# Appendix E

## Statistical Comparison of Site and Background Data for Metals
## Small Weapons Repair Shop, Parcel 66(7)
## McClellan, Anniston, Alabama

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## 1.0 INTRODUCTION

This report presents a statistical evaluation of metals results for the Small Weapons Repair Shop, Parcel 66(7) (Parcel 66[7]) within McClellan, Anniston, Alabama (McClellan). The statistical evaluation consisted of a multi-tiered approach (Tier 1, Tier 2 and Tier 3) to identify metals that may be present at elevated concentrations as a result of site related activities. Statistical evaluations were performed for the surface soil, subsurface soil and groundwater data sets. In the first step of the comparison, the maximum detected concentration (MDC) of each element was compared to two times the arithmetic mean of the background data (background screening value) reported by Science Applications International Corporation (SAIC, 1998). Any metal that had a MDC greater than the background screening value was carried forward through the Tier 2 evaluation, which included the Slippage Test, the Wilcoxon Rank Sum Test (WRS), and comparison to the corresponding background upper tolerance limit value (UTL). Analytical results for metals failing the Tier 2 evaluation were carried through the Tier 3 evaluation. The Tier 3 evaluation is a graphical assessment of relative concentrations of elements typically associated in soil. The Tier 3 evaluation served as the final evaluation to identify metals having anomalously elevated concentrations. Additional description of the multi-tiered statistical processes is provided in the following section.

# 2.0 COMPARISON METHODOLOGY

This section describes the statistical techniques that were employed in the Small Weapons Repair Shop site-to-background comparisons.

## *2.1 Statistical Procedures*

Contamination can be caused by a variety of processes that yield different spatial distributions of elevated contaminant concentrations. Slight but pervasive contamination can occur from non-point-source releases, and can result in slight increases in contaminant concentrations in a large percentage of samples. Localized, or “hot-spot,” contamination can result in elevated concentrations in a small percentage of the total number of site samples. No single two-sample statistical comparison test is sensitive to both of these modes of contamination. For this reason, the use of several simultaneous tests is recommended for a valid and complete comparison of site versus background distributions (U.S. Environmental Protection Agency [EPA], 1989, 1992, and 1994; U.S. Navy, 2002).

Analytes that fail the Tier 1 and Tier 2 comparisons are subject to Tier 3 evaluation to determine if the elevated concentrations are due to natural processes or if they represent potential contamination.

### 2.1.1 Tier 1

In this step of the background screening process, the MDC of the site data set is compared to the background screening value of two times the background mean (SAIC, 1998). Elements for which the site MDC does not exceed the background screening value are considered to be present at background concentrations, and are not considered site-related chemicals. Elements for which the site MDC exceeds the background screening value undergo further evaluation (Tier 2).

### 2.1.2 Tier 2

***Slippage Test.*** The nonparametric Slippage test is designed to detect a difference between the upper tails of two distributions, and has been recommended for use in site-to-background comparisons to identify potential localized, or hot-spot, contamination (U.S. Navy, 2002). The test is performed by counting the number ($K$) of detected concentrations in the site data set that exceed the maximum background measurement, and then comparing this number to a critical value ($K_c$), which is a function of the number of background samples and the number of site samples. If $K > K_c$, then potential contamination is indicated and the analyte will be subjected to geochemical evaluation. If $K \leq K_c$, then localized contamination is not suspected.

Critical values tables for up to 50 site and background data sets (n = 50) are provided in the U.S. Navy's *Guidance for Environmental Background Analysis* (U.S. Navy, 2002). Critical values for larger data sets are calculated using the test statistic provided in Rosenbaum's *Tables for a Nonparametric Test of Location* (Rosenbaum, 1954). In this report, the Slippage test is performed at the 95 percent confidence level. The test cannot be performed if the maximum background value is a nondetect, because the actual concentration in that sample is unknown.

***Wilcoxon Rank Sum Test.*** The nonparametric WRS test is designed to detect a difference between the medians of two data sets, and has been recommended for use in site-to-background comparisons to identify slight but pervasive contamination (EPA, 2000; U.S. Navy, 2002). In this report, the WRS test is performed when the site and background data sets each contain less than 50 percent nondetects (i.e., measurements reported as not detected below the laboratory reporting limit). The WRS test is not performed on data sets containing 50 percent or more nondetects. The medians of such data sets are unknown, and hence the test results would lack sufficient power to yield reliable results.

The WRS test compares two data sets of size $n$ and $m$ ($n > m$), and tests the null hypothesis that the samples are drawn from populations with distributions having the same medians. To perform the test, the two sets of observations are pooled and arranged in order from smallest to largest. Each observation is assigned a rank; that is, the smallest is ranked 1, the next largest is ranked 2, and so on up to the largest observation, which is ranked ($n + m$). If ties occur between or within samples, each one is assigned the mid-rank. Next, the sum of the ranks of smaller data set $m$ is calculated. Then the test statistic Z is determined,

$$Z = \frac{W - m(m+n+1)/2}{\sqrt{mn(m+n+1)/12}}$$

Where:

$W$ = Sum of the ranks of the smaller data set
$m$ = Number of data points in smaller group
$n$ = Number of data points in larger group.

This test statistic Z is used to find the two-sided significance. For instance, if the test statistic yields a probability of a Type I error (p-level) less than 0.2, then there is a statistically significant difference between the medians at the 80 percent confidence level. A Type I error involves rejecting the null hypothesis when it is true. If the p-level is greater than 0.2, then there is no reasonable justification to reject the null hypothesis at the 80 percent confidence level. It can therefore be concluded that the medians of the two data sets are similar, and it can be assumed to be drawn from the same population.

If the p-level is less than 0.2, then the medians of the two distributions are significantly different at the 80 percent confidence level. This can occur if the site data are shifted higher or lower than the background data. If the site data are shifted higher relative to background, then contamination may be indicated, and the analyte in question will be carried on for geochemical evaluation; however, if the site data are shifted lower relative to background, then contamination is not indicated. If the p-level is greater than 0.2, then pervasive site contamination is not suspected.

***Box Plots.*** The box plot comparison is a graphical method recommended by the EPA to visualize and compare two or more sets of data (EPA, 1989 and 1992). These plots provide a summary view of the entire data set, including the overall location and degree of symmetry. Box plots provide a means to visually contrast and compare the distributional characteristics of observed values and are particularly useful when comparing many groups of data. Box plots display the median, 25th percentile, 75th percentile, and values far removed from the rest. The solid line drawn within the box indicates the median. The ends of the box indicate the 25th and 75th percentiles (interquartile range). The ‘whiskers’, extending from both ends of the box, indicate the highest and lowest values. Nondetect results are set equal to one-half of the reporting limit for plotting purposes.

For each analyte, box plots of site and background data are placed side by side to visually compare the distributions and qualitatively determine whether the data sets are similar or distinct. Accordingly, the box plots are a necessary adjunct to the WRS test. As described previously, the WRS test may indicate that the medians of the site and background data sets are significantly different. Examination of the box plots identifies whether that difference is caused by site data that are shifted higher or lower relative to background.

***Hot Measurement Test.*** The hot measurement test consists of comparing each site measurement to a concentration value that is representative of the upper limit of the background distribution (EPA, 1994). This test is performed in instances where the maximum site sample value is a nondetect or the percentage of nondetect sample values exceeds 50 percent. For this test, a site sample with a concentration above the background screening value would, ideally, have a low probability of being a member of the background population, and would be an indicator of contamination. It is important to select such a background screening value carefully so that the probability of falsely identifying site samples as contaminated or uncontaminated is minimized.

The $95^{th}$ upper tolerance limit ($95^{th}$ UTL) is recommended as a screening value for normally or lognormally distributed analytes and the $95^{th}$ percentile is recommended as a screening value for nonparametrically distributed analytes (EPA, 1989, 1992, and 1994). Site samples with concentrations above these values are not necessarily contaminated, but should be considered suspect. To perform the test, each analyte's site MDC is compared to the background $95^{th}$ UTL or $95^{th}$ percentile, in accordance with the type of background distribution. If the site MDC exceeds the $95^{th}$ UTL or $95^{th}$ percentile as appropriate, then that analyte will undergo a Tier 3 evaluation.

### 2.1.3 Tier 3

If an analyte fails either of the statistical tests described above, then the Tier 3 evaluation is performed to identify if the elevated concentrations are caused by natural processes. Naturally occurring trace element concentrations in environmental media commonly exceed screening criteria. Trace element distributions in uncontaminated soil tend to have very large ranges (two to three orders of magnitude are not uncommon), and are highly right-skewed, resembling lognormal distributions. These trace elements are naturally associated with specific soil-forming minerals, and the preferential enrichment of a sample with these minerals will result in elevated trace element concentrations. It is thus important to be able to identify these naturally high concentrations and distinguish them from potential contamination.

The Tier 3 evaluation is performed by first constructing a scatter plot of two metals showing a statistical association or correlation. The evaluation includes the generation of plots in which detected metal concentrations in a set of samples are plotted on the y-axis, and the corresponding detected concentrations of the second metal are plotted on the x-axis. The method can be used with as few as three data points (i.e., three concentration values for each of two metals) (Navy, 2002). Correlation exists between the two metals plotted if the data tend to occur along or near a straight line. Linear regression is used to evaluate the relationship. Prediction limits plotted alongside the linear regression are useful for identifying elevated metal concentrations that may be site related. The slope of a best-fit line through the samples is equal to the average metal/metal ratio. If the metal concentrations plot on the same linear trend, then it is most probable that the observed concentrations are natural. If an individual site sample concentration plots above the trend displayed by the uncontaminated samples, then there is evidence that the sample has an excess metal contribution.

## 3.0 RESULTS OF THE TIER 1 AND TIER 2 EVALUATIONS

This section presents the results of the site-to-background comparisons for 23 metals in the surface soil, subsurface soil, and groundwater at Parcel 66(7). The WRS test results with corresponding box plots are provided in Appendix E1. Tables E3-1 through E3-3 present the Tier 1 and Tier 2 test results for each medium as discussed in the following subsections.

### *3.1 Surface Soil*

Twenty-three metals were evaluated in the Parcel 66(7) surface soil data set. Table E3-1 presents a summary of the Tier 1 and Tier 2 evaluations results for surface soil.

#### 3.1.1 Tier 1 Evaluation Results for Surface Soil

Arsenic, cadmium, lead, manganese, mercury, sodium and thallium have no detected concentrations above their respective background screening values (two times the background mean). Accordingly, these metals pass the Tier 1 evaluation and were not carried forward to the Tier 2 evaluation. The remaining 16 metals were carried forward to the Tier 2 evaluation.

#### 3.1.2 Tier 2 Evaluation Results for Surface Soil

Table E3-1 summarizes the surface soil statistical site to background comparison results. Box plots are provided in Appendix E1. The following text summarizes the results of the Tier 2 evaluations.

**Aluminum**

Slippage Test
$K_c$ for aluminum is 2, and one site sample exceeded the maximum background measurement (K=1). Because K <$K_c$, aluminum passes the Slippage test.

WRS Test
A statistically significant difference exists between the site median and background median at the 80 percent confidence level.

Box Plot
The site MDC is larger than the corresponding background values. The site median is greater than the corresponding background median, and the site interquartile range is greater than the background interquartile range (Figure E1-1).

Conclusion
Because the median aluminum concentration in surface soil is greater than the median background concentration, aluminum was carried forward to the Tier 3 evaluation.

**Antimony**

Slippage Test
The maximum background value for antimony is a nondetect, so the Slippage test could not be performed.

WRS Test
The WRS test was not performed because the data set contained more than 50 percent nondetects.

Box Plot
Box plots were not developed for antimony because of the high percentage (80 percent) of nondetects in the site data set.

Hot Measurement Test
The hot measurement test was performed because neither the WRS nor the Slippage test could be performed. The hot measurement test involved comparing the two detected concentrations of antimony to the 95$^{th}$ percentile (<7.14 mg/kg) of antimony in background surface soil. The detected concentrations of antimony were less than 7.14 mg/kg and passed the hot measurement test.

Conclusion
Antimony was not carried forward to the Tier 3 testing because the detected concentrations of antimony were less than the 95$^{th}$ percentile value.

**Barium**

Slippage Test
$K_c$ for barium is 2, and one site sample concentration exceeded the maximum background measurement (K=1). Because $K < K_c$, barium passes the Slippage test.

WRS Test
A statistically significant difference exists between the site median and background median at the 80 percent confidence level.

Box Plot
The site MDC is larger than the corresponding background values. The site median is greater than the corresponding background median, and the site interquartile range is greater than the background interquartile range (Figure E1-2).

Conclusion

Because the median barium concentration in surface soil is greater than the median background concentration, barium was carried forward to the Tier 3 evaluation.

**Beryllium**

Slippage Test
$K_c$ for beryllium is 2, and five sample concentrations exceeded the maximum background measurement (K=5). Because $K > K_c$, beryllium failed the Slippage test.

WRS Test
A statistically significant difference exists between the site median and background at the 80 percent confidence level.

Box Plot
The site MDC is larger than the corresponding background values. The site median is greater than the corresponding background median, and the site interquartile range is greater than the background interquartile range (Figure E1-3).

Conclusion
Because the median beryllium concentration in surface soil is greater than the median background concentration, beryllium was carried forward to the Tier 3 evaluation.

**Calcium**

Slippage Test
$K_c$ for calcium is 2, and one sample concentration exceeded the maximum background measurement (K=1). Because $K < K_c$, calcium passed the Slippage test.

WRS Test
A statistically significant difference exists between the site median and background at the 80 percent confidence level.

Box Plot
The site MDC is larger than the corresponding background values. The site median is greater than the corresponding background median, and the site interquartile range is greater than the background interquartile range (Figure E1-4).

Conclusion
Because the median calcium concentration in surface soil is greater than the median background concentration, calcium was carried forward to the Tier 3 evaluation.

**Chromium**

Slippage Test
$K_c$ for chromium is 2, and no sample concentrations exceeded the maximum background measurement (K=0). Because $K < K_c$, chromium passed the Slippage test.

WRS Test
A statistically significant difference exists between the site median and background at the 80 percent confidence level.

Box Plot
The site MDC is less than the corresponding background values. However, the site median is greater than the corresponding background median, and the site interquartile range is slightly greater than the background interquartile range (Figure E1-5).

Conclusion
Because the median chromium concentration in surface soil is greater than the median background concentration, chromium was carried forward to the Tier 3 evaluation.

**Cobalt**

Slippage Test
$K_c$ for cobalt is 2, and no sample concentrations exceeded the maximum background measurement (K=0). Because $K < K_c$, cobalt passed the Slippage test.

WRS Test
A statistically significant difference exists between the site median and background at the 80 percent confidence level.

Box Plot
The site MDC is less than the corresponding background values. However, the site median is greater than the corresponding background median, and the site interquartile range is slightly greater than the background interquartile range (Figure E1-6).

Conclusion
Because the median cobalt concentration in surface soil is greater than the median background concentration, cobalt was carried forward to the Tier 3 evaluation.

**Copper**

Slippage Test
$K_c$ for copper is 2, and six sample concentrations exceeded the maximum background measurement (K=6). Because $K > K_c$, copper failed the Slippage test.

WRS Test
A statistically significant difference exists between the site median and background at the 80 percent confidence level.

Box Plot

The site MDC is larger than the corresponding background value. The site median is greater than the corresponding background median, and the site interquartile range is greater than the background interquartile range (Figure E1-7).

Conclusion
Because the median copper concentration in surface soil is greater than the median background concentration, copper was carried forward to the Tier 3 evaluation.

**Iron**

Slippage Test
$K_c$ for iron is 2, and no sample concentrations exceeded the maximum background measurement (K=0). Because $K < K_c$, iron passed the Slippage test.

WRS Test
A statistically significant difference exists between the site median and background at the 80 percent confidence level.

Box Plot
The site MDC is less than the corresponding background values. However, the site median is greater than the corresponding background median, and the site interquartile range is greater than the background interquartile range (Figure E1-8).

Conclusion
Because the median iron concentration in surface soil is greater than the median background concentration, iron was carried forward to the Tier 3 evaluation.

**Magnesium**

Slippage Test
$K_c$ for magnesium is 2, and no sample concentrations exceeded the maximum background measurement (K=0). Because $K < K_c$, magnesium passed the Slippage test.

WRS Test
A statistically significant difference exists between the site median and background at the 80 percent confidence level.

Box Plot
The site MDC is less than the corresponding background values. However, the site median is greater than the corresponding background median, and the site interquartile range is greater than the background interquartile range (Figure E1-9).

Conclusion
Because the median magnesium concentration in surface soil is greater than the median background concentration, magnesium was carried forward to the Tier 3 evaluation.

**Nickel**

Slippage Test
$K_c$ for nickel is 2, and three sample concentrations exceeded the maximum background measurement (K=3). Because $K > K_c$, nickel failed the Slippage test.

WRS Test
A statistically significant difference exists between the site median and background at the 80 percent confidence level.

Box Plot
The site MDC is larger than the corresponding background values. The site median is greater than the corresponding background median, and the site interquartile range is greater than the background interquartile range (Figure E1-10).

Conclusion
Because the median nickel concentration in surface soil is greater than the median background concentration, nickel was carried forward to the Tier 3 evaluation.

**Potassium**

Slippage Test
$K_c$ for potassium is 2, and no sample concentrations exceeded the maximum background measurement (K=0). Because $K < K_c$, potassium passed the Slippage test.

WRS Test
A statistically significant difference exists between the site median and background at the 80 percent confidence level.

Box Plot
The site MDC value is less than the corresponding background values. However, the site median is greater than the corresponding background median, and the site interquartile range is greater than the background interquartile range (Figure E1-11).

Conclusion
Because the median potassium concentration in surface soil is greater than the median background concentration, potassium was carried forward to the Tier 3 evaluation.

**Selenium**

Slippage Test
$K_c$ for selenium is 2o, and two sample concentrations exceeded the maximum background measurement (K=2). Because $K = K_c$, selenium passed the Slippage test.

WRS Test

The WRS test was not performed because the data set contained more than 50 percent nondetects.

Box Plot
Box plots were not developed for selenium because of the high percentage (70 percent) of nondetects in the site data set.

Hot Measurement Test
The hot measurement test was performed because the WRS test could not be performed. The hot measurement test involved comparing the three detected concentrations of selenium to the 95th percentile (0.288 mg/kg) of selenium in background surface soil. The detected concentrations of selenium exceeded 0.288 mg/kg and failed the hot measurement test.

Conclusion
Selenium was carried forward to the Tier 3 testing because the detected concentrations of selenium were greater than the 95th percentile value.

**Silver**

Slippage Test
$K_c$ for silver is 2, and no sample concentrations exceeded the maximum background measurement (K=0). Because $K < K_c$, silver passed the Slippage test.

WRS Test
The WRS test was not performed because the data set contained more than 50 percent nondetects.

Box Plot
Box plots were not developed for silver because of the high percentage (80 percent) of nondetects in the site data set.

Hot Measurement Test
The hot measurement test was performed because the WRS test could not be performed. The hot measurement test involved comparing the two detected concentrations of silver to the 95th percentile (0.402 mg/kg) of silver in background surface soil. The detected concentrations of silver exceeded 0.402 mg/kg and failed the hot measurement test.

Conclusion
Silver was carried forward to the Tier 3 testing because the detected concentrations of silver were greater than the 95th percentile value.

**Vanadium**

Slippage Test
$K_c$ for vanadium is 2, and no sample concentrations exceeded the maximum background measurement (K=0). Because $K < K_c$, vanadium passed the Slippage test.

WRS Test
A statistically significant difference exists between the site median and background at the 80 percent confidence level.

Box Plot
The site MDC is less than the corresponding background values. However, the site median is greater than the corresponding background median, and the site interquartile range is slightly greater than the background interquartile range (Figure E1-12).

Conclusion
Because the median vanadium concentration in surface soil is greater than the median background concentration, vanadium was carried forward to the Tier 3 evaluation.

**Zinc**

Slippage Test
$K_c$ for zinc is 2, and no sample concentrations exceeded the maximum background measurement (K=0). Because $K < K_c$, zinc passed the Slippage test.

WRS Test
A statistically significant difference exists between the site median and background at the 80 percent confidence level.

Box Plot
The site MDC is less than the corresponding background values. However, the site median is greater than the corresponding background values, and the site interquartile range is greater than the background interquartile range (Figure E1-13).

Conclusion
Because the median zinc concentration in surface soil is greater than the median background concentration, zinc was carried forward to the Tier 3 evaluation.

## *3.2 Subsurface Soil*

Twenty-three metals were evaluated in the Parcel 66(7) subsurface soil data set. Table E3-2 presents a summary of the Tier 1 and Tier 2 evaluations results for subsurface soil.

### 3.2.1 Tier 1 Evaluation Results for Subsurface Soil

Arsenic, barium, chromium, lead, manganese, mercury, sodium, and vanadium have no detected concentrations above their respective background screening values (two times the background mean). Accordingly these metals pass the Tier 1 evaluation and were not carried forward to the Tier 2 evaluation. The remaining 15 metals were carried forward for Tier 2 evaluation.

### 3.2.2 Tier 2 Evaluation Results for Subsurface Soil

Table E3-2 summarizes the subsurface soil statistical site to background comparison results. Box plots are presented in Appendix E2. The following text summarizes the results of the Tier 2 evaluations.

**Aluminum**

Slippage Test
$K_c$ for aluminum is 3, and three site samples exceeded the maximum background measurement (K=3). Because $K = K_c$, aluminum passed the Slippage test.

WRS Test
A statistically significant difference exists between the site median and background at the 80 percent confidence level.

Box Plot
The site MDC is larger than the corresponding background values. The site median is greater than the corresponding background median, and the site interquartile range is greater than the background interquartile range (Figure E2-1).

Conclusion
Because the median aluminum concentration in subsurface soil is greater than the median background concentration aluminum was carried forward to the Tier 3 evaluation.

**Antimony**

Slippage Test
The maximum background value for antimony is a nondetect, so the Slippage test could not be performed

WRS Test
The WRS test was not performed because the data set contained more than 50 percent nondetects.

Box Plot
Box plots were not developed for antimony because of the high percentage (93 percent) of nondetects in the site data set.

Hot Measurement Test

The hot measurement test was performed because neither the WRS nor Slippage test could be performed. The hot measurement test involved the comparison of the detected concentration of antimony to the 95$^{th}$ percentile (3.57 mg/kg) of antimony in background subsurface soil. The detected concentration of antimony is less than 3.57 mg/kg and passed the hot measurement test.

<u>Conclusion</u>
Antimony was not carried forward to the Tier 3 testing because the detected concentration of antimony was less than the 95$^{th}$ percentile value.

**Beryllium**

<u>Slippage Test</u>
$K_c$ for beryllium is 3, and one sample concentration exceeded the maximum background measurement (K=1). Because $K < K_c$, beryllium passed the Slippage test.

<u>WRS Test</u>
A statistically significant difference exists between the site median and background at the 80 percent confidence level.

<u>Box Plot</u>
The site MDC is larger than the corresponding background values. The site median is greater than the corresponding background median, and the site interquartile range is greater than the background interquartile range (Figure E2-2).

<u>Conclusion</u>
Because the median beryllium concentration in subsurface soil is greater than the median background concentration, beryllium was carried forward to the Tier 3 evaluation.

**Cadmium**

<u>Slippage Test</u>
$K_c$ for cadmium is 3, and no sample concentrations exceeded the maximum background measurement (K=0). Because $K < K_c$, cadmium passed the Slippage test.

<u>WRS Test</u>
The WRS test was not performed because the data set contained more than 50 percent nondetects.

<u>Box Plot</u>
Box plots were not developed for cadmium because of the high percentage (64 percent) of nondetects in the site data set.

<u>Hot Measurement Test</u>
The hot measurement test was performed because the WRS test could not be performed. The hot measurement test involved the comparison of the five detected concentrations of cadmium to the

95th percentile (0.350 mg/kg) of cadmium in background subsurface soil. The detected concentrations of cadmium exceeded 0.350 mg/kg and failed the hot measurement test..

<u>Conclusion</u>
Because the detected cadmium concentrations in subsurface soil were greater than the 95th percentile value, cadmium was carried forward to the Tier 3 evaluation.

**Calcium**

<u>Slippage Test</u>
$K_c$ for calcium is 3, and four sample concentrations exceeded the maximum background measurement (K=4). Because $K > K_c$, calcium failed the Slippage test.

<u>WRS Test</u>
A statistically significant difference exists between the site median and background at the 80 percent confidence level.

<u>Box Plot</u>
The site MDC is larger than the corresponding background values. The site median is greater than the corresponding background median, and the site interquartile range is greater than the background interquartile range (Figure E2-3).

<u>Conclusion</u>
Because the median calcium concentration in subsurface soil is greater than the median background concentration, calcium was carried forward to the Tier 3 evaluation.

**Cobalt**

<u>Slippage Test</u>
$K_c$ for cobalt is 3, and no sample concentrations exceeded the maximum background measurement (K=0). Because $K < K_c$, cobalt passed the Slippage test.

<u>WRS Test</u>
A statistically significant difference exists between the site median and background at the 80 percent confidence level.

<u>Box Plot</u>
The site MDC is less than the corresponding background values. However, the site median is greater than the corresponding background values, and the site interquartile range is greater than the background interquartile range (Figure E2-4).

<u>Conclusion</u>
Because the median cobalt concentration in subsurface soil is greater than the median background concentration, cobalt was carried forward to the Tier 3 evaluation.

**Copper**

Slippage Test
$K_c$ for copper is 3, and no sample concentrations exceeded the maximum background measurement (K=0). Because $K < K_c$, copper passed the Slippage test.

WRS Test
A statistically significant difference exists between the site median and background at the 80 percent confidence level.

Box Plot
The site MDC is less than the corresponding background values. However, the site median is greater than the corresponding background median, and the site interquartile range is greater than the background interquartile range (Figure E2-5).

Conclusion
Because the median copper concentration in subsurface soil is greater than the median background concentration, copper was carried forward to the Tier 3 evaluation.

**Iron**

Slippage Test
$K_c$ for iron is 3, and no sample concentrations exceeded the maximum background measurement (K=0). Because $K < K_c$, iron passed the Slippage test.

WRS Test
A statistically significant difference exists between the site median and background at the 80 percent confidence level.

Box Plot
The site MDC is less than the corresponding background values. However, the site median is greater than the corresponding background median, and the site interquartile range is greater than the background interquartile range (Figure E2-6).

Conclusion
Because the median iron concentration in subsurface soil is greater than the median background concentration, iron was carried forward to the Tier 3 evaluation.

**Magnesium**

Slippage Test
$K_c$ for magnesium is 3, and 11 sample concentrations exceeded the maximum background measurement (K=11). Because $K > K_c$, magnesium failed the Slippage test.

WRS Test

A statistically significant difference exists between the site median and background at the 80 percent confidence level.

Box Plot
The site MDC is larger than the corresponding background values. The site median is greater than the corresponding background median, and the site interquartile range is greater than the background interquartile range (Figure E2-7).

Conclusion
Because the median magnesium concentration in subsurface soil is greater than the median background concentration, magnesium was carried forward to the Tier 3 evaluation.

**Nickel**

Slippage Test
$K_c$ for nickel is 3, and ten sample concentrations exceeded the maximum background measurement (K=10). Because $K > K_c$, nickel failed the Slippage test.

WRS Test
A statistically significant difference exists between the site median and background at the 80 percent confidence level.

Box Plot
The site MDC is larger than the corresponding background values. The site median is greater than the corresponding background median, and the site interquartile range is greater than the background interquartile range (Figure E2-8).

Conclusion
Because the median nickel concentration in subsurface soil is greater than the median background concentration, nickel was carried forward to the Tier 3 evaluation.

**Potassium**

Slippage Test
$K_c$ for potassium is 3, and no sample concentrations exceeded the maximum background measurement (K=0). Because $K < K_c$, potassium passed the Slippage test.

WRS Test
A statistically significant difference exists between the site median and background at the 80 percent confidence level.

Box Plot
The site MDC is less than the corresponding background values. However, the site median is greater than the corresponding background median, and the site interquartile range is greater than the background interquartile range (Figure E2-9).

Conclusion
Because the median potassium concentration in subsurface soil is greater than the median background concentration, potassium was carried forward to the Tier 3 evaluation.

**Selenium**

Slippage Test
$K_c$ for selenium is 3, and four sample concentrations exceeded the maximum background measurement (K=4). Because $K > K_c$, selenium failed the Slippage test.

WRS Test
The WRS test was not performed because the data set contained more than 50 percent nondetects.

Box Plot
Box plots were not developed for selenium because of the high percentage (71 percent) of nondetects in the site data set.

Hot Measurement Test
The hot measurement test was performed because the WRS test could not be performed. The hot measurement test involved the comparison of the four detected concentrations of selenium to the 95$^{th}$ percentile (0..574 mg/kg) of selenium in background subsurface soil. The detected concentrations of selenium exceed 0..574 mg/kg and failed the hot measurement test.

Conclusion
Selenium was carried forward to the Tier 3 testing because the detected concentrations of selenium were greater than the 95$^{th}$ percentile value.

**Silver**

Slippage Test
$K_c$ for silver is 3, and three sample concentrations exceeded the maximum background measurement (K=3). Because $K = K_c$, silver passed the Slippage test.

WRS Test
The WRS test was not performed because the data set contained more than 50 percent nondetects.

Box Plot
Box plots were not developed for silver because of the high percentage (71 percent) of nondetects in the site data set.

Hot Measurement Test
The hot measurement test was performed because the WRS test could not be performed. The hot measurement test involved the comparison of the four detected concentrations of silver to the

95$^{th}$ percentile (0..574 mg/kg) of silver in background subsurface soil. The detected concentrations of silver exceed 0..574 mg/kg and failed the hot measurement test.

Conclusion
Silver was carried forward to the Tier 3 testing because the detected concentrations of silver were greater than the 95$^{th}$ percentile value.

**Thallium**

Slippage Test
$K_c$ for thallium is 3, and no sample concentrations exceeded the maximum background measurement (K=0). Because $K = K_c$, thallium passed the Slippage test.

WRS Test
The WRS test was not performed because the data set contained more than 50 percent nondetects.

Box Plot
Box plots were not developed for thallium because of the high percentage (79 percent) of nondetects in the site data set.

Hot Measurement Test
The hot measurement test was performed because the WRS test could not be performed. The hot measurement test involved the comparison of the three detected concentrations of thallium to the 95$^{th}$ percentile (6.62 mg/kg) of thallium in background subsurface soil. The detected concentrations of thallium did not exceed 6.62 mg/kg and passed the hot measurement test.

Conclusion
Thallium was not carried forward to the Tier 3 testing because the detected concentrations of thallium less than the 95$^{th}$ percentile value.

**Zinc**

Slippage Test
$K_c$ for zinc is 3, and 10 sample concentrations exceeded the maximum background measurement (K=10). Because $K > K_c$, zinc failed the Slippage test.

WRS Test
A statistically significant difference exists between the site median and background at the 80 percent confidence level.

Box Plot
The site MDC is greater than the corresponding background values. Additionally, the site median is greater than the corresponding background values, and the site interquartile range is greater than the background interquartile range (Figure E2-10).

Conclusion
Because the median zinc concentration in subsurface soil is greater than the median background concentration, zinc was carried forward to the Tier 3 evaluation.

### *3.3 Groundwater*

Twenty-three metals were evaluated in the Parcel 66(7) subsurface soil data set. Table E3-3 presents a summary of the Tier 1 and Tier 2 evaluations results.

### 3.3.1 Tier 1 Evaluation Results for Groundwater

Antimony, arsenic, beryllium, cadmium, copper, lead, mercury, selenium, silver, thallium, vanadium and zinc have no detected concentrations above their respective background screening values (two times the background mean). Accordingly these metals pass the Tier 1 evaluation and were not carried forward to the Tier 2 evaluation. The remaining 11 metals were carried forward to the Tier 2 evaluations.

### 3.3.2 Tier 2 Evaluation Results for Groundwater

Table E3-3 summarizes the groundwater statistical site to background comparison results. Box plots are provided in Appendix E3. The following text summarizes results of statistical evaluations performed for the Tier 2 evaluation.

**Aluminum**

Slippage Test
$K_c$ for aluminum is 3, and no site samples exceeded the maximum background measurement (K=0). Because $K < K_c$, aluminum passed the Slippage test.

WRS Test
A statistically significant difference exists between the site median and background at the 80 percent confidence level.

Box Plot
The site MDC is less than the corresponding background values. However, the site median is greater than the corresponding background median. The interquartile range for the site values is similar to the background interquartile range (Figure E3-1).

Conclusion
Because the median aluminum concentration in groundwater is greater than the median background concentration, aluminum was carried forward to the Tier 3 evaluation.

**Barium**

Slippage Test
$K_c$ for barium is 3, and no site samples exceeded the maximum background measurement (K=0). Because $K < K_c$, barium passed the Slippage test.

WRS Test
A statistically significant difference exists between the site median and background at the 80 percent confidence level.

Box Plot
The site MDC is less than the corresponding background values. However, the site median is slightly greater than the corresponding background median. The interquartile range for the site values is similar to the background interquartile range (Figure E3-2).

Conclusion
Because the median barium concentration in groundwater is greater than the median background concentration barium was carried forward to the Tier 3 evaluation.

**Calcium**

Slippage Test
$K_c$ for calcium is 3, and no site samples exceeded the maximum background measurement (K=0). Because $K < K_c$, calcium passed the Slippage test.

WRS Test
A statistically significant difference exists between the site median and background at the 80 percent confidence level.

Box Plot
The site MDC value is less than the corresponding background values. However, the site median is greater than the corresponding background median and the interquartile range for the site values is greater than the background interquartile range (Figure E3-3).

Conclusion
Because the median calcium concentration in groundwater is greater than the median background concentration, calcium was carried forward to the Tier 3 evaluation.

**Chromium**

Slippage Test
$K_c$ for chromium is 3, and three site samples exceeded the maximum background measurement (K=3). Because $K = K_c$, chromium passed the Slippage test.

WRS Test

The WRS test was not performed because the data set contained more than 50 percent nondetects.

Box Plot
Box plots were not developed for chromium because of the high percentage (73 percent) of nondetects in the site data set.

Hot Measurement Test
The hot measurement test was performed because the WRS test could not be performed. The hot measurement test involved comparison of the three detected concentrations of chromium to the 95$^{th}$ percentile (0.0168 mg/L) of chromium in background groundwater. The detected concentration of chromium in one sample exceeded the 0.0168 mg/L.

Conclusion
Chromium was carried forward to the Tier 3 testing because one detected concentration of chromium was greater than the 95$^{th}$ percentile value.

**Cobalt**

Slippage Test
$K_c$ for cobalt is 3, and two site samples exceeded the maximum background measurement (K=2). Because $K < K_c$, cobalt passed the Slippage test.

WRS Test
The WRS test was not performed because the data set contained more than 50 percent nondetects.

Box Plot
Box plots were not developed for cobalt because of the high percentage (64 percent) of nondetects in the site data set.

Hot Measurement Test
The hot measurement test was performed because the WRS test could not be performed. The hot measurement test involved comparison of the four detected concentrations of cobalt to the 95$^{th}$ percentile (0.0144 mg/L) of cobalt in background groundwater. The detected concentrations of cobalt in two samples exceeded the 0.0144 mg/L.

Conclusion
Cobalt was carried forward to the Tier 3 testing because two detected concentration of cobalt were greater than the 95$^{th}$ percentile value.

**Iron**

Slippage Test
$K_c$ for iron is 3, and no site samples exceeded the maximum background measurement (K=0). Because $K < K_c$, iron passed the Slippage test.

WRS Test
A statistically significant difference exists between the site median and background at the 80 percent confidence level.

Box Plot
The site MDC is less than the corresponding background values. However, the site median is greater than the corresponding background median. The interquartile range for the site values is similar to the background interquartile range (Figure E3-4).

Conclusion
Because the median iron concentration in groundwater is greater than the median background concentration, iron was carried forward to the Tier 3 evaluation.

**Magnesium**

Slippage Test
$K_c$ for magnesium is 3, and 3 site samples exceeded the maximum background measurement (K=3). Because $K = K_c$, magnesium passed the Slippage test.

WRS Test
A statistically significant difference exists between the site median and background at the 80 percent confidence level.

Box Plot
The site MDC is larger than the corresponding background values. The site median is greater than the corresponding background median. The interquartile range for the site values exceeds the background interquartile range (Figure E3-5).

Conclusion
Because the median magnesium concentration in groundwater is greater than the median background concentration, magnesium was carried forward to the Tier 3 evaluation.

**Manganese**

Slippage Test
$K_c$ for manganese is 3, and no site samples exceeded the maximum background measurement (K=0). Because $K < K_c$, manganese passed the Slippage test.

WRS Test
A statistically significant difference exists between the site median and background at the 80 percent confidence level.

Box Plot

The site MDC is less than the corresponding background values. However, the site median is greater than the corresponding background median, and the interquartile range for the site values exceeds the background interquartile range (Figure E3-6).

Conclusion
Because the median manganese concentration in groundwater is greater than the median background concentration, manganese was carried forward to the Tier 3 evaluation.

**Nickel**

Slippage Test
$K_c$ for nickel is 3, and one site sample exceeded the maximum background measurement (K=1). Because $K < K_c$, nickel passed the Slippage test.

WRS Test
The WRS test was not performed because the nickel data set contained more than 50 percent nondetects.

Box Plot
Box plots were not developed for nickel because of the high percentage (64 percent) of nondetects in the site data set.

Hot Measurement Test
The hot measurement test was performed because the WRS test could not be performed. The hot measurement test involved comparison of the four detected concentrations of nickel to the $95^{th}$ percentile (0.0343 mg/L) of nickel in background groundwater. The detected concentration of nickel in one sample exceeded 0.0343 mg/L.

Conclusion
Nickel was carried forward to the Tier 3 testing because one detected concentration of nickel was greater than the $95^{th}$ percentile value.

**Potassium**

Slippage Test
$K_c$ for potassium is 3, and no site samples exceeded the maximum background measurement (K=0). Because $K < K_c$, potassium passed the Slippage test.

WRS Test
A statistically significant difference exists between the site median and background at the 80 percent confidence level.

Box Plot
The site MDC is less than the corresponding background values. However, the site median is greater than the corresponding background median. The interquartile range for the site values is similar to the background interquartile range (Figure E3-7).

Conclusion
Because the median potassium concentration in groundwater is greater than the median background concentration, potassium was carried forward to the Tier 3 evaluation.

**Sodium**

Slippage Test
$K_c$ for sodium is 3, and 8 site samples exceeded the maximum background measurement (K=8). Because $K > K_c$, sodium failed the Slippage test.

WRS Test
A statistically significant difference exists between the site median and background at the 80 percent confidence level.

Box Plot
The site MDC is larger than the corresponding background values. The site median is greater than the corresponding background median, and the interquartile range for the site values exceeds the background interquartile range (Figure E3-8).

Conclusion
Because the median sodium concentration in groundwater is greater than the median background concentration, sodium was carried forward to the Tier 3 evaluation.

## 4.0 RESULTS OF THE TIER 3 EVALUATION

This section provides the results of the Tier 3 evaluation of metals in surface soil, subsurface soil, and groundwater. The Tier 3 evaluation was performed for a total of 15 metals in surface soil, 13 metals in subsurface soil and 11 metals in groundwater to identify whether the subject metals concentrations are naturally occurring or are site related. Scatter plots were developed for each applicable metal-to-metal association. Up to two representative plots for each subject metal are presented in Appendices E4, E5 and E6 for surface soil, subsurface soil and groundwater, respectively. The following subsections discuss the results of the Tier 3 evaluation by medium.

### *4.1 Tier 3 Evaluation Results for Surface Soil*

Scatter plots developed for the Tier 3 evaluation of metals in surface soil are presented in Appendix E4. Table E4-1 presents a summary of the site related metals for surface soil as identified by the Tier 3 evaluation. Discussion of the Tier 3 evaluation of metals in surface soil follows.

**Aluminum**

Analytical results for aluminum in surface soil show a statistically significant relationship with metals in surface soil including beryllium, chromium, copper, iron, and vanadium. Scatter plots were developed showing representative results for aluminum in surface soil. Figures E4-1 and E4-2 show aluminum versus chromium and aluminum versus iron respectively. The figures show the analytical results, the best fit linear model and associated 95 percent prediction limits. The analytical results plot closely to the best fit linear model and it is concluded that aluminum is naturally occurring in surface soil.

**Barium**

Analytical results for barium in surface soil show a statistically significant relationship with metals in surface soil including aluminum, iron and beryllium. Scatter plots of barium versus aluminum and barium versus beryllium are shown in Figures E4-3 and E4-4, respectively. The analytical results plot closely to the best fit linear model with the exception of one barium value at a concentration of 788 mg/kg that falls outside the upper prediction limit (Figure E4-3). With the exception of this one value, it is concluded that barium is naturally occurring in surface soil.

**Beryllium**

Analytical results for beryllium in surface soil show a statistically significant relationship with metals in surface soil including barium, copper, iron and nickel. Scatter plot of beryllium versus iron and beryllium versus nickel are shown in Figures E4-5 and E4-6 respectively. The analytical results plot near the best fit linear model. Based on this analysis it is concluded that beryllium is naturally occurring in surface soil.

**Calcium**

Analytical results for calcium in surface soil do not exhibit a significant statistical relationship with other metals detected in the surface soil. Accordingly, evidence that calcium is not site related is limited. However, calcium is considered a macro nutrient with minimal human or ecological toxicity, therefore, additional statistical analysis of calcium in surface soil was not performed.

**Chromium**

Analytical results for chromium in surface soil show a statistically significant relationship with metals in surface soil including aluminum, copper, iron and vanadium. Scatter plots of chromium versus aluminum and chromium versus iron are shown in Figures E4-7 and E4-8, respectively. The analytical results plot near the best fit linear model. Based on this analysis it is concluded that chromium is naturally occurring in surface soil.

**Cobalt**

Analytical results for cobalt in surface soil show a statistically significant relationship with copper, iron, nickel and zinc. Scatter plots of cobalt versus copper and cobalt versus iron are shown in Figures E4-9 and E4-10, respectively. The analytical results plot near the best fit linear model. Based on this analysis it is concluded that cobalt is naturally occurring in surface soil.

**Copper**

Analytical results for copper in surface soil show a statistically significant relationship with metals including aluminum, beryllium chromium, cobalt, iron and zinc. Scatter plots of copper versus iron and copper versus zinc are shown in Figures E4-11 and E4-12, respectively. The analytical results plot near the best fit linear model. Based on this analysis it is concluded that copper is naturally occurring in surface soil.

**Iron**

Analytical results for iron in surface soil show a statistically significant relationship with metals including aluminum, barium, beryllium, chromium, cobalt, copper and nickel. Scatter plots of iron versus aluminum and iron versus copper are shown in Figures E4-13 and E4-14 respectively. The analytical results plot near the best fit linear model. Based on this analysis it is concluded that iron is naturally occurring in surface soil.

**Magnesium**

Analytical results for magnesium in surface soil do not exhibit a significant statistical relationship with other metals detected in the surface soil. Accordingly, evidence that magnesium is not site related is limited. However, magnesium is considered a macronutrient with minimal human or ecological toxicity, therefore additional statistical analysis of magnesium in surface soil was not performed.

**Nickel**

Analytical results for nickel in surface soil show a statistically significant relationship with metals including beryllium, cobalt, copper, iron and zinc. Scatter plots of nickel versus iron and nickel versus zinc are shown in Figures E4-15 and E4-16, respectively. The analytical results plot near the best fit linear model. Based on this analysis it is concluded that nickel is naturally occurring in surface soil.

**Potassium**

Analytical results for potassium in surface soil exhibit a statistically relationship with aluminum. A scatter plot of potassium versus aluminum is shown in Figure E4-17. The analytical results plot near the best fit linear model. Based on this analysis it is concluded that potassium is naturally occurring in surface soil.

**Selenium**

Analytical results for selenium in surface soil so do not exhibit a significant statistical relationship with other metals detected in the surface soil. Accordingly, evidence that selenium is not site related is limited. Therefore, the three detections of selenium exceeding background concentration are potentially site related (Table E4-1).

**Silver**

Analytical results for silver in surface soil do not exhibit a statistical relationship with other metals detected in the surface soil. Accordingly, evidence that silver is not site related is limited. Therefore, the two detections of silver exceeding background concentration are potentially site related (Table E4-1).

**Vanadium**

Analytical results for vanadium in surface soil exhibit a statistical relationship with aluminum, arsenic and chromium. Scatter plots of vanadium versus aluminum and vanadium versus chromium are shown in Figure E4-18 and Figure E4-19, respectively. The analytical results plot near the best fit linear model. Based on this analysis it is concluded that vanadium is naturally occurring in surface soil.

**Zinc**

Analytical results for zinc in surface soil exhibit a statistical relationship with cobalt iron and nickel. Scatter plots of zinc versus iron and zinc versus nickel are shown in Figure E4-20 and Figure E4-21, respectively. The analytical results plot near the best fit linear model. Based on this analysis it is concluded that zinc is naturally occurring in surface soil.

### *4.2 Tier 3 Evaluation Results for Subsurface Soil*

Scatter plots developed for the Tier 3 evaluation of metals in subsurface soil are presented in Appendix E5. Table E4-1 presents a summary of the site related metals for subsurface soil as identified by the Tier 3 evaluation. Discussion of the Tier 3 evaluation of metals in subsurface soil follows.

**Aluminum**

Analytical results for aluminum in subsurface soil show a statistically significant relationship with metals including barium and chromium (barium and chromium passed the Tier 2 evaluation with concentrations comparable to background). Scatter plots of aluminum versus barium and aluminum versus chromium are shown in Figures E5-1 and E5-2, respectively. The figures show analytical results, the best fit linear model and associated 95 percent prediction limits. The analytical results plot closely to the best fit linear model and it is concluded that aluminum is naturally occurring in subsurface soil.

**Beryllium**

Analytical results for beryllium in subsurface soil show a statistically significant relationship with metals including cobalt, iron, nickel and zinc. Scatter plots of beryllium versus iron and beryllium versus nickel are shown in Figures E5-3 and E5-4, respectively. The figures show analytical results, the best fit linear model and associated 95 percent prediction limits. The analytical results plot closely to the best fit linear model with the exception of beryllium at a concentration of 3.65 mg/kg. This value appears to represent an elevated concentration of beryllium that may be site related (Table E4-1).

**Cadmium**

Analytical results for cadmium in subsurface soil show a statistically significant relationship with metals including aluminum and barium. Scatter plots of cadmium versus aluminum and cadmium versus barium are shown in Figures E5-5 and E5-6, respectively. The figures show analytical results, the best fit linear model and associated 95 percent prediction limits. The analytical results plot closely to the best fit linear model with the exception of cadmium at a concentration of 0.953 mg/kg. This value appears to represent an elevated concentration of cadmium that may be site related.

**Calcium**

Analytical results for calcium in subsurface soil do not exhibit a significant statistical relationship with other metals detected in the subsurface soil. Accordingly, evidence that calcium is not site related is limited. However, calcium is considered a macro nutrient with minimal human or ecological toxicity. Therefore, additional statistical analysis of calcium in subsurface soil was not performed.

**Cobalt**

Analytical results for cobalt in subsurface soil show a statistically significant relationship with metals including beryllium, iron, nickel and zinc. Scatter plots of cobalt versus iron and cobalt versus nickel are shown in Figures E5-7 and E5-8, respectively. The figures show analytical results, the best fit linear model and associated 95 percent prediction limits. The analytical results plot closely to the best fit linear model and it is concluded that cobalt is naturally occurring in subsurface soil.

**Copper**

Analytical results for copper in subsurface soil show a statistically significant relationship with metals in subsurface soil including iron, nickel and zinc. Scatter plots of copper versus iron and copper versus zinc are shown in Figures E5-9 and E5-10, respectively. The figures show analytical results, the best fit linear model and associated 95 percent prediction limits. The analytical results plot closely to the best fit linear model with the exception of copper at a concentration of 58.4 mg/kg. This value appears to represent an elevated concentration of copper that may be site related.

**Iron**

Analytical results for iron in subsurface soil show a statistically significant relationship with metals including beryllium, cobalt, copper, selenium and zinc. Scatter plots of iron versus copper and iron versus zinc are shown in Figures E5-11 and E5-12, respectively. The figures show analytical results, the best fit linear model and associated 95 percent prediction limits. The analytical results plot closely to the best fit linear model and based on this analysis it is concluded that iron in subsurface soil is naturally occurring.

**Magnesium**

Analytical results for magnesium in subsurface soil exhibit significant statistical relationships with other metals detected in the subsurface soil including copper, manganese, iron, nickel and zinc. Scatter plots of magnesium versus copper and magnesium versus iron are shown in Figures E5-13 and E5-14, respectively. The figures show analytical results, the best fit linear model and associated 95 percent prediction limits. The analytical results plot closely to the best fit linear model and based on this analysis it is concluded that magnesium in subsurface soil is naturally occurring.

**Nickel**

Analytical results for nickel in subsurface soil show a statistically significant relationship with metals in subsurface soil including beryllium, cobalt, copper and zinc. Scatter plots of nickel versus copper and nickel versus zinc are shown in Figures E5-15 and E5-16, respectively. The figures show analytical results, the best fit linear model and associated 95 percent prediction limits. The analytical results plot closely to the best fit linear model and based on this analysis it is concluded that nickel in subsurface soil is naturally occurring.

**Potassium**

Analytical results for potassium in subsurface soil exhibit significant statistical relationships with other metals detected in the subsurface soil including aluminum, barium, calcium, chromium and sodium. Scatter plots of potassium versus aluminum and potassium versus chromium are shown in Figures E5-17 and E5-18 respectively. The figures show analytical results, the best fit linear model and associated 95 percent prediction limits. The analytical results plot closely to the best fit linear model and based on this analysis it is concluded that potassium in subsurface soil is naturally occurring.

**Selenium**

Analytical results for selenium in subsurface soil show a statistically significant relationship with iron. A scatter plot of selenium versus iron is shown in Figure E5-19. The figure shows analytical results, the best fit linear model and associated 95 percent prediction limits. The analytical results plot closely to the best fit linear model and based on this analysis it is concluded that selenium in subsurface soil is naturally occurring.

**Silver**

Analytical results for silver in subsurface soil show a statistically significant relationship with aluminum and vanadium. Scatter plots of silver versus aluminum and silver versus vanadium are shown in Figures E5-20 and E5-21. The figures shows analytical results, the best fit linear model and associated 95 percent prediction limits. The analytical results plot closely to the best fit linear model and based on this analysis it is concluded that silver in subsurface soil is naturally occurring.

**Zinc**

Analytical results for zinc in subsurface soil show a statistically significant relationship with copper, iron and nickel. Scatter plots of zinc versus copper and zinc versus iron are shown in Figures E5-22 and E5-23. The figures show analytical results, the best fit linear model and associated 95 percent prediction limits. The analytical results plot closely to the best fit linear model and based on this analysis it is concluded that zinc in subsurface soil is naturally occurring.

### *4.3 Tier 3 Evaluation Results for Groundwater*

Scatter plots developed for the Tier 3 evaluation of metals in groundwater are provided in Appendix E6. Table E4-1 presents a summary of the site related metals for groundwater as identified by the Tier 3 evaluation. Discussion of the Tier 3 evaluation of metals in groundwater follows.

**Aluminum**

Analytical results for aluminum in groundwater show a statistically significant relationship with metals including barium and iron. Scatter plots of aluminum versus barium and aluminum versus iron are shown in Figures E6-1 and E6-2, respectively. The figures show analytical results, the best fit linear model and associated 95 percent prediction limits. The analytical results plot closely to the best fit linear model and based on this analysis it is concluded that aluminum in groundwater is naturally occurring.

**Barium**

Analytical results for barium in groundwater show a statistically significant relationship with metals including aluminum and iron. Scatter plots of barium versus aluminum and barium versus iron are shown in Figures E6-3 and E6-4, respectively. The figures show analytical results, the best fit linear model and associated 95 percent prediction limits. The analytical results plot closely to the best fit linear model and based on this analysis it is concluded that barium in groundwater is naturally occurring.

**Calcium**

Analytical results for calcium in groundwater show a statistically significant relationship with metals including zinc and magnesium. Scatter plots of calcium versus magnesium and calcium versus zinc are shown in Figures E6-5 and E6-6, respectively. The figures show analytical results, the best fit linear model and associated 95 percent prediction limits. The analytical results plot closely to the best fit linear model and based on this analysis it is concluded that calcium in groundwater is naturally occurring.

**Chromium**

Analytical results for chromium detected in groundwater exhibit poor statistical relationships with other metals detected in groundwater. Accordingly, conclusive evidence that chromium is naturally occurring in the groundwater samples is limited. Therefore the detected concentrations of chromium in groundwater may be site related (Table E4-1).

### Cobalt

Analytical results for cobalt detected in groundwater exhibit poor statistical relationships with other metals detected in groundwater. Accordingly, conclusive evidence that cobalt is naturally occurring in the groundwater samples is limited. Therefore the detected concentrations of cobalt in groundwater may be site related (Table E4-1).

### Iron

Analytical results for iron in groundwater show a statistically significant relationship with metals including aluminum and barium. Scatter plots of iron versus aluminum and iron versus barium are shown in Figures E6-7 and E6-8, respectively. The figures show analytical results, the best fit linear model and associated 95 percent prediction limits. The analytical results plot closely to the best fit linear model and based on this analysis it is concluded that iron in groundwater is naturally occurring.

### Magnesium

Analytical results for magnesium in groundwater show a statistically significant relationship with metals including zinc and calcium. Scatter plots of magnesium versus zinc and magnesium versus calcium are shown in Figures E6-9 and E6-10, respectively. The figures show analytical results, the best fit linear model and associated 95 percent prediction limits. The analytical results plot closely to the best fit linear model and based on this analysis it is concluded that magnesium in groundwater is naturally occurring.

### Manganese

Analytical results for manganese in groundwater show a statistically significant relationship with metals including calcium, magnesium and zinc. Scatter plots of manganese versus calcium and manganese versus zinc are shown in Figures E6-11 and E6-12, respectively. The figures show analytical results, the best fit linear model and associated 95 percent prediction limits. The analytical results plot closely to the best fit linear model and based on this analysis it is concluded that manganese in groundwater is naturally occurring.

**Nickel**

Analytical results for nickel detected in groundwater exhibit poor statistical relationships with other metals detected in groundwater. Accordingly, conclusive evidence that nickel is naturally occurring in the groundwater samples is limited. Therefore, the detected concentrations of nickel in groundwater may be site related.

**Potassium and Sodium**

Analytical results for potassium and sodium in groundwater do not exhibit a significant statistical relationship with other metals detected in groundwater. Accordingly, evidence that potassium and sodium are not site related is limited. However, potassium and sodium are considered macronutrients with minimal human or ecological toxicity. Therefore, additional statistical analysis of potassium and sodium in groundwater was not performed.

## 5.0 REFERENCES

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**Table E3-1: Summary of Site to Background Comparison**
**Surface Soil, Small Weapons Repair Shop, Parcel 66(7)**
**McClellan, Anniston, Alabama**

| | FOD | Tier 1 Evaluation | Hits above bkgr max (K) | Slippage Test | Wilcoxon Rank Sum Test | Hot Measurement Test | Perform Tier 3 Test |
|---|---|---|---|---|---|---|---|
| Aluminum | 10 / 10 | Failed | 1 | Passed | Failed | NA | Yes |
| Antimony | 2 / 10 | Failed | NA | NA | NA | Passed | No |
| Arsenic | 10 / 10 | Passed | NA | NA | NA | NA | No |
| Barium | 10 / 10 | Failed | 1 | Passed | Failed | NA | Yes |
| Beryllium | 10 / 10 | Failed | 5 | Failed | Failed | NA | Yes |
| Cadmium | 0 / 10 | Passed | NA | NA | NA | NA | No |
| Calcium | 10 / 10 | Failed | 1 | Passed | Failed | NA | Yes |
| Chromium | 10 / 10 | Failed | 0 | Passed | Failed | NA | Yes |
| Cobalt | 10 / 10 | Failed | 0 | Passed | Failed | NA | Yes |
| Copper | 10 / 10 | Failed | 6 | Failed | Failed | NA | Yes |
| Iron | 10 / 10 | Failed | 0 | Passed | Failed | NA | Yes |
| Lead | 10 / 10 | Passed | NA | NA | NA | NA | No |
| Magnesium | 10 / 10 | Failed | 0 | Passed | Failed | NA | Yes |
| Manganese | 10 / 10 | Passed | NA | NA | NA | NA | No |
| Mercury | 4 / 10 | Passed | NA | NA | NA | NA | No |
| Nickel | 10 / 10 | Failed | 3 | Failed | Failed | NA | Yes |
| Potassium | 10 / 10 | Failed | 0 | Passed | Failed | NA | Yes |
| Selenium | 3 / 10 | Failed | 2 | Passed | NA | Failed | Yes |
| Silver | 2 / 10 | Failed | 0 | Passed | NA | Failed | Yes |
| Sodium | 10 / 10 | Passed | NA | NA | NA | NA | No |
| Thallium | 1 / 10 | Passed | NA | NA | NA | Passed | No |
| Vanadium | 10 / 10 | Failed | 0 | Passed | Failed | NA | Yes |
| Zinc | 10 / 10 | Failed | 0 | Passed | Failed | NA | Yes |

FOD = frequency of detection
K = number of detected concentrations exceeding the maxiumum background value
NA = not applicable

## Table E3-2: Summary of Site to Background Comparison
## Subsurface Soil, Small Weapons Repair Shop, Parcel 66(7)
## McClellan, Anniston, Alabama

| | FOD | Tier 1 Evaluation | Hits above bkgr max (K) | Slippage Test | Wilcoxon Rank Sum Test | Hot Measurement Test | Perform Tier 3 Test |
|---|---|---|---|---|---|---|---|
| Aluminum | 14/14 | Failed | 3 | Passed | Failed | NA | Yes |
| Antimony | 1/14 | Failed | NA | NA | NA | Passed | No |
| Arsenic | 14/14 | Passed | NA | NA | NA | NA | No |
| Barium | 14/14 | Passed | NA | NA | NA | NA | No |
| Beryllium | 14/14 | Failed | 1 | Passed | Failed | NA | Yes |
| Cadmium | 5/14 | Failed | 0 | Passed | NA | Failed | Yes |
| Calcium | 14/14 | Failed | 4 | Failed | Failed | NA | Yes |
| Chromium | 14/14 | Passed | NA | NA | NA | NA | No |
| Cobalt | 14/14 | Failed | 0 | Passed | Failed | NA | Yes |
| Copper | 14/14 | Failed | 0 | Passed | Failed | NA | Yes |
| Iron | 14/14 | Failed | 0 | Passed | Failed | NA | Yes |
| Lead | 14/14 | Passed | NA | NA | NA | NA | No |
| Magnesium | 14/14 | Failed | 11 | Failed | Failed | NA | Yes |
| Manganese | 14/14 | Passed | NA | NA | NA | NA | No |
| Mercury | 7/14 | Passed | NA | NA | NA | NA | No |
| Nickel | 14/14 | Failed | 10 | Failed | Failed | NA | Yes |
| Potassium | 14/14 | Failed | 0 | Passed | Failed | NA | Yes |
| Selenium | 4/14 | Failed | 4 | NA | NA | Failed | Yes |
| Silver | 3/14 | Failed | 3 | NA | NA | Failed | Yes |
| Sodium | 14/14 | Passed | NA | NA | NA | NA | No |
| Thallium | 3/14 | Failed | 0 | Passed | NA | Passed | No |
| Vanadium | 14/14 | Passed | NA | NA | NA | NA | No |
| Zinc | 14/14 | Failed | 10 | Failed | Failed | NA | Yes |

FOD = frequency of detection
K = number of detected concentrations exceeding the maxiumum background value
NA = not applicable

**Table E3-3: Summary of Site to Background Comparison**
**Groundwater, Small Weapons Repair Shop, Parcel 66(7)**
**McClellan, Anniston, Alabama**

| | FOD | Tier 1 Evaluation | Hits above bkgr max | Slippage Test | Wilcoxon Rank Sum Test | Hot Measurement Test | Perform Tier 3 Test |
|---|---|---|---|---|---|---|---|
| Aluminum | 9/11 | Failed | 0 | Passed | Failed | NA | Yes |
| Antimony | 0/11 | Passed | NA | NA | NA | NA | No |
| Arsenic | 0/11 | Passed | NA | NA | NA | NA | No |
| Barium | 11/11 | Failed | 0 | Passed | Failed | NA | Yes |
| Beryllium | 0/11 | Passed | NA | NA | NA | NA | No |
| Cadmium | 0/11 | Passed | NA | NA | NA | NA | No |
| Calcium | 11/11 | Failed | 0 | Passed | Failed | NA | Yes |
| Chromium | 3/11 | Failed | 3 | Passed | NA | Failed | Yes |
| Cobalt | 4/11 | Failed | 2 | Passed | NA | Failed | Yes |
| Copper | 3/11 | Passed | NA | NA | NA | NA | No |
| Iron | 11/11 | Failed | 0 | Passed | Failed | NA | Yes |
| Lead | 1/11 | Passed | NA | NA | NA | NA | No |
| Magnesium | 11/11 | Failed | 3 | Passed | Failed | NA | Yes |
| Manganese | 11/11 | Failed | 0 | Passed | Failed | NA | Yes |
| Mercury | 0/11 | Passed | NA | NA | NA | NA | No |
| Nickel | 4/11 | Failed | 1 | Passed | NA | Failed | Yes |
| Potassium | 11/11 | Failed | 0 | Passed | Failed | NA | Yes |
| Selenium | 0/11 | Passed | NA | NA | NA | NA | No |
| Silver | 0/11 | Passed | NA | NA | NA | NA | No |
| Sodium | 11/11 | Failed | 8 | Failed | Failed | NA | Yes |
| Thallium | 0/11 | Passed | NA | NA | NA | NA | No |
| Vanadium | 1/11 | Passed | NA | NA | NA | NA | No |
| Zinc | 9/11 | Passed | NA | NA | NA | NA | No |

FOD = frequency of detection
K = number of detected concentrations exceeding the maxiumum background value
NA = not applicable

## Table E4-1: Summary of Site Related Metals
## Small Weapons Repair Shop, Parcel 66(7)
## McClellan, Anniston, Alabama

| Medium/Site Identification | Site Related Metals | | |
|---|---|---|---|
| **Surface Soil** | **Selenium (mg/kg)** | **Silver (mg/kg)** | **Barium (mg/kg)** |
| PPMP-75-GP02 | 1.6 | | |
| PPMP-75-GP03 | 1.4 | | |
| SWR-66-SB-18 | 1.28 | | |
| SWR-66-SB-20 | | 1.55 | |
| SWR-66-SB-22 | | 0.78 | |
| SWR-66-SB-24 | | | 788 |
| **Subsurface Soil** | **Beryllium (mg/kg)** | **Cadmium (mg/kg)** | **Copper (mg/kg)** |
| SWR-66-SB-02 (6.5-7.5') | | 0.953 | |
| SWR-66-SB-18 (3-3.5') | | | 58.4 |
| SWR-66-SB-20 (3-3.5') | 3.65 | | |
| **Groundwater** | **Chromium (mg/L)** | **Cobalt (mg/L)** | **Nickel (mg/L)** |
| PPMP-66-MW02 | | | 0.0139 |
| PPMP-66-MW15 | 0.00798 | 0.00933 | |
| PPMP-66-MW16 | 0.00788 | 0.0111 | 0.0206 |
| PPMP-66-MW21 | | 0.109 | 0.0646 |
| PPMP-66-MW24 | 0.0233 | 0.0824 | 0.0221 |

mg/kg = milligrams per kilogram
mg/L = milligrams per liter

# Appendix E1

**Figure E1-1 Box Plot Comparison for Aluminum in Surface Soil**

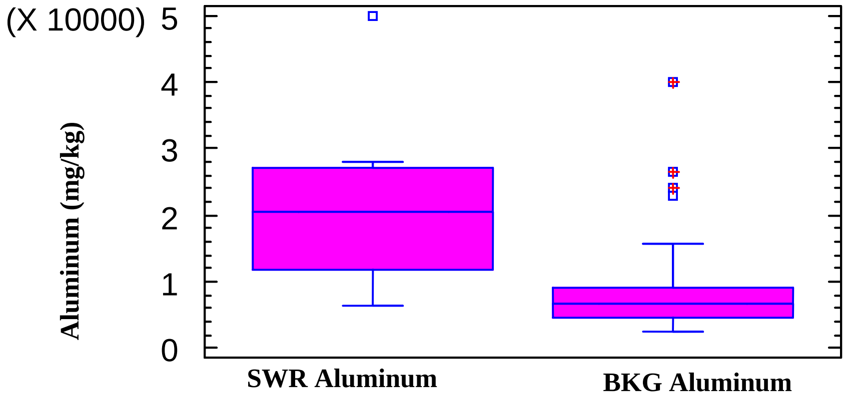



**Figure E1-2 Box Plot Comparison for Barium in Surface Soil**

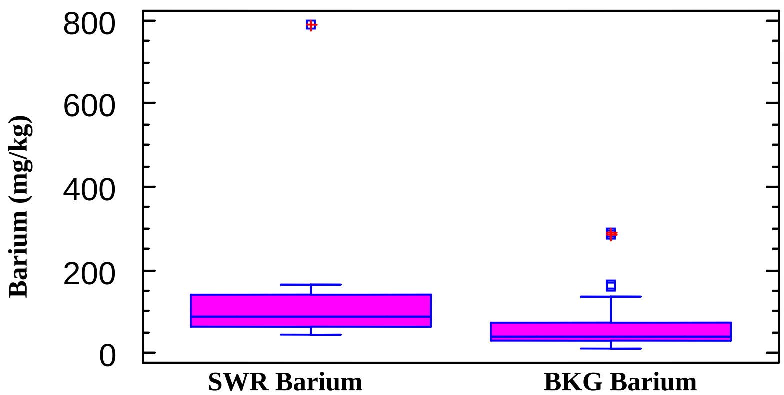


**Figure E1-3 Box Plot Comparison for Beryllium in Surface Soil**

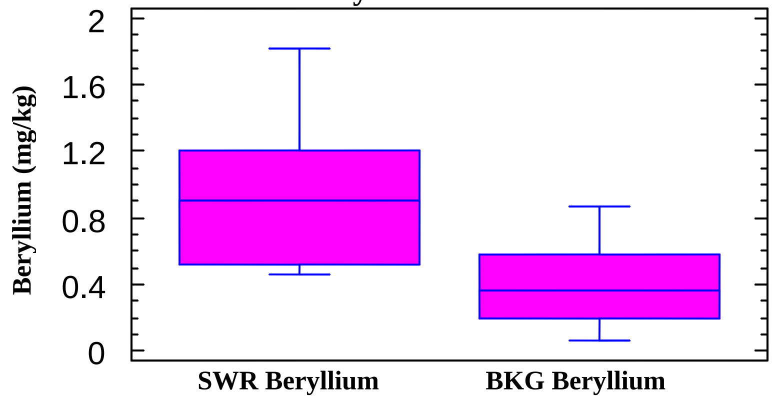



**Figure E1-4 Box Plot Comparison for Calcium in Surface Soil**

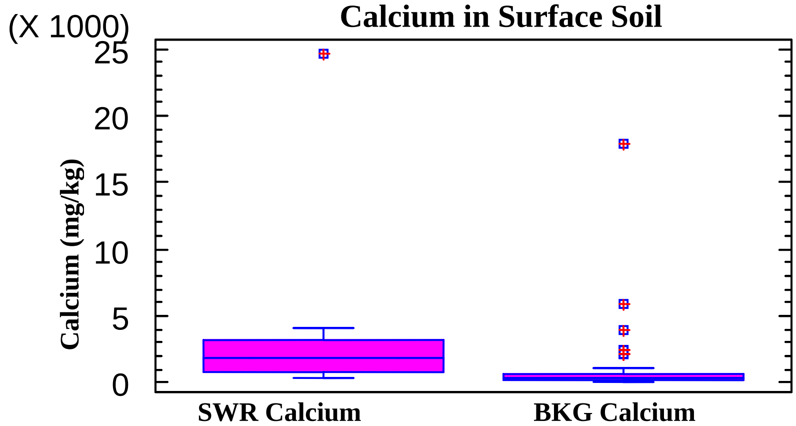


**Figure E1-5 Box Plot Comparison for Chromium in Surface Soil**

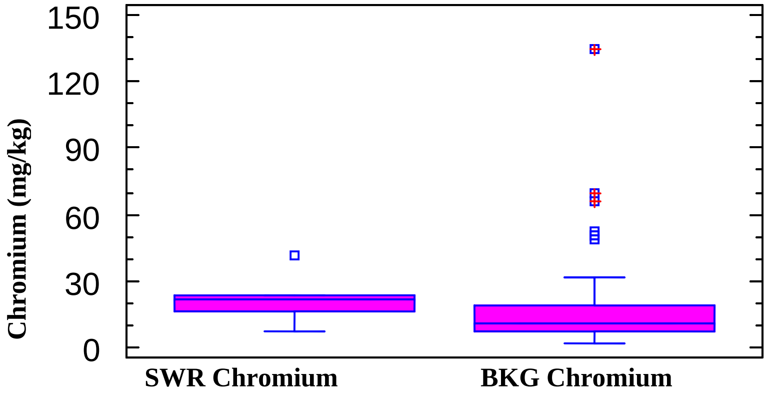



**Figure E1-6 Box Plot Comparison for Cobalt in Surface Soil**

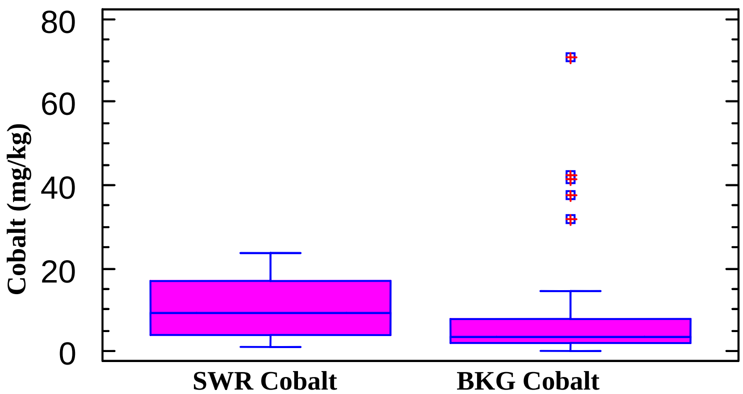


**Figure E1-7 Box Plot Comparison for Copper in Surface Soil**

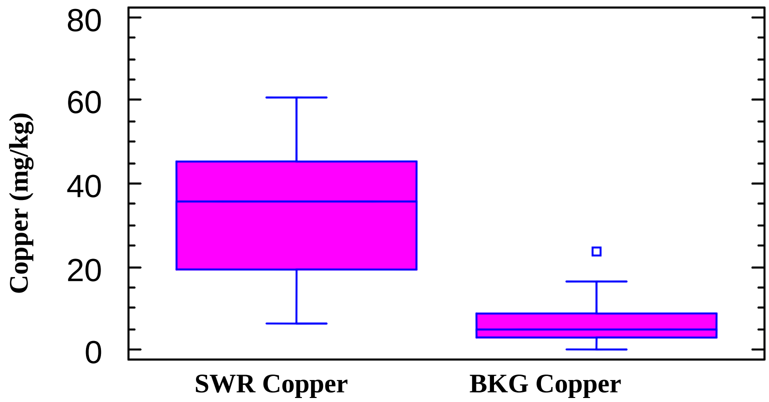



**Figure E1-8 Box Plot Comparison for Iron in Surface Soil**

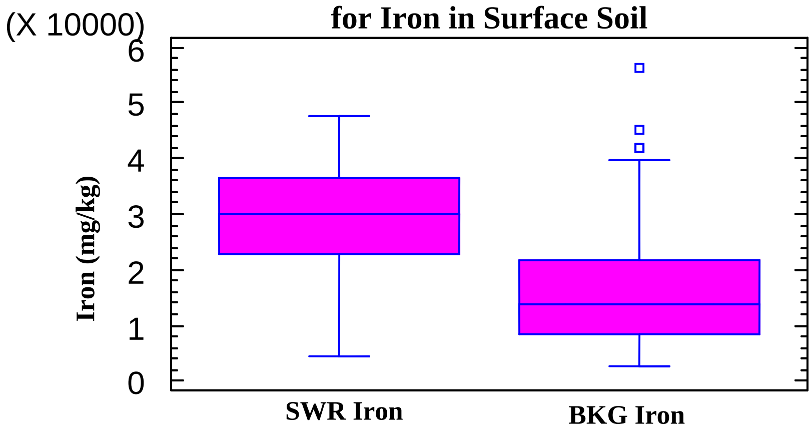


**Figure E1-9 Box Plot Comparison for Magnesium in Surface Soil**

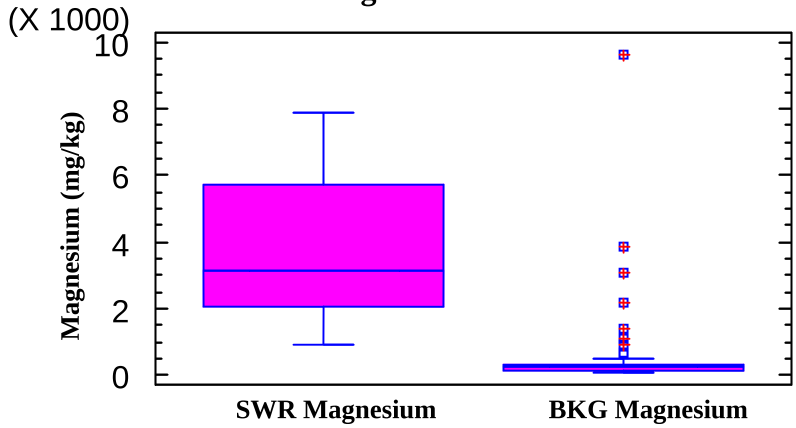



**Figure E1-10 Box Plot Comparison for Nickel in Surface Soil**

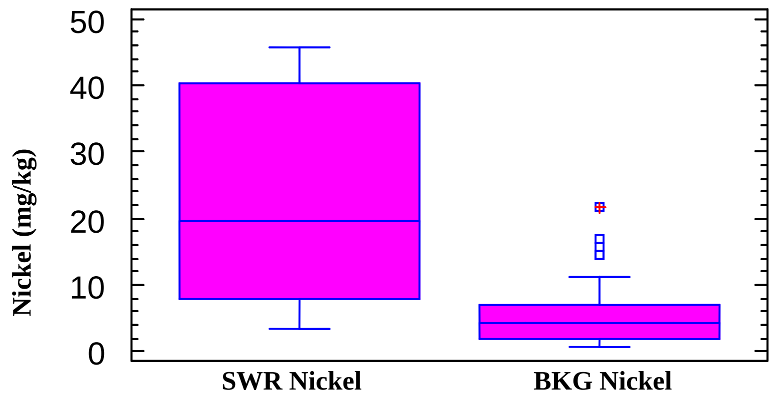


**Figure E1-11 Box Plot Comparison for Potassium in Surface Soil**

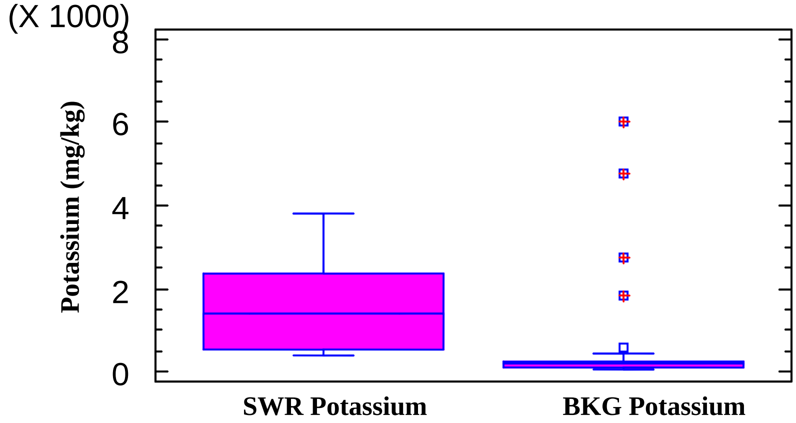



**Figure E1-12 Box Plot Comparison for Vanadium in Surface Soil**

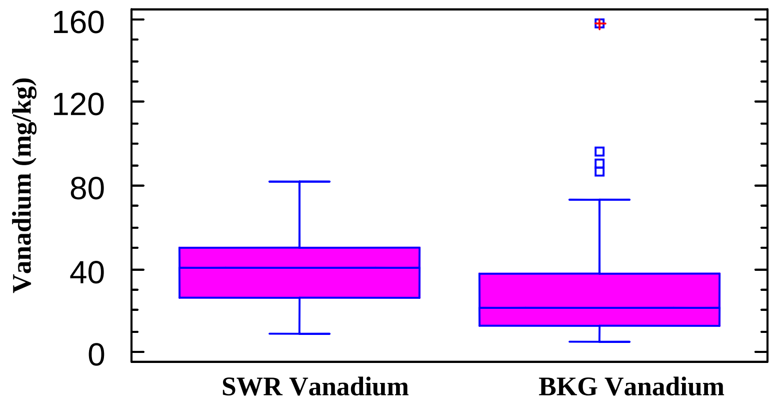
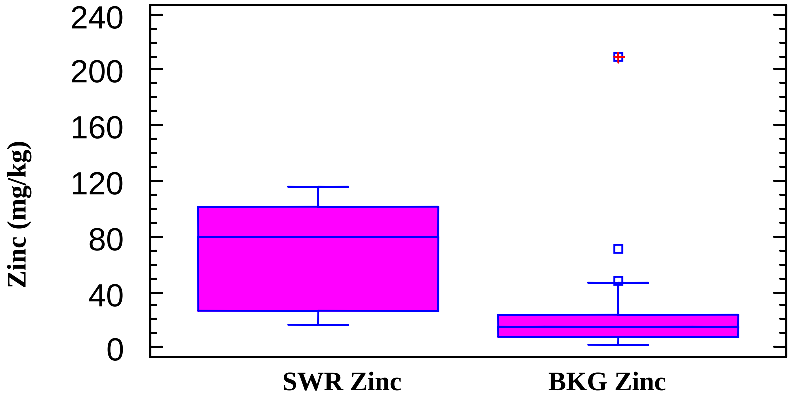


**Figure E1-12 Box Plot Comparison for Zinc in Surface Soil**



# Appendix E2

**Figure E2-1 Box Plot Comparison for Aluminum in Subsurface Soil**

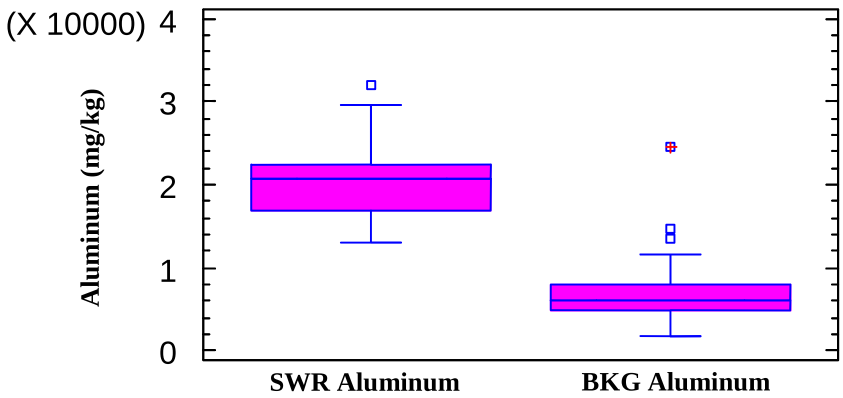



**Figure E2-2 Box Plot Comparison for Beryllium in Subsurface Soil**

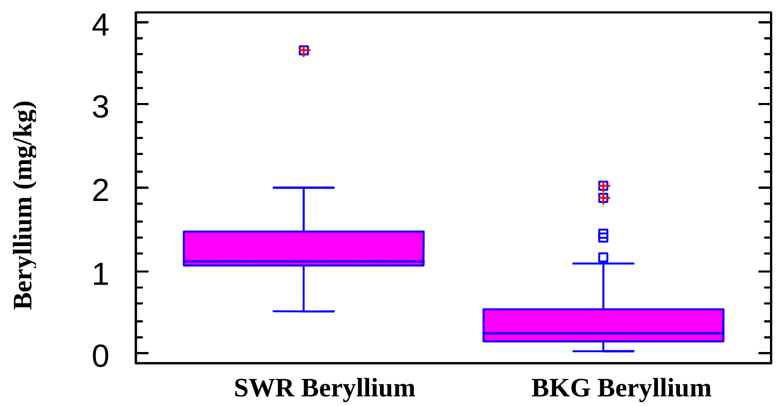


**Figure E2-3 Box Plot Comparison for Calcium in Subsurface Soil**

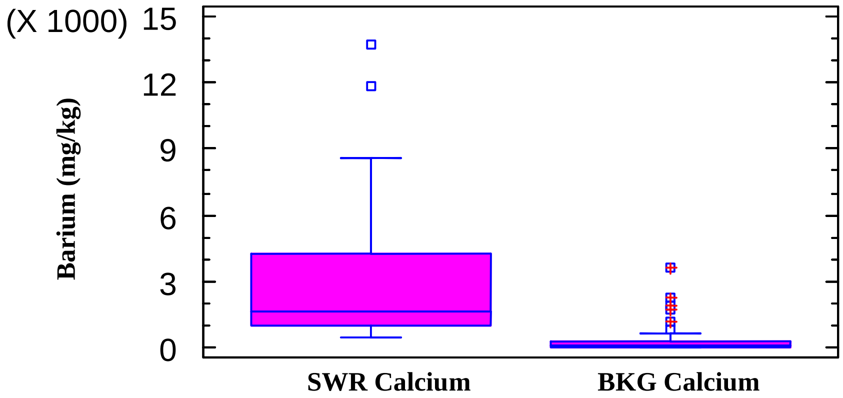



**Figure E2-4 Box Plot Comparison for Cobalt in Subsurface Soil**

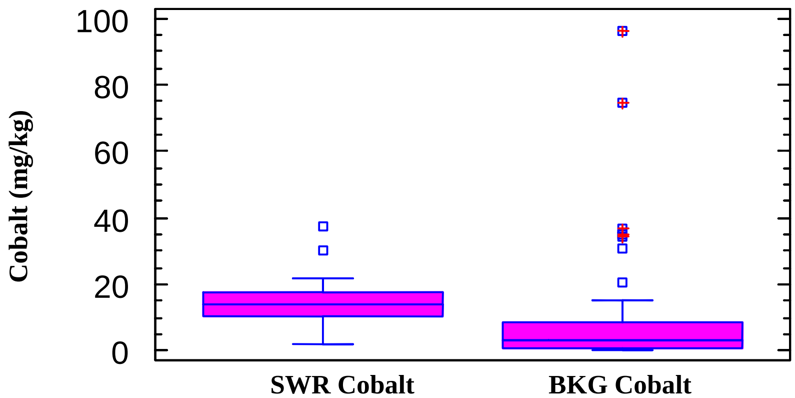


**Figure E2-5 Box Plot Comparison for Copper in Subsurface Soil**

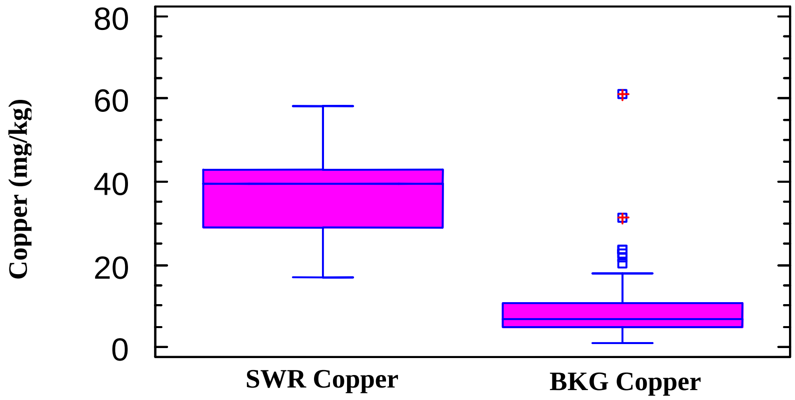



**Figure E2-6 Box Plot Comparison for Iron in Subsurface Soil**

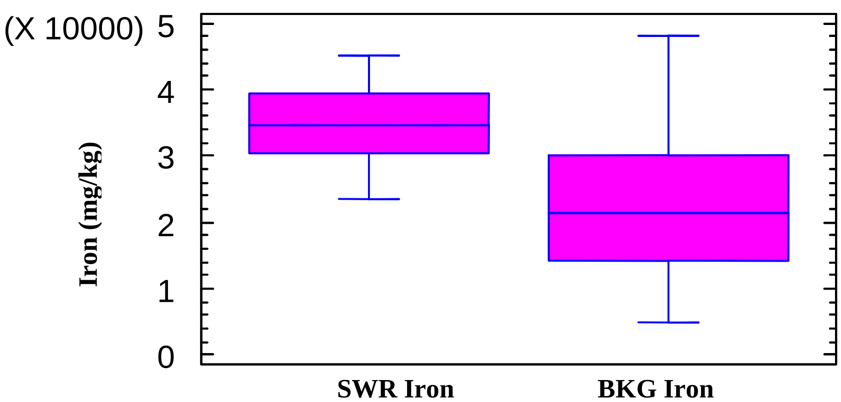


**Figure E2-7 Box Plot Comparison for Magnesium in Subsurface Soil**

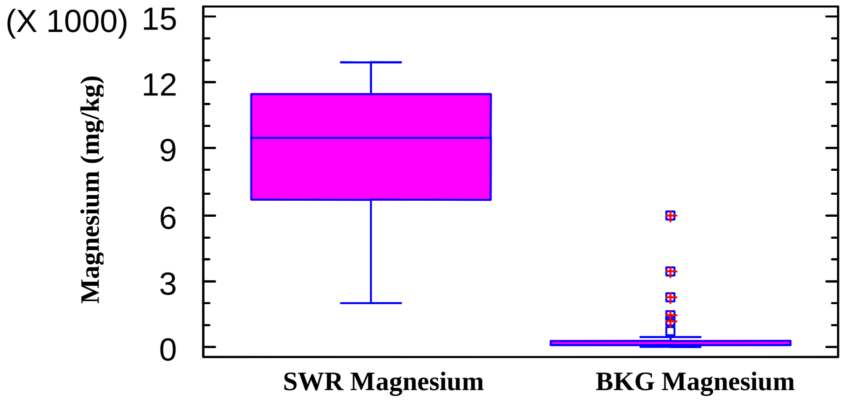



**Figure E2-8 Box Plot Comparison for Nickel in Subsurface Soil**

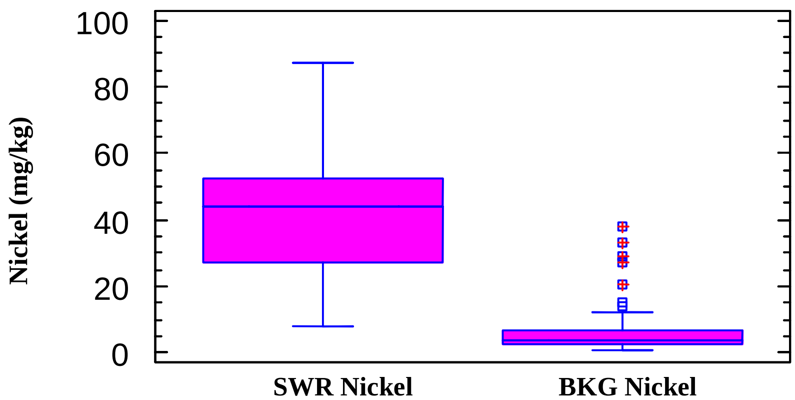


**Figure E2-9 Box Plot Comparison for Potassium in Subsurface Soil**

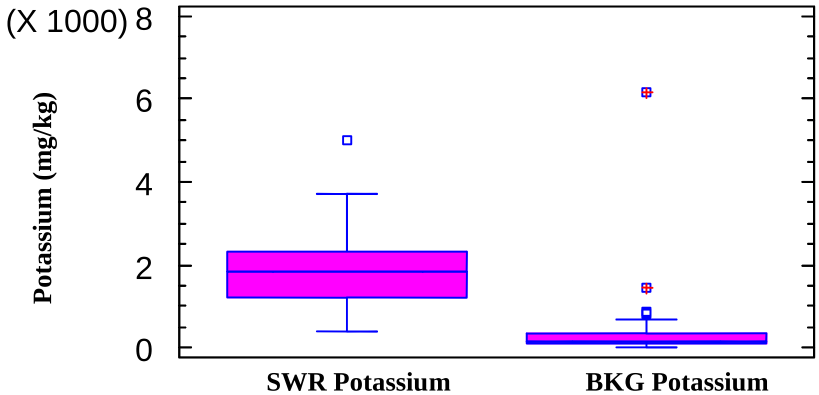
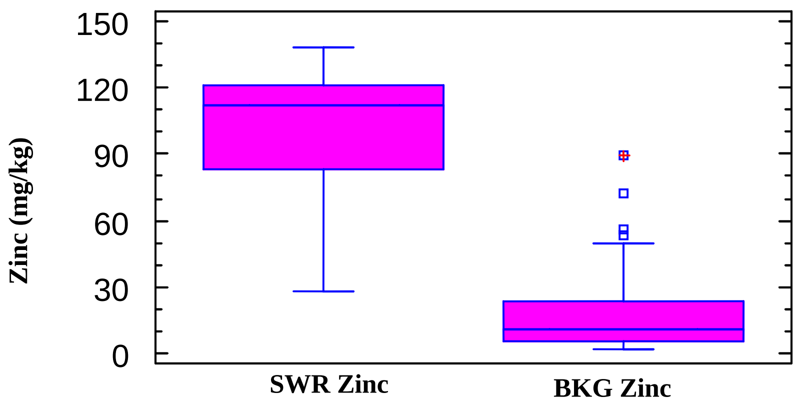



**Figure E2-10 Box Plot Comparison for Zinc in Subsurface Soil**



# Appendix E3

**Figure E3-1 Box Plot Comparison for Aluminum in Groundwater**

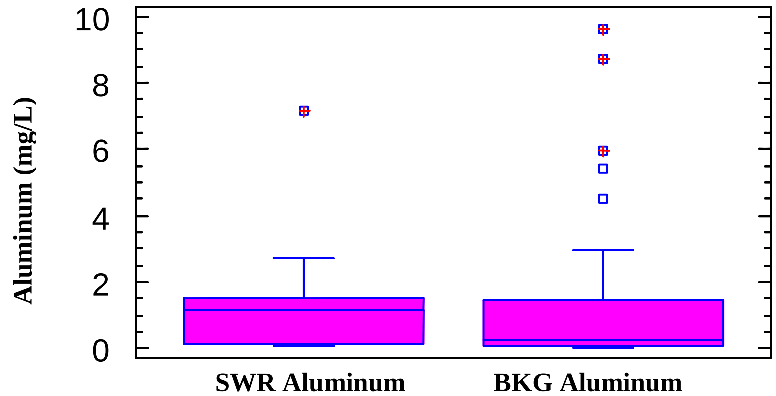



**Figure E3-2 Box Plot Comparison for Barium in Groundwater**

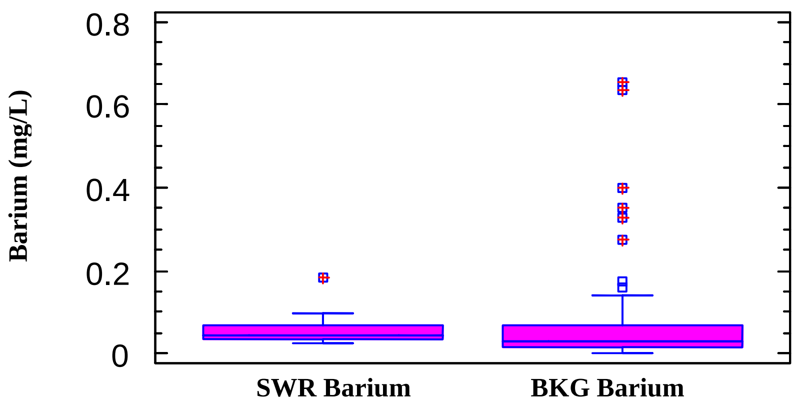


**Figure E3-3 Box Plot Comparison for Calcium in Groundwater**

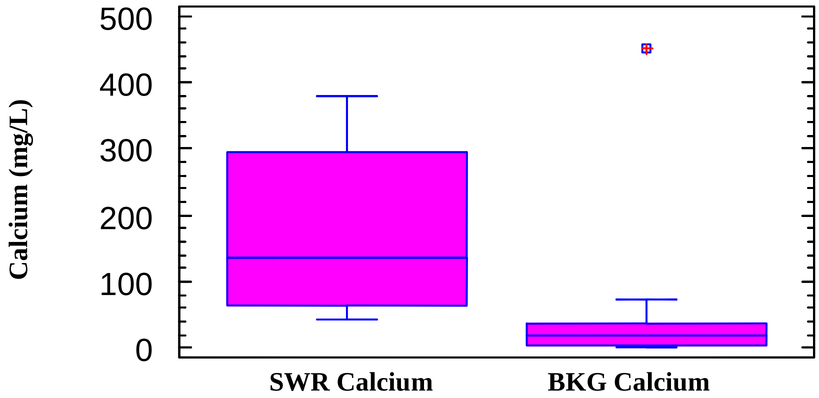



**Figure E3-4 Box Plot Comparison for Iron in Groundwater**

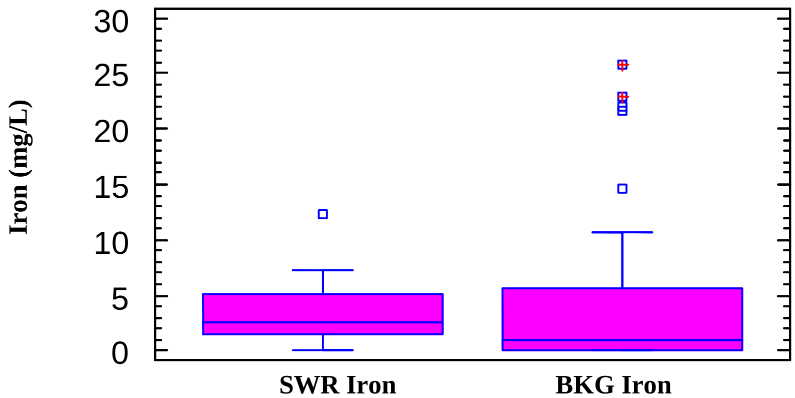


**Figure E3-5 Box Plot Comparison for Magnesium in Groundwater**

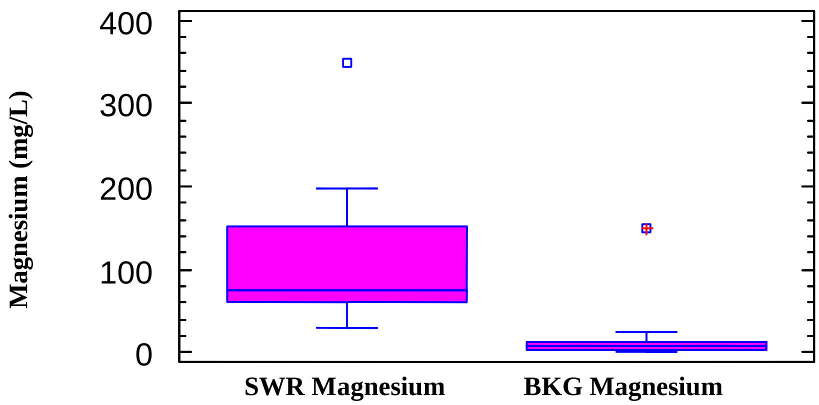



**Figure E3-6 Box Plot Comparison for Manganese in Groundwater**

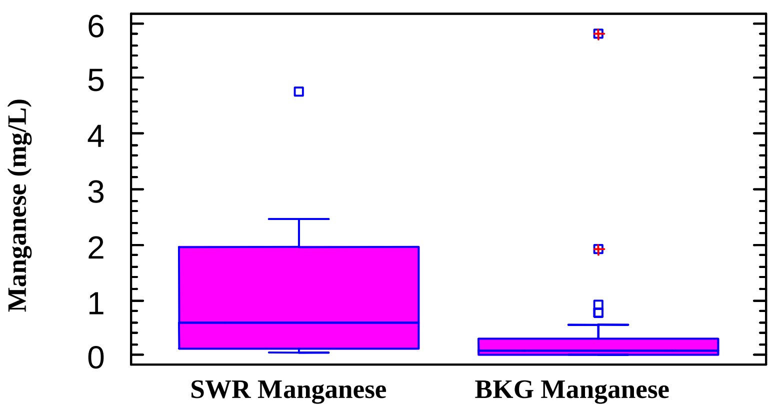


**Figure E3-7 Box Plot Comparison for Potassium in Groundwater**

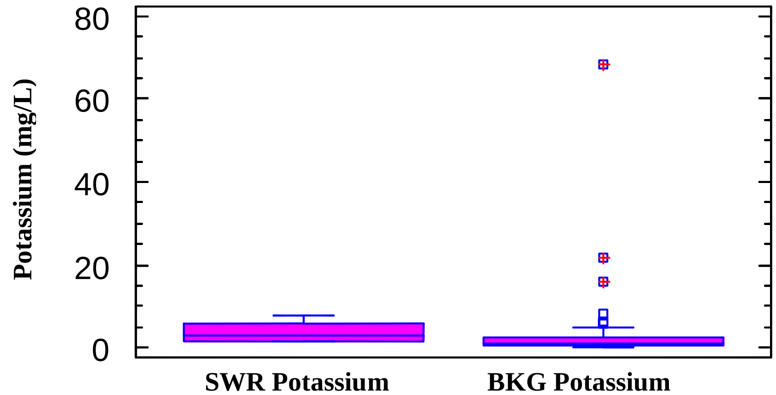
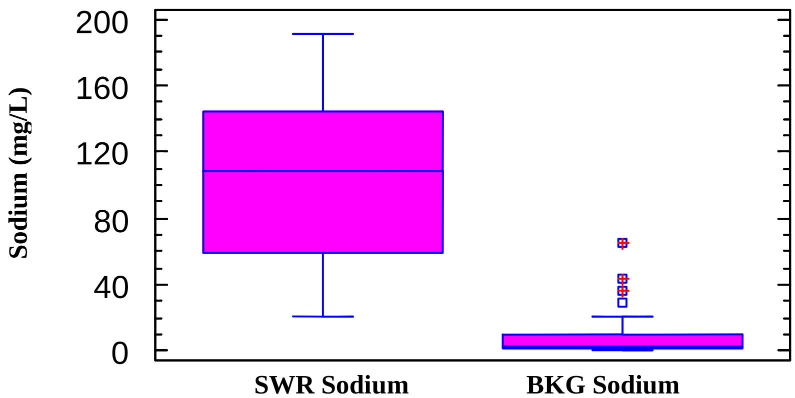



**Figure E3-8 Box Plot Comparison for Sodium in Groundwater**



# Appendix E4

**Figure E4-1 Aluminum vs. Chromium in Surface Soil**

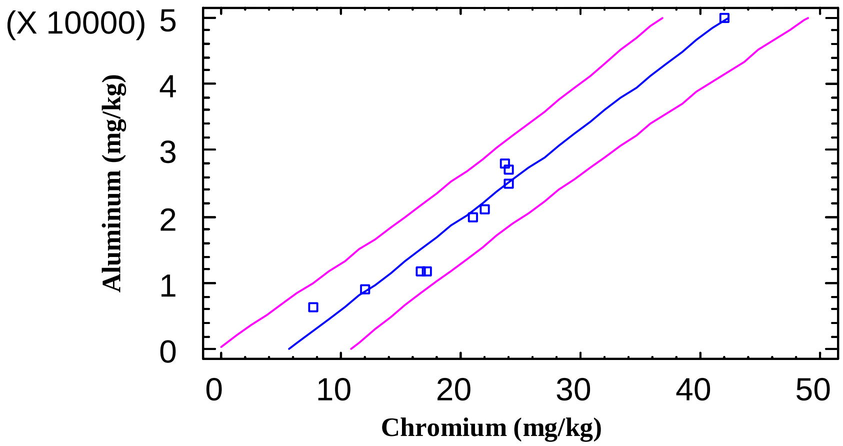



**Figure E4-2 Aluminum vs. Iron in Surface Soil**

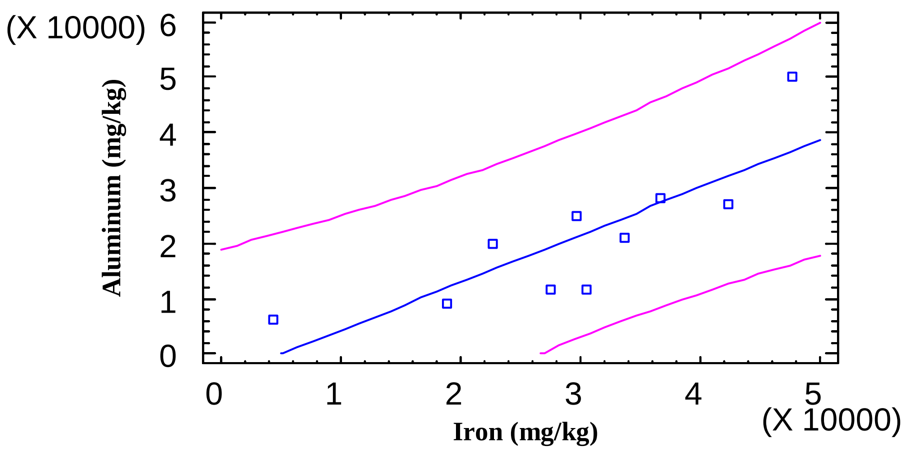


**Figure E4-3 Barium vs. Aluminum in Surface Soil**

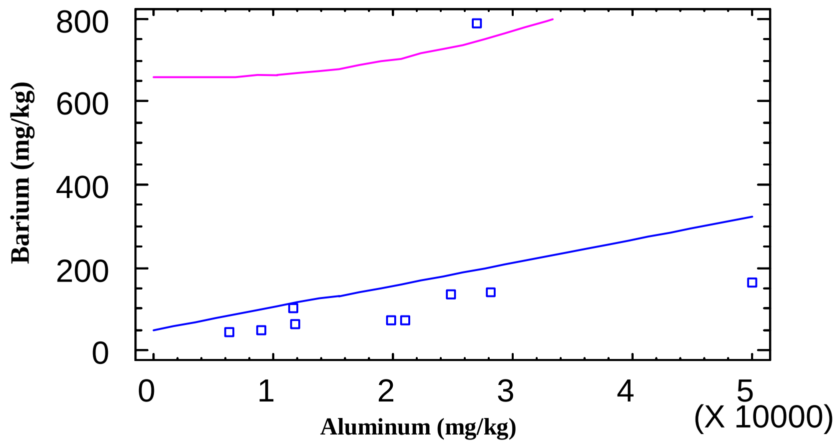



**Figure E4-4 Barium vs. Beryllium in Surface Soil**

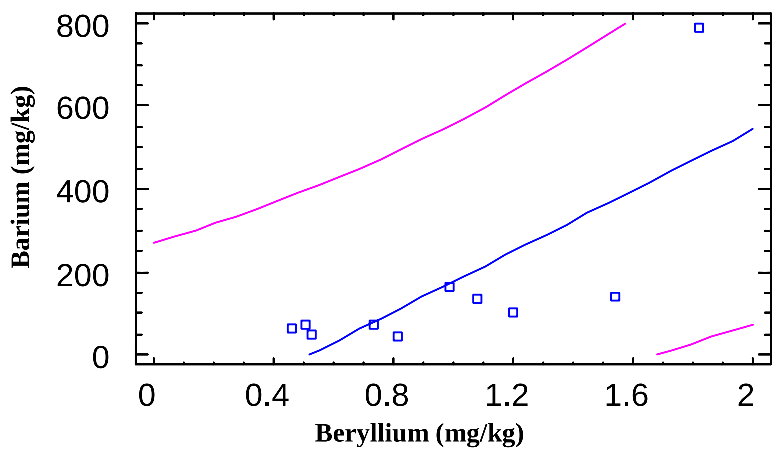


**Figure E4-5 Beryllium vs. Iron in Surface Soil**

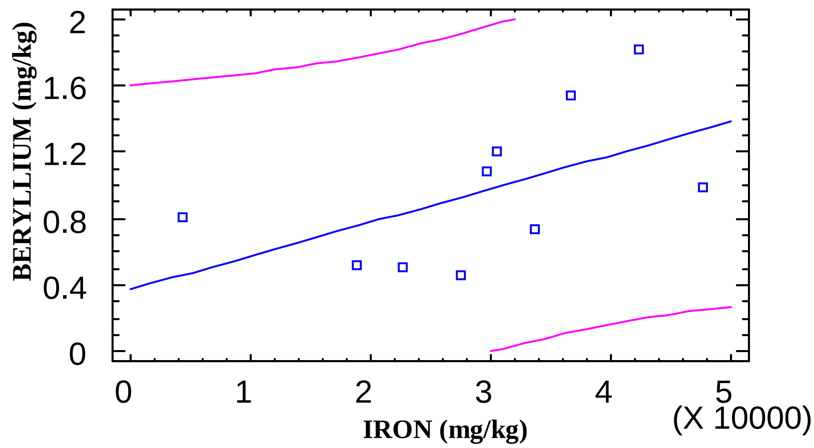



**Figure E4-6 Beryllium vs. Nickel in Surface Soil**

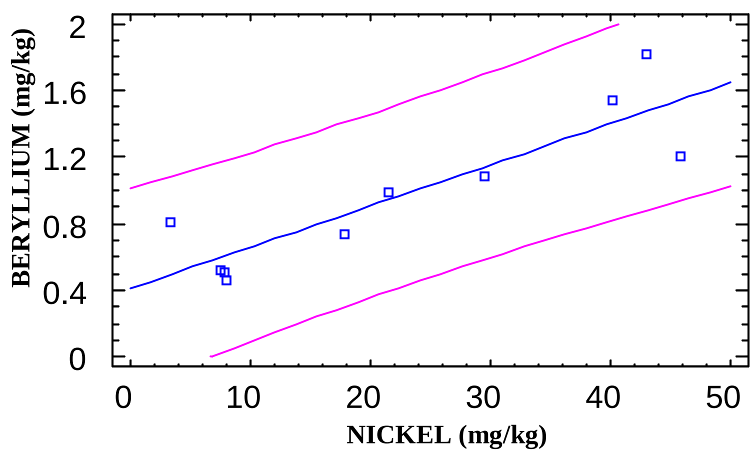


**Figure E4-7 Chromium vs. Aluminum in Surface Soil**

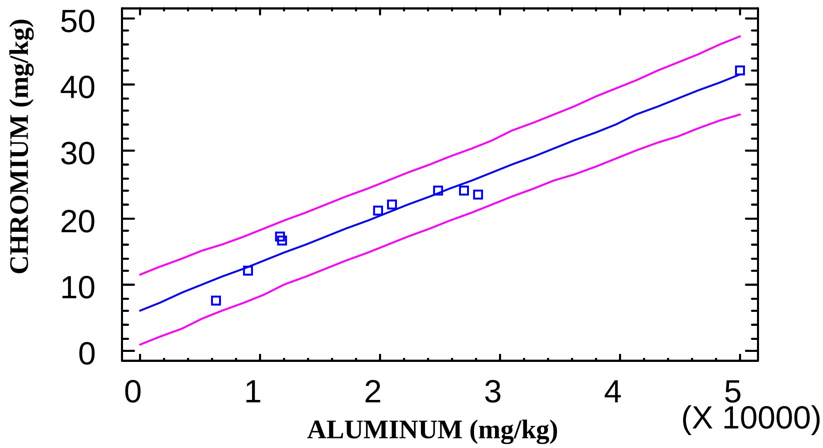



**Figure E4-8 Chromium vs. Iron in Surface Soil**

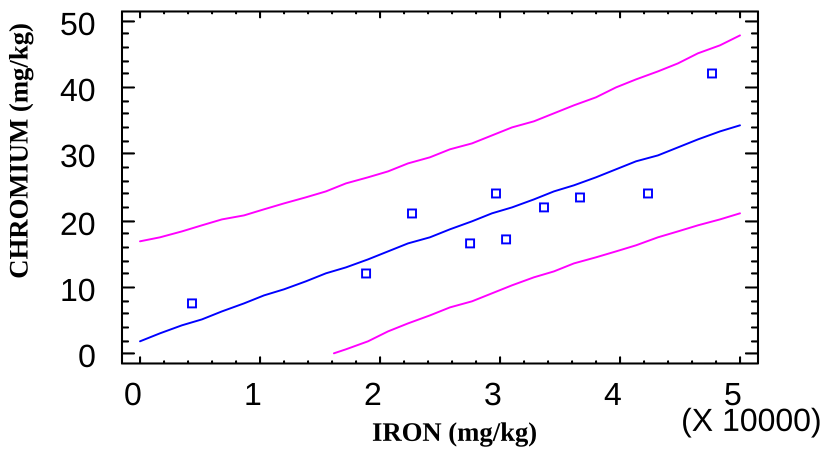


**Figure E4-9 Cobalt vs. Copper in Surface Soil**

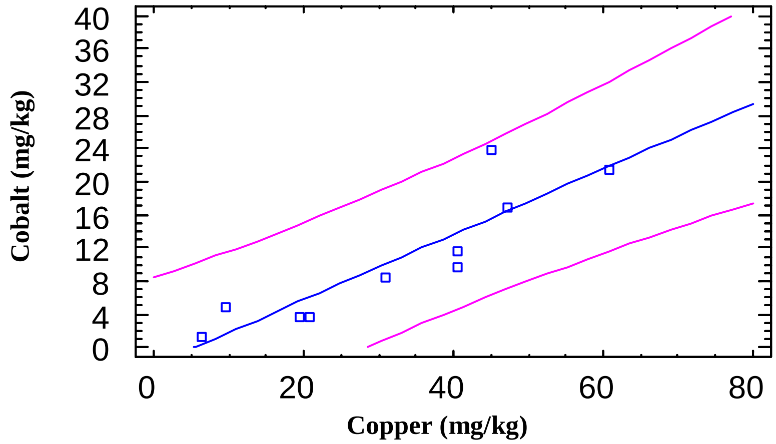



**Figure E4-10 Cobalt vs. Iron in Surface Soil**

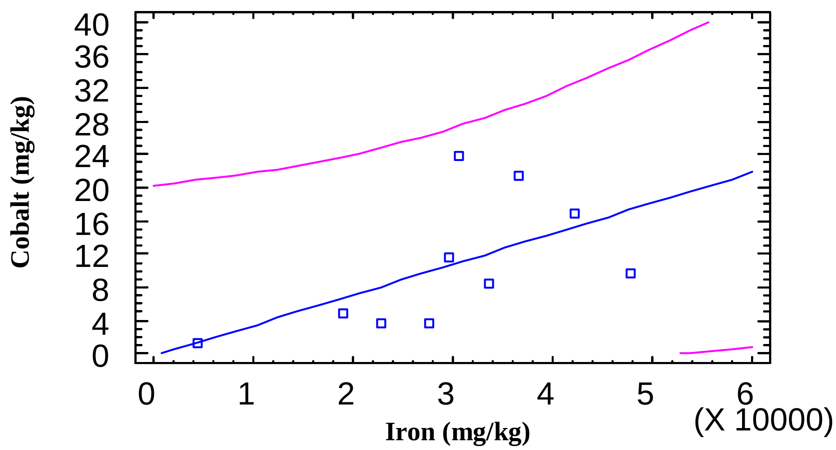


**Figure E4-11 Copper vs. Iron in Surface Soil**

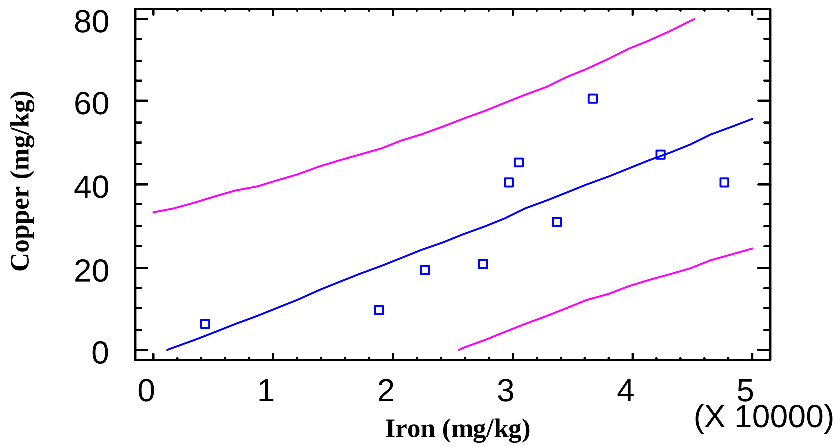



**Figure E4-12 Copper vs. Zinc in Surface Soil**

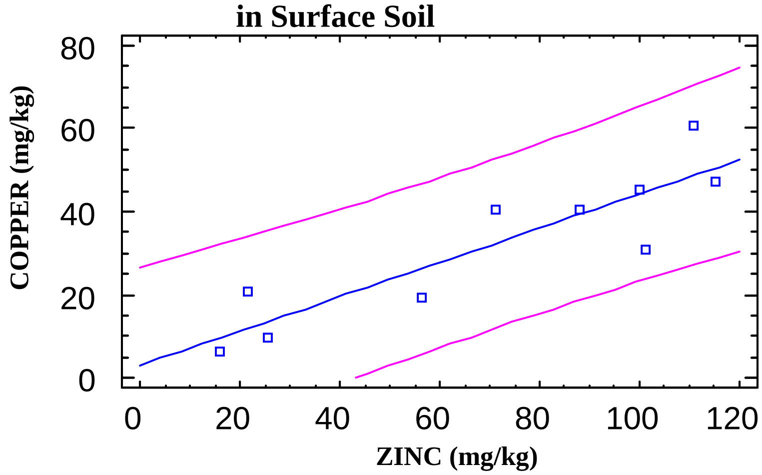


**Figure E4-13 Iron vs. Aluminum in Surface Soil**

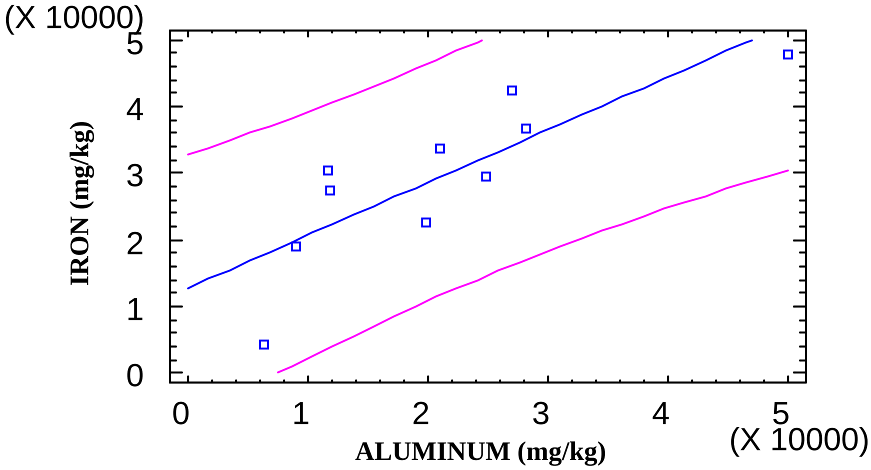



**Figure E4-14 Iron vs. Copper in Surface Soil**

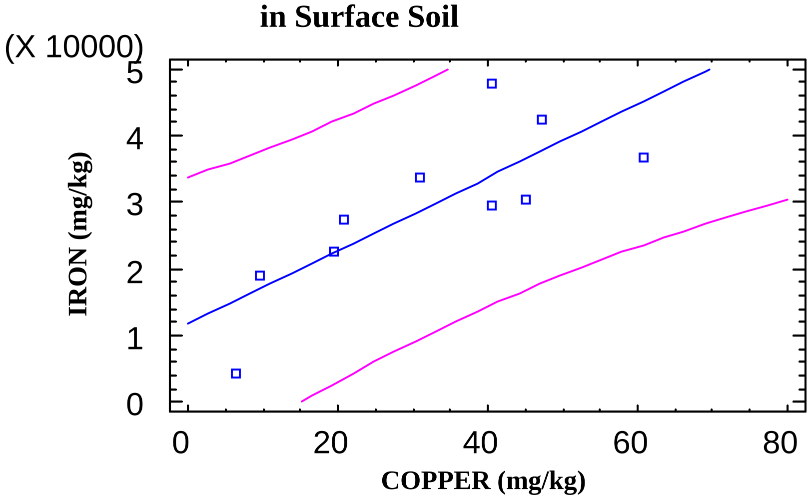


**Figure E4-15 Nickel vs. Iron in Surface Soil**

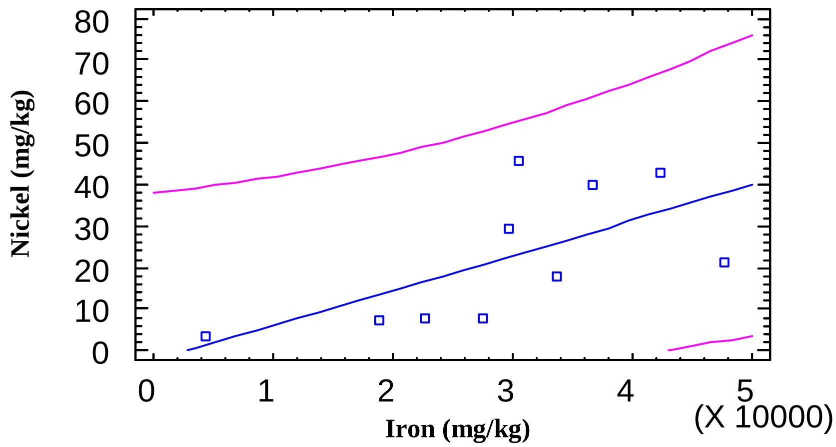



**Figure E4-16 Nickel vs. Zinc in Surface Soil**

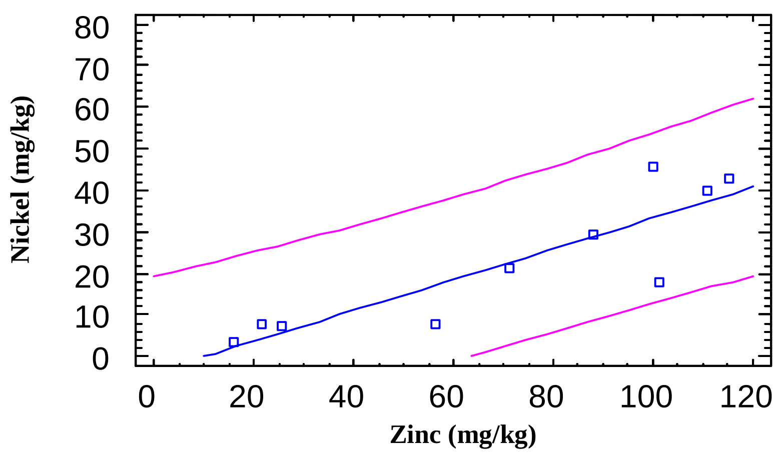


**Figure E4-17 Potassium vs. Aluminumin in Surface Soil**

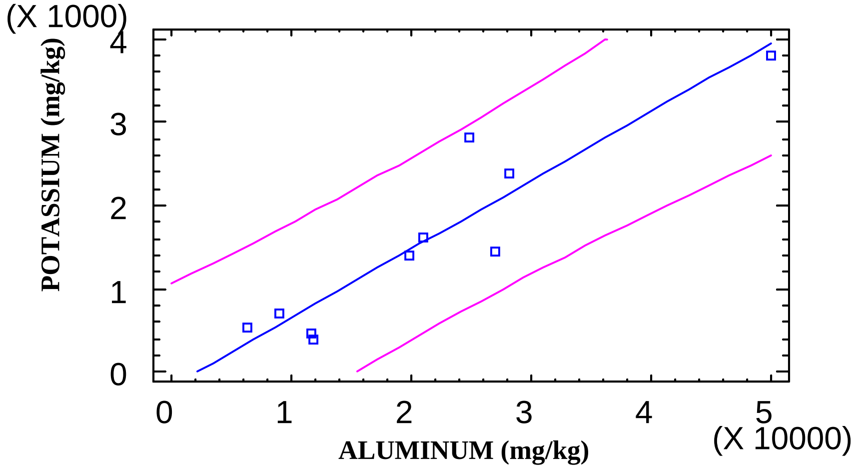



**Figure E4-18 Vanadium vs. Aluminumin in Surface Soil**

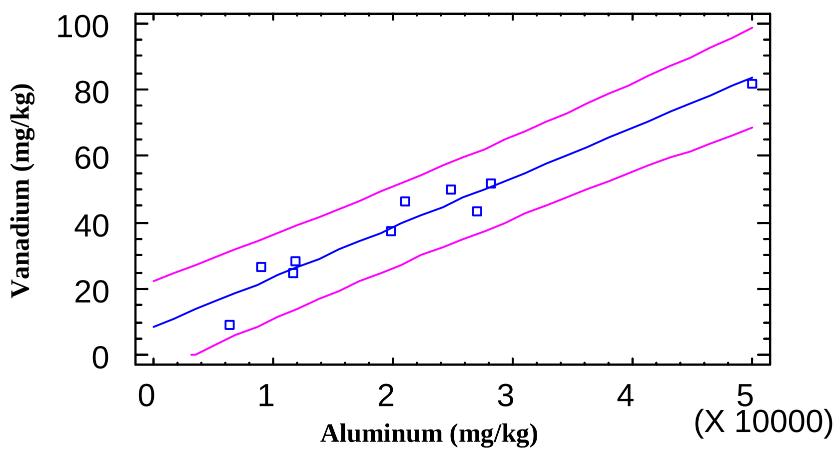


**Figure E4-19 Vanadium vs Chromium in Surface Soil**

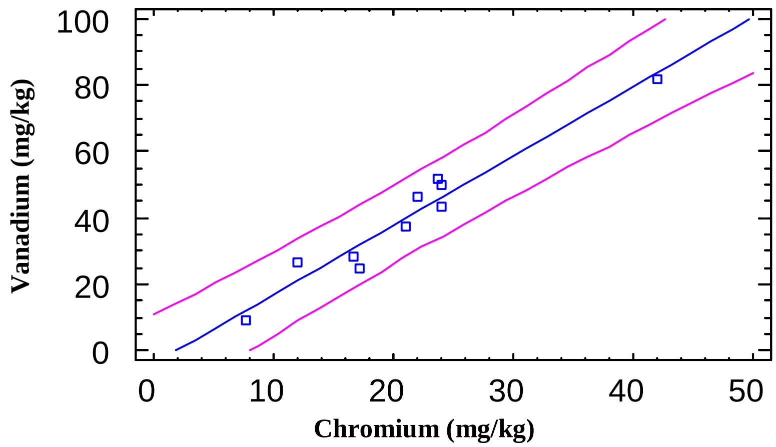



**Figure E4-20 Zinc vs. Iron in Surface Soil**

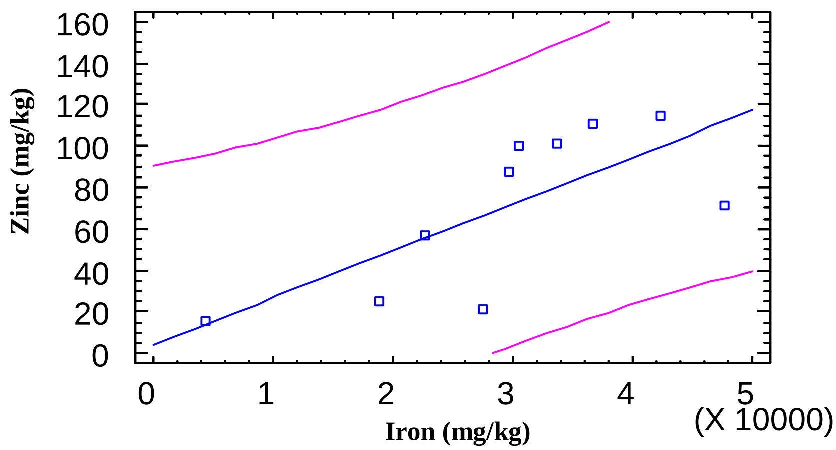
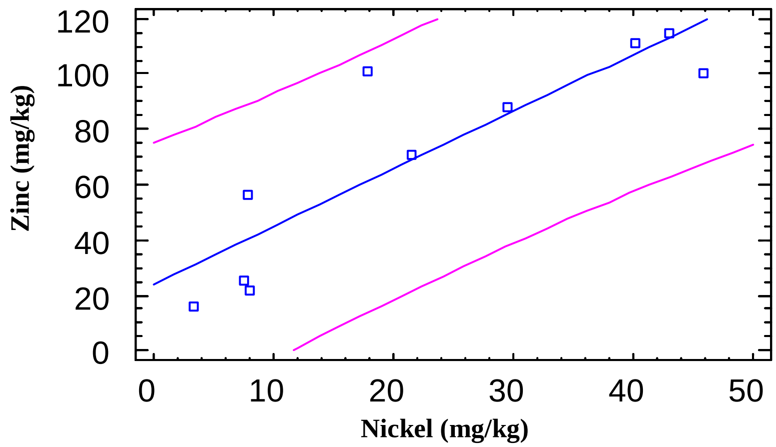


**Figure E4-21 Zinc vs. Nickel in Surface Soil**



**Appendix E5**

**Figure E5-1 Aluminum vs. Barium in Subsurface Soil**

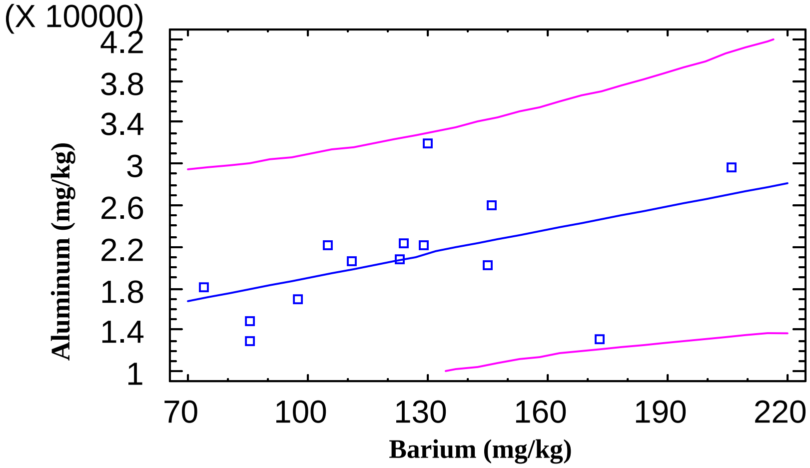



**Figure E5-2 Aluminum vs. Chromium in Subsurface Soil**

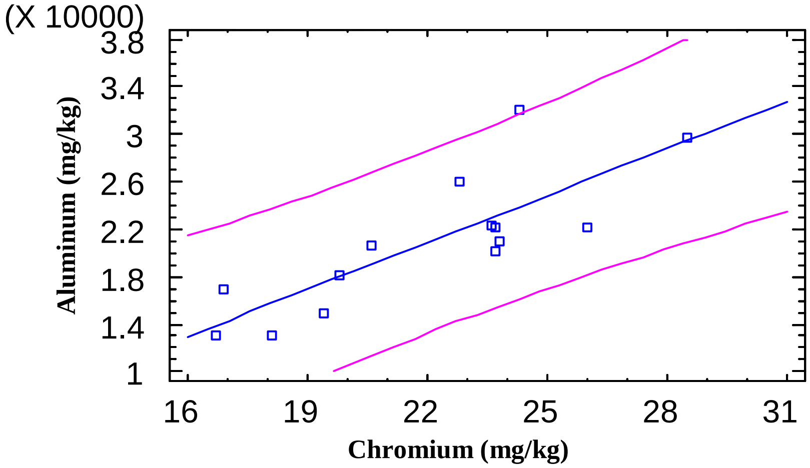


**Figure E5-3 Beryllium vs. Iron in Subsurface Soil**

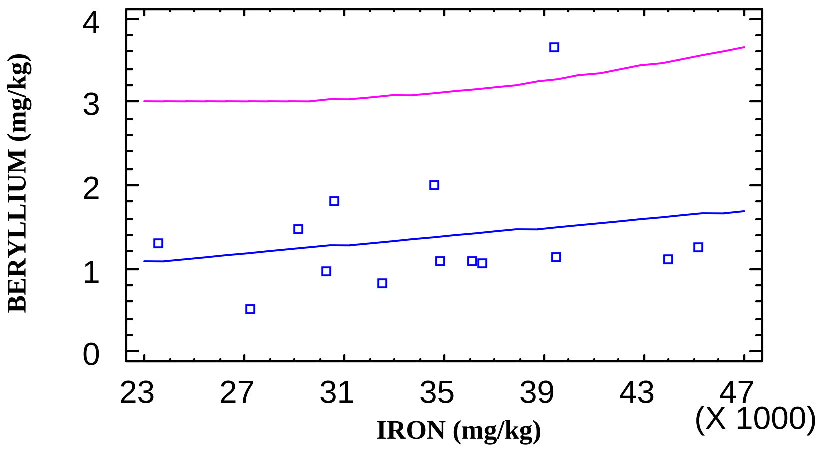



**Figure E5-4 Beryllium vs. Nickel in Subsurface Soil**

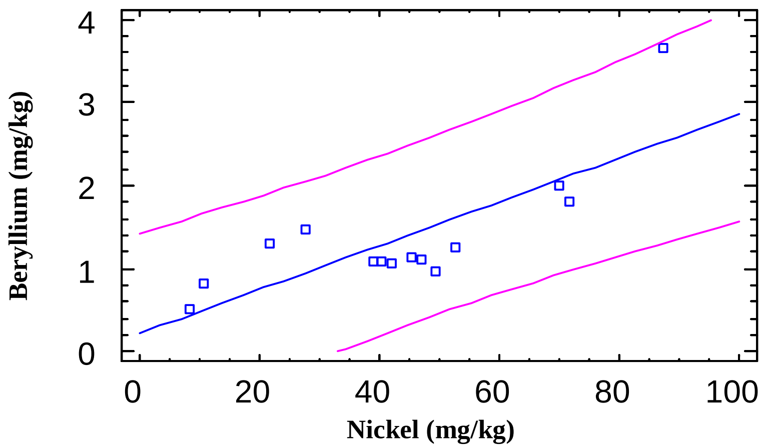


**Figure E5-5 Cadmium vs. Aluminum in Subsurface Soil**

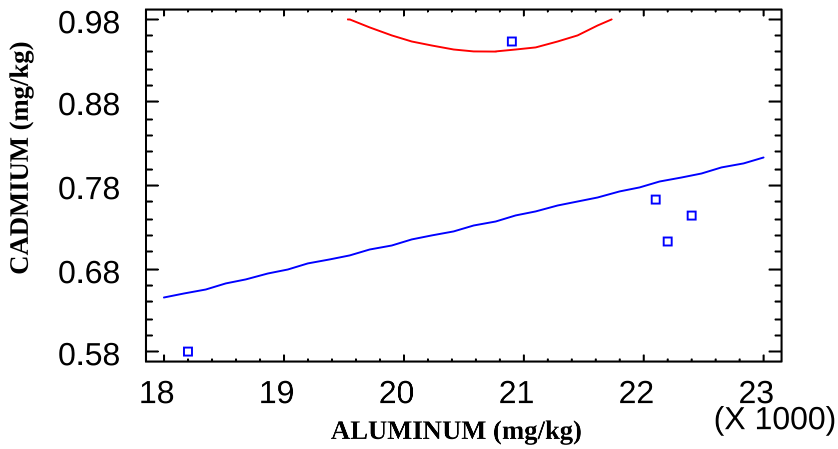



**Figure E5-6 Cadmium vs. Barium in Subsurface Soil**

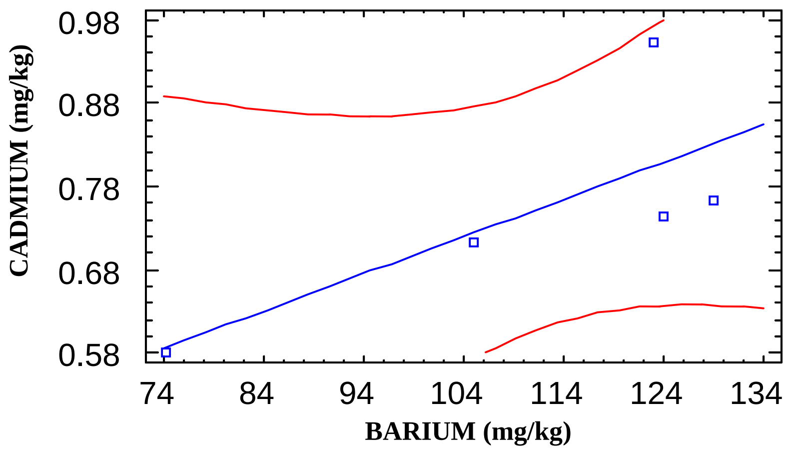


**Figure E5-7 Cobalt vs. Iron in Subsurface Soil**

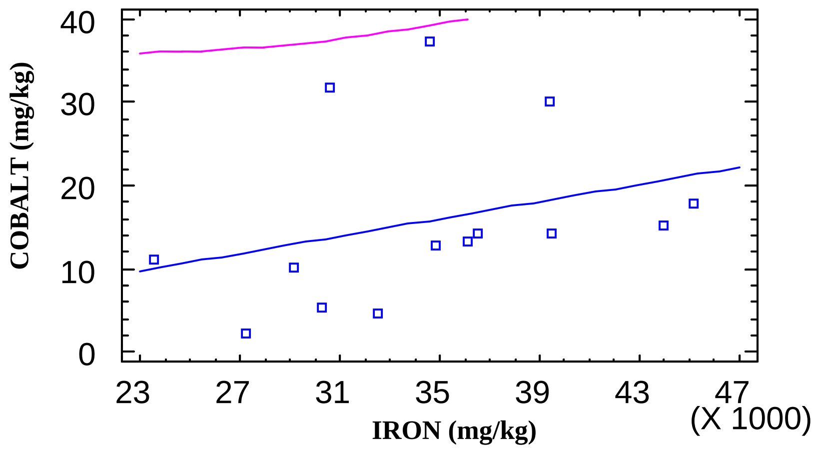



**Figure E5-8 Cobalt vs. Nickel in Subsurface Soil**

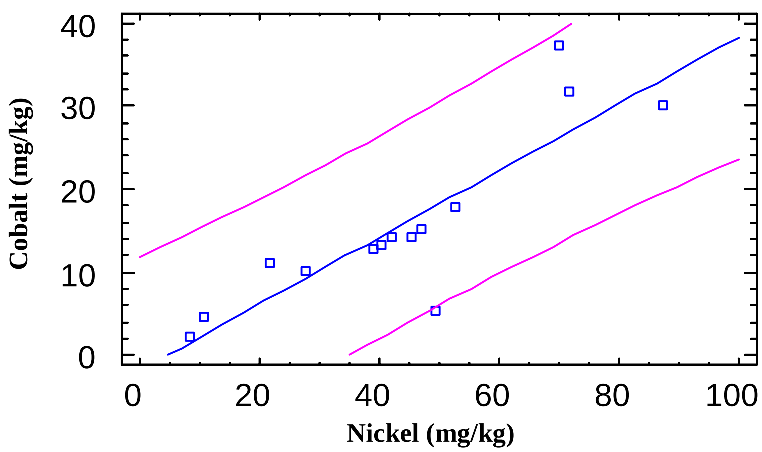


**Figure E5-9 Copper vs. Iron in Subsurface Soil**

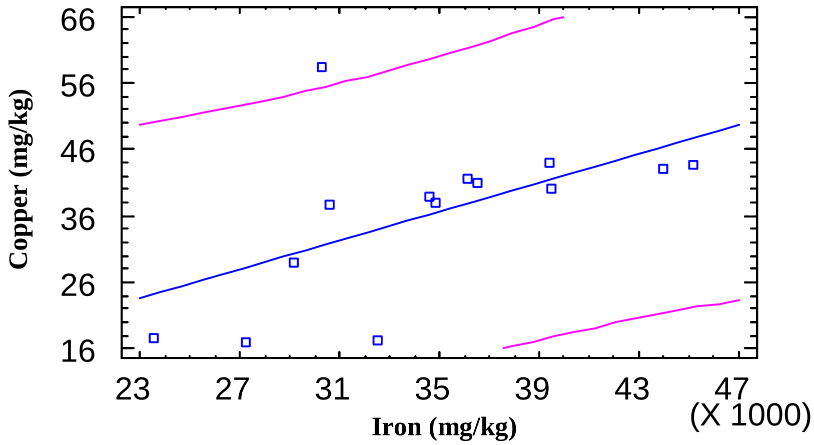



**Figure E5-10 Copper vs. Zinc in Subsurface Soil**

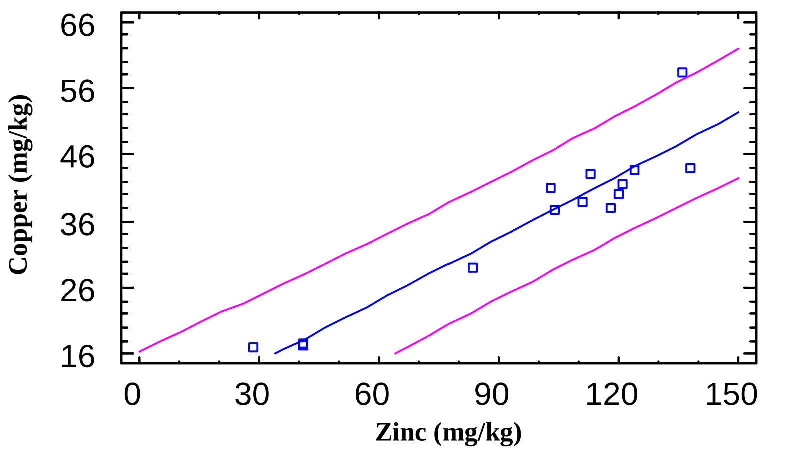


**Figure E5-11 Iron vs. Copper in Subsurface Soil**

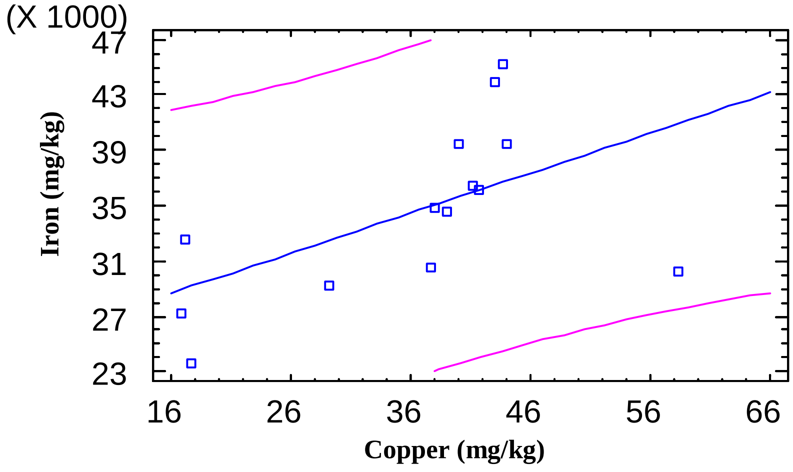



**Figure E5-12 Iron vs. Zinc in Subsurface Soil**

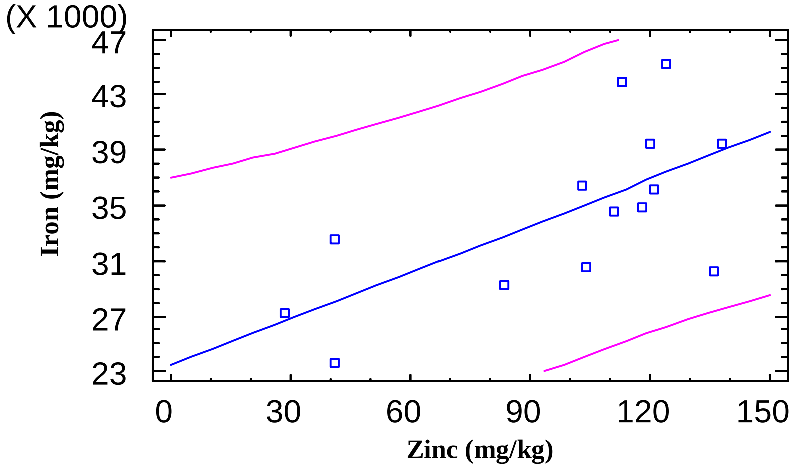


**Figure E5-13 Magnesium vs. Copper in Subsurface Soil**

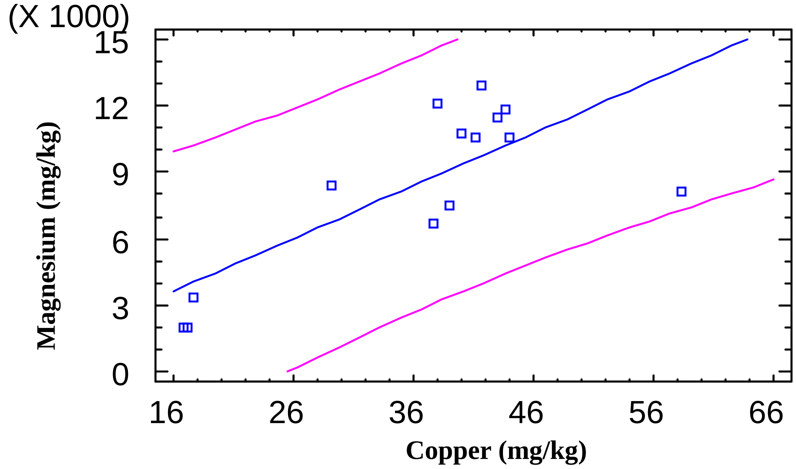



**Figure E5-14 Magnesium vs. Iron in Subsurface Soil**

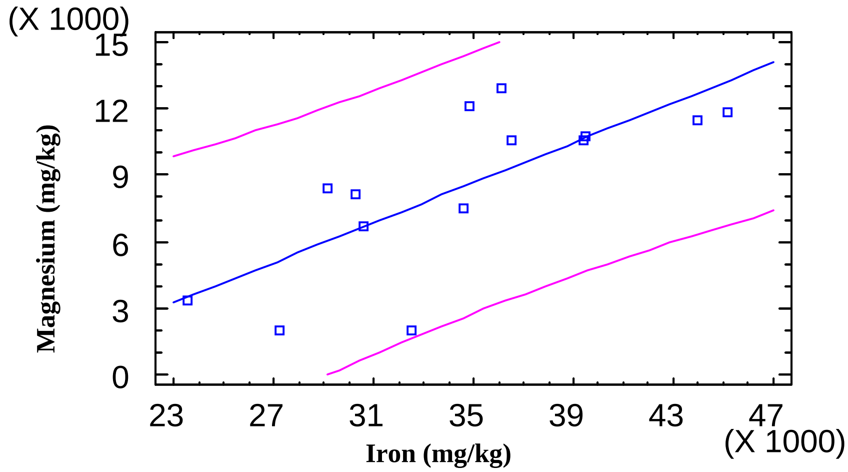


**Figure E5-15 Nickel vs. Copper in Subsurface Soil**

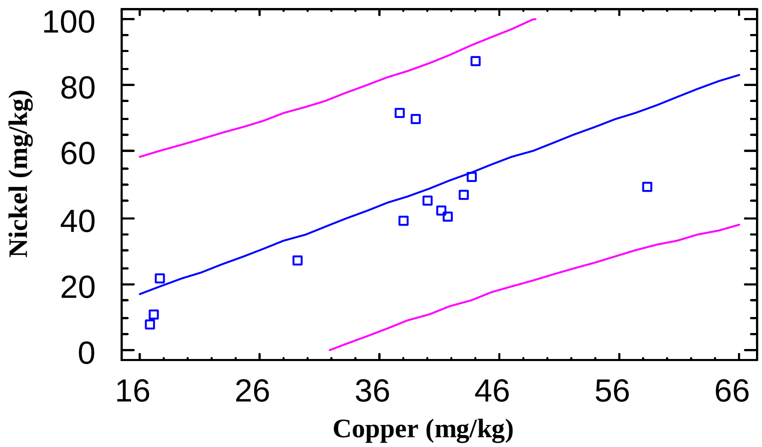



**Figure E5-16 Nickel vs. Zinc in Subsurface Soil**

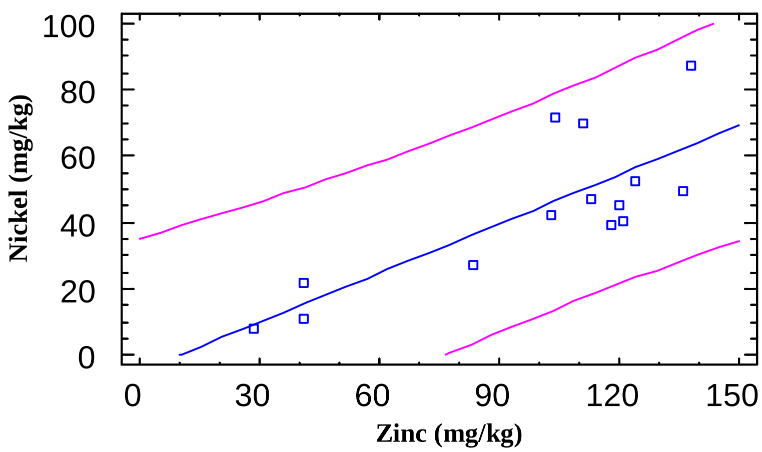


**Figure E5-17 Potassium vs. Aluminum in Subsurface Soil**

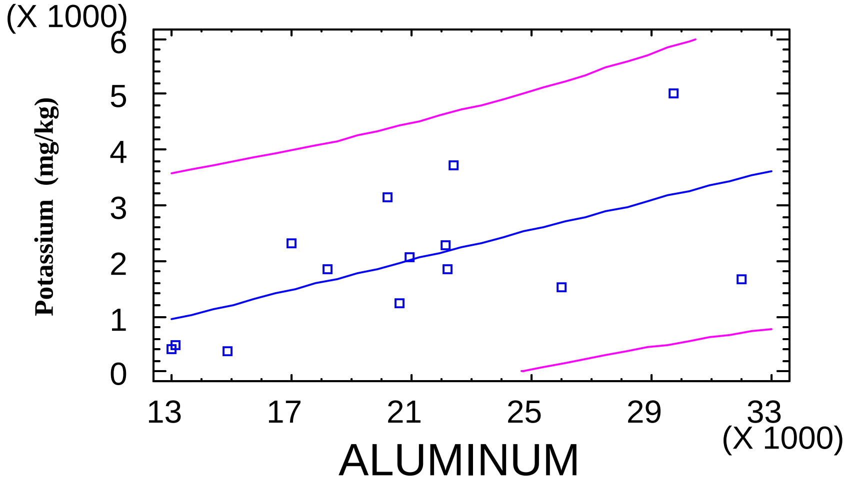



**Figure E5-18 Potassium vs. Chromium in Subsurface Soil**

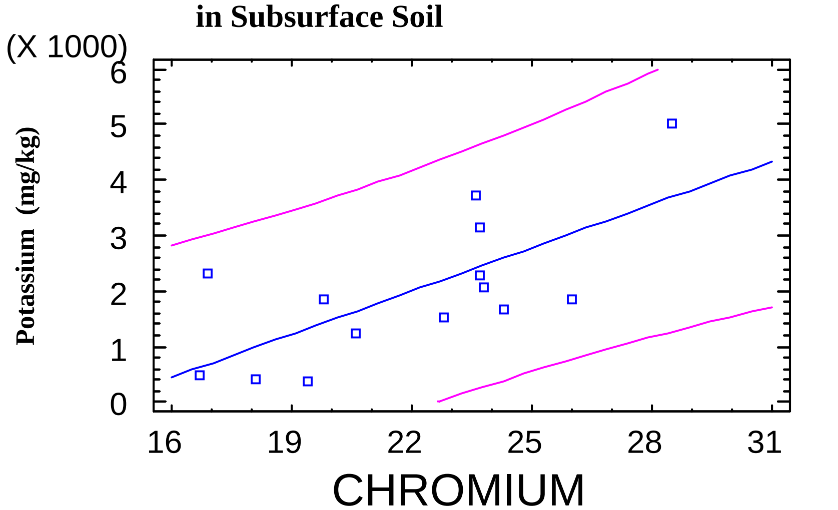


**Figure E5-19 Selenium vs. Iron in Subsurface Soil**

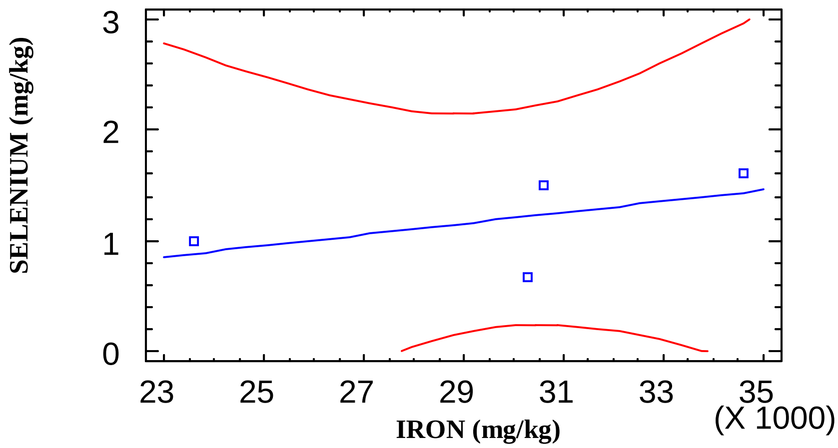



**Figure E5-20 Silver vs. Aluminum in Subsurface Soil**

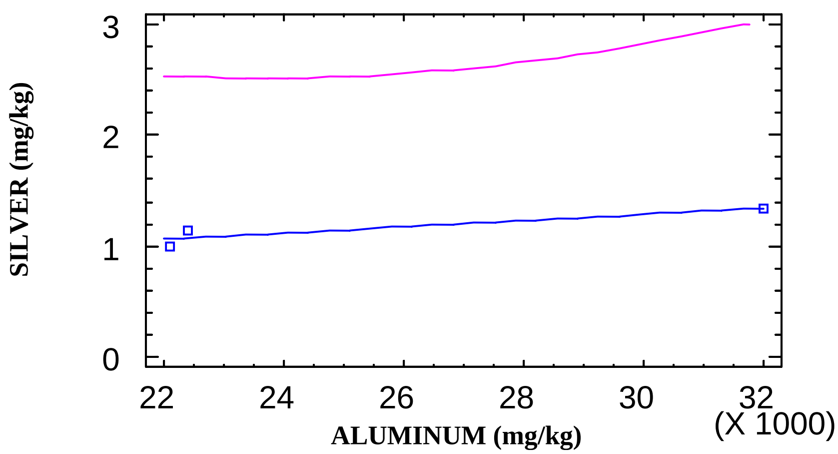


**Figure E5-21 Silver vs. Vanadium in Subsurface Soil**

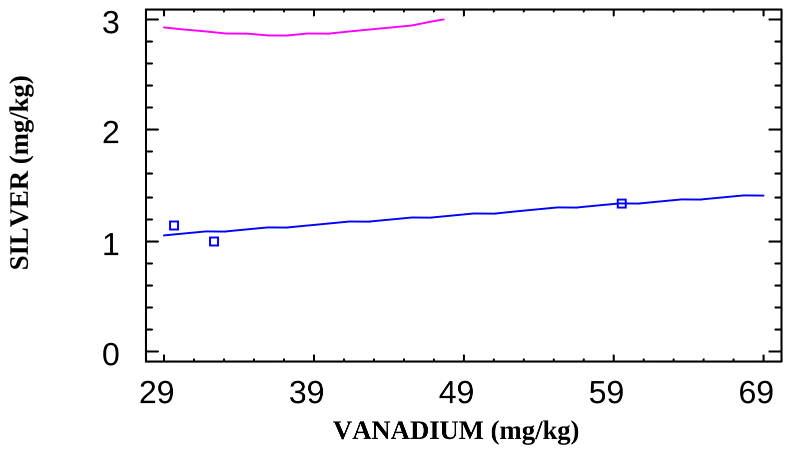



**Figure E5-22 Zinc vs. Copper in Subsurface Soil**

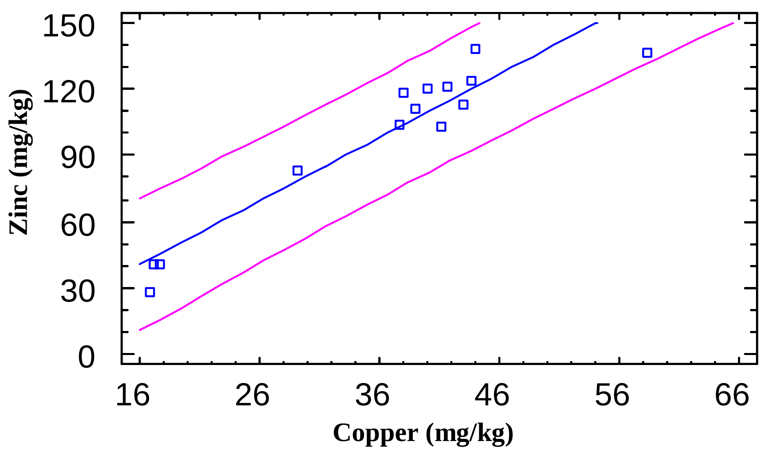
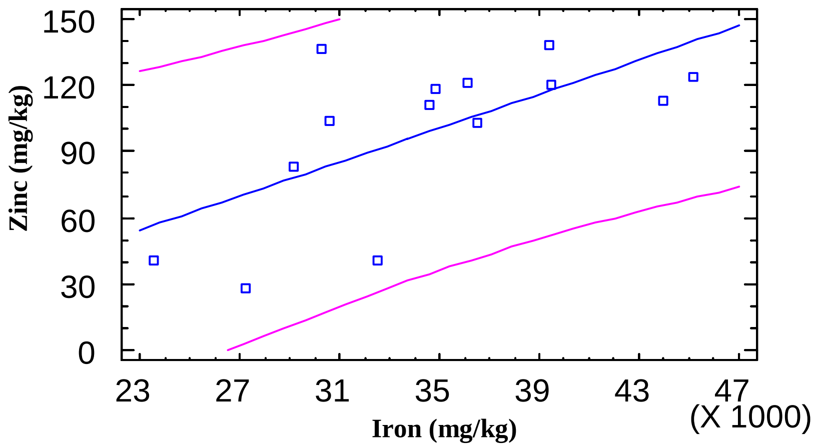


**Figure E5-23 Zinc vs. Iron in Subsurface Soil**



**Appendix E6**

**Figure E6-1 Aluminum vs. Barium in Groundwater**

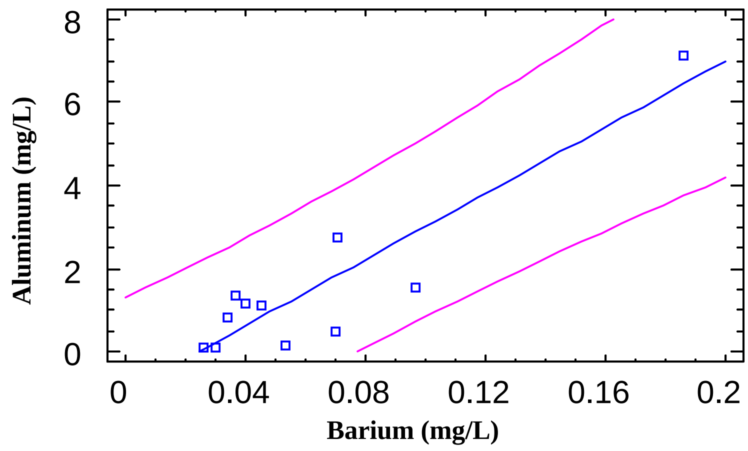



**Figure E6-2 Aluminum vs. Iron in Groundwater**

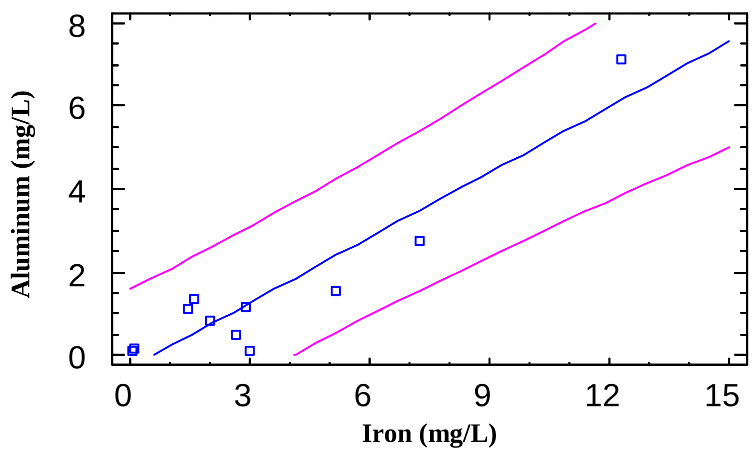


**Figure E6-3 Barium vs. Aluminum in Groundwater**

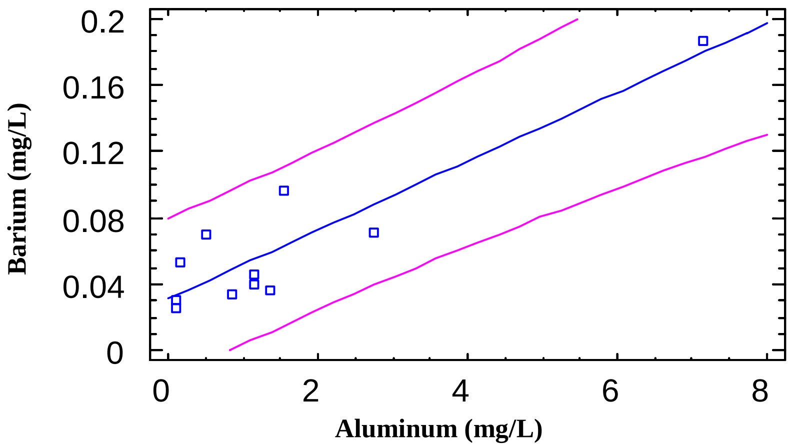



**Figure E6-4 Barium vs. Iron in Groundwater**

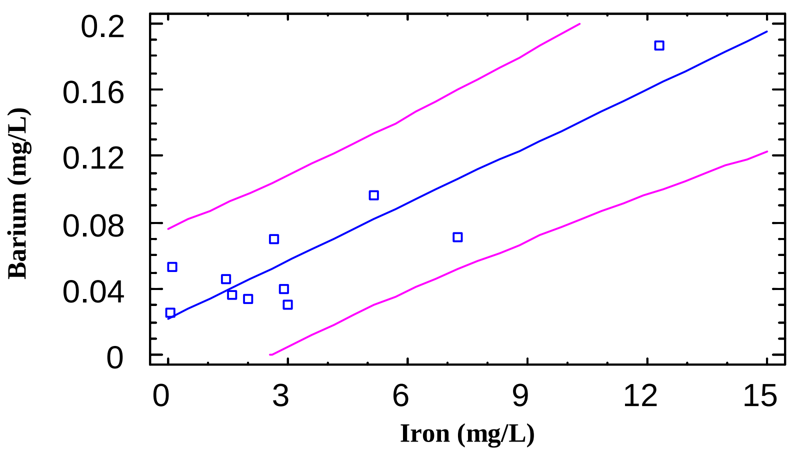


**Figure E6-5 Calcium vs. Magnesium in Groundwater**

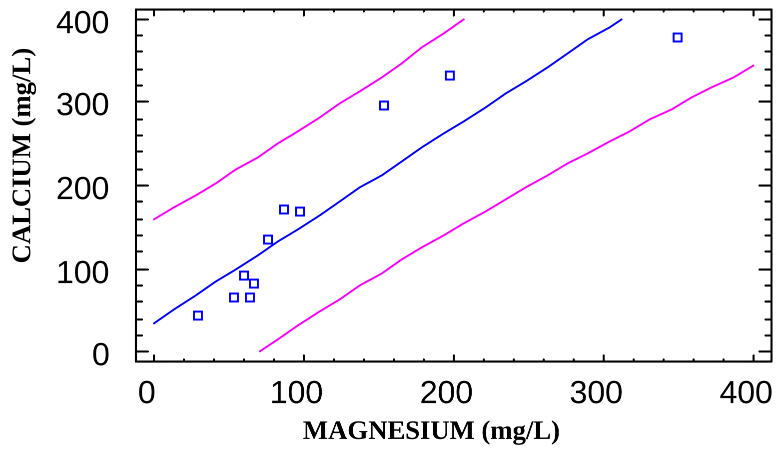



**Figure E6-6 Calcium vs. Zinc in Groundwater**

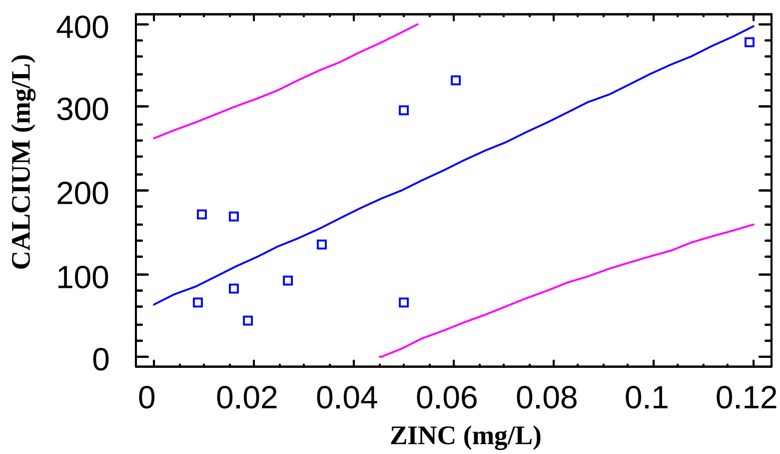


**Figure E6-7 Iron vs. Aluminum in Groundwater**

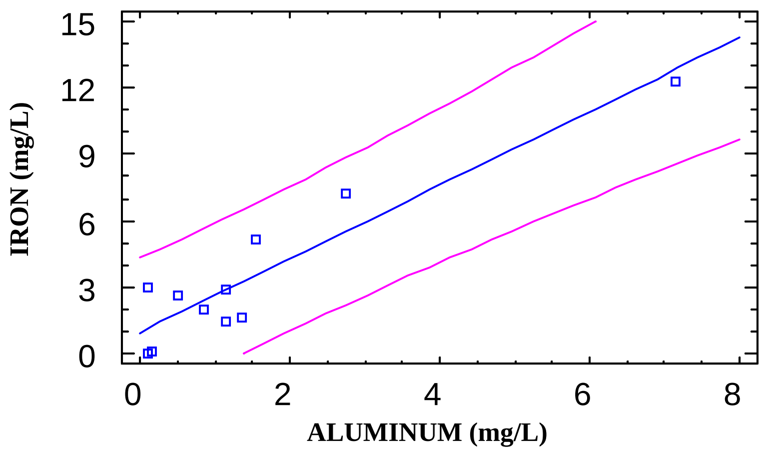



**Figure E6-8 Iron vs. Barium in Groundwater**

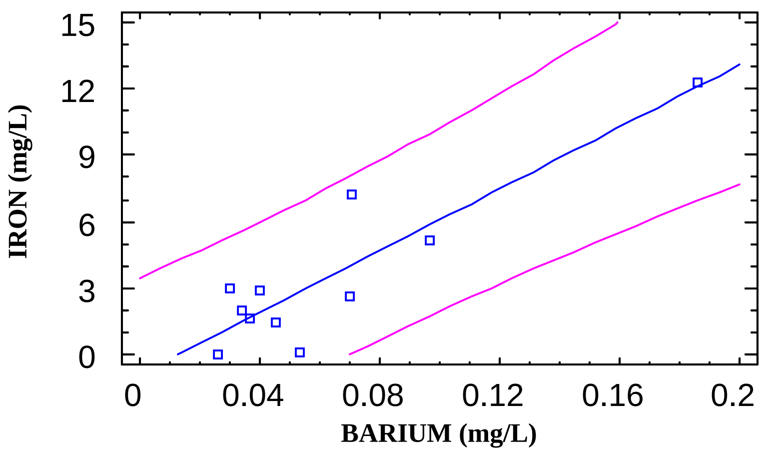


**Figure E6-9 Magnesium vs. Zinc in Groundwater**

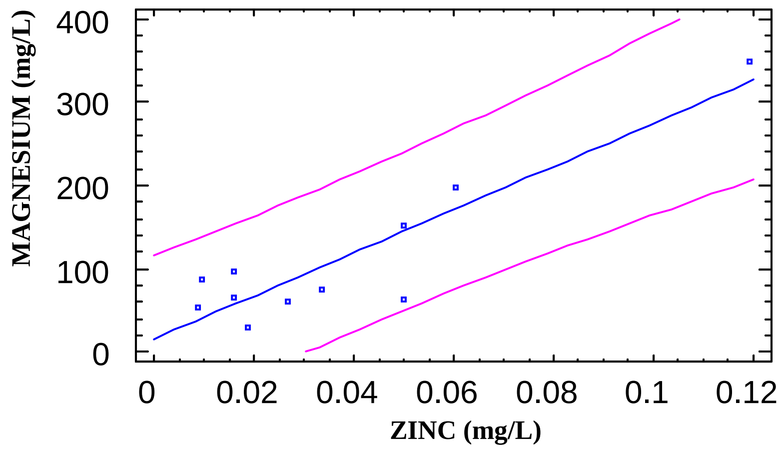



**Figure E6-10 Magnesium vs. Calcium in Groundwater**

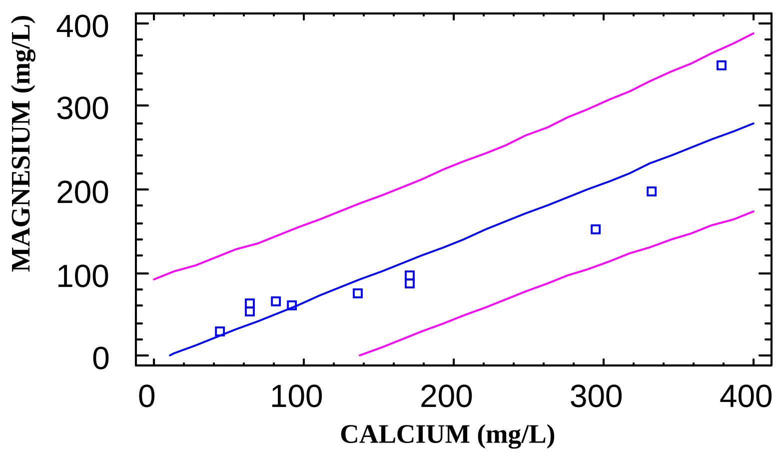


**Figure E6-11 Manganese vs. Calcium in Groundwater**

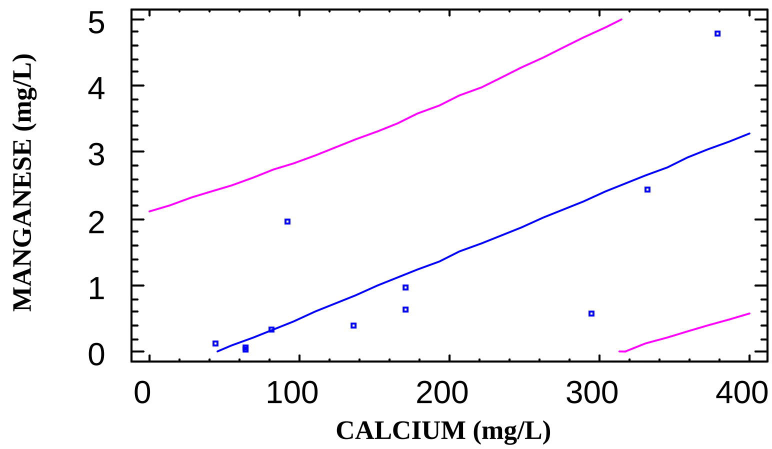



**Figure E6-12 Manganese vs. Zinc in Groundwater**