May 7, 2019

Mr. Eric Zielske
Environmental Engineer
Bureau of Land Management
Phoenix, AZ

Re: Signal Mill Project Proposal

Dear Mr. Zielske:

We, EnviroTech Advising and Consulting, have provided the Signal Mill Preliminary Assessment/Site Investigation (PA/SI) report attached to this document. The PA/SI outlines the engineering analysis done to assess the Signal Mill stamp mill site. The cost of engineering services is $64,608. The PA/SI found increased human health and ecological risk at the site with regards to lead and manganese. It is recommended that remedial action be pursued. Thank you for your business and support throughout the project.

Sincerely,

EnviroTech Advising and Consulting

Angelina Cruse
Anna Gorman
Ali Husain
Wyatt La Fave

CONSULTANTS

ALI HUSAIN

ANGELINA CRUSE

ANNA GORMAN

WYATT LA FAVE

PROJECT

SIGNAL MILL

PRELIMINARY ASSESSMENT/SITE INVESTIGATION

PURPOSE

CENE 486C – ENGINEERING DESIGN

CLIENT: ERIC ZIELSKE

TECHNICAL ADVISOR: DR. BERO

GRADING INSTRUCTOR: DR. BERO

NORTHERN ARIZONA UNIVERSITY

SPRING 2019

Table of Contents

List of Tables

List of Figures

List of Equations

List of Abbreviations

ALM	Adult Lead Model
BLM	Bureau of Land Management
EPA	Environmental Protection Agency
EPC	Exposure Point Concentrations
FAAS	Flame Atomic Adsorption Spectroscopy
IEUBK	Integrated Exposure Uptake Biocentric Model
PRG	Preliminary Remediation Goal
XRF	X-Ray Fluorescence

Acknowledgements

The staff at Envirotech Advising and Consulting would like to thank Eric Zielske and the Bureau of Land Management for supporting the Signal Mill Preliminary Assessment/Site Investigation. Special thanks goes to Josue Juarez for his help during the sampling trip and for his technical advice. Another person who deserves much credit is Dr. Bridget Bero for supervising the project as well as providing technical advice and feedback on the project. Finally, Adam Bringhurst helped tremendously in providing lab access and guidance during lab analysis.

1.0 Introduction

1.1 Project Purpose

The purpose of the Signal Mill project is to conduct a Preliminary Assessment/Site Investigation (PA/SI) that includes human health and ecological risk assessments at the abandoned Signal Mill site. The areal extent of the site is approximately 8 acres and is located on Bureau of Land Management land (BLM) and the severity and spatial extent of contaminants has been determined [1]. This investigation will provide guidance for the Bureau of Land Management (BLM) on how to remediate the site.

1.2 Project Location

Signal Mill is in Arizona, approximately 22 miles south of Wikieup in Mohave County and 72 miles south of Kingman, see Figure 1.1 below for a map of Arizona (AZ). Signal Mill in relation to Wikieup can be seen in Figure 1.2.

Figure 1.1 Map of Arizona Showing Signal Mill Location

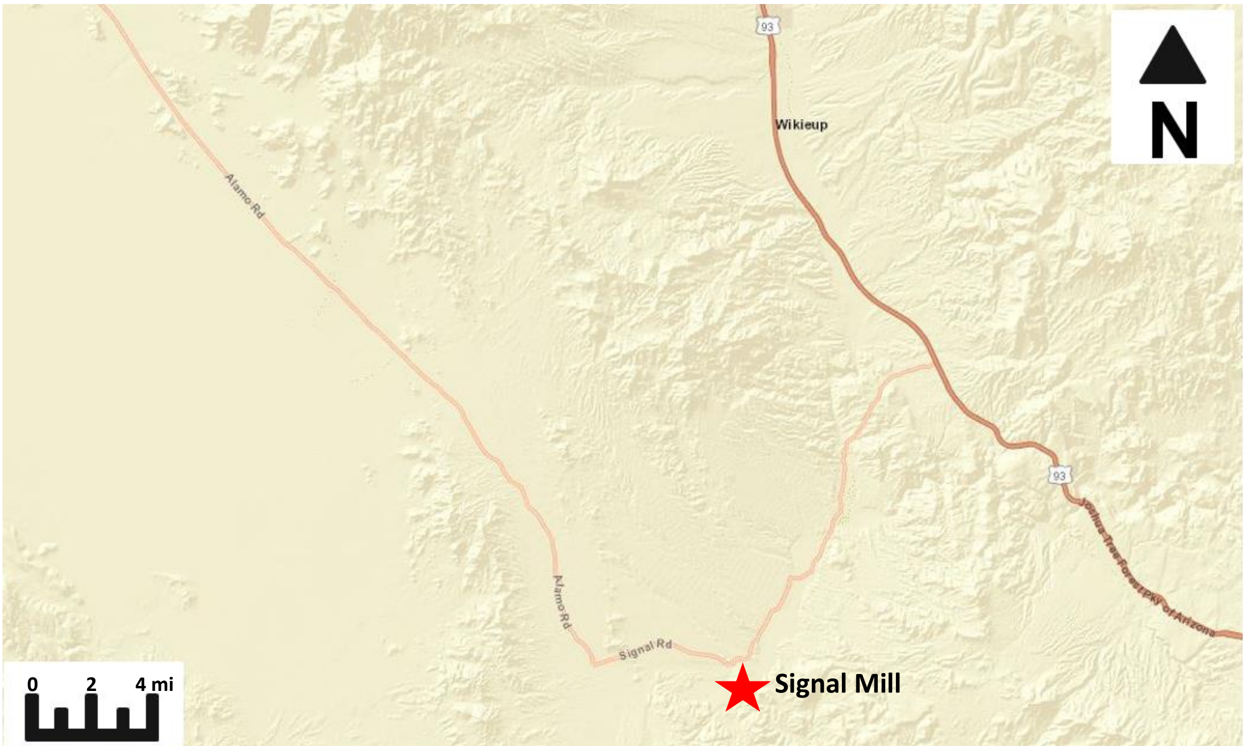


Figure 1.2 Signal Mill in Relation to Wikieup, AZ

Signal Mill borders the western bank of the Big Sandy River and occupies approximately eight acres. A site overview is shown below in Figure 1.3. The aerial image of Signal Mill is outdated and does not fully reflect the site's current conditions.

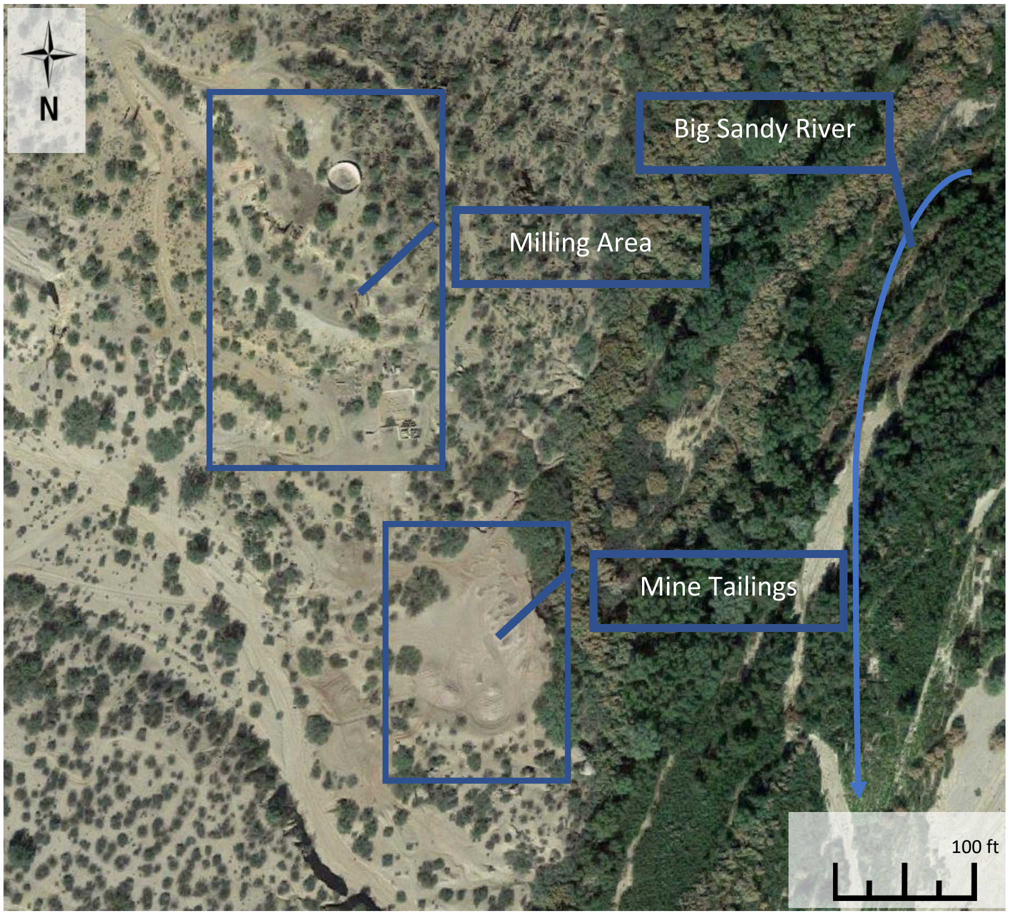


Figure 1.3. Signal Mill Aerial Photo

1.3 Background

Signal Mill was erected by a San Francisco company contracted by McCracken and Owens in 1874. The mill was designed as a 10-stamp mill and later upgraded to a 20-stamp mill in 1884. The mill was setup to take and process ores from the McCracken Mine, most notably lead and silver. The 10-stamp mill burned down in 1893 and Signal Mill was closed in August of 1902 [3]. Signal Mill ran intermittently in the 1920's and 1950's. In 1922 the Signal Mines Company took over the property where the mill was run intermittently up until July of 1925, when the property closed. In the late 1950's milling operations began again and was conducted by Ari-Vada Development Corporation. The last indicated operation period of the mill was in 1959 [4].

As of today, only crumbles remain of Signal Mill. There are broken and abandoned structures scattered throughout the site. An image of the mill's remains is shown below in Figure 1.4. The site is also frequented by recreational users. During the site investigation a group of all-terrain vehicle users was encountered on the site along with tourists visiting the mill.

Figure 1.4 Abandoned Structure at Signal Mill

The only data available on Signal Mill is from the Bureau of Land Management site investigation conducted on April 9, 2018 [1]. The data collected from this brief investigation is presented in Table 1.1 and were obtained by in-situ XRF analysis. The red cells in Table 1.1 represents contaminants concentrations exceeding Arizona Non-Residential Remediation Standards and the yellow cells show contamination levels that are between Arizona Residential Remediation Standards and Arizona Non-Residential Remediation Standards. All values are reported as parts per million (ppm).

Table 1. 1 Signal Mill Site Summary with Contaminants [1]

Sample #	Site	Latitude	Longitude	Contaminant Concentration								
				Pb	As	Hg	Zn	Mn	V	Ba	Ag	Sb
1	Signal Mill	34.47222	-113.62476	14542.4	418.59	75.43	31467.29	66259.59	149.13	36968.43	691.41	31.88
2	Signal Mill	34.47237	-113.62471	11690.38	151.58	79.61	36019.4	10559.25	<LOD	1419.24	219.6	55.53
3	Signal Mill	34.47222	-113.62474	4647.22	182.63	47.65	12266.27	13645.8	73.72	1796.12	11.05	<LOD
4	Signal Mill	34.47209	-113.62469	22400.74	394.96	91.45	42378.46	11158.64	37.17	7285.86	131.93	112.61
5	Signal Mill	34.47203	-113.62446	35907.42	<LOD	77.96	40024.83	11134.78	45.07	9430.04	162.84	67.74
6	Signal Mill	34.47169	-113.62437	19471.04	<LOD	37.84	22344.06	9984.22	40.43	7045.68	115.01	28.91
7	Signal Mill	34.47160	-113.62400	26828.93	328.55	308.86	18575.02	18173.51	70.08	10159.31	236.56	73.59
8	Signal Mill	34.47138	-113.62392	12436.05	<LOD	72.47	29018.56	6873.92	<LOD	2186.35	64.33	67.51
9	Signal Mill	34.47076	-113.62399	13371.81	<LOD	62.42	21750.39	4590.7	88.1	10033.01	83.58	59.99
10	Signal Mill	34.47065	-113.62416	24143.39	767.97	1190.53	35907.79	44584.74	186.36	38543.32	213.74	58.58

Figure 1.5 below shows the location of the 10 sample points that correspond to the data in Table 1.1. Each point was taken in-situ with the use of a handheld XRF device.

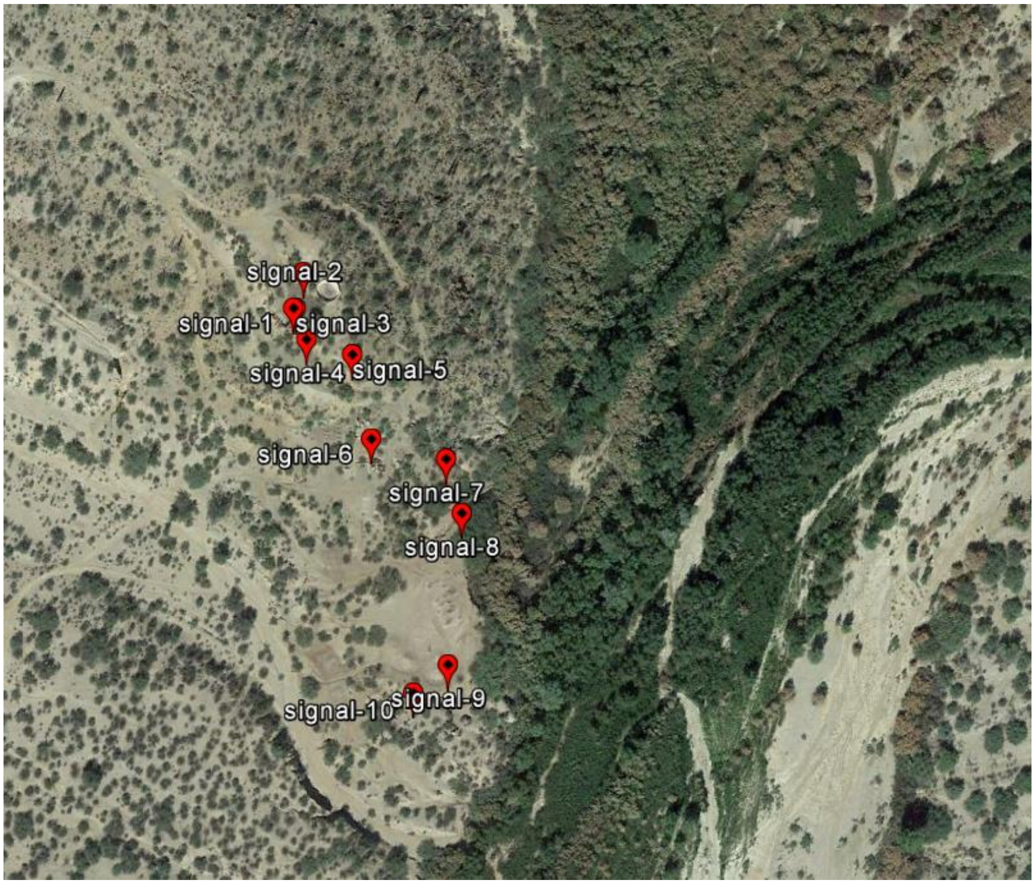


Figure 1.5 Location of Sample Points taken by BLM

1.4 Project Exclusions

Exclusions to the project include water sampling and core soil sampling because the greatest concern at the site is contaminant migration. Therefore, the most effective way to measure this is by testing surface soil samples.

2.0 Work Plan

A Work Plan was prepared detailing the procedures that were followed during the field work. Sampling procedures, analysis methods, and health and safety plans are outlined within the Work Plan. The Work Plan is available in Appendix A.

3.0 Field Sampling

Field sampling occurred on January 18th and January 19th, 2019. The heavy precipitation in the preceding weeks washed out Signal Rd. Therefore, Alamo Road from the Interstate 40 was used to access the site. The day sampling began, the weather was sunny with light wind, and the temperature was 51°F with 74% humidity. The rain event led to high moisture in most samples collected and created thick muddy areas that made access to some sampling locations near the bank of the Big Sandy River difficult.

The site consisted of a lot of hills and some steep drops near the remnants of the mill. Further south, many leftover concrete structures, pads, and the mine tailings were left behind. Just north of this image on a higher ledge, was the round, circular, concrete structure utilized to mark and find all soil samples on site. Figure 3.1 is a sketch of the site looking south, just below the round, concrete structure identified as the starting point for sampling.

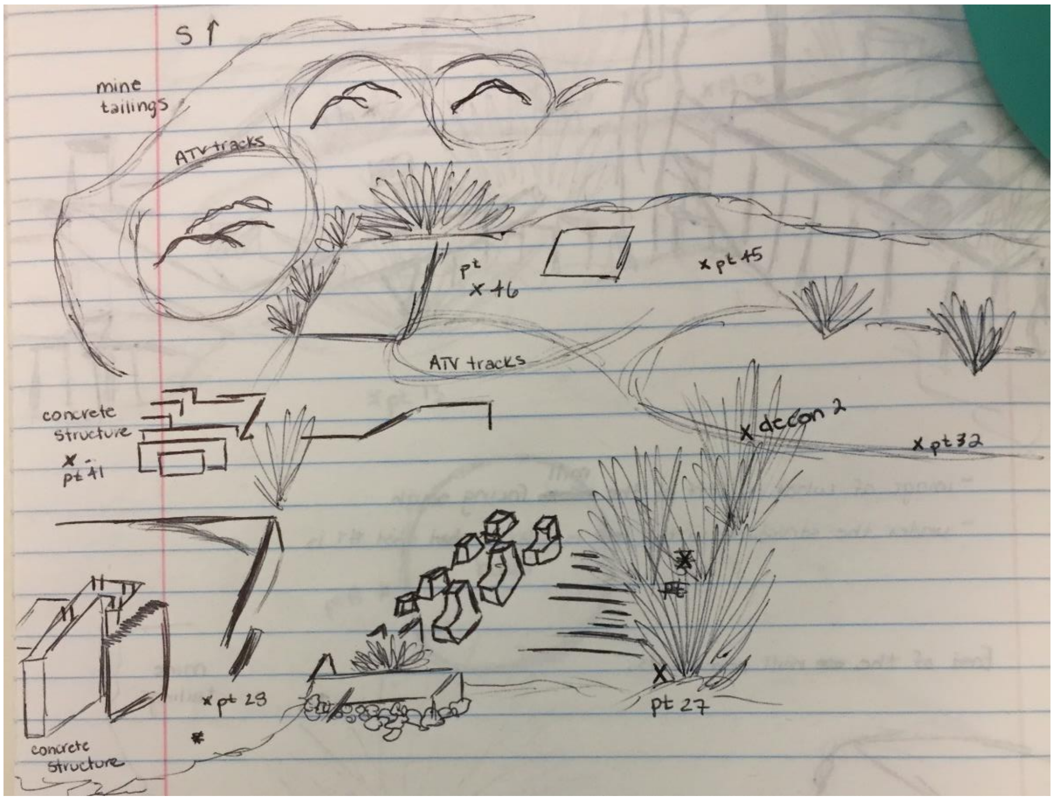


Figure 3.1 Sketch of the Signal Mill Site (not to scale)

The procedures outlined in Section 3.0 of the Sampling and Analysis plan were followed to collect soil samples. It was initially proposed to collect 100 soil samples which included 80 grid samples, 10 background samples, and 10 hot spot samples. Instead, 83 soil samples were collected. Out of the 83 samples, 75 were grid samples, three were background samples, and five were hot spot samples. Grid samples were removed due to inaccessibility. The sampling gridding process was difficult to execute due to the steep terrain present at the site. This lead to difficulty measuring distances between planned sampling locations. Three samples were lost to error during the gridding process, which included grid samples 22, 23, and 24. Four samples were excluded due to thick shrub blocking accessible spots to sampling points which include grid samples 55, 68, 76, and 78. A map of the collected samples is shown below in Figure 3.1. Within the figure excluded samples are crossed out. To compare the proposed grid with the actual grid, see Appendix A Section 3.1.1 of the Sampling and Analysis Plan for the original grid.

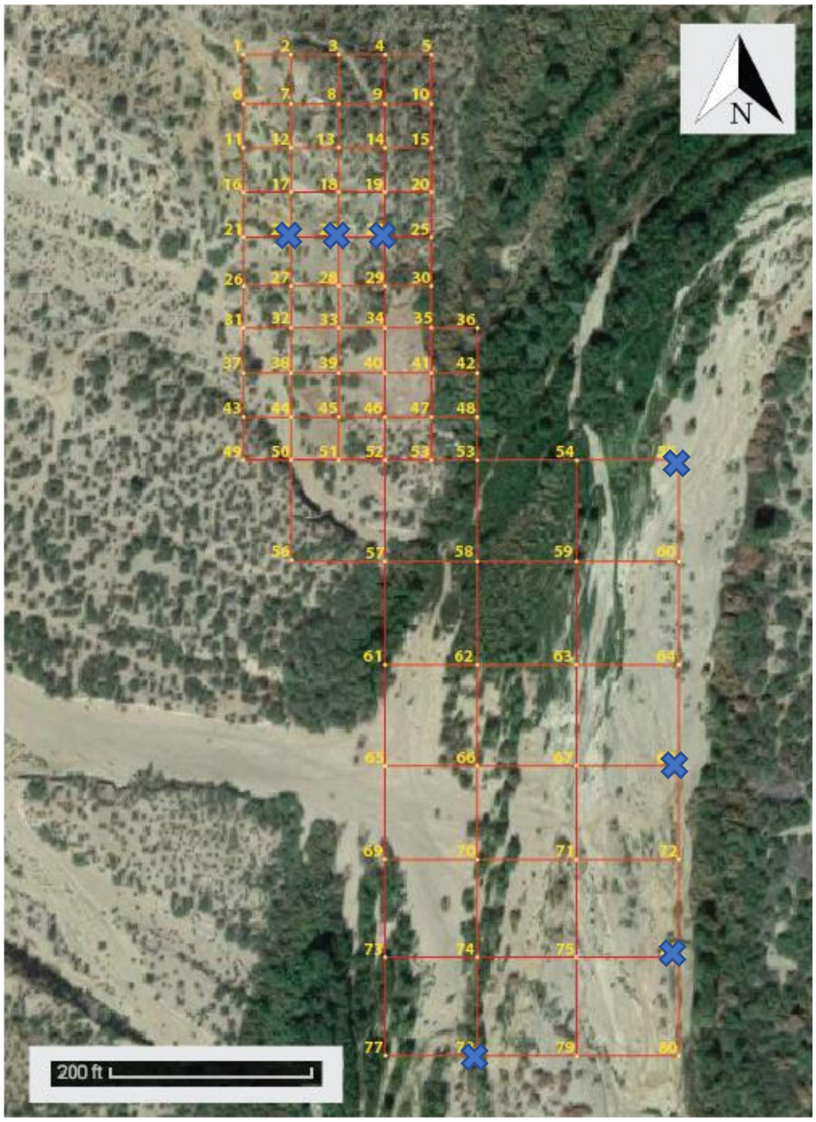


Figure 3.2 Updated Sample Grid

Hot spot and background samples were identified during the course of the investigation. Sample locations for hot spot and background samples were determined by the Technical Advisor (Dr. Bridget Bero) for the duration of the trip. The locations of these samples can be seen in Figure 3.2.

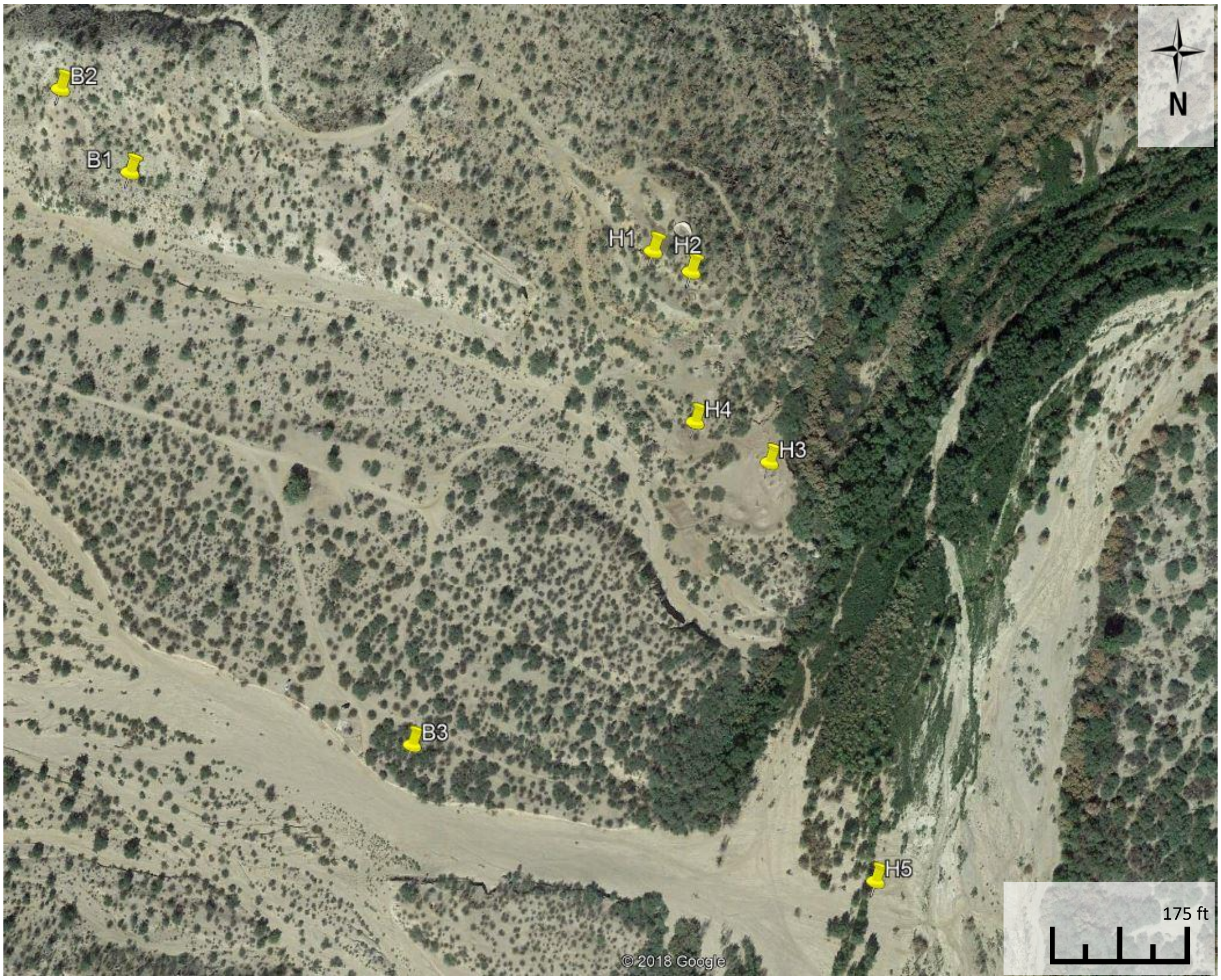


Figure 3.3 Hot Spot and Background Sample Locations

Samples were bagged and labeled following the labeling scheme outlined in the Sampling and Analysis Plan Section 8.2 (see Appendix A). Between each sample collection, sampling equipment was decontaminated following the Health and Safety Plan Section 7.0 (see Appendix A). During the sampling an ecological survey was conducted, noting the flora and fauna present at the site. Once soil samples were collected, the chain of custody forms were filled out and soil samples were sealed inside containers with the chain of custody forms. Samples were transported to Northern Arizona University and stored in Engineering Building, Room 117. Field notes for the field sampling are available in Appendix B. The photo log of the sampling investigation is available in Appendix C.

4.0 Testing and Analysis

4.1 Drying

Drying occurred in Room 117 of the Engineering Building following ASTM D3974 Standard Practices for Extraction of Trace Elements from Sediments. Soil samples were dried at 60 °C to prevent volatilization of mercury in the soil. Soil samples were dried for two days and then bagged in gallon size heavy duty freezer bags. The bags were relabeled to include the sample identification along with a 'D' so that all team members were aware it had been dried. Bagged, dried soil samples were stored in the same containers used during the field sampling investigation. Initially, there was the possibility that there would be issues with some of the samples drying into bricks in the oven. Along with the possibility of mercury being present, all samples were dried at a lower temperature (60 °C) to maintain mercury for possible analysis and prevent solidification.

4.2 Sieving

Sieving was conducted in Room 117 of the Engineering Building. ASTM D6913 Standard Test Method for Particle-Size Distribution of Soils Using Sieve Analysis is the standard method that was followed the dry soil sieve analysis. This method was not followed to create a particle-size distribution but for guidelines on sieve loadings. Soil samples were sieved utilizing a series of sieves and the mechanical shaker. The No.10, No. 16, and No. 40 sieves were utilized to collect soil sample past the No. 40 sieve. Dr. Bridget Bero and Eric Zielske decided that it was acceptable to deviate from EPA Method 6200 to collect sieved soil that passed the No. 40 sieve versus the No. 60 sieve due to the coarse nature of the soil as well as to collect enough soil sample for the x-ray fluorescence analysis. After each sample was sieved, the sieves were decontaminated. This decontamination was done primarily through the use of compressed air and a rinse with water to remove any leftover soil particles prior to the next sample being sieved. As with drying, the samples were placed in gallon size heavy duty freezer bags but separated based upon what went through the No. 40 sieve and what did not. The bags were labeled accordingly by putting an 'S' on what did go through the desired sieve, with the rest going back into the bag with the 'D' on it. The sieve shaker setup used can be seen in Figure 4.1.

Figure 4.1 Mechanical Shaker Setup for Sieving

4.3 XRF Analysis

A handheld Niton XL3t x-ray fluorescence (XRF) device was utilized throughout the lab work time to analyze each soil sample. The XRF analysis followed EPA Method 6200 Field Portable X-Ray Fluorescence Spectrometry for the Determination of Elemental Concentrations in Soil and Sediment and was conducted in Room 117 of the Engineering Building. Nine sub-samples were taken from each sample using plastic cups comprised of four pieces; the base, connector, plastic, and cap. These plastic cups are approximately the size of a dollar coin in diameter and about an inch tall in and can hold approximately 21 g of soil. This setup can be seen in Figure 4.2 below. The side to be analyzed by the device is face down, with the plastic film and lid holding it in the plastic cup (due to a tiny hole in the base, they are upside down).

Figure 4.2 Soil Sample Cups Ready for Analysis

Once ready, one of these cups was placed into the portable XRF stand. On top is a lid surrounded on the interior with lead so that no x-rays escape during analysis. This lid was closed around the sample. The portable XRF device is turned on and snapped into place on the bottom side of the stand. This can be seen in Figure 4.3 below.

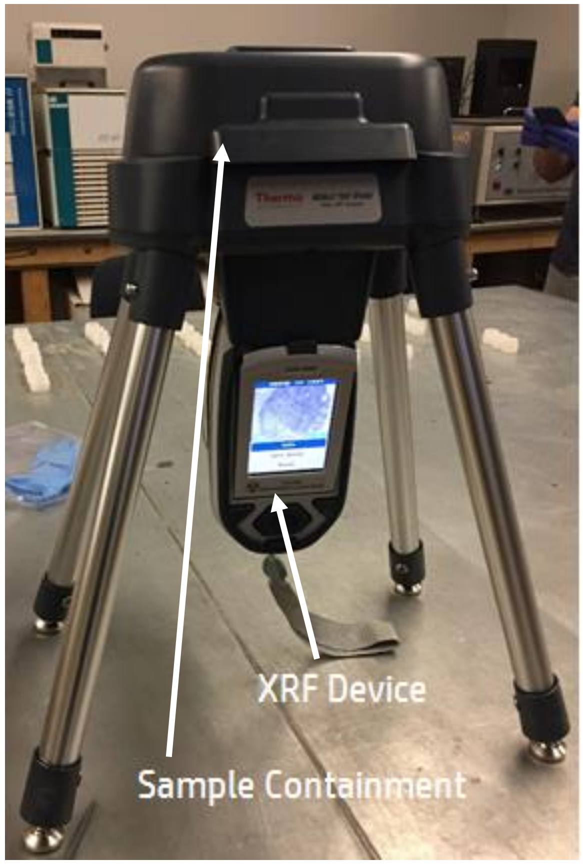


Figure 4.3 XRF Device Snapped into Place on the Portable Stand

Following the sampling and analysis plan outlined in the work plan, each sample was divided into nine sub-samples. Each sub-sample was analyzed for a total of 90 seconds using Soils Mode on the XRF device. The sub-samples were identified by the letters A through I to indicate the different samples. After all sub-samples were analyzed, the soil was placed back into the sample bags. The cup was decontaminated by being scrubbed in a water bath and dried with a paper towel. Waste from the decontamination process was treated as hazardous waste and stored in designated hazardous waste bins.

A log was kept in order to keep track of which samples had already been analyzed so that no duplicates were taken. Once all of the data had been collected, the XRF software was utilized to download the data into an excel file. These excel files will be provided electronically. The data was analyzed, throwing out the highest and lowest values for each element before averaging the rest as per the sampling and analysis plan. In the cases where three to seven readings were <LOD, it was replaced with 10% of the LOD value for each element to provide a number for averaging the data.

The data was compiled into one master excel file. The data can be found in Appendix D. The contaminants of concern (COCs) for human health and ecological risk assessments were determined based on the results and are discussed in the next section.

4.4 Selection of COCs

In selecting the COCs, analysis of the XRF data was performed to determine how many samples exceeded specific values. For the human health assessment, the AZ Soil Remediation Standards were used and for the ecological assessment, the EPA standards for plants, avian wildlife, and mammals were used.

In Table 4.1 below, the AZ Soil Remediation Standards are listed and were used when determining the COCs for the human health risk assessment.

Table 4.1 AZ Soil Remediation Standards for Elements of Concern at Signal Mill [2]

Element	Residential (ppm)	Non-Residential (ppm)
U	16	200
Pb	400	800
As	10	10
Hg	23	310
Zn	23,000	310,000
Mn	3,200	43,000
Ba	5,300	110,000
Sb	31	680
Cd	38	850

From the XRF data and soil remediation standards, cells were highlighted in the excel sheet to determine which samples exceeded residential and non-residential standards. These are summarized in Table 4.2 below, which describes how many samples exceeded these standards. This led us to determine that lead (Pb), arsenic (As), and manganese (Mn) were of the most concern at Signal Mill for the human health risk assessment.

Table 4.2 Number of Soil Samples Exceeding AZ Standards for Residential and Non-Residential

Element	# of samples above Residential	# of samples above Non-Residential
Uranium (U)	5	0
Lead (Pb)	65	59
Arsenic (As)	39	39
Mercury (Hg)	21	1
Zinc (Zn)	5	0
Manganese (Mn)	28	0
Barium (Ba)	13	0
Antimony (Sb)	14	0
Cadmium (Cd)	14	0

In Table 4.3 below, the EPA standards for plants, mammals, and avian wildlife are listed, and these were the values used when determining the COCs for the ecological risk assessment.

Table 4.3 Ecological Standards for Elements of Concern at Signal Mill [2]

Contaminant	Plants (ppm)	Avian Wildlife (ppm)	Mammals (ppm)
Lead	120	11	56
Arsenic	18	43	46
Zinc	160	46	79
Copper	70	28	49
Nickel	38	210	130
Manganese	220	4300	4000
Vanadium		7.8	280
Cadmium	32	0.77	0.36
Silver	560	4.2	14
Barium			2000

The XRF data and these standards were utilized to highlight cells once more based on ecological standards to determine what elements posed the highest risk to plants, mammals, and avian wildlife. These were then organized into Table 4.4 below, which shows how many samples affect each category of biota at Signal Mill. This determined that 9 of the 10 possible elements of concern will be focused on as COCs in the ecological assessment. The ecological assessment will focus on; lead (Pb), zinc (Zn), copper (Cu), nickel (Ni), manganese (Mn), vanadium (V), barium (B), cadmium (Cd), and silver (Ag).

Table 4.4 Number of Soil Samples Exceeding Ecological Standards for Plants, Mammals, and Avian Wildlife

Element	# of samples above Plant Risk	# of samples above Avian Wildlife Risk	# of samples above Mammal Risk
Pb	73	82	76
Zn	77	82	82
Cu	52	82	71
Ni	63	2	6
Mn	59	20	23
V	N/A	79	0
Ba	N/A	N/A	36
Cd	21	44	44
Ag	0	56	44

With the three COCs of focus for the human health risk assessment, a quantitative analysis of the accuracy of the XRF results began. Acid digestion took place in order to prepare 20 samples for Flame Atomic Adsorption Spectroscopy (FAAS) analysis in the NAU Chemistry Lab. Twenty samples for arsenic and 10 samples for manganese were contracted out to Western Technologies, Inc. for FAAS also. The results will be correlated with the XRF data for quality assurance with the collected data.

4.5 Confirmatory Testing and Analysis

EPA method 3050B volatilizes all the selected contaminants in soil and condenses them into a liquid form so the sample is prepared for Flame Atomic Absorption Spectrometry (FAAS) following ASTM E1613-12. Samples chosen for digestion were determined by sorting the lead XRF data from least to greatest. Since 82 samples were collected, every fourth sample analyzed from the organized data was selected for testing for a total of 20 samples. Table 4.5 below shows the samples chosen and the concentrations of the samples. These samples were selected to provide a wide range of contamination so that a strong correlation can be drawn after FAAS analysis.

Table 4.5 Pb Samples Selected for Acid Digestion

Sample	Pb Concentration from XRF Data (ppm)
SM B2	28
SM B3	116
SMG 75	163
SMG 13	336
SMG 10	681
SMG 71	852
SMG 3	1,272
SMG 37	1,774
SMG 7	1,998
SMG 20	2,756
SM H1	3,411
SMG 29	4,011
SMG 14	5,268
SMG 32	5,787
SMG 61	7,352
SMG 35	9,430
SMG 53a	13,563
SMG 33	15,430
SMG 28	21,954
SM H4	26,845

This method required two hot plates, eight condensers and eight flasks. As shown in Figure 4.4 below, the condensers were connected with rubber tubes to a water source. All of the flasks are filled first with nitric acid (HNO3) then 30% hydrogen peroxide (H2O2) and hydrochloric acid (HCl). The concept of adding HCl after HNO3 is to generate aqua regia via the reaction; $3HCl+HNO_3 \rightarrow 2\ H_2O+NOCl+Cl_2$ [3]. This aqua regia reaction will dissolve most of the base elements and provides a good recovery for contaminants of concern; especially lead (Pb) [3].

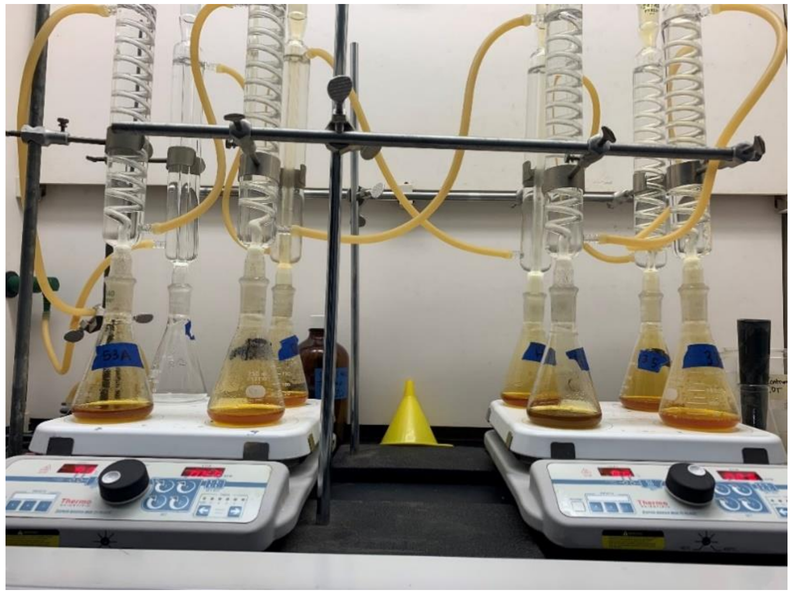


Figure 4.4 Setup for method 3050B under the fume hood.

After performing acid digestion, the samples were sent to Jeff Propster at Northern Arizona University to be analyzed by FAAS. The sample comparison between the XRF readings and the FAAS data generated are shown in Table 4.6. The scatter plot generated is available in Figure 4.5. The correlation showed a r-value of 0.9859. This correlation (y=0.9604x) was used to correct XRF lead data for further risk assessment. The data generate by Jeff Propster is available in Appendix F.

Table 4.6 Samples Comparison for Lead between XRF Readings and NAU Chemistry Lab

Sample #	XRF Reading (ppM)	FAAS Reading (ppm)
B2	28	56
B3	116	86
75	163	180
13	336	338
10	681	1146
71	852	1195
3	1,272	1195
37	1,774	2345
7	1,998	2484
20	2,756	3478
H1	3,411	5521
29	4,011	5618
14	5,268	6030
32	5,787	6599
61	7,352	6629
35	9,430	9242
53a	13,563	12176
33	15,430	15524
28	21,954	23334
H4	26,845	22865

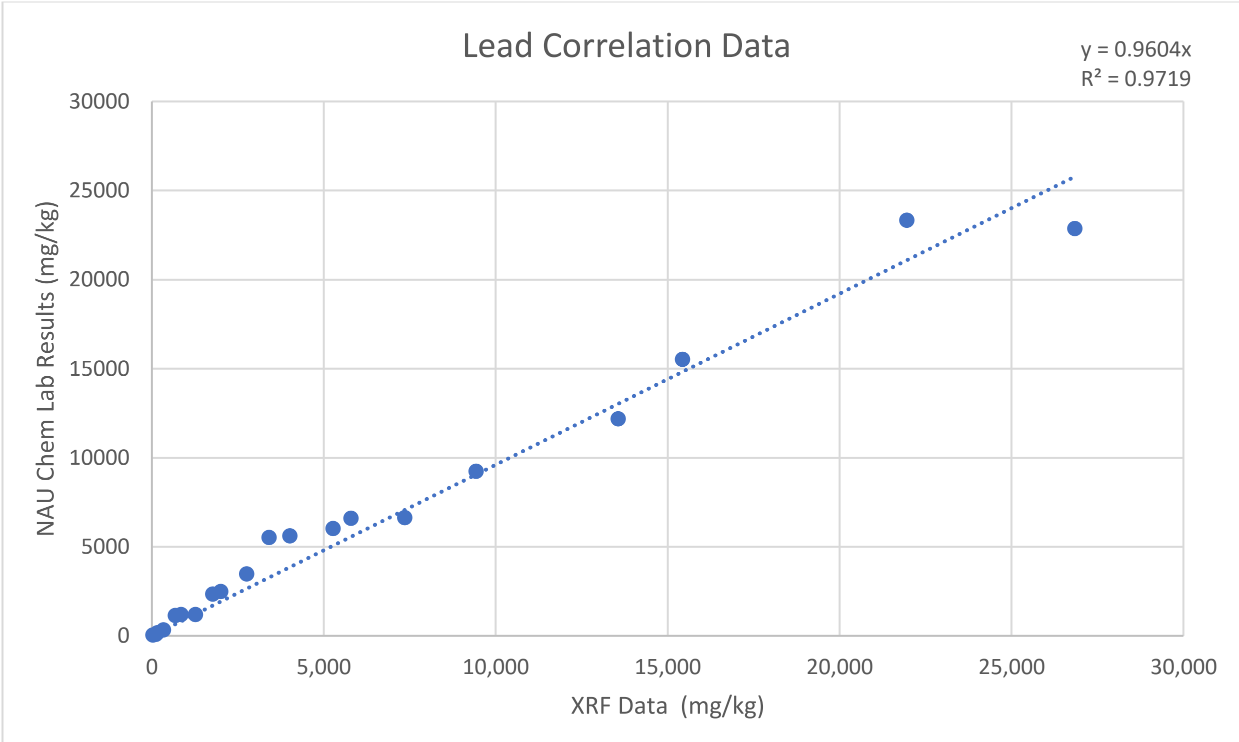


Figure 4.5 Lead Data Correlation Results between XRF and NAU Chemistry Lab

4.6 Results and Correlations

For arsenic and manganese the results from the XRF testing 20 samples for each were selected to be sent out to Western Technologies for FAAS analysis. The samples were chosen to reflect a wide range of contaminant levels so that a stronger correlation could be developed. Similarly to lead, samples were organized in Excel from least to greatest concentration. Then every fourth sample was chosen.

For arsenic, Table 4.7 outlines the samples that were selected to be sent to Western Technologies and compares the results from the XRF readings and the data generated by Western Technologies. Data sheets provided by Western Technologies are available in Appendix E.

Table 4.7 Samples Comparison for Arsenic between XRF Readings and Western Technologies Findings

Sample	XRF Reading (ppm)	FAAS Reading (ppm)
SMG 71	0	6.8
SMG 73	8	3.1
SMG 62	9	4.38
SMG 17	9	10.8
SMG 67	10	2.89
SMG 80	11	6.29
SMG 7	13	9.03
SMG 72	14	8.34
SMG 64	14	4.78
SMG 5	17	9.93
SMG 69	19	3.64
SMG 16	23	11.6
SMG 45	27	11.5
SMG 3	32	7.61
SMG 2	39	10.9
SMG 36	44	17.4
SMG 9	68	8.55
SMG 31	97	31.7
SMG 47	111	10.2
SMG 52	181	12.7

The data from the XRF results and Western Technologies readings was plotted using Excel. The scatter plot formed from this analysis is shown in Figure 4.6. The x-axis on the scatter plot shows the XRF readings while the y-axis shows the Western Technologies results. To correlate the data a trend line that was forced through zero was applied to the plot and the linear equation and r-squared value was added. The initial readings from this test gave a r-value of 0.6928.

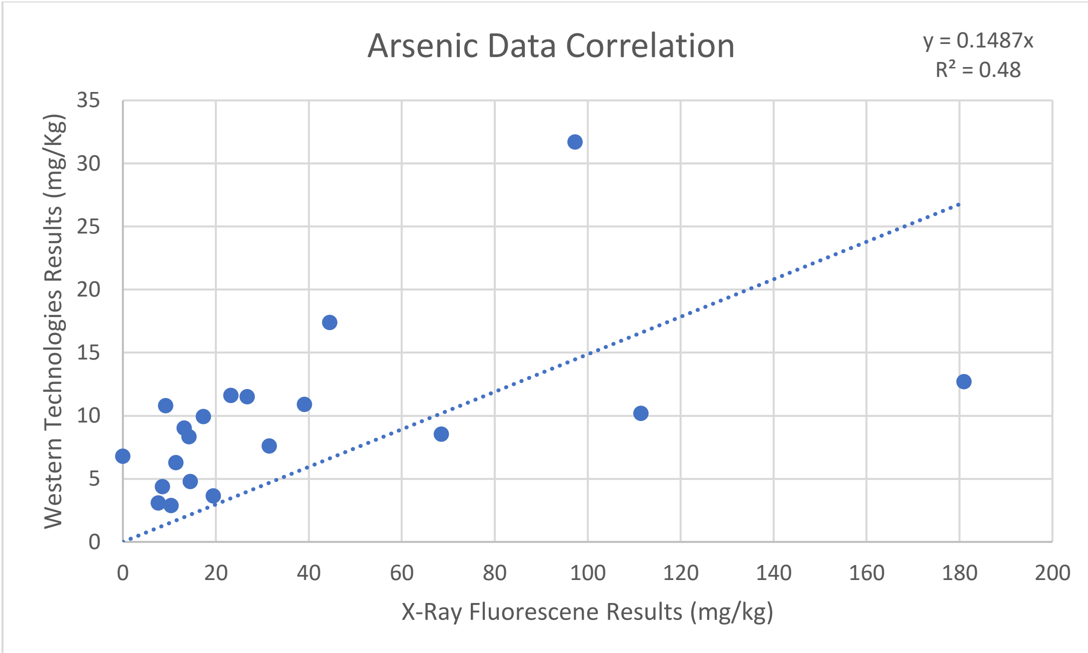


Figure 4.6 Original Arsenic Data Correlation Results between XRF and Western Technologies

The correlation value derived from the initial results for Arsenic was low. After review of the data with the team's technical advisor it was suggested that XRF interferences should be researched. It was found that XRF analysis for arsenic in the presence of lead elevates the readings for arsenic. This happens because lead produces two strong spectral peaks at energy 10.5 keV and at 12.6 keV [5]. Generally, the lead peak at 12.6 keV is used for lead analysis, however arsenic spectral peaks are also read at the energy 10.5 keV. Thus, elevated lead concentration produced interference that overlaps with the arsenic spectral peak. This ultimately reduces the arsenic reading precision on XRF devices [5]. To evaluate this lead concentrations were plotted with the arsenic data. This can be seen in Table 4.8 which adds the lead concentrations to the data correlation.

Table 4.8 Samples Comparison for Arsenic between XRF Readings and Western Technologies Findings with Lead Concentrations

Sample	XRF Reading (ppm)	FAAS Reading (ppm)	XRF Lead Concentration (ppm)
SMG 71	0	6.8	52
SMG 73	8	3.1	149
SMG 62	9	4.38	195
SMG 17	9	10.8	1678
SMG 67	10	2.89	42
SMG 80	11	6.29	37
SMG 7	13	9.03	1998
SMG 72	14	8.34	52
SMG 64	14	4.78	227
SMG 5	17	9.93	1828
SMG 69	19	3.64	124
SMG 16	23	11.6	2262
SMG 45	27	11.5	11206
SMG 3	32	7.61	1272
SMG 2	39	10.9	1102
SMG 36	44	17.4	2923
SMG 9	68	8.55	5042
SMG 31	97	31.7	2468
SMG 47	111	10.2	14840
SMG 52	181	12.7	30033

The data was assessed and XRF readings with high levels of lead were removed from the correlation. The samples that were removed include SMG 52, SMG 47, SMG 45, SMG 36, and SMG 9. Data selected for removal was aided by the team's technical advisor. With the removal of these points a new scatter plot was formed and can be seen in Figure 4.7. This new chart produced a r-value of 0.8387 which confirmed the lead interference with the arsenic readings from the XRF device. This correlation (y=0.3393x) was used to correct XRF arsenic data for further risk assessment.

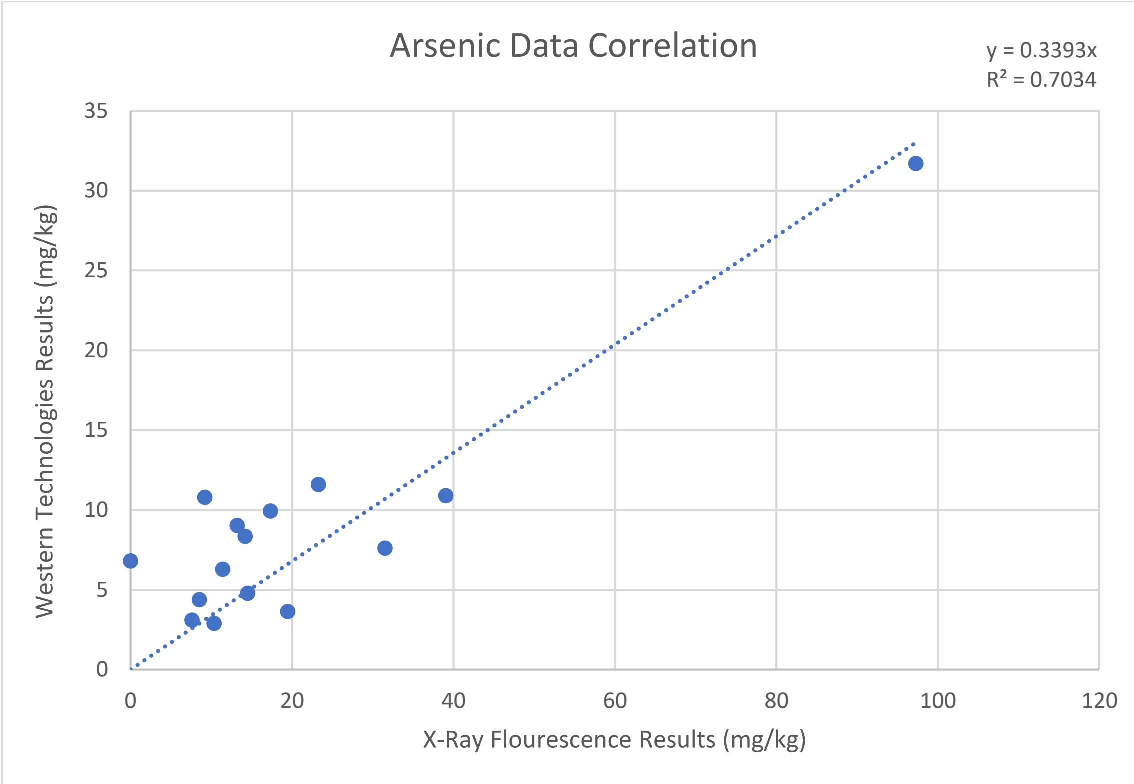


Figure 4.7 Corrected Arsenic Data Correlation Results between XRF and Western Technologies

Similarly for manganese, Table 4.9 shows the samples selected and compares the XRF and FAAS data. The data sheets generated by Western Technologies is available in Appendix E. The scatter plot formed from the analysis is shown below in Figure 4.8. The r-value generated from the correlation was 0.9512. This correlation and trendline equation (y=0.7028x) was used to correct the XRF manganese data for further risk assessment.

Table 4.9 Samples Comparison for Manganese between XRF Readings and Western Technologies Findings

Sample	XRF reading (ppm)	FAAS Reading (ppm)
SM B2	373	228
SMG 75	838	704
SMG 60	1,334	1690
SMG 3	1,659	1370
SMG 54	2,040	3160
SMG 40	2,683	2240
SMG 41	3,620	2790
SMG 29	4,931	7440
SMG 53a	11,926	13000
SM H2	36,342	23300

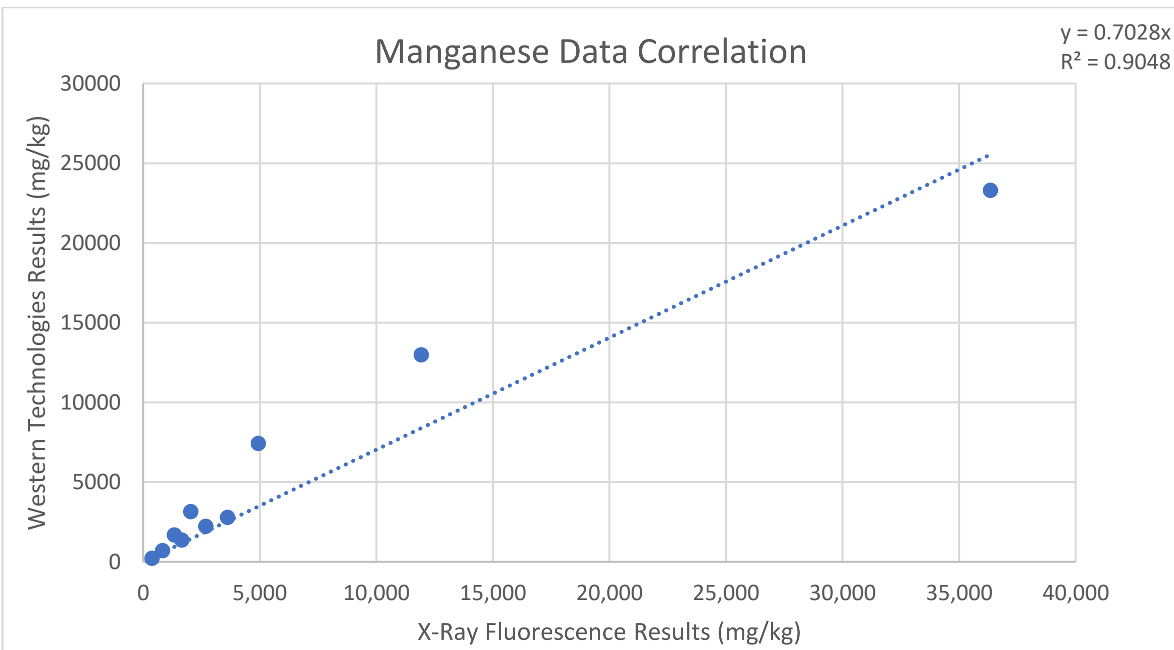


Figure 4.8 Manganese Data Correlation Results between XRF and Western Technologies

The adjusted XRF readings for manganese, arsenic, and lead are available in Appendix G-I.

4.6.1 Human Health Risk Maps

Every element that was analyzed by the handheld XRF produced a value, in parts per million (ppm), and once the data had been averaged, was the overall concentration of that element for each sample. These concentrations were then plotted on the map of the site to show where the higher concentrations are for human health in comparison to the site, pile of mine tailings, and the Big Sandy River that flows by the site.

Figure 4.9 below is the map of lead concentrations based off of the AZ Soil Remediation Standards for human health criteria. Red dots symbolize that the concentration was over the non-residential standard of 800 ppm, yellow dots symbolize that the concentration was over the residential standard of 400 ppm, and green dots symbolize that the concentration was below the residential standard.

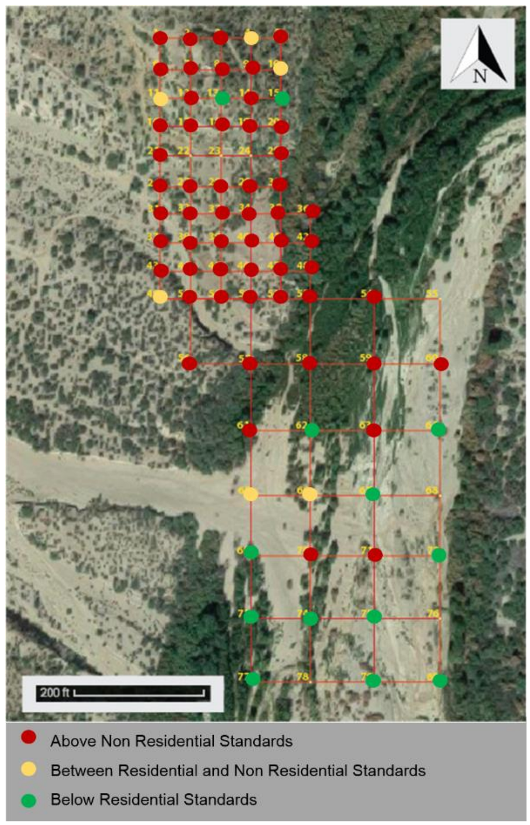


Figure 4.9 Results for Lead (HH Criteria)

Figure 4.10 below is the map of arsenic concentrations based off of the AZ Soil Remediation Standards for human health criteria. Red dots symbolize that the concentration was over the non-residential and residential standard of 10 ppm, and green dots symbolize that the concentration was below the residential standard.

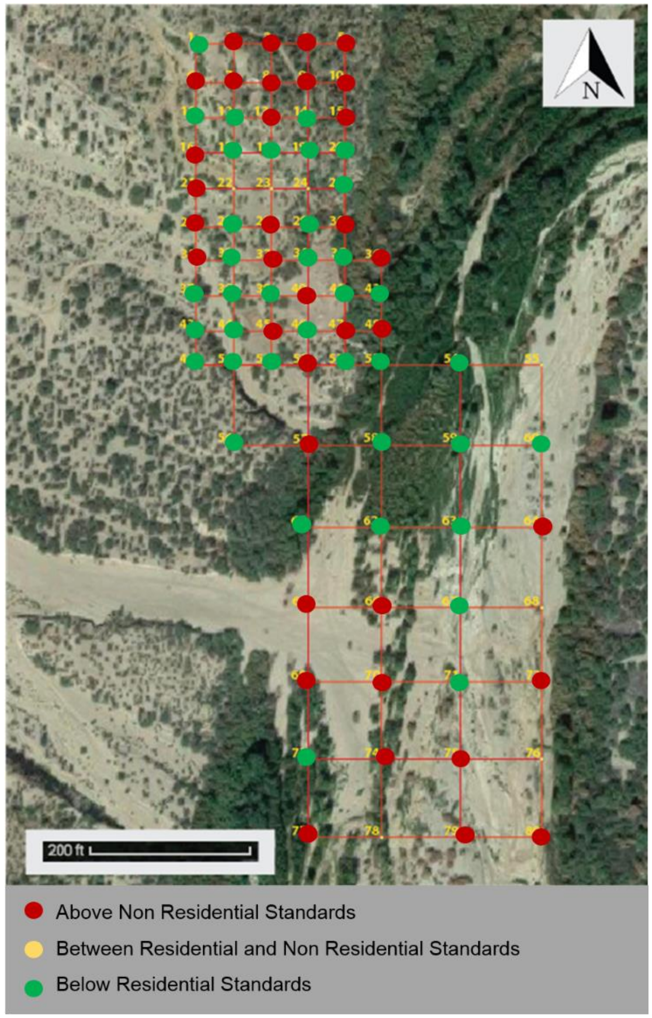


Figure 4.10 Results for Arsenic (HH Criteria)

Figure 4.11 below is the map of manganese concentrations based off of the AZ Soil Remediation Standards for human health criteria. Red dots symbolize that the concentration was over the non-residential standard of 3,200 ppm, yellow dots symbolize that the concentration was over the residential standard of 43,000 ppm, and green dots symbolize that the concentration was below the residential standard.

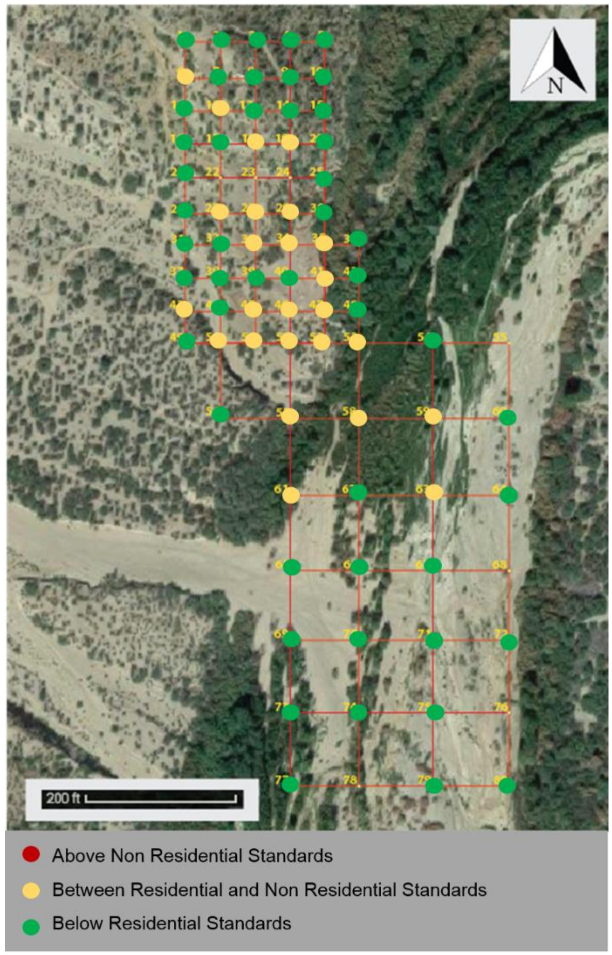


Figure 4.11 Results for Manganese (HH Criteria)

Figure 4.12 below is the map of arsenic concentrations based off of the AZ Soil Remediation Standards for human health criteria. Red dots symbolize that the concentration was over the non-residential and residential standard of 10 ppm, and green dots symbolize that the concentration was below the residential standard.

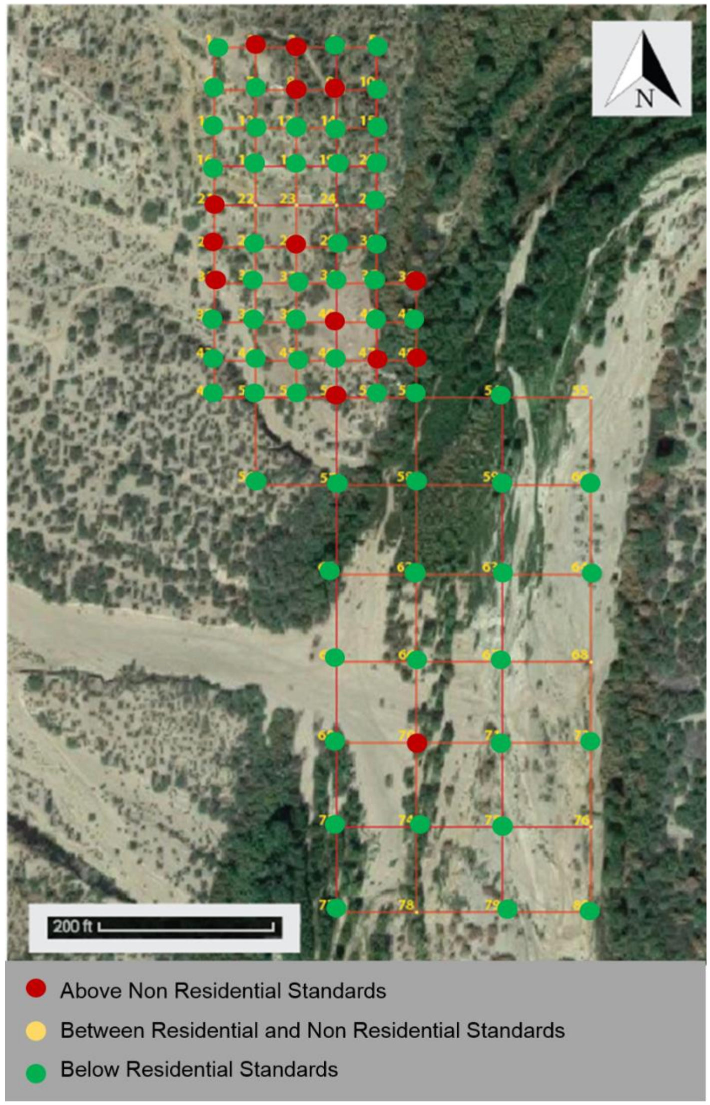


Figure 4.12 Results of Correlated Arsenic Data

Figure 4.13 below is the map of manganese concentrations based off of the AZ Soil Remediation Standards for human health criteria. Red dots symbolize that the concentration was over the non-residential standard of 3,200 ppm, yellow dots symbolize that the concentration was over the residential standard of 43,000 ppm, and green dots symbolize that the concentration was below the residential standard.

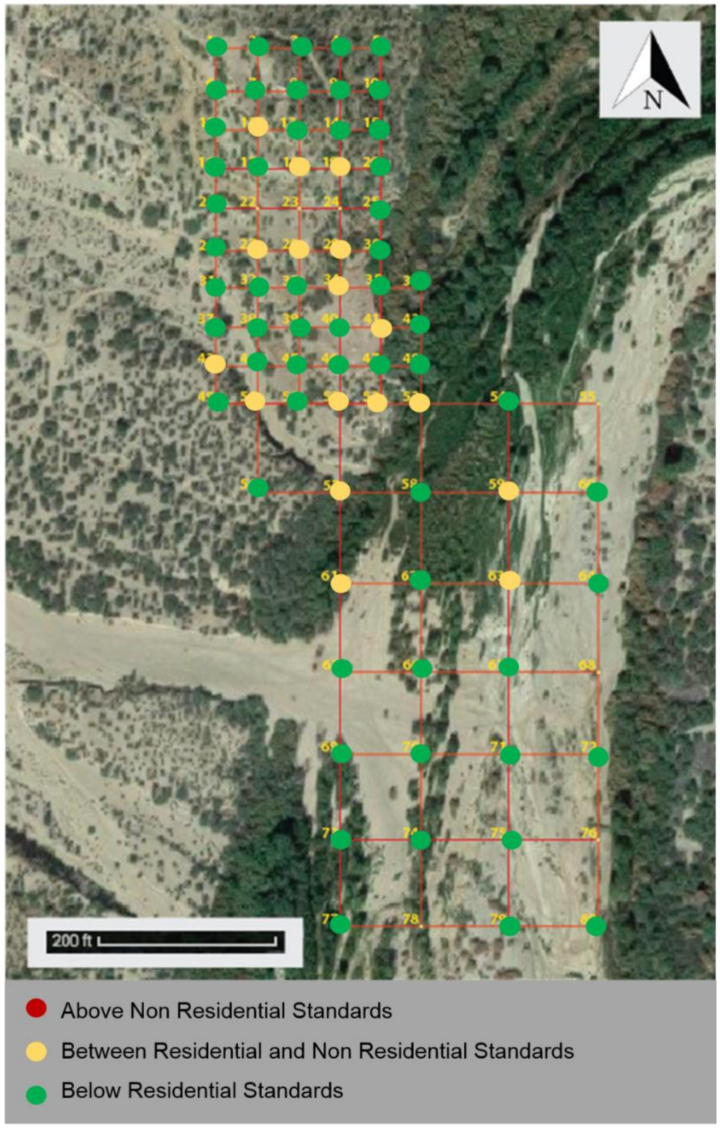


Figure 4.13 Results of Correlated Manganese Data

Figure 4.14 below is the map of lead concentrations based off of the AZ Soil Remediation Standards for human health criteria. Red dots symbolize that the concentration was over the non-residential standard of 800 ppm, yellow dots symbolize that the concentration was over the residential standard of 400 ppm, and green dots symbolize that the concentration was below the residential standard.

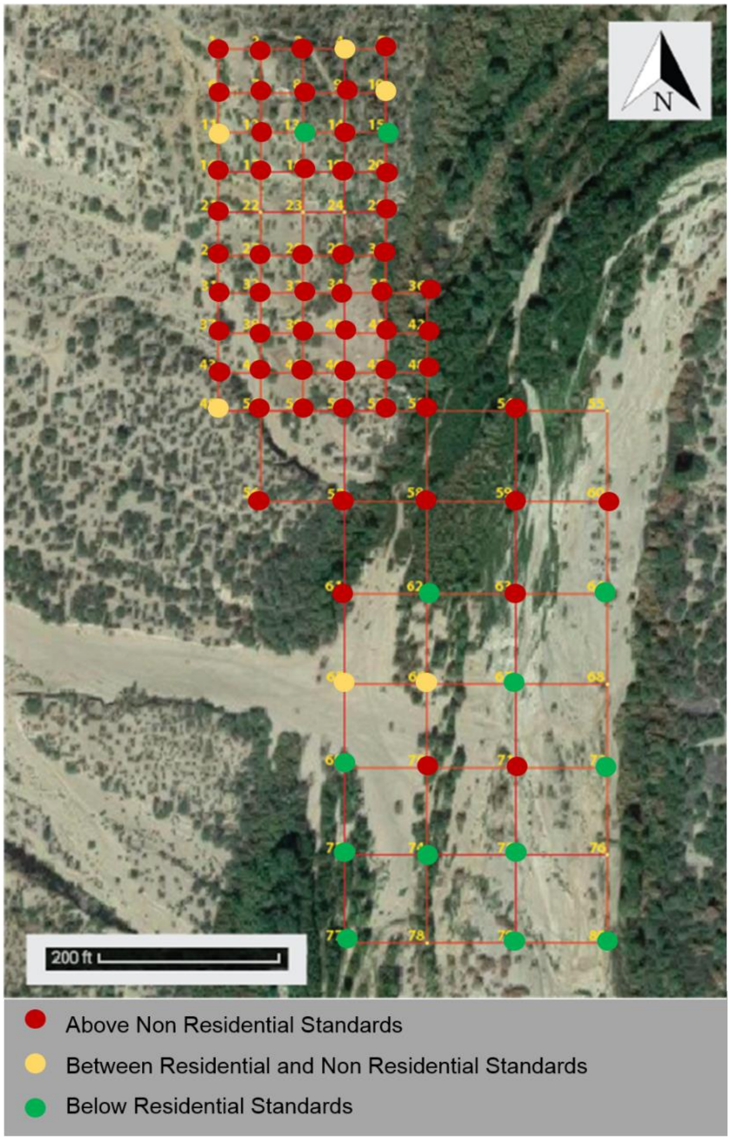


Figure 4.14 Results of Correlated Lead Data

4.6.2 Ecological Risk Maps

Figure 4.15 below is the map of lead concentrations based off of the EPA Ecological Standards for plants, mammals, and avian wildlife criteria. These standards are different for each biota because the contaminants can start adversely affecting them at the levels specified by the EPA. Red dots symbolize that the concentration was over the plant standard of 120 ppm, orange dots symbolize that the concentration was over the mammal standard of 56 ppm, yellow dots symbolize that the concentration was over the avian wildlife standard of 11 ppm, and green dots symbolize that the concentration was below all of the standards.

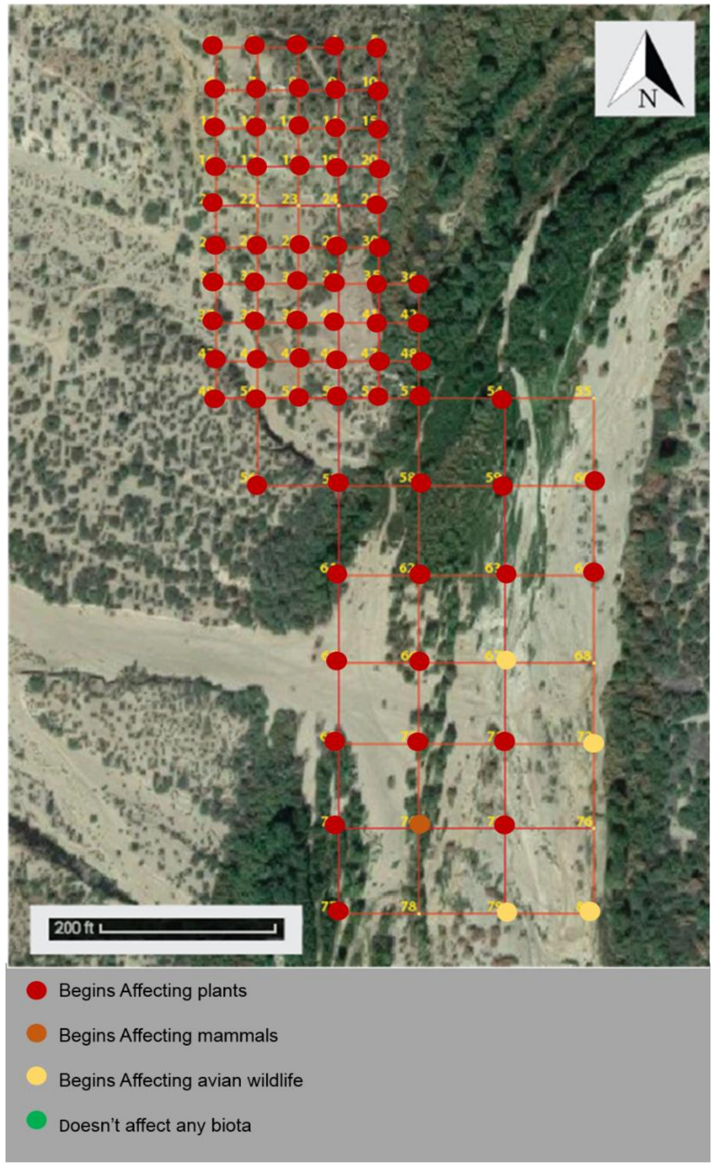


Figure 4.15 Results of Lead (Eco Criteria)

Figure 4.16 below is the map of zinc concentrations based off of the Ecological Standards for plants, mammals, and avian wildlife criteria. Red dots symbolize that the concentration was over the plant standard of 160 ppm, orange dots symbolize that the concentration was over the mammal standard of 79 ppm, yellow dots symbolize that the concentration was over the avian wildlife standard of 46 ppm, and green dots symbolize that the concentration was below all of the standards.

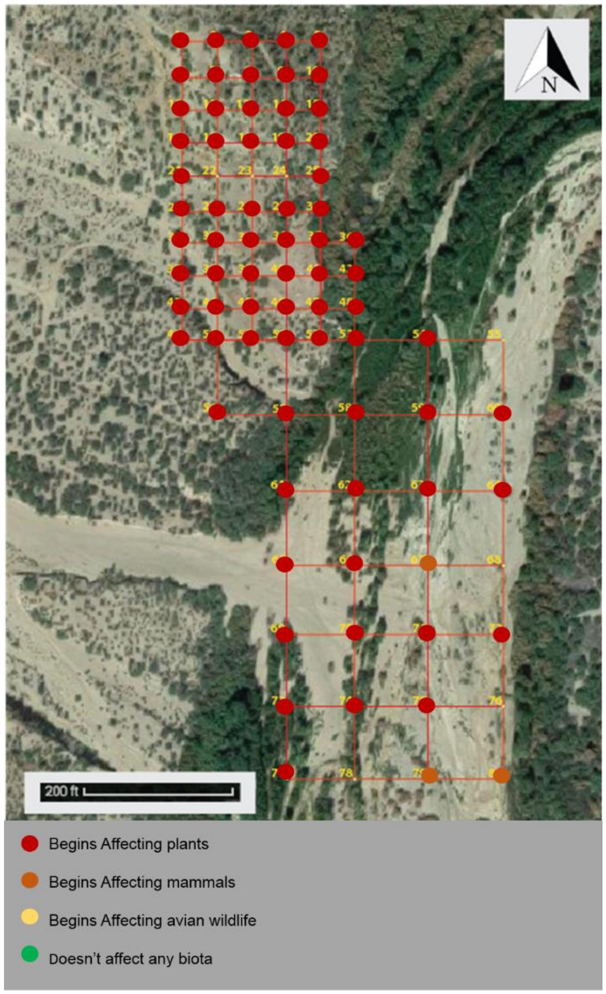


Figure 4.16 Results for Zinc (Eco Criteria)

Figure 4.17 below is the map of copper concentrations based off of the Ecological Standards for plants, mammals, and avian wildlife criteria. Red dots symbolize that the concentration was over the plant standard of 70 ppm, orange dots symbolize that the concentration was over the mammal standard of 49 ppm, yellow dots symbolize that the concentration was over the avian wildlife standard of 28 ppm, and green dots symbolize that the concentration was below all of the standards.

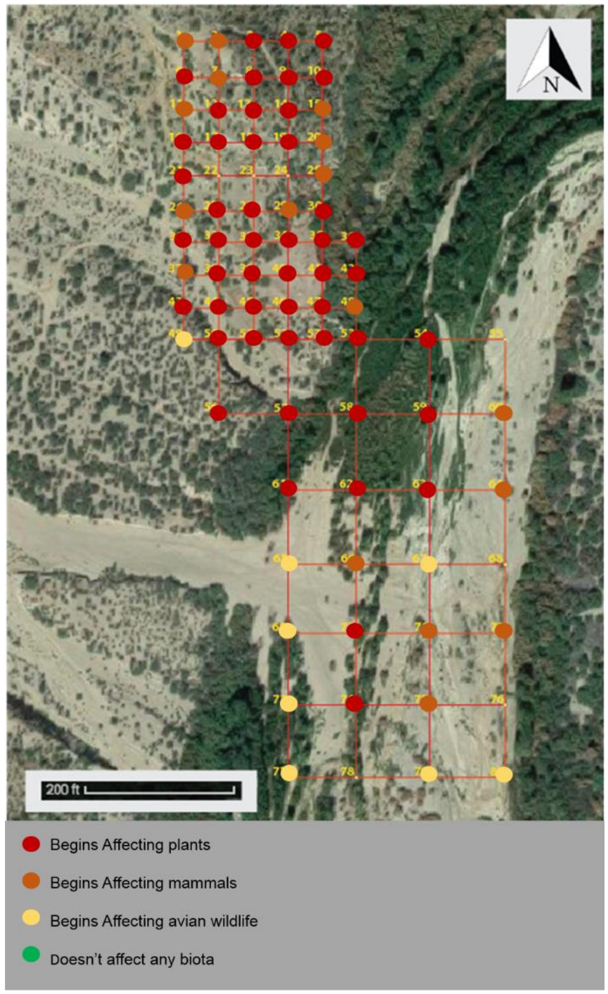


Figure 4.17 Results of Copper (Eco Criteria)

Figure 4.18 below is the map of vanadium concentrations based off of the Ecological Standards for plants, mammals, and avian wildlife criteria. Red dots symbolize that the concentration was over the mammal standard of 280 ppm, orange dots symbolize that the concentration was over the avian wildlife standard of 7.8 ppm, and green dots symbolize that the concentration was below all of the standards. Vanadium did not have any standard levels for plants to compare the XRF data too in order to determine the risk to those biota.

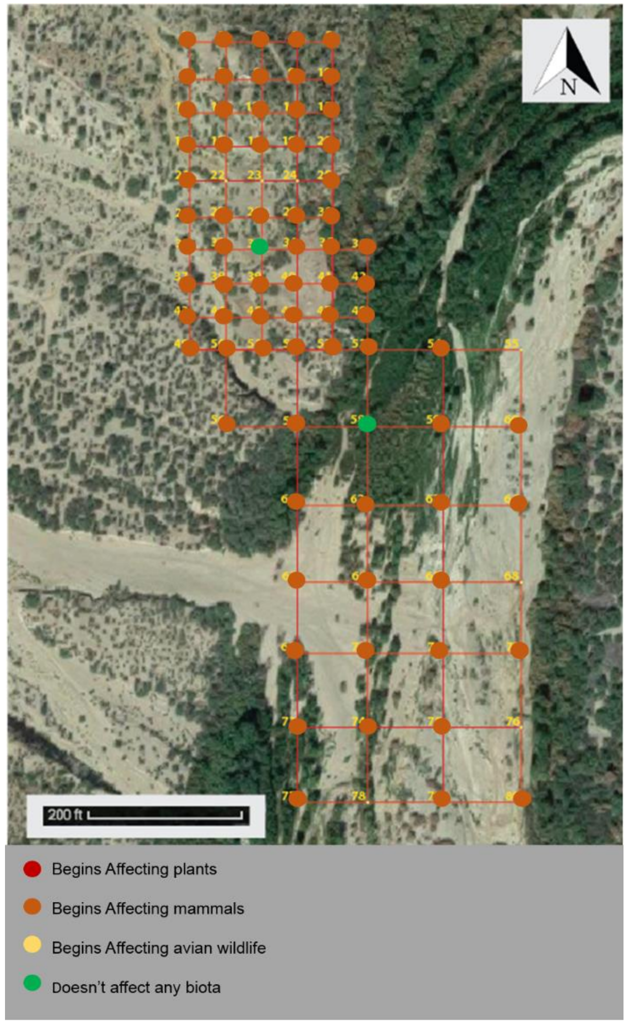


Figure 4.18 Results of Vanadium (Eco Criteria)

Figure 4.19 below is the map of manganese concentrations based off of the Ecological Standards for plants, mammals, and avian wildlife criteria. Red dots symbolize that the concentration was over the avian wildlife standard of 4300 ppm, orange dots symbolize that the concentration was over the mammal standard of 4000 ppm, yellow dots symbolize that the concentration was over the plant standard of 220 ppm, and green dots symbolize that the concentration was below all of the standards.

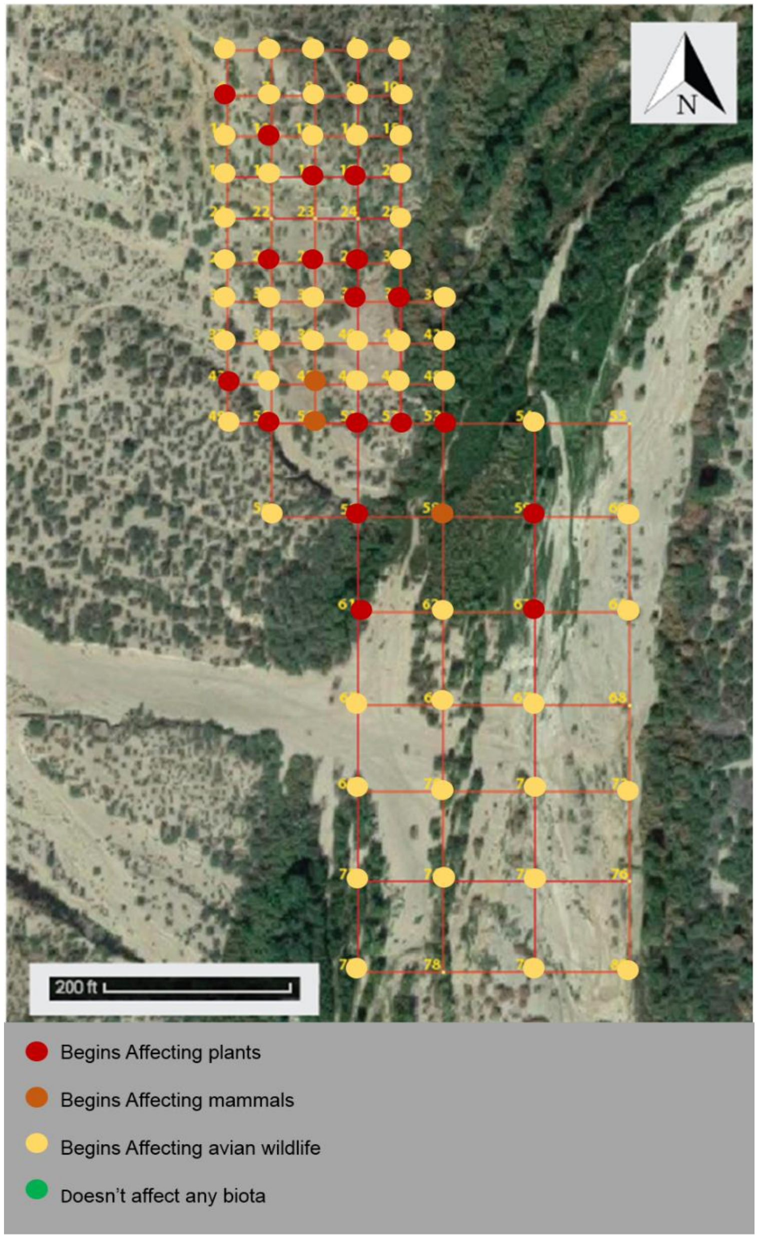


Figure 4.19 Results for Manganese (Eco Criteria)

Figure 4.20 below is the map of cadmium concentrations based off of the Ecological Standards for plants, mammals, and avian wildlife criteria. Red dots symbolize that the concentration was over the plant standard of 32 ppm, orange dots symbolize that the concentration was over the avian wildlife standard of 0.77 ppm, yellow dots symbolize that the concentration was over the mammal standard of 0.36 ppm, and green dots symbolize that the concentration was below all of the standards.

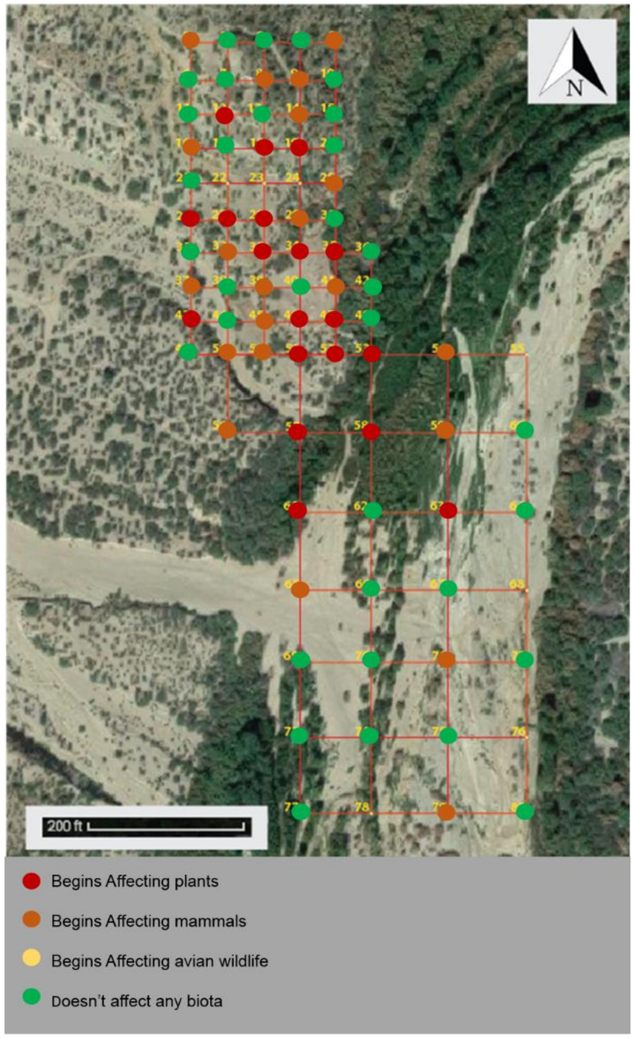


Figure 4.20 Results for Cadmium (Eco Criteria)

Figure 4.21 below is the map of barium concentrations based off of the Ecological Standards for plants, mammals, and avian wildlife criteria. Red dots symbolize that the concentration was over the mammal standard of 2000 ppm and green dots symbolize that the concentration was below all of the standards. Barium did not have any standard levels for plants or avian wildlife to compare the XRF data too in order to determine the risk to those biota.

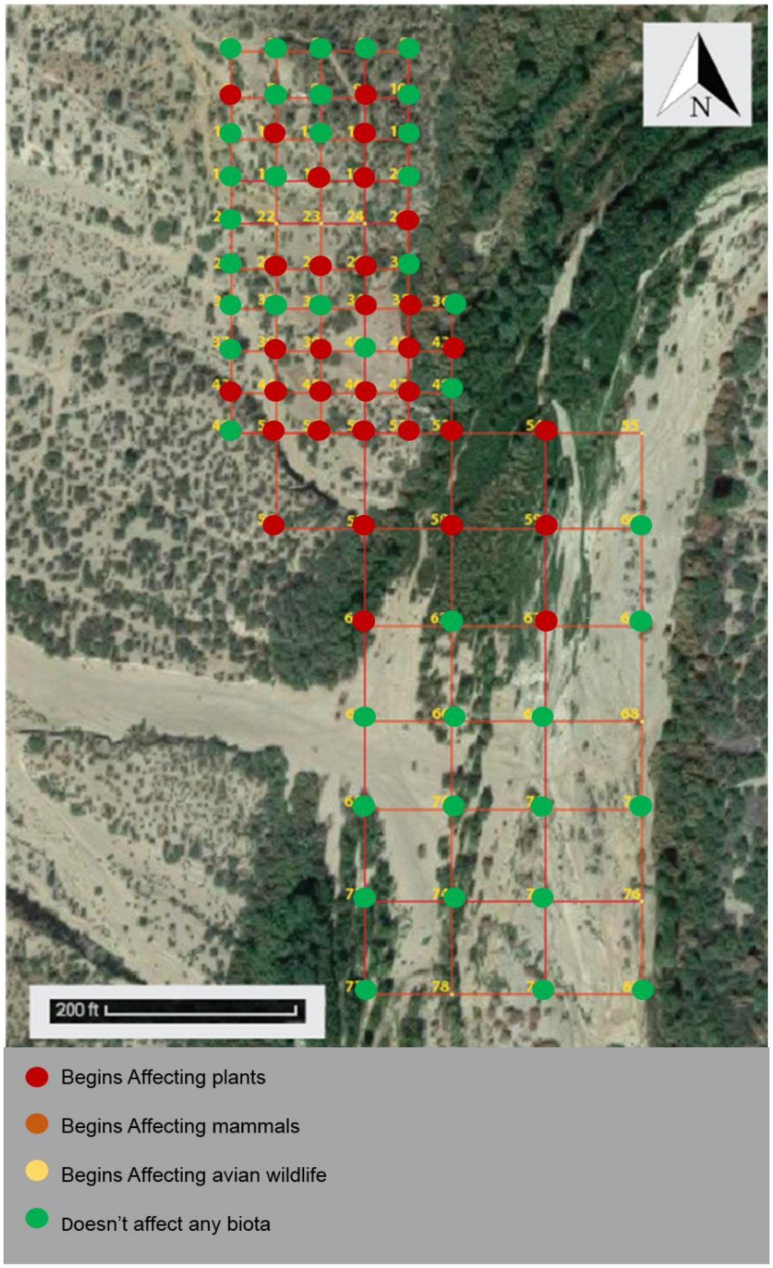


Figure 4.21 Results of Barium (Eco Criteria)

Figure 4.22 below is the map of silver concentrations based off of the Ecological Standards for plants, mammals, and avian wildlife criteria. Red dots symbolize that the concentration was over the plant standard of 560 ppm, orange dots symbolize that the concentration was over the mammal standard of 14 ppm, yellow dots symbolize that the concentration was over the avian wildlife standard of 4.2 ppm, and green dots symbolize that the concentration was below all of the standards.

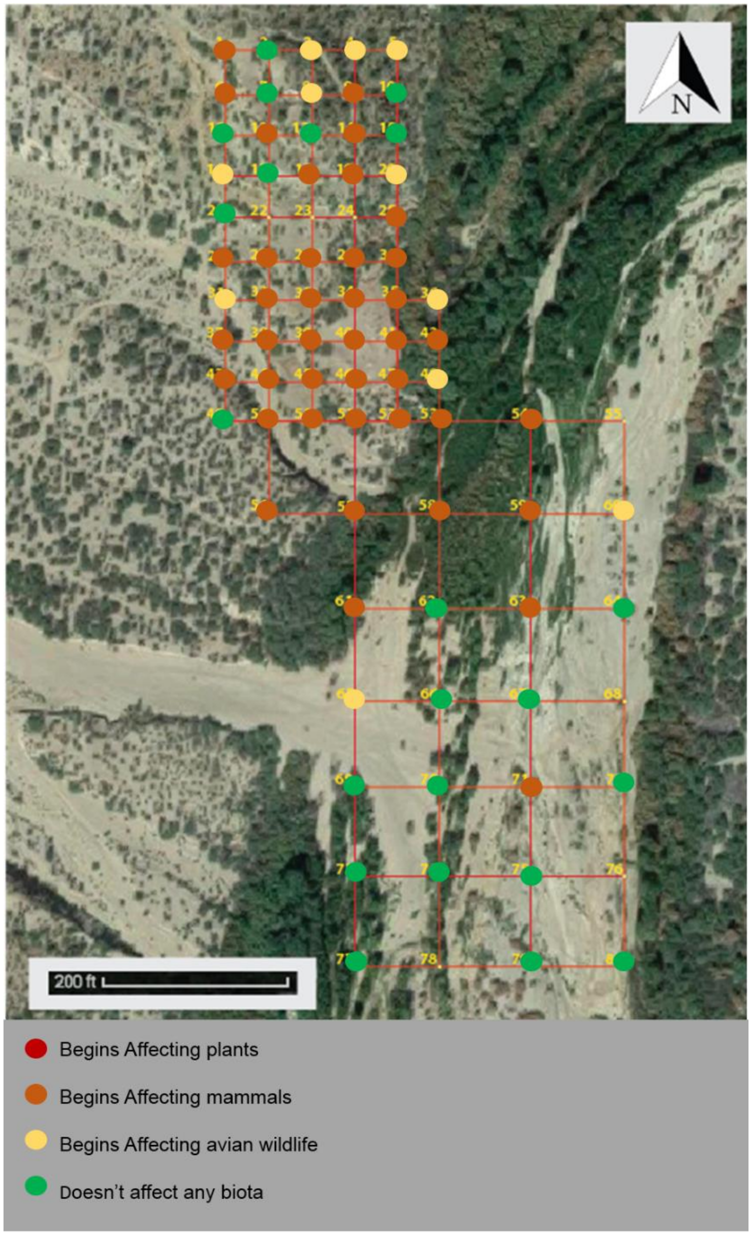


Figure 4.22 Results for Silver (Eco Criteria)

5.0 Risk Assessment

From the XRF analysis, the main contaminants of concern (COCs) were determined for both the human and ecological risk assessments. Human health focused on lead, arsenic, and manganese while the ecological assessment focused on; lead, zinc, copper, vanadium, manganese, nickel, barium, cadmium, and silver.

5.1 Data Distribution and Determination of Exposure Point Concentrations

The adjusted XRF data was utilized to create distributions for each element. This information is presented in Figures 5.1 - 5.3.

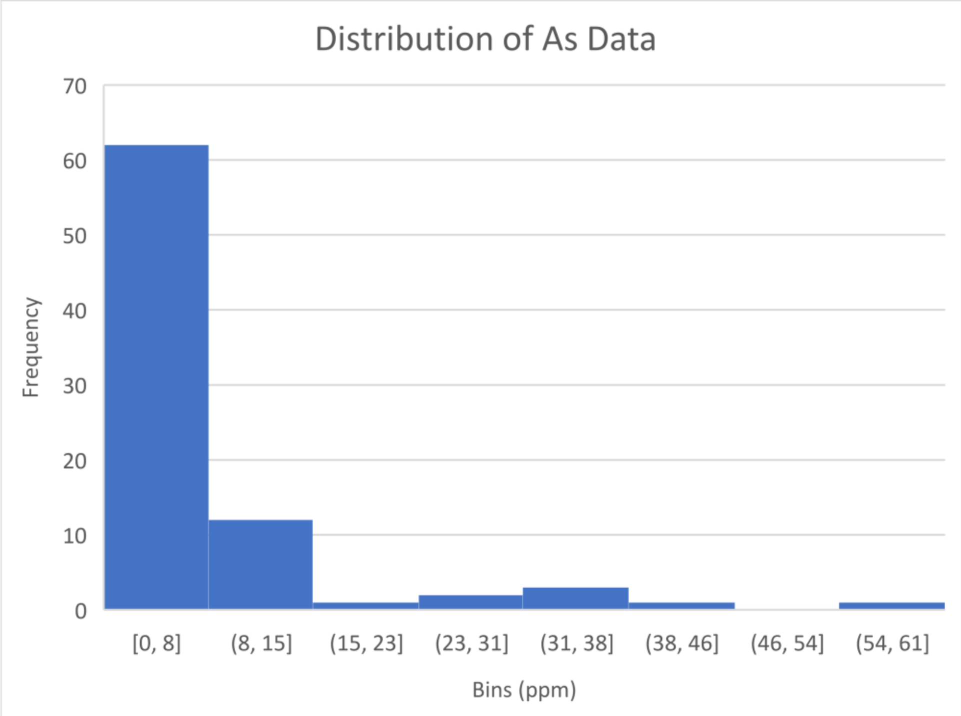


Figure 5.1 Distribution of Arsenic Data

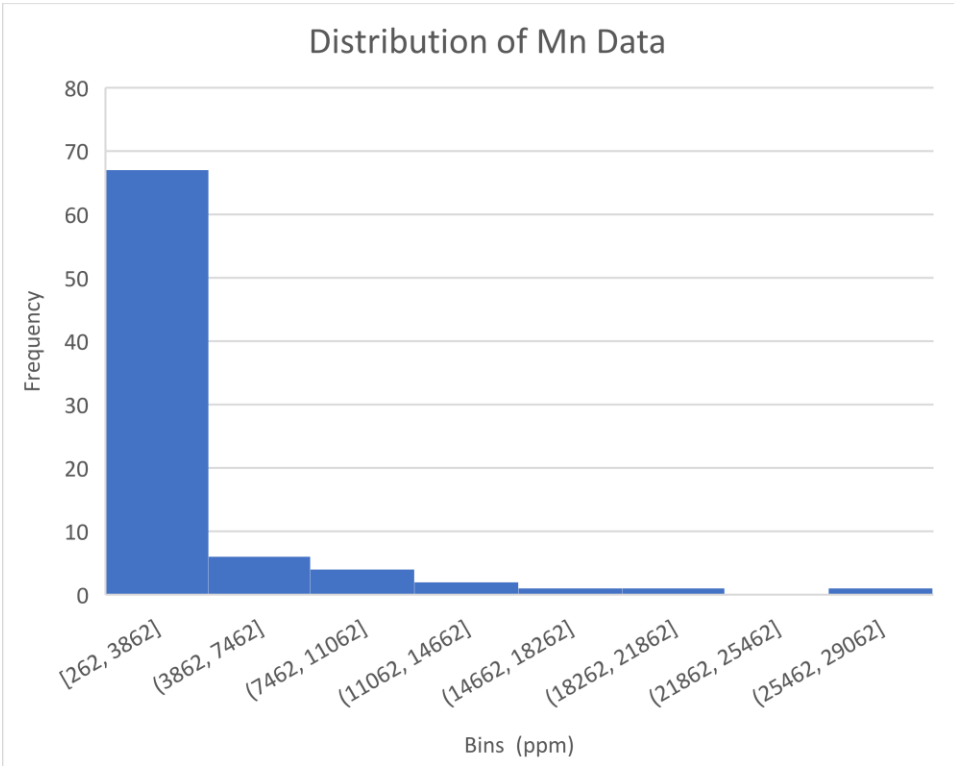


Figure 5.2 Distribution of Manganese Data

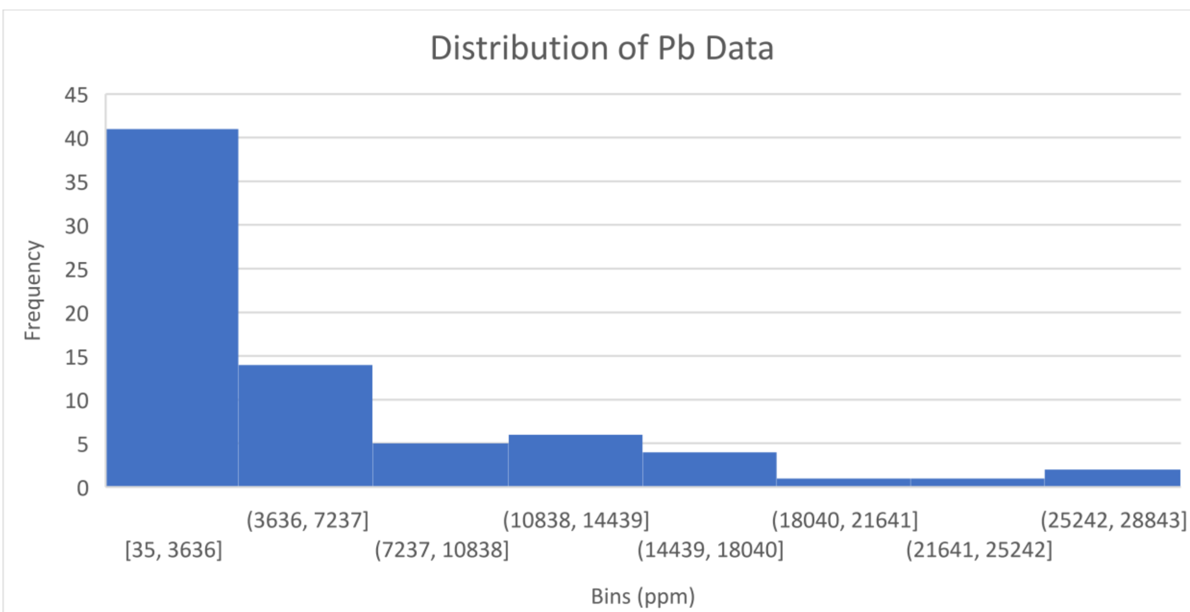


Figure 5.3 Distribution of Lead Data

Due to the irregular distributions of the data, the data was transformed by taking the natural log of the adjusted value. The natural log values were utilized to create a natural log distribution for manganese, arsenic, and lead. These distributions are shown in Figures 5.4 – 5.6.

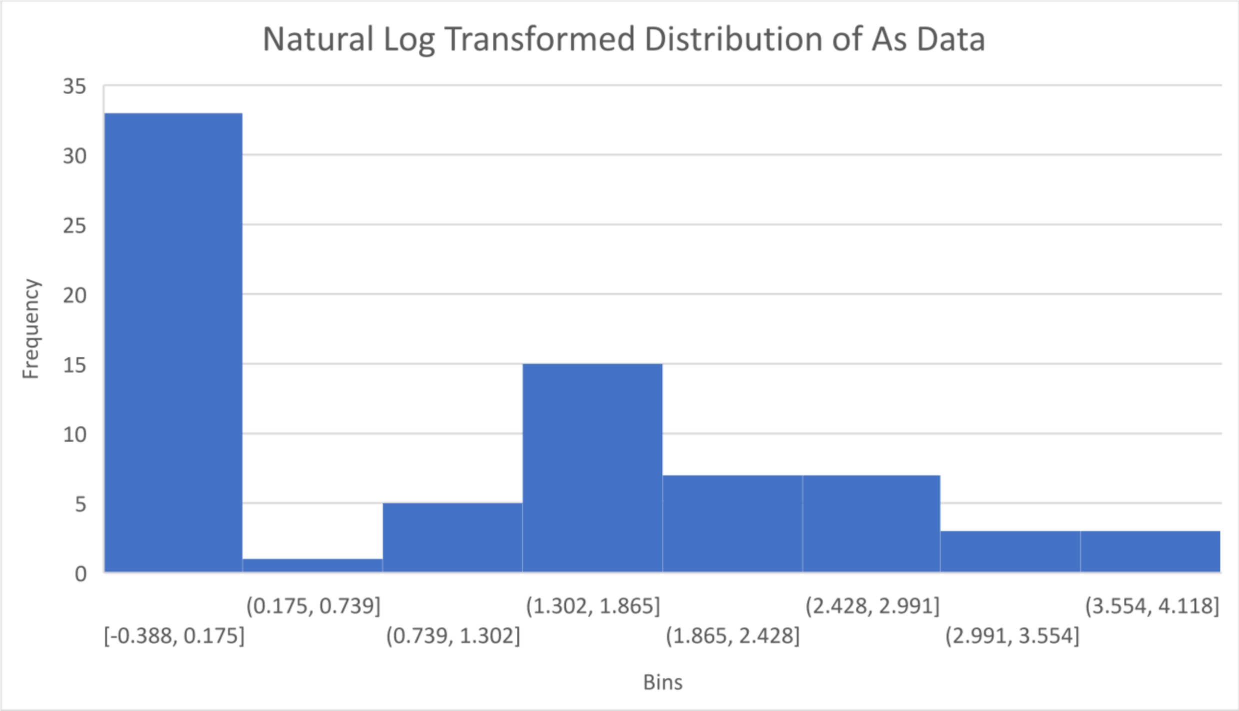


Figure 5.4 Natural Log Distribution of Arsenic Data

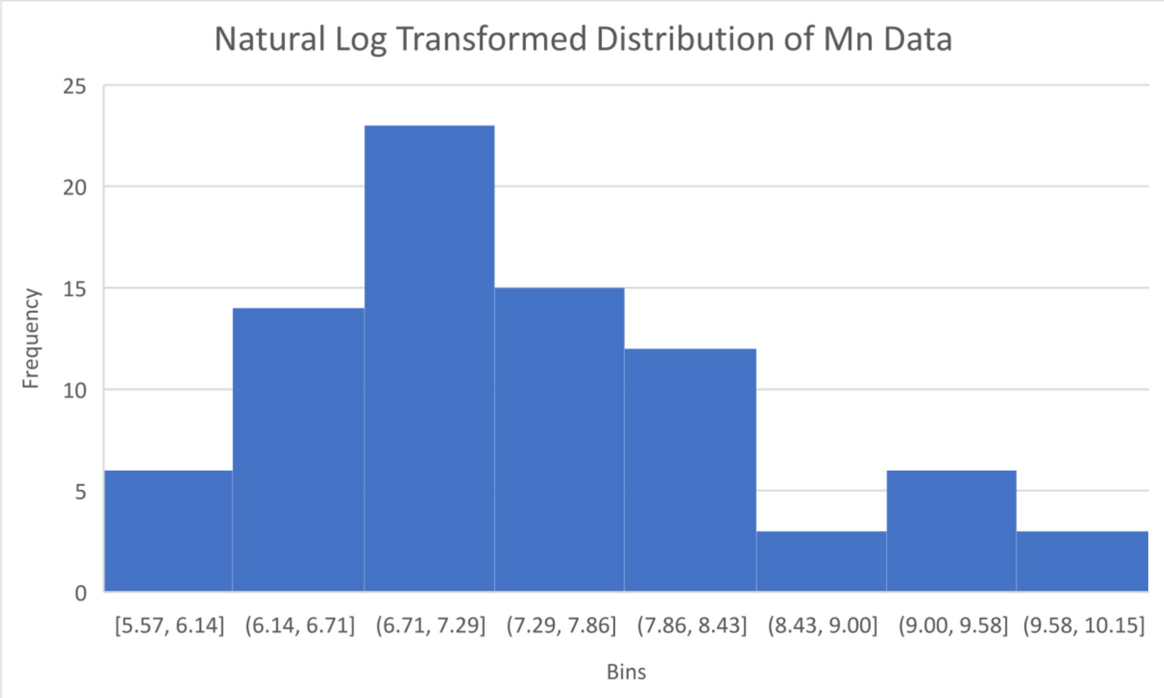


Figure 5.5 Natural Log Distribution of Manganese Data

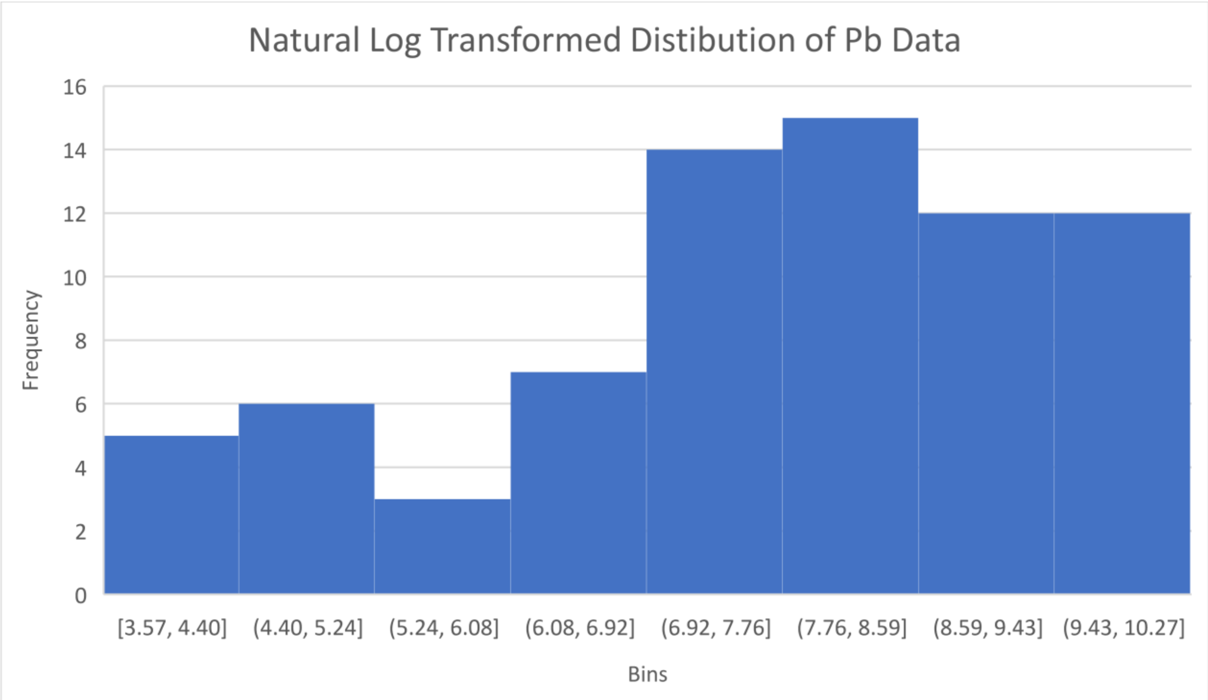


Figure 5.6 Natural Log Distribution of Lead Data

The natural log transformed for each contaminant reflected a more normal distribution. These distributions were utilized to determine the exposure point concentrations for the contaminants. The 50% exposure point concentration was determined geometric mean. To determine the 95% exposure point concentrations, the modified Cox method was utilized on the natural log transformed data set, and then unlogged to get the 95% exposure point concentration [6]. The equation used to determine the 95% exposure point concentration is shown in Equation 5.1.

Equation 5.1 95% Exposure Point Concentration Modified Cox Method [6]

$$95\%\ EPC = AVG + \frac{S^2}{2} + 2\sqrt{\frac{S^2}{n} + \frac{S^4}{2(n-1)}}$$

Where:

AVG: average

S: population standard deviation

n: sample size

The 95% EPC, 50% EPC, standard deviation, and average for the contaminants of concern are summarized below in Table 5.1.

Table 5.1 50% and 95% EPC for COC's

Contaminant	50% EPC (mg/kg)	95% EPC (mg/kg)
Manganese	1662.5	3298.7
Arsenic	3.2	10.1
Lead	2023.4	16425.6

5.2 Human Health Risk Assessment

Human health risk can be evaluated for carcinogenic and non-carcinogenic risk, depending on the nature of the contaminant. Lead and arsenic pose a carcinogenic and non-carcinogenic risk to humans while manganese only poses a non-carcinogenic risk.

For the analysis of both carcinogenic and non-carcinogenic risk, the Chronic Daily Intakes (CDI) must be calculated for soil ingestion based on the EPA Human Health Evaluation Standards for Superfund. The formula to determine CDI is provided below.

Equation 5.2 Chronic Daily Intake [7]

$$CDI = \frac{(CS)(IR)(CF)(FI)(EF)(ED)}{(BW)(AT)}$$

Where:

*CDI: chronic daily intake (mg/[kg*day])*

CS: chemical concentration in soil (mg/kg)

IR: ingestion rate (mg soil/day)

CF: conversion factor for soil 10^{-6} *kg/mg*

FI: fraction ingested = 1 (unitless)

EF: exposure frequency (days/year)

ED: exposure duration (years)

BW: body weight (kg)

AT: averaging time (days)

Some of the variables in this formula are taken from the EPA recommended values for estimating ingestion, which is based on extensive studies of the American population [11]. These values include body weight (BW) and ingestion rate (IR). The body weights used were averages for a standard adult and a child of 6 to 12 years of age. The ingestion rates for soil were evaluated at both the average value and the upper percentile of the data collected by the EPA. The fraction ingested (FI) and conversion factors (CF) are constants, and the exposure duration (ED), exposure frequency (EF), and averaging time (AT) vary based on the scenario used. Finally, the chemical concentration in soil (CS), also known as the exposure point concentration (EPC), was evaluated based on the data obtained in the lab. A 50% and a 95% risk was calculated for each contaminant. All of these variables are used to calculate the chronic daily intake (CDI) for two identified scenarios which are realistic to Signal Mill.

The first exposure scenario was a recreational use scenario, which was evaluated for both adult and child for an assumed period of 14 days, recurring once a year, and repeated ten years total in a lifetime. It was assumed that a larger quantity of soil is consumed while camping than in typical daily life.

The second exposure scenario was a worker scenario in the case of a possible future remediation at Signal Mill. It was assumed that remediation would last one year, and that work would be done 50 weeks a year, seven days a week. This scenario was only applied to adults. Additionally, a 50% exposure point concentration was evaluated with a 50% ingestion rate, and a 95% exposure point concentration was evaluated with a 95% ingestion rate to provide an average and worst-case scenario.

A table of the values used to calculate CDI for the various scenarios is provided in Table 5.2 below.

Table 5.2 Values used to calculate CDI [11]

Adult / Child	Variable	Camping	Worker
-	ED (years)	1	1
-	EF (days/year)	14	350
-	AT (days)	3650	365
Adult	BW (kg)	70	70
Child	BW (kg)	33	-
Adult	50% IR (mg soil/day)	50	50
Adult	95% IR (mg soil/day)	100	100
Child	50% IR (mg soil/day)	100	-
Child	95% IR (mg soil/day)	200	-

After the Chronic Daily Intakes are calculated for each scenario, the carcinogenic and non-carcinogenic risk may be calculated. For non-carcinogenic substances, a hazard index (HI) is used to characterize risk. The EPA defines a hazard index of greater than one as representing a possibility of an adverse effect occurring. Hazard index is calculated with the formula below.

Equation 5.3 Hazard Index [7]

$$HI = \frac{CDI}{RfD}$$

HI: hazard index (unitless)

*RfD: reference dose ([kg*day]/mg)*

For carcinogenic substances, risk is calculated with the formula below. A risk greater than 10^{-6} is considered acceptable, which is the equivalent of one in a million cancer cases.

Equation 5.4 Cancer Risk [7]

$$Risk = CDI \cdot CSF$$

*CSF: cancer slope factor ([kg*day]/mg)*

5.2.1 Arsenic

The results of the arsenic risk assessment are provided in the tables below.

Table 5.3 Arsenic data for risk assessment

Arsenic Specific Data	
50% CS (mg/kg):	3.21
95% CS (mg/kg):	10.1
RfD (ingestion):	0.0003
CSF (kg*day/mg)	1.5

Table 5.4 Arsenic human health risk assessment results

Arsenic – Human Health Risk Assessment						
Scenario	**Person**	**CS**	**IR**	**CDI (mg/kg*day)**	**HI**	**Cancer Risk**
Recreational	Adult	50%	95%	1.76E-08	0.000059	2.64E-08
Recreational	Adult	95%	95%	5.53E-08	0.000184	8.30E-08
Recreational	Child	50%	95%	7.46E-08	0.000249	1.12E-07
Recreational	Child	95%	95%	2.35E-08	0.000783	3.52E-07
Worker	Adult	50%	50%	2.20E-08	0.007329	3.30E-06
Worker	Adult	95%	95%	1.38E-08	0.046119	2.08E-05

Based on the hazard index and cancer risk results, it can be concluded that all the recreational scenarios fall within the acceptable range for human health risk as identified by the EPA. However, both worker scenarios pose a cancer risk as both values are greater than 10^{-6}.

5.2.2 Manganese

The results of the manganese risk assessment are provided in the tables below.

Table 5.5 Manganese data for risk assessment

Manganese Specific Data	
50% CS (mg/kg):	1662.54
95% CS (mg/kg):	3298.74
RfD (ingestion):	0.14

Table 5.6 Manganese human health risk assessment results

Manganese – Human Health Risk Assessment					
Scenario	**Person**	**CS**	**IR**	**CDI (mg/kg*day)**	**HI**
Recreational	Adult	50%	95%	0.000009	0.0000651
Recreational	Adult	95%	95%	0.000018	0.0001291
Recreational	Child	50%	95%	0.000039	0.0002761
Recreational	Child	95%	95%	0.000077	0.0005477
Worker	Adult	50%	50%	0.001139	0.0081338
Worker	Adult	95%	95%	0.004519	0.0322773

Based on the hazard index, it can be concluded that all scenarios fall within the acceptable range for human health risk as identified by the EPA, as all values are less than one.

5.2.3 Lead

Lead risk was modeled using the Integrated Exposure Uptake Bio-kinetic model (IEUBK) and Adult Lead Model (ALM) to evaluate risk. The IEUBK model is used to estimate blood lead levels in children and identify the probability of exceeding 5 micrograms per deciliter of blood lead levels. Based on EPA research, blood lead levels of concern in children is 5 micrograms per deciliter. The ALM calculates the probability of exceeding a specified blood level concentration And estimates a fetal blood lead concentration for a pregnant adult.

For the ALM Model, intake rates were evaluated similar to the manganese and arsenic risk evaluation. The model evaluated only adult scenarios as the IEUBK is used to evaluate the risk for children. The data provided in Table 5.7 through 5.10 show the ALM outputs. Highlighted in the tables are the blood lead levels of adults as well as the 95th percentile blood lead level among fetuses of adult workers. At the end of each ALM output there is also the probability of exceeding the target blood lead level of 5 micrograms per deciliter for fetal blood lead levels.

Table 5.7 ALM Output Table for Recreational Adult 50% EPC

Description of Variable	Units	GSDi and PbBo from Analysis of NHANES 2009-2014
Soil lead concentration	µg/g or ppm	2023.4
Fetal/maternal PbB ratio	--	0.9
Biokinetic Slope Factor	µg/dL per µg/day	0.4
Geometric standard deviation PbB	--	1.8
Baseline PbB	µg/dL	0.6
Soil ingestion rate (including soil-derived indoor dust)	g/day	0.100
Total ingestion rate of outdoor soil and indoor dust	g/day	--
Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--
Mass fraction of soil in dust	--	--
Absorption fraction (same for soil and dust)	--	0.12
Exposure frequency (same for soil and dust)	days/yr	14
Averaging time (same for soil and dust)	days/yr	365
PbB of adult worker, geometric mean	µg/dL	**1.0**
95th percentile PbB among fetuses of adult workers	µg/dL	**2.3**
Target PbB level of concern (e.g., 2-8 ug/dL)	µg/dL	5.0
Probability that fetal PbB exceeds target PbB, assuming lognormal distribution	%	0.2%

Table 5.8 ALM Output Table for Recreational Adult 95% EPC

Description of Variable	Units	GSDi and PbBo from Analysis of NHANES 2009-2014
Soil lead concentration	µg/g or ppm	16425.6
Fetal/maternal PbB ratio	--	0.9
Biokinetic Slope Factor	µg/dL per µg/day	0.4
Geometric standard deviation PbB	--	1.8
Baseline PbB	µg/dL	0.6
Soil ingestion rate (including soil-derived indoor dust)	g/day	0.100
Total ingestion rate of outdoor soil and indoor dust	g/day	--
Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--
Mass fraction of soil in dust	--	--
Absorption fraction (same for soil and dust)	--	0.12
Exposure frequency (same for soil and dust)	days/yr	14
Averaging time (same for soil and dust)	days/yr	365
PbB of adult worker, geometric mean	µg/dL	**3.6**
95th percentile PbB among fetuses of adult workers	µg/dL	**8.6**
Target PbB level of concern (e.g., 2-8 ug/dL)	µg/dL	5.0
Probability that fetal PbB exceeds target PbB, assuming lognormal distribution	%	23.4%

Table 5.9 ALM Output Table for Working Adult 50% EPC

Description of Variable	Units	GSDi and PbBo from Analysis of NHANES 2009-2014
Soil lead concentration	µg/g or ppm	2023.4
Fetal/maternal PbB ratio	--	0.9
Biokinetic Slope Factor	µg/dL per µg/day	0.4
Geometric standard deviation PbB	--	1.8
Baseline PbB	µg/dL	0.6
Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050
Total ingestion rate of outdoor soil and indoor dust	g/day	--
Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--
Mass fraction of soil in dust	--	--
Absorption fraction (same for soil and dust)	--	0.12
Exposure frequency (same for soil and dust)	days/yr	350
Averaging time (same for soil and dust)	days/yr	365
PbB of adult worker, geometric mean	µg/dL	**5.3**
95th percentile PbB among fetuses of adult workers	µg/dL	**12.4**
Target PbB level of concern (e.g., 2-8 ug/dL)	µg/dL	5.0
Probability that fetal PbB exceeds target PbB, assuming lognormal distribution	%	46.3%

Table 5.10 ALM Output Table for Working Adult 95% EPC

Description of Variable	Units	GSDi and PbBo from Analysis of NHANES 2009-2014
Soil lead concentration	µg/g or ppm	16425.6
Fetal/maternal PbB ratio	--	0.9
Biokinetic Slope Factor	µg/dL per µg/day	0.4
Geometric standard deviation PbB	--	1.8
Baseline PbB	µg/dL	0.6
Soil ingestion rate (including soil-derived indoor dust)	g/day	0.100
Total ingestion rate of outdoor soil and indoor dust	g/day	--
Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--
Mass fraction of soil in dust	--	--
Absorption fraction (same for soil and dust)	--	0.12
Exposure frequency (same for soil and dust)	days/yr	350
Averaging time (same for soil and dust)	days/yr	365
PbB of adult worker, geometric mean	µg/dL	**76.2**
95th percentile PbB among fetuses of adult workers	µg/dL	**180.4**
Target PbB level of concern (e.g., 2-8 ug/dL)	µg/dL	5.0
Probability that fetal PbB exceeds target PbB, assuming lognormal distribution	%	100.0%

Based on the outputs of the ALM, workers would have significant risk associated to lead at the site. For both the 50% and 95% EPC scenarios workers had elevated blood lead levels exceeding the 5 micrograms per deciliter. The ALM also showed for the workers that blood lead levels in fetuses would experience severely elevated blood lead levels, especially in the 95% EPC where there is a 100% chance of exceeding EPA recommended levels and the 95th percentile shows fetuses having blood lead levels of 180.4 micrograms per deciliter. Recreational users did not experience elevated blood lead levels for either the 50% or 95% EPC's. There is risk for pregnant adults however in the 96% EPC scenario as the 95th percentile as fetus blood lead levels exceed EPA elevated blood lead level concentration.

The IEUBK model was used to evaluate the probability of exceeding 5 micrograms per deciliter of blood lead level concentrations for children. The model is set up in a way to evaluate risk for children in a residential exposure scenario. As the site is not being evaluated for residential exposure scenarios, soil lead concentrations for the 95% EPC and 50% EPC were adjusted to reflect daily exposure but with the exposure frequency and averaging time factored in. The 95% EPC and 50% EPC were multiplied by the recreational scenario exposure frequency of 14 days then divided by the averaging time of 365 days. These were used as our soil concentration inputs within the model. All other parameters within the model for dietary information, water information, and air concentration information utilized the IEUBK default information as the parameters are unknown for the site.

Tables 5.11 and 5.12 below show the estimated blood lead level concentrations from the IEUBK model. Children exposed to lead concentrations at the 50% EPC on average have blood lead levels below the 5 micrograms per deciliter, suggesting they will be minimally effected by site contamination. Children exposed to lead concentrations at the 95% EPC all experienced blood lead levels exceeding the 5 micrograms per deciliter suggesting excess risk from lead at the site for children.

Table 5.11 IEUBK Estimated Blood Lead Levels Among Children for the 50% EPC

Child Age Range (years)	Blood Pb (µg/dL)
0.5-1	3.0
1-2	2.6
2-3	2.3
3-4	2.2
4-5	2.0
5-6	1.9
6-7	1.8

Table 5.12 IEUBK Estimated Blood Lead Levels Among Children for the 95% EPC

Child Age Range (years)	Blood Pb (µg/dL)
0.5-1	12.9
1-2	11.5
2-3	10.1
3-4	9.7
4-5	9.4
5-6	9.0
6-7	8.4

Figures 5.7 and 5.8 show the distributions curves generated by the model for the 50% EPC and 95% EPC respectively. For the 50% EPC scenario there is a 4.331% chance that children's agreed from 0 to 7 years old will have blood lead levels exceeding 5 micrograms per deciliter. For the 95% EPC scenario there is a 92.75% chance that children aged 0 to 7 years old will have elevated blood lead levels.

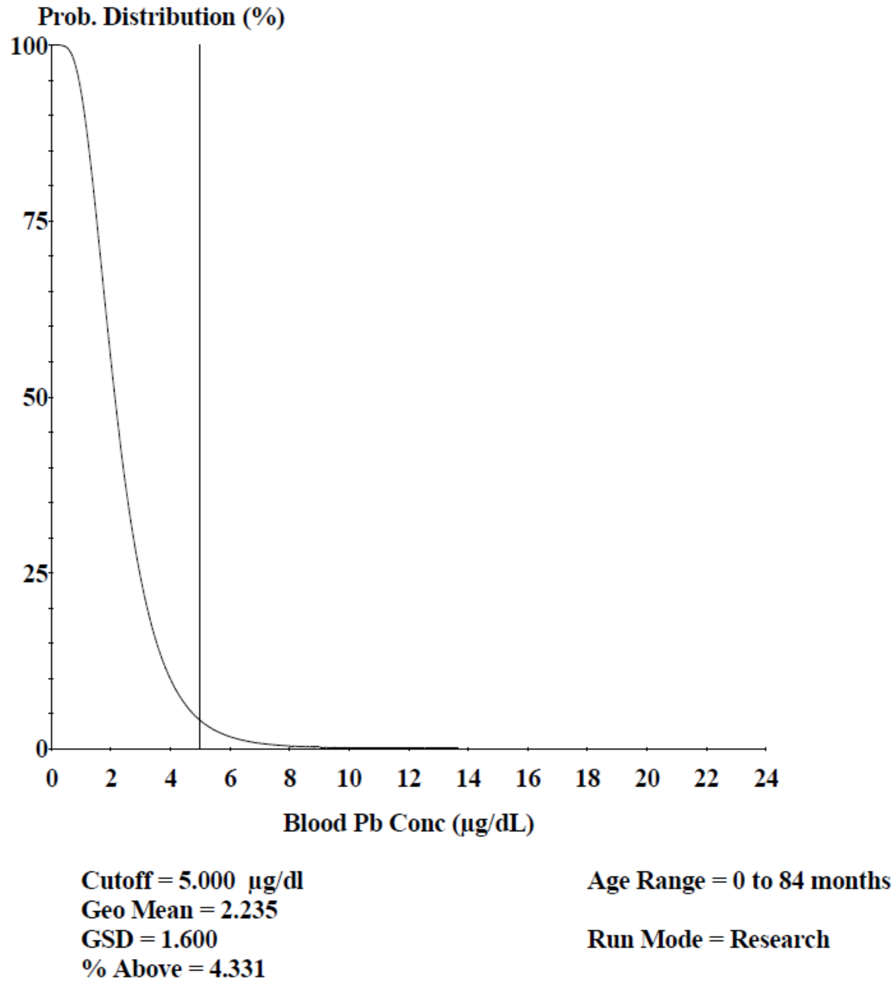


Figure 5.7 IEUBK Model Results for the 50% EPC

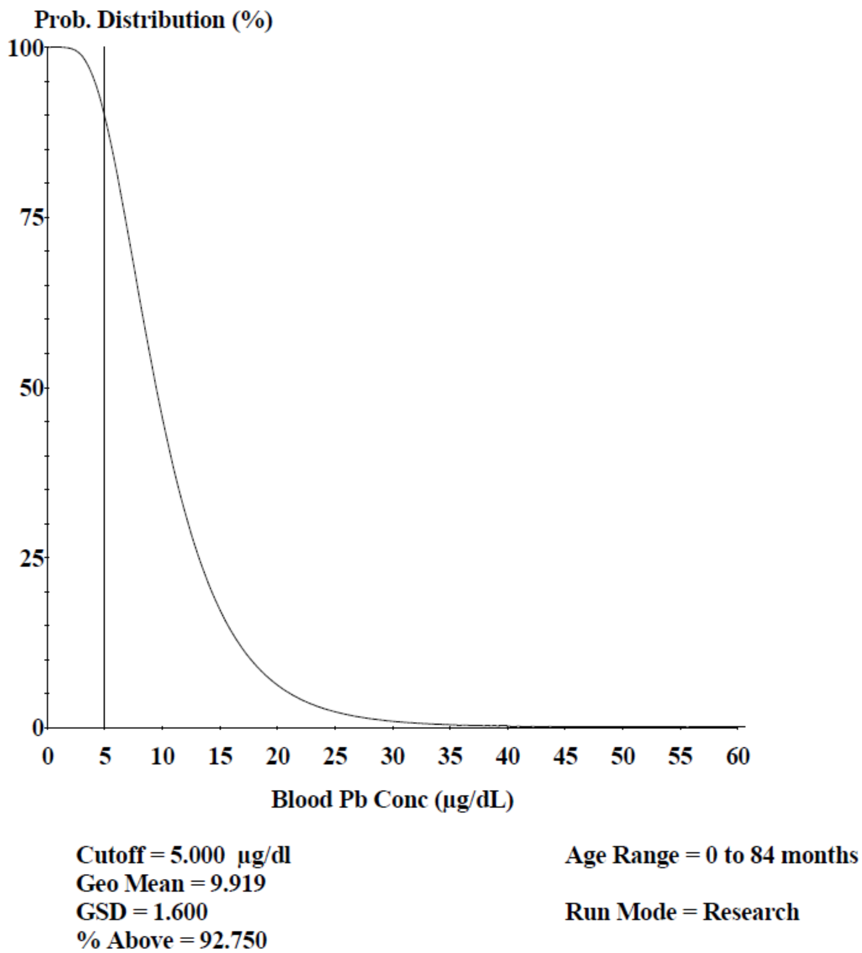


Figure 5.8 IEUBK Model for the 50% EPC

5.3 Ecological Risk Assessment

The habitats and native home ranges of many endangered and threatened species coincide with the Signal Mill site. Due to the ephemeral flow of the Big Sandy, the native tree cover, and sandy vegetative patches around the river; many species have found parts of the ecosystem conditions favorable. Just outside of the landscape of trees and brush around the Big Sandy River, is a more arid, desert ecosystem which finds itself home to other biota as well.

The ecological risk maps of contamination show that many of the areas around the abandoned mill site show that the COCs are starting to migrate towards the Big Sandy and further downstream of it due to the rainfall events that occur at the site. Figure 5.9 shows projections of various storm recurrence intervals and the associated values for that storm occurring within a specified duration. The shorter duration interval combined with the largest storm recurrence interval produces the highest precipitation intensity.

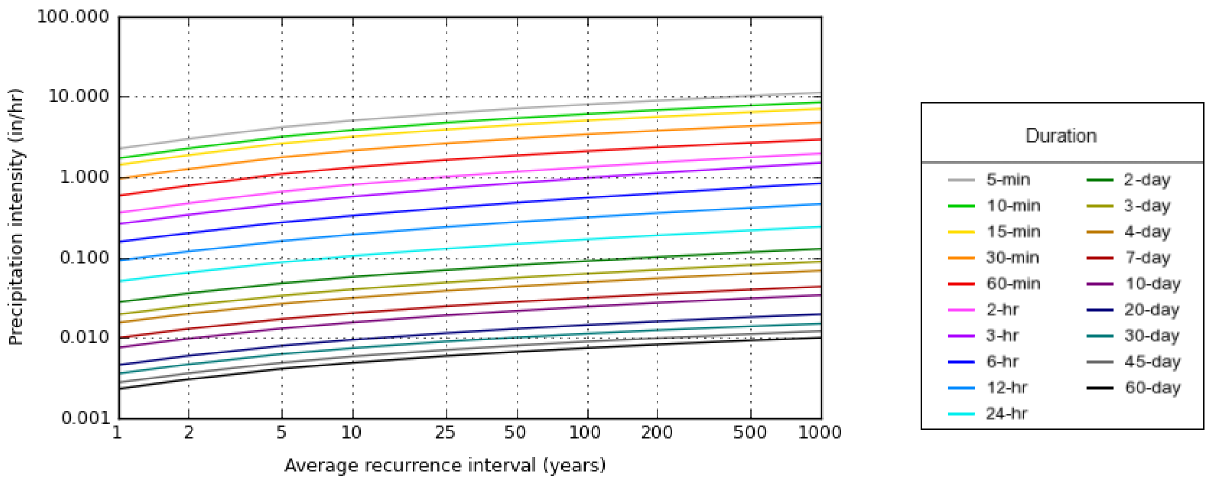


Figure 5.9 NOAA Atlas Precipitation Storm Events for the Signal Mill Site [8]

These rainfall events have already started the migration of contaminants from the abandoned mill and mine tailings towards the Big Sandy. Since all of the COC's exceed at least one, if not more standards for the biota, it will negatively impact ecosystems farther downstream alongside the endangered and threatened species living in and around the site currently.

Endangered species around the site include the Arizona Cliffrose, California Least Tern, and the Southwestern Willow Flycatcher while threatened species include the Desert Tortoise and the Northern Mexican Gartersnake. Figure 5.10 below shows the area these species are known to be in relation to Signal Mill. The red star in the middle is the abandoned mill site and then each of the colored lines signifies the range of the endangered or threatened species relative to the area directly around the site. Navy lines are the Southwestern Willow Flycatcher, light blue for Arizona Cliffrose, orange for the

California Least Tern, green for the Desert Tortoise, and yellow for the Northern Mexican Gartersnake.

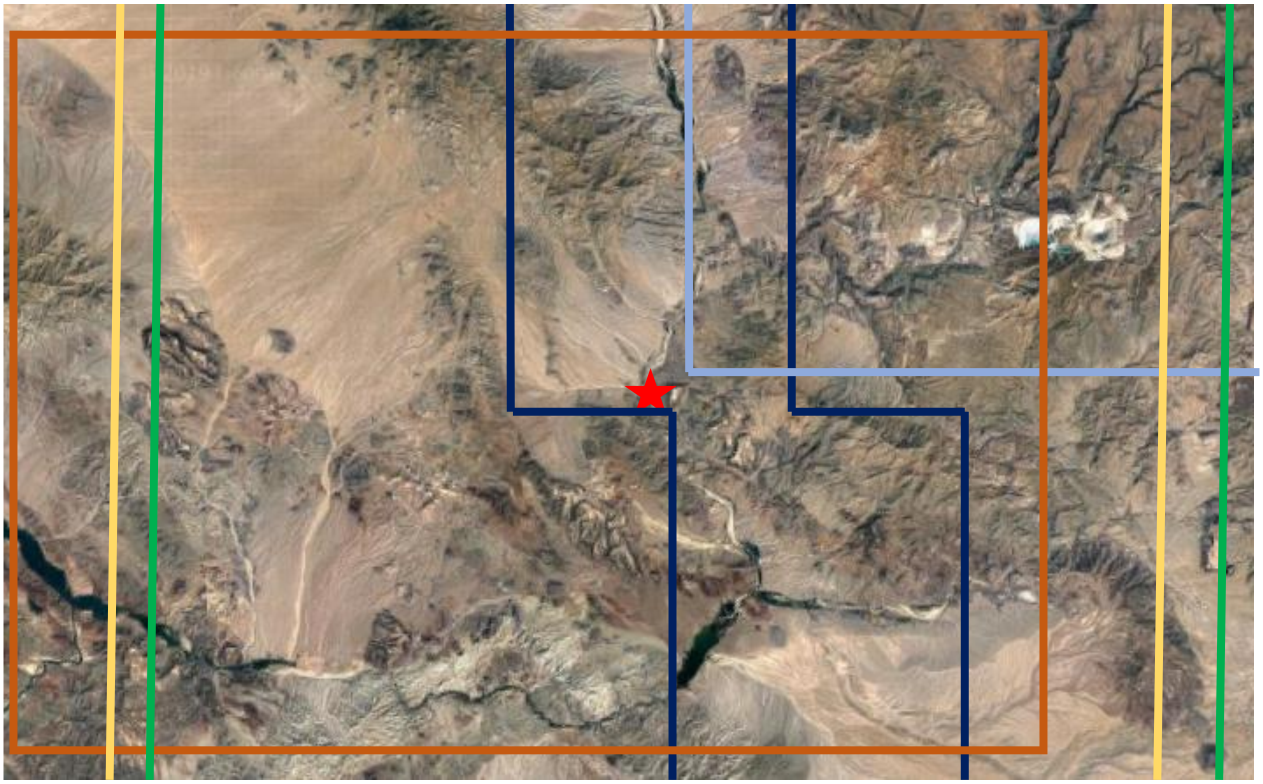


Figure 5.10 Map of Endangered and Threatened Species habitat around Signal Mill [9]

Although the site is in the southern desert area of Arizona, it is still habitat for a wide variety of species, and specifically endangered ones such as these. This poses an ecological risk because of the high concentration and harm that will come about to these species due to contaminant migration and potential uptake.

In Figure 5.11, it shows images of these five endangered and threatened species. These species use the area as habitat, corridors during migratory periods, and a place for nests during reproduction, as well as feeding on the biota that grows.

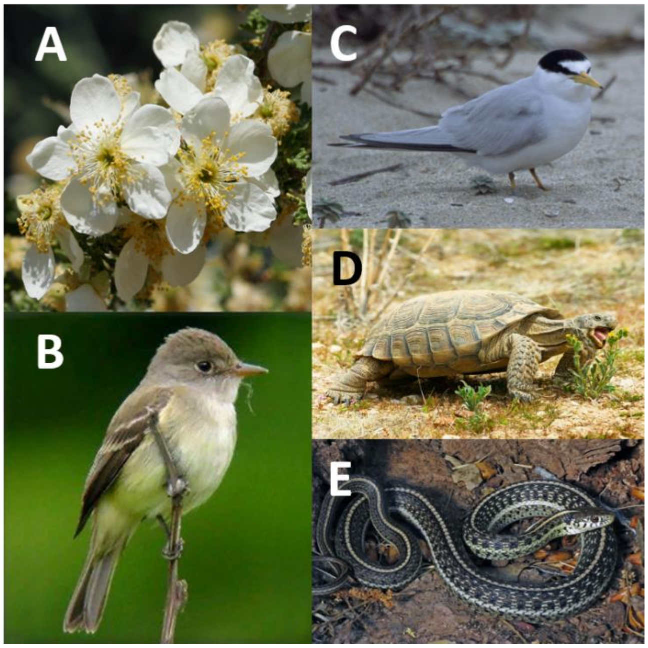


Figure 5.11 [A] Arizona Cliffrose (endangered), [B] Southwestern Willow Flycatcher (endangered), [C] California Least Tern (endangered), [D] Desert Tortoise (threatened), and [E] Northwestern Mexican Gartersnake (threatened)

The Desert Tortoise is at its most active period in the year after the seasonal rains take place and spends its more inactive time in burrows and rock shelters to help it regulate body temperature and prevent water loss. [10] This is the tortoise's way of avoiding the extreme summer heat the desert can have. Since it comes out during times of rainfall, this poses a serious risk to the tortoise's living near Signal Mill and south of it. It is seen in the ecological maps that migration of contaminants has started to occur on the site, and would most notably be after the rainfall. This pushes all the water down through the site and mine tailings before reaching the Big Sandy and continuing south. The diet for the tortoise consists mainly of plants, annual flowers, and new growths of cacti, but rocks and soil can be ingested as well. The high concentrations of COCs are present in the soil itself, but also pose a risk to plants which the tortoise regularly feeds on. There is a risk for this threatened species population numbers to dwindle further due to the ingestion of highly contaminated, untreated soil as well as through bioaccumulation in plants over time.

The Arizona Cliffrose is found in only four areas within the state, one of those being Burro Creek that flows into the Big Sandy near the Signal Mill site. The Arizona Cliffrose can often be found among very rocky soils throughout central Arizona. Due to the small, localized habitats and small populations this plant is extremely vulnerable and as such, listed as endangered. Mineral exploration and development is a major threat to the species, and the population near Signal could have been impacted throughout the duration of the mill operations.

Bioaccumulation will also adversely affect species in the area, but especially those higher up on the food chain. The concentrations, especially those of lead, are extremely high on the site. If plants uptake contaminated water from the site, then an herbivore eats that plant prior to being eaten by a predator, etc… Eventually, those high on the food chain could see adverse effects because of it. Most occurrence of bioaccumulation show these effects occurring in relation to reproduction

6.0 Project Impacts

6.1 Social Impacts

The human health risk assessment outlined a couple social impacts on Signal Mill. The first would affect society in the case that Signal Mill were to be remediated. This became evident in the arsenic risk assessment, where both the average and worst-case worker scenarios were identified to be a carcinogenic hazard by EPA standards. The second social impact was outlined by the lead risk assessment. In the analysis of the adult lead model it was determined that there would be a risk of exceeding a dangerous blood lead level for both the recreational and worker scenarios. Based on the IEUBK model for children, it was determined that a worst-case recreational scenario would put children at a high risk of exceeding a dangerous blood-lead level. All of these results are outlined in Section 5.2, Human Health Risk Assessment. No further social impacts were identified on site as the town of Signal no longer houses any residents.

6.2 Environmental Impacts

The environmental impacts were outlined in the ecological risk assessment. There is a significant threat to biota out on the site, both identified through the flora and fauna survey as well as the endangered/threatened species in the area. The site topography lends itself to a lot of runoff from rainfall events. During this time, the water flows downhill, through the mine tailings left behind, and eventually finding its way into the Big Sandy. If the site were to be remediated, a major focus would be to mitigate this migration of the contaminants so that it doesn't affect biota downstream of the site.

6.3 Economic Impacts

Economic impacts from the investigation would be seen if remediation of the site were to occur. Remediation of the site would funnel tax payer money into the remediation process as the BLM is a government agency. Costs can vary depending on the type of remediation process used on site. Excavation, capping, hauling, and disposing of contaminated soil can create large costs where as phytostabilization is a more cost-effective method. Depending on the remediation tools chosen tax payers will face varied costs. In addition to the effect on the tax payer, remediating the site would open the opportunity for job creation as personnel will be required to remediate the sight.

7.0 Summary of Engineering Work

The original scope of the project has been maintained and followed over the course of the project. The proposed Gantt Chart for the project is reflected in Figure 7.1 below.

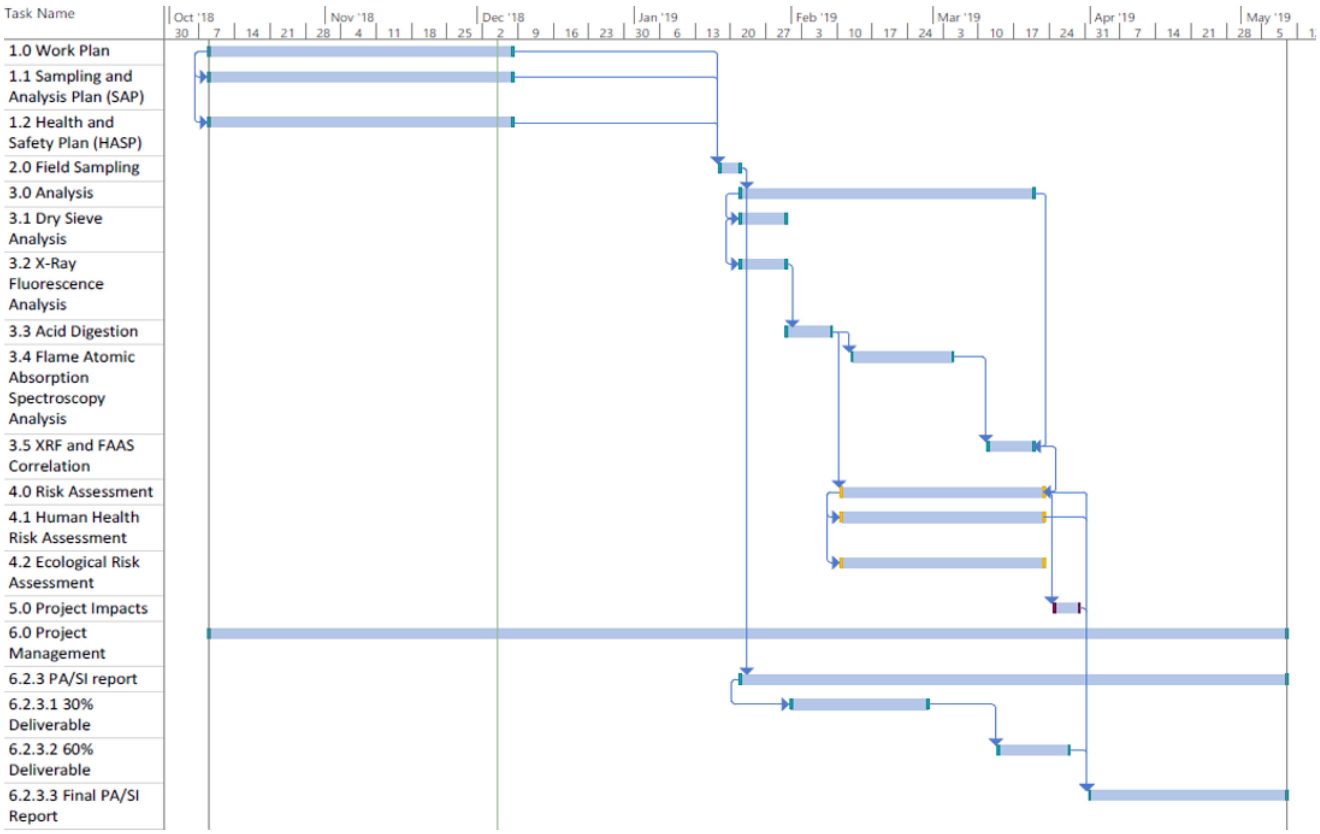


Figure 7.1 Proposed Project Schedule Gantt Chart

The updated Gantt Chart for the project is shown in Figure 7.2. The updated Gantt Chart shows that the drying and sieving process was delayed and extended from the proposed working time. This change occurred due to new lab requirements implemented for the team along with a laboratory accident that occurred which shut down lab work. This pushed the intended start time for the drying and sieve analysis back by a week. Additionally, the time planned to complete the drying and sieving required a more substantial time commitment. This time commitment pushed back the time available to complete the other lab work, ultimately affecting the time available to work on the risk assessment. However, this delay did not affect the completion of the project itself.

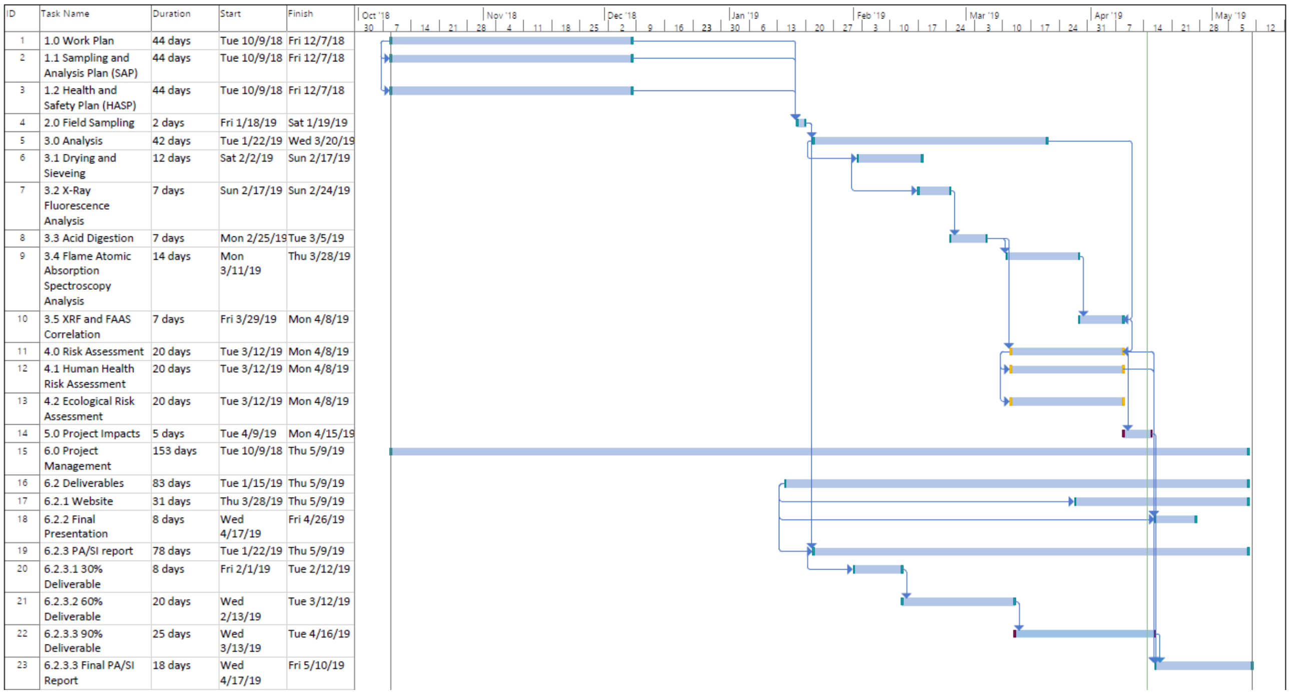


Figure 7.2 Final Project Schedule Gantt Chart

8.0 Summary of Engineering Costs

Table 8.1 summarizes the total hours estimated to complete the project. These tasks below are disturbed between four positions: Senior Engineer (SENG), Engineer (ENG), Engineer in Training (EIT), and Laboratory Technician (LAB).

Table 8.1 Original Hours Estimation

Task	SENG (hr)	ENG (hr)	EIT (hr)	LAB (hr)
1.0 Work Plan (Cumulative)	8	24	24	0
1.1 Sampling and analysis Plan (SAP)	4	12	12	0
1.2 Health and Safety Plan (HASP)	4	12	12	0
2.0 Field Sampling	2	23	23	0
3.0 Analysis (Cumulative)	2	23	23	120
3.1 Dry Sieve Analysis	0	0	0	40
3.2 X-Ray Fluorescence Analysis	0	0	0	40
3.3 Acid Digestion	0	0	0	16
3.4 Flame Atomic Absorption Spectroscopy analysis	0	0	0	12
3.5 XRF and FAAS Correlation	2	23	23	12
4.0 Risk Assessment (Cumulative)	16	48	40	0
4.1 Human Health Risk Assessment	8	24	20	0
4.2 Ecological Risk Assessment	8	24	20	0
5.0 Project Impacts	2	4	2	0
6.0 Project Management (Cumulative)	142	116	78	16
Sum (hours)	170	234	188	136
Total working hours		**728**		

Table 8.2 below outlines the actual hours completed for the project. More hours were spent by the laboratory technician than initially expected. Similarly, hour totals for the engineering staff was decreased. This occurred because a large portion of the project is aimed at deriving the data necessary to perform the risk assessment and conduct the required analysis.

Table 8.2 Updated Hours for the Entire Project

Task	SENG (hr)	ENG (hr)	EIT (hr)	LAB (hr)
1.0 Work Plan (Cumulative)	11	21	20	0
1.1 Sampling and analysis Plan (SAP)	5.5	10.5	10	0
1.2 Health and Safety Plan (HASP)	5.5	10.5	10	0
2.0 Field Sampling	22.5	45	67.5	0
3.0 Analysis (Cumulative)	2.5	11.5	11.5	225
3.1 Dry Sieve Analysis	0	0	0	40
3.2 X-Ray Fluorescence Analysis	1.5	8	9	40
3.3 Acid Digestion	0	0	0	16
3.4 Flame Atomic Absorption Spectroscopy analysis	0	0	0	0
3.5 XRF and FAAS Correlation	1	3.5	2.5	0
4.0 Risk Assessment (Cumulative)	7.5	9.5	5.5	0
4.1 Human Health Risk Assessment	6.5	7.5	2.5	0
4.2 Ecological Risk Assessment	1	2	3	0
5.0 Project Impacts	2	2	0	0
6.0 Project Management (Cumulative)	80.5	69	55	0
Sum (hours)	126	158	159.5	225
Total working hours	**668.5**			

Table 8.3 shows the initial cost estimate for the completion of the project. This table reflected the estimated hours spent by staff member for the completion of the project along with initial estimates of the subcontracting work and the sampling supplies required for the completion of the project.

Table 8.3 Original Cost Estimation of Engineering Services

Line Item	Classification	Quantity	Rate	Cost	Total Cost
1.0 Personnel	SENG	172 hr	$147	$25,284	$57,064
	ENG	238 hr	$76	$18,088	
	LAB	136 hr	$42	$5,712	
	EIT	190 hr	$42	$7,980	
2.0 Travel	Gas	506 mi	$0.38/mi	$192	$1,728
	Per Diem	6 ppl x 3 day	$41/day	$738	
	Vehicle	4 day	$60/day	$240	
	Hotel	3 room x 2 night	$93/night	$558	
3.0 Supplies	Lab and Sampling Supplies	100 sample	$115/sample	$11,500	$17,845
	PPE	6 ppl	$20/person	$120	
	ENE Lab Rental	15 day	$415/day	$6,225	
4.0 Subcontract	Arsenic Test	20 sample	$50/sample	$1,000	$2,150
	FAAS Test	20 sample	$55/sample	$1,100	
	Shipping	1 batch	$50/batch	$50	
5.0 Total Project Cost					**$78,787**

Table 8.4 provides the actual cost of engineering services. The noticeable changes in the total cost come from the reduced hours spent by the engineering staff on the project. Additionally, subcontracting costs were overestimated bringing down the total cost significantly. Lab supplies and sampling supplies total cost was reduced as fewer samples were taken from the sampling investigation. The total cost of engineering services was $64,608.

Table 8.4 Final Cost of Engineering Services

Line Item	Classification	Quantity	Rate	Cost	Total Cost
1.0 Personnel	SENG	126 hr	$147	$18,522	$46,679
	ENG	158 hr	$76	$12,008	
	LAB	225 hr	$42	$9,450	
	EIT	159.5 hr	$42	$6,699	
2.0 Travel	Gas	506 mi	$0.38/mi	$192	$1,482
	Per Diem	6 ppl x 2 day	$41/day	$492	
	Vehicle	4 day	$60/day	$240	
	Hotel	3 room x 2 night	$93/night	$558	
3.0 Supplies	Lab and Sampling Supplies	82 sample	$115/sample	$9,430	$15,775
	PPE	6 ppl	$20/person	$120	
	ENE Lab Rental	15 day	$415/day	$6,225	
4.0 Subcontract	Arsenic/Manganese Test	30 samples	$12/sample	$360	$672
	FAAS Test	20 sample	$13.75/sample	$275	
	Additional Lab Fees	1 batch	$37/batch	$37	
5.0 Total Project Cost					**$64,608**

9.0 Conclusion

Overall, the site would produce the highest risk to human health during the remediation process as the workers would be consistently exposed to the contaminants; especially lead and arsenic. The recreational scenarios showed that for both children and adults, the exposure over the course of ten years does pose a human health risk at the 95% EPC. The ecological risk is more substantial, as most contaminants exceed all of the contaminant level standards for mammals, avian wildlife, and plants. Many of the endangered species in the area use central Arizona for migration, mating, and habitat throughout the changing seasons and weather. Signal Mill does not pose a significant risk to humans but will need further analysis to determine the extent of the harm it may bring to the wildlife found in the area.

10.0 References

[1] Bureau of Land Management, "Signal Mill Site Summary," Bureau of Land Management, 2018.

[2] Arizona Department of Environmental Quality. *Environmental Quality: Appendix A Soil Remediation Levels (SRLs).* Arizona Administrative Code, Title 18, Ch. 7, pp. 9-10. March 31, 2009.

[3] S. Gaudino, C. Galas, M. Belli, S. Barbizzi, P. D. Zorzi, R. Jaćimović, Z. Jeran, A. Pati, and U. Sansone, “The role of different soil sample digestion methods on trace elements analysis: a comparison of ICP-MS and INAA measurement results,” *Accreditation and Quality Assurance*, vol. 12, no. 2, pp. 84–93, 2007.

[4] B. Bero, "McCrackenMohaveT13NR15WSec25_A," Northern Arizona University, Flagstaff, 2018.

[5]"XRF Technology for Analysis of Arsenic and Lead in Soil", *Olympus-ims.com*, 2019. [Online]. Available: https://www.olympus-ims.com/en/applications/xrf-technology-analysis-arsenic-lead-soil/.

[6]U. Olsson, "Confidence Intervals for the Mean of a Log-Normal Distribution", *Journal of Statistics Education*, vol. 13, no. 1, 2005. Available: 10.1080/10691898.2005.11910638.

[7]M. LaGrega, P. Buckingham and J. Evans, *Hazardous waste management*. New Delhi, India: MedTech, 2015.

[8] NOAA Atlas 14. “Point Precipitation Frequency Estimates.” *National Weather Service.* https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html

[9] U.S. Fish and Wildlife Service. “ECOS: Environmental Conservation Online System.” https://ecos.fws.gov/ecp/

[10] Nevada Fish and Wildlife Service. “Mojave Desert Tortoise.” *U.S. Fish and Wildlife Service.* https://www.fws.gov/nevada/desert_tortoise/dt/dt_life.html

[11] United States Environmental Protection Agency, "Superfund Risk Assessment," 2019. [Online]. Available: https://www.epa.gov/risk/superfund-risk-assessment. [Accessed 10 4 2019].

11.0 Appendices

Appendix A: Work Plan

CONSULTANTS

ALI HUSAIN
ANGELINA CRUSE
ANNA GORMAN
WYATT LA FAVE

PROJECT

SIGNAL MILL
WORK PLAN

PURPOSE

CENE 476 - CAPSTONE PREP
TECHNICAL ADVISOR: DR. BERO
GRADING INSTRUCTOR: DR. BERO
NORTHERN ARIZONA UNIVERSITY
FALL 2018

DUE DATE

DECEMBER 18, 2018

Table of Contents

1.0 Introduction

1.1 Project Objectives

The objective of this project is to provide a Preliminary Assessment and Site Investigation report (PA/SI) along with a report outlining the risk associated with the site. This report will contain human risk assessment and ecological risk assessment, determined from the sampling taken on site and analyzed for the PA/SI report that will be provided to the Bureau of Land Management (BLM).

1.2 Project Scope

A list of all the major tasks for the project are provided below:

- **Task 1.** Work Plan
  - **Task 1.1.** Sampling and Analysis Plan (SAP)
  - **Task 1.2.** Health and Safety Plan (HASP)
- **Task 2.** Field Sampling
- **Task 3.** Analysis
  - **Task 3.1.** Dry Sieve Analysis
  - **Task 3.2.** X-Ray Fluorescence Analysis
  - **Task 3.3.** Acid Digestion
  - **Task 3.4.** Flame Atomic Adsorption Spectroscopy (FAAS)w
  - **Task 3.5.** XRF and FAAS Correlation
- **Task 4.** Risk Assessment
  - **Task 4.1.** Human Health Risk Assessment
  - **Task 4.2.** Ecological Risk Assessment
- **Task 5.** Project Impacts
- **Task 6.** Project Management

1.3 Work Plan Schedule

Field sampling is scheduled to occur on the weekend of January 18-20, 2019. In the event of extreme weather, secondary sampling dates were set for February 8-10, 2019. The Sampling and Analysis Plan details the procedures that will be followed during field sampling. The final Preliminary Assessment/ Site Investigation (PA/SI) report will be delivered by May 9th, 2019.

2.0 Project Management

2.1 Project Management Approach

Project management will be upheld through the use of weekly staff meetings, Technical Advisor (TA) meetings, client meetings, correspondence, and schedule management. The following roles have been assigned to each team member:

Angelina Cruse – Secretary
Anna Gorman – Project Manager
Ali Husain – Quality Assurance/ Quality Control Officer
Wyatt La Fave – Safety Officer/ Client Contact

2.2 Project Procedures

Prior to weekly meetings, an agenda will be created outlining discussion items for the meeting. Meetings will be held to discuss the progression of the project as well as to identify upcoming tasks. Meeting minutes will be created at the end of every session and be sent out to all team member within two hours for review. Correspondence will be kept among the team through email, phone, and in-person communication. All scheduling for the team will be kept through a shared Google Calendar.

2.3 Quality Management

To ensure adequate progression of the project meetings amongst the staff will be held on a weekly basis. The documentation of these meetings will be kept in a binder that will be accessible to all team members. The use of Google Calendar as a scheduling tool will aid in planning, as the calendar will be accessible to all team members. All deadlines and Work Plan Schedule items will be emphasized in Google Calendar.

3.0 Site Background Information

3.1 Site Location

Signal Mill is in Arizona, approximately 69 miles southern of Kingman AZ, in Mohave County. See Figure 3.1 below for a general map.

Figure 3.1 Signal Mill in Relation to Kingman

Signal Mill can be accessed most easily by taking Highway 93 through Wikieup. County Road 137 (Signal Rd) is the exit taken off of Highway 93. County Road 137 will be followed approximately 12 miles. After 12 miles a horse corral should be visible, and east of the corral is the road that leads directly to Signal Mill. This route will require crossing the Big Sandy River twice. In the event that the Big Sandy River is flooding and crossing the river with the vehicle presents a potential hazard, an alternate route will be used. The team will need to take the Interstate 40 West from Kingman approximately 26 miles to County Road 15 (Alamo Road) as shown in Figure 3.2. County Road 15 will be followed approximately 38 miles until Country Road 137 is reached. County Road 137 will be followed heading east for 5 miles where the same horse corral should become visible.

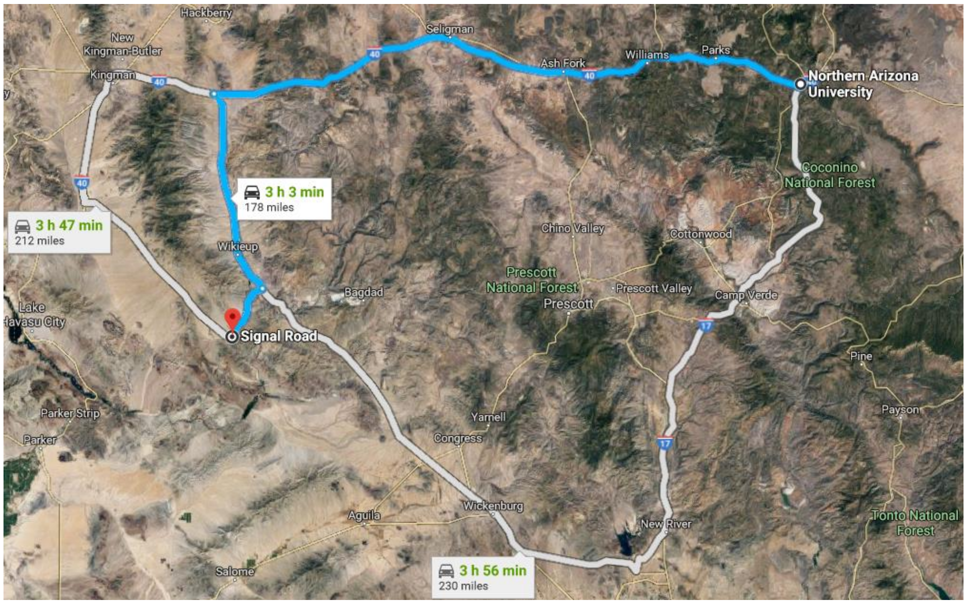


Figure 3.2: Signal Mill in Relation to I-70 and I-40 Roads.

3.2 Site Description

Signal Mill borders the Big Sandy River on the western bank as shown in Figure 3.3 on the following page. Signal Mill was erected by a San Francisco company contracted by McCracken and Owens in 1874. The mill was designed as a 10-stamp mill and later upgraded to a 20-stamp mill in 1884. The mill was setup to take and process ores from the McCracken Mine, most notably lead and silver. The 10-stamp mill later burned down in 1893 and Signal Mill was closed in August of 1902 [1].

3.3 Previous Operations and Investigations

Signal Mill ran intermittently in the 1920's and 1950's. In 1922 the Signal Mines Company took over the property where the mill was run intermittently up until July of 1925, when the property closed. In the late 1950's milling operations began again and was conducted by Ari-Vada Development Corporation. The last indicated operation period of the mill was in 1959. The main cause of the various operation periods is due to the fluctuating price of silver in Arizona [1].

The only data available on Signal Mill is from the Bureau of Land Management site investigation conducted on April 9, 2018 [3]. The data collected from this brief investigation is presented in Table 3.1. The red cells in Table 3.1 represents contaminant concentrations exceeding Arizona Non-Residential Remediation Standards and the yellow cells show contamination levels that are between Arizona Residential Remediation Standards and Arizona Non-Residential Remediation Standards. The most probable contaminants at the site are likely to be those outlined in Table 3.1.

Table 3.1 Signal Mill Site Summary with Contaminants of Concerns [3]

Sample #	Site	Latitude	Longitude	Contaminant Concentration								
				Pb	As	Hg	Zn	Mn	V	Ba	Ag	Sb
1	Signal Mill	34.47222	-113.62476	14542.4	418.59	75.43	31467.29	66259.59	149.13	36968.43	691.41	31.88
2	Signal Mill	34.47237	-113.62471	11690.38	151.58	79.61	36019.4	10559.25	<LOD	1419.24	219.6	55.53
3	Signal Mill	34.47222	-113.62474	4647.22	182.63	47.65	12266.27	13645.8	73.72	1796.12	11.05	<LOD
4	Signal Mill	34.47209	-113.62469	22400.74	394.96	91.45	42378.46	11158.64	37.17	7285.86	131.93	112.61
5	Signal Mill	34.47203	-113.62446	35907.42	<LOD	77.96	40024.83	11134.78	45.07	9430.04	162.84	67.74
6	Signal Mill	34.47169	-113.62437	19471.04	<LOD	37.84	22344.06	9984.22	40.43	7045.68	115.01	28.91
7	Signal Mill	34.47160	-113.62400	26828.93	328.55	308.86	18575.02	18173.51	70.08	10159.31	236.56	73.59
8	Signal Mill	34.47138	-113.62392	12436.05	<LOD	72.47	29018.56	6873.92	<LOD	2186.35	64.33	67.51
9	Signal Mill	34.47076	-113.62399	13371.81	<LOD	62.42	21750.39	4590.7	88.1	10033.01	83.58	59.99
10	Signal Mill	34.47065	-113.62416	24143.39	767.97	1190.53	35907.79	44584.74	186.36	38543.32	213.74	58.58

The data collected in Table 3.1 is visually represented across the site in Figure 3.3. Based on the sampling locations, it is evident that much of the site is contaminated. There is concern that mine tailings located on site have been washed down into the Big Sandy River which borders the area [3].

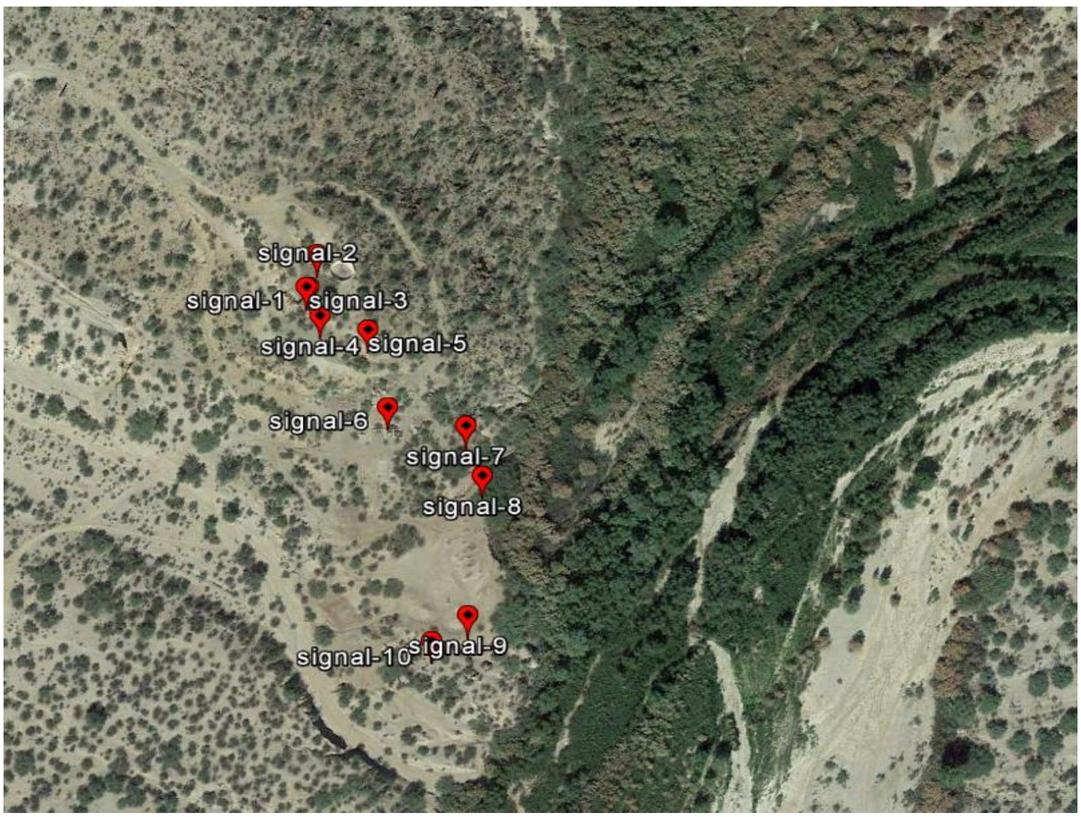


Figure 3.3 Bureau of Land Management Site Investigation Sample Locations [3]

4.0 Investigative Approach

4.1 Site Investigation Objective

The objective of this site investigation is to collect and obtain data that can be used to create a PA/SI report and human health and ecological risk assessments.

4.2 Site Investigation General Approach

On the site, the Sampling and Analysis Plan (SAP) will be followed to collect surface soil samples for analysis. Approximately 80 samples will be obtained through the grid sampling method, as outlined in Figure A3.1 in Section 3.1 of the SAP, while about 20 samples will be reserved for hotspot and background sampling. Hotspot samples will be taken at tailings that are visually present while background samples will be taken in areas that are perceived not to be contaminated.

5.0 Field Investigation Methods and Procedures

This section details the objectives, methods, and rationale for the sampling and analysis procedures with the purpose of providing a template for the project to be completed. The main sections tasks of the SAP are:

- Introduction
- Project Data Quality Objectives
- Sampling Rationale Sampling Analysis Design
- Field Methods and Procedures
- Sample Containers, Preservation, Packaging, and Shipping
- Disposal of Residual Materials
- Sampling Documentation and Shipment
- Deviations from Work Plan

6.0 Investigation-Derived Waste Management

Waste generated during the site investigation is detailed in Section 7.0 of the Sampling and Analysis Plan and Section 7.3 of the Health and Safety Plan (Appendix B).

7.0 Sample Collections Procedures and Analysis

7.1 Sample Containers, Preservations, and Storage

Gallon-sized heavy duty freezer bags will be used to transport and store samples. The detailed process for preservation and storage can be found in Section 6.0 of the Sampling and Analysis Plan (Appendix A).

7.2 Sample Documentation and Shipment

Samples bags will be labeled with a numbering system, each number corresponding to a specific sample. Samples will be logged and transported as outlined in Section 6.0 of the Sampling Analysis Plan (SAP).

7.3 Field Quality Assurance and Quality Control

Measures will be taken to ensure quality assurance and quality control in the field. Quality/Assurance Control Officer will have the responsibility to assure that samples are taken based on the correct procedure of sampling and have the role of counting the entire taken samples. These measures are detailed in Section 2.2.1 of the SAP.

8.0 Deviations from the Work Plan

Any deviations from the Work Plan will be documented in the field log book. Decisions regarding deviations from the Work Plan will be made by the technical advisor (Dr. Bero).

9.0 Preliminary Assessment and Site Investigation Reporting (PA/SI)

The final deliverable for this project will be a Preliminary Assessment and Site Investigation report that outlines the work completed for the project.

10.0 Project Schedule

Table 10.1 represents the project duration tasks including the start and end date. For Field Sampling, the team will visit the site and will spend 3 days sampling on the weekend of January 18, 2019 through January 20, 2019. XRF analysis will be applied in CECMEE Environmental Laboratory at Northern Arizona University (NAU). This task will take 7 days duration and will begin on February 2, 2019. From the total collected samples, the team will have 7 days to prepare acid digestion samples. Acid digestion will begin on February 9, 2019. Soil samples and digestate samples will be sent out to Western Technologies and NAU Chemistry Laboratories for 14 days to conduct the remaining analyses. Samples will be shipped on February 17, 2019. Risk assessment will begin on February 10, 2019 and will have a time period of 14 days to be completed. The final Preliminary Assessment/ Site Investigation report will be completed by May 9, 2019.

Table 10.1 Project Schedule

Task Name	Duration (days)	Start date	End date
1.0 Work Plan	44	Tue 10/9/18	Fri 12/7/18
1.1 Sampling and Analysis Plan (SAP)	44	Tue 10/9/18	Fri 12/7/18
1.2 Health and Safety Plan (HASP)	44	Tue 10/9/18	Fri 12/7/18
2.0 Field Sampling	2	Fri 1/18/19	Mon 1/21/19
3.0 Analysis	42	Tue 1/22/19	Wed 3/20/19
3.1 Dry Sieve Analysis	7	Tue 1/22/19	Wed 1/30/19
3.2 X-Ray Fluorescence	7	Tue 2/2/19	Wed 2/9/19
3.3 Acid Digestion	7	Fri 2/9/19	Mon 2/16/19
3.4 Flame Atomic Absorption Spectroscopy Analysis	14	Wed 2/17/19	Mon 3/4/19
3.5 XRF and FAAS Correlation	7	Tue 3/5/19	Wed 3/13/19
4.0 Risk Assessment	14	Thu 2/10/19	Tue 2/24/19
4.1 Human Health Risk Assessment	14	Thu 2/10/19	Tue 2/24/19
4.2 Ecological Risk Assessment	14	Thu 2/10/19	Tue 2/24/19
5.0 Project Impacts	5	Thu 3/14/19	Wed 3/20/19
6.0 Project Management	153	Tue 10/9/18	Thu 5/9/19
6.1 Project Coordination	153	Tue 10/9/18	Thu 5/9/19
6.1.1 Meetings	153	Tue 10/9/18	Thu 5/9/19
6.1.2 Correspondence	153	Tue 10/9/18	Thu 5/9/19
6.1.3 Schedule Management	153	Tue 10/9/18	Thu 5/9/19
6.2 Deliverables	83	Tue 1/15/19	Thu 5/9/19
6.2.1 Website	31	Thu 3/28/19	Thu 5/9/19
6.2.2 Final Presentation	8	Wed 4/17/19	Fri 4/26/19
6.2.3 PA/SI report	78	Tue 1/22/19	Thu 5/9/19
6.2.3.1 30% Deliverable	19	Fri 2/1/19	Wed 2/27/19
6.2.3.2 60% Deliverable	10	Fri 3/1/19	Thu 4/4/19
6.2.3.3 Final PA/SI Report	9	Mon 4/29/19	Thu 5/9/19

11.0 References

[1] B. Bero, "McCrackenMohaveT13NR15WSec25_A," Northern Arizona University, Flagstaff, 2018.

[3] Bureau of Land Management, "Signal Mill Site Summary," Bureau of Land Management, 2018.

[4] ASTM D3974-09(2015) Standard Practices for Extraction of Trace Elements from Sediments, ASTM International, West Conshohocken, PA, 2015, https://doi.org/10.1520/D3974-09R15

[5]ASTM D6913/D6913M-14 Standard Test Method for Particle-Size Distribution of Soils Using Sieve Analysis, ASTM International, West Conshohocken, PA, 2014, https://doi.org/10.1520/D6913_D6913M-17

[6] U.S. EPA. " SW-846 Test Method 6200: Field Portable X-Ray Fluorescence Spectrometry for the Determination of Elemental Concentrations in Soil and Sediment," Washington, DC. 2007

[7] U.S. EPA. "Method 3050B: Acid Digestion of Sediments, Sludges, and Soils," Revision 2. Washington, DC. 1996

[8] U.S. EPA. " SW-846 Test Method 7000B: Flame Atomic Absorption Spectrophotometry," Washington, DC. 2007

Appendix A Sampling and Analysis Plan

1.0 Introduction

The Sampling and Analysis Plan outlines the relevant procedures and best management practices in order to retrieve effective, quality data while ensuring the safety of the team.

1.1 Responsible Agency

The responsible agency for this project is the Bureau of Land Management (BLM), whose office is located at North Central Ave Suite 800, Phoenix, AZ 85004.

1.2 Project Organization Table

An overview of the staffing plan for the project is provided in the table A1.1 below.

Table A2.1. Project Organization Table

Name	Role
Eric Zielske	BLM Client
Bridget Bero	Technical Advisor, NAU
Angelina Cruse	Secretary
Anna Gorman	Project Manager
Ali Husain	Quality Assurance/ Quality Control Officer
Wyatt La Fave	Safety Officer

The Technical Advisor will accompany the team in the field. One additional person (Josue Juarez) will also help the team with the field sampling investigation.

1.3 Sampling Details

The sampling process is outlined in Section 3.0 below.

2.0 Project Data Quality Objectives

2.1 Project Objectives and Problem Definition

The purpose of this project is to identify the composition and location of contaminants at Signal Mill. This information will allow for the creation of ecological and human health risk assessments. All information will be returned to the BLM to allow them to carry out the remediation process.

2.2 Data Quality Objective (DQO) and Quality Control

2.2.1 Field Quality Control

Quality control is an important aspect in the field to ensure the reliability of the data. When the team arrives on site personal protective equipment will be worn. The sampling location will be located as defined in Section 3.0. Once sample collection beings, team members will collect soil samples and label them appropriately following Section 8.2. Logbooks will be kept to document and detail the sampling of the specimen. Photo logs will be kept, documenting the site and each sample. Between each sample team members will decontaminate the equipment used as detailed in Section 7.2 of the Health and Safety Plan. New gloves will be worn for each sample and waste generated during decontamination will be collected in trash bags. This process will be repeated until the team leaves the site for the day. Before leaving the site, the Quality Control Officer will inspect all logged samples to make sure they are accounted for. The Quality Control Officer will also place the completed chain of custody form within the bins holding the samples and seal the bin with the appropriate custody seal. When the team is ready to leave, personal decontamination will occur, following Section 7.1 of the Health and Safety Plan.

2.2.2 XRF Quality Control

In order to ensure quality control during the XRF analysis, a few precautions will be followed. Before use, the machine must be calibrated to verify that it is working properly. Additionally, the battery life must be monitored. The device should be charged every night so that it doesn't run out of battery during use. It is also important to track which sample is being tested to record the data correctly. Therefore, good organization is required. All data will be recorded in a lab notebook and any computer generated charts will be saved to the team file on Google Drive. Furthermore, the data will be backed up on an external flash drive in case any files are accidentally lost.

2.2.3 Data Analysis Quality Control

Once the data has been collected, it can be analyzed. This will be done in a careful fashion, relying on the attention of at least two team members to avoid error and to check each other's work. A two-person check system will be utilized to provide quality control. Data will be entered in Excel for organization. Furthermore, the values obtained will be compared to the previous data taken at Signal Mill to check for accuracy. The data results will be saved to the team file as well as backed up in a flash drive to avoid losing critical files.

2.2.4 Correlating Samples (XRF and FAAS)

After the XRF and FAAS analyses, a correlation will be drawn between the results in order to check for accuracy of the XRF data. Data will be correlated using Levene's test for equality of variances. This method will examine the variances between the XRF and FAAS analysis. This statistical method will provide a p-value indicating the strength of the correlation. The XRF data will then be corrected based on the correlations provided

2.2.5 Cross-contamination Precautions

Cross-contamination is a source of potential error. This would mostly affect the accuracy of the contaminant migration analysis, rather than the composition of contaminants. In the field, cross-contamination will be avoided by decontaminating the equipment used and by completing the bagging of one sample before beginning another, along with properly labeling bags. Cross-contamination will be avoided in the lab by keeping adequate space between samples and using separate bags. Any vessels or sieves that are to be reused for another sample will be cleaned between uses.

2.3 Data Review, Validation and Management

Data will be checked for accuracy and error among the team with the help of Dr. Bridget Bero as the technical advisor for the project on behalf of BLM. Any errors encountered will be documented.

3.0 Sampling Rationale

3.1 Soil Sampling

3.1.1 Grid Sampling Overview and Rationale

Eighty samples will be taken from a grid pattern, which is provided in Figure A3.1 on the following page. The sampling grid covers the areas where contaminated is expected. The milling area is covered by the grid in the northwest section of the map, while the expected contaminant migration is expected to flow downwards in elevation through the Big Sandy River, shown in the southeastern grid. The old operating site of Signal Mill is outlined by the blue oval. Sample collection will begin at the western edge of the circular structure surrounded between sampling points 7 and 8 in Figure A3.1. From the western edge of the round structure a 200-foot tape measure will be utilized to measure 15 feet west to position the team on sampling point 7. A surveying flag will be placed to mark the location of sampling point seven. Grid marks are spaced approximately 50 feet apart in the northern portion of the site. To find other sampling points a distance of 50 feet can be measured in either the north, south, west, or east direction to locate other sampling locations on the grid. Identified sampling locations will be marked with a surveying flag. To get to sampling point 50 from sampling point 51, the team can use the 200-foot tape measure and measure 100 feet south of point 50 to reach point 51. The grid spacing within the Big Sandy River is 100 feet. The same method for finding grid points within the Big Sandy River can be utilized to mark sample locations.

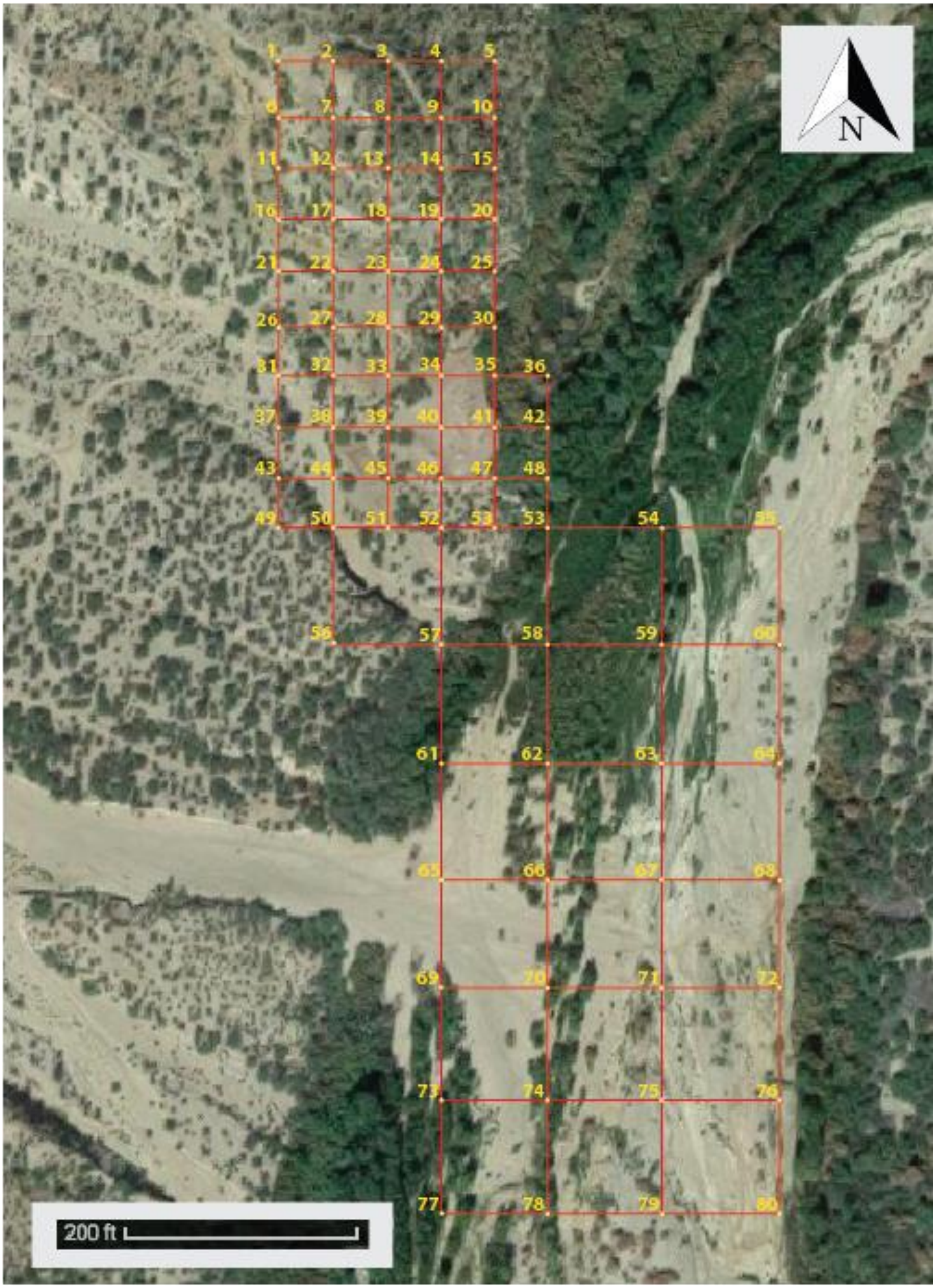


Figure A3.1 Sampling Grid Overview

3.1.2 Hot Spot Sampling Overview and Rationale

In addition to the grid sampling, about 10 hotspot samples will be taken from places where obvious contamination exists. If the team sees tailings, these will be sampled.

3.1.3 Background Sampling Overview and Rationale

Three to five background samples will be taken from places where no contamination is expected to occur. The purpose of these samples is to determine concentrations of contaminants of concern in undisturbed areas showing native vegetation.

3.1.4 Field Decision Criteria

In the field, the Technical Advisor will identify samples that may need to be eliminated based on the following conditions:

- The sample location is physically inaccessible.
- Obtaining the sample poses a risk to health and safety.
- Technical Advisor on site deems the sample unnecessary.

4.0 Sample Analysis Design

4.1 Sample Drying and Sieving-ASTM D3974 + ASTM D6913

All soil samples will be dried before sieving. ASTM D3974 Standard Practices for Extraction of Trace Elements from Sediments will be followed for drying procedures. This method suggests oven drying samples at 60℃ to prevent loss of mercury and other possible volatile metallic compounds [4]. ASTM D6913 Standard Test Method for Particle-Size Distribution of Soils Using Sieve Analysis is the standard method for a dry soil sieve analysis. This will be used to obtain soil samples that are sieved to the No. 60 sieve. The materials required to complete this analysis include a mechanical shaker and drying oven [5]. Sieve stacks will be utilized to prevent overloading limits for the sieve set. The maximum mass retained on an eight-inch sieve for the No. 60 sieve is 60 grams. The sieve analysis will be conducted at Northern Arizona University CECMEE Soils Lab.

4.2 XRF Spectrophotometry

X-Ray Fluorescence (XRF) analysis is used to obtain a preliminary quantitative and qualitative analysis of contaminants present in a soil sample. EPA Method 6200 Field Portable X-Ray Fluorescence Spectrometry for the Determination of Elemental Concentrations in Soil and Sediment will be followed for quality control and calibration. The XRF device will be utilized on sieved soil samples. Soil samples will be in thin gallon plastic bags, where a three by three grid will be drawn over the bag. Using the XRF device nine measurements will be taken in each grid. A sketch of the grid is available below in Figure A4.1. The highest and lowest readings will be disregarded; an average of the remaining readings will be taken and used as the contaminant concentration. The required materials to complete this analysis method include Field Portable X-Ray Fluorescence (FPXRF) device, X-ray window film, and plastics bags [6]. XRF analysis will be conducted in CECMEE Environmental Engineering Lab at Northern Arizona University. This analysis will provide the COC’s from the Signal Mill site.

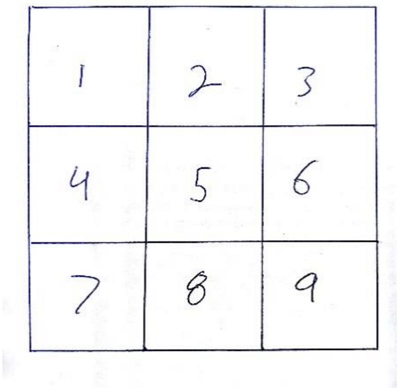


Figure A4.1 Sketch of XRF Soil Analysis Layout

4.3 Acid Digestion

Acid digestion is used to prepare soil samples for Flame Atomic Absorption Spectroscopy or Inductively Coupled Plasma analysis. EPA Method 3050B Acid Digestion of Sediments, Sludges, and Soils will be followed initially until full extent of contamination is understood. EPA Method 3050B works for the elements outlined in Table A4.1. In Table A4.1 the known contaminants of concern at the site are highlighted. The potential Contaminants of Concern will be Antimony, Arsenic, Argon, Barium, Lead, Magnesium, Mercury, Silver, Vanadium, and Zinc. The materials required to complete the analysis include 250 mL digestion vessels, vapor recovery device, drying oven, thermometer, filter paper (Whatman No. 41 or equivalent), centrifuge, centrifuge tubes, analytical balance, hot plate, funnel, graduated cylinder, and 100 mL volumetric flasks. Reagents required for testing include concentrated hydrochloric acid, nitric acid, and hydrogen peroxide (30%) [7]. Twenty samples will be selected for the analysis. Samples will be chosen to reflect a wide range of contaminant concentration. Acid digestion will be completed in the CECMEE Environmental Engineering Lab at Northern Arizona University.

Table A4.1 Elements Suitable for EPA Method 3050B [7]

FLAA/ICP-AES		GFAA/ICP-MS
Aluminum	Magnesium	Arsenic
Antimony	Manganese	Beryllium
Barium	Molybdenum	Cadmium
Beryllium	Nickel	Chromium
Cadmium	Potassium	Cobalt
Calcium	Silver	Iron
Chromium	Sodium	Lead
Cobalt	Thallium	Molybdenum
Copper	Vanadium	Selenium
Iron	Zinc	Thallium
Lead		
Vanadium		

4.4 Flame Atomic Absorption Spectrophotometry

EPA Method 7000B Flame Atomic Absorption Spectrophotometry (FAAS) will be followed to determine contaminant concentrations. The materials required to complete the analysis include atomic absorption spectrophotometer, burner, hollow cathode lamps, graphical display and recorder, pipets, pressure reducing valves, and volumetric flasks. Reagents required for analysis include fuel and oxidant, stock standard metal solutions, calibration blank, and method blank [8]. Samples taken for (FAAS) analysis will be subcontracted out to Western Technologies for arsenic testing while the other subsamples will be analyzed of at the Northern Arizona University Chemistry Laboratory.

5.0 Field Methods and Procedures

5.1 Field Equipment

The equipment used in the field is identified below in Table A5.1. The GPS is used to locate the sampling points at the site. Locations of hotspot and background samples will be identified on-site. Surveying flags will be utilized to mark sample locations. Trowels will be utilized to collect soil surface samples. Heavy duty freezer gallon sized bags will be used for sample storage. The 200-foot tape measure will be utilized to measure distance between sampling points.

Table A5.1 Field Equipment

Equipment	Quantity
GPS	2
Survey Flags	100
Heavy Duty Freezer Plastic Bags (One Gallon)	150
Trowels	6
200-foot Tape Measure	2
Water for decontamination (Gallons)	15
Water for Drinking (Gallons)	15
5 Gallon Buckets	4
Paper Towel (Rolls)	10
Dish Soap (20 fluid ounce bottle)	1
Gloves (100 per carton)	4
Log Book	2
Pens (20 count box)	1
Batteries (backup pair)	2
Scrubbing Brushes	2
Trash Bags (30 gallon trash bags)	25
Storage Bins	4
Permanent Markers	6
Compass	2

5.1.1 Calibration of Field Equipment

The GPS tracking device will be calibrated before taking it out in the field to ensure that it functions properly and doesn't fail in the field. In the event of failure, additional batteries will be kept in the vehicle or if necessary the second GPS will be used.

5.2 Surface Soil Sampling Methods to be Used

5.2.1 Containers

The samples will be collected on-site in heavy duty freezer gallon-sized plastic bags. All sample information will be recorded in the logbook. For labeling of samples refer to Section 8.2.

5.2.2 Sample Locations

The sampler will take a soil surface sample sufficient enough to fill a one-gallon bag using a trowel at sample locations identified in Figure A3.1. The assistant to the sampler will provide geographical coordinates for recordkeeping and sample labeling. Sample bags will be labeled according to Section 8.2. All sample information will be additionally recorded in the logbook.

6.0 Sample Containers, Preservation, Packaging and Shipping

Outlined below are the methods that will be utilized to store and ship soil samples taken during the investigation.

6.1 Soil Samples

Soil samples will be collected in one-gallon plastic bags and will be sealed within a bin with the appropriate chain of custody form. Samples will be kept in labeled bins and will not be unsealed until they have been transported to Northern Arizona University. Samples will be stored at the Northern Arizona CECMEE Environmental Engineering Lab. When the bins are unsealed, it will be documented on the appropriate chain of custody form. Once work is completed with a soil sample, the bin will be resealed with the chain of custody form in the bin. The lab is secured so that only authorized persons may enter.

6.2 Packaging and Shipping

20 soil samples will be shipped to Western Technologies Inc. for arsenic testing. These samples will be sealed in small Ziploc bags and placed in a manila folder with a chain of custody form and delivered by vehicle. Additionally, 20 digestates will be sent to the NAU Chemistry Department for Flame Atomic Adsorption Spectroscopy (FAAS) testing. These digestates will be delivered to NAU chemistry laboratories by hand.

7.0 Disposal of Residual Materials

EPA regulations and procedures will be followed for the disposal of contaminated material generated on site and in the lab.

7.1 IDW Disposal Procedures for Sites with Low Levels of Contamination

The EPA has specific regulations for the disposal of Investigation Derived Waste (IDW). The waste from the investigation may be disposed of on the site of original if it does not further endanger human health or the environment in the process. Water used for contaminated equipment will be disposed of on site.

7.2 Laboratory Waste Disposal

Any of the left-over soil collected from the sieve analysis that is not contaminated will be disposed of in the regular solid waste trash disposal service in the CECMEE Environmental Engineering Lab. What is known to be contaminated and hazardous will be disposed of as hazardous waste, and the proper procedures will be taken according to NAU's Environmental Health and Safety. In Title 40 Subpart K of the Code of Federal Regulations (CFR), specific requirements and procedures are outlined for the disposal of hazardous waste generated from academic laboratories. All waste must be removed from the lab within 12 months of the date it started accumulating. If the laboratory waste bucket is full before scheduled removal, these containers must be sealed and labeled properly and removed within 10 days of exceeding bucket capacity. The bucket capacity under EPA regulations is a 55-gallon bucket. Field waste collected on site will be disposed of off-site through municipal waste collections systems.

8.0 Sampling Documentation and Shipment

8.1 Field Notes

8.1.1 Field Logbooks

Field logbooks will be kept to describe each sampling procedure. Logbooks will detail when a sample was taken, identifying the location of the sample and the time it was taken. General observations of the site will be documented in the logbook. Logbooks will be completed in blue or black pen. Any errors shall be corrected by crossing out the error with a singular line and initialed by the documenter. A table of contents shall be provided on the first two pages of the logbook with page numbers labeled on the bottom right corner of the page. The weather conditions present at the site should be noted along with the names of samplers. Equipment used in the field will be documented. A flora and fauna survey will be conducted during the site investigation and all observed flora and fauna will be logged in the logbooks.

8.1.2 Photographs

Photographs of the site and every sample location will be taken. General site photos will indicate the current condition of the site and present notable features found at the site. All flora and fauna on site will be documented with a photograph.

8.2 Labeling

8.2.1 Labeling System

The labels used on each sample should include the following identifiers:

1. The abbreviation "SM" to indicate the sample came from Signal Mill.
2. Unique sample identifier depending on the type of sample: B = background samples, H = hotspot samples, and G = grid samples.
3. The number of the sample taken for each type of sample.

Sample labels will be written directly on plastic bags with a permanent marker. Example: SM-G5 means Gird soil sample #5.

Samples that have been dried and sieved will follow the same labeling system above. The sieved samples will maintain the samples unique identifier and once it has been sieved the data label will written with an S to indicate it has been sieved. Example: SM-G5 S.

XRF samples should be labeled with the unique identifier given in the field. It should then be followed by the abbreviation X to indicate the XRF analysis. Since a three by three grid is utilized for XRF analysis, the grid will be labeled 1-9 as shown in Figure A4.1. This labeling method will be used to for data collection, the sample does not need to be relabeled after XRF analysis. Example: SM G5 X 1.

The digestates will use the unique identifier given in the after sieving followed by a D to indicate it has gone through acid digestion. Example: SM-G5S- D.

8.3 Sample Chain-of-Custody Forms and Custody Seals

Figure A8.1 is an example of the Chain of Custody form the will be used over the course of the investigation.

<table>
<tr><th colspan="5">CHAIN OF CUSTODY RECORD</th></tr>
<tr><td colspan="3" rowspan="3">Project Title</td><td colspan="2">Organization</td></tr>
<tr><td colspan="2">Contact</td></tr>
<tr><td colspan="2">Address</td></tr>
<tr><td rowspan="2">Sample ID</td><td colspan="2">Collection</td><td rowspan="2">Sampler's Initials</td><td rowspan="2">Sample Specific Comments</td></tr>
<tr><td>Date</td><td>Time</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="5">Shipping Container No. Field Sampler: (Signature and Printed Name) Date: Time:</td></tr>
<tr><td colspan="5">Relinquished by: (Signature and Printed Name) Date: Time: Received by: (Signature and Printed Name) Date: Time:</td></tr>
<tr><td colspan="5">Relinquished by: (Signature and Printed Name) Date: Time: Received by: (Signature and Printed Name) Date: Time:</td></tr>
<tr><td colspan="5">Relinquished by: (Signature and Printed Name) Date: Time: Received by: (Signature and Printed Name) Date: Time:</td></tr>
</table>

Figure A8.1 Sample Chain of Custody Form

Below in Figure A8.2 is the custody seal that will be placed on containers used for storing samples. Custody seals will be placed on containers with clear tape. A break in the tape will provide visual evidence if the seal has been broken or has been tampered with.

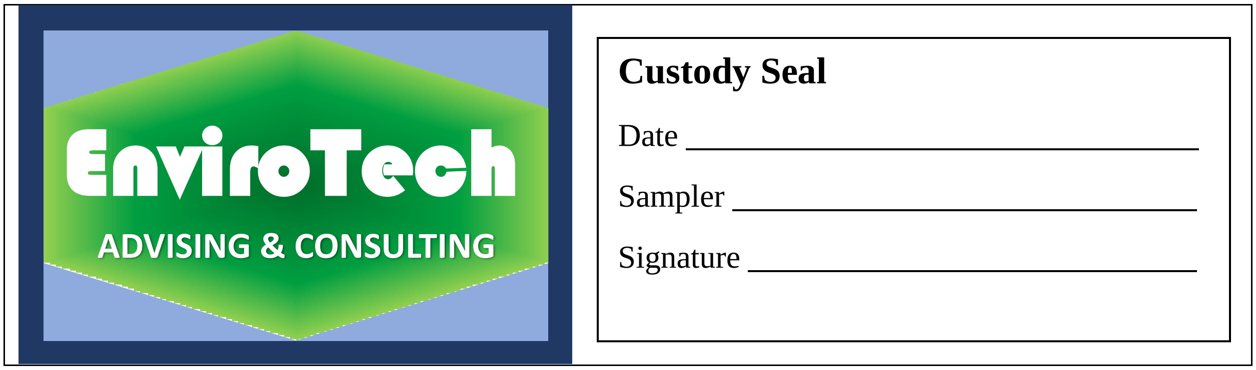


Figure A8.2 Chain of Custody Seal

9.0 Deviations from Work Plan

Any deviations from the Work Plan will be documented in the field log book. Decisions regarding deviations from the Work Plan will be made by the technical advisor (Dr. Bero) with rationale and justification documented in the logbook.

Appendix B Health and Safety Plan

1.0 Job Name and Location

This project is the Signal Mill Preliminary Assessment/Site Investigation. Signal Mill is located in Arizona, approximately 22 miles south of Wikieup in Mohave County and 178 miles from Flagstaff in Coconino County. Signal Mill borders the Big Sandy River on the western bank. A map to the site is provided below in Figure B1.1. From Northern Arizona University the team will take I-40 westbound towards Los Angeles. This road will be followed for approximately 123 miles where exit 71 for US-93 south towards Wickenburg will be taken. After 41 miles the team will exit onto Signal Road and continue for 12.5 miles where the site will be on the right on Signal Road.

Figure B1.1 Map from Northern Arizona University to Signal Mill.

2.0 Safety and Health Administration

The Safety Officer for the investigation is Wyatt La Fave. The responsibilities of the Safety Officer are to ensure compliance with standards outlined in the following sections.

3.0 Hazard Assessment

Hazards that may be encountered out in the field and during analysis are outlined below and separated between physical and chemical hazards.

3.1 Physical Hazards

All the physical hazardous will be outlined in NAU Field Safety Checklist along with mitigation efforts. The NAU Field Safety Checklist is provided below in Figure B3.1.

NAU Field Safety Checklist

NORTHERN ARIZONA UNIVERSITY

This form may be used by the Principal Investigator (PI), or Supervisor, to assist with the planning of field work. **The completed checklist must be shared with all the members of the field team and a copy must be kept on file on campus.** Multiple trips to the same location can be covered by a single checklist. The checklist should be revised whenever a significant change to the location or scope of field work occurs. NAU's Regulatory Compliance groups are available to review these plans, and will conduct periodic reviews of departmental checklists.

Before you go:

☐This checklist must be completed, and a copied maintained on campus, prior to departure for any field work. ☐Prepare first aid kit and manual

☐Assemble and check safety provisions

☐Check to assure all required immunizations are current for all team members

☐Check to assure all emergency health care and insurance requirements have been met.

Principal Investigator/Supervisor: Dr. Bridget Bero

Phone Number: (929) 523-2051

Dates of Travel: January 18-20, 2018

Location of Field Work:

Country: USA Geographical Site: Signal Mill

Nearest City: Wikieup Distance from Site: 24 miles north

Nearest Hospital: Kingman Regional Medical Center Distance from Site*: 74 miles

Field Work: About 100 surface soil samples will be taken around the remnants of Signal Mill.

Emergency Procedures: Refer to Section 8.0 for emergency procedures.

University Contact (Name/ Phone): Dr. Bero (928) 523-2051

Local Field Contact (Name/ Phone): Dr. Bero (928) 523-2051

Special Medical Requirements: (bee sting kits, insulin, etc.)

NA

First Aid Training: (Please list any team members who are first aid trained and the type of training they have).

Angelina Cruse is first aid certified.

Physical Demands:

(Please list any physical demands required for this field work, e.g., Diving, Climbing, Temperature Extremes, High Altitude).

Driving to and from site, low temperatures, carrying heavy weight of samples.

Risk Assessment: Please list identified risks associated with the activity or the physical environment (e.g., extreme heat or cold, chemical use, wild animals, endemic diseases, firearms, explosives, violence). List appropriate measures to be taken to reduce the risks; *Include a separate sheet if necessary. Attach Safety Data Sheets (SDSs) and training documentation for any chemicals that will be used*

Identified Risk	Control of Risk
Venomous desert animals (snakes, spiders, scorpions, etc.)	Team members will take care of be aware of their surroundings, inspecting the ground thoroughly before picking anything up. If a venomous animal is encountered in close proximity, the individual should back away slowly, taking care not to trip over anything.
Contaminated Soils (lead, arsenic, mercury, zinc, manganese, vanadium, antimony, silver, barium)	Personal protective equipment will be worn by all team members, including a Tyvek coverall suit, nitrile gloves, safety glasses, and closed-toed shoes. Additionally, personal decontamination procedures will be followed, as provided in section 7.1.
Slips, trips, falls due to uneven terrain	Team members will watch carefully where they are walking to avoid falling down on uneven terrain and loose, gravelly surfaces. If terrain appears unsafe, an alternative path will be identified.
Extreme cold	Team members will dress appropriately for the weather. In the likely event of extreme cold weather, all individuals will wear adequate warm clothing.

Field Team Membership (Name/ Phone number)

Angelina Cruse (602) 653-4265

Anna Gorman (805) 602-2681

Ali Husain (267) 237-7957

Wyatt La Fave (520) 400-8339

Dr. Bridget Bero (928) 607-2516 (Field Leader)

Josue Juarez (928) 580-1985

Animal Studies: A field study is defined as any study conducted on free living wild animals that does not involve an invasive procedure or materially alter the behavior of the animal under study. In order to help you determine if your study fits this criteria, please answer the following questions.

Does Your Study?
1. Greatly disturb the animals under study? YES_____ NO **X**
(ex. testing predator vocalization, supplemental feeding, nest manipulation)

2. Involve an invasive procedure? YES_____ NO **X**
(ex. blood sampling, tagging)

3. Cause potential harm/injury to the animal? YES NO **X**
(ex. net and trap capture, bagging)

If you answered **YES to any** of these questions, your study involves invasive procedures or materially alters the behavior of the animal under study. Please fill out the full IACUC protocol application form. http://www.research.nau.edu/compliance/iacuc/
If you answered **NO to all three** of these questions and your study will only involve observation of free ranging animals, then an IACUC protocol is not required.

Figure B3.1 NAU Field Safety Checklist (Pages 1 and 2)

3.2 Chemical Hazard

Chemical hazards the may be encountered in the field area identified in Figure B3.1 NAU Field Safety Checklist. In the lab, chemical hazards that could occur is during the handling of the necessary chemicals for acid digestion procedures. Hazardous chemical being handled during acid digestion include hydrochloric acid and nitric acid. Mitigation of chemical handling can be reduced by following proper lab procedures and wearing personal protective equipment such as lab coats, goggles, and nitrile gloves. In the event of a spill, Safety Data Sheets for the chemical should be followed.

4.0 Training Requirements

4.1 HAZWOPER

Team members must complete an online 40-hour HAZWOPER training course provided by Hazardous Waste Operations and Emergency Response under OSHA 29 CFR part 1910.120. The training course helps to protect team members involved with hazardous waste materials.

4.2 NAU Safety Training

Team members are also required to follow NAU safety training online course available at: https://www5.nau.edu/its/mytraining/tutorial/tutorial5.aspx?id=6442503287. This training is required to access the CECMEE Environmental Engineering Lab and to conduct field work.

4.3 XRF Training

Team members will have completed XRF training for safe usage of the device as well as to provide quality data and to ensure the correctness of following the procedure when analyzing the samples.

5.0 Personal Protective Equipment

The personal protective equipment (PPE) used during the investigation will protect all members from dermal contact, inhalation, and ingestion exposure routes. PPE must be worn during the course of the investigation.

5.1 Safety Equipment List

The following list outlines all PPE that sampling members must wear during the investigation.

- Tyvek Coverall Suit
- Nitrile Gloves
- Safety Glasses
- Closed Toed Shoes (preferably boots)

6.0 Site Control and Operating Procedures

To ensure quality assurance and quality control during the site investigation, no person will be left alone during the investigation. During physical sampling of soils, two people will be required to ensure adequacy of the sampling procedure. Additionally, two persons should always be together in the event of an injury. In the event of an injury, the transportation vehicle will have a first aid kit and additional drinking water. The vehicle will be parked once on site and will be considered a meet up point if the team is separated and needs to reconvene.

7.0 Decontamination Procedures

7.1 Personal Decontamination

Personal decontamination will be an essential aspect is maintaining a sterile environment. This will be especially important in minimizing health risk. The team will abide by the following protocol for personal decontamination.

All team members, assistants, and advisors will bring two pairs of shoes to the field. One pair will be worn in the vehicle, while the other pair will only be worn on the site. Trash bags will be transported to the site to store and seal the on-site shoes that may become contaminated. These shoes will be dusted off with a brush and gloves on as much as possible before placed in the storage bags. Tyvek suits will be worn on site, covering clothing and protecting it from contamination. The suits will be dusted off with the brush and placed in a trash bag before being placed in the vehicle. Additionally, nitrile gloves will be worn to protect bare skin from being contaminated. These gloves will be thrown into a trash bag and sealed before entering the vehicle. Hands will be washed on site with soap and water and team members will shower after returning to the hotel.

7.2 Equipment Decontamination On Site

The equipment that will be used on-site and that needs to be decontaminated are the trowels. These will be decontaminated by first brushing off any dirt and debris, and then washed. Trowels will be washed inside one of the five gallon buckets using a scrub brush and soapy water. After scrubbing the trowel, water will be poured over the trowel to rinse it. After the rinse, trowels will be dried with the paper towels. Gloves should be worn during decontamination of the trowels. The gloves and paper towels used during the decontamination process will be stored in trash bags and hauled off site. After sampling and final decontamination occurs, the equipment will also be stored in trash bags to add another layer between them and the vehicle.

7.3 Waste Disposal

Water bottles, papers, plastic bags, gloves and PPE generated in the decontamination process will be disposed of as non-hazardous solid waste. Wash water used during the investigation will be disposed of on site.

Laboratory generated waste will be disposed of as hazardous waste at the NAU CECMEE Environmental Engineering Laboratory. Waste will be disposed of in marked hazardous waste bucket in the lab.

8.0 Emergency Response Procedures

In case of a serious emergency with one of the team members, the team will contact the individual's provided emergency contact. Depending on the severity of the event, emergency medical professionals may be contacted, though this is unlikely to occur. The personal emergency contacts are provided below. A first aid kit will be kept in the vehicle in the event of an injury.

If the emergency warrants a need to go to the hospital the nearest hospital is Kingman Regional Medical Center approximately 74 miles away from the site. The address of the Hospital is, 3269 Stockton Hill Rd, Kingman, AZ 86409. The hospital phone number is (928) 757-2101. A map to the hospital is provided in Figure B8.1. From Signal Mill head northeast on Signal Road toward Dipsoarus Drive. Continue on US-93 North to Kingman and take exit 51 from I-40 West. Continue on Stockton Hill Road until Kingman Regional Medical Center is reached.

Figure B8.1 Kingman Regional Medical Center Map from Signal Mill

8.1 Emergency Contacts

Provide on the following page in Table B8.1 are the emergency contact information for team members.

Table B8.1 Emergency Contact List

Team Member	Cell Phone Number	Emergency Contact	Relationship	Phone Number
Angelina Cruse	(602) 653-4265	Tessa Cruse	Sister	(480) 336-0561
Anna Gorman	(805) 602-2681	Leslie Kneafsey	Mother	(805) 801-2818
Ali Husain	(267) 237-7957	Khaled Dashti	Friend	(424) 666-9940
Wyatt La Fave	(520) 400-8339	Wendy La Fave	Mother	(520) 403-2599
Bridget Bero	(928) 607-2516	Charlie Beadles	Husband	(928) 607-8688
Josue Juarez	(928) 580-1985	Alfredo Juarez	Father	(928) 261-6772

Appendix B: Field Notes

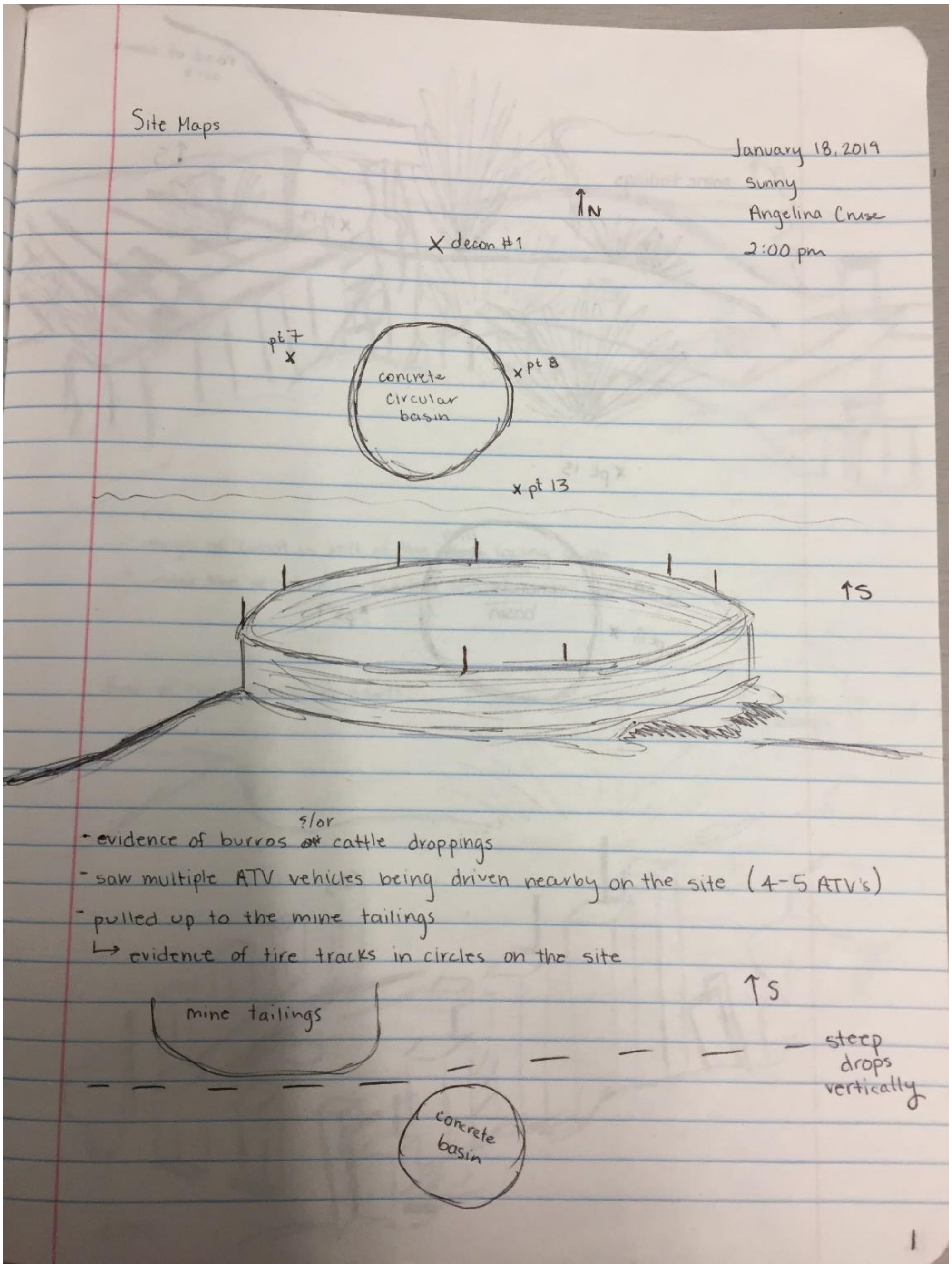


Figure B1. Field Notes Site Sketch page 1

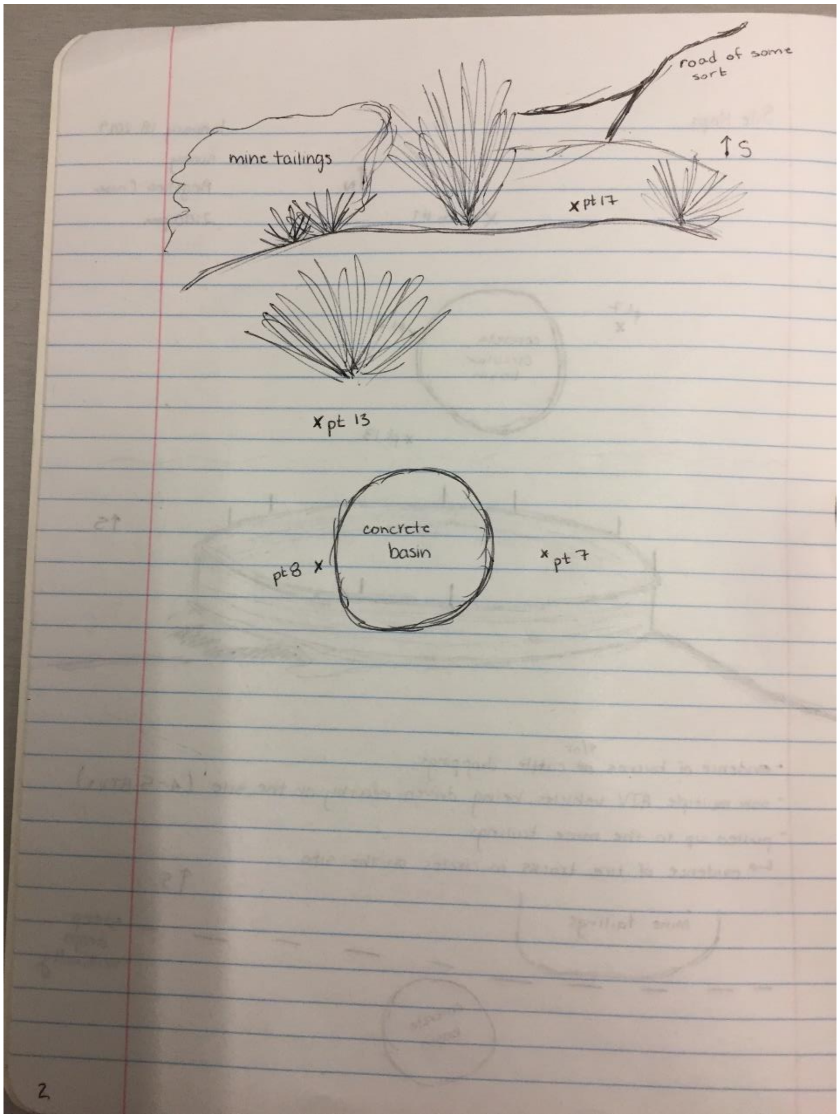


Figure B2. Field Notes Site Sketch page 2

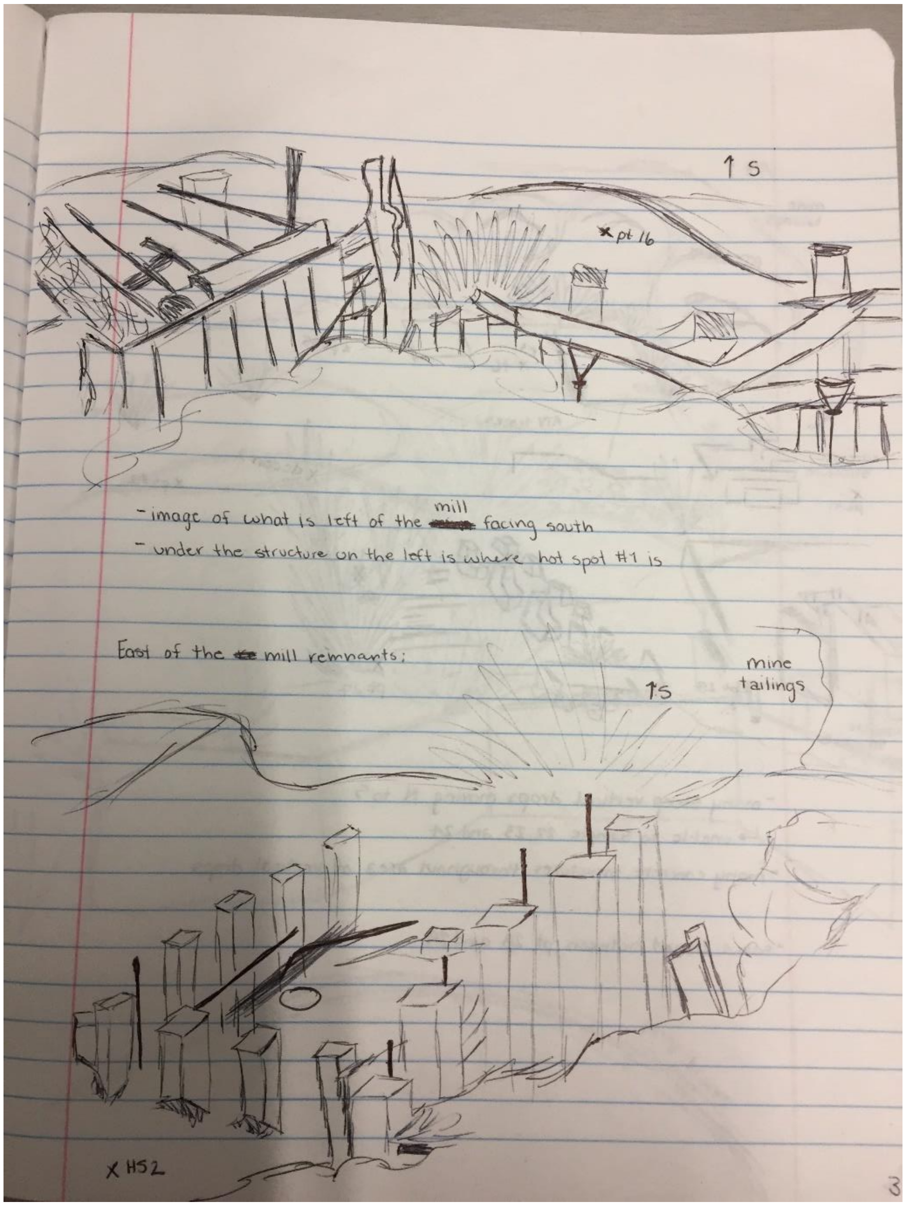


Figure B3. Field Notes Site Sketch page 3

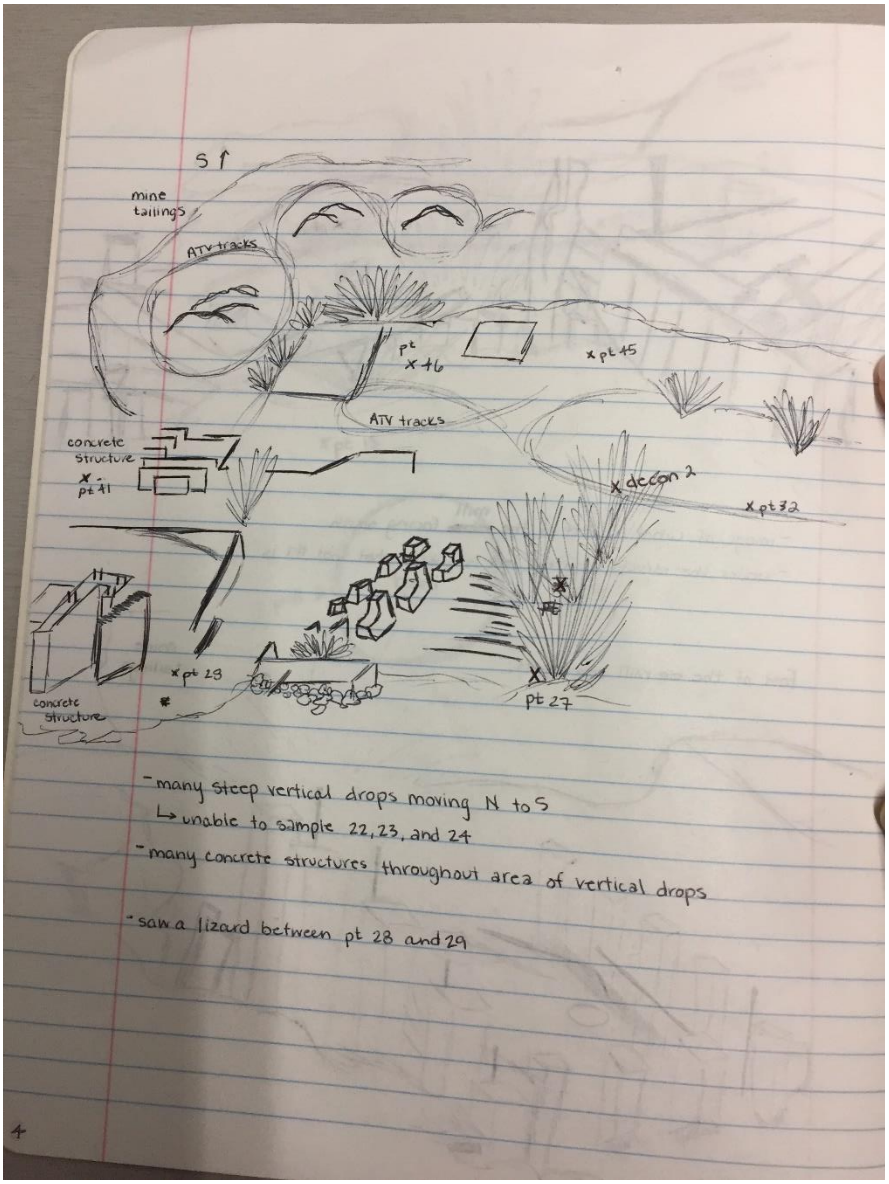


Figure B4. Field Notes Site Sketch page 4

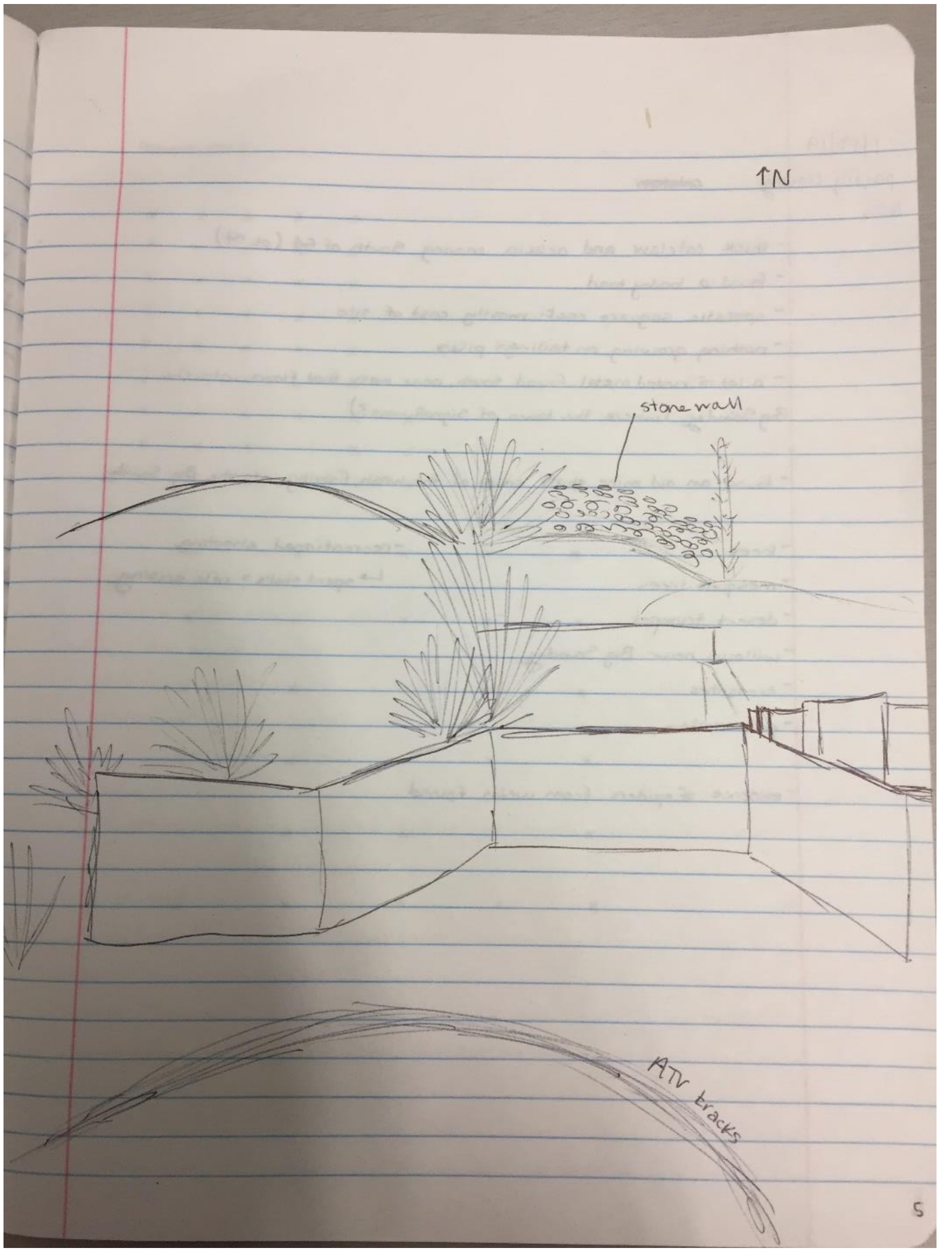
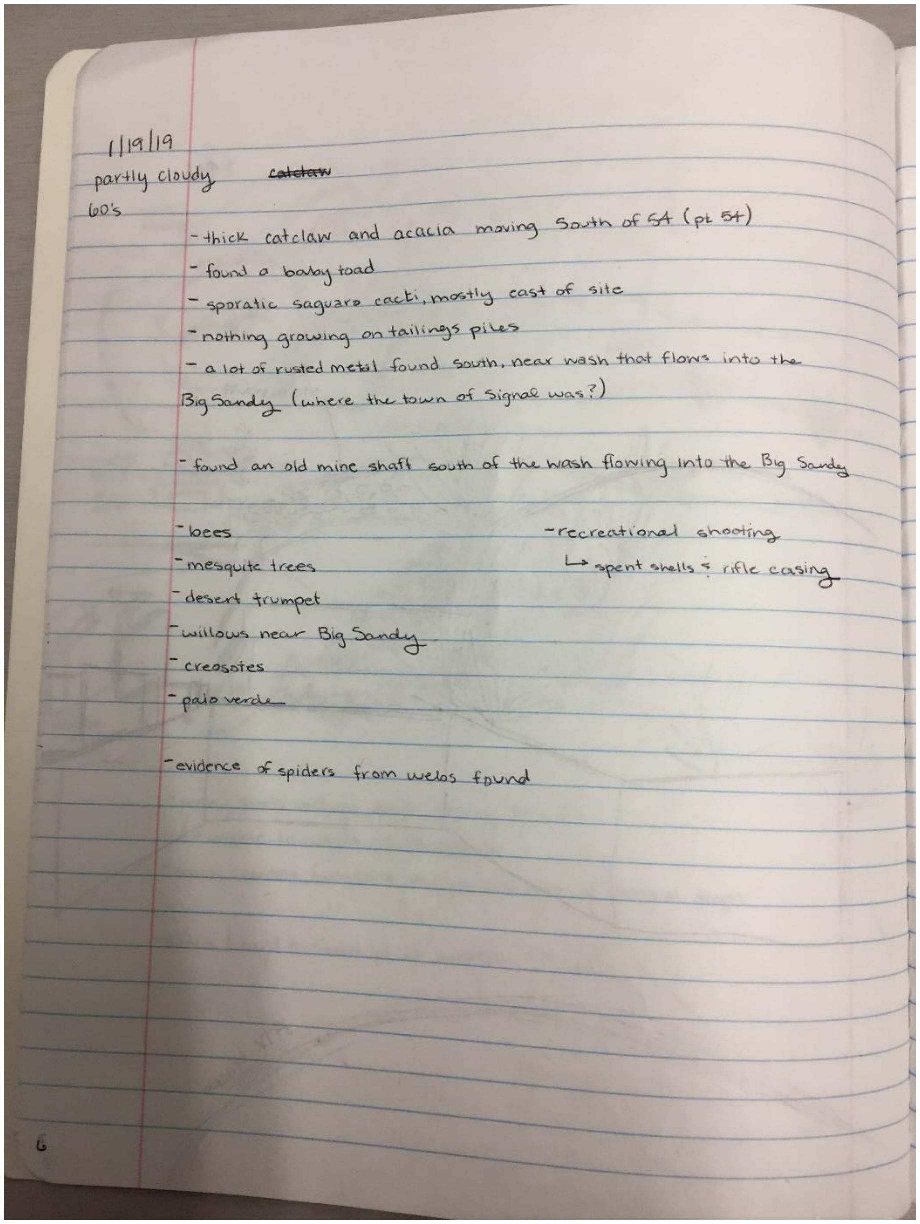


Figure B5. Field Notes Site Sketch page 5


1/19/19
partly cloudy ~~catclaw~~
60's
- thick catclaw and acacia moving South of 54 (pt 54)
- found a baby toad
- sporatic saguaro cacti, mostly east of site
- nothing growing on tailings piles
- a lot of rusted metal found south, near wash that flows into the Big Sandy (where the town of Signal was?)

- found an old mine shaft south of the wash flowing into the Big Sandy

- bees
- mesquite trees
- desert trumpet
- willows near Big Sandy
- creosotes
- palo verde

- recreational shooting
  ↳ spent shells & rifle casing

- evidence of spiders from webs found

6

Figure B6. Field Notes Flora and Fauna Survey page 6

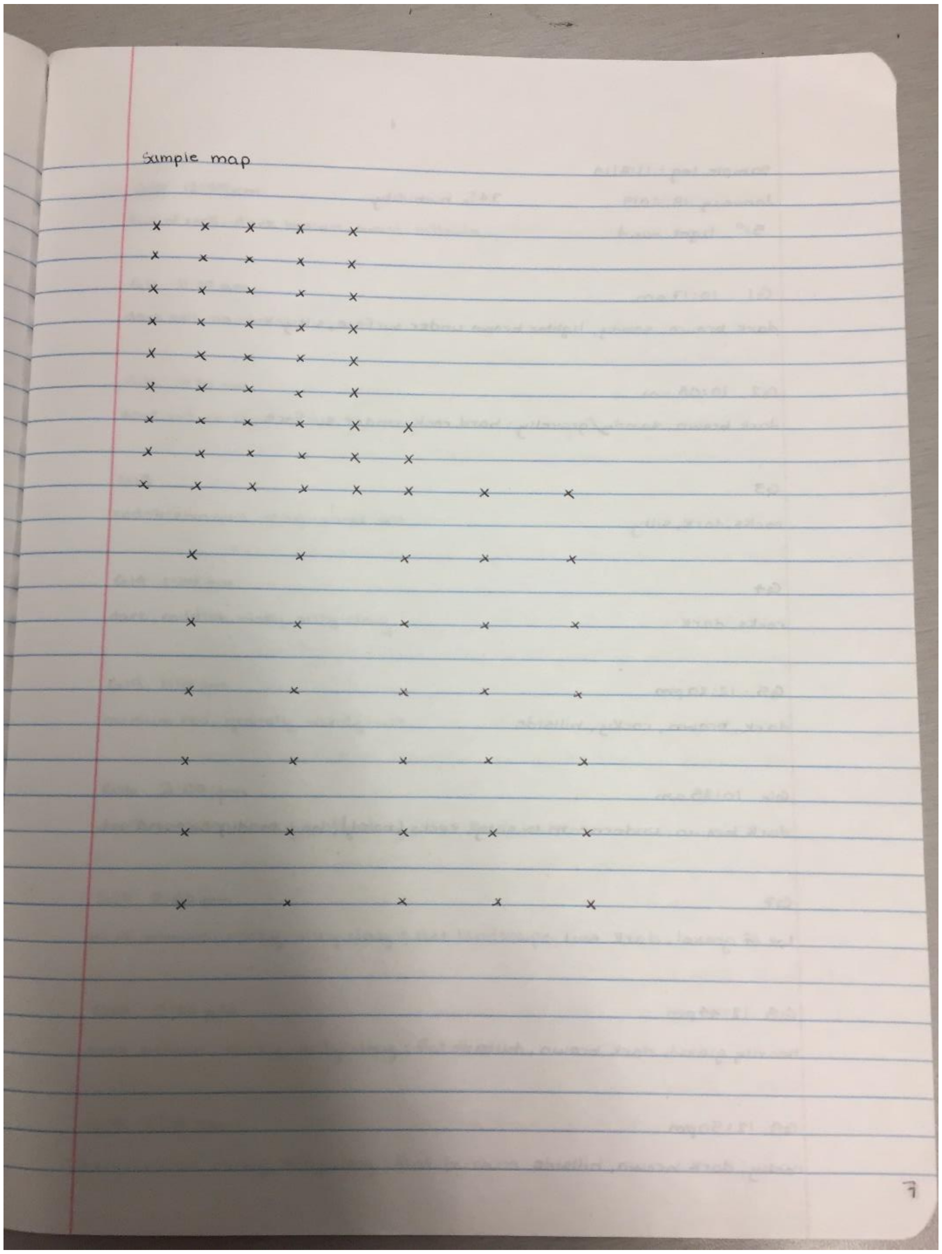
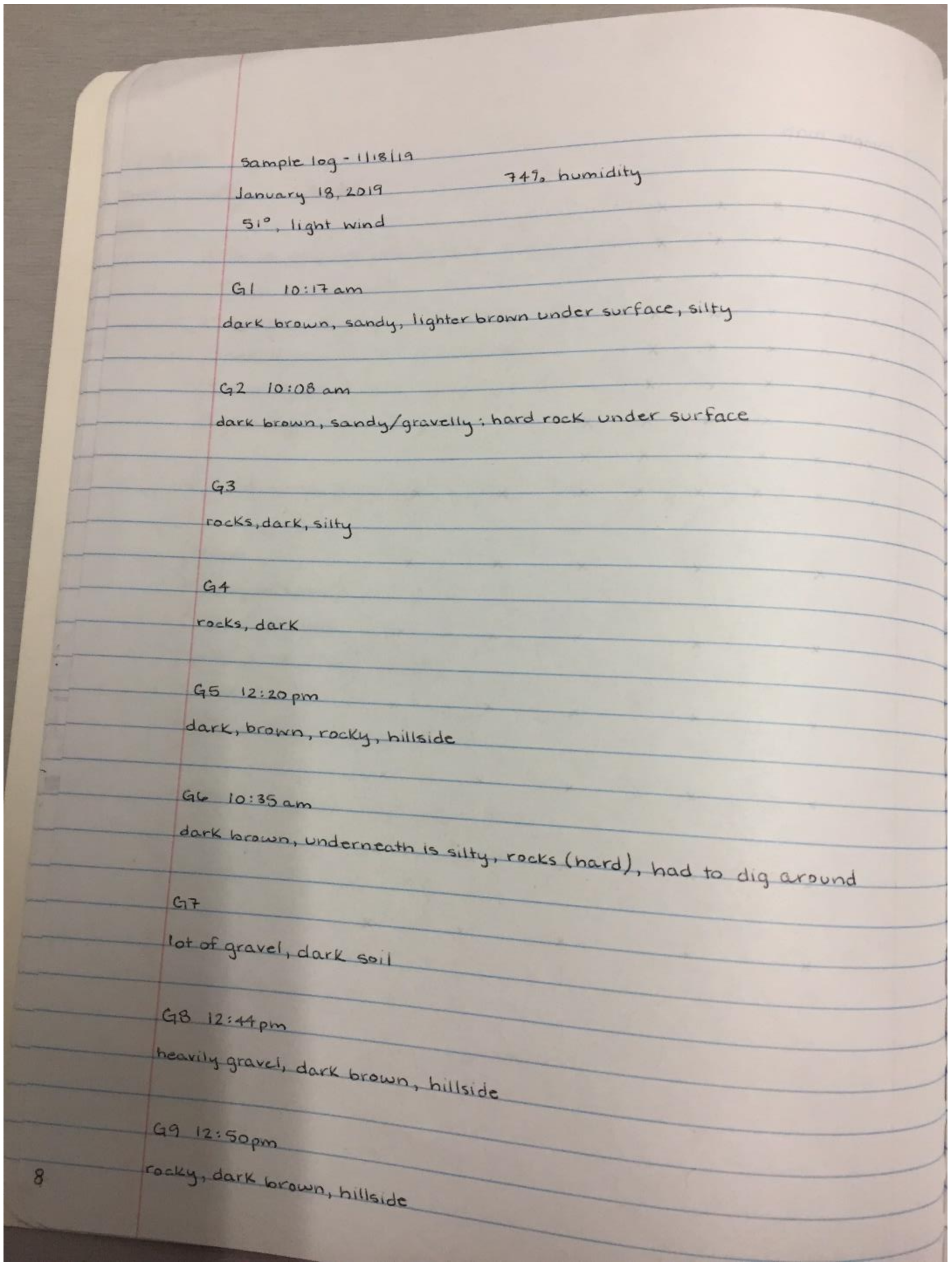


Figure B7. Field Notes Grid Sampling Map page 7



Sample log - 1/18/19
January 18, 2019 74% humidity
51°, light wind

G1 10:17 am
dark brown, sandy, lighter brown under surface, silty

G2 10:08 am
dark brown, sandy/gravelly; hard rock under surface

G3
rocks, dark, silty

G4
rocks, dark

G5 12:20 pm
dark, brown, rocky, hillside

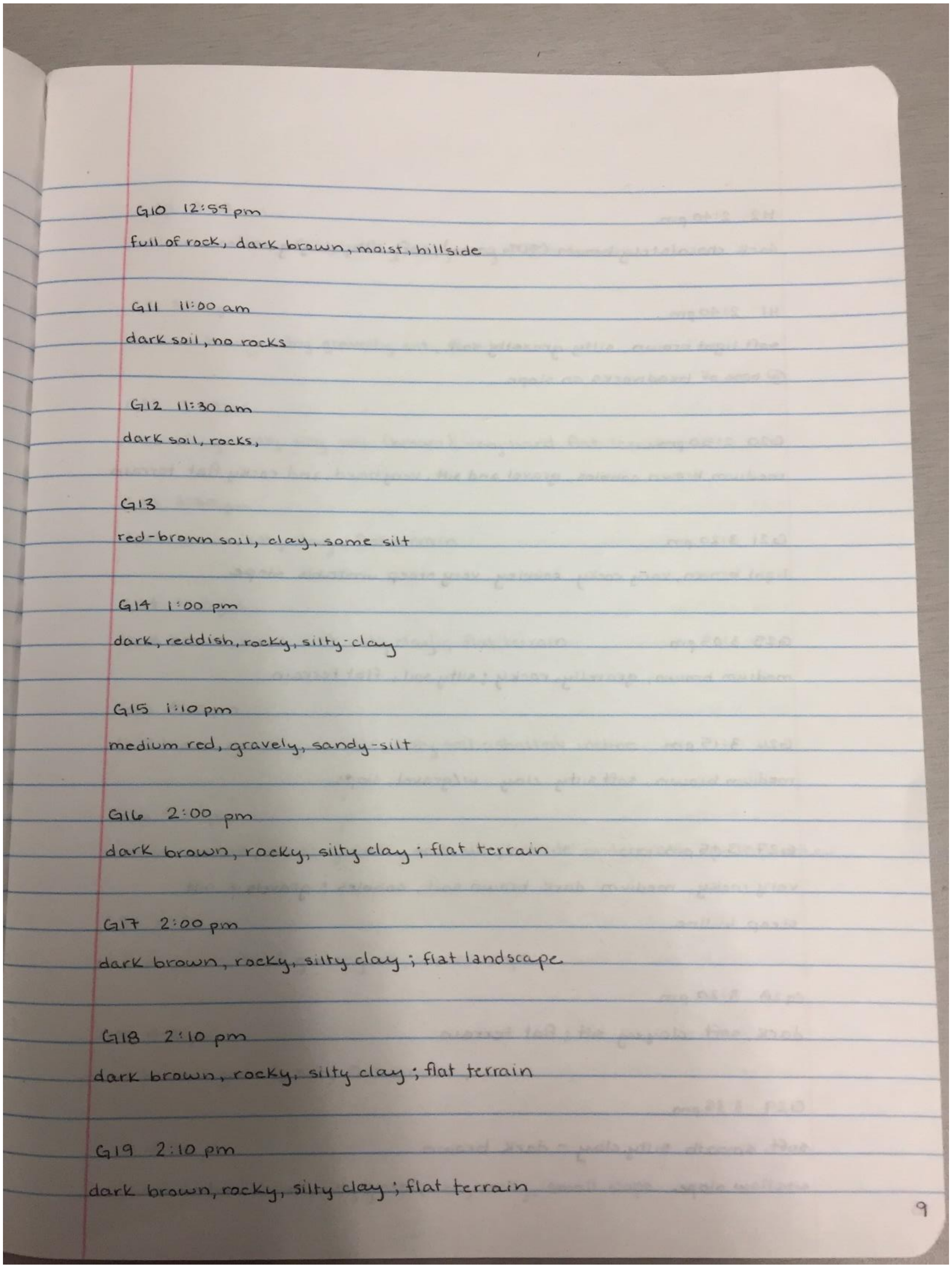
G6 10:35 am
dark brown, underneath is silty, rocks (hard), had to dig around

G7
lot of gravel, dark soil

G8 12:44 pm
heavily gravel, dark brown, hillside

G9 12:50pm
8 rocky, dark brown, hillside

Figure B8. Field Notes Sample Log page 8



G10 12:59 pm
full of rock, dark brown, moist, hillside

G11 11:00 am
dark soil, no rocks

G12 11:30 am
dark soil, rocks,

G13
red-brown soil, clay, some silt

G14 1:00 pm
dark, reddish, rocky, silty-clay

G15 1:10 pm
medium red, gravely, sandy-silt

G16 2:00 pm
dark brown, rocky, silty clay ; flat terrain

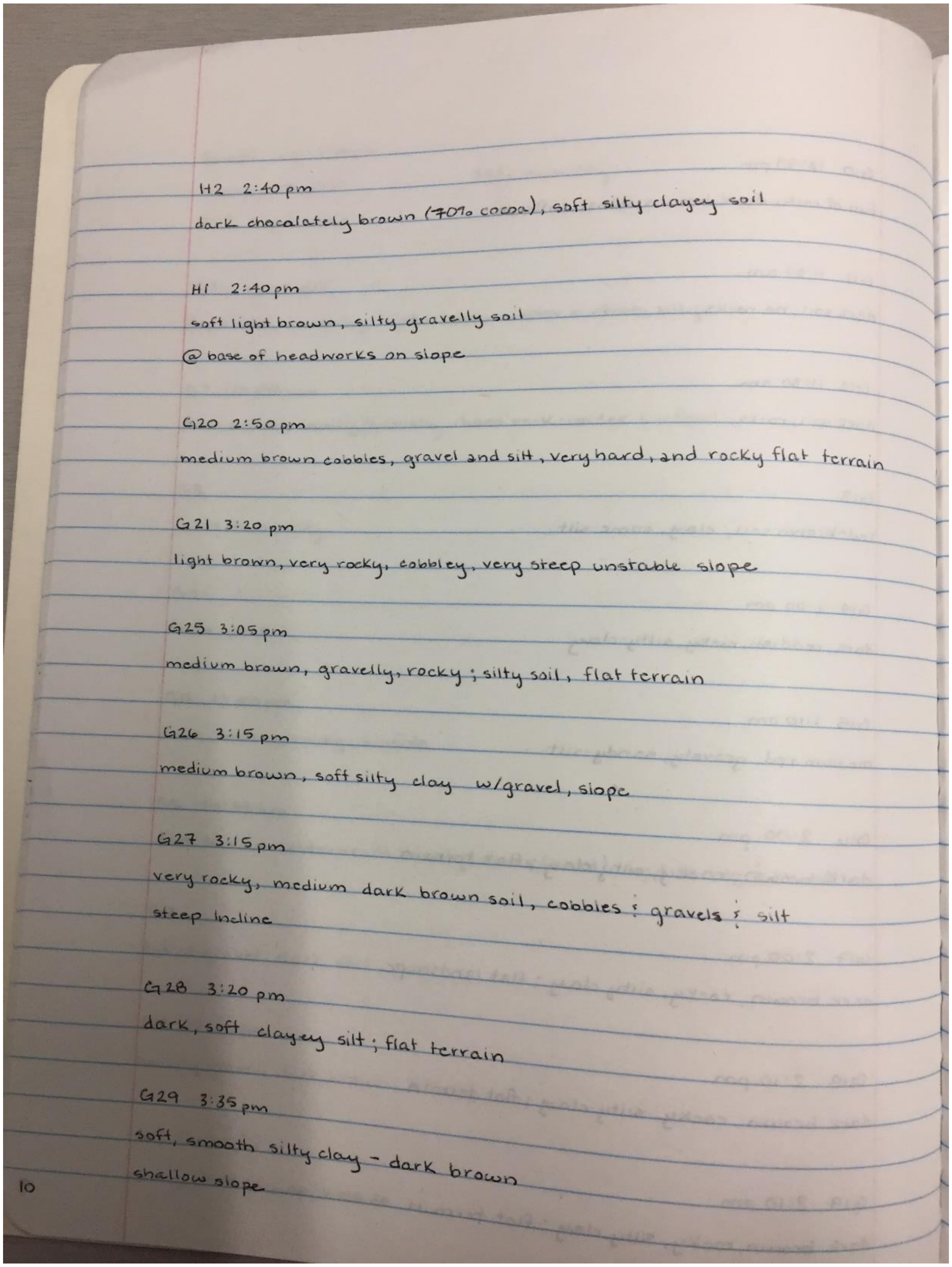
G17 2:00 pm
dark brown, rocky, silty clay ; flat landscape

G18 2:10 pm
dark brown, rocky, silty clay ; flat terrain

G19 2:10 pm
dark brown, rocky, silty clay ; flat terrain

9

Figure B9. Field Notes Sample Log page 9



H2 2:40 pm
dark chocalately brown (70% cocoa), soft silty clayey soil

H1 2:40 pm
soft light brown, silty gravelly soil
@ base of headworks on slope

G20 2:50 pm
medium brown cobbles, gravel and silt, very hard, and rocky flat terrain

G21 3:20 pm
light brown, very rocky, cobbley, very steep unstable slope

G25 3:05 pm
medium brown, gravelly, rocky ; silty soil, flat terrain

G26 3:15 pm
medium brown, soft silty clay w/gravel, slope

G27 3:15 pm
very rocky, medium dark brown soil, cobbles ; gravels ; silt
steep incline

G28 3:20 pm
dark, soft clayey silt ; flat terrain

G29 3:35 pm
soft, smooth silty clay - dark brown
shallow slope

10

Figure B10. Field Notes Sample Log page 10

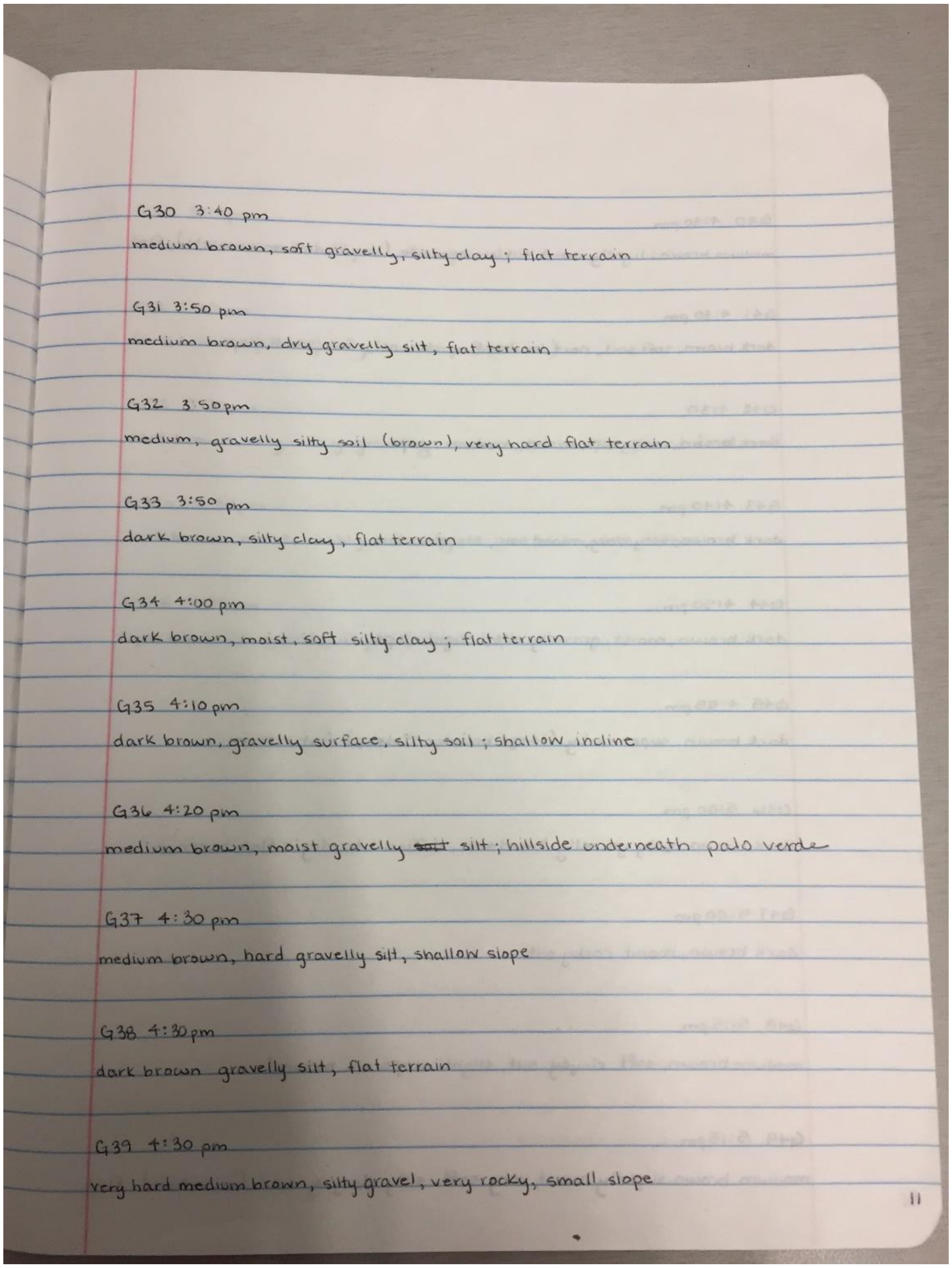
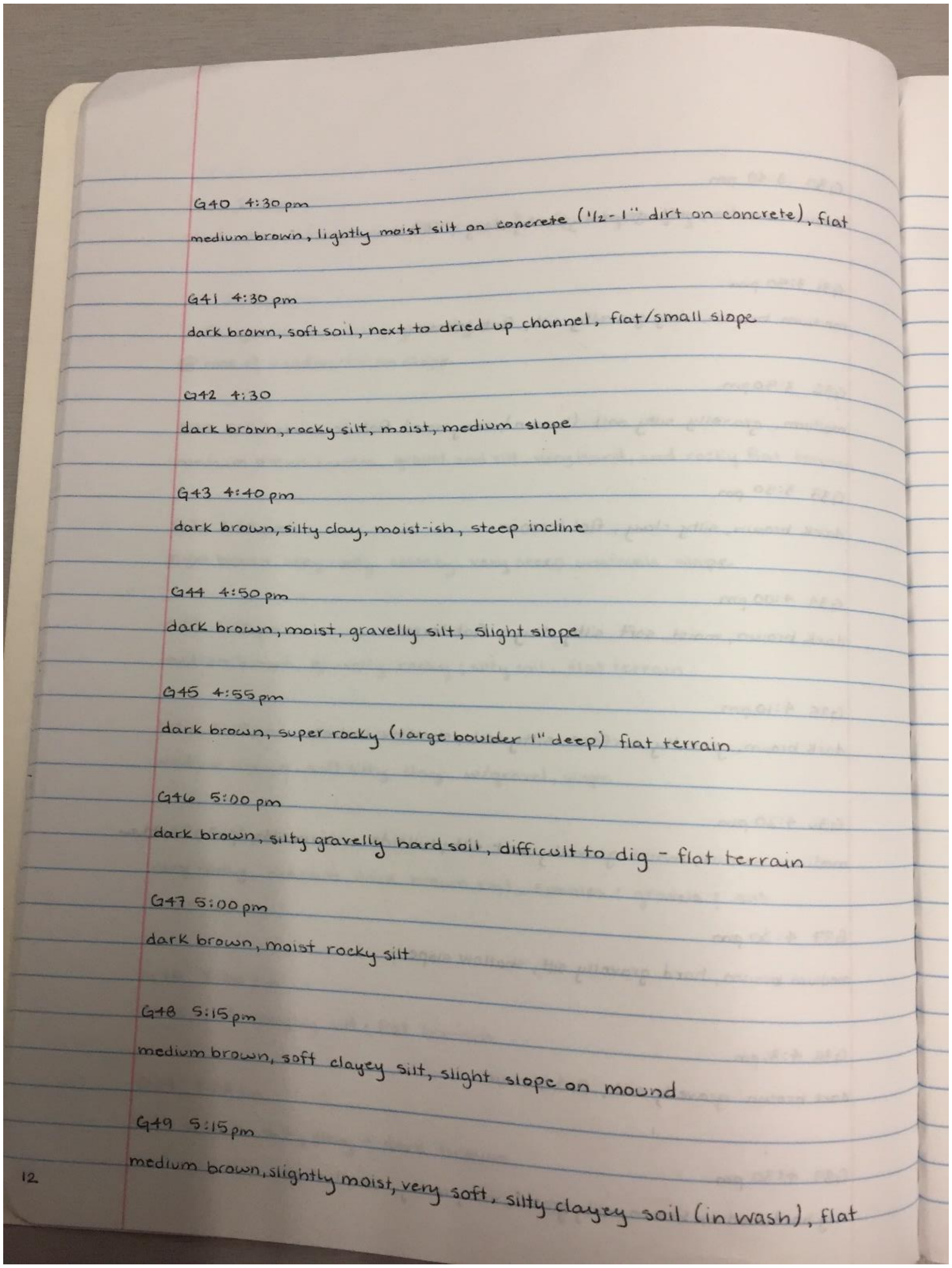


Figure B11. Field Notes Sample Log page 11



G40 4:30 pm
medium brown, lightly moist silt on concrete (½-1" dirt on concrete), flat

G41 4:30 pm
dark brown, soft soil, next to dried up channel, flat/small slope

G42 4:30
dark brown, rocky silt, moist, medium slope

G43 4:40 pm
dark brown, silty clay, moist-ish, steep incline

G44 4:50 pm
dark brown, moist, gravelly silt, slight slope

G45 4:55 pm
dark brown, super rocky (large boulder 1" deep) flat terrain

G46 5:00 pm
dark brown, silty gravelly hard soil, difficult to dig - flat terrain

G47 5:00 pm
dark brown, moist rocky silt

G48 5:15 pm
medium brown, soft clayey silt, slight slope on mound

G49 5:15 pm
12 medium brown, slightly moist, very soft, silty clayey soil (in wash), flat

Figure B12. Field Notes Sample log page 12

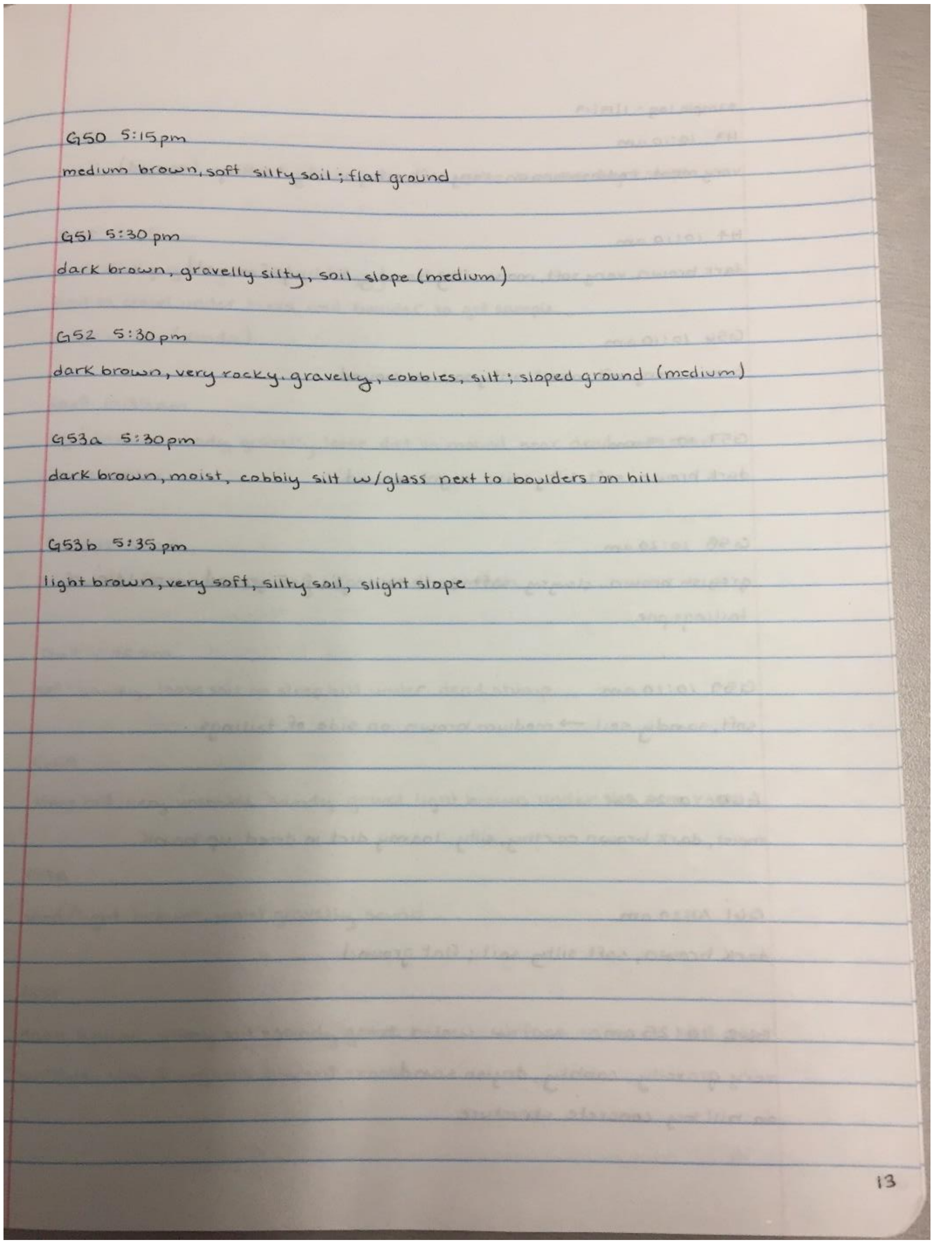
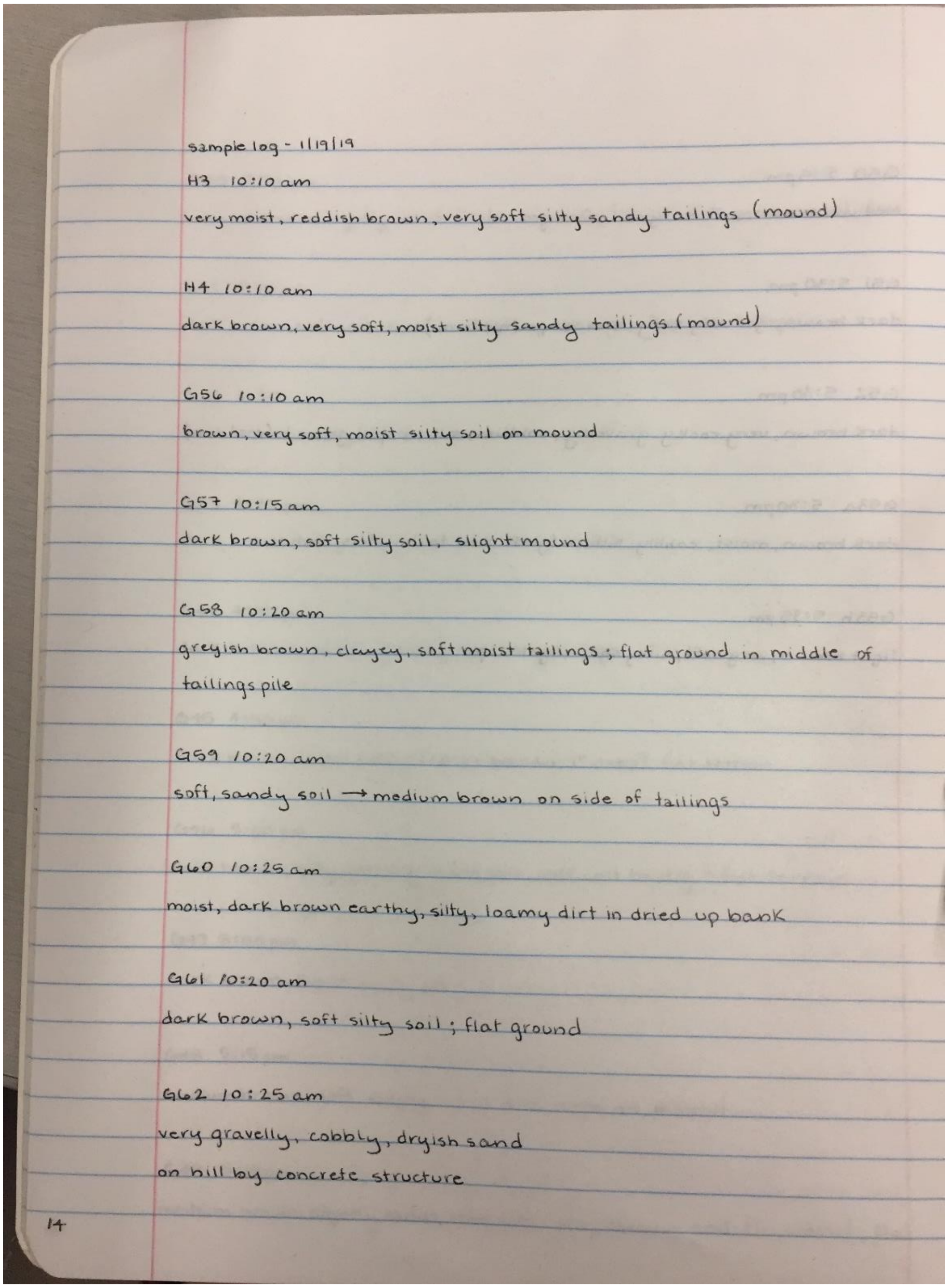


Figure B13. Field Notes Sample Log page 13



sample log - 1/19/19

H3 10:10 am

very moist, reddish brown, very soft silty sandy tailings (mound)

H4 10:10 am

dark brown, very soft, moist silty sandy tailings (mound)

G56 10:10 am

brown, very soft, moist silty soil on mound

G57 10:15 am

dark brown, soft silty soil, slight mound

G58 10:20 am

greyish brown, clayey, soft moist tailings; flat ground in middle of tailings pile

G59 10:20 am

soft, sandy soil → medium brown on side of tailings

G60 10:25 am

moist, dark brown earthy, silty, loamy dirt in dried up bank

G61 10:20 am

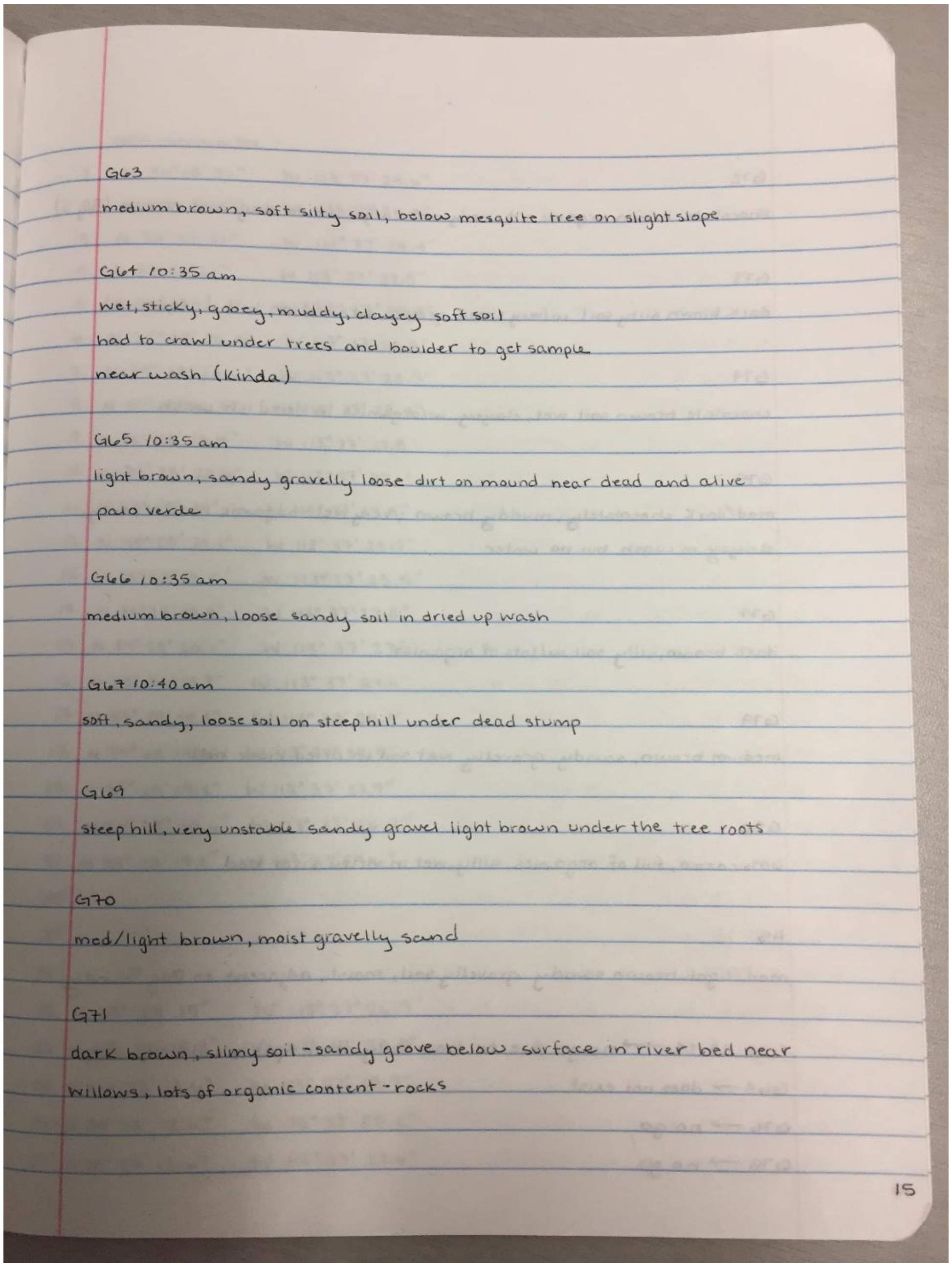
dark brown, soft silty soil; flat ground

G62 10:25 am

very gravelly, cobbly, dryish sand on hill by concrete structure

14

Figure B14. Field Notes Sample Log page 14



G63

medium brown, soft silty soil, below mesquite tree on slight slope

G64 10:35 am

wet, sticky, gooey, muddy, clayey soft soil

had to crawl under trees and boulder to get sample

near wash (kinda)

G65 10:35 am

light brown, sandy gravelly loose dirt on mound near dead and alive

palo verde

G66 10:35 am

medium brown, loose sandy soil in dried up wash

G67 10:40 am

soft, sandy, loose soil on steep hill under dead stump

G69

steep hill, very unstable sandy gravel light brown under the tree roots

G70

med/light brown, moist gravelly sand

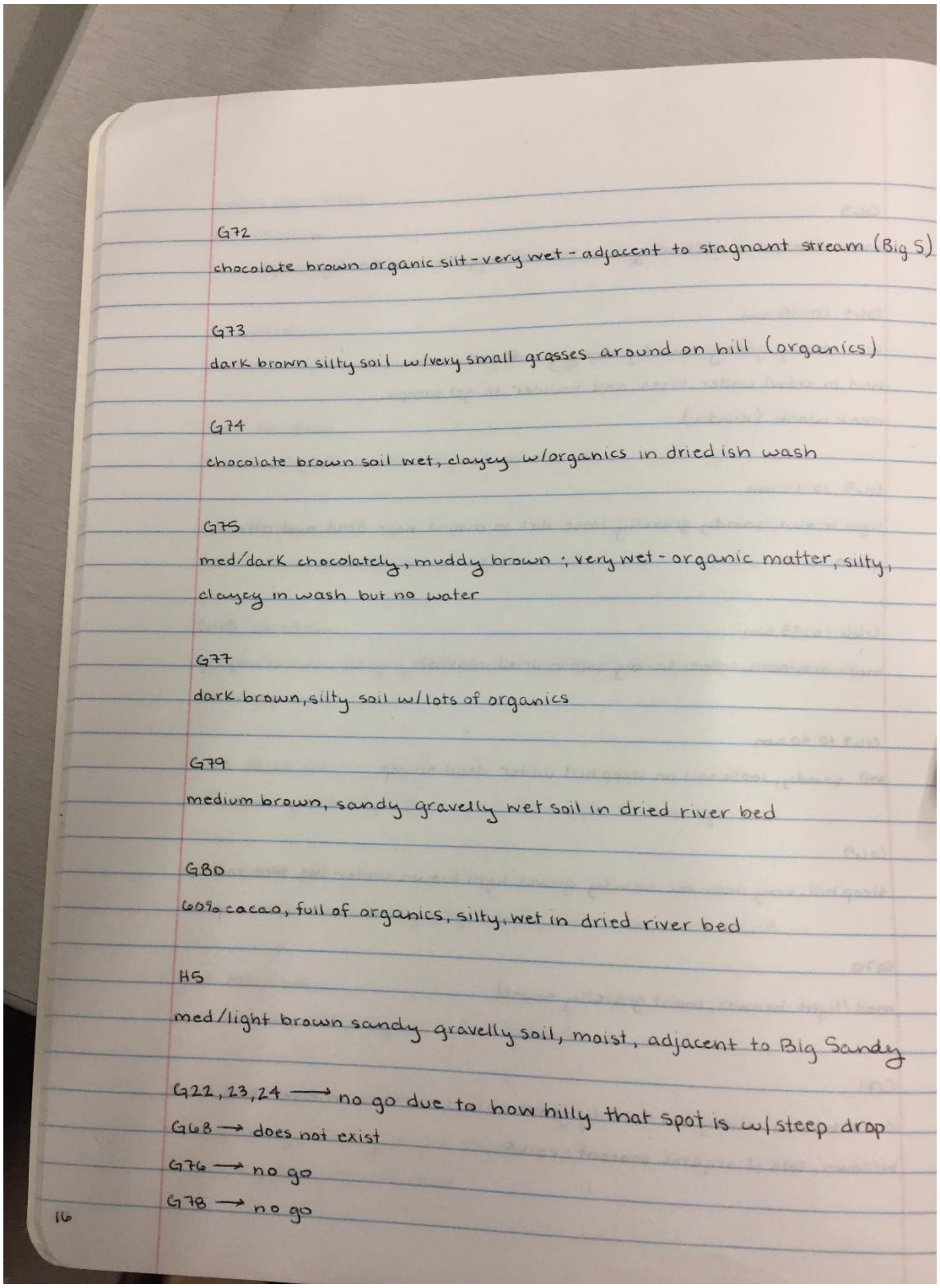
G71

dark brown, slimy soil - sandy grove below surface in river bed near

willows, lots of organic content - rocks

15

Figure B15. Field Notes Sample Log page 15



G72

chocolate brown organic silt - very wet - adjacent to stagnant stream (Big S)

G73

dark brown silty soil w/very small grasses around on hill (organics)

G74

chocolate brown soil wet, clayey w/organics in dried ish wash

G75

med/dark chocolately, muddy brown ; very wet - organic matter, silty, clayey in wash but no water

G77

dark brown, silty soil w/lots of organics

G79

medium brown, sandy gravelly wet soil in dried river bed

G80

60% cacao, full of organics, silty, wet in dried river bed

H5

med/light brown sandy gravelly soil, moist, adjacent to Big Sandy

G22, 23, 24 → no go due to how hilly that spot is w/steep drop

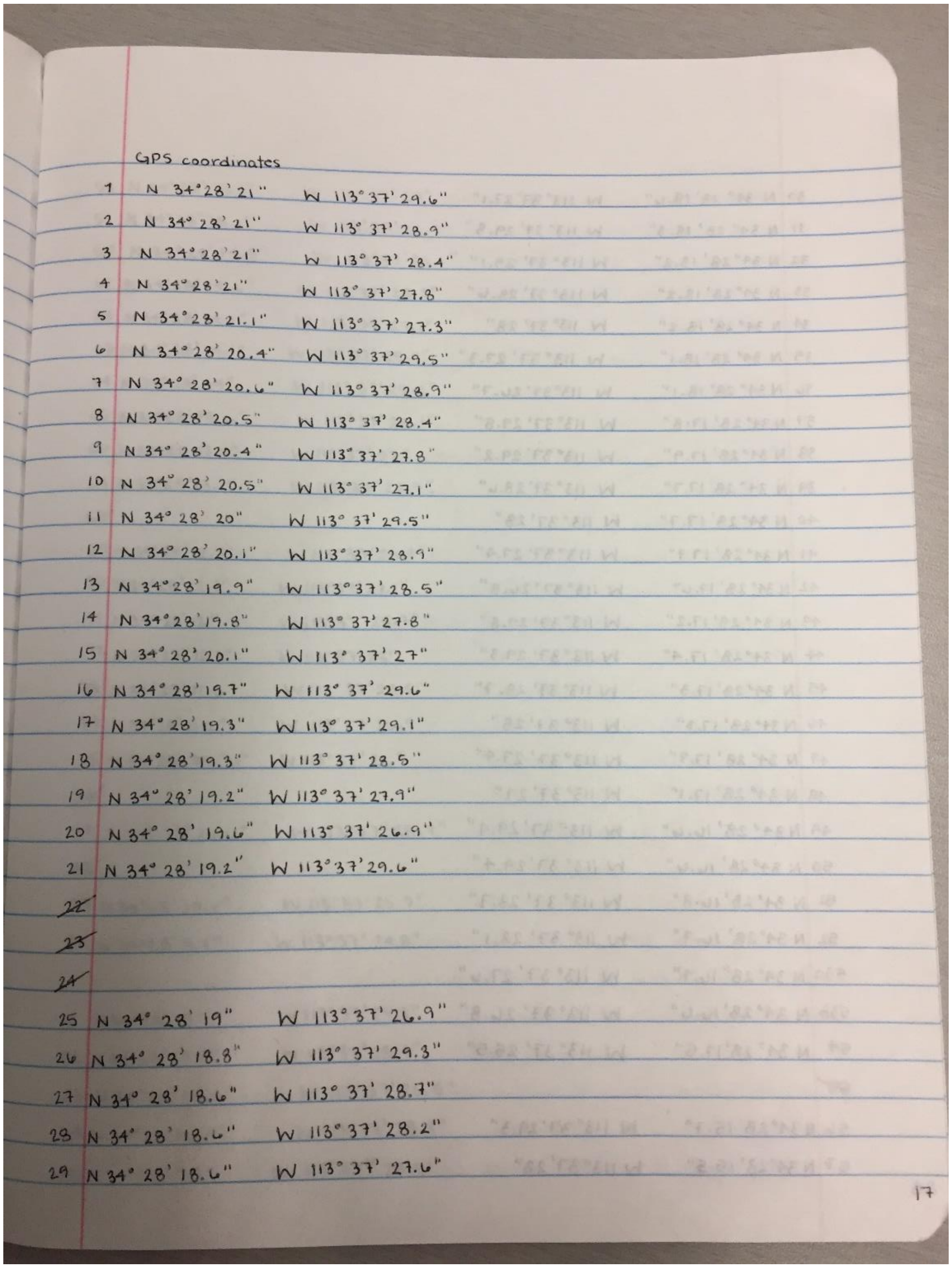
G68 → does not exist

G76 → no go

G78 → no go

16

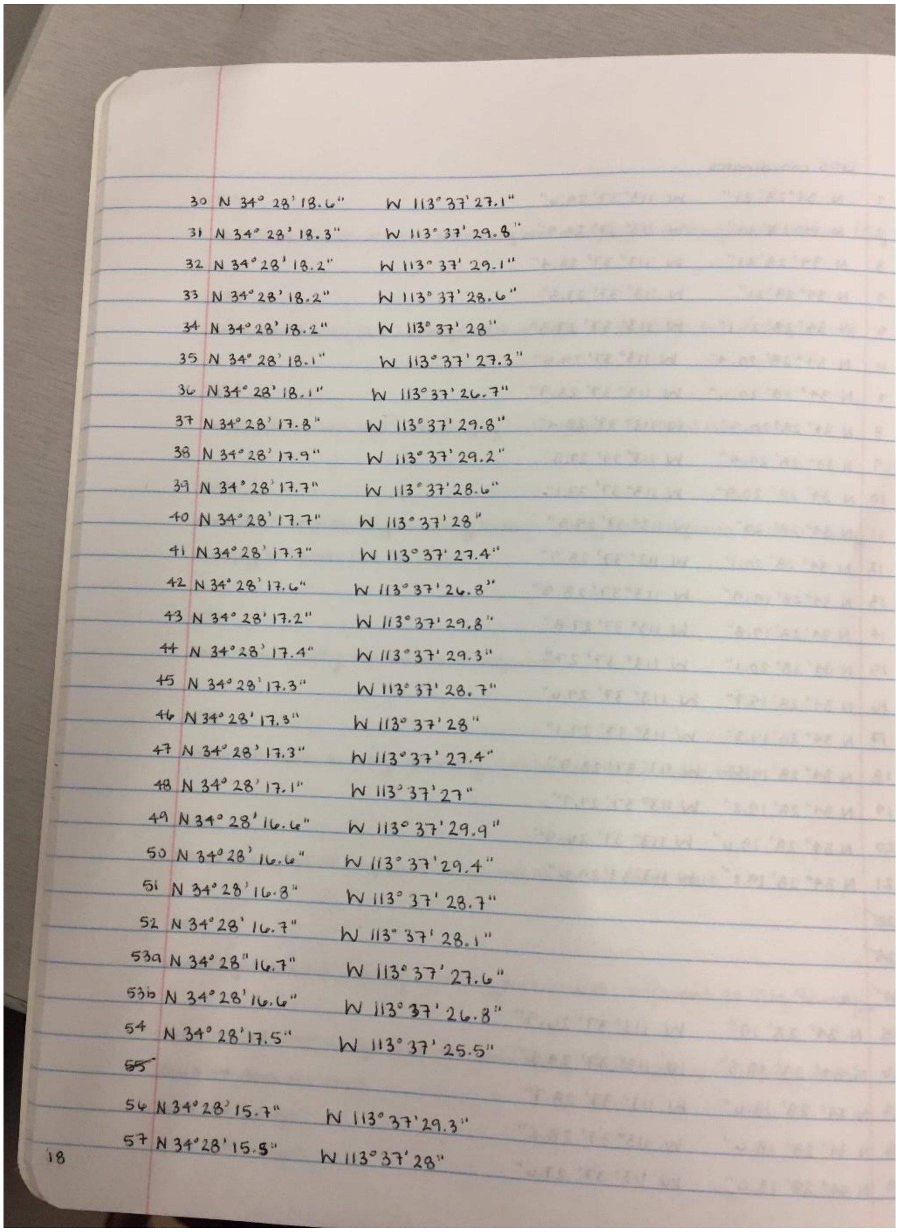
Figure B16. Field Notes Sample Log page 16


GPS coordinates

1	N 34°28'21"	W 113°37'29.6"
2	N 34° 28' 21"	W 113° 37' 28.9"
3	N 34° 28' 21"	W 113° 37' 28.4"
4	N 34° 28' 21"	W 113° 37' 27.8"
5	N 34° 28' 21.1"	W 113° 37' 27.3"
6	N 34° 28' 20.4"	W 113° 37' 29.5"
7	N 34° 28' 20.6"	W 113° 37' 28.9"
8	N 34° 28' 20.5"	W 113° 37' 28.4"
9	N 34° 28' 20.4"	W 113° 37' 27.8"
10	N 34° 28' 20.5"	W 113° 37' 27.1"
11	N 34° 28' 20"	W 113° 37' 29.5"
12	N 34° 28' 20.1"	W 113° 37' 28.9"
13	N 34° 28' 19.9"	W 113° 37' 28.5"
14	N 34° 28' 19.8"	W 113° 37' 27.8"
15	N 34° 28' 20.1"	W 113° 37' 27"
16	N 34° 28' 19.7"	W 113° 37' 29.6"
17	N 34° 28' 19.3"	W 113° 37' 29.1"
18	N 34° 28' 19.3"	W 113° 37' 28.5"
19	N 34° 28' 19.2"	W 113° 37' 27.9"
20	N 34° 28' 19.6"	W 113° 37' 26.9"
21	N 34° 28' 19.2"	W 113° 37' 29.6"
~~22~~		
~~23~~		
~~24~~		
25	N 34° 28' 19"	W 113° 37' 26.9"
26	N 34° 28' 18.8"	W 113° 37' 29.3"
27	N 34° 28' 18.6"	W 113° 37' 28.7"
28	N 34° 28' 18.6"	W 113° 37' 28.2"
29	N 34° 28' 18.6"	W 113° 37' 27.6"

17

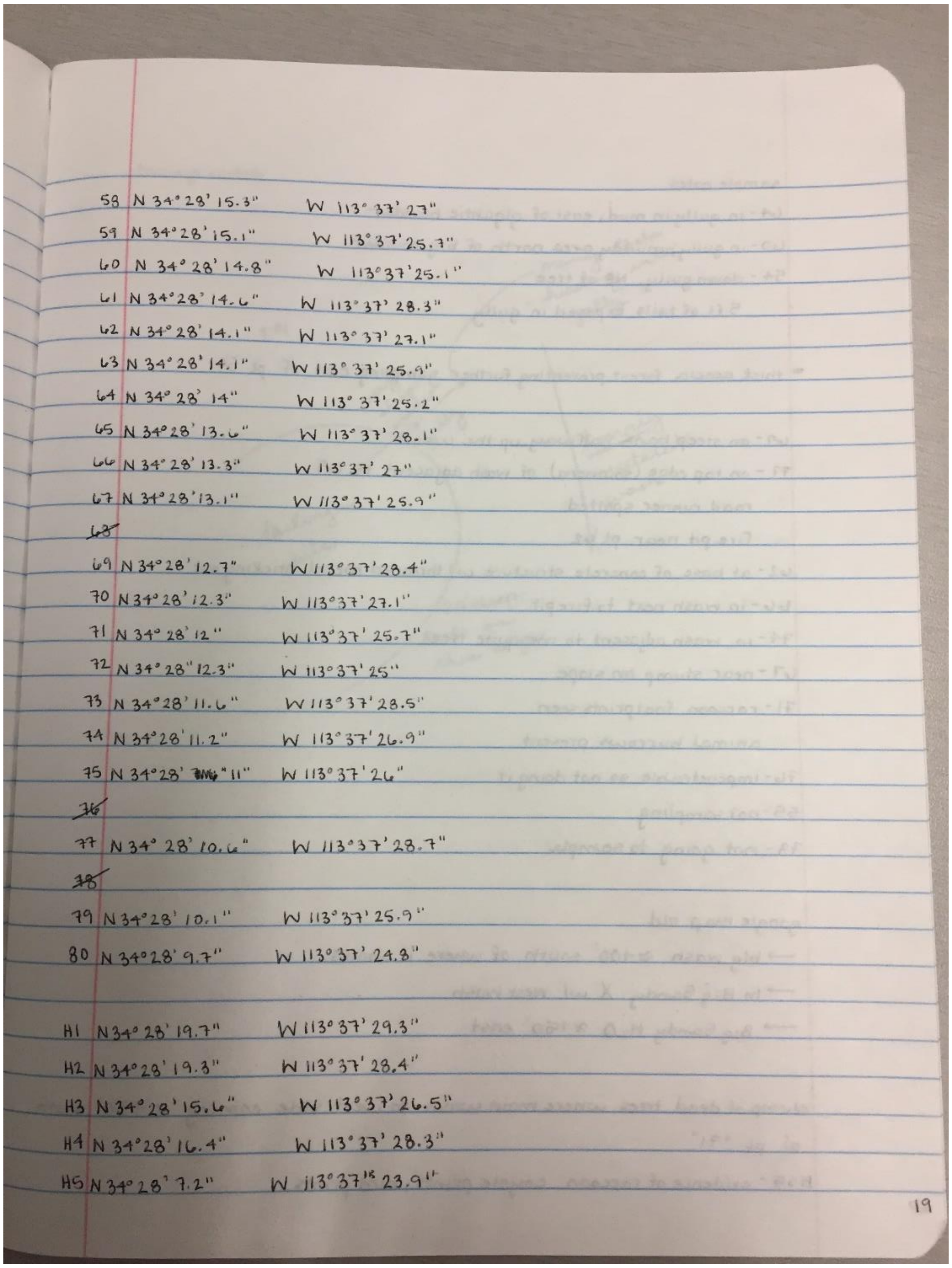
Figure B17. Field Note GPS Coordinates page 17



30	N 34° 28' 18.6"	W 113° 37' 27.1"
31	N 34° 28' 18.3"	W 113° 37' 29.8"
32	N 34° 28' 18.2"	W 113° 37' 29.1"
33	N 34° 28' 18.2"	W 113° 37' 28.6"
34	N 34° 28' 18.2"	W 113° 37' 28"
35	N 34° 28' 18.1"	W 113° 37' 27.3"
36	N 34° 28' 18.1"	W 113° 37' 26.7"
37	N 34° 28' 17.8"	W 113° 37' 29.8"
38	N 34° 28' 17.9"	W 113° 37' 29.2"
39	N 34° 28' 17.7"	W 113° 37' 28.6"
40	N 34° 28' 17.7"	W 113° 37' 28"
41	N 34° 28' 17.7"	W 113° 37' 27.4"
42	N 34° 28' 17.6"	W 113° 37' 26.8"
43	N 34° 28' 17.2"	W 113° 37' 29.8"
44	N 34° 28' 17.4"	W 113° 37' 29.3"
45	N 34° 28' 17.3"	W 113° 37' 28.7"
46	N 34° 28' 17.3"	W 113° 37' 28"
47	N 34° 28' 17.3"	W 113° 37' 27.4"
48	N 34° 28' 17.1"	W 113° 37' 27"
49	N 34° 28' 16.6"	W 113° 37' 29.9"
50	N 34° 28' 16.6"	W 113° 37' 29.4"
51	N 34° 28' 16.8"	W 113° 37' 28.7"
52	N 34° 28' 16.7"	W 113° 37' 28.1"
53a	N 34° 28" 16.7"	W 113° 37' 27.6"
53b	N 34° 28' 16.6"	W 113° 37' 26.8"
54	N 34° 28' 17.5"	W 113° 37' 25.5"
~~55~~		
56	N 34° 28' 15.7"	W 113° 37' 29.3"
57	N 34° 28' 15.5"	W 113° 37' 28"

18

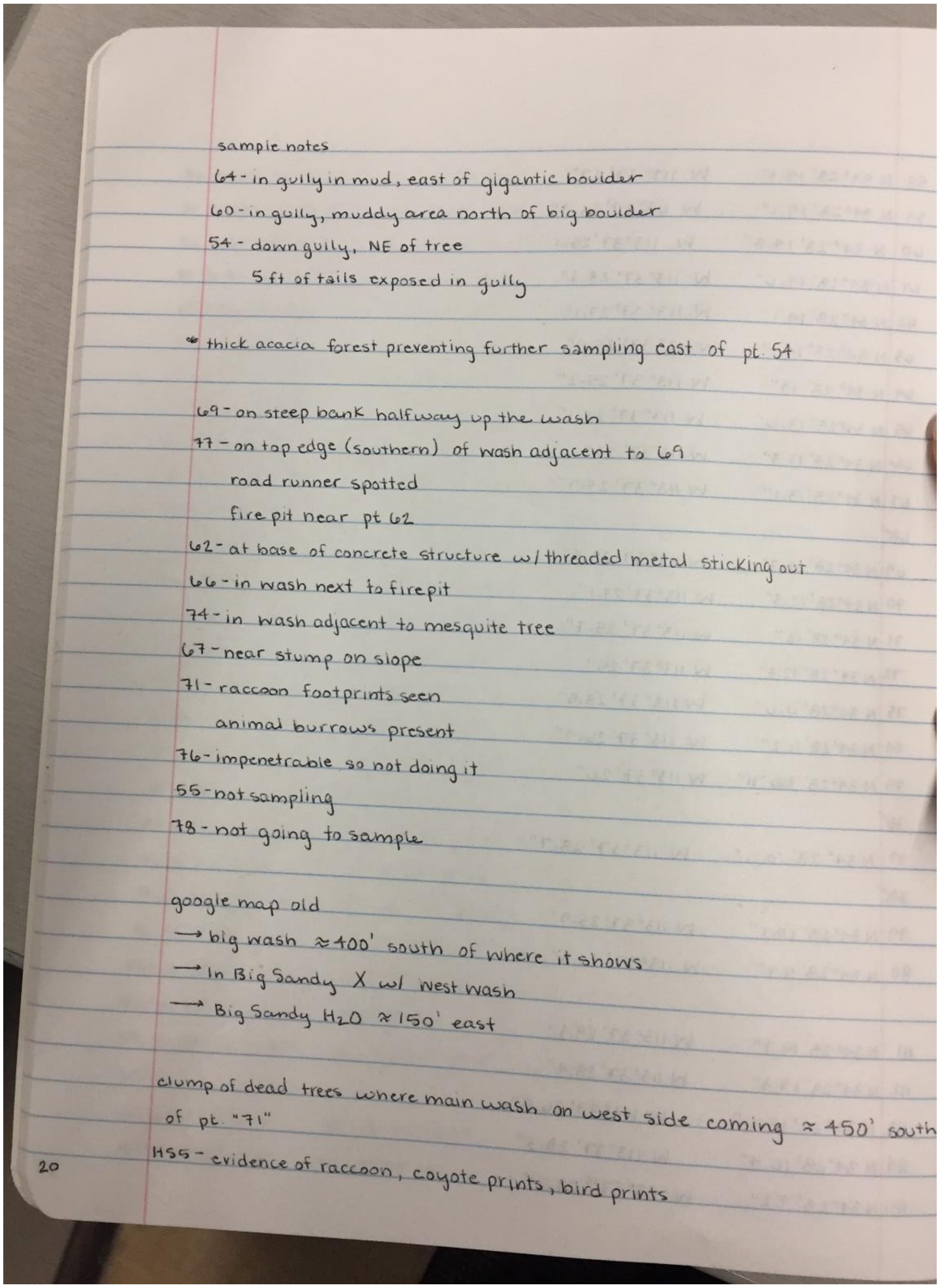
Figure B18. Field Notes GPS Coordinates page 18



58	N 34°28' 15.3"	W 113° 37' 27"
59	N 34°28' 15.1"	W 113°37' 25.7"
60	N 34°28' 14.8"	W 113°37' 25.1"
61	N 34°28' 14.6"	W 113°37' 28.3"
62	N 34°28' 14.1"	W 113°37' 27.1"
63	N 34°28' 14.1"	W 113°37' 25.9"
64	N 34°28' 14"	W 113°37' 25.2"
65	N 34°28' 13.6"	W 113°37' 28.1"
66	N 34°28' 13.3"	W 113°37' 27"
67	N 34°28' 13.1"	W 113°37' 25.9"
~~68~~		
69	N 34°28' 12.7"	W 113°37' 28.4"
70	N 34°28' 12.3"	W 113°37' 27.1"
71	N 34°28' 12"	W 113°37' 25.7"
72	N 34°28" 12.3"	W 113°37' 25"
73	N 34°28' 11.6"	W 113°37' 28.5"
74	N 34°28' 11.2"	W 113°37' 26.9"
75	N 34°28' [illegible] 11"	W 113°37' 26"
~~76~~		
77	N 34°28' 10.6"	W 113°37' 28.7"
~~78~~		
79	N 34°28' 10.1"	W 113°37' 25.9"
80	N 34°28' 9.7"	W 113°37' 24.8"
H1	N 34°28' 19.7"	W 113°37' 29.3"
H2	N 34°28' 19.3"	W 113°37' 28.4"
H3	N 34°28' 15.6"	W 113°37' 26.5"
H4	N 34°28' 16.4"	W 113°37' 28.3"
H5	N 34°28' 7.2"	W 113°37' 23.9"

19

Figure B19. Field Notes GPS Coordinates page 19


sample notes
64 - in gully in mud, east of gigantic boulder
60 - in gully, muddy area north of big boulder
54 - down gully, NE of tree
5 ft of tails exposed in gully

* thick acacia forest preventing further sampling east of pt. 54

69 - on steep bank halfway up the wash
77 - on top edge (southern) of wash adjacent to 69
road runner spotted
fire pit near pt 62
62 - at base of concrete structure w/ threaded metal sticking out
66 - in wash next to firepit
74 - in wash adjacent to mesquite tree
67 - near stump on slope
71 - raccoon footprints seen
animal burrows present
76 - impenetrable so not doing it
55 - not sampling
78 - not going to sample

google map old
→ big wash ≈ 400' south of where it shows
→ In Big Sandy X w/ west wash
→ Big Sandy H_2O ≈ 150' east

clump of dead trees where main wash on west side coming ≈ 450' south of pt "71"
HS5 - evidence of raccoon, coyote prints, bird prints
20

Figure B20. Field Notes Sample Notes page 20

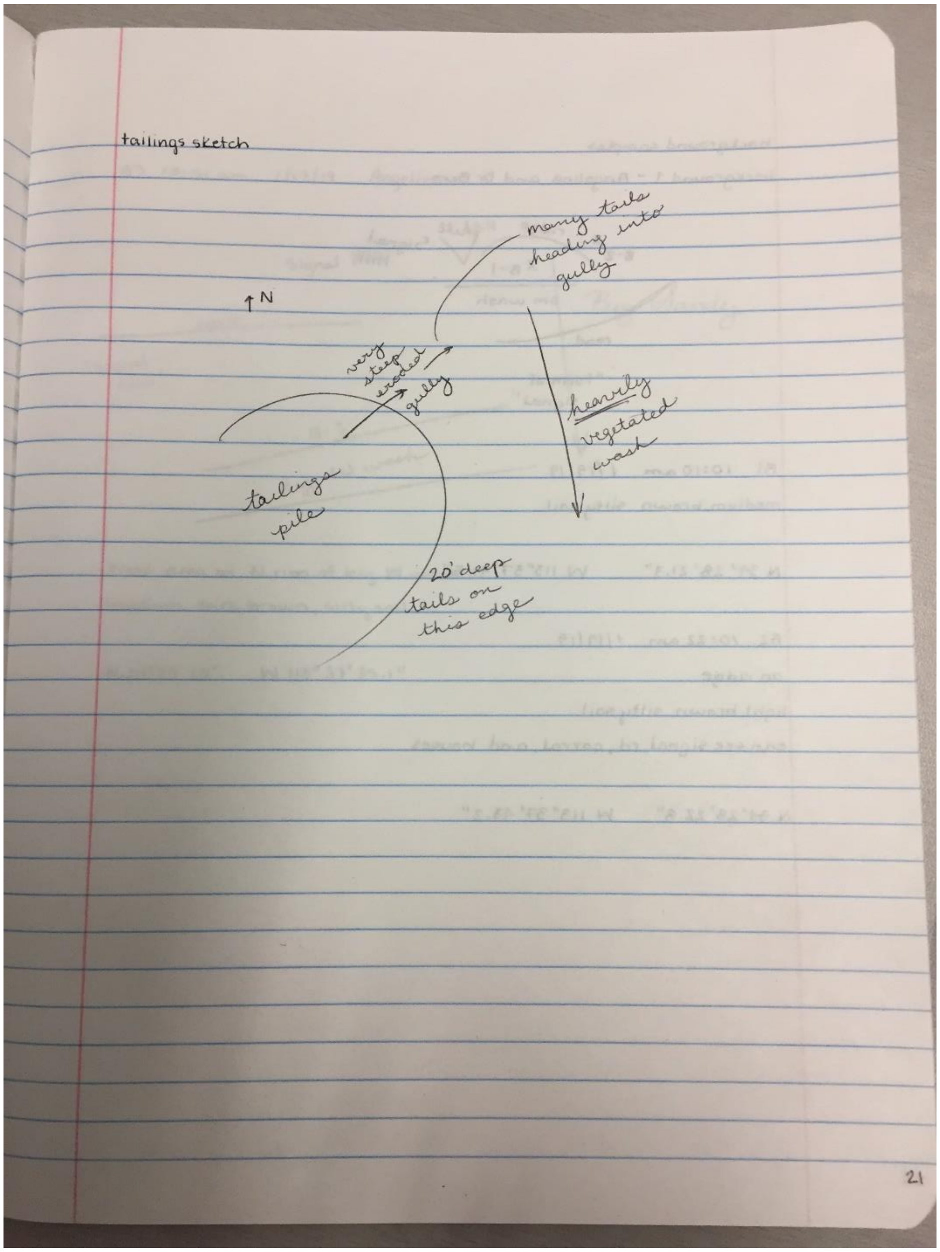
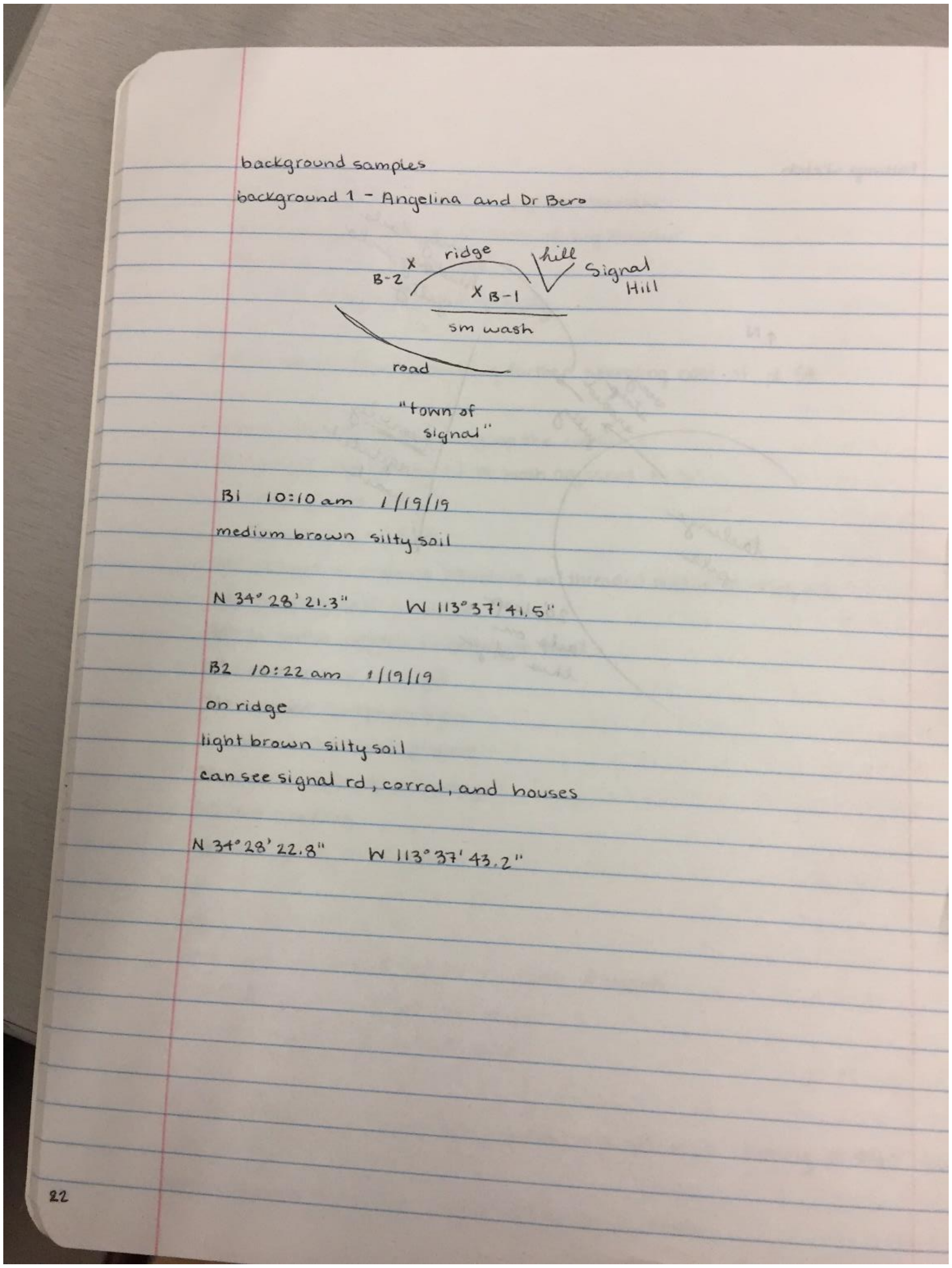


Figure B21. Field Notes Tailings Sketch page 21


background samples

background 1 - Angelina and Dr Bero

B1 10:10 am 1/19/19

medium brown silty soil

N 34° 28' 21.3" W 113° 37' 41.5"

B2 10:22 am 1/19/19

on ridge

light brown silty soil

can see signal rd, corral, and houses

N 34° 28' 22.8" W 113° 37' 43.2"

22

Figure B22. Field Notes Background Samples page 22

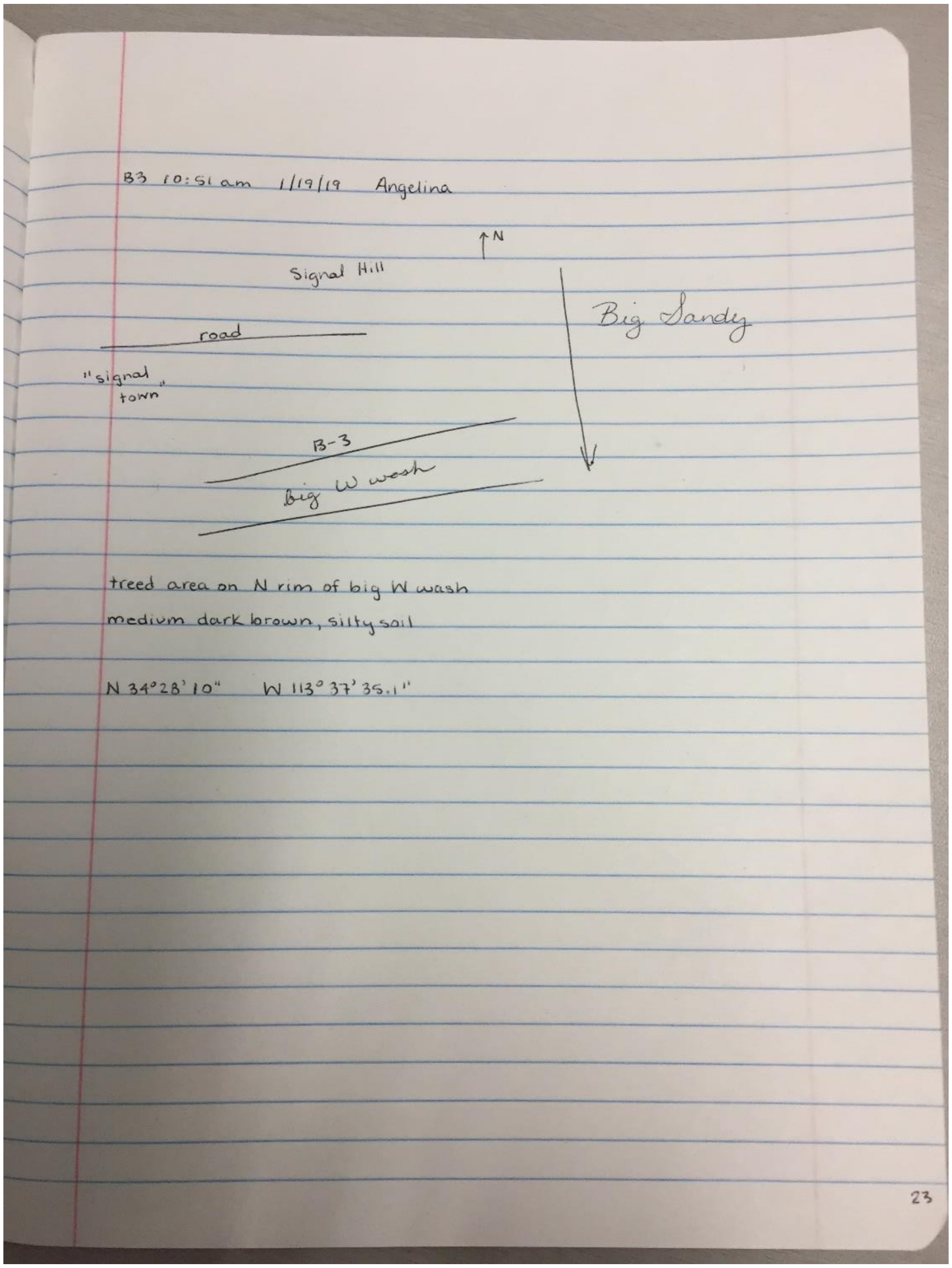


Figure B23. Field Notes Background Samples page 23

Appendix C: Photo Log

Figure C1. Signal Mill Soil Sample Grid 1

Figure C2. Signal Mill Soil Sample Grid 2

Figure C3. Signal Mill Soil Sample Grid 3

Figure C4. Signal Mill Soil Sample Grid 4

Figure C5. Signal Mill Soil Sample Grid 5

Figure C6. Signal Mill Soil Sample Grid 6

Figure C7. Signal Mill Soil Sample Grid 7

Figure C8. Signal Mill Soil Sample Grid 8

Figure C9. Signal Mill Soil Sample Grid 9

Figure C10. Signal Mill Soil Sample Grid 10

Figure C11. Signal Mill Soil Sample Grid 11

Figure C12. Signal Mill Soil Sample Grid 12

Figure C13. Signal Mill Soil Sample Grid 13

Figure C14. Signal Mill Soil Sample Grid 14

Figure C15. Signal Mill Soil Sample Grid 15

Figure C16. Signal Mill Soil Sample Grid 16

Figure C17. Signal Mill Soil Sample Grid 17

Figure C18. Signal Mill Soil Sample Grid 18

Figure C19. Signal Mill Soil Sample Grid 19

Figure C20. Signal Mill Soil Sample Grid 20

Figure C21. Signal Mill Soil Sample Grid 21

Figure C22. Signal Mill Soil Sample Grid 25

Figure C23. Signal Mill Soil Sample Grid 26

Figure C24. Signal Mill Soil Sample Grid 27

Figure C25. Signal Mill Soil Sample Grid 28

Figure C26. Signal Mill Soil Sample Grid 29

Figure C27. Signal Mill Soil Sample Grid 30

Figure C28. Signal Mill Soil Sample Grid 31

Figure C29. Signal Mill Soil Sample Grid 32

Figure C30. Signal Mill Soil Sample Grid 33

Figure C31. Signal Mill Soil Sample Grid 34

Figure C32. Signal Mill Soil Sample Grid 35

Figure C33. Signal Mill Soil Sample Grid 36

Figure C34. Signal Mill Soil Sample Grid 37

Figure C35. Signal Mill Soil Sample Grid 38

Figure C36. Signal Mill Soil Sample Grid 39

Figure C37. Signal Mill Soil Sample Grid 40

Figure C38. Signal Mill Soil Sample Grid 41

Figure C39. Signal Mill Soil Sample Grid 42

Figure C40. Signal Mill Soil Sample Grid 43

Figure C41. Signal Mill Soil Sample Grid 44

Figure C42. Signal Mill Soil Sample Grid 45

Figure C43. Signal Mill Soil Sample Grid 46

Figure C44. Signal Mill Soil Sample Grid 47

Figure C45. Signal Mill Soil Sample Grid 48


Figure C46. Signal Mill Soil Sample Grid 49

Figure C47. Signal Mill Soil Sample Grid 50

Figure C48. Signal Mill Soil Sample Grid 51

Figure C49. Signal Mill Soil Sample Grid 52

Figure C50. Signal Mill Soil Sample Grid 53A

Figure C51. Signal Mill Soil Sample Grid 53B

Figure C52. Signal Mill Soil Sample Grid 54

Figure C53. Signal Mill Soil Sample Grid 56

Figure C54. Signal Mill Soil Sample Grid 57

Figure C55. Signal Mill Soil Sample Grid 58

Figure C56. Signal Mill Soil Sample Grid 59

Figure C57. Signal Mill Soil Sample Grid 60

Figure C58. Signal Mill Soil Sample Grid 61

Figure C59. Signal Mill Soil Sample Grid 62

Figure C60. Signal Mill Soil Sample Grid 63

Figure C61. Signal Mill Soil Sample Grid 64

Figure C62. Signal Mill Soil Sample Grid 65

Figure C63. Signal Mill Soil Sample Grid 66

Figure C64. Signal Mill Soil Sample Grid 67

Figure C65. Signal Mill Soil Sample Grid 69

Figure C66. Signal Mill Soil Sample Grid 70

Figure C67. Signal Mill Soil Sample Grid 71

Figure C68. Signal Mill Soil Sample Grid 72

Figure C69. Signal Mill Soil Sample Grid 73

Figure C70. Signal Mill Soil Sample Grid 74

Figure C71. Signal Mill Soil Sample Grid 77

Figure C72. Signal Mill Soil Sample Grid 79

Figure C73. Signal Mill Soil Sample Grid 80

Figure C74. Signal Mill Soil Sample Hot Spot 1

Figure C75. Signal Mill Soil Sample Hot Spot 2

Figure C76. Signal Mill Soil Sample Hot Spot 3

Figure C77. Signal Mill Soil Sample Hot Spot 4

Figure C78. Signal Mill Soil Sample Hot Spot 5

Figure C79. Signal Mill Frog Spotted on Site

Figure C80. Signal Mill Palo Verde Tree Evidence


Figure C81. Signal Mill Saguaro Cactus Evidence


Figure C82. Signal Mill Creosote Bush Evidence

Figure C83. Signal Mill Old Concrete Structures in the Middle of the Site

Figure C83. Signal Mill North Facing View of Concrete Structures on Site

Figure C84. Signal Mill Evidence of Wild Burros/Cattle on Site

Figure C85. Signal Mill Slumping/Eroding Tailing Pile on the Eastern Side of the Site

Figure C86. Signal Mill Evidence of Animals Paw Prints

Figure C87. Signal Mill Soil Tailing Piles with ATV Tracks


Figure C88. Signal Mill Old Cistern on the Top of the Northern Most Hill on the Site

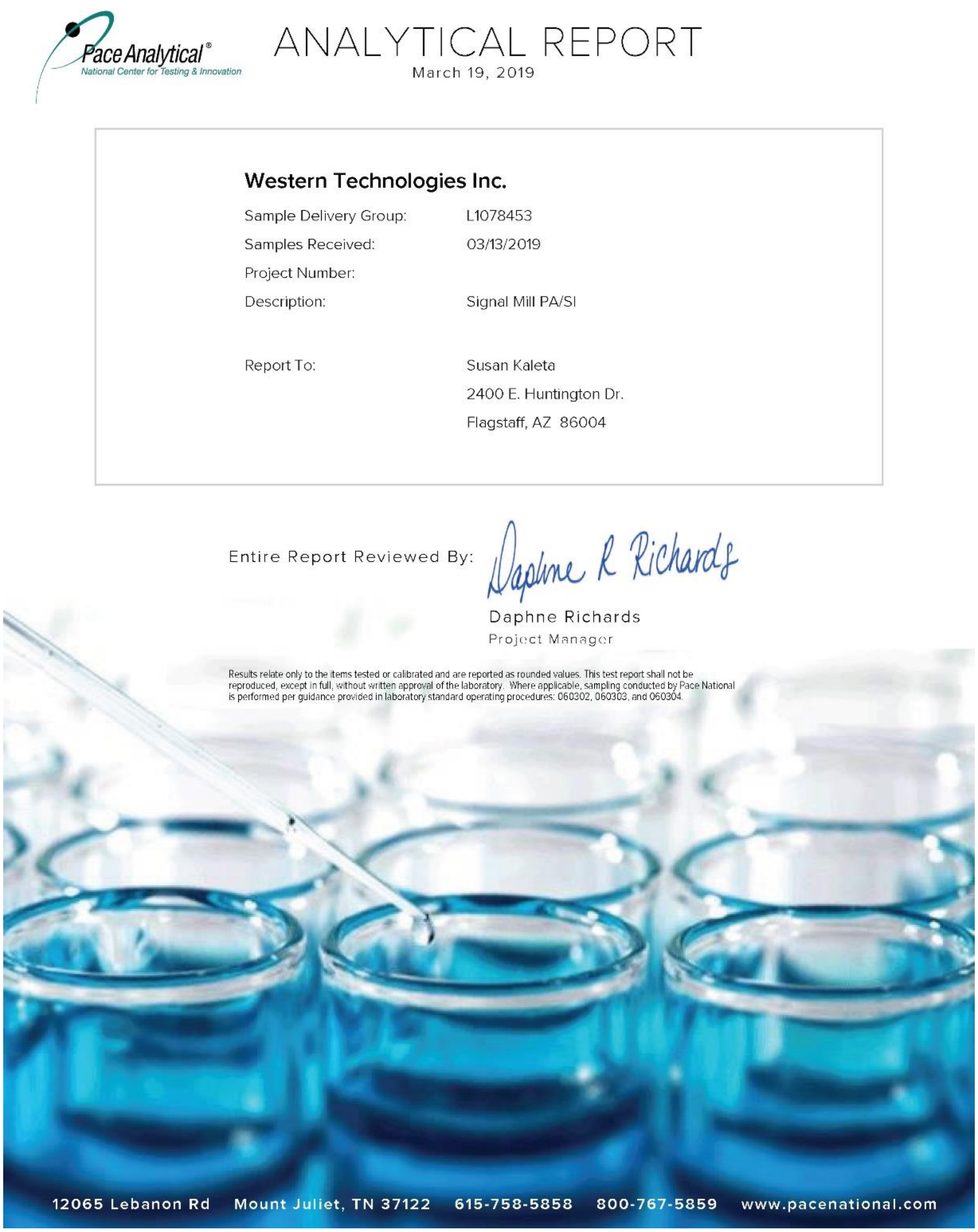

Figure C89. Signal Mill Evidence of Cholla Cactus

Appendix D: XRF Data

Sample	U	Pb	As	Hg	Zn	Cu	Ni	Mn	V	Ba	Sb	Sn	Cd	Ag	Sample	U	Pb	As	Hg	Zn	Cu	Ni	Mn	V	Ba	Sb	Sn	Cd	Ag
B1	10	35	9	<LOD	94	50	43	531	70	637	<LOD	<LOD	<LOD	<LOD	37	7	1,774	<LOD	19	1,158	70	62	1,324	65	1,464	15	9	12	24
B2	7	28	8	<LOD	97	33	46	373	62	628	12	<LOD	<LOD	<LOD	38	16	4,367	<LOD	138	3,042	177	58	2,480	94	2,695	19	<LOD	<LOD	65
B3	8	116	14	3	180	59	56	654	89	686	<LOD	<LOD	<LOD	<LOD	39	13	15,992	<LOD	8	9,219	75	21	2,804	69	3,290	<LOD	16	19	50
H1	7	3,411	<LOD	<LOD	5,550	81	13	3,442	41	3,491	<LOD	<LOD	21	11	40	14	6,395	70	10	3,869	159	77	2,683	104	1,599	15	<LOD	<LOD	33
H2	<LOD	22,306	132	44	46,032	310	350	36,342	25	14,965	<LOD	<LOD	164	122	41	10	8,467	<LOD	23	7,177	92	86	3,620	121	2,108	32	20	27	62
H3	<LOD	3,180	<LOD	13	13,400	45	22	2,230	<LOD	782	16	<LOD	10	41	42	16	2,197	<LOD	31	1,517	88	56	2,503	98	2,704	<LOD	<LOD	<LOD	44
H4	<LOD	26,845	<LOD	313	17,087	364	100	21,613	47	12,169	<LOD	<LOD	33	173	43	14	12,045	<LOD	287	10,137	268	221	20,164	108	18,857	31	<LOD	90	295
H5	9	62	14	3	179	37	55	688	91	818	21	6	<LOD	<LOD	44	14	3,691	<LOD	122	2,584	148	66	2,540	92	3,094	<LOD	<LOD	<LOD	51
1	5	1,899	<LOD	5	4,022	67	71	1,833	77	1,418	25	15	6	17	45	16	11,206	27	33	8,949	187	60	4,030	93	3,315	13	17	20	73
2	15	1,102	39	<LOD	1,382	61	34	1,297	75	725	<LOD	<LOD	<LOD	<LOD	46	9	16,495	<LOD	12	7,979	139	88	3,445	71	3,786	34	24	37	138
3	14	1,272	32	4	1,570	74	77	1,659	134	1,226	21	11	<LOD	6	47	9	14,840	111	20	5,900	128	85	3,694	103	3,161	68	27	34	159
4	11	720	23	10	727	79	12	1,368	87	857	<LOD	<LOD	<LOD	8	48	8	1,426	35	15	1,227	51	50	1,310	72	1,530	<LOD	<LOD	<LOD	13
5	11	1,828	17	2	1,744	79	58	1,740	123	1,191	11	4	4	12	49	8	526	<LOD	8	651	48	41	779	54	1,073	<LOD	<LOD	<LOD	<LOD
6	9	5,443	16	<LOD	5,296	84	89	4,396	98	3,013	<LOD	<LOD	<LOD	64	50	12	8,170	<LOD	154	7,152	170	129	7,800	99	7,412	18	<LOD	17	125
7	12	1,998	13	<LOD	2,777	68	23	2,074	72	1,344	<LOD	<LOD	<LOD	<LOD	51	13	7,218	<LOD	56	7,309	131	47	4,209	66	4,351	<LOD	<LOD	13	111
8	12	1,985	55	12	1,924	123	75	1,727	117	736	20	11	12	8	52	4	30,033	181	111	15,665	311	60	12,850	71	7,800	<LOD	<LOD	36	163
9	11	5,042	68	7	5,699	120	<LOD	2,704	56	2,419	<LOD	8	31	20	53a	8	13,563	<LOD	209	10,198	210	139	11,926	89	12,219	51	24	54	218
10	18	681	25	3	727	237	77	1,618	134	881	18	11	<LOD	<LOD	53b	1	8,195	<LOD	25	18,282	84	93	5,306	46	3,519	21	10	40	57
11	7	530	5	3	703	66	53	786	73	769	<LOD	<LOD	<LOD	<LOD	54	4	3,498	<LOD	29	2,143	72	75	2,040	81	2,461	25	12	19	39
12	<LOD	14,295	<LOD	10	39,176	175	257	28,937	56	11,616	63	30	107	137	56	3	7,062	<LOD	75	16,424	134	86	3,099	45	2,579	<LOD	<LOD	21	67
13	14	336	17	2	486	73	48	933	112	680	<LOD	<LOD	<LOD	<LOD	57	9	5,294	14	117	10,080	224	82	6,850	52	6,278	57	31	56	71
14	12	5,268	<LOD	<LOD	5,279	73	87	3,022	114	3,109	31	15	31	26	58	<LOD	12,927	<LOD	24	34,086	106	66	4,064	<LOD	4,198	27	<LOD	107	38
15	10	148	18	2	203	50	47	719	95	444	<LOD	<LOD	<LOD	<LOD	59	5	4,688	<LOD	28	11,031	79	90	6,466	21	4,767	<LOD	<LOD	17	41
16	15	2,262	23	13	2,771	104	79	2,034	119	1,450	21	14	19	7	60	7	1,315	<LOD	7	2,032	65	24	1,334	75	1,457	<LOD	<LOD	<LOD	8
17	16	1,678	9	5	1,788	111	43	1,527	93	1,147	<LOD	<LOD	<LOD	<LOD	61	7	7,352	<LOD	26	16,608	111	167	14,053	20	9,996	22	<LOD	44	97
18	<LOD	23,819	<LOD	40	38,183	194	195	18,744	87	11,357	64	36	137	136	62	9	195	9	10	487	89	47	794	86	947	26	12	<LOD	<LOD
19	6	26,653	<LOD	21	30,026	208	108	15,026	64	11,097	21	15	167	145	63	3	5,382	<LOD	43	11,725	105	112	5,885	65	5,322	44	18	55	76
20	14	2,756	<LOD	<LOD	2,297	66	55	1,523	81	1,612	<LOD	<LOD	<LOD	9	64	7	227	14	8	338	53	68	796	105	841	<LOD	<LOD	<LOD	<LOD
21	15	1,112	39	<LOD	1,233	104	62	1,586	150	967	16	11	<LOD	<LOD	65	9	408	17	8	781	37	48	682	68	1,022	59	18	18	13
25	16	3,821	<LOD	<LOD	4,024	65	86	2,530	113	2,374	10	7	14	25	66	9	769	18	16	1,444	54	19	1,211	50	1,135	15	<LOD	<LOD	<LOD
26	54	1,153	39	6	1,127	61	62	1,407	124	1,282	52	27	34	25	67	8	42	10	<LOD	133	38	38	608	60	631	<LOD	<LOD	<LOD	<LOD
27	13	13,670	<LOD	<LOD	14,898	137	109	5,786	116	6,840	31	19	53	83	69	9	124	19	<LOD	181	37	30	522	51	676	<LOD	<LOD	<LOD	<LOD
28	3	21,954	107	10	21,896	1,275	83	8,604	45	4,275	<LOD	<LOD	37	104	70	13	827	37	<LOD	796	134	<LOD	1,420	61	915	<LOD	<LOD	<LOD	<LOD
29	7	4,011	<LOD	8	12,472	62	44	4,931	29	2,804	21	<LOD	18	58	71	6	852	<LOD	5	1,457	57	61	1,247	66	1,422	15	9	11	18
30	16	2,887	12	8	1,952	120	59	1,963	102	1,337	<LOD	<LOD	<LOD	25	72	8	52	14	4	248	55	51	738	104	586	<LOD	<LOD	<LOD	<LOD
31	14	2,468	97	19	2,074	81	62	1,767	140	1,500	<LOD	<LOD	<LOD	11	73	6	149	8	18	227	38	60	796	104	951	23	15	<LOD	4
32	11	5,787	<LOD	<LOD	3,431	109	52	1,745	106	1,739	25	16	17	41	74	3	77	18	<LOD	196	102	65	859	113	761	23	13	<LOD	<LOD
33	13	15,430	28	<LOD	17,344	165	<LOD	3,619	<LOD	1,786	41	26	79	139	75	7	163	13	2	363	63	50	838	105	649	<LOD	<LOD	<LOD	<LOD
34	3	16,510	<LOD	2	18,263	151	47	4,587	21	2,760	97	44	59	179	77	8	173	11	9	326	39	47	728	84	839	20	6	<LOD	<LOD
35	17	9,430	<LOD	23	12,453	126	99	4,500	131	2,577	31	19	34	79	79	4	44	10	<LOD	130	36	62	661	93	885	28	14	6	<LOD
36	16	2,923	44	7	2,606	118	70	2,266	105	1,203	<LOD	<LOD	<LOD	7	80	3	37	11	<LOD	152	48	50	693	94	768	26	13	<LOD	<LOD

Figure D1. XRF Data Results used for Human Health and Ecological COC Determination

Appendix E: Western Technologies Data Sheets for Arsenic and Manganese



Pace Analytical®
National Center for Testing & Innovation

ANALYTICAL REPORT
March 19, 2019

Western Technologies Inc.

Sample Delivery Group:	L1078453
Samples Received:	03/13/2019
Project Number:	
Description:	Signal Mill PA/SI
Report To:	Susan Kaleta 2400 E. Huntington Dr. Flagstaff, AZ 86004

Entire Report Reviewed By: Daphne R Richards

Daphne Richards
Project Manager

Results relate only to the items tested or calibrated and are reported as rounded values. This test report shall not be reproduced, except in full, without written approval of the laboratory. Where applicable, sampling conducted by Pace National is performed per guidance provided in laboratory standard operating procedures: 060302, 060303, and 060304.

12065 Lebanon Rd Mount Juliet, TN 37122 615-758-5858 800-767-5859 www.pacenational.com

Figure E1. West Tech Cover Page

SMG2
Collected date/time: 03/12/19 11:00

SAMPLE RESULTS - 01
L1078453

ONE LAB. NATIONWIDE.

Metals (ICP) by Method 6010C

Analyte	Result mg/kg	Qualifier	RDL mg/kg	Dilution	Analysis date / time	Batch
Arsenic	10.9		2.00	1	03/18/2019 16:49	WG1250334

1 Cp
2 Tc
3 Ss
4 Cn
5 Sr
6 Qc
7 Gl
8 Al
9 Sc

ACCOUNT:	PROJECT:	SDG:	DATE/TIME:	PAGE:
Western Technologies Inc.		L1078453	03/19/19 09:30	6 of 26

Figure E2. SMG2 Arsenic Results

SMG73
Collected date/time: 03/12/19 11:00

SAMPLE RESULTS - 02
L1078453

ONE LAB. NATIONWIDE.

Metals (ICP) by Method 6010C

	Result	Qualifier	RDL	Dilution	Analysis	Batch
Analyte	mg/kg		mg/kg		date / time	
Arsenic	3.10		2.00	1	03/18/2019 16:52	WG1250334

1 Cp
2 Tc
3 Ss
4 Cn
5 Sr
6 Qc
7 Gl
8 Al
9 Sc

ACCOUNT:	PROJECT:	SDG:	DATE/TIME:	PAGE:
Western Technologies Inc.		L1078453	03/19/19 09:30	7 of 26

Figure E3. SMG73 Arsenic Results

SMG69
Collected date/time: 03/12/19 11:00

SAMPLE RESULTS - 03
L1078453

ONE LAB. NATIONWIDE.

Cp
2 Tc
3 Ss
4 Cn
5 Sr
6 Qc
7 Gl
8 Al
9 Sc

Metals (ICP) by Method 6010C

Analyte	Result mg/kg	Qualifier	RDL mg/kg	Dilution	Analysis date / time	Batch
Arsenic	3.64		2.00	1	03/18/2019 17:00	WG1250334

ACCOUNT:	PROJECT:	SDG:	DATE/TIME:	PAGE:
Western Technologies Inc.		L1078453	03/19/19 09:30	8 of 26

Figure E4. SMG69 Arsenic Results

SMG3
Collected date/time: 03/12/19 11:00

SAMPLE RESULTS - 04
L1078453

ONE LAB. NATIONWIDE.

Metals (ICP) by Method 6010C

Analyte	Result mg/kg	Qualifier	RDL mg/kg	Dilution	Analysis date / time	Batch
Arsenic	7.61		2.00	1	03/18/2019 17:02	WG1250334

1 Cp
2 Tc
3 Ss
4 Cn
5 Sr
6 Qc
7 Gl
8 Al
9 Sc

ACCOUNT:	PROJECT:	SDG:	DATE/TIME:	PAGE:
Western Technologies Inc.		L1078453	03/19/19 09:30	9 of 26

Figure E5. SMG3 Arsenic Results

SMG52
Collected date/time: 03/12/19 11:00

SAMPLE RESULTS - 05
L1078453

ONE LAB. NATIONWIDE.

Metals (ICP) by Method 6010C

Analyte	Result mg/kg	Qualifier	RDL mg/kg	Dilution	Analysis date / time	Batch
Arsenic	12.7		2.00	1	03/18/2019 17:05	WG1250334

1 Cp
2 Tc
3 Ss
4 Cn
5 Sr
6 Qc
7 Gl
8 Al
9 Sc

ACCOUNT:	PROJECT:	SDG:	DATE/TIME:	PAGE:
Western Technologies Inc.		L1078453	03/19/19 09:30	10 of 26

Figure E6. SMG52 Arsenic Results

SMG9

Collected date/time: 03/12/19 11:00

SAMPLE RESULTS - 06

L1078453

ONE LAB. NATIONWIDE.

Metals (ICP) by Method 6010C

	Result	Qualifier	RDL	Dilution	Analysis	Batch
Analyte	mg/kg		mg/kg		date / time	
Arsenic	8.55		2.00	1	03/18/2019 17:07	WG1250334

1 Cp
2 Tc
3 Ss
4 Cn
5 Sr
6 Qc
7 Gl
8 Al
9 Sc

ACCOUNT:	PROJECT:	SDG:	DATE/TIME:	PAGE:
Western Technologies Inc.		L1078453	03/19/19 09:30	11 of 26

Figure E7. SMG9 Arsenic Results

SMG71
Collected date/time: 03/12/19 11:00

SAMPLE RESULTS - 07
L1078453

ONE LAB. NATIONWIDE.

Metals (ICP) by Method 6010C

Analyte	Result	Qualifier	RDL	Dilution	Analysis	Batch
	mg/kg		mg/kg		date / time	
Arsenic	6.80		2.00	1	03/18/2019 17:10	WG1250334

[1] Cp
[2] Tc
[3] Ss
[4] Cn
[5] Sr
[6] Qc
[7] Gl
[8] Al
[9] Sc

ACCOUNT:	PROJECT:	SDG:	DATE/TIME:	PAGE:
Western Technologies Inc.		L1078453	03/19/19 09:30	12 of 26

Figure E8. SMG71 Arsenic Results

SMG16
Collected date/time: 03/12/19 11:00

SAMPLE RESULTS - 08
L1078453

ONE LAB. NATIONWIDE.

Metals (ICP) by Method 6010C

Analyte	Result mg/kg	Qualifier	RDL mg/kg	Dilution	Analysis date / time	Batch
Arsenic	11.6		2.00	1	03/18/2019 17:13	WG1250334

1 Cp
2 Tc
3 Ss
4 Cn
5 Sr
6 Qc
7 Gl
8 Al
9 Sc

ACCOUNT:	PROJECT:	SDG:	DATE/TIME:	PAGE:
Western Technologies Inc.		L1078453	03/19/19 09:30	13 of 26

Figure E9. SMG16 Arsenic Results

SMG5

Collected date/time: 03/12/19 11:00

SAMPLE RESULTS - 09

L1078453

ONE LAB. NATIONWIDE.

Metals (ICP) by Method 6010C

Analyte	Result mg/kg	Qualifier	RDL mg/kg	Dilution	Analysis date / time	Batch
Arsenic	9.93		2.00	1	03/18/2019 17:15	WG1250334

1 Cp
2 Tc
3 Ss
4 Cn
5 Sr
6 Qc
7 Gl
8 Al
9 Sc

ACCOUNT:	PROJECT:	SDG:	DATE/TIME:	PAGE:
Western Technologies Inc.		L1078453	03/19/19 09:30	14 of 26

Figure E10. SMG5 Arsenic Results

SMG47
Collected date/time: 03/12/19 11:00

SAMPLE RESULTS - 10
L1078453

ONE LAB. NATIONWIDE.

Metals (ICP) by Method 6010C

	Result	Qualifier	RDL	Dilution	Analysis	Batch
Analyte	mg/kg		mg/kg		date / time	
Arsenic	10.2		2.00	1	03/18/2019 17:18	WG1250334

1 Cp
2 Tc
3 Ss
4 Cn
5 Sr
6 Qc
7 Gl
8 Al
9 Sc

ACCOUNT:	PROJECT:	SDG:	DATE/TIME:	PAGE:
Western Technologies Inc.		L1078453	03/19/19 09:30	15 of 26

Figure E11. SMG47 Arsenic Results

Metals (ICP) by Method 6010C

	Result	Qualifier	RDL	Dilution	Analysis	Batch
Analyte	mg/kg		mg/kg		date / time	
Arsenic	8.34		2.00	1	03/18/2019 17:20	WG1250334

Cp
Tc
Ss
Cn
Sr
Qc
Gl
Al
Sc

Figure E12. SMG72 Arsenic Results

SMG45
Collected date/time: 03/12/19 11:00

SAMPLE RESULTS - 12
L1078453

ONE LAB. NATIONWIDE.

Metals (ICP) by Method 6010C

Analyte	Result mg/kg	Qualifier	RDL mg/kg	Dilution	Analysis date / time	Batch
Arsenic	11.5		2.00	1	03/18/2019 17:23	WG1250334

1 Cp
2 Tc
3 Ss
4 Cn
5 Sr
6 Qc
7 Gl
8 Al
9 Sc

ACCOUNT:	PROJECT:	SDG:	DATE/TIME:	PAGE:
Western Technologies Inc.		L1078453	03/19/19 09:30	17 of 26

Figure E13. SMG45 Arsenic Results

SMG62
Collected date/time: 03/12/19 11:00

SAMPLE RESULTS - 13
L1078453

ONE LAB. NATIONWIDE.

Metals (ICP) by Method 6010C

Analyte	Result mg/kg	Qualifier	RDL mg/kg	Dilution	Analysis date / time	Batch
Arsenic	4.38		2.00	1	03/18/2019 17:31	WG1250334

ACCOUNT:	PROJECT:	SDG:	DATE/TIME:	PAGE:
Western Technologies Inc.		L1078453	03/19/19 09:30	18 of 26

Figure E14. SMG62 Arsenic Results

Metals (ICP) by Method 6010C

Analyte	Result mg/kg	Qualifier	RDL mg/kg	Dilution	Analysis date / time	Batch
Arsenic	6.29		2.00	1	03/18/2019 17:33	WG1250334

1 Cp
2 Tc
3 Ss
4 Cn
5 Sr
6 Qc
7 Gl
8 Al
9 Sc

Figure E15. SMG80 Arsenic Results

SMG31
Collected date/time: 03/12/19 11:00

SAMPLE RESULTS - 15
L1078453

ONE LAB. NATIONWIDE.

Metals (ICP) by Method 6010C

Analyte	Result mg/kg	Qualifier	RDL mg/kg	Dilution	Analysis date / time	Batch
Arsenic	31.7		2.00	1	03/18/2019 17:36	WG1250334

1 Cp
2 Tc
3 Ss
4 Cn
5 Sr
6 Qc
7 Gl
8 Al
9 Sc

ACCOUNT:	PROJECT:	SDG:	DATE/TIME:	PAGE:
Western Technologies Inc.		L1078453	03/19/19 09:30	20 of 26

Figure E16. SMG31 Arsenic Results

SMG36

Collected date/time: 03/12/19 11:00

SAMPLE RESULTS - 16

L1078453

ONE LAB. NATIONWIDE.

Metals (ICP) by Method 6010C

Analyte	Result mg/kg	Qualifier	RDL mg/kg	Dilution	Analysis date / time	Batch
Arsenic	17.4		2.00	1	03/18/2019 17:38	WG1250334

1 Cp
2 Tc
3 Ss
4 Cn
5 Sr
6 Qc
7 Gl
8 Al
9 Sc

ACCOUNT:	PROJECT:	SDG:	DATE/TIME:	PAGE:
Western Technologies Inc.		L1078453	03/19/19 09:30	21 of 26

Figure E17. SMG36 Arsenic Results

Pace Analytical®
National Center for Testing & Innovation

ANALYTICAL REPORT

March 21, 2019

Western Technologies Inc.

Sample Delivery Group:	L1079331
Samples Received:	03/15/2019
Project Number:	
Description:	Signal Mill
Report To:	Susan Kaleta
	2400 E. Huntington Dr.
	Flagstaff, AZ 86004

Entire Report Reviewed By: Daphne R Richards

Daphne Richards
Project Manager

Results relate only to the items tested or calibrated and are reported as rounded values. This test report shall not be reproduced, except in full, without written approval of the laboratory. Where applicable, sampling conducted by Pace National is performed per guidance provided in laboratory standard operating procedures: 060302, 060303, and 060304.

12065 Lebanon Rd Mount Juliet, TN 37122 615-758-5858 800-767-5859 www.pacenational.com

Figure E18. West Tech Cover Page

SMB2
Collected date/time: 03/13/19 14:15

SAMPLE RESULTS - 01
L1079331

ONE LAB. NATIONWIDE.

Metals (ICP) by Method 6010C

Analyte	Result mg/kg	Qualifier	RDL mg/kg	Dilution	Analysis date / time	Batch
Manganese	228		1.00	1	03/19/2019 19:12	WG1251285

1 Cp
2 Tc
3 Ss
4 Cn
5 Sr
6 Qc
7 Gl
8 Al
9 Sc

ACCOUNT:	PROJECT:	SDG:	DATE/TIME:	PAGE:
Western Technologies Inc		L1079331	03/21/19 13:58	6 of 23

Figure E19. SMB2 Manganese Results

SMG75
Collected date/time: 03/13/19 14:15

SAMPLE RESULTS - 02
L1079331

ONE LAB. NATIONWIDE.

Metals (ICP) by Method 6010C

Analyte	Result mg/kg	Qualifier	RDL mg/kg	Dilution	Analysis date / time	Batch
Manganese	704		1.00	1	03/19/2019 19:15	WG1251285

Cp Tc Ss Cn Sr Qc Gl Al Sc

ACCOUNT:	PROJECT:	SDG:	DATE/TIME:	PAGE:
Western Technologies Inc.		L1079331	03/21/19 13:58	7 of 23

Figure E20. SMG75 Manganese Results

Metals (ICP) by Method 6010C

Analyte	Result mg/kg	Qualifier	RDL mg/kg	Dilution	Analysis date / time	Batch
Manganese	1690		5.00	5	03/20/2019 19:49	WG1251285

Figure E21. SMG60 Manganese Results

Metals (ICP) by Method 6010C

	Result	Qualifier	RDL	Dilution	Analysis	Batch
Analyte	mg/kg		mg/kg		date / time	
Manganese	1370		5.00	5	03/20/2019 19:51	WG1251285

Cp
Tc
Ss
Cn
Sr
Qc
Gl
Al
Sc

Figure E22. SMG3 Manganese Results

SMG54
Collected date/time: 03/13/19 14:15

SAMPLE RESULTS - 05
L1079331

ONE LAB. NATIONWIDE.

Metals (ICP) by Method 6010C

Analyte	Result mg/kg	Qualifier	RDL mg/kg	Dilution	Analysis date / time	Batch
Manganese	3160		5.00	5	03/20/2019 19:54	WG1251285

1 Cp
2 Tc
3 Ss
4 Cn
5 Sr
6 Qc
7 Gl
8 Al
9 Sc

ACCOUNT:	PROJECT:	SDG:	DATE/TIME:	PAGE:
Western Technologies Inc.		L1079331	03/21/19 13:58	10 of 23

Figure E23. SMG54 Manganese Results

SMG40
Collected date/time: 03/13/19 14:15

SAMPLE RESULTS - 06
L1079331

ONE LAB. NATIONWIDE.

Metals (ICP) by Method 6010C

Analyte	Result mg/kg	Qualifier	RDL mg/kg	Dilution	Analysis date / time	Batch
Manganese	2240		5.00	5	03/20/2019 19:57	WG1251285

1 Cp
2 Tc
3 Ss
4 Cn
5 Sr
6 Qc
7 Gl
8 Al
9 Sc

ACCOUNT:	PROJECT:	SDG:	DATE/TIME:	PAGE:
Western Technologies Inc		L1079331	03/21/19 13:58	11 of 23

Figure E24. SMG40 Manganese Results

Metals (ICP) by Method 6010C

Analyte	Result mg/kg	Qualifier	RDL mg/kg	Dilution	Analysis date / time	Batch
Manganese	2790		5.00	5	03/20/2019 19:59	WG1251285

1 Cp
2 Tc
3 Ss
4 Cn
5 Sr
6 Qc
7 Gl
8 Al
9 Sc

Figure E25. SMG41 Manganese Results

SMG29
Collected date/time: 03/13/19 14:15

SAMPLE RESULTS - 08
L1079331

ONE LAB. NATIONWIDE.

Metals (ICP) by Method 6010C

Analyte	Result mg/kg	Qualifier	RDL mg/kg	Dilution	Analysis date / time	Batch
Manganese	7440		10.0	10	03/20/2019 20:02	WG1251285

Cp
Tc
Ss
Cn
Sr
Qc
Gl
Al
Sc

ACCOUNT:	PROJECT:	SDG:	DATE/TIME:	PAGE:
Western Technologies Inc.		L1079331	03/21/19 13:58	13 of 23

Figure E26. SMG29 Manganese Results

SMG53A
Collected date/time: 03/13/19 14:15

SAMPLE RESULTS - 09
L1079331

ONE LAB. NATIONWIDE.

Metals (ICP) by Method 6010C

Analyte	Result mg/kg	Qualifier	RDL mg/kg	Dilution	Analysis date / time	Batch
Manganese	13000		10.0	10	03/20/2019 20:05	WG1251285

Cp Tc Ss Cn Sr Qc Gl Al Sc

ACCOUNT:	PROJECT:	SDG:	DATE/TIME:	PAGE:
Western Technologies Inc.		L1079331	03/21/19 13:58	14 of 23

Figure E27. SMG53a Manganese Results

Metals (ICP) by Method 6010C

Analyte	Result mg/kg	Qualifier	RDL mg/kg	Dilution	Analysis date / time	Batch
Manganese	23300		40.0	40	03/21/2019 13:18	WG1251285

1 Cp
2 Tc
3 Ss
4 Cn
5 Sr
6 Qc
7 Gl
8 Al
9 Sc

Figure E28. SMH2 Manganese Results

SMG7

Collected date/time: 03/13/19 14:10

SAMPLE RESULTS - 16

L1079331

ONE LAB. NATIONWIDE.

Metals (ICP) by Method 6010C

Analyte	Result mg/kg	Qualifier	RDL mg/kg	Dilution	Analysis date / time	Batch
Arsenic	9.03		2.00	1	03/19/2019 19:43	WG1251285

1 Cp
2 Tc
3 Ss
4 Cn
5 Sr
6 Qc
7 Gl
8 Al
9 Sc

ACCOUNT:	PROJECT:	SDG:	DATE/TIME:	PAGE:
Western Technologies Inc.		L1079331	03/21/19 13:58	16 of 23

Figure E29. SMG7 Arsenic Results

Metals (ICP) by Method 6010C

Analyte	Result mg/kg	Qualifier	RDL mg/kg	Dilution	Analysis date / time	Batch
Arsenic	10.8		2.00	1	03/19/2019 19:45	WG1251285

1 Cp
2 Tc
3 Ss
4 Cn
5 Sr
6 Qc
7 Gl
8 Al
9 Sc

Figure E30. SMG17 Arsenic Results

SMG64
Collected date/time: 03/13/19 14:15

SAMPLE RESULTS - 18
L1079331

ONE LAB. NATIONWIDE.

Metals (ICP) by Method 6010C

Analyte	Result mg/kg	Qualifier	RDL mg/kg	Dilution	Analysis date / time	Batch
Arsenic	4.78		2.00	1	03/19/2019 19:48	WG1251285

1 Cp
2 Tc
3 Ss
4 Cn
5 Sr
6 Qc
7 Gl
8 Al
9 Sc

ACCOUNT:	PROJECT:	SDG:	DATE/TIME:	PAGE:
Western Technologies Inc		L1079331	03/21/19 13:58	18 of 23

Figure E31. SMG64 Arsenic Results

SMG67
Collected date/time: 03/13/19 14:15

SAMPLE RESULTS - 19
L1079331

ONE LAB. NATIONWIDE.

Metals (ICP) by Method 6010C

Analyte	Result mg/kg	Qualifier	RDL mg/kg	Dilution	Analysis date / time	Batch
Arsenic	2.89		2.00	1	03/19/2019 19:51	WG1251285

1 Cp
2 Tc
3 Ss
4 Cn
5 Sr
6 Qc
7 Gl
8 Al
9 Sc

ACCOUNT:	PROJECT:	SDG:	DATE/TIME:	PAGE:
Western Technologies Inc.		L1079331	03/21/19 13:58	19 of 23

Figure E32. SMG67 Arsenic Results

Appendix F: NAU Laboratory Data Sheets for Lead

Base Cations

Colorado Plateau Analytical Laboratory (CPAL)
Wettaw Building, room 108
Northern Arizona University
Flagstaff, AZ 86011

Date:	4/10/2018
Client:	Bridget Bero, Anna Gorman
Technician:	Jeff Propster
Instrument:	Perkin-Elmer Aanalyst 100 flame atomic absorption spectrophotometer
Flame:	Air/Acetylene
Notes:	0.1% lanthanum as LaCl2 and 0.1% cesium as CsCl added to all samples and standards
	All concentrations expressed in mg/L

Pb

Sample ID	Raw Absorbance Average of 3 Reps	Dilution Factor	Standard Concentration	Sample Concentration	Expected Concentration	Final Concentration	
Blank	0.000		0.00	-0.06			
LO1	0.019		2.50	2.33			
LO2	0.042		5.00	5.26			
LO3	0.079		10.00	10.09			
LR	0.151		20.00	19.87			
Hi2	0.415		60.00	60.01			
WS	0.094		12.00	12.09	12.00		
53A	0.734	1.25		117.51		146.89	dilution required
4	1.077	1.25		190.32		237.90	dilution required
B2	0.002	1.25		<0.45		<0.56	
71	0.075	1.25		9.56		11.95	
10	0.072	1.25		9.17		11.46	
blank	0.000	1.25		<0.45		<0.56	
28	1.078	1.25		190.55		238.19	dilution required
32	0.458	1.25		67.19		83.99	dilution required
H1	0.316	1.25		44.17		55.21	
B3	0.006	1.25		0.69		0.86	
75	0.012	1.25		1.44		1.80	
14	0.342	1.25		48.24		60.30	
61	0.461	1.25		67.70		84.62	dilution required
33	0.854	1.25		141.69		177.11	dilution required
29	0.321	1.25		44.95		56.18	
37	0.143	1.25		18.76		23.45	
7	0.151	1.25		19.87		24.84	
3	0.075	1.25		9.56		11.95	
35	0.577	1.25		87.98		109.98	dilution required
20	0.207	1.25		27.82		34.78	
13	0.022	1.25		2.71		3.38	
WS	0.094			12.09	12.00		

Pb (dilutions)

Sample ID	Raw Absorbance Average of 3 Reps	Dilution Factor	Standard Concentration	Sample Concentration	Expected Concentration	Final Concentration
Blank	0.000		0.00	-0.14		
LO1	0.020		2.50	2.40		
LO2	0.042		5.00	5.25		
LO3	0.079		10.00	10.15		
LR	0.149		20.00	19.82		
Hi2	0.408		60.00	60.02		
WS	0.096		12.00	12.45	12.00	
53A	0.222	4		30.44		121.76
4	0.391	4		57.16		228.65
28	0.398	4		58.33		233.34
32	0.239	2		32.99		65.99
61	0.240	2		33.14		66.29
33	0.277	4		38.81		155.24
35	0.324	2		46.21		92.42
WS	0.096			12.45	12.00	

Appendix G: Correlated Data Adjustments for Lead

Sample #	XRF Pb (mg/kg)	Corrected Pb (mg/kg)	Sample #	XRF Pb (mg/kg)	Corrected Pb (mg/kg)	Sample #	XRF Pb (mg/kg)	Corrected Pb (mg/kg)
B1	35	34	26	1,153	1107	56	7,062	6783
B2	28	27	27	13,670	13129	57	5,294	5085
B3	116	112	28	21,954	21084	58	12,927	12415
H1	3,411	3276	29	4,011	3852	59	4,688	4503
H2	22,306	21422	30	2,887	2773	60	1,315	1263
H3	3,180	3054	31	2,468	2370	61	7,352	7061
H4	26,845	25782	32	5,787	5558	62	195	187
H5	62	60	33	15,430	14819	63	5,382	5169
1	1,899	1824	34	16,510	15856	64	227	218
2	1,102	1058	35	9,430	9056	65	408	392
3	1,272	1221	36	2,923	2807	66	769	738
4	720	691	37	1,774	1703	67	42	40
5	1,828	1756	38	4,367	4194	69	124	119
6	5,443	5228	39	15,992	15359	70	827	794
7	1,998	1919	40	6,395	6142	71	852	818
8	1,985	1907	41	8,467	8131	72	52	50
9	5,042	4842	42	2,197	2110	73	149	143
10	681	654	43	12,045	11568	74	77	74
11	530	509	44	3,691	3545	75	163	156
12	14,295	13729	45	11,206	10762	77	173	167
13	336	323	46	16,495	15842	79	44	42
14	5,268	5059	47	14,840	14253	80	37	35
15	148	143	48	1,426	1370			
16	2,262	2172	49	526	505			
17	1,678	1612	50	8,170	7846			
18	23,819	22876	51	7,218	6932			
19	26,653	25598	52	30,033	28843			
20	2,756	2646	53a	13,563	13026			
21	1,112	1068	53b	8,195	7871			
25	3,821	3670	54	3,498	3359			

Appendix H: Correlated Data Adjustments for Arsenic

Sample #	As (mg/kg)	Corrected As (mg/Kg)	Sample #	As (mg/kg)	Corrected As (mg/Kg)	Sample #	As (mg/kg)	Corrected As (mg/Kg)
B1	9	3	26	39	13	56	2	1
B2	8	3	27	2	1	57	14	5
B3	14	5	28	107	36	58	2	1
H1	2	1	29	2	1	59	2	1
H2	132	45	30	12	4	60	2	1
H3	2	1	31	97	33	61	2	1
H4	2	1	32	2	1	62	9	3
H5	14	5	33	28	10	63	2	1
1	2	1	34	2	1	64	14	5
2	39	13	35	2	1	65	17	6
3	32	11	36	44	15	66	18	6
4	23	8	37	2	1	67	10	3
5	17	6	38	2	1	69	19	7
6	16	5	39	2	1	70	37	13
7	13	4	40	70	24	71	2	1
8	55	19	41	2	1	72	14	5
9	68	23	42	2	1	73	8	3
10	25	8	43	2	1	74	18	6
11	5	2	44	2	1	75	13	4
12	2	1	45	27	9	77	11	4
13	17	6	46	2	1	79	10	4
14	2	1	47	111	38	80	11	4
15	18	6	48	35	12			
16	23	8	49	2	1			
17	9	3	50	2	1			
18	2	1	51	2	1			
19	2	1	52	181	61			
20	2	1	53a	2	1			
21	39	13	53b	2	1			
25	2	1	54	2	1			

Appendix I: Correlated Data Adjustments for Manganese

Sample #	Mn (mg/kg)	Mn Corrected (mg/kg)	Sample #	Mn (mg/kg)	Mn Correcte d (mg/kg)	Sample #	Mn (mg/kg)	Mn Correcte d (mg/kg)
B1	531	374	26	1,407	989	56	3,099	2178
B2	373	262	27	5,786	4066	57	6,850	4814
B3	654	460	28	8,604	6047	58	4,064	2856
H1	3,442	2419	29	4,931	3466	59	6,466	4544
H2	36,342	25541	30	1,963	1380	60	1,334	937
H3	2,230	1567	31	1,767	1242	61	14,053	9876
H4	21,613	15190	32	1,745	1226	62	794	558
H5	688	483	33	3,619	2543	63	5,885	4136
1	1,833	1288	34	4,587	3223	64	796	559
2	1,297	912	35	4,500	3162	65	682	479
3	1,659	1166	36	2,266	1593	66	1,211	851
4	1,368	961	37	1,324	930	67	608	427
5	1,740	1223	38	2,480	1743	69	522	367
6	4,396	3090	39	2,804	1970	70	1,420	998
7	2,074	1458	40	2,683	1886	71	1,247	877
8	1,727	1214	41	3,620	2544	72	738	519
9	2,704	1900	42	2,503	1759	73	796	560
10	1,618	1137	43	20,164	14171	74	859	604
11	786	552	44	2,540	1785	75	838	589
12	28,937	20337	45	4,030	2832	77	728	512
13	933	656	46	3,445	2421	79	661	464
14	3,022	2124	47	3,694	2596	80	693	487
15	719	506	48	1,310	920			
16	2,034	1429	49	779	547			
17	1,527	1073	50	7,800	5482			
18	18,744	13173	51	4,209	2958			
19	15,026	10561	52	12,850	9031			
20	1,523	1070	53a	11,926	8382			
21	1,586	1115	53b	5,306	3729			
25	2,530	1778	54	2,040	1434			