ECF-HANFORD-22-0014
Revision 0

# Calculation of Background Threshold Values (BTVs) for the Solid Waste Landfill (SWL) for CYs 2018, 2019, 2020, and 2021

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract 89303320DEM000030

CPCCo
Central Plateau
Cleanup Company

**P.O. Box 1464**
**Richland, Washington 99352**

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# Calculation of Background Threshold Values (BTVs) for the Solid Waste Landfill (SWL) for CYs 2018, 2019, 2020, and 2021

Document Type: ECF Program/Project: Web-Based Reporting Technical Support

C. Brumbaugh
INTERA, Inc.

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**P.O. Box 1464**
**Richland, Washington 99352**

***APPROVED***
***By Julia Raymer at 2:54 pm, Jul 27, 2022***

Release Approval Date

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# ENVIRONMENTAL CALCULATION COVER PAGE

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## Qualifications Summary

**Preparer(s):**

Name: Corey Brumbaugh

Degree, Major, Institution, Year: MS, 2018, Biology, Central Washington University

Degree, Major, Institution, Year: BS, 2015, Biology, Central Washington University

Professional Licenses:

Brief Narrative of Experience: Corey Brumbaugh is an environmental toxicologist. Mr. Brumbaugh's work includes small mammal, amphibian and reptile research and surveys. He currently is a team member in our risk assessment group for INTERA focused on supporting the Hanford nuclear Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) site cleanup. His technical expertise includes predictive population modeling, assessing chemical- and site-specific toxicity, mobility, and bioavailability for the assessment of risk and in developing site-specific remediation levels.

**Checker(s):**

Name: Ryan Nell

Degree, Major, Institution, Year: PhD, Environmental Chemistry, University of Notre Dame, 2016

Degree, Major, Institution, Year: BA, Geology, University of Colorado, 2010

Professional Licenses: Professional Geologist

Brief Narrative of Experience: Ryan Nell brings applied and theoretical laboratory experience in geochemistry and environmental science, and research expertise in designing and executing experiments pertaining to heavy metal remediation using biotic systems. His experience includes collecting and analyzing data to evaluate metal fate and transformation in microbial ecosystems, developing standard operating procedures for fluorescent microscopy imaging of manganese oxidizing fungi, and preparing biological samples for x-ray adsorption spectroscopy analysis. He also led field data collection and analysis of dioritic rock samples for U-Th/He analysis. Ryan has presented the results of his work at conferences and authored several publications in peer-reviewed journals, including Geochimica et Cosmochimica Acta and Chemical Geology.

**Senior Reviewer(s):**

# ENVIRONMENTAL CALCULATION COVER PAGE (Continued)

Name: Donna Morgans

Degree, Major, Institution, Year: MS, Environmental Toxicology, Oregon State University, 2003

Degree, Major, Institution, Year: BS, Microbiology, Oregon State University, 1986

Professional Licenses:

Brief Narrative of Experience: Donna Morgans' professional experience has focused on assessing the potential for adverse human health effects associated with exposure to radiological and nonradiological contaminants in air, soil, water, and animal and plant tissues. In support of restoration efforts to address contamination in a variety of environmental media, she has managed and performed complex risk assessment and data compilation efforts to address a host of federal, state, and local regulations that include Comprehensive Environmental Response, Compensation, and Liability Act lifecycle decisions. Donna is also proficient in the application of aspects related to CERCLA including the development and review of work plans, remedial investigations, feasibility studies, and proposed plans. She has applied this knowledge to a variety of environmental projects and programs for private industry clients and federal government agencies. She has experience in developing risk assessment products and incorporating the appropriate federal and state regulatory requirements on projects throughout the US. Donna also has experience in the statistical evaluation of analytical data to determine population distributions using ProUCL and modeling the effects from exposure to radiological contaminants in soil using RESRAD.

## SECTION 2 - Completed by Preparer

Calculation Number: ECF-HANFORD-22-0014 | Revision Number: 0

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| Role | Print First and Last Name | Position | Signature | Date |
|---|---|---|---|---|
| Preparer(s): | Corey Brumbaugh | Ecological Risk Assesso | Corey Brumbaugh — Digitally signed by Corey Brumbaugh DN: C=US, OU=Ecological Risk Assessment, O=INTERA Incorporated, CN=Corey Brumbaugh, E=cbrumbaugh@intera.com Reason: I am the author of this document Location: West Richland, WA Date: 2022.06.20 08:11:53-07'00' Foxit PhantomPDF Version: 10.1.7 | |
| Checker(s): | Ryan Nell | Hydrogeologist | RYAN NELL (Affiliate) — Digitally signed by RYAN NELL (Affiliate) Date: 2022.06.20 09:20:34 -07'00' | |
| Senior Reviewer(s): | Donna Morgans | Principal Toxicologist | DONNA MORGANS (Affiliate) — Digitally signed by DONNA MORGANS (Affiliate) Date: 2022.06.20 11:14:42 -07'00' | |

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| Responsible Manager(s): | | | |
|---|---|---|---|
| Sean Sexton | | SEAN SEXTON (Affiliate) Digitally signed by SEAN SEXTON (Affiliate) Date: 2022.06.30 13:45:57 -07'00' | |
| *Print First and Last Name* | *Position* | *Signature* | *Date* |

**SECTION 5 - Applicable if Calculation is a Risk Assessment or Uses an Environmental Model**

**Prior to Initiating Modeling:**

Required training for modelers completed:
Integration Lead:

| | |
|---|---|
| Lynette Hale | Lynette Hale Digitally signed by Lynette Hale DN: cn=Lynette Hale, o=INTERA Inc., ou, email=LHALE@INTERA.com, c=US Date: 2022.06.20 12:41:29 -07'00' |
| *Print First and Last Name* | *Signature / Date* |

Safety Software Approved:
Integration Lead:

| | |
|---|---|
| Chris Farrow | CHRISTOPHER FARROW (Affiliate) Digitally signed by CHRISTOPHER FARROW (Affiliate) DN: C=US, O=U.S. Government, OU=Department of Energy, OID.0.9.2342.19200300.100.1.1=89001003727219 + CN=CHRISTOPHER FARROW (Affiliate) Reason: I have reviewed this document Location: your signing location here Date: 2022.06.20 16:28:02-05'00' Foxit PhantomPDF Version: 10.1.7 |
| *Print First and Last Name* | *Signature / Date* |

**Calculation Approved:**

Risk/Modeling Integration Manager:

| | |
|---|---|
| Will Nichols | WILLIAM NICHOLS (Affiliate) Digitally signed by WILLIAM NICHOLS (Affiliate) Reason: I am approving this document Date: 2022.06.20 14:55:02 -07'00' |
| *Print First and Last Name* | *Signature / Date* |

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# Terms

| | |
|---|---|
| BTV | background threshold value |
| CPCCo | Central Plateau Cleanup Company |
| CRAN | Comprehensive R Archive Network |
| ECF | environmental calculation file |
| HEIS | Hanford Environmental Information System |
| MDL | method detection limit |
| SWL | solid waste landfill |

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# 1 Purpose

This environmental calculation file (ECF) presents summary statistics and background threshold values (BTVs) for the Solid Waste Landfill (SWL) constituents for calendar year 2021.

# 2 Background

The SWL is a non-operating landfill located adjacent to the Nonradioactive Dangerous Waste Landfill (Figure 1).

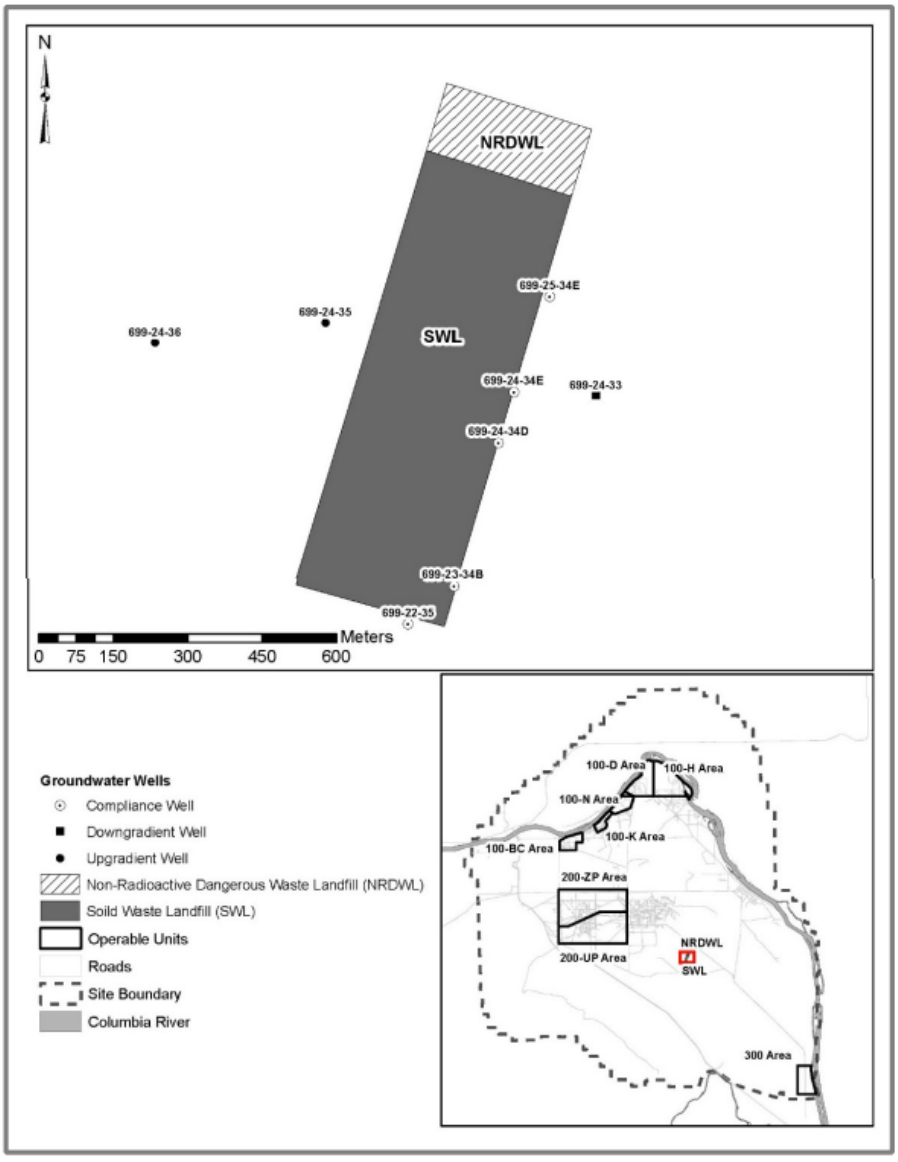


**Figure 1. Solid Waste Landfill and Groundwater Wells**

The SWL operated from 1973 to March 1996 and received nondangerous and nonradioactive solid waste, sewage, and garage wash water (DOE/EA-1707D, *Environmental Assessment: Closure of Nonradioactive Dangerous Waste Landfill (NRDWL) and Solid Waste Landfill (SWL), Hanford Site, Richland Washington*). Groundwater monitoring for SWL is regulated by the Washington State Department of

Ecology (WAC 173-350-500, "Solid Waste Handling Standards," "Groundwater Monitoring"). Monitoring is conducted under DOE/RL-2015-33, *Groundwater Monitoring Plan for Solid Waste Landfill*. The set of constituents being monitored and evaluated against BTVs are listed in WAC 173-350-500(4)(h)(i), (ii), and (iii) and presented in Table 1.

**Table 1. List of Constituents for Statistical Evaluation at Solid Waste Landfill**

| Requirement | Constituent | Type |
|---|---|---|
| WAC 173-350-500 (4)(h)(i), (ii), and (iii) field parameters, geochemical indicator parameters, and leachate indicators | pH | Field Parameter[a] |
| | Specific Conductance | |
| | Temperature | |
| | Alkalinity | Geochemical Indicator Parameters |
| | Bicarbonate | |
| | Total[b] and dissolved[c] Calcium | |
| | Chloride | |
| | Total[b] and dissolved[c] iron | |
| | Total[b] and dissolved[c] magnesium | |
| | Total[b] and dissolved[c] manganese | |
| | Nitrate | |
| | Dissolved[c,d] potassium | |
| | Dissolved[c,d] sodium | |
| | Sulfate | |
| | Ammonia | Leachate Indicators[e] |
| | Total organic carbon | |
| | Total dissolved solids | |
| WAC 173-350-500 (4)(i) site-specific constituents | Total[b] and dissolved[c] Arsenic | |

Reference: WAC 173-350-500, "Solid Waste Handling Standards," "Groundwater Monitoring."

a. Although included as a field parameter in WAC 173-350-500 (4)(h)(i). Water-level measurements will not be statistically evaluated.

b. Total analyte is represented in the Hanford Environmental Information System (HEIS) database under column FILTERED_FLAG with value of "N."

c. Dissolved analyte is denoted in the HEIS database under column FILTERED_FLAG with value of "Y."

d. WAC 173-350-500 (4)(h)(ii) does not identify total potassium or total sodium as indicator parameters but were included in the analysis.

e. Leachate indicators are added for sampling under this revised plan and will be statistically evaluated after the first 2 years of quarterly monitoring results (eight samples) are available to calculate background threshold values.

This document presents summary statistics and calculated BTVs for the constituents listed in Table 1 apart from static water level and the leachate indicators which have not yet completed the first 2 years of quarterly monitoring under DOE/RL-2015-33. The BTVs for each analyte were calculated based on the upgradient well 699-24-36 in the monitoring network. The statistics are based on groundwater concentrations available through the end of December 2021.

# 3 Methodology

This chapter discusses the data and methods used to perform summary statistics and to calculate BTVs presented in this ECF.

## 3.1 Data Acquisition and Processing

This section discusses the acquisition and processing of the groundwater data prior to calculation of the BTVs.

### 3.1.1 Chemistry Data

Groundwater chemistry data were downloaded from the Hanford Environmental Information System (HEIS) database which is maintained by the Central Plateau Cleanup Company (CPCCo) and exported into a Microsoft® Access® database (HEIS2_ADM_PNLGW_STD_RESULTS_MV_14FEB2022_COMBINED.accdb). The data were downloaded from HEIS on February 14, 2022. Table 2 presents the fields extracted from HEIS used in the calculation of summary statistics and BTVs .

**Table 2. HEIS Database Fields for Constituent Data**

| Field Extracted | Definition |
|---|---|
| WELL_NAME | Location identification |
| SAMP_DATE_TIME | Sampling date |
| STD_CON_LONG_NAME | Analyte name |
| STD_VALUE_RPTD | Reported Concentration |
| STD_ANAL_UNITS_RPTD | Units for concentration measurement |
| LAB_QUALIFIER | Laboratory data qualifier |
| REVIEW_QUALIFIER* | Review data qualifier |
| COLLECTION_PURPOSE | Primary reason for sample collection |
| VALIDATION_QUALIFIER | Validation qualifier |

*Additional information may be found in the RESULT_COMMENT field for this record (HNF-38155, *HEIS Sample, Result, and Sampling Site Data Dictionary*)

HEIS = Hanford Environmental Information System

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### 3.1.2 Identifying Nondetects

Nondetect data were identified by using the laboratory qualifier (LAB_QUALIFIER=U or any qualifier combination that contains U).

### 3.1.3 Time Period of Analysis

Consistent with previous years' BTV calculations under Revision 0 of the monitoring plan (DOE/RL-2015-33), BTVs were calculated using a 5-year data window. The time period of analysis for calendar year 2021 was January 1, 2017 to December 31, 2021.

### 3.1.4 Review Qualifiers

Chemistry data were removed from the dataset prior to calculation based on review qualifiers (Table 3).

**Table 3. Review Qualifiers for Data Removal**

| Review Qualifier | Definition |
|---|---|
| R | Do not use. Further review indicates the result is not valid. |
| Y | Result suspect. Review - insufficient evidence to show result valid or invalid. |

Table 4 presents the removed data based on review qualifiers.

**Table 4. Data Removed Based on Review Qualifiers**

| Well Name | Sample Date | Analyte | Reported Value (µg/L) | Qualifier | |
|---|---|---|---|---|---|
| | | | | Laboratory | Review |
| 699-24-36 | 7/12/2021 | Dissolved iron | 637 | -- | Y |

Laboratory qualifier:

-- = data not available or not applicable

Review qualifier:

Y = result suspect; review - insufficient evidence to show result valid or invalid

### 3.1.5 Daily Averaging

Daily averages were calculated for data with multiple measurements on the same day. When all measurements on the same day were nondetect data, the highest detection limit was used for the daily value. For daily duplicates where only one of the samples were nondetect data, the detected value was used for the daily value. Appendix A of this ECF presents the duplicate daily measurements and the calculated daily average.

Table 5 lists the wells for the SWL monitoring network from DOE/RL-2015-33. The BTVs for each analyte were calculated based on the upgradient well 699-24-36 in the monitoring network.

**Table 5. Network Monitoring Wells**

| Well Name | Location (with respect to SWL) |
|---|---|
| 699-24-36 | Upgradient |
| 699-25-34E | Downgradient |
| 699-24-34E | Downgradient |
| 699-24-34D | Downgradient |
| 699-23-34B | Downgradient |
| 699-22-35 | Downgradient |

SWL = Solid Waste Landfill

### 3.1.6 Summary Statistics

Summary statistics were calculated for each analyte. The mean, median, standard deviation, coefficient of variation, minimum, and maximum were determined using detected data only, nondetected data was not included. However, nondetect data were included in determination of percent nondetects and during the comparison to the analytes' method detection limit (MDL). Each summary statistic was calculated as shown in Eq. 1 through Eq. 9.

Percent nondetects: $$PNDs_c = \left(\frac{n_{c,0}}{n_c}\right) x\ 100\% \quad \textbf{(Eq. 1)}$$

Mean: $$m_c = \frac{1}{n_c}\sum_{i=1}^{n_c} x_i \quad \textbf{(Eq. 2)}$$

Median: $$med_c = x_c\left(\frac{n_c+1}{2}\right) \quad \textbf{(Eq. 3)}$$

Standard deviation: $$s_c = \sqrt{\frac{1}{n_c-1}\sum_{i=1}^{n_c}(x_i - m_c)^2} \quad \textbf{(Eq. 4)}$$

Coefficient of variation: $$CV_c = \frac{s_c}{m_c} \quad \textbf{(Eq. 5)}$$

Number of detects above MDL: $$n_{c,a} = \sum_{i=1}^{n_c}\begin{cases}1\ if\ x_i > MDL\\ 0\ if\ x_i < MDL\end{cases} \quad \textbf{(Eq. 6)}$$

Number of detects below MDL: $$n_{c,b} = \sum_{i=1}^{n_c} \begin{cases} 0 \; if \; x_i > MDL \\ 1 \; if \; x_i < MDL \end{cases}$$ (**Eq. 7**)

Minimum: $$min(x_c)$$ (**Eq. 8**)

Maximum: $$max(x_c)$$ (**Eq. 9**)

where:

$PNDs_c$ = percent nondetects for analyte *c*

$n_{c,0}$ = number of nondetects for analyte *c*

$n_c$ = number of measurements for analyte *c*

$m_c$ = mean for analyte *c*

$x_i$ = individual measurement

$med_c$ = median for analyte *c*

$x_c$ = ordered measurements for analyte *c*

$s_c$ = composite sample standard deviation for analyte *c*

$CV_c$ = coefficient of variation for analyte *c*

$MDL$ = method detection limit

$n_{c,a}$ = number of measurements above the MDL for analyte *c*

$n_{c,b}$ = number of measurements below the MDL for analyte *c*.

### 3.1.7 Upper Background Threshold Values

The statistical software package ProUCL version 5.1 calculated upper BTVs (i.e., the 95% upper tolerance limit with 95% coverage) in accordance with the groundwater monitoring plan. ProUCL works with datasets that include nondetect data as well as samples with concentrations less than the MDL. There are several methods available in ProUCL for calculating upper BTVs. The methods account for the underlying distribution of the data and the presence of nondetect data. For datasets with nondetect data that follow a normal, lognormal, or nonparametric distribution, ProUCL uses the Kaplan-Meier method, a nonparametric method for calculating summary statistics and upper BTVs. For datasets with nondetect data that follow a gamma distribution, ProUCL uses a regression on order statistics method for calculating summary statistics and upper BTVs. ProUCL highlights in blue the appropriate data distributions for each dataset in its output file; however, it is important to assess all the methods available and independently verify the most appropriate method through visual inspection of the data, evaluation of the number of available data points, and the data distribution. The upper BTVs were calculated for datasets with at least four detected values. Constituents with fewer than four detections in the background dataset will use the practical quantitation limit for the BTV (not represented in this ECF).

### 3.1.8 Lower Background Threshold Values

The ProUCL software provides upper BTVs and not lower BTVs (i.e., the 95% lower tolerance limit with 95% coverage). For pH measurement, the lower BTV is calculated using the statistical software program

R using the data packages data.table and EnvStats. The data distribution for each pH dataset was determined using ProUCL (based on the method used to determine the upper BTVs as discussed in Section 3.1.7 of this ECF) and lower BTVs were calculated using the EnvStats package based on the appropriate data distribution (Appendix B).

# 4 Assumptions and Inputs

This chapter outlines the assumptions and inputs for the BTV calculations presented in this ECF.

## 4.1 Assumptions

The following is a summary of assumptions:

- The MDL is independent of concentration
- It is assumed that seasonal fluctuations in the data are not present
- Concentrations observed at a well are not significantly affected by active remediation activities at the site for the period over which calculations are made
- All estimated data (LAB_QUALIFIER=B or J) were treated as detected values

# 5 Software Applications

Software used to generate the summary statistics and BTV calculations were in accordance with CPCCo's software control management plan, CPCC-PRO-IRM-309, *Controlled Software Management.*

## 5.1 Approved Software

The following software were used to perform calculations in addition to being approved and compliant with CPCC-PRO-IRM-309 and consistent with CHPRC-01270, *ProUCL Software Management Plan*. Following are brief descriptions of the software.

### 5.1.1 ProUCL (Controlled Calculation Software)

- **Software Title:** ProUCL (EPA/600/R-07/041, *ProUCL Version 5.1 Technical Guide: Statistical Software for Environmental Applications for Data Sets with and without Nondetect Observations*) uses statistical methods to estimate exposure point concentrations (EPCs), not-to-exceed values, and BTVs for datasets with detected and nondetected observations.
- **Software Version:** Version 5.1
- **Hanford Information System Inventory Identification Number**: 2831
- **Workstation type and property number (from which software is run)**: INTERA Inc. workstation 00905

### 5.1.2 Software Installation and Checkout

Verification that the software specified in Section 5.1.1 is qualified for use is documented in the Software Installation and Checkout Form. Appendix D of this ECF provides a copy of the form.

## 5.2 Support Software

R is a public domain computing platform that provides data manipulation, calculation, and graphical display capabilities to support data analysis (Venables et al., 2017, *An Introduction to R, Notes on R: A Programming Environment for Data Analysis and Graphics*). It is freely available to the public and can be compiled and run on a variety of platforms. The base installation of R contains statistical and plotting functions and many more are available for download through the Comprehensive R Archive Network (CRAN). The R routines described previously were independently checked and verified by detailed review as part of this preparation of this calculation file.

The following R packages, as listed in Table 6, were downloaded from CRAN and used for data preparation and lower BTV calculations.

**Table 6. R Packages Used for Data Preparation and Lower BTV Calculations**

| R Package | Package Description | Version |
|---|---|---|
| data.table | Extension of data.frame | 1.14.2 |
| EnvStats | Package for environmental statistics, including EPA guidance | 2.5.0 |
| reshape2 | Restructure and aggregate data | 1.4.4 |
| XLConnect | Excel® connector for R | 1.0.5 |

Note: Excel is a registered trademark of the Microsoft Corporation in the United States and other countries.
EPA = U.S. Environmental Protection Agency
BTV = background threshold value

# 6 Calculation

The following input files were used in the implementation of this analysis:

- *qryChemHeis1.txt*: concentration data from HEIS database
- *ProUCL_Datasets_2021.xlsx*: dataset for use in ProUCL 2021

Datasets were imported into ProUCL software and upper BTVs were calculated using all available methods accounting for the presence of nondetect data. The reported upper BTV was selected based on ProUCL results, including evaluation of the data distribution and sample size. Lower BTVs for pH were calculated using the R script 02_BTVs_pH.R. All R scripts (ImportData_ChemistryData, BTVs_pH, SummaryStatistics, and ExportDatasets) and R functions (bicarbonate, readCHEMHEIS) that were used in the calculation of upper and lower BTVs in addition to summary statistics. Appendix B of this ECF provides the R Code BTV calculations.

# 7 Results

Table 7 provides the BTVs for the analytes listed in Table 1 of this ECF. In addition to the BTVs and their associated data distributions, summary statistics such as n-value, mean, median, minimum, maximum, standard deviation, coefficient of variation, and percent nondect data are reported in Table 7. Appendix A of this ECF lists the duplicate data and their daily averages. Appendix B of this ECF presents the various R scripts and functions that were used to determine BTVs and summary statistics. Appendix C presents the final dataset (the culmination of the abovmentioned filtering steps) that were used to calculate BTVs and the output files from ProUCL.

**Table 7. Summary Statistics and Background Threshold Values - 2021**

| Analyte | Date Range | n | Nondetects (%) | Mean | Median | Std Dev | CV | n > MDL | n < MDL | Min | Max | BTV | Units | Distribution |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Alkalinity | 1/27/2017 - 10/13/2021 | 15 | 0 | 168,433 | 169,000 | 5,577 | 0.033 | 15 | 0 | 155,000 | 177,000 | 182,744 | µg/L | Normal |
| Dissolved Arsenic | 1/27/2017 - 10/13/2021 | 14 | 43 | 5.7 | 5.6 | 1.8 | 0.308 | 8 | 6 | 3.7 | 8.6 | 9.1 | µg/L | Normal |
| Total Arsenic | 1/27/2017 - 10/13/2021 | 14 | 43 | 5.9 | 4.6 | 2.4 | 0.413 | 8 | 6 | 3.7 | 9.9 | 11.9 | µg/L | Lognormal |
| Bicarbonate | 1/27/2017 - 10/13/2021 | 15 | 0 | 168,433 | 169,000 | 5,577 | 0.033 | 15 | 0 | 155,000 | 177,000 | 182,744 | µg/L | Normal |
| Dissolved Calcium | 1/27/2017 - 10/13/2021 | 15 | 0 | 50,153 | 50,000 | 1,850 | 0.037 | 15 | 0 | 47,000 | 52,800 | 54,901 | µg/L | Normal |
| Total Calcium | 1/27/2017 - 10/13/2021 | 15 | 0 | 50,687 | 50,200 | 2,362 | 0.047 | 15 | 0 | 46,700 | 55,500 | 56,748 | µg/L | Normal |
| Chloride | 1/27/2017 - 10/13/2021 | 15 | 0 | 5,682 | 5,640 | 187 | 0.033 | 15 | 0 | 5,340 | 6,100 | 6,161 | µg/L | Normal |
| Dissolved Iron | 1/27/2017 - 10/13/2021 | 14 | 93 | NA | NA | NA | NA | 1 | 13 | NA | NA | NA | µg/L | NA |
| Total Iron | 1/27/2017 - 10/13/2021 | 15 | 93 | NA | NA | NA | NA | 1 | 14 | NA | NA | NA | µg/L | NA |
| Dissolved Magnesium | 1/27/2017 - 10/13/2021 | 15 | 0 | 12,713 | 12,700 | 417 | 0.033 | 15 | 0 | 12,000 | 13,600 | 13,784 | µg/L | Normal |
| Total Magnesium | 1/27/2017 - 10/13/2021 | 15 | 0 | 12,743 | 12,750 | 651 | 0.051 | 15 | 0 | 12,000 | 14,300 | 14,414 | µg/L | Normal |
| Dissolved Manganese | 1/27/2017 - 10/13/2021 | 15 | 60 | 1.3 | 1.0 | 1.1 | 0.880 | 6 | 9 | 0.4 | 3.4 | 3.0 | µg/L | Normal |
| Total Manganese | 1/27/2017 - 10/13/2021 | 15 | 60 | 1.0 | 0.5 | 1.0 | 1.01 | 6 | 9 | 0.3 | 3.0 | 2.8 | µg/L | Gamma |
| Nitrate | 1/27/2017 - 10/13/2021 | 15 | 0 | 13,517 | 13,500 | 513 | 0.038 | 15 | 0 | 12,400 | 14,200 | 14,832 | µg/L | Normal |
| pH Measurement | 1/27/2017 - 10/13/2021 | 15 | 0 | 7.67 | 7.65 | 0.09 | 0.012 | 15 | 0 | 7.53 | 7.85 | 7.90 (U)<br>7.40 (L) | unitless | Normal |
| Dissolved Potassium | 1/27/2017 – 10/13/2021 | 15 | 0 | 6,787 | 6,700 | 483 | 0.071 | 15 | 0 | 6,110 | 7,800 | 8,026 | µg/L | Normal |
| Total Potassium | 1/27/2017 – 10/13/2021 | 15 | 0 | 6,765 | 6,630 | 498 | 0.074 | 15 | 0 | 6,030 | 7,900 | 8,044 | µg/L | Normal |
| Dissolved Sodium | 1/27/2017 – 10/13/2021 | 15 | 0 | 20,910 | 21,100 | 904 | 0.043 | 15 | 0 | 18,500 | 22,100 | 23,231 | µg/L | Normal |
| Total Sodium | 1/27/2017 – 10/13/2021 | 15 | 0 | 20,860 | 21,000 | 1,350 | 0.065 | 15 | 0 | 18,400 | 23,800 | 24,324 | µg/L | Normal |
| Specific Conductance | 1/27/2017 – 10/13/2021 | 15 | 0 | 425 | 438 | 51 | 0.119 | 15 | 0 | 245 | 450 | 450 | µS/cm | Nonparametric |
| Sulfate | 1/27/2017 – 10/13/2021 | 15 | 0 | 43,363 | 44,000 | 1,991 | 0.046 | 15 | 0 | 40,200 | 47,000 | 48,472 | µg/L | Normal |
| Temperature | 1/27/2017 – 10/13/2021 | 15 | 0 | 18.6 | 18.5 | 0.4 | 0.024 | 15 | 0 | 17.8 | 19.6 | 19.7 | Deg C | Normal |

NA = Constituent has fewer than four detections in the background dataset and the practical quantitation limit will be used for the BTV. Determination of the practical quantitation limit is not included in this calculation.
BTV = background threshold value
CV = coefficient of variation
L = lower BTV value (pH)
Max = maximum value
MDL = method detection limit
Min = minimum value
Std Dev = standard deviation
U = upper BTV value (pH)

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# 8 References

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# Appendix A

# Daily Averaging Results

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**Table A-1. Daily Averaged Samples**

| Well Name | Sample Date | Analyte | Reported Value and Laboratory Qualifier (µg/L) | Final Value (µg/L) |
|---|---|---|---|---|
| 699-24-36 | 9/22/2021 | Alkalinity | 179,000<br>170,000 X | 174,500 |
| 699-24-36 | 9/22/2021 | Bicarbonate | 179,000<br>170,000 X | 174,500 |
| 699-24-36 | 9/22/2021 | Chloride | 5,550<br>5,700 D | 5,625 |
| 699-24-36 | 9/22/2021 | Dissolved Calcium | 50,300<br>50,700 | 50,500 |
| 699-24-36 | 9/22/2021 | Dissolved Iron | 30 U<br>31 B | 31 B |
| 699-24-36 | 9/22/2021 | Dissolved Magnesium | 13,000<br>12,800 | 12,900 |
| 699-24-36 | 9/22/2021 | Dissolved Manganese | 1 U<br>0.31 U | 1 U |
| 699-24-36 | 9/22/2021 | Dissolved Potassium | 6,520<br>6,580 | 6,550 |
| 699-24-36 | 9/22/2021 | Dissolved Sodium | 20,400<br>20,700 | 20,550 |
| 699-24-36 | 9/22/2021 | Nitrate | 12,800<br>13,500 D | 13,150 |
| 699-24-36 | 9/22/2021 | Sulfate | 41,500 D<br>40,800 D | 41,150 D |
| 699-24-36 | 9/22/2021 | Total Calcium | 51,400<br>49,000 | 50,200 |
| 699-24-36 | 9/22/2021 | Total Iron | 22 U<br>30 U | 30 U |
| 699-24-36 | 9/22/2021 | Total Magnesium | 13,000<br>12,500 | 12,750 |
| 699-24-36 | 9/22/2021 | Total Manganese | 1 U<br>0.48 B | 0.5 B |

**Table A-1. Daily Averaged Samples**

| Well Name | Sample Date | Analyte | Reported Value and Laboratory Qualifier (µg/L) | Final Value (µg/L) |
|---|---|---|---|---|
| 699-24-36 | 9/22/2021 | Total Potassium | 6,680<br>6,350 | 6,515 |
| 699-24-36 | 9/22/2021 | Total Sodium | 20,900<br>19,900 | 20,400 |

Laboratory Qualifiers:

B = The analyte was detected at a value less than the contract required detection limit but greater than or equal to the instrument detection limit/method detection limit, as appropriate

D = Analyte was reported at a secondary dilution factor, typically >1 (i.e., the primary preparation required dilution either to bring the analyte to within the calibration range or minimize interference). Required for organics/wetchem if the sample was diluted

U = Analyzed for but not detected above limiting criteria

X = The result-specific translation of this qualifier code is provided in the hardcopy data report and/or case narrative. Additional result-specific translation information may also be found in the RESULT_COMMENT field for this record

# Appendix B

# R Code Background Threshold Value Calculations

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### B.1 ImportData_ChemistryData R script

```
#-------------------------------------------------------------------------------#
#--Import and Select Chemistry Data for Trend Analysis
#--by: C. Brumbaugh (INTERA)
#--Modified from: ECF-200PO1-21-0002, REV.0
#-------------------------------------------------------------------------------#
#-------------------------------------------------------------------------------#
#--Load Packages--#
library(data.table)
library(reshape2)
library(XLConnect)
#-------------------------------------------------------------------------------#
#-------------------------------------------------------------------------------#
#--Set Working Directory--#
DIR <- 'C:/Users/CBrumbaugh/OneDrive - INTERA Inc/Desktop/Projects/Critical Means and BTV Calcs/BTV/V3_3-3-2022'
setwd(DIR)
#-------------------------------------------------------------------------------#
#-------------------------------------------------------------------------------#
#--Load Project-Specific Functions--#
source('R Functions/readCHEMHEIS.R')
source('R Functions/bicarbonate.R')
#-------------------------------------------------------------------------------#
#-------------------------------------------------------------------------------#
#--Import Chemistry Dataset--#
CHEM <- readCHEMHEIS('Data/Data Pull 2-14-2022/qryChemHeis1.txt')
CHEM2 <- CHEM
CHEM <- CHEM2
#-------------------------------------------------------------------------------#
#-------------------------------------------------------------------------------#
#--List of Wells and Analytes for Analysis--#
WELLS <- c('699-24-36')
```

```
ANALYTES <- c('pH Measurement','Specific Conductance','Temperature',
              'Alkalinity','Bicarbonate','Calcium','Chloride','Iron',
              'Magnesium','Manganese','Nitrate','Potassium','Sodium','Sulfate',
              'Arsenic', 'Ammonia', 'Total organic carbon', 'Total dissolved solids')
#---------------------------------------------------------------------------#
#---------------------------------------------------------------------------#
#--Limit Wells and Analytes to those found in the project well list--#
CHEM <- CHEM[ANALYTE%in% ANALYTES]
CHEM <- CHEM[NAME%in% WELLS]
CHEM <- CHEM[year(EVENT) >= 2017]
#---------------------------------------------------------------------------#
#---------------------------------------------------------------------------#
#--Remove Qualified Data--#
FLAG <- CHEM[REVIEWQ%like% 'Y' | REVIEWQ%like% 'R' | REVIEWQ%like% 'F']
ROWS <- which(CHEM$REVIEWQ%like% 'Y' | CHEM$REVIEWQ%like% 'R' |
CHEM$REVIEWQ%like% 'F')
CHEM <- CHEM[-ROWS,]
write.table(FLAG,file='Output/Runs 3-29-2022/Data Removed by Review
Qualifier.csv',sep=',',row.names=FALSE)
#---------------------------------------------------------------------------#
#---------------------------------------------------------------------------#
#---Correct Bicarbonate Values---#
bicarb <- CHEM[ANALYTE == 'Alkalinity' & EVENT %like% '2017-10-12'|
                 ANALYTE == 'Alkalinity' & EVENT %like% '2018-01-08'|
                 ANALYTE == 'Alkalinity' & EVENT %like% '2018-07-19'|
                 ANALYTE == 'Alkalinity' & EVENT %like% '2018-10-16'|
                 ANALYTE == 'Alkalinity' & EVENT %like% '2021-09-22']
bicarb[bicarb=="Alkalinity"] <- "Bicarbonate"
bicarb[,"ANALYTE"] <- "Bicarbonate"
setkey(bicarb,'Analyte')
CHEM <- rbind(CHEM,bicarb)
CHEM <- CHEM[-323,]#--Calculate Bicarbonate--#
```

```
#--list <- split(CHEM,CHEM$NAME)

#--bicarb <- lapply(list,bicarbonate)

#--bicarb <- do.call('rbind',bicarb)

#-------------------------------------------------------------------------------#

#-------------------------------------------------------------------------------#

#--Combine Bicarbonate into Dataset--#

#--CHEM$NDS <- ifelse(CHEM$LABQ%like% 'U',TRUE,FALSE)

#--CHEM <-
subset(CHEM,select=c("NAME","EVENT","ANALYTE","FILTERED","VAL","LABQ","UNIT","MDL","NDS"))

#--setnames(bicarb,names(bicarb),names(CHEM))

#--CHEM <- rbind(CHEM,bicarb)

#-------------------------------------------------------------------------------#

#-------------------------------------------------------------------------------#

#--Set-up Table for Duplicate Tracking--#

duplicates <- NULL

#-------------------------------------------------------------------------------#

#-------------------------------------------------------------------------------#

#--Loop Through Each Well--#

for(i in 1:length(WELLS)){

  #-----------------------------------------------------------------------------#

  #--Loop Through Each Analyte--#

  for(j in 1:length(ANALYTES)){

    #---------------------------------------------------------------------------#

    #--Subset Data by Well and Analyte--#

    sub <- CHEM[NAME == WELLS[i] & ANALYTE == ANALYTES[j]]

    #---------------------------------------------------------------------------#

    #---------------------------------------------------------------------------#

    #--Find Duplicates--#

    if(ANALYTES[j]%in% c('Calcium','Iron','Magnesium','Manganese','Potassium','Sodium','Arsenic')){

      sub$match <- paste0(sub$EVENT,'-',sub$FILTERED)

    } else {
```

```
  sub$match <- paste0(sub$EVENT)
 }
 dups <- sub[duplicated(sub$match),]
 #-------------------------------------------------------------------------------#
 #-------------------------------------------------------------------------------#
 #--Duplicate Handling--#
 if(nrow(dups) > 0){
  #-------------------------------------------------------------------------------#
  #--Loop Through Duplicates--#
  for(k in 1:nrow(dups)){
   #-------------------------------------------------------------------------------#
   #--Extract Duplicates--#
   subdup <- subset(sub,sub$match == dups$match[k])
   #-------------------------------------------------------------------------------#
   #-------------------------------------------------------------------------------#
   #--Remove Duplicates from Chemistry Dataset--#
   rows <- which(CHEM$NAME == WELLS[i] & CHEM$FILTERED == dups$FILTERED[k] &
CHEM$ANALYTE == ANALYTES[j] & CHEM$EVENT == dups$EVENT[k])
   CHEM <- CHEM[!rows,]
   #-------------------------------------------------------------------------------#
   #-------------------------------------------------------------------------------#
   #--Calculate Mean if All Data are Detected--#
   if(sum(subdup$NDS) == 0){

    dup <- subdup[1,]
    dup$VAL <- mean(subdup$VAL)
    #-------------------------------------------------------------------------------#
    #-------------------------------------------------------------------------------#
    #--Use Maximum Detection Limit if All Data Are Non-Detect--#
   } else if(sum(subdup$NDS) == 2){

    dup <- subdup[1,]
```

```
  dup$VAL <- max(subdup$VAL)
  #-------------------------------------------------------------------------------#
  #-------------------------------------------------------------------------------#
  #--Use the Detected Value if One is Detected and One is Non-Detect--#
} else if(sum(subdup$NDS) == 1){

  dup <- subdup[1,]
  dup$VAL <- subdup[NDS == FALSE]$VAL
  dup$LABQ <- subdup[NDS==FALSE]$LABQ
  #-------------------------------------------------------------------------------#
  #-------------------------------------------------------------------------------#
  #--Report Error if Scenario not supported--#
} else {
  stop('Undefined Duplicated Handling')
}
#-------------------------------------------------------------------------------#
#-------------------------------------------------------------------------------#
#--Remove Match Field--#
dup$match <- NULL
subdup$match <- NULL
#-------------------------------------------------------------------------------#
#-------------------------------------------------------------------------------#
#--Combine Processed Duplicate with Original Dataset--#
CHEM <- rbind(CHEM,dup)
#-------------------------------------------------------------------------------#
#-------------------------------------------------------------------------------#
#--Add Calculated Value for Duplicates to List of Duplicate Samples--#
subdup$NewVAL <- dup$VAL
subdup$NewQUAL <- dup$LABQ
#-------------------------------------------------------------------------------#
#-------------------------------------------------------------------------------#
```

```
      #--Combine All Duplicates--#
      duplicates <- rbind(duplicates,subdup)
      #-----------------------------------------------------------------------------#
    }
    #-----------------------------------------------------------------------------#
  }
  #-----------------------------------------------------------------------------#
 }
#-----------------------------------------------------------------------------#
}
#-----------------------------------------------------------------------------#
#-----------------------------------------------------------------------------#
#--Set Analyte Names for Total and Dissolved--#
CHEM$ANALYTE2 <- ifelse(CHEM$ANALYTE%in%
c('Calcium','Iron','Magnesium','Manganese','Potassium','Sodium','Arsenic') & CHEM$FILTERED == 'N',
                        paste0('Total ',CHEM$ANALYTE),
                        ifelse(CHEM$ANALYTE%in%
c('Calcium','Iron','Magnesium','Manganese','Potassium','Sodium','Arsenic') & CHEM$FILTERED == 'Y',
                               paste0('Dissolved ',CHEM$ANALYTE),CHEM$ANALYTE))
#-----------------------------------------------------------------------------#
#-----------------------------------------------------------------------------#
#--Set-up ProUCL Dataset--#
Pro <- subset(CHEM,select=c('NAME','EVENT','ANALYTE2','VAL','UNIT','LABQ'))
Pro$D_VAL <- ifelse(Pro$LABQ%like% 'U',0,1)
#-----------------------------------------------------------------------------#
#-----------------------------------------------------------------------------#
#--Subset by Year--#
Pro_2021 <- Pro[year(EVENT) <= 2021]
Well_24_36 <- Pro_2021[NAME == '699-24-36']
ProUCL <- list(`2021` = Pro_2021, Well_24_36 = Well_24_36)
#-----------------------------------------------------------------------------#
#-----------------------------------------------------------------------------#
```

```
#--Export ProUCL Datasets--#

writeWorksheetToFile('ProUCL/Runs 3-29-
2022/ProUCL_Datasets_2021.xlsx',Pro_2021,sheet='ProUCL_Datasets_2021')

writeWorksheetToFile('ProUCL/Runs 3-29-
2022/ProUCL_Datasets_2022_24_36.xlsx',Well_24_36,sheet='Well_24_36')

#---------------------------------------------------------------------------#

#---------------------------------------------------------------------------#

#--Save Datasets--#

write.table(duplicates,file='Output/Runs 3-29-
2022/Duplicates_03292022.csv',sep=',',row.names=FALSE)

write.table(CHEM,file='Output/Runs 3-29-
2022/ChemistryData_030292022.csv',sep=',',row.names=FALSE)

save(CHEM,file='Data/Runs 3-29-2022/ChemistryData_03292022.RData')

save(ProUCL,file='Data/Runs 3-29-2022/ProUCLDatasests.RData')

#---------------------------------------------------------------------------#
```

### B.2 BTV_pH R script

```
#---------------------------------------------------------------------------#

#--Calculate BTVs for pH

#--by: C. Brumbaugh (INTERA)

#--Modified from: ECF-200PO1-21-0002, REV.0

#---------------------------------------------------------------------------#


#---------------------------------------------------------------------------#

#--Load Packages--#

library(data.table)

library(EnvStats)

#---------------------------------------------------------------------------#


#---------------------------------------------------------------------------#

#--Set Working Directory--#

DIR <- 'C:/Users/CBrumbaugh/OneDrive - INTERA Inc/Desktop/Projects/Critical Means and BTV
Calcs/BTV/V3_3-3-2022'
```

```
setwd(DIR)
#-------------------------------------------------------------------------------#

#-------------------------------------------------------------------------------#
#--Import Chemistry Dataset--#
load('Data/Runs 3-29-2022/ChemistryData_03212022.RData')
#-------------------------------------------------------------------------------#

#-------------------------------------------------------------------------------#
#--Extract Only pH Data--#
CHEM <- CHEM[ANALYTE == 'pH Measurement']
#-------------------------------------------------------------------------------#

#-------------------------------------------------------------------------------#
#--Years and Wells for Analysis--#
yrs <- c(2021)
wells <- sort(unique(CHEM$NAME))
#-------------------------------------------------------------------------------#

#-------------------------------------------------------------------------------#
#--BTV Summary Table--#
btvs <- NULL
#-------------------------------------------------------------------------------#

#-------------------------------------------------------------------------------#
#--Loop through Each Year--#
for(i in 1:length(yrs)){

  #-------------------------------------------------------------------------------#
  #--Loop through Each Well--#
```

```
for(j in 1:length(wells)){

 #-------------------------------------------------------------------------------#
 #--Determine Start and End Years for Dataset - Rolling 5 Year--#
 start <- yrs[i] - 4
 end <- yrs[i]
 #-------------------------------------------------------------------------------#

 #-------------------------------------------------------------------------------#
 #--Subset Data by Year--#
 sub <- CHEM[year(EVENT) >= start & year(EVENT) <= end & NAME == wells[j]]
 #-------------------------------------------------------------------------------#

 #-------------------------------------------------------------------------------#
 #--Determine Distribution--#
 dist <- suppressWarnings(distChooseCensored(sub$VAL,sub$NDS))$decision
 if(wells[j] == '699-24-36'){
  dist <- 'Normal'
 }
 #-------------------------------------------------------------------------------#

 #-------------------------------------------------------------------------------#
 #--Calculate BTVs Based on Distribution--#
 if(dist == 'Normal'){

  btv <- tolIntNorm(sub$VAL,coverage = 0.95,ti.type = “two-sided”)

 } else if(dist == 'Lognormal'){

  btv <- tolIntLnorm(sub$VAL,coverage = 0.95,ti.type = “two-sided”)
```

```
    } else if(dist == 'Gamma'){

      btv <- tolIntGamma(sub$VAL,coverage = 0.95, ti.type = 'two-
sided',conf.level=0.95,normal.approx.transform="cube.root")

    } else {

      btv <- tolIntNpar(sub$VAL,ti.type = 'two-sided',conf.level=0.95)

    }
    #-------------------------------------------------------------------------------#

    #-------------------------------------------------------------------------------#
    #--Summarize BTV--#
    btvsub <- data.table(Year = yrs[i],
                         WellName = wells[j],
                         LowerBTV = as.numeric(btv$interval$limits[1]),
                         UpperBTV = as.numeric(btv$interval$limits[2]),
                         Distribution = dist)
    btvs <- rbind(btvs,btvsub)
    #-------------------------------------------------------------------------------#

  }
  #-------------------------------------------------------------------------------#

}
#-------------------------------------------------------------------------------#

#-------------------------------------------------------------------------------#
#--Save Table--#
```

```
write.table(btvs,file='Output/Runs 3-29-2022/BTV_pH.csv',sep=',',row.names=FALSE)
#--------------------------------------------------------------------------------#
```

### B.3 Summary Statistics R Script

```
#--------------------------------------------------------------------------------#
#--Summary Statistics
#--by: C. Brumbaugh (INTERA)
#--Modified from: ECF-200PO1-21-0002, REV.0
#--------------------------------------------------------------------------------#

#--------------------------------------------------------------------------------#
#--Load Packages--#
library(data.table)
library(EnvStats)
#--------------------------------------------------------------------------------#

#--------------------------------------------------------------------------------#
#--Set Working Directory--#
DIR <- 'C:/Users/CBrumbaugh/OneDrive - INTERA Inc/Desktop/Projects/Critical Means and BTV Calcs/BTV/V3_3-3-2022'
setwd(DIR)
#--------------------------------------------------------------------------------#

#--------------------------------------------------------------------------------#
#--Import Datasets--#
load('Data/Runs 3-29-2022/ProUCLDatasests.RData')
#--------------------------------------------------------------------------------#

ProUCL <- subset(ProUCL,names(ProUCL)%in% c('Well_24_36'))

#--------------------------------------------------------------------------------#
#--Data Summary Table--#
```

```
summary <- NULL
#---------------------------------------------------------------------------#

#---------------------------------------------------------------------------#
#--Loop Through Each Dataset--#
for(i in 1:length(ProUCL)){

 #---------------------------------------------------------------------------#
 #--Extract Dataset--#
 sub <- ProUCL[[i]]
 nm <- names(ProUCL)[i]
 #---------------------------------------------------------------------------#

 #---------------------------------------------------------------------------#
 #--Extract Analytes--#
 an <- sort(unique(sub$ANALYTE2))
 #---------------------------------------------------------------------------#

 #---------------------------------------------------------------------------#
 #--Loop Through each Analyte--#
 for(j in 1:length(an)){

  #---------------------------------------------------------------------------#
  #--Subset by Analyte--#
  ansub <- sub[ANALYTE2 == an[j]]
  #---------------------------------------------------------------------------#

  #---------------------------------------------------------------------------#
  #--Calculate Summary Statistics--#
  if(all(ansub$D_VAL == 1)){
```

```
 dt <- data.table(Dataset=nm,
                  Analyte=an[j],
                  MinDate=min(ansub$EVENT),
                  MaxDate=max(ansub$EVENT),
                  PNDs=0,
                  Mean=mean(ansub$VAL),
                  Median=median(ansub$VAL),
                  Stdev=sd(ansub$VAL),
                  CV=sd(ansub$VAL)/mean(ansub$VAL),
                  N=nrow(ansub),
                  `N > MDL` = nrow(ansub),
                  `N < MDL` = 0,
                  MinValue=min(ansub$VAL),
                  MaxValue=max(ansub$VAL))

 summary <- rbind(summary,dt)


} else if(all(ansub$D_VAL == 0) | nrow(ansub[D_VAL == 1]) < 4){

 dt <- data.table(Dataset=nm,
                  Analyte=an[j],
                  MinDate=min(ansub$EVENT),
                  MaxDate=max(ansub$EVENT),
                  PNDs=nrow(ansub[D_VAL == 0])/nrow(ansub),
                  Mean=NA,
                  Median=NA,
                  Stdev=NA,
                  CV=NA,
                  N=nrow(ansub),
```

```
                `N > MDL` = nrow(ansub[D_VAL == 1]),
                `N < MDL` = nrow(ansub[D_VAL == 0]),
                MinValue=NA,
                MaxValue=NA)

summary <- rbind(summary,dt)

} else {

  stats <- subset(ansub, ansub$D_VAL == 1)

  dt <- data.table(Dataset=nm,
                Analyte=an[j],
                MinDate=min(ansub$EVENT),
                MaxDate=max(ansub$EVENT),
                PNDs=nrow(ansub[D_VAL == 0])/nrow(ansub),
                Mean=mean(stats$VAL),
                Median=median(stats$VAL),
                Stdev=sd(stats$VAL),
                CV=sd(stats$VAL)/mean(stats$VAL),
                N=nrow(ansub),
                `N > MDL` = nrow(ansub[D_VAL == 1]),
                `N < MDL` = nrow(ansub[D_VAL == 0]),
                MinValue=min(stats$VAL),
                MaxValue=max(stats$VAL))

  summary <- rbind(summary,dt)

}
#-------------------------------------------------------------------------------#
```

```
 }
 #-----------------------------------------------------------------------------#

}
#-----------------------------------------------------------------------------#

#-----------------------------------------------------------------------------#
#--Export Dataset--#
write.table(summary,file='ProUCL/Runs 3-29-2022/DataSummary.csv',sep=',',row.names=FALSE)
#-----------------------------------------------------------------------------#
```

### B.4 Export Dataset R Script

```
#-----------------------------------------------------------------------------#
#--Export Dataset
#--by: C. Brumbaugh (INTERA)
#--Modified from: ECF-200PO1-21-0002, REV.0
#-----------------------------------------------------------------------------#
#-----------------------------------------------------------------------------#
#--Load Packages--#
library(data.table)
library(EnvStats)
library(XLConnect)
#-----------------------------------------------------------------------------#
#-----------------------------------------------------------------------------#
#--Set Working Directory--#
DIR <- 'C:/Users/CBrumbaugh/OneDrive - INTERA Inc/Desktop/Projects/Critical Means and BTV Calcs/BTV/V3_3-3-2022'
setwd(DIR)
#-----------------------------------------------------------------------------#
#-----------------------------------------------------------------------------#
#--Import Chemistry Dataset--#
```

```
load('Data/Runs 3-29-2022/ChemistryData_03292022.RData')
#---------------------------------------------------------------------------#
#---------------------------------------------------------------------------#
#--Years of Analysis--#
yrs <- c(2021)
#---------------------------------------------------------------------------#
#---------------------------------------------------------------------------#
#--Loop through Each Year--#
for(i in 1:length(yrs)){
  #---------------------------------------------------------------------------#
  #--Determine Start and End Years for Dataset - Rolling 5 Year--#
  start <- yrs[i] - 4
  end <- yrs[i]
  #---------------------------------------------------------------------------#
  #---------------------------------------------------------------------------#
  #--Subset Data by Year--#
  sub <- CHEM[year(EVENT) >= start & year(EVENT) <= end]
  #---------------------------------------------------------------------------#
  #---------------------------------------------------------------------------#
  #--Export Entire Dataset--#
  sh <- yrs[i]
  writeWorksheetToFile('Output/Runs 3-29-2022/BTV Datasets.xlsx',sub,sheet=paste0(sh))
  #---------------------------------------------------------------------------#
}
#---------------------------------------------------------------------------#
```

### B.5 Bicarbonate R function

```
#============================================================================
=====
#' Calculate Bicarbonate Alkalinity from Total Alkalinity
#'
#' @param X data.table or data.frame of chemistry data
```

```
#' @param alk character vector representing alkalinity units
#' @param ALK character vector of Alkalinity (Total) Analyte Name
#' @param pH character vector of pH Name
#' @param NM character vector of Location Name field title
#' @param EVENT character vector of Date field title
#' @param ANALYTE character vector of Analyte Name field title
#' @param VAL character vector of Result field title
#'
#' @return data.table of calculated bicarbonate alkalinity
#'
#' @eXport
#' @import reshape2
#================================================================================
=====
bicarbonate <- function (X,
                         alk = 'CaCO3',
                         ALK = 'Alkalinity',
                         pH = 'pH Measurement',
                         NM = 'NAME',
                         EVENT = 'EVENT',
                         ANALYTE = 'ANALYTE',
                         VAL = 'VAL'){


  #--------------------------------------------------------------------------#
  #--Rename Columns--#
  setnames(X,NM,'NAME')
  setnames(X,EVENT,'EVENT')
  setnames(X,ANALYTE,'ANALYTE')
  setnames(X,VAL,'VAL')
  #--------------------------------------------------------------------------#
```

```
#-------------------------------------------------------------------------------#
#--Reshape Dataset to Crosstab--#
X <- melt(data=X,id.vars=
c(“NAME”,”EVENT”,”ANALYTE”),measure.vars=“VAL”,variable_name=“VAL”,na.rm=TRUE)
X <- dcast(X,formula = NAME + EVENT ~ ANALYTE, fun.aggregate=mean)
X <- subset(X,!is.na(X[[ALK]]))
#-------------------------------------------------------------------------------#

#-------------------------------------------------------------------------------#
#--Molecular weight of CaCO3--------#
MW_CaCO3 <- (40.08 + 12.01115 + (3*15.9994))*10^6
#--Molecular weight of HCO3--------#
#-------------------------------------------------------------------------------#
MW_HCO3 <- (1.00797 + 12.01115 + (3*15.9994))*10^6
#-------------------------------------------------------------------------------#
X$Alk2 <- X[[ALK]]/MW_CaCO3
X$HCO3 <- (((2*X$Alk2) - (10^(-14+X[[pH]])))/(1 + 2*(10^-10.33)*10^X[[pH]]))
X$CO3 <- ((10^-10.33)*(X$HCO3)*(10^X[[pH]]))
X$HCO3 <- X$HCO3 * MW_HCO3
X$CO3 <- X$CO3 * (MW_HCO3-1.00797)
#-------------------------------------------------------------------------------#

#-------------------------------------------------------------------------------#
#--Remove Measured Bicarbonate Results--#
X <- subset(X,is.na(X$Bicarbonate))
X <- subset(X,!is.na(X$`pH Measurement`))
#-------------------------------------------------------------------------------#

#-------------------------------------------------------------------------------#
#--Add Additional Columns to Dataset--#
X$ANALYTE <- 'Bicarbonate'
```

```
  X$QUAL <- ''
  X$UNITS <- 'ug/L as CaCO3'
  X$NDS <- FALSE
  X$FILTERED <- 'N'
  X$MDL <- NA
  #--------------------------------------------------------------------------#


  #--------------------------------------------------------------------------#
  #--Reorder and Rename Data fields--#
  X <- subset(X,select =
c('NAME','EVENT','ANALYTE','FILTERED','HCO3','QUAL','UNITS','MDL','NDS'))
  setnames(X,'HCO3','VAL')
  #--------------------------------------------------------------------------#


  return(X)
}
```

### B.6 ReadCHEMHEIS R function

```
#============================================================================
=====
#' Read in chemistry data from the HEIS database.
#'
#' @param FILE the file name to read (text file with | separator)
#' @param EFORM the format for the dates (EVENT)
#'
#' @return the chemistry data from HEIS database
#'
#' @export
#' @import data.table
#============================================================================
=====
readCHEMHEIS <- function(FILE, EFORM='%m/%d/%Y%H:%M:%S'){
```

```
#-------------------------------------------------------------------------------#
#--Define Column Classes and Read in Data--#
CLASS <- c('character','character','character','character','numeric',
        'character','character','character','character','numeric',
        'character','character','character','character','character','numeric')
CHEM <- fread(FILE, colClasses=CLASS, sep='|', header=TRUE, stringsAsFactors=FALSE)
#-------------------------------------------------------------------------------#

#-------------------------------------------------------------------------------#
#--Remove Discrete Depth Samples--#
#CHEM <- CHEM[DEPTH != 'm']
#-------------------------------------------------------------------------------#

#-------------------------------------------------------------------------------#
#--Remove Blank Data--#
CHEM <- CHEM[!is.na(VAL)]
#-------------------------------------------------------------------------------#

#-------------------------------------------------------------------------------#
#--Convert Dates--#
CHEM[, EVENT:=sub('EDT ', '', EVENT)]
CHEM[, EVENT:=sub('EST ', '', EVENT)]
CHEM[, LOAD_DATE_TIME:=sub('EDT ', '', LOAD_DATE_TIME)]
CHEM[, LOAD_DATE_TIME:=sub('EST ', '', LOAD_DATE_TIME)]
CHEM[,EVENT:= as.POSIXct(CHEM$EVENT, format=EFORM, tz="US/Pacific")]
CHEM[,LOAD_DATE_TIME:= as.POSIXct(CHEM$LOAD_DATE_TIME, format=EFORM,
tz="US/Pacific")]
#-------------------------------------------------------------------------------#

#-------------------------------------------------------------------------------#
```

```
  #--Set key--#
  setkey(CHEM, NULL)
  CHEM <- unique(CHEM)
  #-------------------------------------------------------------------------------#

  return(CHEM)
}
```

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# Appendix C

# Background Threshold Value Datasets and ProUCL Output

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**Table C-1. BTV Dataset for 2021**

| Well Name | Sample Date | Analyte | Result | Laboratory Qualifier | Unit |
|---|---|---|---|---|---|
| 699-24-36 | 1/27/2017 | Alkalinity | 170,000 | -- | µg/L |
| 699-24-36 | 4/10/2017 | Alkalinity | 172,000 | -- | µg/L |
| 699-24-36 | 8/7/2017 | Alkalinity | 177,000 | -- | µg/L |
| 699-24-36 | 10/12/2017 | Alkalinity | 163,000 | -- | µg/L |
| 699-24-36 | 1/8/2018 | Alkalinity | 155,000 | -- | µg/L |
| 699-24-36 | 4/26/2018 | Alkalinity | 170,000 | -- | µg/L |
| 699-24-36 | 7/19/2018 | Alkalinity | 168,000 | -- | µg/L |
| 699-24-36 | 10/16/2018 | Alkalinity | 163,000 | -- | µg/L |
| 699-24-36 | 4/4/2019 | Alkalinity | 168,000 | -- | µg/L |
| 699-24-36 | 10/4/2019 | Alkalinity | 165,000 | -- | µg/L |
| 699-24-36 | 9/30/2020 | Alkalinity | 169,000 | -- | µg/L |
| 699-24-36 | 1/5/2021 | Alkalinity | 166,000 | -- | µg/L |
| 699-24-36 | 7/12/2021 | Alkalinity | 175,000 | -- | µg/L |
| 699-24-36 | 9/22/2021 | Alkalinity[a] | 174,500 | -- | µg/L |
| 699-24-36 | 10/13/2021 | Alkalinity | 171,000 | -- | µg/L |
| 699-24-36 | 7/12/2021 | Ammonia | 88.6 | C | µg/L |
| 699-24-36 | 10/13/2021 | Ammonia | 20.7 | U | µg/L |
| 699-24-36 | 1/27/2017 | Bicarbonate | 170,000 | -- | µg/L |
| 699-24-36 | 4/10/2017 | Bicarbonate | 172,000 | -- | µg/L |
| 699-24-36 | 8/7/2017 | Bicarbonate | 177,000 | -- | µg/L |
| 699-24-36 | 10/12/2017 | Bicarbonate | 163,000 | -- | µg/L |
| 699-24-36 | 1/8/2018 | Bicarbonate | 155,000 | -- | µg/L |
| 699-24-36 | 4/26/2018 | Bicarbonate | 170,000 | -- | µg/L |
| 699-24-36 | 7/19/2018 | Bicarbonate | 168,000 | -- | µg/L |
| 699-24-36 | 10/16/2018 | Bicarbonate | 163,000 | -- | µg/L |
| 699-24-36 | 4/4/2019 | Bicarbonate | 168,000 | -- | µg/L |
| 699-24-36 | 10/4/2019 | Bicarbonate | 165,000 | -- | µg/L |
| 699-24-36 | 9/30/2020 | Bicarbonate | 169,000 | -- | µg/L |
| 699-24-36 | 1/5/2021 | Bicarbonate | 166,000 | -- | µg/L |
| 699-24-36 | 7/12/2021 | Bicarbonate | 175,000 | -- | µg/L |
| 699-24-36 | 9/22/2021 | Bicarbonate[a] | 174,500 | X | µg/L |

**Table C-1. BTV Dataset for 2021**

| Well Name | Sample Date | Analyte | Result | Laboratory Qualifier | Unit |
|---|---|---|---|---|---|
| 699-24-36 | 10/13/2021 | Bicarbonate | 171,000 | -- | µg/L |
| 699-24-36 | 1/27/2017 | Chloride | 5,500 | D | µg/L |
| 699-24-36 | 4/10/2017 | Chloride | 5,590 | -- | µg/L |
| 699-24-36 | 8/7/2017 | Chloride | 5,340 | -- | µg/L |
| 699-24-36 | 10/12/2017 | Chloride | 5,600 | D | µg/L |
| 699-24-36 | 1/8/2018 | Chloride | 5,700 | D | µg/L |
| 699-24-36 | 4/26/2018 | Chloride | 5,500 | D | µg/L |
| 699-24-36 | 7/19/2018 | Chloride | 5,900 | D | µg/L |
| 699-24-36 | 10/16/2018 | Chloride | 5,800 | D | µg/L |
| 699-24-36 | 4/4/2019 | Chloride | 5,870 | -- | µg/L |
| 699-24-36 | 10/4/2019 | Chloride | 6,100 | D | µg/L |
| 699-24-36 | 9/30/2020 | Chloride | 5,600 | D | µg/L |
| 699-24-36 | 1/5/2021 | Chloride | 5,730 | D | µg/L |
| 699-24-36 | 7/12/2021 | Chloride | 5,640 | D | µg/L |
| 699-24-36 | 9/22/2021 | Chloride[a] | 5,625 | -- | µg/L |
| 699-24-36 | 10/13/2021 | Chloride | 5,740 | D | µg/L |
| 699-24-36 | 1/27/2017 | Dissolved Arsenic | 5.0 | U | µg/L |
| 699-24-36 | 4/10/2017 | Dissolved Arsenic | 5.3 | B | µg/L |
| 699-24-36 | 8/7/2017 | Dissolved Arsenic | 5.0 | U | µg/L |
| 699-24-36 | 10/12/2017 | Dissolved Arsenic | 8.6 | B | µg/L |
| 699-24-36 | 1/8/2018 | Dissolved Arsenic | 4.4 | U | µg/L |
| 699-24-36 | 4/26/2018 | Dissolved Arsenic | 6.1 | B | µg/L |
| 699-24-36 | 7/19/2018 | Dissolved Arsenic | 4.0 | U | µg/L |
| 699-24-36 | 10/16/2018 | Dissolved Arsenic | 7.7 | B | µg/L |
| 699-24-36 | 4/4/2019 | Dissolved Arsenic | 4.4 | U | µg/L |
| 699-24-36 | 10/4/2019 | Dissolved Arsenic | 5.8 | B | µg/L |
| 699-24-36 | 9/30/2020 | Dissolved Arsenic | 14 | U | µg/L |
| 699-24-36 | 1/5/2021 | Dissolved Arsenic | 3.7 | -- | µg/L |
| 699-24-36 | 7/12/2021 | Dissolved Arsenic | 3.8 | B | µg/L |
| 699-24-36 | 10/13/2021 | Dissolved Arsenic | 4.6 | BD | µg/L |
| 699-24-36 | 1/27/2017 | Dissolved Calcium | 49,600 | -- | µg/L |

**Table C-1. BTV Dataset for 2021**

| Well Name | Sample Date | Analyte | Result | Laboratory Qualifier | Unit |
|---|---|---|---|---|---|
| 699-24-36 | 4/10/2017 | Dissolved Calcium | 47,000 | -- | µg/L |
| 699-24-36 | 8/7/2017 | Dissolved Calcium | 49,900 | -- | µg/L |
| 699-24-36 | 10/12/2017 | Dissolved Calcium | 47,800 | -- | µg/L |
| 699-24-36 | 1/8/2018 | Dissolved Calcium | 48,800 | -- | µg/L |
| 699-24-36 | 4/26/2018 | Dissolved Calcium | 52,300 | -- | µg/L |
| 699-24-36 | 7/19/2018 | Dissolved Calcium | 50,600 | -- | µg/L |
| 699-24-36 | 10/16/2018 | Dissolved Calcium | 52,300 | -- | µg/L |
| 699-24-36 | 4/4/2019 | Dissolved Calcium | 52,700 | -- | µg/L |
| 699-24-36 | 10/4/2019 | Dissolved Calcium | 47,500 | -- | µg/L |
| 699-24-36 | 9/30/2020 | Dissolved Calcium | 50,000 | -- | µg/L |
| 699-24-36 | 1/5/2021 | Dissolved Calcium | 50,000 | -- | µg/L |
| 699-24-36 | 7/12/2021 | Dissolved Calcium | 50,500 | -- | µg/L |
| 699-24-36 | 9/22/2021 | Dissolved Calcium[a] | 50,500 | -- | µg/L |
| 699-24-36 | 10/13/2021 | Dissolved Calcium | 52,800 | -- | µg/L |
| 699-24-36 | 1/27/2017 | Dissolved Iron | 30 | U | µg/L |
| 699-24-36 | 4/10/2017 | Dissolved Iron | 22 | U | µg/L |
| 699-24-36 | 8/7/2017 | Dissolved Iron | 30 | U | µg/L |
| 699-24-36 | 10/12/2017 | Dissolved Iron | 22 | U | µg/L |
| 699-24-36 | 1/8/2018 | Dissolved Iron | 22 | U | µg/L |
| 699-24-36 | 4/26/2018 | Dissolved Iron | 30 | U | µg/L |
| 699-24-36 | 7/19/2018 | Dissolved Iron | 30 | U | µg/L |
| 699-24-36 | 10/16/2018 | Dissolved Iron | 22 | U | µg/L |
| 699-24-36 | 4/4/2019 | Dissolved Iron | 22 | U | µg/L |
| 699-24-36 | 10/4/2019 | Dissolved Iron | 30 | U | µg/L |
| 699-24-36 | 9/30/2020 | Dissolved Iron | 44 | U | µg/L |
| 699-24-36 | 1/5/2021 | Dissolved Iron | 44 | U | µg/L |
| 699-24-36 | 9/22/2021 | Dissolved Iron[a] | 31 | B | µg/L |
| 699-24-36 | 10/13/2021 | Dissolved Iron | 53 | U | µg/L |
| 699-24-36 | 1/27/2017 | Dissolved Magnesium | 12,900 | -- | µg/L |
| 699-24-36 | 4/10/2017 | Dissolved Magnesium | 13,000 | -- | µg/L |
| 699-24-36 | 8/7/2017 | Dissolved Magnesium | 12,600 | -- | µg/L |

**Table C-1. BTV Dataset for 2021**

| Well Name | Sample Date | Analyte | Result | Laboratory Qualifier | Unit |
|---|---|---|---|---|---|
| 699-24-36 | 10/12/2017 | Dissolved Magnesium | 12,500 | -- | µg/L |
| 699-24-36 | 1/8/2018 | Dissolved Magnesium | 12,500 | -- | µg/L |
| 699-24-36 | 4/26/2018 | Dissolved Magnesium | 12,100 | -- | µg/L |
| 699-24-36 | 7/19/2018 | Dissolved Magnesium | 12,700 | -- | µg/L |
| 699-24-36 | 10/16/2018 | Dissolved Magnesium | 13,000 | -- | µg/L |
| 699-24-36 | 4/4/2019 | Dissolved Magnesium | 13,000 | -- | µg/L |
| 699-24-36 | 10/4/2019 | Dissolved Magnesium | 12,200 | -- | µg/L |
| 699-24-36 | 9/30/2020 | Dissolved Magnesium | 13,000 | -- | µg/L |
| 699-24-36 | 1/5/2021 | Dissolved Magnesium | 12,000 | -- | µg/L |
| 699-24-36 | 7/12/2021 | Dissolved Magnesium | 12,700 | -- | µg/L |
| 699-24-36 | 9/22/2021 | Dissolved Magnesium[a] | 12,900 | -- | µg/L |
| 699-24-36 | 10/13/2021 | Dissolved Magnesium | 13,600 | -- | µg/L |
| 699-24-36 | 1/27/2017 | Dissolved Manganese | 3.4 | B | µg/L |
| 699-24-36 | 4/10/2017 | Dissolved Manganese | 1.1 | B | µg/L |
| 699-24-36 | 8/7/2017 | Dissolved Manganese | 2.0 | U | µg/L |
| 699-24-36 | 10/12/2017 | Dissolved Manganese | 0.46 | B | µg/L |
| 699-24-36 | 1/8/2018 | Dissolved Manganese | 0.39 | BC | µg/L |
| 699-24-36 | 4/26/2018 | Dissolved Manganese | 4.0 | U | µg/L |
| 699-24-36 | 7/19/2018 | Dissolved Manganese | 4.0 | U | µg/L |
| 699-24-36 | 10/16/2018 | Dissolved Manganese | 0.83 | BC | µg/L |
| 699-24-36 | 4/4/2019 | Dissolved Manganese | 1.9 | U | µg/L |
| 699-24-36 | 10/4/2019 | Dissolved Manganese | 2.0 | U | µg/L |
| 699-24-36 | 9/30/2020 | Dissolved Manganese | 1.4 | B | µg/L |
| 699-24-36 | 1/5/2021 | Dissolved Manganese | 2.4 | U | µg/L |
| 699-24-36 | 7/12/2021 | Dissolved Manganese | 0.31 | U | µg/L |
| 699-24-36 | 9/22/2021 | Dissolved Manganese[a] | 1.0 | U | µg/L |
| 699-24-36 | 10/13/2021 | Dissolved Manganese | 1.5 | UD | µg/L |
| 699-24-36 | 1/27/2017 | Dissolved Potassium | 6,120 | -- | µg/L |
| 699-24-36 | 4/10/2017 | Dissolved Potassium | 7,340 | -- | µg/L |
| 699-24-36 | 8/7/2017 | Dissolved Potassium | 6,280 | -- | µg/L |
| 699-24-36 | 10/12/2017 | Dissolved Potassium | 6,980 | -- | µg/L |

**Table C-1. BTV Dataset for 2021**

| Well Name | Sample Date | Analyte | Result | Laboratory Qualifier | Unit |
|---|---|---|---|---|---|
| 699-24-36 | 1/8/2018 | Dissolved Potassium | 6,740 | -- | µg/L |
| 699-24-36 | 4/26/2018 | Dissolved Potassium | 6,490 | -- | µg/L |
| 699-24-36 | 7/19/2018 | Dissolved Potassium | 6,630 | -- | µg/L |
| 699-24-36 | 10/16/2018 | Dissolved Potassium | 6,700 | -- | µg/L |
| 699-24-36 | 4/4/2019 | Dissolved Potassium | 7,120 | -- | µg/L |
| 699-24-36 | 10/4/2019 | Dissolved Potassium | 6,110 | -- | µg/L |
| 699-24-36 | 9/30/2020 | Dissolved Potassium | 7,800 | -- | µg/L |
| 699-24-36 | 1/5/2021 | Dissolved Potassium | 7,400 | -- | µg/L |
| 699-24-36 | 7/12/2021 | Dissolved Potassium | 6,580 | -- | µg/L |
| 699-24-36 | 9/22/2021 | Dissolved Potassium[a] | 6,550 | -- | µg/L |
| 699-24-36 | 10/13/2021 | Dissolved Potassium | 6,960 | -- | µg/L |
| 699-24-36 | 1/27/2017 | Dissolved Sodium | 21,400 | -- | µg/L |
| 699-24-36 | 4/10/2017 | Dissolved Sodium | 21,600 | -- | µg/L |
| 699-24-36 | 8/7/2017 | Dissolved Sodium | 20,200 | -- | µg/L |
| 699-24-36 | 10/12/2017 | Dissolved Sodium | 21,200 | -- | µg/L |
| 699-24-36 | 1/8/2018 | Dissolved Sodium | 20,300 | -- | µg/L |
| 699-24-36 | 4/26/2018 | Dissolved Sodium | 20,000 | -- | µg/L |
| 699-24-36 | 7/19/2018 | Dissolved Sodium | 21,200 | -- | µg/L |
| 699-24-36 | 10/16/2018 | Dissolved Sodium | 21,900 | -- | µg/L |
| 699-24-36 | 4/4/2019 | Dissolved Sodium | 22,100 | -- | µg/L |
| 699-24-36 | 10/4/2019 | Dissolved Sodium | 18,500 | -- | µg/L |
| 699-24-36 | 9/30/2020 | Dissolved Sodium | 21,000 | -- | µg/L |
| 699-24-36 | 1/5/2021 | Dissolved Sodium | 21,000 | -- | µg/L |
| 699-24-36 | 7/12/2021 | Dissolved Sodium | 21,600 | -- | µg/L |
| 699-24-36 | 9/22/2021 | Dissolved Sodium[a] | 20,550 | -- | µg/L |
| 699-24-36 | 10/13/2021 | Dissolved Sodium | 21,100 | -- | µg/L |
| 699-24-36 | 1/27/2017 | Nitrate | 14,200 | D | µg/L |
| 699-24-36 | 4/10/2017 | Nitrate | 13,900 | D | µg/L |
| 699-24-36 | 8/7/2017 | Nitrate | 12,900 | -- | µg/L |
| 699-24-36 | 10/12/2017 | Nitrate | 13,700 | D | µg/L |
| 699-24-36 | 1/8/2018 | Nitrate | 14,200 | D | µg/L |

**Table C-1. BTV Dataset for 2021**

| Well Name | Sample Date | Analyte | Result | Laboratory Qualifier | Unit |
|---|---|---|---|---|---|
| 699-24-36 | 4/26/2018 | Nitrate | 13,300 | D | µg/L |
| 699-24-36 | 7/19/2018 | Nitrate | 14,200 | D | µg/L |
| 699-24-36 | 10/16/2018 | Nitrate | 13,700 | D | µg/L |
| 699-24-36 | 4/4/2019 | Nitrate | 13,100 | -- | µg/L |
| 699-24-36 | 10/4/2019 | Nitrate | 13,300 | ZD | µg/L |
| 699-24-36 | 9/30/2020 | Nitrate | 12,400 | DZN | µg/L |
| 699-24-36 | 1/5/2021 | Nitrate | 13,500 | D | µg/L |
| 699-24-36 | 7/12/2021 | Nitrate | 13,700 | D | µg/L |
| 699-24-36 | 9/22/2021 | Nitrate[a] | 13,150 | -- | µg/L |
| 699-24-36 | 10/13/2021 | Nitrate | 13,500 | D | µg/L |
| 699-24-36 | 1/27/2017 | pH Measurement | 7.57 | -- | unitless |
| 699-24-36 | 4/10/2017 | pH Measurement | 7.65 | -- | unitless |
| 699-24-36 | 8/7/2017 | pH Measurement | 7.60 | -- | unitless |
| 699-24-36 | 10/12/2017 | pH Measurement | 7.57 | -- | unitless |
| 699-24-36 | 1/8/2018 | pH Measurement | 7.76 | -- | unitless |
| 699-24-36 | 4/26/2018 | pH Measurement | 7.62 | -- | unitless |
| 699-24-36 | 7/19/2018 | pH Measurement | 7.53 | -- | unitless |
| 699-24-36 | 10/16/2018 | pH Measurement | 7.85 | -- | unitless |
| 699-24-36 | 4/4/2019 | pH Measurement | 7.67 | -- | unitless |
| 699-24-36 | 10/4/2019 | pH Measurement | 7.65 | -- | unitless |
| 699-24-36 | 9/30/2020 | pH Measurement | 7.67 | -- | unitless |
| 699-24-36 | 1/5/2021 | pH Measurement | 7.77 | -- | unitless |
| 699-24-36 | 7/12/2021 | pH Measurement | 7.76 | -- | unitless |
| 699-24-36 | 9/22/2021 | pH Measurement | 7.62 | -- | unitless |
| 699-24-36 | 10/13/2021 | pH Measurement | 7.75 | -- | unitless |
| 699-24-36 | 1/27/2017 | Specific Conductance | 441 | -- | µS/cm |
| 699-24-36 | 4/10/2017 | Specific Conductance | 450 | -- | µS/cm |
| 699-24-36 | 8/7/2017 | Specific Conductance | 444 | -- | µS/cm |
| 699-24-36 | 10/12/2017 | Specific Conductance | 443 | -- | µS/cm |
| 699-24-36 | 1/8/2018 | Specific Conductance | 450 | -- | µS/cm |
| 699-24-36 | 4/26/2018 | Specific Conductance | 245 | -- | µS/cm |

**Table C-1. BTV Dataset for 2021**

| Well Name | Sample Date | Analyte | Result | Laboratory Qualifier | Unit |
|---|---|---|---|---|---|
| 699-24-36 | 7/19/2018 | Specific Conductance | 441 | -- | µS/cm |
| 699-24-36 | 10/16/2018 | Specific Conductance | 435 | -- | µS/cm |
| 699-24-36 | 4/4/2019 | Specific Conductance | 431 | -- | µS/cm |
| 699-24-36 | 10/4/2019 | Specific Conductance | 422 | -- | µS/cm |
| 699-24-36 | 9/30/2020 | Specific Conductance | 437 | -- | µS/cm |
| 699-24-36 | 1/5/2021 | Specific Conductance | 438 | -- | µS/cm |
| 699-24-36 | 7/12/2021 | Specific Conductance | 447 | -- | µS/cm |
| 699-24-36 | 9/22/2021 | Specific Conductance | 427 | -- | µS/cm |
| 699-24-36 | 10/13/2021 | Specific Conductance | 425 | -- | µS/cm |
| 699-24-36 | 1/27/2017 | Sulfate | 44,000 | D | µg/L |
| 699-24-36 | 4/10/2017 | Sulfate | 42,900 | D | µg/L |
| 699-24-36 | 8/7/2017 | Sulfate | 41,600 | D | µg/L |
| 699-24-36 | 10/12/2017 | Sulfate | 44,000 | D | µg/L |
| 699-24-36 | 1/8/2018 | Sulfate | 47,000 | D | µg/L |
| 699-24-36 | 4/26/2018 | Sulfate | 42,000 | D | µg/L |
| 699-24-36 | 7/19/2018 | Sulfate | 46,000 | D | µg/L |
| 699-24-36 | 10/16/2018 | Sulfate | 45,000 | D | µg/L |
| 699-24-36 | 4/4/2019 | Sulfate | 44,200 | D | µg/L |
| 699-24-36 | 10/4/2019 | Sulfate | 42,000 | D | µg/L |
| 699-24-36 | 9/30/2020 | Sulfate | 41,000 | D | µg/L |
| 699-24-36 | 1/5/2021 | Sulfate | 44,600 | D | µg/L |
| 699-24-36 | 7/12/2021 | Sulfate | 44,800 | D | µg/L |
| 699-24-36 | 9/22/2021 | Sulfate[a] | 41,150 | D | µg/L |
| 699-24-36 | 10/13/2021 | Sulfate | 40,200 | D | µg/L |
| 699-24-36 | 1/27/2017 | Temperature | 18.3 | -- | Deg C |
| 699-24-36 | 4/10/2017 | Temperature | 18.6 | -- | Deg C |
| 699-24-36 | 8/7/2017 | Temperature | 19.2 | -- | Deg C |
| 699-24-36 | 10/12/2017 | Temperature | 18.4 | -- | Deg C |
| 699-24-36 | 1/8/2018 | Temperature | 18.2 | -- | Deg C |
| 699-24-36 | 4/26/2018 | Temperature | 18.7 | -- | Deg C |
| 699-24-36 | 7/19/2018 | Temperature | 18.4 | -- | Deg C |

**Table C-1. BTV Dataset for 2021**

| Well Name | Sample Date | Analyte | Result | Laboratory Qualifier | Unit |
|---|---|---|---|---|---|
| 699-24-36 | 10/16/2018 | Temperature | 18.2 | -- | Deg C |
| 699-24-36 | 4/4/2019 | Temperature | 18.5 | -- | Deg C |
| 699-24-36 | 10/4/2019 | Temperature | 18.7 | -- | Deg C |
| 699-24-36 | 9/30/2020 | Temperature | 19.1 | -- | Deg C |
| 699-24-36 | 1/5/2021 | Temperature | 17.8 | -- | Deg C |
| 699-24-36 | 7/12/2021 | Temperature | 19.6 | -- | Deg C |
| 699-24-36 | 9/22/2021 | Temperature | 18.5 | -- | Deg C |
| 699-24-36 | 10/13/2021 | Temperature | 18.4 | -- | Deg C |
| 699-24-36 | 1/27/2017 | Total Arsenic | 5.0 | U | µg/L |
| 699-24-36 | 4/10/2017 | Total Arsenic | 9.9 | BC | µg/L |
| 699-24-36 | 8/7/2017 | Total Arsenic | 5.0 | U | µg/L |
| 699-24-36 | 10/12/2017 | Total Arsenic | 4.4 | U | µg/L |
| 699-24-36 | 1/8/2018 | Total Arsenic | 8.1 | B | µg/L |
| 699-24-36 | 4/26/2018 | Total Arsenic | 4.6 | B | µg/L |
| 699-24-36 | 7/19/2018 | Total Arsenic | 4.2 | B | µg/L |
| 699-24-36 | 10/16/2018 | Total Arsenic | 8.3 | B | µg/L |
| 699-24-36 | 4/4/2019 | Total Arsenic | 4.4 | U | µg/L |
| 699-24-36 | 10/4/2019 | Total Arsenic | 5.0 | U | µg/L |
| 699-24-36 | 9/30/2020 | Total Arsenic | 14 | U | µg/L |
| 699-24-36 | 1/5/2021 | Total Arsenic | 3.9 | -- | µg/L |
| 699-24-36 | 7/12/2021 | Total Arsenic | 3.7 | B | µg/L |
| 699-24-36 | 10/13/2021 | Total Arsenic | 4.6 | BD | µg/L |
| 699-24-36 | 1/27/2017 | Total Calcium | 49,500 | -- | µg/L |
| 699-24-36 | 4/10/2017 | Total Calcium | 49,200 | -- | µg/L |
| 699-24-36 | 8/7/2017 | Total Calcium | 49,600 | -- | µg/L |
| 699-24-36 | 10/12/2017 | Total Calcium | 48,500 | -- | µg/L |
| 699-24-36 | 1/8/2018 | Total Calcium | 55,500 | -- | µg/L |
| 699-24-36 | 4/26/2018 | Total Calcium | 52,600 | -- | µg/L |
| 699-24-36 | 7/19/2018 | Total Calcium | 49,800 | -- | µg/L |
| 699-24-36 | 10/16/2018 | Total Calcium | 50,500 | -- | µg/L |
| 699-24-36 | 4/4/2019 | Total Calcium | 52,200 | -- | µg/L |

**Table C-1. BTV Dataset for 2021**

| Well Name | Sample Date | Analyte | Result | Laboratory Qualifier | Unit |
|---|---|---|---|---|---|
| 699-24-36 | 10/4/2019 | Total Calcium | 46,700 | -- | µg/L |
| 699-24-36 | 9/30/2020 | Total Calcium | 51,000 | -- | µg/L |
| 699-24-36 | 1/5/2021 | Total Calcium | 49,000 | -- | µg/L |
| 699-24-36 | 7/12/2021 | Total Calcium | 50,900 | -- | µg/L |
| 699-24-36 | 9/22/2021 | Total Calcium[a] | 50,200 | -- | µg/L |
| 699-24-36 | 10/13/2021 | Total Calcium | 55,100 | -- | µg/L |
| 699-24-36 | 7/12/2021 | Total dissolved solids | 303,000 | -- | µg/L |
| 699-24-36 | 10/13/2021 | Total dissolved solids | 271,000 | -- | µg/L |
| 699-24-36 | 1/27/2017 | Total Iron | 30 | U | µg/L |
| 699-24-36 | 4/10/2017 | Total Iron | 37 | B | µg/L |
| 699-24-36 | 8/7/2017 | Total Iron | 30 | U | µg/L |
| 699-24-36 | 10/12/2017 | Total Iron | 22 | U | µg/L |
| 699-24-36 | 1/8/2018 | Total Iron | 22 | U | µg/L |
| 699-24-36 | 4/26/2018 | Total Iron | 30 | U | µg/L |
| 699-24-36 | 7/19/2018 | Total Iron | 30 | U | µg/L |
| 699-24-36 | 10/16/2018 | Total Iron | 22 | U | µg/L |
| 699-24-36 | 4/4/2019 | Total Iron | 22 | U | µg/L |
| 699-24-36 | 10/4/2019 | Total Iron | 30 | U | µg/L |
| 699-24-36 | 9/30/2020 | Total Iron | 44 | U | µg/L |
| 699-24-36 | 1/5/2021 | Total Iron | 44 | U | µg/L |
| 699-24-36 | 7/12/2021 | Total Iron | 22 | U | µg/L |
| 699-24-36 | 9/22/2021 | Total Iron[a] | 30 | U | µg/L |
| 699-24-36 | 10/13/2021 | Total Iron | 53 | U | µg/L |
| 699-24-36 | 1/27/2017 | Total Magnesium | 12,900 | -- | µg/L |
| 699-24-36 | 4/10/2017 | Total Magnesium | 12,100 | -- | µg/L |
| 699-24-36 | 8/7/2017 | Total Magnesium | 12,800 | -- | µg/L |
| 699-24-36 | 10/12/2017 | Total Magnesium | 12,400 | -- | µg/L |
| 699-24-36 | 1/8/2018 | Total Magnesium | 14,300 | -- | µg/L |
| 699-24-36 | 4/26/2018 | Total Magnesium | 12,100 | -- | µg/L |
| 699-24-36 | 7/19/2018 | Total Magnesium | 12,700 | -- | µg/L |
| 699-24-36 | 10/16/2018 | Total Magnesium | 12,600 | -- | µg/L |

**Table C-1. BTV Dataset for 2021**

| Well Name | Sample Date | Analyte | Result | Laboratory Qualifier | Unit |
|---|---|---|---|---|---|
| 699-24-36 | 4/4/2019 | Total Magnesium | 12,800 | -- | µg/L |
| 699-24-36 | 10/4/2019 | Total Magnesium | 12,000 | -- | µg/L |
| 699-24-36 | 9/30/2020 | Total Magnesium | 13,000 | -- | µg/L |
| 699-24-36 | 1/5/2021 | Total Magnesium | 12,000 | -- | µg/L |
| 699-24-36 | 7/12/2021 | Total Magnesium | 12,800 | -- | µg/L |
| 699-24-36 | 9/22/2021 | Total Magnesium[a] | 12,750 | -- | µg/L |
| 699-24-36 | 10/13/2021 | Total Magnesium | 13,900 | -- | µg/L |
| 699-24-36 | 1/27/2017 | Total Manganese | 3.0 | B | µg/L |
| 699-24-36 | 4/10/2017 | Total Manganese | 1.4 | BC | µg/L |
| 699-24-36 | 8/7/2017 | Total Manganese | 2.0 | U | µg/L |
| 699-24-36 | 10/12/2017 | Total Manganese | 0.51 | B | µg/L |
| 699-24-36 | 1/8/2018 | Total Manganese | 0.26 | U | µg/L |
| 699-24-36 | 4/26/2018 | Total Manganese | 4.0 | U | µg/L |
| 699-24-36 | 7/19/2018 | Total Manganese | 4.0 | U | µg/L |
| 699-24-36 | 10/16/2018 | Total Manganese | 0.31 | BC | µg/L |
| 699-24-36 | 4/4/2019 | Total Manganese | 1.9 | U | µg/L |
| 699-24-36 | 10/4/2019 | Total Manganese | 2.0 | U | µg/L |
| 699-24-36 | 9/30/2020 | Total Manganese | 0.74 | U | µg/L |
| 699-24-36 | 1/5/2021 | Total Manganese | 2.4 | U | µg/L |
| 699-24-36 | 7/12/2021 | Total Manganese | 0.45 | B | µg/L |
| 699-24-36 | 9/22/2021 | Total Manganese[a] | 0.48 | B | µg/L |
| 699-24-36 | 10/13/2021 | Total Manganese | 1.5 | UD | µg/L |
| 699-24-36 | 7/12/2021 | Total organic carbon | 330 | U | µg/L |
| 699-24-36 | 10/13/2021 | Total organic carbon | 330 | U | µg/L |
| 699-24-36 | 1/27/2017 | Total Potassium | 6,090 | -- | µg/L |
| 699-24-36 | 4/10/2017 | Total Potassium | 7,170 | -- | µg/L |
| 699-24-36 | 8/7/2017 | Total Potassium | 6,410 | -- | µg/L |
| 699-24-36 | 10/12/2017 | Total Potassium | 6,880 | -- | µg/L |
| 699-24-36 | 1/8/2018 | Total Potassium | 7,000 | -- | µg/L |
| 699-24-36 | 4/26/2018 | Total Potassium | 6,470 | -- | µg/L |
| 699-24-36 | 7/19/2018 | Total Potassium | 6,510 | -- | µg/L |

**Table C-1. BTV Dataset for 2021**

| Well Name | Sample Date | Analyte | Result | Laboratory Qualifier | Unit |
|---|---|---|---|---|---|
| 699-24-36 | 10/16/2018 | Total Potassium | 6,470 | -- | µg/L |
| 699-24-36 | 4/4/2019 | Total Potassium | 7,010 | -- | µg/L |
| 699-24-36 | 10/4/2019 | Total Potassium | 6,030 | -- | µg/L |
| 699-24-36 | 9/30/2020 | Total Potassium | 7,900 | -- | µg/L |
| 699-24-36 | 1/5/2021 | Total Potassium | 7,400 | -- | µg/L |
| 699-24-36 | 7/12/2021 | Total Potassium | 6,630 | -- | µg/L |
| 699-24-36 | 9/22/2021 | Total Potassium[a] | 6,515 | -- | µg/L |
| 699-24-36 | 10/13/2021 | Total Potassium | 6,990 | -- | µg/L |
| 699-24-36 | 1/27/2017 | Total Sodium | 20,200 | -- | µg/L |
| 699-24-36 | 4/10/2017 | Total Sodium | 23,800 | -- | µg/L |
| 699-24-36 | 8/7/2017 | Total Sodium | 20,100 | -- | µg/L |
| 699-24-36 | 10/12/2017 | Total Sodium | 18,600 | -- | µg/L |
| 699-24-36 | 1/8/2018 | Total Sodium | 22,200 | -- | µg/L |
| 699-24-36 | 4/26/2018 | Total Sodium | 20,100 | -- | µg/L |
| 699-24-36 | 7/19/2018 | Total Sodium | 21,000 | -- | µg/L |
| 699-24-36 | 10/16/2018 | Total Sodium | 21,100 | -- | µg/L |
| 699-24-36 | 4/4/2019 | Total Sodium | 21,800 | -- | µg/L |
| 699-24-36 | 10/4/2019 | Total Sodium | 18,400 | -- | µg/L |
| 699-24-36 | 9/30/2020 | Total Sodium | 21,000 | -- | µg/L |
| 699-24-36 | 1/5/2021 | Total Sodium | 21,000 | -- | µg/L |
| 699-24-36 | 7/12/2021 | Total Sodium | 21,700 | -- | µg/L |
| 699-24-36 | 9/22/2021 | Total Sodium[a] | 20,400 | -- | µg/L |
| 699-24-36 | 10/13/2021 | Total Sodium | 21,500 | -- | µg/L |

a. Analyte result is based on the daily average since multiple sampling events occurred on the same day

BTV = background threshold value

## 2021 ProUCL Output

**Background Statistics for Data Sets with Non-Detects**

**User Selected Options**

| | |
|---|---|
| Date/Time of Computation | ProUCL 5.15/24/2022 4:20:44 PM |
| From File | ProUCL_Datasets_2021 5_24_22 updates bicarbonate.xls |
| Full Precision | OFF |
| Confidence Coefficient | 95% |
| Coverage | 95% |
| Different or Future K Observations | 1 |
| Number of Bootstrap Operations | 2000 |

**VAL (alkalinity)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 15 | Number of Distinct Observations | 12 |
| Minimum | 155000 | First Quartile | 165500 |
| Second Largest | 175000 | Median | 169000 |
| Maximum | 177000 | Third Quartile | 171500 |
| Mean | 168433 | SD | 5577 |
| Coefficient of Variation | 0.0331 | Skewness | -0.758 |
| Mean of logged Data | 12.03 | SD of logged Data | 0.0335 |

**Critical Values for Background Threshold Values (BTVs)**

| | | | |
|---|---|---|---|
| Tolerance Factor K (For UTL) | 2.566 | d2max (for USL) | 2.409 |

**Normal GOF Test**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.958 | **Shapiro Wilk GOF Test** |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.136 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.22 | Data appear Normal at 5% Significance Level |

**Data appear Normal at 5% Significance Level**

**Background Statistics Assuming Normal Distribution**

| | | | |
|---|---|---|---|
| 95% UTL with | 95% Coverage 182744 | 90% Percentile (z) | 175580 |
| | 95% UPL (t) 178578 | 95% Percentile (z) | 177607 |
| | 95% USL 181868 | 99% Percentile (z) | 181407 |

**Gamma GOF Test**

| | | |
|---|---|---|
| A-D Test Statistic | 0.258 | **Anderson-Darling Gamma GOF Test** |

| | | |
|---|---|---|
| 5% A-D Critical Value | 0.734 | Detected data appear Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.139 | **Kolmogorov-Smirnov Gamma GOF Test** |
| 5% K-S Critical Value | 0.221 | Detected data appear Gamma Distributed at 5% Significance Level |

Detected data appear Gamma Distributed at 5% Significance Level

**Gamma Statistics**

| | | | |
|---|---|---|---|
| k hat (MLE) | 961.8 | k star (bias corrected MLE) | 769.5 |
| Theta hat (MLE) | 175.1 | Theta star (bias corrected MLE) | 218.9 |
| nu hat (MLE) | 28853 | nu star (bias corrected) | 23084 |
| MLE Mean (bias corrected) | 168433 | MLE Sd (bias corrected) | 6072 |

**Background Statistics Assuming Gamma Distribution**

| | | | |
|---|---|---|---|
| 95% Wilson Hilferty (WH) Approx. Gamma UPL | 178808 | 90% Percentile | 176260 |
| 95% Hawkins Wixley (HW) Approx. Gamma UPL | 178838 | 95% Percentile | 178544 |
| 95% WH Approx. Gamma UTL with 95% Coverage | 183213 | 99% Percentile | 182880 |
| 95% HW Approx. Gamma UTL with 95% Coverage | 183275 | | |
| 95% WH USL | 182281 | 95% HW USL | 182336 |

**Lognormal GOF Test**

| | | | |
|---|---|---|---|
| Shapiro Wilk Test Statistic | 0.95 | **Shapiro Wilk Lognormal GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Lognormal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.142 | **Lilliefors Lognormal GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data appear Lognormal at 5% Significance Level | |

Data appear Lognormal at 5% Significance Level

**Background Statistics assuming Lognormal Distribution**

| | | | |
|---|---|---|---|
| 95% UTL with 95% Coverage | 183466 | 90% Percentile (z) | 175735 |
| 95% UPL (t) | 178930 | 95% Percentile (z) | 177888 |
| 95% USL | 182504 | 99% Percentile (z) | 181999 |

**Nonparametric Distribution Free Background Statistics**

Data appear Normal at 5% Significance Level

**Nonparametric Upper Limits for Background Threshold Values**

| | | | |
|---|---|---|---|
| Order of Statistic, r | 15 | 95% UTL with 95% Coverage | 177000 |
| Approx, f used to compute achieved CC | 0.789 | Approximate Actual Confidence Coefficient achieved by UTL | 0.537 |
| | | Approximate Sample Size needed to achieve specified CC | 59 |
| 95% Percentile Bootstrap UTL with 95% Coverage | 177000 | 95% BCA Bootstrap UTL with 95% Coverage | 177000 |
| 95% UPL | 177000 | 90% Percentile | 174800 |
| 90% Chebyshev UPL | 185713 | 95% Percentile | 175600 |

| | | | |
|---|---|---|---|
| 95% Chebyshev UPL | 193540 | 99% Percentile | 176720 |
| 95% USL | 177000 | | |

Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20. Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers and consists of observations collected from clean unimpacted locations.
The use of USL tends to provide a balance between false positives and false negatives provided the data represents a background data set and when many onsite observations need to be compared with the BTV.

**VAL (ammonia)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 2 | Number of Missing Observations | 0 |
| Number of Distinct Observations | 2 | | |
| Number of Detects | 1 | Number of Non-Detects | 1 |
| Number of Distinct Detects | 1 | Number of Distinct Non-Detects | 1 |
| Minimum Detect | 88.6 | Minimum Non-Detect | 20.7 |
| Maximum Detect | 88.6 | Maximum Non-Detect | 20.7 |
| Variance Detected | N/A | Percent Non-Detects | 50% |
| Mean Detected | 88.6 | SD Detected | N/A |
| Mean of Detected Logged Data | 4.484 | SD of Detected Logged Data | N/A |

**Warning: This data set only has 2 observations!**
**Data set is too small to compute reliable and meaningful statistics and estimates!**
**The data set for variable VAL (ammonia) was not processed!**

**It is suggested to collect at least 8 to 10 observations before using these statistical methods!**
**If possible, compute and collect Data Quality Objectives (DQO) based sample size and analytical results.**

**VAL (bicarbonate)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 15 | Number of Distinct Observations | 12 |
| Minimum | 155000 | First Quartile | 165500 |
| Second Largest | 175000 | Median | 169000 |
| Maximum | 177000 | Third Quartile | 171500 |
| Mean | 168433 | SD | 5577 |
| Coefficient of Variation | 0.0331 | Skewness | -0.758 |
| Mean of logged Data | 12.03 | SD of logged Data | 0.0335 |

**Critical Values for Background Threshold Values (BTVs)**

| | | | |
|---|---|---|---|
| Tolerance Factor K (For UTL) | 2.566 | d2max (for USL) | 2.409 |

**Normal GOF Test**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.958 | **Shapiro Wilk GOF Test** |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.136 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.22 | Data appear Normal at 5% Significance Level |

Data appear Normal at 5% Significance Level

**Background Statistics Assuming Normal Distribution**

| | | | |
|---|---|---|---|
| 95% UTL with 95% Coverage | 182744 | 90% Percentile (z) | 175580 |
| 95% UPL (t) | 178578 | 95% Percentile (z) | 177607 |
| 95% USL | 181868 | 99% Percentile (z) | 181407 |

**Gamma GOF Test**

| | | |
|---|---|---|
| A-D Test Statistic | 0.258 | **Anderson-Darling Gamma GOF Test** |
| 5% A-D Critical Value | 0.734 | Detected data appear Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.139 | **Kolmogorov-Smirnov Gamma GOF Test** |
| 5% K-S Critical Value | 0.221 | Detected data appear Gamma Distributed at 5% Significance Level |

Detected data appear Gamma Distributed at 5% Significance Level

**Gamma Statistics**

| | | | |
|---|---|---|---|
| k hat (MLE) | 961.8 | k star (bias corrected MLE) | 769.5 |
| Theta hat (MLE) | 175.1 | Theta star (bias corrected MLE) | 218.9 |
| nu hat (MLE) | 28853 | nu star (bias corrected) | 23084 |
| MLE Mean (bias corrected) | 168433 | MLE Sd (bias corrected) | 6072 |

**Background Statistics Assuming Gamma Distribution**

| | | | |
|---|---|---|---|
| 95% Wilson Hilferty (WH) Approx. Gamma UPL | 178808 | 90% Percentile | 176260 |
| 95% Hawkins Wixley (HW) Approx. Gamma UPL | 178838 | 95% Percentile | 178544 |
| 95% WH Approx. Gamma UTL with 95% Coverage | 183213 | 99% Percentile | 182880 |
| 95% HW Approx. Gamma UTL with 95% Coverage | 183275 | | |
| 95% WH USL | 182281 | 95% HW USL | 182336 |

**Lognormal GOF Test**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.95 | **Shapiro Wilk Lognormal GOF Test** |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Lognormal at 5% Significance Level |
| Lilliefors Test Statistic | 0.142 | **Lilliefors Lognormal GOF Test** |

| | | |
|---|---|---|
| 5% Lilliefors Critical Value | 0.22 | Data appear Lognormal at 5% Significance Level |

Data appear Lognormal at 5% Significance Level

**Background Statistics assuming Lognormal Distribution**

| | | | |
|---|---|---|---|
| 95% UTL with | 95% Coverage | 183466 | 90% Percentile (z) 175735 |
| | 95% UPL (t) | 178930 | 95% Percentile (z) 177888 |
| | 95% USL | 182504 | 99% Percentile (z) 181999 |

**Nonparametric Distribution Free Background Statistics**

Data appear Normal at 5% Significance Level

**Nonparametric Upper Limits for Background Threshold Values**

| | | | |
|---|---|---|---|
| Order of Statistic, r | 15 | 95% UTL with | 95% Coverage 177000 |
| Approx, f used to compute achieved CC | 0.789 | Approximate Actual Confidence Coefficient achieved by UTL | 0.537 |
| | | Approximate Sample Size needed to achieve specified CC | 59 |
| 95% Percentile Bootstrap UTL with | 95% Coverage 177000 | 95% BCA Bootstrap UTL with | 95% Coverage 177000 |
| 95% UPL | 177000 | 90% Percentile | 174800 |
| 90% Chebyshev UPL | 185713 | 95% Percentile | 175600 |
| 95% Chebyshev UPL | 193540 | 99% Percentile | 176720 |
| 95% USL | 177000 | | |

Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.
Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers and consists of observations collected from clean unimpacted locations.
The use of USL tends to provide a balance between false positives and false negatives provided the data represents a background data set and when many onsite observations need to be compared with the BTV.

**VAL (chloride)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 15 | Number of Distinct Observations | 13 |
| Minimum | 5340 | First Quartile | 5595 |
| Second Largest | 5900 | Median | 5640 |
| Maximum | 6100 | Third Quartile | 5770 |
| Mean | 5682 | SD | 186.6 |
| Coefficient of Variation | 0.0328 | Skewness | 0.473 |
| Mean of logged Data | 8.645 | SD of logged Data | 0.0327 |

**Critical Values for Background Threshold Values (BTVs)**

| | | | |
|---|---|---|---|
| Tolerance Factor K (For UTL) | 2.566 | d2max (for USL) | 2.409 |

**Normal GOF Test**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.974 | **Shapiro Wilk GOF Test** |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.123 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.22 | Data appear Normal at 5% Significance Level |

Data appear Normal at 5% Significance Level

**Background Statistics Assuming Normal Distribution**

| | | | |
|---|---|---|---|
| 95% UTL with 95% Coverage | 6161 | 90% Percentile (z) | 5922 |
| 95% UPL (t) | 6022 | 95% Percentile (z) | 5989 |
| 95% USL | 6132 | 99% Percentile (z) | 6117 |

**Gamma GOF Test**

| | | |
|---|---|---|
| A-D Test Statistic | 0.229 | **Anderson-Darling Gamma GOF Test** |
| 5% A-D Critical Value | 0.734 | Detected data appear Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.123 | **Kolmogorov-Smirnov Gamma GOF Test** |
| 5% K-S Critical Value | 0.221 | Detected data appear Gamma Distributed at 5% Significance Level |

Detected data appear Gamma Distributed at 5% Significance Level

**Gamma Statistics**

| | | | |
|---|---|---|---|
| k hat (MLE) | 1001 | k star (bias corrected MLE) | 800.7 |
| Theta hat (MLE) | 5.678 | Theta star (bias corrected MLE) | 7.097 |
| nu hat (MLE) | 30024 | nu star (bias corrected) | 24020 |
| MLE Mean (bias corrected) | 5682 | MLE Sd (bias corrected) | 200.8 |

**Background Statistics Assuming Gamma Distribution**

| | | | |
|---|---|---|---|
| 95% Wilson Hilferty (WH) Approx. Gamma UPL | 6025 | 90% Percentile | 5941 |
| 95% Hawkins Wixley (HW) Approx. Gamma UPL | 6026 | 95% Percentile | 6017 |
| 95% WH Approx. Gamma UTL with 95% Coverage | 6171 | 99% Percentile | 6160 |
| 95% HW Approx. Gamma UTL with 95% Coverage | 6172 | | |
| 95% WH USL | 6140 | 95% HW USL | 6141 |

**Lognormal GOF Test**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.978 | **Shapiro Wilk Lognormal GOF Test** |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Lognormal at 5% Significance Level |
| Lilliefors Test Statistic | 0.118 | **Lilliefors Lognormal GOF Test** |
| 5% Lilliefors Critical Value | 0.22 | Data appear Lognormal at 5% Significance Level |

Data appear Lognormal at 5% Significance Level

**Background Statistics assuming Lognormal Distribution**

| | | | | | |
|---|---|---|---|---|---|
| 95% UTL with | 95% Coverage | 6176 | 90% Percentile (z) | | 5922 |
| | 95% UPL (t) | 6027 | 95% Percentile (z) | | 5993 |
| | 95% USL | 6144 | 99% Percentile (z) | | 6128 |

**Nonparametric Distribution Free Background Statistics**

Data appear Normal at 5% Significance Level

**Nonparametric Upper Limits for Background Threshold Values**

| | | | | | |
|---|---|---|---|---|---|
| Order of Statistic, r | | 15 | 95% UTL with | 95% Coverage | 6100 |
| Approx, f used to compute achieved CC | | 0.789 | Approximate Actual Confidence Coefficient achieved by UTL | | 0.537 |
| | | | Approximate Sample Size needed to achieve specified CC | | 59 |
| 95% Percentile Bootstrap UTL with | 95% Coverage | 6100 | 95% BCA Bootstrap UTL with | 95% Coverage | 6100 |
| | 95% UPL | 6100 | | 90% Percentile | 5888 |
| | 90% Chebyshev UPL | 6261 | | 95% Percentile | 5960 |
| | 95% Chebyshev UPL | 6523 | | 99% Percentile | 6072 |
| | 95% USL | 6100 | | | |

Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20. Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers and consists of observations collected from clean unimpacted locations.

The use of USL tends to provide a balance between false positives and false negatives provided the data represents a background data set and when many onsite observations need to be compared with the BTV.

**VAL (dissolved arsenic)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 14 | Number of Missing Observations | 0 |
| Number of Distinct Observations | 12 | | |
| Number of Detects | 8 | Number of Non-Detects | 6 |
| Number of Distinct Detects | 8 | Number of Distinct Non-Detects | 4 |
| Minimum Detect | 3.7 | Minimum Non-Detect | 4 |
| Maximum Detect | 8.6 | Maximum Non-Detect | 14 |
| Variance Detected | 3.08 | Percent Non-Detects | 42.86% |
| Mean Detected | 5.701 | SD Detected | 1.755 |
| Mean of Detected Logged Data | 1.7 | SD of Detected Logged Data | 0.306 |

**Critical Values for Background Threshold Values (BTVs)**

| | | | |
|---|---|---|---|
| Tolerance Factor K (For UTL) | 2.614 | d2max (for USL) | 2.372 |

**Normal GOF Test on Detects Only**

| | | | |
|---|---|---|---|
| Shapiro Wilk Test Statistic | 0.935 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.818 | Detected Data appear Normal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.16 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.283 | Detected Data appear Normal at 5% Significance Level | |

Detected Data appear Normal at 5% Significance Level

**Kaplan Meier (KM) Background Statistics Assuming Normal Distribution**

| | | | |
|---|---|---|---|
| KM Mean | 4.973 | KM SD | 1.589 |
| 95% UTL95% Coverage | 9.127 | 95% KM UPL (t) | 7.886 |
| 90% KM Percentile (z) | 7.01 | 95% KM Percentile (z) | 7.587 |
| 99% KM Percentile (z) | 8.67 | 95% KM USL | 8.742 |

**DL/2 Substitution Background Statistics Assuming Normal Distribution**

| | | | |
|---|---|---|---|
| Mean | 4.572 | SD | 2.221 |
| 95% UTL95% Coverage | 10.38 | 95% UPL (t) | 8.643 |
| 90% Percentile (z) | 7.418 | 95% Percentile (z) | 8.225 |
| 99% Percentile (z) | 9.738 | 95% USL | 9.839 |

DL/2 is not a recommended method. DL/2 provided for comparisons and historical reasons

**Gamma GOF Tests on Detected Observations Only**

| | | | |
|---|---|---|---|
| A-D Test Statistic | 0.234 | **Anderson-Darling GOF Test** | |
| 5% A-D Critical Value | 0.715 | Detected data appear Gamma Distributed at 5% Significance Level | |
| K-S Test Statistic | 0.142 | **Kolmogorov-Smirnov GOF** | |
| 5% K-S Critical Value | 0.294 | Detected data appear Gamma Distributed at 5% Significance Level | |

Detected data appear Gamma Distributed at 5% Significance Level

**Gamma Statistics on Detected Data Only**

| | | | |
|---|---|---|---|
| k hat (MLE) | 12.38 | k star (bias corrected MLE) | 7.819 |
| Theta hat (MLE) | 0.461 | Theta star (bias corrected MLE) | 0.729 |
| nu hat (MLE) | 198 | nu star (bias corrected) | 125.1 |
| MLE Mean (bias corrected) | 5.701 | | |
| MLE Sd (bias corrected) | 2.039 | 95% Percentile of Chisquare (2kstar) | 25.83 |

**Gamma ROS Statistics using Imputed Non-Detects**

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)

For such situations, GROS method may yield incorrect values of UCLs and BTVs

This is especially true when the sample size is small.

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

| | | | |
|---|---|---|---|
| Minimum | 3 | Mean | 4.873 |

| | | | |
|---|---|---|---|
| Maximum | 8.6 | Median | 4.434 |
| SD | 1.676 | CV | 0.344 |
| k hat (MLE) | 10.33 | k star (bias corrected MLE) | 8.165 |
| Theta hat (MLE) | 0.472 | Theta star (bias corrected MLE) | 0.597 |
| nu hat (MLE) | 289.3 | nu star (bias corrected) | 228.6 |
| MLE Mean (bias corrected) | 4.873 | MLE Sd (bias corrected) | 1.705 |
| 95% Percentile of Chisquare (2kstar) | 26.72 | 90% Percentile | 7.146 |
| 95% Percentile | 7.974 | 99% Percentile | 9.688 |

**The following statistics are computed using Gamma ROS Statistics on Imputed Data**

**Upper Limits using Wilson Hilferty (WH) and Hawkins Wixley (HW) Methods**

| | WH | HW | | WH | HW |
|---|---|---|---|---|---|
| 95% Approx. Gamma UTL with 95% Coverage | 9.992 | 10.13 | 95% Approx. Gamma UPL | 8.136 | 8.173 |
| 95% Gamma USL | 9.388 | 9.488 | | | |

**Estimates of Gamma Parameters using KM Estimates**

| | | | |
|---|---|---|---|
| Mean (KM) | 4.973 | SD (KM) | 1.589 |
| Variance (KM) | 2.526 | SE of Mean (KM) | 0.473 |
| k hat (KM) | 9.787 | k star (KM) | 7.738 |
| nu hat (KM) | 274 | nu star (KM) | 216.7 |
| theta hat (KM) | 0.508 | theta star (KM) | 0.643 |
| 80% gamma percentile (KM) | 6.381 | 90% gamma percentile (KM) | 7.357 |
| 95% gamma percentile (KM) | 8.231 | 99% gamma percentile (KM) | 10.04 |

**The following statistics are computed using gamma distribution and KM estimates**

**Upper Limits using Wilson Hilferty (WH) and Hawkins Wixley (HW) Methods**

| | WH | HW | | WH | HW |
|---|---|---|---|---|---|
| 95% Approx. Gamma UTL with 95% Coverage | 9.661 | 9.755 | 95% Approx. Gamma UPL | 7.98 | 7.998 |
| 95% KM Gamma Percentile | 7.606 | 7.612 | 95% Gamma USL | 9.116 | 9.181 |

**Lognormal GOF Test on Detected Observations Only**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.95 | **Shapiro Wilk GOF Test** |
| 5% Shapiro Wilk Critical Value | 0.818 | Detected Data appear Lognormal at 5% Significance Level |
| Lilliefors Test Statistic | 0.134 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.283 | Detected Data appear Lognormal at 5% Significance Level |

Detected Data appear Lognormal at 5% Significance Level

**Background Lognormal ROS Statistics Assuming Lognormal Distribution Using Imputed Non-Detects**

| | | | |
|---|---|---|---|
| Mean in Original Scale | 4.932 | Mean in Log Scale | 1.552 |
| SD in Original Scale | 1.617 | SD in Log Scale | 0.297 |
| 95% UTL95% Coverage | 10.27 | 95% BCA UTL95% Coverage | 8.6 |

| | | | |
|---|---|---|---|
| 95% Bootstrap (%) UTL95% Coverage | 8.6 | 95% UPL (t) | 8.143 |
| 90% Percentile (z) | 6.911 | 95% Percentile (z) | 7.7 |
| 99% Percentile (z) | 9.429 | 95% USL | 9.557 |

**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**

| | | | |
|---|---|---|---|
| KM Mean of Logged Data | 1.56 | 95% KM UTL (Lognormal)95% Coverage | 10.09 |
| KM SD of Logged Data | 0.288 | 95% KM UPL (Lognormal) | 8.061 |
| 95% KM Percentile Lognormal (z) | 7.636 | 95% KM USL (Lognormal) | 9.412 |

**Background DL/2 Statistics Assuming Lognormal Distribution**

| | | | |
|---|---|---|---|
| Mean in Original Scale | 4.572 | Mean in Log Scale | 1.403 |
| SD in Original Scale | 2.221 | SD in Log Scale | 0.51 |
| 95% UTL95% Coverage | 15.45 | 95% UPL (t) | 10.37 |
| 90% Percentile (z) | 7.825 | 95% Percentile (z) | 9.419 |
| 99% Percentile (z) | 13.34 | 95% USL | 13.65 |

DL/2 is not a Recommended Method. DL/2 provided for comparisons and historical reasons.

**Nonparametric Distribution Free Background Statistics**

Data appear to follow a Discernible Distribution at 5% Significance Level

**Nonparametric Upper Limits for BTVs(no distinction made between detects and nondetects)**

| | | | |
|---|---|---|---|
| Order of Statistic, r | 14 | 95% UTL with95% Coverage | 14 |
| Approx, f used to compute achieved CC | 0.737 | Approximate Actual Confidence Coefficient achieved by UTL | 0.512 |
| Approximate Sample Size needed to achieve specified CC | 59 | 95% UPL | 14 |
| 95% USL | 14 | 95% KM Chebyshev UPL | 12.14 |

Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20. Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers and consists of observations collected from clean unimpacted locations.

The use of USL tends to provide a balance between false positives and false negatives provided the data represents a background data set and when many onsite observations need to be compared with the BTV.

**VAL (dissolved calcium)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 15 | Number of Distinct Observations | 12 |
| Minimum | 47000 | First Quartile | 49200 |
| Second Largest | 52700 | Median | 50000 |
| Maximum | 52800 | Third Quartile | 51450 |
| Mean | 50153 | SD | 1850 |

| | | | |
|---|---|---|---|
| Coefficient of Variation | 0.0369 | Skewness | -0.14 |
| Mean of logged Data | 10.82 | SD of logged Data | 0.037 |

**Critical Values for Background Threshold Values (BTVs)**

| | | | |
|---|---|---|---|
| Tolerance Factor K (For UTL) | 2.566 | d2max (for USL) | 2.409 |

**Normal GOF Test**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.936 | **Shapiro Wilk GOF Test** |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.144 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.22 | Data appear Normal at 5% Significance Level |

Data appear Normal at 5% Significance Level

**Background Statistics Assuming Normal Distribution**

| | | | |
|---|---|---|---|
| 95% UTL with 95% Coverage | 54901 | 90% Percentile (z) | 52524 |
| 95% UPL (t) | 53519 | 95% Percentile (z) | 53196 |
| 95% USL | 54610 | 99% Percentile (z) | 54457 |

**Gamma GOF Test**

| | | |
|---|---|---|
| A-D Test Statistic | 0.406 | **Anderson-Darling Gamma GOF Test** |
| 5% A-D Critical Value | 0.734 | Detected data appear Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.15 | **Kolmogorov-Smirnov Gamma GOF Test** |
| 5% K-S Critical Value | 0.221 | Detected data appear Gamma Distributed at 5% Significance Level |

Detected data appear Gamma Distributed at 5% Significance Level

**Gamma Statistics**

| | | | |
|---|---|---|---|
| k hat (MLE) | 784.2 | k star (bias corrected MLE) | 627.4 |
| Theta hat (MLE) | 63.95 | Theta star (bias corrected MLE) | 79.94 |
| nu hat (MLE) | 23526 | nu star (bias corrected) | 18822 |
| MLE Mean (bias corrected) | 50153 | MLE Sd (bias corrected) | 2002 |

**Background Statistics Assuming Gamma Distribution**

| | | | |
|---|---|---|---|
| 95% Wilson Hilferty (WH) Approx. Gamma UPL | 53579 | 90% Percentile | 52736 |
| 95% Hawkins Wixley (HW) Approx. Gamma UPL | 53587 | 95% Percentile | 53492 |
| 95% WH Approx. Gamma UTL with 95% Coverage | 55040 | 99% Percentile | 54929 |
| 95% HW Approx. Gamma UTL with 95% Coverage | 55058 | | |
| 95% WH USL | 54731 | 95% HW USL | 54746 |

**Lognormal GOF Test**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.935 | **Shapiro Wilk Lognormal GOF Test** |

| | | |
|---|---|---|
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Lognormal at 5% Significance Level |
| Lilliefors Test Statistic | 0.142 | **Lilliefors Lognormal GOF Test** |
| 5% Lilliefors Critical Value | 0.22 | Data appear Lognormal at 5% Significance Level |

Data appear Lognormal at 5% Significance Level

**Background Statistics assuming Lognormal Distribution**

| | | | | |
|---|---|---|---|---|
| 95% UTL with | 95% Coverage | 55114 | 90% Percentile (z) | 52556 |
| | 95% UPL (t) | 53612 | 95% Percentile (z) | 53267 |
| | 95% USL | 54795 | 99% Percentile (z) | 54628 |

**Nonparametric Distribution Free Background Statistics**

Data appear Normal at 5% Significance Level

**Nonparametric Upper Limits for Background Threshold Values**

| | | | | |
|---|---|---|---|---|
| Order of Statistic, r | 15 | 95% UTL with | 95% Coverage | 52800 |
| Approx, f used to compute achieved CC | 0.789 | Approximate Actual Confidence Coefficient achieved by UTL | | 0.537 |
| | | Approximate Sample Size needed to achieve specified CC | | 59 |
| 95% Percentile Bootstrap UTL with | 95% Coverage 52800 | 95% BCA Bootstrap UTL with | 95% Coverage | 52800 |
| | 95% UPL 52800 | | 90% Percentile | 52540 |
| | 90% Chebyshev UPL 55885 | | 95% Percentile | 52730 |
| | 95% Chebyshev UPL 58482 | | 99% Percentile | 52786 |
| | 95% USL 52800 | | | |

Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20. Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers and consists of observations collected from clean unimpacted locations.

The use of USL tends to provide a balance between false positives and false negatives provided the data represents a background data set and when many onsite observations need to be compared with the BTV.

**VAL (dissolved iron)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 14 | Number of Missing Observations | 0 |
| Number of Distinct Observations | 5 | | |
| Number of Detects | 1 | Number of Non-Detects | 13 |
| Number of Distinct Detects | 1 | Number of Distinct Non-Detects | 4 |
| Minimum Detect | 30.7 | Minimum Non-Detect | 22 |
| Maximum Detect | 30.7 | Maximum Non-Detect | 53 |
| Variance Detected | N/A | Percent Non-Detects | 92.86% |
| Mean Detected | 30.7 | SD Detected | N/A |

| | | | |
|---|---|---|---|
| Mean of Detected Logged Data | 3.424 | SD of Detected Logged Data | N/A |

Warning: Only one distinct data value was detected! ProUCL (or any other software) should not be used on such a data set!

It is suggested to use alternative site specific values determined by the Project Team to estimate environmental parameters (e.g., EPC, BTV).

The data set for variable VAL (dissolved iron) was not processed!

**VAL (dissolved magnesium)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 15 | Number of Distinct Observations | 9 |
| Minimum | 12000 | First Quartile | 12500 |
| Second Largest | 13000 | Median | 12700 |
| Maximum | 13600 | Third Quartile | 13000 |
| Mean | 12713 | SD | 417.2 |
| Coefficient of Variation | 0.0328 | Skewness | 0.0618 |
| Mean of logged Data | 9.45 | SD of logged Data | 0.0328 |

**Critical Values for Background Threshold Values (BTVs)**

| | | | |
|---|---|---|---|
| Tolerance Factor K (For UTL) | 2.566 | d2max (for USL) | 2.409 |

**Normal GOF Test**

| | | | |
|---|---|---|---|
| Shapiro Wilk Test Statistic | 0.945 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Normal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.179 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data appear Normal at 5% Significance Level | |

Data appear Normal at 5% Significance Level

**Background Statistics Assuming Normal Distribution**

| | | | | | |
|---|---|---|---|---|---|
| 95% UTL with | 95% Coverage | 13784 | 90% Percentile (z) | 13248 |
| | 95% UPL (t) | 13472 | 95% Percentile (z) | 13400 |
| | 95% USL | 13718 | 99% Percentile (z) | 13684 |

**Gamma GOF Test**

| | | | |
|---|---|---|---|
| A-D Test Statistic | 0.416 | **Anderson-Darling Gamma GOF Test** | |
| 5% A-D Critical Value | 0.734 | Detected data appear Gamma Distributed at 5% Significance Level | |
| K-S Test Statistic | 0.17 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 5% K-S Critical Value | 0.221 | Detected data appear Gamma Distributed at 5% Significance Level | |

Detected data appear Gamma Distributed at 5% Significance Level

**Gamma Statistics**

| | | | |
|---|---|---|---|
| k hat (MLE) | 994.6 | k star (bias corrected MLE) | 795.8 |
| Theta hat (MLE) | 12.78 | Theta star (bias corrected MLE) | 15.98 |
| nu hat (MLE) | 29839 | nu star (bias corrected) | 23873 |
| MLE Mean (bias corrected) | 12713 | MLE Sd (bias corrected) | 450.7 |

**Background Statistics Assuming Gamma Distribution**

| | | | |
|---|---|---|---|
| 95% Wilson Hilferty (WH) Approx. Gamma UPL | 13483 | 90% Percentile | 13294 |
| 95% Hawkins Wixley (HW) Approx. Gamma UPL | 13485 | 95% Percentile | 13464 |
| 95% WH Approx. Gamma UTL with 95% Coverage | 13810 | 99% Percentile | 13785 |
| 95% HW Approx. Gamma UTL with 95% Coverage | 13813 | | |
| 95% WH USL | 13741 | 95% HW USL | 13744 |

**Lognormal GOF Test**

| | | | |
|---|---|---|---|
| Shapiro Wilk Test Statistic | 0.946 | **Shapiro Wilk Lognormal GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Lognormal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.177 | **Lilliefors Lognormal GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data appear Lognormal at 5% Significance Level | |

Data appear Lognormal at 5% Significance Level

**Background Statistics assuming Lognormal Distribution**

| | | | |
|---|---|---|---|
| 95% UTL with 95% Coverage | 13824 | 90% Percentile (z) | 13253 |
| 95% UPL (t) | 13489 | 95% Percentile (z) | 13412 |
| 95% USL | 13753 | 99% Percentile (z) | 13715 |

**Nonparametric Distribution Free Background Statistics**

Data appear Normal at 5% Significance Level

**Nonparametric Upper Limits for Background Threshold Values**

| | | | |
|---|---|---|---|
| Order of Statistic, r | 15 | 95% UTL with 95% Coverage | 13600 |
| Approx, f used to compute achieved CC | 0.789 | Approximate Actual Confidence Coefficient achieved by UTL | 0.537 |
| | | Approximate Sample Size needed to achieve specified CC | 59 |
| 95% Percentile Bootstrap UTL with 95% Coverage | 13600 | 95% BCA Bootstrap UTL with 95% Coverage | 13600 |
| 95% UPL | 13600 | 90% Percentile | 13000 |
| 90% Chebyshev UPL | 14006 | 95% Percentile | 13180 |
| 95% Chebyshev UPL | 14592 | 99% Percentile | 13516 |
| 95% USL | 13600 | | |

Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.

Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers and consists of observations collected from clean unimpacted locations.

The use of USL tends to provide a balance between false positives and false negatives provided the data represents a background data set and when many onsite observations need to be compared with the BTV.

**VAL (dissolved manganese)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 15 | Number of Missing Observations | 0 |
| Number of Distinct Observations | 13 | | |
| Number of Detects | 6 | Number of Non-Detects | 9 |
| Number of Distinct Detects | 6 | Number of Distinct Non-Detects | 7 |
| Minimum Detect | 0.39 | Minimum Non-Detect | 0.31 |
| Maximum Detect | 3.39 | Maximum Non-Detect | 4 |
| Variance Detected | 1.233 | Percent Non-Detects | 60% |
| Mean Detected | 1.262 | SD Detected | 1.11 |
| Mean of Detected Logged Data | -0.042 | SD of Detected Logged Data | 0.791 |

**Critical Values for Background Threshold Values (BTVs)**

| | | | |
|---|---|---|---|
| Tolerance Factor K (For UTL) | 2.566 | d2max (for USL) | 2.409 |

**Normal GOF Test on Detects Only**

| | | | |
|---|---|---|---|
| Shapiro Wilk Test Statistic | 0.797 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.788 | Detected Data appear Normal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.284 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.325 | Detected Data appear Normal at 5% Significance Level | |

Detected Data appear Normal at 5% Significance Level

**Kaplan Meier (KM) Background Statistics Assuming Normal Distribution**

| | | | |
|---|---|---|---|
| KM Mean | 0.918 | KM SD | 0.805 |
| 95% UTL95% Coverage | 2.984 | 95% KM UPL (t) | 2.383 |
| 90% KM Percentile (z) | 1.95 | 95% KM Percentile (z) | 2.242 |
| 99% KM Percentile (z) | 2.791 | 95% KM USL | 2.857 |

**DL/2 Substitution Background Statistics Assuming Normal Distribution**

| | | | |
|---|---|---|---|
| Mean | 1.142 | SD | 0.817 |
| 95% UTL95% Coverage | 3.238 | 95% UPL (t) | 2.628 |
| 90% Percentile (z) | 2.189 | 95% Percentile (z) | 2.485 |
| 99% Percentile (z) | 3.042 | 95% USL | 3.11 |

DL/2 is not a recommended method. DL/2 provided for comparisons and historical reasons

**Gamma GOF Tests on Detected Observations Only**

| | | | |
|---|---|---|---|
| A-D Test Statistic | 0.311 | **Anderson-Darling GOF Test** | |
| 5% A-D Critical Value | 0.704 | Detected data appear Gamma Distributed at 5% Significance Level | |
| K-S Test Statistic | 0.183 | **Kolmogorov-Smirnov GOF** | |
| 5% K-S Critical Value | 0.336 | Detected data appear Gamma Distributed at 5% Significance Level | |

**Detected data appear Gamma Distributed at 5% Significance Level**

**Gamma Statistics on Detected Data Only**

| | | | |
|---|---|---|---|
| k hat (MLE) | 1.972 | k star (bias corrected MLE) | 1.097 |
| Theta hat (MLE) | 0.64 | Theta star (bias corrected MLE) | 1.15 |
| nu hat (MLE) | 23.67 | nu star (bias corrected) | 13.17 |
| MLE Mean (bias corrected) | 1.262 | | |
| MLE Sd (bias corrected) | 1.204 | 95% Percentile of Chisquare (2kstar) | 6.363 |

**Gamma ROS Statistics using Imputed Non-Detects**

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)

For such situations, GROS method may yield incorrect values of UCLs and BTVs

This is especially true when the sample size is small.

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

| | | | |
|---|---|---|---|
| Minimum | 0.01 | Mean | 0.797 |
| Maximum | 3.39 | Median | 0.541 |
| SD | 0.813 | CV | 1.02 |
| k hat (MLE) | 1.145 | k star (bias corrected MLE) | 0.96 |
| Theta hat (MLE) | 0.696 | Theta star (bias corrected MLE) | 0.83 |
| nu hat (MLE) | 34.34 | nu star (bias corrected) | 28.81 |
| MLE Mean (bias corrected) | 0.797 | MLE Sd (bias corrected) | 0.814 |
| 95% Percentile of Chisquare (2kstar) | 5.836 | 90% Percentile | 1.854 |
| 95% Percentile | 2.423 | 99% Percentile | 3.748 |

**The following statistics are computed using Gamma ROS Statistics on Imputed Data**

**Upper Limits using Wilson Hilferty (WH) and Hawkins Wixley (HW) Methods**

| | WH | HW | | WH | HW |
|---|---|---|---|---|---|
| 95% Approx. Gamma UTL with 95% Coverage | 3.946 | 4.564 | 95% Approx. Gamma UPL | 2.547 | 2.764 |
| 95% Gamma USL | 3.618 | 4.129 | | | |

**Estimates of Gamma Parameters using KM Estimates**

| | | | |
|---|---|---|---|
| Mean (KM) | 0.918 | SD (KM) | 0.805 |
| Variance (KM) | 0.648 | SE of Mean (KM) | 0.265 |
| k hat (KM) | 1.302 | k star (KM) | 1.086 |
| nu hat (KM) | 39.07 | nu star (KM) | 32.59 |

| | | | |
|---|---|---|---|
| theta hat (KM) | 0.705 | theta star (KM) | 0.846 |
| 80% gamma percentile (KM) | 1.468 | 90% gamma percentile (KM) | 2.072 |
| 95% gamma percentile (KM) | 2.673 | 99% gamma percentile (KM) | 4.058 |

**The following statistics are computed using gamma distribution and KM estimates**

**Upper Limits using Wilson Hilferty (WH) and Hawkins Wixley (HW) Methods**

| | WH | HW | | WH | HW |
|---|---|---|---|---|---|
| 95% Approx. Gamma UTL with 95% Coverage | 3.374 | 3.501 | 95% Approx. Gamma UPL | 2.348 | 2.366 |
| 95% KM Gamma Percentile | 2.143 | 2.146 | 95% Gamma USL | 3.137 | 3.234 |

**Lognormal GOF Test on Detected Observations Only**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.955 | **Shapiro Wilk GOF Test** |
| 5% Shapiro Wilk Critical Value | 0.788 | Detected Data appear Lognormal at 5% Significance Level |
| Lilliefors Test Statistic | 0.157 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.325 | Detected Data appear Lognormal at 5% Significance Level |

Detected Data appear Lognormal at 5% Significance Level

**Background Lognormal ROS Statistics Assuming Lognormal Distribution Using Imputed Non-Detects**

| | | | |
|---|---|---|---|
| Mean in Original Scale | 0.834 | Mean in Log Scale | -0.433 |
| SD in Original Scale | 0.775 | SD in Log Scale | 0.684 |
| 95% UTL95% Coverage | 3.749 | 95% BCA UTL95% Coverage | 3.39 |
| 95% Bootstrap (%) UTL95% Coverage | 3.39 | 95% UPL (t) | 2.25 |
| 90% Percentile (z) | 1.558 | 95% Percentile (z) | 1.997 |
| 99% Percentile (z) | 3.182 | 95% USL | 3.367 |

**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**

| | | | |
|---|---|---|---|
| KM Mean of Logged Data | -0.356 | 95% KM UTL (Lognormal)95% Coverage | 4.154 |
| KM SD of Logged Data | 0.694 | 95% KM UPL (Lognormal) | 2.474 |
| 95% KM Percentile Lognormal (z) | 2.192 | 95% KM USL (Lognormal) | 3.725 |

**Background DL/2 Statistics Assuming Lognormal Distribution**

| | | | |
|---|---|---|---|
| Mean in Original Scale | 1.142 | Mean in Log Scale | -0.105 |
| SD in Original Scale | 0.817 | SD in Log Scale | 0.756 |
| 95% UTL95% Coverage | 6.266 | 95% UPL (t) | 3.562 |
| 90% Percentile (z) | 2.372 | 95% Percentile (z) | 3.122 |
| 99% Percentile (z) | 5.228 | 95% USL | 5.565 |

DL/2 is not a Recommended Method. DL/2 provided for comparisons and historical reasons.

**Nonparametric Distribution Free Background Statistics**

Data appear to follow a Discernible Distribution at 5% Significance Level

**Nonparametric Upper Limits for BTVs(no distinction made between detects and nondetects)**

| | | | |
|---|---|---|---|
| Order of Statistic, r | 15 | 95% UTL with95% Coverage | 4 |
| Approx, f used to compute achieved CC | 0.789 | Approximate Actual Confidence Coefficient achieved by UTL | 0.537 |
| Approximate Sample Size needed to achieve specified CC | 59 | 95% UPL | 4 |
| 95% USL | 4 | 95% KM Chebyshev UPL | 4.542 |

Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.
Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers and consists of observations collected from clean unimpacted locations.
The use of USL tends to provide a balance between false positives and false negatives provided the data represents a background data set and when many onsite observations need to be compared with the BTV.

**VAL (dissolved potassium)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 15 | Number of Distinct Observations | 15 |
| Minimum | 6110 | First Quartile | 6520 |
| Second Largest | 7400 | Median | 6700 |
| Maximum | 7800 | Third Quartile | 7050 |
| Mean | 6787 | SD | 483.1 |
| Coefficient of Variation | 0.0712 | Skewness | 0.512 |
| Mean of logged Data | 8.82 | SD of logged Data | 0.0704 |

**Critical Values for Background Threshold Values (BTVs)**

| | | | |
|---|---|---|---|
| Tolerance Factor K (For UTL) | 2.566 | d2max (for USL) | 2.409 |

**Normal GOF Test**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.962 | **Shapiro Wilk GOF Test** |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.138 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.22 | Data appear Normal at 5% Significance Level |

Data appear Normal at 5% Significance Level

**Background Statistics Assuming Normal Distribution**

| | | | | | |
|---|---|---|---|---|---|
| 95% UTL with | 95% Coverage | 8026 | 90% Percentile (z) | 7406 |
| | 95% UPL (t) | 7666 | 95% Percentile (z) | 7581 |
| | 95% USL | 7951 | 99% Percentile (z) | 7911 |

**Gamma GOF Test**

| | | | |
|---|---|---|---|
| A-D Test Statistic | 0.217 | **Anderson-Darling Gamma GOF Test** | |
| 5% A-D Critical Value | 0.734 | Detected data appear Gamma Distributed at 5% Significance Level | |
| K-S Test Statistic | 0.131 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 5% K-S Critical Value | 0.221 | Detected data appear Gamma Distributed at 5% Significance Level | |

Detected data appear Gamma Distributed at 5% Significance Level

**Gamma Statistics**

| | | | |
|---|---|---|---|
| k hat (MLE) | 214.9 | k star (bias corrected MLE) | 172 |
| Theta hat (MLE) | 31.58 | Theta star (bias corrected MLE) | 39.46 |
| nu hat (MLE) | 6447 | nu star (bias corrected) | 5159 |
| MLE Mean (bias corrected) | 6787 | MLE Sd (bias corrected) | 517.5 |

**Background Statistics Assuming Gamma Distribution**

| | | | |
|---|---|---|---|
| 95% Wilson Hilferty (WH) Approx. Gamma UPL | 7685 | 90% Percentile | 7458 |
| 95% Hawkins Wixley (HW) Approx. Gamma UPL | 7687 | 95% Percentile | 7660 |
| 95% WH Approx. Gamma UTL with 95% Coverage | 8080 | 99% Percentile | 8048 |
| 95% HW Approx. Gamma UTL with 95% Coverage | 8088 | | |
| 95% WH USL | 7996 | 95% HW USL | 8002 |

**Lognormal GOF Test**

| | | | |
|---|---|---|---|
| Shapiro Wilk Test Statistic | 0.968 | **Shapiro Wilk Lognormal GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Lognormal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.126 | **Lilliefors Lognormal GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data appear Lognormal at 5% Significance Level | |

Data appear Lognormal at 5% Significance Level

**Background Statistics assuming Lognormal Distribution**

| | | | |
|---|---|---|---|
| 95% UTL with 95% Coverage | 8111 | 90% Percentile (z) | 7410 |
| 95% UPL (t) | 7696 | 95% Percentile (z) | 7602 |
| 95% USL | 8022 | 99% Percentile (z) | 7975 |

**Nonparametric Distribution Free Background Statistics**

Data appear Normal at 5% Significance Level

**Nonparametric Upper Limits for Background Threshold Values**

| | | | |
|---|---|---|---|
| Order of Statistic, r | 15 | 95% UTL with 95% Coverage | 7800 |
| Approx, f used to compute achieved CC | 0.789 | Approximate Actual Confidence Coefficient achieved by UTL | 0.537 |
| | | Approximate Sample Size needed to achieve specified CC | 59 |
| 95% Percentile Bootstrap UTL with 95% Coverage | 7800 | 95% BCA Bootstrap UTL with 95% Coverage | 7800 |
| 95% UPL | 7800 | 90% Percentile | 7376 |

| | | | |
|---|---|---|---|
| 90% Chebyshev UPL | 8284 | 95% Percentile | 7520 |
| 95% Chebyshev UPL | 8962 | 99% Percentile | 7744 |
| 95% USL | 7800 | | |

Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.
Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers and consists of observations collected from clean unimpacted locations.
The use of USL tends to provide a balance between false positives and false negatives provided the data represents a background data set and when many onsite observations need to be compared with the BTV.

**VAL (dissolved sodium)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 15 | Number of Distinct Observations | 12 |
| Minimum | 18500 | First Quartile | 20425 |
| Second Largest | 21900 | Median | 21100 |
| Maximum | 22100 | Third Quartile | 21500 |
| Mean | 20910 | SD | 904.4 |
| Coefficient of Variation | 0.0433 | Skewness | -1.325 |
| Mean of logged Data | 9.947 | SD of logged Data | 0.0445 |

**Critical Values for Background Threshold Values (BTVs)**

| | | | |
|---|---|---|---|
| Tolerance Factor K (For UTL) | 2.566 | d2max (for USL) | 2.409 |

**Normal GOF Test**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.904 | **Shapiro Wilk GOF Test** |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.206 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.22 | Data appear Normal at 5% Significance Level |

Data appear Normal at 5% Significance Level

**Background Statistics Assuming Normal Distribution**

| | | | |
|---|---|---|---|
| 95% UTL with 95% Coverage | 23231 | 90% Percentile (z) | 22069 |
| 95% UPL (t) | 22555 | 95% Percentile (z) | 22398 |
| 95% USL | 23089 | 99% Percentile (z) | 23014 |

**Gamma GOF Test**

| | | |
|---|---|---|
| A-D Test Statistic | 0.531 | **Anderson-Darling Gamma GOF Test** |
| 5% A-D Critical Value | 0.734 | Detected data appear Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.213 | **Kolmogorov-Smirnov Gamma GOF Test** |

| | | | |
|---|---|---|---|
| 5% K-S Critical Value | 0.221 | Detected data appear Gamma Distributed at 5% Significance Level | |

Detected data appear Gamma Distributed at 5% Significance Level

**Gamma Statistics**

| | | | |
|---|---|---|---|
| k hat (MLE) | 552.3 | k star (bias corrected MLE) | 441.9 |
| Theta hat (MLE) | 37.86 | Theta star (bias corrected MLE) | 47.32 |
| nu hat (MLE) | 16570 | nu star (bias corrected) | 13257 |
| MLE Mean (bias corrected) | 20910 | MLE Sd (bias corrected) | 994.7 |

**Background Statistics Assuming Gamma Distribution**

| | | | |
|---|---|---|---|
| 95% Wilson Hilferty (WH) Approx. Gamma UPL | 22617 | 90% Percentile | 22194 |
| 95% Hawkins Wixley (HW) Approx. Gamma UPL | 22625 | 95% Percentile | 22573 |
| 95% WH Approx. Gamma UTL with 95% Coverage | 23350 | 99% Percentile | 23293 |
| 95% HW Approx. Gamma UTL with 95% Coverage | 23366 | | |
| 95% WH USL | 23195 | 95% HW USL | 23209 |

**Lognormal GOF Test**

| | | | |
|---|---|---|---|
| Shapiro Wilk Test Statistic | 0.887 | **Shapiro Wilk Lognormal GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Lognormal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.213 | **Lilliefors Lognormal GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data appear Lognormal at 5% Significance Level | |

Data appear Lognormal at 5% Significance Level

**Background Statistics assuming Lognormal Distribution**

| | | | |
|---|---|---|---|
| 95% UTL with 95% Coverage | 23416 | 90% Percentile (z) | 22116 |
| 95% UPL (t) | 22651 | 95% Percentile (z) | 22476 |
| 95% USL | 23253 | 99% Percentile (z) | 23168 |

**Nonparametric Distribution Free Background Statistics**

Data appear Normal at 5% Significance Level

**Nonparametric Upper Limits for Background Threshold Values**

| | | | |
|---|---|---|---|
| Order of Statistic, r | 15 | 95% UTL with 95% Coverage | 22100 |
| Approx, f used to compute achieved CC | 0.789 | Approximate Actual Confidence Coefficient achieved by UTL | 0.537 |
| | | Approximate Sample Size needed to achieve specified CC | 59 |
| 95% Percentile Bootstrap UTL with 95% Coverage | 22100 | 95% BCA Bootstrap UTL with 95% Coverage | 22100 |
| 95% UPL | 22100 | 90% Percentile | 21780 |
| 90% Chebyshev UPL | 23712 | 95% Percentile | 21960 |
| 95% Chebyshev UPL | 24981 | 99% Percentile | 22072 |
| 95% USL | 22100 | | |

Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20. Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers and consists of observations collected from clean unimpacted locations.
The use of USL tends to provide a balance between false positives and false negatives provided the data represents a background data set and when many onsite observations need to be compared with the BTV.

**VAL (nitrate)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 15 | Number of Distinct Observations | 9 |
| Minimum | 12400 | First Quartile | 13225 |
| Second Largest | 14200 | Median | 13500 |
| Maximum | 14200 | Third Quartile | 13800 |
| Mean | 13517 | SD | 512.6 |
| Coefficient of Variation | 0.0379 | Skewness | -0.451 |
| Mean of logged Data | 9.511 | SD of logged Data | 0.0383 |

**Critical Values for Background Threshold Values (BTVs)**

| | | | |
|---|---|---|---|
| Tolerance Factor K (For UTL) | 2.566 | d2max (for USL) | 2.409 |

**Normal GOF Test**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.951 | **Shapiro Wilk GOF Test** |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.109 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.22 | Data appear Normal at 5% Significance Level |

Data appear Normal at 5% Significance Level

**Background Statistics Assuming Normal Distribution**

| | | | |
|---|---|---|---|
| 95% UTL with 95% Coverage | 14832 | 90% Percentile (z) | 14174 |
| 95% UPL (t) | 14449 | 95% Percentile (z) | 14360 |
| 95% USL | 14751 | 99% Percentile (z) | 14709 |

**Gamma GOF Test**

| | | |
|---|---|---|
| A-D Test Statistic | 0.274 | **Anderson-Darling Gamma GOF Test** |
| 5% A-D Critical Value | 0.734 | Detected data appear Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.114 | **Kolmogorov-Smirnov Gamma GOF Test** |
| 5% K-S Critical Value | 0.221 | Detected data appear Gamma Distributed at 5% Significance Level |

Detected data appear Gamma Distributed at 5% Significance Level

**Gamma Statistics**

| | | | |
|---|---|---|---|
| k hat (MLE) | 736.5 | k star (bias corrected MLE) | 589.3 |
| Theta hat (MLE) | 18.35 | Theta star (bias corrected MLE) | 22.94 |
| nu hat (MLE) | 22096 | nu star (bias corrected) | 17678 |
| MLE Mean (bias corrected) | 13517 | MLE Sd (bias corrected) | 556.8 |

**Background Statistics Assuming Gamma Distribution**

| | | | |
|---|---|---|---|
| 95% Wilson Hilferty (WH) Approx. Gamma UPL | 14470 | 90% Percentile | 14235 |
| 95% Hawkins Wixley (HW) Approx. Gamma UPL | 14473 | 95% Percentile | 14445 |
| 95% WH Approx. Gamma UTL with 95% Coverage | 14877 | 99% Percentile | 14846 |
| 95% HW Approx. Gamma UTL with 95% Coverage | 14883 | | |
| 95% WH USL | 14791 | 95% HW USL | 14796 |

**Lognormal GOF Test**

| | | | |
|---|---|---|---|
| Shapiro Wilk Test Statistic | 0.947 | **Shapiro Wilk Lognormal GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Lognormal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.111 | **Lilliefors Lognormal GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data appear Lognormal at 5% Significance Level | |

Data appear Lognormal at 5% Significance Level

**Background Statistics assuming Lognormal Distribution**

| | | | |
|---|---|---|---|
| 95% UTL with 95% Coverage | 14901 | 90% Percentile (z) | 14186 |
| 95% UPL (t) | 14481 | 95% Percentile (z) | 14385 |
| 95% USL | 14812 | 99% Percentile (z) | 14765 |

**Nonparametric Distribution Free Background Statistics**

Data appear Normal at 5% Significance Level

**Nonparametric Upper Limits for Background Threshold Values**

| | | | |
|---|---|---|---|
| Order of Statistic, r | 15 | 95% UTL with 95% Coverage | 14200 |
| Approx, f used to compute achieved CC | 0.789 | Approximate Actual Confidence Coefficient achieved by UTL | 0.537 |
| | | Approximate Sample Size needed to achieve specified CC | 59 |
| 95% Percentile Bootstrap UTL with 95% Coverage | 14200 | 95% BCA Bootstrap UTL with 95% Coverage | 14200 |
| 95% UPL | 14200 | 90% Percentile | 14200 |
| 90% Chebyshev UPL | 15105 | 95% Percentile | 14200 |
| 95% Chebyshev UPL | 15824 | 99% Percentile | 14200 |
| 95% USL | 14200 | | |

Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.

Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers

and consists of observations collected from clean unimpacted locations.

The use of USL tends to provide a balance between false positives and false negatives provided the data represents a background data set and when many onsite observations need to be compared with the BTV.

**VAL (ph measurement)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 15 | Number of Distinct Observations | 10 |
| Minimum | 7.53 | First Quartile | 7.61 |
| Second Largest | 7.77 | Median | 7.65 |
| Maximum | 7.85 | Third Quartile | 7.755 |
| Mean | 7.669 | SD | 0.0907 |
| Coefficient of Variation | 0.0118 | Skewness | 0.406 |
| Mean of logged Data | 2.037 | SD of logged Data | 0.0118 |

**Critical Values for Background Threshold Values (BTVs)**

| | | | |
|---|---|---|---|
| Tolerance Factor K (For UTL) | 2.566 | d2max (for USL) | 2.409 |

**Normal GOF Test**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.952 | **Shapiro Wilk GOF Test** |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.164 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.22 | Data appear Normal at 5% Significance Level |

Data appear Normal at 5% Significance Level

**Background Statistics Assuming Normal Distribution**

| | | | | |
|---|---|---|---|---|
| 95% UTL with | 95% Coverage | 7.902 | 90% Percentile (z) | 7.786 |
| | 95% UPL (t) | 7.834 | 95% Percentile (z) | 7.819 |
| | 95% USL | 7.888 | 99% Percentile (z) | 7.88 |

**Gamma GOF Test**

| | | |
|---|---|---|
| A-D Test Statistic | 0.93 | **Anderson-Darling Gamma GOF Test** |
| 5% A-D Critical Value | 0.734 | Data Not Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.289 | **Kolmogorov-Smirnov Gamma GOF Test** |
| 5% K-S Critical Value | 0.221 | Data Not Gamma Distributed at 5% Significance Level |

Data Not Gamma Distributed at 5% Significance Level

**Gamma Statistics**

| | | | |
|---|---|---|---|
| k hat (MLE) | 7673 | k star (bias corrected MLE) | 6138 |
| Theta hat (MLE) | 9.9954E-4 | Theta star (bias corrected MLE) | 0.00125 |

| | | | |
|---|---|---|---|
| nu hat (MLE) | 230185 | nu star (bias corrected) | 184149 |
| MLE Mean (bias corrected) | 7.669 | MLE Sd (bias corrected) | 0.0979 |

**Background Statistics Assuming Gamma Distribution**

| | | | |
|---|---|---|---|
| 95% Wilson Hilferty (WH) Approx. Gamma UPL | 7.835 | 90% Percentile | 7.795 |
| 95% Hawkins Wixley (HW) Approx. Gamma UPL | 7.835 | 95% Percentile | 7.831 |
| 95% WH Approx. Gamma UTL with 95% Coverage | 7.904 | 99% Percentile | 7.899 |
| 95% HW Approx. Gamma UTL with 95% Coverage | 7.904 | | |
| 95% WH USL | 7.889 | 95% HW USL | 7.89 |

**Lognormal GOF Test**

| | | | |
|---|---|---|---|
| Shapiro Wilk Test Statistic | 0.953 | **Shapiro Wilk Lognormal GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Lognormal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.162 | **Lilliefors Lognormal GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data appear Lognormal at 5% Significance Level | |

Data appear Lognormal at 5% Significance Level

**Background Statistics assuming Lognormal Distribution**

| | | | |
|---|---|---|---|
| 95% UTL with 95% Coverage | 7.905 | 90% Percentile (z) | 7.786 |
| 95% UPL (t) | 7.835 | 95% Percentile (z) | 7.819 |
| 95% USL | 7.89 | 99% Percentile (z) | 7.882 |

**Nonparametric Distribution Free Background Statistics**

Data appear Normal at 5% Significance Level

**Nonparametric Upper Limits for Background Threshold Values**

| | | | |
|---|---|---|---|
| Order of Statistic, r | 15 | 95% UTL with 95% Coverage | 7.85 |
| Approx, f used to compute achieved CC | 0.789 | Approximate Actual Confidence Coefficient achieved by UTL | 0.537 |
| | | Approximate Sample Size needed to achieve specified CC | 59 |
| 95% Percentile Bootstrap UTL with 95% Coverage | 7.85 | 95% BCA Bootstrap UTL with 95% Coverage | 7.85 |
| 95% UPL | 7.85 | 90% Percentile | 7.766 |
| 90% Chebyshev UPL | 7.951 | 95% Percentile | 7.794 |
| 95% Chebyshev UPL | 8.078 | 99% Percentile | 7.839 |
| 95% USL | 7.85 | | |

Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20. Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers and consists of observations collected from clean unimpacted locations.

The use of USL tends to provide a balance between false positives and false negatives provided the data represents a background data set and when many onsite observations need to be compared with the BTV.

**VAL (specific conductance)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 15 | Number of Distinct Observations | 13 |
| Minimum | 245 | First Quartile | 429 |
| Second Largest | 450 | Median | 438 |
| Maximum | 450 | Third Quartile | 443.5 |
| Mean | 425.1 | SD | 50.56 |
| Coefficient of Variation | 0.119 | Skewness | -3.679 |
| Mean of logged Data | 6.043 | SD of logged Data | 0.151 |

**Critical Values for Background Threshold Values (BTVs)**

| | | | |
|---|---|---|---|
| Tolerance Factor K (For UTL) | 2.566 | d2max (for USL) | 2.409 |

**Normal GOF Test**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.442 | **Shapiro Wilk GOF Test** |
| 5% Shapiro Wilk Critical Value | 0.881 | Data Not Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.409 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.22 | Data Not Normal at 5% Significance Level |

Data Not Normal at 5% Significance Level

**Background Statistics Assuming Normal Distribution**

| | | | | |
|---|---|---|---|---|
| 95% UTL with | 95% Coverage | 554.8 | 90% Percentile (z) | 489.9 |
| | 95% UPL (t) | 517 | 95% Percentile (z) | 508.2 |
| | 95% USL | 546.9 | 99% Percentile (z) | 542.7 |

**Gamma GOF Test**

| | | |
|---|---|---|
| A-D Test Statistic | 3.668 | **Anderson-Darling Gamma GOF Test** |
| 5% A-D Critical Value | 0.734 | Data Not Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.43 | **Kolmogorov-Smirnov Gamma GOF Test** |
| 5% K-S Critical Value | 0.221 | Data Not Gamma Distributed at 5% Significance Level |

Data Not Gamma Distributed at 5% Significance Level

**Gamma Statistics**

| | | | |
|---|---|---|---|
| k hat (MLE) | 55.15 | k star (bias corrected MLE) | 44.16 |
| Theta hat (MLE) | 7.708 | Theta star (bias corrected MLE) | 9.625 |
| nu hat (MLE) | 1654 | nu star (bias corrected) | 1325 |
| MLE Mean (bias corrected) | 425.1 | MLE Sd (bias corrected) | 63.96 |

**Background Statistics Assuming Gamma Distribution**

| | | | |
|---|---|---|---|
| 95% Wilson Hilferty (WH) Approx. Gamma UPL | 539.1 | 90% Percentile | 508.8 |
| 95% Hawkins Wixley (HW) Approx. Gamma UPL | 542.6 | 95% Percentile | 535.5 |
| 95% WH Approx. Gamma UTL with 95% Coverage | 592.5 | 99% Percentile | 587.8 |
| 95% HW Approx. Gamma UTL with 95% Coverage | 598.8 | | |
| 95% WH USL | 581 | 95% HW USL | 586.7 |

**Lognormal GOF Test**

| | | | |
|---|---|---|---|
| Shapiro Wilk Test Statistic | 0.404 | **Shapiro Wilk Lognormal GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data Not Lognormal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.438 | **Lilliefors Lognormal GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data Not Lognormal at 5% Significance Level | |

Data Not Lognormal at 5% Significance Level

**Background Statistics assuming Lognormal Distribution**

| | | | |
|---|---|---|---|
| 95% UTL with 95% Coverage | 620.9 | 90% Percentile (z) | 511.3 |
| 95% UPL (t) | 554.6 | 95% Percentile (z) | 540.2 |
| 95% USL | 606.3 | 99% Percentile (z) | 598.8 |

**Nonparametric Distribution Free Background Statistics**

Data do not follow a Discernible Distribution (0.05)

**Nonparametric Upper Limits for Background Threshold Values**

| | | | |
|---|---|---|---|
| Order of Statistic, r | 15 | 95% UTL with 95% Coverage | 450 |
| Approx, f used to compute achieved CC | 0.789 | Approximate Actual Confidence Coefficient achieved by UTL | 0.537 |
| | | Approximate Sample Size needed to achieve specified CC | 59 |
| 95% Percentile Bootstrap UTL with 95% Coverage | 450 | 95% BCA Bootstrap UTL with 95% Coverage | 450 |
| 95% UPL | 450 | 90% Percentile | 448.8 |
| 90% Chebyshev UPL | 581.7 | 95% Percentile | 450 |
| 95% Chebyshev UPL | 652.7 | 99% Percentile | 450 |
| 95% USL | 450 | | |

Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20. Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers and consists of observations collected from clean unimpacted locations.

The use of USL tends to provide a balance between false positives and false negatives provided the data represents a background data set and when many onsite observations need to be compared with the BTV.

**VAL (sulfate)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 15 | Number of Distinct Observations | 13 |
| Minimum | 40200 | First Quartile | 41800 |
| Second Largest | 46000 | Median | 44000 |
| Maximum | 47000 | Third Quartile | 44700 |
| Mean | 43363 | SD | 1991 |
| Coefficient of Variation | 0.0459 | Skewness | 0.109 |
| Mean of logged Data | 10.68 | SD of logged Data | 0.0459 |

**Critical Values for Background Threshold Values (BTVs)**

| | | | |
|---|---|---|---|
| Tolerance Factor K (For UTL) | 2.566 | d2max (for USL) | 2.409 |

**Normal GOF Test**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.963 | **Shapiro Wilk GOF Test** |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.159 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.22 | Data appear Normal at 5% Significance Level |

Data appear Normal at 5% Significance Level

**Background Statistics Assuming Normal Distribution**

| | | | |
|---|---|---|---|
| 95% UTL with 95% Coverage | 48472 | 90% Percentile (z) | 45915 |
| 95% UPL (t) | 46985 | 95% Percentile (z) | 46638 |
| 95% USL | 48160 | 99% Percentile (z) | 47995 |

**Gamma GOF Test**

| | | |
|---|---|---|
| A-D Test Statistic | 0.312 | **Anderson-Darling Gamma GOF Test** |
| 5% A-D Critical Value | 0.734 | Detected data appear Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.168 | **Kolmogorov-Smirnov Gamma GOF Test** |
| 5% K-S Critical Value | 0.221 | Detected data appear Gamma Distributed at 5% Significance Level |

Detected data appear Gamma Distributed at 5% Significance Level

**Gamma Statistics**

| | | | |
|---|---|---|---|
| k hat (MLE) | 508.9 | k star (bias corrected MLE) | 407.2 |
| Theta hat (MLE) | 85.21 | Theta star (bias corrected MLE) | 106.5 |
| nu hat (MLE) | 15268 | nu star (bias corrected) | 12216 |
| MLE Mean (bias corrected) | 43363 | MLE Sd (bias corrected) | 2149 |

**Background Statistics Assuming Gamma Distribution**

| | | | |
|---|---|---|---|
| 95% Wilson Hilferty (WH) Approx. Gamma UPL | 47054 | 90% Percentile | 46139 |
| 95% Hawkins Wixley (HW) Approx. Gamma UPL | 47064 | 95% Percentile | 46958 |
| 95% WH Approx. Gamma UTL with 95% Coverage | 48641 | 99% Percentile | 48519 |
| 95% HW Approx. Gamma UTL with 95% Coverage | 48664 | | |
| 95% WH USL | 48305 | 95% HW USL | 48324 |

**Lognormal GOF Test**

| | | | |
|---|---|---|---|
| Shapiro Wilk Test Statistic | 0.963 | **Shapiro Wilk Lognormal GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Lognormal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.166 | **Lilliefors Lognormal GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data appear Lognormal at 5% Significance Level | |

Data appear Lognormal at 5% Significance Level

**Background Statistics assuming Lognormal Distribution**

| | | | |
|---|---|---|---|
| 95% UTL with 95% Coverage | 48734 | 90% Percentile (z) | 45944 |
| 95% UPL (t) | 47092 | 95% Percentile (z) | 46717 |
| 95% USL | 48384 | 99% Percentile (z) | 48201 |

**Nonparametric Distribution Free Background Statistics**

Data appear Normal at 5% Significance Level

**Nonparametric Upper Limits for Background Threshold Values**

| | | | |
|---|---|---|---|
| Order of Statistic, r | 15 | 95% UTL with 95% Coverage | 47000 |
| Approx, f used to compute achieved CC | 0.789 | Approximate Actual Confidence Coefficient achieved by UTL | 0.537 |
| | | Approximate Sample Size needed to achieve specified CC | 59 |
| 95% Percentile Bootstrap UTL with 95% Coverage | 47000 | 95% BCA Bootstrap UTL with 95% Coverage | 47000 |
| 95% UPL | 47000 | 90% Percentile | 45600 |
| 90% Chebyshev UPL | 49532 | 95% Percentile | 46300 |
| 95% Chebyshev UPL | 52326 | 99% Percentile | 46860 |
| 95% USL | 47000 | | |

Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20. Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers and consists of observations collected from clean unimpacted locations.

The use of USL tends to provide a balance between false positives and false negatives provided the data represents a background data set and when many onsite observations need to be compared with the BTV.

**VAL (temperature)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 15 | Number of Distinct Observations | 10 |
| Minimum | 17.8 | First Quartile | 18.35 |
| Second Largest | 19.2 | Median | 18.5 |
| Maximum | 19.6 | Third Quartile | 18.7 |
| Mean | 18.57 | SD | 0.448 |
| Coefficient of Variation | 0.0241 | Skewness | 0.802 |
| Mean of logged Data | 2.921 | SD of logged Data | 0.0239 |

**Critical Values for Background Threshold Values (BTVs)**

| | | | |
|---|---|---|---|
| Tolerance Factor K (For UTL) | 2.566 | d2max (for USL) | 2.409 |

**Normal GOF Test**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.934 | **Shapiro Wilk GOF Test** |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.189 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.22 | Data appear Normal at 5% Significance Level |

Data appear Normal at 5% Significance Level

**Background Statistics Assuming Normal Distribution**

| | | | | |
|---|---|---|---|---|
| 95% UTL with | 95% Coverage | 19.72 | 90% Percentile (z) | 19.15 |
| | 95% UPL (t) | 19.39 | 95% Percentile (z) | 19.31 |
| | 95% USL | 19.65 | 99% Percentile (z) | 19.62 |

**Gamma GOF Test**

| | | |
|---|---|---|
| A-D Test Statistic | 0.52 | **Anderson-Darling Gamma GOF Test** |
| 5% A-D Critical Value | 0.734 | Detected data appear Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.182 | **Kolmogorov-Smirnov Gamma GOF Test** |
| 5% K-S Critical Value | 0.221 | Detected data appear Gamma Distributed at 5% Significance Level |

Detected data appear Gamma Distributed at 5% Significance Level

**Gamma Statistics**

| | | | |
|---|---|---|---|
| k hat (MLE) | 1861 | k star (bias corrected MLE) | 1489 |
| Theta hat (MLE) | 0.00998 | Theta star (bias corrected MLE) | 0.0125 |
| nu hat (MLE) | 55837 | nu star (bias corrected) | 44671 |
| MLE Mean (bias corrected) | 18.57 | MLE Sd (bias corrected) | 0.481 |

**Background Statistics Assuming Gamma Distribution**

| | | | |
|---|---|---|---|
| 95% Wilson Hilferty (WH) Approx. Gamma UPL | 19.39 | 90% Percentile | 19.19 |
| 95% Hawkins Wixley (HW) Approx. Gamma UPL | 19.39 | 95% Percentile | 19.37 |
| 95% WH Approx. Gamma UTL with 95% Coverage | 19.74 | 99% Percentile | 19.71 |
| 95% HW Approx. Gamma UTL with 95% Coverage | 19.74 | | |
| 95% WH USL | 19.66 | 95% HW USL | 19.67 |

**Lognormal GOF Test**

| | | | |
|---|---|---|---|
| Shapiro Wilk Test Statistic | 0.939 | **Shapiro Wilk Lognormal GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Lognormal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.184 | **Lilliefors Lognormal GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data appear Lognormal at 5% Significance Level | |

Data appear Lognormal at 5% Significance Level

**Background Statistics assuming Lognormal Distribution**

| | | | |
|---|---|---|---|
| 95% UTL with 95% Coverage | 19.74 | 90% Percentile (z) | 19.15 |
| 95% UPL (t) | 19.39 | 95% Percentile (z) | 19.31 |
| 95% USL | 19.67 | 99% Percentile (z) | 19.63 |

**Nonparametric Distribution Free Background Statistics**

Data appear Normal at 5% Significance Level

**Nonparametric Upper Limits for Background Threshold Values**

| | | | |
|---|---|---|---|
| Order of Statistic, r | 15 | 95% UTL with 95% Coverage | 19.6 |
| Approx, f used to compute achieved CC | 0.789 | Approximate Actual Confidence Coefficient achieved by UTL | 0.537 |
| | | Approximate Sample Size needed to achieve specified CC | 59 |
| 95% Percentile Bootstrap UTL with 95% Coverage | 19.6 | 95% BCA Bootstrap UTL with 95% Coverage | 19.6 |
| 95% UPL | 19.6 | 90% Percentile | 19.16 |
| 90% Chebyshev UPL | 19.96 | 95% Percentile | 19.32 |
| 95% Chebyshev UPL | 20.59 | 99% Percentile | 19.54 |
| 95% USL | 19.6 | | |

Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20. Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers and consists of observations collected from clean unimpacted locations.

The use of USL tends to provide a balance between false positives and false negatives provided the data represents a background data set and when many onsite observations need to be compared with the BTV.

**VAL (total arsenic)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 14 | Number of Missing Observations | 0 |
| Number of Distinct Observations | 10 | | |
| Number of Detects | 8 | Number of Non-Detects | 6 |
| Number of Distinct Detects | 7 | Number of Distinct Non-Detects | 3 |
| Minimum Detect | 3.7 | Minimum Non-Detect | 4.4 |
| Maximum Detect | 9.9 | Maximum Non-Detect | 14 |
| Variance Detected | 5.958 | Percent Non-Detects | 42.86% |
| Mean Detected | 5.913 | SD Detected | 2.441 |
| Mean of Detected Logged Data | 1.707 | SD of Detected Logged Data | 0.392 |

**Critical Values for Background Threshold Values (BTVs)**

| | | | |
|---|---|---|---|
| Tolerance Factor K (For UTL) | 2.614 | d2max (for USL) | 2.372 |

**Normal GOF Test on Detects Only**

| | | | |
|---|---|---|---|
| Shapiro Wilk Test Statistic | 0.813 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.818 | Data Not Normal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.33 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.283 | Data Not Normal at 5% Significance Level | |

Data Not Normal at 5% Significance Level

**Kaplan Meier (KM) Background Statistics Assuming Normal Distribution**

| | | | |
|---|---|---|---|
| KM Mean | 5.195 | KM SD | 2.017 |
| 95% UTL95% Coverage | 10.47 | 95% KM UPL (t) | 8.893 |
| 90% KM Percentile (z) | 7.78 | 95% KM Percentile (z) | 8.513 |
| 99% KM Percentile (z) | 9.888 | 95% KM USL | 9.979 |

**DL/2 Substitution Background Statistics Assuming Normal Distribution**

| | | | |
|---|---|---|---|
| Mean | 4.729 | SD | 2.569 |
| 95% UTL95% Coverage | 11.44 | 95% UPL (t) | 9.437 |
| 90% Percentile (z) | 8.02 | 95% Percentile (z) | 8.954 |
| 99% Percentile (z) | 10.7 | 95% USL | 10.82 |

DL/2 is not a recommended method. DL/2 provided for comparisons and historical reasons

**Gamma GOF Tests on Detected Observations Only**

| | | | |
|---|---|---|---|
| A-D Test Statistic | 0.761 | **Anderson-Darling GOF Test** | |

| | | | |
|---|---|---|---|
| 5% A-D Critical Value | 0.717 | Data Not Gamma Distributed at 5% Significance Level | |
| K-S Test Statistic | 0.325 | **Kolmogorov-Smirnov GOF** | |
| 5% K-S Critical Value | 0.295 | Data Not Gamma Distributed at 5% Significance Level | |

**Data Not Gamma Distributed at 5% Significance Level**

**Gamma Statistics on Detected Data Only**

| | | | |
|---|---|---|---|
| k hat (MLE) | 7.313 | k star (bias corrected MLE) | 4.654 |
| Theta hat (MLE) | 0.808 | Theta star (bias corrected MLE) | 1.27 |
| nu hat (MLE) | 117 | nu star (bias corrected) | 74.47 |
| MLE Mean (bias corrected) | 5.913 | | |
| MLE Sd (bias corrected) | 2.741 | 95% Percentile of Chisquare (2kstar) | 17.35 |

**Gamma ROS Statistics using Imputed Non-Detects**

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)

For such situations, GROS method may yield incorrect values of UCLs and BTVs

This is especially true when the sample size is small.

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

| | | | |
|---|---|---|---|
| Minimum | 3.05 | Mean | 5.152 |
| Maximum | 9.9 | Median | 4.426 |
| SD | 2.091 | CV | 0.406 |
| k hat (MLE) | 7.902 | k star (bias corrected MLE) | 6.256 |
| Theta hat (MLE) | 0.652 | Theta star (bias corrected MLE) | 0.823 |
| nu hat (MLE) | 221.3 | nu star (bias corrected) | 175.2 |
| MLE Mean (bias corrected) | 5.152 | MLE Sd (bias corrected) | 2.06 |
| 95% Percentile of Chisquare (2kstar) | 21.71 | 90% Percentile | 7.905 |
| 95% Percentile | 8.94 | 99% Percentile | 11.11 |

**The following statistics are computed using Gamma ROS Statistics on Imputed Data**

**Upper Limits using Wilson Hilferty (WH) and Hawkins Wixley (HW) Methods**

| | WH | HW | | WH | HW |
|---|---|---|---|---|---|
| 95% Approx. Gamma UTL with 95% Coverage | 11.51 | 11.68 | 95% Approx. Gamma UPL | 9.151 | 9.186 |
| 95% Gamma USL | 10.74 | 10.86 | | | |

**Estimates of Gamma Parameters using KM Estimates**

| | | | |
|---|---|---|---|
| Mean (KM) | 5.195 | SD (KM) | 2.017 |
| Variance (KM) | 4.069 | SE of Mean (KM) | 0.603 |
| k hat (KM) | 6.633 | k star (KM) | 5.259 |
| nu hat (KM) | 185.7 | nu star (KM) | 147.3 |

| | | | |
|---|---|---|---|
| theta hat (KM) | 0.783 | theta star (KM) | 0.988 |
| 80% gamma percentile (KM) | 6.944 | 90% gamma percentile (KM) | 8.227 |
| 95% gamma percentile (KM) | 9.394 | 99% gamma percentile (KM) | 11.85 |

**The following statistics are computed using gamma distribution and KM estimates**

**Upper Limits using Wilson Hilferty (WH) and Hawkins Wixley (HW) Methods**

| | WH | HW | | WH | HW |
|---|---|---|---|---|---|
| 95% Approx. Gamma UTL with 95% Coverage | 11.06 | 11.17 | 95% Approx. Gamma UPL | 8.907 | 8.912 |
| 95% KM Gamma Percentile | 8.432 | 8.423 | 95% Gamma USL | 10.36 | 10.43 |

**Lognormal GOF Test on Detected Observations Only**

| | | | |
|---|---|---|---|
| Shapiro Wilk Test Statistic | 0.837 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.818 | Detected Data appear Lognormal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.303 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.283 | Data Not Lognormal at 5% Significance Level | |

Detected Data appear Approximate Lognormal at 5% Significance Level

**Background Lognormal ROS Statistics Assuming Lognormal Distribution Using Imputed Non-Detects**

| | | | |
|---|---|---|---|
| Mean in Original Scale | 5.196 | Mean in Log Scale | 1.589 |
| SD in Original Scale | 2.038 | SD in Log Scale | 0.339 |
| 95% UTL95% Coverage | 11.88 | 95% BCA UTL95% Coverage | 9.9 |
| 95% Bootstrap (%) UTL95% Coverage | 9.9 | 95% UPL (t) | 9.116 |
| 90% Percentile (z) | 7.563 | 95% Percentile (z) | 8.553 |
| 99% Percentile (z) | 10.77 | 95% USL | 10.94 |

**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**

| | | | |
|---|---|---|---|
| KM Mean of Logged Data | 1.587 | 95% KM UTL (Lognormal)95% Coverage | 11.55 |
| KM SD of Logged Data | 0.329 | 95% KM UPL (Lognormal) | 8.933 |
| 95% KM Percentile Lognormal (z) | 8.397 | 95% KM USL (Lognormal) | 10.66 |

**Background DL/2 Statistics Assuming Lognormal Distribution**

| | | | |
|---|---|---|---|
| Mean in Original Scale | 4.729 | Mean in Log Scale | 1.423 |
| SD in Original Scale | 2.569 | SD in Log Scale | 0.524 |
| 95% UTL95% Coverage | 16.34 | 95% UPL (t) | 10.85 |
| 90% Percentile (z) | 8.127 | 95% Percentile (z) | 9.832 |
| 99% Percentile (z) | 14.05 | 95% USL | 14.39 |

DL/2 is not a Recommended Method. DL/2 provided for comparisons and historical reasons.

**Nonparametric Distribution Free Background Statistics**

Data appear to follow a Discernible Distribution at 5% Significance Level

**Nonparametric Upper Limits for BTVs(no distinction made between detects and nondetects)**

| | | | |
|---|---|---|---|
| Order of Statistic, r | 14 | 95% UTL with95% Coverage | 14 |
| Approx, f used to compute achieved CC | 0.737 | Approximate Actual Confidence Coefficient achieved by UTL | 0.512 |
| Approximate Sample Size needed to achieve specified CC | 59 | 95% UPL | 14 |
| 95% USL | 14 | 95% KM Chebyshev UPL | 14.3 |

Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.
Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers and consists of observations collected from clean unimpacted locations.
The use of USL tends to provide a balance between false positives and false negatives provided the data represents a background data set and when many onsite observations need to be compared with the BTV.

**VAL (total calcium)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 15 | Number of Distinct Observations | 15 |
| Minimum | 46700 | First Quartile | 49350 |
| Second Largest | 55100 | Median | 50200 |
| Maximum | 55500 | Third Quartile | 51600 |
| Mean | 50687 | SD | 2362 |
| Coefficient of Variation | 0.0466 | Skewness | 0.765 |
| Mean of logged Data | 10.83 | SD of logged Data | 0.046 |

**Critical Values for Background Threshold Values (BTVs)**

| | | | |
|---|---|---|---|
| Tolerance Factor K (For UTL) | 2.566 | d2max (for USL) | 2.409 |

**Normal GOF Test**

| | | | |
|---|---|---|---|
| Shapiro Wilk Test Statistic | 0.93 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Normal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.181 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data appear Normal at 5% Significance Level | |

Data appear Normal at 5% Significance Level

**Background Statistics Assuming Normal Distribution**

| | | | | | |
|---|---|---|---|---|---|
| 95% UTL with | 95% Coverage | 56748 | | 90% Percentile (z) | 53714 |
| | 95% UPL (t) | 54984 | | 95% Percentile (z) | 54572 |
| | 95% USL | 56377 | | 99% Percentile (z) | 56182 |

**Gamma GOF Test**

| | | | |
|---|---|---|---|
| A-D Test Statistic | 0.467 | **Anderson-Darling Gamma GOF Test** | |
| 5% A-D Critical Value | 0.734 | Detected data appear Gamma Distributed at 5% Significance Level | |
| K-S Test Statistic | 0.172 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 5% K-S Critical Value | 0.221 | Detected data appear Gamma Distributed at 5% Significance Level | |

Detected data appear Gamma Distributed at 5% Significance Level

**Gamma Statistics**

| | | | |
|---|---|---|---|
| k hat (MLE) | 502.4 | k star (bias corrected MLE) | 401.9 |
| Theta hat (MLE) | 100.9 | Theta star (bias corrected MLE) | 126.1 |
| nu hat (MLE) | 15071 | nu star (bias corrected) | 12058 |
| MLE Mean (bias corrected) | 50687 | MLE Sd (bias corrected) | 2528 |

**Background Statistics Assuming Gamma Distribution**

| | | | |
|---|---|---|---|
| 95% Wilson Hilferty (WH) Approx. Gamma UPL | 55030 | 90% Percentile | 53953 |
| 95% Hawkins Wixley (HW) Approx. Gamma UPL | 55036 | 95% Percentile | 54916 |
| 95% WH Approx. Gamma UTL with 95% Coverage | 56897 | 99% Percentile | 56753 |
| 95% HW Approx. Gamma UTL with 95% Coverage | 56917 | | |
| 95% WH USL | 56501 | 95% HW USL | 56518 |

**Lognormal GOF Test**

| | | | |
|---|---|---|---|
| Shapiro Wilk Test Statistic | 0.94 | **Shapiro Wilk Lognormal GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Lognormal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.171 | **Lilliefors Lognormal GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data appear Lognormal at 5% Significance Level | |

Data appear Lognormal at 5% Significance Level

**Background Statistics assuming Lognormal Distribution**

| | | | | | |
|---|---|---|---|---|---|
| 95% UTL with | 95% Coverage | 56979 | | 90% Percentile (z) | 53711 |
| | 95% UPL (t) | 55055 | | 95% Percentile (z) | 54616 |
| | 95% USL | 56569 | | 99% Percentile (z) | 56355 |

**Nonparametric Distribution Free Background Statistics**

Data appear Normal at 5% Significance Level

**Nonparametric Upper Limits for Background Threshold Values**

| | | | |
|---|---|---|---|
| Order of Statistic, r | 15 | 95% UTL with 95% Coverage | 55500 |
| Approx, f used to compute achieved CC | 0.789 | Approximate Actual Confidence Coefficient achieved by UTL | 0.537 |
| | | Approximate Sample Size needed to achieve specified CC | 59 |
| 95% Percentile Bootstrap UTL with 95% Coverage | 55500 | 95% BCA Bootstrap UTL with 95% Coverage | 55500 |
| 95% UPL | 55500 | 90% Percentile | 54100 |
| 90% Chebyshev UPL | 58006 | 95% Percentile | 55220 |
| 95% Chebyshev UPL | 61321 | 99% Percentile | 55444 |
| 95% USL | 55500 | | |

Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.
Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers and consists of observations collected from clean unimpacted locations.
The use of USL tends to provide a balance between false positives and false negatives provided the data represents a background data set and when many onsite observations need to be compared with the BTV.

**VAL (total dissolved solids)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 2 | Number of Distinct Observations | 2 |
| Minimum | 271000 | First Quartile | 279000 |
| Second Largest | 271000 | Median | 287000 |
| Maximum | 303000 | Third Quartile | 295000 |
| Mean | 287000 | SD | 22627 |
| Coefficient of Variation | 0.0788 | Skewness | N/A |

Warning: This data set only has 2 observations!
Data set is too small to compute reliable and meaningful statistics and estimates!
The data set for variable VAL (total dissolved solids) was not processed!

It is suggested to collect at least 8 to 10 observations before using these statistical methods!
If possible, compute and collect Data Quality Objectives (DQO) based sample size and analytical results.

**VAL (total iron)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 15 | Number of Missing Observations | 0 |
| Number of Distinct Observations | 5 | | |

| | | | |
|---|---|---|---|
| Number of Detects | 1 | Number of Non-Detects | 14 |
| Number of Distinct Detects | 1 | Number of Distinct Non-Detects | 4 |
| Minimum Detect | 37 | Minimum Non-Detect | 22 |
| Maximum Detect | 37 | Maximum Non-Detect | 53 |
| Variance Detected | N/A | Percent Non-Detects | 93.33% |
| Mean Detected | 37 | SD Detected | N/A |
| Mean of Detected Logged Data | 3.611 | SD of Detected Logged Data | N/A |

Warning: Only one distinct data value was detected! ProUCL (or any other software) should not be used on such a data set!

It is suggested to use alternative site specific values determined by the Project Team to estimate environmental parameters (e.g., EPC, BTV).

The data set for variable VAL (total iron) was not processed!

**VAL (total magnesium)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 15 | Number of Distinct Observations | 11 |
| Minimum | 12000 | First Quartile | 12250 |
| Second Largest | 13900 | Median | 12750 |
| Maximum | 14300 | Third Quartile | 12850 |
| Mean | 12743 | SD | 651.1 |
| Coefficient of Variation | 0.0511 | Skewness | 1.178 |
| Mean of logged Data | 9.452 | SD of logged Data | 0.0499 |

**Critical Values for Background Threshold Values (BTVs)**

| | | | |
|---|---|---|---|
| Tolerance Factor K (For UTL) | 2.566 | d2max (for USL) | 2.409 |

**Normal GOF Test**

| | | | |
|---|---|---|---|
| Shapiro Wilk Test Statistic | 0.863 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data Not Normal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.213 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data appear Normal at 5% Significance Level | |

Data appear Approximate Normal at 5% Significance Level

**Background Statistics Assuming Normal Distribution**

| | | | | |
|---|---|---|---|---|
| 95% UTL with | 95% Coverage | 14414 | 90% Percentile (z) | 13578 |
| | 95% UPL (t) | 13928 | 95% Percentile (z) | 13814 |
| | 95% USL | 14312 | 99% Percentile (z) | 14258 |

**Gamma GOF Test**

| | | | |
|---|---|---|---|
| A-D Test Statistic | 0.75 | **Anderson-Darling Gamma GOF Test** | |
| 5% A-D Critical Value | 0.734 | Data Not Gamma Distributed at 5% Significance Level | |
| K-S Test Statistic | 0.201 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 5% K-S Critical Value | 0.221 | Detected data appear Gamma Distributed at 5% Significance Level | |

Detected data follow Appr. Gamma Distribution at 5% Significance Level

**Gamma Statistics**

| | | | |
|---|---|---|---|
| k hat (MLE) | 423.6 | k star (bias corrected MLE) | 338.9 |
| Theta hat (MLE) | 30.08 | Theta star (bias corrected MLE) | 37.6 |
| nu hat (MLE) | 12708 | nu star (bias corrected) | 10168 |
| MLE Mean (bias corrected) | 12743 | MLE Sd (bias corrected) | 692.2 |

**Background Statistics Assuming Gamma Distribution**

| | | | |
|---|---|---|---|
| 95% Wilson Hilferty (WH) Approx. Gamma UPL | 13934 | 90% Percentile | 13638 |
| 95% Hawkins Wixley (HW) Approx. Gamma UPL | 13935 | 95% Percentile | 13903 |
| 95% WH Approx. Gamma UTL with 95% Coverage | 14449 | 99% Percentile | 14409 |
| 95% HW Approx. Gamma UTL with 95% Coverage | 14453 | | |
| 95% WH USL | 14340 | 95% HW USL | 14343 |

**Lognormal GOF Test**

| | | | |
|---|---|---|---|
| Shapiro Wilk Test Statistic | 0.876 | **Shapiro Wilk Lognormal GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data Not Lognormal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.203 | **Lilliefors Lognormal GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data appear Lognormal at 5% Significance Level | |

Data appear Approximate Lognormal at 5% Significance Level

**Background Statistics assuming Lognormal Distribution**

| | | | |
|---|---|---|---|
| 95% UTL with 95% Coverage | 14468 | 90% Percentile (z) | 13569 |
| 95% UPL (t) | 13938 | 95% Percentile (z) | 13818 |
| 95% USL | 14355 | 99% Percentile (z) | 14296 |

**Nonparametric Distribution Free Background Statistics**

Data appear Approximate Normal at 5% Significance Level

**Nonparametric Upper Limits for Background Threshold Values**

| | | | |
|---|---|---|---|
| Order of Statistic, r | 15 | 95% UTL with 95% Coverage | 14300 |
| Approx, f used to compute achieved CC | 0.789 | Approximate Actual Confidence Coefficient achieved by UTL | 0.537 |

| | | | |
|---|---|---|---|
| | | Approximate Sample Size needed to achieve specified CC | 59 |
| 95% Percentile Bootstrap UTL with 95% Coverage | 14300 | 95% BCA Bootstrap UTL with 95% Coverage | 14300 |
| 95% UPL | 14300 | 90% Percentile | 13540 |
| 90% Chebyshev UPL | 14761 | 95% Percentile | 14020 |
| 95% Chebyshev UPL | 15674 | 99% Percentile | 14244 |
| 95% USL | 14300 | | |

Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20. Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers and consists of observations collected from clean unimpacted locations.

The use of USL tends to provide a balance between false positives and false negatives provided the data represents a background data set and when many onsite observations need to be compared with the BTV.

**VAL (total manganese)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 15 | Number of Missing Observations | 0 |
| Number of Distinct Observations | 13 | | |
| Number of Detects | 6 | Number of Non-Detects | 9 |
| Number of Distinct Detects | 6 | Number of Distinct Non-Detects | 7 |
| Minimum Detect | 0.31 | Minimum Non-Detect | 0.26 |
| Maximum Detect | 2.97 | Maximum Non-Detect | 4 |
| Variance Detected | 1.066 | Percent Non-Detects | 60% |
| Mean Detected | 1.02 | SD Detected | 1.032 |
| Mean of Detected Logged Data | -0.325 | SD of Detected Logged Data | 0.856 |

**Critical Values for Background Threshold Values (BTVs)**

| | | | |
|---|---|---|---|
| Tolerance Factor K (For UTL) | 2.566 | d2max (for USL) | 2.409 |

**Normal GOF Test on Detects Only**

| | | | |
|---|---|---|---|
| Shapiro Wilk Test Statistic | 0.736 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.788 | Data Not Normal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.356 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.325 | Data Not Normal at 5% Significance Level | |

Data Not Normal at 5% Significance Level

**Kaplan Meier (KM) Background Statistics Assuming Normal Distribution**

| | | | |
|---|---|---|---|
| KM Mean | 0.731 | KM SD | 0.733 |
| 95% UTL95% Coverage | 2.613 | 95% KM UPL (t) | 2.065 |

| | | | |
|---|---|---|---|
| 90% KM Percentile (z) | 1.671 | 95% KM Percentile (z) | 1.938 |
| 99% KM Percentile (z) | 2.437 | 95% KM USL | 2.498 |

**DL/2 Substitution Background Statistics Assuming Normal Distribution**

| | | | |
|---|---|---|---|
| Mean | 1.035 | SD | 0.782 |
| 95% UTL95% Coverage | 3.042 | 95% UPL (t) | 2.458 |
| 90% Percentile (z) | 2.037 | 95% Percentile (z) | 2.322 |
| 99% Percentile (z) | 2.855 | 95% USL | 2.92 |

DL/2 is not a recommended method. DL/2 provided for comparisons and historical reasons

**Gamma GOF Tests on Detected Observations Only**

| | | | |
|---|---|---|---|
| A-D Test Statistic | 0.644 | **Anderson-Darling GOF Test** | |
| 5% A-D Critical Value | 0.707 | Detected data appear Gamma Distributed at 5% Significance Level | |
| K-S Test Statistic | 0.36 | **Kolmogorov-Smirnov GOF** | |
| 5% K-S Critical Value | 0.337 | Data Not Gamma Distributed at 5% Significance Level | |

Detected data follow Appr. Gamma Distribution at 5% Significance Level

**Gamma Statistics on Detected Data Only**

| | | | |
|---|---|---|---|
| k hat (MLE) | 1.595 | k star (bias corrected MLE) | 0.909 |
| Theta hat (MLE) | 0.64 | Theta star (bias corrected MLE) | 1.123 |
| nu hat (MLE) | 19.14 | nu star (bias corrected) | 10.9 |
| MLE Mean (bias corrected) | 1.02 | | |
| MLE Sd (bias corrected) | 1.07 | 95% Percentile of Chisquare (2kstar) | 5.632 |

**Gamma ROS Statistics using Imputed Non-Detects**

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)

For such situations, GROS method may yield incorrect values of UCLs and BTVs

This is especially true when the sample size is small.

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

| | | | |
|---|---|---|---|
| Minimum | 0.01 | Mean | 0.626 |
| Maximum | 2.97 | Median | 0.384 |
| SD | 0.732 | CV | 1.17 |
| k hat (MLE) | 1.037 | k star (bias corrected MLE) | 0.874 |
| Theta hat (MLE) | 0.603 | Theta star (bias corrected MLE) | 0.715 |
| nu hat (MLE) | 31.12 | nu star (bias corrected) | 26.23 |
| MLE Mean (bias corrected) | 0.626 | MLE Sd (bias corrected) | 0.669 |
| 95% Percentile of Chisquare (2kstar) | 5.495 | 90% Percentile | 1.489 |

| | | | |
|---|---|---|---|
| 95% Percentile | 1.966 | 99% Percentile | 3.084 |

**The following statistics are computed using Gamma ROS Statistics on Imputed Data**

**Upper Limits using Wilson Hilferty (WH) and Hawkins Wixley (HW) Methods**

| | WH | HW | | WH | HW |
|---|---|---|---|---|---|
| 95% Approx. Gamma UTL with 95% Coverage | 3.261 | 3.712 | 95% Approx. Gamma UPL | 2.068 | 2.209 |
| 95% Gamma USL | 2.98 | 3.346 | | | |

**Estimates of Gamma Parameters using KM Estimates**

| | | | |
|---|---|---|---|
| Mean (KM) | 0.731 | SD (KM) | 0.733 |
| Variance (KM) | 0.538 | SE of Mean (KM) | 0.24 |
| k hat (KM) | 0.994 | k star (KM) | 0.839 |
| nu hat (KM) | 29.81 | nu star (KM) | 25.18 |
| theta hat (KM) | 0.736 | theta star (KM) | 0.871 |
| 80% gamma percentile (KM) | 1.192 | 90% gamma percentile (KM) | 1.757 |
| 95% gamma percentile (KM) | 2.331 | 99% gamma percentile (KM) | 3.682 |

**The following statistics are computed using gamma distribution and KM estimates**

**Upper Limits using Wilson Hilferty (WH) and Hawkins Wixley (HW) Methods**

| | WH | HW | | WH | HW |
|---|---|---|---|---|---|
| 95% Approx. Gamma UTL with 95% Coverage | 2.812 | 2.878 | 95% Approx. Gamma UPL | 1.927 | 1.918 |
| 95% KM Gamma Percentile | 1.752 | 1.734 | 95% Gamma USL | 2.608 | 2.652 |

**Lognormal GOF Test on Detected Observations Only**

| | | | |
|---|---|---|---|
| Shapiro Wilk Test Statistic | 0.862 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.788 | Detected Data appear Lognormal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.324 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.325 | Detected Data appear Lognormal at 5% Significance Level | |

Detected Data appear Lognormal at 5% Significance Level

**Background Lognormal ROS Statistics Assuming Lognormal Distribution Using Imputed Non-Detects**

| | | | |
|---|---|---|---|
| Mean in Original Scale | 0.659 | Mean in Log Scale | -0.713 |
| SD in Original Scale | 0.701 | SD in Log Scale | 0.721 |
| 95% UTL95% Coverage | 3.121 | 95% BCA UTL95% Coverage | 2.97 |
| 95% Bootstrap (%) UTL95% Coverage | 2.97 | 95% UPL (t) | 1.821 |
| 90% Percentile (z) | 1.236 | 95% Percentile (z) | 1.606 |
| 99% Percentile (z) | 2.626 | 95% USL | 2.787 |

**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**

| | | | |
|---|---|---|---|
| KM Mean of Logged Data | -0.619 | 95% KM UTL (Lognormal)95% Coverage | 3.211 |
| KM SD of Logged Data | 0.696 | 95% KM UPL (Lognormal) | 1.909 |
| 95% KM Percentile Lognormal (z) | 1.691 | 95% KM USL (Lognormal) | 2.879 |

**Background DL/2 Statistics Assuming Lognormal Distribution**

| | | | |
|---|---|---|---|
| Mean in Original Scale | 1.035 | Mean in Log Scale | -0.25 |
| SD in Original Scale | 0.782 | SD in Log Scale | 0.828 |
| 95% UTL95% Coverage | 6.509 | 95% UPL (t) | 3.508 |
| 90% Percentile (z) | 2.248 | 95% Percentile (z) | 3.037 |
| 99% Percentile (z) | 5.338 | 95% USL | 5.716 |

DL/2 is not a Recommended Method. DL/2 provided for comparisons and historical reasons.

**Nonparametric Distribution Free Background Statistics**

Data appear to follow a Discernible Distribution at 5% Significance Level

**Nonparametric Upper Limits for BTVs(no distinction made between detects and nondetects)**

| | | | |
|---|---|---|---|
| Order of Statistic, r | 15 | 95% UTL with95% Coverage | 4 |
| Approx, f used to compute achieved CC | 0.789 | Approximate Actual Confidence Coefficient achieved by UTL | 0.537 |
| Approximate Sample Size needed to achieve specified CC | 59 | 95% UPL | 4 |
| 95% USL | 4 | 95% KM Chebyshev UPL | 4.033 |

Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20. Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers and consists of observations collected from clean unimpacted locations.

The use of USL tends to provide a balance between false positives and false negatives provided the data represents a background data set and when many onsite observations need to be compared with the BTV.

**VAL (total organic carbon)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 2 | Number of Missing Observations | 0 |
| Number of Distinct Observations | 1 | | |
| Number of Detects | 0 | Number of Non-Detects | 2 |
| Number of Distinct Detects | 0 | Number of Distinct Non-Detects | 1 |
| Minimum Detect | N/A | Minimum Non-Detect | 330 |
| Maximum Detect | N/A | Maximum Non-Detect | 330 |
| Variance Detected | N/A | Percent Non-Detects | 100% |
| Mean Detected | N/A | SD Detected | N/A |

| | | | |
|---|---|---|---|
| Mean of Detected Logged Data | N/A | SD of Detected Logged Data | N/A |

Warning: This data set only has 2 observations!

Data set is too small to compute reliable and meaningful statistics and estimates!

The data set for variable VAL (total organic carbon) was not processed!

It is suggested to collect at least 8 to 10 observations before using these statistical methods!

If possible, compute and collect Data Quality Objectives (DQO) based sample size and analytical results.

**VAL (total potassium)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 15 | Number of Distinct Observations | 14 |
| Minimum | 6030 | First Quartile | 6470 |
| Second Largest | 7400 | Median | 6630 |
| Maximum | 7900 | Third Quartile | 7005 |
| Mean | 6765 | SD | 498.3 |
| Coefficient of Variation | 0.0737 | Skewness | 0.659 |
| Mean of logged Data | 8.817 | SD of logged Data | 0.0725 |

**Critical Values for Background Threshold Values (BTVs)**

| | | | |
|---|---|---|---|
| Tolerance Factor K (For UTL) | 2.566 | d2max (for USL) | 2.409 |

**Normal GOF Test**

| | | | |
|---|---|---|---|
| Shapiro Wilk Test Statistic | 0.95 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Normal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.159 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data appear Normal at 5% Significance Level | |

Data appear Normal at 5% Significance Level

**Background Statistics Assuming Normal Distribution**

| | | | |
|---|---|---|---|
| 95% UTL with 95% Coverage | 8044 | 90% Percentile (z) | 7404 |
| 95% UPL (t) | 7671 | 95% Percentile (z) | 7585 |
| 95% USL | 7965 | 99% Percentile (z) | 7924 |

**Gamma GOF Test**

| | | | |
|---|---|---|---|
| A-D Test Statistic | 0.324 | **Anderson-Darling Gamma GOF Test** | |
| 5% A-D Critical Value | 0.734 | Detected data appear Gamma Distributed at 5% Significance Level | |

| | | | |
|---|---|---|---|
| K-S Test Statistic | 0.161 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 5% K-S Critical Value | 0.221 | Detected data appear Gamma Distributed at 5% Significance Level | |

Detected data appear Gamma Distributed at 5% Significance Level

**Gamma Statistics**

| | | | |
|---|---|---|---|
| k hat (MLE) | 201.9 | k star (bias corrected MLE) | 161.6 |
| Theta hat (MLE) | 33.51 | Theta star (bias corrected MLE) | 41.87 |
| nu hat (MLE) | 6057 | nu star (bias corrected) | 4847 |
| MLE Mean (bias corrected) | 6765 | MLE Sd (bias corrected) | 532.2 |

**Background Statistics Assuming Gamma Distribution**

| | | | |
|---|---|---|---|
| 95% Wilson Hilferty (WH) Approx. Gamma UPL | 7689 | 90% Percentile | 7455 |
| 95% Hawkins Wixley (HW) Approx. Gamma UPL | 7692 | 95% Percentile | 7664 |
| 95% WH Approx. Gamma UTL with 95% Coverage | 8097 | 99% Percentile | 8064 |
| 95% HW Approx. Gamma UTL with 95% Coverage | 8105 | | |
| 95% WH USL | 8011 | 95% HW USL | 8017 |

**Lognormal GOF Test**

| | | | |
|---|---|---|---|
| Shapiro Wilk Test Statistic | 0.959 | **Shapiro Wilk Lognormal GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Lognormal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.153 | **Lilliefors Lognormal GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data appear Lognormal at 5% Significance Level | |

Data appear Lognormal at 5% Significance Level

**Background Statistics assuming Lognormal Distribution**

| | | | |
|---|---|---|---|
| 95% UTL with 95% Coverage | 8129 | 90% Percentile (z) | 7406 |
| 95% UPL (t) | 7700 | 95% Percentile (z) | 7603 |
| 95% USL | 8037 | 99% Percentile (z) | 7989 |

**Nonparametric Distribution Free Background Statistics**

Data appear Normal at 5% Significance Level

**Nonparametric Upper Limits for Background Threshold Values**

| | | | |
|---|---|---|---|
| Order of Statistic, r | 15 | 95% UTL with 95% Coverage | 7900 |
| Approx, f used to compute achieved CC | 0.789 | Approximate Actual Confidence Coefficient achieved by UTL | 0.537 |
| | | Approximate Sample Size needed to achieve specified CC | 59 |
| 95% Percentile Bootstrap UTL with 95% Coverage | 7900 | 95% BCA Bootstrap UTL with 95% Coverage | 7900 |
| 95% UPL | 7900 | 90% Percentile | 7308 |
| 90% Chebyshev UPL | 8309 | 95% Percentile | 7550 |

| | | | |
|---|---|---|---|
| 95% Chebyshev UPL | 9008 | 99% Percentile | 7830 |
| 95% USL | 7900 | | |

Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20. Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers and consists of observations collected from clean unimpacted locations.
The use of USL tends to provide a balance between false positives and false negatives provided the data represents a background data set and when many onsite observations need to be compared with the BTV.

**VAL (total sodium)**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 15 | Number of Distinct Observations | 12 |
| Minimum | 18400 | First Quartile | 20150 |
| Second Largest | 22200 | Median | 21000 |
| Maximum | 23800 | Third Quartile | 21600 |
| Mean | 20860 | SD | 1350 |
| Coefficient of Variation | 0.0647 | Skewness | 0.0614 |
| Mean of logged Data | 9.944 | SD of logged Data | 0.065 |

**Critical Values for Background Threshold Values (BTVs)**

| | | | |
|---|---|---|---|
| Tolerance Factor K (For UTL) | 2.566 | d2max (for USL) | 2.409 |

**Normal GOF Test**

| | | | |
|---|---|---|---|
| Shapiro Wilk Test Statistic | 0.954 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Normal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.153 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data appear Normal at 5% Significance Level | |

**Data appear Normal at 5% Significance Level**

**Background Statistics Assuming Normal Distribution**

| | | | |
|---|---|---|---|
| 95% UTL with 95% Coverage | 24324 | 90% Percentile (z) | 22590 |
| 95% UPL (t) | 23316 | 95% Percentile (z) | 23081 |
| 95% USL | 24112 | 99% Percentile (z) | 24001 |

**Gamma GOF Test**

| | | | |
|---|---|---|---|
| A-D Test Statistic | 0.371 | **Anderson-Darling Gamma GOF Test** | |
| 5% A-D Critical Value | 0.734 | Detected data appear Gamma Distributed at 5% Significance Level | |
| K-S Test Statistic | 0.152 | **Kolmogorov-Smirnov Gamma GOF Test** | |

| | | | |
|---|---|---|---|
| 5% K-S Critical Value | 0.221 | Detected data appear Gamma Distributed at 5% Significance Level | |

Detected data appear Gamma Distributed at 5% Significance Level

**Gamma Statistics**

| | | | |
|---|---|---|---|
| k hat (MLE) | 254.9 | k star (bias corrected MLE) | 204 |
| Theta hat (MLE) | 81.83 | Theta star (bias corrected MLE) | 102.3 |
| nu hat (MLE) | 7648 | nu star (bias corrected) | 6120 |
| MLE Mean (bias corrected) | 20860 | MLE Sd (bias corrected) | 1461 |

**Background Statistics Assuming Gamma Distribution**

| | | | |
|---|---|---|---|
| 95% Wilson Hilferty (WH) Approx. Gamma UPL | 23389 | 90% Percentile | 22752 |
| 95% Hawkins Wixley (HW) Approx. Gamma UPL | 23399 | 95% Percentile | 23319 |
| 95% WH Approx. Gamma UTL with 95% Coverage | 24496 | 99% Percentile | 24407 |
| 95% HW Approx. Gamma UTL with 95% Coverage | 24520 | | |
| 95% WH USL | 24260 | 95% HW USL | 24281 |

**Lognormal GOF Test**

| | | | |
|---|---|---|---|
| Shapiro Wilk Test Statistic | 0.952 | **Shapiro Wilk Lognormal GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Lognormal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.161 | **Lilliefors Lognormal GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data appear Lognormal at 5% Significance Level | |

Data appear Lognormal at 5% Significance Level

**Background Statistics assuming Lognormal Distribution**

| | | | |
|---|---|---|---|
| 95% UTL with 95% Coverage | 24595 | 90% Percentile (z) | 22626 |
| 95% UPL (t) | 23430 | 95% Percentile (z) | 23167 |
| 95% USL | 24345 | 99% Percentile (z) | 24215 |

**Nonparametric Distribution Free Background Statistics**

Data appear Normal at 5% Significance Level

**Nonparametric Upper Limits for Background Threshold Values**

| | | | |
|---|---|---|---|
| Order of Statistic, r | 15 | 95% UTL with 95% Coverage | 23800 |
| Approx, f used to compute achieved CC | 0.789 | Approximate Actual Confidence Coefficient achieved by UTL | 0.537 |
| | | Approximate Sample Size needed to achieve specified CC | 59 |
| 95% Percentile Bootstrap UTL with 95% Coverage | 23800 | 95% BCA Bootstrap UTL with 95% Coverage | 23800 |
| 95% UPL | 23800 | 90% Percentile | 22040 |
| 90% Chebyshev UPL | 25043 | 95% Percentile | 22680 |
| 95% Chebyshev UPL | 26938 | 99% Percentile | 23576 |

95% USL 23800

Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20. Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers and consists of observations collected from clean unimpacted locations.

The use of USL tends to provide a balance between false positives and false negatives provided the data represents a background data set and when many onsite observations need to be compared with the BTV.

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# Appendix D

# Software Installation and Checkout Form

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## SOFTWARE INSTALLATION AND CHECKOUT FORM

**Software Owner Instructions:**
Complete Fields 1-13, then run test cases in Field 14. Compare test case results listed in Field 15 to corresponding Test Report outputs. If results are the same, sign and date Field 19. If not, resolve differences and repeat above steps.

**Software Subject Matter Expert Instructions:**
Assign test personnel. Approve the installation of the code by signing and dating Field 21, then maintain form as part of the software support documentation.

**GENERAL INFORMATION**

1. Software Name: ProUCL Version No.: 5.1

**EXECUTABLE INFORMATION**

2. Executable Name *(include path)*:
Following executable files in directory: [DIRECTORY]

3. Executable Size *(bytes)*: MD5 signatures above uniquely identify each executable file

**COMPILATION INFORMATION**

4. Hardware System *(i.e., property number or ID)*:
Acquired software; compile by vendor (EPA)

5. Operating System *(include version number)*:
Acquired software; compile by vendor (EPA)

**INSTALLATION AND CHECKOUT INFORMATION**

6. Hardware System *(i.e., property number or ID)*:
00905

7. Operating System *(include version number)*:
Windows 10 Pro V.10.0.19043

8. Open Problem Report? ☐ Yes ☒ No PR/CR No.:

**TEST CASE INFORMATION**

9. Directory/Path:
[redacted]RiskModeling\software-management

10. Procedures:
CHPRC-01270, ProUCL Software Management Plan

11. Libraries:
N/A

12. Input Files:
ProUCL InstallationTestCase.xls

13. Output Files:
to screen

14. Test Cases:
ITC-ProUCL-1, Installation Test Problem

15. Test Case Results:
Pass

16. Test Performed By: Corey Brumbaugh

17. Test Results: ☒ Satisfactory, Accepted for Use ☐ Unsatisfactory

18. Disposition *(include HISI update)*:

**SOFTWARE INSTALLATION AND CHECKOUT FORM** (Continued)

| | |
|---|---|
| **19. Prepared By *(Software Owner)*:**<br>Christopher Farrow<br>*Print First and Last Name* | CHRISTOPHER FARROW (Affiliate)<br>Digitally signed by CHRISTOPHER FARROW (Affiliate)<br>DN: C=US, O=U.S. Government, OU=Department of Energy, OID.0.9.2342.19200300.100.1.1=8800100037727219 + CN=CHRISTOPHER FARROW (Affiliate)<br>Reason: I have reviewed this document<br>Location: your signing location here<br>Date: 2022.03.03 11:05:27-06'00'<br>Foxit PhantomPDF Version: 10.1.6<br>*Signature / Date* |
| **20. Test Personnel:**<br>**Title: Ecological Risk Assessor**<br>Corey Brumbaugh<br>*Print First and Last Name* | Corey Brumbaugh<br>Digitally signed by Corey Brumbaugh<br>DN: C=US, OU=Ecological Risk Assessment, O=INTERA Incorporated, CN=Corey Brumbaugh, E=cbrumbaugh@intera.com<br>Reason: I am the author of this document<br>Location: West Richland, WA<br>Date: 2022.03.03 08:22:34-08'00'<br>Foxit PhantomPDF Version: 10.1.6<br>*Signature / Date* |
| **Title:**<br>*Print First and Last Name* | *Signature / Date* |
| **Title:**<br>*Print First and Last Name* | *Signature / Date* |
| **21. Approved By *(Software SME)*:**<br>*Print First and Last Name* | *Signature / Date* |