FINAL

GROUNDWATER BACKGROUND EVALUATION

Fort Wingate Depot Activity
McKinley County, New Mexico

December 19, 2022

Contract No. W912DQ18D3010
Task Order No. W912BV19F0038

Prepared for:

US Army Corps of Engineers - Tulsa District
1645 South 101st East Avenue
Tulsa, OK 74128

Prepared by:

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December 27, 2022

Base Realignment and Closure Operations Branch

Mr. Rick Shean
Chief, Hazardous Waste Bureau
New Mexico Environment Department
2905 Rodeo Park Drive East, Building 1
Santa Fe, New Mexico 87505-6303

RE: Final Groundwater Background Evaluation, Army's Response to the New Mexico Environment Department Letter of Disapproval dated July 6, 2021. Fort Wingate Depot Activity, McKinley County, New Mexico. EPA# NM6213820974, HWB-FWDA-20-001

Dear Mr. Shean:

This letter is in reply to the New Mexico Environment Department (NMED) Letter of Disapproval dated July 6, 2021, reference number HWB-FWDA-20-001, Final Groundwater Background Evaluation. The following are Army's response to NMED comments, detailing where each comment was addressed and cross referencing the numbered NMED comments.

Comments:

SPECIFIC COMMENTS

1. Permittee's Response to NMED's Disapproval Comment 2, dated September 15, 2020

Permittee Statement: "Pursuant to the Army's response to the NMED comment #4 from the Groundwater Periodic Monitoring Report July through December 2018; it is not BGMW08 that is providing erroneous geochemical data, but TMW02. As presented in the Army's response (cited above), bedrock groundwater at TMW02 is likely mixing with alluvial groundwater creating erroneous observations. Therefore, the Army has proposed the retention of BGMW08 concurrent with decommissioning TMW02. No changes were made to the revised report."

NMED Comment: The Permittee's statement is outdated and no longer relevant. Comment 3 of the NMED's November 5, 2020 *Approval with Modifications* states, "it is more appropriate to retain well TMW02 as an alluvial groundwater monitoring well and continue to monitor groundwater quality." The Permittee must not abandon well TMW02, as directed.

In addition, Comment 5 of the *NMED's Approval with Modifications Second Response to the Approval with Modifications, Response to Approval with Modifications, Final Revision 1 Groundwater Periodic Monitoring Report, July Through December 2018*, dated March 29, 2021, states, "[t]he Permittee may propose to submit a work plan to install a new background monitoring well in the vicinity of BGMW08. However, the Permittee must not abandon well BGMW08 at this time. Retain well BGMW08 as a bedrock groundwater monitoring well and continue to monitor groundwater quality, as previously directed." The Permittee must comply with the NMED's directions. Include the most updated information in the revised Report.

Army Response
Concur. Wells TMW02 and BGMW08 will be retained for future groundwater monitoring.

2. Permittee's Response to NMED's Disapproval Comment 3, dated September 15, 2020
Permittee Statements: "It was determined that there were no detections of anthropogenic compounds in samples collected from BGMW01 and BGMW09. A single detection of one constituent (methyl acetate) out of all of the compounds in these analysis suites was reported from BGMW10." and "[D]etections of anthropogenic compounds, if any, do not preclude the use of these wells as background monitoring points, as these detections are representative of local or regional conditions."

NMED Comment: According to the *Final Groundwater Periodic Monitoring Report July through December 2019*, dated December 2020, the limits of detection (LODs) for multiple contaminants (e.g., 1,2-diphenylhydrazine, nitrobenzene, nitroglycerin) were reported higher than their respective screening levels in groundwater samples collected from wells BGMW01, BGMW09, and BGMW10. Therefore, the absence/presence of anthropogenic compounds is unknown. Resolve this recurring issue where LODs exceed the screening levels prior to completion of the Groundwater Background Evaluation. The February 1, 2021 email from Mr. Wear of NMED to Mr. Cushman of FWDA provides a clarification and direction regarding the analytes where the LODs exceed the applicable screening levels.

In addition, the detection of anthropogenic compounds (e.g., VOCs, explosive compounds) may indicate that the concentrations of the naturally occurring metals and anions have potentially been affected by previous site activities. Unless the LOD issue is resolved and the absence of anthropogenic compounds is demonstrated, the use of wells BGMW01, BGMW09, and BGMW10 for the background evaluation is not appropriate.

Army Response
Comment noted. With respect to the LOD issue, the Army is working to address the LOD issue with NMED under separate cover, and requests to resolve the issue in that forum and apply the results accordingly.

In the interim, with respect to whether concentrations of naturally occurring metals and anions have potentially been affected by previous site activities, the Army has determined they have not for the following reasons:

a. There is no historic evidence of contaminating operations at or near background locations BGMW01, BGMW08, BGMW09 or at BGMW10, or that historic operations influence groundwater quality at these locations (see Section 1.3, pg 3, Lines 33-36).

b. Groundwater monitoring wells are at hydrogeologically upgradient locations that are not influenced by activities at FWDA (see Section 1.3, pg 2, Lines 25-28).

To determine whether BGMW01, BGMW09 and BGMW10 should be excluded as background monitoring wells due to the presence anthropogenic constituents, a review of groundwater analytical results for anthropogenic compounds (explosives, volatile organic compounds, semi-volatile compounds, polychlorinated biphenyls, herbicides and pesticides) was performed. From this review the following was determined:

- There were no detections of anthropogenic compounds in samples collected from BGMW01 and BGMW09.

- A single detection of one constituent (methyl acetate) was reported from BGMW10. However, subsequent sampling and analysis of this well to date has not reported additional detections of methyl acetate.

USEPA guidance (USEPA 2018) as referenced in the report (see Section 1.3, pg 4, Lines 28-35) clarifies that the presence of anthropogenic compounds is not necessarily sufficient to exclude monitoring points for background monitoring. Based on the discussion above, the Army requests that the discussion presented in the *Groundwater Background Evaluation* report be accepted.

3. Permittee's Response to NMED's Disapproval Comment 10, dated September 15, 2020
Permittee's Statement: "The Groundwater Periodic Monitoring Reports from Spring 2009 to Spring 2012 show a collection of 449 samples, with 27% of samples having turbidity greater than100 NTU. In Fall 2019, 69% of samples had turbidity greater than 100 NTU."

NMED Comment: If sampling techniques are not the cause for the turbidity issues, the condition of the wells may require evaluation. Clogged well screens and other issues can lead to higher turbidity in groundwater, requiring well re-development. If the wells continue to have turbidity issues, propose to evaluate current sampling techniques, potential alternative sampling techniques, and the conditions of the wells in the revised Report.

Army Response
Comment noted. As part of the continuing interim groundwater monitoring program, the Army is reviewing the sampling techniques and monitoring well conditions to achieve turbidity of 100 NTU or less during groundwater monitoring events.

If you have questions or require further information, please contact me at George.h.cushman.civ@mail.mil, 703-455-3234 (Temporary Home Office, preferred) or 703-608-2245 (Mobile).

Sincerely,

George H. Cushman IV

George H. Cushman IV
BRAC Environmental Coordinator
Fort Wingate Depot Activity
BRAC Operations Branch
Environmental Division

Enclosures
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14. ABSTRACT

This report presents the statistical analysis of background groundwater quality for the Northern Area groundwater regime at Fort Wingate Depot Activity (FWDA) located in McKinley County, New Mexico. The background groundwater quality was evaluated such that statistically-derived background threshold values (BTVs) could be established for constituents in the alluvial and bedrock aquifers.

15. SUBJECT TERMS

Monitoring well, groundwater, aquifer, alluvial, bedrock, background threshold value (BTV)

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BRAC OPS	(U. S. Army) Base Realignment and Closure Ops Branch
FWDA BEC	Fort Wingate Depot Activity Base Environmental Coordinator
NM	New Mexico
NMED HWB	New Mexico Environment Department Hazardous Waste Bureau
NN	Navajo Nation
OH	Ohio
POZ	Pueblo of Zuni
USACE SWF	U.S. Army Corps of Engineers – Fort Worth District
USEPA	United States Environmental Protection Agency

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Tables

Figures

Acronyms and Abbreviations

ANOVA	analysis of variance
BTVs	background threshold values
COC	Contaminant of Concern
DL	detection limit
DQR	double quantification rule
FWDA	Fort Wingate Depot Activity
GOF	goodness of fit
GPMR	Groundwater Periodic Monitoring Report
IQR	inter-quartile range
LOD	limit of detection
LOQ	limit of quantitation
MDL	method detection limit
mg/L	milligrams per liter
MLE	maximum likelihood estimation
NCSS	Number Cruncher Statistical System
ND	non-detect
NMED	New Mexico Environment Department
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
SPSS	Statistical Package for the Social Sciences
UPL	upper prediction limit
UTL	upper tolerance limit
U.S.	United States
USACE	U.S. Army Corps of Engineers – Tulsa District
USACE SWF	U.S. Army Corps of Engineers – Fort Worth District
USEPA	U.S. Environmental Protection Agency

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1 Introduction

This report describes the development of background threshold values (BTVs) for chemical constituents in groundwater in the Northern Area alluvial and bedrock aquifers at Fort Wingate Depot Activity (FWDA), McKinley County, New Mexico (**Figure 1**). BTVs represent background or aquifer conditions unaffected by FWDA activities and provide a basis for comparison with monitoring and sampling results as an indicator of whether FWDA activities may have affected groundwater. If the monitoring or sampling results for a constituent exceed the applicable BTV, then further action may be required. The BTVs were calculated from analytical results for groundwater samples collected from approved background wells. The number of approved downgradient wells in the monitoring network was used as input for establishing BTVs that satisfy site-wide false positive objectives. The statistical analysis was performed in support of the site's Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) as required by the Permit NM6213820974 (NMED 2015a). The BTVs can be used to compare groundwater analytical results from FWDA monitoring wells as an indication of changes in groundwater quality.

1.1 Report Organization

This report is organized as follows:

- Section 2 characterizes the distributions and trends of the constituent concentrations in the alluvial and bedrock aquifers.
- Section 3 presents the estimated BTVs for the constituents in the alluvial and bedrock aquifers. The BTVs are derived from upper prediction limits (UPLs), which represent the upper boundary of a prediction interval for an independently obtained observation (or an independent future observation). The use of UPLs was presented to in a letter dated June 2019 (DOA 2019)
- Section 4 summarizes the findings from the analysis.
- Appendix A (provided electronically), presents statistical summary reports supporting the statistical output used to profile the data sets, assess outliers, evaluate distributions, assess trends, test for differences in concentration between the two aquifers, and the calculation of estimated UPLs for aquifer-specific BTVs.

The tables and figures are provided at the end of the report.

1.2 Site Summary

The former mission of FWDA was to store, ship, and receive material and to dispose of obsolete or deteriorated explosives and ammunition (PMC Environmental 2001). The FWDA mission ceased and the installation closed in January 1993. The current FWDA operations in the Northern Area are focused on assessment and remediation of contamination resulting from these past military activities. Large quantities of wastewater associated with demilitarization operations were historically pumped to the leaching beds where the waste water infiltrated to the soil column and groundwater. This resulted in groundwater contamination from explosives, perchlorate, and nitrate in the Northern Area alluvial and bedrock groundwater aquifers.

The corrective action and cleanup objective for groundwater, as currently outlined in the RCRA permit is to reduce concentrations of contaminants of concern (COCs) in the Northern Area groundwater to cleanup levels for explosives, perchlorate, and nitrate in accordance with Permit Section VI.B.6a (Monitoring of Hazardous Constituents).

1.3 Study Methodology

BTVs for chemical constituents in groundwater are needed to support the evaluation of groundwater conditions and determine changes in groundwater quality. Background is defined as the natural or baseline groundwater quality at a site, and can be characterized using data from upgradient, historical, or sometimes cross-gradient well samples. For this study, background wells and wells located downgradient from the background wells in each groundwater aquifer were selected. Background data were evaluated, and background levels established for 23 total and dissolved metals, nitrate, and perchlorate. Background was not established for explosives because those constituents would be considered to represent contamination.

In the Northern Area there are 47 active wells in the alluvial aquifer and 18 wells in the bedrock aquifer from where groundwater samples are collected. Background groundwater monitoring wells for statistical analysis were selected based upon the monitoring well completion interval (alluvial or bedrock aquifer) and potential for water quality influence from FWDA operations (**Figure 2**). The well completion interval was determined from the Groundwater Periodic Monitoring Report (GPMR) designations (Sundance 2019). The following criteria were used to select the background wells:

- Distance from historic FWDA operations.
- Groundwater monitoring well located hydrogeologically upgradient from FWDA operations as documented in the GPMRs with repeated groundwater flow direction and repeated sufficient gradient to preclude FWDA operations as a contaminating source (Sundance 2019, Sundance 2017, Sundance 2015).
- Consultation with the Army and directive from the New Mexico Environment Department (NMED) (NMED 2015b).

Based upon these criteria, there are seven alluvial wells in the in the northeastern portion of the site that are hydrogeologically upgradient with sufficient distance from FWDA operations. These wells are TMW24, TMW26, TMW27, TMW28, BGMW01, BGMW02, and BGMW03. Six of these wells were excluded for the following reasons:

- Administration Area alluvial wells TMW24 and TMW26 are adjacent to the historic leaky cistern and actively leaking deep bedrock well 69 (Sundance 2019). The leakage of bedrock water to the alluvial aquifer may influence groundwater quality at TMW24 and TMW26 and therefore these wells were not included as background wells.
- Alluvial monitoring wells TMW27 was identified as potentially impacted by site activities and was not included as a background well (NMED 2015b).
- Alluvial monitoring well TMW28 is located immediately adjacent to the Rio Puerco and groundwater at this location may be influenced by surface water recharge, therefore this well was not included as a background well.

Alluvial monitoring wells BGMW01, BGMW02 and BGMW03 were identified by NMED as potentially impacted by site activities (NMED 2015b). Therefore, BGMW02 and BGMW03 were not included as background wells but BGMW01 was included for the following reasons:

Monitoring well BGMW01 was the only alluvial well retained because it is located at one of the most hydraulically upgradient locations (Sundance 2019, Sundance 2017, Sundance 2015) and at the greatest distance from historic FWDA operations. BGMW01 is located approximately 107 feet from a northern branch of the Rio Puerco and at an elevation of 6,690.82 feet mean sea level and hydraulically upgradient of TMW28. Comparatively, TMW28 is located 52 feet from this same northern branch of the Rio Puerco, and at an elevation of 6,688.08 feet mean sea level. According to FWDA personnel, TMW28 is subject to flooding while BGMW01 is not (verbal communication with FWDA staff 2019). The upgradient location of BGMW01, its distance from the drainage, and its higher elevation make the groundwater at BGMW01 less likely to be influenced by surface waters. Lastly, the USGS cites TMW28 in its documentation of the Puerco Flow Path: “A flow path originating from the saturated alluvial deposits underlying the South Fork of the Puerco River”. This statement suggests surface water recharge to groundwater at well TMW28 (USGS 2009).

For the bedrock aquifer, there are 18 active wells from where groundwater samples are collected (Sundance 2019). Fifteen of these wells are located south of the Administration Area and in close proximity to historic FWDA operational areas. Therefore, these fifteen wells were excluded from consideration as background wells due to their close proximity to historic FWDA operations. In addition, two of these fifteen bedrock monitoring wells (TMW17 and TMW19) were identified as potentially impacted by site activities providing further reason for not including them as background wells (NMED 2015b). Three wells remaining wells (BGMW08, BGMW09, BGMW10) located east and hydrogeologically upgradient of the Administration Area were retained as these three wells are furthest from FWDA operations and are the most hydrogeologically upgradient of the bedrock wells (Sundance 2019).

There is no evidence to suggest that historic contaminating operations were performed at or near background locations BGMW01, BGMW08, BGMW09 or at BGMW10 or that historic operations influence groundwater quality at these locations. However, the hydraulically upgradient locations of these wells does not preclude the potential for detections of anthropogenic compounds.

To determine whether or not BGMW01, BGMW08, BGMW09 and BGMW10 should be included or excluded due to the presence anthropogenic constituents, a review of groundwater analytical results for anthropogenic compounds (explosives, volatile semi-volatile compounds, polychlorinated biphenyls, herbicides and pesticides) from BGMW01, BGMW08, BGMW09, and BGMW10 was performed.

It was determined that there were no detections of anthropogenic compounds in samples collected from BGMW01 and BGMW09. A single detection of one constituent (methyl acetate) out of all of the compounds in these analysis suites was reported from BGMW10. Upon further review of the laboratory chromatogram and mass spectrum for this sample result, it was determined that although the target analyte identification criteria (mass spectra ion relative intensities and relative retention times) were nominally met, the analyte identification was still questionable. The secondary ion at m/z 43 maximized 1.4 seconds after the primary ion at m/z 74, the tertiary ion at m/z 59 was not present (albeit possibly due to the low concentration), and there were a number of ion masses that appeared in the sample spectrum at approximately the same relative intensities as m/z 43. Further, m/z 43 is a common ion fragment mass and shows up commonly in the mass spectra of lighter analytes, such as methyl acetate. This result would have been more appropriately reported as non-detect at the sample limit of quantitation (LOQ). This single result is not considered valid as it should have been reported as non-detect (U) at the LOQ. In addition, at BGMW08, low level detections of one herbicide (dinoseb) and two VOCs (benzene and toluene) were reported at estimated concentrations below the limit of detection (LOD) from groundwater samples collected during the 2018 groundwater sampling events. Herbicides have not been reported in bedrock wells BGMW09 or BGMW10, and it has since been recommended to discontinue analyzing for herbicides in these wells during future groundwater monitoring events, as agreed upon in the Army response to the Approval with Modifications letter HWB-FWDA-17-008 dated January 8, 2018. For this reason, the single report of one herbicide (dinoseb) is considered insignificant. The two VOCs (benzene and toluene) are also anthropogenic compounds. Based upon the low estimated concentrations of these two compounds and the hydraulic upgradient location of BGMW08, the estimated detection of the two VOCs (benzene and toluene) are not considered significant to this background evaluation.

The USEPA has recognized, in several documents, the potential for anthropogenic compounds to be present at background monitoring locations (USEPA 2018). The issues for background monitoring points is not the lack of anthropogenic compounds, but the lack of hydrogeologic influence from the site-specific contaminating source(s). Therefore, detections of anthropogenic compounds, if any, do not preclude the use of these wells as background monitoring points as these detections are representative of local or regional conditions. For example, the concentrations of nitrate and perchlorate detected in the alluvial background wells are orders of magnitude less than the highest concentrations observed in the downgradient wells.

- From April 2012 to October 2018, 327 samples were collected from the alluvial aquifer downgradient wells for analysis of nitrite. The alluvial aquifer downgradient nitrite detections ranged from 0.063 to 4.7 mg/L. Background concentrations of nitrite were not reported for the alluvial background well for this study.

- From April 2012 to October 2018, 327 samples were collected from the alluvial aquifer downgradient wells for nitrate. The alluvial aquifer downgradient nitrate detections ranged from 0.044 to 97 mg/L; and in the single background alluvial well nitrate detections ranged from 0.0970 to 1.90 mg/L.

- From April 2012 to October 2018, 262 samples were collected from the alluvial aquifer downgradient wells for perchlorate. The alluvial aquifer downgradient perchlorate detections ranged from 0.0000041 to 0.0015 mg/L; and in the single background alluvial well perchlorate was non-detect (LOQ 0.00005 - 0.0002 mg/L).

The concentration of nitrate and perchlorate detected in the bedrock background wells are orders of magnitude less than the highest concentrations observed in the downgradient wells.

- From April 2012 – October 2018, 179 samples were collected from the bedrock aquifer downgradient wells with a nitrite range of 0.053 to 1.2 mg/L. Background concentrations of nitrite were not reported for the bedrock background wells for this study.
- From April 2012 – October 2018, 179 samples were collected from the bedrock aquifer downgradient wells for nitrate. The bedrock aquifer downgradient nitrate detections ranged from 0.046 to 50 mg/L; with a single background bedrock detection of 0.0870 mg/L.
- From April 2012 – October 2018, 194 samples collected in the bedrock aquifer downgradient wells for perchlorate. The bedrock aquifer downgradient perchlorate detections ranged from 0.0000063 to 4.4 mg/L; with a bedrock background detections range of 0.0000057 to 0.00000950 mg/L.

Based upon these criteria presented above, one well (BGMW01) was utilized to establish BTVs in the alluvial aquifer and three wells (BGMW08, BGMW09, BGMW10) were utilized to establish BTVs in the bedrock aquifer. It was beyond the scope of this study to assess differences in groundwater quality among the excluded wells or to perform a comparison of BTVs with and without the excluded wells.

The single alluvial well BGMW01, which is at the most upgradient location for the alluvial aquifer in this portion of FWDA, has sufficient data points (15 monitoring events collected across 7 years) to conduct a statistical analysis of alluvial data. The three bedrock background wells BGMW08, BGMW09, BGMW10 each had 3 monitoring events (collected across 1-1/2 years); therefore the data were pooled to derive a sufficient number of samples for a statistical analysis of bedrock groundwater data (USEPA 2009). Pooling the data increases the statistical power of the analyses and increases the confidence in the final BTVs. When considering a distribution, it is not the number of wells but the number of samples utilized that drives the statistical analysis.

Groundwater analytical results were used to establish BTVs for the selected chemical constituents in groundwater in the alluvial and bedrock aquifers. Fifteen monitoring events at alluvial well BGMW01 were taken between April 2012 and April 2019 and used to establish BTVs for the alluvial aquifer. Three monitoring events at each of the three bedrock wells BGMW08, BGMW09 and BGMW10 were taken between April 2018 and April 2019, and used to establish BTVs for the bedrock aquifer.

The downgradient wells were selected as those wells which are hydrogeologically downgradient from the background wells and completed within the same aquifer as the background well(s) (Table 1). Background wells are used to calculate BTVs, with downgradient monitoring points only used to determine significance levels for the UPLs. Analytical results from the downgradient wells were not used to calculate BTVs were not used for comparative purposes, therefore any potential influence of the Rio Puerco and/or from well 69 is not pertinent to this statistical analysis.

It is the number of downgradient wells that are used to determine the individual test significance level per UPL - not the well location (i.e. wells located south of the Rio Puerco) and not the groundwater analytical results at the downgradient location. The number of downgradient wells is used as input to satisfy the site-wide false positive rate and produce a test significance level. It is only the count of downgradient wells that is required, not the actual location of the wells. This is because the requirement to establish the site-wide false positive rate is of a statistical nature, not of a hydrogeological nature. The Unified Guidance methodology was followed to set individual test significance levels such that their sum over all potential tests in a year does not exceed the recommended site wide false positive rate (SWFPR) of 10 percent (see Section 6, page 6-9, USEPA Unified Guidance 2009).

While groundwater mixing certainly occurs in the Administration Area, and surface water from the Rio Puerco infiltrates to the alluvial aquifer, these inputs to the hydrogeologic regime do not preclude comparison of BTVs calculated from the background monitoring wells to be used as comparative values at downgradient locations. The Army based its rationale on the selection of these 23 downgradient wells per USEPA Federal Register (80 FR 21399.) This states "*Because hydrogeologic conditions vary so widely from one site to another, the rule does not prescribe the exact number, location and depth of monitoring wells needed to achieve the general performance standard*." Table 1 identifies the background and downgradient wells by aquifer.

Since multiple constituents from multiple downgradient wells are being compared there is a cumulative risk of false positive errors; that is, of incorrectly indicating an exceedance of background. The number of downgradient wells is utilized to identify the number of background comparison tests so that the appropriate significance level for establishing the BTVs is selected to control for the side-wide false positive errors.

Software packages ProUCL (Singh and Singh 2015), Number Cruncher Statistical System (NCSS) (NCSS 2013), R (R Core Team 2018), and Statistical Package for the Social Sciences (SPSS) (IBM 2013) were used in the production of the statistics. ProUCL is offered by the United States Environmental Protection Agency (USEPA), R is a free software environment, NCSS and SPSS are licensed software packages. The choice of statistical methods used in the analysis of groundwater data and in the development of BTVs primarily uses concepts and approaches documented in the USEPA's "Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities: Unified Guidance" (Unified Guidance) (USEPA 2009).

2 Statistical Analysis

This section identifies the wells and monitoring constituents used for this study and presents a descriptive statistical evaluation of the groundwater data. This evaluation was performed to assess outliers, evaluate distributions, assess trends, and test for differences in concentration between the two aquifers. The statistical tests described in this section include the following:

- Analysis for statistical outliers using Dixon's test for outliers (Section 2.1). Outliers are values that are not representative of the population from which they are sampled and may be excluded from further analysis to avoid potentially biasing the calculation of background concentrations.
- Goodness Of Fit (GOF) tests to indicate whether parametric or nonparametric distributions best model the observed data (Section 2.2). The outcome of the GOF test (parametric or nonparametric) decides which statistical method to use when assessing trends over time. The two methods considered are the Maximum Likelihood Regression (MLE) for parametric distributions or the Mann-Kendall trend test for nonparametric distributions.
- Trend tests to determine whether groundwater conditions are stable (Section 2.3). The presence of a trend can signify several possibilities such as contaminated background, site-wide changes in the aquifer, seasonal fluctuations, or aquifer disturbances due to new well installation.
- Calculation and comparison of the central tendencies (means or medians) of the constituents between the alluvial and bedrock background wells using analysis of variance (ANOVA) methods (Section 2.4). This analysis addresses the question whether the background data across both aquifers can be pooled to represent overall groundwater conditions.

The wells listed in **Table 1** were selected to be included in the evaluation based upon the well selection criteria described in Section 1.3. The analytical results from the background wells were used to compute the BTVs. The number of downgradient wells were used to determine the number of comparisons required between the BTVs and the analytical results from FWDA monitoring wells to achieve the target site-wide false positive rates. **Figure 2** shows the location of the background wells and the respective downgradient wells. **Table 2** lists the constituents included in the evaluation. The alluvial and bedrock background sample sizes (i.e., quantity of qualifying samples) were evaluated per constituent. In instances where duplicate samples were collected on a given date, the median of the two values was used to represent the sampling event. If duplicate samples exhibited a mix of detect and non-detect (ND) values, the detected value was selected. Descriptive statistics were calculated for the background data set including ND values and excluding ND values. The descriptive analysis was performed with NDs removed to better understand the central tendency and range of the detected values.

The method detection limit (MDL) also referred to as the detection limit (DL), is the lowest level at which a result can be reliably distinguished from method blank results. For the descriptive statistics of background data sets that included NDs, the DL was substituted as the ND value. When the DL value was not available, the limit of detection (LOD) was used. For consistency throughout this report, DL will be used, regardless of whether the value used was the DL or the LOD.

A summary of the descriptive statistics for each of the alluvial and bedrock background data sets is provided in **Table 3**. Note that for the trend analyses described in Section 2.3 and for the establishment of statistically-derived BTVs in Section 3, imputation methods using the MLE for NDs, Regression on Order Statistics or Kaplan-Meier methods, where appropriate, were used.

Following the calculation of descriptive statistics, the statistical analysis for the alluvial and bedrock background data sets were performed to evaluate for outliers, data distributions, and trends for total and dissolved metals, nitrate, and perchlorate, where data quantity and quality permit. Mean or median concentration differences between the alluvial and bedrock background wells were evaluated for each constituent to assess whether the data across the aquifers can be pooled for establishing BTVs. A total of 15 samples (one sample per monitoring event) from well BGMW01 were included for the descriptive analysis of the background alluvial monitoring well results for the constituents of interest. Nine samples (three monitoring events from BGMW08, BGMW09, and BGMW10) were included for the descriptive analysis of the background bedrock monitoring well results for the same constituents.

Supporting statistical output used to profile the data sets, assess outliers, evaluate distributions, assess trends, and test for differences in concentration between the two aquifers is presented in **Appendix A**.

2.1 Outlier Test Results – Background Wells

Outliers are values that are not representative of the population from which they are sampled. The background data sets were screened for outliers using Dixon's outlier test, which is suitable for data sets containing less than 25 samples. The outlier test was conducted using a significance of one percent or a confidence level of 99 percent. Based upon review of the groundwater analytical results utilized for this background evaluation, there were no elevated laboratory detection limits. For those constituents that had NDs, the NDs were removed prior to conducting the Dixon's outlier tests. The NDs that were excluded for Dixon's outlier tests did not have high reporting limits. NDs were not included as part of Dixon's outlier tests for the following reasons:

- While ProUCL states to include the NDs at the limit or ½ limit value, this inclusion is misleading. Researchers in the last 20 years have expounded on not using this substitution method as it produces bias in the estimates. For example, we have found when using ND values with ProUCL that the NDs themselves became outliers.

- ProUCL chose to use the variant of the Dixon's outlier test which assumes an underlying normal distribution except for the outlier and that there is only one outlier in the sample. The choice of the normal distribution is unexpected as most of the technical guidance emphasizes the gamma and lognormal distributions as appropriate distributions to model groundwater constituent concentrations. Even the lognormal distribution comes with caveats. Including data samples with NDs and then using the simple substitution method could further distort the distribution from an assumed normal one.

- Dixon's outlier test was conducted with what is available in ProUCL, but multiple lines of evidence were applied using scatter plots and box and whiskers plots which included using all detect and non-detect values combined with scientific and historic knowledge of the area to determine if the highest value should be removed or kept.

While there are other methods to test for outliers in the presence of NDs in very small samples, the Army's approach is in compliance with the Unified Guidance (USEPA 2009). Due to the small sample sizes, the Army supplemented the statistical outlier tests with visual means using scatter plots and box and whisker plots. When background sample sizes accumulate to 20 or more samples, a sensitivity test may be done to compare outlier test results with or without NDs.

The issue of elimination of values with high reporting limits is not of concern as the eliminated values did not have high reporting limits. Only detected values were analyzed when running Dixon's outlier test. Using multiple lines of evidence, the statistical outlier tests were substantiated with visual means using scatter plots and box and whiskers plots which used all detect and non-detect values along with scientific and historic knowledge of the area to determine if the highest value should be removed or retained. In accordance with the Unified Guidance (USEPA 2009), HDR's review by a statistician and hydrogeologist determined that the values exhibited unexceptional ranges from a geological perspective for the constituents in the area.

Statistical outliers were identified in the background data set evaluated both in alluvial and bedrock wells. The constituent concentrations identified as statistical outliers were sampled from alluvial well BGMW01 and bedrock well BGMW09, and are listed in **Table 4**.

As stated in the ProUCL Technical Guide (Singh and Singh 2015), groundwater sample concentrations are typically highly variable in nature, hence outliers identified in a statistical context are expected but do not necessarily signify that the outliers are from different distributions. A visual inspection of concentration versus time plots for constituents including the outliers listed in **Table 4** reveal the presence of the potential outliers as shown in **Figures 3a – 3c.** The Unified Guidance (USEPA 2009) recommends not removing statistically identified outliers unless some basis for a likely error or discrepancy can be identified or they are of high-magnitude compared to other concentrations. The statistical outliers were investigated but neither data entry or measurement errors were identified. Although the elevated values appear as statistical outliers, the values varied within one order of magnitude which is considered a reasonable range of variability. Given the variable nature of groundwater samples and the small sample sizes, the statistical outliers should not be removed from the data set at this time for purposes of determining background concentrations. As additional background samples are collected over time, the variability in concentrations can be better understood. As new data become available, outlier test results may change and earlier observations thought to be outliers may no longer be outliers.
The justification for inclusion of the apparent outliers is based on a review of range of the concentrations in light of the small sample sizes. The review was done in four steps:

1. Identify which constituent-well pairs had statistical outliers based on ProUCL's Dixon's test.

2. Study range of data in scatter plots from the same constituent-well pairs identified in Step 1. Note if the highest values were a magnitude or less in difference from the other values.
3. Study range of data from box and whisker plots for all constituent-well pairs, including those identified in Step 1. Note if the highest values were a magnitude or less in difference from the other values.
4. Check if human activity or error occurred on the dates of the apparent statistical outliers. Since no reason could be found, the values were included in the development of the BTVs.

Outlier tests whether they are based on Dixon's or use graphical means (e.g., box and whisker plots) are less definitive for very small datasets (less than 20 observations) as we have gathered from the alluvial and bedrock wells. What appears to be an extreme value or outlier in the small dataset is most likely from a portion of the background distribution that has yet to be sampled (See Unified Guidance (2009), page 5-5). Outliers flagged by statistical tests or by means of scatter plots (Figures 3a – 3c) or box and whisker plots (figures 4A – 4D) were evaluated for anomalous ranges and the values are deemed reasonable and expected. The Army does not have other technical information, knowledge or basis at this time with a very small dataset to remove the highlighted values. Lastly, the values in figures 4A and 4D appear to be outliers because they are plots of all constituents and some of the constituents had statistical outliers based on Dixon's tests as listed in Table 4. Based upon review of the box and whisker plots for ranges within one order of magnitude or less, it was determined the values were not due to data errors, discrepancy or other non-background populations.

The Unified Guidance (USEPA 2009) recommends not removing statistically identified outliers unless some basis for a likely error or discrepancy can be identified or they are of high magnitude compared to other concentrations. The Unified Guidance (USEPA 2009) recognizes that statistical outlier tests should be done on datasets, however, the decision to drop them rests on whether the values are in error or of very high magnitude (USEPA Unified Guidance page 5-5). Some statisticians have discussed dropping outliers as a rule, however, this is not substantiated with very small sample sets. Small sample sets are not fully representative of the populations from which they are drawn as they only have a partial picture of the underlying distribution of groundwater concentrations. What appears to be an extreme value or outlier in the small dataset is most likely from a portion of the background distribution that has yet to be sampled (Unified Guidance 2009). Nevertheless, the outlier analysis for this work was not performed solely by the software; the model output was reviewed by a degreed and practicing statistician and hydrogeologist to ensure the outlier evaluation was appropriate for this specific site evaluation.

2.2 Data Distribution

Groundwater data was fit to known distribution models using GOF tests incorporated into ProUCL. For data sets comprised of 50 or fewer samples, ProUCL's GOF module incorporates the Shapiro-Wilk GOF test to determine normal or lognormal distribution and Anderson-Darling to determine gamma distribution. The GOF tests are performed at the 0.05 level of significance. Normal, lognormal and gamma distributions are parametric distributions. If a data set could not be fit with any of these three parametric distributions, it was considered to follow a nonparametric distribution. Background samples that consisted of more than 50 percent NDs were considered to follow a non-parametric distribution as they had an insufficient number of detected values for identifying an appropriate parametric distribution. Data distributions are listed in **Table 5**.

It is important to correctly specify the method used for computing the BTVs. Statistical tests conducted under parametric distribution assumptions have more power to detect an exceedance when compared to tests conducted under nonparametric distribution assumptions; however, if incorrectly specified, parametric tests can result in misleading and inaccurate results. With parametric tests, the distribution is known so more information is available about the characteristics of the data. As a result, inferences can be made about the data with smaller sample sizes. Nonparametric tests are based solely on the data as there is no discernible distribution. Hence, nonparametric tests have less power because they require a larger sample size to draw conclusions with the same degree of confidence. However, nonparametric test results are more reliable when the distribution of the data is not evident.

2.3 Background Trends

Background constituent concentrations in groundwater should demonstrate stable conditions through time, free of trends. As stated in the Unified Guidance (USEPA 2009), a trend can signify several conditions, including contamination, site-wide changes in the aquifer, seasonal fluctuations, or aquifer disturbances due to new well installation. Constituents were analyzed for trends within the data set using a MLE regression for constituents which followed parametric distributions and Mann-Kendall tests for those that were treated under nonparametric distributional assumptions. The MLE regression can be applied to data sets that can be fitted to a specific distribution model and that contain NDs with multiple DLs. The Mann-Kendall test is suitable for data series with no discernable distributions and the same DL value for NDs.

Constituents treated with more than 50 percent NDs or with multiple DLs were not assessed for trends. A trend analysis was conducted for constituents in each of the alluvial and bedrock aquifers with background data sets that had a sufficient number of detected values. Constituents that exhibited a statistically significant trend in the alluvial or bedrock aquifer are summarized in **Table 6**.

Of the 48 different constituents (23 metals (total and dissolved), nitrate and perchlorate) potentially available for trend testing, only three constituents (dissolved nickel and total arsenic in the alluvial well, and total chromium in the bedrock wells) exhibited statistically significant trends. The background well regression analysis showed potentially decreasing trends for dissolved nickel and total arsenic from the alluvial background monitoring well and for total chromium from the bedrock well monitoring wells. There were no increasing or decreasing trends identified for other monitoring constituents with sufficient data quantity and quality for testing with the MLE analysis or Mann-Kendall test. Although statistical trends were identified for these three constituents, these trends were not consistent among alluvial and bedrock monitoring wells (**Table 6**). Additionally, the limited duration of the sampling program adds potential uncertainty as to the environmentally relevant significance of these trends.

2.4 Statistical Comparison of Alluvial and Bedrock Background Wells

The locations of the one alluvial background well and the three bedrock background wells have been selected to represent overall groundwater conditions at the FWDA site. Given that the wells are screened in different aquifers, aquifer specific BTVs have been derived. However, if the distributions of the monitoring constituents for each of the aquifers are the same (i.e. the constituent follows a normal or lognormal distribution in samples from both aquifers), it may be possible to pool all the data. Pooling increases the sample size for each constituent, providing stronger statistical power to reject the null hypotheses that there are no exceedances when there really are exceedances. To determine if pooling the data between background wells from the two aquifers is possible from a statistical perspective, ANOVA tests were conducted for each monitoring constituent provided the constituent did not have 100 percent of its observations as NDs.

Two different types of hypothesis tests under lognormal and nonparametric distributional assumptions were conducted for each of the background data sets using two types of ANOVA tests: lognormal (parametric) and nonparametric ANOVA. Both methods attempt to assess whether distinct observations differ on average. Specifically for this analysis, the ANOVA was used to determine whether there is a difference between observations collected from the alluvial well BGMW01 and the pooled observations from the bedrock wells BGMW08, BGMW09 and BGMW10 for each of the dissolved metals, total metals, and nitrate, where data quantity and quality permit. Perchlorate was not analyzed as all of the observations in the alluvial well are NDs.

The lognormal (log) ANOVA test is identical to the ANOVA under normality assumptions; that is, the data are independent and identically distributed, the residuals of the data are normally distributed, and the variances among the groups under study are constant. As many groundwater constituents follow lognormal or lognormal-like distributions, the raw data were transformed by taking their natural logarithms. The Kruskal-Wallis test is a non-parametric, rank-based alternative to the parametric ANOVA. Instead of a test of means, the Kruskal-Wallis tests differences among average population ranks equivalent to the medians.

While some constituents followed parametric distributions (see **Table 5**), their distributions were not always consistent between the two background aquifers. For example, a constituent may have both the alluvial and bedrock aquifer distributions as parametric, one parametric and one nonparametric or both nonparametric. Both classes of ANOVA were applied to the monitoring constituents as further lines of evidence and their outcomes are summarized in **Table 7.** In over 60 percent of all tests, the log ANOVA or the Kruskal-Wallis indicated that the background concentrations between the two aquifers were different and hence one would reject the null hypothesis that there are no differences between the results for the background wells from the two aquifers at the 5 percent level of significance. With the majority of constituents showing differences in average concentrations based on the ANOVA tests, there is evidence to support the assumption that the data from the two aquifers should be treated separately from a groundwater monitoring and data evaluation perspective. **Figure 4** presents side-by-side box and whisker plots for each monitoring constituent. Side-by-side box and whisker plots are a simple visualization tool to demonstrate the degree as how distributions can vary because they summarize the center and spread of the data. The Inter-Quartile Range (IQR) is the distance between the upper (75th percentile) and lower (25th percentile) lines of the box and is a common measure of spread. The box plot whisker is a line that goes out from the box to the whisker boundaries, which is 1.5 times the IQR. Extreme values (outliers), indicated by the red dots, are usually three times the IQR. When plots of differing distributions are placed side-by-side, differences in central tendencies and spread or variance can be observed.

A primary trend which can be easily observed is that the medians of the bedrock constituents tend to be higher than the medians found in the alluvial background well. The variability in the concentrations collected from the three bedrock background wells is notably larger than observed alluvial concentrations. While the sample sizes for the alluvial and bedrock background wells are relatively small, the ANOVA test results and the apparent differences of the distributions based on the side-by-side box and whisker plots between the alluvial and bedrock background wells suggest that the BTVs should be specific to an aquifer and should not be pooled. As more data is collected at the background wells, tests for differences in means or medians between the two monitoring networks may be updated to monitor changes in the distributional differences.

2.5 Summary of Statistical Analysis

A summary of the statistical analysis results is provided in **Table 8,** and is discussed below. Based on the analysis results, the following assumptions were applied to develop the BTVs:

- The statistical outliers identified for the dissolved and total metals from alluvial well BGMW01 and bedrock well BGMW09 were not removed from the data set to be used for developing background concentrations for the site at this time. These metals are flagged as outliers in **Table 8.**
- Monitoring constituents from the alluvial and bedrock monitoring network that are 100 percent NDs were treated under nonparametric distribution assumptions with the maximum DL chosen to represent background.
- For the background alluvial well BGMW01, monitoring constituents which exhibited a more than 50 percent NDs were treated under nonparametric distribution assumptions with the maximum detect value chosen to represent background, until additional results can be included in the data sets. GOF tests were used to fit dissolved and total metals with sufficient background data to known parametric distribution models (e.g., gamma, lognormal, or normal). Metals that could not be fit to a discernible distribution are nonparametric. The monitoring constituents from the alluvial aquifer treated under nonparametric assumptions are listed in **Table 8**.
- For the background data set from the three bedrock aquifer wells BGMW08, BGMW09 and BGMW10, monitoring constituents which exhibited a high percentage of NDs were treated under nonparametric distribution assumptions with the maximum detected value chosen to represent background, until additional results can be included in the data sets. These constituents are listed in **Table 8**. All dissolved and total metals with sufficient background data were fit to a known parametric distribution model using GOF tests.

- Based on the small data set (less than 20 samples) and/or short duration (less than 3 full seasonal cycles for bedrock data) of the monitoring program, results from the outlier and trend analyses should be considered preliminary until additional sample results are included in the data set and re-evaluated.
- Testing and graphing for differences in concentration between the alluvial and bedrock aquifers for the monitoring constituents revealed sufficient differences to treat the two aquifers as distinct to date. As background sample size grows, changes in the differences in concentration should be re-evaluated.

3 Background Threshold Values

This section presents the BTVs for the monitoring constituents in alluvial and bedrock wells.

The BTV is the statistically-derived background concentration (the UPL), or, depending on the proportion of NDs, the maximum detected value or the maximum DL.

Although the upper tolerance limit (UTL) has been used in the past to derive BTVs as suggested in the Risk Guidance (NMED 2019) the UPL is the statistic recommended by both the Unified Guidance (USEPA 2009) and the ProUCL Technical Guide (Singh and Singh 2015) to estimate BTVs for groundwater concentrations. The construction of a UTL is highly similar to that of a UPL; however, the statistical interpretation is different. Unlike the UTL, the UPL can be constructed to control for site-wide false positive errors and improve statistical power. False positive errors arise when concentration increases above background are identified when in actuality no true exceedance has occurred. Good statistical power suggests that concentration increases above background are correctly identified. The UTL lacks the statistical properties that allow practitioners to implement strategies that meet these two performance characteristics for testing for exceedances in background concentrations.

The UPL represents the upper boundary of a prediction interval for an independently obtained observation (or an independent future observation). The significance level per UPL is modified to control for the site-wide false positive rate incurred when evaluating multiple downgradient well-constituent during semi-annual monitoring events for potential exceedances over background. As recommended by the Unified Guidance (USEPA 2009), individual test significance levels are set such that the overall cumulative false positive rate is 10 percent or less. In addition, the UPL estimation methodology incorporates the number of verification sampling events to confirm whether an observed exceedance from a constituent at a particular downgradient well is actually an exceedance or an outcome of random variation.

For constituents that have all ND background values, the maximum DL was chosen to represent the background value and the double quantification rule[1] (DQR) was used to evaluate whether or not there was an exceedance.

The test significance level per constituent was estimated such that the cumulative false positive rate over all well-constituent pair comparisons was approximately ten percent. Depending on the aquifer and constituent, individual UPL test significance levels ranged from 0.0001 to 0.0207 percent (i.e., UPLs ranged from 99.9% to 97.9% confidence levels).

The number of verification samples per constituent was selected to provide sufficient statistical power to detect an exceedance when an exceedance occurred, conditional to the background sample size, its distributional properties, and the total number of statistical test comparisons.

[1]Regardless of the background sample size, when 100 percent of the measurements are NDs, then the DQR can be used to test for an exceedance relative to background. According to the Unified Guidance, a confirmed exceedance is registered if any well-constituent pair in the ‘100% ND’ group exhibits quantified measurements in two consecutive sample and resample events.

The calculated alluvial and bedrock aquifer BTVs for each monitoring constituent are provided in **Table 9**.

4 Findings

The findings of the statistical analyses are provided below:

1. The statistical evaluations deemed the analytical results from the background wells to be representative of current background conditions and therefore appropriate for establishing BTVs.

2. The BTVs were calculated for dissolved metals, total metals, perchlorate, and nitrate for the alluvial and bedrock aquifers. The BTVs are considered to represent background or aquifer conditions unaffected by FWDA activities, and are used to provide a numerical basis for comparison with groundwater monitoring results. Values exceeding the BTV may indicate contamination is present and additional action may be required. The BTVs are provided in **Table 9**.

Based upon the ANOVA test results of dissolved and total metals between the alluvial and bedrock aquifers, it appears that the samples were not derived from the same population because they do not share similar concentration averages and variability. Therefore, results for samples collected from the two aquifers should be considered to represent separate populations and the monitoring constituents should be evaluated separately by aquifer.

4. Samples collected from FWDA often have high turbidity which can affect observed analytical results (Sundance, 2019). Well turbidity can introduce excess naturally occurring trace elements into the samples and result in elevated, inconsistent, and incomparable metals results within and between wells. The BTVs for each monitoring constituent from the alluvial and bedrock aquifers reflect the background conditions from which they were sampled. The background data should continue to be monitored and assessed to provide additional information about groundwater quality at the facility. As more data is collected, the BTVs can be updated to reflect background conditions at the facility.

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5 References

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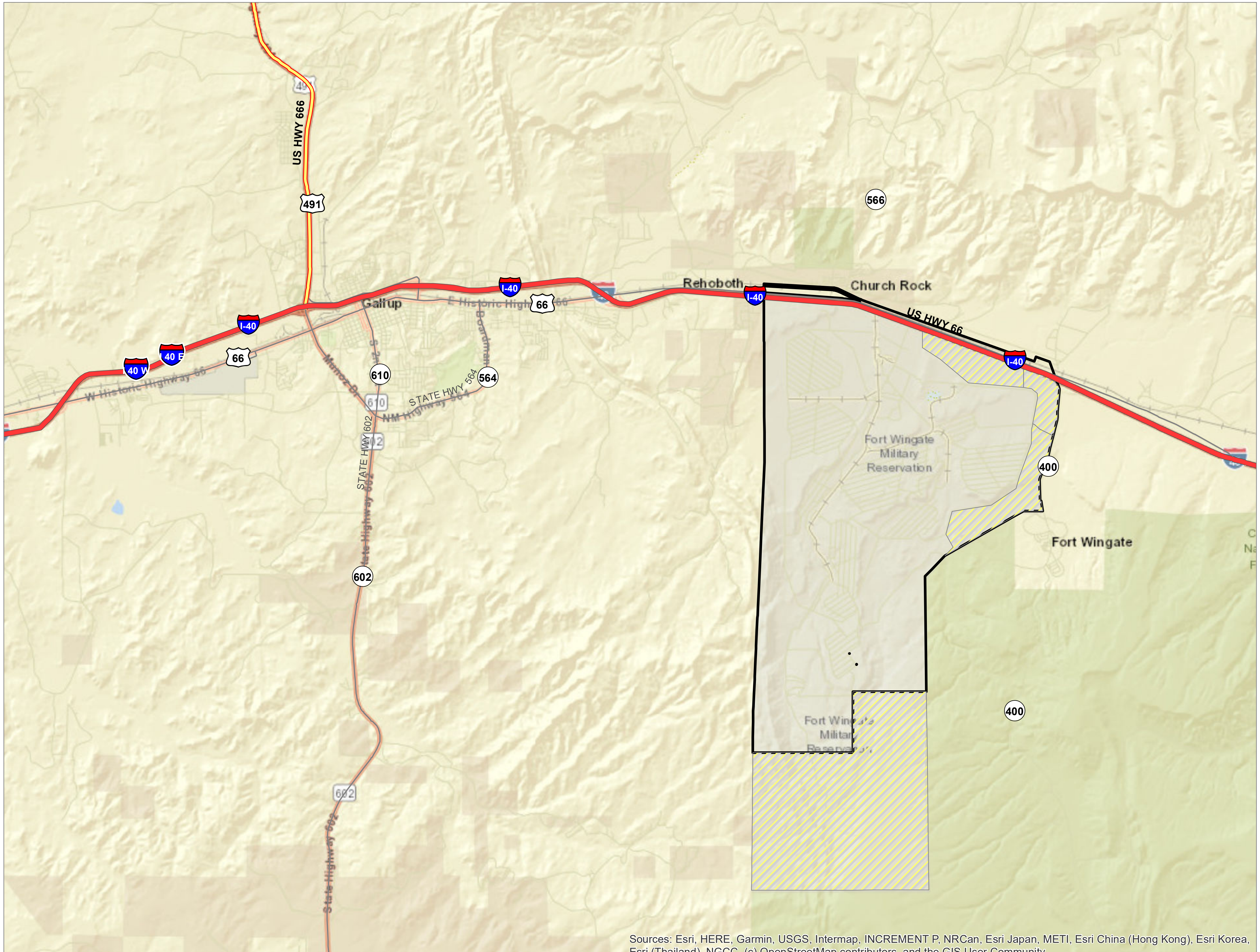
Figures



Legend

- FWDA Site Boundary
- Transferred FWDA Property
- Interstate
- Highways
- Secondary Roads

N W E S

0 0.5 1 2 3 Miles

0 1 2 4 Kilometers

Coordinate System:
WGS 1984 Web Mercator Auxiliary Sphere
Projection:
Mercator Auxiliary Sphere
Datum:
WGS 1984

HDR

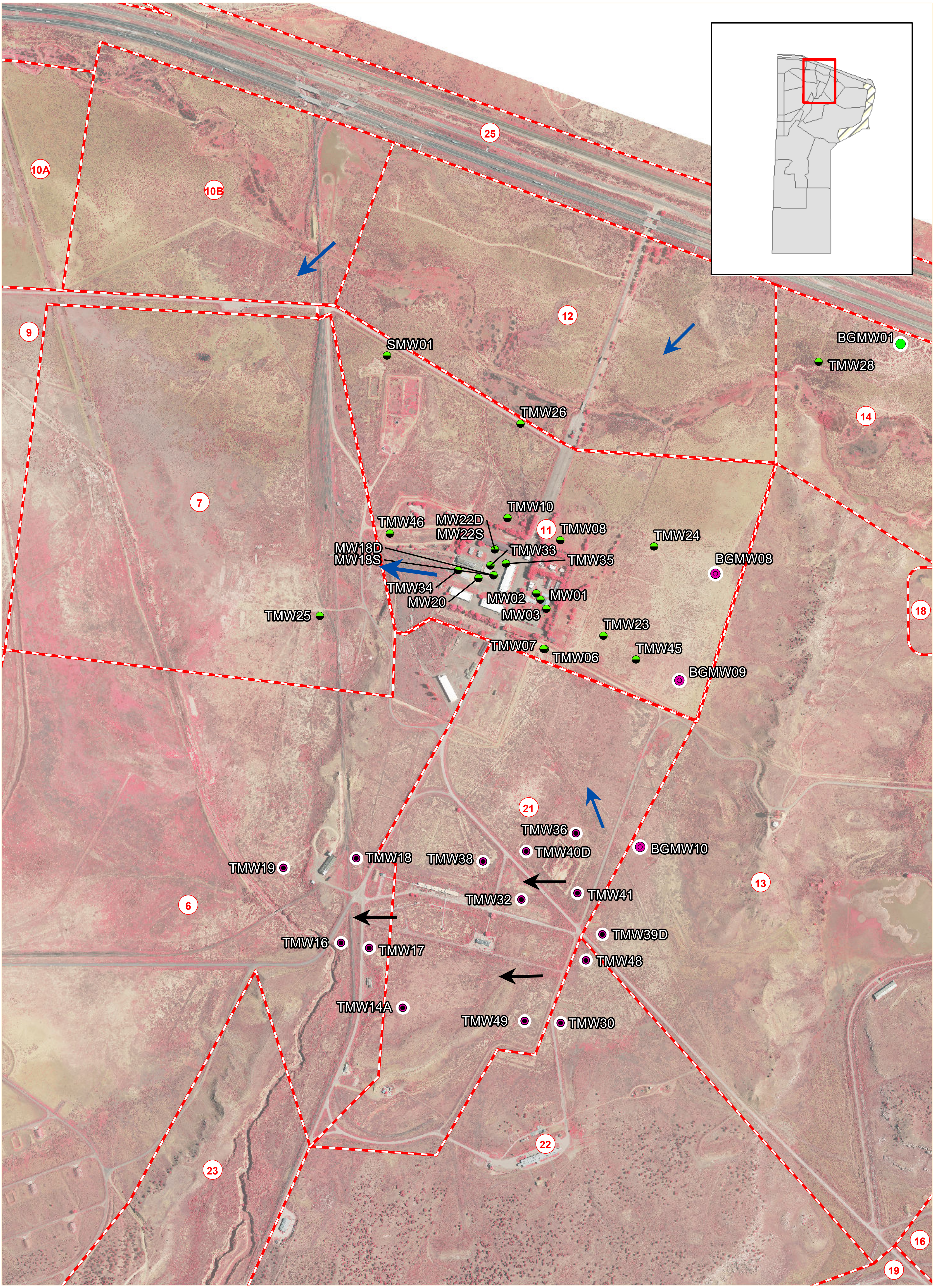
Figure 1

SITE LOCATION MAP

GROUNDWATER BACKGROUND EVALUATION

FORT WINGATE DEPOT ACTIVITY
MCKINLEY COUNTY, NEW MEXICO

Document Path: C:\FortWingate\GIS\BackgroundStudyReport\FWDA-01SiteLoc.mxd



Legend

- Alluvial Background Well
- Alluvial Downgradient Well
- Bedrock Background Well
- Bedrock Downgradient Well
- Alluvial Aquifer Groundwater Flow Direction
- Bedrock Aquifer Groundwater Flow Direction
- FWDA Parcel Boundaries
- 1 FWDA Parcel Number

Notes

FWDA = Fort Wingate Depot Activity

N W E S

0 375 750 1,500
Feet

0 115 230 460
Meters

Coordinate System:
WGS 1984 Web Mercator Auxiliary Sphere
Projection:
Mercator Auxiliary Sphere
Datum:
WGS 1984

Updated:
12/11/2019 10:30:06 AM

Figure 2

MONITORING WELLS UTILIZED FOR STATISTICAL ANALYSIS

GROUNDWATER BACKGROUND EVALUATION

FORT WINGATE DEPOT ACTIVITY
MCKINLEY COUNTY, NEW MEXICO

Document Path: C:\FortWingate\GIS\BackgroundStudyReport\FWDA-02_WellNetwork.mxd

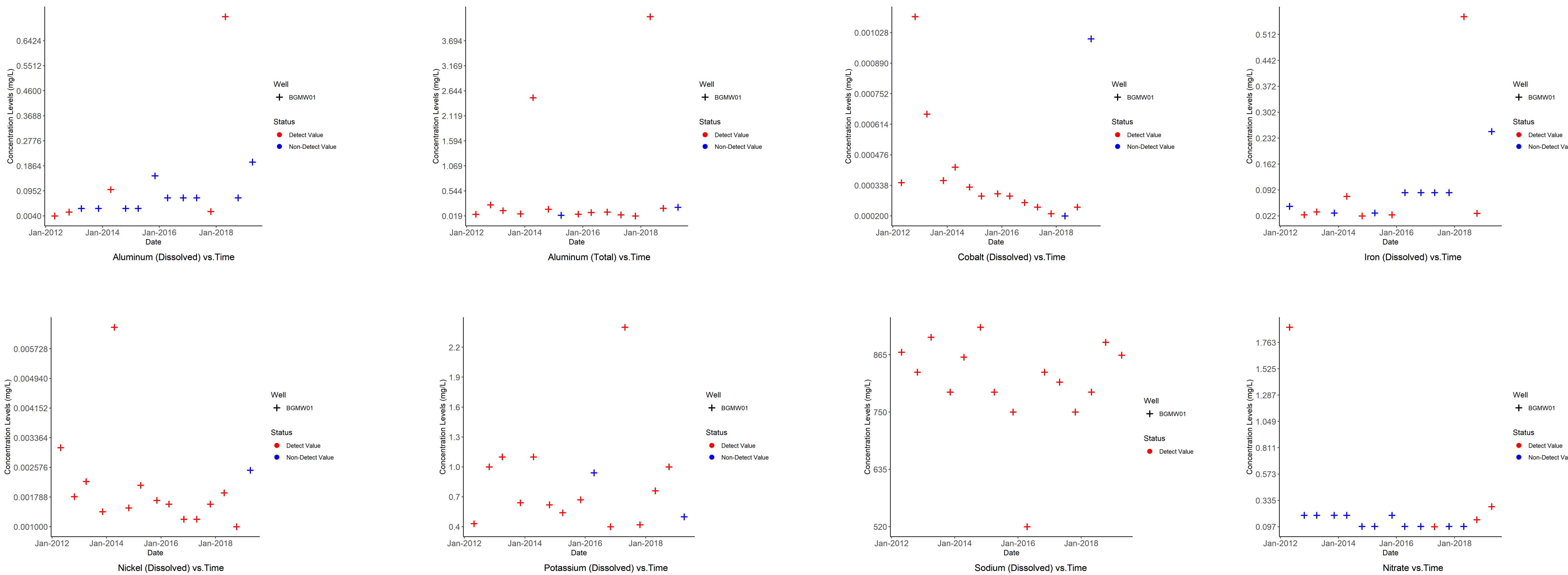


Figure 3A

SCATTER PLOTS IN SUPPORT OF OUTLIER ANALYSIS - ALLUVIAL GROUNDWATER BACKGROUND EVALUATION

FORT WINGATE DEPOT ACTIVITY MCKINLEY COUNTY, NEW MEXICO

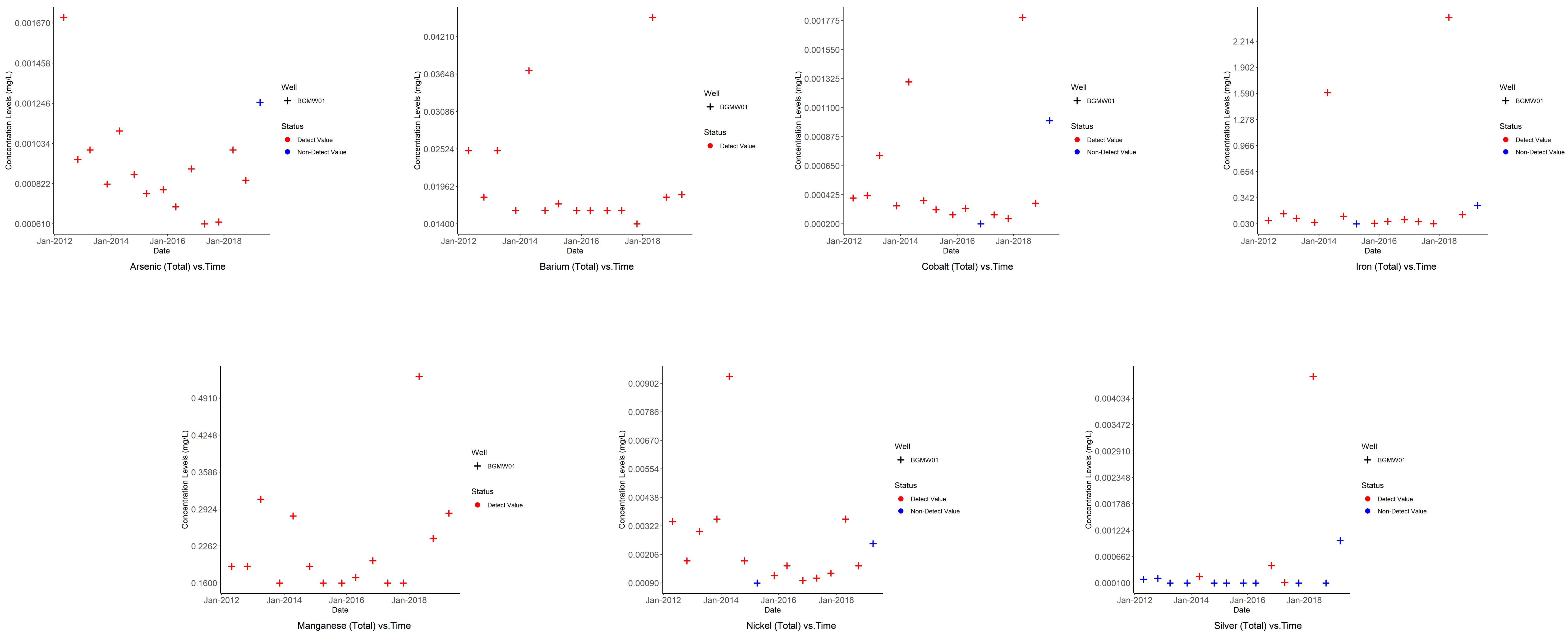
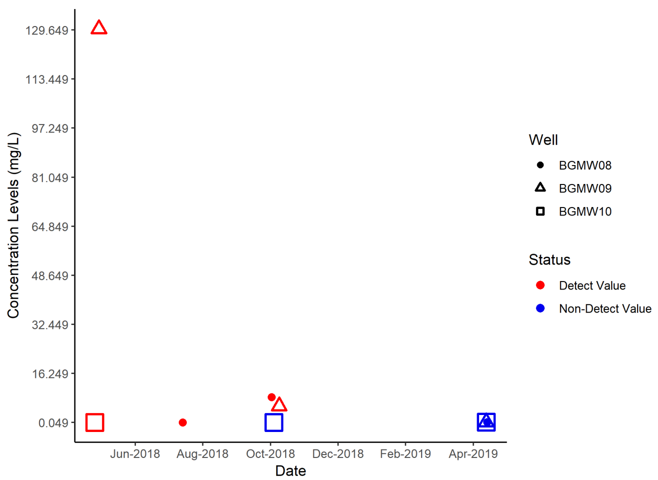
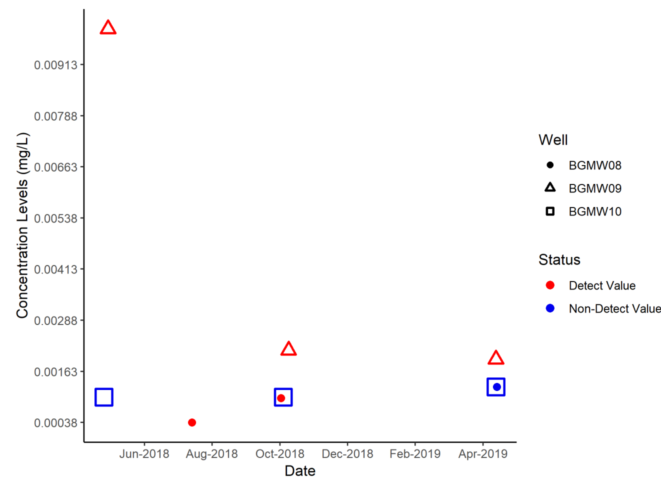


Figure 3B

SCATTER PLOTS IN SUPPORT OF OUTLIER ANALYSIS - ALLUVIAL
GROUNDWATER BACKGROUND EVALUATION
FORT WINGATE DEPOT ACTIVITY MCKINLEY COUNTY, NEW MEXICO

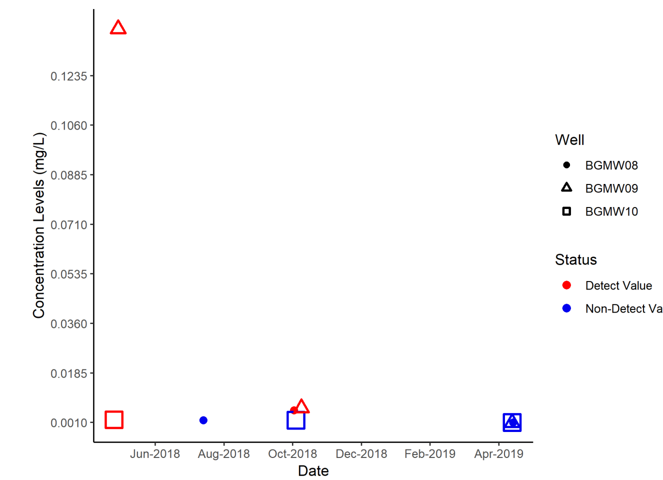


Aluminum (Dissolved) vs.Time

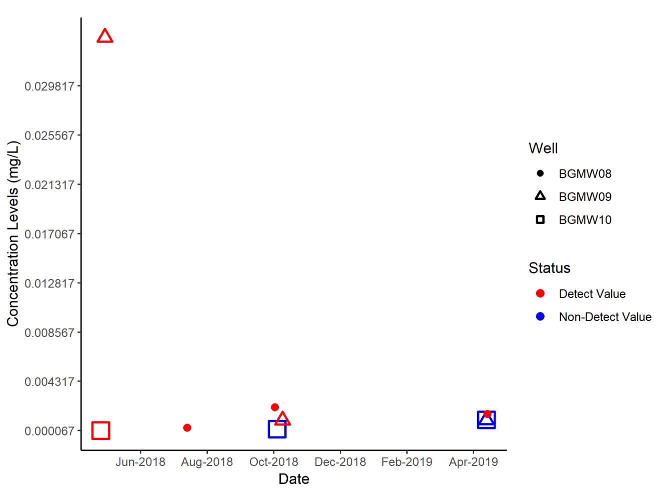


Arsenic (Dissolved) vs.Time

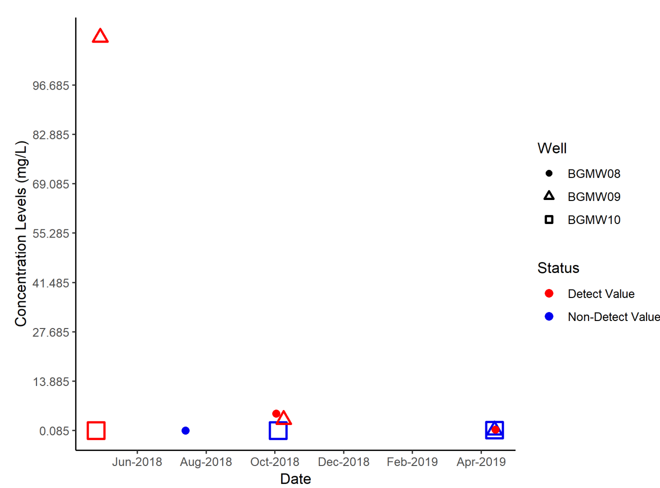
Barium (Dissolved) vs.Time



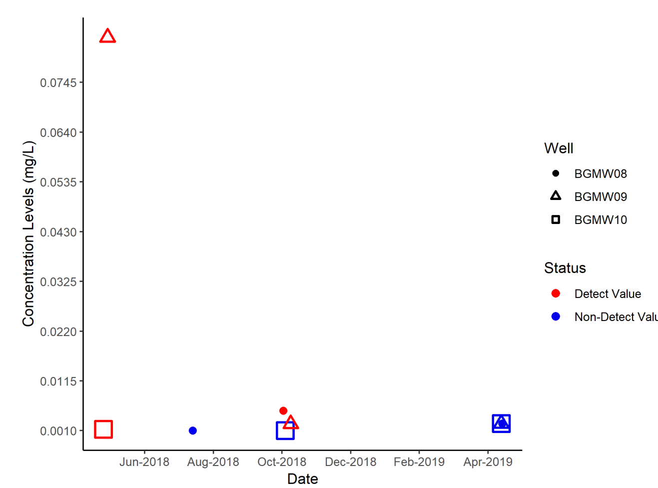
Chromium (Dissolved) vs.Time



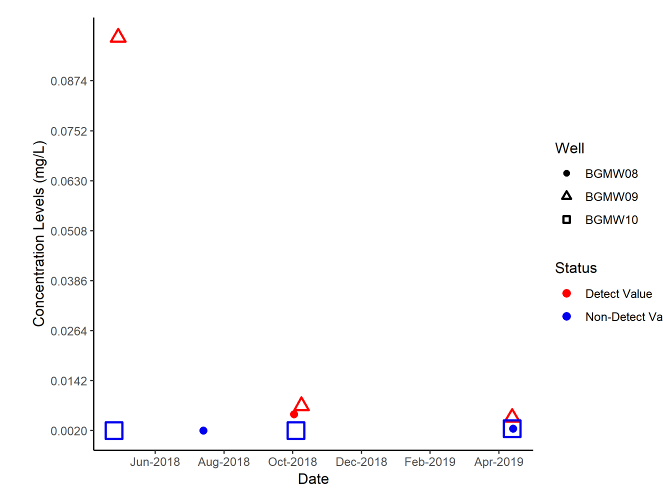
Cobalt (Dissolved) vs.Time



Iron (Dissolved) vs.Time



Nickel (Dissolved) vs.Time



Vanadium (Dissolved) vs.Time

Figure 3C

SCATTER PLOTS IN SUPPORT OF OUTLIER ANALYSIS - BEDROCK
GROUNDWATER BACKGROUND EVALUATION
FORT WINGATE DEPOT ACTIVITY MCKINLEY COUNTY, NEW MEXICO

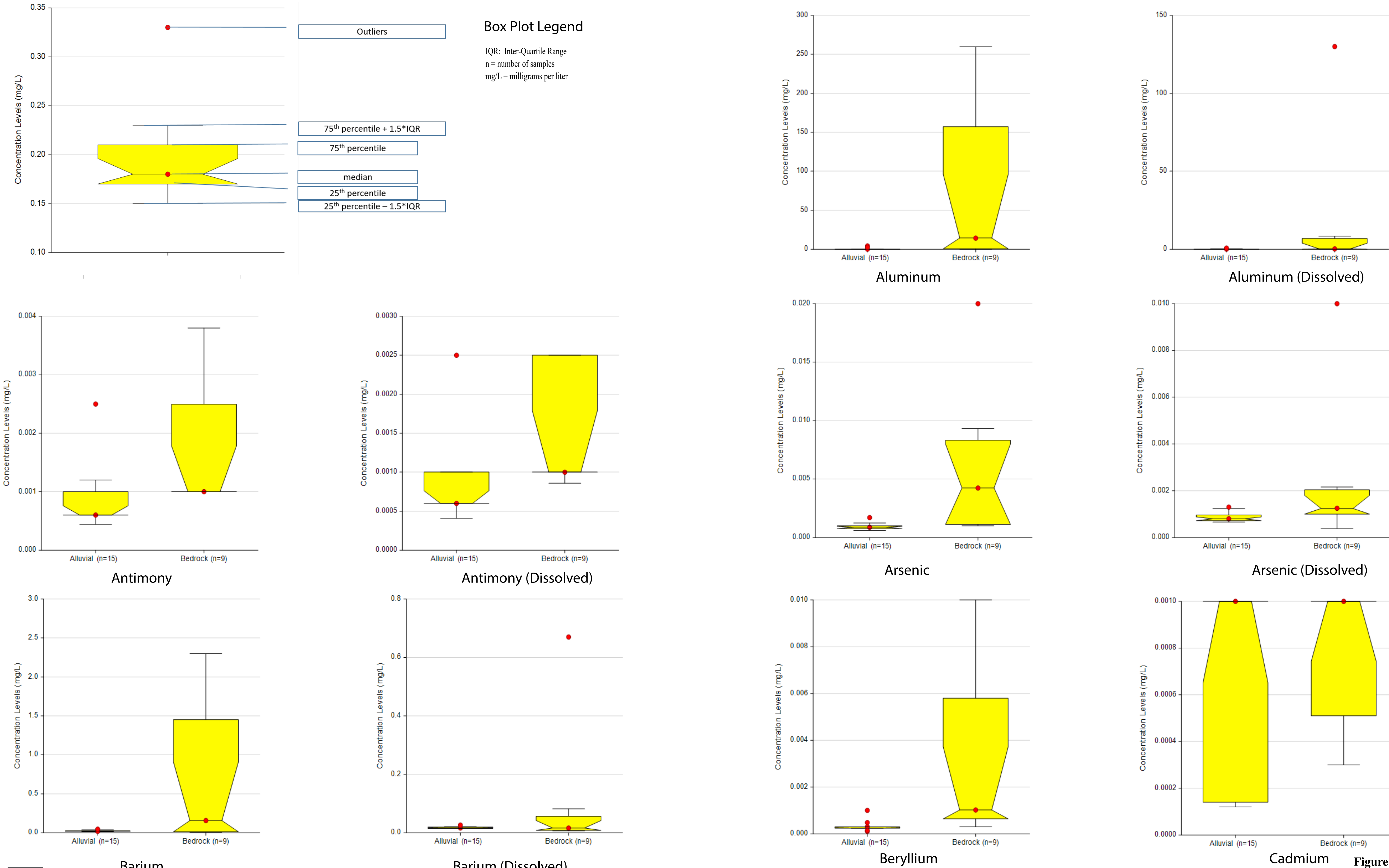


Figure 4A

BOX AND WHISKER PLOTS

GROUNDWATER BACKGROUND EVALUATION

FORT WINGATE DEPOT ACTIVITY MCKINLEY COUNTY, NEW MEXICO

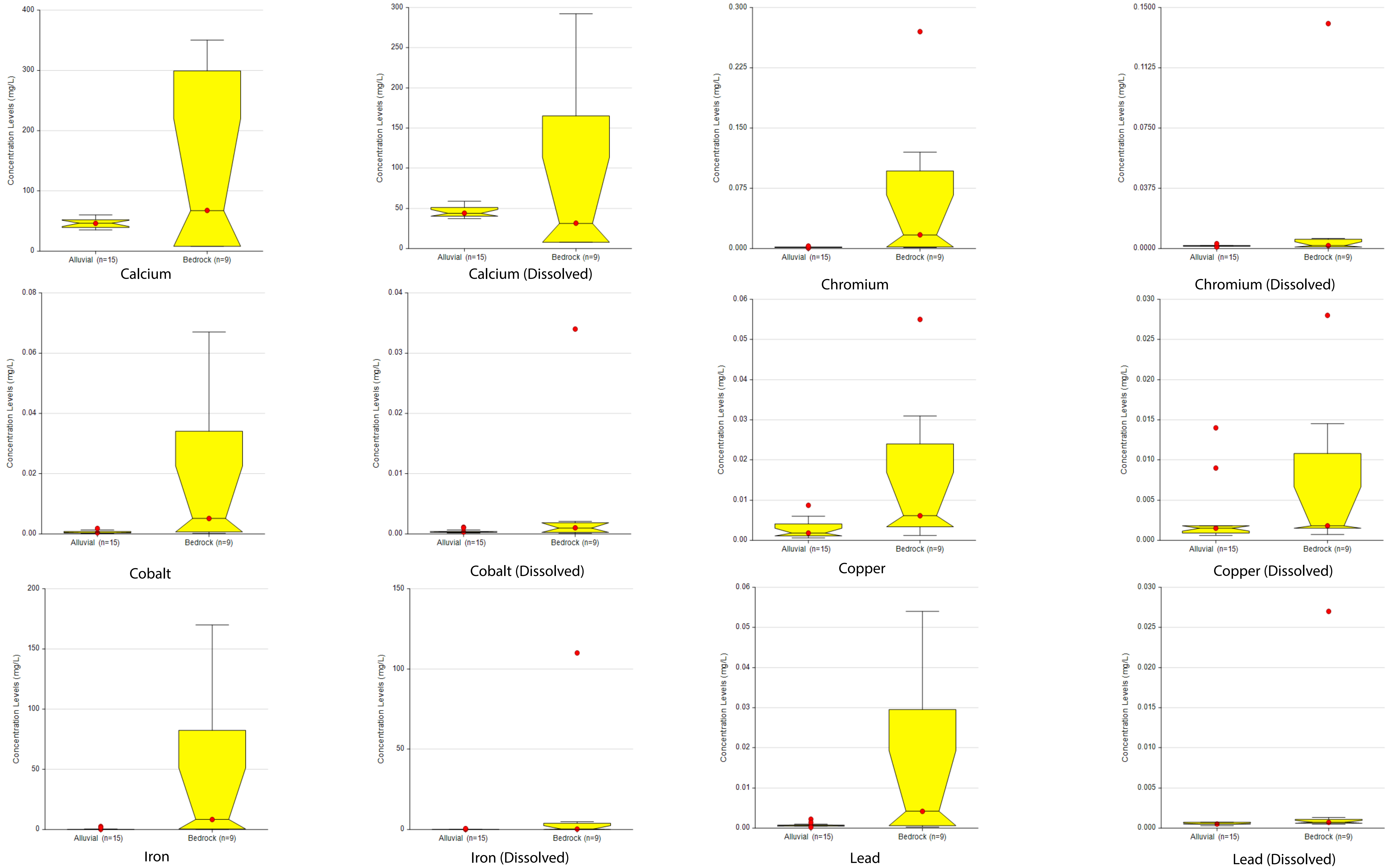


Figure 4B

BOX AND WHISKER PLOTS

GROUNDWATER BACKGROUND EVALUATION

FORT WINGATE DEPOT ACTIVITY MCKINLEY COUNTY, NEW MEXICO

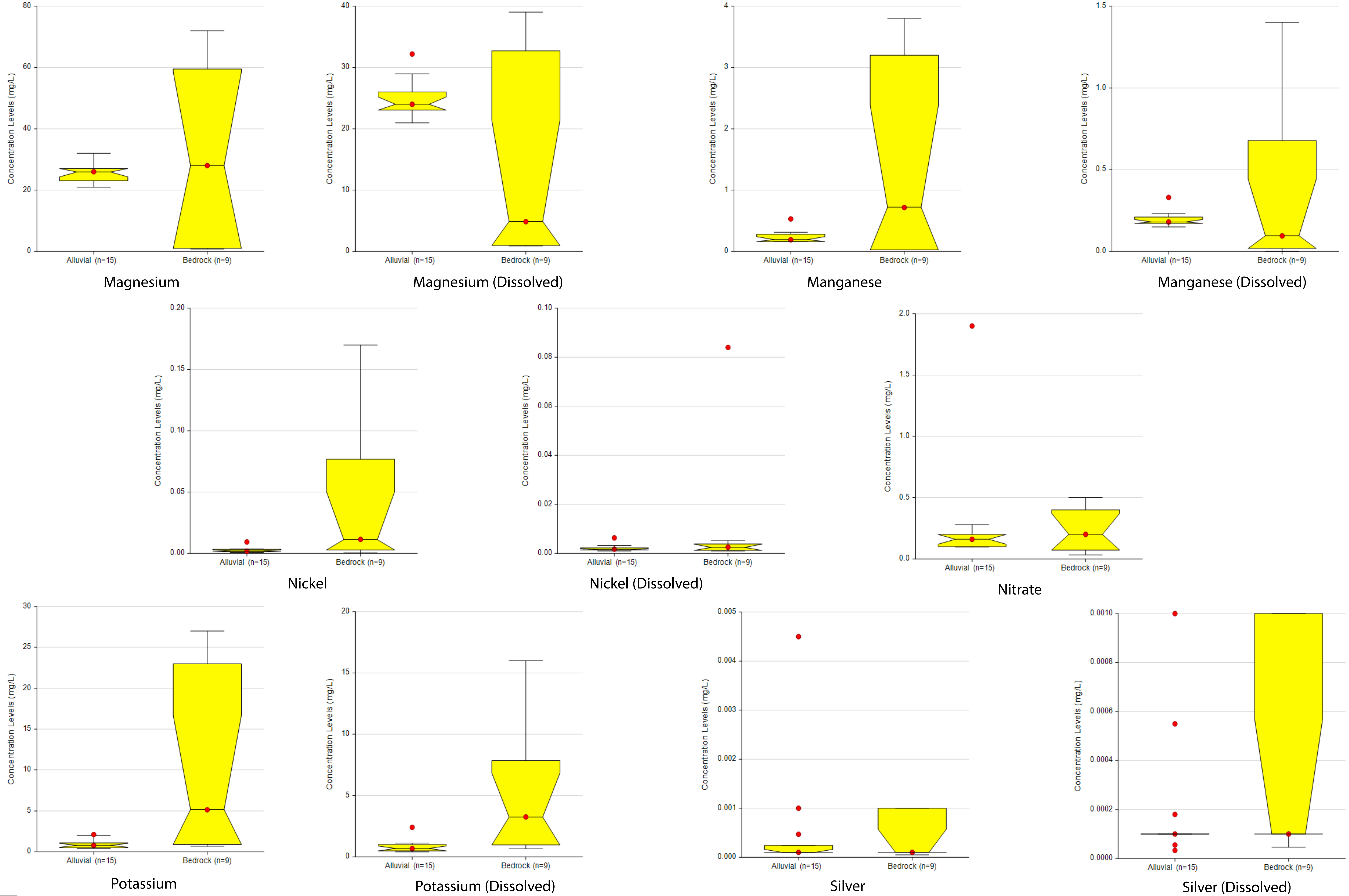
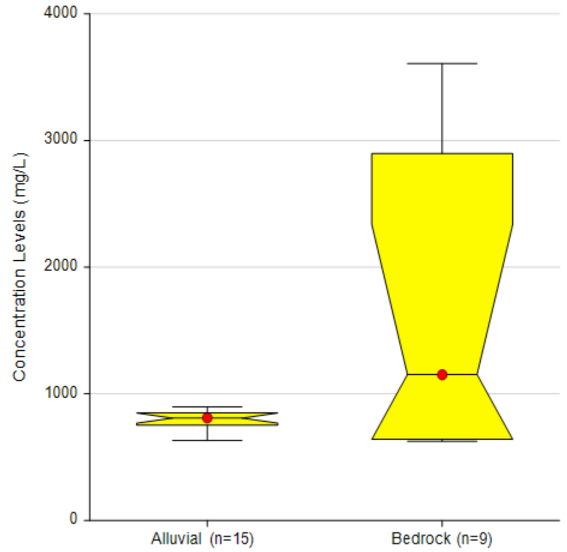


Figure 4C

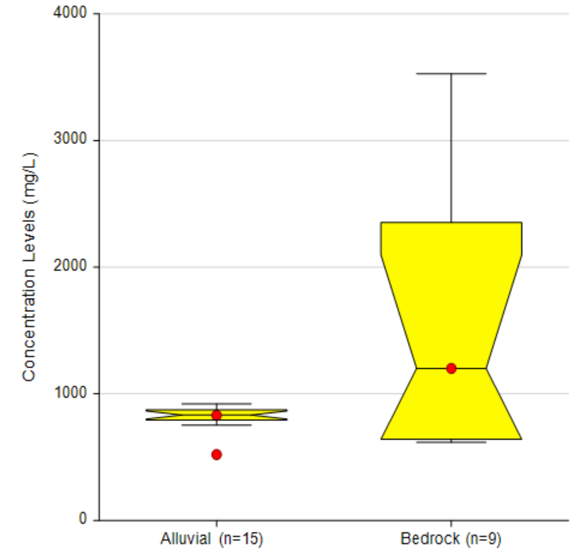
BOX AND WHISKER PLOTS

GROUNDWATER BACKGROUND EVALUATION

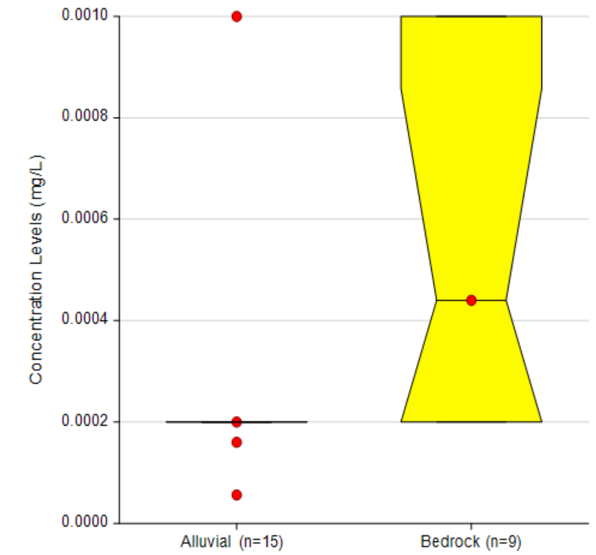
FORT WINGATE DEPOT ACTIVITY MCKINLEY COUNTY, NEW MEXICO



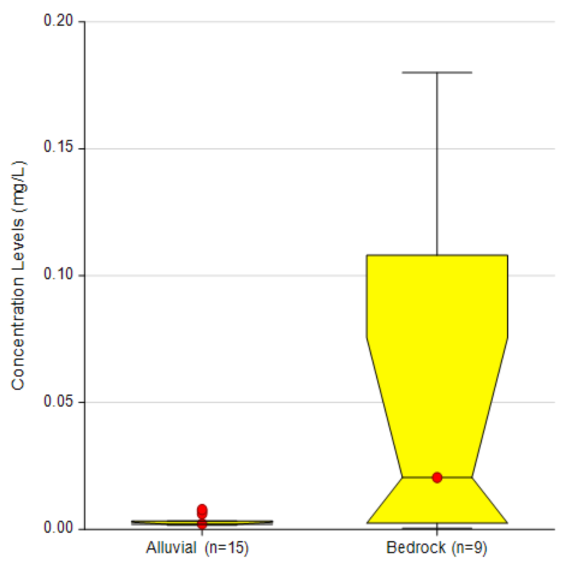
Sodium



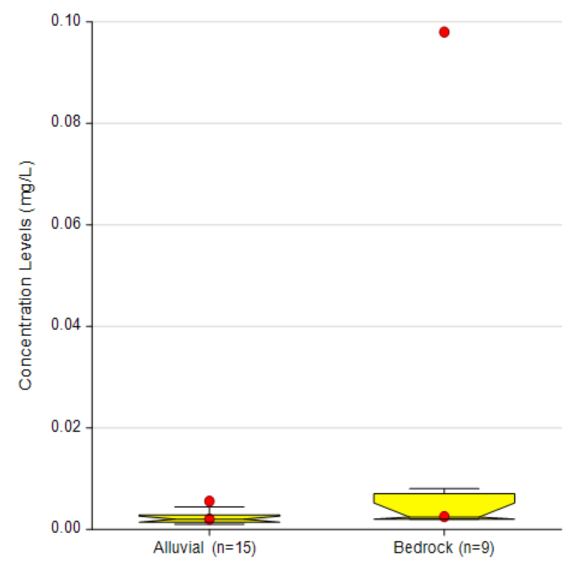
Sodium (Dissolved)



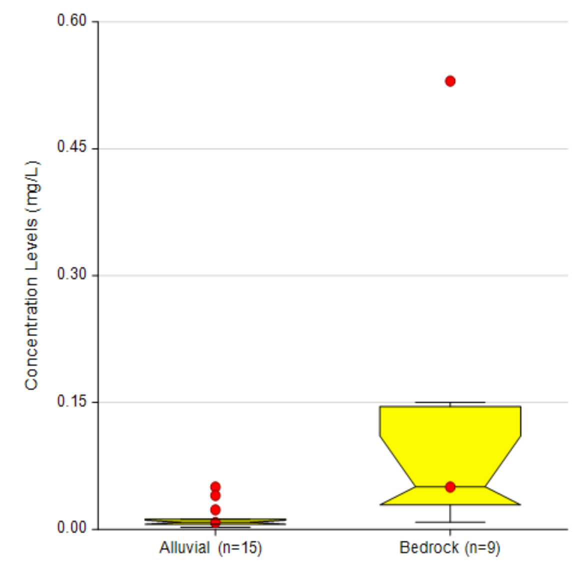
Thallium



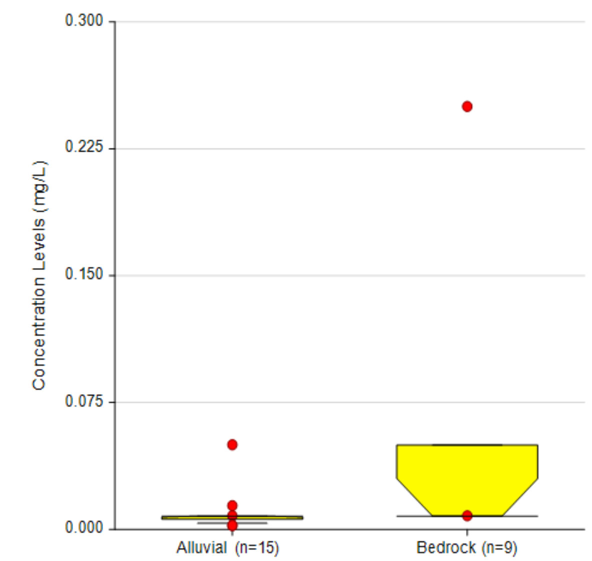
Vanadium



Vanadium (Dissolved)



Zinc



Zinc (Dissolved)

Figure 4D
BOX AND WHISKER PLOTS
GROUNDWATER BACKGROUND EVALUATION
FORT WINGATE DEPOT ACTIVITY MCKINLEY COUNTY, NEW MEXICO

Tables

Table 1: Monitoring Wells Utilized for Statistical Analysis

Background Wells[1]	
Alluvial	**Bedrock**
BGMW01	BGMW08
	BGMW09
	BGMW10
Downgradient Wells[2]	
Alluvial	**Bedrock**
MW01	TMW14A
MW02	TMW16
MW03	TMW17
MW18D	TMW18
MW18S	TMW19
MW22D	TMW30
MW22S	TMW32
SMW01	TMW36
TMW06	TMW38
TMW07	TMW39D
TMW08	TMW40D
TMW10	TMW41A
MW20	TMW48
TMW23	TMW49
TMW24	
TMW25	
TMW26	
TMW28	
TMW33	
TMW34	
TMW35	
TMW45	
TMW46	

[1] The analytical results from the background wells were used to compute the BTVs.
[2] The number of downgradient wells were used to determine the number of comparisons required between the BTVs and the analytical results from FWDA monitoring wells to achieve the target site-wide false positive rates.

Table 2: Constituents Utilized for Statistical Analysis

Dissolved Metals	Total Metals	Other Compounds
Aluminum	Aluminum	Nitrate
Antimony	Antimony	Perchlorate
Arsenic	Arsenic	
Barium	Barium	
Beryllium	Beryllium	
Cadmium	Cadmium	
Calcium	Calcium	
Chromium	Chromium	
Cobalt	Cobalt	
Copper	Copper	
Iron	Iron	
Lead	Lead	
Magnesium	Magnesium	
Manganese	Manganese	
Mercury	Mercury	
Nickel	Nickel	
Potassium	Potassium	
Selenium	Selenium	
Silver	Silver	
Sodium	Sodium	
Thallium	Thallium	
Vanadium	Vanadium	
Zinc	Zinc	

Table 3: Descriptive Statistics for the Background Data Set

Constituent	Aquifer	Unit	Sample Size	No. of NDs	With NDs=DLs Included				With NDs Removed			
					Minimum	Maximum	Mean	Median	Minimum	Maximum	Mean	Median
Dissolved Metals												
Aluminum	Alluvial	mg/L	15	10	0.00400	0.730	0.108	0.0700	0.00400	0.730	0.174	0.0200
Antimony	Alluvial	mg/L	15	13	0.000410	0.00250	0.000837	0.000600	0.000410	0.000530	0.000470	0.000470
Arsenic	Alluvial	mg/L	15	1	0.000660	0.00130	0.000857	0.000800	0.000660	0.00130	0.000829	0.000795
Barium	Alluvial	mg/L	15	0	0.0140	0.0260	0.0175	0.0160	0.0140	0.0260	0.0175	0.0160
Beryllium	Alluvial	mg/L	15	15	0.000240	0.00100	0.000319	0.000300	--	--	--	--
Cadmium	Alluvial	mg/L	15	15	0.000120	0.00100	0.000618	0.00100	--	--	--	--
Calcium	Alluvial	mg/L	15	0	37.0	58.6	45.6	44.0	37.0	58.6	45.6	44.0
Chromium	Alluvial	mg/L	15	13	0.000970	0.00300	0.00165	0.00150	0.000970	0.00300	0.00198	0.00198
Cobalt	Alluvial	mg/L	15	2	0.000200	0.00110	0.000417	0.000300	0.000210	0.00110	0.000388	0.000300
Copper	Alluvial	mg/L	15	6	0.000580	0.0140	0.00262	0.00150	0.000580	0.0140	0.00330	0.00110
Iron	Alluvial	mg/L	15	8	0.0220	0.560	0.0978	0.0480	0.0220	0.560	0.110	0.0290
Lead	Alluvial	mg/L	15	12	0.000280	0.000700	0.000560	0.000500	0.000280	0.000584	0.000401	0.000340
Magnesium	Alluvial	mg/L	15	0	21.0	32.2	25.1	24.0	21.0	32.2	25.1	24.0
Manganese	Alluvial	mg/L	15	0	0.150	0.330	0.195	0.180	0.150	0.330	0.195	0.180
Mercury	Alluvial	mg/L	15	15	0.0000520	0.000100	0.0000795	0.0000800	--	--	--	--
Nickel	Alluvial	mg/L	15	1	0.00100	0.00630	0.00207	0.00170	0.00100	0.00630	0.00204	0.00165
Potassium	Alluvial	mg/L	15	2	0.400	2.40	0.835	0.670	0.400	2.40	0.852	0.670
Selenium	Alluvial	mg/L	15	14	0.00150	0.00300	0.00203	0.00200	0.00300	0.00300	0.00300	0.00300
Silver	Alluvial	mg/L	15	12	0.0000330	0.00100	0.000188	0.000100	0.0000330	0.000550	0.000213	0.0000550
Sodium	Alluvial	mg/L	15	0	520	920	811	830	520	920	811	830
Thallium	Alluvial	mg/L	15	15	0.000100	0.00100	0.000244	0.000200	--	--	--	--
Vanadium	Alluvial	mg/L	15	1	0.00100	0.00554	0.00230	0.00200	0.00100	0.00554	0.00232	0.00185
Zinc	Alluvial	mg/L	15	10	0.00220	0.0500	0.00963	0.00800	0.00220	0.0140	0.00570	0.00340
Aluminum	Bedrock	mg/L	9	4	0.0490	130	16.1	0.200	0.0490	130	28.8	5.55
Antimony	Bedrock	mg/L	9	7	0.000860	0.00250	0.00152	0.00100	0.000860	0.00130	0.00108	0.00108

Table 3: Descriptive Statistics for the Background Data Set (continued)

Constituent	Aquifer	Unit	Sample Size	No. of NDs	With NDs=DLs Included				With NDs Removed			
					Minimum	Maximum	Mean	Median	Minimum	Maximum	Mean	Median
Dissolved Metals												
Arsenic	Bedrock	mg/L	9	4	0.000380	0.0100	0.00222	0.00125	0.000380	0.0100	0.00309	0.00193
Barium	Bedrock	mg/L	9	0	0.00678	0.670	0.0960	0.0158	0.00678	0.670	0.0960	0.0158
Beryllium	Bedrock	mg/L	9	7	0.000130	0.00550	0.00109	0.000300	0.000130	0.00550	0.00282	0.00282
Cadmium	Bedrock	mg/L	9	9	0.00100	0.00100	0.00100	0.00100	--	--	--	--
Calcium	Bedrock	mg/L	9	0	7.80	292	88.3	31.5	7.80	292	88.3	31.5
Chromium	Bedrock	mg/L	9	5	0.00100	0.140	0.0178	0.00180	0.00200	0.140	0.0384	0.00575
Cobalt	Bedrock	mg/L	9	3	0.0000670	0.0340	0.00458	0.00100	0.0000670	0.0340	0.00650	0.00125
Copper	Bedrock	mg/L	9	4	0.000700	0.0280	0.00688	0.00180	0.000700	0.0280	0.0103	0.00715
Iron	Bedrock	mg/L	9	4	0.0850	110	13.3	0.250	0.0880	110	23.7	3.17
Lead	Bedrock	mg/L	9	6	0.000500	0.0270	0.00366	0.000700	0.000874	0.0270	0.00972	0.00130
Magnesium	Bedrock	mg/L	9	0	0.876	39.0	14.3	4.85	0.876	39.0	14.3	4.85
Manganese	Bedrock	mg/L	9	1	0.000950	1.40	0.366	0.0950	0.0174	1.40	0.412	0.212
Mercury	Bedrock	mg/L	9	9	0.0000800	0.000100	0.0000867	0.0000800	--	--	--	--
Nickel	Bedrock	mg/L	9	5	0.00100	0.0840	0.0114	0.00250	0.00130	0.0840	0.0232	0.00382
Potassium	Bedrock	mg/L	9	0	0.645	16.0	4.80	3.25	0.645	16.0	4.80	3.25
Selenium	Bedrock	mg/L	9	9	0.00150	0.00200	0.00183	0.00200	--	--	--	--
Silver	Bedrock	mg/L	9	8	0.0000460	0.00100	0.000394	0.000100	0.0000460	0.0000460	0.0000460	0.0000460
Sodium	Bedrock	mg/L	9	0	618	3,530	1,523	1,200	618	3,530	1,523	1,200
Thallium	Bedrock	mg/L	9	8	0.000200	0.00100	0.000483	0.000200	0.000350	0.000350	0.000350	0.000350
Vanadium	Bedrock	mg/L	9	5	0.00200	0.0980	0.0143	0.00250	0.00523	0.0980	0.0293	0.00703
Zinc	Bedrock	mg/L	9	8	0.00800	0.250	0.0489	0.00800	0.250	0.250	0.250	0.250
Total Metals												
Aluminum	Alluvial	mg/L	15	2	0.0190	4.20	0.538	0.100	0.0190	4.20	0.603	0.100
Antimony	Alluvial	mg/L	15	13	0.000440	0.00250	0.000879	0.000600	0.000440	0.000530	0.000485	0.000485
Arsenic	Alluvial	mg/L	15	1	0.000610	0.00170	0.000928	0.000870	0.000610	0.00170	0.000905	0.000855

Table 3: Descriptive Statistics for the Background Data Set (continued)

Constituent	Aquifer	Unit	Sample Size	No. of NDs	With NDs=DLs Included				With NDs Removed			
					Minimum	Maximum	Mean	Median	Minimum	Maximum	Mean	Median
Total Metals												
Barium	Alluvial	mg/L	15	0	0.0140	0.0450	0.0209	0.0170	0.0140	0.0450	0.0209	0.0170
Beryllium	Alluvial	mg/L	15	13	0.000110	0.00100	0.000316	0.000300	0.000110	0.000140	0.000125	0.000125
Cadmium	Alluvial	mg/L	15	13	0.000120	0.00100	0.000634	0.00100	0.000140	0.000370	0.000255	0.000255
Calcium	Alluvial	mg/L	15	0	35.0	60.0	46.1	46.0	35.0	60.0	46.1	46.0
Chromium	Alluvial	mg/L	15	10	0.000620	0.00300	0.00164	0.00170	0.000620	0.00260	0.00149	0.00170
Cobalt	Alluvial	mg/L	15	2	0.000200	0.00180	0.000556	0.000360	0.000240	0.00180	0.000549	0.000360
Copper	Alluvial	mg/L	15	5	0.000590	0.00870	0.00264	0.00180	0.000590	0.00870	0.00278	0.00145
Iron	Alluvial	mg/L	15	2	0.0300	2.50	0.351	0.0810	0.0310	2.50	0.384	0.0810
Lead	Alluvial	mg/L	15	11	0.000190	0.00220	0.000762	0.000700	0.000190	0.00220	0.00111	0.00102
Magnesium	Alluvial	mg/L	15	0	21.0	32.0	25.6	26.0	21.0	32.0	25.6	26.0
Manganese	Alluvial	mg/L	15	0	0.160	0.530	0.226	0.190	0.160	0.530	0.226	0.190
Mercury	Alluvial	mg/L	15	15	0.0000270	0.000100	0.0000778	0.0000800	--	--	--	--
Nickel	Alluvial	mg/L	15	2	0.000900	0.00930	0.00250	0.00180	0.00100	0.00930	0.00262	0.00180
Potassium	Alluvial	mg/L	15	1	0.420	2.10	0.943	0.770	0.420	2.10	0.975	0.795
Selenium	Alluvial	mg/L	15	14	0.00150	0.00460	0.00227	0.00200	0.00460	0.00460	0.00460	0.00460
Silver	Alluvial	mg/L	15	11	0.000100	0.00450	0.000500	0.000100	0.000110	0.00450	0.00133	0.000355
Sodium	Alluvial	mg/L	15	0	630	894	794	810	630	894	794	810
Thallium	Alluvial	mg/L	15	14	0.0000560	0.00100	0.000241	0.000200	0.0000560	0.0000560	0.0000560	0.0000560
Vanadium	Alluvial	mg/L	15	2	0.00150	0.00780	0.00315	0.00210	0.00150	0.00780	0.00332	0.00220
Zinc	Alluvial	mg/L	15	10	0.00200	0.0500	0.0127	0.00800	0.00200	0.0400	0.0142	0.00320
Aluminum	Bedrock	mg/L	9	2	0.0700	260	74.5	14.2	0.560	260	95.7	78.0
Antimony	Bedrock	mg/L	9	8	0.00100	0.00380	0.00181	0.00100	0.00380	0.00380	0.00380	0.00380
Arsenic	Bedrock	mg/L	9	3	0.00100	0.0200	0.00576	0.00423	0.00144	0.0200	0.00810	0.00683
Barium	Bedrock	mg/L	9	0	0.00758	2.30	0.659	0.156	0.00758	2.30	0.659	0.156
Beryllium	Bedrock	mg/L	9	4	0.000300	0.0100	0.00312	0.00102	0.00102	0.0100	0.00510	0.00380

Table 3: Descriptive Statistics for the Background Data Set (continued)

Constituent	Aquifer	Unit	Sample Size	No. of NDs	With NDs=DLs Included				With NDs Removed			
					Minimum	Maximum	Mean	Median	Minimum	Maximum	Mean	Median
Total Metals												
Cadmium	Bedrock	mg/L	9	6	0.000300	0.00100	0.000813	0.00100	0.000300	0.000540	0.000440	0.000480
Calcium	Bedrock	mg/L	9	0	7.70	350	139	67.5	7.70	350	139	67.5
Chromium	Bedrock	mg/L	9	1	0.00100	0.270	0.0624	0.0170	0.00100	0.270	0.0701	0.0440
Cobalt	Bedrock	mg/L	9	2	0.000200	0.0670	0.0187	0.00511	0.000260	0.0670	0.0238	0.0240
Copper	Bedrock	mg/L	9	3	0.00120	0.0550	0.0149	0.00611	0.00120	0.0550	0.0204	0.0145
Iron	Bedrock	mg/L	9	1	0.0250	170	42.7	8.26	0.0250	170	48.0	24.1
Lead	Bedrock	mg/L	9	2	0.000210	0.0540	0.0154	0.00416	0.000210	0.0540	0.0196	0.0190
Magnesium	Bedrock	mg/L	9	0	0.870	72.0	29.6	28.0	0.870	72.0	29.6	28.0
Manganese	Bedrock	mg/L	9	0	0.0230	3.80	1.35	0.716	0.0230	3.80	1.35	0.716
Mercury	Bedrock	mg/L	9	8	0.0000260	0.000100	0.0000771	0.0000800	0.0000260	0.0000260	0.0000260	0.0000260
Nickel	Bedrock	mg/L	9	1	0.000420	0.170	0.0444	0.0114	0.000420	0.170	0.0496	0.0332
Potassium	Bedrock	mg/L	9	1	0.660	27.0	10.5	5.13	0.660	27.0	11.7	8.39
Selenium	Bedrock	mg/L	9	9	0.00150	0.00200	0.00183	0.00200	--	--	--	--
Silver	Bedrock	mg/L	9	7	0.0000460	0.00100	0.000394	0.000100	0.0000460	0.000100	0.0000730	0.0000730
Sodium	Bedrock	mg/L	9	0	623	3,610	1,647	1,150	623	3,610	1,647	1,150
Thallium	Bedrock	mg/L	9	6	0.000200	0.00100	0.000560	0.000440	0.000300	0.000700	0.000480	0.000440
Vanadium	Bedrock	mg/L	9	2	0.000560	0.180	0.0558	0.0204	0.000560	0.180	0.0712	0.0780
Zinc	Bedrock	mg/L	9	5	0.00800	0.530	0.120	0.0500	0.0910	0.530	0.228	0.145
Other Compounds												
Nitrate	Alluvial	mg/L	15	11	0.0970	1.90	0.269	0.160	0.0970	1.90	0.609	0.220
Nitrate	Bedrock	mg/L	9	8	0.0300	0.500	0.220	0.200	0.0870	0.0870	0.0870	0.0870
Perchlorate	Alluvial	mg/L	15	15	0.0000100	0.000100	0.0000287	0.0000200	--	--	--	--
Perchlorate	Bedrock	mg/L	9	6	0.00000570	0.0000500	0.0000236	0.0000100	0.00000570	0.00000950	0.00000760	0.00000760

Notes:
1. ND = not detected above the laboratory method detection limit.
2. DL = detection limit.
3. "--" indicates all results for the respective constituent were NDs. NDs were flagged but the laboratory did not provide a value for the DL.
4. Numbers are displayed using the same number of significant figures as reported by the laboratory , which is three significant figures.
5. If a constituent had 100% detections the descriptive statistics provided above are identical for the data including NDs and excluding NDs.
6. mg/L = milligram per liter

Table 4: Dixon's Outlier Test Results

Aquifer	Well	Constituent	Constituent Type	Potential Outlier Value	Units	Sampling Event	Sample Date
Alluvial	BGMW01	Aluminum (Dissolved)	Dissolved Metals	0.730	mg/L	April 2018	4/27/2018
		Cobalt (Dissolved)	Dissolved Metals	0.00110	mg/L	October 2012	10/26/2012
		Iron (Dissolved)	Dissolved Metals	0.560	mg/L	April 2018	4/27/2018
		Nickel (Dissolved)	Dissolved Metals	0.00630	mg/L	April 2014	4/15/2014
		Potassium (Dissolved)	Dissolved Metals	2.40	mg/L	April 2017	4/24/2017
		Sodium (Dissolved)	Dissolved Metals	520	mg/L	April 2016	4/15/2016
		Aluminum	Total Metals	4.20	mg/L	April 2018	4/27/2018
		Arsenic	Total Metals	0.00170	mg/L	April 2012	4/25/2012
		Barium	Total Metals	0.0450	mg/L	April 2018	4/27/2018
		Cobalt	Total Metals	0.00180	mg/L	April 2018	4/27/2018
		Iron	Total Metals	2.50	mg/L	April 2018	4/27/2018
		Manganese	Total Metals	0.530	mg/L	April 2018	4/27/2018
		Nickel	Total Metals	0.00930	mg/L	April 2014	4/15/2014
		Silver	Total Metals	0.00450	mg/L	April 2018	4/27/2018
		Nitrate	Other Compounds	1.90	mg/L	April 2012	4/25/2012
Bedrock	BGMW09	Aluminum (Dissolved)	Dissolved Metals	130	mg/L	April 2018	5/1/2018
		Arsenic (Dissolved)	Dissolved Metals	0.0100	mg/L	April 2018	5/1/2018
		Barium (Dissolved)	Dissolved Metals	0.670	mg/L	April 2018	5/1/2018
		Chromium (Dissolved)	Dissolved Metals	0.140	mg/L	April 2018	5/1/2018
		Cobalt (Dissolved)	Dissolved Metals	0.0340	mg/L	April 2018	5/1/2018
		Iron (Dissolved)	Dissolved Metals	110	mg/L	April 2018	5/1/2018
		Nickel (Dissolved)	Dissolved Metals	0.0840	mg/L	April 2018	5/1/2018
		Vanadium (Dissolved)	Dissolved Metals	0.0980	mg/L	April 2018	5/1/2018

Notes:
1. mg/L = milligrams per liter
2. Only constituents from wells in the alluvial or bedrock aquifer that had statistically identified outliers are displayed

Table 5: Data Distributions – Background

Constituent	Aquifer	Sample Size	No. of NDs	Distribution Fit[1]
Dissolved Metals				
Aluminum	Alluvial	15	10	Nonparametric
Antimony	Alluvial	15	13	Nonparametric
Arsenic	Alluvial	15	1	Parametric
Barium	Alluvial	15	0	Parametric
Beryllium	Alluvial	15	15	Nonparametric
Cadmium	Alluvial	15	15	Nonparametric
Calcium	Alluvial	15	0	Parametric
Chromium	Alluvial	15	13	Nonparametric
Cobalt	Alluvial	15	2	Parametric
Copper	Alluvial	15	6	Nonparametric
Iron	Alluvial	15	8	Nonparametric
Lead	Alluvial	15	12	Nonparametric
Magnesium	Alluvial	15	0	Parametric
Manganese	Alluvial	15	0	Parametric
Mercury	Alluvial	15	15	Nonparametric
Nickel	Alluvial	15	1	Parametric
Potassium	Alluvial	15	2	Parametric
Selenium	Alluvial	15	14	Nonparametric
Silver	Alluvial	15	12	Nonparametric
Sodium	Alluvial	15	0	Parametric
Thallium	Alluvial	15	15	Nonparametric
Vanadium	Alluvial	15	1	Parametric
Zinc	Alluvial	15	10	Nonparametric
Aluminum	Bedrock	9	4	Parametric
Antimony	Bedrock	9	7	Nonparametric
Arsenic	Bedrock	9	4	Parametric
Barium	Bedrock	9	0	Parametric
Beryllium	Bedrock	9	7	Nonparametric
Cadmium	Bedrock	9	9	Nonparametric
Calcium	Bedrock	9	0	Parametric
Chromium	Bedrock	9	5	Nonparametric
Cobalt	Bedrock	9	3	Parametric
Copper	Bedrock	9	4	Parametric
Iron	Bedrock	9	4	Parametric
Lead	Bedrock	9	6	Nonparametric
Magnesium	Bedrock	9	0	Parametric

Table 5: Data Distributions – Background (continued)

Constituent	Aquifer	Sample Size	No. of NDs	Distribution Fit[1]
Dissolved Metals				
Manganese	Bedrock	9	1	Parametric
Mercury	Bedrock	9	9	Nonparametric
Nickel	Bedrock	9	5	Nonparametric
Potassium	Bedrock	9	0	Parametric
Selenium	Bedrock	9	9	Nonparametric
Silver	Bedrock	9	8	Nonparametric
Sodium	Bedrock	9	0	Parametric
Thallium	Bedrock	9	8	Nonparametric
Vanadium	Bedrock	9	5	Nonparametric
Zinc	Bedrock	9	8	Nonparametric
Total Metals				
Aluminum	Alluvial	15	2	Parametric
Antimony	Alluvial	15	13	Nonparametric
Arsenic	Alluvial	15	1	Parametric
Barium	Alluvial	15	0	Nonparametric
Beryllium	Alluvial	15	13	Nonparametric
Cadmium	Alluvial	15	13	Nonparametric
Calcium	Alluvial	15	0	Parametric
Chromium	Alluvial	15	10	Nonparametric
Cobalt	Alluvial	15	2	Nonparametric
Copper	Alluvial	15	5	Parametric
Iron	Alluvial	15	2	Nonparametric
Lead	Alluvial	15	11	Nonparametric
Magnesium	Alluvial	15	0	Parametric
Manganese	Alluvial	15	0	Nonparametric
Mercury	Alluvial	15	15	Nonparametric
Nickel	Alluvial	15	2	Parametric
Potassium	Alluvial	15	1	Parametric
Selenium	Alluvial	15	14	Nonparametric
Silver	Alluvial	15	11	Nonparametric
Sodium	Alluvial	15	0	Parametric
Thallium	Alluvial	15	14	Nonparametric
Vanadium	Alluvial	15	2	Nonparametric
Zinc	Alluvial	15	10	Nonparametric
Aluminum	Bedrock	9	2	Parametric
Antimony	Bedrock	9	8	Nonparametric

Table 5: Data Distributions – Background (continued)

Constituent	Aquifer	Sample Size	No. of NDs	Distribution Fit[1]
Total Metals				
Arsenic	Bedrock	9	3	Parametric
Barium	Bedrock	9	0	Parametric
Beryllium	Bedrock	9	4	Parametric
Cadmium	Bedrock	9	6	Nonparametric
Calcium	Bedrock	9	0	Parametric
Chromium	Bedrock	9	1	Parametric
Cobalt	Bedrock	9	2	Parametric
Copper	Bedrock	9	3	Parametric
Iron	Bedrock	9	1	Parametric
Lead	Bedrock	9	2	Parametric
Magnesium	Bedrock	9	0	Parametric
Manganese	Bedrock	9	0	Parametric
Mercury	Bedrock	9	8	Nonparametric
Nickel	Bedrock	9	1	Parametric
Potassium	Bedrock	9	1	Parametric
Selenium	Bedrock	9	9	Nonparametric
Silver	Bedrock	9	7	Nonparametric
Sodium	Bedrock	9	0	Parametric
Thallium	Bedrock	9	6	Nonparametric
Vanadium	Bedrock	9	2	Parametric
Zinc	Bedrock	9	5	Nonparametric
Other Compounds				
Nitrate	Alluvial	15	11	Nonparametric
Nitrate	Bedrock	9	8	Nonparametric
Perchlorate	Alluvial	15	15	Nonparametric
Perchlorate	Bedrock	9	6	Nonparametric

Notes:
1. Best fit is based on detected data.
Constituents are assigned a nonparametric distribution if they could not be fit to a discernible distribution (e.g gamma, lognormal, normal), have a high percentage of NDs, or are all NDs. Constituents that are not flagged as nonparametric follow a parametric distribution.

Table 6: Trend Analysis Results

Constituent[1]	Trend	
	Alluvial	Bedrock
Dissolved Metals		
Nickel	Decreasing	No Trend
Total Metals		
Arsenic	Decreasing	No Trend
Chromium	No Trend	Decreasing

[1] Only displays constituents that had a statistically significant trend in the alluvial or bedrock aquifer.

Table 7: ANOVA Test Results for Differences in Monitoring Constituent Concentrations Between Alluvial & Bedrock Aquifers

Constituent	Constituent Type	Unit	Mean		Median		Sample Size			Test	
			Alluvial	Bedrock	Alluvial	Bedrock	Alluvial	Bedrock	Total	Log ANOVA	Kruskal-Wallis
Aluminum	Dissolved Metals	mg/L	0.108	16.1	0.0700	0.200	15	9	24	✓	✓
	Total Metals	mg/L	0.538	74.5	0.100	14.2	15	9	24	✓	✓
Antimony	Dissolved Metals	mg/L	0.000837	0.00152	0.000600	0.00100	15	9	24	✓	✓
	Total Metals	mg/L	0.000879	0.00181	0.000600	0.00100	15	9	24	✓	✓
Arsenic	Dissolved Metals	mg/L	0.000857	0.00222	0.000800	0.00125	15	9	24	✓	✓
	Total Metals	mg/L	0.000928	0.00576	0.000870	0.00423	15	9	24	✓	✓
Barium	Dissolved Metals	mg/L	0.0175	0.0960	0.0160	0.0158	15	9	24		
	Total Metals	mg/L	0.0209	0.659	0.0170	0.156	15	9	24	✓	
Beryllium	Total Metals	mg/L	0.000316	0.00312	0.000300	0.00102	15	9	24	✓	✓
Cadmium	Total Metals	mg/L	0.000634	0.000813	0.00100	0.00100	15	9	24		
Calcium	Dissolved Metals	mg/L	45.6	88.3	44.0	31.5	15	9	24		
	Total Metals	mg/L	46.1	139	46.0	67.5	15	9	24		
Chromium	Dissolved Metals	mg/L	0.00165	0.0178	0.00150	0.00180	15	9	24		
	Total Metals	mg/L	0.00164	0.0624	0.00170	0.0170	15	9	24	✓	✓

Table 7: ANOVA Test Results for Differences in Monitoring Constituent Concentrations Between Alluvial & Bedrock Aquifers (continued)

Constituent	Constituent Type	Unit	Mean		Median		Sample Size			Test	
			Alluvial	Bedrock	Alluvial	Bedrock	Alluvial	Bedrock	Total	Log ANOVA	Kruskal-Wallis
Cobalt	Dissolved Metals	mg/L	0.000417	0.00458	0.000300	0.00100	15	9	24		
	Total Metals	mg/L	0.000556	0.0187	0.000360	0.00511	15	9	24	✓	✓
Copper	Dissolved Metals	mg/L	0.00262	0.00688	0.00150	0.00180	15	9	24		
	Total Metals	mg/L	0.00264	0.0149	0.00180	0.00611	15	9	24	✓	✓
Iron	Dissolved Metals	mg/L	0.0978	13.3	0.0480	0.250	15	9	24	✓	✓
	Total Metals	mg/L	0.351	42.7	0.0810	8.26	15	9	24	✓	✓
Lead	Dissolved Metals	mg/L	0.000560	0.00366	0.000500	0.000700	15	9	24		✓
	Total Metals	mg/L	0.000762	0.0154	0.000700	0.00416	15	9	24	✓	✓
Magnesium	Dissolved Metals	mg/L	25.1	14.3	24.0	4.85	15	9	24	✓	
	Total Metals	mg/L	25.6	29.6	26.0	28.0	15	9	24		
Manganese	Dissolved Metals	mg/L	0.195	0.366	0.180	0.0950	15	9	24		
	Total Metals	mg/L	0.226	1.35	0.190	0.716	15	9	24		
Nickel	Dissolved Metals	mg/L	0.00207	0.0114	0.00170	0.00250	15	9	24		
	Total Metals	mg/L	0.00250	0.0444	0.00180	0.0114	15	9	24	✓	✓
Nitrate	Other Compound	mg/L	0.269	0.220	0.160	0.200	15	9	24		

Table 7: ANOVA Test Results for Differences in Monitoring Constituent Concentrations Between Alluvial & Bedrock Aquifers (continued)

Constituent	Constituent Type	Unit	Mean		Median		Sample Size			Test	
			Alluvial	Bedrock	Alluvial	Bedrock	Alluvial	Bedrock	Total	Log ANOVA	Kruskal-Wallis
Potassium	Dissolved Metals	mg/L	0.835	4.80	0.670	3.25	15	9	24	✓	✓
	Total Metals	mg/L	0.943	10.5	0.770	5.13	15	9	24	✓	✓
Silver	Dissolved Metals	mg/L	0.000188	0.000394	0.000100	0.000100	15	9	24		
	Total Metals	mg/L	0.000500	0.000394	0.000100	0.000100	15	9	24		
Sodium	Dissolved Metals	mg/L	811	1,523	830	1,200	15	9	24	✓	
	Total Metals	mg/L	794	1,647	810	1,150	15	9	24	✓	
Thallium	Total Metals	mg/L	0.000241	0.000560	0.000200	0.000440	15	9	24	✓	✓
Vanadium	Dissolved Metals	mg/L	0.00230	0.0143	0.00200	0.00250	15	9	24	✓	✓
	Total Metals	mg/L	0.00315	0.0558	0.00210	0.0204	15	9	24	✓	
Zinc	Dissolved Metals	mg/L	0.00963	0.0489	0.00800	0.00800	15	9	24	✓	✓
	Total Metals	mg/L	0.0127	0.120	0.00800	0.0500	15	9	24	✓	✓

Notes:
✓Indicates test for differences was statistically significant at the 5 percent significance level.
mg/L = milligrams per liter
The following constituents were not tested as either the alluvial or bedrock aquifer observations had 100 percent NDs: dissolved beryllium, dissolved cadmium, total and dissolved mercury, and total and dissolved selenium.

Table 8: Summary of Background Data Analysis

Constituent	Aquifer	Statistical Outlier	Nonparametric Data Distribution	Trend
Dissolved Metals				
Aluminum	Alluvial	✓	✓	
Antimony	Alluvial		✓	
Beryllium	Alluvial		✓	
Cadmium	Alluvial		✓	
Chromium	Alluvial		✓	
Cobalt	Alluvial	✓		
Copper	Alluvial		✓	
Iron	Alluvial	✓	✓	
Lead	Alluvial		✓	
Mercury	Alluvial		✓	
Nickel	Alluvial	✓		✓
Potassium	Alluvial	✓		
Selenium	Alluvial		✓	
Silver	Alluvial		✓	
Sodium	Alluvial	✓		
Thallium	Alluvial		✓	
Zinc	Alluvial		✓	
Aluminum	Bedrock	✓		
Antimony	Bedrock		✓	
Arsenic	Bedrock	✓		
Barium	Bedrock	✓		
Beryllium	Bedrock		✓	
Cadmium	Bedrock		✓	
Chromium	Bedrock	✓	✓	
Cobalt	Bedrock	✓		
Iron	Bedrock	✓		
Lead	Bedrock		✓	
Mercury	Bedrock		✓	
Nickel	Bedrock	✓	✓	
Selenium	Bedrock		✓	
Silver	Bedrock		✓	
Thallium	Bedrock		✓	
Vanadium	Bedrock	✓	✓	
Zinc	Bedrock		✓	
Total Metals				
Aluminum	Alluvial	✓		
Antimony	Alluvial		✓	

Table 8: Summary of Background Data Analysis (continued)

Constituent	Aquifer	Statistical Outlier	Nonparametric Data Distribution	Trend
Total Metals				
Arsenic	Alluvial	✓		✓
Barium	Alluvial	✓	✓	
Beryllium	Alluvial		✓	
Cadmium	Alluvial		✓	
Chromium	Alluvial		✓	
Cobalt	Alluvial	✓	✓	
Iron	Alluvial	✓	✓	
Lead	Alluvial		✓	
Manganese	Alluvial	✓	✓	
Mercury	Alluvial		✓	
Nickel	Alluvial	✓		
Selenium	Alluvial		✓	
Silver	Alluvial	✓	✓	
Thallium	Alluvial		✓	
Vanadium	Alluvial		✓	
Zinc	Alluvial		✓	
Antimony	Bedrock		✓	
Cadmium	Bedrock		✓	
Chromium	Bedrock			✓
Mercury	Bedrock		✓	
Selenium	Bedrock		✓	
Silver	Bedrock		✓	
Thallium	Bedrock		✓	
Zinc	Bedrock		✓	
Other Compounds				
Nitrate	Alluvial	✓	✓	
Perchlorate	Alluvial		✓	
Nitrate	Bedrock		✓	
Perchlorate	Bedrock		✓	

Notes:
✓Constituent was flagged during the statistical analysis
Constituents are assigned a nonparametric distribution if they could not be fit to a discernible distribution (e.g gamma, lognormal, normal), have a high percentage of NDs, or are all NDs. Constituents that are not flagged as nonparametric follow a parametric distribution.

Table 9: Background Threshold Values for Monitoring Constituents

Constituent	Aquifer	Unit	No. of Verification Samples	BTV
				(UPL)
Dissolved Metals				
Aluminum	Alluvial	mg/L	4	0.730
Antimony	Alluvial	mg/L	4	0.000530
Arsenic	Alluvial	mg/L	2	0.00125
Barium	Alluvial	mg/L	2	0.0257
Beryllium	Alluvial	mg/L	NA	*0.00100*
Cadmium	Alluvial	mg/L	NA	*0.00100*
Calcium	Alluvial	mg/L	2	64.7
Chromium	Alluvial	mg/L	4	0.00300
Cobalt	Alluvial	mg/L	2	0.00103
Copper	Alluvial	mg/L	4	0.0140
Iron	Alluvial	mg/L	4	0.560
Lead	Alluvial	mg/L	4	0.000584
Magnesium	Alluvial	mg/L	2	32.3
Manganese	Alluvial	mg/L	2	0.310
Mercury	Alluvial	mg/L	NA	*0.000100*
Nickel	Alluvial	mg/L	2	0.00531
Potassium	Alluvial	mg/L	2	2.21
Selenium	Alluvial	mg/L	4	0.00300
Silver	Alluvial	mg/L	4	0.000550
Sodium	Alluvial	mg/L	2	1,048
Thallium	Alluvial	mg/L	NA	*0.00100*
Vanadium	Alluvial	mg/L	2	0.00772
Zinc	Alluvial	mg/L	4	0.0500
Aluminum	Bedrock	mg/L	3	136
Antimony	Bedrock	mg/L	6	0.00130
Arsenic	Bedrock	mg/L	3	0.0107
Barium	Bedrock	mg/L	3	0.720
Beryllium	Bedrock	mg/L	6	0.00550
Cadmium	Bedrock	mg/L	NA	*0.00100*
Calcium	Bedrock	mg/L	3	623
Chromium	Bedrock	mg/L	6	0.140
Cobalt	Bedrock	mg/L	3	0.0336
Copper	Bedrock	mg/L	3	0.0413
Iron	Bedrock	mg/L	3	104
Lead	Bedrock	mg/L	6	0.0270

Table 9: Background Threshold Values for Monitoring Constituents (continued)

Constituent	Aquifer	Unit	No. of Verification Samples	BTV
				(UPL)
Dissolved Metals				
Magnesium	Bedrock	mg/L	3	111
Manganese	Bedrock	mg/L	3	3.07
Mercury	Bedrock	mg/L	NA	*0.000100*
Nickel	Bedrock	mg/L	6	0.0840
Potassium	Bedrock	mg/L	3	28.1
Selenium	Bedrock	mg/L	NA	*0.00200*
Silver	Bedrock	mg/L	6	0.0000460
Sodium	Bedrock	mg/L	3	5,240
Thallium	Bedrock	mg/L	6	0.000350
Vanadium	Bedrock	mg/L	6	0.0980
Zinc	Bedrock	mg/L	6	0.250
Total Metals				
Aluminum	Alluvial	mg/L	2	3.43
Antimony	Alluvial	mg/L	4	0.000530
Arsenic	Alluvial	mg/L	2	0.00381
Barium	Alluvial	mg/L	4	0.0450
Beryllium	Alluvial	mg/L	4	0.000140
Cadmium	Alluvial	mg/L	4	0.000370
Calcium	Alluvial	mg/L	2	68.8
Chromium	Alluvial	mg/L	4	0.00300
Cobalt	Alluvial	mg/L	4	0.00180
Copper	Alluvial	mg/L	2	0.0179
Iron	Alluvial	mg/L	4	2.50
Lead	Alluvial	mg/L	4	0.00220
Magnesium	Alluvial	mg/L	2	34.3
Manganese	Alluvial	mg/L	4	0.530
Mercury	Alluvial	mg/L	NA	*0.000100*
Nickel	Alluvial	mg/L	2	0.00969
Potassium	Alluvial	mg/L	2	2.62
Selenium	Alluvial	mg/L	4	0.00460
Silver	Alluvial	mg/L	4	0.00450
Sodium	Alluvial	mg/L	2	986
Thallium	Alluvial	mg/L	4	0.0000560
Vanadium	Alluvial	mg/L	4	0.00780
Zinc	Alluvial	mg/L	4	0.0500

Table 10: Background Threshold Values for Monitoring Constituents (continued)

Constituent	Aquifer	Unit	No. of Verification Samples	BTV
				(UPL)
Total Metals				
Aluminum	Bedrock	mg/L	3	791
Antimony	Bedrock	mg/L	6	0.00380
Arsenic	Bedrock	mg/L	3	0.0306
Barium	Bedrock	mg/L	3	6.76
Beryllium	Bedrock	mg/L	3	0.0199
Cadmium	Bedrock	mg/L	6	0.000540
Calcium	Bedrock	mg/L	3	1,076
Chromium	Bedrock	mg/L	3	0.525
Cobalt	Bedrock	mg/L	3	0.167
Copper	Bedrock	mg/L	3	0.0963
Iron	Bedrock	mg/L	3	459
Lead	Bedrock	mg/L	3	0.140
Magnesium	Bedrock	mg/L	3	254
Manganese	Bedrock	mg/L	3	12.9
Mercury	Bedrock	mg/L	6	0.0000260
Nickel	Bedrock	mg/L	3	0.388
Potassium	Bedrock	mg/L	3	70.7
Selenium	Bedrock	mg/L	NA	*0.00200*
Silver	Bedrock	mg/L	6	0.000100
Sodium	Bedrock	mg/L	3	6,129
Thallium	Bedrock	mg/L	6	0.000700
Vanadium	Bedrock	mg/L	3	0.524
Zinc	Bedrock	mg/L	6	0.530
Other Compounds				
Nitrate	Alluvial	mg/L	4.0	1.90
Perchlorate	Alluvial	mg/L	NA	*0.000100*
Nitrate	Bedrock	mg/L	6	0.0870
Perchlorate	Bedrock	mg/L	6	0.00000950

Notes:
Italic concentration indicates background sample was 100% non-detect value and that the DQR is recommended for statistical evaluation of downgradient concentrations. The DQR states that a confirmed exceedance is registered if any well-constituent pair in the '100% ND' group exhibits quantified measurements in two consecutive sample and resample events.
NA – Not Applicable
mg/L = milligram per liter
The number of verification samples *m* is the maximum number of resamples permitted to confirm whether an observed exceedance from a given constituent in a given well and aquifer is actually an exceedance or an outcome of random variation. If the initial groundwater observation exceeds the BTV, then as many as *m* samples might be collected. If all *m* values are larger than the BTVs, then an exceedance is declared.

Appendix A: Statistical Summary Reports (CD Only)

Appendix B: NCSS Output (CD Only)

Appendix C: ProUCL Output (CD Only)

Appendix D: SPSS Output (CD Only)