Stantec Consulting Services Inc.
3325 South Timberline Road Suite 150, Fort Collins CO 80525-3681

May 5, 2021
File: 233001363

Attention: Mr. David Ennis
Mining and Minerals Division
Wendell Chino Building, Third Floor
1220 South St. Francis Drive
Santa Fe, NM 87505

Dear Mr. Ennis,

Reference: St. Anthony Mine – Work Plan for Pit 1 Field Investigation

On behalf of United Nuclear Corporation (UNC), Stantec has prepared the attached work plan to conduct a field program to evaluate highwall stability for Pit 1 at the St. Anthony Mine. The results of this work and analyses will be incorporated into the Closure/Closeout Plan for the site. Appended to the attached work plan is the Phase 1 analysis that Stantec completed for the highwalls. This work included updated survey, geologic field reconnaissance, and preliminary stability modeling for the pit. The Phase 2 work will include geotechnical drilling to characterize the stratigraphy, laboratory testing, slope stability models for Pit 1, and rockfall runout analyses.

UNC would like to initiate the Phase 2 field program in June 2021 but welcomes any feedback the Mining and Minerals Division may have on the proposed investigation program. Please contact us or Mr. Lance Hauer with any questions.

Regards,

Stantec Consulting Services Inc.

Jason Cumbers PE
Senior Associate/Geotechnical Engineer
Phone: 970 212 2755
Jason.Cumbers@stantec.com

Melanie M. Davis

Melanie Davis PE, PMP
Project Manager/ Principal Engineer
Phone: 970-212-2749
Melanie.Davis@stantec.com

Attachment: St. Anthony Mine Pit 1 Highwall Stability - Phase 2 Work Plan
c. Mr. Lance Hauer, Ms. Monique Mooney, Mr. Chad Baker

St. Anthony Mine Pit 1 Highwall Stability - Phase 2 Work Plan

May 5, 2021

Prepared for:

United Nuclear Corporation

Prepared by:

Stantec Consulting Service Inc.

File No: 233001363

Table of Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Executive Summary

This highwall stability Phase 2 Work Plan (work plan) describes the proposed investigation, data evaluation, and analysis to provide sufficient supplemental geotechnical information required for the Pit 1 highwall slope stability. This work plan describes the proposed borehole drilling program including details on the in-situ testing, sampling and laboratory testing and the proposed slope stability analysis including a detailed rockfall analysis specific to the Pit 1 highwalls at the St. Anthony Mine Site. A site-specific Health and Safety Plan (HSP) covering field activities associated with drilling 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 to support decision making for the pit backfill and cover design, material balance and grading plans, hydraulic modeling, and revegetation plans for the closure design.

Abbreviations

ASTM	American Society for Testing and Materials
BGS	below ground surface
BH	borehole
CA	Modified California Sample
CC	Continuous core
CCOP	closure/closeout plan
CO	Colorado
FoS	factor of safety
GPS	global positioning system
HSP	Health and Safety Plan
mrem/hr	Millirem per hour
MMD	New Mexico Mining and Minerals Division
MSDS	Material Safety Data Sheet
NM	New Mexico
NMAC	New Mexico Administrative Code
NMED	New Mexico Environmental Department
OCD	New Mexico Oil Conservation Division
NMOSE	New Mexico Office of the State Engineer
PEL	permissible exposure limit
RC	rock core
RF	rock fall
RSO	Radiation Safety Officer
SOP	standard operating procedure
SPT	standard penetration test
SS	split-spoon
UCS	unconfined compressive strength
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 10^{th}, 1964 and was surrendered by a Release of Mineral Lease dated October 24, 1988. UNC has access to the mine site through access agreements with the Cebolleta Land Grant and an adjacent landowner.

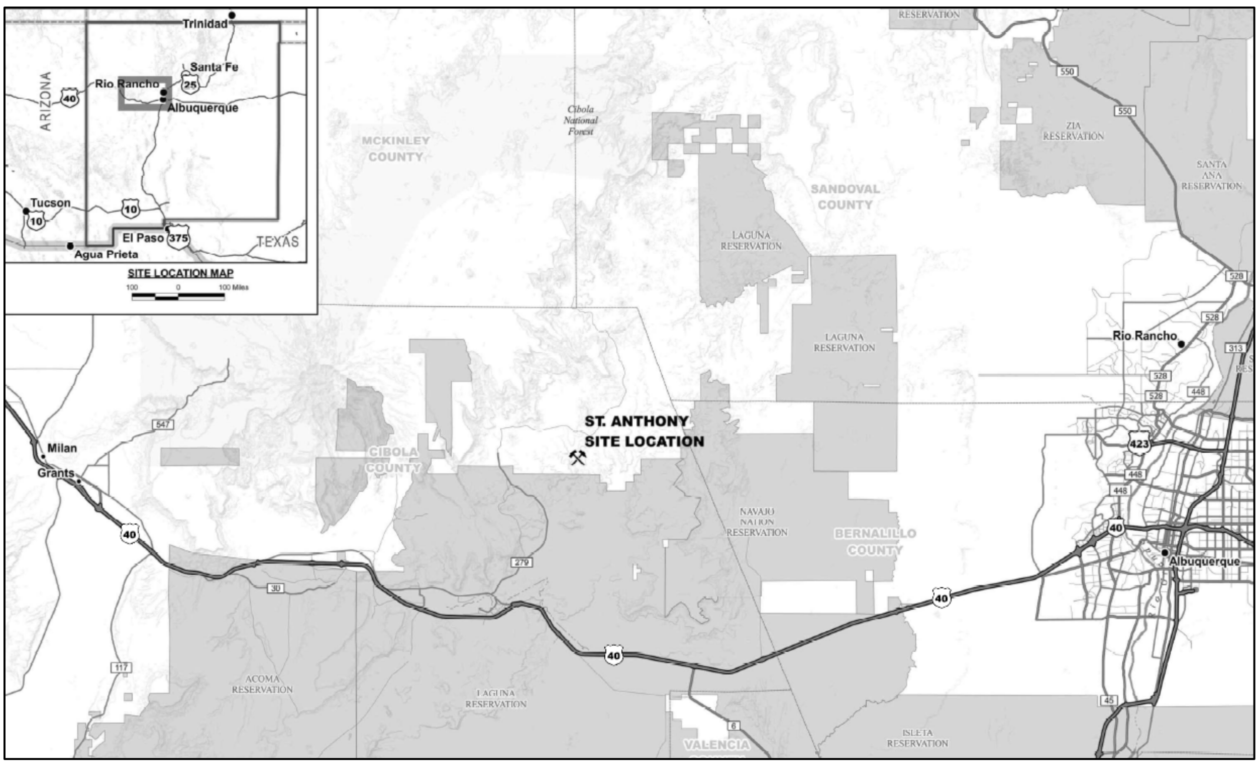


Figure 1 Site Location and Vicinity Map

In January 2006, a Closeout Plan and a Materials Characterization Plan were submitted to the New Mexico Mining and Minerals Division (MMD) for the St. Anthony Mine Site (the Site) and a materials characterization program followed in 2006 and 2007. This program included drilling and sampling on the existing waste piles. In 2018, supplemental investigations were carried out that included supplemental materials characterization and a geotechnical investigation which included additional drilling on the waste piles, test pitting between piles, and characterization of borrow sources for the proposed construction. The 2006 Closeout Plan was then revised, updated, and submitted in March 2019 to the MMD. MMD comments received on that plan requested further evaluation of the Pit 1 highwalls and the potential inclusion of remedial safety measures to address wall stability.

This work plan as well as the Phase 1 highwall evaluation completed in 2020 (Appendix A) are intended to fill data gaps to address Pit 1 highwall stability. The information collected for both phases of the Pit 1 highwall stability will be used to advance the design for the Pit 1 highwalls and this will be incorporated into the revised design for Pit 1.

The Pit 1 highwalls at the Site have been separated, for the purposes of analyses, into three areas 1) West Highwall, 2) South Highwall and 3) North Highwall, as shown in Figure 2. 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. All field activities proposed in this Phase 2 Work Plan will occur within the mine permit boundary.

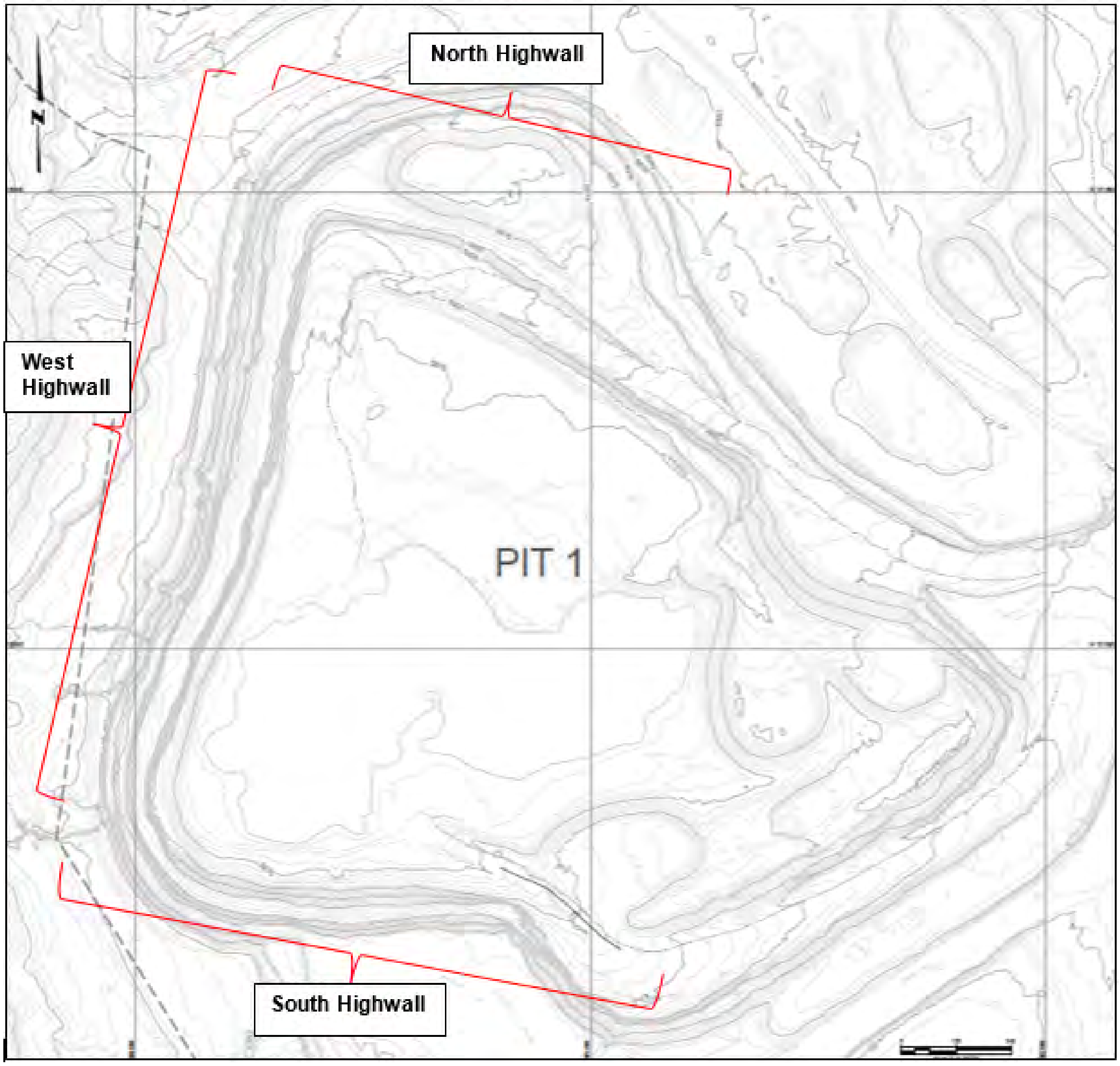


Figure 2 Site Layout

1.2 PURPOSE

This work plan has been prepared to detail the proposed additional highwall investigations and associated analyses. A previous analysis of the pit walls was conducted at the Site by Stantec in 2020, the results of which are presented in the attached *Geotechnical Analysis and Recommendations, St. Anthony Mine – Pit 1 Highwall, Phase 1* (Phase 1), included as Appendix A. The Phase 2 work plan generally consists of two parts: a borehole investigation field program and a detailed rockfall and slope stability modeling program.

A subsurface borehole investigation and laboratory testing program will be conducted to better define the highwall bedrock stratigraphy and bedrock properties assumed during the Phase 1 preliminary global stability analysis. Information collected in the borehole and laboratory program will be used to refine the parameters in the global stability analysis and reduce uncertainty and assumptions within the modeling. The boreholes are necessary to verify the rock strengths in the profile for the slope stability model in order to justify adequate long-term factor of safety (FoS) for the highwalls.

A rock fall modeling program will be conducted to effectively design hazard avoidance, or hazard protection, solutions. Modeling will involve simulating rock falls from various locations and height along the highwall and calculating the trajectories and impact forces expected. This will include calibration modeling to review current conditions as well as forward (prediction) modeling for the current slope trajectory and for changes to the trajectory once the benches accumulate additional scree. The rock fall modeling will allow for design of rockfall mitigation measures in the pit bottom to be incorporated with the proposed design for the Pit 1 cover.

The data collected from the borehole investigation, updates to stability modeling and the rock fall modeling will be summarized in a report, to be included as an attachment to the CCOP.

2.0 HEALTH AND SAFETY PLAN

All sampling, drilling, and investigation activities will be performed under the Site-Specific Health and Safety Plan (HSP) included in Appendix B. Key safety concerns include the possible presence of natural gases while drilling and hazards associated with work performed near the Pit 1 highwall. These concerns are discussed below and additional detail is provided in the HSP.

During previous drilling activities at the Site, carbon monoxide, hydrogen sulfide, and methane gases were encountered within some of the geologic materials at concentrations greater than permissible exposure limits (PEL). Since these gases may be present within the geologic formations investigated as part of this work plan, drilling activities will require a meter to monitor gas levels near the drill stem if the presence of gases is suspected. Engineering controls, such as fans, will be used near the work area if there is no wind present. If the PEL for a chemical of concern is exceeded with engineering controls, work will stop immediately and personnel will evacuate the work area until the hazard can be addressed.

Special precautions will also be taken to maintain safe working conditions during drilling activities conducted in proximity to the edge of the Pit 1 highwall. Personnel will examine the highwall for stability and other hazards prior to the start of any work in the vicinity. Safety measures will include a berm, or barrier, of sufficient height to prevent equipment and personnel from falling. If work is performed in areas with a danger of falling, and a safe working distance and barrier cannot be maintained, personnel will take measures to eliminate the risk or wear the appropriate fall protection.

3.0 BOREHOLE INVESTIGATION

3.1 OBJECTIVE OF THE BOREHOLE INVESTIGATION

The objective of the borehole investigation is to identify the engineering properties of the bedrock, including the depth of each stratigraphic rock unit, to further define the slope stability parameters used in the preliminary analysis; to demonstrate compliance with NMAC 19.10.5.506 and 507 as part of the non-coal mining, existing mining operations, regulations for Closeout Plans and Performance and Reclamation Standards and Requirements.

Structural rock mass data, including properties and orientation of the discontinuities (such as joints, bedding, and faults) in the bedrock will be collected with a televiewer survey to confirm the kinematic stability assessment completed in Phase 1. Televiewer surveys will be performed in select boreholes after the drilling to determine the orientation (dip and dip direction) and spacing of the discontinuities that are relevant for subsequent analysis.

The proposed borehole locations are located adjacent to the Pit 1 area and within the mine permit boundary. Access to the area will be by existing roads at the site. Overland travel will be in areas previously disturbed by mining and the locations will be reclaimed as part of the activities described in the CCOP.

3.2 FIELD INVESTIGATION

The Pit 1 highwall borehole investigation will consist of hollow-stem auger and wash rotary diamond-type drilling at select locations along the crest of the highwalls. Overburden soils will be drilled using hollow-stem augers and bedrock will be drilled using wash rotary boring type drilling. The proposed plan includes four (4) boreholes with a total drilling depth of approximately 1100 feet. Boreholes BH-2 and BH-4 will be drilled at angles of 25 degrees from vertical and azimuths shown in Table 1 below. The other boreholes will be vertical.

Locations were selected based on a spatial distribution to obtain representative samples and define the stratigraphy of the pit walls. Spacing between boreholes varies from approximately 600 to 1000 ft. Locations of boreholes were selected to determine the variability of the stratigraphy across the Site. The actual borehole locations will be adjusted to account for drill rig accessibility and safe working areas.

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

1. In the North Highwall Area, the borehole is proposed at the intersection with the West Highwall. A borehole depth of 250 is recommended. The proposed borehole location should avoid the previously completed boreholes in the Topsoil North Area.
2. In the West Highwall Area, two (2) boreholes are proposed to be evenly spaced along the entire length of the wall. Boreholes depths of 300 feet are recommended.

3. In the South Highwall Area, the borehole is proposed near the center of the wall. The borehole will be located at the crest of the lower highwall which has been previously described as the middle bench. A borehole depth of 250 feet is recommended.

Borehole locations shown on Figure 3 will be located in the field with a handheld GPS unit prior to beginning the field sampling. A safe borehole distance from the crest of the highwall will be determined in the field. Access for the drill rig is anticipated to require traveling both along the south side of the pit and then north since the drill rig will likely not be able to cross the large erosional features near the southwest corner of the pit. Field sampling and in-situ testing plans are further described in Section 3.3 and 3.4.

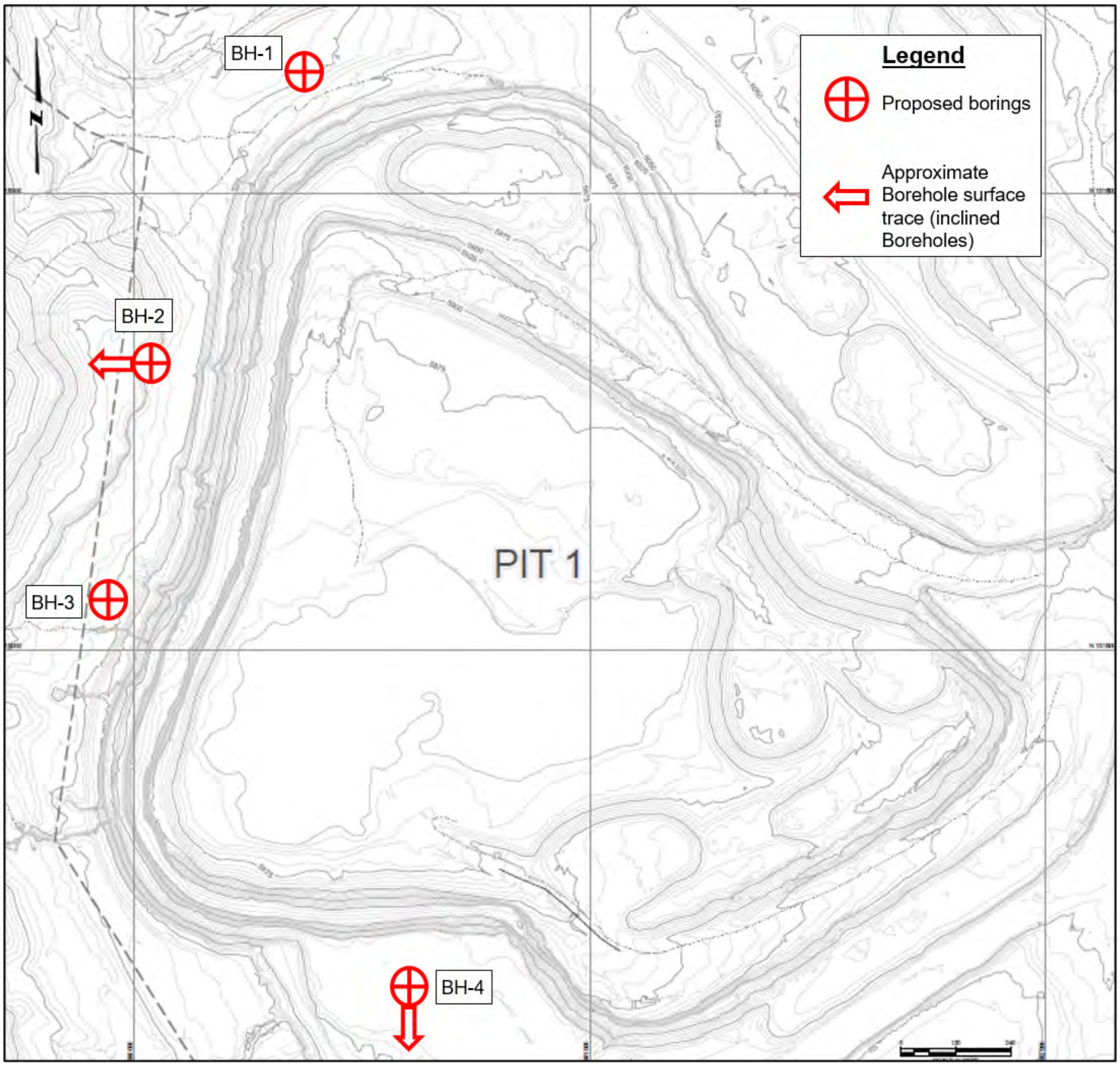


Figure 3 Proposed Borehole Locations

3.3 FIELD SAMPLING AND TESTING PLAN

The borehole investigation will be conducted at select locations (described above) to determine the stratigraphy and to obtain soil and rock samples to estimate the engineering properties of the materials. Hollow-stem augers with continuous core samples and SPT-interval samples will be performed in the overburden and weathered Mancos Shale for the vertical boreholes. Wash boring drilling will be required in the overburden of the inclined boreholes. No overburden testing (SPT) will be completed in inclined boreholes (BH-2 and BH-4). The inclined boreholes will be surveyed with an acoustic and optical televiewer after the borehole is completed to gather discontinuity orientation data.

Table 1 summarizes the anticipated exploration depth, the angles, azimuths, and the in-situ testing for the proposed borehole locations.

Table 1 Estimated Depths at Proposed Sampling Locations

Area	Boreholes Number	Angle (Degree)	Azimuth (Degrees)	Proposed Depth(s) (ft)	In-situ Testing
North Highwall	BH-1	0	-	250	-
West Highwall	BH-2	25	270	300	Televiewer
	BH-3	0	-	300	Dilatometer
South Highwall	BH-4	25	180	250	Televiewer

Notes:
1. Estimated depths based on modeling from Phase 1 investigation and existing height of the pit walls.
2. Sampling locations are shown on Figure 3.
3. Depths are in feet below ground surface (bgs).
4. Angle of borehole is measured from vertical (i.e., an angle of 0 degrees represents a vertical borehole)
5. Azimuth of borehole is measured from north.
6. If borehole conditions do not allow for the televiewer data to be collected on the inclined boreholes, the survey will be attempted on vertical boreholes.

Drilling and sampling will be conducted according to the following general method:

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 C). Pre-drilling background gamma radiation levels will be characterized at each borehole location using a Ludlum Model 19, or similar gamma radiation measurement device, before and after drilling.
2. A track-mounted drill rig (CME or equivalent) equipped with hollow-stem augers, HQ diamond drilling and sampling equipment will be used to collect the samples
3. Overburden drilling and sampling will include continuous soil core sampling with 4.25-inch augers and will take place in general accordance with SOP-01 (Appendix C). The continuous samples will be collected in five-foot intervals for the full depth of the overburden soils. Sampling will be completed in vertical boreholes only (BH-1 and BH-3). Testing will include continuous sampling of the auger material, 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 (Appendix C). Disturbed and undisturbed samples will be collected and used for laboratory testing. The angled boreholes will be cased with temporary casing through the overburden and into the weathered shale zone to prevent collapse of the upper portion of the borehole.

4. Bedrock drilling and sampling will include wash boring, rock core sampling with 3.78-inch HQ triple tube core barrel and will take place in general accordance with SOP-01 (Appendix C). The continuous samples will be collected in five-foot intervals for the full depth of bedrock in the boreholes. Rock core samples will be collected and used for laboratory testing.
5. A water truck will supply the water required for the bedrock drilling. All drilling fluids additives must be approved for use, in advance by Stantec. Used drilling fluid and excess cuttings will be disposed of in Pit 1 or Pit 2 at the completion of drilling.
6. The boreholes will be advanced to the approximate depths shown on Table 1. Proposed depths correspond to the estimated height of the adjacent highwall from the base of the pit plus an additional 30 feet.
7. A Stantec engineer or geologist will perform detailed core logging of the boreholes in the field and record the pertinent field test data as outlined in Table 2 and in accordance with SOP-17 (Appendix C) and Stantec’s Geotechnical Core Logging Manual (Appendix D). Point Load index strength testing will be completed in the field at each borehole location in accordance with the American Society for Testing and Materials (ASTM) Standard. The recovered core samples will be tested at 2-foot intervals or as deemed necessary. General field conditions will be logged and photographs will be taken in accordance with SOP-14 (Appendix C).
8. Upon completion of the boreholes and the downhole in-situ testing as detailed in section 3.4, augers and drill string will be removed, and grouted or backfilled with bentonite. All unused drill cutting and drilling mud that shows gamma radiation in excess of background levels shall be buried and covered with no less than three (3) feet or earthen material. If water or gas is encountered during drilling it will be reported to the New Mexico Office of the State Engineer (NMOSE) and New Mexico Oil Conservation Division (OCD) respectively and the boreholes will be plugged in accordance with the NMOSE regulations.
9. Core samples will be scanned for activity levels upon removal from the boreholes and activity levels will be recorded by the field personnel on the drillhole logs. Samples recovered with activity levels greater than 0.2 mrem/hr will be excluded from lab testing and will remain at the Site.
10. Samples selected for testing will be sealed for transport to the laboratory in accordance with SOP-06 (Appendix C). 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 site, UNC property or at the laboratory until it has been determined that additional testing on the extra samples is no longer required. The extra samples will be transferred to UNC for disposal at St. Anthony, or properly disposed in accordance with State and Federal requirements.
11. 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 (Appendix C).

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

The areas where the boreholes will be completed will be revegetated and reclaimed as part of the site restoration described in the CCOP.

3.4 IN-SITU BOREHOLE TESTING

In-situ testing is required to determine the rock mass and discontinuity properties and will supplement the laboratory test data collected. The following downhole tests will be completed in select boreholes at the time of drilling and will be completed by a qualified and approved subcontractor. In the event of borehole collapse, in-situ testing may be limited to the length of the borehole above a collapse area. The decision to lower an instrument down the borehole will be completed at the drill by the subcontractor.

3.4.1 Acoustic and Optical Televiewer

An acoustic and optical downhole televiewer survey will be used in the inclined boreholes to determine the condition and orientation of the discontinuities (joints, bedding, faults etc.) present in the rock mass. The data collected will confirm the kinematic stability assessment completed in Phase 1 and also identify any faults or highly fractured zones in the highwall stratigraphy which may affect the global stability.

The acoustic and optical televiewer probe consists of a metal probe with a three-axis magnetometer and three accelerometers mounted at the tip, which provides an oriented 360-degree view of the borehole walls. The probe is lowered into the borehole with a specialized winch to record the data. Acoustic televiewer images must be collected in water. Optical televiewer generally does not require water but may be done in very clear water.

The drilling subcontractor will be required to clear the borehole of obstructions, flush, and add flocculent (Insta-Vis Plus – Liquid drilling fluid polymer or approved equal) in preparation for the televiewer surveys. The material safety data sheet (MSDS) for a typical polymer used for this application is included as Appendix E. Following completion of the televiewer surveys the casing will be removed from the borehole and the boreholes backfilled or sealed with grout.

If borehole conditions do not allow for the televiewer data to be collected on the inclined boreholes, the survey will be attempted on vertical boreholes.

3.4.2 Dilatometer

In-situ dilatometer testing will be used to determine the engineering properties of the Mancos Shale stratigraphic unit. The friable weak properties of the shale often make it difficult to recover intact samples for laboratory testing. In-situ testing of the Mancos shale unit will help reduce uncertainty of sample recovery and laboratory testing required for determining engineering properties.

The dilatometer probe consists of a metal central body with an inflatable rubber membrane equipped with sensors. The probe is lowered into the borehole to the required testing depth and the membrane is pressurized with dry gas (nitrogen or air) in progressive steps and the diametrical deformation is measured. The tests will provide the elastic modulus and the anisotropic behavior of the rock mass which will be used in the global stability analysis.

Table 2 Geotechnical Characterization Objectives and Sampling Methods

Evaluation	In-situ (Sample Type)	Laboratory (Sample Type)
Overburden and Weathered Mancos	• Thickness/stratigraphy: visual classification (CC, CA, SS) • Modified penetration tests (SPT)	• Water content (CA, SS, CA, or bulk) • Unit weight (CA) • Particle-size (CA, CC, SS, or bulk) • Atterberg limits (CA, CC, SS)
Bedrock	• Thickness/stratigraphy: visual classification (RC) • Wash boring diamond drilling, triple-tube core barrel (RC)	• Unconfined compressive strength (RC) • Slake durability test (RC, or bulk) • Triaxial Strength (RC) • Direct Shear (RC) • Slake Durability (RC) • Magnesium Sulfate Rock Durability Testing (RC) • Point Load (RC)

Notes
CC = continuous core; SPT = Modified penetration test
CA = Modified California samples; Bulk = bulk samples
SS = split-spoon samples; RC = Rock Core

3.5 LABORATORY SAMPLE ANALYSIS

Laboratory testing will include index properties (i.e., Unconfined compressive strength (UCS), point loads (with some partner UCS, triaxial, direct shear, slake durability, and magnesium sulfate rock durability tests) for geotechnical characterization for an estimated 125 samples. The samples will be selected upon review of all the borehole data (field borehole logs, in-situ testing, photos etc.). The sample intervals will be evenly spaced throughout Mancos shale with sandstone lithology and any zone of interest which may include zones of weakness (faults) or increased weathering. Limited samples will be selected from more competent lower Jackpile sandstone unit, unless conditions warrant.

The geotechnical laboratory testing program is summarized in Table 3. Laboratory testing will be conducted according to applicable ASTM standards. This laboratory testing program will be modified based on a review of the samples collected during the investigation.

Selected samples will also be submitted to a laboratory for analysis to determine properties of the materials. The probable number of samples to be submitted to the laboratory is estimated to be 125; however, the actual quantities will depend on field conditions and materials encountered. The laboratory program is estimated to take 4 to 6 weeks to complete. Laboratory testing will be conducted by subcontractors to Stantec.

Table 3 Geotechnical Evaluation Proposed Laboratory Testing Schedule

Material Type	Geotechnical Laboratory Test	Estimated Number of Laboratory Tests	Reference Method or Sample Type
Rock	Unconfined compressive Strength – No Strain (6)	25	ASTM D7012 / Method C
	Unconfined compressive Strength – with Strain recorded (6)	25	ASTM D7012 / Method D
	Triaxial Compressive Strength	5	ASTM D7012 / Method B
	Direct Shear Strength (4,5)	10	ASTM D5607
	Slake Durability Testing(7)	5	ASTM D4644 or ATT RP-37
	Evaluation of Durability - Freeze Thaw	2	ASTM D5212
	Evaluation of Durability - Wet Dry	3	ASTM D5213
	Point load – (Partner with UCS tests) (6)	25	ASTM D5731
Overburden	Moisture content (2)	10	ASTM D2216 / disturbed and undisturbed
	Dry density	5	ASTM D2937 / undisturbed
	Particle-size: sieve and hydrometer(1,2)	5	ASTM D422 / disturbed and undisturbed
	Atterberg limits(2)	5	ASTM D4318 / disturbed and undisturbed

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.
4. All raw data from direct shear laboratory testing data is required for post-processing.
5. The horizontal and vertical displacement must be recorded for the direct shear laboratory testing.
6. Partner point load laboratory tests will be completed on rock samples selected for unconfined compressive strength testing. The Point load strength tests completed at or very near the depth of the UCS test will be used to correlate the point load test data collected in the field at the drill location with the laboratory data.
7. ATT RP-37 - Jar Slake Test

4.0 DETAILED ROCK FALL AND GLOBAL STABILITY ANALYSIS

4.1 PREVIOUS DATA COLLECTION

A preliminary rock fall and kinematic analysis was conducted at the Site by Stantec in 2020. The scope of work in Phase 1 included the collection of existing rock fall data from the pit wall and the pit floor and determining if rock fall hazards are present at the Site. A light detection and ranging (LiDAR) and photogrammetry drone survey was completed to visually assess the potential rock fall hazard and estimate the size and extent of potential rock fall. In addition, the point cloud models were used to determine the topography and the discontinuity models of the pit highwall and was used to produce one cross section that was used for preliminary slope stability analysis.

4.2 PHASE 2 – GLOBAL STABILITY ANALYSIS

A global stability analysis will be completed by combining the rock mass properties collected in the Phase 2 borehole investigation and the topographic information collected from Phase 1. Modeling will involve global stability analysis from four (4) different locations along the Pit 1 highwall at the locations of the Phase 2 boreholes. The analysis will be completed using a limited equilibrium 2D slope stability analysis program (Slide 2 from RocScience Inc. or SLOPE/W from GEO-SLOPE International Inc.). At each profile, the stratigraphy depth and strength properties of each soil and bedrock unit encountered in the borehole will be modeled. If groundwater is encountered in the borehole, the groundwater level and anticipated seasonal variability will be included in the global stability analysis.

The global stability analysis will then be used to provide a FoS against global circular failure to determine the remedial work required for the reclamation to satisfy the New Mexico Mining Act requirements.

4.3 PHASE 2 - DETAILED ROCK FALL ANALYSIS

Using the information collected from Phase 1, Stantec will undertake a detailed rock fall analysis to effectively design a hazard avoidance or hazard protection solution. The information collected in the Phase 2 borehole investigation will provide information on the stratigraphy and rock properties. Modeling will involve simulating rock falls from eight (8) different locations along the Pit 1 highwall, as shown on Figure 4. The rock fall analysis will be completed using a 2D statistical analysis program RocFall from RocScience Inc. At each rock fall location, the energy, velocity, bounce height, and location endpoints will be determined for a range of rock sizes, shapes, and material types (i.e., sandstone, shale); which have been dislodged from various heights of the slope face. The existing rock fall material accumulated at the toe of the pit walls (collected in Phase 1) will be used to calibrate the modeling results.

The proposed rock fall analysis locations are described below and shown on Figure 4. The exact location to perform the analysis will be determined during the evaluation of the rock fall material accumulation pattern and the proximity to access road or working locations.

- North Highwall Area, 2 rock fall analysis sections (RF-1, RF-2)

- West Highwall Area, 4 rock fall analysis sections (RF-3, 4, 5, and 6)
- South Highwall Area, 2 rock fall analysis sections (RF-7, RF-8)

The rock fall modeling will then be used to design rockfall mitigation measures in the pit bottom, if necessary, which will be incorporated into the proposed closure design for the Pit 1 backfill and cover.

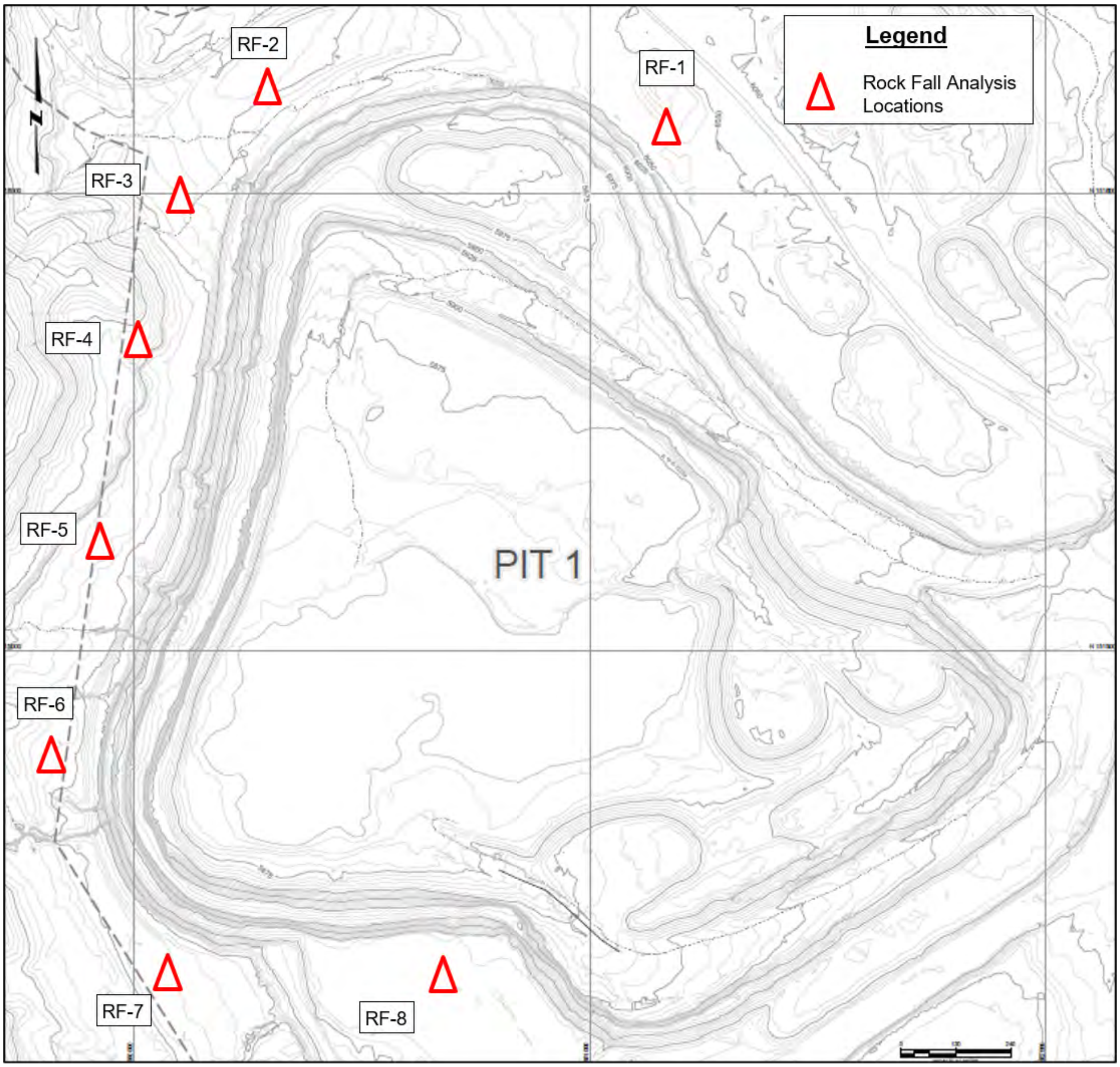


Figure 4 Approximate Rock Fall Analysis Locations

5.0 REFERENCES

Stantec, 2020. Geotechnical Analysis and Recommendations, St. *Anthony Mine – Pit 1 Highwall, Phase 1*, November.

New Mexico Mining and Minerals Division 1996. *Closeout Plan Guidelines for Existing Mines*. April 30

APPENDIX A

Phase 1 Highwall Report

APPENDIX B

Health and Safety Plan

APPENDIX C

Standard Operating Procedures

APPENDIX D

Stantec's Geotechnical Core Logging Manual

APPENDIX E

MSDS INSTA-VIS PLUS Drilling Fluid

St. Anthony Mine Phase 1 Pit 1 Highwall Stability - Geotechnical Analysis and Recommendations

May 5, 2021

Prepared for:

United Nuclear Corporation

Prepared by:

Stantec Consulting Services Inc.

File No: 233001363

Table of Contents

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

1.0 INTRODUCTION

On behalf of the United Nuclear Corporation (UNC), Stantec Consulting Services Inc (Stantec) completed a preliminary slope stability assessment and gap analysis of the St. Anthony Mine Pit 1 Highwall to support preparation of the Closure-Closeout Plan (Stantec, 2020). The St Anthony Mine (the Site) is located in Cibola County, New Mexico, in a remote, sparsely populated area on the Cebolleta Land Grant approximately 40 miles west of Albuquerque and 4.6 miles southeast of Seboyeta.

The purpose of the evaluation was to:

- Conduct a preliminary assessment of the stability of the Pit 1 Highwall
- Review the likely impact of potential highwall instabilities on long term reclamation
- Identify rockfall hazards from the highwall
- Provide recommendations to address data gaps with additional field investigation and analysis

The pit walls are being evaluated to comply with NMAC 19.10.5.506, 507, and 508 as part of the non-coal mining regulations for existing Mining Operations Closeout Plans and Performance and Reclamation Standards and Requirements. The primary objective is to evaluate and eliminate “current or future hazard to public health or safety” (NMAC 19.10.5.507.B.2) related to the open pit. The stability of the pit walls is being assessed to evaluate stable placement of the proposed diversion structures west of the highwall, minimize mass movement into the pit bottom, and develop a long-term design that controls erosion. Although not specified in the NMAC non-coal, Closeout Plan Guidance, based on typical industry standards Stantec selected a minimum factor of safety for the Pit 1 Highwall as a non-critical structure of 1.3 and 1.1 for long-term static conditions and pseudo-static conditions, respectively. Because of the competency of the lower rock strata, the Dakota and Jackpile formations, potential excavation of material for stability and erosional improvements from the highwall, if necessary, will focus on the upper Mancos Shale.

This report summarizes the findings from the background study, presents the results from the field study and data analysis, and provides recommendations for remedial measures.

2.0 SITE DESCRIPTION

2.1 Site Location

The Site includes underground workings comprising one mine shaft and several vent shafts that are now sealed at the surface, two open pits (one currently containing groundwater), numerous smaller piles of non-economical mine materials, and three topsoil and/or overburden piles. Pit 1 has three primary highwalls which are oriented generally towards east, south, and north. Other areas of the pit contain groundwater, waste rock stockpiles, and access roads. The mine site location is shown in Figure 1. The two open pits at the Site are in Sections 19 and 30, Township 11 North, Range 4 West, and the entrance to the underground mine is in Section 24, Township 11 North, Range 5 West.

.

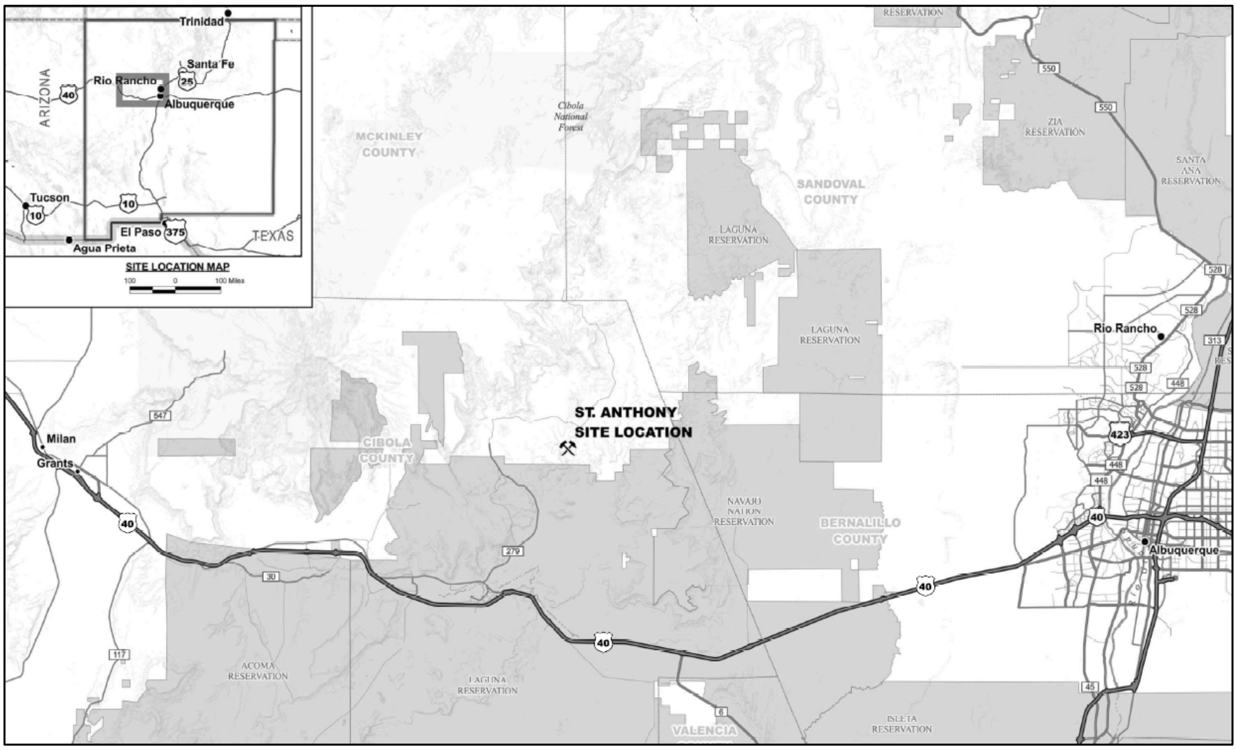


Figure 1 Site Location

2.2 Physiographic and Geological Setting

The Site is on the Colorado Plateau physiographic province, broadly characterized by plateaus and mesas of stratified sedimentary rock overlying tectonically stable Precambrian basement. Within the southeastern portion of the Colorado Plateau lies the San Juan Basin, a structural depression encompassing most of northwestern New Mexico and adjoining parts of Colorado and Utah. The strata of the San Juan Basin dip gently to the north (approximately 2 degrees), although small faults and folds alter the dip of the strata locally. The San Juan Basin is truncated on its southeastern margin by the Jemez lineament, a northeasterly trending structural boundary between the Colorado Plateau to the northwest and the Rio Grande Rift to the south and east. The Site is within the Grants uranium district that lies on this transitional margin amidst many prominent Late Cenozoic volcanic fields that demarcate the Jemez lineament and the southeast margin of the San Juan Basin.

Sediments in the Grants area were deposited in various continental environments. During later Permian time, Glorieta sandstone and San Andreas limestone were deposited. The region was subsequently uplifted in Laramide time and the sediments of the Chinle Formation, San Rafael Group, and Morrison Formation were deposited. Upper Cretaceous strata consist of marine shore zone sandstones, marine shales, and various continental deposits. In ascending order, these are represented by the Dakota Sandstone, Mancos Shale, and the Mesaverde Group.

Stratigraphy of interest at the Site includes the Mancos Formation (Late Cretaceous), the Dakota Formation (Early and Late Cretaceous) and the Morrison Formation (Late Jurassic). The surficial geologic unit at the Site is the Mancos Formation consisting of three sandstone units and interbedded shale units with a maximum thickness of 465 feet. The upper sandstone caps Gavilan Mesa to the south of the pits. The Dakota Formation sandstone is 6 to 20 feet thick in the Site area and is below the Mancos Formation. The Morrison Formation is approximately 600 feet thick and is below the Dakota Formation. The Morrison Formation is comprised of the Jackpile Member (sandstone), the Brushy Basin Member (interlayered mudstone and sandstone), the Westwater Canyon Member (sandstone), and the Recapture member (interbedded claystone and sandstone).

The Jackpile Member of the Morrison Formation is the source rock for the uranium production at the Site, with each pit penetrating approximately 75 feet into this unit. The thickness of the Jackpile sandstone in the Site vicinity varies from 80 to 120 feet and is representative of deposition in a braided stream environment.

3.0 METHODOLOGY

3.1 Background Study

Stantec completed a background study to review available historical data for the site in relation to rock slope instability occurrences, as well as the geological and physiographic conditions that may contribute to highwall instability. Several factors such as slope geometry, bedrock and overburden geology, surface water and groundwater conditions, climate, vegetation, and historical development from human activity can contribute to potential instabilities.

The various documents and data reviewed for this project consisted primarily of information from published regional geological sources. No site-specific information on the original slope topography, design, blasting methods, dates of construction, and slope stability issues during operation are available.

3.2 Field Study

Stantec personnel completed a 1-day site visit on September 28, 2020 to investigate the condition of the Highwall and rim area of Pit 1 and collect geological and geotechnical information about the site. The weather during the site visit was clear and sunny. The investigation consisted of a visual inspection of the rock faces, general measurements for the size and distance of potential rockfall, and discontinuity orientations.

For safety reasons, no manual geological field mapping was performed during the site visit due to the large amount of loose rock on the faces and the associated rockfall hazard. No samples for laboratory testing were taken during the site visit as part of this assignment.

The visual inspection of the rock faces and the crest area was carried out from the bottom of the rock face and, where accessible, from the area above the slope. The inspection included an assessment of the structural features visible on the exposed rock faces, such as discontinuities and bedding, observed seepage and general weathering or alteration of the rock faces. Photographs were taken using a digital camera. Annotated photographs of the rock slope are embedded in the following sections.

3.3 Remote Mapping

Mapping of the structural features of the rock slope was carried out using digital photogrammetry, a method for the measurement and assessment of three-dimensional (3D) imagery of rock and other terrain surfaces. The data acquisition in the field was completed by NV5 Inc. from Albuquerque, New Mexico using a Sony A7R camera mounted to a drone. Overlapping high-resolution photographs were taken at oblique angles of the entire pit area. The photogrammetric analysis was performed with the ShapeMetrix^{3D} UAV system from 3GSM. The overlapping photos taken along the rock faces were loaded into the ShapeMetrix^{3D} UAV software and combined to generate a 3D image. Geological and geotechnical analyses of the 3D images that are available in ShapeMetrix^{3D} include discontinuity orientation (dip and dip direction) and spacing, lithological mapping as well as distance and area calculations. The topographic survey was conducted to support the Pit 1 Highwall preliminary slope stability and data gaps assessment. Additional, or ongoing, topographic surveys of the highwalls are not planned.

4.0 SITE OBSERVATIONS

The following sections provide information about the site conditions observed during the site visit. Slope conditions are subject to change due to seasonal changes of the environment and due to ongoing weathering processes acting on the slopes; therefore, the following descriptions reflect the status of the slopes during the site visit.

4.1 General Site Conditions

The Pit 1 Highwall has been separated into three areas 1) West Highwall, 2) South Highwall and 3) North Highwall, as shown in Figure 2. The following sub-sections describe the field and drone observations.

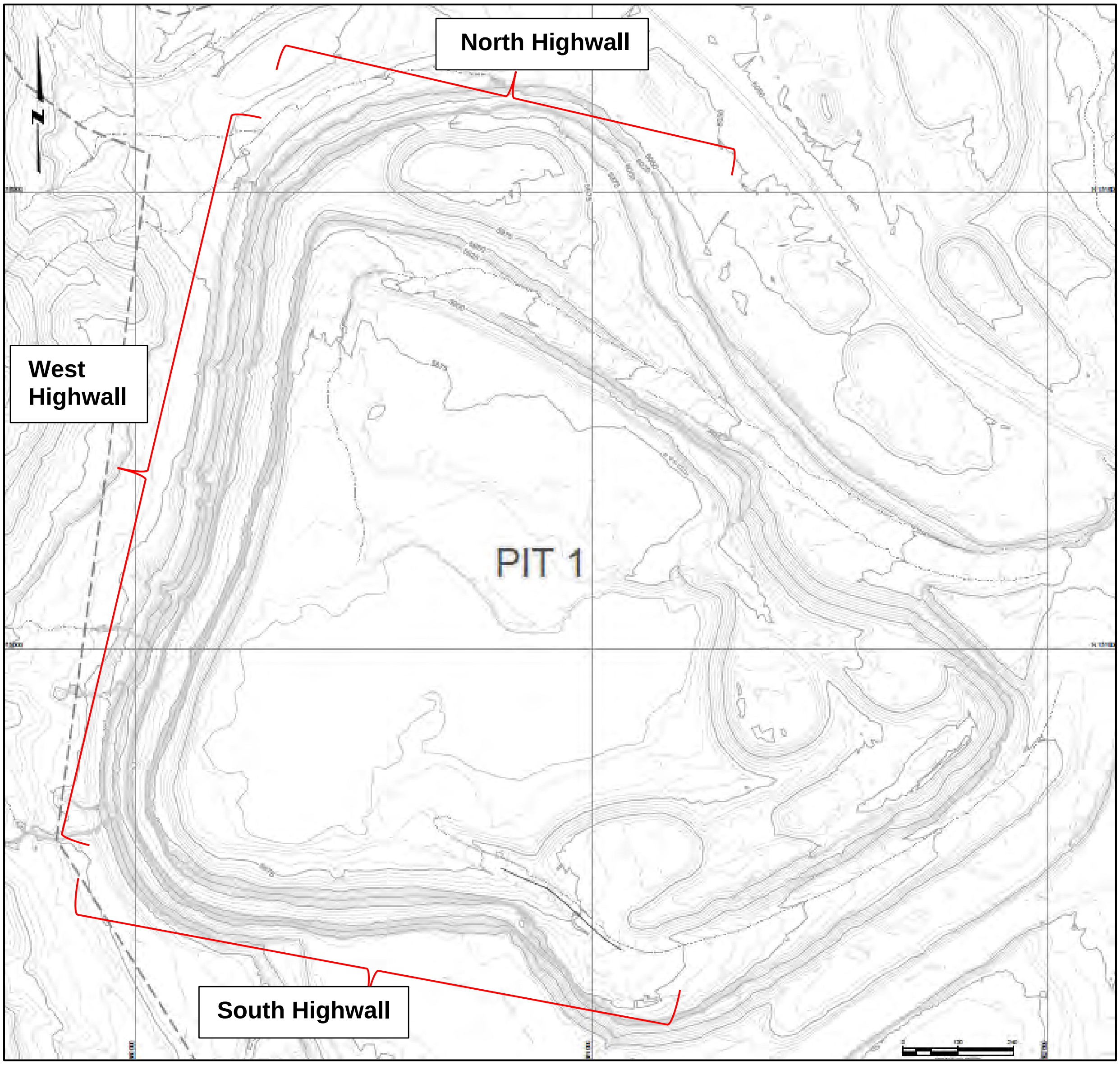


Figure 2 General Pit 1 Highwall Areas

West Highwall

The West Highwall rock slope has an approximate length of 1,600 ft. The height of the rock slope increases from approximately 120 ft at the north end, near the intersection with the North Highwall, to approximately 270 ft at the south end with the intersection with the South Highwall.

The West Highwall is composed of three primary benches ranging from approximately 30 to 50 ft wide and 30 to 90 ft in height. The top bench is mostly covered in erosional scree. The near vertical bench faces comprise interbedded, locally pale brown, sandstone, and mudstone. The rock is generally fractured and mostly blocky due to near horizontal bedding planes and steeply inclined joints. Layers of foliated shale were observed at various heights of the slope face. Undercutting of rock and small ledges were noted throughout the slope. Large amounts of scree were noted on the face and ongoing raveling of small rock material from the face was observed, as shown in Figure 3.

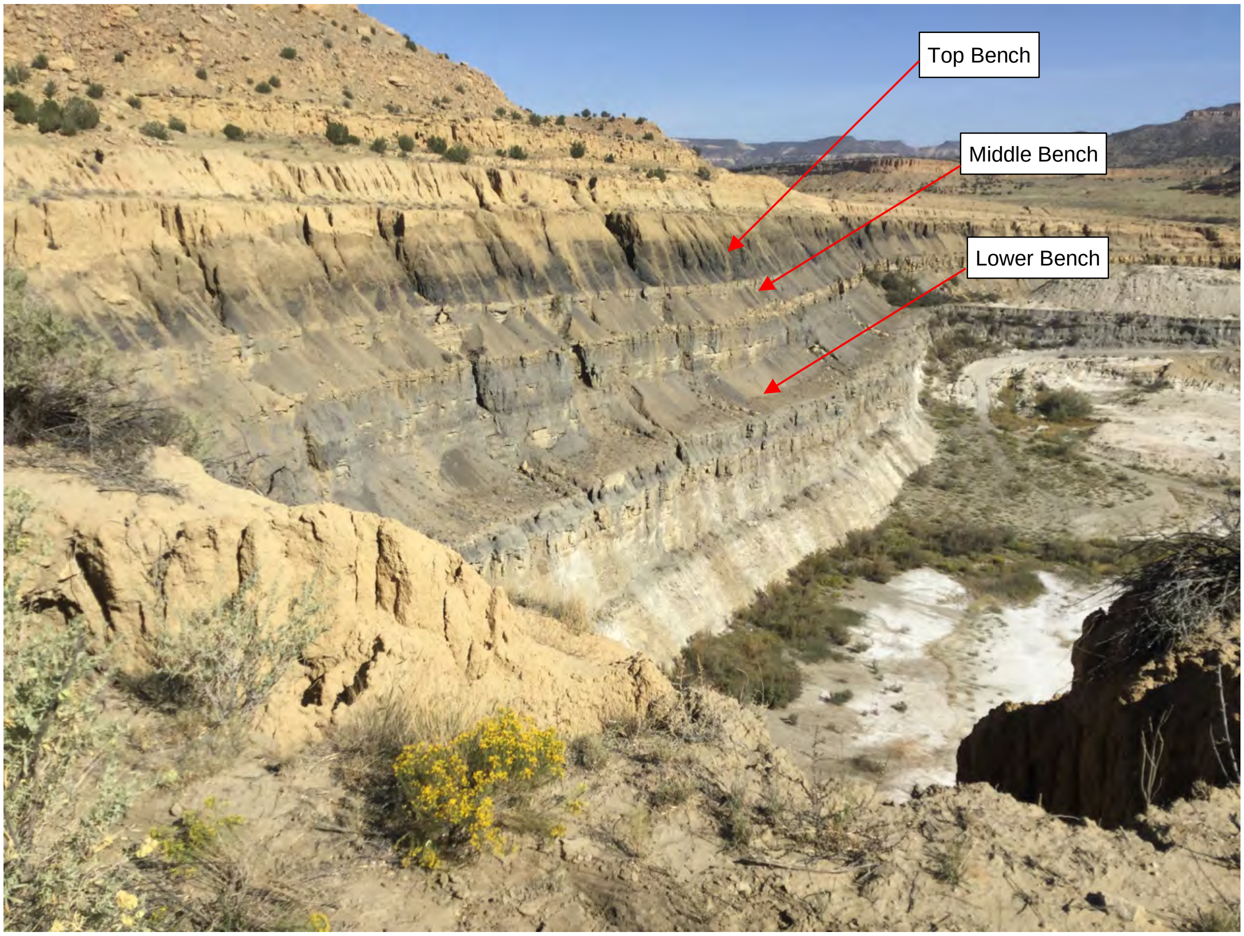


Figure 3 West Highwall Configuration (view to the North)

At the upper part of the West Highwall, the rock has eroded from the face as a result of ongoing weathering and thus undermined the overburden material. Fragments of surface overburden are eroding the crest of the column of unstable rock (see Figures 4 and 5 below).

Figure 4 Crest of West Highwall (view to the North)

Figure 5 West Highwall Configuration (view to the East)

Small to medium sized rock debris has accumulated along the toe of the slope, ranging in dimension from gravel-size pieces to blocks or plate shaped debris with approximately 2- to 3-foot side lengths and up to 5-foot side lengths. Due to the steepness of the slope, the debris has the tendency to fall straight to the toe of the slope. No designated catchment area was observed at the toe. The accumulated debris forms a talus slope at the toe that permits falling debris to roll or slide away from the slope towards the path.

No significant groundwater seepage or surface water runoff was noted on the West Highwall during the site visit and it is assumed that the area is drained due to the open faces of the highwall. There was minor seepage observed at the top contact of the Jackpile sandstone, primarily at the north end of the West Highwall. Surface water runoff down the wall can be expected during and after the high-intensity rainstorms that tend to occur most frequently during the summer monsoon season (and occasionally during the fall months). Runoff due to melting snow may also occur throughout the fall, winter, and spring months, though is likely smaller in magnitude compared to rainfall-driven runoff.

Small shrubs and trees were observed on the slope benches and the scree piles and along the slope toe in the pit.

South Highwall

The South Highwall rock slope has an approximate length of 800 ft. The height of the rock slope increases from approximately 180 ft at the east end near the South Haul Ramp to approximately 270 ft at the west end with the intersection with the West Highwall.

The South Highwall is also composed of 3 benches with similar dimensions as the West Highwall. The benches and the toe are mostly covered in erosional scree. At approximately 250 feet east from the West Highwall intersection the South Highwall height drops to about 180 feet and only the bottom bench remains, and the crest of the slope is at the elevation of the middle bench. The near vertical bench faces comprise interbedded, locally pale brown, sandstone, and mudstone. The rock is generally very fractured and mostly blocky due to near horizontal bedding planes and steeply inclined joints. Layers of foliated shale were observed at various heights of the slope face, see Figure 6 below. Undercutting of rock and small ledges were noted throughout the slope. Large amounts of loose rock were noted on the face and ongoing raveling of small rock material from the face was observed.

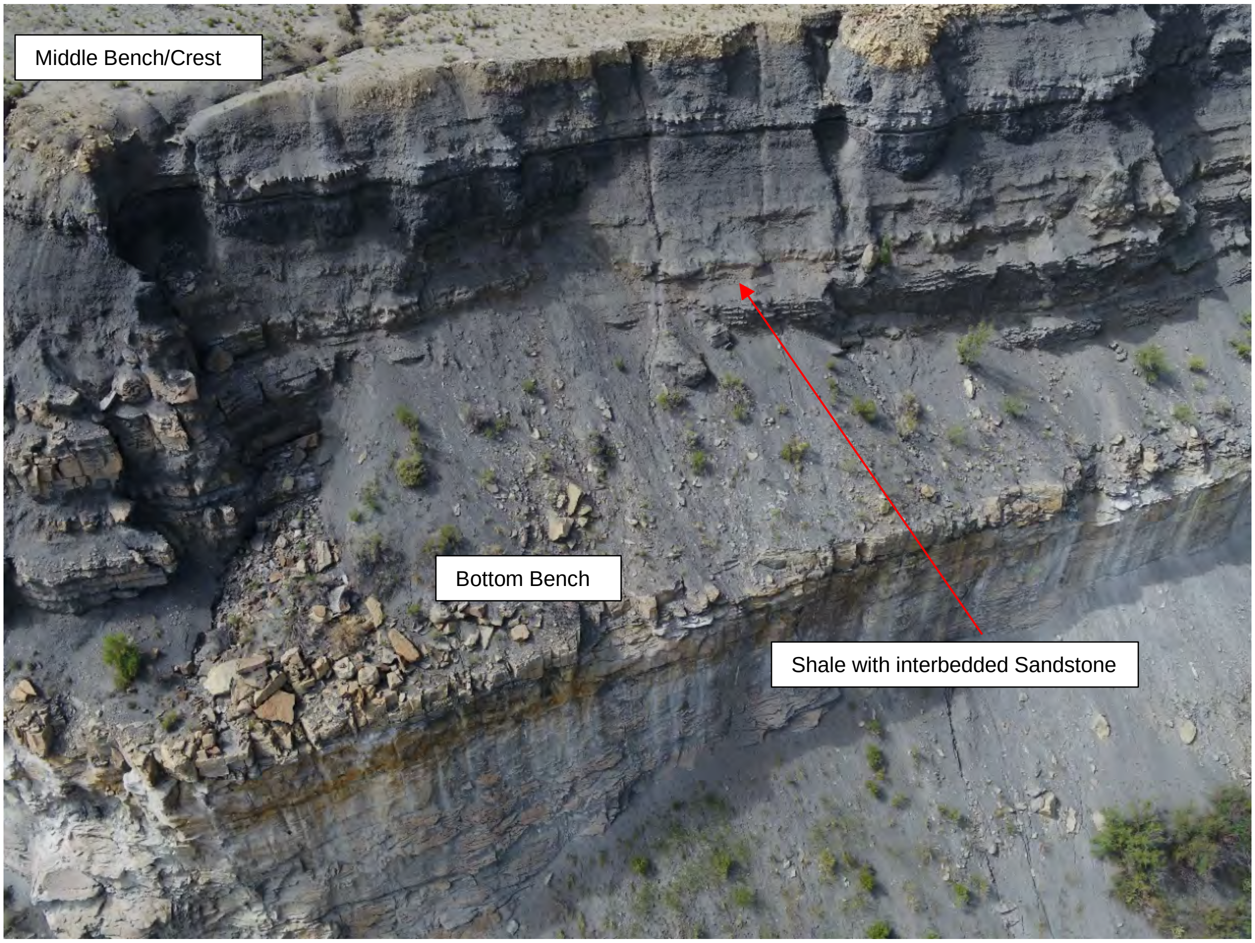


Figure 6 South Highwall Configuration

At the upper part of the highwall, the rock has eroded from the face and is resting on loose scree material as a result of ongoing weathering and undermined overburden material. The zone of the transition on the South Highwall where the height decreases from 270 ft to 180 ft, appears to bulge from the slope face, as shown in Figure 7.

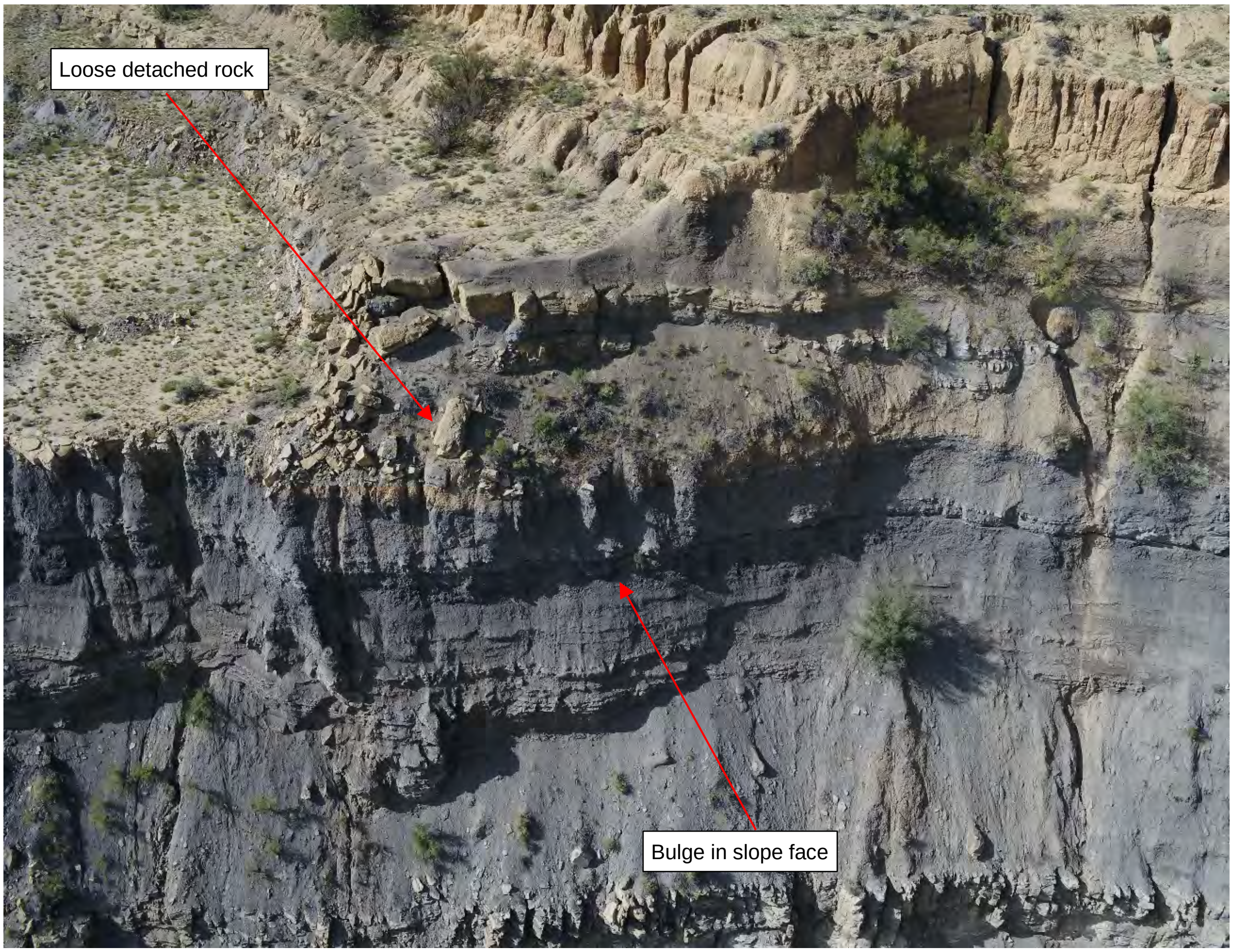


Figure 7 South Highwall Transition (view to the South)

At the east end near the South Haul Ramp there is evidence of a potential bench scale failure of the highwall, as shown in Figure 8. The possible mechanism of failure is discussed further in section 5.5.

No significant groundwater seepage or surface water runoff was noted on the South Highwall during the site visit. It is assumed that the area is drained due to the open faces of the highwall.

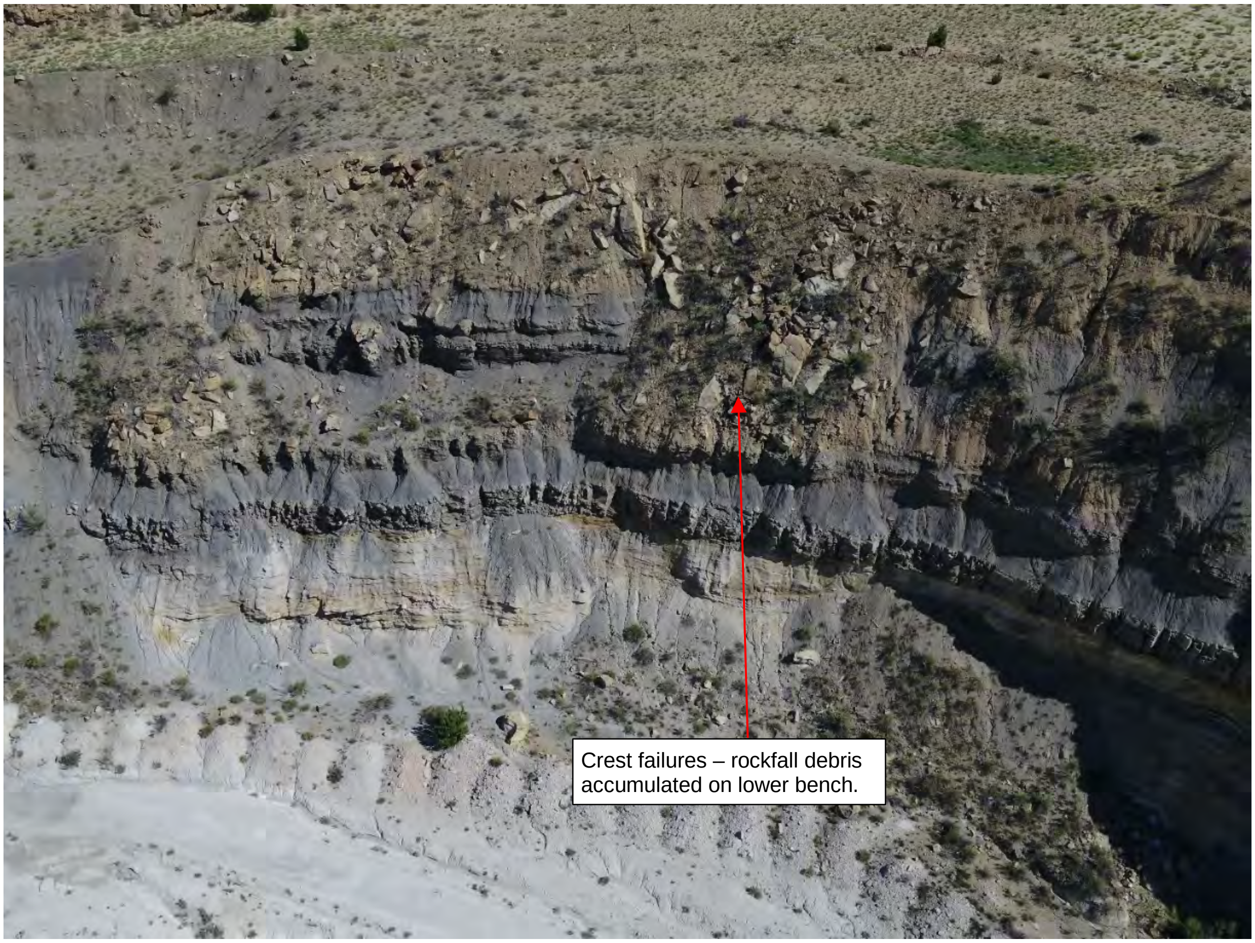


Figure 8 South Highwall Bench Scale Failure (view to the South)

North Highwall

The North Highwall rock slope is convex semi-circle in shape with a diameter of approximately 800 ft and a perimeter length of approximately 2,300 ft. A waste rock stockpile of rock fragments is in the center of the highwall semi-circle and an access road is located across the bottom of the circle. The height of the highwall is approximately 140 ft at center and increases to 180 ft at the intersection with the West Highwall.

The North Highwall is composed of two benches. The top bench is mostly covered in erosional scree and the bottom bench forms the platform for the waste rock stockpile. The near vertical bench faces comprise interbedded, locally pale brown, sandstone, and mudstone. The rock is very fractured and mostly blocky due to near horizontal bedding planes and steeply inclined joints. Layers of foliated shale were observed throughout the slope face. Undercutting of rock and small ledges were noted throughout the slope, see Figure 9. Large amounts of loose rock were noted on the face and ongoing raveling of small rock material from the face was observed.

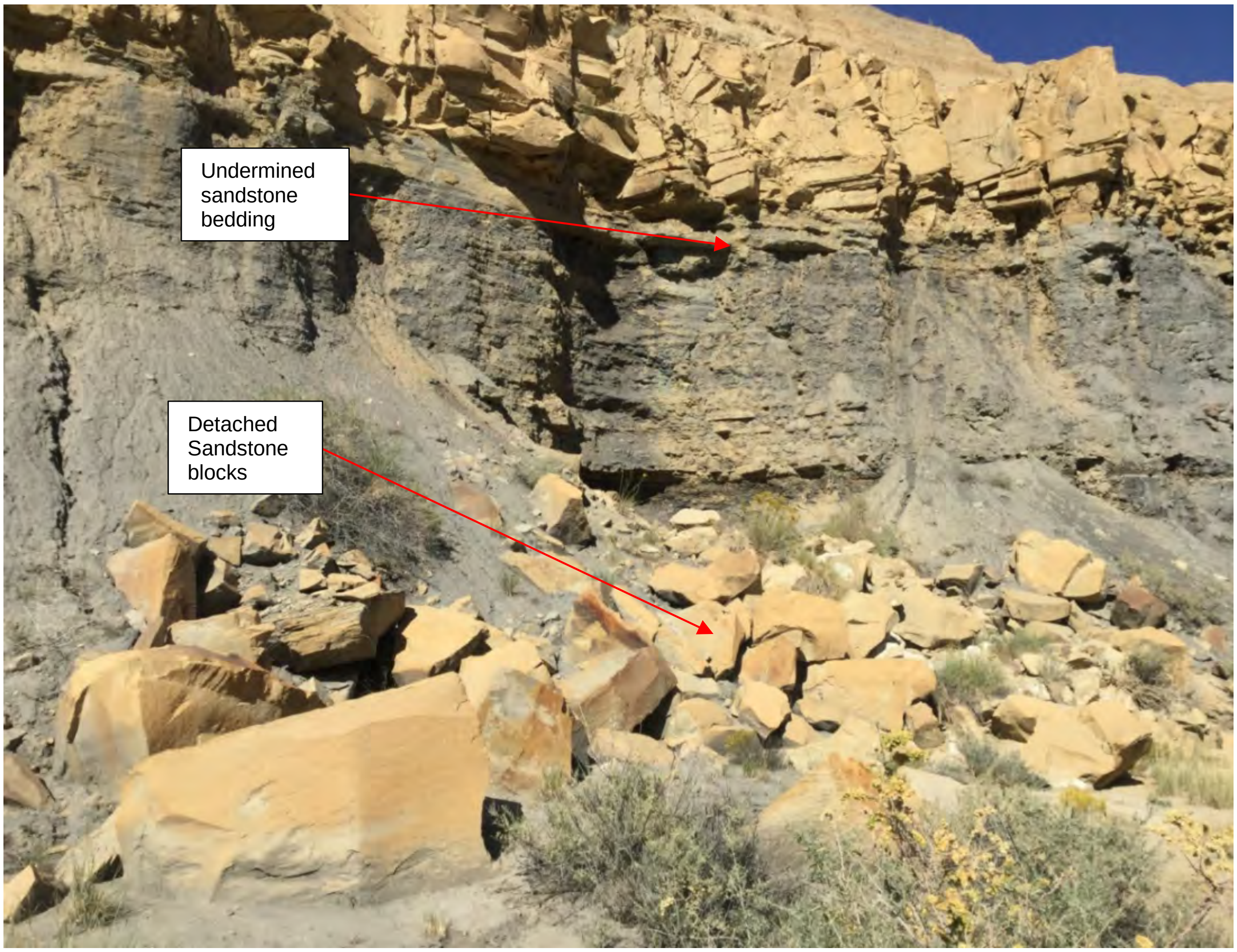


Figure 9 North Highwall Configuration (view to the Northwest)

Small to large sized rock debris has accumulated along the toe of the slope, ranging in dimension from gravel-size pieces to blocks or plate shaped debris with approximate diameters up to 16 feet and located up to approximately 30 feet from the toe of the slope, see Figure 10. Due to the steepness of the slope, the debris has the tendency to fall straight to the toe of the slope. No designated catchment area was observed at the toe. The accumulated debris forms a talus slope at the toe that permits falling debris to roll, or slide away from, the slope towards the path.

Figure 10 Large Sandstone Rock Fall Debris at the North Highwall Toe (view to the West)

In general, competency of the Pit 1 Highwall geologic units is a function of induration (i.e., well lithified). Induration varies by stratigraphic unit on the highwall; the Jackpile sandstone appears fairly well indurated, whereas the Dakota sandstone, while also indurated, exhibits numerous joints and fractures on the pit wall exposures resulting in loose blocks of various sizes. Shale beds in the overlying Mancos formation are poorly lithified and easily erode, whereas the sandstone interbeds in this formation are well indurated. Thus, these sandstones exhibit spalling as erosion of the underlying shales causes overhanging of the sandstone. Spalled sandstone blocks from the Mancos formation can be seen in Figure 6 through Figure 9.

4.2 Erosional Channels

Erosional channels located at the Pit 1 Highwall rim, presumably formed by periods of intense concentrated seasonal rainfall, were observed on the South and West Highwalls. Three major erosional channels were observed and extended back between 125 and 250 feet, from the crest. Figure 11 shows the major erosional channel at the West Highwall. The channel walls of the erosional features were near vertical with a flat channel base, usually consisting of a more competent rock layer, and the channels were typically deeper than they were wide. The channels expanded to widths of approximately 10 to 15 feet and depths of 10 to 20 feet. The vertical channel walls often formed pillars of material with the potential for slumping or toppling mechanisms. The overburden material was loose near the edges of the channels.

Figure 11 Erosional Channel on West Highwall

4.3 Mesa

At the crest of the West Highwall a mesa was located approximately 300 feet toward the west and 50 feet above the crest. The flat-topped elevation is subject to differential erosion and large amounts of loose rock and talus were noted on the base within 100 feet of the West Highwall crest, see Figure 12.

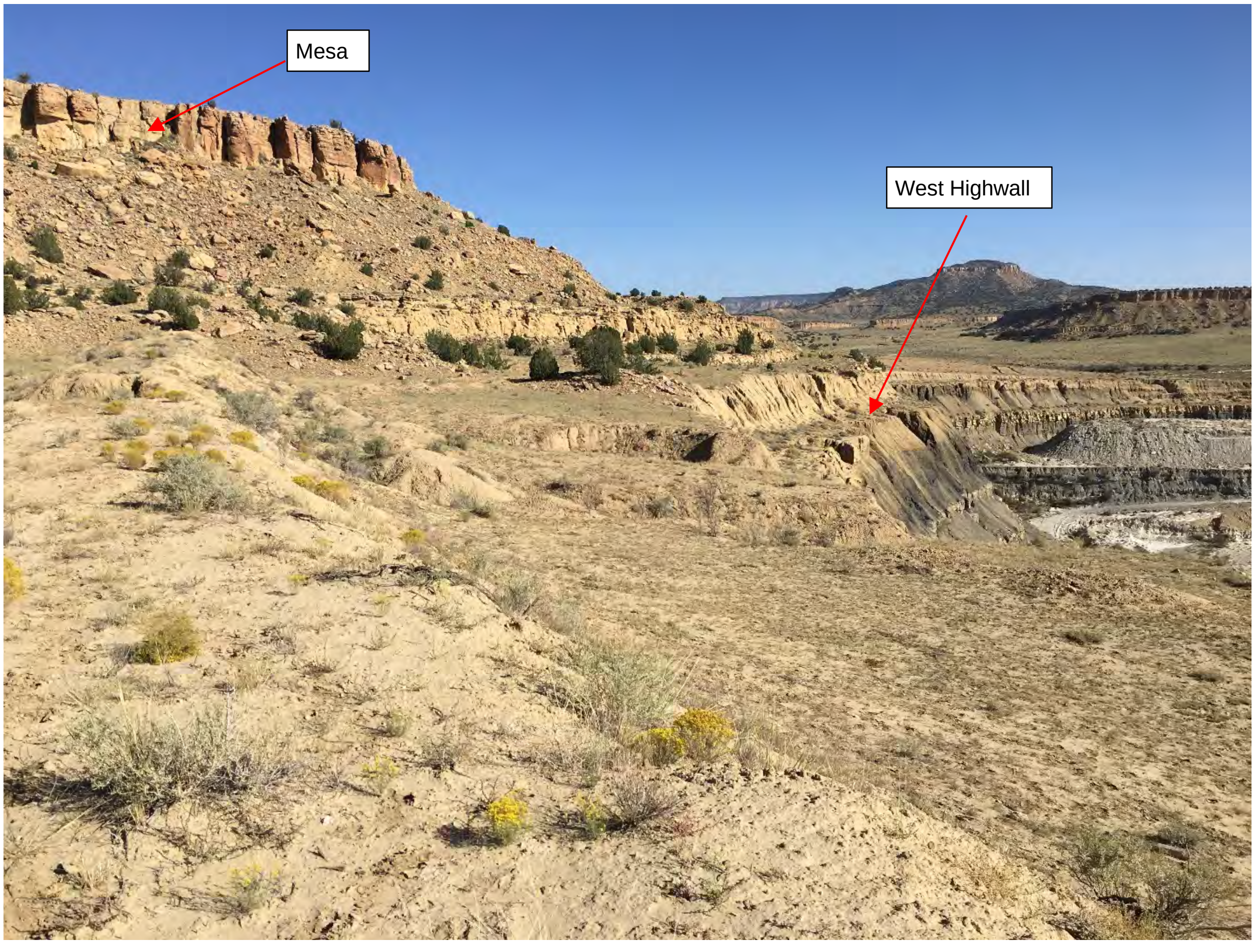


Figure 12 West Highwall Mesa (view to the North)

4.4 Bedrock Conditions

4.4.1 Rock Type

The bedrock encountered at the site consists of greyish-white sandstone of the Jackpile Member of the Morrison Formation which forms the lower portion of the highwall, with the Dakota Formation (sandstone) and the Mancos Formation (shale and sandstone layers) forming the mid to upper portion of the highwall. The sandstone of the Jackpile Member and Dakota Formation at the pit base appear to be competent rock and hold near vertical highwalls. The Jackpile sandstone member appeared relatively massive with observed crossbedding while the Dakota Formation sandstone was more fractured compared to the Jackpile. The Mancos Formation consists of dark grey to black marine shale units with layers of competent sandstone units. The Mancos Formation depicts the greatest amount of differential weathering in the highwall with the shale forming weathered talus piles that undermine the more competent sandstone layers, resulting in the sandstone rockfall observed at the benches and pit bottom.

4.4.2 Generalized Bedrock Stratigraphy

The stratigraphy of the bedrock was estimated using drone photography, LiDAR models and field observations. Multiple topographical cross-sections were extracted from the LiDAR model and photogrammetry models. The approximate thickness and depth of each rock formation is shown in Figure 21 and summarized in Table 1 below. In most areas of the pit, the stratigraphy was difficult to discern due to the rock scree piles on the benches covering the rock faces and the general erosion of the highwall.

Table 1 Approximate Bedrock Stratigraphy

Rock Formation	Elevation Top (Ft)	Elevation Bottom (Ft)	Thickness (Ft)
Overburden	6120*	6105	15
Mancos Shale (upper layer)	6105	6070	35
Interbedded Sandstone in Mancos	6070	6045	25
Mancos Shale (lower layer)	6045	5945	100
Dakota Sandstone	5945	5930	15
Jackpile Sandstone	5930	5850**	80
Slope Height			**270**
Notes: *Average over undulating ground surface near the crest; ** Base of the pit			

4.4.3 Discontinuity Characterization

Field observations indicate that the discontinuity surfaces vary from smooth and planar to rough and planar. The discontinuities were typically clean.

Based on a review of empirical data tables, the suggested range for basic friction angles ϕ for unweathered joint surfaces in Dakota and Jackpile sandstone is 25º to 35º and in Mancos shale is 27º (Barton and Choubey, 1977). Based on this empirical data and Stantec's experience with similar geological conditions, the shear strength along the joints was estimated to be represented by a friction angle ϕ = 27º. For the purpose of kinematic stability analyses, a cohesion c = 0 kPa was assumed for the joints.

4.4.4 Structural Geology Model

A structural geology model typically includes the systematic discontinuity network (including joints and bedding planes) as well as major structures (such as regional faults, folds, etc.). The structural model of the site was used for input to the overall stability analyses, to determine potential failure modes that may result from the relative orientations of the structural features in relation to the orientation of the highwall.

Data collection was limited to areas of exposed outcrop. Surfaces in the exposed sandstone were primarily used to measure structural orientations due to their relative resistance to erosional forces compared to the Mancos shale. In total, the orientation (dip and dip direction) of 179 discontinuities were measured from the ShapeMetrix^{3D} models and field mapping, an example of the structural measurement is shown in red in Figure 13.

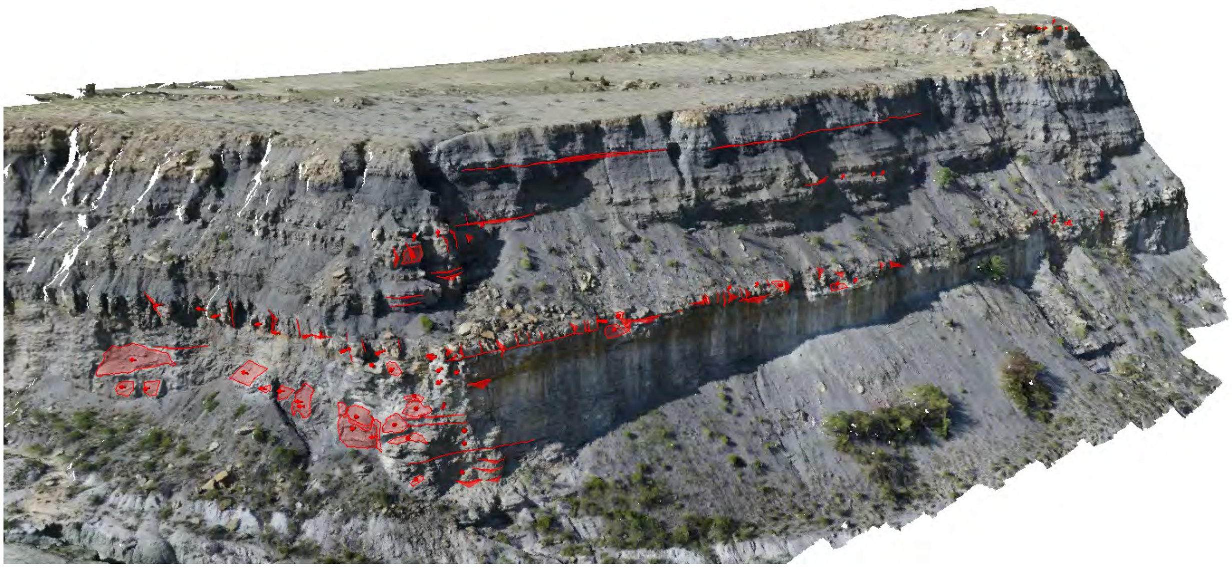


Figure 13 ShapeMetrix Model

Structural information for the site was collected from the photographs processed using the ShapeMetrix3D software (as described in Section 3.3) to develop the structural geology model. The structural data were then plotted in stereographic projection from which prominent data concentrations (indicating joint sets) were identified. These joint sets are summarized in Table 2 below. Stereographic plots of all structural data collected are shown in Figure 14 below.

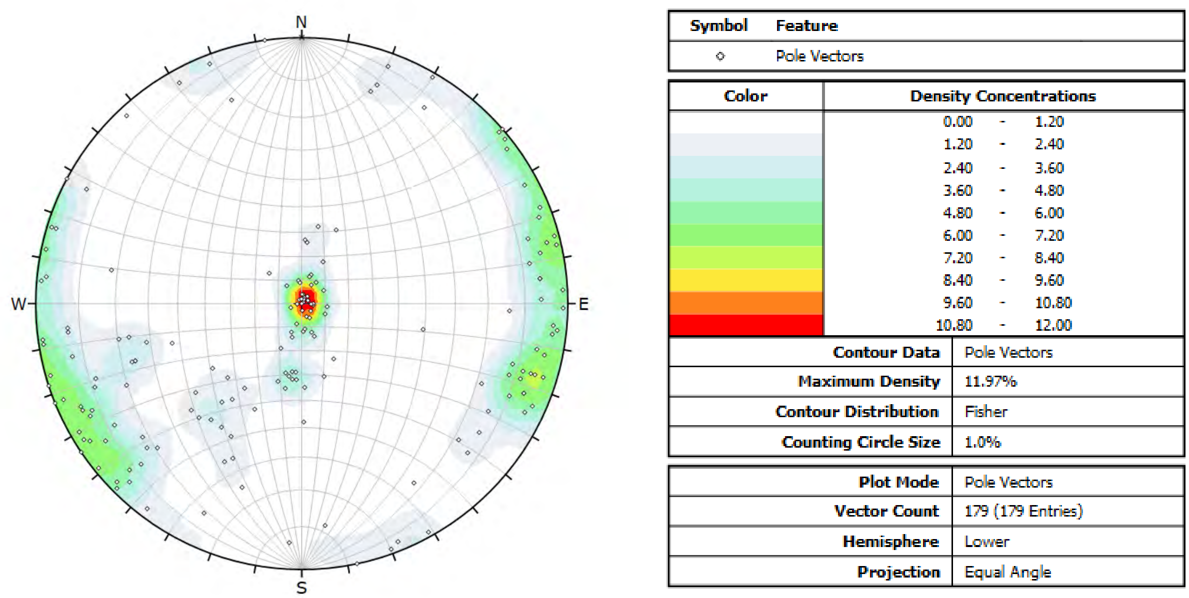
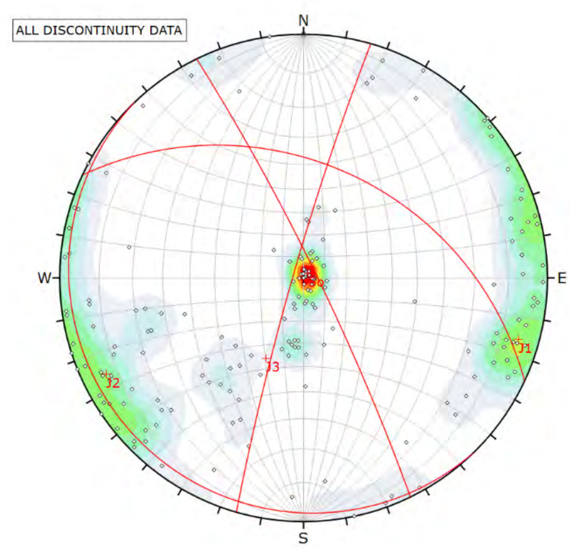


Figure 14 Stereographic plot with discontinuity sets

Table 2 Structural Data Summary

Set	Mean Dip[1,2] [°]	Mean Dip Direction[2] [°]	Description	
So	3 (± 10)	226 (± 10)	Sub-horizontal dipping set; mean dip direction towards SW	
J1	85 (± 20)	286 (± 20)	Steeply dipping set; mean dip direction towards NW	
J2	84 (± 30)	64 (± 30)	Steeply dipping set; mean dip direction towards NE, partly overturned dipping towards SW	
J3	40 (± 30)	25 (± 30)	Shallow dipping set; mean dip direction towards NE.	

[1] The dip angle is measured from the horizontal.

[2] The variability limits were determined based on visual assessment of the stereographic projections.

4.4.5 Rock Mass Shear Strength

The shear strength of a rock mass is a function of the in-situ conditions and how the characteristics of the rock mass relate to the type, distribution, continuity and orientation of discontinuities and the applied normal stresses. The strength characteristics of the rock can be described using friction angle and cohesion strengths that correlate the Hoek-Brown strength criterion in a Mohr-Coulomb relationship in which the shear strength (τ) of the sliding surface is expressed in terms of the cohesion (c) and the friction angle (ϕ). The shear strength developed when an effective normal stress (σ') is acting on a sliding surface is:

$$\tau = c + \sigma' \tan \phi$$

The Geological Strength Index (GSI) for the rock mass encountered at this site has been estimated using the chart provided in Marinos and Hoek (2001), based on geological descriptions. The composition and structure of the rock mass at the site can be described as shale with interbedded sandstone and the surface conditions of the discontinuities are good (rough, slightly weathered) to fair (smooth, moderately weathered and altered surfaces). Based on these descriptions, rock mass values are assigned to each of the three primary rock formations encountered in the Pit 1 Highwall, Mancos Shale, Dakota Sandstone and the Jackpile sandstone.

Using the RocLab^tm^ software from Rocscience, the rock mass parameters for each rock unit at the site are summarized in Table 3. A slope height of 230 feet and unit weight of 155 pcf was used in the analysis to account for the estimated height of the interbedded sandstone and shale unit.

The Hoek-Brown strength criterion is not applicable for anisotropic rock masses such as strength along rock discontinuities. To account for the anisotropic conditions, the Snowden Modified Anisotropic Linear strength model was used to modify the Hoek-criterion for bedding strength and direction.

The Snowden Modified Anisotropic Linear strength model was applied to the Mancos shale unit. The model considers a strength of the bedding planes separate from the rock mass strength. The rock mass strength was determined from parameters in Table 3 and the bedding planes in the Mancos shale were assigned the following parameters:

- Cohesion (c) - 0 MPa
- Friction Angle (ϕ).- 27°

Table 3 Estimated Generalized Hoek-Brown Strength Parameters

Criteria		Parameters	Rock Unit		
			Mancos Shale	**Dakota Sandstone***	**Jackpile Sandstone**
Input Parameters	**Hoek-Brown Classification**	Intact uniaxial compressive strength	40 MPa	100 MPa	175 Mpa
		GSI	35	70	75
		Mi	6	17	17
		Disturbance Factor (D)	0.7	0.7	0.7
		Modulus Ratio (Mr)	200	275	275
		*Elastic Modulus for intact rock (Ei)	8,000 MPa	27,500 MPa	48,125 MPa
Output Parameters	**Hoek-Brown Criterion**	Mb	0.169	3.27	5.665
		S	0.0000811	0.013	0.055
		a	0.52	0.501	0.501
	Mohr-Columb Fit	Cohesion (c)	0.21 MPa	1.75 MPa	5.17 MPa
		Friction Angle (ϕ).	27.7°	55.2°	59.7°
	Rock Mass Parameters	Tensile Strength	-0.019 MPa	-0.396 MPa	-1.702
		Uniaxial Compressive Strength	0.31 MPa	11.3 MPa	41.0 MPa
		Global Strength	2.00 MPa	25.3 MPa	62.9 MPa
		Deformation Modulus	358.4 MPa	9284.41 MPa	22966.3 MPa

Note:
* Interbedded sandstone in Mancos shale assumed to have similar strength parameters as Dakota Sandstone

4.5 Groundwater Conditions

Previous investigation drilling activities conducted in 2004, 2008, and 2012 showed that the Jackpile sandstone unit is the first water-bearing unit beneath the ground surface in the immediate vicinity of Pit 1. Comprising a relatively well-lithified, medium- to coarse-grained, arkosic sandstone, the Jackpile sandstone has a relatively low hydraulic conductivity (0.005 to 0.9 foot/day) and, where saturated, generally has low yields of groundwater. During the Site visit, an immeasurable amount of seepage was observed at the Jackpile and Dakota contact, in the pit bottom on the wall near the northwest corner of the pit (see Figure 16 in Section 5.1.3).

Other studies in the St. Anthony area indicate that there are discontinuous water-bearing zones in the Mancos Shale and Dakota Sandstone units (INTERA, 2006). Groundwater was not observed in these units during the Site visit.

4.6 Seismic Design Considerations

The USGS Unified Hazard Tool (https://earthquake.usgs.gov/hazards/interactive/) was used to evaluate the seismic hazard for an Annual Exceedance Probability (AEP) of 1×10^{-4} using the 2014 Revision of

Time-Independent Probabilistic Seismic Hazard Maps for the United States. The peak ground acceleration (PGA) for an AEP of $1x10^{-4}$ is approximately 0.27 g, assuming a generic site condition of 760 m/s. The hazard curves from the USGS Unified Hazard Tool are provided in Figure 15.

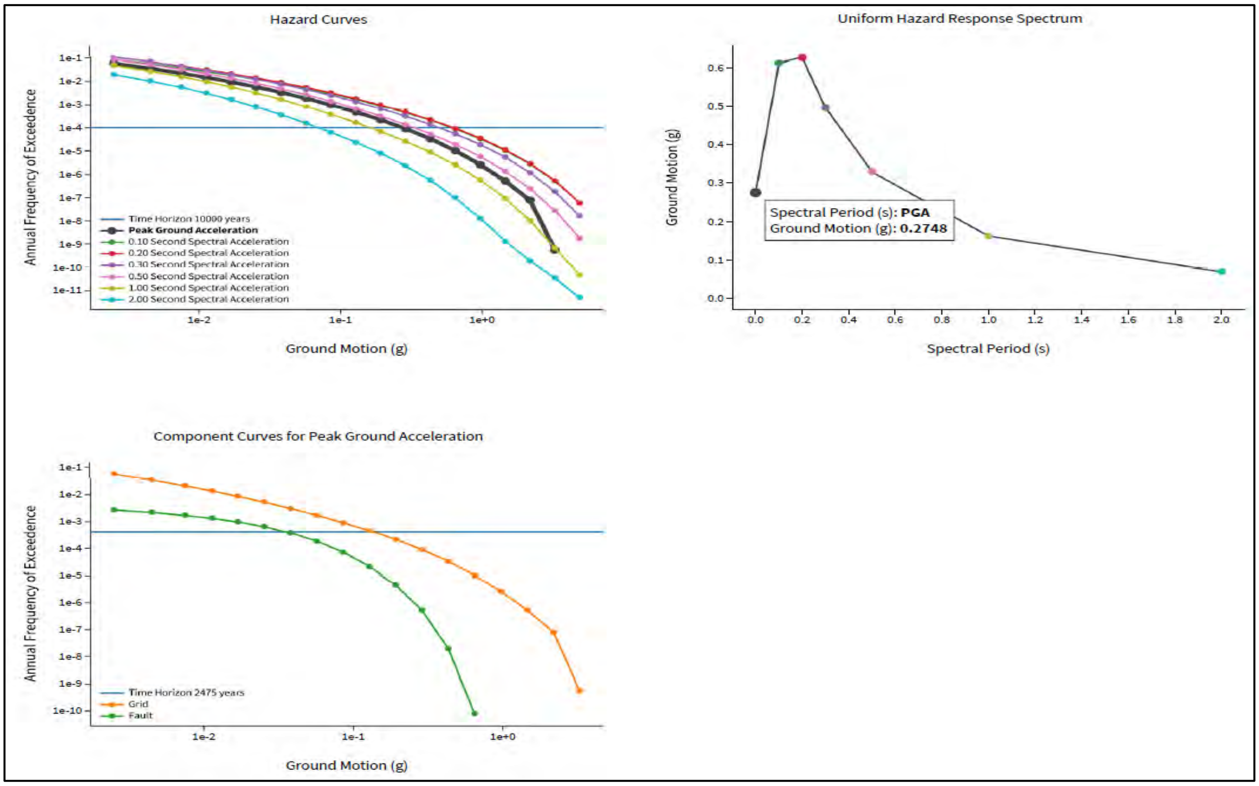


Figure 15 Hazard Curves from the USGS Unified Hazard Tool for the PGA

5.0 PRELIMINARY SLOPE STABILITY ASSESSMENT

Rock slope instabilities that result in the detachment and fall of individual rock blocks or a rock mass can be categorized in two predominant failure modes: structurally controlled failures or environmentally controlled failures. Structurally controlled failures are controlled by discontinuities within the rock mass, such as joints or bedding planes. Environmentally controlled failures are controlled by weathering and erosion processes.

The three basic mechanisms of structurally controlled failure in rock slopes are planar, wedge, and toppling failures. In addition, circular sliding may also be considered a structurally controlled failure. Although a typical failure mechanism in soil, circular failure of a rock mass might occur in highly weathered or highly fractured rock, or in low strength material and could be considered environmentally controlled. Additional environmentally controlled failures types include differential erosion and raveling. For this assessment, Stantec has included circular failures as environmentally controlled failures.

5.1 Factors of Influence

Based on the visual inspection, the stability of the Pit 1 Highwall is mainly governed by the structure and the characteristics of the rock mass and by weathering processes acting on the rock.

5.1.1 Rock Mass Structure

Rock mass structure refers to the nature and occurrence of discontinuities within a rock mass. Discontinuities refer to all fractures occurring naturally within the rock mass, including joints, bedding planes, faults, etc.; they represent weakness planes, which can reduce the effective rock mass strength as they increase in length (persistence) and frequency (decrease in spacing). The size and shape of blocks within the rock mass is governed by the spacing, orientation and persistence of the discontinuities. Wall roughness, aperture size, infilling materials, and water conditions define the nature of the discontinuities and control the shear resistance along the discontinuity.

The discontinuities observed include near-horizontal bedding planes as well as inclined joints. In general, the near-horizontal beddings and inclined joints promote sliding failures and toppling. Evidence was observed that indicated large-scale failures have occurred in the past.

5.1.2 Freeze-Thaw Cycles

Open fractures in the rock mass are exposed to freezing and subsequent ice jacking during cold periods due to the presence of water in the fractures. The volume increase that occurs when water turns to ice causes a ‘jacking’ force within the fracture which further widens the fracture. Over time, this force may lead to instability of rock blocks through progressively jacking them apart and may eventually result in failures. Intact rock susceptible to frost action might flake and crumble in response to freeze-thaw cycles.

Stantec understands that the environment at the site is generally hot and dry but freezing conditions are common during the winter months. Open fractures were observed on the rock face that are susceptible to freeze-thaw processes.

5.1.3 Weathering

Weathering refers to the process of breaking down of rock through environmental factors such as water, temperature, etc. Potential weathering processes include physical (mechanical), chemical or biological processes. Possible weathering processes identified at the Site include water and vegetation impacts.

5.1.3.1 Water

Water plays a significant role in rock slope stability and most instability mechanisms are aggravated by the presence of water, such as causing erosion or increasing the potential for sliding failures. During the Site visit, water originating from the following sources was observed:

- Groundwater: The Jackpile Unit is the first groundwater-bearing unit in the immediate vicinity of Pit 1. It is assumed that groundwater levels in the rock mass will be seasonably variable. During the Site inspection and drone imagery review, an area of seepage from lower sandstone bedding planes (near the transition from Dakota to Jackpile Units) was observed in the form of moisture forming on the slope face, as shown on Figure 16. However, this seepage is likely not continuous throughout the year.
- Surface Water: Evidence of surface water runoff was noted in the form of erosional channels along the crest on the Pit 1 Highwall.

Figure 16 Water Seepage - Lower Sandstone Rock (Jackpile and Dakota Units)

5.2 Potential Failure Mechanisms

<u>Structural Controlled Failures</u>

Structurally controlled failure in rock occurs as the result of movement along discontinuities (such as joints and bedding planes). The presence of a discontinuity itself does not result in failure, but rather provides a plane of weakness which may contribute to failures in the rock face. The three basic mechanisms of structurally controlled failure in rock slopes are illustrated in Figure 17.

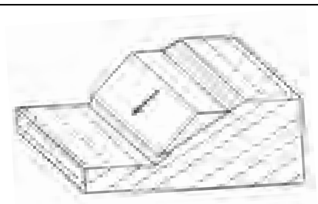
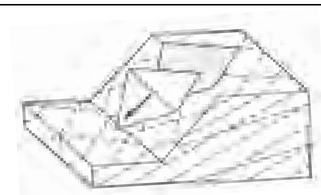
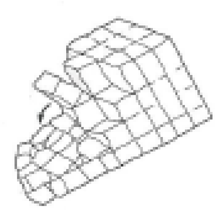
		
A) Planar Failure	B) Wedge Failure	C) Toppling Failure

Figure 17 Basic structurally controlled Slope Failure Modes (after Wyllie and Mah, 2018)

Planar failure describes the sliding of rock blocks on inclined discontinuities; it can occur when a geological discontinuity dips out of a rock slope at an angle that is shallower than the inclination of the rock face and steeper than the effective angle of friction along the discontinuity. Planar failures will develop to a significant extent only if the dip direction of the discontinuity is approximately within ±20° of the dip direction of the slope face.

Wedge failure describes the sliding of a rock block along two intersecting discontinuities; it can occur when two or more discontinuities intersect to form a wedge. For a wedge to fail, the line of intersection of the wedge must dip out of the slope at an inclination that is shallower than the inclination of the slope face, but steeper than the effective angle of friction along the discontinuities. Wedge failures will only develop to a significant extent if the azimuth of the line of intersection is within ±45° of the dip direction of the slope face.

Toppling describes the rotational fall of rock blocks from a steep rock surface. Toppling failure may develop when a rock mass contains multiple, parallel, steeply dipping continuous geologic structures, such as continuous joints/foliation planes, that strike nearly parallel to the strike of the face of the rock slope. Toppling failure will generally only develop when the strike of the structures is approximately within ±20° of the azimuth of the slope face.

<u>Environmentally Controlled Failures</u>

Potential environmentally controlled failure mechanisms include differential erosion, raveling and shallow circular failure in weathered rock as illustrated in Figure 18.

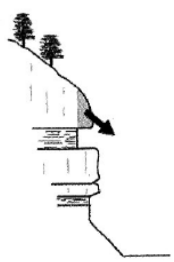
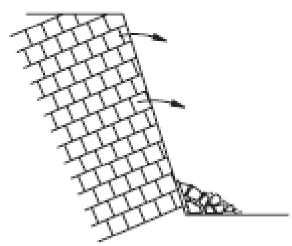
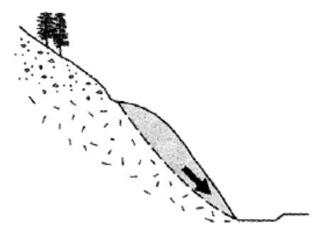
		
A) Differential Erosion	B) Raveling	C) Shallow Circular Failure in Weak Rock

Figure 18 Basic Environmentally Controlled Slope Failures (after Wyllie and Mah, 2018)

Differential erosion occurs when weathering of adjacent horizontal beds occurs at various intensities resulting in an uneven slope face where the more resistant material protrudes above the softer less resistant bed. This is typical for interbedded shale and sandstone stratigraphy where the shale erodes faster than the more resistant sandstone resulting in an overhanging sandstone layer.

Raveling describes the progressive loosening and eventual fall of individual rock blocks from the rock face.

Shallow circular failure occurs where the surficial layer of weak rock fails through the rock mass.

5.3 Kinematic Analysis

A kinematic analysis was performed to evaluate the potential for structurally controlled slope failures using the structural information gathered from the site investigation.

The kinematic analysis was carried out using the software Dips 7.0 from Rocscience to evaluate the potential for planar, wedge and toppling failure modes using stereographic projections. The results of the kinematic analysis are presented in Appendix A and are further discussed in the following sections.

The kinematic analyses have been completed using the following assumptions and guiding principles.

- In practice, it has been observed that planar failure tends to occur only if the dip direction of a plane is within a certain angular range of the slope face dip direction (Wyllie and Mah, 2018). Typically, a value of 20 to 30 degrees is used based on empirical observations. For the planar failure analysis, a lateral limit of ± 20º has been used (i.e., the dip direction of the planar discontinuity must be within 20º of the dip direction of the slope face).
- For planar sliding on a single plane, a release mechanism (e.g., lateral joints, tension cracks or other mechanism) must exist to enable sliding of a block or rock mass on a single plane to occur. For the analysis, it is assumed that release planes exist which allow a planar failure to occur; however, these release planes are not explicitly modeled in the kinematic analysis.
- The probability of failure is based on an estimate of the percentages of poles or intersections within a failure region on the stereographic projections as determined by the Dips software.
- The overall inclination and azimuths of all highwall slopes were estimated from LiDAR and photogrammetry models. The inclination of the bench faces was assumed to be 72° from the horizontal and the following azimuths were assumed:
  - West Highwall - 100°
  - South Highwall - 355°
  - North Highwall - 205°
- The shear strength along the discontinuities was assumed to be represented by a friction angle of 27º and a cohesion of 0 kPa.

5.3.1 Results of Kinematic Analysis

Structurally controlled failure is a function of the discontinuities that dissect a rock mass and the orientation of the slope. The kinematic analysis was divided into three general highwall orientations, the West, South and North Highwalls, as illustrated in Figure 2. The results of the kinematic analyses are summarized in Table 4 and the associated stereoplots are presented in Appendix A.

Table 4 Kinematic Analysis Results

Area	Probability of Failure		
	Planar Sliding	**Flexural Toppling**	**Wedge Sliding**
West Highwall	34% of poles in Set J3	2% of all poles	22% of all intersections
South Highwall	3% of poles in Set J1	69% of poles in Set J1	7% of all intersections
North Highwall	1% of all poles	31% of all poles	5% of all intersections

The percentages give an estimate of probability of failure with respect to all the discontinuities mapped for the site. The percentage is for all discontinuities or for sets of discontinuities, identified above in Table 2.

The results of the kinematic analysis using the stereographic projections are summarized by the following points:

- There is potential for planar failures along the inclined discontinuities, namely set J3 on the west highwall. Refer to Figure KIN-1.
- The analysis also indicates a potential for toppling failures, namely set J1 on the south highwall. The results of the flexural toppling analysis are presented in KIN-5.
- There is potential for wedge failures controlled by intersections of discontinuities J1 with J2 and J1 with J2. The mean set intersection is on the perimeter of the critical zone, refer to Figures KIN-3.

The most predominant structurally controlled failure mode observed in the pit is planar and toppling type failures as supported by the kinematic analysis. The predominant failure modes will be used in Phase 2 for evaluating mitigation measures for rockfall hazards.

5.4 Current Rockfall Hazards

The primary rockfall hazard identified at the Site appear to be failures that are attributed to localized undermining of sandstone layers within the Mancos shale unit. The differential erosion of the slope face appears to be environmental controlled by erosional forces. Figures and 19 are example of the sandstone layer being undermined resulting in a rock fall event.

Figure 19 West Highwall Differential Erosion

Continual raveling of the slope will occur along the highwall crest where blocks of rock are dislodged by periods of seasonal intense rainfall, or root growth. The presence of water on the slope also indicates that freeze-thaw cycles during the colder months may also contribute to the dislodgement and failure of blocks along the slope.

The size of falling rock material is largely controlled by the bedding thickness and discontinuity spacing of the sandstone. The bedding thickness appears to vary between 5 to 25 feet resulting in failure of mostly gravel size material to large blocks up to 16 feet in largest dimension.

The large amount of loose rock on the slope faces and the ongoing weathering of the rock result in a high probability of rockfall in the pit area.

Figure 20 North Highwall Differential Erosion

Bench scale, shallow, circular failures are present throughout the site. These failures can also contribute to progressive large-scale failure and increased raveling. An example of a shallow circular bench scale failure is shown in Figure 8.

5.5 Potential Instabilities Involving Major Structures

No major structural features, such as fault zones, were noted during the site inspection and review of the drone photos or LiDAR model. Therefore, large-scale failures involving major structures appear to be unlikely based on the structural interpretation. However, a subsurface investigation was not completed as part of this assessment to identify any potentially continuous structures that may affect the global stability of the rock slope.

5.6 Global Stability Review

Global stability analysis involves the failure of the rock mass and not along existing sliding discontinuities. Rock mass failure can occur on different scales within the highwall, such as single bench, multiple benches or the entire highwall. The purpose of this global stability analysis was to estimate the highwall stability using estimates of rock strength to help guide decisions for further site investigations.

The analysis was completed using a limited equilibrium method software Slide2 by RocScience and the rock mass was characterized using the Hoek-Brown strength criterion and the Snowden Anisotropic Strength Modeling. Rock mass strength was determined based on background data, field observation and experience. The stratigraphy was estimated using photogrammetry models and site photographs. The profile was extracted from LiDAR survey at the intersection of the south and west highwall. The rock mass strength parameters selected as input parameter in the analysis software RocLab 5.0 by RocScience to determine the strength envelopes based on the Morgenstern-Price method.

The preliminary results of the global stability analysis show an estimated Factor of Safety (FoS) against pit scale circular to 1.04, an example analysis is shown in Figure 21. Small bench scale shallow circular failures (FoS > 1) were modelled near the crest of the slope. The pit scale failures occurred in the in the Mancos shale unit which is in the interbedded sandstone. Because there are no critical structures in the vicinity of Pit 1, a FoS of 1.3 is considered to be an acceptable long-term static factor of safety for Pit 1, based on industry standards.

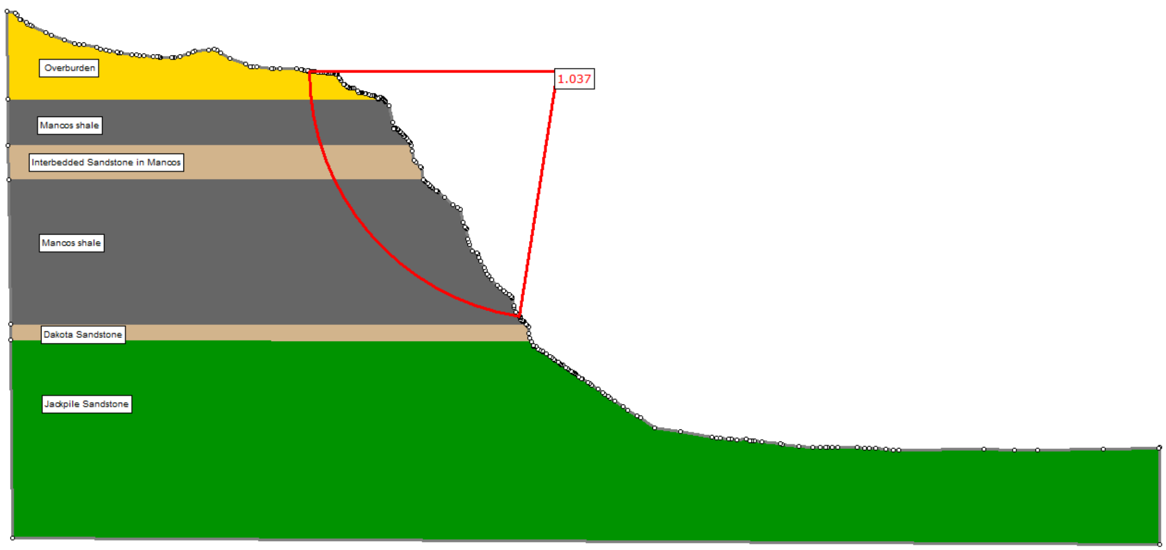


Figure 21 Preliminary Global Stability Model

A sensitivity analysis was completed by varying the unconfined compressive strength (UCS) and the Geological Strength Index (GSI) parameters in the Mancos shale. Results of the sensitivity analysis, presented in Table 5, show the range of FoS for pit pit-scale failure. Pit-scale failures were assumed to have a minimum depth of 30 ft.

Table 5 Global Stability Sensitivity Analysis – FoS of Pit Scale Failure

		Unconfined Compressive Strength (UCS) (MPa)				
		20	**40***	50	60	80
Geological Strength Index (GSI)	25	0.52	0.79	0.85	0.90	1.05
	35*	0.82	**1.04***	1.11	1.18	1.27
	45	1.03	1.27	1.37	1.45	1.58

Notes:
***** Indicates the estimated parameters selected for the pit slope

Multiple bench failures were contained within the Mancos shale and overburden unit and did not extend into the Dakota Sandstone or Jackpile Sandstone. Failure was typically estimated to range from 25 to 75 feet back from the crest of the slope, and therefore the estimated volume of material for a circular failure is variable. As modelled, the overall stability is marginal, however the disturbance factor (D) estimated in Table 3 may mean the FoS values presented in Table 5 are underestimated.

6.0 DISCUSSION

Based on the investigation results, rockfall hazards were identified along the highwall, primarily in the Mancos shale units with the interbedded sandstone layers. Therefore, the Mancos shale unit will be the primary focus of future remedial actions along the highwall. These hazards should be assessed and addressed, particularly in work zones, to prevent potential injuries during remedial work due to rockfalls from the highwall. Rockfalls from the vertical faces and from the benches above are structurally controlled (controlled by the discontinuities in the rock mass) or caused by raveling and differential erosion because of weathering processes acting on the rock.

The structural data collected at the site indicates that three major discontinuity sets contribute to the observed instabilities. These discontinuities provide the release and sliding surfaces required for rockfall failures to occur. The intersecting discontinuities produced rock blocks with the potential to fail as individual blocks or as groups of blocks. The block sizes range from 1 to 16 feet in diameter due to the sandstone bedding thickness and discontinuity spacing between the near vertical joints.

Raveling and differential erosion are the environmentally controlled failure modes observed throughout the site. The results of the kinematic analysis presented herein supports the conclusion that the most likely structurally controlled failure mode at the site is toppling failure and sliding along inclined discontinuities. These failures will most likely be advanced or accelerated by environmental impacts such as the presence of water and freeze-thaw actions.

The ongoing weathering and erosion of the slope as well as the potential for structurally controlled failures will continue to create rockfall hazards in the areas along the slope toes and will result in further recession of the slope face over time. Although rockfalls from the highwall have currently no immediate impact on the stability, the continuing recession of the slopes might potentially impact the proposed surface water channels around the top of the pit or proposed water channels at the base of the pit area in the longer term (Barton and Choubey, 1977). As scree accumulates at the toe of the highwalls the rockfall distribution, trajectory, and general pattern of rockfalls may change.

The remediation of the slope should address both the rockfall hazards that impact the general area along the slope toe and pose a risk for the public or temporary construction workers, as well as the potential impacts of slope erosion and recession on the long-term closure requirements. Potential remediation options for the highwalls will be evaluated by Stantec following the completion of the second phase of study.

7.0 RECOMMENDATIONS FOR PHASE 2

Based on the information collected from Phase 1 of the project Stantec recommends the following for Phase 2:

- Detailed rock fall modeling, to effectively design the hazard avoidance or hazard protection solutions. Modeling will involve simulating rock falls from various locations and height along the highwall and calculating the trajectories and impact forces expect. This will include calibration modeling to review current conditions as well as forward modeling for the current slope trajectory and as the trajectory may change once the benches accumulate additional scree. The rock fall modeling will allow for design of rockfall mitigation measures and avoidance zones in the pit bottom to be incorporated with the proposed design for the Pit 1 cover.
- A subsurface borehole investigation and laboratory testing program to better define the highwall bedrock stratigraphy and bedrock properties assumed in the global stability analysis. The boreholes are necessary to collect physical samples of the rock and verify the rock strengths in the profile for the slope stability models. Information collected during the borehole and laboratory program will be used to refine the parameters in the global stability analysis and reduce uncertainty and assumptions within the modeling. The following scope of work is recommended for the Phase 2 borehole investigation:
  - Approximately 3 to 4 boreholes evenly distributed along the Pit 1 Highwall crest to depths of approximately 30 feet below the pit bottom. One or two of the boreholes should be angled from the vertical to avoid bias when collecting discontinuity data, Detailed core logging is required to describe and evaluate the onsite lithology and select samples for additional laboratory testing (rock strength and characterization).
  - Acoustic and optical downhole televiewer is recommended in 2 or 3 boreholes to evaluate the discontinuity spacing and orientation.

8.0 REFERENCES

Stantec, 2020. St. Anthony Mine Site Closure-Closeout Plan Draft Preliminary 30% Report. August 17.

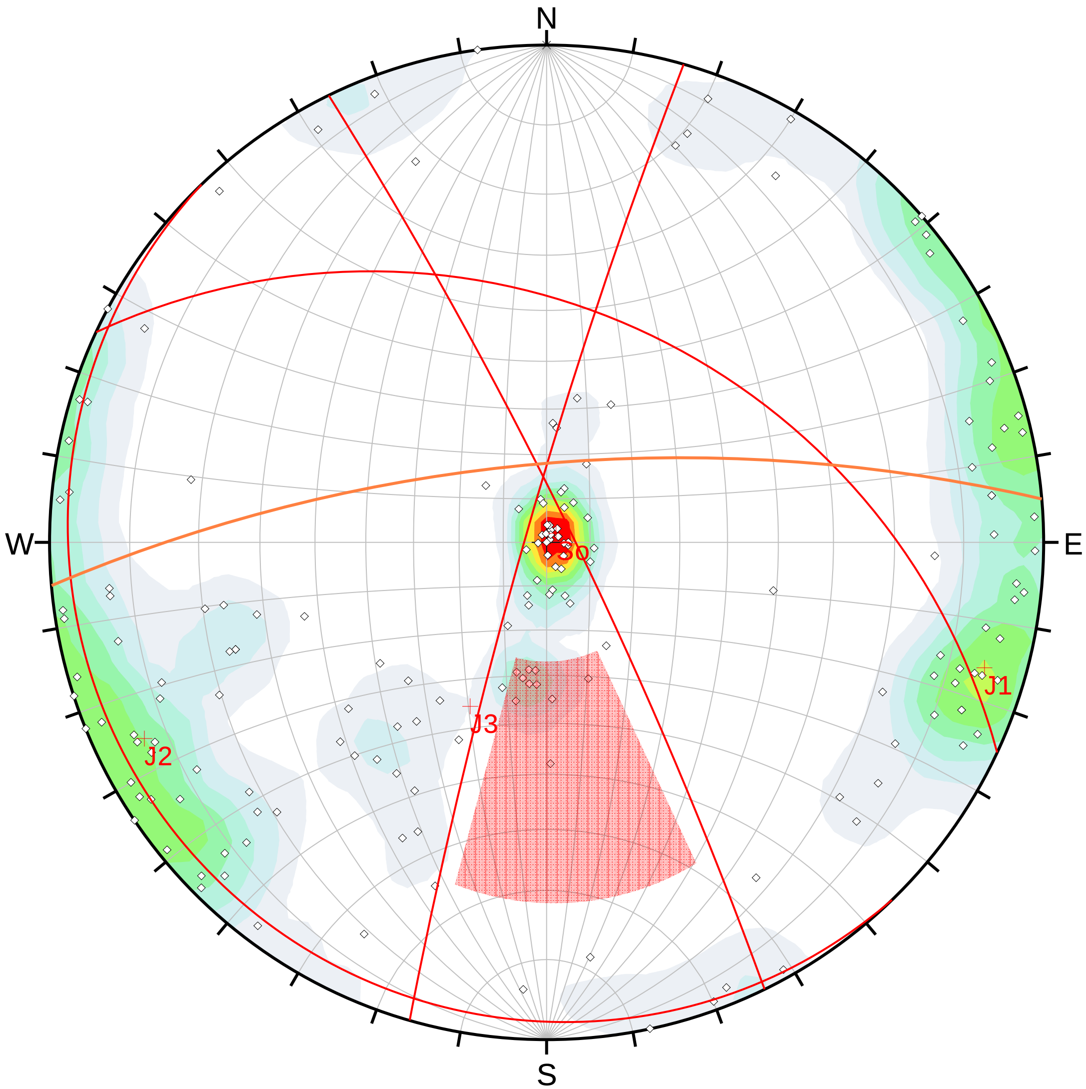
Barton, N. and Choubey, V. 1977. The Shear Strength of Rock Joints in Theory and Practice. *Rock Mech*. 10: 1-54.

Marinos, P. and Hoek, E. 2001. Estimating the geotechnical properties of heterogeneous rock masses such as flysch. Bull. Engg. Geol. Env. (IAEG), 60, 85-92.

Wyllie, D.C. and Mah, C.W. 2018. Rock Slope Engineering. Civil and Mining. 5th edition. Spon Press.

APPENDIX A

Kinematic Analysis



Symbol	Feature
◇	Pole Vectors

Color	Density Concentrations
	0.00 - 1.20
	1.20 - 2.40
	2.40 - 3.60
	3.60 - 4.80
	4.80 - 6.00
	6.00 - 7.20
	7.20 - 8.40
	8.40 - 9.60
	9.60 - 10.80
	10.80 - 12.00

Contour Data	Pole Vectors
Maximum Density	11.97%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Planar Sliding
Slope Dip	72
Slope Dip Direction	355
Friction Angle	27°
Lateral Limits	20°

	Critical	Total	%
Planar Sliding (All)	10	179	5.59%
Planar Sliding (Set 5: J3)	10	29	34.48%

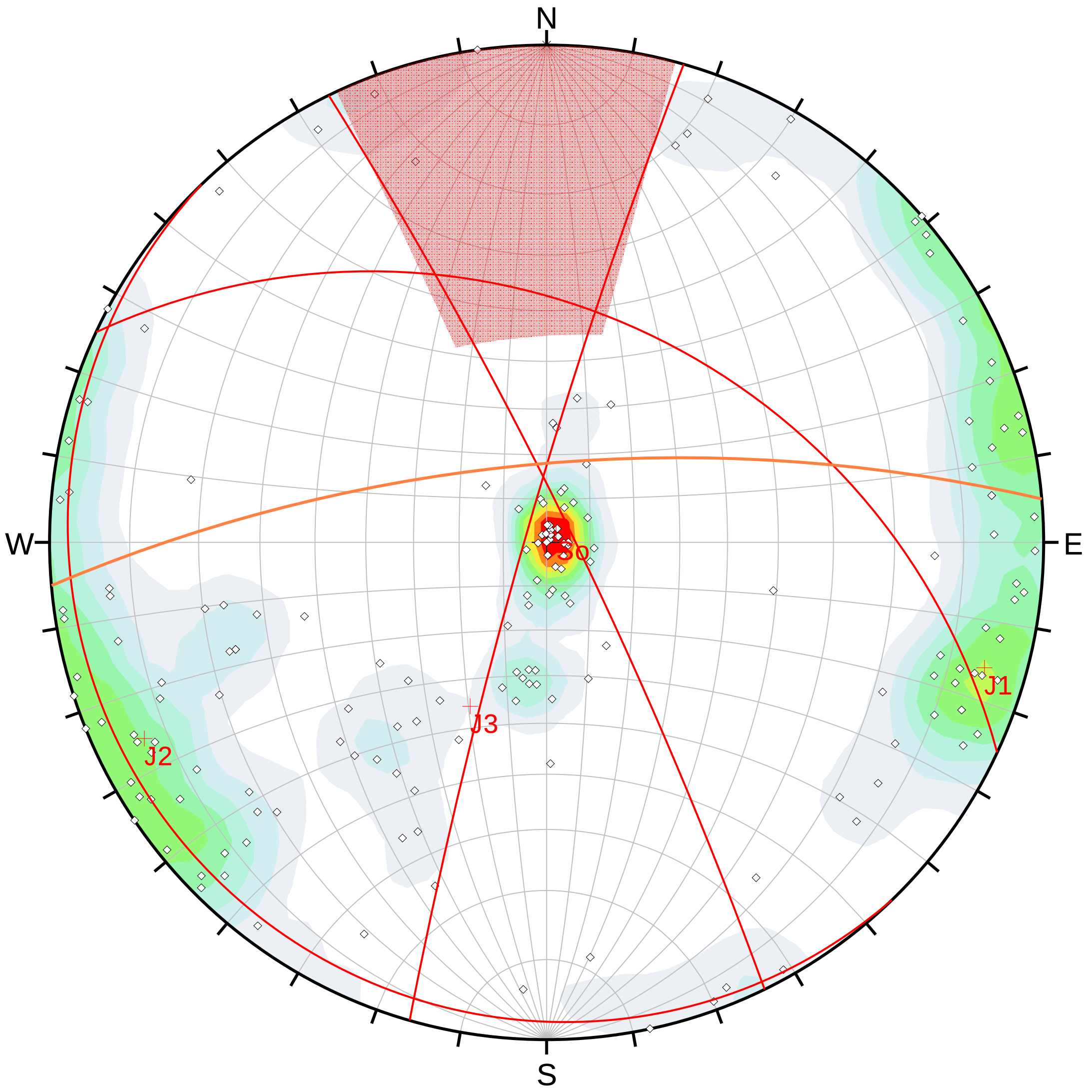
	Color	Dip	Dip Direction	Label
Mean Set Planes				
2m		3	226	So
3m		85	286	J1
4m		84	64	J2
5m		40	25	J3

Plot Mode	Pole Vectors
Vector Count	179 (179 Entries)
Hemisphere	Lower
Projection	Equal Angle

Stantec

DIPS 7.018

Project	St. Anthony Mine - Pit 1 Highwall
Analysis Description	South Highwall - Planar Sliding
Drawn By	J.Nichols
Company	Stantec
Date	2020-10-29
Figure	KIN-1



Symbol	Feature
◇	Pole Vectors

Color	Density Concentrations
	0.00 - 1.20
	1.20 - 2.40
	2.40 - 3.60
	3.60 - 4.80
	4.80 - 6.00
	6.00 - 7.20
	7.20 - 8.40
	8.40 - 9.60
	9.60 - 10.80
	10.80 - 12.00

Contour Data	Pole Vectors
Maximum Density	11.97%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Flexural Toppling		
Slope Dip	72		
Slope Dip Direction	355		
Friction Angle	27°		
Lateral Limits	20°		
	Critical	Total	%
Flexural Toppling (All)	3	179	1.68%

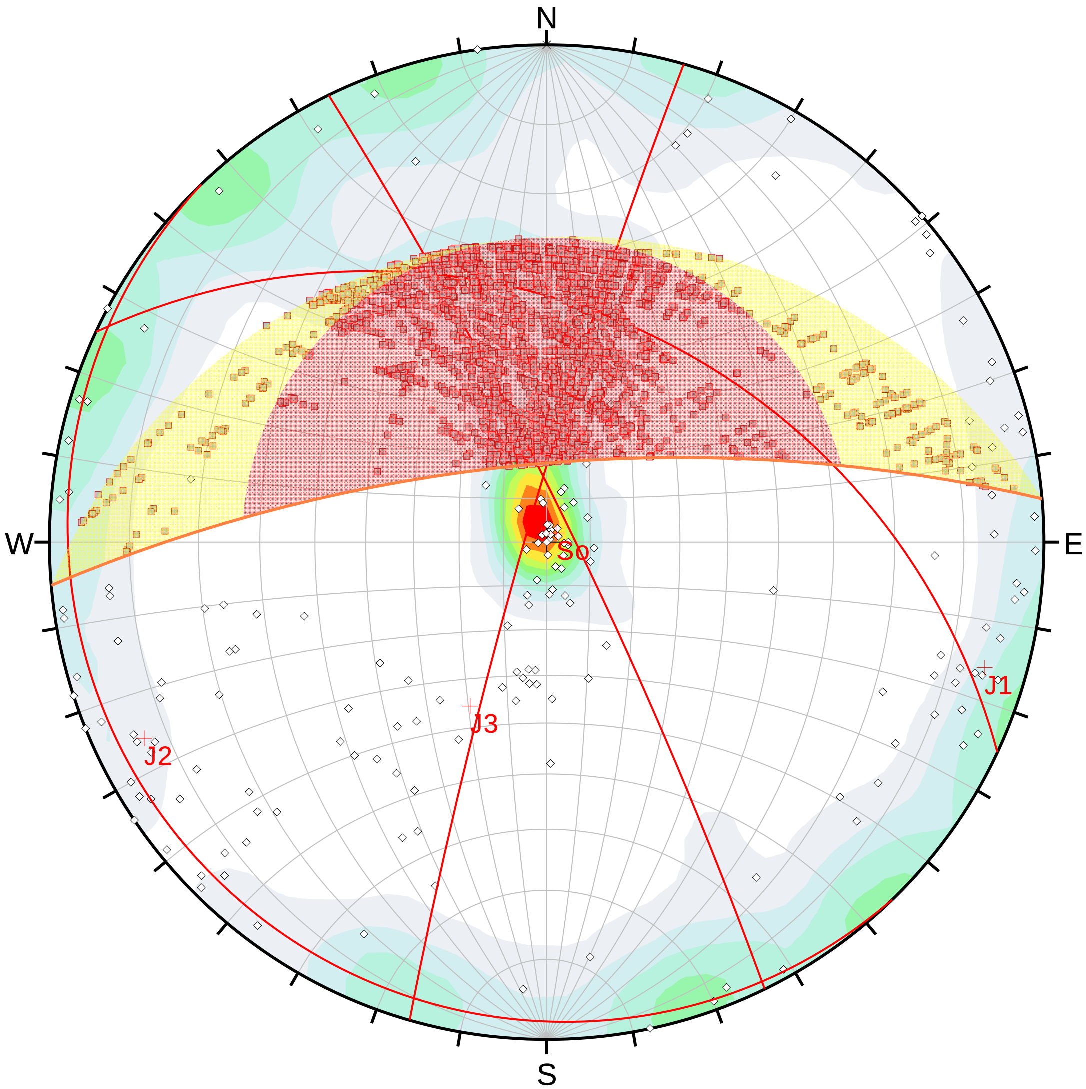
	Color	Dip	Dip Direction	Label
Mean Set Planes				
2m		3	226	So
3m		85	286	J1
4m		84	64	J2
5m		40	25	J3

Plot Mode	Pole Vectors
Vector Count	179 (179 Entries)
Hemisphere	Lower
Projection	Equal Angle

Stantec

Project St. Anthony Mine - Pit 1 Highwall	
Analysis Description South Highwall - Flexual Toppling	
Drawn By J.Nichols	*Company* Stantec
Date 2020-10-29	*Figure* KIN-2

DIPS 7.018



Symbol	Feature
◇	Pole Vectors
▫	Critical Intersection

Color	Density Concentrations
	0.00 - 0.90
	0.90 - 1.80
	1.80 - 2.70
	2.70 - 3.60
	3.60 - 4.50
	4.50 - 5.40
	5.40 - 6.30
	6.30 - 7.20
	7.20 - 8.10
	8.10 - 9.00

Contour Data	Intersections
Maximum Density	8.94%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Wedge Sliding
Slope Dip	72
Slope Dip Direction	355
Friction Angle	27°

	Critical	Total	%
Wedge Sliding	3500	15927	21.98%

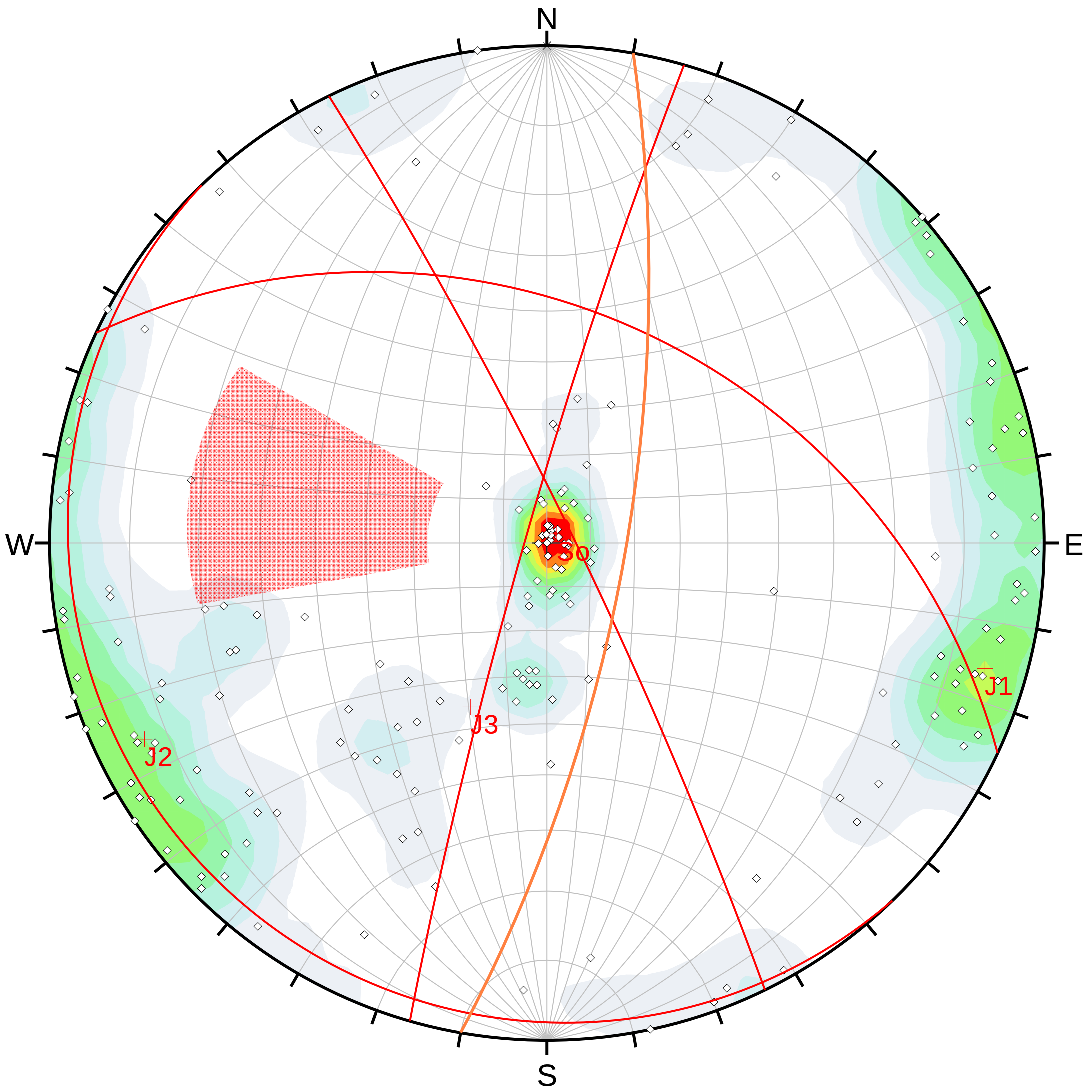
	Color	Dip	Dip Direction	Label
Mean Set Planes				
2m		3	226	So
3m		85	286	J1
4m		84	64	J2
5m		40	25	J3

Plot Mode	Pole Vectors
Vector Count	179 (179 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	15927
Hemisphere	Lower
Projection	Equal Angle

Stantec

Project	St. Anthony Mine - Pit 1 Highwall
Analysis Description	South Highwall - Wedge Sliding
Drawn By	J.Nichols
Company	Stantec
Date	2020-10-29
Figure	KIN-3

DIPS 7.018



Symbol	Feature
◇	Pole Vectors

Color	Density Concentrations
	0.00 - 1.20
	1.20 - 2.40
	2.40 - 3.60
	3.60 - 4.80
	4.80 - 6.00
	6.00 - 7.20
	7.20 - 8.40
	8.40 - 9.60
	9.60 - 10.80
	10.80 - 12.00

Contour Data	Pole Vectors
Maximum Density	11.97%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Planar Sliding
Slope Dip	72
Slope Dip Direction	100
Friction Angle	27°
Lateral Limits	20°

	Critical	Total	%
Planar Sliding (All)	1	179	0.56%
Planar Sliding (Set 3: J1)	1	36	2.78%

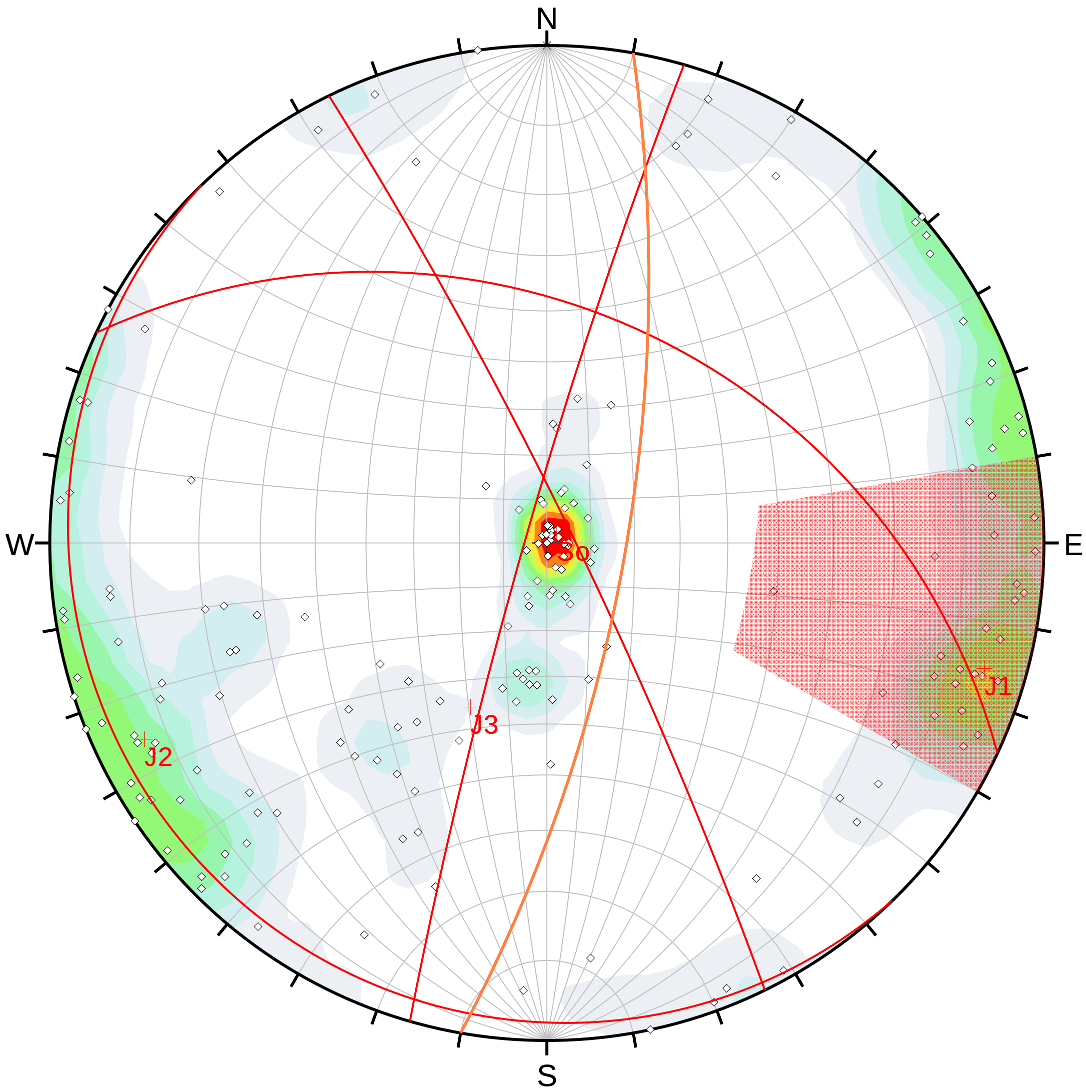
	Color	Dip	Dip Direction	Label
Mean Set Planes				
2m		3	226	So
3m		85	286	J1
4m		84	64	J2
5m		40	25	J3

Plot Mode	Pole Vectors
Vector Count	179 (179 Entries)
Hemisphere	Lower
Projection	Equal Angle

Stantec

DIPS 7.018

Project	St. Anthony Mine - Pit 1 Highwall
Analysis Description	West Highwall - Planar Sliding
Drawn By	J.Nichols
Company	Stantec
Date	2020-10-29
Figure	KIN-4



Symbol	Feature
◇	Pole Vectors

Color	Density Concentrations
	0.00 - 1.20
	1.20 - 2.40
	2.40 - 3.60
	3.60 - 4.80
	4.80 - 6.00
	6.00 - 7.20
	7.20 - 8.40
	8.40 - 9.60
	9.60 - 10.80
	10.80 - 12.00

Contour Data	Pole Vectors
Maximum Density	11.97%
Contour Distribution	Fisher
Counting Circle Size	1.0%

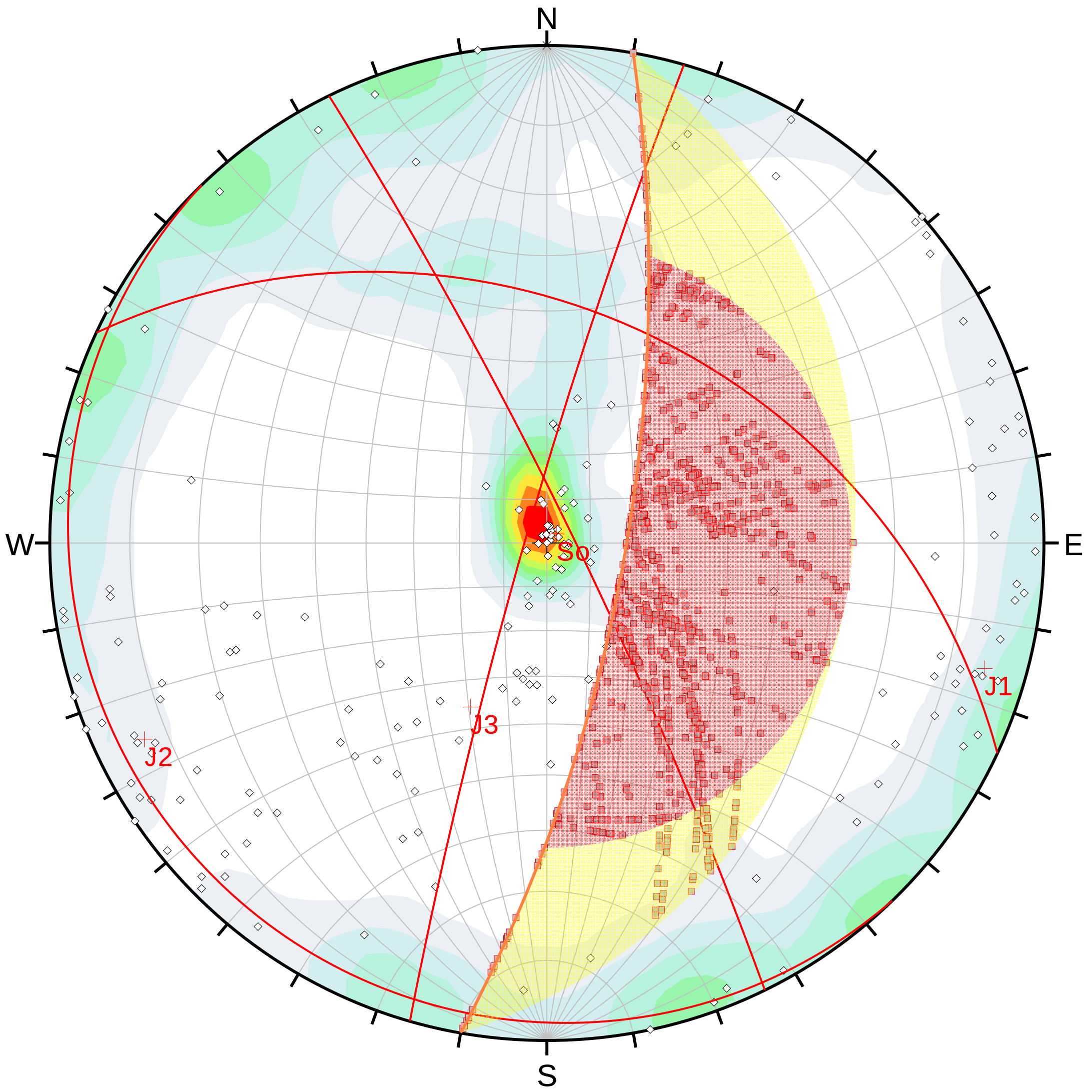
Kinematic Analysis	Flexural Toppling
Slope Dip	72
Slope Dip Direction	100
Friction Angle	27°
Lateral Limits	20°

	Critical	Total	%
Flexural Toppling (All)	27	179	15.08%
Flexural Toppling (Set 3: J1)	25	36	69.44%
Flexural Toppling (Set 4: J2)	1	51	1.96%

	Color	Dip	Dip Direction	Label
Mean Set Planes				
2m		3	226	So
3m		85	286	J1
4m		84	64	J2
5m		40	25	J3

Plot Mode	Pole Vectors
Vector Count	179 (179 Entries)
Hemisphere	Lower
Projection	Equal Angle

Stantec	*Project* St. Anthony Mine - Pit 1 Highwall		
	Analysis Description West Highwall - Flexural Toppling		
	Drawn By J.Nichols	*Company* Stantec	
DIPS 7.018	*Date* 2020-10-29	Figure KIN-5	



Symbol	Feature
◇	Pole Vectors
■	Critical Intersection

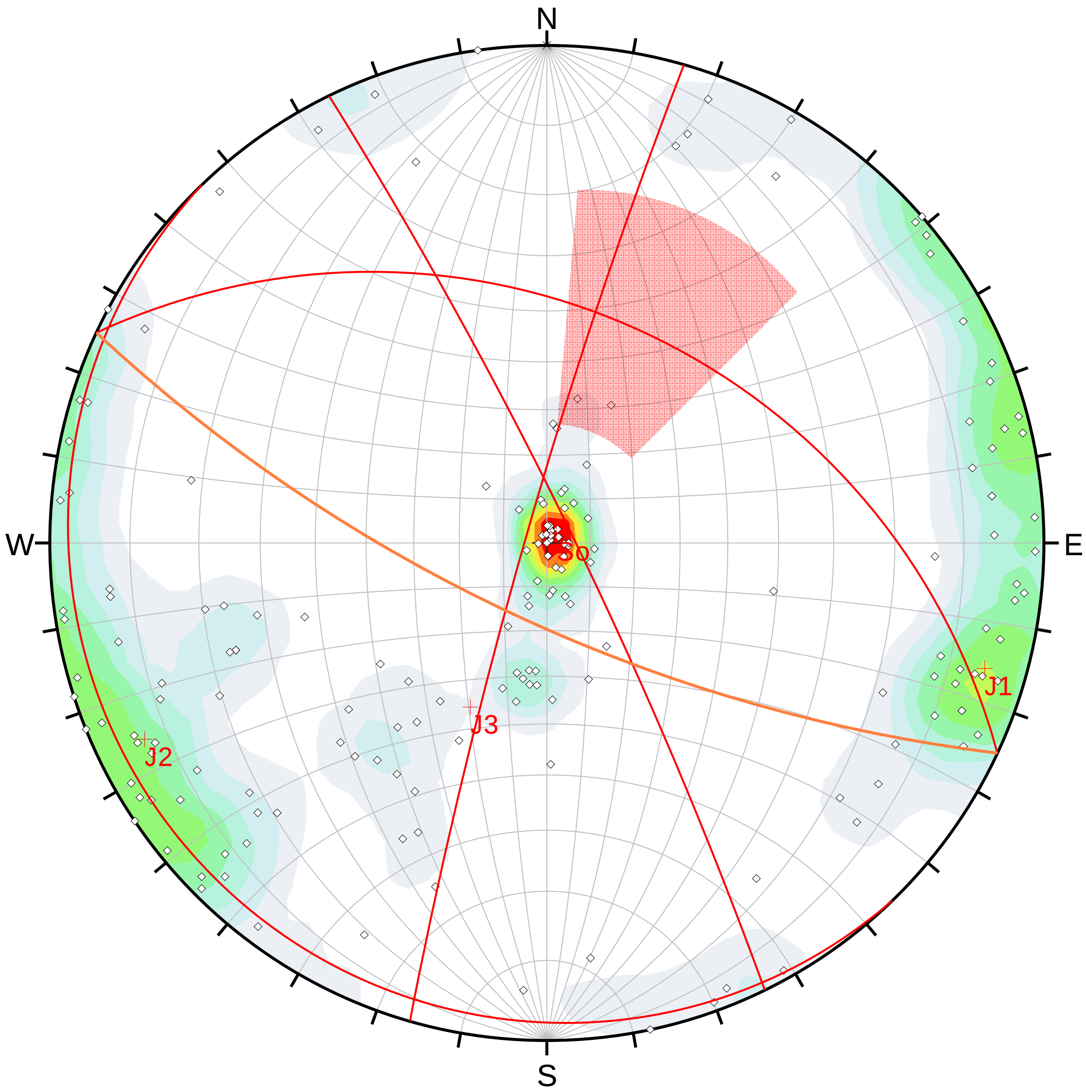
Color	Density Concentrations
	0.00 - 0.90
	0.90 - 1.80
	1.80 - 2.70
	2.70 - 3.60
	3.60 - 4.50
	4.50 - 5.40
	5.40 - 6.30
	6.30 - 7.20
	7.20 - 8.10
	8.10 - 9.00
Contour Data	Intersections
Maximum Density	8.94%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Wedge Sliding		
Slope Dip	72		
Slope Dip Direction	100		
Friction Angle	27°		
	Critical	**Total**	**%**
Wedge Sliding	1073	15927	6.74%

	Color	Dip	Dip Direction	Label
Mean Set Planes				
2m		3	226	So
3m		85	286	J1
4m		84	64	J2
5m		40	25	J3

Plot Mode	Pole Vectors
Vector Count	179 (179 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	15927
Hemisphere	Lower
Projection	Equal Angle

Stantec	*Project* St. Anthony Mine - Pit 1 Highwall	
	Analysis Description West Highwall - Wedge Sliding	
	Drawn By J.Nichols	*Company* Stantec
DIPS 7.018	*Date* 2020-10-29	Figure KIN-6



Symbol	Feature
◇	Pole Vectors

Color	Density Concentrations
	0.00 - 1.20
	1.20 - 2.40
	2.40 - 3.60
	3.60 - 4.80
	4.80 - 6.00
	6.00 - 7.20
	7.20 - 8.40
	8.40 - 9.60
	9.60 - 10.80
	10.80 - 12.00

Contour Data	Pole Vectors
Maximum Density	11.97%
Contour Distribution	Fisher
Counting Circle Size	1.0%

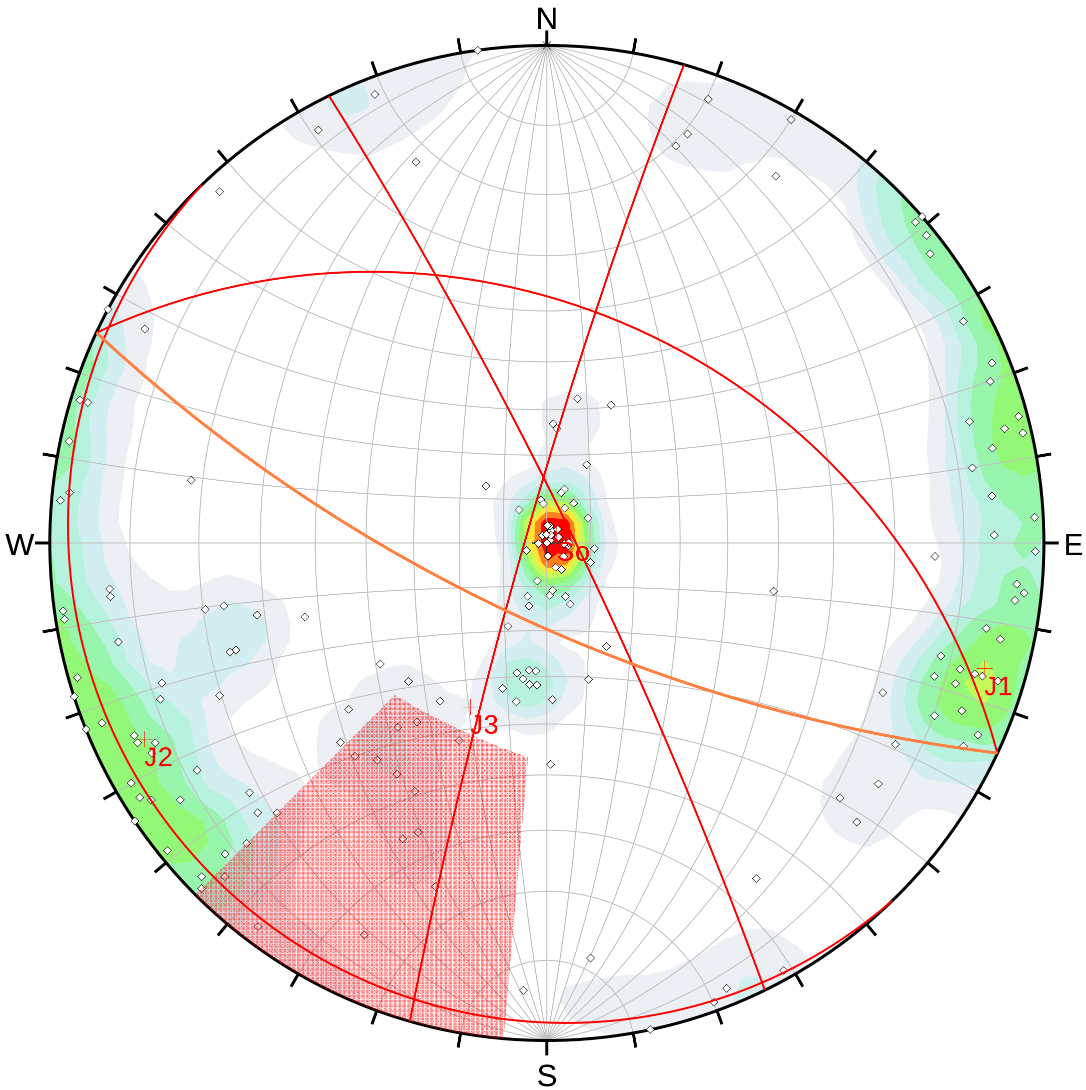
Kinematic Analysis	Planar Sliding
Slope Dip	72
Slope Dip Direction	205
Friction Angle	27°
Lateral Limits	20°

	Critical	Total	%
Planar Sliding (All)	2	179	1.12%

	Color	Dip	Dip Direction	Label
Mean Set Planes				
2m		3	226	So
3m		85	286	J1
4m		84	64	J2
5m		40	25	J3

Plot Mode	Pole Vectors
Vector Count	179 (179 Entries)
Hemisphere	Lower
Projection	Equal Angle

Stantec	*Project* St. Anthony Mine - Pit 1 Highwall	
	Analysis Description North Highwall - Planar Sliding	
	Drawn By J.Nichols	*Company* Stantec
DIPS 7.018	*Date* 2020-10-29	Figure KIN-7



Symbol	Feature
◇	Pole Vectors

Color	Density Concentrations
	0.00 - 1.20
	1.20 - 2.40
	2.40 - 3.60
	3.60 - 4.80
	4.80 - 6.00
	6.00 - 7.20
	7.20 - 8.40
	8.40 - 9.60
	9.60 - 10.80
	10.80 - 12.00

Contour Data	Pole Vectors
Maximum Density	11.97%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Flexural Toppling
Slope Dip	72
Slope Dip Direction	205
Friction Angle	27°
Lateral Limits	20°

	Critical	Total	%
Flexural Toppling (All)	16	179	8.94%
Flexural Toppling (Set 4: J2)	5	51	9.80%
Flexural Toppling (Set 5: J3)	9	29	31.03%

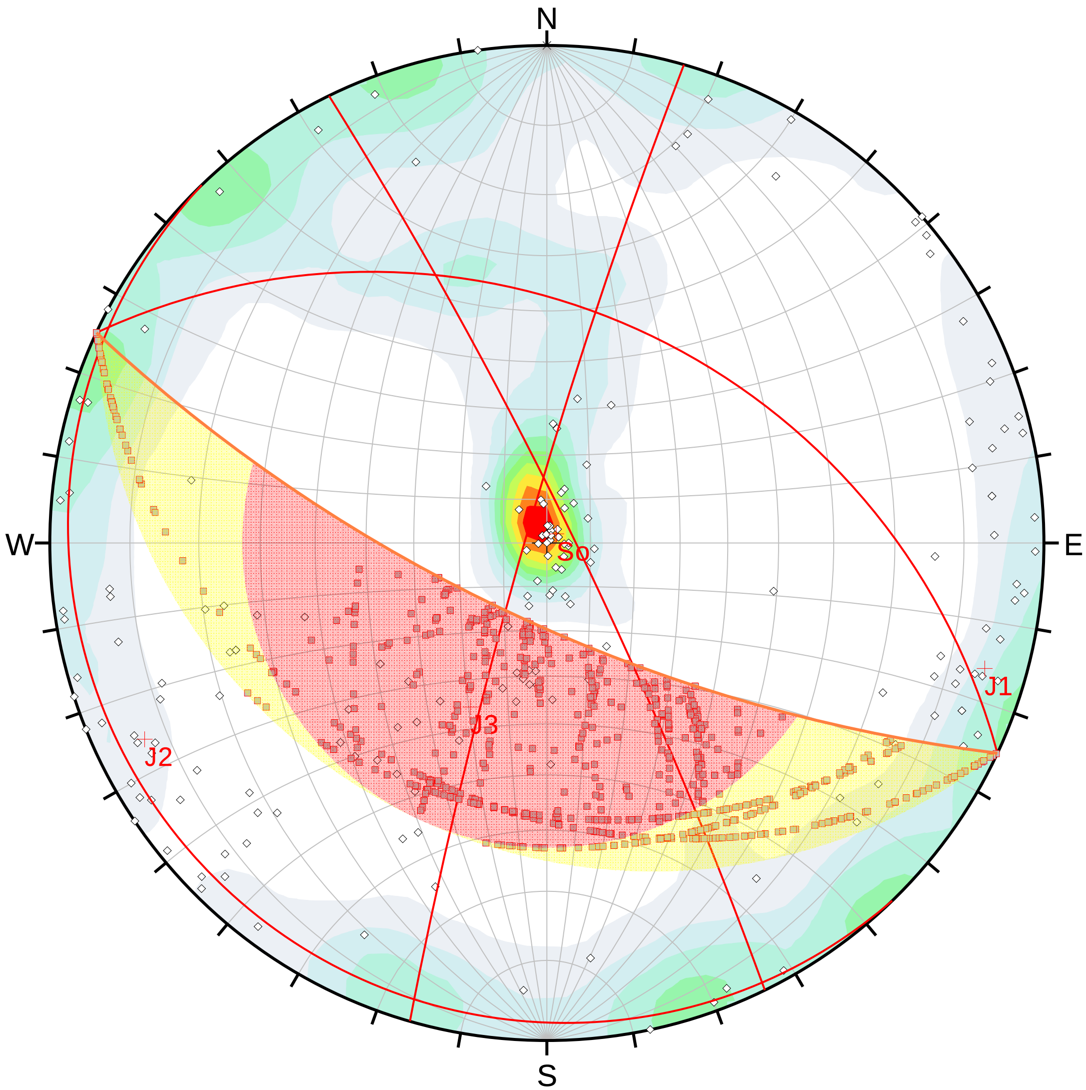
	Color	Dip	Dip Direction	Label
Mean Set Planes				
2m		3	226	So
3m		85	286	J1
4m		84	64	J2
5m		40	25	J3

Plot Mode	Pole Vectors
Vector Count	179 (179 Entries)
Hemisphere	Lower
Projection	Equal Angle

Stantec

Project	St. Anthony Mine - Pit 1 Highwall	
Analysis Description	North Highwall -Flexural Toppling	
Drawn By J.Nichols	*Company* Stantec	
Date 2020-10-29	Figure KIN-8	

DIPS 7.018



Symbol	Feature
◇	Pole Vectors
■	Critical Intersection

Color	Density Concentrations
	0.00 - 0.90
	0.90 - 1.80
	1.80 - 2.70
	2.70 - 3.60
	3.60 - 4.50
	4.50 - 5.40
	5.40 - 6.30
	6.30 - 7.20
	7.20 - 8.10
	8.10 - 9.00
Contour Data	Intersections
Maximum Density	8.94%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Wedge Sliding		
Slope Dip	72		
Slope Dip Direction	205		
Friction Angle	27°		
	Critical	**Total**	**%**
Wedge Sliding	742	15927	4.66%

	Color	Dip	Dip Direction	Label
Mean Set Planes				
2m		3	226	So
3m		85	286	J1
4m		84	64	J2
5m		40	25	J3

Plot Mode	Pole Vectors
Vector Count	179 (179 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	15927
Hemisphere	Lower
Projection	Equal Angle

Stantec

DIPS 7.018

Project	St. Anthony Mine - Pit 1 Highwall
Analysis Description	North Highwall - Wedge Sliding
Drawn By	J.Nichols
Company	Stantec
Date	2020-10-29
Figure	KIN-9

Site Specific Health and Safety Plan

St. Anthony Mine, Cibola County, New Mexico

March 16, 2021

Prepared for:

United Nuclear Corporation
PO Box 3077
Gallup, NM 87305

Prepared by:

Stantec Consulting Services Inc.
3325 South Timberline Road
Suite 150
Fort Collins, CO 80525

CHANGE SUMMARY PAGE

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

Change No.	Date	Affected Page(s)	Change Summary
REV. 0	02/2018	ALL	Original Issuance
	03/2018	Appendix A	Minor changes to AHA for Radiation Safety in Appendix A and added Incident Reporting form RMS3 and current Incident reporting protocol.
REV. 1	04/2018	1-4, 3-3, 6-1, 6-3. AHA p4	Added chemical COC's related to gases encountered in borehole while drilling.
REV. 2	06/2018	3-18, Sect 3.12.9	Added Underground Obstacle hazards and controls
REV. 3	03/2021	1-1, 1-3, 1-4, 2-1, 3-3, 4-1, 6-9, 6-10, 10-1	Updated project personnel and contact information. Updated scope of work. Added Highwall Safety hazards and controls.

Sign-off Sheet

This document entitled Site Specific Health and Safety Plan was prepared by Stantec Consulting Services Inc. ("Stantec") for the account of United Nuclear Corporation (the "Client"). Any reliance on this document by any third party is strictly prohibited. The material in it reflects Stantec's professional judgment in light of the scope, schedule and other limitations stated in the document and in the contract between Stantec and the Client. The opinions in the document are based on conditions and information existing at the time the document was published and do not take into account any subsequent changes. In preparing the document, Stantec did not verify information supplied to it by others. Any use which a third party makes of this document is the responsibility of such third party. Such third party agrees that Stantec shall not be responsible for costs or damages of any kind, if any, suffered by it or any other third party as a result of decisions made or actions taken based on this document.

Prepared by ____

(signature)

Enter Name

Reviewed by ____

(signature)

Enter Name

Approved by ____

(signature)

Enter Name

Table of Contents

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

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 (Kevin O'Barr). 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 HSP 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. 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 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 Pit 1 Highwall Stability Phase 2 Investigation Work Plan includes drilling and sampling of subsurface soils in the vicinity of Pit 1, which is the larger of two open mine pits at the site. The work will be conducted at various locations along the top of the highwalls surrounding Pit 1.

Site activities will include the following tasks:

- Drilling or boring
- Grab sampling
- Site reconnaissance

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 (attached) 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. Naturally occurring gases such as methane, carbon monoxide and hydrogen sulfide may exist within the geologic materials at the site. The table below summarizes exposure limits for naturally occurring gases.

COC	NIOSH PEL (8-hour TWA)	OSHA PEL	LEL
Carbon monoxide	35 ppm (200 ceiling)	50 ppm	12.5%/vol.
Hydrogen sulfide	ACGIH TWA – 1.0 ppm STEL – 5.0 ppm	20 ppm (ceiling) or maximum peak of 50 ppm for 10 minutes once	4.0%/vol.
Methane	1,000 ppm (max during 8 hour day)	n/a	5.0%/vol.

PEL = Permissible Exposure Limit (8-hour TWA), LEL = lower explosive limit, STEL = Short Term Exposure Limit

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

Kevin O'Barr 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

Christina Brueckman 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
- Work in proximity to highwalls and drop-offs
- 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/Explosive Gas in the borehole
- ☐ 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: Underground hazards

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.

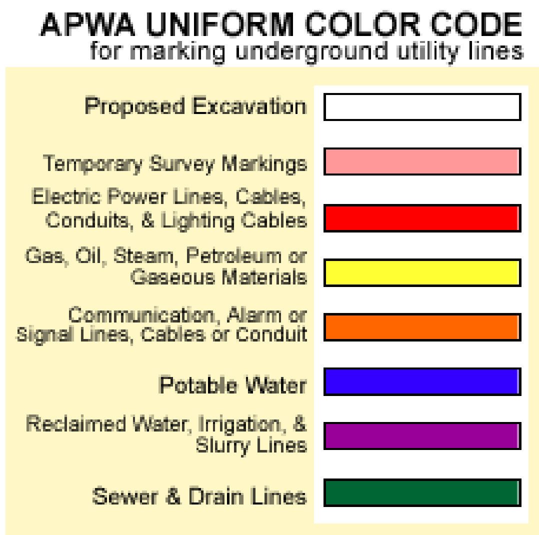
3.12.9 Underground Obstacle Hazards

The importance of safe excavation, trenching, drilling and other ground disturbance activities cannot be overstated. Knowing where underground utility lines are buried before each ground disturbance activity helps to prevent injury, fines, repair costs and disruption of vital utility services to the client or community.

Stantec SWP 213 – Utility Clearance and OSHA Standard 29 CFR 1926.651 (Specific Excavation Requirements) and state regulations require that a utility mark-out be performed prior to any excavation, trenching, drilling, direct push, or other ground disturbance activities. By calling 811 anywhere in the US, you will be connected with the local “Call Before You Dig” or “One Call” center. Each state has different rules and regulations governing ground disturbance, some stricter than others. Where “One Call” services are not available a private location contractor or client support may be utilized.

The practices detailed in SWP 213 must be followed prior to any ground disturbance.

Any mark-out conducted by the State or by any other non-affiliated services will conform with the American Public Works Association (APWA) Uniform Color Code for marking underground utility lines (see insert).



3.12.10 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.

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

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
- Chemical 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 Radiological 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 Chemical Hazards

Carbon monoxide, hydrogen sulfide, and methane may be present within some of the geologic formations at the site. Drilling activities will require a meter to monitor gas levels near the drill stem, if the presence of gases is suspected. Engineering controls, such as fans should be used near the work area if there is no wind present. If level of the COC's are exceeded with engineering controls, work must stop immediately and personnel must evacuate the work area until the hazard can be addressed.

6.1.5 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.

6.1.6 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.

<u>Heat Stress</u>

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.

6.1.7 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.

6.1.8 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.

6.1.9 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.)

6.1.10 Highwall Safety

When working near highwalls, slope benches, or other hazardous features with the potential for personnel and rock falls, special precautions must be taken to maintain a safe distance between all personnel/equipment and the edge of the highwall.

To protect equipment and personnel from falling, a berm, or barrier, of sufficient height must be placed and maintained. In addition to berms or barriers, if there are areas where there is a danger of falling and safe working distance and a barrier cannot be maintained, personnel shall take measures to eliminate the risk or wear the appropriate fall protection, this may include the use of safety harnesses, self-retracting lanyards, barricades, rails, etc. In the event there are others working in this vicinity without the appropriate fall protection, an exclusion zone shall be established beginning at a distance of at least six (6) feet from the fall hazard to prevent personnel from approaching the highwall. Drilling activities should be performed in locations that comply with the drilling subcontractor’s requirements for mobilization and setup of equipment in proximity to steep slopes.

- Highwalls must be examined for stability and hazards by designated competent person(s) prior to beginning any work in the vicinity.
- Workers outside of vehicles have increased exposure to falling rocks and whenever possible should be discouraged from performing work at the base, or close to the edge of a highwall.
- Never place yourself between a highwall and any piece of equipment or other obstruction. Remember if escape could be hindered, no work or travel is permitted.
- Always wear the appropriate PPE when working at heights.

The health of benches, highwalls and berms can change quickly and may not be visible upon first inspection, therefore it is crucial for all personnel to be diligent in looking for potential hazards. Changes in weather, high winds, vibration from equipment and other factors can make working conditions unsafe and create a potential for rocks to slide or fall. Keep an eye out for:

- Faults, fractures, fissures.
- Erosion or seepage.
- Loose, sliding or falling rocks on bench surfaces.
- Rock mass failures causing sloughing/sliding.
- Recent freezing/thawing damage.

If it is determined that a bench or highwall is unstable or in need of corrective work or maintenance, access shall be prohibited for work or travel, other than corrective work, in areas where hazardous ground conditions exist. Posting of a warning against entry is required until corrective work is completed if workers could enter the area inadvertently. In addition, barriers are required if the area is left unattended prior to the completion of the corrective work. The mode of travel in the area must be evaluated to determine what type of barrier is appropriate to impede unauthorized entry.

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 (attached). 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 SURVEILLANCE

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 (attached) 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
March 16, 2021

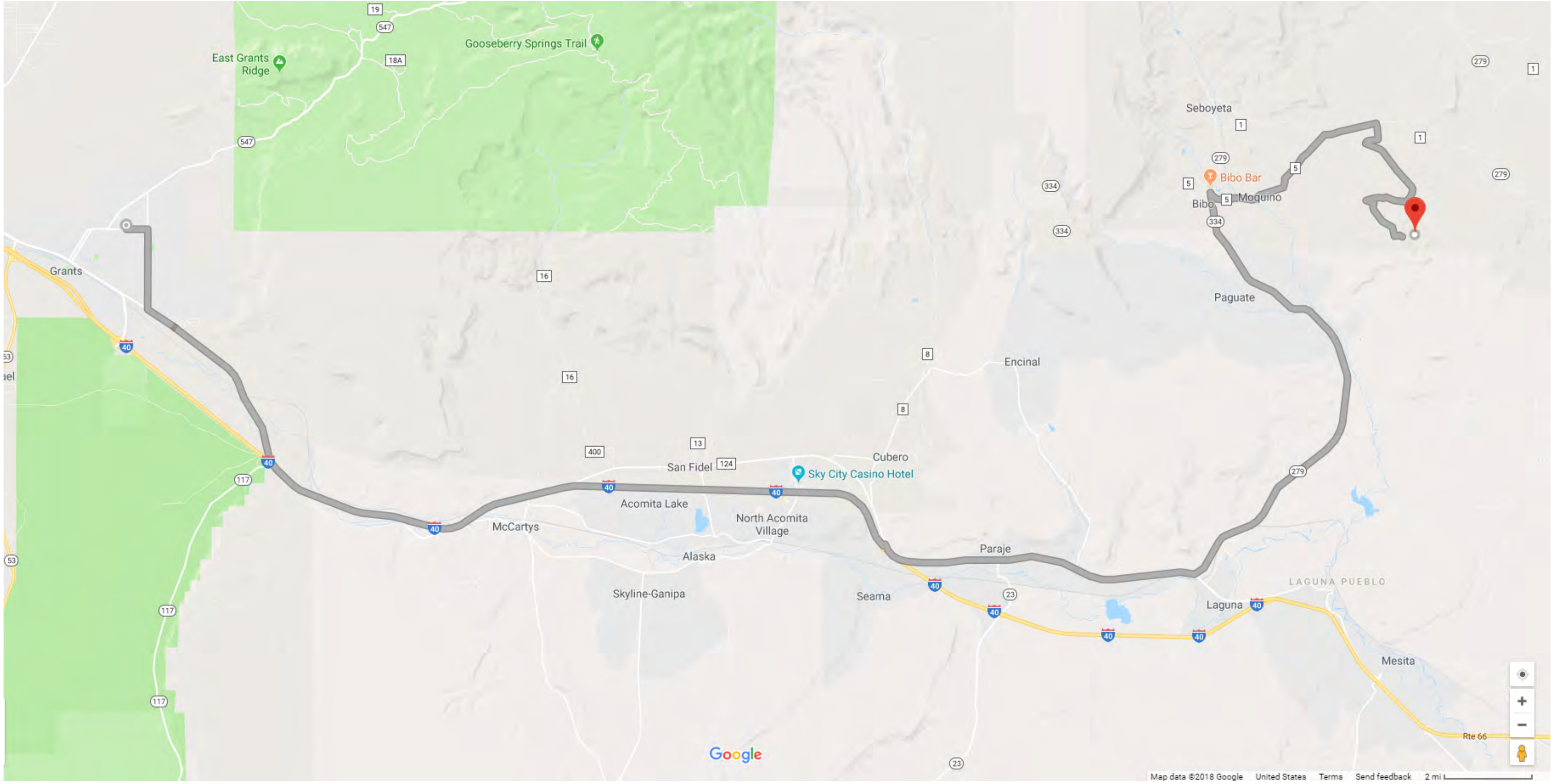


Figure 1 - Route to Hospital

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	Christina Brueckman Cameron Fritz	(303) 291-2156 (Work) (303) 807-5864 (Cell) (970) 212-2759 (Work) (907) 947-2225 (Cell)
Project Health and Safety Manager	Kevin O'Barr	(480) 687-6187 (Work) (480) 245-3954 (Cell)
RSO	AVM	(505) 287-4593 (Work) (505) 290-0737 (Cell)
Corporate H&S Reporting for accidents/injuries/illness	WorkCare	(888) 449-7787 (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

American Conference of Governmental Industrial Hygienists. 2006 TLVs & BEIs. 2006

American Red Cross. Standard First Aid. 1988.

Humantech, Inc. Applied Ergonomics Manual. 1995

USEPA. Standard Operating Safety Guides. June 1992.

USEPA. Health and Safety Audit Guidelines SARA Tile I Section 126. December 1989.

USEPA, NIOSH, OSHA, USCG. Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities. October 1985.

U.S. Department of the Army. 1100 Area RD/RA Site Safety and Health Plan prepared for the U.S. Department of Energy. June 1994.

U.S. Department of Health and Human Services, NIOSH. The Industrial Environment, its Evaluation and Control. 1973.

U.S. Department of Health and Human Services, NIOSH, Centers for Disease Control. Pocket Guide to Chemical Hazards. Current edition, www.cdc.gov

U.S. Department of Labor - Occupational Safety and Health Administration. 29 Code of Federal Regulations Part 1910 and Part 1926

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

HSP ACKNOWLEDGMENT FORM

As a component of the HSP designed to ensure personnel safety during project activities, you are required to read and understand the HSP 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 HSP 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 HSP, 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

March 16, 2021

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. <u>LIGHTNING</u> • 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. <u>TORNADO AND HIGH WIND WARNING</u> • 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 • Monitor work area breathing zone for downhole gases such as CO, H_2S, LEL (CH_4) • If flammable downhole conditions are detected, ventilate the space or develop an alternate safe plan	• High-visibility vest • Hearing protection • Safety-toed boots • Hard hat • Safety glasses • 4-gas meter (O_2, LEL, CO, H_2S)	• Review of safe use practices • Operation of 4-gas meter	• Per operator • Call prior to use and immediately after
Working near high walls	• Examine highwall for signs of instability before and during work • Maintain safe working distance at all times for personnel and equipment • Establish berm or barrier to restrict access to edge of highwall • Post warning signage against entry if corrective work is required in the case of unstable conditions	• Fall protection (if barrier/safe working distance not maintained) • Barricades, rails, signage, etc.	• None	• Inspect highwall for signs of instability
Radiological Hazards	• Complete on-site radiation safety training • Use the principles of time, distance, and shielding • Follow the Radiation Protection Plan detailed in Appendix B • Field level risk assessment RMS2 and LMRA conducted prior to task execution	• TLD badge • Protective clothing required by RPP • Respiratory protection as required	• On-site radiation safety training conducted by UNC • Radiation Protection	• None • PPE including respiratory protection prior to use

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.)

RMS 3 – OCCUPATIONAL INCIDENT REPORTING FORM

HSSE event report – RMS3

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 HSSE manager/advisor to discuss incident severity and determine further notification. 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 HSSE, 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 HSSE 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:		Incident Time:		Date Reported:	
Project name:				Project number:	
Client Name:					
Person in charge:				Person in Charge Phone:	

SECTION 2: INVOLVED 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 sign below. **See StanNet for a list of Incident Type Definitions**

Incident Severity (0-4 Serious):		**Incident Likelihood: (1-4 Very Likely)**	
☐ **Report Only*	☐ First Aid	☐ Motor Vehicle Incident	☐ 3rd Party Incident (i.e., Public)
☐ **Hazard Identification*	☐ Medical Aid – No Lost Time	☐ Property Damage - Vehicle	☐ Spill or Release
☐ **Near Miss*	☐ Restricted Work	☐ Property Damage - Other	☐ Utility Strike
☐ **Safety Opportunity*	☐ Lost Time	☐ Security	☐ Fire/Explosion/Flood
☐ ***Critical Risk?***	☐ Fatality	☐ Contractor Recordable Incident	☐ Stop Work Authority
☐ ***High Potential Incident?***	☐ Violence or Harassment	☐ Non-compliance	☐ Work Refusal
Describe incident in detail: (include any issues related to people, equipment, materials, environment, and processes)			
Immediate corrective actions taken:			
Submitted by (add signature):			

SECTION 4: MEDICAL INFORMATION	
Name of first aid attendant:	Injury recorded in first aid log? Yes ☐ No ☐ N/A ☐

Canada East (Atlantic) – Kyle Ferguson (902-240-3847); Canada East (ON) – Jared Memory (647-969-3709);
Canada East (Quebec) – Claudine Tremblay (514-668-4820); Canada Mountain – Shawna Robichaud (587-894-2635);
Canada Prairies – Yvonne Beattie (780-616-8909); International – Kev Metcalfe (780-231-2185); US Northeast – Fred Miller (610-235-7315);
US Central & US South - Keith Kuhlmann (740-816-6170); US West – Tony Wong (805-234-6227)

Description of first aid or medical treatment administered:	
Clinic/hospital sent to:	
Attending physician/paramedic (if known):	

Area of Injury – Please check all that apply:

				Left		Right	Left		Right	Left		Right	Left		Right
☐ Head	☐ Teeth	☐ Upper back													
☐ Face	☐ Neck	☐ Lower back		☐	Shoulder	☐	☐	Wrist	☐	☐	Hip	☐	☐	Ankle	☐
☐ Eye(s)	☐ Chest	☐ Abdomen		☐	Arm	☐	☐	Hand	☐	☐	Thigh	☐	☐	Foot	☐
☐ Ear(s)		☐ Pelvis		☐	Elbow	☐	☐	Finger(s)	☐	☐	Knee	☐	☐	Toe(s)	☐
☐ Other	Specify			☐	Forearm	☐				☐	Lower Leg	☐			

Has the injured employee had a previous similar injury or disability?	Yes ☐	No ☐

SECTION 5: PROPERTY OR VEHICLE DAMAGE: STANTEC			
Ownership Details (choose one):	☐ Rented (attach rental agreement)	☐ Stantec Owned	☐ Personal (employee vehicle)
Year, Make, and Model of Vehicle:		Vehicle ID # (VIN)	
Nature of damage:		Estimated cost of damage:	$
Description of damaged property:			
Attending police officer (if known):		Badge #:	
Copy of police report received	Yes ☐ No ☐ If yes, file number:	(attach copy of police report)	
PROPERTY OR VEHICLE DAMAGE: 3RD PARTY			
Name of owner and contact number:			
Year, Make, and Model of Vehicle:		License Plate Number:	
Insurer and Policy Number:			
Injured parties? Yes ☐ No ☐	If yes, describe Injuries:		
Diagram or photographs attached?	Yes ☐ No ☐		

WITNESS INFORMATION - #1			
Name:		Phone Number:	
Witness statement provided?	Yes (attached) ☐	No ☐	

WITNESS INFORMATION - #2			
Name:		Phone Number:	
Witness statement provided?	Yes (attached) ☐	No ☐	

SECTION 6: SPILL OR RELEASE			
Substance:			
Quantity:		Employee(s) exposed via:	☐ Inhalation ☐ Contact ☐ Ingestion ☐ n/a
Off-site impacts observed or anticipated?	Yes ☐ No ☐ If yes, describe:		
Name of regulatory agencies contacted:			
Contact name, number, date and time of call:			

SECTION 7: ANALYSIS
DIRECT CAUSES
A. ACTIONS TO IMPROVE (check off as many as necessary)

- ☐ Operating equipment without authority
- ☐ Lack of warning
- ☐ Did not secure
- ☐ Operating at improper speed
- ☐ Disabling/removing safety devices
- ☐ Using defective/improper equipment
- ☐ Using equipment improperly
- ☐ Did not use personal protective equipment (PPE)
- ☐ Improper loading
- ☐ Improper placement
- ☐ Improper lifting or handling
- ☐ Improper position for a task
- ☐ Servicing equipment in operation
- ☐ Horseplay
- ☐ Procedure, policy, or practice, not followed
- ☐ Hazard or risk not identified
- ☐ Inattention
- ☐ Communication/coordination needs improvement
- ☐ Influence of alcohol or drugs suspected
- ☐ Did not check/monitor
- ☐ Did not react or correct

B. CONDITIONS TO IMPROVE (check off as many as necessary)

- ☐ Inadequate guards/barriers
- ☐ Improper/inadequate PPE
- ☐ Defective tools or equipment
- ☐ Congested work area
- ☐ Inadequate warning system
- ☐ Fire and explosion hazards
- ☐ Poor housekeeping; disorder
- ☐ Noise exposure
- ☐ Radiation exposure
- ☐ Temperature extremes
- ☐ Inadequate or excess illumination
- ☐ Inadequate ventilation
- ☐ Presence of harmful materials or environment
- ☐ Instructions/procedures need improvement
- ☐ Inadequate information/data
- ☐ Preparation/planning needs improvement
- ☐ Opportunity to improve support/assistance
- ☐ Road conditions
- ☐ Weather conditions
- ☐ Communications need improvement (hardware/software)

ROOT CAUSES

C. PERSONAL FACTORS (check off as many as necessary)

- ☐ Physical Capability
- ☐ Physical Stress
- ☐ Mental Stress
- ☐ Lack of Skill
- ☐ Lack of Knowledge
- ☐ Improper Motivation
- ☐ Abuse or Misuse
- ☐ Mental/Psychological Capability

D. JOB FACTORS (check off as many as necessary)

- ☐ Leadership or supervision
- ☐ Engineering
- ☐ Purchasing
- ☐ Maintenance (scheduled or preventative)
- ☐ Tools or equipment
- ☐ Work standards
- ☐ Excessive wear and tear
- ☐ Communications
- ☐ Other: Specify

Canada East (Atlantic) – Kyle Ferguson (902-240-3847); Canada East (ON) – Jared Memory (647-969-3709);
Canada East (Quebec) – Claudine Tremblay (514-668-4820); Canada Mountain – Shawna Robichaud (587-894-2635);
Canada Prairies – Yvonne Beattie (780-616-8909); International – Kev Metcalfe (780-231-2185); US Northeast – Fred Miller (610-235-7315);
US Central & US South - Keith Kuhlmann (740-816-6170); US West – Tony Wong (805-234-6227)

SECTION 8: FOLLOW-UP				
Short-term:	**Corrective Action**	**Assigned To**	**Target Date**	**Completion Date**
Long-term:	**Corrective Action**	**Assigned To**	**Target Date**	**Completion Date**

REVIEW COMMENTS

Involved Employee Comments:

Signature: Print Name: Date:
Job Title:

Supervisor/Project Manager:

Signature: Print Name: Date:
Job Title:

HSSE Representative (OSEC/JH&S Committee/HSSE Manager/HSSE Advisor):

Signature: Print Name: Date:
Job Title:

Management Review: (☐ not applicable)

Signature: Print Name: Date:
Job Title:

Additional Comments:

Incident Reporting Protocol - US

IMMEDIATE 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 **WorkCare (24-hour service): 1-888-449-7787** 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 Manager or HSSE Advisor by phone to discuss incident severity and determine if further notifications (internal or external) are required.
6. When an employee is guided by WorkCare 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 WorkCare 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	Wes Cline	615-885-1144	916-281-7459
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 - US	Tami Renkoski	303-533-1964	720-530-7274
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/HSP? ☐ Yes ☐ No
   If yes, include in the Job Safety Analysis (JSA).
7. Working alone or remote work? ☐ Yes ☐ No
   If yes, complete call in/out process – Safe Work form must be completed.

Notifications and Permits

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

☐ ☐ ☐

☐ ☐ ☐

Stantec

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

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			

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

Post-Day	

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	Access/Egress Hazards	Rigging & Hoisting Hazards
1. Work area clean ☐	23. Aerial life/Man basket (inspected & tagged) ☐	38. Lift study required ☐
2. Material storage identified ☐	24. Scaffold (inspected & tagged) ☐	39. Proper tools used ☐
3. Dust/Mist/Fume ☐	25. Ladders (tied off) ☐	40. Tools inspected ☐
4. Noise in area ☐	26. Slips & trips ☐	41. Equipment inspected ☐
5. Extreme temperatures ☐	27. Hoisting (tools, equipment) ☐	42. Slings inspected ☐
6. Spill potential ☐	28. Evacuation (alarms, routes, ph. #) ☐	43. Others working overhead/below ☐
7. Waste containers needed ☐	29. Confined space entry permit required ☐	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 ☐

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 ☐

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	$8x10^{-15}\mu$Ci/ml	sampling 8 hours/day; counting time = 60 min
Eberline	MSA Escort Elf	Lapel Air Sampler	$2.4x10^{-13}\mu$Ci/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 (1×10^{-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 $8.48x10^{-13}$ 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):

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

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.

STANDARD OPERATING PROCEDURES ST. ANTHONY MINE SITE	SOP-01 Revision: 1 Date: March 2021
# HOLLOW STEM AUGER DRILLING, ROCK CORING, AND SAMPLING	

TABLE OF CONTENTS

LIST OF ATTACHMENTS

1.0 SCOPE AND APPLICABILITY

This Standard Operating Procedure (SOP) describes the procedures for hollow stem auger (HSA) drilling, HQ triple-barrel rock coring, and geotechnical soil sample collection. 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 HOLLOW STEM AUGER DRILLING

CME soil coring will be completed using a track-mounted drill rig equipped with 4.25-inch hollow stem augers (HSA). HSA drilling will be implemented in overburden soils where advancement of the auger is not restricted by hard or otherwise resistant strata. Standard borehole casing will be advanced at nearly the same rate as the drilling advancement to prevent sidewall collapse, particularly in any inclined boreholes. Soil sampling may include continuous cores, California barrel samples, standard split spoon samples, and Shelby tube samples. In non-mine-impacted areas, drill cuttings will be placed on the ground adjacent to the boreholes. If applicable, in areas of concern, the cuttings will be placed on plastic sheeting or plywood, until they are drummed.

2.3 ROCK CORING

Rock core drilling will be utilized to advance the boreholes through bedrock or other soil strata that are too hard or large to be penetrated using HSA drilling. The work will be performed using the same CME drill rig used for HSA drilling, which will be equipped for both auger drilling and rotary diamond-bit wash boring. Continuous coring will be performed using wire-line HQ triple-tube core barrels. Drilling fluids or additives may be used if approved for use at the site. Drilling rates will be kept at a sufficiently slow rate to reduce the potential for clogging at the base of the hole and buildup of pressure at the location of the bit. Pump pressures and drill down-pressure should be continuously monitored. If clay buildup or sand lock initiates, the drill rods (stem) are to be slowly raised and the hole cleaned/flushed. The core barrel shall be removed from the holes immediately if blocking of the bit or grinding of the core is indicated by the drill behavior or water pressure, regardless of the length of run that has been made.

2.3.1 Downhole Geophysical Investigation

After rock coring in the inclined boreholes is completed, the boreholes will be surveyed with an optical and acoustic televiewer to record detailed orientation and discontinuity data.

2.4 SOIL AND ROCK 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 or HQ core barrel as the HSA or core barrel 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 under Sample Descriptions and in SOP-17 Soil Logging. After logging and photographing the core, samples may be retained by one of the following procedures at the discretion of the field geologist or geotechnical engineer, as follows:

1. Core samples: intact, or nearly intact, rock core samples may be retained and stored in core boxes. Boxes will be capable of holding HQ-sized cores in parallel rows and will contain partitions extending over the full length of the box to prevent movement of the core samples. Labeled, wooden blocks will be used to mark the ends of core runs and depth ranges of core loss.

2. 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.

3. 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 in the overburden material. 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 Abandonment

Specific abandonment procedures may vary depending on the sampling location at the site. Boreholes 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

			Description	Symbol
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	SOP-06 Revision: 1 Date: March 2021
SAMPLE MANAGEMENT AND SHIPPING	

STANDARD OPERATING PROCEDURE 06
SAMPLE MANAGEMENT AND SHIPPING

TABLE OF CONTENTS

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

MWH	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

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

Number of Containers
Sample Type: A W S V B O
Air Water Soils/Solids
Vegetation Bioassay Other

ANALYSIS REQUESTED

SEE ATTACHED

Normal Turnaround (TAT)

R U S H

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	MATRIX										SEE ATTACHED	Normal TAT	RUSH	Comments	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:
	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.

ENERGY LABORATORIES

Billings, MT
Corporate Headquarters
1120 South 27th Street (59101)
PO Box 30916 (59107)
E-mail: eli@energylab.com
Toll Free: 800.735.4489
Voice: 406.252.6325
Fax: 406.252.6069

Casper, WY
2393 Salt Creek Highway (82601)
PO Box 3258 (82602)
E-mail: casper@energylab.com
Toll Free: 888.235.0515
Voice: 307.235.0515
Fax: 307.234.1639

College Station, TX
415 Graham Road (77845)
E-mail: cseli@energylab.com
Toll Free: 888.690.2218
Voice: 979.690.2217
Fax: 979.690.2045

Gillette, WY
400 West Boxelder Rd. (82716)
E-mail: gillette@energylab.com
Toll Free: 866.686.7175
Voice: 307.686.7175
Fax: 307.682.4625

Helena, MT
3161 East Lyndale Avenue (59601)
PO Box 5688 (59604)
E-mail: helena@energylab.com
Toll Free: 877.472.0711
Voice: 406.442.0711
Fax: 406.442.0712

Idaho Falls, ID
940 East Lincoln Road
Idaho Falls, ID (83401)
E-mail: idaho_falls@energylab.com
Toll Free: 866.522.4498
Voice: 208.522.4498
Fax: 208.522.1049

Rapid City, SD
2821 Plant Street (57702)
E-mail: rapid_city@energylab.com
Toll Free: 888.672.1225
Voice: 605.342.1225
Fax: 605.342.1397

Elko, NV
Satellite Location
156 Commercial Street (89801)
PO Box 1102 (89803)
E-mail: elko@energylab.com
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.

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

Number of Containers Sample Type: A W S V B O Air Water Soils/Solids Vegetation Bioassay Other

SEE ATTACHED — Normal Turnaround (TAT) — RUSH

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	MATRIX	Radium 226	Ammonia	Nitrate	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								

Example

LABORATORY USE ONLY

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:
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.

ATTACHMENT 3

CUSTODY SEAL

STANDARD OPERATING PROCEDURES ST. ANTHONY MINE SITE	SOP-07 Revision: 1 Date: March 2021
SOIL SAMPLING	

STANDARD OPERATING PROCEDURE 7
SOIL SAMPLING

TABLE OF CONTENTS

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 pre-sampling 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 width 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-10 Revision: 1 Date: March 2021
SURVEYING	

STANDARD OPERATING PROCEDURE 10 SURVEYING

TABLE OF CONTENTS

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

Davis, R.E., F.S. Foote, J.M. Anderson, and E.M. Mikhail, 1981. Surveying Theory and Practice. McGraw-Hill, Inc.

Moffitt, F.H., and H. Bouchard, 1982. Surveying (Seventh Edition). Harper & Row Publishers, Inc.

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

<table>
<tr><td>STANDARD OPERATING PROCEDURES

ST. ANTHONY MINE SITE</td><td rowspan="2">SOP-14
Revision: 1

Date: March 2021</td></tr>
<tr><td>FIELD DOCUMENTATION</td></tr>
</table>

STANDARD OPERATING PROCEDURE 14 FIELD DOCUMENTATION

TABLE OF CONTENTS

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	SOP-17 Revision: 1 Date: March 2021
SOIL LOGGING	

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 <u>in that order</u>. 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

SOILS

MWH
BUILDING A BETTER WORLD

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)

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

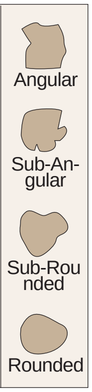
** = 140 pound hammer dropped 30 inches*

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

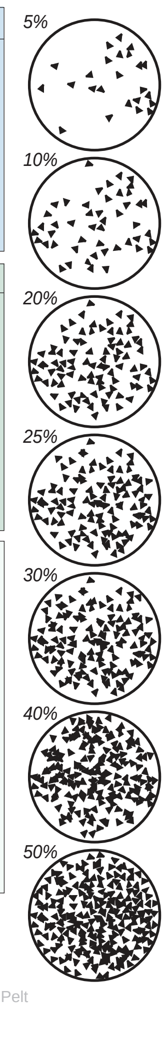
Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

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

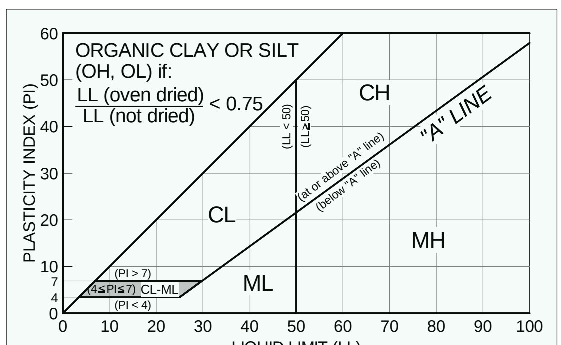
Fast, distinctive reaction = clean very fine sand

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



INCHES 0 1 2 3 4 5 6 7

CENTIMETERS 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

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

BUILDING A BETTER WORLD

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

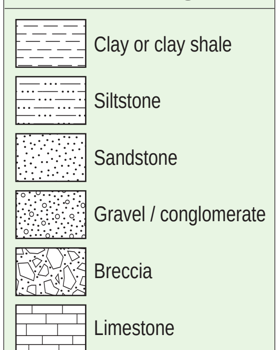
≤ 5% fines	well-graded		SW	< 15% gravel	Well-graded sand
				≥ 15% gravel	Well-graded sand with gravel
	poorly-graded		SP	< 15% gravel	Poorly-graded sand
				≥ 15% gravel	Poorly-graded sand with gravel
> 5% - < 15% fines	well-graded	fines = ML or MH	SW-SM	< 15% gravel	Well-graded sand with silt
				≥ 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

Fine-grained soils

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

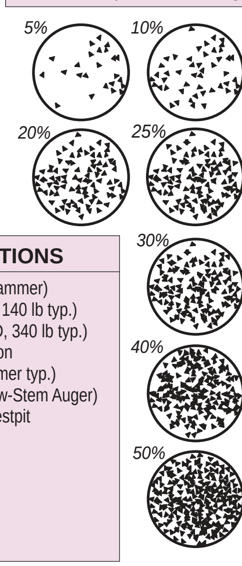
Gravels or sands with 5% to 15% fines require dual symbols (GW-GM, GW-GC, GP-GM, GP-GC, SW-SM, SW-SC, SP-SM, SP-SC) and add "with clay" or "with silt" to group name. If fines classify as CL-ML for GM or SM, use dual symbol GC-GM or SC-SM. $D_{X\%)}$ s soil particle diameter where X% is % finer. *Optional 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



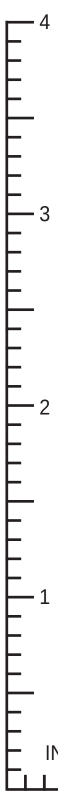
DRILLING NOTES

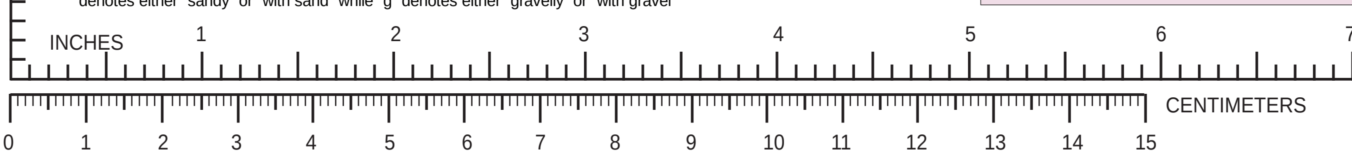
- Drilling rate
- Rig behavior (chatter)
- Heaving sands
- Loss of drilling fluid
- Caving / sloughing
- Sudden drops / rate changes



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

Client:

Project Number:

SOIL BORING LOG FORM

BOREHOLE No.:

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	SOP-31 Revision: 1 Date: March 2021
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.

GEOTECHNICAL CORE LOGGING MANUAL

FIELD PROCEDURES & RESOURCES

INTERNAL STANTEC REFERENCE DOCUMENT

October 2017 Rev 0

Stantec

Design with community in mind

GEOTECHNICAL CORE LOGGING MANUAL – INTERNAL STANTEC REFERENCE DOCUMENT

FIELD PROCEDURES AND REFERENCES

FOR STANTEC INTERNAL USE ONLY

October 26, 2017

Revision 1

Table of Contents

LIST OF FIGURES

LIST OF APPENDICES

Abbreviations

ASTM	American Society for Testing and Materials
CSIR	Council for Scientific and Industrial Research
DSLR	Digital Single-Lens Reflex Camera
ISRM	International Society for Rock Mechanics
JCR	Joint Condition Rating (RMR system)
NGI	Norwegian Geotechnical Institute
RQD	Rock Quality Designation
SCR	Solid Core Recovery
TCR	Total Core Recovery

Revision Record

Revision	Date of issue	Author (s)	Reason for Issue	Changes
0	November 2016	Maureen Matthew Lucy Philip Paul Deering	For use internally in Stantec Canada (issued to small group for reference and discussion)	Initial Issue
1	October 26 2017	Maureen Matthew Lucy Philip Paul Deering		Appendices re-organized Updated Appendix A

This document has been put together by Maureen Matthew with contributions from Lucy Philip. Lucy Philip and Paul Deering have reviewed the document. If you recommend any changes, have any queries with respect to the document or have any technical queries please contact Maureen, Lucy, or Paul.

1.0 INTRODUCTION

This manual provides an overview of the basic core logging procedures for obtaining geotechnical data from bedrock drill core. This document does not present an exhaustive summary of all geotechnical core logging procedures. Therefore, it is important that a review of the procedures outlined herein along with a review of all applicable standards and project requirements be undertaken for each project.

This document has been prepared as an internal reference document and is not meant for general distribution. Any use which a third party makes of this report is the responsibility of such third party.

1.1 REFERENCES

Several standards, suggested methods and classification systems are referenced within this manual. The key references that this manual generally follows include:

ASTM Standard Test Methods

- D6032: Determining Rock Quality Designation (RQD) of Rock Core;
- D2113: Rock Core Drilling and Sampling of Rock for Site Investigation;
- D5731: Determination of the Point Load Strength Index of Rocks, and Application to Rock Strength Classifications;
- D420-98: Site Characterization for Engineering, Design, and Construction; and
- D7012: Compressive Strength and Elastic Moduli of Intact Rock Core Specimens under Varying States of Stress and Temperatures.

ISRM Suggested Methods

- Basic Geotechnical Description of Rock Masses (1981);
- Suggested Methods for the Quantitative Description of Discontinuities in Rock Masses (1978);
- Rock Characterization Testing and Monitoring: ISRM Suggested Methods (1981); and
- Suggested Methods for Determining Point Load Strength (1985).

Rock Mass Characterization Systems

- The NGI Tunneling Quality Index, Q-System (Barton et al., 1974);
- The CSIR Rock Mass Rating RMR System (Bieniawski, 1976).

2.0 ROCK MASS CLASSIFICATION

A rock mass is a combination of intact blocks and the discontinuities around them. The quality of a rock mass, or overall rock mass strength, is controlled by both the strength of the intact material as well as the degree of fracturing and condition of the discontinuities within the mass.

Geotechnical data collected from drill core is used to classify the rock mass according to its quality. These data are input to rock mass classification systems, which allow for comparison of rock mass conditions across a site as well as for comparison to other sites. The most common rock mass classification systems include the NGI Q-system, the CSIR Rock Mass Rating (RMR) systems, both of which have been continuously refined since their adoption in the mid 1970's to include a large database of rock excavations and ground conditions worldwide.

The main rock mass classification systems use generally similar data to classify rock according to its overall quality. Generally, the Q-system is applied to underground excavations such as mine workings, tunnels, and HDD; whereas, typically the RMR system is applied to surface excavations in rock. It is, however, not uncommon to apply each system to any rock engineering application and these generalizations should not be considered rules. Note that some inputs to these rock mass classifications are difficult to get from core alone (such as Jn, Jw, etc.)

The following geotechnical parameters are collected from rock core for any rock mass classification system. They are further described in Section 4.0:

<u>Basic Geotechnical Interval Logging</u>

- Logging interval
- Total Core Recovery (TCR)
- Rock Quality Designation (RQD)
- Solid Core Recovery (SCR)
- Field Estimate of Intact Rock Strength
- Weathering/Alteration State

<u>Discontinuity Logging</u>

- Discontinuity Depth
- Discontinuity Type
- Joint Surface Condition
- Dip with Respect to Core Axis

3.0 FIELD PREPARATION

3.1 REFERENCES AND FORMS

The following is a list of reference field forms that will be useful to carry out the core logging:

- Geotechnical Core Logging Manual
- Field logging forms (basic or detailed)
- Point load field sheet (optional)
- Field "cheat sheet" tables for intact rock and joint condition descriptors

Copies of the most up-to-date templates and field forms are included in Appendix A. Field classification "cheat sheets", including rock/joint description tables, are in Appendix B.

3.2 EQUIPMENT

The following is a list of tools and equipment typically required for core logging:

- Safety goggles
- Gloves
- Anti-fatigue mats for standing
- Clip board
- Writing utensils (pencils, erasers, markers)
- Small straight edge/ruler
- Tape measure (imperial and metric units)
- Lumber crayons, chalk, or china markers for marking core (multiple colours)
- Permanent marker for marking on core box or sample containers
- Calculator
- Rock hammer
- Knife (steel)
- Carpenters protractor for measuring the angle with respect to core axis
- Hand lens
- Acid bottle (10% HCl solution)
- Spray bottle or water bucket for wetting core
- Duct tape, bubble wrap and stretch wrap for collecting and shipping core samples
- Labels and sample tracking templates for shipment
- Digital camera (recommended DSLR)
- Dry erase board with markers to display borehole and core box information in core photographs

4.0 GEOTECHNICAL CORE LOGGING

This section describes the procedures for collecting geotechnical data from drill core. It covers basic core logging, generally collected at the drill rig by the rig supervisor, as well as additional core logging which is generally collected off-site under more controlled conditions.

4.1 GENERAL BOREHOLE INFORMATION

The following information is required and should be recorded for all borehole logs:

- Project Name and Location
- Date logged (and date drilled, if different)
- Name of logging personnel
- Driller information (company, rig manufacturer and model, flush)
- Borehole ID
- Borehole location – include coordinates as well as physical description of location
- Borehole orientation (inclination and azimuth)
- Collar elevation (include survey datum)
- Core diameter (NQ, NQ3, HQ, etc.)
- Length drilled
- Groundwater conditions encountered in the borehole

4.2 CORE PHOTOGRAPHY

4.2.1 Core Photographs at the Rig

The core should be photographed at the rig even if subsequent core photography is taken later. These photos are important to document the core immediately after drilling and before transport to best capture the closest rock mass conditions to in-situ. It is common for core to break, disc or become crushed after transport and/or exposure to the elements prior to advanced core logging and photography.

Photographs taken at the rig should include a photo of the core by run in the barrel. Additional photographs should be taken of each filled core box. Efforts should be made to take photographs directly above and normal to the core barrel and/or box. The camera used should be a good quality, digital field camera.

Always include in the following information/items in core photos:

- Project Number, Name, and Location
- Borehole ID
- Run IDs, Depths (From, To)
- Tape measure for scale

4.2.2 Core Photographs Off-Site

Certain projects may require additional high-resolution core photographs to be taken in a more controlled off-site location such as a core shack or laboratory. Photos are taken with a more advanced camera such as a DSLR to provide detailed, high resolution images for further assessment. These photos are often helpful for inclusion in a report, for annotation as well as for communication to the client or other team members.

- High resolution photos are generally taken of two-three core boxes laid out on core logging tables in order of borehole depth (left to right, top to bottom).
- A dry erase board with the following information shall be included in each photo:
  - Project Name, Number
  - Borehole ID
  - Runs and corresponding depth (From and To) included in the photograph
  - Colour chart
- A tape measure should be lined up within the photo to provide a length reference.
- Ensure all labels/annotations/mark-ups on core boxes or core itself are clear and legible for inclusion in the photographs. Certain projects may require that fracture identification be completed prior to photography (see Section 4.4.1).
- A step-stool, ladder or scaffolding is required for the photographer to get to a suitable height above the core boxes to capture the photo.
- Consider the availability of lighting in the core shack or laboratory/warehouse where photographs are being taken. Light should be as close to full spectrum photograph backlighting as possible (or diffuse, bright light). If adequate lighting is unavailable, use flash as needed.
- Center photo vertically and horizontally in the frame of the camera. A DSLR with an adjustable LCD screen is very useful to ensure that photos are taken orthographically.
- Repeat this procedure for both dry and wet core conditions.
  - Dry photos generally capture fracture frequency and characteristics better while wet photos typically exhibit lithological variations more clearly.
  - A sprayer or bucket of water with a rag/paint brush is useful to have on hand to efficiently wet the core after taking the dry photos.
  - It is important to have a dry rag or towel on hand to "dab" the core after wetting to limit excessive shine/reflection in the photographs.

4.2.3 Core Photographs File Storage and Organization

Depending on the project, a large number of digital image files may be generated. It is important for all field staff to download, rename, file and back-up all images taken of the core daily. This is particularly important when office staff must review and evaluate core condition while the field program is ongoing. The following naming convention for all core photos (rig or off-site) is recommended:

BHID_xx.xm-xx.xm_wet/dry.jpg

4.3 INTERVAL LOGGING

The following parameters are collected for a given geotechnical depth interval.

4.3.1 Geotechnical Interval (Depth)

For basic core logging, the geotechnical depth interval is typically equal to the drill run or divided into m runs. The parameters described in Sections 4.3.2 to 4.3.6 are typically averaged over the length of the drill run or m run.

For more advanced core logging, or as required by the project (tunnel projects may be different to foundation projects etc.) or dictated by the geology, drill runs should be subdivided based on notable changes in the physical condition of the core such as rock type, strength, weathering or fracture frequency. In that way, an interval is based upon 'likeness' or similar rock. Bear in mind that a drill run (or an m run) is an arbitrary way of dividing a core which is not based on any inherent attribute of the rock. It is recommended that the minimum geotechnical interval should be 10% of the drill run length (i.e., no less than 150 mm (6") for a 1.5 m (5') drill run). If a zone less than 10% of the drill run length is observed in the core, it should be noted in the discontinuity information and/or in general comments for the interval. Figure 4-1 shows how different intervals can be applied. There is no requirement to have intervals of the same length.

Please establish with your technical project team how they would like the intervals to be determined; if some of the logging is done in the field and some in the lab it makes sense to use the same intervals and basis for logging. Note that the ISRM method is for advanced logging and that should be our default, unless budget, client requests or project specifics dictate.

This core comprises a couple of different rock types. It makes sense to have different intervals for different rock types as it can help in post-processing data. For example, we may want to give average RQD values for a rock type, and this becomes difficult if we have intervals spanning several rock types

Figure 1 Examples of Interval Logging

4.3.2 Total Core Recovery (TCR)

Total Core Recovery (TCR) is the total length of core recovered divided by the total length of borehole drilled for each drill run or geotechnical interval, presented as a percentage.

$$TCR = \left(\frac{l_{\text{sum of pieces}}}{l_{\text{tot core run}}} \right) \times 100$$

Lengths of broken core, crushed core or gouge material must be estimate as its true, in-situ, length and not as it appears in the core barrel or core box – include this in the total length recovered.

A common error with TCR is reporting values >100%. This can often occur when the core is pulled out of the whole and a small amount of over break results. It is recommended to count only up to 100% of the length drilled. If the measured length of recovered core exceeds the drilled length, apply the remainder (or over break) to the subsequent run when measuring TCR. Values should not exceed 100% in the TCR field.

Where recovery is significantly less than 100% the rock and fracture descriptions should not be extended to cover the entire run; they should only be applied to the recovered rock. Typically, non-recovered rock is either weaker or more fractured than the recovered rock and it is misleading to extend the description into non-recovered zones. Sometimes the driller can identify why core loss occurred or when in a run that the core loss happened and sometimes geophysics can help. However, if the likely depth of core loss is not identifiable, it is typically recorded as occurring at the end of a run.

4.3.3 Solid Core Recovery (SCR)

Solid Core Recovery (SCR) is defined as total length of solid core divided by the total drilled length, presented as a percentage. Solid core is defined as core with at least one full diameter.

$$SCR = \left(\frac{l_{\text{sum of solid core pieces}}}{l_{\text{tot core run}}} \right) \times 100$$

4.3.4 Rock Quality Designation (RQD)

Rock Quality Designation (RQD) is a modified core recovery that incorporates only sound (solid) pieces of core that are equal to or greater than 10 cm (4”) along the core axis. It is calculated as the total cumulative length of sound core (> 10 cm) as measured along the centerline of the core divided by the total length of borehole drilled for each drill run or geotechnical interval, presented as a percentage.

$$RQD = \frac{sum\ of\ core\ pieces \geq 10\ cm}{total\ length\ of\ drill\ run} * 100\ (\%)$$

The measurement is made along the center line of the core axis as shown in Figure 1.

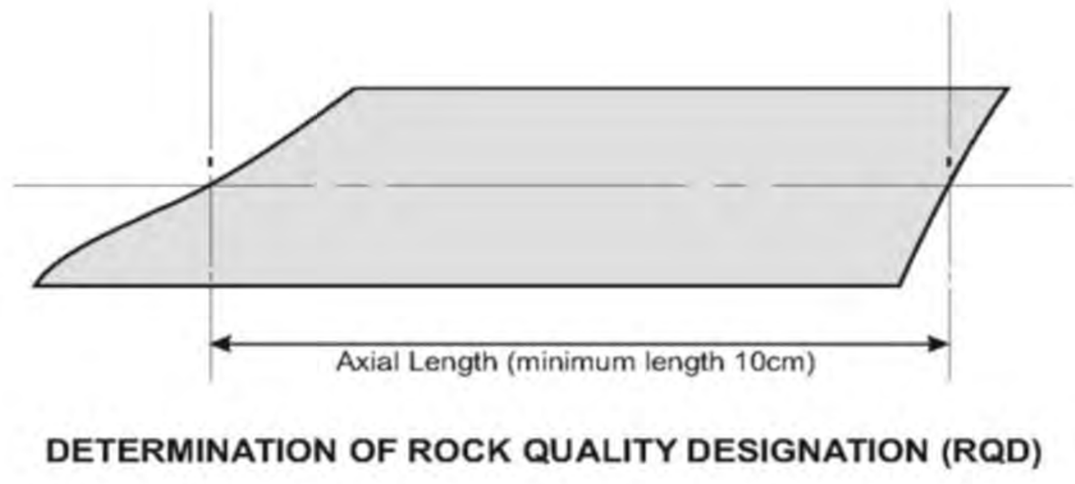


Figure 2 RQD Measurement Along Core Axis

Sound core is intact rock that has an estimated intact rock strength of weak (R2) or higher and a weathering grade of moderate (W3) or less. Very weak or highly weathered rock is not considered sound core and should not be included in the RQD calculation. Generally, RQD is not a valid index for rock quality in poorly indurated materials such as weak sedimentary units or highly altered/weathered masses; however, it is always recorded and notes on the low material strength should be added. See Sections 4.3.5 and 4.3.6 for the procedures for making strength and weathering estimates.

Mechanical breaks or drilling-induced fractures should be fitted together and the core considered intact across those breaks. The purpose of RQD is to estimate as close to in-situ conditions as possible.

High angle fractures that run along the length of the core axis should also be included in the measured length for RQD (as illustrated in Figure 4-3). Fit the longitudinal core pieces together for inclusion.

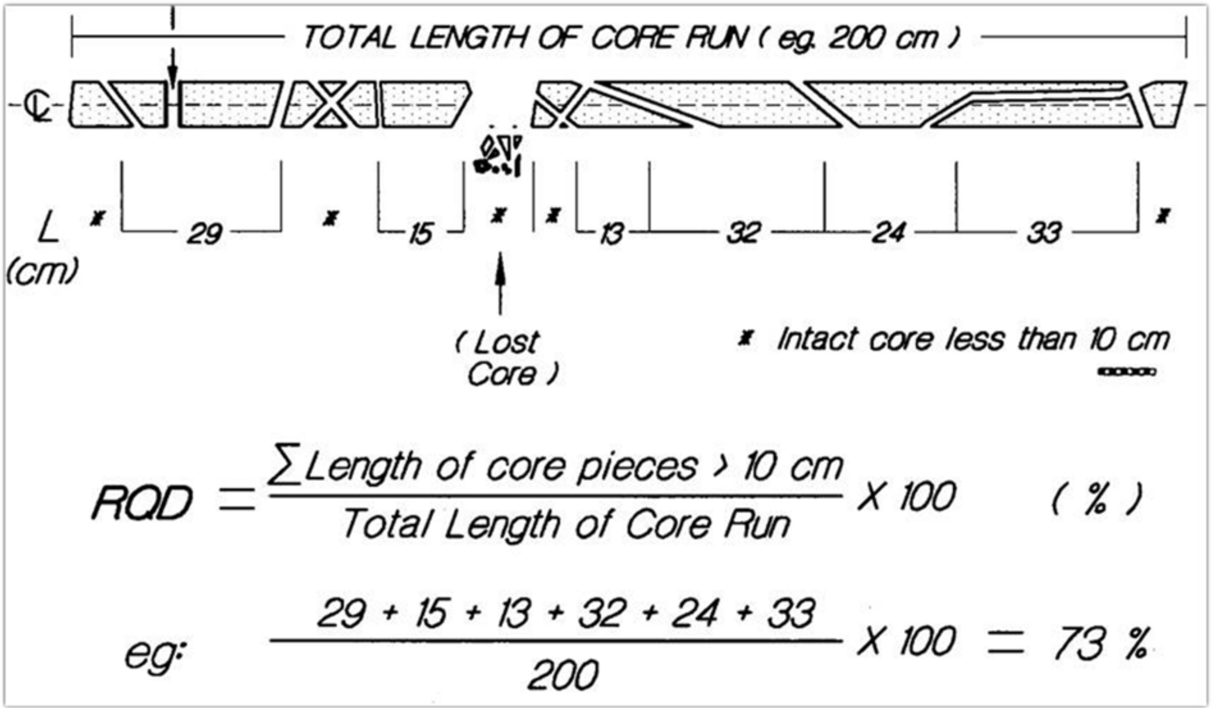


Figure 3 RQD Determination

4.3.5 TCR/SCR/RQD Comparative values

TCR is always greater than or equal to SCR which is always greater than or equal to RQD.

TCR ≥ SCR ≥ RQD

4.3.6 Fracture Index/Frequency/Fracture count

This is usually assigned in intervals, ratioed up to m long runs (fracture index) or is simply the number of fractures added up for a given interval (fracture count). Sometimes the minimum and maximum spacing is recorded instead. So long as it is clear what you are doing and recording, it doesn't matter which way you provide this attribute.

4.3.7 Strength Index

The strength index is a field estimate of intact rock strength. This estimate can be made following the procedures outlined in Table B-1 (ISRM, 1981), Appendix B, using a rock hammer and pocket knife. One estimate is typically made per drill run or geotechnical interval.

If warranted, point load tests can be performed in the field as part of the logging procedure. Point load testing should be completed in accordance with ASTM D5731-07: Determination of the Point Load Strength Index of Rocks, and Application to Rock Strength Classifications. These index tests provide a quantitative measure of intact rock strength which can support the field estimates described above and in Table B-1. Further discussion of field point load testing is provided in Section 5.0.

4.3.8 Weathering/Alteration Index

The weathering/alteration index is a categorization of the degree of degradation of the intact rock. This index can be applied using Table B-2 (ISRM, 1981), Appendix B, and provides a qualitative measure of the degree of weathering of the original intact rock material.

4.3.9 Rock Description and Rock Type

The rock type should be identified by a geologist and should be consistent with the naming used by the client if a system already exists. It is even more important to be consistent in naming geological units on a project than to be technically accurate, especially if there is more than one logger involved. This is especially helpful for categorizing units with respect to geotechnical properties and correlating them across a site. When in doubt, consult a project geologist.

Note that spacing is usually applied to the discontinuities; this should be the true spacing and if using apparent spacing it should be stated. True spacing runs perpendicular to the discontinuities and is the shortest distance between two discontinuities. Apparent spacing is the spacing as measured vertically in the core.

A couple of simple aids to rock description and rock type identification are given in Appendix B.

4.3.10 Broken Core and Fault Zones

Broken core is generally indicative of poor quality rock and, even if likely mechanical, should be noted as an indicator of rock quality and strength. It is characterized by core pieces that do not form full circumferential segments and typically consists of angular fragments. Disking, a unique form of broken core, must be noted separately and highlighted to the project engineer as this can be indicative of either high in-situ stresses or swelling potential of the rock mass.

Fault zones are areas along which there has been noticeable displacement. The rock walls are generally polished or slickensided resulting from the shear displacement. Material on either side of the fault is often shattered, crushed, altered, or weathered resulting in infillings such as breccia and gouge. Fault width can range anywhere from a few millimeters to meters in width.

Broken core and fault zones should be recorded at exact depths.

4.4 DISCONTINUITY LOGGING

Logging of individual discontinuities is typically completed during advanced core logging and is generally required on projects that require detailed rock engineering such as large surface excavations or underground excavations such as tunnels, HDD and mine workings.

4.4.1 Natural vs. Mechanical Fractures

The first, and most important, step in core logging is the determination of natural and mechanical (drill or impact induced) fractures. These can be challenging to confidently identify, therefore, when in doubt, consider the fracture natural. This will provide conservative estimates of rock quality, unless the issue is one of excavatability where overestimating the fractures could be unconservative.

Mechanical fractures are characteristically clean, fresh with irregular surfaces and oriented close to 90º to the core axis. These fractures can often be put back together with only the finest, hairline separation. For labeling the core, mechanical breaks are marked by with an X that intersects the fracture with a consistently coloured marker/crayon chosen for the project.

Natural fractures are often stained, weathered, contain infilling or coatings and occur at a variety of angles with respect to the core axis. When labeling the core directly, natural fractures are identified by drawing two parallel lines across either side of the fracture in a colour chosen for the project.

Labeling the natural and mechanical fractures of the core is particularly useful for high resolution core photography as well as re-handling of the core boxes as any additional mechanical breaks will be obvious due to their lack of marking.

4.4.2 Depth

The depth of each discontinuity (fracture, fault) should be recorded and shown on the log. For fractures that are steeply inclined with respect to the core axis, the depth of the feature along the centerline of the core axis is to be recorded.

4.4.3 Discontinuity Type

The type of discontinuity should be identified as one of the following:

- Bedding (S_o) — A discontinuity associated with laminar sedimentary processes
- Fault (FLT) — A major structural feature characterized by broken core or breccia, clay, silt, or sand gouge. See section 4.3.8 for more details.
- Foliation (FOL) — A preferential direction of structural weakness in the rock due to alignment of minerals during metamorphism
- Fracture (F) — A discontinuity of uncertain origin (i.e., possible mechanical break)
- Joint (JN) — A natural discontinuity with no evidence of previous shear movement
- Vein (VN) — An open discontinuity infilled by a mineral such as quartz, calcite, etc.

4.4.4 Dip with Respect to Core Axis

Measure and record the dip angle or range of angles for fractures noted along the core length. The dip angle is measured with respect to the core axis where 0º = parallel to the core axis and 90º = perpendicular (for vertical boreholes). If you are logging inclined holes you should contact your local rock engineering specialist to ensure you record the angles correctly. Note that dip with respect to core axis is different from the dip angle of a discontinuity.

Note that fracture angles and attributes (Section 4.4.5) should not be lumped together to produces averages for a given run or interval. The information may be used in design and important information can be lost this way.

4.4.5 Surface Condition

4.4.5.1 SHAPE AND ROUGHNESS (JR)

The shape of a fracture is given by the geometry of the fracture at the scale of the rock core. It is typically described using the following terminology:

- Planar
- Undulating
- Stepped
- Curved, or
- Irregular

Joint roughness categorizes the micro-scale “feel” of the joint and is generally described as:

- Slickensided or polished
- Smooth
- Slightly rough
- Rough, or
- Very rough

Visual examples of the above-noted shapes and textures are provided for reference in Table B-3, Appendix B. The Q-system, a rock mass classification system developed by NGI, uses the parameter Jr (joint roughness) to quantify the shape and roughness of joints. Determination of Jr is described in Table B-7 (NGI, 2013), Appendix B.

4.4.5.2 Staining, Alteration, Infill (Ja)

The nature of material that stains, coats or infills a joint surface should be recorded. This information is particularly important for the determination of friction angle along a given joint or joint set.

• None	Clean, unaltered, unstained fracture walls
• Partially Coated	Partial thin coverage which coats, but does not fill in the small scale pits in the roughness; some areas of the joint surface are softer than the wall rock
• Completely Coated	Complete thin coverage which coats the surface, but does not fill in the roughness or prevent the hard rock walls from touching each other
• Filled	Infill material is thick enough to fill in all the pits in the surface roughness. The two hard wall rock surfaces may or may not be completely separated with a layer of soft material. Additional information should be recorded.

Further information on joint infill character and aperture descriptions is provided in Tables B-4 and B-5, Appendix B.

The Q-system similarly uses the parameter Ja (joint alteration) to quantify the nature of the joint surface and infill type. Determination of Ja is described in Table B-8 (NGI, 2013), Appendix B.

4.4.5.3 Joint Condition Rating (JCR, RMR76)

Joint Condition Rating (JCR) is the primary joint condition parameter for the RMR rock mass classification system. JCR combines surface shape/roughness and infill/aperture character in a single value. Details on the method for determining JCR are provided in Table B-6 and Figures B-1 and B-2 in, Appendix B.

4.4.5.4 Joint wall compressive strength (JCS)

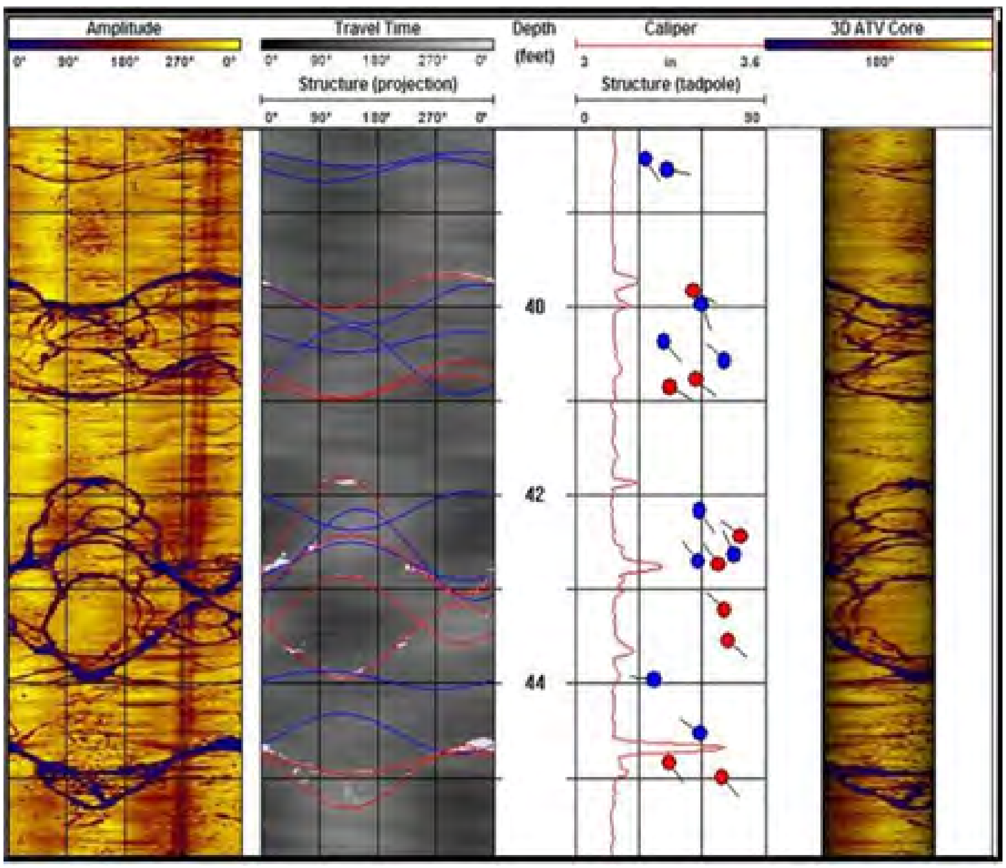
It can be useful to assign a strength grade to the joint wall for projects where the shear strength of discontinuities is important. Later, Barton's relationship can determine the shear strength of a rock joint, using JRC and JCS:

$$\tau = \sigma_n \tan\left[\phi_b + JRC \log_{10}\left(\frac{JCS}{\sigma_n}\right)\right]$$

The joint wall compressive strength can be expressed as a modifier to the rock intact compressive strength. The joint wall compressive strength (JWCS) modifier is a measure of how the strength of the joint wall compares to the intact strength of the rock and is based on the Field strength grades. The JWCS modifier is positive if the strength of the wall rock is stronger that the intact rock and negative if the strength is weaker. For instance, if the intact rock is medium strong (R3) and the joint wall is weak to medium strong (R2.5) the JWCS modifier would be -0.5. Note that the JWCS modifier is assigned a value of 0 if the joint wall and intact strength are the same.

4.5 CALIBRATION WITH TELEVIEWING

Televiewing (typically acoustic but sometime optical) is becoming more common and is used when orientation information about fractures is required. As televiewers record the wall rather than the core, they do not over-estimate the fractures as much as a core does. If televiewing has been undertaken it is worth calibrating the core (and particularly fractures described in the core) with the televiewer logs. It makes sense to do this at the same time as the logging and doing it this way means it is easier to discern natural rather than drilling induced fractures. Calibrating core with televiewer data means that fewer discontinuities should be described and so it can save time as well as provide orientation data and a truer representation of the



fracturing in the rock. Typically, the televiewer log would be open on a screen and viewed as the core is being logged.

An example televiewer log is shown in Figure 4-4.

Figure 4 Example Televiewer Log

5.0 FIELD STRENGTH TESTING

Depending on the project requirements, point load testing at regular intervals along the borehole length to develop an intact rock strength model many be required. Point load testing should be completed in accordance with ASTM D5731-07: Determination of the Point Load Strength Index of Rocks, and Application to Rock Strength Classifications.

Point load testing is a quick and simple test that can be completed as part of the core logging procedure. It is important to log all point load tests on the appropriate field test form (see Appendix A) and replace the sample into the core box after testing, if possible, clearly labelled as a point load (PL) test sample.

6.0 SAMPLE COLLECTION/SHIPMENT

Rock core samples may be collected for advanced testing such as: unconfined compressive strength (UCS), tensile strength, direct shear, drillability indices, etc. It is recommended that samples be a minimum of 2.5x the core diameter in length and free of defects. Samples are to be as representative of the intact rock mass as possible.

The project requirements will define the frequency of sample collection and nature of samples to be collected. All samples should be recorded and separators should be placed into the core box to fill the remaining space. Information to be included in the sample log is: borehole ID, depth, length, rock type and requested testing.

Samples should be labelled directly on the core with black permanent marker with the above-noted information. Where labeling directly on the core is not possible, a water- and tear-proof label should be included with the sample and affixed to it.

To preserve the integrity of the sample during shipment, samples should be wrapped in plastic stretch wrap to preserve natural moisture content, if possible, and then wrapped in bubble wrap and tape. Further labeling of the wrapped sample is recommended.

7.0 REFERENCES

Barton, N., Lien, R., Lunde, J.,1974, Engineering classification of rock masses for the design of tunnel support. Rock Mechanics, 6, (4), pp. 189-236.

Bieniawski. 1989. Engineering Rock Mass Classifications. John Wiley & Sons.

Brown, 1981. Rock Characterization Testing and Monitoring: ISRM Suggested Methods. International Society for Rock Mechanics.

Deere, D., 1989. Rock Quality Designation (RQD) after twenty years. Rocky Mountain Consultants Inc. Report to U.S. Army Corps of Engineers.

APPENDIX A

Field Guide for Rock Core Logging

Stantec FIELD GUIDE FOR ROCK CORE LOGGING

STEP 1

IDENTIFY DISCONTINUITIES AND LABEL CORE

- NATURAL FRACTURES: MARK WITH SINGLE STRIKE PERPENDICULAR ACROSS JOINT
- DEPTH: MARK DEPTH INTERVAL AT TOP AND BOTTOM OF RUN

STEP 2

PHOTOGRAPH CORE

PHOTOGRAPH NORMAL PERPENDICULAR TO CORE

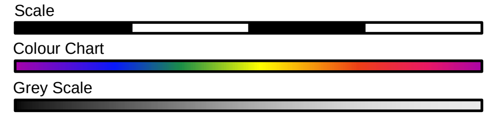
BASIC (RIG) PHOTOGRAPH:

- PHOTOGRAPH EACH RUN IMMEDIATELY (WET/DRY)

DETAILED PHOTOGRAPH:

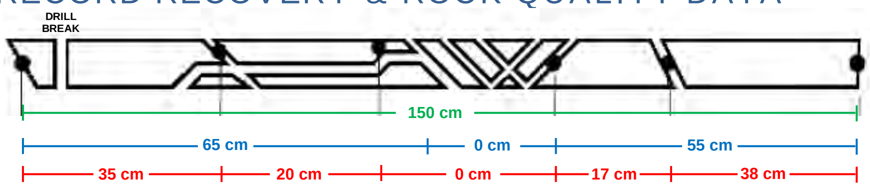
- GROUP CORE BOXES, POSSIBLE

Proj. Name: __________ Proj. No.:
Borehole ID: __________ Date:
Box: ______ Depth From: ______ To:



STEP 3

RECORD RECOVERY & ROCK QUALITY DATA



TCR = [150/150]*100 = 100%
SCR = [120/150]*100 = 80%
RQD = [110/150]*100 = 73%

Total Core Recovery: [Sum of total pieces (including non-intact core) / core run]*100
Solid Core Recovery: [Sum of total pieces (excluding non-intact core) / core run]*100
Rock Quality Designation: [Sum of total core pieces > 10 cm in length / core run]*100

USE DRILLER'S INTERVALS TO CALCULATE > SUBDIVIDE GEOTECHNICAL INTERVALS AS REQUIRED (MIN. 0.5 m)

STEP 4

DESCRIBE ROCK CORE

Description to include the following (in this order): **Quality > Spacing > Colour > Weathering > Strength > Rock Type**

Quality

RQD DESCRIPTION:
0 – 25 = Very Poor;
26 – 50 = Poor;
51 – 75 = Fair;
76 – 90 = Good;
91 – 100 = Excellent

Joint/Bedding Spacing

SPACING (mm)	DISCONTINUITY	BEDDING/LAMINATIONS/BANDS
>6000	EXTREMELY WIDE	-
2000 – 6000	VERY WIDE	VERY THICK
600 – 2000	WIDE	THICK
200 – 600	MODERATE	MEDIUM
60 – 200	CLOSE	THIN
20 – 60	VERY CLOSE	VERY THIN
< 20	EXTREMELY CLOSE	LAMINATED
<6	-	THINLY LAMINATED

Colour

IS MATRIX FRESH?
- YES → **MATRIX COLOUR** List dominant first
- NO → DISCOLOURATION DUE TO OXIDATION?
  - YES → **OXIDIZED COLOUR**
  - NO → **SECONDARY COLOUR(S)**

Note distribution & occurrence

Weathering

GRADE/CLASSIFICATION		DESCRIPTION
W1	FRESH	NO VISIBLE SIGNS OF WEATHERING
W2	SLIGHTLY	DISCOLORATION, WEATHERING ON DISCONTINUITIES
W3	MODERATELY	<50% OF ROCK MATERIAL IS DECOMPOSED; FRESK CORE STONES
W4	HIGHLY	>50% DECOMPOSED TO SOIL; FRESH CORE STONES
W5	COMPLETELY	100% DECOMPOSED TO SOIL; ORIGINAL STRUCTURE INTACT
W6	RESIDUAL SOIL	ALL ROCK CONVERTED TO SOIL, STRUCTURE AND FABRIC DESTROYED

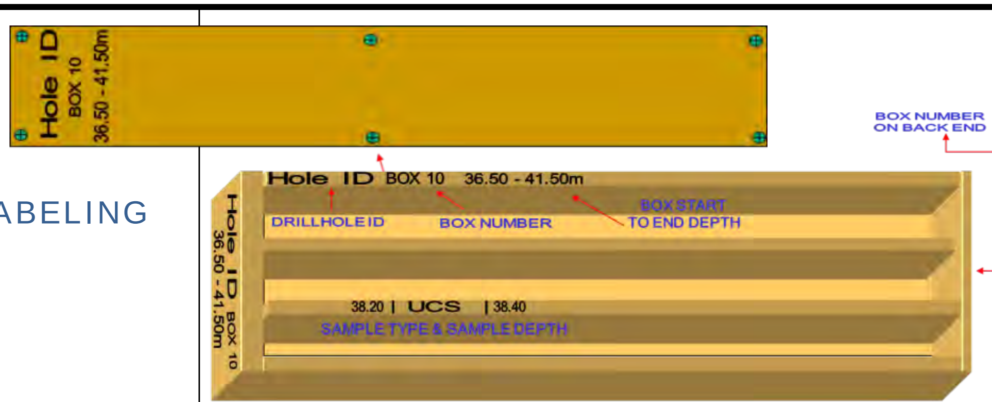
Strength

GRADE/CLASSIFICATION		DESCRIPTION	EST. STRENGTH (MPa)
R0	EXTREMELY WEAK	INDENTED BY THUMBNAIL	0.25 – 1.0
R1	VERY WEAK	CRUMBLES UNDER FIRM BLOWS AND WITH POINT OF GEOLOGICAL HAMMER, PEELED WITH KNIFE	1.0 – 5.0
R2	WEAK	PEELED BY KNIFE WITH DIFFICULTY, SHALLOW INDENTATIONS WITH POINT OF HAMMER	5.0 – 25.0
R3	MEDIUM STRONG	CANNOT BE SCRAPED OR PEELED WITH KNIFE, CAN BE FRACTURED WITH SINGLE FIRM BLOW OF GEOL. HAMMER	25.0 – 50.0
R4	STRONG	MORE THAN ONE BLOW TO FRACTURE	50.0 – 100.0
R5	VERY STRONG	MANY BLOWS TO FRACTURE	100.0 – 200.0
R6	EXTREMELY STRONG	CAN ONLY BE CHIPPED WITH GEOLOGICAL HAMMER	>250.0

Rock Type	DEVELOP “LIBRARY” OF ROCKS SPECIFIC TO PROJECT INCLUDE FORMAL GEOLOGIC NAME OF UNIT/FORMATION, IF KNOWN AT A MINIMUM, IDENTIFY GENERAL ROCK TYPE AND DESCRIBE THOROUGHLY **IGNEOUS – METAMORPHIC – SEDIMENTARY**

STEP 5

CORE BOX LABELING



STEP 6

DETAILED CORE LOGGING (AS REQUESTED BY PM/TECHNICAL LEAD)

DETAILED DISCONTINUITY DESCRIPTIONS

FOR EACH DISCONTINUITY, RECORD DEPTH AND THE FOLLOWING PARAMETERS:
SEE AVAILABLE DETAILED FLOW-CHART FIELD GUIDES FOR Ja, Jr, Jn and JRC PARAMETERS

Type

BD	BEDDING
JN	JOINT
FOL	FOLIATION
CON	CONTACT
FLT	FAULT
VN	VEIN

Infill

PARTIALLY COATED

COMPLETED COATED

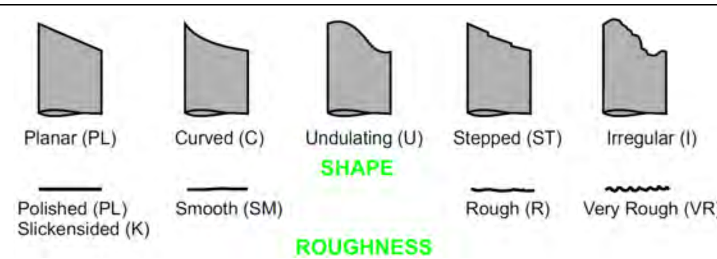
FILLED

Joint Number (Jn)

Jn	DESCRIPTION
0.5 – 1.0	MASSIVE, NO OR FEW JOINTS ONE JOINT SET (PLUS RANDOM)
2 (3)	TWO JOINT SETS (PLUS RANDOM)
4 (6)9 (12)	THREE JOINT SETS (PLUS RANDOM)
15	FOUR OR MORE JOINT SETS, RANDOM HEAVILY JOINTED
20	CRUSHED ROCK

Joint Roughness (Jr)

Jr	DESCRIPTION
4.0	DISCONTINUOUS JOINTS
3.0	ROUGH, IRREGULAR, UNDULATING
2.0	SMOOTH, UNDULATING
1.5	SLICKENSIDED, UNDULATING
1.5	ROUGH OR IRREGULAR, PLANAR
1.0	SMOOTH, PLANAR
0.5	SLICKENSIDED, PLANAR



Joint Alteration (Ja)

Ja	DESCRIPTION
0.75	TIGHTLY HEALED, HARD, NON-SOFTENING, IMPERMEABLE
1.0	UNALTERED, STAINING ONLY
2.0	SLIGHTLY ALTERED, NON-SOFTENING MINERAL COATINGS, SANDY PARTICLES
3.0	SILTY OR SANDY-CLAY COATINGS
4.0	SOFTENING OR LOW FRICTION CLAY MINERAL COATINGS
4.0	SANDY PARTICLES, CLAY-FREE DISINTEGRATED ROCK
6.0	STRONGLY OVER CONSOLIDATED, NON-SOFTENING CLAY MINERAL FILLINGS (< 5 mm)
8.0	MEDIUM OR LOW OVER-CONSOLIDATION, SOFTENING, CLAY MINERALS (5 mm thick)
8.0 – 12.0	SWELLING CLAY FILLINGS
5.0	ZONES OF BANDS OF SILTY, SANDY CLAY (non-softening)
8.0 – 12.0	ZONES/BAN DS OF CRUSHED ROCK AND CLAY
10.0 – 13.0	THICK BANDS OF CLAY – NON-SOFTENING
13.0 – 20.0	THICK BANDS OF CLAY – SOFTENING

RMR Joint Condition Rating (76) (JCR)

JCR	DESCRIPTIONS
26	VERY ROUGH SURFACE, NOT CONTINUOUS, NO SEPARATION, HARD JOINT WALL ROCK
20	SLIGHTLY ROUGH SURFACES, SEPARATION < 1 mm, HARD JOINT WALL ROCK.
12	SLIGHTLY ROUGH SURFACE SEPARATION < 1 mm, SOFT JOINT WALL ROCK.
6	SLIGHTLY ROUGH SURFACES OR GOUGE <5 mm, OR JOINTS OPEN 1-5 mm, CONTINUOUS JOINTS.
0	SOFT GOUGE > 5 mm THICK OR JOINTS OPEN > 5 mm, CONTINUOUS JOINTS.

APPENDIX B

Field Forms and Templates

Field Borehole Record

(Daily Log)

Client:	Stn Project No.:
Project:	Borehole No.:
Drilling Contractor:	Sheet No.: of

Weather & Temperature:	Casing Size:	Hole Started:	Date:	Time:
STN Rep.:	Auger Type: N/A	Hole Finished:	Date:	Time:
Grd Surf El. Datum	Water Level:	Water Level:	Date:	Time:

LOG: FILL; M SILT; G GRAVEL; CL CLAY; S SAND; BEDROCK

(1) SAMPLE TYPE: SPLIT SPOON SS; SHELBY TUBE ST; ROCK CORE RC; AUGER SAMPLE AS; OTHER ___________

(2) SAMPLE SIZE: DIAMETER FOR SS & ST; BX, NX, ETC. FOR RC

NOTES & SAMPLE DESCRIPTION: Sample No., rock quality, colour, strength, weathering, rock type, changes in rock type, wash water colour and loss, insitu testing, drilling details, etc.	LOG	DEPTH	SAMPLES FROM TO	SIZE	NO.	TCR	SCR	RQD	STRATIGRAPHIC DESCRIPTION (Include generalized description of strata, and show boundaries)

HOURS DRILLING	TOTAL TO DATE	DIAMONDS
HOURS NON-DRILLING	TOTAL TO DATE	WATER LEVEL DURING DRILLING

FIELD BOREHOLE RECORD OF ROCK CORE DRILLING

CLIENT ______ DATUM: ______ PAGE 1 OF ______

PROJECT ______ ELEVATION (m): ______ PROJECT No. ______

LOCATION ______ INCLINATION: ______ COORDINATES: N ______ E ______

TECHNICIAN/ENGINEER: ______ AZIMUTH: ______ DATE: (mm-dd-yy): ______

DRILLING CONTRACTOR: ______ DRILL RIG: ______ SIZE: ______ BOREHOLE No.: ______

DEPTH (m)	RUN No.	CORE RECOVERY				FAULT BRECCIA/GOUGE	BROKEN CORE	ADDITIONAL TESTING	STRENGTH		STRATA PLOT	DISCONTINUITY DATA							DESCRIPTION
		TOTAL CORE RECOVERY, TCR	SOLID CORE RECOVERY, SCR	ROCK QUALITY DESIGNATION, RQD	FRACTURES PER M				WEATHERING INDEX	STRENGTH INDEX		DEPTH (m)	TYPE	DIP WRT CORE AXIS	JOINT ROUGHNESS (Jr)	JOINT ALTERATION (Ja)	JOINT SET No. (Jn)	JOINT CONDITION (JCR)	

121614000_LOG_TEMPLATE2.DWG

FIELD BOREHOLE RECORD OF ROCK CORE DRILLING

BOREHOLE No: ______________ PROJECT No: ______________ PAGE ______ OF ______

DEPTH (m)	RUN No.	CORE RECOVERY				FAULT BRECCIA/GOUGE	BROKEN CORE	ADDITIONAL TESTING	STRENGTH		STRATA PLOT	DISCONTINUITY DATA							DESCRIPTION
		TOTAL CORE RECOVERY, TCR	SOLID CORE RECOVERY, SCR	ROCK QUALITY DESIGNATION, RQD	FRACTURES PER M				WEATHERING INDEX	STRENGTH INDEX		DEPTH (m)	TYPE	DIP WRT CORE AXIS	JOINT ROUGHNESS (Jr)	JOINT ALTERATION (Ja)	JOINT SET No. (Jn)	JOINT CONDITION (JCR)	

12161400_LOG_TEMPLATE2.DWG

POINT LOAD TEST RECORD

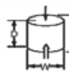
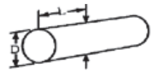
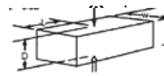
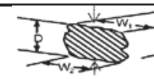
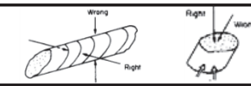
(ASTM D5731-08)

Sheet ___ of ___

Project No.: ____________ **Project:** ____________ **Location:** ____________

Date: ____________ **Test Device:** ____________ **Tested By:** ____________

Calibration Date: ____________ **Test Device Conversion Factor (eg. Failure Load, $L = P \times 9.48 \times 10^{-4}$ m²):** ____________

[1]Test Type:	**(A)** axial 0.3W<D<W 	**(D)** diametral L > 0.5D 	**(B)** block 0.3W<D<W L > 0.5D 	ular lump D<W L > 0.5D  W=(W1+W2)/2	⊥ perpendicular to plane of weakness // parallel to plane of weakness **(s)** saw-cut **(c)** chisel split
[2]Break Validity:	**Valid:** 			**Invalid:** 	Loading Directions for Anisotropic Rock: 

Test Specimen (Test hole/Sample #)	Sample Depth [ ]	[1]Test Type and Sample Preparation	Sample Length [ ]	Core Diameter [ ]	F. Gauge Reading, P [ ]	[2]Break Validity [Y/N]	Additional Notes *(Specimen preparation, specimen description/rock type, validity of break, etc.)*

APPENDIX C

Field Classification Reference Sheets

TABLE C-1: INTACT MATERIAL (ROCK AND SOIL) STRENGTH CLASSIFICATION (MODIFIED FROM: ISRM, 1981)

Description	Grade	Field Identification	Approx. Range of Uniaxial Compressive Strength (MPa) and (psi)
Granular Soil	G	Cohesionless, friable, granular soil, sand.	0
Very Soft Clay	S1	Easily penetrated several centimetres by fist.	< 0.025
Soft Clay	S2	Easily penetrated several centimetres by thumb.	0.025 – 0.05
Firm Clay	S3	Can be penetrated several centimetres with thumb with moderate effort. Crumbles under light pressure from a nail.	0.05 – 0.1 (< 1.0 on pocket penetrometer)
Stiff Clay	S4	Readily indented by thumb, but penetrated only with great effort. Crumbles under moderate pressure from a nail.	0.10 – 0.25 (1.0 to 2.5 on pocket penetrometer)
Very Stiff Clay	S5	Readily indented by thumbnail.	0.25 – 0.50
Hard Clay	S6	Indented with difficulty by thumbnail.	> 0.50
Extremely Weak Rock	R0	Indented by thumbnail.	0.25 – 1.0 (> 2.5 on pocket penetrometer)
Very Weak Rock	R1	Crumbles under firm blows with point of geological hammer, can be peeled by a pocket knife.	1.0 – 5.0 (pocket penetrometer does not indent)
Weak Rock	R2	Can be peeled by a pocket knife with difficulty, shallow indentations made by firm blow with point of geological hammer.	5 – 25
Medium Strong Rock	R3	Cannot be scraped or peeled with a pocket knife, specimen can be fractured with single firm blow of geological hammer.	25 – 50
Strong Rock	R4	Specimen requires more than one blow of geological hammer to fracture it.	50 – 100
Very Strong Rock	R5	Specimen requires many blow of geological hammer to fracture it.	100 – 250
Extremely Strong Rock	R6	Specimen can only be chipped with geological hammer.	> 250

Reference: Brown, 1981, “Rock Characterisation Testing and Monitoring: ISRM Suggested Methods”, International Society for Rock Mechanics.

TABLE C-2: WEATHERING/ALTERATION CLASSIFICATION

Symbol	Term	Description	Discolouration Extent	Fracture Condition	Surface Characteristics
W1/A1	Fresh	No visible sign of rock material weathering.	None	Closed or Discoloured	Unchanged
W2/A2	Slightly Weathered or Altered	Discolouration indicates weathering of rock material on discontinuity surfaces. Less than 5% of rock mass altered.	Less than 20% of fracture spacing on both sides of fracture.	Discoloured; may contain thin filling.	Partial discolouration
W3/A3	Moderately Weathered or Altered	Less than 50% of the rock material is decomposed and/or disintegrated to a soil, or altered. Fresh or discoloured rock is present either as a discontinuous framework or as core stones.	Greater than 20% of fracture spacing on both sides of fracture.	Discoloured, may contain thick filling.	Partial to complete discolouration, not friable except poorly cemented rocks.
W4/A4	Highly Weathered or Altered	More than 50% of the rock material is decomposed and/or disintegrated to a soil or is altered. Fresh or discoloured rock is present either as a discontinuous framework or as core stones.	Throughout	Filled with alteration minerals.	Friable and possibly pitted
W5/A5	Completely Weathered or Altered	100% of rock material is decomposed and/or disintegrated to soil or 100% of minerals have been replaced with alteration minerals. The original mass structure is still largely intact	Throughout	Filled with alteration minerals.	Resembles soil, or all original minerals have been replaced with alteration minerals.
W6	Residual Soil (applies to weathering only)	All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported.	Throughout	N/A	Resembles soil

Reference: Brown, 1981, “Rock Characterisation Testing and Monitoring: ISRM Suggested Methods”, International Society for Rock Mechanics

TABLE C-3: FRACTURE SHALE AND ROUGHNESS

Fracture Shape	Fracture Roughness
Planar – PL	Slickensided – K
Curved – C	Polished – PO
Undulating – UN	Smooth – SM
Stepped – ST	Rough – R
Irregular - IR	Very Rough - VR

TABLE C-4: FRACTURE INFILLING CHARACTER

Character	Symbol	Description
None	n/a	Clean, unaltered, unstained fracture walls.
Partially Coated	PC	Partial thin coverage (≤ 2 mm) which coats, but does not fill in the small scale pits in the roughness; some areas of the joint surface are softer than the wall rock.
Completely Coated	CC	Complete thin coverage (≤ 1 mm) which coats the surface, but does not fill in the roughness or prevent the hard rock walls from touching each other.
Filled	IN	Infill material is thick enough to fill in all the pits in the surface roughness (> 1 mm). The two hard wall rock surfaces may or may not be completed separated with a layer of soft material. Additional information should be recorded.

TABLE C-5: THICKNESS / APERTURE DESCRIPTION (ISRM)

Thickness/Aperture	Description	General Terminology
< 0.1 mm	Very Tight	"Closed" Features
0.1 – 0.25 mm	Tight	
0.25 – 0.5 mm	Partly Open	
0.5 – 2.5 mm	Open	"Gapped" Features
2.5 – 10 mm	Moderately Wide	
> 10 mm	Wide	
1 – 10 cm	Very Wide	"Open" Features
10 – 100 cm	Extremely Wide	
> 1 m	Cavernous	

TABLE C-6: JOINT CONDITION RATING (JCR) (RMR_{76})

Discontinuity Description					JCR Rating
Infilled	Soft gouge or soft infill > 5 mm				0
	Infill > 1 mm to 5 mm or slickensided or polished surfaces				6
Completely coated ≤ 1 mm					12
Not Infilled	Clean, Stained, Slightly Altered or Partially Coated	Planar Surface	Smooth	Slightly Altered or Partially Coated	12
				Clean or Stained	16
			Rough	Slightly Altered or Partially Coated	16
				Clean or Stained	20
			Very Rough	Slightly Altered or Partially Coated	20
				Clean or Stained	22
		Wavy Surface	Smooth	Slightly Altered or Partially Coated	16
				Clean or Stained	20
			Rough	Slightly Altered or Partially Coated	20
				Clean or Stained	22
			Very Rough	Slightly Altered or Partially Coated	20
				Clean or Stained	25

TABLE C-7: BIENIAWSKI 1976 RMR PARAMETER RATINGS

<table>
<tr><th colspan="3">Parameter</th><th colspan="7">Range of values</th></tr>
<tr><td rowspan="2">1</td><td rowspan="2">Strength of intact rock material</td><td>Point-load strength index</td><td>> 8 MPa</td><td>4 – 8 MPa</td><td>2-4 MPa</td><td>1-2 MPa</td><td colspan="3">For this low range, uniaxial compressive test is preferred</td></tr>
<tr><td>Uniaxial compressive strength</td><td>> 200 MPa</td><td>100 – 200 MPa</td><td>50-100 MPa</td><td>25-50 MPa</td><td>10-25 MPa</td><td>3-10 MPa</td><td>1-3 MPa</td></tr>
<tr><td></td><td colspan="2">Rating</td><td>15</td><td>12</td><td>7</td><td>4</td><td>2</td><td>1</td><td>0</td></tr>
<tr><td>2</td><td colspan="2">Drill core quality RQD</td><td>90-100%</td><td>75-90%</td><td>50-75%</td><td>25-50%</td><td colspan="3"><25%</td></tr>
<tr><td></td><td colspan="2">Rating</td><td>20</td><td>17</td><td>13</td><td>8</td><td colspan="3">3</td></tr>
<tr><td>3</td><td colspan="2">Spacing of joints</td><td>> 3 m</td><td>1-3 m</td><td>0.3-1 m</td><td>50-300 mm</td><td colspan="3">< 50 mm</td></tr>
<tr><td></td><td colspan="2">Rating</td><td>30</td><td>25</td><td>20</td><td>10</td><td colspan="3">5</td></tr>
<tr><td>4</td><td colspan="2">Condition of Joints (JCR)</td><td>Very rough surfaces. Not continuous. No separation. Hard joint wall contact.</td><td>Slightly rough surfaces. Separation < 1 mm. Hard joint wall contact.</td><td>Slightly rough surfaces. Separation < 1 mm. Soft joint wall contact.</td><td>Slickensided surfaces OR Gouge < 5 mm thick. Joints open 1-5 mm. Continuous joints.</td><td colspan="3">Soft gouge> 5 mm thick OR Joints open > 5 mm. Continuous joints.</td></tr>
<tr><td></td><td colspan="2">Rating</td><td>25</td><td>20</td><td>12</td><td>6</td><td colspan="3">0</td></tr>
</table>

TABLE B-8: RMR CALIBRATED AGAINST ROCK MASS QUALITY

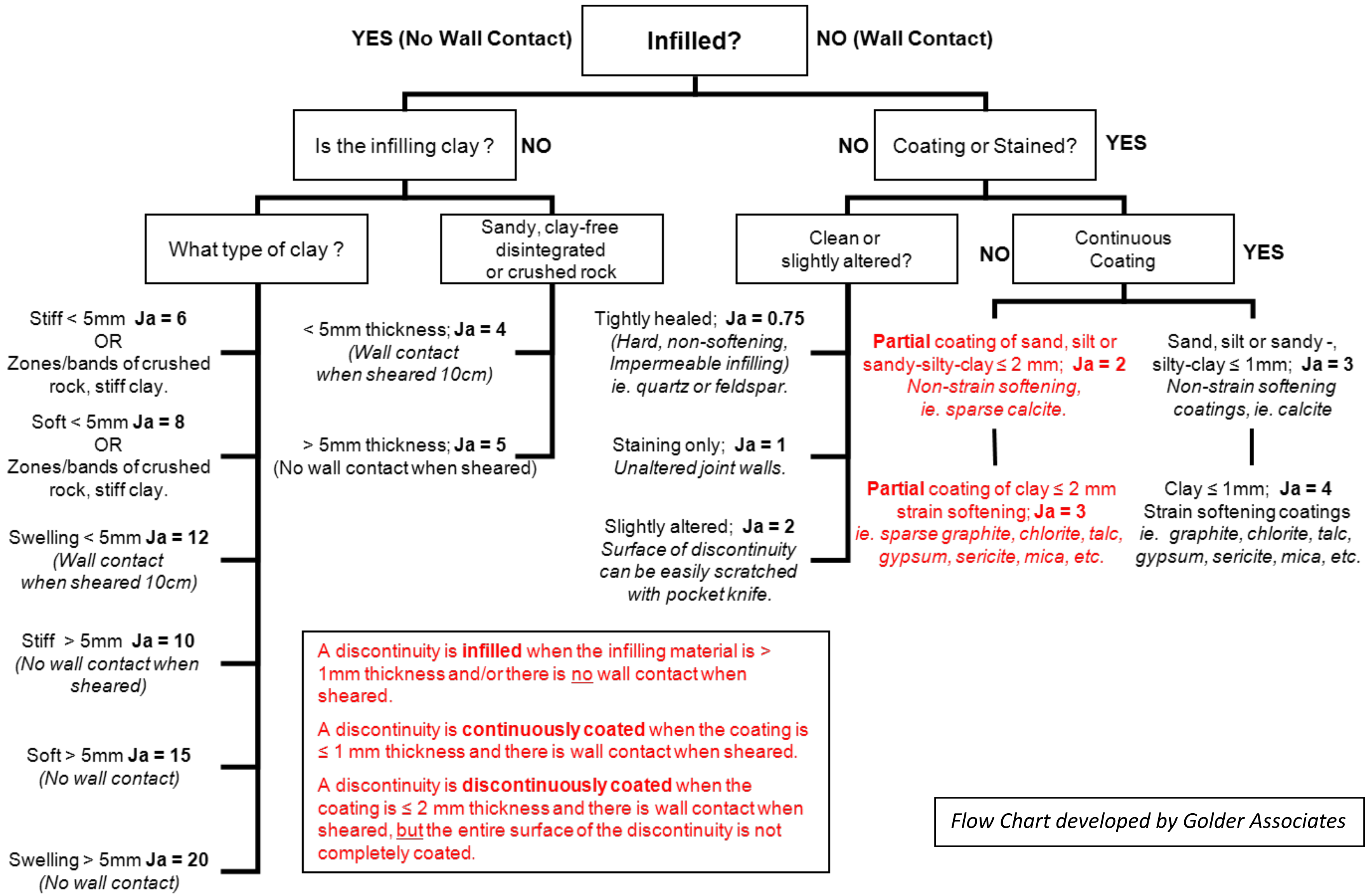
RMR Rating	Description
81-100	Very good rock
61-80	Good rock
41-60	Fair rock
40-21	Poor rock
< 21	Very poor rock

TABLE C-9: RATING GUIDE FOR JOINT SET NUMBER (JN, Q-SYSTEM)

Parameter	Item and Description	Value
Joint Set Number (Jn)	Massive	0.5
	One or two randomly oriented joints	1
	One discontinuity set	2
	One discontinuity set plus randomly oriented joints	3
	Two discontinuity sets	4
	Two discontinuity sets plus randomly oriented joints	6
	Three discontinuity sets	9
	Three discontinuity sets plus randomly oriented joints	12
	Four discontinuity sets	15
	Crushed Rock	20

Reference: Barton, N., Lien, R., Lunde, J., 1974, Engineering classification of rock masses for the design of tunnel support. Rock Mechanics, 6, (4), pp. 189-236.

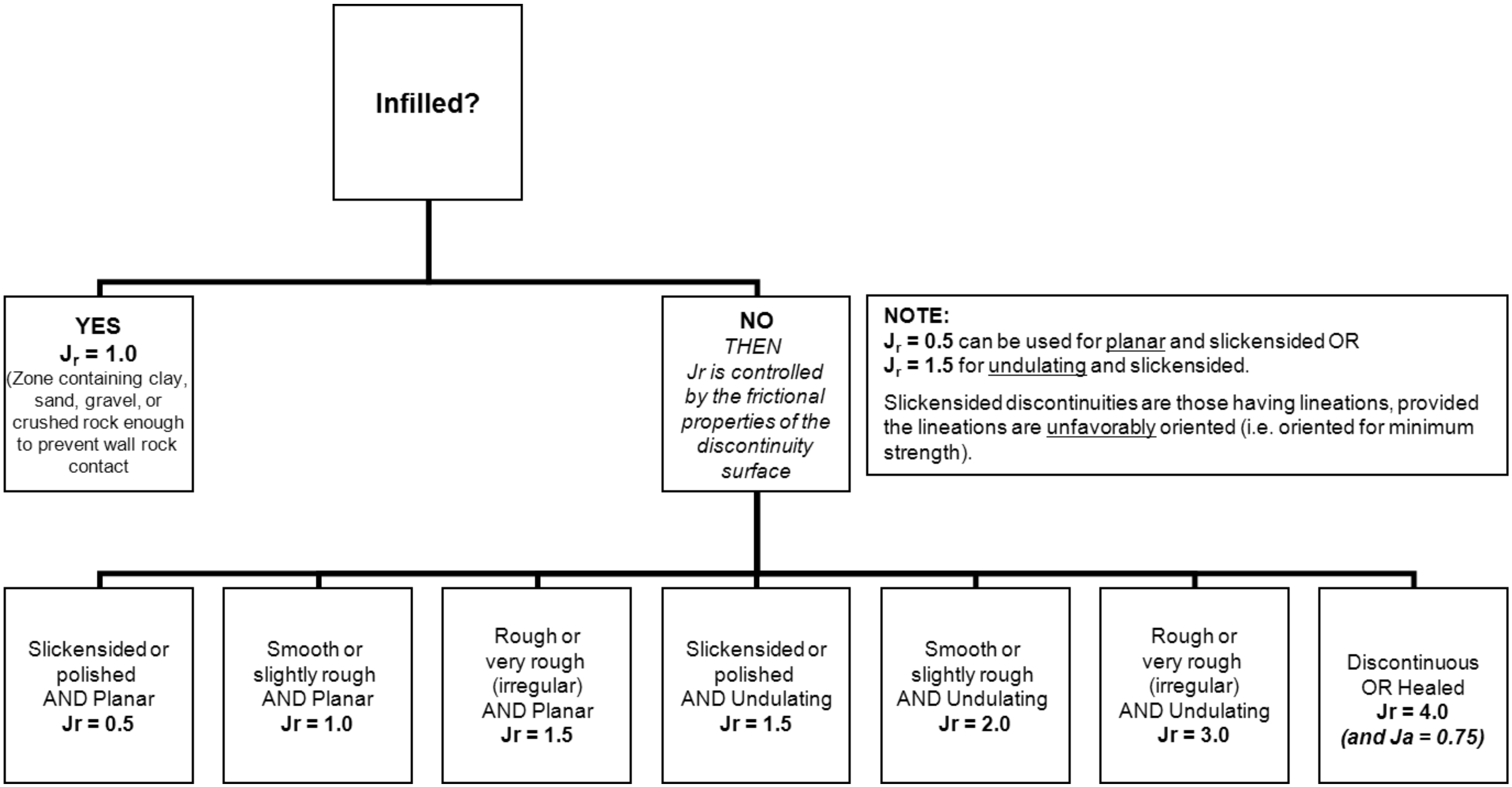
CHART B-10: FLOW CHART TO DETERMINE JOINT ALTERATION (JA)



Design with community in mind

Stantec

CHART B-11: FLOW CHART TO DETERMINE JOINT ROUGHNESS (JR)



A discontinuity is **infilled** when the infilling material is > 1mm thickness and/or there is no wall contact when sheared.

A discontinuity is **continuously coated** when the coating is ≤ 1 mm thickness and there is wall contact when sheared.

A discontinuity is **discontinuously coated** when the coating is ≤ 2 mm thickness and there is wall contact when sheared, but the entire surface of the discontinuity is not completely coated.

Flow Chart developed by Golder Associates

SAFETY DATA SHEET

1. Identification

Product identifier **INSTA-VIS™ PLUS**

Other means of identification None.

Recommended use Not available.

Recommended restrictions None known.

Manufacturer/Importer/Supplier/Distributor information

Manufacturer

Company name CETCO, an MTI Company

Address 2870 Forbs Avenue
Hoffman Estates, IL 60192
United States

Telephone General Information 800 527-9948

Website http://www.cetco.com/

E-mail safetydata@mineralstech.com

Emergency phone number Emergency 1.866.519.4752/1 760 476 3962

Americas 1.866.519.4752 (US, Canada, Mexico) 1 760 476 3962

2. Hazard(s) identification

Physical hazards Not classified.

Health hazards Not classified.

Environmental hazards Not classified.

OSHA defined hazards Not classified.

Label elements

Hazard symbol None.

Signal word None.

Hazard statement The mixture does not meet the criteria for classification.

Precautionary statement

Prevention Wash thoroughly after handling.

Response Wash hands after handling.

Storage Store away from incompatible materials.

Disposal Dispose of waste and residues in accordance with local authority requirements.

Hazard(s) not otherwise classified (HNOC) None known.

Supplemental information 5% of the mixture consists of component(s) of unknown acute oral toxicity. 5% of the mixture consists of component(s) of unknown acute dermal toxicity. 2.5% of the mixture consists of component(s) of unknown long-term hazards to the aquatic environment.

3. Composition/information on ingredients

Mixtures

Chemical name	Common name and synonyms	CAS number	%
TRADE SECRET*		Proprietary*	30 - < 40
Other components below reportable levels			60 - < 70

4. First-aid measures

Inhalation If gas/fume/vapor/dust/mist from the material is inhaled, remove the affected person immediately to fresh air.

Skin contact Immediately flush skin with running water for at least 20 minutes. Launder contaminated clothing before reuse.

Eye contact Rinse with water. Get medical attention if irritation develops and persists.

Ingestion	Do not induce vomiting without advice from poison control center. If vomiting occurs, keep head low so that stomach content doesn't get into the lungs. No need for first aid is anticipated if material is swallowed. Product is not considered toxic in small amounts.
Most important symptoms/effects, acute and delayed	Vapors have a narcotic effect and may cause headache, fatigue, dizziness and nausea.
Indication of immediate medical attention and special treatment needed	Treat symptomatically.
General information	Ensure that medical personnel are aware of the material(s) involved, and take precautions to protect themselves.

5. Fire-fighting measures

Suitable extinguishing media	Alcohol resistant foam. Powder. Dry chemical, CO_2, water spray or regular foam. Dry chemicals.
Unsuitable extinguishing media	Do not use water jet as an extinguisher, as this will spread the fire.
Specific hazards arising from the chemical	During fire, gases hazardous to health may be formed.
Special protective equipment and precautions for firefighters	As in any fire, wear self-contained breathing apparatus pressure-demand, MSHA/NIOSH (approved or equivalent) and full protective gear.
Fire fighting equipment/instructions	Cool containers exposed to heat with water spray and remove container, if no risk is involved.
Specific methods	Use standard firefighting procedures and consider the hazards of other involved materials.
General fire hazards	Will burn if involved in a fire. No unusual fire or explosion hazards noted.

6. Accidental release measures

Personal precautions, protective equipment and emergency procedures	Keep unnecessary personnel away. For personal protection, see section 8 of the SDS.
Methods and materials for containment and cleaning up	Use water spray to reduce vapors or divert vapor cloud drift. Large Spills: Stop the flow of material, if this is without risk. Dike the spilled material, where this is possible. Following product recovery, flush area with water. Small Spills: Absorb with earth, sand or other non-combustible material and transfer to containers for later disposal. Wipe up with absorbent material (e.g. cloth, fleece). Clean surface thoroughly to remove residual contamination. Never return spills to original containers for re-use. For waste disposal, see section 13 of the SDS.
Environmental precautions	Prevent further leakage or spillage if safe to do so. Do not contaminate water. Do not flush into surface water or sanitary sewer system.

7. Handling and storage

Precautions for safe handling	Avoid prolonged or repeated contact with skin. Use only in well-ventilated areas. Avoid release to the environment.
Conditions for safe storage, including any incompatibilities	Keep at temperatures between 0 and 30°C. Keep away from heat and sources of ignition. Keep containers tightly closed in a dry, cool and well-ventilated place. Keep out of the reach of children. Store away from incompatible materials (see Section 10 of the SDS). Do not freeze.

8. Exposure controls/personal protection

Occupational exposure limits	This mixture has no ingredients that have PEL, TLV, or other recommended exposure limit.
Biological limit values	No biological exposure limits noted for the ingredient(s).
Appropriate engineering controls	Ensure adequate ventilation, especially in confined areas. Ventilation should effectively remove and prevent buildup of any vapor/mist/fume/dust generated from the handling of this product.

Individual protection measures, such as personal protective equipment

Eye/face protection	Applicable for industrial settings only. Wear safety glasses with side shields (or goggles).
Skin protection	
Hand protection	Applicable for industrial settings only. Wear appropriate chemical resistant gloves.
Other	Wear oil-impervious garments if contact is unavoidable. Applicable for industrial settings only. Normal work clothing (long sleeved shirts and long pants) is recommended. Use impervious gloves.

Respiratory protection	Applicable for industrial settings only. In case of insufficient ventilation, wear suitable respiratory equipment. If mist is generated (heating, spraying) and engineering controls are not sufficient, wear approved organic vapor respirator suitable for oil mist.
Thermal hazards	Wear appropriate thermal protective clothing, when necessary.
General hygiene considerations	Use good industrial hygiene practices in handling this material. Eye wash fountain and emergency showers are recommended.

9. Physical and chemical properties

Appearance	Viscous.
Physical state	Liquid.
Form	Liquid.
Color	White. Milky.
Odor	Aliphatic.
Odor threshold	Not available.
pH	5.5 - 8.5
Melting point/freezing point	< 41 °F (< 5 °C)
Initial boiling point and boiling range	> 212 °F (> 100 °C)
Flash point	Not available.
Evaporation rate	Not available.
Flammability (solid, gas)	Not applicable.
Upper/lower flammability or explosive limits	
Flammability limit - lower (%)	Not available.
Flammability limit - upper (%)	Not available.
Explosive limit - lower (%)	Not available.
Explosive limit - upper (%)	Not available.
Vapor pressure	2.3 kPa @20°C
Vapor density	Not available.
Relative density	1 - 1.2
Solubility(ies)	
Solubility (water)	miscible
Partition coefficient (n-octanol/water)	Not available.
Auto-ignition temperature	Not available.
Decomposition temperature	> 302 °F (> 150 °C)
Viscosity	> 20.5 mm²/s @40°C
Other information	
Explosive properties	Not explosive.
Oxidizing properties	Not oxidizing.
VOC	CARB

10. Stability and reactivity

Reactivity	The product is stable and non-reactive under normal conditions of use, storage and transport.
Chemical stability	Stable at normal conditions.
Possibility of hazardous reactions	Will not occur.
Conditions to avoid	Contact with incompatible materials.
Incompatible materials	Strong oxidizing agents.
Hazardous decomposition products	At thermal decomposition temperatures, carbon monoxide and carbon dioxide.

11. Toxicological information

Information on likely routes of exposure

Inhalation	Vapors have a narcotic effect and may cause headache, fatigue, dizziness and nausea.
Skin contact	Knowledge about health hazard is incomplete.
Eye contact	Direct contact with eyes may cause temporary irritation.
Ingestion	Knowledge about health hazard is incomplete.
Symptoms related to the physical, chemical and toxicological characteristics	Direct contact with eyes may cause temporary irritation.

Information on toxicological effects

Acute toxicity Not known.

Components	Species	Test Results
TRADE SECRET		
Acute		
Dermal		
LD50	Rabbit	2000 mg/kg
Inhalation		
LC50	Rat	5.2 mg/l/4h
Oral		
LD50	Rat	5000 mg/kg

Skin corrosion/irritation	Based on available data, the classification criteria are not met.
Serious eye damage/eye irritation	Direct contact with eyes may cause temporary irritation.

Respiratory or skin sensitization

Respiratory sensitization	Due to partial or complete lack of data the classification is not possible.
Skin sensitization	Due to partial or complete lack of data the classification is not possible. Repeated or prolonged exposure may cause skin irritation and dermatitis, due to degreasing properties of the product.
Germ cell mutagenicity	Due to partial or complete lack of data the classification is not possible.
Carcinogenicity	This product is not considered to be a carcinogen by IARC, ACGIH, NTP, or OSHA. This product contains trace levels (<0.1%) of a potential carcinogen.

IARC Monographs. Overall Evaluation of Carcinogenicity

Not listed.

OSHA Specifically Regulated Substances (29 CFR 1910.1001-1053)

Not listed.

US. National Toxicology Program (NTP) Report on Carcinogens

Not listed.

Reproductive toxicity	Due to partial or complete lack of data the classification is not possible.
Specific target organ toxicity - single exposure	Not classified.
Specific target organ toxicity - repeated exposure	Due to partial or complete lack of data the classification is not possible.
Aspiration hazard	Knowledge about health hazard is incomplete.

12. Ecological information

Ecotoxicity Not readily biodegradable (40 % after 28 days).

Components		Species	Test Results
TRADE SECRET			
Aquatic			
Fish	LC50	Fish	45 mg/L, 96 Hours
		Rainbow trout,donaldson trout (Oncorhynchus mykiss)	2.9 mg/l, 96 hours

Persistence and degradability No data is available on the degradability of this product.

Bioaccumulative potential	No data available.
Mobility in soil	No data available.
Other adverse effects	No other adverse environmental effects (e.g. ozone depletion, photochemical ozone creation potential, endocrine disruption, global warming potential) are expected from this component.

13. Disposal considerations

Disposal instructions	Do not allow this material to drain into sewers/water supplies.
Local disposal regulations	Dispose in accordance with all applicable regulations.
Hazardous waste code	The waste code should be assigned in discussion between the user, the producer and the waste disposal company.
Waste from residues / unused products	Dispose of in accordance with local regulations. Empty containers or liners may retain some product residues. This material and its container must be disposed of in a safe manner (see: Disposal instructions).
Contaminated packaging	Since emptied containers may retain product residue, follow label warnings even after container is emptied. Empty containers should be taken to an approved waste handling site for recycling or disposal.

14. Transport information

DOT

Not regulated as dangerous goods.

IATA

Not regulated as dangerous goods.

IMDG

Not regulated as dangerous goods.

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code Not established.

15. Regulatory information

US federal regulations This product is not known to be a "Hazardous Chemical" as defined by the OSHA Hazard Communication Standard, 29 CFR 1910.1200.
OSHA Process Safety Standard: This material is not known to be hazardous by the OSHA Highly Hazardous Process Safety Standard, 29 CFR 1910.119.

Toxic Substances Control Act (TSCA)

TSCA Section 12(b) Export Notification (40 CFR 707, Subpt. D)

Not regulated.

CERCLA Hazardous Substance List (40 CFR 302.4)

Not listed.

SARA 304 Emergency release notification

Not regulated.

OSHA Specifically Regulated Substances (29 CFR 1910.1001-1053)

Not listed.

Superfund Amendments and Reauthorization Act of 1986 (SARA)

SARA 302 Extremely hazardous substance

Not listed.

SARA 311/312 Hazardous chemical No (Exempt)

SARA 313 (TRI reporting)

Not regulated.

Other federal regulations

Clean Air Act (CAA) Section 112 Hazardous Air Pollutants (HAPs) List

Not regulated.

Clean Air Act (CAA) Section 112(r) Accidental Release Prevention (40 CFR 68.130)

Not regulated.

Safe Drinking Water Act (SDWA) Not regulated.

US state regulations

California Proposition 65

California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65): This material is not known to contain any chemicals currently listed as carcinogens or reproductive toxins. For more information go to www.P65Warnings.ca.gov.

International Inventories

Country(s) or region	Inventory name	On inventory (yes/no)*
Australia	Australian Inventory of Chemical Substances (AICS)	Yes
Canada	Domestic Substances List (DSL)	Yes
Canada	Non-Domestic Substances List (NDSL)	No
China	Inventory of Existing Chemical Substances in China (IECSC)	Yes
Europe	European Inventory of Existing Commercial Chemical Substances (EINECS)	Yes
Europe	European List of Notified Chemical Substances (ELINCS)	No
Japan	Inventory of Existing and New Chemical Substances (ENCS)	Yes
Korea	Existing Chemicals List (ECL)	Yes
New Zealand	New Zealand Inventory	No
Philippines	Philippine Inventory of Chemicals and Chemical Substances (PICCS)	Yes
Taiwan	Taiwan Chemical Substance Inventory (TCSI)	No
United States & Puerto Rico	Toxic Substances Control Act (TSCA) Inventory	Yes

*A "Yes" indicates that all components of this product comply with the inventory requirements administered by the governing country(s)
A "No" indicates that one or more components of the product are not listed or exempt from listing on the inventory administered by the governing country(s).

16. Other information, including date of preparation or last revision

Issue date 18-November-2013

Revision date 19-August-2020

Version # 21

Further information This safety datasheet only contains information relating to safety and does not replace any product information or product specification. HMIS® is a registered trade and service mark of the NPCA.

HMIS® ratings
Health: 0
Flammability: 1
Physical hazard: 0
Personal protection: B

NFPA ratings
Health: 0
Flammability: 1
Instability: 0

Disclaimer CETCO, an MTI Company cannot anticipate all conditions under which this information and its product, or the products of other manufacturers in combination with its product, may be used. It is the user’s responsibility to ensure safe conditions for handling, storage and disposal of the product, and to assume liability for loss, injury, damage or expense due to improper use. The information in the sheet was written based on the best knowledge and experience currently available. The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as a guidance for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered a warranty or quality specification. The manufacturer expressly does not make any representations, warranties, or guarantees as to its accuracy, reliability or completeness nor assumes any liability, for its use. It is the user's responsibility to verify the suitability and completeness of such information for each particular use.

Third party materials: Insofar as materials not manufactured or supplied by this manufacturer are used in conjunction with, or instead of this product, it is the responsibility of the customer to obtain, from the manufacturer or supplier, all technical data and other properties relating to these and other materials and to obtain all necessary information relating to them. No liability can be accepted in respect of the use of this product in conjunction with materials from another supplier. The information relates only to the specific material designated and may not be valid for such material used in combination with any other materials or in any process, unless specified in the text.

Revision information Disposal considerations: Disposal instructions