each well will have exactly one groundwater concentration per constituent. Having unbiased statistics was determined to be more important than temporal variability since the temporal variability within a well is typically small compared to the variability between wells. Analysis using this approach is presented for the fourth dataset (Appendix B) and the final dataset (Table 2 and Appendix C).

Use of Kaplan-Meier (KM) analysis method. For datasets with a mix of detected concentrations and non-detects, the KM statistical method was used to estimate summary statistics such as the mean, median and standard deviation. The KM method is recommended by the EPA in its ProUCL 5.0 software (EPA 2013)[3]. The KM method efficiently utilizes information available for non-detects and is recommended over simple substitution methods such as replacing non-detects with half the detection limit. Substitution methods have been shown to introduce bias in the calculation of summary statistics.

Consideration of other statistical methods. Statistical methods such as principal components analysis (PCA) and cluster analysis were considered for the fourth dataset in order to statistically group the wells by hydrogeological characteristics. PCA and cluster analysis require concentration data for each constituent and well. If a single well was not analyzed for a particular constituent, then that constituent cannot be included in the PCA or cluster analysis due to just one missing value.

The 77 wells in the dataset were not sampled consistently for the same set of constituents, so there are many missing values for concentrations in these wells compared to the full suite of constituents analyzed. It was therefore determined that the data were too sparse to use imputation techniques (i.e., methods used to handle missing data during analyses). No constituent was analyzed in all 77 wells. Alpha activity and beta activity were the most frequently analyzed constituents in 76 of the 77 wells. Chloride and sulfate were the next most frequently analyzed constituents in 73 of the wells. The most frequently analyzed metal is sodium in 72 wells followed by lead in 67 wells. Even physical parameters such as conductivity and pH were only analyzed in 52 and 51 wells, respectively.

[3]ProUCL is a comprehensive statistical software package initially developed by EPA for computing statistical intervals to respond to concerns at a specific Superfund site. With significant interest, use, and user feedback on the software from the remediation community, EPA has updated the software adding new tools and statistical methods.

4.2.1.2 Comparison of data to screening criteria

Another way to identify wells that may have been impacted previously is to compare analyte results to health-based screening criteria. Data were compared to the following screening criteria:

- EPA Regional Screening Levels (RSLs) for tap water at a target risk (TR) of 1×10^{-6} and a hazard quotient (HQ) of 0.1,
- EPA preliminary remediation goals (PRGs) for radionuclides at a TR of 1×10^{-6}, and
- EPA national primary drinking water standard maximum contaminant levels (MCLs).

The number of detected concentrations that exceed the carcinogenic or non-carcinogenic RSLs, PRGs or MCLs for two interim datasets (second and fourth datasets) are shown in Table A.1 in Appendix A and Table B.1 in Appendix B, respectively.

4.2.1.3 Probability plots

Based on the summary statistics, specific constituents were selected for producing normal probability plots to evaluate the presence of outliers. Probability plots show the entire distribution of measured concentrations, ranging from the lowest value to the highest value, against percentile of the distribution of measured concentration. These plots are useful for identifying data distribution, range, clusters and outliers. Examination of the plots provides insight to support or discount the conclusion that the dataset appears to be drawn from a single population. The plots were used to identify outliers that likely should be removed from the dataset. For many analytes, analysis of the plots indicated a true background concentration could likely be established.

Probability plots from analysis of select metals, anions, and radionuclides from two interim datasets (second and fourth datasets) are contained in Figures A.1 – A.15 in Appendix A and Figures B.1 – B.27 in Appendix B, respectively. The plots also include the frequency of detects and the various screening levels.

Analysis of potential outliers in fourth dataset. Normal probability plots generated from the fourth dataset (Figures B.1 through B.27 in Appendix B) showed potential outliers for several constituents. A matrix was used to further evaluate suspected outliers by well (Table B.2 in Appendix B). The matrix shows concentrations for seven analytes from the PLC well are suspected outliers, while concentrations for five analytes from CCC well #2 are suspected outliers. Table B.3 and Figure B.28 in Appendix B show how eliminating individual or groups of wells would affect the plots of other analytes. Figure B.28 is a Pareto chart[4] showing the number of outliers by well and a line chart of cumulative number of outliers with the number of wells. The line chart shows a steeper slope when eliminating the two wells with the highest number of outliers and then gets flatter as the number of wells eliminated increases.

4.2.2 Data Filtering

Data filtering of the interim datasets included a series of steps to eliminate possible impacted locations and removal of inappropriate data and analytes and outliers. The statistical analyses described in Section 4.2.1 were key tools for identifying data to be filtered.

[4]A Pareto chart is used to graphically summarize and display the relative importance of the differences between groups of data. (http://www.isixsigma.com/tools-templates/pareto)

4.2.2.1 Elimination of possible impacted locations

Early in the process, wells were eliminated in the footprints of Y-12, Oak Ridge National Laboratory, and ETTP and the two major disposal watersheds, Bear Creek Valley and Melton Valley. In addition, possible impacted locations or locations within areas of known contamination were eliminated in the filtering steps:

- From the OREIS portion of the dataset, well locations in areas where a large number of wells were identified as outliers were removed including:
  - Some wells in the contaminated areas that had inadvertently been left in the dataset, e.g., some wells near the Waste Area Groupings in Melton Valley.
  - Numerous wells in the Chestnut Ridge area in the vicinity of the landfills and former waste sites on the ridge.
- From the TDEC portion of the dataset, possible impacted locations identified and removed included:
  - Springs on the ORR that had been sampled by TDEC.
  - Select off-site locations that exhibited the potential for anthropogenic impacts (e.g., spring USGS-10-895 at ETTP and RWA-104 [also referred to as Hound Dog 2 Well] and Frog Strangler Spring in the Bethel Valley area). These were identified as potentially impacted wells during DQO planning for the Off-site Groundwater Assessment.

4.2.2.2 Removal of inappropriate data and analytes and outliers

The goal of the filtering process was to identify and remove any previous sampling locations that may not represent background, or naturally-occurring, conditions. Some outliers identified early in the filtering steps appeared to represent area potentially impacted by ORR operations, e.g., the Chestnut Ridge wells mentioned above. In some cases the outliers could not be as easily explained. Although EPA guidance recommends that outliers identified by testing generally not be removed from background data unless some basis for a likely error or discrepancy can be identified, the guidance also states that it may be advisable at times to remove high-magnitude outliers in a background dataset because the overall impact of removal will tend to improve the power of prediction limits, and thus result in a more environmentally protective program (EPA 530/R-09-007). For this reason, even unexplained outlier wells were often removed.

Removal of data for filtered groundwater samples. Although the use of unfiltered groundwater samples can result in uncertainties in the data from samples with elevated turbidity and preservation and laboratory analysis of those samples, the available filtered groundwater sample dataset was significantly smaller than the available unfiltered groundwater data. Thus, it was determined that only unfiltered data would be used for this study. Data from the interim datasets (Appendices A and B) and in the final dataset represent unfiltered groundwater samples only.

Removal of data with high non-detect values. Several constituents with high non-detect values that dominated the high end of the distribution found during analysis of interim datasets were identified and eliminated.

Removal of data for organic constituents. Although UTL95/95s were calculated for organic constituents in the second dataset (Appendix A), the presence of these compounds is not considered to be

representative of background groundwater quality on the ORR. However, some locations with organic constituent data were initially retained to evaluate if these locations could provide reasonable background concentrations for other analytes. In subsequent steps, semivolatile organics, volatile organics and polychlorinated biphenyls analytical results were eliminated because of the low frequency of sampling and low frequency of detection. Also, man-made organic compounds are not typically assumed to be part of the list of naturally-occurring compounds. Summary statistics for the fourth dataset (Appendix B) and final dataset (Table 2) reflect the removal of organic constituents.

Removal of 7 wells from third dataset. The third dataset contained 84 locations. Seven wells (BF-001 through BF-006 and RWA-76) were eliminated from this dataset because these wells contributed frequently to additional outlier issues, and on further review it was determined that there was lack of information on how the "BF" wells were constructed (e.g., there was some indication they were placed in very shallow zones near the Clinch River on a proposed "Boeing Floodplain" site).

Removal of outliers from fourth dataset. Since the fourth dataset contained only 77 remaining locations (with one median concentration per location per constituent), Table B.2, Table B.3, and Figure B.28 in Appendix B were evaluated with the goal of eliminating the most outliers while eliminating the fewest number of wells, while considering that some constituents are more important than others for establishing background concentrations. It was determined that three additional locations would be eliminated:

- PLC well which affects seven analytes,
- CCC well #2 which affects five analytes and
- CCC well #1 which affects three analytes (U-234, U-235 and U-238).

At this point, it was determined that no additional sample locations would be removed.

4.3 ANALYSIS OF FINAL DATASET (STEP 11)

The fifth and final dataset consists of 74 locations and 2,759 observations. Some of the TDEC data and all of the OREIS data considered in the evaluation process outlined above were removed, resulting in all data in the final dataset being data originally obtained from TDEC. Table 2 provides summary statistics derived to represent upper bound estimates of the background population for select metals, anions, and radionuclides in the final dataset. The frequency of exceedances of screening criteria is also shown. Normal probability plots of analytes in the final background dataset are shown in Appendix C, Figures C.1 through C.27.

These normal probability plots show the distribution of various constituents. When the data plot approximately linearly along the regression line, the data are approximately normally distributed. Otherwise, curvature and breaks in the distribution indicate departures from normality. Potential outliers are also shown as data points that plot far away from the remaining distribution.

An important item to note about the final set of probability distribution plots is that the analyte concentration ranges on the y-axis have been greatly reduced in the filtering process. As outliers on the high end of the range were eliminated, the maximum concentrations dropped significantly. For example, the maximum arsenic concentration in the probability plots from the second dataset (Figure A.1 in Appendix A) is almost 0.16 mg/L. In the plot from the final dataset (Figure C.2 in Appendix C), the maximum arsenic concentration is approximately 0.005 mg/L, reducing the range by slightly under two orders of magnitude, leaving a much tighter range to define background.

Table 3 provides a comparison of the median, 50th and 90th percentile, and UTL background concentrations derived from the final dataset for the ORR to various 50th and 90th percentile concentrations compiled by the USGS to evaluate if the ORR concentrations are within a reasonable range for background concentrations. The USGS concentrations were obtained from the four indicated reports (USGS 1997, USGS 2008, USGS 2010, USGS 2011) . Table 3 shows the 50th percentile (median) and 90th percentile values for most constituents in the final dataset generally agree with statistics from the other listed USGS studies.

Box plot analyses comparing analytes in the final background dataset to USGS background concentration ranges (USGS 2013) are shown in Appendix C, Figures C.28 through C.46. These box plots also show the distributions of most constituents in the final dataset generally agree with the distributions of the USGS datasets.

Table 4 is a summary of the five USGS sources used to obtain data for comparison to the final background dataset. Information listed includes what was sampled in each USGS study (i.e., number of domestic wells, springs, etc.), whether the results are from filtered or unfiltered samples, the geographic region, geologic provence(s) or regionally-extensive aquifers, and source rock types. The areas sampled in these USGS studies include some with generally similar geologic conditions as those found on the ORR.

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Table 2. Summary statistics from final dataset (ORR area unfiltered groundwater)

Constituent	Frequency of Detection	Units	Non-detect Detection Limits[a]		Min[b]	Mean[b]	Median[b]	Max[b]	S.D.[b]	Detected				Dist.[c]	UCL90	UCL95	UTL95/95	EPA Tap Water				MCL[e]	Frequency > MCL[e]	Max Detected Station
			Min	Max						Min	Mean	Max	S.D.					RSL[d] TR=1E-6	Frequency > TR=1E-6	RSL[d] HQ=0.1	Frequency > HQ=0.1			
Metals																								
Aluminum	33 / 51	mg/L	0.003	0.1	0.001	0.17	0.009	4.25	0.65	0.001	0.258	4.25	0.806	X*	0.447	0.572	--	--	--	2	**2 / 51**	--	--	RWA-94
Antimony	3 / 52	mg/L	1.2E-04	0.003	6.0E-05	0.035	6.4E-04	1.8	0.247	6.4E-04	0.601	1.8	1.04	X*	0.161	0.218	--	--	--	7.8E-04	**2 / 52**	0.006	**1 / 52**	SEC Well
Arsenic	8 / 56	mg/L	8.2E-04	0.005	4.1E-04	0.001	9.0E-04	0.004	7.6E-04	9.0E-04	0.002	0.004	9.9E-04	X*	0.002	0.002	--	5.2E-05	**8 / 56**	6.0E-04	**8 / 56**	0.01	0 / 56	RWA-95
Barium	47 / 52	mg/L	0.003	0.1	0.001	0.068	0.05	0.245	0.058	0.003	0.072	0.245	0.06	X*	0.093	0.104	--	--	--	0.38	0 / 52	2	0 / 52	RWA-63
Beryllium	1 / 40	mg/L	1.1E-04	0.02	5.5E-05	4.5E-04	1.1E-04	0.01	0.002	4.8E-04	4.8E-04	4.8E-04	--	X	0.001	0.002	--	--	--	0.003	0 / 40	0.004	0 / 40	RWA-94
Boron	27 / 50	mg/L	0.045	0.09	0.023	0.169	0.14	0.705	0.137	0.038	0.228	0.705	0.159	X*	0.232	0.26	--	--	--	0.4	**4 / 50**	--	--	RWA-117
Cadmium	1 / 52	mg/L	2.1E-04	0.001	1.1E-04	2.6E-04	2.1E-04	0.001	1.6E-04	0.001	0.001	0.001	--	X	3.3E-04	3.6E-04	--	--	--	9.2E-04	**1 / 52**	0.005	0 / 52	RWA-64
Calcium	58 / 59	mg/L	0.036	0.036	0.018	43.8	42.6	329	44.6	0.445	44.6	329	45.0	X*	61.4	69.4	329	--	--	--	--	--	--	SEC Well
Chromium	23 / 56	mg/L	6.0E-04	0.005	3.0E-04	0.002	0.001	0.005	0.001	6.5E-04	0.002	0.005	0.001	X*	0.002	0.003	--	--	--	--	--	0.1	0 / 56	RWA-94
Cobalt	11 / 37	mg/L	4.0E-05	0.01	2.0E-05	3.9E-04	2.8E-04	0.005	5.4E-04	7.0E-05	5.6E-04	0.003	8.9E-04	X*	7.3E-04	8.8E-04	--	--	--	6.0E-04	**2 / 37**	--	--	RWA-94
Copper	33 / 38	mg/L	3.4E-04	8.7E-04	1.7E-04	0.007	0.004	0.03	0.007	9.4E-04	0.008	0.03	0.007	L*	0.01	0.011	0.065	--	--	0.08	0 / 38	1.3	0 / 38	RWA-107
Iron	46 / 53	mg/L	0.003	0.031	0.001	0.631	0.064	11.6	1.88	0.007	0.725	11.6	2.02	L*	0.857	1.05	4.15	--	--	1.4	**6 / 53**	--	--	RWA-114
Lead	48 / 65	mg/L	1.0E-04	0.001	5.0E-05	0.002	8.0E-04	0.012	0.002	1.8E-04	0.002	0.012	0.002	L*	0.002	0.002	0.009	--	--	0.015	0 / 65	0.015	0 / 65	RWA-64
Lithium	48 / 51	mg/L	1.9E-04	4.1E-04	9.5E-05	0.014	0.004	0.06	0.018	2.6E-04	0.015	0.06	0.018	X*	0.021	0.025	--	--	--	0.004	**29 / 51**	--	--	RWA-58
Magnesium	58 / 59	mg/L	0.043	0.043	0.012	11.2	9.65	30.4	9.05	0.012	11.4	30.4	9.08	X*	14.8	16.4	30.4	--	--	--	--	--	--	RWA-116
Manganese	33 / 44	mg/L	2.2E-04	0.005	1.1E-04	0.026	0.002	0.28	0.054	4.6E-04	0.035	0.28	0.061	L*	0.058	0.076	0.35	--	--	0.043	**8 / 44**	--	--	RWA-94
Mercury	0 / 40	mg/L	2.9E-05	4.2E-04	1.5E-05	4.2E-05	1.9E-05	2.1E-04	4.3E-05	--	--	--	--	O	--	--	--	--	--	6.3E-05	0 / 40	0.002	0 / 40	--
Molybdenum	1 / 8	mg/L	4.0E-05	0.004	2.0E-05	0.002	0.002	0.002	8.7E-04	2.5E-04	2.5E-04	2.5E-04	--	X	0.002	0.003	--	--	--	0.01	0 / 8	--	--	RWA-22
Nickel	41 / 51	mg/L	2.5E-04	0.01	1.3E-04	0.002	0.001	0.006	0.001	3.4E-04	0.002	0.006	0.001	X*	0.002	0.002	--	--	--	0.039	0 / 51	--	--	RWA-99
Niobium	2 / 3	mg/L	7.3E-04	7.3E-04	1.4E-05	1.8E-05	2.1E-05	3.7E-04	3.3E-06	1.4E-05	1.8E-05	2.1E-05	4.6E-06	L*	2.3E-05	2.7E-05	--	--	--	--	--	--	--	RWA-117
Phosphorous	10 / 12	mg/L	0.01	0.07	0.005	0.034	0.03	0.09	0.026	0.007	0.038	0.09	0.028	N*	0.045	0.049	0.106	--	--	4.0E-05	**10 / 12**	--	--	RWA-51
Potassium	59 / 59	mg/L	--	--	0.055	2.03	1.65	8.3	1.54	0.055	2.03	8.3	1.54	X	2.63	2.9	8.3	--	--	--	--	--	--	RWA-107
Selenium	5 / 53	mg/L	9.7E-04	0.005	4.8E-04	0.002	0.002	0.003	6.9E-04	0.001	0.002	0.003	8.2E-04	X*	0.003	0.003	--	--	--	0.01	0 / 53	0.05	0 / 53	RWA-52
Silica	31 / 31	mg/L	--	--	0.1	12.3	10.3	39.5	7.09	0.1	12.3	39.5	7.09	X	16.1	17.8	--	--	--	--	--	--	--	RWA-110
Silver	6 / 38	mg/L	1.4E-05	0.07	1.6E-08	4.3E-04	3.0E-05	0.035	0.002	1.6E-08	0.002	0.014	0.006	X*	0.002	0.002	--	--	--	0.009	**1 / 38**	--	--	RWA-78
Sodium	69 / 69	mg/L	--	--	0.5	31.5	5.3	241	51.6	0.5	31.5	241	51.6	X	50.2	58.6	241	--	--	--	--	--	--	RWA-117
Strontium	50 / 51	mg/L	4.7E-04	4.7E-04	2.4E-04	0.183	0.11	0.785	0.195	0.012	0.187	0.785	0.197	G*	0.222	0.234	0.777	--	--	1.2	0 / 51	--	--	Rarity Ridge
Thallium	31 / 52	mg/L	3.0E-05	0.002	1.5E-05	3.7E-04	2.8E-04	0.002	3.8E-04	5.0E-05	3.9E-04	0.002	4.5E-04	X*	5.5E-04	6.3E-04	--	--	--	2.0E-05	**31 / 52**	0.002	**1 / 52**	SEC Well
Uranium	36 / 51	mg/L	1.0E-05	0.02	5.0E-06	4.1E-04	2.3E-04	0.01	9.9E-04	2.5E-05	4.5E-04	0.007	0.001	X*	8.5E-04	0.001	--	--	--	0.006	**1 / 51**	0.03	0 / 51	RWA-74
Vanadium	11 / 41	mg/L	1.0E-05	0.005	5.0E-06	0.001	6.2E-04	0.005	9.4E-04	3.7E-04	0.001	0.005	0.002	X*	0.002	0.002	--	--	--	0.009	0 / 41	--	--	RWA-94
Zinc	57 / 59	mg/L	7.6E-04	0.002	3.8E-04	0.082	0.014	2.87	0.371	0.001	0.085	2.87	0.381	X*	0.228	0.294	2.87	--	--	0.6	**1 / 59**	--	--	RWA-64
Anions																								
Chloride	65 / 70	mg/L	1.9	4	0.948	7.32	3.4	72.5	10.7	1	7.69	72.5	11.1	X*	11.2	13.0	72.5	--	--	--	--	--	--	RWA-97
Fluoride	52 / 56	mg/L	0.05	0.05	0.025	0.398	0.13	3.48	0.654	0.04	0.423	3.48	0.678	G*	0.495	0.528	1.67	--	--	0.08	**42 / 56**	--	--	RWA-53
Nitrate	19 / 23	mg/L	0.002	0.007	0.001	0.699	0.45	2.4	0.714	0.026	0.843	2.4	0.725	X*	1.16	1.37	--	--	--	3.2	0 / 23	10	0 / 23	RWA-85
Nitrate/Nitrite	50 / 60	mg/L	0.007	0.1	0.004	0.548	0.22	3	0.63	0.02	0.649	3	0.65	X*	0.794	0.906	3	--	--	--	--	10	0 / 60	RWA-105
Nitrite	1 / 33	mg/L	0.002	0.01	0.001	0.002	0.003	0.01	0.002	0.01	0.01	0.01	--	X	0.003	0.004	--	--	--	0.2	0 / 33	1	0 / 33	RWA-22

Table 2. Summary statistics from final dataset (ORR area unfiltered groundwater) (cont.)

Constituent	Frequency of Detection	Units	Non-detect Detection Limits[a]		Min[b]	Mean[b]	Median[b]	Max[b]	S.D.[b]	Detected				Dist.[c]	UCL90	UCL95	UTL95/95	EPA Tap Water				MCL[e]	Frequency > MCL[e]	Max Detected Station
			Min	Max						Min	Mean	Max	S.D.					RSL[d] TR=1E-6	Frequency > TR=1E-6	RSL[d] HQ=0.1	Frequency > HQ=0.1			
Nitrogen, NO3 & NO2	1 / 1	mg/L	--	--	0.075	0.075	0.075	0.075	--	0.075	0.075	0.075	--	D	--	--	--	--	--	--	--	--	--	--	SEC Well
Sulfate	69 / 70	mg/L	2.5	2.5	1.25	12.3	7	119	16.3	1.9	12.5	119	16.5	L*	14.0	14.8	49.0	--	--	--	--	--	--	RWA-66
Sulfide	0 / 1	mg/L	1	1	0.5	0.5	0.5	0.5	--	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
Physical																								
Calcium Hardness	4 / 4	mg/L	--	--	1.75	69.9	53	172	74.2	1.75	69.9	172	74.2	N	131	157	452	--	--	--	--	--	--	RWA-63
Conductivity	52 / 52	µmhos/cm	--	--	2.4	417	388	985	201	2.4	417	985	201	X	500	538	--	--	--	--	--	--	--	RWA-117
Dissolved Residue	24 / 24	mg/L	--	--	67	230	202	604	110	67	230	604	110	L	262	273	566	--	--	--	--	--	--	RWA-53
Hardness, total as CaCO3	1 / 1	mg/L	--	--	218	218	218	218	--	218	218	218	--	D	--	--	--	--	--	--	--	--	--	SEC Well
Suspended Residue	10 / 10	mg/L	--	--	2	26.4	3	200	61.5	2	26.4	200	61.5	G	69.4	97.6	274	--	--	--	--	--	--	RWA-64
Total Hardness	48 / 49	mg/L	3.8	3.8	1.9	150	161	301	84.2	10	153	301	83.5	X*	187	203	--	--	--	--	--	--	--	RWA-64
pH	51 / 51	Std. Units	--	--	6.35	7.83	7.7	9.64	0.68	6.35	7.83	9.64	0.68	X	8.11	8.24	--	--	--	--	--	--	--	RWA-79
Radionuclides																								
Actinium-228	2 / 2	pCi/L	--	--	12.3	13.9	13.9	15.5	2.26	12.3	13.9	15.5	2.26	D	--	--	--	23.9	0 / 2	--	--	5	**2 / 2**	RWA-63
Alpha activity	31 / 73	pCi/L	0.455	15	-3.1	1.26	1	9.9	2.03	0.135	2.32	9.9	2.5	X	1.98	2.3	9.9	--	--	--	--	15	0 / 73	RWA-59
Americium-241	0 / 5	pCi/L	0.14	0.81	0.017	0.097	0.049	0.26	0.099	--	--	--	--	N	0.165	0.191	0.512	0.458	0 / 5	--	--	15	0 / 5	--
Beta activity	43 / 73	pCi/L	0.9	4.4	0	2.6	1.8	22.0	2.94	0.4	3.62	22.0	3.44	L	3.1	3.26	9.89	--	--	--	--	--	--	RWA-66
Bismuth-212	2 / 2	pCi/L	--	--	34.2	56.1	56.1	78	31.0	34.2	56.1	78	31.0	D	--	--	--	67.1	**1 / 2**	--	--	5	**2 / 2**	RWA-117
Bismuth-214	66 / 66	pCi/L	--	--	10.6	82.1	63.9	312	65.3	10.6	82.1	312	65.3	L	96.6	101	287	248	**3 / 66**	--	--	5	**66 / 66**	RWA-87
Carbon-14	1 / 8	pCi/L	9.6	15.4	-7	-1.53	-3.5	8.4	4.63	8.4	8.4	8.4	--	N	0.792	1.58	13.2	1.29	**1 / 8**	--	--	2000	0 / 8	RWA-88
Curium-243/244	1 / 5	pCi/L	0.13	0.74	-0.02	0.093	0.04	0.22	0.109	0.22	0.22	0.22	--	N	0.168	0.197	0.552	0.503	0 / 5	--	--	15	0 / 5	RWA-63
Gamma Radionuclides	0 / 1	pCi/L	9	9	9	9	9	9	--	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
Lead-212	7 / 7	pCi/L	--	--	8.7	14.4	11	29	7.51	8.7	14.4	29	7.51	L	19.7	22.5	60.7	1.9	**7 / 7**	--	--	5	**7 / 7**	RWA-100
Lead-214	65 / 65	pCi/L	--	--	13.5	75.0	52.8	294	63.5	13.5	75.0	294	63.5	L	85.2	89.0	244	138	**8 / 65**	--	--	5	**65 / 65**	RWA-87
Neptunium-237	0 / 5	pCi/L	0.119	0.39	0.02	0.033	0.028	0.05	0.014	--	--	--	--	N	0.042	0.046	0.091	0.771	0 / 5	--	--	15	0 / 5	--
Plutonium-238	0 / 5	pCi/L	0.087	0.74	-0.022	0.005	0	0.028	0.021	--	--	--	--	N	0.02	0.026	0.094	0.364	0 / 5	--	--	15	0 / 5	--
Plutonium-239/240	0 / 5	pCi/L	0.043	0.74	-0.064	-0.002	0	0.032	0.037	--	--	--	--	N	0.024	0.034	0.156	0.353	0 / 5	--	--	15	0 / 5	--
Potassium-40	2 / 2	pCi/L	--	--	62	62	62	62	0	62	62	62	0	D	--	--	--	1.93	**2 / 2**	--	--	11	**2 / 2**	SEC Well
Radium-226	5 / 7	pCi/L	0.44	0.44	-1.2	0.52	0.355	2.33	1.09	0.14	0.956	2.33	0.868	N	1.11	1.32	4.23	8.2E-04	**5 / 7**	--	--	5	0 / 7	RWA-72
Radium-228	3 / 4	pCi/L	1.52	1.52	0.055	2.05	0.29	7.56	3.68	0.055	2.7	7.56	4.21	L	5.29	6.99	--	0.046	**3 / 4**	--	--	5	**1 / 4**	RWA-118
Strontium-89	13 / 67	pCi/L	0.11	0.54	-0.76	0.233	-0.065	10	1.75	0.055	0.288	0.98	0.23	X	0.875	1.17	10	3.72	0 / 67	--	--	20	0 / 67	RWA-87
Strontium-90	24 / 67	pCi/L	-0.26	0.27	-0.68	0.127	0.055	2	0.386	0.02	0.252	0.51	0.141	L	0.376	0.41	1.74	0.852	0 / 67	--	--	8	0 / 67	RWA-114
Technetium-99	20 / 49	pCi/L	0.57	0.8	-0.55	0.35	0.26	1.6	0.466	0.26	0.591	1.42	0.282	L	0.767	0.799	2.2	17.3	0 / 49	--	--	900	0 / 49	RWA-23
Thallium-208	1 / 1	pCi/L	--	--	3.3	3.3	3.3	3.3	--	3.3	3.3	3.3	--	D	--	--	--	--	--	--	--	5	0 / 1	RWA-67
Thorium-228	0 / 3	pCi/L	0.21	0.3	0.05	0.067	0.06	0.09	0.021	--	--	--	--	N	0.089	0.102	0.226	0.445	0 / 3	--	--	15	0 / 3	--
Thorium-230	3 / 3	pCi/L	--	--	0.34	0.36	0.34	0.4	0.035	0.34	0.36	0.4	0.035	X	0.42	0.447	--	0.523	0 / 3	--	--	15	0 / 3	RWA-63
Thorium-232	1 / 3	pCi/L	0.204	0.22	0.041	0.08	0.08	0.12	0.04	0.12	0.12	0.12	--	N	0.123	0.147	0.383	0.471	0 / 3	--	--	15	0 / 3	RWA-63
Tritium	32 / 69	pCi/L	65	534	-170	60.3	49	310	93.2	60.5	143	310	49.4	X	93.9	109	310	--	--	--	--	20,000	0 / 69	RWA-36
Uranium-234	28 / 34	pCi/L	0.12	0.44	0.04	0.258	0.197	0.94	0.204	0.085	0.299	0.94	0.202	L	0.332	0.358	1.1	0.674	**1 / 34**	--	--	15	0 / 34	RWA-72
Uranium-235	3 / 34	pCi/L	0.073	0.44	-0.037	0.038	0.034	0.106	0.031	0.068	0.089	0.1	0.018	N	0.045	0.047	0.105	0.684	0 / 34	--	--	15	0 / 34	RWA-98

Table 2. Summary statistics from final dataset (ORR area unfiltered groundwater) (cont.)

Constituent	Frequency of Detection	Units	Non-detect Detection Limits[a]		Min[b]	Mean[b]	Median[b]	Max[b]	S.D.[b]	Detected				Dist.[c]	UCL90	UCL95	UTL95/95	EPA Tap Water				MCL[e]	Frequency > MCL[e]	Max Detected Station
			Min	Max						Min	Mean	Max	S.D.					RSL[d] TR=1E-6	Frequency > TR=1E-6	RSL[d] HQ=0.1	Frequency > HQ=0.1			
Uranium-238	14 / 34	pCi/L	0.069	0.35	-0.052	0.093	0.068	0.35	0.084	0.066	0.166	0.35	0.08	L	0.129	0.139	0.428	0.744	0 / 34	--	--	15	0 / 34	RWA-72
Wet Chemistry																								
Acidity	3 / 5	mg/L	0.7	0.7	0.35	4.08	4	10	3.43	4	6.33	10	3.21	N*	6.96	8.08	15.2	--	--	--	--	--	--	RWA-63
Acidity as CaCO3	1 / 1	mg/L	--	--	11	11	11	11	--	11	11	11	--	D	--	--	--	--	--	--	--	--	--	SEC Well
Alkalinity	62 / 62	mg/L	--	--	49	207	202	559	98.3	49	207	559	98.3	L	227	234	494	--	--	--	--	--	--	RWA-53
Alkalinity as CaCO3	8 / 8	mg/L	--	--	155	204	213	257	38.9	155	204	257	38.9	N	223	230	328	--	--	--	--	--	--	RWA-67
Ammonia	3 / 4	mg/L	0.033	0.033	0.017	0.057	0.06	0.07	0.012	0.04	0.057	0.07	0.015	N*	0.071	0.077	0.121	--	--	--	--	--	--	RWA-58
Cyanide	0 / 1	mg/L	0.03	0.03	0.015	0.015	0.015	0.015	--	--	--	--	--	O	--	--	--	--	--	1.5E-04	0 / 1	0.2	0 / 1	--
Dissolved Solids	41 / 41	mg/L	--	--	41	222	198	491	95.7	41	222	491	95.7	L	249	257	534	--	--	--	--	--	--	RWA-117

Bold value indicates exceedance of a screening criterion.

[a]One half of the detection limits shown are used as proxy values for non-detected inorganics. The radionuclide results were used as reported whether detected or not.
[b]This summary statistic is calculated using both detects and proxy values for non-detects.
[c]Dist. = distribution. Distribution flags are defined as:
D = UCL90 and UCL95 were not calculated with fewer than three samples.
G = gamma. UCL90 and UCL95 were calculated using either the adjusted or unadjusted gamma.
L = lognormal. UCL90 and UCL95 were calculated using Land's statistic, Chebyshev minimum variance unbiased estimator, or nonparametric Chebyshev inequality method.
N = normal. UCL90 and UCL95 were calculated using t statistic.
O = no detected results to calculate some summary statistics.
X = neither normal, lognormal nor gamma. UCL90 and UCL95 were calculated using a nonparametric bootstrap or the nonparametric Chebyshev inequality method.
*Kaplan-Meier estimates of the mean, median and standard deviation are shown for inorganics with at least one non-detect and two distinct detected results.
[d]EPA RSL for tap water from May 2014 (*http://www.epa.gov/region9/superfund//prg/index.html*) for inorganics. EPA PRGs (*http://epa-prgs.ornl.gov/radionuclides/download.html*) for radionuclides.
[e]EPA MCL from May 2014 (*http://www.epa.gov/region9/superfund//prg/index.html*) for inorganics. 40 CFR 141.66 (December 7, 2000) and *National Interim Primary Drinking Water Regulations* (EPA 570/9-76-003) for radionuclides.

EPA = U.S. Environmental Protection Agency
HQ = hazard quotient
Max = maximum
MCL = maximum contaminant level
mg/L = milligrams per liter
Min = minimum
ORR = Oak Ridge Reservation
pCi/L = picocuries per liter
PRG = preliminary remediation goal
RSL = Regional Screening Level
S.D. = standard deviation
TR = target risk
UCL90 = upper confidence limit on the mean concentration with 90% confidence using both detects and non-detects
UCL95 = upper confidence limit on the mean concentration with 95% confidence using both detects and non-detects
UTL95/95 = upper tolerance limit on the maximum concentration with 95% confidence and 95% coverage using both detects and non-detects
-- = Not applicable, not available or insufficient data to calculate the statistic

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Table 3. Comparison of derived background concentrations from final dataset to published groundwater quality data

Constituent	USGS 2011[a]		USGS 2010		USGS 2008		USGS 1997[b]		Final dataset (ORR area unfiltered groundwater) results from Table 2		
	Percentile concentrations		Percentile concentrations		Percentile concentrations		Percentile concentrations		Percentile concentrations		UTL
	50th (median)	90th	50th (median)	90th	50th (median)	90th	50th (median)	90th	50th (median)	90th	95/95
Inorganics and physical properties (mg/L)											
Alkalinity (as $CaCO_3$)	–	–	158	295	156	325	122	253	212.5	257	328.1
Aluminum	0.0033	0.016	<0.001	0.0058	0.00189	0.00528	–	–	0.0094	0.19	–
Ammonia (as N)	–	–	0.01	0.5	0.02	0.33	0.03	0.15	0.06	0.07	0.121
Antimony	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	–	–	6.4E-04	8.3E-04	–
Arsenic	0.00041	0.005	<0.001	0.0094	0.0092	0.00753	–	–	9.0E-04	0.0013	–
Barium	0.047	0.24	0.0467	0.1641	0.05	0.219	–	–	0.05	0.14	–
Beryllium	<0.001	<0.001	ND	ND	<0.001	<0.001	–	–	<0.001	<0.001	–
Bicarbonate	–	–	–	–	–	–	150	310	–	–	–
Boron	0.026	0.16	0.0514	0.3609	0.024	0.218	–	–	0.14	0.355	–
Bromide	–	–	0.07	0.3	0.04	0.2	–	–	–	–	–
Cadmium	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	–	–	<0.001	<0.001	–
Calcium	–	–	50.5	98	43	95.3	42	108	42.6	74	328.8
Carbonate	–	–	–	–	–	–	149		–	–	–
Chloride	–	–	16.5	100.7	8.6	62.8	6	33	3.4	15.9	72.45
Chromium	0.0012	0.005	<0.001	0.0043	0.0081	0.004	–	–	0.0012	0.0024	–
Cobalt	0.00016	0.0013	<0.001	<0.001	0.00011	0.00052	–	–	2.8E-04	<0.006	–
Copper	0.001	0.0011	0.0012	0.0055	0.00107	0.0123	–	–	0.0043	0.0175	0.065
Fluoride	–	–	0.2	1	0.2	1.1	0.2	0.4	0.13	1.065	1.67
Hardness (as $CaCO_3$)	–	–	182.3	350.8	162	370	149	359	218	218	–
Iron	0.0011	2.1	<0.010	0.7142	0.00853	1.11	0.1	2.2	0.064	1.46	4.15
Lead	0.00012	0.0012	<0.001	0.0018	8.0E-05	0.00109	–	–	8.0E-04	0.0037	0.009
Lithium	0.0028	0.011	0.0048	0.0789	0.00587	0.0438	–	–	0.0041	0.044	–

Table 3. Comparison of derived ORR background concentrations to published groundwater quality data (cont.)

Constituent	USGS 2011[a]		USGS 2010		USGS 2008		USGS 1997[b]		Final dataset (ORR area unfiltered groundwater) results from Table 2		
	Percentile concentrations		Percentile concentrations		Percentile concentrations		Percentile concentrations		Percentile concentrations		UTL
	50th (median)	90th	50th (median)	90th	50th (median)	90th	50th (median)	90th	50th (median)	90th	95/95
Magnesium	–	–	10.7	33.4	11	36	10	33	9.65	26.1	30.35
Manganese	0.013	0.37	0.0016	0.0971	0.00206	0.172	0.04	0.76	0.0021	0.079	0.35
Molybdenum	0.00054	0.005	0.0011	0.0067	0.00092	0.006	–	–	<0.004	<0.004	–
Nickel	0.001	0.0045	<0.001	0.0041	0.0007	0.003	–	–	0.0011	0.005	–
Nitrate, as N	–	–	0.7	5.3	0.55	5.79	3.1	14	–	–	–
pH (standard units)	–	–	7.3	7.9	7.3	7.9	7.3	7.9	7.7	8.935	–
Phosphorus (dissolved, as P)	–	–	0.01	0.1	0.01	0.11	0.02	0.07	–	–	–
Phosphorus (total)	–	–	–	–	–	–	–	–	0.03	0.08	0.106
Potassium	–	–	2.4	8	1.7	6.6	1.1	7.3	1.65	4.05	8.3
Selenium	<0.001	0.0011	<0.001	0.0019	0.00059	0.00302	–	–	0.0015	<0.0035	–
Silver	<0.001	<0.001	ND	ND	<0.001	<0.001	–	–	3.0E-05	<0.005	–
Sodium	–	–	21	91.9	11	78.7	5.8	27	5.3	110	241
Specific conductance (µS/cm)	–	–	471	964	417	945	380	817	388	594	–
Strontium	0.16	0.89	0.3845	1.8113	0.207	2.24	–	–	0.11	0.465	0.777
Sulfate	–	–	21.8	133.5	14.4	94	20	78	7	27	49
Thallium	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	–	–	2.8E-04	6.8E-04	–
Total Dissolved solids	–	–	293.4	615	254	590	226	499	198	375.5	534.3
Uranium	0.00017	0.0045	<0.001	0.0069	0.00039	0.00803	–	–	2.3E-04	6.9E-04	–
Vanadium	0.0004	0.01	0.0025	0.0219	0.00129	0.0204	–	–	6.2E-04	<0.005	–
Zinc	0.0041	0.056	0.0037	0.0224	0.00857	0.0999	–	–	0.014	0.11	2.87
Radionuclides (pCi/L)											
Gross alpha	–	–	1.8	12	<3	8.7	–	–	<1	<3	9.9
Gross beta	–	–	4.8	11.4	<4	10.8	–	–	1.8	4.4	9.89
Radium-226	–	–	0.83	7.53	–	–	–	–	0.355	2.33	4.23

Table 3. Comparison of derived ORR background concentrations to published groundwater quality data (cont.)

Constituent	USGS 2011[a]		USGS 2010		USGS 2008		USGS 1997[b]		Final dataset (ORR area unfiltered groundwater) results from Table 2		
	Percentile concentrations		Percentile concentrations		Percentile concentrations		Percentile concentrations		Percentile concentrations		UTL
	50th (median)	90th	50th (median)	90th	50th (median)	90th	50th (median)	90th	50th (median)	90th	95/95
Radium-228	–	–	–	–	–	–	–	–	0.29	7.56	–
Radon-222	430	2,100	326	1,156	434	2,150	–	–	–	–	–

[a]Results shown are for humid regions of United States
[b]Results are for Valley and Ridge Province.
– = not analyzed/not available.

ORR = Oak Ridge Reservation
USGS = U.S. Geological Survey
UTL = upper tolerance limit

Table 4. Summary of USGS data sources

Reference	What was Sampled	Sample Procedure(s)	Filtered/ Unfiltered	Geographic Region	Geologic Provence(s) or Regionally-Extensive Aquifers	Source Rock Types	Comments
USGS data referenced in Table 3 of this study							
USGS 2011	5,183 Monitoring and Domestic Water Wells	USGS NAWQA	Filtered	United States	Nation-wide covering the Major NAWQA Aquifer Types and Systems	Eight major aquifer types ranging from unconsolidated sand and gravel; unconsolidated glacial; semi-consolidated sand; sandstone; sandstone and carbonate; carbonate; basaltic and volcanic, and crystalline bedrock aquifers	Results stratified by humid eastern regions and dry western regions. Also stratified by the eight major aquifer types (unconsolidated to various bedrock aquifers)
USGS 2010	974 Public Water Supply Wells	USGS NAWQA	Filtered	United States	Nation-wide covering the Major NAWQA Aquifer Types and Systems	Eight major aquifer types ranging from unconsolidated sand and gravel; unconsolidated glacial; semi-consolidated sand; sandstone; sandstone and carbonate; carbonate; basaltic and volcanic, and crystalline bedrock aquifers	Results stratified by the eight major aquifer types (unconsolidated to various bedrock aquifers)
USGS 2008	2,167 Domestic Wells	USGS NAWQA	Filtered	United States	Thirty Regionally Extensive Aquifers	Eight major aquifer types ranging from unconsolidated sand and gravel; unconsolidated glacial; semi-consolidated sand; sandstone; sandstone and carbonate; carbonate; basaltic and volcanic, and crystalline bedrock aquifers	Results stratified by the eight major aquifer types (unconsolidated to various bedrock aquifers)
USGS 1997	10,564 Well; 608 Spring; and 4,091 Stream Sites (18,008 analyses from well sites and 177,149 analyses from stream sites)	USGS RASA (Regional Aquifer System Analysis)	Filtered and Unfiltered	Eastern United States – Alabama to New Jersey	Appalachian Valley (28.5% of Well Sites), Blue Ridge(5.5% of Well Sites), and Piedmont (66% of Well Sites)	Results not stratified by aquifer type	Results stratified by Well, Spring, and Stream Water for each of the three physiographic provinces
USGS data referenced in Figures C.28 through C.46, Appendix C (box plots) of this study							
USGS 2013	346 Drinking Water Wells and Springs	USGS NAWQA (National Water Quality Assessment)	Filtered	Georgia through New Jersey	Blue Ridge; Piedmont	Late Paleozoic to Cambrian Crystalline Aquifers; Mesozoic Siliclastic Basins	Fourteen lithologic groups were defined in the regional sampling. Water quality results were summarized, compared, and contrasted by lithologic groups

NAWQA = National Water-Quality Assessment
RASA = Regional Aquifer System Analysis
USGS = U.S. Geological Survey

5. CONCLUSIONS AND RECOMMENDATIONS

The evaluation process began with initial identification of available data in OREIS and from TDEC from previous sampling in and around the ORR. Following data review and cleanup, a series of alternating steps of data analysis and filtering was performed. Data analysis included calculation of summary statistics and comparison to screening values, preparation of probability plots for select constituents, and identification of sample locations that may not be representative of background due to analyte outliers in interim datasets. Based on the data analysis, these locations were filtered out. This process resulted in a final dataset for select metals, anions, and radionuclides. Based on comparison to USGS background datasets, the concentrations of most constituents fall within a reasonable range, however, these derived values represent preliminary background concentrations due to the limitations of available data. Uncertainty in these background estimates resulted from the following factors:

- The identified available data for the study from OREIS and TDEC were collected by multiple projects for multiple purposes, often with different field procedures, analytical methods, detection limits, and data management processes specified for individual projects.

- The final dataset is comprised of TDEC off-site groundwater data only. The data is deemed equivalent to "screening-level data" under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) process. As such, the data lack the quantitative statistical rigor of fully verified and validated data that are accompanied by a Level 4 data package.

- Information on well construction and current conditions are limited in most of the wells used in the final background dataset. The integrity of well casings and annular seals cannot be evaluated from available information.

- Differentiation of the groundwater data into specific formations is not possible due to the absence of well construction information and the likely open-hole completion of these wells across multiple formations. The pooling of data across geologic formations introduces some uncertainty in the background dataset. Major ion concentrations may vary between formations. However, as shown in Y/ER-234, for some of the trace elements, distinct associations between the Knox Aquifer units and the Aquitard units are not clear. Therefore, pooling of these data from all formations is not anticipated to present a significant biased representation of these data, and the increase in the sample size provides a better statistical basis for the background levels. This is also consistent with the recommendation in EPA guidance (EPA 530/R-09-007) to establish background sample sizes as large as feasible.

- There were insufficient data from filtered samples to conduct background statistical calculations, therefore, only data from unfiltered samples were used to determine background concentrations in the final dataset. Preferably, the dataset would include data from both filtered and unfiltered samples to provide background concentrations for analytes in dissolved and suspended solid forms.

- Many wells remaining in the final background dataset are located in the area downgradient and south of the ORR. This is the same area where wells and springs are being sampled in 2015 for the Off-site Groundwater Assessment (Figure 2), an investigation to determine if there is potential off-site migration of contaminants from the ORR. Additionally, some of the wells in the final background dataset are the same wells being sampled for the Off-site Groundwater Assessment. Discussions are underway about potential upcoming sampling efforts to obtain additional background locations in areas northeast of the ORR (generally upgradient of groundwater flow). Data obtained from these

efforts may be used to supplement or augment, where appropriate, the background dataset presented in this report.

- Although many of the wells used in this study are in the same area as the Off-site Groundwater Assessment study, the cumulative effect of combining all the data into one data distribution provides a relatively clear understanding of the distribution of naturally-occurring concentrations of inorganics in groundwater in the region. While recognizing that the dataset has limitations, it does serve an important purpose of providing reasonable boundaries for concentrations of naturally occurring chemicals. It also provides an understanding of the central tendency of the background concentrations. As such, the dataset can be used in a semi-quantitative manner to understand if detected inorganics and radionuclides are within the range of background concentrations. Techniques such as box plot comparisons with USGS data and probability plots (see Appendix C) are useful with this dataset and can help in this manner. This approach is similar to the types of regional-scale data comparisons that are performed using data that are compiled from multiple sources by the USGS to better understand naturally-occurring background and anthropogenic concentrations of chemicals within regional scale aquifers throughout the Eastern United States.

Specific recommendations based on this evaluation:

- Stakeholders will be evaluating and determining the type and quality of background dataset needed to make final groundwater decisions for the ORR under CERCLA. This determination should be made using a formal DQO process to review options and solicit input from stakeholders on the background data quality levels needed to support final Records of Decisions. Options range from a statistically defensible dataset collected in a formal background study that includes drilling new wells, to collecting data from existing wells that are off-site and upgradient of the ORR, to using historical data as presented here (both local and USGS-derived).

- Previous ORR background studies have not resulted in a comprehensive set of background values for groundwaters on the ORR and environs. For the current study which is based solely on existing available data, there are questions related to lack of proper data validation, lack of well construction and condition information, application of variable analytical methods with differing and divergent detection limits, lack of documentation of field procedures, lack of consistent field protocols and consistent procedures, and lack of rigorous data archival and management processes. These questions all impact the dataset to varying degrees and, while impossible to quantify, the cumulative effect has negatively impacted the power of the results obtained. As such, it is recommended that future efforts to determine comprehensive and rigorous background values be based on sampling and analysis of a specific group of wells that represent the geologic diversity and variability of the ORR, but are distal from the impacts of operations on the ORR. Well selection methods, sampling approach, and analytical methods and their resultant detection limits must be well thought out and documented in advance of such a study. Satisfactory resolution of such issues is essential to future efforts.

- Despite the various issues discussed surrounding the current background study, the general consistency of the results to those obtained for generally similar (in some cases, at least) hydrogeologic settings to the ORR is encouraging, and speaks to a recommendation that the results of this study be used on an interim, provisional basis until further investigations are proposed and implemented.

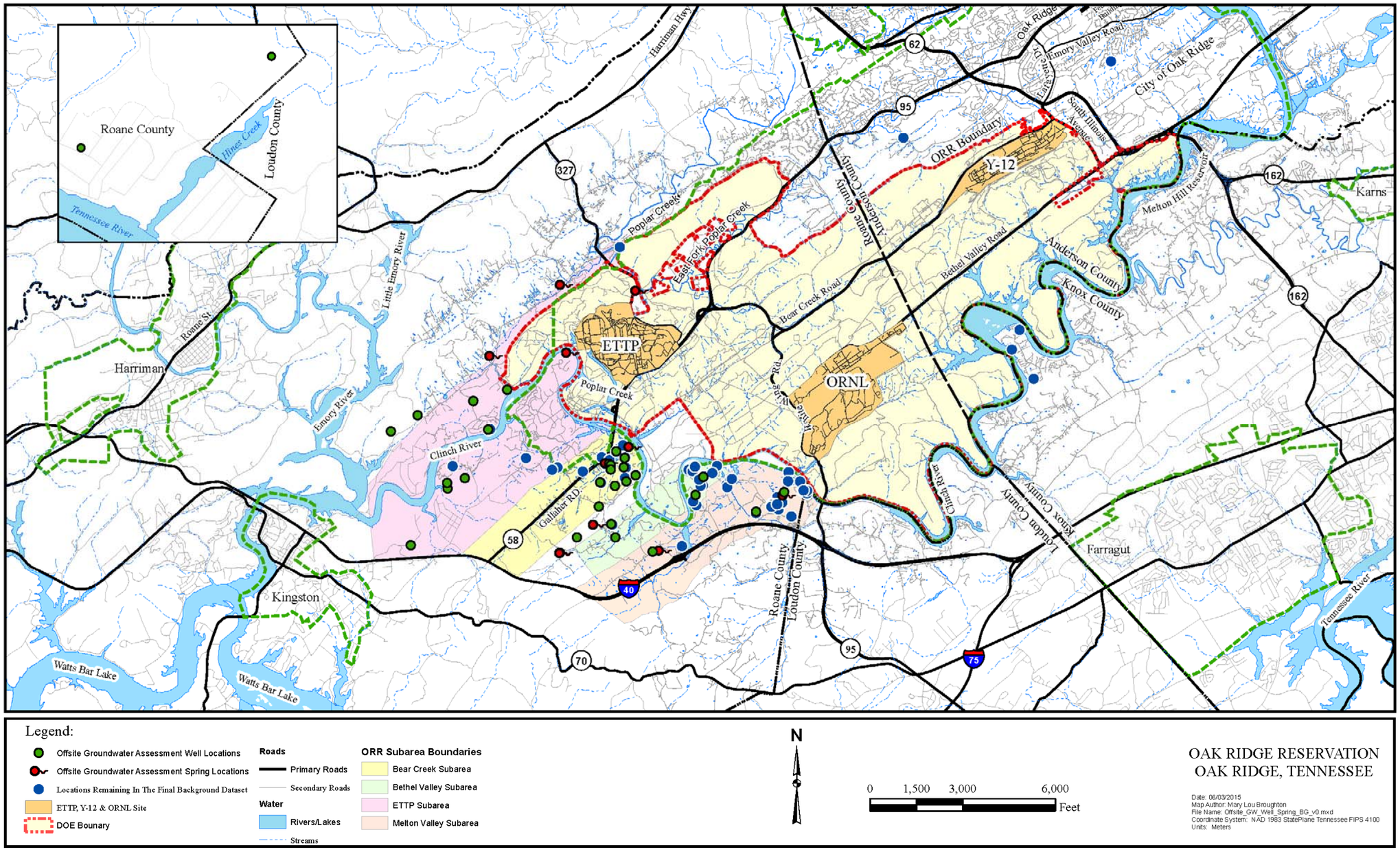

Figure 2. Locations remaining in the final background dataset and locations sampled in the Off-site Groundwater Assessment.

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APPENDIX A
OUTPUT FROM ANALYSIS OF SECOND DATASET

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Table A.1. Summary statistics from second dataset (ORR area unfiltered groundwater)

Constituent	Frequency of Detection	Units	Non-detect Detection Limits[a]		Min[b]	Mean[b]	Median[b]	Max[b]	S.D.[b]	Detected				Dist.[c]	UCL90	UCL95	UTL95/95	EPA Tap Water				MCL[e]	Frequency ≥ MCL[e]	Max Detected Station
			Min	Max						Min	Mean	Max	S.D.					RSL[d] TR=1E-6	Frequency ≥ TR=1E-6	RSL[d] HQ=0.1	Frequency ≥ HQ=0.1			
Anions																								
Ammonia as Nitrogen	14 / 27	mg/L	0.02	0.1	0.01	6.36	0.03	151	28.6	0.02	12.2	151	40.3	X*	23.5	31.3	--	--	--	--	--	--	--	Outfall 2 Sp.
Chloride	508 / 558	mg/L	0.003	4	0.002	15.9	3.5	494	51.5	1	17.3	494	53.8	X*	22.4	25.4	134	--	--	--	--	--	--	RWA-76
Fluoride	182 / 268	mg/L	1.0E-04	0.1	5.0E-05	0.507	0.1	5.3	0.918	0.04	0.718	5.3	1.05	X*	0.675	0.752	3.3	--	--	0.08	**161 / 268**	--	--	UA-2
Kjeldahl Nitrogen	19 / 25	mg/L	0.1	0.1	0.05	7.26	0.11	151	29.8	0.08	9.53	151	34.8	X*	25.6	33.9	--	--	--	--	--	--	--	Outfall 2 Sp.
Nitrate	30 / 51	mg/L	0.002	0.01	0.001	1.16	0.17	37.8	5.21	0.026	1.92	37.8	6.81	X*	3.38	4.39	--	--	--	3.2	**1 / 51**	10	**1 / 51**	SS-6
Nitrate as Nitrogen	68 / 69	mg/L	0.02	0.02	0.01	1.35	0.716	7.7	1.43	0.03	1.37	7.7	1.44	G*	1.64	1.73	5.74	--	--	--	--	--	--	SS-5 Spring
Nitrate/Nitrite	143 / 190	mg/L	0.006	0.1	0.003	0.454	0.21	3	0.541	0.019	0.591	3	0.559	X*	0.572	0.626	2	--	--	--	--	--	--	RWA-105
Nitrite	13 / 107	mg/L	0.002	0.1	0.001	0.05	0.003	0.79	0.176	0.003	0.389	0.79	0.368	X*	0.103	0.127	0.77	--	--	0.2	**7 / 107**	1	0 / 107	UA-2
Nitrogen, NO3 & NO2	389 / 395	mg/L	0.006	0.1	0.003	2.96	0.39	275	16.6	0.01	3.01	275	16.8	X*	5.48	6.62	16.9	--	--	--	--	--	--	Outfall 2 Sp.
Nitrogen, Nitrite	2 / 22	mg/L	0.002	1	0.001	0.023	0.02	0.5	0.013	0.02	0.05	0.08	0.042	X*	0.035	0.041	--	--	--	--	--	--	--	Errai Sp.
Nitrogen, total organic	10 / 10	mg/L	--	--	0.08	0.205	0.14	0.58	0.154	0.08	0.205	0.58	0.154	L	0.294	0.34	1.05	--	--	--	--	--	--	Gaston Sp.
Sulfate	385 / 408	mg/L	0.39	5	0.195	15.0	8.4	179	21.7	1.59	15.8	179	22.1	X*	18.2	19.7	71	--	--	--	--	--	--	RCB Sp.
Sulfide	0 / 1	mg/L	1	1	0.5	0.5	0.5	0.5	--	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
Petroleum Hydrocarbons																								
Extractable Petroleum Hydrocarbons	1 / 1	µg/L	--	--	690	690	690	690	--	690	690	690	--	D	--	--	--	--	--	--	--	--	--	J. A. Jones Sp.
Gasoline Range Organics	1 / 1	µg/L	--	--	120	120	120	120	--	120	120	120	--	D	--	--	--	--	--	--	--	--	--	J. A. Jones Sp.
Physical																								
Calcium Hardness	6 / 7	mg/L	1	1	0.5	53.4	32	172	58.2	3	61.8	172	64.4	N*	87.5	99.5	268	--	--	--	--	--	--	RWA-63
Conductivity	224 / 224	µmhos/cm	--	--	2.3	404	336	2290	304	2.3	404	2290	304	X	465	493	1180	--	--	--	--	--	--	RWA-76
Dissolved Residue	323 / 323	mg/L	--	--	0.371	188	170	604	94.6	0.371	188	604	94.6	X	203	211	426	--	--	--	--	--	--	RWA-53
Hardness, total as CaCO3	70 / 70	mg/L	--	--	17	183	187	426	71.3	17	183	426	71.3	N	194	198	325	--	--	--	--	--	--	PCO Seep
Hydrogen Ion Activity (pH)	65 / 65	pH units	--	--	5.8	7.35	7.4	8.4	0.48	5.8	7.35	8.4	0.48	N	7.43	7.45	8.32	--	--	--	--	--	--	SS-6
Suspended Residue	128 / 141	mg/L	10	10	1	28.8	15	458	53.0	1	31.4	458	55.2	X*	42.2	48.3	200	--	--	--	--	--	--	Cedar Sp.
Total Hardness	86 / 88	mg/L	1	3.8	0.5	144	159	321	89.5	5	147	321	88.6	X*	172	185	321	--	--	--	--	--	--	UA-2
Turbidity	68 / 68	NTU	--	--	0.886	8.57	3.11	180	24.1	0.886	8.57	180	24.1	X	17.3	21.3	180	--	--	--	--	--	--	SS-6
pH	177 / 177	Std. Units	--	--	5.35	7.93	7.67	11	0.95	5.35	7.93	11	0.95	X	8.14	8.24	10.6	--	--	--	--	--	--	UA-2
Metals																								
Aluminum	181 / 306	mg/L	0.003	0.1	0.001	0.478	0.04	25.9	1.94	0.001	0.797	25.9	2.48	X*	0.812	0.963	2.8	--	--	2	**14 / 306**	--	--	BF-006
Antimony	38 / 241	mg/L	1.2E-04	0.003	6.0E-05	0.025	3.6E-04	3.9	0.276	0.00036	0.155	3.9	0.688	X*	0.079	0.103	0.006	--	--	7.8E-04	**35 / 241**	0.006	**7 / 241**	CCC well #2
Arsenic	82 / 345	mg/L	5.7E-04	0.005	2.9E-04	0.004	9.7E-04	0.154	0.015	0.00097	0.013	0.154	0.028	X*	0.006	0.007	0.023	5.2E-05	**82 / 345**	6.0E-04	**82 / 345**	0.01	**13 / 345**	Bootlegger Sp.
Barium	210 / 272	mg/L	3.4E-04	0.1	1.7E-04	0.064	0.044	0.603	0.068	0.003	0.073	0.603	0.074	X*	0.076	0.082	0.24	--	--	0.38	**1 / 272**	2	0 / 272	UA-1
Beryllium	5 / 250	mg/L	1.1E-04	0.1	5.5E-05	3.5E-04	3.2E-04	0.05	2.5E-04	0.00032	0.002	0.004	0.001	X*	4.1E-04	4.3E-04	3.2E-04	--	--	0.003	**1 / 250**	0.004	0 / 250	RWA-116
Boron	146 / 206	mg/L	9.0E-05	90	4.5E-05	0.212	0.09	45	0.322	0.00034	0.28	1.7	0.36	X*	0.28	0.311	1.4	--	--	0.4	**32 / 206**	--	--	RWA-76
Cadmium	31 / 272	mg/L	2.1E-04	0.001	1.1E-04	6.1E-04	5.0E-04	0.004	5.3E-04	0.0005	0.001	0.004	0.001	X*	7.1E-04	7.5E-04	0.002	--	--	9.2E-04	**16 / 272**	0.005	0 / 272	SS-6
Calcium	372 / 374	mg/L	0.034	0.037	0.017	43.6	39.6	598	38.4	0.44	43.9	598	38.4	X*	49.6	52.3	101	--	--	--	--	--	--	SEC Well
Chromium	160 / 396	mg/L	6.0E-04	1	3.0E-04	0.005	0.001	0.558	0.033	0.00044	0.01	0.558	0.052	X*	0.01	0.012	0.02	--	--	--	--	0.1	**2 / 396**	21002 Sp. B
Chromium, hexavalent	4 / 5	mg/L	0.008	0.008	0.004	2.21	0.011	11	4.91	0.009	2.76	11	5.49	D	--	--	--	3.5E-05	**4 / 5**	0.004	**4 / 5**	--	--	Bootlegger Sp.
Cobalt	45 / 197	mg/L	4.0E-05	0.01	2.0E-05	0.001	3.4E-04	0.027	0.003	0.000044	0.003	0.027	0.006	X*	0.002	0.002	0.01	--	--	6.0E-04	**20 / 197**	--	--	BF-006

Table A.1. Summary statistics from second dataset (ORR area unfiltered groundwater) (cont.)

Constituent	Frequency of Detection	Units	Non-detect Detection Limits[a]		Min[b]	Mean[b]	Median[b]	Max[b]	S.D.[b]	Detected				Dist.[c]	UCL90	UCL95	UTL95/95	EPA Tap Water				MCL[e]	Frequency ≥ MCL[e]	Max Detected Station
			Min	Max						Min	Mean	Max	S.D.					RSL[d] TR=1E-6	Frequency ≥ TR=1E-6	RSL[d] HQ=0.1	Frequency ≥ HQ=0.1			
Copper	121 / 233	mg/L	3.0E-04	0.001	1.5E-04	0.007	0.002	0.182	0.014	0.00034	0.011	0.182	0.019	X*	0.009	0.011	0.034	--	--	0.08	**1 / 233**	1.3	0 / 233	SCR5.4SP
Iron	309 / 334	mg/L	1.6E-04	0.1	8.0E-05	0.964	0.128	41.3	3.7	0.002	1.04	41.3	3.85	X*	1.57	1.85	6.8	--	--	1.4	**40 / 334**	--	--	BF-006
Lead	239 / 397	mg/L	0	0.001	0	0.018	6.2E-04	5.16	0.26	0.00012	0.03	5.16	0.335	X*	0.057	0.075	0.031	--	--	--	--	0.015	**23 / 397**	UA-1
Lithium	171 / 211	mg/L	0	5.9E-04	0	0.03	0.007	0.44	0.066	0.00026	0.036	0.44	0.072	X*	0.043	0.05	0.33	--	--	0.004	**120 / 211**	--	--	RWA-76
Magnesium	323 / 329	mg/L	0.015	0.1	0.008	12.5	11.6	126	10.0	0.012	12.7	126	9.99	X*	14.2	14.9	27	--	--	--	--	--	--	Gallaher Sp.
Manganese	251 / 305	mg/L	2.2E-04	0.005	1.1E-04	0.089	0.012	3.97	0.309	0.00021	0.108	3.97	0.339	X*	0.142	0.166	0.577	--	--	0.043	**89 / 305**	--	--	BF-002A
Mercury	8 / 234	mg/L	2.0E-05	0.002	1.0E-05	3.9E-05	2.8E-05	0.001	9.1E-05	0.000028	3.4E-04	0.001	0.000395	G*	1.6E-05	1.7E-05	3.3E-04	--	--	6.3E-05	**7 / 234**	0.002	0 / 234	Orwell Sp.
Molybdenum	7 / 66	mg/L	4.0E-05	0.004	2.0E-05	0.001	4.0E-04	0.015	0.003	0.00025	0.008	0.015	0.007	X*	0.003	0.003	0.015	--	--	0.01	**4 / 66**	--	--	UA-2
Nickel	142 / 304	mg/L	1.0E-04	0.01	5.0E-05	0.005	0.001	0.053	0.01	0.00016	0.009	0.053	0.014	X*	0.007	0.007	0.05	--	--	0.039	**13 / 304**	--	--	TOMSSEEP
Niobium	10 / 26	mg/L	6.1E-06	7.3E-04	3.1E-06	2.3E-04	1.6E-05	0.1	5.1E-04	0.00001	2.8E-04	0.002	0.000578	X*	7.0E-04	9.1E-04	--	--	--	--	--	--	--	RWA-116
Phosphorous	18 / 39	mg/L	0.004	0.07	0.002	0.038	0.02	0.25	0.044	0.007	0.053	0.18	0.05	G*	0.059	0.069	0.574	--	--	4.0E-05	**18 / 39**	--	--	SS-5 Spring
Potassium	311 / 318	mg/L	0.02	0.1	0.01	1.84	1.21	20	2.25	0.05	1.88	20	2.27	X*	2.22	2.4	6.2	--	--	--	--	--	--	UA-2
Selenium	42 / 276	mg/L	7.3E-04	0.016	3.7E-04	0.002	0.001	0.032	0.003	0.001	0.007	0.032	0.006	X*	0.003	0.003	0.01	--	--	0.01	**21 / 276**	0.05	0 / 276	BF-003
Silica	54 / 54	mg/L	--	--	0.1	11.9	10.2	39.5	6.6	0.1	11.9	39.5	6.6	X	14.6	15.8	--	--	--	--	--	--	--	RWA-110
Silicon	16 / 16	mg/L	--	--	3.2	3.85	3.69	5.4	0.591	3.2	3.85	5.4	0.591	X	4.29	4.49	--	--	--	--	--	--	--	SS-8
Silver	13 / 132	mg/L	1.4E-05	0.07	1.6E-08	2.8E-04	3.0E-05	0.035	0.001	1.6E-08	0.002	0.014	0.004	G*	4.5E-04	4.9E-04	0.005	--	--	0.009	**1 / 132**	--	--	RWA-78
Sodium	385 / 387	mg/L	0.1	1	0.05	40.1	3.18	820	94.3	0.2	40.3	820	94.6	X*	54.5	61.0	242	--	--	--	--	--	--	RWA-97
Strontium	231 / 233	mg/L	4.7E-04	4.7E-04	2.4E-04	0.136	0.082	0.785	0.159	0.00055	0.137	0.785	0.16	X*	0.168	0.182	0.672	--	--	1.2	0 / 233	--	--	Rarity Ridge
Sulfur	11 / 11	mg/L	--	--	1.51	2.21	2.28	2.87	0.466	1.51	2.21	2.87	0.466	N	2.41	2.47	3.53	--	--	--	--	--	--	SCR2.2SP
Thallium	93 / 299	mg/L	3.0E-05	0.018	1.5E-05	6.0E-04	2.0E-04	0.026	0.002	0.00003	0.001	0.026	0.004	X*	0.001	0.001	0.002	--	--	2.0E-05	**93 / 299**	0.002	**9 / 299**	BF-001
Thorium	11 / 78	mg/L	--	--	0.1	0.114	0.1	0.2	0.035	0.2	0.2	0.2	0	X	0.126	0.131	0.2	--	--	--	--	--	--	SCR5.4SP
Tin	0 / 1	mg/L	--	--	0.2	0.2	0.2	0.2	--	--	--	--	--	O	--	--	--	--	--	1.2	0 / 1	--	--	--
Titanium	0 / 9	mg/L	--	--	0.025	0.033	0.025	0.1	0.025	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
Total Uranium	2 / 23	mg/L	--	--	5.0E-04	0.007	0.001	0.15	0.03	0.001	0.076	0.15	0.105	X*	0.034	0.047	--	--	--	--	--	--	--	SS-6
Uranium	148 / 245	mg/L	1.0E-05	0.02	5.0E-06	0.019	3.2E-04	3.31	0.213	0.000012	0.03	3.31	0.274	X*	0.059	0.078	0.051	--	--	0.006	**18 / 245**	0.03	**9 / 245**	UA-1
Vanadium	45 / 228	mg/L	1.0E-05	0.01	5.0E-06	0.002	6.2E-04	0.082	0.007	0.00014	0.008	0.082	0.015	X*	0.004	0.004	0.014	--	--	0.009	**11 / 228**	--	--	BF-006
Zinc	521 / 533	mg/L	7.6E-04	0.002	3.8E-04	0.026	0.007	2.87	0.136	0.00088	0.026	2.87	0.138	X*	0.043	0.051	0.12	--	--	0.6	**2 / 533**	--	--	RWA-64
Zirconium	0 / 8	mg/L	--	--	0.1	0.1	0.1	0.1	0	--	--	--	--	O	--	--	--	--	--	1.6E-04	0 / 8	--	--	--
Pesticides																								
Pesticides	0 / 1	µg/L	0.2	0.2	0.1	0.1	0.1	0.1	--	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
Polychlorinated Biphenyls																								
PCB-1221	0 / 12	µg/L	0.07	10	0.035	2.53	2.55	5	2.58	--	--	--	--	O	--	--	--	0.005	0 / 12	--	--	0.5	0 / 12	--
PCB-1232	0 / 12	µg/L	0.06	10	0.03	2.53	2.55	5	2.58	--	--	--	--	O	--	--	--	0.005	0 / 12	--	--	0.5	0 / 12	--
PCB-1242	0 / 12	µg/L	0.03	2	0.015	0.529	0.55	1	0.493	--	--	--	--	O	--	--	--	0.039	0 / 12	--	--	0.5	0 / 12	--
PCB-1248	0 / 12	µg/L	0.06	2	0.03	0.533	0.55	1	0.489	--	--	--	--	O	--	--	--	0.039	0 / 12	--	--	0.5	0 / 12	--
PCB-1254	0 / 12	µg/L	0.08	2	0.04	0.535	0.55	1	0.486	--	--	--	--	O	--	--	--	0.039	0 / 12	0.04	0 / 12	0.5	0 / 12	--
PCB-1260	0 / 12	µg/L	0.05	2	0.025	0.531	0.55	1	0.49	--	--	--	--	O	--	--	--	0.039	0 / 12	--	--	0.5	0 / 12	--
Semivolatile Organics																								
1,2,4-Trichlorobenzene	0 / 16	µg/L	0.028	11	0.014	1.92	0.014	5.5	2.54	--	--	--	--	O	--	--	--	1.1	0 / 16	0.4	0 / 16	70	0 / 16	--
1,3-Dichlorobenzene	0 / 15	µg/L	0.036	10	0.018	1.68	0.018	5	2.43	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
2,2'-Dichlorodiisopropyl ether	0 / 6	µg/L	10	11	5	5.08	5	5.5	0.204	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
2,4,5-Trichlorophenol	0 / 6	µg/L	10	11	5	5.08	5	5.5	0.204	--	--	--	--	O	--	--	--	--	--	120	0 / 6	--	--	--

Table A.1. Summary statistics from second dataset (ORR area unfiltered groundwater) (cont.)

Constituent	Frequency of Detection	Units	Non-detect Detection Limits[a]		Min[b]	Mean[b]	Median[b]	Max[b]	S.D.[b]	Detected				Dist.[c]	UCL90	UCL95	UTL95/95	EPA Tap Water				MCL[e]	Frequency ≥ MCL[e]	Max Detected Station
			Min	Max						Min	Mean	Max	S.D.					RSL[d] TR=1E-6	Frequency ≥ TR=1E-6	RSL[d] HQ=0.1	Frequency ≥ HQ=0.1			
2,4,6-Trichlorophenol	0 / 6	µg/L	10	11	5	5.08	5	5.5	0.204	--	--	--	--	O	--	--	--	4	0 / 6	1.2	0 / 6	--	--	--
2,4-Dichlorophenol	0 / 6	µg/L	10	11	5	5.08	5	5.5	0.204	--	--	--	--	O	--	--	--	--	--	4.6	0 / 6	--	--	--
2,4-Dimethylphenol	0 / 6	µg/L	10	11	5	5.08	5	5.5	0.204	--	--	--	--	O	--	--	--	--	--	36	0 / 6	--	--	--
2,4-Dinitrophenol	0 / 6	µg/L	48	57	24	25	24	28.5	1.82	--	--	--	--	O	--	--	--	--	--	3.9	0 / 6	--	--	--
2,4-Dinitrotoluene	0 / 6	µg/L	10	11	5	5.08	5	5.5	0.204	--	--	--	--	O	--	--	--	0.24	0 / 6	3.8	0 / 6	--	--	--
2,6-Dinitrotoluene	0 / 6	µg/L	10	11	5	5.08	5	5.5	0.204	--	--	--	--	O	--	--	--	0.048	0 / 6	0.57	0 / 6	--	--	--
2-Chloronaphthalene	0 / 6	µg/L	10	11	5	5.08	5	5.5	0.204	--	--	--	--	O	--	--	--	--	--	75	0 / 6	--	--	--
2-Chlorophenol	0 / 6	µg/L	10	11	5	5.08	5	5.5	0.204	--	--	--	--	O	--	--	--	--	--	9.1	0 / 6	--	--	--
2-Methyl-4,6-dinitrophenol	0 / 6	µg/L	48	57	24	25	24	28.5	1.82	--	--	--	--	O	--	--	--	--	--	0.15	0 / 6	--	--	--
2-Methylphenol	0 / 6	µg/L	10	11	5	5.08	5	5.5	0.204	--	--	--	--	O	--	--	--	--	--	93	0 / 6	--	--	--
2-Nitrophenol	0 / 6	µg/L	10	11	5	5.08	5	5.5	0.204	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
4-Bromophenyl phenyl ether	0 / 6	µg/L	10	11	5	5.08	5	5.5	0.204	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
4-Chloro-3-methylphenol	0 / 6	µg/L	19	23	9.5	9.92	9.5	11.5	0.801	--	--	--	--	O	--	--	--	--	--	140	0 / 6	--	--	--
4-Chlorophenyl phenyl ether	0 / 6	µg/L	10	11	5	5.08	5	5.5	0.204	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
4-Nitrophenol	0 / 6	µg/L	48	57	24	25	24	28.5	1.82	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
Acenaphthene	0 / 6	µg/L	10	11	5	5.08	5	5.5	0.204	--	--	--	--	O	--	--	--	--	--	53	0 / 6	--	--	--
Acenaphthylene	0 / 6	µg/L	10	11	5	5.08	5	5.5	0.204	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
Anthracene	0 / 6	µg/L	10	11	5	5.08	5	5.5	0.204	--	--	--	--	O	--	--	--	--	--	180	0 / 6	--	--	--
Benz(a)anthracene	0 / 6	µg/L	10	11	5	5.08	5	5.5	0.204	--	--	--	--	O	--	--	--	0.034	0 / 6	--	--	--	--	--
Benzo(a)pyrene	0 / 6	µg/L	10	11	5	5.08	5	5.5	0.204	--	--	--	--	O	--	--	--	0.003	0 / 6	--	--	0.2	0 / 6	--
Benzo(b)fluoranthene	0 / 6	µg/L	10	11	5	5.08	5	5.5	0.204	--	--	--	--	O	--	--	--	0.034	0 / 6	--	--	--	--	--
Benzo(ghi)perylene	0 / 6	µg/L	10	11	5	5.08	5	5.5	0.204	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
Benzo(k)fluoranthene	0 / 6	µg/L	10	11	5	5.08	5	5.5	0.204	--	--	--	--	O	--	--	--	0.34	0 / 6	--	--	--	--	--
Bis(2-chloroethoxy)methane	0 / 6	µg/L	10	11	5	5.08	5	5.5	0.204	--	--	--	--	O	--	--	--	--	--	5.9	0 / 6	--	--	--
Bis(2-chloroethyl) ether	0 / 6	µg/L	10	11	5	5.08	5	5.5	0.204	--	--	--	--	O	--	--	--	0.014	0 / 6	--	--	--	--	--
Bis(2-ethylhexyl)phthalate	1 / 6	µg/L	10	11	5	7.58	5	20	6.09	20	20	20	--	X	15.0	18.4	--	5.6	**1 / 6**	40	0 / 6	6	**1 / 6**	BF-004
Butyl benzyl phthalate	0 / 6	µg/L	10	11	5	5.08	5	5.5	0.204	--	--	--	--	O	--	--	--	16	0 / 6	170	0 / 6	--	--	--
Chrysene	0 / 6	µg/L	10	11	5	5.08	5	5.5	0.204	--	--	--	--	O	--	--	--	3.4	0 / 6	--	--	--	--	--
Di-n-butyl phthalate	0 / 6	µg/L	10	11	5	5.08	5	5.5	0.204	--	--	--	--	O	--	--	--	--	--	90	0 / 6	--	--	--
Di-n-octylphthalate	0 / 6	µg/L	10	11	5	5.08	5	5.5	0.204	--	--	--	--	O	--	--	--	--	--	20	0 / 6	--	--	--
Dibenz(a,h)anthracene	0 / 6	µg/L	10	11	5	5.08	5	5.5	0.204	--	--	--	--	O	--	--	--	0.003	0 / 6	--	--	--	--	--
Diethyl phthalate	0 / 6	µg/L	10	11	5	5.08	5	5.5	0.204	--	--	--	--	O	--	--	--	--	--	1500	0 / 6	--	--	--
Dimethyl phthalate	0 / 6	µg/L	10	11	5	5.08	5	5.5	0.204	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
Diphenyldiazene	0 / 6	µg/L	10	11	5	5.08	5	5.5	0.204	--	--	--	--	O	--	--	--	0.12	0 / 6	--	--	--	--	--
Fluoranthene	0 / 6	µg/L	10	11	5	5.08	5	5.5	0.204	--	--	--	--	O	--	--	--	--	--	80	0 / 6	--	--	--
Fluorene	0 / 6	µg/L	10	11	5	5.08	5	5.5	0.204	--	--	--	--	O	--	--	--	--	--	29	0 / 6	--	--	--
Hexachlorobenzene	0 / 6	µg/L	10	11	5	5.08	5	5.5	0.204	--	--	--	--	O	--	--	--	0.049	0 / 6	1.6	0 / 6	1	0 / 6	--
Hexachlorobutadiene	0 / 16	µg/L	0.1	11	0.05	1.94	0.05	5.5	2.52	--	--	--	--	O	--	--	--	0.3	0 / 16	0.65	0 / 16	--	--	--
Hexachloroethane	0 / 6	µg/L	10	11	5	5.08	5	5.5	0.204	--	--	--	--	O	--	--	--	0.9	0 / 6	0.69	0 / 6	--	--	--
Indeno(1,2,3-cd)pyrene	0 / 6	µg/L	10	11	5	5.08	5	5.5	0.204	--	--	--	--	O	--	--	--	0.034	0 / 6	--	--	--	--	--

Table A.1. Summary statistics from second dataset (ORR area unfiltered groundwater) (cont.)

Constituent	Frequency of Detection	Units	Non-detect Detection Limits[a]		Min[b]	Mean[b]	Median[b]	Max[b]	S.D.[b]	Detected				Dist.[c]	UCL90	UCL95	UTL95/95	EPA Tap Water				MCL[e]	Frequency ≥ MCL[e]	Max Detected Station
			Min	Max						Min	Mean	Max	S.D.					RSL[d] TR=1E-6	Frequency ≥ TR=1E-6	RSL[d] HQ=0.1	Frequency ≥ HQ=0.1			
Isophorone	0 / 6	µg/L	10	11	5	5.08	5	5.5	0.204	--	--	--	--	O	--	--	--	78	0 / 6	380	0 / 6	--	--	--
N-Nitroso-di-n-propylamine	0 / 6	µg/L	10	11	5	5.08	5	5.5	0.204	--	--	--	--	O	--	--	--	0.011	0 / 6	--	--	--	--	--
N-Nitrosodimethylamine	0 / 6	µg/L	10	11	5	5.08	5	5.5	0.204	--	--	--	--	O	--	--	--	4.9E-04	0 / 6	0.016	0 / 6	--	--	--
N-Nitrosodiphenylamine	0 / 6	µg/L	10	11	5	5.08	5	5.5	0.204	--	--	--	--	O	--	--	--	12	0 / 6	--	--	--	--	--
Naphthalene	1 / 17	µg/L	0.03	11	0.015	1.86	0.015	5.5	2.47	0.94	0.94	0.94	--	X	3.65	4.47	--	0.17	**1 / 17**	0.61	**1 / 17**	--	--	RWA-76
Nitrobenzene	0 / 6	µg/L	10	11	5	5.08	5	5.5	0.204	--	--	--	--	O	--	--	--	0.14	0 / 6	1.3	0 / 6	--	--	--
Pentachlorophenol	0 / 6	µg/L	48	57	24	25	24	28.5	1.82	--	--	--	--	O	--	--	--	0.04	0 / 6	2.3	0 / 6	1	0 / 6	--
Phenanthrene	0 / 6	µg/L	10	11	5	5.08	5	5.5	0.204	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
Phenol	1 / 7	µg/L	10	11	5	8.33	5	27.8	8.59	27.8	27.8	27.8	--	X	18.1	22.5	--	--	--	580	0 / 7	--	--	UA-2
Pyrene	0 / 6	µg/L	10	11	5	5.08	5	5.5	0.204	--	--	--	--	O	--	--	--	--	--	12	0 / 6	--	--	--
Pyridine	0 / 6	µg/L	10	11	5	5.08	5	5.5	0.204	--	--	--	--	O	--	--	--	--	--	2	0 / 6	--	--	--
m+p Methylphenol	0 / 6	µg/L	10	11	5	5.08	5	5.5	0.204	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
Volatile Organics																								
1,1,1,2-Tetrachloroethane	0 / 48	µg/L	0.33	0.33	0.165	3.11	2.5	5	1.89	--	--	--	--	O	--	--	--	0.57	0 / 48	48	0 / 48	--	--	--
1,1,1-Trichloroethane	39 / 116	µg/L	0.05	2	0.025	1.14	1	5.6	0.861	0.2	1.48	5.6	1.13	G*	1.32	1.37	6.41	--	--	800	0 / 116	200	0 / 116	21002 Sp. C
1,1,2,2-Tetrachloroethane	0 / 92	µg/L	0.09	2	0.045	2.14	2.5	2.5	0.822	--	--	--	--	O	--	--	--	0.076	0 / 92	36	0 / 92	--	--	--
1,1,2-Trichloro-1,2,2-trifluoroethane	0 / 16	µg/L	1.7	1.7	0.85	1.47	0.85	2.5	0.825	--	--	--	--	O	--	--	--	--	--	5500	0 / 16	--	--	--
1,1,2-Trichloroethane	0 / 65	µg/L	0.042	2	0.021	1.98	2.5	2.5	0.947	--	--	--	--	O	--	--	--	0.28	0 / 65	0.041	0 / 65	5	0 / 65	--
1,1-Dichloroethane	43 / 120	µg/L	0.048	2	0.024	1.31	0.9	9.3	1.48	0.3	1.86	9.3	2.12	X*	1.8	2.02	8.96	2.7	**8 / 120**	380	0 / 120	--	--	TOMSSEEP
1,1-Dichloroethene	52 / 116	µg/L	0.045	2	0.023	1.49	0.8	9.2	1.49	0.3	1.83	9.2	1.72	X*	2.02	2.26	4.8	--	--	28	0 / 116	7	**1 / 116**	JES Sludge Seep
1,1-Dichloropropene	0 / 10	µg/L	0.04	0.04	0.02	0.02	0.02	0.02	0	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
1,2,3-Trichlorobenzene	0 / 10	µg/L	0.037	0.037	0.019	0.019	0.019	0.019	0	--	--	--	--	O	--	--	--	--	--	0.7	0 / 10	--	--	--
1,2,3-Trichloropropane	0 / 55	µg/L	0.085	0.085	0.043	2.92	2.5	5	1.77	--	--	--	--	O	--	--	--	7.5E-04	0 / 55	0.062	0 / 55	--	--	--
1,2,4-Trimethylbenzene	0 / 10	µg/L	0.02	0.02	0.01	0.01	0.01	0.01	0	--	--	--	--	O	--	--	--	--	--	1.5	0 / 10	--	--	--
1,2-Dibromo-3-chloropropane	0 / 37	µg/L	0.37	0.37	0.185	3.7	5	5	2.17	--	--	--	--	O	--	--	--	3.3E-04	0 / 37	0.037	0 / 37	0.2	0 / 37	--
1,2-Dibromoethane	0 / 66	µg/L	0.078	0.078	0.039	2.13	2.5	2.5	0.889	--	--	--	--	O	--	--	--	0.008	0 / 66	1.7	0 / 66	0.05	0 / 66	--
1,2-Dichlorobenzene	0 / 48	µg/L	0.04	0.04	0.02	1.98	2.5	2.5	1.02	--	--	--	--	O	--	--	--	--	--	30	0 / 48	600	0 / 48	--
1,2-Dichloroethane	0 / 92	µg/L	0.18	2	0.09	2.14	2.5	2.5	0.81	--	--	--	--	O	--	--	--	0.17	0 / 92	1.3	0 / 92	5	0 / 92	--
1,2-Dichloroethene	2 / 76	µg/L	--	--	1	1.08	1	7	0.684	1	4	7	4.24	X*	1.41	1.56	7	--	--	--	--	--	--	SS-6
1,2-Dichloropropane	0 / 86	µg/L	0.06	2	0.03	2.11	2.5	2.5	0.849	--	--	--	--	O	--	--	--	0.44	0 / 86	0.83	0 / 86	5	0 / 86	--
1,2-Dimethylbenzene	1 / 17	µg/L	0.036	2	0.018	0.374	0.018	1	0.478	0.17	0.17	0.17	--	X	0.722	0.879	--	--	--	19	0 / 17	--	--	RWA-76
1,3,5-Trimethylbenzene	0 / 10	µg/L	0.034	0.034	0.017	0.017	0.017	0.017	0	--	--	--	--	O	--	--	--	--	--	12	0 / 10	--	--	--
1,3-Dichloropropane	0 / 10	µg/L	0.045	0.045	0.023	0.023	0.023	0.023	0	--	--	--	--	O	--	--	--	--	--	37	0 / 10	--	--	--
1,4-Dichloro-2-butene	0 / 27	µg/L	--	--	2.5	2.5	2.5	2.5	0	--	--	--	--	O	--	--	--	0.001	0 / 27	--	--	--	--	--
1,4-Dichlorobenzene	7 / 29	µg/L	0.032	0.032	0.016	0.257	0.27	2.5	0.109	0.09	0.257	0.4	0.117	G*	0.293	0.304	8.69	0.48	0 / 29	57	0 / 29	75	0 / 29	UA-2
1,4-Dioxane	2 / 47	µg/L	0.2	0.5	0.1	1.15	1.13	1.99	0.124	1.13	1.56	1.99	0.608	X*	1.23	1.26	--	0.78	**2 / 47**	60	0 / 47	--	--	RWA-29
2,2-Dichloropropane	0 / 10	µg/L	0.067	0.067	0.034	0.034	0.034	0.034	0	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
2-Butanone	8 / 47	µg/L	5.1	5.1	2	3.6	3	11	1.98	2	5.54	11	3.62	G*	4.16	4.29	8.29	--	--	560	0 / 47	--	--	RWA-111
2-Chloroethyl vinyl ether	0 / 55	µg/L	5.9	5.9	2.95	4.63	5	5	0.798	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
2-Chlorotoluene	1 / 11	µg/L	0.06	0.06	0.03	0.34	0.03	3.44	1.03	3.44	3.44	3.44	--	X	1.27	1.69	--	--	--	24	0 / 11	--	--	RWA-76

Table A.1. Summary statistics from second dataset (ORR area unfiltered groundwater) (cont.)

Constituent	Frequency of Detection	Units	Non-detect Detection Limits[a]		Min[b]	Mean[b]	Median[b]	Max[b]	S.D.[b]	Detected				Dist.[c]	UCL90	UCL95	UTL95/95	EPA Tap Water				MCL[e]	Frequency ≥ MCL[e]	Max Detected Station
			Min	Max						Min	Mean	Max	S.D.					RSL[d] TR=1E-6	Frequency ≥ TR=1E-6	RSL[d] HQ=0.1	Frequency ≥ HQ=0.1			
2-Hexanone	0 / 92	µg/L	3.1	10	1.55	3.97	5	5	1.37	--	--	--	--	O	--	--	--	--	--	3.8	0 / 92	--	--	--
4-Chlorotoluene	1 / 11	µg/L	0.047	0.047	0.024	0.382	0.024	3.97	1.19	3.97	3.97	3.97	--	X	1.46	1.95	--	--	--	25	0 / 11	--	--	RWA-76
4-Isopropyltoluene	0 / 10	µg/L	0.029	0.029	0.015	0.015	0.015	0.015	0	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
4-Methyl-2-pentanone	3 / 52	µg/L	9.3	50	2	2.58	2.73	25	0.422	2	2.58	3	0.517	X*	3.47	3.88	--	--	--	120	0 / 52	--	--	SS-8
Acetone	39 / 102	µg/L	7.8	7.8	0.9	10.3	4	100	16.8	0.9	20.5	100	23.4	G*	14.5	16.2	35.5	--	--	1400	0 / 102	--	--	Burns Cemetery Sp.
Acrolein	0 / 61	µg/L	3.4	3.4	1.7	4.46	5	5	1.23	--	--	--	--	O	--	--	--	--	--	0.004	0 / 61	--	--	--
Acrylonitrile	0 / 37	µg/L	2.4	2.4	1.2	3.16	2.5	5	1.62	--	--	--	--	O	--	--	--	0.052	0 / 37	0.41	0 / 37	--	--	--
Benzaldehyde	1 / 1	µg/L	--	--	11	11	11	11	--	11	11	11	--	D	--	--	--	--	--	190	0 / 1	--	--	UA-2
Benzene	2 / 94	µg/L	0.04	2	0.02	1.23	1.2	2.5	0.111	1.2	1.4	1.6	0.283	X*	1.37	1.43	1.2	0.45	**2 / 94**	3.3	0 / 94	5	0 / 94	RWA-71
Bromobenzene	1 / 11	µg/L	0.032	0.032	0.016	0.054	0.016	0.435	0.126	0.435	0.435	0.435	--	X	0.168	0.22	--	--	--	6.2	0 / 11	--	--	RWA-76
Bromochloromethane	0 / 54	µg/L	0.084	0.084	0.042	3.2	2.5	5	1.89	--	--	--	--	O	--	--	--	--	--	8.3	0 / 54	--	--	--
Bromodichloromethane	2 / 94	µg/L	0.042	2	0.021	1.48	1.1	37	3.68	1.1	19.1	37	25.4	X*	3.09	3.82	1.1	0.13	**2 / 94**	38	0 / 94	80	0 / 94	RWA-76
Bromoform	1 / 93	µg/L	0.13	2	0.065	2.53	2.5	38.2	3.83	38.2	38.2	38.2	--	X	3.72	4.25	38.2	9.2	**1 / 93**	38	**1 / 93**	80	0 / 93	RWA-76
Bromomethane	1 / 93	µg/L	0.35	4	0.175	3.6	5	5	1.71	1	1	1	--	X	4.13	4.37	1	--	--	0.75	**1 / 93**	--	--	SS-5 Spring
Carbon disulfide	32 / 117	µg/L	0.032	5	0.016	6.07	0.56	217	26.3	0.11	20.6	217	48.0	X*	13.5	16.8	153	--	--	81	**3 / 117**	--	--	Doug's Drip Sp.
Carbon tetrachloride	46 / 124	µg/L	0.1	2	0.05	2.36	2	14	2.11	0.2	3.6	14	2.48	G*	2.81	2.96	8.62	0.45	**45 / 124**	4.9	**10 / 124**	5	**10 / 124**	Cattail West Sp.
Chlorobenzene	4 / 96	µg/L	0.022	2	0.011	0.515	0.3	2.5	0.446	0.3	1.05	1.8	0.623	X*	0.929	1.12	1.2	--	--	7.8	0 / 96	100	0 / 96	JES Sludge Seep
Chloroethane	19 / 97	µg/L	0.49	4	0.245	1.95	0.65	13.8	2.42	0.3	4.1	13.8	3.47	G*	2.64	2.91	11.5	--	--	2100	0 / 97	--	--	UA-1
Chloroform	54 / 131	µg/L	0.21	2	0.1	0.855	0.415	33.7	2.91	0.1	1.26	33.7	4.52	X*	1.64	1.99	1.79	0.22	**48 / 131**	9.7	**1 / 131**	80	0 / 131	RWA-76
Chloromethane	21 / 93	µg/L	0.17	4	0.085	0.407	0.26	5	0.28	0.11	0.432	1.27	0.303	G*	0.445	0.458	11.7	--	--	19	0 / 93	--	--	Gallaher Sp.
Cyclohexane	0 / 10	µg/L	0.13	0.13	0.065	0.065	0.065	0.065	0	--	--	--	--	O	--	--	--	--	--	1300	0 / 10	--	--	--
Dibromochloromethane	1 / 93	µg/L	0.07	2	0.035	2.67	2.5	51.8	5.22	51.8	51.8	51.8	--	X	4.29	5.03	51.8	0.17	**1 / 93**	38	**1 / 93**	80	0 / 93	RWA-76
Dibromomethane	0 / 66	µg/L	0.068	0.068	0.034	3.26	2.5	5	1.8	--	--	--	--	O	--	--	--	--	--	0.8	0 / 66	--	--	--
Dichlorodifluoromethane	0 / 37	µg/L	0.066	0.066	0.033	1.83	2.5	2.5	1.11	--	--	--	--	O	--	--	--	--	--	20	0 / 37	--	--	--
Diisopropyl ether	0 / 10	µg/L	0.13	0.13	0.065	0.065	0.065	0.065	0	--	--	--	--	O	--	--	--	--	--	150	0 / 10	--	--	--
Ethanol	0 / 45	µg/L	--	--	100	187	250	250	74.9	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
Ethyl methacrylate	0 / 56	µg/L	--	--	2.5	2.5	2.5	2.5	0	--	--	--	--	O	--	--	--	--	--	46	0 / 56	--	--	--
Ethylbenzene	0 / 51	µg/L	0.03	2	0.015	1.84	2.5	2.5	1.03	--	--	--	--	O	--	--	--	1.5	0 / 51	81	0 / 51	700	0 / 51	--
Iodomethane	0 / 45	µg/L	--	--	2.5	2.5	2.5	2.5	0	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
Isopropylbenzene	0 / 10	µg/L	0.027	0.027	0.014	0.014	0.014	0.014	0	--	--	--	--	O	--	--	--	--	--	45	0 / 10	--	--	--
M + P Xylene	0 / 6	µg/L	2	2	1	1	1	1	0	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
Methyl acetate	0 / 10	µg/L	0.23	0.23	0.115	0.115	0.115	0.115	0	--	--	--	--	O	--	--	--	--	--	2000	0 / 10	--	--	--
Methyl-t-butyl ether	0 / 10	µg/L	0.09	0.09	0.045	0.045	0.045	0.045	0	--	--	--	--	O	--	--	--	14	0 / 10	630	0 / 10	--	--	--
Methylcyclohexane	0 / 10	µg/L	0.13	0.13	0.065	0.065	0.065	0.065	0	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
Methylene chloride	39 / 101	µg/L	0.044	2	0.022	0.578	0.2	2.9	0.847	0.03	0.732	2.9	0.975	X*	0.927	1.08	2.9	11	0 / 101	11	0 / 101	5	0 / 101	Reference Sp.
Styrene	0 / 78	µg/L	0.03	2	0.015	2.07	2.5	2.5	0.887	--	--	--	--	O	--	--	--	--	--	120	0 / 78	100	0 / 78	--
Tetrachloroethene	106 / 196	µg/L	0.044	2	0.022	1.23	0.9	5.66	0.931	0.1	1.35	5.66	0.974	G*	1.32	1.35	5.46	11	0 / 196	4.1	**1 / 196**	5	**1 / 196**	UA-1
Toluene	14 / 79	µg/L	0.042	2	0.021	0.701	0.4	4.76	0.951	0.1	1.1	4.76	1.31	G*	0.977	1.09	8.04	--	--	110	0 / 79	1000	0 / 79	SNS 2 Sp.
Total Xylene	3 / 75	µg/L	0.1	0.1	0.05	0.594	0.49	2.5	0.316	0.49	0.94	1.68	0.646	X*	0.916	1.06	1.68	--	--	19	0 / 75	10,000	0 / 75	Doug's Drip Sp.
Trichloroethene	117 / 192	µg/L	0.034	2	0.017	8.06	2	183	20.8	0.1	12.4	183	25.7	X*	12.6	14.6	42	0.49	**101 / 192**	0.28	**105 / 192**	5	**50 / 192**	TOMSSEEP
Trichlorofluoromethane	8 / 74	µg/L	0.26	0.26	0.13	0.564	0.4	2.5	0.248	0.4	0.77	1.2	0.268	G*	0.588	0.612	6.58	--	--	110	0 / 74	--	--	Bootlegger Sp.
Vinyl acetate	1 / 73	µg/L	0.18	0.18	0.09	4.28	5	5	1.74	1.2	1.2	1.2	--	X	4.89	5.16	1.2	--	--	41	0 / 73	--	--	Burns Cemetery Sp.

Table A.1. Summary statistics from second dataset (ORR area unfiltered groundwater) (cont.)

Constituent	Frequency of Detection	Units	Non-detect Detection Limits[a]		Min[b]	Mean[b]	Median[b]	Max[b]	S.D.[b]	Detected				Dist.[c]	UCL90	UCL95	UTL95/95	EPA Tap Water				MCL[e]	Frequency ≥ MCL[e]	Max Detected Station
			Min	Max						Min	Mean	Max	S.D.					RSL[d] TR=1E-6	Frequency ≥ TR=1E-6	RSL[d] HQ=0.1	Frequency ≥ HQ=0.1			
Vinyl chloride	12 / 63	µg/L	0.28	1	0.14	3.68	0.3	74.3	12.4	0.3	17.1	74.3	25.2	G*	7.38	9.07	24.1	0.019	**12 / 63**	4.4	**5 / 63**	2	**9 / 63**	TOMSSEEP
Volatile Organics	0 / 5	µg/L	0.21	0.21	0.105	0.105	0.105	0.105	0	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
cis-1,2-Dichloroethene	95 / 163	µg/L	0.032	2	0.016	13.3	1.5	494	63.4	0.1	22.0	494	82.4	X*	28.3	35.1	147	--	--	3.6	**22 / 163**	70	**7 / 163**	TOMSSEEP
cis-1,3-Dichloropropene	0 / 86	µg/L	0.042	2	0.021	2.11	2.5	2.5	0.852	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
n-Butylbenzene	0 / 10	µg/L	0.045	0.045	0.023	0.023	0.023	0.023	0	--	--	--	--	O	--	--	--	--	--	100	0 / 10	--	--	--
n-Propylbenzene	0 / 10	µg/L	0.037	0.037	0.019	0.019	0.019	0.019	0	--	--	--	--	O	--	--	--	--	--	66	0 / 10	--	--	--
sec-Butylbenzene	0 / 10	µg/L	0.035	0.035	0.018	0.018	0.018	0.018	0	--	--	--	--	O	--	--	--	--	--	200	0 / 10	--	--	--
t-Butanol	1 / 11	µg/L	4.4	4.4	2.2	3.29	2.2	14.2	3.62	14.2	14.2	14.2	--	X	6.56	8.05	--	--	--	--	--	--	--	RWA-111
tert-Butylbenzene	0 / 10	µg/L	0.038	0.038	0.019	0.019	0.019	0.019	0	--	--	--	--	O	--	--	--	--	--	69	0 / 10	--	--	--
trans-1,2-Dichloroethene	6 / 67	µg/L	0.038	2	0.019	0.574	0.1	7.79	1.58	0.1	4.26	7.79	3.71	G*	1.27	1.52	10.2	--	--	36	0 / 67	100	0 / 67	TOMSSEEP
trans-1,3-Dichloropropene	0 / 65	µg/L	0.08	2	0.04	1.98	2.5	2.5	0.941	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
trans-1,4-Dichloro-2-butene	0 / 51	µg/L	--	--	2.5	2.5	2.5	2.5	0	--	--	--	--	O	--	--	--	0.001	0 / 51	--	--	--	--	--
Radionuclides																								
Actinium-228	11 / 11	pCi/L	--	--	12.1	19.0	16.9	29.2	5.48	12.1	19.0	29.2	5.48	N	21.3	22.0	34.5	23.9	**2 / 11**	--	--	5	**11 / 11**	Cattail West Sp.
Alpha activity	366 / 945	pCi/L	0.06	17	-7.4	8.9	0.9	4727	154	0.2	22.7	4727	248	X	24.0	30.8	20.8	--	--	--	--	15	**50 / 945**	Bear Creek North Seep
Americium-241	0 / 11	pCi/L	0.1	1.35	-0.12	0.102	0.069	0.55	0.18	--	--	--	--	N	0.176	0.2	0.607	0.458	0 / 11	--	--	15	0 / 11	--
Beryllium-7	1 / 1	pCi/L	--	--	23.6	23.6	23.6	23.6	--	23.6	23.6	23.6	--	X	--	23.6	--	550	0 / 1	--	--	6000	0 / 1	Edwards Sp.
Beta activity	501 / 944	pCi/L	0.8	17	-5.26	14.2	2.2	4928	202	0.8	26.0	4928	276	X	33.9	42.8	31.6	--	--	--	--	--	--	N.W. Trib Sp. 1
Bismuth-212	4 / 4	pCi/L	--	--	34	46.3	36.6	78	21.3	34	46.3	78	21.3	X	78.2	92.6	--	67.1	**1 / 4**	--	--	5	**4 / 4**	RWA-117
Bismuth-214	675 / 677	pCi/L	--	--	0	73.4	51	490	67.5	5.6	73.6	490	67.5	X	81.2	84.7	236	248	**23 / 677**	--	--	5	**675 / 677**	CCC well #1
Carbon-14	2 / 12	pCi/L	9.6	15.4	-7	0.292	-1.7	8.4	5.07	7.4	7.9	8.4	0.707	N	2.29	2.92	14.2	1.29	**2 / 12**	--	--	2000	0 / 12	RWA-88
Curium-243/244	1 / 9	pCi/L	0.095	0.89	-0.042	0.06	0.04	0.22	0.092	0.22	0.22	0.22	--	N	0.103	0.117	0.339	0.503	0 / 9	--	--	15	0 / 9	RWA-63
Gamma Radionuclides	0 / 1	pCi/L	9	9	9	9	9	9	--	--	--	--	--	X	--	9	--	--	--	--	--	--	--	--
Lead-210	5 / 5	pCi/L	--	--	99	116	116	133	12.5	99	116	133	12.5	X	133	140	--	0.054	**5 / 5**	--	--	5	**5 / 5**	Doug's Drip Sp.
Lead-212	20 / 20	pCi/L	--	--	4.33	12.2	10.5	29	5.46	4.33	12.2	29	5.46	L	14.0	14.6	29.5	1.9	**20 / 20**	--	--	5	**19 / 20**	RWA-100
Lead-214	599 / 600	pCi/L	--	--	7.7	70.6	49.5	512	65.8	7.7	70.7	512	65.8	X	78.6	82.3	235	138	**70 / 600**	--	--	5	**599 / 600**	CCC well #1
Neptunium-237	1 / 11	pCi/L	0.119	0.48	-0.18	######	0.024	0.061	0.083	0.061	0.061	0.061	--	L	0.047	0.051	0.137	0.771	0 / 11	--	--	15	0 / 11	RWA-76
Plutonium-238	0 / 11	pCi/L	0.068	0.74	-0.024	0.014	0.015	0.075	0.029	--	--	--	--	N	0.026	0.03	0.096	0.364	0 / 11	--	--	15	0 / 11	--
Plutonium-239/240	0 / 11	pCi/L	0.043	0.74	-0.111	0.01	0.015	0.087	0.049	--	--	--	--	N	0.03	0.037	0.148	0.353	0 / 11	--	--	15	0 / 11	--
Potassium-40	7 / 7	pCi/L	--	--	42	80.9	69	172	42.5	42	80.9	172	42.5	L	109	123	324	1.93	**7 / 7**	--	--	11	**7 / 7**	Bear Creek North Seep
Radium-226	8 / 15	pCi/L	0.256	0.74	-1.2	0.395	0.25	2.33	0.81	0.14	0.859	2.33	0.766	N	0.677	0.764	2.47	8.2E-04	**8 / 15**	--	--	5	0 / 15	RWA-72
Radium-228	6 / 11	pCi/L	1.52	2.21	-1.28	0.797	0.1	7.56	2.4	0.1	1.95	7.56	2.78	L	9.12	16.9	130	0.046	**6 / 11**	--	--	5	**1 / 11**	RWA-118
Strontium	0 / 3	pCi/L	--	--	-5.99	-4.49	-5.79	-1.7	2.42	--	--	--	--	X	-3.06	-3.06	--	--	--	--	--	8	0 / 3	--
Strontium-89	68 / 259	pCi/L	-0.14	0.6	-1.8	0.093	-0.01	10	1.08	0.02	0.528	6.3	0.829	X	0.294	0.384	1.6	3.72	**1 / 259**	--	--	20	0 / 259	Sycamore Sp.
Strontium-90	100 / 264	pCi/L	-0.26	19	-2.61	0.303	0.08	21.8	1.83	0.02	0.88	21.8	2.85	X	0.641	0.794	2	0.852	**8 / 264**	--	--	8	**3 / 264**	Sycamore Sp.
Technetium-99	100 / 224	pCi/L	0.46	60	-38	1.98	0.545	58.3	7.05	0.49	4.57	58.3	9.16	X	3.39	4.03	22.1	17.3	**8 / 224**	--	--	900	0 / 224	SS-4 Spring
Thallium-208	20 / 20	pCi/L	--	--	3.28	21.3	5.5	316	69.4	3.28	21.3	316	69.4	X	67.9	89.0	--	--	--	--	--	5	**14 / 20**	Terry's Sp.
Thorium	0 / 1	pCi/L	--	--	-0.22	-0.22	-0.22	-0.22	--	--	--	--	--	X	--	-0.22	--	--	--	--	--	15	0 / 1	--
Thorium-228	2 / 7	pCi/L	0.21	0.3	0.021	0.084	0.09	0.17	0.048	0.1	0.135	0.17	0.049	N	0.11	0.119	0.247	0.445	0 / 7	--	--	15	0 / 7	UA-2
Thorium-230	6 / 7	pCi/L	0.37	0.37	0.13	0.326	0.34	0.52	0.14	0.15	0.358	0.52	0.121	N	0.402	0.429	0.803	0.523	0 / 7	--	--	15	0 / 7	RWA-76
Thorium-232	2 / 7	pCi/L	0.16	0.27	0.021	0.067	0.058	0.12	0.035	0.1	0.11	0.12	0.014	N	0.086	0.093	0.185	0.471	0 / 7	--	--	15	0 / 7	RWA-63

Table A.1. Summary statistics from second dataset (ORR area unfiltered groundwater) (cont.)

Constituent	Frequency of Detection	Units	Non-detect Detection Limits[a]		Min[b]	Mean[b]	Median[b]	Max[b]	S.D.[b]	Detected				Dist.[c]	UCL90	UCL95	UTL95/95	EPA Tap Water				MCL[e]	Frequency ≥ MCL[e]	Max Detected Station
			Min	Max						Min	Mean	Max	S.D.					RSL[d] TR=1E-6	Frequency ≥ TR=1E-6	RSL[d] HQ=0.1	Frequency ≥ HQ=0.1			
Thorium-234	1 / 1	pCi/L	--	--	2260	2260	2260	2260	--	2260	2260	2260	--	X	--	2260	--	2.06	**1 / 1**	--	--	15	**1 / 1**	Bear Creek North Seep
Tritium	234 / 617	pCi/L	56	534	-191	79.3	36	1610	164	42	215	1610	192	X	99.1	108	397	--	--	--	--	20,000	0 / 617	Regina Loves Bobby Sp.
Uranium	1 / 4	pCi/L	--	--	0	1.04	0.235	3.7	1.78	3.7	3.7	3.7	--	X	3.71	4.93	--	--	--	--	--	30	0 / 4	Green Barn Sp.
Uranium-233/234	2 / 2	pCi/L	--	--	0.67	0.675	0.675	0.68	0.007	0.67	0.675	0.68	0.007	X	0.69	0.697	--	0.663	**2 / 2**	--	--	15	0 / 2	BF-003
Uranium-234	67 / 103	pCi/L	0.089	0.44	-1.3	0.434	0.199	10	1.18	0.085	0.664	10	1.39	L	0.549	0.583	2.12	0.674	**12 / 103**	--	--	15	0 / 103	SS-4 Spring
Uranium-235	20 / 102	pCi/L	0.051	0.44	-0.41	1.66	0.033	163	16.1	0.037	8.32	163	36.3	X	6.44	8.61	0.93	0.684	**2 / 102**	--	--	15	**1 / 102**	Bear Creek North Seep
Uranium-236	0 / 2	pCi/L	0.19	0.23	-0.036	-0.009	-0.009	0.019	0.039	--	--	--	--	X	0.074	0.111	--	0.711	0 / 2	--	--	15	0 / 2	--
Uranium-238	46 / 100	pCi/L	0.068	0.41	-0.434	0.463	0.09	19	2.07	0.066	0.911	19	3.01	X	1.09	1.37	8.17	0.744	**6 / 100**	--	--	15	**1 / 100**	SS-4 Spring
Wet Chemistry																								
Acidity	7 / 13	mg/L	0.7	0.7	0.35	5.77	4	10	2.45	4	7.29	10	2.69	G*	9.6	12.7	36.0	--	--	--	--	--	--	UA-1
Acidity as CaCO3	24 / 24	mg/L	--	--	4	14.9	11.5	46	11.9	4	14.9	46	11.9	L	18.3	19.6	54.1	--	--	--	--	--	--	Bootlegger Sp.
Alkalinity	219 / 219	mg/L	--	--	16	202	183	941	116	16	202	941	116	X	225	236	480	--	--	--	--	--	--	PLC well
Alkalinity as CO3	0 / 76	mg/L	--	--	0.5	0.737	0.5	5	1.01	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
Alkalinity as CaCO3	265 / 265	mg/L	--	--	4	164	163	380	59.0	4	164	380	59.0	X	175	180	282	--	--	--	--	--	--	PCO Seep
Alkalinity as HCO3	53 / 53	mg/L	--	--	42.2	126	124	248	48.3	42.2	126	248	48.3	N	134	137	225	--	--	--	--	--	--	SCR5.4SP
Ammonia	7 / 17	mg/L	0.033	0.033	0.017	0.054	0.053	0.11	0.018	0.039	0.059	0.11	0.025	G*	0.062	0.065	0.121	--	--	--	--	--	--	SS-2 Spring
Bicarbonate	1 / 1	mg/L	--	--	76	76	76	76	--	76	76	76	--	D	--	--	--	--	--	--	--	--	--	SCR4.3SP
Carbonate	0 / 2	mg/L	--	--	0.5	0.5	0.5	0.5	0	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
Cyanide	0 / 1	mg/L	0.03	0.03	0.015	0.015	0.015	0.015	--	--	--	--	--	O	--	--	--	--	--	1.5E-04	0 / 1	0.2	0 / 1	--
Dissolved Solids	162 / 162	mg/L	--	--	27	210	184	679	117	27	210	679	117	X	238	251	567	--	--	--	--	--	--	RWA-117
Phosphate, total	9 / 9	mg/L	--	--	0.005	0.041	0.007	0.15	0.05	0.005	0.041	0.15	0.05	X	0.092	0.115	--	--	--	97	0 / 9	--	--	21002 Sp. B
Suspended Solids	61 / 91	mg/L	10	10	0.5	66.2	2	1640	276	1	98.3	1640	335	X*	154	193	1640	--	--	--	--	--	--	BF-005
Total Residue	14 / 14	mg/L	--	--	114	214	178	697	148	114	214	697	148	X	332	386	--	--	--	--	--	--	--	Cedar Sp.
Total Solids	3 / 3	mg/L	--	--	95	155	152	217	61.0	95	155	217	61.0	D	--	--	--	--	--	--	--	--	--	USGS 8-900 Sp.

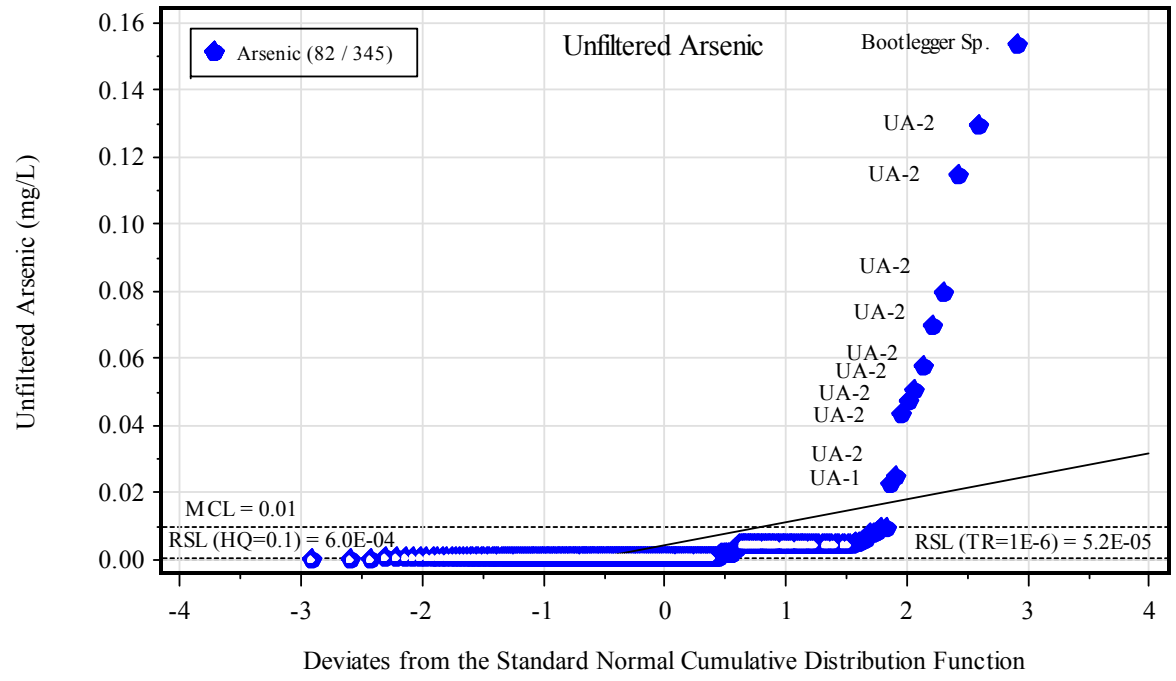
Bold value indicates exceedance of a screening criterion.

[a]One half of the detection limits shown are used as proxy values for non-detected organics and inorganics. The radionuclide results were used as reported whether detected or not.
[b]This summary statistic is calculated using both detects and proxy values for non-detects.
[c]Dist. = distribution. Distribution flags are defined as:
D = UCL90 and UCL95 were not calculated with fewer than 3 samples.
G = gamma. UCL90 and UCL95 were calculated using either the adjusted or unadjusted gamma.
L = lognormal. UCL90 and UCL95 were calculated using Land's statistic, Chebyshev minimum variance unbiased estimator, or nonparametric Chebyshev inequality method.
N = normal. UCL90 and UCL95 were calculated using t statistic.
O = no detected results to calculate some summary statistics.
X = neither normal, lognormal nor gamma. UCL90 and UCL95 were calculated using a nonparametric bootstrap or the nonparametric Chebyshev inequality method.
*Kaplan-Meier estimates of the mean, median and standard deviation are shown for organics and inorganics with at least one non-detect and two distinct detected results.
[d]EPA RSL for tap water from May 2014 (*http://www.epa.gov/region9/superfund//prg/index.html*) for organics and inorganics. EPA PRGs (*http://epa-prgs.ornl.gov/radionuclides/download.html*) for radionuclides.
[e]EPA MCL from May 2014 (*http://www.epa.gov/region9/superfund//prg/index.html*) for inorganics. 40 CFR 141.66 (December 7, 2000) and *National Interim Primary Drinking Water Regulations* (EPA 570/9-76-003) for radionuclides.

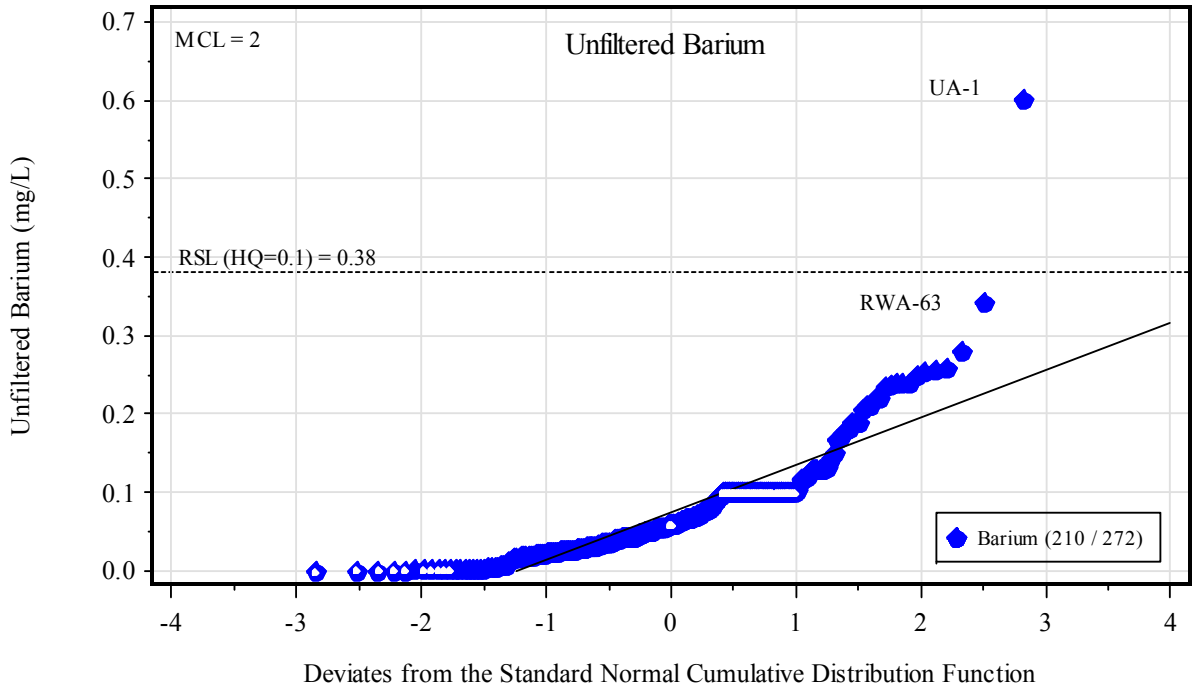
EPA = U.S. Environmental Protection Agency
HQ = hazard quotient
MCL = maximum contaminant level
Max = maximum
Min = minimum
ORR = Oak Ridge Reservation
PRG = preliminary remediation goal
RSL = Regional Screening Level
S.D. = standard deviation
TR = target risk

Table A.1. Summary statistics from second dataset (ORR area unfiltered groundwater) (cont.)

UCL90 = upper confidence limit on the mean concentration with 90% confidence using both detects and non-detects
UCL95 = upper confidence limit on the mean concentration with 95% confidence using both detects and non-detects
UTL95/95 = upper tolerance limit on the maximum concentration with 95% confidence and 95% coverage using both detects and non-detects
-- = Not applicable, not available or insufficient data to calculate the statistic

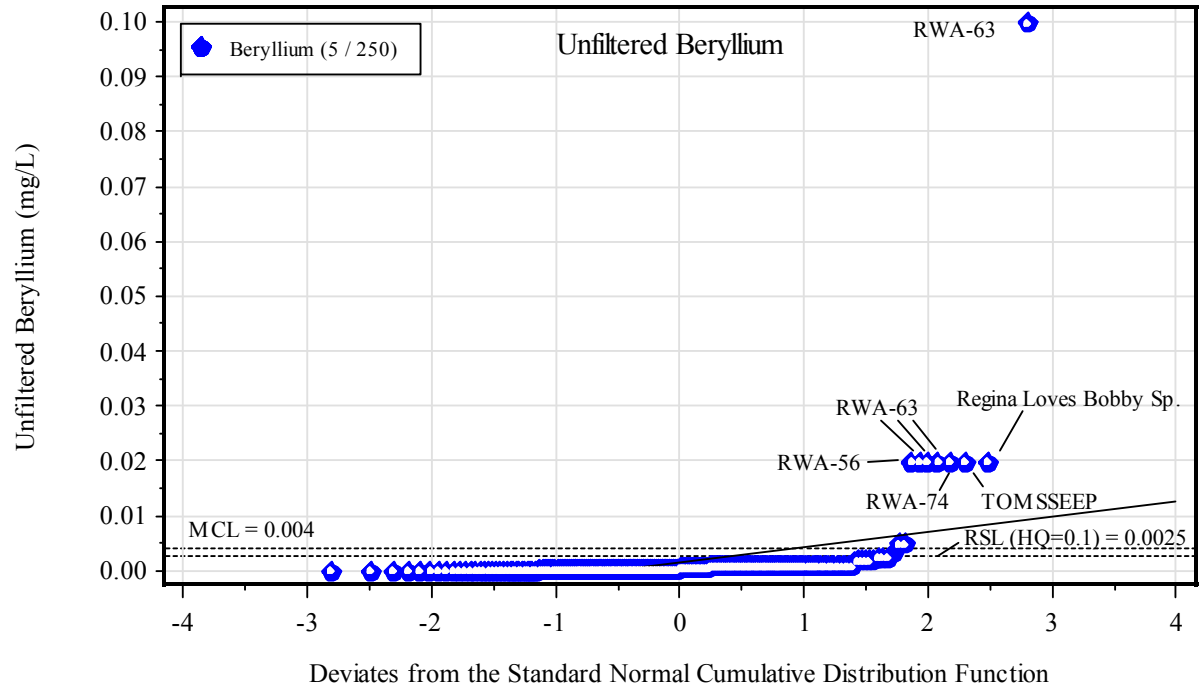


Hollow symbols denote the detection limit was used for non-detects.

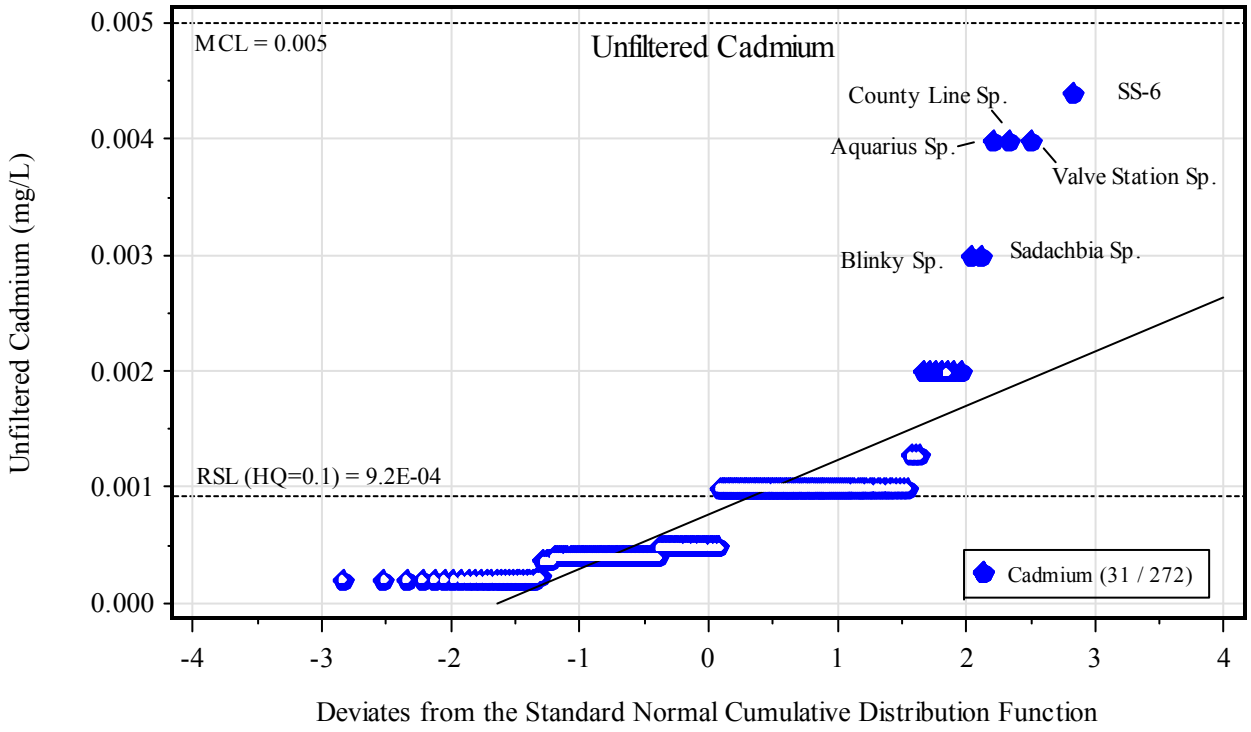


Hollow symbols denote the detection limit was used for non-detects.

Figure A.1. Normal probability plots of unfiltered arsenic and barium (second dataset).

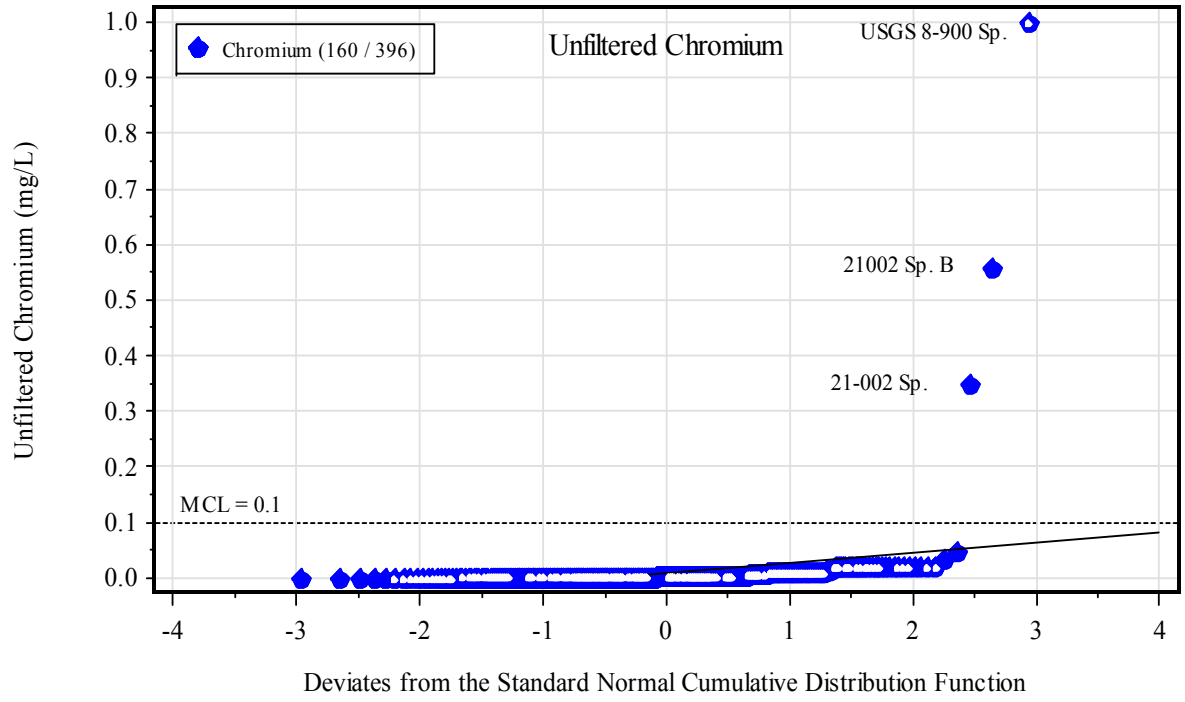


Hollow symbols denote the detection limit was used for non-detects.

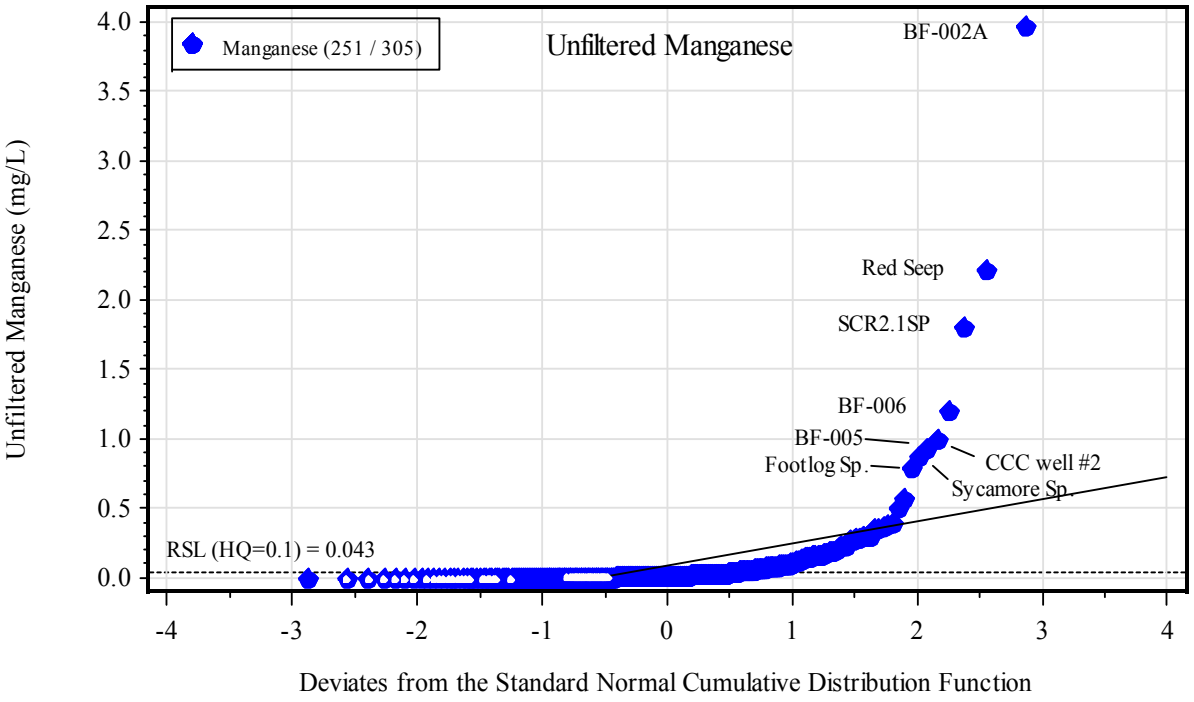


Hollow symbols denote the detection limit was used for non-detects.

Figure A.2. Normal probability plots of unfiltered beryllium and cadmium (second dataset).

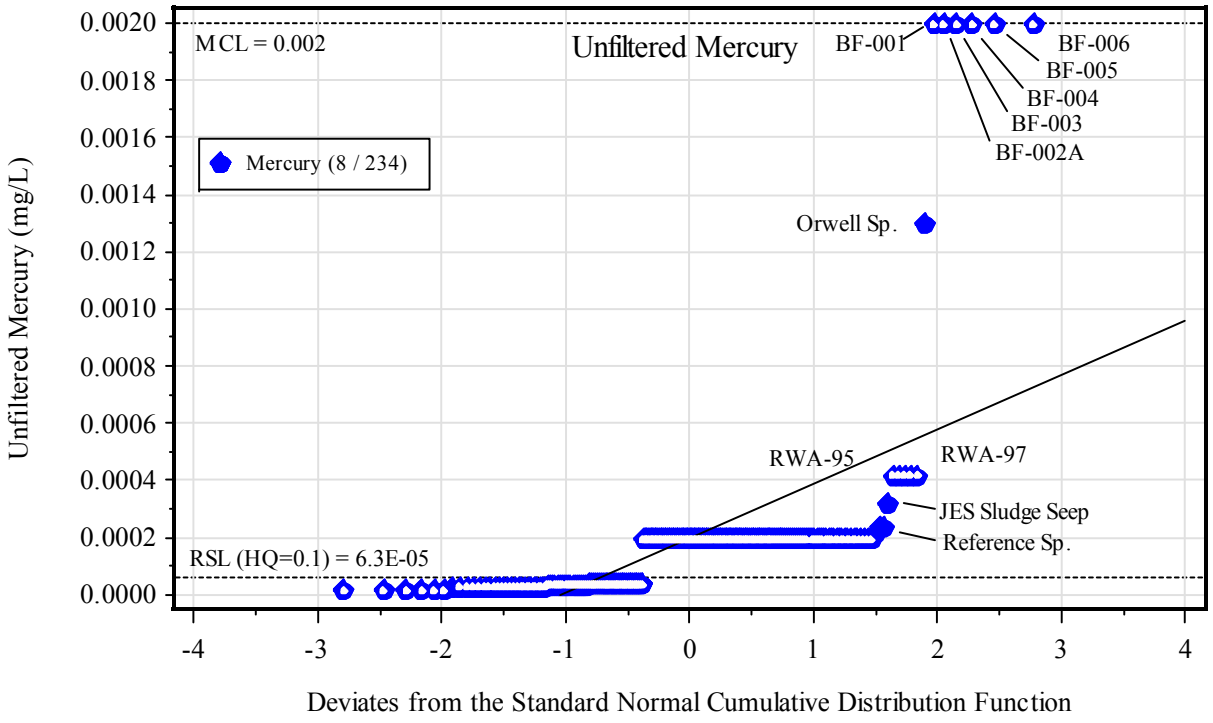


Hollow symbols denote the detection limit was used for non-detects.

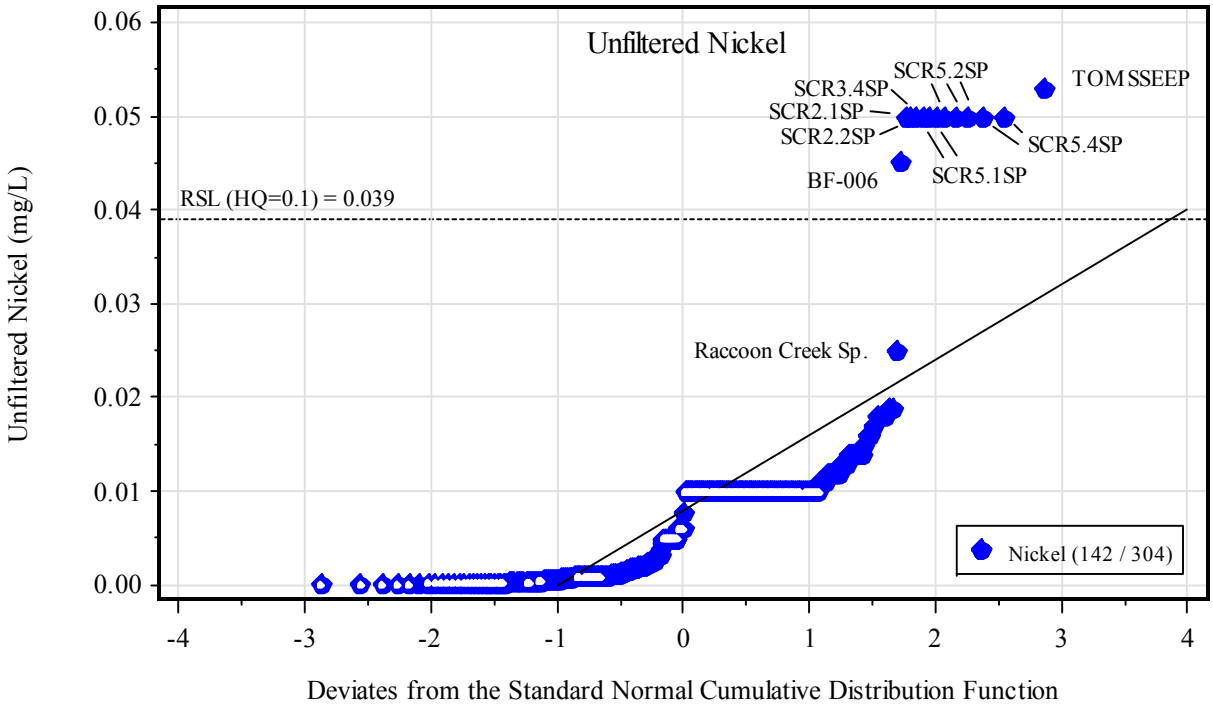


Hollow symbols denote the detection limit was used for non-detects.

Figure A.3. Normal probability plots of unfiltered chromium and manganese (second dataset).

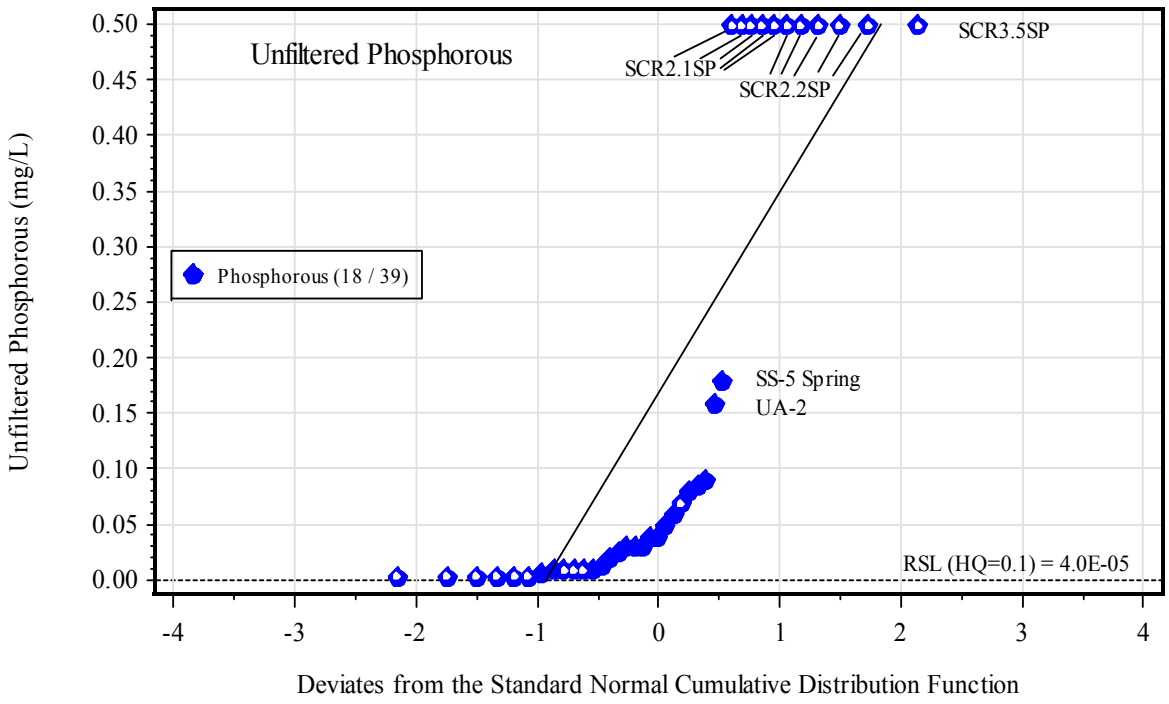


Hollow symbols denote the detection limit was used for non-detects.

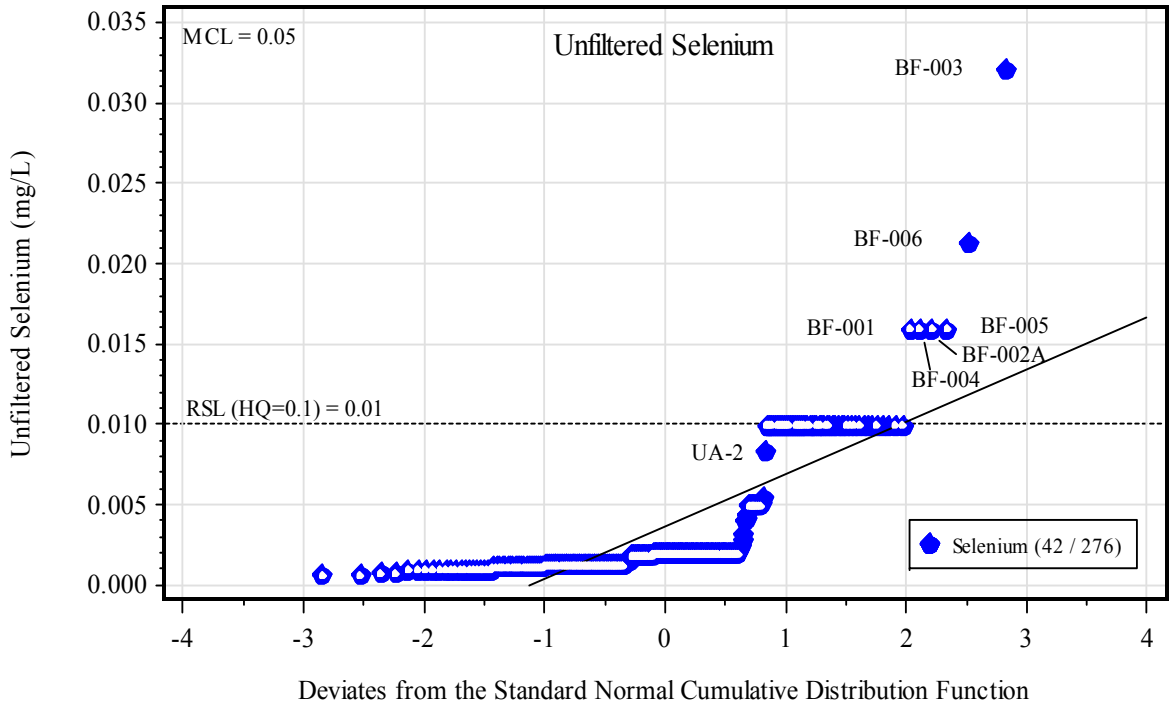


Hollow symbols denote the detection limit was used for non-detects.

Figure A.4. Normal probability plots of unfiltered mercury and nickel (second dataset).

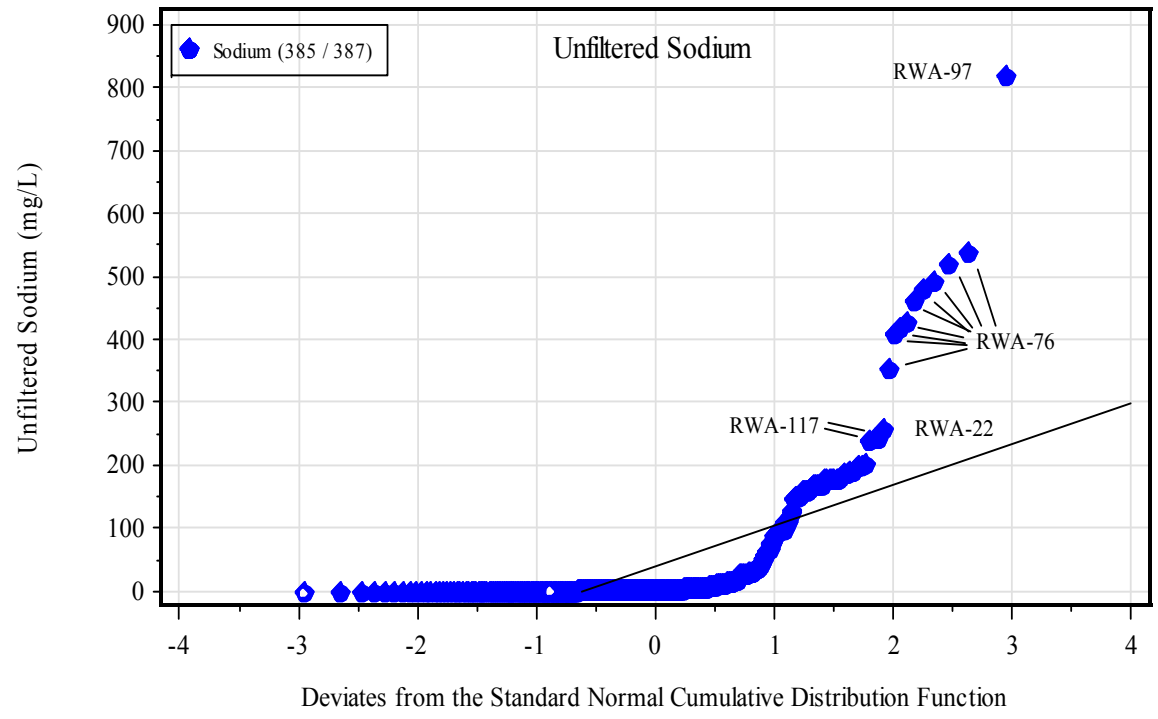


Hollow symbols denote the detection limit was used for non-detects.

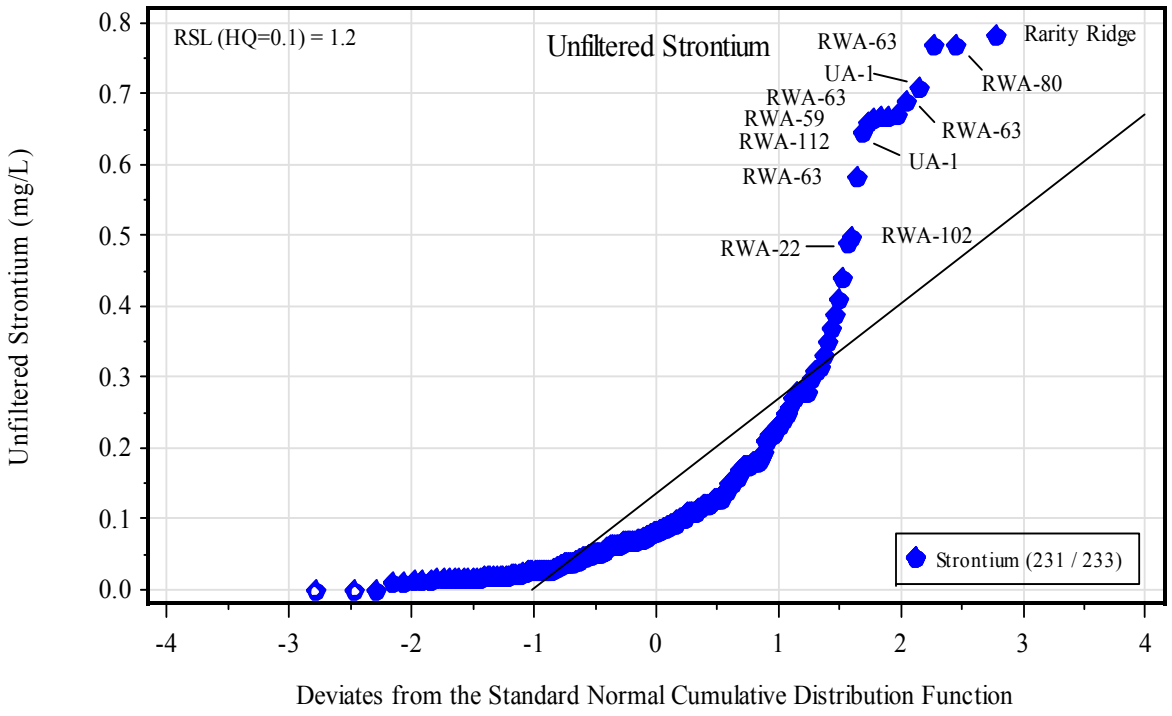


Hollow symbols denote the detection limit was used for non-detects.

Figure A.5. Normal probability plots of unfiltered phosphorous and selenium (second dataset).

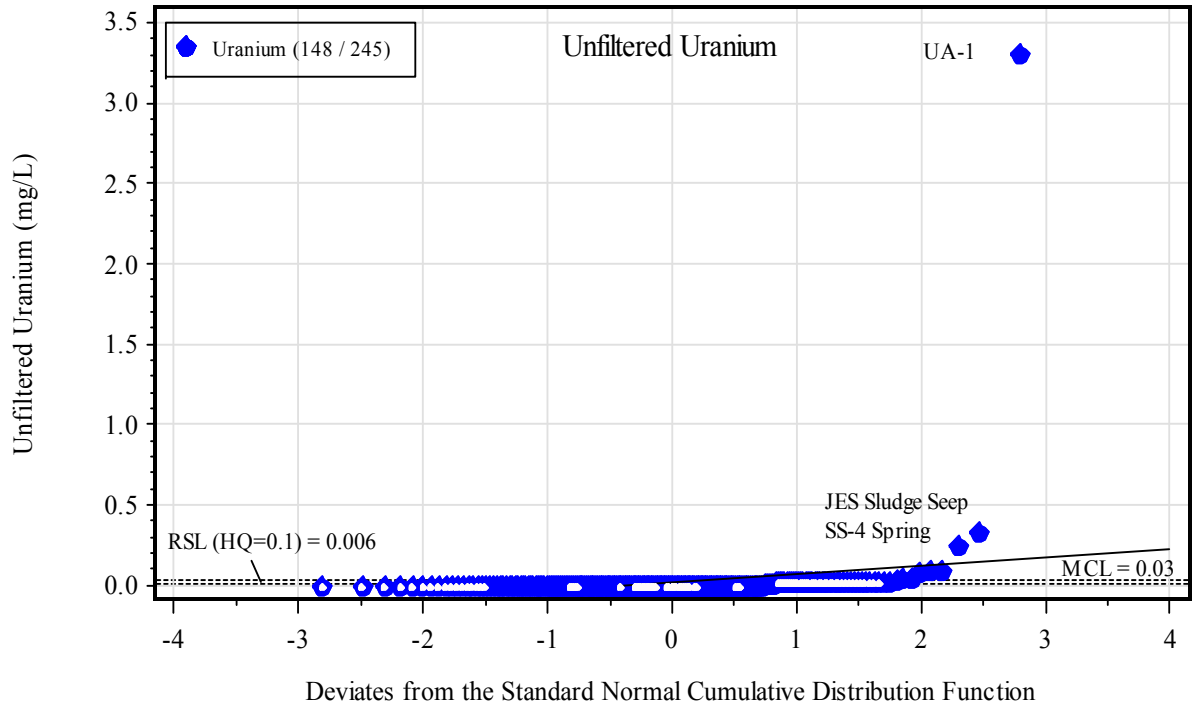


Hollow symbols denote the detection limit was used for non-detects.

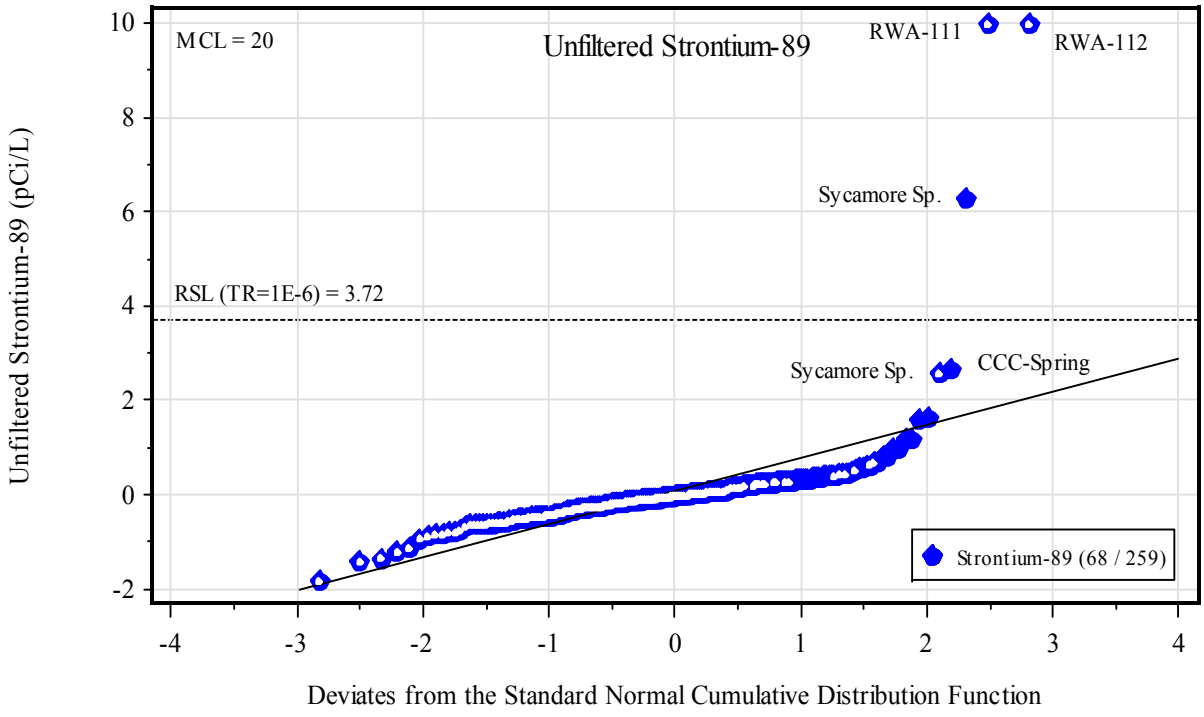


Hollow symbols denote the detection limit was used for non-detects.

Figure A.6. Normal probability plots of unfiltered sodium and strontium (second dataset).

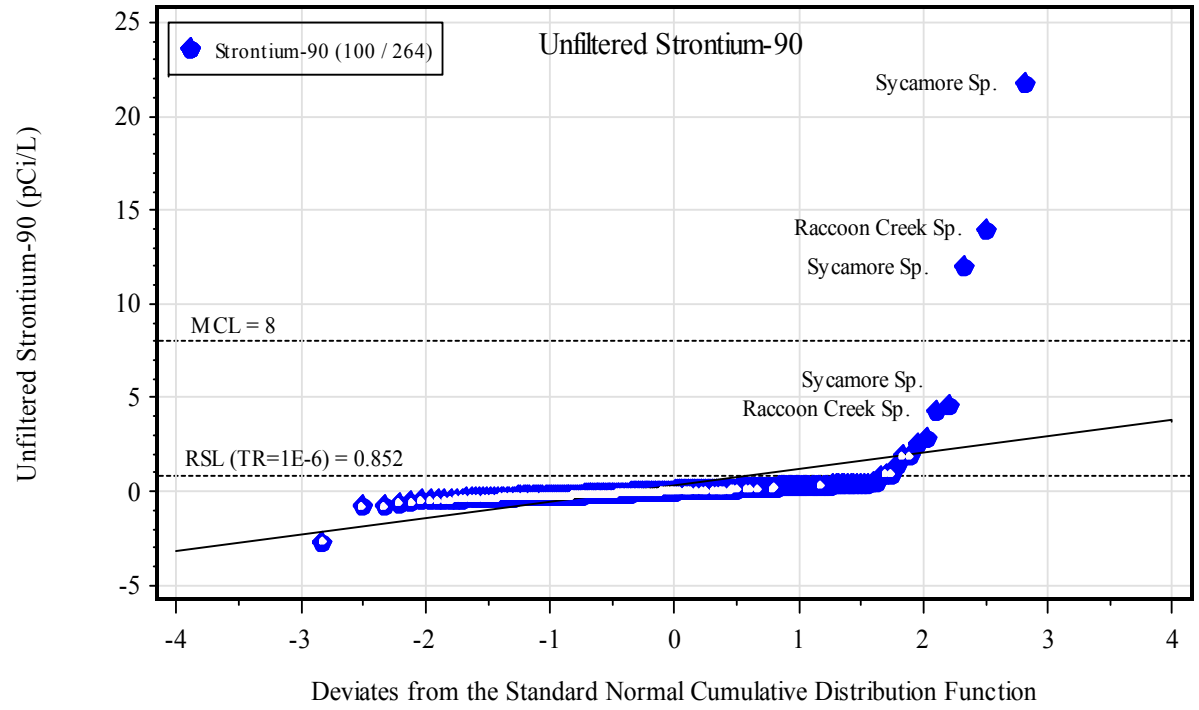


Hollow symbols denote the detection limit was used for non-detects.

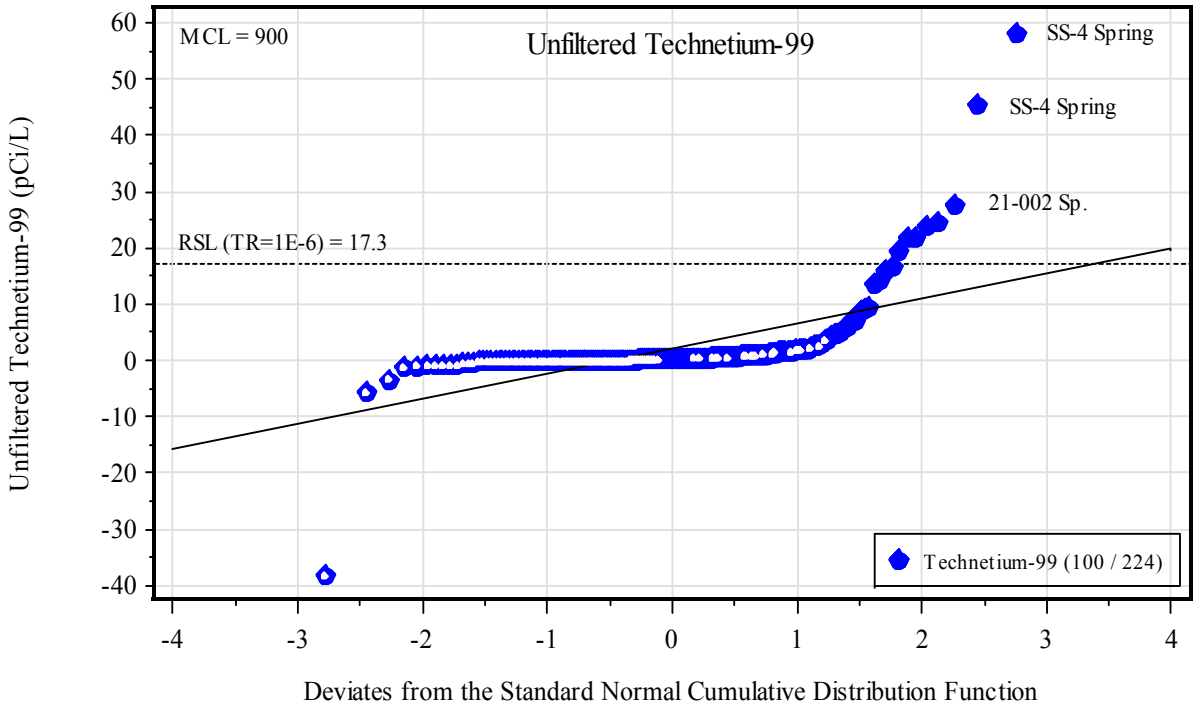


Hollow symbols denote the concentration was not detected.

Figure A.7. Normal probability plots of unfiltered uranium and strontium-89 (second dataset).

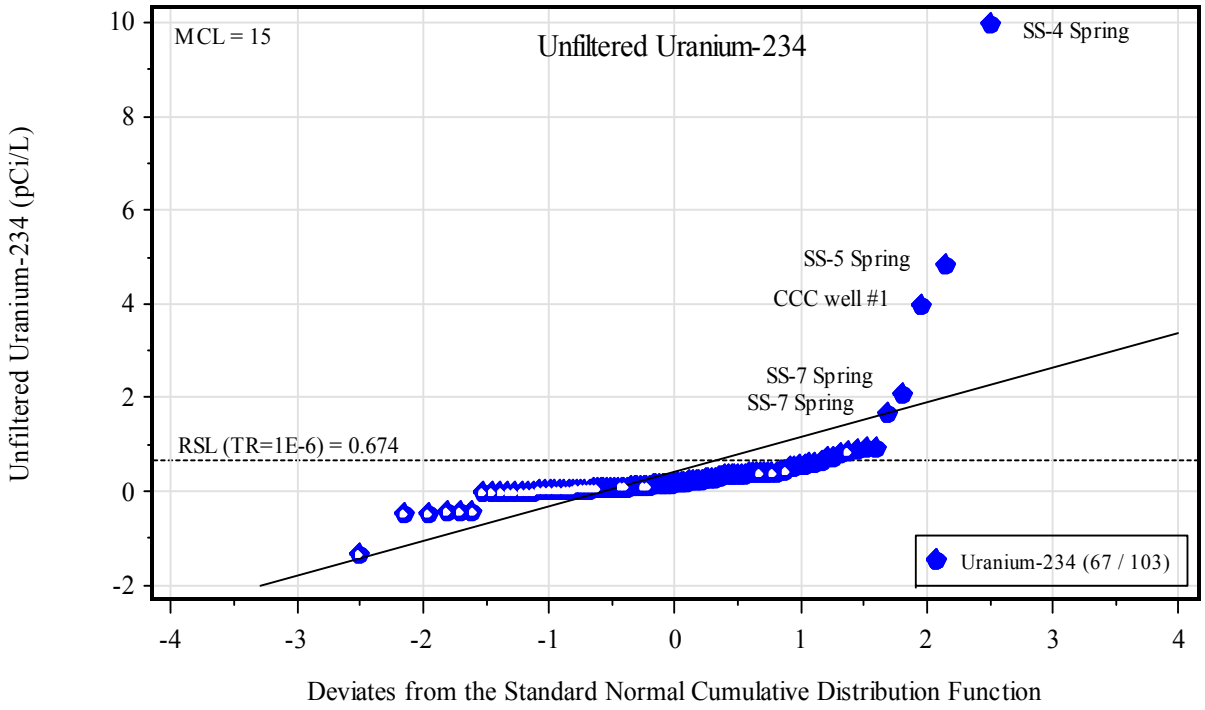


Hollow symbols denote the concentration was not detected.

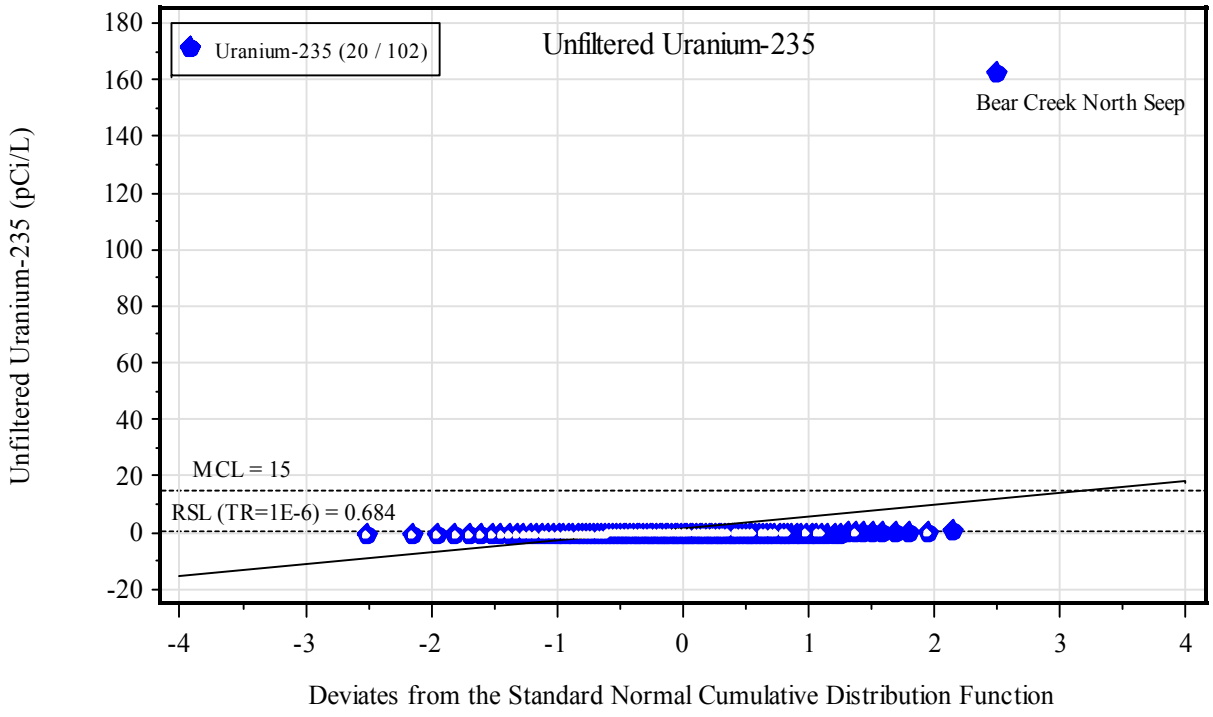


Hollow symbols denote the concentration was not detected.

Figure A.8. Normal probability plots of unfiltered strontium-90 and technetium-99 (second dataset).

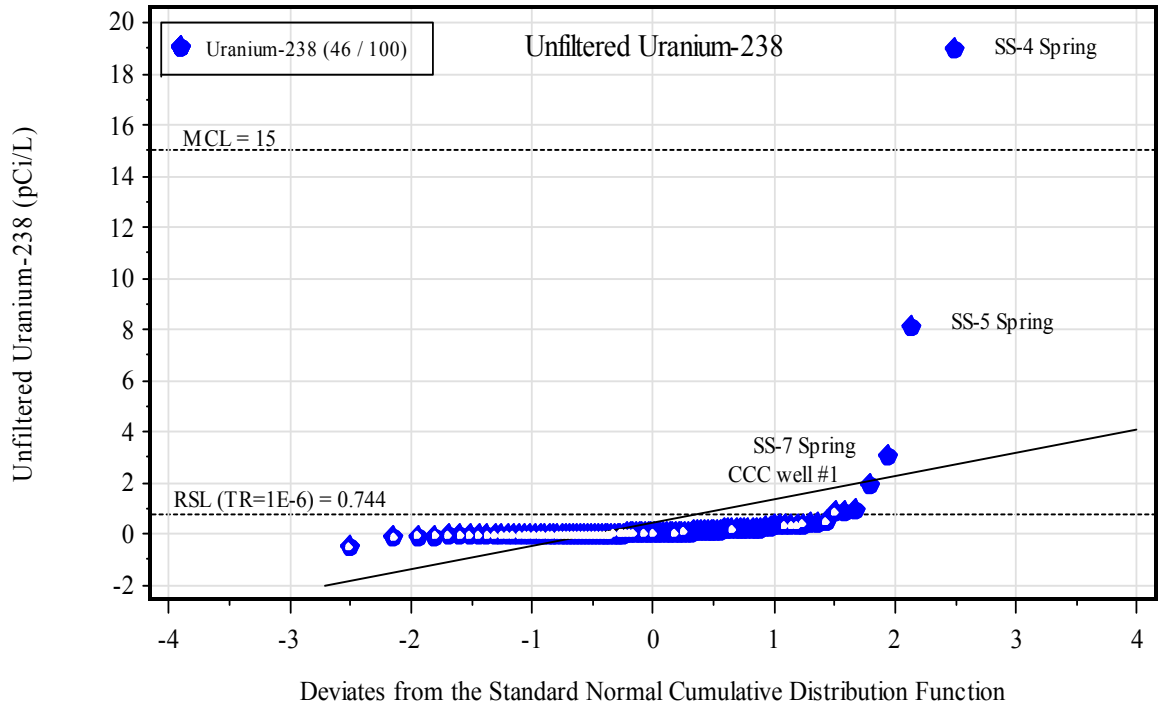


Hollow symbols denote the concentration was not detected.

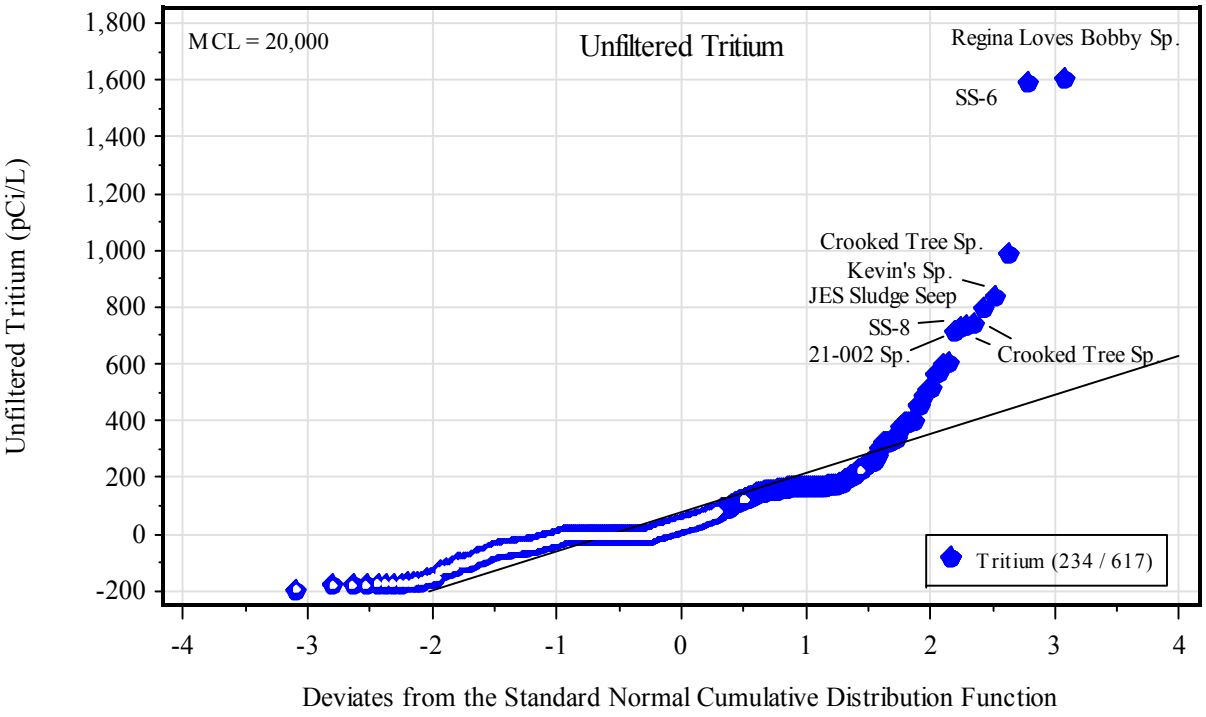


Hollow symbols denote the concentration was not detected.

Figure A.9. Normal probability plots of unfiltered uranium-234 and uranium-235 (second dataset).

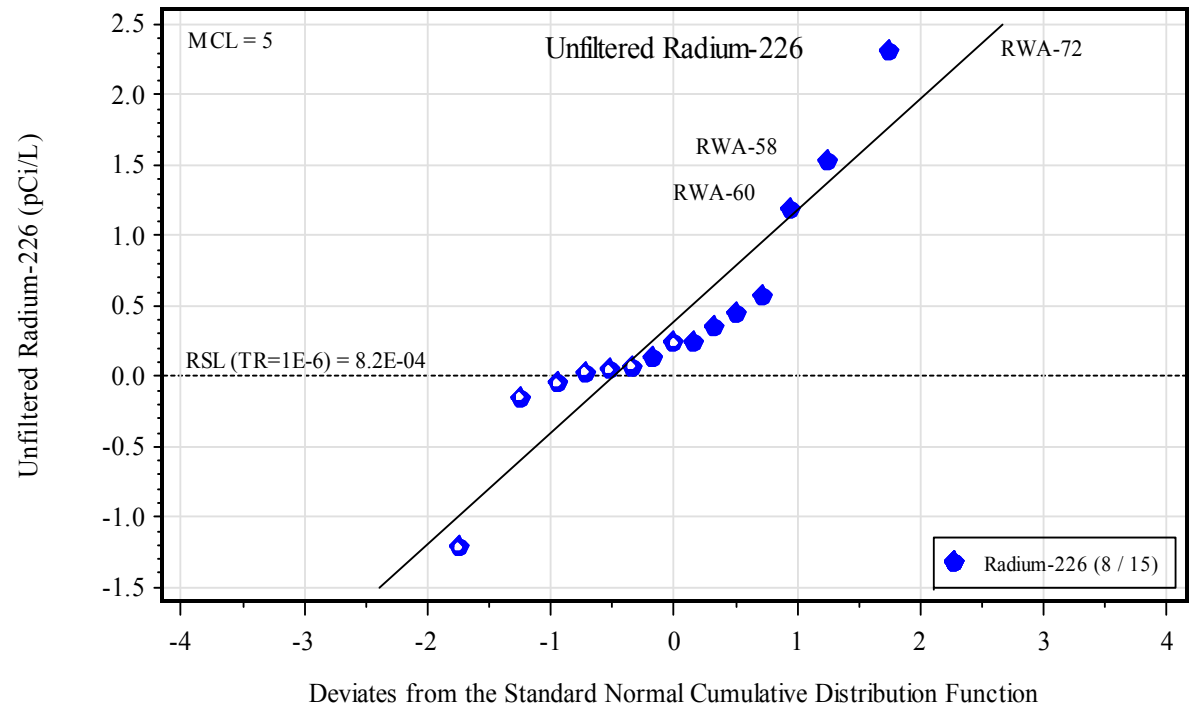


Hollow symbols denote the concentration was not detected.

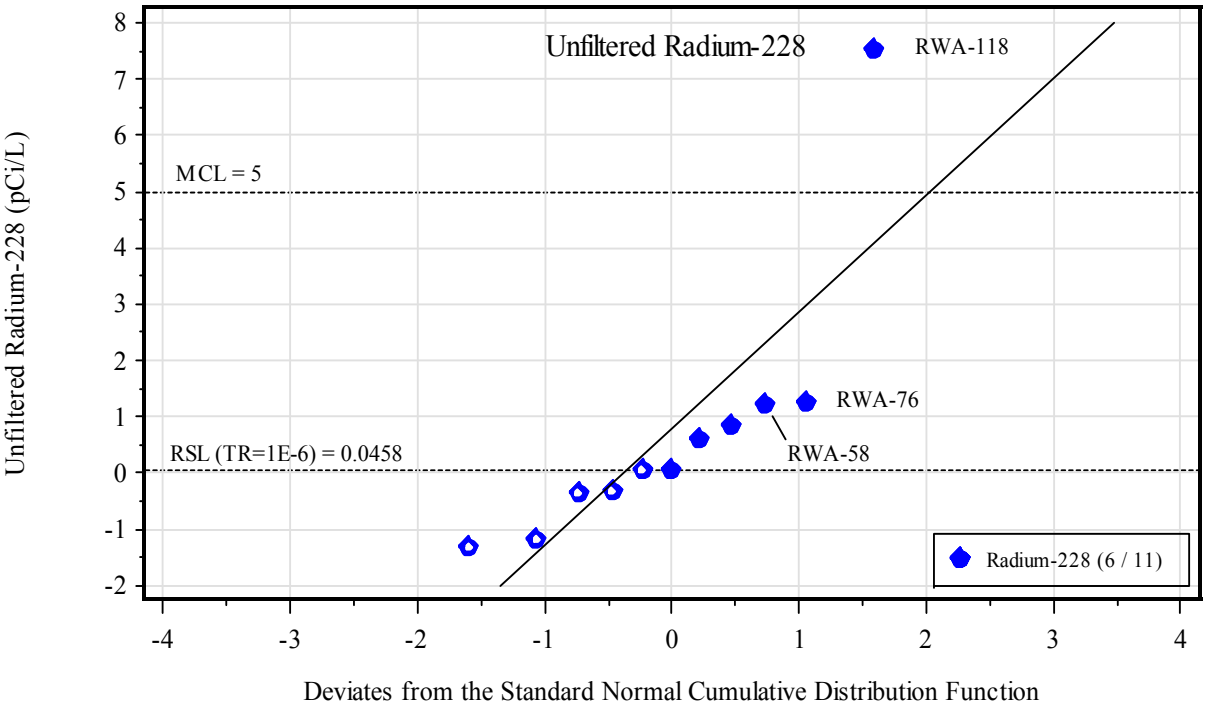


Hollow symbols denote the concentration was not detected.

Figure A.10. Normal probability plots of unfiltered uranium-238 and tritium (second dataset).



Hollow symbols denote the concentration was not detected.



Hollow symbols denote the concentration was not detected.

Figure A.11. Normal probability plots of unfiltered radium-226 and radium-228 (second dataset).

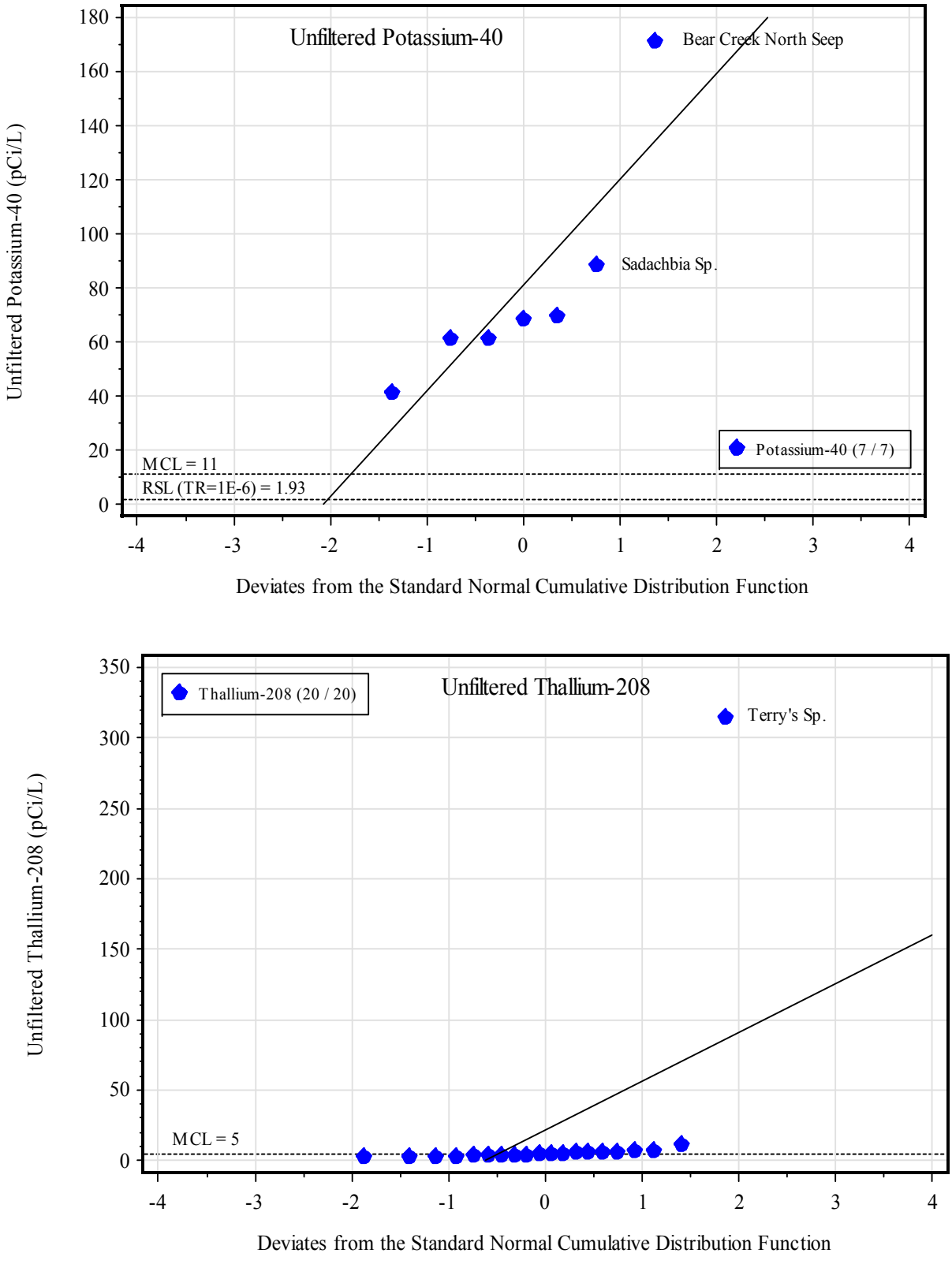
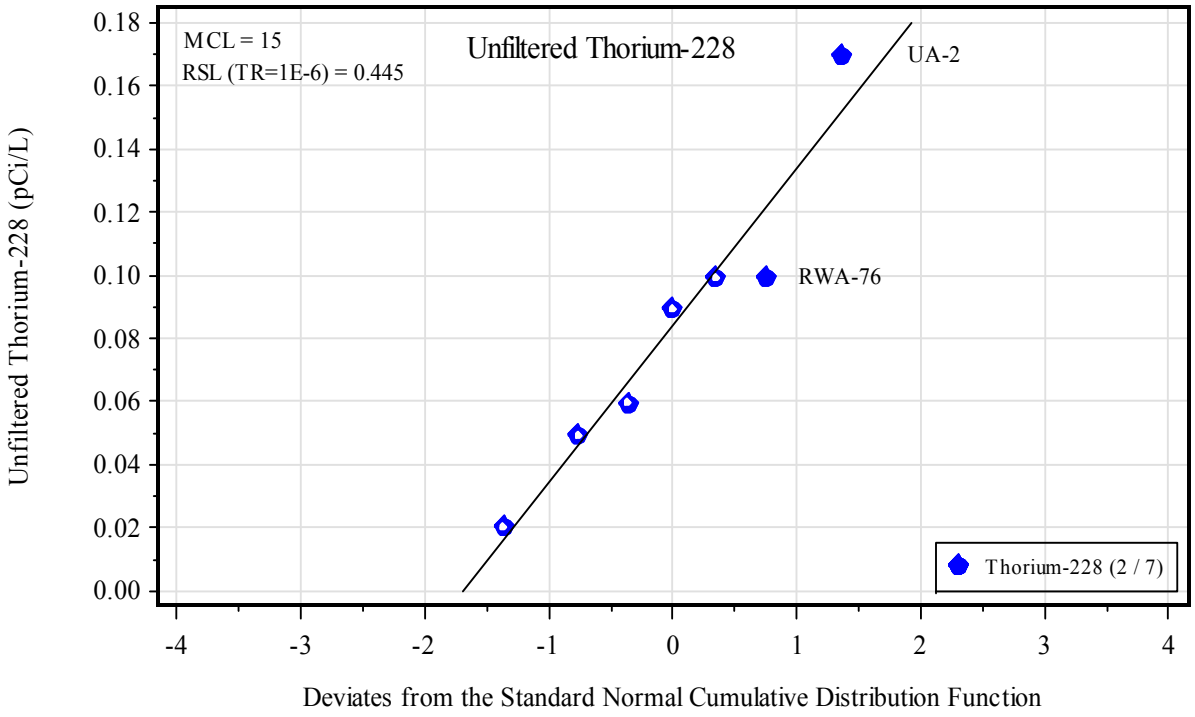
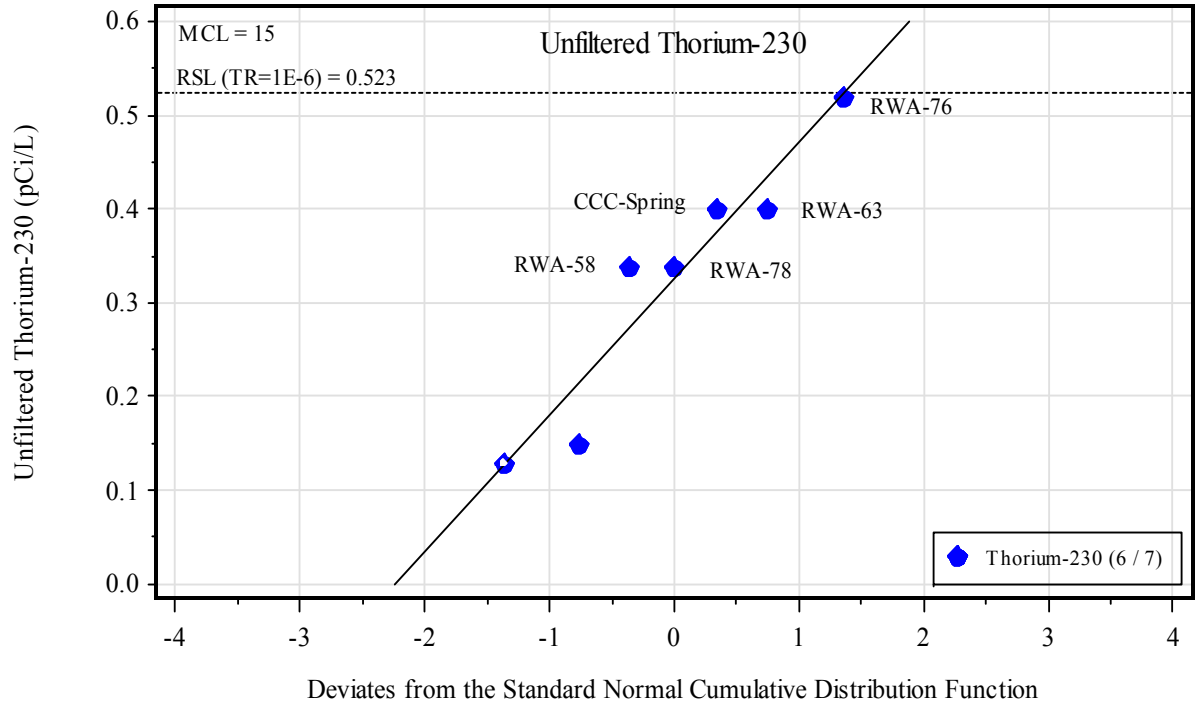


Figure A.12. Normal probability plots of unfiltered potassium-40 and thallium-208 (second dataset).

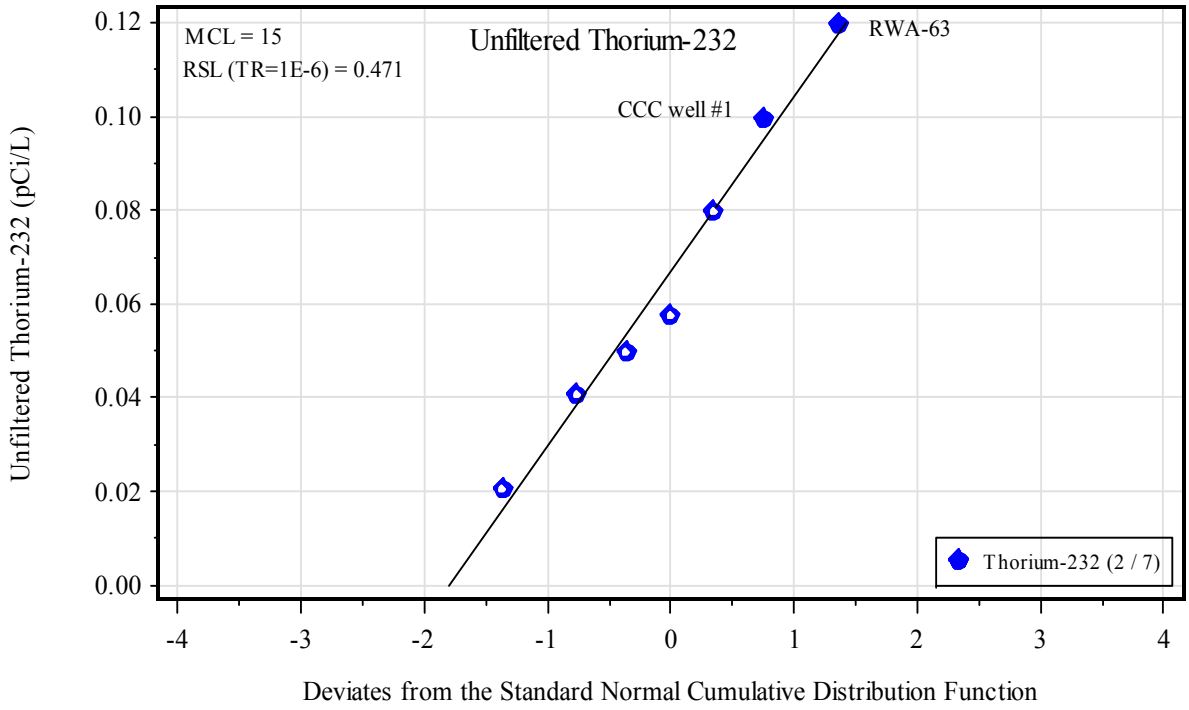


Hollow symbols denote the concentration was not detected.

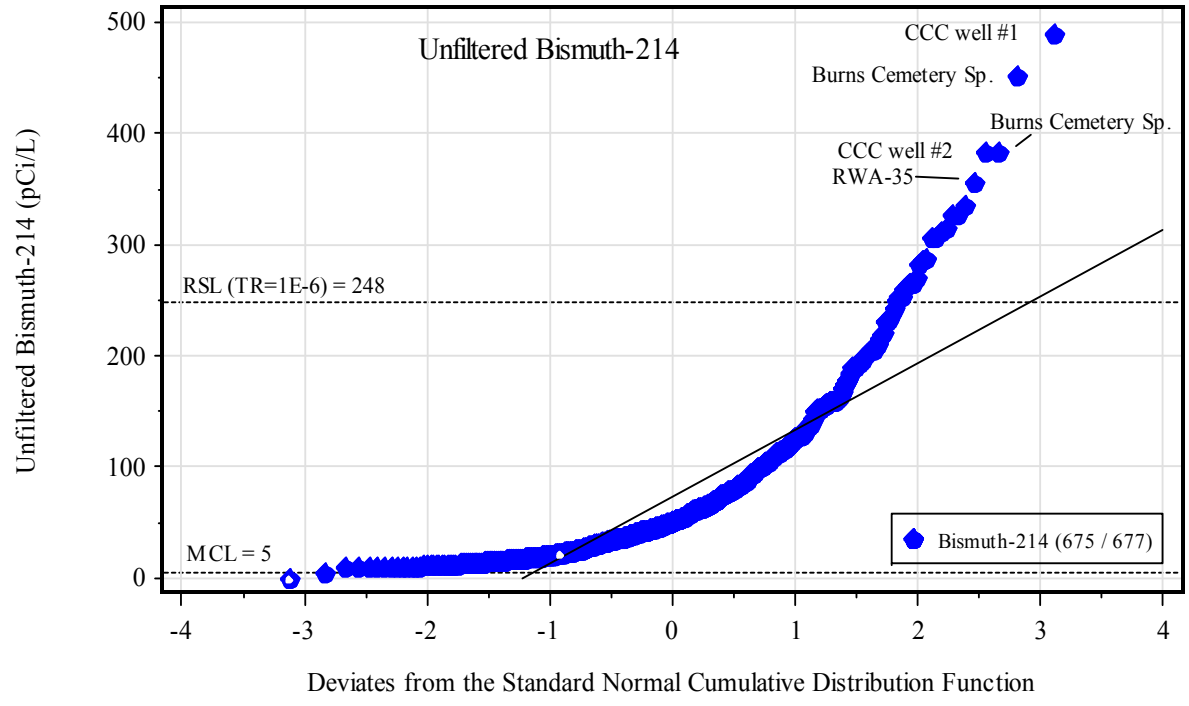


Hollow symbols denote the concentration was not detected.

Figure A.13. Normal probability plots of unfiltered thorium-228 and thorium-230 (second dataset).

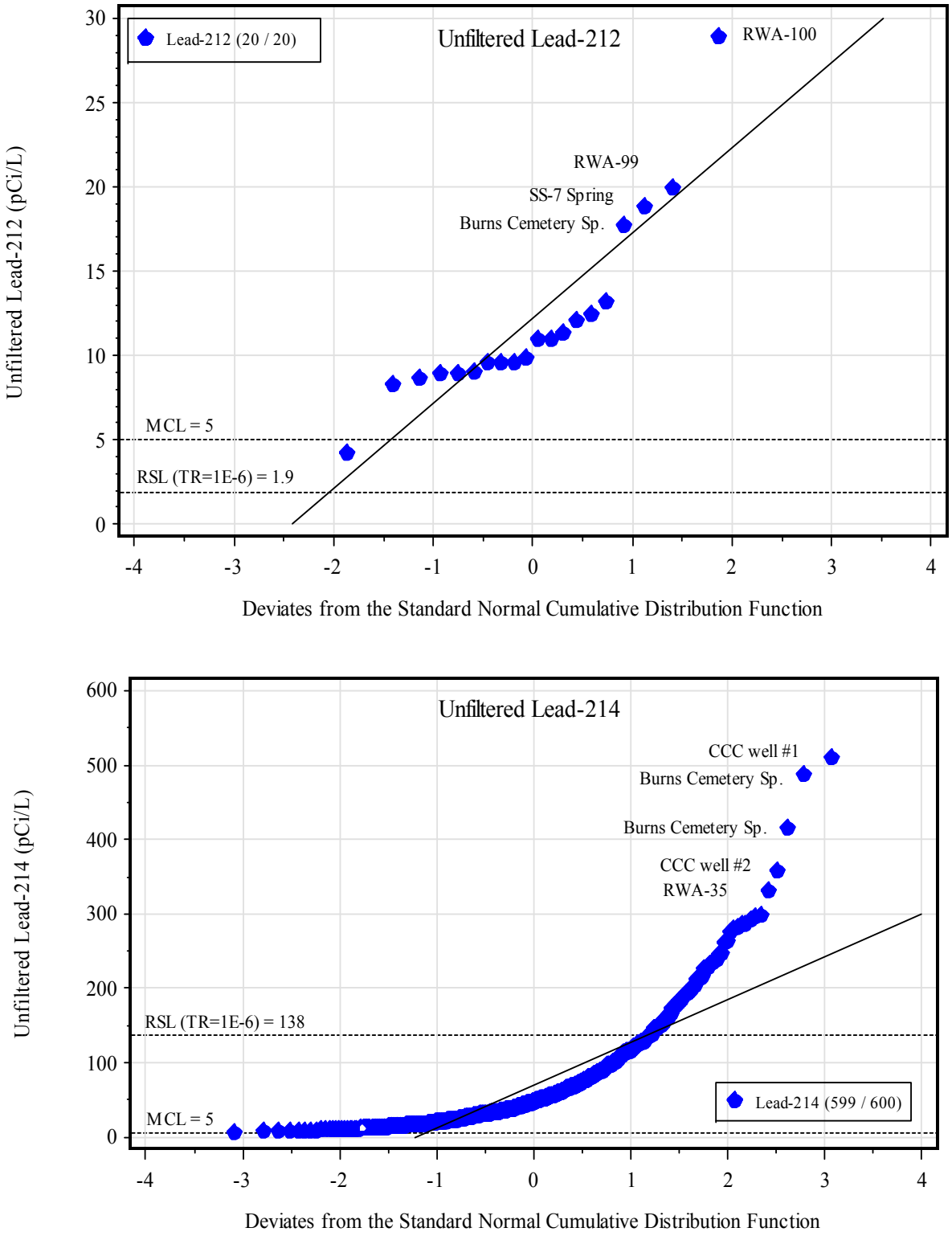


Hollow symbols denote the concentration was not detected.



Hollow symbols denote the concentration was not detected.

Figure A.14. Normal probability plots of unfiltered thorium-232 and bismuth-214 (second dataset).



Hollow symbols denote the concentration was not detected.

Figure A.15. Normal probability plots of unfiltered lead-212 and lead-214 (second dataset).

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APPENDIX B
OUTPUT FROM ANALYSIS OF FOURTH DATASET

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Table B.1. Summary statistics from fourth dataset (ORR area unfiltered groundwater)

Constituent	Frequency of Detection	Units	Non-detect Detection Limits[a]		Min[b]	Mean[b]	Median[b]	Max[b]	S.D.[b]	Detected				Dist[c]	UCL90	UCL95	UTL95/95	EPA Tap Water				MCL[e]	Frequency > MCL[e]	Max Detected Station
			Min	Max						Min	Mean	Max	S.D.					RSL[d] TR=1E-6	Frequency > TR=1E-6	RSL[d] HQ=0.1	Frequency > HQ=0.1			
ORR Groundwater																								
Metals																								
Aluminum	33 / 51	mg/L	0.003	0.1	0.001	0.17	0.009	4.25	0.65	0.001	0.258	4.25	0.806	X*	0.447	0.572	--	--	--	2	**2 / 51**	--	--	RWA-94
Antimony	3 / 52	mg/L	1.2E-04	0.003	6.0E-05	0.035	6.4E-04	1.8	0.247	6.4E-04	0.601	1.8	1.04	X*	0.161	0.218	--	--	--	7.8E-04	**2 / 52**	0.006	**1 / 52**	SEC Well
Arsenic	8 / 56	mg/L	8.2E-04	0.005	4.1E-04	0.001	9.0E-04	0.004	7.6E-04	9.0E-04	0.002	0.004	9.9E-04	X*	0.002	0.002	--	5.2E-05	**8 / 56**	6.0E-04	**8 / 56**	0.01	0 / 56	RWA-95
Barium	47 / 52	mg/L	0.003	0.1	0.001	0.068	0.05	0.245	0.058	0.003	0.072	0.245	0.06	X*	0.093	0.104	--	--	--	0.38	0 / 52	2	0 / 52	RWA-63
Beryllium	1 / 40	mg/L	1.1E-04	0.02	5.5E-05	4.5E-04	1.1E-04	0.01	0.002	4.8E-04	4.8E-04	4.8E-04	--	X	0.001	0.002	--	--	--	0.003	0 / 40	0.004	0 / 40	RWA-94
Boron	27 / 50	mg/L	0.045	0.09	0.023	0.169	0.14	0.705	0.137	0.038	0.228	0.705	0.159	X*	0.232	0.26	--	--	--	0.4	**4 / 50**	--	--	RWA-117
Cadmium	1 / 52	mg/L	2.1E-04	0.001	1.1E-04	2.6E-04	2.1E-04	0.001	1.6E-04	0.001	0.001	0.001	--	X	3.3E-04	3.6E-04	--	--	--	9.2E-04	**1 / 52**	0.005	0 / 52	RWA-64
Calcium	58 / 59	mg/L	0.036	0.036	0.018	43.8	42.6	329	44.6	0.445	44.6	329	45.0	X*	61.4	69.4	329	--	--	--	--	--	--	SEC Well
Chromium	23 / 56	mg/L	6.0E-04	0.005	3.0E-04	0.002	0.001	0.005	0.001	6.5E-04	0.002	0.005	0.001	X*	0.002	0.003	--	--	--	--	--	0.1	0 / 56	RWA-94
Cobalt	11 / 37	mg/L	4.0E-05	0.01	2.0E-05	3.9E-04	2.8E-04	0.005	5.4E-04	7.0E-05	5.6E-04	0.003	8.9E-04	X*	7.3E-04	8.8E-04	--	--	--	6.0E-04	**2 / 37**	--	--	RWA-94
Copper	33 / 38	mg/L	3.4E-04	8.7E-04	1.7E-04	0.007	0.004	0.03	0.007	9.4E-04	0.008	0.03	0.007	L*	0.01	0.011	0.065	--	--	0.08	0 / 38	1.3	0 / 38	RWA-107
Iron	46 / 53	mg/L	0.003	0.031	0.001	0.631	0.064	11.6	1.88	0.007	0.725	11.6	2.02	L*	0.857	1.05	4.15	--	--	1.4	**6 / 53**	--	--	RWA-114
Lead	48 / 65	mg/L	1.0E-04	0.001	5.0E-05	0.002	8.0E-04	0.012	0.002	1.8E-04	0.002	0.012	0.002	L*	0.002	0.002	0.009	--	--	0.015	0 / 65	0.015	0 / 65	RWA-64
Lithium	48 / 51	mg/L	1.9E-04	4.1E-04	9.5E-05	0.014	0.004	0.06	0.018	2.6E-04	0.015	0.06	0.018	X*	0.021	0.025	--	--	--	0.004	**29 / 51**	--	--	RWA-58
Magnesium	58 / 59	mg/L	0.043	0.043	0.012	11.2	9.65	30.4	9.05	0.012	11.4	30.4	9.08	X*	14.8	16.4	30.4	--	--	--	--	--	--	RWA-116
Manganese	33 / 44	mg/L	2.2E-04	0.005	1.1E-04	0.026	0.002	0.28	0.054	4.6E-04	0.035	0.28	0.061	L*	0.058	0.076	0.35	--	--	0.043	**8 / 44**	--	--	RWA-94
Mercury	0 / 40	mg/L	2.9E-05	4.2E-04	1.5E-05	4.2E-05	1.9E-05	2.1E-04	4.3E-05	--	--	--	--	O	--	--	--	--	--	6.3E-05	0 / 40	0.002	0 / 40	--
Molybdenum	1 / 8	mg/L	4.0E-05	0.004	2.0E-05	0.002	0.002	0.002	8.7E-04	2.5E-04	2.5E-04	2.5E-04	--	X	0.002	0.003	--	--	--	0.01	0 / 8	--	--	RWA-22
Nickel	41 / 51	mg/L	2.5E-04	0.01	1.3E-04	0.002	0.001	0.006	0.001	3.4E-04	0.002	0.006	0.001	X*	0.002	0.002	--	--	--	0.039	0 / 51	--	--	RWA-99
Niobium	2 / 3	mg/L	7.3E-04	7.3E-04	1.4E-05	1.8E-05	2.1E-05	3.7E-04	3.3E-06	1.4E-05	1.8E-05	2.1E-05	4.6E-06	L*	2.3E-05	2.7E-05	--	--	--	--	--	--	--	RWA-117
Phosphorous	10 / 12	mg/L	0.01	0.07	0.005	0.034	0.03	0.09	0.026	0.007	0.038	0.09	0.028	N*	0.045	0.049	0.106	--	--	4.0E-05	**10 / 12**	--	--	RWA-51
Potassium	59 / 59	mg/L	--	--	0.055	2.03	1.65	8.3	1.54	0.055	2.03	8.3	1.54	X	2.63	2.9	8.3	--	--	--	--	--	--	RWA-107
Selenium	5 / 53	mg/L	9.7E-04	0.005	4.8E-04	0.002	0.002	0.003	6.9E-04	0.001	0.002	0.003	8.2E-04	X*	0.003	0.003	--	--	--	0.01	0 / 53	0.05	0 / 53	RWA-52
Silica	31 / 31	mg/L	--	--	0.1	12.3	10.3	39.5	7.09	0.1	12.3	39.5	7.09	X	16.1	17.8	--	--	--	--	--	--	--	RWA-110
Silver	6 / 38	mg/L	1.4E-05	0.07	1.6E-08	4.3E-04	3.0E-05	0.035	0.002	1.6E-08	0.002	0.014	0.006	X*	0.002	0.002	--	--	--	0.009	**1 / 38**	--	--	RWA-78
Sodium	69 / 69	mg/L	--	--	0.5	31.5	5.3	241	51.6	0.5	31.5	241	51.6	X	50.2	58.6	241	--	--	--	--	--	--	RWA-117
Strontium	50 / 51	mg/L	4.7E-04	4.7E-04	2.4E-04	0.183	0.11	0.785	0.195	0.012	0.187	0.785	0.197	G*	0.222	0.234	0.777	--	--	1.2	0 / 51	--	--	Rarity Ridge
Thallium	31 / 52	mg/L	3.0E-05	0.002	1.5E-05	3.7E-04	2.8E-04	0.002	3.8E-04	5.0E-05	3.9E-04	0.002	4.5E-04	X*	5.5E-04	6.3E-04	--	--	--	2.0E-05	**31 / 52**	0.002	**1 / 52**	SEC Well
Uranium	36 / 51	mg/L	1.0E-05	0.02	5.0E-06	4.1E-04	2.3E-04	0.01	9.9E-04	2.5E-05	4.5E-04	0.007	0.001	X*	8.5E-04	0.001	--	--	--	0.006	**1 / 51**	0.03	0 / 51	RWA-74
Vanadium	11 / 41	mg/L	1.0E-05	0.005	5.0E-06	0.001	6.2E-04	0.005	9.4E-04	3.7E-04	0.001	0.005	0.002	X*	0.002	0.002	--	--	--	0.009	0 / 41	--	--	RWA-94
Zinc	57 / 59	mg/L	7.6E-04	0.002	3.8E-04	0.082	0.014	2.87	0.371	0.001	0.085	2.87	0.381	X*	0.228	0.294	2.87	--	--	0.6	**1 / 59**	--	--	RWA-64
Anions																								
Chloride	65 / 70	mg/L	1.9	4	0.948	7.32	3.4	72.5	10.7	1	7.69	72.5	11.1	X*	11.2	13.0	72.5	--	--	--	--	--	--	RWA-97
Fluoride	52 / 56	mg/L	0.05	0.05	0.025	0.398	0.13	3.48	0.654	0.04	0.423	3.48	0.678	G*	0.495	0.528	1.67	--	--	0.08	**42 / 56**	--	--	RWA-53
Nitrate	19 / 23	mg/L	0.002	0.007	0.001	0.699	0.45	2.4	0.714	0.026	0.843	2.4	0.725	X*	1.16	1.37	--	--	--	3.2	0 / 23	10	0 / 23	RWA-85
Nitrate/Nitrite	50 / 60	mg/L	0.007	0.1	0.004	0.548	0.22	3	0.63	0.02	0.649	3	0.65	X*	0.794	0.906	3	--	--	--	--	10	0 / 60	RWA-105
Nitrite	1 / 33	mg/L	0.002	0.01	0.001	0.002	0.003	0.01	0.002	0.01	0.01	0.01	--	X	0.003	0.004	--	--	--	0.2	0 / 33	1	0 / 33	RWA-22

Table B.1. Summary statistics from analysis of fourth dataset (ORR area unfiltered groundwater) (cont.)

Constituent	Frequency of Detection	Units	Non-detect Detection Limits[a]		Min[b]	Mean[b]	Median[b]	Max[b]	S.D.[b]	Detected				Dist[c]	UCL90	UCL95	UTL95/95	EPA Tap Water				MCL[e]	Frequency > MCL[e]	Max Detected Station
			Min	Max						Min	Mean	Max	S.D.					RSL[d] TR=1E-6	Frequency > TR=1E-6	RSL[d] HQ=0.1	Frequency > HQ=0.1			
Nitrogen, NO3 & NO2	1 / 1	mg/L	--	--	0.075	0.075	0.075	0.075	--	0.075	0.075	0.075	--	D	--	--	--	--	--	--	--	--	--	SEC Well
Sulfate	69 / 70	mg/L	2.5	2.5	1.25	12.3	7	119	16.3	1.9	12.5	119	16.5	L*	14.0	14.8	49.0	--	--	--	--	--	--	RWA-66
Sulfide	0 / 1	mg/L	1	1	0.5	0.5	0.5	0.5	--	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
Physical																								
Calcium Hardness	4 / 4	mg/L	--	--	1.75	69.9	53	172	74.2	1.75	69.9	172	74.2	N	131	157	452	--	--	--	--	--	--	RWA-63
Conductivity	52 / 52	µmhos/cm	--	--	2.4	417	388	985	201	2.4	417	985	201	X	500	538	--	--	--	--	--	--	--	RWA-117
Dissolved Residue	24 / 24	mg/L	--	--	67	230	202	604	110	67	230	604	110	L	262	273	566	--	--	--	--	--	--	RWA-53
Hardness, total as CaCO3	1 / 1	mg/L	--	--	218	218	218	218	--	218	218	218	--	D	--	--	--	--	--	--	--	--	--	SEC Well
Suspended Residue	10 / 10	mg/L	--	--	2	26.4	3	200	61.5	2	26.4	200	61.5	G	69.4	97.6	274	--	--	--	--	--	--	RWA-64
Total Hardness	48 / 49	mg/L	3.8	3.8	1.9	150	161	301	84.2	10	153	301	83.5	X*	187	203	--	--	--	--	--	--	--	RWA-64
pH	51 / 51	Std. Units	--	--	6.35	7.83	7.7	9.64	0.68	6.35	7.83	9.64	0.68	X	8.11	8.24	--	--	--	--	--	--	--	RWA-79
Radionuclides																								
Actinium-228	2 / 2	pCi/L	--	--	12.3	13.9	13.9	15.5	2.26	12.3	13.9	15.5	2.26	D	--	--	--	23.9	0 / 2	--	--	5	**2 / 2**	RWA-63
Alpha activity	31 / 73	pCi/L	0.455	15	-3.1	1.26	1	9.9	2.03	0.135	2.32	9.9	2.5	X	1.98	2.3	9.9	--	--	--	--	15	0 / 73	RWA-59
Americium-241	0 / 5	pCi/L	0.14	0.81	0.017	0.097	0.049	0.26	0.099	--	--	--	--	N	0.165	0.191	0.512	0.458	0 / 5	--	--	15	0 / 5	--
Beta activity	43 / 73	pCi/L	0.9	4.4	0	2.6	1.8	22.0	2.94	0.4	3.62	22.0	3.44	L	3.1	3.26	9.89	--	--	--	--	--	--	RWA-66
Bismuth-212	2 / 2	pCi/L	--	--	34.2	56.1	56.1	78	31.0	34.2	56.1	78	31.0	D	--	--	--	67.1	**1 / 2**	--	--	5	**2 / 2**	RWA-117
Bismuth-214	66 / 66	pCi/L	--	--	10.6	82.1	63.9	312	65.3	10.6	82.1	312	65.3	L	96.6	101	287	248	**3 / 66**	--	--	5	**66 / 66**	RWA-87
Carbon-14	1 / 8	pCi/L	9.6	15.4	-7	-1.53	-3.5	8.4	4.63	8.4	8.4	8.4	--	N	0.792	1.58	13.2	1.29	**1 / 8**	--	--	2000	0 / 8	RWA-88
Curium-243/244	1 / 5	pCi/L	0.13	0.74	-0.02	0.093	0.04	0.22	0.109	0.22	0.22	0.22	--	N	0.168	0.197	0.552	0.503	0 / 5	--	--	15	0 / 5	RWA-63
Gamma Radionuclides	0 / 1	pCi/L	9	9	9	9	9	9	--	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
Lead-212	7 / 7	pCi/L	--	--	8.7	14.4	11	29	7.51	8.7	14.4	29	7.51	L	19.7	22.5	60.7	1.9	**7 / 7**	--	--	5	**7 / 7**	RWA-100
Lead-214	65 / 65	pCi/L	--	--	13.5	75.0	52.8	294	63.5	13.5	75.0	294	63.5	L	85.2	89.0	244	138	**8 / 65**	--	--	5	**65 / 65**	RWA-87
Neptunium-237	0 / 5	pCi/L	0.119	0.39	0.02	0.033	0.028	0.05	0.014	--	--	--	--	N	0.042	0.046	0.091	0.771	0 / 5	--	--	15	0 / 5	--
Plutonium-238	0 / 5	pCi/L	0.087	0.74	-0.022	0.005	0	0.028	0.021	--	--	--	--	N	0.02	0.026	0.094	0.364	0 / 5	--	--	15	0 / 5	--
Plutonium-239/240	0 / 5	pCi/L	0.043	0.74	-0.064	-0.002	0	0.032	0.037	--	--	--	--	N	0.024	0.034	0.156	0.353	0 / 5	--	--	15	0 / 5	--
Potassium-40	2 / 2	pCi/L	--	--	62	62	62	62	0	62	62	62	0	D	--	--	--	1.93	**2 / 2**	--	--	11	**2 / 2**	SEC Well
Radium-226	5 / 7	pCi/L	0.44	0.44	-1.2	0.52	0.355	2.33	1.09	0.14	0.956	2.33	0.868	N	1.11	1.32	4.23	8.2E-04	**5 / 7**	--	--	5	0 / 7	RWA-72
Radium-228	3 / 4	pCi/L	1.52	1.52	0.055	2.05	0.29	7.56	3.68	0.055	2.7	7.56	4.21	L	5.29	6.99	--	0.046	**3 / 4**	--	--	5	**1 / 4**	RWA-118
Strontium-89	13 / 67	pCi/L	0.11	0.54	-0.76	0.233	-0.065	10	1.75	0.055	0.288	0.98	0.23	X	0.875	1.17	10	3.72	0 / 67	--	--	20	0 / 67	RWA-87
Strontium-90	24 / 67	pCi/L	-0.26	0.27	-0.68	0.127	0.055	2	0.386	0.02	0.252	0.51	0.141	L	0.376	0.41	1.74	0.852	0 / 67	--	--	8	0 / 67	RWA-114
Technetium-99	20 / 49	pCi/L	0.57	0.8	-0.55	0.35	0.26	1.6	0.466	0.26	0.591	1.42	0.282	L	0.767	0.799	2.2	17.3	0 / 49	--	--	900	0 / 49	RWA-23
Thallium-208	1 / 1	pCi/L	--	--	3.3	3.3	3.3	3.3	--	3.3	3.3	3.3	--	D	--	--	--	--	--	--	--	5	0 / 1	RWA-67
Thorium-228	0 / 3	pCi/L	0.21	0.3	0.05	0.067	0.06	0.09	0.021	--	--	--	--	N	0.089	0.102	0.226	0.445	0 / 3	--	--	15	0 / 3	--
Thorium-230	3 / 3	pCi/L	--	--	0.34	0.36	0.34	0.4	0.035	0.34	0.36	0.4	0.035	X	0.42	0.447	--	0.523	0 / 3	--	--	15	0 / 3	RWA-63
Thorium-232	1 / 3	pCi/L	0.204	0.22	0.041	0.08	0.08	0.12	0.04	0.12	0.12	0.12	--	N	0.123	0.147	0.383	0.471	0 / 3	--	--	15	0 / 3	RWA-63
Tritium	32 / 69	pCi/L	65	534	-170	60.3	49	310	93.2	60.5	143	310	49.4	X	93.9	109	310	--	--	--	--	20,000	0 / 69	RWA-36
Uranium-234	28 / 34	pCi/L	0.12	0.44	0.04	0.258	0.197	0.94	0.204	0.085	0.299	0.94	0.202	L	0.332	0.358	1.1	0.674	**1 / 34**	--	--	15	0 / 34	RWA-72
Uranium-235	3 / 34	pCi/L	0.073	0.44	-0.037	0.038	0.034	0.106	0.031	0.068	0.089	0.1	0.018	N	0.045	0.047	0.105	0.684	0 / 34	--	--	15	0 / 34	RWA-98
Uranium-238	14 / 34	pCi/L	0.069	0.35	-0.052	0.093	0.068	0.35	0.084	0.066	0.166	0.35	0.08	L	0.129	0.139	0.428	0.744	0 / 34	--	--	15	0 / 34	RWA-72

Table B.1. Summary statistics from analysis of fourth dataset (ORR area unfiltered groundwater) (cont.)

Constituent	Frequency of Detection	Units	Non-detect Detection Limits[a]		Min[b]	Mean[b]	Median[b]	Max[b]	S.D.[b]	Detected				Dist[c]	UCL90	UCL95	UTL95/95	EPA Tap Water				MCL[e]	Frequency > MCL[e]	Max Detected Station
			Min	Max						Min	Mean	Max	S.D.					RSL[d] TR=1E-6	Frequency > TR=1E-6	RSL[d] HQ=0.1	Frequency > HQ=0.1			
Wet Chemistry																								
Acidity	3 / 5	mg/L	0.7	0.7	0.35	4.08	4	10	3.43	4	6.33	10	3.21	N*	6.96	8.08	15.2	--	--	--	--	--	--	RWA-63
Acidity as CaCO3	1 / 1	mg/L	--	--	11	11	11	11	--	11	11	11	--	D	--	--	--	--	--	--	--	--	--	SEC Well
Alkalinity	62 / 62	mg/L	--	--	49	207	202	559	98.3	49	207	559	98.3	L	227	234	494	--	--	--	--	--	--	RWA-53
Alkalinity as CaCO3	8 / 8	mg/L	--	--	155	204	213	257	38.9	155	204	257	38.9	N	223	230	328	--	--	--	--	--	--	RWA-67
Ammonia	3 / 4	mg/L	0.033	0.033	0.017	0.057	0.06	0.07	0.012	0.04	0.057	0.07	0.015	N*	0.071	0.077	0.121	--	--	--	--	--	--	RWA-58
Cyanide	0 / 1	mg/L	0.03	0.03	0.015	0.015	0.015	0.015	--	--	--	--	--	O	--	--	--	--	--	1.5E-04	0 / 1	0.2	0 / 1	--
Dissolved Solids	41 / 41	mg/L	--	--	41	222	198	491	95.7	41	222	491	95.7	L	249	257	534	--	--	--	--	--	--	RWA-117

Bold value indicates exceedance of a screening criterion.

[a]One half of the detection limits shown are used as proxy values for non-detected inorganics. The radionuclide results were used as reported whether detected or not.
[b]This summary statistic is calculated using both detects and proxy values for non-detects.
[c]Dist. = distribution. Distribution flags are defined as:
D = UCL90 and UCL95 were not calculated with fewer than 3 samples.
G = gamma. UCL90 and UCL95 were calculated using either the adjusted or unadjusted gamma.
L = lognormal. UCL90 and UCL95 were calculated using Land's statistic, Chebyshev minimum variance unbiased estimator, or nonparametric Chebyshev inequality method.
N = normal. UCL90 and UCL95 were calculated using t statistic.
O = no detected results to calculate some summary statistics.
X = neither normal, lognormal nor gamma. UCL90 and UCL95 were calculated using a nonparametric bootstrap or the nonparametric Chebyshev inequality method.
*Kaplan-Meier estimates of the mean, median and standard deviation are shown for inorganics with at least one non-detect and two distinct detected results.
[d]EPA RSL for tap water from May 2014 (*http://www.epa.gov/region9/superfund//prg/index.html*) for inorganics. EPA PRGs (*http://epa-prgs.ornl.gov/radionuclides/download.html*) for radionuclides.
[e]EPA MCL from May 2014 (*http://www.epa.gov/region9/superfund//prg/index.html*) for inorganics. 40 CFR 141.66 (December 7, 2000) and *National Interim Primary Drinking Water Regulations* (EPA 570/9-76-003) for radionuclides.

EPA = U.S. Environmental Protection Agency
HQ = hazard quotient
MCL = maximum contaminant level
Max = maximum
Min = minimum
ORR = Oak Ridge Reservation
PRG = preliminary remediation goal
RSL = Regional Screening Level
S.D. = standard deviation
TR = target risk
UCL90 = upper confidence limit on the mean concentration with 90% confidence using both detects and non-detects
UCL95 = upper confidence limit on the mean concentration with 95% confidence using both detects and non-detects
UTL95/95 = upper tolerance limit on the maximum concentration with 95% confidence and 95% coverage using both detects and non-detects
-- = Not applicable, not available or insufficient data to calculate the statistic

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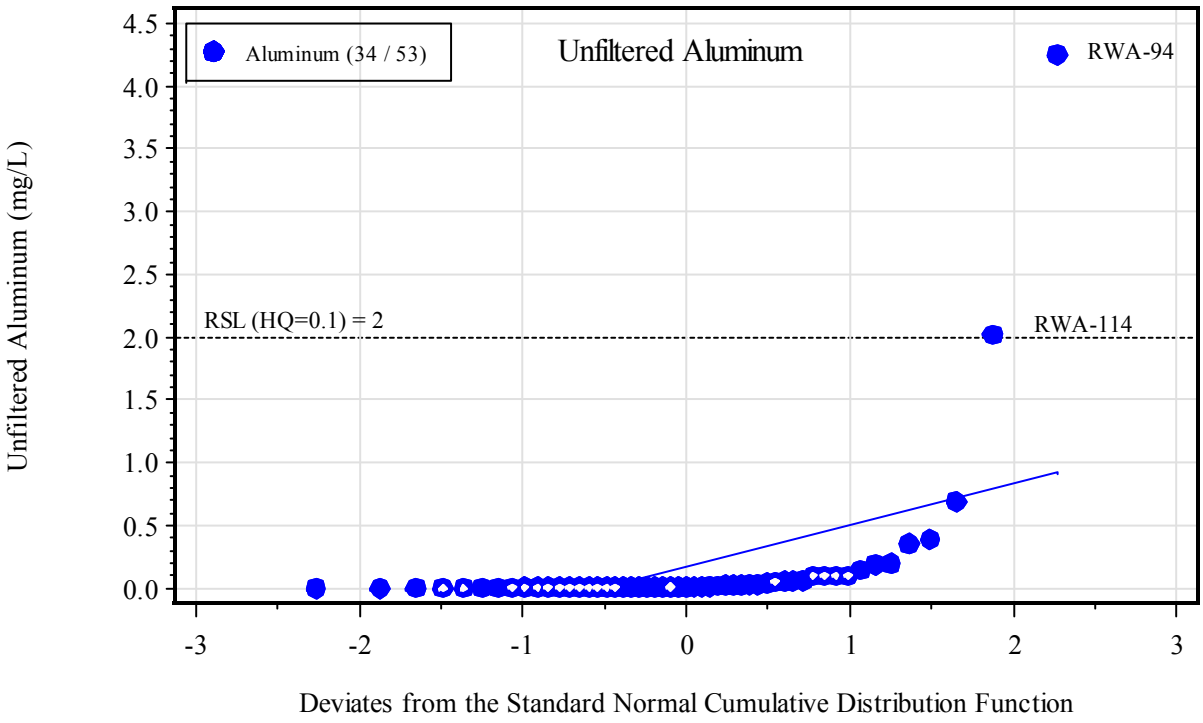
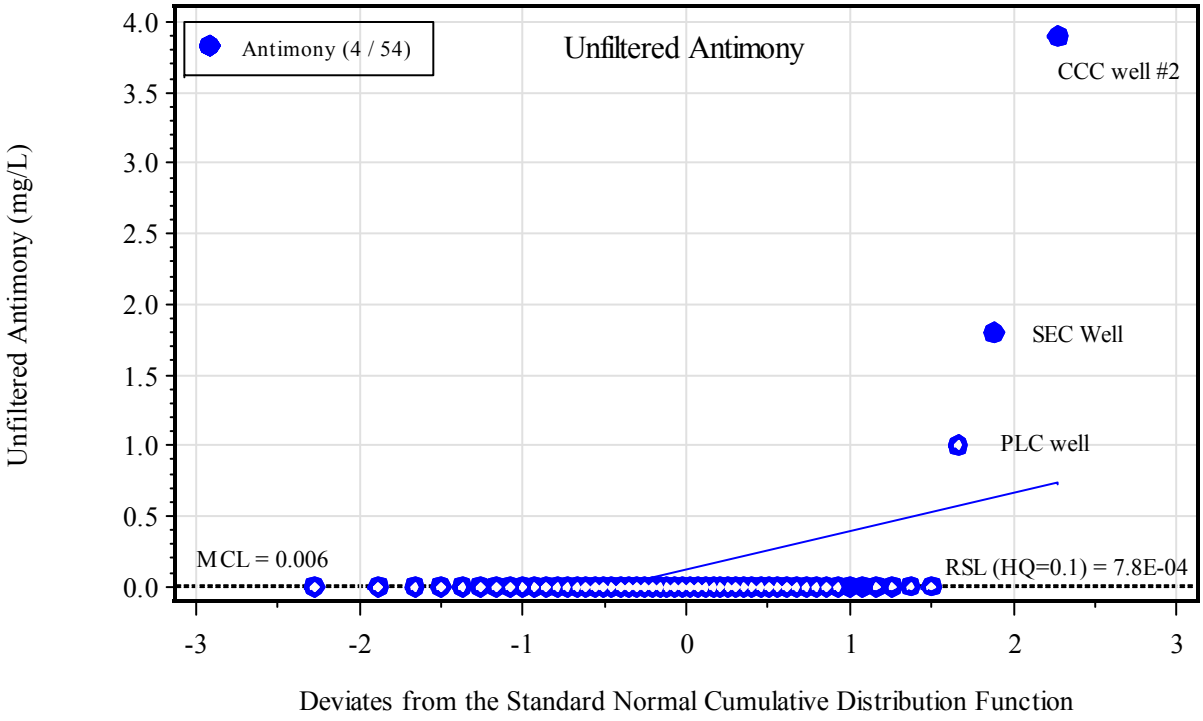
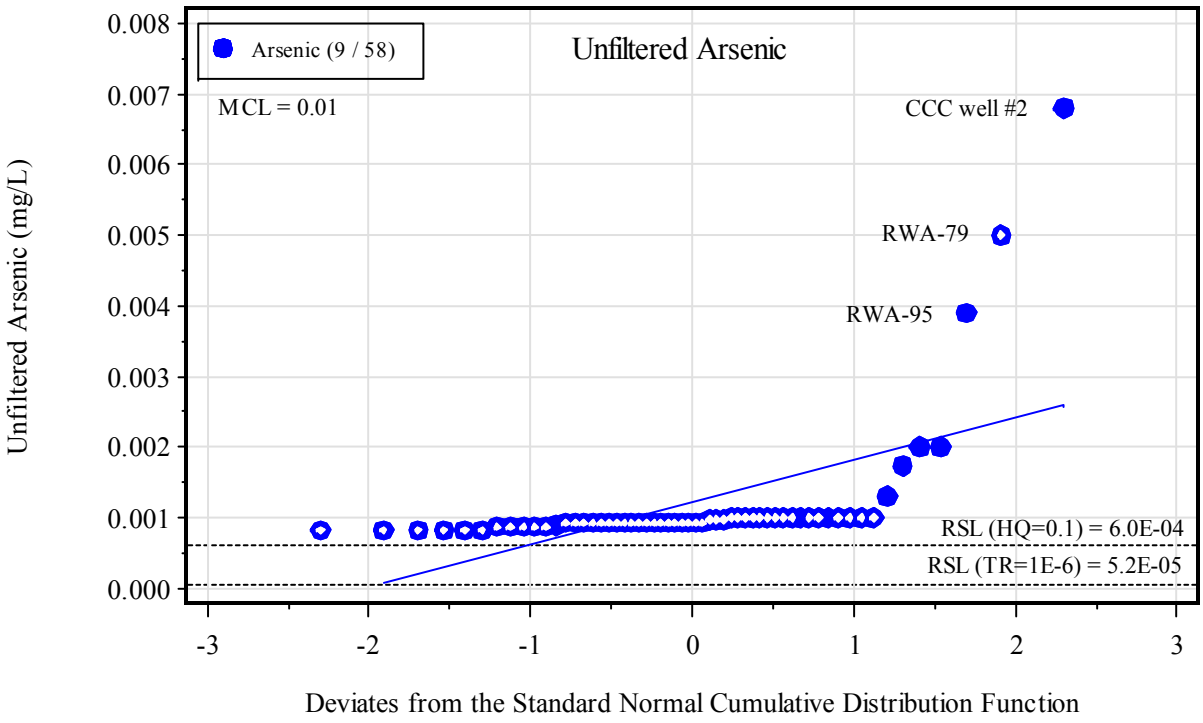


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

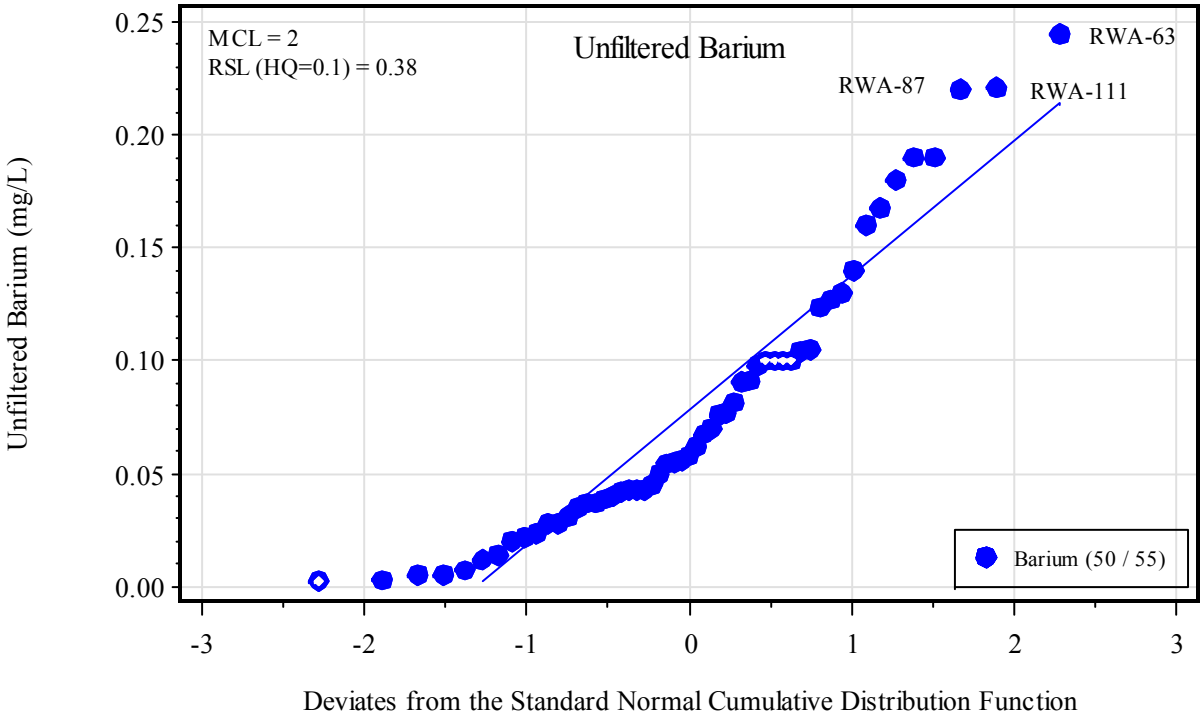


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

Figure B.1. Normal probability plots of unfiltered aluminum and antimony (fourth dataset).

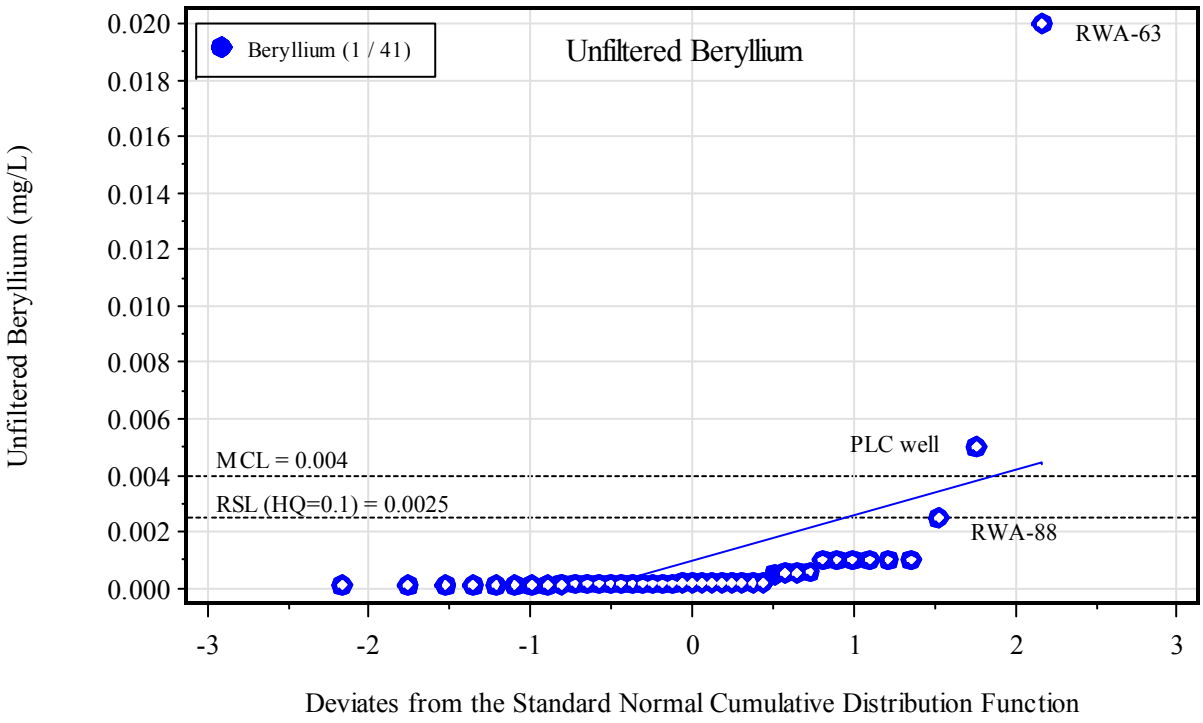


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

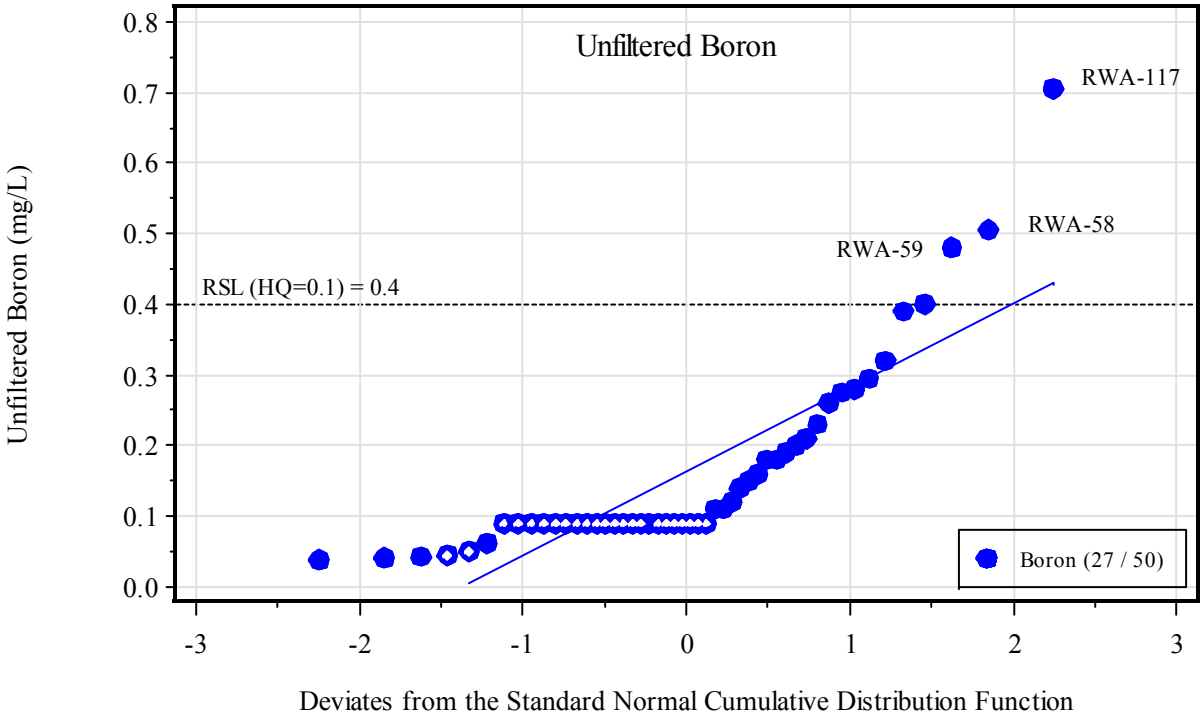


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

Figure B.2. Normal probability plots of unfiltered arsenic and barium (fourth dataset).

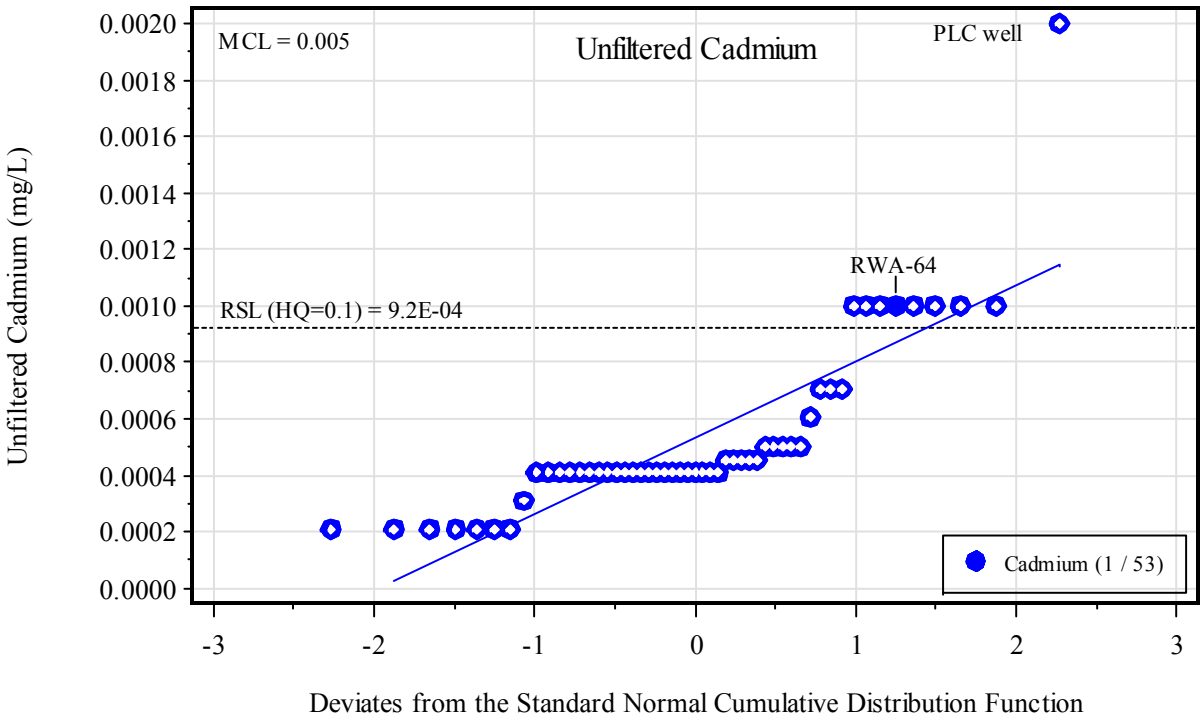


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

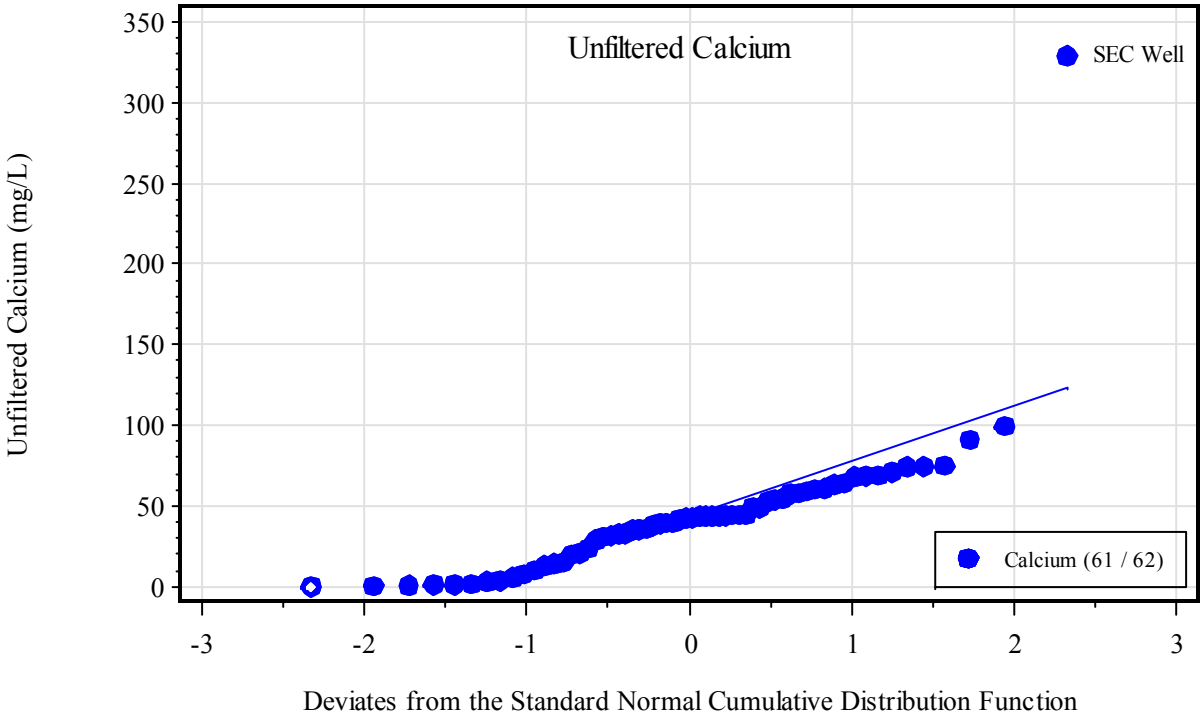


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

Figure B.3. Normal probability plots of unfiltered beryllium and boron (fourth dataset).

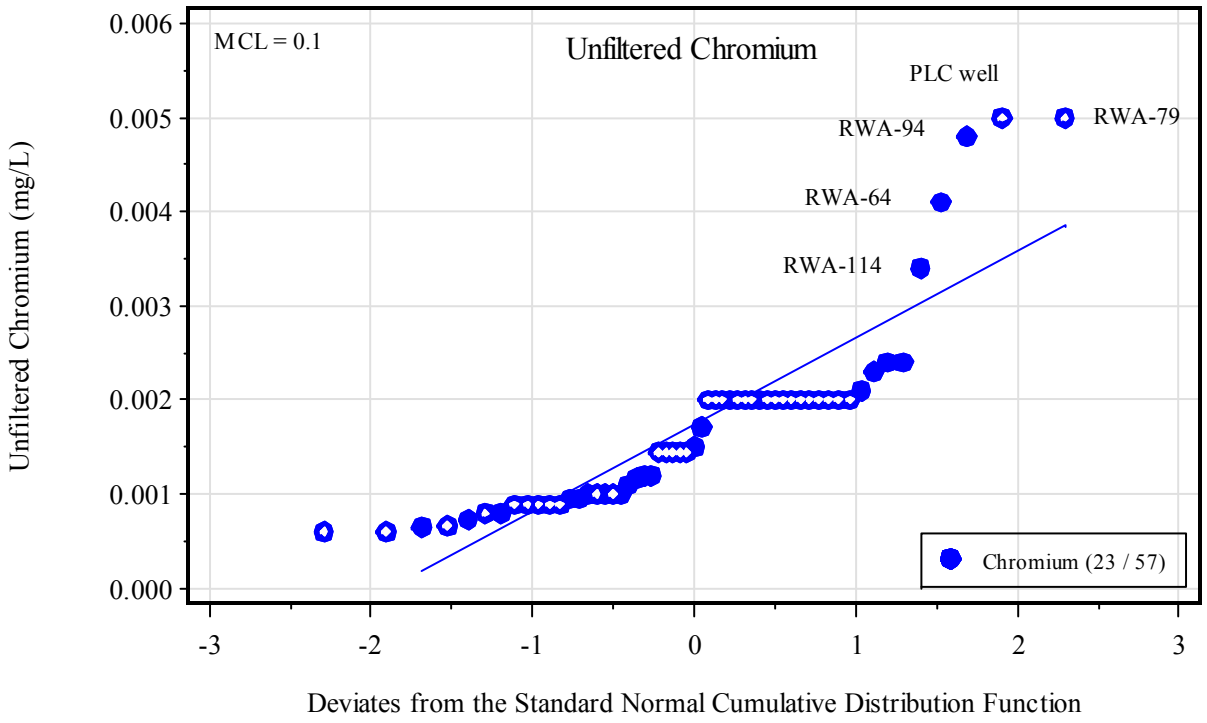


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

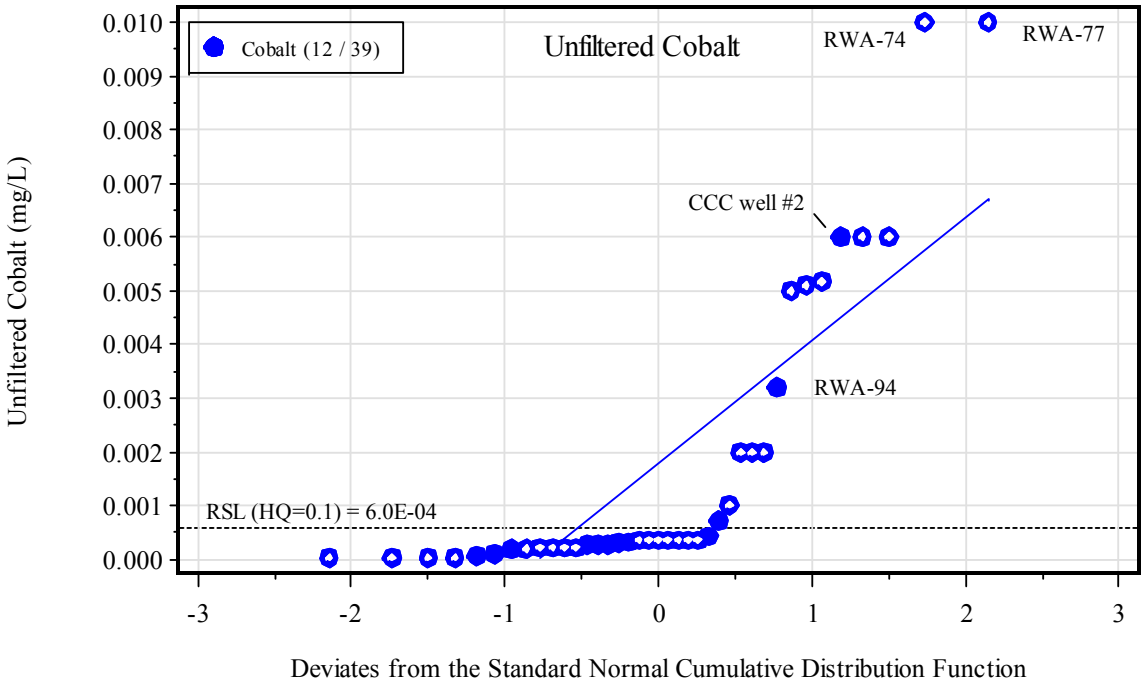


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

Figure B.4. Normal probability plots of unfiltered cadmium and calcium (fourth dataset).

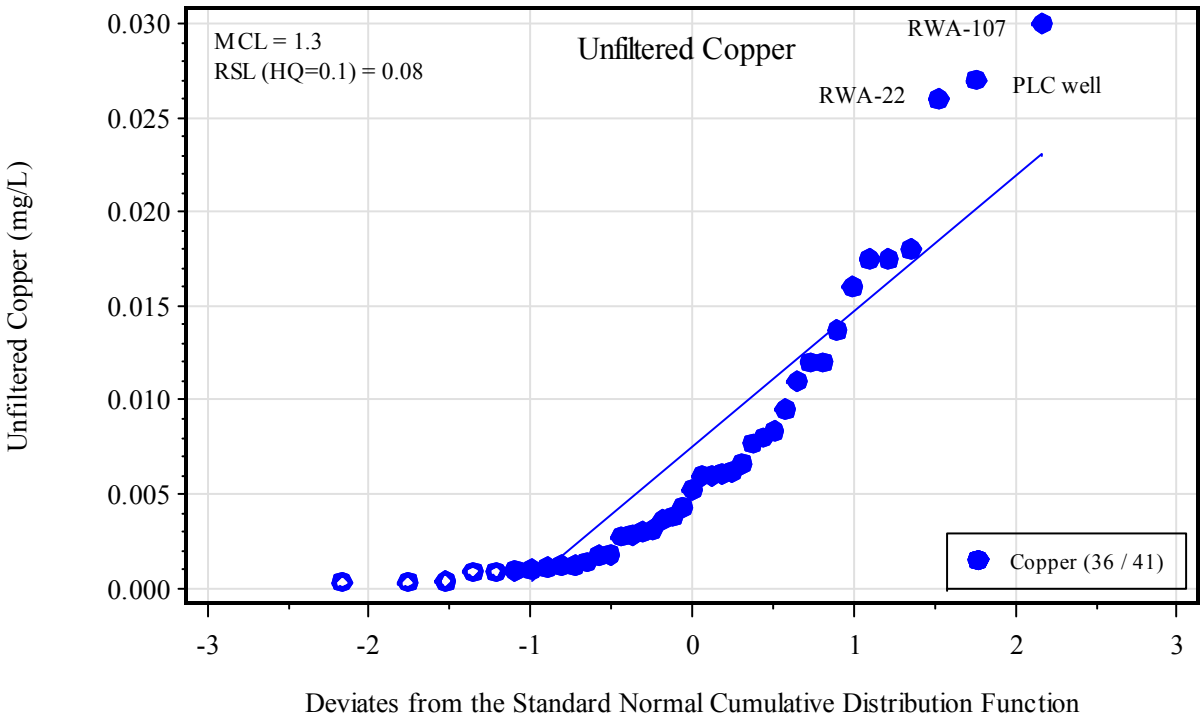


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

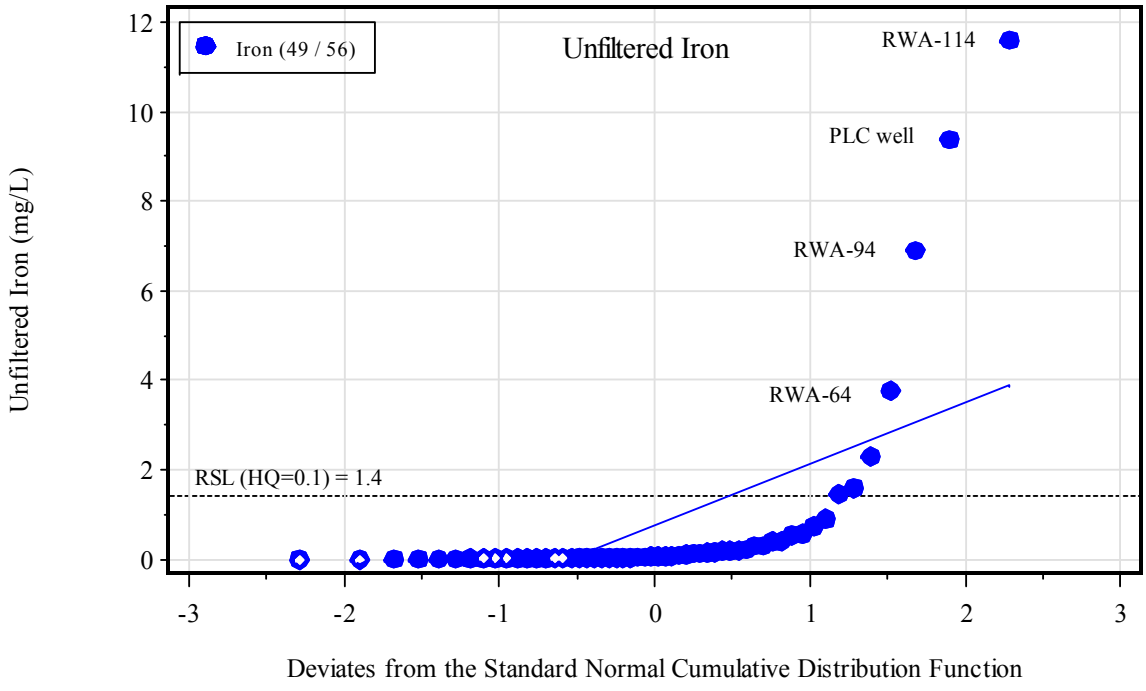


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

Figure B.5. Normal probability plots of unfiltered chromium and cobalt (fourth dataset).

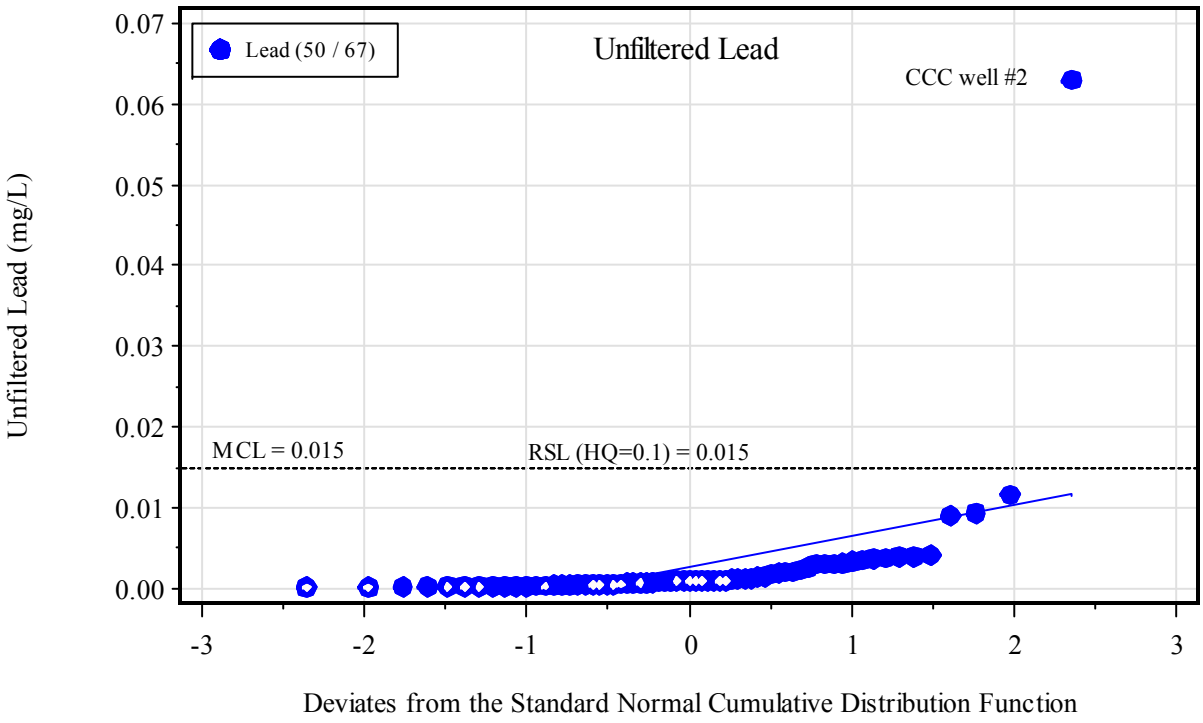


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

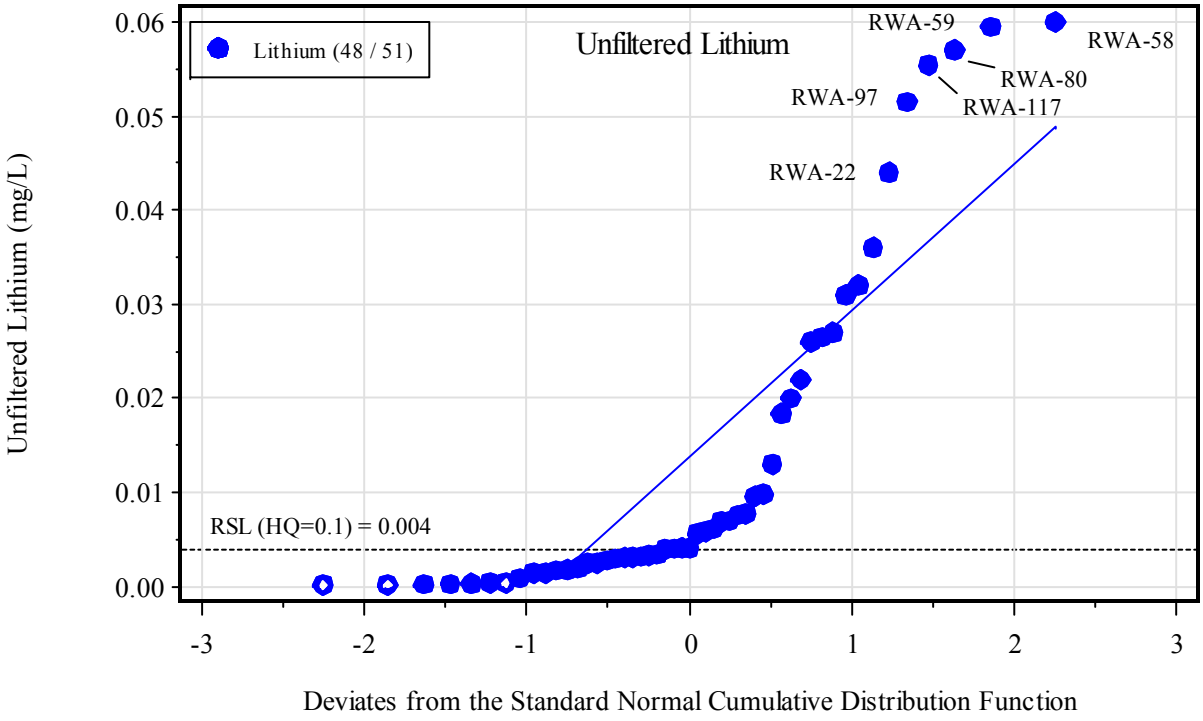


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

Figure B.6. Normal probability plots of unfiltered copper and iron (fourth dataset).

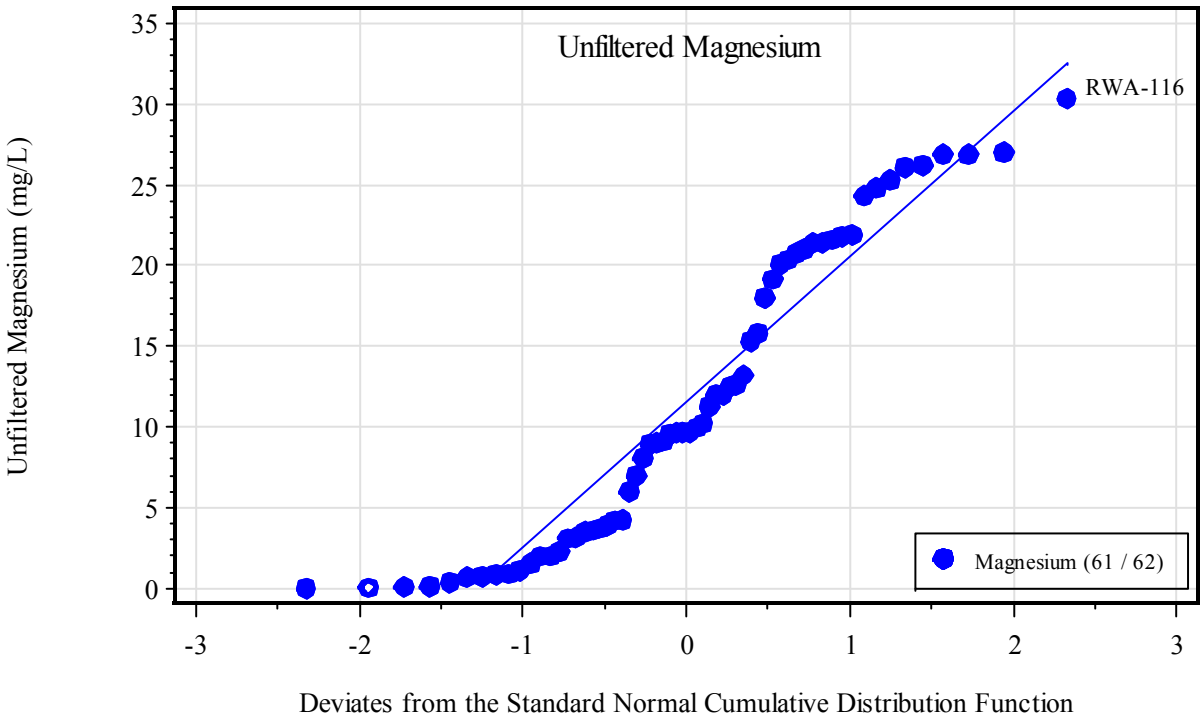


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

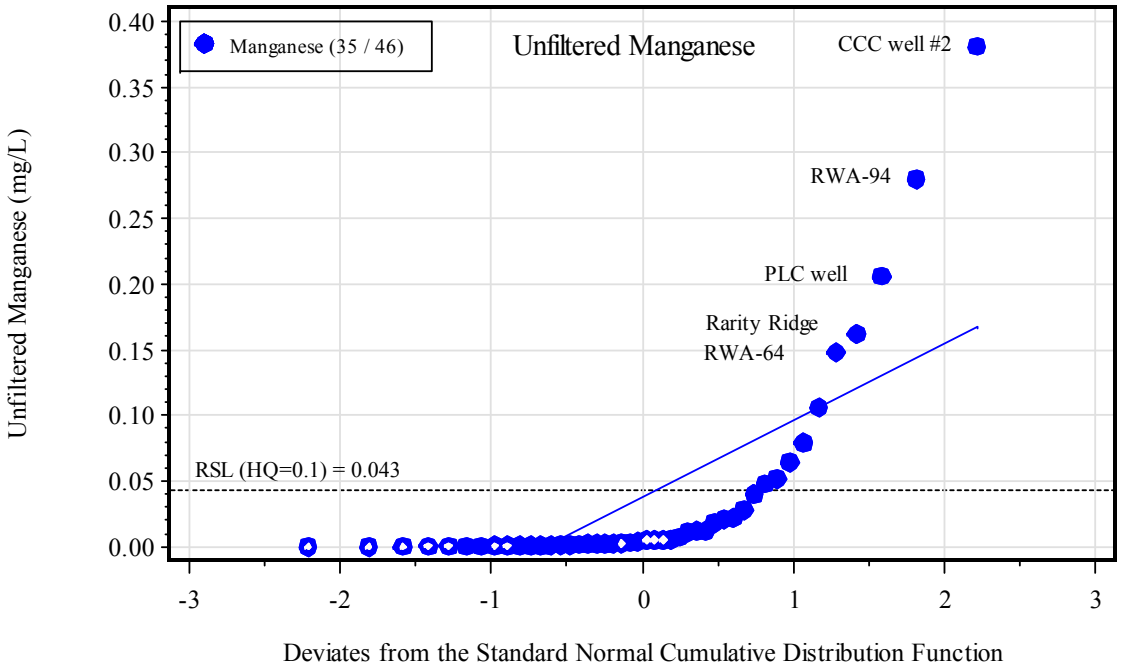


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

Figure B.7. Normal probability plots of unfiltered lead and lithium (fourth dataset).

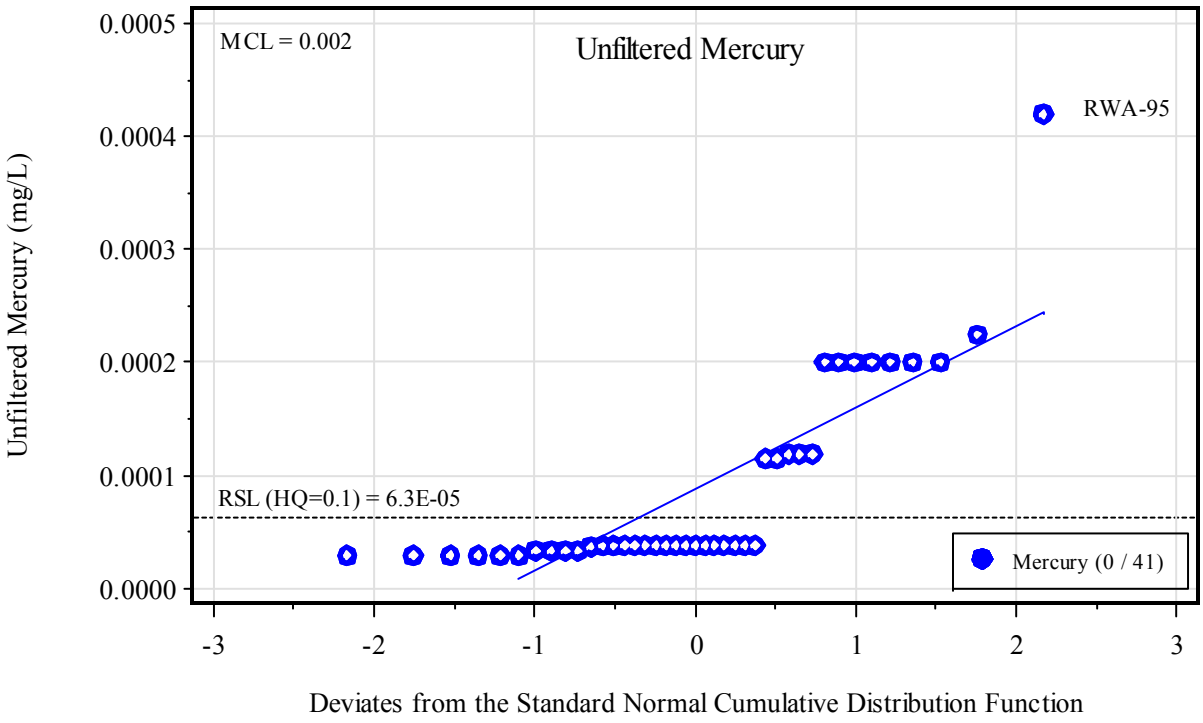


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

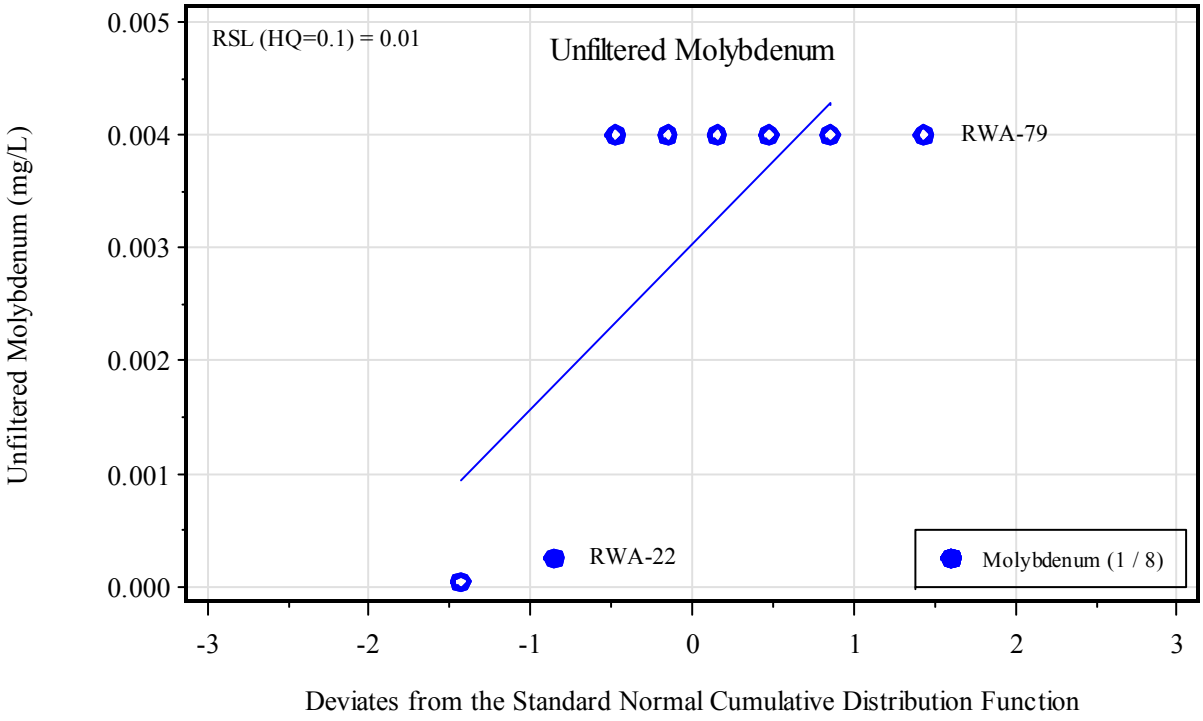


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

Figure B.8. Normal probability plots of unfiltered magnesium and manganese (fourth dataset).

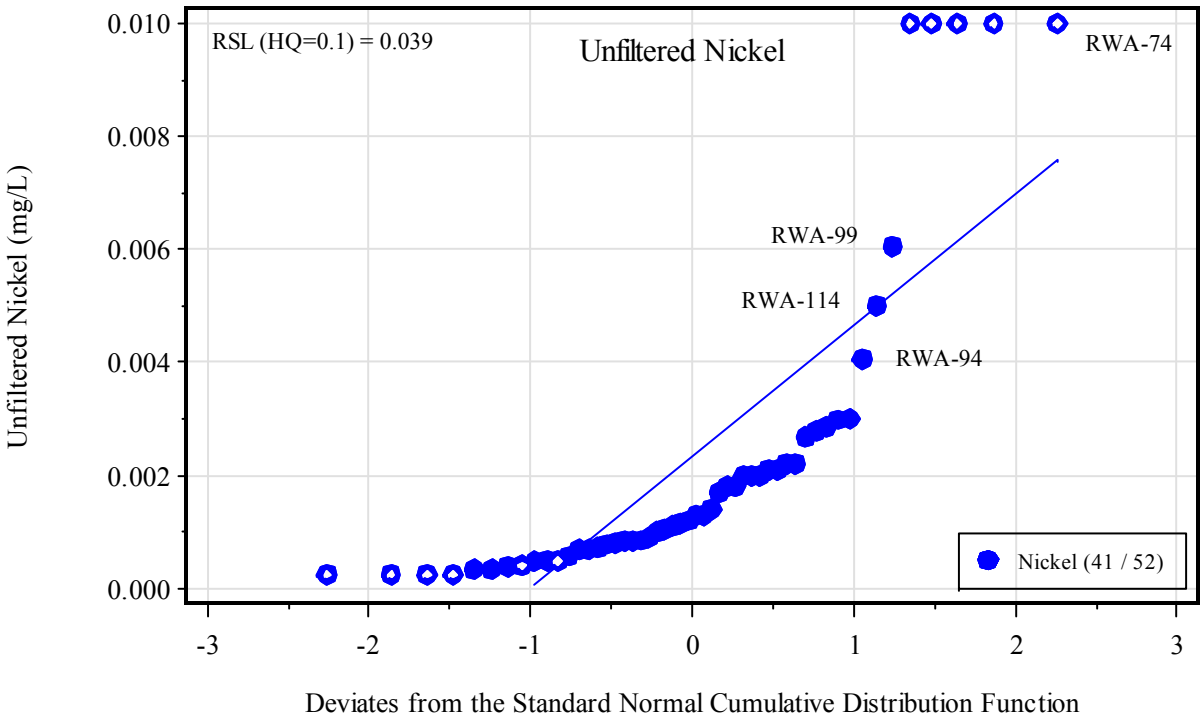


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

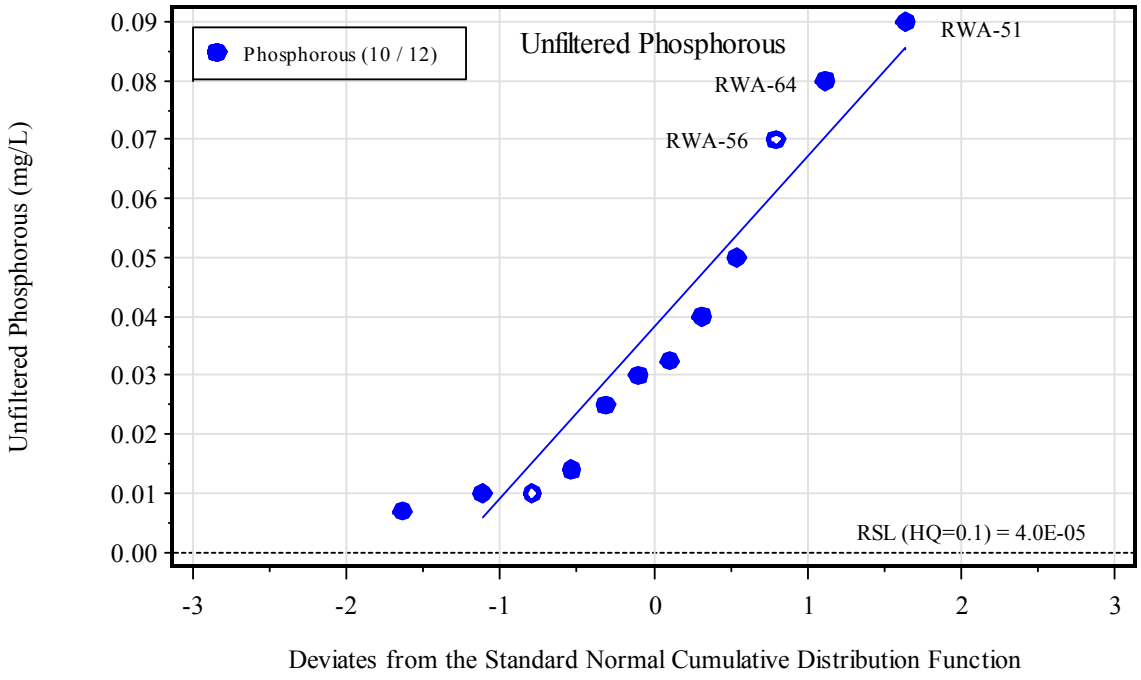


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

Figure B.9. Normal probability plots of unfiltered mercury and molybdenum (fourth dataset) .

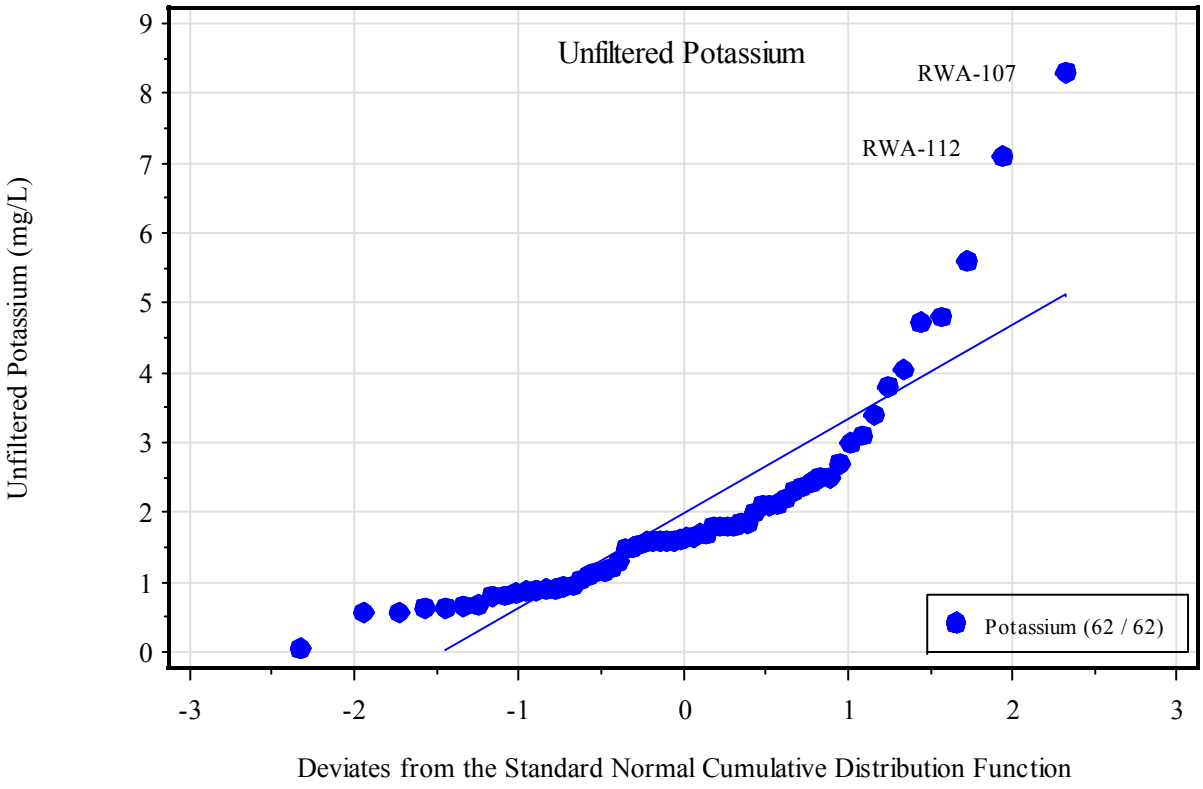


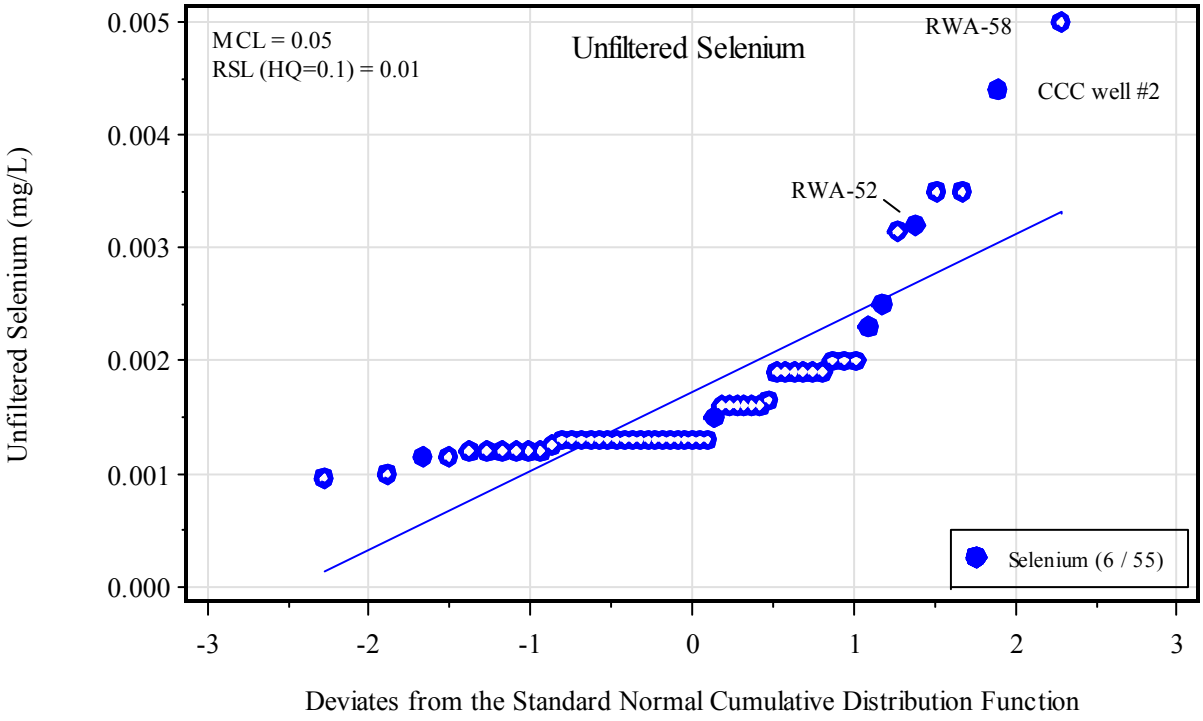
Hollow symbols denote non-detects. Solid symbols denote detected concentrations.



Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

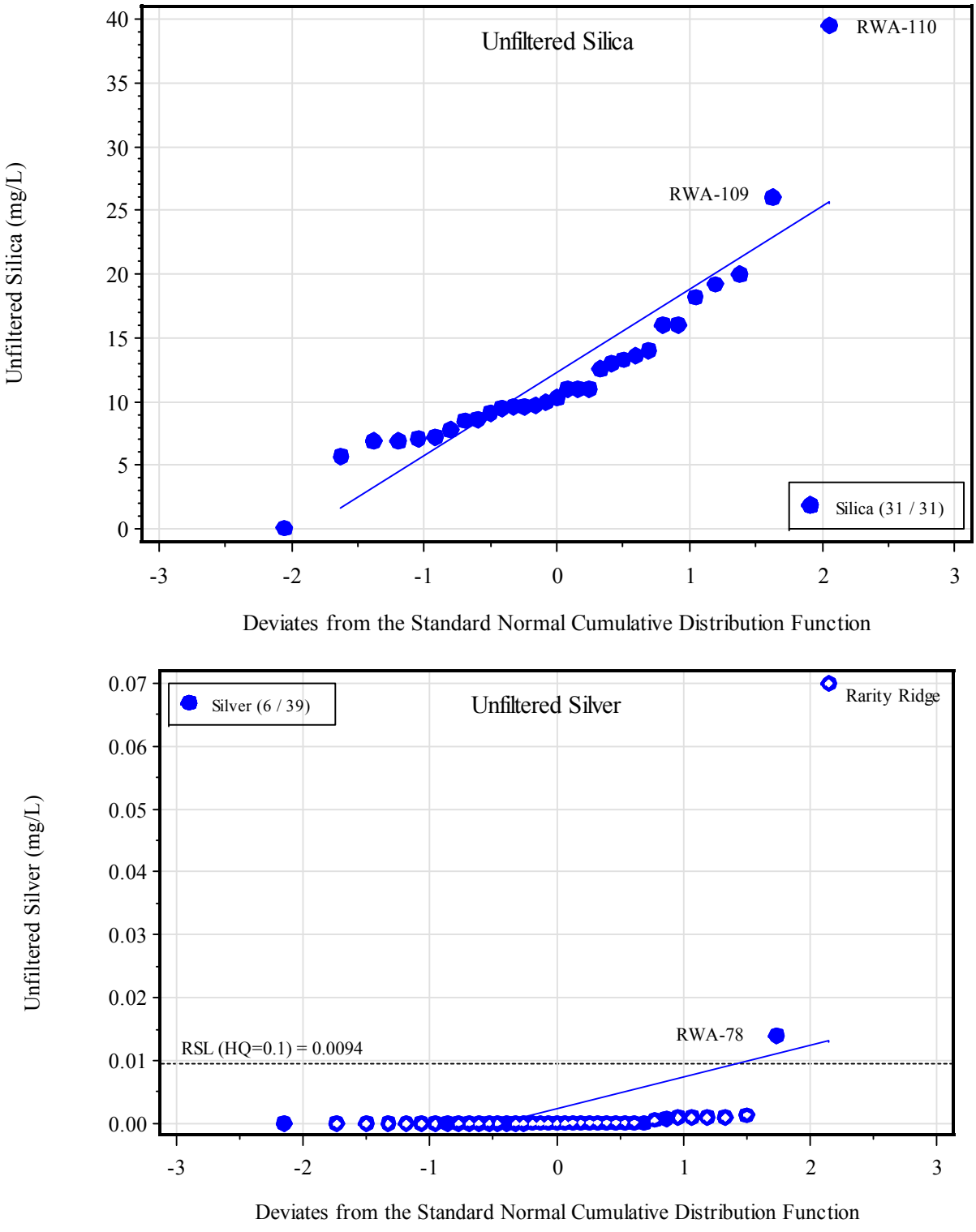
Figure B.10. Normal probability plots of unfiltered nickel and phosphorous (fourth dataset).





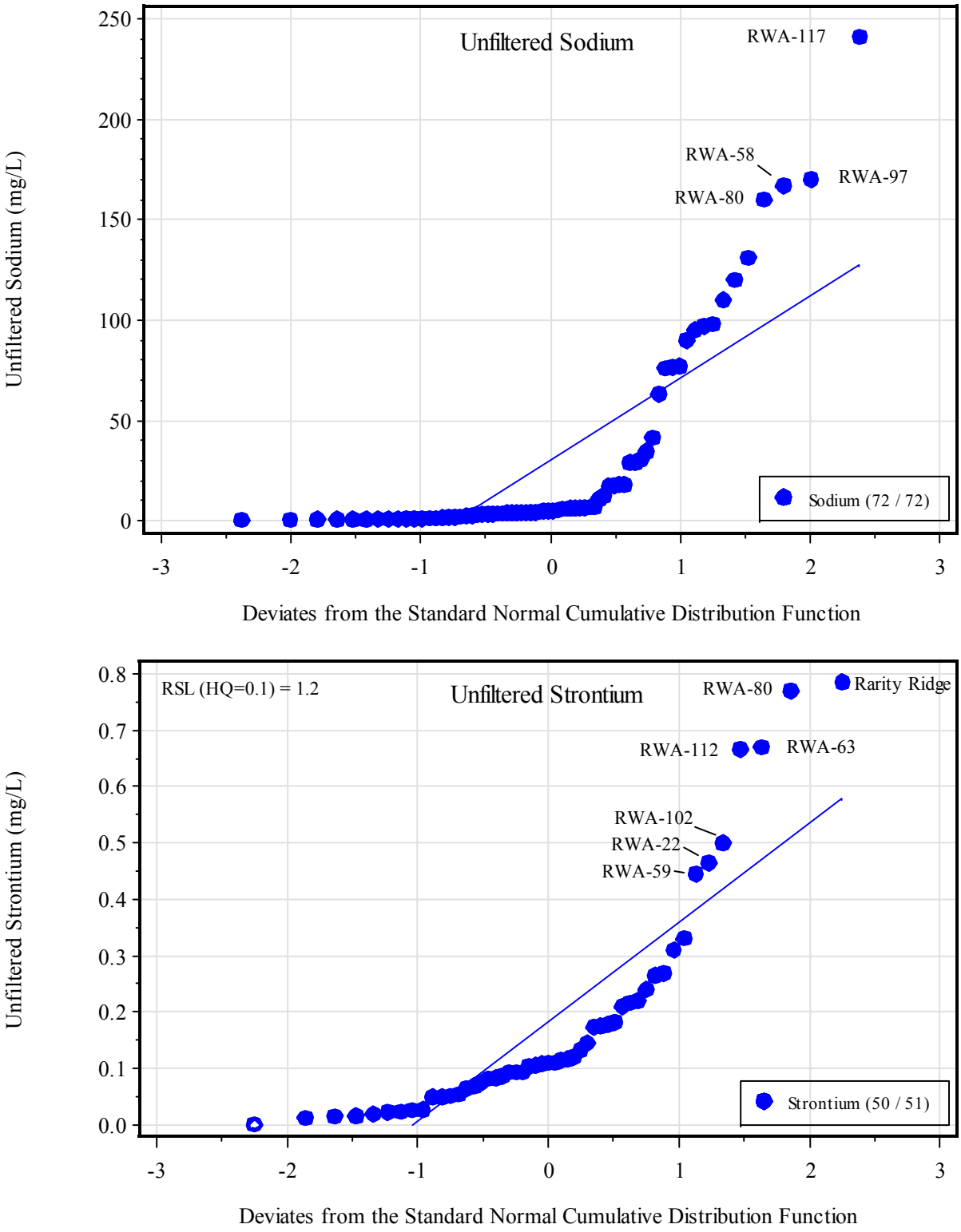
Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

Figure B.11. Normal probability plots of unfiltered potassium and selenium (fourth dataset).



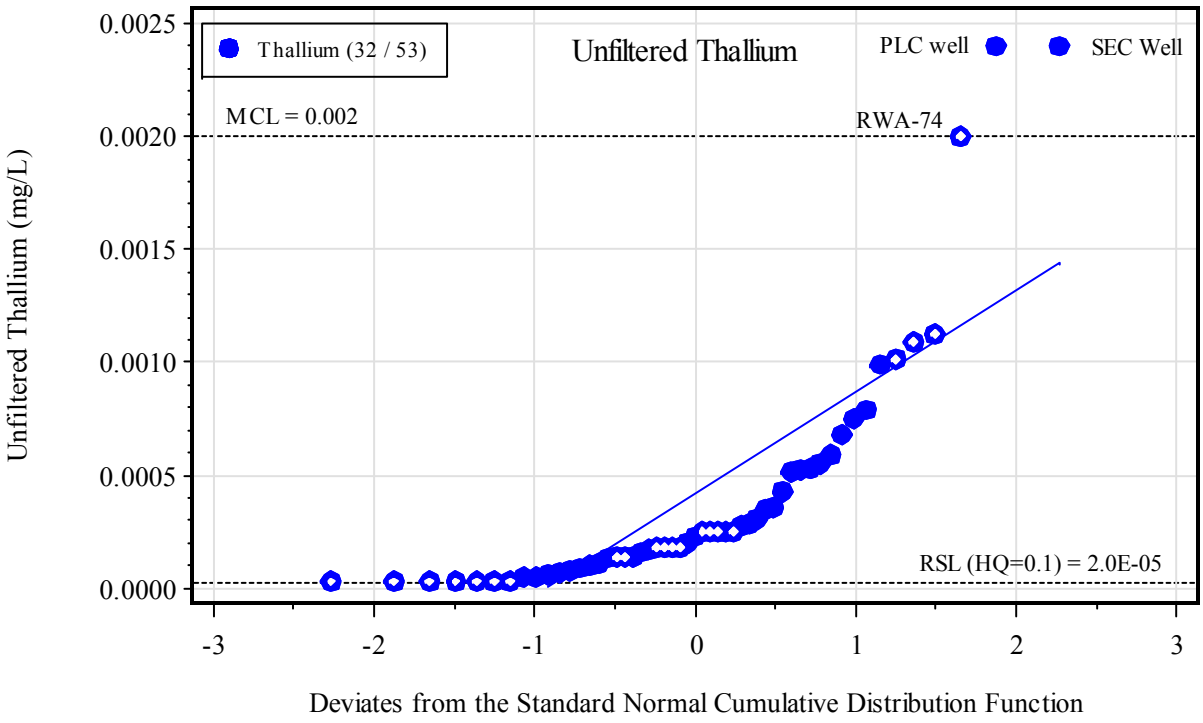
Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

Figure B.12. Normal probability plots of unfiltered silica and silver (fourth dataset).

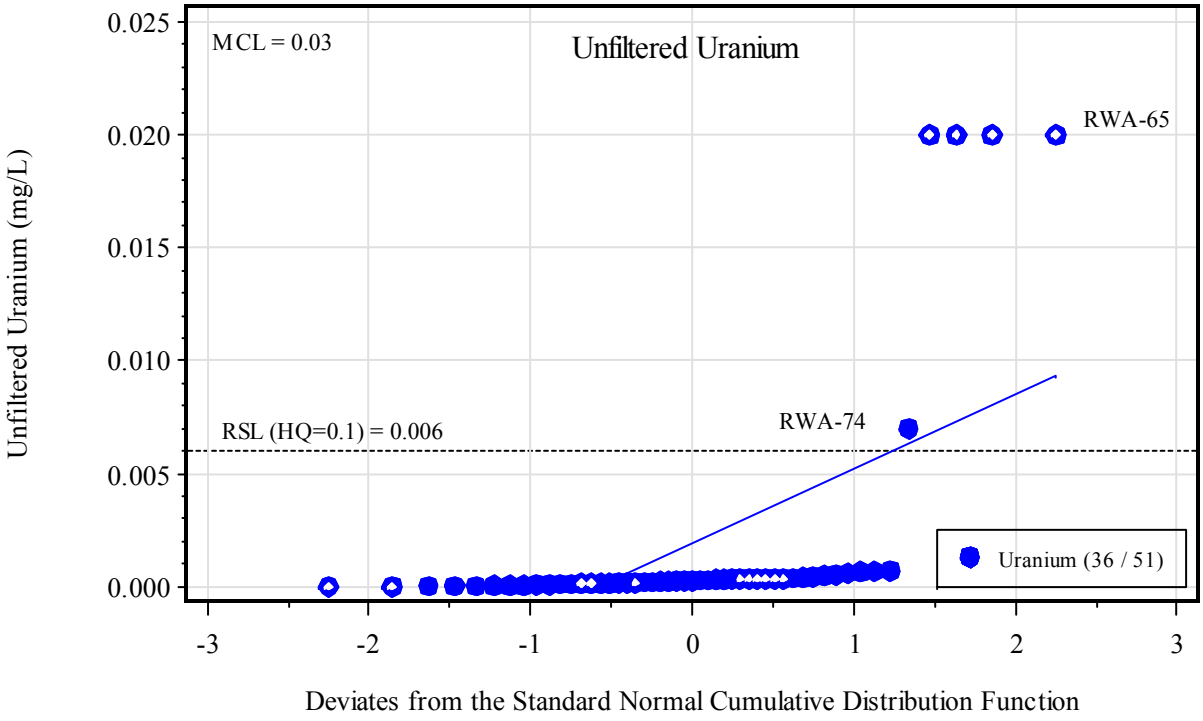


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

Figure B.13. Normal probability plots of unfiltered sodium and strontium (fourth dataset).

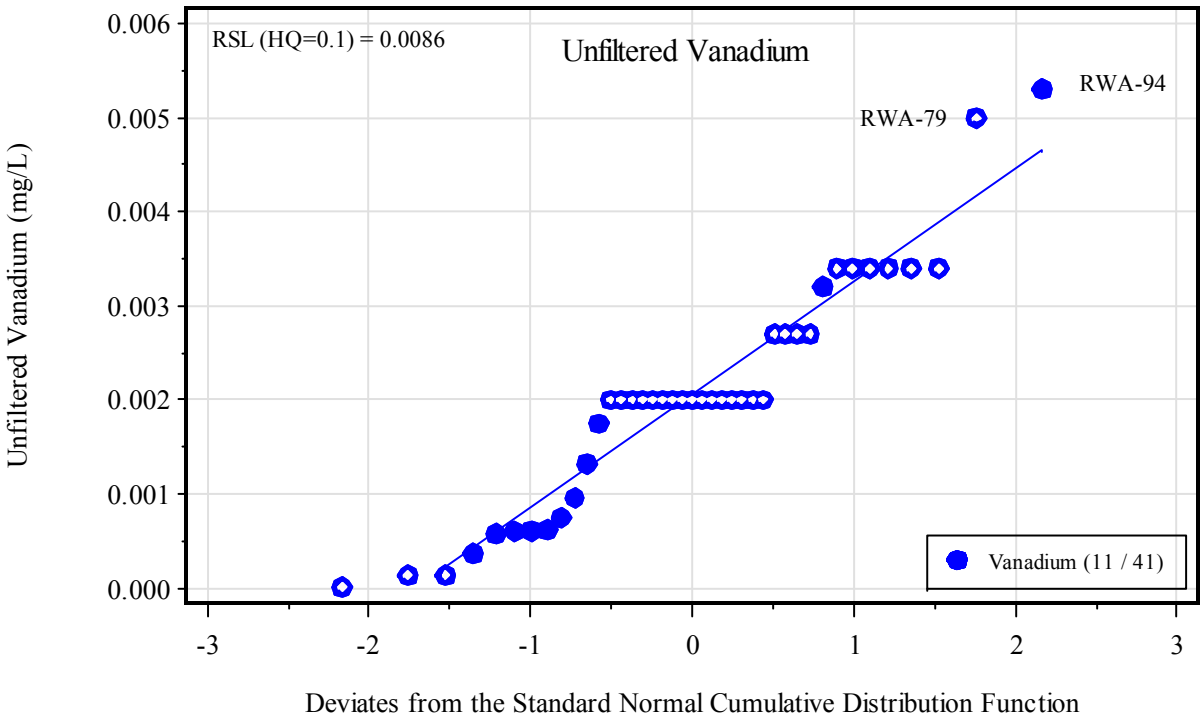


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

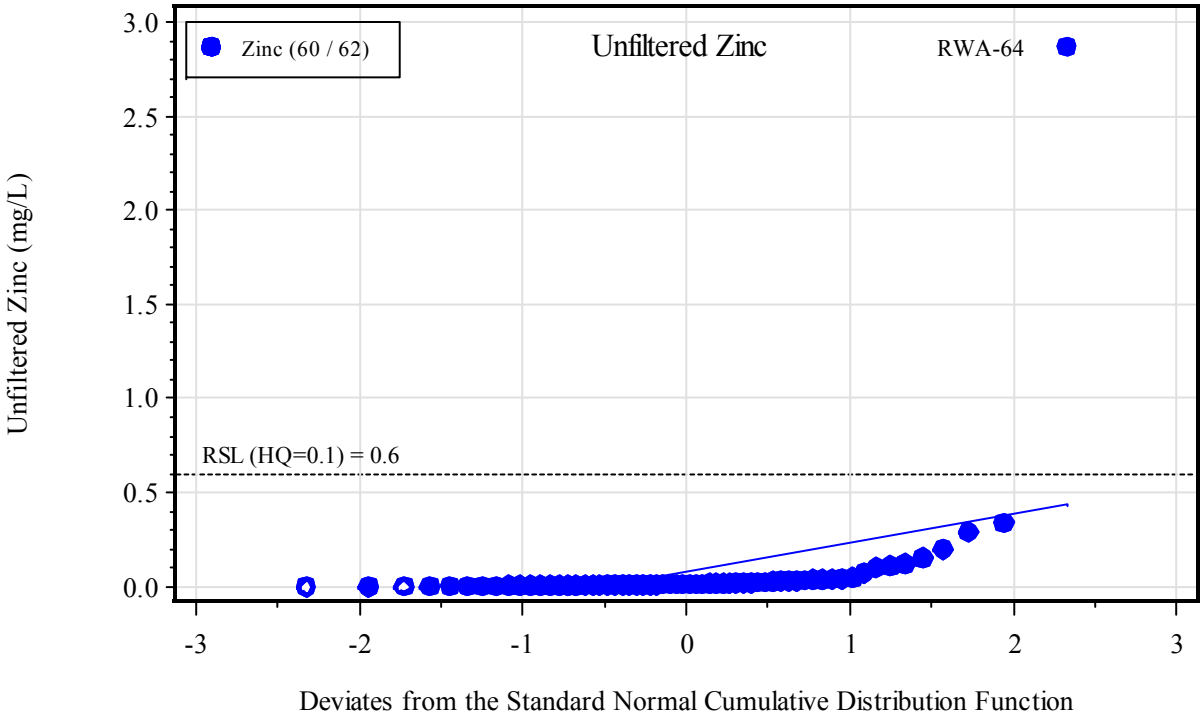


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

Figure B.14. Normal probability plots of unfiltered thallium and uranium (fourth dataset).

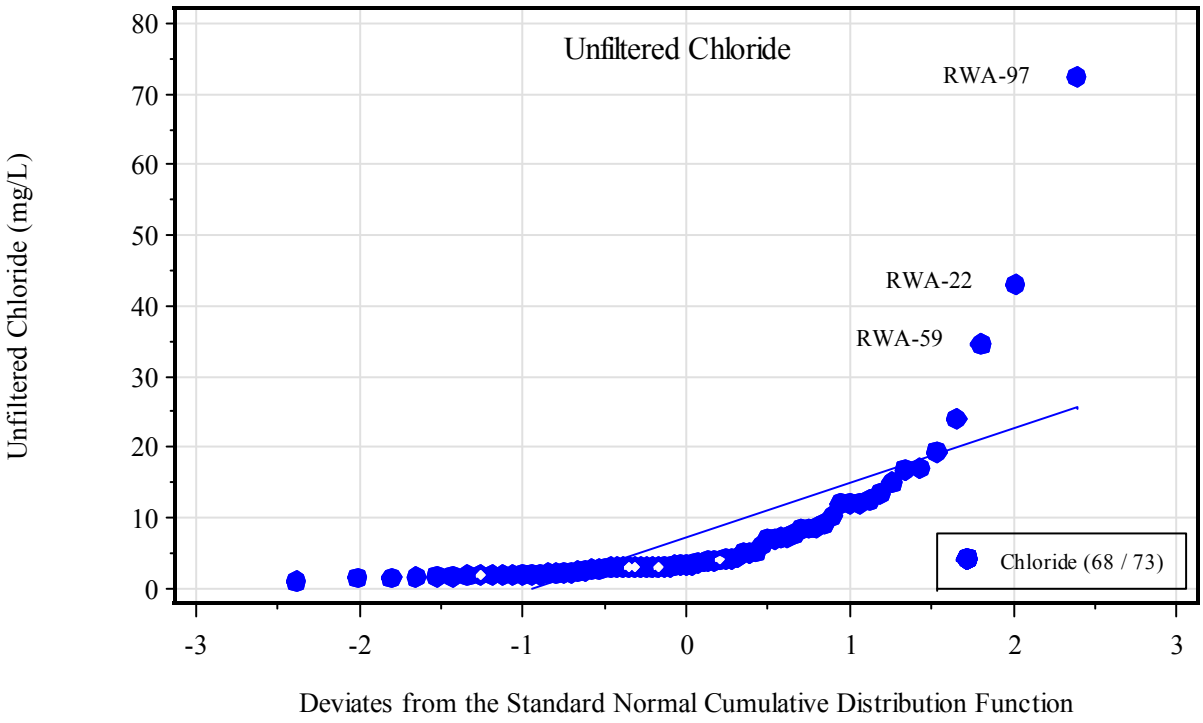


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

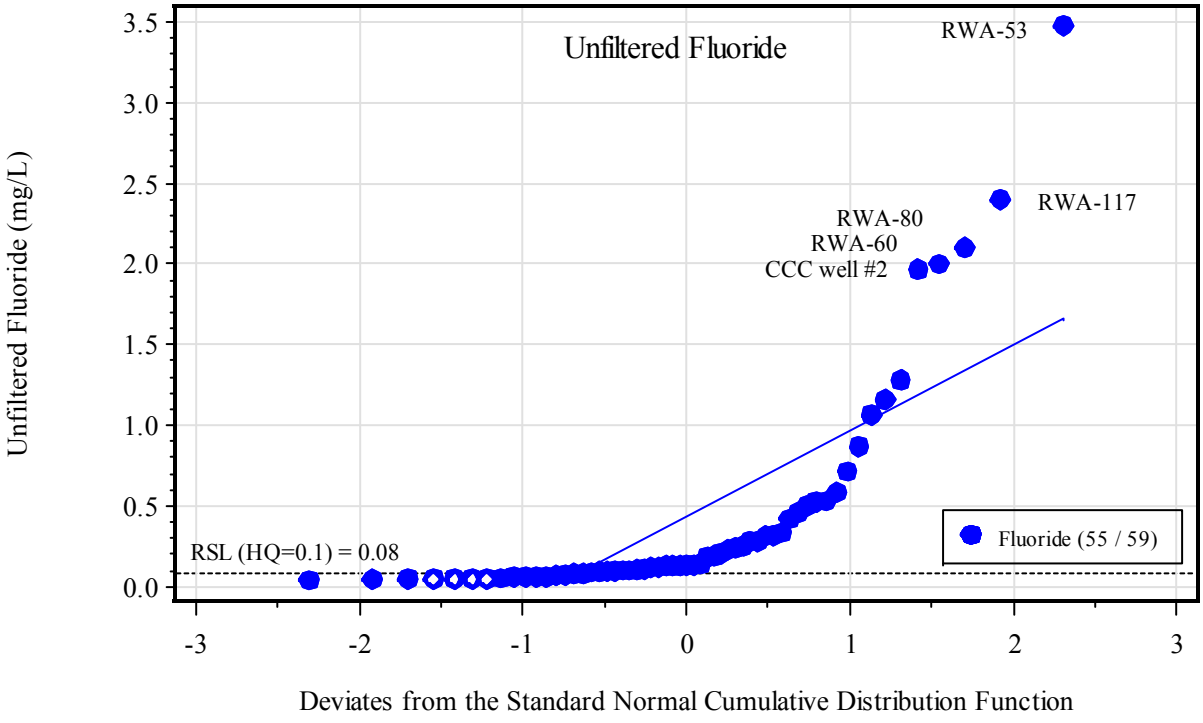


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

Figure B.15. Normal probability plots of unfiltered vanadium and zinc (fourth dataset).

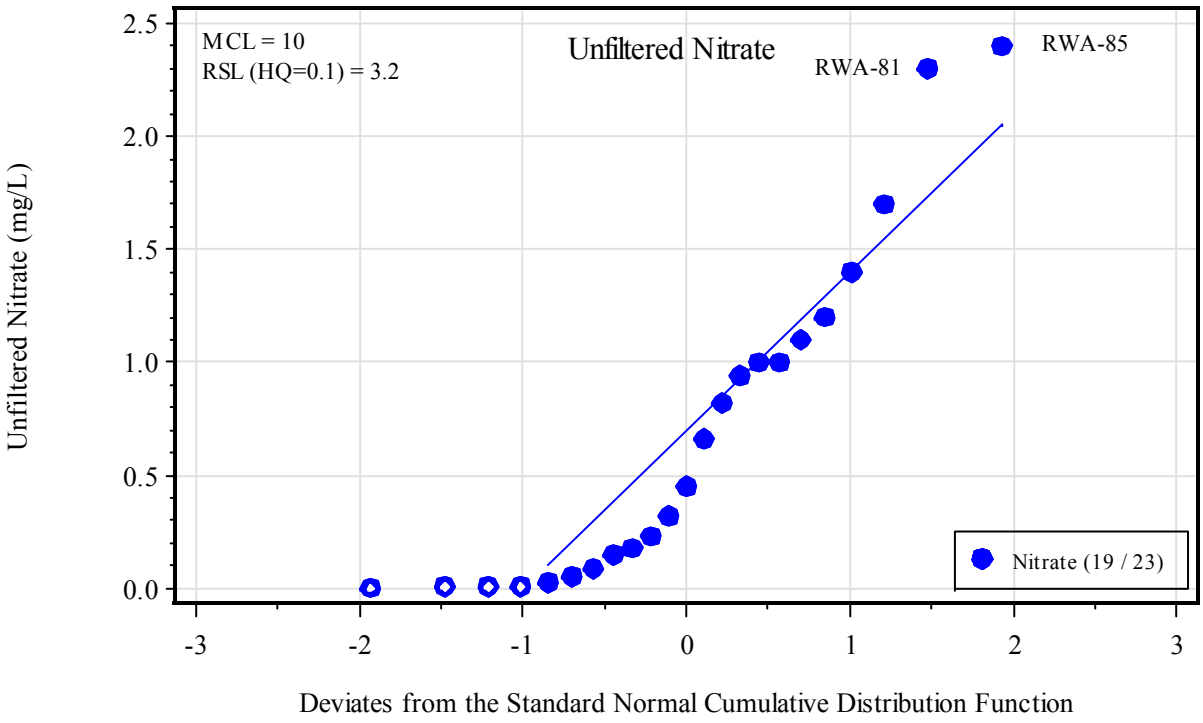


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

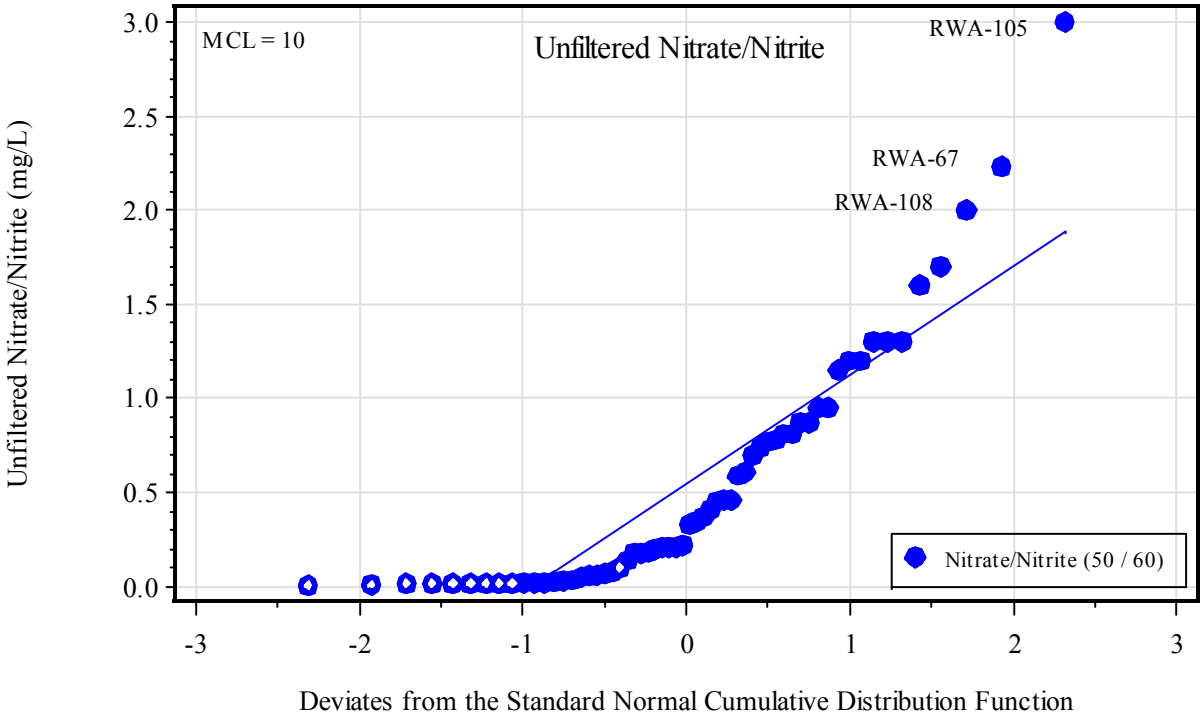


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

Figure B.16. Normal probability plots of unfiltered chloride and fluoride (fourth dataset).

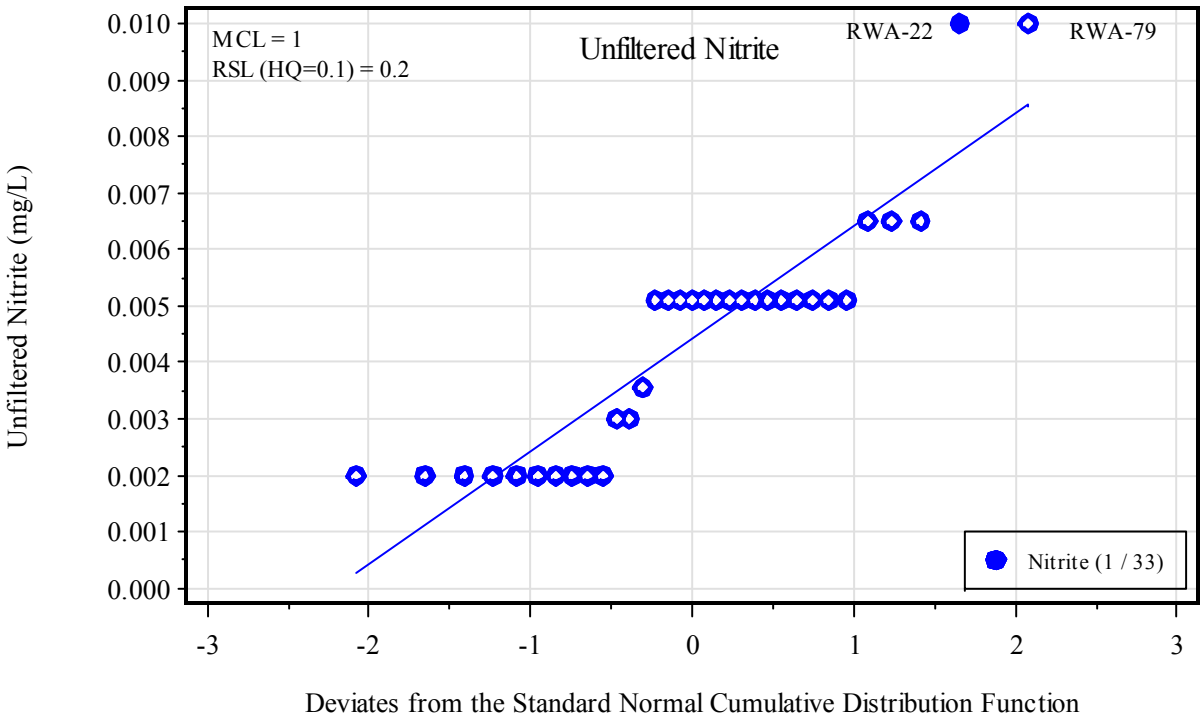


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

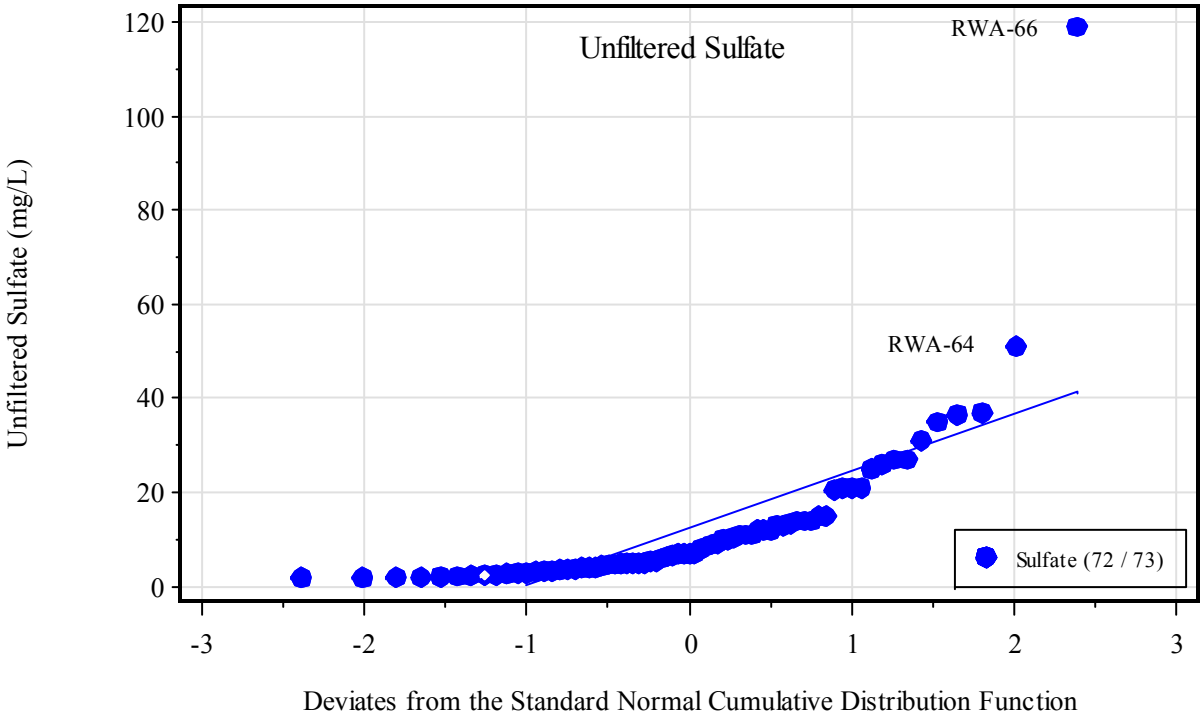


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

Figure B.17. Normal probability plots of unfiltered nitrate and nitrate/nitrite (fourth dataset).



Hollow symbols denote non-detects. Solid symbols denote detected concentrations.



Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

Figure B.18. Normal probability plots of unfiltered nitrite and sulfate (fourth dataset).

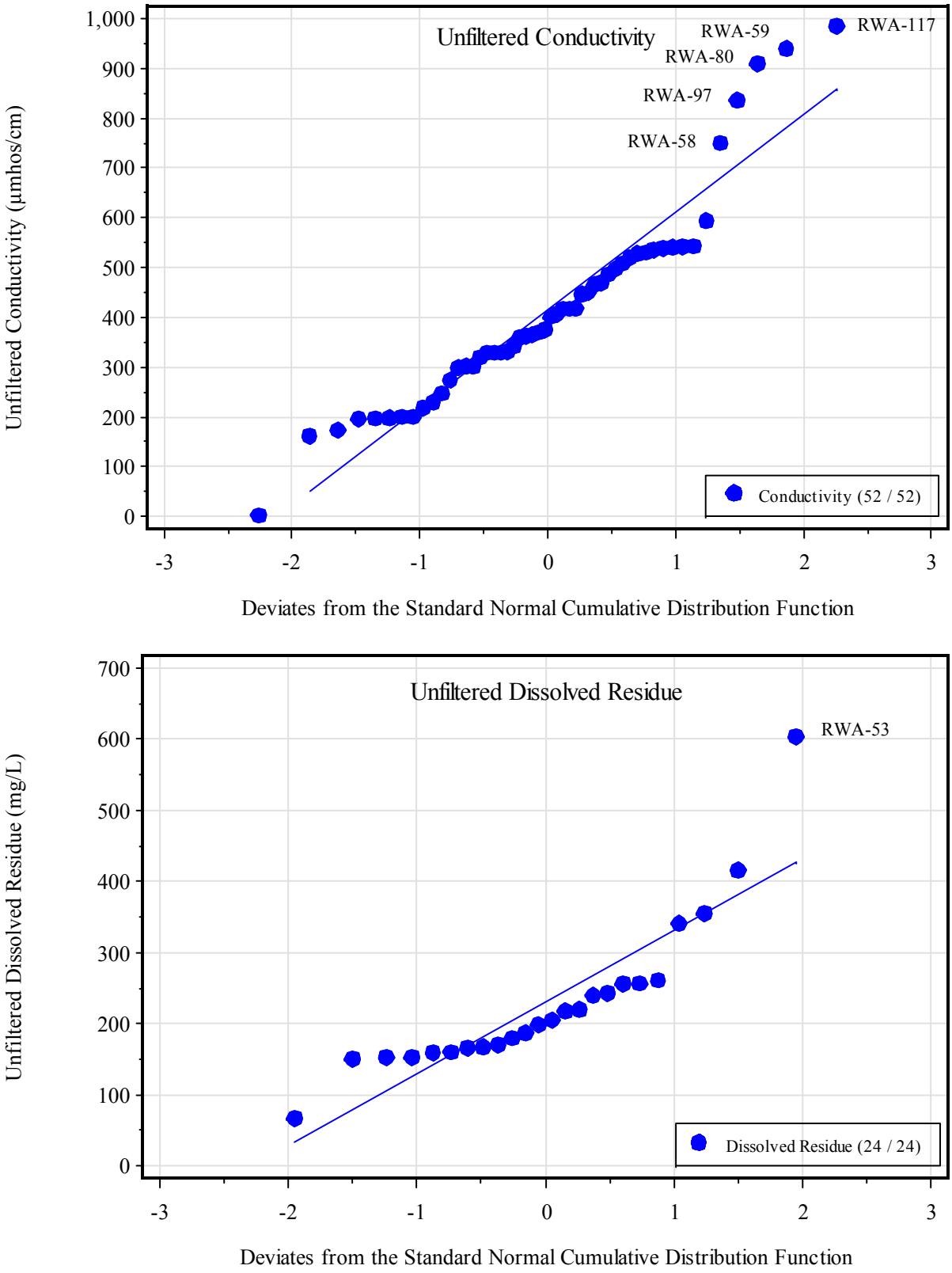
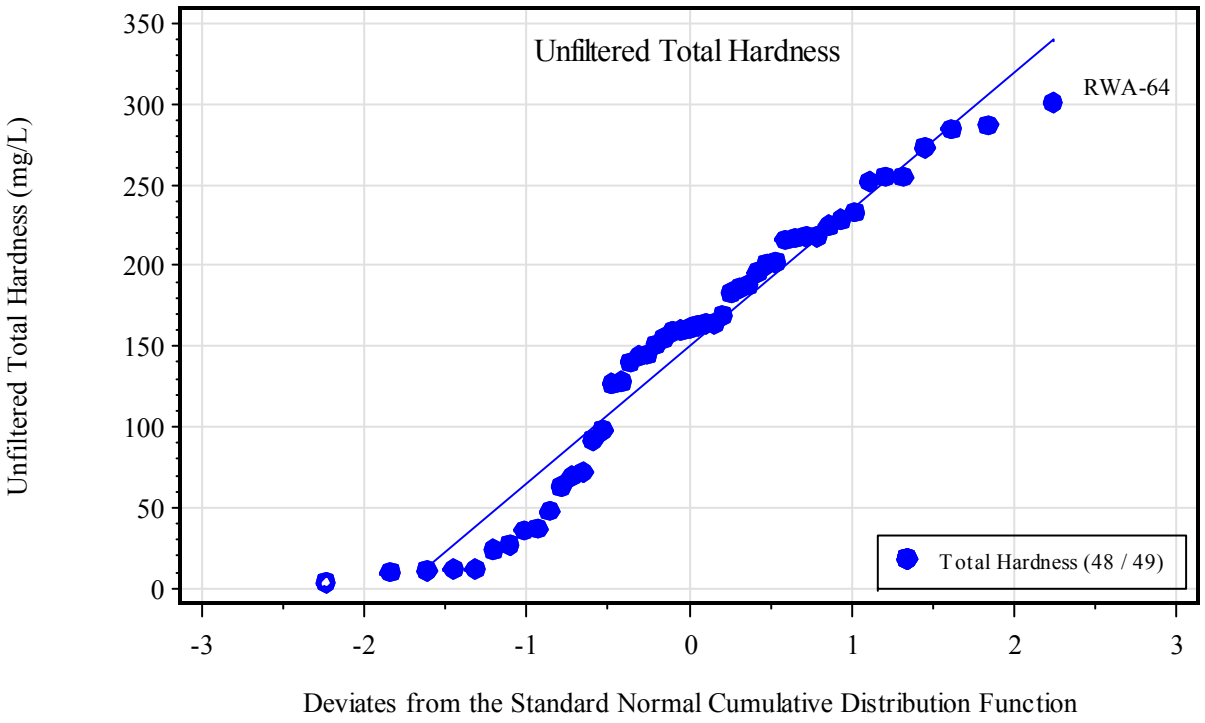


Figure B.19. Normal probability plots of unfiltered conductivity and dissolved residue (fourth dataset).



Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

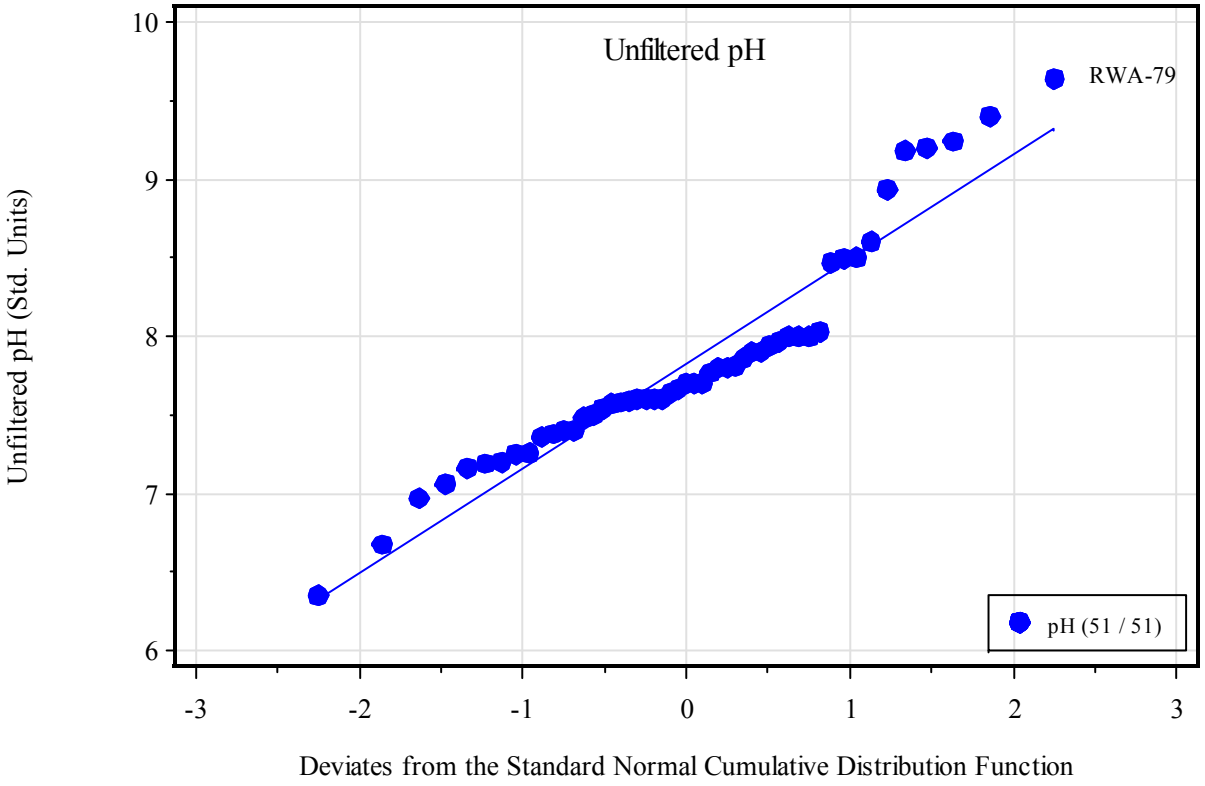
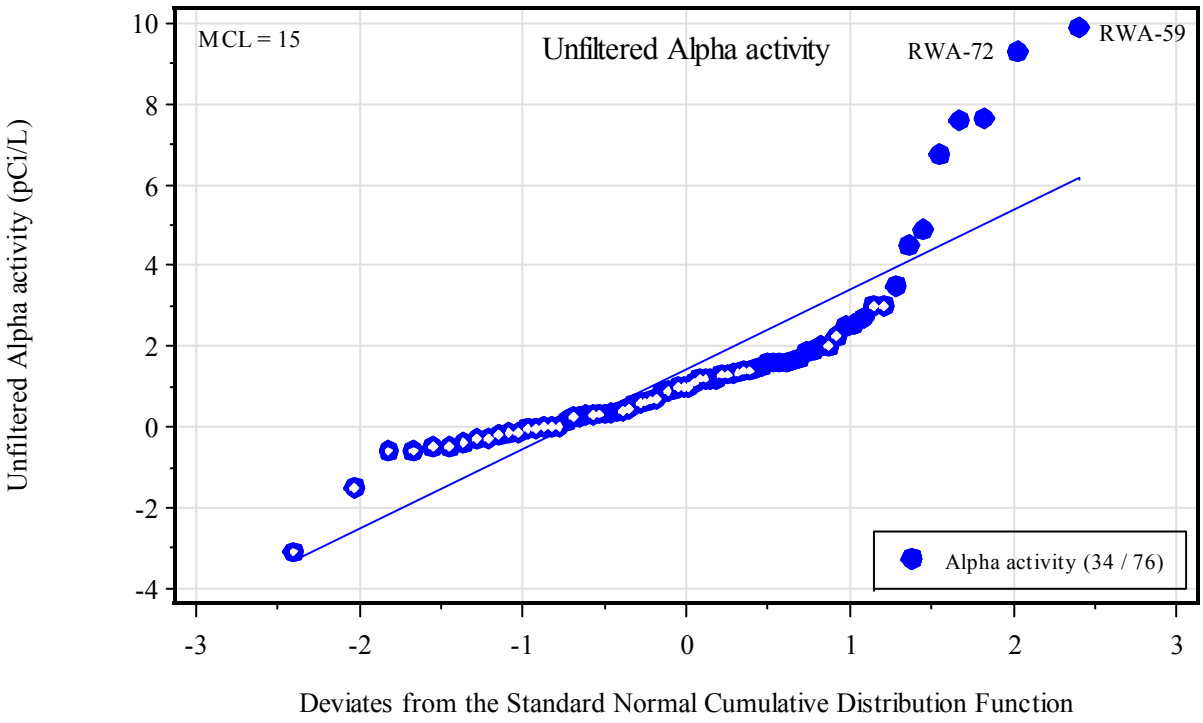
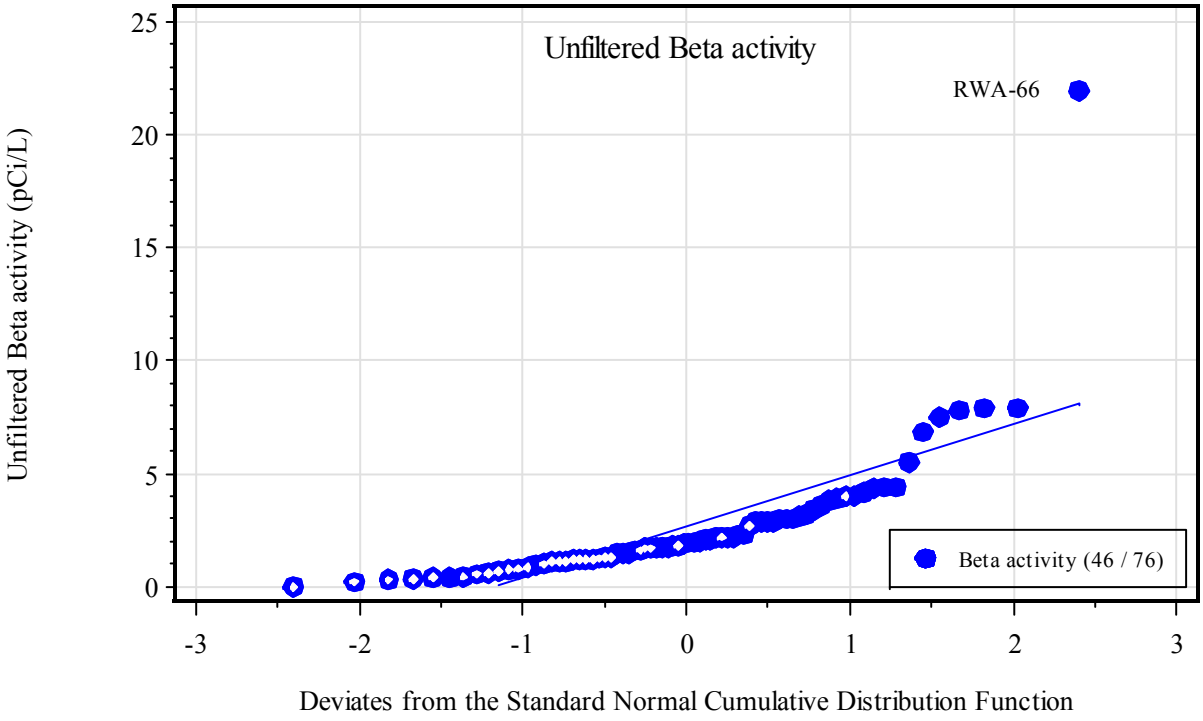


Figure B.20. Normal probability plots of unfiltered total hardness and pH (fourth dataset).



Hollow symbols denote non-detects. Solid symbols denote detected concentrations.



Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

Figure B.21. Normal probability plots of unfiltered alpha activity and beta activity (fourth dataset).

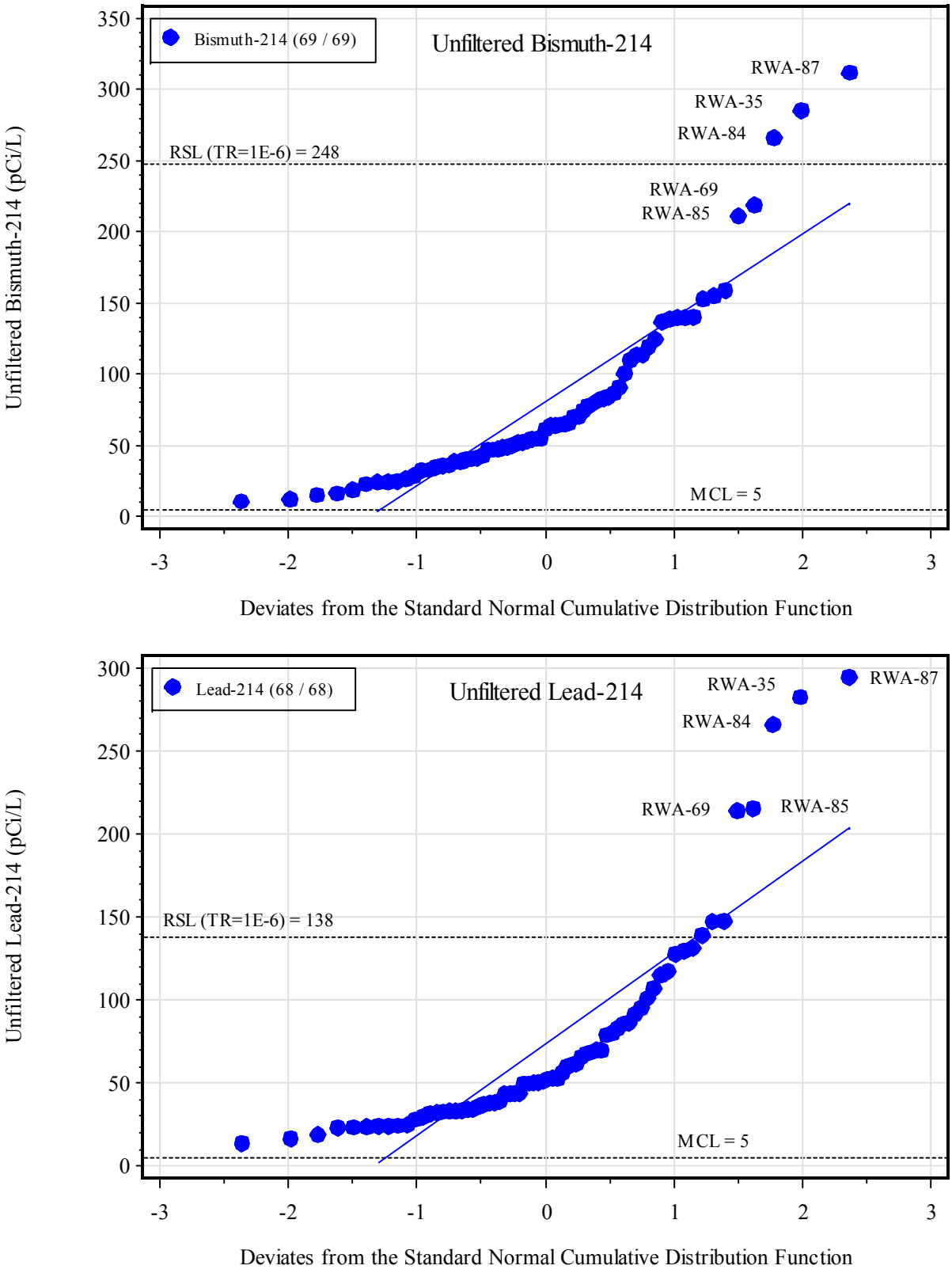
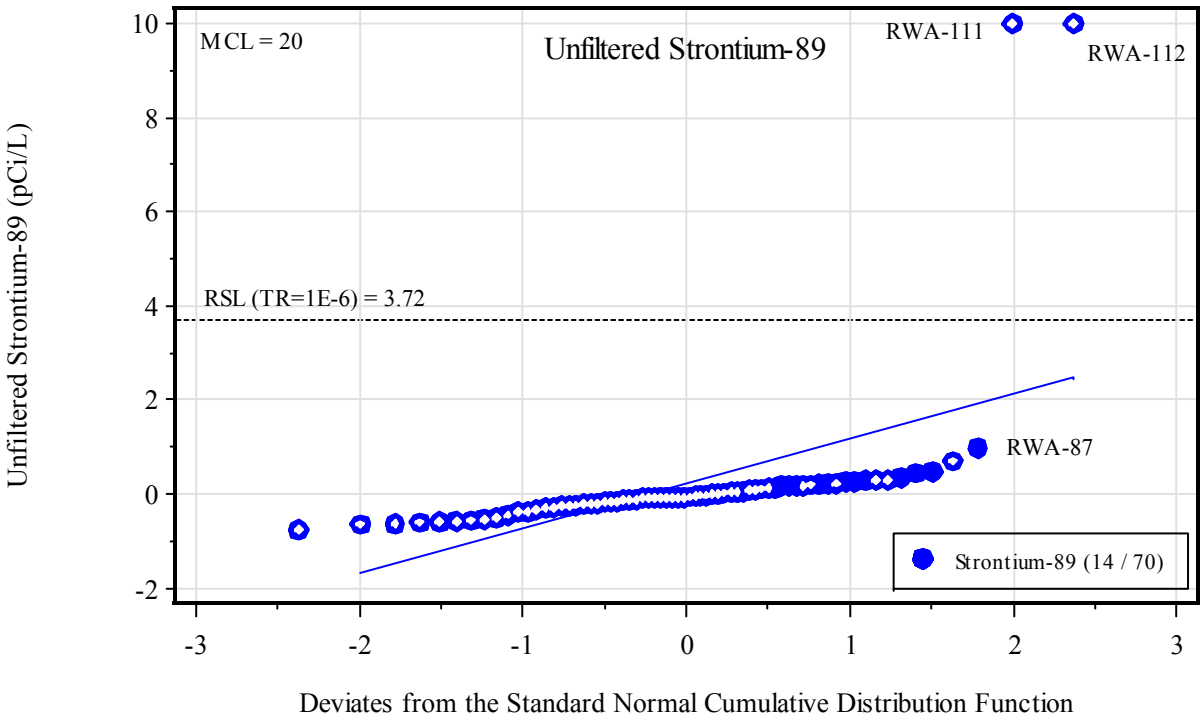
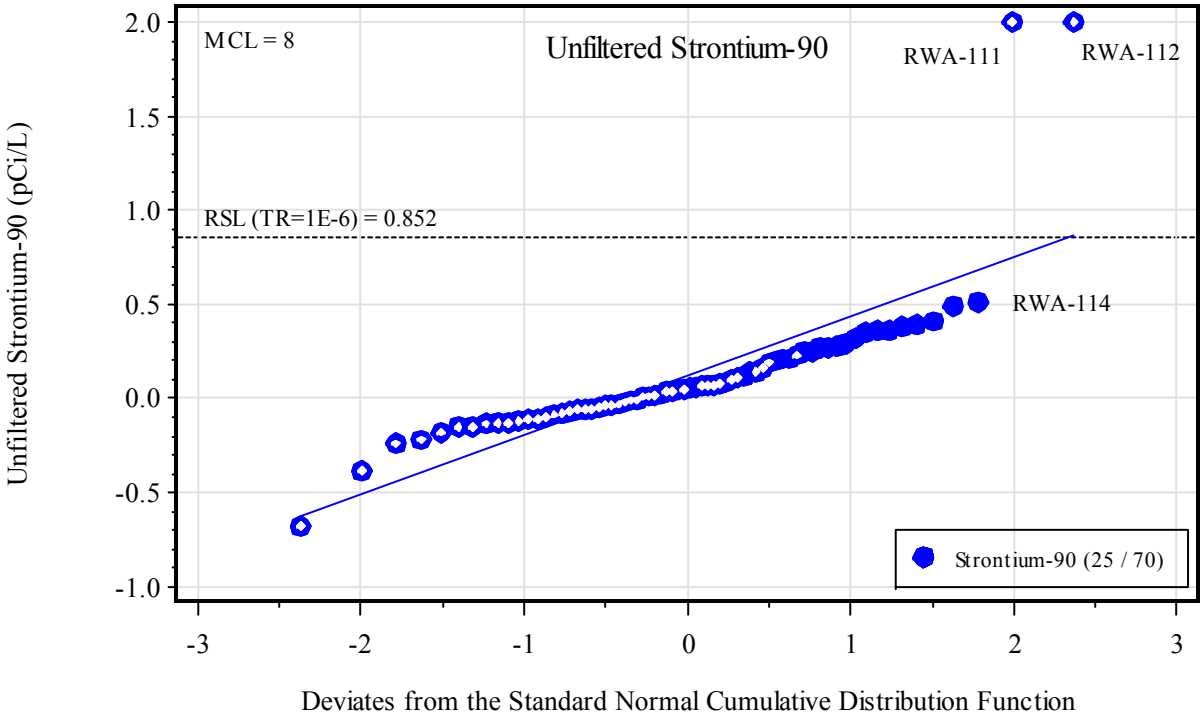


Figure B.22. Normal probability plots of unfiltered bismuth-214 and lead-214 (fourth dataset).

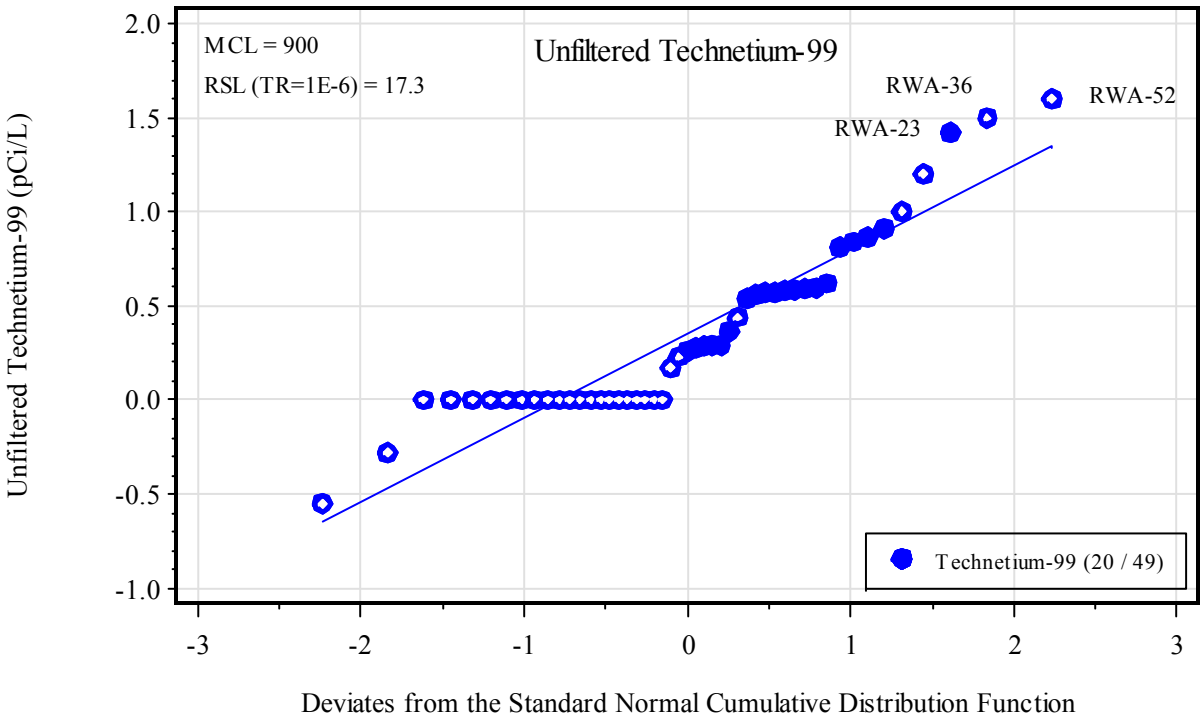


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

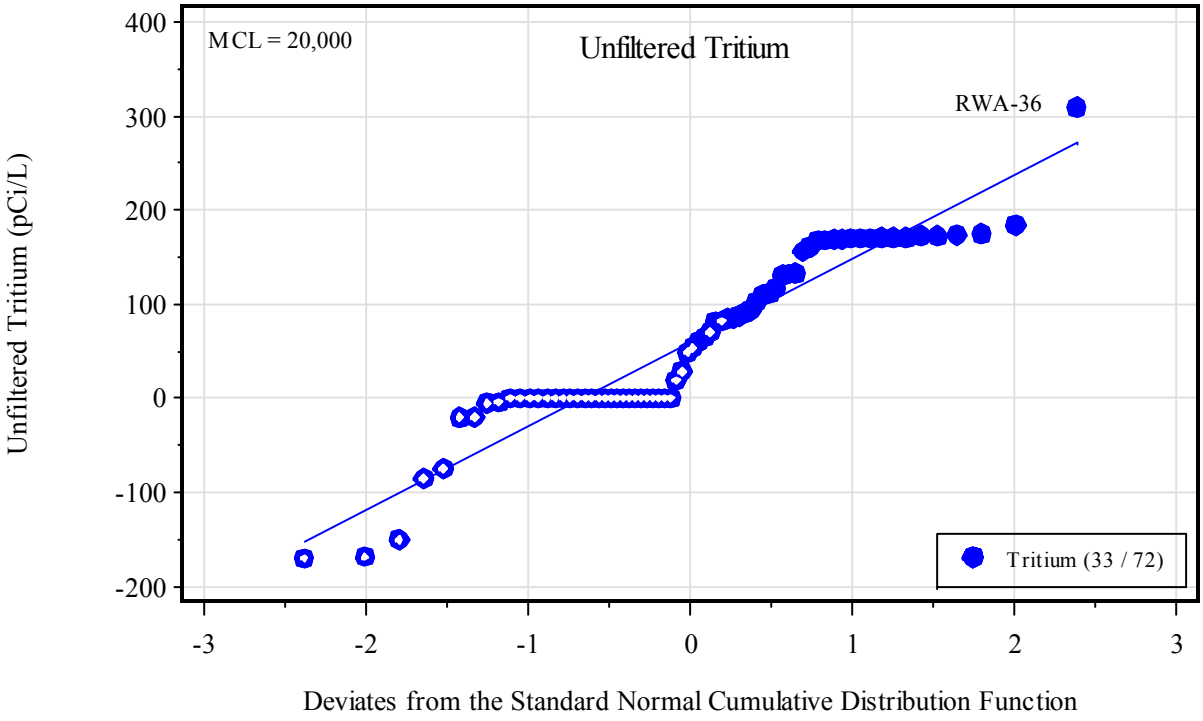


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

Figure B.23. Normal probability plots of unfiltered strontium-89 and strontium-90 (fourth dataset).

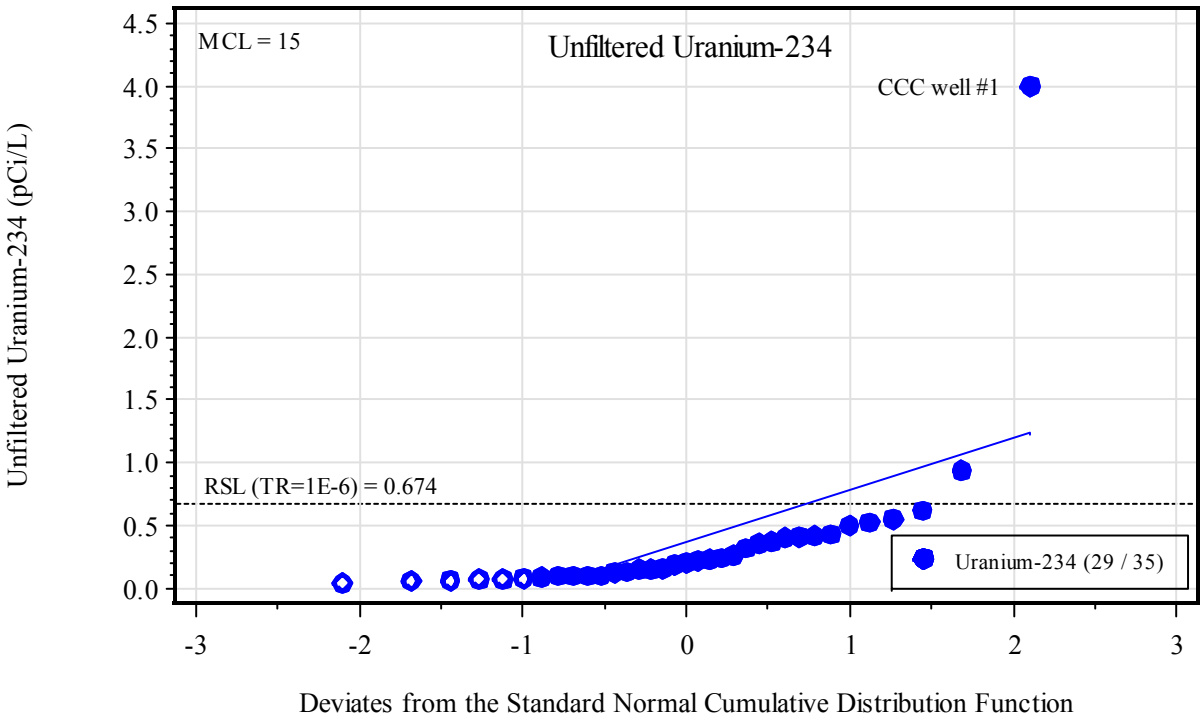


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

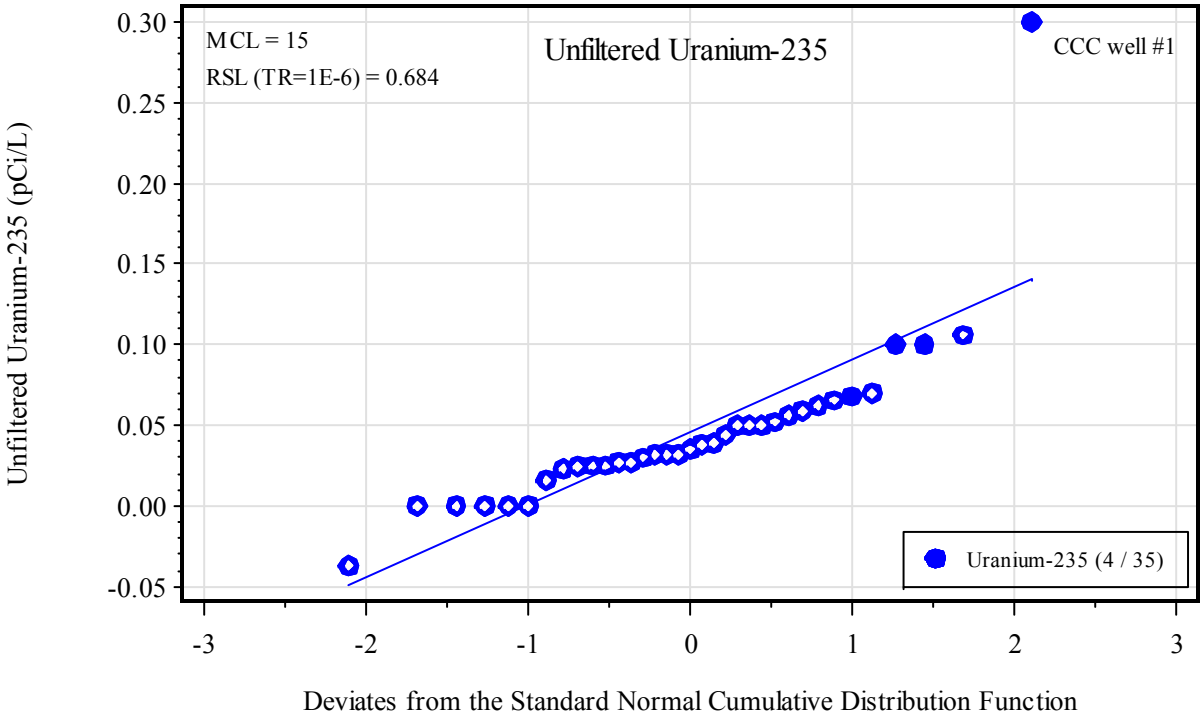


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

Figure B.24. Normal probability plots of unfiltered technetium-99 and tritium (fourth dataset).

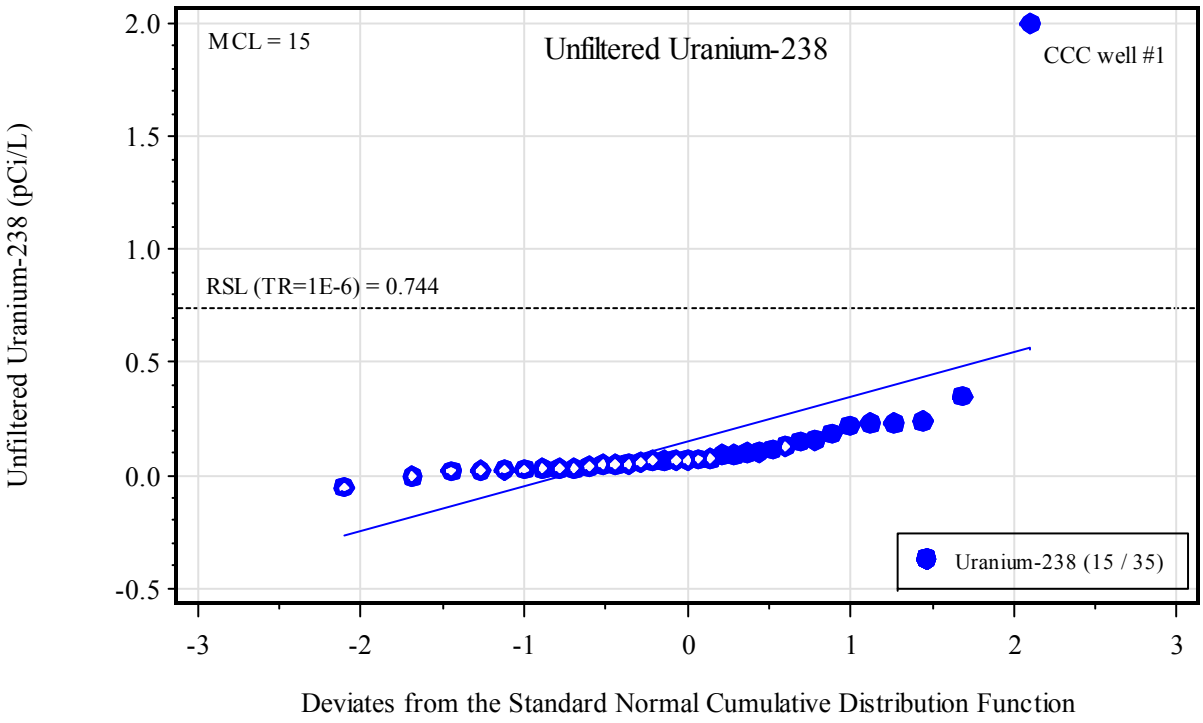


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.



Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

Figure B.25. Normal probability plots of unfiltered uranium-234 and uranium-235 (fourth dataset).



Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

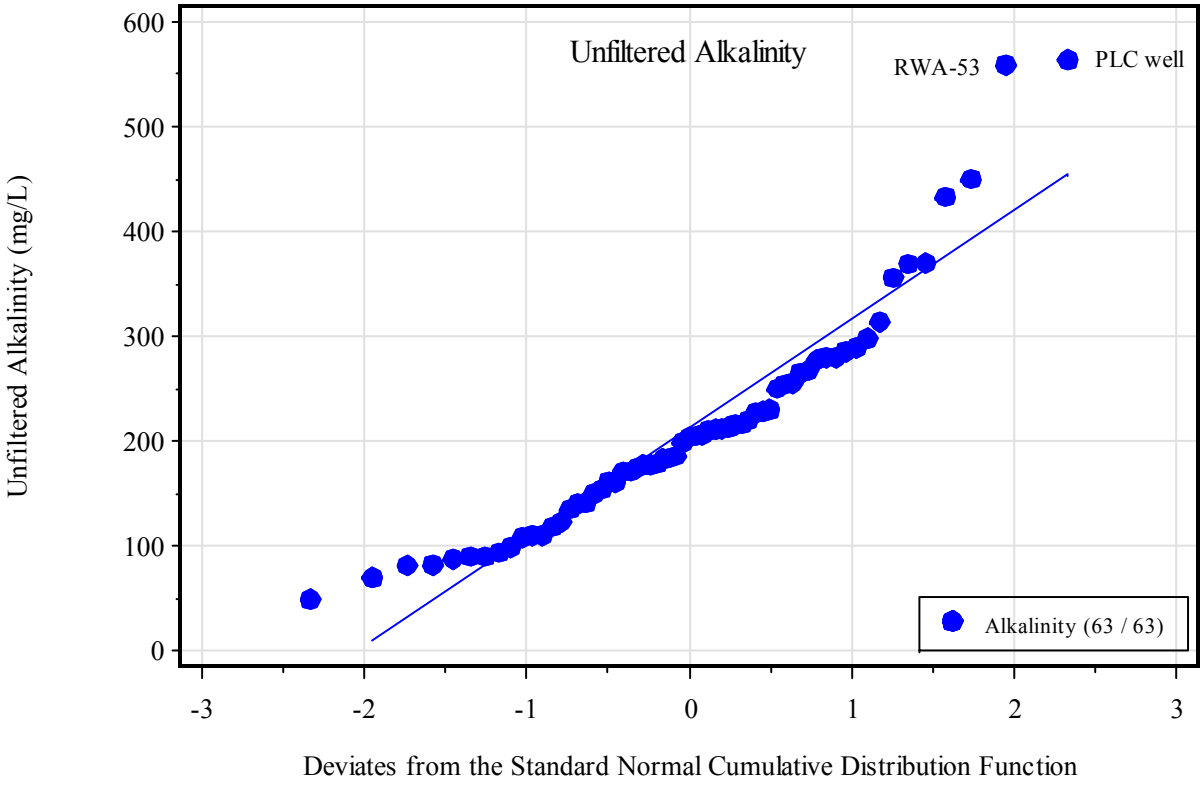


Figure B.26. Normal probability plots of unfiltered uranium-238 and alkalinity (fourth dataset).

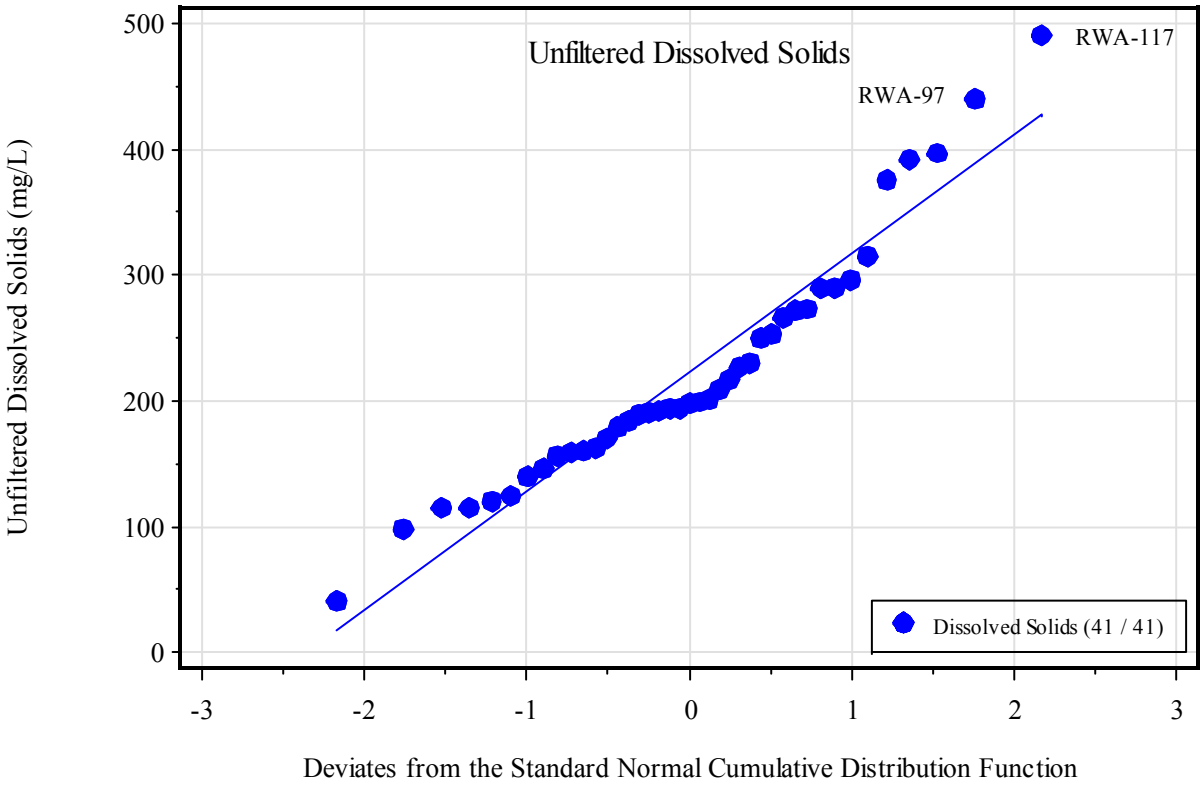


Figure B.27. Normal probability plot of unfiltered dissolved solids (fourth dataset).

Table B.2. Matrix identifying possible wells to eliminate based on outliers from probability plots (Figures B.1 – B. 27)

Well	Totals	Aluminum	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Selenium	Silica	Silver	Sodium	Thallium	Uranium	Zinc	Chloride	Fluoride	Sulfate	Beta Activity	Sr-89	Sr-90	Tritium	U-234	U-235	U-238
CCC well #1	3																															1	1	1
CCC well #2	5		1	1										1		1		1																
PLC well	7		1			1		1		1		1	1									1												
Rarity Ridge	1																			1														
RWA-22	1											1																						
RWA-36	1																														1			
RWA-53	1																									1								
RWA-58	1																	1																
RWA-63	2				1	1																												
RWA-64	2									1														1										
RWA-65	1																						1											
RWA-66	2																										1	1						
RWA-74	3										1											1	1											
RWA-77	1										1																							
RWA-79	2			1						1																								
RWA-87	1				1																													
RWA-88	1					1																												
RWA-94	3	1								1			1																					
RWA-95	2			1													1																	
RWA-97	1																								1									
RWA-107	1											1																						
RWA-110	1																		1															
RWA-111	3				1																								1	1				
RWA-112	2																												1	1				
RWA-114	3	1								1			1																					
RWA-116	1														1																			
RWA-117	2						1														1													
SEC well	3		1						1													1												
Totals	57	2	3	3	3	3	1	1	1	5	2	3	3	1	1	1	1	2	1	1	1	3	2	1	1	1	1	1	2	2	1	1	1	1

Table B.3. Tables relating wells and potential outliers

Well	Number of Outliers	Cumulative Number of Outliers	Number of Wells Eliminated with Removal Outliers
PLC well	7	7	1
CCC well #2	5	12	2
CCC well #1	3	15	3
RWA-74	3	18	4
RWA-94	3	21	5
RWA-111	3	24	6
RWA-114	3	27	7
SEC well	3	30	8
RWA-63	2	32	9
RWA-64	2	34	10
RWA-66	2	36	11
RWA-79	2	38	12
RWA-95	2	40	13
RWA-112	2	42	14
RWA-117	2	44	15
Rarity Ridge	1	45	16
RWA-22	1	46	17
RWA-36	1	47	18
RWA-53	1	48	19
RWA-58	1	49	20
RWA-65	1	50	21
RWA-77	1	51	22
RWA-87	1	52	23
RWA-88	1	53	24
RWA-97	1	54	25
RWA-107	1	55	26
RWA-110	1	56	27
RWA-116	1	57	28

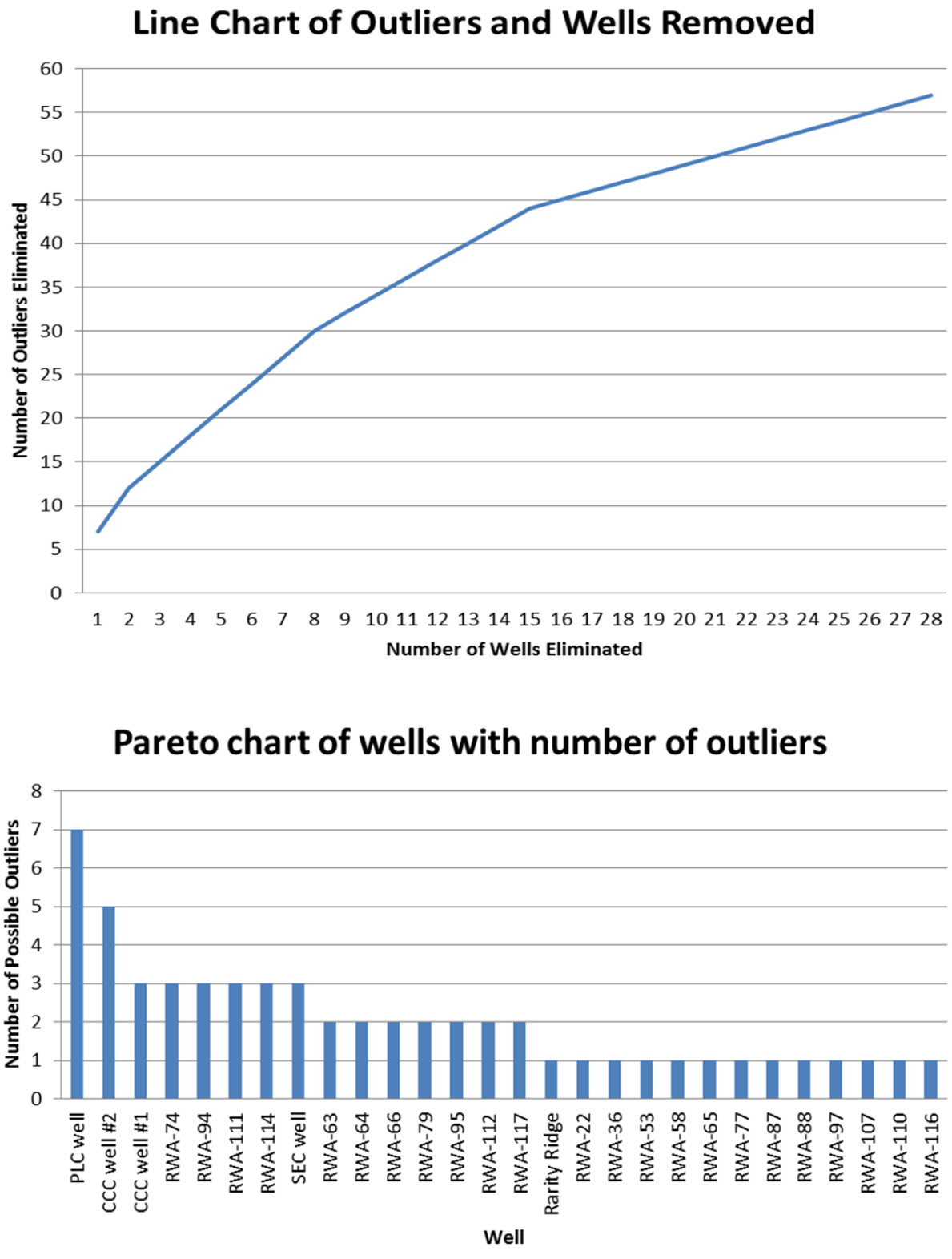


Figure B.28. Charts relating wells and potential outliers.

APPENDIX C
OUTPUT FROM ANALYSIS OF FINAL DATASET

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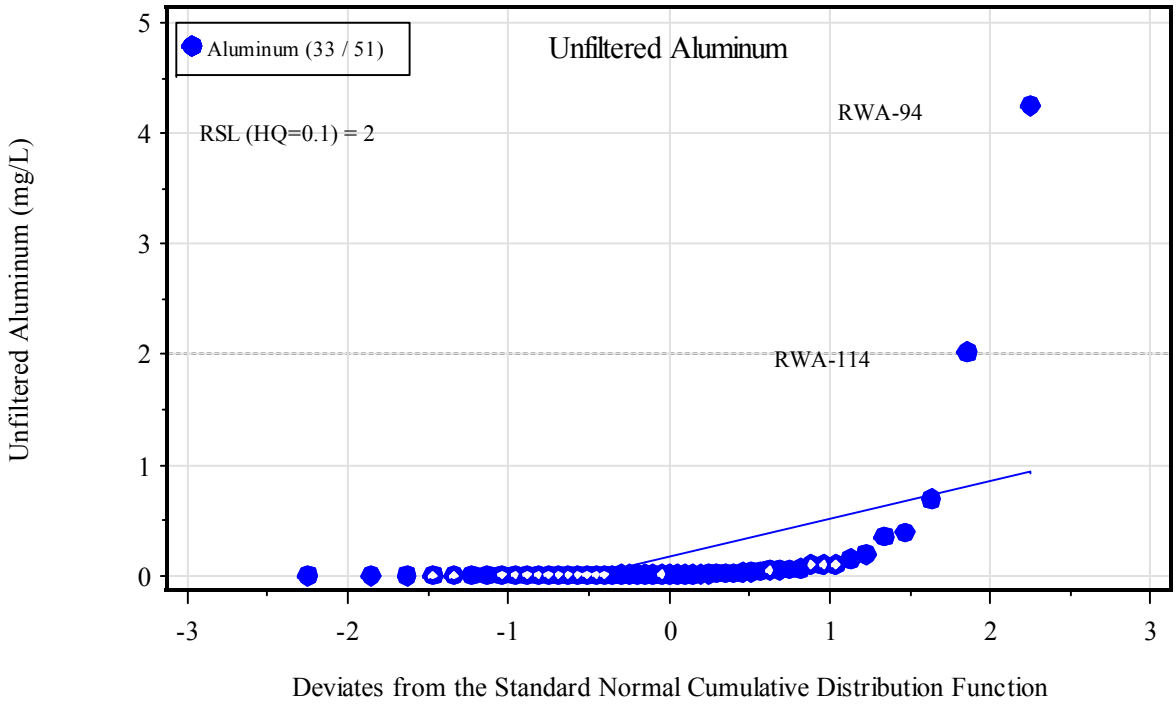
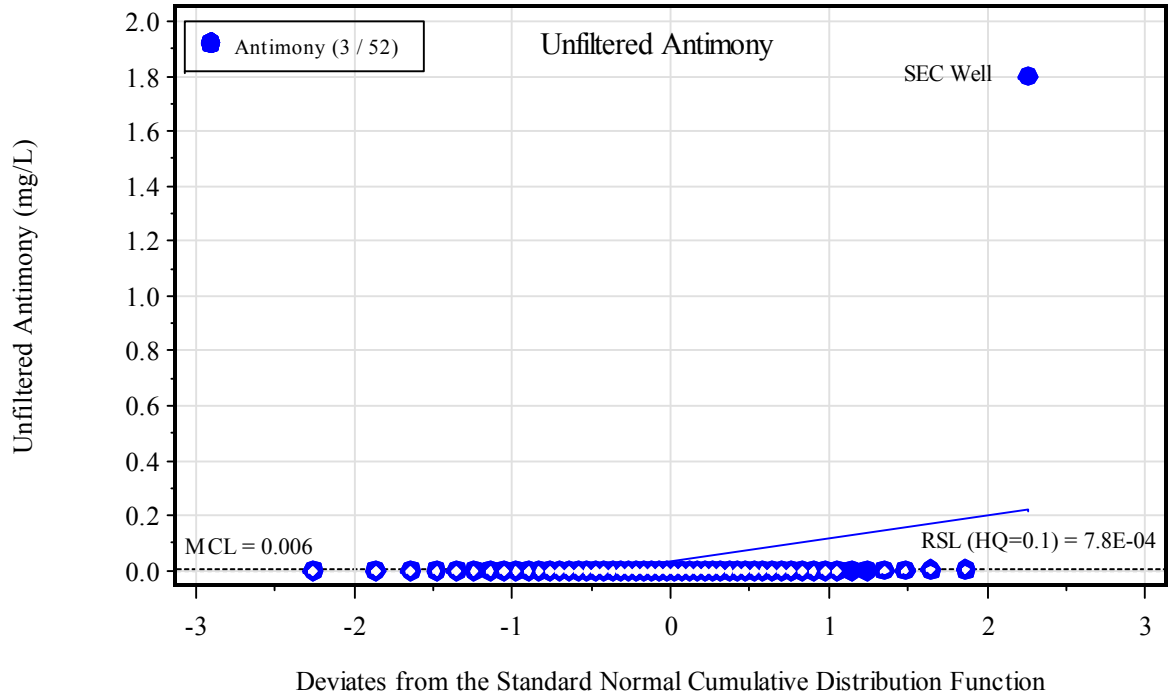
FORMATION APPREVIATIONS FROM CHAPMAN U.S. GEOLOGICAL SURVEY 2013

- CLSD clastic sedimentary rocks
- CLSDF feldspar-rich clastic sedimentary rocks
- CLSDLAC clastic lacustrine/evaporate sedimentary rocks
- CLSDMT metamorphosed clastic sedimentary rocks
- CLSDQ quartz-rich sedimentary rocks
- IGMTF felsic igneous and metamorphic rocks
- IGMTI intermediate igneous or metamorphic rocks
- IGMTM mafic igneous and metamorphic rocks
- MTQ quartz-rich metamorphic rocks
- ULMAF ultramafic rocks

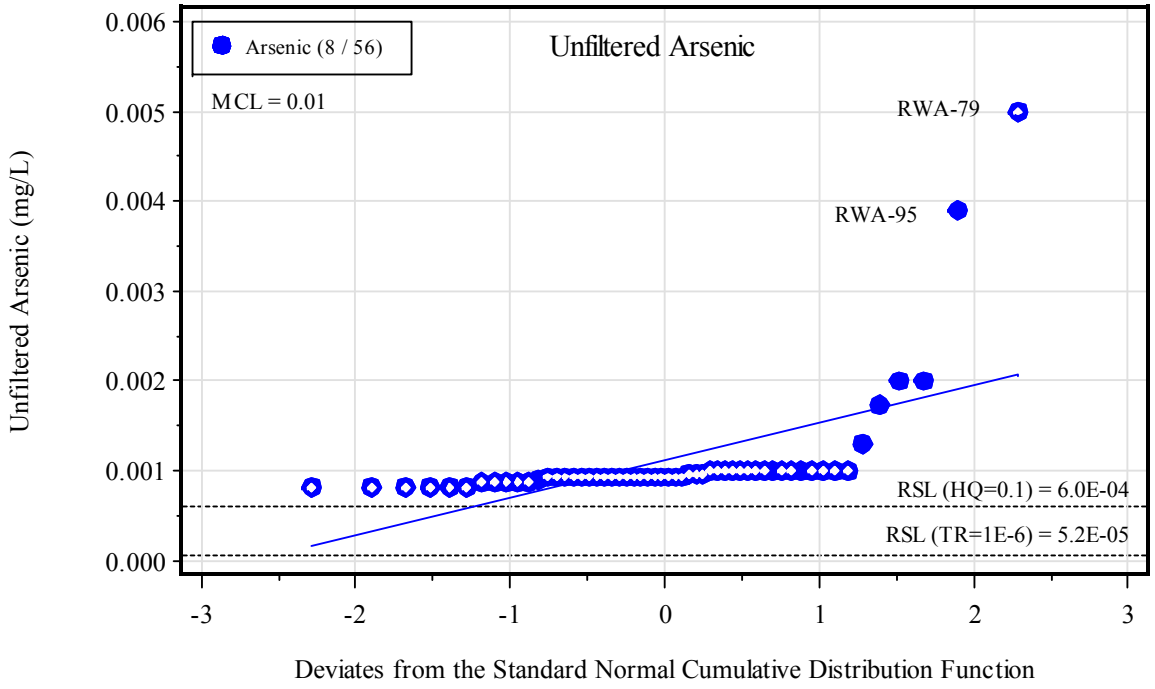


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

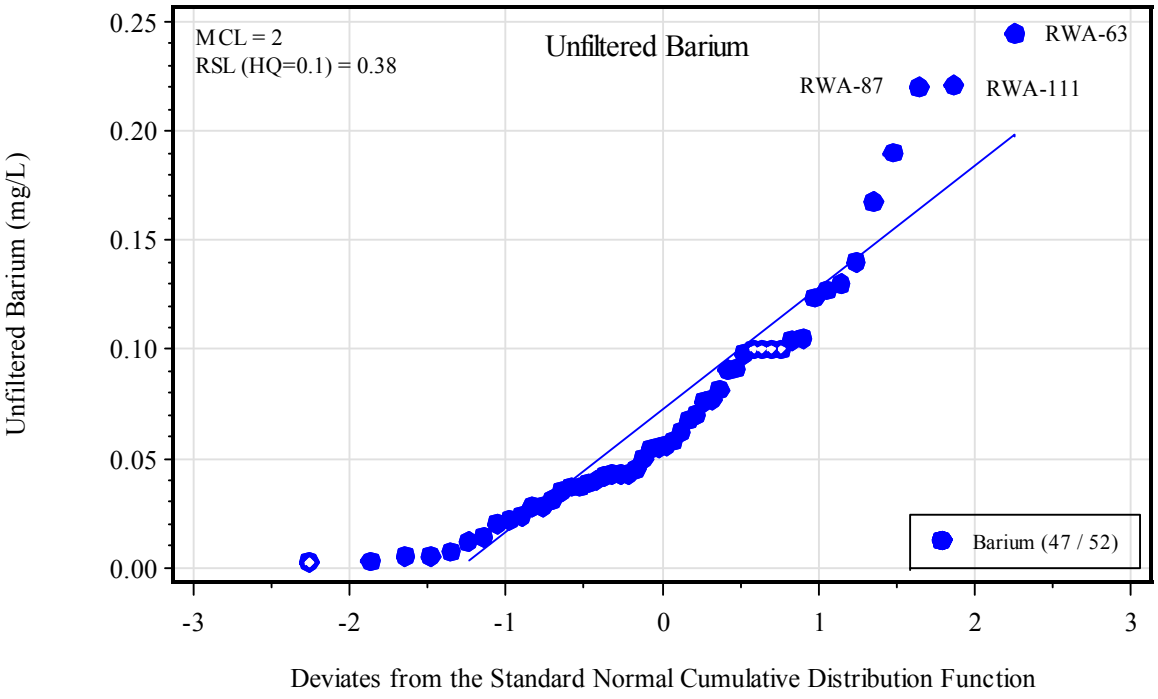


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

Figure C.1. Normal probability plots for unfiltered aluminum and antimony (final dataset).

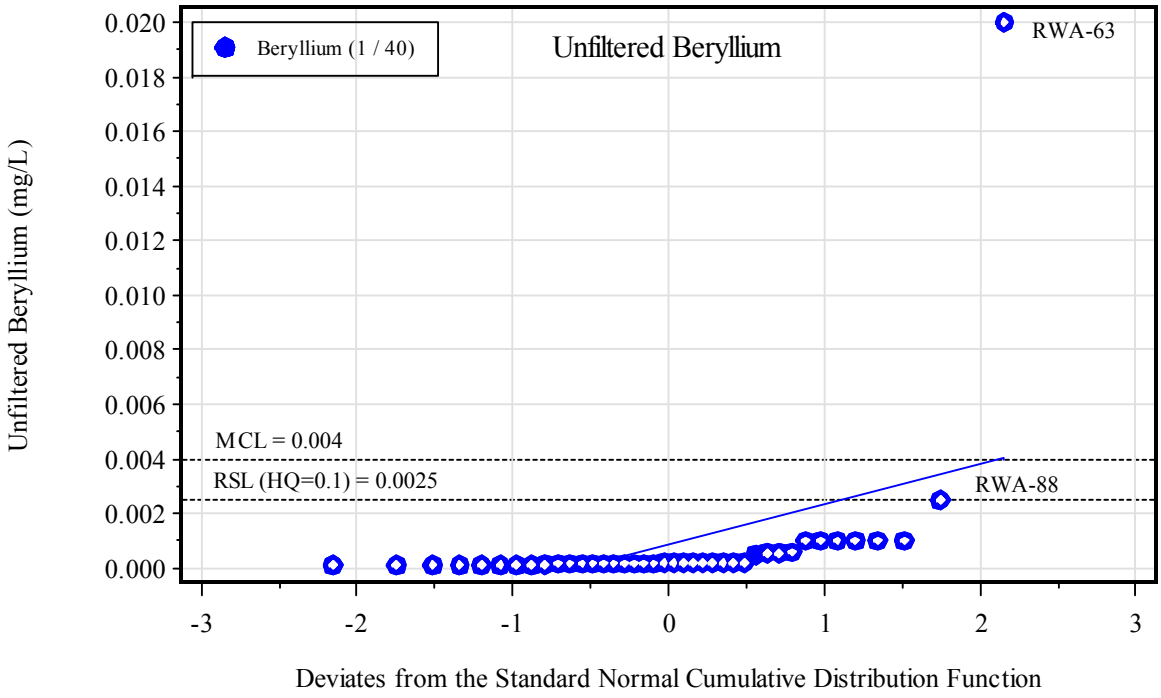


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

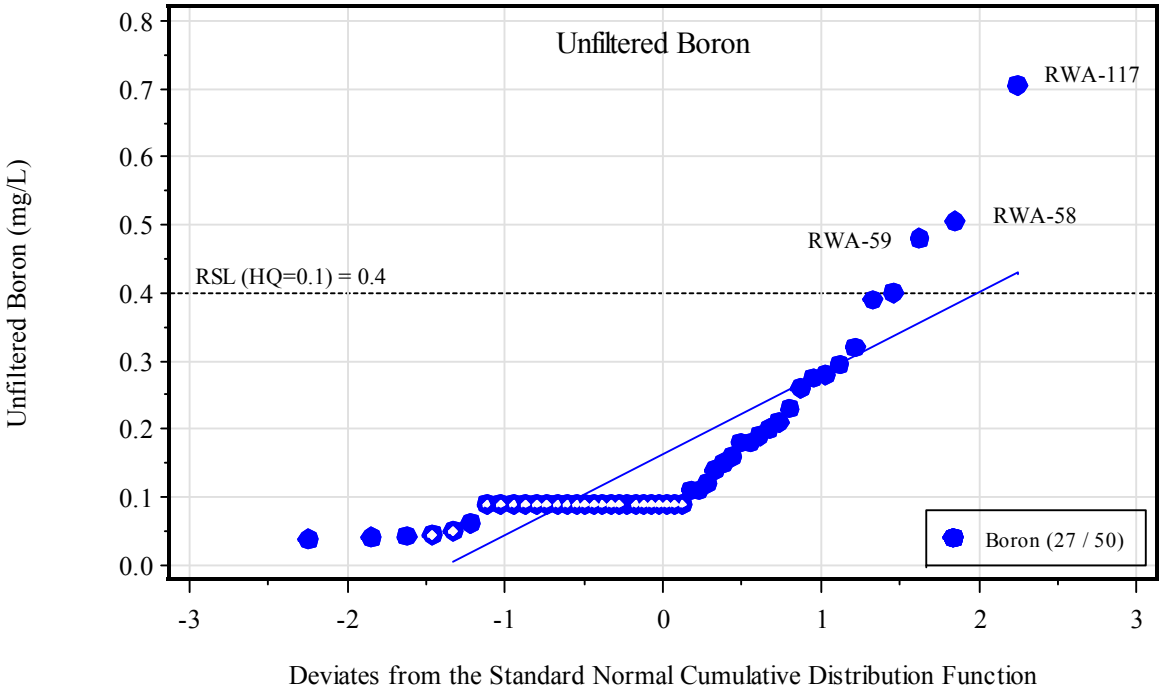


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

Figure C.2. Normal probability plots for unfiltered arsenic and barium (final dataset).

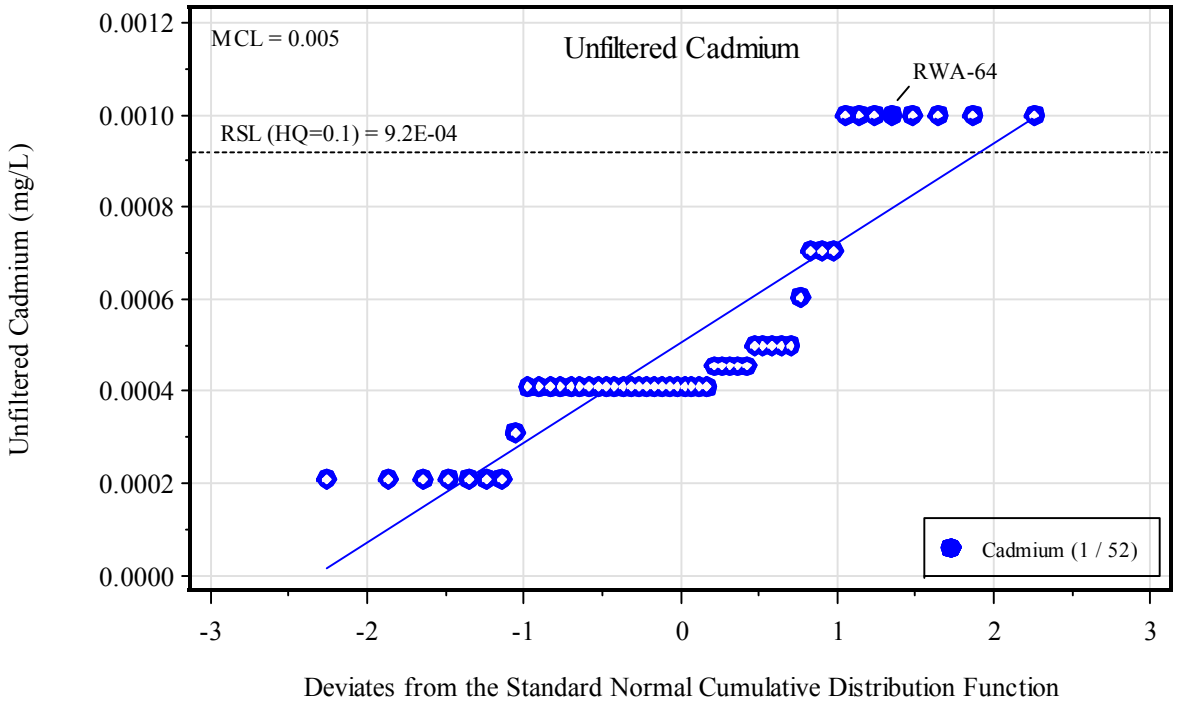


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

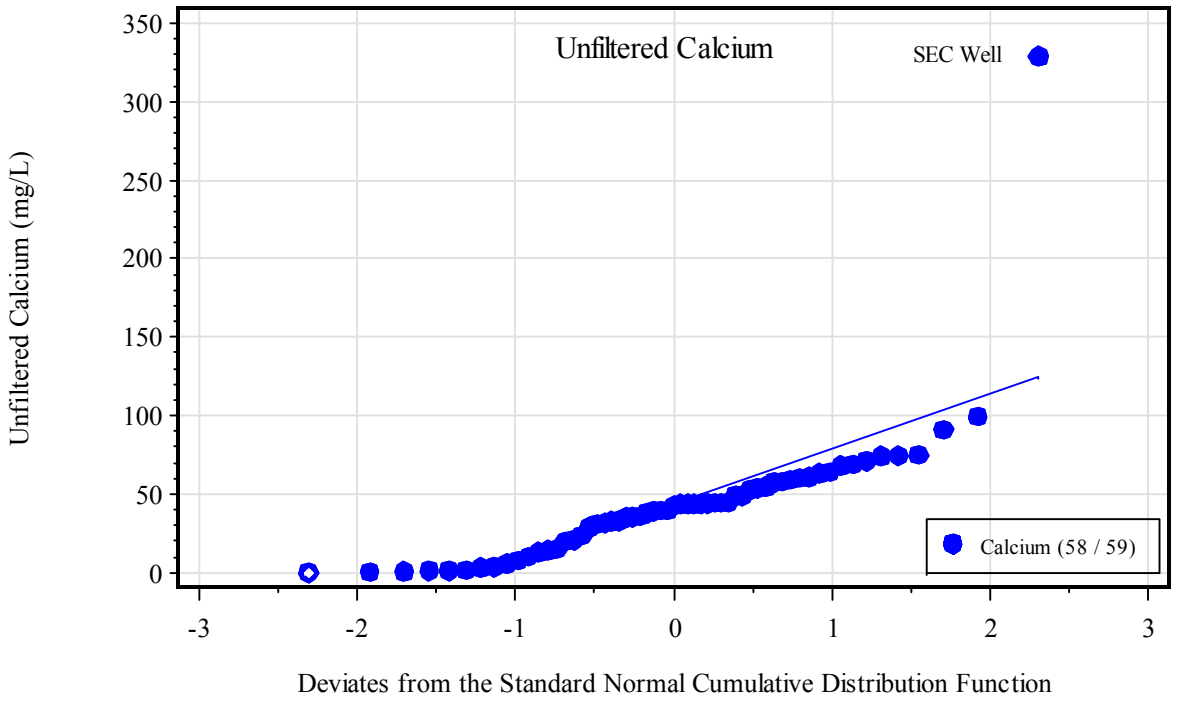


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

Figure C.3. Normal probability plots for unfiltered beryllium and boron (final dataset).

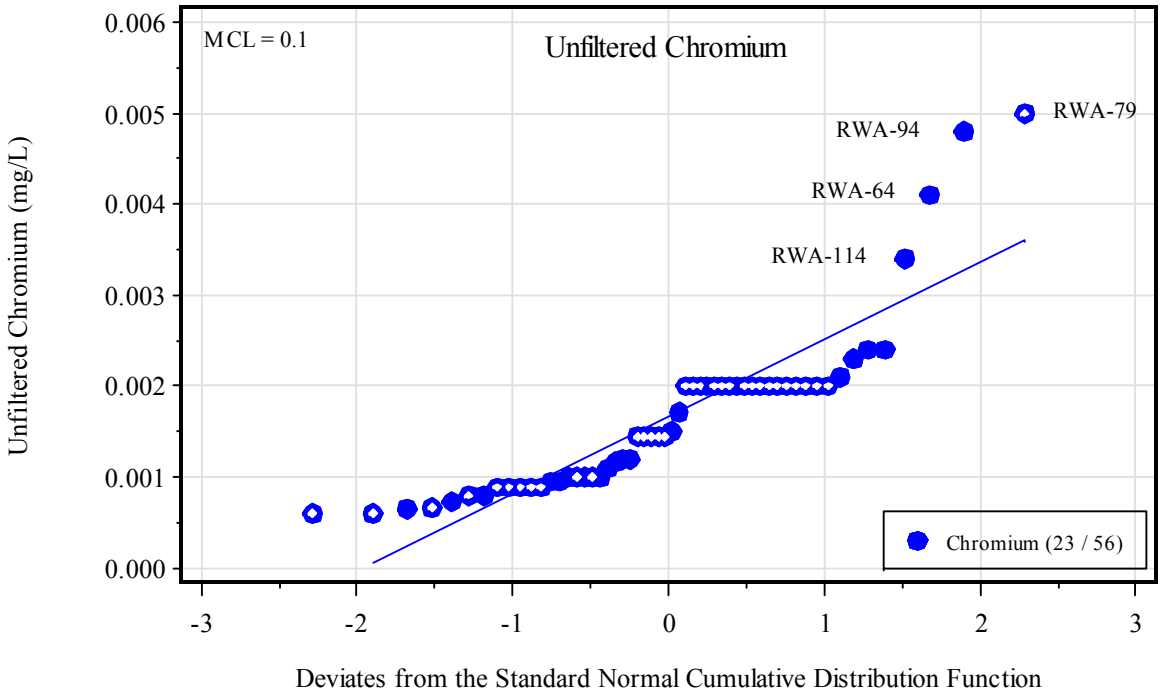


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

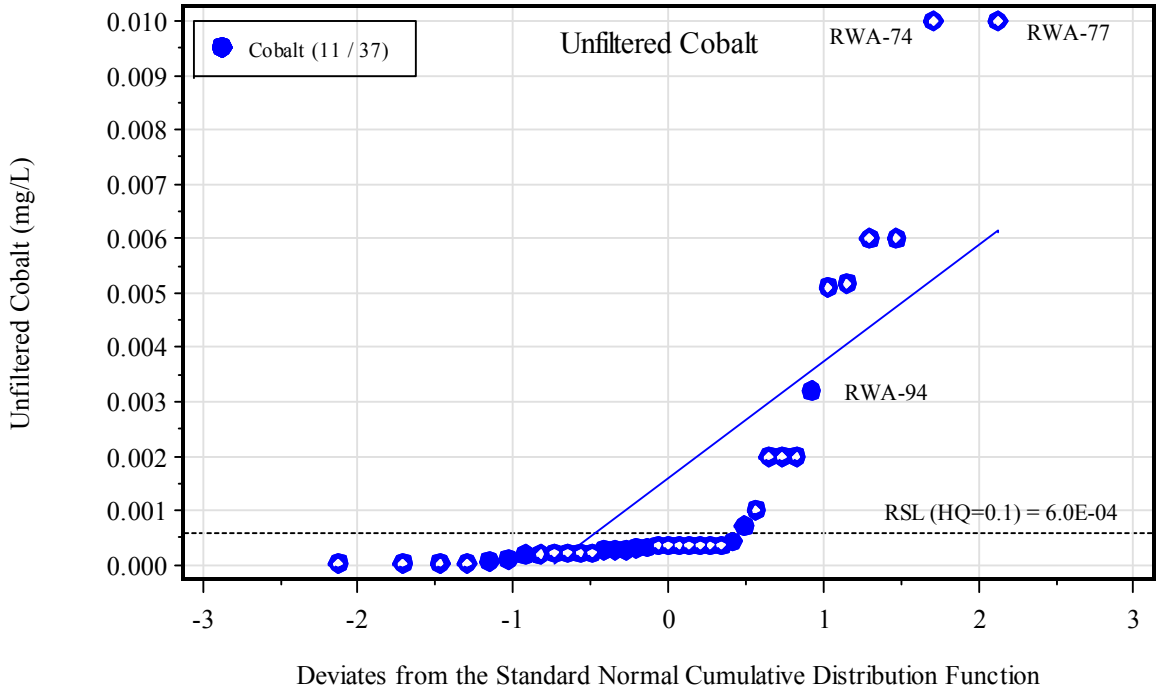


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

Figure C.4. Normal probability plots for unfiltered cadmium and calcium (final dataset).

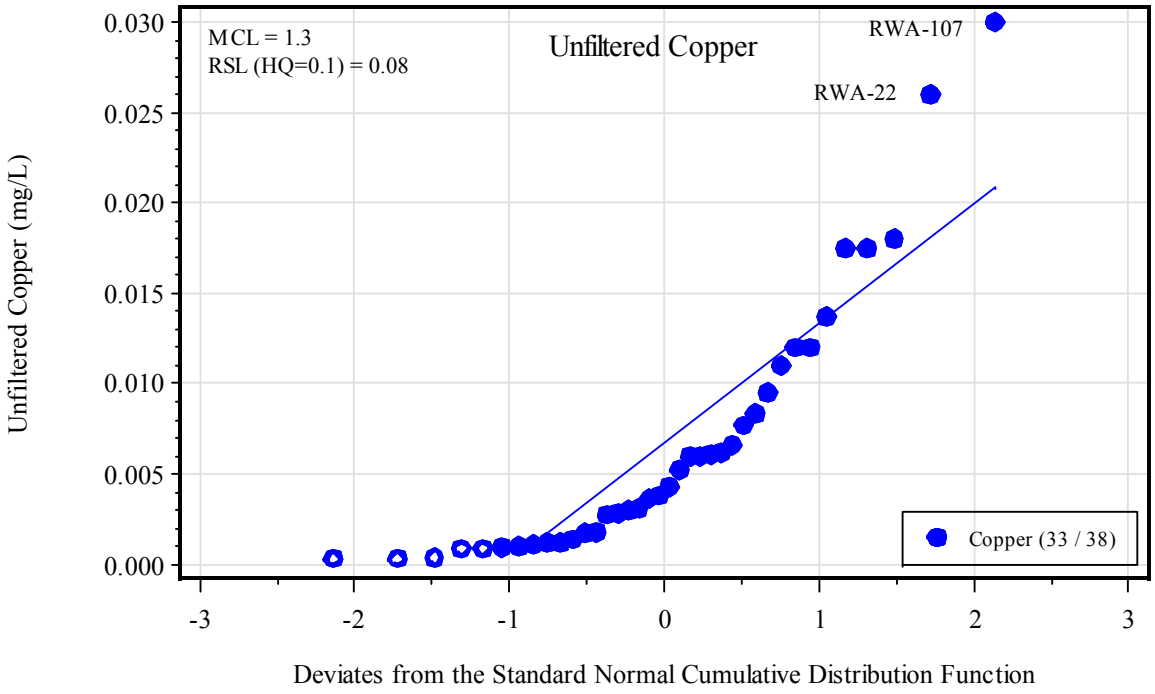


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

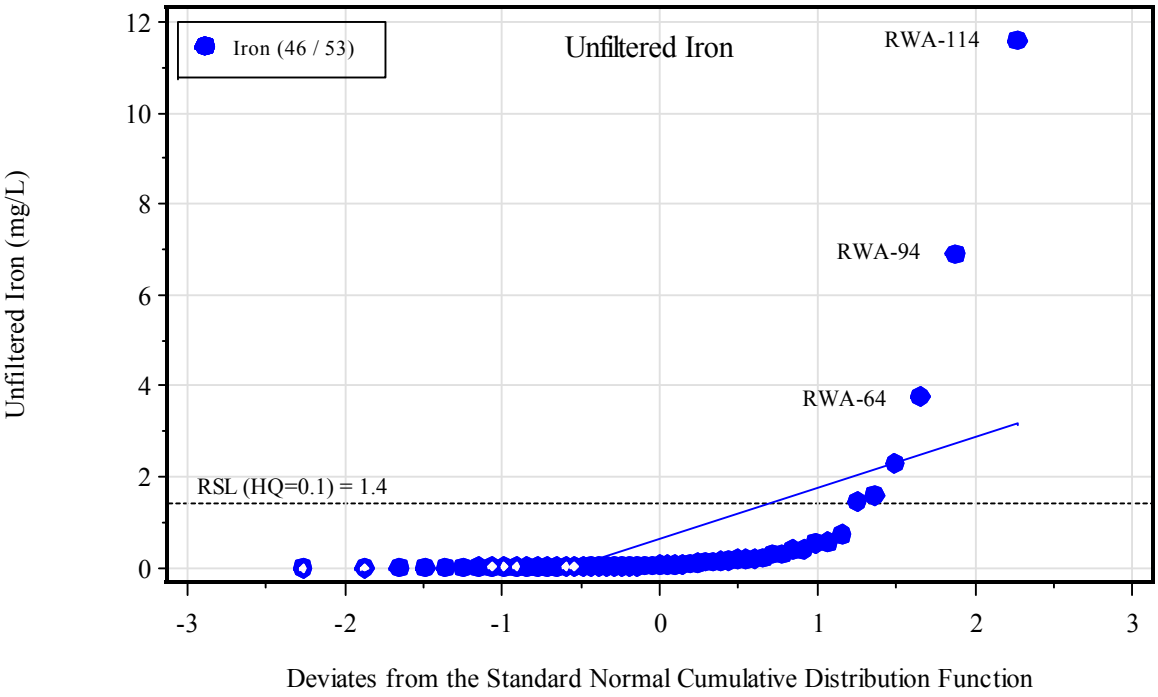


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

Figure C.5. Normal probability plots for unfiltered chromium and cobalt (final dataset).

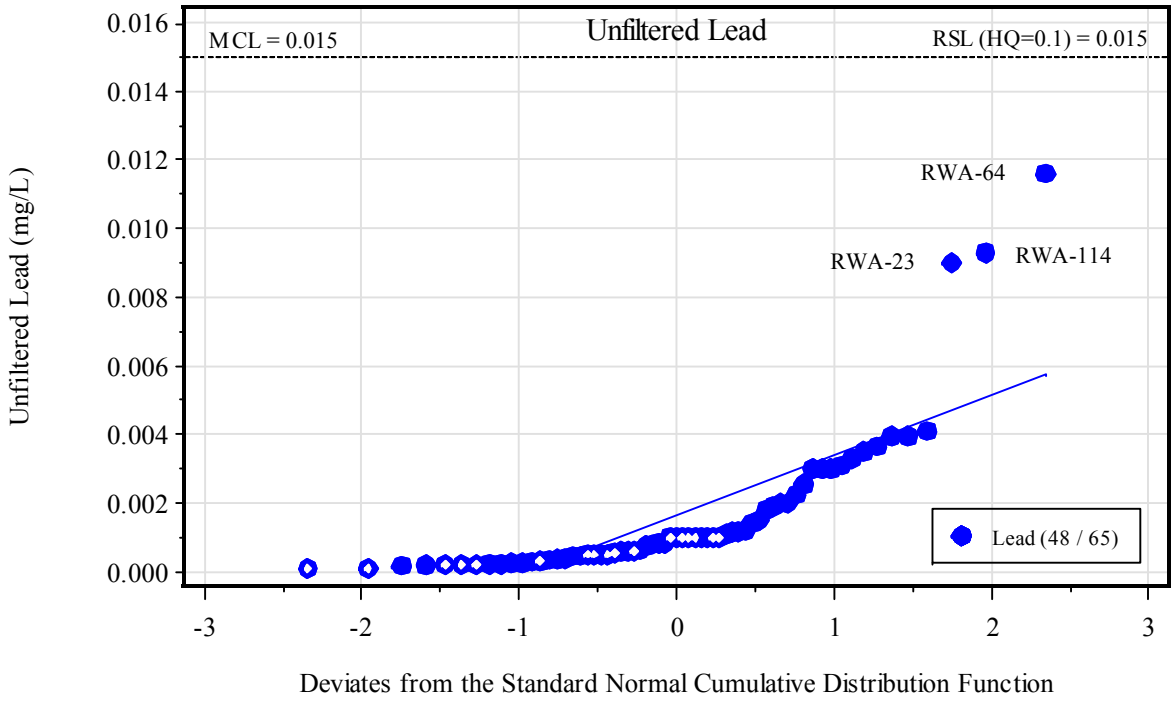


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

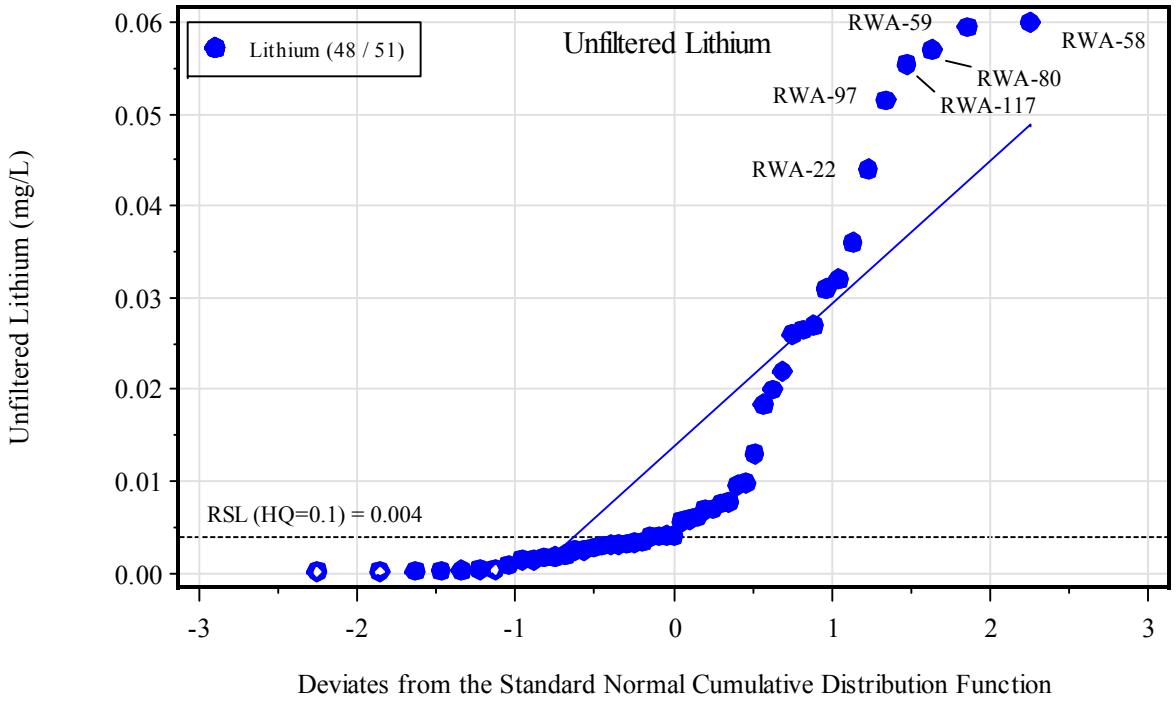


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

Figure C.6. Normal probability plots for unfiltered copper and iron (final dataset).

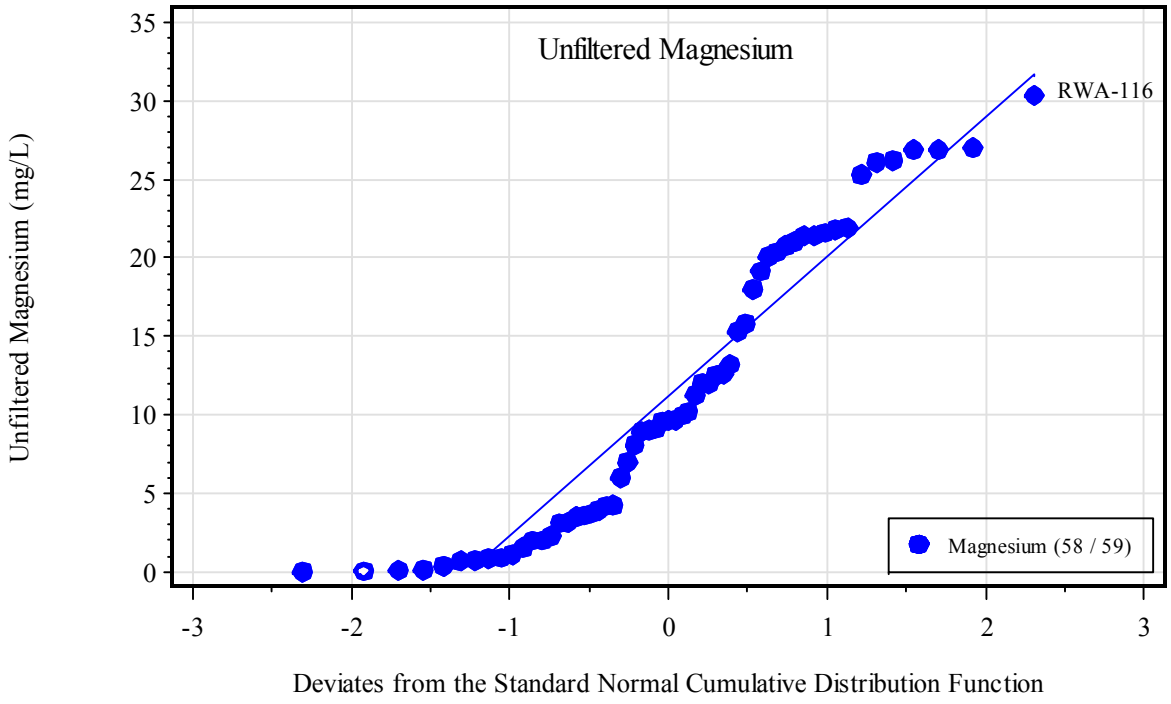


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

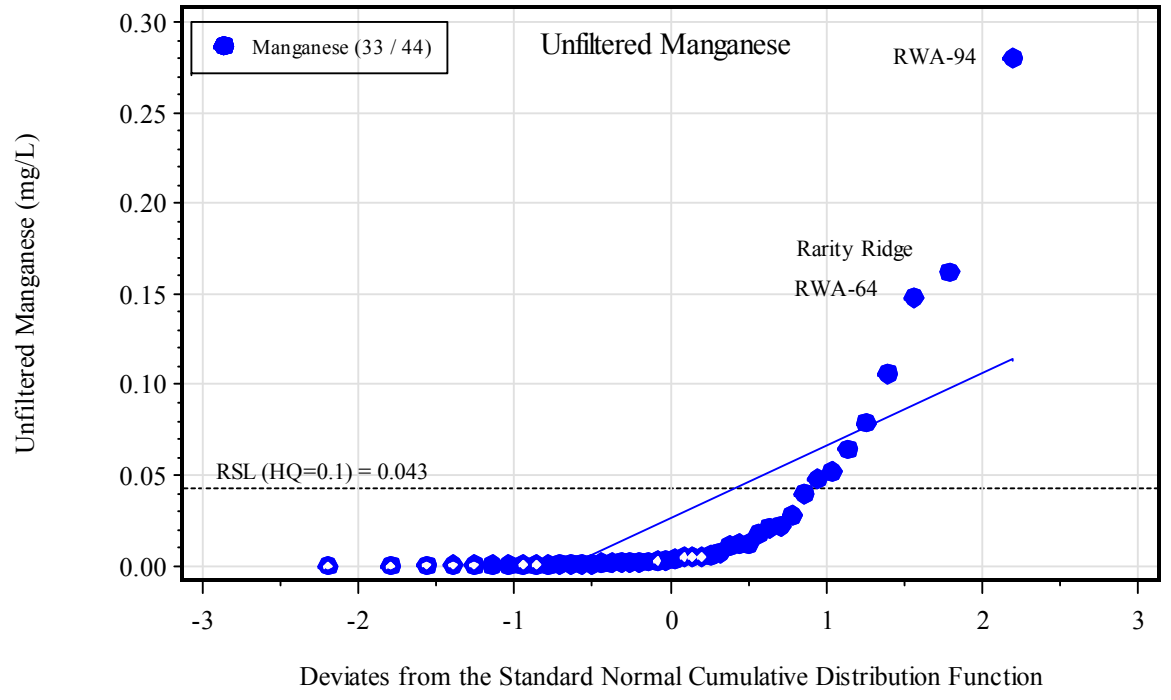


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

Figure C.7. Normal probability plots for unfiltered lead and lithium (final dataset).

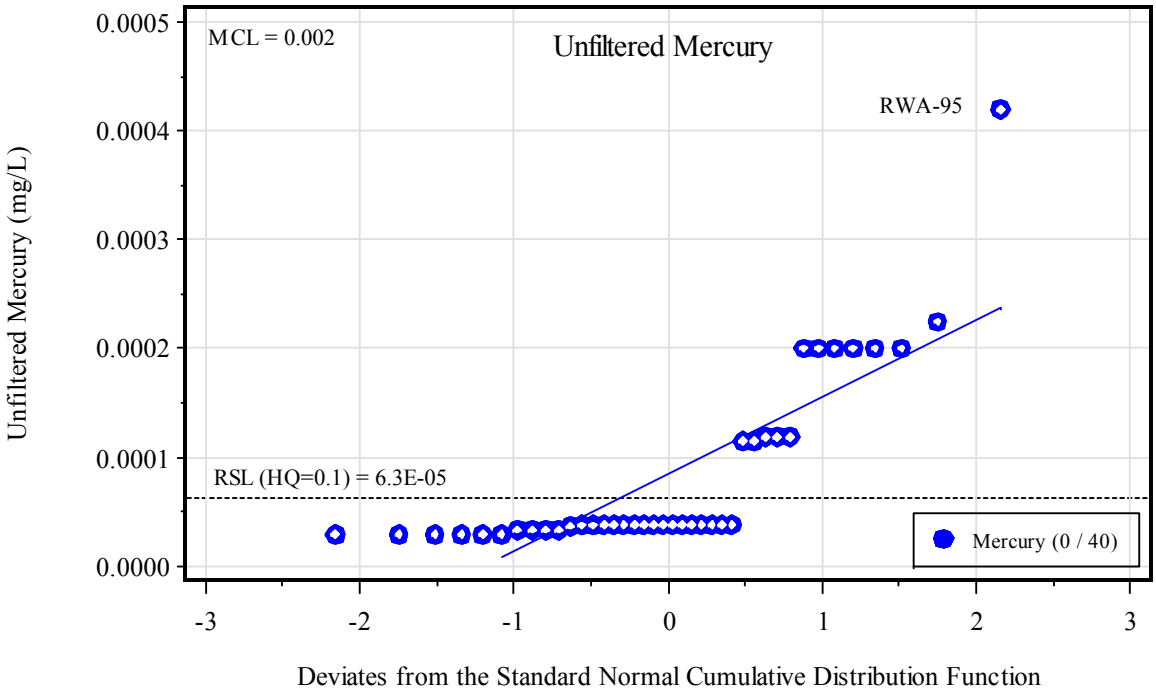


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

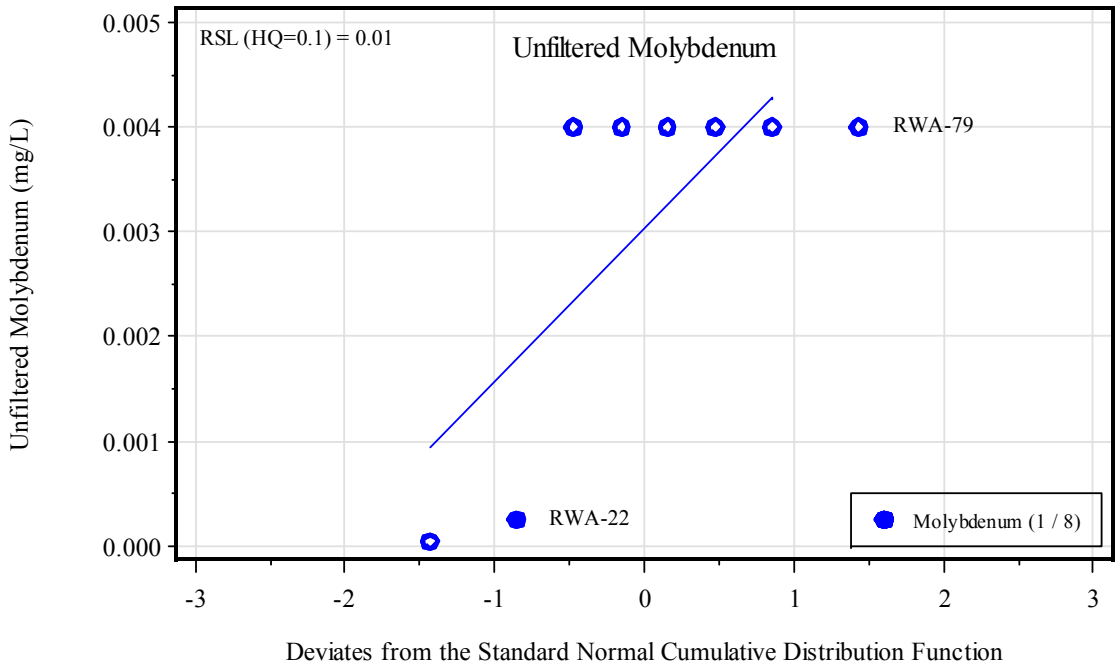


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

Figure C.8. Normal probability plots for unfiltered magnesium and manganese (final dataset).

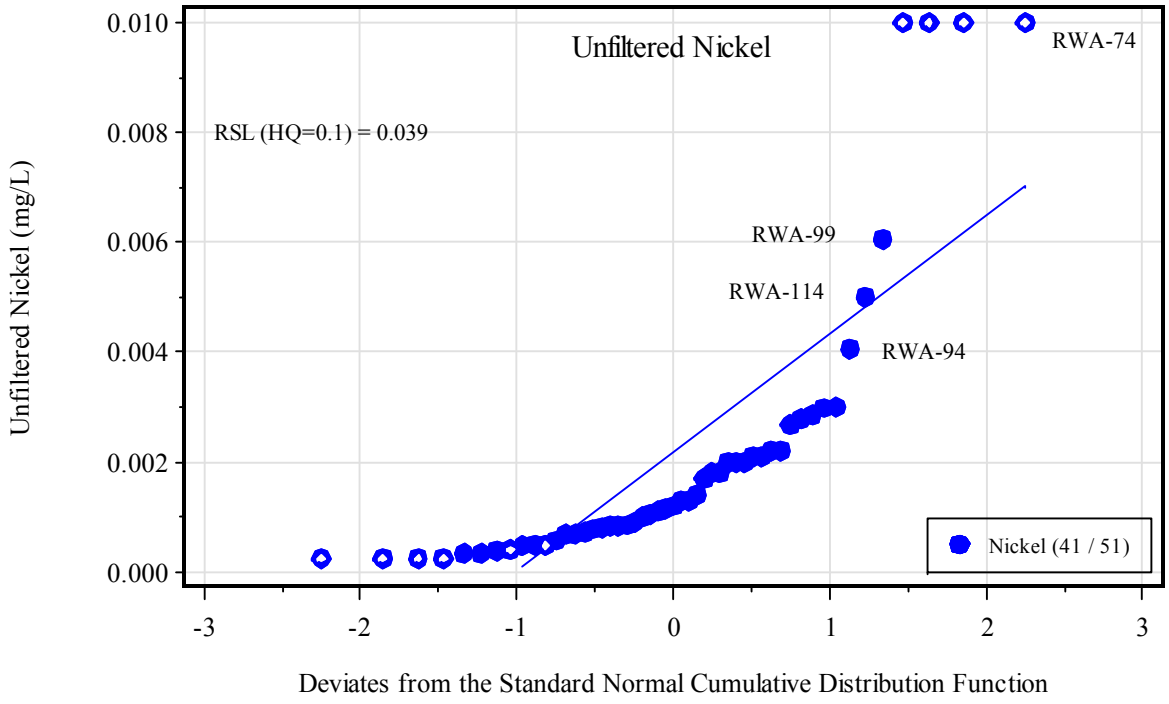


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

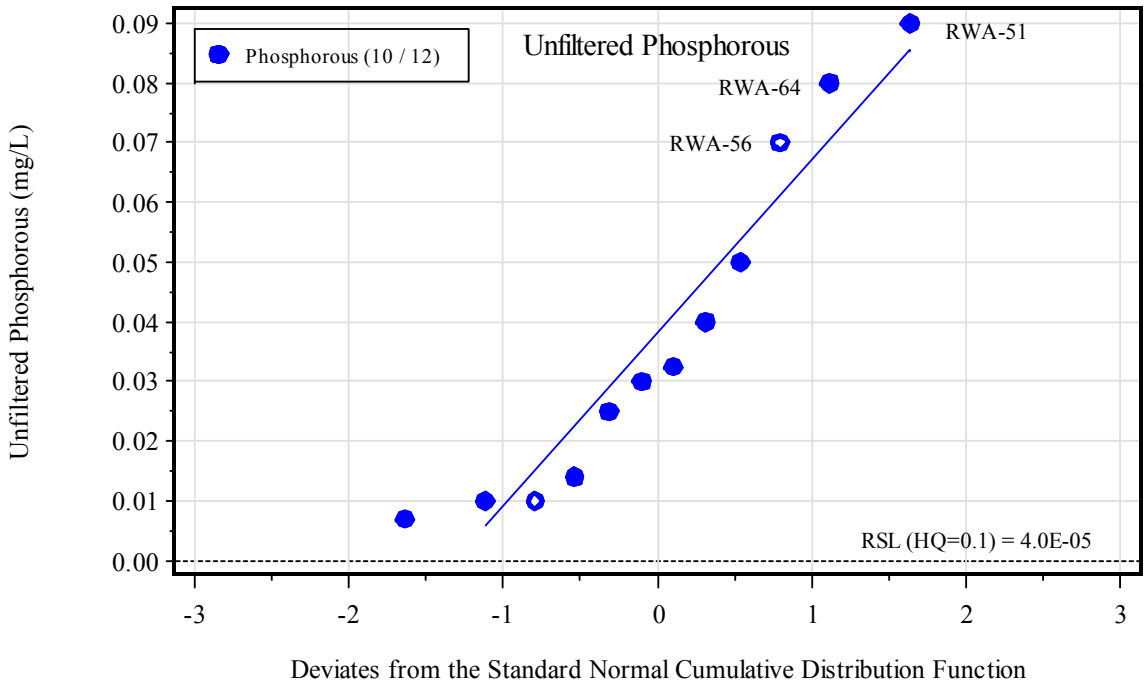


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

Figure C.9. Normal probability plots for unfiltered mercury and molybdenum (final dataset).

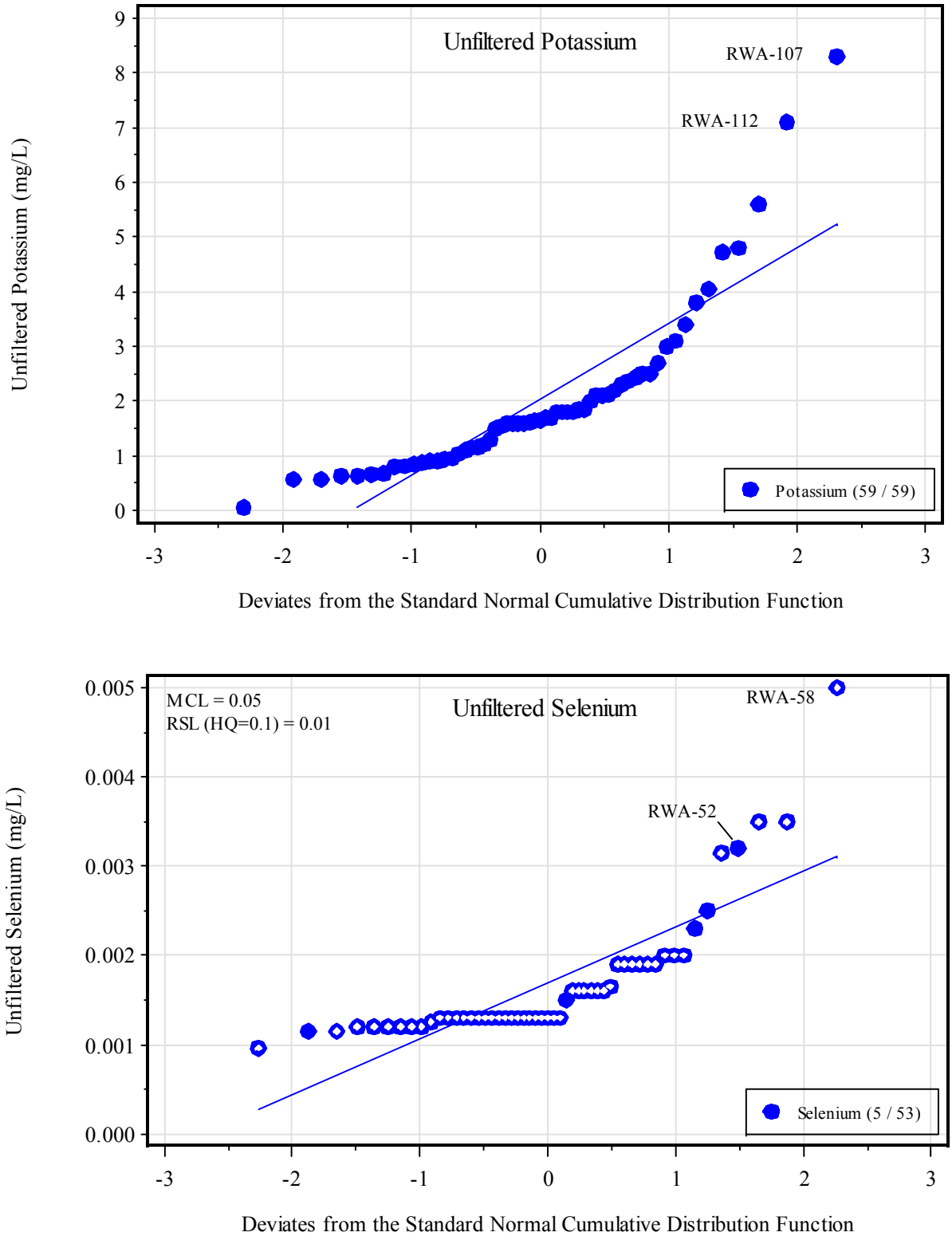


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.



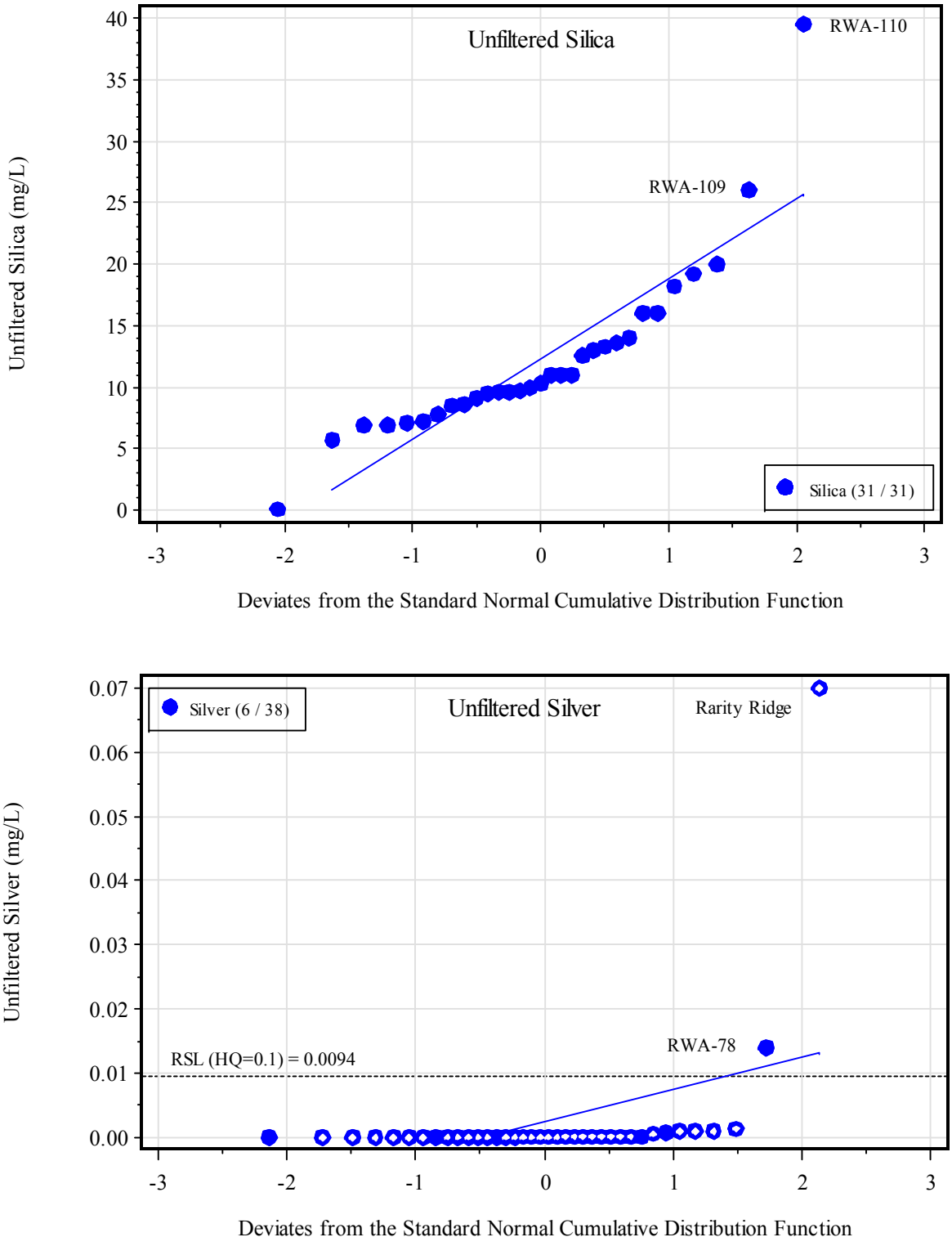
Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

Figure C.10. Normal probability plots for unfiltered nickel and phosphorous (final dataset).



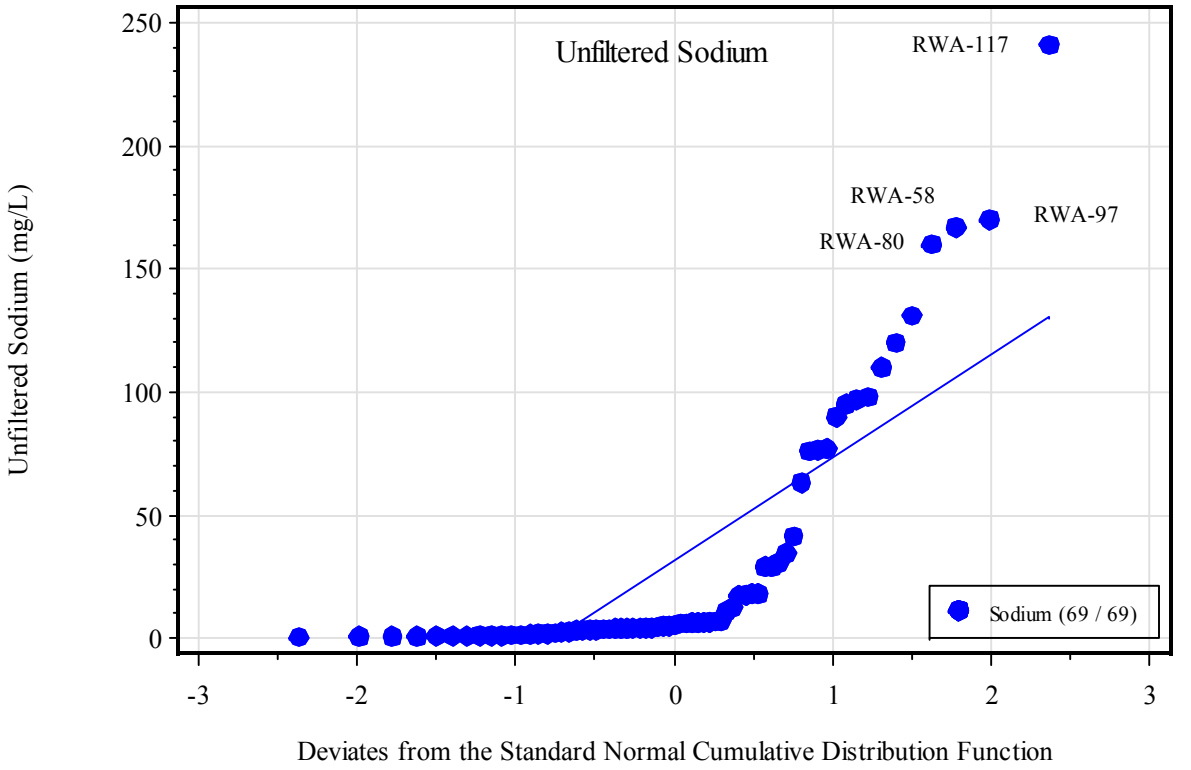
Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

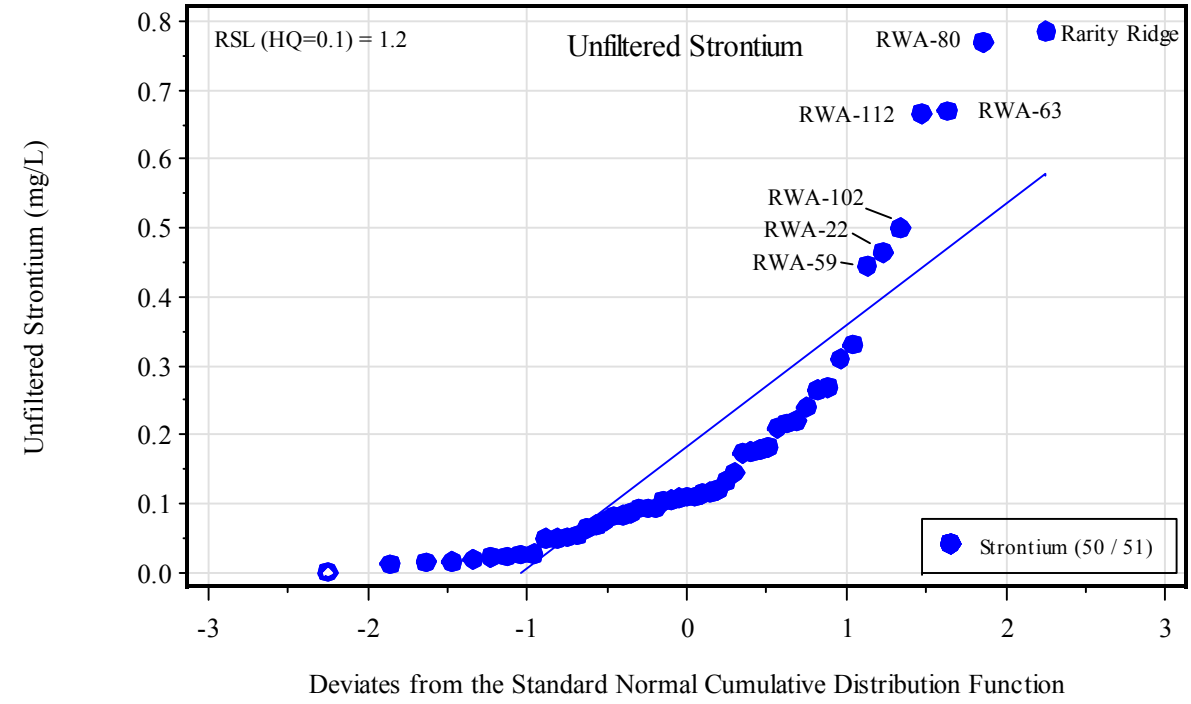
Figure C.11. Normal probability plots for unfiltered potassium and selenium (final dataset).



Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

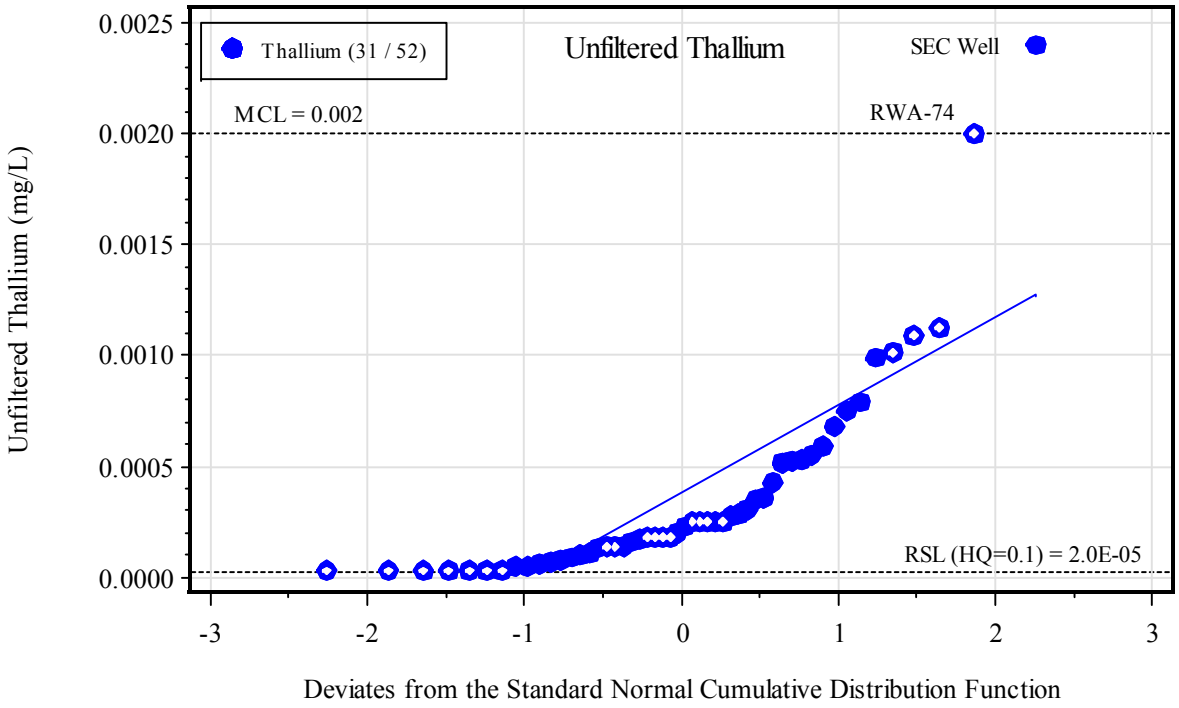
Figure C.12. Normal probability plots for unfiltered silica and silver (final dataset).



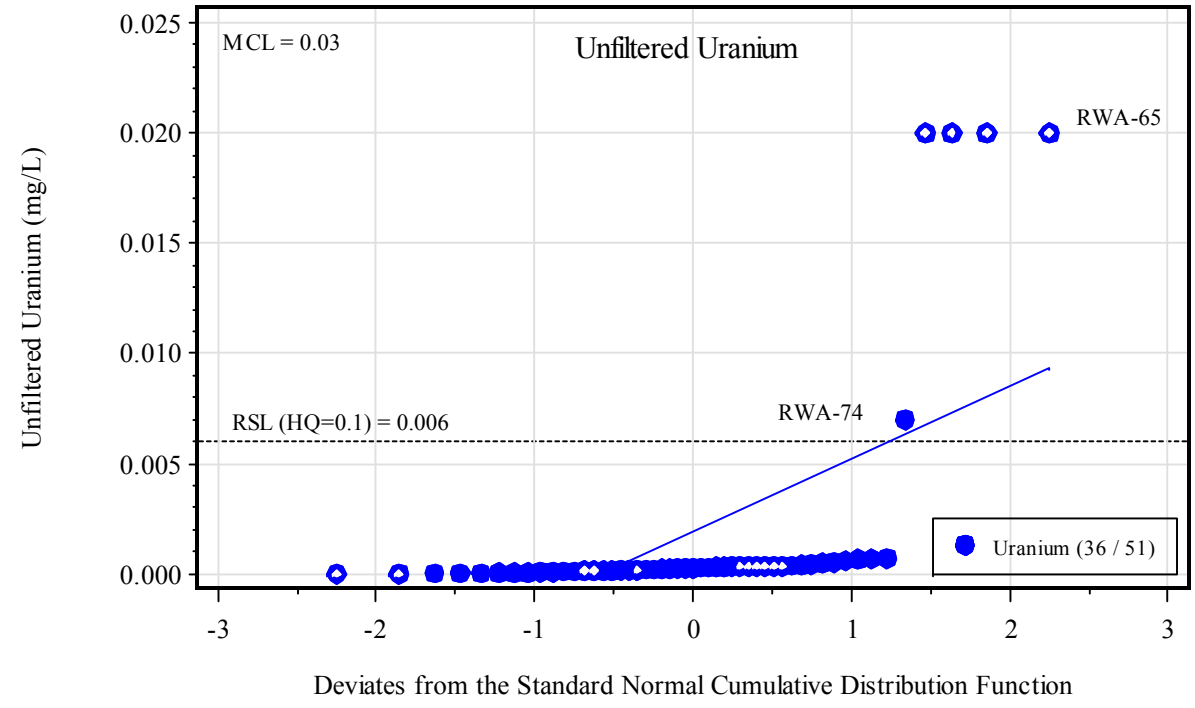


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

Figure C.13. Normal probability plots for unfiltered sodium and strontium (final dataset).

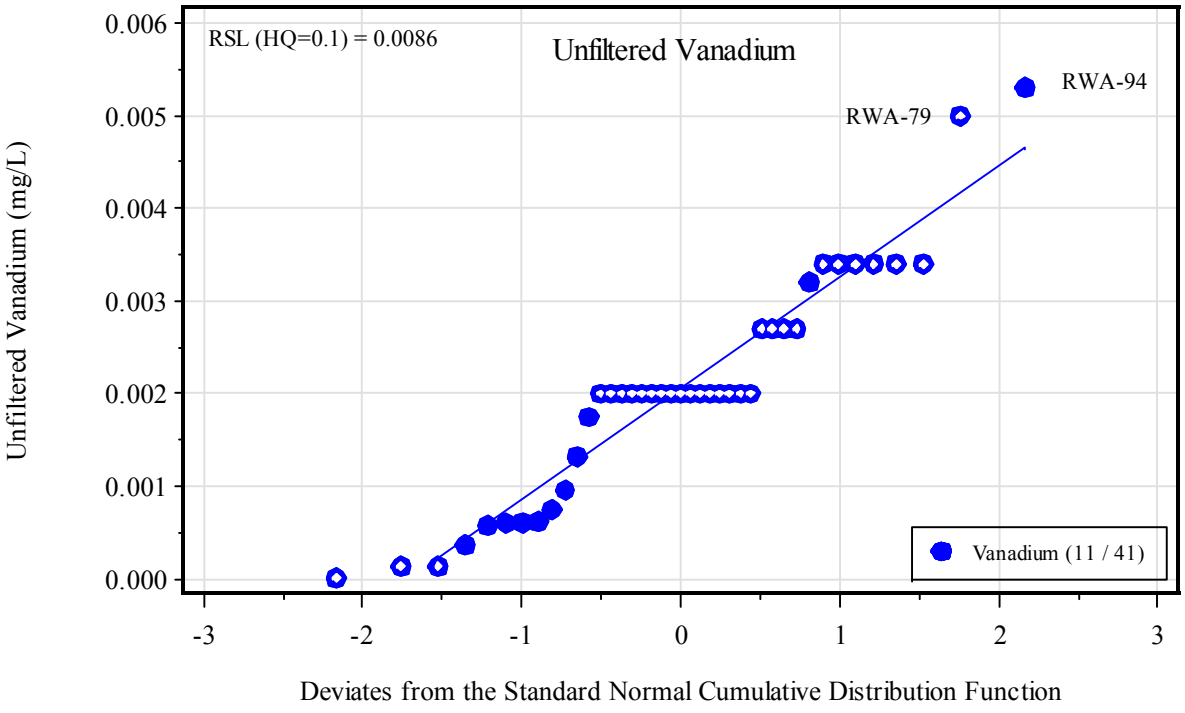


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

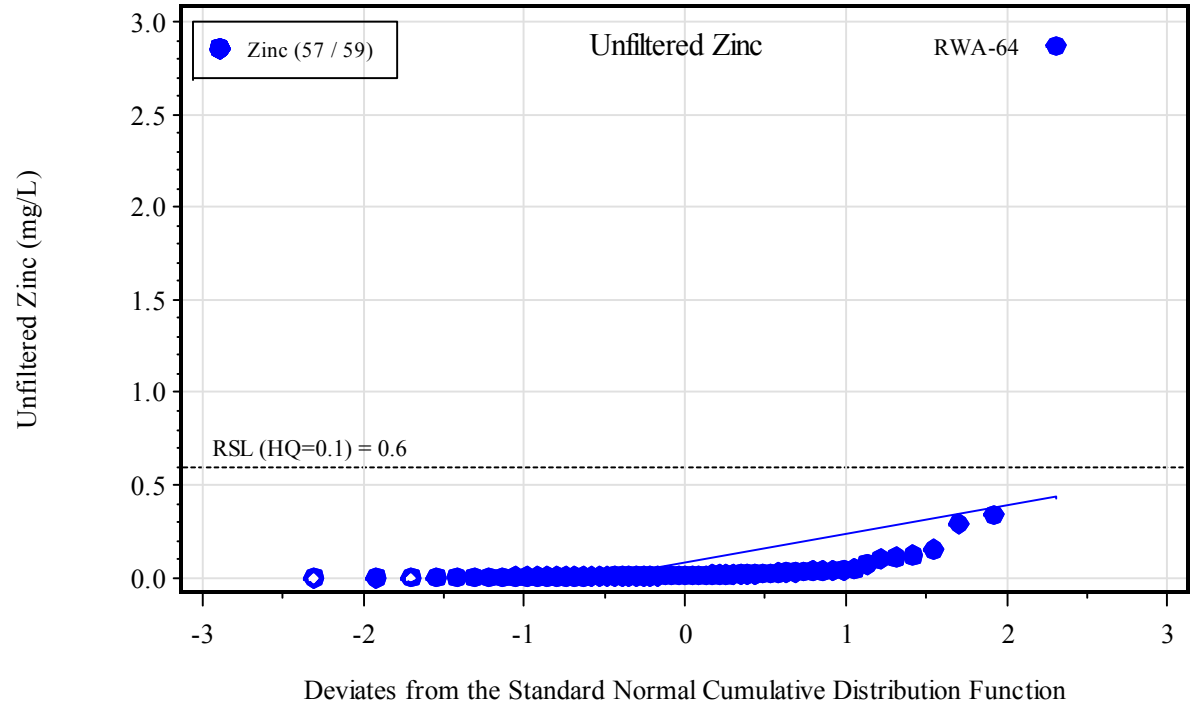


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

Figure C.14. Normal probability plots for unfiltered thallium and uranium (final dataset).

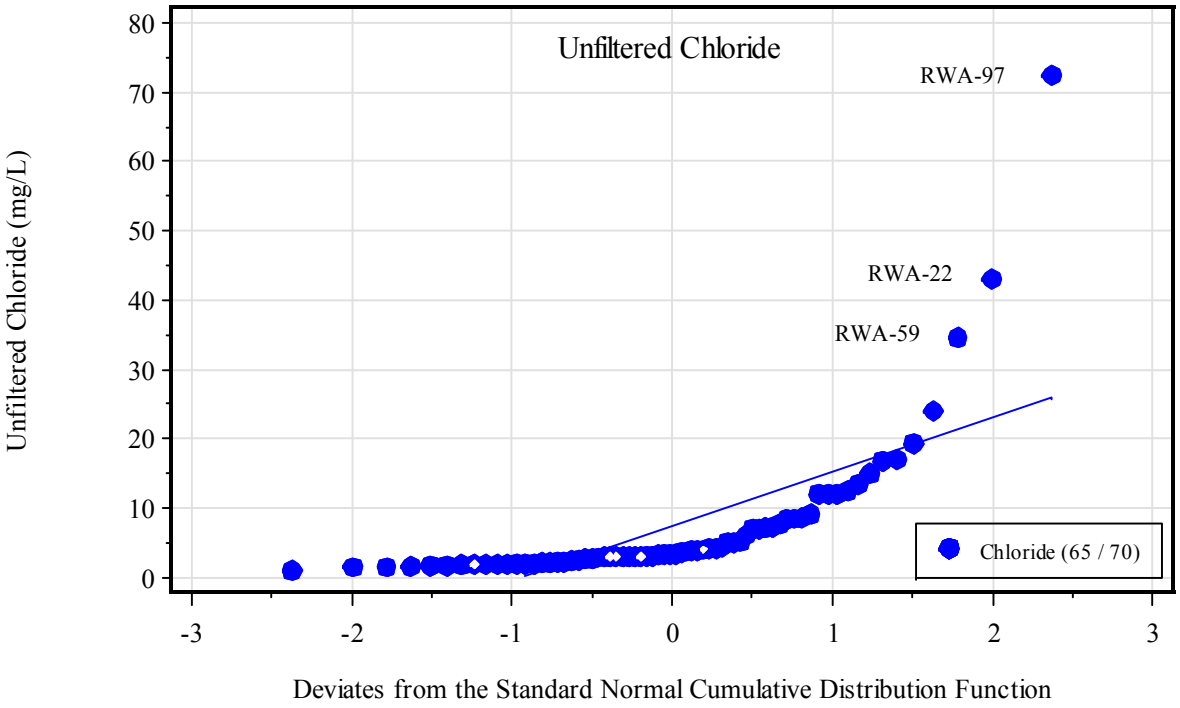


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

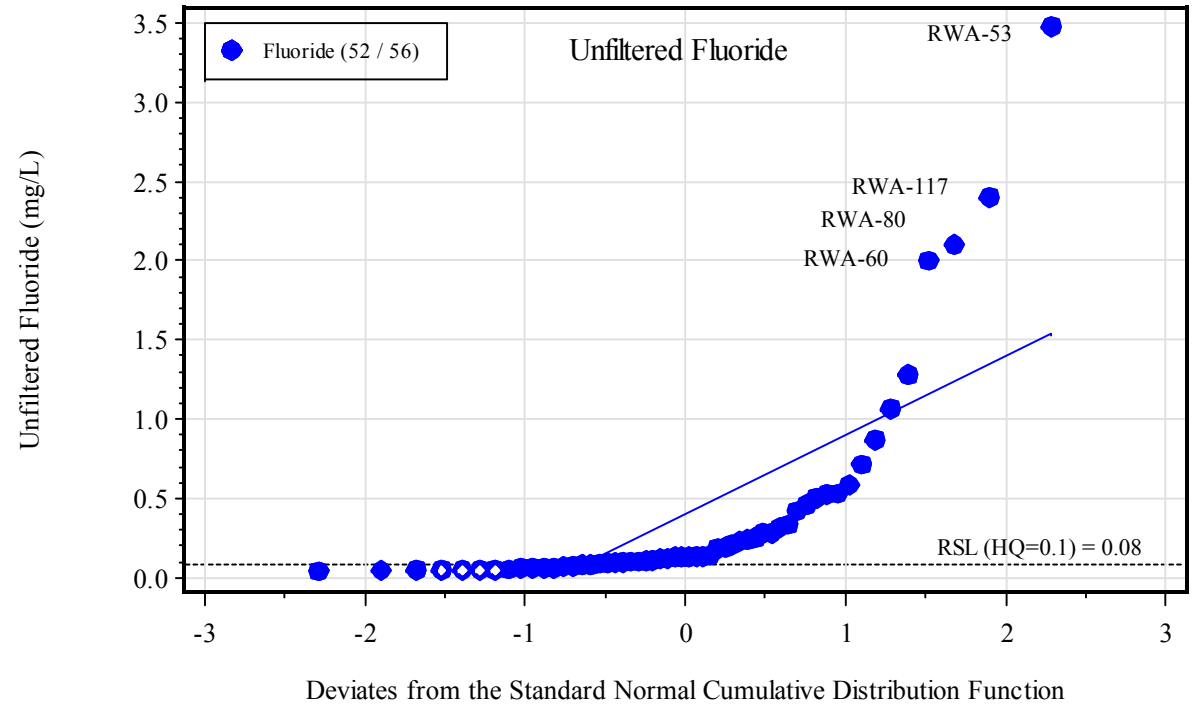


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

Figure C.15. Normal probability plots of ORR final background data for unfiltered vanadium and zinc.

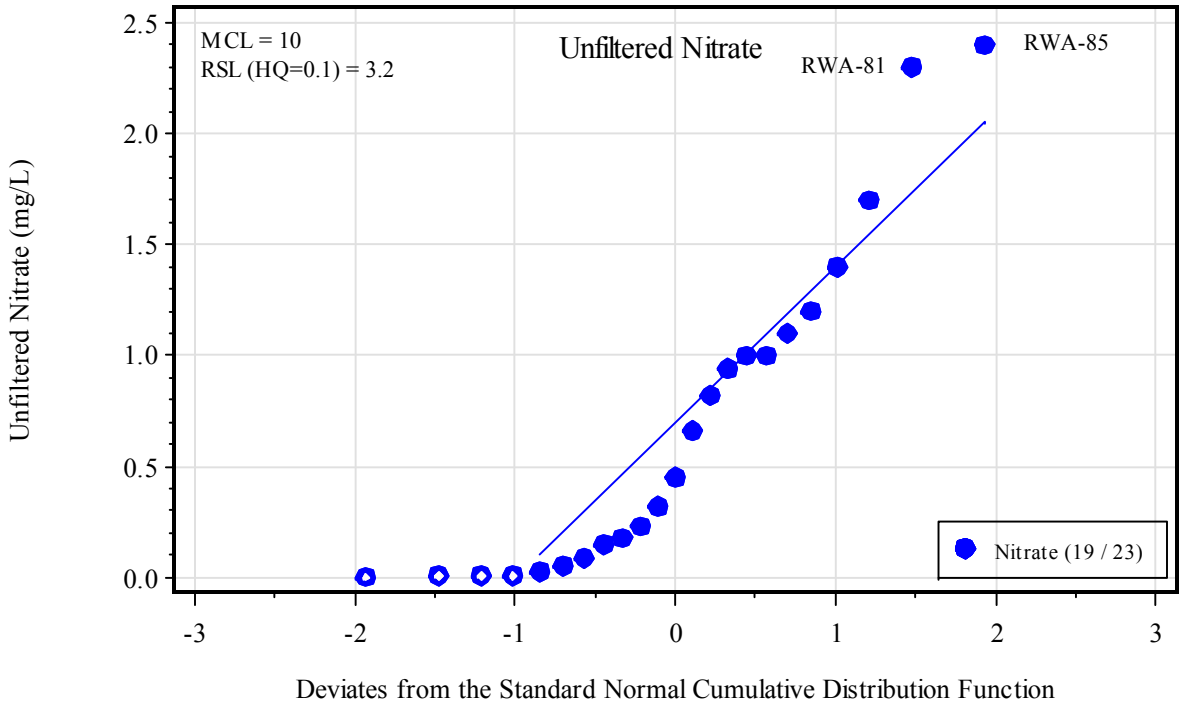


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

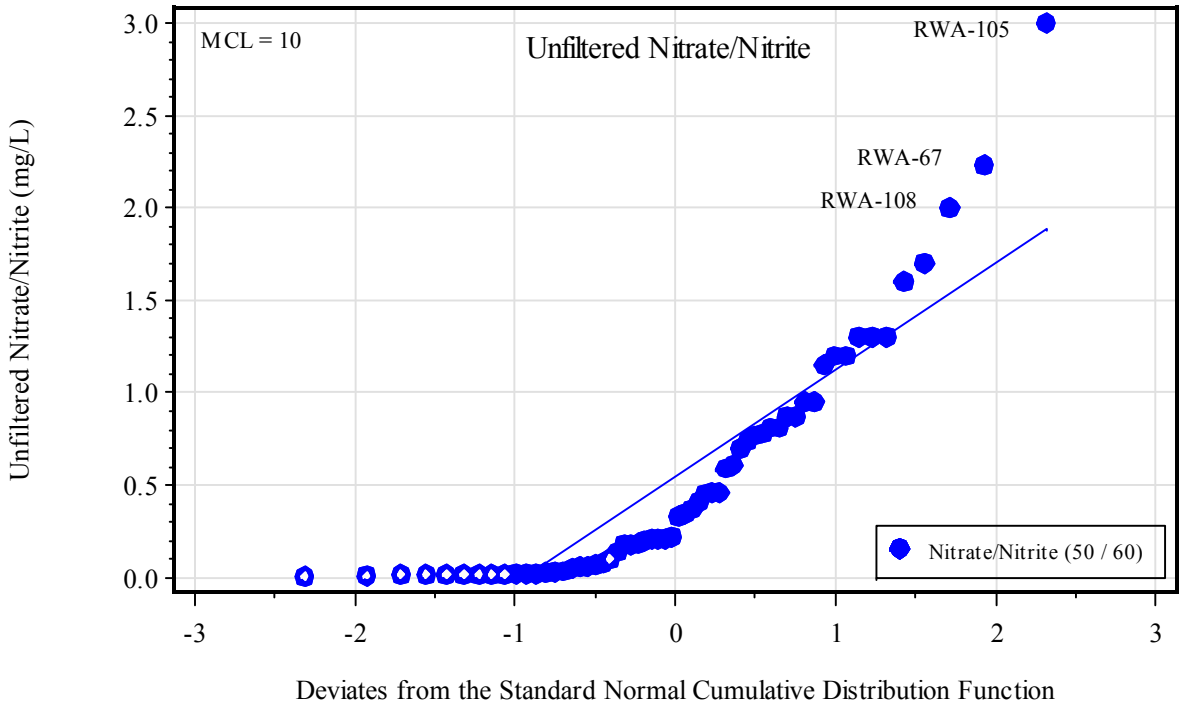


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

Figure C.16. Normal probability plots for unfiltered chloride and fluoride (final dataset).

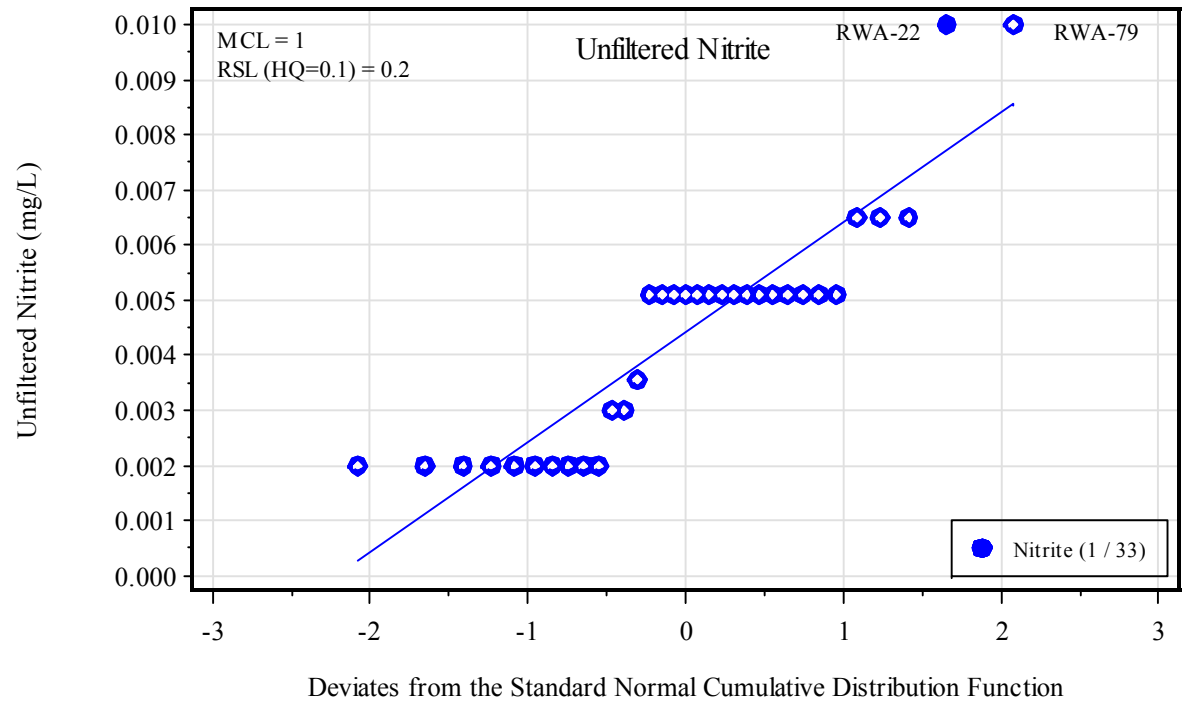


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

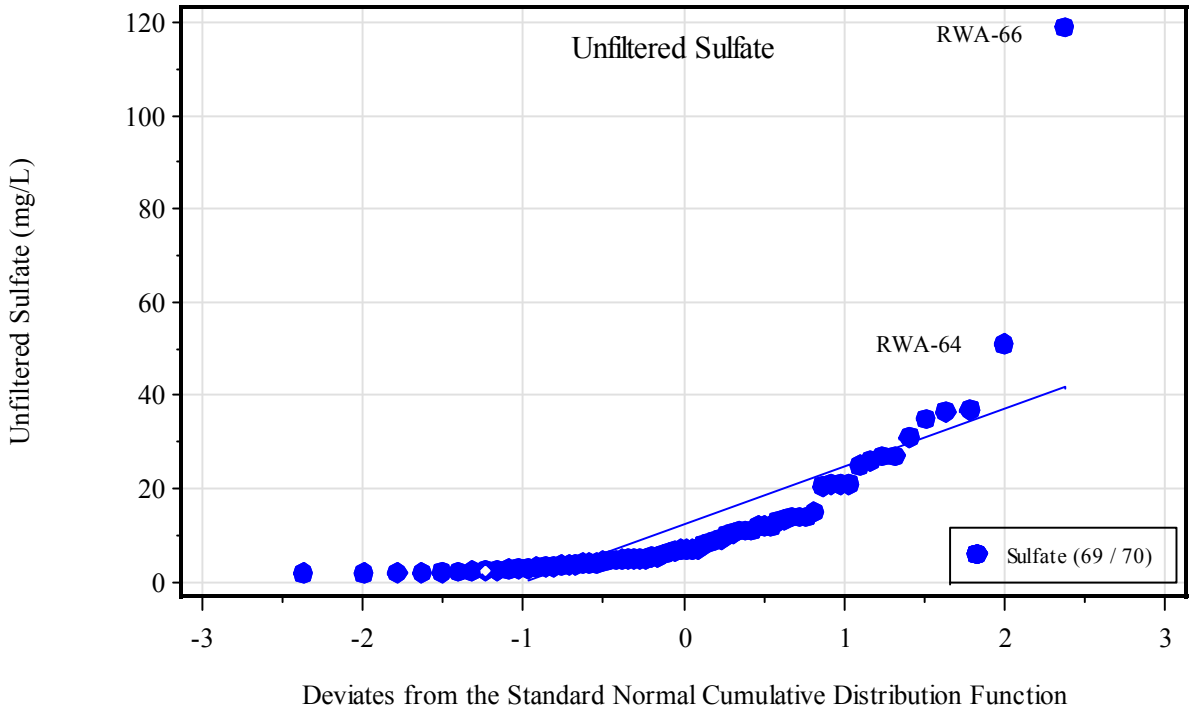


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

Figure C.17. Normal probability plots for unfiltered nitrate and nitrate/nitrite (final dataset).

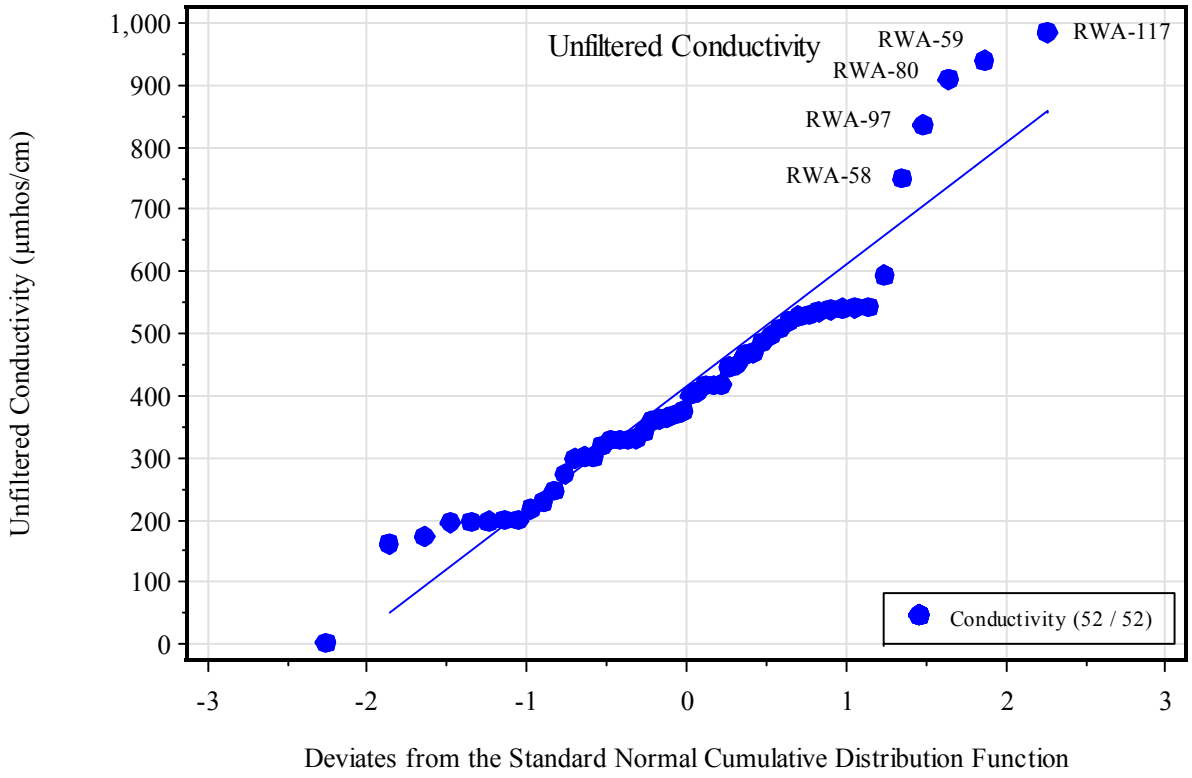


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.



Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

Figure C.18. Normal probability plots for unfiltered nitrite and sulfate (final dataset).



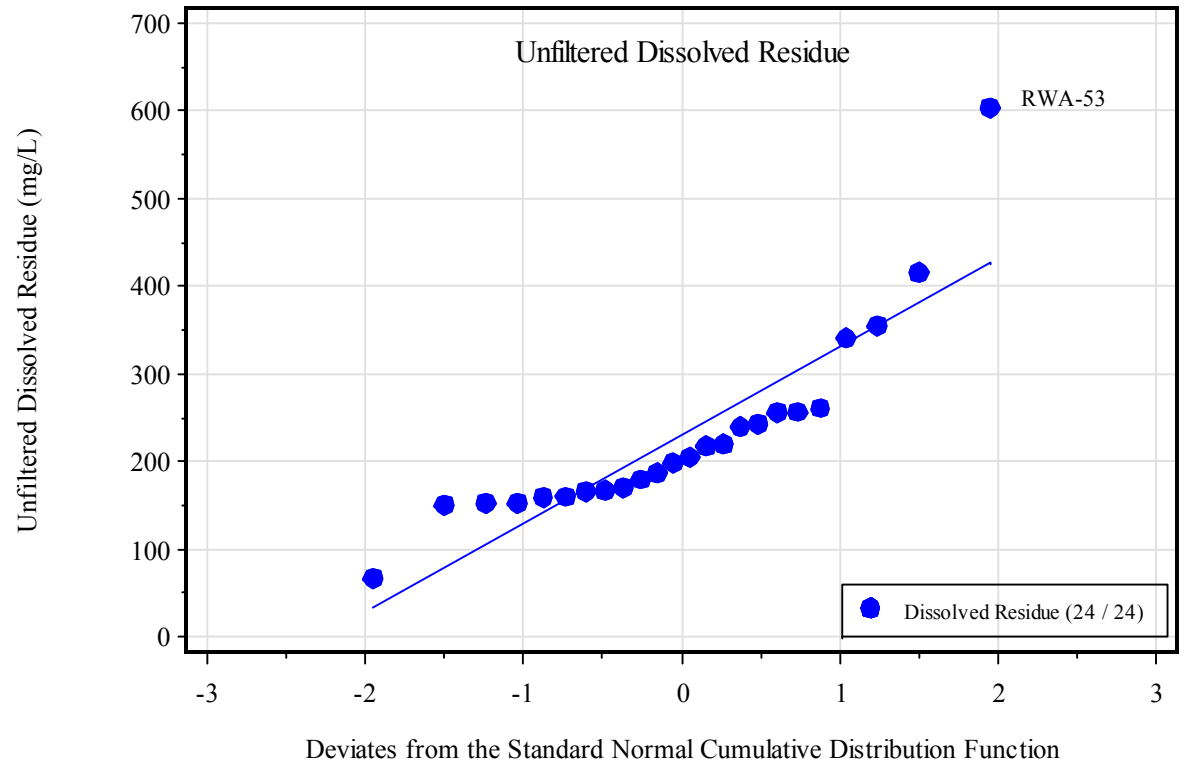
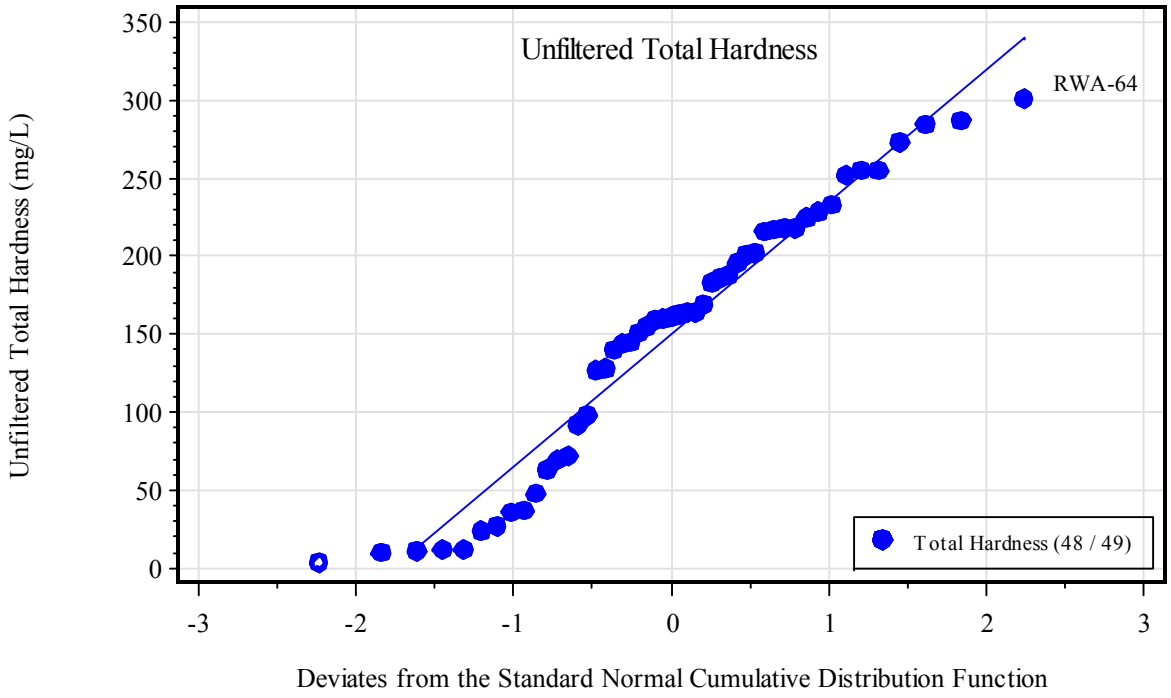


Figure C.19. Normal probability plots for unfiltered conductivity and dissolved residue (final dataset).



Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

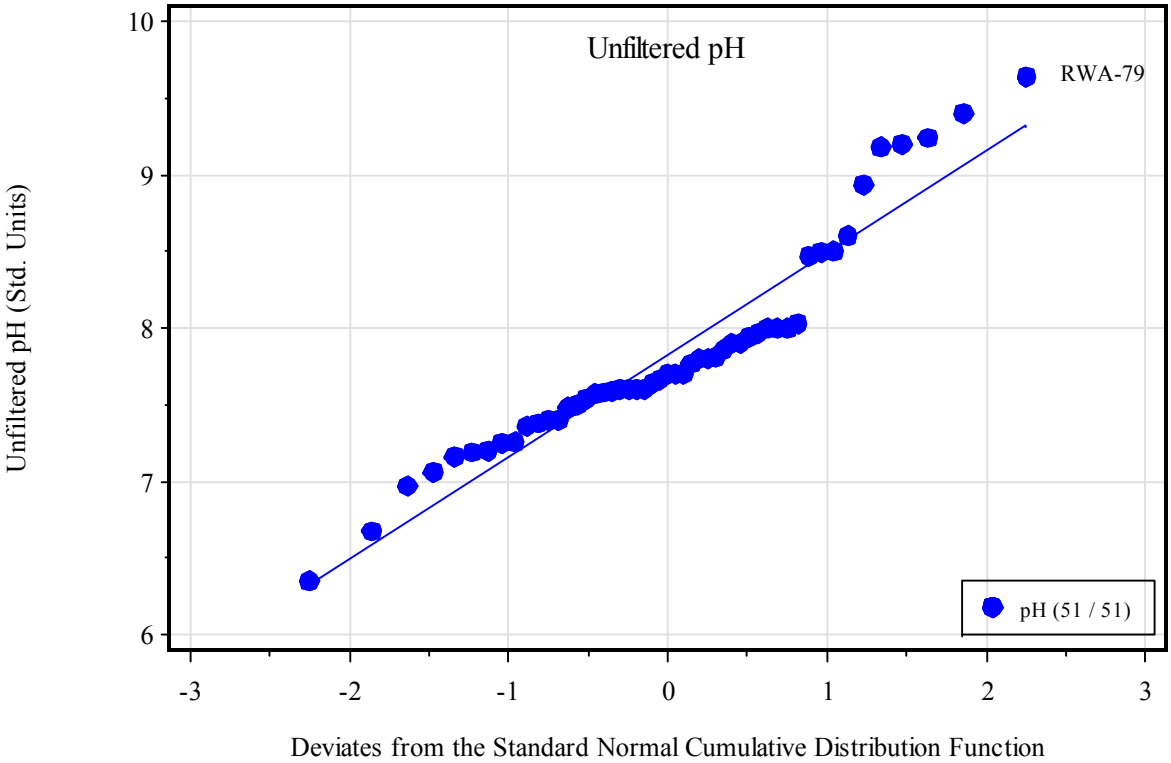
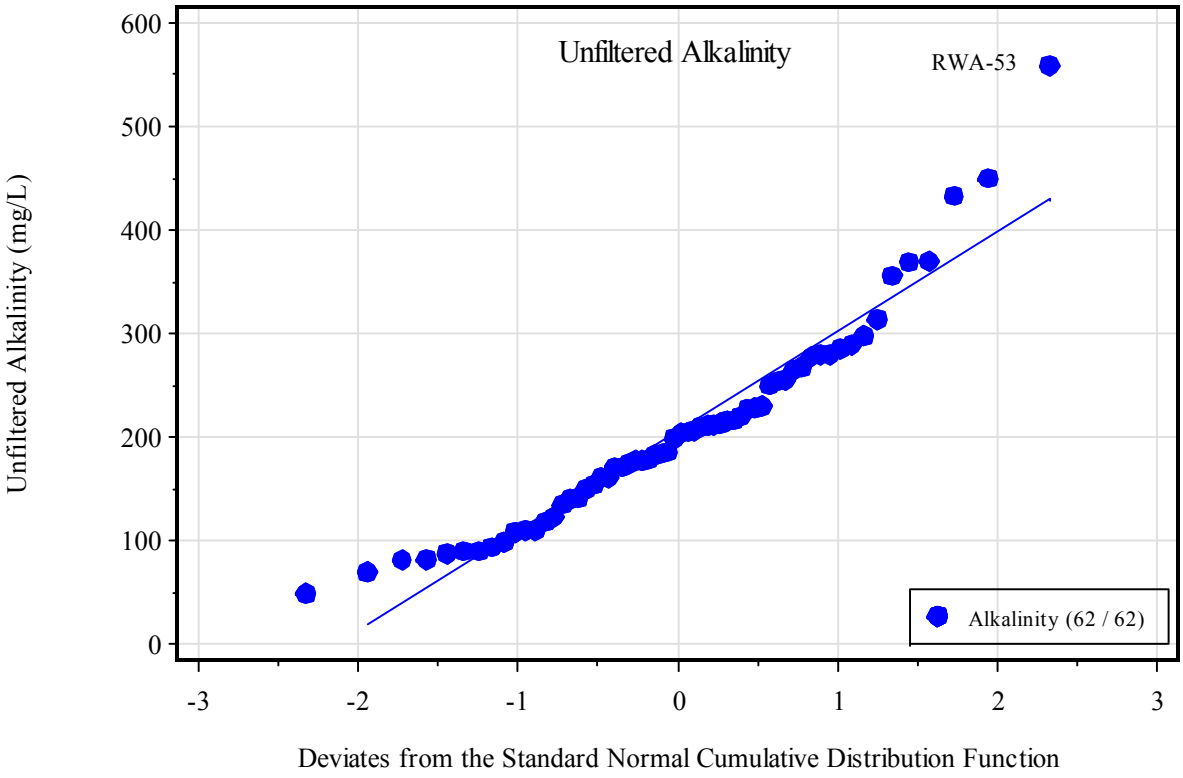


Figure C.20. Normal probability plots for unfiltered total hardness and pH (final dataset).



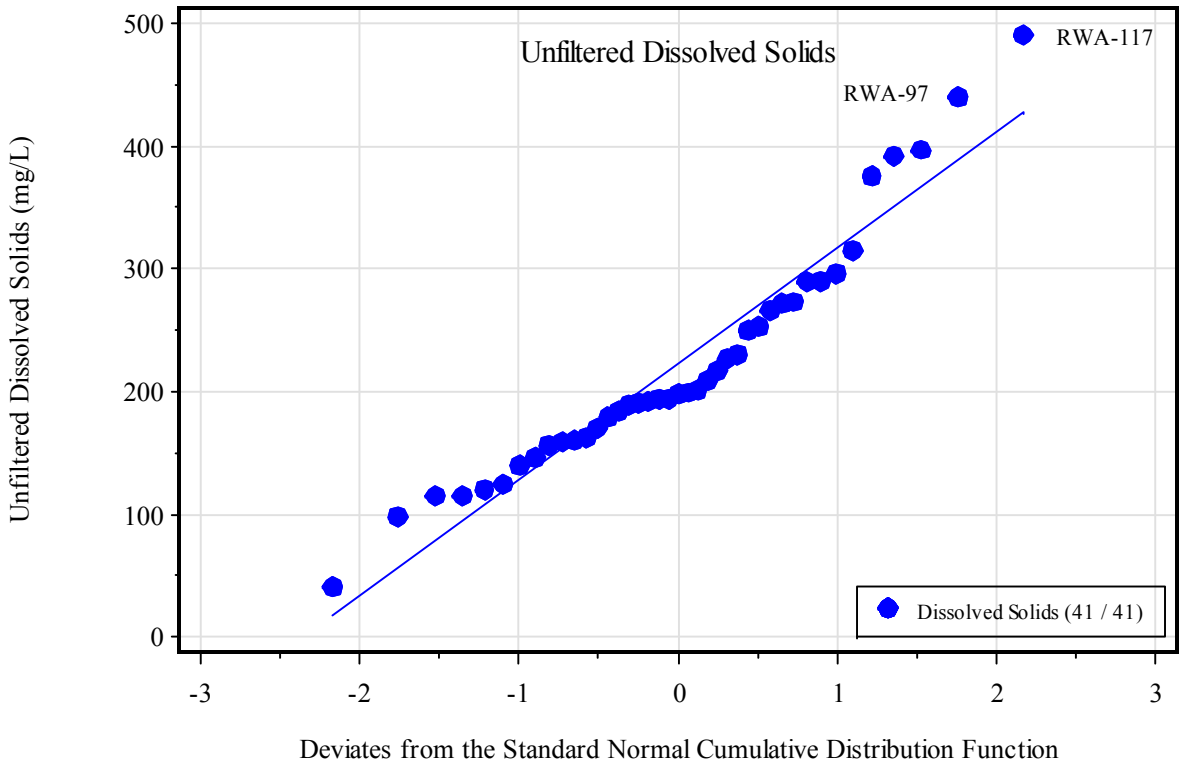
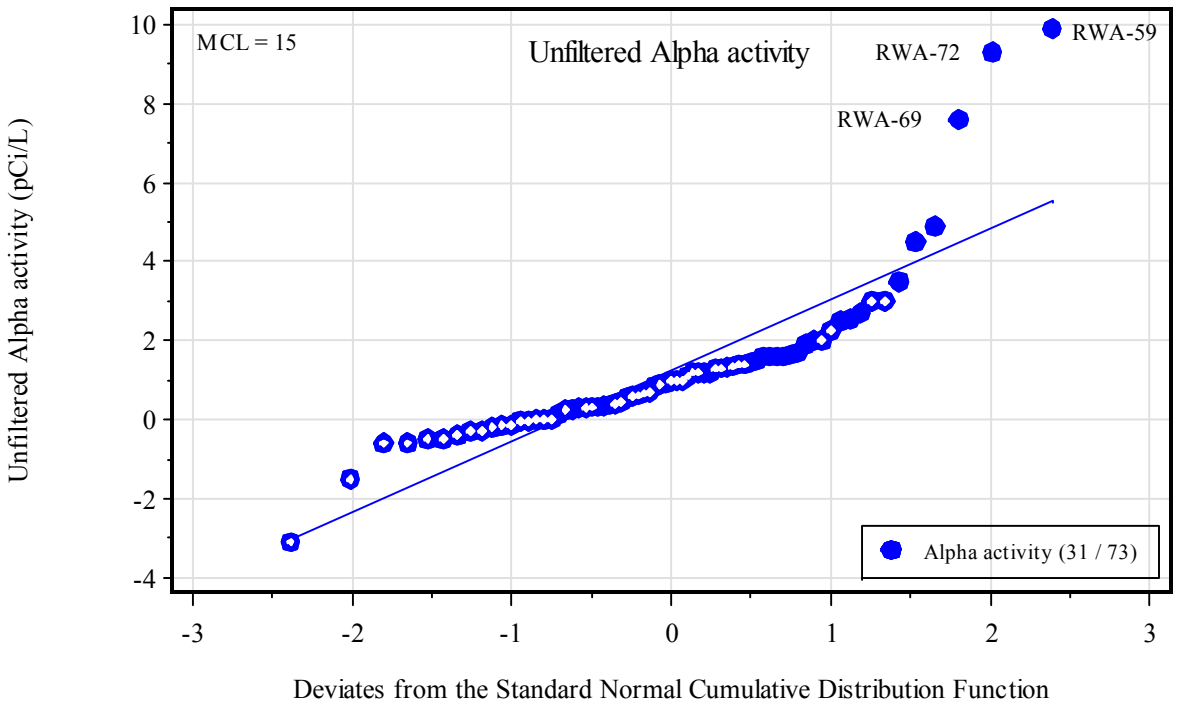
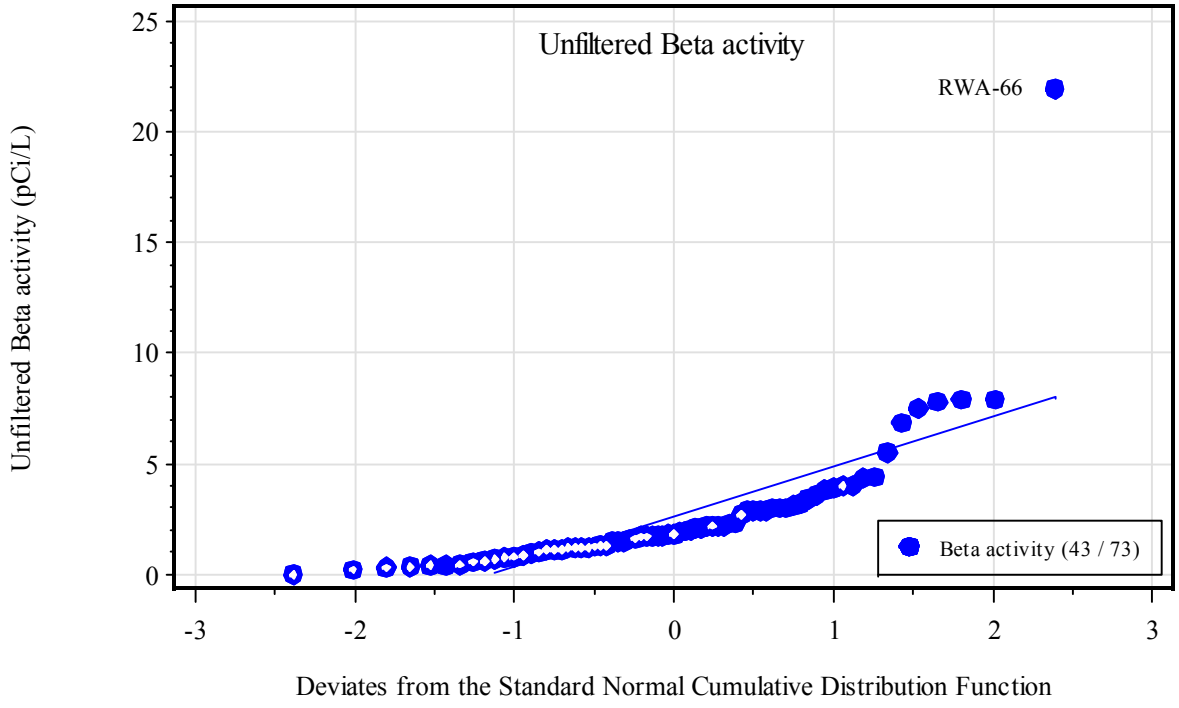


Figure C.21. Normal probability plots for unfiltered alkalinity and dissolved solids (final dataset).



Hollow symbols denote non-detects. Solid symbols denote detected concentrations.



Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

Figure C.22. Normal probability plots for unfiltered alpha activity and beta activity (final dataset).

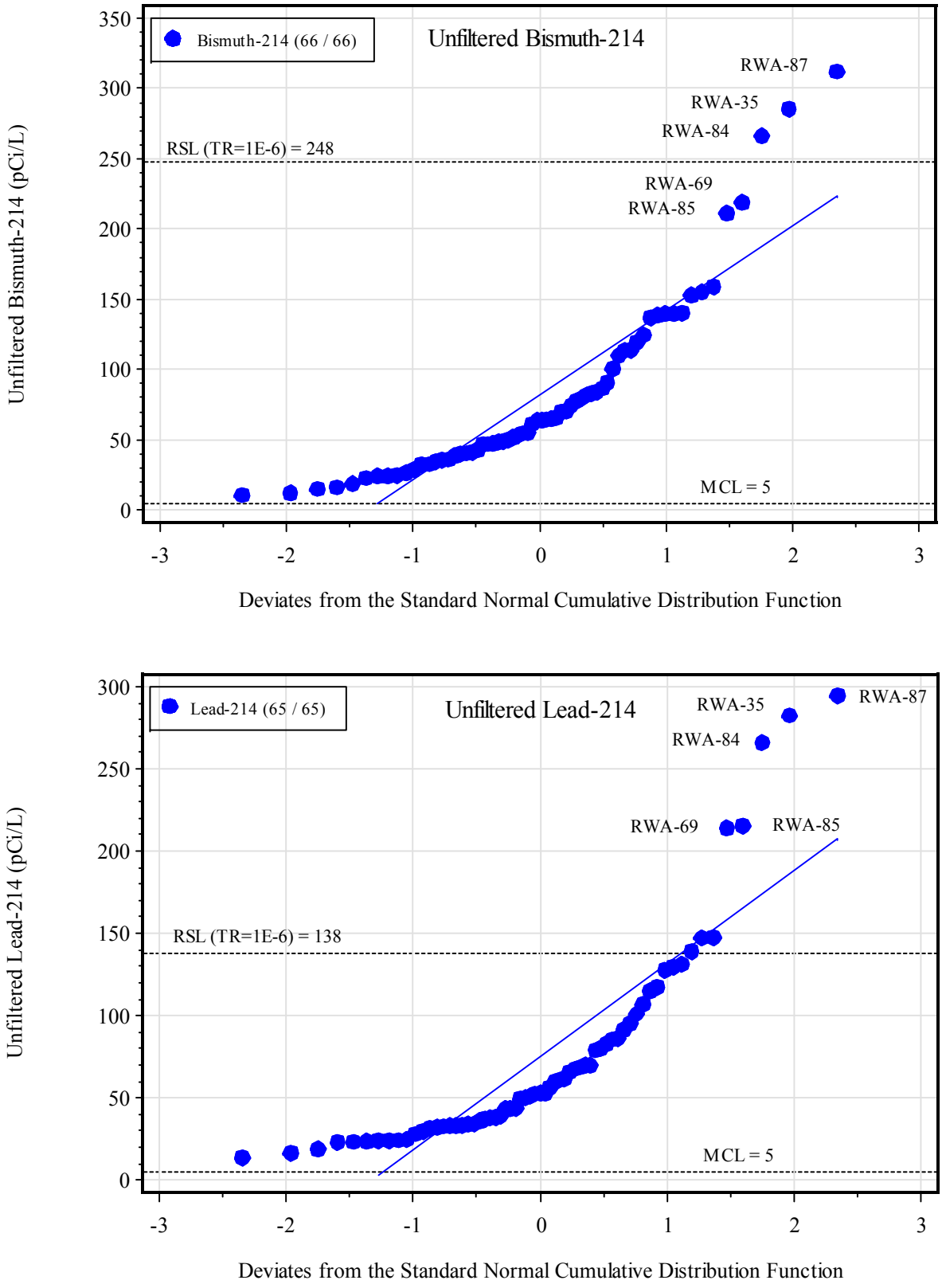
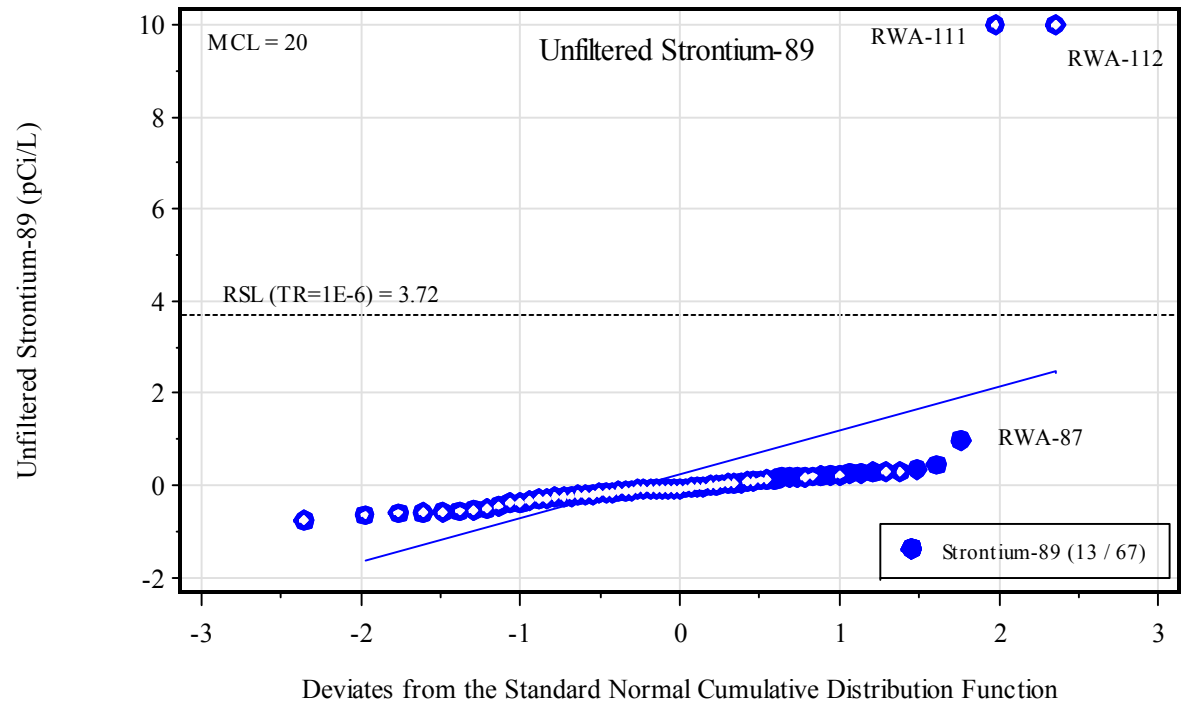
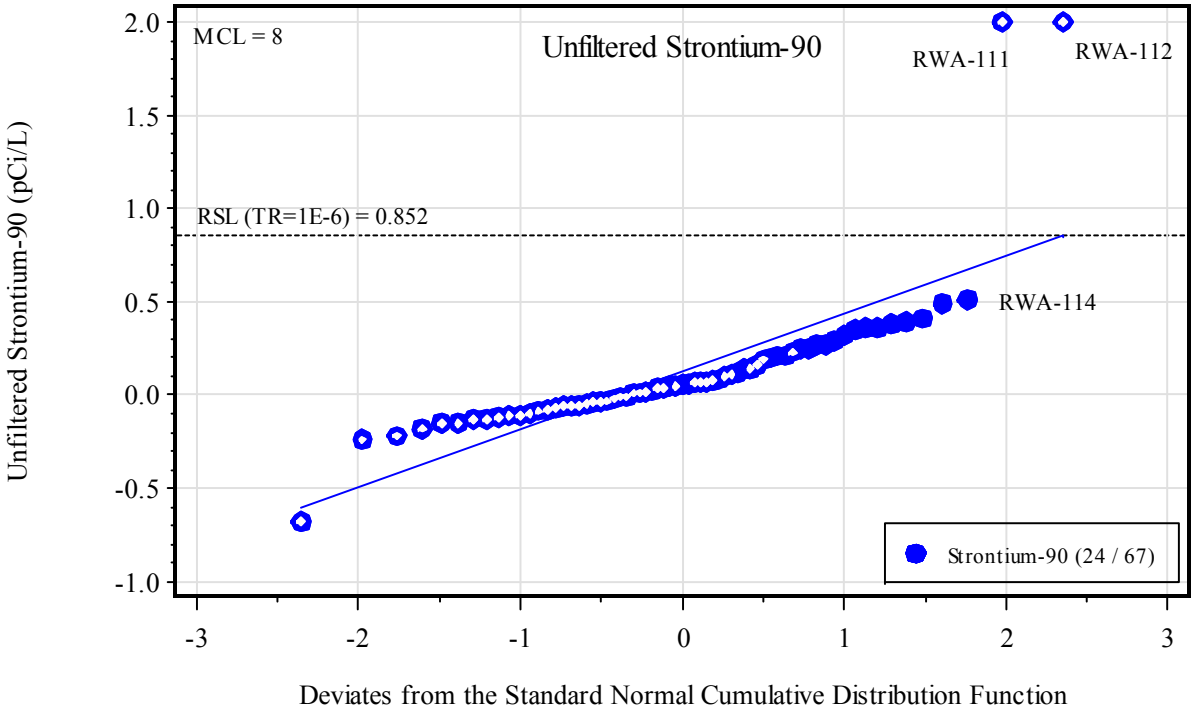


Figure C.23. Normal probability for unfiltered bismuth-214 and lead-214 (final dataset).

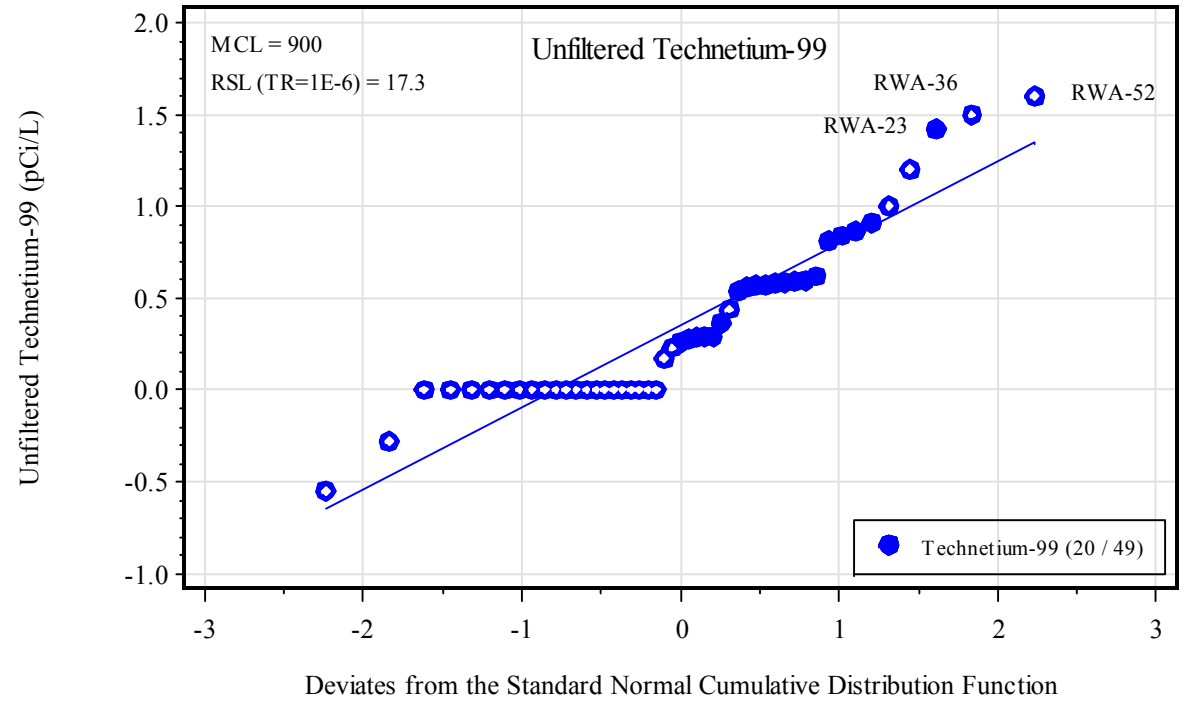


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

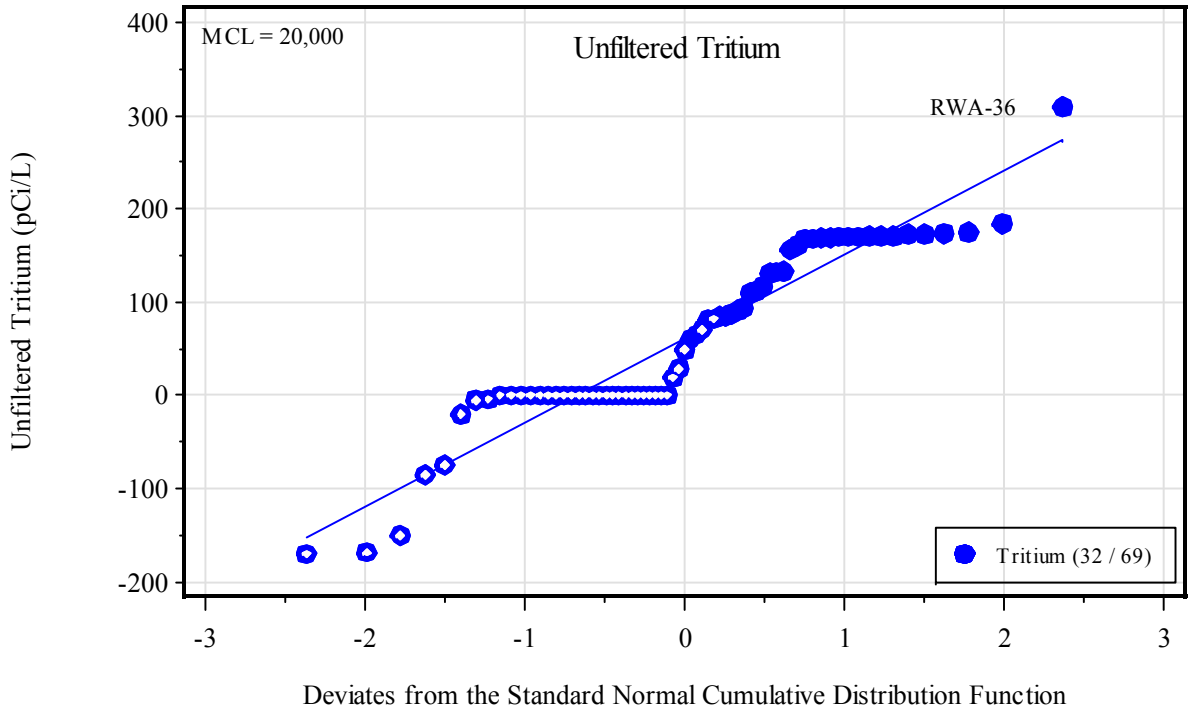


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

Figure C.24. Normal probability plots for unfiltered strontium-89 and strontium-90 (final dataset).

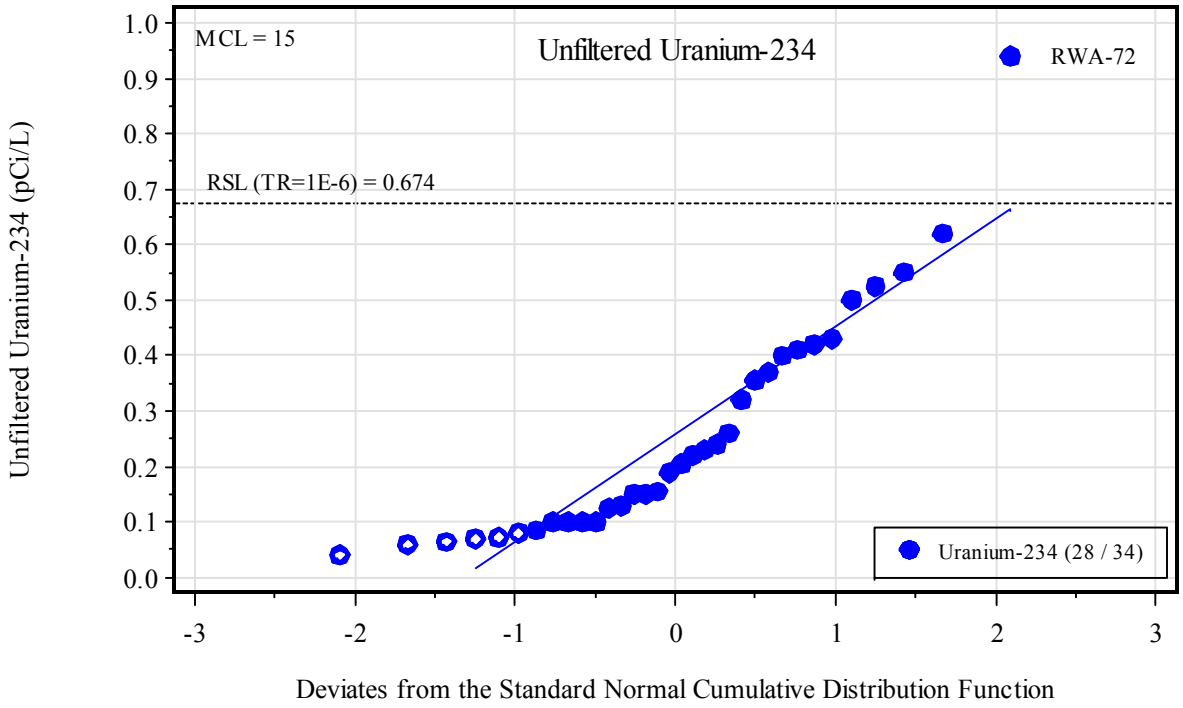


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

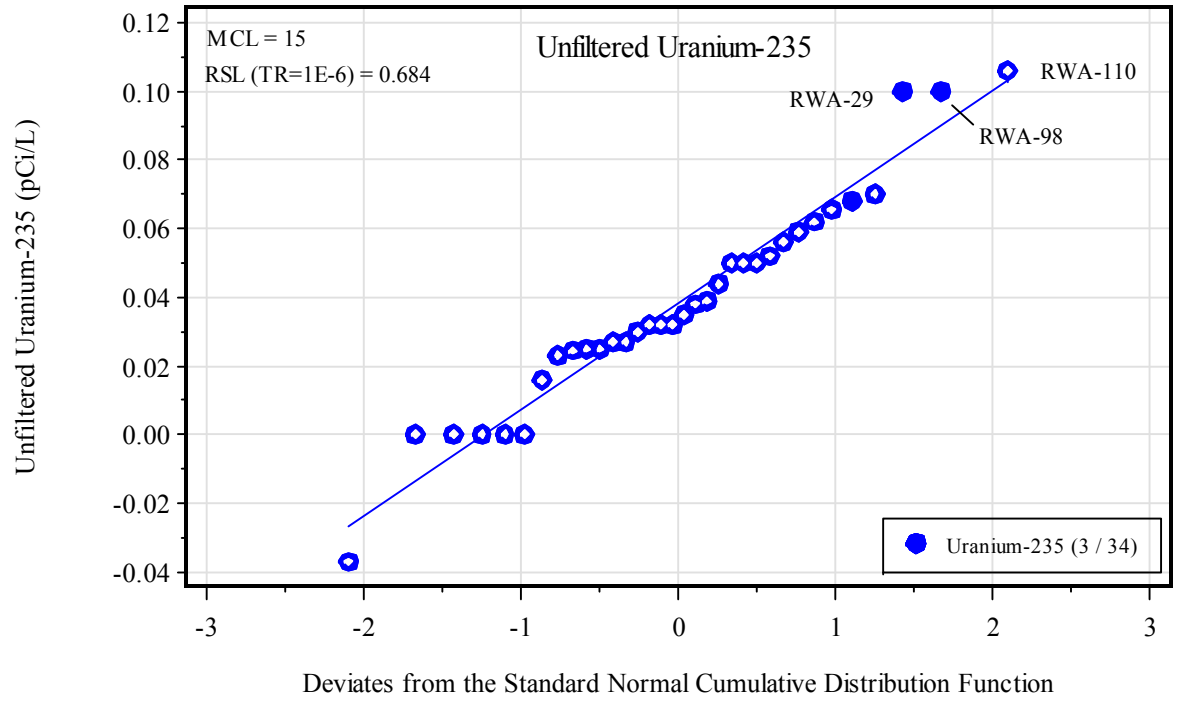


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

Figure C.25. Normal probability plots for unfiltered technetium-99 and tritium (final dataset).

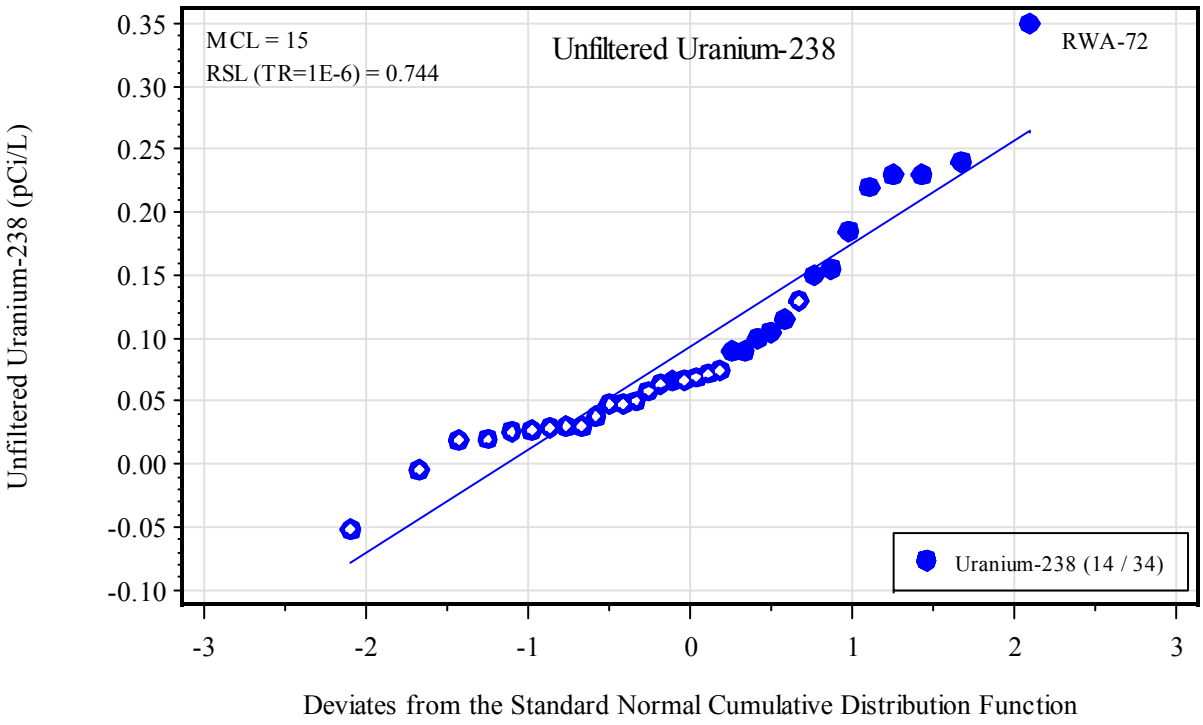


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.



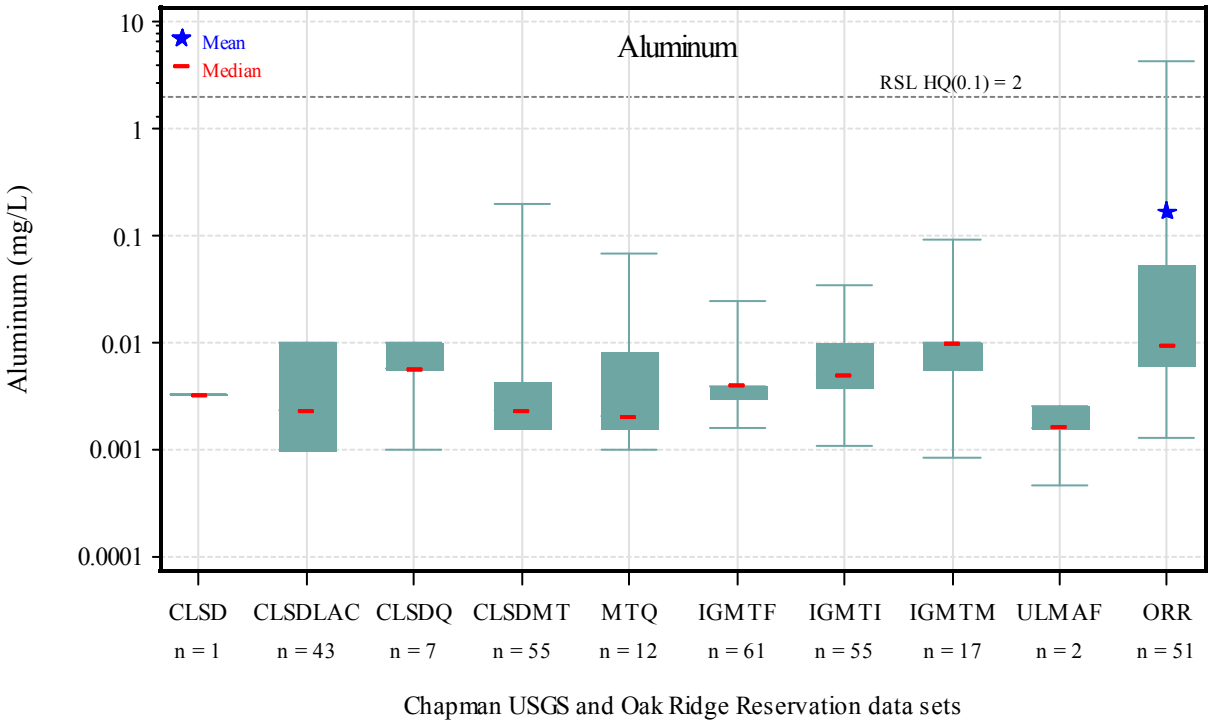
Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

Figure C.26. Normal probability plots for unfiltered uranium-234 and uranium-235 (final dataset).

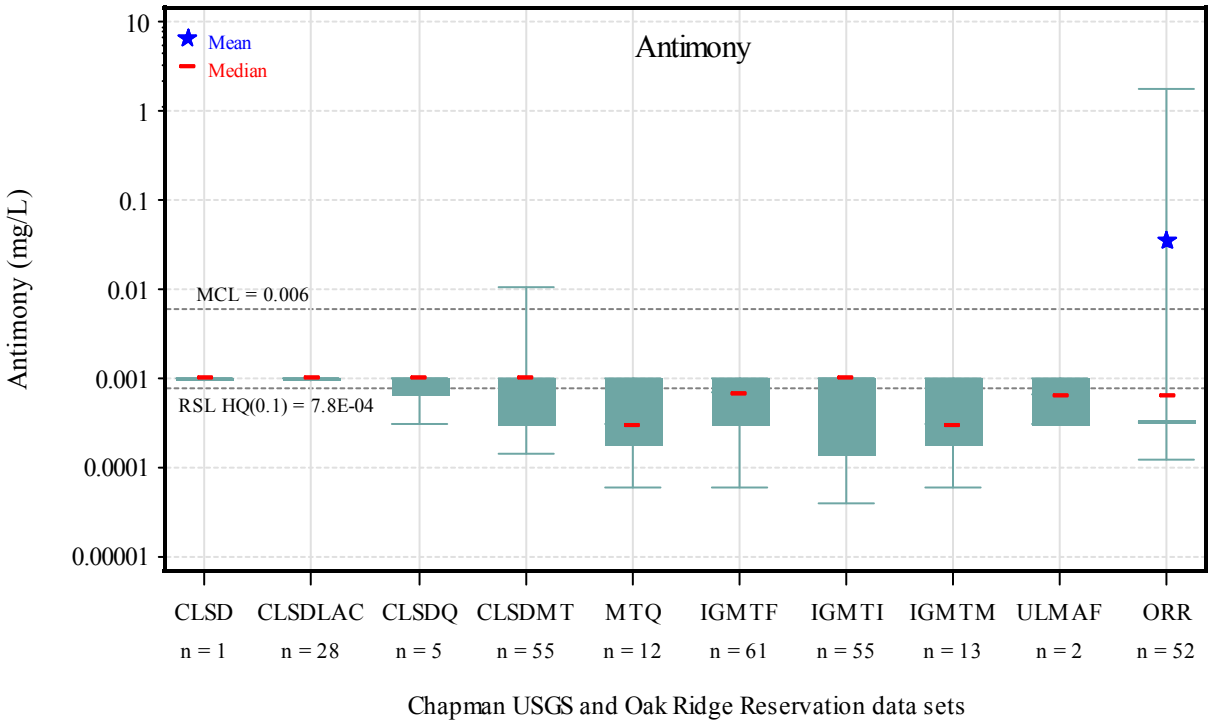


Hollow symbols denote non-detects. Solid symbols denote detected concentrations.

Figure C.27. Normal probability plot for unfiltered uranium-238 (final dataset).

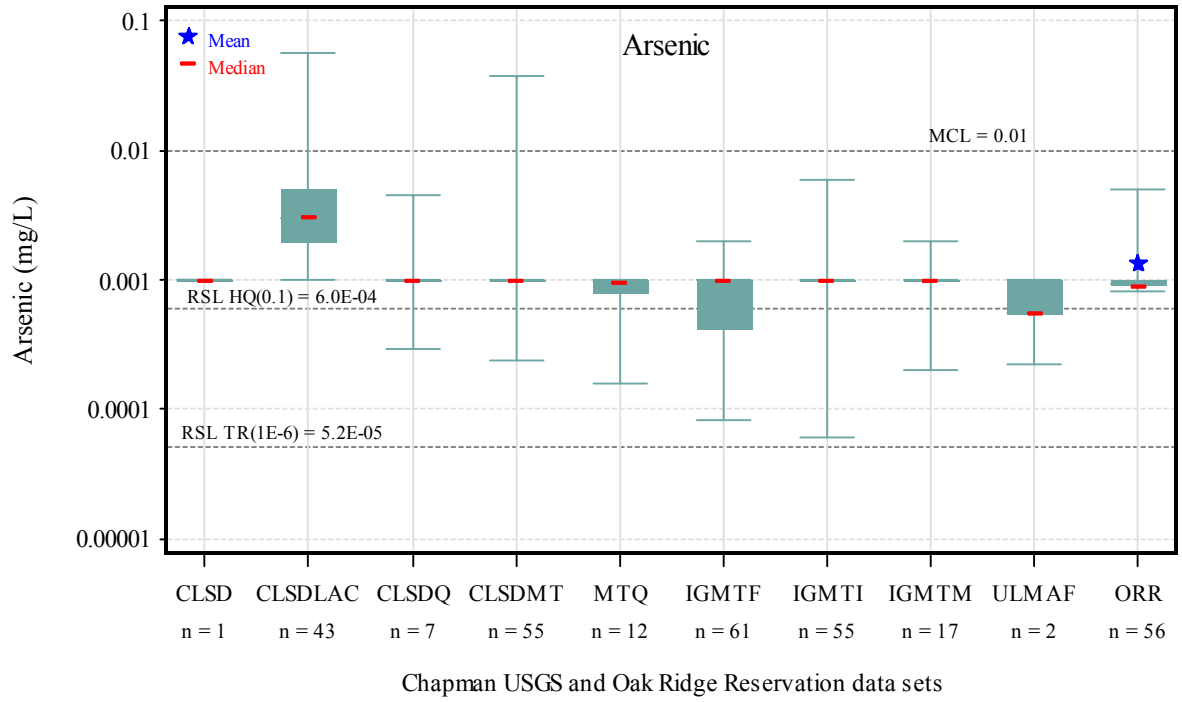


Detection limits were plotted for non-detects.

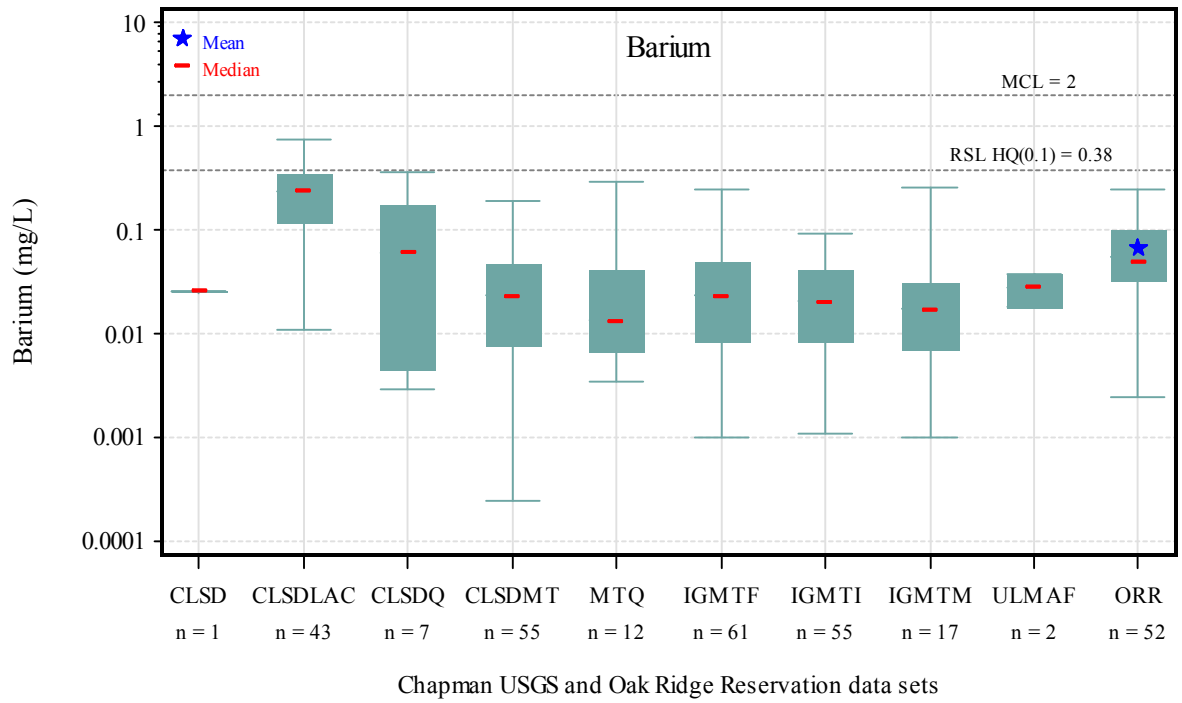


Detection limits were plotted for non-detects.

Figure C.28. Box plots of Chapman USGS data with ORR final background dataset for aluminum and antimony.

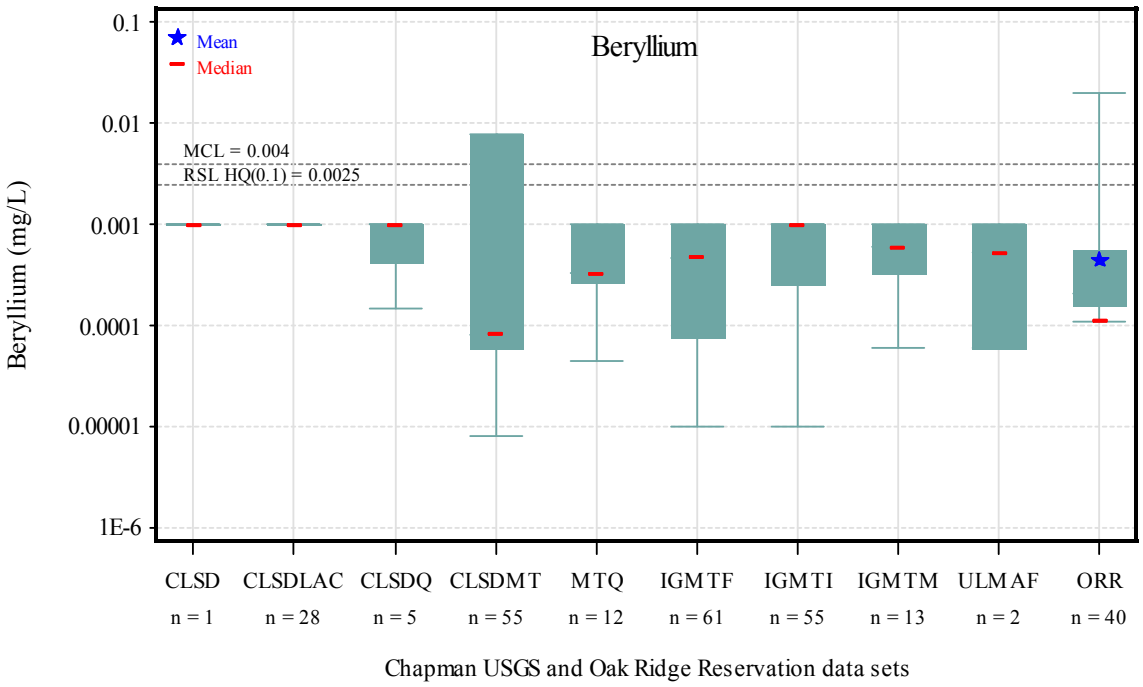


Detection limits were plotted for non-detects.

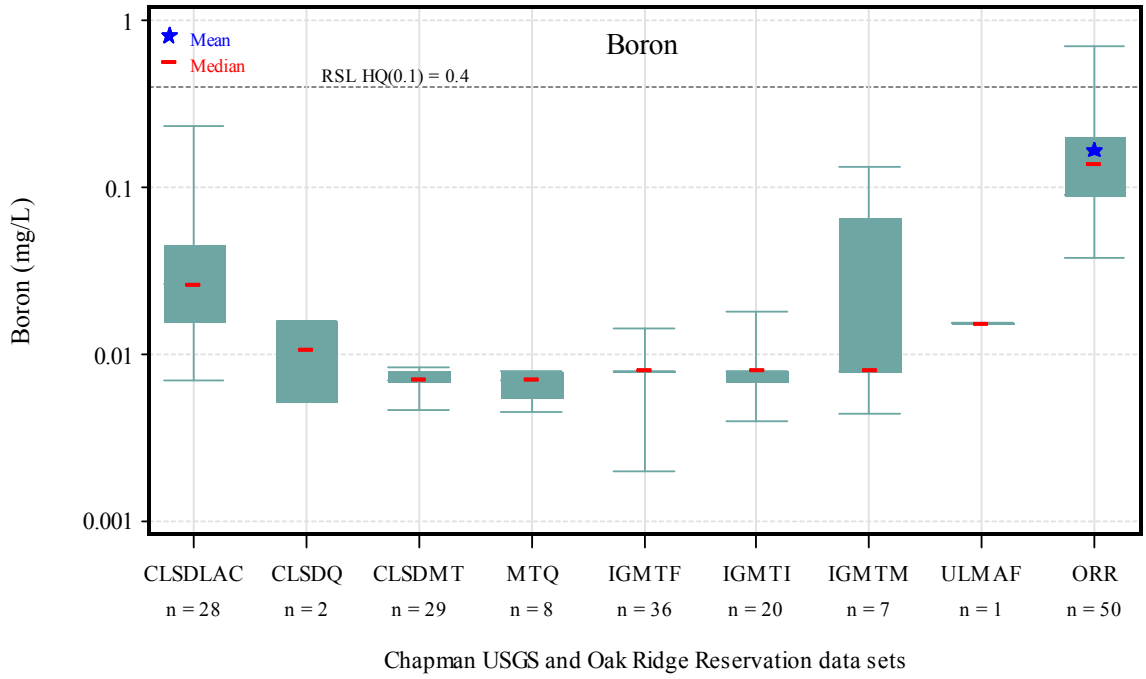


Detection limits were plotted for non-detects.

Figure C.29. Box plots of Chapman USGS data with ORR final background dataset for arsenic and barium.

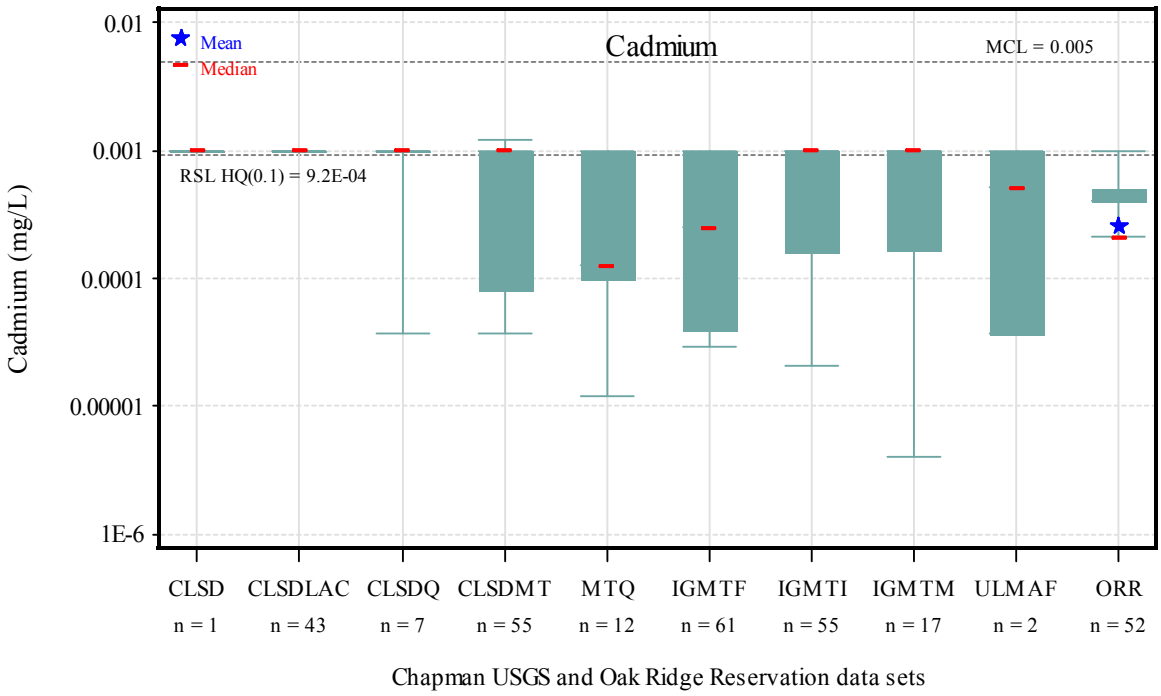


Detection limits were plotted for non-detects.

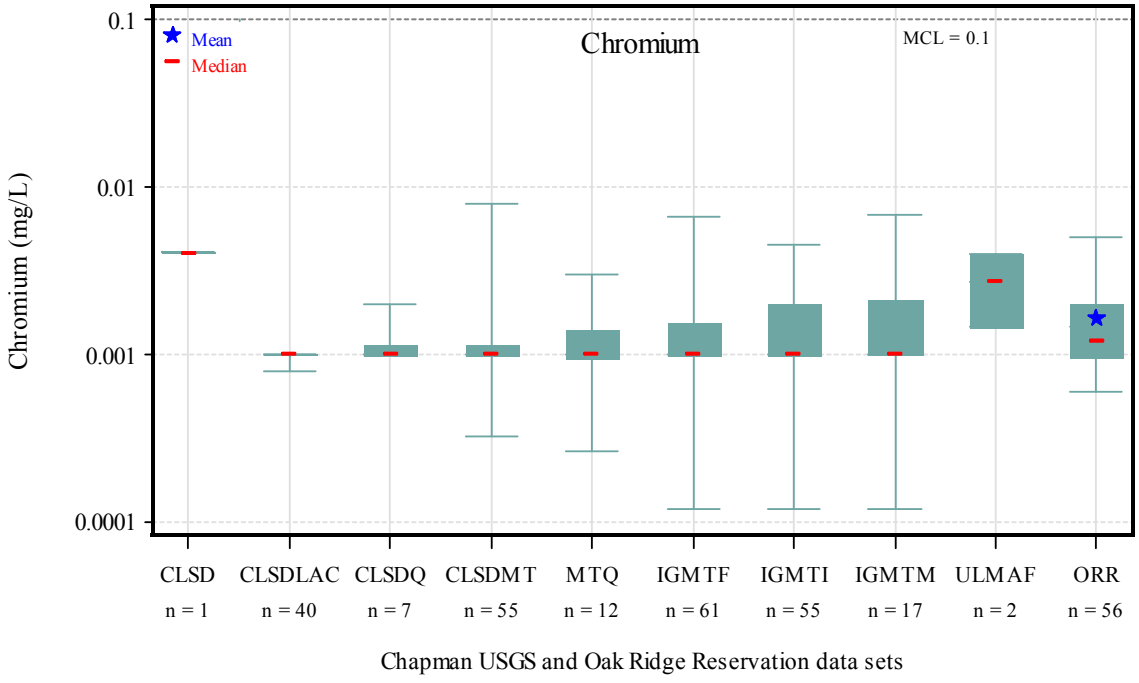


Detection limits were plotted for non-detects.

Figure C.30. Box plots of Chapman USGS data with ORR final background dataset for beryllium and boron.

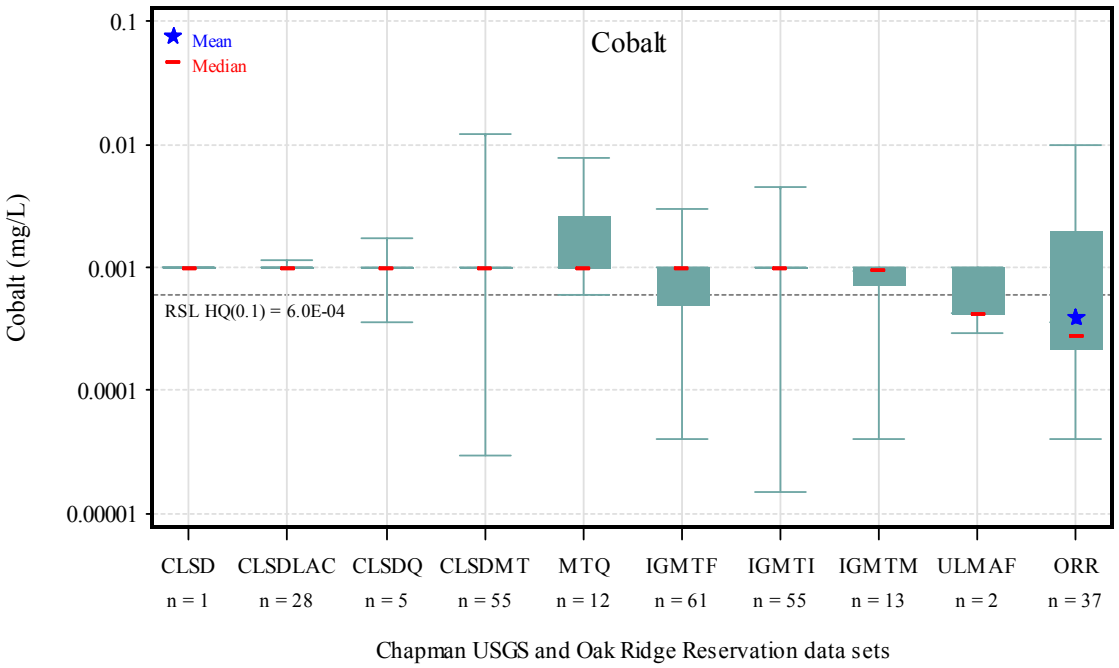


Detection limits were plotted for non-detects.

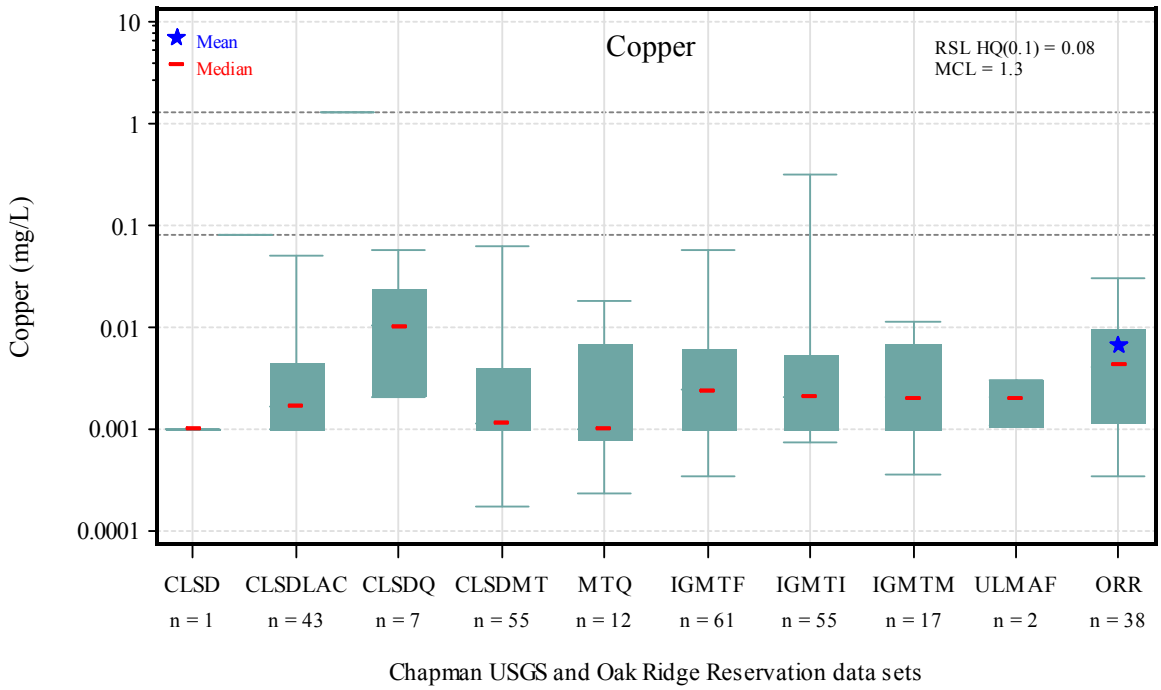


Detection limits were plotted for non-detects.

Figure C.31. Box plots of Chapman USGS data with ORR final background dataset for cadmium and chromium.

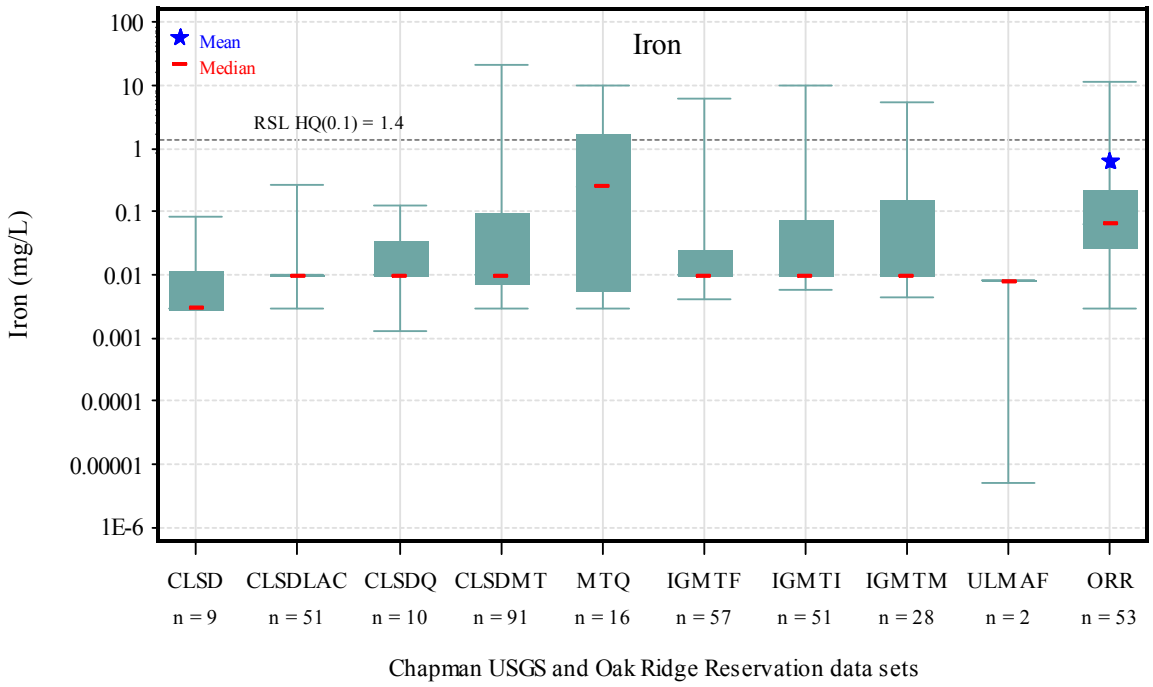


Detection limits were plotted for non-detects.

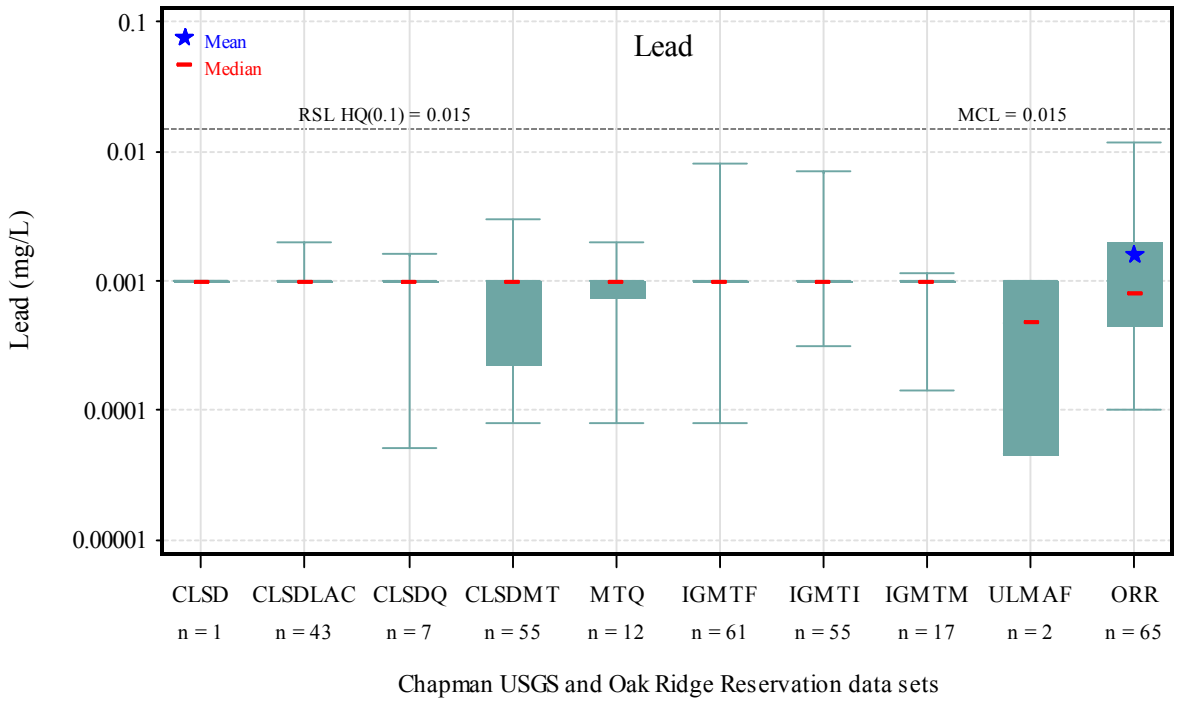


Detection limits were plotted for non-detects.

Figure C.32. Box plots of Chapman USGS data with ORR final background dataset for cobalt and copper.

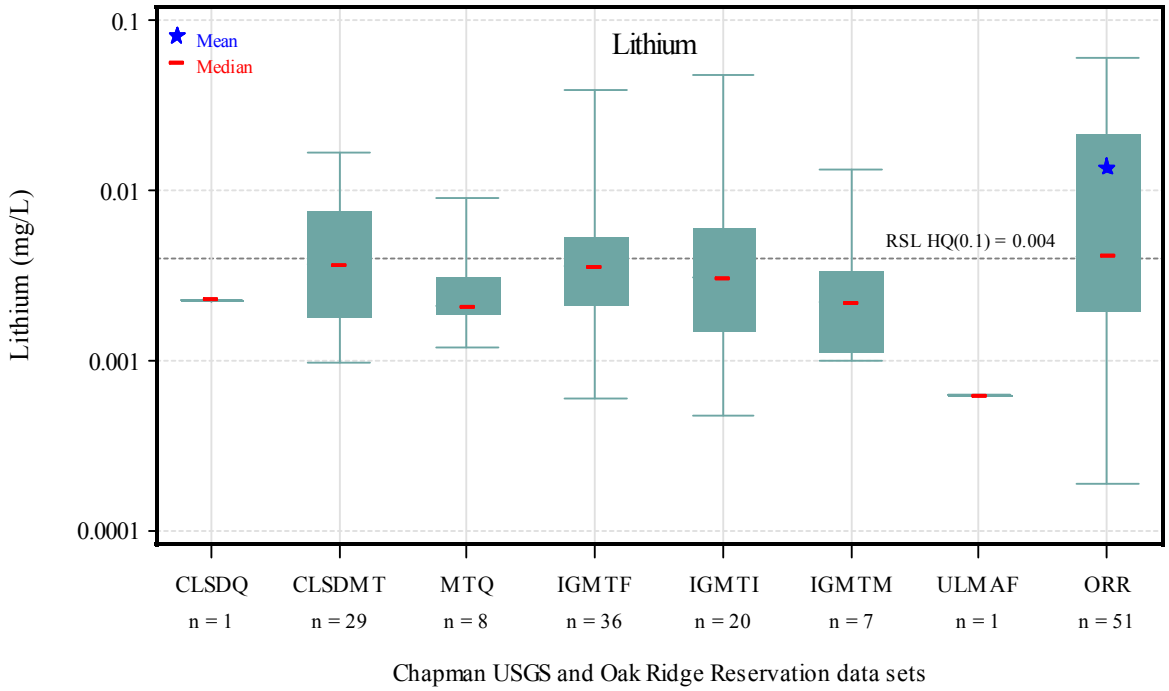


Detection limits were plotted for non-detects.

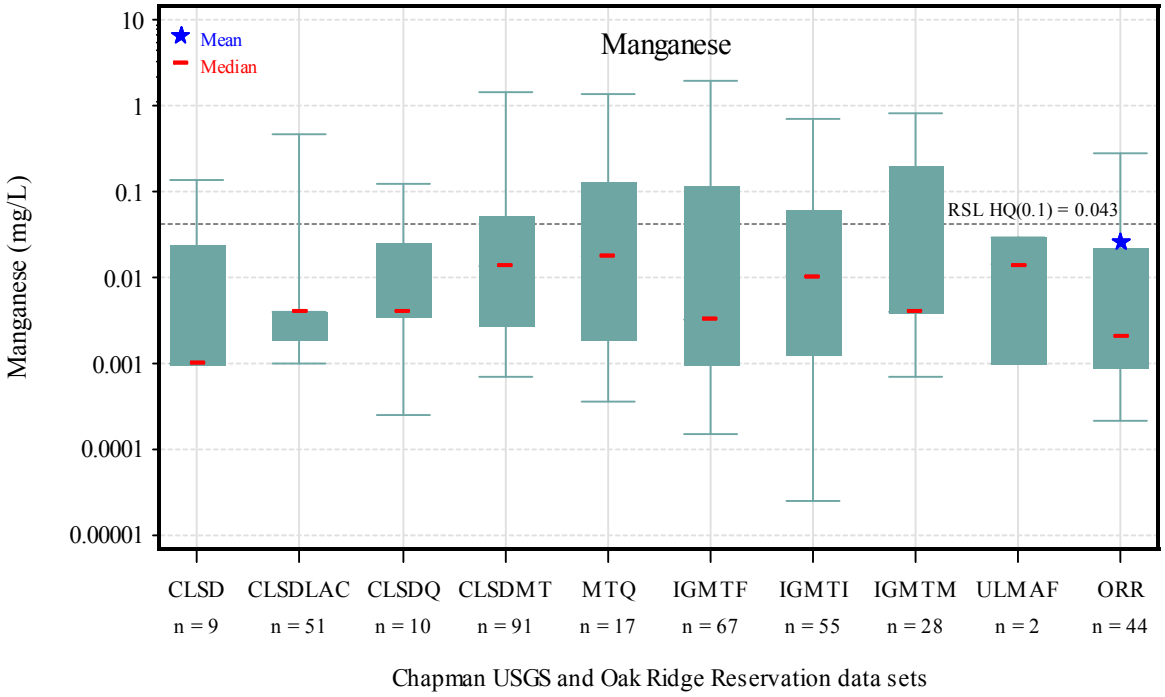


Detection limits were plotted for non-detects.

Figure C.33. Box plots of Chapman USGS data with ORR final background dataset for iron and lead.

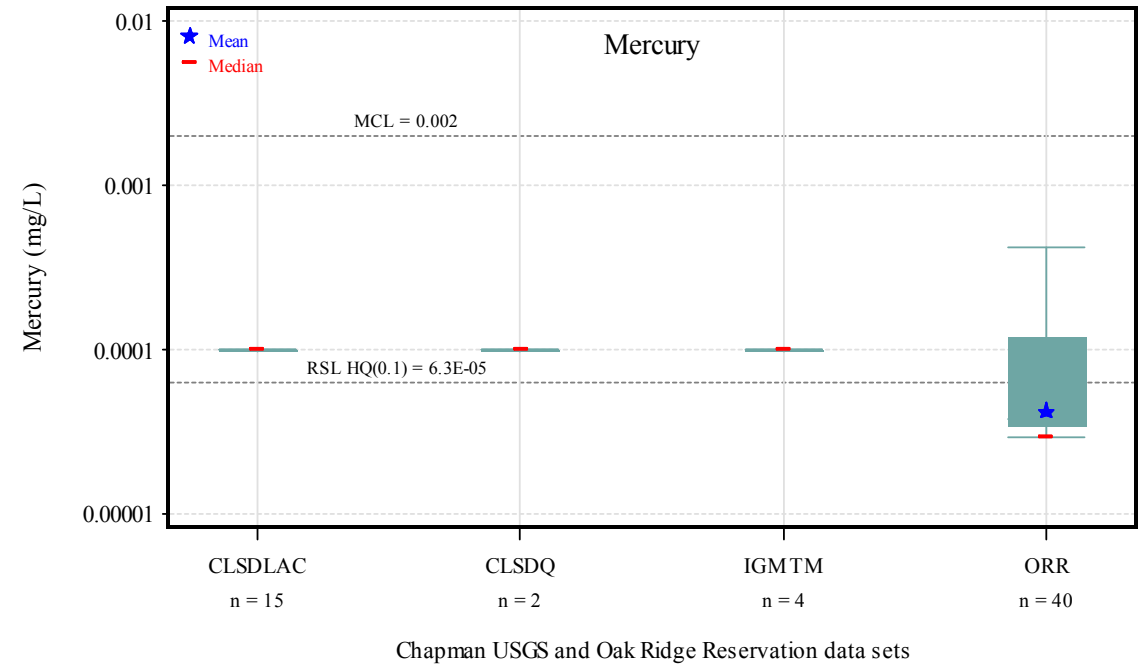


Detection limits were plotted for non-detects.

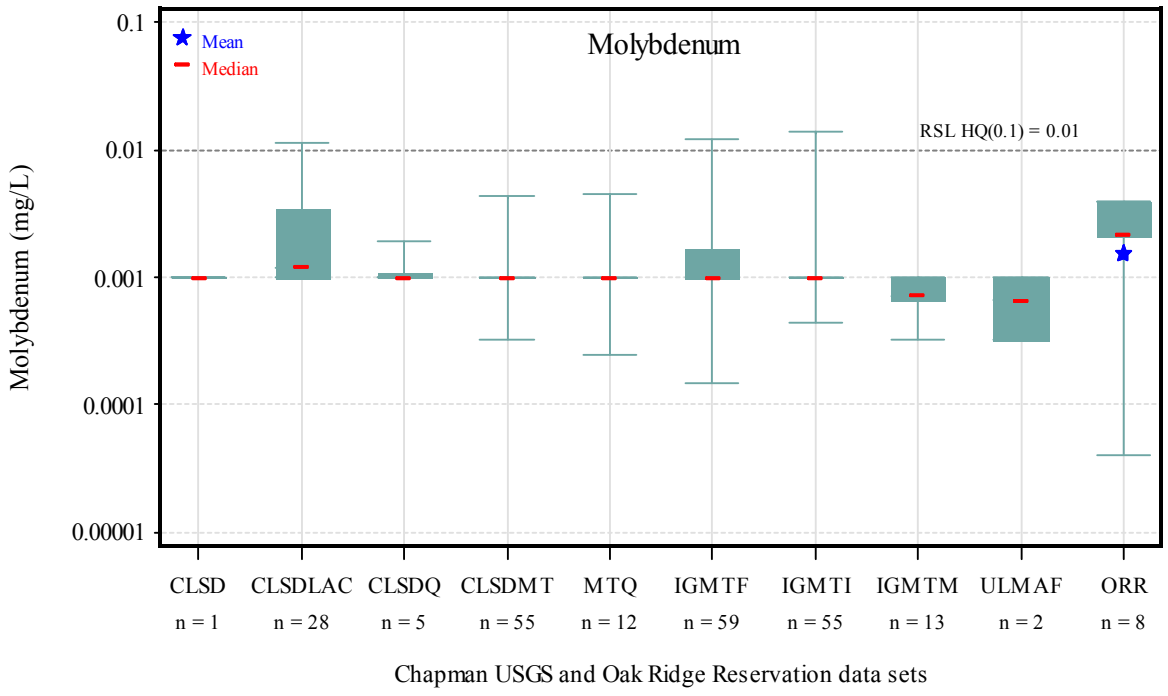


Detection limits were plotted for non-detects.

Figure C.34. Box plots of Chapman USGS data with ORR final background dataset for lithium and manganese.

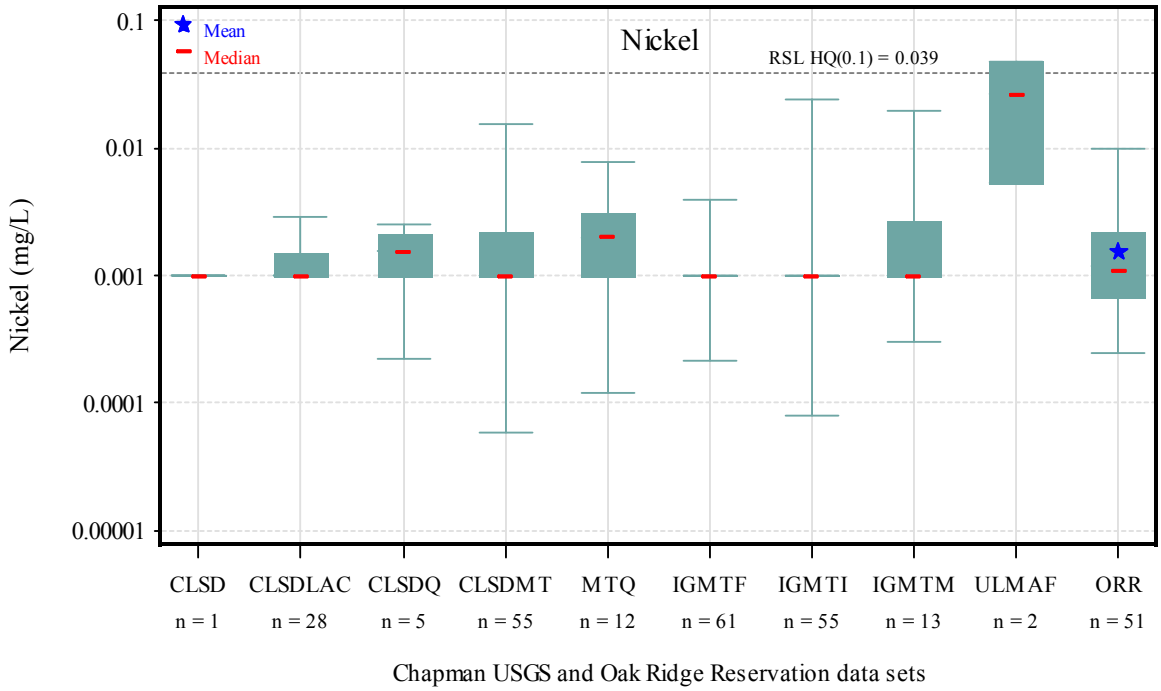


Detection limits were plotted for non-detects.

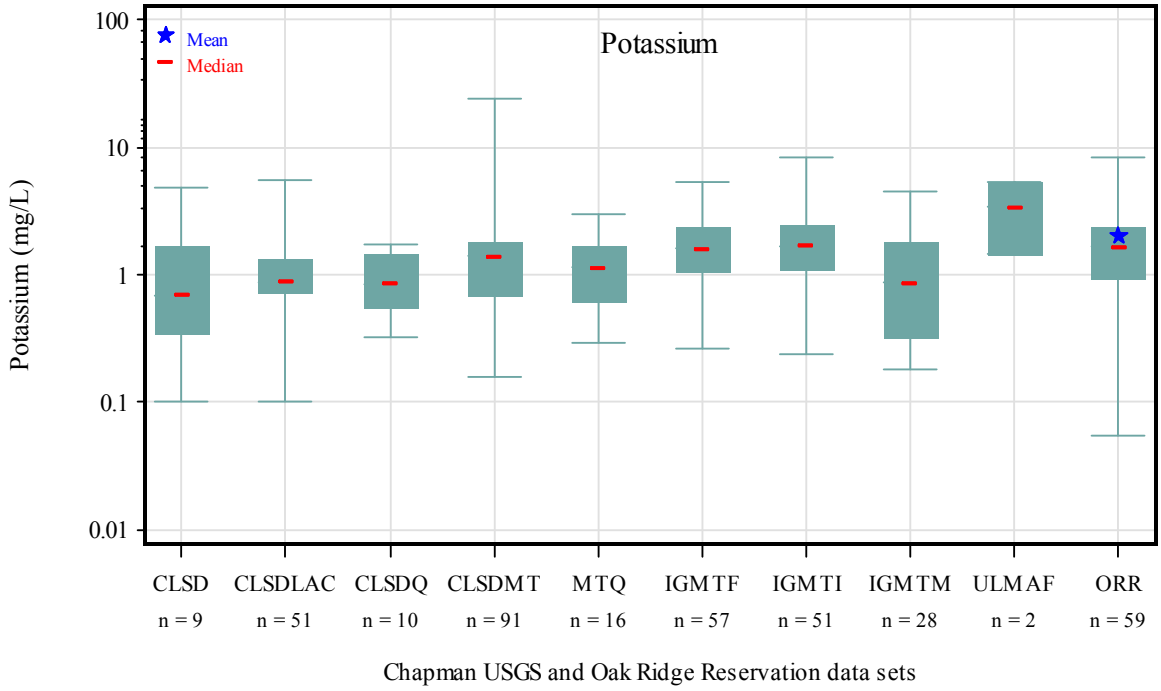


Detection limits were plotted for non-detects.

Figure C.35. Box plots of Chapman USGS data with ORR final background dataset for mercury and molybdenum.

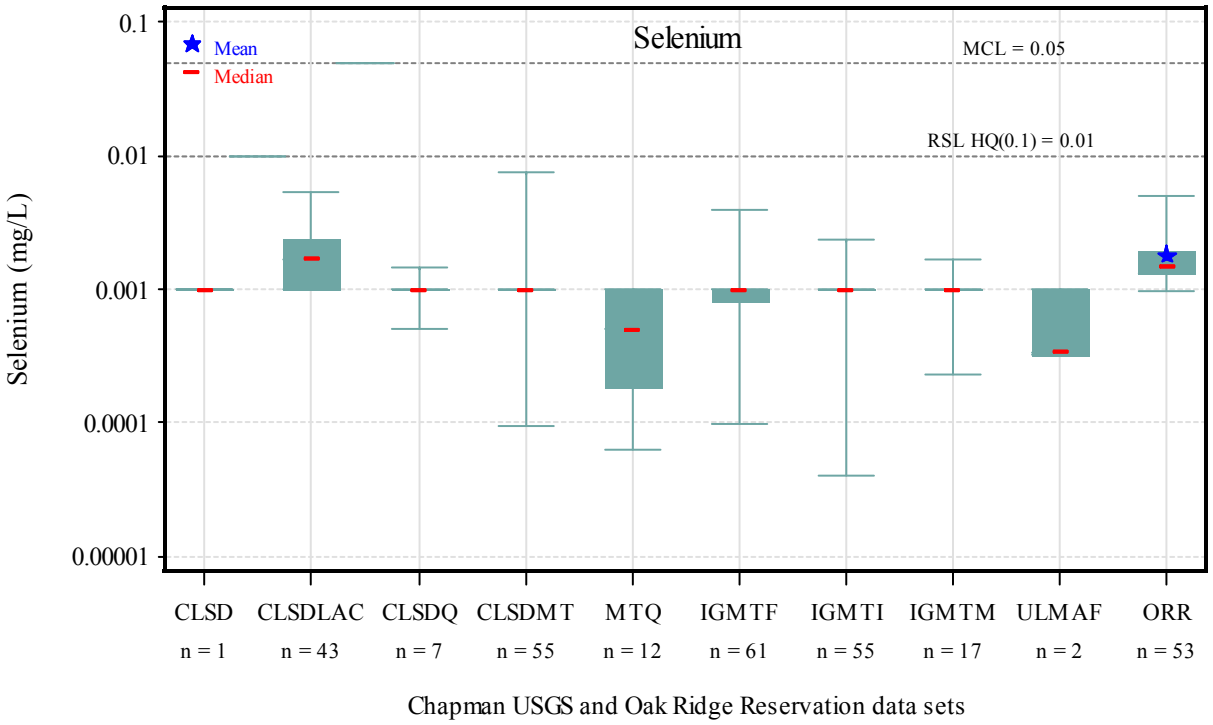


Detection limits were plotted for non-detects.

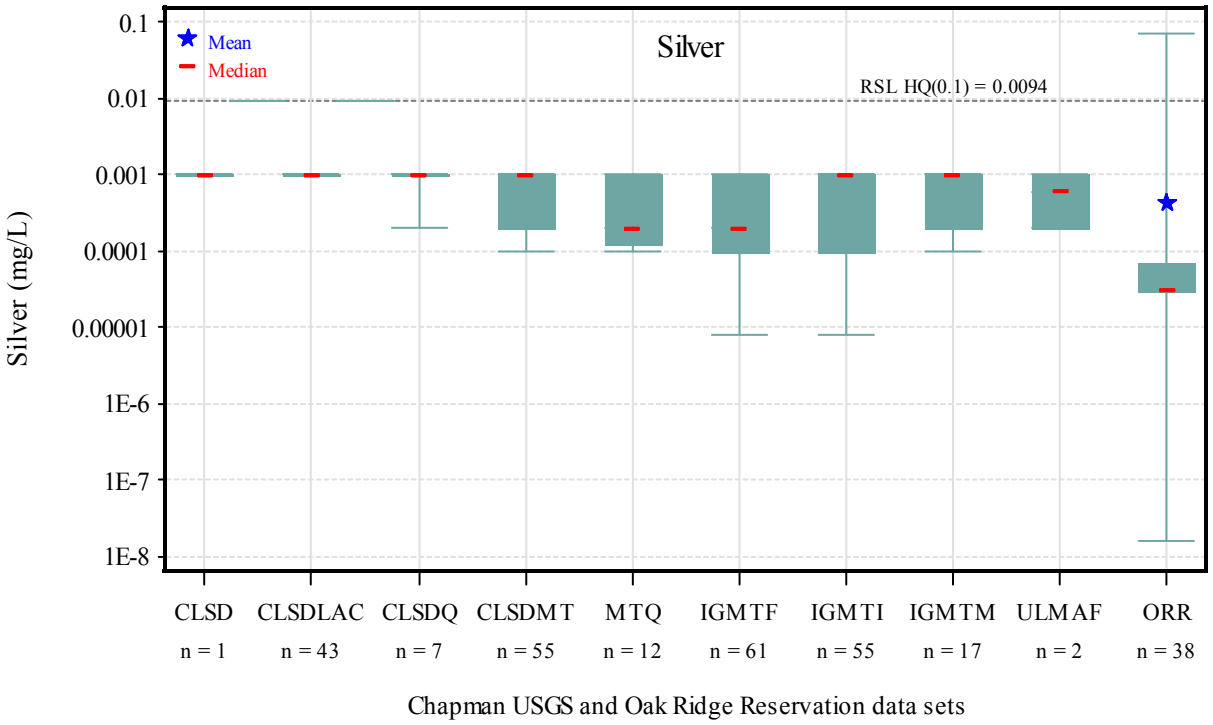


Detection limits were plotted for non-detects.

Figure C.36. Box plots of Chapman USGS data with ORR final background dataset for nickel and potassium.

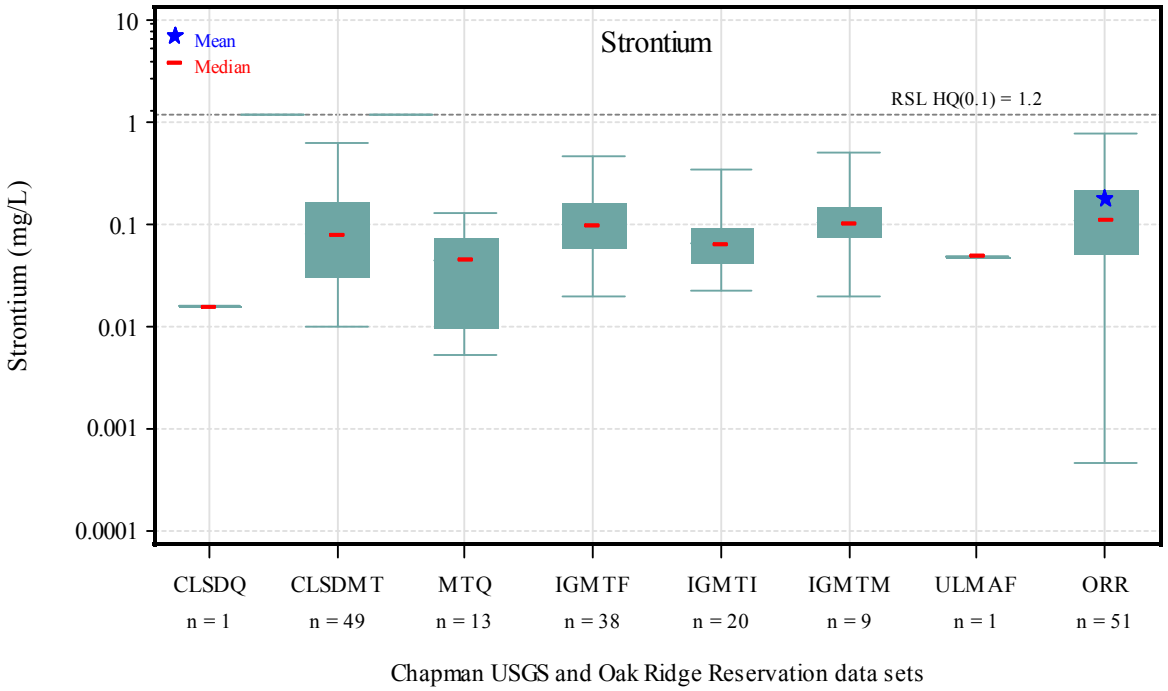


Detection limits were plotted for non-detects.

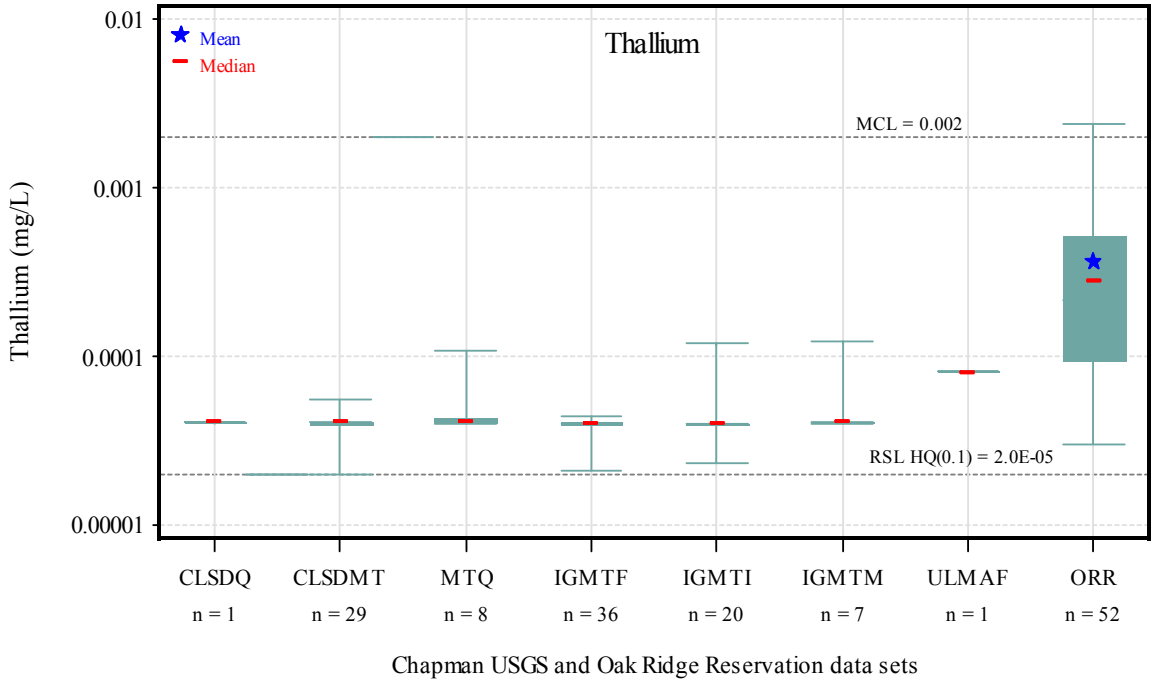


Detection limits were plotted for non-detects.

Figure C.37. Box plots of Chapman USGS data with ORR final background dataset for selenium and silver.

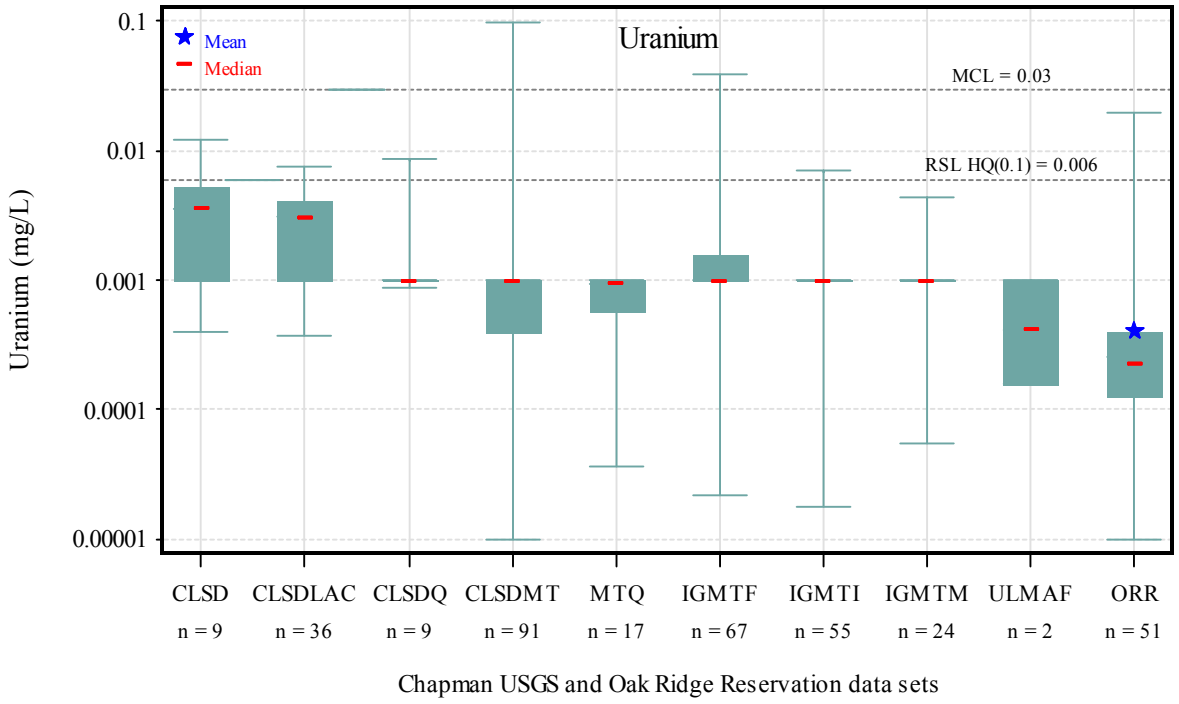


Detection limits were plotted for non-detects.

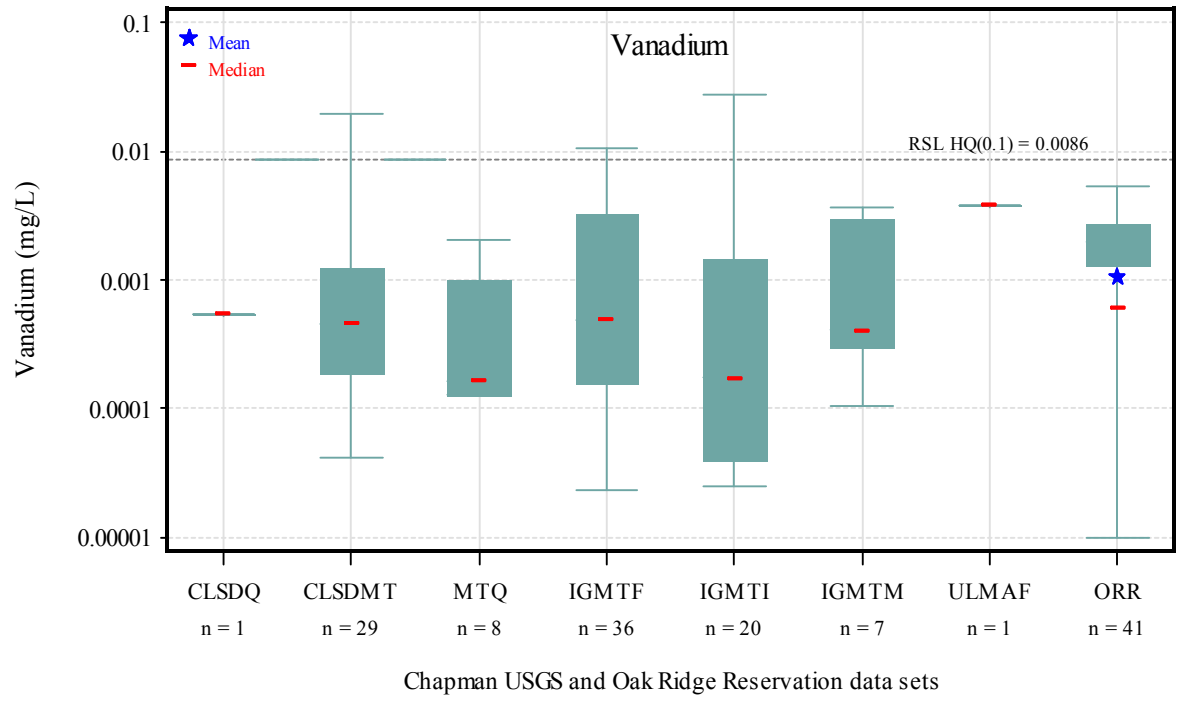


Detection limits were plotted for non-detects.

Figure C.38. Box plots of Chapman USGS data with ORR final background dataset for strontium and thallium.

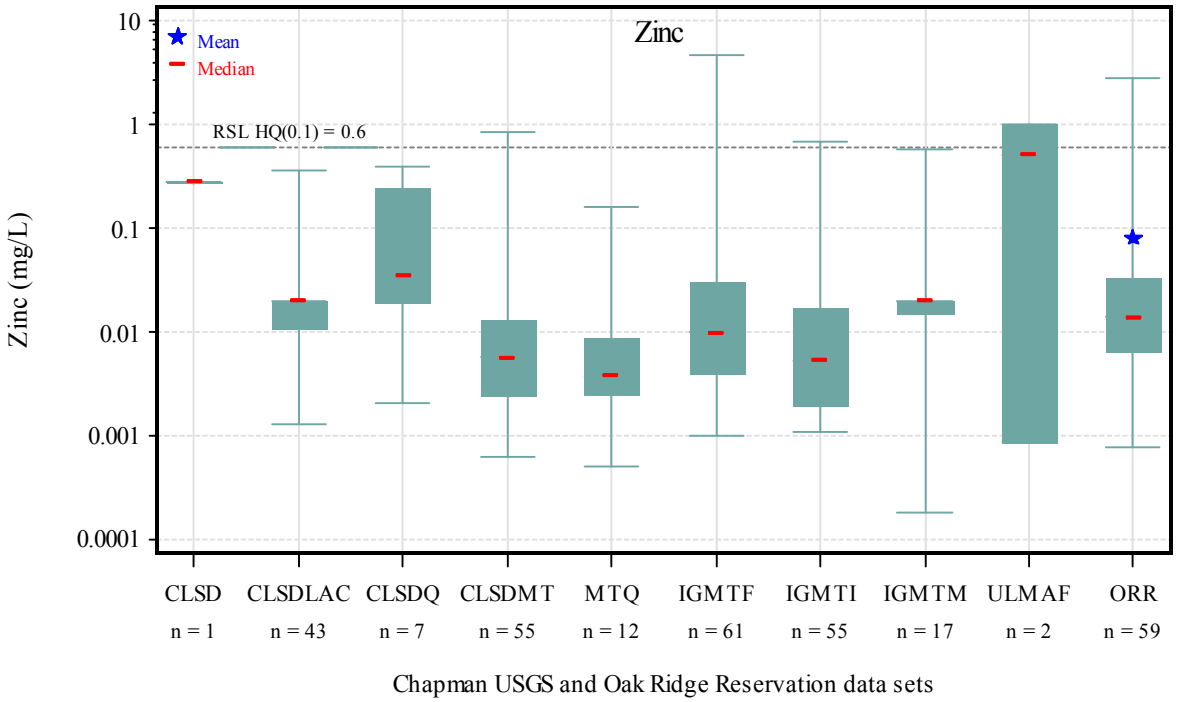


Detection limits were plotted for non-detects.

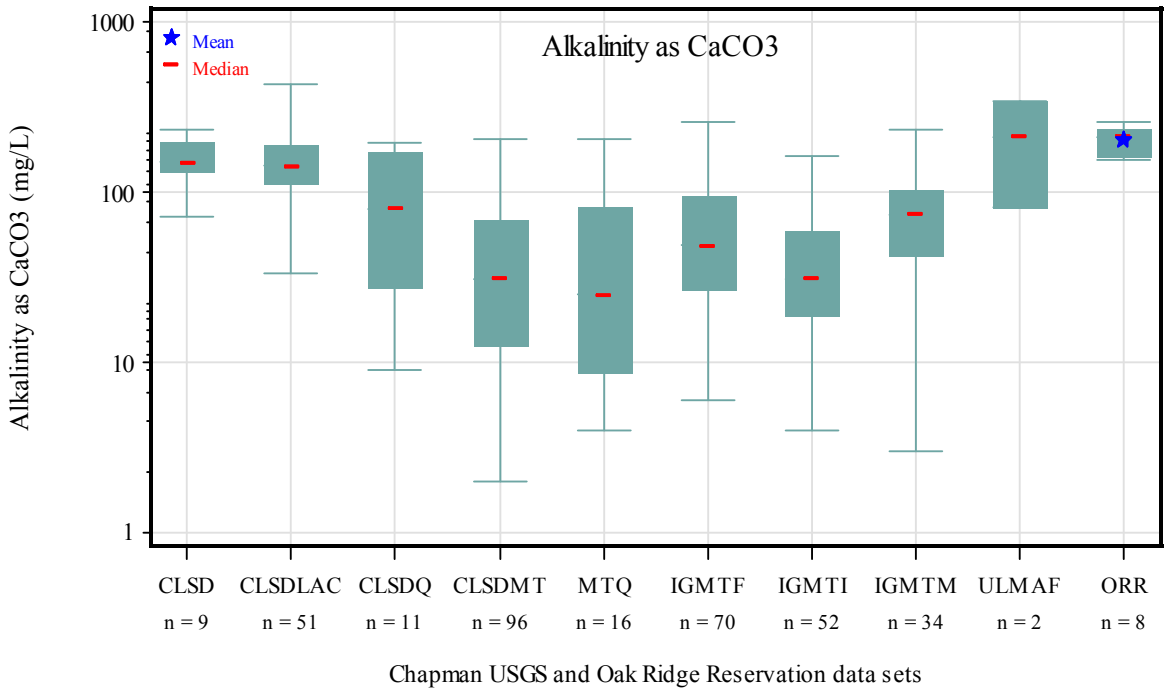


Detection limits were plotted for non-detects.

Figure C.39. Box plots of Chapman USGS data with ORR final background dataset for uranium and vanadium.

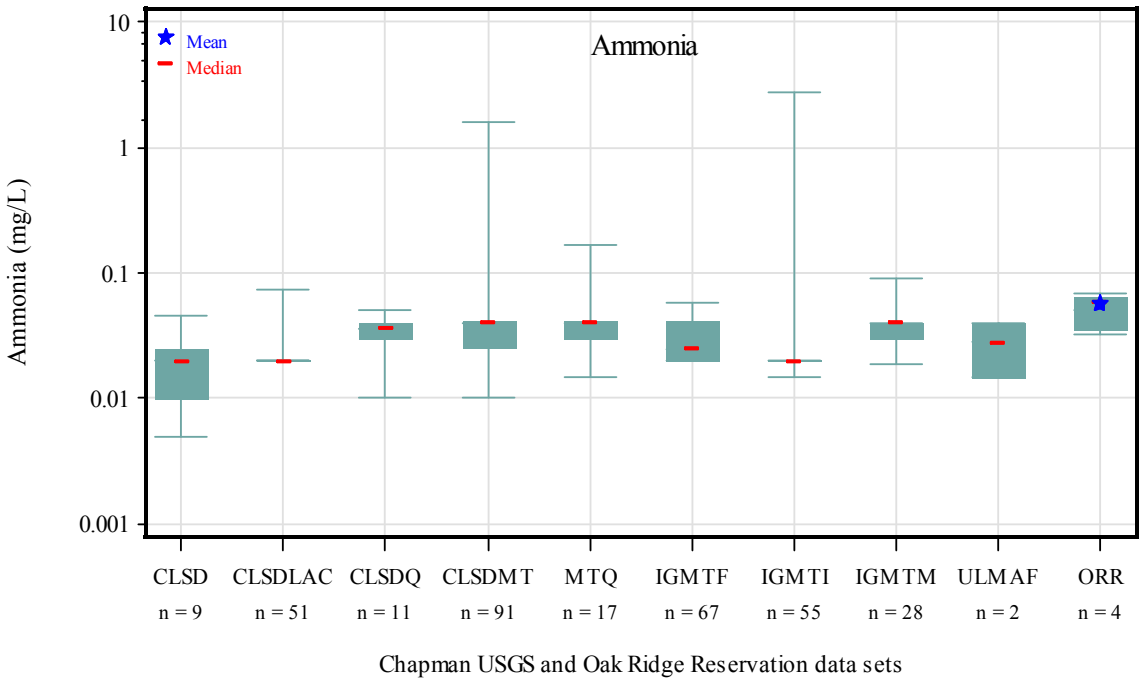


Detection limits were plotted for non-detects.

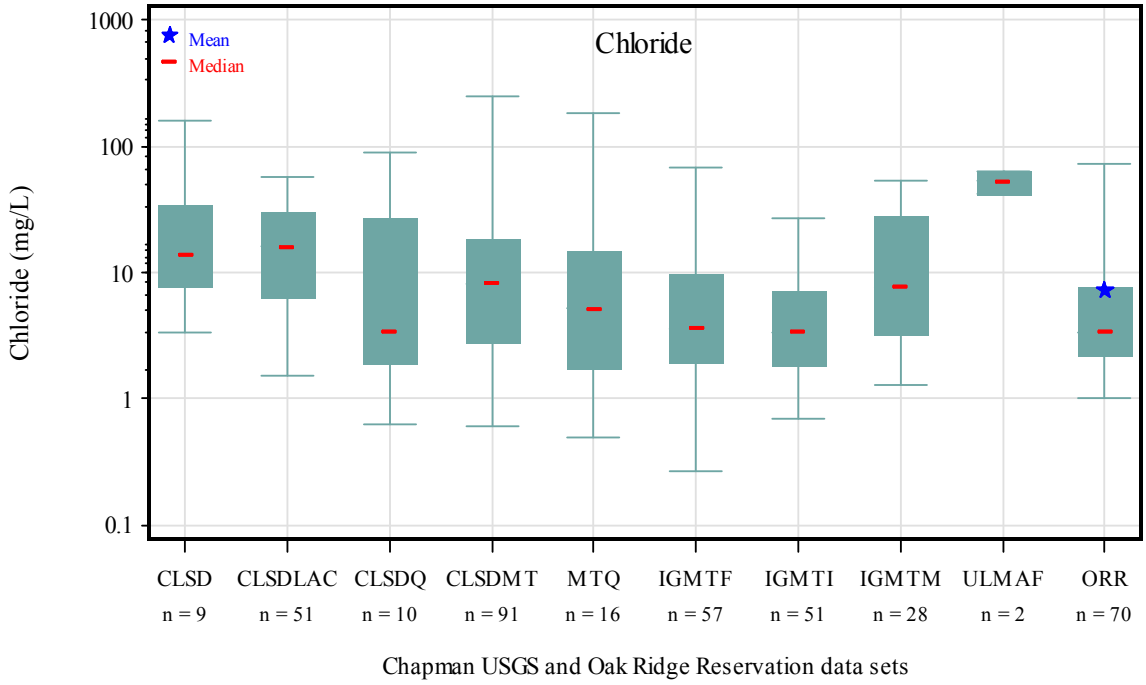


Detection limits were plotted for non-detects.

Figure C.40. Box plots of Chapman USGS data with ORR final background dataset for zinc and alkalinity as CaCO3.

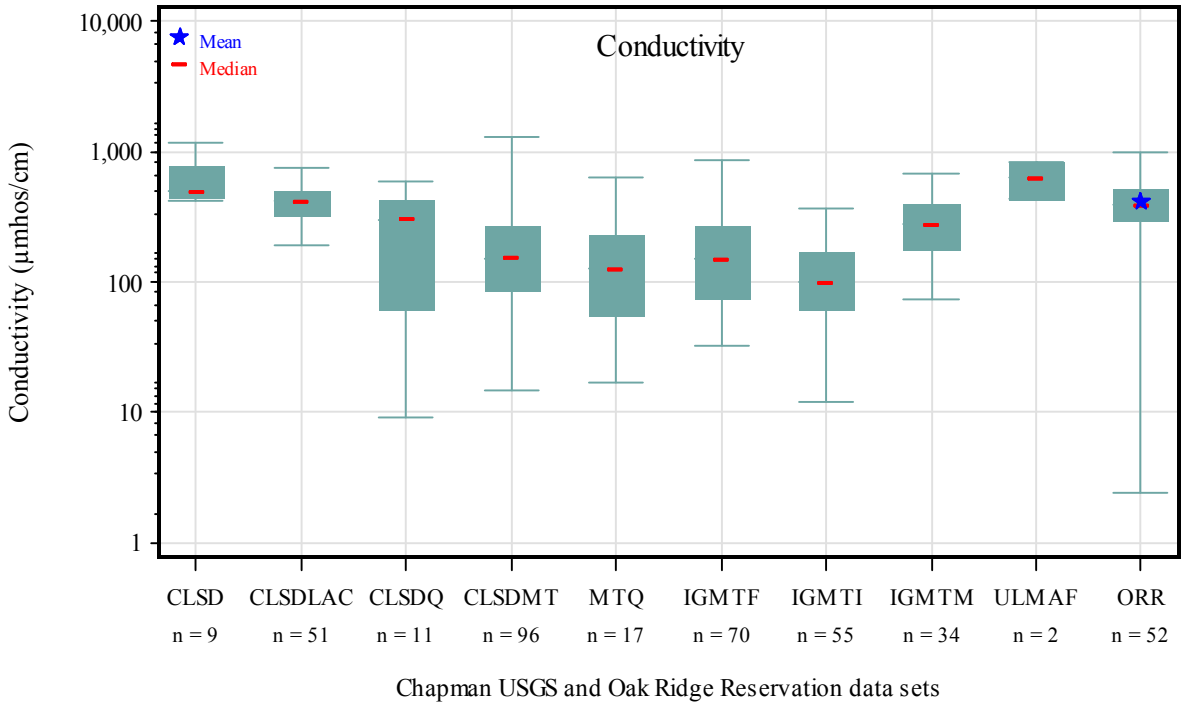


Detection limits were plotted for non-detects.

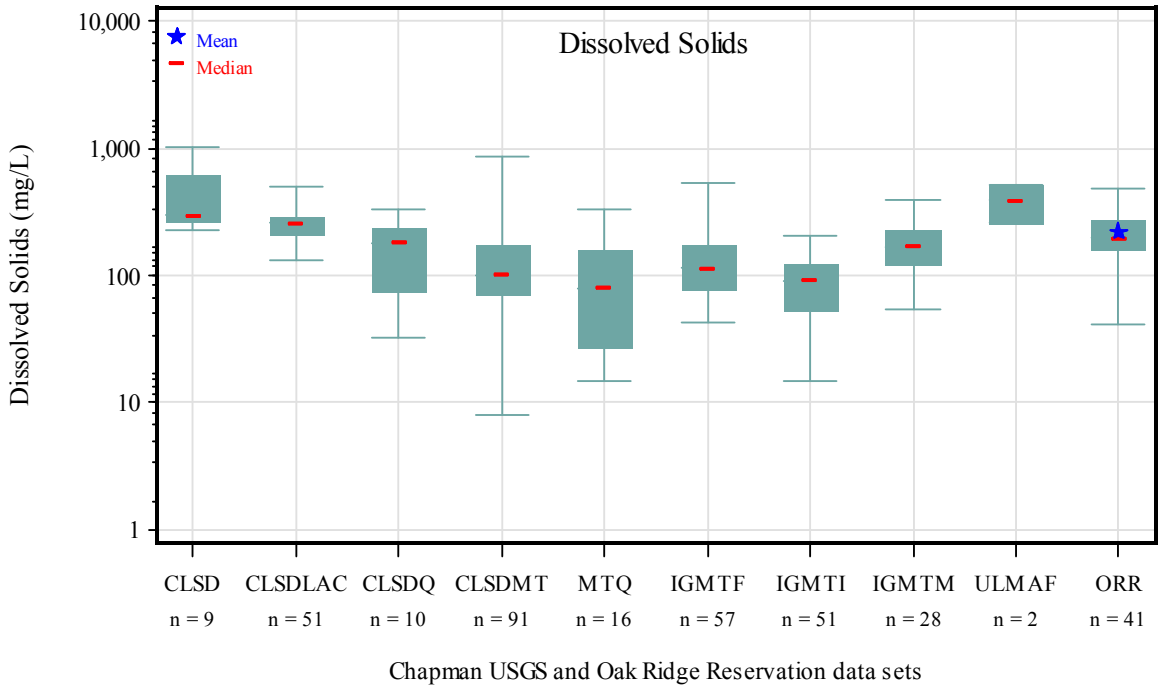


Detection limits were plotted for non-detects.

Figure C.41. Box plots of Chapman USGS data with ORR final background dataset for ammonia and chloride.

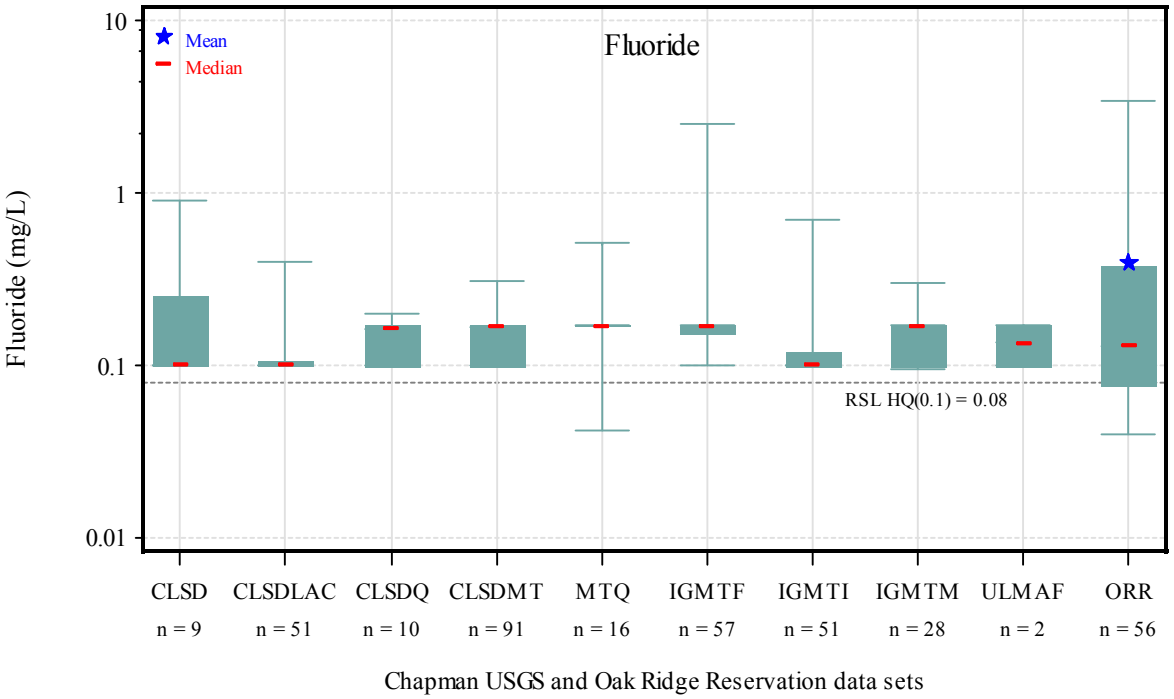


Detection limits were plotted for non-detects.

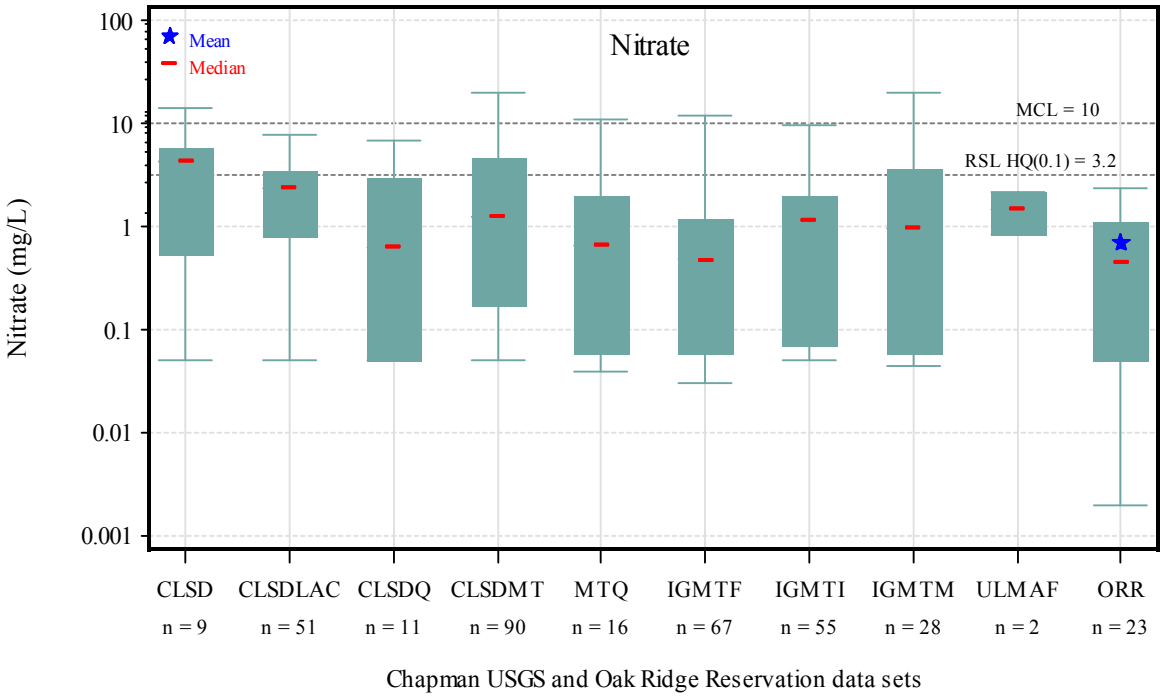


Detection limits were plotted for non-detects.

Figure C.42. Box plots of Chapman USGS data with ORR final background dataset for conductivity and dissolved solids

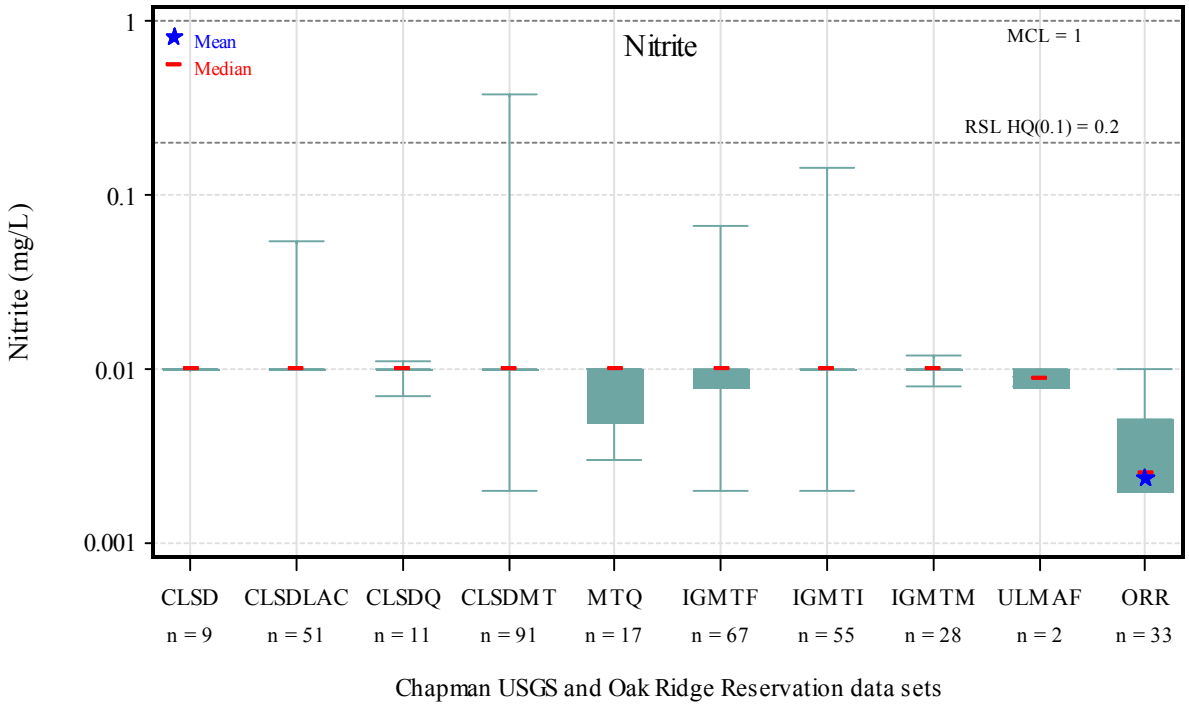


Detection limits were plotted for non-detects.

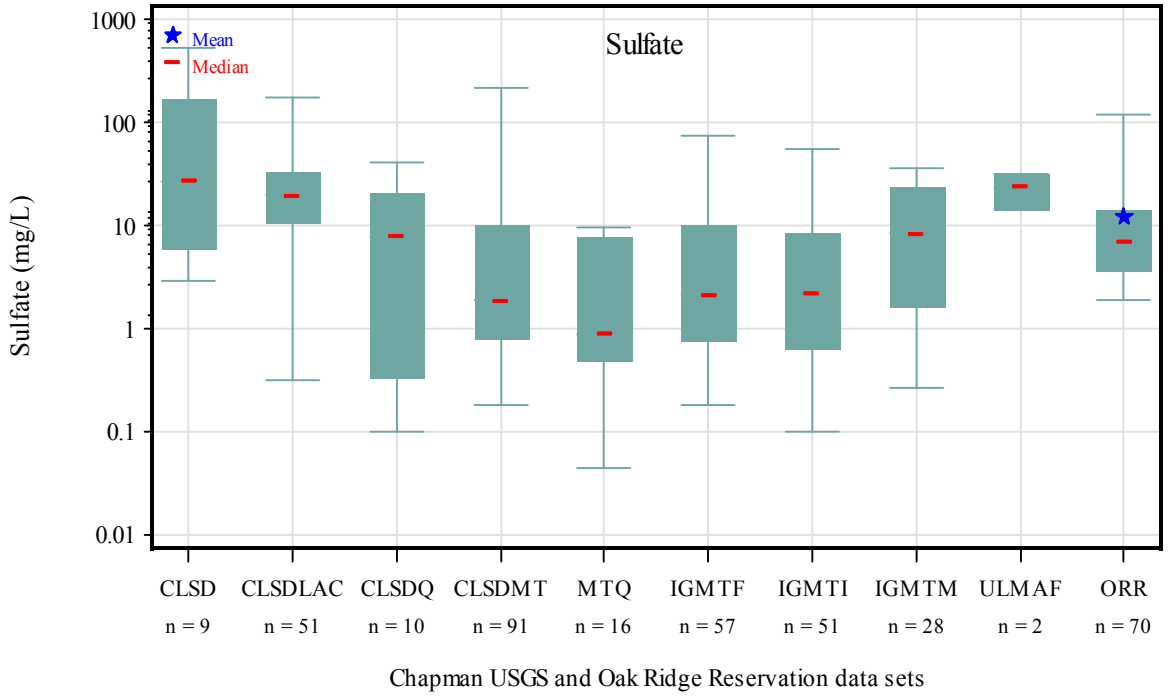


Detection limits were plotted for non-detects.

Figure C.43. Box plots of Chapman USGS data with ORR final background dataset for fluoride and nitrate.

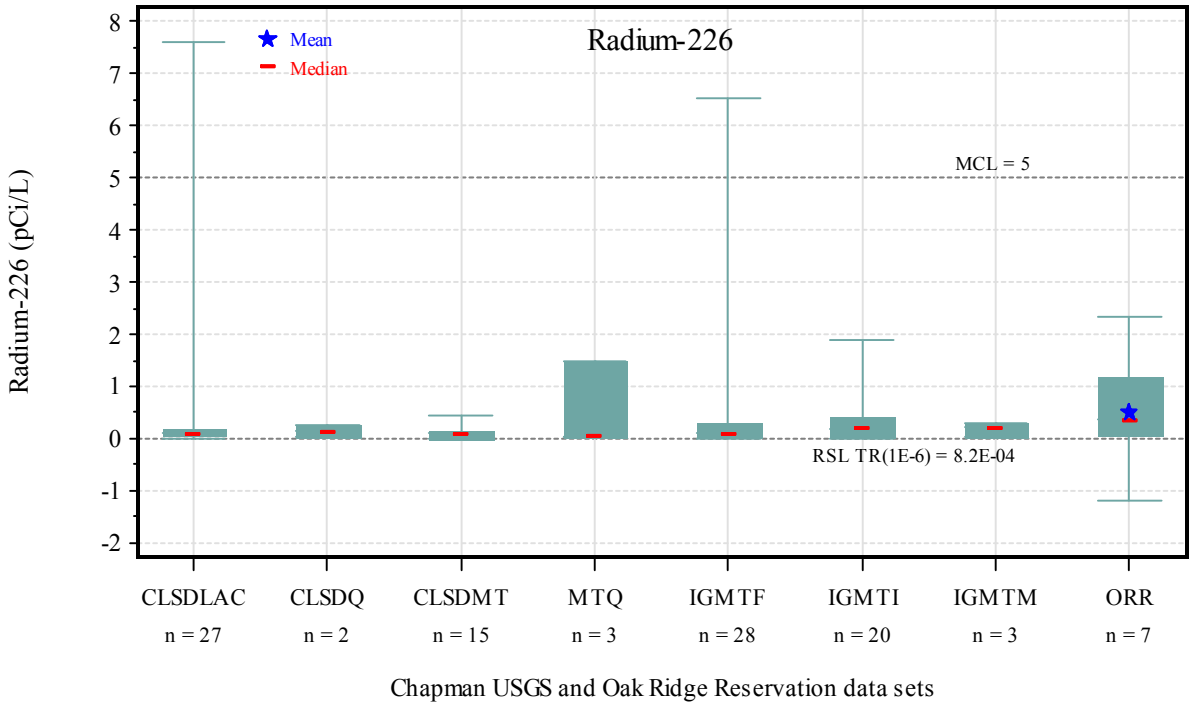


Detection limits were plotted for non-detects.

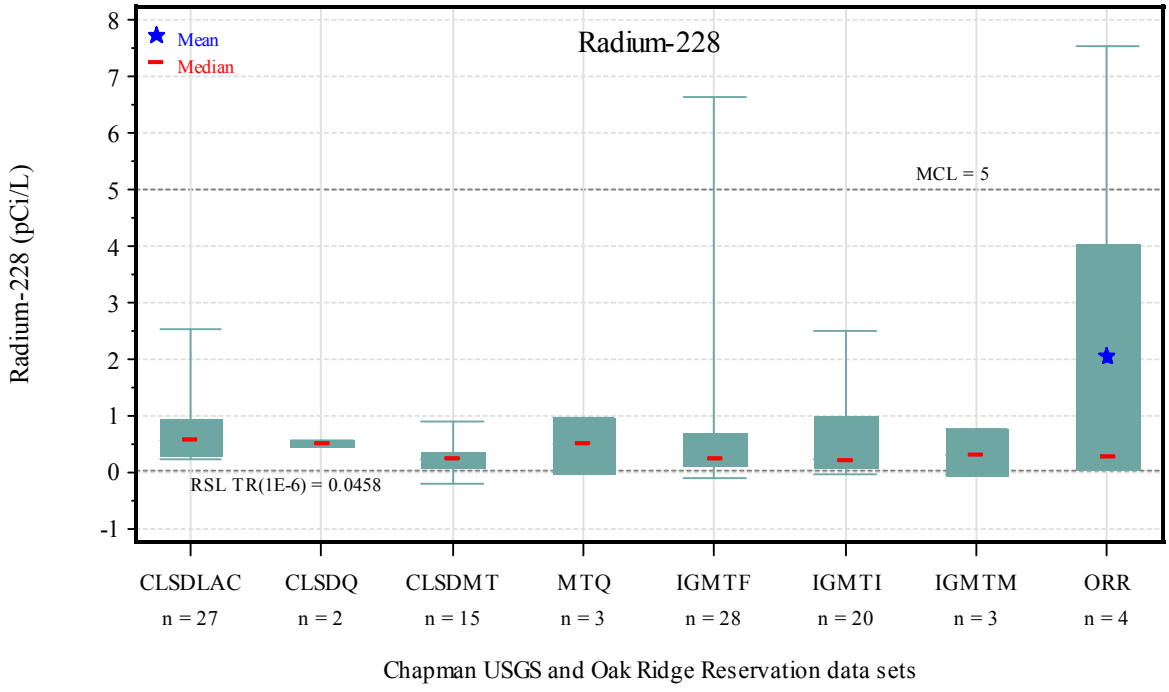


Detection limits were plotted for non-detects.

Figure C.44. Box plots of Chapman USGS data with ORR final background dataset for nitrite and sulfate.

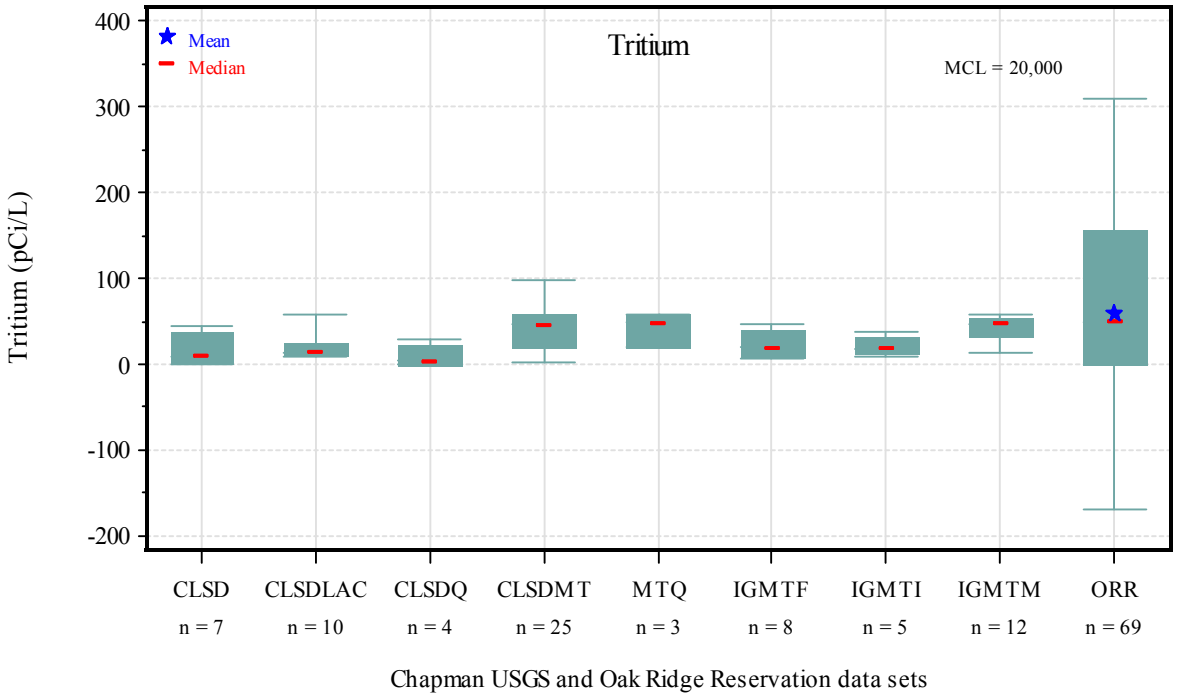


Detection limits were plotted for non-detects.

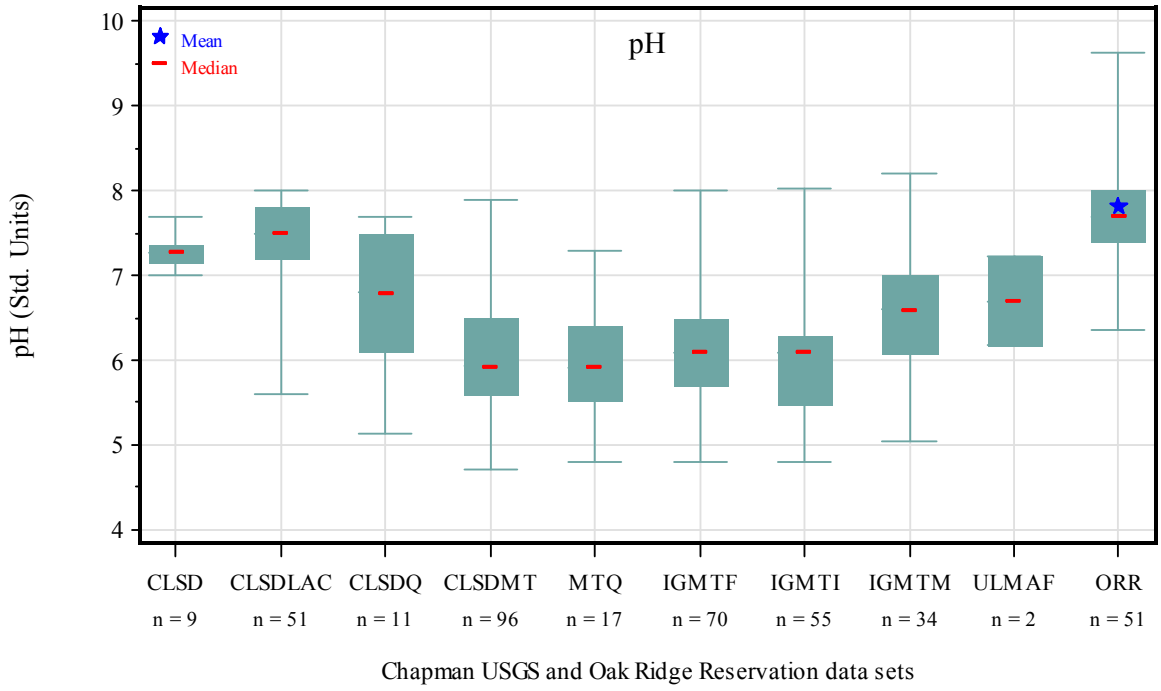


Detection limits were plotted for non-detects.

Figure C.45. Box plots of Chapman USGS data with ORR final background dataset for radium-226 and radium-228.



Detection limits were plotted for non-detects.



Detection limits were plotted for non-detects.

Figure C.46. Box plots of Chapman USGS data with ORR final background dataset for tritium and pH.

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APPENDIX D
ORIGINAL DATA FILES AND FINAL DATASET

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This appendix contains a compact disk with an electronic copy of the original data files and final dataset. Filenames are as follows:

Original data files:
OREIS original data set.xlsx
TDEC original data set.xlsx

Final dataset:
ORR GW background final data set.xlsx

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