ECOVESTOR

PILGRIM MINE SITE PRELIMINARY ASSESSMENT AND SITE INVESTIGATION

100% Design Report

Final Draft

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List of Acronyms

BLM	Bureau of Land Management
FLAA	Flame Atomic Absorption
GIS	Geographic Information System
GPS	Global Positioning System
HASP	Health and Safety Plan
ICP-MS	Inductively Coupled Mass Spectrometry
PASI	Preliminary Assessment and Site Investigation
SAP	Sampling and Analysis Plan
XRF	X-ray Fluorescence

Acknowledgements

We would like to acknowledge our technical advisor Dr. Bridget Bero with guiding our team throughout the project. We would also like to thank Eric Zielske of the Bureau of Land Management for sponsoring the project; as well as Dani Halloran for sharing her time and experience with our team. Lastly, a special thanks to Jeff Propster of the Northern Arizona University Center for Ecosystem Science and Society; as well as Michael Ketterer of the Metropolitan State University of Denver Chemistry Laboratory using inductively coupled plasma mass spectrometry (ICP-MS).

1.0 Project Description

The Pilgrim Mine Site is the site of a former gold mine that occupies approximately 12 acres of land located 21 miles north of Kingman, Arizona and 10 miles west of the town of Chloride, AZ [BLM 2015]. An image of the site within Arizona is shown in Figure 1.1, below. The site was also mined for lead, iron, copper, and sulfide. The abandoned mine is currently managed by the Bureau of Land Management (BLM) and borders undeveloped private land [BLM 2015]. The site was previously operated under the name of the Pioneer Gold Mining Co., Mine, the Katherine Treasure Vault Mine and the Al Smith Producer Mill Mine. Flotation mills, cyanidation, heap leaching, tank leaching carbon-in-pulp, and carbon-in-leach are methods that were previously used at the site [BLM 2015]. No previous site investigations have taken place.

The area is presently utilized for recreational use and neighbors ranching lands. The mine poses a potential threat to human and ecological health as contaminants are left open to the public and migration away from the site is slowly occurring. The mine site consists of three separate tailings piles and a wash located north of the tailings pile, which runs north, away from the tailings piles. Soil samples were collected from the specified areas of concern using a gridded system for the tailings piles, as well as transects along the wash (perpendicular to the wash's trajectory). Gridded and transect sampling was used to ensure unbiased sampling, as well as establishing the extent of the contamination. Hot spot or high concentration samples were taken in the wash when visible tailings were observed. Lastly, background samples were taken of native, undisturbed soils to the south and north of the site to determine the natural concentration of contaminants in the soil.

Figure 1.1 - Location of the Pilgrim Mine in Arizona

The samples were analyzed to identify the contaminants of concern, their corresponding concentrations, and to determine if any migration is occurring away from the site. Figure 1.2 on the following page shows a map of the Pilgrim Mine Site. The soil samples were dried and sieved prior to x-ray fluorescence (XRF) spectrometry. Acid digestion followed by atomic absorption spectrometry will be completed on 15 samples to correlate the XRF data. Following the sample analysis, a preliminary assessment and site investigation will be completed for this site, which includes both a human health and an ecological risk assessment. In addition, a field screening level analysis will be completed, as defined by the State of Arizona's non-residential soil remediation standards for the identified contaminants of concern. This report will be given to the Bureau of Land Management, who will determine if remedial action is required at the mine site.

2.0 Work Plan

On December 19th, 2016, Ecovestor completed a Work Plan for the Pilgrim Mine Site. The work plan specified field sampling procedures and rationale, as well as the soil testing techniques that will be completed in the laboratory. The Work Plan includes a Health and Safety Plan (HASP) and a Sampling and Analysis Plan (SAP). The Work Plan is included in Appendix A. All deviations from the Work Plan are noted and discussed in the following sections.

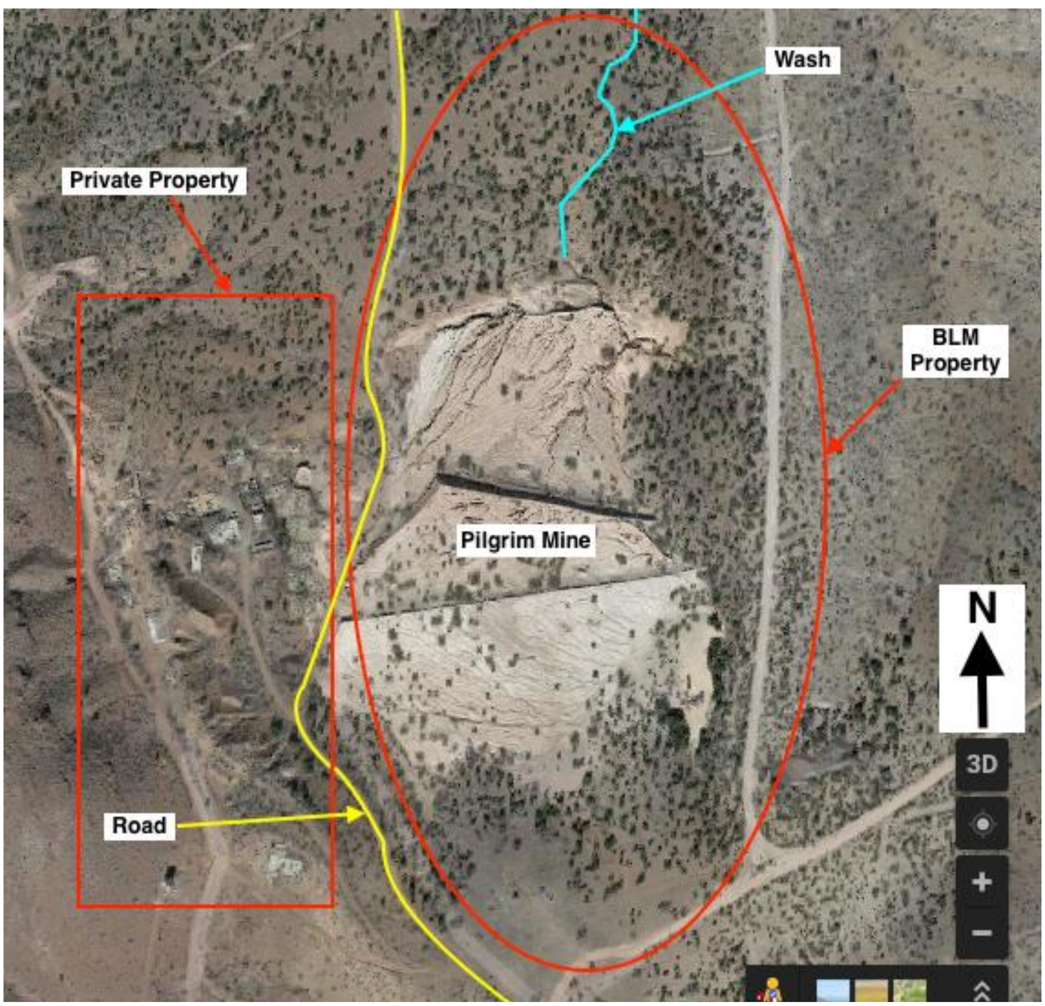

Figure 2.1 - Detailed Map of Pilgrim Mine Site

3.0 Field Sampling

On January 27, 2017, at approximately 10:30 in the morning the field sampling began with five technicians: two technicians used the GPS and 100-ft measuring tape to flag pre-determined data points while the other three technicians prepared the decontamination station and began sampling flagged points. Two technicians collected soil samples, while the third recorded observations and provided direction to the soil samplers. The decontamination station, as depicted in Figure 3.1 on the following page, consists of a four-bucket decontamination system used to clean the trowels after every sample collected, as discussed in the work plan in Appendix A. Each technician also employed proper personal protection equipment by wearing full protective Tyvek coveralls, along with facemasks, as shown in Figure 3.2 on the following page.

Figure 3.1 - Decontamination Station for On-Site Decontamination of Trowels

The weather for the entire sampling regime was clear, cold and sunny with high northeasterly winds. The ground was frozen early in the day in for many sampling locations that were shaded by bushes or tailings pile walls.

The first immediate deviation from the work plan occurred when one of the predetermined points, sample S-15, on the south tailings pile was eliminated because it was in the middle of a small pond created by heavy rainfall in the days before the sampling began.

As the day continued, the predetermined grid system changed for the central tailings pile; originally, the sampling points were to be horizontal from the west to the east but the grid rotated slightly west of north, following the natural bank of the central tailing pile. Further, the grid spacing between each sample within the central tailings pile, going south to north, was adjusted from 105 ft. to 86 ft., such that two rows of samples could be collected within the central tailings pile.

Another deviation occurred when flagging the southernmost tailing pile; sample S-1 was converted to C-12 because it was determined on site that S-1 was located on the central tailings pile. A final deviation during sampling was the removal of sample C-5, due to its location on the dam separating the central and northern tailings piles.

The tailings piles had a layer of sand at the southermost ends of each tailings pile from blowing dust, which covered and mixed with the mine tailings. The greatest accumulation of sand was found in the northern tailings pile, with some accumulation in the central tailings pile, and the least amount of sand was found in the southern tailings pile; most likely due to the location and size of the dams. Most of the samples from the tailings piles were extremely fine and silty. Native soil samples taken away from noticeable tailings piles were very coarse. In some sample locations, the ground was frozen due to low temperatures and the previously stated rains that occurred before the sample regime. The samples taken in the unnamed wash directly north of the northern tailings pile were coarse with large amounts of organic matter. The beginning of the wash, just north of the northern tailings pile, was approximately 200 to 300 ft. in width, but was generally about 5 to 10 ft. from bank to bank and showed some evidence of visible tailings.

Figure 3.2 - Personal Protection Equipment

The wash was sampled using east to west transects; which consisted of 3 to 4 samples, running east to west, with transect spacing ranging initially from 100 ft. to 20 ft. to 10ft. between each sample for a given transect (decreasing along with the wash's width). Further, each transect was taken from 100 ft. to 200 ft. from the former, going south to north, with the spacing increasing as distance from the tailings piles increased. With exception to the first transect where four samples were taken, three samples were taken at each transect for the east bank, west bank and thalweg of the wash. Finally, two hot spot samples were collected in the wash between transects where any visible tailings were observed.

The final samples collected were the background samples, which were all located well away from the tailings piles; two were collected to the north of the site, one to the west of the wash, and the other to the east of the wash, at approximately one-quarter mile from the tailings piles. The final background sample was collected to the south of the tailings piles, again at a distance of approximately one-quarter mile. It is also important to note that background sample locations were selected based on the observed wind patterns during the two days sampling took place; these wind patterns were generally very strong northeasterly wind.

All of the sample locations are shown in Figures 3.3.

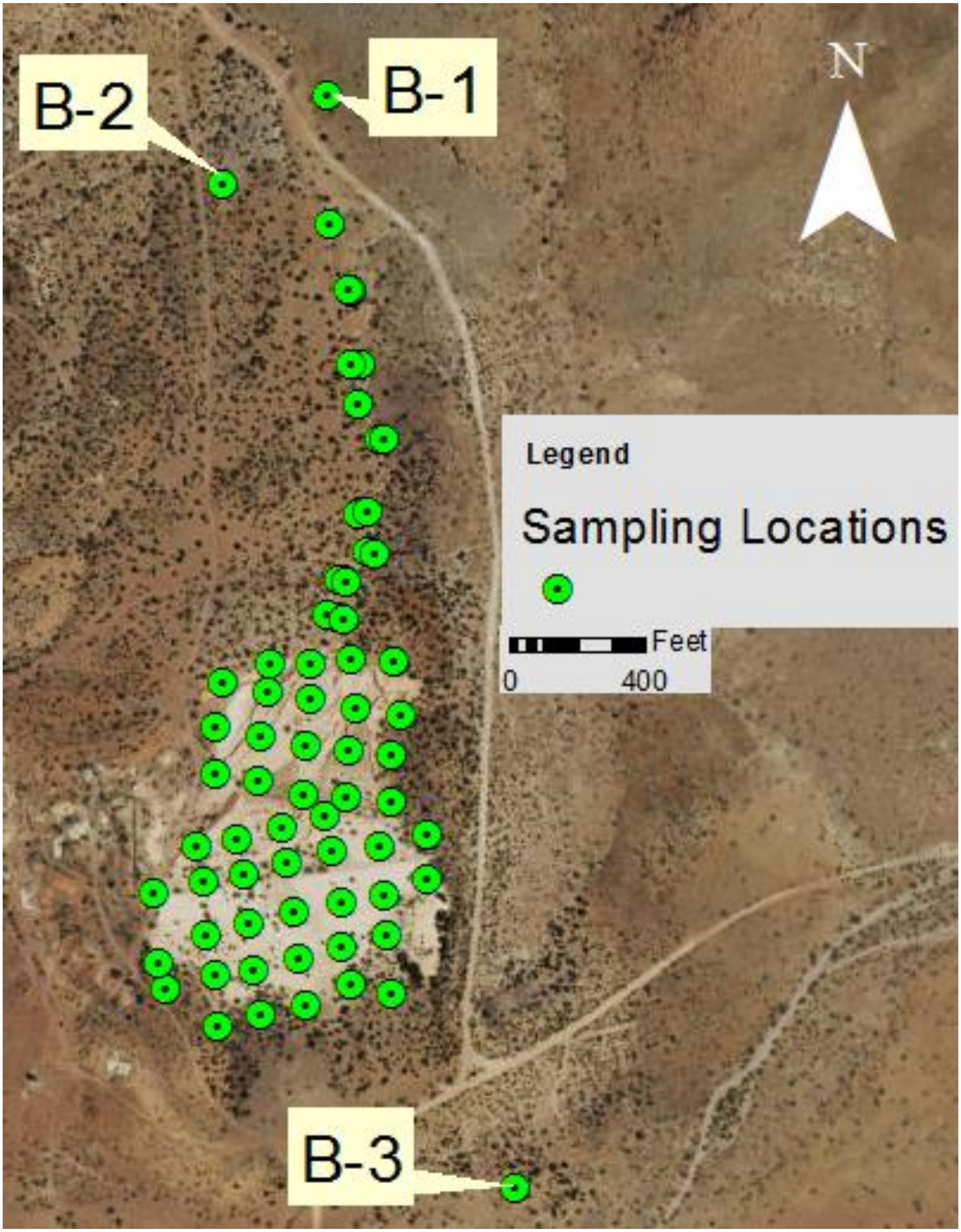

Figure 3.3 - Sample Locations for the Pilgrim Mine Site

4.0 Sample Analysis

Figure 4.1 - Sieve Stack

Once the samples were transported from the field to the Northern Arizona University Engineering Soils Laboratory, the samples underwent significant preparation, as well as sample analyses to determine contaminants of concern and their concentrations with respect to Arizona Residential and Non-Residential Soil Remediation Standards. The sample analyses included both X-ray florescence spectrometry and atomic absorption.

Before releasing any of the samples to other laboratories for further analysis, a chain-of-custody form was filled out. The chain-of-custody form identifies the contents of each shipment and maintain the custodial integrity of the samples. Generally, a sample is considered to be in someone's custody if the sample is either in someone's physical possession, in someone's view, locked up, or kept in a secured area that is restricted to authorized personnel. The chain-of-custody forms were completed and sent with 31 lab samples. The samples were labeled by "P" and the sample's ID number. In the field, each sample was given a sample ID that identifies where the sample was taken and a number to distinguish the sample from others taken from the same location. The sample ID method is discussed further in the Work Plan.16 of those samples were released to Dr. Ketterer on March 7th and 16 were released to Jeffery Propster on March 15th. The results were returned in April and the sample IDs corresponded with the chain-of-custody forms shipping content. This reduces the risk of missing a sample and helps to identify which sample is missing.

4.1 Sample Drying and Sieving

All samples were dried prior to sieving to remove the excess moisture within the soil to ensure proper sieving as well as maximizing the sieved sample volume. Each sample was placed in either a metal or a clay bowl before placing the samples in the convection oven at temperatures ranging from 200 to 300 degrees Fahrenheit, for at least 24 hours. After 24 hours, several of the samples were still moist, and placed back into the convection oven until completely devoid of moisture.

Each sample was pulverized in a clean metal bowl until there were little to no clumps present in the sample. The sieves were stacked from top to bottom in the following order: pan, #60, #35, #20, #14, #4 and lid. However, sieve #60 was consistently obstructed for many of the samples containing tailings, so sieves #40, #45, or #50 were added to the stack to address this problem. An image of the sieve stack is displayed below in Figure 4.1. The nest of sieves containing the sample was then taken to the mechanical sieve shaker and run for 10 minutes. Each sieve was decontaminated and the waste was disposed of into a waste bucket lined with a plastic garbage bag. The sieved soil sample was placed into the original, gridded plastic bag.

A one-gallon gridded plastic bag was made for each sample, consisting of a 3 by 3 square grid, with each square having dimensions of 3 inches by 3 inches. Two other sandwich-size (6.5 inches by 5.5 inches) gridded plastic bags were made for two samples that lacked adequate soil volume to be analyzed in one-gallon bags. The grid created for the smaller bags consisted of a 3 by 3 rectangle grid, with each rectangle having dimensions of 2 inches by 1.6 inches. An image of one of the gridded gallon bags is shown in Figure 4.2.

Figure 4.2 - Gridded Gallon Bag with Sieved Sample

4.2 X-Ray Fluorescence Spectrometry Analysis

At the beginning of each x-ray fluorescence (XRF) spectrometry analysis or when the battery of the XRF spectrometer was changed, a system check was performed to calibrate the spectrometer. Before analyzing each bag containing the sieved sample, the sample was evenly dispersed on a flat surface such that each square had an equal amount of soil. Once evenly distributed, each square was analyzed with the XRF for 90 seconds in "soils mode". This process is demonstrated in Figure 4.3. After each square was analyzed, the sample was placed in storage. After all nine squares were analyzed by XRF spectrometry, the data from the analyses were exported and analyzed within Microsoft Excel; this data analysis is described in detail in Section 5.1.

Figure 4.3 - XRF Analysis of a Soil Sample

4.3 Contaminants of Concern

After analyzing the initial XRF data readings, the concentration values clearly identified that the contaminants of concern for the mine site consisted of lead, arsenic and chromium; which were selected based on their relative concentrations to the Arizona Residential and Non-Residential Soil Remediation Standards, which are displayed in Table 4.1.

The XRF spectrometer did not designate the form of chromium that was present in the soil, so it was conservatively assumed that hexavalent chromium was found at the site based on the high toxicity and carcinogenicity of hexavalent chromium. Hexavalent Chromium (Chromium 6) and Trivalent Chromium (Chromium 3) are both presented in Table 4.1, to demonstrate the vast difference in soil remediation standards, which was the determining factor in assuming Hexavalent Chromium over Trivalent Chromium.

Table 4.1 – Arizona Soil Remediation Standards

Arizona Soil Remediation Levels			
	Residential		**Non-Residential (mg/kg)**
	Carcinogen	**Non-Carcinogen**	
Contaminant	**as 10-6 Cancer Risk**	**(mg/kg)**	
Arsenic	10	10	10
Lead		400	800
Chromium 3		120,000	1,000,000
Chromium 6	30		65

4.4 Acid Digestion

To further analyze the soil samples and correlate the XRF data with a more precise analytical method, a representative number of soil samples were analyzed by atomic absorption (AA) and inductively coupled plasma mass spectrometry (ICP-MS). In order to complete the AA and ICP-MS analyses, the samples were first prepared by acid digestion. The samples to chosen for the analyses were selected based on every fifth sample, starting with the lowest concentration, including the highest concentration to ensure a broad range of concentrations. This was done for both arsenic and lead (as well as chromium) concentration ranges. 17 soil samples were selected for ICP-MS analysis but one was lost during the acid digestion procedure, so only 16 soil samples were sent for arsenic analysis. Similarly, 16 separate soil samples were subcontracted to another laboratory at Northern Arizona University for lead and chromium AA analyses.

The acid digestion procedure was adapted from the Environmental Protection Agency's Method 3050B: *Acid Digestion of Sediments, Sludges and Soils*, along with guidance and oversight from out technical advisors, Dani Halloran and Taylor Oster. As previously discussed, both lead, chromium and arsenic were designated as contaminants of concern, which required two different spectrometry analyses, as well as different acid digestion processes. The arsenic samples were prepared by acid digestion first; as they were subcontracted to a laboratory in Denver, Colorado, which required more time due to sample shipment. The lead and chromium samples were completed in the following weeks and hand delivered to the NAU laboratory. The samples were delivered using proper chain-of-custody forms, and whatever soil was left was disposed of by the subcontracted laboratories.

4.5 Atomic Absorption and Inductively Coupled Plasma Mass Spectrometry Analysis

As previously stated, the AA and ICP-MS analyses were subcontracted out to two separate laboratories; the details of each analysis are described below.

Lead and chromium concentrations were analyzed by Jeffrey Propster in the Northern Arizona University Center for Ecosystem Science Laboratory using flame atomic absorption (FLAA) spectrometry.

Arsenic concentrations were analyzed by Dr. Michael Ketterer in the Metropolitan State University of Denver Chemistry Laboratory using inductively coupled plasma mass spectrometry (ICP-MS).

Similarly, the results from the analyses were sent to Ecovestor Engineering by email and further analyzed within Microsoft Excel for their statistical significance. The Results of the Data Analysis are presented in Section 5.1, below.

5.0 Results

The results presented in the following subsections outline the processes and results from the following analyses:

- data analysis for XRF and AA/ICP-MS Results
- geographic information systems (GIS) for mapping sample concentration spatial distributions
- human health risk assessments
    - including the adult lead model (ALM) for adult exposure to lead
    - child lead exposure modelling using the EPA's integrated exposure uptake biokinetic (IEUBK) model and lastly
- ecological risk assessment

As previously discussed, the chromium concentrations were found to exceed the Arizona Non-Residential Soil Remediation Standards for hexavalent chromium but did not exceed Arizona Residential Soil Remediation Standard for trivalent chromium (Table 4.1). However, the chromium compound present within the tailings piles was never positively identified. If hexavalent chromium was present at the site, then the corrected hexavalent chromium concentrations (based on AA correlation data) would not exceed Arizona Soil

Non-Residential Remediation Standards. Therefore, it was decided that chromium was no longer a contaminant of concern after the data analysis was completed. Although chromium was excluded from other analyses, the data analysis results for chromium are included in this report to support the decision to exclude chromium from the contaminants of concern.

5.1 Data Analysis

The primary objectives of performing the XRF and ICP-MS/AA analyses were to principally identify the contaminants of concern, their concentrations and their locations/extent; as well as correlate the XRF results with the analytical (AA and ICP-MS) analyses results to observe the validity of the XRF analysis, as compared to the more accurate AA/ICP-MS analyses. The raw data for the XRF, ICP-MS and FLAA analyses are presented in Appendices D, E and F.

The data correlation between AA and ICP-MS analyses and XRF analysis for chromium, arsenic and lead are shown in Figures 5.1, 5.2, and 5.3.

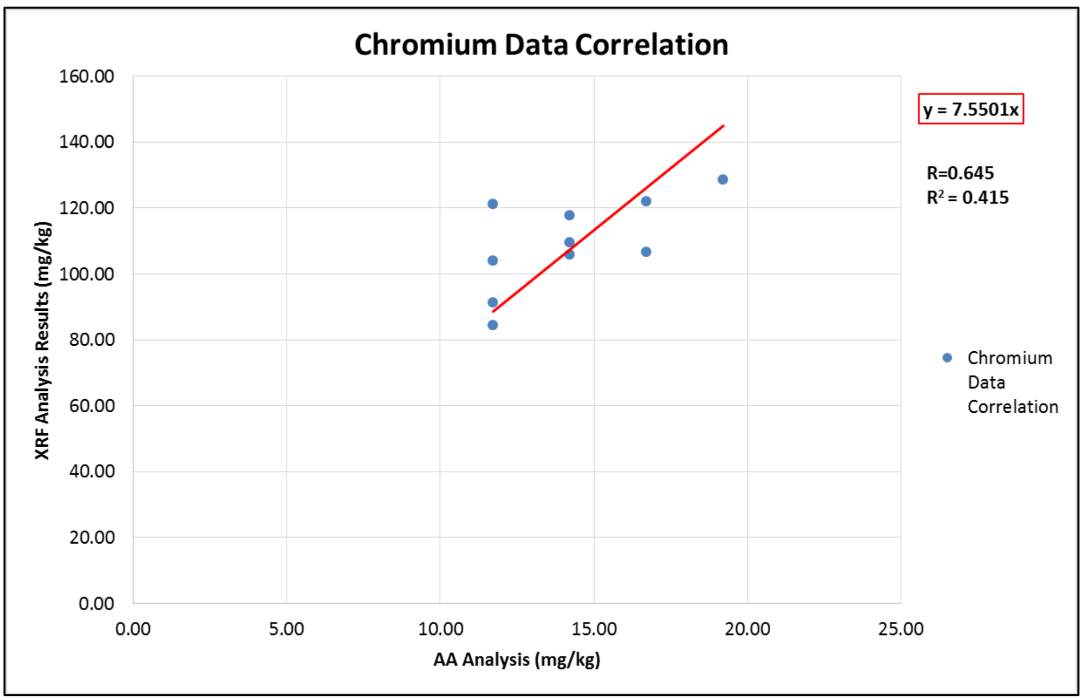

Figure 5.1 – Chromium Data Correlation

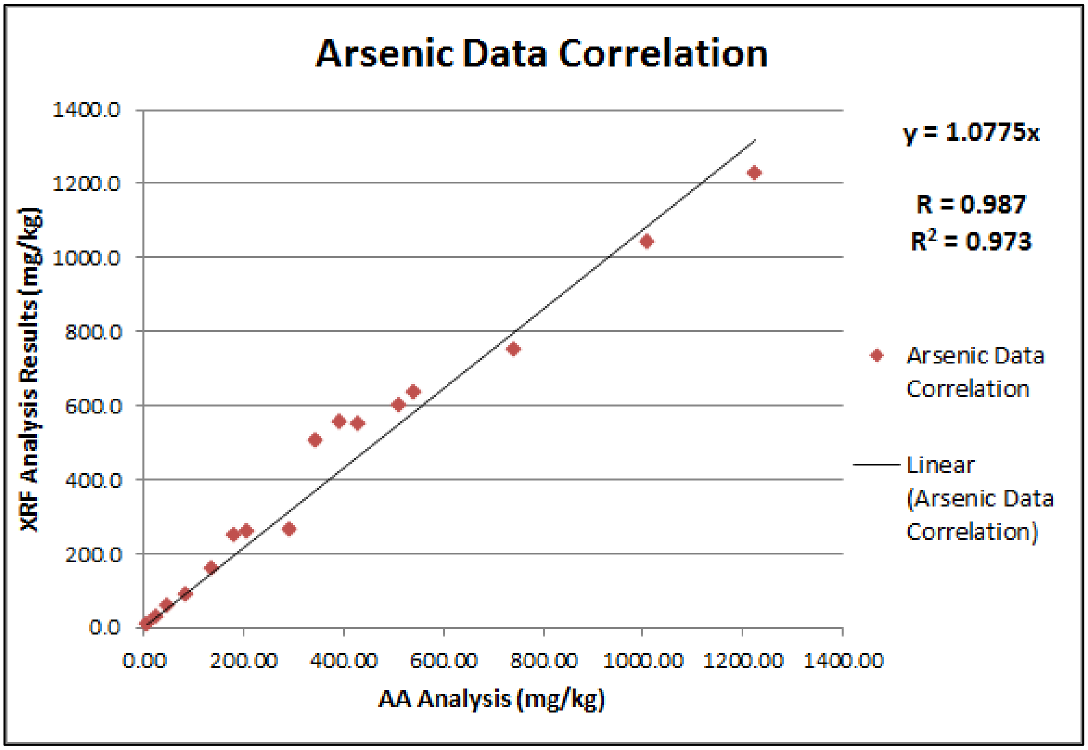

Figure 5.2 - Arsenic Data Correlation

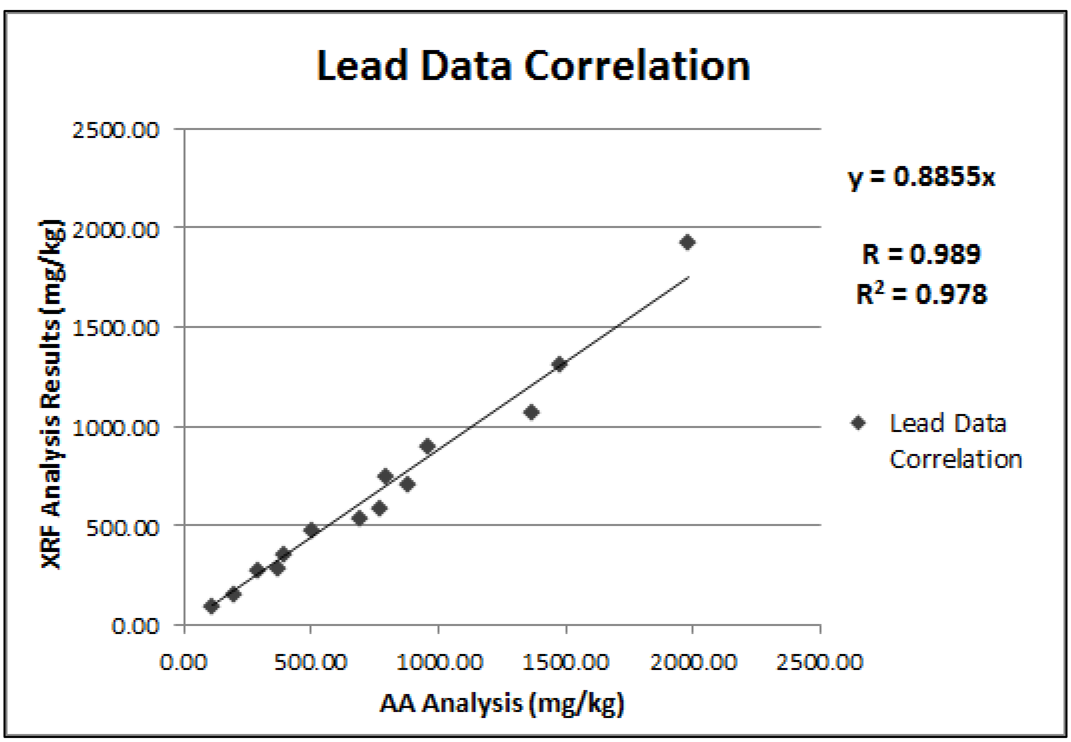

Figure 5.3 - Lead Data Correlation

The arsenic and lead data were normalized to use statistical analyses to better organize and understand the significance of the data. The normal distribution for chromium is shown in Figure 5.4 and the log-normal distributions for lead and arsenic are presented in Figures 5.5 and 5.6; the Arizona Remediation Standard is also presented in the figures as a reference.

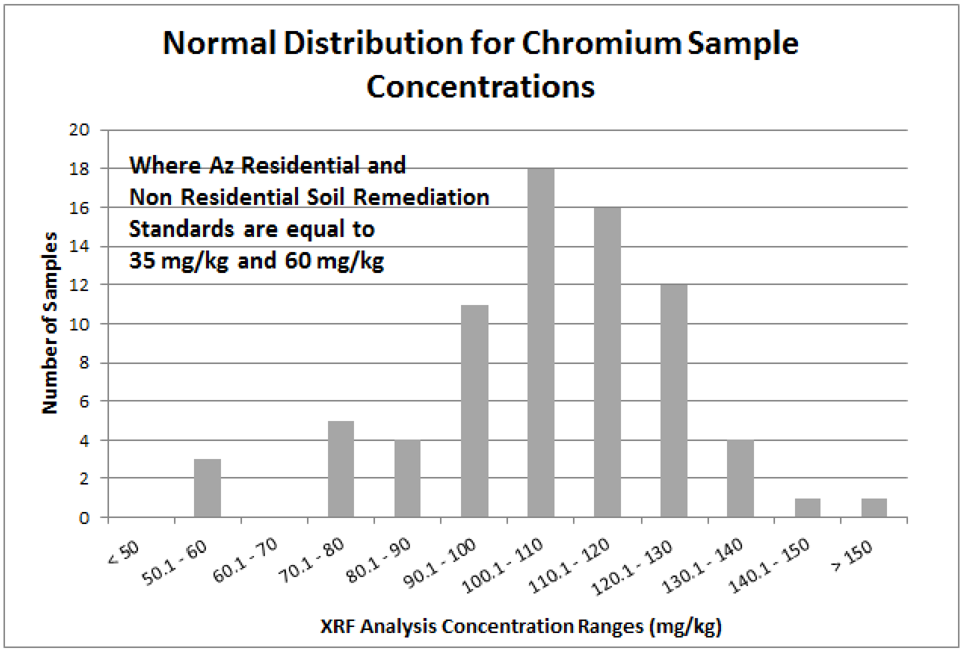

Figure 5.4 - Chromium Distribution Histogram

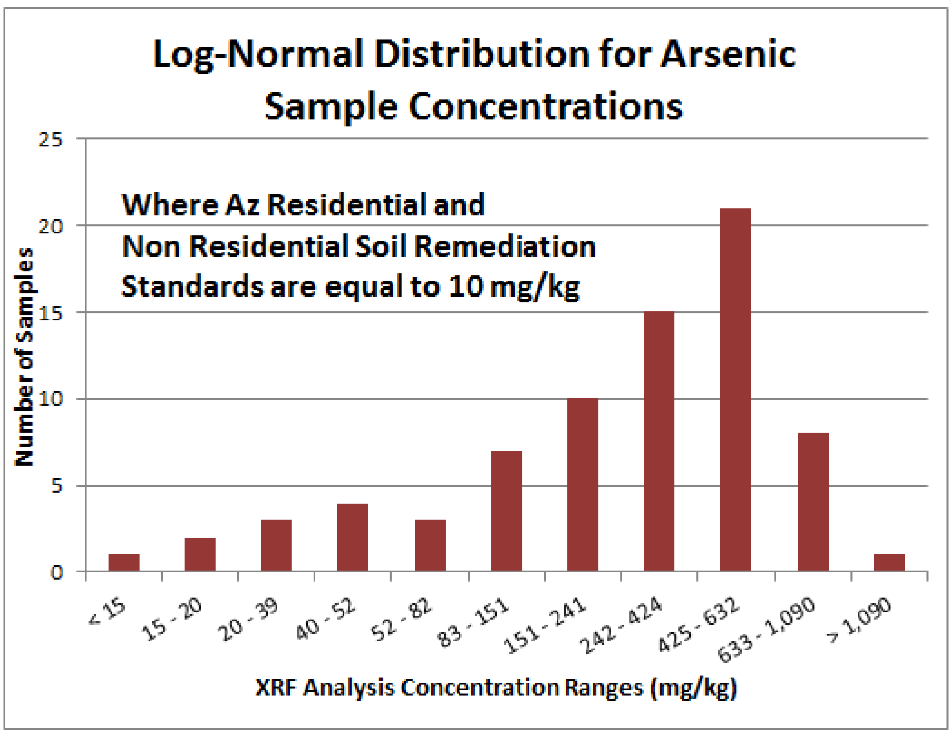

Figure 5.5 - Arsenic Distribution Histogram

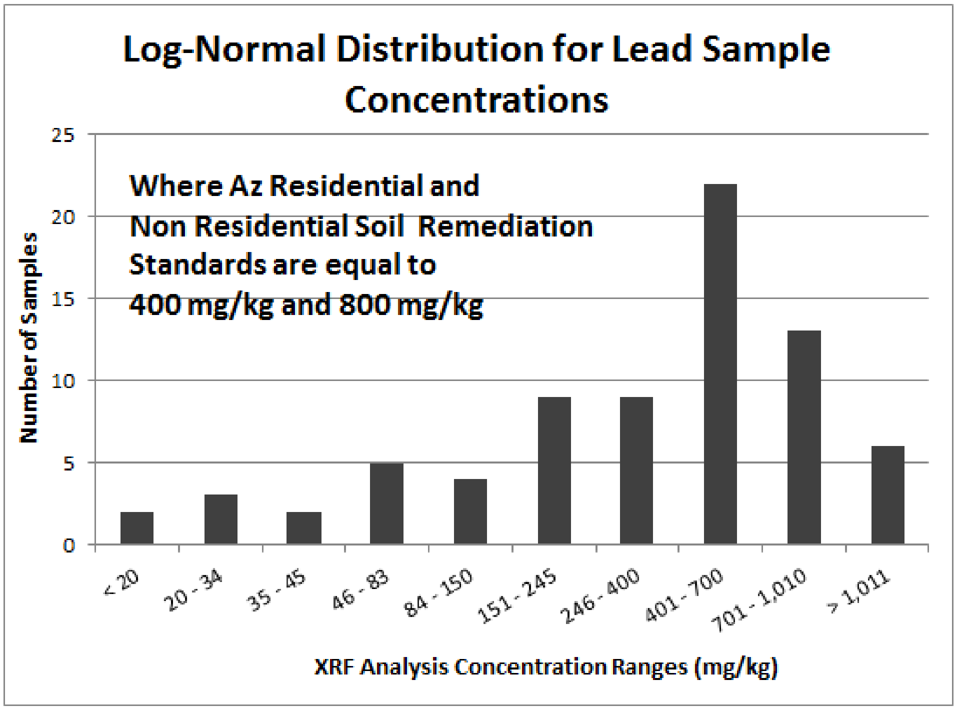

Figure 5.6 - Lead Distribution Histogram

The variance and the p-values generated from t-tests were used to understand the statistical significance of the different locations; however, every analysis showed that there was no statistically significant difference between tailings piles and wash contaminant concentrations as no p-value was found to be less than 0.05. This means that contaminant concentrations are high enough in the wash to treat them as tailings piles.

The results found for the t-tests and p-values from those tests are shown below in Table 5.1, the arrays selected were the tailings piles (north, south and central) and the wash soil samples for a one-tailed distribution, and the t-test type was two-sample equal variance (homoscedastic). The values for lead and arsenic were taken from their natural-log values used for the log-normal distribution; chromium concentrations were not adjusted.

Table 5.1 - T-Test Results and P-Values between Wash Samples and Tailings Piles

Contaminant	T-Test Results	P-Value
Arsenic	1.046E-06	1.0
Chromium	0.1293	0.9181
Lead	3.49E-07	1.0

The data analysis found the 50^{th} and 95^{th} percentiles for lead and arsenic, which are presented below in Table 5.2, which were then used to find both the human and animal toxicity calculations. It is also important to note that the values found for the 50^{th} and 95^{th} percentiles were calculated without the use of background and hot spot samples, to remove sampling biases.

Table 5.2 - 50th and 95th Percentiles for Contaminants of Concern

Contaminant	50th Percentile Concentration (mg/kg)	95th Percentile Concentration (mg/kg)
Arsenic	372.97	999.975
Chromium	107.98	131.08
Lead	466.99	1,195.16

5.2 Spatial Distribution of Contaminant Concentrations

Figure 5.7 identifies arsenic data points, where the yellow and red points are above the residential and non-residential standards. The majority of the samples are in the range of 10 to 500 mg/kg of arsenic; with a smaller portion of samples above the 500 mg/kg and of those samples, the majority are located to the south. The southernmost tailings pile is assumed to be the newest and has less weathering. The rest of the high arsenic values are located near exposed tailing crevasses, created from water flow and wind erosion.

The background samples (B-2 and B-3) were above 10 mg/kg soil standard but their values were 26.1 and 14.5 mg/kg respectively. It is unlikely that the tailings would have

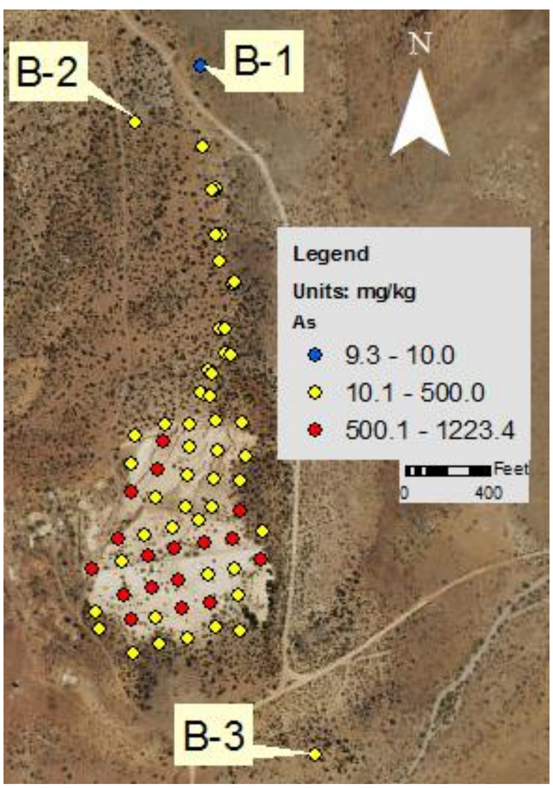

Figure 5.7 - Arsenic Concentration Spatial Distribution

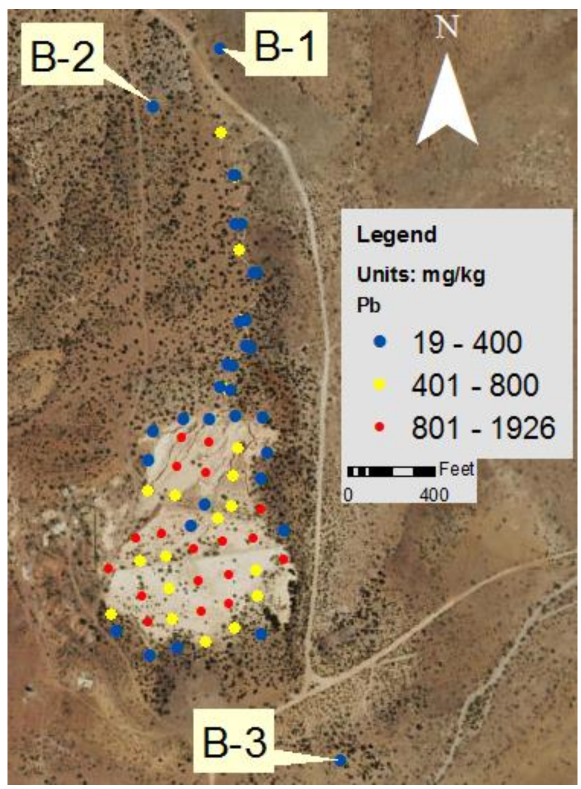

Figure 5.8 - Lead Concentration Spatial Distribution

travelled off site to the extent of contaminating background soils both north and south of the site. This indicates that the site may have naturally high arsenic concentrations, which generally occurs where gold and silver deposits are found.

Figure 5.8 shows the range of lead contaminant levels found at the Pilgrim Mine site and for non-residential areas like the Pilgrim Mine, the Arizona standard specifies a maximum acceptable lead concentration of 800 mg/kg. There is a clear trend shown in Figure 5.8 where the tailings are outlined in blue dots, which indicates that lead migration is not moving off site with exception of the wash. The wash does show evidence of lead migration but not to the extent of exceeding non-residential standards. The background samples are below residential standards and show that lead is not a naturally occurring element. This means that the wash samples that exceed residential standards are not due to the natural environment, but tailings.

5.4 Human Health Risk Assessment

To assess the risk to human health at this mine site a human health risk assessment was completed. The contaminants of concern at this site are arsenic and lead. As previously discussed, these contaminants were found to exceed the residential and non-residential soil remediation standards for Arizona. All the contaminants of concern at the site pose risk to human health.

5.4.1 Exposure Scenarios

To estimate how much time a person spends at the site and what activities the site is used for, exposure scenarios were determined. The mine site is in a remote location, a few miles drive down a rugged dirt road. There are no residential areas near the site. The site contains three tailings piles and debris from the abandoned mine, and does not contain any major attractions that would interest visitors. The people who would likely visit the site would be a remediation worker and a recreational user. The remediation worker would be any person hired by the BLM if remediation is deemed necessary. The recreational user was broken down into a daytime and overnight recreational user. A daytime recreation user would be someone spending the afternoon at the site possibly off-roading or shooting guns. An overnight recreational user would be someone who is camping at the site. An exposure frequency was determined for each scenario. The values used for each scenario are shown in Table 5.3.

The remediation worker scenario focused on adults. The recreational user focused on adults, children ages 6-12 and children ages 2-6.

Table 5.3 – Exposure Scenarios and Exposure Frequency

Scenario	Hr/Day	Day/Year	Exposure Frequency (hr/yr)
Remediation Worker	8	280	2240
Recreational User - Day	8	14	112
Recreational User - Overnight	24	4	96

5.4.2 Arsenic

Arsenic has different health effects, which depend on exposure type and exposure duration. Some of the most common health effects of Arsenic are changes to the skin including darkening or the appearance of "warts", decreased production of red and white blood cells, circulatory and peripheral nervous disorders, lung cancer and skin cancer [1].

The risk to human health is different for cancerous and non-cancerous risk. Both risks look at a person's contaminant intake. The intake was calculated using Equation 5.1. The two principal parameters in this equation are body weight and contact rate. These parameters change by age group; the parameters used for each age group were summarized in Table 5.4. The carcinogenic risk was calculated using a slope factor shown in Equation 5.2. The non-carcinogen risk was calculated using a reference dose shown in Equation 5.3. Slope factors and reference doses were found using the Integrated Risk Information System (IRIS) program produced by the EPA.

$$Intake\left(\frac{mg}{kg * day}\right) = \frac{(C * CR * EF * ED)}{BW * AT}$$

Where:

- *C = Concentration at exposure point (mg/kg)*
- *CR = Contact rate (mg/day)*
- *EF = Exposure frequency (hr/year)*
- *ED = Exposure duration (yr)*
- *BW = Body weight (kg)*
- *AT = Averaging time (days)*

Equation 5.1 – Human Contaminant Intake Equation and Parameters

Table 5.4 – Intake Variables for Different Age Groups

Age Group	Average Body Weight (kg)	Contact Rate (mg/day)	Exposure Duration (yr)
Adult	70	100	30
Child 6-12	29	100	6
Child 2-6	16	200	4

$$Carcinogenic\ Risk\ (unitless) = Intake\ of\ Carcinogen\ \left(\frac{mg}{kg * day}\right) * Carcinogen\ Slope\ Factor\ \left(\frac{kg * day}{mg}\right)$$

Equation 5.2 – Carcinogenic Risk Calculation

$$Hazard\ Index\ (unitless) = \frac{Intake\ of\ Non - Carcinogen\ \left(\frac{mg}{kg * day}\right)}{Reference\ Dose\ \left(\frac{kg * day}{mg}\right)}$$

Equation 5.3 – Carcinogenic Risk Calculation

The analysis focused on the exposure pathway of soil ingestion. Inhalation and dermal contact are two other potential exposure pathways at this site, but were not assessed in this analysis. Insufficient IRIS data, local wind data and a general lack of resources would have caused broad assumptions to complete risk calculations for these exposure scenarios. Focusing on soil ingestion, the slope factors and RfD's were found for the two contaminants of concern. The RfD's and slope factors found are summarized in the Table 5.5, listed with their uncertainty factors. For values that were not assessed under IRIS, "NA" is shown.

Table 5.5 – Slope factors and reference doses found for each contaminant

Contaminant	Slope Factor $(mg/kg*day)^{-1}$	Uncertainty	RfD (mg/kg*day)	Uncertainty
Arsenic	1.5	3	3.0E-4	3
Lead	NA	NA	NA	NA

Arsenic was evaluated for cancerous and non-cancerous risk. The risk due to lead was analyzed using blood lead modeling. The risk for each situation was assessed using the 90^{th} and 50^{th} percentile concentration. The 90^{th} percentile concentration gave a more conservative risk estimate and the 50^{th} percentile gave an averaged risk. These concentrations were used along with the parameters and equations listed above to calculate risk. The results are presented in Table 5.6.

Table 5.6 - Adult health risk due to arsenic exposure

Cancerous Risk			
Contaminant	**Remediation Worker**	**Recreational User Day**	**Recreational User Overnight**
Arsenic 95th	**2.10E-4**	**11.7E-4**	0.101E-4
Arsenic 50th	**0.782E-4**	**4.38E-4**	0.0375E-4
Non-cancerous Risk			
Contaminant	**Remediation Worker**	**Recreational User Day**	**Recreational User Overnight**
Arsenic 95th	**1.09**	0.0609	0.0522
Arsenic 50th	0.405	0.0227	0.0195

Table 5.7 – Child age 6-12 health risk due to arsenic exposure

Cancerous Risk		
Contaminant	**Recreational User Day**	**Recreational User Overnight**
Arsenic 95th	**5.67E-4**	0.0486E-4
Arsenic 50th	**2.11E-4**	0.00182E-4
Non-cancerous Risk		
Contaminant	**Recreational User Day**	**Recreational User Overnight**
Arsenic 95th	0.147	0.126
Arsenic 50th	0.0548	0.0469

Table 5.8 – Child age 2-6 health risk due to arsenic exposure

Cancerous Risk		
Contaminant	**Recreational User Day**	**Recreational User Overnight**
Arsenic 95th	**27.4E-4**	0.174E-4
Arsenic 50th	**10.2E-4**	0.0438E-4
Non-cancerous Risk		
Contaminant	**Recreational User Day**	**Recreational User Overnight**
Arsenic 95th	0.533	0.228
Arsenic 50th	0.199	0.170

Cancerous risk is measure by the likelihood of how many people out of a population equally exposed to a contaminant would contract cancer is exposed over a period of 70 years [2]. The acceptable cancer risk set by the EPA is less than 1 in 10,000 persons; which, in scientific notation, is equivalent to 1E-4 anything above this number is considered unacceptable risk and anything below this number is considered acceptable. While the EPA guidelines provide a general standard, a specific site can have stricter guidelines for acceptable cancer risk. Non-cancerous risk was measured using a hazard index. The hazard index measures the ratio of potential exposure to the substance and the level at which no adverse effects are expected [2]. Anything above a value of one is considered unacceptable risk and anything below one is considered acceptable risk.

Cancerous risk for arsenic was exceeded for the remediation worker for both concentrations. The cancerous risk for arsenic was also exceeded for both concentrations for the recreational day user for all age groups. Acceptable non-cancerous risk was exceeded one time for the arsenic for the adult remediation worker at the 95th percentile concentration. The greatest risk at this site to human health is cancer risk due to arsenic. The only unacceptable non-cancer risk was due to arsenic for the remediation worker. When performing these calculations no adjustments were made for personal protective equipment, the use of personal protective equipment would reduce risk for the remediation worker.

5.4.1 Lead Models

The health effects in lead are different in children and adults. In adults, lead can cause increased blood pressure, hypertension, increased risk of kidney problems and reproduction problems; and in pregnant women lead can cause reduced growth of the fetus and premature birth [3]. In children lead can cause behavioral and learning issues, reduced IQ, hyperactivity, slowed growth, anemia and hearing problems [3]. In rare cases, lead can cause comatose and death.

5.4.1.1 Adult Lead Model

The Adult Lead Model (ALM) was used for assessing risks associated with non-residential adult exposures to lead in soil. The model relates soil lead concentrations to blood lead concentrations in the exposed population according to the algorithms described in the ALM methodology guidance page. The ALM focuses on estimating fetal blood lead concentration in women exposed to lead contaminated soils. The model can also be used to evaluate risks of elevated blood lead concentrations among exposed adults [2].

Table 5.9 presents the results of the ALM lead model through three different exposure scenarios, which are recreational overnight user, recreational daytime user, and remediation worker. The geometric standard deviation and the baseline concentration values were assumed from the Third National Health and Nutrition Examination Survey (NHANES III). The NHANES III was a nationwide probability sample of 39,695 persons. It was conducted from 1988-1994 in two phases [Centers for Disease Control and Prevention]. The blood lead level of concern was determined to be 10 ug/dL and the ALM results show that none of the exposure scenarios exceeded the level of concern. The raw results and inputs are displayed in Appendix B.

Table 5.9 - Adult Lead Model Results

	Recreational User - Overnight		**Recreational User - Day**		**Remediation Worker**	
	50^{th} Percentile Exposure	95^{th} Percentile Exposure	50^{th} Percentile Exposure	95^{th} Percentile Exposure	50^{th} Percentile Exposure	95^{th} Percentile Exposure
Soil lead concentration (ppm)	466.99	1195.16	466.99	1195.16	466.99	1195.16
Exposure frequency (days/yr)	14	14	2.33	2.33	93.33	93.33
PbB of adult worker (ug/dL)	1.6	1.7	1.5	1.5	2.1	3.0
Probability that PbB > 10 ug/g	0.4%	0.6%	0.4%	0.4%	1.2%	3.8%

5.4.1.2 Child Lead Model

The Integrated Exposure Uptake Biokinetic (IEUBK) Model for Lead in Children is a stand-alone, PC compatible software package. The model utilizes interrelated modules to estimate blood lead levels in children exposed to lead contaminated media. It allows the user to estimate for a hypothetical child or population of children, a plausible distribution of blood lead concentrations centered on the geometric mean blood lead concentration predicted by the model from available information about children's exposure to lead. From this distribution, the model calculates the probability that children's blood lead concentrations will exceed the level of concern, which is 10 ug/dL. The model predicts the residential blood lead level of children, however since the Pilgrim mine site is located at a remote location, the input concentrations were adjusted using Equation 5.4 to represent the chosen exposure cases. 200 ug/g is the plausible default constant value of lead concentration in soil [3].

$$Adjusted\ Concentration = \frac{Contaminant\ Concentration\ (\frac{mg}{kg})\ (50^{th}\ or\ 95^{th}\ Percentile)}{365\ days/Exposure\ Frequency} + \frac{200\ \text{ug/dL}}{365\ \text{days}/(365 - \text{Exposure Frequency})}$$

Equation 5.4 - Calculation for Adjusting Contaminant Exposure

Table 5.10 presents the results of the IEUBK lead model through two different exposure scenarios, which are recreational overnight user, and recreational daytime user. The results show that none of the exposure scenarios exceeded the level of concern. The raw results and inputs are displayed in Appendix B.

Table 5.10 – IEUBK Child Lead Model Results

Year	**Recreational User - Overnight**		**Recreational User - Day**	
	50th Percentile Exposure	95th Percentile Exposure	50th Percentile Exposure	95th Percentile Exposure
	Blood (µg/dL)	Blood (µg/dL)	Blood (µg/dL)	Blood (µg/dL)
0.5-1	6.6	7.2	6.4	6.6
1-2	5.7	6.3	5.5	5.7
2-3	5	5.5	4.8	5.0
3-4	4.7	5.2	4.6	4.8
4-5	4.5	5	4.4	4.5
5-6	4.3	4.7	4.1	4.3
6-7	4	4.4	3.9	4.0

5.5 Ecological Risk Assessment

Ecological risk assessments are used to estimate the exposure to a contaminant from plants and animals for a contaminated site. The pilgrim mine has many animals present; however, only beef cattle, cottontail rabbits and mule deer were quantitatively assessed for the site. The major defects from arsenic and lead toxicosis in small mammals were found to be liver and offspring number reduction in rats for lead exposure [7], while arsenic caused declining litter sizes over time in mice [8]. The ecological risk assessment also provides a qualitative assessment of plant growth by referencing aerial photos to observe the change in flora over time.

The ecological risk assessment was created based off of the Department of Energy's *Toxicological Benchmarks for Wildlife: 1996 Revision*, which outlines several processes for conducting an Ecological Risk Assessment [9]. The analysis included calculations for extrapolating Lowest Observable Adverse Effects Levels (LOAEL) from available toxicity data from rats and mice to larger animals using body weight factors, this calculation is demonstrated in Equation 5.6, below. Exposure calculations were found using parameter such as animal body weight, soil and plant consumption rates, as well contaminant concentrations in the soil, these parameters were found in the *Toxicological Benchmarks for Wildlife.*

The general process for estimating exposure to a contaminant began by calculating the exposure to a specified media, for this ecological risk assessment, only soil and plant consumption were taken into consideration. Inhalation exposure could not be calculated due to a lack of time and resources. The equation for calculating an animal's exposure to a certain media is presented below in Equation 5.5. Values for media consumption rates and animal body weights were found within *Toxicological Benchmarks for Wildlife*. The values used for the analyte concentration were the 50th and 95th percentile concentrations for lead and arsenic. The results from the exposure calculations are presented in Tables 5.11, 5.12 and 5.13.

$$Exposure\ to\ Media\ (mg/kg/bodyweight\ (kg)/day) = \frac{media\ consumption\ rate\ (\frac{kg}{day}) * analyte\ concentration\ (\frac{mg}{kg})}{animal\ body\ weight\ (kg)}$$

Equation 5.5 - Exposure to Specified Media

Once the exposure to soil and plant media was calculated, the total exposure for the animal could be calculated; the equation for total exposure is not presented in this report but was found to be the sum of exposure to soil and plant media.

The LOAEL for each animal was extrapolated from studies conducted on rats and mice. The LOAELs doses used for the extrapolation came from studies that were summarized in the *Toxicological Benchmarks for Wildlife* document. The oral arsenic LOAEL dose used was 1.26 mg/kg/day in the form of sodium arsenite; while the oral lead LOAEL dose used was 80 mg/kg/day in the form of lead acetate. The extrapolated LOAEL dose for each animal was calculated using Equation 5.6.

$$LOAEL_{wild\ species} = (LOAEL_{test\ species}) * \left(\frac{body\ weight_{test\ species}\ (kg)}{body\ weight_{wild\ species}\ (kg)}\right)^{\frac{1}{4}}$$

Equation 5.6 - LOAEL Extrapolation

Finally, to understand the significance of the exposure to plant and soil media, a hazard quotient value was calculated for each animal, for both arsenic and lead. A hazard quotient value less than one indicates that no adverse health effects are expected. The hazard quotient equation used is presented in Equation 5.7.

$$Hazard\ Quotient\ (unitless) = \frac{Total\ Exposure}{LOAEL}$$

Equation 5.7 - Hazard Quotient Calculation

The results of the hazard quotient calculation are presented with the exposure results, in Tables 5.11, 5.12 and 5.13.

Table 5.11 - Cottontail Rabbit Results and Parameters for Calculating Exposures and Hazard Quotients for Lead and Arsenic

Cottontail Rabbit											
Analyte	Animal Body Weight (kg)	Plant Uptake Factor (unitless)	Soil Consumption Rate (kg/day)	Plant Consumption Rate (kg/day)	Contaminant Concentrations in Media for 50th Percentile (mg/kg)		Contaminant Exposure for 50th Percentile (mg/kg bw/day)			Extrapolated LOAEL	Hazard Quotient
					Soil	Plants	Soil	Diet	Total		
Arsenic	1.2	0.12762	0.015	0.135	372.97	47.61	4.66	5.36	10.02	0.50	19.88
Lead		0.04			466.99	18.68	5.84	2.10	7.94	58.79	0.14

Table 5.12 – Mule Deer Results and Parameters for Calculating Exposures and Hazard Quotients for Lead and Arsenic

Mule Deer											
Analyte	Animal Body Weight (kg)	Plant Uptake Factor (unitless)	Soil Consumption Rate (kg/day)	Plant Consumption Rate (kg/day)	Contaminant Concentrations in Media for 50th Percentile (mg/kg)		Contaminant Exposure for 50th Percentile (mg/kg bw/day)			Extrapolated LOAEL	Hazard Quotient
					Soil	Plants	Soil	Diet	Total		
Arsenic	56.5	0.12762	0.0348	1.74	372.97	47.61	0.23	1.47	1.70	0.19	8.97
Lead		0.04			466.99	18.68	0.29	0.58	0.86	22.44	0.04

Table 5.13 – Beef Cattle Results and Parameters for Calculating Exposures and Hazard Quotients for Lead and Arsenic

Beef Cattle											
Analyte	Animal Body Weight (kg)	Plant Uptake Factor (unitless)	Soil Consumption Rate (kg/day)	Plant Consumption Rate (kg/day)	Contaminant Concentrations in Media for 50th Percentile (mg/kg)		Contaminant Exposure for 50th Percentile (mg/kg bw/day)			Extrapolated LOAEL	Hazard Quotient
					Soil	Plants	Soil	Diet	Total		
Arsenic	544	0.12762	0.5	11	372.97	47.61	0.34	0.96	1.31	0.11	12.05
Lead		0.04			466.99	18.68	0.43	0.38	0.81	12.74	0.06

Finally, a qualitative assessment of the desert tortoise was completed by researching the effects of arsenic and lead on the desert tortoise, which has been shown to lead to adverse health effects such as upper respiratory tract infection, urolithiasis, metabolic disease, and shell diseases [10].

5.6.1 Ecological Risk Assessment Assumptions

Many assumptions were made to complete the ecological risk assessment, as many studies and resources were not available; these assumptions included:

- The diet of the animals assessed consisted of food foraged solely on the site

- No water was consumed by the animals assessed on the site
- 50^{th} percentile concentrations were used to calculate exposure to soil and food media
- Extrapolations from rat and mice LOAEL doses cause the same adverse effects in much larger animals
- No inhalation calculations were made due to a lack of resources and time

5.6.2 Plant Growth and Density

To qualitatively determine if the tailings are affecting the plant growth in the area, satellite photographs were utilized to visually compare plant growth and density through time. Due to the limited satellite photographs of the area. The oldest image is from 1997. Figure 5.9 shows the mine tailings and their effect on the native vegetation. Using images taken from google earth from 1997, 2007 and 2015 we can see the progression of plant density on the tailings. Plant density at the Pilgrim Mine site has not changed significantly from each image.

The 1997 photo provides a baseline for plant density on the tailings. After the first decade (1997 to 2007) produced almost no change in new plant growth. However, the existing plants that were previously established did increase in size. The poor pixel quality does make it difficult to identify new plants within or near larger established plants. The black and white color also hinders distinguishing shadows from plants.

The 2007 image has an improved pixel quality and color. The image shows clear erosion lines on the northern tailings pile. This either means that the pixel quality revealed the erosion lines or the erosion occurred in the decade gap between images. If the erosion lines were created in the decade gap than that means, a severe precipitation event eroded the northern tailings. The image from 2007 shows the most new growth was occurring on the south and central tailings pile. This may be due to precipitation ponding between the south and central tailings pile. The ponding provides water moisture for the roots and native soil could settle providing nutrients to promote plant growth.

The 2015 image is the most recent image of the tailings pile and has the clearest pixel quality and color. The image shows further plant growth in the central and south tailings pile. The plant growth seems the greatest just along the end of the southern tailings pile dam. This could be due to native soil settling out and providing nutrients to establish new plant growth. If this trend continues, more plants should appear near the end of the southern and central tailings pile.

Figure 5.9 - Satellite Photos of the Pilgrim Mine Site over time

6.0 Summary of Project Cost

6.1 Staffing

The staffing on this project will include a senior engineer, engineer in training, technician, and an intern. Table 6.1 shows the total hours dedicated to the Pilgrim Mine investigation for Ecovestor employees. The senior engineer was in charge of approving, reviewing and signing off on all major completed tasks, which included the work plan, risk assessments, and the PA/SI and oversaw the project management. The engineer in training (EIT) reviewed all reports completed by the intern, wrote reports, and submitted them to the senior engineer for revisions; these included the work plan, risk assessments, and the PA/SI; the EIT was also be marginally involved with the data correlation and data analysis, following the sample analysis. The technician was responsible for implementing the work plan, which included the field sampling, completing the HAZWOPER training, determination and collection of PPE and field equipment, creating the project DQOs, as well as documentation and chain-of-custody protocols in the field. Further, the technician was responsible for the complete sample analysis and served as the quality assurance officer, following closely the data quality objectives and QA/QC protocols for lab analyses. The intern had many different roles throughout the project, mainly serving as the initial report writer and researcher, but was also involved in the field sampling, assisting the technician during field sampling.

6.2 Cost

The PA/SI cost was lower than previously projected. The total actual cost of the PA/SI was $64,255.5 dollars. This cost was calculated by personnel, travel, subcontracts, and operational costs. The personnel cost were calculated from hours logged per person per role, and the average rate of pay for that role. The travel cost include hotel, gas, and food costs. The subcontracts consisted of lab fees for laboratory tests conducted by Dr. Ketterer and Jeff Propster. The operational cost includes office supplies, building space cost, and software costs, etc.

Table 6.1 shows that the change in cost, from the projected proposal, was due to the change in hours for the personnel. The difference in projected and actual total cost was $6,830.00 and was due to changes in hours for the personnel. Originally, the senior engineer was estimated to put in 171 hours but in reality, they put in 80 hours. By reducing the largest paying personnel’s hours, saved about 9,200 dollars. The next deviation from the projected hours for personnel was the intern. The intern was projected to work 219 hours but actually worked 35 hours. The reduction in hours for the intern created 9,646 dollars difference in projected and actual costs. The EIT also had a slight decrease in hours, which contributed to the total reduced cost, which summed to 21,282 dollars. The technician however used most of those hours and costed twice as much as projected. The technician’s hours doubled to 445 hours and the difference from the projected and actual was 14,580 dollars. The overall savings in personnel cost was 6,702 dollars. The rest of the cost in the PA/Si remained constant except for the lab fees, which were cheaper than previously projected.

Table 6.1 - Project Costs

1.0 Personnel	Projected Hours	Actual Hours	Projected Cost	Actual Cost
Senior Engineer	171	80	$18,126.00	$8,480
Engineer in Training (EIT)	220	192	$19,140.00	$16,704.00
Technician	202	445	$12,120.00	$26,700.00
Intern	219	35	$10,950.00	$1,750.00
Total Personnel			$60,336.00	$60,336.00
2.0 Travel Cost			$985.00	$985.00
3.0 Subcontract			$240.00	$112.50
4.0 Operations			$9,524.00	$9,524.00
5.0 Total Cost			$71,085.00	$64,255.50

7.0 Conclusions and Recommendations

The main takeaways from the PA/SI were the following:

- The contaminants of concern at the site are lead and arsenic
- Lead and arsenic migration is most likely occurring away from the site, in the wash at the northern end of the tailings piles that flows north, away from the site. Wind erosion most certainly is causing contaminant migration although quantitative evidence was not collected; only observed during the site visit.
- Arsenic poses the greatest risk to animal and human populations
    - Lead concentrations were not shown to have cancerous risk above unacceptable levels
    - Arsenic 95th percentile concentrations were shown to cause cancer in all three exposure scenarios with cancer risk values greater than 1.0E-4 (remediation worker, overnight and day recreational users)
    - Hazard quotient values for arsenic 50th percentile concentrations were found to greatly exceed 1 for all three animals analyzed (beef cattle, cottontail rabbit and mule deer)
- Plant growth and plant density is slowly increasing at the site, possibly due to native (non-contaminated) soil migration onto the site

Going forward, Ecovestor recommends that further investigation of the tailings piles is required, especially with respect to the extent of migration away from the site. Wind erosion certainly has an effect on the migration of contaminants; however, these could not be proven with absolute certainty with the team's limited resources. That being said, dermal and inhalation contact to the contaminants could not be found for the same reason, so Ecovestor recommends further investigation into the human risk assessments. Ecovestor also recommends looking into possible groundwater contamination and water sampling surrounding wells, which was excluded from this PA/SI report.

Lastly, grazing beef cattle were seen in the area and animal feces were found on the tailings piles, which is a cause for concern and should be further investigated, if possible, with the ranchers in the area.

8.0 References

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9.0 Appendices

Appendix A: Work Plan

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Appendix B: Adult Lead Model Inputs

Tables 1 through 6 present the inputs and results of the Adult Lead Model.

Table 1: Recreational daytime user, 50th percentile

Variable	Description of Variable	Units	GSDi and PbBo from Analysis of NHANES III (Phases 1&2)
PbS	Soil lead concentration	ug/g or ppm	466.99
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9
BKSF	Biokinetic Slope Factor	ug/dL per ug/day	0.4
GSD_i	Geometric standard deviation PbB	--	2.1
PbB_0	Baseline PbB	ug/dL	1.5
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.100
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	0.100
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	1.000
K_{SD}	Mass fraction of soil in dust	--	1.000
$AF_{S, D}$	Absorption fraction (same for soil and dust)	--	0.12
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	2.333333
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	365
PbB_{adult}	**PbB of adult worker, geometric mean**	**ug/dL**	**1.5**
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adult workers	ug/dL	4.8
PbB_t	Target PbB level of concern (e.g., 10 ug/dL)	ug/dL	**10.0**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	**%**	**0.4%**

Table 2: Recreational daytime user, 95th percentile

Variable	Description of Variable	Units	GSDi and PbBo from Analysis of NHANES III (Phases 1&2)
PbS	Soil lead concentration	ug/g or ppm	1195.16
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9
BKSF	Biokinetic Slope Factor	ug/dL per ug/day	0.4
GSD_i	Geometric standard deviation PbB	--	2.1
PbB_0	Baseline PbB	ug/dL	1.5
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.100
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	0.100
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	1.000
K_{SD}	Mass fraction of soil in dust	--	1.000
$AF_{S, D}$	Absorption fraction (same for soil and dust)	--	0.12
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	2.333333
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	365
PbB_{adult}	**PbB of adult worker, geometric mean**	**ug/dL**	**1.5**
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adult workers	ug/dL	4.8
PbB_t	Target PbB level of concern (e.g., 10 ug/dL)	ug/dL	**10.0**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	**%**	**0.4%**

Table 3: Recreational overnight user, 50th percentile

Variable	Description of Variable	Units	GSDi and PbBo from Analysis of NHANES III (Phases 1&2)
PbS	Soil lead concentration	ug/g or ppm	466.99
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9
BKSF	Biokinetic Slope Factor	ug/dL per ug/day	0.4
GSD_i	Geometric standard deviation PbB	--	2.1
PbB_0	Baseline PbB	ug/dL	1.5
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.100
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	0.100
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	1.000
K_{SD}	Mass fraction of soil in dust	--	1.000
$AF_{S, D}$	Absorption fraction (same for soil and dust)	--	0.12
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	14
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	365
PbB_{adult}	**PbB of adult worker, geometric mean**	**ug/dL**	**1.6**
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adult workers	ug/dL	4.8
PbB_t	Target PbB level of concern (e.g., 10 ug/dL)	ug/dL	**10.0**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	**%**	**0.4%**

Table 4: Recreational overnight user, 95th percentile

Variable	Description of Variable	Units	GSDi and PbBo from Analysis of NHANES III (Phases 1&2)
PbS	Soil lead concentration	ug/g or ppm	1195.16
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9
BKSF	Biokinetic Slope Factor	ug/dL per ug/day	0.4
GSD_i	Geometric standard deviation PbB	--	2.1
PbB_0	Baseline PbB	ug/dL	1.5
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.100
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	0.100
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	1.000
K_{SD}	Mass fraction of soil in dust	--	1.000
$AF_{S,\ D}$	Absorption fraction (same for soil and dust)	--	0.12
$EF_{S,\ D}$	Exposure frequency (same for soil and dust)	days/yr	14
$AT_{S,\ D}$	Averaging time (same for soil and dust)	days/yr	365
PbB_{adult}	**PbB of adult worker, geometric mean**	**ug/dL**	**1.7**
$PbB_{fetal,\ 0.95}$	95th percentile PbB among fetuses of adult workers	ug/dL	4.8
PbB_t	Target PbB level of concern (e.g., 10 ug/dL)	ug/dL	**10.0**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	**%**	**0.6%**

Table 5: Remediation worker, 50th percentile

Variable	Description of Variable	Units	GSDi and PbBo from Analysis of NHANES III (Phases 1&2)
PbS	Soil lead concentration	ug/g or ppm	466.99
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9
BKSF	Biokinetic Slope Factor	ug/dL per ug/day	0.4
GSD_i	Geometric standard deviation PbB	--	2.1
PbB_0	Baseline PbB	ug/dL	1.5
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.100
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	0.100
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	1.000
K_{SD}	Mass fraction of soil in dust	--	1.000
$AF_{S, D}$	Absorption fraction (same for soil and dust)	--	0.12
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	93.333333
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	365
PbB_{adult}	**PbB of adult worker, geometric mean**	**ug/dL**	**2.1**
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adult workers	ug/dL	4.8
PbB_t	Target PbB level of concern (e.g., 10 ug/dL)	ug/dL	**10.0**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	**%**	**1.2%**

Table 6: Remediation worker, 95th percentile

Variable	Description of Variable	Units	GSDi and PbBo from Analysis of NHANES III (Phases 1&2)
PbS	Soil lead concentration	ug/g or ppm	1195.16
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9
BKSF	Biokinetic Slope Factor	ug/dL per ug/day	0.4
GSD_i	Geometric standard deviation PbB	--	2.1
PbB_0	Baseline PbB	ug/dL	1.5
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.100
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	0.100
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	1.000
K_{SD}	Mass fraction of soil in dust	--	1.000
$AF_{S, D}$	Absorption fraction (same for soil and dust)	--	0.12
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	93.333333
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	365
PbB_{adult}	**PbB of adult worker, geometric mean**	**ug/dL**	**3.0**
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adult workers	ug/dL	4.8
PbB_t	Target PbB level of concern (e.g., 10 ug/dL)	ug/dL	**10.0**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	**%**	**3.8%**

Appendix C: IEUBK Lead Model Inputs and Results

Figures 1 through 5 present the inputs and Tables 7 to 9 present the results of the IEUBK Lead Model.

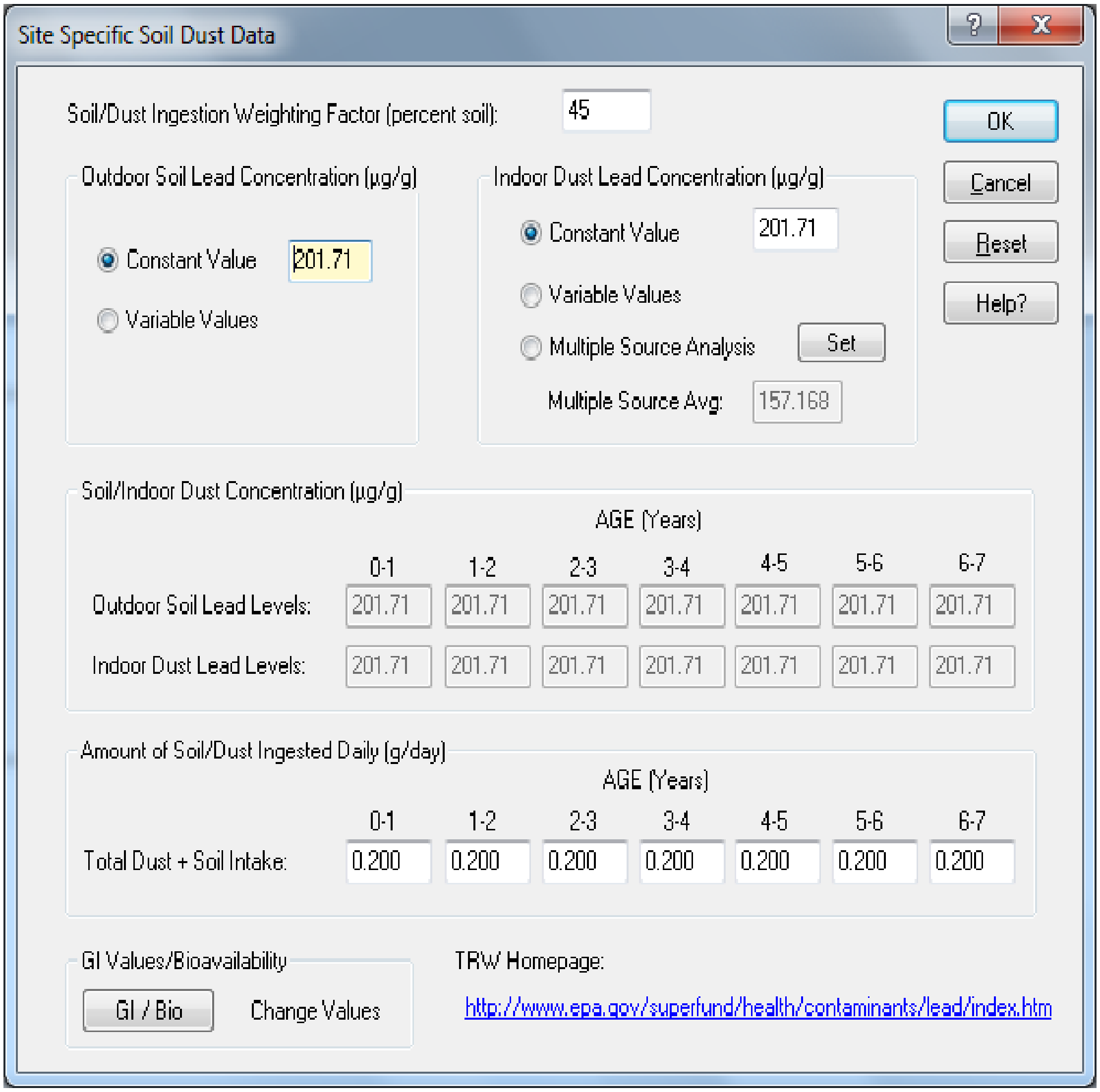

Figure 1: Recreational daytime user 50th percentile model inputs

Table 7: Recreational daytime user 50th percentile result

Year	Soil + Dust (ug/day)	Total Lead (ug/day)	Blood Lead (ug/dL)
0.5-1	10.549	11.904	6.4
1-2	10.825	12.631	5.5
2-3	10.986	12.959	4.8
3-4	11.134	13.114	4.6
4-5	11.255	13.251	4.4
5-6	11.337	13.477	4.1
6-7	11.391	13.639	3.9

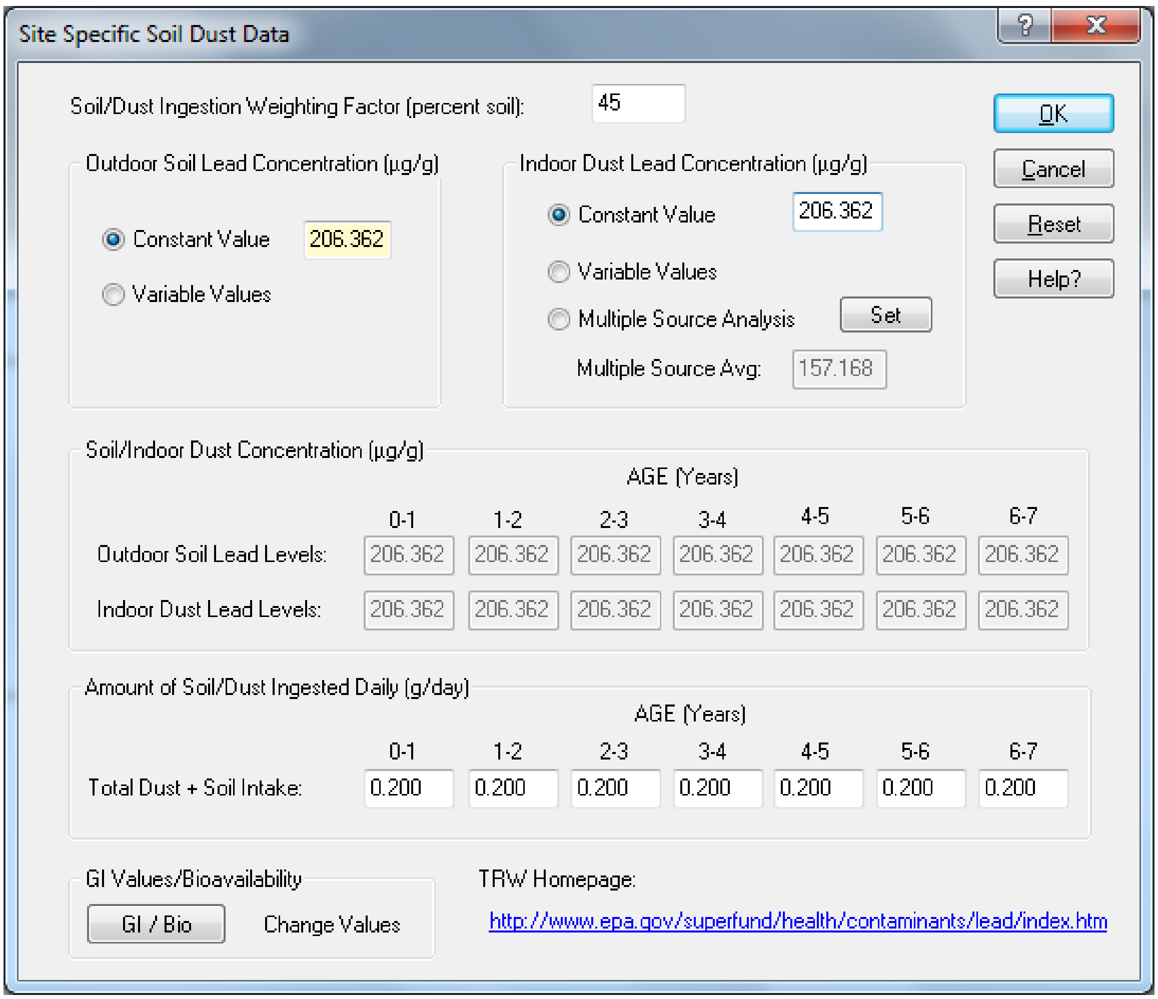

Figure 2: Recreational daytime user 95th percentile model inputs

Table 8: Recreational daytime user 50th percentile result

Year	Soil + Dust (ug/day)	Total Lead (ug/day)	Blood Lead (ug/dL)
0.5-1	10.756	12.108	6.5
1-2	11.043	12.845	5.6
2-3	11.210	13.179	4.9
3-4	11.363	13.340	4.7
4-5	11.488	13.482	4.5
5-6	11.574	13.712	4.2
6-7	11.630	13.876	3.9

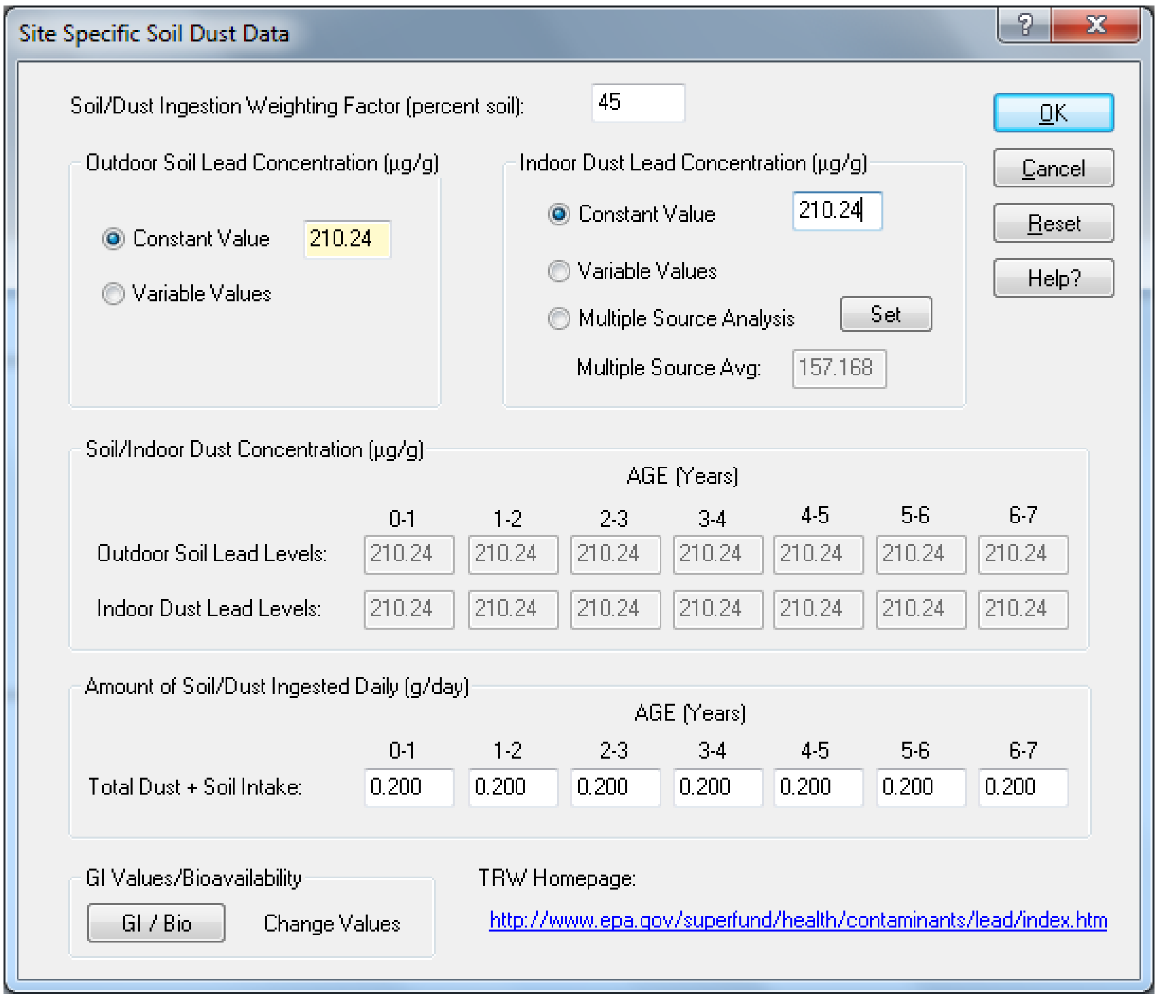

Figure 3: Recreational overnight user 50th percentile model inputs

Table 9: Recreational overnight user 50th percentile result

Year	Soil + Dust (ug/day)	Total Lead (ug/day)	Blood Lead (ug/dL)
0.5-1	10.945	12.294	6.6
1-2	11.241	13.040	5.7
2-3	11.414	13.380	5.0
3-4	11.572	13.547	4.7
4-5	11.701	13.693	4.5
5-6	11.790	13.926	4.3
6-7	11.848	14.092	4.0

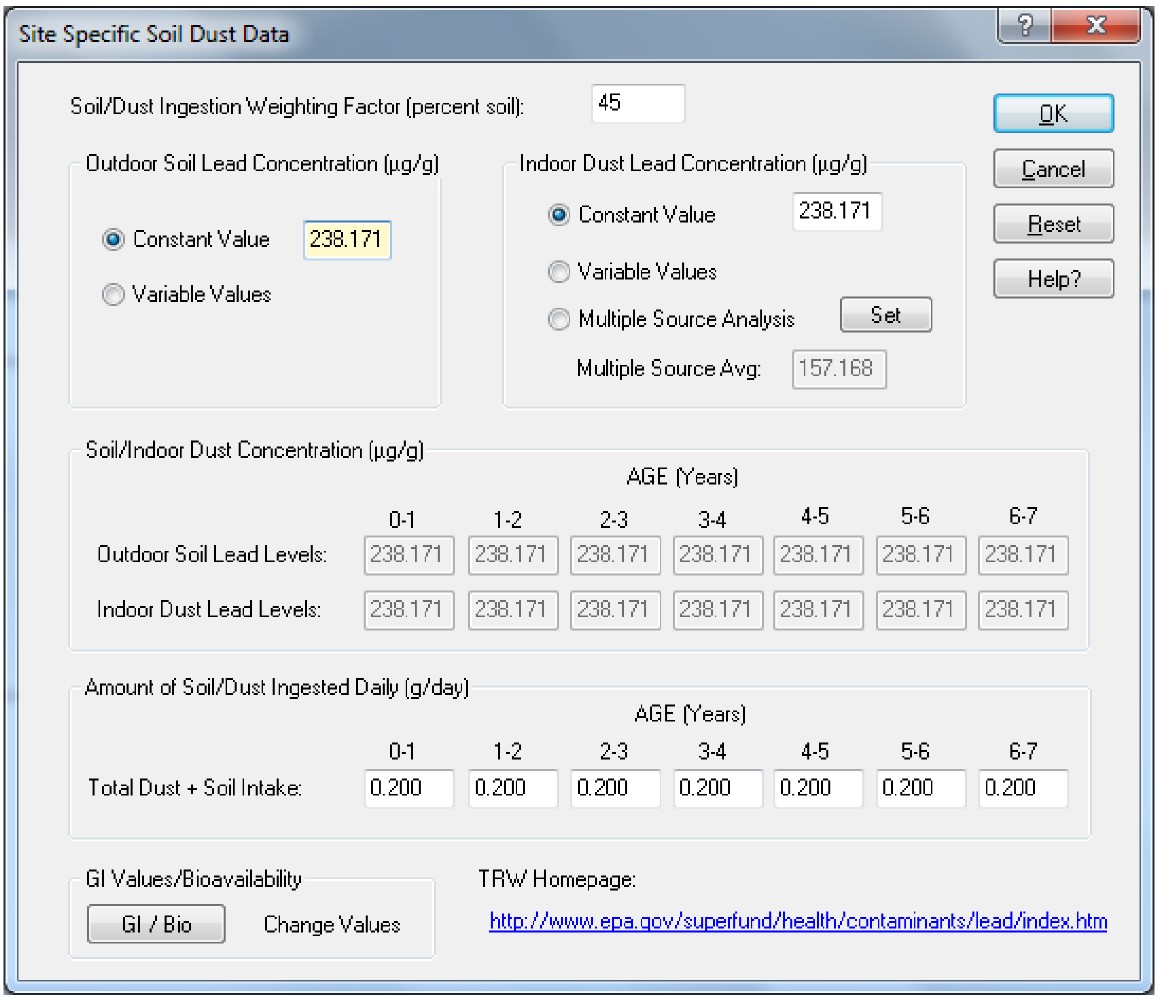

Figure 4: Recreational overnight user 95th percentile model inputs

Table 10: Recreational overnight user 95th percentile result

Year	Soil + Dust (ug/day)	Total Lead (ug/day)	Blood Lead (ug/dL)
0.5-1	12.216	13.545	7.2
1-2	12.583	14.361	6.3
2-3	12.795	14.742	5.5
3-4	12.990	14.947	5.2
4-5	13.150	15.126	5.0
5-6	13.260	15.381	4.7
6-7	13.332	15.562	4.4

Appendix D: XRF Raw Data Results (Chromium, Arsenic and Lead)

Table 11: Raw and Averaged XRF Readings (Hi's and Low's Omitted from Average) where Purple Cellsand Bolded Values Indicate Individual Sample Averages

Sample ID	Lead (mg/kg)	Arsenic (mg/kg)	Chromium (mg/kg)
S14-1	635.02	490.29	32.41
S14-2	732.57	524.05	56.06
S14-3	619.03	490.01	57.36
S14-4	734.82	505.36	57.79
S14-5	631.70	505.32	48.89
S14-6	593.10	541.00	39.58
S14-7	684.00	462.92	54.86
S14-8	706.22	482.24	66.95
S14-9	629.90	405.36	61.36
S14 Average	**662.63**	**494.31**	**53.70**
S8-1	1052.71	504.08	66.91
S8-2	1140.91	507.35	76.92
S8-3	1008.51	524.19	44.84
S8-4	1045.67	552.36	65.48
S8-5	1177.94	535.46	69.89
S8-6	1057.13	529.01	45.83
S8-7	1083.03	546.71	68.35
S8-8	1069.75	493.45	52.90
S8-9	969.42	463.33	28.56
S8 Average	**1065.39**	**520.04**	**59.17**
W17-1	23.01	57.12	116.69
W17-2	23.45	29.13	112.96
W17-3	21.24	23.89	114.78
W17-4	21.63	30.06	124.85
W17-5	40.19	30.20	123.07
W17-6	22.83	31.33	120.28
W17-7	26.86	21.96	149.52
W17-8	27.57	26.87	151.55
W17-9	21.05	25.93	133.87
W17 Average	**23.80**	**28.20**	**126.15**
W10-1	194.75	138.24	91.82
W10-2	191.07	118.88	116.14
W10-3	198.77	119.86	90.21
W10-4	192.86	158.31	72.04
W10-5	201.94	142.27	99.31

Table 11: Raw and Averaged XRF Readings (Hi's and Low's Omitted from Average) where Purple Cellsand Bolded Values Indicate Individual Sample Averages

W10-6	249.40	143.63	116.39
W10-7	214.76	137.78	85.87
W10-8	220.70	124.22	95.60
W10-9	198.41	141.52	96.39
W10 Average	**203.17**	**135.36**	**96.48**
W4-1	76.73	38.99	107.30
W4-2	73.98	43.09	128.12
W4-3	66.68	48.70	105.50
W4-4	84.86	40.28	128.17
W4-5	85.51	52.12	115.28
W4-6	78.08	51.77	117.28
W4-7	78.30	73.02	102.67
W4-8	75.67	54.23	125.14
W4-9	76.92	43.73	107.03
W4 Average	**77.79**	**47.70**	**115.09**
C2-1	969.59	395.77	95.02
C2-2	959.43	370.59	102.91
C2-3	1046.05	422.15	95.97
C2-4	1032.84	449.34	111.39
C2-5	1005.93	491.98	107.03
C2-6	959.59	401.50	107.55
C2-7	924.21	400.55	96.87
C2-8	925.76	410.27	105.73
C2-9	999.37	467.77	105.16
C2 Average	**978.93**	**421.05**	**103.03**
W23-1	74.81	39.88	189.88
W23-2	75.50	44.75	176.72
W23-3	78.04	38.35	183.50
W23-4	61.39	50.01	165.10
W23-5	64.89	47.13	153.12
W23-6	64.69	45.11	180.19
W23-7	68.83	44.76	170.05
W23-8	72.93	59.61	170.27
W23-9	70.22	54.66	170.10
W23 Average	**70.27**	**46.61**	**173.70**
C9-1	1137.93	545.00	126.38
C9-2	1290.49	600.12	141.55
C9-3	1143.29	442.11	100.41
C9-4	1111.10	470.86	128.45
C9-5	1125.31	584.89	138.87
C9-6	1184.96	550.98	115.99
C9-7	790.86	389.09	79.99

Table 11: Raw and Averaged XRF Readings (Hi's and Low's Omitted from Average) where Purple Cellsand Bolded Values Indicate Individual Sample Averages

C9-8	1124.82	528.96	124.79
C9-9	1121.96	485.77	117.16
C9 Average	**1135.62**	**515.51**	**121.72**
S9-1	189.25	134.18	133.70
S9-2	185.12	184.34	121.87
S9-3	185.97	154.24	125.58
S9-4	209.50	128.87	128.94
S9-5	179.25	143.05	149.64
S9-6	185.46	143.33	101.78
S9-7	191.48	131.42	142.28
S9-8	180.94	138.07	135.57
S9-9	189.83	130.63	127.28
S9 Average	186.86	139.27	130.75
S20-1	332.82	182.57	133.11
S20-2	333.56	222.48	130.33
S20-3	338.01	193.93	135.75
S20-4	302.83	190.27	129.64
S20-5	361.75	213.00	112.36
S20-6	339.30	208.92	138.55
S20-7	307.28	200.49	125.08
S20-8	358.72	218.64	127.46
S20-9	307.09	192.17	218.34
S20 Average	330.97	202.49	131.42
C11-1	1212.68	943.33	103.62
C11-2	1062.82	871.82	115.03
C11-3	1159.87	965.87	98.57
C11-4	1078.45	899.75	96.46
C11-5	1096.47	824.51	115.35
C11-6	1143.34	883.70	111.46
C11-7	1189.06	1008.85	99.16
C11-8	1114.04	951.75	122.62
C11-9	1089.46	855.48	112.70
C11 Average	**1124.38**	**910.24**	**107.98**
W14-1	117.42	75.64	121.45
W14-2	121.42	95.76	122.92
W14-3	133.06	81.00	130.10
W14-4	140.32	77.42	132.99
W14-5	122.35	82.25	130.64
W14-6	122.35	79.01	123.04
W14-7	106.81	75.18	121.19
W14-8	38.20	37.81	0.00
W14-9	110.29	58.49	217.58

Table 11: Raw and Averaged XRF Readings (Hi's and Low's Omitted from Average) where Purple Cellsand Bolded Values Indicate Individual Sample Averages

W14 Average	**119.10**	**75.57**	**126.05**
S12-1	1246.64	844.76	96.14
S12-2	1423.63	911.68	129.41
S12-3	1331.97	859.37	93.72
S12-4	1308.94	851.63	119.95
S12-5	1325.83	879.16	115.29
S12-6	1302.01	829.32	93.84
S12-7	1244.49	912.96	92.37
S12-8	1330.33	840.84	115.19
S12-9	1300.23	828.71	107.48
S12 Average	**1306.56**	**859.54**	**105.94**
S13-1	1520.17	978.82	116.70
S13-2	1505.12	1005.90	126.54
S13-3	1504.79	1001.56	106.52
S13-4	1501.40	1079.13	115.20
S13-5	1434.27	973.46	122.14
S13-6	1444.04	1002.62	111.53
S13-7	1503.97	1033.58	109.72
S13-8	1466.86	971.25	129.55
S13-9	1531.54	1154.87	107.64
S13 Average	**1492.34**	**1010.72**	**115.64**
S6-1	1222.42	321.91	67.96
S6-2	1441.16	412.80	107.29
S6-3	1368.59	353.51	75.45
S6-4	1393.77	405.61	73.82
S6-5	1429.11	382.32	88.20
S6-6	1435.09	390.79	69.14
S6-7	1294.24	393.92	75.43
S6-8	1470.67	369.80	96.24
S6-9	1387.85	361.19	71.08
S6 Average	**1392.83**	**379.59**	**78.48**
N12-1	486.39	286.06	74.88
N12-2	585.79	409.57	110.48
N12-3	708.74	489.87	106.94
N12-4	547.76	383.20	104.45
N12-5	634.16	446.49	106.12
N12-6	654.42	405.28	97.68
N12-7	466.72	343.07	84.18
N12-8	599.65	392.09	126.17
N12-9	596.10	366.72	107.94
N12 Average	**586.32**	**392.35**	**102.54**
N13-1	270.29	162.69	92.89

Table 11: Raw and Averaged XRF Readings (Hi's and Low's Omitted from Average) where Purple Cellsand Bolded Values Indicate Individual Sample Averages

N13-2	388.60	221.10	114.01
N13-3	341.76	218.34	102.30
N13-4	306.54	229.92	101.94
N13-5	333.09	246.58	115.99
N13-6	429.49	319.63	107.70
N13-7	360.85	220.71	109.48
N13-8	375.08	242.01	128.66
N13-9	366.32	186.21	103.00
N13 Average	**353.18**	**223.55**	**107.77**
S2-1	420.78	395.87	80.93
S2-2	518.72	444.85	108.41
S2-3	584.89	417.64	112.12
S2-4	522.13	400.27	132.90
S2-5	608.62	427.75	136.08
S2-6	546.62	427.06	117.77
S2-7	432.42	358.00	88.03
S2-8	596.37	379.82	106.15
S2-9	526.93	338.05	23.51
S2 Average	**532.58**	**400.92**	**106.62**
S4-1	640.90	427.16	92.07
S4-2	767.57	471.26	103.35
S4-3	781.14	552.95	89.62
S4-4	755.11	544.39	98.10
S4-5	741.61	540.36	102.10
S4-6	807.90	547.61	83.90
S4-7	593.64	392.00	76.01
S4-8	793.65	583.23	89.28
S4-9	759.63	433.38	90.64
S4 Average	**748.52**	**502.44**	**92.24**
C10-1	730.86	442.08	85.03
C10-2	1004.54	566.20	110.99
C10-3	853.00	546.72	99.70
C10-4	823.07	591.17	83.00
C10-5	938.43	501.18	98.30
C10-6	914.17	552.51	102.24
C10-7	710.86	458.93	74.51
C10-8	930.19	637.39	98.72
C10-9	731.06	537.89	91.36
C10 Average	**845.83**	**536.37**	**94.05**
S5-1	986.96	948.20	106.27
S5-2	1103.13	963.04	114.39
S5-3	1145.60	914.32	91.99

Table 11: Raw and Averaged XRF Readings (Hi's and Low's Omitted from Average) where Purple Cellsand Bolded Values Indicate Individual Sample Averages

S5-4	1046.66	968.93	127.40
S5-5	1064.69	985.12	107.55
S5-6	1056.78	883.50	120.35
S5-7	1114.50	903.82	119.15
S5-8	1056.18	937.57	112.87
S5-9	1158.36	1014.60	142.69
S5 Average	**1083.93**	**945.86**	**115.43**
S3-1	1918.94	1202.52	74.46
S3-2	1902.86	1255.58	66.39
S3-3	2016.07	1340.27	61.68
S3-4	1863.58	1160.60	71.62
S3-5	1881.99	1184.29	91.93
S3-6	1997.91	1183.51	89.57
S3-7	1879.49	1260.53	71.14
S3-8	1985.04	1236.41	61.77
S3-9	1917.21	1240.72	91.87
S3 Average	**1926.21**	**1223.37**	**75.26**
W21-1	520.42	286.59	84.55
W21-2	493.34	360.11	79.30
W21-3	436.87	216.07	84.72
W21-4	496.77	403.30	71.86
W21-5	404.59	331.73	78.10
W21-6	485.58	313.83	71.21
W21-7	429.13	338.43	74.46
W21-8	517.40	276.77	67.68
W21-9	471.58	286.85	61.18
W21 Average	**475.81**	**313.47**	**75.31**
S18-1	591.98	495.77	94.41
S18-2	623.09	393.00	74.88
S18-3	542.91	329.08	73.20
S18-4	581.97	421.22	85.02
S18-5	489.05	394.25	69.44
S18-6	608.24	412.53	90.05
S18-7	580.29	540.74	62.02
S18-8	544.54	456.72	53.93
S18-9	671.81	556.21	73.32
S18 Average	**581.86**	**444.89**	**75.42**
W3-1	23.74	19.62	60.20
W3-2	20.55	17.60	56.16
W3-3	22.44	15.09	58.50
W3-4	21.55	14.17	61.42
W3-5	20.57	18.56	63.45

Table 11: Raw and Averaged XRF Readings (Hi's and Low's Omitted from Average) where Purple Cellsand Bolded Values Indicate Individual Sample Averages

W3-6	19.50	20.69	65.63
W3-7	20.10	16.98	43.93
W3-8	21.29	18.25	38.54
W3-9	23.25	15.17	45.04
W3 Average	**21.39**	**17.32**	**55.53**
W2-1	221.53	139.56	83.66
W2-2	224.37	141.85	90.26
W2-3	234.48	120.85	86.85
W2-4	234.50	134.45	103.64
W2-5	244.44	156.13	106.61
W2-6	188.74	117.39	105.21
W2-7	216.99	118.06	100.43
W2-8	237.58	132.78	100.66
W2-9	222.83	131.65	99.89
W2 Average	**227.47**	**131.31**	**98.13**
W1-1	21.63	25.97	119.83
W1-2	15.33	26.03	101.81
W1-3	19.56	28.16	113.39
W1-4	19.47	25.16	114.01
W1-5	21.30	24.74	115.50
W1-6	19.12	28.68	128.27
W1-7	18.55	25.29	125.64
W1-8	18.01	24.84	114.35
W1-9	18.56	23.66	122.29
W1 Average	**19.22**	**25.74**	**117.86**
S21-1	374.96	213.07	103.32
S21-2	358.27	189.04	108.93
S21-3	411.36	266.78	100.95
S21-4	383.33	242.06	130.70
S21-5	371.92	191.39	128.88
S21-6	373.49	198.33	137.46
S21-7	369.64	177.18	125.33
S21-8	369.53	208.14	113.06
S21-9	367.97	215.53	108.06
S21 Average	**372.98**	**208.22**	**116.90**
W7-1	136.34	74.62	101.33
W7-2	174.27	113.13	83.79
W7-3	184.32	96.50	101.05
W7-4	137.43	94.65	120.30
W7-5	156.84	127.55	107.79
W7-6	144.96	97.72	114.38
W7-7	148.86	68.75	108.70

Table 11: Raw and Averaged XRF Readings (Hi's and Low's Omitted from Average) where Purple Cellsand Bolded Values Indicate Individual Sample Averages

W7-8	140.23	72.38	97.56
W7-9	138.32	105.24	107.98
W7 Average	**148.70**	**93.46**	**105.54**
W12-1	702.05	435.00	112.65
W12-2	724.69	535.44	122.58
W12-3	650.52	570.14	102.13
W12-4	593.98	524.79	123.55
W12-5	699.66	576.60	124.48
W12-6	640.31	494.40	127.46
W12-7	670.45	517.47	117.07
W12-8	601.41	505.65	130.50
W12-9	587.12	393.01	134.66
W12 Average	**651.20**	**511.84**	**122.61**
N14-1	556.13	348.06	84.39
N14-2	665.20	353.28	96.42
N14-3	625.06	420.50	87.71
N14-4	587.21	319.22	113.71
N14-5	601.28	339.93	121.18
N14-6	604.88	352.60	121.41
N14-7	482.95	303.46	130.72
N14-8	496.72	330.35	123.95
N14-9	580.66	379.55	97.31
N14 Average	**578.85**	**346.14**	**108.81**
B3-1	32.17	13.00	104.74
B3-2	36.89	14.90	122.94
B3-3	33.16	12.57	136.52
B3-4	36.03	13.31	99.67
B3-5	39.16	20.35	94.14
B3-6	37.51	14.59	107.18
B3-7	33.40	10.81	148.05
B3-8	34.27	19.17	102.92
B3-9	32.42	13.87	98.11
B3 Average	**34.81**	**14.49**	**110.30**
C1-1	901.03	611.54	80.38
C1-2	962.59	618.56	98.36
C1-3	956.70	537.56	98.98
C1-4	870.60	630.08	119.77
C1-5	964.62	561.37	110.50
C1-6	951.00	707.75	104.22
C1-7	894.61	518.37	90.83
C1-8	955.61	566.05	92.82
C1-9	1064.01	580.27	107.98

Table 11: Raw and Averaged XRF Readings (Hi's and Low's Omitted from Average) where Purple Cellsand Bolded Values Indicate Individual Sample Averages

C1 Average	**940.88**	**586.49**	**100.53**
W5-1	269.11	209.42	95.42
W5-2	266.56	164.55	102.77
W5-3	287.12	156.92	86.25
W5-4	301.54	221.76	68.94
W5-5	285.17	156.87	111.94
W5-6	221.95	151.77	82.30
W5-7	260.29	168.96	112.69
W5-8	293.89	166.79	117.44
W5-9	271.82	159.58	100.10
W5 Average	**276.28**	**169.01**	**98.78**
W20-1	145.99	77.75	103.90
W20-2	165.60	126.35	114.81
W20-3	156.61	128.14	128.55
W20-4	149.36	97.54	104.19
W20-5	142.56	94.17	103.94
W20-6	142.21	146.50	102.32
W20-7	175.43	129.31	118.40
W20-8	148.58	85.14	105.43
W20-9	139.94	103.89	118.36
W20 Average	**150.13**	**109.22**	**109.86**
W9-1	555.17	332.26	117.67
W9-2	484.63	367.19	129.44
W9-3	538.75	427.21	94.57
W9-4	502.55	266.58	124.01
W9-5	439.97	302.29	107.17
W9-6	500.40	430.21	102.85
W9-7	497.49	535.91	105.90
W9-8	545.55	502.47	122.36
W9-9	374.24	268.87	106.81
W9 Average	**501.33**	**375.79**	**112.40**
W6-1	497.11	417.25	92.51
W6-2	530.74	395.95	109.06
W6-3	559.67	335.50	109.94
W6-4	582.12	395.60	116.68
W6-5	607.86	500.99	118.30
W6-6	544.59	510.49	108.09
W6-7	437.54	359.66	104.38
W6-8	571.85	430.21	105.13
W6-9	585.31	386.50	102.34
W6 Average	**553.06**	**412.31**	**107.95**
W13-1	274.44	204.18	119.07

Table 11: Raw and Averaged XRF Readings (Hi's and Low's Omitted from Average) where Purple Cellsand Bolded Values Indicate Individual Sample Averages

W13-2	254.30	165.77	138.65
W13-3	306.11	194.14	124.28
W13-4	234.95	179.20	131.48
W13-5	286.50	193.54	140.98
W13-6	266.55	182.30	124.37
W13-7	276.22	177.10	122.40
W13-8	283.89	191.99	137.10
W13-9	268.31	164.74	124.57
W13 Average	**272.89**	**183.43**	**128.98**
W22-1	317.29	286.54	134.97
W22-2	396.79	302.77	105.93
W22-3	370.58	292.05	111.93
W22-4	382.70	206.90	116.09
W22-5	385.01	304.08	117.73
W22-6	304.53	230.91	131.77
W22-7	302.06	223.65	119.70
W22-8	347.64	237.29	146.05
W22-9	367.93	281.47	116.02
W22 Average	**353.67**	**264.95**	**121.17**
C6-1	953.16	614.01	109.14
C6-2	894.75	560.08	102.81
C6-3	905.19	742.18	107.40
C6-4	900.76	682.07	105.78
C6-5	867.32	633.22	98.57
C6-6	916.31	685.66	97.02
C6-7	854.21	594.18	114.37
C6-8	1001.68	725.24	106.27
C6-9	829.17	622.17	93.71
C6 Average	**898.81**	**650.94**	**103.86**
B2-1	29.22	8.06	123.83
B2-2	24.76	7.71	145.95
B2-3	21.91	8.87	167.33
B2-4	20.29	10.71	112.31
B2-5	28.42	9.26	142.17
B2-6	27.25	7.96	130.01
B2-7	31.79	0.00	147.14
B2-8	33.32	12.54	124.90
B2-9	37.55	14.38	124.50
B2 Average	**28.10**	**9.30**	**134.07**
S17-1	196.50	164.85	141.73
S17-2	221.55	141.84	155.62
S17-3	190.51	121.62	120.56

Table 11: Raw and Averaged XRF Readings (Hi's and Low's Omitted from Average) where Purple Cellsand Bolded Values Indicate Individual Sample Averages

S17-4	205.09	163.91	117.01
S17-5	232.24	155.64	133.45
S17-6	196.71	164.62	125.51
S17-7	208.73	183.52	129.12
S17-8	198.69	138.38	112.92
S17-9	221.55	188.74	120.85
S17 Average	**206.97**	**158.97**	**126.89**
W11-1	267.09	193.61	111.76
W11-2	298.45	180.52	116.09
W11-3	278.36	180.46	109.54
W11-4	302.32	187.49	102.22
W11-5	279.03	157.41	92.80
W11-6	288.47	185.00	112.23
W11-7	259.85	154.10	112.63
W11-8	257.60	147.26	90.89
W11-9	260.41	155.36	104.47
W11 Average	**275.95**	**171.48**	**106.52**
W8-1	65.20	33.49	129.46
W8-2	58.97	40.38	131.17
W8-3	78.12	36.66	132.00
W8-4	58.54	45.41	132.35
W8-5	72.01	33.20	127.87
W8-6	66.77	44.09	111.18
W8-7	61.39	38.91	132.86
W8-8	53.89	36.70	126.82
W8-9	71.06	24.50	115.75
W8 Average	**64.85**	**37.63**	**127.92**
W25-1	303.02	155.72	94.02
W25-2	243.29	203.51	90.22
W25-3	261.01	150.98	88.62
W25-4	318.68	201.27	94.19
W25-5	236.88	159.35	84.84
W25-6	303.24	192.72	91.91
W25-7	250.08	167.93	94.81
W25-8	254.48	287.72	87.39
W25-9	275.14	183.66	93.16
W25 Average	**270.04**	**180.59**	**91.36**
S19-1	659.13	627.42	86.90
S19-2	779.84	511.08	80.61
S19-3	641.55	421.67	76.53
S19-4	676.00	525.46	106.10
S19-5	628.98	451.24	92.22

Table 11: Raw and Averaged XRF Readings (Hi's and Low's Omitted from Average) where Purple Cellsand Bolded Values Indicate Individual Sample Averages

S19-6	521.56	404.93	88.29
S19-7	553.47	380.40	78.76
S19-8	643.70	409.64	94.37
S19-9	738.62	553.03	95.48
S19 Average	**648.78**	**468.15**	**88.09**
N15-1	970.02	533.81	103.44
N15-2	923.62	592.98	108.14
N15-3	963.34	505.07	115.08
N15-4	1006.18	536.99	128.52
N15-5	907.53	566.84	115.72
N15-6	943.34	474.21	120.94
N15-7	1012.44	596.74	103.76
N15-8	889.80	549.19	114.13
N15-9	916.39	519.77	105.34
N15 Average	**947.20**	**543.52**	**111.87**
N11-1	822.40	653.88	107.74
N11-2	732.24	577.77	120.48
N11-3	721.98	693.26	103.53
N11-4	729.33	657.76	126.17
N11-5	699.00	631.11	116.00
N11-6	770.87	590.24	113.46
N11-7	722.70	579.05	125.27
N11-8	789.29	667.68	112.17
N11-9	689.51	561.93	115.42
N11 Average	**737.92**	**622.50**	**115.79**
C7-1	602.80	363.98	119.85
C7-2	722.56	575.09	122.67
C7-3	710.37	442.48	116.21
C7-4	615.50	425.85	138.36
C7-5	754.95	463.65	131.69
C7-6	732.42	466.40	129.96
C7-7	771.88	454.28	117.95
C7-8	710.11	407.64	115.38
C7-9	667.20	354.86	114.41
C7 Average	**701.87**	**432.04**	**121.96**
C3-1	350.95	131.78	111.05
C3-2	342.88	115.08	104.43
C3-3	337.35	111.69	118.87
C3-4	340.39	103.33	118.65
C3-5	333.06	111.85	115.28
C3-6	347.79	108.33	119.14
C3-7	312.54	110.81	103.10

Table 11: Raw and Averaged XRF Readings (Hi's and Low's Omitted from Average) where Purple Cellsand Bolded Values Indicate Individual Sample Averages

C3-8	336.94	115.94	119.42
C3-9	357.62	145.42	119.15
C3 Average	**341.34**	**115.07**	**115.22**
HS2-1	576.35	424.02	66.16
HS2-2	454.25	308.37	56.35
HS2-3	490.04	349.54	82.52
HS2-4	506.08	428.86	81.06
HS2-5	466.94	380.45	77.74
HS2-6	475.90	412.58	89.48
HS2-7	386.91	250.13	69.44
HS2-8	527.66	387.72	75.68
HS2-9	451.01	338.55	73.23
HS2 Average	**481.70**	**371.60**	**75.12**
C8-1	764.22	566.66	100.58
C8-2	788.05	560.22	106.84
C8-3	805.39	560.69	99.31
C8-4	760.02	657.30	93.64
C8-5	778.07	575.54	100.75
C8-6	801.63	493.06	84.60
C8-7	852.14	521.42	94.93
C8-8	748.05	587.64	113.07
C8-9	916.14	524.64	96.11
C8 Average	**792.79**	**556.69**	**98.88**
W16-1	281.61	148.06	132.61
W16-2	260.74	180.01	124.37
W16-3	362.13	231.63	149.67
W16-4	241.62	194.93	113.33
W16-5	252.31	179.68	117.78
W16-6	275.35	169.38	113.61
W16-7	322.46	234.89	120.78
W16-8	259.04	185.07	120.44
W16-9	264.48	193.29	108.57
W16 Average	**273.71**	**190.57**	**120.42**
W15-1	563.29	569.18	108.24
W15-2	582.68	489.58	97.94
W15-3	616.96	454.46	118.72
W15-4	714.53	534.94	104.15
W15-5	670.45	440.44	122.39
W15-6	672.87	579.54	125.88
W15-7	544.21	334.89	102.67
W15-8	511.81	455.82	91.04
W15-9	568.90	414.29	101.16

Table 11: Raw and Averaged XRF Readings (Hi's and Low's Omitted from Average) where Purple Cellsand Bolded Values Indicate Individual Sample Averages

W15 Average	**602.77**	**479.82**	**107.90**
W19-1	95.02	54.35	123.57
W19-2	99.24	55.62	127.41
W19-3	96.03	51.33	124.30
W19-4	92.06	60.84	137.88
W19-5	103.58	63.17	157.05
W19-6	100.46	59.28	152.13
W19-7	69.32	50.96	143.22
W19-8	96.65	52.07	170.86
W19-9	69.51	46.33	146.66
W19 Average	**92.71**	**54.92**	**141.24**
W18-1	378.35	236.31	92.43
W18-2	587.84	380.28	108.79
W18-3	655.45	435.49	92.94
W18-4	494.25	281.79	106.69
W18-5	495.70	338.03	101.28
W18-6	578.15	421.96	106.68
W18-7	435.79	338.94	96.80
W18-8	523.59	338.78	84.92
W18-9	489.64	309.70	86.30
W18 Average	**514.99**	**344.21**	**97.59**
N10-1	279.37	179.25	95.89
N10-2	279.67	186.39	129.96
N10-3	259.74	172.55	85.00
N10-4	260.91	203.58	118.81
N10-5	314.05	229.79	140.96
N10-6	302.46	195.97	112.08
N10-7	173.45	159.45	60.72
N10-8	307.06	223.63	125.05
N10-9	290.68	222.19	100.81
N10 Average	**282.84**	**197.65**	**109.66**
N8-1	1045.89	442.42	101.98
N8-2	927.37	442.21	112.49
N8-3	951.84	462.02	110.76
N8-4	934.08	476.47	123.65
N8-5	1069.99	483.77	143.24
N8-6	879.38	432.22	139.40
N8-7	1088.87	550.10	128.95
N8-8	1089.12	556.63	118.91
N8-9	915.46	465.78	127.77
N8 Average	**990.50**	**474.68**	**123.13**
N7-1	1271.50	736.36	105.48

Table 11: Raw and Averaged XRF Readings (Hi's and Low's Omitted from Average) where Purple Cellsand Bolded Values Indicate Individual Sample Averages

N7-2	1304.45	745.15	104.59
N7-3	1343.51	812.45	114.06
N7-4	1301.25	804.84	117.62
N7-5	1248.06	711.52	125.65
N7-6	1247.18	731.75	121.09
N7-7	1172.87	753.99	115.51
N7-8	1243.18	711.64	111.12
N7-9	1148.50	724.97	121.41
N7 Average	**1255.50**	**744.10**	**115.18**
N6-1	344.61	284.27	110.75
N6-2	341.31	280.88	99.80
N6-3	360.57	326.79	94.13
N6-4	352.49	252.86	121.56
N6-5	337.60	300.60	134.54
N6-6	351.07	308.54	109.27
N6-7	340.01	343.65	113.02
N6-8	390.83	285.51	128.93
N6-9	311.21	217.67	132.16
N6 Average	**346.81**	**291.35**	**116.50**
N5-1	94.63	56.94	102.73
N5-2	94.39	67.31	90.61
N5-3	109.91	76.87	105.06
N5-4	92.74	58.52	79.75
N5-5	89.25	66.67	74.41
N5-6	93.88	71.43	101.84
N5-7	72.87	59.16	52.75
N5-8	62.39	54.20	71.68
N5-9	91.80	60.76	69.19
N5 Average	**89.94**	**62.97**	**84.32**
N3-1	785.30	370.29	108.06
N3-2	729.86	403.93	100.46
N3-3	998.22	467.71	102.50
N3-4	859.33	437.38	136.33
N3-5	994.71	552.16	131.15
N3-6	818.08	450.92	124.58
N3-7	858.01	454.07	106.67
N3-8	487.33	309.08	50.25
N3-9	701.43	430.04	93.54
N3 Average	**820.96**	**430.62**	**109.57**
N4-1	704.82	282.05	120.47
N4-2	714.76	285.67	118.30
N4-3	697.21	299.57	112.68

Table 11: Raw and Averaged XRF Readings (Hi's and Low's Omitted from Average) where Purple Cellsand Bolded Values Indicate Individual Sample Averages

N4-4	761.06	303.71	111.21
N4-5	779.19	291.67	121.53
N4-6	680.58	286.34	106.20
N4-7	736.67	301.89	118.59
N4-8	745.00	295.84	109.32
N4-9	421.80	208.86	67.74
N4 Average	**720.01**	**291.86**	**113.82**
N2-1	766.95	526.77	92.43
N2-2	777.39	510.17	98.94
N2-3	842.74	512.92	124.00
N2-4	793.75	523.10	106.28
N2-5	832.79	483.79	85.19
N2-6	837.55	474.59	111.81
N2-7	842.29	561.14	80.67
N2-8	874.82	460.62	84.90
N2-9	844.92	543.64	94.65
N2 Average	**824.49**	**510.71**	**96.31**
C12-1	116.02	77.01	143.16
C12-2	107.86	91.02	130.75
C12-3	118.95	71.38	147.08
C12-4	135.21	83.25	142.05
C12-5	124.21	87.75	145.40
C12-6	128.95	119.48	135.57
C12-7	116.89	91.81	135.32
C12-8	150.82	101.68	127.73
C12-9	116.43	66.67	127.86
C12 Average	**122.38**	**86.27**	**137.16**
N1-1	57.34	56.40	110.51
N1-2	38.70	30.20	93.60
N1-3	49.48	47.58	110.28
N1-4	49.53	37.87	109.29
N1-5	40.99	47.03	124.60
N1-6	63.35	49.11	119.20
N1-7	49.29	53.09	120.77
N1-8	70.87	57.77	104.42
N1-9	37.75	38.69	117.68
N1 Average	**49.81**	**47.11**	**113.16**
S7-1	511.42	499.84	92.29
S7-2	419.36	403.98	82.99
S7-3	409.95	365.15	83.45
S7-4	485.79	470.59	86.55
S7-5	500.49	439.92	93.06

Table 11: Raw and Averaged XRF Readings (Hi's and Low's Omitted from Average) where Purple Cellsand Bolded Values Indicate Individual Sample Averages

S7-6	427.97	457.26	106.58
S7-7	439.26	456.15	90.35
S7-8	434.46	455.42	92.55
S7-9	423.55	398.02	95.09
S7 Average	**447.27**	**440.19**	**90.48**
S10-1	1811.22	930.16	95.59
S10-2	1786.63	1060.99	88.00
S10-3	1708.26	997.67	107.02
S10-4	1588.83	951.48	103.36
S10-5	1695.70	1009.87	112.31
S10-6	1711.99	981.25	109.91
S10-7	1665.98	931.44	92.48
S10-8	1564.07	949.53	96.50
S10-9	1663.98	931.55	105.64
S10 Average	**1688.77**	**964.68**	**101.50**
S11-1	515.85	422.74	99.16
S11-2	554.76	501.08	93.14
S11-3	603.37	492.64	100.62
S11-4	510.43	425.80	108.79
S11-5	650.71	482.24	112.35
S11-6	588.06	478.37	112.96
S11-7	544.98	469.89	102.62
S11-8	546.23	410.82	111.31
S11-9	620.37	465.91	116.49
S11 Average	**567.66**	**462.51**	**106.83**
B1-1	43.43	29.02	129.57
B1-2	44.18	27.58	146.34
B1-3	31.87	28.63	132.33
B1-4	41.85	20.88	120.92
B1-5	41.89	25.50	119.27
B1-6	43.92	26.49	128.37
B1-7	41.85	17.03	112.50
B1-8	48.28	33.41	142.67
B1-9	35.54	24.54	126.93
B1 Average	**41.81**	**26.09**	**128.58**
W24-1	516.28	403.00	80.16
W24-2	607.94	360.93	83.41
W24-3	550.74	450.17	99.88
W24-4	506.76	405.83	79.58
W24-5	473.11	379.78	82.55
W24-6	710.67	495.18	83.90
W24-7	497.51	379.02	64.23

Table 11: Raw and Averaged XRF Readings (Hi's and Low's Omitted from Average) where Purple Cellsand Bolded Values Indicate Individual Sample Averages

W24-8	510.46	371.35	79.79
W24-9	501.92	358.29	93.23
W24 Average	**527.37**	**392.87**	**83.23**
HS1-1	519.31	367.54	79.95
HS1-2	453.57	339.31	85.63
HS1-3	472.72	304.73	91.62
HS1-4	477.90	353.18	71.34
HS1-5	467.04	331.55	86.55
HS1-6	470.94	327.20	84.77
HS1-7	500.72	324.44	76.82
HS1-8	445.29	321.16	74.57
HS1-9	440.52	325.18	76.55
HS1 Average	**469.74**	**331.72**	**80.69**
S16-1	385.85	304.71	115.89
S16-2	381.68	332.01	121.80
S16-3	394.66	293.34	153.16
S16-4	394.99	358.70	118.53
S16-5	400.08	317.35	115.81
S16-6	394.98	324.36	107.75
S16-7	427.19	356.65	124.15
S16-8	385.21	303.63	121.78
S16-9	399.74	349.55	115.97
S16 Average	**393.64**	**326.89**	**119.13**
N9-1	723.94	378.23	101.30
N9-2	806.35	354.04	101.96
N9-3	730.80	339.22	95.59
N9-4	754.90	373.30	103.81
N9-5	749.93	357.19	89.30
N9-6	756.53	381.09	114.02
N9-7	766.97	371.43	90.07
N9-8	724.45	309.50	75.41
N9-9	724.85	333.61	101.19
N9 Average	**744.06**	**358.15**	**97.60**
C4-1	726.32	239.17	119.78
C4-2	723.95	210.93	109.25
C4-3	748.86	245.10	119.15
C4-4	700.21	370.39	116.86
C4-5	714.44	233.89	113.62
C4-6	652.88	194.43	108.39
C4-7	706.96	261.84	82.72
C4-8	750.13	242.13	84.20
C4-9	678.48	201.14	125.27

Table 11: Raw and Averaged XRF Readings (Hi's and Low's Omitted from Average) where Purple Cellsand Bolded Values Indicate Individual Sample Averages

C4 Average	**714.17**	**233.46**	**110.18**

Appendix E: FLAA Raw Data Results (Lead and Chromium)

Table 12 - FLAA Raw Data Results from Jeff Propster

Sample ID	FlameAA Pb	FlameAA Cr	digested soil	digest vol	total soil Pb	total soil Cr
	ug/mL	ug/mL	g	ml	ug/g	ug/g
B1	<0.80	0.19	1.00	100	<80	19.20
C6	9.61	0.12	1.00	100	961.41	11.72
C7	8.80	0.17	1.00	100	880.21	16.71
HS-2	67.10	<0.10	1.00	100	6709.62	<10
N10	3.72	0.14	1.00	100	371.78	14.22
N12	7.72	<0.10	1.00	100	772.34	<10
N5	1.14	0.12	1.00	100	114.17	11.72
S12	14.81	0.14	1.00	100	1481.44	14.22
S2	6.92	0.17	1.00	100	691.73	16.71
S3	19.83	<0.10	1.00	100	1983.33	<10
S4	7.99	<0.10	1.00	100	799.27	<10
S8	13.71	<0.10	1.00	100	1371.12	<10
T1-4	8.26	<0.10	1.00	100	826.22	<10
T2-7	<0.80	<0.10	1.00	100	<80	<10
W1	<0.80	0.14	1.00	100	<80	14.22
W20	1.97	<0.10	1.00	100	196.59	<10
W21	5.05	<0.10	1.00	100	504.60	<10
W22	3.98	0.12	1.00	100	398.29	11.72
W25	2.92	0.12	1.00	100	292.41	11.72

Appendix F: ICP-MS Raw Data Results (Arsenic)

Table 13 - ICP-MS Raw Data Results from Dr. Michael Ketterer

Sample ID	Arsenic Concentration, mg/kg	Standard Deviation	Relative Standard Deviation, %
Unknown Digest B2 50X	11.3	0.2	2.0%
Unknown Digest B1 50X	27.6	0.3	1.1%
Unknown Digest N1 50X	60.6	1.4	2.4%
Unknown Digest N2 50X	601	4.4	0.7%
Unknown Digest N3 50X	551	8.1	1.5%
Unknown Digest N4 50X	263	3.2	1.2%
Unknown Digest N7 50X	753	10	1.4%
Unknown Digest N14 50X	505	5.7	1.1%
Unknown Digest N15 50X	637	6.4	1.0%
Unknown Digest W25 50X	250	2.7	1.1%
Unknown Digest C12 50X	91.3	1.5	1.7%
Unknown Digest S 21 50X	260	1.3	0.5%
Unknown Digest S 13 50X	1040	9.6	0.9%
Unknown Digest S 9 50X	162	1.9	1.2%
Unknown Digest S 3 50X	1230	17	1.4%
Unknown Digest N-12 50X	556	5	0.9%