Flag Environmental
Solutions

CANYON CITY MILL

# WORK PLAN

*Dec.5 2022*

Prepared for:

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## Table of Contents

## List of Tables:



## List of Figures:



## List of Equations:

# 1.0 Project Description

## 1.1. Project Objective

Completion of a Preliminary Assessment and Site Investigation (PA/SI) report for the Bureau of Land Management (BLM) for the Canyon City Mill site. The site was utilized for milling activities, including a cyanide heap leaching process, that led to the release of hazardous substances. Understanding the extent of the contamination and determining the risk to human and environmental health is imperative in determining if further remedial action is required at the site.

## 1.2. Project Scope

The scope of this site investigation will include approximately 110 soil samples that will be collected from the Canyon City Mill site. These samples will be analyzed for contaminants of concerns and possible migration pathways will be identified.

## 1.3. Project Schedule

The project will begin on the 25th of October 2022, and complete on May 5th, 2023. The site investigation will occur Friday, January 20th and Saturday, January 21st of 2023. The team will leave early Friday morning and arrive at the Canyon Mill site that same morning. At the end of the day, the team will stay at a nearby hotel. The next morning, the team will continue the site investigation and leave that afternoon to drive back to Flagstaff, Arizona.

# 2.0 Site Background Information

## 2.1. Site Location

The abandoned Canyon City Mill is located 1.5 miles south of the town of Oatman, Arizona, in the eastern portion of the state within Mohave County. The geographical coordinates are as follows:

- Latitude: 35°0'14.04"N
- Longitude: 114°23'3.57"W

Figure 2.1 below shows the location of the abandoned mine site within the state of Arizona and within Mohave County.


*Figure 2.1: Geographical Location of Site (Google Maps)*

Surrounding cities include Kingman, Arizona (located northeast of the site), Yucca, Arizona (located southeast of the site), Las Vegas, Nevada (located northwest of the site), and Needles, California (located southwest of the site). The site can be accessed from Flagstaff by traveling on I-40 westbound and exiting on State Route 10 (Oatman Highway). The Oatman Highway is followed for approximately 1.5 miles past the town of Oatman until an access road is reached. Figure 2.2 below shows an aerial image of the site in relation to Oatman.


*Figure 2.2: Site Location in Relation to Oatman*

Figure 2.3 below shows a closeup image of the site. The aerial image shows washes south of the site, which flow from northeast to west/southwest towards the Colorado River. The Colorado River is located approximately 14.5 miles downstream of the site. Highway 10 is indicated by the yellow path in the top left corner of the image.


*Figure 2.3: Site Location with Surrounding Washes (Google Earth)*

## 2.2. Site Description

The Canyon City Mill began operation in 1986. The owner of the site, at the time of operation, was Charlie Stoll. Robert Graham, the owner of Canyon City Mill, was subleasing the site from Stoll. The site was used for a cyanide leaching process to extract gold from mined ore from underground gold mines near Oatman, Arizona. One source of the ore was the Minneapolis Mine. No mining was done at the site.

The operation used three 30,000-gallon tanks to store sodium cyanide solution (shown in Figure 2.4). The cyanide solution was sprayed or dripped onto piles of crushed ore in the leach field. As the cyanide passed through the ore, the gold was leached from the rock, creating what is known as the pregnant leach solution (PLS). The leach solution flowed into the pregnant solution pond (shown in Figure 2.5). Cinders, consisting of burnt wood or charcoal, were used as a carbon source in the pregnant solution pond to adsorb the gold from the cyanide-gold complexes. The gold was recovered from the activated carbon, and the cyanide was recycled back to the cyanide solution tanks.

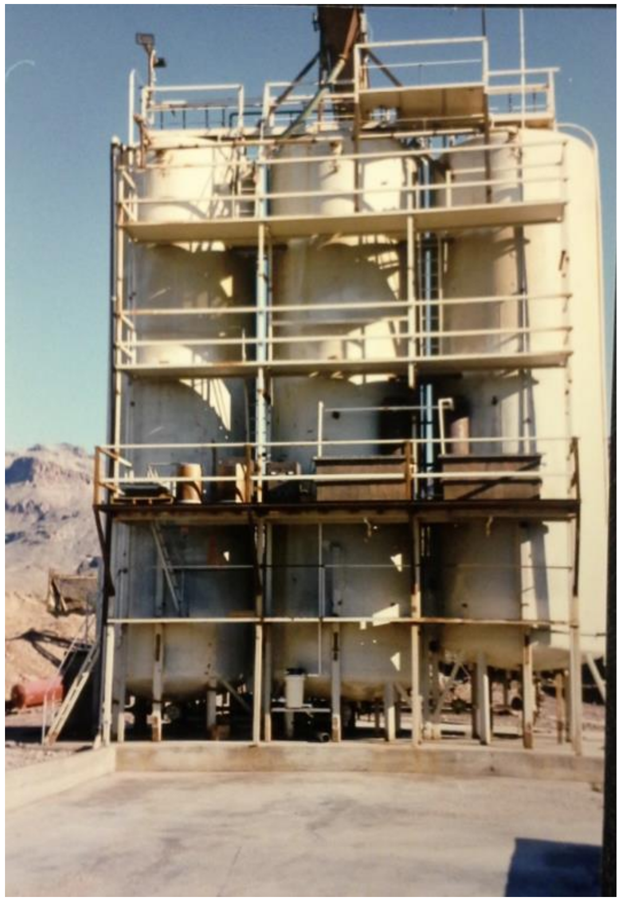

*Figure 2.4 : 30,000 Gallon Cyanide Solution Tanks [1]*

*Figure 2.5: Pregnant Leach Solution Tank and Pond [1]*

Figure 2.6 below shows a block diagram of the general cyanide leaching process.

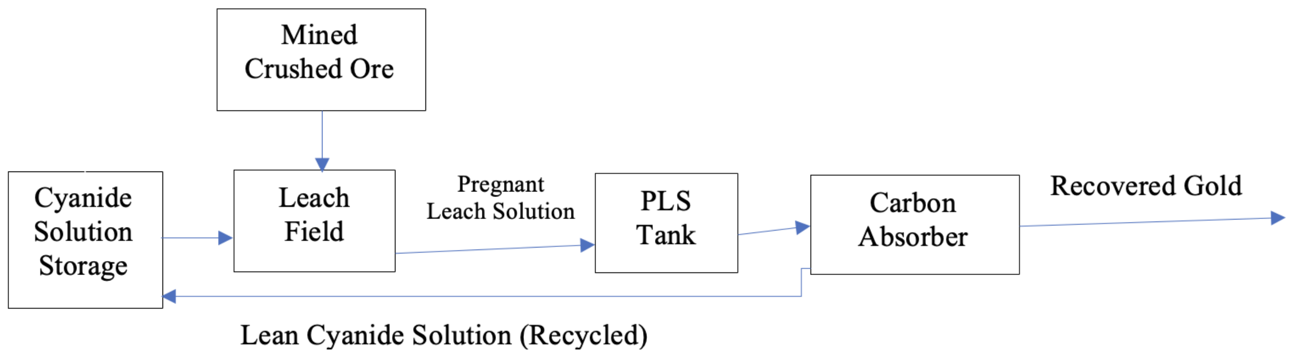


*Figure 2.6: Cyanide Leaching Process Block Diagram*

## 2.3. Site History

In 1991, the three 30,000-gallon tanks holding the cyanide solution were dumped on the site. The Bureau of Land Management and the Arizona Department of Environmental Quality (ADEQ) Emergency Response Unit were contacted and informed of the spill. This prompted a site investigation in 1991, completed by ADEQ's Office of Waste and Water Quality Management.

The mill site has been abandoned since 1991 when extraction operations stopped after the cyanide solution spill. The operational equipment was subsequently removed from the site after operations ceased, leaving behind a concrete holding pond, multiple concrete slabs used for holding cyanide solutions and cyanide leaching, a building foundation, and debris. Figure 2.7 below shows the current site conditions as found from Google Earth aerial imagery. The access road runs to the north of the site, and a wash is present to the south of the site that runs in the southwest direction towards Oatman Highway.

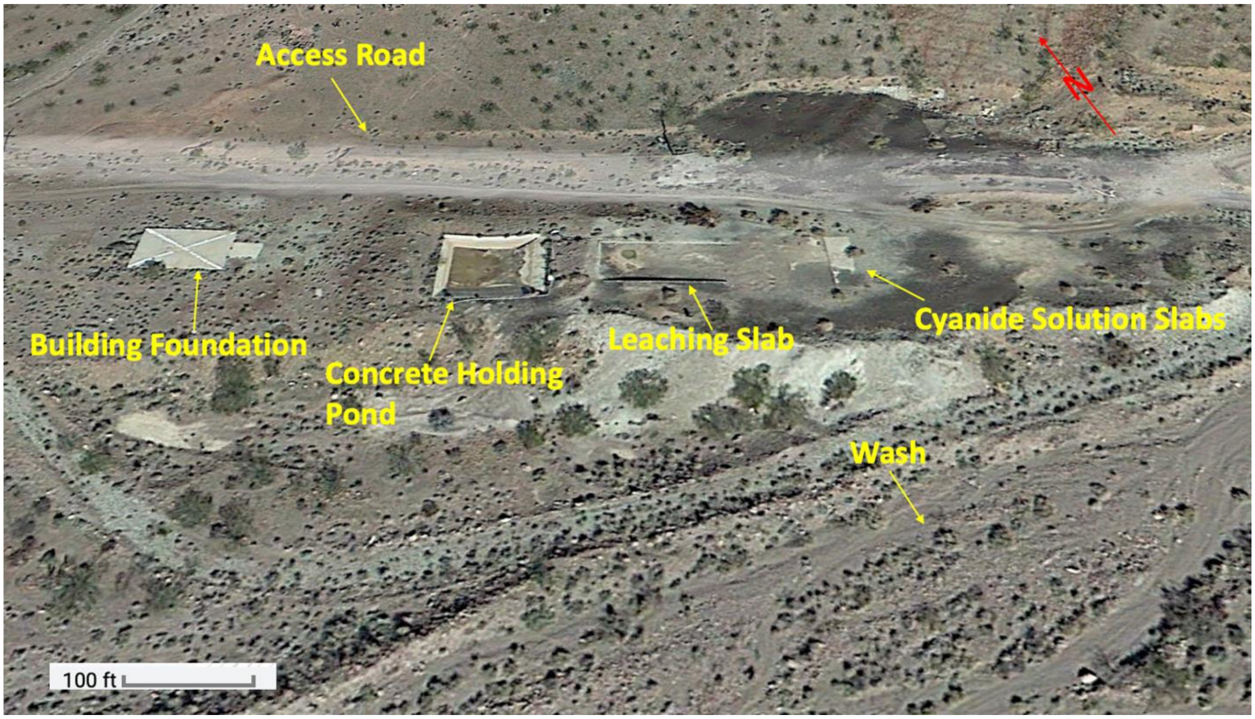

*Figure 2.7: Current Site Condition (Google Earth)*

## 2.4. Previous Investigations

A previous site investigation and sampling effort was done by ECM consultants in 2016. According to the document review completed in the ECM PA/SI, Malcom Pirnie, Inc. evaluated the potential cyanide contamination at the site. Their investigation did not detect cyanide in any form above existing health-based guidance levels (HBGLs). ADEQ conducted a site investigation in 1991 after 90,000 gallons of cyanide solution (containing varying concentrations) were spilled on site. After their investigation, the mill's operations ceased. ECM conducted their own field sampling in 2015 and collected 24 soil samples and 1 groundwater sample collected at a pre-existing well. In-situ X-Ray fluorescence (XRF) readings in addition to ex-situ laboratory analysis were conducted [2]. Figure 2.8 below shows the sampling locations.


*Figure 2.8: ECM PA/SI Sampling Locations [2]*

The samples indicated in purple (CC-S-50 through CC-S-59) were samples taken at the cyanidation plant, while samples in red (CC-SO-60 through CC-SO-63) were taken at the spent ore piles. Yellow samples were taken on the ore pile loadout ramp, green samples were sediment samples taken downstream, and blue samples were sediment samples taken upstream. CC-GW-102 is the groundwater sample [2].
ECM's results were compared to ADEQ Soil Remediation Levels (SRLs) for non-residential exposures and the EPA Ecological Soil Screening Levels (Eco-SSLs). The analytical results indicated lead and arsenic levels above SRLs. Table 2.1 below shows the results of the laboratory analysis for lead conducted according to EPA Method 6010B and EPA Method 6200 (XRF analysis) that exceeded the human health screening level of 800 ppm [2].

*Table 2.1: Laboratory Analysis Results for Lead in Soil [2]*

| EPA Method 6010B | |
|---|---|
| Sample ID # | Lead Concentration (mg/kg) |
| CC-S-50 | 1,160 |
| CC-S-51 | 1,480 |
| CC-S-65 | 1,200 |
| EPA Method 6200 | |
| CC-S-50 | 1,075 |
| CC-S-50 | 1,996 |
| CC-S-65 | 1,652 |

The cells highlighted in orange in table 2.1 are lead concentrations that were found to be at least twice as high as the human health screening levels. The two EPA methods produced slightly different results, but both methods showed that two of the samples taken in the ore leach field and one sample from the ore pile loadout ramp had lead concentrations exceeding the standard. Table 2.2 below shows the laboratory analysis results conducted according to EPA Method 6010 B for arsenic in soil that exceeded the screening criteria of 10 ppm [2].

*Table 2.2 Laboratory Analysis Results for Arsenic in Soil [2]*

| EPA Method 6010B | |
|---|---|
| Sample ID # | Arsenic Concentration (mg/kg) |
| CC-S-50 | 20.5 |
| CC-S-51 | 17.9 |
| CC-S-53 | 45.2 |
| CC-S-54 | 159 |
| CC-S-55 | 69.8 |
| CC-S-56 | 174 |
| CC-S-57 | 137 |
| CC-S-73 BD | 154 |
| CC-S-58 | 214 |
| CC-S-59 | 106 |
| CC-S-65 | 20 |
| CC-S-66 | 180 |
| CC-SO-61 | 17.5 |
| CC-SO-62 | 134 |
| CC-SO-63 | 20.7 |
| CC-SO-64 | 18.3 |

The cells in table 2.2 highlighted in orange are arsenic concentrations that are greater than 10 times the human health screening levels. There was a greater amount of soils samples with high arsenic concentrations than lead concentrations, and 4/5 of the spent ore samples contained high arsenic concentrations.

# 3.0 Project Management

## 3.1. Site Investigation Objective & Project Management Approach

The goal of the site investigation is to find the special distribution of COC concentration levels of the contaminates on the site.

Project management will prioritize that the schedule is on track and that the health and safety, quality assurance (QA), and quality control (QC) guidelines are being followed. Client Eric Zielske of the BLM and Dr. Bridget Bero of NAU will be the primary field leads and will be make any needed decisions/changes that may be required in protocols. Claire Griffiths is the primary client contact. Frankie Martinez is QA/QC officer. Her main objectives are to assure compliance with all protocols during the site investigation and lab activities, as well as to assure data quality of the results. Evan Downs is the Health and Safety (HS) officer. His main objective is to make sure that the health and safety protocols are being followed in the field and lab.

### 3.2. Quality Management

The quality management in both the field and in the lab will be controlled by the QA/QC officer, Frankie Martinez. Frankie Martinez will implement the QA/QC controls and procedures to ensure that the samples and data collected meet the data quality objectives for the project. Appendix A, Section 2 further details data quality objectives.

## 4.0 Field Methods & Procedure

The filed methods and procedures will follow the protocols defined in the Sampling and Analysis Plan (SAP) found in Appendix A and the Health and Safety Plan (HASP) found in Appendix B.

## 5.0 Deviations from the Work Plan

All deviations from the submitted Work Plan will be approved by technical advisor, Bridget Bero, or by the client, Eric Zielske. The Assigned QA/QC officer will document any changes to the Work Plan.

## 6.0 References

[1] ECM Consultants, “Field Photolog,” 2016. [Accessed 19-Sept-2022].

[2] ECM Consultants, “Preliminary Assessment and Site Inspection Report,” 2016. [Accessed 19-Sept-2022].

[3] Environmental Protection Agency, "Guidance on Systematic Planning Using the Data Quality Objectives Process," Office of Environmental Information , Washington DC, 2006.

[4] Environmental Protection Agency. (n.d.). Field X-Ray Fluorescence Measurement. EPA. Retrieved November 11, 2022, from https://www.epa.gov/quality/field-x-ray-fluorescence measurement

[5] Environmental Protection Agency. (n.d.). Regional 4 Superfund X-Ray Fluorescence Field Operations Guide. EPA. Retrieved November 11, 2022, from https://www.epa.gov/risk/regional-4-superfund-x-ray-fluorescence-field-operations-guide.

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[10] EPA, “Logbooks,” 2017. [Online]. Available: https://www.epa.gov/sites/default/files/2015-06/documents/Logbooks.pdf [Accessed: 07-Nov-2022].

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[13] ASTM, "Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis”. [Online]. [Accessed: 3-Oct-2022].

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[15] EPA, “Microwave Assisted Acid Digestion of Siliceous and Organically Based Matrices”. [Online]. [Accessed: 3-Oct-2022].

[16] EPA, “Flame Atomic Absoprtion Spectrophotometry”. [Online]. [Accessed: 10-Nov-2022].

[17] EPA, “Inductively Coupled Plasma-Atomic Emission Spectrometry”. [Online]. [Accessed: 10-Nov-2022].

[18] Occupational Safety and Health Administration, "Principal Emergency Response and Preparedness: Requirements and Guidance," U.S. Department of Labor, Washington, DC, 2004

[19] Northern Arizona University, "Chemical Hygiene Plan 2021," Northern Arizona University, Flagstaff, 2021.

# Appendix A: Sampling and Analysis Plan (SAP)

# 1.0 Introduction

## 1.1 Responsible Agency

The responsible agency for the Canyon City Mill project is the Bureau of Land Management (BLM) Arizona State Office, specifically Eric Zielske.

## 1.2 Project Organization Table

The following table displays the project personnel and their responsibilities associated with the project.

*Table 1.1A: Personnel and Responsibilities*

| Title and Responsibility | Name | Email |
|---|---|---|
| Client | Eric Zielske | ezielske@blm.gov |
| Professional Engineer, Technical Advisor | Bridget Bero | bridget.bero@nau.edu |
| Staff Engineer, Field Geologist | Chloe Blackhurst | cab847@nau.edu |
| Staff Engineer, HS Officer | Evan Downs | ejd234@nau.edu |
| Staff Engineer | Claire Griffiths | cjg445@nau.edu |
| Staff Engineer, QA/QC Officer | Frankie Martinez | fim23@nau.edu |

## 1.3 Sampling Overview

A total of 110 samples will be taken, 62 of which will be grid samples over the facility area. Thirty transect samples will be taken in the wash south of the site. Up to 10 hotspot samples may be taken, along with 3 background samples and 2 core samples.

# 2.0 Project Data Quality Objectives and QA/QC Methods

## 2.1 Project Objective

A site investigation will be conducted to identify all contaminants of concern at the Canyon City Mill site and surrounding land. Soil sampling will be used to determine the spatial distribution and migration pathways of the COCs. The ecological and human health risks will be computed using data collected from the site investigation.

## 2.2 Data Quality Objectives (DQO)

According to the Environmental Protection Agency, the Data Quality Objectives (DQO) process is used to determine acceptable type, quality, and quantity of environmental data [3]. The DQO for this project are to obtain estimates of the identified COC concentrations that are within an acceptable range of uncertainty appropriate for screening level data.

## 2.3 Quality Assurance and Control

Quality assurance (QA) and quality control (QC) are needed to generate acceptable data for the project. QA and QC apply to both the laboratory and field procedures. QA will be maintained by documenting that the proper sampling procedures and analytical methods identified in this document are correctly followed. QC procedures will be utilized to guarantee the accuracy and precision for the data collected. The subsections below detail the specific QC activities that will be followed.

### 2.3.1 Field QC Procedures

The team will collect field duplicate samples at a rate of one duplicate for every 20 samples taken. Field duplicates are samples that are taken from the same source under the same conditions as the normal sample. Field duplicates are used to measure the samples variability in concentration levels and or collection techniques. This is done by computing the relative percent difference between the samples. The DQO for duplicates is less than 50 RPD for soil and sediments [7]. The RPD will be calculated using Equation 2-1A [7]. Equation 2-1A can be found below:

*Equation 0-1A*

$$\%RPD = \frac{2|O_i - D_i|}{(O_i + D_i)} \times 100\%$$

*Where:*
%RPD = Relative Percent Difference for compound i
$O_i$ = Value of compound i in original sample
$D_i$ = Value of compound i in duplicate sample

The correct sample locations will be assured by GPS location of the initial sampling point, marking with a tagged flag, and identifying the rest of the grid using compass and measuring tape. Each sample location will be documented with its GPS coordinates when collecting the sample.

To assure that all samples are collected, a checklist of the samples will be maintained by the QA/QC officer.

Correct sample bag labeling will be checked by the QA/QC officer according to the sample naming scheme discussed in Section 3.4.

The samples will be stored, secured, and tracked according to the methods discussed in Sections 3.5 and 3.6 below.

### 2.3.2 XRF QC Procedures

An XRF will be used to determine COC concentrations in the samples. It is expected that XRF will be used to obtain in-situ metals concentrations at each sampling location, in addition to further XRF analysis of samples after drying and sieving in the lab. To maintain the quality of data from the XRF, the team will follow the manufacturing instructions, EPA Method 6200, and the Science and Ecosystem Support Division (SESD) Operating Procedure for Equipment Inventory and Management for the XRF

(SESDPROC-108-R5) [4]. The following sections describe the different QC checks that will be performed for the XRF.

#### *2.3.2.1 Calibration Check*

The team will conduct an internal system check each time the device is turned on. The XRF has a built-in system calibration function that can be accessed from the main menu. The XRF will state whether the system passes internal calibration or not. If the system does not pass, the team will contact Thermo Scientific Services.

#### *2.3.2.2 Operational Use*

To ensure QA the team must perform the proper operational use of the XRF. The XRF device must be operated in "soils" mode, as opposed to the alternative "mineral" mode. The ambient temperature of the area must also be recorded during operation and will be recorded every 30 minutes during use of the XRF. According to the SESDPROC-108-R5 if the temperature changes more than 10°F during operation, a recalibration must be performed.

#### *2.3.2.3 XRF Data*

For laboratory XRF analysis, each sample will be sub-sampled nine times and nine XRF readings will be taken. For each metal, the highest and lowest XRF reading will be eliminated, and the other seven will be averaged to give the sample's concentration value along with the standard deviation of the readings.

The XRF also returns a standard deviation (error) value with each metal reading; any readings within that standard deviation will be flagged.

Additionally, each metal has a different lower limit of detection by XRF.  Any readings designated "not detected" will be flagged and assigned a numerical value half that of the detection limit.

### 2.3.3 Data Analysis

Data quality indicators (DQIs) include precision, accuracy, representativeness, completeness, comparability, and sensitivity (PARCCS) [6]. The details regarding PARCCS are described below.

#### *2.3.3.1 Precision*

Precision is the degree of mutual agreement between independent measurements of a similar property [6]. Precision will be reported in relative percent difference [RPD] between duplicate samples as discussed in Section 2.3.1.

#### *2.3.3.2. Accuracy*

Accuracy is the degree of agreement of a measurement with a true value [6]. From prior experience, it is known that the XRF returns accurate data for Pb concentrations. As concentrations, however, are hindered by the overlap of As and Pb fluorescence wavelengths. As concentrations by XRF are biased high when high levels of Pb are present in the sample.  Therefore, As samples will be sent to an external laboratory for confirmatory ICP or FAA analysis at a rate of one per 10 samples. The XRF data will be correlated with the ICP/FAA results using a correlation curve and all XRF will be corrected.

#### *2.3.3.3 Representativeness*

Representativeness is the degree to which data are accurate and precise [6]. The QA/QC Officer will assure that all samples collected he representative of the site conditions. As the team has not yet visited the site, the proposed sampling locations (see Section 3.1) may be adjusted to assure representative sampling, and not excessive background sampling. Any changes to the sampling plan will be made in the field by the Technical Advisor Dr. Bero.

#### *2.3.3.4 Completeness*

Completeness is the percent of actual usable data collected compared to the amount expected [7]. Unwanted values for completeness may come from not collecting all samples, loss of samples, instrument failures, technical mistakes, etc. Typical goals are within the 75-90% range. For this project, the DQO for completeness is 90%.

#### *2.3.3.5 Comparability*

Comparability is the confidence with one data set compared to another and does not apply to this project as no exactly similar data sets exist [6].

#### *2.3.3.6 Sensitivity*

Sensitivity is the method detection limits (MDLs). The MDLs will be identified for both XRF and any ICP/FAA data, and any non-detects will be assigned a numerical value equal to that of half the MDL.

#### *2.3.3.7 Cross-Contamination in the Field*

To prevent cross contamination the team will perform the following during sample collection:

1. Wear a new pair of nitrile gloves when collecting each sample
2. Dispose of nitrile gloves after equipment has been decontaminated
3. The team will not touch the inside of the sampling bag
4. All equipment will be decontaminated before each use
5. All samples will be sealed, labeled, and documented correctly; any sample bags that are found to have punctures will be double bagged.
6. All notes will be kept in the field logbook

#### *2.3.3.8 Cross-Contamination in the Lab*

To avoid cross-contamination in the lab, drying containers, sieves, and the XRF cups will be decontaminated after each use between samples. All equipment and surfaces used in the lab will be cleaned thoroughly between sample analysis. Gloves will be used when handling the samples during analysis. All containers will be sealed.

### 2.3.4 Data Review & Validation

Data review and validation will be an assessment of the laboratory performance and sample specific criteria. This is done to eliminate data that are unacceptable. The QA/QC Officer will be responsible for reviewing all data and will determine to what extent the DQOs were met. All usable data should adhere to the EPA "National Functional Guidelines for Inorganic Superfund Methods Data Review" [8]. All results of the quality review will be reported in the project report. Unaccepted data will be flagged.

### 2.3.5 Data Management

All data files will be backed up in OneDrive and on an external flash drive. All work should be double checked by the QA/QC Officer and one other teammate.

# 3.0 Field Sampling Protocols

## 3.1 Soil Sampling

Approximately 110 samples will be collected at the site, of which approximately 62 will be collected using grid sampling methods. Samples will be collected at the surface, unless defined otherwise. The location of the grid samples that will be taken over the mill area is found in Figure 3.1.A below. Each sample in the grid is approximately 50 feet apart, with a closer grid over the facility area with samples taken every 25 feet. Three background samples will be taken, as well as up to ten hot-spot samples where elevated contaminant concentrations may be found. Up to two core samples will be taken at a depth of 12 inches. The locations of the hotspot, core, and background samples will be decided during the site investigation. The sample identification scheme shown in the figure is discussed in Section 3.4 below.

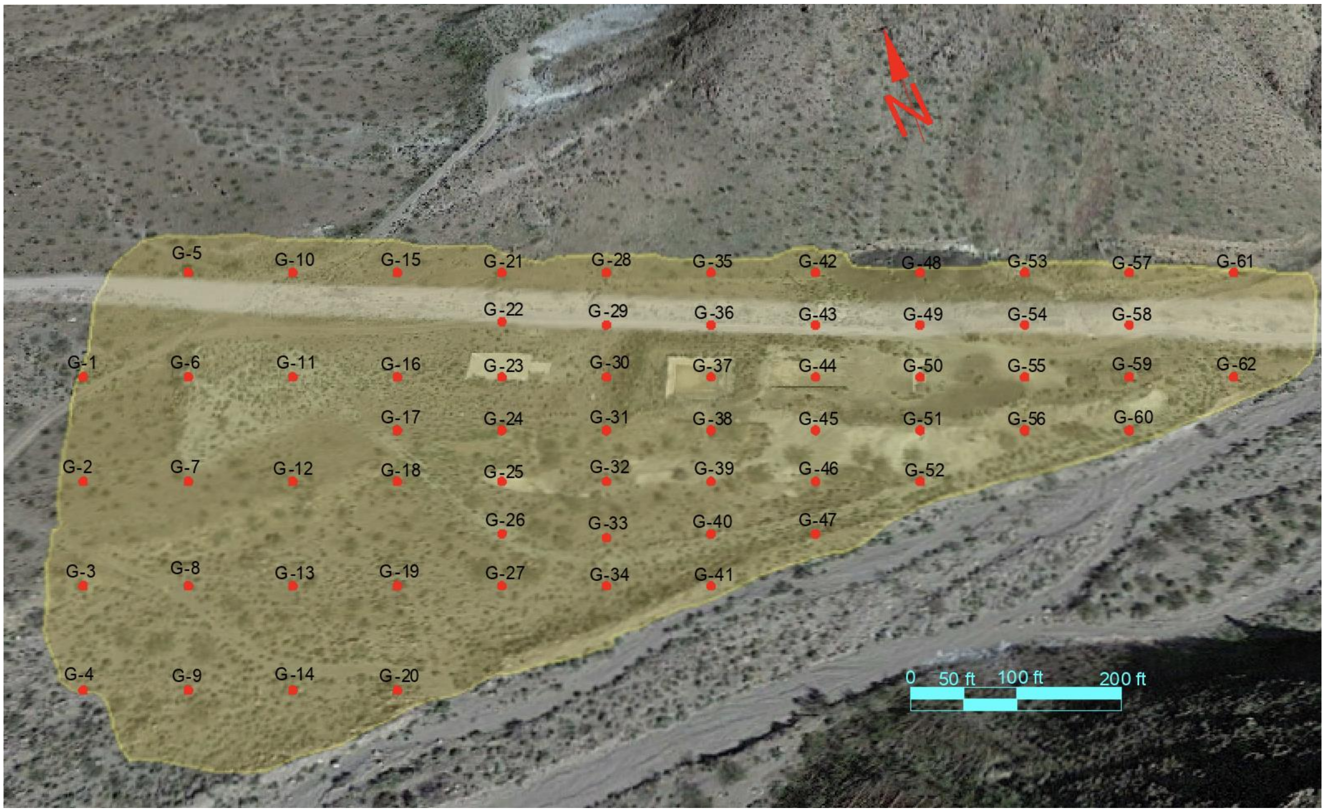

*Figure 3.1.A: Grid Soil Sample Locations*

Approximately 30 transect surface soil samples will be taken in the wash. The portion of wash being sampled is 1,800 feet long. The location of the transect wash samples is shown in Figure 3.2.A below. In narrow portions of the wash, 3 samples will be taken at the right and left banks, and the thalweg. In wider sections, 4 equidistant samples will be taken. Transects will be spaced approximately 200 feet apart, for a total of 9 transects.

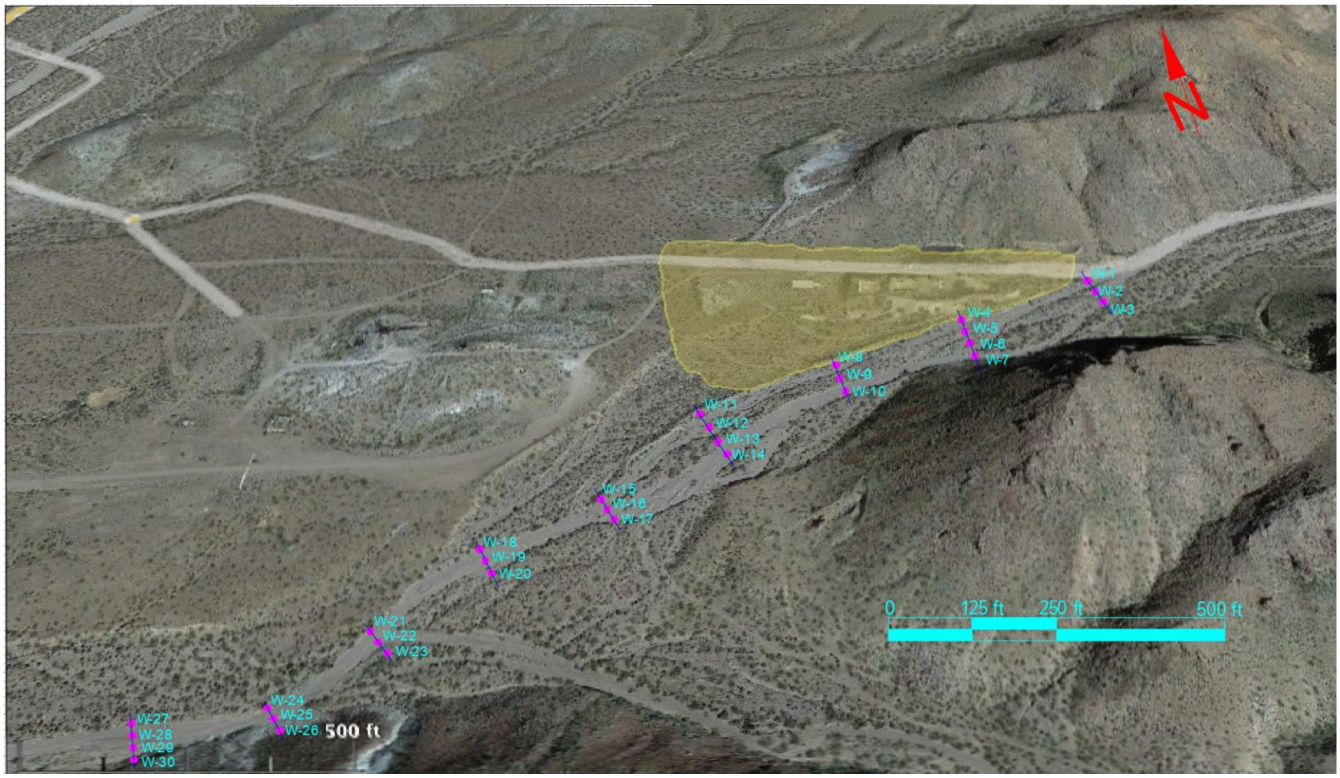


*Figure 3.2A: Wash Soil Sampling Locations*

### 3.1.1 Soil Collection

Surface soil samples will be collected approximately 0-3 inches below ground surface. Any surface litter (vegetation, rocks, gravel) will be removed with a trowel prior to sample collection. A clean stainless-steel trowel will be used to collect ½-¾ gallon of a sample. The sample will be placed into a gallon sized heavy duty (freezer) Ziploc bag and properly labeled as outlined in Section 3.4. Weather permitting, an XRF reading at the sample location will be conducted after surface litter is removed and prior to sample collection.

### 3.1.2 Background Soil Samples

Three background samples will be collected using the methods described in Section 3.1.1. The location of the background samples will be determined on-site during the site investigation.

### 3.1.3 Soil Collection at Hot-Spots

Up to ten hot-spot samples will be collected where high levels of contamination is suspected to be present. These samples will be collected using the methods described in Section 3.1.1.

### 3.1.4 Core Soil Samples

Up to two core soil samples will be collected using a clean hand auger. The sleeves will be properly capped and placed into gallon sized Ziploc bags. The samples will be labeled as outlined in Section 3.4.

## 3.2 Field Equipment and Calibration

Necessary equipment to collect the surface soil samples are a stainless-steel trowel, gallon sized Ziplock bags, 5-gallon buckets, marking flags for the field, measuring tapes, and a handheld GPS. Core samples will be taken with a hand auger with plastic sleeve inserts. Field notebooks, pens/markers, and a camera will be used to document the work. Sampling equipment will be cleaned after each sample using wash water, dish soap, and a scrub brush (see Section 3.6).
The XRF device will be used to take readings in the field once the surface samples have been collected. The internal calibration will be run each time the unit is turned on.

## 3.3 Sample Containers

Once collected, the samples will each be placed in separate gallon sized heavy duty (freezer) Ziplock bags from a new, unopened package to ensure they are sterile. The bags will be placed in large plastic bins for storage and transport.

## 3.4 Sample Labeling

The samples will be named according to the site, sample location, and sampling method used. Grid samples will be named CC-G-#, where "#" is the sample number. Background samples will be named CC-B-# and transect samples taken in the wash will be named CC-T-#. Core samples will be divided into 0-6" and 6-12" subsamples and will be named CC-C-06-# or CC-C-612-#, and hotspot samples will be named CC-HS-#. Samples taken in the wash will be named CC-W-#.

## 3.5 Sample Preservation, Packaging, Shipping

Sample preservation is not required. The samples will be logged onto a Chain of Custody Form (see Section 3.7.3) and placed in a bin that when full, will be sealed with the Custody Seal (see Section 4.2.4) for transport from the site back to NAU.

For samples sent to the subcontracted lab, 5 grams of soil will be placed in a labeled glass vial and wrapped Styrofoam vial shipping containers with chain of custody documentation included inside. The packaged samples intended for the subcontracted lab analysis will be delivered by a team member who will ensure that the samples are kept at standard conditions (no extreme temperatures or excess moisture).

## 3.6 Equipment Decontamination Procedures

The stainless-steel trowel and hand auger will be decontaminated after each sample is taken to ensure the sample is representative of the location from which it was taken. The equipment will be cleaned using dish soap and water stored in a 5-gallon bucket and a scrubbing brush.

## 3.7 Documentation

### 3.7.1 Field & Laboratory Logbooks

Each team member will keep logbooks documenting project name, location, and each team member's full name. Any deviations from the Work Plan in addition to field observations, data and necessary calculations will be recorded in each logbook with pen. Maps and sketches will be included in the logbook where necessary, and page numbers will be labeled as "x of y," where "y" is the total number of pages [10]. For each sample collected, the date and time of collection, sample location (GPS coordinates), sample ID, sampling collection method, description of sample, and whether an XRF reading was taken will be recorded in the field logbooks.

Laboratory logbooks will be completed on NAU Laboratory Project Activity Log sheets, and will include the team member names, date and start/end times of each project activity, activity description, and project name. The lab activities include sample preparation, sample analysis, and equipment checks. For laboratory analysis, the following items must be documented in the lab logbooks: Date and time of analysis, sample ID, instrument name and serial number, calibration records, ID of preparation equipment, if necessary, reagents/standards used, if necessary, units, measurement results, and disposal and decontamination procedures used (see Appendix B) [10].

### 3.7.2 Photographs

The team will use their cellphones to photograph and document the site conditions. Photographs will include images of each sample taken, the flora and fauna in the area, and any disturbed soil or visible tailings on site. The photographs will be compiled in a shared drive and on a flash drive.

### 3.7.3 Chain of Custody Form

The Chain of Custody Form is the documentation tracking the movement of samples from their collection to their handling and transport to their analysis [11]. The record must include the location of the samples and the names of who is in possession of the samples each time the samples undergo a change in custody. Figure 3.3A shows the form that will be used for the project.

**Chain of Custody Record**

| | |
|---|---|
| **Project Title:** | **Organization:** |
| **Bin #:** | **Contact:** |
| **Field Samplers:** *print* *signature* | **Address:** |

| Date | Sample ID | Sample Type | Date | Sample ID | Sample Type |
|---|---|---|---|---|---|
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| **Relinquished by** (*print and signature*): | **Received by** (*print and signature*): |
|---|---|
| | |
| | |
| | |
| | |
| | |
| | |

*Figure 3.3A: Chain of Custody Form*

The form will remain with the sample(s) at all times. The Chain of Custody form for each sample will be checked at each change of custody to ensure consistency between form and sample and the person relinquishing/accepting the sample will sign the form.

### 3.7.4 Custody Seals

A Chain of Custody Seal will be seal the lid of each bin containing the samples. The Custody seal to be used is shown in Figure 3.3A below.

**Chain of Custody Seal**
***Flag Environmental Solutions Northern Arizona University***

**Storage Conditions:** ______________________ **Site Name:** ___________________________

**Bucket #:** _______________ **Sample Type:** ______________________________

**Date Sealed:** ____________ **Sealed By:** _______________________________________

**Sample Range Included:**_________________________________________________________

*Figure 3.4A: Chain of Custody Seal*

# 4.0 Laboratory Analyses

## 4.1 Sample Drying

The soil samples will be dried according to ASTM Method D2216 in the NAU CENE Soils Lab [12].

## 4.2 Sample Sieving

Soil samples will be sieved with a 60-mesh sieve (< 250 µm) in order to achieve size homogeneity and remove large particles. The soil samples will be sieved using ASTM Method D6913 [13].

## 4.3 XRF

The XRF Analysis will be conducted according to EPA Method 6200 [14]. Each sample will be divided into nine replicates and placed into XRF sample cups. The sample is positioned in front of the probe window, while an electronic multichannel analyzer measures the sample's pulse amplitudes. The element's concentration proportional to the number of counts as its characteristic given energy per unit of time. The XRF analysis will be conducted in the NAU Soils Lab using a NITON XL3t 600 XRF.

## 4.4 Acid Digestion

If human health COCs other than lead and arsenic are found, soil samples will be digested in order to prepare for the FAA or ICP testing for confirmatory analysis. It is known that lead concentrations in soil by XRF are accurate so no further analysis is required; arsenic digestions will be performed by a subcontracted lab. The EPA Method 3052 will be used [15].

## 4.5 FAA/ICP Confirmation

To confirm concentrations of the COCs, an FAA or ICP analysis will be conducted by Western Technologies Lab. FAA analysis will be conducted using EPA Method 7000B and the ICP analysis will be conducted using EPA Method 6010B [16] [17].

# 5.0 Disposal of Residual Materials

## 5.1 Field Disposal

After the equipment is decontaminated, the fluid left over must be disposed of. To do this the team will pour the fluid back into soil. The decontaminated fluid is diluted therefore it is does not affect the environment or human health.

## 5.2 Laboratory Waste Disposal

In the lab any hazardous chemical must be disposed of properly. Liquid and soil hazardous waste will be handled in different manners. Soil waste will be sealed in a container that is labeled as “Hazardous Waste” from the Environmental Health and Safety (EHS) department. The container will be picked up by EHS. “Overs” from the sieving process are considered nonhazardous and will be disposed of as solid waste. Liquid waste considered hazardous from decontamination activities will be also sealed in container labeled “Hazardous Waste”. This will be picked up by  EHS.

# Appendix B: Health & Safety Plan (HASP)

# 1.0 Job Name & Location

A Preliminary Assessment and Site Investigation will be conducted of the Canyon City Mill site. The Canyon City mill site is located 1.5 miles south of the town of Oatman, Arizona.

# 2.0 Safety & Health Administration

The Health and Safety officer, Evan Downs, will be responsible for the safety and well-being of the other team members during the project, in both the field and the lab. This document details an emergency action plan for the team, and includes an analysis of risks present, risk mitigation, locations of nearby emergency services, and contact information of emergency services and participating personnel.

# 3.0 Hazard Assessment

## 3.1 Field Hazards and Associated Personal Protective Equipment

Table 3.1.B shows the possible hazards that may be encountered in the field. The Personal Protective Equipment (PPE) required for the Site Investigation includes, closed toed shoes, gloves, a hat, long sleeves, and pants. For all field work, the team will implement the "buddy system" whereby no team member will be alone in the field.

*Table 3.1.B Possible Field Hazards*

| Possible Field Hazard | Suggested Mitigations |
|---|---|
| Physical | |
| Prolonged Sun Exposure | Apply sunscreen as needed, wear appropriate clothing (including a hat), drink water, find shade if needed. |
| Extreme Temperatures | Bring clothing for a variety of temperature possibilities |
| Inclement Weather | Monitor weather conditions, bring appropriate clothing. |
| Slips and Falls | Be mindful of where you are steeping, especially during elevation changes. Wear sturdy boots. |
| Strains from Lifting Heavy Bins | Ask for help when lifting heavy objects, always protect back when lifting. |
| Chemical | |
| Dermal/Ingestion Exposure to Identified COC's | Wear protective clothing and gloves, tie up/cover long hair; remove clothing to secure bag after use. |
| Inhalation Exposure to Identified COC's | Wear a facemask if windy conditions are present. |
| Biological | |

| | |
|---|---|
| Contact with Dangerous Flora and Fauna | Be aware of potential hazards (snakes, thorny plants). Avoid all contact with unknown or potentially dangerous flora and fauna. |
| Radiological | |
| Use of XRF | Use at arm's length, keeping the device as far away from body core as possible |

### 3.2 Laboratory Hazards and Associated Personal Protective Equipment

Table 3.2.B below shows hazards that may be encountered in the lab. The Personal Protective Equipment (PPE) required for the laboratory analysis includes closed toed shoes, gloves, a lab coat, and eye protection.

*Table 3.2.B Possible Lab Hazards*

| Possible Lab Hazards | Suggested Mitigations |
|---|---|
| Physical | |
| Burns | Wear thermal gloves when using the drying oven |
| Slips and Falls | Take precaution of possible tripping hazards in the lab |
| Cuts from Broken Glass | Have caution when handling glassware; wear appropriate PPE. |
| Chemical | |
| Dermal/Ingestion Exposure to Identified COC's | Wear required laboratory PPE |
| Inhalation Exposure to Identified COC's | Work outdoors or in hood when dusts from samples are present; wear appropriate PPE |
| Chemical Burns | Wear appropriate PPE; work in hood when possible. |
| Biological | |
| NA | NA |
| Radiological | |
| Use of XRF | Operate only using containment apparatus |

## 4.0 Training Requirements

### 4.1 NAU Lab Safety

Required NAU lab safety courses will be completed by all members entering the lab. Each member will present their completed lab training certificates.

### 4.2 XRF

Each team member will have a thorough understanding of how to operate the XRF instrument. A skilled XRF operator will guide team members on how to properly use the XRF, and team members will reference the training manual for further instructions.

# 5.0 Site Control & Operating Procedures

The site controls and operating procedures will follow the Occupational Health and Safety Administrations (OSHA) guidance. This guidance includes the requirement of a site map, the use of a buddy system, and emergency response information [18]. For the laboratory setting it is important to note that working alone in the laboratory is not permitted.

# 6.0 Decontamination Procedures

Procedures for decontamination will follow OSHA guidelines. This guidance addresses the required method for decontamination of workers, methods for reducing contamination to workers, and methods for disposing of contaminated clothing.

## 6.1 Field

Possible contamination in the field will be limited by minimizing contact with potential hazards by wearing appropriate clothing and PPE. Contaminated clothing will be removed prior to returning to the van and will be placed in a plastic bag until it can be washed by the user. Handwashing will be required prior to eating. Wash liquids will be disposed of on site.

## 6.2 Lab

To prevent possible contamination in the laboratory environment the Northern Arizona University Chemical Hygiene Plan will be followed [19]. If an accident occurs in the lab the NAU accident must be reported according to the Responding to Accidents and Emergencies section of the Standard Operating Procedures for Chemical Procedures.

## 6.3 Field Waste Disposal

Non-hazardous solid waste such as paper towels and empty bottles generated in the field will be disposed of by placing it in trash bags and will be kept until it can be safely disposed of.

# 7.0 Emergency Response Procedures

Any injury sustained on site must be reported to the supervisor immediately. If required emergency services will be called and the injured person will receive the required medical attention. Details regarding emergency services can be found in the following sections. First aid kits will be provided and available on site for minor injuries.

## 7.1 Closest Medical Facilities

The closest full-service medical facility to the Canyon City Mill Site is the Western Arizona Regional Medical Center, located in Bullhead City, Arizona. The travel time from the site to the Western Arizona Regional Medical Center is 37 minutes. The address for Western Arizona Regional Medical Center is 2735 Silver Creek Rd, Bullhead City, AZ 86442, their phone number is 928-763-2273. Figure 7.1.B shows the distance from the site to the nearest medical center. Figure 7.2.B shows the distance from the NAU engineering department to the NAU clinic, in case of accidents in the lab. The total travel time from the engineering building to the NAU clinic is 5 minutes. The address for the NAU clinic is 824 S San Francisco St, Flagstaff, AZ 86001, their phone number is 928-523-2131.

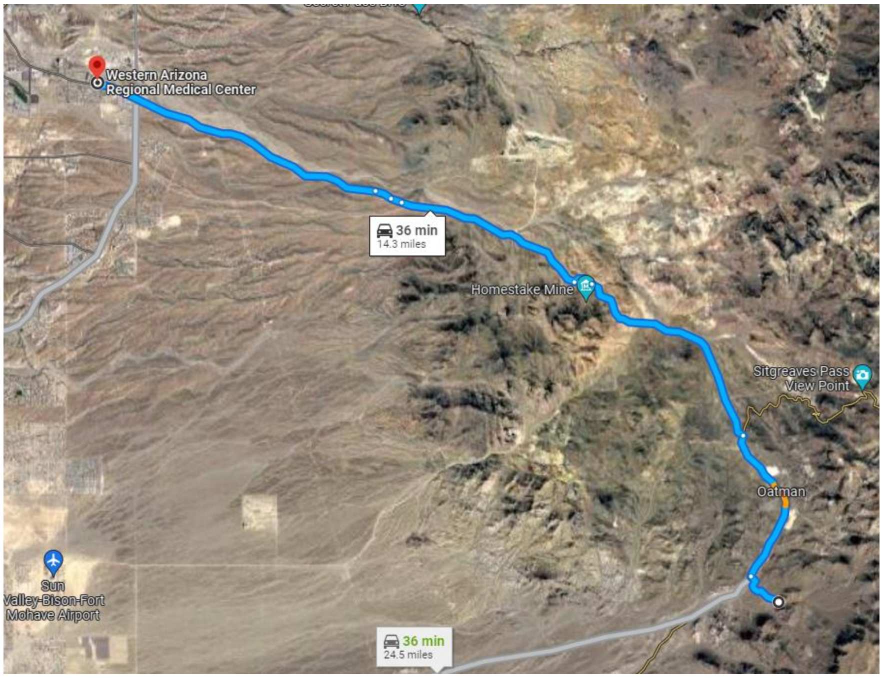


*Figure 7.1.B Distance to Western Arizona Regional Medical Center*

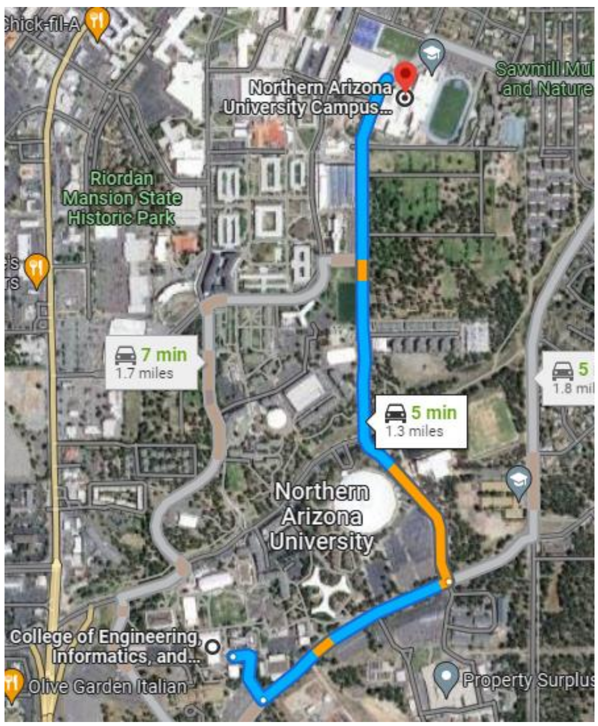


*Figure 7.2.B Distance from Engineering Building to NAU Clinic*

## 7.2 Emergency Contact List

Tables 7.2.B and 7.3.B shows the emergency contact lists relevant to the project.

*Table 7.2.B Emergency Contact List*

| Emergency Contact | Number |
|---|---|
| National Poison Control Center | (800) 222-1222 |
| Bullhead City Police Department | (928) 763-9200 |
| Bullhead City Fire Department | (928) 758-3971 |
| Arizona Bureau of Land Management | (602) 417-9200 |
| Northern Arizona University Engineering Department | (928) 523-5251 |
| Northern Arizona University Clinic | (928) 523-2131 |

*Table 7.3.B Personal Emergency Contact Information*

| Name | Emergency Contact | Relation | Emergency Contact Number |
|---|---|---|---|
| Dr. Bridget Bero | Charles Beadles | Spouse | (928) 607-8688 |
| Chloe Blackhurst | Alan Blackhurst | Father | (801) 793-1788 |
| Evan Downs | Michelle Downs | Mother | (951) 837-3766 |
| Claire Griffiths | Paul Griffiths | Father | (503) 679-2898 |
| Frankie Martinez | Lorraine Martinez | Mother | (602) 312-4026 |