MINTO MINE
OPERATED BY MINTO EXPLORATIONS LTD.

Updated Closure Cover Design for the Minto Mine 2016 Reclamation and Closure Plan

Prepared for

Minto Explorations Ltd.

Prepared by

SRK Consulting (Canada) Inc.
1CM002.049
August 2016

Updated Closure Cover Design for the Minto Mine 2016 Closure and Reclamation Plan Update

August 2016

Prepared for

Capstone Mining Corp. – Minto Mine
Suite 13 – 151 Industrial Road
Whitehorse, YT Y1A 2V3
Canada

Tel: +1 604 424 8084
Web: www.capstonemining.com

Prepared by

SRK Consulting (Canada) Inc.
2200–1066 West Hastings Street
Vancouver, BC V6E 3X2
Canada

Tel: +1 604 681 4196
Web: www.srk.com

Project No: 1CM002.049

File Name: MintoUpdatedClosureCoverDesign_1CM002-049_20160805_EK_dbm

srk consulting

Executive Summary

This report provides updated closure cover designs for the Southwest Waste Dump; the Dry Stack Tailings Storage Facility; the Mill Valley Fill, and Mill Valley Fill Extension Stage 1 and 2; the Main Waste Dump, Main Waste Dump Expansion; Main Pit Dump; subaerial Main Pit tailings; and the Area 118 Backfill Dump. This document is considered the most current closure cover design, and has been completed in consideration of all previous work.

Several aspects of the closure design have been advanced from previous work, most notably a recommended minimum cover thickness, an envelope of acceptable cover material, an updated erosion and stability analysis, and an advancement in the re-vegetation plan and hydrotechnical designs. In addition, the re-grading and shaping of the structures have been advanced.

This document shows the reader how a minimum cover thickness of 0.5 m was determined and, based on the re-grading plans presented, how it results in a total cover volume requirement of approximately 753,000 m^3; which is well within the estimated 2.3 Million bank cubic metres of cover material available for use from the reclamation overburden dump, and the additional 1.3 Million bank cubic metres available from the potential development of the Area 2 Stage 3 pit. The closure covers are to be constructed of material with no less than 10% silt and clay sized particles. In general, the re-grading of the facility was completed to provide a cut/fill balance targeting overall slopes as shallow as possible.

The updated stability analysis indicates that slopes shallower than 3H:1V are anticipated to be stable in the long term, but should slopes of 2.5H:1V be proposed, additional work is necessary to confirm these slopes will be stable.

The updated erosion analysis has concluded that bare (unvegetated) site cover material is highly susceptible to erosion on slopes; therefore, establishing a vegetated cover is important to the success of the cover. The proposed revegetation plan for slopes is anticipated to consist of seed mixes of native grasses, and application of fertilizer in support of establishing a strong vegetative cover to reduce the potential for sheet erosion and gully development on the cover. In areas where slopes are flatter, such as facility tops and benches, the revegetation plan is intended to include seeding of native plant communities.

The ability for each facility to shed and direct water was considered against a 1:200 year flood event. The approach adopted for the tops of structures was to limit the flow to less than 1 m^3/sec, such that armoured channels or swales would not be required, but that erosional protection could be achieved through vegetation. The flow directed over slopes was intended to be rip-rapped, with detailed specifications or riprap thickness to be established at a later date.

Table of Contents

List of Figures

List of Tables

List of Appendices

1 Introduction

The Minto Mine is a high-grade copper mine located in the Yukon, approximately 240 km north of Whitehorse. The mine site occupies the valley in the upper reaches of Minto Creek, a tributary on the west side of the Yukon River, about 9 km from the mouth. Operations began in October 2007 and are currently ongoing (2016). Three pits have been completed to date: the Main Pit, the Area 118 Pit, and the Area 2 Stage 2 Pit.

Initially tailings were deposited in the Dry Stack Tailings Storage Facility (DSTSF) which was completed in 2012. Currently tailings and process water are managed in the Main Pit Tailings Management Facility (MPTMF) and the Area 2 Pit Tailings Management Facility (A2PTMF). Various waste rock storage facilities exist across the site including the Main Waste Dump (MWD), Main Waste Dump Expansion (MWDE), Main Pit Dump (MPD- planned), Southwest Waste Dump (SWD), Area 118 Dump, and the Mill Valley Fill (MVF) currently undergoing the Stage 2 expansion. Figure 1 illustrates these site facilities at the site.

1.1 Background

Numerous previous documents have been completed in support of various levels of closure planning. The most relevant document considered in support of this document include:

- Dry-stack Tailings Storage Facility Interim Cover Investigation. SRK, 2016a.
- Closure Landform Design and Reclamation landform Units for the Minto Mine. SRK, 2016b.
- Minto Mine Closure Covers: Results of Numerical Modelling to Bracket Percolation Predictions. SRK, 2015.
- Scoping Level Cover Assessment for Minto Closure Covers. SRK, 2013a.
- 2012 Overburden Characterization Data Report for Minto Closure Covers. SRK, 2013b.

This document has been prepared with the understanding that the above mentioned reports are available to the reader and that should the reader choose, all relevant background to the cover designs is described.

Key conclusions from previous work have included:

- Cover materials placed without appropriate erosion protection are highly erodible and susceptible to gully development on the cover.
- The fine grained and mixed materials used to construct the interim cover of the DSTSF are suitable for use in the construction of final cover, but some revegetation efforts are necessary to achieve cover functionality. The Residuum material is not a suitable stand-alone cover material as it cannot readily establish vegetation (SRK, 2016a).

- The natural materials on-site are not expected to capable of meeting the performance specifications of a low-permeability cover. Should a low-permeability cover be required, other options (including a geosynthetic) should be considered (SRK, 2013a).

1.2 Scope of Work

This report has been prepared to propose updated closure cover designs for the Southwest Waste Dump; Dry Stack Tailings Storage Facility; Mill Valley Fill, Mill Valley Fill Extension Stage 1 and 2; Main Waste Dump, Main Waste Dump Expansion; Main Pit Dump; subaerial Main Pit tailings; and the Area 118 Backfill Dump. This document is considered the most current closure cover design, and has been completed in consideration of all previous work, while continuing to advance the level of detail in the engineering. This report supersedes previous cover designs for the project including the designs proposed in previous closure plans.

This report is structured to lead the reader through descriptions of the closure cover objectives and criteria: the cover material characteristics, including overburden characterization, cover material thickness, erosion loss estimates, physical stability analysis, grading designs, water conveyance considerations, and re-vegetation descriptions for each of the above referenced facilities.

2 Objectives and Criteria

2.1 Design Objectives and Functions

It is currently proposed that the primary cover functions will be to:

- Reduce infiltration to the extent practical using locally available material;
- Ensure a stable landform that will promote establishment of natural vegetation endemic to the area; and
- Minimize ponding and surface erosion on the final landform.

2.2 Design Criteria

The proposed design criteria for closure covers at the Minto Mine are outlined in Table 1.

Table 1: Design Criteria

Component	Criteria	Comment/Rationale
Design Life	100 years.	Discussions related to closure often infer that closure measures (the soil cover, in this case) must last into perpetuity. While it is recognized that the cover will remain in place for a very long period, performance cannot credibly be measured in geologic timelines. Setting a realistic standard allows measurable targets to be set.

Component	Criteria	Comment/Rationale
Oxygen Reduction	Not a defined criteria.	Preventing the unoxidized tailings from oxidizing by limiting oxygen ingress will not make a discernible difference in the acidity of the pore water and therefore constructing an oxygen limiting cover is not warranted.
Infiltration Reduction	Not a defined criteria.	Minto and other project stakeholders wish to reduce infiltration (and net percolation) to the extent possible based on the available cover material's physical properties. The results of the cover modelling (SRK, 2015) indicate that the net percolation is approximately 23%, but depending on the climactic conditions, can vary from 6% to 43%. Additional discussion is provided in Section 3.2.
Load Reduction	No specific target.	The site wide water and load balance is based on 20% net percolation through the cover, but acknowledges that loadings may be greater or lower, depending on the climactic conditions.
Settlement	No criteria.	Settlement of the covers is not anticipated to occur as there is no settlement anticipated in the immediate foundation materials (waste rock, and compacted tailings).
Seismicity	1 in 475 year recurrence interval.	Consistent with the BC Mined Rock and Overburden Piles Investigation and Design Manual, May 1991.
Physical Exposure	As far as practicable keep tailings and peripheral areas covered. At no time may more than 0.25 m^2 of mine waste be exposed as a contiguous area for the life of the structure.	It is recognized that the cover will evolve over time and factors such as extreme surface runoff beyond the stated design criteria, burrowing animals or human activities may cause damage to the cover.
Slope Stability	Overall factor of safety for the cover of 1.1.	Consistent with the BC Mined Rock and Overburden Piles Investigation and Design Manual, May 1991.
Wind Erosion	No visible dust up to and including wind speeds with a recurrence interval of 1:10 years, for any given duration. In no areas may overall cover thickness be less than 75% of original design thickness for the life of the structure.	In the event that there is physical exposure of mine waste, this defines the dust criteria.
Overland Surface Runoff	Capable of withstanding 1:200 year, 24 hour duration storm during peak freshet with no damage. An average soil loss of <6 tonnes/hectare /year is target from slopes, following the establishment and implementation of erosion mitigation strategies, such as vegetation. In no areas may overall cover thickness be less than 75% of original design thickness for the life of the structure.	Intend to construct a cover that could meet a soil erosion classification of Very Low (Wall, 2002)
Evapo-Concentration	No defined criteria.	It is understood that there is no evidence of evapo-concentration on any of the Minto mine waste facilities.

Component	Criteria	Comment/Rationale
Root-Uptake	No defined criteria.	Root-uptake of porewater is not expected to be problematic, as there is no evidence of this occurring on current revegetated areas.
Vegetation	Self-sustaining vegetation cover native to the region within 30 years of initial revegetation.	In areas of potential erosion concern (i.e. sloped cover facets), revegetation will focus on the rapid establishment of herbaceous ground-cover species using a mix of native grasses and one or more agronomic legumes, coupled with fertilizer applications in the early years (1-3) of establishment. In areas not targeted for the erosion-control treatment (i.e., landform plateaus and benches), revegetation will focus on re-establishing locally common native plant communities. Use of fertilizers on these areas will likely be avoided or minimized.
Land Use	General wilderness area. Large and small terrestrial animals, birds and aquatic life will be present. Humans will travel through the area infrequently (mostly hunters and trappers). Specific measures to preclude damage to the covers due to human and/or animal use is not required.	Wildlife habitat suitability will vary by vegetation type and structural stage as the re-created vegetation types develop.
Landform	Promote use of landforms consistent with the current landscape. Provide for variability on cover thicknesses and landscaping as necessary to promote establishment of microclimates and variability.	The Closure Landform Design and Reclamation Landform Units for the Minto Mine will be used to guide the practical application of the landform design.

3 Cover Material Characteristics

3.1 Overburden Characterization

3.1.1 Geotechnical Characteristics

SRK evaluated 167 particle size distribution analyses and 38 Atterberg Limit (liquid and plastic limit) analysis completed on overburden samples at the Minto Site. Data was obtained from investigations completed, and documented by SRK (SRK, 2013, 2016a&b). The data was reviewed, and indicated that in general the material can be variable from a particle size distribution, with the amount of fines (less than 0.075 mm) in samples ranging between less than 5% to greater than 95%. Generally, the majority of the material that exists within the existing overburden stockpiles is expected to be in the range of 10% to 75% fines. Fines are used as a key indicator of the material as it can be used in the correlation of many soil parameters, including the moisture retention capacity of a soil. Typically, residuum samples were identified to have less than 10% fines. Residuum is a weathered bedrock material that the consistency of a sand, and is typically a material that can be identified visually.

The Atterberg Limits are utilized to characterize the material in accordance with the Unified Soil Classification System (USCS) and the Modified Unified Soil Classification System (MUSCS). The material classifications generally range between CL-ML (Clayey Silt) to CL (Clay), which indicates the soils to have low to intermediate plasticity, and in the case of an ML (Silt), the behaviour is dominated by the silt sized particles present. The residuum material was deemed to be non-plastic.

For additional details related to the characterization of the geotechnical characterization of the overburden materials, refer to Appendix A.

3.1.2 Erosion

Soil erosion classification is based on the USDA soil textural classification. Table 2 provides a summary of the particle size diameter range based on the USCS / MUSCS, and the United States Department of Agriculture (USDA) soil textural classification.

Table 2: USCS vs USDA Particle Size Distribution Systems

Soil Component	Particle Size Diameter Rage (millimeters)	
	USCS / MUSCS	USDA
Boulders	> 200	n/a
Cobbles	200 – 76	n/a
Gravel	76 – 4.75	n/a
Sand	4.75 – 0.075	2.0 – 0.05
Silt	0.075 – 0.002	0.05 – 0.002
Clay	< 0.002	< 0.002

The samples were re-classified, and plotted on a soil texture triangle to determine the general soil texture. The samples typically categorized as sandy loam. For additional details related to the characterization of the soil classification of the USDA methodology, please refer to Appendix A.

3.1.3 Quantities

The reclamation overburden dump (ROD) contains approximately 2.3 Million bank cubic metres (EBA, 2010) of overburden. The overburden was characterized prior to mining, and a summary of the material properties is provided in Appendix A. The PSD of the material recovered from Area 2 is listed in Tables 2 and 3. Generally, the overburden material was not selectively placed within the ROD during placement, and material that would be excavated from the ROD for cover purposes is expected to be somewhat variable in quality, but with greater than 10% fines.

The Area 2 Stage 3 Pit is anticipated to contain an additional 1.3 Million bank cubic metres of material (personal communication with Kevin Cymbalisty, 2016). The overburden characterization indicates that the material is similar to the overburden currently contained in the ROD, but with some samples containing higher degrees of clay and silt. Based on the investigation completed, there do not appear to be any mineable units within this area to discretely target material of higher or lower fines content. A more detailed description of the investigation and results in provided in Appendix B.

In 2014 overburden fine grained soils and residuum was place on portions of the DSTSF as a trial overburden cover. Those areas capped predominately with residuum do not support vegetation, and therefore do not meet the cover objectives. Areas of fine grained soils, and areas of mixed fine grained soils and residuum do support vegetation and therefore do meet the cover objectives.

3.2 Cover Thickness to Satisfy Net Percolation

SRK completed numerical modelling to bracket percolation predictions in 2015 (SRK, 2015). The modelling indicated that without a cover, the net percolation could be between 39% percent and 45%, and depending on climactic conditions, could vary between 26% and 65%. Cover materials were applied, with the base case cover material consisting of material properties from sample MWD-TP4 collected at the Minto mine, which is a gravel and sand material with more than 25% fines (<0.075 mm). The results indicate that the net percolation is approximately 23%, but depending on the climactic conditions, can vary from 6% to 43%. The cover material was varied and an analysis was also completed considering a coarse material (MWD-TP3), which is predominantly gravel and sand with less than 10% fines (<0.075 mm). The results of this analysis indicate that the net percolation was approximately 23%, but depending on the climactic conditions, can vary from 5% to 44%.

The modelling results indicate that there is nearly a 20% decrease in net percolation after cover materials are included in the analysis. The cover thickness was assumed to be approximately 0.5 m thick, and following sensitivity analysis to the thickness (1 m and 2 m) minor decreases in net percolation were estimated. Therefore, a minimum cover thickness of 0.5 m was adopted for the project, with materials containing greater than 10% fines.

3.3 Erosion Loss Estimate

The purpose of this analysis was to present the potential effects of erosion due to sheet and rill water erosion that could occur on the engineered slopes at Minto, and evaluate a range of conditions and parameters to help guide the landform designs. Sheet and rill erosion occurs as a result of flows that are not concentrated into a particular flow path, but over time, if allowed to persist, can develop into larger erosion features such as gullies. The intent is then to determine which methods of erosion protection are sufficient to reduce erosion to acceptable levels, to minimize the potential for development of gullies, and to characterize what (if any) sacrificial thickness should be added to the cover to account for erosion. This section provides a summary of the erosion loss analysis completed, with additional details found in Appendix C.

Erosion that may occur within channel flow and the associated armouring is not considered in this discussion.

Based on the RUSLEFAC equation, SRK has targeted a soil erosion classification of “Very Low” which means that an acceptable rate of erosion loss is approximately 6 Tonnes per hectare per year (Wall et al., 2002). Soils with erosion classifications of “Very Low” demonstrate slight to no erosion potential. Minimal erosion problems should occur if good soil conservation management methods are used. A tolerable soil loss (<6 T/ha/year) is the maximum annual amount of soil which can be removed before the long term natural soil productivity of a hillslope is adversely affected (Wall et al., 2002). By targeting a soil erosion classification of “Very Low”, the intent is to limit the development of rill, inter-rill, and ultimately gully erosion. In some cases, a soil can meet this target on its own, but in many cases, as is the case at the Minto site, support practices are required to achieve this target.

As described in Appendix C, soil loss over the course of the design life (100 years) was calculated to determine whether the average depth of soil loss would reduce the initial cover thickness to below the required cover thickness. The soil loss was calculated for unvegetated (bare) soils, and for soils with 80% coverage with short rooted plants. As is observed on the vegetation trials on the Main Waste Dump, under appropriate conditions, this can easily be achieved.

Annual soil loss due to water erosion was multiplied by 100 years to determine design life soil loss, which is presented for several straight slope scenarios in Table 3. Construction of complex slopes was calculated to have a potential impact on decreasing erosion by approximately 10%, which is discussed further in Appendix C. Average annual soil loss (in T/ha/year) is also presented in Table 3.

Table 3: Calculated Water Erosion Design Life Soil Loss

Slope Condition		**Design Life Soil Loss (mm) per Slope Length**							
		50 m		**85 m**		**100 m**		**150 m**	
		Annual (T/ha/yr)	100 yrs (cm)	Annual (T/ha/yr)	100 yrs (cm)	Annual (T/ha/yr)	100 yrs (cm)	Annual (T/ha/yr)	100 yrs (cm)
Non-Vegetated	**2.5H:1V**	31.8	19.9	41.8	26.1	45.6	28.5	56.2	35.1
	3H:1V	26.2	16.4	34.1	21.3	37.1	23.2	45.5	28.4
	3.5H:1V	22.1	13.8	28.6	17.9	31.0	19.4	37.8	23.6
	4H:1V	19.0	11.9	24.3	15.2	26.4	16.5	31.9	19.9
	5H:1V	14.6	9.1	18.4	11.5	19.8	12.4	23.7	14.8
Vegetated (80% Short-Rooted Plant Coverage)	**2.5H:1V**	3.7	2.3	4.8	3.0	2.3	3.3	6.5	4.1
	3H:1V	3.0	1.9	3.9	2.5	4.3	2.7	5.2	3.3
	3.5H:1V	2.6	1.6	3.3	2.1	3.6	2.2	4.4	2.7
	4H:1V	2.2	1.4	2.8	1.8	3.0	1.89	3.7	2.3
	5H:1V	1.7	1.1	2.1	1.3	2.3	1.4	2.7	1.7

Table 3 illustrates the value of vegetation, and therefore the establishment of vegetation on the slopes is critical to the success of the closure covers. Short term support practices will be required to develop a good vegetated cover. Examples of short term support practices are rolled erosion control products, slope texturing, and hydro-seeing with an erosion resistant tackifier. The potential effect that short term support practices have on reducing cover erosion are discussed in further detail in Appendix C. Once vegetation is established, the soil loss is less than 5 cm, which is generally within the placement tolerance of earthworks when using large equipment.

3.4 Physical Stability

SRK evaluated the cover stability of the closure covers at various slope angles to identify if some of the available borrow material is better suited to some areas versus others. The global stability of the operational design of each of the waste facilities, under both operations and closure conditions, have been previously evaluated in their respective design documents. Generally, closure configurations will result in resloped/landscaped configurations with shallower slopes. Global stability is not considered in this analysis, but may be considered further following the development of final re-grading plans discussed in this document.

Generally, the physical stability of a cover is a function of the normal stress over the cover, the internal shear strength of the cover material, the interface shear strength between the underlying material and the cover material, as well as the seepage forces present within the cover. In the case of most of the Minto cover designs, a lower strength cover material is proposed to be placed over a material with higher strength – either compacted tailings, the compacted shell of the DSTSF, or waste rock. Therefore, the critical failure mode is a failure that occurs along the interface of the two materials, and is controlled by the shear strength in the weaker cover material.

SRK completed a 2-dimensional limit equilibrium analysis stability analysis as described in Appendix D. The analyses were focused on base case scenarios where a piezometric surface was placed midway through the cover thickness, and the material underlying the cover was considered impenetrable to force the cover failure either through the cover material, or along the interface. Two sets of analyses were completed to demonstrate the effect of a cover constructed of residuum material versus a cover constructed of silty sand material. Analyses were completed for slopes of 2.5H:1V, 3H:1V, 4H:1V, and 5H:1V. Various sensitivity analysis were completed, which indicated that the models were most sensitive to the piezometric surface in the cover.

All of the base case scenarios met the minimum target factor of safety with the exception of the placement of a silty sand cover material on a 2.5H:1V slope. Additional analyses to evaluate the impact of a variable piezometric surface in the cover placed over a 2.5H:1V slope were completed as the base case conditions for the silty sand cover did not meet the minimum target factor of safety. The results indicated that increases in the piezometric surface decreased the factor of safety below the base case, while decreases in the piezometric surface increased the factor of safety above the target criteria.

The analysis concluded:

- Residuum material is preferable to be placed on a 2.5H:1V slope from a geotechnical stability perspective. Erosional susceptibility of the material (as discussed in Appendix C) and its ability to support re-vegetation efforts should be considered prior to final selection of cover material. It should also be noted that currently the Main Waste Rock Dump has 2.5H:1V slopes, and has been covered with silty sand material, and vegetation trials are on-going. The cover material does not appear to be prone to continued sloughing or cover failure, and it is likely that the waste rock below drains the cover and limits the potential for the piezometric level to increase to such a point that the seepage forces influence the cover stability below unity. Vegetation on the cover varies from well covered to sparsely covered.
- Slopes of 3H:1V, or shallower are not restricted to the type of cover material based on geotechnical performance.

For all slope configurations it is suggested that, prior to final re-grading, detailed stability analysis be completed to confirm the target factor of safety can be achieved under each area's site specific condition.

3.5 Design Parameters

Table 4 provides a summary of proposed design parameters to be adopted for the Minto Closure Covers, based on the particle size distributions, and the net percolation cover modelling completed (SRK, 2015).

Table 4: Closure Cover Design Parameters

Description		Value
Cover Thickness		0.5 m (minimum)
Cover Material Specifications	Gravel	0 % to 40%
	Sand	60% to 90%
	Fines	> 10%
Soil Texture Classification	Sandy Loam	Sandy Loam

4 Revegetation

The preliminary revegetation plan is designed to achieve the land-use objectives of wildlife habitat re-creation, creation of habitat for traditionally used plants, and the return of biodiversity values over time. The primary focal wildlife species is moose, although re-creation of habitat for prey species such as snowshoe hare and upland game birds may be possible. Revegetation treatments are designed to achieve these objectives, and also to perform the key task of protecting the placed cover materials from erosion where required. This can be accomplished through the application of two general vegetation treatments:

- **Erosion-control treatment** – in areas of potential erosion concern (i.e. sloped cover facets), revegetation will focus on the rapid establishment of herbaceous ground-cover species. This would be accomplished through relatively high-rate seeding (e.g. >35 kg/ha), likely using a mix of native grasses and one or more agronomic legumes, coupled with fertilizer applications simultaneous with seeding and in the early years (1-3) of establishment. In recent years the use of agronomic species in mine reclamation in western and northern Canada has declined due to increasing focus on biodiversity and "restoration" objectives, but experience at multiple sites in the Yukon indicates that agronomic species can be successfully used as a rapidly establishing temporary ground cover that is not prohibitive of a longer-term transition to ecosystems dominated by native plant communities.

- **Native-species establishment –** in areas not targeted for the erosion-control treatment (i.e., landform plateaus and benches), revegetation will focus on re-establishing locally common native plant communities, using a combination of seeding and planting establishment techniques. Use of fertilizers on these areas will likely be avoided or minimized.

Yukon Energy, Mines and Resources (2013b) defines re-vegetation as the re-establishment of vegetation on land which previously had vegetation cover. The objective of revegetation of mining disturbances is "*to leave the ground in such a way as to provide a good chance for successful re-vegetation by plant species native to the site and the area (natural revegetation).*" It is anticipated that the two primary revegetation treatments proposed above for Minto are consistent with this over-arching objective, as although the erosion-control treatment will likely include non-native species, it will provide the highest probability of successful revegetation by native plant species over the longer term. Native species tend to be slower to establish than agronomics (which have been selectively bred for rapid establishment), and with the high silt content and erosion susceptibility of the Minto cover materials, rapid revegetation is critical to minimize erosion and protect the cover material. Restriction to use of native species only would likely result in high erosion rates, loss of cover materials through sheet and/or rill/gully erosion, and likely subsequent poor revegetation. Targeted use of agronomics will promote cover stability at the ground surface, and will be more successful in eventually establishing native species. As excessive erosion would be a key failure mode for the cover system, the revegetation treatments have been developed to give priority to reduction of risk of this failure mode. A transition to native species on these erosion-control areas is anticipated to occur naturally, due to the focus on native-species establishment on other mine areas and due to the proximity of surrounding vegetation-propagule sources in adjacent intact ecosystems. However, the revegetation should be monitored, and a second phase of revegetation may be required if/where necessary to initiate or augment the transition to native species. This second phase would involve planting of native herbaceous and/or woody plant species.

Detailed facility-specific revegetation treatments will be developed using Reclamation Landscape Unit concepts developed by SRK (2016b), with candidate species selected using guidance provided for Yukon mine reclamation and site-specific information on the occurrence and vegetation composition of pre-disturbance vegetation types. Additional detail on development of revegetation treatments, and associated recommendations, are provided in the technical memo attached as Appendix E.

5 Regarding Designs

5.1 Southwest Waste Dump

Progressive reclamation of the southwest west waste dump began in 2015. Minto re-sloped the face of the dumps to slopes ranging roughly between 12H:1V and 4H:1V. Remaining work to be completed includes:

- minor re-grading on the top surface to shed water into swales designed to carry the flow down the face of the dump without causing significant erosion;
- additional design work;
- construction of swales;
- cover placement; and
- detailed planning and implementation of revegetation plans.

A minimum cover thickness of 0.5 m is proposed for the Southwest Waste Dump across the facility, with the exception of the high grade waste stockpile. Localized areas may require additional grading to meet design grades, and it is proposed that final grades (prior to cover placement) can be achieved through the placement of either waste rock, or overburden based on Minto's scheduling plans.

The high grade waste area is proposed to be covered using a low-permeability cover achieved through placement of a geomembrane.

To shed water, the top of the medium grade waste area is proposed to be split into six small catchment areas while the bulk waste area is proposed to be split into three small catchment areas. These catchment areas are illustrated in the detailed hydraulic analysis information contained in Appendix F. The intent is to minimize the amount of water that flows directly over the slope as sheet flow. Each of these small catchments would be constructed to direct water into a broad swale, currently considered to be 2 m wide at the base, and have side slopes of 10H:1V. The swales were designed based on contributing watershed area, and flow depths are anticipated to range between 0.1 m and 0.26 m during a 1:200 year 24 hour flood event. The reported depths are double that of the calculated depths to allow for ice accumulation.

The swales have been designed to flow over and maintain the same base with the slope, but transition to 3H:1V side slopes. The swales on the top are proposed to be armoured with vegetation, while the slopes are proposed to be armoured with a gravel to cobble sized rip rap. Rip rap thickness and final dimensions are yet to be determined. Details regarding the hydraulic designs of these swales are provided in Appendix F.

The proposed re-grading and swale locations are illustrated on Figure 2. The proposed plan includes approximately 37,300 m^3 of cut and 37,800 m^3 of fill to achieve the intent of the general re-grading (intended to be achieved through movement of waste rock) at the high grade waste stockpile; 35,800 m^3 of cut and 42,700 m^3 of fill to achieve the grading on the main pile; and a cut/fill balance to only achieve minimal grading at the norther end of the pile. The High Grade Waste area will require approximately 17,700 m^3 of cover material and approximately 35,400 m^2 of geomembrane cover. The Medium Grade Waste area and Bulk Waste area will required approximately 496,400 m^3 of cover material.

5.2 Dry Stack Tailings Storage Facility

Progressive reclamation of the DSTSF completed to date has consisted of placement of an interim cover over the tailings. This served multiple purposes, including isolating the tailings from wind and water erosion, as well as informing the success of using different cover materials. Observation of the interim cover has led to the conclusion that residuum material on its own is not a preferred cover material; however, a mix of residuum and fine-grained overburden will be able to achieve the overall closure cover objectives. Remaining work to be completed includes:

- re-grading the rock shell face of the DSTSF;
- re-grading and surface material amendment on the top of the DSTSF to cover/mix the regions currently covered with residuum material alone, and grading the top surface to shed water into swales designed to route surface runoff to design flowpath alignments;
- additional design work; and
- detailed planning and implementation of revegetation plans.

Consistent with the Southwest Waste Dump design, a minimum cover thickness of 0.5 m is proposed for the DSTSF. Localized areas currently maintain greater than 1 m of cover material, which during regrading of the top, is proposed to be utilized to achieve the design grades. Should there be a need for additional material to meet the proposed final grades (prior to cover placement), it is anticipated that this would be achieved through the placement of additional overburden material, as opposed to waste rock.

To shed water, the top of the primary waste rock pile at the southern edge of the facility is proposed to be split into three small catchment areas. These catchment areas are illustrated in the detailed hydraulic analysis information contained in Appendix F. The intent is to minimize the amount of water that flows directly over the slope as sheet flow. Each of these small catchments would be constructed to direct water into a broad swale, currently considered to be 2 m wide at the base, and have side slopes of 10H:1V. The swales were designed based on contributing watershed area, and flow depths are anticipated to range between 0.2 m and 0.5 m during a 1:200 year flood event.

Again, consistent with the design of the Southwest Waste Dump, the swales have been designed to flow away from the main slope, with the exception of one swale, which is intended to carry water down the face of the DSTSF, and onto the Mill Valley Fill Expansion. Where this swale transitions from the top of the DSTSF to the face of the DSTSF, it will transition to a 2 m wide base channel with 3H:1V side slopes. The swales on the top are proposed to be armoured with vegetation, while the swale on the slope is proposed to be armoured with a gravel to cobble sized rip rap. Rip rap thickness and final dimensions are yet to be determined.

The proposed re-grading and swale locations are illustrated on Figure 3. The proposed plan includes approximately 28,800 m^3 of cut and 225,700 m^3 of fill to achieve the intent of the general re-grading, and 108,000 m^3 of cover material.

As discussed in Section 3.3, soil loss due to erosion caused by overland sheet flow has the ability to impact the integrity of the cover and it is proposed that the revegetation concepts described in Section 4 be implemented. The proposed slopes are 4H:1V or shallower, and therefore physical stability of the cover is not anticipated to be problematic.

5.3 Mill Valley Fill, and Mill Valley Fill Extension Stage 1 & 2

The Mill Valley Fill and Mill Valley Fill Extension Stage 1 and 2 are currently under construction, and were designed with closure in mind. The top surfaces were generally graded to shed water, such that minimal re-grading would be required. As illustrated in Figure 4, there are three main terraces to the waste dump.

The first westernmost terrace will require some effort to re-grade so that water is directed to the west, rather than to the north. The middle terrace is proposed to be graded north and will also convey water shed off the DSTSF (through constructed swales). The eastern terrace is proposed to be graded to shed water off to the north-east.

Consistent with other facilities, a minimum cover thickness of 0.5 m is proposed and localized areas may require additional grading to meet design grades. Design grades may be achieved through the placement of either waste rock, or overburden based on Minto's scheduling plans.

To shed water, the top of this facility was separated into four small catchment areas. These catchment areas are illustrated in the detailed hydraulic analysis information contained in Appendix F. Consisted with the other facilities, the intent is to minimize the amount of water that flows directly over the slope as sheet flow. Three of these small catchments (western terraces, and eastern terrace) would be constructed to direct water into a broad swale, currently considered to be 2 m wide at the base, and have side slopes of 10H:1V. The middle terrace is proposed to be 5.5 m wide at the base, with side slopes of 10H:1V due to the increased watershed contributed by the DSTSF. The swales were designed based on contributing watershed area, and flow depths of approximately 0.1 m during a 1:200 year 24 hour flood event.

Consistent with the design philosophy employed with the other facilities, the swales have been designed to flow over the slope and transition to a channel base width equal to that of the swale on the top surface with 3H:1V side slopes. The swales on the top are proposed to be armoured with vegetation, while the slopes are proposed to be armoured with a gravel to cobble sized rip rap. Rip rap thickness and final dimensions are yet to be determined.

The proposed re-grading and swale locations are illustrated in Figure 4. The proposed plan includes approximately 7,600 m^3 of cut and 27,000 m^3 of fill to achieve the intent of the general re-grading, and 68,700 m^3 of cover material.

As discussed in Section 3.3, soil loss due to erosion caused by overland sheet flow has the ability to impact the integrity of the cover. However, it is proposed that the revegetation concepts described in Section 4 be implemented on the slopes to minimize erosion, and increase the rate of success for revegetation. The proposed slopes are 3H:1V or shallower, and therefore physical stability of the cover is not anticipated to be problematic.

5.4 Main Waste Dump and Main Waste Dump Expansion

Progressive reclamation began at the main waste dump through the placement of cover material, and vegetation trials on two portions of the re-sloped benches. The trials have illustrated various level of success, but reinforces the conclusions from the erosion analysis: that without vegetative support, when placed on slopes the overburden material is highly susceptible to rill erosion, which has led to the development of gullies along the face where vegetation has not been successful. The re-graded slopes were re-graded to 2.5H:1V.

The main waste dump expansion was designed with closure in mind; however, it is still under construction and therefore, the majority of reclamation activities, including repair of the currently placed cover, will be required. Re-graded slopes are proposed to be variable, and are currently designed to be as steep as 2.5H:1V, and as shallow as 4H:1V.

Consistent with the overall theme of this document, a minimum cover thickness of 0.5 m is proposed recognizing that localized areas may require additional grading to meet the final design grades. Much of the dump slopes will require re-grading and, with the exception of the south-east corner of the dump, this will be completed on a balanced cut-fill basis using the existing waste rock.

To shed water, the top of the main dump expansion has been designed to be split into two main catchments with water shed to the west. These catchment areas are illustrated in the detailed hydraulic analysis information contained in Appendix F. The intent is to minimize the amount of water that flows directly over the slope as sheet flow to that which falls and accumulates on the slopes. Each of these small catchments would be constructed to direct water into a broad swale, currently considered to be 2 m wide at the base, and have side slopes of 10H:1V. The swales were designed based on contributing watershed area, and flow depths were both calculated to be 0.21 m during a 1:200 year 24 hour flood event.

The swales have been designed to flow over the slope, and transition to a 2 m wide base channel with 3H:1V side slopes. The swales on the top are proposed to be armoured with vegetation, while the slopes are proposed to be armoured with a gravel to cobble sized rip rap. Rip rap thickness and final dimensions are yet to be determined.

The proposed re-grading and swale locations are illustrated in Figure 5. The proposed plan includes approximately 115,800 m^3 of cut and 215,800 m^3 of fill to achieve the intent of the general re-grading, including the area in the south east corner and 106,900 m^3 of cover material.

As discussed in Section 3.3, soil loss due to erosion caused by overland sheet flow has the ability to impact the integrity of the cover. Due to the size of the dump, and the length of the slopes, a variety of support practices have been adopted to reduce the overall erosion susceptibility of the slope. These support practices include complex slopes, benches to reduce flow velocity and provide areas of sediment deposition. Of critical importance will be the establishment of a strong vegetative cover early on in the closure to further reduce the potential for erosion along the slopes. The short-term revegetation concept is described in Section 4.

Additional design work is warranted to confirm the physical stability of the cover on slopes greater than 3H:1V will not be problematic. It is currently envisaged that in development of an updated stability model, areas where slopes of 2.5H:1V are currently proposed is at the top of the slope where the piezometric surface in the cover will most likely be the lowest along the slope.

5.5 Main Pit Dump & Subaerial Tailings

The main pit dump is currently under construction and the final configuration of the dump has yet to be finalized. It is currently proposed that the dump will be graded to the north at approximately 5%, and that a swale will be designed to carry water into the pit. The dump slopes will be designed in consideration of long-term stability and in consideration of minimizing long-term erosion.

A minimum cover thickness of 0.5 m is proposed, with little need for re-grading as the dump is under construction. To shed water, the top of the Main Pit Dump has been designed as one catchment with water shedding to the north into the pit. This catchment area is illustrated in the detailed hydraulic analysis information contained in Appendix F. A broad swale, with dimensions of 7.0 m wide at the base and side slopes of 10H:1V is currently proposed. The swale was designed based on contributing watershed area and the flow depth has been estimated to be 0.13 m during a 1:200 year 24 hour flood event, accounting for ice accumulation within the swale. A swale is also proposed to carry the water collected on the top surface down the slope. This swale has been designed to flow over the slope and transition to a channel with the same base width, but with 3H:1V side slopes. The swale on the top are proposed to be armoured with vegetation, while the slopes are proposed to be armoured with a gravel to cobble sized rip rap. Rip rap thickness and final dimensions are yet to be determined.

As part of covering the Main Pit Dump, a cover will be required for the subaerially deposited tailings which are expected to be above the high water level in the pit at closure. These tailings will be covered with a rock trafficking layer and a 0.5 m thick overburden cover; however, detailed engineering has not been advanced for this concept.

A preliminary plan for re-grading and the swale location is illustrated on Figure 6. The proposed plan does not include regrading the pile, but does include approximately 43,700 m^3 of cover material, which is exclusive of the fill volume required for covering the subaerial tailings.

As discussed in Section 3.3, soil loss due to erosion caused by overland sheet flow has the ability to impact the integrity of the cover. However, it is proposed that the revegetation concepts described in Section 4 be implemented on the slopes to minimize erosion, and increase the rate of success for revegetation.

The currently illustrated dump faces are at an angle of repose (~1.3H:1V), and therefore it is recommended that final grading of this structure be completed prior to commenting on the physical stability.

5.6 Area 118 Pit Backfill Dump

The Area 118 Pit Backfill Dump is not constructed, and is currently in the planning stages. The proposed re-grading plan is intended to fill in the dump, while contouring the dump slopes at 3H:1V or shallower. A minimum cover thickness of 0.5 m is proposed, and it is anticipated that the dump will be constructed to facilitate ease of reclamation. The entire grading concept is intended to shed water off the cover, and this area has been delineated into one catchment area (detailed provided in Appendix F). A broad swale with dimensions of 3.5 m wide at the base and side slopes of 10H:1V is currently proposed. The swale was designed based on contributing watershed area and the flow depth has been estimated to be 0.15 m during a 1:200 year 24 hour flood event, accounting for ice accumulation within the swale. As this area does not have a flatter top to it, the swale will be constructed on the slope. The swale is proposed to be armoured with vegetation.

A preliminary plan for re-grading and the swale location is illustrated in Figure 7. The proposed plan includes approximately 704,200 m^3 of fill to achieve the intent of the general re-grading and 19,700 m^3 of cover material.

As discussed in Section 3.3, soil loss due to erosion caused by overland sheet flow will be an important consideration for this facility, and the revegetation concepts described in Section 4 will be incorporated into the design.

The currently illustrated dump faces are at angles of 3H:1V or shallower, and therefore the physical stability of the cover is not considered to be problematic.

6 Conclusions

This document presents an updated design for the closure covers at the Minto site and supersedes any previous cover designs at the site. A description of how the design objectives and function were met is provided in the table below:

Design Objective and Function	**Design Component**
Minimize infiltration to the extent practical using locally available material.	Specifying a material particle size distribution demonstrated to appropriate reduce infiltration through numerical modelling (SRK, 2015).
Ensure a stable landform that will promote establishment of natural vegetation endemic to the area.	Analysis has been completed to demonstrate the erosion susceptibility of the proposed cover soils; however, methods to limit the erosion have been proposed. Analysis has been completed to determine the physical stability of the covers, and that on steep slopes (e.g. 2.5H:1V) the analysis requires further evaluation.

Design Objective and Function	**Design Component**
Minimize ponding and surface erosion on the final landform.	The grading plans developed have been done so to reduce the risk of surface water ponding, and flow velocities have been considered in completing the sizing of the channels.

Other primary conclusions of this document include:

- Approximately 2.3 Million bank cubic metres is available for use as closure cover from the reclamation overburden dump and an additional 1.3 Million bank cubic metres may be available from the proposed Area 2 Stage 3 Pit.
- The cover thickness is proposed as a minimum 0.5 m thick and the cover material is proposed to have greater than 10% fines. Based on current grading plans, this results in approximately 753,000 m^3 of cover material to be placed.
- Revegetation is to occur following two main strategies:
  - Erosion control treatment on slopes consisting of seed mixes of native grasses, and application of fertilizer to in support of establishing a strong vegetative cover to reduce the potential for gully development and erosion of the cover; and
  - Native species establishment in areas of tables and benches using native plant communities.
- Facilities have been designed with re-graded slopes intended to provide a cut/fill balance while targeting overall slopes as shallow as possible.
- Facilities are to be graded to reduce the amount of water that flows over slopes. Facility tops are graded to central swales designed to accommodate a 1:200 year event, without the need for aggregate riprap, and that rely on vegetation to provide roughness within the channel.
- Additional work is required prior to implementation of these cover designs.

This report, Updated Closure Cover Design for the Minto Mine 2016 Reclamation and Closure Plan, was prepared by

Original Signed By

Erik Ketilson, MEng, PEng
Senior Consultant

and reviewed by

Original Signed By

Maritz Rykaart, PhD, PEng
Practice Leader

Original Signed By

Dylan MacGregor, MSc, PGeo
Practice Leader

All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

Disclaimer—SRK Consulting (Canada) Inc. has prepared this document for Minto Explorations Ltd. Any use or decisions by which a third party makes of this document are the responsibility of such third parties. In no circumstance does SRK accept any consequential liability arising from commercial decisions or actions resulting from the use of this report by a third party.

The opinions expressed in this report have been based on the information available to SRK at the time of preparation. SRK has exercised all due care in reviewing information supplied by others for use on this project. Whilst SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information, except to the extent that SRK was hired to verify the data.

7 References

EBA, 2010. Reclamation Overburden Dump Expansion Geotechnical Design Report. Technical Memorandum. Prepared for Minto Explorations Ltd. EBA File W14101068.004. June 29, 2010.

Personal communication with Kevin Cymbalisty. June 22, 2016.

SRK, 2013a. Scoping Level Cover Assessment for Minto Closure Covers. Report. Prepared for Minto Explorations Ltd. SRK Consulting (Canada) Inc. Project No. 1CM002.007. August 2013.

SRK, 2013b. 2012 Overburden Characterization Data Report for Minto Closure Covers. Report. Prepared for Minto Explorations Ltd. SRK Consulting (Canada) Inc. Project No. 1CM002.007. October 2013.

SRK, 2014. Review of geotechnical strength properties at Minto Mine. Technical Memorandum. Prepared for Minto Explorations Ltd. SRK Consulting (Canada) Inc. Project No. 1CM002.018.110. July 17, 2014.

SRK, 2015. Minto Mine Closure Covers: Results of Numerical Modelling to Bracket Percolation Predications. Technical Memorandum. Prepared for Minto Explorations Ltd. SRK Consulting (Canada) Inc. Project No. 1CM002.030. January 5, 2015.

SRK, 2016a. Dry-stack Tailings Storage Facility Interim Cover Investigation. Technical Memorandum. Prepared for Minto Explorations Ltd. SRK Consulting (Canada) Inc. Project No. 1CM002.031.0500.03. April 7, 2016.

SRK, 2016b. Closure Landform Design and Reclamation Landform Units for the Minto Mine. Report. Prepared for Minto Explorations Ltd. SRK Consulting (Canada) Inc. Project No. 1CM002.031. May 2016.

Wall, G.J., D.R. Coote, E.A. Pringle and I.J. Shelton (editors). 2002. RUSLEFAC –Revised Universal Soil Loss Equation for Application in Canada: A Handbook for Estimating Soil Loss from Water Erosion in Canada. Research Branch, Agriculture and Agri-Food Canada. Ottawa. Contribution No. AAFC/AAC2244E. 117pp.

Yukon Energy, Mines and Resources. (2013b). Re-vegetation on Mineral Claims. Interpretive Bulletin 2013-01. Mining Lands, Mineral Resources, Department of Energy, Mines and Resources, Yukon Government, Whitehorse. 3 pp.

Figures

REFERENCE

Orthophoto obtained in 2014 and provided by client

srk consulting

capstone
MINTO MINE
OPERATED BY MINTO EXPLORATIONS LTD.

Minto Explorations Ltd.

2016 Updated Closure Cover Design

Overall Site Plan

SRK JOB NO.: 1CM002.049
FILE NAME: 1CM002.049 - GA-2.dwg

DATE: July 2016
APPROVED: EPK
FIGURE: 1

\\ssk-svr0.ssk.na.srk.ad\Saskatoon Projects\01_SITES\Minto Mine YK Capstone\1CM002.049_DetailedCoverDesign\Civil3D-DESIGN\Minto\Re-Grading\1CM002.049 - GA-2.dwg

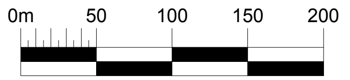
LEGEND

— — — Drainage Channel

▨ Areas to be covered

NOTES

1. Contours data set provided by Minto in May 2016.
2. Contours shown at a 2.0m interval.



srk consulting

capstone
MINTO MINE
OPERATED BY MINTO EXPLORATIONS LTD.

Minto Explorations Ltd.

SRK JOB NO.: 1CM002.049

FILE NAME: 1CM002.049-SW-WRD-2.dwg

2016 Updated Closure Cover Design

Southwest Waste Dump
Cover Area

DATE: July 2016	APPROVED: EPK	FIGURE: 2

\\ssk-svr0.ssk.na.srk.ad\Saskatoon Projects\01_SITES\Minto Mine YK Capstone\1CM002.049_DetailedCoverDesign\Civil3D-DESIGN\Minto\Re-Grading\1CM002.049-SW-WRD-2.dwg

LEGEND

- – – – Drainage Channel
- ▨ Areas to be covered

NOTES

1. Contours data set provided by Minto in May 2016.
2. Contours shown at a 2.0m interval.

0m 30 60 90 120

srk consulting

capstone MINTO MINE
OPERATED BY MINTO EXPLORATIONS LTD.

2016 Updated Closure Cover Design

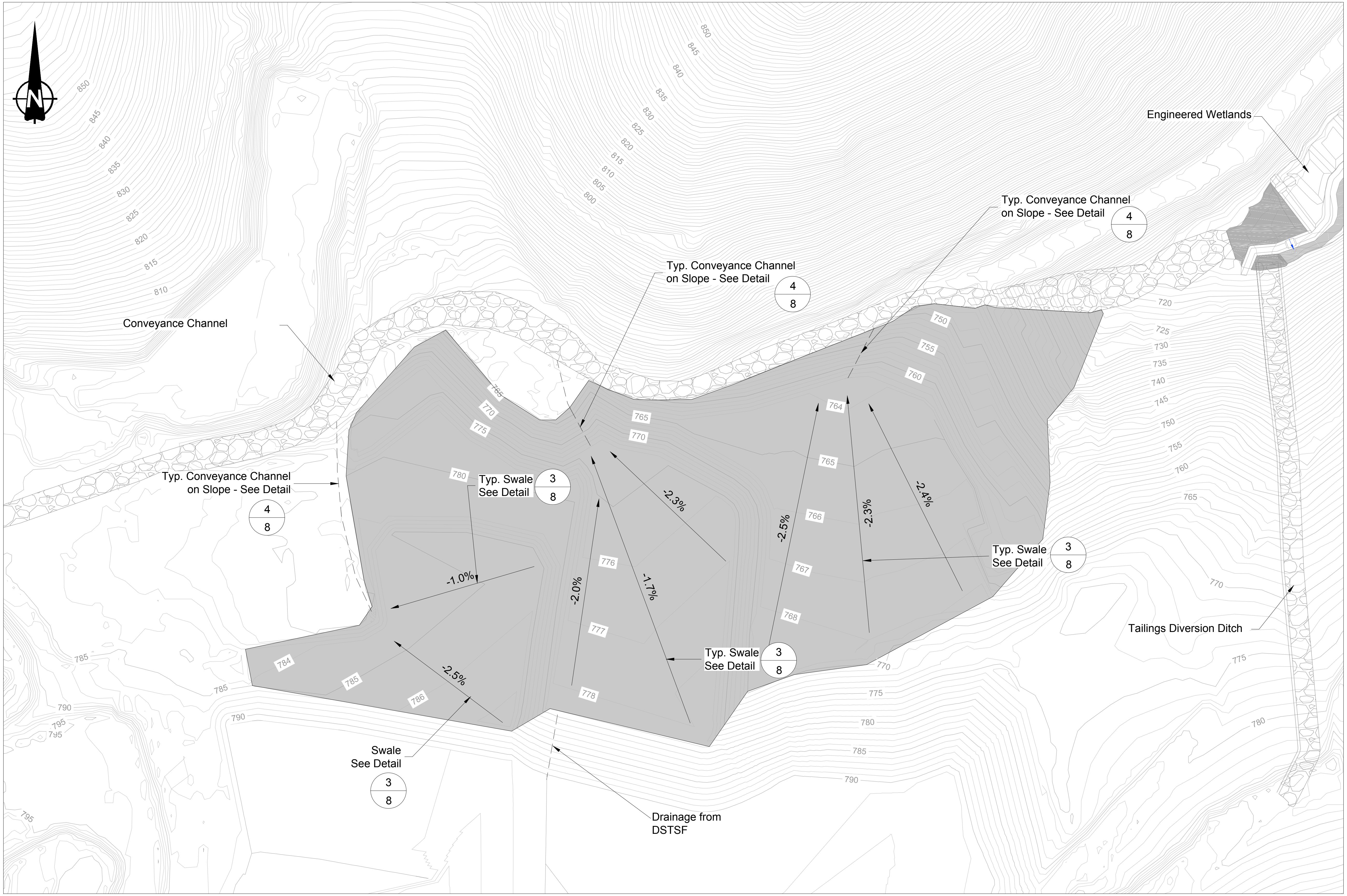
Drystack Tailings Storage Facility
Cover Area

SRK JOB NO.:	1CM002.049
FILE NAME:	1CM002.049 - Dry Stack_2.dwg

Minto Explorations Ltd.

DATE:	APPROVED:	FIGURE:
July 2016	EPK	3

\\ssk-svr0.ssk.na.srk.ad\Saskatoon Projects\01_SITES\Minto Mine YK Capstone\1CM002.049_DetailedCoverDesign\Civil3D-DESIGN\Minto\Re-Grading\1CM002.049 - Dry Stack_2.dwg

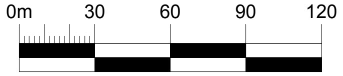


LEGEND

— — —	Drainage Channel
▨	Areas to be covered

NOTES

1. Contours data set provided by Minto in May 2016.
2. Contours shown at a 2.0m interval.



srk consulting

capstone
MINTO MINE
OPERATED BY MINTO EXPLORATIONS LTD.

SRK JOB NO.: 1CM002.049
FILE NAME: 1CM002.049 - Mill Valley-2.dwg

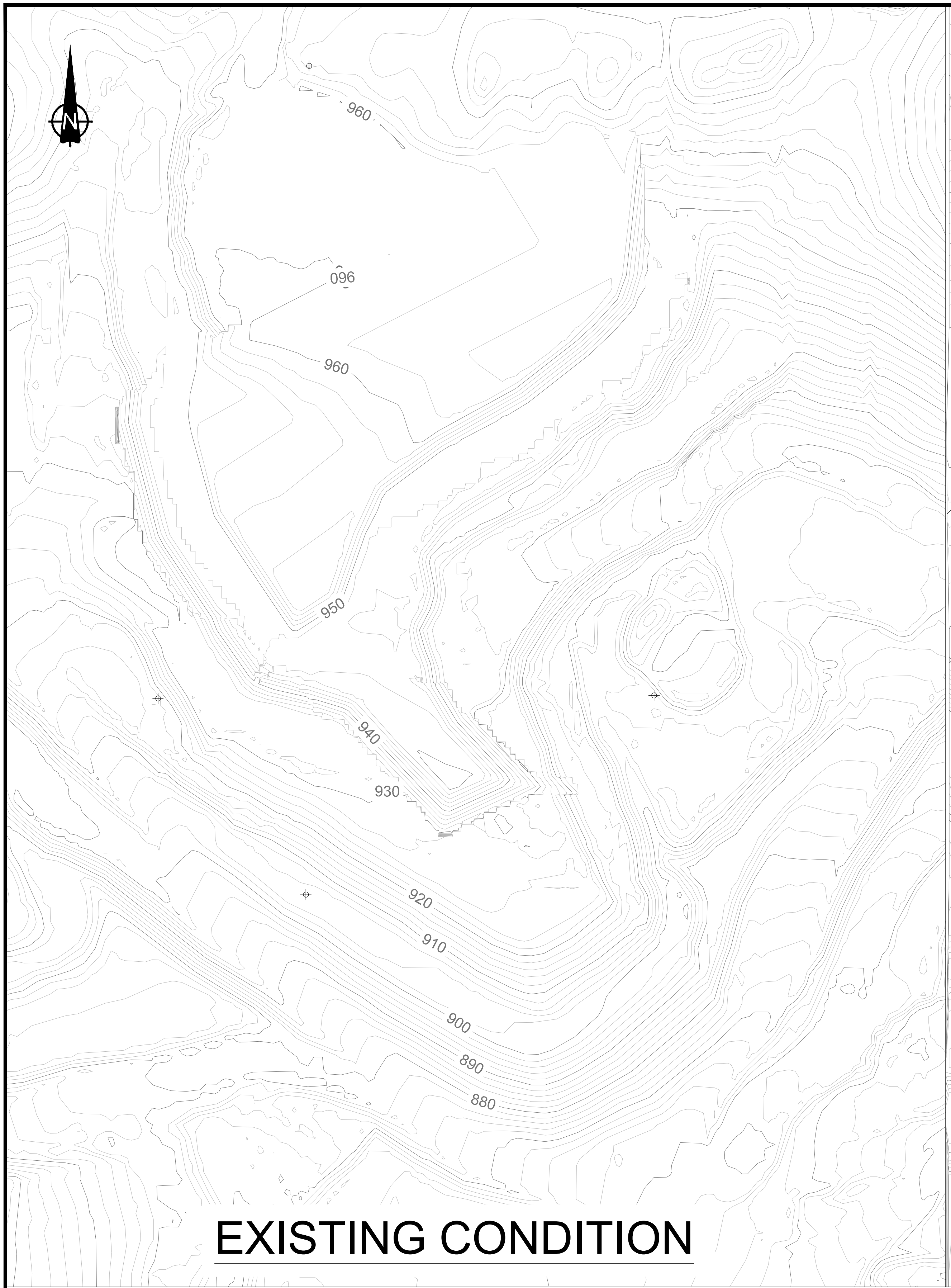
Minto Explorations Ltd.

2016 Updated Closure Cover Design

Mill Valley Fill & Extensions
Cover Area

DATE: July 2016
APPROVED: EPK
FIGURE: 4

\\ssk-svr0.ssk.na.srk.ad\Saskatoon Projects\01_SITES\Minto Mine YK Capstone\1CM002.049_DetailedCoverDesign\Civil3D-DESIGN\Minto\Re-Grading\1CM002.049 - Mill Valley-2.dwg



EXISTING CONDITION

CLOSURE CONFIGURATION

LEGEND

— — —	Drainage Channel
▨	Areas to be covered

NOTES

1. Contour data set provided by Minto in May 2016.
2. Contours shown at a 2.0m interval.

0m 40 80 120 160

srk consulting

SRK JOB NO.: 1CM002.049

FILE NAME: 1CM002.049 – Main Waste Dump-2.dwg

capstone
MINTO MINE
OPERATED BY MINTO EXPLORATIONS LTD.

Minto Explorations Ltd.

2016 Updated Closure Cover Design

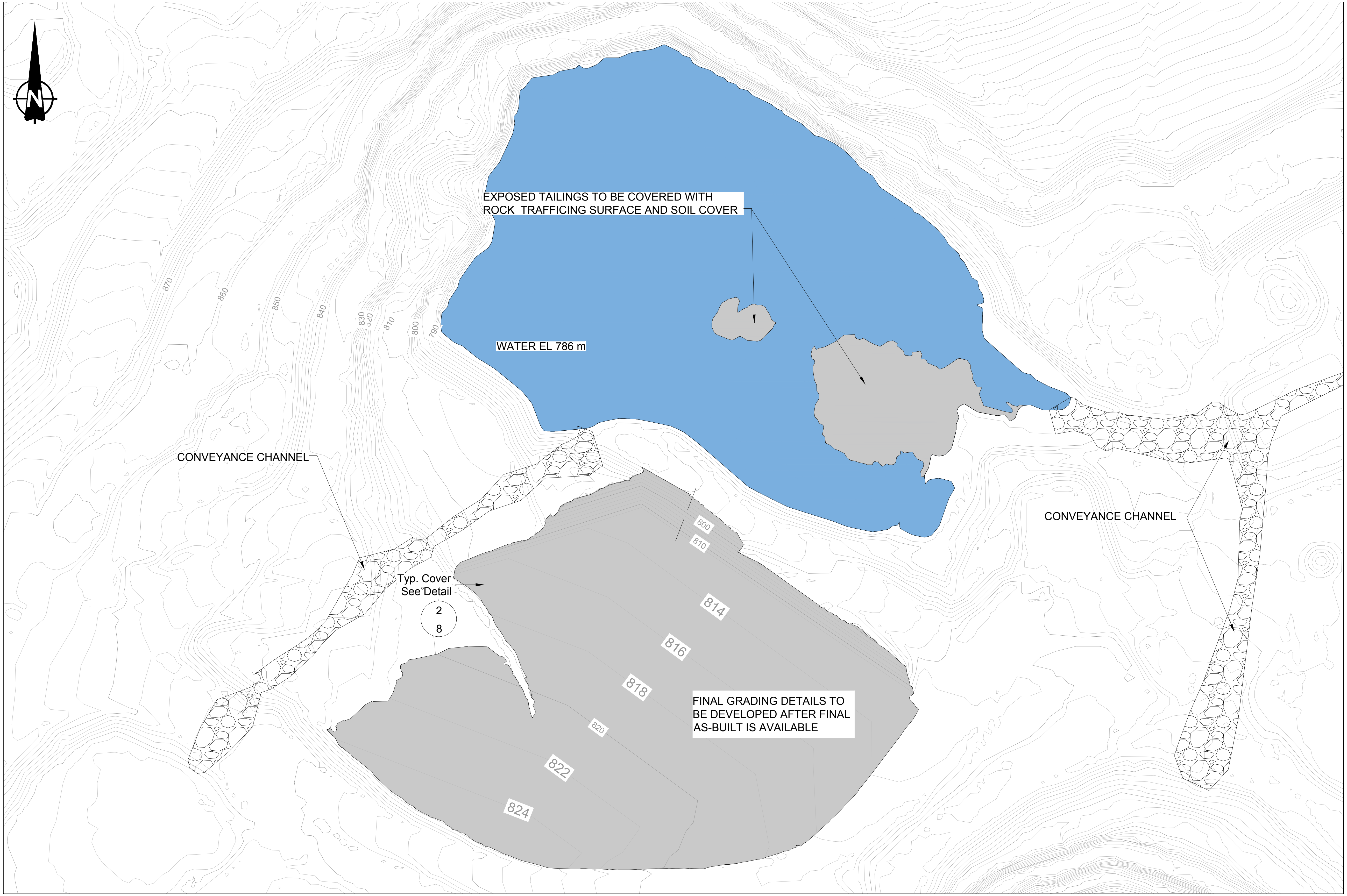
Main Waste Dump & Expansion
Soil Cover

DATE: JULY 2016

APPROVED: EPK

FIGURE: 5

\\ssk-svr0.ssk.na.srk.ad\Saskatoon Projects\01_SITES\Minto Mine YK Capstone\1CM002.049_DetailedCoverDesign\Civil3D-DESIGN\Minto\Re-Grading\1CM002.049 - Main Waste Dump-2.dwg



LEGEND

— — —	Drainage Channel
▨	Areas to be covered

NOTES

1. Contour data set provided by Minto in May 2016.
2. Contours shown at a 2.0m interval.

0m 30 60 90 120

srk consulting

capstone MINTO MINE
OPERATED BY MINTO EXPLORATIONS LTD.

SRK JOB NO.: 1CM002.049
FILE NAME: 1CM002.049 - Main Pit Dump-2.dwg

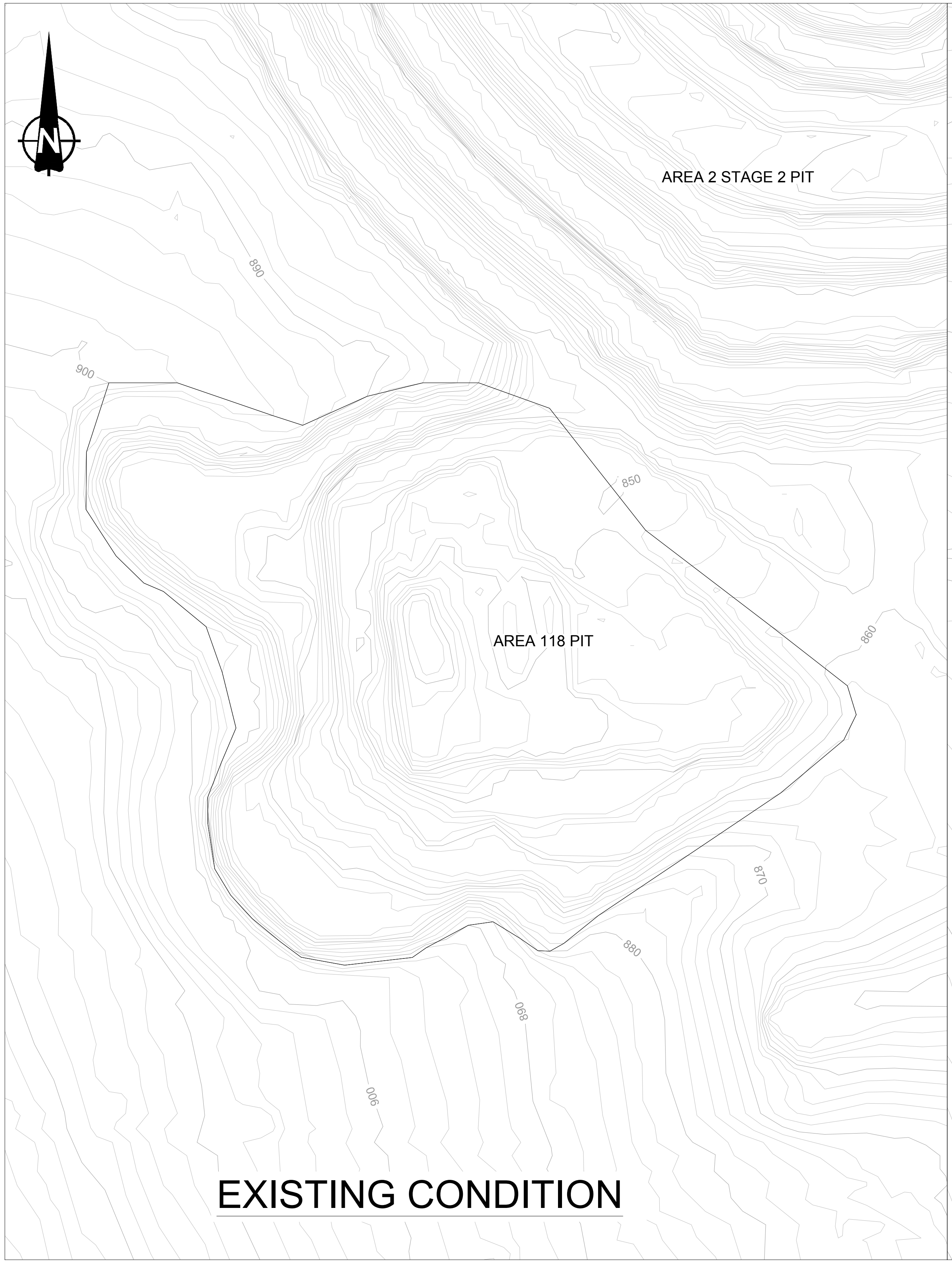
Minto Explorations Ltd.

2016 Updated Closure Cover Design

Main Pit Dump & Subaerial Tailings
Cover Area

DATE:	APPROVED:	FIGURE:
July 2016	EPK	6

\\ssk-svr0.ssk.na.srk.ad\Saskatoon Projects\01_SITES\Minto Mine YK Capstone\1CM002.049_DetailedCoverDesign\Civil3D-DESIGN\Minto\Re-Grading\1CM002.049 - Main Pit Dump-2.dwg



EXISTING CONDITION

CLOSURE CONDITION

LEGEND

— — — Drainage Channel
▨ Areas to be covered

NOTES

1. Contour data set provided by Minto in May 2016.
2. Contours shown at a 2.0m interval.

0m 30 60 90 120

srk consulting

capstone
MINTO MINE
OPERATED BY MINTO EXPLORATIONS LTD.

SRK JOB NO.:	1CM002.049
FILE NAME:	1CM002.049 - Area 118_2.dwg

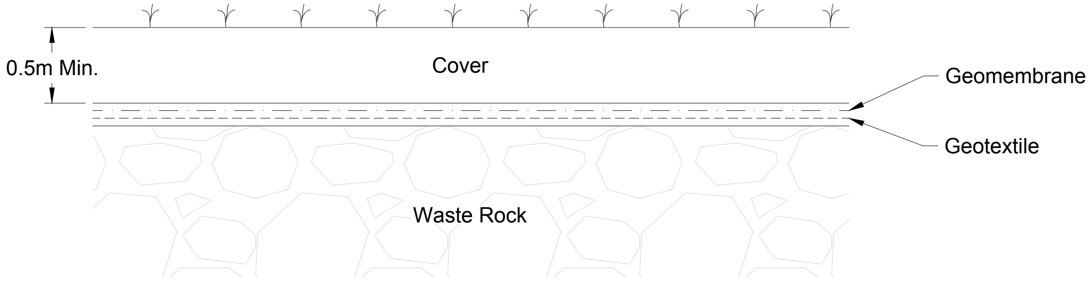
Minto Explorations Ltd.

2016 Updated Closure Cover Design

Area 118 Pit Backfill Dump
Cover Area

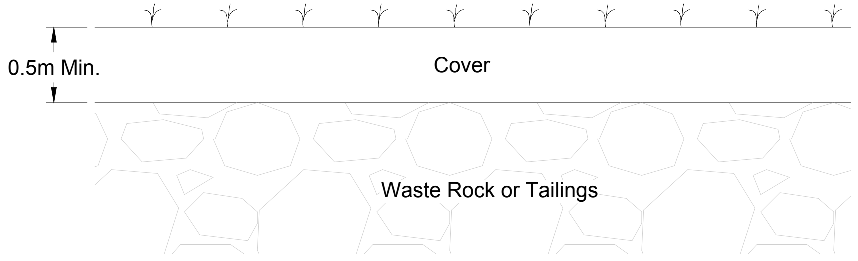
DATE:	APPROVED:	FIGURE:
July 2016	EPK	7

\\ssk-svr0.ssk.na.srk.ad\Saskatoon Projects\01_SITES\Minto Mine YK Capstone\1CM002.049_DetailedCoverDesign\Civil3D-DESIGN\Minto\Re-Grading\1CM002.049 - Area 118_2.dwg



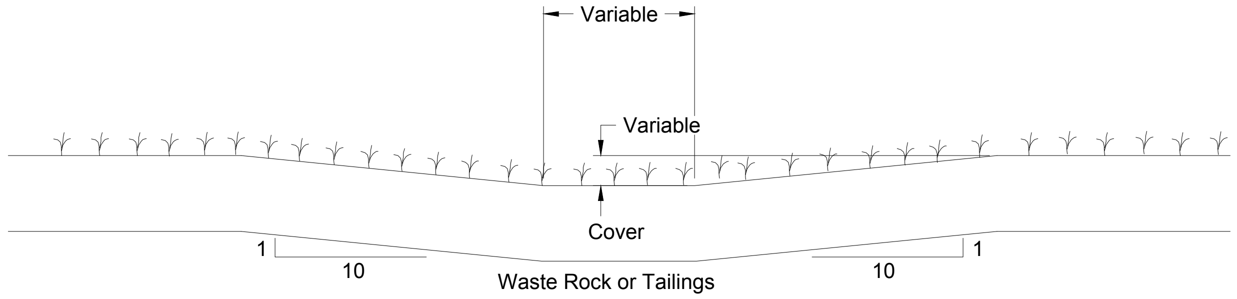
1 High Grade Waste Cover

Not To Scale



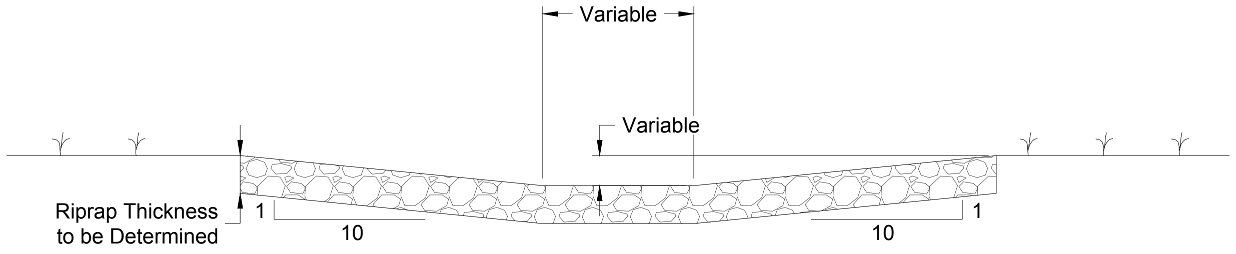
2 Cover Detail

Not To Scale



3 Swale Detail

Not To Scale



4 Slope Swale Detail

Not To Scale

srk consulting

capstone
MINTO MINE
OPERATED BY MINTO EXPLORATIONS LTD.

SRK JOB NO.: 1CM002.049
FILE NAME: 1CM002.049 - Details_2.dwg

Minto Explorations Ltd.

2016 Updated Closure Cover Design

Details

DATE: July 2016
APPROVED: EPK
FIGURE: 8

\\ssk-svr0.ssk.na.srk.ad\Saskatoon Projects\01_SITES\Minto Mine YK Capstone\1CM002.049_DetailedCoverDesign\Civil3D-DESIGN\Minto\Re-Grading\1CM002.049 - Details_2.dwg

Appendix A: Minto Closure Cover Design – Geotechnical Characteristics of the Cover Materials

SRK Consulting (Canada) Inc.
2200–1066 West Hastings Street
Vancouver, BC V6E 3X2

T: +1.604.681.4196
F: +1.604.687.5532
vancouver@srk.com
www.srk.com

Memo

To:	File	**Client:**	Minto Exploration Ltd.
From:	Erik Ketilson, MEng, PEng.	**Project No:**	1CM002.049
Reviewed by:	Maritz Rykaart, PhD, PEng.	**Date:**	July 20, 2016
Subject:	Minto Closure Cover Design – Geotechnical Characterization of the Cover Materials		

1 Introduction

The Minto Mine requires closure covers to be placed over the waste rock and tailings facilities. The purpose of this memo is to characterize the overburden material to provide an appropriate material envelope to guide the construction of the cover material.

2 Cover Requirements

SRK completed numerical modelling to bracket percolation predictions in 2015 (SRK, 2015). The modelling indicated that without a cover, the net percolation could be between 39% and 45% and, depending on climactic conditions, could vary between 26% and 65%. Cover materials were applied, with the base case cover material consisting of material properties from sample MWD-TP4 collected at the Minto mine, which is a gravel and sand material with more than 25% fines (<0.075 microns). The results indicate that the net percolation is approximately 23%, but depending on the climactic conditions, can vary from 6% to 43%. The cover material was varied and an analysis was also completed considering a coarse material (MWD-TP3), which is predominantly gravel and sand with less than 10% fines (<0.075 microns). The results of this analysis indicated that the net percolation was approximately 23%, but depending on the climactic conditions, can vary from 5% to 44%.

The modelling results indicate that there is nearly a 20% decrease in net percolation after cover materials are included in the analysis. The cover thickness was assumed to be approximately 0.5 m thick, and following sensitivity analysis to the thickness (1 m and 2 m) minor decreases in net percolation were estimated. Therefore, a minimum cover thickness of 0.5 m was adopted for the project, with materials containing greater than 10% fines. Based on preliminary closure cover revegetation work completed by Integral Ecology Group (IEG) in 2016 (IEG, 2016), overburden materials containing greater than 10% fines are expected to support the growth of vegetation.

3 Geotechnical Material Characteristics

3.1 Particle Size Distribution

SRK evaluated 167 particle size distribution analyses completed on overburden samples at the Minto Site, and classified the particle size distribution based on the Modified Unified Soil Classification System (MUSCS) and the Unified Soil Classification System (USCS). Data was obtained from investigations completed, and documented by SRK (SRK, 2013, 2016a&b). By correlating the specific sample analysis with borehole location, SRK was able to classify the overburden by source location. Figure 1 illustrates the upper and lower bound of the particle size distributions for each area.

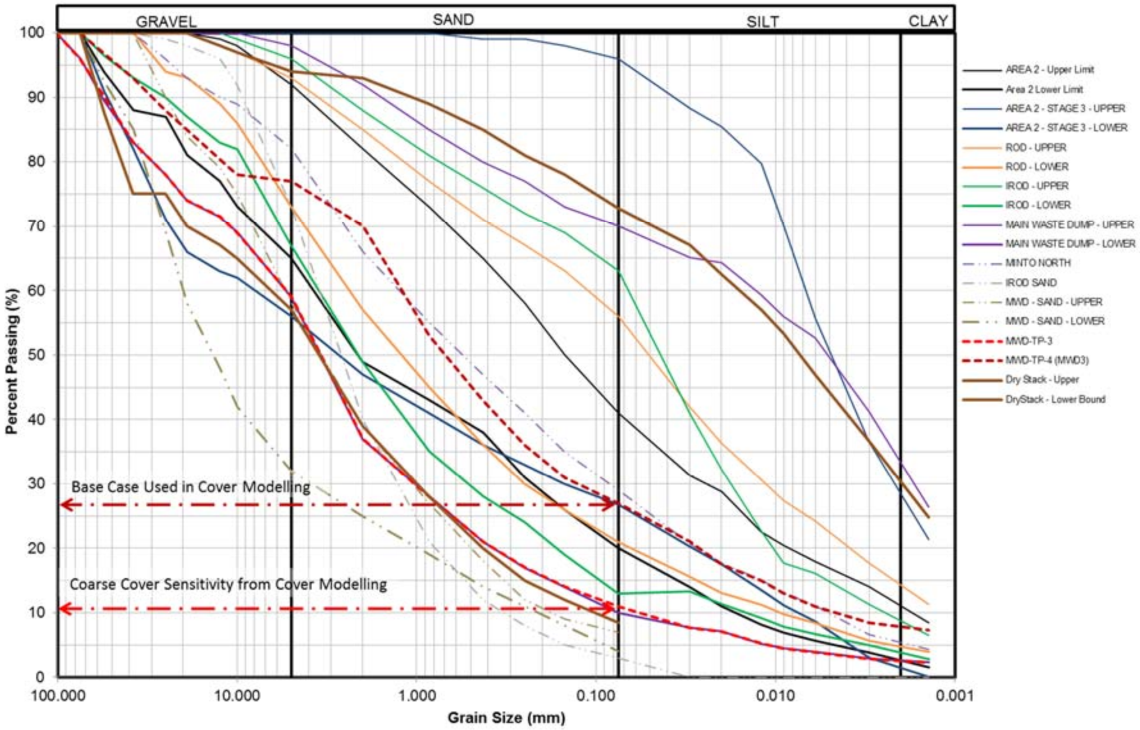


Figure 1: Particle Size Distribution

Source: Minto_MaterialProperties_1CM002-049_Rev00_EK.xlsx

The upper boundaries are also listed in tabular form in Table 1. The lower boundaries are listed in tabular form in Table 2.

Table 1: PSD Area Upper Bound

Upper Bound - Finer Limit					
Area	**Gravel**	**Sand**	**Fines**	**Silt**	**Clay**
Area 2	8	51	41	31	11
Area 2 - Stage 3	0	4	96	69	27
Drystack Tailings Cover	6	21	73	44	29
Ice Rich Overburden Dump	4	33	63	55	8
Main Waste Dump	2	28	70	38	32
Reclamation Overburden Dump	7	37	56	42	14

Source: Minto_MaterialProperties_1CM002-049_Rev00_EK.xlsx

Table 2: PSD Area Lower Bound

Lower Bound - Coarser Limit					
Area	**Gravel**	**Sand**	**Fines**	**Silt**	**Clay**
Area 2	35	45	20	18	2
Area 2 - Stage 3	44	29	27	26	1
Drystack Tailings Cover	43	49	9	2	6
Ice Rich Overburden Dump	33	54	13	9	4
Main Waste Dump	41	49	10	7	3
Reclamation Overburden Dump	27	52	21	16	5

Source: Minto_MaterialProperties_1CM002-049_Rev00_EK.xlsx

3.2 Atterberg Limits

Of the available samples, 38 had completed analysis to determine the Atterberg Limits (liquid and plastic limits). Data was obtained from investigations completed, and documented by SRK (SRK, 2013, 2016a&b). Figure 2 illustrates soil classification according to the modified unified soil classification system. The modified unified soil classification system is similar to the Unified Soil Classification System, however, splits low plastic clay classification into two categories including a clay of intermediate plasticity (CI).

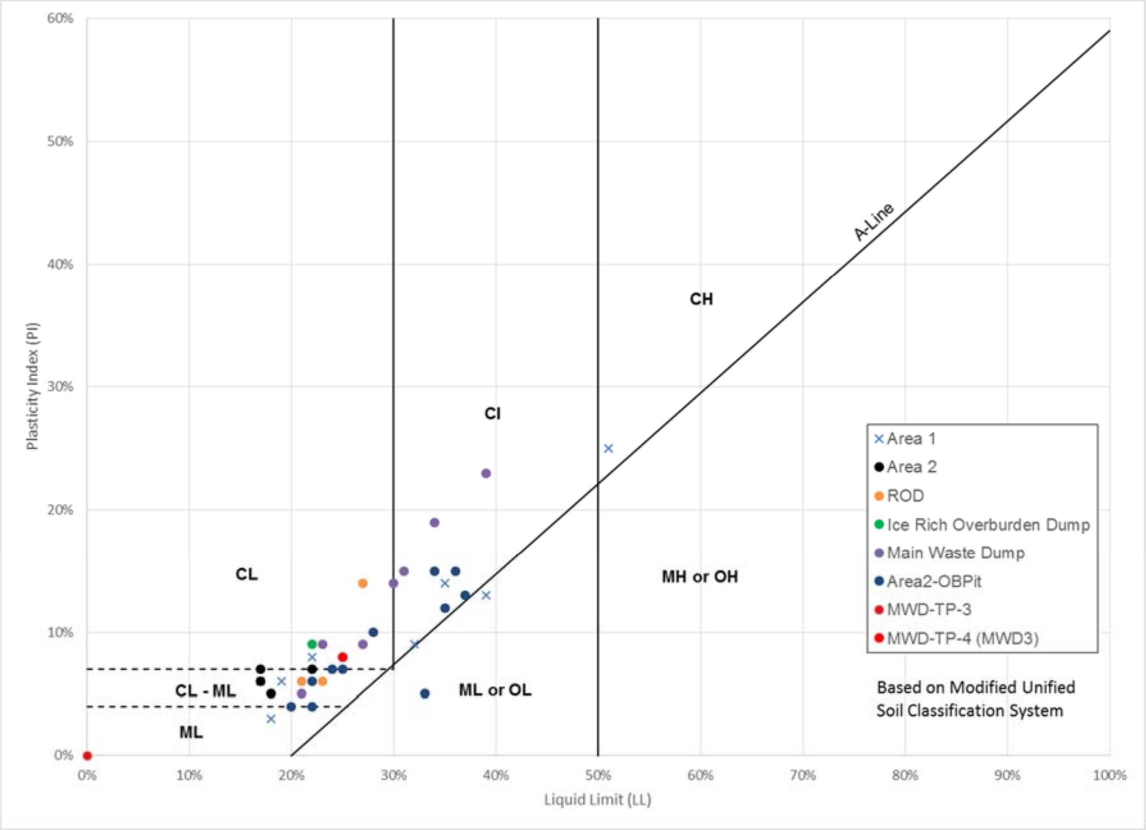


Figure 2: Atterberg Limits

Source: Minto_MaterialProperties_1CM002-049_Rev00_EK.xlsx

3.3 Strength

Strength characteristics for the site materials at Minto are provided within the review of geotechnical strength properties memorandum prepared by SRK (SRK, 2014).

3.4 Erosion

Soil erosion classification is based on the USDA soil textural classification. Table 3 provides a summary of the particle size diameter range based on the Unified soil classification system (USCS), and the United States Department of Agriculture (USDA) soil textural classification.

Table 3: USCS vs USDA Particle Size Distribution Systems

Soil Component	Particle Size Diameter Rage (millimeters)	
	USCS / MUSCS	**USDA**
Boulders	> 200	
Cobbles	200 – 76	
Gravel	76 – 4.75	
Sand	4.75 – 0.075	2.0 – 0.05
Silt	0.075 – 0.002	0.05 – 0.002
Clay	< 0.002	< 0.002

The samples were re-classified, and plotted on a soil texture triangle (Figure 3) to determine the general soil texture. The samples typically categorized as sandy loam.

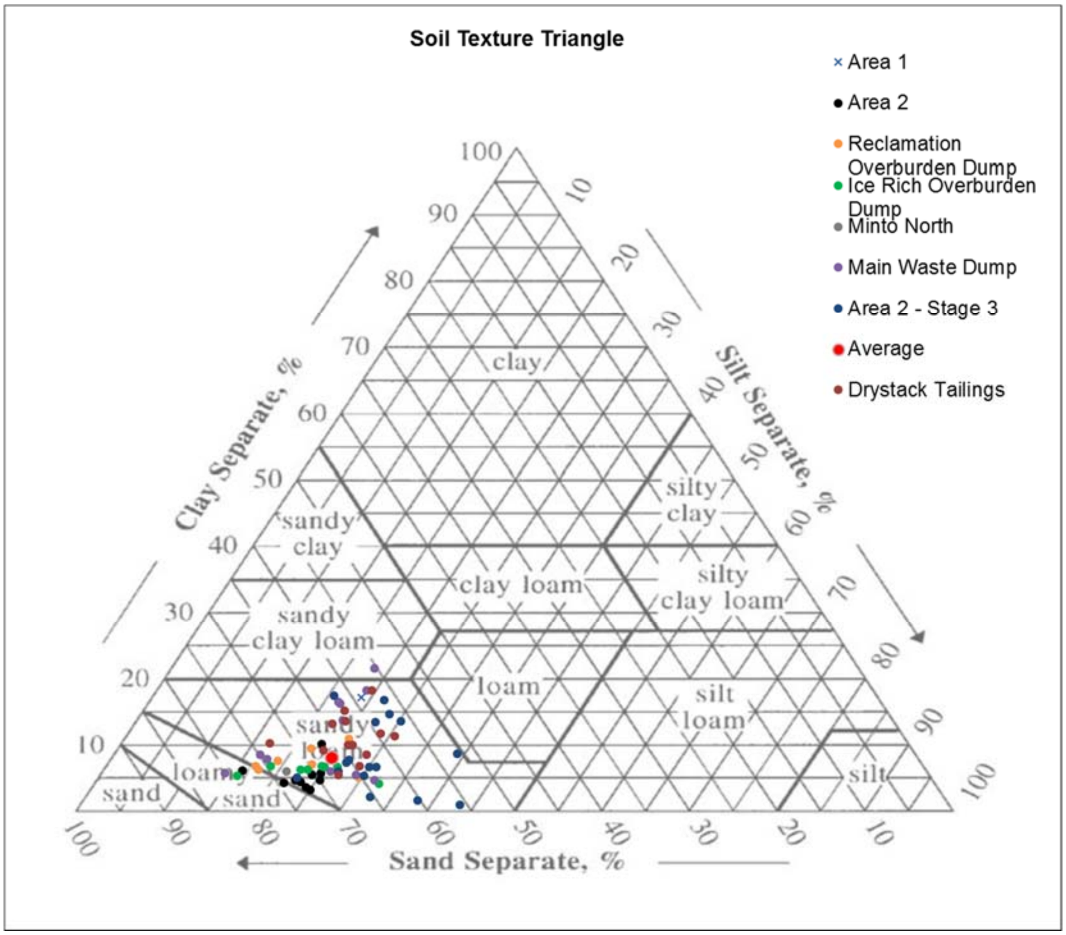


Figure 3: Soil Classification Based on Soil Texture Triangle

Source: Minto_MaterialProperties_1CM002-049_Rev00_EK.xlsx

4 Design Parameters

Based on the particle size distributions, and the net percolation cover modelling completed (SRK, 2015), Table 1 provides a summary of proposed design parameters to be adopted for the Minto Closure Covers.

Table 4: Closure Cover Design Parameters

Description		Value
Cover Thickness		0.5 m (minimum)
Cover Material Specifications	Gravel	0 % to 40%
	Sand	60% to 90%
	Fines	> 10%
Soil Texture Classification	Sandy Loam	Sandy Loam

Disclaimer—SRK Consulting (Canada) Inc. has prepared this document for Minto Explorations Ltd. Any use or decisions by which a third party makes of this document are the responsibility of such third parties. In no circumstance does SRK accept any consequential liability arising from commercial decisions or actions resulting from the use of this report by a third party.

The opinions expressed in this report have been based on the information available to SRK at the time of preparation. SRK has exercised all due care in reviewing information supplied by others for use on this project. Whilst SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information, except to the extent that SRK was hired to verify the data.

5 References

(IEG, 2016). Minto Mine preliminary closure cover revegetation plan. Memorandum. Prepared for SRK Consulting (Canada) Inc. for the Minto Mine Site. Integral Ecology Group. July 29, 2016.

(SRK, 2013). 2012 Overburden Characterization Data Report for Minto Closure Covers. Report. Prepared for Minto Explorations Ltd. SRK Consulting (Canada) Inc. Project No. 1CM002.007. October 2013.

(SRK, 2014). Review of geotechnical strength properties at Minto Mine. Technical Memorandum. Prepared for Minto Explorations Ltd. SRK Consulting (Canada) Inc. Project No. 1CM002.018.110. July 17, 2014.

(SRK, 2015). Minto Mine Closure Covers: Results of Numerical Modelling to Bracket Percolation Predications. Technical Memorandum. Prepared for Minto Explorations Ltd. SRK Consulting (Canada) Inc. Project No. 1CM002.030. January 5, 2015.

(SRK, 2016a). Dry-stack Tailings Storage Facility Interim Cover Investigation. Technical Memorandum. Prepared for Minto Explorations Ltd. SRK Consulting (Canada) Inc. Project No. 1CM002.031.0500.03. April 7, 2016.

(SRK, 2016b). Minto Mine – 2014 and 2015 Area 2 Stage 3 Overburden Drilling. Technical Memorandum. SRK Consulting (Canada) Inc. Project No. 1CM002.037. July 2016.

Appendix B: Minto Mine – 2014 and 2015 Area 2 Stage 3 Overburden Drilling

SRK Consulting (Canada) Inc.
2200–1066 West Hastings Street
Vancouver, BC V6E 3X2

T: +1.604.681.4196
F: +1.604.687.5532
vancouver@srk.com
www.srk.com

Memo

To:	File	**Client:**	Minto Explorations Ltd.
From:	Kaitlyn Kooy, EIT; Erik Ketilson, MEng, PEng	**Project No:**	1CM002.037
Reviewed by:	Maritz Rykaart, PhD, PEng	**Date:**	July 13, 2016
Subject:	Minto Mine - 2014 and 2015 Area 2 Stage 3 Overburden Drilling		

1 Introduction

The Minto Mine is a high-grade copper mine located in the Yukon, approximately 240 km north of Whitehorse. The mine site occupies the valley in the upper reaches of Minto Creek, a tributary on the west side of the Yukon River, about 9 km from the mouth. Operations are ongoing at this time (2016) and began in October 2007. Three pits have been completed to date: the Main Pit, the Area 118 Pit, and the Area 2 Stage 2 Pit.

In support of developing a more robust understanding of the resource within the proposed Stage 3 expansion of the Area 2 pit, Minto planned and executed a drilling program. This program provided an opportunity for Minto to evaluate if there may be minable units of cover material within the overburden that will be excavated as part of the pit development. SRK recommended that the Minto staff receive some basic training in soil logging to help identify possible soils that could be beneficial for closure purposes. SRK provided Minto with on-site staff training for soil logging of some boreholes completed in 2014 and 2015.

The memorandum provides a summary of SRK's assistance during the drilling program, interpretation of the material properties, and comments regarding the potential for mineable units of cover material within the identified overburden for boreholes completed under the supervision of SRK.

2 Field Visit

SRK's Murray McGregor, EIT, visited the Minto site from October 27th through November 5th 2014. During this time, Mr. McGregor was responsible for logging the overburden soils from the initial drill holes as well as training several site staff in basic soil logging methods. Soils were logged according to the Unified Soil Classification System and samples of each material unit were collected for laboratory testing (discussed in Section 4.0). Boreholes were advanced using an HQ diameter, diamond drill bit.

3 Borehole Locations

Table 1 provides a list of boreholes drilled during the 2014 and 2015 programs. The locations of the boreholes are provided in Figure 1. Borehole logs are provided in Attachment 1 and photos of the core form Attachment 2.

Table 1: 2014 – 2015 Drilling Program Boreholes

Hole ID	Easting(1)	Northing(1)	Drill Program
14-SWC-966	385107.8	6944363.1	Oct/Nov 2014
14-SWC-967	385146.1	6944317.3	Oct/Nov 2014
14-SWC-968	385169.1	6944289.2	Oct/Nov 2014
14-SWC-969	385172.2	6944225.0	Oct/Nov 2014
14-SWC-970	385125.3	6944272.0	Oct/Nov 2014
14-SWC-971	385075.1	6944288.0	Oct/Nov 2014
14-SWC-972	385215.6	6944284.0	Oct/Nov 2014
14-SWC-973	385164.4	6944349.0	Oct/Nov 2014
14-SWC-974	385140.0	6944379.0	Oct/Nov 2014
14-SWC-975	385156.1	6944428.0	Oct/Nov 2014
14-SWC-976	385075.3	6944328.0	Oct/Nov 2014
14-SWC-977	385097.9	6944254.0	Oct/Nov 2014
14-SWC-978	385122.4	6944219.0	Oct/Nov 2014
14-SWC-979	385218.8	6944233.0	Oct/Nov 2014
14-SWC-980	385194.5	6944261.0	Oct/Nov 2014
14-SWC-981	385148.0	6944188.0	Oct/Nov 2014
15-SWC-995	385096.1	6944251.6	Feb 2015
15-SWC-996	385161.0	6944314.9	Feb 2015
15-SWC-997	385140.9	6944124.0	Feb 2015

Notes:

(1) Easting and Northing presented in NAD 1983 UTM UTM Zone 8N

4 Soil Description

The encountered overburden materials within the Area 2, Stage 3 pit consists of layers with variable thickness of sand, gravel, silts, and clays. The borehole logs are included as Attachment 1, and photos of the core collected form Attachment 2.

An organic layer was noted only in one borehole – 14-SWC-979. The layer was identified between 0.7 m and 1.0 m below ground surface, and the layer was identified to contain primarily clay and silt sized particles with trace sand sized particles encountered. The soil was brown/black in colour, moist, and of medium plasticity.

Discontinuous layers of sand were identified in each of the boreholes. The sand was quite variable, and consisted of varying content of gravel, silt, and clay content and ranged from well to poorly graded, based on visual identification. The sand was generally brown, with varying shades of grey and red throughout. The sand was primarily identified as moist, with the exception of discreet layers in 14-SWC-968, 14-SWC-970, 14-SWC-971, 14-SWC-972, 14-SWC-973, 15-SWC-995, and 15-SWC-996 where the sand was identified as wet. In some cases, the sand was classified with low or medium plasticity – this was identified in boreholes 14-SWC-967, 14-SWC-969, 15-SWC-995, 15-SWC-996, and 15-SWC-997. The sand was otherwise identified as non-plastic. Generally, the sand unit was considered massive with the exception of 14-SWC-967; 15-SWC-997, and 15-SWC-997 where layers of sand were identified to be laminated or blocky.

Gravel layers were identified in boreholes 14-SWC-966; 14-SWC-967; 14-SWC-973; 14-SWC-975; 14-SWC-981; and 15-SWC-997. The gravel contained varying levels of sand, silt, and clay content. The material was generally brown, with varying shades or red and grey. The material was primarily identified as moist, with the exception of some layers in 15-SWC-997 which were identified as wet. The gravel layers were non-plastic, and massive.

Material classified as silt contained varying degrees of clay, sand, and gravel. The material was generally classified as poorly graded; however, layers were identified in 14-SWC-967, 14-SWC-972, 14-SWC-973, 15-SWC-995, 15-SWC-996, and 15-SWC-997. Generally, the silt was identified to be brown, with varying shades of grey. The moisture content was visually identified as primarily moist, with the exception of some layers identified in borehole 14-SWC-972, 14-SWC-974, 14-SWC-979, 15-SWC-995, and 15-SWC-996 as wet; and one layer from 28.6 m to 28.9 m in borehole 14-SWC-979 was identified as dry. The silt ranged from low to high plasticity. The material was generally classified as massive, with laminated layers identified in boreholes 14-SWC-969, 14-SWC-979, 15-SWC-996, and 15-SWC-997; and one layer was identified as blocky in each of boreholes 14-SWC-973 and 15-SWC-996.

Clay layers primarily contained silt with varying level of sand and gravel. The clay was generally poorly graded, and grey in colour, although some layers were identified as brown. The material was moist, with the exception of layers identified in 14-SWC-974 and 15-SWC-995 which were identified as wet. Clay samples were generally exhibited medium to high degrees of plasticity.

Bedrock was encountered at depths ranging between 3.15 m (14-SWC-966) to 26.5 m (14-SWC-973).

5 Laboratory Testing

During a subsequent site visit in February 2015, Mr. McGregor selected samples from the combined drilling of 2014 and 2015 programs to seek out continuous units of fine grained material containing clay which could be used in cover construction. Several samples were collected from boreholes beneath the Area 2 ring road. A summary of the laboratory tests performed are shown in Table 2.

Table 2: Laboratory Tests Performed

Hole ID	From (m)	To (m)	Sample ID	Moisture Content	Particle Size Analysis	Atterberg Limits
14-SWC-968	15.05	15.40	MM-101259	✓	✓	✓
14-SWC-970	5.65	6.00	MM-101262	✓	✓	✓
14-SWC-969	12.00	12.30	MM-101270	✓	✓	
	19.05	19.35	MM-101273	✓	✓	
14-SWC-972	9.25	9.55	MM-101277	✓	✓	✓
	18.55	18.85	MM-101280	✓	✓	
14-SWC-973	2.80	3.10	MM-101285	✓	✓	✓
	9.17	9.47	MM-101288	✓	✓	✓
14-SWC-975	5.70	6.00	MM-101298	✓	✓	✓
14-SWC-979	20.60	20.90	MM-101317	✓	✓	✓
14-SWC-980	19.40	19.70	MM-101326	✓	✓	✓
15-SWC-995	8.60	8.90	58554	✓	✓	
15-SWC-996	6.12	6.42	58557	✓	✓	✓
	10.69	11.00	58558	✓		
	14.73	15.10	58559	✓	✓	✓
15-SWC-997	9.79	10.11	160025	✓	✓	✓
	15.64	15.88	58565	✓		
	23.09	23.43	58568	✓	✓	✓
	30.60	30.91	58570	✓		
	41.32	41.67	58572	✓	✓	✓

5.1 Test Results

The test results are presented in Attachment 3. Natural moisture content analysis results are summarized in Table 3. Particle size distribution analysis is illustrated in Figure 1, while results of the Atterberg Limits, as classified using the Modified Unified Soil Classification System (MUSCS), is illustrated in Figure 2.

Table 3: Natural Moisture Content Analysis Results

Hole ID	From (m)	To (m)	Moisture Content
14-SWC-968	15.05	15.40	16.6%
14-SWC-970	5.65	6.00	27.6%
14-SWC-969	12.00	12.30	10.7%
	19.05	19.35	26.3%
14-SWC-972	9.25	9.55	16.6%
	18.55	18.85	31.7%
14-SWC-973	2.80	3.10	35.9%
	9.17	9.47	13.2%
14-SWC-975	5.70	6.00	28.1%
14-SWC-979	20.60	20.90	26.5%
14-SWC-980	19.40	19.70	18.8%
15-SWC-995	8.60	8.90	13.4%
15-SWC-996	6.12	6.42	14.8%
	10.69	11.00	21.7%
	14.73	15.10	16.1%
15-SWC-997	9.79	10.11	10.3%
	15.64	15.88	13.7%
	23.09	23.43	11.7%
	30.60	30.91	15.4%
	41.32	41.67	12.7%

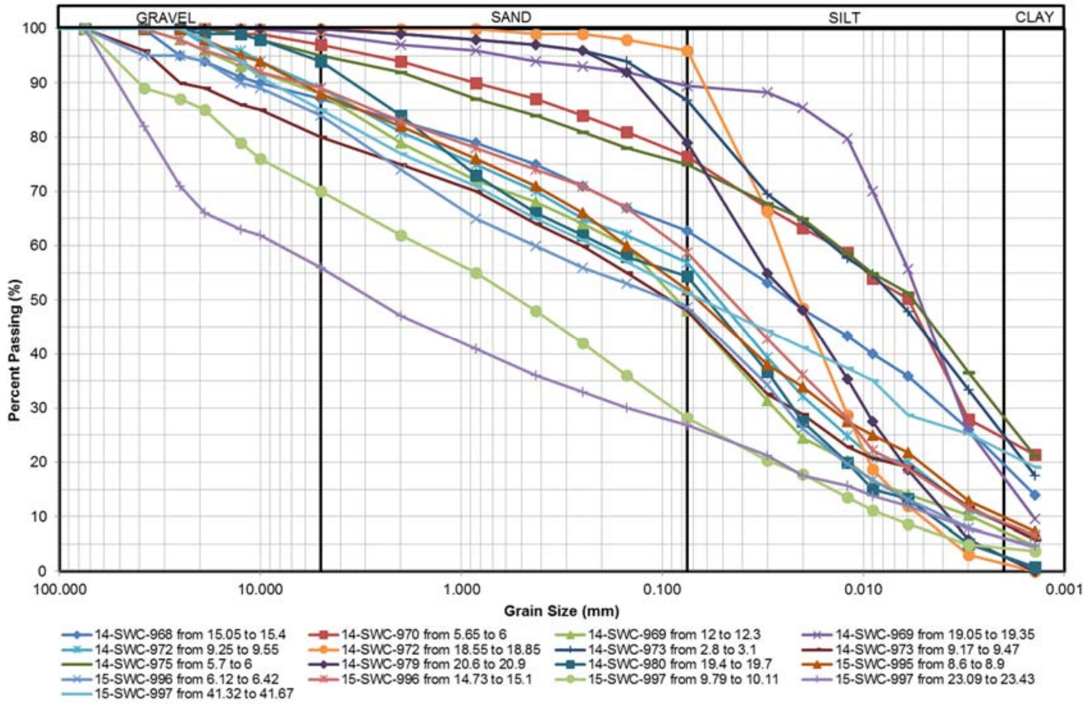


Figure 1: Particle Size Distribution Analysis Results

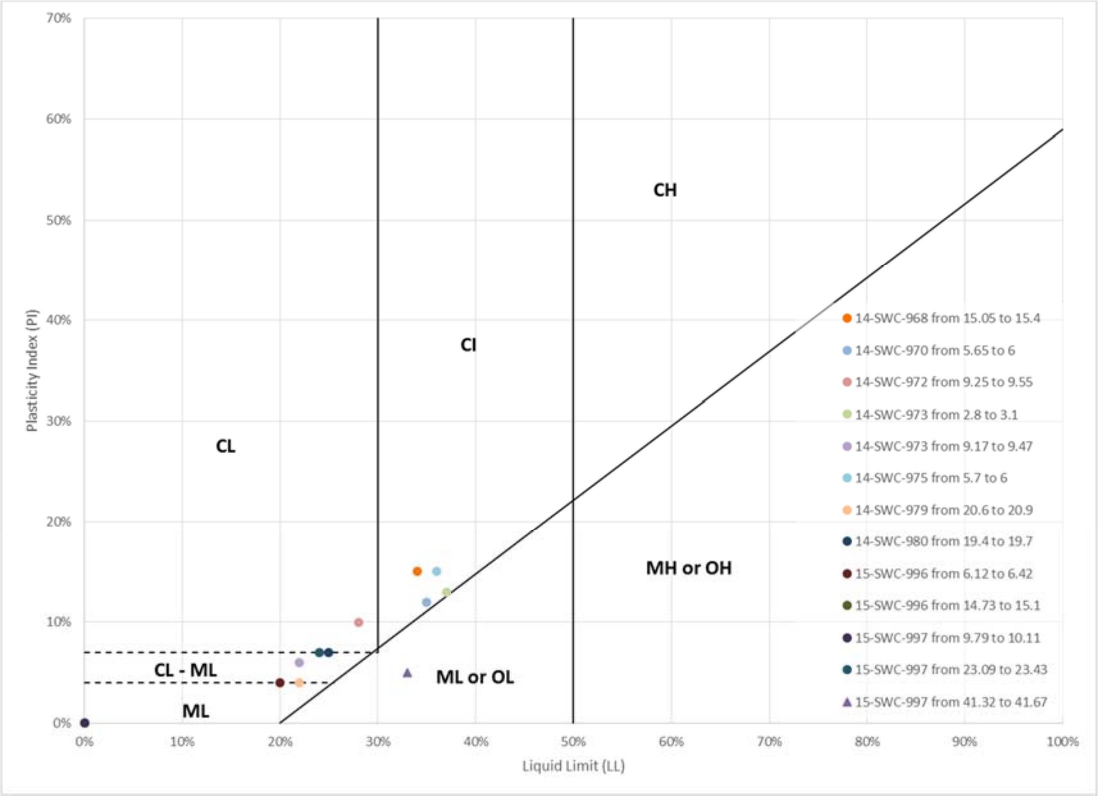


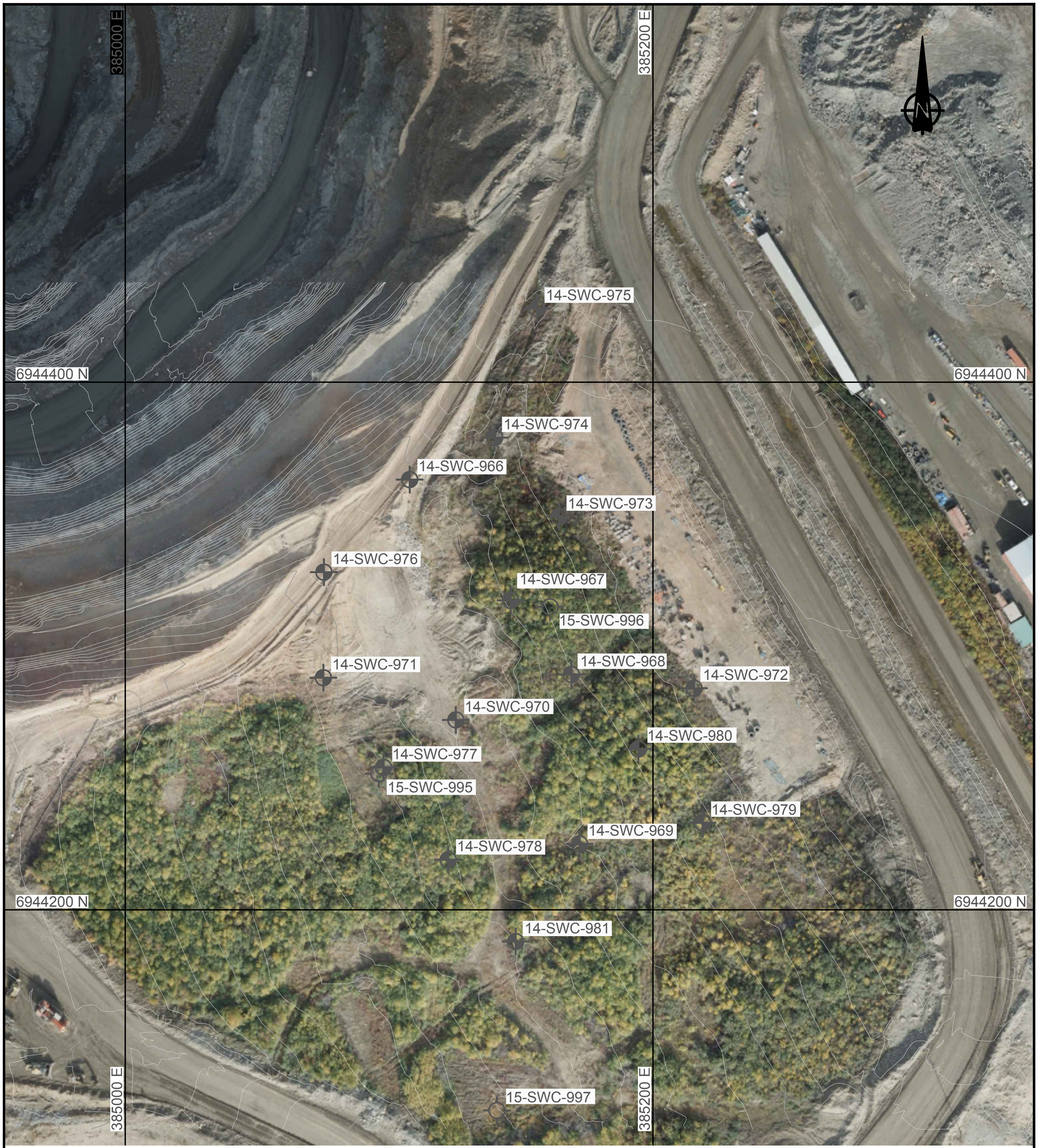
Figure 2: Atterberg Limit Analysis Results

6 Conclusions

Based on review of the borehole logs, and laboratory testing results, the data suggests that the overburden material encountered is not present in appropriate continuity to facilitate effective selection and segregation of materials using mass mining methods.

Testing indicates that the natural moisture content ranges between 10% and 36%. Particle size distributions analysis indicated fines content ranging between 26% and 96%; with clay sized particles ranging between <1% to approximately 30%. Atterberg limit analysis indicated that the sample classification was variable, including intermediate plasticity clays, and low plasticity clays and/or silts.

Figure



LEGEND

● Oct./Nov. 2014 Drill Program

○ Feb. 2015 Drill Program

NOTES

1. Data presented in NAD83 UTM Zone 8N.
2. Orthophoto provided by Minto Mine, 2014.

0 20 40 60 80 100

Scale in Metres

srk consulting

capstone
MINTO MINE
OPERATED BY MINTO EXPLORATIONS LTD.

SRK JOB NO.: 1CM002.037

FILE NAME: OVB_Drilling_Borehole_Plan_1CM002_037.dwg

Minto Mine

Area 2 Stage 3 Overburden Drilling

Area 2 Stage 3 2014/2015
Overburden Drilling Locations

DATE:	APPROVED:	FIGURE:
July 2016	KNK	1

Z:\01_SITES\Minto\!040_AutoCAD\OVB Drilling 2014-15\OVB_Drilling_Borehole_Plan_1CM002_037.dwg

Attachment 1: Borehole Logs

srk consulting

capstone MINTO MINE

PROJECT: Minto
CLIENT: Minto Exploration Ltd.

HOLE ID:	**14-SWC-966**
LOCATION:	Yukon
PROJECT NO:	1CM002.037
DRILLING CONTRACTOR:	Driftwood
DRILLING TYPE & CORE DIA:	HQ Diamond
LOGGED BY:	MJM
BORING DATE:	Oct/Nov 2014

COORDINATES:	385107.8 E 6944363.1 N
DATUM:	UTM Zone 8
GROUND ELEV (m):	830.7
AZIMUTH:	0
COLLAR DIP:	-90
EOH ELEV. (m):	827.05
TOTAL DEPTH (m):	3.65

DEPOSIT AREA:
Area 2

Lithological Symbol

🟫	Organics	░	Sand	▦	Bedrock
▨	Clay	◌	Gravel	◍	Cobbles
▥	Silt	●	Boulder		

Sample Type: 🟧 Grab, 🟩 SPT

■ Moisture Content
♦ Liquid Limit
● Plastic Limit
(%) 0 20 40 60 80 100

PSD Gravel / Sand / Silt / Clay(%)

Recovery % 0 20 40 60 80 100

Depth (m)	Elev (m)	Sample Type	USCS	Soil Description	Drilling Notes & Additional Comments
0	830.6	MM-1012 51	░	SAND, few gravel, well graded, light brown, sub-angular, moist, non-plastic, non-cohesive, massive	
			●	BOULDER	Granoriorite
			░	SAND, few gravel, well graded, light brown, sub-angular, moist, non-plastic, non-cohesive, massive	
2	828.6	MM-1012 52	◌	GRAVEL, some sand , well graded, light brown, sub-angular, moist, non-plastic, non-cohesive, massive	Minor fines near bedrock transition
			▦	BEDROCK	Weathered granodiorite
4					

srk consulting

capstone
MINTO MINE

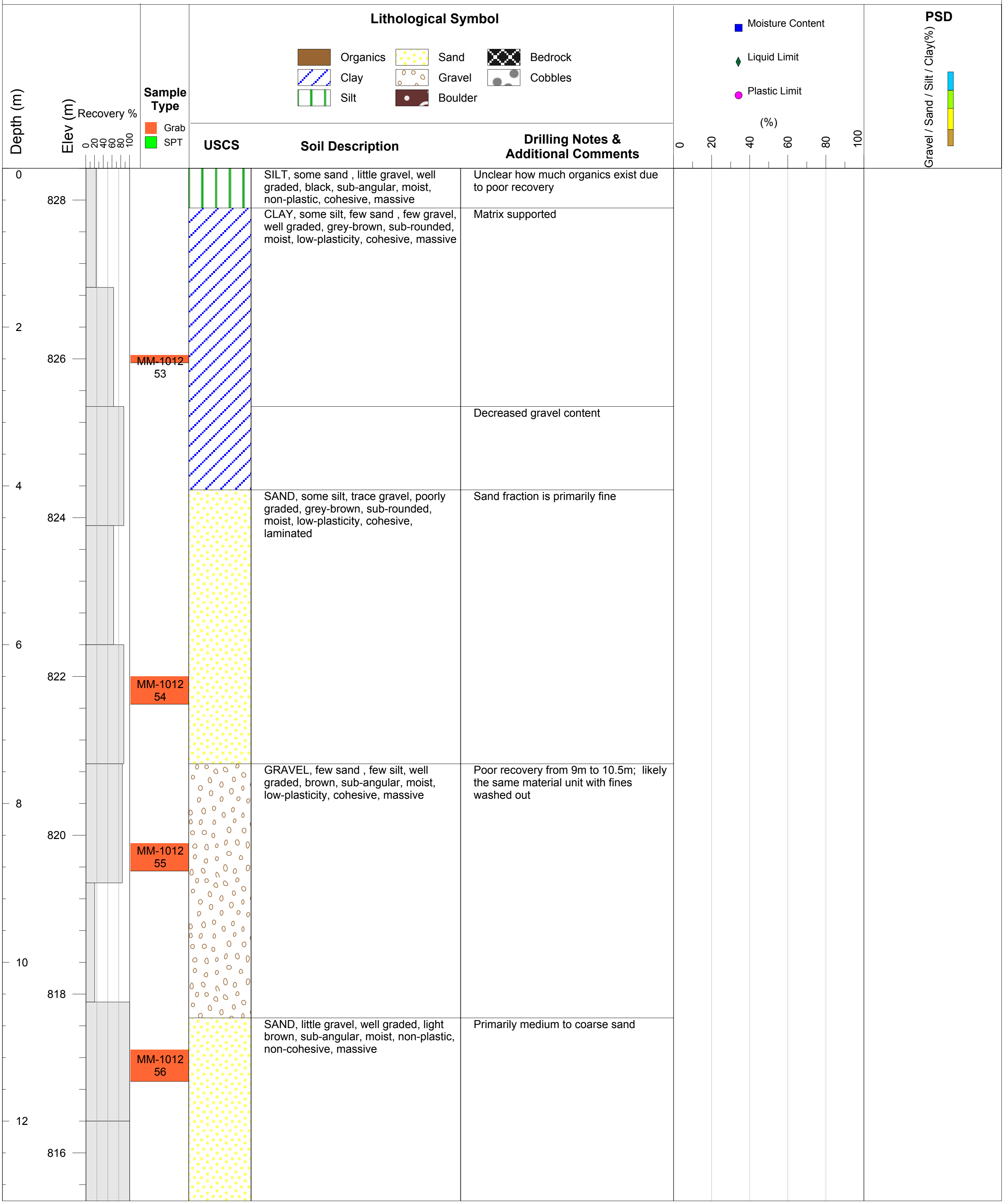
PROJECT:	Minto		
CLIENT:	Minto Exploration Ltd.		
HOLE ID:	**14-SWC-967**	COORDINATES:	385146.1 E 6944317.3 N
LOCATION:	Yukon	DATUM:	UTM Zone 8
PROJECT NO:	1CM002.037	GROUND ELEV (m):	828.4
DRILLING CONTRACTOR:	Driftwood	AZIMUTH:	0
		COLLAR DIP:	-90
DRILLING TYPE & CORE DIA:	HQ Diamond	EOH ELEV. (m):	814.4
LOGGED BY:	MJM	TOTAL DEPTH (m):	14
BORING DATE:	Oct/Nov 2014	DEPOSIT AREA:	Area 2

Lithological Symbol

▇ Organics	▨ Sand	▩ Bedrock
▨ Clay	▨ Gravel	● Cobbles
▥ Silt	● Boulder	

Sample Type: 🟥 Grab, 🟩 SPT

■ Moisture Content
♦ Liquid Limit
● Plastic Limit



Soil Description	Drilling Notes & Additional Comments
SILT, some sand , little gravel, well graded, black, sub-angular, moist, non-plastic, cohesive, massive	Unclear how much organics exist due to poor recovery
CLAY, some silt, few sand , few gravel, well graded, grey-brown, sub-rounded, moist, low-plasticity, cohesive, massive	Matrix supported
	Decreased gravel content
SAND, some silt, trace gravel, poorly graded, grey-brown, sub-rounded, moist, low-plasticity, cohesive, laminated	Sand fraction is primarily fine
GRAVEL, few sand , few silt, well graded, brown, sub-angular, moist, low-plasticity, cohesive, massive	Poor recovery from 9m to 10.5m; likely the same material unit with fines washed out
SAND, little gravel, well graded, light brown, sub-angular, moist, non-plastic, non-cohesive, massive	Primarily medium to coarse sand

srk consulting

capstone MINTO MINE

PROJECT: Minto
CLIENT: Minto Exploration Ltd.

HOLE ID: **14-SWC-967**
LOCATION: Yukon
PROJECT NO: 1CM002.037
DRILLING CONTRACTOR: Driftwood
DRILLING TYPE & CORE DIA: HQ Diamond
LOGGED BY: MJM
BORING DATE: Oct/Nov 2014

COORDINATES: 385146.1 E 6944317.3 N
DATUM: UTM Zone 8
GROUND ELEV (m): 828.4
AZIMUTH: 0
COLLAR DIP: -90
EOH ELEV. (m): 814.4
TOTAL DEPTH (m): 14

DEPOSIT AREA:
Area 2

Lithological Symbol

▨	Organics	▨	Sand	▨	Bedrock
▨	Clay	▨	Gravel	▨	Cobbles
▨	Silt	▨	Boulder		

Sample Type: 🟥 Grab, 🟩 SPT

■ Moisture Content
◆ Liquid Limit
● Plastic Limit

(%) 0 20 40 60 80 100

PSD: Gravel / Sand / Silt / Clay(%)

Depth (m)	Elev (m)	Recovery % (0 20 40 60 80 100)	Sample Type	USCS	Soil Description	Drilling Notes & Additional Comments
				Sand		
14				Bedrock	BEDROCK	Weathered granodiorite

srk consulting

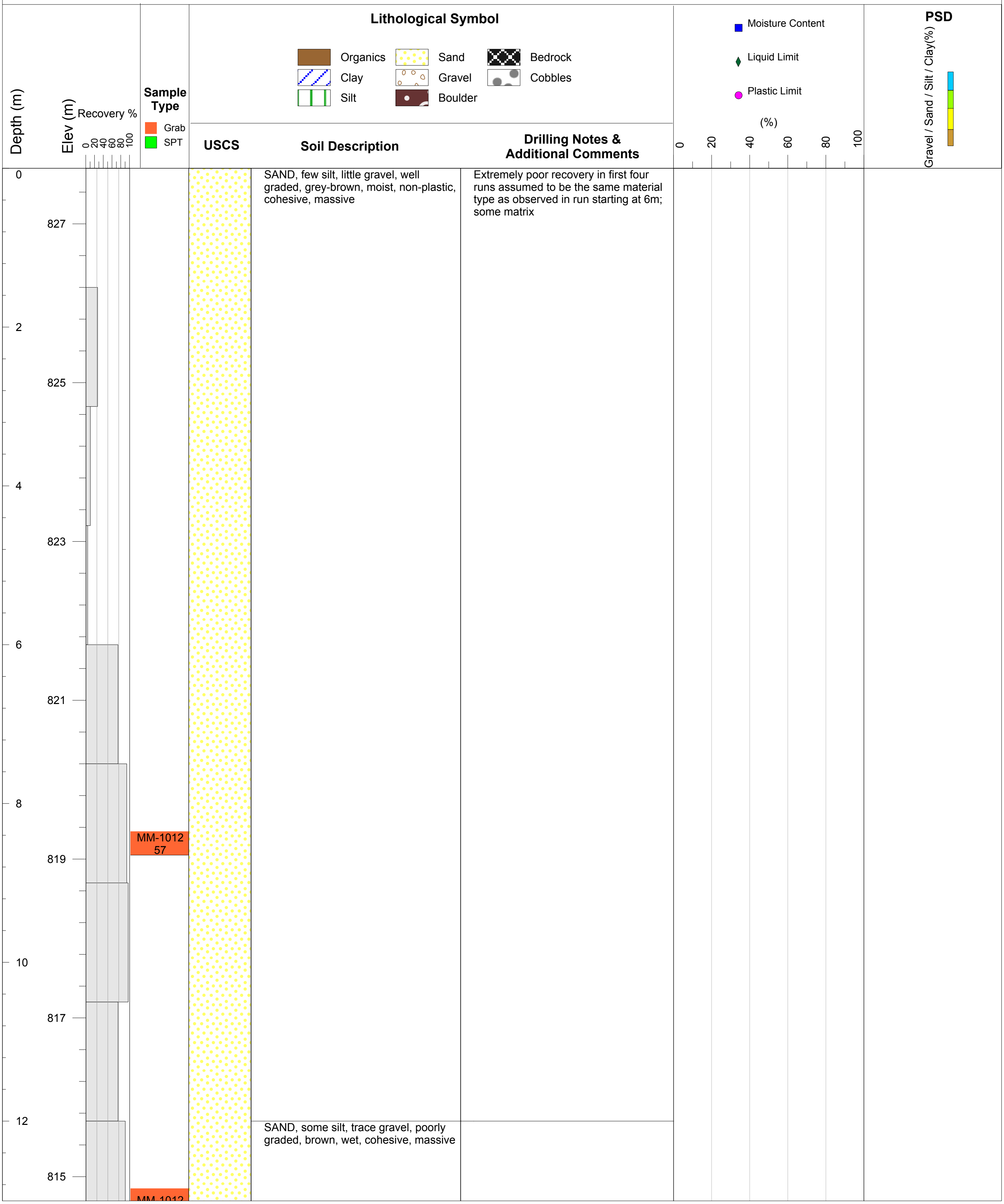
Capstone MINTO MINE

PROJECT: Minto
CLIENT: Minto Exploration Ltd.

HOLE ID: **14-SWC-968**
LOCATION: Yukon
PROJECT NO: 1CM002.037
DRILLING CONTRACTOR: Driftwood
DRILLING TYPE & CORE DIA: HQ Diamond
LOGGED BY: MJM
BORING DATE: Oct/Nov 2014

COORDINATES: 385169.1 E 6944289.2 N
DATUM: UTM Zone 8
GROUND ELEV (m): 827.7
AZIMUTH: 0
COLLAR DIP: -90
EOH ELEV. (m): 807.7
TOTAL DEPTH (m): 20

DEPOSIT AREA: Area 2



Depth (m)	Soil Description	Drilling Notes & Additional Comments
0	SAND, few silt, little gravel, well graded, grey-brown, moist, non-plastic, cohesive, massive	Extremely poor recovery in first four runs assumed to be the same material type as observed in run starting at 6m; some matrix
12	SAND, some silt, trace gravel, poorly graded, brown, wet, cohesive, massive	

srk consulting

Capstone MINTO MINE

PROJECT: Minto
CLIENT: Minto Exploration Ltd.

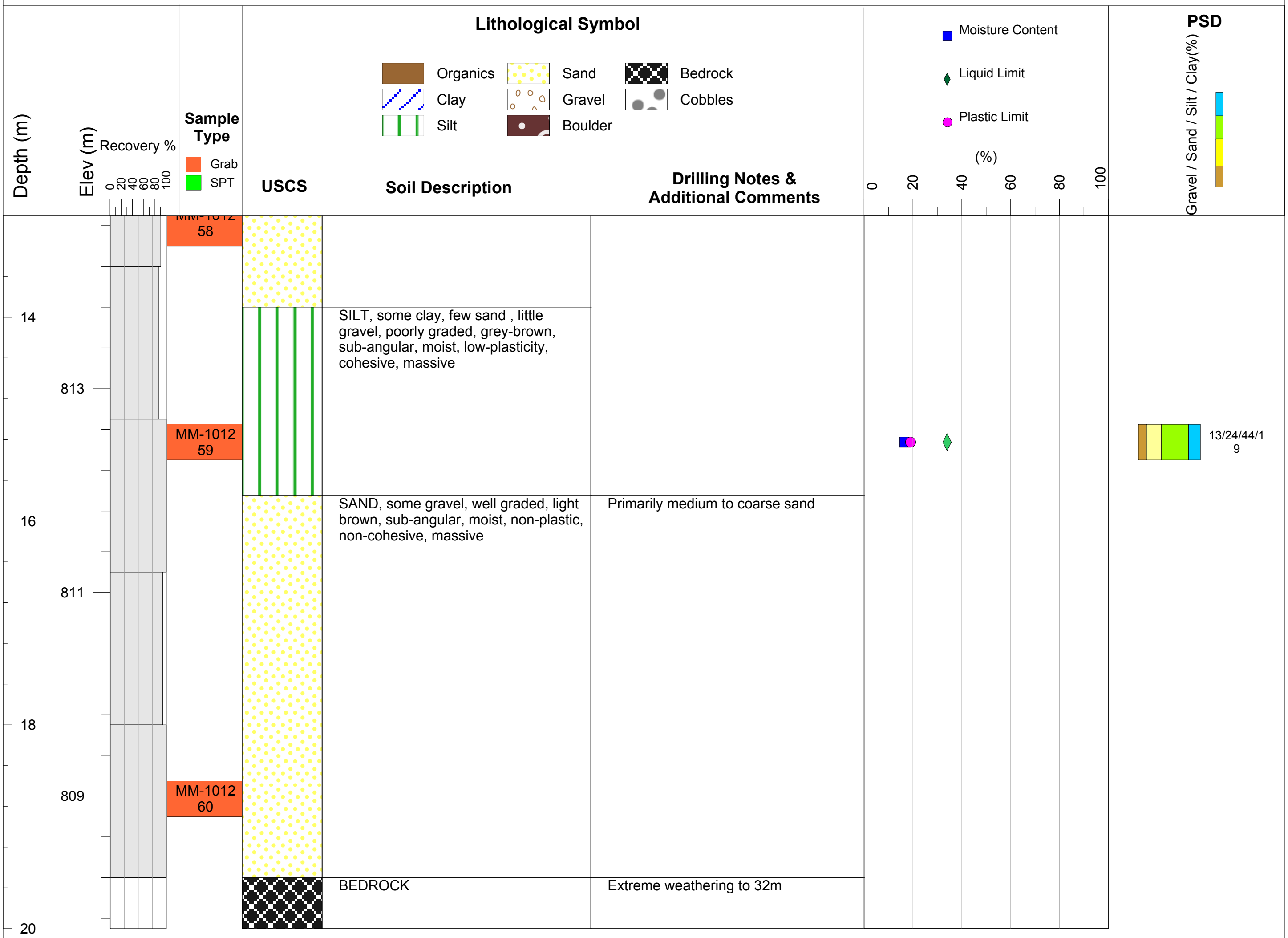
HOLE ID: **14-SWC-968**
LOCATION: Yukon
PROJECT NO: 1CM002.037
DRILLING CONTRACTOR: Driftwood
DRILLING TYPE & CORE DIA: HQ Diamond
LOGGED BY: MJM
BORING DATE: Oct/Nov 2014

COORDINATES: 385169.1 E 6944289.2 N
DATUM: UTM Zone 8
GROUND ELEV (m): 827.7
AZIMUTH: 0
COLLAR DIP: -90
EOH ELEV. (m): 807.7
TOTAL DEPTH (m): 20
DEPOSIT AREA: Area 2

Lithological Symbol

▨	Organics	▨	Sand	▨	Bedrock
▨	Clay	▨	Gravel	▨	Cobbles
▨	Silt	▨	Boulder		

■ Moisture Content
◆ Liquid Limit
● Plastic Limit



Soil Description	Drilling Notes & Additional Comments
SILT, some clay, few sand , little gravel, poorly graded, grey-brown, sub-angular, moist, low-plasticity, cohesive, massive	
SAND, some gravel, well graded, light brown, sub-angular, moist, non-plastic, non-cohesive, massive	Primarily medium to coarse sand
BEDROCK	Extreme weathering to 32m

srk consulting

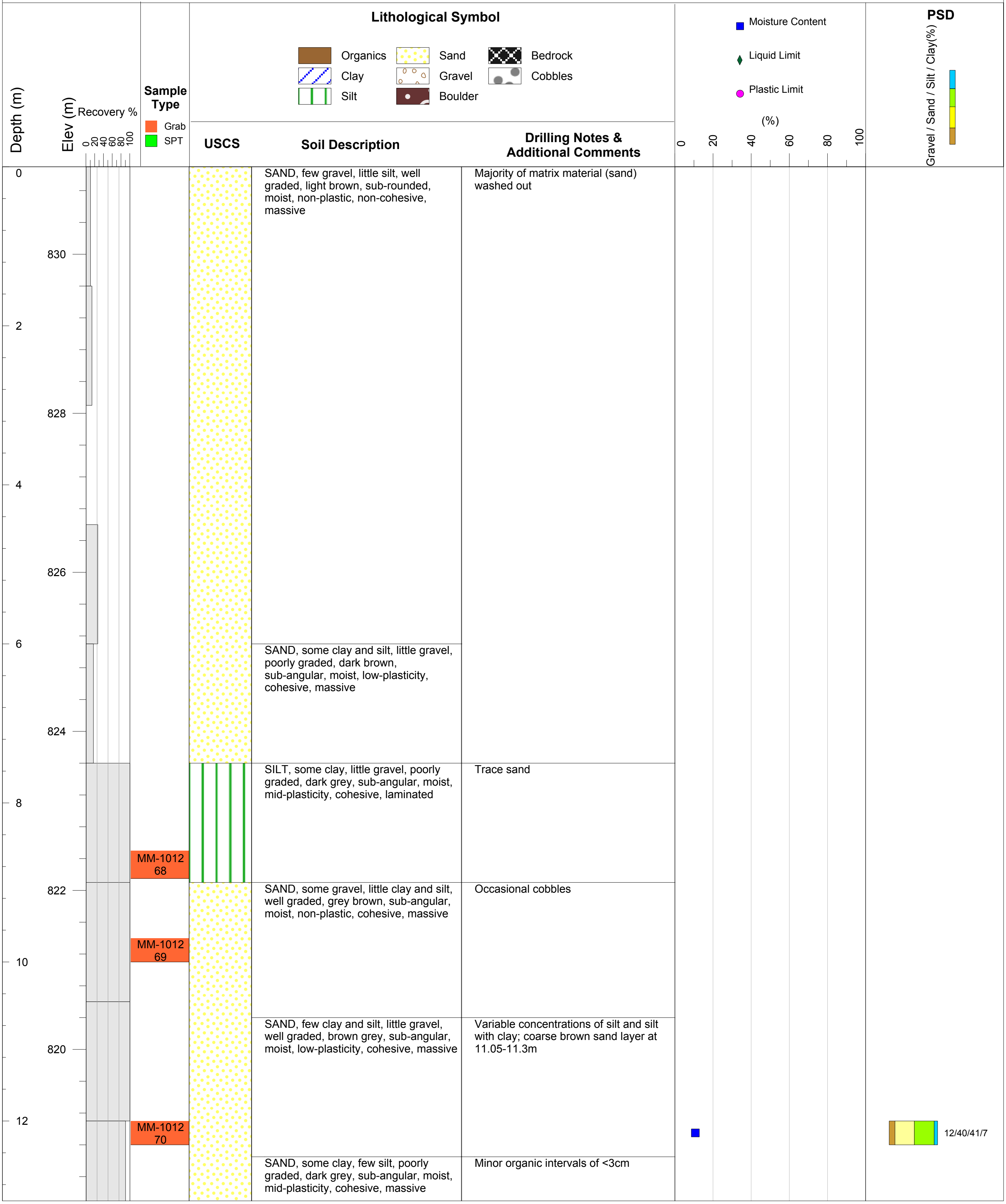
capstone MINTO MINE

PROJECT: Minto
CLIENT: Minto Exploration Ltd.

HOLE ID:	**14-SWC-969**
LOCATION:	Yukon
PROJECT NO:	1CM002.037
DRILLING CONTRACTOR:	Driftwood
DRILLING TYPE & CORE DIA:	HQ Diamond
LOGGED BY:	MJM
BORING DATE:	Oct/Nov 2014

COORDINATES:	385172.2 E 6944225 N
DATUM:	UTM Zone 8
GROUND ELEV (m):	831.1
AZIMUTH:	0
COLLAR DIP:	-90
EOH ELEV. (m):	808.1
TOTAL DEPTH (m):	23

DEPOSIT AREA:
Area 2



Soil Description	Drilling Notes & Additional Comments
SAND, few gravel, little silt, well graded, light brown, sub-rounded, moist, non-plastic, non-cohesive, massive	Majority of matrix material (sand) washed out
SAND, some clay and silt, little gravel, poorly graded, dark brown, sub-angular, moist, low-plasticity, cohesive, massive	
SILT, some clay, little gravel, poorly graded, dark grey, sub-angular, moist, mid-plasticity, cohesive, laminated	Trace sand
SAND, some gravel, little clay and silt, well graded, grey brown, sub-angular, moist, non-plastic, cohesive, massive	Occasional cobbles
SAND, few clay and silt, little gravel, well graded, brown grey, sub-angular, moist, low-plasticity, cohesive, massive	Variable concentrations of silt and silt with clay; coarse brown sand layer at 11.05-11.3m
SAND, some clay, few silt, poorly graded, dark grey, sub-angular, moist, mid-plasticity, cohesive, massive	Minor organic intervals of <3cm

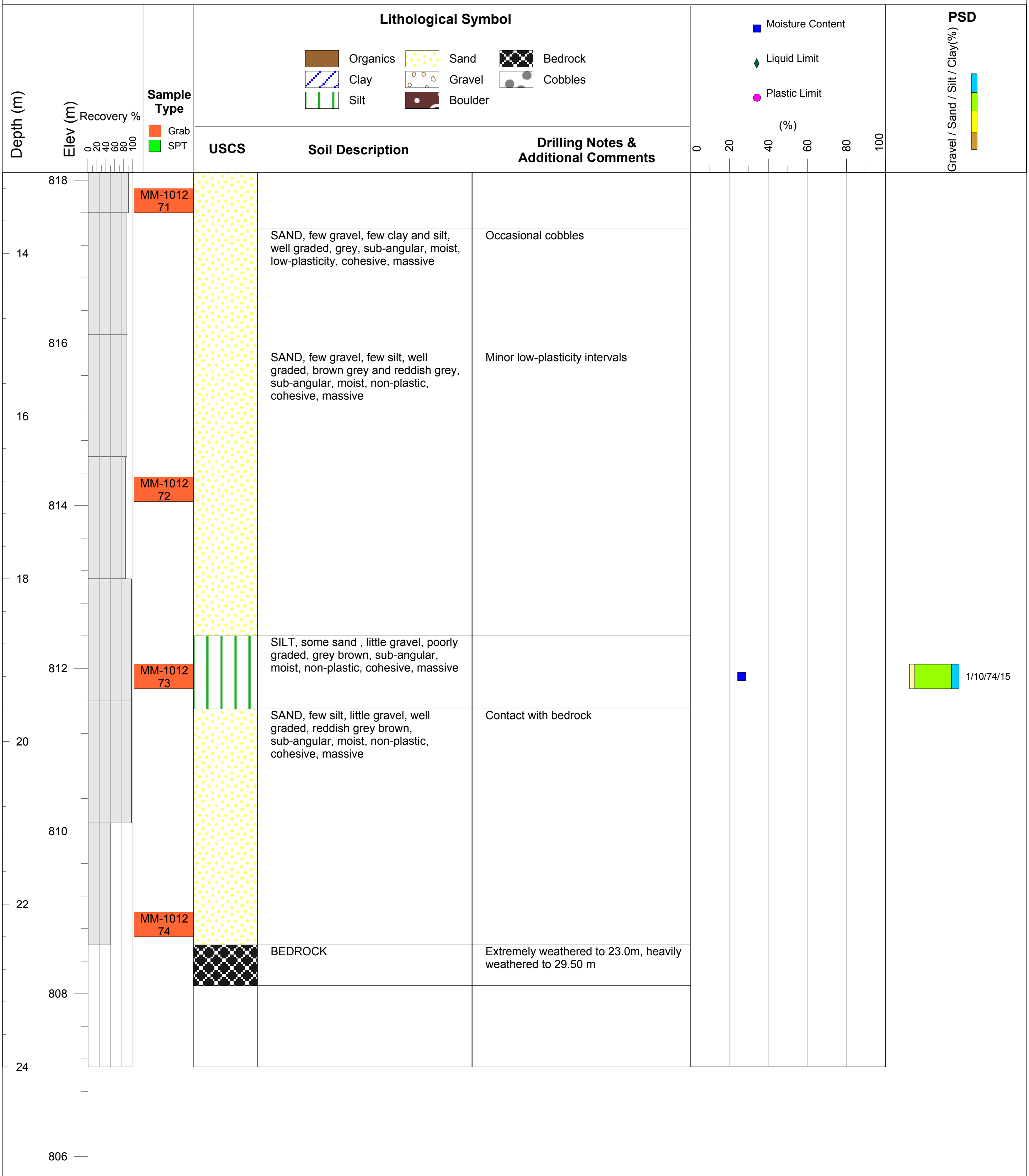
srk consulting

capstone MINTO MINE

PROJECT: Minto
CLIENT: Minto Exploration Ltd.

HOLE ID:	**14-SWC-969**
LOCATION:	Yukon
PROJECT NO:	1CM002.037
DRILLING CONTRACTOR:	Driftwood
DRILLING TYPE & CORE DIA:	HQ Diamond
LOGGED BY:	MJM
BORING DATE:	Oct/Nov 2014
COORDINATES:	385172.2 E 6944225 N
DATUM:	UTM Zone 8
GROUND ELEV (m):	831.1
AZIMUTH:	0
COLLAR DIP:	-90
EOH ELEV. (m):	808.1
TOTAL DEPTH (m):	23

DEPOSIT AREA:
Area 2



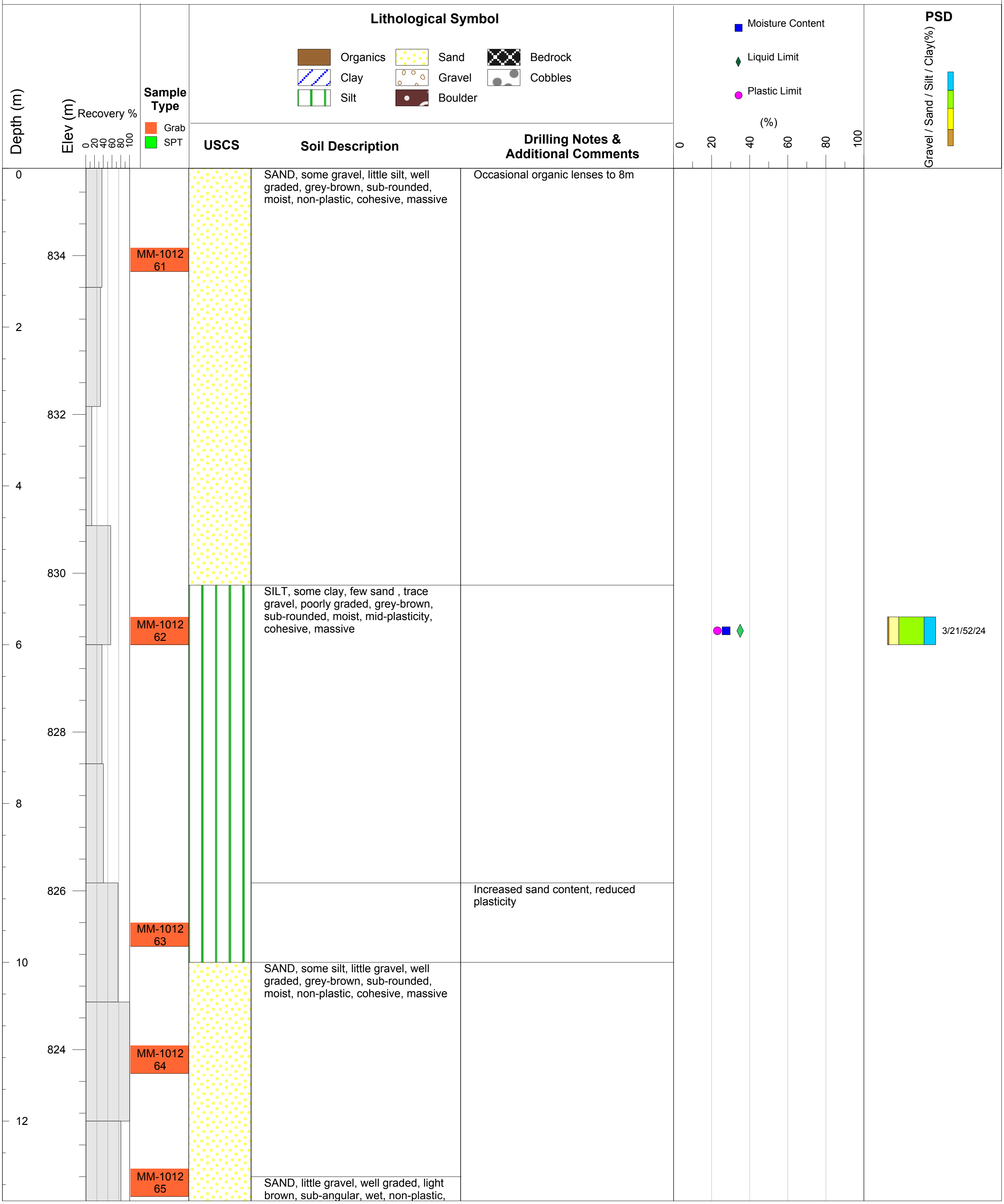
Soil Description	Drilling Notes & Additional Comments
SAND, few gravel, few clay and silt, well graded, grey, sub-angular, moist, low-plasticity, cohesive, massive	Occasional cobbles
SAND, few gravel, few silt, well graded, brown grey and reddish grey, sub-angular, moist, non-plastic, cohesive, massive	Minor low-plasticity intervals
SILT, some sand , little gravel, poorly graded, grey brown, sub-angular, moist, non-plastic, cohesive, massive	
SAND, few silt, little gravel, well graded, reddish grey brown, sub-angular, moist, non-plastic, cohesive, massive	Contact with bedrock
BEDROCK	Extremely weathered to 23.0m, heavily weathered to 29.50 m

HOLE ID: **14-SWC-970**
LOCATION: Yukon
PROJECT NO: 1CM002.037
DRILLING CONTRACTOR: Driftwood
DRILLING TYPE & CORE DIA: HQ Diamond
LOGGED BY: MJM
BORING DATE: Oct/Nov 2014

COORDINATES: 385125.3 E 6944272 N
DATUM: UTM Zone 8
GROUND ELEV (m): 835.1
AZIMUTH: 0
COLLAR DIP: -90
EOH ELEV. (m): 820.75
TOTAL DEPTH (m): 14.35

PROJECT: Minto
CLIENT: Minto Exploration Ltd.

DEPOSIT AREA: Area 2



SAND, some gravel, little silt, well graded, grey-brown, sub-rounded, moist, non-plastic, cohesive, massive

Occasional organic lenses to 8m

SILT, some clay, few sand , trace gravel, poorly graded, grey-brown, sub-rounded, moist, mid-plasticity, cohesive, massive

Increased sand content, reduced plasticity

SAND, some silt, little gravel, well graded, grey-brown, sub-rounded, moist, non-plastic, cohesive, massive

SAND, little gravel, well graded, light brown, sub-angular, wet, non-plastic,

srk consulting

capstone MINTO MINE

PROJECT:	Minto
CLIENT:	Minto Exploration Ltd.

HOLE ID:	**14-SWC-970**
LOCATION:	Yukon
PROJECT NO:	1CM002.037
DRILLING CONTRACTOR:	Driftwood
DRILLING TYPE & CORE DIA:	HQ Diamond
LOGGED BY:	MJM
BORING DATE:	Oct/Nov 2014

COORDINATES:	385125.3 E 6944272 N
DATUM:	UTM Zone 8
GROUND ELEV (m):	835.1
AZIMUTH:	0
COLLAR DIP:	-90
EOH ELEV. (m):	820.75
TOTAL DEPTH (m):	14.35

DEPOSIT AREA:
Area 2

Lithological Symbol

🟫	Organics	▨	Sand	▦	Bedrock
▨	Clay	▨	Gravel	▨	Cobbles
▥	Silt	🟫	Boulder		

🟦 Moisture Content

◆ Liquid Limit

● Plastic Limit

(%)

0 20 40 60 80 100

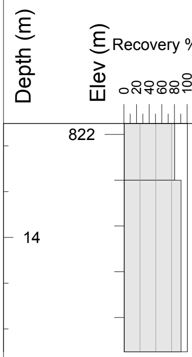
PSD

Gravel / Sand / Silt / Clay(%)

Sample Type

🟥 Grab

🟩 SPT



USCS	**Soil Description**	**Drilling Notes & Additional Comments**
	non-cohesive, massive	
	BEDROCK	Heavily weathered to 14.35m

srk consulting

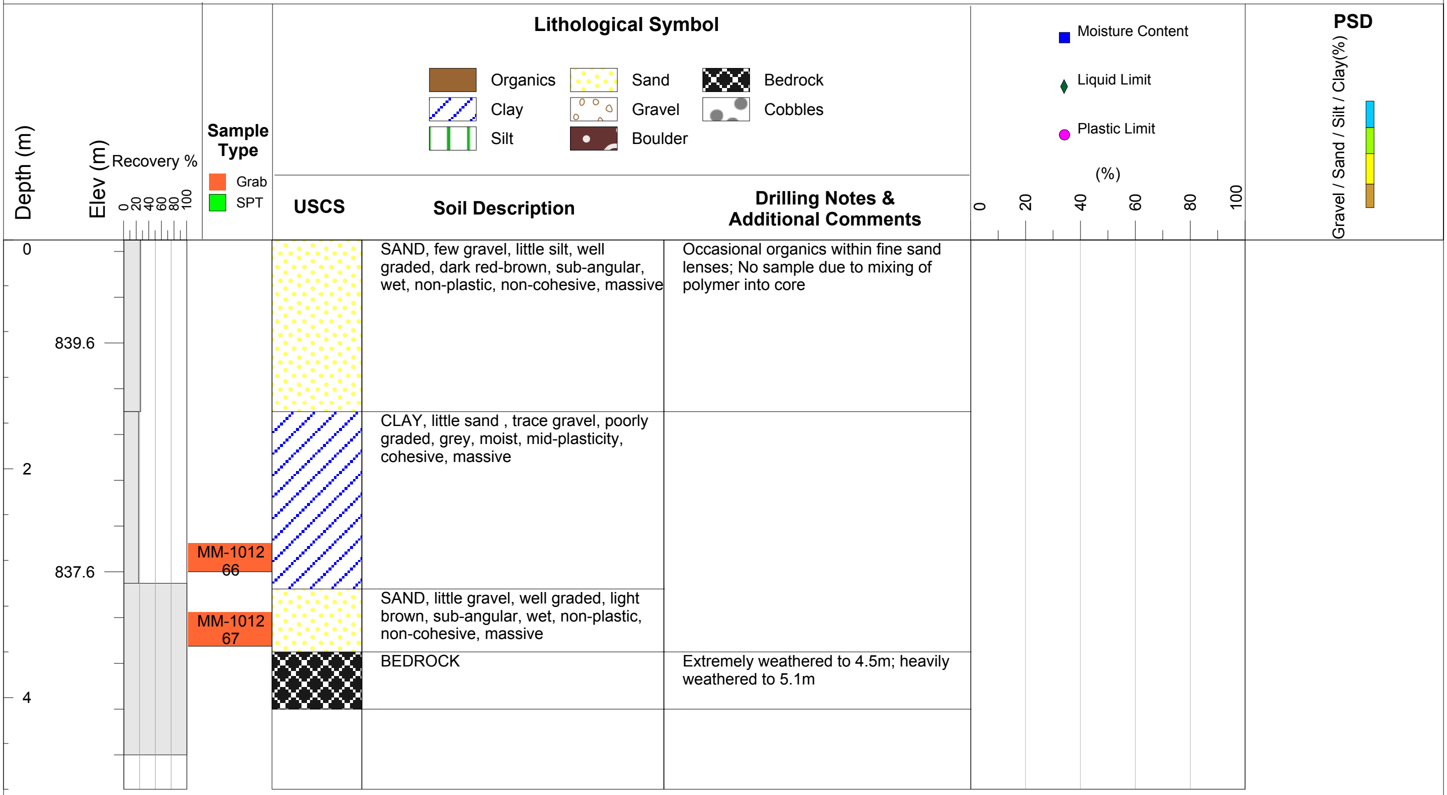
capstone MINTO MINE

HOLE ID:	**14-SWC-971**	COORDINATES:	385075.1 E 6944288 N
LOCATION:	Yukon	DATUM:	UTM Zone 8
PROJECT NO:	1CM002.037	GROUND ELEV (m):	840.5
DRILLING CONTRACTOR:	Driftwood	AZIMUTH:	0
DRILLING TYPE & CORE DIA:	HQ Diamond	COLLAR DIP:	-90
LOGGED BY:	MJM	EOH ELEV. (m):	836.4
BORING DATE:	Oct/Nov 2014	TOTAL DEPTH (m):	4.1

PROJECT: Minto

CLIENT: Minto Exploration Ltd.

DEPOSIT AREA: Area 2



Soil Description	Drilling Notes & Additional Comments
SAND, few gravel, little silt, well graded, dark red-brown, sub-angular, wet, non-plastic, non-cohesive, massive	Occasional organics within fine sand lenses; No sample due to mixing of polymer into core
CLAY, little sand , trace gravel, poorly graded, grey, moist, mid-plasticity, cohesive, massive	
SAND, little gravel, well graded, light brown, sub-angular, wet, non-plastic, non-cohesive, massive	
BEDROCK	Extremely weathered to 4.5m; heavily weathered to 5.1m

srk consulting

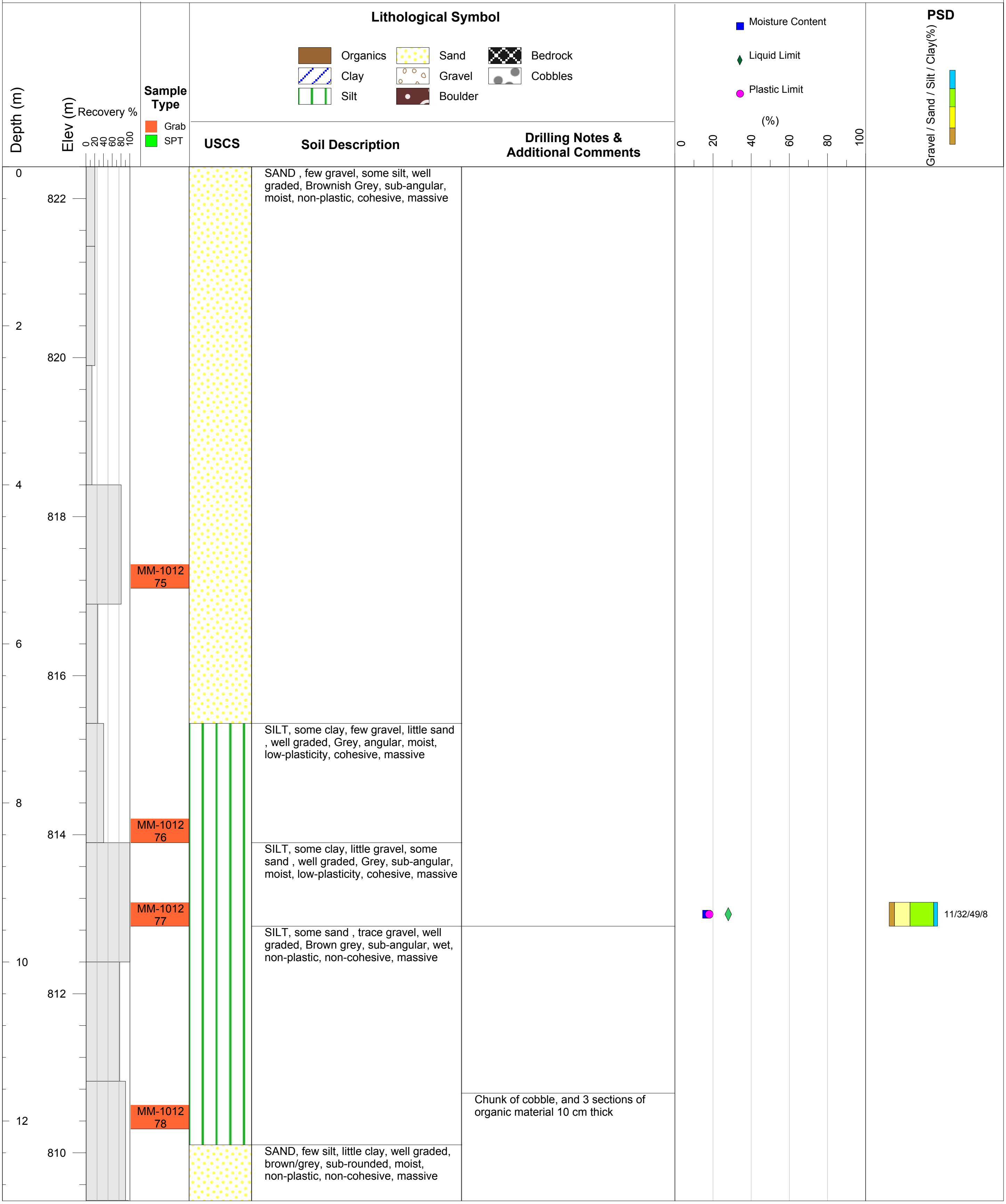
capstone MINTO MINE

HOLE ID:	**14-SWC-972**	COORDINATES:	385215.6 E 6944284 N
LOCATION:	Yukon	DATUM:	UTM Zone 8
PROJECT NO:	1CM002.037	GROUND ELEV (m):	822.4
DRILLING CONTRACTOR:	Driftwood	AZIMUTH:	0
DRILLING TYPE & CORE DIA:	HQ Diamond	COLLAR DIP:	-90
		EOH ELEV. (m):	797.1
LOGGED BY:	MJM	TOTAL DEPTH (m):	25.3
BORING DATE:	Oct/Nov 2014		

PROJECT: Minto

CLIENT: Minto Exploration Ltd.

DEPOSIT AREA: Area 2



SAND , few gravel, some silt, well graded, Brownish Grey, sub-angular, moist, non-plastic, cohesive, massive

SILT, some clay, few gravel, little sand , well graded, Grey, angular, moist, low-plasticity, cohesive, massive

SILT, some clay, little gravel, some sand , well graded, Grey, sub-angular, moist, low-plasticity, cohesive, massive

SILT, some sand , trace gravel, well graded, Brown grey, sub-angular, wet, non-plastic, non-cohesive, massive

Chunk of cobble, and 3 sections of organic material 10 cm thick

SAND, few silt, little clay, well graded, brown/grey, sub-rounded, moist, non-plastic, non-cohesive, massive

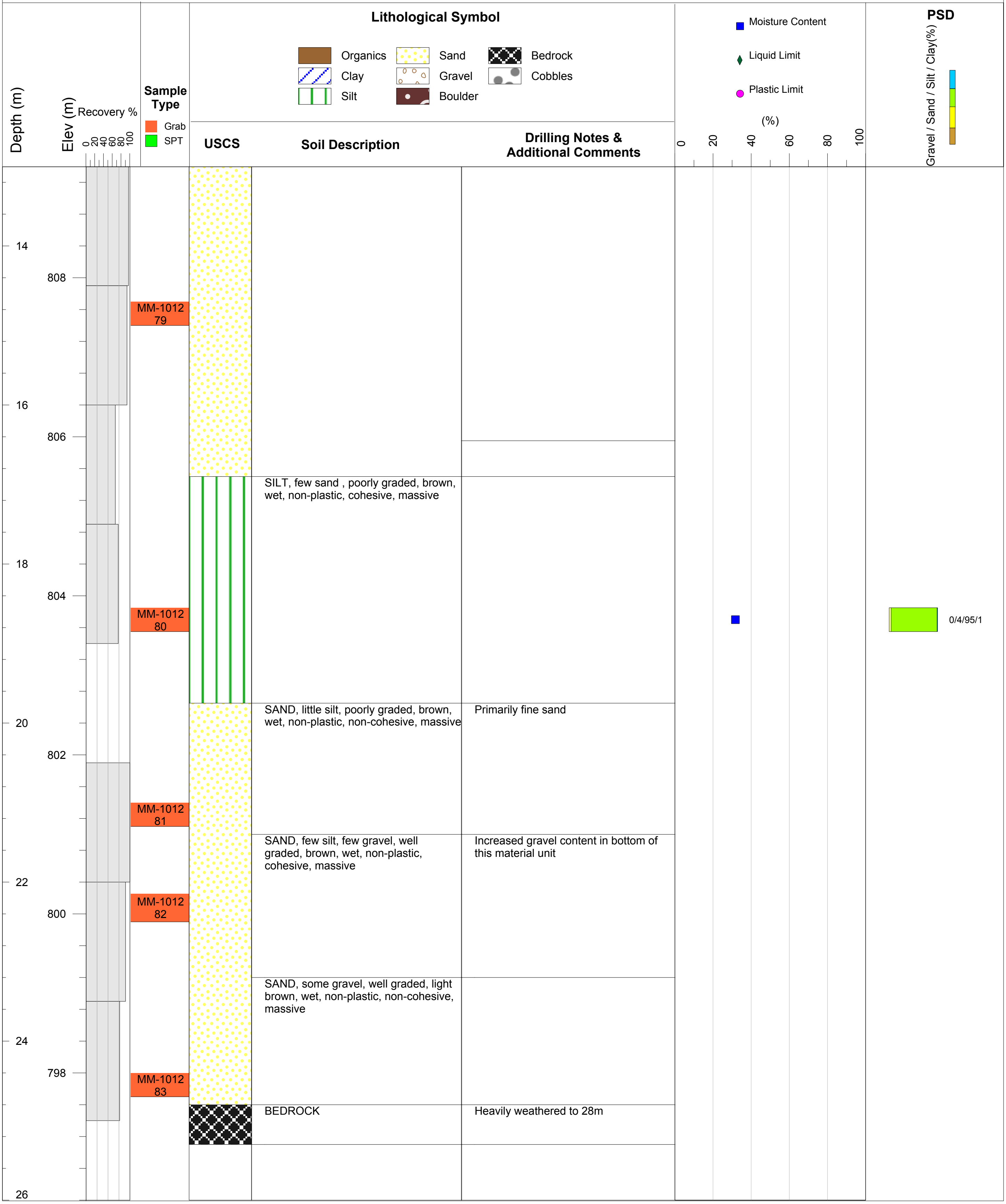
HOLE ID: **14-SWC-972**
LOCATION: Yukon
PROJECT NO: 1CM002.037
DRILLING CONTRACTOR: Driftwood
DRILLING TYPE & CORE DIA: HQ Diamond
LOGGED BY: MJM
BORING DATE: Oct/Nov 2014

COORDINATES: 385215.6 E 6944284 N
DATUM: UTM Zone 8
GROUND ELEV (m): 822.4
AZIMUTH: 0
COLLAR DIP: -90
EOH ELEV. (m): 797.1
TOTAL DEPTH (m): 25.3

PROJECT: Minto
CLIENT: Minto Exploration Ltd.

DEPOSIT AREA:
Area 2

Lithological Symbol



Soil Description	Drilling Notes & Additional Comments
SILT, few sand , poorly graded, brown, wet, non-plastic, cohesive, massive	
SAND, little silt, poorly graded, brown, wet, non-plastic, non-cohesive, massive	Primarily fine sand
SAND, few silt, few gravel, well graded, brown, wet, non-plastic, cohesive, massive	Increased gravel content in bottom of this material unit
SAND, some gravel, well graded, light brown, wet, non-plastic, non-cohesive, massive	
BEDROCK	Heavily weathered to 28m

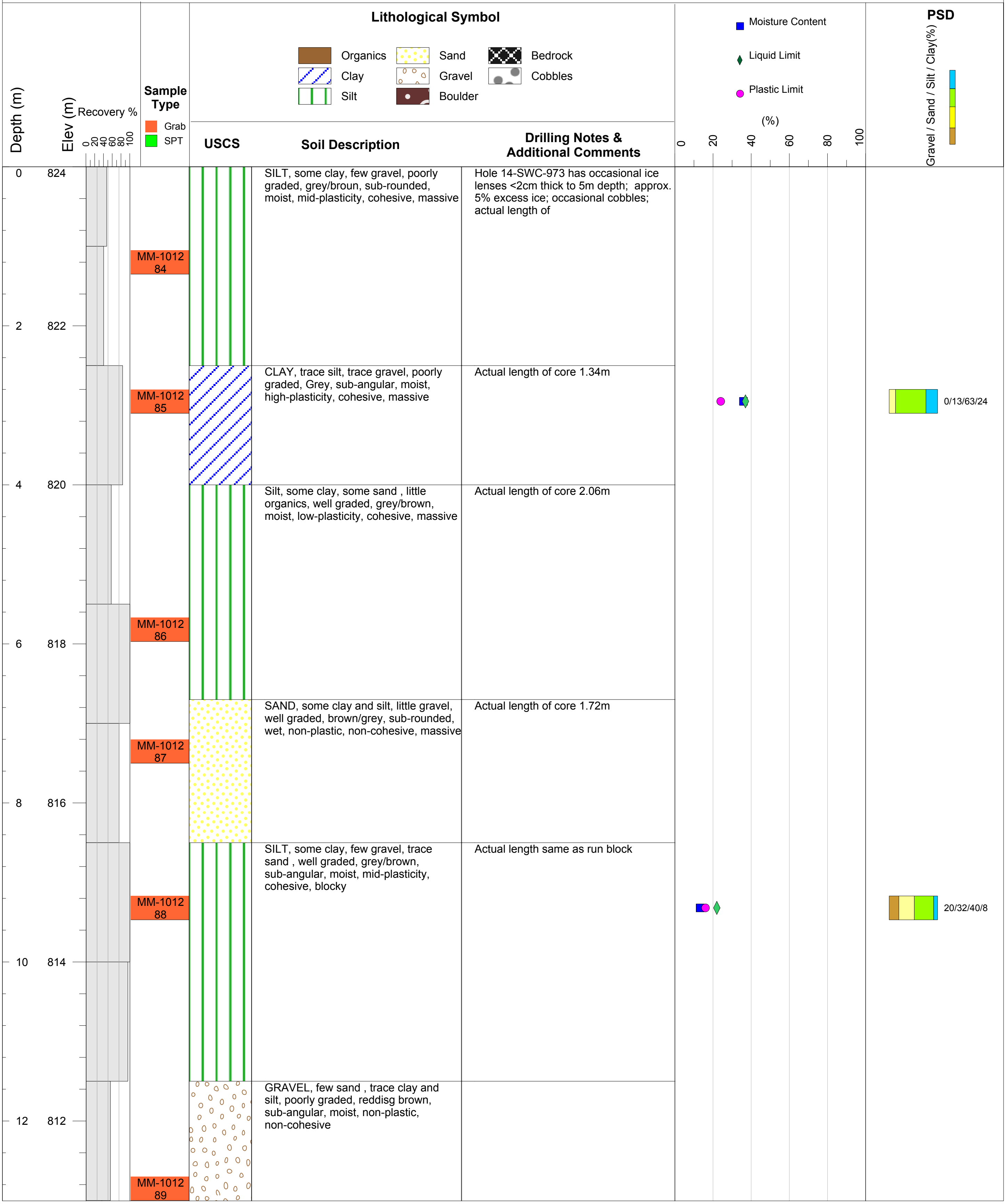
srk consulting

capstone MINTO MINE

HOLE ID:	**14-SWC-973**	COORDINATES:	385164.4 E 6944349 N
LOCATION:	Yukon	DATUM:	UTM Zone 8
PROJECT NO:	1CM002.037	GROUND ELEV (m):	824
DRILLING CONTRACTOR:	Driftwood	AZIMUTH:	0
DRILLING TYPE & CORE DIA:	HQ Diamond	COLLAR DIP:	-90
		EOH ELEV. (m):	797
LOGGED BY:	MJM	TOTAL DEPTH (m):	27
BORING DATE:	Oct/Nov 2014	DEPOSIT AREA:	Area 2

PROJECT: Minto

CLIENT: Minto Exploration Ltd.



Soil Description	Drilling Notes & Additional Comments
SILT, some clay, few gravel, poorly graded, grey/broun, sub-rounded, moist, mid-plasticity, cohesive, massive	Hole 14-SWC-973 has occasional ice lenses <2cm thick to 5m depth; approx. 5% excess ice; occasional cobbles; actual length of
CLAY, trace silt, trace gravel, poorly graded, Grey, sub-angular, moist, high-plasticity, cohesive, massive	Actual length of core 1.34m
Silt, some clay, some sand , little organics, well graded, grey/brown, moist, low-plasticity, cohesive, massive	Actual length of core 2.06m
SAND, some clay and silt, little gravel, well graded, brown/grey, sub-rounded, wet, non-plastic, non-cohesive, massive	Actual length of core 1.72m
SILT, some clay, few gravel, trace sand , well graded, grey/brown, sub-angular, moist, mid-plasticity, cohesive, blocky	Actual length same as run block
GRAVEL, few sand , trace clay and silt, poorly graded, reddisg brown, sub-angular, moist, non-plastic, non-cohesive	

srk consulting

capstone MINTO MINE

PROJECT: Minto
CLIENT: Minto Exploration Ltd.

HOLE ID:	**14-SWC-973**
LOCATION:	Yukon
PROJECT NO:	1CM002.037
DRILLING CONTRACTOR:	Driftwood
DRILLING TYPE & CORE DIA:	HQ Diamond
LOGGED BY:	MJM
BORING DATE:	Oct/Nov 2014

COORDINATES:	385164.4 E 6944349 N
DATUM:	UTM Zone 8
GROUND ELEV (m):	824
AZIMUTH:	0
COLLAR DIP:	-90
EOH ELEV. (m):	797
TOTAL DEPTH (m):	27

DEPOSIT AREA:
Area 2

Soil Description	Drilling Notes & Additional Comments
GRAVEL, little sand , poorly graded, grey/black brown, angular, moist, non-plastic, non-cohesive	No sample
GRAVEL, some sand , trace silt, well graded, brown, angular, moist, non-plastic, non-cohesive, massive	One sample from box
GRAVEL, few sand , trace silt, poorly graded, brown, angular, moist, non-plastic, non-cohesive, massive	

srk consulting

capstone MINTO MINE

PROJECT: Minto
CLIENT: Minto Exploration Ltd.

HOLE ID:	**14-SWC-973**
LOCATION:	Yukon
PROJECT NO:	1CM002.037
DRILLING CONTRACTOR:	Driftwood
DRILLING TYPE & CORE DIA:	HQ Diamond
LOGGED BY:	MJM
BORING DATE:	Oct/Nov 2014

COORDINATES:	385164.4 E 6944349 N
DATUM:	UTM Zone 8
GROUND ELEV (m):	824
AZIMUTH:	0
COLLAR DIP:	-90
EOH ELEV. (m):	797
TOTAL DEPTH (m):	27

DEPOSIT AREA:
Area 2

Lithological Symbol

🟫	Organics	▨	Sand	▩	Bedrock
▨	Clay	▨	Gravel	▨	Cobbles
▥	Silt	■	Boulder		

Sample Type
🟥 Grab
🟩 SPT

■ Moisture Content
◆ Liquid Limit
● Plastic Limit

PSD
Gravel / Sand / Silt / Clay(%)

Recovery % 0 20 40 60 80 100

(%) 0 20 40 60 80 100

Depth (m)	Elev (m)	Recovery %	Sample Type	USCS	Soil Description	Drilling Notes & Additional Comments
26	798					
					BEDROCK	Rock to 29.5m; no sample
28	796					

srk consulting

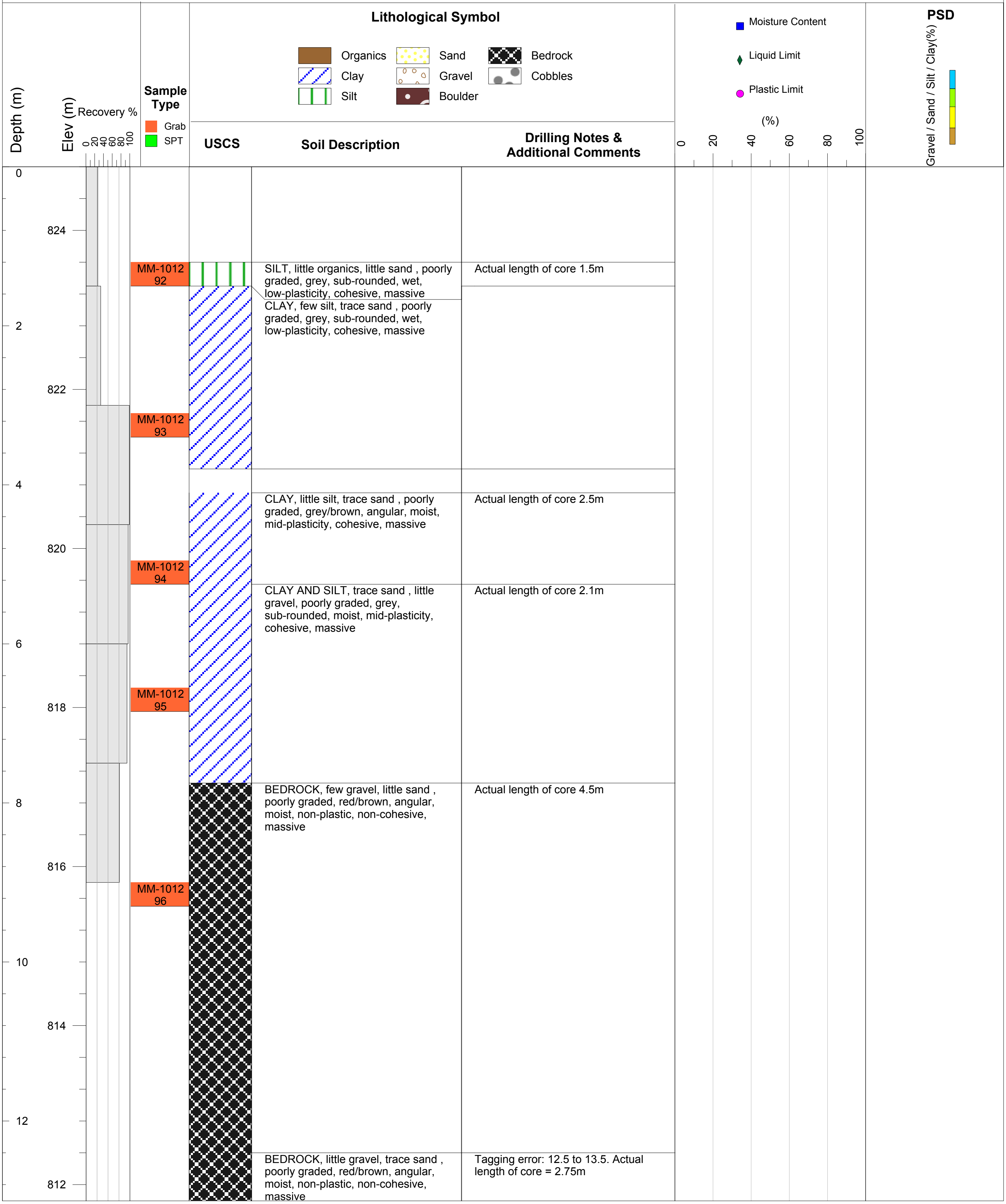
Capstone MINTO MINE

PROJECT: Minto
CLIENT: Minto Exploration Ltd.

HOLE ID: **14-SWC-974**
LOCATION: Yukon
PROJECT NO: 1CM002.037
DRILLING CONTRACTOR: Driftwood
DRILLING TYPE & CORE DIA: HQ Diamond
LOGGED BY: MJM
BORING DATE: Oct/Nov 2014

COORDINATES: 385140 E 6944379 N
DATUM: UTM Zone 8
GROUND ELEV (m): 824.8
AZIMUTH: 0
COLLAR DIP: -90
EOH ELEV. (m): 811.3
TOTAL DEPTH (m): 13.5

DEPOSIT AREA: Area 2



Soil Description	Drilling Notes & Additional Comments
SILT, little organics, little sand , poorly graded, grey, sub-rounded, wet, low-plasticity, cohesive, massive	Actual length of core 1.5m
CLAY, few silt, trace sand , poorly graded, grey, sub-rounded, wet, low-plasticity, cohesive, massive	
CLAY, little silt, trace sand , poorly graded, grey/brown, angular, moist, mid-plasticity, cohesive, massive	Actual length of core 2.5m
CLAY AND SILT, trace sand , little gravel, poorly graded, grey, sub-rounded, moist, mid-plasticity, cohesive, massive	Actual length of core 2.1m
BEDROCK, few gravel, little sand , poorly graded, red/brown, angular, moist, non-plastic, non-cohesive, massive	Actual length of core 4.5m
BEDROCK, little gravel, trace sand , poorly graded, red/brown, angular, moist, non-plastic, non-cohesive, massive	Tagging error: 12.5 to 13.5. Actual length of core = 2.75m

srk consulting

capstone MINTO MINE

HOLE ID:	**14-SWC-974**	COORDINATES:	385140 E 6944379 N
LOCATION:	Yukon	DATUM:	UTM Zone 8
PROJECT NO:	1CM002.037	GROUND ELEV (m):	824.8
DRILLING CONTRACTOR:	Driftwood	AZIMUTH:	0
DRILLING TYPE & CORE DIA:	HQ Diamond	COLLAR DIP:	-90
LOGGED BY:	MJM	EOH ELEV. (m):	811.3
BORING DATE:	Oct/Nov 2014	TOTAL DEPTH (m):	13.5

PROJECT: Minto

CLIENT: Minto Exploration Ltd.

DEPOSIT AREA: Area 2

Lithological Symbol

▨	Organics	▨	Sand	▨	Bedrock
▨	Clay	▨	Gravel	▨	Cobbles
▨	Silt	▨	Boulder		

Sample Type

🟥 Grab

🟩 SPT

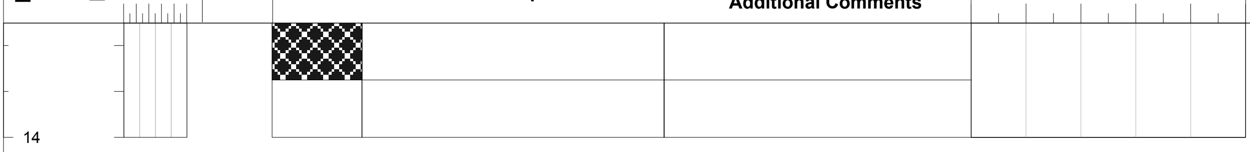
■ Moisture Content

◆ Liquid Limit

● Plastic Limit

PSD

Depth (m) | Elev (m) | Recovery % | **Sample Type** | **USCS** | **Soil Description** | **Drilling Notes & Additional Comments** | (%) | Gravel / Sand / Silt / Clay(%)



srk consulting

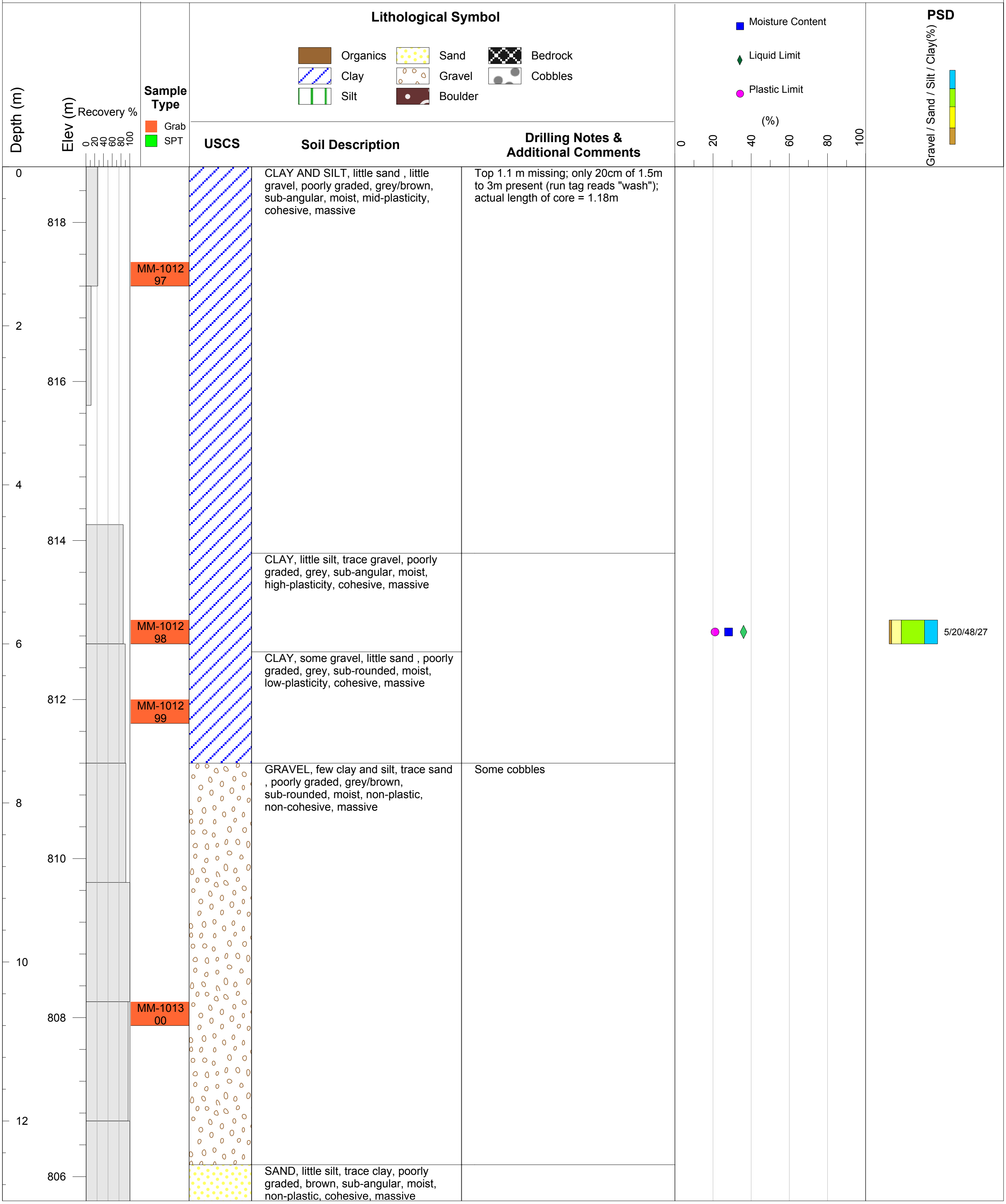
capstone
MINTO MINE

HOLE ID: **14-SWC-975**
LOCATION: Yukon
PROJECT NO: 1CM002.037
DRILLING CONTRACTOR: Driftwood
DRILLING TYPE & CORE DIA: HQ Diamond
LOGGED BY: MJM
BORING DATE: Oct/Nov 2014

COORDINATES: 385156.1 E 6944428 N
DATUM: UTM Zone 8
GROUND ELEV (m): 818.7
AZIMUTH: 0
COLLAR DIP: -90
EOH ELEV. (m): 796.3
TOTAL DEPTH (m): 22.4

PROJECT: Minto
CLIENT: Minto Exploration Ltd.

DEPOSIT AREA: Area 2



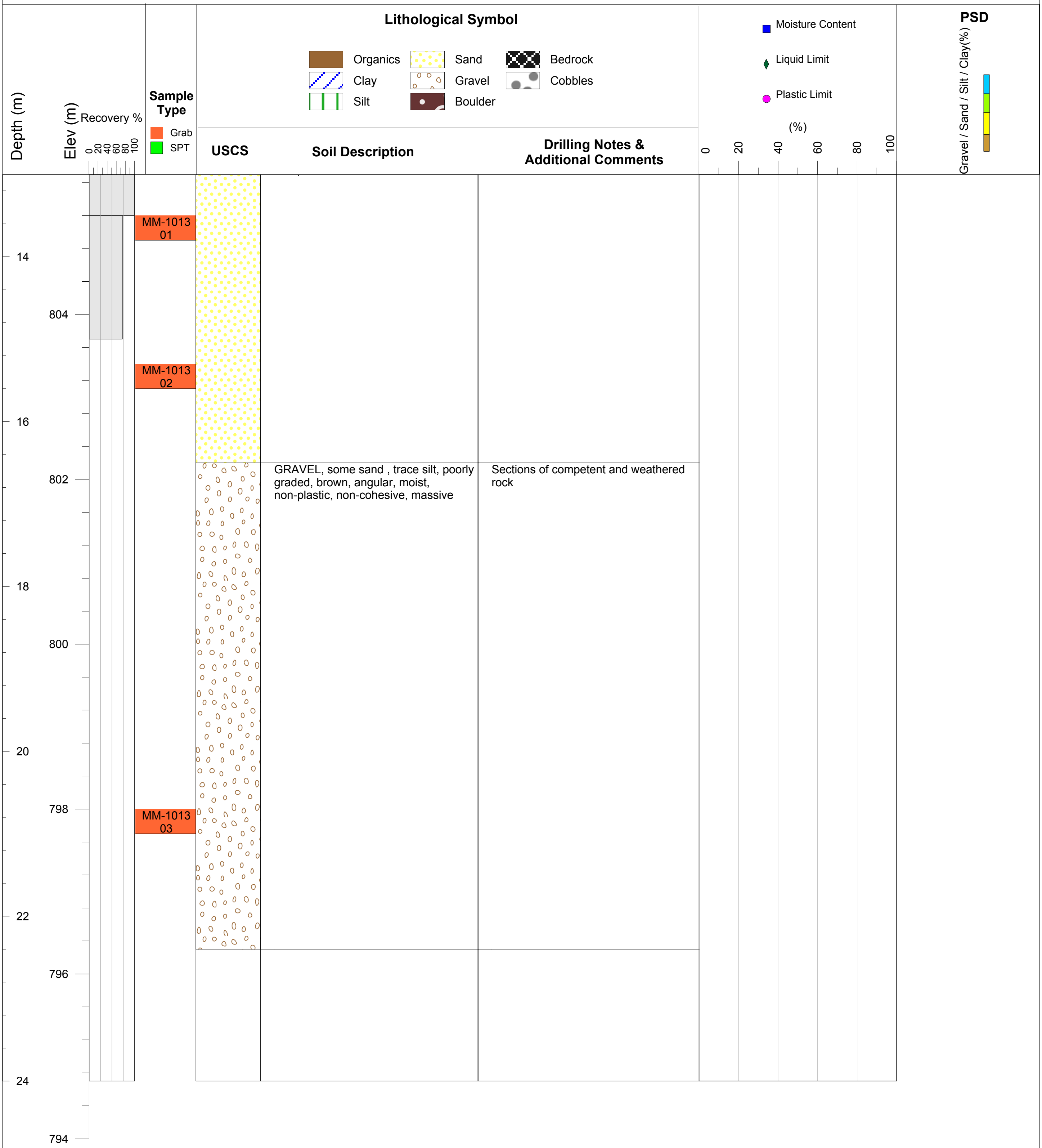
Soil Description	Drilling Notes & Additional Comments
CLAY AND SILT, little sand , little gravel, poorly graded, grey/brown, sub-angular, moist, mid-plasticity, cohesive, massive	Top 1.1 m missing; only 20cm of 1.5m to 3m present (run tag reads "wash"); actual length of core = 1.18m
CLAY, little silt, trace gravel, poorly graded, grey, sub-angular, moist, high-plasticity, cohesive, massive	
CLAY, some gravel, little sand , poorly graded, grey, sub-rounded, moist, low-plasticity, cohesive, massive	
GRAVEL, few clay and silt, trace sand , poorly graded, grey/brown, sub-rounded, moist, non-plastic, non-cohesive, massive	Some cobbles
SAND, little silt, trace clay, poorly graded, brown, sub-angular, moist, non-plastic, cohesive, massive	

HOLE ID: **14-SWC-975**
LOCATION: Yukon
PROJECT NO: 1CM002.037
DRILLING CONTRACTOR: Driftwood
DRILLING TYPE & CORE DIA: HQ Diamond
LOGGED BY: MJM
BORING DATE: Oct/Nov 2014

PROJECT: Minto
CLIENT: Minto Exploration Ltd.

COORDINATES: 385156.1 E 6944428 N
DATUM: UTM Zone 8
GROUND ELEV (m): 818.7
AZIMUTH: 0
COLLAR DIP: -90
EOH ELEV. (m): 796.3
TOTAL DEPTH (m): 22.4

DEPOSIT AREA: Area 2



GRAVEL, some sand , trace silt, poorly graded, brown, angular, moist, non-plastic, non-cohesive, massive

Sections of competent and weathered rock

srk consulting

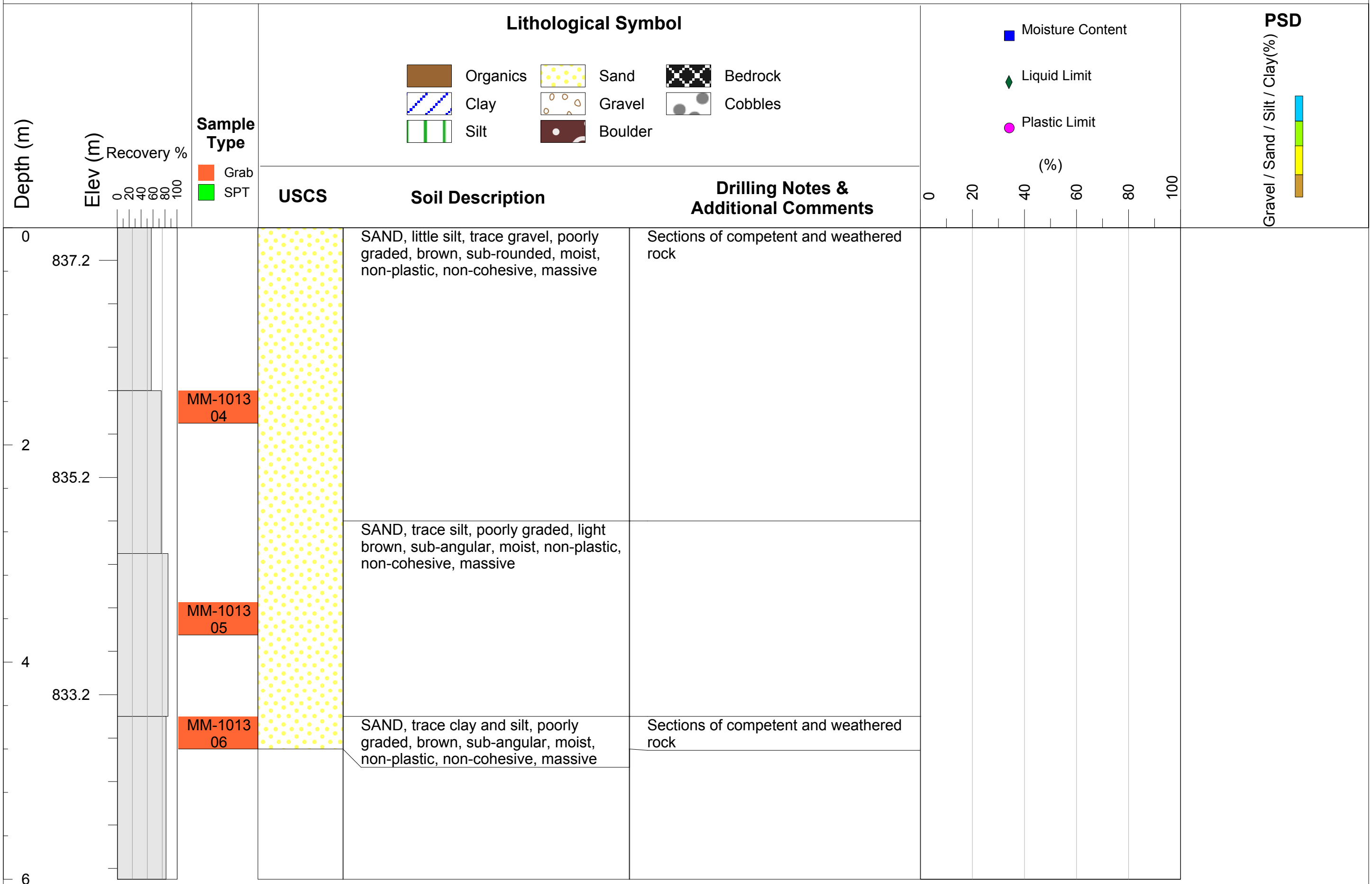
capstone
MINTO MINE

PROJECT: Minto
CLIENT: Minto Exploration Ltd.

HOLE ID: **14-SWC-976**
LOCATION: Yukon
PROJECT NO: 1CM002.037
DRILLING CONTRACTOR: Driftwood
DRILLING TYPE & CORE DIA: HQ Diamond
LOGGED BY: MJM
BORING DATE: Oct/Nov 2014

COORDINATES: 385075.3 E 6944328 N
DATUM: UTM Zone 8
GROUND ELEV (m): 837.5
AZIMUTH: 0
COLLAR DIP: -90
EOH ELEV. (m): 832.77
TOTAL DEPTH (m): 4.8

DEPOSIT AREA:
Area 2



Soil Description	Drilling Notes & Additional Comments
SAND, little silt, trace gravel, poorly graded, brown, sub-rounded, moist, non-plastic, non-cohesive, massive	Sections of competent and weathered rock
SAND, trace silt, poorly graded, light brown, sub-angular, moist, non-plastic, non-cohesive, massive	
SAND, trace clay and silt, poorly graded, brown, sub-angular, moist, non-plastic, non-cohesive, massive	Sections of competent and weathered rock

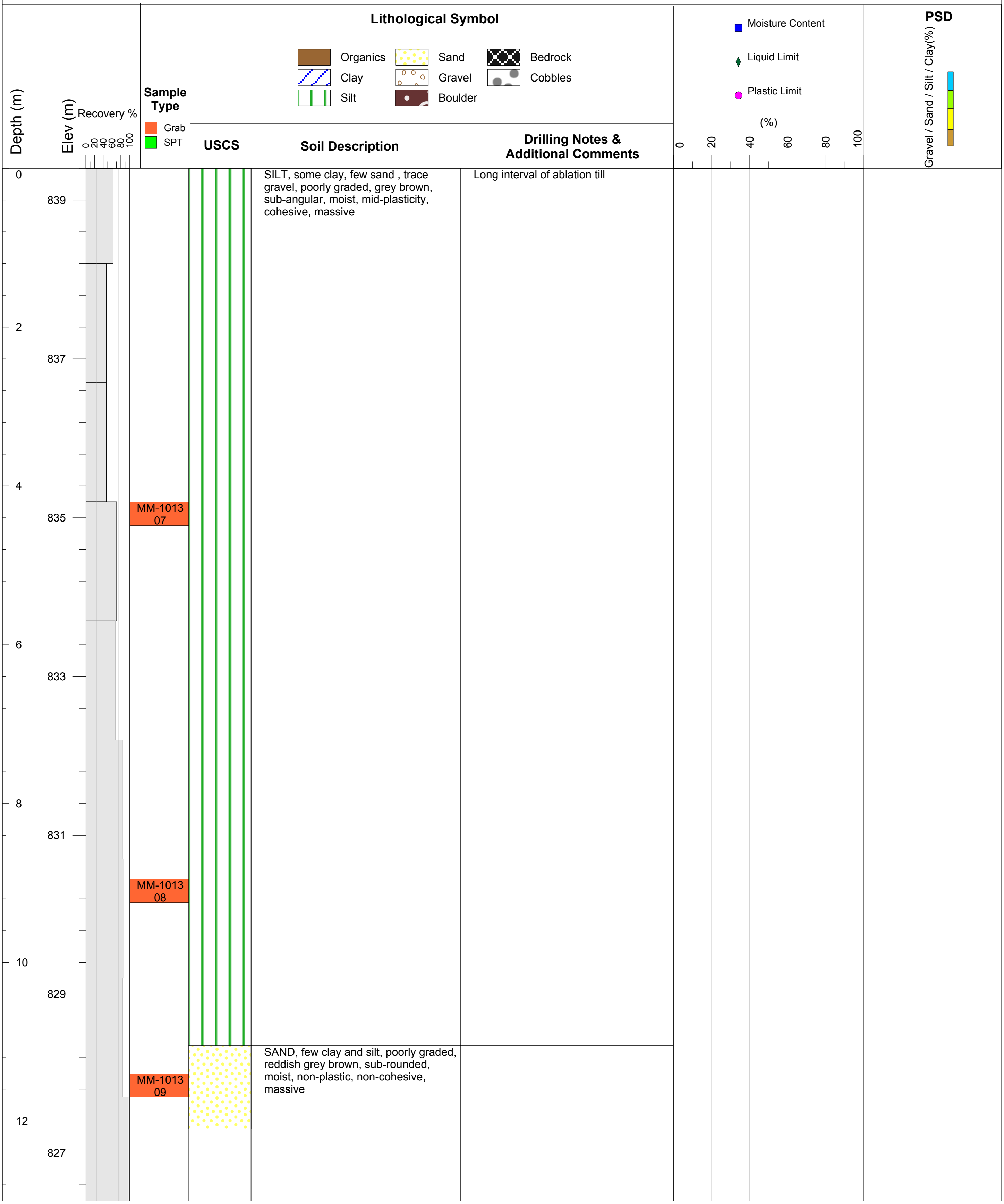
srk consulting

capstone MINTO MINE

PROJECT: Minto
CLIENT: Minto Exploration Ltd.

HOLE ID: **14-SWC-977**
LOCATION: Yukon
PROJECT NO: 1CM002.037
DRILLING CONTRACTOR: Driftwood
DRILLING TYPE & CORE DIA: HQ Diamond
LOGGED BY: MJM
BORING DATE: Oct/Nov 2014

COORDINATES: 385097.9 E 6944254 N
DATUM: UTM Zone 8
GROUND ELEV (m): 839.4
AZIMUTH: 0
COLLAR DIP: -90
EOH ELEV. (m): 827.3
TOTAL DEPTH (m): 12.1
DEPOSIT AREA: Area 2



SILT, some clay, few sand , trace gravel, poorly graded, grey brown, sub-angular, moist, mid-plasticity, cohesive, massive

Long interval of ablation till

SAND, few clay and silt, poorly graded, reddish grey brown, sub-rounded, moist, non-plastic, non-cohesive, massive

srk consulting

capstone MINTO MINE

HOLE ID:	**14-SWC-977**	COORDINATES:	385097.9 E 6944254 N
LOCATION:	Yukon	DATUM:	UTM Zone 8
PROJECT NO:	1CM002.037	GROUND ELEV (m):	839.4
DRILLING CONTRACTOR:	Driftwood	AZIMUTH:	0
DRILLING TYPE & CORE DIA:	HQ Diamond	COLLAR DIP:	-90
		EOH ELEV. (m):	827.3
LOGGED BY:	MJM	TOTAL DEPTH (m):	12.1
BORING DATE:	Oct/Nov 2014	DEPOSIT AREA:	Area 2

PROJECT: Minto

CLIENT: Minto Exploration Ltd.

Lithological Symbol

▨	Organics	▨	Sand	▨	Bedrock
▨	Clay	▨	Gravel	▨	Cobbles
▨	Silt	▨	Boulder		

■ Moisture Content

◆ Liquid Limit

● Plastic Limit

(%)

0 20 40 60 80 100

PSD

Gravel / Sand / Silt / Clay(%)

Depth (m)	Elev (m)	Recovery % 0 20 40 60 80 100	**Sample Type** 🟥 Grab 🟩 SPT	**USCS**	**Soil Description**	**Drilling Notes & Additional Comments**
14						

srk consulting

capstone MINTO MINE

PROJECT: Minto
CLIENT: Minto Exploration Ltd.

HOLE ID:	**14-SWC-978**	COORDINATES:	385122.4 E 6944219 N
LOCATION:	Yukon	DATUM:	UTM Zone 8
PROJECT NO:	1CM002.037	GROUND ELEV (m):	837.2
DRILLING CONTRACTOR:	Driftwood	AZIMUTH:	0
DRILLING TYPE & CORE DIA:	HQ Diamond	COLLAR DIP:	-90
		EOH ELEV. (m):	825.9
LOGGED BY:	MJM	TOTAL DEPTH (m):	11.3
BORING DATE:	Oct/Nov 2014		

DEPOSIT AREA:
Area 2

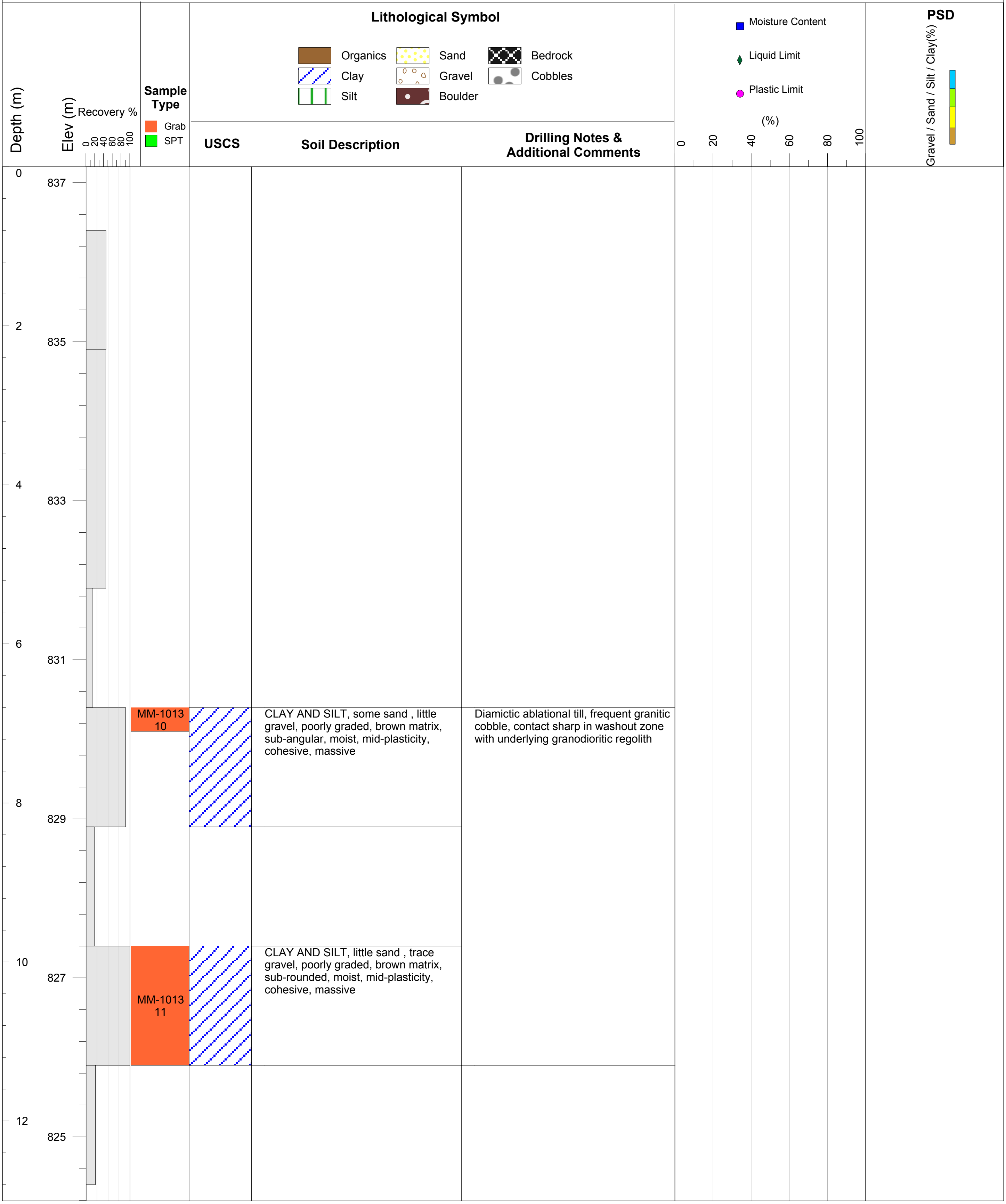
Lithological Symbol

🟫	Organics	▨	Sand	▩	Bedrock
▧	Clay	▨	Gravel	●	Cobbles
▥	Silt	●	Boulder		

Sample Type
🟥 Grab
🟩 SPT

■ Moisture Content
◆ Liquid Limit
● Plastic Limit

PSD



Soil Description	Drilling Notes & Additional Comments
CLAY AND SILT, some sand , little gravel, poorly graded, brown matrix, sub-angular, moist, mid-plasticity, cohesive, massive	Diamictic ablational till, frequent granitic cobble, contact sharp in washout zone with underlying granodioritic regolith
CLAY AND SILT, little sand , trace gravel, poorly graded, brown matrix, sub-rounded, moist, mid-plasticity, cohesive, massive	

srk consulting

capstone MINTO MINE

PROJECT: Minto
CLIENT: Minto Exploration Ltd.

HOLE ID: **14-SWC-978**
LOCATION: Yukon
PROJECT NO: 1CM002.037
DRILLING CONTRACTOR: Driftwood
DRILLING TYPE & CORE DIA: HQ Diamond
LOGGED BY: MJM
BORING DATE: Oct/Nov 2014

COORDINATES: 385122.4 E 6944219 N
DATUM: UTM Zone 8
GROUND ELEV (m): 837.2
AZIMUTH: 0
COLLAR DIP: -90
EOH ELEV. (m): 825.9
TOTAL DEPTH (m): 11.3

DEPOSIT AREA:
Area 2

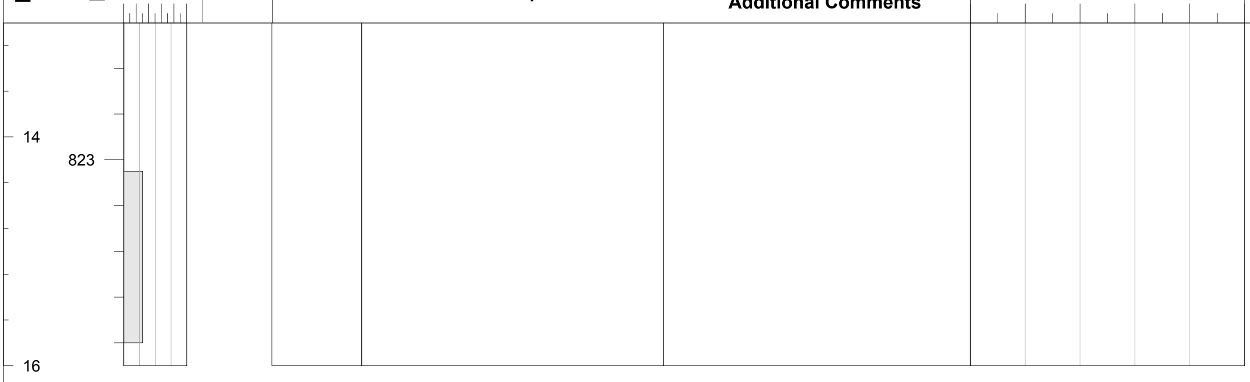
Lithological Symbol

🟫	Organics	▨	Sand	▩	Bedrock
▨	Clay	▨	Gravel	●	Cobbles
▥	Silt	■	Boulder		

■ Moisture Content
◆ Liquid Limit
● Plastic Limit

Sample Type
🟥 Grab
🟩 SPT

Depth (m)	Elev (m)	Recovery %	**Sample Type**	**USCS**	**Soil Description**	**Drilling Notes & Additional Comments**	(%)	**PSD** Gravel / Sand / Silt / Clay(%)



srk consulting

capstone MINTO MINE

PROJECT: Minto
CLIENT: Minto Exploration Ltd.

HOLE ID:	**14-SWC-979**
LOCATION:	Yukon
PROJECT NO:	1CM002.037
DRILLING CONTRACTOR:	Driftwood
DRILLING TYPE & CORE DIA:	HQ Diamond
LOGGED BY:	MJM
BORING DATE:	Oct/Nov 2014

COORDINATES:	385218.8 E 6944233 N
DATUM:	UTM Zone 8
GROUND ELEV (m):	826.9
AZIMUTH:	0
COLLAR DIP:	-90
EOH ELEV. (m):	795.4
TOTAL DEPTH (m):	31.5

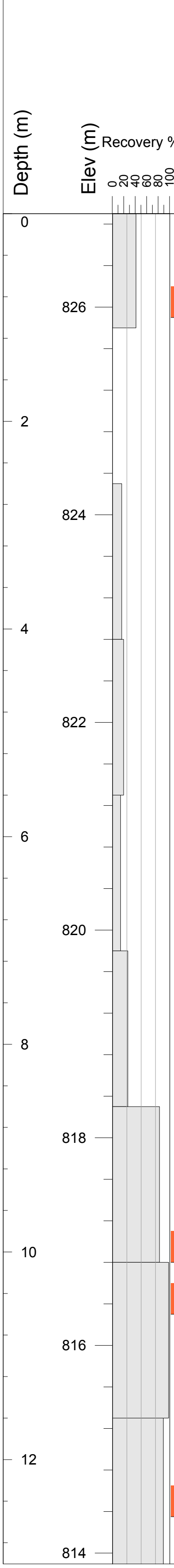
DEPOSIT AREA: Area 2

Lithological Symbol

🟫	Organics	▒	Sand	▩	Bedrock
▨	Clay	○	Gravel	●	Cobbles
‖	Silt	◘	Boulder		

■ Moisture Content
♦ Liquid Limit
● Plastic Limit
(%) 0 20 40 60 80 100

PSD
Gravel / Sand / Silt / Clay(%)



Sample Type: 🟥 Grab 🟩 SPT

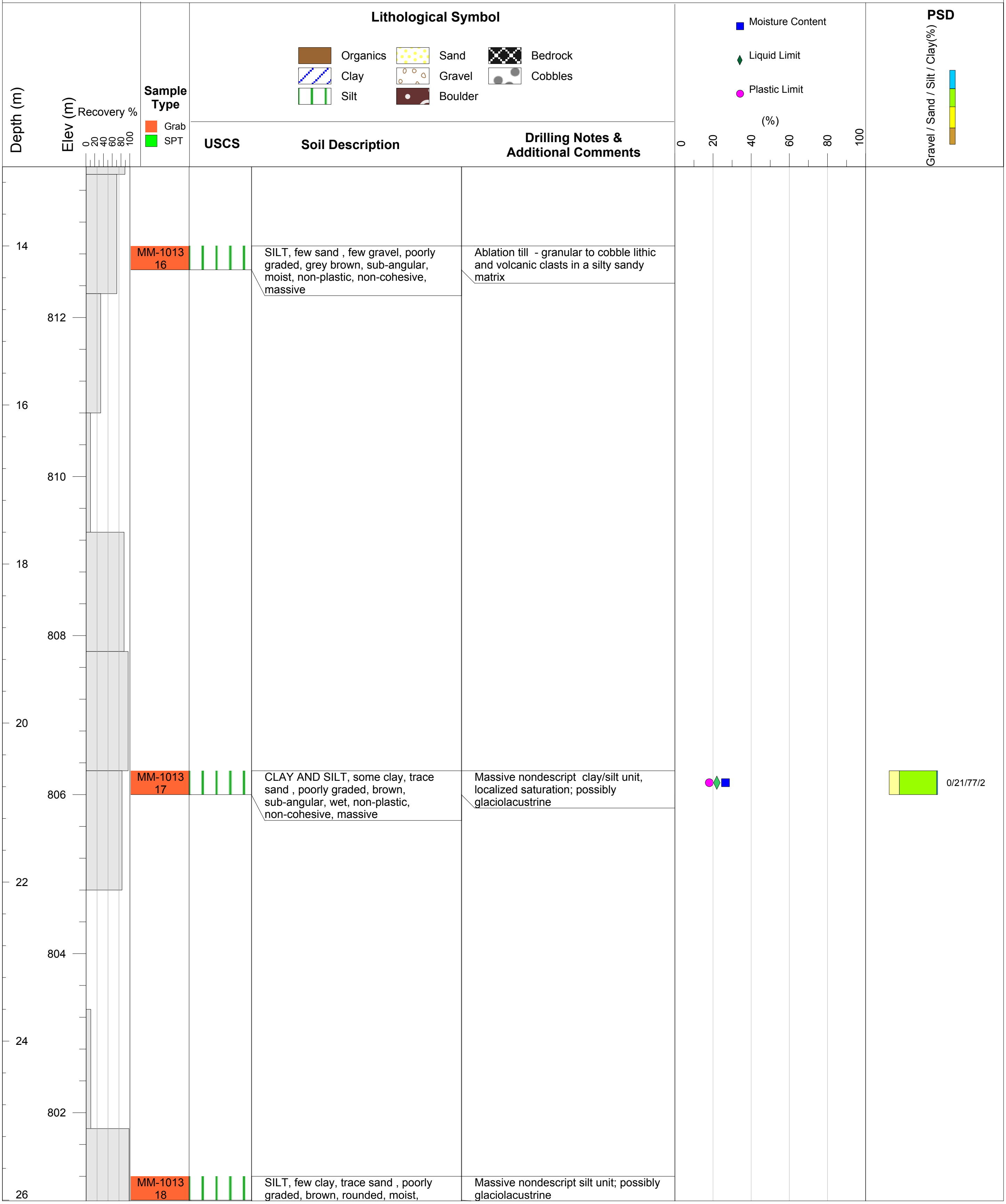
Sample Type	USCS	Soil Description	Drilling Notes & Additional Comments
MM-1013 12	🟫	ORGANICS, few clay and silt, trace sand , poorly graded, Brown/Black, sub-rounded, moist, mid-plasticity, cohesive, massive	Mixed black humus and dark grey silt/sand, roots, branches, even trunk fragments scattered throughout
MM-1013 13	‖	CLAY AND SILT, some silt, trace sand , poorly graded, dark brown/grey, sub-rounded, moist, mid-plasticity, cohesive, massive	Contact sharp with overlying organics, large intervals of washed out zones with clean gravel
MM-1013 14	‖	CLAY AND SILT, little silt, trace gravel, poorly graded, black/dark bbrown, sub-angular, moist, mid-plasticity, cohesive, massi	Primarily clay/minor silt unit, black oily look when wet, popssibly glaciolacustrine
MM-1013 15	‖	CLAY AND SILT, few silt, few sand , gap graded, black/dy grey/brown, sub-angular, moist, mid-plasticity, cohesive, laminated	Crudely laminated sand with clay interbeds, vertical zonation of clay and sand, possible ball and plume structures, possibly gl

srk consulting

capstone MINTO MINE

PROJECT:	Minto	HOLE ID:	**14-SWC-979**
CLIENT:	Minto Exploration Ltd.	LOCATION:	Yukon
		PROJECT NO:	1CM002.037
		DRILLING CONTRACTOR:	Driftwood
		DRILLING TYPE & CORE DIA:	HQ Diamond
		LOGGED BY:	MJM
		BORING DATE:	Oct/Nov 2014

COORDINATES:	385218.8 E 6944233 N
DATUM:	UTM Zone 8
GROUND ELEV (m):	826.9
AZIMUTH:	0
COLLAR DIP:	-90
EOH ELEV. (m):	795.4
TOTAL DEPTH (m):	31.5
DEPOSIT AREA:	Area 2



Sample	Soil Description	Drilling Notes & Additional Comments
MM-1013 16	SILT, few sand , few gravel, poorly graded, grey brown, sub-angular, moist, non-plastic, non-cohesive, massive	Ablation till - granular to cobble lithic and volcanic clasts in a silty sandy matrix
MM-1013 17	CLAY AND SILT, some clay, trace sand , poorly graded, brown, sub-angular, wet, non-plastic, non-cohesive, massive	Massive nondescript clay/silt unit, localized saturation; possibly glaciolacustrine
MM-1013 18	SILT, few clay, trace sand , poorly graded, brown, rounded, moist,	Massive nondescript silt unit; possibly glaciolacustrine

srk consulting

capstone MINTO MINE

PROJECT: Minto
CLIENT: Minto Exploration Ltd.

HOLE ID:	**14-SWC-979**	COORDINATES:	385218.8 E 6944233 N
LOCATION:	Yukon	DATUM:	UTM Zone 8
PROJECT NO:	1CM002.037	GROUND ELEV (m):	826.9
DRILLING CONTRACTOR:	Driftwood	AZIMUTH:	0
DRILLING TYPE & CORE DIA:	HQ Diamond	COLLAR DIP:	-90
		EOH ELEV. (m):	795.4
LOGGED BY:	MJM	TOTAL DEPTH (m):	31.5
BORING DATE:	Oct/Nov 2014		

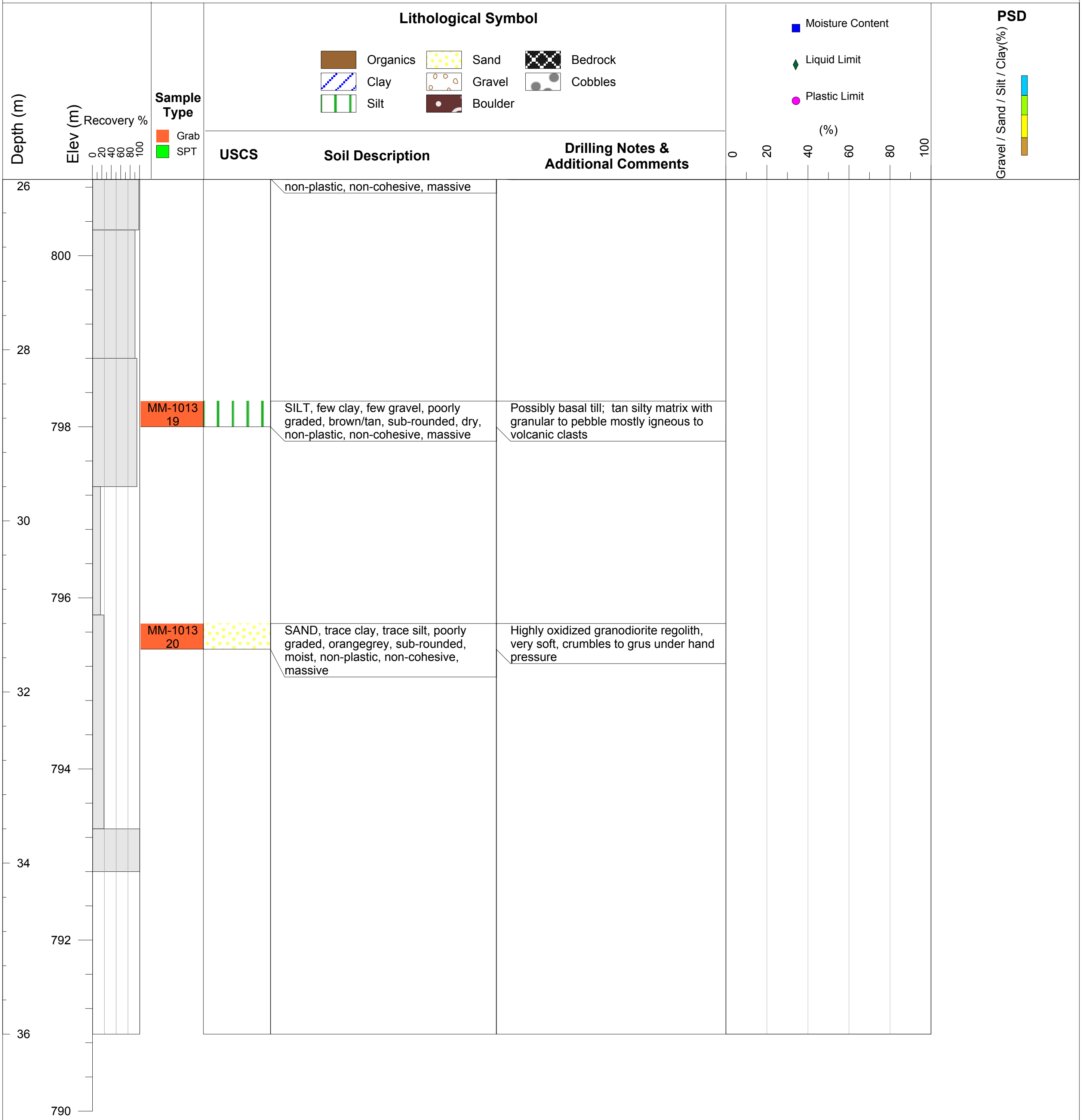
DEPOSIT AREA:
Area 2

Lithological Symbol

Organics	Sand	Bedrock
Clay	Gravel	Cobbles
Silt	Boulder	

Sample Type
- 🟥 Grab
- 🟩 SPT

- ■ Moisture Content
- ♦ Liquid Limit
- ● Plastic Limit



Sample Type	Soil Description	Drilling Notes & Additional Comments
	non-plastic, non-cohesive, massive	
MM-1013 19	SILT, few clay, few gravel, poorly graded, brown/tan, sub-rounded, dry, non-plastic, non-cohesive, massive	Possibly basal till; tan silty matrix with granular to pebble mostly igneous to volcanic clasts
MM-1013 20	SAND, trace clay, trace silt, poorly graded, orangegrey, sub-rounded, moist, non-plastic, non-cohesive, massive	Highly oxidized granodiorite regolith, very soft, crumbles to grus under hand pressure

srk consulting

capstone
MINTO MINE

HOLE ID:	**14-SWC-980**	COORDINATES:	385194.5 E 6944261 N
LOCATION:	Yukon	DATUM:	UTM Zone 8
PROJECT NO:	1CM002.037	GROUND ELEV (m):	826.5
DRILLING CONTRACTOR:	Driftwood	AZIMUTH:	0
DRILLING TYPE & CORE DIA:	HQ Diamond	COLLAR DIP:	-90
		EOH ELEV. (m):	804.9
LOGGED BY:	MJM	TOTAL DEPTH (m):	21.6
BORING DATE:	Oct/Nov 2014	DEPOSIT AREA:	Area 2

PROJECT: Minto
CLIENT: Minto Exploration Ltd.

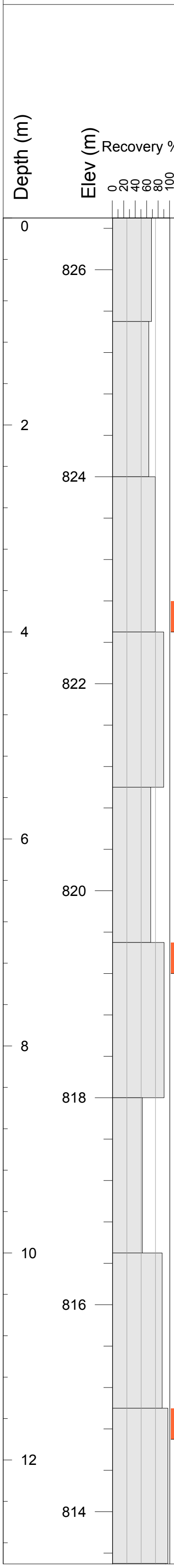
Lithological Symbol

🟫	Organics	▒	Sand	▦	Bedrock
▨	Clay	▒	Gravel	●	Cobbles
▥	Silt	●	Boulder		

■ Moisture Content
♦ Liquid Limit
● Plastic Limit

PSD
Gravel / Sand / Silt / Clay(%)

Sample Type
🟥 Grab
🟩 SPT



Sample Type	USCS	Soil Description	Drilling Notes & Additional Comments
MM-1013 21	▥	SILT, few sand , few gravel, poorly graded, brown, sub-rounded, moist, non-plastic, cohesive, massive	Diamictic till; silty matrix
MM-1013 22	▨	CLAY, few sand , little gravel, poorly graded, grey/brown, sub-rounded, moist, mid-plasticity, cohesive, massive	Massive clay with lenses of sand; bedding non apparent
MM-1013 23	▨	CLAY, some silt, little gravel, poorly graded, grey/brown, sub-angular, moist, mid-plasticity, cohesive, massive	Clay with discontinous sand lenses; bedding non-apparent

(%)
0 20 40 60 80 100

srk consulting

capstone MINTO MINE

PROJECT: Minto
CLIENT: Minto Exploration Ltd.

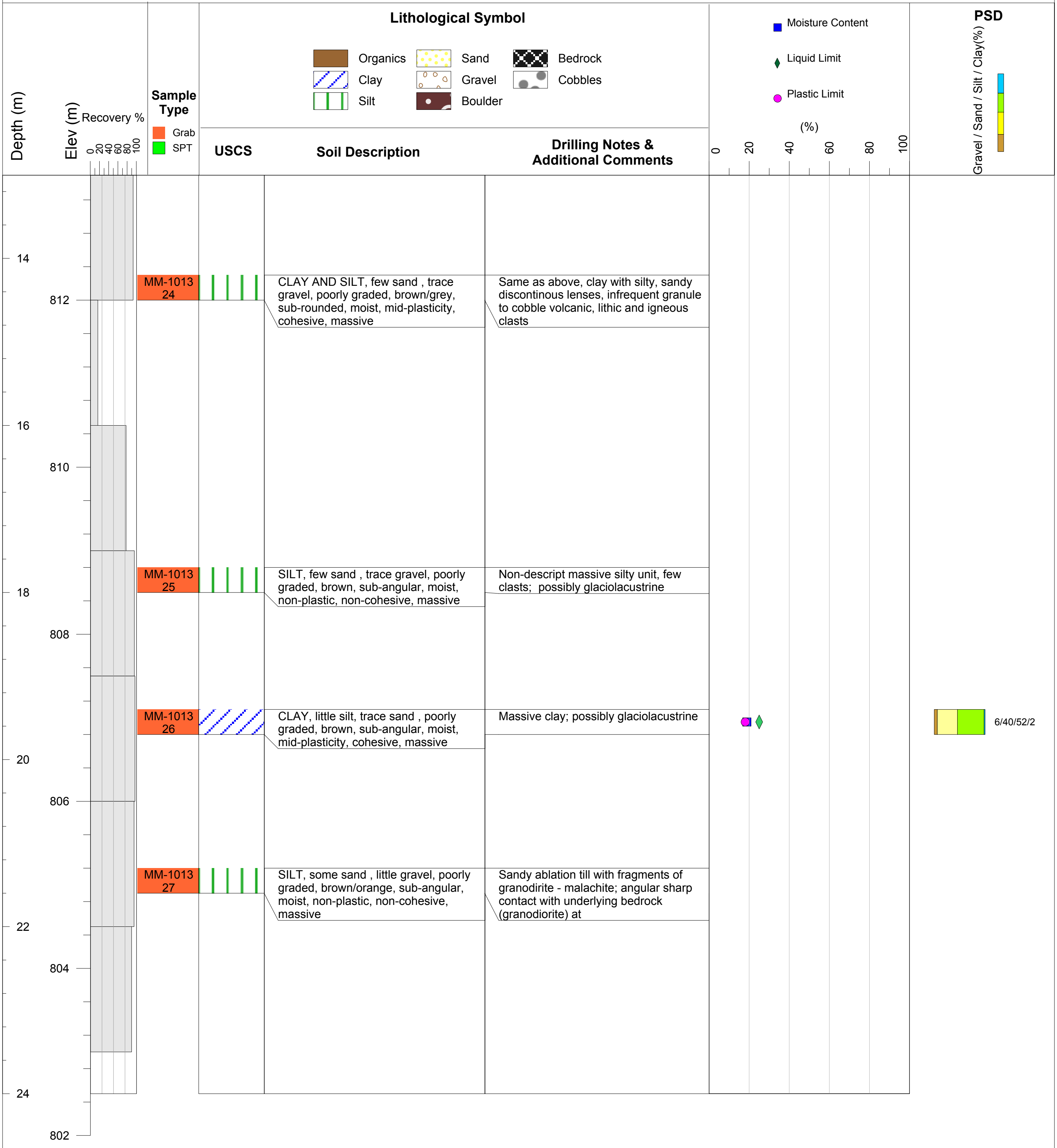
HOLE ID:	**14-SWC-980**	COORDINATES:	385194.5 E 6944261 N
LOCATION:	Yukon	DATUM:	UTM Zone 8
PROJECT NO:	1CM002.037	GROUND ELEV (m):	826.5
DRILLING CONTRACTOR:	Driftwood	AZIMUTH:	0
DRILLING TYPE & CORE DIA:	HQ Diamond	COLLAR DIP:	-90
		EOH ELEV. (m):	804.9
LOGGED BY:	MJM	TOTAL DEPTH (m):	21.6
BORING DATE:	Oct/Nov 2014	DEPOSIT AREA:	Area 2

Lithological Symbol

Organics	Sand	Bedrock
Clay	Gravel	Cobbles
Silt	Boulder	

Sample Type: 🟧 Grab, 🟩 SPT

■ Moisture Content
◆ Liquid Limit
● Plastic Limit



Sample Type	USCS	Soil Description	Drilling Notes & Additional Comments
MM-1013 24	▥	CLAY AND SILT, few sand , trace gravel, poorly graded, brown/grey, sub-rounded, moist, mid-plasticity, cohesive, massive	Same as above, clay with silty, sandy discontinous lenses, infrequent granule to cobble volcanic, lithic and igneous clasts
MM-1013 25	▥	SILT, few sand , trace gravel, poorly graded, brown, sub-angular, moist, non-plastic, non-cohesive, massive	Non-descript massive silty unit, few clasts; possibly glaciolacustrine
MM-1013 26	▨	CLAY, little silt, trace sand , poorly graded, brown, sub-angular, moist, mid-plasticity, cohesive, massive	Massive clay; possibly glaciolacustrine
MM-1013 27	▥	SILT, some sand , little gravel, poorly graded, brown/orange, sub-angular, moist, non-plastic, non-cohesive, massive	Sandy ablation till with fragments of granodirite - malachite; angular sharp contact with underlying bedrock (granodiorite) at

srk consulting

capstone MINTO MINE

PROJECT: Minto
CLIENT: Minto Exploration Ltd.

HOLE ID:	**14-SWC-981**	COORDINATES:	385148 E 6944188 N
LOCATION:	Yukon	DATUM:	UTM Zone 8
PROJECT NO:	1CM002.037	GROUND ELEV (m):	837.838
DRILLING CONTRACTOR:	Driftwood	AZIMUTH:	0
DRILLING TYPE & CORE DIA:	HQ Diamond	COLLAR DIP:	-90
LOGGED BY:	MJM	EOH ELEV. (m):	807.89
BORING DATE:	Oct/Nov 2014	TOTAL DEPTH (m):	29.95

DEPOSIT AREA: Area 2

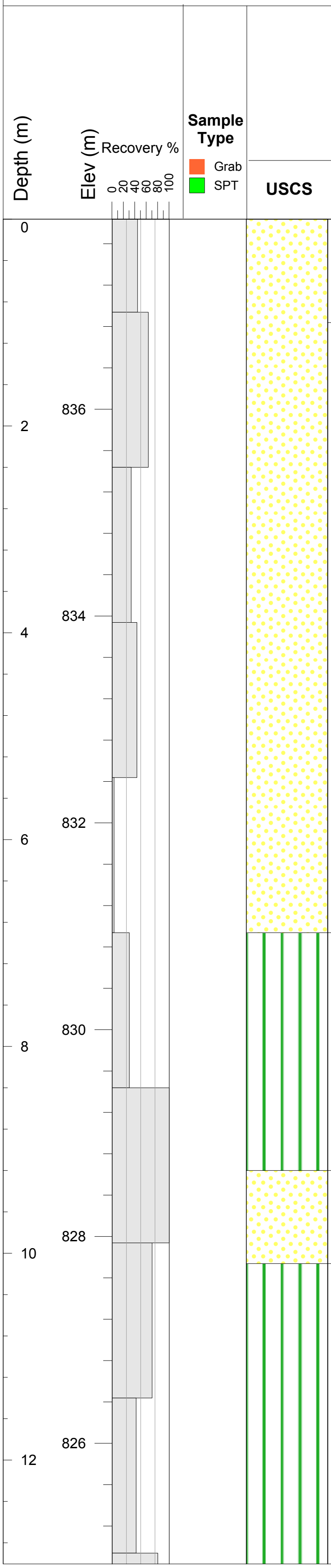
Lithological Symbol

Organics
Sand
Bedrock
Clay
Gravel
Cobbles
Silt
Boulder

Sample Type
🟧 Grab
🟩 SPT

■ Moisture Content
♦ Liquid Limit
● Plastic Limit

PSD
Gravel / Sand / Silt / Clay(%)



Soil Description	Drilling Notes & Additional Comments
SAND, few silt, trace gravel, poorly graded, dark brown, sub-rounded, moist, non-plastic, non-cohesive, massive	Organic matter (tree root) for initial 10 cm
SAND, few gravel, poorly graded, brown, sub-rounded, moist, non-plastic, non-cohesive, massive	No recovery (loss of matrix sand) from 5.4-6.9m
CLAY AND SILT, few sand , little gravel, poorly graded, grey brown, sub-rounded, moist, mid-plasticity, cohesive, massive	
SAND, some gravel, trace silt, poorly graded, brown, sub-rounded, moist, non-plastic, non-cohesive, massive	
CLAY AND SILT, few gravel, little sand , poorly graded, dark grey, sub-rounded, moist, mid-plasticity, cohesive, massive	Minor organic matter including twigs

(%)
0 20 40 60 80 100

srk consulting

capstone MINTO MINE

PROJECT: Minto
CLIENT: Minto Exploration Ltd.

HOLE ID: **14-SWC-981**
LOCATION: Yukon
PROJECT NO: 1CM002.037
DRILLING CONTRACTOR: Driftwood
DRILLING TYPE & CORE DIA: HQ Diamond
LOGGED BY: MJM
BORING DATE: Oct/Nov 2014

COORDINATES: 385148 E 6944188 N
DATUM: UTM Zone 8
GROUND ELEV (m): 837.838
AZIMUTH: 0
COLLAR DIP: -90
EOH ELEV. (m): 807.89
TOTAL DEPTH (m): 29.95

DEPOSIT AREA: Area 2

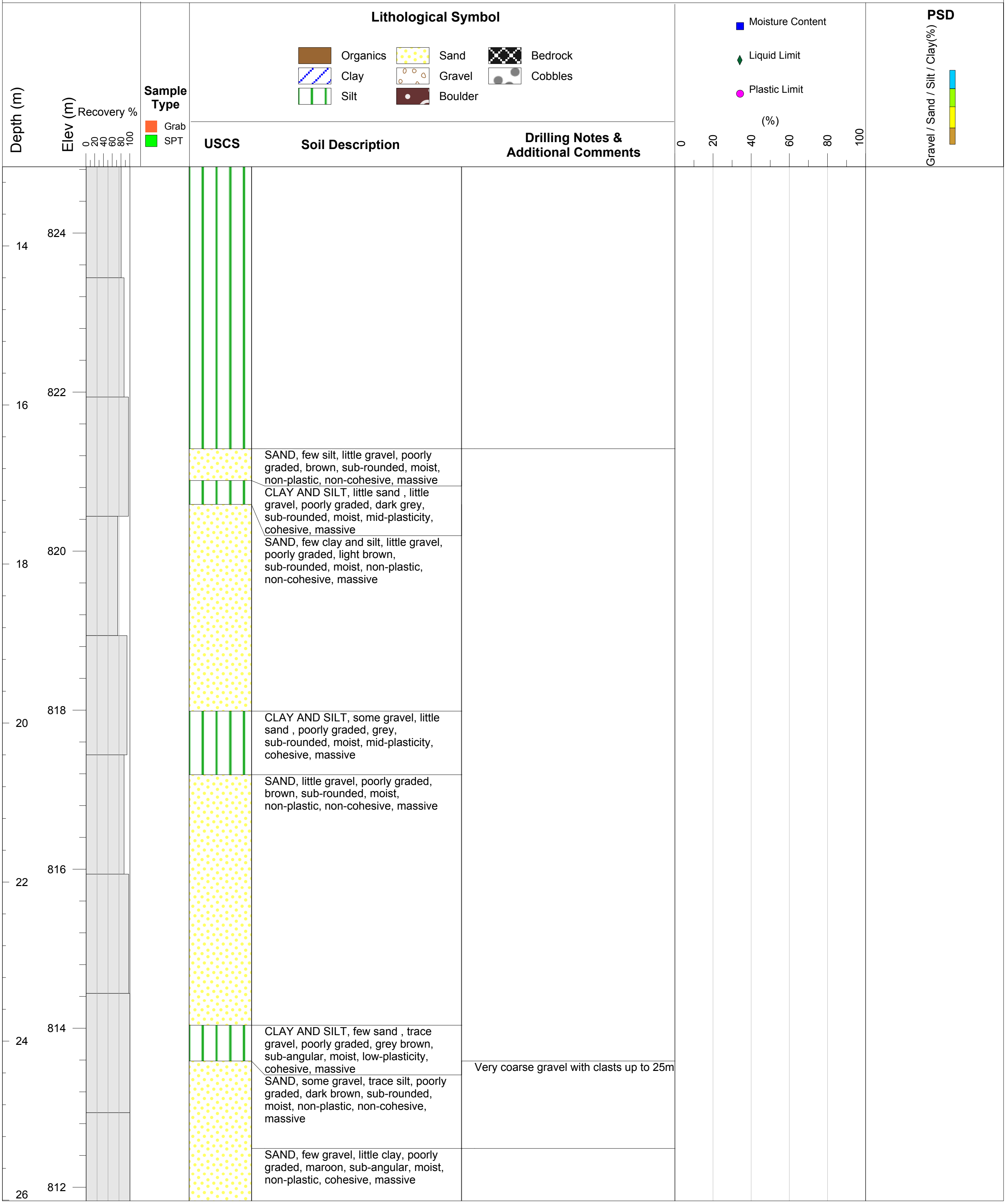
Lithological Symbol

Organics
Clay
Silt
Sand
Gravel
Boulder
Bedrock
Cobbles

Sample Type
🟥 Grab
🟩 SPT

■ Moisture Content
♦ Liquid Limit
● Plastic Limit
(%)

PSD
Gravel / Sand / Silt / Clay(%)



Soil Description	Drilling Notes & Additional Comments
SAND, few silt, little gravel, poorly graded, brown, sub-rounded, moist, non-plastic, non-cohesive, massive	
CLAY AND SILT, little sand , little gravel, poorly graded, dark grey, sub-rounded, moist, mid-plasticity, cohesive, massive	
SAND, few clay and silt, little gravel, poorly graded, light brown, sub-rounded, moist, non-plastic, non-cohesive, massive	
CLAY AND SILT, some gravel, little sand , poorly graded, grey, sub-rounded, moist, mid-plasticity, cohesive, massive	
SAND, little gravel, poorly graded, brown, sub-rounded, moist, non-plastic, non-cohesive, massive	
CLAY AND SILT, few sand , trace gravel, poorly graded, grey brown, sub-angular, moist, low-plasticity, cohesive, massive	Very coarse gravel with clasts up to 25m
SAND, some gravel, trace silt, poorly graded, dark brown, sub-rounded, moist, non-plastic, non-cohesive, massive	
SAND, few gravel, little clay, poorly graded, maroon, sub-angular, moist, non-plastic, cohesive, massive	

srk consulting

capstone
MINTO MINE

PROJECT: Minto
CLIENT: Minto Exploration Ltd.

HOLE ID: **14-SWC-981**
LOCATION: Yukon
PROJECT NO: 1CM002.037
DRILLING CONTRACTOR: Driftwood
DRILLING TYPE & CORE DIA: HQ Diamond
LOGGED BY: MJM
BORING DATE: Oct/Nov 2014

COORDINATES: 385148 E 6944188 N
DATUM: UTM Zone 8
GROUND ELEV (m): 837.838
AZIMUTH: 0
COLLAR DIP: -90
EOH ELEV. (m): 807.89
TOTAL DEPTH (m): 29.95

DEPOSIT AREA: Area 2

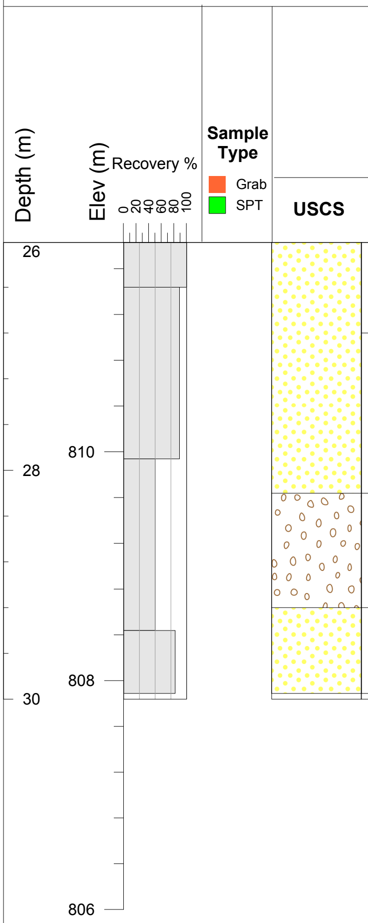
Lithological Symbol

▨	Organics	▨	Sand	▨	Bedrock
▨	Clay	▨	Gravel	▨	Cobbles
▨	Silt	▨	Boulder		

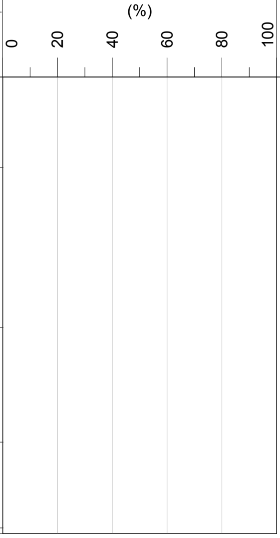
■ Moisture Content
◆ Liquid Limit
● Plastic Limit

Sample Type
🟥 Grab
🟩 SPT

PSD
Gravel / Sand / Silt / Clay(%)



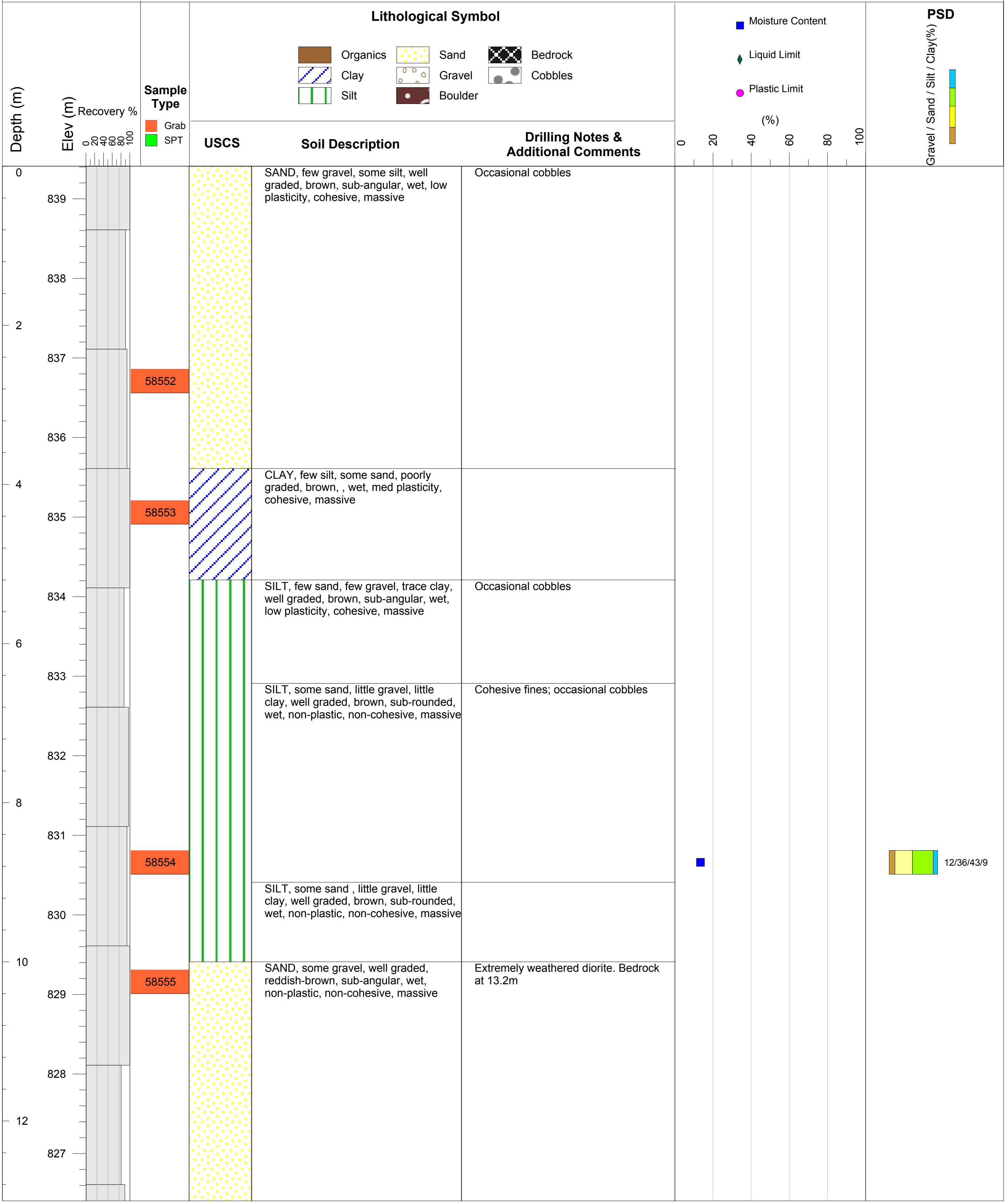
Soil Description	Drilling Notes & Additional Comments
SAND, some gravel, little clay, poorly graded, grey, sub-angular, moist, non-plastic, cohesive, massive	Local highly oxidized limoinitic fragments; some with malachite
GRAVEL, little sand , maroon, sub-rounded, moist, non-plastic, non-cohesive, massive	Fines almost completely washed away; only cobbles remaining
SAND, little gravel, poorly graded, maroon, angular, moist, non-plastic, non-cohesive, massive	Probably strongly altered rock but behaving as a soil



srk consulting

capstone MINTO MINE

PROJECT:	Minto
CLIENT:	Minto Exploration Ltd.
HOLE ID:	**15-SWC-995**
LOCATION:	Yukon
PROJECT NO:	1CM002.037
DRILLING CONTRACTOR:	Driftwood
DRILLING TYPE & CORE DIA:	HQ Diamond
LOGGED BY:	MJM/DM
BORING DATE:	5-Feb-15 To 9-Feb-15
COORDINATES:	385096.08 E 6944251.64 N
DATUM:	UTM Zone 8
GROUND ELEV (m):	839.41
AZIMUTH:	0
COLLAR DIP:	-90
EOH ELEV. (m):	826.66
TOTAL DEPTH (m):	13.2
DEPOSIT AREA:	Area 2



Soil Description	Drilling Notes & Additional Comments
SAND, few gravel, some silt, well graded, brown, sub-angular, wet, low plasticity, cohesive, massive	Occasional cobbles
CLAY, few silt, some sand, poorly graded, brown, , wet, med plasticity, cohesive, massive	
SILT, few sand, few gravel, trace clay, well graded, brown, sub-angular, wet, low plasticity, cohesive, massive	Occasional cobbles
SILT, some sand, little gravel, little clay, well graded, brown, sub-rounded, wet, non-plastic, non-cohesive, massive	Cohesive fines; occasional cobbles
SILT, some sand , little gravel, little clay, well graded, brown, sub-rounded, wet, non-plastic, non-cohesive, massive	
SAND, some gravel, well graded, reddish-brown, sub-angular, wet, non-plastic, non-cohesive, massive	Extremely weathered diorite. Bedrock at 13.2m

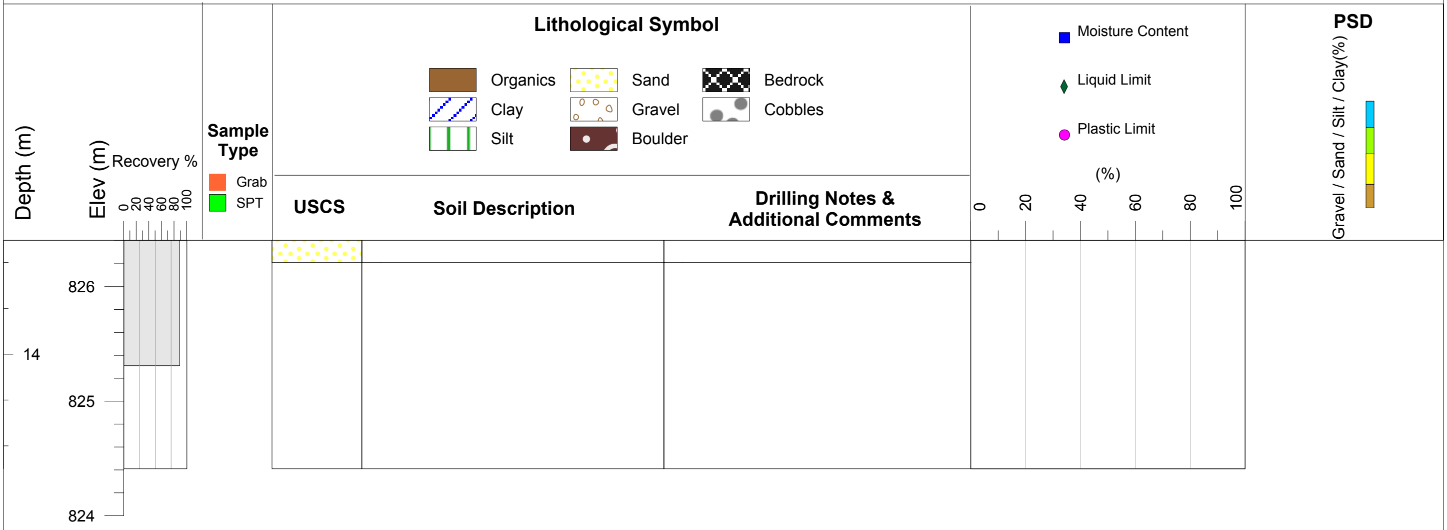
srk consulting

capstone MINTO MINE

HOLE ID:	**15-SWC-995**	COORDINATES:	385096.08 E 6944251.64 N
LOCATION:	Yukon	DATUM:	UTM Zone 8
PROJECT NO:	1CM002.037	GROUND ELEV (m):	839.41
DRILLING CONTRACTOR:	Driftwood	AZIMUTH:	0
DRILLING TYPE & CORE DIA:	HQ Diamond	COLLAR DIP:	-90
		EOH ELEV. (m):	826.66
LOGGED BY:	MJM/DM	TOTAL DEPTH (m):	13.2
BORING DATE:	5-Feb-15 To 9-Feb-15	DEPOSIT AREA:	Area 2

PROJECT: Minto

CLIENT: Minto Exploration Ltd.



srk consulting

capstone MINTO MINE

PROJECT: Minto
CLIENT: Minto Exploration Ltd.

HOLE ID: **15-SWC-996**
LOCATION: Yukon
PROJECT NO: 1CM002.037
DRILLING CONTRACTOR: Driftwood
DRILLING TYPE & CORE DIA: HQ Diamond
LOGGED BY: MJM/DM
BORING DATE: 9-Feb-15 To 11-Feb-15

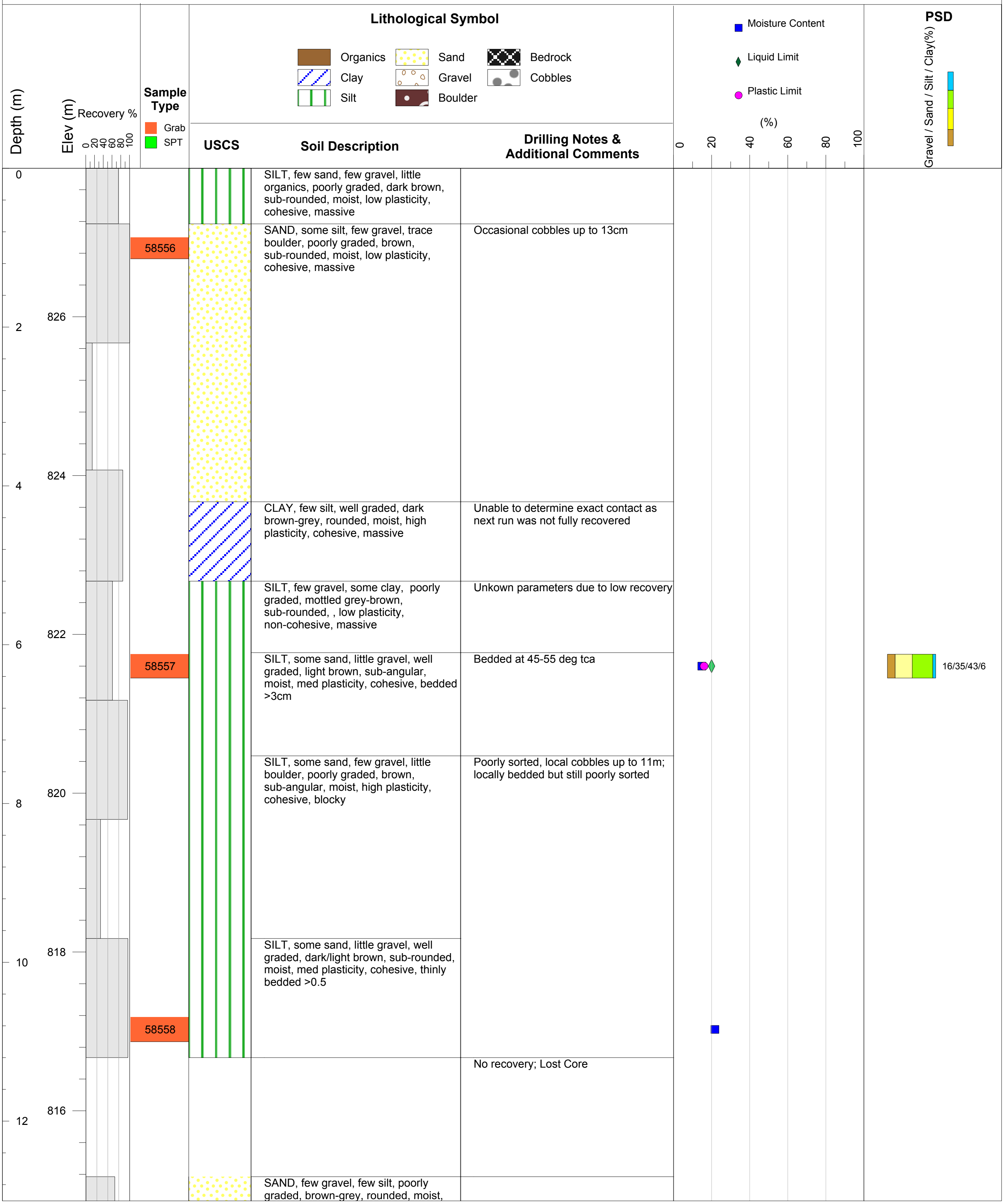
COORDINATES: 385161 E 6944314.88 N
DATUM: UTM Zone 8
GROUND ELEV (m): 827.87
AZIMUTH: 0
COLLAR DIP: -90
EOH ELEV. (m): 803.45
TOTAL DEPTH (m): 28.2
DEPOSIT AREA: Area 2

Lithological Symbol

- ▇ Organics
- ▨ Clay
- ▥ Silt
- ░ Sand
- ○ Gravel
- ● Boulder
- ▩ Bedrock
- ● Cobbles

Sample Type: 🟥 Grab, 🟩 SPT

■ Moisture Content
◆ Liquid Limit
● Plastic Limit



Soil Description	Drilling Notes & Additional Comments
SILT, few sand, few gravel, little organics, poorly graded, dark brown, sub-rounded, moist, low plasticity, cohesive, massive	
SAND, some silt, few gravel, trace boulder, poorly graded, brown, sub-rounded, moist, low plasticity, cohesive, massive	Occasional cobbles up to 13cm
CLAY, few silt, well graded, dark brown-grey, rounded, moist, high plasticity, cohesive, massive	Unable to determine exact contact as next run was not fully recovered
SILT, few gravel, some clay, poorly graded, mottled grey-brown, sub-rounded, , low plasticity, non-cohesive, massive	Unkown parameters due to low recovery
SILT, some sand, little gravel, well graded, light brown, sub-angular, moist, med plasticity, cohesive, bedded >3cm	Bedded at 45-55 deg tca
SILT, some sand, few gravel, little boulder, poorly graded, brown, sub-angular, moist, high plasticity, cohesive, blocky	Poorly sorted, local cobbles up to 11m; locally bedded but still poorly sorted
SILT, some sand, little gravel, well graded, dark/light brown, sub-rounded, moist, med plasticity, cohesive, thinly bedded >0.5	
	No recovery; Lost Core
SAND, few gravel, few silt, poorly graded, brown-grey, rounded, moist,	

srk consulting

capstone MINTO MINE

HOLE ID: **15-SWC-996**
LOCATION: Yukon
PROJECT NO: 1CM002.037
DRILLING CONTRACTOR: Driftwood
DRILLING TYPE & CORE DIA: HQ Diamond
LOGGED BY: MJM/DM
BORING DATE: 9-Feb-15 To 11-Feb-15

COORDINATES: 385161 E 6944314.88 N
DATUM: UTM Zone 8
GROUND ELEV (m): 827.87
AZIMUTH: 0
COLLAR DIP: -90
EOH ELEV. (m): 803.45
TOTAL DEPTH (m): 28.2

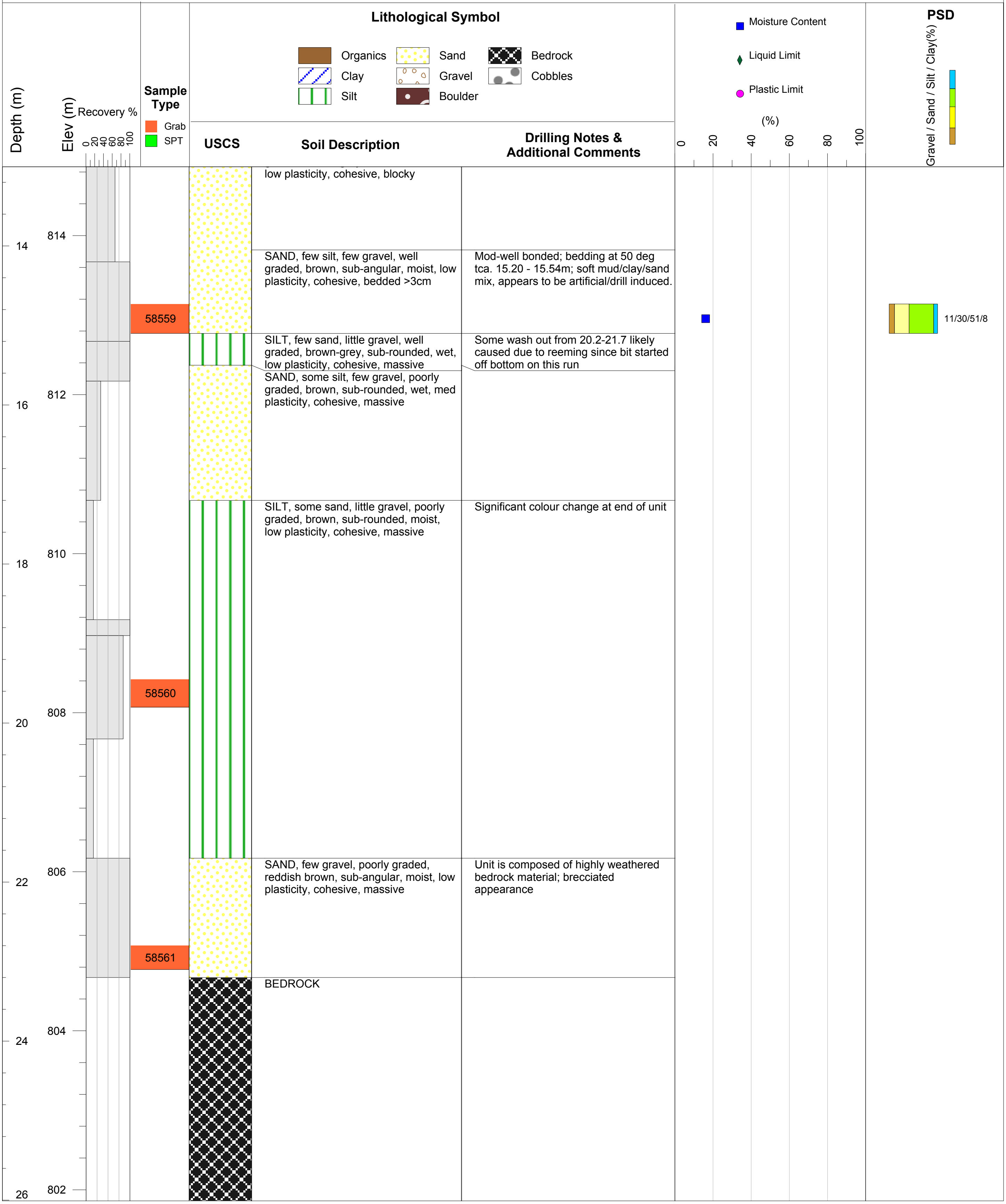
PROJECT: Minto
CLIENT: Minto Exploration Ltd.

DEPOSIT AREA: Area 2

Lithological Symbol

▨	Organics	▨	Sand	▨	Bedrock
▨	Clay	▨	Gravel	▨	Cobbles
▨	Silt	▨	Boulder		

■ Moisture Content
◆ Liquid Limit
● Plastic Limit



Soil Description	Drilling Notes & Additional Comments
low plasticity, cohesive, blocky	
SAND, few silt, few gravel, well graded, brown, sub-angular, moist, low plasticity, cohesive, bedded >3cm	Mod-well bonded; bedding at 50 deg tca. 15.20 - 15.54m; soft mud/clay/sand mix, appears to be artificial/drill induced.
SILT, few sand, little gravel, well graded, brown-grey, sub-rounded, wet, low plasticity, cohesive, massive	Some wash out from 20.2-21.7 likely caused due to reeming since bit started off bottom on this run
SAND, some silt, few gravel, poorly graded, brown, sub-rounded, wet, med plasticity, cohesive, massive	
SILT, some sand, little gravel, poorly graded, brown, sub-rounded, moist, low plasticity, cohesive, massive	Significant colour change at end of unit
SAND, few gravel, poorly graded, reddish brown, sub-angular, moist, low plasticity, cohesive, massive	Unit is composed of highly weathered bedrock material; brecciated appearance
BEDROCK	

srk consulting

capstone MINTO MINE

HOLE ID:	**15-SWC-996**	COORDINATES:	385161 E 6944314.88 N
LOCATION:	Yukon	DATUM:	UTM Zone 8
PROJECT NO:	1CM002.037	GROUND ELEV (m):	827.87
DRILLING CONTRACTOR:	Driftwood	AZIMUTH:	0
DRILLING TYPE & CORE DIA:	HQ Diamond	COLLAR DIP:	-90
LOGGED BY:	MJM/DM	EOH ELEV. (m):	803.45
BORING DATE:	9-Feb-15 To 11-Feb-15	TOTAL DEPTH (m):	28.2

PROJECT: Minto

CLIENT: Minto Exploration Ltd.

DEPOSIT AREA: Area 2

Lithological Symbol

▨ Organics	▨ Sand	▨ Bedrock
▨ Clay	▨ Gravel	▨ Cobbles
▨ Silt	▨ Boulder	

■ Moisture Content

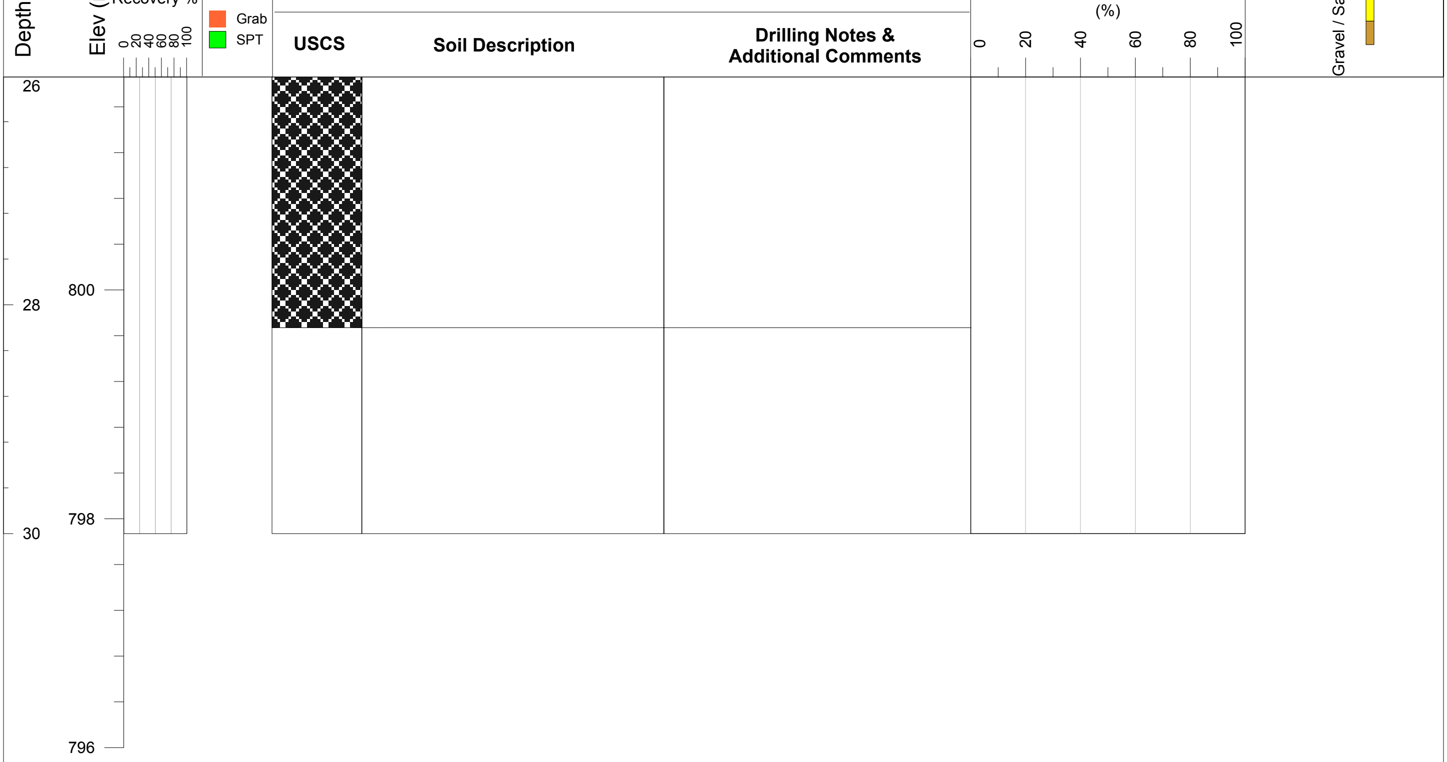
◆ Liquid Limit

● Plastic Limit

Sample Type

🟥 Grab

🟩 SPT



srk consulting

capstone MINTO MINE

PROJECT: Minto
CLIENT: Minto Exploration Ltd.

HOLE ID: **15-SWC-997**
LOCATION: Yukon
PROJECT NO: 1CM002.037
DRILLING CONTRACTOR: Driftwood
DRILLING TYPE & CORE DIA: HQ Diamond
LOGGED BY: MJM/DM
BORING DATE: 12-Feb-15 To 14-Feb-15

COORDINATES: 385140.87 E 6944123.97 N
DATUM: UTM Zone 8
GROUND ELEV (m): 841.65
AZIMUTH: 0
COLLAR DIP: -90
EOH ELEV. (m): 789.65
TOTAL DEPTH (m): 52.8

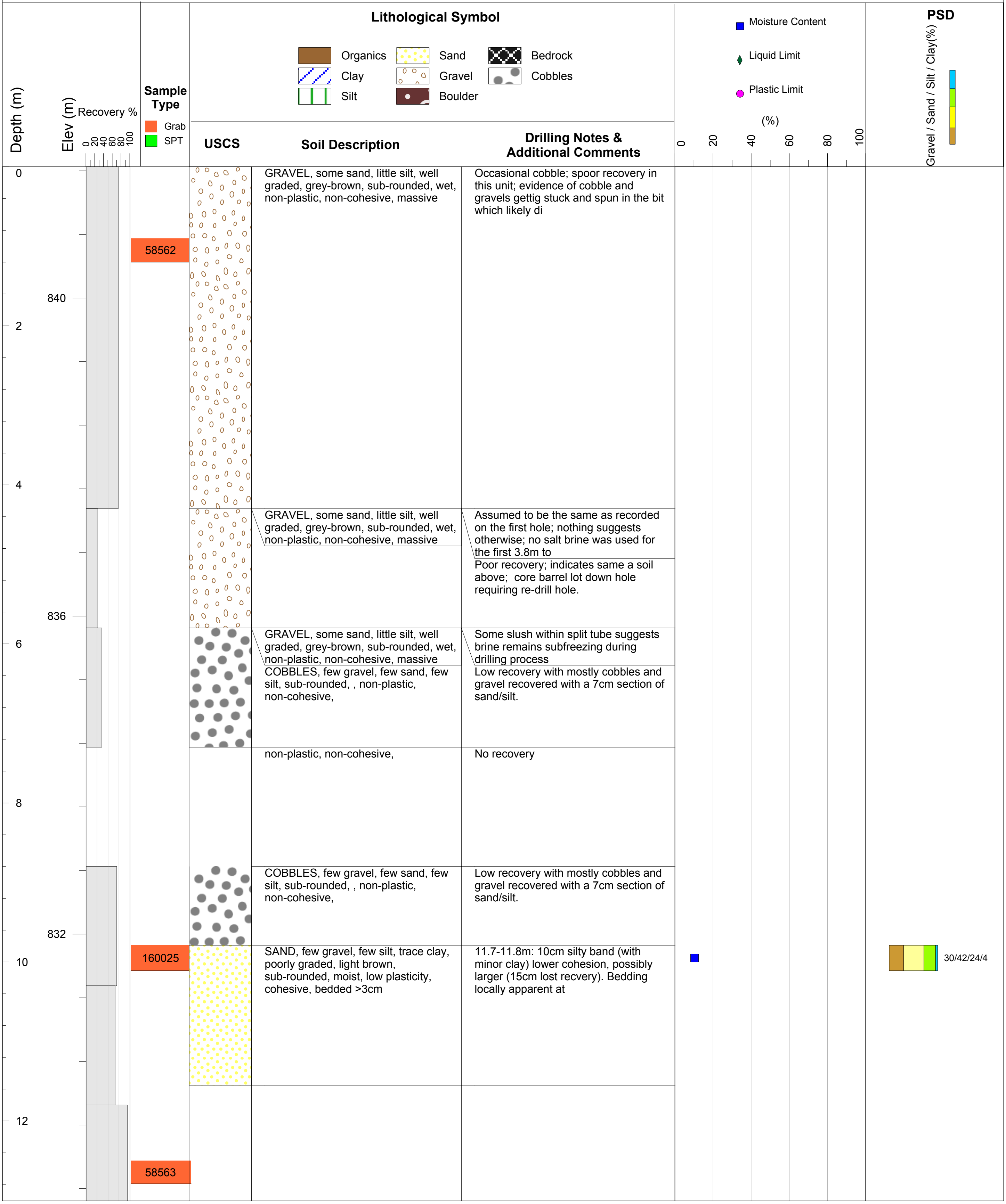
DEPOSIT AREA: Area 2

Lithological Symbol

Organics	Sand	Bedrock
Clay	Gravel	Cobbles
Silt	Boulder	

Sample Type: 🟧 Grab, 🟩 SPT

■ Moisture Content
◆ Liquid Limit
● Plastic Limit



Sample	Soil Description	Drilling Notes & Additional Comments
58562	GRAVEL, some sand, little silt, well graded, grey-brown, sub-rounded, wet, non-plastic, non-cohesive, massive	Occasional cobble; spoor recovery in this unit; evidence of cobble and gravels gettig stuck and spun in the bit which likely di
	GRAVEL, some sand, little silt, well graded, grey-brown, sub-rounded, wet, non-plastic, non-cohesive, massive	Assumed to be the same as recorded on the first hole; nothing suggests otherwise; no salt brine was used for the first 3.8m to Poor recovery; indicates same a soil above; core barrel lot down hole requiring re-drill hole.
	GRAVEL, some sand, little silt, well graded, grey-brown, sub-rounded, wet, non-plastic, non-cohesive, massive COBBLES, few gravel, few sand, few silt, sub-rounded, , non-plastic, non-cohesive,	Some slush within split tube suggests brine remains subfreezing during drilling process Low recovery with mostly cobbles and gravel recovered with a 7cm section of sand/silt.
	non-plastic, non-cohesive,	No recovery
	COBBLES, few gravel, few sand, few silt, sub-rounded, , non-plastic, non-cohesive,	Low recovery with mostly cobbles and gravel recovered with a 7cm section of sand/silt.
160025	SAND, few gravel, few silt, trace clay, poorly graded, light brown, sub-rounded, moist, low plasticity, cohesive, bedded >3cm	11.7-11.8m: 10cm silty band (with minor clay) lower cohesion, possibly larger (15cm lost recvery). Bedding locally apparent at
58563		

srk consulting

capstone MINTO MINE

PROJECT: Minto
CLIENT: Minto Exploration Ltd.

HOLE ID:	**15-SWC-997**	COORDINATES:	385140.87 E 6944123.97 N
LOCATION:	Yukon	DATUM:	UTM Zone 8
PROJECT NO:	1CM002.037	GROUND ELEV (m):	841.65
DRILLING CONTRACTOR:	Driftwood	AZIMUTH:	0
DRILLING TYPE & CORE DIA:	HQ Diamond	COLLAR DIP:	-90
		EOH ELEV. (m):	789.65
LOGGED BY:	MJM/DM	TOTAL DEPTH (m):	52.8
BORING DATE:	12-Feb-15 To 14-Feb-15		

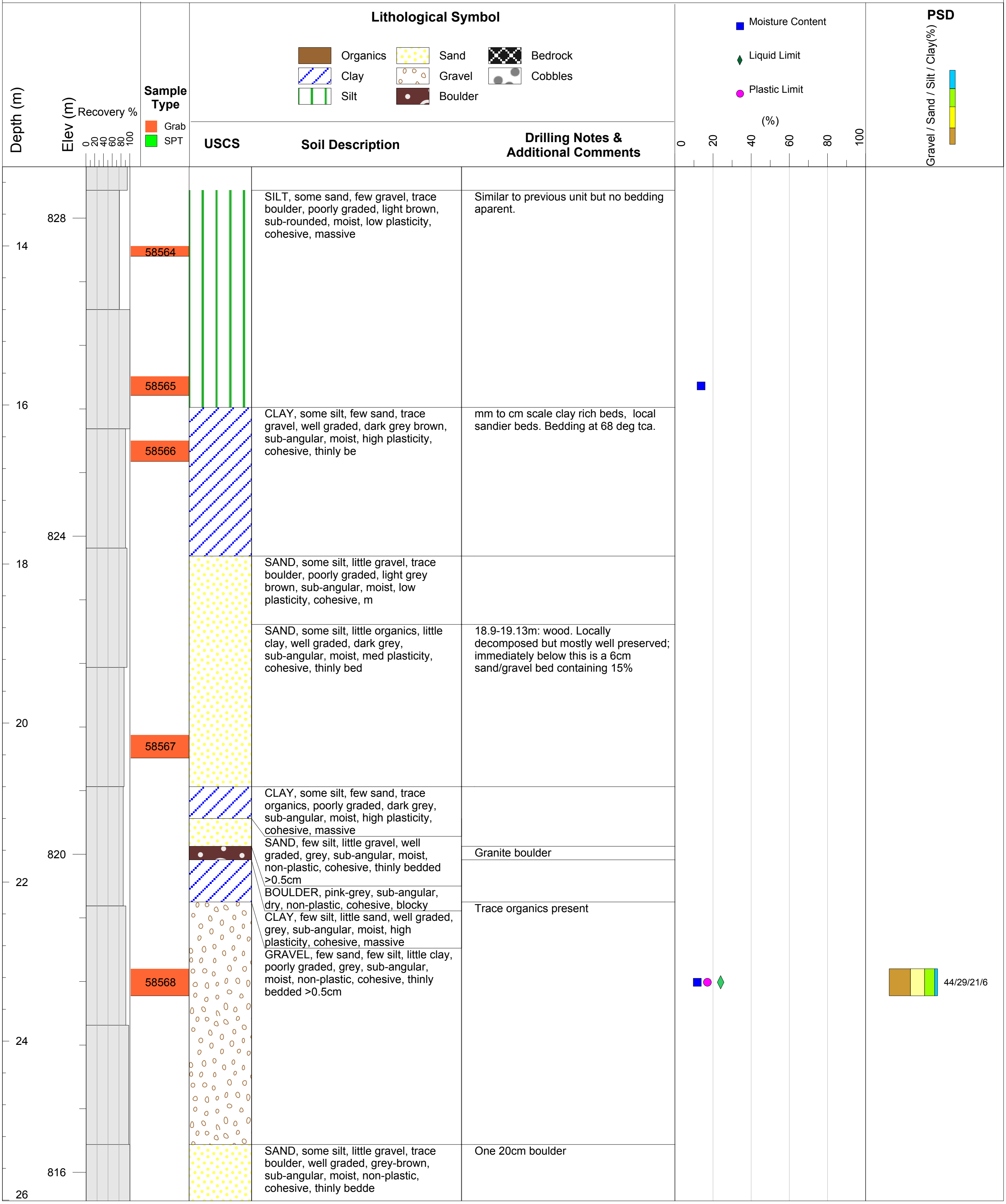
DEPOSIT AREA:
Area 2

Lithological Symbol

▨	Organics	▨	Sand	▨	Bedrock
▨	Clay	▨	Gravel	▨	Cobbles
▨	Silt	▨	Boulder		

■ Moisture Content
♦ Liquid Limit
● Plastic Limit

Sample Type: 🟥 Grab 🟩 SPT



Soil Description	Drilling Notes & Additional Comments
SILT, some sand, few gravel, trace boulder, poorly graded, light brown, sub-rounded, moist, low plasticity, cohesive, massive	Similar to previous unit but no bedding aparent.
CLAY, some silt, few sand, trace gravel, well graded, dark grey brown, sub-angular, moist, high plasticity, cohesive, thinly be	mm to cm scale clay rich beds, local sandier beds. Bedding at 68 deg tca.
SAND, some silt, little gravel, trace boulder, poorly graded, light grey brown, sub-angular, moist, low plasticity, cohesive, m	
SAND, some silt, little organics, little clay, well graded, dark grey, sub-angular, moist, med plasticity, cohesive, thinly bed	18.9-19.13m: wood. Locally decomposed but mostly well preserved; immediately below this is a 6cm sand/gravel bed containing 15%
CLAY, some silt, few sand, trace organics, poorly graded, dark grey, sub-angular, moist, high plasticity, cohesive, massive	
SAND, few silt, little gravel, well graded, grey, sub-angular, moist, non-plastic, cohesive, thinly bedded >0.5cm	
BOULDER, pink-grey, sub-angular, dry, non-plastic, cohesive, blocky	Granite boulder
CLAY, few silt, little sand, well graded, grey, sub-angular, moist, high plasticity, cohesive, massive	
GRAVEL, few sand, few silt, little clay, poorly graded, grey, sub-angular, moist, non-plastic, cohesive, thinly bedded >0.5cm	Trace organics present
SAND, some silt, little gravel, trace boulder, well graded, grey-brown, sub-angular, moist, non-plastic, cohesive, thinly bedde	One 20cm boulder

srk consulting

capstone MINTO MINE

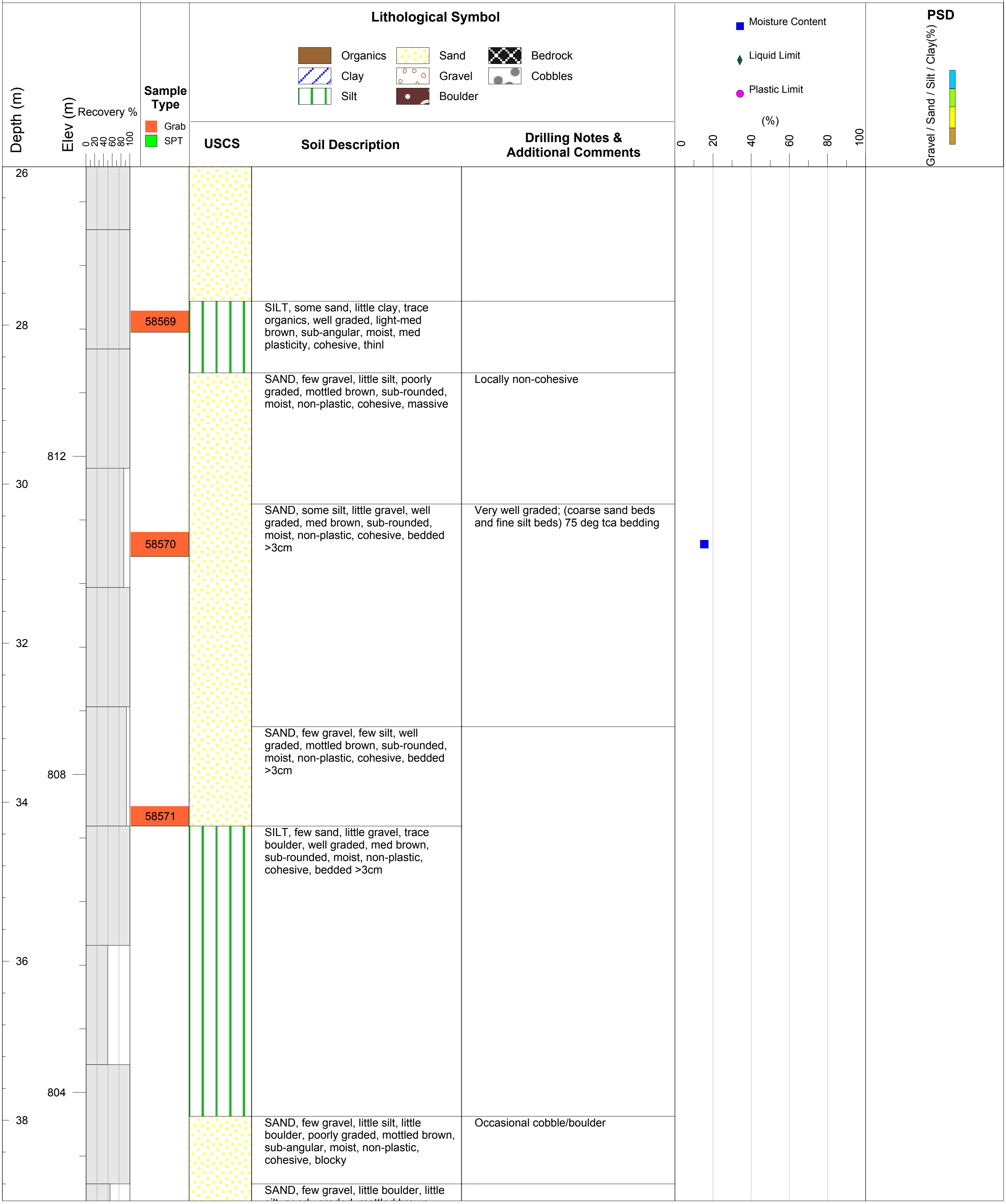
PROJECT: Minto
CLIENT: Minto Exploration Ltd.

HOLE ID:	**15-SWC-997**	COORDINATES:	385140.87 E 6944123.97 N
LOCATION:	Yukon	DATUM:	UTM Zone 8
PROJECT NO:	1CM002.037	GROUND ELEV (m):	841.65
DRILLING CONTRACTOR:	Driftwood	AZIMUTH:	0
DRILLING TYPE & CORE DIA:	HQ Diamond	COLLAR DIP:	-90
		EOH ELEV. (m):	789.65
LOGGED BY:	MJM/DM	TOTAL DEPTH (m):	52.8
BORING DATE:	12-Feb-15 To 14-Feb-15	DEPOSIT AREA:	Area 2

Lithological Symbol

▨	Organics	▨	Sand	▨	Bedrock
▨	Clay	▨	Gravel	▨	Cobbles
▨	Silt	▨	Boulder		

■ Moisture Content
♦ Liquid Limit
● Plastic Limit



Soil Description	Drilling Notes & Additional Comments
SILT, some sand, little clay, trace organics, well graded, light-med brown, sub-angular, moist, med plasticity, cohesive, thinl	
SAND, few gravel, little silt, poorly graded, mottled brown, sub-rounded, moist, non-plastic, cohesive, massive	Locally non-cohesive
SAND, some silt, little gravel, well graded, med brown, sub-rounded, moist, non-plastic, cohesive, bedded >3cm	Very well graded; (coarse sand beds and fine silt beds) 75 deg tca bedding
SAND, few gravel, few silt, well graded, mottled brown, sub-rounded, moist, non-plastic, cohesive, bedded >3cm	
SILT, few sand, little gravel, trace boulder, well graded, med brown, sub-rounded, moist, non-plastic, cohesive, bedded >3cm	
SAND, few gravel, little silt, little boulder, poorly graded, mottled brown, sub-angular, moist, non-plastic, cohesive, blocky	Occasional cobble/boulder
SAND, few gravel, little boulder, little	

srk consulting

capstone MINTO MINE

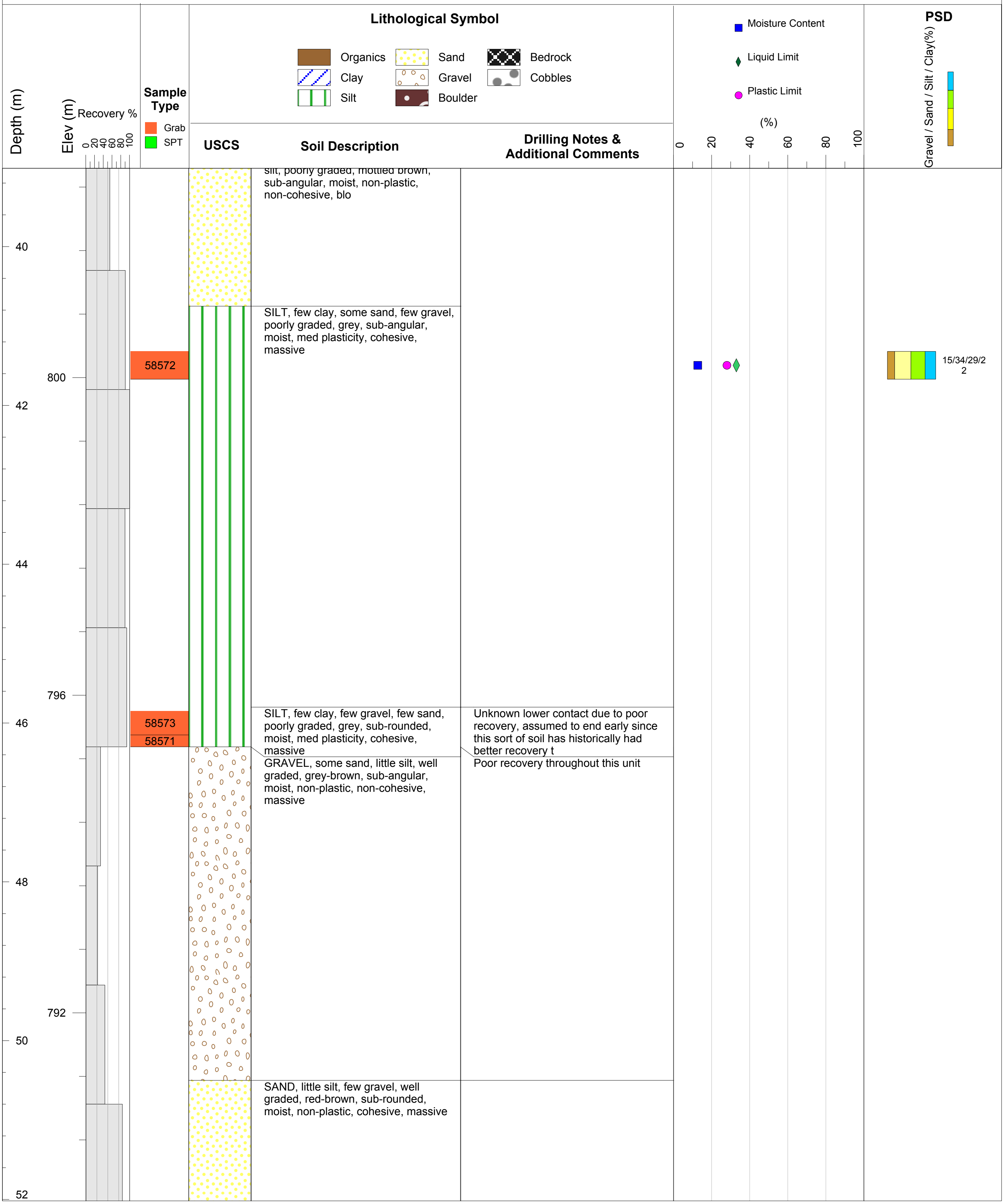
HOLE ID:	**15-SWC-997**	COORDINATES:	385140.87 E 6944123.97 N
LOCATION:	Yukon	DATUM:	UTM Zone 8
PROJECT NO:	1CM002.037	GROUND ELEV (m):	841.65
DRILLING CONTRACTOR:	Driftwood	AZIMUTH:	0
DRILLING TYPE & CORE DIA:	HQ Diamond	COLLAR DIP:	-90
		EOH ELEV. (m):	789.65
LOGGED BY:	MJM/DM	TOTAL DEPTH (m):	52.8
BORING DATE:	12-Feb-15 To 14-Feb-15	DEPOSIT AREA:	Area 2

PROJECT: Minto

CLIENT: Minto Exploration Ltd.

Lithological Symbol

Organics	Sand	Bedrock
Clay	Gravel	Cobbles
Silt	Boulder	



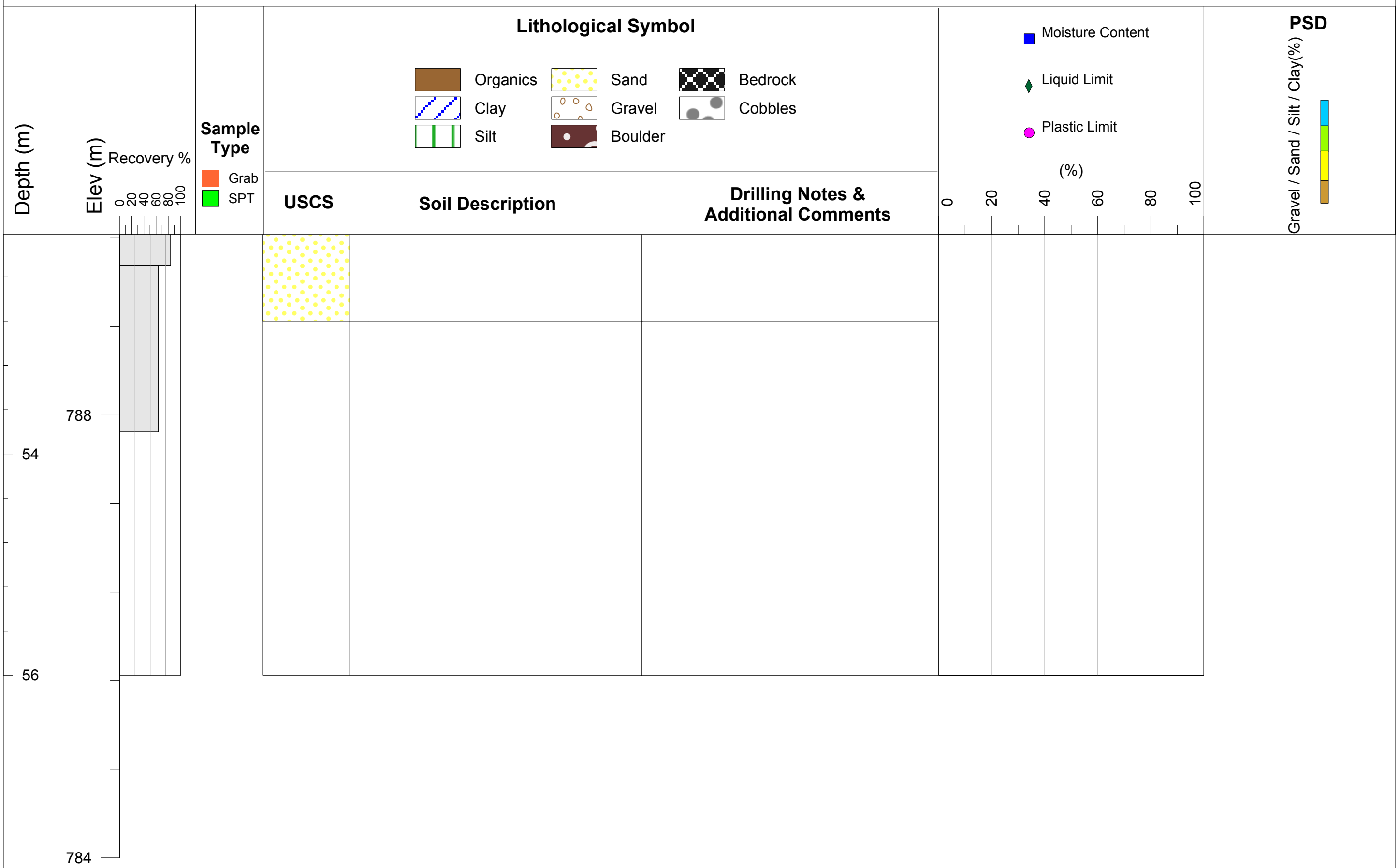
Soil Description	Drilling Notes & Additional Comments
silt, poorly graded, mottled brown, sub-angular, moist, non-plastic, non-cohesive, blo	
SILT, few clay, some sand, few gravel, poorly graded, grey, sub-angular, moist, med plasticity, cohesive, massive	
SILT, few clay, few gravel, few sand, poorly graded, grey, sub-rounded, moist, med plasticity, cohesive, massive	Unknown lower contact due to poor recovery, assumed to end early since this sort of soil has historically had better recovery t
GRAVEL, some sand, little silt, well graded, grey-brown, sub-angular, moist, non-plastic, non-cohesive, massive	Poor recovery throughout this unit
SAND, little silt, few gravel, well graded, red-brown, sub-rounded, moist, non-plastic, cohesive, massive	

HOLE ID: **15-SWC-997**
LOCATION: Yukon
PROJECT NO: 1CM002.037
DRILLING CONTRACTOR: Driftwood
DRILLING TYPE & CORE DIA: HQ Diamond
LOGGED BY: MJM/DM
BORING DATE: 12-Feb-15 To 14-Feb-15

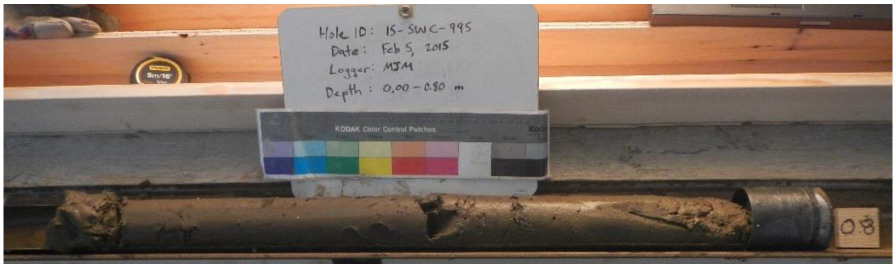
COORDINATES: 385140.87 E 6944123.97 N
DATUM: UTM Zone 8
GROUND ELEV (m): 841.65
AZIMUTH: 0
COLLAR DIP: -90
EOH ELEV. (m): 789.65
TOTAL DEPTH (m): 52.8

PROJECT: Minto
CLIENT: Minto Exploration Ltd.

DEPOSIT AREA: Area 2

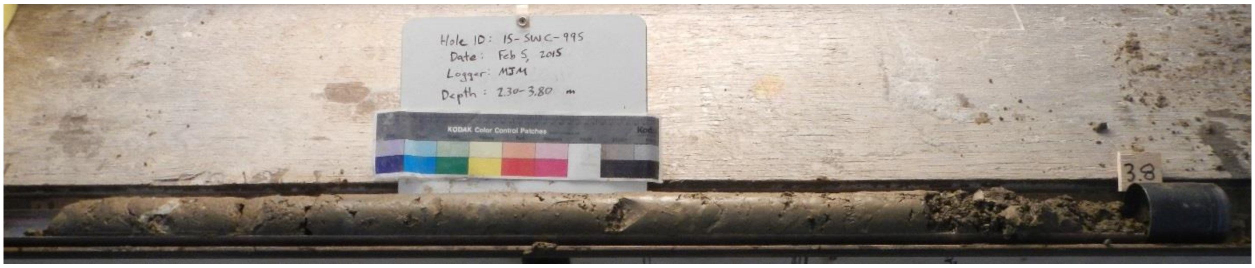


Attachment 2: Core Photos



15-SWC-995: 0 m - 0.8 m

15-SWC-995: 0.8 m - 2.3 m



15-SWC-995: 2.3 m - 3.8 m

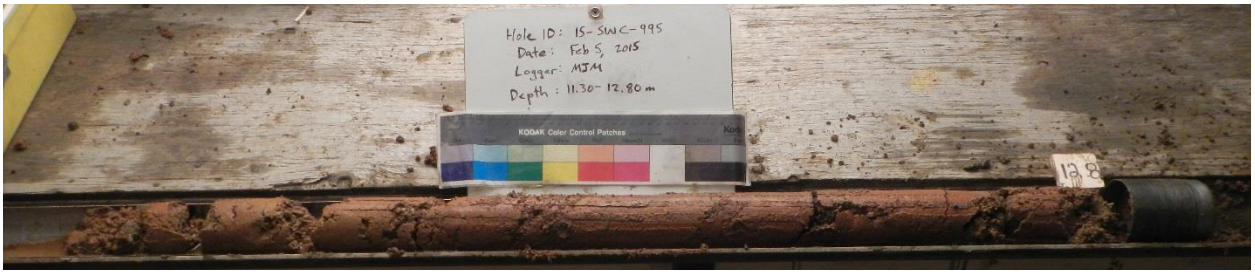
15-SWC-995: 3.8 m - 5.3 m

15-SWC-995: 5.3 m - 6.8 m

15-SWC-995: 6.8 m - 8.3 m

15-SWC-995: 8.3 m - 9.8 m

15-SWC-995: 9.8 m - 11.3 m



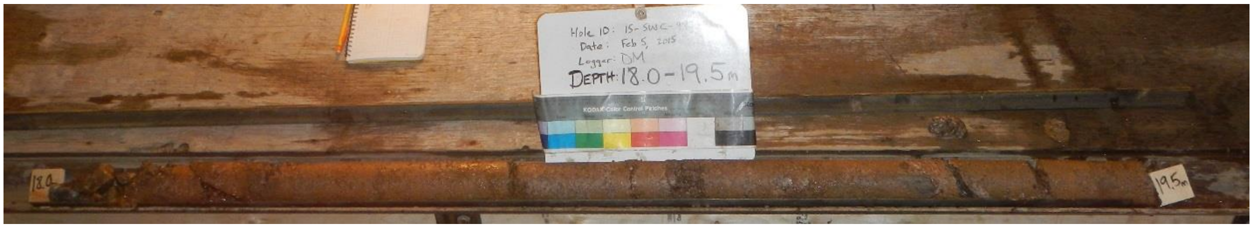
15-SWC-995: 11.3 m - 12.8 m

15-SWC-995: 12.8 m - 14.1 m

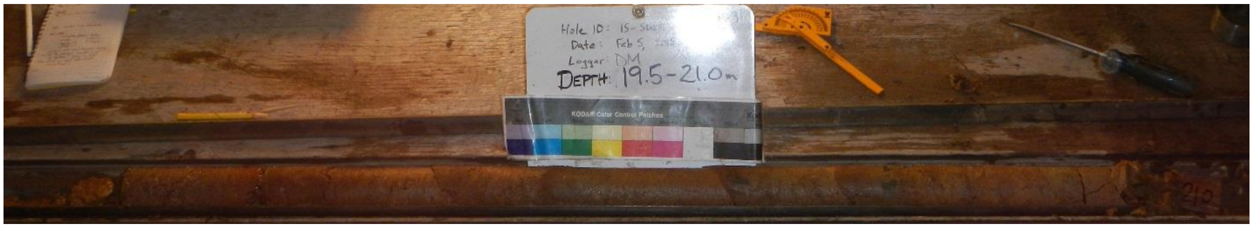
15-SWC-995: 14.1 m - 15.6 m

15-SWC-995: 15.6 m - 17.1 m

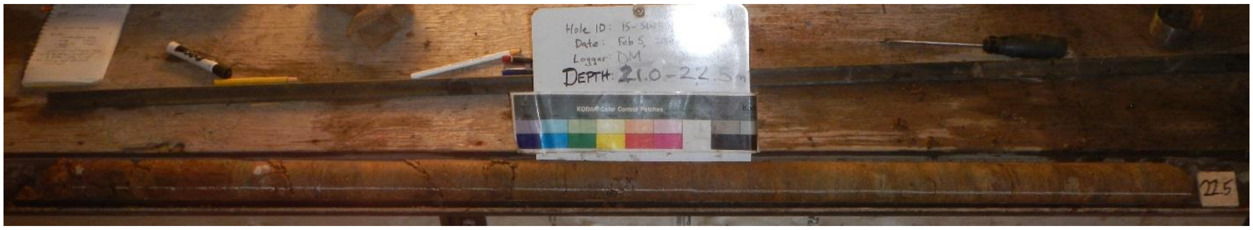
15-SWC-995: 17.1 m - 18 m



15-SWC-995: 18 m - 19.5 m



15-SWC-995: 19.5 m - 21 m



15-SWC-995: 21 m - 22.5 m

15-SWC-995: 22.5 m - 24 m

15-SWC-995: 24 m - 25.5 m

15-SWC-995: 25.5 m - 27 m

15-SWC-995: 27 m - 28.5 m

15-SWC-995: 28.5 m - 30 m

15-SWC-995: 30 m - 31.5 m

15-SWC-995: 31.5 m - 33 m

15-SWC-995: 33 m - 34.5 m

15-SWC-995: 34.5 m - 36 m

15-SWC-995: 36 m - 37.5 m

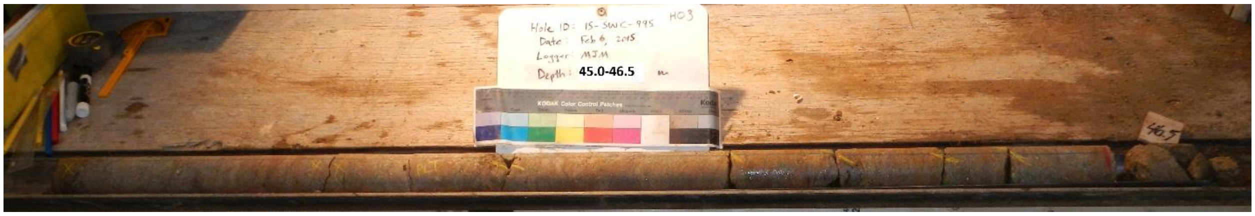
15-SWC-995: 37.5 m - 39 m

15-SWC-995: 39 m - 40.5 m

15-SWC-995: 40.5 m - 42 m

15-SWC-995: 42 m - 43.5 m

15-SWC-995: 43.5 m - 45 m



15-SWC-995: 45 m - 46.5 m

15-SWC-995: 46.5 m - 48 m

15-SWC-995: 48 m - 49.5 m

15-SWC-995: 49.5 m - 51 m

15-SWC-995: 51 m - 52.5 m

15-SWC-995: 52.5 m - 54 m

15-SWC-995: 54 m - 55.5 m

15-SWC-995: 55.5 m - 57 m

15-SWC-995: 57 m - 58.5 m

15-SWC-995: 58.5 m - 60 m

15-SWC-995: 60 m - 61.5 m

15-SWC-995: 61.5 m - 63 m

15-SWC-995: 63 m - 64.5 m

15-SWC-995: 64.5 m - 66 m

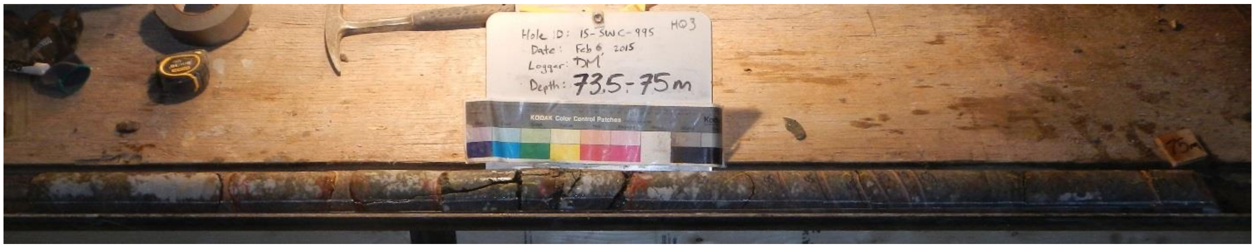
15-SWC-995: 66 m - 67.5 m

15-SWC-995: 67.5 m - 69 m

15-SWC-995: 69 m - 70.5 m

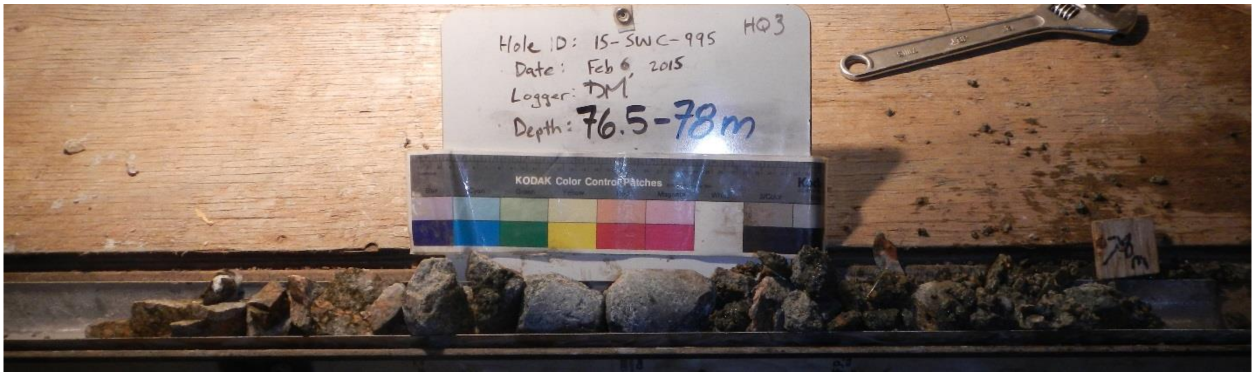
15-SWC-995: 70.5 m - 72 m

15-SWC-995: 72 m - 73.5 m



15-SWC-995: 73.5 m - 75 m

15-SWC-995: 75 m - 76.5 m



15-SWC-995: 76.5 m - 78 m

15-SWC-995: 78 m - 79.5 m

15-SWC-995: 79.5 m - 81 m

15-SWC-995: 81 m - 82.5 m

15-SWC-995: 82.5 m - 84 m

15-SWC-995: 84 m - 85.5 m

15-SWC-995: 85.5 m - 87 m

15-SWC-995: 87 m - 88.5 m

15-SWC-995: 88.5 m - 90 m

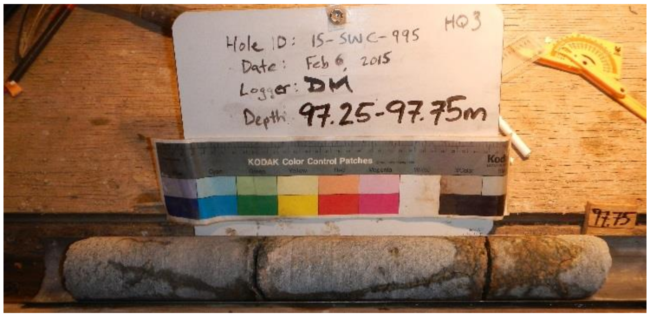
15-SWC-995: 90 m - 91.5 m

15-SWC-995: 91.5 m - 93 m

15-SWC-995: 93 m - 94.25 m

15-SWC-995: 94.25 m - 95.75 m

15-SWC-995: 95.75 m - 97.25 m

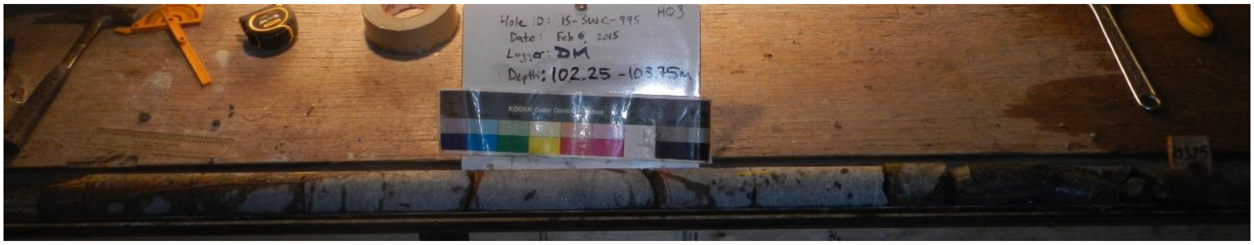


15-SWC-995: 97.25 m - 97.75 m

15-SWC-995: 97.75 m - 99.25 m

15-SWC-995: 99.25 m - 100.75 m

15-SWC-995: 100.75 m - 102.25 m



15-SWC-995: 102.25 m - 103.75 m

15-SWC-995: 103.75 m - 105 m

15-SWC-995: 105 m - 106.5 m

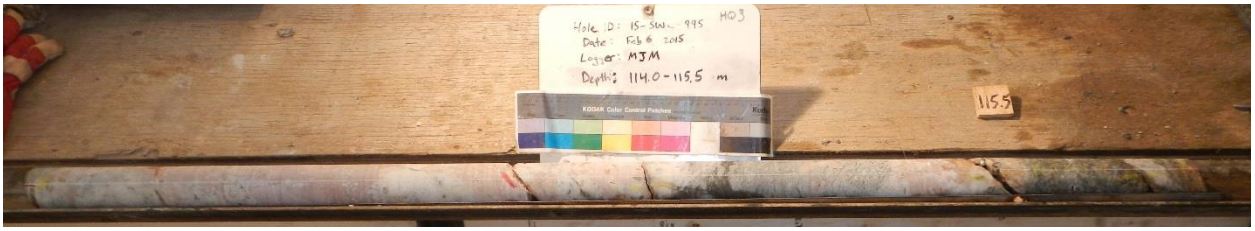
15-SWC-995: 106.5 m - 108 m

15-SWC-995: 108 m - 109.5 m

15-SWC-995: 109.5 m - 111 m

15-SWC-995: 111 m - 112.5 m

15-SWC-995: 112.5 m - 114 m



15-SWC-995: 114 m - 115.5 m

15-SWC-995: 115.5 m - 117 m

15-SWC-995: 117 m - 118.5 m

15-SWC-995: 118.5 m - 120 m

15-SWC-995: 120 m - 121.5 m

15-SWC-995: 121.5 m - 123 m

15-SWC-995: 123 m - 124.5 m

15-SWC-995: 124.5 m - 126 m

15-SWC-995: 126 m - 127.5 m

15-SWC-995: 127.5 m - 129 m

15-SWC-995: 129 m - 130.5 m

15-SWC-995: 130.5 m - 132 m

15-SWC-995: 132 m - 133.5 m

15-SWC-995: 133.5 m - 135 m

15-SWC-995: 135 m - 136.5 m

15-SWC-995: 136.5 m - 138 m

15-SWC-995: 138 m - 139.5 m

15-SWC-995: 139.5 m - 141 m

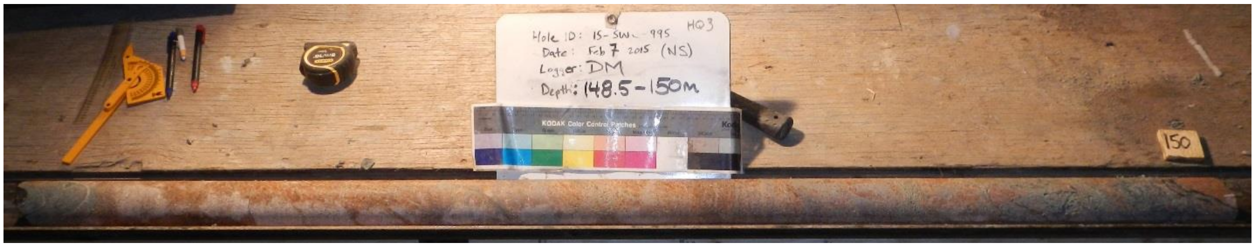
15-SWC-995: 141 m - 142.5 m

15-SWC-995: 142.5 m - 144 m

15-SWC-995: 144 m - 145.5 m

15-SWC-995: 145.5 m - 147 m

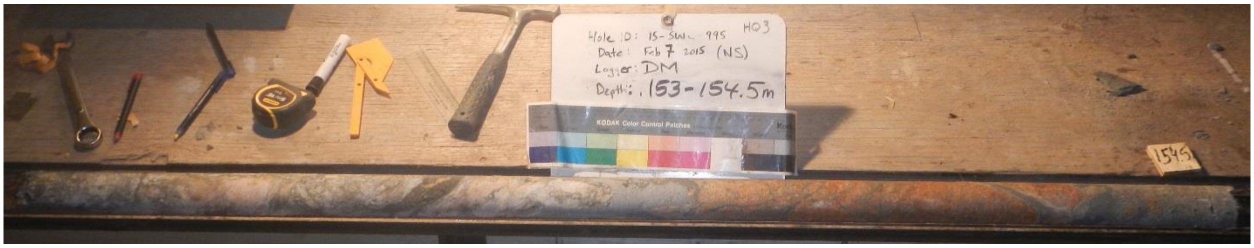
15-SWC-995: 147 m - 148.5 m



15-SWC-995: 148.5 m - 150 m

15-SWC-995: 150 m - 151.5 m

15-SWC-995: 151.5 m - 153 m



15-SWC-995: 153 m - 154.5 m

15-SWC-995: 154.5 m - 156 m

15-SWC-995: 156 m - 157.5 m

15-SWC-995: 157.5 m - 159 m

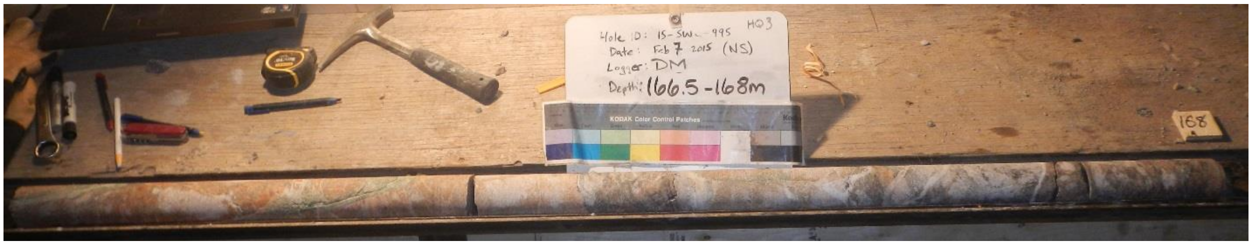
15-SWC-995: 159 m - 160.5 m

15-SWC-995: 160.5 m - 162 m

15-SWC-995: 162 m - 163.5 m

15-SWC-995: 163.5 m - 165 m

15-SWC-995: 165 m - 166.5 m



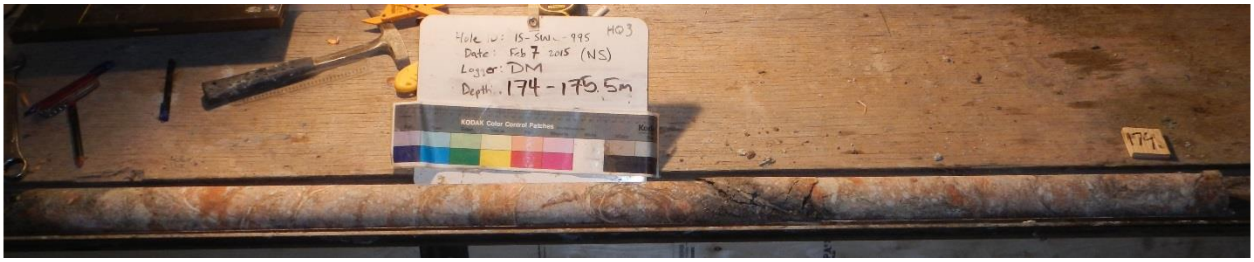
15-SWC-995: 166.5 m - 168 m

15-SWC-995: 168 m - 169.5 m

15-SWC-995: 169.5 m - 171 m

15-SWC-995: 171 m - 172.5 m

15-SWC-995: 172.5 m - 174 m



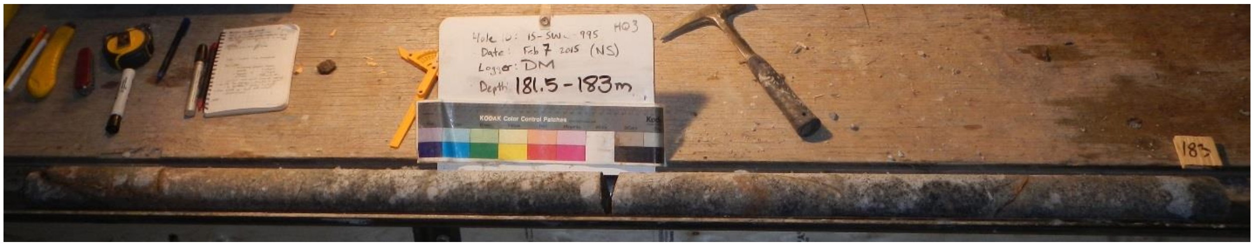
15-SWC-995: 174 m - 175.5 m

15-SWC-995: 175.5 m - 177 m

15-SWC-995: 177 m - 178.5 m

15-SWC-995: 178.5 m - 180 m

15-SWC-995: 180 m - 181.5 m



15-SWC-995: 181.5 m - 183 m

15-SWC-995: 183 m - 184.5 m

15-SWC-995: 184.5 m - 186 m

15-SWC-995: 186 m - 187.5 m

15-SWC-995: 189 m - 190.5 m

15-SWC-995: 190.5 m - 192 m

15-SWC-995: 192 m - 193.5 m

15-SWC-995: 193.5 m - 195 m

15-SWC-995: 195 m - 196.5 m

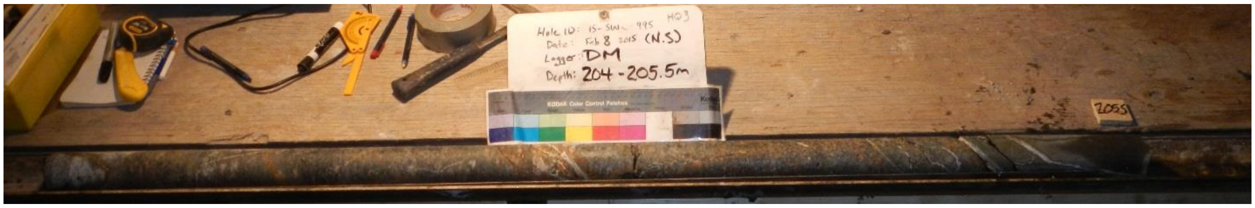
15-SWC-995: 196.5 m - 198 m

15-SWC-995: 198 m - 199.5 m

15-SWC-995: 199.5 m - 201 m

15-SWC-995: 201 m - 202.5 m

15-SWC-995: 202.5 m - 204 m



15-SWC-995: 204 m - 205.5 m

15-SWC-995: 205.5 m - 207 m

15-SWC-995: 207 m - 208.2 m

15-SWC-995: 208.2 m - 209.7 m

15-SWC-995: 209.7 m - 211.3 m

15-SWC-995: 211.3 m - 212.8 m

15-SWC-995: 212.8 m - 214.4 m

15-SWC-995: 214.4 m - 216 m

15-SWC-995: 216 m - 217.5 m

15-SWC-995: 217.5 m - 219 m

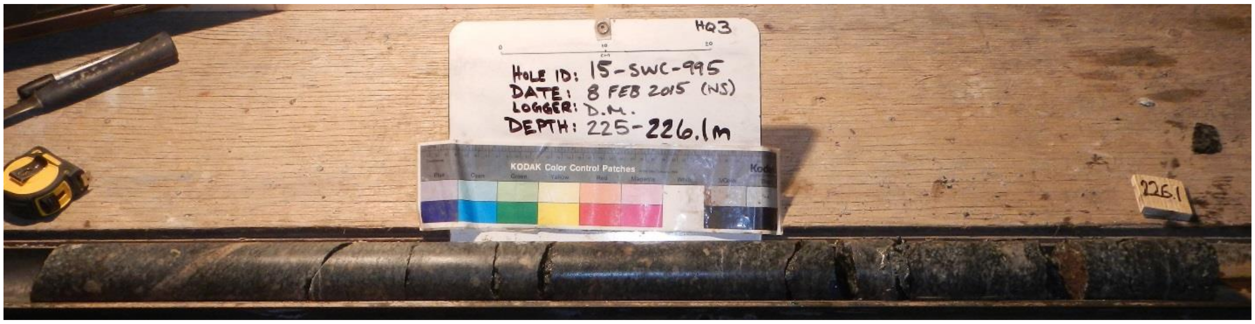
15-SWC-995: 219 m - 220.5 m

15-SWC-995: 220.5 m - 221.8 m

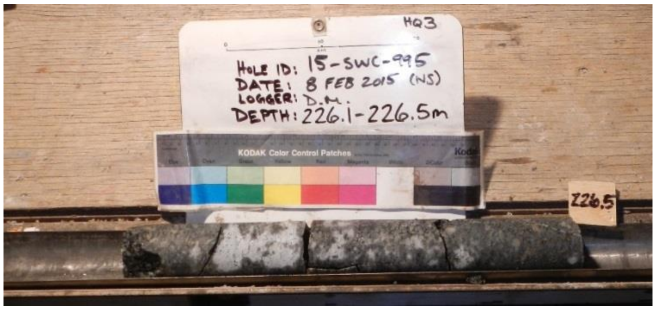
15-SWC-995: 221.8 m - 223.3 m

15-SWC-995: 223.3 m - 223.7 m

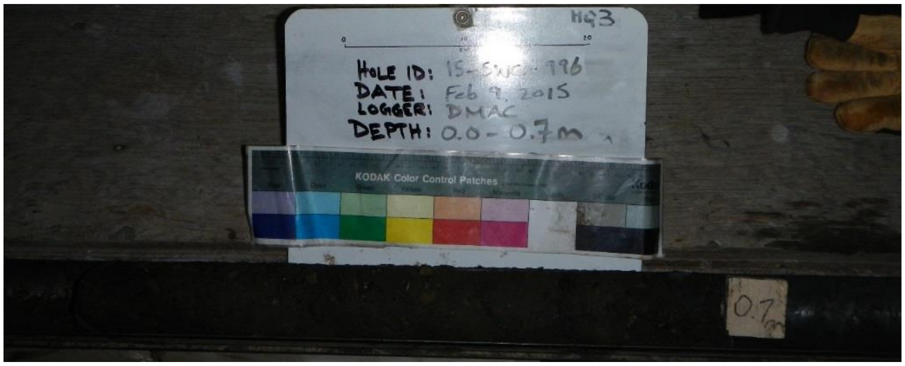
15-SWC-995: 223.7 m - 225 m



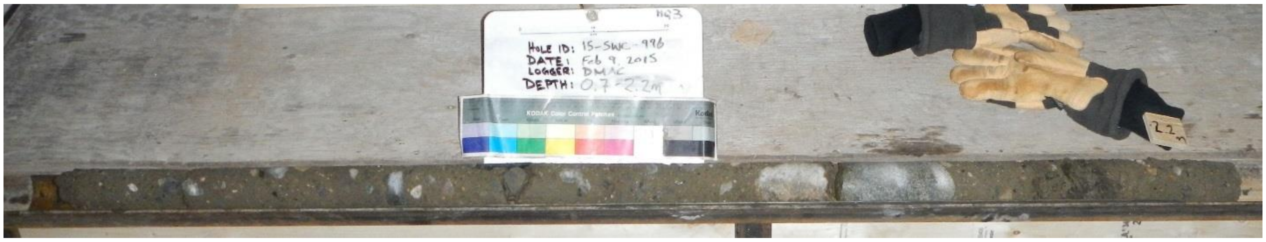
15-SWC-995: 225 m - 226.1 m



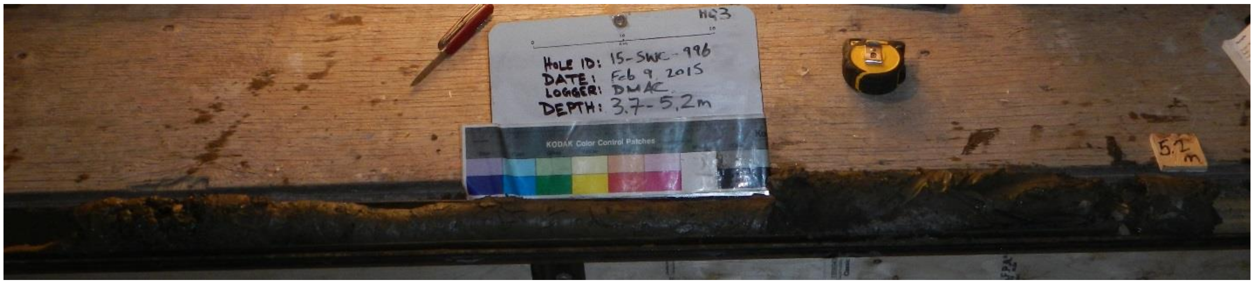
15-SWC-995: 226.1 m - 226.5 m



15-SWC-996: 0 m - 0.7 m



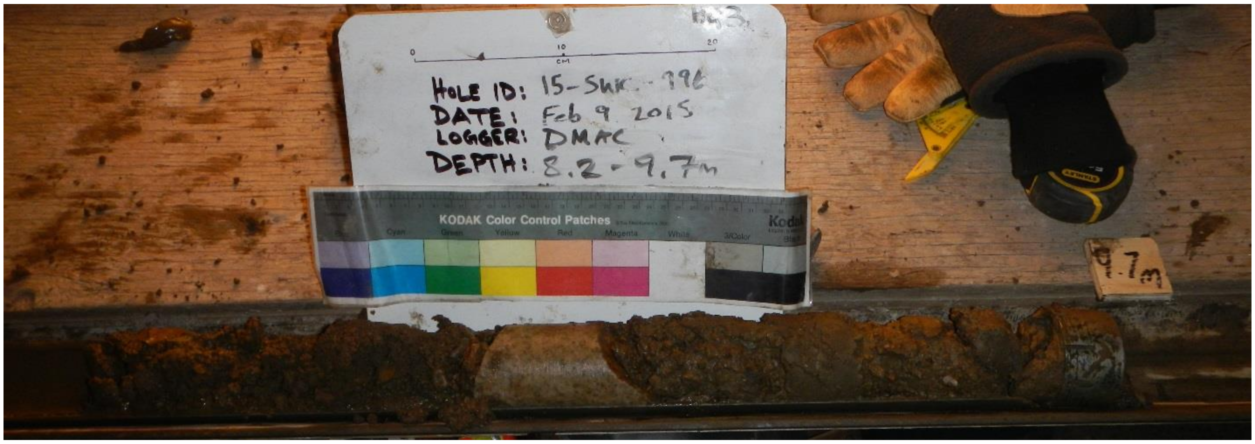
15-SWC-996: 0.7 m - 2.2 m



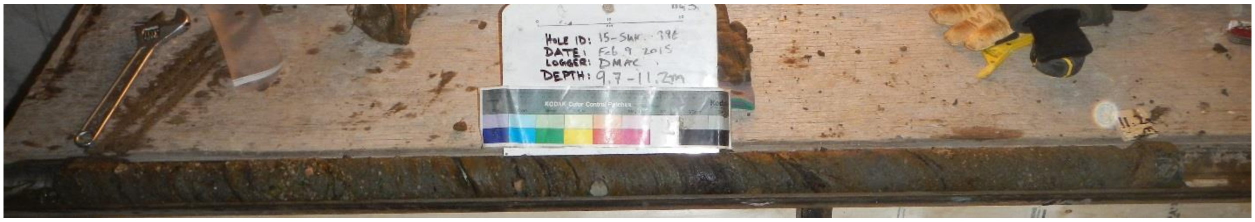
15-SWC-996: 3.7 m - 5.2 m

15-SWC-996: 5.2 m - 6.7 m

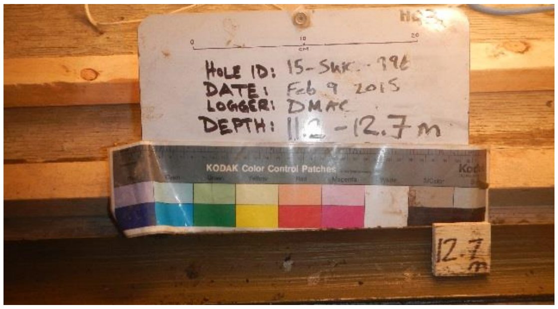
15-SWC-996: 6.7 m - 8.2 m



15-SWC-996: 8.2 m - 9.7 m



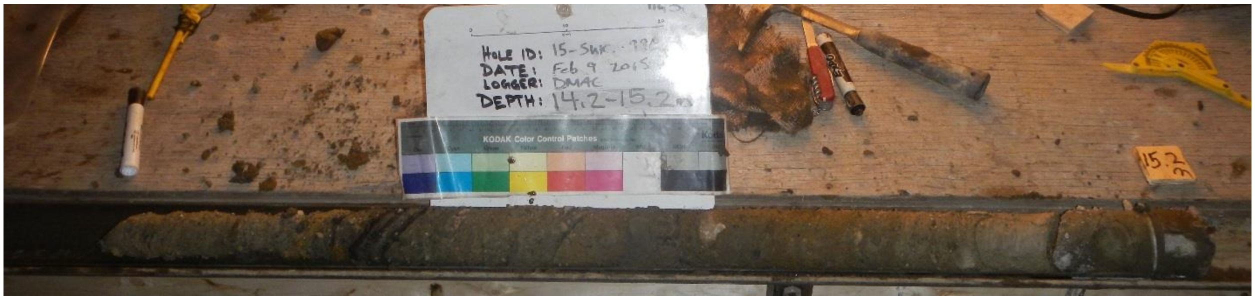
15-SWC-996: 9.7 m - 11.2 m



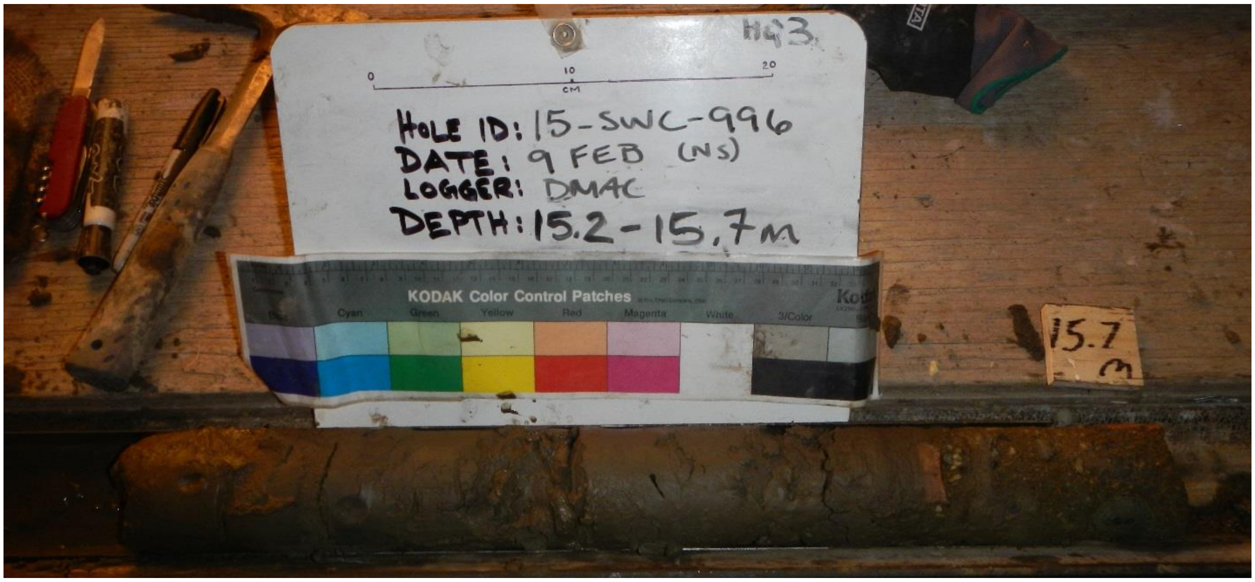
15-SWC-996: 11.2 m - 12.7 m

15-SWC-996: 12.7 m - 14.2 m

15-SWC-996: 13.6 m

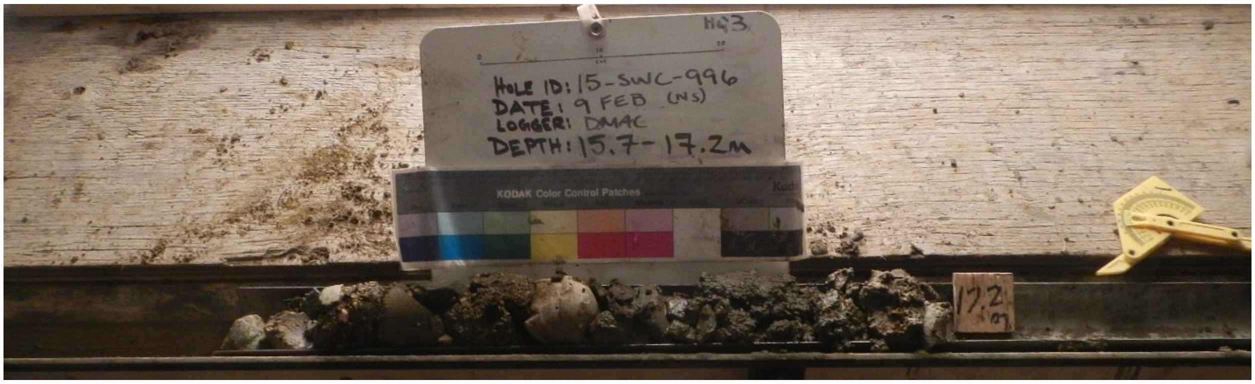


15-SWC-996: 14.2 m - 15.2 m

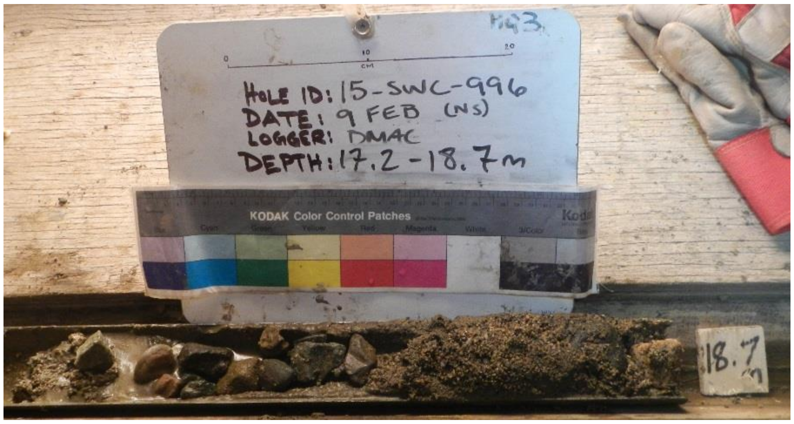


HOLE ID: 15-SWC-996
DATE: 9 FEB (NS)
LOGGER: DMAC
DEPTH: 15.2-15.7m

15-SWC-996: 15.2 m - 15.7 m



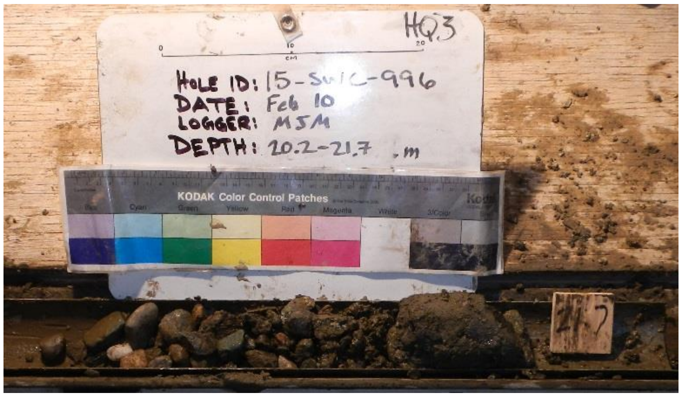
15-SWC-996: 15.7 m - 17.2 m



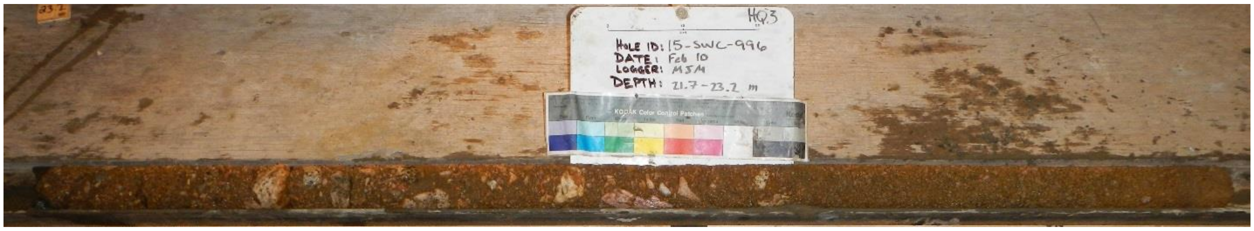
15-SWC-996: 17.2 m - 18.7 m

15-SWC-996: 18.7 m - 18.9 m

15-SWC-996: 18.9 m - 20.2 m



15-SWC-996: 20.2 m - 21.7 m



15-SWC-996: 21.7 m - 23.2 m

15-SWC-996: 23.2 m - 24.7 m

15-SWC-996: 24.7 m - 26.2 m

15-SWC-996: 26.2 m - 27.7 m

15-SWC-996: 27.7 m - 29.2 m

15-SWC-996: 29.2 m - 30.7 m

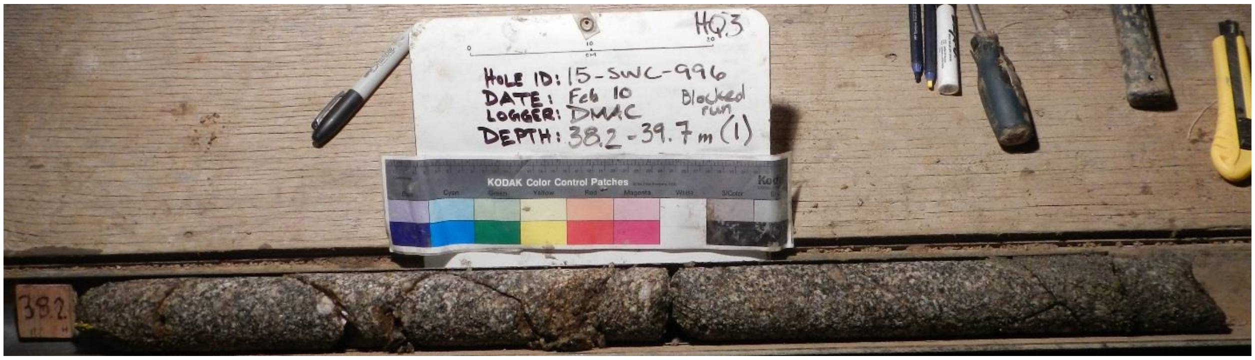
15-SWC-996: 30.7 m - 32.2 m

15-SWC-996: 32.2 m - 33.7 m

15-SWC-996: 33.7 m - 35.2 m

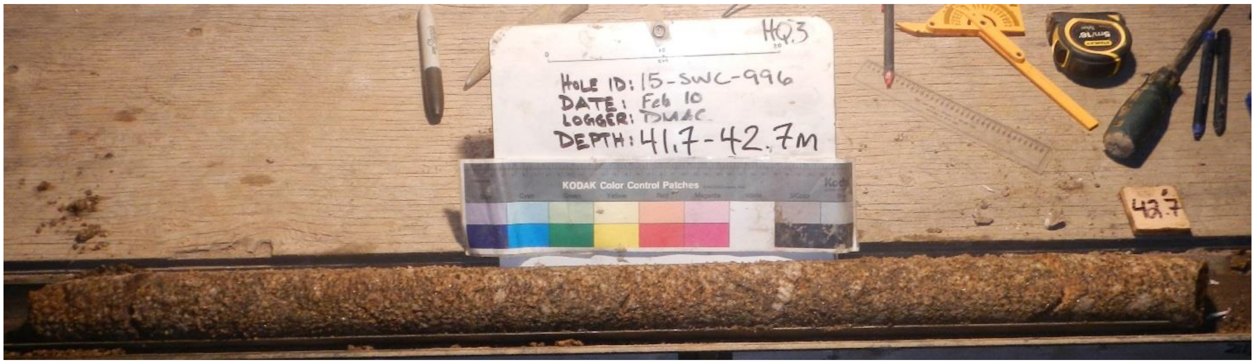
15-SWC-996: 35.2 m - 36.7 m

15-SWC-996: 36.7 m - 38.2 m



15-SWC-996: 38.2 m – 39.7 m

15-SWC-996: 39.7 m - 41.7 m



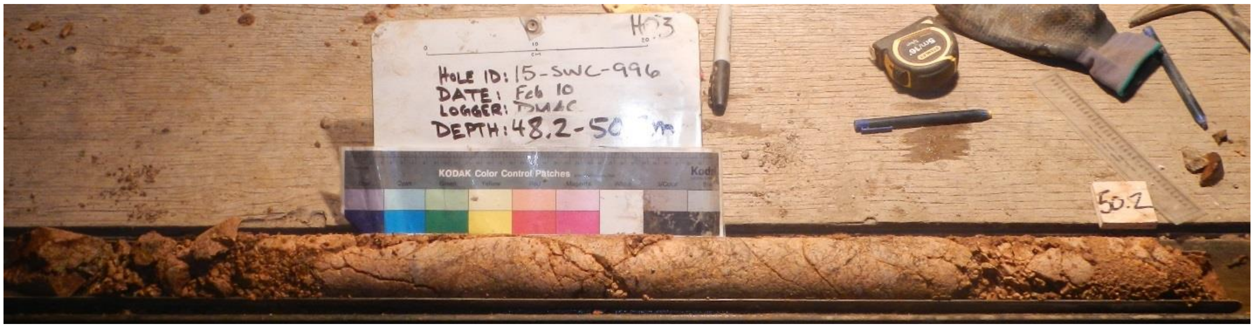
15-SWC-996: 41.7 m - 42.7 m

15-SWC-996: 42.7 m - 44.2 m

15-SWC-996: 44.2 m - 45.7 m

15-SWC-996: 45.7 m - 47.2 m

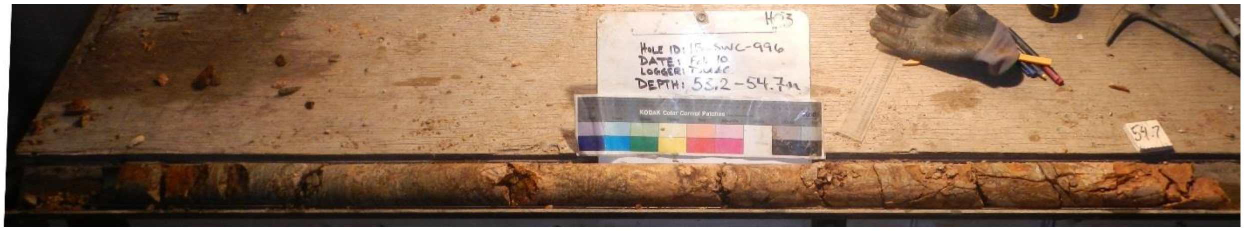
15-SWC-996: 47.2 m - 48.7 m



15-SWC-996: 48.7 m - 50.2 m

15-SWC-996: 50.2 m - 51.7 m

15-SWC-996: 51.7 m - 53.2 m

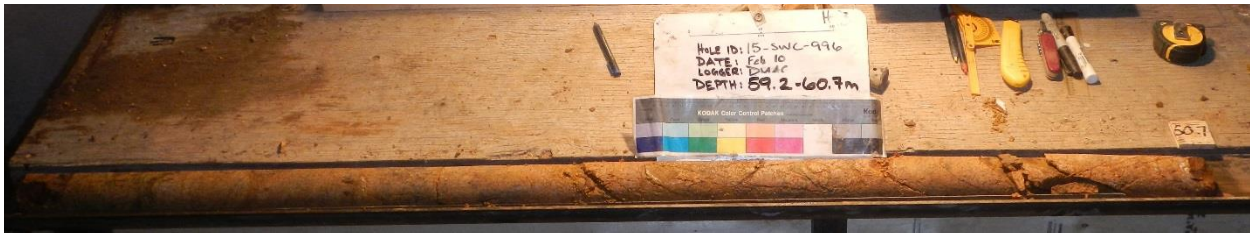


15-SWC-996: 53.2 m - 54.7 m

15-SWC-996: 54.7 m - 56.2 m

15-SWC-996: 56.2 m - 57.7 m

15-SWC-996: 57.7 m - 59.2 m



15-SWC-996: 59.2 m - 60.7 m

15-SWC-996: 60.7 m - 62.2 m

15-SWC-996: 62.2 m - 63.7 m

15-SWC-996: 63.7 m - 65.2 m

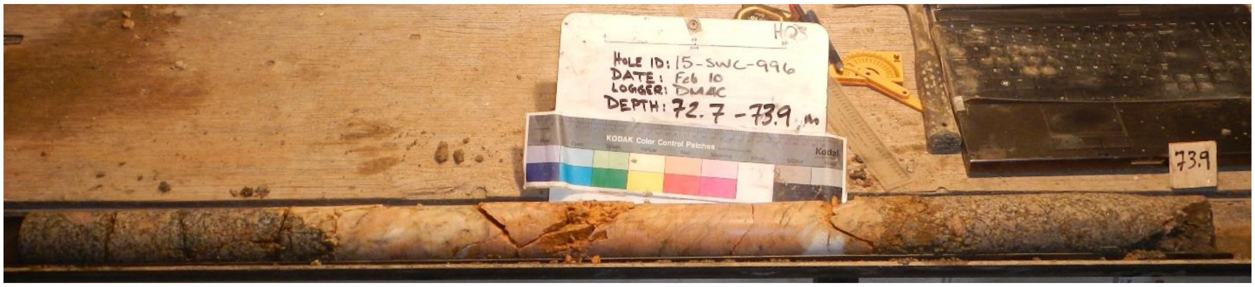
15-SWC-996: 65.2 m - 66.7 m

15-SWC-996: 66.7 m - 68.2 m

15-SWC-996: 68.2 m - 69.7 m

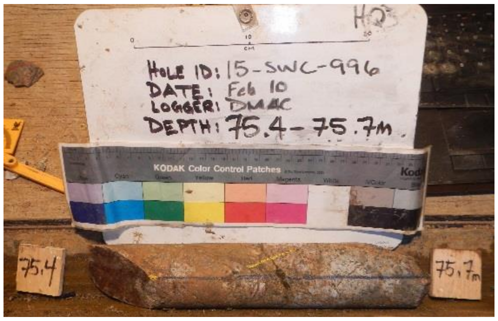
15-SWC-996: 69.7 m - 71.2 m

15-SWC-996: 71.2 m - 72.7 m

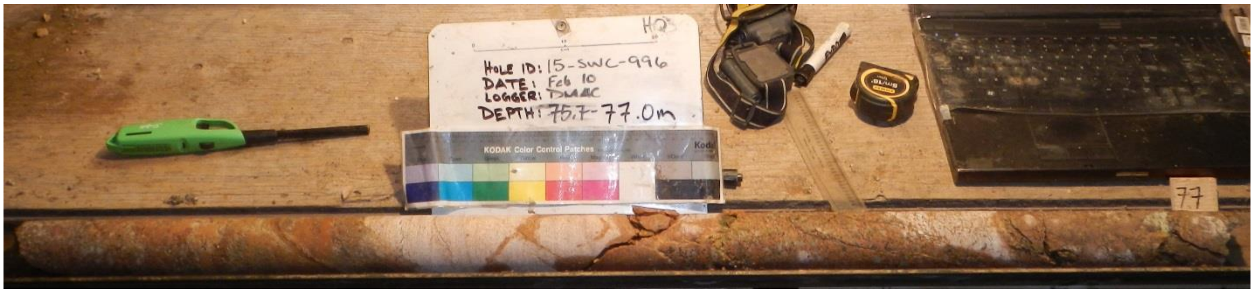


15-SWC-996: 72.7 m - 73.9 m

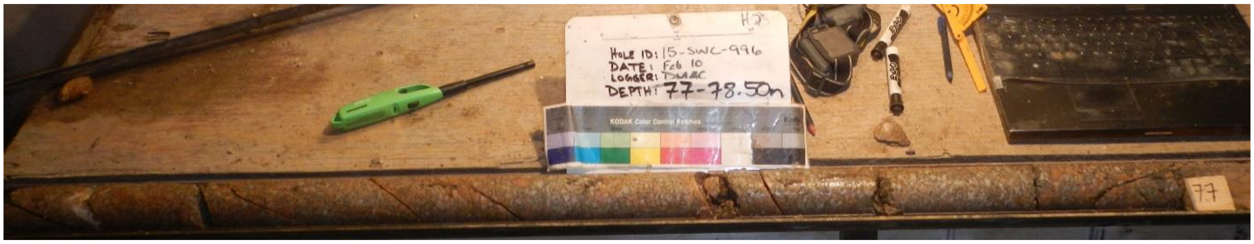
15-SWC-996: 73.9 m - 75.4 m



15-SWC-996: 75.4 m - 75.7 m



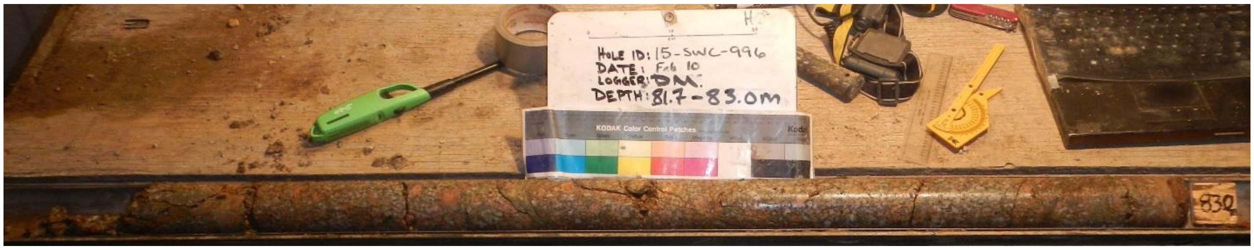
15-SWC-996: 75.7 m - 77 m



15-SWC-996: 77 m - 78.5 m

15-SWC-996: 78.5 m - 80.1 m

15-SWC-996: 80.1 m - 81.7 m



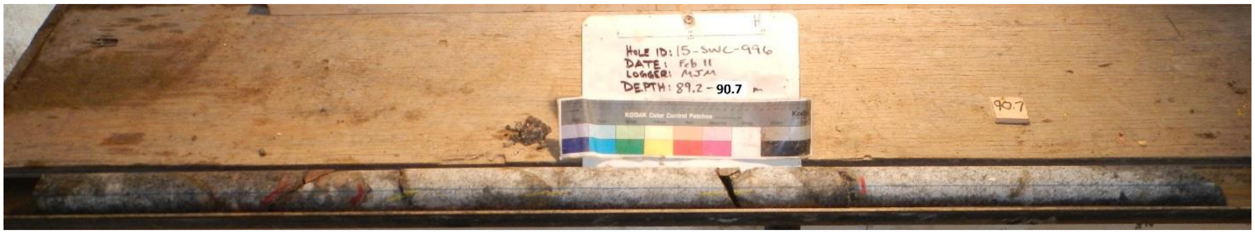
15-SWC-996: 81.7 m - 83 m

15-SWC-996: 83 m - 84.7 m

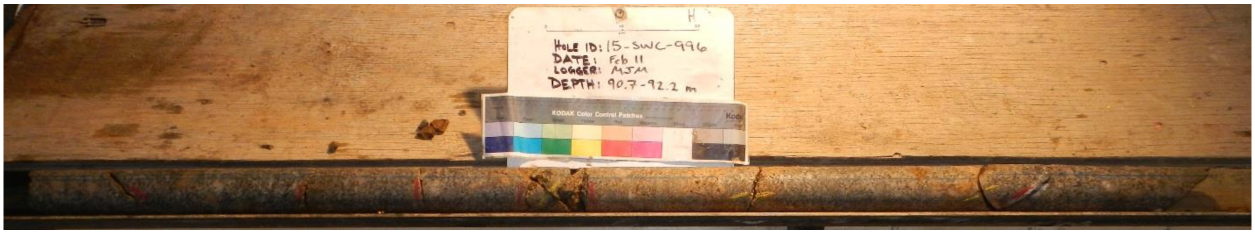
15-SWC-996: 84.7 m - 86.2 m

15-SWC-996: 86.2 m - 87.7 m

15-SWC-996: 87.7 m - 89.2 m



15-SWC-996: 89.2 m - 90.7 m



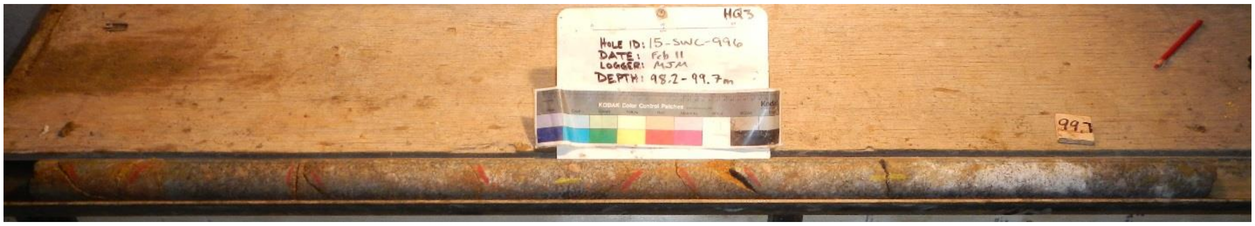
15-SWC-996: 90.7 m - 92.2 m

15-SWC-996: 92.2 m - 93.7 m

15-SWC-996: 93.7 m - 95.2 m

15-SWC-996: 95.2 m - 96.7 m

15-SWC-996: 96.7 m - 98.2 m



15-SWC-996: 98.2 m - 99.7 m

15-SWC-996: 99.7 m - 101.2 m

15-SWC-996: 101.2 m - 102.7 m

15-SWC-996: 102.7 m - 104.2 m

15-SWC-996: 104.2 m - 105.7 m

15-SWC-996: 105.7 m - 107.2 m

15-SWC-996: 107.2 m - 108.7 m

15-SWC-996: 108.7 m - 110.2 m

15-SWC-996: 110.2 m - 111.7 m

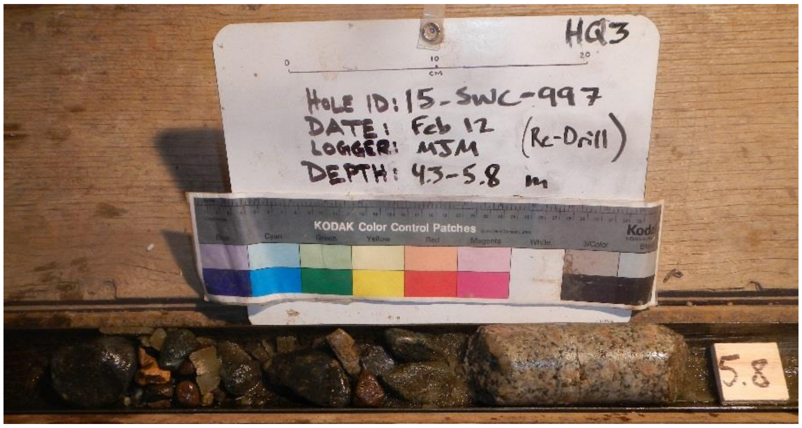
15-SWC-997: 0 m - 1.3 m

15-SWC-997: 1.3 m - 2.8 m

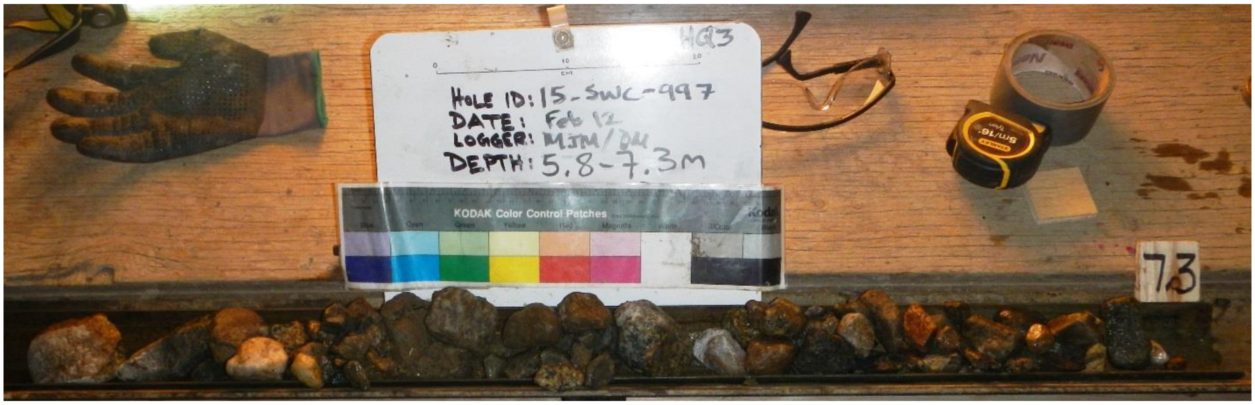
15-SWC-997: 2.8 m - 4.3 m

15-SWC-997: 0 m - 4.3 m re-drill

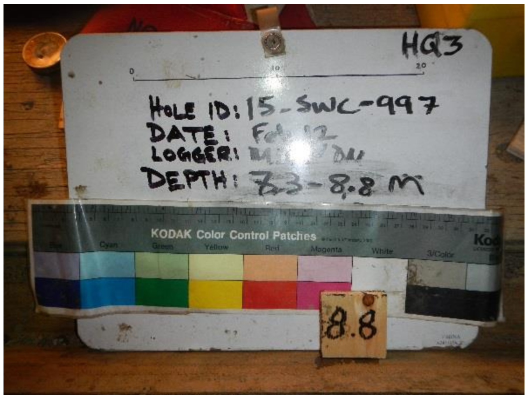
15-SWC-997: 4.3 m - 5.8 m



15-SWC-997: 4.3 m - 5.8 m re-drill

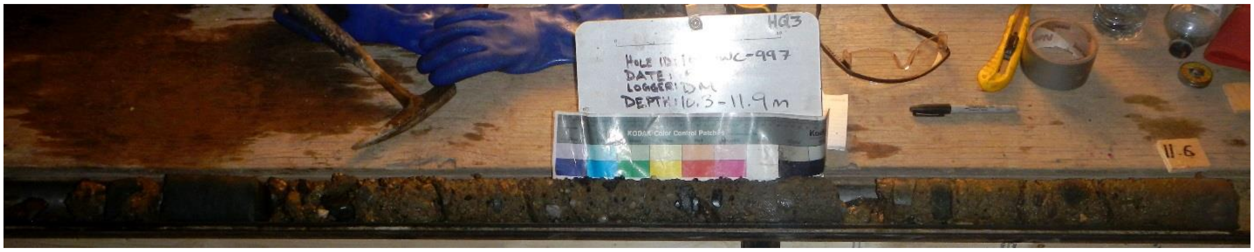


15-SWC-997: 5.8 m - 7.3 m

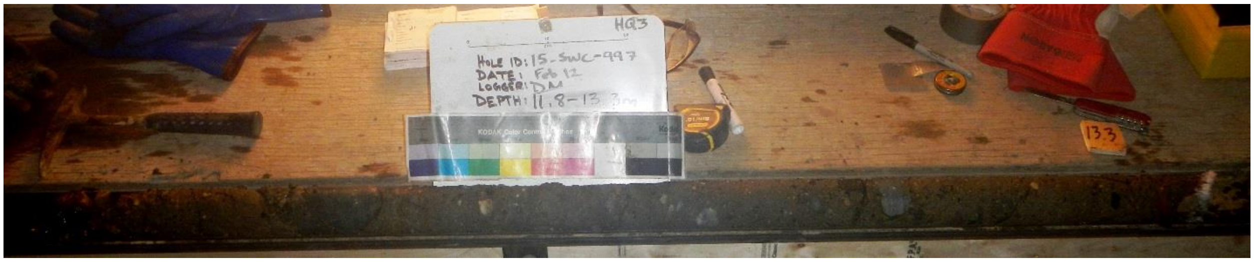


15-SWC-997: 7.3 m - 8.8 m

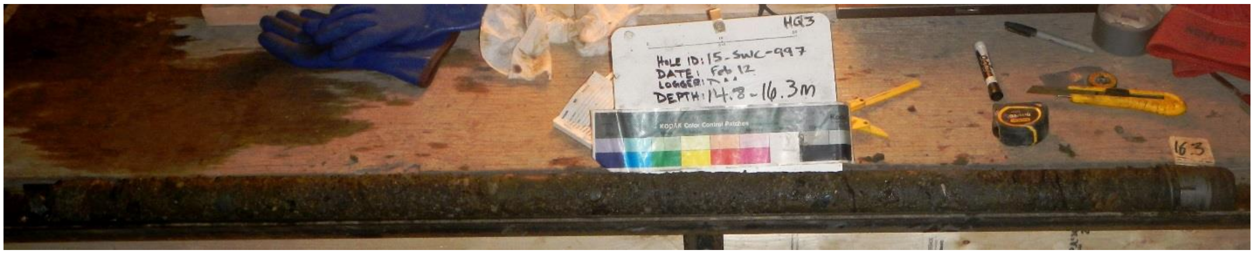
15-SWC-997: 8.8 m - 10.3 m



15-SWC-997: 10.3 m - 11.9 m

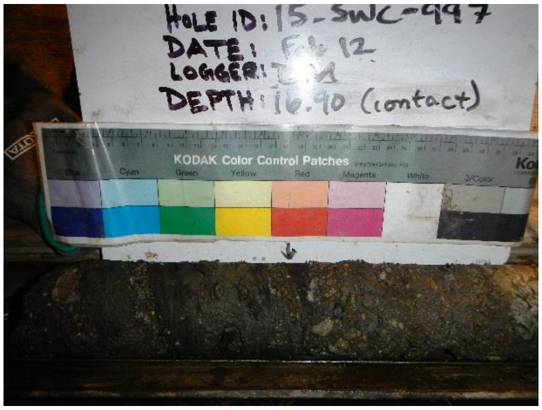


15-SWC-997: 11.8 m - 13.3 m



15-SWC-997: 14.8 m - 16.3 m

15-SWC-997: 16.3 m - 17.8 m



15-SWC-997: 16.9 m contact

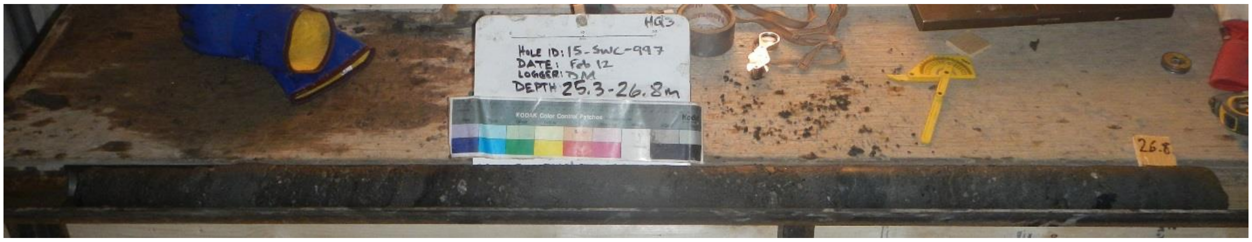
15-SWC-997: 17.8 m - 19.3 m

15-SWC-997: 19.3 m - 20.8 m

15-SWC-997: 20.8 m - 22.3 m

15-SWC-997: 22.3 m - 23.8 m

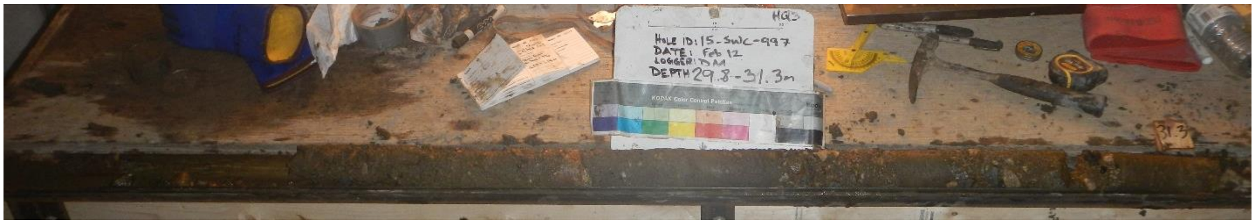
15-SWC-997: 23.8 m - 25.3 m



15-SWC-997: 25.3 m - 26.8 m

15-SWC-997: 26.8 m - 28.3 m

15-SWC-997: 28.3 m - 29.8 m



15-SWC-997: 29.8 m - 31.3 m

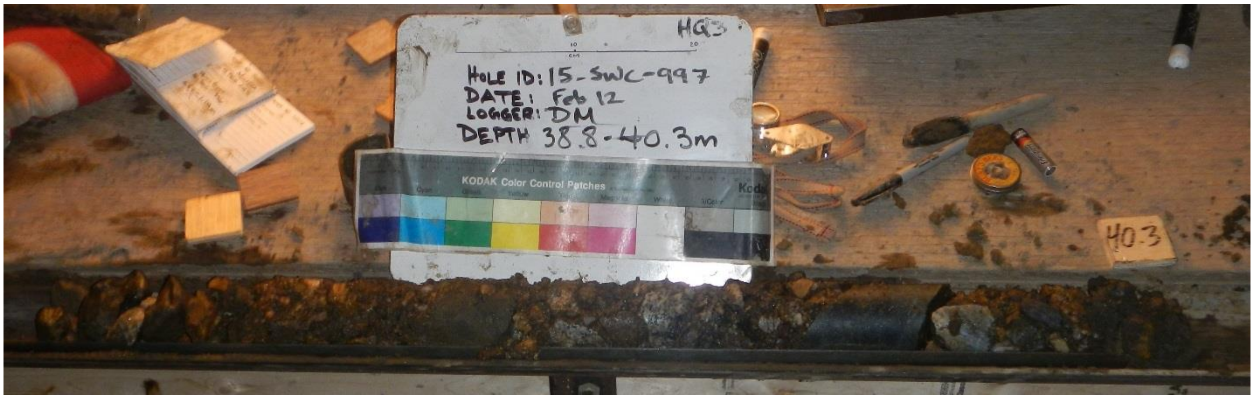
15-SWC-997: 31.3 m - 32.8 m

15-SWC-997: 32.8 m - 34.3 m

15-SWC-997: 34.3 m - 35.8 m

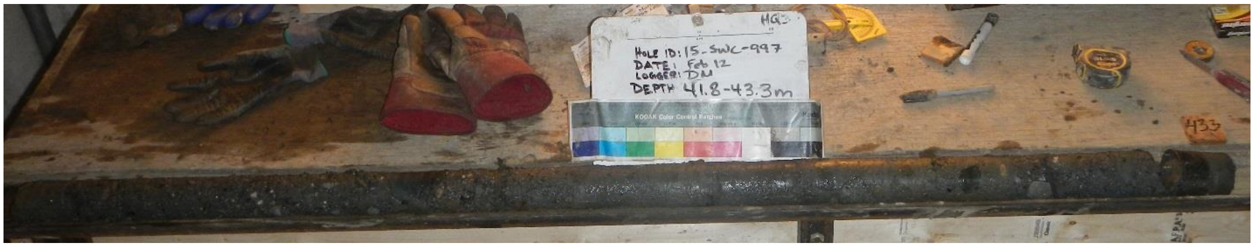
15-SWC-997: 35.8 m - 37.3 m

15-SWC-997: 37.3 m - 38.8 m



15-SWC-997: 38.8 m - 40.3 m

15-SWC-997: 40.3 m - 41.8 m



15-SWC-997: 41.8 m - 43.3 m

15-SWC-997: 43.3 m - 44.8 m

15-SWC-997: 44.8 m - 46.3 m

15-SWC-997: 46.3 m - 47.8 m

15-SWC-997: 47.8 m - 49.3 m

15-SWC-997: 49.3 m - 50.8 m

15-SWC-997: 50.8 m - 52.3 m

15-SWC-997: 52.3 m - 53.8 m

15-SWC-997: 53.8 m - 55.3 m

15-SWC-997: 55.3 m - 56.8 m

15-SWC-997: 56.8 m - 58.3 m

15-SWC-997: 58.3 m - 59.8 m

15-SWC-997: 59.8m – 61.3 m

Attachment 3: Soil Testing Results

MOISTURE CONTENT TEST RESULTS

ASTM D2216

Project:	SRK Minto Samples - Feb. 2015 Lab Testing	Sample No.:	
Project No.:	W14103546-01	Date Tested:	February 27, 2015
Client:	SRK Consulting (Canada) Inc.	Tested By:	AMT
Address:		Page:	1 of 1

B.H. Number	Sample Number	Moisture Content (%)	Visual Description of Soil
14-SWC-968	MM-101259	16.6	
14-SWC-970	MM-101262	27.6	
14-SWC-969	MM-101270	10.7	
14-SWC-969	MM-101273	26.3	
14-SWC-972	MM-101277	16.5	
14-SWC-972	MM-101280	31.7	
14-SWC-973	MM-101285	35.9	
14-SWC-973	MM-101288	13.2	
14-SWC-975	MM-101298	28.1	
14-SWC-979	MM-101317	26.5	
14-SWC-980	MM-101326	18.8	
15-SWC-995	58554	13.4	
15-SWC-996	58557	14.8	
15-SWC-996	58558	21.7	
15-SWC-996	58559	16.1	
15-SWC-997	160025	10.3	
15-SWC-997	58565	13.7	
15-SWC-997	58568	11.7	
15-SWC-997	58570	15.4	
15-SWC-997	58572	12.7	

Reviewed By: ______________________ P.Eng.

FROZEN BULK RELATIVE DENSITY RESULTS

Project: SRK Minto Samples - Feb. 2015 Lab Testing

Sample No.:

Project No.: W14103546-01

Date Tested: 27-Feb-15

Client: SRK Consulting (Canada) Inc.

Tested By: AMT

Address:

Page: 1 of 1

Bore Hole Number	Sample Number	Relative Density kg/m³	
15-SWC-997	160025	2317.63	
15-SWC-997	58568	2221.89	
15-SWC-997	58570	2224.24	
15-SWC-997	58572	2243.78	
15-SWC-997	58565	2353.06	
15-SWC-996	58557	2186.32	
15-SWC-996	58558	2026.10	
15-SWC-996	58559	2126.37	

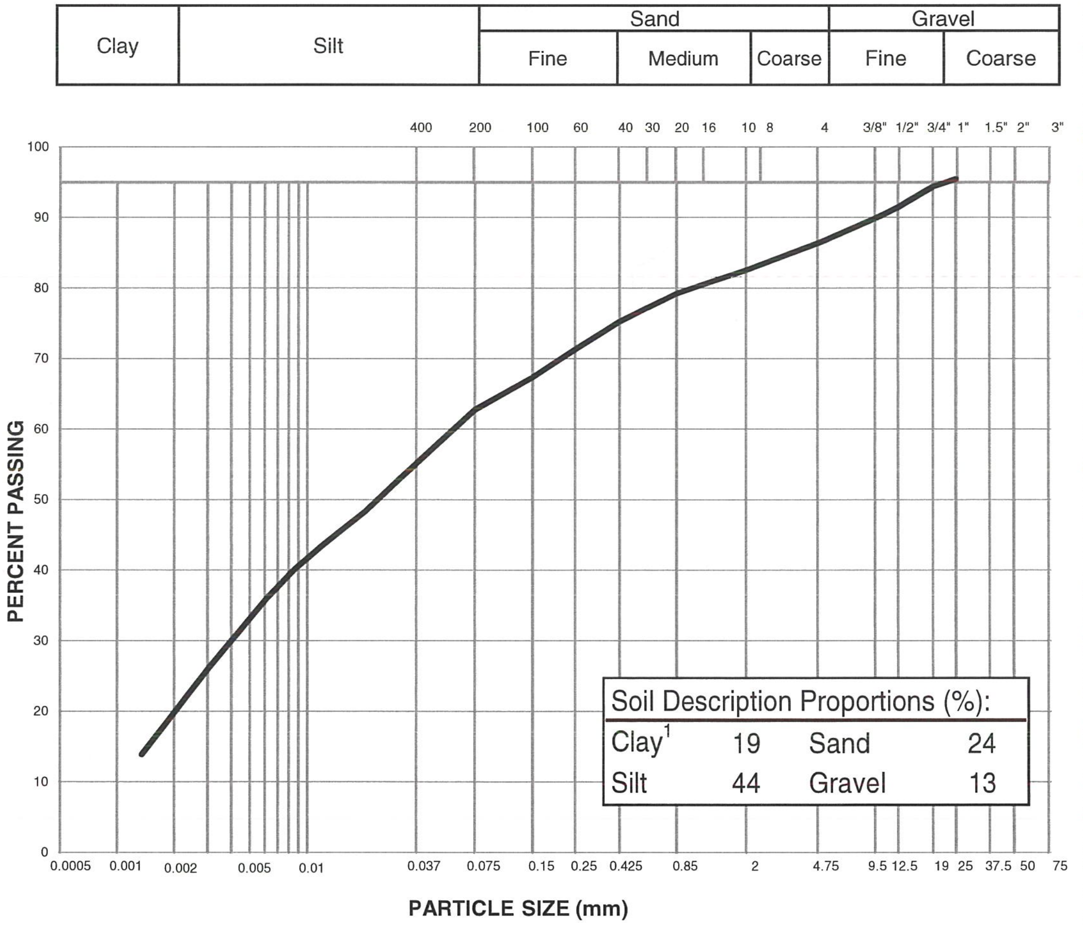
Reviewed By:

PARTICLE SIZE ANALYSIS REPORT

ASTM D422, C136 & C117

Project:	Minto February 2015 Lab Testing	Sample No.:	MM-101259
Project No.:	W14103546-01	Material Type:	
Site:	Minto Mine, YT	Sample Loc.:	14-SWC-968
Client:	SRK Consulting (Canada) Inc.	Sample Depth:	15.05 - 15.40 m
Client Rep.:	Murray McGregor	Sampling Method:	Grab
Date Tested:	March 5, 2015 By: AMT	Date sampled:	November 1, 2014
Soil Description[2]:	SILT - sandy, some clay, some gravel	Sampled By:	Client
		USC Classification:	Cu: #N/A
Moisture Content:	16.6%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
38	
25	95
19	94
12.5	91
10	90
5	87
2	83
0.85	79
0.425	75
0.25	71
0.15	67
0.075	62.7
0.0308	53.1
0.0199	48.2
0.0117	43.3
0.0085	40.0
0.0061	35.9
0.0030	26.1
0.0014	13.9



Soil Description Proportions (%):

Clay[1]	19	Sand	24
Silt	44	Gravel	13

Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: ______________________

Remarks: ______________________

Reviewed By: ______________________ C.E.T.

TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project: Minto February 2015 Lab Testing

Sample Number: MM-101259

Borehole Number: 14-SWC-968

Project No: W14103546-01

Depth: 15.05 - 15.40 m

Client: SRK Consulting (Canada) Inc.

Sampled By: Client

Tested By: AMT

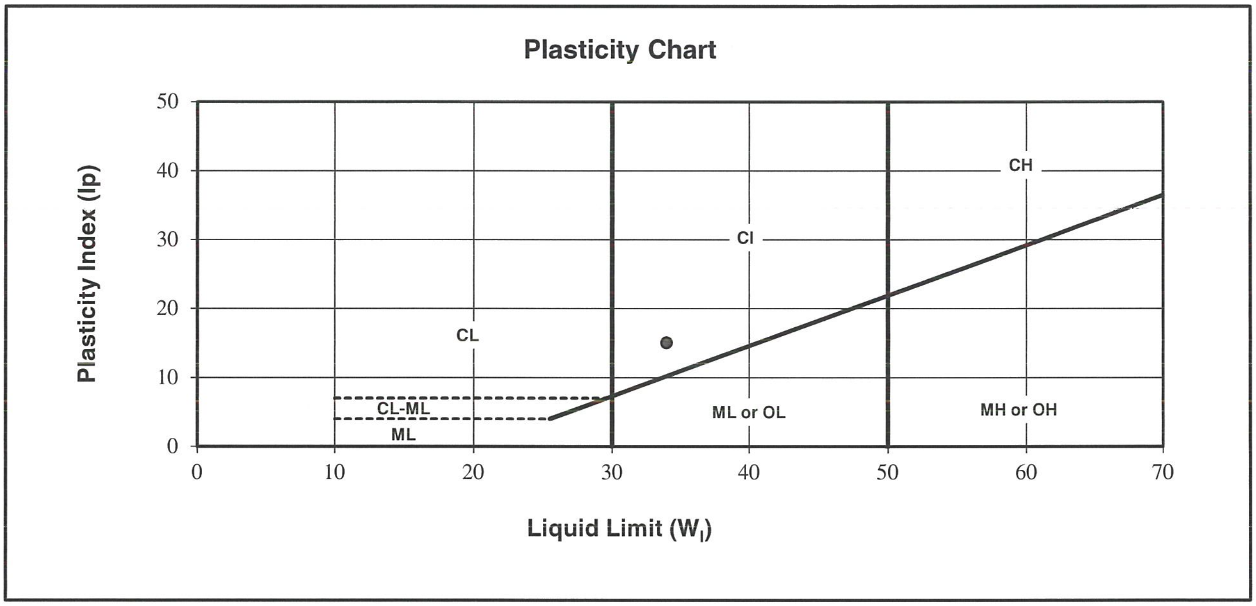
Attention: Murrary McGregor

Date Sampled: November 1, 2014

Email:

Date Tested: March 6, 2015

Sample Description: SILT - sandy, some clay, some gravel



Liquid Limit (W$_{1)}$:	34	Natural Moisture (%)	16.6
Plastic Limit :	19	Soil Plasticity:	Medium
Plasticity Index (Ip) :	**15**	Mod.USCS Symbol:	CI

Remarks:

Reviewed By: C.E.T.

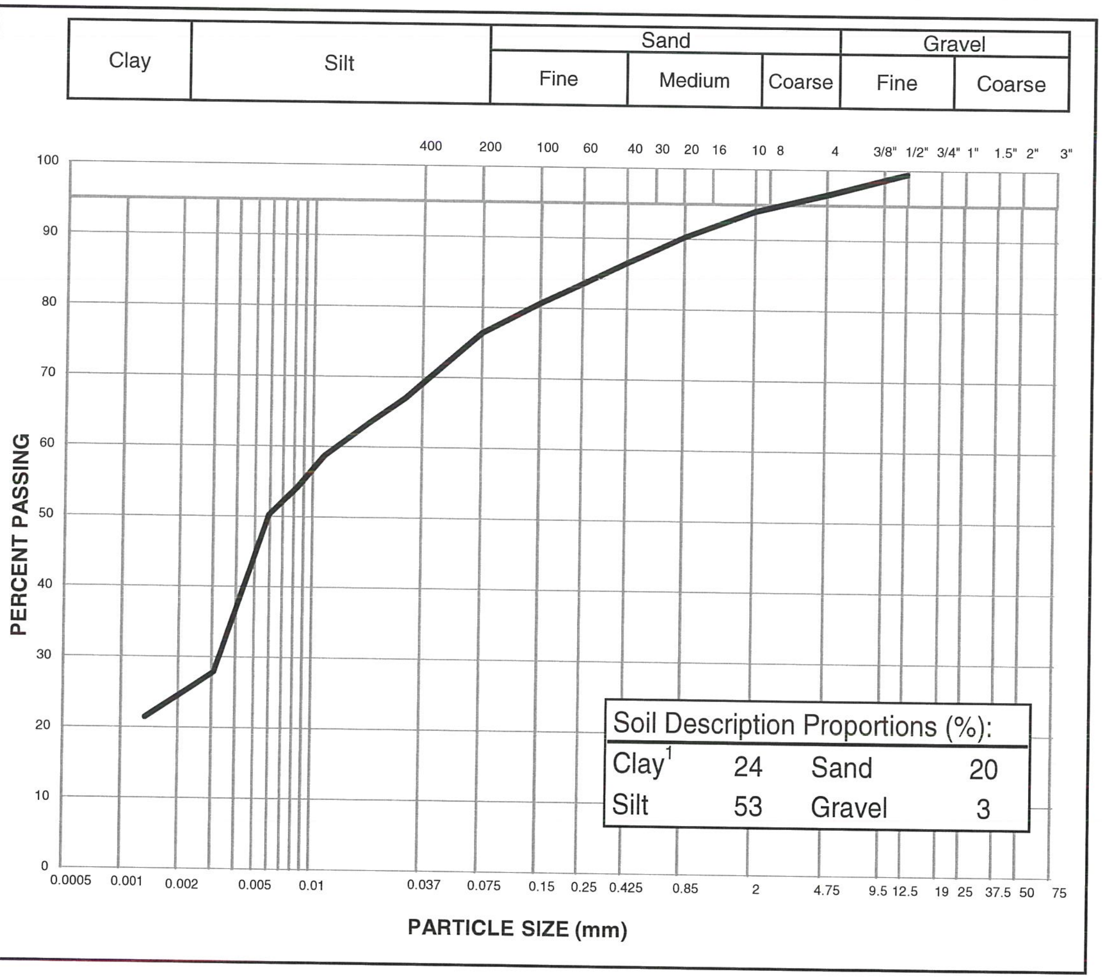
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D422, C136 & C117

Project:	Minto February 2015 Lab Testing	Sample No.:	MM-101262
Project No.:	W14103546-01	Material Type:	
Site:	Minto Mine, YT	Sample Loc.:	14-SWC-970
Client:	SRK Consulting (Canada) Inc.	Sample Depth:	5.65 - 6.00 m
Client Rep.:	Murray McGregor	Sampling Method:	Grab
Date Tested:	March 3, 2015 By: AMT	Date sampled:	November 2, 2014
Soil Description[2]:	SILT and CLAY - some sand, trace gravel	Sampled By:	Client
		USC Classification:	Cu: #N/A
Moisture Content:	27.6%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
38	
25	
19	
12.5	99
10	99
5	97
2	94
0.85	90
0.425	87
0.25	84
0.15	81
0.075	76.4
0.0303	67.0
0.0194	63.3
0.0114	58.7
0.0082	54.0
0.0059	50.3
0.0031	27.9
0.0013	21.4



Soil Description Proportions (%):

Clay[1]	24	Sand	20
Silt	53	Gravel	3

Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: __________

Remarks: __________

Reviewed By: __________ C.E.T.

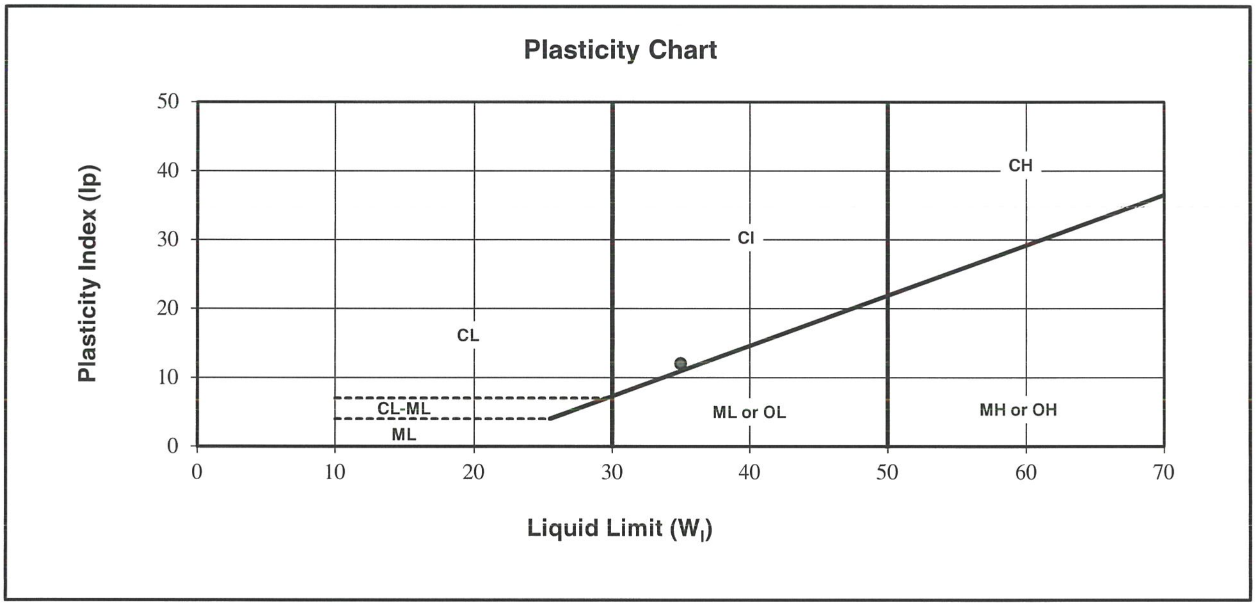
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Minto February 2015 Lab Testing	Sample Number:	MM-101262
		Borehole Number:	14-SWC-967
Project No:	W14103546-01	Depth:	5.65 - 6.00 m
Client:	SRK Consulting (Canada) Inc.	Sampled By:	Client Tested By: AMT
Attention:	Murrary McGregor	Date Sampled:	November 2, 2014
Email:		Date Tested:	March 6, 2015

Sample Description: SILT and CLAY - some sand, trace gravel



Liquid Limit ($W_{1)}$:	35	Natural Moisture (%)	16.6
Plastic Limit :	23	Soil Plasticity:	Medium
Plasticity Index (Ip) :	**12**	Mod.USCS Symbol:	CI

Remarks:

Reviewed By: ______________ C.E.T.

TETRA TECH

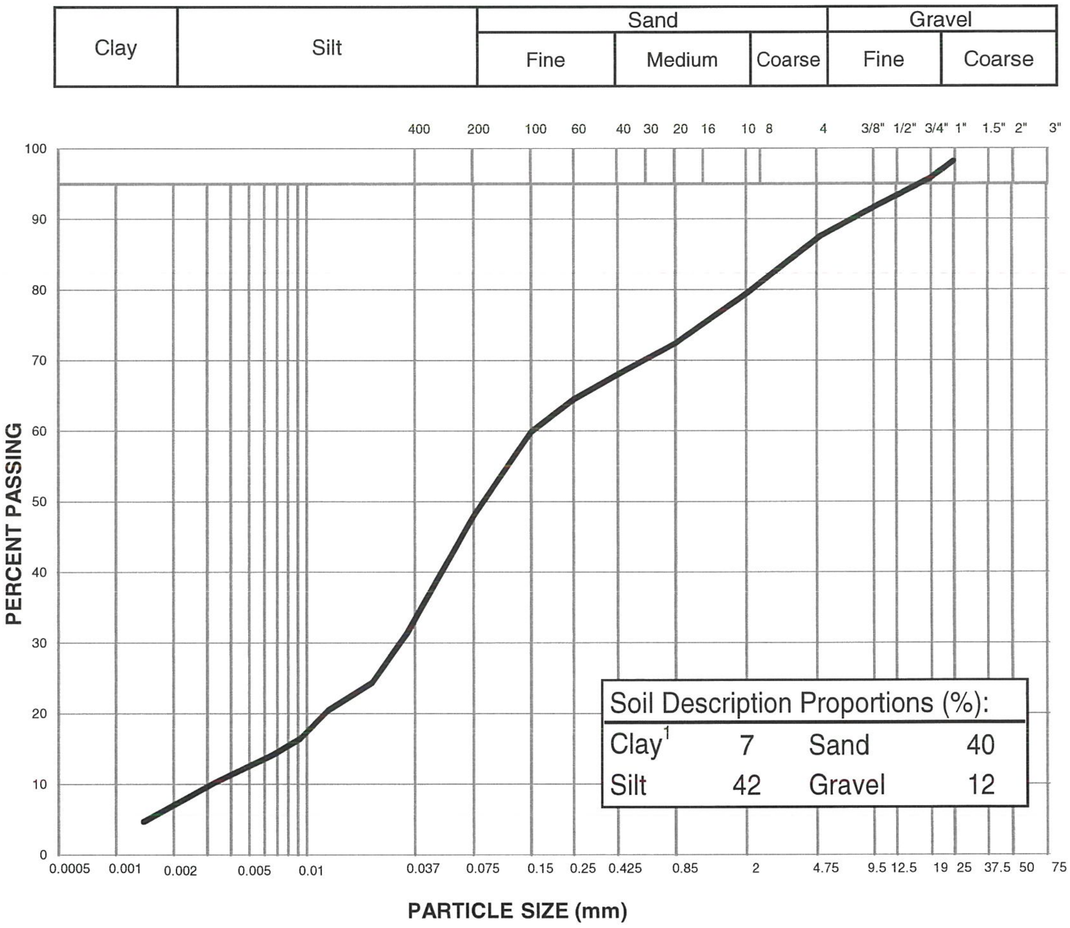
PARTICLE SIZE ANALYSIS REPORT

ASTM D422, C136 & C117

Project: Minto February 2015 Lab Testing
Project No.: W14103546-01
Site: Minto Mine, YT
Client: SRK Consulting (Canada) Inc.
Client Rep.: Murray McGregor
Date Tested: March 4, 2015 By: AMT
Soil Description[2]: SILT and SAND - some gravel, trace clay
Moisture Content: 10.7%

Sample No.: MM-101270
Material Type:
Sample Loc.: 14-SWC-969
Sample Depth: 12.00 - 12.30 m
Sampling Method: Grab
Date sampled: November 2, 2014
Sampled By: Client
USC Classification:
Cu: 47.7
Cc: 2.0

Particle Size (mm)	Percent Passing
75	
50	
38	
25	98
19	96
12.5	93
10	92
5	88
2	79
0.85	72
0.425	68
0.25	64
0.15	60
0.075	48.0
0.0339	31.4
0.0220	24.4
0.0129	20.4
0.0093	16.5
0.0066	14.1
0.0033	10.2
0.0014	4.7



Soil Description Proportions (%):

Clay[1]	7	Sand	40
Silt	42	Gravel	12

Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: __________

Remarks: __________

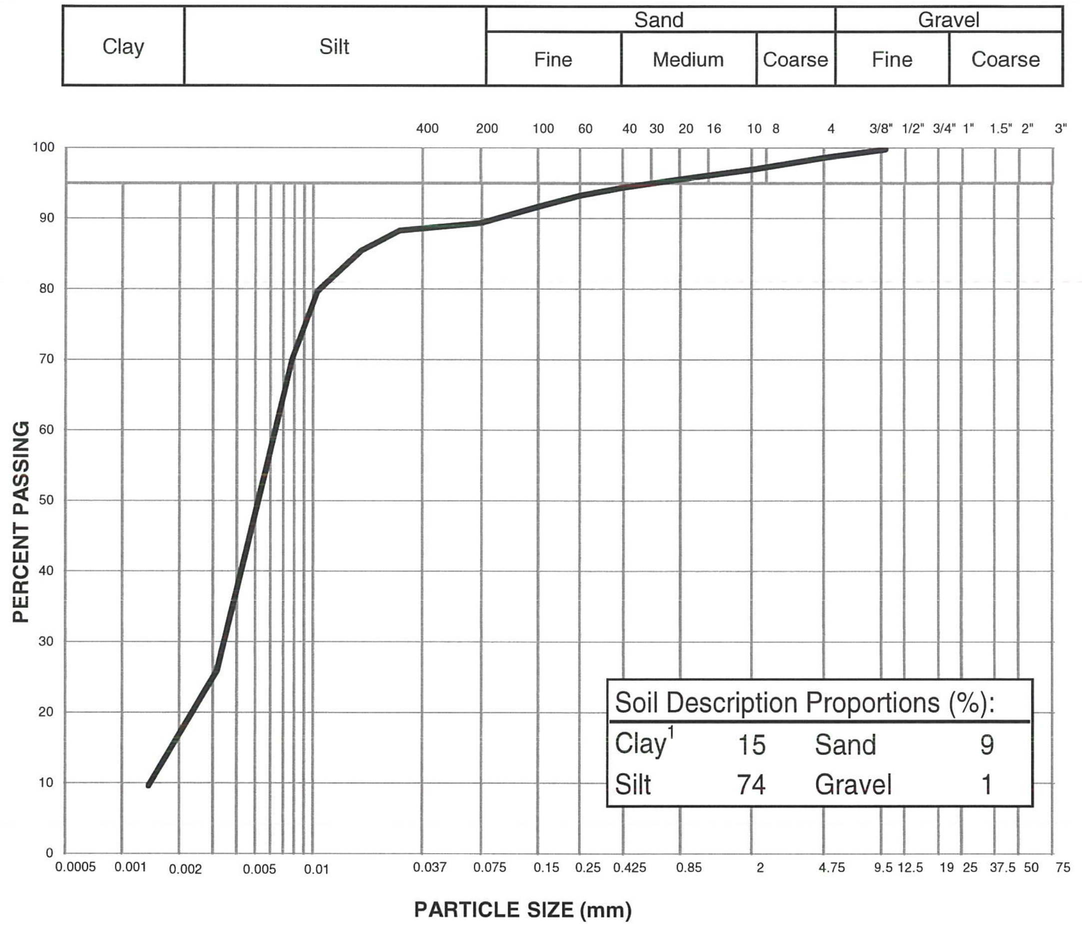
Reviewed By: __________ C.E.T.

PARTICLE SIZE ANALYSIS REPORT

ASTM D422, C136 & C117

Project:	Minto February 2015 Lab Testing	Sample No.:	MM-101273
Project No.:	W14103546-01	Material Type:	
Site:	Minto Mine, YT	Sample Loc.:	14-SWC-969
Client:	SRK Consulting (Canada) Inc.	Sample Depth:	19.05 - 19.35 m
Client Rep.:	Murray McGregor	Sampling Method:	Grab
Date Tested:	March 4, 2015 By: AMT	Date sampled:	November 2, 2014
Soil Description[2]:	SILT - some clay, trace sand, trace gravel	Sampled By:	Client
		USC Classification:	Cu: 4.5
Moisture Content:	26.3%		Cc: 1.4

Particle Size (mm)	Percent Passing
75	
50	
38	
25	
19	
12.5	
10	100
5	99
2	97
0.85	96
0.425	94
0.25	93
0.15	92
0.075	89.4
0.0282	88.3
0.0178	85.4
0.0106	79.7
0.0078	70.1
0.0058	55.7
0.0032	25.9
0.0014	9.6



Soil Description Proportions (%):			
Clay[1]	15	Sand	9
Silt	74	Gravel	1

Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: ____________________

Remarks: ____________________

Reviewed By: ____________________ C.E.T.

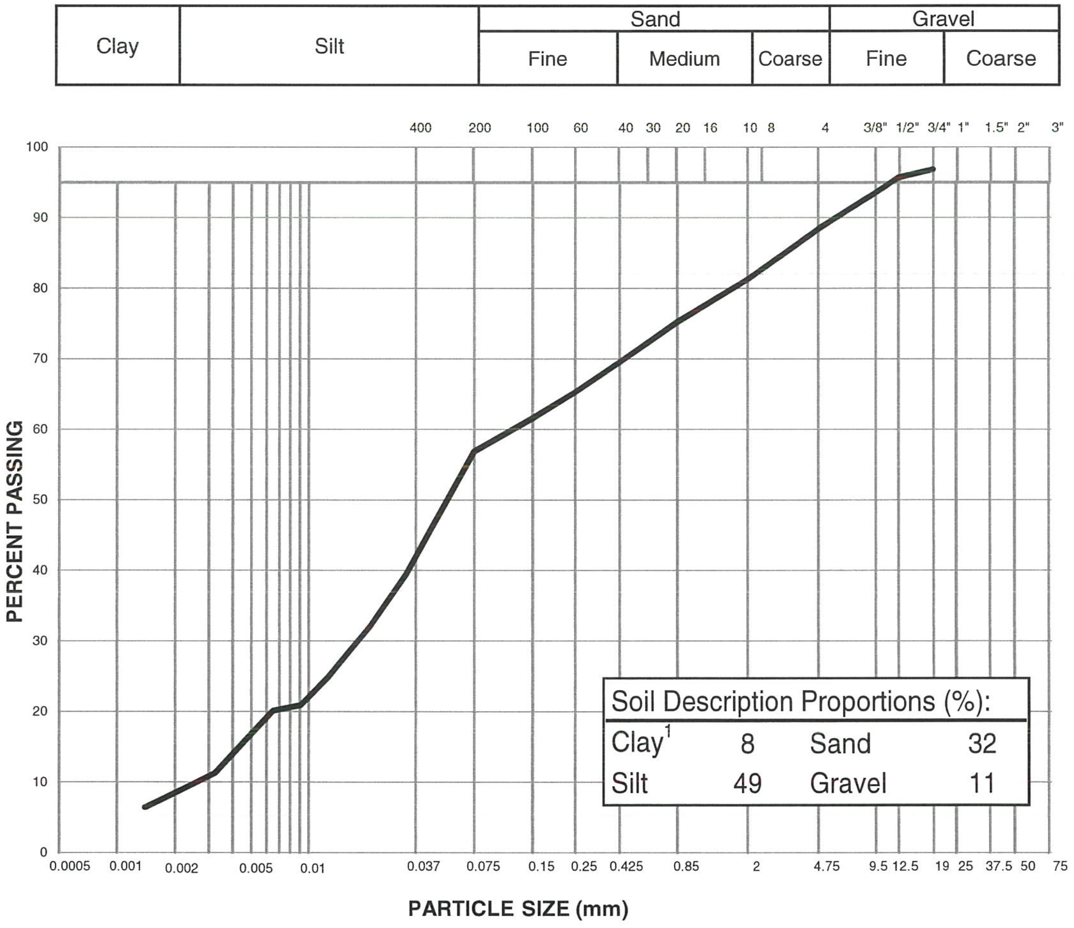
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D422, C136 & C117

Project:	Minto February 2015 Lab Testing	Sample No.:	MM-101277
Project No.:	W14103546-01	Material Type:	
Site:	Minto Mine, YT	Sample Loc.:	14-SWC-972
Client:	SRK Consulting (Canada) Inc.	Sample Depth:	9.25 - 9.55 m
Client Rep.:	Murray McGregor	Sampling Method:	Grab
Date Tested:	March 3, 2015 By: AMT	Date sampled:	November 4, 2014
Soil Description[2]:	SILT - sandy, some gravel, trace clay	Sampled By:	Client
		USC Classification:	Cu: 45.3
Moisture Content:	16.6%		Cc: 1.0

Particle Size (mm)	Percent Passing
75	
50	
38	
25	
19	97
12.5	96
10	94
5	89
2	81
0.85	75
0.425	70
0.25	65
0.15	62
0.075	56.9
0.0329	39.4
0.0214	32.2
0.0127	24.9
0.0091	20.9
0.0065	20.1
0.0032	11.3
0.0014	6.4



Soil Description Proportions (%):			
Clay[1]	8	Sand	32
Silt	49	Gravel	11

Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: ______________________

Remarks: ______________________

Reviewed By: ______________________ C.E.T.

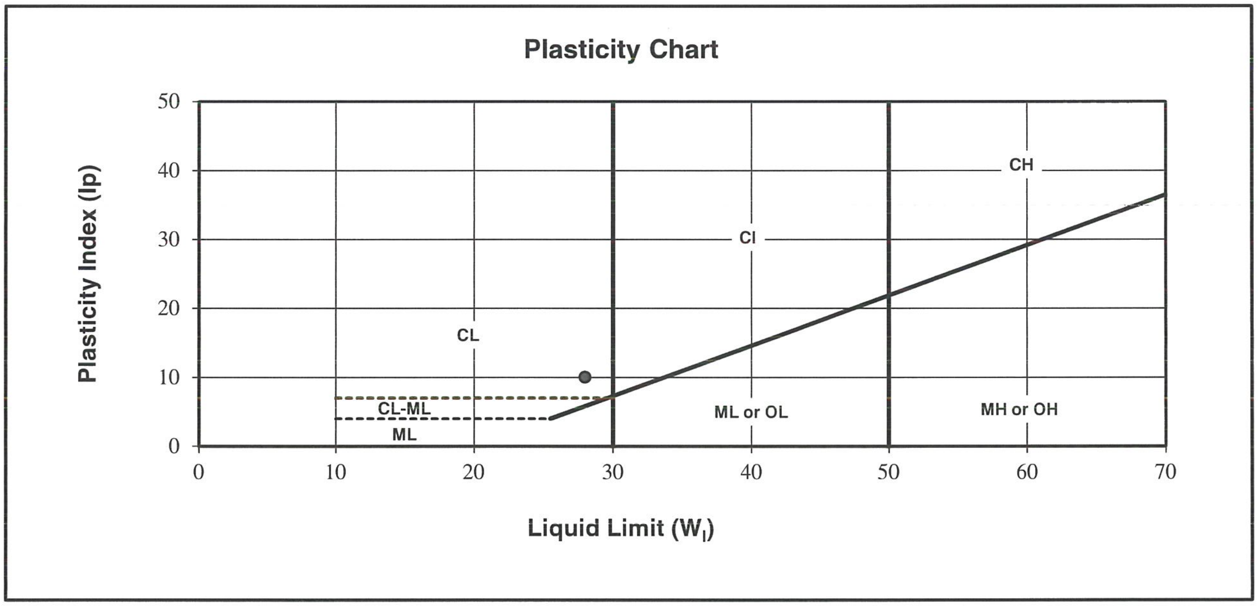
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Minto February 2015 Lab Testing	Sample Number:	MM-101277
		Borehole Number:	14-SWC-272
Project No:	W14103546-01	Depth:	9.25 - 9.55 m
Client:	SRK Consulting (Canada) Inc.	Sampled By:	Client Tested By: AMT
Attention:	Murrary McGregor	Date Sampled:	November 4, 2014
Email:		Date Tested:	March 5, 2015

Sample Description: SILT - sandy, some gravel, trace clay



Liquid Limit ($W_{1)}$:	28	Natural Moisture (%)	16.6
Plastic Limit :	18	Soil Plasticity:	Low to Medium
Plasticity Index (Ip) :	**10**	Mod.USCS Symbol:	CL-CI

Remarks:

Reviewed By: C.E.T.

TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D422, C136 & C117

Project: Minto February 2015 Lab Testing

Project No.: W14103546-01

Site: Minto Mine, YT

Client: SRK Consulting (Canada) Inc.

Client Rep.: Murray McGregor

Date Tested: March 3, 2015 By: AMT

Soil Description[2]: SILT - trace sand, trace clay

Moisture Content: 31.7%

Sample No.: MM-101280

Material Type:

Sample Loc.: 14-SWC-972

Sample Depth: 18.55 - 18.85 m

Sampling Method: Grab

Date sampled: November 4, 2014

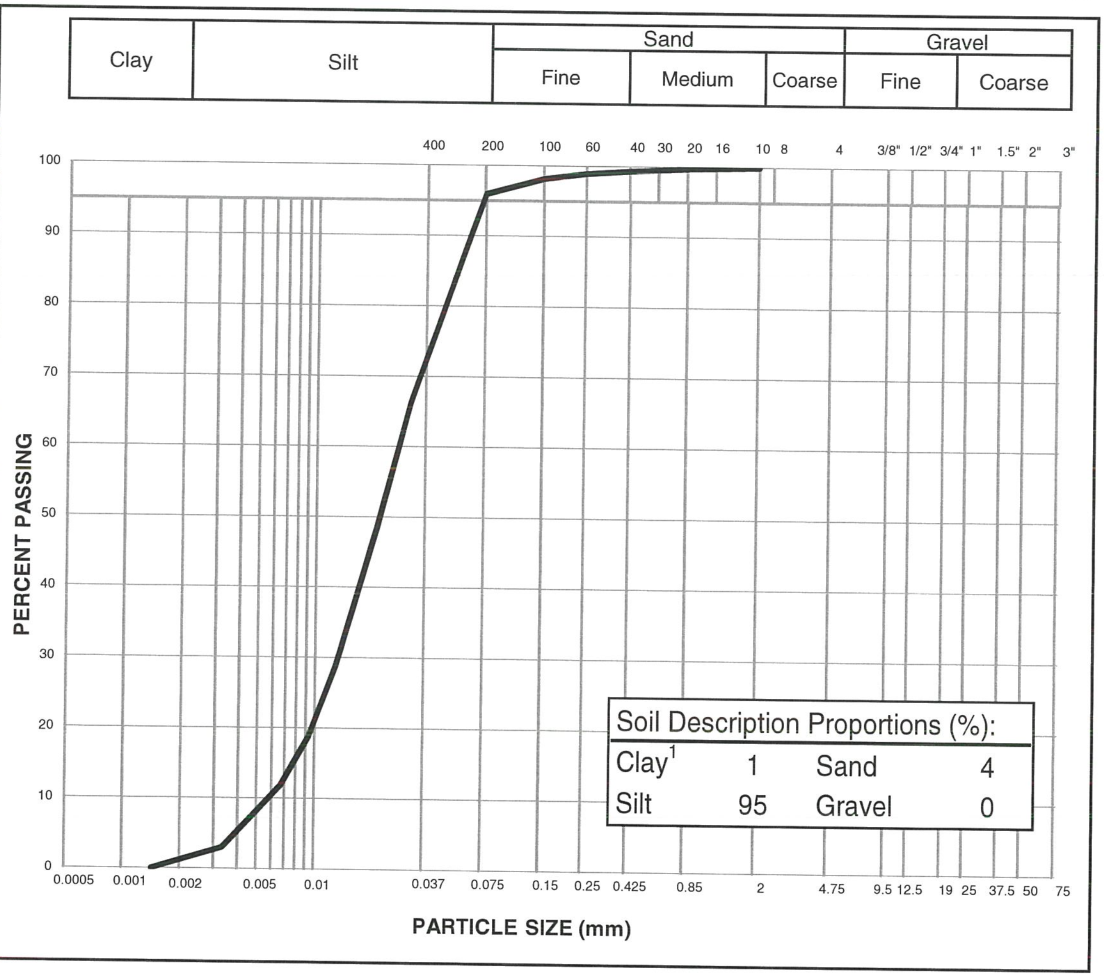
Sampled By: Client

USC Classification:

Cu: 4.6

Cc: 1.1

Particle Size (mm)	Percent Passing
75	
50	
38	
25	
19	
12.5	
10	
5	
2	100
0.85	100
0.425	99
0.25	99
0.15	98
0.075	96.0
0.0309	66.3
0.0208	48.5
0.0128	28.7
0.0093	18.8
0.0067	11.9
0.0033	3.0
0.0014	0.0



Soil Description Proportions (%):

Clay[1]	1	Sand	4
Silt	95	Gravel	0

Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification:

Remarks:

Reviewed By: C.E.T.

TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

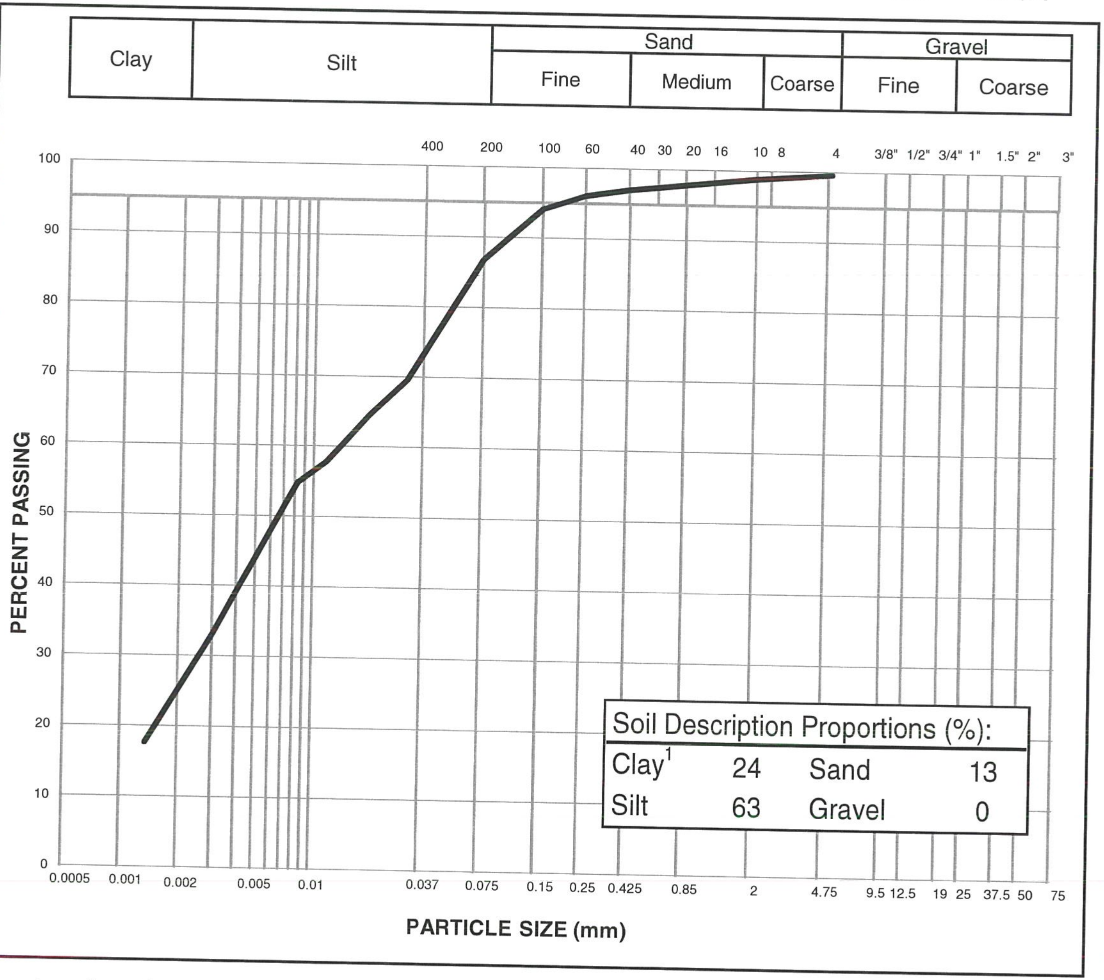
ASTM D422, C136 & C117

Project: Minto February 2015 Lab Testing
Project No.: W14103546-01
Site: Minto Mine, YT
Client: SRK Consulting (Canada) Inc.
Client Rep.: Murray McGregor
Date Tested: March 3, 2015 By: AMT
Soil Description[2]: SILT and CLAY - some sand

Sample No.: MM-101285
Material Type:
Sample Loc.: 14-SWC-973
Sample Depth: 2.80 - 3.10 m
Sampling Method: Grab
Date sampled: November 6, 2014
Sampled By: Client
USC Classification:
Cu: #N/A
Cc: #N/A

Moisture Content: 35.9%

Particle Size (mm)	Percent Passing
75	
50	
38	
25	
19	
12.5	
10	
5	100
2	99
0.85	98
0.425	97
0.25	96
0.15	94
0.075	86.8
0.0304	69.5
0.0196	64.6
0.0116	57.7
0.0083	54.8
0.0060	47.9
0.0030	33.3
0.0014	17.6



Soil Description Proportions (%):

Clay[1]	24	Sand	13
Silt	63	Gravel	0

Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual
[2] The description is visually based & subject to EBA description protocols

Specification: __________

Remarks: __________

Reviewed By: __________ C.E.T.

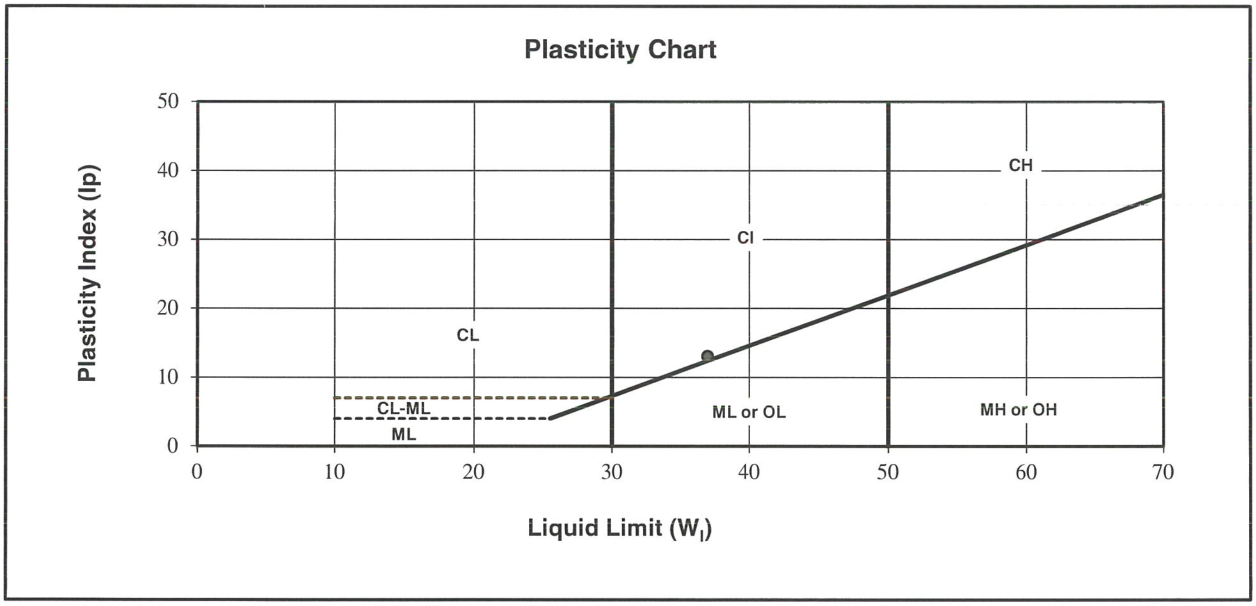
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Minto February 2015 Lab Testing	Sample Number:	MM-101285
		Borehole Number:	14-SWC-973
Project No:	W14103546-01	Depth:	2.80 - 3.10 m
Client:	SRK Consulting (Canada) Inc.	Sampled By:	Client Tested By: AMT
Attention:	Murrary McGregor	Date Sampled:	November 6, 2014
Email:		Date Tested:	March 5, 2015

Sample Description: SILT and CLAY - some sand



Liquid Limit ($W_{1)}$:	37	Natural Moisture (%)	35.9
Plastic Limit :	24	Soil Plasticity:	Medium
Plasticity Index (Ip) :	**13**	Mod.USCS Symbol:	CI

Remarks:

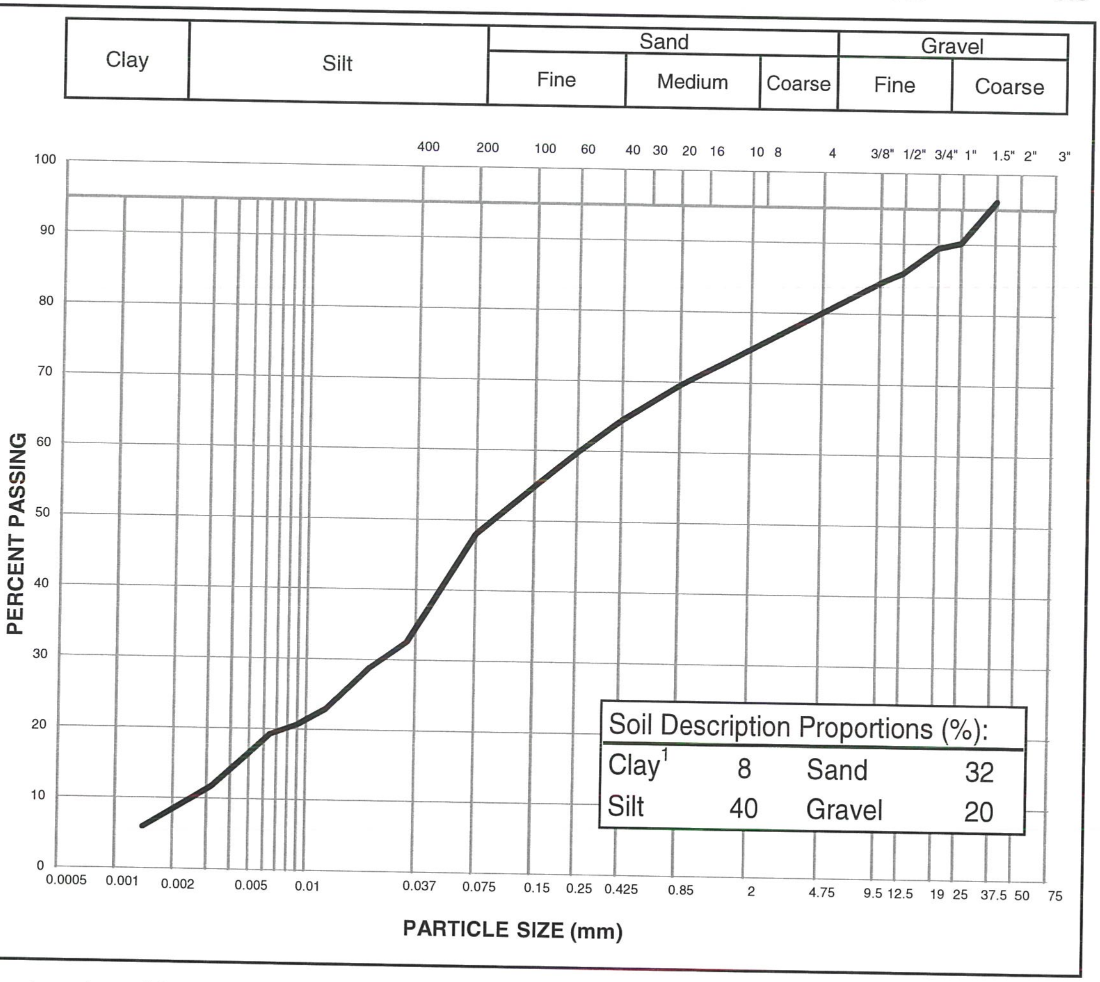
Reviewed By: C.E.T.

PARTICLE SIZE ANALYSIS REPORT

ASTM D422, C136 & C117

Project:	Minto February 2015 Lab Testing	Sample No.:	MM-101288
Project No.:	W14103546-01	Material Type:	
Site:	Minto Mine, YT	Sample Loc.:	14-SWC-973
Client:	SRK Consulting (Canada) Inc.	Sample Depth:	9.17 - 9.47 m
Client Rep.:	Murray McGregor	Sampling Method:	Grab
Date Tested:	March 3, 2015 By: AMT	Date sampled:	November 6, 2014
Soil Description[2]:	SILT - sandy, some gravel, trace clay	Sampled By:	Client
		USC Classification:	Cu: 97.2
Moisture Content:	13.2%		Cc: 0.9

Particle Size (mm)	Percent Passing
75	
50	
38	96
25	90
19	89
12.5	86
10	85
5	80
2	75
0.85	70
0.425	64
0.25	60
0.15	55
0.075	48.0
0.0335	32.6
0.0215	28.9
0.0127	22.9
0.0091	20.7
0.0065	19.2
0.0032	11.8
0.0014	5.9



Soil Description Proportions (%):			
Clay[1]	8	Sand	32
Silt	40	Gravel	20

Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification:

Remarks:

Reviewed By: C.E.T.

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project: Minto February 2015 Lab Testing

Sample Number: MM-101288

Borehole Number: 14-SWC-973

Project No: W14103546-01

Depth: 9.17 - 9.47 m

Client: SRK Consulting (Canada) Inc.

Sampled By: Client Tested By: AMT

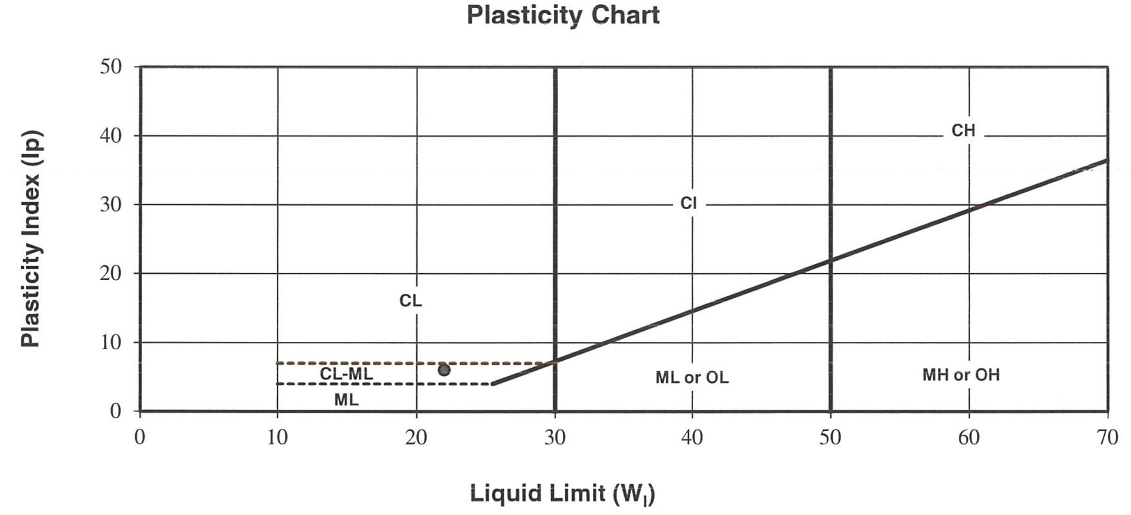
Attention: Murrary McGregor

Date Sampled: November 6, 2014

Email:

Date Tested: March 5, 2015

Sample Description: SILT - sandy, some gravel, trace silt



Liquid Limit (W$_{1)}$:	22	Natural Moisture (%)	35.9
Plastic Limit :	16	Soil Plasticity:	Low
Plasticity Index (Ip) :	**6**	Mod.USCS Symbol:	CL-ML

Remarks:

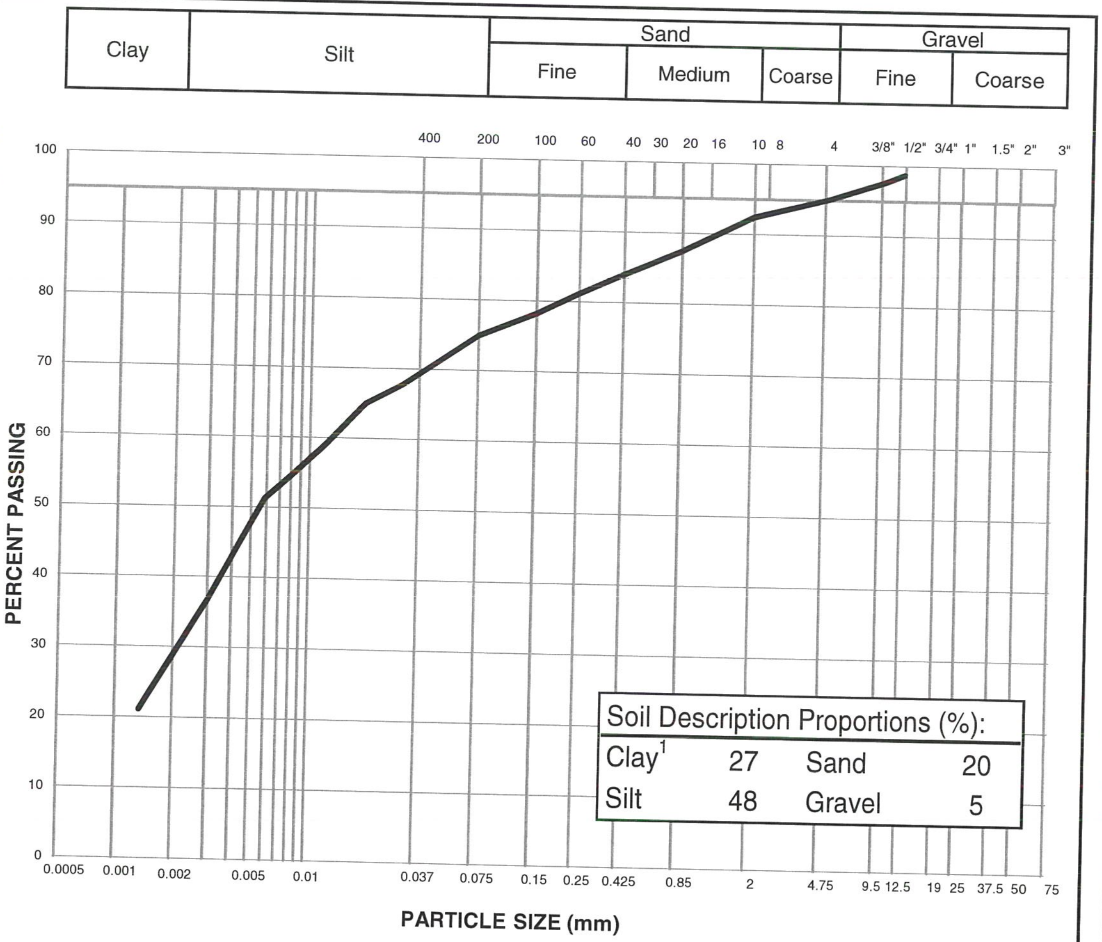
Reviewed By: C.E.T.

PARTICLE SIZE ANALYSIS REPORT

ASTM D422, C136 & C117

Project:	Minto February 2015 Lab Testing	Sample No.:	MM-101298
Project No.:	W14103546-01	Material Type:	
Site:	Minto Mine, YT	Sample Loc.:	14-SWC-975
Client:	SRK Consulting (Canada) Inc.	Sample Depth:	5.70 - 6.00 m
Client Rep.:	Murray McGregor	Sampling Method:	Grab
Date Tested:	March 3, 2015 By: AMT	Date sampled:	November 9, 2014
Soil Description[2]:	SILT and CLAY - some sand, trace gravel	Sampled By:	Client
		USC Classification:	Cu: #N/A
Moisture Content:	28.1%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
38	
25	
19	
12.5	99
10	98
5	95
2	92
0.85	87
0.425	84
0.25	81
0.15	78
0.075	74.9
0.0304	67.8
0.0195	65.0
0.0116	58.6
0.0083	54.9
0.0059	51.3
0.0030	36.6
0.0013	21.1



Soil Description Proportions (%):

Clay[1]	27	Sand	20
Silt	48	Gravel	5

Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification:

Remarks:

Reviewed By: C.E.T.

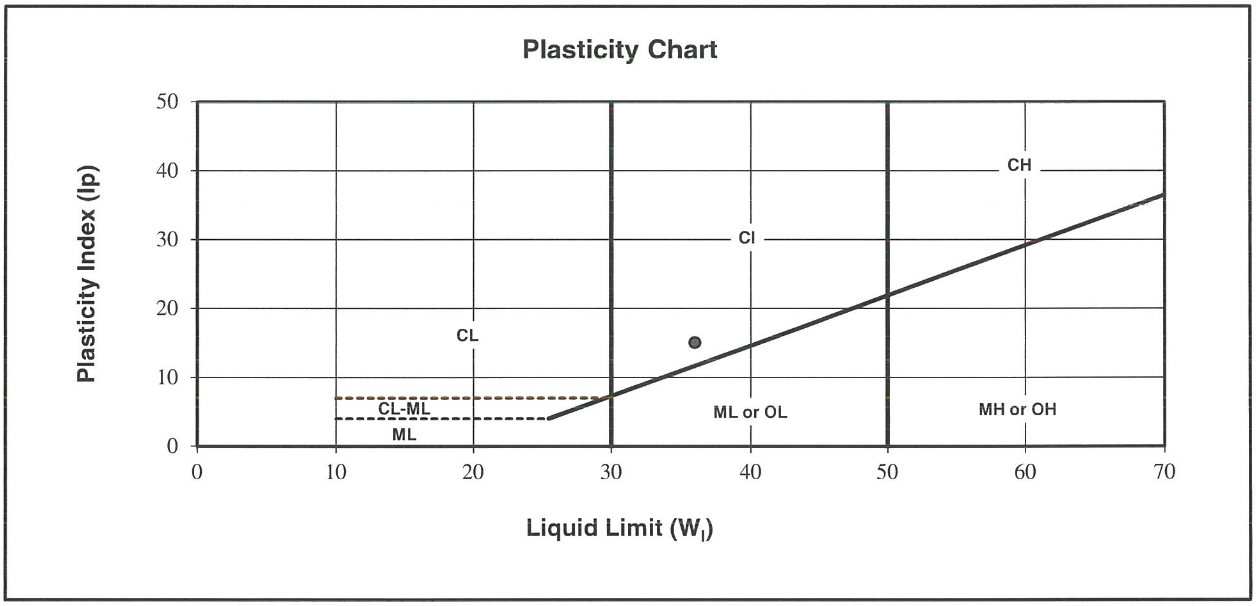
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Minto February 2015 Lab Testing	Sample Number:	MM-101298
		Borehole Number:	14-SWC-975
Project No:	W14103546-01	Depth:	5.70 - 6.00 m
Client:	SRK Consulting (Canada) Inc.	Sampled By:	Client Tested By: AMT
Attention:	Murrary McGregor	Date Sampled:	November 9, 2014
Email:		Date Tested:	March 5, 2015

Sample Description: SILT and CLAY - some sand, trace gravel



Liquid Limit ($W_{1)}$:	36	Natural Moisture (%)	35.9
Plastic Limit :	21	Soil Plasticity:	Medium
Plasticity Index (Ip) :	**15**	Mod.USCS Symbol:	CI

Remarks:

Reviewed By: C.E.T.

PARTICLE SIZE ANALYSIS REPORT

ASTM D422, C136 & C117

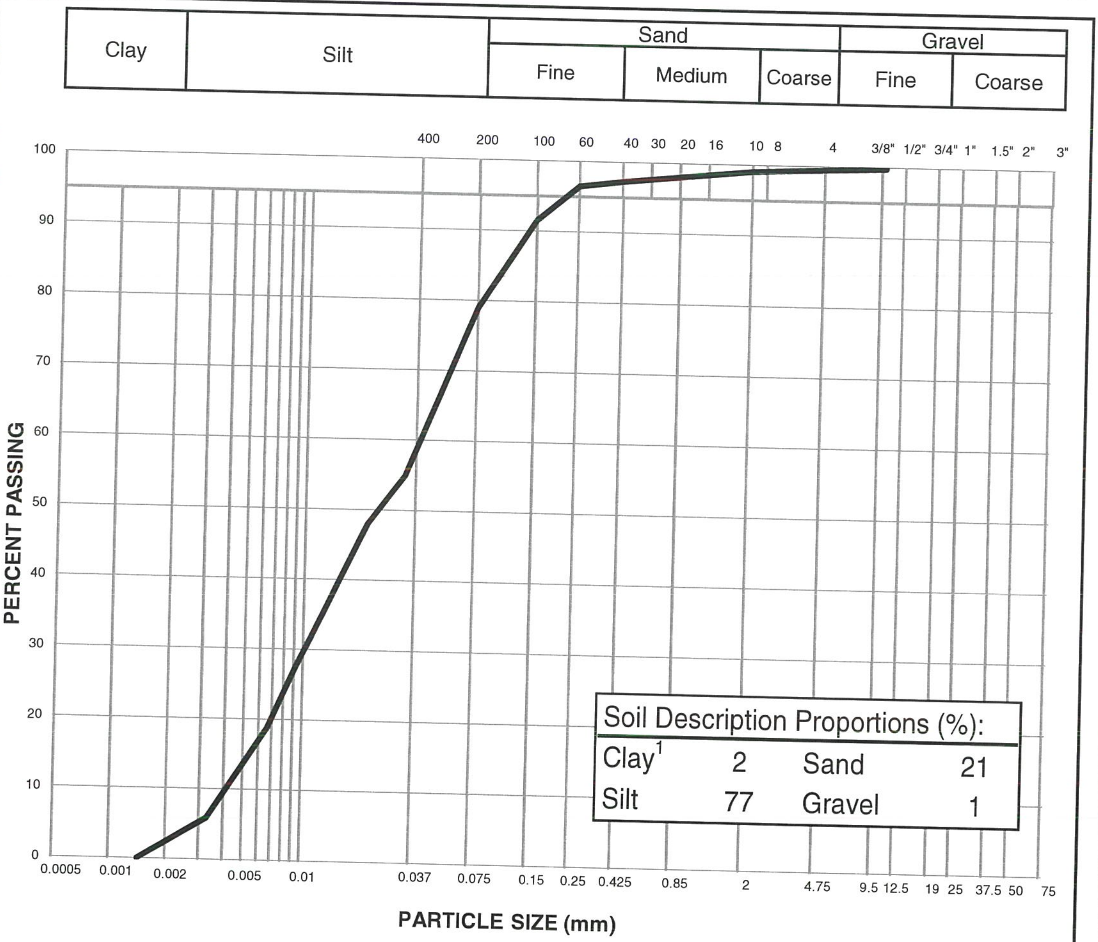
Project:	Minto February 2015 Lab Testing	Sample No.:	MM-101317
Project No.:	W14103546-01	Material Type:	
Site:	Minto Mine, YT	Sample Loc.:	14-SWC-979
Client:	SRK Consulting (Canada) Inc.	Sample Depth:	20.60 - 20.90 m
Client Rep.:	Murray McGregor	Sampling Method:	Grab
Date Tested:	March 3, 2015 By: AMT	Date sampled:	November 9, 2014
Soil Description[2]:	SILT - sandy, trace clay, trace gravel	Sampled By:	Client
		USC Classification:	

Cu: 9.5

Cc: 0.6

Moisture Content: 26.5%

Particle Size (mm)	Percent Passing
75	
50	
38	
25	
19	
12.5	
10	100
5	100
2	99
0.85	98
0.425	97
0.25	96
0.15	92
0.075	78.9
0.0325	54.9
0.0211	48.1
0.0127	35.3
0.0092	27.5
0.0066	18.6
0.0033	5.9
0.0014	0.0



Soil Description Proportions (%):

Clay[1]	2	Sand	21
Silt	77	Gravel	1

Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: ______

Remarks: ______

Reviewed By: ______ C.E.T.

TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project: Minto February 2015 Lab Testing

Sample Number: MM-101317

Borehole Number: 14-SWC-979

Project No: W14103546-01

Depth: 20.60 - 20.90 m

Client: SRK Consulting (Canada) Inc.

Sampled By: Client Tested By: AMT

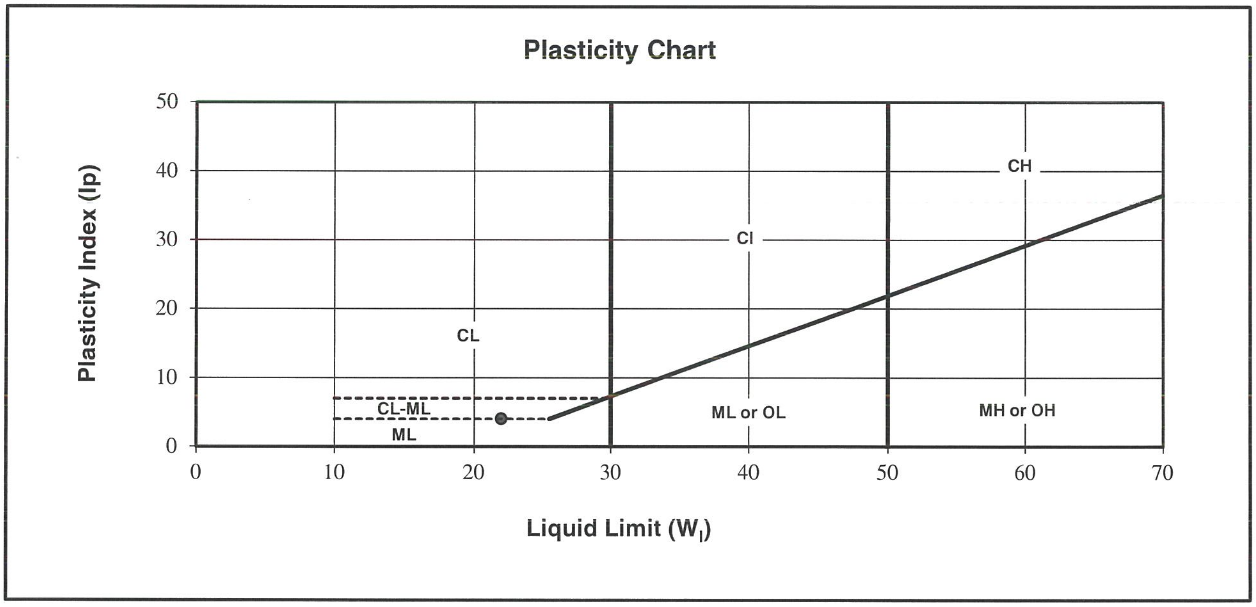
Attention: Murrary McGregor

Date Sampled: November 9, 2014

Email:

Date Tested: March 5, 2015

Sample Description: SILT - sandy, trace clay, trace gravel



Liquid Limit (W$_{1)}$: 22

Plastic Limit : 18

Plasticity Index (Ip) : 4

Natural Moisture (%) 35.9

Soil Plasticity: Low

Mod.USCS Symbol: CL-ML

Remarks:

Reviewed By: C.E.T.

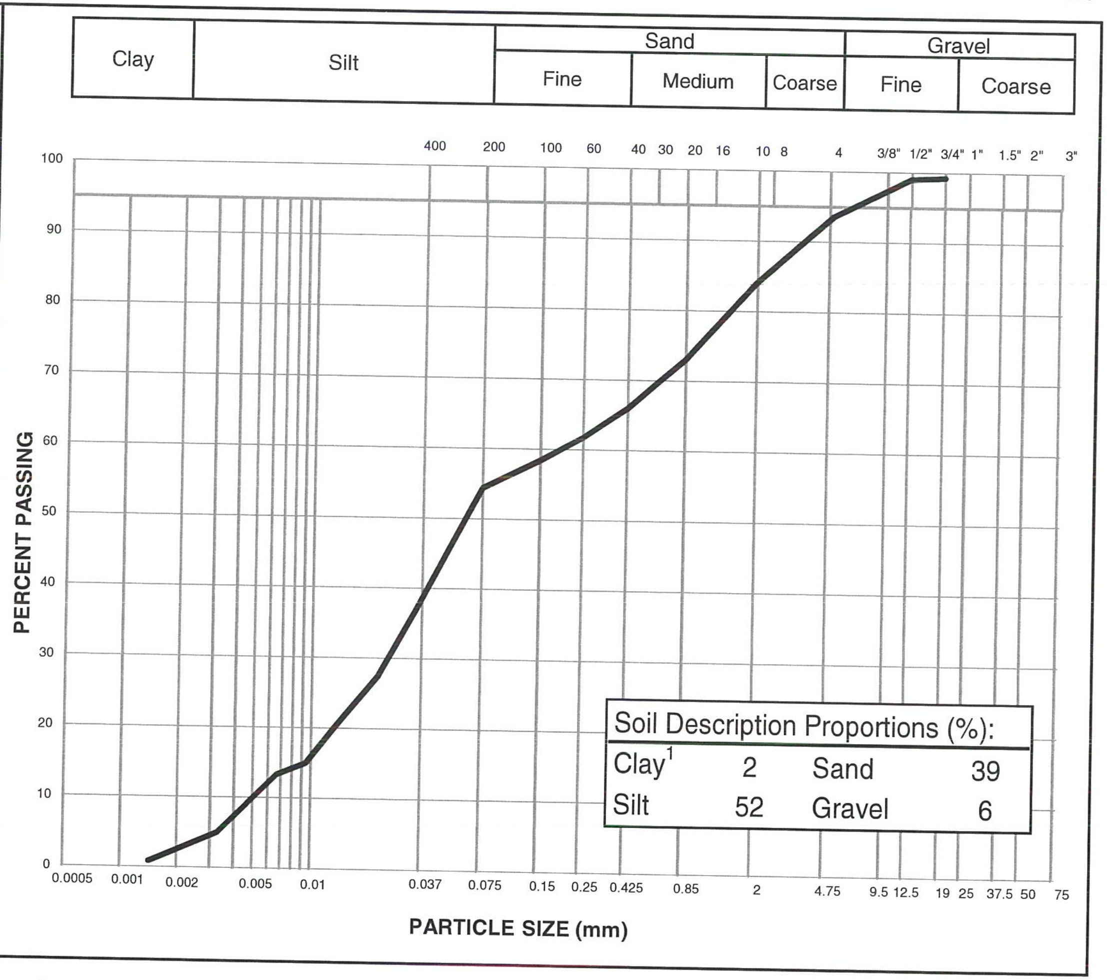
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D422, C136 & C117

Project:	Minto February 2015 Lab Testing	Sample No.:	MM-101326
Project No.:	W14103546-01	Material Type:	
Site:	Minto Mine, YT	Sample Loc.:	14-SWC-980
Client:	SRK Consulting (Canada) Inc.	Sample Depth:	19.40 - 19.70 m
Client Rep.:	Murray McGregor	Sampling Method:	Grab
Date Tested:	March 3, 2015 By: AMT	Date sampled:	November 9, 2014
Soil Description[2]:	SILT and SAND - trace gravel, trace clay	Sampled By:	Client
Moisture Content:	18.8%	USC Classification:	Cu: 37.1 Cc: 0.6

Particle Size (mm)	Percent Passing
75	
50	
38	
25	
19	99
12.5	99
10	98
5	94
2	84
0.85	73
0.425	66
0.25	62
0.15	58
0.075	54.4
0.0339	36.7
0.0222	27.5
0.0131	20.0
0.0094	15.0
0.0066	13.3
0.0033	5.0
0.0014	0.8



Soil Description Proportions (%):

Clay[1]	2	Sand	39
Silt	52	Gravel	6

Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: ______________________

Remarks: ______________________

Reviewed By: ______________________ C.E.T.

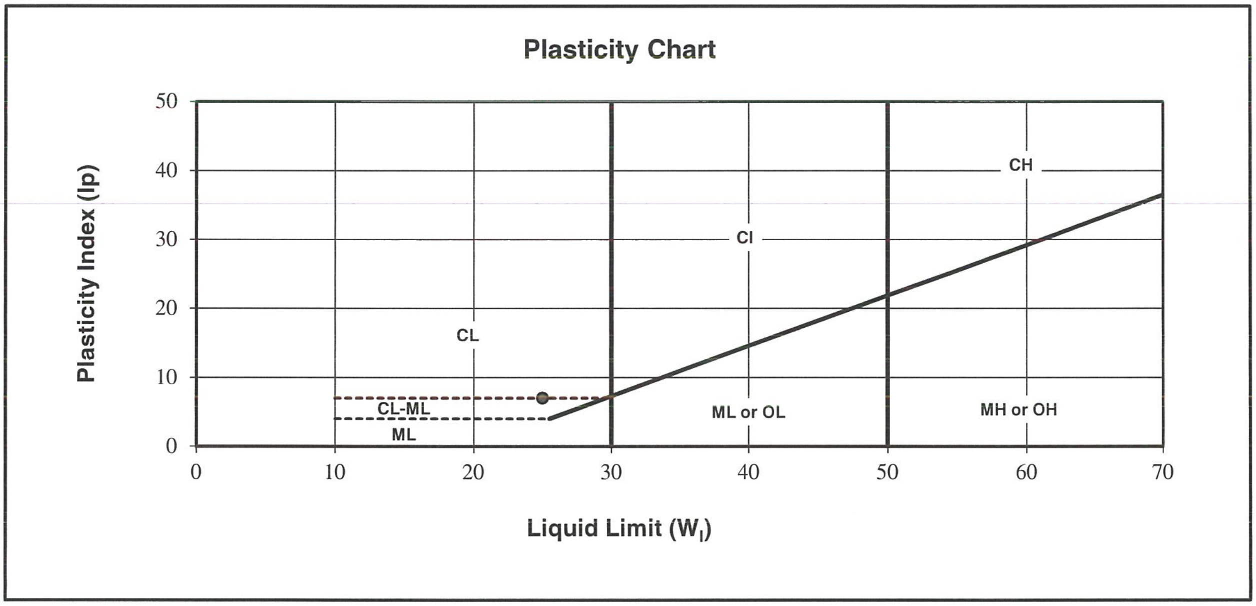
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Minto February 2015 Lab Testing	Sample Number:	MM-101326
		Borehole Number:	14-SWC-980
Project No:	W14103546-01	Depth:	19.40 - 19.70 m
Client:	SRK Consulting (Canada) Inc.	Sampled By:	Client Tested By: AMT
Attention:	Murrary McGregor	Date Sampled:	November 9, 2014
Email:		Date Tested:	March 5, 2015

Sample Description: SILT and SAND - trace gravel, trace clay



Liquid Limit (W$_{1)}$:	25	Natural Moisture (%)	35.9
Plastic Limit :	18	Soil Plasticity:	Low
Plasticity Index (Ip) :	**7**	Mod.USCS Symbol:	CL-ML

Remarks:

Reviewed By: C.E.T.

TETRA TECH

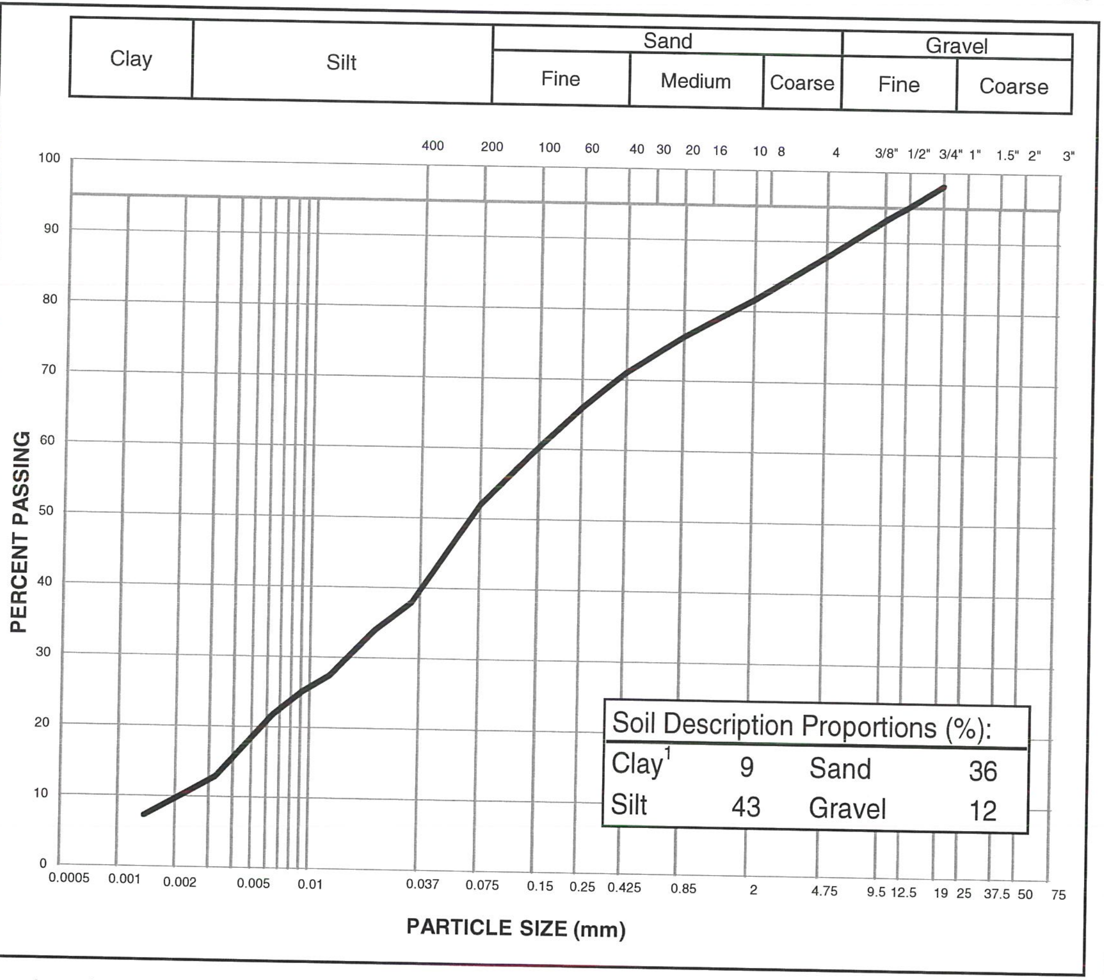
PARTICLE SIZE ANALYSIS REPORT

ASTM D422, C136 & C117

Project: Minto February 2015 Lab Testing
Project No.: W14103546-01
Site: Minto Mine, YT
Client: SRK Consulting (Canada) Inc.
Client Rep.: Murray McGregor
Date Tested: March 4, 2015 By: AMT
Soil Description[2]: SILT and SAND - some gravel, trace clay
Moisture Content: 13.4%

Sample No.: 58554
Material Type:
Sample Loc.: 15-SWC-995
Sample Depth: 8.60 - 8.90 m
Sampling Method: Grab
Date sampled: February 9, 2015
Sampled By: Client
USC Classification:
Cu: 64.8
Cc: 0.8

Particle Size (mm)	Percent Passing
75	
50	
38	
25	
19	98
12.5	95
10	94
5	88
2	82
0.85	76
0.425	71
0.25	66
0.15	60
0.075	51.9
0.0335	38.0
0.0216	33.9
0.0128	27.5
0.0091	25.0
0.0064	21.8
0.0033	12.9
0.0014	7.3



Soil Description Proportions (%):

Clay[1]	9	Sand	36
Silt	43	Gravel	12

Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual
[2] The description is visually based & subject to EBA description protocols

Specification:

Remarks:

Reviewed By: C.E.T.

TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

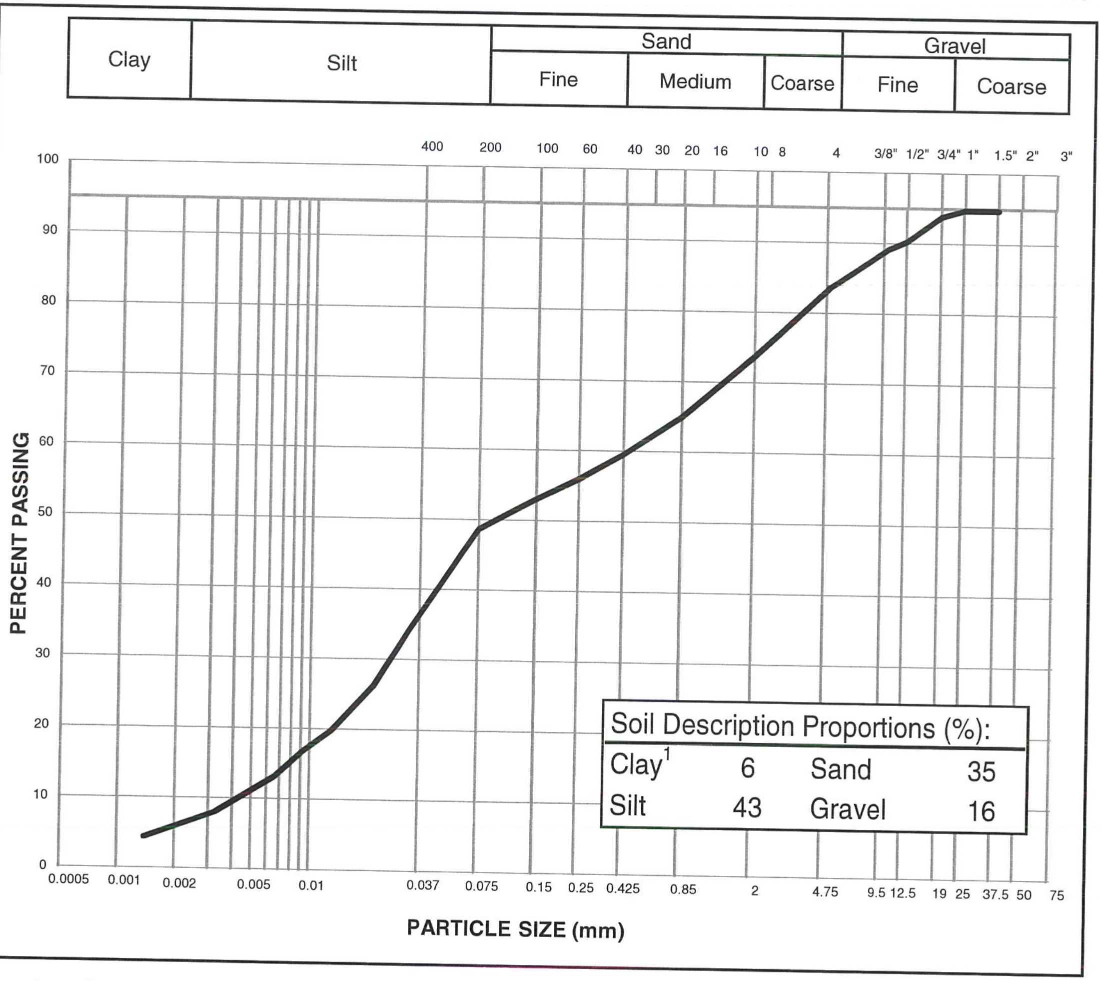
ASTM D422, C136 & C117

Project: Minto February 2015 Lab Testing
Project No.: W14103546-01
Site: Minto Mine, YT
Client: SRK Consulting (Canada) Inc.
Client Rep.: Murray McGregor
Date Tested: March 4, 2015 By: AMT
Soil Description[2]: SILT - sandy, some gravel, trace clay

Sample No.: 58557
Material Type:
Sample Loc.: 15-SWC-996
Sample Depth: 6.12 - 6.42 m
Sampling Method: Grab
Date sampled: February 9, 2015
Sampled By: Client
USC Classification:
Cu: 101.8
Cc: 0.3

Moisture Content: 14.8%

Particle Size (mm)	Percent Passing
75	
50	
38	95
25	95
19	94
12.5	90
10	89
5	84
2	74
0.85	65
0.425	60
0.25	56
0.15	53
0.075	48.6
0.0327	34.3
0.0214	26.2
0.0129	19.7
0.0092	16.8
0.0066	13.1
0.0033	8.0
0.0014	4.4



Soil Description Proportions (%):

Clay[1]	6	Sand	35
Silt	43	Gravel	16

Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual
[2] The description is visually based & subject to EBA description protocols

Specification:

Remarks:

Reviewed By: C.E.T.

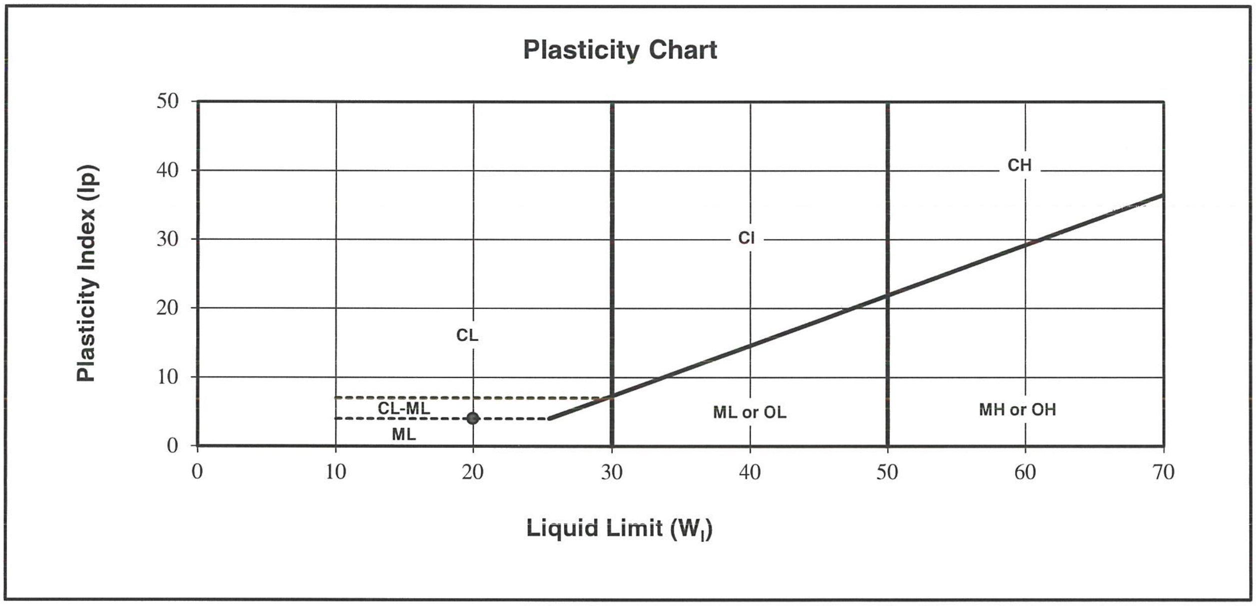
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Minto February 2015 Lab Testing	Sample Number:	58557
		Borehole Number:	15-SWC-996
Project No:	W14103546-01	Depth:	6.12 - 6.42 m
Client:	SRK Consulting (Canada) Inc.	Sampled By:	Client Tested By: AMT
Attention:	Murrary McGregor	Date Sampled:	February 9, 2015
Email:		Date Tested:	March 6, 2015

Sample Description: SILT - sandy, some gravel, trace clay



Liquid Limit ($W_{1)}$:	20	Natural Moisture (%)	35.9
Plastic Limit :	16	Soil Plasticity:	Low
Plasticity Index (Ip) :	**4**	Mod.USCS Symbol:	CL-ML

Remarks:

Reviewed By: ____________ C.E.T.

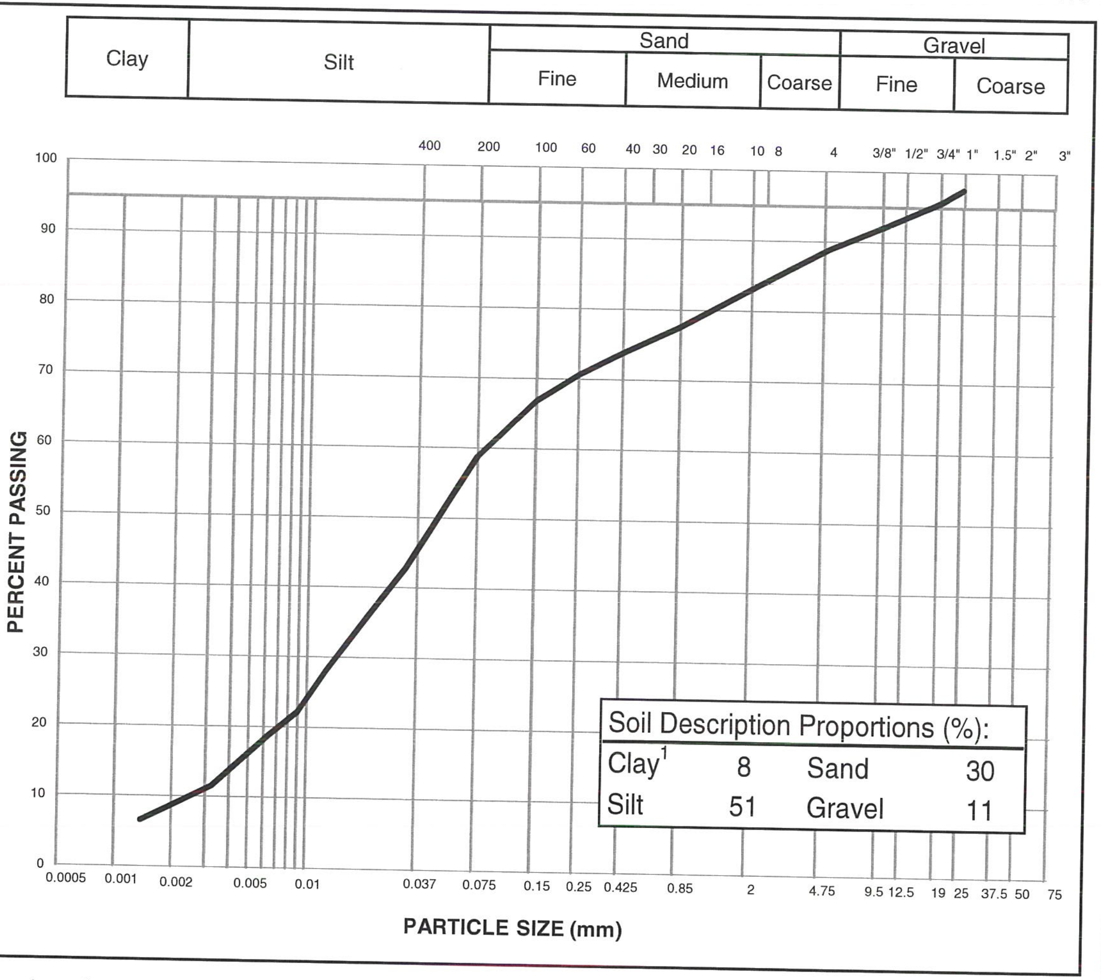
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D422, C136 & C117

Project:	Minto February 2015 Lab Testing	Sample No.:	58559
Project No.:	W14103546-01	Material Type:	
Site:	Minto Mine, YT	Sample Loc.:	15-SWC-996
Client:	SRK Consulting (Canada) Inc.	Sample Depth:	14.73 - 15.10 m
Client Rep.:	Murray McGregor	Sampling Method:	Grab
Date Tested:	March 5, 2015 By: AMT	Date sampled:	February 9, 2015
Soil Description[2]:	SILT - sandy, some gravel, trace clay	Sampled By:	Client
		USC Classification:	Cu: 32.3
Moisture Content:	16.1%		Cc: 0.9

Particle Size (mm)	Percent Passing
75	
50	
38	
25	98
19	96
12.5	94
10	92
5	89
2	83
0.85	78
0.425	74
0.25	71
0.15	67
0.075	58.8
0.0321	42.8
0.0209	36.2
0.0124	28.0
0.0090	22.2
0.0064	18.9
0.0032	11.5
0.0014	6.6



Soil Description Proportions (%):

Clay[1]	8	Sand	30
Silt	51	Gravel	11

Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: ________________

Remarks: ________________

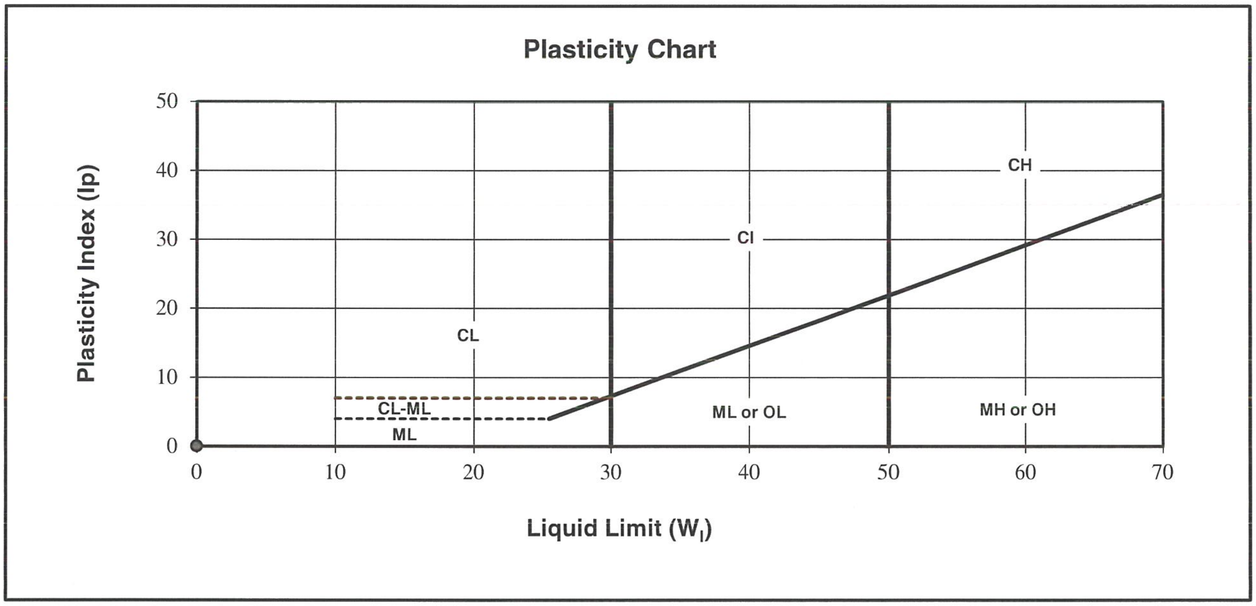
Reviewed By: ________________ C.E.T.

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project: Minto February 2015 Lab Testing
Sample Number: 58559
Borehole Number: 15-SWC-996
Project No: W14103546-01
Depth: 14.73 - 15.10 m
Client: SRK Consulting (Canada) Inc.
Sampled By: Client
Tested By: AMT
Attention: Murrary McGregor
Date Sampled: February 9, 2015
Email:
Date Tested: March 6, 2015

Sample Description: SILT - sandy, some gravel, trace clay



Liquid Limit (W_1) : 0
Natural Moisture (%) 35.9
Plastic Limit : 0
Soil Plasticity: NP
Plasticity Index (Ip) : **0**
Mod.USCS Symbol: N/A

Remarks: An atterberg was attempted and material was found to be non-plastic.

Reviewed By: C.E.T.

TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

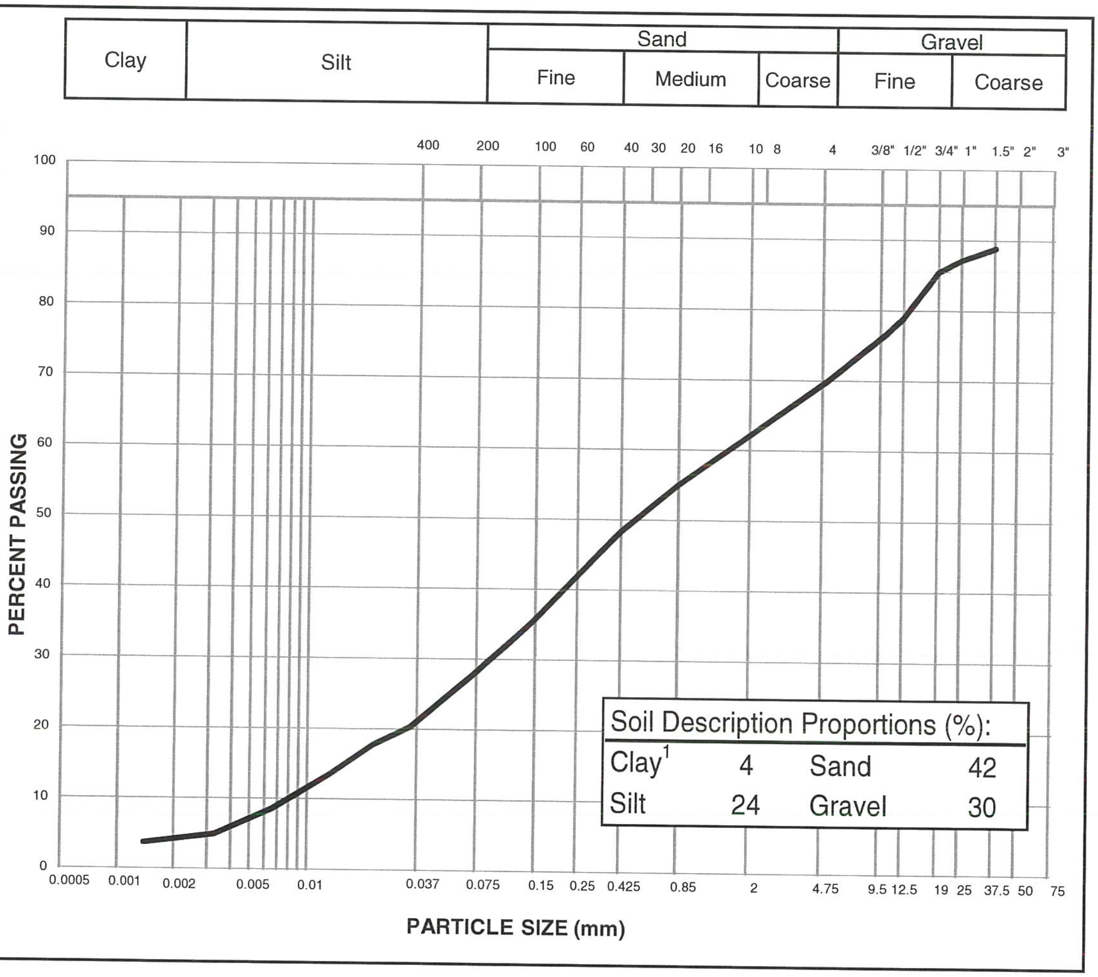
ASTM D422, C136 & C117

Project: Minto February 2015 Lab Testing
Project No.: W14103546-01
Site: Minto Mine, YT
Client: SRK Consulting (Canada) Inc.
Client Rep.: Murray McGregor
Date Tested: March 5, 2015 By: AMT
Soil Description[2]: SAND - gravelley, silty, trace clay

Sample No.: 160025
Material Type:
Sample Loc.: 15-SWC-997
Sample Depth: 9.79 - 10.11 m
Sampling Method: Grab
Date sampled: February 9, 2015
Sampled By: Client
USC Classification:
Cu: 203.9
Cc: 0.6

Moisture Content: 10.3%

Particle Size (mm)	Percent Passing
75	
50	
38	89
25	87
19	85
12.5	79
10	76
5	70
2	62
0.85	55
0.425	48
0.25	42
0.15	36
0.075	28.2
0.0342	20.3
0.0221	17.8
0.0131	13.5
0.0093	11.1
0.0066	8.6
0.0033	4.9
0.0014	3.7



Soil Description Proportions (%):

Clay[1]	4	Sand	42
Silt	24	Gravel	30

Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual
[2] The description is visually based & subject to EBA description protocols

Specification:

Remarks:

Reviewed By: C.E.T.

TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project: Minto February 2015 Lab Testing

Sample Number: 160025

Borehole Number: 15-SWC-997

Project No: W14103546-01

Depth: 9.79 - 10.11 m

Client: SRK Consulting (Canada) Inc.

Sampled By: Client Tested By: AMT

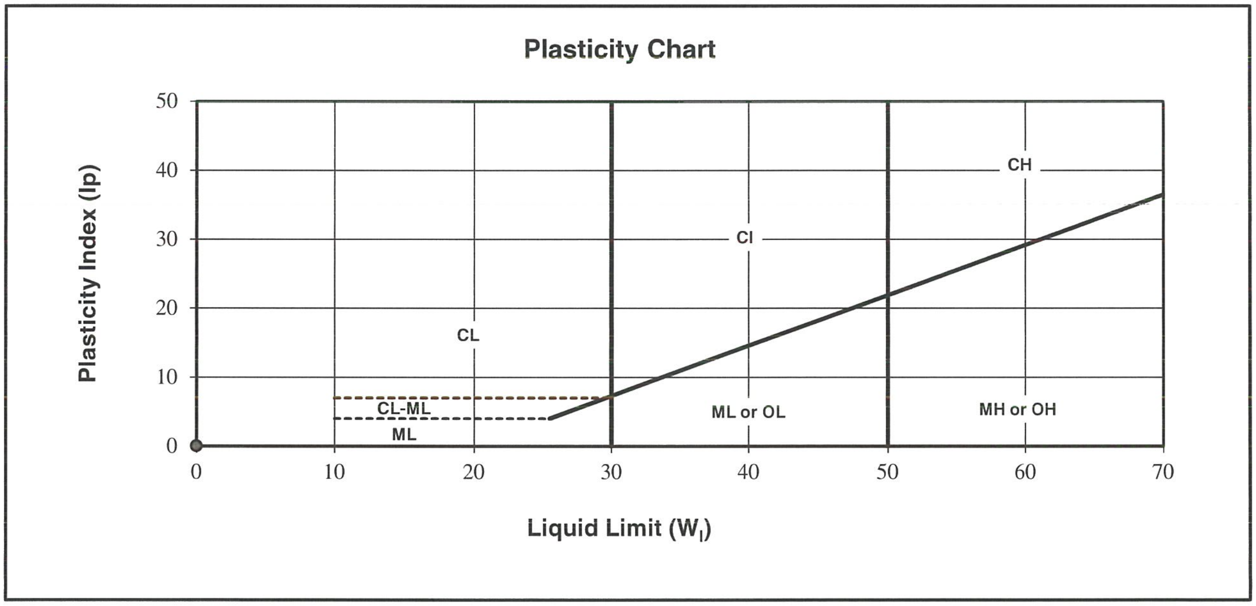
Attention: Murrary McGregor

Date Sampled: February 9, 2015

Email:

Date Tested: March 5, 2015

Sample Description: SAND - gravelley, silty, trace clay



Liquid Limit (W$_{1)}$:	0	Natural Moisture (%)	35.9
Plastic Limit :	0	Soil Plasticity:	NP
Plasticity Index (Ip) :	**0**	Mod.USCS Symbol:	N/A

Remarks: An atterberg was attempted and material was found to be non-plastic.

Reviewed By: C.E.T.

TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D422, C136 & C117

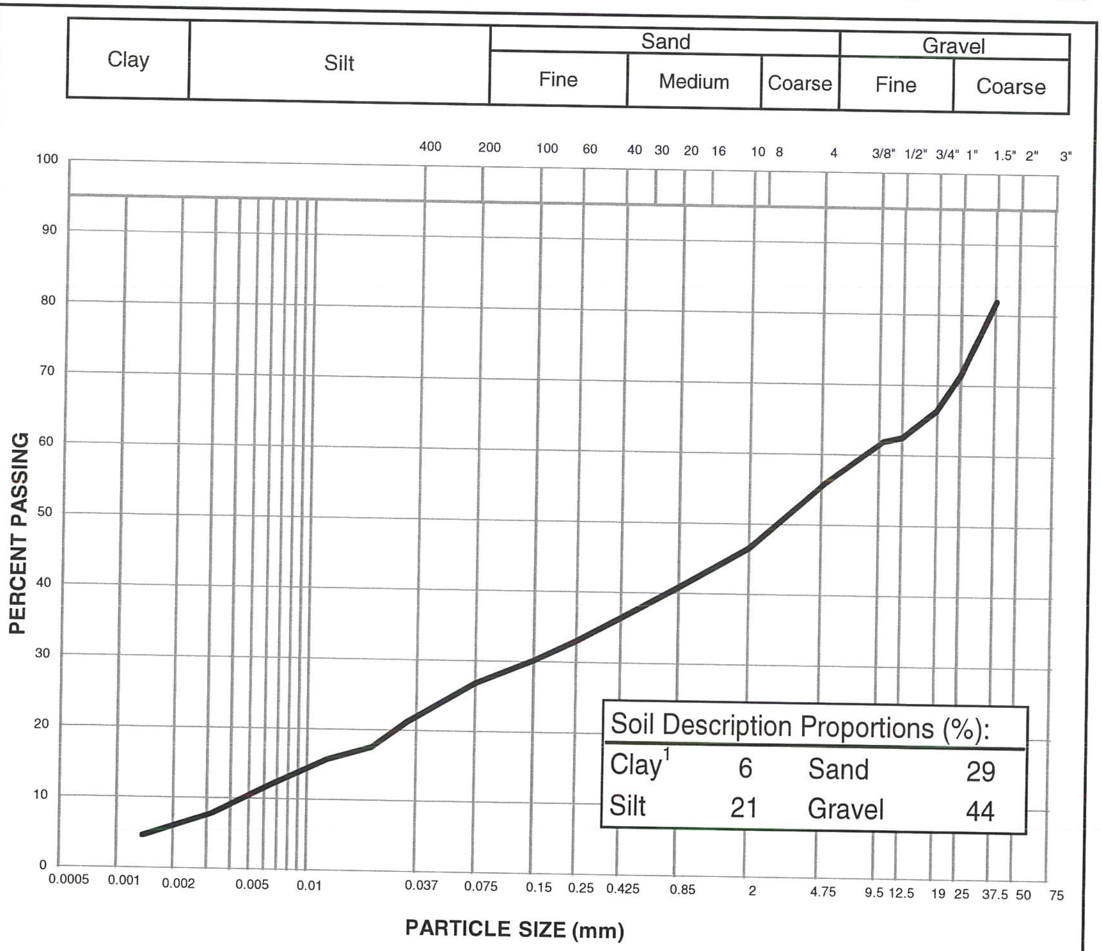
Project:	Minto February 2015 Lab Testing	Sample No.:	58568
Project No.:	W14103546-01	Material Type:	
Site:	Minto Mine, YT	Sample Loc.:	15-SWC-997
Client:	SRK Consulting (Canada) Inc.	Sample Depth:	23.09 - 23.43 m
Client Rep.:	Murray McGregor	Sampling Method:	Grab
Date Tested:	March 5, 2015 By: AMT	Date sampled:	February 9, 2015
Soil Description[2]:	GRAVEL - sandy, silty, trace clay	Sampled By:	Client
		USC Classification:	

Cu: 1712.3

Cc: 0.5

Moisture Content: 11.7%

Particle Size (mm)	Percent Passing
75	
50	
38	82
25	71
19	66
12.5	63
10	62
5	56
2	47
0.85	41
0.425	36
0.25	33
0.15	30
0.075	26.8
0.0332	21.2
0.0216	17.5
0.0126	15.7
0.0090	13.8
0.0065	12.0
0.0032	7.8
0.0014	4.6



Soil Description Proportions (%):

Clay[1]	6	Sand	29
Silt	21	Gravel	44

Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: __________

Remarks: __________

Reviewed By: __________ C.E.T.

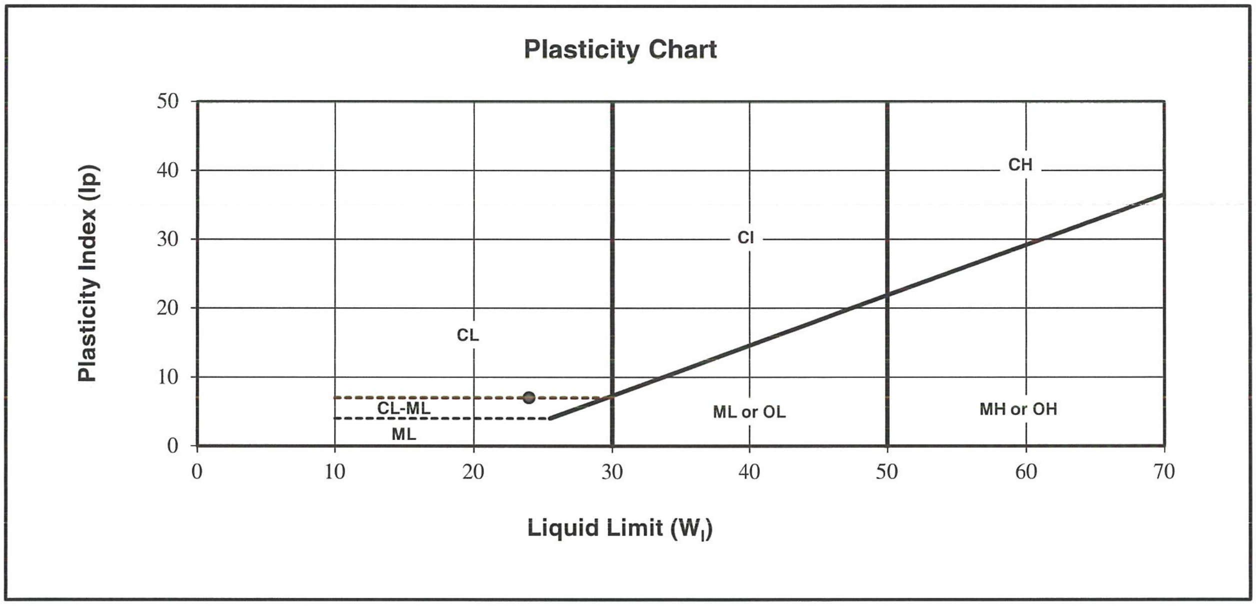
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Minto February 2015 Lab Testing	Sample Number:	58568
		Borehole Number:	15-SWC-997
Project No:	W14103546-01	Depth:	23.09 - 23.43 m
Client:	SRK Consulting (Canada) Inc.	Sampled By:	Client
		Tested By:	AMT
Attention:	Murray McGregor	Date Sampled:	February 9, 2015
Email:		Date Tested:	March 5, 2015

Sample Description: GRAVEL - sandy, silty, trace clay



Liquid Limit ($W_{1)}$:	24	Natural Moisture (%)	35.9
Plastic Limit :	17	Soil Plasticity:	Low
Plasticity Index (Ip) :	7	Mod.USCS Symbol:	CL-ML

Remarks:

Reviewed By: C.E.T.

TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

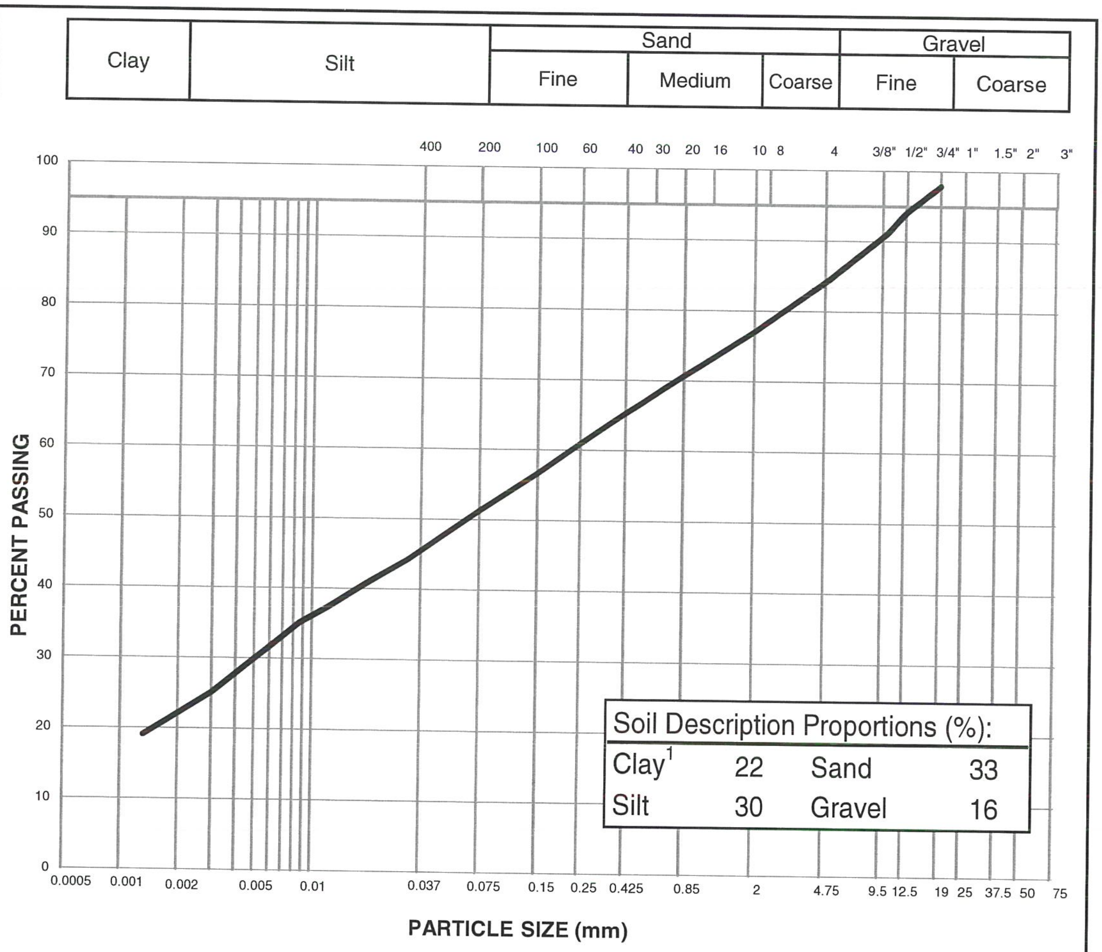
ASTM D422, C136 & C117

Project: Minto February 2015 Lab Testing
Project No.: W14103546-01
Site: Minto Mine, YT
Client: SRK Consulting (Canada) Inc.
Client Rep.: Murray McGregor
Date Tested: March 5, 2015 By: AMT
Soil Description[2]: CLAY - sandy, silty, some gravel

Sample No.: 58572
Material Type:
Sample Loc.: 15-SWC-997
Sample Depth: 41.32 - 41.67 m
Sampling Method: Grab
Date sampled: February 9, 2015
Sampled By: Client
USC Classification:
Cu: #N/A
Cc: #N/A

Moisture Content: 12.7%

Particle Size (mm)	Percent Passing
75	
50	
38	
25	
19	98
12.5	94
10	91
5	85
2	77
0.85	71
0.425	65
0.25	61
0.15	57
0.075	51.3
0.0315	44.2
0.0202	41.2
0.0120	37.3
0.0086	35.1
#N/A	28.7
0.0030	25.2
0.0013	19.1



Soil Description Proportions (%):

Clay[1]	22	Sand	33
Silt	30	Gravel	16

Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual
[2] The description is visually based & subject to EBA description protocols

Specification:

Remarks:

Reviewed By: C.E.T.

TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project: Minto February 2015 Lab Testing

Project No: W14103546-01

Client: SRK Consulting (Canada) Inc.

Attention: Murrary McGregor

Email:

Sample Number: 58572

Borehole Number: 15-SWC-997

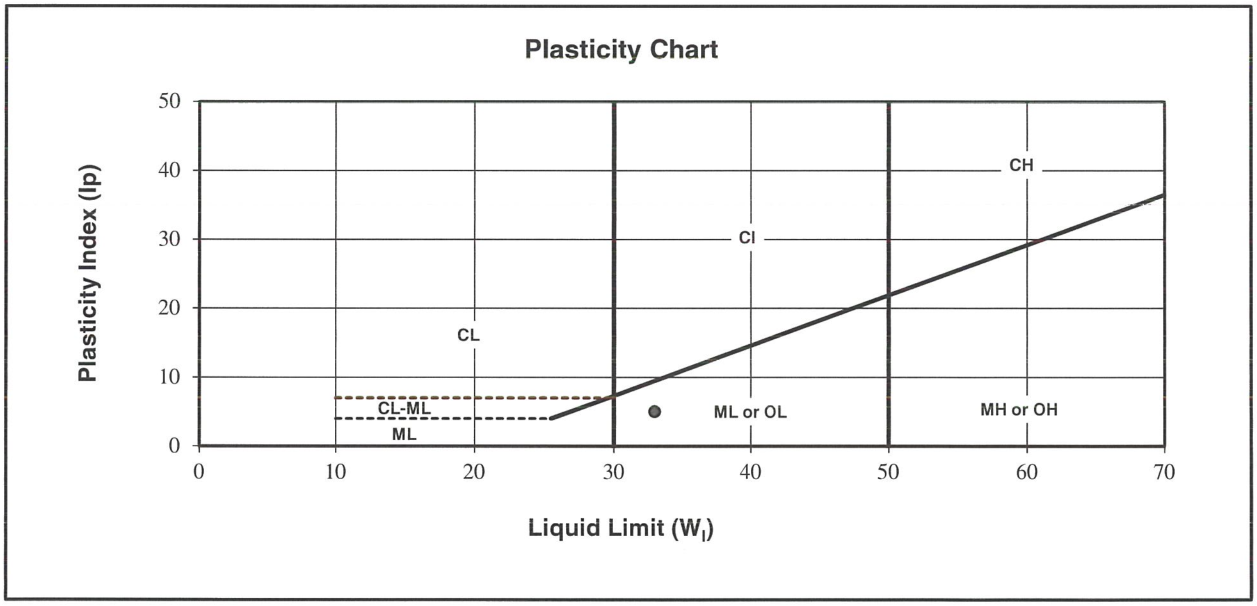
Depth: 41.32 - 41.67 m

Sampled By: Client Tested By: AMT

Date Sampled: February 9, 2015

Date Tested: March 6, 2015

Sample Description: CLAY - sandy, silty, some gravel



Liquid Limit ($W_{1)}$: 33

Plastic Limit : 28

Plasticity Index (Ip) : **5**

Natural Moisture (%) 12.7

Soil Plasticity: Low

Mod.USCS Symbol: ML

Remarks:

Reviewed By: C.E.T.

Appendix C: Minto Closure Cover Design – Cover System Erosion Analysis

SRK Consulting (Canada) Inc.
205–2100 Airport Drive
Saskatoon, SK S7L 6M6

T: +1.306.955.4778
F: +1.306.955.4750
saskatoon@srk.com
www.srk.com

Memo

To:	Project File	**Client:**	Minto Exploration Ltd.
From:	Jordan Graham, EIT, Erik Ketilson, PEng.	**Project No:**	1CM002.49
Reviewed by:	Maritz Rykaart, PEng.	**Date:**	July 26, 2016
Subject:	Minto Closure Cover Design - Cover System Erosion Analysis		

1 Introduction

SRK Consulting (Canada) Inc. (SRK) is currently undertaking the update to the closure plan for the Minto Site. Understanding the erosion process is important such that suitable landform designs can be completed, as erosion can significantly alter an engineered landscape.

The purpose of this memo is twofold: first to update the previous erosion analysis completed as part of the closure landform design and reclamation landform unit work completed by SRK (SRK, 2016); and secondly to present the potential effects of erosion due to sheet and rill water erosion that could occur on the engineered slopes at the Site, and evaluate a range of conditions and parameters to help guide the landform designs at Minto. Sheet and rill water erosion occurs as a result of flows that are not concentrated into a particular flow path.

Erosion that may occur within channel flow and the necessary protection to avoid channel erosion is not addressed in this memo.

All calculated erosion estimates are presented as “soil loss”. Soil loss is a mass or depth of eroded material that leaves the slope entirely. Therefore, the estimates within this memo are not representative of the total volume of material that is displaced by water. Although the calculation does not report material that is detached and deposited along the slope, it is factored into the overall calculation.

2 Soil Loss Estimation Methods

There are several methods available for estimating water erosion including the Universal Soil Loss Equation (USLE) (USDA, 1978), the Revised Universal Soil Loss Equation (RUSLE) Versions 1 (USDA, 1997) and 2 (USDA, 2008), the Revised Universal Soil Loss Equation for Use in Canada (RUSLEFAC) (Wall, 2002), the Water Erosion Prediction Project (WEPP) (Flanagan, 2007), SIBERIA (Willgoose, 2005), and many others. Most of these programs take several factors into account to compute soil loss such as climate, topography, soil type, vegetation, and land management practices. The key difference between these methods is that some are based on empirical data while others are based on a mathematical approach using soil physics. The USLE and its variations are largely based on empirical data, while WEPP and SIBERIA are based on soil physics. RUSLE Version 2 is based on empirical data, but uses soil physics to fill in gaps in empirical data.

The USLE was developed in 1960 and then revised in 1978 (RUSLE) by the United States Department of Agriculture. The empirical relationships in the RUSLE were modified by the Provincial and Federal Governments in 2001 for use in Canada (RUSLEFAC) (Wall et al., 2002). The RUSLEFAC uses metric units and input parameters that apply to Canadian conditions.

The soil loss analysis described within this Memo uses only the RUSLEFAC method. The RUSLEFAC has an advantage over other current methods in that it can be calculated manually and the effects related to the variability of each of the input parameter can be thoroughly evaluated.

3 RUSLEFAC Scope and Limitations

The RUSLEFAC (Wall et al., 2002) is a tool for calculating sheet flow erosion and rill erosion, and as stated in Section 2, is based on empirical data. The experimental soil plots used to develop the equations were subjected to conditions that generally reflected average annual climatic conditions. Therefore, the intent of the RUSLEFAC is to produce a numerical representation of an average annual quantity of soil loss in the units of tonnes per hectare per year, which can be converted to depth per year given an understanding of the soil's in-situ density. The equation is a useful tool for long term predictions, and can also be used for short term losses; however, due to the nature of the experimental data that was collected to develop the equations, short term estimates are likely associated with a greater degree of error.

The RUSLEFAC has the following limitations (Wall et al., 2002):

- It does not accurately estimate soil loss from a single rainfall event. However, the erosivity of a single storm can be estimated using the method described in the RUSLE;
- It does not account for erosional losses once gullies or streams form;
- Although there is some account for erosional losses due to snow melt, the equation does not account for this loss with great accuracy; and
- Freeze/thaw can cause ice lenses in soil that will affect the rate of soil loss: the RUSLEFAC does not take this into account.

Ice lensing is typically a greater issue in areas where repeated freeze/thaw cycles occur during one winter season. At the site, however, the surface material is more likely to freeze in the fall and stay frozen throughout the winter and into the spring without repetitive freeze/thaw action. Therefore, the impact of freeze-thaw on the results of the analysis for the Minto site is not considered to be a major influencing factor on erosion of the cover.

4 Design Criteria

Table 4-1 presents the soil erosion classes included in the RUSLEFAC.

Table 4-1: Soil Erosion Classes

Soil Erosion Class	Potential Soil Loss (T/ha/year)
1. Very Low (i.e. tolerable)	< 6
2. Low	6-11
3. Moderate	11-22
4. High	22-33
5. Severe	> 33

For the Minto site, in an effort to minimize erosion of cover material, there is a preference to achieve a Class 1 soil erosion class. In cases where the native Minto soils may not naturally meet a Class 1 soil erosion classification, additional mitigation measures, or support practices may be necessary to achieve very low rates of erosion. The RUSLEFAC considers Class 1 soils to have:

> "Slight to no erosion potential. Minimal erosion problems should occur if good soil conservation management methods are used... A tolerable soil loss (<6 T/ha/year) is the maximum annual amount of soil which can be removed before the long term natural soil productivity of a hillslope is adversely affected." (Wall et al., 2002).

5 RUSLEFAC Equation

The RUSLEFAC equation is calculated manually by first determining several inputs. The RUSLEFAC equation is:

$$A = RKLSCP$$

Where,

A is the potential long term average annual soil loss in tonnes per hectare. *A* can be converted to depth per year if the density of the soil is known.

R is the rainfall factor, which is expressed in energy multiplied by depth over area times duration (MJmm/hah), is calculated using the equation:

$$R = EI$$

Where *E* is the volume of rainfall and runoff (mm/ha) and *I* is the prolonged peak rate of detachment that occurs with runoff (MJ/h).

- R value contours (isoerodent maps) have been developed by the Government of Canada and are included in the RUSLEFAC document (Wall et al., 2002). To determine the R value in a particular area, interpolation between contours is often required.

- R can be calculated for a single storm event using the R equation if the storm distribution is known or can be estimated.

K is the soil erodibility factor, which is expressed in terms of area multiplied by duration over energy times depth (hah/MJmm).

- *K* is dependent on the sand content, fine sand content, silt content, organic matter content, soil structure, and permeability of the soil.
- *K* is determined by applying the appropriate parameters to the soil erodibility nomograph included in the RUSLEFAC.

L is the length of slope factor (dimensionless).

S is the slope steepness factor (dimensionless).

- *L and S* are typically presented as a single value.
- The *LS* factor represents a ratio of soil loss in comparison to a “standard plot”, which is an experimental plot that has a steepness of 9% and a slope length of 22.13 m. Charts based on experimental data are included in the RUSLEFAC document (Wall et al., 2002), which is used to determine the *LS* factor.
- The *LS* factors presented in the RUSLEFAC are representative of straight slopes, but can be manipulated to represent complex slopes (i.e. convex, concave, slopes with benches).

C is the cover factor (dimensionless).

- *C* is *dependent* on the vegetative cover and the land use.
- This factor is based on tables available in the RUSLEFAC document (Wall et al., 2002).

P is the support practice factor (dimensionless).

- The support practice factor accounts for the effects of practices that may reduce the volume or rate of runoff water by altering the flow pattern, surface grade, or direction of surface runoff.

6 RUSLEFAC Inputs

To determine the impact and sensitivity of the input variables on soil loss, a range of values were used for each variable. The ranges of input values are discussed in the following subsections. The results of the analyses using the discussed ranges of input values are included in Section 7.

6.1 Erosivity/Rainfall Factor (R)

Annual erosivity represents the average precipitation energy that causes soil loss over the course of an average year. The annual erositivity value can be used to determine the cumulative soil loss over a long period of time.

Annual R values are not shown on the Canadian Isoerodent Maps in the Yukon Territory near the Site. As discussed in Section 5, erosivity is greatly dependent on rainfall. Therefore, to determine the erosivity at the site, SRK compared total annual precipitation as rainfall to erosivity in locations with known erosivities, then applied the trends to the site (annual precipitation as rainfall for the site was taken from Environment Canada's Pelly Crossing Station). Based on the application of the trends, the erosivity at the site likely falls within the range of 200 to 240 MJmm/hah. For conservatism, SRK applied a 25% contingency to the upper end of the range. The conservatively estimated R value for the site is therefore 300 MJmm/hah.

Soil loss estimates for short term periods (i.e. single storm events) were not included in this analysis.

6.2 Soil Erodibility Factor (K)

Figure 1 illustrates the particle size distribution data plotted in accordance with the USDA Soil Textural classification, and the general site area from which that sample was obtained. Figure 1 also illustrates the average of all samples (on which the majority of this analysis is completed), and the upper (maximum) and lower (minimum) bounds, discussed in further detail in Section 7.4. The material available for cover is generally classified as a sandy loam. Material properties from 70 soil samples were averaged and evaluated using the soil erodibility nomograph (Wall et al., 2002); the resulting K value was 0.027. Approximate minimum and maximum K values were then estimated using the soil erodibility nomograph, which were 0.011 and 0.051, respectively.

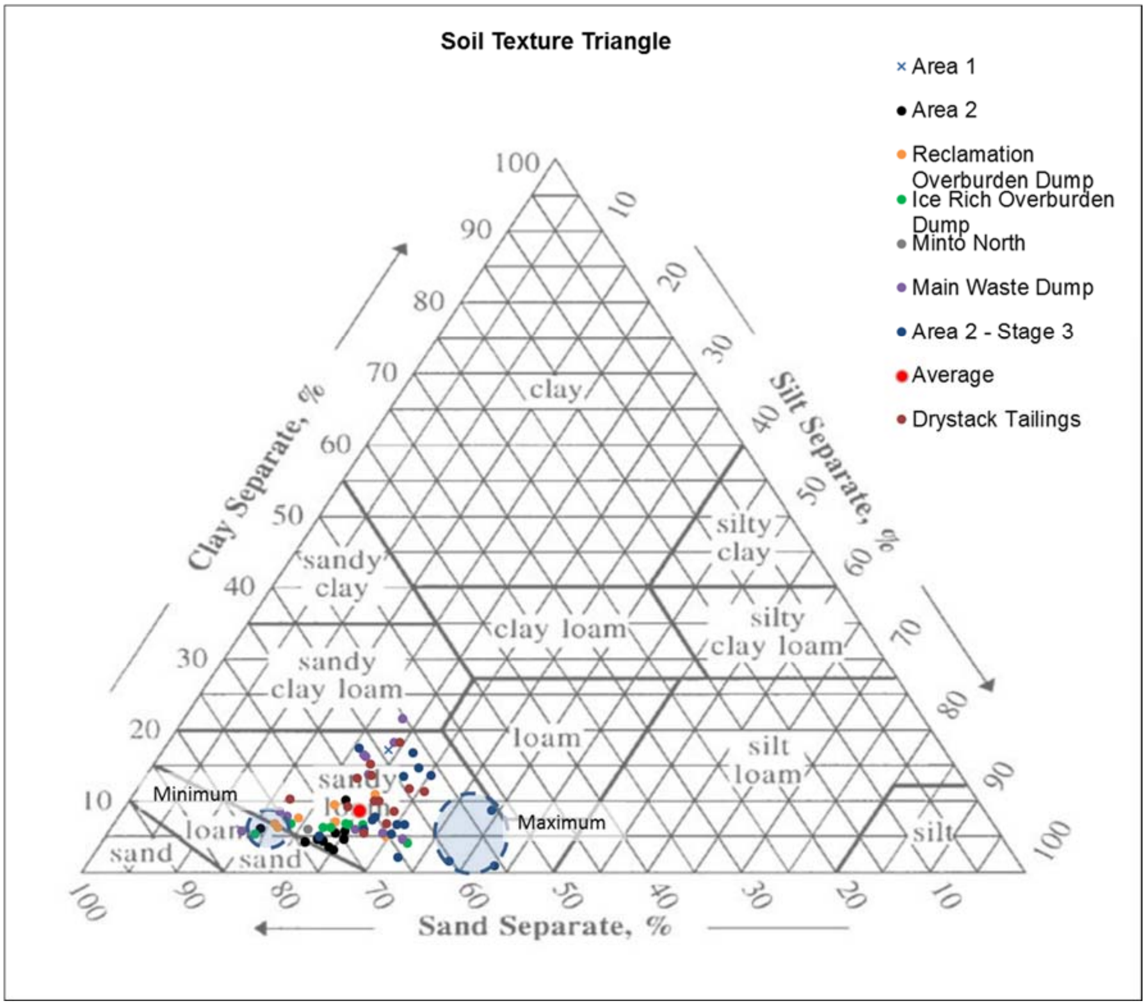


Figure 1: Soil Texture Triangle

6.3 Length and Slope Steepness Factors (L&S)

Several different straight and complex slopes were assessed. Straight slopes of 6H:1V, 5H:1V, 4H:1V, 3.5H:1V, 3H:1V, 2.5H:1V, and 2H:1V were each assessed for lengths of 10 m up to 200 m.

A variety of complex slopes were assessed that each had an average slope of 4H:1V and a length of 100 m. The complex slopes were assessed for the same length and slope to show the comparative difference between each type of slope. The complex slopes included four concave slopes (consisting of two to four straight segments), a straight slope with one 10 meter bench, and a straight slope with two 10 meter benches (the straight portions consisted of 4H:1V slopes, therefore the overall slope was substantially flatter than 4H:1V). The types of slopes that were assessed are illustrated in Figure 2. The figure indicates the horizontal to vertical slopes, but it is not drawn to scale.

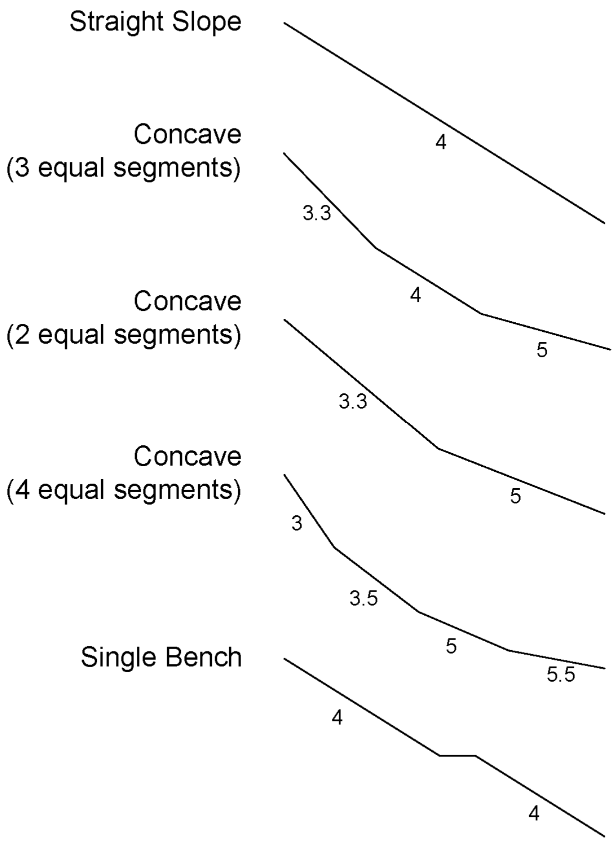


Figure 2: Types of Slopes Assessed

6.4 Cover Factor (C)

The *C* factor was determined using Table C-5 in the RUSLEFAC. Values decrease with lesser cover (yielding lesser soil loss). The value for bare, undisturbed soil with no vegetative canopy (canopy is considered having plants/weeds/shrubs of 0.5 m height or greater) or surface cover is 0.45. The value for 40% small, short-rooted plant coverage with no canopy is 0.15, and the value for 40% small, short-rooted plant coverage with a taller plant canopy is 0.13. Increasing small, short-rooted plant coverage to 80% with canopy decreases the cover factor to 0.04.

6.5 Support Practice Factor (P)

The base case P factor was to have no impact the on the soil loss equation and was made equal to one. The support practice factor is proportional to soil loss (i.e. a support practice factor of zero will yield zero soil loss).

Short term support practices could be incorporated into the design to support the process of establishing vegetation on the slopes. The support practices are likely to include slope texturing, sediment fencing (or other flow velocity reduction measures), and/or the use of rolled erosion control products. The respective support practice factors are 0.9, 0.6, and 0.1 respectively (Alberta, 2011). As stated, although not included as base case conditions, the effect of support practices was included as a sensitivity to demonstrate the impact in reducing soil loss.

7 Results and Discussion

The figures within this section show soil loss in units of tonnes per hectare per year (T/ha/year) and in millimeters per year (mm/year). The depth per year values were determined using an average dry density of 1.6 T/m³. The depth represents the average depth of soil loss over the entire erodible surface area. The guideline values for the Class 1 soil erosion class of 6 T/ha/year corresponds to a depth of 0.35 mm/year. The guideline values are not shown on Figures 5, 6, and 7, as these figures are intended to show the relative difference of how certain parameters affect erosion, and were not necessarily intended to show the design slopes that will be selected at the site.

7.1 Straight Slopes

Figure 3 illustrates the expected straight slope soil loss with the average available material if no vegetative cover is established. None of the scenarios meet the target of 6 T/ha/year.

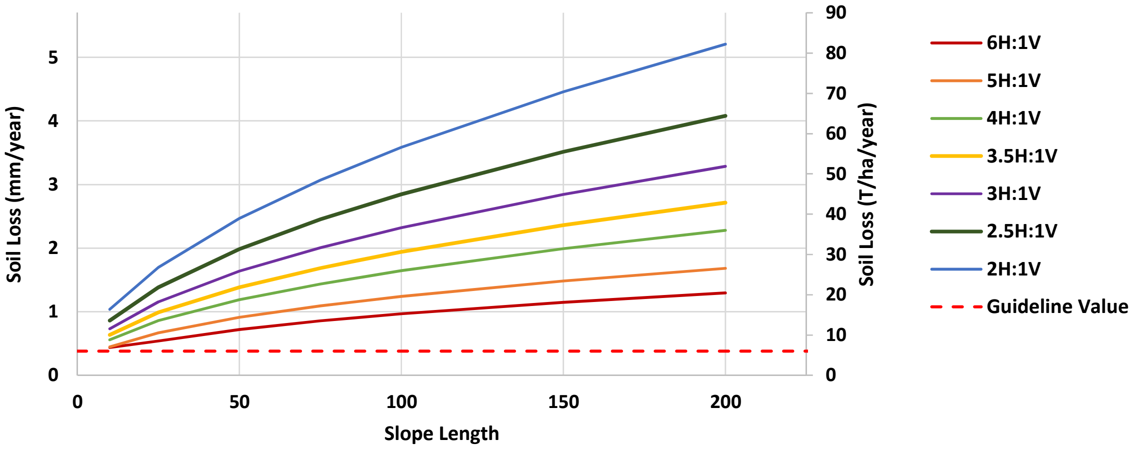


Figure 3: Straight Slopes using Average Material with no Vegetative Cover

7.2 Effects of Vegetation

Figure 4 illustrates the expected straight slope soil loss with 80% small, short-rooted plant coverage and no vegetative canopy. Comparing Figure 3 and Figure 4 shows that established vegetation significantly reduces soil loss due to water erosion. Most of the assessed slope conditions meet the target of 6 T/ha/year.

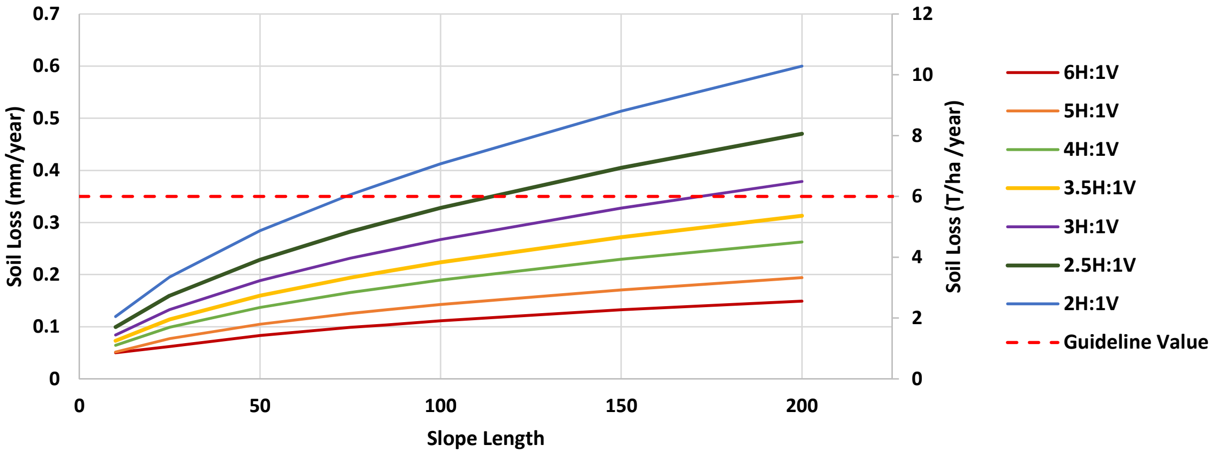


Figure 4: Straight Slopes using Average Material with 80% Small, Short-rooted Plant Coverage and No Vegetative Canopy

Figure 5 shows the effects that increased vegetation coverage have on a particular slope. The figure shows that achieving at least some vegetation coverage (20%) reduces soil loss due to erosion by a significant margin.

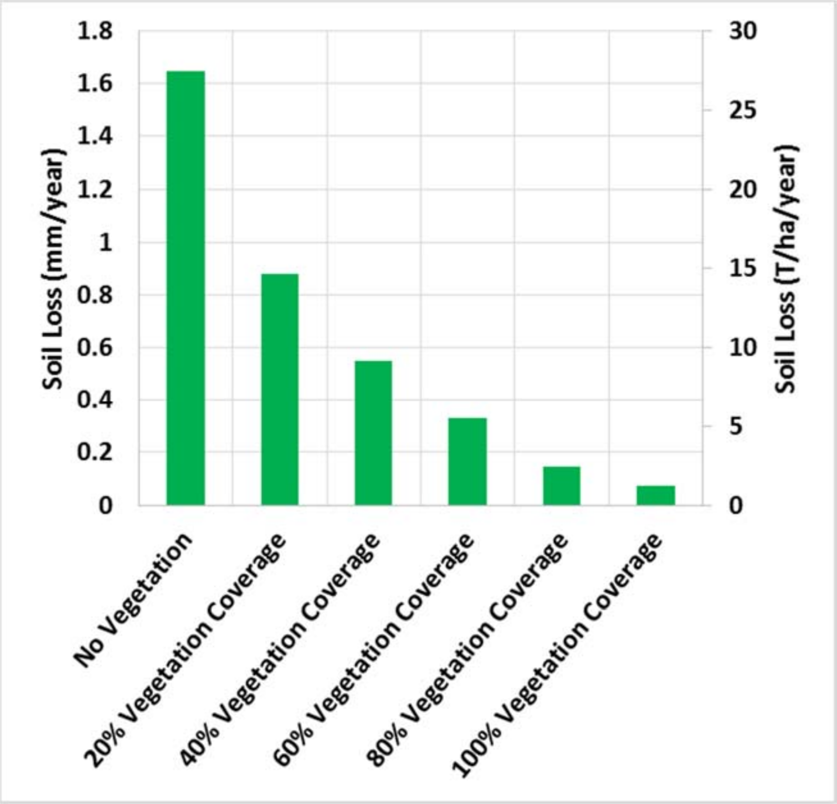


Figure 5: The Effects of Vegetation Coverage on a 4H:1V, 100 m Slope with Average Material

7.3 Effects of Complex Slopes

The soil losses for 100 m long complex slopes at 4H:1V with no vegetative cover and average site material are shown in Figure 6. The figure indicates that each of the complex slopes yields less soil loss than an equivalent straight slope. Complex slopes were somewhat effective at reducing soil loss in this analysis: soil loss was approximately 9% less on concave slopes than on straight slopes. Although only 100 m, 4H:1V slopes are presented, SRK has determined via the RUSLEFAC, the reduction in soil loss on complex slopes is similar for other slopes and slope lengths in the same order of magnitude (i.e. 5H:1V slopes, 50 to 125 m slope lengths). The soil loss reductions are expected to be less similar to those presented if the slope length or steepness is increased substantially.

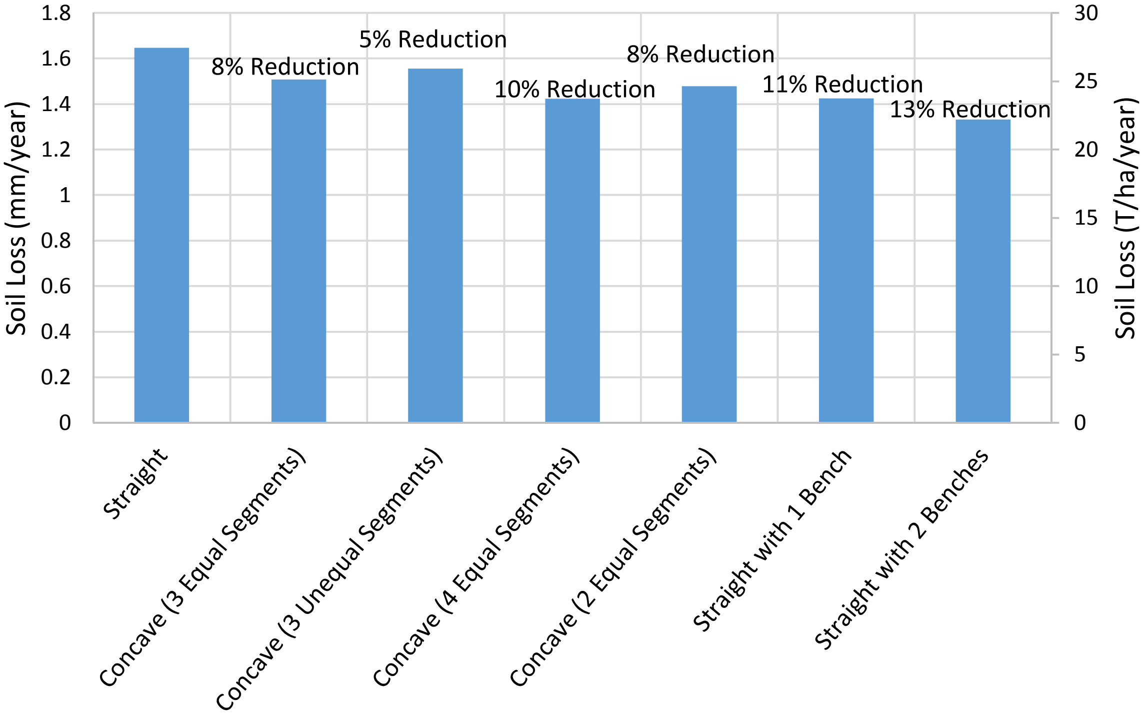


Figure 6: Complex Slope Comparison (100 m Long at 4H:1V and No Vegetative Cover)

7.4 Effects of Soil Type

The effects of soil type are presented in Figure 7. Each of the soil loss estimates are based on 100 m long 4H:1V straight slopes, and no vegetative cover. The figure indicates the range in erosion susceptible material available on site. It is important that material susceptibility to erosion be considered in design stage of the cover. By choosing material that is more susceptible than the average material available on site, erosion estimates can increase by as much as 100%. More erosion susceptible material contains a greater percentage of silt and fine sand, while less erodible material contains less silt and fine sand. The classification of these soils is described in Section 6.2.

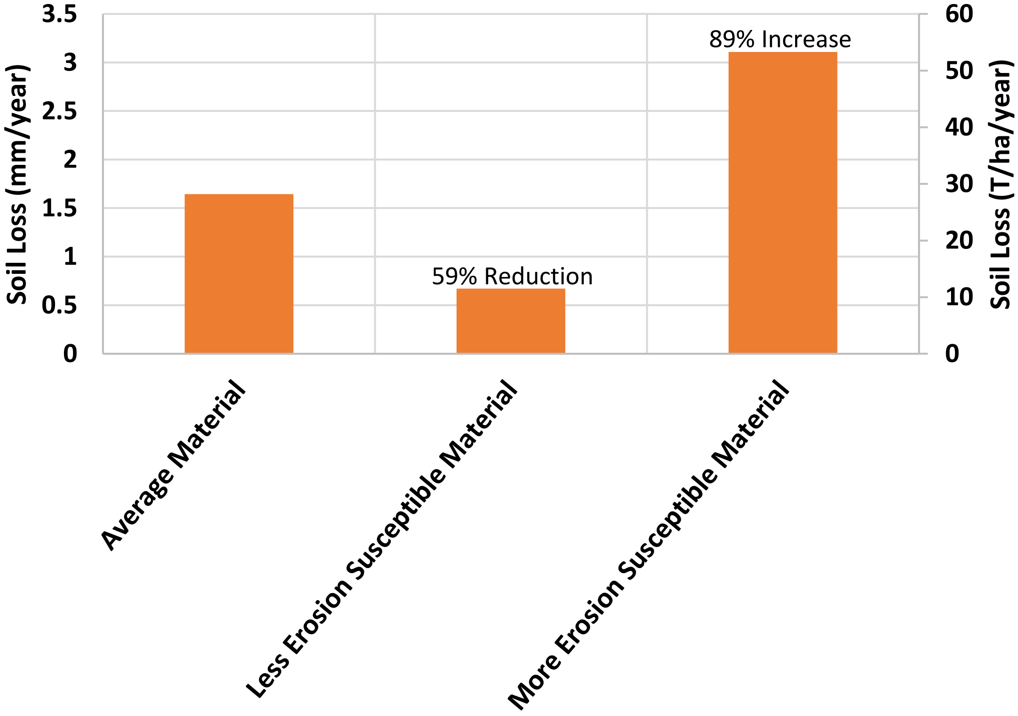


Figure 7: Soil Type Comparison (Based on 100 m Long 4H:1V Straight Slopes)

7.5 Effects of Support Practice Factor

The effects of the support practice factor were evaluated on non-vegetated, 100 m long, 4H:1V slope, covered with average material available on site. The results are presented in Figure 8. The figure shows that through the use of support practices, also commonly referred to as the incorporation of microtopography, the estimates of erosion can be decreased to the target of 6 T/ha/year even without the establishment of vegetation. The use of soil texturing alone will not reduce the rate of erosion to the target; rolled erosion control products would be required to meet the target without vegetation. Sediment fencing is grouped together with wattles as velocity reducers, as their effectiveness in reducing erosion is similar.

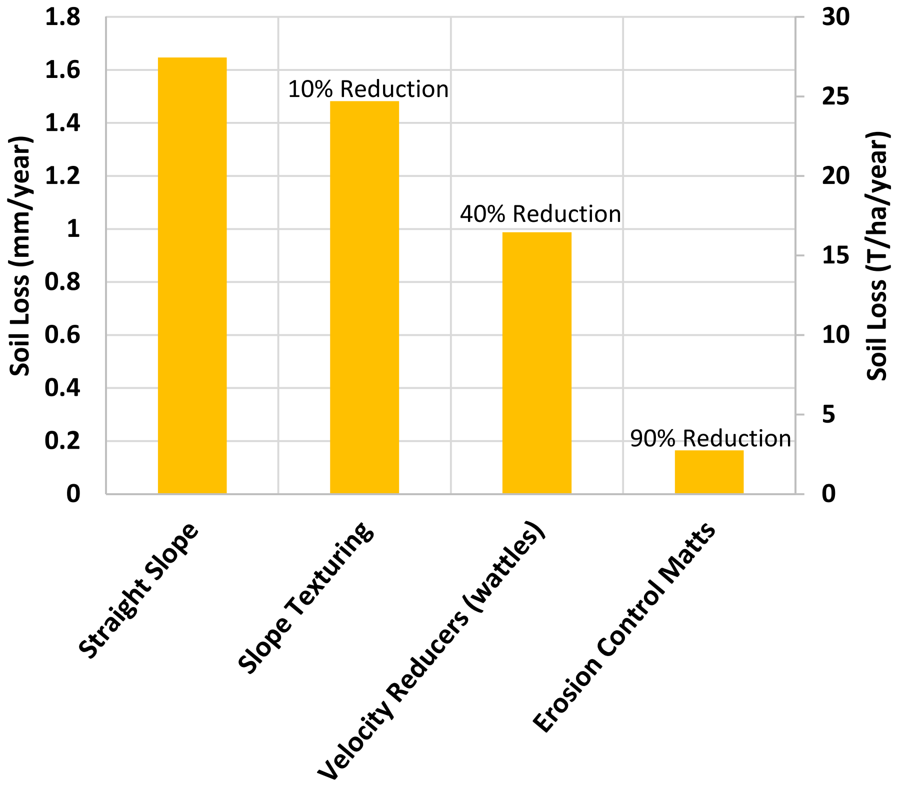


Figure 8: Support Practice Comparison (No Vegetation)

8 Total Soil Loss

Soil loss over the course of the design life was calculated to determine whether the average depth of soil loss would reduce the initial cover thickness to below the required cover thickness. Annual soil loss due to water erosion was multiplied by 100 years to determine design life soil loss, which is presented for several straight slope scenarios in Table 8-1. Average annual soil loss (in T/ha/year) is also presented in the table.

Table 8-1: Calculated Water Erosion Design Life Soil Loss

Slope Condition		**Design Life Soil Loss (mm) per Slope Length**							
		50 m		**85 m**		**100 m**		**150 m**	
		Annual (T/ha/yr)	100 yrs (cm)	Annual (T/ha/yr)	100 yrs (cm)	Annual (T/ha/yr)	100 yrs (cm)	Annual (T/ha/yr)	100 yrs (cm)
Non-Vegetated	**2.5H:1V**	31.8	19.9	41.8	26.1	45.6	28.5	56.2	35.1
	3H:1V	26.2	16.4	34.1	21.3	37.1	23.2	45.5	28.4
	3.5H:1V	22.1	13.8	28.6	17.9	31.0	19.4	37.8	23.6
	4H:1V	19.0	11.9	24.3	15.2	26.4	16.5	31.9	19.9
	5H:1V	14.6	9.1	18.4	11.5	19.8	12.4	23.7	14.8
Vegetated (80% Short-Rooted Plant Coverage)	**2.5H:1V**	3.7	2.3	4.8	3.0	2.3	3.3	6.5	4.1
	3H:1V	3.0	1.9	3.9	2.5	4.3	2.7	5.2	3.3
	3.5H:1V	2.6	1.6	3.3	2.1	3.6	2.2	4.4	2.7
	4H:1V	2.2	1.4	2.8	1.8	3.0	1.89	3.7	2.3
	5H:1V	1.7	1.1	2.1	1.3	2.3	1.4	2.7	1.7

9 References

Alberta Transportation (Alberta, 2011). Erosion and Sediment Control Manual, June 2011: http://www.transportation.alberta.ca/4626.htm

Clark, D. Geomorphic Reclamation in New Mexico: A Regulator's Perspective. Presentation, New Mexico Mining and Minerals Division. Retrieved From: http://www.landforma.com/wp-content/uploads/2009/04/Clark-2008-Powerpoint.pfd

Flanagan, D.C, Gilley, J.E., Franti, T.G. (Flanagan, 2007). Water Erosion Prediction Project (WEPP): Development History, Model Capabilities, and Future Enhancements. American Society of Agricultural and Bilogical Engineers. Vol. 50(5): 1603-1612. 2007.

United States Department of Agriculture (USDA, 1978). Predicting Rainfall Erosion Losses – A Guide to Conservation Planning. Agriculture Handbook No. 573.

United States Department of Agriculture (USDA, 1997). Predicting Soil Erosion by Water: A guide to Conservation Planning with the Revised Universal Soil Loss Equation (RUSLE). Agriculture Handbook No. 703.

USDA – Agricultural Research Service (USDA, 2008). DRAFT User's Reference Guide – Revised Universal Soil Loss Equation Version 2 (RUSLE2). May 15, 2008.

Wall, G.J., D.R. Coote, E.A. Pringle and I.J. Shelton (editors). 2002. RUSLEFAC –Revised Universal Soil Loss Equation for Application in Canada: A Handbook for Estimating Soil Loss from Water Erosion in Canada. Research Branch, Agriculture and Agri-Food Canada. Ottawa. Contribution No. AAFC/AAC2244E. 117pp.

Willgoose, G. 2005. User Manual for SIBERIA (Version 8.30). http://www.telluricresearch.com/siberia_8.30_manual.pdf. Accessed June 2016.

Wischmeier and Smith, 1978. Predicting Rainfall Erosion Losses. A Guide to Conservation Planning. United States Department of Agriculture.

Sawatsky, L.F., Beersing, A. (2014). Configuring Mine Disturbed Landforms for Long-Term Sustainability. Paper presented at Mine Closure Solutions Conference, April 26-30, Ouro Preto, Brazil.

Appendix D: Minto Closure Cover Design – Stability Assessment

SRK Consulting (Canada) Inc.
2200–1066 West Hastings Street
Vancouver, BC V6E 3X2

T: +1.604.681.4196
F: +1.604.687.5532
vancouver@srk.com
www.srk.com

Memo

To:	File	**Client:**	Minto Exploration Ltd.
From:	Kaitlyn Kooy, Erik Ketilson, PEng	**Project No:**	1CM002.049
Reviewed by:	Peter Mikes, PEng	**Date:**	July 16, 2016
Subject:	Minto Closure Cover Design – Stability Assessment		

1 Introduction

The Minto Mine requires closure covers to be placed over the waste rock and tailings facilities. The purpose of this memo was to evaluate the cover stability of the closure covers at various slope angles, and to identify if some of the available borrow material is better suited to some areas versus others. The global stability of the operational design of each of the waste facilities, under both operations and closure conditions, have been previously evaluated in their respective design documents. Generally, closure configurations will result in resloped / landscaped configurations with shallower slopes; however, the global stability is not considered in this analysis, but may be considered further following the development of final re-grading plans.

2 Conceptual Model and Problem Definition

The physical stability of a cover is a function of the normal stress over the cover, the internal shear strength of the cover material, the interface shear strength between the underlying material and the cover material, as well as the seepage forces present within the cover. Generally in this analysis, a lower strength cover material is placed over a material with higher strength. Therefore, the critical failure mode is a failure that occurs along the interface of the two materials, and is controlled by the shear strength in the weaker cover material.

3 Methodology

The cover stability analysis was carried out after the development of the conceptual model and primary failure modes were defined.

The base case model was define for two plausible cover materials (residuum and silty sand), with a variety of slopes ranging from 2.5H:1V to 5H:1V. The base case models included:

- 0.5 m thick layer of cover material;
- A foundation consisting of an impenetrable “impenetrable base” where the resulting failure occurred either within the cover, or along the interface;

- A piezometric surface in the cover applied at half the cover thickness; and
- Slopes of 2.5H:1V; 3H:1V; 4H:1V, and 5H:1V.

Sensitivity analysis were completed, considering:

- A 1.0 m thick layer of cover material;
- A foundation consisting of compacted tailings and waste rock;
- A piezometric surface in the cover applied at the base of the cover, and the top of the cover; and
- Slopes of 2.5H:1V and 4H:1V for waste rock slopes, and 4H:1V only for compacted tailings as this scenario only occurs at one location, and regraded slopes are not anticipated to be greater than 4H:1V.

The piezometric surface at the top of the cover was intended to represent conditions of prolonged rain, or during spring when the cover thaws, and the underlying material is frozen, at which point the cover could experience short term periods with a high piezometric level before the foundation is able to drain.

The geotechnical properties of the proposed cover borrow and the ground conditions were determined based on soil testing of samples collected at Minto Mine over several field programs as compiled by SRK in 2014 (SRK 2014).

4 Stability Analysis

4.1 General

The stability analysis for the cover was carried out using the Morgenstern-Price limit equilibrium method. Other methods such as the Bishop Simplified, Janbu Simplified, and Spencer were also used in the stability analysis to confirm the results were not sensitive to any specific method. The analysis was completed using the commercially available limit equilibrium slope stability software package SLOPE/W, a component of GeoStudio 2012 (version 8.15.5.11777) developed by Geo-Slope International. The entry-exit method of determining the slope failure surface was specified, and pore water pressure conditions were generated from a specified piezometric line.

4.2 Design Criteria

The analysis was evaluated based on a factor of safety (FOS) approach. The FOS is defined as the ratio of the forces tending to resist failure over the forces tending to cause failure along a given slip surface. The target FOS values are based on the design guidelines for stability of dump surfaces (Piteau, 1991), which recommend a short term (during construction) FOS of 1.0, and a long term (reclamation – abandonment) FOS of 1.1; provided there is a high level of confidence in the critical analysis parameters; conservative interpretation of conditions and assumptions; minimal consequences of failure; rigorous stability analysis method; stability analysis method simulates physical conditions well; and high level of confidence in critical failure mechanism(s).

A target FOS of 1.1 has been adopted for cover conditions.

4.3 Model Configuration

Models were developed to represent two cover scenarios as a base case, and several sensitivities, as described in Table 1. A total of four different slopes were modelled at an approximate slope height of 40 m: 2.5H:1V; 3H:1V; 4H:1V; and, 5H:1V. The length of the slope modelled was approximately 100 m; 125 m; 160 m; and 200 m, respectively.

Table 1: Cover Scenarios

Scenario	Cover	Base / Cover Foundation	Piezometric Level	Slope	Cover Thickness
Base case					
1	Residuum	Impenetrable	Midway through cover	2.5H:1V, 3H:1V, 4H:1V & 5H:1V	0.5 m
2	Silty Sand	Impenetrable	Midway through cover	2.5H:1V, 3H:1V, 4H:1V & 5H:1V	0.5 m
Sensitivity Analysis					
1a	Residuum	Impenetrable	Midway through cover	4H:1V	1.0 m
1b	Residuum	Impenetrable	Base of cover	4H:1V	0.5 m
1c	Residuum	Impenetrable	Top of cover	4H:1V	0.5 m
1d	Residuum	DSTSF compacted tailings	Midway through cover	4H:1V	0.5 m
1e	Residuum	Waste rock	Midway through cover	4H:1V	0.5 m
1f	Residuum	DSTSF compacted tailings	Top of cover	4H:1V	0.5 m
1g	Residuum	Waste rock	Top of cover	4H:1V	0.5 m
1h	Residuum	Waste rock	Base of cover	2.5H:1V	0.5 m
1i	Residuum	Waste rock	Top of cover	2.5H:1V	0.5 m
2a	Silty Sand	Impenetrable	Midway through cover	4H:1V	1.0 m
2b	Silty Sand	Impenetrable	Base of cover	4H:1V	0.5 m
2c	Silty Sand	Impenetrable	Top of cover	4H:1V	0.5 m
2d	Silty Sand	DSTSF compacted tailings	Midway through cover	4H:1V	0.5 m
2e	Silty Sand	Waste rock	Midway through cover	4H:1V	0.5 m

Scenario	Cover	Base / Cover Foundation	Piezometric Level	Slope	Cover Thickness
2f	Silty Sand	DSTSF compacted tailings	Top of cover	4H:1V	0.5 m
2g	Silty Sand	Waste rock	Top of cover	4H:1V	0.5 m
2h	Silty Sand	Waste rock	Base of cover	2.5H:1V	0.5 m
2i	Silty Sand	Waste rock	Top of cover	2.5H:1V	0.5 m

4.4 Material Properties

The material properties are presented in Table 2. The material parameters were selected from the compilation of Minto Mine soil testing results in SRK (2014). Bedrock with infinite strength parameters was used to model the base condition to restrict the failure surface to the cover material, and in order to assess the stability of the cover independently from the base material.

Table 2: Stability Assessment Material Properties

Material	Constitutive Strength Model	Description	Bulk Density (T/m^3)	Friction Angle (º)	Cohesion (kPa)
Cover	Mohr Coulomb	Residuum	1.9	35	0
Cover	Mohr Coulomb	Silty Sand	1.8	30	0
Foundation – Bedrock	Infinite Strength	Bedrock	N/A	N/A	N/A
Foundation – Waste Rock	Mohr Coulomb	Waste Rock	2.1	37	0
Foundation – Tailings	Mohr Coulomb	DSTSF compacted tailings	1.9	35	0

4.5 Results

4.5.1 Base Case

The calculated base case results are presented in Table 3.

Table 3: Calculated Factor of Safety for Base Case Scenarios

Scenario	Cover	Base / Cover Foundation	Piezometric Level	Cover Thickness	Slope	Factor of Safety
1	Residuum	Impenetrable	Midway through cover	0.5 m	2.5H:1V	1.2
					3H:1V	1.5
					4H:1V	2.0
					5H:1V	2.4
2	Silty Sand	Impenetrable	Midway through cover	0.5 m	2.5H:1V	0.9
					3H:1V	1.2
					4H:1V	1.6
					5H:1V	2.0

4.5.2 Sensitivity Analysis

A sensitivity analysis was carried out to demonstrate how sensitive the model results were to various aspects of the model configuration. The results are presented in Table 4.

Table 4: Calculated Factor of Safety for Sensitivity Scenarios

Scenario	Cover	Base / Cover Foundation	Piezometric Level	Cover Thickness	Slope	Factor of Safety
1a	Residuum	Impenetrable	Midway through cover	1.0 m	4H:1V	2.0
1b	Residuum	Impenetrable	Base of cover	0.5 m	4H:1V	2.8
1c	Residuum	Impenetrable	Top of cover	0.5 m	4H:1V	1.3
1d	Residuum	DSTSF compacted tailings	Midway through cover	0.5 m	4H:1V	1.4
1e	Residuum	Waste rock	Midway through cover	0.5 m	4H:1V	1.7
1f	Residuum	DSTSF compacted tailings	Top of cover	0.5 m	4H:1V	1.3
1g	Residuum	Waste rock	Top of cover	0.5 m	4H:1V	1.4
1h	Residuum	Waste rock	Base of cover	0.5 m	2.5H:1V	1.7
1i	Residuum	Waste rock	Top of cover	0.5 m	2.5H:1V	0.7
2a	Silty Sand	Impenetrable	Midway through cover	1.0 m	4H:1V	1.7
2b	Silty Sand	Impenetrable	Base of cover	0.5 m	4H:1V	2.3
2c	Silty Sand	Impenetrable	Top of cover	0.5 m	4H:1V	1.0
2d	Silty Sand	DSTSF compacted tailings	Midway through cover	0.5 m	4H:1V	1.4
2e	Silty Sand	Waste rock	Midway through cover	0.5 m	4H:1V	1.6
2f	Silty Sand	DSTSF compacted tailings	Top of cover	0.5 m	4H:1V	1.1
2g	Silty Sand	Waste rock	Top of cover	0.5 m	4H:1V	1.2

Scenario	Cover	Base / Cover Foundation	Piezometric Level	Cover Thickness	Slope	Factor of Safety
2h	Silty Sand	Waste rock	Base of cover	0.5 m	2.5H:1V	1.4
2i	Silty Sand	Waste rock	Top of cover	0.5 m	2.5H:1V	0.6

5 Discussion

5.1 General

Generally, the analysis indicates that:

- The base case scenarios meet the minimum target factor of safety of 1.1, with the exception of the placement of a silty sand cover material on a 2.5H:1V slope.
- The model indicates that a thicker cover of 1.0 would result in a similar factor of safety to that calculated for a 0.5 m thick cover.
- A decrease in the peizometric level would increase the factor of safety, while an increase in the piezometric level would decrease the factor of safety.
- When the cover foundation material were varied, the minimum factor of safety decreased in the case of utilizing a residuum cover; but only decreased for a silty sand cover over DSTSF compacted tailings and stayed the same for the waste rock. This may be counterintuitive, but due to the automatic generation of slip surfaces, when the foundation material were modified the model reported other critical slip surfaces, and therefore the results do not directly compare slip surfaces.
- Additional analyses to evaluate the impact of a variable piezometric surface in the cover placed over a 2.5H:1V slope were completed as the base case conditions for the silty sand cover did not meet the minimum target factor of safety. The results indicate that increases in the piezometric surface decreased the factor of safety below the base case, while decreases in the piezometric surface decreased the factor of safety above the target criteria.

For all slope configurations, it is suggested that upon completion of the final re-grading piles, detailed stability analysis be completed to confirm the factor of safety will be a target criteria of 1.1, and if determined warranted, pore pressures should be developed using seepage analysis software.

Pertinent discussions relevant to each slope configurations are discussed in the following sections.

5.2 2.5H:1V Slope

The stability results indicate that for a 2.5H:1V slope, a cover constructed of residuum material in preferable over a cover constructed of a siltier material due to its higher friction angle. As the water level in the cover increases, the factor of safety decreases, and should the water table be observed at the top of the cover, it is likely that the material would not be stable.

Typically, the entire slope of a cover does not become saturated; however, for illustration purposes, this approach was adopted. The water level within the cover is influenced by many factors, and in the case of a cover placed on a 2.5H:1V slope – this condition is only anticipated to potentially occur over waste rock piles. The waste rock would be expected to act as a drain to the cover, and localized areas at the base of the slope may become saturated; however, this can be mitigated through measures such as a base drain at the ground/cover interface, or alternate measures such as additional material placement at the toe that can provide additional buttressing.

Currently, the main waste rock dump has 2.5H:1V slopes, and has been covered. The cover material does not appear to be prone to continued sloughing or cover failure, and it is likely that the waste rock below drains the cover and limits the potential for the piezometric level to increase to such a point that the seepage forces influence the cover stability below unity. Vegetation on the cover varies from well covered, to sparsely covered.

5.3 3H:1V Slope

The stability results indicate that for a 3H:1V slope, a cover can be constructed of either cover material, and achieve factors of safety above unity. Slopes of this angle are anticipated to occur on the waste rock piles, and similar to the discussion presented in Section 5.2, the foundation materials would be waste rock, and anticipated to limit the development of a high piezometric surface in the cover.

5.4 4H:1V and 5H:1V Slope

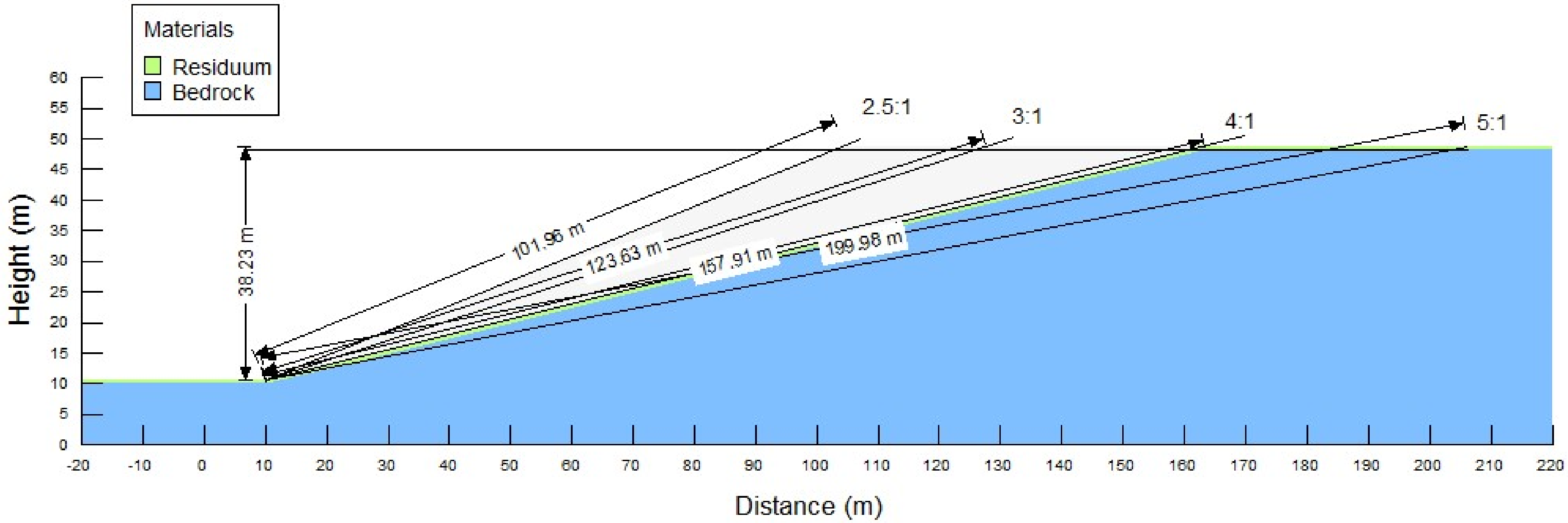
The stability results indicate that for a 4H:1V or a 5H:1V slope, a cover can be constructed of either cover material. The only potential areas of concern exist with 4H:1V slopes in conditions where silty sand cover material is placed, and the piezometric level reaches the top of the cover; however, when the similar condition was analyzed considering compacted tailings or waste rock as foundation material rather than an impenetrable base, the factors of safety increased to meet the design criteria.

6 References

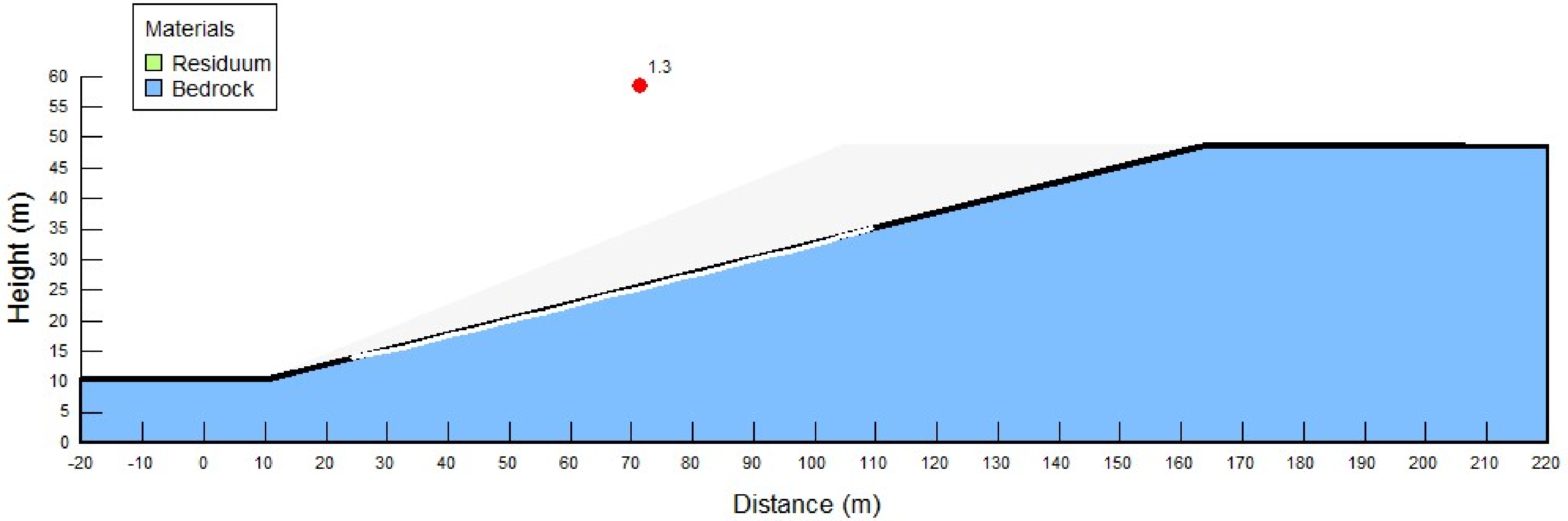
Piteau Associates Engineering Ltd., 1991. Investigation and Design of Mine Dumps, Interim Guidelines. Prepared for the British Columbia Mine Dump Committee. May 1991.

SRK Consulting (Canada) Inc. 2014. Review of geotechnical strength properties at Minto Mine. Memo prepared for Minto Explorations Ltd. SRK project number 1CM002.018. July 17, 2014.

Attachment 1 – Stability Analysis Results



Input



Results

srk consulting

capstone
MINTO MINE
OPERATED BY MINTO EXPLORATIONS LTD.

Stability Assessment

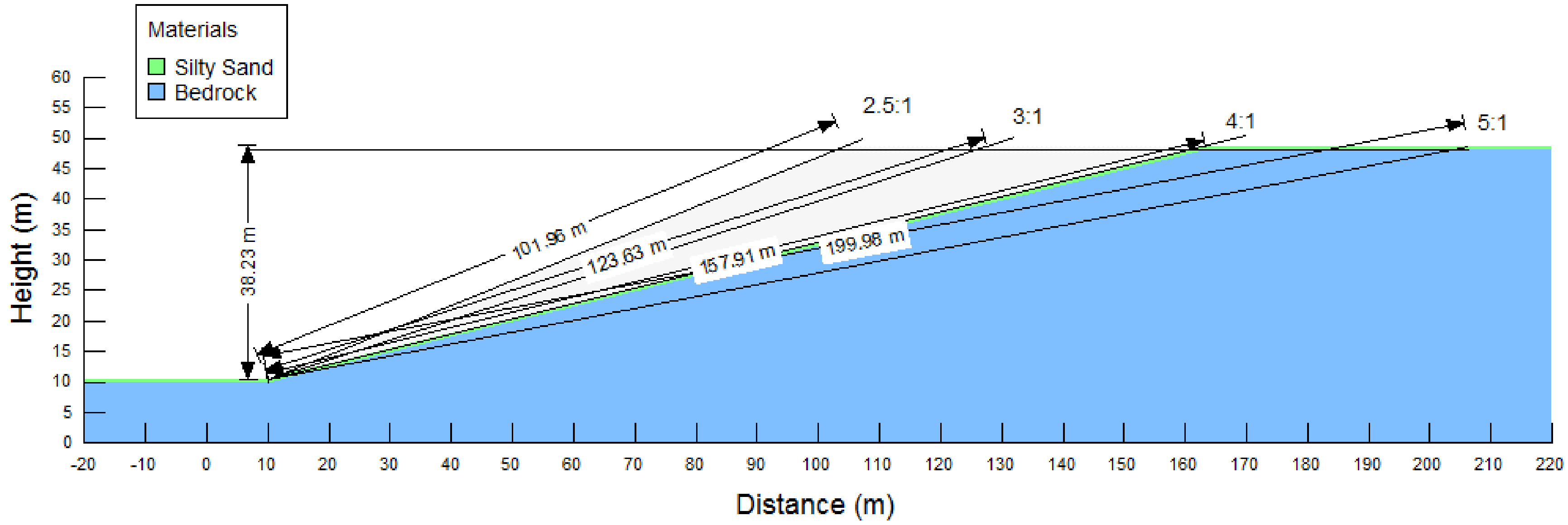
Scenario 1

Job No: 1CM002.049

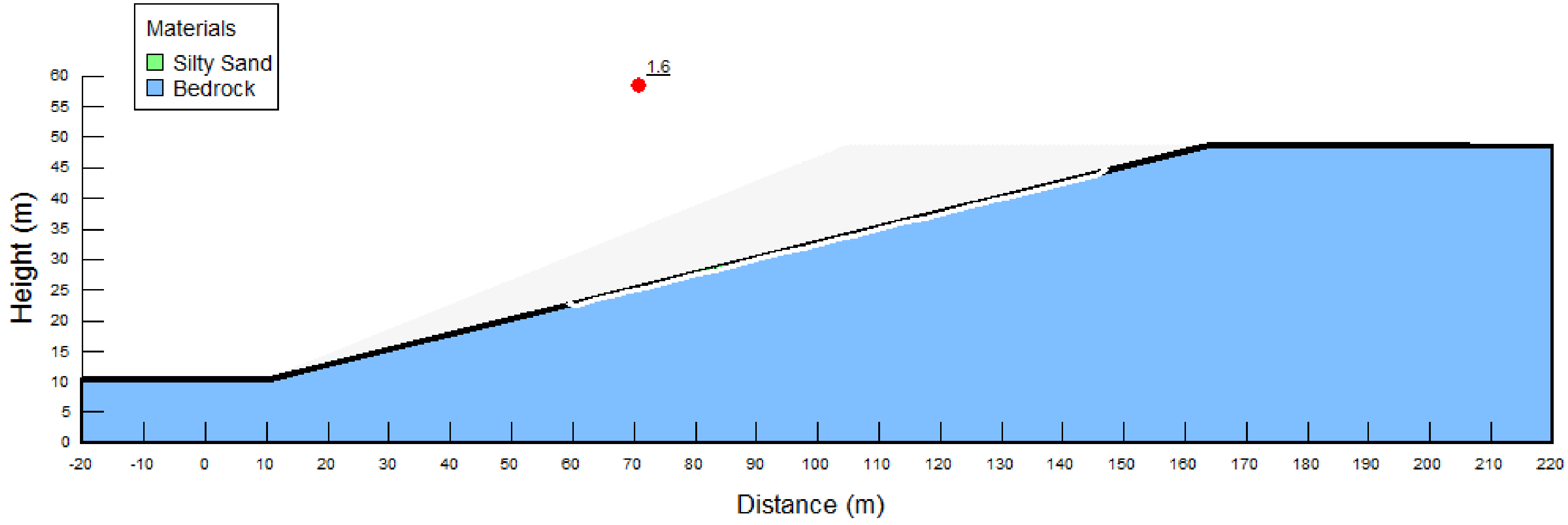
Filename: StabilityAnalysis-Figures-1CM002-049_REV0-EK.pptx

Minto Closure Cover Design

Date:	Approved:	Figure:
July 2016	EK	**1**



Input



Results

srk consulting

capstone
MINTO MINE
OPERATED BY MINTO EXPLORATIONS LTD.

Stability Assessment

Scenario 2

Job No: 1CM002.049

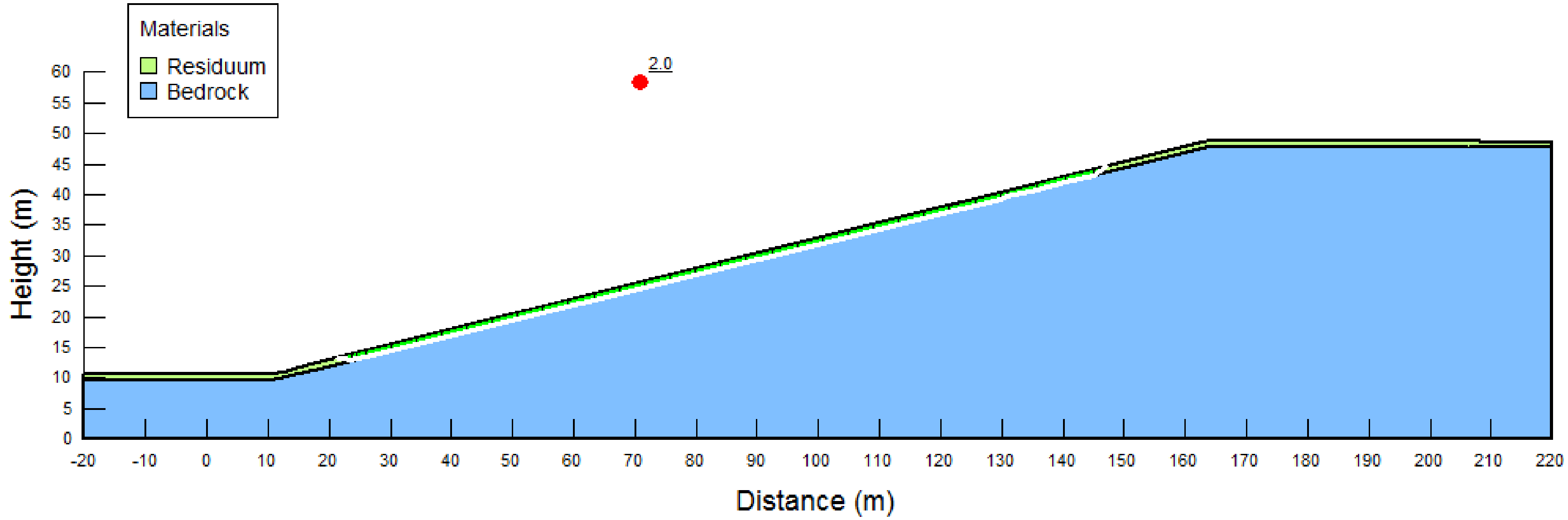
Filename: StabilityAnalysis-Figures-1CM002-049_REV0-EK.pptx

Minto Closure Cover Design

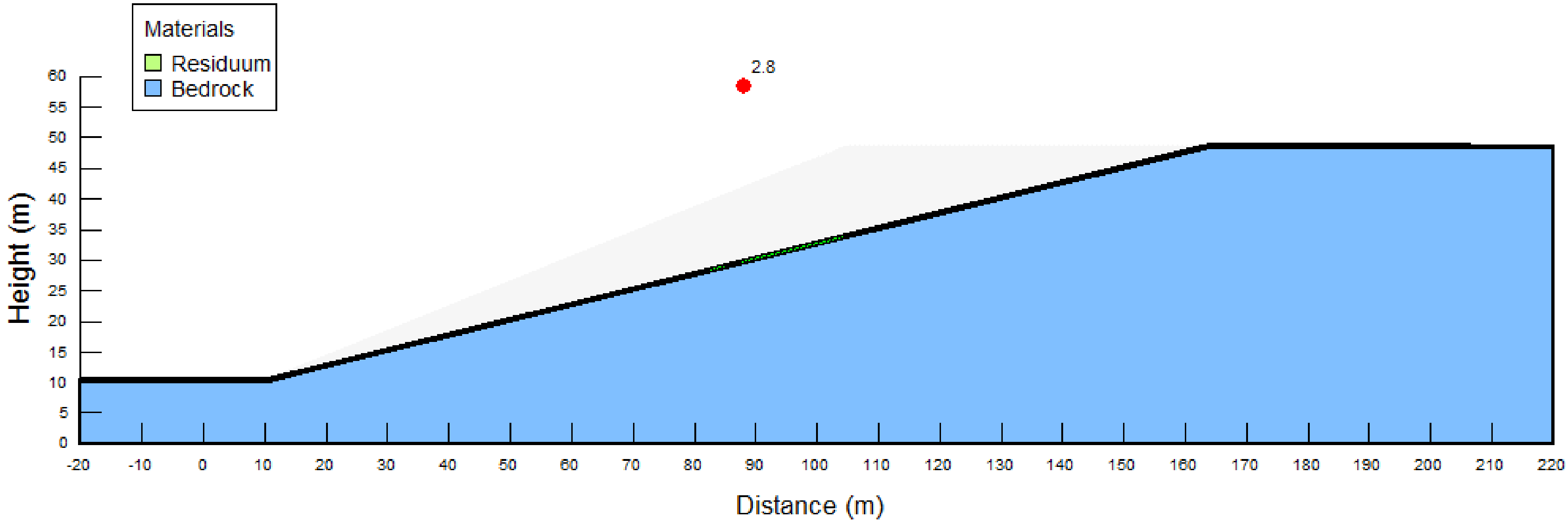
Date: July 2016

Approved: EK

Figure: 2



Scenario 1a



Scenario 1b

srk consulting

capstone
MINTO MINE
OPERATED BY MINTO EXPLORATIONS LTD.

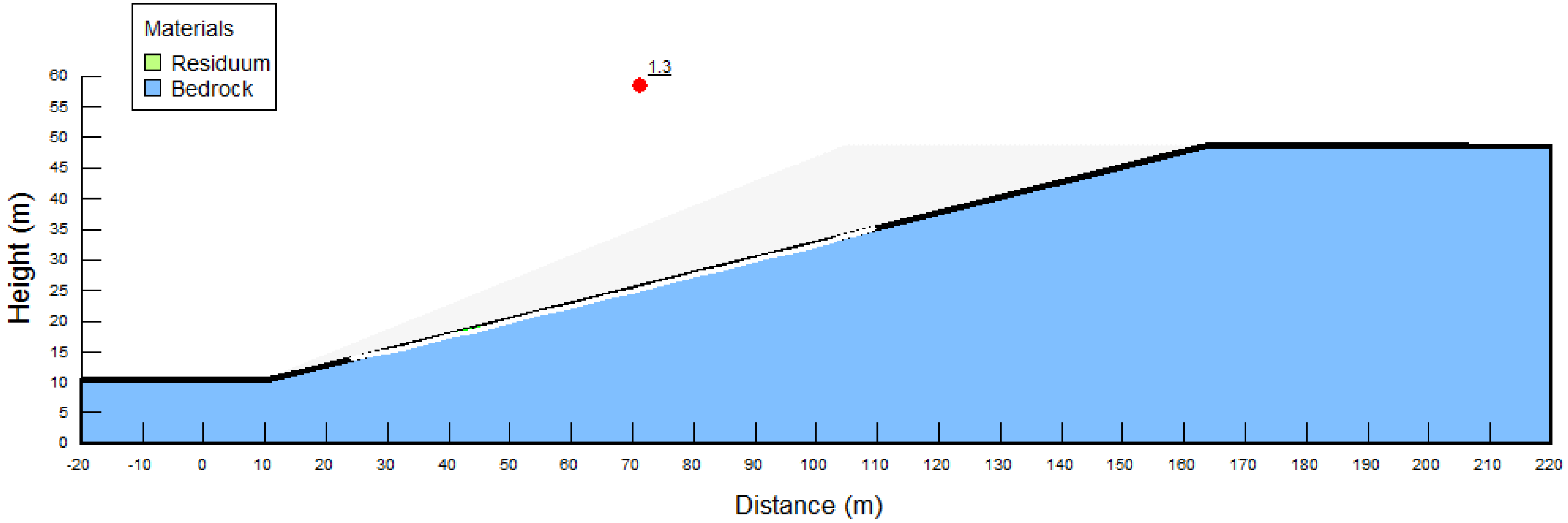
Stability Assessment

Scenario 1 Sensitivity

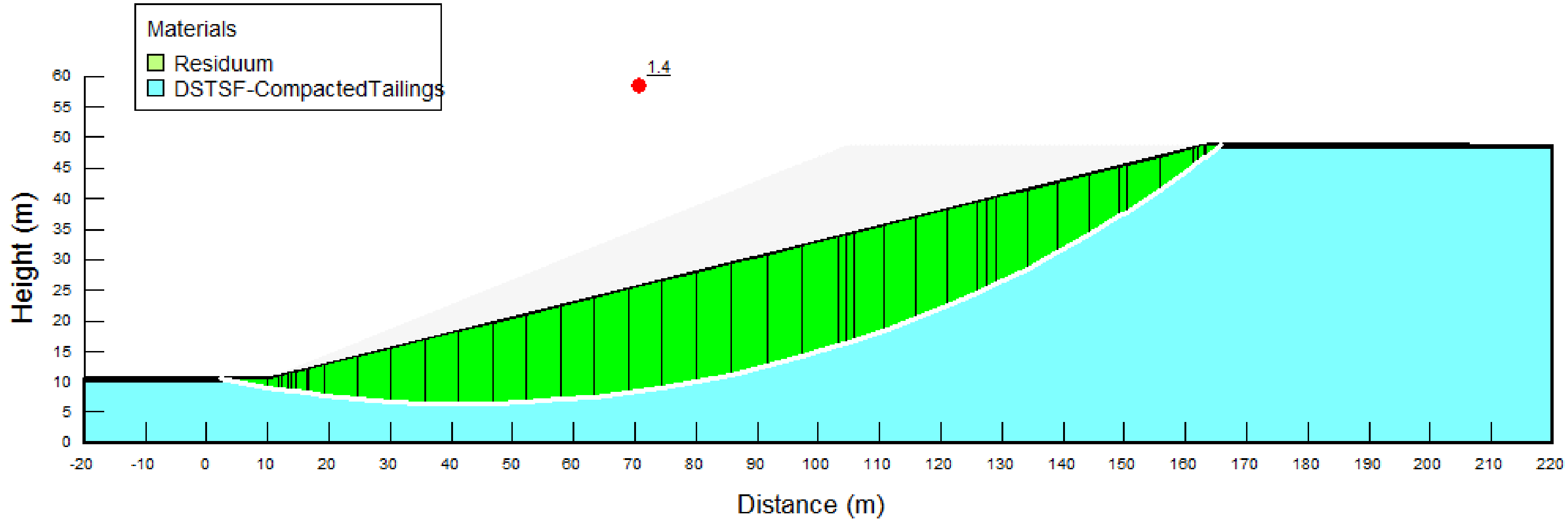
Job No: 1CM002.049
Filename: StabilityAnalysis-Figures-1CM002-049_REV0-EK.pptx

Minto Closure Cover Design

Date:	Approved:	Figure:
July 2016	EK	3



Scenario 1c



Scenario 1d

srk consulting

capstone
MINTO MINE
OPERATED BY MINTO EXPLORATIONS LTD.

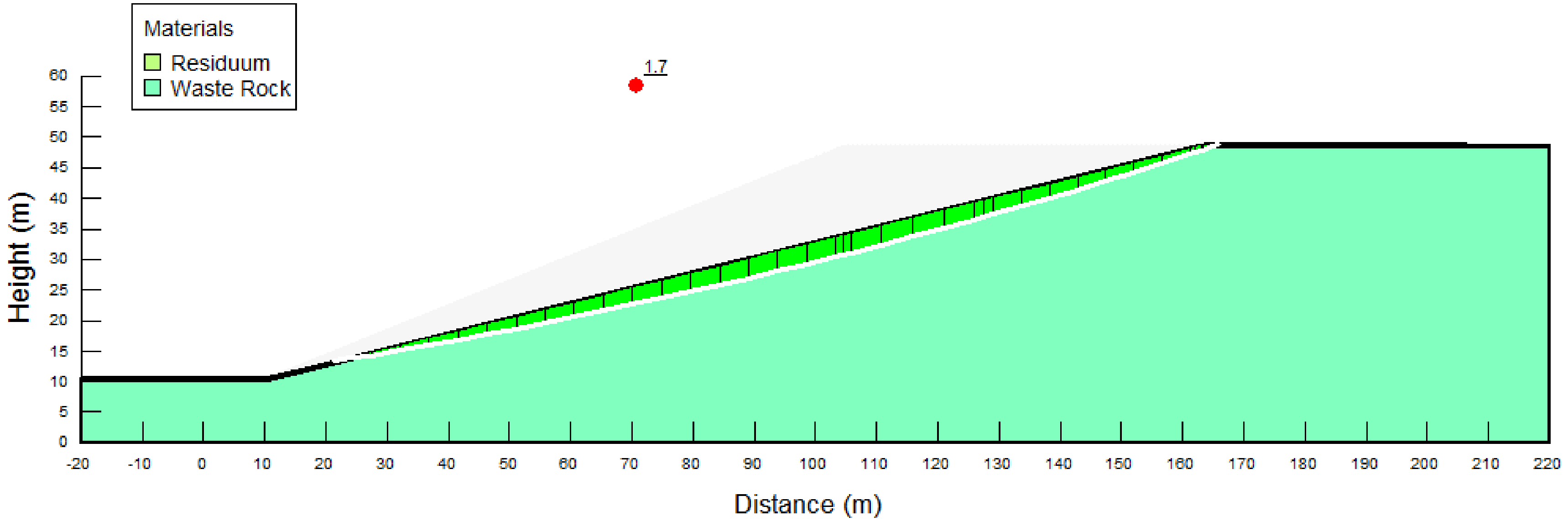
Stability Assessment

Scenario 1 Sensitivity (con't)

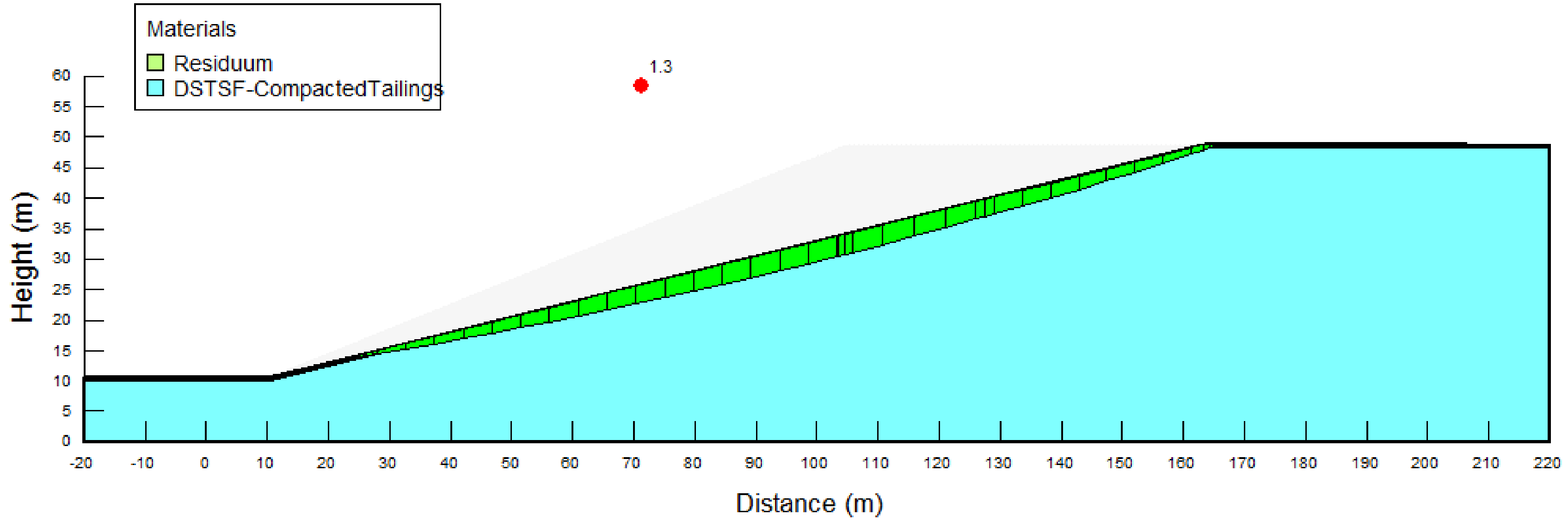
Job No: 1CM002.049
Filename: StabilityAnalysis-Figures-1CM002-049_REV0-EK.pptx

Minto Closure Cover Design

Date: July 2016
Approved: EK
Figure: 4



Scenario 1e



Scenario 1f

srk consulting

capstone
MINTO MINE
OPERATED BY MINTO EXPLORATIONS LTD.

Stability Assessment

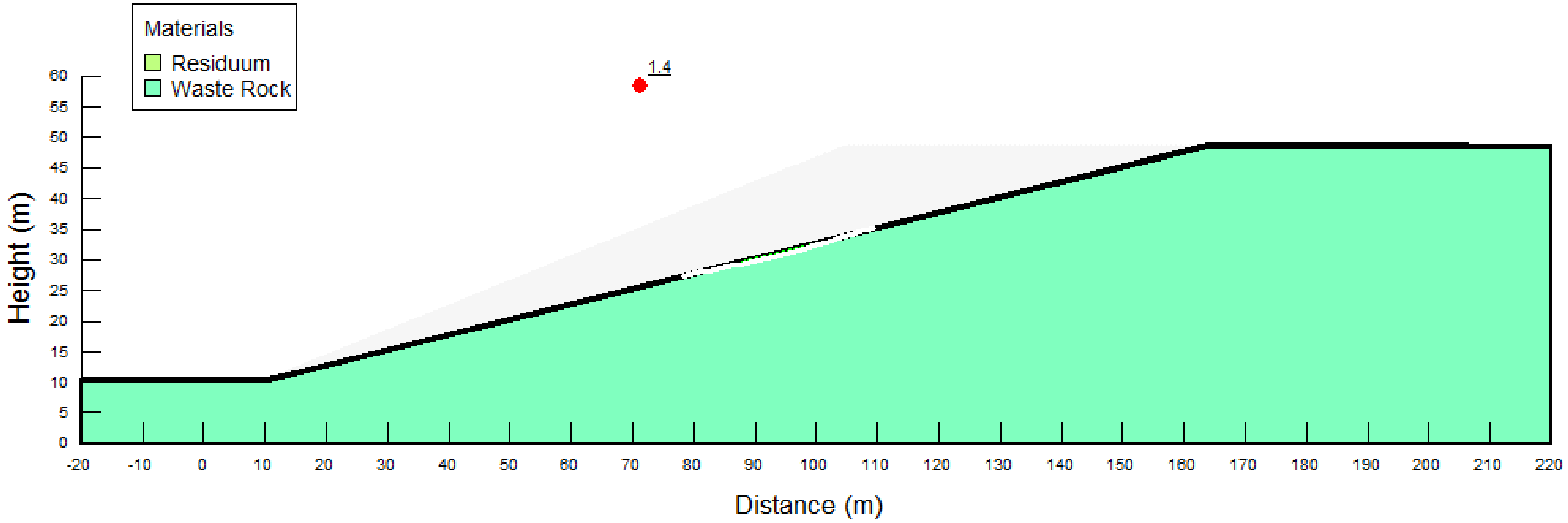
Scenario 1 Sensitivity (con’t)

Job No: 1CM002.049

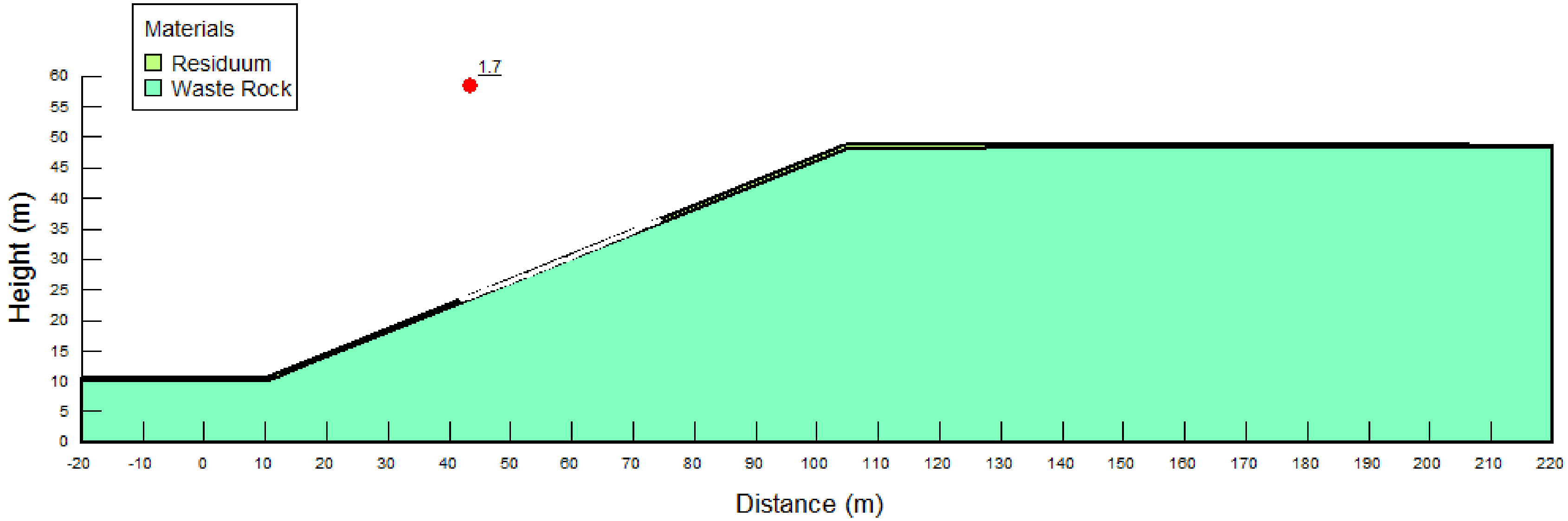
Filename: StabilityAnalysis-Figures-1CM002-049_REV0-EK.pptx

Minto Closure Cover Design

Date:	Approved:	Figure:
July 2016	EK	5



Scenario 1e



Scenario 1f

srk consulting

capstone MINTO MINE
OPERATED BY MINTO EXPLORATIONS LTD.

Stability Assessment

Scenario 1 Sensitivity (con't)

Job No: 1CM002.049

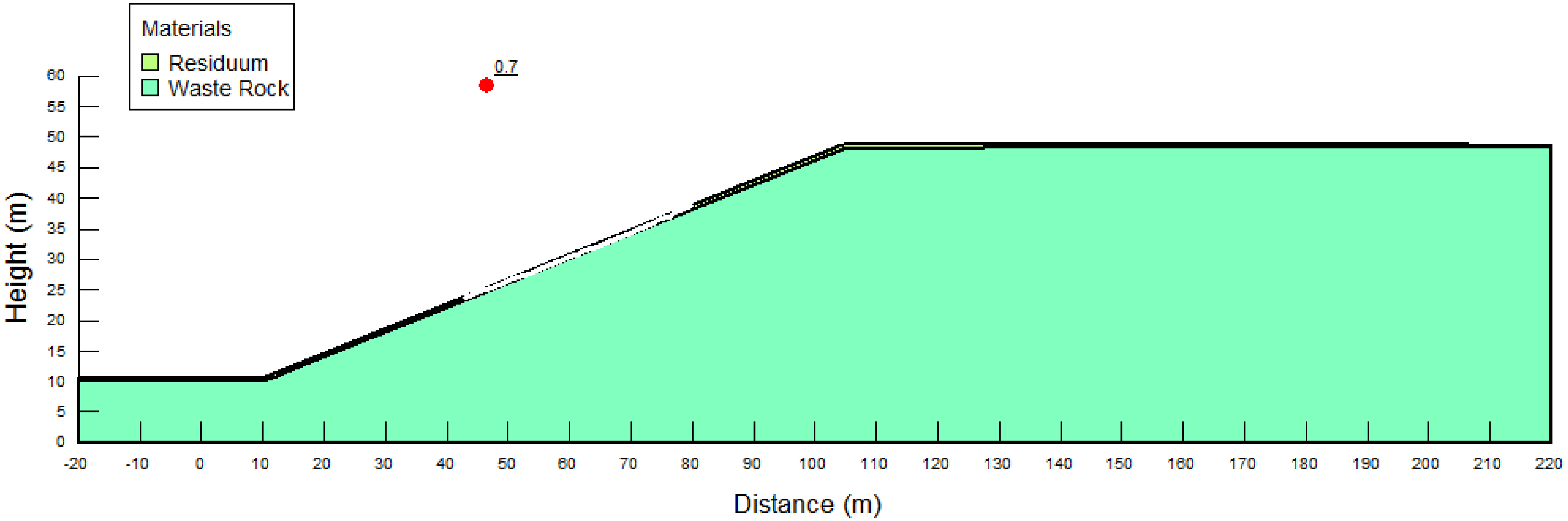
Filename: StabilityAnalysis-Figures-1CM002-049_REV0-EK.pptx

Minto Closure Cover Design

Date: July 2016

Approved: EK

Figure: 6



Scenario 1i

srk consulting

capstone
MINTO MINE
OPERATED BY MINTO EXPLORATIONS LTD.

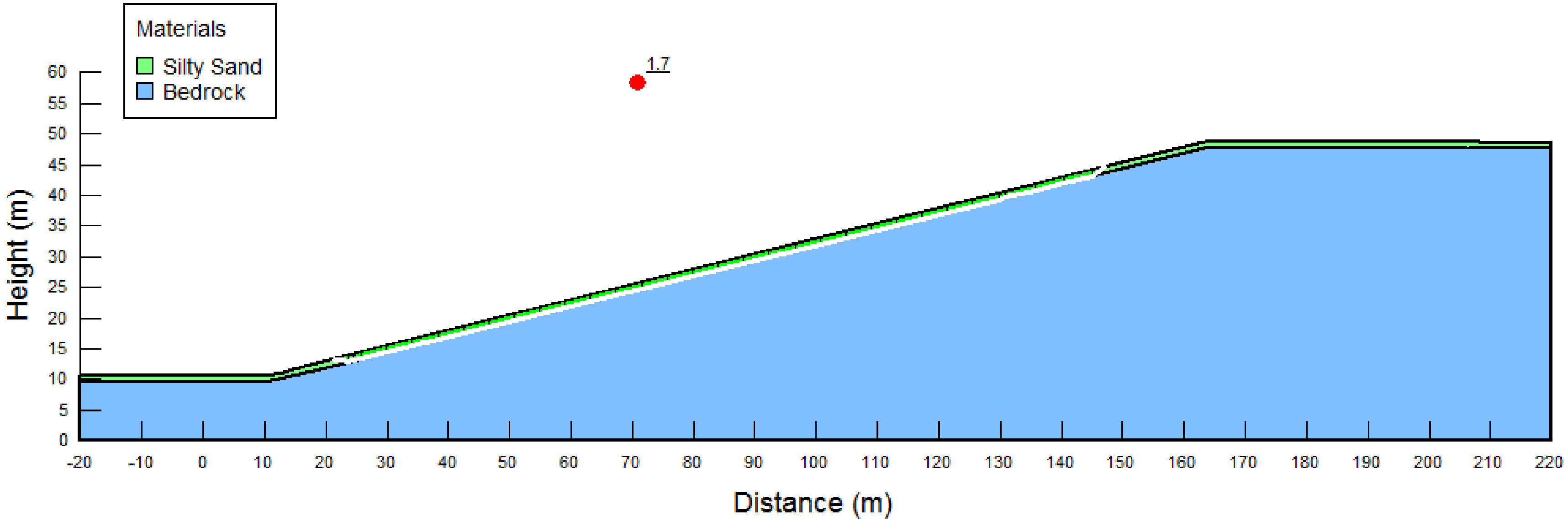
Stability Assessment

Scenario 1 Sensitivity (con't)

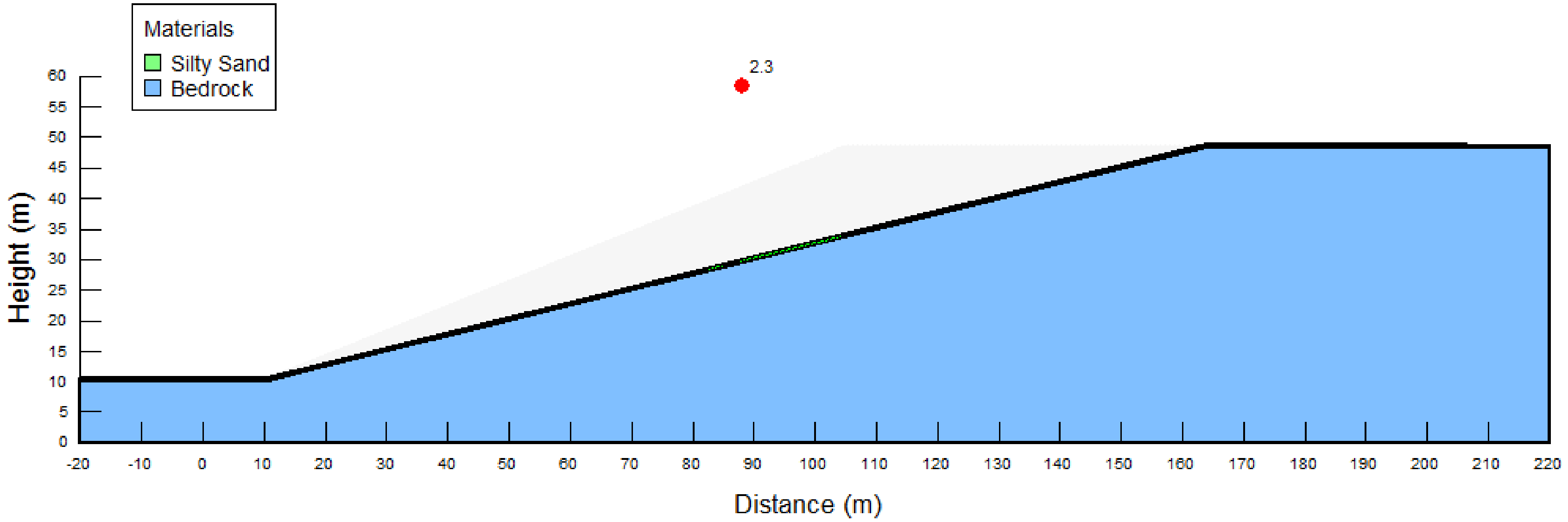
Job No: 1CM002.049
Filename: StabilityAnalysis-Figures-1CM002-049_REV0-EK.pptx

Minto Closure Cover Design

Date:	Approved:	Figure:
July 2016	EK	7



Scenario 2a



Scenario 2b

srk consulting

capstone
MINTO MINE
OPERATED BY MINTO EXPLORATIONS LTD.

Stability Assessment

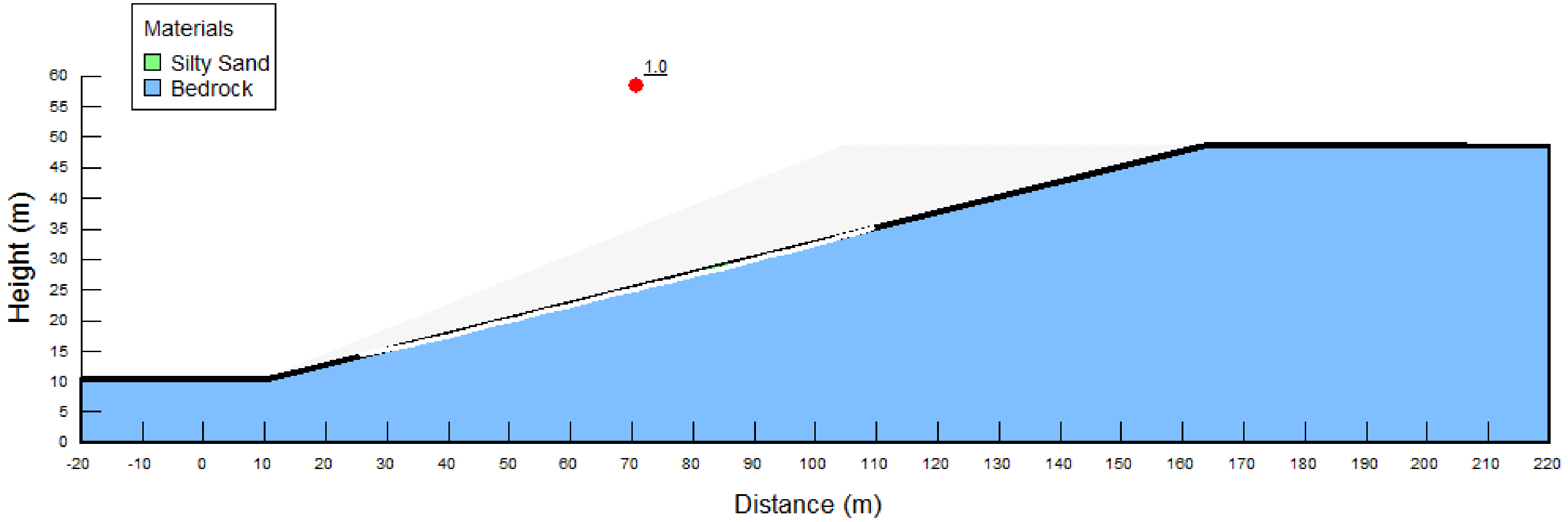
Scenario 2 Sensitivity

Job No: 1CM002.049

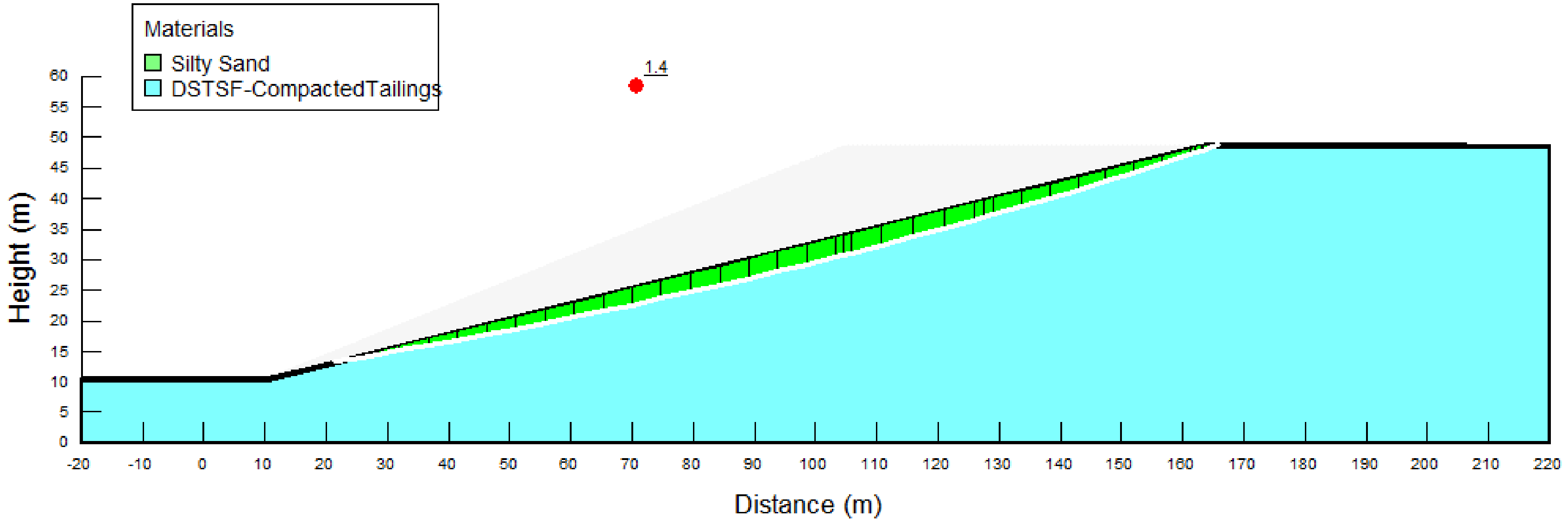
Filename: StabilityAnalysis-Figures-1CM002-049_REV0-EK.pptx

Minto Closure Cover Design

Date: July 2016	Approved: EK	Figure: 8



Scenario 2c



Scenario 2d

srk consulting

capstone
MINTO MINE
OPERATED BY MINTO EXPLORATIONS LTD.

Stability Assessment

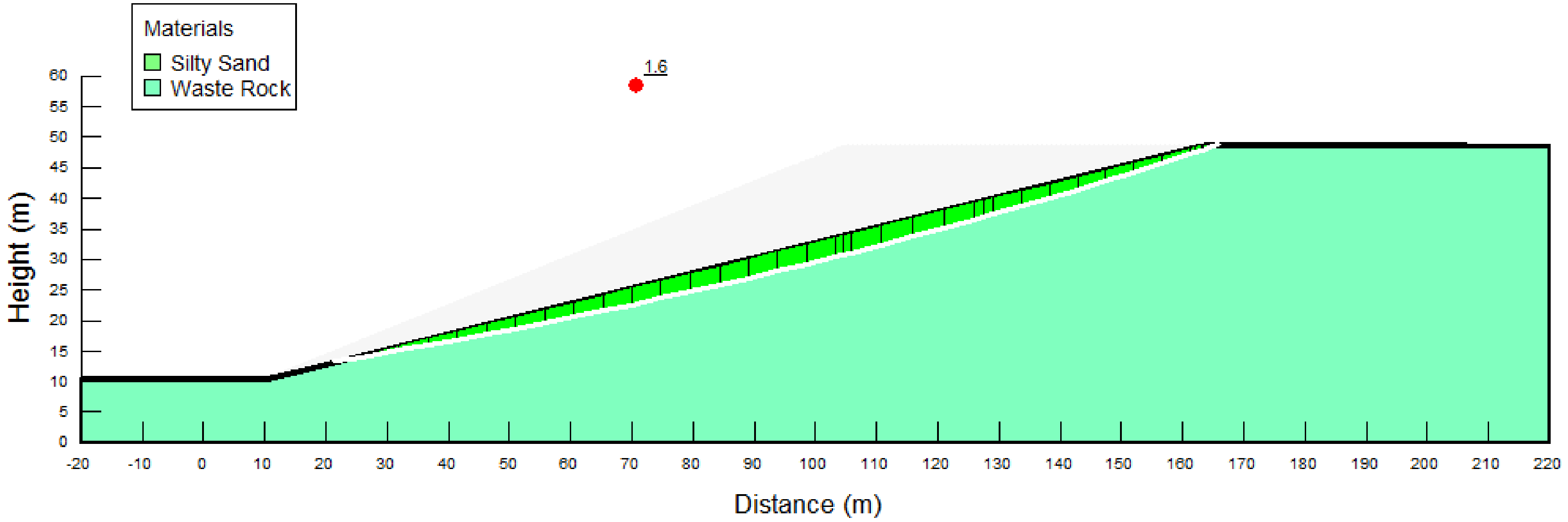
Scenario 2 Sensitivity (con't)

Job No: 1CM002.049

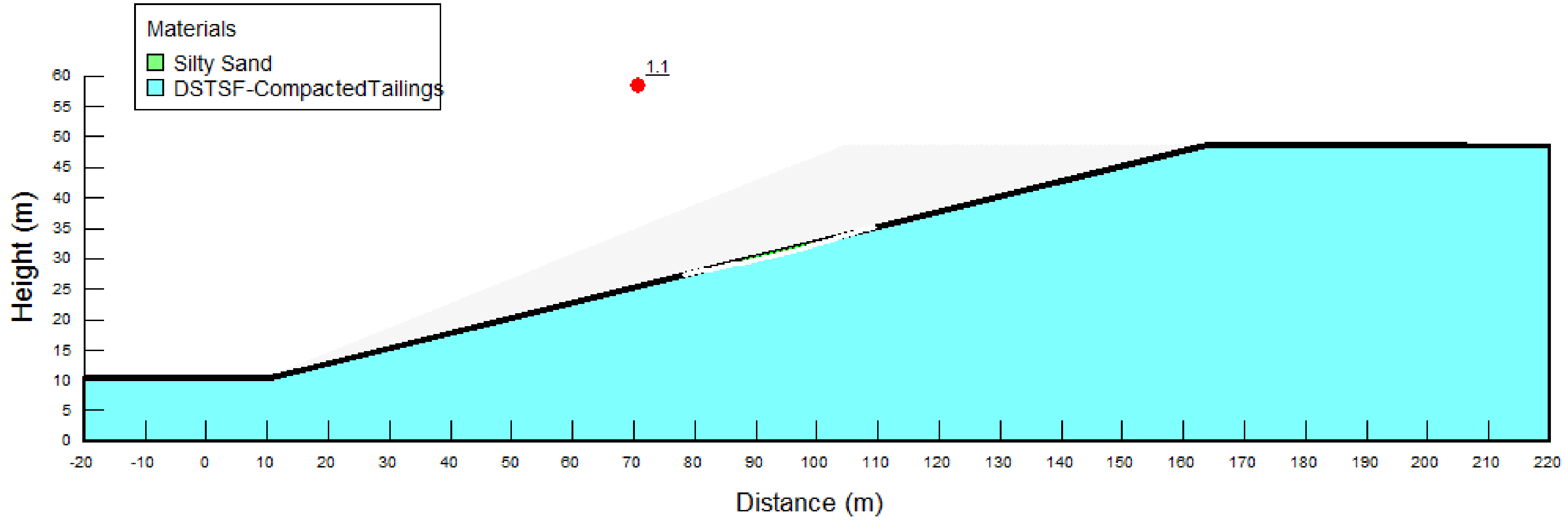
Filename: StabilityAnalysis-Figures-1CM002-049_REV0-EK.pptx

Minto Closure Cover Design

Date:	Approved:	Figure:
July 2016	EK	9



Scenario 2e



Scenario 2f

srk consulting

capstone
MINTO MINE
OPERATED BY MINTO EXPLORATIONS LTD.

Stability Assessment

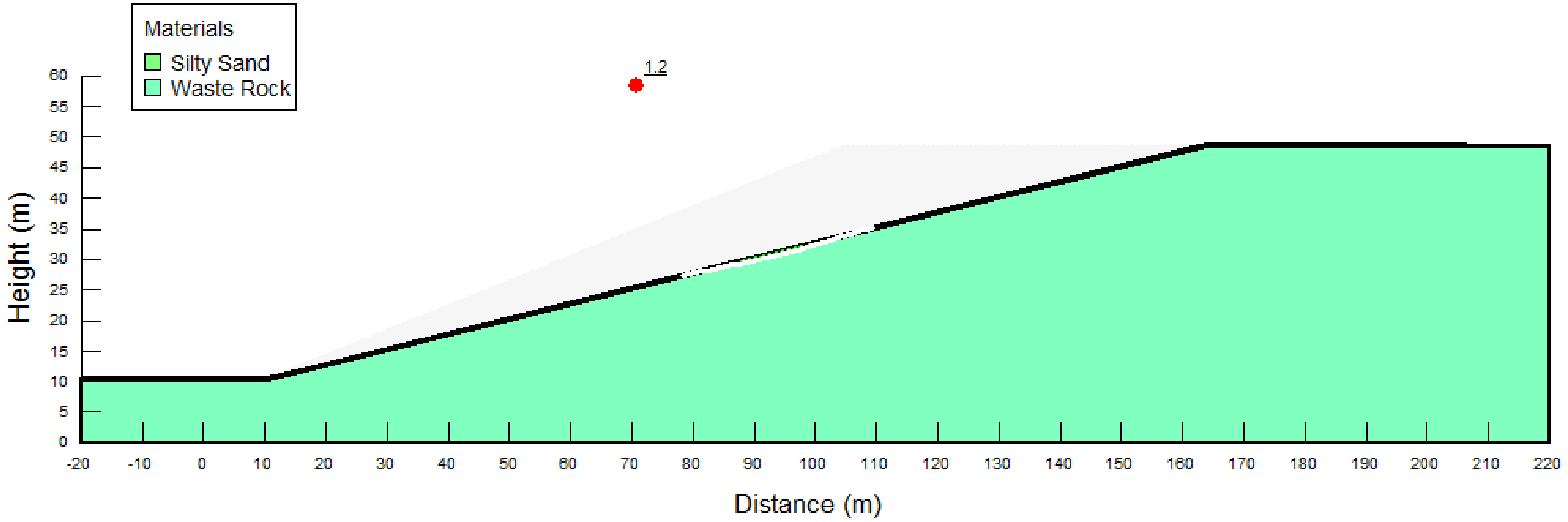
Scenario 2 Sensitivity (con't)

Job No: 1CM002.049

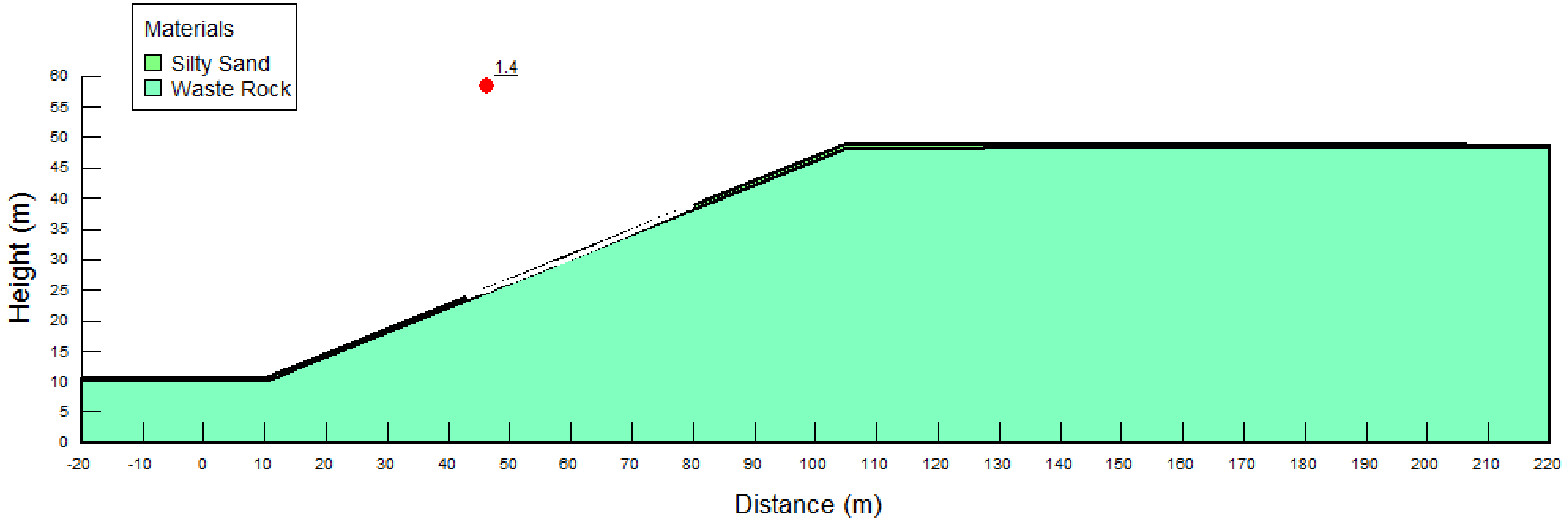
Filename: StabilityAnalysis-Figures-1CM002-049_REV0-EK.pptx

Minto Closure Cover Design

Date:	Approved:	Figure:
July 2016	EK	**10**

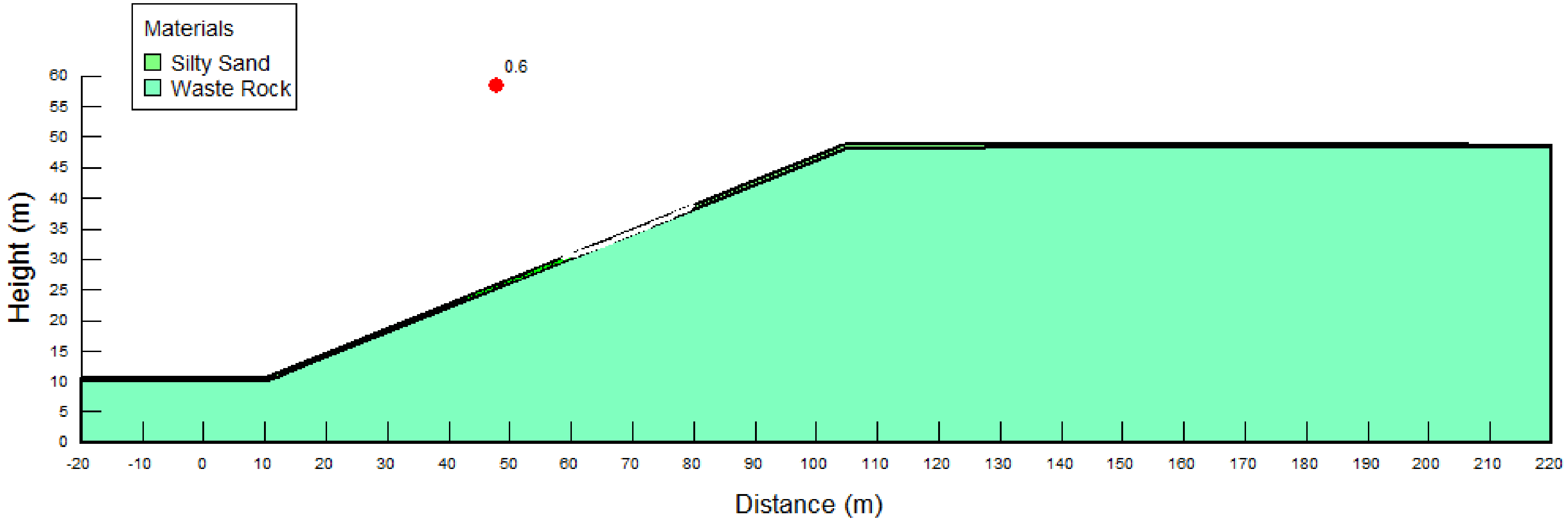


Scenario 2g



Scenario 2h

srk consulting	capstone MINTO MINE OPERATED BY MINTO EXPLORATIONS LTD.	Stability Assessment **Scenario 2 Sensitivity (con't)**
Job No: 1CM002.049 Filename: StabilityAnalysis-Figures-1CM002-049_REV0-EK.pptx	Minto Closure Cover Design	Date: July 2016 Approved: EK Figure: **11**



Scenario 1i

srk consulting

capstone
MINTO MINE
OPERATED BY MINTO EXPLORATIONS LTD.

Stability Assessment

Scenario 2 Sensitivity (con't)

Job No: 1CM002.049
Filename: StabilityAnalysis-Figures-1CM002-049_REV0-EK.pptx

Minto Closure Cover Design

Date: July 2016
Approved: EK
Figure: **12**

Appendix E: Minto Mine Preliminary Closure Cover Revegetation Plan

IEG
Integral Ecology Group
iegconsulting.com

MEMORANDUM

July 29, 2016

TO: Erik Ketilson, SRK Consulting
FROM: Justin Straker
RE: Minto Mine preliminary closure cover revegetation plan
COPY: Clint Smyth, Trevor Baker – IEG

The Integral Ecology Group (IEG) was requested by SRK Consulting (SRK) to develop recommendations on revegetation aspects of the preliminary closure cover design for Capstone's Minto Mine (Minto), based on a review of existing studies provided by SRK. IEG's review of this previous work was conducted from July 11-21, 2016, and this memo presents the results of this review and our preliminary recommendations for revegetation at Minto. We expect that these recommendations will need to be revisited and refined as more detailed closure and cover planning proceeds for specific facilities at Minto.

Objectives

The Government of Yukon (Energy, Mines and Resources 2013a) prescribes the following reclamation and closure objectives:

- protection of aquatic, terrestrial, and atmospheric environments from mine-related degradation and the restoration of environments that have been degraded by mine-related activities; and
- support of self-sustaining biological communities that achieve land-use objectives.

We have incorporated these two objectives into our preliminary revegetation design for Minto. Due to the physical characteristics of the potential cover materials at the site, a primary "protection" objective is the minimization of erosion (and corresponding sediment delivery) from sloped cover areas. In addition, the revegetated covers are expected to contribute to reductions in infiltration of meteoric waters to underlying mine wastes, to the extent achievable given available cover resources.

Site conditions

Site-preparation, fertilizer, and seed-mix research trials have been initiated at the Minto Mine (Capstone 2012, Access 2014) but results have not yet been compiled and analyzed. In the absence of results from site-specific studies, relevant published literature sources were consulted in preparing this technical memo. A summary of biophysical descriptions developed in support of this preliminary revegetation plan is provided as Appendix B to this memo.

Revegetation plan

Land-use objectives

This revegetation plan is designed to achieve the land-use objectives of wildlife habitat re-creation, creation of habitat for traditionally used plants (and the direct replacement through revegetation of a small subset of these plants), and the return of biodiversity values over time. The primary focal wildlife species will be moose, although re-creation of habitat for prey species such as snowshoe hare and upland game birds may be possible. Wildlife habitat suitability will vary by vegetation type and structural stage as the re-created vegetation types develop.

Rooting-zone cover materials

The natural landscape in the Minto area consists of:

- slopes with coarser and thinner soils in crest and upslope positions, supporting drier forests, shrublands and grasslands; and
- finer and deeper soils towards the bottoms of slopes supporting denser forests and riparian areas (Access 2013b).

Soil texture and depth, as well as topographic and historic factors, are key characteristics that have led to the diversity of ecosystems that have developed in the local area. Although natural processes, topographic variation, and inherent (unplanned) variation in placed cover materials will support development of heterogeneity over time in the post-closure Minto landscape, the depth, selection, and placement of cover materials may be important to the development of some ecosystem types, particularly submesic-mesic uplands (and wetlands, to the extent that their development is possible on the post-closure landscape).

Our review of available data on overburden properties at Minto indicates that these materials are generally favourable for vegetation establishment and growth. All overburden stockpiles appear to contain material with suitable nutrient- and water-retention properties to support vegetation. The majority of overburden materials will be deficient in macronutrients (Access 2013b), but this is a common feature of reclamation landscapes and is not expected to significantly limit reclamation progress. Nutrient deficiencies can be addressed through the addition of organic matter using rapidly establishing vegetation species (e.g., native grasses and agronomic ground-cover species), and through use of fertilizers. There do not appear to be contaminant concerns in soils of the Minto area (Access 2013b), but testing for chemical parameters, including element concentrations, should be conducted for overburden intended for use in cover rooting zones.

The best potential cover materials, particularly for water retention, are those with lower coarse-fragment contents and higher silt contents – the fine-grained overburden deposits derived from glaciolacustrine (or related) deposition – although these materials are also susceptible to erosion. There are some coarser materials – weathered bedrock overburden (residuum) – present in the stockpiled overburden that are not expected to hold water or nutrients well, but will withstand erosion better.

Recommendations for cover placement

It is our understanding that the cover design proposed by SRK for Minto specifies placement of 0.5 m of overburden across all mine-waste deposits – including the Southwest Waste Dump, Dry Stack Tailings Storage Facility (DSTSF), Mill Valley Fill and extensions, Main Waste Dump and expansion, Main Pit Dump, and Area 118 Dump – and that there are sufficient stockpiled or recoverable materials to support this placement.

To the extent that it occurs during recovery of cover materials from stockpile and placement on reclamation areas, some blending of the two overburden types – glaciolacustrine and residuum – will be beneficial, as both have less desirable properties (erosion susceptibility for the glaciolacustrine sediments and lack of water/nutrient retention for residuum) that will be ameliorated through mixing, without substantially degrading the resultant mixed material's ability to support vegetation.

A preliminary analysis of the plant-available water storage capacity (AWSC) of overburden samples is presented in Figure 1. This analysis shows the differentiation between the coarser/residuum materials and the finer glaciolacustrine materials, and suggests that the mixed material could be expected to have a mean AWSC of 80-100 mm of water stored per m of depth (or 40-50 mm of water stored in the 50-cm cover layer).

Unmixed glaciolacustrine materials will be suitable for revegetation, but will be best suited to use in areas where erosion is not a primary concern (e.g., plateaus) – if used on sloped areas, particular attention will need to be directed to measures to control erosion. Unmixed residuum may be of use as a "rock-mulch" cover in specific areas of high erosion potential, but we recommend that this practice be restricted to crests and upper slope positions, consistent with natural landscape features that have resulted in drier shrublands and grasslands in these topographical locations, particularly warm southern exposures. Thus in areas where recovery from stockpile yields primarily glaciolacustrine materials, these materials would be best directed to placement on level areas. Where recovery yields primarily residuum materials, these will be best directed to placement on steeper areas on the upper portions of dump slopes, or for other targeted erosion prevention, and are less suitable for widespread placement across other areas.

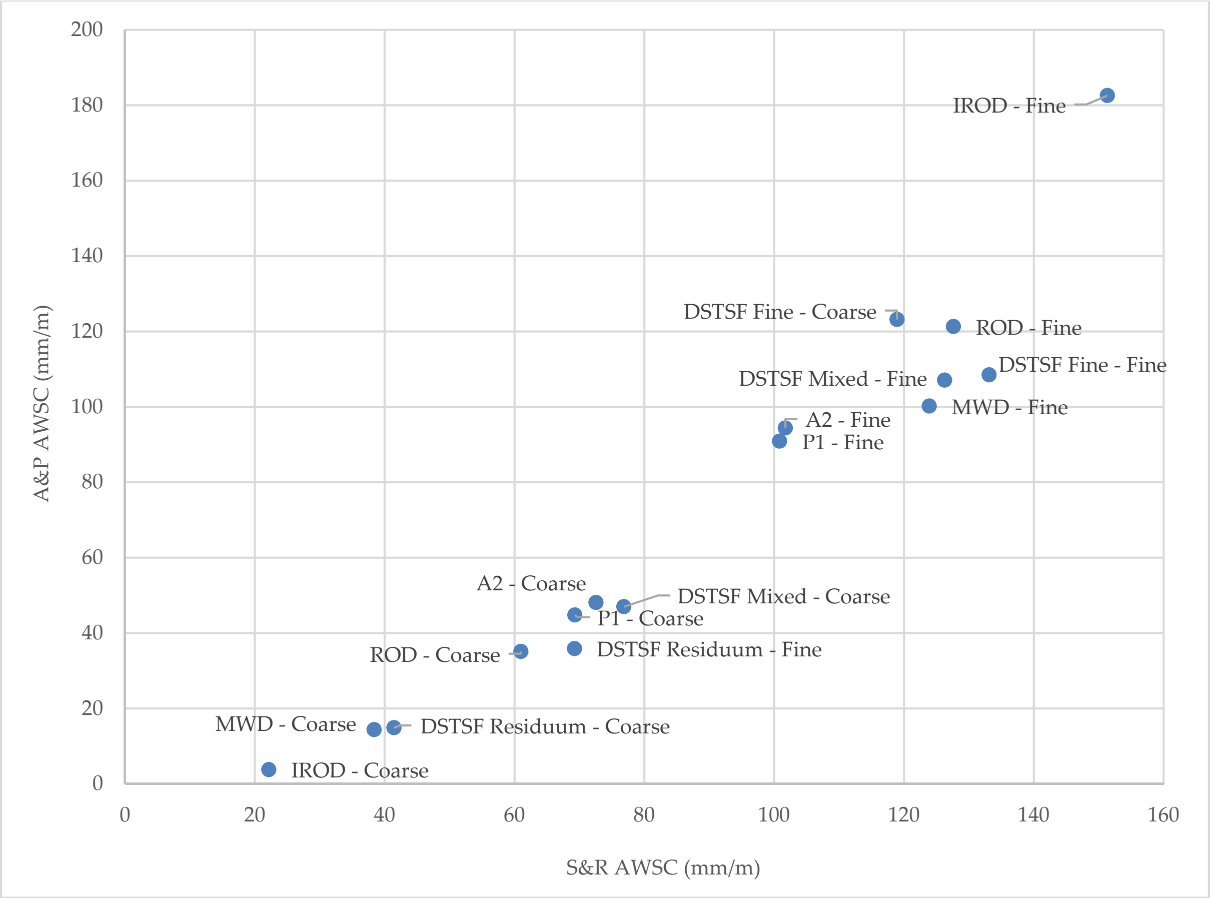


Figure 1. Plant-available water storage capacity (AWSC) estimated by two methods[1] for samples of potential cover materials at Minto.

Under the proposed cover design, we expect drier landscapes and vegetation types (e.g., grasslands, trembling aspen / grasslands, and trembling aspen / lodgepole pine / white spruce forests – see Tables 6) to develop due to topographical position, material properties, and possible localized erosion and soil loss. We expect it will be difficult to recreate wetter ecosystems in low slope positions, which typically receive water from upslope by run-on or shallow lateral groundwater flow. These lateral water fluxes will occur less on the post-closure landscape due to the relatively well drained nature of mine wastes underlying cover materials. The development of mesic and wetter vegetation types (e.g., black spruce / Labrador tea / sphagnum, white spruce / black spruce, willow / trembling aspen, and willow /scrub birch vegetation types– see Table 6)

---

[1] The "S&R" label on the abscissa indicates AWSC estimated per Saxton and Rawls (2006), while the "A&P" label on the ordinate axis indicates AWSC estimated per Arya and Paris (1981).

could be enhanced by placing deeper covers (1.0 m) in selected lower slope and/or level areas.

Revegetation

As noted above, revegetation treatments at Minto will need to be designed to achieve restoration and land-use objectives, while achieving the "protection" objective of maintaining surficial substrate stability and erosion control where necessary. We propose that this be accomplished through the application of two primary vegetation treatments:

1. **Erosion-control treatment** – in areas of potential erosion concern (i.e. sloped cover facets), revegetation will focus on the rapid establishment of herbaceous ground-cover species. This would be accomplished through relatively high-rate seeding (e.g. >35 kg/ha), likely using a mix of native grasses and one or more agronomic legumes, coupled with fertilizer applications simultaneous with seeding and in the early years (1-3) of establishment. In recent years the use of agronomic species in mine reclamation in western and northern Canada has declined due to increasing focus on biodiversity and "restoration" objectives, but experience at multiple sites in the Yukon indicates that agronomic species can be successfully used as a rapidly establishing temporary ground cover that is not prohibitive of a longer-term transition to ecosystems dominated by native plant communities.[2]
2. **Native-species establishment –** in areas not targeted for the erosion-control treatment (i.e., landform plateaus and benches), revegetation will focus on re-establishing locally common native plant communities, using a combination of seeding and planting establishment techniques. Use of fertilizers on these areas will likely be avoided or minimized.

Yukon Energy, Mines and Resources (2013b) defines re-vegetation as the re-establishment of vegetation on land which previously had vegetation cover. The objective of revegetation of mining disturbances is "to leave the ground in such a way as to provide a good chance for successful re-vegetation by plant species native to the site and the area (natural revegetation)." We believe that the two primary revegetation treatments proposed above for Minto are consistent with this over-arching objective, as

---

[2] Recent observations at the Faro Mine Complex demonstrated that an area seeded with clover prior to 2002 has subsequently transitioned, without management intervention, to a lodgepole-pine-dominated forest with a diversity of native understory species. In addition, Laberge (2007) reported that establishing woody species on mine disturbances previously seeded with grasses and clovers was possible at Brewery Creek. The study results showed that black spruce and Alaska birch established well on north-facing (cool) slopes, trembling aspen and Alaska birch established well on south-facing (warm) slopes, and dwarf birch, prickly rose, and trembling aspen established well on level (neutral) sites.

although the erosion-control treatment will likely include non-native species, it in fact provides the best chance for successful revegetation by native plant species over the longer term. Native species tend to be slower to establish than agronomics (which have been selectively bred for rapid establishment), and with the high silt content and erosion susceptibility of the Minto cover materials, rapid revegetation is critical to minimize erosion and protect the cover material. Restriction to use of native species only would likely result in high erosion rates, loss of cover materials through sheet and/or rill/gully erosion, and likely subsequent poor revegetation. Targeted use of agronomics will promote cover stability at the ground surface, and will be more successful in eventually establishing native species. As excessive erosion would be a key failure mode for the cover system, we have developed the revegetation treatments to give priority to reduction of risk of this failure mode. We believe that a transition to native species on these erosion-control areas will occur naturally, due to the focus on native-species establishment on other mine areas and due to the proximity of surrounding vegetation-propagule sources in adjacent intact ecosystems. However, we propose that revegetation be monitored, and that a second phase of revegetation occur if/where necessary to initiate or augment the transition to native species. This second phase would involve planting of native herbaceous and/or woody plant species.

Revegetation species selection

The majority of the ecosystems surrounding the mine are dominated by woody species (Appendix B). A list of candidate woody species from Matheus and Omtzigt (2012) is presented in Table 1. The majority of these species are consistent with the pre-disturbance vegetation types, and have been identified by both Access (2014) and Withers (1999) as potential reclamation candidates.

Table 1. Native woody species for sites in the Yukon (Matheus and Omtzigt 2012).

Growth Habit	Common Name	Scientific Name
Tree	Alaska Birch	*Betula papyrifera*
	Balsam Poplar	*Populus balsamifera*
	Black Spruce	*Picea mariana*
	Lodgepole Pine	*Pinus contorta*
	Trembling Aspen	*Populus tremuloides*
	White Spruce	*Picea glauca*
Shrubs	Common Juniper	*Juniperus communis*
	Prickly Rose	*Rosa acicularis*
	Scrub Birch	*Betula glandulosa*
	Willows	*Salix* spp.
	Drummond's mountain avens[3]	*Dryas drummondii*
	Kinnikinnick[3]	*Arctostaphylos uva-ursi*
	Soapberry[4]	*Shepherdia canadensis*

In addition to the woody species listed in the original source material for Table 1, Lister (2010) identified the shrub kinnikinnick (*Arctostaphylos uva ursi*) as a high-frequency colonist of disturbed sites in the Yukon, which makes this species a candidate for revegetation at Minto, particularly on drier sites.

Matheus and Omtzigt (2012) identified potential herbaceous revegetation candidates (Tables 2-3). These authors state that low levels of the plant macronutrient nitrogen in the soil are limiting to revegetation in the Yukon – for this reason, we recommend inclusion of nitrogen-fixing species in revegetation treatments at Minto. The nitrogen-fixing forb arctic lupine (*Lupinus arcticus*) and the nitrogen-fixing shrub soapberry (*Shepherdia canadensis*) were reported in the Minto study area (Access 2013) and are candidates for re-establishment through revegetation at Minto. The actinorrhizal nitrogen-fixer, Drummond's mountain avens (*Dryas drummondii*), also may be a good candidate (Lister 2010).

---

[3] Species added to cited table based on observations by Lister (2010) – see text this page.

[4] Species added to cited table based on observations by Access (2013) – see text this page.

Table 2. Herbaceous species for revegetation of low slope, low to mid-elevation sites in the Yukon (Matheus and Omtzigt 2012).

Source	Common Name	Scientific Name
Agronomic Species	Streambank Wheatgrass (cv. Sodar)	*Elymus lanceolatus*
	Meadow foxtail (cv. common)	*Alopecurus pratensis*
	Canada Bluegrass (cv. Reubens, common)	*Poa compressa*
	Creeping Red Fescue (cv. Boreal)	*Festuca rubra*
	Redtop (cv. common)	*Agrostis gigantea*
	Sheep Fescue (cv. Common)	*Festuca ovina*
	Alsike Clover (cv. Common)	*Trifolium hybridum*
Commercially Available Natives	Bluejoint Reedgrass (cv. Sourdough, common)	*Calamagrostis canadensis*
	Fowl Bluegrass (cv. common)	*Poa palustris*
	Glaucous Bluegrass (cv. Tundra, common)	*Poa glauca*
	Rocky Mountain Fescue (cv. common)	*Festuca saximontana*
	Slender Wheatgrass (cv. Revenue, Adanac, Highlander, common)	*Elymus trachycaulus*
	Ticklegrass (cv. Common)	*Agrostis scabra*
	Tufted Hairgrass (cv. Common)	*Deschampsia caespitosa*
	Violet Wheatgrass (cv. common)	*Elymus alaskanus*
Locally-Collected Natives	Arctic Lupine	*Lupinus arcticus*
	Bear Root	*Hedysarum alpinum*
	Macrourum's Wheatgrass	*Elymus macrourus*
	Mackenzie's Hedysarum	*Hedysarum mackenzii*
	Mountain Avens	*Dryas* spp.
	Northern Brome	*Bromus pumpellianus*
	Northern Rough Fescue	*Festuca altaica*
	Showy Locoweed	*Oxytropis splendens*
	Sweetgrass	*Hierochloë hirta*
	Wormwood / Sage	*Artemisia* spp.
	Yarrow	*Achillea millefolium*
	Yellow Locoweed	*Oxytropis campestris*

Table 3. Herbaceous species for revegetation of steep slopes in the Yukon (Matheus and Omtzigt 2012).

Source	Common Name	Scientific Name
Agronomic Species	Streambank Wheatgrass (cv. Sodar)	*Elymus lanceolatus*
	Meadow foxtail (cv. common)	*Alopecurus pratensis*
	Canada Bluegrass (cv. Reubens, common)	*Poa compressa*
	Creeping Red Fescue (cv. Boreal)	*Festuca rubra*
	Alfalfa (cv. Rangelander, Rambler, Peace)	*Medicago sativa*
Commercially Available Natives	Glaucous Bluegrass (cv. Tundra, common)	*Poa glauca*
	Rocky Mountain Fescue (cv. common)	*Festuca saximontana*
	Slender Wheatgrass (cv. Revenue, Adanac, Highlander, common)	*Elymus trachycaulus*
	Violet Wheatgrass (cv. common)	*Elymus alaskanus*
Locally-Collected Natives	Macrourum's Wheatgrass	*Elymus macrourus*
	Northern Brome	*Bromus pumpellianus*
	Northern Rough Fescue	*Festuca altaica*
	Sweetgrass	*Hierochloë hirta*
	Wormwood / Sage	*Artemisia* spp.

Application of revegetation treatments to Minto facilities

Reclamation Land Units (RLUs) have been developed as the basis for end land-use planning. RLUs are based on slope, aspect, and elevation criteria (SRK 2016). A preliminary estimation of occurrence of RLUs on the six major facilities included in the Minto closure cover design is provided in Table 4. Concordance between these RLUs and pre-disturbance vegetation types is estimated in Table 5, based on information summarized in Table 6. Characteristic plant species for each pre-disturbance vegetation type are listed in Table 7.

Table 4. Disturbance areas and Reclamation Land Units (RLUs)[5]

Facilities	Reclamation Land Units (RLUs) (SRK 2016)
• Southwest Waste Dump • Drystack Tailings Storage Facility • Mill Valley Fill and Mill Valley Extension Stages 1 and 2 • Main Waste Dump and Main Waste Dump Expansion • Main Pit Dump • Area 118 Dump	• Forested (Low – Mid-elevation / Cool – Neutral Aspects) (FLmCN) • Forest (Low – Mid-elevation / Warm Aspect) (FLmW) • Deciduous Shrubland (Low – Mid-elevation / Cool – Neutral Aspects) (SLmCN) • Deciduous Shrubland (Low – Mid-elevation / Warm Aspect) (SLmW) • Rocky Slope (High-elevation / Steep Slopes / All Aspects) (RH)

Table 5. Reclamation Land Units and potential vegetation types.

Reclamation Land Unit (RLU)	Potential Analog Vegetation Type (Access 2013)
FLmCN	• Willow / Trembling Aspen
FLmW	• Trembling Aspen / Lodgepole Pine / White Spruce • White Spruce / Black Spruce
SLmCN	• Willow / Trembling Aspen • Willow / Scrub Birch
SLmW	• Trembling Aspen / Lodgepole Pine / White Spruce
RH	• Trembling Aspen / Lodgepole Pine / White Spruce • Trembling Aspen / Grasslands • Grasslands

---

[5] Our work indicates that although SRK identified 9 RLUs, only 5 are likely to have substantial occurrence on the post-closure Minto site. Elevations at Minto are too low to have occurrence of either Subalpine or higher-elevation Boreal Highlands. For this reason, the warm-aspect deciduous shrubland RLU code has been modified in our work from SLhW (denoting higher elevations) to SLmW (denoting moderate elevations. Wetlands will likely develop opportunistically in localized areas, and will also be included as passive water-treatment systems downstream of the Mill Valley Fill and extensions. Revegetation of these systems will require site-specific planning based on the detailed wetland designs, and is not addressed further in this memo.

Table 6. Habitat conditions of the vegetation types within and in the vicinity of the Minto Mine (source: Access 2013, 2014).

Vegetation Type	Slope Position	Aspect	Soil Moisture Regime	Soil Texture	Drainage
Trembling Aspen / Lodgepole Pine / White Spruce	mid-upper slope	south-facing (warm)	mesic – subxeric	coarse	well-drained
Black Spruce / Labrador Tea / Sphagnum	lower slope – toe	north-facing (cool)	mesic – hydric	organic	poorly-drained
White Spruce / Black Spruce	lower slope	south-facing (warm)	mesic – subhygric	not provided	moderately-well to imperfectly drained
Willow / Trembling Aspen	mid-slope and terraces	north- to south-facing slopes (cool – warm)	subxeric – subhygric	not provided	well – moderately-well drained
Willow / Scrub Birch	level – depression	no aspect	subhygric – hydric	not provided	moderately-well – poorly drained
Trembling Aspen / Grasslands	steep slopes	south and southwest-facing (warm)	subxeric – mesic	not provided	not provided
Grasslands	crest – steep slopes	south-facing	very xeric – subxeric	coarse or shallow soils	rapid – well-drained

Table 7. Representative plant species found in the vegetation types within and in the vicinity of the Minto Mine (Access 2013, 2014).

Vegetation Type	Trees	Shrubs	Herbs
Trembling Aspen / Lodgepole Pine / White Spruce	lodgepole pine, trembling aspen	Alaskan birch, mountain alder, prickly rose, willow species, kinnikinnick	Arctic lupine, fireweed, lingonberry, tall bluebells
Black Spruce / Labrador Tea / Sphagnum	black spruce	bog blueberry, Labrador tea, scrub birch, willows	cloudberry, horsetail, sweet coltsfoot
White Spruce / Black Spruce	white spruce, black spruce	Labrador tea, willow species	bastard toadflax, bog blueberry, crowberry, lingonberry
Willow / Trembling Aspen	Alaskan paper birch, balsam poplar, lodgepole pine, trembling aspen, white spruce	green alder, willow species	no information provided
Willow / Scrub Birch	none	Labrador tea, scrub birch, shrubby cinquefoil	bluejoint grass, rushes, water sedge
Trembling Aspen / Grasslands	lodgepole pine, trembling aspen	prickly rose, soapberry, kinnikinnick	common yarrow, fireweed, goldenrod, purple reedgrass, pussytoes, rough cinquefoil
Grasslands	not applicable	common juniper, kinnikinick	common yarrow, fireweed, goldenrod, purple reedgrass, pussytoes, Rocky Mountain fescue, rough cinquefoil

Application of the above information presented in Tables 1-7 and associated text to facility/RLU-specific planning will involve the following steps:

1. Delineation of erosion-control areas;
    a. Development of appropriate seed mixes. These mixes will primarily be based on agronomic and commercially available native species from Table 3, but may also include species from the same categories in Table 2. It is also possible that

    erosion-control treatments will include some planting of woody species from Table 1.

2. Delineation of additional non-erosion-control (native-species focus) RLUs at the facility level based on the SRK (2016) report and Table 4;
    a. identifying associated pre-disturbance vegetation types (Table 5), and
    b. selecting appropriate species for each delineated RLU and associated vegetation type from Tables 1-3 and 7.

In the event that post-revegetation monitoring indicates that a second revegetation entry is required on original erosion-control areas to facilitate transition to native-dominated ecosystems, species would be selected as per step #2 above.

APPENDIX A

References

Access Consulting Group (Access). (2013a). Minto Climate Baseline Report YESAB Project Proposal Phase V/VI. Prepared by Access Consultants Limited, Whitehorse. 62 pp.

Access Consulting Group (Access). (2013b). Minto Ecosystems and Vegetation Baseline Report YESAB Project Proposal Phase V/VI. Prepared by Access Consultants Limited, Whitehorse. 77 pp.

Access Consulting Group (Access). (2014). Minto Mine Phase V/VI Reclamation and Closure Plan. Revision 5.1. Prepared for Capstone by Access Consultants Limited, Whitehorse. 289 pp.

Arya, L.M. and Paris, J.F. (1981) A physicoempirical model to predict the soil moisture characteristic from particle-size distribution and bulk density data, Soil Science Society of America Journal, Vol. 45(6), pp. 1023–1030.

Capstone Mining Corporation / Minto Mine (Capstone). (2012). Minto Mine Reclamation Research Plan. Prepared by Capstone Mining Corporation, Minto Mine, Whitehorse. 25 pp.

Carter, L. and P. Tobler. (2014). Faro Mine Complex revegetation activities. Thirty Eighth Annual Mine Reclamation Symposium. Convened on September 16-19, 2013 at the Sheraton Wall Centre, Vancouver. The British Columbia Technical and Research Committee on Reclamation. Organized by the British Columbia Technical and Research Committee on Reclamation, Victoria. 9 pp.

EBA Engineering Consultants Limited (EBA). (2010a). Minto Mine Environmental Baseline Ecosystems and Vegetation Report. Report W14101068.024. Prepared for Minto Explorations Limited by EBA Engineering Consultants Limited, Whitehorse. 25 pp.

EBA Engineering Consultants Limited (EBA). (2010b). Minto Mine Environmental Baseline Studies Wildlife Report. Report W14101068.023. Prepared for Minto Explorations Limited by EBA Engineering Consultants Limited, Whitehorse. 29 pp.

Government of Yukon. (2006). Yukon Mine Site Reclamation and Closure Policy. Energy, Mines and Resources, Government of Yukon, Whitehorse. 18 pp.

Government of Yukon. (2006). Handbook of Reclamation Techniques and Mining Land Use. Energy, Mines and Resources, Government of Yukon, Whitehorse. 71 pp.

Helmers, E. (2016). Memo – Dry-Stack Tailings Storage Facility Interim Cover Investigation. Prepared from Minto Explorations Limited by SRK Consulting (Canada) Incorporated, Vancouver. 101 pp.

Laberge Environmental Services (Laberge). (2007). Shrub Trial Plots – Brewery Creek Mine 2006 Follow-Up Monitoring Report. MPERG 2007-4 Report. Prepared for the Mining Petroleum Environment Research Group by Laberge Environmental Services, Whitehorse. 28 pp.

Lister, D. (2010). An evaluation of factors influencing spontaneous vegetation succession in northern latitude disturbances: assessment of natural recolonization of disturbances in the Yukon. Reclamation: From Planning to Closure. Thirty Fourth Annual Mine Reclamation Symposium and the Thirty Fifth Canadian Land Reclamation Association Conference. The British Columbia Technical and Research Committee on Reclamation and the Canadian Land Reclamation Association. Courtenay, September 20-23, 2010. Organized by the British Columbia Technical and Research Committee on Reclamation, Victoria. 10 pp.

Matheus, P. and T. Omtzigt. (2012). Yukon Revegetation Manual. Practical Approaches and Methods. MPERG Document 2011-XX. Mining and Petroleum Environmental Research Group (MPERG), Department of Energy, Mines and Resources, Government of Yukon, Whitehorse. 176 pp.

Minto Exploration Limited. (2014a). Minto Mine 2014 Wildlife Protection Plan. Prepared by Minto Exploration Limited, Capstone Minto Mine, Whitehorse. 46 pp.

Minto Exploration Limited. (2014b). Minto Mine 2014 Heritage Resources Protection Plan. Prepared by Minto Exploration Limited, Capstone Minto Mine, Whitehorse. 21 pp.

Saxton, K.E. and Rawls, W.J. (2006) Soil water characteristic estimates by texture and organic matter for hydrologic solutions, Soil Science Society of America Journal, Vol. 70(5), pp. 1569–1578.

SRK Consulting (Canada) Incorporated (SRK). (2013). 2012 Overburden Characterization Data Report for Minto Closure Covers. Prepared for Minto Exploration Limited / Capstone Mining Corporation by SRK Consulting (Canada) Incorporated, Vancouver. 155 pp.

SRK Consulting (Canada) Incorporated (SRK). (2016). Closure Landform Design and Reclamation Landform Units for the Minto Mine. Prepared for Minto Exploration Limited / Capstone Mining Corporation by SRK Consulting (Canada) Incorporated, Vancouver. 43 pp.

Wang, T., A. Hamann, D. Spittlehouse, and T.N. Murdock. (2012). ClimateWNA – High-resolution spatial climate data for western North America. Journal of Applied Meteorology and Climatology 61, 16-29.

Withers, S.P. (1999). Natural Vegetation Succession and Sustainable Reclamation at Yukon Mine and Mineral Exploration Sites. MERG Report 1999-1. Prepared for the Mining Environment Research Group by Laberge Environmental Services, Whitehorse. 67 pp.

Yukon Ecoregions Working Group (YEWC). (2004). Yukon Plateau – Central. Ecoregions of the Yukon Territory. Biophysical Properties of Yukon Landscapes. PARC Technical Bulletin 04-01. Agriculture and Agri-Food Canada, Summerland. pp. 187 – 196.

Yukon Energy, Mines and Resources. (2013a). Reclamation and Closure Planning for Quartz Mining Projects. Plan Requirements and Closure Costing Guidance. Yukon Water Board, Energy, Mines and Resources, Yukon Government, Whitehorse. 87 pp.

Yukon Energy, Mines and Resources. (2013b). Re-vegetation on Mineral Claims. Interpretive Bulletin 2013-01. Mining Lands, Mineral Resources, Department of Energy, Mines and Resources, Yukon Government, Whitehorse. 3 pp.

APPENDIX B

Site conditions

Climate

The ecoclimate of the Minto site is classified as Northern Cordilleran High Boreal (NCh) (SRK 2016). To provide more site-specific information, the ClimateNA software (Wang et al. 2012) was used to model ambient air temperatures and precipitation for four locations at the mine. The locations modeled were the Dry Stack Tailings Facility (DSTF), Main Waste Dump (MWD), Reclamation Overburden Dump (ROD), and Southwest Waste Dump (SWD). Modeled mean annual temperatures (MAT) at the mine site ranges from -2.2oC to -4.4oC while mean annual precipitation (MAP) ranges from 396 mm to 415 mm. The lowest MAP and MAT statistics were calculated for the DSTF. Modeled MAT and MAP statistics were similar at the MWD, ROD, SWD locations. Precipitation is lowest in the spring and highest in the summer at all sites.

Physiography, Parent Materials, and Soils

The Minto Mine is situated in eastern section of the Dawson Range (EBA 2010a). Elevations range from 700 m to 950 m. The physiography of the area is characterized by rounded mountains and broad valleys with drainages that flow into the Yukon River.

The surficial geology of the region is influenced by the Pleistocene glaciation (YEWC 2004). Morainal blanket and veneer deposits are present at lower elevations while colluvial blankets and veneers occur on upper slopes at higher elevations.

Eutric Brunisols occur in association with northern- and eastern-aspect mixedwood forests as well as trembling aspens stands with thick moder humus forms. Melanic Brunisols are present in association with south-facing grasslands. Orthic and Humic Regosols occur in association with talus slopes and rock outcrops. Wetlands are associated with Organic Cryosols and Gleysolic Turbic Cryosols.

Vegetation

The Minto Mine is located in the Yukon Plateau-Central Boreal Cordillera Ecozone (YEWC 2004). Biogeoclimatic zones have not been delineated for the Minto Mine site. However, SRK (2016) extrapolated from the mapping completed for the Dawson Planning Region to the west (McKenna et al. 2010) and determined that the majority of the Minto mine site is situated with the Boreal High (BOH) biogeoclimatic zone with a smaller proportion within the upper elevation Subalpine (SUB) zone and a small proportion within the Boreal Low (BOL) zone.

The vegetation of valley bottoms and floodplains typically consists of white spruce (*Picea glauca*) and feather mosses. Understory species include roses (*Rosa* spp.), horsetails (*Equisetum* spp.), willows (*Salix* spp.) and alder (*Alnus* spp.) on floodplains, and kinnikinnick (*Arctostaphylos uva-ursi*) and lichens on coarse-textured soils. On well drained and warm aspects, lodgepole pine (*Pinus contorta*) and trembling aspen (*Populus tremuloides*) replace the white-spruce-dominated forests. Grasslands occur on steep, warm aspects and include sageworts (*Artemisia* spp.), kinnikinnick, rose and juniper

(*Juniperus* spp). Subalpine vegetation is dominated by subalpine fir (*Abies lasiocarpa*) and lodgepole pine.

Wildlife

Several wildlife studies have been conducted in the area of the Minto mine since the early 1990s (EBA 2010b). The diversity of vegetation types and structural stages in the Minto mine area provide habitat for 46 mammals (i.e., bats, carnivores, insectivores, lagomorphs, rodents, and ungulates), 60 bird species, and one amphibian.

Four ungulates are known to inhabit the area. Moose (*Alces alces*) is common in the vicinity of the mine site. Two woodland caribou (*Rangifer tarandus*) herds occur within the Minto Mine area. The Klaza herd occupies habitat to the west while the Tachum herd occupies habitat to the east of the Yukon River. Although the ranges of the Klaza and Tachum herds do not overlap, caribou still pass through the Minto Mine area. Dall's sheep (*Ovis dalli dalli*) use habitat near the project area, particularly the Minto Bluffs, but time spent in the vicinity of the mine is expected to be short. Mule deer (*Odocoileus hemionus*) is at its northern distribution in the region and is not commonly observed in the area.

Carnivores that have been observed at the mine include black bear (*Ursus americanus*), grizzly bear (*Ursus arctos*), gray wolf (*Canus lupus*), lynx (*Lynx canadensis*), and river otter (*Lutra canadensis*). Hares (*Lepus americanus*) are common in the area and provide an important prey base for lynx.

Ninety-nine bird species are potentially present in the area. Several raptors are potentially present in the vicinity of the mine but only peregrine falcon (*Falco peregrinus anatum*), red-tailed hawk (*Buteo jamaicensis*), and golden eagle (*Aquila chrysaetos*) have been reported. Five amphibians may be present in the area but only wood frog (*Rana sylvatica*) has been observed. No reptiles have been reported.

Land uses

Pre-mining land-use in the area included habitat provision for several wildlife species (EBA 2010b) as well as traditional uses of hunting, trapping, and berry-picking (Minto Exploration Limited 2014b).

Appendix F: Minto Closure Cover Design – Hydrotechnical Designs for Engineered Landforms

SRK Consulting (Canada) Inc.
205–2100 Airport Drive
Saskatoon, SK S7L 6M6

T: +1.306.955.4778
F: +1.306.955.4750
saskatoon@srk.com
www.srk.com

Memo

To:	File	**Client:**	Minto Explorations Ltd.
From:	Jordan Graham, EIT; Erik Ketilson, MEng, PEng	**Project No:**	1CM002.049
Reviewed by:	Maritz Rykaart, PhD, PEng	**Date:**	July 28, 2016
Subject:	Minto Closure Cover Design – Hydrotechnical Designs for Engineered Landforms		

1 Introduction

SRK Consulting (Canada) Inc. (SRK) is undertaking an update to the Minto Closure Plan, which includes landform grading designs for the waste facilities, and consideration to shedding water off of these structures. Several areas of the site require varying degrees of hydrotechnical features to collect and convey storm water over the covers. Wide, shallow channels (swales) have been sized for the six main engineered landforms: the Mill Valley Fill (MVF), the Southwest Waste Dump (SWD), the Dry Stack Tailings Storage Facility (DSTSF), the Main Waste Dump and Main Waste Dump and Expansion (MWD), the Main Pit Dump (MPD), and the Area 118 Pit Backfill Dump (Area 118). This memo summarizes the design process and presents the swale designs for each area.

2 Watershed Analysis

Watershed areas were delineated for each of the six main landforms based on closure configurations as presented in the Updated Closure Cover Design Report (SRK, 2016a). Each landform, with the exception of the MPD and Area 118, was then subdivided into smaller watershed areas that will collect water independently of one another to shed water off the top of the structure, and then into a channel directed down-slope. The areas and their general flow directions are presented in Figure 1.

3 Hydrology

Site Hydrology was updated by SRK in 2016; complete hydrological details are included in The Minto Mine – Closure Water Conveyance System Design Update Report (SRK, 2016b). The updated flow vs. watershed area relationships yield substantially greater flows than in previous site hydrological assessments completed by SRK and Janowicz (SRK, 2016b). The increase is due in part to the fact that for return periods greater than 1:5 year event, Environment Canada’s hydrometric station, the Little South Klondike River below Ross Creek presents the highest unit peak. For this reason, the Little South Klondike River below Ross Creek hydrometric station was selected for calibration purposes in order to generate a conservatively high estimate for unit peak flows.

The swales were designed to accommodate a 1 in 200 year, 24 hour storm event consistent with the approach presented by SRK (2016b). The flows expected on each watershed are presented in Table 3-1, with watershed areas illustrated on Figure 1.

Table 3-1: Watershed Areas and Design Flow Rates

Area	ID	Contributing Area (m^2)	1 in 200 Year Flow Rate (m^3/s)
DSTSF	1	38,653	0.25
	2	115,560	0.65
	3	26,020	0.18
MVF	4	29,329	0.20
	5	150,393	0.82
	6	55,632	0.35
	7	11,373	0.09
SWD	8	8,201	0.07
	9	21,138	0.15
	10	16,704	0.12
	11	18,713	0.13
	12	18,693	0.13
	13	15,303	0.11
	14	34,961	0.23
	15	15,062	0.11
	16	18,350	0.13
	17	19,249	0.14
	18	19,278	0.14
MWD	19	42,245	0.27
	20	25,001	0.17
MPD	21	83,470	0.49
Area 118	22	51,479	0.32

4 Swale Designs

Drainage swales have been designed for the top surfaces and slopes of the six main engineered landforms. The channel depths were determined using Manning's Equation, and were then increased by a factor of 2 to account for the potential effects that ice may have on flow within the channel. This approach is consistent with other sites in the Yukon, where there is a need to account for increased channel capacity and quantification of the increased capacity is challenging.

The cross sections of the swales on the top surfaces are trapezoidal, primarily with a base width of 2 m, but in the case of Watershed ID 5 (which accepts much of the water from the DSTSF), a base width of 5.5 m was considered; and 10H:1V side slopes. Each swale was designed with a variable grade, representative of the closure cover design, the grades are presented in Table 4-1. A Manning's "n" in each channel of 0.035 was applied, which is representative of roughness due to the presence scattered brush and heavy weeds in flood plains (Bedient et al, 2008).

The cross sections of the swales on the slopes are trapezoidal, with base widths equal to those of the swales on the top surfaces, but with 3H:1V side slopes. Each swale was designed with a variable grade, representative of the closure cover design, the grades are presented in Table 4-2**Error! Reference source not found.**. A Manning's "n" in each channel of 0.040 was applied, which is representative of roughness due to the presence a bottom with gravels, and cobbles in mountain streams (Bedient et al, 2008).

The dimensions of each channel are indicated in Table 4-1 for the facility tops, and Table 4-2 the slopes. Flow velocity is also included in the table.

Table 4-1: Channel Dimensions and Flow Velocities for Facility Tops

Area	ID	Channel Dimensions				Channel Dimensions for n=0.035				
		Longitudinal Grade (%)	Length (m)	Bottom Width (m)	Side Slopes (H:V)	Depth of Flow (m)	Allotment for Ice Formation (m)	Total Depth (m)	Top Width (m)	Flow Velocity (m/s)
DSTSF	1	0.5%	130	2.0	10	0.11	0.11	0.22	6.3	0.75
	2	1.0%	180	2.0	10	0.25	0.25	0.49	11.9	0.59
	3	0.5%	60	2.0	10	0.11	0.11	0.22	6.3	0.53
MVF	4	2.5%	120	2.0	10	0.14	0.14	0.27	7.5	0.43
	5	2.0%	205	5.5	10	0.12	0.12	0.25	10.4	1.00
	6	2.5%	250	2.0	10	0.13	0.13	0.26	7.1	0.82
	7	3.4%	48	2.0	10	0.06	0.06	0.11	4.3	0.59
SWD	8	0.5%	75	2.0	10	0.04	0.04	0.09	3.8	0.59
	9	1.3%	75	2.0	10	0.12	0.12	0.24	6.7	0.39
	10	1.2%	125	2.0	10	0.08	0.08	0.17	5.3	0.52
	11	1.7%	110	2.0	10	0.09	0.09	0.18	5.6	0.52
	12	1.3%	150	2.0	10	0.08	0.08	0.16	5.2	0.59
	13	1.2%	160	2.0	10	0.08	0.08	0.16	5.2	0.51
	14	2.0%	275	2.0	10	0.12	0.12	0.24	6.7	0.61
	15	2.2%	70	2.0	10	0.07	0.07	0.14	4.8	0.59
	16	1.7%	150	2.0	10	0.07	0.07	0.15	5.0	0.64
	17	0.3%	35	2.0	10	0.08	0.08	0.16	5.3	0.59
	18	2.5%	33	2.0	10	0.13	0.13	0.26	7.2	0.32
MWD	19	1.0%	275	2.0	10	0.11	0.11	0.21	6.3	0.83
	20	5.1%	130	2.0	10	0.11	0.11	0.21	6.3	0.53
MPD	21	4.5%	150	7.0	10	0.07	0.07	0.13	9.6	0.99
Area 118	22	25.0%	160	3.5	10	0.08	0.08	0.15	6.6	0.98

Table 4-2: Channel Dimensions and Flow Velocities for Facility Slopes

Area	ID	Channel Dimensions				Channel Dimensions for n=0.040				
		Longitudinal Grade (%)	Length (m)	Bottom Width (m)	Side Slopes (H:V)	Depth of Flow (m)	Allotment for Ice Formation (m)	Total Depth (m)	Top Width (m)	Flow Velocity (m/s)
DSTSF	1	NA				NA				
	2	22.2%	50	2.0	3	0.08	0.08	0.15	2.9	2.03
	3	18.5%	33	2.0	3	0.04	0.04	0.07	2.4	1.17
MVF	4	23.7%	16.8	2.0	3	0.04	0.04	0.07	2.4	1.32
	5	32.5%	32.8	5.5	3	0.04	0.04	0.09	6.0	1.73
	6	36.0%	40	2.0	3	0.05	0.05	0.09	2.5	1.85
	7	33.5%	45	2.0	3	0.02	0.02	0.04	2.2	1.06
SWD	8	10.0%	85	2.0	3	0.02	0.02	0.05	2.3	0.66
	9	18.0%	80	2.0	3	0.03	0.03	0.07	2.4	1.08
	10	13.0%	130	2.0	3	0.03	0.03	0.07	2.4	0.91
	11	17.0%	180	2.0	3	0.03	0.03	0.06	2.4	1.02
	12	26.0%	70	2.0	3	0.03	0.03	0.06	2.3	1.16
	13	11.0%	35	2.0	3	0.03	0.03	0.07	2.4	0.84
	14	11.0%	200	2.0	3	0.05	0.05	0.10	2.6	1.10
	15	13.4%	40	2.0	3	0.03	0.03	0.06	2.4	0.88
	16	14.0%	100	2.0	3	0.03	0.03	0.07	2.4	0.96
	17	9.0%	15	2.0	3	0.04	0.04	0.08	2.5	0.85
	18	16.0%	170	2.0	3	0.03	0.03	0.07	2.4	1.01
MWD	19	32.5%	60	2.0	3	0.04	0.04	0.08	2.5	1.64
	20	29.0%	53	2.0	3	0.03	0.03	0.06	2.4	1.33
MPD	21	75.0%	40	7.0	3	0.02	0.02	0.04	7.3	1.65
Area 118	22	NA				NA				

5 Conclusion

As stated by SRK (2016b), engineered designs to reduce erosion within the swales may be required for flow velocities greater than 1 m/s (engineered designs could include rip rap, other armouring, or velocity reducing features within the swale). Engineered designs to reduce erosion in cases where flow velocities are less than 1 m/s are not required; in these scenarios, short term erosion control support practices, such as the use of rolled erosion control products and/or hydroseeding is sufficient to reduce erosion until surface vegetation is established.

The swales for the facility tops have a base width of either 2 m, 3.5 m, 5.5 m, or 7.0 m, and are 0.1 to 0.5 m deep and have 3.8 to 11.9 m top widths. All designs were completed to equal a flow velocity of 1.0 m/s or less such that channel protection can be achieved using surface vegetation.

The swales for the facility slopes have base widths equal to the facility tops. Flow depths were estimated to be between 0.04 m and 0.15 m deep, and have top widths ranging between 2.24 m and 7.25 m. Nearly all of the flow velocities are greater than 1.0 m/s, while considering a base consisting of gravel and cobble rip rap protection. Therefore, detailed design of these structures should account for appropriate riprap protection, with sizing of the rip rap to be completed at that time.

Disclaimer—SRK Consulting (Canada) Inc. has prepared this document for Minto Explorations Ltd.. Any use or decisions by which a third party makes of this document are the responsibility of such third parties. In no circumstance does SRK accept any consequential liability arising from commercial decisions or actions resulting from the use of this report by a third party.

The opinions expressed in this report have been based on the information available to SRK at the time of preparation. SRK has exercised all due care in reviewing information supplied by others for use on this project. Whilst SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information, except to the extent that SRK was hired to verify the data.

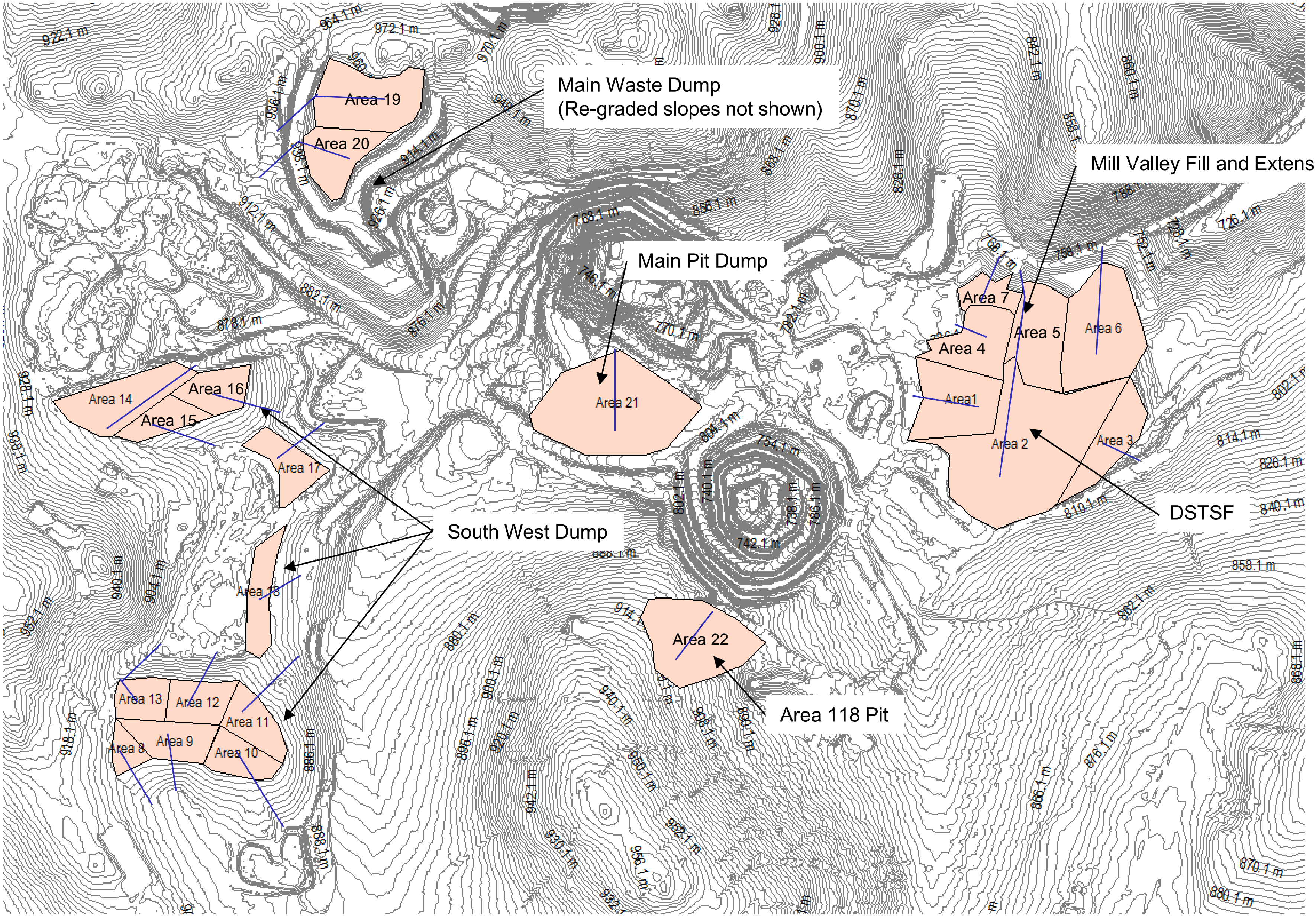
6 References

Bedient, P; Humber, W.; Vieux; B. 2008. Hydrology and Floodplain Analysis – 4th Edition. Textbook. Prentice-Hall, Inc. Upper Saddle River, NJ.

SRK Consulting, 2016a. Minto Mine – Updated Closure Cover Designs. Prepared for Minto Explorations Ltd. SRK Consulting (Canada) Inc. Project No. 1CM002.049. July 2016.

SRK Consulting, 2016b. Minto Mine – Closure Water Conveyance System Design Update Report. Prepared for Minto Explorations Ltd. SRK Consulting (Canada) Inc. Project No. 1CM002.042. June 2016.

Figures



— Flow Path

▨ Watershed Area

srk consulting

capstone
MINTO MINE
OPERATED BY MINTO EXPLORATIONS LTD.

Hydrotechnical Designs for Engineered Landforms

Watershed Areas

Job No: 1CM002.049

Filename: Figure xxxx.pptx

Minto Mine, Yukon

Date: July, 2016

Approved: EK

Figure: 1