Supplemental Investigations Work Plan

Work Plan for St. Anthony Mine Site
Supplemental Investigations

February 23, 2018

Prepared for:

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Executive Summary

This Supplemental Material Characterization Work Plan (work plan) describes the proposed investigation and data evaluation to provide sufficient supplemental radiological, agronomic and geotechnical information required for the Closeout Plan. This work plan describes the proposed drilling program and provides a geotechnical field sampling plan specific to the borrow areas and stockpiles at the St. Anthony Mine Site, as well as some additional test pit locations to collect samples for the geomorphic evaluation. It also describes the radiological investigation which will cover areas not included in the previous investigation, as well as additional scanning in areas previously characterized. A site-specific Health and Safety Plan (HASP) covering field activities associated with drilling, test pits, and sampling at the St. Anthony Mine Site as well as standard operating procedures (SOPs) are included in the appendices. Information collected will be used for the cover designs, revegetation plans, hydraulic modeling, material balance and grading plans for the design.

Abbreviations

ASTM	American Society for Testing and Materials
BGS	below ground surface
FSP	field sampling plan
DGPS	differential global positioning system
GPS	global positioning system
HASP	Health and Safety Plan
MDC	minimum detectable concentration
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
NMAC	New Mexico Administrative Code
PRRL	post-reclamation radiation level
RSO	Radiation Safety Officer
SOP	standard operating procedure
SPT	standard penetration test
UNC	United Nuclear Corporation

1.0 INTRODUCTION

1.1 BACKGROUND

The St. Anthony Mine was an open pit and underground shaft uranium mine located on the Cebolleta Land Grant approximately 40 miles West of Albuquerque, New Mexico located in Cibola County approximately 4.6 miles southeast of Seboyeta, New Mexico. The mine site is located in a remote, sparsely populated area with difficult access. A location map is included as Figure 1. UNC operated the St. Anthony Mine from 1975 to 1981, pursuant to a mineral lease with the Cebolleta Land Grant, the current owner of the surface and mineral rights. The original lease covered approximately 2,560 acres. This lease was obtained on February 10th, 1964 and was surrendered by a Release of Mineral Lease dated October 24, 1988. UNC has access to the Site through access agreements with the Cebolleta Land Grant and an adjacent landowner.

The Site includes underground workings consisting of one shaft, one vent shaft that is sealed at the surface, two open pits (one containing a pit lake), five inactive ponds, seven piles of non-economical mine materials with some revegetation, numerous smaller piles of non-economical mine materials, and three topsoil piles. No perennial streams occur within the St. Anthony site, but an arroyo (Meyer Draw) passes through the Site and joins Arroyo Del Valle on the southeast side of the site. The Site layout of the St. Anthony Mine is included as Figure 2. The two open pits at the mine site are located in Sections 19 and 30, Township 11 North, Range 4 West, and the entrance to the underground mine is located in Section 24, Township 11 North, Range 5 West. The mine permit boundary area encompasses approximately 430 acres and includes roads and other disturbed areas along with the open pits and non-economical mine materials piles.

1.2 PURPOSE

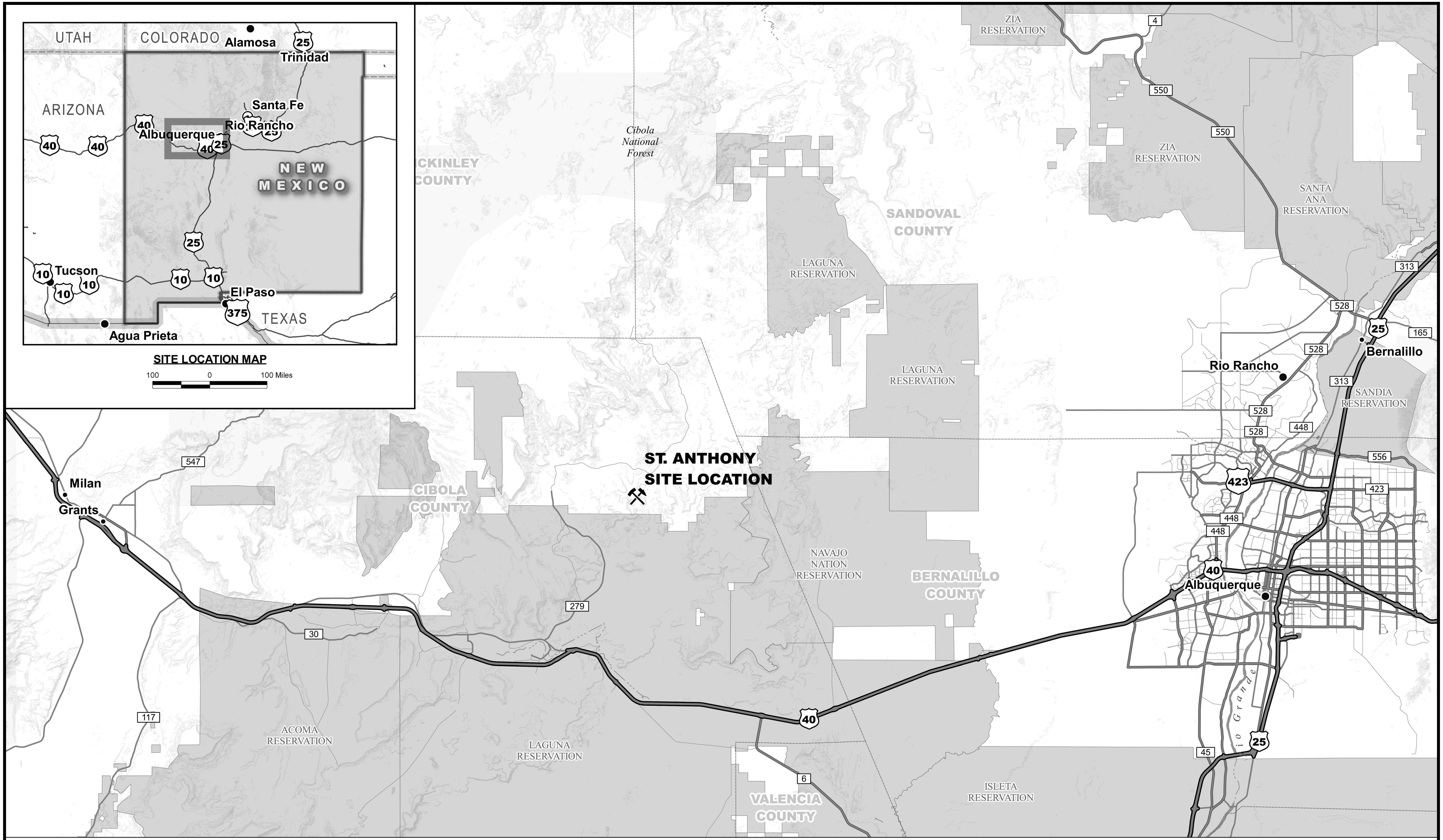
This Supplemental Investigations Work Plan (work plan) has been prepared to detail the proposed investigations and approach to the radiological investigation and data evaluation. Drilling and sampling will be conducted at the borrow and stockpile locations to estimate the quantity of materials available in the borrow areas and existing stockpiles, and to estimate engineering properties of these materials for laboratory testing. The investigation results will be used for the preliminary design including updating the cover designs, material balance, and grading plans.

An ecological subcontractor will provide an onsite soil specialist during the borrow and stockpile investigation to evaluate agronomic potential of the borrow sites. The subcontractor will observe, characterize, and sample soil and geologic materials during the drilling investigation on piles and potential soil borrow sources to identify growth media for use in mine facility reclamation. Both potential growth media and all distinct geologic materials will be sampled and characterized, to fully describe the range of chemical and physical properties of the eventual surface growth media and subsurface rooting media. Laboratory analysis to measure agronomic properties of the samples will be completed.

A hydrology and hydraulics investigation will be conducted by Stantec engineers during a one-day site visit to observe the Meyer Draw and waste rock stockpiles. Soil/sediment grab samples will be collected from the Meyer Draw and waste rock stockpiles and will be sent to a laboratory for geotechnical testing, to evaluate physical (geotechnical properties) properties.

A supplemental radiological investigation will be conducted to cover areas that were not included in the previous investigation as well as additional scanning in areas previously characterized to provide sufficient information required for the Closeout Plan and determination of the site-specific post-reclamation radiation level (PRRL). This investigation will be conducted by AVM with oversight from Stantec.

The data collected from the borrow and stockpiles investigation and geomorphic evaluation and radiological evaluation will be summarized reports, to be included as attachments to the Mine Closeout Plan and Design.



SITE LOCATION MAP

SITE VICINITY MAP

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UNITED NUCLEAR CORPERATION AND ST. ANTHONY MINE
CIBOLA COUNTY, NEW MEXICO

SITE LOCATION AND VICINITY MAP

FIGURE
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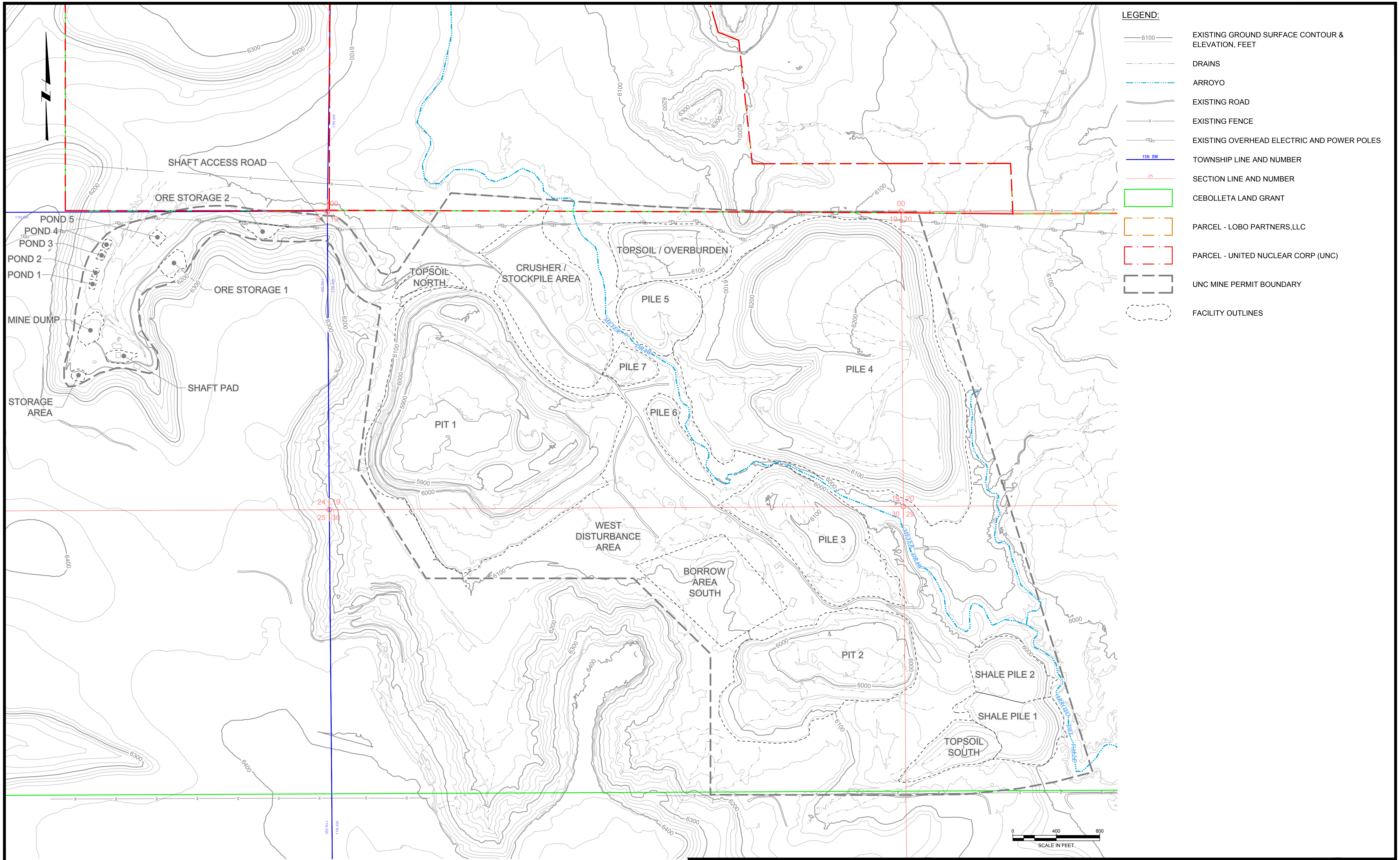

DRAWING REFERENCES:
1. All coordinates in New Mexico State Plane West, NAD83, Feet (U.S. Survey).
2. Elevations/Topo;
  2.1. On site: Cooper Aerial, 05/09/2011, (050911-1000overview3d.dwg)
  2.2. Supplemental Off Site: USGS DEM 10m
3. Township and Section lines: rgis.unm.edu, 08/04/2014
4. Parcels, and Cebolleta Land Grant: Cibola County, cibolacountynm.com, 02/15/18
5. Permit Boundary: (1008506X001.dwg)

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CIBOLA COUNTY, NEW MEXICO

SITE LAYOUT

FIGURE
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2.0 SUPPLEMENTAL BORROW AND STOCKPILES INVESTIGATION AND GEOMORPHIC EVALUATION

2.1 PREVIOUS GEOTECHNICAL SAMPLING

Previous soil sampling and characterization was conducted at the Site by MWH (now Stantec) in 2007, the results of which are presented in the *Materials Characterization Report, Saint Anthony Mine Site* (MWH, 2007). Over 30 test pits and drill holes were completed throughout the Site during that investigation and these locations are shown on Figure 3 with the proposed borehole locations for this work plan. The majority of the sampling done by MWH was completed using test pits, although several boreholes were drilled using an air rotary hammer drill rig in piles 3 and 4, where native soils were anticipated to be found at greater depths than the borrow areas and other disturbance areas. Borehole locations were concentrated along the edges of piles 3 and 4, such that a significant portion of the piles remained unexplored. No sampling was conducted in shale piles 1 and 2. Test pits were excavated to depths of 15 feet, in areas where the highest gamma measurements had been recorded, and 6 feet in borrow areas. Samples were subjected to laboratory testing for agronomic, geotechnical, radiological properties, and for analysis of metals in leachate.

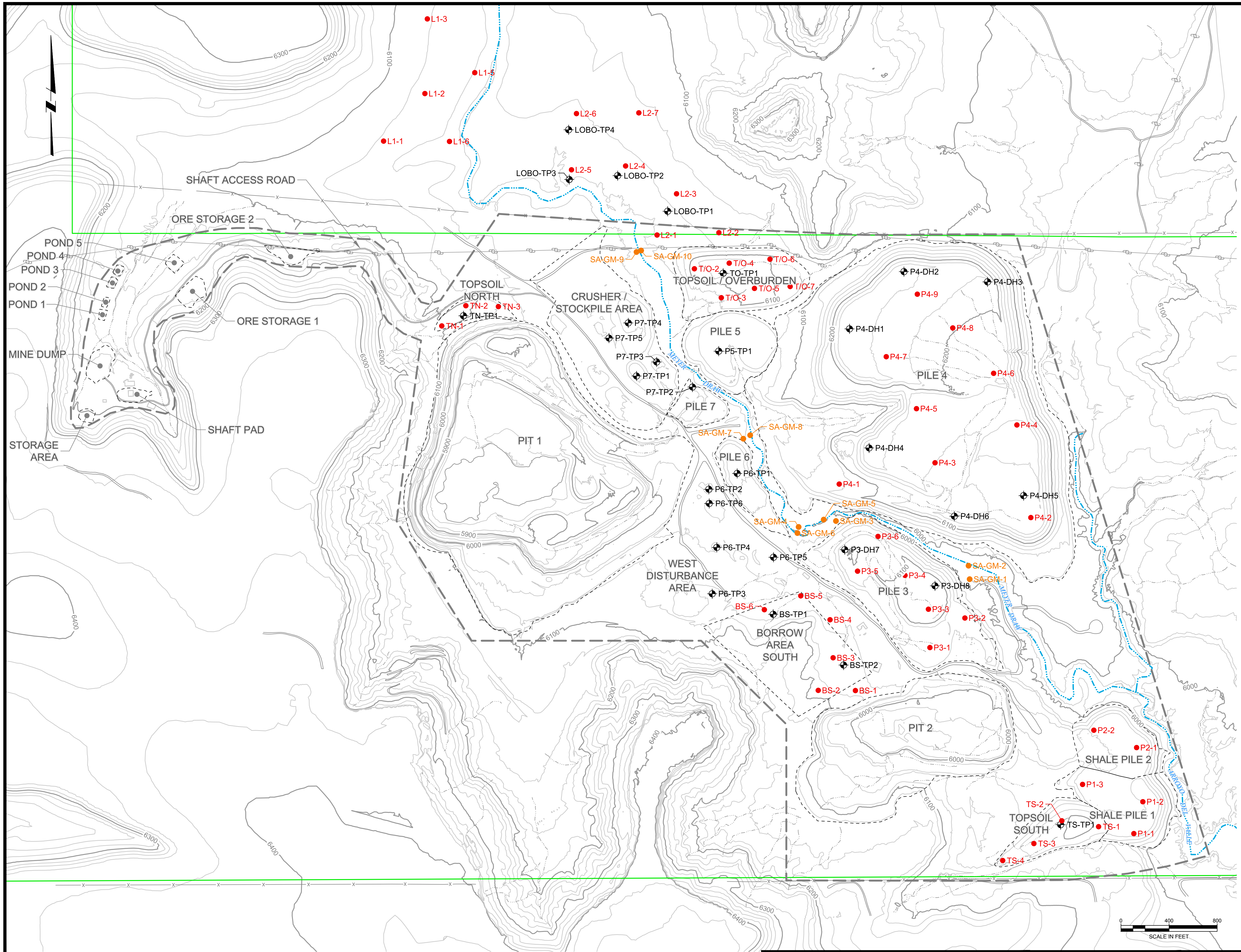
The primary focus of the 2007 materials characterization was to evaluate the presence of constituents of concern (e.g., gross alpha, radium-226, aluminum) and their effect on surface water and groundwater throughout the various facilities at the Site. Testing for geotechnical properties therefore was limited, and included gradations (percent content of clay, sand, and silt) as well as moisture content of select soil samples. Other properties that were not previously evaluated and are necessary for design include densities, gradations, Atterberg limits, and compaction properties. As a result, a more comprehensive drilling and sampling program is proposed for this investigation to evaluate additional locations within the Site facilities to obtain additional geotechnical properties required for design of the earthworks program.

2.2 SUMMARY OF DATA NEEDS EVALUATION

Stantec reviewed the previous geotechnical investigations and sampling and determined that additional characterization is necessary for the preliminary design and Closeout Plan. A supplemental borrow and stockpiles investigation will be conducted to estimate the quantity of materials available in the existing stockpiles (Piles 1- 4, and Shale Piles 1 and 2) and borrow areas (north, overburden, and south topsoil stockpiles, and south and Lobo Tract borrow areas), and to obtain soil samples to estimate the engineering properties via laboratory testing. An agronomic analysis will be conducted during the geotechnical investigation to evaluate the agronomic potential of the borrow sites as well as agronomic properties of the piles to evaluate potential for direct revegetation. The investigation results will be used for the material balance, cover and erosion protection designs, hydraulic modeling, and grading plans for preliminary design and to update the Closeout Plan (MWH, 2010).

2.3 BORROW AND STOCKPILES INVESTIGATION

The borrow area and stockpiles investigation will consist of hollow-stem auger drilling at select locations in the borrow areas and existing stockpiles. Locations were selected based on a spatial distribution to obtain representative samples from each of the stockpiles and borrow areas. Spacing between boreholes in the topsoil, overburden, and borrow areas ranges from 300 feet in the south borrow and topsoil areas to 500 feet in the much larger Lobo Tract borrow area. Locations of boreholes in these areas also were selected to avoid drilling and sampling in rock or other potentially unsuitable borrow materials. Boreholes in Piles 1-4 were similarly located using spacing of approximately



LEGEND:

6100	EXISTING GROUND SURFACE CONTOUR & ELEVATION, FEET
	DRAINS
	ARROYO
	EXISTING ROAD
x	EXISTING FENCE
	EXISTING OVERHEAD ELECTRIC AND POWER POLES
	UNC PERMIT BOUNDARY
	FACILITY OUTLINES
P4-DH2	HISTORICAL BORINGS (MWH, 2007)
● P4-9	PROPOSED BORINGS
● SA-GM-5	PROPOSED GEOMORPHIC SAMPLE LOCATIONS

DRAWING REFERENCES:
1. All coordinates in New Mexico State Plane West, NAD83, Feet (U.S. Survey).
2. Elevations/Topo;
   2.1. On site: Cooper Aerial, 05/09/2011, (050911-1000overview3d.dwg)
   2.2. Supplemental Off Site: USGS DEM 10m
3. Township and Section lines: rgis.unm.edu, 08/04/2014
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5. Permit Boundary: (1008506X001.dwg)

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APPROVED J CUMBERS

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PROPOSED SAMPLING LOCATIONS

FIGURE
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300 feet in the relatively small piles (Piles 1-3) and 500-800 feet in the larger Pile 4. Variations in spacing resulted from the adjustment of borehole locations to account for previous drilling locations and drill rig accessibility. The proposed plan includes 51 boreholes with a total drilling depth of approximately 2,200 feet. Laboratory testing will include index properties (i.e., moisture/density, Atterberg limits, gradations and hydrometer, and standard Proctor compaction testing) for geotechnical characterization for an estimated 113 samples. The field investigation is estimated to take four weeks to complete. Drilling and laboratory testing will be conducted by subcontractors.

The proposed sampling locations are described below and shown on Figure 3.

1. In the Lobo Tract Area, five boreholes are proposed on the west side of Meyer Draw (L1) and seven on the east side of Meyer Draw (L2). These boreholes are anticipated to be shallow (approximately 20 feet deep).
2. Six boreholes in Borrow Area South (BS). These boreholes are anticipated to be shallow (approximately 20 feet deep).
3. Three boreholes in Topsoil North stockpile (TN). These boreholes are anticipated to be shallow (two 15 feet deep, and one 25 feet deep).
4. Five boreholes in the Topsoil/Overburden stockpile (T/O). These boreholes range in depth from 20 feet to 75 feet.
5. Four boreholes in the Topsoil South stockpile (TS). Three of these boreholes are anticipated to be 60 feet deep, and one at 25 feet deep.
6. Three on Pile 1 stockpile (P1). Anticipated drilling depths are one at 120 feet, one at 60 feet, and one at 20 feet.
7. Two on Pile 2 stockpile (P2). Anticipated drilling depths are 120 feet and 20 feet.
8. Six on Pile 3 stockpile (P3). These boreholes are anticipated to be drilled to approximately 60 feet deep.
9. Nine on Pile 4 stockpile (P4). These boreholes are anticipated to be drilled to approximately 70 feet deep.

Standard penetration testing (SPT) will be conducted using a Modified California (CA) sampler to record blow counts and collect soil samples for index testing. Samples will include CA brass liner samples, and may include Shelby tubes and/or bulk samples of the drill cuttings. On select boreholes, CME continuous core samples will be collected for additional visual classification and sampling. Results of the supplemental borrow and stockpile investigation will be used in the preliminary design analyses and models for the Closeout Plan update. Field sampling plans are further described in Section 3.

2.4 AGRONOMIC ANALYSIS

During the drilling program, an agronomic analysis will be conducted by ecological subcontractor, Cedar Creek Associates, Inc. (Cedar Creek). Cedar Creek will observe drilling of the boreholes, to describe and characterize the properties and features of materials pertinent to reclamation and revegetation success. Grab samples will be collected throughout the drilling process for laboratory analysis of agronomic properties. In addition to the drilling observation, Cedar Creek will perform a growth media sampling and characterization with hand sampling tools (shovels and bucket augers) on Piles 3 and 4, where portions of Piles 3 and 4 are confirmed to be vegetated. Both vegetated and unvegetated portions of the piles will be sampled for agronomic properties. Revegetated areas can be compared against underperforming or barren areas to establish site specific thresholds of suitable agronomic properties. Any material suitable for use in reclamation will be noted for potential salvage and/or opportunities for direct revegetation of the surface.

Observations will be made in contrasting areas that are currently supporting vegetation with unvegetated areas across the site. Emphasis will be on soil and geomorphic features. In areas supporting vegetation over unsuitable subsoils, observations of growth media depth required to support vegetation will be specifically noted and sampled. Optimizing the required cover thickness for site specific conditions could facilitate higher quality reclamation across larger acreages if growth media volume shortages are encountered. Opportunities for direct seeding/reclamation into suitable geologic materials will also be noted. The sampling approach for the agronomic analysis is described in Section 3.

2.5 GEOMORPHIC EVALUATION

Stantec hydrology and hydraulic engineers will conduct a one-day site visit to the St. Anthony site during the field program. Points of observation on the site visit will be Meyer Draw and the waste rock stockpiles. Locations of rock outcrops or other erosion control points along the arroyo will be noted as will be the cut banks and bed material. Stantec will inspect Pile 4 and focus on the headcut on the east side of the pile and the natural drainage outfall from Pile 4 into the Meyer Draw. During the site visit, Stantec will select locations for soil/sediment grab samples. Preliminary locations are shown in Figure 3. Field sampling plans are further described in Section 3.

3.0 FIELD SAMPLING PLANS

3.1 GEOTECHNICAL EVALUATION OF THE BORROW AREAS AND STOCKPILES

The geotechnical investigation will consist of hollow-stem auger drilling within the borrow areas and existing stockpiles. The borehole investigation will be conducted at select locations (described in Section 2.3) within the existing stockpiles and borrow areas to estimate the quantity and types of materials available and to obtain soil samples to estimate the engineering properties of the materials. Sampling locations shown on Figure 3 will be located in the field with a handheld GPS unit prior to beginning the field sampling.

Table 1 summarizes the anticipated exploration depth for the proposed borehole locations. The geotechnical sampling plan was developed to obtain the material properties outlined in Table 2, using the sample types proposed. The number and specific type of samples retrieved will depend on the conditions encountered.

Table 1. Estimated Depths at Proposed Sampling Locations

Area	ID	Number of Boreholes	Proposed Depth(s) (ft)
Lobo Tract (W of arroyo)	L1	5	20
Lobo Tract (E of arroyo)	L2	7	20
Borrow Area South	BS	6	20
Topsoil North	TN	3	25, 15, 15
Topsoil/Overburden	T/O	6	75, 75, 45, 30, 25, 20
Topsoil South	TS	4	60, 60, 60, 25
Pile 1	P1	3	120, 60, 20
Pile 2	P2	2	120, 20
Pile 3	P3	6	60
Pile 4	P4	9	70
	Total	**51**	**2220**

Notes:

1. Estimated depths based on historical information and previous drilling investigations.
2. Sampling locations are shown on Figure 3.
3. Depths are in feet below ground surface (bgs).

Table 2. Geotechnical Characterization Objectives and Sampling Methods

Evaluation	In-situ (Sample Type)	Laboratory (Sample Type)
Geotechnical	• Thickness/stratigraphy: visual classification (CA, SS) • Standard penetration tests (SPT)	• Water content (CA, SS, ST, or bulk) • Unit weight (CA or ST) • Particle-size (CA, SS, ST, or bulk) • Atterberg limits (CA, SS, or ST) • Standard Proctor (bulk)
Agronomic	• Visual classification (CA, SS)	• Agronomic analysis (bulk)
Geomorphic	• Visual classification (CA, SS)	• Particle-size (bulk) • Atterberg limits (bulk)

Notes:
SPT = standard penetration test
CA = California samples
ST = Shelby tube samples
Bulk = bulk samples
SS = split-spoon samples
NA = not applicable

Hollow-stem auger drilling and sampling will be conducted following the general method listed below:

1. A pre-excavation survey of all vehicles and equipment will be performed prior to entering the mine site using methods and equipment specified by the site Radiation Safety Officer (RSO), in accordance with SOP-31 (see Appendix B).

2. A track-mounted CME drill rig equipped with hollow-stem augers and sampling equipment will be used to collect the samples. At several locations within each area, the auger drilling and sampling will include continuous CME soil core sampling with 4.25 inch augers and will take place in general accordance with SOP-01 (Appendix B). The continuous samples will be collected in five-foot intervals for the full depth of approximately 1 to 2 boreholes per Site area. For all boreholes, including those with continuous sampling, modified standard penetration tests (SPT) will be conducted at 5-foot drilling intervals using a 2.5-inch outside diameter California-type sampler driven into the soil with blows of a 140-pound hammer falling 30 inches, in accordance with SOP-07. Disturbed and undisturbed samples will collected and used for laboratory testing.

3. The boreholes will be advanced to the approximate depths shown on Table 1. Proposed depths correspond to the estimated depth of native material, or depths to which material is expected to be moved from the topsoil and overburden stockpiles, and to the approximate depth of excavation that will be required within the borrow areas and piles 1-4 (with excavation depths estimated based on a preliminary material balance).

4. A Stantec engineer or geologist will log the boreholes in the field and record the pertinent field test data in accordance with SOP-17 (Appendix B). General field conditions will be logged and photographs will be taken in accordance with SOP-14.

5. Samples selected for testing will be sealed for transport to the laboratory in accordance with SOP-06 (Appendix B). A preliminary testing plan is shown in Table 3. Samples will be transported for geotechnical laboratory testing offsite either to DB Stephens & Associates’ soil testing laboratory in Albuquerque, NM or to Advanced Terra Testing in Lakewood, CO. Extra samples not selected for testing will be stored at the UNC Mill Site offices or at the laboratory until it has been determined that additional testing on the extra samples is no longer required.

6. Upon completion of the holes, the augers will be removed and the holes will be backfilled with the stockpiled cuttings. Contact with groundwater is not anticipated during drilling operations; however, in the event this does occur, the holes will be grouted to above the encountered groundwater level in accordance with NMAC 19.27.4.36.

7. The drill rig, hand tools, and any support vehicles or equipment will be decontaminated and surveyed for radiological contamination, using methods and equipment specified by the site RSO prior to leaving the Site. The decontamination procedures are described in SOP-31.

8. The completed borehole locations will be staked and surveyed with handheld GPS unit in accordance with SOP-10 (Appendix B).

3.2 ANALYTICAL TESTING

Select soil samples collected from boreholes in Piles 1, 2, and 4 will be tested for Radium-226, Uranium, Thorium-230, and Gross-Alpha using the same sampling procedures described later in Section 4.3.2 of this work plan. These constituents have been selected to allow comparison with the dataset from 2007. These piles are being evaluated as potential backfill sources for Pit 1.

3.3 AGRONOMIC ANALYSIS

Soil and geologic materials will be sampled by a combination of systematic and targeted sampling approaches. Because of the disturbance history within the piles and across the site, professional judgment will be required in deciding which materials should be sampled and tested for agronomic analysis to adequately characterize the site.

Field characterizations for agronomic samples will follow NRCS soil description protocols and terminology in version 3 of the *Field Book for Describing and Sampling Soils* (Schoeneberger et al., 2012). NRCS pedon description data sheets will be utilized for field descriptions, focusing on features such as color, texture, structure, pedon concentrations, consistence, roots and pores, chemical response, coarse fragments, and any other information that is encountered and deemed pertinent for informing revegetation success.

A soil pH meter and separate EC meter will be available during sampling and used to investigate materials exhibiting unique properties that may warrant additional field description or laboratory analysis (e.g. materials with apparent saline/sodic influences, or geologic material derived from potentially acid generating marine shales).

Once field observations and sampling is complete, samples will be subject to laboratory analysis. Results of these data will be used to determine suitability of the soils as growth media including availability of nutrients and any potential toxicities. The results will be provided in a detailed report which will be used to update to the Reclamation and Revegetation Plan. The parameters and methods planned for laboratory analysis are summarized in Section 3.2 and Table 4.

3.4 GEOMORPHIC EVALUATION

During the field work, soil/sediment grab samples will be collected from Meyer Draw. A maximum of 14 samples will be collected from test pits or from just below the surface (0 to 2 feet). General sampling locations for 10 of the samples are shown on Figure 3, but locations will be determined and finalized in the field. Up to four additional samples may be collected depending on conditions observed during the site visit. These samples will be submitted to the geotechnical laboratory for analysis of particle-size distribution and Atterberg limits, as specified in Table 2. Test pits and sampling for the geomorphic evaluation will be conducted following the general method listed below:

1. A pre-excavation survey of all vehicles and equipment will be performed prior to excavation and sampling using methods and equipment specified by the site RSO, in accordance with SOP-31.
2. An excavator and hand shovels will be used to excavate test pits, in Meyer Draw or arroyo terrace/bank, with area dimensions up to 5-ft by 5-ft test and depths between 2 feet and 5 feet. The surface material will be scraped off and stockpiled near the sampling location on plywood or similar material. The subgrade material will be determined by visual inspection and will be excavated and stockpiled near the sampling location on a separate piece of plywood or similar material to separate the subgrade material from the surface material.
3. Bulk samples of the material will be obtained and labeled in accordance with SOP-06.

4. Materials encountered during sampling will be logged in accordance with SOP-17. General field conditions will be logged and photographs will be taken in accordance with SOP-14. The sample handling and shipping will be performed as described in SOP-06.
5. Following the test pit excavation and sampling, the stockpiled materials will be replaced in the excavated area to match surrounding grades and profile, and compacted by wheel tracking with the excavator or tamping with the shovel.
6. The excavator, hand shovels, and any support vehicles will be decontaminated, if necessary, and surveyed prior to leaving the Site. The decontamination procedures are described in SOP-31.

The geomorphic sampling locations will be surveyed with a GPS in accordance with SOP-10.

3.5 SAMPLE ANALYSIS

The geotechnical laboratory testing program is summarized in Table 3. Laboratory testing will be conducted according to applicable American Society for Testing and Materials (ASTM) standards. This laboratory testing program will be modified based on a review of the actual samples collected during the investigation.

Selected samples will also be submitted to a laboratory for analysis to determine agronomic and analytical properties of the materials. The probable number of samples to be submitted to the agronomic laboratory is estimated to be 200; however, the actual quantities will depend on field conditions and materials encountered. An estimate of 40 samples will be submitted for radiochemical analysis from the boreholes. The list of analytes, extraction methods, and acceptable values for the agronomic and analytical testing is included in Table 4.

Table 3. Geotechnical Evaluation Proposed Laboratory Testing Schedule

Geotechnical Laboratory Test	Estimated Number of Laboratory Tests	Test Method Reference/Sample Type
Moisture content	25	ASTM D2216 / disturbed and undisturbed
Dry density	25	ASTM D2937 / undisturbed
Particle-size (sieve and hydrometer(1))	50	ASTM D422 / disturbed and undisturbed
Atterberg limits	30	ASTM D4318 / disturbed and undisturbed
Standard Proctor	8	ASTM D698 / disturbed

Notes:

1. Hydrometer to be used, as applicable, based on material types.
2. Sample volumes will be determined in accordance with the ASTM standards listed.
3. Testing schedule subject to change based on quantities of samples obtained.

Table 4. Agronomic and Analytical Analyses

Parameter	Method	Acceptable Average Values	Units
pH (paste)	1:1 paste	6 – 8.3	N/A
Electrical Conductivity	1:1 paste	<2 <6	Mm hos/cm
Organic Matter	ASTM F1647 – 11	<4 <10	% of Total Soil
NO_3N	4D6*	>0.1+	ppm
Phosphorus (P)	4D6*	>1+	ppm
Potassium (K)	4D6*	>20+	ppm
Zinc (Zn)	4D6*	>0.25+	ppm
Iron (Fe)	4D6*	>1.0+	ppm
Manganese (Mn)	4D6*	>0.1+	ppm
Copper (Cu)	4D6*	>0.1+	ppm
Calcium (Ca)	EPA Method 3050B	Addressed as SAR	meq/L
Magnesium (Mg)	EPA Method 3050B	Addressed as SAR	meq/L
Sodium (Na)	EPA Method 3050B	Addressed as SAR	meq/L
Texture by hydrometer	ASTM D422-63(2007)e2	No Textural Extremes	% Size Fraction
Sodium Adsorption Ratio	EPA Method 3050B	<13	N/A
Radium-226	EPA 901.1 (soil)	-	pCi/g
Uranium	EPA 901.1 (soil)	-	mg/kg
Thorium-230	EPA 901.1 (soil)	-	pCi/g
Gross Alpha	EPA 901.1 (soil)	-	pCi/g

*Soil Survey 2014 as Reference

+Values can be increased through OM additions

4.0 SUPPLEMENTAL MATERIALS CHARACTERIZATION

4.1 PREVIOUS MATERIALS CHARACTERIZATION

A Materials Characterization was conducted at the Site that consisted of investigating surface and subsurface materials at various areas/features within and near the Site in accordance with the approved *Materials Characterization Work Plan* (MWH, 2007a). The results of gamma exposure rate surveys conducted during the Materials Characterization are summarized in Table 3 and shown on Figure 3, and the radionuclide analytical results of the soil samples are summarized in Table 5 and shown on Figure 5 of the *Materials Characterization Report* (MWH, 2007b). The gamma exposure rate surveys included exposure rate measurements at one meter above the ground surface. Figure 3 of the *Materials Characterization Report* shows elevated gamma exposure rates likely to be above the equivalent investigation level within the site features. Figure 3 also shows that gamma exposure rates are likely below the investigation level where surveys were performed at or just inside the permit boundary.

As seen in Figure 3 and Figure 5 of the *Materials Characterization Report* (MWH 2007b), the areas between the site features were not characterized. Additionally, the radiologic contamination boundary was not identified in the 2007 Materials Characterization. The radiologic investigation level for the Supplemental Radiologic Characterization is in Ra-226 soil concentration, picocurie per gram (pCi/g), as presented in Section 4.2.1 below. The gamma radiation surveys that were conducted during the Materials Characterization were performed for exposure rates (µR/hr). Therefore, the 2007 Characterization gamma survey results in exposure rates (uR/hr) need to be converted and normalized to direct gamma radiation levels in the counts per minute (CPM) equivalent of Ra-226 surface soil concentrations, making it consistent with the supplemental characterization data, thus corresponding to the investigation level (see Section 4.2.1).

4.2 OBJECTIVE OF THE SUPPLEMENTAL MATERIALS CHARACTERIZATION

The Site is a former uranium mine and the surface and subsurface soil is expected to be impacted by radionuclides associated with the uranium decay series, with Ra-226 being the primary Constituent of Concern (COC). The Site is located in a very remote, sparsely populated area with difficult access. Current and anticipated land use surrounding the Site is grazing and wildlife habitat. This is the designated post-mining land use supported by the land owner. An investigation level based on risk-based cleanup criteria for a ranching scenario is appropriate for the site. Radiation Cleanup Criteria are specified in the March 2016 *Joint Guidance for the Cleanup and Reclamation of Existing Uranium Mining Operations in New Mexico* by the MMD and New Mexico Environment Department (NMMMD, 2016)). In contrast, the cleanup criteria specified in the Joint Guidance are taken from the UMTRCA (40CFR192), which are based on an unrestricted land use exposure scenario. This unrestricted concentration level will be used as the investigation level; however, it does not represent the levels which should be attained to support the designated post-mining land use. A Ra-226 investigation level of 5.0 pCi/g above the background level (average 1.6 pCi/g) in land averaged over 100 square meters in surface soil (top six inches), and 15.0 pCi/g above the background level (1.6 pCi/g) in subsurface soil (soil below the top six inch layer) will be used for the Supplemental Materials Characterization. The Ra-226 average background level of 1.6 pCi/g that was determined in the Materials Characterization from nine soil samples will be used (MWH, 2007b).

A site-specific correlation will be performed to convert the results of the supplemental characterization gamma radiation surveys in CPM to Ra-226 soil concentration (pCi/g). An additional objective is to perform a cross-calibration of exposure rate survey equipment, to convert and normalize the Materials exposure rates to direct gamma radiation levels in the CPM equivalent of Ra-226 surface soil concentrations, making it consistent with the supplemental characterization data and the Ra-226 soil concentration investigation level.

4.3 FIELD INVESTIGATION

The supplemental characterization will be conducted by AVM, with oversight from Stantec. Site areas that will be characterized by field radiologic investigations under this work plan and the Site features previously characterized are shown on Figure 4. The field investigation will include gamma radiologic surveys, both static measurements and Global Positioning System (GPS) based scan surveys, along with ex-situ and in-situ soil screening, and soil sampling and analysis.

A GPS-based gamma radiation scan survey in CPM will be performed within the estimated 500 acre Supplemental Materials Characterization area shown on Figure 4. The geo-located gamma scan data will be plotted on aerial maps and will provide Ra-226 concentration level estimates in surface soil within the scanned areas. The gamma scan data, along with visual observations, will also be used to determine up to 30 locations for subsurface soil screening and sampling. The geo-located gamma scan data plotted on aerial maps will assist in determining if the radiologic contamination boundary corresponding to the investigation level is within the permit boundary, or if it is located outside the permit boundary. Based on the Materials Characterization survey data, no significant contamination above the investigation level is expected beyond the permit boundary. If any portion of the permit boundary, including the arroyo bed, exceeds the investigation level, a step-out gamma scan will be performed until gamma radiation levels below the investigation level are detected.

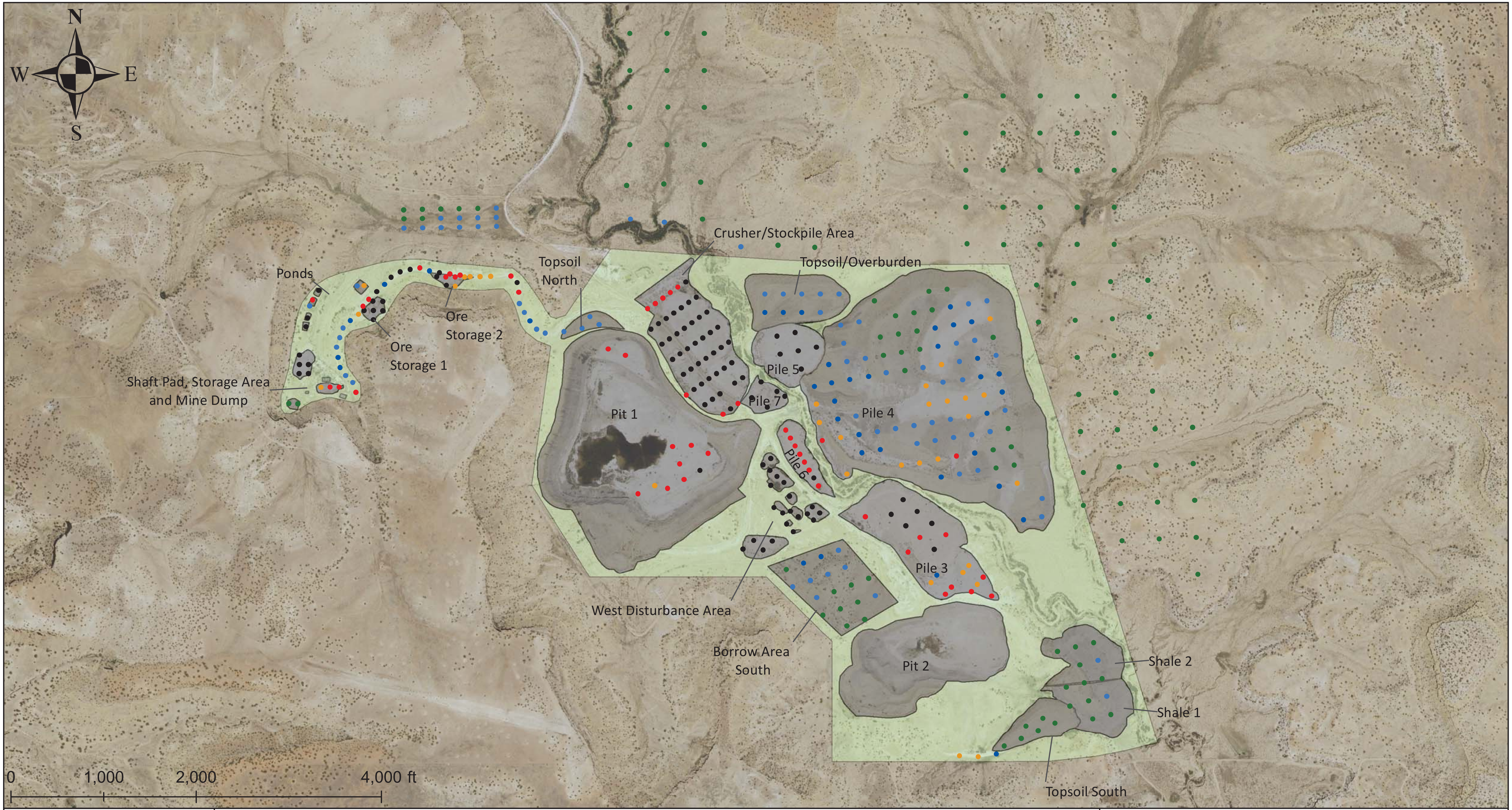
Depending on the type of soil matrix, ex-situ gamma radiation soil screening or in-situ gamma radiation level measurements will be performed at the subsurface soil investigation locations. The ex-situ gamma radiation soil screening or in-situ gamma radiation level measurements will provide real-time information to estimate subsurface contamination depth. Additionally, gamma radiation static surveys in CPM will be performed in the Background Area to confirm background levels collected in exposure rates (µR/hr) during the 2007 Materials Characterization. Also, gamma static surveys and surface soil sampling will be performed at selected locations for the site-specific correlation.

4.3.1 Field Investigation Methods

4.3.1.1 Gamma Radiation Surveys

Direct gamma radiation surveys, gamma exposure rate surveys, ex-situ and in-situ gamma radiation soil screening, and soil sampling and analysis will be used for the supplemental materials characterization of the Site. These methods are described in the following subsections. Gamma radiation surveys are an efficient tool for the characterization of Ra-226 at uranium mine sites. Direct gamma radiation surveys will be used to detect Ra-226 in soils for the supplemental characterization at the Site. Ra-226 is primarily an alpha emitting radionuclide with a gamma radiation emission of 186 keV at about 4 percent intensity. Field measurement of alpha radiation from soils using radiation detection methods are an inadequate technique. Due to the low energy of its gamma radiation emission, field determination of Ra-226 is not practical. However, Ra-226 in soil can be determined by measuring gamma radiation levels of its decay products (Pb-214 and Bi-214), which emit high energy gamma radiation at higher intensities and are easily detected and quantified by a sodium iodide (NaI) scintillation detector. This is a surrogate method consistent with MARSSIM guidance.

The investigation level is presented in terms of Ra-226 mass activity concentration and is expressed in units of activity per unit mass of soil, pCi/g. The direct gamma radiation measurements, using a NaI scintillation detector, provide radiation levels in counts per unit time. The counts per unit time for a given radioactivity depend on the



AVM Environmental Services, Inc.

Figure 4
St. Anthony Mine Site
Supplemental Radiological Investigation Area

Legend

2007 Material Characterization Data

Exposure Rate

●	<15 uR/hr
●	16 - 25 uR/hr
●	26 - 40 uR/hr
●	41 - 60 uR/hr
●	61 - 100 uR/hr
●	>100 uR/hr
▨	Mine Features Previously Characterized
🟩	Supplemental Characterization Area

efficiency of the detector. Pb-214 and Bi-214 are decay products of Ra-226 through radon-222, a gaseous form, some of which emanates from soil. This process results in activity disequilibrium between Ra-226 and Bi-214 in the soil. The Rn-222 gas emanation fraction from the soil varies with different geometric characteristics of a particular soil. Therefore, a site-specific calibration is necessary. Typically, about 20 percent of the Rn-222 gas decayed from Ra-226 in soil emanates out of the surface soil, indicating that a significant percentage (about 80 percent) of this will decay into Pb-214 and Bi-214 in the soil matrix. If the soil geometry and other parameters such as moisture, radon emanation fraction, contamination distribution profile, gamma ray shine from nearby sources, and land topography are consistent, the ratio of Pb-214/Bi-214 to Ra-226 is constant. This results in a direct correlation between Pb-214/Bi-214 gross gamma radiation levels and Ra-226 concentrations in the soil. Therefore, a correlation between direct gamma radiation levels and Ra-226 soil concentrations in pCi/g at uranium mine site will be used to convert the CPM measurement to equivalent Ra-226 in soil.

4.3.1.2 Gamma Radiation Survey Instrumentation

The instrumentation configuration for direct gamma radiation level measurement during this characterization consists of a 2x2 NaI scintillation detector (such as Eberline SPA-3 and Ludlum 44-10) for detection of gamma radiation, connected to a scaler/rate meter (such as Ludlum 2221 or Ludlum 2241) for processing and counting the detected gamma radiation. This instrument configuration has been used widely for this type of application, and is recommended by the MARSSIM. The SPA-3 and L44-10 scintillation detectors are rugged with high sensitivity gamma radiation detection for field applications and this type of field survey. For radiation surveys at discrete points where significant shine interference is suspected from nearby areas, such as areas with deep excavation and areas within close proximity of waste piles, the 2x2 NaI scintillation detector will be installed in a 0.5-inch-thick lead collimator to mitigate gamma shine interference. During the gamma surveys, the detector will be held approximately 12 inches above ground level. The scaler/rate meter will be interfaced with a sub-meter accurate Differential Global Positioning system (DGPS) and a data logger controller for electronically recording the gamma radiation levels to corresponding location coordinates for systematic gamma scan surveys. Judgmental gamma exposure rate (uR/hr) measurements will be performed during the supplemental characterization to confirm the survey conducted during the Materials Characterization in the Background Area, and in other locations selected for possible correlation locations. The instrumentation will be calibrated consistent with AVM Standard Operating Procedure 1 (AVM SOP-1), included in Appendix B.

The site-specific correlation included in this work plan (see AVM SOP-2 in Appendix B) will not be available during the field activities for making decisions. Therefore, correlations used at similar uranium mine sites will initially be used for determining the investigation level in CPM for use during the field activities. A site-specific correlation between co-located surface soil Ra-226 concentration and direct gamma radiation levels for bare and 0.5-inch thick lead collimated 2x2 NaI detectors was developed for UNC's NECR Mine Site and the San Mateo Mine Site, both nearby. Both of these correlations are essentially the same. For the same correlation and survey assumptions, the soil matrix is the only factor causing variation from site-to-site, which is due to radon progeny content and gamma radiation attenuation, which is likely to be less than 20%. The site-specific correlation developed for UNC’s NECR Mine Site will be used for initially determining the investigation level in gamma radiation level CPM for 2x2 NaI detectors.

The NECR correlations between surface soil Ra-226 concentration and direct gamma radiation level for bare and 0.5 inch thick collimated 2x2 NaI detector are included in Appendix C. As shown in Appendix C, the regression for the bare detector yielded a correlation equation of Ra-226 pCi/g = (CPM x 0.0005) - 6.14 with a R^2 of 0.88, and a p-value significantly lower than 0.05, with a low MSE of 1.29. The regression for the collimated detector yielded a correlation equation of Ra-226 pCi/g = (CPM x 0.0013) - 4.40 with a R^2 of 0.93 and p-value significantly lower than 0.05, with a low MSE of 1.61. Based on these correlation equations, the gamma radiation level in CPM equivalent to 6.6 pCi/g

Ra-226 in surface soil is 25,480 CPM for the bare 2x2 NaI detector and 8,462 CPM for the 0.5 inch thick lead collimated 2x2 NaI detector.

4.3.1.3 Gamma Scan Surveys

A GPS-based geo-located systematic gamma radiation scan survey will be performed within the area between Site features that have been previously characterized (MWH, 2007b), which is estimated to be approximately 500 acres. The geo-located gamma scan surveys serve three purposes:

- Provide an estimate of Ra-226 concentration levels in the surface soil within the areas between the Site features.
- Provide the data to determine if the radiologic contamination boundary, determined by the investigation level, is within the Site lease boundary, or if contamination has migrated beyond the boundary and if additional step-out gamma scans are necessary to delineate the contamination boundary.

Gamma scan surveys will be performed in a manner that provides approximately 20 percent coverage of the ground surfaces by scanning along transects with a bare detector at 12 inches above the ground surface (see AVM SOP-3 in Appendix B). The gamma scan survey will be performed in safely accessible areas. Depending on terrain in areas at the Site, a walkover or an all-terrain vehicle (ATV) assisted gamma scan survey may be performed. Initially, a 30-foot transect spacing has been determined based on a conservative bare detector field of view (FOV) of at least 6.0 feet and 20 percent coverage. A scan rate of about three feet per second will be maintained depending on terrain, but will not exceed four feet per second. The systematic gamma scan survey measurements will be electronically logged with a suitable sub-meter differentially corrected GPS which provides real-time corrected location coordinates. Random gamma scan surveying without GPS integration may also be performed in discrete areas if needed during the characterization.

Procedures are provided in the MARSSIM for calculating scan MDCs for particular survey and instrument parameters. More detail on signal detection theory and instrument response is provided in NUREG-1507, *Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions* (NRC 1998). Based on scan rate, detector background counting rate, detector response factor, detector FOV and the desired sensitivity index, the selected instrumentation will meet the scan MDC at less than 50 percent of the 6.6 pCi/g Ra-226 soil investigation level for the Site.

A typical/example scan MDC calculation consistent with the MARSSIM Section 6.7.2, scan MDC for Land Areas, based on similar survey and instrumentation parameters at a uranium mine site is described in AVM SOP-1. The scan MDC will be calculated using actual characterization instrumentation and survey parameters to demonstrate that it does not exceed the investigation level Based on operational and function check data, and survey parameters for this instrumentation during previous surveys at other mine sites, a scan MDC for a 2x2 NaI bare detector is estimated at less than 2.0 pCi/g, well below the investigation level, for both bare and for a 0.5 inch lead collimated 2x2 NaI detector.

4.3.1.4 Gamma Static Surveys

The gamma static surveys will be conducted using the same instrumentation as used for the gamma scan surveys. The detector may be fit with a 0.5-inch lead collimator, as needed, to mitigate radiation shine interferences from nearby areas. Gamma static surveys will be performed at discrete locations for confirmation of the scan survey results at any point, or location, of interest during characterization (such as any questionable gamma scan measurements, scan measurements near the investigation level at the boundary, and correlation sampling points). The detector will be held about 12 inches above the ground surface. The scaler/rate meter will be set in the count

SCALER MODE and a one-minute count of gamma radiation levels will be conducted at each location for gamma static radiation survey. Details of the gamma static survey are described in AVM SOP-3.

A detailed, typical example of a static measurement MDC calculation based on site-specific survey and instrumentation parameters is described in AVM SOP-1, which was calculated in accordance with MARSSIM Section 6.7.1. Based on operational and function check data, and survey parameters for this instrumentation during previous surveys at similar uranium mine sites, the static gamma measurement MDC for a 2x2 NaI detector is estimated at less than 1.0 pCi/g for the bare and collimated detector, well below 50 percent of the 6.6 pCi/g investigation level. The gamma static surveys will be electronically logged with a suitable sub-meter accuracy DGPS which provides real time corrected location coordinate data.

4.3.1.5 Ex-situ Gamma Radiation Soil Screening

On-site, ex-situ gamma radiation soil screening will be performed for subsurface investigations in the characterization areas. Ex-situ soil screening provides real-time information regarding Ra-226 concentrations in soil sample. Ex-situ soil screening may also be performed as necessary to confirm direct gamma radiation surveys from areas with suspected subsurface gamma shine. The on-site ex-situ soil screening method consists of selectively measuring the 609 KeV region gamma radiations of Bi-214, a decay product of Ra-226 (see AVM SOP-4 in Appendix B). This method, which is more reliable than the in-situ direct gamma survey, was successfully implemented at the NECR Mine Site, and other uranium mine sites, for expedited estimates of Ra-226 in soil. A single channel analyzer, such as Ludlum L2221 integrated with a Ludlum 44-20 3x3 NaI scintillation detector will be used to measure the 609 keV energy peak region of Bi-214. The soil sample is placed around the plastic lined detector in a heavily shielded counting chamber. The shielded counting chamber lowers the system background counts, improving the system MDC. Based on data from previous use of this system at the Site, the MDC is expected to be less than 50 percent of the Ra-226 investigation level. A typical MDC calculated from the previous ex-situ analysis at the Site is provided in AVM SOP-4. For an expedited estimate of Ra-226 in soil, a reference soil with a known Ra-226 concentration near the investigation level will be prepared and used. The 609 KeV gamma radiation counts will be obtained and compared to the sample soil for field screening during excavation control.

4.3.2 Soil Sampling and Analysis

4.3.2.1 Soil Sampling

Surface and subsurface soil sampling and analysis for Ra-226 will be performed during the supplemental radiologic characterization at the Site. Surface soil samples, generally described as the top six inches of ground surface, will be collected from some areas such as the Background Area and near contamination boundaries for confirmation of gamma survey results. Surface soil sample results will also be collected for the correlation. Surface soil samples will be collected using a stainless steel scoop or spoon and will be homogenized in a stainless steel bowl and placed in a sample bag (see AVM SOP-5 in Appendix B).

Subsurface soil sampling for on-site ex-situ gamma soil screening will be performed for subsurface soil radiologic contamination characterization at up to 30 locations, primarily in the areas between the Site features. Initially, a subsurface soil sample will be collected from the 1-2 foot depth interval at each location. Where gamma measurements exceed the investigation level in the initial sample, an additional sample will be collected at 1 foot depth intervals until gamma levels are below the investigation level. The subsurface soil samples will be collected using hand augers or a backhoe (see AVM SOP-5), depending on the type of soil and the sample depths.

Field QA/QC duplicates will be collected at a frequency 10% of the total soil samples collected and will be sent to offsite vendor laboratory for analysis.

4.3.2.2 Field Decontamination

Field sampling equipment, such as stainless steel scoops, bowls, spoons, core barrels, and hand auger barrels, used for soil sampling will be decontaminated between sample locations. The soil sampling equipment decontamination will be conducted by removing loose visible soil by brushing off, washing equipment with detergent water and rinsing with distilled water. Other equipment used during investigation sampling activities that directly contact sample materials (such as the backhoe bucket) will be cleaned to remove loose visible soil contamination. Soil generated from boreholes and excavation of test pits for subsurface investigation and excess soil samples will be put back into the holes that it came from. Equipment decontamination water/rinsate will be poured on top of excess soil and excess sample placed back into the test holes and pits. Personal protection equipment (PPE), such as gloves and Tyvek coveralls will be brushed off and scanned for residual contamination, and will be disposed of as solid waste.

4.3.2.3 Soil Sample Analysis

The subsurface soil samples will be analyzed by on-site ex-situ gamma radiation soil screening (AVM SOP-4) to estimate Ra-226 concentrations. Surface soil samples and confirmatory subsurface soil samples in labeled Ziploc bags with a completed Chain of Custody (COC), will be packaged in rigid-body coolers for shipment to off-site vendor laboratory for analysis. The off-site vendor laboratory will document the condition of the environmental samples upon receipt. All samples collected during the project will be shipped within the sample holding time specified by the analytical method. Samples will be stored in a secure area between sample collection and shipment to the laboratory.

Soil samples will be analyzed for Ra-226 (reporting Limit of 0.5 pCi/g) using EPA method 901.1 modified for soil media. The laboratory method, instruments and sensitivities will be in accordance with EPA protocols for environmental analysis. The laboratory used for environmental sample analysis will have appropriate Environmental Laboratory Approval Program certification, or equivalent. Laboratory instrumentation will be calibrated by using National Institute of Standards and Technology (NIST) traceable standards.

4.3.3 Site-Specific Gamma Radiation Level to Surface Soil Ra-226 Concentration Correlation

The site-specific correlation will be developed for both the collimated and bare 2x2 NaI detectors (see AVM SOP-2). Co-located gamma static measurements and soil samples analyzed for Ra-226 will be selected judgmentally in order to ensure that the full range of concentrations will be included. As such, approximately 15 sample locations from the Site will be used for the correlation. Using co-located gamma static measurements and soil sample Ra-226 analytical results from these locations, a linear regression will be developed for each detector type. The regression analysis results will be used for converting the static and scan gamma radiation levels in CPM to equivalent surface soil Ra-226 concentrations. The correlation will meet an R2 value of at least 0.8. Also, a cross-calibration of calibrated exposure rate meter and the 2x2 NaI detector, at a known ore source such as DOE calibration pad, will be performed to convert and normalize some of the 2007 Materials characterization survey results in exposure rate (µR/hr) to equivalent direct gamma radiation level in CPM/Ra-226 surface soil concentration.

4.4 QUALITY ASSURANCE AND QUALITY CONTROL MEASURES

Quality Assurance/Quality Control (QA/QC) measures will be employed throughout the Supplemental Characterization to ensure that decisions are made based on data of acceptable quality. The QA/QC measures will include annual instrument calibrations, meeting specified minimum detectable concentration (MDC) requirements, daily instrument operational function checks, and replicate field measurements. Instruments and equipment used will be operated, calibrated, and maintained according to AVM SOP-1 and/or the manufacturer's guidelines and recommendations. Equipment that fails calibration or becomes otherwise inoperable will be removed from service and segregated to prevent inadvertent use. Such equipment will be tagged to indicate that it should not be used until the problem is corrected. Equipment requiring repair or recalibration must be approved for use before being placed back into service. Equipment that cannot be repaired or recalibrated will be replaced. These measures are described in appropriate AVM SOP-1.

4.5 SAFETY AND RADIATION PROTECTION

The field activities for the Supplemental Materials Characterization will require working at the Site with rugged terrain and features, which poses a potential elevated safety risk. Safety and radiation protection during excavation control is addressed in the *Health and Safety Plan* (see Appendix A).

5.0 CLOSURE PRELIMINARY DESIGN

5.1 VOLUMES AND PIT BACKFILL

The material balance and grading will be updated from the 2010 Closeout Plan to include new information since the previous plan and incorporate results of the supplemental investigations. The following are the preliminary design conditions and concepts for the Closure Plan.

- The estimated potentiometric surface in Pit 1 is based on the Phase II Abatement report (INTERA, 2015) which states: "Results for the predictive simulation showed that the groundwater head at the Large Pit will eventually rebound to 5966 ft,"
- Backfill from the current Pit 1 configuration to 5966 will require approximately 6.04M CY.
- The backfilled Pit 1 will have a minimum of 3 feet of unimpacted material at the surface, and be contoured to promote positive drainage away from the backfilled pit.
- Backfill for Pit 2 to establish positive drainage is estimated to require approximately 1.58m CY.
- Shale Piles (1 and 2) contain about 1.05M CY. These piles can be moved to Pit 1 for backfill.
- The remaining backfill for Pit 1 can be moved from Pile 4.
- Pile 4 will then be regraded and re-contoured for long-term erosional stability.
- Pile 3 contains an estimated volume of 1.56M CY. This pile can be moved to Pit 2.
- Piles 5, 6, and 7 can be consolidated into one pile and covered in the crusher area.
- Additional material, which is expected to be only a nominal volume, from the Shaft and Ore Storage areas can be consolidated in Pit 2.

5.2 COVERS AND REVEGETATION

Cover thicknesses for the pit backfills and remaining stockpiles to be left in-place will be evaluated based on erosional stability, radon emanation, and agronomic properties for revegetation. The cover designs will be updated from the 2010 Closeout Plan to evaluate varying cover thicknesses for the stockpiles remaining in-place and for the cover over backfilled material in Pits 1 and 2. For Pit 1 per NMED, the minimum cover thickness required is three feet. The cover material for Pit 1 as well as the other areas will be evaluated on a case-by-case basis to optimize material handling. A four-foot cover beginning at elevation 5966 feet in Pit 1 will require 321,000 CY of soil. Cover designs will also be required for the consolidated material in the crusher area, and the material placed in Pit 2.

The covers will be designed to:

- Achieve revegetation performance criteria required by the post-mining designated land use.
- Limit radon emanation to below 20 pCi/m^2/s per the MMD and New Mexico Environment Department March 2016 *Joint Guidance for the Cleanup and Reclamation of Existing Uranium Mining Operations in New Mexico*. Where radon emanation is modeled to be below 20 pCi/m^2/s, direct revegetation of the top surface will be evaluated. Radon emanation will be modeled using the U.S. Nuclear Regulatory Agency 1989 RADON model. Data from the field investigations will be used in the modeling, as well as the evaluation of vegetation.
- Maintain erosional stability under the design storm flow.

- Borrow soils for covers are expected to come from Borrow Area South (137,000 CY), Topsoil South (265,000 CY), Topsoil North (32,000 CY), the Topsoil/Overburden Pile (542,000 CY) and the Lobo Tract (up to 1M CY, or more).

The previous revegetation plan will be updated to incorporate the supplemental investigation results, and will provide recommendations of cover thicknesses to achieve revegetation performance criteria. The revegetation work will be primarily conducted by an ecological subcontractor (Cedar Creek) with oversight from Stantec.

5.3 HYDROLOGIC ANALYSIS

Stormwater and erosion control analysis will be conducted for the preliminary design. A hydrologic assessment will be conducted that builds on the site assessment conducted by MWH in 2010 and incorporates information collected during the 2018 hydrologic evaluation site visit. A hydrologic and hydraulic model will be prepared for existing and post-reclamation conditions for the 5-year to 500-year storm events. A preliminary arroyo setback analysis will be conducted and Stantec will communicate up to 2 design alternatives for arroyo stabilization in addition to a setback consideration (if necessary). Preliminary design of stormwater controls will include:

(a) Arroyo stabilization and/or setbacks,

(b) Pile 4 slope length, rock cover (erosion protection), and collection channels,

(c) Conveyance channel at the base of Pile 4 and its outfall into Meyer Draw, and

(d) Mitigation of the headcut on the east side of Pile 4.

6.0 HEALTH AND SAFETY PLAN

All sampling, drilling, and investigation activities will be performed under the Site Specific Health and Safety Plan included in Appendix A.

7.0 REFERENCES

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APPENDIX A
HEALTH AND SAFETY PLAN

Site Specific Health and Safety Plan

St. Anthony Mine, Cibola County, New Mexico

February 26, 2018

Prepared for:

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CHANGE SUMMARY PAGE

Procedure/Plan No: St. Anthony - HSP – 001

Change No.	Date	Affected Page(s)	Change Summary
REV. 0	02/18	ALL	Original Issuance

Sign-off Sheet

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Prepared by ____

(signature)

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Reviewed by ____

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Approved by ____

(signature)

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Abbreviations

ACGIH	American Conference of Governmental Industrial Hygienists
AIDS	Acquired Immunodeficiency Syndrome
ALARA	As Low as Reasonably Achievable
ANSI	American National Standards Institute
APR	Air Purifying Respirator
CFR	Code of Federal Regulations
CIH	Certified Industrial Hygienist
CMS	Chip Measurement System
CPR	Cardiopulmonary Resuscitation
CRZ	Contamination Reduction Zone
dB	Decibels
dBA	Decibels on the ‘A’ Weighted Scale
DEET	N,N-Dimethyl-m-toluamide
eV	Electron Volt
F	Degrees Fahrenheit
FID	Flame Ionization Detector
HAZMAT	Hazardous Material
HAZWOPER	Hazardous Waste Operations and Emergency Response
HEPA	High Efficiency Particulate Air
HIV	Human Immunodeficiency Virus
HSP	Health and Safety Plan
IATA	International Air Transport Association
IDLH	Immediately Dangerous to Life and Health
kV	Kilovolt
LEL	Lower Explosive Limit
mg/m^3	Milligrams per Cubic Meter
MSDS	Material Safety Data Sheet
MWH	MWH Americas, Inc.
NMED	New Mexico Environment Department
NIOSH	National Institute for Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
OSO	On-Site Safety Officer
PCB	Polychlorinated Biphenyl
PEL	Permissible Exposure Limit
PID	Photoionization Detector
PPE	Personal Protective Equipment
Ppm	Parts Per Million
PSO	Project Safety Officer
REL	Recommended Exposure Limit
RSO	Radiation Safety Officer
SOP	Standard Operating Procedure
SVOC	Semi Volatile Organic Compound
TLV	Threshold Limit Value

TLD	Thermoluminescent detectors
TWA	Time Weighted Average
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound

1.0 INTRODUCTION

Stantec Consulting Services Inc. (Stantec) prepared this site-specific Health and Safety Plan (HSP) for the team involved in the materials characterization at the former United Nuclear Corporation (UNC) St. Anthony Mine. This HSP was developed in accordance with relevant occupational safety and health regulations and requirements as well as Stantec's internal health, safety, security and environment (HSSE) guidelines. It applies to all field sites and workplaces established during the site activities at St. Anthony Mine.

The radiation protection plan (RPP) included as Appendix B, provides specific information about controls to protect against radiation.

1.1 PURPOSE OF THE HEALTH AND SAFETY PLAN

This HSP, in conjunction with the RPP, provides information to site workers so that they can complete the project objectives in a safe and healthful manner. The evaluation of hazards, levels of protection and procedures specified in this HSP are based on the best information available at this time. It is recognized that every feasible safety or health hazard faced on site may not be contained in this document and that site conditions change. Therefore, it is part of every employee's job to continuously assess site and work conditions. If an employee lacks clarity in how to do a job safely or is unsure of the potential for adverse exposure to a contaminant, that employee shall bring this to the attention of the On-Site Safety Officer (OSO), the Project Manager (Melanie Davis) or Stantec's HSSE Manager (Randy Jones). No employee is expected to do work that he/she does not know how to do properly and safely.

All project activities will be performed in accordance with applicable sections of the Code of Federal Regulations (CFRs), including: relevant requirements in CFR Titles 10, and 40; Occupational Safety and Health Administration (OSHA) Standards 29 Code of Federal Regulations (CFR) 1910 and 29 CFR 1926; and applicable sections of the New Mexico Administrative Code (NMAC) Title(s) 19 and 20. All Stantec employees, contractors, and visitors must comply with the requirements of this HSP.

1.2 HSSE POLICY STATEMENT

1.2.1 Policy

Stantec is committed to providing and maintaining a healthy, safe, and secure workplace for our staff, clients, partners, and subcontractors and to responsibly managing all the environmental aspects of its business

1.2.2 Practice

Our core company values guide us in all that we do. The way we treat our people, our clients, and our neighbors reflects who we are, what we believe in, and how we do our work. At Stantec, we believe in doing what is right and being Safer Together, which includes zero harm to the environment and sending our people home injury-free, every day.

Stantec's HSSE Program is a cornerstone of the Occupational Health and Safety Management System (OHSMS) and the Environmental Management System (EMS). In turn, these Management Systems are part of Stantec's overall Integrated Management System.

Stantec strives to:

- Visibly demonstrate a commitment to HSSE by providing responsible leadership, and clearly communicating expectations.
- Assist and support employees in developing an awareness and understanding of the health, safety, security, and environmental issues related to their work.
- Identify, assess, and manage the health, safety, security and environmental hazards and risks to which its employees are exposed
- Minimize the environmental aspects and impacts associated with the services and products it provides
- Comply with legislation, regulations, and appropriate industry standards
- Monitor and enhance the health, safety, security and environmental practices through inspections, audits, reviews, investigations, corrective actions, shared learnings, review of best practices, and behavior-based processes
- Share lessons learned and integrate best HSSE practices into our businesses
- Provide a framework which supports the continual improvement of the system
- Work collaboratively with employees to achieve health, safety, security, and environmental objectives, at work and at home
- Foster a culture of being Safer Together, in which all employees, partners, and subcontractors share a commitment to health, safety, security, and the environment.

1.3 EMPLOYEE MANAGEMENT EMPOWERMENT

Employees are Stantec’s most valuable asset; their safety is of vital concern. It is the intent on this project for employees to accept responsibility and ownership of the HSSE Program. This HSP is a living document, and the goal of Stantec is that employees are involved in the development and evolution of the HSP.

Everyone working for Stantec is responsible and accountable for Stantec’s health, safety, security and environmental performance. Management, supervisors, employees, and subcontractors are expected to understand their roles and responsibilities as outlined by the HSSE Program and to comply with the practices of the Occupational Health and Safety Management System, and the Environmental Management System.

These goals can be accomplished by anticipating, recognizing, evaluating and controlling unsafe acts and conditions.

Management personnel at all levels shall, through personal example, create a work climate in which all assigned employees develop a concern, not only for their own safety and health, but also for the safety and health of their fellow workers and the environment

1.4 SAFETY MANAGEMENT

The objective of safety management is to integrate health, safety, security and environmental protection into all services. Stantec will accomplish this objective by involving all employees in the planning the performance of services, development of the HSSE Program, and development and updating of procedures.

1.5 MODIFYING THE HEALTH AND SAFETY PLAN

This HSP must be modified if, new hazards are identified, the scope of work is revised, or the provisions specified in the HSP are not adequate to protect the health and safety of all personnel. Modifications will be accomplished by consultation with all project Health and Safety personnel, who in turn shall recommend appropriate modifications after approval by the Stantec Project Manager or her designee. All HSP modifications shall be documented on the form included in Appendix A (HSP Change Form). The form must have referenced verbal concurrence, or the signature from the Project Safety Officer (PSO).

HSP changes shall be documented with the appropriate revision number. The Project Manager must approve the changes to this document. This process is to be documented in the HSP and the project files. The Project Manager will be responsible for informing staff and contractors of all changes.

1.6 HSSE TRAINING FOR SITE ACCESS

Stantec will provide its employees with the proper training required for conducting the required work or services. At a minimum, Stantec employees or Subcontractors performing services or activities must be familiar with the requirements of this HSP, including the emergency contact information. This will be documented by signature on the Acknowledgement Form (Appendix A).

In addition, specific training may be required for the performance of specific services or activities. All employees providing services or activities under this HASP will comply with appropriate procedures and training requirements outlined herein.

1.7 SITE LOCATION AND DESCRIPTION

The St. Anthony Mine was an open pit and underground shaft uranium mine located on the Cebolleta Land Grant approximately 40 miles West of Albuquerque, New Mexico located in Cibola County approximately 4.6 miles southeast of Seboyeta, New Mexico. The mine site is located in a very remote, sparsely populated area with difficult access. A location map is included as Figure 1, General Location Map of the Supplemental Investigations Work Plan (Work Plan). UNC operated the St. Anthony Mine from 1975 to 1981, pursuant to a mineral lease with the Cebolleta Land Grant, the current owner of the surface and mineral rights. The original lease covered approximately 2,560 acres. This lease was obtained on February 10, 1964 and was surrendered by a Release of Mineral Lease dated October 24, 1988. UNC has access to the Site through access agreements with the Cebolleta Land Grant and an adjacent landowner.

The Site includes underground workings consisting of one sealed shaft, one sealed vent shaft, two open pits (one containing a pond), five inactive ponds, seven piles of non-economical mine materials with some revegetation, numerous smaller piles of non-economical mine materials, and three topsoil piles. No perennial streams occur within the St. Anthony site, but an arroyo (Meyer Gulch) passes through the Site. The Site layout of the St. Anthony Mine is included as Figure 2, Site Layout of the Work Plan. The two open pits at the mine site are located in Sections 19 and 30, Township 11 North, Range 4 West, and the entrance to the underground mine is located in Section 24, Township 11 North, Range 5 West. The actively mined area encompasses approximately 430 acres and includes roads and other disturbed areas along with the open pits and non-economical mine materials piles.

1.8 SCOPE OF WORK

The St. Anthony Supplemental Investigations Work Plan includes sampling of surface and subsurface soils, and a radiological survey will be conducted to evaluate the suitability as plant growth material and the potential impact of these materials to surface and groundwater. The work will be conducted at various locations at the site.

Site activities will include the following tasks:

- Excavation and trenching
- Drilling or boring
- Grab sampling
- Site reconnaissance
- Radiological surveying

1.9 CHEMICALS OF CONCERN

This section provides site hazard characterization information so that initial levels of personal protective equipment (PPE) can be selected, as well as appropriate monitoring for chemical and physical hazards. Section 7 describes initial and up-grade PPE ensembles and describes the monitoring program with action levels for up- or down-grading PPE or evacuating a site.

1.9.1 Site-Related Chemicals

The primary chemicals identified in site soil include: arsenic, molybdenum, selenium, and radionuclides radium-226 and uranium. Table 1 was created from the list of chemicals to provide occupational exposure limits, some physical and chemical properties, routes of exposure and signs and symptoms of exposure. Material characterization will include a radiological survey of non-economic materials at the Site, drilling and sampling of non-economic materials and sampling of potential cover material borrow sources.

1.9.2 Radiation Hazards

The Radiation Protection Plan (Appendix B) addresses the radiation hazards, in accordance with 10 CFR § 20.1101. The radiation protection plan is summarized as follows:

- The primary hazards are Uranium 238 and its decay progeny. Its decay process liberates alpha and beta particles, gamma radiation, and radon-222 (radon).
- Radon gas is a significant health concern. Alpha particles liberated during its decay can damage lung tissue and can potentially cause lung cancer.
- Radon-222 control actions will reduce exposure to radon-220, which is a less important source of exposure to humans than radon-222 due to its shorter half-life and limited mobility.
- The Radiation Safety Officer (RSO) will provide radiation training to all personnel prior to the start of work. Training records related to radiation training will be available onsite for review.
- The RSO will monitor the air daily to quantify the amount of alpha radiation being generated by invasive site activities.

- The RSO will use derived air concentrations (DACs) to limit radiation exposure by way of inhalation of alpha particles.
- The RSO will use a portable Ludlum 44-10 sodium iodide scintillation detector, coupled to a Ludlum 2221 ratemeter/scaler, to measure direct radiation (gamma) dose rates at the surfaces of soil piles, construction equipment, and other surfaces of concern.
- Stantec will issue thermoluminescent detectors (TLDs) to all Stantec site workers to monitor their external exposure. Subcontractors will be required to provide TLDs to their workers. Workers will clasp the TLDs under protective clothing to prevent their possible contamination from dirt or airborne dust. Field personnel will store control TLDs in the support zone; personnel TLDs will be stored in the support zone when they are not used. TLDs will be submitted to and analyzed monthly by Landauer, Inc., which is certified by the National Voluntary Laboratory Accreditation Program.
- The Site RSO will work with field personnel to limit exposures to ALARA and below the maximum acceptable dose rate for workers: a TEDE of 5 rem/yr.
- The Site RSO will implement the principles of time, distance, and shielding to protect workers from radiation. The Site RSO will track exposures to radiation workers by having them record times in and out on a sign-in/sign-out sheet.
- Field personnel will start work in Level D PPE. Upgrading to respirators may be required if air monitoring indicates that airborne radon levels are unacceptable and planned activities and wind conditions are anticipated to generate more dust than those conducted during the evaluation. PPE requirements also will be based on the anticipated hazards associated with other decommission tasks such as but not limited to airborne concentrations of non-radioactive particulates, noise, and struck by hazards.

1.9.3 Chemicals Brought to Support Work

During the course of fieldwork, Stantec contractors will bring certain chemicals to the site. These may include:

- Gasoline fuel for generator
- Diesel Fuel
- Alconox
- Isobutylene calibration gas

Material Data Sheets (MDSs) for these chemicals kept at the jobsite. All containers must be labeled with the identity of the contents as well as a hazard warning and emergency notices.

2.0 PROJECT ROLES AND RESPONSIBILITIES

2.1 ROLES AND RESPONSIBILITIES

Stantec is responsible for verifying that the project activities are carried out in accordance with the agreed upon scope of work and related contract documents. Along with this responsibility, Stantec will verify that project activities are carried out in a manner consistent with applicable health and safety regulations, Stantec's HSSE requirements and this HSP.

2.2 HEALTH AND SAFETY RESPONSIBILITIES

Safety, loss prevention and strict adherence to this HSP are a direct responsibility of all levels of management under all projects. The efforts of multiple organizations are necessary for completing investigations and remedial objectives associated with hazardous waste site work. Each individual assigned to oversee or conduct field work will be responsible for conducting his/her job in a safe and healthful manner.

2.2.1 Project Manager

The Stantec Project Manager, Melanie Davis, has overall responsibility and authority for the project and therefore the safety of Stantec's employees and contractors working on this project.

2.2.2 US West HSSE Advisor

Randy Jones, CSP will serve as the safety advisor at the corporate level. His duties include, but are not limited to:

- Provide corporate oversight of Stantec services from a health and safety standpoint
- Interact with project staff as needed

2.2.3 On-Site Safety Officer

Tom Osborn and/or Cameron Fritz will serve as the on-site safety officer (OSO). Specific actions of the OSO include:

- Serve as the project lead for all issues related to health and safety.
- Ensure that risk assessments reflect actual conditions and the Field Level Risk Assessment (RMS2) is performed daily prior to activities.
- Conduct a daily safety meeting
- Maintain necessary project health and safety documentation and records.
- Verify that employees wear the prescribed level of personal protective equipment.
- Verify that the project bulletin board, where applicable, contains the necessary health and safety postings and that the information is current.
- Maintain the Hazard Communication Program for the site
- Enforce the "buddy system" as appropriate for site activities
- Prepare incident reports (RMS3) for near miss accidents and actual work-related injuries, illnesses or losses involving the environment or property.

- Ensuring general implementation of the HSP, including necessary coordination and integration of subcontractors into the site safety program.
- Conducting regular inspections of the work areas, whether formally documented or visually observed, to ensure implementation of the safety plan and safe and healthful work conditions.
- Maintaining current certification in cardiopulmonary resuscitation (CPR) and first aid by an authorized training organization such as The American Red Cross, or equivalent. Ensuring adequate first aid supplies and fire extinguishers, etc. are available at the site and that access (phone number if not 911, route map) to an ambulance or emergency services provider is known and posted for all team members to see.
- Halting or modifying any working conditions, or removing personnel from the site, if the Project Manager or RSO considers conditions to be unsafe.
- Leading during any on-site emergency situation.
- Seeking guidance from the HSSE Advisor and/or the RSO when unanticipated conditions develop.
- Overseeing the air monitoring program (i.e., calibration documentation, monitoring documentation, equipment maintenance), and ensuring proper PPE is available and used.
- Coordinating site control that includes work zones, decontamination station and the buddy system.
- Knowing how to safely implement the project objectives, including familiarization with the site background and equipment operation.
- Putting a stop to any unsafe acts or activity.
- Ensuring lines of communication and points of contact are known to all team members.
- Notifying the Project Manager and HSSE Advisor of any site evacuation, injury or site-related illness, property damage or near miss.

2.2.4 Contractor Safety Personnel

Each contractor shall designate a competent person (capable of recognizing hazards, with the authority to immediately correct) in a supervisory position, to administer its HSP. Should the contractor's safety effort be considered inadequate, Stantec has the option to request replacement of the designated safety representative. This person shall be named and on-site whenever the subcontractor is performing work. Specific actions of the subcontractor’s competent person shall include:

- Knowing how to safely implement the project objectives, including familiarization with the site background and equipment operation.
- Leading by example the safe way to complete the job.
- Putting a stop to any unsafe acts or activity.
- Actively participating in Tailgate Safety Meetings and providing relevant safety information about the subcontractor’s means and methods to the Field Team Leader or Field Manager.

2.2.5 Field Personnel

Specific actions of field personnel include:

- Understanding and complying with the HSP.
- Bringing all perceived unsafe site conditions to the attention of the OSO. This includes situations when the person does not know how to do a job safely.
- Having stop-work authority if imminent danger exists.

2.2.6 Site Visitors

Personnel visiting the site who are invitees (visitors), employees, or subcontractors will be permitted to enter work areas only with prior approval by the Project Manager or designee. The Project Manager or OSO must adequately inform the visitors of the current hazards and controls including the protective equipment required.

Visitors wishing to enter the site exclusion or contamination reduction zone must provide verification to the OSO that he/she has been medically approved and trained per the Hazardous Waste Operations and Emergency Response (HAZWOPER) Standard. Unless prior arrangements are made, PPE other than hard hat, safety glasses and high visibility vests will not be provided to visitors. In no case will field staff provide respiratory protection to site visitors. Prior to entry, this HSP must reviewed and a Personal Acknowledgement form signed.

3.0 STANDARD OPERATING GUIDELINES

Stantec and its contractors will implement and enforce the requirements of the HSP in this document and comply with relevant OSHA requirements in Safety and Health Regulations for the Construction Industry (29 CFR Part 1926), Safety and Health Regulations for General Industry (29 CFR Part 1910), the Hazardous Waste Operations and Emergency Response (HAZWOPER) Standard (29 CFR § 1910.120 and 29 CFR § 1926.65) and relevant requirements in CFR Titles 10, and 40, and applicable sections of the New Mexico Administrative Code (NMAC) Title(s) 19 and 20..

3.1 GENERAL

The following practices are expressly forbidden during on-site work:

- Smoking, eating, drinking, chewing tobacco, or applying cosmetics while in the exclusion zone, contamination reduction zone (CRZ), or any potentially contaminated area.
- Ignition of flammable materials in the work zone (equipment needed to work around flammable materials will be bonded and grounded, spark proof and explosion resistant, as appropriate).
- Contact with potentially contaminated substances, this includes walking through puddles or pools of liquid; kneeling on the ground; or leaning, sitting, or placing equipment on contaminated soil.
- Performance of tasks in the exclusion zone without a “buddy” or specified system accounting for a buddy.
- Personnel must keep the following guidelines in mind when on site conducting field activities:
- Hazard assessment is a continual process; personnel must be aware of their surroundings and constantly be aware of the chemical/physical hazards that are present.
- The number of personnel in the exclusion zone will be the minimum number necessary to perform work tasks in a safe and efficient manner.
- Team members will be familiar with the physical characteristics of each site including wind direction, site access, and location of communication devices and safety equipment.
- The location of overhead power lines and underground utilities must be established.
- Where economically and practically feasible, engineering controls will be selected to reduce exposure of site personnel to health or safety hazards. Engineering controls that may be feasible include use of pressurized cabs or control booths on equipment, use of remotely operated material handling equipment, dust suppression techniques (such as wetting down a surface with a water spray), noise insulation barriers, and use of shoring devices for trench or excavation entry.

When engineering controls are not feasible, administrative controls in the form of work practices will be implemented to minimize risk to personnel from site hazards. Work practices that may be instituted include removing all non-essential personnel from the exclusion zone and locating employees upwind of the hot zone. Work rotation will be used to control exposures to extreme thermal stresses; however, work rotation for the purpose of limiting exposure to site personnel from airborne chemical hazards is unacceptable.

3.2 RECORDKEEPING

Documentation is one of the methods of ensuring that the site safety program is implemented properly. The Project shall establish reporting and recordkeeping requirements in accordance with Federal and/or State law. Some, but likely not all, of the recordkeeping forms needed for projects are provided in Appendix A. It is the OSO's responsibility to maintain and update these documents. Appropriate regulatory agency and Stantec personnel shall be granted ready access to these records. Listed below is the minimum project health and safety compliance documentation requirements:

- A copy of this HSP must be on site.
- OSHA Job Safety and Health Protection poster, posted at the site
- OSHA Injury and Illness Recordkeeping Form 300 (required for remedial and clean construction job sites only).
- Calibration records for health hazard assessment monitoring equipment.
- Record of health hazard assessment monitoring results (RMS2).
- Incident reports, including near misses, for the project (RMS3).
- Inspections (RMS5).
- Personal acknowledgement forms signed by all site workers.
- Daily tailgate safety meeting forms.
- Visitor sign-in sheet.
- Respirator fit test and equipment inspection documentation for Level C or higher jobs.
- Permits, if required, for the job:
  - Permit Required Confined Space
  - Hot Work
  - Lockout / Tagout
  - Excavation entry
- Training and medical surveillance certifications:
  - Initial 40-hour, or 24-hour, HAZWOPER training
  - 8-hour refresher HAZWOPER training
  - OSO's 8-hour supervisory HAZWOPER training
  - On-the-job training, 3-day or 1-day
  - First Aid / CPR
  - Medical clearance for working on hazardous waste sites and wearing respiratory protection

3.3 SITE HAZARDS

Persons performing limited and occasional services outside their normal home office, such as visiting a potential project site or an existing project facility, may be subject to the hazards posed by various activities taking place. This section of the HSP is meant to provide a brief description of the controls that should be taken to prevent injury to employees observing or participating in such services. The following types of activities and associated hazards are anticipated on the project.

- Contingency Planning - Inclement weather; natural disasters; equipment failure; etc.
- Irregular Terrain - Uneven walking surfaces
- Biological hazards
- Wildlife encounters
- Chemical hazards
- Temperature extremes
- Work in congested areas – Traffic hazards; Mobile equipment operation nearby, etc.
- Exposure to UV radiation - Sunburn prevention
- Falling rock
- Sharp objects and/or projection hazards
- High noise environments
- Motor Vehicle Operation

Additional information concerning the prevention and control of injury or illness related to these hazards is included in the Stantec Safe Work Practices hyperlinked below.

Hazard Recognition

Health Hazard (Check all appropriate categories)

Are Safety Data Sheets (SDSs) required? ☒ Yes ☐ No

If yes, copies of SDSs must be available at project site and attached to this document.

Chemical

☐ Acids or Caustics
☐ Asbestos
☐ H_2S
☐ Halogenated Organic Compounds
☐ Heavy Metals
☒ Metals
☐ PCBs
☐ Pesticides / Herbicides
☐ Petroleum Hydrocarbons
☐ Poisonous Materials
☒ Solvents/Flammables
☐ Other – specify:

Physical

☒ Cold Stress/Frostbite
☐ Confined Space
☐ Driver Fatigue
☒ Dust / Dusty environments
☒ Flora or Fauna (type):
☒ Heat Stress / Sunburn
☒ Noise
☒ Radiation (type):Radium-226 and Uranium
☒ Remote Location
☒ Rough Terrain/Heavy Brush
☒ Road / Trail Conditions
☐ Vibration
☐ Water
☒ Wildlife
☐ Working at Heights
☐ Other – specify:

Material Handling & Task Completion

☒ Bending
☐ Falling/Flying Objects
☐ Fatigue
☐ Heavy Load (> 50 pounds)
☒ Load (< 50 pounds)
☐ Repetitive
☒ Sharp/Rough Surface
☐ Twisting
☐ Other – specify:

Ergonomic

☐ Force
☐ Posture
☐ Repetitive Motion
☒ Tools
☐ Workplace Design
☐ Other – specify:

Biological

☐ Bacterial Control Cultures
☐ Domestic Waste
☐ Medical Waste
☐ Sewage / Wastewater
☒ Other – specify: Animals/ Plants/Insects

Energy

☐ Chemical
☐ Electrical
☐ Hydraulic
☐ Mechanical
☐ Pneumatic

Other Hazards not listed

Wildlife, Plants and Insects

A site-specific summary of key Safe Work Practices and other developed controls are highlighted in the following subsections. Relevant Safe Work Practices are locally available and hyperlinked to this document as follows:

100 Series – General HSE

- ☐ 102 – Workplace Violence Prevention Program
- ☐ 103 – Workplace Hazardous Materials Information System (WHMIS)
- ☒ 104 - Hazard Communication
- ☒ 105 – Personal Protective Equipment (PPE)
- ☒ 107 – First Aid
- ☐ 108 – Bloodborne Pathogens
- ☐ 111 – Medical Surveillance
- ☒ 113 – Heat Stress
- ☒ 114 – Working in Cold Environments
- ☒ 115 – Material Handling and Safe Lifting
- ☒ 116 – Office Safety
- ☒ 118 – Working Alone in the Field
- ☒ 124 – Safe Driving
- ☒ 125 – Workstation Ergonomics
- ☐ 126 – Using a Chainsaw
- ☐ 130 – Rail Safety

200 Series – Construction HSE

- ☐ 201 – Fall Protection/Working from Heights
- ☐ 202 – Ladder Safety
- ☐ 203 – Aerial Work Platforms
- ☐ 205 –Scaffold Safety
- ☒ 206 – Hand and Portable Power Tools
- ☐ 208 – Hoisting and Lifting
- ☐ 213 – Utility Clearance
- ☐ 214 – Entering Excavations and Trenches
- ☐ 215 – Supervision of Hydro-Excavation Activities
- ☒ 216 – Working Near Mobile Equipment
- ☐ 217 – Forklift Operation

300 Series – Hazardous Materials

- ☐ 304 – Asbestos Safety
- ☐ 305 – Benzene Safety
- ☐ 308 – Working in Geotechnical and Materials Laboratories
- ☐ 310 – Compressed Gas Cylinders
- ☐ 311 – Working in Environmental Laboratories
- ☐ 312 – Fueling Gasoline Engines
- ☐ 314 - Working Around Hazardous Waste and Wastewater
- ☒ 315 - Arsenic Safety

400 Series – Program Specific

- ☐ 406 – Electrical Safety Program
- ☐ 407 - Traffic Control and Protection Planning
- ☐ 408 – Lock, Tag & Try (LTT)
- ☒ 409 – Respiratory Protection
- ☐ 411 – Confined Space Entry
- ☐ 414 – Hot Work
- ☒ 416 – Supervision of Contracted Drilling Activities

500 – PA/PC/Regn Sp Programs

- ☐ 501 - Using the Spot Messenger System
- ☐ 502 - Use and Handling of Nuclear Density Gauges
- ☐ 504 - Backpack and Boat Mounted Electro-fishing
- ☐ 507 – Aircraft Safety
- ☒ 508 – Wildlife Encounters
- ☐ 509 - Guideline for 2-way Radio Use on Radio Controlled Roads in BC
- ☐ 510 – Working in Abandoned Buildings
- ☐ 513 – Boat and Water Safety
- ☐ 514 – Working On or Near Ice
- ☒ 516 – Radiation Safety (US)
- ☐ 517 – Safe Machete Use
- ☐ 519 – Post-Disaster Building Entry

3.4 GUIDELINES FOR OBSERVED OR IDENTIFIED HAZARDS

3.4.1 Hazards Created By or Identified During Work Controlled By Stantec or Contractors

When apparent non-compliance to the HSP or unsafe conditions or practices are observed, the Stantec Project Manager, and/or HSSE Advisor will be notified and corrective actions completed. For Stantec contractors, the contractor's H&S Representative or Project Manager will be notified and corrective actions will be required. For work activities performed by the contractor, the contractor is responsible for determining and implementing necessary controls and corrective actions.

When Stantec employees or contractors may be exposed to an apparent imminent danger, immediately stop work and alert all affected individuals. Remove all affected Stantec and contractor employees from the danger and notify the Project Manager, and/or HSSE Advisor, and the contractor's H&S Representative or Project Manager where appropriate. Do not allow work to resume until adequate corrective measures are implemented and documented and accepted by the H&S Representative or his/her designee.

3.4.2 Hazards Identified with Other Third Party Work Activities

In carrying out Stantec's responsibilities of assuring safety compliance for Stantec and contractor employees, the following guidelines are implemented when employees identify hazardous conditions created by the Stantec or Contractors (third party) within or adjacent to their work area:

- If a condition is identified that could immediately result in an accident causing severe injury or death:
  - Take appropriate measures to ensure your own safety and all other Stantec and contractor employees by immediately removing yourself from the immediate danger of the hazard zone.
  - Advise others in the area of your potential concern. This would include notifying the client representative. Do not advise how to correct the immediate hazard, only that one appears to exist.
  - If the potential concern is not addressed, the Stantec employee should notify the project Manager or his/her designee, who then may notify the Owner of the potential concern. It is the Owner's responsibility to determine, and implement if appropriate, the issuance of a stop work order or to suspend the affected activity. Additionally, only the Owner can authorize a restart of the suspended work activity following mitigation of the immediate hazard.
- If a condition is identified that may not be an immediate danger, but could result in an accident involving less serious or minor injury, damage to equipment, or environmental release:
  - Take appropriate measures to ensure your own safety and the safety of all other Stantec and/or contractor employees in immediately removing yourself/them from the immediate hazard zone.
  - Advise others in the area of your concern. This would include notifying the client representative. Do not advise how to correct the deficiency; only that it appears that one exist.

In either case, notify the Project Manager and/or HSSE Advisor. The situation will be evaluated and protective actions taken to ensure the safety of Stantec and contractor employees during the performance of their work activities.

3.5 ENFORCEMENT OF SAFE WORK PRACTICES IN A MULTI-EMPLOYER JOB SETTING

Enforcement of safe work practices starts with a disciplinary action program. All persons assigned to the field are expected to conduct themselves in a manner that promotes the health and safety of themselves and their fellow workers. Employees not able to conform to the safety and health protocols contained in this document will be subject to disciplinary action, up to and including termination. Personnel who knowingly disobey safe operating procedures will be disciplined. Depending on the nature of the infraction, the disciplinary action will progress from a verbal warning, to a written warning, to a suspension from site activities, to dismissal from the site.

Enforcing safe work practices at a multiple employer job setting presents many challenges. Stantec recognizes its responsibility as prime contractor to create and enforce a work environment that is safe and healthful. According to OSHA, each employer is required to provide a safe and healthful working environment for its employees. Most hazardous waste site activities require that more than one contractor work simultaneously on a given work site. In this situation, activities of one company could potentially cause a hazard to employees of another company, and so forth. It is not possible to present every subtle hazard associated with a particular piece of equipment or process or site condition in an HSP; therefore, it is necessary for each company to inform site workers of the particular safety and health issues associated with the means and methods of accomplishing site tasks. The forum for disseminating this information is through safety meetings, Quantified Hazard Assessment (RMS7), and Field Level Risk Assessments (RMS2).

When conducting site activities, it is possible for personnel to forget or ignore certain provisions of the HSP. Project staff noticing deviations from accepted safe work practices will remind personnel of the proper procedures. Should this fail to correct the deviation, the OSO (and Subcontractor designated competent person[s], as appropriate) will be informed of the circumstances. Under no conditions are deviations from safe work practices to be tolerated by anyone on site. Unsafe behavior or unsafe conditions at the site shall be corrected in accordance with this HSP. Should this attempt fail, Stantec will halt site activities. Non-cooperative subcontractors may be terminated.

3.6 SPILL CONTAINMENT PROGRAM

In most cases Stantec and contractors are on site to investigate or remove already spilled hazardous materials. There are, however, hazardous materials sometimes brought to the site to accomplish the project objectives. These include decontamination solvents, acid preservatives, and electric generator fuels. Drums or other containers will be on site to store decontamination fluids and waste PPE. All field team members will exercise care when decontaminating equipment and personnel, and will treat any spilled decontamination water or fluid as a hazardous material. If a spill or release (e.g., via fire or explosion) of any hazardous material on site occurs, field team members will:

- Assess the need to don a higher level of PPE. This assessment will depend on the volume of the spill, nature of the spilled material, and measurements from air monitoring equipment.
- Attempt to dike or stop the spread of the spilled material with absorbent pillows or material (e.g., kitty litter); or cover the material if it is volatile with Visqueen, or equivalent. The OSO and Field Manager should assess during the planning stage the need to mobilize this kind of equipment.
- Obtain an appropriate drum or container to package the spilled material.

- Pump or scoop up the spilled material and any additional contaminated soil or articles, and place the material in a drum or other suitable container.
- In the event that the spill is too large to be handled safely by the field team, the area around the spill will be secured and the OSO will initiate clean-up activities by notifying the appropriate emergency or spill response organization (e.g., Stantec, fire department, contracted response company, etc.).
- Once efforts to mitigate the spill are underway, the Project Manager and appropriate Stantec representatives shall be notified.
- If any agency notifications are necessary, such as when State or Federal reportable quantities are exceeded, Stantec will notify the appropriate entities to report the spill, unless otherwise agreed to in writing between Stantec and contractors.

3.7 FIRE PROTECTION PLAN

Field activities associated with hazardous waste operations potentially could result in a fire at a site. Cigarette smoking is expressly forbidden in the exclusion zone. Air monitoring equipment used to monitor for flammable mixtures will be intrinsically safe if required and measurements collected at a frequency which will allow for a reliable assessment of the fire hazards at a site. At least one Class ABC dry chemical fire extinguisher, 10-pound minimum, will be available for use at each site.

All electrical wiring will be free from frayed ends and sections, and all hook-ups will be checked for loose fittings. Portable power tools will be connected to a ground fault circuit interrupter and care will be taken to ensure that electrical connections do not exceed the maximum load capacity for any one circuit.

Wildfires

Areas (particularly the southwestern United States) with wide open spaces of natural brush present the danger of wildfires when dry grasses and brush catch fire. Many project sites have structures that can provide enough of a fire break to prevent wildfires from endangering site personnel, but, it is not an absolute protective measure. As warranted, the OSO will check regularly with the local fire department during the most common wildfire months (July through November). Should a wildfire threaten a work site, the OSO will watch for changing conditions and evacuate and secure each active site, in accordance with local fire department instructions.

Fire or Explosion Response Action

The actions listed below are in a general chronological sequence. Conditions and common sense may dictate changes in the sequence of actions and the addition, elimination, or modification of specific steps.

1. Upon detecting a fire/explosion, employees will notify the OSO and one person will be directed to notify the fire department.
2. A determination will be made as to whether or not the fire is small enough to extinguish readily with immediately available portable extinguishers or water, or if other fire-fighting methods are necessary.
3. Non-essential personnel will be directed away from the area of the fire.
4. Someone will be directed to greet the fire crew and show them the way to the site over non-contaminated ground if possible. Once the fire department arrives, the senior fire official is now in charge of the site.

5. If it is judged that a fire is small enough to fight with available extinguishing media, employees will attempt to extinguish the fire provided that:
    - They are able to approach the fire from the upwind side, or opposite to the direction of the fire's progress.
    - The correct extinguisher is readily available or a water source or heavy equipment operator that can put soil on the fire is available.
    - No known complicating factors are present, such as likelihood of rapid spread, imminent risk of explosion, or gross contamination.
    - The OSO or designee will perform a head count for that work area.
6. The OSO will assist the fire crew in performing any necessary decontamination of the fire equipment.

Fire Extinguisher Information

The four classes of fire, along with their constituents, are as follows:

- Class A - Wood, cloth, paper, rubber, many plastics, ordinary combustible materials. Extinguish with water or ABC dry chemical extinguisher or other A-rated extinguishing media.
- Class B - Flammable liquids, gases, and greases. Extinguish with ABC dry chemical, Purple K, carbon dioxide or other B-rated media.
- Class C - Energized electrical equipment. Extinguish with ABC dry chemical, carbon dioxide or other C-rated media.
- Class D - Combustible metals such as magnesium, titanium, sodium, and potassium. Extinguish with Metal-X Dry Chemical.

The OSO shall conduct an initial inspection of the fire extinguisher(s) and on a monthly basis to ensure that the unit is adequately charged with extinguishing media. Do not store a fire extinguisher on its side. To use the extinguisher, follow the acronym PASS for instructions listed below:

1. **P**ull the pin on the top of the unit.
2. **A**im at the base of the fire.
3. **S**queeze the handle on the top of the unit.
4. **S**weep the extinguishing media along the base of the fire until the fire is out. Ensure that the fire is fully cooled before assuming it is completely extinguished.

3.8 EARTHQUAKE AND DISASTER PREPAREDNESS

If an earthquake or other disaster occurs during working hours and the magnitude is such that site personnel may be in danger, the OSO will initiate the site evacuation procedure. This action is to be taken only if in the judgment of project personnel and/or OSO that the earthquake is large enough to have potentially caused damage to any of the structures or equipment being used on the site.

If the earthquake or disaster occurs during non-working hours the OSO will determine whether safe entry into the exclusion zones can be made, or if an inspection is needed first. If at any time, the inspection team feels that they need the assistance of the fire department, the inspection shall cease until the fire department is able to assist. The inspection will be conducted using the buddy system. The team will look at all structures, equipment, and any chemical storage areas for signs of cracks or deterioration. When assessing areas known to contain chemicals, appropriate air monitoring equipment will be used to ensure that leaks are detected quickly and without injury to the inspection team. When inspecting areas where chemical releases could have occurred as a result of a breach of containment, Level B PPE is recommended. (Note: Stantec Personnel are not authorized to don Level B PPE). Level B PPE is not anticipated to be required for use during the field work. However, in the event that site conditions change and the use of Level B becomes warranted, a specialty contractor will be subcontracted to provide assistance with the Level B equipment and work tasks.

In the event of a catastrophic earthquake or disaster, up to 72 hours could elapse before emergency assistance arrives. Therefore, it is advisable for the project team to maintain enough supplies (food, water, emergency supplies such as first aid kits, personal medication, and any other applicable supplies) for each person scheduled to work on a full-time basis. These supplies should be stored in a place that is not likely to be impacted by an earthquake or other type of disaster.

3.9 SANITATION

Work breaks, eating, drinking, and conducting paperwork tasks will be performed in the field vehicle or other suitable location outside of the exclusion zone and CRZ. Field personnel will wash their hands prior to eating or drinking.

Project site toilet facilities may be available to site workers. If it is determined that an existing toilet facility is not located within a suitable distance (up to 5 minutes vehicle ride) to a particular site, portable toilet facilities will be rented and brought to the project site. One toilet will be rented if the anticipated size of the field crew is less than 20. All rented toilets will be equipped with a door that is lockable from the inside. Rental toilets will include at a minimum, a weekly cleaning service. A visual search for spiders (particularly black widow spiders) should be conducted prior to using any portable toilet.

Potable water will be available in the support zone for all field team members. The OSO is responsible for ensuring that an adequate supply of water is available at the site. During times of heavy labor and hot temperatures, it is recommended that approximately 1 liter of water per hour be ingested. Electrolyte replacement beverages also may be provided for site personnel. Non-potable water outlets must be clearly identified. When decontamination procedures are prohibitive for the purpose of ingesting water during work, field team members may drink water without prior personnel decontamination under the following stipulations:

- Water is dispensed from a cooler with a pull-lever or top push pouring spout. Push-button pouring spouts are unacceptable as dirty fingers can easily contaminate the pouring spout.
- Disposable drinking cups must be used and discarded after each use.
- Drinking cups must be dispensed out of a plastic or metal dispenser attached to the cooler allowing the bottom of the cup to be grabbed without touching the rim of the top.

Support zone food handling activities must comply with local requirements governing the use of barbecues and vending. Remember to store food at above 140 degrees F or below 40 degrees F to kill or retard food-borne pathogenic microorganisms.

3.10 ILLUMINATION

Most site work will be done during daylight hours. When performing work during non-daylight hours, personnel must be furnished with sufficient light. OSHA requires a minimum of 5 foot-candles of light for general work sites. Five foot-candles is likely to be inadequate and additional light may be required. Most equipment rental companies maintain light sources capable of providing enough light for site work. Ensure that all electrical lines are properly grounded (i.e., with a ground-fault circuit interrupter) and that explosion-proof lighting is used in flammable atmospheres.

3.11 HOUSEKEEPING

One of the best ways to keep a safe site is to keep a clean and orderly site. The OSO shall remind all site workers that it is their responsibility to ensure that housekeeping is kept up and that the sites, staging areas and parking areas where Stantec and its contractors work are free from trash, debris and cluttered walkways. This includes the following:

- The OSO will designate trash receptacles.
- The OSO will designate appropriate storage for flammable materials (e.g., decontamination solvents). This may include a flammables cabinet or short term use of a Stantec's storage facility.
- The OSO will designate "Smoking Areas" that are acceptable to Stantec and site conditions (e.g., no smoking near dry grass).
- All materials shall be stored such that it is stacked, braced, racked, blocked, interlocked, or otherwise secured to prevent sliding, rolling, falling or collapse.
- Any protruding materials (e.g., nails) will be kept clear from walkways and positioned such that someone will not accidentally lean on them.
- Dangerous depressions in the ground shall be avoided by setting up work so that people are not required to walk over them. If that cannot be done, the depression should be temporarily covered or otherwise made safe.
- Any combustible scrap (e.g., cardboard boxes) shall be removed at regular intervals.
- Hoses and cords shall be run the minimum distance necessary and if they must pass over walkways, they must be secured or passed overhead.

3.12 COMMON PHYSICAL HAZARDS AND CONTROLS

This section provides information concerning common physical hazards associated with hazardous waste operations and recommended controls to minimize risk to site personnel. Anything unique or different from the standard information provided in this section will be provided as appropriate.

3.12.1 Slip/Trip/Fall

All field team members are to be vigilant in providing clear footing, clearly identifying obstructions, holes, or other tripping hazards and maintaining an Awareness of uneven terrain and slippery surfaces. If necessary shoes providing more elaborate tread will be worn to minimize slip, trip and fall hazards. Care shall be taken to contain liquids so as not to create a muddy or slippery condition. Absorbent or gravel material may be used (with Stantec approval) to help prevent slippery conditions during wet and rainy seasons.

Working at heights above 6 feet is not anticipated to be necessary during the course of most projects. If work at such heights is necessary for this project fall protection must be provided. When it is known that access to the top of a storage tank (e.g., Baker tank) or treatment system canister will be required, order the equipment with an attached ladder and guard rail system. Fall protection involves the use of either a personal fall arrest system (five point harness with shock absorbing lanyard), guard rail or safety net. All fall protection systems must be as specified in 29 CFR 1926 Subpart M, Fall Protection.

3.12.2 Heavy Lifting

During manual lifting tasks, all personnel will remember to lift with the force of the load suspended on their legs and not their backs. They are to follow these principles of back safety:

- Get help from a co-worker or mechanical device when possible.
- Maintain the natural ‘S’ curve.
- Build a bridge when lifting relatively light objects by placing one hand on a leg or other surface.
- Lock the stomach muscles.
- Hold the object close to the body.
- Do not twist and lift.
- Try to plan tasks so that you lift from waist height to waist height.
- Place containers on a table to fill them instead of filling them while on the ground.

3.12.3 Electrical Hazards

Underground Utilities

An underground utility service must be contacted in advance of invasive work. The utility locator service in conjunction with a review with Stantec of as-built construction drawings will identify and locate all utilities prior to invasive activities. Additional geophysical surveys may be needed if uncertainties remain. Invasive activities must be at least 5 feet away from marked underground utilities. Hand digging to 5 feet will be required when historical evidence suggests that the other utility locator methods may not be enough to locate all underground services.

Overhead Utilities

In all cases, personnel will be vigilant about the presence of overhead lines before raising the mast of a drill rig, backhoe bucket, or crane arm or other extending device, including ladders. Generally, clearances of 20 feet or more are recommended. Minimum distances from mast to overhead electrical lines, based on voltage, are as follows:

Nominal Power Line System (kV)	Minimum Required Clearance (feet)
0–50	10
51–200	15
201–300	20
301–500	25
501–750	35
751–1,000	45

Source: United States Army Corps of Engineers
kV: kilovolt

Electrical Equipment

Only authorized electricians are permitted to perform electrical work.

A minimum of 3 feet clearance is required around all electrical panels; the OSO is to ensure that such clearance is maintained during inspections of the field office, if one is brought to the site. This also applies to working around electrical panels at the Site.

Field personnel are responsible for ensuring that equipment brought to the work site is grounded before use. Additionally, the use of ground-fault circuit interrupters are required for all portable electrical tools and fixed electrical equipment to be used at the site.

Extension cords must be inspected prior to use. Any frays or missing ground prongs shall be cause to take the cord out of service. Extension cords are to be used for temporary purposes only and are not be used to hoist equipment. Extension cords are not permitted to be placed in water or in a walkway (if it must cross a walkway it shall be routed overhead). Work on electrically energized systems requires lockout/tagout.

3.12.4 Motor Vehicle Hazards

Motor vehicle accidents may happen any time people drive. All field staff are required to employ defensive driving techniques, and obey all site speed limits and vehicle safety requirements. Seat belts are required during all conducted business in motor vehicles (cars and trucks). Each occupant must have a seat. All accidents are to be reported to the OSO.

3.12.5 Hot Work Permits

Any welding, torch cutting or other hot work will be performed in accordance with a site-specific hot work permit. Each permit is issued for a specified task and shall not extend from one day to the next. All hot work must be done with the complete knowledge of the OSO and a fire watch nearby with a suitable fire extinguisher. The fire watch may not be dismissed until 30 minutes after the work has been completed. During the hot work process screens may be needed to control sparks.

All compressed gas cylinders used must be kept in an upright and secured position. If not on a cylinder dolly the cylinders shall be strapped to a secured wall or structure. The cylinder must be labeled as to its contents and whether it is “full,” “in-use,” or “empty.” The regulator valve shall be closed and covered when not in use. Oxygen cylinders shall be stored at least 20-feet from acetylene. Flammable cylinder storage areas shall be posted with “No Smoking” signs.

3.12.6 Sharp Objects and Pinch Points

During the course of the field work, it is feasible that personnel will encounter sharp objects and pinch points. Sharp objects include site debris, field tools (e.g., knives, scissors), equipment, or other objects. When danger of cuts to the hands or other body parts is probable, employees will either arrange paths where personnel may walk free of sharp edges, or ensure during the tailgate safety meeting that areas with known sharp edges are brought to the attention of the entire field crew. Heavy work gloves shall be used in conjunction with any chemical resistant gloves when handling sharp objects is required. Listed below are rules when using sharp tools:

- Use the right tool for the job. Do not use a knife when a more appropriate tool can be used. For example, plastic cable ties must be cut with some form of diagonal cutter or scissors, not with a knife (the box nodule can be cut if it is too difficult to get under the tie).

- Examine every tool for damage prior to use. Do not use knives with dull blades or broken handles.
- When using a knife, apply the appropriate safety practices. Do not point the knife toward others. Make sure you have adequate space. Make sure that other workers are clear from the immediate area. Do not pull the knife toward you. Make sure you have an appropriate cutting surface. Make sure that you are properly balanced and have firm footing.
- Consider a protective glove made of Kevlar or similar material. Maintain a pair of protective gloves as standard protective gear in your field bag or tool box.
- Make sure that new employees working with you are properly trained in the proper use of all of the tools that they are likely to use.
- Think you need a knife? Think again.

Pinch points are places where the hands may be caught between objects or moving parts. If you are unfamiliar with a piece of equipment that has moving parts – stop and become familiar with it, including knowing where the guards are meant to be. Do not operate or work around something you are not familiar with. It is unacceptable to work with any tool that has had its guard removed or altered. In general guards are required over blades, drive trains, pulleys, fly wheels, rotating parts, belts, motors, etc.

3.12.7 Noise

Noise levels will vary during the course of field activities at any site. Noise monitoring will be required when noise values are unknown and likely to exceed the OSHA action level of 85 dBA for an 8-hour Time Weighted Average (TWA). If noise levels can be inferred from previous work with similar equipment (e.g., hollow stem auger drilling) than the use of hearing protection will be indicated in Section 7. If noise monitoring is done, ideally it will be done during the initial stages of site work or when it is anticipated that noise levels will need to be characterized. Workers will receive training about hearing loss and the OSHA standard as well as the proper way to don hearing protection devices. The program also includes audiometric testing as part of the medical surveillance examination and hearing protection is provided as part of the standard PPE ensemble.

3.12.8 Heavy Equipment Use

General safety precautions for work around drill rigs, excavating equipment and dump trucks is included herein. All other pieces of equipment must have detailed activity hazard analyses. All equipment may only be operated by personnel that have been trained to use the specific piece of equipment and know the limitations and emergency shut off procedures. All equipment shall be maintained and operated in accordance with the manufacturer’s guidelines.

Drilling Operations

Drill rigs and support equipment must be inspected before each day or at the beginning of each shift. The inspection must be done in accordance with the manufacturers’ and owners’ operating requirements by someone qualified to conduct the inspection. When deficiencies that affect the operation of equipment are found, the equipment will be immediately taken out of service until unsafe conditions are corrected. When corrections are made, the equipment will be re-tested for safe use before being returned to service. The following represent general operating safety considerations:

- Before any drilling begins, a utility survey must be completed that include buried and overhead utilities. The OSO must ensure that this survey takes place in a timely manner and is documented in the project files before drilling begins. Safe clearances are described in Section 3.12.3.
- As applicable the drilling site shall be clear and leveled. The ground must be capable of supporting the impact imposed by the drill rig and associated equipment. The drill rig must be leveled and stabilized with leveling jacks. Cribbing shall be used as necessary. Outriggers shall be extended per the manufacturer's specifications.
- Before drilling equipment is mobilized to the drilling pad, the travel route shall be surveyed for overhead and terrain hazards. Access roads shall be designed, constructed, and maintained to safely accommodate the movement of the drill rig and other equipment.
- The drilling equipment shall be equipped with two easily accessible emergency shut down devices. The location of these should be made clear to all affected site personnel.
- Control levels for the drill rig shall be labeled indicating the function and direction of the control levers and shall be posted on the power unit controls.
- Gears and moving parts, constituting a hazard to employees, shall be guarded to prevent accidental contact.
- Drill crewmembers, and other support personnel, shall not wear loose clothing or clothing with loose ends, straps, drawstrings, and belts or otherwise unfastened parts that might catch on rotating or translating components of the drill rig. Rings and jewelry shall not be worn during a work shift.
- Unattended boreholes shall be covered, or protected to avoid the possibility of animals or people accidentally falling into them.
- Good housekeeping shall be maintained at all time. Litter will be properly stored, hand tools and other hardware will be properly secured on the drill rig. Prior to moving a drill rig a check shall be made for loose tools and hardware. Drill rods and augers should be placed on dunage and secured to prevent movement. Always use a sling or strap while handling rods and augers.
- Stand to the side while tripping and tailing rods and augers. Never stand under the rod/auger or between the rig and service truck while tripping rods or augers.
- Prior to starting the operator shall verify that all gear boxes are in neutral, all hoist levers are disengaged, hydraulic lever are in the correct non-actuating positions.
- The operator shall verbally alert workers and visually verify that workers are clear from the dangerous parts of equipment before starting the equipment.
- Unsecured equipment shall be removed from the mast before raising. Cables, mud lines, and cat line rope must be secured to the mast before raising.
- Drilling equipment shall not be transported for even a short distance with the mast up.
- The drill rig shall always be operated from the control panel. The operator must never leave the control panel while the drill is in operations. Only one person should operate the machine. If the operator must leave the area of the controls, the operator must shift the transmission controlling the rotary drive into neutral and place the feed control level in neutral. The drill rig shall be shut down before he operator leaves the vicinity of the drill.

- Where drill rigs are equipped with a platform, the platform shall be constructed out of material strong enough to support the weight of the load that will be placed on the platform. Platforms shall be accessed using a ladder or steps. Platforms over 4 feet above ground surface shall be equipped with a guardrail system that includes a toeboard.
- Pressurized lines such as airlines, mud hose, etc. shall be equipped with safety-type couplings and secured with wire or chain at each coupling to prevent whipping in the event of failure. All pressurized lines shall not be disconnected until shut off and bled to reduce the pressure.
- The discharging of drilling fluids shall be channeled away from the work area to prevent the ponding of water. Mud pits and drainage channels should be safely sloped and located to provide minimum interference with the work. Where necessary, suitable barricades or temporary fencing should be provided to reduce the possibility of injury.
- All wire ropes and rigging hardware shall be thoroughly inspected before use. Defective equipment shall not be used. Shop fabricated rigging, or hooks without latches, are not permitted. Where a chain sling is used it shall be an alloy chain and shall be tagged.
- Hoist and rigging hardware shall be used only for their designated intent and shall not be loaded beyond their rated capacity. Steps shall be taken to prevent two-blocking of hoist.
- Tool handling hoist shall only be used for vertical lifting of tools. The tool hoist must not be used to pull on objects away from the drill rig, unless the hoist has been designed for this purpose.
- Drill rods shall be neither run nor be rotated through rod slipping devices: no more than 1 foot of drill column shall be hoisted above the top of the drill mast. Drill rod tools joints shall not be made up, tighten, or loosened while a rod-slipping device supports the rod column.
- A string of drill rods shall not be braked, during lowering into the hole, by the chuck jaws. A cat line or hoisting cable or plug should be used for braking prior to tightening the chuck.
- Loads shall not be hoisted over the head, body or feet of any person. Loads shall not be left suspended in the air when the hoist is unattended. Work is not permitted under a suspended load.
- Hoist lines shall not be used to ride up the mast of a drill rig.
- Wire rope must be properly matched with each sheave. Too large and the rope will pinch, too small and the sheave will groove. Once a sheave is grooved, it will pinch and damage the larger rope.
- Protect wire rope from sharp corners and edges. Replace faulty guides and rollers.
- When handling wire rope, always wear gloves. Do not guide rope on to hoist drums with your hands. Replace the wire rope according to manufacturer’s specifications. When new rope is installed, first lift a light load to allow the rope to adjust.

Rotary and Core Drilling

- If an air rotary duct becomes plugged, no person shall be positioned toward the front of the ducting – when the plug is released it can send rock and debris out like a shotgun.
- The exclusion zone shall be large enough to ensure that the support zone does not exceed 85 dBA from noise generated by the rig. A general rule of thumb is a radius of 30 feet.

- Water swivels, hoist plugs, rod chuck jaws, etc. shall be inspected prior to use. Defective equipment shall not be used.
- Only the operator of the drill rig shall brake or set a manual chuck so that rotation of the chuck will not occur prior to removing the wrench from the chuck.
- Drill rods shall not be braked during lowering into hole with drill rod chick jaws. Drill rods shall not be held or lowered into the hole with pipe wrenches. If a string of drill rods are accidentally or inadvertently released into the hole, no attempt shall be made to grab the falling rods with hands or a wrench.
- When drill rods are hoisted from the hole, they shall be cleaned for safe handling with a rubber or other suitable rod wiper. The hand should not be used to clean drilling fluids from drill rods.
- Drill rods shall never be lifted and leaned unsecured against the mast. Drill rods shall be secured to the upper ends of the drill rod sections for safe vertical storage or lay the rods down.
- The spinning chain is very powerful and must be treated with respect. Spinning chains must have a rope tail. Good communication between the driller and tool handler will ensure safe operation of the spinning chain.

Backhoe and Excavator Operations

As with drilling equipment, only trained and authorized operators are permitted to use backhoes or excavators and like equipment. The following safety precautions will be utilized when working around an operating backhoe or excavator:

- Equipment inspections must be performed by a competent, trained person prior to use. Inspections must be done in accordance with the manufacturer’s recommendations.
- The underground and overhead utilities must be identified prior to digging. If a buried utility will be uncovered, a plan to support it must be arranged in advance. If an unanticipated underground utility is identified work shall stop and the project manager notified.
- No one will be permitted into a trench or excavation without specific procedures provided and a named “competent person.”
- The buddy system will be employed at all times.
- No trench or excavation will be left unattended or open without adequate barricades, caution tape, and safety signs.
- Personnel and equipment will maintain a minimum 3-foot clearance from the edge of the excavation.
- The spoil pile will also be kept at least 3-feet back from the edge. The spoil pile shall be sloped to prevent soil from sliding back into the hole.
- Water in the hole shall be evaluated with respect to the safety of the side wall. If there is danger of collapse the minimum clearance shall be extended and/or the sides supported.
- Suitable storage for all tools, materials, supplies will be provided by the contractor (or subcontractor).
- Work areas will be kept free of materials, obstructions, and substances that could cause a surface to become slick or otherwise hazardous.
- Tools and equipment will be used in accordance with the manufacturers recommended methods. The operators shall be responsible for establishing safe equipment use procedures.

- No one shall approach a moving piece of heavy equipment without first obtaining eye contact and a positive signal to approach from the operator.
- Ground personnel shall wear a highly visible safety vest and stay out of the swing radius of the moving equipment. Ask the operator about blind spots if there is any doubt.
- Soil shall be backfilled as soon as possible.
- Equipment shall be stabilized prior to use.
- Personnel may only ride in designated seats.
- Never stand beneath a suspended load.
- All maintenance must be conducted in accordance with manufacturer’s directions, any hazardous energy must be locked out prior to being worked.
- Backup alarms must be functional.
- All belts, gears, shafts, pulleys, sprockets, spindles, drums, flywheels, chains or other reciprocating, rotating or moving parts must be guarded when exposed to contact by persons or when they otherwise create a hazard.
- All diesel powered equipment shall be shut off prior to refueling.

3.12.9 Ladders

A stairway or ladder shall be provided at all points of personnel access where there is a break in elevation of 19 inches or more and no other means of safe access is available. General requirements include:

- All portable ladders shall be of the extra heavy-duty type (ANSI Type IA ladder).
- A competent person shall periodically inspect ladders for visible defects and after any incident that could affect its safe use.
- When portable extension ladders are used the side rails shall extend at least 3 feet above the upper landing surface. The ladder shall be secured. Ladders that can be displaced by jobsite activities or traffic shall be secured to prevent accidental movement or a barricade should be used to keep traffic activities away from the ladder.
- Ladders should be maintained free of oil, grease and slipping hazards.
- Ladders shall not be loaded beyond the maximum intended load.
- Ladders shall be used only for the purpose for which they are designed.
- Metal ladders shall not be used around electrical equipment.
- The area around the top and bottom of the ladders shall be kept clear.
- Ladders should not be moved, shifted or extended while in use.
- Employees shall not attempt to ascend or descend a ladder while carrying tools or materials in their hands. All tools and materials shall be hoisted by mechanical means to the working level.
- Employees shall face the ladder and should maintain at least 3 points of contact when climbing a ladder.

3.12.10 Ergonomics

Ergonomic injuries are the result of three factors: awkward postures, forceful motions and repetitive motions. The key to minimizing or even eliminating ergonomic injuries is by keeping the body in a neutral position through as much of the day as possible. A neutral position means that all of the bones are in their natural alignment (e.g., neck straight, back with 'S' curve, arms dangle from shoulders, not hunched) when a bend is needed such as when sitting or using a computer the elbows, hips and knees are at right angles and the wrists are straight with feet either flat on the floor or on a foot rest. Try to incorporate these natural and neutral postures into all tasks being done throughout the day. When a job requires force – try to think of another means of accomplishing the task, is there a tool or someone that can help? If you do a repetitive job, seek ways to automate it or build in frequent breaks from that task to give your body some rest. Build in a stretching routine throughout your day to give you back, wrists and neck a break. Ask your OSO for some tips if you are unsure of a good way to stretch.

Consider the following list developed by Humantech (1995), a specialty ergonomics consulting firm, and try to find ways of incorporating proper posture, less force and breakup repetitive tasks as much as possible:

Ergonomics Hit List	Comment
Wash rag	Wrists twisted and bent – try to arrange work so that wrist is straight
Tool/target interface	Try to arrange so that the body is in a neutral position
Elbows out, winging it	Often a compensation to keep the wrist straight. Back off and try to rearrange the work to keep the whole body in neutral.
Bad vibes	Often from hand tool use – ensure that tools are in good working order, try anti-vibration gloves. If riding on bumpy roads in vehicles, build in breaks to get out and stretch.
Shoulder too high or too low	If the shoulder is too high, the job is too high. If the shoulder is too low, the job is too low.
Comfort zone	Look at the span of your arm – try to keep work in this zone.
Hungry head	If you find your head searching so you can see the job, your neck is in an awkward posture
Butts up	When bent over for prolonged periods the spine is subject to high compressive forces – take a seat on a bucket or put the item you are working on at a higher level.
Twist and shout	Twisted body parts lead to injuries.
Sit – stand	Choose the best method to do the job safely. Visual jobs are best done seated, forceful jobs are best done standing.
Don't give me static	Prolonged static postures are fatiguing. Make sure to keep the body moving throughout the day, get up and stretch.

3.13 EMERGENCY RESPONSE PLAN

The objective of this HSP is to minimize the potential for chemical, biological, and physical hazards, and operational incidents. As part of this program, emergency response planning provides procedures for responding to emergencies that may occur during the project. ***It is not the intention of this program to include professional emergency response activities as part of the field operations. Thus, all site personnel are instructed to assess emergencies in terms of whether the problem can be solved safely with the personnel and equipment at the site. If it is determined that site personnel are able to contain the emergency safely, they should do so. If it is determined that the emergency is beyond the abilities of site personnel, evacuation and notification must take place immediately.*** This section provides general information for responding to emergency situations.

Emergency Medical Assistance Network. Section 10 provides this site-specific information. Emergency telephone numbers and a map showing the locations of the hospital(s) or emergency clinic(s) capable of providing emergency service for hazardous waste site workers are provided. Telephone numbers for the Poison Control Center, local Police and/or Sheriff's Department, local Fire Department, Office of Emergency Services, utility service or "one call" system number, management, workers' compensation reporting and Stantec contacts also are included. This information must be reviewed periodically by the OSO to ensure that it is current.

Standby Vehicles. Vehicles that can be used to transport injured personnel, if an ambulance is not necessary, from work sites will be available during working hours.

Communication System. If cellular phones or two-way radios cannot be used at the site or are ineffective due to terrain, an alternate communication system must be preplanned and communicated. This information will be inserted in Section 10 or posted at the site.

Emergency Response Leader. The OSO assumes overall lead of the situation. Each subcontractor's "competent person" will work with the OSO to control the emergency. These people will take time during the beginning of the project to establish or confirm the following:

- Best <u>route</u> to the specified medical facility.
- <u>Assembly area</u>, in the event of an emergency (preferably upwind, uphill at least 100 feet from the support zone).
- <u>Number of people</u> on site at any given time (a count must be made at assembly area during emergencies).
- <u>Alarms</u> and communication methods (phones, horn, verbal, etc.).
- <u>First aid supplies</u> available and in clean condition; identification of at least two field team members with current training certificates.
- <u>Evacuation routes</u> clear and posted (as necessary, such as inside buildings).

Emergency Reporting. All accidents, safety related incidents, and safety related near misses will be documented and reported to the OSO who will make the subsequent necessary notifications.

4.0 HEALTH AND SAFETY TRAINING REQUIREMENTS

Health and safety training is an integral part of the total project health and safety program. The objectives of such training are to educate workers about the potential health and safety hazards associated with working at the project site. The Project Manager is expected to instruct employees about the hazards of the project and site before allowing them to perform work on site. The site orientation should include an overview of this HSP, emergency information, and other relevant information that would provide the worker with safety and health information prior to entering the project site. Examples of health and safety training that apply to work activities, as applicable:

- Excavation and Trenching
- Fall Protection
- First Aid and CPR
- Hazard Communication
- Hearing Protection
- Lockout/Tagout
- Personal Protective Equipment
- Radiation Safety

This is not an all-inclusive list of training requirements; as work scope changes and new training requirements are identified, they will be incorporated into the program. Stantec and contractors are required to verify that their employees have received the necessary training and that documentation is available.

Prior to commencement of site activities, the OSO will ensure that all Stantec and contractor's employees engaged in a work activity are informed of the nature and degree of exposure to chemical and physical hazards that are likely to result from performance of work. All Stantec and contractor employees must also complete any other training that may be required for the project and by OSHA-specific standards or other applicable standards before initiating work requiring specific training. The Subcontractor's designated OSOs are responsible for ensuring that all subcontractor personnel have received St. Anthony Safety and Health indoctrination training and have submitted in writing their intent to comply with the general Stantec requirements. Additionally, each subcontractor's OSO is responsible for implementing the subcontractor's Site Specific Safety and Health Plan. Subcontractor OSOs are responsible for providing a Weekly Subcontractor Safety and Health Report to the OSO, or his/her designee.

Prior to work initiation, each Subcontractor OSO will prepare and submit to Stantec as requested, AHAs for review and approval. When requested, the Subcontractor HSM shall assure that Subcontractor site-specific HSPs contain pertinent health and safety information regarding the subcontractor's activities and equipment.

It is the responsibility of each subcontractor's OSO to ensure that the particular safety and health hazards associated with the subcontractor's work are made known to all other affected site personnel - this will be accomplished by means of ad hoc safety meetings, or by holding a pre project briefing.

Each subcontractor's OSO will be the primary contact for the Stantec OSO in cases where subcontractor behavior has been determined to be unsafe and is creating unsafe conditions. Each subcontractor's HSM will be responsible for following up on such notices, correcting unsafe conditions and disciplining unsafe personnel.

4.1 PERSONNEL TRAINING

All personnel who enter a hazardous waste site or construction site must recognize and understand the potential hazards to health and safety associated with operations at the site. It is the intent of this health and safety program to provide every person engaged in on-site activities a level of health and safety training consistent with his or her job functions and responsibilities.

Employees working on hazardous waste and construction job sites will be provided the training described in HAZWOPER, 29 CFR 1910.120/29 CFR 1926.65 (e) and like State laws.

In addition to HAZWOPER specific topics there are other related safety and health regulations requiring training applicable to this project. Information about these subjects is included in the initial off-site training as well as the refresher training and supplemented as deemed necessary. These include the training requirements specified in:

- “Respiratory Protection” (29 CFR 1910.134)
- “Hearing Conservation” (29 CFR 1910.95)
- “Hazard Communication Standard” (29 CFR 1910.1200)
- “Bloodborne Pathogens” (29 CFR 1910.1030)
- “Confined Space Entry” (29 CFR 1910.146)
- “Excavation and Trenching” (29 CFR 1926 Subpart P)
- “Construction Safety Awareness” (29 CFR 1926)

When a State regulation exists for a standard presented above, the standards of the State regulation shall supersede the Federal equivalent.

4.1.1 Initial Training

Stantec and contractor employees assigned to hazardous waste sites will receive 40 hours of initial off-site instruction, and a minimum of three days actual field experience under the direct supervision of a trained, experienced supervisor. Some individuals, Company officers or surveyors, that meet the occasional site worker requirements, will receive a minimum 24 hours of initial off-site instruction and a minimum of one day actual field experience under the direct supervision of a trained, experienced supervisor. These individuals are limited to work areas that have been characterized and do not pose the hazard of exposure to chemical contaminants in concentrations exceeding published occupational exposure limits. The initial off-site training must be documented with a certificate of completion by the instructor. The supervised field work must also be documented with the name of the supervisor, company affiliation, dates and location. Training topics to be covered in the initial training include the following:

- Review of the HAZWOPER standard and associated safety and health regulations.
- Names and roles of personnel responsible for site safety and health.
- Safety, health and other typical hazardous waste site operation hazards present at a site.
- Use of PPE.

- Types and use of equipment used to monitor the breathing zone and work areas of site personnel (i.e., photoionization detectors, combustible gas indicators, colorimetric indicator tube systems, dust meters and noise monitors).
- Work practices by which the employee can minimize risks from hazards.
- Safe use of engineering controls and equipment.
- Medical surveillance program requirements, including recognition of symptoms and signs that might indicate overexposure to hazards.
- Decontamination set-up and procedures.
- Emergency response planning, including proper PPE and equipment selection and use for emergency response.
- Spill containment program elements.
- General principles of toxicology and review of the major categories of typical hazardous waste site contaminants.
- General industrial hygiene principles of recognition, evaluation and control of health and safety hazards.

4.1.2 On-Site Managers and Safety Officer Training

The on-site managers and individuals responsible for supervising personnel engaged in site work must have at least eight additional hours of specialized training on managing such operations. This specialized training includes a review of Stantec's safety and health program (including training programs), PPE selection, use, maintenance and limitations, spill containment program, and health hazard monitoring procedures and techniques. This training must be documented with a certificate of completion from the instructor. Persons designated as the OSO must also be currently certified in First Aid and CPR.

4.1.3 Refresher Training

All site workers shall complete 8 hours of off-site refresher training annually on the items covered in the 40-hour or 24-hour initial training program. Additional topics include a review of site incidents and lessons learned during the previous year. This training must be documented with a certificate of completion signed by the instructor.

4.1.4 Site-Specific Training

Prior to starting site work all personnel assigned to the job site shall receive a site-specific orientation. This is also referred to as the “kick-off” meeting or “pre-entry briefing.” This includes contractors and subcontractors who plan to enter the exclusion and contamination reduction zones at the site and who have met the requirements of 29 CFR 1910.120/29 CFR 1926.65. Training will be conducted prior to job start-up and, as necessary, thereafter. The PSO, OSO or Field Team Leader/Field Manager will conduct initial site-specific training. The purpose of the pre job start-up training/orientation is to ensure that employees have a thorough understanding of the HSP, Standard Operating Procedures (SOPs), and physical, safety, biological, radiological, and chemical hazards of the site. This training is documented by signing the Personal Acknowledgement Form (Appendix A). Topics addressed in the initial site-specific health and safety training will include:

- Names of employees and others responsible for safety and health.

- General rules of conduct.
- Review of the chemicals of concern (radiation hazards, if applicable) and specific air monitoring that will be conducted as well as action levels of up- or down-grading PPE or evacuating the site.
- Review of major machinery and physical hazards, ergonomics hazards, and biological hazards and recommended controls.
- Personal cleanliness and restrictions on eating, drinking, and smoking.
- Review of emergency procedures and facilities, including blood borne pathogens and universal precautions.
- Incident reporting procedures.

4.2 FIRST AID, CPR AND BLOODBORNE PATHOGENS

Personnel assigned to conduct field work for this project do not conduct first aid or CPR as a primary job function. Rather, selected employees are trained in CPR and first aid for emergency situations only. Acting in the capacity of a designated emergency first aid provider is not mandatory, and anyone who is uncomfortable with the possibility of being so designated should notify the OSO or Project Manager.

An indoctrination to the blood borne pathogens standard (29 CFR 1910.1030) will be provided to all employees either during their first aid training, and/or during the initial site health and safety meeting. The Hepatitis B and Human Immunodeficiency Virus (HIV) which causes Acquired Immune Deficiency Syndrome (AIDS), among other pathogenic microorganisms, can be contracted during emergency first aid and CPR through contact with blood. It is important to recognize the concept of universal precautions. Universal precautions require one to assume that all blood and bodily fluids contain pathogens and require the use of protective barriers to prevent exposure. Latex gloves and CPR barriers will be available in the first aid supplies stored at each site and should be used prior to attending to a victim’s needs. Additionally, washing any body part or surface that has been contaminated with blood is an important part of the universal precautions. The OSO should be notified of any potential contact with blood or bodily fluids resulting from first aid or CPR administered on the job.

A vaccine exists for Hepatitis B. Employees trained in first aid and CPR may elect to acquire the vaccine, their employer will arrange to have the series of inoculations provided. Employees offered the vaccine that do not want it must sign a declination form to be kept with the employee’s medical surveillance records (see the PSO if there are any questions). While less efficient, the Hepatitis B vaccine also is effective when administered after exposure to blood containing the Hepatitis B virus.

5.0 REQUIRED MEETINGS

Stantec and contractor employees are to attend a project safety orientation, as well as periodic safety meetings. Stantec meeting safety topics discussed are to be documented accompanied with an attendance signature sheet. The Stantec meetings to be conducted are as follows:

Meeting Type	Purpose	Length	Frequency
Project Orientation	To acquaint employees with the Stantec Project scope of work and field activities.	Approximately one hour.	At time of first assignment to the Project.
Daily Safety Meeting or Pre-Task review of field work.	To cover specific safety topics; or to review hazards and safety practices required for field walk downs.	Approximately 10-30 minutes.	Daily or at the beginning of new field activities.

5.1 DAILY TAILGATE SAFETY MEETINGS

The OSO or designee at each active work site shall hold a Tailgate Safety Meeting (also called Toolbox Safety Talks) prior to starting work in the morning or later in the day if conditions change. The meeting is to be documented using a form such as the one included in Appendix A. The contents of the meeting shall include:

- Discussion of work to be done that day or portion of the day.
- Anticipated chemical, physical, radiological, ergonomic and biological hazards and controls.
- Method(s) of communication and emergency reporting.
- Review of materials covered in the orientation as they apply to daily activities.
- Employee issues or concerns.

6.0 PROJECT/SITE HAZARDS AND THEIR CONTROL

6.1 SITE HAZARDS

Field personnel may be subject to the hazards posed by various activities taking place. This section of the HSP is meant to provide a brief description of the controls that should be taken to prevent injury to employees observing or participating in such tasks. The following types of activities are anticipated on the project.

- Biological Hazards
- Radiological Hazards
- Drilling
- Excavation
- Hand tools
- Temperature Extremes
- Severe Weather
- Traffic Safety

6.1.1 Field Site Access

Any staff member entering a project area managed by the Client or Client's Construction Contractor will comply with their health and safety requirements. Staff will inquire as to the work activities being performed, potential hazards, policies and site requirements and the protocol for site visitors entering the site. A site briefing may be provided by the Client or Contractor prior to entering the site.

Staff making a single day or occasional field or facility visit will receive a project site/safety briefing regarding site conditions and safety practices. Staff shall wear the proper personal protective equipment (PPE) while performing their tasks. Safety vests are required for all field activities where staff is exposed to equipment operation or vehicle traffic.

6.1.2 Biological Hazards

Potential biological hazards may include of snakes, spiders, ticks, fleas, poisonous plants such as poison oak and poison ivy, and microorganisms such as the Hantavirus or yeasts left in dried bird excrement. There are no unique or significant biological hazards observed at this site. Animal and plant populations were characterized by Audobon International during two events in 1999 (March and June). No poisonous plants or animals were observed during the surveys. However, due to the desert location of the site, rattlesnakes and scorpions may potentially be encountered as well as black widow or brown recluse spiders. Detailed information on possible biological hazards at work sites are discussed below.

Spiders, snakes, and fleas exist in cool, dark, moist areas. The potential for encounters exist when reaching into dark, covered places. Suggestions for control include using a long stick to break apart webs or loosen soil from certain areas. A flashlight should also be used when reaching into a dark area. Field personnel shall be aware of their surroundings and avoid contact with all insects. An insect repellent with the active ingredient DEET (no more than 35 percent) should be considered if insects are a hazard. The repellent can be applied to clothing or hard hats if skin contact is undesirable. Avoiding the use of perfumes/colognes and choosing light colored clothing or wearing paper tyvek suites can also help prevent insect bites. In the case of tics it is a good habit to check oneself at the end of each field day paying close attention to the hair, neck and cuff areas (e.g., pant leg bottoms, wrists). Medical attention should be sought if symptoms persist or if one has an allergy or if an infection is starting to appear.

Venomous spiders may also pose a hazard during fieldwork. The black widow (*Latrodectus mactans*) is a large spider that is easily recognized by its shiny bulbous abdomen. The brown recluse (*Loxosceles reclusa*), or “fiddleback” spider is a brown spider with a fiddle-shaped marking on the head. Both spiders can be found in brush and loose debris. Hazard controls for spider bites are the same as those for snakebite and scorpion stings. In the event of a spider bite, the victim should contact the OSO immediately for assistance. The OSO should transport the victim to the nearest medical facility where antivenin or other medical treatment can be administered.

Rattlesnakes and scorpions are indigenous to many parts of the United States. The OSO will inform field team members at the daily tailgate safety meetings to be on the lookout for rattlesnakes and scorpions if they may be present. It should be noted that the American Red Cross does not advocate the use of snake bite kits for snake bite injuries. Rather, experience has shown that the victim has a better chance of recovery without permanent damage when the site of the wound is immobilized and the victim rushed to the closest emergency medical facility (preferably within 30 minutes).

Poisonous plants such as poison ivy and poison oak grow wild in dark, moist areas, and at the base or surrounding seedling or adult trees. Some individuals are prone to break out in dermal (skin) rashes upon contact with the plant oil. A visual site inspection and identification of the plants should be completed prior to each work shift so that all individuals are aware of the potential exposure. Barrier creams may be used or paper Tyvek suites to help prevent direct contact.

Hantavirus has resulted in several deaths in the southwestern part of the United States. Most infections result from exposure in closed spaces to active infestations of infected rodents. While there may not have been any outbreaks or notices of the virus at a particular project site, field team members should be aware of the cause and potential control methods. The Hantavirus has been shown to be transmitted through the aerosolization of dried rodent excreta. The Hantavirus-associated disease begins with one or more symptoms including fever, muscle aches, headache, and cough and progresses rapidly to severe lung disease, often requiring intensive care treatment. To control potential contact with dust that may be carrying the rodent excreta, the field team will conduct a visual survey of the area around each site to note whether rodents are thriving in the area. If it is determined that non-domesticated rodents may be living near the work area, or the area is affected by wind blowing dust into the work area, dust suppression techniques and/or respiratory protection (dust mask or dual cartridge air purifying respirator [APR] with dust filters) will be required. The Center for Disease Control, in Atlanta Georgia, has established a hotline for inquiries regarding the Hantavirus: (800) 532-9929.

Other microbiological hazards can exist at projects sites such as landfills and include yeasts from bird excrement and medical (biological) wastes. If these hazards are suspected this HSP will be updated to include specific information about the site specific conditions.

6.1.3 Radiologial Hazards

See the RPP (Appendix B) for discussion of the radiological hazards. The Client requires that all vehicles and equipment entering and leaving the fenced “restricted area” be monitored for fixed and removable alpha radiation. This monitoring must be performed by an individual trained and supervised by the Client’s Radiation Safety Officer.

Also, all individuals must be monitored for alpha radiation prior to leaving the “restricted area” daily. After training this monitoring may be performed by each individual, upon approval by the onsite Radiation Safety Officer.

6.1.4 Elevated Surfaces (Scaffolding and Ladders)

No Stantec employees or contractors working on elevated surfaces or at elevated heights should be exposed to unprotected falls of four feet or greater for general work activities or six feet or greater for construction work activities. Refer to the appropriate OSHA standard for specific fall protection requirements. Where work must be performed at unprotected elevations, a job hazard analysis should be completed to identify the specific hazard, requirements, and fall protection equipment needed.

6.1.5 Temperature Extremes

Hot or cold weather is generally a consideration at any site and cannot be controlled. Site workers need to be aware of controls that can reduce temperature stress, the signs and symptoms of temperatures stress, and first aid measures for victims of temperature stress.

The project site is located in Central New Mexico, in a typical desert climate. Heat stress is a major concern at this jobsite and should be closely monitored in all field personnel. Heat stress is discussed in detail in below.

Heat Stress

The OSO shall determine the extent to which heat stress monitoring and control is needed based on the guidance provided in this section. The stress of working in a hot environment can cause a variety of illnesses including heat exhaustion or heat stroke; the latter can be fatal. PPE (i.e., U.S. Environmental Protection Agency [USEPA] Level C protection) can increase heat stress significantly. To reduce or prevent heat stress, frequent rest periods and beverage consumption to replace body fluids and salts is required. It should be noted that heat stress can occur in people wearing regular, permeable work clothing.

Quantitative physiological monitoring for heat stress may be conducted. Physiological monitoring for heat stress includes heart rate as a primary indicator and oral temperature as a secondary indicator. The frequency of monitoring depends on the ambient temperature and the level of protection used on site. To determine the initial monitoring frequency, after a work period of moderate exertion, use the table below (source, NIOSH/OSHA/United States Coast Guard/USEPA Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities):

Adjusted Temperature*	Level D	Level C
90 F or above	After 45 minutes	After 15 minutes
87.5 to 90 F	After 60 minutes	After 30 minutes
82.5 to 87.5 F	After 90 minutes	After 60 minutes
77.5 to 82.5 F	After 120 minutes	After 90 minutes
72.5 to 77.5 F	After 150 minutes	After 120 minutes

F – Degrees Fahrenheit
*Adjusted air temperature (F) = observed temp + (0.13 x percent sunshine)
Observed temp = air temperature measured with bulb shielded from radiant heat.
Percent sunshine = the time sun is not covered by clouds thick enough to produce a shadow (100 percent = no cloud cover and a sharp, distinct shadow; 0 percent = no shadows).

Heart rate: Count the radial pulse during a 30-second period as early as possible in the rest period. If the heart rate exceeds 110 beats per minute at the beginning of the rest period, shorten the next work cycle one-third and keep the rest period the same. If the heart rate exceeds the 110 beats per minute at the next rest period, shorten the following work cycle by another one-third and also monitor oral temperature.

Oral temperature: Use a clinical thermometer (3 minutes under the tongue), temperature strip or ear thermometer to measure the temperature at the end of the work period (before drinking). If the temperature exceeds 99.6 F, shorten the next work cycle by one-third without changing the rest period. If the temperature exceeds 99.6 F at the beginning of the next rest period, shorten the following work cycle by one-third. ***DO NOT*** allow a field team member to wear USEPA Level C protection when the measured temperature exceeds 100.6 °F.

Personnel will pay particular attention to the information in this section in order to recognize the symptoms of heat stress and the appropriate action to take upon recognition. Even though physiological monitoring is not always necessary, it is essential that personnel understand the significance of heat stress and its recognition.

Symptoms that indicate **heat exhaustion** are:

- Clammy skin
- Weakness, fatigue
- Lightheadedness
- Confusion
- Slurred speech
- Fainting
- Rapid pulse
- Nausea (vomiting)

If these conditions are noted, the following steps should be taken:

- Remove the victim to a cool and uncontaminated area
- Remove protective clothing
- Give water to drink, if conscious.

Symptoms that indicate **heat stroke** include:

- Staggering gait
- Mental confusion
- Hot skin, high temp (yet may feel chilled)
- Convulsions
- Unconsciousness
- Incoherent, delirious

If heat stroke conditions are noted, immediately perform the following steps:

- Remove victim to a cool, uncontaminated area

- Cool the victim, whole body, with water, compresses and/or rapid fanning
- Give water to drink, if conscious
- Transport the victim to the designated medical facility for further cooling and monitoring of body functions. ***HEAT STROKE IS A MEDICAL EMERGENCY***!

Sunburns are another hazard of performing outdoor work. If hard hats are not necessary, team members should consider a brimmed hat and possibly neck flaps. Many weather reports now include an ultraviolet index to aid in the determination to apply sunscreen. When using sunscreen it is important to get one with a sun protection factor of about 30. Apply the sunscreen at least 30 minutes prior to going outdoors and reapply during the day. The OSO is responsible for ensuring that sunscreen is brought to the site and available for use.

Cold Stress

On days with low temperatures, high winds, and humidity, anyone can suffer from the extreme cold. Severe cold exposure can be life threatening. Several factors increase the harmful effects of cold: being very young or very old, wet clothing, having wounds or fractures, smoking, drinking alcoholic beverages, fatigue, emotional stress, and certain diseases and medications.

Cold weather injuries may be local or systemic. Local cold weather injuries include chilblains (chronic injury of the skin and peripheral capillary circulation) and frostbite. Frostbite occurs in three progressive stages: frostnip, superficial frostbite, and deep frostbite. Systemic cold injuries, due to hypothermia, are those that affect the entire body system. Hypothermia is caused by exposure to cold and is aggravated by moisture, cold winds, fatigue, hunger and inadequate clothing or shelter. Precautionary measures that will be taken include:

- Providing field shelters or wind screens.
- Monitoring temperature and wind speed to determine appropriate cold stress personal safety measures.
- Adjusting work schedule based on weather conditions and temperature.
- Providing insulated clothing for field workers.
- Adhering strictly to the buddy system so that workers can assess cold stress symptoms in their co-workers.

Frostbite Monitoring. Frostbite is a potentially crippling condition that can occur when inadequately protected skin or body parts are subjected to freezing weather. All team members should continually be alert for signs of frostbite in coworkers and bring it to the attention of the OSO. A cold feeling, pain, and numbness precede the onset of frostbite. Frostbite usually appears as gray or white waxy spots on skin. Areas most susceptible are nose, ears, and cheeks. The following steps should be taken to avoid frostbite:

- Dress warmly (avoid cotton, wear polypropylene, wool, gortex or other moisture wicking materials instead).
- Wear layers of clothes.
- Keep boots and gloves loose-fitting.
- Stay dry; carry extra clothing.
- Avoid touching cold metal with bare hands.
- Avoid spilling cold fuel, alcohol, or other liquids that freeze below 32 degrees F on your body or clothing.

If a person suffers frostbite, get them to a hospital as soon as possible. If transport to a hospital is not immediately available, get the person to a warm shelter and immediately perform the following:

- Cover exposed areas with additional clothing while still exposed to the elements.
- Wrap the person in blankets or a sleeping bag.
- Give the person warm drinks (no liquor).
- Undress the frozen part and submerge the frozen part in a tub of warm water (102° F to 105°F), or put the frostbitten person in a large tub of warm water, if available, and stir the water.
- Warm with skin to skin contact, such as placing warm hands on frozen nose or ears, but do not rub.
- Get the person to a hospital as soon as possible.

Do ***not*** allow the following to occur:

- Do not rub the frozen part.
- Do not give the person liquor.
- Do not allow the person to walk on thawed feet.
- Do not let the person smoke.
- Do not break any blisters that may form.
- Do not let the thawed part freeze again.
- Do not warm the frozen part in front of a source of dry heat (open fire, oven, etc.).

Hypothermia Monitoring. Hypothermia is a lowering of the body's temperature due to exposure to cold or cool temperatures. All team members should continually be alert for signs of hypothermia in co-workers and bring it to the attention of the OSO. Most cases of hypothermia occur at temperatures between 30 degrees F and 50 degrees F. If not properly treated, hypothermia can cause death. Safety equipment for hypothermia should include a synthetic sleeping bag and a hypothermia thermometer. ***HYPOTHERMIA IS A MEDICAL EMERGENCY!*** Transport to a hospital as soon as possible, even if victim appears to be recovering.

To prevent hypothermia:

- Eat well prior to exposure.
- Dress warmly (avoid cotton, wear polypropylene, wool, gortex or other moisture wicking materials instead).
- Avoid becoming wet due to sweating, rain or snow, or falling in water.

Early signs of hypothermia may include:

- Violent shivering.
- Slurred speech.
- Decrease in coordination.
- Confusion, inability to answer simple questions.
- Unusually irritable behavior.

- Strange behavior.
- Tendency to drop or lose clothing or equipment.

As hypothermia progresses into more serious stages victims typically:

- Develop trouble seeing clearly.
- Become sleepy and numb.
- Move with difficulty.
- Eventually become unconscious, if not properly cared for.

The following actions should be taken to treat a hypothermia victim:

- Get the victim to a warm, dry shelter as soon as possible.
- Remove any wet or cold garments and dry the person thoroughly.
- Wrap the victim in blankets, sleeping bags or dry clothing to prevent more heat loss.
- If a warm area is not available:
    - Build a shelter and put the victim in the warmest, driest area available.
    - Remove any wet or cold garments.
    - Have one or more persons remove their clothing and lay next to the victim, providing skin to skin contact.
    - Wrap the victim and rescuers in dry warm blankets, sleeping bags or clothing.
    - When the victim becomes conscious, place warm objects along the victim’s sides to warm vital areas.
- When the victim is able to swallow easily, provide warm, sweetened drinks and food (preferably candy or sweetened food).
- Do not give the victim alcohol or allow to smoke.
- Do not rub the victim’s skin.
- Keep checking the victim and give additional assistance as needed.

6.1.6 Severe Weather

While each project site will be subject to varying types of weather conditions, this section provides general information and controls on several types of severe weather.

Lightning. If a lightning storm is suspected or observed, all site activities must be stopped, and site equipment must be evaluated for its potential for acting as a lightning rod. Drill rig masts provide conduits for lightning to strike and injure workers. Personnel should wait indoors for the storm or lightning event to end. If the strike of lightning occurs and personnel are out in the field, the response should be to disband from one another and lay low to the ground by dropping to your knees and bending forward with your hands wrapped around your knees, away from any poles or trees.

Persons struck by lightning receive a severe electrical shock and may be burned, but they carry no electrical charge and can be handled safely. Someone who appears to have been killed by lightning often can be revived by prompt action. Those unconscious but breathing probably will recover spontaneously. First aid and CPR should be administered as appropriate until medical assistance arrives. Realize that victims who appear to be only stunned or otherwise unhurt also need attention. Check for burns, especially at fingers and toes and next to metal buckles, jewelry, or personal items that the victim is wearing. Remember to treat for shock.

Tornadoes. Tornadoes usually develop from thunderstorms and normally occur at the trailing edge of the storm. Most tornadoes occur in the months of May, June, and July in the late afternoon and early evening hours. When storms are predicted for the project areas, monitor weather conditions on a radio. A tornado watch is issued when favorable conditions exist for the development of a tornado. A tornado warning is issued by the local weather service office whenever a tornado has actually been sighted or is strongly indicated by radar.

If a tornado warning is issued, seek shelter immediately. If there are permanent buildings located on site, go there immediately, moving toward interior hallways or small rooms on the lowest floor. If you are in a vehicle or a site trailer, leave and go to the nearest building. If there are no buildings nearby, go in the nearest ditch, ravine, or culvert, with your hands shielding your head. If a tornado is sighted or a warning issued while you are in open country, lie flat in a ditch or depression. Hold onto something on the ground, such as a bush or wooden fence post, if possible.

Once a tornado has passed the site, site personnel are to assemble at the designated assembly area to determine if anyone is missing or injured. Administer first aid and seek medical attention as needed.

Winter Storms. When snow or ice storms are predicted for the project area, site personnel should monitor radio reported weather conditions. A winter storm watch is issued when a storm has formed and is approaching the area. A winter storm warning is issued when a storm is imminent and immediate action is to be taken.

When a storm watch is issued, monitor weather conditions and prepare to halt site activities. Notify the project manager of the situation. Seek shelter at site buildings or leave the site and seek warm shelter. If you are caught in a severe winter storm while traveling, seek warm shelter if road conditions prevent safe travel. If you are stranded in a vehicle during a winter storm:

- Stay in the vehicle. Disorientation comes quickly in blowing and drifting snow.
- Wait for help.
- Keep a window open an inch or so to avoid carbon monoxide poisoning.
- Run the engine and heater sparingly.
- Keep watch - do not let everyone sleep at the same time.
- Exercise occasionally.

6.1.7 Ionizing Radiation

The gamma survey meter will be used to augment the personal exposure monitoring. Geiger Mueller Counter/Eberline H-260 zinc sulfide probe will be used to monitor alpha radiation. If the radiation is found twice the background level, the area will be misted with water to reduce the risk of particle inhalation, and a full face Air Purifying Respirator with a P-100 cartridge will be donned. The action level shall not exceed 2 milliRem per hour at any time. In addition, gross alpha particles usually adhere to solids, therefore dust generation should be minimized during field activities. (See the Radiation Protection Program - Appendix B) for detailed discussion of radiological hazards and monitoring procedures.

6.1.8 Traffic Safety

Where exposed to vehicle traffic, it is necessary for employees on foot to remain aware of vehicle traffic and to wear a high-visibility safety vest. Where Stantec or contractor employees must block active roadways to perform their work activities, personnel will establish traffic control in accordance with the Department of Transportation Manual on Uniform Traffic Control Devices, Part IV. (See http://mutcd.fhwa.dot.gov/pdfs/2003/Ch6A-E.pdf or contact the Stantec Project Manager for assistance.)

6.2 THE BUDDY SYSTEM

The “buddy” system will be used at all times when employees are within an exclusion or contamination reduction zone. The “buddy” system is a method of organizing work groups so that there is someone that is always available to:

- Provide his or her partner with assistance in an emergency.
- Observe his or her partner for signs of chemical or physical exposure.
- Periodically check the integrity of his or her partner’s PPE.
- Notify the emergency response personnel when an emergency situation occurs.

The “buddy” system usually requires that two or more people work within visual range from one another. However, the “buddy” system can include radio contact if site conditions are such that a person could otherwise work alone. In order to deviate from the “buddy” system, an explanation of the specific task to be completed is required, along with a procedure for assuring that single person work parties are safe. Any deviations from the “buddy” system as it is described here will be presented.

6.3 SITE WORK ZONES

USEPA suggests that contaminated work sites be divided into three working zones: exclusion (hot or work) zone, CRZ, and support (cool) zone. Site work zones are discussed below.

6.3.1 Exclusion Zone

The exclusion zone is the zone where contamination or potential contamination exists. Because this zone has the potential for workers to be exposed to contaminants, all field staff entering this zone will wear the appropriate PPE, and adhere to the training and medical surveillance requirements presented in Sections 7 and 9 of this document. Field personnel will enter and exit the exclusion zone through an identified entry/exit point. Gross decontamination will take place near the “hotline,” before proceeding to the CRZ. The exclusion zone will be demarcated by using lines, traffic cones, hazard tape and/or signs, or enclosed by physical barriers, such as chains, fences or ropes.

6.3.2 Contamination Reduction Zone

The CRZ is either a zone or the entry/exit point of the exclusion zone where field staff and equipment will undergo gross decontamination. This zone or point is located between the exclusion and support zones. The CRZ will serve as a buffer to further reduce the probability of the clean zone becoming contaminated or being affected by other existing hazards. In most Level D projects, the CRZ is simply the entry/exit point to the exclusion zone. In Levels C or B it is an actual zone.

Initially, the CRZ will be considered to be a noncontaminated area. As operations proceed, the area around the decontamination station may become contaminated, but to a much lesser degree than the exclusion zone. At the boundary between the exclusion and the CRZ, decontamination stations will be established, one for personnel and one for heavy equipment. Personnel assisting with decontamination will wear a level of PPE at or one below that used by personnel in the exclusion zone.

6.3.3 Support Zone

The support zone, the outermost part of the regulated area, is free from recognized site hazards. Support equipment such as a command post, site vehicles, and paperwork stations will be located in this area. Since normal work attire is appropriate within this zone, potentially contaminated personal protective clothing, equipment and un-containerized samples will not be permitted.

The location of support facilities in the support zone should be set up, to the extent possible at the site, upwind, uphill and where people would logically congregate in an emergency evacuation scenario. When the CRZ is actually a zone, specific entry and exit points shall be identified from the support zone.

6.3.4 Site Security

Site control at project sites will vary from no controls to strict property perimeter controls. When possible, Stantec personnel will be requested to investigate any suspicious activities at the field sites. In some cases an independent security watch may be needed. Security at the sites will be the responsibility of Stantec during nonactivity times (including weekends).

To maintain security at the sites during working hours, the OSO will:

- Control all site entrances/exits through the support zone via appropriate barricades, signs, and/or signal lights.
- Require field team members to sign in on the daily tailgate safety meeting form and require visitors to sign in on the visitor log.
- Utilize temporary fencing, where feasible and necessary.
- Post warning signs around the perimeter of the support zone, should the use of temporary fencing be infeasible or insufficient.

To maintain security during nonworking hours, the OSO will secure the site prior to leaving at the end of a working day. All equipment and supplies will be secured or stored in locked facilities, and open holes and trenches will be covered with plywood or similar materials.

6.3.5 Communication Systems

Two general types of communications systems should be available for all workers assigned to field projects. One system will ensure adequate communication between site personnel, and the other will ensure the ability to contact personnel and emergency assistance off the site. On-site communications are generally audible and/or visual. Off-site or communications among several sites at one project location or property is usually accomplished with electronic devices such as radios or cell phones. Any deviations from these standard modes of communication must be pre-arranged.

Common types of internal communications include conversation, noisemakers (horns, bells) or hand signals. The common hand signals are provided below:

Signal	**Interpretation**
Hand gripping throat	Respirator problems, can’t breathe
Grip team member’s wrist or place both hands around waist	Leave site immediately; no debate!
Thumbs up	OK, I’m all right; I understand
Thumbs down	No, negative
Hands on face	Put on respirator

7.0 PERSONAL PROTECTIVE EQUIPMENT

Work conducted as part of a HAZWOPER program must meet a minimum level of personal protection. OSHA and the USEPA have identified standard levels of PPE, a description of USEPA Levels A, B, C and D are provided below of the standard part of this HSP. This section indicates the specific PPE ensembles for work at the site.

The proper selection, fit-testing, use, maintenance, disposal and limitations of each piece of PPE shall be reviewed during the training programs described in Section 4. These training topics should be reviewed periodically during tailgate safety meetings. All respiratory protective equipment, APR or supplied air respirators shall be National Institute for Occupational Safety and Health (NIOSH) approved. All footwear, hard hats and safety glasses/goggles shall be American National Standards Institute (ANSI) approved. There is no longer an OSHA prohibition for the use of contact lenses with respiratory protective devices. Individuals who feel that the contact lens provides them superior vision and comfort may use them on site and with respirators.

All of the work conducted at the site is anticipated to be completed in Level D PPE. Level C PPE information is provided herein in the event that site conditions warrant upgrade. Level B conditions will require work to stop until the situation is evaluated and an addendum prepared for work to continue safely.

The standard PPE ensemble for work is Level D as specified below. Tasks with a deviation from the standard are listed in the table, with only the changed information. If a sign posted by the OSO indicates that a piece of PPE is needed, obey the posted sign regardless of what the task is or the table below indicates.

7.1 STANDARD LEVEL D PPE

The following items must be available for use during all field programs. Individual items may not be necessary if the hazard is not present (e.g., no overhead machinery or hazards means no hard hat required, unless posted signs state the area as hard hat required, or moving heavy equipment is present). It is acceptable when exposures above occupational exposure limits are not anticipated, immersion or engulfment is not expected and the atmosphere contains between 19.5 and 22 percent oxygen.

The standard Level D PPE ensemble includes:

Item	Description
Boots	Steel-toed work boots or steel toed rubber or polyvinyl chloride (PVC) boots meeting ANSI or ASTM specifications.
Clothing	Dedicated work clothing includes long pants, long sleeve shirts, or coverall. Can be cotton, poly-cotton blend or Tyvek. If splashing occurs during well development or groundwater sampling, workers handling the task shall incorporate a coated tyvek coverall for that task only.
Gloves	Thin nitrile gloves (e.g., N-Dex) when handling potentially contaminated soil, water, debris, equipment or articles. Heavy work gloves are to be available for handling sharp objects or when using a sharp cutting tool.
Safety glasses	Side shields (plain or sun glass tint depending on brightness).
Hard hat	When overhead hazard or working around heavy equipment (ANSI Z89.1).
Safety vest	Brightly colored traffic-type safety vest when working in roadways or around moving heavy equipment.
Hearing protection	When working in areas where noise levels exceed 85 decibels on the “A” weighted scale (dBA). If unsure, have the task or area tested. A rule of thumb is having to shout to be heard at a distance of 3 feet.

The only recognized modified Level D PPE ensemble is a standard Level D ensemble changed to accommodate biological hazards (e.g., Hantavirus, bird droppings). If there is documented evidence or a strong likelihood that a microbial hazard exists, the need for respiratory protection (APR, half-face or full-face, with either a dust filter [any N, R or P series filter] or high efficiency particulate air [HEPA], now referred to as P100, filter) will be indicated. Otherwise, employees may opt to wear an APR to protect against potential microorganisms that may be present at the site.

7.2 STANDARD LEVEL C PPE

In the event that air monitoring indicates the need to upgrade into Level C PPE, additions shall be made to the existing standard Level D PPE ensemble. A half-facepiece or full-facepiece APR will be used in combination with organic vapor/acid mist/P100 (yellow stacked with purple cartridges). The cartridges should be changed at the end of every shift. Double gloves with thin Nitrile under thick Nitrile will be worn and taped to the sleeves of a disposable coverall. Either boot covers, with substantial tread, or PVC or rubber steel-toed boots will be worn, taped to a disposal coverall. A poly-coated Tyvek, or equivalent, coverall will be worn.

Item	Description
Boots	Steel-toed work boots or steel toed rubber or polyvinyl chloride (PVC) boots meeting ANSI or ASTM specifications.
Clothing	Chemical resistant coveralls as specified in Section 7.5. Cuffs duct-taped to hand and foot protection.
Gloves	Inner and outer chemical resistant gloves as specified in Section 7.5 to be used with work gloves and cut resistant gloves.
Safety glasses	Safety glasses with side shields or goggles (ANSI Z87.1). Faceshield over safety glasses or goggles, when saw cutting, working with pressure devices or when splash is likely. If corrective lenses are needed when wearing a full-face APR, brand-specific inserts must be purchased in advance.
Hard hat	When overhead hazard or working around heavy equipment (ANSI Z89.1).
Safety vest	Brightly colored traffic-type safety vest when working in roadways or around moving heavy equipment.
Hearing protection	When working in areas where noise levels exceed 85 decibels on the “A” weighted scale (dBA). If unsure, have the task or area tested. A rule of thumb is having to shout to be heard at a distance of 3 feet.

The following items must be available for use during all field programs. Individual items may not be necessary if the hazard is not present (e.g., no overhead machinery or hazards means no hard hat required, unless posted signs state the area as hard hat required, or moving heavy equipment is present). It is acceptable when exposures above occupational exposure limits are not anticipated, immersion or engulfment is not expected and the atmosphere contains between 19.5 and 22 percent oxygen.

7.3 STANDARD LEVEL B PPE

(Note: Stantec Personnel are not authorized to don Level B PPE). Level B PPE is not anticipated to be required for use during the field work. However, in the event that site conditions change and the use of Level B becomes warranted, a specialty contractor will be subcontracted to provide assistance with the Level B equipment and work tasks. Level B protection shall be used as either the initial level of PPE or when action levels specified in Section 7.5 indicate the need to upgrade from the initial level prescribed. Level B is appropriate when the types of air contaminants have not been fully identified, but skin exposure is not considered significant. This includes immediately dangerous to life and health (IDLH) and oxygen deficient atmospheres.

The standard Level B PPE ensemble generally uses the standard Level C ensemble but changes to supplied air respiratory protective equipment. The supplied air equipment can be airline or self-contained breathing apparatus; however, both require the use of an emergency egress bottle. An electronic communication system should also be considered if the line of sight method of keeping track and talking will not work. Use of Level B PPE requires that at least one person be available as a backup, ready to provide emergency assistance and to assist with the air supply.

7.4 STANDARD LEVEL A PPE

Level A is not permitted under this HSP. Should Level A conditions arise, work shall stop and an amendment to this HSP developed to adequately address the increased hazards, protective gear and site personnel.

7.5 EXPOSURE ASSESSMENT AND AIR MONITORING

This section describes the exposure assessment methodology for field work. Cartridge change-out schedules are based in part on the USEPA Personal Protection and Safety document, *Chapter 2 Air-Purifying Respirators* and the studies conducted on generic cartridges. The common pieces of instrumentation are listed below.

- Radiation survey meter capable of measuring gross alpha radiation
- Personal air sampling pumps equipped with filter media for particulate sampling
- Thermoluminescent detectors
- Dust meter (possibly)
- Sound Level Meter or Dosimeter (possibly)

While the contamination at the site poses an environmental hazard, the concentrations of the chemicals are not in the range to pose a significant occupational health hazard (i.e., they are below OSHA, NIOSH, and American Conference of Governmental Industrial Scientists [ACGIH] exposure limits). See the RPP for discussion of radiological monitoring.

Activity	Instrument	Action Level
Site Reconnaissance Walks, Radiological Surveying	▪ Radiation survey meter.	1. Radiation survey meter ▪ At 2 times background level upgrade to Level C. ▪ At 2 milliRem per hour stop work and contact the PSO. ▪ Implement dust suppression during all activities, as needed, to lower gross alpha concentration
Excavation/trenching, Rig Drilling, Soil Sample Collection, Well Installation	▪ Radiation survey meter. ▪ Noise meter if not automatically wearing hearing protection. ▪ Dust meter if visible dust cannot be controlled. ▪ Personal dust monitor	2. Radiation survey meter ▪ At 2 times background level upgrade to Level C. ▪ At 2 milliRem per hour stop work and contact the PSO. ▪ Implement dust suppression during all activities, as needed, to lower gross alpha concentration. 3. Dust: If unable to control visible dust, implement dust suppression (e.g., water spray). If still visible get dust meter and upgrade to Level C. At 10 milligrams per cubic meter (mg/m^3) stop work and contact the PSO. 4. Noise: > 85 dBA wear hearing protection.

Activity	Instrument	Action Level
Groundwater Well Development, Hydraulic Testing, Groundwater Sampling	▪ Radiation survey meter. ▪ Noise meter if not automatically wearing hearing protection ▪ Dust meter if visible dust cannot be controlled	5. Radiation survey meter ▪ At 2 times background level upgrade to Level C. ▪ At 2 milliRem per hour stop work and contact the PSO. ▪ Implement dust suppression during all activities, as needed, to lower gross alpha concentration. 6. Dust: If unable to control visible dust, implement dust suppression (e.g., water spray). If still visible get dust meter and upgrade to Level C. At 10 milligrams per cubic meter (mg/m^3) stop work and contact the PSO. 7. Noise: > 85 dBA wear hearing protection.

7.6 ACTIVITY HAZARD ANALYSIS

Activity Hazard Analyses summarize the text herein and identify specific physical hazards associated with site tasks. Attachment A presents the quantified hazard assessment (RMS-07) for the drilling and sampling work task.

8.0 PERSONNEL AND EQUIPMENT DECONTAMINATION

Decontamination procedures are implemented to control potential migration of chemicals or other site contaminants to clean areas, and to prevent personnel exposure to chemicals or pathogens that may contaminate clothing or protective gear. ***Personnel entering exclusion zones during field activities must decontaminate upon exit from the exclusion zone.*** Any material that is generated during decontamination procedures will be labeled and stored until final disposal arrangements are made.

Standard decontamination materials and procedures are included in this section. Deviation from the standard protocol will be identified.

8.1 PERSONNEL DECONTAMINATION

All personnel will go through decontamination before leaving the exclusion zone. This requires that at a minimum, people wash their hands (and face optional) with soap before eating, drinking (unless specific procedures are in place to ensure that a drink can be taken without the possibility of contamination), and before leaving the CRZ or line. Personnel also will go through decontamination if their protective clothing becomes torn. Personnel may return to the exclusion zone after changing into clean protective gear. The standard decontamination procedures for Level D and Level C field work are provided in Table 2. Typical materials needed for decontamination include the following:

- Plastic sheeting or trash bags to place things on
- Plastic buckets
- Spray bottles for soap and water
- Long handled, soft bristled brushes
- Hand soap
- Detergent like Alconox
- Water
- Paper towels
- Clean sealable plastic bags for respirator storage
- Steam cleaning equipment

8.2 GENERAL DECONTAMINATION PROCEDURES

The following decontamination procedures and guidelines shall be implemented:

- Detailed sampling for residual radiological contamination is discussed in the RPP (Appendix B).
- Any respirators used will be inspected and washed in soapy water, if necessary, at least at the end of each work shift. All respirators used will be disinfected with sanitary wipes or sanitizer solution every day. All respirators will be stored in sealable plastic bags in a location that is free from chemical or biologic hazards and temperature extremes.
- The decontamination sequence will be designed to prevent or minimize direct contact with waste materials.

- Use of disposable protective clothing will eliminate the need for extensive decontamination procedures and subsequent evaluation of the effectiveness of decontamination procedures. Thus, disposable items shall be chosen when feasible.
- Nondisposable clothing will either be decontaminated on site or taken offsite for laundering.

8.3 EMERGENCY DECONTAMINATION

It is not anticipated that emergency decontamination of heavy equipment will be necessary. Emergency decontamination of site personnel may be necessary for medical reasons or in the event of major contamination by contact with contaminated material. Emergency procedures will include:

- Assistance by on-site personnel for removal of contaminated protective clothing.
- If the employee is injured and cannot be moved, attempts will be made to cut away any contaminated clothing for removal.
- If the situation is life-threatening, decontamination or removal of protective clothing must still be considered. Many hospital emergency rooms and ambulance services will not risk putting the facility out of service due to decontamination issues. Thus, in order to minimize the spread of contaminants, contaminated personnel will be wrapped in blankets and/or plastic sheeting (maintaining an open airway) during transport to the emergency treatment facility. Emergency personnel will be notified of the nature of the contaminated material so that necessary protective measures can be taken by emergency personnel.
- If the employee can walk or be moved without injury, all affected skin areas should be washed thoroughly with soapy water and rinsed.
- Equipment will be disposed in appropriate collection containers.

8.4 EQUIPMENT DECONTAMINATION

Equipment used in the exclusion zone in areas where contact with site contaminants is likely will be protected from contamination by measures such as enclosure in plastic bags, or by preventing contact with contaminated materials. Equipment decontamination will be determined by the nature and extent of contamination. Employees engaged in equipment and vehicle decontamination will wear adequate PPE to protect from splashes.

Heavy equipment and vehicles involved with site work or construction associated with potentially contaminated material will be decontaminated in a designated decontamination area. In some cases a centralized decontamination pad will be available and will require gross decontamination (brushing off mud or clumps) in the exclusion zone. Most pieces of heavy equipment are steam cleaned.

8.5 DECONTAMINATION WASTE HANDLING AND DISPOSAL

Wastes generated as a result of site activities will be handled in accordance with applicable environmental regulations. Unless otherwise specified, water used during personnel decontamination activities will be considered contaminated. Investigation derived wastes and contaminated site materials will be handled and disposed of in accordance with the provisions of an accompanying work plan or Stantec specifications. Unless, specifically stated, personnel are to treat decontamination wastes as part of the investigation or remediation derived wastes. If in doubt about what to do, ask the OSO.

9.0 MEDICAL SURVELLIANCE

All personnel entering the exclusion or contamination reduction zones as defined in this HSP must be actively participating in a medical surveillance program tailored to hazardous waste operations, respiratory protection, hearing conservation and any site-specific substance-specific standards (e.g., radiation). These standards have been referenced in Section 4 above for the training requirements and anything listed as a unique site condition that varies from the standard protocol.

9.1 PROGRAM ADMINISTRATION

Stantec's medical surveillance program may be administered by WorkCare, an occupational medical consulting firm directed by a licensed physician, or other occupational medical service. WorkCare can be reached at:

WorkCare

333 South Anita Drive

Orange, California 92868

800-455-6155

Contractors and other site personnel shall participate in an equivalent program overseen by a licensed physician who is certified in Occupational Medicine by the American Board of Preventive Medicine, or who by necessary training and experience is Board-eligible. The medical surveillance examinations, and necessary consultations, are provided at no cost to employees.

The medical surveillance program includes the following types of examinations:

- Initial, prior to hazardous waste site activities.
- Periodic, usually annually, bi-annually for people in the field less than 30 days per year.
- Upon termination.
- Following exposure or injury.
- Additionally, as necessary, on a case-specific basis.

Prior to the examination, employees are required to complete Medical Surveillance Forms, including the OSHA Respirator Medical Evaluation Questionnaire. Examinations are scheduled by WorkCare or other occupational medical service at clinics set up to process employees in accordance with a standard protocol and send biological samples to a contracted laboratory. Each examination record is reviewed by a WorkCare or other occupational health physician. Upon completion of each examination and review, a Health Status Report is issued that signifies the person is fit for duty, not fit for duty or has restrictions. A copy of the Health Status Report (or subcontractor's fitness for duty form) shall be kept in a file maintained by the OSO at the site, in addition to the home office master employee file. The home office file copy of the Health Status Report is kept for the duration of employment plus an additional 30 years.

An injury or illness (whether on or off the job) may require work restrictions after the employee returns to work. If the injury or illness required seeing a physician, either the attending physician or the physician giving the employment physical will be involved in the decision of when the employee will return to work, and if any work restrictions will apply.

9.2 STANDARD EXAMINATION PROTOCOL

The standard hazardous waste site medical surveillance examination consists of the following elements:

- Occupational and Personal Medical History Questionnaire
- Physical examination performed by a medical doctor
- Testing of vital signs
- Pulmonary Function Test
- Vision Test
- Audiogram
- X-Ray (typical frequency is every 3 years)
- Resting Electrocardiogram (EKG) (typical frequency is every 3 years)
- Laboratory blood tests
- Laboratory urine tests

9.3 NON-STANDARD EXAMINATION PROTOCOL

Any non-standard protocols will be listed. Some common non-standard examination elements include:

- Substance-specific testing (e.g., lead/zinc protoporphyrin, asbestos).
- Radiation counts.
- Optional immunizations for working with sewage (e.g., Hepatitis A, Hepatitis B, Tetanus).
- International travel vaccines.
- Tests consistent with employee complaints of exposure to chemicals of concern at the site.
- Substance abuse testing –Stantec and contractor employees will adhere to a strict Substance Abuse Policy. The substance abuse testing program is administered by WorkCare.

9.4 EMERGENCY MEDICAL ASSISTANCE AND FIRST AID

Prior to work start-up, an emergency medical assistance network will be established. The Fire Department, ambulance service, and clinic or hospital emergency room are identified in Section 10 of this HSP. A vehicle shall be available on site during all work activities to transport injured personnel to the identified emergency medical facility if an ambulance is clearly not needed.

The OSO shall ensure that, when necessary, an ample supply of the following is available for all site personnel:

- Insect repellent, with active ingredient N,N-diethyl-m-toluamide (DEET) at about 30 percent.
- Ivy Block, Tecnu, or equivalent, barrier or washing cream for work around poison ivy, poison oak or poison sumac as well as itch relief products.
- Sunscreen with sun protection factor of at least 30.
- Electrolyte replacing fluids such as Gatorade, Squencher, etc.

The OSO and at least one other field team member will be certified to render both first aid and CPR. A first aid kit, including necessary protection against bloodborne pathogens, will be available at each site for use by trained personnel. Table 3 presents a list of first aid supplies that should be available for use during field work. An adequate supply of fresh potable water for emergency eye wash purposes or a portable emergency eyewash, also will be available at each site.

10.0 EMERGENCY CONTACT INFORMATION

ALWAYS PROVIDE YOUR EXACT LOCATION TO A 911 OPERATOR

The Project Manager, or designee, will be responsible for taking necessary action and contacting the appropriate emergency contacts (e.g., Stantec Project Manager, contractor) and Stantec or contractor employees in the event of an emergency. The following are contacts for emergencies that may occur during fieldwork activities at St. Anthony:

10.1 SITE-SPECIFIC INFORMATION

Site Location: St. Anthony Mine Site

Cibola County, New Mexico

4.6 miles SE of Seboyeta, New Mexico

10.2 24-HOUR EMERGENCY HOSPITAL

Cibola General Hospital 1016 E. Roosevelt

Grants, NM 87020

Phone: (505) 287-4446

(25 miles West of Seboyeta, NM)

Directions. Take County Road 5 and State Route 279 to Route 66. Continue on Route 66 to Interstate 40 (I-40). Go west on I-40/Route 66 to East Santa Fe Ave., go north on E. Santa Fe Ave, to Route 66, go east on Route 66, then north (left) on Sakalares Blvd., then left on Roosevelt to 1016 East Roosevelt.

SITE SPECIFIC HEALTH AND SAFETY PLAN

EMERGENCY CONTACT INFORMATION
February 26, 2018

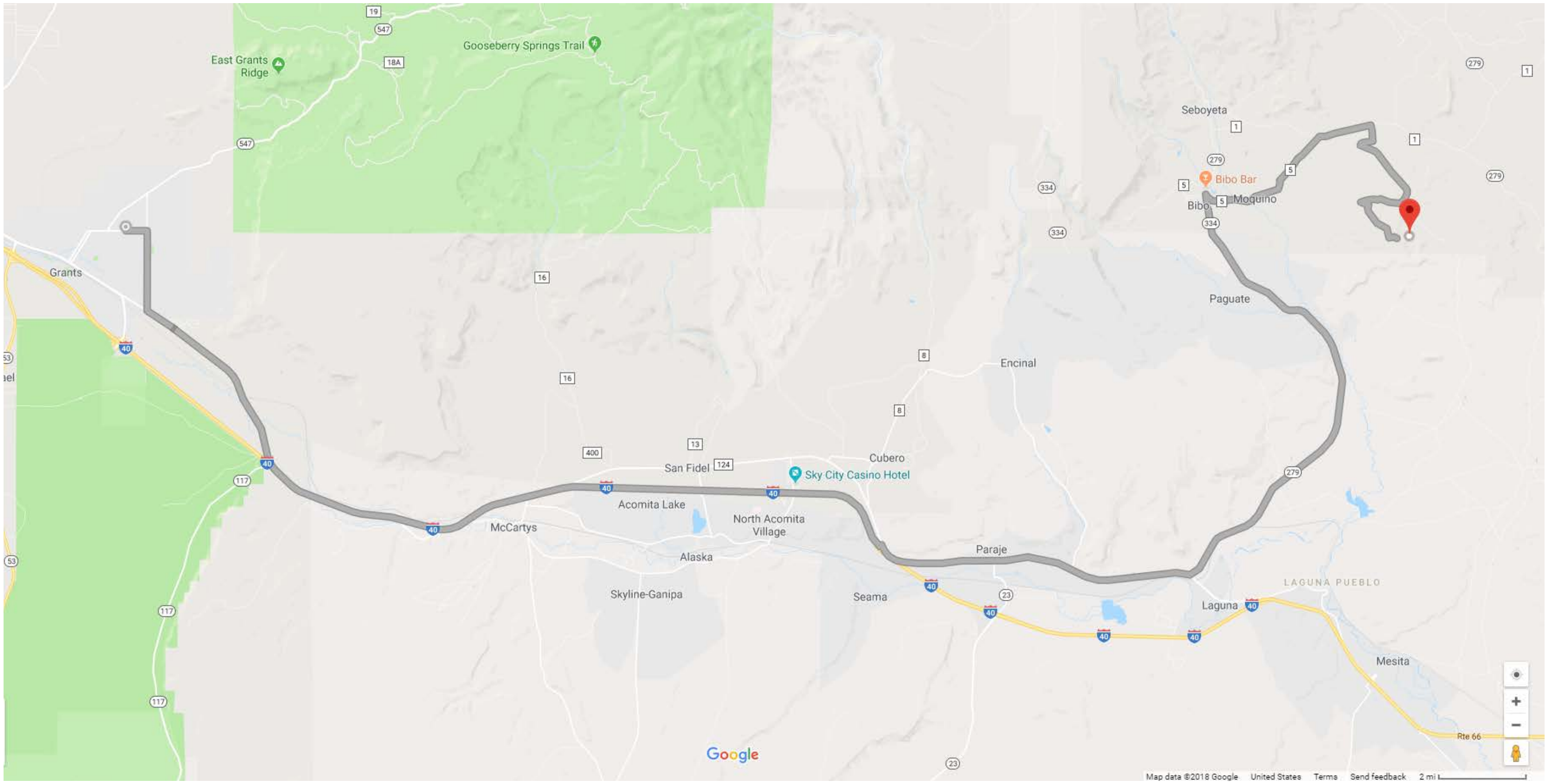

Figure 1 - Route to Hospital

10.3 STANTEC AND CONTRACTOR PERSONNEL CONTACT LIST

Personnel and Emergency Reporting

Position	Name	Phone Number(s)
Project Manager	Melanie Davis	(970) 212-2749 (Work) (970) 214-6403 (Cell)
OSO	Cameron Fritz Tom Osborn	(970) 212-2759 (Work) (907) 947-2225 (Cell) (801) 617-3327 (Work) (801) 243-7613 (Cell)
Project Health and Safety Manager	Randy Jones	(303) 533-1919 (Work) (907) 707-9305 (Cell)
RSO	AVM	(505) 287-4593 (Work) (505) 290-0737 (Cell)
Corporate H&S Reporting for accidents/injuries/illness	AllOne Health	(800) 350-4511 (24-hour number)

10.4 24-HOUR EMERGENCY HOSPITAL

Emergency Contact Numbers

Ambulance	911
Fire Department	911
Police Department	911
Poison Control	800-876-4766
National Response Center	800-424-8802
Utilities Underground Service Alert	800-227-2600

11.0 REFERENCES CITED

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TABLES

TABLE 1

OCCUPATIONAL HEALTH EXPOSURE AND TOXICOLOGICAL PROPERTIES FOR CONTAMINANTS OF OCCUPATIONAL HEALTH CONCERN

CONTAMINANT	OSHA PEL	NIOSH REL	ACGIH TLV	ACGIH/OSHA STEL	OSHA/ NIOSH IDLH	IP eV	Vapor Pressure (mmHg)	Route of Exposure	Symptoms of Exposure
ARSENIC (CAS 7440-38-2)	0.005 mg/m^3	C 0.002 mg/m^3 Ca	0.01 mg/m^3	NA	NA	NA	NA	INH, ING, CON, ABS	Ulceration of nasal septum, dermatitis, gastro-intestinal disturbances, peripheral neuropathy, respiratory irritant, hyperpigmentation of the skin, CARCINOGEN
DUST, TOTAL	15 mg/m^3	NA	NA	NA	NA	Depends on compound	Depends on compound	INH, CON	Nuisance, may cause sneezing or itchy eyes
DUST, RESPIRABLE	5 mg/m^3	NA	NA	NA	NA	Depends on compound	Depends on compound	INH, CON	Nuisance, may cause sneezing, coughing, or itchy eyes
MOLYBDENUM (soluble) (CAS 7439-98-7)	5 mg/m^3	NA	0.5 mg/m^3	NA	1000 mg/m^3	Depends on compound	NA	INH, ING, CON	In animals: irritation eyes, nose, throat; anorexia, diarrhea, weight loss; listlessness; liver, kidney damage
RADON (See RPP)	ALARA	NA	NA	NA	NA	NA		INH	CANCER
SELENIUM (CAS 7782-49-2)	NA	0.2 mg/m^3	0.2 mg/m^3	NA	1.0 mg/m3	NA	0	INH, ING, CON	Irritation eyes, skin, nose, throat; visual disturbance; headache; chills, fever; dyspnea (breathing difficulty), bronchitis; metallic taste, garlic breath, gastrointestinal disturbance; dermatitis; eye, skin burns; in animals: anemia; liver necrosis, cirrhosis; kidney, spleen damage
URANIUM (CAS 7440-61-1)	0.05 mg/m^3	0.05 mg/m^3	0.2 mg/m^3	0.6 mg/m^3	10 mg/m^3	NA	0	INH, ING, CON	Dermatitis; kidney damage; blood changes; [potential occupational carcinogen]; in animals: lung, lymph node damage [Potential for cancer is a result of alpha-emitting properties & radioactive decay products (e.g., radon).]

CONTAMINANT	OSHA PEL	NIOSH REL	ACGIH TLV	ACGIH/OSHA STEL	OSHA/ NIOSH IDLH	IP eV	Vapor Pressure (mmHg)	Route of Exposure	Symptoms of Exposure
VANADIUM (CAS 7440-62-2)	0.1 mg/m^3	0.05 mg/m^3	NA	NA	35 mg/m^3	NA	0	INH, ING, CON	Irritation eyes, skin, throat; green tongue, metallic taste, eczema; cough; fine rales, wheezing, bronchitis, dyspnea (breathing difficulty)

Key:

%	percent
A1	ACGIH notation for a confirmed human carcinogen
ABS	Absorption
ACGIH	American Conference of Governmental Industrial Hygienists
C	Ceiling REL
Ca	Carcinogen
Con	Contact
IDLH	Immediately Dangerous to Life and Health
Ing	Ingestion
Inh	Inhalation
LFT	Lowest Feasible Concentration
mg/m3	milligrams per cubic meter
NIOSH	National Institute for Occupational Safety and Health
NL	Not Listed
OSHA	Occupational Safety and Health Administration
PEL	Permissible Exposure Limit (8-hour TWA)
ppm	parts per million
REL	Recommended Exposure Limit
ST	Designated STEL preceding the value
STEL	Short Term Exposure Limit (15-minute TWA)
TLV	Threshold Limit Value
TWA	Time–Weighed Average.

TABLE 2

TYPICAL LEVEL D AND LEVEL C DECONTAMINATION APPROACH

	Purpose	Equipment	Discussion
Step 1:	Equipment Drop	Plastic Bucket or Trash Bag	Deposit equipment in plastic bucket, or in or on a trash bag to segregate from other equipment.
Step 2:	Gross Decontamination	Stiff Brush and/or Stick	Remove visible mud or other muck from outer clothing or equipment.
Step 3: (Option 1)	Hand Washing	a) Spray Bottle with Soap Solution b) Spray Bottle with Water c) Paper Towels	This setup is used most often for projects where field activities take place in multiple locations in one day.
Step 3: (Option 2)	Hand Washing	a) Bucket with Clean Water b) Soap Dispenser c) Paper Towels	This setup is used most often on sites where work will take place in one location for at least one day. The supplies are usually set up on a table at the “step-off” decontamination line.
Step 3: (Option 3)	Hand Washing	Baby Wipes	This option is used for projects where cold weather prohibits the use of water and hands are covered with both impermeable gloves and cold weather gloves.
Step 4:	Disposable PPE Drop	Trash Bags	This station is used to discard disposable gloves, coveralls, ear plugs, respirator cartridges, etc.

Note:

These steps are generally considered for personnel conducting environmental sampling. Any or all of these steps may be eliminated for personnel conducting site observations that do not contact equipment or potentially contaminated environmental media.

TABLE 3

EMERGENCY SUPPLIES

FIRST AID SUPPLIES

Container that will ensure that all supplies are kept clean and sanitary.
Aspirin or non-aspirin substitute
Eye drops
Burn spray or ointment
Cold spray or other topical anesthesia, anti-itch cream
Antiseptic spray, cream or ointment
Hydrogen peroxide 3% solution
Bandaids: knuckle bandaid, elastic strips (3"x7/8"), adhesive bandage (3"x3/4"), finger tip (2"x13/4")
Triangle bandage and safety pins, pressure dressings
Gauze bandages: 2 and 4 inch square pads and 1,2, and 4 inch rolls or compresses
First aid tape
Ace bandage
Clean wipes, antiseptic hand cleaner
Sterile water
Antiseptic swabs
Eye dressing packet
Instant ice packs
Cotton balls
Scissors and tweezers
Latex gloves
CPR barricade, to prevent mouth to mouth contact
Tourniquet and forceps
S.A.M. - moldable splint
Ammonia inhalant
First aid guidebook
Blankets (mylar)
Burn sheet
Plastic sheeting, to be used for wrapping a contaminated victim

OTHER EMERGENCY SUPPLIES, AS NEEDED BASED ON SITE CONDITIONS

Sun screen
Insect repellent
Poison Oak or Ivy cream
Emergency eyewash station capable of delivering 15 minutes of uninterrupted flow
Flashlight
Potable water
Stokes stretcher
10-minute escape breathing apparatus
Fire extinguishers (10 pound ABC minimum)
Water hoses
Spill absorbent and container
Rope
Spare shovels and tools
Communications equipment (e.g., cell phone)

APPENDIX A: SITE SPECIFIC FORMS

HASP ACKNOWLEDGMENT FORM

As a component of the Health and Safety Plan (HASP) designed to ensure personnel safety during project activities, you are required to read and understand the HASP before commencing any work. When you have fulfilled this requirement, please sign and date this personal acknowledgment form.

I have been provided with a copy of the HASP for this field project and have become familiar with it. I understand the Emergency response actions, contact numbers and locations of emergency facilities outlined in Section 10.

I will complete my tasks in a manner conforming to the HASP, Stantec HSSE Procedures, and specific additional guidance provided during pre-job briefings, and will inform the Health and Safety Representative of any conditions affecting site safety.

Printed Name	Signature	Date

ACTIVITY HAZARD ANALYSIS – GEOTECHNICAL INVESTIGATION

ACTIVITY HAZARD ANALYSIS				
Potential Hazards (Activity/Location)	**Actions to Eliminate or Minimize Hazards**	**PPE/Other Equipment**	**Training Requirements**	**Inspection Requirements**
Wildlife Hazards - Animals - Stinging/Biting Insects - Poisonous Plants	• Pre-Briefing with client / owner to identify biological hazards • Avoid nesting areas / likely habitat of wildlife • Be observant of signs for presence of wild animals, including footprints, feces, habitat • Use insect repellent containing DEET to protect against ticks and mosquitoes, Apply to clothes if it is not desired to have repellant directly on skin. • Wear long sleeve shirts and pants • Wear insect repelling (i.e., insect shield) or insect proof (i.e., Bug Baffler) clothing • Wear light colored clothing so insects are more visible • Avoid contact with vegetation • Educate yourself and be observant of poison Ivy, Oak and Sumac • Use poison ivy pre-exposure barrier cream and post-exposure cleanser to reduce urushiol-induced contact dermatitis. • Contain and decontaminate any clothing, tools or equipment that have been exposed to poison plants. Urushiol, the oil which causes adverse reaction in 85% of the population can remain active for up to 5 years. • Bring EpiPen if allergic to bee or wasp stings. • Contact client/owner or local authorities to remove potentially rabid animals and dead birds	• Wear light colored clothing so that ticks are more visible • Wear snake-resistant chaps or high boots • DEET • Soap and Clean Water • Benadryl® • EpiPen® Workers allergic to stinging inspects must carry EpiPen and alert team members • Mosquito netting	• Mace handling and safety procedures, if used • Review symptoms of inspected-transmitted illness and disease	• Inspect self and coworkers for ticks • Inspect site and remove standing water which may be a mosquito breeding area • Keep a general awareness to the surroundings

ACTIVITY HAZARD ANALYSIS

Potential Hazards (Activity/Location)	Actions to Eliminate or Minimize Hazards	PPE/Other Equipment	Training Requirements	Inspection Requirements
Driving Hazards (Driving on minimal maintained roads)	• Read and understand operator instructions • Always wear available safety devices prior to operation • Use headlights at all times • Speed should be based upon conditions present • Use caution while behind the wheel • Do not drive moist terrain • Do not cross flooded roads or trails • Before driving, select the appropriate 4WD or AWD vehicle with approved tires/tread.	• Helmet and eye protection when on ATUV unless seatbelts and rollover protection are provided • It is recommended that the vehicles have an emergency roadside kit (DOT Approved)	• Understanding how to perform Pre and Post trip inspections • Follow country driving laws	• Pre-road inspection • Post trip inspection
High/Low Ambient Temperatures	• Monitor for heat/cold stress and provide breaks as necessary. • Provide fluids to prevent worker dehydration. • Implement work/rest regimen. • Wear clothing appropriate for weather conditions.	• Sunscreen • Sunglasses • Wide brim hat • Clothes suitable for conditions	• None	• None
Sharp Edges	• Wear cut resistant work gloves when the possibility of lacerations or other injury may be caused by sharp edges or objects.	• Cut resistant work gloves	• None	• Inspect for sharp edges and objects
Hand Tools - Rock hammer - Spade	• Review of the hand, eye, and noise hazards of hand tools.	• As appropriate depending on the tool and activity	• Review of safe use practices	• Per manufacturer

ACTIVITY HAZARD ANALYSIS

Potential Hazards (Activity/Location)	Actions to Eliminate or Minimize Hazards	PPE/Other Equipment	Training Requirements	Inspection Requirements
Contingency Planning Equipment failure, fire, smoke, explosion, flood/slide earthquake, uncontrolled releases, water handling equipment failures, flooding, engulfment, medical emergencies, injuries, self-rescue, non-entry rescue, first responder, entry rescue, outside emergency responders, communication.	Before the severe weather or natural disaster occurs: • Find a way to monitor real-time Information (television, AM/FM radio, the Internet, NOAA All-Hazards Radio). • Prepare an Emergency Contingency Plan that identifies evacuation routes, shelter in place options and hazard-specific responses. • Identify a safe shelter area and stock with emergency supplies. Generally, the best safe shelter areas will be in the interior of buildings away from windows. Tornado shelters should be below ground (basements). Shelters from flooding should be on high ground. LIGHTNING • If you can hear thunder, you are within 10 miles of a storm and are in danger. This is the time to seek shelter. • Buildings that are not equipped with grounded plumbing or electrical wiring are unable to conduct electrical current and do not offer protection from lightning. This means that you are still vulnerable if you seek shelter in a bus stop, shed, pavilion, etc. • An automobile can offer protection from lightning by acting like a Faraday cage, provided that the occupants do not touch the metal of the car while inside. • Stay away from tall objects if caught in a lightning storm. Trees are one of the worst forms of shelter from lightning. They offer a false sense of security and, if anything, attract lightning. TORNADO AND HIGH WIND WARNING • Allow yourself plenty of time to get to your tornado shelter. This is EXTREMELY important. If you are outside, get inside. If you're already inside, get as far into the middle of the building as possible. Get underground if possible. If you cannot, go to the lowest floor possible. Flying and falling debris are a storm's number one killer. Use pillows, blankets, coats, helmets, etc. to cover up and protect your head and body from flying debris. DO NOT seek shelter under a highway overpass. They are not safe! DO NOT open doors or windows. This does not help! DO NOT go outside to find the tornado, even if you think it's far away	• As prescribed in client/owner plan • First aid kit • Extra food, water and medicine • Cell phones, flashlights and extra batteries • Rain suits and cold weather gear	• Train and drill everyone in the Emergency Contingency Plan including where to go and what to if severe weather or a natural disaster impacts your location. • Provide training on the emergency alert notification systems (e.g. air horn, sirens, whistles) and practice drills.	• Inspect emergency supplies and replenish depleted supplies. • Practice “first-in / first out” inventory management • Ensure safe shelter areas are accessible. • Ensure evacuation routes, and emergency procedures are posted

ACTIVITY HAZARD ANALYSIS				
Potential Hazards (Activity/Location)	**Actions to Eliminate or Minimize Hazards**	**PPE/Other Equipment**	**Training Requirements**	**Inspection Requirements**
Exposure to ultraviolet (UV) rays (sunburn)	• Avoid periods of the day when UV index is highest • Work in the shade when possible (e.g. portable shelters, beach umbrella	• Wear long sleeve shirt and a wide-brimmed hat • Wear broad-spectrum sunblock with SPF 30 or higher	• None	• None
Test pits/Trenching	• Make eye contact whenever you come near the operator • Do not approach the backhoe when it is still operating.	• High-visibility vest • Hearing protection • Safety-toed boots • Hard hat • Safety glasses	• Review of safe use practices	• Per operator
Drilling – Soil auger and rock auger	• Make eye contact whenever you come near the operator • Daily safety briefings with the drilling to review daily operations • Do not approach while the rig is still running • Be aware of overhead risks • Do not wear loose clothing	• High-visibility vest • Hearing protection • Safety-toed boots • Hard hat • Safety glasses	• Review of safe use practices	• Per operator
Radiological Hazards	• Complete on-site radiation safety training • Use the principles of time, distance, and shielding	• TLD badge	• On-site radiation safety training conducted by UNC	• None

ACTIVITY HAZARD ANALYSIS				
Potential Hazards (Activity/Location)	**Actions to Eliminate or Minimize Hazards**	**PPE/Other Equipment**	**Training Requirements**	**Inspection Requirements**
Working in congested areas near mobile equipment	**Elimination/Substitution** • Avoid areas where mobile equipment are actively operating (i.e., tour area at break times, after hours, etc.) **Engineering Controls/Guarding** • Erect barricades, stanchions with flashing lights, traffic cones or other traffic control devices or stay behind them **Administrative Controls** • Review SWP 216 – Working Near Mobile Equipment and follow the safe work practices • Make eye contact with operators before approaching equipment, and verify they see you (i.e. hand wave response) • Understand and review hand signals • Use a spotter for heavy equipment operations • Barricade heavy equipment swing radius • Obtain required permits and comply with the Manual on Uniform Traffic Control Devices (MUTCD) and other requirements. • Position yourself in clear view, upwind of the equipment at a safe distance • Wear reflective vests when working near heavy equipment and vehicle traffic	• High-visibility/reflective vest	• None	• None

ACTIVITY HAZARD ANALYSIS

Potential Hazards (Activity/Location)	Actions to Eliminate or Minimize Hazards	PPE/Other Equipment	Training Requirements	Inspection Requirements
Manual Material Handling	**Elimination/Substitution** • Avoid direct handling if possible **Engineering Controls** • Use mechanical assistance when possible (hand truck, pallet jack, carts, etc.) – 50 lb single person limit in ideal conditions **Administrative Controls** • JSA/FLRA/LMRA to plan task • Inspect prior to lift (test weight and center of gravity) • Proper ergonomic practices when lifting (item close to body, back straight, lift with legs vs back, no twisting or bending, control load and placement between knees and shoulders, etc.) • Coordinated lifting when possible – adequate manpower Situational awareness (check load stability prior to opening doors, unbanding/unstrapping, etc.), anticipate pinch points, keep body and extremities out of line-of-fire from shifting, falling, rolling objects, know your path of travel and maintain line of sight or use spotter to guide you	• Appropriate hand protection for the items being lifted • Fall protection if exposed to heights greater than 4 feet • Mechanical assistance if necessary	• Safe lifting	• Verify load is safe to lift as stated in actions to minimize hazards
Irregular terrain	**Elimination/Substitution** • Avoid steep slopes, stay away from edges of embankments. • Stay off spillway and outlet structures not designed for pedestrian access. • Do not rely on handrails as fall protection. • Avoid rip rap or other rough surfaces, if necessary use 3 points of contact while walking on rip rap. • Avoid wet or muddy surfaces. If you must access areas with irregular surfaces, start at bottom and progress with caution. Don't climb down embankments!	• Rugged boots with slip resistant / tractive soles and ankle support.	• None	• Inspect for wet or slick surfaces. • Inspect integrity of passive fall protection equipment (e.g. guard rails, stair rails, grating, etc.)

OCCUPATIONAL INCIDENT REPORTING FORM

Incidents involving injury, potential injury, or report of pain, soreness, or discomfort must be reported immediately (within one hour) to a supervisor. Supervisors will then immediately contact ***their HSE representative to develop a plan for assessment and care***. This form must be completed and **submitted within 24 hours** of any incident. Do not delay submission waiting for signatures. **Email to hsse@stantec.com or fax unsigned report to (780) 969-2030** and file locally in compliance with the corporate records retention policy and practices once all signatures have been obtained.

This document contains privileged and confidential information prepared at the request of Stantec's Legal Counsel. The contents of this report are restricted to HR personnel, Risk Management Representatives, Project Manager and BC Leader, and Stantec's Insurer, Adjuster and Legal Counsel. Information collected will be used solely for the purpose of meeting the requirements of Stantec's HSE and insurance programs, complying with applicable legislation, and will be used in accordance with any governing privacy legislation. The information collected will be maintained electronically and may be included in required reports.

SECTION 1: GENERAL INFORMATION

Office location:		BC number:	
Location of incident:			
Incident date and Time:		Date Reported:	
Project name:		Project number:	
Client Name:			
Person in charge:		Person in Charge Phone:	

SECTION 2: STANTEC EMPLOYEE INFORMATION (if more than one identify extras in incident details below)

Name:		Phone:	
Job position:		Group name:	
Time employee began work:		Job Experience (in years)	
Type of employment:	Full Time ☐ ; Visitor ☐ ; Contract ☐ ; Volunteer ☐ ; Seasonal ☐		
Supervisor:		Supervisor Phone:	

SECTION 3: INCIDENT DETAILS

Type of Incident:

*incident types marked with an asterisk, please complete sections 1, 2 and 3 and signature

See StanNet for a list of Incident Type Definitions

☐ *****_Report Only_
☐ ***Hazard Identification**
☐ ***Near Miss**
☐ ***Safety Opportunity**

☐ First Aid
☐ Medical Aid – No Lost Time
☐ Restricted Work
☐ Lost Time
☐ Fatality
☐ Violence or Harassment

☐ Motor Vehicle Incident
☐ Property Damage - Vehicle
☐ Property Damage - Other
☐ Theft
☐ Contractor Recordable Incident
☐ Non-compliance

☐ 3rd Party
☐ Spill or R
☐ Utility Stri
☐ Fire/Expl
☐ Stop Wo
☐ Work Re

Describe incident in detail: (include any issues related to people, equipment, materials, environment, and

Incident Reporting Protocol - US

ACTIONS

1 Keeping safety in mind, care for injured people (if applicable) and stabilize the scene.
2 For life threatening injuries, **immediately contact 911.** Accompany the injured employee to the medical facility whenever possible.
3 Call **AllOne Health (24-hour service): 1-800-350-4511** for work-related symptoms or injuries, and speak to a medical professional for guidance and treatment options.
4 Make voice contact with your supervisor within 1 hour or less of the incident occurring. Leaving a voicemail does not count. If you cannot contact your supervisor, contact the HSSE Manager or HSSE Advisor for your region.
5 Supervisors must immediately contact their HSSE representative to develop a plan for assessment and care.
6 When an employee is guided by AllOne Health to obtain medical assistance, or the employee requests medical attention for a non-life threatening injury, and after alerting the supervisor; the employee must **immediately call Melissa Helton, Stantec's US WC Claims Coordinator at 513-720-3706** for assistance.
7 In most cases AOH will provide guidance about which clinic is available and provide directions. Some job sites already have prescribed clinics such as US Healthworks. Here is a link accessing additional clinic locations: Clinic Search link .
8 Additional notifications may be required based on the client requirements.

Contacts		Landline	Cell
HSSE Manager – US Central	Tami Renkoski	303-533-1964	720-530-7274
HSSE Manager – US South	Keith Kuhlmann	740-816-6170	740-816-6170
HSSE Manager – US Northeast	Fred Miller	610-235-7315	610-235-7315
HSSE Manager – US West	Tony Wong	805-250-2860	805-234-6227
HSSE Manager - International	Kev Metcalfe	780-917-7023	780-231-2185
Director HSSE Operations	Jim Elkins	613-738-6097	613-404-8508
HSSE Senior Vice President	Jon Lessard	713-548-5700	281-513-5538
Your OSEC or HSSE Advisor	Master HSSE Representative Listing		

Region	WC Claims Coordinator	Landline	Cell
US (All Regions)	Melissa Helton	513-720-3706	513-720-3706

REPORTING

- **Within 24 hours of the incident, an RMS3 – Incident Report must be completed with as much information as possible and emailed to hsse@stantec.com.**
- Do not delay submitting the report to wait for signatures. Follow-up with signatures when possible.
- Complete the balance of the RMS3 within 5 business days, including signatures. Include information and corrective actions determined during the investigation/ Incident Causation Analysis (ICA), as coordinated by HSSE Advisor and/or HSSE Manager.
- Other protocols dictated by a client or project agreement, or internal practice may also need to be completed.

RMS2

Stantec

FIELD LEVEL RISK ASSESSMENT (FIT FOR DUTY), 5 DAY – RMS 2

Project: ______________________ Project No: ______________

Client: ______________________

Location: ______________________

Start Date: ______________________

Documentation and Procedure Review

1.	Risk Management Strategy (RMS1) form and/or Site Specific Health and Safety Plan signed and reviewed?	☐ Yes ☐ **No***
2.	Emergency Response Plan reviewed?	☐ Yes ☐ **No*** ☐ N/A
3.	Tested two-way communications (cell phone, satellite phone) and security measures?	☐ Yes ☐ **No***
4.	Attended Client Site Health and Safety meeting?	☐ Yes ☐ **No*** ☐ N/A
5.	Conducted Stantec site safety meeting with all workforces?	☐ Yes ☐ **No*** ☐ N/A
6.	Are there any new or unexpected hazards not identified in the RMS1/HASP? *If yes, include in the Job Safety Analysis (JSA).*	☐ Yes ☐ No
7.	Working alone or remote work? *If yes, complete call in/out process – Safe Work form must be completed.*	☐ Yes ☐ No

Notifications and Permits

8.	Are work permits required for this site? *If yes, have they been completed and submitted as required?*	☐ Yes ☐ No ☐ Yes ☐ **No***
9.	Are utility locates required for this site? *If yes, have they been completed and reviewed?*	☐ Yes ☐ No ☐ Yes ☐ **No***
10.	Does the Client require any notification prior to starting the work? *If yes, has the notification been provided?*	☐ Yes ☐ No ☐ Yes ☐ **No***

***Contact your Project Manager immediately.**

Work Description

Provide a general description of the work to be conducted.

Personal Protective Equipment

List specific PPE as needed. Verify type and inspect condition.

☐ Head Protection Type: ________	☐ Hearing Protection: ________	☐ Gloves Type: ________
☐ Foot Protection Type: ________	☐ Respiratory Protection: ________	☐ Water Safety Gear: ________
☐ Eye Protection Type: ________	☐ Fire Retardant Coveralls: ________	☐ ________
☐ High Visibility Vest: ________	☐ Fall Protection: ________	☐ ________

Tools and Equipment

List specific equipment to be used. Verify type and inspect condition.

☐ ☐ ☐

☐ ☐ ☐

Daily Tailgate Discussions/Subcontractor Input

Date:	**Time:**	**Weather:**
Start		
Mid-Day		
Post-Day		
Date:	**Time:**	**Weather:**
Start		
Mid-Day		
Post-Day		
Date:	**Time:**	**Weather:**
Start		
Mid-Day		
Post-Day		
Date:	**Time:**	**Weather:**
Start		
Mid-Day		
Post-Day		
Date:	**Time:**	**Weather:**
Start		
Mid-Day		

Post-Day	

Stantec

FIELD LEVEL RISK ASSESSMENT (FIT FOR DUTY), 5 DAY – RMS 2

I know the hazards:

By signing here, you are stating the following:

1. I have been involved in the Job Safety Analysis (JSA) and understand the hazards and risk control actions associated with each task I am about to perform.
2. I understand the permit to work requirements applicable to the work I am about to perform (if it includes permitted activities).
3. I am aware that work that has not been risk–assessed must not be performed.
4. I am aware of my ability and obligation to **Stop Work** (*See below).*

I arrived and departed fit for duty (see Fit for Duty card for further information):

5. I am physically and mentally fit for duty.
6. I am not under the influence of any type of medication, drugs or alcohol that could affect my ability to work safely.
7. I am aware of my responsibility to bring any illness, injury (regardless of where or when it occurred), symptoms of soreness or discomfort, or fatigue issue I may have to the attention of the Crew Lead or Supervisor.
8. I sign out uninjured unless I have otherwise informed the Crew Lead or Supervisor.

Insert fitness level under corresponding time column: Fit for Duty = F Alternate Plan = AP
Team Lead to contact Project Manager for any personnel identified as AP

Individual Name/Company Name/Signature	Date:			Date:			Date:			Date:			Date:		
	Time:	Time:	Time:	Time:	Time:	Time:	Time:	Time:	Time:	Time:	Time:	Time:	Time:	Time:	Time:

I will STOP WORK any time anyone is concerned or uncertain about safety. **I will STOP WORK** if anyone identifies a hazard or additional mitigation not recorded. **I will** be alert to any changes in personnel or their fitness level (AP), conditions at the work site or hazards. If it is necessary to **STOP WORK**, I will reassess the task, hazards and mitigations; and then proceed only when safe to do so.

Conclusion of day: I certify that the planned work activities are completed for the day and all injuries and first aids have been reported via RMS3.

Signature of Crew Lead: ______________________ **Date:** __________
Signature of Crew Lead: ______________________ **Date:** __________
Signature of Crew Lead: ______________________ **Date:** __________
Signature of Crew Lead: ______________________ **Date:** __________
Signature of Crew Lead: ______________________ **Date:** __________

FIELD LEVEL RISK ASSESSMENT (FIT FOR DUTY), 5 DAY – RMS 2

Job Safety Analysis (JSA) **Must be completed for all field activities.**

Basic Job Steps	Potential Hazards	Controls to Reduce or Eliminate Hazard	Person Responsible

Review the hazard categories below and check the mitigation measures applicable to the identified scope of work.

Environmental Hazards

1. Work area clean ☐
2. Material storage identified ☐
3. Dust/Mist/Fume ☐
4. Noise in area ☐
5. Extreme temperatures ☐
6. Spill potential ☐
7. Waste containers needed

Access/Egress Hazards

23. Aerial life/Man basket (inspected & tagged) ☐
24. Scaffold (inspected & tagged) ☐
25. Ladders (tied off) ☐
26. Slips & trips ☐
27. Hoisting (tools, equipment) ☐
28. Evacuation (alarms, routes, ph. #) ☐
29. Confined space entry permit required ☐

Rigging & Hoisting Hazards

38. Lift study required ☐
39. Proper tools used ☐
40. Tools inspected ☐
41. Equipment inspected ☐
42. Slings inspected ☐
43. Others working overhead/below ☐
44. Critical lift permit ☐

FIELD LEVEL RISK ASSESSMENT (FIT FOR DUTY), 5 DAY – RMS 2

☐
8. Waste properly disposed
☐
9. Waste plan identified
☐
10. Excavation permit required
☐
11. Other workers in area
☐
12. Weather conditions
☐
13. MSDS reviewed
☐

Ergonomic Hazards

14. Awkward body position
☐
15. Over extension
☐
16. Prolonged twisting/bending motion
☐
17. Working in a tight area
☐
18. Lift too heavy/awkward to lift
☐
19. Parts of body in line of fire
☐
20. Repetitive motion
☐
21. Hands not in line of sight
☐
22. Working above your head
☐

Are you ready to work safely?

Remember to

1. Stop and think
2. Look around
3. Assess risk
4. Control risks
5. Begin/resume work

Overhead Hazards

30. Barricades & signs in place
☐
31. Hole coverings identified
☐
32. Harness/lanyard inspected
☐
33. 100% Tie-off with harness
☐
34. Tie off points identified
☐
35. Falling items
☐
36. Foreign bodies in eyes
☐
37. Hoisting or moving loads overhead
☐

Electrical Hazards

45. GFI test
☐
46. Lighting levels too low
☐
47. Working on/near energized equipment
☐
48. Electrical cords condition
☐
49. Electrical tools condition
☐
50. Fire extinguisher
☐
51. Hot work or electrical permit required
☐

Personal Limitations/Hazards

52. Procedure not available for task
☐
53. Confusing instructions
☐
54. No training for task or tools to be used
☐
55. First time performing the task
☐
56. Micro break (stretching/flexing)
☐
57. Report all injuries to your supervisor
☐

FIELD LEVEL RISK ASSESSMENT
(FIT FOR DUTY), 5 DAY – RMS 2

It is important that all relevant hazards have plans in place to reduce risk.
Be sure that all associated permits are closed off at the end of the job.
Remember: Stop and Think

Reviewed by Name and Signature: ______________________________

APPENDIX B: RADIATION PROTECTION PLAN

APPENDIX B: RADIATION PROTECTION PLAN

1.0 MANAGEMENT AND WORK CONTROLS

This radiation protection plan is designed to meet the requirements in 10 CFR Parts 19 and 20 and is a supplement to the Site Specific Health and Safety Plan.

1.1 SITE MANAGEMENT

Melanie Davis will serve as the Project Manager; Nat Patel (AVM) is the Site RSO. The Site RSO will implement this plan and have the authority to stop work should radiation safety concerns arise.

1.2 SITE CONTROL

Site control is necessary to prevent unauthorized, untrained, or unprotected personnel from entering the site. The security fence for each of the training sites will be used to control access. Rope barriers with “Caution Radioactive Material” signs and “No Entry” signs will be used to prevent workers, visitors, and equipment from entering the slightly contaminated areas that extend beyond the fences. These measures will be taken to limit the spread of contamination and to reduce the radiation exposures to ALARA levels, even though the soil concentrations in these areas are not considered high enough to require radiological monitoring of occupants.

Each training site will be divided into work zones as defined in the following subsections.

1.2.1 Project Support Zone

This work area is maintained free of contamination and is used for project administration functions, an onsite gamma spectroscopy laboratory, personnel and equipment staging, rest breaks and other personal needs, donning PPE, and access control.

1.2.2 Contamination Reduction Zone

The contamination reduction zone serves as a transition area to reduce contamination levels on personnel and equipment before entering the project support zone. The area is initially clean and will be maintained to prevent gross levels of contamination. The contamination monitoring station is placed at the boundary between this zone and the project support zone. Field personnel will remove PPE and decontaminate when necessary, before monitoring. Personnel and equipment will be monitored before entering the project support zone. Drums for potentially contaminated PPE will be placed in this area.

1.2.3 Radiological Exclusion Zone

The radiological exclusion zone initially contains all contaminated materials identified for removal from the site. Removal equipment and waste containers will be brought into this area. All equipment and full container exteriors will be decontaminated, if necessary, and monitored for compliance with unconditional release criteria before leaving this area. All equipment having the potential for being contaminated at other sites will be monitored. Equipment will be cleaned before being taken off a particular training site.

Signs, barriers, and instructions will be posted in appropriate areas to assist personnel in identifying work zones and performing such tasks as donning and doffing PPE. No smoking, eating, drinking, or chewing will be allowed in this area.

1.2.4 Radiological Exclusion Zone Access

Field personnel entering the exclusion zone must have prior authorization from the Site RSO. They must sign the access log upon entry, providing the date, time, and job-related information. Field personnel also will enter the time and respirator use information upon exiting. Regular personnel will be trained to frisk themselves and to don and doff PPE. The Site RSO will closely monitor these activities.

Visitors or short-term workers will be allowed onsite only upon prior approval by the Project Manager and RSO. Visitors or short-term workers may be given abbreviated radiation safety training by the RSO or his designee and escorted into areas not requiring respiratory protection. Visitors or short-term workers will follow all radiation safety practices under the supervision of the escort. Escorted individuals will be frisked for radioactive contamination prior to leaving the site.

2.0 AS LOW AS REASONABLY ACHIEVABLE POLICY

Stantec is committed to keeping individual and collective radiation doses to ALARA levels and supports an administrative organization for radiation safety. Stantec has developed the project HSP and instructions to foster the ALARA concept within the organization.

The Site RSO will assess the radiation protection plan monthly. He will change operating and maintenance procedures and equipment and facilities to reduce exposures unless the cost is considered unjustified. In addition to maintaining doses to individuals as far below the limits as is reasonably achievable, the sum of the doses received by all exposed individuals also will be maintained at the lowest practicable level.

3.0 STANDARD OPERATING PROCEDURES

The Site RSO has developed written standard operating procedures (SOPs) for performing all major tasks associated with this plan. Major tasks include how to conduct radiation measurements, how to don and doff PPE and how to administer the respiratory protection program.

Generalized written procedures also have been developed for contamination control, equipment decontamination, access/egress control, and monitoring of waste containers. The SOPs will be maintained onsite during decommissioning and update as necessary.

Section 6.0 describes generalized procedures for conducting characterization, support, and final status surveys, including scanning measurements.

4.0 WORKER TRAINING

All workers in potentially contaminated areas will attend a formal radiological safety training program that conforms to 10 CFR §19.12. Emphasis will be placed on site-specific operations and radiological safety practices, including personal decontamination. The training session will last from 4 to 8 hours. The Site RSO will retain documentation of the training, in the form of a written examination for each employee. The content of the radiation safety training is as follows:

- General History and Site Overview
- Regulatory Overview
- Fundamentals of Radiological Protection
- Biological Effects
- Radiation Limits
- ALARA
- Personnel Monitoring Programs
- Radioactive Contamination Control
- Radiological Postings and Site Control
- Emergency Procedures

Site safety personnel also will conduct brief, weekly safety meetings to discuss any safety issues that may concern onsite workers or the Site RSO.

5.0 RADIOLOGICAL MONITORING

The RSO will conduct general work area monitoring to assess potential radiation exposures to workers and for planning purposes to verify that radiation exposures are ALARA. The two principal radiation exposure pathways are direct gamma radiation from the contaminated soil and inhalation of long-lived airborne particulate radionuclides. Airborne radon and the short-lived particulate radon progeny should not present a significant hazard, because of the small size of the thorium-contaminated areas and because particles will dilute rapidly in the atmosphere. The RSO will leak-test sources every six months and store sources in a locked drawer or cabinet when not in use.

5.1 MONITORING EQUIPMENT CALIBRATION AND MAINTENANCE

A large inventory of radiological monitoring equipment is available to support this project. Table 5-1 lists the equipment and associated information. Radiation monitoring instruments such as alpha scintillometers, gamma scintillometers, and Geiger-Müeller detectors will be function-checked prior to use each day using appropriate radioactive sources. The Site RSO will calibrate radiation monitoring equipment semiannually unless damaged, in which case it will be sent for repair and replaced with another calibrated meter. Monitoring equipment will be recalibrated after repair. Air sampling equipment will be calibrated at a frequency of three months or less.

Sealed radioactive sources are used in instrument calibration and efficiency testing. All sources were chosen such that they are small quantity sources exempted from licensing by the NRC.

Table 5-1. Radiological Monitoring Equipment to Support Decommissioning Activities, Installation Restoration Program Site OT-10

Manufacturer	Model	Instrument	MDA/MDC	Count Time[a]
EG&G Ortec	To be determined	Sodium iodide Spectrometer	To be determined	1800 sec
Eberline	RAS-1	Work Area or Perimeter Air Sampler	8x10^{-15}μCi/ml	sampling 8 hours/day; counting time = 60 min
Eberline	MSA Escort Elf	Lapel Air Sampler	2.4x10^{-13}μCi/ml	sampling 8 hours/day; counting time = 60 min
Ludlum	Model 19	μR-meter	3 μR/hr	instantaneous
Ludlum	Model 2929/Model 43-10-1	Alpha-beta counter	0.5 dpm	60-min count
Ludlum	Model 12/ Model 43-5	Alpha survey meter	86 dpm/100 cm^2	static
Ludlum	Model 12/ Model 43-90	Alpha survey meter	42 dpm/100 cm^2	static
Ludlum	Model 12/ Model 43-5	Alpha survey meter	680 α-dpm/100 cm^2	scanning @ 2 cm/sec with detection probability of 0.9
Ludlum	Model 12/ Model 43-5	Alpha survey meter	170 α-dpm /100 cm^2	scanning @ 2 cm/sec with detection probability of 0.5
Ludlum	Model 12/ Model 43-90	Alpha survey meter	680 α-dpm/100 cm^2	scanning @ 8 cm/sec with detection probability of 0.9
Ludlum	Model 12/ Model 43-90	Alpha survey meter	170 α- dpm /100 cm^2	scanning @ 2 cm/sec with detection probability of 0.9
Ludlum	Model 12/ Model 44-9	α β, γ survey meter	552 dpm/100 cm^2 above background	scanning with 1-sec interval
Ludlum	Model 2221/ Model 44-10	Gamma scanning survey	● 0.40 pCi/g (bare) and 0.51 pCi/g (collimated) ● 1.3 pCi/g (bare) 1.4 pCi/g (collimated)	● scanning at 2 ft/sec ● static

Notes:

[a] Where a counting time is specified, the background count time is equal to the sample count time.

cm = centimeter
cm^2 = square centimeters
dpm = disintegrations per minute
ft = feet
MDA = minimum detectable activity
MDC = minimum detectable concentration
min = minute
pCi/g = picocuries per gram
sec = second
μCi/ml = microcuries per milliliter
μR/hr = microRoentgens per hour

5.1.1 Personnel Contamination Monitoring and Decontamination

Personnel leaving the radiological exclusion zone or contacting potentially contaminated material will be monitored with a portable alpha detector. Field personnel will remove their contaminated clothing such as gloves, boot covers, and Tyvek® suits and place them in a designated radioactive waste container for disposal as radioactive waste. The Tyvek® suits will include attached Tyvek® booties that will serve as the primary contamination barrier. Field personnel will wear rubber overshoes, which will be removed prior to entry into the contamination reduction zone for later reuse.

Personnel will clean any skin contamination reading above background, by washing the affected area. The RSO will re-survey the affected area until background levels are achieved. Skin contamination is easily removed by washing with soap and water.

5.2 EXTERNAL GAMMA EXPOSURE

The RSO will take weekly exposure rate measurements in the work area using a Ludlum Model 19-μR meter or equivalent. ERG will produce site exposure-rate maps to guide construction activities toward minimizing radiation exposure.

Stantec will issue individual TLDs to all field personnel to monitor their external exposure. Field personnel will wear the TLDs under protective clothing to prevent possible contamination of the TLD from dirt or airborne dust. All TLDs, as well as controls, will be placed in the support zone when not in use. Landauer, Inc., will provide and read TLDs monthly.

5.3 AIRBORNE PARTICULATE SAMPLING IN THE WORKPLACE

Exposure to airborne particulate radionuclides is a primary concern in limiting radiation exposure to workers. For this project, the work area will be small with only a few people involved in most tasks. Therefore, one work-area air sampler will be sufficient to obtain an estimate of the exposure of personnel to airborne particulates. The sampler will be located to obtain a realistic estimate of the personnel exposure and the location will be determined on a task-specific basis. The work area monitoring data will be supplemented with data from lapel samplers that will be worn by various workers.

Respiratory protection is required for initial entries into work areas. Downgrading the respiratory protection requirements will be considered once data are available to project the daily DAC levels. If justified, the Site RSO will recommend to the Site Manager that work may proceed without respiratory protection. Projected work-area particulate levels of less than 10 percent of the DAC, averaged over a daily work period, will be used as a minimum requirement for not using respiratory protection.

Airborne areas will be posted according to the requirements in 10 CFR § 20.1902(e).

5.3.1 Work-Area Monitoring Using Lapel Air Samplers

Selected personnel will wear lapel samplers each day that waste material is being handled or when their work activity isolates them from the general work-area monitoring. A lapel sampler (MSA Escort Elf Air Sampler or equivalent) with a flow rate of approximately 2 liters per minute (lpm) and a 37-millimeter (mm) filter cassette with a Type A/E glass fiber filter will be used.

The Site RSO will analyze the effectiveness of the lapel samplers as follows. The samplers are assumed to be operating for an 8-hour day, resulting in 960 liters of air being pulled through the filter. The sample will be removed and counted 12 or more hours later, after the radon-222 progeny have decayed. A final count will be made after one week when most of the radon-220 (thoron) progeny has decayed. Gross alpha emissions will be counted on Ludlum Model 2929/Ludlum Model 43-10-1 tray counters. These counters have an alpha background count rate of approximately 4 counts per hour and an efficiency of approximately 0.4 counts per minute (cpm) per dpm for thorium-230. This corresponds to a minimum detectable activity (MDA) of 0.5 dpm or an MDC of 2.4×10^{-13} microcuries per milliliter (μCi/ml) for the lapel sampler under the assumed conditions. This MDC is 24 percent of the DAC for thorium-232.

A filter having 1 dpm activity deposited during a 60-minute count would emit 24 counts, assuming a gross alpha air particulate concentration corresponding to the DAC for thorium-232 ($1x10^{-12}$ μCi/ml)(see 10 CFR Part 20, Appendix B, Table 1) and a sampling period of 8 hours. An additional 4 counts would be expected from the counter background. This clearly demonstrates that the lapel samplers may be used to assess exposures of 1 DAC or less even if all counts are considered attributable to thorium-232.

The following paragraph shows that the assumption that all measured activity is thorium-232 leads to an over prediction of the percent of the radionuclide-weighted DAC by a factor of three. The discussion of lapel samplers above and the following analysis assume that the background radon-220 and radon-222 progeny have been allowed to decay so that they do not contribute to the analyses.

This analysis evaluates the error resulting from assuming thorium-232 is the only radionuclide on the filter. An average thorium-232 to thorium-230 concentration ratio of 9.1 is assumed for the site, based on isotopic thorium analyses of 120 soil samples collected in the 2000/2001 and 1994/1995 investigations (USAF, 2002a, and USAF, 1997a, respectively). The unsupported short-lived alpha-emitting radionuclides were not considered in this analysis because their DACs are very high and would not change the results of the analysis. Considering the thorium-232 decay series, for every dpm of activity arising from the decay of thorium-232, there will be 1 dpm alpha activity from the decay of thorium-228 and one dpm alpha activity from the decay of radium-224. Assuming conservatively that the thorium-230 is in equilibrium with the uranium-238 series, then for every dpm of thorium-230 activity, there will also be an additional dpm from uranium-238, uranium-234, and radium-226, or a total of 4 dpm from the uranium-238 decay series. Table 5-2 lists the DACs for radionuclides of concern at OT-10.

Table 5-2. Derived Air Concentrations for Specific Radionuclides

Radionuclide[a]	**DAC (μCi/ml)**[a]
Thorium-232	1x10-12
Thorium-228	7x10-12
Thorium-230	6x10-12
Radium-224	7x10-10
Uranium-238	2x10-11
Uranium-234	2x10-11
Radium-226	2x10-11

Notes:
[a] 10 CFR Part 20, Appendix B, Table 1
DAC = derived air concentration
μCi/ml = microcuries per milliliter

For a mixture of radionuclides, 10 CFR § 20.1202 requires that the sum of the fractions of the concentrations divided by the respective DACs be equal to or less than unity. Using the conservative assumption that the activity of thorium-232 equals the activity of thorium-228 and radium-224, the activity of thorium-230 equals that of uranium-238, uranium-234, and radium-226, and the activity ratio of thorium-232 to thorium-230 equals 9.1, the sum of the fractions equation may be written

$$C_{thorium}{}^{232}\left(\frac{1}{1x10^{-12}}+\frac{1}{7x10^{-12}}+\frac{1}{7x10^{-10}}\right)+\left(\frac{C_{thorium}{}^{232}}{9.1}\right)\left(\frac{3}{2x10^{-11}}+\frac{1}{6x10^{-12}}\right)=1, \qquad \text{Eq. 5-1}$$

where:

C = concentration.

Solving for $C_{thorium\text{-}232}$, the concentration of thorium-232 at the maximum allowable limit for this radionuclide mixture is 8.48×10^{-13} μCi/ml, or approximately 85 percent of the DAC for thorium-232.

Total alpha decays are comprised of alpha decays from all alpha emitters in the mixture and can be shown using the above ratios and assumptions to be equal to 3.4 times the count rate from thorium-232. Table 5-3 lists the fractions of alpha emissions, which start the derivation.

Table 5-3. Alpha Decays

Radionuclide	Alpha Emissions
Thorium-232	1
Thorium-228	1
Thorium-230	1/9.1 = 0.1
Radium-224	1
Uranium-238	1/9.1 = 0.1
Uranium-234	1/9.1 = 0.1
Radium-226	1/9.1 = 0.1
Total	3.4

When the air is at the maximum allowable limit (sum of the fractions =1), the gross alpha decay rate would be equal to 3.4 * 0.85, or 3 times the alpha count rate from thorium-232, because the allowable limit for the concentration of thorium-232 in this mixture is 85 percent of the DAC for thorium-232. Therefore, there is a factor of 3 conservatism in the method if all of the gross alpha is assumed to be derived from thorium-232.

The actual MDC for the lapel samplers with an 8-hour sample is 8 percent of the DAC for thorium-232, considering the factor of three conservatism discussed above and the calculated MDC and assuming all of the activity is thorium-232.

5.3.2 Work-Area Monitoring Using RAS-1 Air Samplers

The RSO will collect work-area airborne particulate samples using an Eberline RAS-1 intermediate volume air sampler (or equivalent) with a flow rate of approximately 60 lpm. Samples will collect on 47-mm glass fiber filters installed in the air samplers. The sampling station will be located at a point as near to the workers as practical and will be changed as the work and other factors change. Considerations for locating the sampler include wind rose data, the prevailing wind direction, site activities, and source term strengths. Air samples will be collected at a height of 1 to 1.5 m above ground level in locations free from unusual micrometeorological or other conditions that could result in artificially high or low concentrations. General work-area air monitoring will be performed during invasive work or when site activities can release airborne radioactivity.

It can be shown using the same calculations as presented in Section 5.3.4.1, that a very short sampling period would be required to measure radionuclides in air at DAC-levels, because the flow rate of these samplers is approximately 60 lpm. However, because the samples will be stored for several days to allow for the decay of the unsupported radon-220 and radon-222 progeny, a sampling time of less than a work shift is not anticipated.

The filters will be counted for gross alpha using the onsite alpha tray counter after the filters have been aged sufficiently for radon progeny decay. The archived air samples will be composited and sent to an offsite laboratory for analysis for isotopic uranium, radium-226, and isotopic thorium if any personnel are exposed to an average gross alpha air concentration exceeding 10 percent of the DAC (assuming all radionuclides are thorium-232 but considering the reduction factor based upon the assigned protection factor in 10 CFR Part 20 for respirator use). Laboratory results will determine the final committed effective dose equivalent.

5.4 WORK AREA RADON MONITORING

It is not anticipated that the radon or radon progeny concentrations will be significant because the contaminated areas are small and the work is being conducted outside. The winds should disperse the radon and progeny to levels much below concern for worker protection.

Grab sample measurements of radon-222 and radon-220 (thoron) progeny working levels will be performed prior to beginning work and periodically thereafter to evaluate exposure to radon progeny. Long-term radon or working level measurements will be implemented if levels exceed 10 percent of the 10 CFR Part 20, Appendix B, Table 1 values.

5.5 ENVIRONMENTAL MONITORING

Eberline RAS-1 air samplers with 47-mm Type A/E glass fiber filters will be sited on the upwind and downwind perimeters of the each site, to evaluate compliance with 10 CFR Part 20, Appendix B, Table 2 air concentration limits. Air filters will be counted onsite for gross alpha activity, which will be compared to the limit for thorium-232 ($6x10^{-15}$ μCi/ml), the most restrictive isotope of thorium. Samplers will be operated for approximately 12 hours per workday. The upwind station will be used to establish background. The net concentration will be used to assess compliance with the thorium limit.

Over a 12-hour sampling period at 60 lpm, $4.32x10^4$ liters of air will be drawn through the filter. If thorium-232 is the only radionuclide present and the gross alpha air concentration is at 100 percent of the DAC, then the total activity on the filter will be 0.57 dpm. This corresponds to a total count of 14 counts in an hour using the onsite alpha tray counter. In addition, there will be approximately 4 counts arising from the counter background count rate or an MDA of 0.5 dpm ($5.3x10^{-15}$ μCi/ml). This shows that a 12-hour sample time is sufficient to detect airborne particulate activity at the thorium-232 limits.

A weekly change-out of the filter is anticipated (five 12-hour days) for normal operations. The use of gross alpha counting to demonstrate compliance with the regulations is adequate, considering the longer sampling time and the factor of three conservatism built into the method from assuming all alpha activity arises from thorium-232 decay. These factors will bring the MDA calculated above to approximately 6 percent of the DAC for thorium-232.

The RSO will inspect the RAS-1 air filters for mass loading at the end of each workday. They will change the air filters if mass loading is noted or the sampler flow rate declines. This is anticipated during extremely dusty conditions (dust generated primarily offsite).

The administrative and engineering controls (discussed in Section 5.4) to limit the work-area airborne particulate concentrations are expected to limit the probability of high measured concentrations at the site boundary. The RSO will be notified immediately (within 1 hour) if gross alpha air concentrations approach/exceed the 10 CFR Part 20, Appendix B, Table 2 limits. In addition, the archived air sample filters will be composited and sent to a vendor laboratory for analysis for isotopic uranium, radium-226, and isotopic thorium if the average gross alpha air concentrations approach or exceed the offsite limits. The laboratory results will be used to calculate the offsite concentrations. Finally, both the Project Manager and the RSO must approve engineering controls employed by the excavation/packaging contractor to attain acceptable offsite limits prior to resuming operations.

It is not anticipated that measurable radon or radon progeny concentrations will be detected at the site perimeter. The grab radon progeny measurements in the work area will be used to guide whether to implement a perimeter radon or radon-progeny monitoring program. A site perimeter-monitoring program for radon will be instituted if work-area measurements indicate that it is necessary to protect the workers from exposure to radon progeny.

5.6 MONITORING EQUIPMENT FOR UNCONDITIONAL RELEASE

The client has adopted limits for unconditional release of equipment referenced in Tables 11.1.5 and 11.1.6 of *The Heath Physics and Radiological Health Handbook* (Shleien et al, 1998). The reference limits for monitoring equipment are reproduced in Tables 5-4 and 5-5.

Table 5-4. Acceptable Surface Contamination Limits for Equipment

	Acceptable Surface Contamination Limits		
Nuclide[a]	**Total Average**[b,c,f]	**Total Maximum**[b,d,f]	**Removable**[b,e,f c]
Natural uranium, uranium-235, uranium-238, and associated decay products	5,000 dpm alpha / 100 cm^2	15,000 dpm alpha / 100cm^2	1,000 dpm alpha / 100 cm^2
Transuranics, radium-226, radium-228, thorium-230, thorium-228, protactinium-231, actinium-227, iodine-125, iodine-129	100 dpm / 100 cm^2	300 dpm / 100 cm^2	20 dpm / 100 cm^2
Natural thorium, thorium-232, strontium-90, radium-223, radium-224, uranium-232, iodine-126, iodine-131, iodine-133	1000 dpm / 100 cm^2	3000 dpm / 100 cm^2	200 dpm / 100 cm^2
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except strontium-90 and others noted above	5,000 dpm beta, gamma / 100 cm^2	15,000 dpm β,γ / 100 cm^2	1,000 dpm beta, gamma / 100 cm^2

<u>Notes:</u>

Adapted from "Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material" (from NRC Division of Industrial and Medical Nuclear Safety, 1987)

[a] Where surface contamination by both alpha and beta-gamma emitting nuclides exists, the limits established for alpha and beta-gamma emitting nuclides should apply independently.

[b] As used in this table, dpm means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

[c] Measurements of average contaminant should not be averaged over more than 1 m^2. For objects of less surface area, the average should be derived for each such object.

[d] The maximum contamination applies to an area not more than 100 cm^2.

[e] The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels should be reduced proportionally. The entire surface should be wiped.

[f] The average and maximum radiation levels associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/hr at 1 cm and 1.0 mrad/hr at 1 cm, respectively, measured through not more than 7 milligrams per square centimeter of total absorber.

cm = centimeters
cm^2 = square centimeters
dpm = disintegrations per minute
mrad/hr = millirad per hour
m^2 = square meter

Table 5-5. Guidelines for Radioactive Surface Contamination

		Activity Guide (dpm/100 cm^2)	
Group No	**Group Description**	**Removable**	**Total**[a]
I	All alpha emitters (except those in Group II) plus lead-210 (polonium-210) and radium-228 (thorium-228)	20	100
II	Uranium (natural, depleted, enriched [<10%]), thorium (natural)	200	1,000
III	Strontium-90, iodine-125, iodine-126, iodine-129, iodine-131	200	5,000
IV	All beta, gamma emitters not in Groups I, II, or III except beta emitters with $E_{max} \leq 0.15$ MeV[b]	1,000	5,000

Notes:

Adapted from Health Physics Society Draft Standard (ANSI N13.12, 1987)

[a] "Total" includes removable and fixed contamination.

[b] Pure beta-emitting radionuclides with maximum beta energies less than 0.15 MeV must be handled on a case-by-case basis because they are not detectable by conventional monitoring instruments.

cm^2 = square centimeters

dpm = disintecgrations per minute

MeV = million electron volts

There also is a requirement to reduce surface contamination to ALARA levels below the limits. Items that cannot be decontaminated to ALARA levels below these limits will be considered radioactive waste and disposed of accordingly.

A Ludlum Model 43-5 or a Model 43-90 alpha scintillation detector, coupled to a Model 12 ratemeter (or equivalent), will be used to scan or make static counts on potentially contaminated items. The Model 43-5 alpha detector has an active area of 76 cm^2 and an alpha efficiency of approximately 0.13 cpm/dpm. The Model 43-90 alpha detector has an active area of 125 cm^2 and an alpha efficiency of 0.16. The background count rate for both detectors is normally l cpm or less. Accepted guidance documents recommend that the scanning sensitivity should be done empirically although there are methods for estimating the sensitivity. For scanning, the technician listens for an audible increase in the count rate and then stops the scanning and evaluates the level either by waiting for the rate meter to register the full count rate (time depending on the time constant of the ratemeter) or performs an integrated count with a scaler. Since the background for this detector is normally very low, most technicians are trained to pause after hearing a single event.

The surface activity MDA, using a Ludlum 43-5 alpha detector coupled to a ratemeter and under static conditions, can be approximated by the following equation (Knoll, 1979):

$$MDA = 4.65 \sqrt{B_R / 2t_c} \Big/ \left(E * A / 100\right) \qquad \text{Eq. 5-2}$$

where :

B_R = background rate in counts/minute (1 cpm),

t_c = meter time constant in minutes (0.161 min),

E = detector efficiency (approximately 0.13 cpm/dpm), and

A = detector area 76 cm^2.

Substituting the values discussed above into the equation results in an MDA of 86 dpm/100 cm^2. A similar calculation for the Model 43-90 gives an MDA of 42 dpm/100 cm^2.

These detectors should be adequate to detect 1,000 dpm/100 cm^2 (680 alpha dpm/100 cm^2), averaged over an area of 1 m^2 or less. The active area of the Model 43-5 is 76 cm^2. It is reasonable to assume that 0.5 audible counts per second will adequately distinguish the count rate of a contaminated surface from background (approximately 5 counts/min). This is referred to as the audible discernable increase in count rate. A rough estimate of the scanning MDA may be calculated by dividing the audible discernable rate by the detector efficiency and detector area (NRC, 1997). This corresponds to an MDA of approximately 300 dpm/100 cm^2 for the Ludlum 43-5 detector. The MDA is 150 dpm/100 cm^2 for the Model 43-90. Both of these values are less than 1,000 dpm/100 cm^2. MARSSIM Equation 6-12 does not recommend calculating the scanning MDA for alpha detectors, but provides a statistical method for calculating the probability of detecting contamination as a function of the scanning speed (EPA, 2000a). The technician stops scanning upon hearing a count, because the background count rate is about 1 cpm for alpha detectors. The technician then pauses for a few seconds to determine whether the area is contaminated. A static count is made with the count time determined by the desired MDA and release limits if the counts continue. The probability of one or more counts while scanning is presented as

$$P(n \geq 1) = 1 - e^{(GEd\ /\ 60v)} \qquad \text{Eq. 5-3}$$

where:

P = probability of observing one or more counts,

G = contamination activity (dpm),

E = detection efficiency,

d = width of detector in direction of scan (cm), and

v = scanning speed.

The detection probabilities were calculated for the Model 43-5 and Model 43-90 alpha detectors using the limits for releasing equipment (680 dpm alpha/100 cm^2) and the limit for the structures (170 dpm alpha/100 cm^2). Table 5-6 provides the parameters and the results of the calculations.

Table 5-6. Probability of Detecting One or More Counts Using Alpha Detectors

Detector	Contamination Activity (dpm)	Detection Efficiency (cpm/dpm)	Width of Detector (cm)	Scanning Speed (cm/sec)	Probability $P(n \geq 1)$
Ludlum Model 43-90 Area = 125 cm^2 170 dpm/100 cm^2	213	0.16	7.5	1	0.99
	213	0.16	7.5	2	0.88
	213	0.16	7.5	3	0.76
	213	0.16	7.5	4	0.65
Ludlum Model 43-5 Area = 76 cm^2 170 dpm/100 cm^2	129	0.13	4.4	1	0.71
	129	0.13	4.4	2	0.46
Ludlum Model 43-90 Area = 125 cm^2 680 dpm/100 cm^2	850	0.16	7.5	1	1.0
	850	0.16	7.5	2	0.9998
	850	0.16	7.5	4	0.9857
	850	0.16	7.5	6	0.9411
Ludlum Model 43-5 Area = 76 cm^2 680 dpm/100 cm^2	517	0.13	4.4	1	0.993
	517	0.13	4.4	2	0.915
	517	0.13	4.4	2	0.806
	517	0.13	4.4	4	0.708
	517	0.13	4.4	6	0.560

Notes:
cm = centimeter
cm^2 = square centimeters
dpm = disintegrations per minute
/sec = per second

The probabilities in Table 5-6 are calculated for detecting smaller contaminated areas than the 1 m^2 area to which the release limits are applied. The probability of detecting at least one of two contiguous areas contaminated at the specified levels is increased by a factor of two, using probability theory. Therefore, it is almost certain that when a relatively large area contaminated at the specified levels is scanned, the technician will stop many times to take static measurements to define the contamination levels.

The MDA cannot be determined empirically at this time because the material is not available. However, a depleted uranium plated source (47 mm diameter) having an activity of 453 dpm was used to check whether a Ludlum Model 43-5 detector would detect its presence at a scanning speed of approximately 10 cm/sec. There was an audible indication that the detector was measuring above background levels during each of several passes. The detection efficiency for depleted uranium was approximately 10 percent. The MDA should be lower for thorium contamination, because the average alpha energy from the mixture of radionuclides at OT-10 sites should be significantly higher than that of depleted uranium (and thus a much higher detector efficiency). This test provided a high degree of certainty that the instrumentation is adequate to detect levels below 680 dpm/100 cm^2, averaged over an area no larger than 1 m^2.

Direct integrated readings can be taken using a Ludlum Model 43-5 alpha scintillation detector coupled to a Ludlum Model 2221 ratemeter/scaler, or equivalent. This is useful to obtain an average over 1 m^2 or to obtain a more precise value at a single location. In these situations, the measurement is made by integrating the detector counts over time.

Monitoring for removable contamination will be performed as indicated in the notes to Table 5-4. The RSO will wipe an area of 100 cm^2 with a dry filter or soft absorbent paper while moderate pressure is applied. Cloth media may be used instead of the paper. At least one wipe sample will be collected from each item. The RSO will collect wipe samples for removable contamination from all 1-m^2 areas in large items where direct readings indicate that the removable limit may be exceeded. The wipe samples will be counted for gross alpha using the Ludlum Model

2929/Ludlum Model 43-10-1 alpha-beta tray counter. The counting time will be adjusted to produce an MDA of 10 percent of the applicable limit.

5.7 CLEAN AREA MONITORING

Facilities within the support zone will be monitored for surface contamination at a frequency of not less than once per week to verify that contamination control has been maintained. Wipe samples will be taken from administrative offices, the break room, the onsite laboratory, and other appropriate areas and analyzed for surface contamination levels. Areas above natural background levels will be decontaminated; the Site RSO will review contamination control procedures in this case.

5.8 MONITORING WASTE PACKAGES AND CONVEYANCES FOR U.S. DEPARTMENT OF TRANSPORTATION COMPLIANCE

49 CFR §173.427 provides transport requirements for LSA Class 7 materials. Waste containers will be surveyed for contamination limits prior to release from the site to verify compliance with the DOT limits presented in 49 CFR §173.443. Dose-rate measurements will be made using a Ludlum Model 19 microR-meter (or equivalent)

Outgoing tractor-trailers will be monitored for compliance with the dose rate criteria of 10 CFR §173.441 after the transportation contractor places the intermodal containers on them. The exteriors of fully laden railcars will be monitored for compliance with 10 CFR §173.441. Tractor-trailers and railcars will not be monitored for surface contamination criteria in 10 CFR §173.443, because they will not contact the waste.

The surface contamination limits for shipment of LSA material, 2.2 dpm/cm^2 based on a 300 cm^2 area (660 dpm/300 cm^2), apply only to removable contamination. There are no limits for fixed contamination. The gamma-ray exposure rate limit is 10 mrem/hour, measured at 2 m from any exterior lateral surface of the vehicle (excluding the top and bottom), and 200 mrem/hour, measured on contact with any exterior surface. The limit for any occupied space in a vehicle is 2 mrem/hour.

The RSO will collect at least two surface wipe samples from the waste containers at locations considered to have the greatest potential for contamination. Additional samples will be collected from areas exhibiting the presence of soil or soil-like material. Samples will be analyzed onsite for gross alpha using a Ludlum Model 2929 scaler coupled to a Ludlum Model 43-10 alpha tray counter (or equivalent).

6.0 RESPIRATORY PROTECTION

Field personnel will apply administrative and engineering controls to limit airborne particulate to ALARA levels. Some of the measures that may be used when needed include

- Applying water to areas to be excavated,
- Spraying water during excavation and material handling operations,
- Modifying or stopping work during windy conditions (presence of visible dust),
- Controlling locations of work stations relative to wind direction, and
- Conducting invasive work during low wind conditions (normally in the morning).

Field personnel working in the radiological exclusion zone will wear air-purifying respirators if airborne concentrations of radioactivity in the work area exceed that defined as an "airborne radioactivity area" (10 CFR § 20.1003). The respiratory protection program will comply with 10 CFR Part 20, Subpart H, and the OSHA standard for respiratory protection (29 CFR § 1910.134). Other acceptable methods meeting the requirements in Subpart H include limiting exposure times and controlling access.

7.0 PERSONAL PROTECTIVE EQUIPMENT

PPE requirements differ for invasive and non-invasive activities. Invasive activities are defined as disturbing soils with mechanized equipment where the potential for significant concentrations of airborne particulates exists.

Invasive activities will require all personnel entering the exclusion zone to be in Level C protection and a respirator as directed by the Site RSO. Work will continue in Level C until it can be demonstrated that the airborne particulate levels are less than 10 percent of the airborne DAC for the mixture of radionuclides and will likely remain at or below these levels.

A modified EPA-defined Level D PPE will be worn for non-invasive activities, including steel-toe safety shoes, Tyvek® coveralls, shoe covers, and inner surgical (latex or nitrile) and outer cloth gloves.

8.0 BIOASSAY

Personnel working in an area of potential airborne thorium activity may be required, at the discretion of the Site RSO, to provide baseline and exit whole-body counts at a nuclear facility (such as SNL/NM). This program is designed to quantify the radionuclides within each worker prior to beginning work at the site and at the end of the project. Special whole-body counts may be done if there is a reason to believe that a worker has had a significant intake of radionuclides.

9.0 INCIDENTS

The Site RSO will thoroughly document all incidents, including those involving skin contamination, potential inhalation or ingestion of radionuclide materials, or whole-body exposure. Incidents will be reported as required by 10 CFR Part 20, Subpart M.

Before the project starts, Melanie Davis, the Project Manager, will coordinate with the client response organizations to properly treat potentially contaminated victims of a construction accident. Lovelace Hospital is fully prepared to accept radiologically contaminated victims and will be the designated hospital for medical treatment. Industrial accident victims will be monitored and decontaminated, if necessary, prior to leaving the site only if their injuries are not life threatening and decontamination will not affect the injury. Otherwise, the victims will be handled in the traditional manner as described in the HSP (Section 5.0). A radiation safety technician, the Site RSO, or the Project Manager will accompany the victim for treatment to facilitate communication with medical response personnel. Accidental spills of radioactive material during loading or transport will be handled according to the spill and discharge control plan (Section 3.2).

The following sections describe the NRC and incident reporting requirements.

9.1 NOTIFICATION REQUIREMENTS

Any events that require reporting will be reported by the Site RSO or his designee through the Stantec Project Manager, and the appropriate regulatory agencies. In non-emergencies, Stantec will not contact federal or state agencies without authorization from the Client. Immediate reporting is required when a loss of control of radioactive material that presents a real or potential hazard to off-installation populations, such as:

- The discovery of any detectable levels of radioactive material tracked or transferred off the site.
- A loss of radioactive material under circumstances that could result in the material leaving the site.
- Loss of control of radioactive material that presents a threat to life or health.
- Any event, such as fire, explosion, or toxic gas release, involving radioactive material that prevents taking the immediate protective actions needed to avoid exposures to radiation or radioactive material, or to avoid releases of licensed or permitted material, above regulatory limits.
- Any unexpected event involving radioactive material or radiation exposure deemed serious enough to warrant the interest or action of officials or agencies. This includes:
    - Events that may cause inquiries by the public or press;
    - Events requiring immediate NRC notification

Any event that causes a significant reduction in the effectiveness of any authorized shipping package during use. The Site RSO will detail the defects and their safety significance, explain how the defects were repaired and detail the plan to prevent their recurrence.

9.1.1 Incidents

Immediate notification is required for incidents involving radioactive material that can or has caused the following exposures:

- 25 rem TEDE
- 75 rem EDE
- 250 rem SDE
- Potential intakes of 5 times the ALI in 24 hours

Twenty-four-hour notification is required for incidents involving radioactive material that can or has caused the following exposures:

- 5 rem TEDE
- 15 rem EDE
- 50 rem SDE
- Potential intakes exceeding the ALI in 24 hours

Written notifications will be submitted within 30 days for the following:

- Any incident for which notification is required by 10 CFR § 20.2202;
- Doses exceeding occupational limits for adults;
- Doses exceeding occupational limits for minors;
- Doses exceeding occupational limits for an embryo/fetus;
- Doses exceeding license limits;
- Levels of radiation or concentrations of radioactive material in a restricted areas exceeding applicable

license limits;

- Levels of radiation or concentrations of radioactive material in unrestricted areas exceeding 10 times applicable license limits;

10.0 RECORDS

All surveys, radiation monitoring, and disposal will be documented, and the records will be maintained in accordance with 10 CFR Part 20, Subpart L. In addition, all workers will be required to provide documentation of previous exposure history prior to beginning work at the site.

APPENDIX B
STANDARD OPERATING PROCEDURES

STANDARD OPERATING PROCEDURES ST. ANTHONY MINE SITE	SOP-01 Revision: 2
HOLLOW STEM AUGER DRILLING, SAMPLING, AND CONE PENETRATION TESTING (CPT)	Date: March 2018

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LIST OF ATTACHMENTS

1.0 SCOPE AND APPLICABILITY

This Standard Operating Procedure (SOP) describes the procedure for hollow stem auger (HSA) drilling and collecting geotechnical soil samples, as well as cone penetration testing (CPT). The borings and test locations will be conducted at locations specified in the Work Plan. The sample intervals and test parameters are specified in the Work Plan. The procedures presented here are intended to be general in nature to allow various methods to be used based on variable site specific conditions.

2.0 PROCEDURES

2.1 BOREHOLE AND TEST LOCATIONS

Borehole locations will be initially located by a surveyor or by field staff using hand-held GPS coordinates as described in the Work Plan. Locations may be adjusted as needed in any direction from the preliminary location to facilitate drill rig access or to obstacles. Actual (adjusted) locations based on GPS coordinates will be noted on the field logs at time of drilling.

On completion of backfilling of each borehole, the location will be marked with a survey stake, noting the borehole number as provided in the Work Plan. On completion of backfilling and marking by survey stakes of all boreholes, ground surveys will be completed to locate the boreholes according to the marked locations.

2.2 CONE PENETRATION TESTING

A CPT(u) rig capable of measuring pore pressures in-situ and performing seismic CPTs will be used to advance the cone penetrometer through the tailings and native site soils (as applicable) according to the procedures outlined in ASTM D5778 (ASTM, 2012). If necessary, waste rock or other stiff surficial soils that cannot be penetrated without damaging CPT equipment will be penetrated using hydro-punch or auger drilling method to provide a pilot hole through such layers prior to CPT sounding.

The cone penetrometer will be advanced into the tailings at a target constant rate of about 2 cm/sec to provide a continuous profile of the material. The cone penetrometer will be advanced until refusal. Should refusal occur at a significantly shallower depth than expected, the rig will be moved five feet and the penetrometer will again be advanced until the anticipated depth at that location is reached.

2.2.1 Porewater Pressure Dissipation Tests

If perched water is encountered, pore pressure dissipation tests will be performed, once per sounding location, where positive pore pressure conditions exist, or as directed by the supervising field engineer or geologist. In order to properly measure pore pressures, the operator will de-air the porous stones to be used within the probe before each sounding is started.

The field engineer or geologist will monitor pore pressures, in real-time, while the probe is being pushed. The dissipation tests will be performed at locations identified during soundings by the field personnel. If the pressures indicate a zone of saturation, within a material of interest; advancement of the probe will be stopped. A test will be initiated and the changes in porewater pressure will be recorded over time.

Dissipation tests performed for C_h and K_h estimates will be run until at least 50% dynamic pore pressure dissipation has occurred. Dissipation tests performed to provide estimates of equilibrium pore pressures will generally target higher permeability sand zones (as determined by generalized CPT-based soil behavior type or site-specific CPT-soil type correlations) and will be run until stabilized pore pressure measurements are obtained (per ASTM D5778 Section 12.3.7). Regardless of test objective, CPT dissipation tests will not be run for a duration greater than one hour.

2.3 HOLLOW STEM AUGER DRILLING

The boreholes will be drilled with hollow stem augers (HSA) of various sizes. Soil sampling may include continuous core, California barrel samples, standard split spoon samples, and Shelby tube samples. In borrow areas, drill cuttings will be placed on the ground adjacent to the boreholes. In areas of concern, the cuttings will be placed on plastic sheeting or plywood, until they are drummed.

2.4 SOIL SAMPLING

The types and frequencies of soil samples will be provided in the Work Plan. Descriptions of the proposed sample types are included in the following sections.

2.4.1 Continuous Core Samples

Continuous core samples will be collected with a five-foot long continuous sampler barrel advanced inside the HSA as the HSA are advanced. Acrylic sample sleeves (30 or 60-inches long) may be used within the continuous core sampler to collect samples of sensitive materials. The continuous sampler barrel will be retrieved, opened, and the recovery measured/recorded. Out of place soils (slough) at the top of the sampler will be discarded. The soil core will be transferred intact to a core-logging table or truck bed, and core depth intervals marked with legible labels. Samples may be either removed from the core barrels prior to logging, or may be retained in transparent liners.

Photos of the labeled soil core will be taken. The samples will be logged and classified as specified in under Sample Descriptions and in SOP-17 Soil Logging. After logging and photographing the core, samples may be retained by one of two procedures at the discretion of the field geologist or geotechnical engineer, as follows:

1. Bulk samples: zones of similarly classified materials greater than 1-foot thick may be placed in bulk sample containers and handled as specified in Section 2.4.5. Adjacent core materials from the subsequent run or runs having similar classifications may be combined (composited) with the previously collected bulk samples. Subsamples of minor strata (less than 1 foot thick) having distinctly different field classifications than adjacent major strata, and samples for moisture testing will be placed in 1 gallon resealable bags and placed inside the sample buckets on top of the associated bulk composite samples.

2. Liner samples: Samples collected in transparent plastic liners may be retained in the liners. Liner caps will be sealed with plastic tape. Sample orientation will be indicated by an arrow pointing up or a “T” on the top cap.

Sample buckets, bags, and retained liners will be marked with the boring number and depth interval in accordance with SOP-14.

2.4.2 Split-spoon Samples

Split-spoon samples will be collected by driving the split spoon ahead of the HSA with a 140-lb hammer falling 30 inches. The sampler will be driven 18 inches and blow counts will be recorded for 6-inch intervals. Various diameters of split-spoon samplers may be used. The HSA will be advanced into the soils as necessary to provide discrete sample intervals. When retrieved, the split-spoon sampler will be opened, the recovery will be measured/recorded, and the soil described as specified in Section 2.4.6.

Split-spoon samples will be collected on a maximum of five feet vertical intervals. The sampled interval will be placed in gallon resealable bags. Out of place soils (slough) at the top of the sampler will not be sampled. Samples will be labeled and handled as specified in SOPs-06, 14, and 17. Sample depth will be the starting depth of the sample.

2.4.3 California Split-barrel Samples

California split-barrel samples will be collected by driving the California split barrel ahead of the HSA with a 140-lb hammer falling 30 inches. The California split-barrel sampler will be driven 18 inches and blow counts will be recorded for 6-inch intervals. California split-barrel samples will be collected utilizing a 2.5-inch outside diameter (OD) California split barrel sampler lined with three 2-inch diameter by 4-inch long brass liners, plus additional brass liners as necessary to fill the California split barrel sampler. Alternate sampler diameters may be considered for use, depending on the application.

The sample recovery will be measured/recorded and the soil described as specified in Section 2.4.6. The bottom two, 4-inch long, brass liners will be retained and capped; other recovered soils will be discarded. The brass liners will be labeled with the project number, borehole, sample depth, liner identification, sample date, and orientation. Sample depth is defined as the starting depth of the sample drive. Brass liner identification is “A” for the bottom brass liner and “B” for the brass liner above the “A” brass liner. Sample orientation is an arrow pointing up, a “T” on the top cap, or the orientation of the sample labeling.

2.4.4 Shelby Tube Samples

Shelby tube samples will be collected at locations and intervals specified in the Work Plan. Shelby tube samples will be collected by hydraulically advancing a 3-inch diameter (or other approved diameter), 30-inch long, Shelby tube sampler two feet or to refusal. The recovery will be measured and the soils described as specified in Section 2.4.6 by inspecting the soils at the top and bottom of the Shelby tube.

The Shelby tubes will be sealed before transport. The bottom cap will be secured with plastic tape. Melted wax (paraffin or paraffin with beeswax) will be poured into the top of the Shelby tube to stabilize and seal the top of the sample and be used to seal the end tape and caps. Spacers may also be used to stabilize the samples within the tubes. The top cap will then be secured with plastic tape (see SOP-06).

Both the Shelby tube and the top cap will be labeled with the job number, borehole, sample interval, orientation, and sample date. Shelby tubes must be handled, transported, and stored vertically and cushioned against shock and vibration.

2.4.5 Bulk Samples

Bulk samples will be collected at intervals specified in the Work Plan. Bulk samples may be collected from continuous core samples (Section 2.4.1), or auger cuttings as indicated in the Work Plan and placed in plastic buckets (3.5 or 5 gallon) for geotechnical testing and classification.

The sealed buckets will be labeled and handled as specified in the SOP-14.

2.4.6 Sample Descriptions

Soils will be described and classified in general accordance with SOP-17 (Soil Logging) and ASTM D2488 - Standard Practice for Description and Identification of Soils (Visual - Manual Procedure) (ASTM, 2009). Sample descriptions will include soil type, moisture content, color (Munsell Color), density or consistency, plasticity, grain-size and shape, and other descriptors, as applicable.

Boreholes will be logged on Stantec Borehole Log forms. An example Stantec Borehole Log form for recording field information is attached to this SOP as Appendix A. Sample intervals, recovery, blow counts (if performed), soil descriptions, and sample time will be recorded.

2.4.7 Field QA/QC Samples

Field duplicate and equipment blank samples for geotechnical samples will not be collected. Equipment blanks of geotechnical sampling equipment will not be collected.

2.5 DECONTAMINATION

HSA and CPT equipment will be decontaminated by removing visible material with a scraper or brush between test holes. Geotechnical sampling equipment will be decontaminated by removing visible material with a scraper or brush between samples. Equipment will be decontaminated at the drill sites. See also SOP-31 for additional details.

2.5.1 Borehole and CPT Abandonment

Abandonment specifics will be described in the Work Plan and may vary depending on the sampling location at the site. HSA boreholes and CPT holes will be abandoned with bentonite grout or soil cuttings.

3.0 DOCUMENTATION AND RECORDS MANAGEMENT

Field data will be recorded in bound field books or on Borehole Log forms (Attachment 1). Documentation and records procedures are specified in SOP-14. Field data collected during CPT will be recorded in bound field books and by the instruments associated with the cone penetrometer. Data recorded by the cone penetrometer instrumentation will be provided, by the operator, to Stantec within seven days of completion of CPT activities.

4.0 REFERENCES

ASTM. 2012. Standard Test Method for Electronic Friction Cone and Piezocone Penetration Testing of Soils. ASTM D5778-12. American Society for Testing and Materials, West Conshohocken, PA.

ASTM. 2009. Standard Practice for Description and Identification of Soils (Visual- Manual Procedure). D2488-09a. American Society for Testing and Materials, West Conshohocken, PA.

ATTACHMENT 1

SAMPLE BOREHOLE LOG

Stantec

Client:		**SOIL BORING LOG FORM**	BOREHOLE No.:
Project Number:			Sheet _______ of _______

Drilling Company:	Drilling Rig:	Bit Type:	Start Date:
Drillers (day / night):	Drilling Method:	Logged by:	Finish Date:
Field Representitive (day / night):	Core Diameter:		Total Depth:

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details

COARSE-GRAINED SOILS <50% passes #200 sieve	**GRAVELS** <50% coarse fraction passes #4 sieve	**GRAVELS** with little or no fines	Well-graded◊ gravels, gravel-sand mixtures, little or no fines	**GW**
			Poorly-graded◊ gravels, gravel-sand mixtures, little or no fines	**GP**
		GRAVELS with >15% fines	Silty gravels, poorly-graded◊ gravel-sand-silt mixtures	**GM**
			Clayey gravels, poorly-graded◊ gravel-sand-clay mixtures	**GC**
	SANDS <50% coarse fraction passes #4 sieve	**SANDS** with little or no fines	Well-graded◊ sands, gravelly sands, little or no fines	**SW**
			Poorly-graded◊ sands, gravelly sands, little or no fines	**SP**
		SANDS with >15% fines	Silty sands, poorly-graded◊ sand-gravel-silt mixtures	**SM**
			Clayey sands, poorly-graded◊ sand-gravel-clay mixtures	**SC**
FINE-GRAINED SOILS >50% passes #200 sieve	**SILTS AND CLAYS** liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity	**ML**
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	**CL**
			Organic silts and clays of low plasticity	**OL**
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	**MH**
			Inorganic clays of high plasticity, fat clays	**CH**
			Organic silts and clays of medium to high plasticity	**OH**
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	**PT**

CONSISTENCY *(Silts and Clays)*

Term	**Blows/ft*** *(SPT)* 1.4"ID	2.0"ID	*(modCAL)* 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY *(Sands and Gravels)*

Term	**Blows/ft*** *(SPT)* 1.4"ID	2.0"ID	*(modCAL)* 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

** = 140 pound hammer dropped 30 inches*

GRAIN SIZE

Term	**Size (mm)**	**Size (inches)**
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below:

Term	***%***
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

◊Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

PLASTICITY

- Nonplastic
- Low
- Medium
- High

MOISTURE

Term	**Field Test**
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	**Field Test**
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

▽	Depth to first water (time and date)
▼	Depth to water after drilling (time and date)

STANDARD OPERATING PROCEDURES

ST. ANTHONY MINE SITE

SAMPLE MANAGEMENT AND SHIPPING

SOP-06
Revision: 1

Date: March 2018

STANDARD OPERATING PROCEDURE 06
SAMPLE MANAGEMENT AND SHIPPING

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LIST OF ATTACHMENTS

1.0 SCOPE AND APPLICABILITY

This standard operating procedure (SOP) describes the requirements for sample identification, handling, storage, chain-of-custody (COC) documentation, and shipping. The purpose of this SOP is to define sample management activities as performed from the time of sample collection to the time they are received by the laboratory.

These procedures apply to all work conducted for Stantec clients, by Stantec, or under direction of Stantec at the St. Anthony Mine site. The information in this SOP may be used by direct reference or incorporated into project-specific plans. Deviations or modifications to procedures addressed herein must be brought to the attention of, and approved by, the Project Manager.

2.0 SAMPLE MANAGEMENT PROCEDURES

2.1 SAMPLE CONTAINERS

Samples will be placed in containers that are appropriate for the type of sample collected and the analyses that will be performed.

2.1.1 Chemical Samples

Samples to be submitted for chemical analysis will be placed in contaminant-free containers. Containers will be stored in cool, dry, clean areas to prevent exposure to fuels, solvents, and other non-site related impacts. Sample containers with preservatives added by the laboratory will not be used if held for an extended period on the job site or exposed to extreme heat conditions.

The sample containers to be used will be dependent on the sample matrix and analyses desired. Sample containers will be filled with adequate headspace if necessary (approximately 90 percent) for safe handling upon opening, except containers for volatile organic compound (VOC) analyses, which will be filled completely with no headspace. The no-headspace requirement applies to both soil and groundwater samples.

Once opened, the containers will be used immediately. If the container is used for any reason in the field (e.g., screening) and not sent to the laboratory for analysis, it will be discarded. Prior to discarding the contents of the used container and/or the container, disposal requirements will be evaluated to assess whether the contents or the container require disposal as a hazardous material. The containers will be stored (before and after sampling) remain separate from solvents and other volatile organic materials.

2.1.2 Geotechnical Samples

Samples to be submitted for geotechnical analysis will be collected in brass or plastic sleeves, or Shelby tubes as undisturbed samples, or in plastic bags or buckets as bulk samples. Undisturbed tube samples will be capped with plastic end caps and taped at both ends and/or sealed in re-sealable plastic bags to maintain sample moisture content. For Shelby tube samples, spacers will be used to stabilize the samples along with cheesecloth and wax. Wax will then be used in addition to plastic caps to seal both ends of each sample prior to prevent moisture loss.

2.2 FIELD SAMPLE IDENTIFICATION AND LABELING

2.2.1 Field Sample Identification

A protocol for field sample identification will be clearly defined at the beginning of the project based on client requirements and will be carried forward throughout the duration of the project. A coding system will be used to uniquely identify each sample collected.

The sample identifier should include sufficient information to allow for quick data retrieval and tracking throughout the project. This information could include the area of sample collection (such as Borrow Area South, Pile 1, etc.), test pit or boring identification, and depth of sample collection. As an example, the sample identifier “BS-1 @ 4-5’ ” would designate a sample collected by Stantec from borehole #1 in the Borrow Area South area from a depth of 4 to 5 feet. Regardless of the specific format used, it should be defined at the beginning of the project and carried forward through the duration of the project.

2.2.2 Sample Label

A sample label similar to that shown in Attachment 1 will be affixed to all sample containers. The sample label, at a minimum will be completed with the following information:

- Client name, project title, or project location
- Sample location
- Sample identification number
- Date and time of sample collection
- Type of sample (grab or composite)
- Initials of sampler
- Preservative used (if applicable)
- Label number (if applicable)

Alternatively, the above information may be written directly on the sample containers with permanent, waterproof ink.

If a sample is split with another party, identical labels will be attached to each sample container.

2.3 SAMPLE HANDLING AND STORAGE

After labeling, each aqueous sample will be refrigerated or placed upright in a cooler. Wet ice, in double re-sealable bags (to prevent leakage), will be placed around, among, and on top of the sample bottles. Enough ice will be used so that the samples will be chilled and maintained at 4 degrees Celsius (°C) + 2 °C prior to and during transport to the laboratory.

Geotechnical samples will be stored in a sturdy box, cooler, plastic bucket, or similar container. Care should be taken to store the samples out of direct sunlight. Shelby tubes and similar undisturbed samples will be stored upright and will be protected from excessive vibration and disturbance. If samples will be stored for several days prior to transport to the laboratory, they should be stored in a secure location rather than in a vehicle to protect them from vibration and disturbance.

Some sample types require specific handling procedures, including:

- Compressed gas cylinders
- Radioactive substances
- Biological hazards
- Chemical warfare agents
- Drugs (controlled substances)
- Explosive ordnance
- Explosives (as per the Department of Transportation [DOT])
- Shock-sensitive materials

If any of these materials are associated with a project, the field personnel must follow the health and safety procedures defined in the project-specific plans.

2.4 SAMPLE PRESERVATION

The requirements for sample preservation depend on the desired analyses and the sample matrix. Sample preservation requirements outlined in the project-specific work plan will be followed. When an acid or base is used as preservative, pH paper will be used to determine if an adequate amount of preservative is being used to preserve analytical samples. When testing pH for VOC samples, a third VOC sample will be collected, tested with pH paper, and then disposed of properly.

2.5 QUALITY CONTROL SAMPLES

The number and types of quality control (QC) samples to be collected for a project will be defined in the project-specific plans. The following briefly describes field QC samples that may be collected during a field program.

2.5.1 Trip Blanks

Trip blanks are used to assess cross-contamination of samples for VOC analysis from sample containers or during sample transport and storage at the laboratory. Trip blanks consist of 40 milliliter (ml) amber glass vials filled by the laboratories with acidified reagent-grade water, then sealed by the laboratories prior to shipment. Trip blank vials accompany the empty bottles to the site and remain with the samples throughout sample collection and shipment.

2.5.2 Equipment Rinseate Blanks

Equipment rinseate blanks are used to evaluate sample equipment decontamination procedures and are prepared in the field (after decontamination of sampling equipment is complete). These samples are prepared by collecting the final equipment decontamination rinse water into the appropriate sample container.

2.5.3 Filter Blanks

If water samples are collected for dissolved metals analysis, a filter blank (for each lot of filters) should be collected prior to sample collection to evaluate whether the filter is a source of metals to the samples. This sample is collected in the field by passing the source water through the same filter type that will be used to filter water media for dissolved metals analysis.

2.5.4 Duplicate Samples

Duplicate field samples (water samples) are used to assess variability in the sample media and to assess sampling and analytical precision. A duplicate sample pair is a single aqueous grab sample that is split into two samples during collection. If the field duplicate is being submitted blind to the laboratory, one of the samples is labeled with the correct sample identification and the other is labeled with fictitious sample identification. Regardless of whether the samples are submitted blind to the laboratory or not, the field duplicate and parent sample are submitted to the same laboratory as two separate samples.

2.5.5 Replicate Samples

Replicate field samples (air, soil, or sediment) are used to assess variability in the sample media and to assess sampling and analytical precision. A replicate sample pair is a single soil grab sample that is split into two samples during collection. If the field replicate is being submitted blind to the laboratory one of the samples is labeled with the correct sample identification and the other is labeled with a fictitious sample name. Regardless of whether the samples are submitted blind to the laboratory or not, the field replicate and parent sample are submitted to the same laboratory as two separate samples.

2.6 SAMPLE HOLDING TIMES

The holding times for samples will depend on the analysis and the sample matrix. Unless otherwise specified, holding times listed in project-specific work plans will be followed. For geotechnical samples, holding times do not apply. However, samples will be shipped as soon as possible and kept cool to prevent drying and mold growth.

2.7 CHAIN-OF-CUSTODY (COC)

Chain-of-custody procedures require a written record of the possession of individual samples from the time of collection through laboratory analyses. A sample is considered to be in custody if it is:

- In a person's possession
- In view after being in physical possession
- In a secured condition after having been in physical custody
- In a designated secure area, restricted to authorized personnel

2.7.1 COC Record

The COC record, similar to the example shown in Attachment 2, will be used to document the samples collected and the required analyses. Information recorded by field personnel on the COC record will include the following:

- Client name
- Project name
- Project location
- Sampling location
- Signature of sampler(s)
- Sample identification number
- Date and time of collection
- Sample designation (grab or composite)
- Sample matrix
- Signature of individuals involved in custody transfer (including date and time of transfer)
- Airbill number (if appropriate)
- Number and type of samples collected for each analysis
- Type of analysis and laboratory method number
- Any comments regarding individual samples (e.g., organic vapor meter readings, special instructions)

All COC entries will be made using indelible ink and will be legible. Any errors will be corrected by drawing a single line through the incorrect entry, entering the correct information, and then initialing and dating the change. Unused portions of the COC form will be crossed out with a single strike through and initialed and dated by the field sampler.

If the samples are transferred directly from the field sampler to the laboratory, both the receiving and relinquishing individuals will sign the COC. If samples are transported to the laboratory by a commercial carrier, signed airbills or other applicable bills of lading will serve as evidence of custody transfer between the field sampler and carrier as well as carrier and laboratory.

The sampler will retain copies of the COC record and airbills, or bills of lading. If the COC records are sequentially numbered the record number and airbill number will be cross-referenced in the field logbook or appropriate field form.

2.7.2 Custody Seals

Custody seals, similar to the label shown in Attachment 3, will be used on each sample (if required) and/or shipping container to ensure custody. Custody seals used during the course of the project will consist of security tape with the date and initials of the sampler. As a minimum, custody seals will be placed in two locations (the front right and back left of the cooler) across the cooler closure to ensure that any tampering is detected. If required by the client, a seal will be placed on each sample container so that it must be broken to gain access to the contents. Because VOC samples may be subject to contamination by the tape, VOC sample containers will first be secured in a re-sealable plastic bag. The plastic bag will then be sealed with a completed custody seal. If the seals are serially numbered, these numbers will be cross-referenced in both the field logbook and the COC form.

2.7.3 Sample Register/Sample Tracking

The sample register maybe electronic or a bound logbook with sequentially numbered pages. The sample register is used to document which samples were collected each day. The sample register is also used as the key to correlate field samples with duplicate samples. Information that will be recorded in the sample register includes the following:

- Client name
- Project name and location
- Job number
- Date and time of collection
- Sample identification number
- Sample designation (e.g., grab or composite, etc.)
- Sample matrix (e.g., soil, groundwater, etc.)
- Number and type of bottles
- Type of analysis
- Sample destination
- Sampler's initials

If the sample register is electronic, a hard copy of each day's sampling activities will be maintained in the field logbook.

2.8 SAMPLE SHIPPING

Geotechnical samples will be preserved and transported in general accordance with ASTM D4220. Shelby tube samples and brass liners will be transported vertically in the orientation in which they were obtained. If the samples will be driven to the laboratory by field staff, they will be secured for transport against excessive vibration inside the cab of the vehicle on the seats. If the samples will be shipped by a commercial carrier, shipping containers designed to maintain orientation and minimize disturbance will be used.

Procedures for packaging and transporting samples to the laboratory are based on the actual chemical, physical, and hazard properties of the material. The procedures may also be based on an estimation of contaminant concentrations/properties in the samples to be shipped. Samples will be identified as environmental samples, excepted quantities samples, limited quantities samples, or standard hazardous materials.

- Environmental samples are defined as solid or liquid samples collected for chemical or geotechnical analysis.

- Excepted quantities involve the shipment of a few milliliters of either an acid or base preservative in an otherwise empty sample container.
- Limited quantities are restricted amounts of hazardous materials that may be shipped in generic, sturdy containers (this includes geotechnical samples of mill tailings).
- Standard hazardous material shipments require the use of stamped/certified containers.

Samples other than those listed above (refer to Section 2.3) must be shipped according to the requirements of 49 CFR 173.24 and other applicable Federal, state, and local regulations. Prior to the collection and shipment of these samples, shipment requirements will be researched, a written description of shipment procedures will be prepared, and the description reviewed and approved by a Stantec certified industrial hygienist prior to sample collection. These shipment procedures will be included in the project-specific plans. Examples of such samples include materials that potentially contain asbestos, radioactive materials, explosives, and chemical warfare agents, and transformer fluids (refer to Section 2.3).

The following paragraphs describe standard sample shipping procedures for different types of samples. Any exceptions to these procedures will be defined in the project-specific work plan. If the samples to be collected are potentially limited quantity or standard hazardous materials the most current DOT regulations must be reviewed to ensure that the most current shipping procedures are used. The carrier service selected for transport may also be able to provide information needed for sample shipping procedures. It is the responsibility of the sampler to understand Department of Transportation requirements and limitations associated with the shipment of all types of samples.

No samples, other than geotechnical samples, will be held on site for more than 24 hours, except during weekend field activities. Samples collected on the weekend will be stored under refrigeration and shipped the following Monday. Sampling activities for analytes with extremely short holding times, such as 24 hours, will not be scheduled for weekend collection.

Occasionally, multiple coolers or packages will be sent in one shipment to the laboratory. One cooler will have the original COC Record and the other coolers will have copies. The plastic bag in which the COC Records are placed will be marked appropriately “ORIGINAL” or “COPY.” In addition, the outside of the coolers will be marked to indicate how many coolers are in the shipment (i.e. “1 of 2” or “2 of 2”).

2.8.1 Environmental Samples

Hand-Delivered Samples: For aqueous or solid samples that will be hand carried to the Contract Laboratory the following procedures apply:

- Sample labels will be completed and attached to sample containers as described in Section 2.2.
- The samples will be placed upright in a waterproof metal (or equivalent strength plastic) ice chest or cooler.
- Wet ice in double re-sealable bags (to prevent leakage) will be placed around, among, and on top of the sample bottles. Enough ice will be used so that the samples will be chilled during transport to the laboratory.
- To prevent the sample containers from shifting inside the cooler, the remaining space in cooler will be filled with inert cushioning material, such as shipping peanuts, additional bubble pack, or cardboard dividers.
- The original copy of the completed COC Record will accompany the samples to the laboratory.
- A copy of the COC Record will be retained for the project files.

Commercial Carrier: For aqueous or non-geotechnical solid samples that are shipped to the Contract Laboratory via a commercial carrier the following procedures apply:

- Sample labels will be completed and attached to sample containers as described in Section 2.2.
- The samples will be placed upright in a waterproof metal (or equivalent strength plastic) ice chest or cooler. If the container has a drain, the drain will be taped shut and a large plastic bag used as a liner for the cooler. Each sample will be placed in a separate re-sealable or bubble-wrap bag. As much air as possible will be squeezed from the bag before sealing. Bags may be sealed with a custody seal if required by the client.
- Wet ice in double re-sealable bags (to prevent leakage) will be placed around, among, and on top of the sample bottles. Enough ice will be used so that the samples will be chilled and maintained at 4 degrees Celsius ± 2 degrees Celsius during transport to the laboratory. Dry ice will not be used. In addition, experience has shown that blue ice is inadequate to maintain sample temperature and it will not be used for sample preservation.
- To prevent the sample containers from shifting inside the cooler, the remaining space in the cooler will be filled with inert cushioning material, such as shipping peanuts, additional bubble pack, or cardboard dividers.
- The original copy of the completed COC Record will be placed in a waterproof plastic bag and taped to the inside of the cooler lid.
- The lid will be secured by wrapping strapping tape completely around the cooler in two locations.
- As a minimum, custody seals similar to those shown in Attachment 3 will be placed in two locations (the front right and back left of the cooler) across the cooler closure to ensure that any tampering is detected.
- The airbill will be filled out before the samples are handed over to the carrier. The laboratory will be notified if Stantec personnel suspect that the sample contains any substance for which the laboratory personnel should take safety precautions.
- A copy of the COC Record and the signed air bill will be retained for the project files.

Geotechnical Samples: Geotechnical samples may be hand-delivered or shipped in a sturdy box or other container. No ice is necessary. Enough packing material will be added so that samples remain undisturbed. COC procedures as described previously will be followed to generate defensible data. Any hazardous nature of the samples, including any organic vapor measurements, name of suspected contaminants present, and the approximate range of concentrations, if know, should be noted on the COC Record.

2.8.2 Excepted Quantities

Usually, corrosive preservatives (e.g., hydrochloric acid, sulfuric acid, nitric acid, or sodium hydroxide) are added to otherwise empty sample bottles by the analytical laboratory prior to shipment to field sites. However, if there is an occasion whereby personnel are required to ship bottles with these undiluted acids or bases, the containers will be shipped in the following manner:

- Each individual sample container will have not more than 30 milliliters of preservative.
- Collectively, these individual containers will not exceed 500 milliliters in the same outer box or package.
- Despite the small quantities, only chemically compatible material may be placed in the same outer box, i.e., sodium hydroxide, a base, must be packaged separately from the acids.
- Federal Express will transport nitric acid only in concentrations of 40 percent or less.
- A "Dangerous Goods in Excepted Quantities" Label will be affixed to the outside of the outer box or container. Information required on the label includes:
    - Signature of Shipper
    - Title of Shipper
    - Date
    - Name and Address of Shipper

- Check of Applicable Hazard Class
- Listing of UN Numbers for Materials in Hazard Classes.

2.8.3 Limited Quantities

Occasionally, it may become necessary to ship known hazardous materials, such as pure product (e.g., light or dense non-aqueous phase liquids, geotechnical samples of uranium mill tailings). DOT regulations still permit the shipment of many hazardous materials in "sturdy" packages, such as an ice chest or cardboard box (not a specially constructed and certified container), provided the following conditions are met:

- Each sample bottle of liquid is placed in a plastic bag, and the bag is sealed. Each VOC vial is wrapped in a paper towel, and the two vials are placed in one bag. As much air as possible is squeezed from the bag before sealing. Bags may be sealed with evidence tape for additional security.
- Each bottle of liquid is placed in a separate paint can, the paint can is filled with vermiculite, and the lid is affixed to the can. The lid must be sealed with metal clips, filament, or evidence tape. If clips are used, the manufacturer typically recommends six clips.
- The outside of each can will contain the proper DOT shipping name and identification number for the sample. The information may be placed on stickers or printed legibly. A liquid sample of an uncertain nature will be shipped as a flammable liquid with the shipping name “FLAMMABLE Liquid N.O.S.” and the identification number “UN1993.” If the nature of the sample is known, Title 49, Cold of Feral Regulations, Parts 171 to 177 (49 CFR 171-177) will be consulted to determine the proper labeling and packaging requirements. The carrier should be contacted to ensure that the information provided is correct.
- The cans are placed upright in a cooler that has had the drain plug taped shut inside and outside and lined with a large plastic bag. Approximately 1 inch of packing material, such as vermiculite or other type adsorbent sufficient to retain any liquid that may be spilled, is placed in the bottom of the liner. Three sizes of paint cans may be used: pint, half-gallon, and gallon. The pint or half- gallon paint cans may be stored on top of each other; however, the gallon cans are too high to stack. The cooler will be filled with additional packing material, and the liner will be taped shut. Only containers having chemically compatible material may be packaged in each cooler or other outer container.
- The COC Record will be paced inside a sealed plastic bag and attached to the inside of the cooler lid. The sampler retains one copy of the COC Record. The laboratory will be notified if the sample is suspected of containing any substance for which the laboratory personnel should take safety precautions.
- The lid will be secured by wrapping strapping tape completely around the cooler in two locations. As a minimum, custody seals similar to those shown in Attachment 3 will be placed in two locations (the front right and back left of the cooler) across the cooler closure to ensure that any tampering is detected.

- The following markings are placed on the side of the cooler:
  - Proper Shipping Name (Column B, List of Dangerous Goods, Section 4, IATA Dangerous Goods Regulations [DGR])
  - UN Number (Column A, List of Dangerous Goods, Section 4, IATA DGR)
  - Shipper's name and address
  - Consignee's name and address
  - The words "LIMITED QUANTITY"
  - Hazard Labels (Column E, List of Dangerous Goods, Section 4, IATA DGR)
  - “Cargo Aircraft Only” (if applicable as identified in 49 CFR 172.101).

  - Two Orientation (Arrow) labels (indicating “This End Up”) placed on opposite sides of the cooler.
- The Airbill/Declaration of Dangerous Goods form will be completed as follows:
  - Shipper's name and address
  - Consignee's name and address
  - Services, Delivery & Special Handling Instructions
  - Passenger or Cargo Aircraft (cross off the non-applicable items. Up to
  - 25 pounds of flammable solid per cooler can be shipped on a passenger aircraft. Up to 1 quart of flammable liquid per cooler can be shipped on a passenger aircraft and up to 10 gallons of flammable liquid can be shipped on a cargo aircraft).
  - Cross out "Radioactive" under Shipment Type
  - Nature and Quantity of Dangerous Goods
  - Proper Shipping Name (Column B, List of Dangerous Goods, Section 4, IATA DGR)
  - Class or Division (Column C, List of Dangerous Goods, Section 4, IATA DGR)
  - UN Number (Column A, List of Dangerous Goods, Section 4, IATA DGR)
  - Packing Group (Column F, List of Dangerous Goods, Section 4, IATA DGR)
  - Subsidiary Risk, if any (Column D, List of Dangerous Goods, Section 4, IATA DGR)
  - Quantity and type of packing (number and type of containers: for example, "3 plastic boxes", and the quantity per container, "2 L", is noted as "3 Plastic boxes X 2 L". This refers to 3 plastic boxes (coolers are referred to as plastic boxes) with 2 liters in each box.
  - Packing Instructions (Column G, List of Dangerous Goods, Section 4, IATA DGR). Note: Only those Packing Instructions in Column G that begin with the letter "Y" may be used. These refer specifically to the Limited Quantity provisions.
  - Authorization (Write in the words Limited Quantity)
  - Emergency Telephone Number (List 800-535-5053. This is the number for INFOTRAC.)
  - Printed Name and Title, Place and Date, Signature

2.8.4 Standard Hazardous Materials

Shipment of hazardous materials using this option presents the most difficulty and expense. However, there may be occasion whereby a hazardous material cannot be shipped under the Limited Quantity provisions, e.g., where there is no Packing Instruction in Column G, List of Dangerous Goods, IATA Dangerous Goods Regulations, that is preceded by the letter "Y."

In such cases, the general instructions noted above but for non-Limited Quantity materials will apply, but with one important difference: standard hazardous materials shipment requires the use of certified outer shipping containers. These containers have undergone rigid testing and are, therefore, designated by a "UN" stamp on the outside, usually along the bottom of a container's side. The UN stamp is also accompanied by codes specifying container type, packing group rating, gross mass, density, test pressure, year of manufacturer, state of manufacturer, and manufacturer code name. The transport of lithium batteries in Hermit Data Loggers is an example of a standard hazardous material, and where only a designated outer shipping container may be used. Contact the DOT for the most current shipping regulations.

2.9 TRAINING

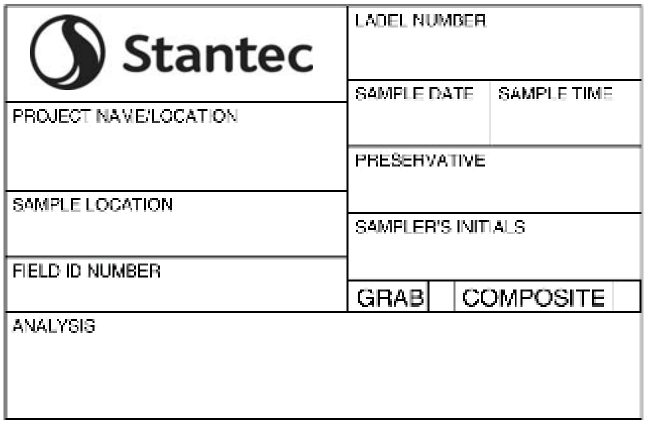
The U.S. Department of Transportation requires that all employees involved in any aspect of hazardous materials transport (shipping, transport, receipt, preparing documents) receive training at least bi-annually. Project Managers have the overall responsibility for ensuring all sampling staff have appropriate training.

3.0 REFERENCES

U.S. Environmental Protection Agency, 1996. *EPA Test Method for Evaluating Solid Waste Physical/Chemical Methods* (SW-846), U.S. EPA Third Edition, September 1986; Final Update III, December 1996.

ATTACHMENT 1

SAMPLE LABEL



Stantec

LABEL NUMBER

PROJECT NAME/LOCATION

SAMPLE DATE

SAMPLE TIME

PRESERVATIVE

SAMPLE LOCATION

SAMPLER'S INITIALS

FIELD ID NUMBER

GRAB ☐ COMPOSITE ☐

ANALYSIS

ATTACHMENT 2

CHAIN-OF-CUSTODY RECORD

ATTACHMENT 3

CUSTODY SEAL

Lynn Peavey Co.
1-800-255-6499

LAB SAMPLE
DO NOT TAMPER

DATE ______________

INITIALS ____________

ENERGY LABORATORIES

Chain of Custody and Analytical Request Record

Page _____ of _____

PLEASE PRINT- Provide as much information as possible.

Company Name:

Project Name, PWS, Permit, Etc.

Sample Origin
State:

EPA/State Compliance:
Yes ☐ No ☐

Report Mail Address:

Contact Name:

Phone/Fax:

Email:

Sampler: (Please Print)

Invoice Address:

Invoice Contact & Phone:

Purchase Order:

Quote/Bottle Order:

Special Report/Formats – ELI must be notified prior to sample submittal for the following:

- ☐ DW
- ☐ GSA
- ☐ POTW/WWTP
- ☐ State: ___________
- ☐ Other: ____________
- ☐ A2LA
- ☐ EDD/EDT(Electronic Data)
- **Format:**____________
- ☐ LEVEL IV
- ☐ NELAC

Contact ELI prior to **RUSH** sample submittal for charges and scheduling – See Instruction Page

Comments:

Shipped by:

Cooler ID(s):

Receipt Temp
__________ ° C

On Ice:
Yes **No**

Custody Seal **Y** **N**
Intact **Y** **N**
Signature Match **Y** **N**

SAMPLE IDENTIFICATION (Name, Location, Interval, etc.)	Collection Date	Collection Time	**Number of Containers** Sample Type: A W S V B O Air Water Soils/Solids Vegetation Bioassay Other **MATRIX**	ANALYSIS REQUESTED									SEE ATTACHED	Normal Turnaround (TAT)	**R U S H**		LABORATORY USE ONLY
1																	
2																	
3																	
4																	
5																	
6																	
7																	
8																	
9																	
10																	

Custody Record MUST be Signed

Relinquished by (print): Date/Time: Signature:
Received by (print): Date/Time: Signature:
Relinquished by (print): Date/Time: Signature:
Received by (print): Date/Time: Signature:
Received by Laboratory: Date/Time: Signature:
Sample Disposal: Return to Client: ____________ Lab Disposal: ____________

In certain circumstances, samples submitted to Energy Laboratories, Inc. may be subcontracted to other certified laboratories in order to complete the analysis requested.
This serves as notice of this possibility. All sub-contract data will be clearly notated on your analytical report.
Visit our web site at www.energylab.com for additional information, downloadable fee schedule, forms, and links.

PLEASE read and remove before completing the attached Chain of Custody (COC) form. **PLEASE** read and remove before completing the attached Chain of Custody (COC) form.

PLEASE read and remove before completing the attached Chain of Custody (COC) form.

ENERGY LABORATORIES

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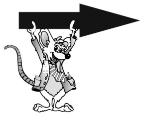
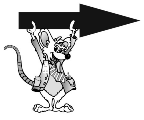
Voice: 775.777.0956
Fax: 775.777.0956
Cell: 775.750.0956

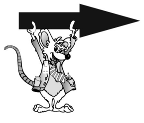
BEFORE COMPLETING THE ATTACHED CHAIN OF CUSTODY (COC) FORM:



If you wish to request RUSH Turn Around Time (TAT), contact the lab PRIOR to sample submittal to confirm that RUSH analysis is available for your request. Verify date required. Additional charges will apply for RUSH Turn Around Time (TAT).



Please contact ELI PRIOR to sample submittal if services are other than standard.

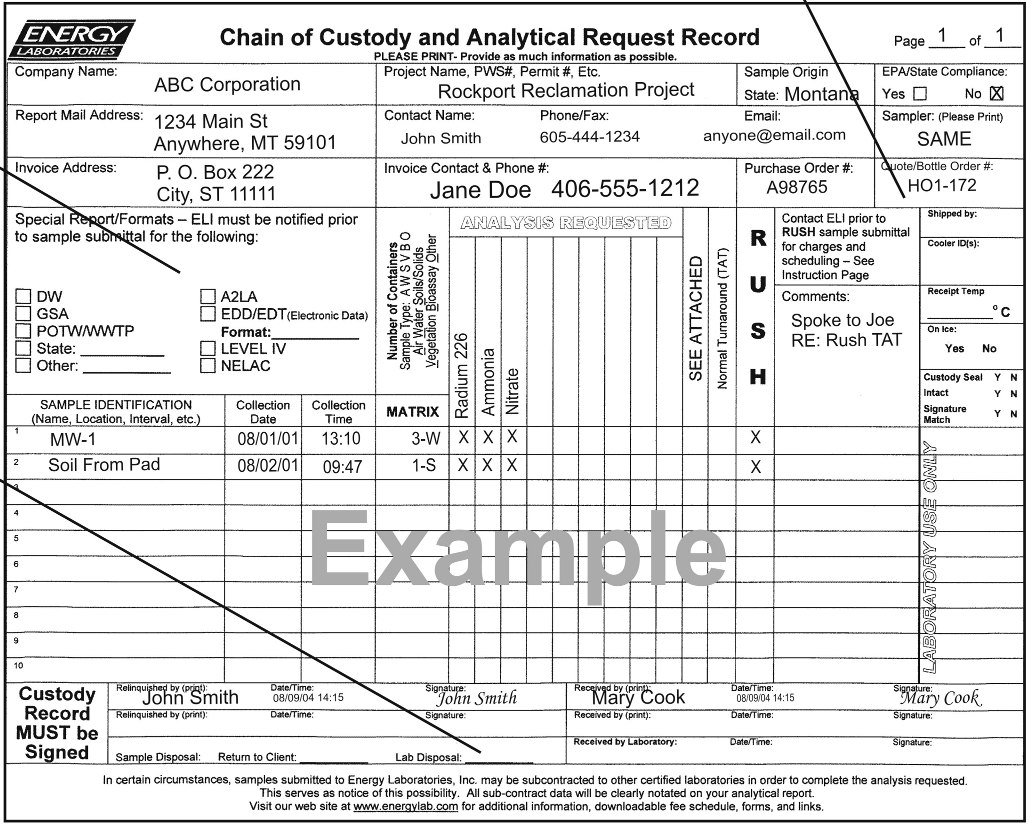


It is important to complete the attached Chain Of Custody(COC) form with as much detailed information as possible. This information is required so that the appropriate analytical services, reporting and invoicing can be provided for your project.

Quote Number or Bottle Order Number:
ELI provides quotes for project specific sampling requirements. It is very important to provide the ELI quote number or bottle order number to assure that you receive the quoted pricing for your project.

Select the types of services you need:
If services other than standard are required for your analytical project, contact ELI PRIOR to sample submittal.

Sample Disposal:
ELI, when applicable, will dispose of all non-hazardous samples. Routinely, hazardous samples will be returned to the client. If requested, ELI will dispose of hazardous samples at client's expense.



ENERGY LABORATORIES

Chain of Custody and Analytical Request Record

Page 1 of 1

PLEASE PRINT- Provide as much information as possible.

Company Name: ABC Corporation
Project Name, PWS#, Permit #, Etc. Rockport Reclamation Project
Sample Origin State: Montana
EPA/State Compliance: Yes ☐ No ☒
Report Mail Address: 1234 Main St Anywhere, MT 59101
Contact Name: John Smith
Phone/Fax: 605-444-1234
Email: anyone@email.com
Sampler: (Please Print) SAME
Invoice Address: P. O. Box 222 City, ST 11111
Invoice Contact & Phone #: Jane Doe 406-555-1212
Purchase Order #: A98765
Quote/Bottle Order #: HO1-172

Special Report/Formats – ELI must be notified prior to sample submittal for the following:

☐ DW
☐ GSA
☐ POTW/WWTP
☐ State: __________
☐ Other: __________
☐ A2LA
☐ EDD/EDT(Electronic Data)
Format:__________
☐ LEVEL IV
☐ NELAC

ANALYSIS REQUESTED

R U S H

Contact ELI prior to **RUSH** sample submittal for charges and scheduling – See Instruction Page

Comments: Spoke to Joe RE: Rush TAT

Shipped by:
Cooler ID(s):
Receipt Temp ________ °C
On Ice: Yes No
Custody Seal Y N
Intact Y N
Signature Match Y N

	SAMPLE IDENTIFICATION (Name, Location, Interval, etc.)	Collection Date	Collection Time	**Number of Containers** Sample Type: A W S V B O Air Water Soils/Solids Vegetation Bioassay Other **MATRIX**	Radium 226	Ammonia	Nitrate							SEE ATTACHED	Normal Turnaround (TAT)	RUSH
1	MW-1	08/01/01	13:10	3-W	X	X	X									X
2	Soil From Pad	08/02/01	09:47	1-S	X	X	X									X
3																
4																
5																
6																
7																
8																
9																
10																

LABORATORY USE ONLY

Example

Custody Record MUST be Signed

Relinquished by (print): John Smith Date/Time: 08/09/04 14:15 Signature: John Smith
Received by (print): Mary Cook Date/Time: 08/09/04 14:15 Signature: Mary Cook
Relinquished by (print): Date/Time: Signature:
Received by (print): Date/Time: Signature:
Sample Disposal: Return to Client: ________ Lab Disposal: ________
Received by Laboratory: Date/Time: Signature:

In certain circumstances, samples submitted to Energy Laboratories, Inc. may be subcontracted to other certified laboratories in order to complete the analysis requested. This serves as notice of this possibility. All sub-contract data will be clearly notated on your analytical report. Visit our web site at www.energylab.com for additional information, downloadable fee schedule, forms, and links.

PLEASE read and remove before completing the attached Chain of Custody (COC) form.

PLEASE read and remove before completing the attached Chain of Custody (COC) form. **PLEASE** read and remove before completing the attached Chain of Custody (COC) form.

STANDARD OPERATING PROCEDURES ST. ANTHONY MINE SITE	SOP-07 Revision: 1 Date: March 2018
SOIL SAMPLING	

STANDARD OPERATING PROCEDURE 7
SOIL SAMPLING

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1.0 SCOPE AND APPLICABILITY

This standard operating procedure (SOP) presents the soil sampling procedures to be used at the St. Anthony Mine site. This guideline focuses on methods and equipment that are readily available and typically applied. It is not intended to provide an all-inclusive discussion of soil sampling methods. Sample types, samplers, and sampling methods are discussed.

2.0 SOIL SAMPLING

2.1 TYPES OF SAMPLES

Four basic types of samples are collected in site investigation work: bulk samples, representative samples, "undisturbed" samples, and composite samples.

2.1.1 Bulk Samples

Bulk samples are generally a shovelful or trowelful of material taken from cuttings. There is usually significant uncertainty regarding which interval the cuttings represent. Bulk samples are typically collected from test pits, trenches, or drill cuttings.

2.1.2 Representative Samples

Representative samples are collected with a drive or push tube. They do not represent undisturbed conditions but do represent all the constituents that exist at a certain interval.

2.1.3 Undisturbed Samples

"Undisturbed" samples are high-quality samples collected under strictly controlled conditions to minimize the structural disturbance of the sample. Undisturbed samples should be collected when all the presampling relationships need to be preserved. Every effort is made to avoid altering the sample during the sampling process. Undisturbed samples are generally required for geotechnical work and are rarely necessary to assess environmental quality.

2.1.4 Composite Samples

Composite samples are a blend or mix of sample material, usually combined from two or more stratigraphic intervals mixed in such a way as to represent the total borehole. Homogenized samples are samples that are composited over a discreet interval. For example, if a sample represented the 10- to 11.5-foot interval, the material from that interval would be mechanically blended before being put into the appropriate sample container. VOC samples are never composited or homogenized.

2.2 SAMPLING METHODS

2.2.1 Solid-Barrel Samplers

The length of the solid barrel sampler is 1 to 6 inches and the length is between 12 and 60 inches. The sampler is usually made out of steel or stainless steel and can be used with thin-walled liners that can be slid into or out of the sampler barrel. Liners may be made of brass, aluminum, stainless steel, or synthetic materials. Allowable liner materials are based on the types of materials, tests, and analyses performed.

2.2.2 Split-Spoon Samplers

Split-spoon samplers are the most commonly used sampler for monitoring and geotechnical work and can be applied to a variety of drilling methods. Split-spoon samplers are usually made out of steel or stainless steel. They are tubular in shape and are split longitudinally into two semi-cylindrical halves. They may be lined or unlined. Liners are made of brass, aluminum, stainless steel, or various synthetic materials. Split-spoon samplers are generally available in 2-, 2.5-, 3-, 3.5-, and 4-inch outside diameters (OD). Lengths range between 12 and 60 inches. The 18-inch long sampler is the most commonly used. Three 6-inch liners are commonly used with this sampler. Sixty-inch samplers are commonly used when continuous coring is necessary.

Driving (hammering) is the most common method of obtaining split-spoon samples up to 2.5 feet in length. For most sampling a 140-pound hammer is used. The hammer may either be at the ground surface or in-hole. A standard penetration test should be conducted in accordance with American Society for Testing and Materials (ASTM) D1586. Samples are collected from the split-spoon sampler by driving the sampler into undisturbed material beneath the bottom of the casing or borehole with a weighted hammer. The number of blow counts per 6-inch increment of total drive are recorded. An estimate of the density and consistency of the subsurface soils can be made from the relationships among the hammer weight, drop, and number of blows required to advance the split spoon in 6-inch increments.

If the sampler cannot be advanced 6 inches with a reasonable number of blows (usually about 50) than sampler refusal occurs and the sampling effort at that particular interval is terminated. If "auger refusal" has not occurred, the hole is advanced to the next sampling interval where another attempt at sample retrieval is made.

After the split spoon is removed, it is opened for visual inspection and classification. If an adequate sample volume has not been retrieved, additional sample shall be collected from a second sampler from the interval immediately below the preceding interval.

If volatile organic compounds (VOCs) are to be analyzed, the sample is to be immediately transferred into the appropriate sampling jars upon retrieval of the split spoon from the borehole. Following sample description the contents of the samples for non-VOC analyses shall be emptied into a stainless steel bowl and the sample shall be thoroughly blended before transfer into the sample jars. Care shall be taken to ensure that the sample collected is representative of the sample interval, and not slough material. All slough material shall be discarded. A representative sample shall be retained in an archive box.

2.2.3 Thin-Walled Tube Samplers

The thin-walled tube (Shelby tube) sampler is a 30- or 36-inch-long, thin-walled steel, aluminum, brass, or stainless steel tube equipped with a connector head. It is primarily used in soft or clayey formations where it will provide more sample recovery than a split-spoon sampler and when relatively undisturbed samples are desired. The most commonly used sampler has a 3-inch OD and a 2.81-inch cutting diameter, and is 30 inches long.

Pressing or pushing without rotation is the normal mode of advance for the thin-walled sampler. If the tube cannot be advanced by pressing, it may become necessary to drive the sample with drill rods and hammers without rotation. The tubes are generally allowed to stay in the hole 10 to 15 minutes to allow the buildup of skin friction prior to removal. The tube is then rotated to separate it from the soil beneath it, prior to being brought to the surface.

After removal, the sample is inspected to ensure an adequate sample volume has been collected. If an inadequate volume has been collected, the above sampling procedure shall be repeated.

Upon retrieval, the soil core shall be described and recorded in the logbook and any disturbed soil shall be removed from the end of the tube. VOC samples shall be removed and placed in the appropriate sample containers immediately upon sample retrieval. Thin-walled tubes shall be capped with nonreactive material for transport.

2.2.4 Continuous Coring

Continuous coring is usually performed with a 60-inch split-spoon sampler that is advanced by pressing without rotating while the drill bit is rotating. The sampling tube is lowered into and retrieved from the augers or drill stem using a wireline or drill rods.

The sampling tube is locked into place so that the sampler protrudes slightly ahead of the drill bit. As the bit is advanced, the auger is pressed into the formation. After the hole has been advanced the length of the sampling tube, the full sampler is retrieved and an empty sampler is put down the hole. Sampling procedures will follow those described in Section 2.2.2.

STANDARD OPERATING PROCEDURES **ST. ANTHONY MINE SITE**	**SOP-08** **Revision: 1** **Date: March 2018**
TRENCHING AND TEST PITS	

STANDARD OPERATING PROCEDURE 8 TRENCHING AND TEST PITS
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1.0 SCOPE AND APPLICABILITY

This standard operating procedure (SOP) describes the methods and equipment to be used for conducting trench and test pit excavations. Shallow test pits and trench excavations are used to: 1) permit both lateral and vertical examination of subsurface conditions, 2) provide access for collecting shallow soil and groundwater samples, and 3) provide a means of determining the orientation of discontinuities in the subsurface.

2.0 TRENCHING AND TEST PIT PROCEDURES

2.1 EQUIPMENT

Trench and test pit excavations are typically carried out by motorized equipment such as rubber tires backhoes and track mounted excavators. Operators of excavating equipment shall be skilled and experienced in safe use of the equipment. A typical backhoe with an extending arm can excavate to a depth of approximately 15 feet. If investigations are required to extend beyond 15 feet, test pits may not be the most appropriate method of investigation and the use of other methods (e.g., soil borings) should be considered.

2.2 SAFETY REQUIREMENTS AND PROCEDURES

Safety is perhaps the most critical consideration in any excavation project. This SOP does not address compliance with the regulations of the Occupational Safety and Health Administration (OSHA). Those issues shall be addressed in project-specific health and safety plans. Prior to all excavations, the sampling team must confirm that any underground utilities (electric, gas, telephone, water, etc.) in the general vicinity have been clearly identified.

During excavation activities, standard hand signals shall be used for rapid and efficient communication between the backhoe operator and the ground crew. Before approaching the test pit or excavating machine, the ground crew must ascertain that the equipment operator has noted their presence and has stopped operation of the equipment.

Upon locating the area for excavation, the field sampling personnel shall determine wind direction and position the excavator upwind of the pending excavation. The backhoe operator shall outline the area of investigation by extending the bucket arm to its maximum length, and tracing a 180-degree outline around the area to be excavated to create the exclusion zone. The support crew shall cordon off the exclusion zone with barricades and brightly colored "caution" tape.

Once the equipment has been appropriately positioned, excavation can begin. If the area of investigation is beneath vegetative cover or surface debris, the backhoe operator shall scrape the initial 6 inches of topsoil to allow a clear and safe working area. In areas without ground cover, any excavated fill material shall be stockpiled away from the immediate edge and away from the native soil to be excavated and sampled. The excavated native soil will be placed on clean plastic or native soil in 2-foot lifts. Both fill material and native soil shall be placed away from the trench to prevent excavated soil from re-entering the trench or pit, and to reduce pressure on the sidewalls. Sidewalls of the excavation may be sloped in loose soils to stabilize the sidewalls and prevent caving.

Excavated soil shall be stockpiled downwind of the ground crew and the equipment operator. Shifting winds may cause the equipment operator and ground crew to periodically move in order to remain upwind, or to curtail further activities. The support crew shall regularly monitor the equipment operator and ground crew’s airspace.

Material brought to the surface and handled shall be disposed of in accordance with procedures outlined in the project-specific work plan.

Entry of personnel into pits or trenches is strictly prohibited unless specifically approved by the site-specific health and safety plan, and special precautions and accommodations are provided. Strict adherence to state and federal Occupational Safety and Health Administration (OSHA) trenching guidelines (29 CFR 1926.650) shall be observed. Under this standard, when personnel are required to enter an excavation 5 feet deep or more, adequate means of exit such as ladders, steps, ramps, and other full lateral support of the sidewalls must be provided and be within 25 feet of lateral travel. In addition, personnel entering the trench may be exposed to toxic, explosive, or oxygen-deficient atmospheres. If these atmospheres are anticipated, air monitoring shall be performed before and during entry, and appropriate respiratory gear and protective clothing can be worn, if necessary. Caution must be exercised at all times and at least two people must be present at the immediate site (OSHA, 1990).

Care shall be taken to ensure that personnel do not stand too close to the edge of the trench, especially during sampling or depth measurements. The added weight of a person adjacent to the pit can increase the risk of sidewall failure.

Depending on the desired depth of excavation, the trench may require shoring (lateral support) to prevent the sides from collapsing. Lateral support may be provided by a portable aluminum frame system that uses a hydraulic pump to apply pressure to the sidewalls and that can be quickly inserted or extracted, or the sides benched to an appropriate angle. Only skilled personnel shall install timber supports or any other alternative support required in excavations.

Although personnel shall normally not be required to enter the excavation, it is important to know the possible behavior of the various soil types and conditions that may be encountered. Excavations in fill are generally more unstable than those in native soil. Table 1 below indicates maximum allowable slopes for different soil types (Federal register, Rules and Regulations, Vol. 84, October 1989).

Table 1. MAXIMUM ALLOWABLE SLOPES

Soil or Rock Type	Maximum Allowable Slope (H:V) for Excavations Less Than 20 Feet
Stable Rock	Vertical (90 degrees)
Type A	3/4:1 (53 degrees)
Type B	1:1 (45 degrees)
Type C	1-1/2:1 (34 degrees)

The numbers shown above in parentheses, next to the maximum allowable slopes (MAS), are angles measured from the horizontal. In addition, a short-term MAS of 1/2:1 (63 degrees) is allowed in excavations in Type A soil that are 12 feet or less in depth. Short-term MAS for excavations in Type A soil greater than 12 feet in depth are ¾:1 (53 degrees). Sloping or benching for excavations greater than 20 feet in depth shall be designed by a registered professional engineer.

Excavations in very soft, normally consolidated clay should stand vertically, without support, to depths of approximately 12 feet in the short term only. This critical depth increases as the clays increase in consistency. Long-term stability is dependent on a combination of factors including the soil type, pore water pressures, and other forces acting within the soil. Fissured clays can fail along well-defined shear planes and, therefore, their long-term stability is not dependent on their shear strength and is difficult to predict.

Dry sands and gravels can stand at slopes equal to their natural angle of repose regardless of the depth of the excavation (angles can range from approximately 28 to 46 degrees depending on the angularity of grains and relative density).

Moist sands and gravels possess some cohesion and can stand vertically for a short period of time. However, the stability of water-bearing sands is very difficult to predict in open excavations. If they are cut steeply, as in trench excavation, seepage of water from the face will result in erosion at the toe followed by collapse of the upper part of the face until a stable angle of approximately 15 to 20 degrees is obtained.

Dry silts should stand unsupported vertically, especially if slightly cemented. Saturated silt is the most difficult material to excavate. Seepage of water into excavations in silt leads to slumping and undermining with subsequent collapse, eventually reaching a very shallow angle of repose.

It should not be assumed that excavations in rock will stand with vertical slopes unsupported. Their stability depends on the soundness, angle of bedding planes or joints, and the degree of fracturing. Unstable conditions can occur if bedding planes or joints slope steeply towards the excavation, especially in the presence of groundwater.

2.3 FIELD RECORDING AND SAMPLING TECHNIQUES

The field record shall include a field form giving the location, dimensions, and orientation of the pit or excavation, together with dimensioned sections of the sidewalls, description of the strata encountered, and details of any sampling or testing performed. Working from the ground surface, the technician or other designated personnel shall prepare a visual log of the strata/soil profile and decide the sampling interval. If possible, a photographic record of the excavation, with an appropriate scale, shall be obtained.

Soil samples from excavations can be either disturbed or undisturbed. Soil sample collection methods and procedures are described in SOP-07. Details of sample collection shall be provided in site-specific sampling plans.

2.4 BACKFILLING

Test pits or trenches shall be backfilled immediately upon completion of the excavation and soil sampling, or at a time determined by the Project Manager. Excavated material, including fill material, will be placed back into the excavation in the order it was removed. During backfilling, the excavated material will be compacted in one or two foot lifts with the backhoe or excavator bucket. The backfilled material will be compacted to prevent settling of soil.

3.0 REFERENCES

U.S. Department of Labor, Occupational Safety and Health Administration (OSHA), 1990 (Revised). Excavations.

Federal Register, Rules and Regulations, Vol. 84, No. 209, October 1989.

STANDARD OPERATING PROCEDURES ST. ANTHONY MINE SITE	SOP-10 Revision: 1 Date: March 2018
SURVEYING	

STANDARD OPERATING PROCEDURE 10 SURVEYING

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1.0 INTRODUCTION

This Standard Operating Procedure (SOP) describes the general types of surveys and requirements for performing the various surveys. This document will describe the applicability and operation of control, land, topographic, and aerial surveys along with precision and accuracy required for each. This document is intended for the project manager to help develop work plans and manage resources.

2.0 SURVEY GUIDELINES

The following sections provide guidelines to the performance of several types of surveys and the precision and accuracy required for each. Emphasis is placed on the application of surveying techniques to geoenvironmental investigations. With the exception of recording some locations using hand-held GPS equipment, the surveys will be performed by a licensed professional surveyor, under subcontract to Stantec.

2.1 PERFORMING SURVEYS

The following sections briefly describe the various types of surveys that may be performed at the site, what information may be required to perform the survey, and when each survey may be appropriate. In general, survey will be used on the project to record the locations of sample collection, and soil borings and to document the existing site features and topography, as well as the as-built features upon completion of construction.

2.1.1 Establishing Control (Monuments, Baselines, etc.)

Prior to initiating any type of survey, control must be established. The type of control needed depends on the order (first, second, or third) of accuracy that is required. Established control points are based on the National Geodetic Survey which publishes specifications for first-, second-, and third-order horizontal and vertical control surveys. These specifications provide a starting point for establishing standards on most projects that required basic control surveys.

Accuracy refers to the closeness between measurements and expectations or true values. The farther a measurement is from its expected value, the less accurate it is. Observations may be accurate but not precise if they are well distributed about the expected value but are significantly disbursed from one another. Accuracy is often referred to in terms of its order (i.e., first, second, or third order accuracy). The order of accuracy refers to the error of closure allowed; guidelines for each order of accuracy are as follows:

Order of Accuracy	Maximum Error
1st	1/25,000
2nd	1/10,000
3rd	1/5,000
4th	1/3,000
5th	1/1,000
Lowest	1/500

The surveying contractor should be familiar with established control points near the site to be surveyed. From these control points the Surveyor will measure angles and distances to the site to be surveyed to establish local control at the site. Based on the project requirements, monuments can be set at the site that can be used in future site-surveys as a control point. Care must be taken when establishing new control points and elevations from other agencies' vertical control points that all the old control bench marks are on the same datum or reference plane. The monument will be stamped with the state plane coordinates and the elevation (feet above mean sea level) such that it will serve as a reference point for additional surveys. This can save time in future surveys as the surveying contractor will not have to survey new locations from distant established control points.

For boundary surveys, the Bureau of Land Management keeps a file on property survey data related to public lands. State, county, city and town engineering and surveyors offices may also be consulted for useful survey data on private property. This information is used by the Surveyor to locate property boundaries based on existing markers, monuments, angles and distances.

2.1.2 Control Survey

This is the most common type of survey performed in a geoenvironmental investigation. It is used to establish the horizontal and vertical positions of points such as soil borings or monitoring wells. Control is typically established horizontally from a theodolite and electronic distance measurement instrument or using a transit and stadia as part of a three-dimensional traverse. The traverse is used to measure the distance and direction from a known point and the elevation with reference to a known monument. Horizontal and vertical data are then plotted and elevation data interpolated. This type of survey should be used for small areas and for locating particular points.

2.1.3 Topographic Survey

A topographic survey is made to secure data from which a map can be made indicating the configuration of the terrain and location of natural and man-made objects. This type of survey can be performed either using established control monuments or by aerial photography using a digital terrain model (DTM) or digital elevation model (DEM). Contour intervals should be determined before measurement and specified such that enough detail of the site topography is provided. The field surveying methods employed will be determined by the scale to which the map is drawn. The topographic survey is used to identify high and low spots at a site as well as natural drainage patterns. Topographic surveys can be performed on a site of any size but contour intervals will dictate the time and cost of the survey.

2.1.4 Aerial Survey

An aerial survey is performed by a high-precision camera mounted in an aircraft. Photographs are taken in an organized manner as the aircraft flies over the terrain. Aerial surveys are commonly used for larger sites where boundaries and topography are to be defined. Ground surveys are also required in conjunction with aerial surveys to establish control points for the aerial survey.

The main advantages of aerial surveys over ground methods include: 1) speed of compilation; 2) reduction in the amount of control surveying required to control the mapping; 3) high accuracy of the locations of planimetric features; 4) faithful reproduction of the configuration of the ground by continuously-traced contour lines; 5) not restricted due to inaccessible terrain; and 6) can be designed for a map scale ranging from 1 inch = 20 feet to 1 inch = 20,000 feet with as small as 0.5-foot contour intervals.

The disadvantages associated with aerial surveys include: 1) difficulties in plotting areas with heavy ground cover (high grass, timber, and underbrush); 2) high cost per acre of mapping areas smaller than 5 acres; 3) difficulties in locating positions of contour lines in flat terrain; and 4) editing requirements to include road classifications, boundary lines, drainage classification, and names of places, roads, and other map features.

2.1.5 Boundary Survey

A boundary, land, or property survey is performed to determine the length and direction of land lines and to establish the position of these lines on the ground. The area of the tract bounded by the lines can also be determined. This type of survey is made using established control monuments and establishing angles and distances from those monuments based on a legal description of the property.

2.1.6 As-Built Survey

An as-built survey is a post-construction survey that shows the exact final location and layout of civil engineering works. This type of survey provides positional verification and records that include design changes.

2.2 REQUIRED ACCURACY AND PRECISION

The required survey accuracy and precision depends on the intended purpose of the survey work. Such requirements could range from gross estimation of a sampling station for inclusion on a small-scale vicinity map to the determination of top of casing elevations to 0.01 feet to establish groundwater gradients. In general, no more than third order accuracy is required for sampling station location and elevation measurements performed in environmental investigations. However, higher accuracies may be required for boundary surveys, topographic surveys, etc. The following sections discuss accuracy and precision requirements for specific survey types.

2.2.1 Geoenvironmental Investigations

For environmental investigations, surveying activities generally consist of obtaining horizontal and vertical coordinates of sampling locations to assess the migration and extent of contaminants in the soil and/or groundwater. The following sections describe precision and accuracy requirements for various field investigation activities.

2.2.1.1 Borings, CPT, and Test Pits

Boring and test pit locations will be located (and laid out) using either hand-held GPS or survey methods depending on the location. The borings, CPT, and test pit locations will be marked with stakes upon completion, so that the completed locations can be recorded by a surveyor.

Surveyed horizontal locations and ground surface elevations for borings and test pits are used to graphically indicate locations on site maps and are often included in boring logs and test pit logs. The surveyed locations are also used to construct geologic sections or profiles. Horizontal locations should be staked out to ± 1.0 foot, and ground surface elevations measured to ± 0.1 feet.

Typically, locations of borings/test pits are surveyed after completion, and care must be taken to measure the original surface elevation as accurately as possible (e.g., a mound or depression may remain in the trench area). The location and outline of the trench/test pit must be adequately staked to permit the required surveying, and stakes should be used to facilitate locating the trench. Stakes can also be used to make boring locations readily visible.

2.2.1.2 Monitoring Wells, Pumping Wells and Piezometers

Horizontal location and ground surface and top of casing elevation criteria for wells and piezometers are generally similar to those of test pits or borings. However, vertical precision in the elevation measurements is essential due to the groundwater elevation measurements that will be collected subsequent to the well installation.

All surveying data, including horizontal location, ground surface elevation, and the elevation of the top of the inner casing will be surveyed after well installation. The accuracy of the horizontal plane survey should be ± 1 foot (unless greater accuracy is desired) and is measured to any point on the well casing cover. The vertical plane survey measurements at the ground surface and on the north side of the top of the inner casing must be accurate to ± 0.01 feet. The point at which the elevation was measured on the inner casing should be scribed so that water level measurements may be taken at the same location. The inner casing shall be inscribed appropriately by the field team and directions will be provided to the Surveying Contractor to collect vertical measurements from the correct location. This procedure is used for both above ground and flush-mounted monitoring well completions.

2.2.1.3 Surface Water Sampling Locations

When grab samples are obtained from the edges of surface water bodies, the sampler can often estimate and mark the approximate location and elevation directly on a site topographic map. Typically, such sampling locations do not require great location accuracy (within several feet), since they are usually only indicated graphically on the site map. However, depending on the accuracy required for the project, a location stake at the shoreline may be installed that marks the sampling location with the station number, coordinates, and water surface elevation.

When samples are to be taken within the surface water body away from the shoreline, better horizontal control is usually required. Sampling locations are determined by the sampler using on-shore baselines or ranges.

2.2.1.4 Surface Soil Sampling Locations

The measurement and layout requirements for obtaining a single grab sample of surface soil are comparable to those for obtaining surface water grab samples from the shoreline. Where a composited sample is to be collected from a sampling grid, the surveyors should stake out the grid and indicate the station number(s), coordinates or orientation of the grid, and ground elevation(s) on the stakes. Generally, a precision of 1.0 foot for location and 0.1 feet for elevation will suffice for grab or grid surface sampling.

2.2.1.5 Air Sampling Stations

Air sampling stations generally need no more layout precision than grab sampling. Therefore, horizontal and vertical plane survey accuracy should be within 1.0 and 0.1 feet, respectively.

2.2.1.6 Other Sampling Locations

Other sampling points can be located using methods similar to those described above. For example, biological sampling stations can be established with the same surveying methods and precision as for the air, water, or soil grab sampling. For unusual or unique sampling methods, appropriate surveying requirements must be developed in consideration of the specific intentions and site conditions. For sampling man-made facilities such as drums, tanks, and pipelines, it is usually most convenient if the sampler identifies these locations at the time of sampling, directly on a topographic map of these facilities.

2.2.2 Topographic Surveys

The results of topographic surveys are usually only represented graphically on maps. Thus, the required accuracy and precision of the field survey is dependent upon the required accuracy and precision for the map as determined by the map scale. Typically, when the scale of 1 inch = 100 feet is to be used, horizontal distances can be plotted to the nearest 1 or 2 feet, while if the scale is 1 inch = 1,000 feet, the plotting will be to the nearest 10 or 20 feet and the field measurements can be correspondingly less precise. For most purposes, horizontal measurements in the field need be no more than third order accuracy and to a precision of the nearest foot. Vertical field survey measurements are depicted on maps graphically as contour lines, and numerically as spot elevations. For most purposes, such vertical field measurements can be performed to no more than third order accuracy and to a precision of 0.1 feet. Commonly, maps showing contour intervals of one foot or more indicate spot elevations between or beyond contour lines to the nearest tenth of a foot.

2.2.3 Aerial Surveys

The standards to be followed in using aerial photography in preparing topographic maps depend on the specific equipment and techniques used in obtaining the photographs and preparing the map.

2.2.4 As-Built Surveys

As-built surveys will show locations of all buildings, channels, utilities, roads, or other structures constructed at the site. Locations should be referenced to base lines or to at least two other fixed points with an accuracy to the nearest 1.0 foot.

2.2.5 Boundary Surveys

Accuracies for boundary maps are usually determined by State or Municipal law. Generally, second order accuracy is required for the survey so that property boundaries can be established to a precision of one second in their bearing and 0.01 feet in their length. In addition to being graphically plotted to scale on the boundary map, the results of the boundary survey are also numerically recorded on the map as the actual bearing and length of each site border.

3.0 REFERENCES

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Wirshing, J.R., and R.H. Wirshing, 1985. Shaum's Outline of Theory and Problems of Introductory Surveying. McGraw-Hill, Inc.

STANDARD OPERATING PROCEDURES ST. ANTHONY MINE SITE	SOP-14 Revision: 1 Date: March 2018
FIELD DOCUMENTATION	

STANDARD OPERATING PROCEDURE 14 FIELD DOCUMENTATION

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1.0 INTRODUCTION

This guideline is a general reference for the required documentation to be completed by personnel during field investigations. Documentation in the form of field logbooks, reports, and forms should be completed for every activity in the field. Records should be maintained on a daily basis as the work progresses. All field documentation should be accurate and legible because it is part of the client's product and may potentially serve as a legal document.

2.0 FIELD DOCUMENTATION GUIDELINES

Field documentation serves as the primary foundation for all field data collected that will be used to evaluate the project site. Field activities will be documented in field logbooks and task-specific logs and forms. All field documentation should be accurate, legible and written in indelible ink. Absolutely no pencils or erasures are to be used. Mistakes written in the field books, logs, or on forms that need to be deleted should be crossed out with one line, initialed, and dated. Skipped pages or blank sections at the end of a page should be crossed out with an "X" covering the entire page or blank section; "No Further Entries," initials, and date should be written by the person making the correction. The responsible field team member should write his/her signature, date, and time after each day's last entry. To further assist in the organization of the field books, logs, or forms, it is important to write the date on top of each page and the significant activity description (e.g., boring or well number). In addition, all original field documentation should be submitted to the project files.

The descriptions of field data/documentation given below serve as a guideline; individual projects will vary in documentation needs.

2.1 FIELD LOGBOOKS

The field logbook is a bound, weatherproof book with numbered pages that serves primarily as a daily log of the activities carried out during the investigation. All entries should be made in indelible ink. A field logbook should be completed for each operation undertaken during the investigation. The logbook should serve as a diary of the events of the day.

A description of the general information that should be recorded in all logbooks is provided below, followed by a listing of task-specific information that may also be recorded.

2.1.1 General Logbook Information

The following general information should be recorded in each logbook:

- Project and site name
- Date
- Weather conditions
- Personnel and subcontractors on the site and time spent on the site
- Site visitors
- Record of tailgate meetings
- General field observations
- Health and safety activities including calibration records for health and safety equipment, personnel contamination prevention and decontamination procedures, and record of daily tailgate safety meetings

2.1.2 Supervisory Activities

Supervisory responsibilities include general supervision, support, assistance, and coordination of the various field investigation activities. In addition to the general information listed above, records of supervisory activities should be maintained in a logbook and will include:

- Field operations and personnel assigned to each activities
- Log of supervisory activities including time spent supervising each operation and summary of daily operations as provided by field team members
- Problems encountered and related corrective actions
- Deviations from the sampling plan
- Records of communications with the client, subcontractors, field team members, and Project Manager
- Information on addresses and contacts
- Record of invoices signed and other billing information

2.1.3 Drilling and Soil Sampling Activities

In addition to the general information listed above, personnel involved in drilling and soil sampling are responsible for recording the following information:

- Site name and well or soil boring number
- Sample location (sketch)
- Drilling method and equipment used
- Name of drilling company or excavation contractor
- Name of name of contractor personnel including driller and helpers
- Calibration of field equipment
- Drilling activities:
    - Borehole diameter
    - Drill cuttings disposal/containerization (number of drums, roll off-bins, etc.)
    - Type and amount of drilling fluids used (mud, water, etc.)
    - Depth and time at which first groundwater was encountered, depth to water at completion of drilling, and the stabilized depth to water. The absence of water in the boring should also be noted.
    - Total drilling depth of well or soil boring
    - Type and amount of materials used for well installation
    - Well construction details [depth of grout (mixture, weight), bentonite seal, filter pack, etc. [include type and amount used, calculate estimated amount that should be used]
    - Type and amount of material used to backfill soil borings
    - Time and date of drilling, completion, and backfilling
- Sampling information including date and time of sample collection, sample interval, and number of

samples collected

- Equipment decontamination procedures
- Disposal of contaminated wastes (PPE, paper towels, visqueen, etc.)
- Problems encountered and corrective action taken
- Deviations from the sampling plan

2.1.4 Groundwater Sampling/Development Activities

In addition to the general information listed above, the groundwater sampling and development team members are responsible for recording the following information:

- Calibration of field equipment
- Disposal of contaminated wastes (PPE, paper towels, visqueen, etc.)
- Site name, well number
- Water levels and product levels [time and datum that water levels are measured (i.e. top of casing)]. Purging of the well (include calculations, well volumes) with the following information:
    - Measured field parameters (temperature, pH, conductivity, odor, color, cloudiness, etc.)
    - Amount of water purged
    - Purge method: indicate bailer/pump, diameter and length of bailer, material that the bailer is composed of, type of pump, new nylon rope, etc.
- Purge waterdisposal/containment (Baker tank/drums, number used, identification, etc.)
- Well sampling including number of samples collected, type of containers used, date and time of sample collection, QA/QC samples collected; names given to blind samples
- Equipment decontamination procedures
- Problems encountered and corrective actions taken
- Deviations from the sampling plan

2.2 TASK-SPECIFIC LOGS AND FORMS

In addition to field logbooks, task-specific logs and forms will be used to record pertinent field information. These are provided in the applicable SOP for each task type. The following are common types of logs and forms and a listing of the information that must be recorded. Other task-specific forms may be used, depending on project needs.

2.2.1 Boring Logs

The preparation of drill logs is the responsibility of the field team members assigned to the drill rig. A detailed description of well logging is provided in SOP-17. The following basic information should be recorded on the log regardless of the format:

- Project and site name
- Date and weather conditions
- Name of driller and drilling company
- Well/soil boring ID and location (sketch)

- Drilling and backfilling dates and times
- Reference elevation for all depth measurements
- Total depth of completed soil boring/well
- Depth of grouting, sealing, and grout mixes
- Signature of the logger
- Detailed description of all materials encountered (see Soil Logging SOP-17)
- Stratigraphic/lithologic changes; depths at which changes occur
- Depth intervals at which sampling was attempted and amount of sample recovered
- Blow counts
- Depth intervals from which samples are retained
- Depth at which first groundwater was encountered, depth to water at completion of drilling, and the stabilized depth to water. The absence of water in the boring should also be noted.
- Loss and depth of drilling fluids, rate of loss, and total volume of loss
- Use of drilling fluids
- Drilling and sampling problems
- PID readings

2.2.2 Well Construction Diagrams

The preparation of well construction diagrams is also the responsibility of field team members assigned to the drilling operations. The following basic information should be recorded and/or illustrated on the diagram regardless of the format:

- Project and site name
- Well identification number
- Name of driller and drilling company
- Depth and type of well casing
- Description of well screen and blank
- Borehole diameter
- Any sealing off of water-bearing strata
- Static water level upon completion of the well and after development
- Drilling and installation dates
- Type and amount of annulus materials used; depth measurements of annulus materials
- Other construction details (filter pack type and interval, location of centralizers, etc.)
- Surface elevation and reference elevation of all depth measurements

2.2.3 Groundwater Sampling/Development Logs

The groundwater sampling/development documented any time that a well is developed or sampled. The following information should be recorded on the log:

- Project name and site
- Well identification number
- The date and time of sampling/development
- The water level and reference elevation
- Volume of water to be purged
- Pertinent well construction information (total depth, well diameter, etc.)
- Measurement of field parameters such as pH, turbidity, conductivity, and temperature, as well as the times at which the readings were taken
- Type of purging and sampling equipment used
- Type of samples collected
- Sampler's initials

2.2.4 Aquifer Testing Logs

The aquifer testing team is responsible for setting up, collecting, tracking, and organizing data. The information listed below is a partial listing of required information.

- Well number/identification (data logger identification)
- Data logger information/parameter setup
- Water level (include date, time, and measurement reference (such as top of casing)
- Type of aquifer test (slug, step-drawdown, pump test, etc.)
- Slug test (include length and diameter of slug for volume calculations)
- Start time of test
- Duration of test
- Pump tests (include disposal/containment of water information)
- Field observations and problems
- Tester's name

STANDARD OPERATING PROCEDURES

ST. ANTHONY MINE SITE

SOIL LOGGING

SOP-17
Revision: 1

Date: March 2018

STANDARD OPERATING PROCEDURE 17 SOIL LOGGING

TABLE OF CONTENTS

LIST OF TABLES

ATTACHMENTS

1.0 INTRODUCTION

This standard operating procedure (SOP) is applicable to logging soils at all sites requiring soil investigation by Stantec. The SOP is based on the Unified Soils Classification System (USCS) and the American Society for Testing and Materials (ASTM) Standard D2488-00 Standard Practice for Description and Identification of Soils (Visual-Manual Procedure) (ASTM, 2000). Variance from the logging procedures described here shall be warranted only if specifically required in writing by a particular client or regulatory agency. A solid working knowledge of this SOP is important for Stantec field personnel to standardize logging procedures and to enable subsequent correlations between borings at a site, allowing for accurate and thorough site characterization.

The information in this SOP is summarized in two soil logging field guides (attached). Laminated copies of these guides are available for field personnel; use of the field guides is strongly recommended. Other field guidance references may also be used according to personal preference, however; such references should be based on the USCS. Note that many references (for example, AGI Data Sheet grain-size scales) base soil classifications on the Wentworth Scale. Such scales may vary significantly from the USCS and may lead to inaccurate or inconsistent soil descriptions.

2.0 DEFINITIONS

Use of the USCS requires familiarity with the grain-size ranges that define a particular type of soil, as well as several other physical characteristics. The grain size definitions and physical characteristics upon which soil descriptions are based are presented below. This information is also presented in tabular format on the field guides.

2.1 GRAIN SIZES

USCS grain sizes are based on U.S. standard sieve sizes, which are named as follows:

- Standard sieves with larger openings are named according to the size of the openings in the sieve mesh. For example, a "3-inch" sieve contains openings that are 3 inches square.
- Standard sieves with smaller openings are given numbered designations that indicate the number of openings per inch. For example, a "No. 4" sieve contains 4 openings per inch.

The following grain size definitions are paraphrased from the ASTM Standard D2488-

Field personnel should familiarize themselves with the grain size definitions and refer to the appropriate field guide for a visual reference.

Boulders: Particles of rock that will not pass a 12-inch (300-mm) square opening.

Cobbles: Particles of rock that will pass a 12-inch (300-mm) square opening and be retained on a 3-inch (75-mm) sieve.

Gravel: Particles of rock that will pass a 3-inch (75-mm) sieve and be retained on a No. 4 (4.75-mm) sieve with the following subdivisions:

- Coarse gravel passes a 3-inch (75-mm) sieve and is retained on a 3/4-inch (19-mm) sieve.
- Fine gravel passes a 3/4-inch (19-mm) sieve and is retained on a No. 4 (4.75-mm) sieve.

Sand: Particles of rock that will pass a No. 4 (0.19-inch or 4.75-mm) sieve and be retained on a No. 200 (0.003-inch or 75-µm) sieve with the following subdivisions:

- Coarse sand passes a No. 4 (0.19-inch or 4.75-mm) sieve and is retained on a No. 10 (0.08-inch or 2-mm) sieve.

- Medium sand passes a No. 10 (0.08-inch or 2-mm) sieve and is retained on a No. 40 (0.017-inch or 425-µm) sieve.

- Fine sand passes a No. 40 (0.017-inch or 425-µm) sieve and is retained on a No. 200 (0.003-inch or 75-µm) sieve.

Silt: Soil passing a No. 200 (0.003-inch or 75-µm) sieve that is non-plastic or very slightly plastic and that exhibits little or no strength when air dried. Individual silt particles are not visible to the naked eye.

Clay: Soil passing a No. 200 (0.003 inch or 75-µm) sieve that can be made to exhibit plasticity within a range of water contents and that exhibits considerable strength when air-dried. Individual clay particles are not visible to the naked eye.

2.2 PHYSICAL CHARACTERISTICS

The following physical characteristics are used in the USCS classification for fine-grained soils. A brief definition of each physical characteristic is presented below. Tables 1 through 4 present descriptions of field tests that may be performed to estimate these properties in a field sample. However, with the exception of plasticity, the tests are generally too time-consuming to perform regularly in the field. A determination of the type of fine-grained soil present in the sample can generally be made on the basis of plasticity, as described in Section 3.1.2.

Dry Strength: The ease with which a dry lump of soil crushes between the fingers (Table 1).

Dilatancy Reaction: The speed with which water appears in a moist pat of soil when shaking in the hand, and disappears while squeezing (Table 2).

Toughness: The strength of a soil, moistened near its plastic limit, when rolled into a 1/8-inch diameter thread (Table 3).

Plasticity: The extent to which a soil may be rolled into a 1/8-inch thread, and re-rolled when drier than the plastic limit (Table 4).

TABLE 1 CRITERIA FOR DESCRIBING DRY STRENGTH

Description	Criteria
None	The dry specimen crumbles into powder with mere pressure of handling.
Low	The dry specimen crumbles into powder with some finger pressure.
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure.
High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface.
Very High	The dry specimen cannot be broken between the thumb and a hard surface.

TABLE 2 CRITERIA FOR DESCRIBING DILATANCY

Description	Criteria
None	No visible change in the specimen.
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing.
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing.

TABLE 3 CRITERIA FOR DESCRIBING TOUGHNESS

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft.
Medium	Medium pressure is required to roll the thread to near the plastic limit. The thread and the lump have medium stiffness.
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness.

TABLE 4 CRITERIA FOR DESCRIBING PLASTICITY

Description	Criteria
Non-plastic	A 1/8-inch (3-mm) thread cannot be rolled at any water content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be re-rolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be re-rolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.

3.0 SOIL LOGGING PROCEDURES

The following aspects of a project must be considered before sampling and soil logging commences. This information is generally summarized in a project-specific work plan or field sampling plan, which should be thoroughly reviewed by field personnel prior to the initiation of work.

- Purpose of the soil logging (e.g., initial investigation, subsequent investigation, remediation)
- Known or anticipated hydrogeologic setting including: lithology (consolidated/unconsolidated, depositional environment, presence of fill material), physical characteristics of the aquifer (porosity/permeability), type of aquifer (confined/unconfined), recharge/discharge conditions, aquifer thickness and ground water/surface water interrelationships
- Drilling conditions
- Previous soil boring or borehole geophysical logs
- Soil sampling and geotechnical testing program
- Characteristics of potential chemical release(s) (chemistry, density, viscosity, reactivity, and concentration)
- Health and Safety protection requirements
- Regulatory requirements

The procedures used to determine the correct soil sample classification are described below. These procedures are presented in tabular and flow chart form on the field guides.

3.1 FIELD CLASSIFICATION OF SOILS

The following soil classification procedures are based on the ASTM Standard D2488-00 for visual-manual identification of soils (ASTM, 2000). The flow chart is Attachment 1 to this SOP and presented in the field guide can be used to assign the appropriate soil group name and symbol. When naming soils, the proper USCS soil group name is given, followed by the group symbol. For clarity, it is recommended that the group symbol be placed in parentheses after the written soil group name.

Soil identification using the visual-manual procedures is based on naming the portion of the soil sample that will pass a 3-inch (75-mm) sieve. Therefore, before classifying a soil, any particles larger than 3 inches (cobbles and boulders) should be removed, if possible. Estimate and note the percentage of cobbles and boulders.

Using the remaining soil, the next step is to estimate the percentages, by dry weight, of the gravel, sand, and fine fractions (particles passing a No. 200 sieve). The percentages are to be estimated to the closest 5 percent. In general, the soil is *fine-grained* (e.g., a silt or a clay) if it contains 50 percent or more fines, and *coarse-grained* (e.g., a sand or a gravel) if it contains less than 50 percent fines. If one of the components is present but estimated to be less than 5 percent, its presence is indicated by the term *trace*. For example, “trace of fines” would be added as additional information following the formal USCS soil description.

3.1.1 Procedure for Identifying Coarse-Grained Soils

Coarse-grained soil contains less that 50 percent fines. If it has been determined that the soil contains less than 50 percent fines, the soil is a *gravel* if the percentage of gravel is estimated to be more than the percentage of sand. The soil is a *sand* if the percentage of gravel is estimated to be equal to or less than the percentage of sand.

If the soil is predominantly sand or gravel but contains an estimated 15 percent or more of the other coarse-grained constituent, the words "with gravel" or "with sand" is added to the group name. For example: "gravel with sand (GP)." If the sample contains any cobbles or boulders, the words "with cobbles" or "with cobbles and boulders" are added to the group name. For example: "silty gravel with cobbles (GM)."

Five Percent or Less Fines

The soil is a “clean gravel” or “clean sand” if the percentage of fines is estimated to be 5 percent or less. “Clean” is not a formal USCS name, but rather a general descriptor for implying little to no fines. Clean sands and gravels are given the USCS designation as either *well-graded* or *poorly-graded*, as described below.

Identify the soil as a *well-graded gravel* (GW) or as a *well-graded sand* (SW) if it has a wide range of particle sizes and substantial amounts of the intermediate particle sizes. Identify the soil as a *poorly-graded gravel* (GP) or as a *poorly-graded sand* (SP) if it consists predominantly of one grain size (uniformly graded), or has a wide range of sizes with some intermediate sizes obviously missing (gap- or skip-graded).

Note: When using the USCS designation, keep in mind the difference between grading and sorting. The term grading is used to indicate the range of particles contained in the sample. For example, a poorly-graded sand containing predominantly one grain size would be considered well-sorted, and vice-versa. One notable exception to this general rule is a skip-graded (bimodally distributed) sample; a sand containing two distinct grain sizes would be considered both poorly-sorted and poorly-graded. The USCS uses only the *grading* descriptor in soil naming, not the sorting descriptor.

Greater than or equal to 15 Percent Fines
The soil is a *silty* or *clayey gravel* or a *silty* or *clayey sand* if the percentage of fines is estimated to be 15 percent or more. For example, identify the soil as *clayey gravel* (GC) or a *clayey sand* (SC) if the fines are clayey. Identify the soil as a *silty gravel* (GM) or a *silty sand* (SM) if the fines are silty. The coarse grained descriptor "poorly-graded" or "well-graded" is not included in the soil name, but rather, should be included as additional information following the formal USCS soil description.

Greater than 5 Percent but less than 15 Percent Fines
If the soil is estimated to contain greater than 5 percent but less than 15 percent fines, give the soil a dual identification using two group symbols. The first group symbol corresponds to a clean gravel or sand (GW, GP, SW, SP) and the second symbol corresponds to a clayey/silty gravel or sand (GC, GM, SC, SM). The group name corresponds to the first group symbol, and include the words "poorly-graded" or "well- graded" plus the words "with clay" or "with silt" to indicate the character of the fines. For example, "poorly-graded gravel with silt (GP-GM)."

3.1.2 Procedure for Identifying Fine-Grained Soils

Fine-grained soil contains 50 percent or more fines. The USCS classifies inorganic fine-grained soils according to their degree of plasticity (no or low plasticity, indicated with an "L"; or high plasticity, indicated with an "H") and other physical characteristics (defined in Section 2.2 and Tables 1 through 4). As indicated in Section 2.2, the field tests used to determine dry strength, dilatancy, and toughness are generally too time consuming to be performed on a routine basis. Field personnel should be familiar with the definitions of the physical characteristics and the concepts of the field tests; however, field classifications will generally be based primarily on plasticity. If precise engineering properties are necessary for the project (i.e., construction, modeling, etc.), geotechnical samples should be collected for laboratory testing. The results of the laboratory tests should be compared to the field logging results. Soil classifications based on plasticity are as follows:

- Lean clay (CL) soil has medium to high dry strength, no or slow dilatancy, and medium toughness and plasticity.
- Fat clay (CH) soil has high to very high dry strength, no dilatancy, and high toughness and plasticity.
- Silt (ML) soil has no to low dry strength, slow to rapid dilatancy, and low toughness and plasticity, or is nonplastic.
- Elastic silt (MH) soil has low to medium dry strength, no to slow dilatancy, and low to medium toughness and plasticity. They will air dry more quickly than lean clay and have a smooth, silky feel when dry.
- Organic soil (OL or OH) soil contains enough organic particles to influence the soil properties. Organic soils usually have a dark brown to black color and may have an organic odor. Organic soils will often change color, from black to brown for example, when exposed to the air. Organic soils normally will not have a high toughness or plasticity.

3.1.3 Other Modifiers for Use with Fine-Grained Soils

15 Percent to 25 Percent Coarse-grained Material
If the soil is estimated to have 15 percent to 25 percent sand, gravel, or both, the words "with sand" or "with gravel" (whichever is predominant) is added to the group name. For example: "lean clay with sand (CL)" or "silt with gravel (ML)". If the percentage of sand is equal to the percentage of gravel; use "with sand."

Greater than 30 Percent Coarse-grained Material
If the soil is estimated to have 30 percent or more sand, gravel, or both, the words "sandy" or "gravelly" is added to the group name. Add the word "sandy" if there appears to be the same

or more sand than gravel. Add the word "gravelly" if there appears to be more gravel than sand. For example: "sandy silt (ML)" or "gravelly fat clay (CH)."

3.1.4 Procedure for Identifying Borderline Soils

To indicate that the soil may fall into one of two possible basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example, a soil containing an estimated 50 percent silt and 50 percent fine grained sand may be assigned a borderline symbol "SM/ML". Borderline symbols should not be used indiscriminately. Every effort should be made to first place the soil into a single group and then to estimate percentages following the USCS soil description.

3.2 DESCRIPTIVE INFORMATION FOR SOILS

After the soil name and symbol are assigned; (1) the soil color, (2) consistency/density, and (3) moisture content are to be described in that order. Other information is presented later in the description, as applicable.

3.2.1 Color

Color is an important property in identifying organic soils, and may also be useful in identifying materials of similar geologic or depositional origin in a given location. The Munsell Soil Color Charts (Munsell Color, 1992) should be used, if possible.

When using the Munsell Soil Color Charts, a general color (such as brown, gray, or red) is assigned to the soil, etc. Once the general color is assigned, go to the correct area in the charts and assign the applicable color name and Munsell symbol. The ability to detect minor color differences varies among people, and the chance of finding a perfect color match in the charts is rare. Keeping this in mind should help field personnel avoid spending unnecessary time and confusion going through the chart pages. In addition, attempting to describe detail beyond the reasonable accuracy of field observations could lead to making poorer soil descriptions than by simply expressing the dominant colors.

If the color charts are not being used or are unavailable, attempt to assign general colors to soils. Comparing a particular soil sample to samples from different locations in the borehole will help keep the eye "calibrated." For example, by holding two soils together, it may become evident that one is obviously greenish-brown, while another is reddish.

3.2.2 Consistency/Density

For intact, fine-grained soil, describe consistency as very soft, soft, medium stiff, stiff, very stiff, or hard, based on the blows per foot using a 140-pound hammer dropped 30 inches (Table 5). If blow counts are not available, perform the field test described in Table 6 to determine consistency.

For coarse-grained soils, describe density based on blows per foot as very loose, loose, medium dense, dense, and very dense (Table 5). If blow counts are not available, attempt to estimate the soil density by observation, since a practical field test is not available. Be sure to clearly indicate on the field boring log if blow counts could not be obtained.

TABLE 5 DENSITY/CONSISTENCY BASED ON BLOW COUNTS

Density (Sand and Gravel) Blows/ft[a]				Consistency (Silt and Clay) Blows/ft[a]			
Term	**1.4” ID**	**2.0” ID**	**2.5” ID**	**Term**	**1.4” ID**	**2.0” ID**	**2.5” ID**
Very Loose	0 – 4	0 – 5	0 – 7	Very Soft	0 – 2	0 – 2	0 – 2
Loose	4 – 10	5 – 12	7 – 18	Soft	2 – 4	2 – 4	2 – 4
Medium Dense	10 – 29	12 – 37	18 – 51	Medium Stiff	4 – 8	4 – 9	4 – 9
Dense	29 – 47	37 – 60	51 – 86	Stiff	8 – 15	9 – 17	9 – 18
Very Dense	>47	>60	>86	Very Stiff	15 – 30	17 – 39	18 – 42
				Hard	30 – 60	39 – 78	42 – 85
				Very Hard	>60	>78	>85

[a] 140 lb. Hammer dropped 30 inches

TABLE 6 CRITERIA FOR DESCRIBING CONSISTENCY

Description	Criteria
Very Soft	Thumb will penetrate soil more than 1 inch (25 mm)
Soft	Thumb will penetrate soil about 1 inch (25 mm)
Firm	Thumb will indent soil about ¼ inch (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very Hard	Thumbnail will not indent soil

3.2.3 Moisture

Describe the moisture condition of the soil as dry (absence of moisture, dusty, dry to the touch), moist (damp but no visible water), or wet (visible free water, saturated).

3.2.4 Grain Size

Describe the maximum particle size found in the sample in accordance with the following information:

- Sand Size – Describe as fine, medium, or coarse (see Section 2.1 for sand size definitions)
- Gravel Size – Describe the diameter of the maximum particle size in inches
- Cobble or Boulder Size – Describe the maximum dimension of the largest particle

For gravel and sand components, describe the range of particle sizes within each component. For example, "about 20 percent fine to coarse gravel, about 40 percent fine to coarse sand."

3.2.5 Odor

Due to health and safety concerns, **NEVER** intentionally smell the soil. This could result in exposure to volatile contaminants that may be present in the soil. If, however, an odor is noticed, it should be described if organic or unusual (e.g., petroleum product or chemical). Soils containing a significant amount of organic material usually have a distinctive odor of decaying vegetation (sometimes a hydrogen sulfide [rotten egg] smell). Organic vapor readings from a photoionization detector or similar instrument should be noted on the field boring log. The project-specific health and safety plan should then be consulted to determine the appropriate level of protection necessary to continue field work.

3.2.6 Cementation

Describe the cementation of intact coarse-grained soils as weak, moderate, or strong, in accordance with the following criteria:

- Weak – Crumbles or breaks with handling or little finger pressure
- Moderate – crumbles or breaks with considerable finger pressure
- Strong – Will not crumble or break with finger pressure

The presence of calcium carbonate may be confirmed on the basis of effervescence with dilute hydrochloric acid (HCl) if calcium carbonate or caliche is believed to be present in the soil. Proper health and safety precautions must be followed when mixing, handling, storing, or transporting HCl.

3.2.7 Angularity

The angularity of the sand (coarse sizes only), gravel, cobbles, and boulders, as angular, subangular, subrounded, or rounded are described in accordance with the following criteria:

- Angular particles have sharp edges and relatively planar sides with unpolished surfaces.
- Subangular particles are similar to angular description but have rounded edges.
- Subrounded particles have nearly plane sides but have well-rounded corners and edges.
- Rounded particles have smoothly curved sides and no edges.

A range of angularity may be stated, such as "subrounded to rounded."

3.2.8 Structure

Describe the structure of intact soils in accordance with the criteria in Table 7.

TABLE 7. CRITERIA FOR DESCRIBING STRUCTURE

Description	Criteria
Stratified	Alternating layers of varying materials or color with layers at least 6 mm thick; note thickness
Laminated	Alternating layers of varying materials or color with the layers less than 6 mm thick; note thickness
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided	Fracture planes appear polished or glossy, sometimes striated
Blocky	Cohesive soil that can be broken down in small angular lumps that resist further breakdown
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness
Homogenous	Same color and appearance throughout

3.2.9 Lithology

Describe the lithology (rock or mineral type) of the sand, gravel, cobbles, and boulders, if possible. It may be difficult to determine the lithology of fine and medium-grained sand or particles that have undergone alteration.

3.2.10 Additional Comments

Additional comments may include the presence of roots or other vegetation, fossils or organic debris, staining, mottling, oxidation, difficulty in drilling, and caving or sloughing of the borehole walls. Also, when drilling in an area known or suspected to contain imported fill material, every effort should be made to identify the contact between fill and native soils. If a soil is suspected to be fill, this should be clearly indicated on the log following the soil description. Stratigraphic units and their contacts should be noted wherever possible.

3.2.11 Bedrock Descriptions

If the soil boring penetrates bedrock, the boring log should indicate the rock type, color, weathering, fracturing, competency, mineralogy, age (if known), and any other miscellaneous information available. Definitions of these terms are not included in this SOP, because only a small percentage of drilling activities conducted by Stantec penetrate bedrock. If bedrock drilling is planned, the field team leader, with the concurrence of the project manager, makes arrangements to provide the field team with appropriate definitions and indicate the types with information that should be collected.

3.3 ADDITIONAL BORING LOG INFORMATION

The boring log form included in Attachment 2 should be used. Information in the log heading should be complete and accurate. In addition to soil descriptions, the following information should be included, at a minimum:

- Boring or monitoring well number
- Project name and job number
- Site name
- Name of individual who logged the boring
- Name of boring log reviewer
- Drilling contractor
- Drill rig type and method of drilling (for example, "CME 75, hollow stem auger")
- Name of drilling company
- Name of driller and helper
- Borehole diameter and drill bit type
- Type of soil sampler (for example, Modified California, continuous core, etc.)
- Time and date that drilling started and finished
- Time and date that the well was completed, or the soil boring backfilled, as appropriate
- Method of borehole abandonment
- Sketch map of boring or well location with estimated distances to major site features such as property lines or buildings, and north arrow

Soil sample information should include the depth interval that was sampled, the blow counts per six inches, the amount of soil recovered, and the portion submitted for analysis or testing, if any. The sample identification number may also be noted on the log.

The degree to which soil samples are collected during a field effort depends on the overall scope and purpose of the investigation, which should be clearly defined before the field effort commences. Additional soil samples may need to be collected if, for example, soils are very heterogeneous or unexpected conditions such as perched water zones or zones of contamination are encountered.

If groundwater is encountered during drilling, the depth to water and the time and date of the observation should be recorded. If the first water encountered is a perched zone, the depth, time, and date that any additional groundwater zones are encountered should also be recorded. Depth to water after drilling, the measuring point, and the date and time of the measurement(s) must be noted. Additional measurements of depth to groundwater, including depth and time, may be beneficial.

If a monitoring well is installed, the construction details such as casing material type, screen length and slot size should be noted on the boring log. The annulus fill material (sand pack, bentonite, grout, etc.) should also be recorded.

If the soil boring is abandoned, the backfill material used (e.g., grout, bentonite, etc.) and volume used, should be recorded on the boring log.

4.0 REFERENCES

ASTM, 2000. Standard D2488-00 Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).

Munsell Color, 1992. Munsell Soil Color Charts, Revised Edition. Macbeth, Division of Kollmorgen Instruments Corp., Newburgh, New York

ATTACHMENT 1

STANTEC FIELD CLASSIFICATION GUIDES

ORDER OF DESCRIPTION

1. Soil type
2. USCS Symbol
3. Color (Munsell I.D.)
4. Consistancy/Density
5. Moisture
6. Grain size (% each)
7. Cementation
8. Plasticity (clays)
9. Miscellaneous

SOILS

Stantec

Example soil descriptions:

Poorly-graded sand with gravel (SP), light brown (7.5YR,6/4), loose, moist, predominantly fine sand (75%), trace medium sand (5%), fine gravel (20%), hydro carbon odor and staining

Lean clay with sand (CL), olive brown (2.5Y,4/4), medium stiff, moist, trace medium sand (5%), coarse sand (15%), fine gravel (5%), weakly cemented, low plasticity

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

COARSE-GRAINED SOILS <50% passes #200 sieve	**GRAVELS** <50% coarse fraction passes #4 sieve	**GRAVELS** with little or no fines	Well-graded◊ gravels, gravel-sand mixtures, little or no fines	**GW**
			Poorly-graded◊ gravels, gravel-sand mixtures, little or no fines	**GP**
		GRAVELS with >15% fines	Silty gravels, poorly-graded◊ gravel-sand-silt mixtures	**GM**
			Clayey gravels, poorly-graded◊ gravel-sand-clay mixtures	**GC**
	SANDS >50% coarse fraction passes #4 sieve	**SANDS** with little or no fines	Well-graded◊ sands, gravelly sands, little or no fines	**SW**
			Poorly-graded◊ sands, gravelly sands, little or no fines	**SP**
		SANDS with >15% fines	Silty sands, poorly-graded◊ sand-gravel-silt mixtures	**SM**
			Clayey sands, poorly-graded◊ sand-gravel-clay mixtures	**SC**
FINE-GRAINED SOILS >50% passes #200 sieve	**SILTS AND CLAYS** liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity	**ML**
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	**CL**
			Organic silts and clays of low plasticity	**OL**
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	**MH**
			Inorganic clays of high plasticity, fat clays	**CH**
			Organic silts and clays of medium to high plasticity	**OH**
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	**PT**

◊Note: Well-graded = poorly sorted - Poorly-graded = well sorted

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below:

Term	*%*
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

Borderline Symbol—A borderline symbol is two symbols separated by a slash, for example, **CL/CH**, **GM/SM**, **CL/ML**. A borderline symbol should be used to indicate that the soil has been identified as having properties that do not distinctly place the soil into a specific group. (ASTM D2488)

CONSISTENCY of FINE GRAINED (†COHESIVE) SOILS *(Silts and Clays)*

†Soils possessing the characteristics of plasticity, and exhibiting undrained behavior.

Term	Blows/ft* (N) (SPT) 1.4"ID	(modCAL) 2.0"ID	2.5"ID	Unconfined Compresive Strength	Field Test *(when blow counts not available)*
very soft	0-2	0-2	0-2	<0.25 tsf	Easily penetrated several inches by thumb; extrudes when squeezed
soft	2-4	2-4	2-4	0.25-0.50 tsf	Easily penetrated one inch by thumb; molded by light pressure
medium stiff	4-8	4-8	4-8	0.50-1.00 tsf	Penetrated > 1/2" by thumb with moderate effort; molded with strong pressure
stiff	8-15	9-17	9-18	1.00-2.00 tsf	Redily Indented by thumb but penetrated with great effort
very stiff	15-30	17-39	18-42	2.00-4.00 tsf	Readily indented by thumbnail
hard	30-60	39-78	42-85	>4.00 tsf	Indented with difficulty by thumbnail
very hard	>60	>78	>85		Thumbnail will not indent soil

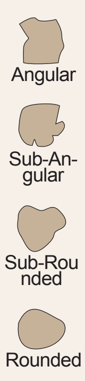
** = 140 pound hammer dropped 30 inches*

DENSITY *(Cohesionless Soils**)*

Relative Density	Blows/ft* (SPT) 1.4"ID	(modCAL) 2.0"ID	2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-29	12-37	18-51
dense	30-49	37-60	51-86
very dense	>49	>60	>86

**Soils consisting of gravel, sand, and silt, either separately or in combination possessing no characteristics of plasticity, and exhibiting drained behavior.

ANGULARITY



MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Slightly Moist	*Below optimum moisture content*
Moist	Near optimum moisture content
Very Moist	*Over optimum moisture content*
Wet	Visible Free Water

Italics = geotech

CEMENTATION

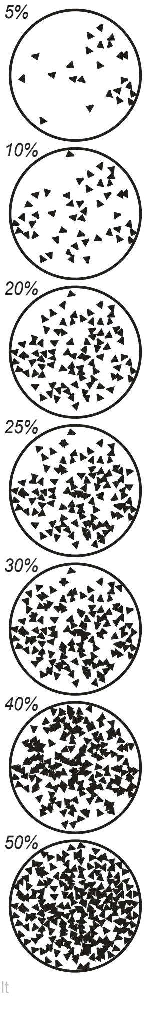
Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

GRAIN SIZE

Term	Size (mm)	Size (inches)	Scale size
Boulders	>300	>12	Larger than basketball
Cobbles	75 to 300	3 to 12	Fist to basketball
Coarse gravel	19 to 75	3 to $^3/_4$	Thumb to fist
Fine gravel	4.75 to 19	$^3/_{16}$ to $^3/_4$	Pea to thumb
Coarse sand	2.0 to 4.75	$^1/_{16}$ to $^3/_{16}$	Rock-salt to pea ●
Medium sand	0.425 to 2.0	$^1/_{64}$ to $^1/_{16}$	Sugar to rock-salt •
Fine sand	0.075 to 0.425	0.003 to $^1/_{64}$	Flour to sugar
Silt / clay (fines)	<0.075	<0.003	Smaller than flour

PLASTICITY

Term	Field Test
Nonplastic	Thread (1/8" or 3mm) cannot be rolled at any water content
Low	Thread can barely be rolled. Lump cannot be formed when drier than plastic limit.
Medium	Thread is easy to roll and not much time is required to reach the plastic limit. Thread cannot be rerolled after reaching the plastic limit. Lump crumbles when drier than plastic limit.
High	Takes considerable time rolling and kneading to reach the plastic limit. Thread can be rerolled several times after reaching the plastic limit. Lump can be formed without crumbling when drier than the plastic limit.



IDENTIFICATION CRITERIA FOR FINE-GRAINED SOILS

USCS	Dilatancy	‡Dry Strength	Toughness
ML	Slow to rapid	None to low	Low/no thread
CL	None to slow	Medium to high	Medium
MH	Low to medium	None to slow	Low to medium
CH	None	High to v. High	High

‡DRY STRENGTH

Very low	sample crumbles with minor handling
Low	sample crumbles to powder with little finger pressure
Medium	breaks into pieces / crumbles with considerable pressure
High	sample breaks to pieces but does not crush to powder
Very high	cannot break between thumb and hard surface

‡1/2 in. (12 mm) molded ball of material, dried, and crushed between fingers

TOUGHNESS

Low	Slight pressure required to roll thread near plastic limit. Thread and lump are weak and soft
Medium	Medium pressure required to roll thread near plastic limit. Thread and lump have medium stiffness
High	Considerable pressure required to roll thread to near the plastic limit. Thread and lump have very high stiffness

DILATANCY

Fast, distinctive reaction = clean very fine sand

Rapid, moderate reaction = inorganic silt

No reaction = plastic clay

1/2 in. (12 mm) ball of molded material with soft, not sticky consistency (water added if necessary), smoothed in palm of hand. Shake horizontally striking side of hand. Note reaction of water appearing on surface. Squeeze sample by pinching between fingers, note speed of water absorption into soil.

Unified Soil Classification System - ASTM D2487, ASTM D2488, USBR-5000, USBR-5001, USBR-3900

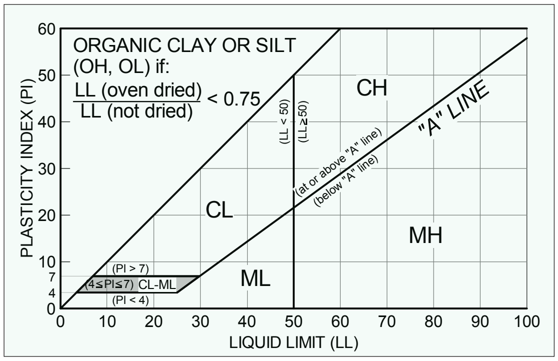


Chart Design by Jennifer Van Pelt
Version 2016-Feb

SOILS

ORDER OF DESCRIPTION

1. Soil type
2. USCS Symbol
3. Color (Munsell I.D.)
4. Consistancy/Density
5. Moisture
6. Grain size (% each)
7. Cementation
8. Plasticity (clays)
9. Miscellaneous

Example soil descriptions:

Poorly-graded sand with gravel (SP), light brown (7.5YR,6/4), loose, moist, predominantly fine sand (75%), trace medium sand (5%), fine gravel (20%), hydro carbon odor and staining

Lean clay with sand (CL), olive brown (2.5Y,4/4), medium stiff, moist, trace medium sand (5%), coarse sand (15%), fine gravel (5%), weakly cemented, low plasticity

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

MISCELLANEOUS

- Fill or native material (e.g. soil, alluvium, bedrock)
- Stratigraphic unit (if known)
- Organics, carbon, vegetation, debris
- Structure (e.g. layering, stratified, blocky, lenses)
- Coloration (e.g. staining, mottling, oxidation)
- Lithology (e.g. quartz, mafic minerals)
- Degree of rounding/angularity
- Odor (e.g. earthy, vegetative, hydro carbon)

STRUCTURE *(FABRIC)*

Stratified	Alternating layers of varying materials or color; note thicknesses
Laminated[1]	Alternating layers of varying material or color with layers less than 6 mm thick; note thicknesses
Fissured[1]	Breaks along definite planes with little resistance to fracturing
Slickensided[1]	Fracture planes appear polished or glossy, sometimes striated
Blocky[1]	Cohesive soil that can be broken into small angular lumps which resist further breakdown
Lenses	Inclusion of small pockets of different soils such as small lenses of sand scattered through a mass of clay; note thicknesses
Homogeneous	Same color and textural or structural appearance throughout

[1] Do not use for coarse grained soils with the exception of fine sands which can be laminated

REACTION WITH HCL

None	No visible reaction
Weak	Some reaction, with bubbles forming slowly
Strong	Violent reaction, with bubbles forming immediately

GRAVEL
% gravel > % sand

≤ 5% fines	well-graded		**GW**	< 15% sand	Well-graded gravel
				≥ 15% sand	Well-graded gravel with sand
	poorly-graded		**GP**	< 15% sand	Poorly-graded gravel
				≥ 15% sand	Poorly-graded gravel with sand
> 5% - < 15% fines	well-graded	fines = ML or MH	**GW-GM**	< 15% sand	Well-graded gravel with silt
				≥ 15% sand	Well-graded gravel with silt and sand
		fines = CL or CH	**GW-GC**	< 15% sand	Well-graded gravel with clay
				≥ 15% sand	Well-graded gravel with clay and sand
	poorly-graded	fines = ML or MH	**GP-GM**	< 15% sand	Poorly-graded gravel with silt
				≥ 15% sand	Poorly-graded gravel with silt and sand
		fines = CL or CH	**GP-GC**	< 15% sand	Poorly-graded gravel with clay
				≥ 15% sand	Poorly-graded gravel with clay and sand
≥ 15% fines		fines = ML or MH	**GM**	< 15% sand	Silty gravel
				≥ 15% sand	Silty gravel with sand
		fines = CL or CH	**GC**	< 15% sand	Clayey gravel
				≥ 15% sand	Clayey gravel with sand

SAND
% sand > % gravel

≤ 5% fines	well-graded		**SW**	< 15% gravel	Well-graded sand
				≥ 15% gravel	Well-graded sand with gravel
	poorly-graded		**SP**	< 15% gravel	Poorly-graded sand
				≥ 15% gravel	Poorly-graded sand with gravel
> 5% - < 15% fines	well-graded	fines = ML or MH	**SW-SM**	< 15% gravel	Well-graded sand with silt
				≥ 15% gravel	Well-graded sand with silt and gravel
		fines = CL or CH	**SW-SC**	< 15% gravel	Well-graded sand with clay
				≥ 15% gravel	Well-graded sand with clay and gravel
	poorly-graded	fines = ML or MH	**SP-SM**	< 15% gravel	Poorly-graded sand with silt
				≥ 15% gravel	Poorly-graded sand with silt and gravel
		fines = CL or CH	**SP-SC**	< 15% gravel	Poorly-graded sand with clay
				≥ 15% gravel	Poorly-graded sand with clay and gravel
≥ 15% fines		fines = ML or MH	**SM**	< 15% gravel	Silty sand
				≥ 15% gravel	Silty sand with gravel
		fines = CL or CH	**SC**	< 15% gravel	Clayey sand
				≥ 15% gravel	Clayey sand with gravel

CL	< 30% plus No. 200	< 15% plus No. 200			Lean clay
		15-29% plus No. 200	% sand ≥ % gravel		Lean clay with sand
			% sand < % gravel		Lean clay with gravel
	≥ 30% plus No. 200	% sand ≥ % gravel	< 15% gravel		Sandy lean clay
			≥ 15% gravel		Sandy lean clay with gravel
		% sand < % gravel	< 15% sand		Gravelly lean clay
			≥ 15% sand		Gravelly lean clay with sand
ML	< 30% plus No. 200	< 15% plus No. 200			Silt
		15-29% plus No. 200	% sand ≥ % gravel		Silt with sand
			% sand < % gravel		Silt with gravel
	≥ 30% plus No. 200	% sand ≥ % gravel	< 15% gravel		Sandy silt
			≥ 15% gravel		Sandy silt with gravel
		% sand < % gravel	< 15% sand		Gravelly silt
			≥ 15% sand		Gravelly silt with sand
CH	< 30% plus No. 200	< 15% plus No. 200			Fat clay
		15-29% plus No. 200	% sand ≥ % gravel		Fay clay with sand
			% sand < % gravel		Fat clay with gravel
	≥ 30% plus No. 200	% sand ≥ % gravel	< 15% gravel		Sandy fat clay
			≥ 15% gravel		Sandy fat clay with gravel
		% sand < % gravel	< 15% sand		Gravelly fat clay
			≥ 15% sand		Gravelly fat clay with sand
MH	< 30% plus No. 200	< 15% plus No. 200			Elastic silt
		15-29% plus No. 200	% sand ≥ % gravel		Elastic silt with sand
			% sand < % gravel		Elastic silt with gravel
	≥ 30% plus No. 200	% sand ≥ % gravel	< 15% gravel		Sandy elastic silt
			≥ 15% gravel		Sandy elastic silt with gravel
		% sand < % gravel	< 15% sand		Gravelly elastic silt
			≥ 15% sand		Gravelly elastic silt with sand

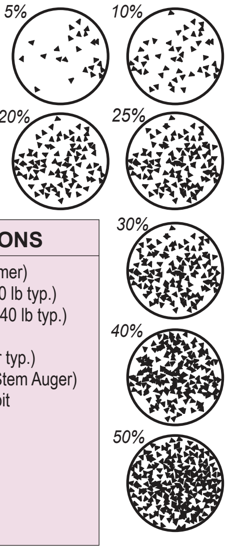
Gravels or sands with 5% to 15% fines require dual symbols (GW-GM, GW-GC, GP-GM, GP-GC, SW-SM, SW-SC, SP-SM, SP-SC) and add "with clay" or "with silt" to group name. If fines classify as CL-ML for GM or SM, use dual symbol GC-GM or SC-SM. $D_{X\%)}$ s soil particle diameter where X% is % finer. *Optional Abbeviations:* Lower case "s" after USCS group symbol denotes either "sandy" or "with sand" while "g" denotes either "gravelly" or "with gravel"

COMMON LITHOLOGY PATTERNS

- ▤ Clay or clay shale
- ▤ Siltstone
- ▨ Sandstone
- ▨ Gravel / conglomerate
- ▨ Breccia
- ▦ Limestone

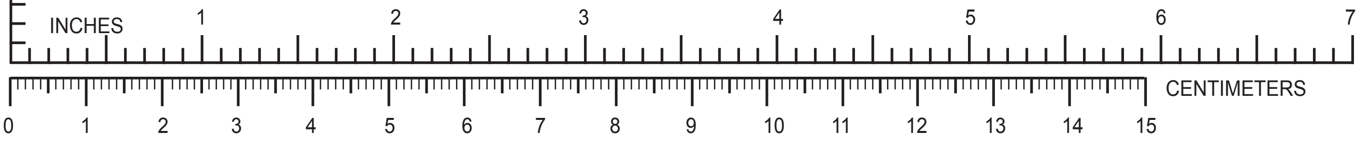
DRILLING NOTES

- Drilling rate
- Rig behavior (chatter)
- Heaving sands
- Loss of drilling fluid
- Caving / sloughing
- Sudden drops / rate changes



SAMPLER ABBREVIATIONS

SS	SPT Sampler (2" OD, 140 lb hammer)
SSO	Oversize Split Spoon (2.5" OD 140 lb typ.)
HD	Heavy Duty Split Spoon (3" OD, 340 lb typ.)
BL	Brass Liners used in Split Spoon
BD	Bulk Drive (4" OD, 340 lb hammer typ.)
CA	Continuous Core (Soil in Hollow-Stem Auger)
GS	Grab Sample from Surface / Testpit
C	Core (Rock)
TW	Thin Wall (Shelby Tube)
MS	Modified Shelby
GP	Geoprobe
RC	Air Rotary Cuttings
AG	Auger Cuttings



ATTACHMENT 2

EXAMPLE STANTEC BORING LOG FORMS

Stantec	Project: Project Location: Project Number:	SOIL LOGGING FORM	BOREHOLE No.: Sheet _______ of _______:

Drilling Company:	Sampling Method(s):	Groundwater Level & Date Measured						Start Date:
Drillier:	Hammer Data:	Water Level:						Finish Date:
Drilling Method:	Northing:	Date:						Total Depth:
Drilling Rig:	Easting:	Time:						Logged By:
Drill Bit Type/Size:	Elevation:	Casing Depth						Checked By:

	SAMPLES								
Depth	Type	Number	Sampling Resistance, blows / 6 inches	Driven (in)	Recovered (in)	Graphic Log	Material Description	Remarks	Well Details

COARSE-GRAINED SOILS <50% passes #200 sieve	**GRAVELS** <50% coarse fraction passes #4 sieve	**GRAVELS** with little or no fines	Well-graded◊ gravels, gravel-sand mixtures, little or no fines	**GW**
			Poorly-graded◊ gravels, gravel-sand mixtures, little or no fines	**GP**
		GRAVELS with >15% fines	Silty gravels, poorly-graded◊ gravel-sand-silt mixtures	**GM**
			Clayey gravels, poorly-graded◊ gravel-sand-clay mixtures	**GC**
	SANDS <50% coarse fraction passes #4 sieve	**SANDS** with little or no fines	Well-graded◊ sands, gravelly sands, little or no fines	**SW**
			Poorly-graded◊ sands, gravelly sands, little or no fines	**SP**
		SANDS with >15% fines	Silty sands, poorly-graded◊ sand-gravel-silt mixtures	**SM**
			Clayey sands, poorly-graded◊ sand-gravel-clay mixtures	**SC**
FINE-GRAINED SOILS >50% passes #200 sieve	**SILTS AND CLAYS** liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity	**ML**
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	**CL**
			Organic silts and clays of low plasticity	**OL**
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	**MH**
			Inorganic clays of high plasticity, fat clays	**CH**
			Organic silts and clays of medium to high plasticity	**OH**
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	**PT**

CONSISTENCY *(Silts and Clays)*

Term	**Blows/ft*** *(SPT)* 1.4"ID	2.0"ID	*(modCAL)* 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY *(Sands and Gravels)*

Term	**Blows/ft*** *(SPT)* 1.4"ID	2.0"ID	*(modCAL)* 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

** = 140 pound hammer dropped 30 inches*

GRAIN SIZE

Term	**Size (mm)**	**Size (inches)**
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Sand/Gravel (Silt) Term	% fines
trace	<5
little	5-15
some	15-30
clayey / silty	>30

Silt/Clay Term	% coarse
trace	<5
little	5-15
some	15-30
sandy / gravelly	>30

◊Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

PLASTICITY
- Nonplastic
- Low
- Medium
- High

MOISTURE

Term	**Field Test**
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	**Field Test**
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

∇ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

Stantec

Client:

Project Number:

SOIL BORING LOG FORM

BOREHOLE No.:

Sheet ______ of ______

Drilling Company:
Drillers (day / night):
Field Representitive (day / night):
Drilling Rig:
Drilling Method:
Core Diameter:
Bit Type:
Logged by:
Start Date:
Finish Date:
Total Depth:

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details

COARSE-GRAINED SOILS <50% passes #200 sieve	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded◊ gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded◊ gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded◊ gravel-sand-silt mixtures	GM
			Clayey gravels, poorly-graded◊ gravel-sand-clay mixtures	GC
	SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded◊ sands, gravelly sands, little or no fines	SW
			Poorly-graded◊ sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded◊ sand-gravel-silt mixtures	SM
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FINE-GRAINED SOILS >50% passes #200 sieve	SILTS AND CLAYS liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	PT

CONSISTENCY (*Silts and Clays*)

Term	Blows/ft* (*SPT*) 1.4"ID	Blows/ft* 2.0"ID	Blows/ft* (*modCAL*) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (*Sands and Gravels*)

Term	Blows/ft* (*SPT*) 1.4"ID	Blows/ft* 2.0"ID	Blows/ft* (*modCAL*) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

** = 140 pound hammer dropped 30 inches*

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below:

Term	*%*
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

◊Note:
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Poorly-graded = well sorted

PLASTICITY

Nonplastic
Low
Medium
High

MOISTURE

Term	Field Test
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Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

∇ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

STANDARD OPERATING PROCEDURES ST. ANTHONY MINE SITE	SOP-31 Revision: 1 Date: March 2018
EQUIPMENT DECONTAMINATION	

STANDARD OPERATING PROCEDURE 31
EQUIPMENT DECONTAMINATION

TABLE OF CONTENTS

1.0 SCOPE AND APPLICABILITY

This standard operating procedure (SOP) presents the decontamination procedures to be used at the St. Anthony Mine Site. The purpose of these decontamination procedures is to prevent foreign contamination of the samples and cross-contamination between sites and material types during excavation, drilling, and sampling.

This document focuses on methods and equipment that are readily available and typically applied during geotechnical soil sampling activities. It is not intended to provide an all-inclusive discussion of decontamination methods. This SOP does not replace any site-specific decontamination procedures, nor does it address all the requirements for equipment decontamination prior to release from the site.

2.0 PROCEDURES

2.1 DECONTAMINATION OF GEOTECHNICAL SAMPLING EQUIPMENT

All geotechnical soil sampling equipment that may directly contact samples will be decontaminated on site prior to use at each sampling location.

- Liquid Investigation Derived Waste (IDW) will be collected and discharged in designated containment locations.
- Solid IDW will be screened and placed back in the boreholes or excavations.

The following decontamination procedures will be observed:

1. Remove all visible soil and debris from the surface of the equipment with brushes or scrapers.
2. Rinse with clean water to remove all visible debris.
3. For large equipment such as excavator buckets and drilling augers, a pressure washer may be necessary to thoroughly remove all material.
4. For smaller equipment such as split-spoon samplers or shovels, a bucket may be used to rinse the equipment.
5. If the equipment has only come in contact with cover material or clean borrow material, all decontamination debris and rinse water may be discharged to the ground surface at the sampling location.
6. If the equipment has come into contact with tailings or other contaminants, the decontamination solids and rinse water will be contained and disposed of as described above, as applicable. Plastic sheeting will be used if necessary to prevent the debris and rinse water from contacting clean material.
7. Decontamination will take place for each sampling location prior to moving to the next location.

2.2 DECONTAMINATION OF CHEMICAL SAMPLING EQUIPMENT

To decontaminate equipment used to collect samples for chemical analysis, the following additional procedures will be observed:

1. Wash and scrub the equipment with detergent (laboratory grade, non-phosphate detergent)
2. Rinse with tap water
3. Rinse twice with deionized water
4. Air dry
5. Protect the cleaned equipment from fugitive dust

2.3 DECONTAMINATION PRIOR TO FINAL RELEASE FROM THE SITE

All sampling equipment including drill rigs, drill augers, excavators, small equipment, and support vehicles will be decontaminated and inspected prior to leaving the site. This work will take place under the direction of the site Radiation Safety Officer (RSO) and will include, at a minimum:

1. At the last sampling location prior to leaving the site, thoroughly clean all equipment according to the procedures in Section 2.1 above.
2. Inspect all equipment to ensure all visible soil and debris has been removed. Pressure washing may be necessary to thoroughly clean the equipment.
3. Scan the equipment using the methods and equipment specified by the site RSO.

SOP-1
AVM Environmental Services, Inc.
Calibration of Gamma Radiation Survey Instruments
St. Anthony Mine Site Characterization

1. SCOPE

1.1 Purpose

To provide a standard procedure for calibration of the Ludlum Scaler/Ratemeter, model 2221 with a 2”x2” NaI Scintillation Detector (the Ludlum 44-10 or Eberline SPA-3) for gamma radiation surveys during St. Anthony Mine Site characterization.

The Ludlum 2221 is a portable, battery operated, self-contained counting instrument designed for operation with scintillation, proportional or G-M detectors. When combined with a 2”x2” NaI scintillation detector, the Ludlum 2221 is used for the detection and measurement of gamma radiations. This instrument configuration is used for detection of the soil Ra-226 gamma radioactivity.

1.2 Applicability

This instrument will be calibrated every twelve months, after repairs, or when the instrument function check fails. This method can be used with any Scaler/Ratemeter with a 2”x2” NaI scintillation detector configuration.

2. REFERENCES

2.1 Technical Manual for Scaler Ratemeter, Model 2221

3. REQUIREMENTS

3.1 Tools, Material, Equipment

3.1.1 Small flat head screwdriver.

3.1.2 Ludlum Model 500 Pulser or equivalent.

3.1.3 A source of sufficient gamma radiation activity to allow a response For high voltage plateau and function check. A 1% uranium ore in a sealed can is used.

3.1.4 Detector response factor for Ra-226 gamma survey is performed as described in Section 7

3.2 Precautions, Limit

3.2.1 The detector to Scaler/Ratemeter connector cable could easily be damaged if the weight of the 2”x2” NaI detector is suspended with it.

3.2.2 The NaI scintillation crystal is fragile. Shock to the crystal could cause a fracture or a crack, which could impact operation.

3.2.3 Do not leave the reading lamp on for any length of time as it will rapidly drain the battery voltage.

3.2.4 The meter firmware affects the measurements outputted via the RS-232 communication port. Based on the selected integrated count output for specific scan survey, verify appropriate firmware version installed for the Model L2221. The L2221 should have firmware version 261-02-N11 for one second integrated count output, and the firmware version 26106n03 two second integrated count output. The firmware version will appear on the L2221 display after turning it ON.

3.3 Acceptance Criteria

The instrument response to the calibration source should be within ± 20%.

4. LUDLUM 2221 OPERATION CALIBRATION

If the Ludlum 2221 has been calibrated by the vendor within 12 months, skip this procedure in this section and start with detector calibration in Section 5. Record Scaler/Ratemeter information (model and serial number, and calibration date) on the Scaler/Ratemeter Calibration Form. Record information about the calibration source (Pulser and/or source, 1% uranium ore standard).

4.1 Check the battery condition by pressing the “BAT” button with instrument switched on. If the meter does not indicate the battery charge above 5.3 volts, replace the four (4) D-cell batteries.

4.2 Set the threshold value as follows:

4.2.1 With the instrument turned on, press the threshold button. Read the displayed reading. If necessary adjust the **“**THR**”** adjustment screw until the threshold reads 100.

NOTE: The "THR” adjustment screw is located under the calibration cover

4.3 Set the WIN (window) IN/OUT to OUT.

4.4 Connect the Ludlum 500 Pulser to the 2221.

4.5 Switch SCALER/DIG RATEMETER switch to DIG RATEMETER.

4.6 Select 400 CPM on the Pulser (multiplier switch to 1 and count rate adjusted to 400 cpm).

4.7 Adjust the pulser amplitude above the set threshold (100 mV) until a steady count rate is observed.

4.8 Record the meter rate count response in AS FOUND column on the calibration form. If the meter response is not within 10% of the Pulser set count rate of 400 cpm, adjust the R40 Meter Cal (Labeled MCAL) on the processor board for 400 cpm on the meter.

4.9 Repeat steps 4.6 to 4.8 for 4000, 40,000 and 400,000 cpm pulses.

4.10 Switch the SCALER/DIG RATEMETER switch to SCALER. Select Count Time to 1 Minute.

4.11 Select 400 counts on the pulser (multiplier switch to 1 and count rate adjusted to 400)

4.12 Count the pulses on the meter for one minute by pressing COUNT switch.

4.13 Record the meter response counts in AS FOUND column on the calibration form. If the meter count is not within 10% of the pulser set counts of 400 cpm, adjust the R40 Meter Cal (Labeled MCAL) on the processor board and repeat step 5.12 until a count of 400 is observed on the meter.

4.14 Repeat steps 4.11 to 4.13 for 4000, 40,000 and 400,000 pulses.

If the meter reading could not be set within 10% of the pulses generated by the pulser, the meter requires repair and calibration prior to use.

The Ludlum 2221 is ready for detector calibration and operation.

5. DETECTOR HIGH VOLTAGE AND BACKGROUND CALIBRATION

Record Scaler/Ratemeter (Ludlum 2221) and 2”x2” NaI detector (Eberline SPA-3 or Ludlum 44-10) information (model and serial number, and calibration date) on the Scaler/Detector Calibration Form. Record information about the radiation source (1% uranium ore standard).

5.1 Connect the calibrated Ludlum 2221 to the 2”x2” NaI detector.

5.2 Turn the Ludlum 2221 ON. Set WIN ON/OFF to OFF.

5.3 Check Threshold setting. Should be at 100 mV.

5.4 Switch SCALER/DIG RATEMETER switch to SCALER. Select Count Time to 1 Minute.

5.5 Set HV to 500 VDC.

5.6 Expose the detector to the 1% uranium ore can by placing directly under the detector.

5.7 Obtain one-minute counts with the detector exposed to the source at every 50-volt increment until voltage plateau is passed and sudden increase in the counts is observed. (Usually for the 2”x2” NaI detector, the high voltage plateau maximum voltage is about 1300 to 1400 VDC.). Record the counts under the READING CPM SOURCE in the calibration form.

5.8 Return HV setting back to 500 VDC.

5.9 Remove the calibration source away from the detector. Obtain one-minute background counts with the detector shielded from the source at every 50-volt increment until similar voltage to the source high voltage plateau reading. Record the counts under the READING CPM BACKGROUND in the calibration form.

5.10 Plot voltage versus cpm reading for both the source and background high voltage data.
From the plot, select the optimum operating high voltage, which is usually at least about 50 volts above the knee of the source response plateau curve for greater counting stability. The optimum high voltage should be also within 50 volts of the background plateau curve for background counting stability.

5.11 Set the Ludlum HV at the optimum operating voltage determined above.

5.12 Record the HV voltage setting on the Scaler/Detector Calibration Form.

The Ludlum 2221 and the 2”x2” NaI detector configuration are ready for determining the detector response factor and establishing the operating background and source function check.

6. OPERATING BACKGROUND AND SOURCE FUNCTION CHECK DETERMINATION

6.1 Set the Ludlum 2221 to Scaler mode, Count Time at 1 minute, with WIN OUT and THR at 100.

6.2 Remove any type of sources of radioactivity from the detector. Obtain five one-minute background counts. Record the background counts in the calibration form. Average the five one-minute background counts. Record the average background counts in the calibration form. The daily function check background counts should be within 20% of this average.

6.3 Expose the 1% uranium ore source (in the sealed can). Note the exact location of the source to the detector. Obtain five one-minute background counts with the detector exposed to the source. Record the source counts in the calibration form. Average the five one-minute source counts. Record the average source counts in the calibration form. The source position to the detector for the function check should be exactly the same as this calibration, and the source counts for the daily source function check counts should be within 20% of this average.

7. DETECTOR RESPONSE FACTOR AND FIELD OF VISION

7.1 Filed Vision

A detector field of vision (FOV) is used for determining observation interval of gamma scan survey for scan MDC calculations, and for transects spacing calculations for scan gamma survey coverage. Detection range of a photon from a particular source by a detector is related to FOV for that detector. The detection range is dependent on the energy of radiation (photon) being detected since it is a characteristic of photon energy, not a detector. Detection range will be longer for a photon with higher energy than a photon of lower energy. FOV is a circular area with the detection range as radius. A minimum FOV of 6.0 feet for bare and 3.0 feet for collimated 2x2 NaI detectors for Ra-226 (uranium ore) photons will be used for observation interval for MDC calculations. If a different FOV is used, it will be verified by conducting a FOV test.

7.2 Detector Response Factor

For the calculation of minimum detectable concentrations (MDCs), the detector response factor, a.k.a detector efficiency, which is a conversion constant in units of cpm per pCi/g is required. There are several methods for determining the detector response factor, such as using calibration pads, source modeling or a concentration to gamma radiation level correlation study. Since final gamma radiation level to Ra-226 surface soil concentration correlations for bare and collimated detectors have been established for a similar mine site (NECR mine site), the appropriate detector response factor from these correlations will be initially used for MDC calculations for gamma surveys during the St. Anthony mine site field gamma survey activities. The correlations were developed for the ground surface assumptions similar to what is expected at the St. Anthony mine site, i.e. fairly homogeneous and distribution of Ra-226 concentration in surface soils by using sampling data from appropriate conditions. These correlations meet the statistical acceptance criteria and the project data quality objectives.

The slope of the regression represents the relationship between the field gamma measurement in cpm and the Ra-226 surface soil concentration in pCi/g. Thus, the slope is in units of pCi/g/cpm. The final correlations yielded a regression slope of 0.0005 pCi/gm/cpm (or 2000 cpm/pCi/g) for bare 2x2 NaI Detectors, and 0.0013 pCi/gm/cpm (or 970 cpm/pCi/g) for 0.5-inch lead collimated 2x2 NaI detectors.

Response factor for all 2x2 NaI scintillation detectors are fairly comparable. However, if a detector is repaired, replaced or new one is used, the comparability of the response factor should be verified by cross measurement against the original calibrated detector using a constant uranium ore source with sufficient activity, or preferably at the DOE uranium ore calibration pad. The response should be within ±20%.

8. DETECTOR MINIMUM DETECTABLE CONCENTRATION CALCULATION

8.1 MDC for Static Gamma Radiation Measurement (for 0.05 probability for both false positive and false negative errors)

The calculation below is an example for illustrative purposes and the static MDC will be calculated in the field based on actual field background measurements from function checks. It is important to note that these MDC calculations necessarily depend on several assumptions of consistent conditions in the field such as homogeneous distributions of contamination in soil, infinite plane geometry, consistent thickness of the contaminated layer of material, and consistent detector to soil surface relationship. Those conditions will not be ideal when field measurements are performed and the MDC will likely be greater than the value calculated below.

$$MDC = C \times [3 + 4.65\sqrt{} B]$$

Where,

C = Detector response factor, cpm/pCi/g

B = Background count rate in cpm.

Example:

- For the bare 2x2 NaI detector, estimated background count rate of 10,000 cpm from previous function checks, detector response of 0.0005 pCi/g/cpm from Section 7.2 above, then the MDC for a one minute static measurement would be:

  $$MDC = 0.0005 \text{ pCi/g/cpm} \times [3 + 4.65\sqrt{} (10{,}000 \text{ cpm}] = 0.23 \text{ pCi/gm}$$

- For the 0.5-inch lead collimated 2x2 detector, estimated background count rate of 3,000 cpm from previous function checks, detector response of 0.0013 pCi/g/cpm from Section 7.2 above, then the MDC for a one minute static measurement would be:

  $$MDC = 0.0013 \text{ pCi/g/cpm} \times [3 + 4.65\sqrt{} (3{,}000 \text{ cpm}] = 0.33 \text{ pCi/gm}$$

The integration count time for static measurement may be changed to attain MDCs to required levels. Tolerable maximum instrument background count rate to attain a specified MDC can be calculated by solving the above equation using other accepted parameters (integration time and detector response factor). A daily function check must be performed prior to use.

The total propagated uncertainty will be calculated for the static survey measurement and reported with the static MDC values in all reports, tables, and figures.

8.2 MDC for Scan Gamma Radiation survey

The scan MDC is assumed for a scan rate of about 3 feet per second and a 2 second interval. For a single component scan, such as GPS based gamma scan for St. Anthony mine site characterization, the scan CPM is recorded using DGPS and Data logger for later evaluation of data with no pausing for stationary survey investigation needed in the field during the scan, and variability in the actual scan speed due to human inconsistencies in scan rate and detector height, a surveyor efficiency (p) of 0.8 is appropriate. For a dual component where a surveyor may pause during a scan survey for investigation, a surveyor efficiency of 0.5 will be used. The calculation below is an example for illustrative purposes and the scan MDC will be calculated in the field based on actual field conditions (based on the actual detector response factor, surveyor efficiency, field of view, scan rate to meet the scan MDC requirements, and background; d’ is fixed as indicated below).

First calculate the Minimum Detectable Count Rate (MDCR) as follows:

$$MDCR = (d' \times \sqrt{bi}) \times (60/i)$$

Where:

d’ = value for true positive and false positive proportion. A value of 1.38 (MARSSIM Table 6.5) will be used for 95% true and 60% false positive proportion.

bi = number of background counts in the interval i [(background rate in cpm/60 sec/min) x 2 for two second interval].

Example: For the bare 2x2 NaI detector background count of 10,000 cpm estimated from previous function checks, the MDCR for two second observation interval (6.0 feet FOV/3.0 feet per second scan rate) would be:

bi (2 sec) = (10,000 cpm) x (1 min/60 sec) x (2 sec) = 333 counts

MDCR cpm = (1.38) x √[333 counts] x (60 sec/min)/(2 sec) = 756 cpm.

The MDCR $_{\text{surveyor}}$ using surveyor efficiency (p) of 0.8 would be:

MDCR $_{\text{surveyor}}$ = MDCR/√p = 756 cpm/√0.8 = 845 cpm.

From the MDCR $_{\text{surveyor}}$, calculate the scan MDC using the following:

Scan MDC = MDCR $_{\text{surveyor}}$, cpm x C, cpm/pCi/gm

Where: C = Detector response factor, 0.0005 pCi/g/cpm (from Section 7.2 above)

Scan MDC = 756 cpm x 0.0005 pCi/g/cpm = 0.42 pCi/gm

For the 0.5-inch lead collimated detector with a background of 3,000 cpm, C of 0.0013 pCi/g/cpm, observation interval of one second (3.0 feet FOV/3.0 feet per second scan rate), the scan MDC would be 0.85 pCi/g.

A daily function check must be performed prior to use. The scan rate for radiation scan survey may be changed to attain MDCs to required levels. The tolerable maximum instrument background count rate to attain a specified scan MDC can be calculated by solving the above equation using the other approved instrument and survey parameter values, such as survey sensitivity (d'); detector response factor; scan rate; observation interval; and surveyor efficiency. Likewise, maximum scan rate for scan survey to attain a specified scan MDCs can be calculated by solving the above equation with using other instrument and survey parameter values, such as survey sensitivity (d'); instrument background count rate; detector response factor; detector FOV for Ra-226; and surveyor efficiency factor.

Attachment A

Scaler/Ratemeter Calibration Form

Model____________________________ S/N ____________________

Calibration Source____

Threshold (input sensitivity), Found at________________ mV Left or Set at __________ mV

Window, In/Out__________ Window ________________ mV

Pulser Amplitude Set @_____________________________mV

Range/Mode	Calibration Point (Pulser Setting) cpm x multiplier	As Found Reading	Left or Set Reading

HV Set @________________ VDC

Date __________________________ Calibrated By ____

Attachment B

AVM Environmental Services Inc.
Scaler/Ratemeter - Detector Calibration Form

Scaler/Ratemeter : Ludlum 2221, SR #
Detector: 0.5 Inch Lead Collimated SPA-3, #

Source: ____________________________ Strength: ________________

Scaler/Ratemeter Threshhold set @ 100 (10mV); Window IN/OUT: OUT; Window: N/A mV

HV	Reading, CPM (Source)	Reading, CPM (Background)
500		
550		
600		
650		
700		
750		
800		
850		
900		
950		
1000		
1050		
1100		
1150		
1200		
1250		
1300		
1350		
1400		

at designated function check location in office.

Count #	Reading (CPM)
1	
2	
3	
4	
5	
Average	

Count Readings with 1 percent U_3O_8 can directly under collimated detector on designated function check location in office.

Count #	Reading (CPM)
1	
2	
3	
4	
5	
Average	

HV Set @ ______________________ VDC (Instrument) __________________ VDC (DVM Fluke 8020B)

Input Sensitivity (THR), mV ________________

Function Check with 1 percent U_3O_8 ore in can. Can Directly under the detector.
Acceptable Function check range is: ______________________ to ___________________ CPM

Count Readings for Calibration Pad GPL (87.78 pCi/gm Ra-226)

#1 ______________ cpm
#2 ______________ cpm Average ______________ cpm
#3 ______________ cpm
#4 ______________ cpm Efficiency ______________ cpm/pCi/gm
#5 ______________ cpm Efficiency ______________ pCi/gm/cpm (1/cpm/pCi/gm)

Date ____________________________ By _____________________________________

AVM SOP-2
AVM Environnemental Services, Inc.
Direct Gamma Radiation Level to Ra-226 Soil Concentration Correlation Update
At. Anthony Mine Site Characterization

1.0 Purpose

The purpose of this procedure is to develop a Site specific surface soil Ra-226 concentrations to direct gamma radiation level correlations for St. Anthony Mine Site radiologic characterization. The correlation is developed basically for a site-specific calibration of field instrumentation (2'x2' NaI scintillation detector), for assessing Ra-226 concentration in surface soil by performing direct gamma radiation level survey.

2.0 Scope

The Ra-226 levels in soil could be measured as a surrogate by measuring Pb-214 and Bi-214 gamma radiation levels, as to the measurement described in Section 4.3.2 of the MARSSIM. Pb-214 and Bi-214 are decay products of Ra-226 through radon-222 (Rn-222), a gaseous form, some of which emanates from soil. This process results in activity disequilibrium between Ra-226 and PB-214/Bi-214 in the soil. The Rn-222 gas emanation fraction from the soil varies with different characteristics of a particular soil. Therefore, a site-specific calibration of the detector is necessary. Studies have shown that about 20 percent of the Rn-222 gas decayed from Ra-226 in soil emanates out of the surface soil, indicating that a significant percentage (about 80 percent) of Ra-226 will decay into Pb-214 and Bi-214 in the soil matrix. If the soil characteristics and other parameters (such as moisture, radon emanation fraction, contamination distribution profile, gamma ray shine from nearby sources, and land topography) are consistent, the ratio of Pb-214/Bi-214 to Ra-226 will be consistent. This results in a direct correlation between Pb-214/Bi-214 gross gamma radiation levels and Ra-226 concentrations in the soil. The gamma radiation from other naturally occurring isotopes in soil, such as Th-232 decay products and K^{40}, may contribute to gross gamma radiation intensity. In addition, background gamma radiation from cosmic rays also contributes to gross gamma radiation intensity. However, the gamma radiation level from such naturally occurring isotopes and sources are generally at a constant level. A linear regression would identify such a constant to correct for and minimize interference with the gamma radiation level and Ra-226 soil concentration correlation.

Primary assumption for gamma radiation survey with this correlation is the contamination distribution. A The site specific correlations for both the bare and collimated 2x2 NaI detectors will be developed with primary assumption of contamination distribution in surface soil by correlation soil sampling and gamma radiation level measurements made in areas with contamination in surface soil only. A surface soil correlation may over estimate Ra-226 level in areas with elevated subsurface Ra-226 distribution due to subsurface shine, but would provide more accurate estimate of Ra-226 concentration in areas with no significant subsurface contamination, similar to the expected contamination distribution in areas near the contamination boundary. A correlation with this assumption is most appropriate for excavation control and final status surveys during removal actions because the contamination distribution is expected to be fairly homogeneous in surface soils following the removal action. Only gamma radiation level measurements and soil sample Ra-226 data from corresponding locations with this correlation assumption will be used to update the correlations.

3.0 Instrumentation

Instrumentation to collect gamma radiation level measurements will be the same as used during the development of previous correlations. A 2”x2” NaI Scintillation detector (an Eberline SPA-3 or Ludlum 44-10 detector) and a Scaler/Ratemeter, (Ludlum Model 2221 or 2241) will be used for field gamma radiation level measurements and to select sampling locations. A 2x2 NaI detector with 0.5-inch thick lead collimator will also be used for gamma radiation level measurement for the collimated detector correlation. The Scaler/Ratemeter will be calibrated consistent with SOP-1 to assure that it properly counts the electronic pulses generated and sent by the 2x2 NaI detector. An optimum operating high voltage for the detector will be established by performing a high voltage plateau on the detector using AVM SOP-1. The input sensitivity (threshold) of the Scaler/Ratemeter will be set @ 10.0 mV to avoid interference from low level background radiation. The pulses generated by the detector for Ra-226 gamma radiations (primarily from the Pb-124 and Bi-214 decay products) are significantly higher than 10.0 mV, as verified by using 1% uranium ore source standard.

4.0 Gamma Radiation Level Measurements and Soil Sample Collection for Correlation

If any surface soil sampling is performed during excavation control with a co-located static gamma radiation level measurement, the data may be used to update the correlation. One minute static gamma radiation level measurements will be performed consistent SOP-1. The co-located surface soil sample will be collected consistent with SOP-5, and will be analyzed for Ra-226 by an offsite vendor laboratory using EPA Method 901.1.

Gamma radiation measurements for the correlation will be performed using static gamma radiation survey as described in the SOP -3. The gamma radiation survey and surface soil sample locations will be identified by gamma radiation levels to retrieve the entire range of concentrations from background to elevated activity for correlation. The selected sampling location areas will be relatively flat terrains, and large enough so that moving around several steps in each direction should not affect readings significantly. For the selected sample location, one-minute counts will be obtained at each location. The detector will be approximately 12 inches from the ground surface.

Soil samples for the correlation will be collected using surface soil sampling AVM SOP-5. A soil sample at a depth of 0” to 6” will be collected directly underneath the detector from each of the gamma radiation level measurement location. Each soil sample aliquot will be approximately 400 grams, collected by using the hand scoop method if soil texture is loose, or a using a hand augur if soil texture is sufficiently compacted. The sampling locations will be marked with flags. The sample will be thoroughly mixed in a mixing bowl, homogenized and placed in a sample bag. Each sample bag will be marked and labeled with appropriate sample identification. Soils samples will be shipped to an off-site vendor laboratory for Ra-226 analysis using EPA gamma spectroscopy method 901.1.

5.0 Linear Regression Analysis

The relationship between gamma radiations from Ra-226 decay products to detector response is linear. To determine the correlation between gamma radiation level counts and corresponding Ra-226 concentration, i.e. to determine a calibration equation, a liner regression analysis will be performed on the sample Ra-226 concentration in pCi/gm, Y, and the associated gamma radiation level count rate, cpm at X, from all the sample locations using a least-square liner regression and plotting the results. A linear regression is the only statistical approach determined to be appropriate because the 2x2 NaI detector response to gamma radiation detection is linear, specifically at the levels emanating from uranium ore and tailings impacted soil. Linear regression data will be summarized by the generalized equation:

$$Y = mX + b$$

where,

Y = soil concentration in pCi/gm,
m = slope, pCi/gm/cpm
X = count rate (the mean) in cpm
b = constant, y intercept

This correlation will provide a site specific calibration factor (m) in pCi/gm/cpm for the 2"x2" NaI detectors, with a constant (b) to correct for any interference, specifically at lower range. The correlation with acceptable statistical parameters (correlation coefficient R^2 of >0.8, <0.5 p-value and low MSEs).

AVM SOP-3
AVM Environnemental Services, Inc.
Field Gamma Radiation Survey for Ra-226 Concentration in Soil
St. Anthony Mine Site Characterization

1.0 SCOPE

1.1 Purpose

This procedure will be used for direct gamma radiation surveys to detect Ra-226 in surface soil for performing investigation at the St. Anthony Mine Site during radiologic characterization.

2.0 EQUIPMENT AND MATERIALS

2.1 A Ludlum model 2221 or 2241 Scaler/Ratemeter coupled with a Ludlum 44-10 or an Eberline SPA-3 2"x2" NaI crystal scintillation detector for direct gamma radiation detection. (SPA-3 and Ludlum 44-10 are both similar 2"x2" NaI crystal scintillation detectors).

2.2 A global positioning system (GPS) with real time differential correction and data logging capability

2.3 A 0.5 inch lead Collimator for use with 2"x2" NaI detectors, if needed to mitigate nearby lateral gamma-ray shine interference and focus on the area of interest under detector. The 0.5-inch thick collimator, which surrounds the NaI crystal, is contained within a protective marlex housing.

2.4 A vendor calibrated Exposure Rate (uR/hr) meter.

2.5 Map of survey areas with marked points, grid nodes and transects. Ink pen and appropriate Field Survey Forms to record survey readings and notes.

2.6 Measuring tape, pin flags, area markers and marking paint.

3.0 INSTRUMENT CONFIGURATION & OPERATIONS

Prior to any instrument function check or operation, the technician will read the Technical Manual for the instrument operations (Ludlum 2221) and the correlation Method (AVM SOP-2) for the rationale behind the gamma radiation surveys.

The field gamma radiation level surveys for Ra-226 in surface soil will be performed using a Ludlum 2221 Scaler/Ratemeter connected to a 2"x2" NaI crystal scintillation detector (SPA-3 or Ludlum 44-10) which detects gamma radiation emitted from radium-226 decay products (primarily Pb-214 and Bi-214) in the soil. The detector will be held at approximately 12 inches from the ground surface. The bare (uncollimated) detector should be sensitive to an area at least six feet in diameter under the detector. The Model 2221 Scaler/Ratemeter with external RS232 connector can be coupled to a DGPS/data logger where the gamma radiation count rate in CPM would be logged with its corresponding location coordinates.

For gamma radiation surveys where significant shine interference is present from nearby areas, the 2”x2” NaI crystal scintillation detector will be installed in a 0.5 inch thick lead collimator to reduce gamma shine interference. During the survey, the detector will be held approximately 12 inches above ground level, which should focus and be most sensitive to an approximate 36 inch diameter area under the detector.

The instrumentation must be calibrated consistent with AVM SOP-1 prior to use.

3.1 Instrument Function Check

An operational function check will be performed on the Scaler/Ratemeter (L2221) and the detector (SPA-3 or Ludlum 44-10) configuration each day prior to any field surveys. The operator will verify calibration validity for the Scaler/Ratemeter and the detector. The calibration date for the instruments must be within one year. If not, the instrument must be removed from service and calibrated with a certificate in file. The function check will be performed in the field office. The following function check procedures will be used and the pertinent information recorded on the Scaler/Ratemeter-Detector Function Check Form (Attachment A).

3.1.1 Visual Inspection

Perform a visual inspection checking for signs of any damage on the instrument, cables, detector and the shield. Test for possible electrical shorts in the cable with the instrument in the audio on mode, move the cable and note for any sudden increase in audible “clicks” and also and sudden increase in counts on the Scaler/Ratemeter display.

3.1.2 Calibration Due

Verify calibration validity for the Scaler/Ratemeter and the detector. Calibration date for the instruments must be within one year and have a current Calibration Certificate on file.

3.1.3 Battery Charge

Assure that the Scaler/Ratemeter battery is functional. For ESP Scaler/Ratemeter it should not be indicating a “Low BAT” signal. For Ludlum 2221, the battery voltage digital readout must be at least 5.3 volts.

3.1.4 High Voltage

The detector high voltage must match that determined during high voltage calibration (HV Plateau) for that detector.

3.1.5 Threshold (input sensitivity)

Check and make sure that the Scaler/Ratemeter threshold is set at 100 mV. If not, set the threshold to 100 as all gross gamma measurements are performed with 10 mV (equivalent to 100 setting on instrument) threshold. Ludlum 2221 Threshold can be set by the instrument digital read out display.

3.1.6 Window

If Ludlum 2221 Scaler/Ratemeter is used for instrument configuration, the WIN (window) toggle switch must be in the OUT position for gross gamma measurements.

3.1.7 Background Counts

The background counts will be determined for the same time interval as the field static survey count time, generally one minute. The background counts will be performed at the designated location in the field office. A location will be designated in the field office for obtaining the required daily background counts. Keep all beta/gamma radiation sources away from the detector while performing the background check. The background function check counts at the field office must be within 20% or lower than the background counts obtained during the detector high voltage calibration.

3.1.8 Source Function Counts

Obtain the gamma radiation function check source, (1% U_3O_8 ore standard sealed in a can marked "Function Check Source”). The 1% ore standard was used to determine the acceptable count range for the detector following calibration. Place the source at the same location on the detector used to obtain the source function check counts during calibration. Count the source for one minute and note the counts in CPM. The source function check counts must be within 20% of the source counts obtained during the detector and Scaler/Ratemeter calibration.

3.1.9 Instrument Tolerance

The Scaler/Ratemeter and detector counting and detecting tolerance are expressed as percent deviation from the mean of the acceptable count range. The background counts and the source function check counts must be within 20% of the mean established following instrument calibration. If the source count is outside this range, pull the instrument from service. The instrument must be repaired and/or re-calibrated prior to use.

3.1.10 Technician

After completing the function check, initial in the column marked TECH of the function check form.

3.2 Instrument Minimum Detectable Concentration Calculation

When required, calculate Minimum Detectable Concentration (MDC) for the instrumentation using the function check background readings as described in AVM SOP-1 (Instrument MDC Calculation). Acceptable MDCs are below the specified investigation or Action Levels. The acceptable Ra-226 MDC limit for St. Anthony Mine Site characterization static gamma survey is 3.3 pCi/g (50% of the 6.6 pCi/g Investigation level) and scan MDC limit for scan gamma survey is also 3.3 pCi/g. Calculate MDC for appropriate survey, i.e. Direct Measurement MDC for static (stationary) gamma radiation survey and scan MDC for scan or walkthrough gamma radiation survey instrument background information. Record in the Function Check Form (Attachment A) if the instrument MDC is less than the acceptable limit.

The integration count time for static measurement and the scan rate for scan survey may be changed to attain MDCs at acceptable levels

4.0 FIELD GAMMA RADIATION SURVEYS

The direct gamma radiation level survey for Ra-226 in surface soil will be conducted as either scan survey (walkthrough) or static survey (stationary) measurements.

4.1 Scan Gamma Radiation Survey

Scan gamma radiation surveys (walkthrough surveys) will be performed by walking with the detector at about 12 inches from the ground surface with the scaler/Ratemeter in count RATE MODE. Scan surveys will be performed to determine level of Ra-226 in surface soil in areas between the site features and to delineate contamination boundary above the investigation level during the St. Anthony Mine Site characterization. Scan gamma surveys will be performed using a bare 2x2 NaI detector. A 0.5 inch lead collimator for 2”x2” NaI detectors will be used if needed to reduce lateral gamma-ray shine interference and focus on an area of interest under the detector. The scan rate and walking speed depends on the desired scan MDC for the survey. For this instrument configuration, a scan walking rate of 3 feet per second (fps) results in a Ra-226 scan MDC of 1.5 pCi/g, which is below the scan MDC limit of 3.3 pCi/g. For a different san MDC, the scan walking rate may be modified.

A GPS based gamma radiation scan survey can be performed to log a gamma radiation rate with corresponding point location coordinates in a data logger. A GPS based scan survey paired with a scaler/ratemeter and a bare 2”x2” detector will be used the St. Anthony Mine site characterization surveys. This scan survey can be performed by walking along the specified transects in the areas using a 2x2 NaI detector with a ratemeter coupled with a DGPS/data logger unit. The GPS-gamma scan survey system will consist of a Ludlum 2221 Scaler/Ratemeter/ with SPA-3 2x2 NaI Detector coupled to a DGPS/data logger system. Where terrain allows, the scan survey may also be performed using an all terrain vehicle (ATV) mounted scan survey system. The Ludlum 2221 will be operated in Ratemeter mode, allowing a gamma count rate (cpm) to be logged with its corresponding coordinates in one or two second intervals. Appropriate walk-over transect spacing based on the scan coverage rate and the detector FOV for Ra-226 will be used for this survey, as discussed in AVM SOP-1.

The logging process can be partially automated by logging points by interval. You can log points after a specified time period has elapsed. The procedure for using the Log By Interval function in SoloField mapping software is described below:

1. Select **Log** > **Log by Interval**, or tap the **Log by Interval** button in the Mode Toolbar. This will open the **Select Feature to Log** screen.
2. You will be prompted to select a feature and to complete the attribute entry. When you tap on the **OK** button in the **Attributes** screen, the **Log by Interval** screen will be displayed.
3. Select between **Log by TIME interval.**
4. Enter the **2.00 Seconds** log interval in the **Log every** field.
5. Tap the **Start** button to begin logging by interval.

The first point will be logged at your current position. Once you have waited the specified time another point will be logged. This will continue until you tap the **Pause** button or close the screen. At the end of each survey day, the field data will be downloaded into a computer and processed for tabularization and mapping. Download the survey file as follow:

Select **File** > **More** > **Export** to open the **File Export** screen.

You may select the **Export Format** by tapping on the down arrow to the right of the selection box. choose Text, All exported files are stored in \My\Documents\SOLO\Export by default, otherwise. If **Prompt for filename** is selected, you can customize the names as each file is created.

Depending upon the export format selected, you may choose to export your features in two ways; a unique file for each feature layer, or one file.

With **Text *.txt** selected as the **Export Format**, tap **Options** to display the text options. You may turn these options on/off using the checkbox next to each option.

When you are satisfied with your selections, tap the **Export** button to create the file(s) in the selected format

The technician will perform the static gamma radiation survey as follows:

1. The scan survey coverage in different areas may be different. Obtain appropriate scan coverage for the survey unit from the FSS Plan.

2. Calculate Transect spacing for the FSS systematic gamma scan using the detector field of view (FOV) for the Ra-226 gamma radiations:

   transect spacing = FOV**/**Required % scan coverage.

   For example, for FOV of 6.0 feet for 2x2 NaI detectors, a 20 percent scan coverage requires a transect spacing of 30.0 feet.

3. Field locate and mark the specified transects in a survey areas using a GPS and

appropriate marking material.

4. Conduct the scan survey along transects as described above.
5. Download the scan survey data as described in Section 4.1.

A QA/QC review of the scan data will be performed. The scan data will be reviewed to determine if the survey unit is ready for the static gamma survey.

4.2 Static Gamma Radiation Survey

Static gamma radiation surveys will be performed at any point or location of interest during surface soil characterization surveys including correlation sampling points. The detector will be held at about 12 inches from the ground surface. The Scaler/Ratemeter will be set in the count SCALER MODE. A one-minute integrated count (CPM) of gamma radiation level will be obtained at each location for a static gamma radiation survey. A DGPS integrated with a data logger may be used to log the gamma counts and location for static surveys. A 0.5 inch lead collimator for the 2”x2” NaI detectors will be used if needed to reduce lateral gamma-ray shine interference and focus on the area of interest under detector. For this instrument configuration, a one-minute integrated count results into a Ra-226 MDC of about 0.6 pCi/g. For a different MDC, the integrated count period may be modified.

The technician will perform the static gamma radiation survey as follows:

1. Perform the function check as indicated in Section 3.1 of this SOP for bare and/or collimated detector as appropriate.
2. Verify that the Scaler/Ratemeter (Ludlum 2221) is set in scaler (integration) mode and that the count time is set for one minute. Turn the Scaler/Ratemeter audio speaker to the ON position.
3. Obtain coordinates or location of of static survey.
4. Locate the static survey points using the static survey point coordinate data, and a DGPS system.
5. Hold the detector at approximately 12 inches from the ground surface above the survey point. Obtain a one minute integrated count.
6. Log the survey point ID, coordinates and counts in the DGPS/data logger. The technician may also record the counts in CPM and appropriate corresponding survey point information (location ID and/or coordinates etc) on the Static Gamma Radiation Survey Field Form (Attachment C).
7. Repeat steps 4 to 6 for additional static radiation measurements.

9. The Ra-226 concentration in the soil will be calculated from the gamma radiation survey counts (CPM) using the linear regression equation established from the

correlation for that detector. The static gamma survey data will be reviewed for QA/QC.

5.0 ATTACHMENTS

Attachment A	Scaler/Ratemeter-Detector Function Check Form
Attachment B	Scan/Walkthrough Gamma Radiation Survey Field Form
Attachment C	Static Gamma Radiation Survey Field Form

Attachment A, SOP-03

Scaler/Ratemeter - 2" x 2" NaI Detector Function Check

Scaler/Ratemeter ID:___________________________________

Function Check Source ID: 1% U_3O_8 Ore in Sealed can

2" x 2" Detector ID:_____________________________________

Acceptable background Count (cpm) Range (20%) ______________________ to ____________________

Acceptable Source Count (cpm) Range (20%) ______________________ to _______________________

Date	Physical Check	Cal Due	Battery(1) Volts or OK	HV Volts	Threshhold mV (2)	Window In or OUT(3)	C.C.(4)	BKG Counts cpm	Source Counrts cpm	Within Acceptable Range Y or N	MDC pCi/gm	Tech

Note: (1) Battery Voltage for Ludlum 2221 must be >5.3 volts; (2) Threshhold must be at 100 mV; (3) Window Position must be OUT; (4)

Attachment B, SOP-03

Scan/Walkthrough Gamma Radiation Survey Field Form

Instrumentation : Scaler/Ratemeter__________________________________, Detector____

Instrument Calibration Date: ______________________________, Instrument Daily Function Check Performed: __________

2"x2" NaI Detector Collimated ______ Yes or ______ No.

Survey Area/Unit Decsription ____

Survey Date/Time	Survey Area-Transect ID/Description	Gamma Radiation Reading Range CPM	Comments/Notes

Technician Signature ___________________________________, Reviewed by _______________________________________

Attachment C, SOP-03

Static Gamma Radiation Survey Field Form

Instrumentation : Scaler/Ratemeter____________________________, Detector ____

Instrument Calibration Date: _______________________________, Instrument Daily Function Check Performed: __________

2"x2" NaI Detector Collimated ______ Yes or ______ No.

Survey Area/Unit Decsription ____

Survey Date/Time	Survey Point ID/Description	Survey Point Coordinate		Gamma Radiation Reading, CPM	Comments/Notes
		Northing	Easting		

Technician Signature ____________________________________, Reviewed by _______________________________________

AVM SOP-4
AVM Environmental Services, Inc.
Field Soil Gamma Radiation Screening Procedure
St. Anthony Mine Site Characterization

1.0 Introduction

This field soil screening procedure for Ra-226 consists of measuring 609 KeV gamma radiations of Bi-214, a decay product of Ra-226 through Rn-222. The 609 KeV gamma radiation counts of the sample soil is compared to a reference soil from the Site with a known Ra-226 concentration for field screening. Although the Rn-222 is a gas and the soil is not sealed, the soil retains over 80 % of Rn-222 gas within the soil matrix, resulting in a significant amount of Bi-214 decay product and its gamma radiations. Bi-214 609 KeV gamma radiation is at fairly high intensity (46%) and isolated, which mitigates interference from other energy gamma radiations. A single channel analyzer (SCA), such as Ludlum L221 integrated with Ludlum 44-20 3x3 NaI scintillation detector will be used to measure radiation of a particular energy of Bi-214. The heavily shielded counting chamber lowers the background counts without lowering the counting efficiency for that geometry and sample size, thus lowers the detectable concentration. For a quick estimate of Ra-226 in soil, a reference soil with a known Ra-226 concentration (similar to screening level), which is not previously sealed, the 609 KeV gamma radiation level of Bi-214 can be measured (pulse height analysis) for field screening. The sample in a plastic bag is placed in a counting chamber (1.5 inch thick x 7.5 Inch ID x 12 inch tall lead ring collimator with a 1.5 inch thick lead bottom shield) around the 3x3 NaI detector and 609 KeV gamma radiation counts are obtained and compared to the reference soil and sample soil for field screening. The soil screening results are estimated for confirmation of gamma survey results during excavation control, and are not used for FSS confirmation of removal actions at specified limits. If the soil screening result is used for confirmation of FSS survey and indicate that the sample concentration is at or below the RAL, the sample must be sent off site vendor laboratory analysis for confirmation.

2.0 L2221/44-20 Window Operation and Energy Calibration Procedure

The following procedure calibrates threshold directly in keV.

1. Setup the counting chamber shield system with L 44-20 detector inside the chamber and connected to L2221 scaler/ratemeter. The L44-20 3x3 NaI detector is situated in the shielded counting chamber with the detector crystal facing up.

2. Place RATEMETER multiplier switch to LOG position.

3. Unscrew and remove CAL cover.

4. Press HV pushbutton. The HV should read out on the display directly in volts. While depressing the HV pushbutton, turn HV potentiometer maximum counterclockwise. The HV should be less than 50 volts.

5. Depress the THR pushbutton. Turn the THR potentiometer clockwise until 652 displays.

6. With WIN IN/OUT switch IN, depress the WIN pushbutton. Turn the WIN potentiometer until 20 appears on the display.

7. Switch WIN IN/OUT to OUT.

8. Connect the detector (Ludlum 44-20) and expose to Cs-137 source.

9. Increase HV (if HV potentiometer is at minimum, it will take approximately 3 turns before any change is indicated). While increasing the HV, observe the log scale of the ratemeter. Increase HV until ratemeter indication occurs.

10. Switch WIN IN/OUT switch to IN.

11. Turn the HV control until maximum reading occurs on the log scale. Increase HV until reading starts to drop off, and then decrease the HV for maximum reading.

12. Turn RATEMETER selector switch to the X1K position.

13. Press ZERO pushbutton and release. If meter does not read, switch to a lower range until a reading occurs.

14. Carefully adjust HV potentiometer until maximum reading is achieved on the range scale. The instrument is now peaked for Cs137 on both the LOG and Linear scales. Record HV for energy calibration.

NOTE: When the THR control is adjusted, the effective window width remains constant. As an example, if the THR is set at 559, the WIN at 100, a 609 KeV peak +559 (100 divided by 2) will be centered in the window. Then the threshold point is equivalent to 559 KeV with a 100 KeV window and calibrated for 100 KeV per turn. Now if the thresh hold is reduced to 250, the threshold is equivalent to 250 KeV, but the window (100) is still equal to 100 KeV. Proportionally, this represents a broader window.

15. Set THR at 559 and window at 100 for Bi-214 609 KeV (559 to 669 KeV ROI) gamma radiation measurement. Expose the detector with a 1% Uranium ore function check source and obtain a one minute counts. Remove the function check source and obtain a one minute background counts.

16. Record the energy calibration data in the L2221SCA/L44-20 Energy Calibration Form (Attachment A).

3.0 Minimum Detectable Concentration

The calculation below is an example for illustrative purposes for minimum detectable concentration (MDC), and the actual MDC will be calculated in the field based on actual field background measurements from function checks. The MDC, for 0.05 probability for both false positive and false negative errors, is calculated using equation 6-7 in Section 6.7.1 of the MARSSIM Guidance,

$MDC = C \times [3 + 4.65.\sqrt{B}]$
Where,
C = Detector response factor, pCi/g/cpm
B = Background count rate in cpm.

Example:

For the 3x3 NaI detector of the soil screening system, estimated background count rate of 80 cpm from previous function checks and the detector response of 32.8 pCi/g/cpm (18,299 cpm for 3,000 gm reference soil @ 200 pCi/g of Ra-226) sample at a uranium mine site, then the Ra-226 MDC for a 3,000 gm screening sample for a one minute measurement is calculated to be:

$MDC = (0.0109\underline{\text{ pCi/g/cpm}) \times [3 + 4.65.\sqrt{(80\text{ cpm}]}} = 0.49\text{ pCi/gm}$

The required MDC for the St. Anthony Mine Site characterization is <3.3 pCi/g (50% of the 6.6 pCi/g investigation level). The soil screening counting system will meet the required MDC limit of with one minute background counts of less than <500 cpm

Note: The MDC calculation assumes the weight of reference soil and screening soil to be same, 3000 grams, and the background and sample counting time be the same, least one minute. The measurement (integration) time of background and sample may be changed to attain desired MDC.

4.0 Field Soil Screening Procedure

1. Setup the L2221 parameters (HV, Threshold and Window) obtained during energy calibration above and connect the 44-20 detector. Make sure the window toggle switch is in the IN position.

2. Setup the counting chamber shield system in back of pick-up truck.

3. The L44-20 3x3 NaI detector is situated in the shielded counting chamber with the detector crystal facing up.

4. Perform background and source (1% Uranium ore) function checks and record in the Function Check Form (Attachment B).

5. Insert a clean plastic bag in the counting chamber for lining detector and counting chamber to avoid cross contamination.. Obtain 3,000 grams of appropriate reference soil, not previously sealed, and place in the plastic bag so that the sample is around the detector without any void, similar to the Marinelli Beaker geometry to provide the best counting efficiency. Cover the chamber opening with lead lid.

6. Obtain an integrated count for specified time period, generally one minute, with L2221 in Scaler mode and record in the soil screening Field Form (Attachment C). The reference soil counts may be used for efficiency calculation (pCi/g/com) for MDC calculation.

7. Remove the plastic bag with soil. Insert new plastic bag in the chamber for liner. Homogenize sample in stainless steel bowl and weigh 3000 grams of sample. Repeat step 5 and 6 for next soil sample. Change counting chamber liner between every sample.

8. Compare the reference soil counts to the sample soil counts to determine the sample Ra-226 concentration at above or below the reference soil concentration.

9. Following completion of soil screening, split a sample aliquot if needed for confirmatory analysis using EPA Method 901.1 by vendor laboratory. Return the unused sample at the location collected from.

QA/QC Procedure

1. The instrumentation, L2221 must be calibrated at least annually. Although the operating HV for the 3x3 NaI detector for soil screening is established during energy calibration discussed above, an HV plateau should be performed at least annually to verify proper detector operation throughout the HV range.
2. The background and source (with uranium ore check source to verify 609 KeV ROI calibration) function checks must be performed daily prior to use.
3. The reference soil material concentration must be determined from vendor laboratory analysis, or prepared using a certified reference material.
4. Duplicate measurement will be performed for 10% of the samples.
5. For PTW and final status survey soil screening, any soil sample screening result less than RAL and PTW threshold level, respectively, will be sent to a vendor laboratory for confirmation.

Attachment A

AVM Environmental Services Inc.

L2221 SCA/L44-20 Energy Calibration Form

SCA: L2221, SR #68782 Detector: Ludlum 44-20 (3x3 NaI Scintillator)

Calibration Source: Cs-137 Check Source, 5 uCi (August 2008) For 662 KeV Peak Cal

Threshold (input sensitiv **652**

Window, In/Ou___**IN**___ Window ____**20**____

HV Initial ___________, At Peak _____________

Maximum CPM: ________________________ Background CPM: _________________

HV Set @______________ VDC

For Bi-214 609.2 KeV Peak (559 - 659 KeV ROI), Set Threshold @ 559, Window @ 100

CBi-214 609 KeV ROI Calibration Check: 1% U3O8 Ore Check Source: _______________ CPM
Background count (empty chamber) ____________ CPM

Date _______________________ Calibrated By ____________________________________

Attachment B

AVM Environmental Services, Inc.
Ludlum SCA L2221 - 44-20 3x3 NaI Detector Function Check
559 - 659 KeV Gamma Radiation Soil Screening

L2221 #68782

Function Check Source ID: 1% U_3O_8 Ore in Sealed can

Ludlum 44-20 3x3 NaI Detector, #PR295573

Acceptable background Count (cpm) Range (20%) ______________________ to ____________________

Acceptable Source Count (cpm) Range (20%) ______________________ to _______________________

Date	Physical Check	Cal Date	Battery$^{(1)}$ Volts or OK	HV Volts	Threshhold mV $^{(2)}$	Window mV	Window In/Out	BKG Counts cpm	Source Counrts cpm	Within Acceptable Range Y or N	MDC pCi/gm	Tech

Note: (1) Battery Voltage for Ludlum 2221 must be >5.3 volts; (2) Threshhold must be at 220 mV; (3) Window @ 440, must be IN

Attachment C

AVM Environmental Services, Inc.

Field Soil Sample Gamma Radiation Screening Form

Instrumentation : Scaler/Ratemeter________________________, Detector __________________________________

Instrument Calibration Date: ___________________________, Instrument Function Check Performed: _________

Survey Area/Unit Decsription ____

Date/Time	Soil Sample ID	Sample Weight Grams	609 (559-669) Kev Gross Counts	Weight Corrected Counts	CPM	Estimated Ra-226 pCi/g	Comments

Technician Signature ______________________________, Reviewed by _________________________________

AVM SOP-5
AVM Environnemental Services, Inc.
Surface Soil Sampling
St. Anthony Mine Site Radiologic Characterization

1.0 Introduction

This standard operating procedure (SOP) describes methods and equipment commonly used for collecting environmental surface soil samples for radiologic and chemical analyses. The information presented in this SOP is generally applicable to the collection of all surface soil samples, except where the analyte(s) may interact with the sampling equipment. This SOP defines sample collection procedures using hand augers and shovels/trowels samplers. This document focuses on methods and equipment that are readily available and typically applied in collecting surface soil samples. It is not intended to provide an all-inclusive discussion of sample collection methods.

The objective of surface soil sampling is to characterize radiologic and chemical properties of the soil. Details pertaining to sample locations, number of samples, and type of analyses required, are presented in the Supplemental Characterization Work Plan.

2.0 Scope

This SOP describes procedures for surface soil sampling using hand tools for Ra-226, total uranium and CPOC metals analysis as required during the St. Anthony Mine Site characterization.

3.0 Sample Type

Surface soil samples are typically collected from the ground surface to 6 inches below ground surface. Samples collected from greater than 6 inches below ground surface are referred to as subsurface soil samples. Soil sampling includes samples for confirmation of in-situ gamma radiation level and ex-situ gamma radiation soil screening, and for site-specific correlation Surface soil samples may be collected as grab samples or as composite samples. The sample method is determined based on the physical characteristics of the sample location and soil matrix.

- Grab sample: A sample taken from a particular location. Grab samples are useful in determining discrete concentrations, but also provide spatial variability when multiple samples are collected. Grab samples will be collected from sampling locations for the final status survey and during excavation control.

- Composite sample: A number of samples that are individually collected then combined (homogenized) into a single sample for subsequent analysis. Composite samples are useful when averaged or normalized concentration estimates of a waste stream or an area are desired. Also, multi-point composite samples may be collected for correlation sampling location.

4.0 Sampling Equipment and Technique

The following materials will be available, as required, during soil sampling activities:

- Personal protective equipment (PPE), as specified by the site HASP
- Stainless steel bowls
- Stainless steel spoons
- Stainless steel spatulas
- Stainless steel trowel
- Stainless steel spades
- Stainless steel hand augers
- Rock pick
- Permanent Indelible ink pens
- Tape measure or a ruler
- Sealable plastic bags (e.g., Ziploc®)
- Appropriate sample location coordinates and/or area maps or figures
- Equipment decontamination materials
- Transport container such as cooler (if sampling for laboratory analysis)
- Appropriate Field Sampling Data forms

A grab surface soil sample may consist of a single scoop or core, or the sample may be a composite of several individual samples. Surface soil samples shall be obtained using hand augers, shovels/trowels, or soil core samplers.

Hand Auger: A hand auger consists of a stainless steel tube with two sharpened spiral wings at the tip. The auger typically cuts a 2-inch to 3-inch diameter boring and works better in consolidated or slightly moist soils. Because the auger is hand-driven, penetration in dense or rocky/gravelly soil may be difficult. For surface soil sample collection, the procedures outlined below shall be followed.

1. Advance the auger by hand into the soil, to the desired depth (6 inches or less for surface soil samples), by turning in a clockwise direction with down force applied.

2. Retrieve the auger by pulling straight up until completely out of the hole, preferably without any rotation.

3. Fill the sample container, generally a Ziploc bag for Ra-226 and/or other container for metals as specified in the Quality Assurance Project Plan (QAPP), using clean stainless steel spatulas or spoons. Repeat step 1 and 2 until a sufficient amount of sample is collected for specified analysis. For Ra-226 analysis by Method 901.1, about 400 grams in a quart size Ziploc bag is sufficient. For on-site ex-situ soil screening, about 3000

grams in a gallon size Ziploc bag will be required. Affix label on the sample container with appropriate sample information.

Shovel/Trowel: Various shovel/trowel designs and sizes are commercially available for a variety of sampling applications. These devices are hand-driven and are typically used for sampling relatively soft, unconsolidated surface soils. Some designs (e.g., the sharpshooterTM) can be driven into hard, rocky soil by opening a deep, narrow hole. All shovels or trowels used for soil sampling shall be made of stainless steel. The procedures outlined below shall be followed while collecting samples with shovels or trowels.

1. Drive the shovel/trowel into the soil six inches deep.

2. Retrieve the shovel/trowel being careful to not spill sample.

3. Fill the sample container, generally a Ziploc bag for Ra-226 and/or other type sample container for metals as specified in the QAPP, using clean stainless steel spatulas or spoons. Repeat step 1 and 2 until sufficient amount of sample is collected for specified analysis. For Ra-226 analysis by Method 901.1, about 400 grams in a quart size Ziploc bag is sufficient. For on-site ex-situ soil screening, about 3000 grams in a gallon size Ziploc bag will be required. Affix label on the sample container with appropriate sample information.

This procedure can also be used for collecting soil samples collected for ex-situ gamma radiation soil screening for subsurface soil investigation from the base of shallow test holes, pits or trenches excavated by hand tool such as a shovel or by a backhoe. Any soil sample collected for on-site ex-situ gamma screening may require sending to off-site vendor laboratory for Ra-226 analysis based on the ex-situ soil screening results. Split an aliquot for the off-site vendor laboratory from the ex-situ sample, which would had been already homogenized and of ample quantity.

5.0 Sample Equipment Decontamination

All sampling tool and equipment used for soil sampling will be clean prior to any soil sample collection. Sampling tools and equipment that are reusable will be decontaminated in between sample collection at different locations to avoid sample cross contamination. Hand tools, such as trowels, shovels, spoons, mixing bowls, etc. will be decontaminated at the sample locations. Any large equipment may be decontaminated at the designated decontamination area at the Site to for appropriate disposal of residual soil and rinsate. Since the sampling involves soil that may be potentially impacted by the COCs, Ra-226, uranium, and the COPC metals from uranium ore, which are mostly insoluble, the following procedure will be used to decontaminate soil sampling tools and equipment:

1. Brush off any loose soil from the sampling tool.
2. Wash the sampling tool with water and a residue free detergent, such as Alconox, in a bucket using a brush.
3. Rinse the sampling tool in a bucket with fresh water.
4. Rinse the sample tool with de-ionized water.

6.0 Investigation Derived Waste

The surface soil sampling is not expected to generate any Investigation Derived Waste (IDW) other than PPE (disposable gloves) and paper towels. Any excess soil from soil sample will be backfilled into the hole created from sample collection. Sampling tool decontamination rinse water will be poured on top of the backfilled sample hole for compaction. This method does not create any additional contamination or waste. If it is not feasible to put the excess sample back in the sample location, the excess soil will be contained and placed in the Pit which already contains elevated level of material, and will eventually be remediated. disposed of in the repository.

7.0 Sampling Data Recording, Handling and

Field sampling documentation will be completed to provide sample information. Fill out sample information in the Field Soil Sample Log Form, included in Attachment A. Any additional information may be included in the log book. Sample handling requirements, such as storage, shipping and chain of custody, are specified in the QAPP. The soil samples collected for the COCs and CPOC metals do not require any specific preservatives. Complete sample chain of custody provided by laboratory. The field supervisor will retain all site documentation while in the field and add to project files when the field mobilization is complete.

8.0 QA/QC Requirements

Quality assurance quality control (QA/QC) includes following the SOP as discussed above, which includes proper decontamination to avoid cross contamination and sampling data recording and handling. Field QA/QC samples will be collected at the frequency specified in the work plan as listed below:

- Sampling equipment rinsate sample as discussed above in the section 5.0.
- Field QA/QC soil sample duplicate at a frequency of 10% of the samples collected.

Other applicable QA/QC requirements for laboratory, such as blanks, duplicate analyses, matrix spike are specified in the QAPP.

Attachment A

Field Soil Sample Log Form

St. Anthony Mine Site Characterization

Sample ID	Sample Date and Time	Sample Location (Coordinates)	Sample collection method/container/preservative	Analyses	Sample Type/Description	Comments/Notes	Sample Tech

Please include other applicable information, such as sampling activity/event, COC#, sampling depth, soil description, sample sub-location, etc in sample description or comments/notes

APPENDIX C
GAMMA RADIATION LEVEL TO SURFACE SOIL RA-226 CORRELATION

Attachment 1

Gamma Radiation Level to Surface Soil Ra-226 Correlation
NECR Excavation Control and FSS Design

Gamma radiation level to surface soil Ra-226 Correlations for 2x2 NaI bare and 0.5-inch lead collimated detectors are developed to meet the acceptable criteria of a R^2 at greater than 0.80, p-value of less than 0.05 (DQO Type I error) and low mean squared error (MSE) for the North East Church Rock (NECR) excavation control (removal action support) and Final Status Survey (FSS) design. The RA of the contaminated soil at NECR is expected to change the contamination distribution and concentration to a fairly homogeneous distribution at or near the cleanup level in surface soils. Therefore, the contaminant distribution assumption for correlation for remedial action support survey and the FSS will be for fairly homogeneous distribution in surface soils near the 2.24 pCi/g cleanup level concentration.

During the excavation control survey (remedial action support survey), it is likely that the Ra-226 concentration in soil near the excavated areas will be elevated. Gamma radiation shine from such areas may interfere with gamma radiation level measurement at excavated areas, since the high-energy gamma radiation can travel long distances in air before ionizing. In areas with heterogeneous contamination distribution with nearby isolated hotspots, shine interference will be reduced by placing the detector in a 0.5-inch thick collimator. In addition to developing a correlation for a bare (un-collimated) detector, a correlation is also being developed for a lead collimated detector from gamma radiation level measurements and co-located soil samples using approved SOPs for correlations used during the NECR Removal Site Evaluations (RSEs) and Interim Removal Actions (IRAs). The correlations will be used to convert gamma radiation level measurements in CPM to surface soil Ra-226 concentration in pCi/g.

Collimated 2x2 NaI Detector Correlation

Collimated 2x2 NaI detectors were primarily used for characterization, excavation control and interim status surveys during previous RSEs and IRAs at NECR. The NECR correlation data for collimated detectors were collected from about 156 points during the 2006 RSE, 2008 supplemental RSE (SRSE), 2009 IRA Work Plan correlation, 2009 IRA, 2011 East Drainage (ED) area SRSE and 2012 East Drainage Removal Action (EDRA), as shown in Table 1. Data from total of 17 points (as highlighted in the attached Table 1), were excluded from the correlation data because they were either erroneous or did not meet the correlation assumptions discussed below:

- All of the 2009 IRA Work Plan correlation data (11 points) were excluded because they were erroneous. The soil samples were sent to a new vendor laboratory, Paragon Analytics Laboratories, for Ra-226 analysis using gamma spectroscopy Method 901.1. The results from these samples did not fit the correlation data from previous correlations. Discussion with the laboratory revealed that rather than crushing the entire sample, the laboratory had excluded larger fraction, such as pebbles, from the sample and prepared the sample for analysis using the finer portion. Because the analytical method used differed from the method used in previous and subsequent sample events, these data are not comparable and were excluded from the final correlation.

- Invalid data from 6 points were excluded because they did not fit the correlation assumption of surface contamination distribution of a depth of less than six inches. Data from the six points collected from EDRA area (SRSE-GS-92, -101, -103, -123, -198 and -224 shown in Figure 1 and Figure 2 of the August 2011 East Drainage SRSE Report) during the 2011 ED Area SRSE were excluded because the Ra-226 contamination distribution was much deeper than six inches as confirmed by excavation of up to four feet during the 2012 EDRA.

Following the exclusion of data from the 17 points, a linear regression was performed using data from 139 points. The regression yielded a correlation equation of Ra-226 pCi/g = (CPM x 0.0013) - 4.40 with a R^2 of 0.93 as shown in Figure 1, which exceeds the acceptable criteria of >0.80. The resulting equation is similar to the most recent 2012 EDRA updated correlation (Ra-226 pCi/g = (CPM x 0.0013) - 4.4308 with a R^2 of 0.92). The correlation regression also yielded a p-value significantly lower than the acceptable criteria of less than specified DQO Type I error of 0.05, with a low MSE of 1.61 as shown in Table 2.

Bare 2x2 NaI Detector Correlation

A correlation for a bare (un-collimated) detector was developed using data from 15 points collected during the RSE, as shown in Table 3 and reported in the October 2006, *Technical Memorandum, Results of the Background and Ra-226 Correlation Sampling, Northeast Church Rock Mine Site, United Nuclear Corporation*. As shown in Figure 2, the correlation yielded a correlation equation of Ra-226 pCi/g = (CPM x 0.0005) - 6.14 with a R^2 of 0.88. The regression analysis yielded a p-value significantly lower than the specified DQO Type I error of 0.05, with a low MSE of 1.29 as shown in Table 4. This bare detector correlation was used for scan (walkover) surveys as appropriate during previous RSEs and IRAs. The correlation was not updated since no static measurements were performed using the bare detectors. This bare detector correlation will be used as appropriate during the NECR removal action excavation control and FSS for scan surveys. If any soil sampling is performed with a co-located static survey location where surface contamination distribution of less than six inches occurs during excavation control, the data may be used to update the correlation.

NECR Gamma Radiation Level to Surface Soil Ra-226 Concentration Correlation Data for 2x2 NaI Collimated Detector

Table 1: Collimated Detector Correlation Sampling Data

Survey Point ID		Gamma Radiation Level CPM	Laboratory Soil Ra-226 Conc pCi/g
2006 RSE Correlation Data	NECR-COR-A-01	3840	1.90
	NECR-COR-A-02	6767	5.40
	NECR-COR-A-03	6335	4.50
	NECR-COR-A-04	4835	1.80
	NECR-COR-A-05	5145	3.70
	NECR-COR-A-06	4036	1.10
	NECR-COR-A-07	4410	1.50
	NECR-COR-A-08	5879	3.50
	NECR-COR-A-09	7064	6.60
	NECR-COR-A-11	4789	1.90
	NECR-COR-A-12	6086	6.80
	NECR-COR-A-13	6693	8.90
	NECR-COR-A-14	8309	10.30
	NECR-COR-A-15	7265	9.20
	NECR-COR-A-16	6436	6.20
	NECR-COR-A-19	3732	1.00
2009 IRA WP Cor Data	IRA COR -01	4295	2.1
	IRA COR -02	5092	1.99
	IRA COR -03	5379	6.55
	IRA COR -04	4918	1.96
	IRA COR -05	17174	51.7
	IRA COR -06	6738	9.4
	IRA COR -07	7465	21.4
	IRA COR -08	7703	9.9
	IRA COR -09	9210	29.8
	IRA COR -10	6140	3.31
	IRA COR -12	9224	17.3
2008 SRSE Data	home-014	10488	9.2
	home-105	20401	18.7
	home-112	5606	3.4
	home-130	24105	28.5
	home-146	8176	5.3
	home-148	5697	2.5
	home-149	4846	2.0
	home-151	5169	5.4
	home-153	5522	0.9
	home-154	5186	2.5
	home-155	4649	0.7
	home-156	5064	1.5
	home-157	5678	2.0
	home-158	5794	2.9
	home-159	4860	1.3
	home-160	5121	1.7
	home-161	5551	2.5
	home-162	14628	17.1
	home-163	4692	1.1
	home-164	4461	0.9
	home-165	4650	1.1
	home-167	5588	4.1
	home-168	5563	3.2
	home-170	7166	9.5
	home-171	4810	1.8
	home-172	6388	4.4
	home-173	5355	1.4
	home-174	6374	2.5
	home-175	4939	1.9
	home-176	5291	1.2
	home-177	5821	1.7
	home-182	7526	4.8
	home-57	7577	4.6
	home-86	6206	2.9
	tp-103	7650	3.2
	tp-107	4781	0.9
	tp-115	5663	0.9
	tp-125	5628	2.9
	tp-127	6995	4.1
	tp-129	6246	2.1
	tp-133	8706	3.8
	tp-137	11143	8.9
	vent-103	3915	0.6
	vent-104	3565	0.9
	vent-112	4884	2.9
	vent-113	3791	0.8
	vent-124	4432	1.2
	vent-136	4155	0.3
	vent-147	5661	1.1
	vent-148	3195	0.6
	vent-160	4222	1.9
	vent-166	5758	3.1
	vent-170	3384	0.5
	vent-179	4901	1.4
	vent-180	4315	1.8
	vent-185	3800	0.8
	vent-192	3546	0.6
	vent-196	4039	1.1
2009 IRA Data	SSPT-046	4523	1.7
	SSPT-049	4644	1.0
	SSPT-053	5155	1.5
	SSPT-057	4829	1.5
	SSPT-061	5565	2.3
	SSPT-064	5070	2.1
	SSPT-132	4617	1.1
	SSPT-136	4730	1.5
	SSPT-140	4651	1.8
	SSPT-144	4131	2.2
	SSPT-147	4131	0.7
	SSPT-172	4924	1.1
	SSPT-181	4660	1.1
	SSPT-185	4473	1.2
	SSPT-189	4518	0.5
	SSPT-213	5077	3.6
	SSPT-215	4222	1.5
	SSPT-235	4190	1.2
	SSPT-239	4634	1.7
	SSPT-243	4317	1.3
	SSPT-264	4562	1.0
	SSPT-269	4630	2.0
	Z4NSS01	4491	1.2
	Z4NSS02	4680	0.9
	Z4NSS07	4838	2.0
	Z4NSS08	4567	1.2
	Z4NSS09	4769	0.9
2011 EDA SRSE Data	SRSE-GS-021	11,705	13.4
	SRSE-GS-025	10,317	9.7
	SRSE-GS-029	4,919	2.6
	SRSE-GS-032	5,458	3.9
	SRSE-GS-034	7,054	3.7
	SRSE-GS-036	4,619	2.0
	SRSE-GS-038	4,434	1.5
	SRSE-GS-040	4,538	1.6
	SRSE-GS-041	18,331	21.9
	SRSE-GS-045	9,237	8.0
	SRSE-GS-049	11,335	10.2
	SRSE-GS-054	4,741	2.1
	SRSE-GS-056	4,696	2.2
	SRSE-GS-058	4,515	1.9
	SRSE-GS-060	4,588	1.3
	SRSE-GS-065	5,837	5.9
	SRSE-GS-092	9,535	13.8
	SRSE-GS-101	63,249	64.5
	SRSE-GS-103	8,826	15.5
	SRSE-GS-123	11,186	21.5
	SRSE-GS-198	14,932	25.3
	SRSE-GS-224	9,199	19.2
	SRSE-GS-237	6,159	3.6
	SRSE-GS-264	10,178	8.7
	SRSE-GS-279	5,104	1.9
	SRSE-GS-283	5,239	2.0
	SRSE-GS-288	4,925	0.9
	SRSE-GS-290	6,329	4.3
	SRSE-GS-291	30,731	34.5
2012 EDRA Data	SSPT-011	4,575	1.4
	SSPT-022	4,997	1.9
	SSPT-033	4,997	1.5
	SSPT-044	4,661	1.8
	SSPT-055	4,394	1.6
	SSPT-066	4,573	1.0
	SSPT-074	4,773	1.5
	SSPT-077	4,698	1.2
	SSPT-088	4,982	1.5
	SSPT-099	4,984	2.2
	SSPT-110	5,211	1.4
	SSPT-121	4,386	1.6
	SSPT-132	4,773	2.0
	SSPT-143	4,954	1.9
	SSPT-030, Z-6	4,557	1.3

Key: Data Excluded From Correlation

Figure 1: Collimated Detector

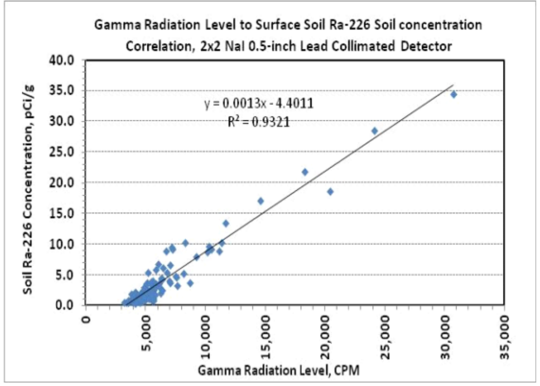

Table 2: REGRESSION SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.97
R Square	**0.93**
Adjusted R Square	0.93
Standard Error	1.27
Observations	**139**

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	3021.36	3021.36	1880.00	**6.93E-82**
Residual	137	220.17	**1.61**		
Total	**138**	3241.54			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	**-4.40**	0.21	-20.79	**3.32E-44**	-4.82	-3.98	-4.82	-3.98
Gamma Radiation Level CPM	**0.0013**	3.03E-05	43.36	**6.93E-82**	0.00125	0.00137	0.00125	0.00137

NECR Gamma Radiation Level to Surface Soil Ra-226 Concentration Correlation Data for 2x2 NaI Bare Detector

Table 3: Collimated Detector Correlation Sampling Data

Survey/Soil Sample Location	Gamma Radiation Level, cpm	Ra-226 in Soil pCi/gm
NECR-COR-A-01	13819	1.9
NECR-COR-A-02	22399	5.4
NECR-COR-A-03	21604	4.5
NECR-COR-A-04	17018	1.8
NECR-COR-A-05	18421	3.7
NECR-COR-A-06	15322	1.1
NECR-COR-A-07	16630	1.5
NECR-COR-A-09	29168	6.6
NECR-COR-A-11	20143	1.9
NECR-COR-A-12	25491	6.8
NECR-COR-A-13	27466	8.9
NECR-COR-A-14	29203	10.3
NECR-COR-A-15	29949	9.2
NECR-COR-A-16	24480	6.2
NECR-COR-A-19	12029	1.0

Figure 2: Bare Detector Correlation Figure

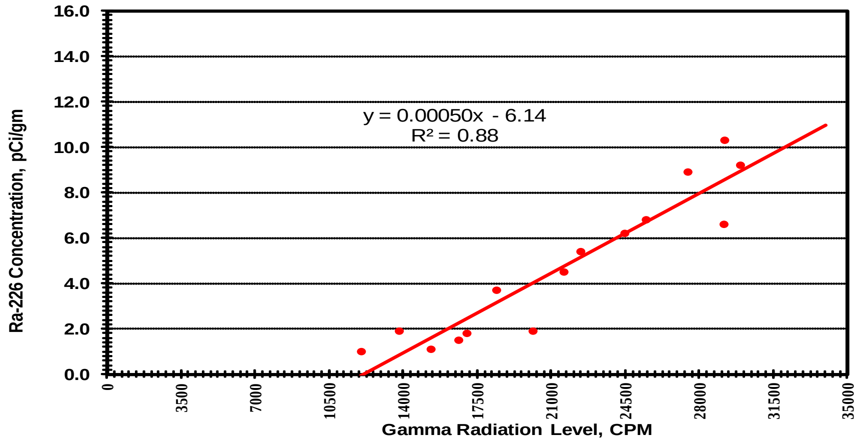

Table 4: REGRESSION SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.94
R Square	**0.88**
Adjusted R Square	0.87
Standard Error	1.13
Observations	15

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	125.31	125.31	97.49	**2.08E-07**
Residual	13	16.71	**1.29**		
Total	14	142.024			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-6.14	1.14	-5.40	**1.22E-04**	-8.60	-3.68	-8.60	-3.68
Gamma Radiation Level, c	**0.00050**	5.10767E-05	9.873776212	**2.08E-07**	0.00039	0.00061	0.00039	0.00061