TETRA TECH

April 30, 2020

ISSUED FOR USE
FILE: ENW.EENW03031-10
Via Email: ron.gee@canada.ca

Crown-Indigenous Relations and Northern Affairs Canada
Room 415C – 300 Main Street
Whitehorse, YT Y1A 2B5

Attention: Ron Gee, P.Eng. – Senior Engineer (CIRNAC)
Cc: Michael Bernardin – Project Manager (PSPC)

Subject: Results of 2019 Drilling Program and Dam Stability Update
Venus Tailings Storage Facility, Yukon

1.0 INTRODUCTION

Tetra Tech Canada Inc. (Tetra Tech) was retained by the Government of Canada (Canada) to carry out a geotechnical drilling program and an updated evaluation of dam stability at the Venus Tailings Storage Facility (TSF), located south of Carcross, Yukon, at about km 86.5 on the South Klondike Highway (Yukon Highway No. 2).

The work was procured by Public Services and Procurement Canada (PSPC) via Standing Offer Agreement (SOA) EW699-170520/004/NCS, on behalf of Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC).

This letter presents the results of the fieldwork completed at the site in November 2019 and an updated slope stability assessment of the dam embankment.

2.0 BACKGROUND

Tetra Tech was retained by CIRNAC to carry out an assessment of the Venus TSF in 2018-19, which consisted of a technical review of geotechnical, hydrotechnical and environmental aspects of the dam design using existing information, in order to evaluate the TSF with respect to applicable guidelines provided by the Canadian Dam Association (CDA 2013, CDA 2014). Tetra Tech's Dam Assessment Report was Issued For Use to CIRNAC in April 2019 (Tetra Tech 2019).

The report included a geotechnical assessment of the TSF, which focused on the stability of the tailings dam and included a program of slope stability modeling using subsurface geotechnical information that was available in historical reports pertaining to the site.

The results of the slope stability modeling suggested that the dam meets applicable CDA criteria for slope stability under regular operating conditions but did not meet CDA criteria for seismic conditions. Significant uncertainty was noted with respect to practically all input parameters used in the slope stability modeling, including the subsurface stratigraphy of the native soils and geometry of the dam embankment at the site, material parameters of the various subsurface strata, and groundwater elevations throughout the site.

As a result, the dam assessment report recommended carrying out a geotechnical field program including geotechnical drilling, Cone Penetration Testing (CPT), laboratory testing, and installation of piezometers in order to resolve data gaps and facilitate an updated slope stability assessment with less uncertainty.

3.0 GEOTECHNICAL FIELD PROGRAM

3.1 Fieldwork

A geotechnical field program was carried out at the site between November 7 and November 14, 2019, in conjunction with other drilling work (by others) to install new monitoring wells at the Venus and Arctic Gold and Silver tailings sites. No work was done on some days during the field program due to equipment damage and breakdowns.

The geotechnical field program included drilling of boreholes using a sonic drilling rig operated by Metro Drilling (Metro) of Carcross, Yukon, and CPT soundings conducted by Gregg Drilling (Gregg) of Prince George, BC. CPTs were advanced using a hydraulic ram mounted on the sonic drilling rig. Metro and Gregg were retained by the Carcross/Tagish Energy Corporation (C/TEC), on behalf of CIRNAC.

Underhill Geomatics Ltd. (Underhill) of Whitehorse was retained by Tetra Tech to lay out the proposed borehole and CPT locations in the field, which are shown on Figure 1, attached.

Sonic boreholes were logged in the field by a geotechnical engineer from Tetra Tech's Whitehorse office, and representative disturbed samples were collected from the sonic core and by Standard Penetration Testing (SPT) and returned to Tetra Tech's Whitehorse laboratory for geotechnical index testing. It was noted in the field that SPTs were conducted with the SPT drop hammer suspended from a winch line on the sonic drill, which was difficult to keep plumb while conducting SPTs, and therefore the resulting SPT N-values (blow counts measuring penetration resistance) may be of limited use. Vibrating Wire Piezometers (VWPs) were installed and grouted into place in selected boreholes (see Figure 1) to provide ongoing measurements of porewater pressure in the ground.

Tetra Tech's field representative was also present during all of the CPT soundings, to monitor progress and to identify suitable depths to conduct porewater dissipation testing. Seismic shear wave velocity was measured in selected CPT soundings (see Figure 1).

It was not possible to complete the full scope of the proposed field program due to scheduling and budget constraints, as summarized below and illustrated on Figure 1. Elements of the field program that were not completed included the following:

- CPT19-01 encountered premature refusal at or near the base of the tailings and was not drilled out and re-attempted.
- Proposed sonic borehole BH19-02 was not drilled.
- Proposed sonic borehole BH19-03 was not drilled.
- Proposed sonic borehole BH19-04 was not drilled, which would have had two VWPs installed.
- Proposed sonic borehole BH19-05 was not drilled, which would have had one VWP installed.

The results of the drilling program are presented on the borehole logs and laboratory test results from the sonic drilling program, which are attached in Appendix B, and in Gregg's Cone Penetration Testing Report, which is attached in Appendix C.

4.0 UPDATED SLOPE STABILITY MODELING

Slope stability modeling was undertaken to update the slope model developed during the dam assessment study in 2018-19, using the results of the field drilling and CPT programs. Slope stability modeling was undertaken using Slope/W software (Geo-Slope 2016).

As described in the OMS Manual for the dam at the Venus TSF (Tetra Tech 2018), the dam is assumed to have a consequence classification of "High" and to be in the "Closure – Passive Care" life cycle phase, as described by the CDA (2013, 2014). Slope modeling used appropriate design criteria (e.g., target factors of safety and earthquake hazard levels) recommended by the CDA.

4.1 Design Criteria

The CDA (2013, 2014) provides design criteria for evaluation slope stability of dams, which generally consists of target minimum Factors of Safety (FS) for various loading conditions. The updated slope stability model used the same design criteria as the previous dam assessment study, which were taken from CDA (2014) for mining dams in the "Closure – Passive Care" life-cycle phase, and are reproduced on Table 1 below:

Table 1: Target FS for Slope Stability Modeling

Loading Condition	Target FS	Slope
Long-term (steady-state seepage, normal reservoir level)	1.5	Downstream
Seismic (Pseudostatic)	1.0	Upstream and Downstream
Post-Seismic (e.g., liquefaction)	1.2 to 1.3	Upstream and Downstream

4.2 Model Geometry

Similar to the previous dam assessment, slope stability was evaluated by modeling a cross-section through the southern portion of the TSF, where the dam embankment reaches its maximum height above Tagish Lake and the surrounding bedrock-controlled topography. The location of the cross-section through the tailings is shown on Figure 1.

Subsurface stratigraphy used in the model was constructed with reference primarily to the drilling and CPT programs completed in November 2019, with other available information (SRK 1998, SRK 2017) used to fill gaps where boreholes were not drilled in 2019.

In general, the tailings are contained in the reservoir of the TSF behind a constructed embankment with a gravel toe buttress on the downslope side. Within the tailings, a relatively coarse-grained layer was encountered close to the ground surface, with finer-grained tailings below.

Natural soils beneath the tailings and embankment consisted of fine-grained soil of varying plasticity (non-plastic silt to medium-plastic clay), over till-like, gravelly soil, over probable bedrock.

It is noted that the subsurface geometry in the vicinity of the dam embankment remains relatively uncertain, since no boreholes were drilled in that area to recover physical soil samples that would allow for more reliable interpretation of the subsurface stratigraphy.

The model geometry used in the slope model is shown on figures presenting the slope stability results, which are attached in Appendix D.

4.3 Material Parameters

Soil strength models were selected for each soil type to match the expected soil behaviour (i.e., “sand-like” vs. “clay-like”), based on interpretation of the CPT data, borehole logs, and laboratory test results. Material parameters used to model each layer in the slope stability model were developed primarily by interpretation of the CPT data, since it is considered to be more reliable than the SPT N-values recorded during the drilling program.

In general, it was considered appropriate to model most of the soil types using the Mohr-Coulomb model, with cohesion set to zero and a friction angle assigned based on interpretation of the CPT data in most cases, and based on engineering judgement in the case of the gravel toe buttress. The fine tailings and native clay layer were modeled as fine-grained materials and assigned an undrained strength. In the case of the native clay, undrained strength was assigned to vary with depth, which is consistent with the interpretation of the CPT data.

Unit weights for most materials were estimated by using the natural moisture content of saturated samples and an assumed specific gravity of 2.7, which is typical for natural soils originating from granitic rock. The unit weight of the tailings was estimated using a specific gravity of 3.2, which was estimated by Klohn (1994) for the processed tailings material to reflect the relatively high content of metals in the tailings.

Liquefied shear strength parameters used to evaluate post-seismic slope stability were estimated from the CPT data; this is discussed in more detail in Section 4.5.2.

Material models and parameters are presented on the figures showing slope stability results in Appendix D.

The sheet piles that form the Waterloo Barrier were modeled the same way as in the previous slope stability model, based on the cross-sectional area and an assumed shear strength for the steel sheets, resulting in an ultimate shear resistance of 1,615 kN/m (Tetra Tech 2019). Compared to the previous model, the bottom elevation of the Waterloo Barrier has been raised to leave a bigger gap between the bottom of the sheet and the underlying bedrock, which reflects the as-built sheet pile lengths provided in a construction management report prepared by PWGSC (1995); sheet pile-driving logs included in the report show that the longest sheet pile installed in the Waterloo Barrier was only 5.8 m long, which suggests that the sheet piles installed in the highest part of the dam embankment may have encountered refusal on cobbles and boulders in the till-like material before reaching bedrock.

4.4 Groundwater

The groundwater elevation used in the model was developed based on groundwater elevations that have been measured from the VWPs that were installed in BH19-01A and BH19-06, as well as groundwater levels from other monitoring wells installed at the site, which are monitored by Tetra Tech on a monthly basis (Tetra Tech, 2019a).

The available data suggest that groundwater is present nominally at the surface of the covered tailings behind the dam, drops significantly through the dam embankment, and then follows approximately the native ground surface beneath the (permeable) gravel toe buttress and daylights downslope near Tagish Lake.

VWPs in BH19-01A and BH19-06 were installed below the clay layer to measure porewater pressure just above the bedrock, since it has been postulated that artesian pressure may be present beneath the low-permeability clay layer (SRK 1998). Porewater pressure measured to date on these instruments have not showed artesian pressure and seem to be in generally good agreement with water levels observed in monitoring wells installed above the clay layer at the site.

4.5 Seismic

4.5.1 Design Seismic Hazard

Seismic hazard levels used in the updated slope stability model are the same as those used in the previous dam assessment study (Tetra Tech 2019) and are summarized below on Table 2:

Table 2: Summary of PGA for Seismic Design Hazard Levels

Seismic Hazard Level	Peak Ground Acceleration (PGA)
1:475 year	0.108g
1:975 year	0.155g
1:2,475 year	0.236g
1:10,000 year	0.458g
CDA Design Ground Motion (50% between 1:2,475 and 1:10,000)	0.347g

As shown on the table, the design seismic event recommended by the CDA for a dam with consequence classification of “High” in the “Closure – Passive Care” life cycle phase is an event with PGA that is 50% between the design events with return periods of 1 in 2,475 years and 1 in 10,000 years.

Seismic conditions were modeled in the slope model using the pseudostatic approach, where seismic shaking is represented by a horizontal static force that is equal to the PGA.

4.5.2 Liquefaction

Liquefaction potential was discussed in Tetra Tech’s dam assessment report (2019). The extent of potentially liquefiable soils under the design earthquake can be checked using CPT data and SPT N-values in accordance with the Simplified Method described by Idriss and Boulanger (2008).

Liquefaction triggering analysis suggests that all or most of the stored tailings would be susceptible to seismic liquefaction. Liquefaction of the native foundation soils is possible, but the extent would depend on the type of soil behaviour displayed by the various soil strata. Soil behaviour can be estimated by interpretation of CPT data, or preferably by plasticity testing in the laboratory (Atterberg Limits) conducted on representative soil samples.

Where data were available, the clay layer was found to exhibit “clay-like” behaviour based on both the CPT data and plasticity testing, and therefore may be susceptible to some relatively minor softening and strength loss following an earthquake but would be unlikely to undergo liquefaction.

The behaviour of the till-like material above the bedrock is less certain, particularly in the critical area beneath the dam embankment, since no boreholes were drilled in that area and therefore no samples were available for plasticity testing. Interpretation of the CPT data in the till-like soil suggest that the material demonstrates slightly plastic, intermediate behaviour that falls somewhere between the “sand-like” (i.e., liquefiable) and “clay-like” (i.e, subject to softening but not liquefiable) extremes. If the material demonstrates sand-like behaviour, it would be considered to be liquefiable under the design earthquake. As such, two post-seismic slope stability cases have been considered in the slope model, one with liquefied shear strength applied to the tailings only, and another assuming that liquefaction occurs both in the tailings and throughout the till-like foundation soil. The case with liquefied soil strength applied throughout the foundation soil is likely conservative and represents a worst-case scenario; if liquefiable material is present it likely exists in discontinuous zones or pockets, however it is impossible to reliably estimate the location or extent of any such zones using the available data.

The shear strength used for liquefied soil in the slope model was estimated using CPT data according to simplified procedures described by Idriss and Boulanger (2008). In general, the shear strength of sand-like soil is severely impacted by liquefaction; the post-seismic strength of liquefied sand is typically reduced by about 90% compared to its non-liquefied state. As such, the extent of liquefaction has a major impact on slope stability.

4.6 Results

Factors of Safety computed using Slope/W for the various load cases are summarized on Table 3 below:

Table 3: Factors of Safety from Slope Stability Modeling

Load Case	Target FS	Computed FS	Acceptable FS?
Static	1.5	2.89	Yes
Pseudostatic (1:475 year EQ)	1.0	1.74	Yes
Pseudostatic (1:975 year EQ)	1.0	1.48	Yes
Pseudostatic (1:2,475 year EQ)	1.0	1.18	Yes
Pseudostatic (CDA Design Ground Motion)	1.0	0.76	No
Post-Seismic (Liquefied tailings)	1.3	2.81	Yes
Post-Seismic (Liquefied tailings and foundation soil)	1.3	0.72	No

The results of slope stability modeling summarized on Table 3 suggest that the dam meets applicable CDA criteria for slope stability under static (i.e., normal operating) conditions, as well as for various levels of seismic event up to, but not including, the design ground motion recommended by the CDA. An acceptable FS is also achieved for post-seismic conditions if it is assumed that liquefaction occurs only within the stored tailings.

However, less than acceptable FS were achieved for the design seismic event and for the post-seismic condition if widespread liquefaction is triggered in the foundation soils.

Seismic slope displacements were estimated in Tetra Tech’s dam assessment study (2019), which suggested that up to about 1 m of horizontal displacement would be expected under the design seismic event. This analysis has not been repeated using the updated slope stability modeling results, but would be expected to result in similar, or slightly reduced, estimates of seismic displacement compared to the previous study.

It is possible that the dam would be able to sustain displacements of up to 1 m without releasing a significant quantity of tailings. However, it is important to note that the estimated displacement does not consider the effect of soil liquefaction. In the (very likely) event that the tailings liquify following the design earthquake they would become temporarily fluid and flowable. One metre of displacement could result in cracking, settlement or other damage to the dam embankment, which could allow a significant quantity of liquefied tailings to escape the TSF and flow into Tagish Lake.

For post-seismic conditions, the FS computed by the slope model is extremely sensitive to the extent of liquefaction assigned in the model, due to the major loss of shear strength that occurs when the soil liquefies. In the worst case that was evaluated, where it was assumed that liquefaction would occur throughout the foundation soil beneath the dam embankment, the FS would be less than unity and it is likely that the resulting displacement of the dam would be much greater than 1 m; in that case, catastrophic failure of the dam embankment and uncontrolled flow of liquefied tailings into the lake would be likely.

Alternatively, if the foundation soil is not liquefiable, or if the extent of liquefiable soil is limited, the resulting FS would be relatively higher and may satisfy CDA design guidelines.

5.0 RECOMMENDATIONS

Based on the results of slope stability modeling described in Section 4.6, the Venus TSF meets CDA requirements for slope stability under normal operating conditions, but does not meet applicable target FS for the design seismic event and potentially for post-seismic conditions, depending on the extent of liquefiable material that is present within the native foundation soils underlying the dam.

However, we note that there is still significant uncertainty in the model since it was not possible to complete the full scope of fieldwork that was planned at the site. In particular, the geometry and material behaviour of soils in the immediate vicinity of the dam embankment are still uncertain, since the proposed sonic boreholes in that area were not drilled.

Therefore, we recommend that the remaining scope of the field program be completed in order to achieve the following:

- Delineate the geometry of the dam embankment.
- Delineate the stratigraphy of the native soils beneath the dam embankment.
- Collect SPT N-values from the remaining boreholes to collect additional information that can be used to refine soil strength parameters. The drilling contractor retained for any future work should provide a drilling rig is equipped with either an integral SPT drop hammer or other means to keep the hammer plumb and collect reliable, repeatable SPT N-values. It not acceptable to conduct SPT by suspending the hammer from a winch line with no other restraint.
- Collect representative soil samples from the dam embankment and foundation soils for laboratory testing to evaluate material behaviour and potential for susceptibility to liquefaction and/or piping and internal erosion.
- Install VWPs in the native foundation soils on either side of the Waterloo Barrier, to detect potential artesian pressures confined beneath the clay layer and/or to estimate the hydraulic gradient through the dam for evaluation of potential for piping and internal erosion.

The results of the remaining fieldwork would be used to further refine the updated slope model and to carry out an evaluation of potential for piping and internal erosion through the dam and foundation soils; the evaluation of piping potential was intended to be carried out as part of the current scope of work, but was not possible to complete since sonic boreholes BH19-04 and BH19-05 were not drilled.

Updates to the slope model will consist of changes to model geometry and material parameters based on the conditions observed in the remaining boreholes, a refined estimate of the extent of liquefiable soil which may result in the model achieving the target FS for post-seismic conditions, and an updated estimate of seismic displacement, which may suggest that the expected displacement will be acceptably small to avoid significant adverse impact to the dam and/or release of tailings from the TSF.

If favourable conditions are encountered (e.g., soil material types are confirmed to be not susceptible to liquefaction or piping, VWPs detect no artesian pressure and low gradient across the dam), it is possible that the outcome of the remaining work will confirm that the dam meets applicable CDA criteria for slope stability with no remedial work needed. If unfavourable conditions are encountered, it will be possible to develop options for remedial measures to improve dam stability, if required.

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7.0 CLOSURE

We trust this document meets your present requirements. If you have any questions or comments, please contact the undersigned.

Respectfully Submitted,
Tetra Tech Canada Inc.

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30 Apr 2020

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FIGURES

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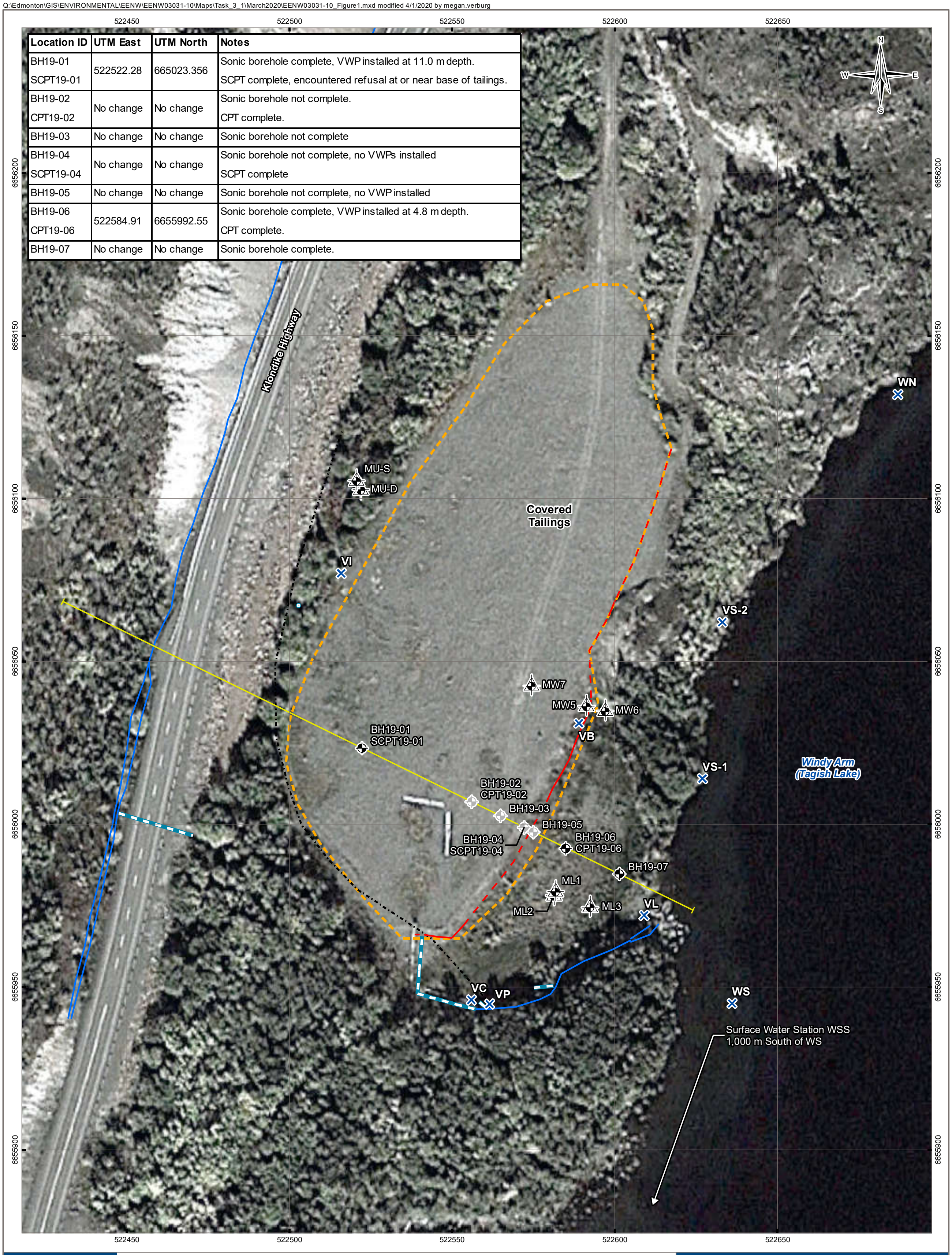

Location ID	UTM East	UTM North	Notes
BH19-01 SCPT19-01	522522.28	665023.356	Sonic borehole complete, VWP installed at 11.0 m depth. SCPT complete, encountered refusal at or near base of tailings.
BH19-02 CPT19-02	No change	No change	Sonic borehole not complete. CPT complete.
BH19-03	No change	No change	Sonic borehole not complete
BH19-04 SCPT19-04	No change	No change	Sonic borehole not complete, no VWPs installed SCPT complete
BH19-05	No change	No change	Sonic borehole not complete, no VWP installed
BH19-06 CPT19-06	522584.91	6655992.55	Sonic borehole complete, VWP installed at 4.8 m depth. CPT complete.
BH19-07	No change	No change	Sonic borehole complete.

LEGEND

- ⌖ Groundwater Monitoring Well
- ◆ Borehole and/or CPT Location
- ◇ Proposed Borehole (Incomplete)
- ✕ Surface Water Station
- -·-· Groundwater Diversion Pipe
- ▬ Drainage Culvert
- — Ditch
- — Slope Stability Cross-Section
- — Waterloo Barrier (Surveyed November 2018)
- – – Waterloo Barrier (Not Visible Under Tailings Cover)
- ▭ Extent of Covered Tailings
- ▭ Former Mill Area

NOTES
Site features digitized based on figure from SRK Consulting (2017).
Base data source: Geomatics Yukon.
Imagery: ©2018 Google, DigitalGlobe (September 13, 2009)

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GEOTECHNICAL DRILLING PROGRAM VENUS TAILINGS STORAGE FACILITY

Site Plan Showing Sonic Borehole and CPT Locations

PROJECTION UTM Zone 8
DATUM NAD83
CLIENT CIRNAC

Scale: 1:1,100
20 10 0 20
Metres

FILE NO. EENW03031-10_Figure1.mxd

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Tt-EDM	MRV	SL	AWW	0

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Figure 1

APPENDIX A

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GEOTECHNICAL

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The Professional Document is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site conditions present, or variation in assumed conditions which might form the basis of design or recommendations as outlined in this document, at or on the development proposed as of the date of the Professional Document requires a supplementary exploration, investigation, and assessment.

TETRA TECH is neither qualified to, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the Client.

1.7 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, TETRA TECH has not been retained to explore, address or consider and has not explored, addressed or considered any environmental or regulatory issues associated with development on the subject site.

1.8 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems, methods and standards employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from the system or method prevail, they are specifically mentioned.

Classification and identification of geological units are judgmental in nature as to both type and condition. TETRA TECH does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

Where subsurface conditions encountered during development are different from those described in this report, qualified geotechnical personnel should revisit the site and review recommendations in light of the actual conditions encountered.

1.9 LOGS OF TESTHOLES

The testhole logs are a compilation of conditions and classification of soils and rocks as obtained from field observations and laboratory testing of selected samples. Soil and rock zones have been interpreted. Change from one geological zone to the other, indicated on the logs as a distinct line, can be, in fact, transitional. The extent of transition is interpretive. Any circumstance which requires precise definition of soil or rock zone transition elevations may require further investigation and review.

1.10 STRATIGRAPHIC AND GEOLOGICAL INFORMATION

The stratigraphic and geological information indicated on drawings contained in this report are inferred from logs of test holes and/or soil/rock exposures. Stratigraphy is known only at the locations of the test hole or exposure. Actual geology and stratigraphy between test holes and/or exposures may vary from that shown on these drawings. Natural variations in geological conditions are inherent and are a function of the historical environment. TETRA TECH does not represent the conditions illustrated as exact but recognizes that variations will exist. Where knowledge of more precise locations of geological units is necessary, additional exploration and review may be necessary.

1.11 PROTECTION OF EXPOSED GROUND

Excavation and construction operations expose geological materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance which can cause severe deterioration. Unless otherwise specifically indicated in this report, the walls and floors of excavations must be protected from the elements, particularly moisture, desiccation, frost action and construction traffic.

1.12 SUPPORT OF ADJACENT GROUND AND STRUCTURES

Unless otherwise specifically advised, support of ground and structures adjacent to the anticipated construction and preservation of adjacent ground and structures from the adverse impact of construction activity is required.

1.13 INFLUENCE OF CONSTRUCTION ACTIVITY

Construction activity can impact structural performance of adjacent buildings and other installations. The influence of all anticipated construction activities should be considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques, and construction sequence are known.

1.14 OBSERVATIONS DURING CONSTRUCTION

Because of the nature of geological deposits, the judgmental nature of geotechnical engineering, and the potential of adverse circumstances arising from construction activity, observations during site preparation, excavation and construction should be carried out by a geotechnical engineer. These observations may then serve as the basis for confirmation and/or alteration of geotechnical recommendations or design guidelines presented herein.

1.15 DRAINAGE SYSTEMS

Unless otherwise specified, it is a condition of this report that effective temporary and permanent drainage systems are required and that they must be considered in relation to project purpose and function. Where temporary or permanent drainage systems are installed within or around a structure, these systems must protect the structure from loss of ground due to mechanisms such as internal erosion and must be designed so as to assure continued satisfactory performance of the drains. Specific design details regarding the geotechnical aspects of such systems (e.g. bedding material, surrounding soil, soil cover, geotextile type) should be reviewed by the geotechnical engineer to confirm the performance of the system is consistent with the conditions used in the geotechnical design.

1.16 DESIGN PARAMETERS

Bearing capacities for Limit States or Allowable Stress Design, strength/stiffness properties and similar geotechnical design parameters quoted in this report relate to a specific soil or rock type and condition. Construction activity and environmental circumstances can materially change the condition of soil or rock. The elevation at which a soil or rock type occurs is variable. It is a requirement of this report that structural elements be founded in and/or upon geological materials of the type and in the condition used in this report. Sufficient observations should be made by qualified geotechnical personnel during construction to assure that the soil and/or rock conditions considered in this report in fact exist at the site.

1.17 SAMPLES

TETRA TECH will retain all soil and rock samples for 30 days after this report is issued. Further storage or transfer of samples can be made at the Client's expense upon written request, otherwise samples will be discarded.

1.18 APPLICABLE CODES, STANDARDS, GUIDELINES & BEST PRACTICE

This document has been prepared based on the applicable codes, standards, guidelines or best practice as identified in the report. Some mandated codes, standards and guidelines (such as ASTM, AASHTO Bridge Design/Construction Codes, Canadian Highway Bridge Design Code, National/Provincial Building Codes) are routinely updated and corrections made. TETRA TECH cannot predict nor be held liable for any such future changes, amendments, errors or omissions in these documents that may have a bearing on the assessment, design or analyses included in this report.

APPENDIX B

BOREHOLE LOGS AND LABORATORY TEST RESULTS

TERMS USED ON BOREHOLE LOGS

TERMS DESCRIBING CONSISTENCY OR CONDITION

COARSE GRAINED SOILS (major portion retained on 0.075mm sieve): Includes (1) clean gravels and sands, and (2) silty or clayey gravels and sands. Condition is rated according to relative density, as inferred from laboratory or in situ tests.

DESCRIPTIVE TERM	RELATIVE DENSITY	N (blows per 0.3m)
Very Loose	0 TO 20%	0 to 4
Loose	20 TO 40%	4 to 10
Compact	40 TO 75%	10 to 30
Dense	75 TO 90%	30 to 50
Very Dense	90 TO 100%	greater than 50

The number of blows, N, on a 51mm O.D. split spoon sampler of a 63.5kg weight falling 0.76m, required to drive the sampler a distance of 0.3m from 0.15m to 0.45m.

FINE GRAINED SOILS (major portion passing 0.075mm sieve): Includes (1) inorganic and organic silts and clays, (2) gravelly, sandy, or silty clays, and (3) clayey silts. Consistency is rated according to shearing strength, as estimated from laboratory or in situ tests.

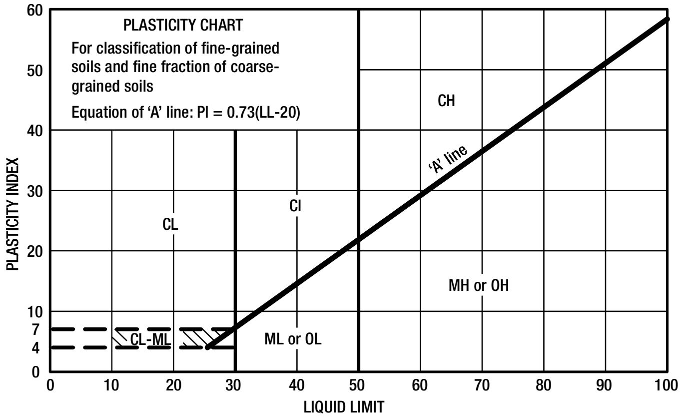
DESCRIPTIVE TERM	UNCONFINED COMPRESSIVE STRENGTH (KPA)
Very Soft	Less than 25
Soft	25 to 50
Firm	50 to 100
Stiff	100 to 200
Very Stiff	200 to 400
Hard	Greater than 400

NOTE: Slickensided and fissured clays may have lower unconfined compressive strengths than shown above, because of planes of weakness or cracks in the soil.

GENERAL DESCRIPTIVE TERMS

Slickensided - having inclined planes of weakness that are slick and glossy in appearance.
Fissured - containing shrinkage cracks, frequently filled with fine sand or silt; usually more or less vertical.
Laminated - composed of thin layers of varying colour and texture.
Interbedded - composed of alternate layers of different soil types.
Calcareous - containing appreciable quantities of calcium carbonate.;
Well graded - having wide range in grain sizes and substantial amounts of intermediate particle sizes.
Poorly graded - predominantly of one grain size, or having a range of sizes with some intermediate size missing.

MODIFIED UNIFIED SOIL CLASSIFICATION

MAJOR DIVISION			GROUP SYMBOL	TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA		
COARSE - GRAINED SOILS More than 50% retained on No. 75 µm sieve*	GRAVELS 50% or more of coarse fraction retained on No. 4 sieve	CLEAN GRAVELS	GW	Well-graded gravels and gravel-sand mixtures, little or no fines	Classification on basis of percentage of fines Less than 5% pass 75 µm sieve GW, GP, SW, SP More than 12% pass 75 µm sieve GM, GC, SM, SC 5% to 12% pass 75 µm sieve Borderline classification requiring use of dual symbols	$C_u = D_{60} / D_{10}$ Greater than 4 $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3	
			GP	Poorly-graded gravels and gravel-sand mixtures, little or no fines		Not meeting both criteria for GW	
		GRAVELS WITH FINES	GM	Silty gravels, gravel-sand-silt mixtures		Atterberg limits plot below 'A' line or plasticity index less than 4	Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols
			GC	Clayey gravels, gravel-sand-clay mixtures		Atterberg limits plot above 'A' line and plasticity index greater than 7	
	SANDS More than 50% of coarse fraction passes No. 4 sieve	CLEAN SANDS	SW	Well-graded sands and gravelly sands, little or no fines		$C_u = D_{60} / D_{10}$ Greater than 6 $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3	
			SP	Poorly-graded sands and gravelly sands, little or no fines		Not meeting both criteria for SW	
		SANDS WITH FINES	SM	Silty sands, sand-silt mixtures		Atterberg limits plot above 'A' line and plasticity index less than 4	Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols
			SC	Clayey sands, sand-clay mixtures		Atterberg limits plot above 'A' line and plasticity index greater than 7	
FINE-GRAINED SOILS (by behavior) 50% or more passes 75 µm sieve*	SILTS	Liquid limit <50	ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands of slight plasticity			
		Liquid limit >50	MH	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts			
	CLAYS Above "A" line on plasticity chart negligible organic content	Liquid limit <30	CL	Inorganic clays of low plasticity, gravelly clays, sandy clays, silty clays, lean clays			
		Liquid limit 30-50	CI	Inorganic clay of medium plasticity, silty clays			
		Liquid limit >50	CH	Inorganic clay of high plasticity, fat clays			
	ORGANIC SILTS AND CLAYS	Liquid limit <50	OL	Organic silts and organic silty clays of low plasticity			
		Liquid limit >50	OH	Organic clays of medium to high plasticity			
HIGHLY ORGANIC SOILS			PT	Peat, muck and other highly organic soils			

* Based on the material passing the 75 mm sieve

† ASTM Designation D 2487, for identification procedure see D 2488 USC as modified by PFRA

GROUND ICE DESCRIPTION

ICE NOT VISIBLE

GROUP SYMBOL	SYMBOL	SUBGROUP DESCRIPTION	
N	Nf	Poorly-bonded or friable	▨
	Nbn	No excess ice, well-bonded	▨
	Nbe	Excess ice, well-bonded	▨

VISIBLE ICE LESS THAN 50% BY VOLUME

GROUP SYMBOL	SYMBOL	SUBGROUP DESCRIPTION	
V	Vx	Individual ice crystals or inclusions	▨
	Vc	Ice coatings on particles	▨
	Vr	Random or irregularly oriented ice formations	▨
	Vs	Stratified or distinctly oriented ice formations	▨

VISIBLE ICE GREATER THAN 50% BY VOLUME

ICE	ICE + Soil Type	Ice with soil inclusions	■
	ICE	Ice without soil inclusions (greater than 25 mm thick	■

NOTES:

1. Dual symbols are used to indicate borderline or mixed ice classifications.
2. Visual estimates of ice contents indicated on borehole logs ± 5%
3. This system of ground ice description has been modified from NRC Technical Memo 79, Guide to the Field Description of Permafrost for Engineering Purposes.

LEGEND: Soil ☐ Ice ■

TETRA TECH

BOREHOLE KEYSHEET

Water Level Measurement

- ▼ Measured in standpipe, piezometer or well
- ▽ Inferred

Sample Types

- ☰ A-Casing
- ◫ Core
- ▩ Disturbed, Bag, Grab
- ▥ HQ Core
- ⧅ Jar
- ⧅ Jar and Bag
- ⧓ 75 mm SPT
- ◢ No Recovery
- ⊠ Split Spoon/SPT
- ▥ Tube
- ◥ CRREL Core

Backfill Materials

- ■ Asphalt
- ▩ Bentonite
- ⁘ Cement/ Grout
- ▧ Drill Cuttings
- ⁘ Grout
- ⁙ Gravel
- ∴ Sand
- ▥ Slough
- ⁘ Topsoil Backfill

Lithology - Graphical Legend[1]

- ■ Asphalt
- ▧ Bedrock
- ○ Cobbles/Boulders
- ▨ Clay
- ■ Coal
- ⁘ Concrete
- ▩ Fill
- ○ Gravel
- ▦ Limestone
- ◇ Mudstone
- 〰 Organics
- ⁘ Peat
- ∴ Sand
- ⊠ Sandstone
- ☰ Shale
- ▥ Silt
- ⊠ Siltstone
- ⊠ Conglomerate
- ⁘ Topsoil
- ▩ Till

1. The graphical legend is an approximation and for visual representation only. Soil strata may comprise a combination of the basic symbols shown above. Particle sizes are not drawn to scale

TETRA TECH

Crown-Indigineous Relations and Northern Affairs Canada

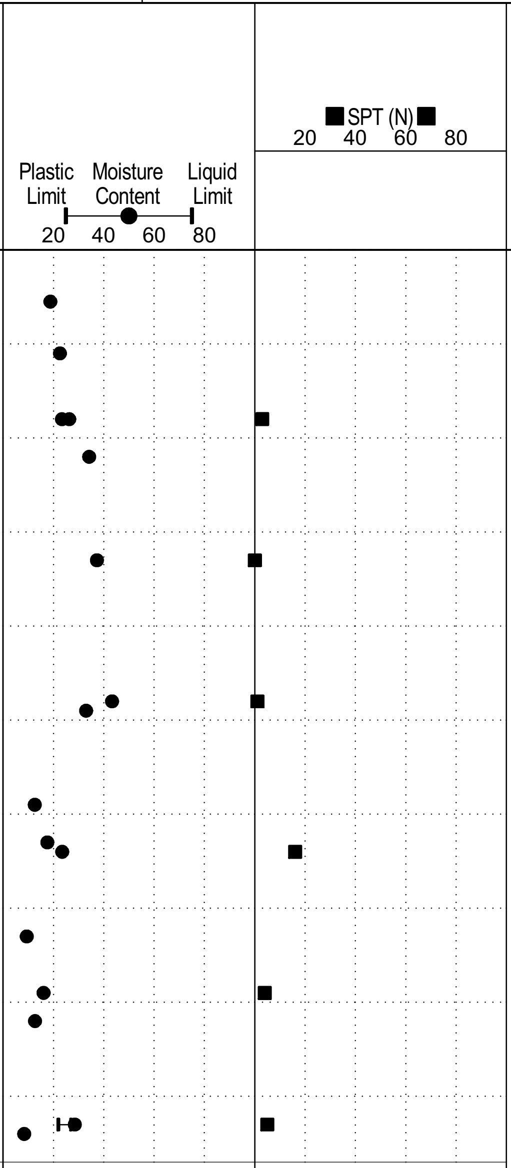
Borehole No: **BH19-01**

Project: Venus TSF - Geotechnical Drilling Program	Project No: ENW.EENW03031-10
Location: South Klondike Highway KM 86	
Carcross, Yukon	UTM: 522522.279 E; 6656023.356 N; Z 8 NAD83

Method	Soil Description	Sample Number	SPT (N)	Moisture Content (%)
Sonic	TAILINGS COVER: 0.5 m of GRAVEL (drain rock), over 0.25 m of CLAY, over Geotextile.	SA01		18.8
	SAND (Tailings) - silty, interbedded layers varying from sand to silt.	SA02		22.6
		SA03	3	26.3
	- wet, soft SAND and SILT between 2.0 and 2.4 m	SA04		23.4
		SA05		34.2
	- sandy SILT and silty SAND between 2.4 and 3.0 m			
	- no recovery in sonic core between 3.0 and 4.5 m	SA06	0	37.3
	SILT (Probable Tailings) - some clay, trace of sand, wet, soft, non-plastic.	SA07	1	43.3
		SA08		33
	SAND - silty, some gravel, moist, light brown.	SA09		12.6
	SILT - sandy, gravelly, moist to wet, firm, tan-brown.	SA11	16	17.6
		SA10		23.5
	- grey, silty SAND below 6.9 m			
		SA12		9.4
	- trace to some gravel at 7.6 m			
		SA13	4	16.1
		SA14		12.7
SPT	CLAY (CL-ML) - silty, trace of sand, wet, soft, low plastic, grey.	SA15	5	28.5
		SA16		8.4

END of BOREHOLE at 9.7 m (Abandoned due to sonic casing sheared off down the hole).

Note: SPTs were conducted with the drop hammer suspended from a winch line on the drilling rig and not secured to be plumb with SPT rods. SPT N-values may not be representative and should be used with caution.



Contractor: Metro Drilling	Completion Depth: 9.7 m
Drilling Rig Type: Fraste RS2 Sonic	Start Date: November 9, 2019
Logged By: IM	Completion Date: November 9, 2019
Reviewed By: AWW	Page 1 of 1

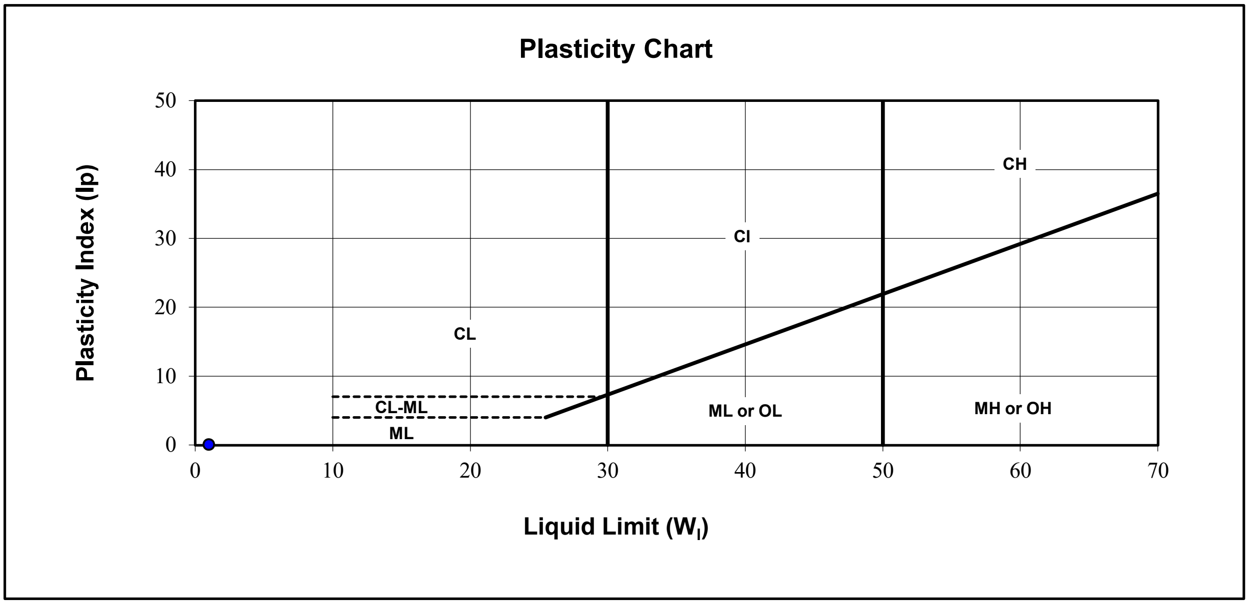
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Venus Tailings Storage Facility	Sample Number:	SA05
	2019 Geotechnical Drilling Program	Borehole Number:	BH19-01
Project No:	ENW.WENW03031-10	Source:	-
Client:	CIRNAC	Sampled By:	IM Tested By: BW
Attention:	Ron Gee	Date Sampled:	November 9, 2019
Email:	ron.gee@canada.ca	Date Tested:	January 23, 2020

Sample Description: SILT - sandy, some clay



Liquid Limit ($W_{1)}$:	NA	Natural Moisture (%)	34.2
Plastic Limit :	NA	Soil Plasticity:	NA
Plasticity Index (Ip) :	**NA**	Mod.USCS Symbol:	ML

Remarks:

Reviewed By: P.Eng.

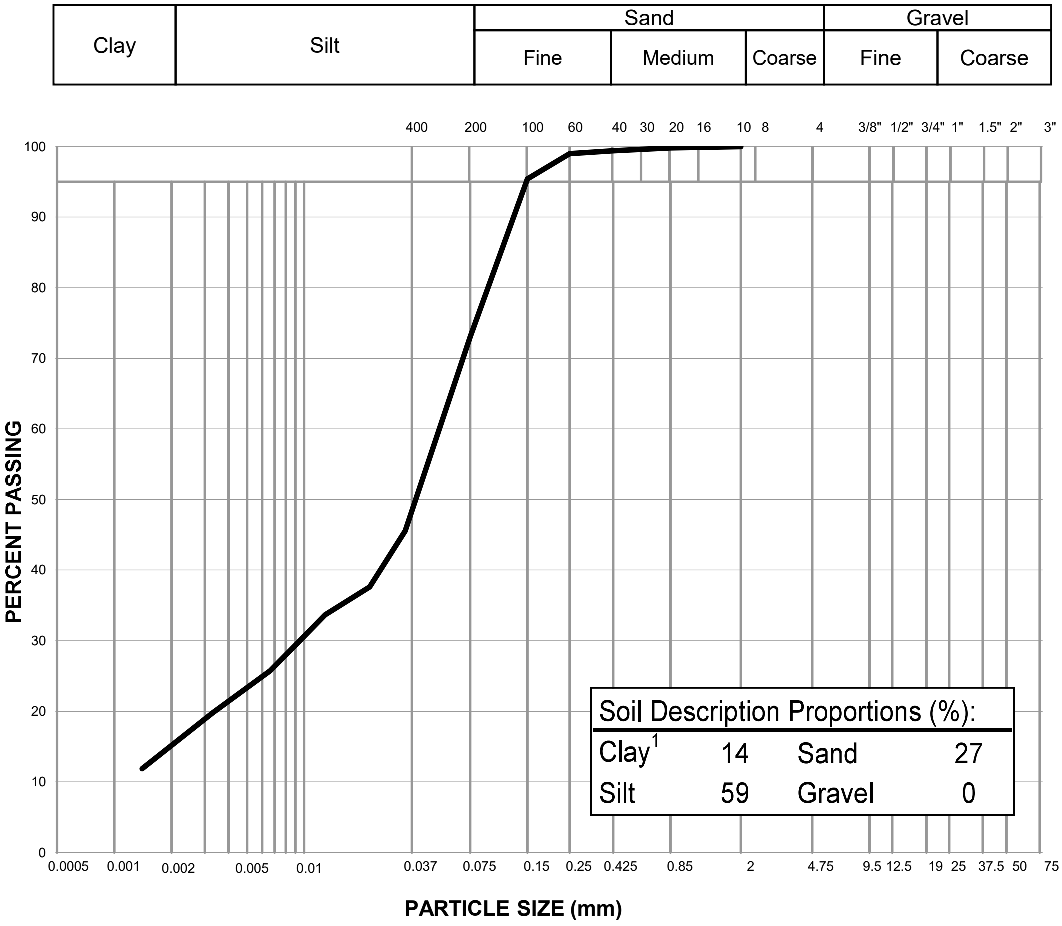
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928 & C136

Project:	2019 Geotechnical Drilling Program	Sample No.:	SA05
Project No.:	ENW.WENW03031-10	Material Type:	-
Site:	Venus TSF	Sample Loc.:	BH19-01
Client:	CIRNAC	Sample Depth:	2.1 - 2.3 m
Client Rep.:	Ron Gee	Sampling Method:	Grab
Date Tested:	December 20, 2019 By: BW	Date Sampled:	November 9, 2019
Soil Description[2]:	SILT - sandy, some clay	Sampled By:	IM
		USC Classification:	ML Cu: #N/A
Moisture Content:	34.2%		Cc: #N/A

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	95
0.075	73.0
0.0340	45.5
0.0221	37.6
0.0129	33.7
0.0092	29.7
0.0066	25.7
0.0033	19.8
0.0014	11.9



Soil Description Proportions (%):

Clay[1]	14	Sand	27
Silt	59	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 Tetra Tech description protocols

Specification: ______________________

Remarks: ______________________

Reviewed By: ______________________ P.Eng.

TETRA TECH

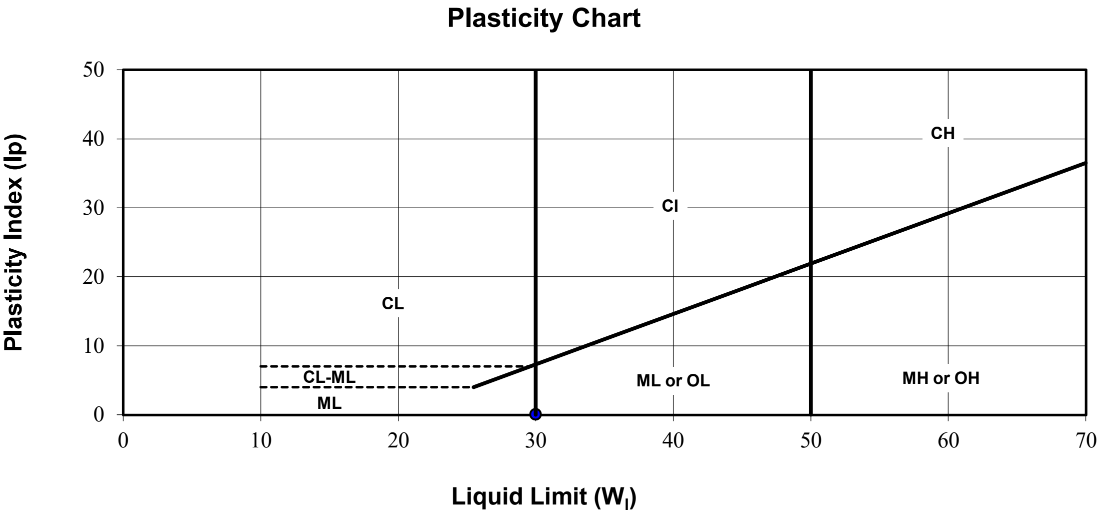
ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project: Venus Tailings Storage Facility
2019 Geotechnical Drilling Program
Project No: ENW.WENW03031-10
Client: CIRNAC
Attention: Ron Gee
Email: ron.gee@canada.ca

Sample Number: SA07
Borehole Number: BH19-01
Source: -
Sampled By: IM Tested By: BW
Date Sampled: November 9, 2019
Date Tested: January 23, 2020

Sample Description: SILT - some clay, trace sand



Liquid Limit (W$_{1)}$: 30
Plastic Limit : NA
Plasticity Index (Ip) : **NA**

Natural Moisture (%) 43.3
Soil Plasticity: NP
Mod.USCS Symbol: ML

Remarks:

Reviewed By: P.Eng.

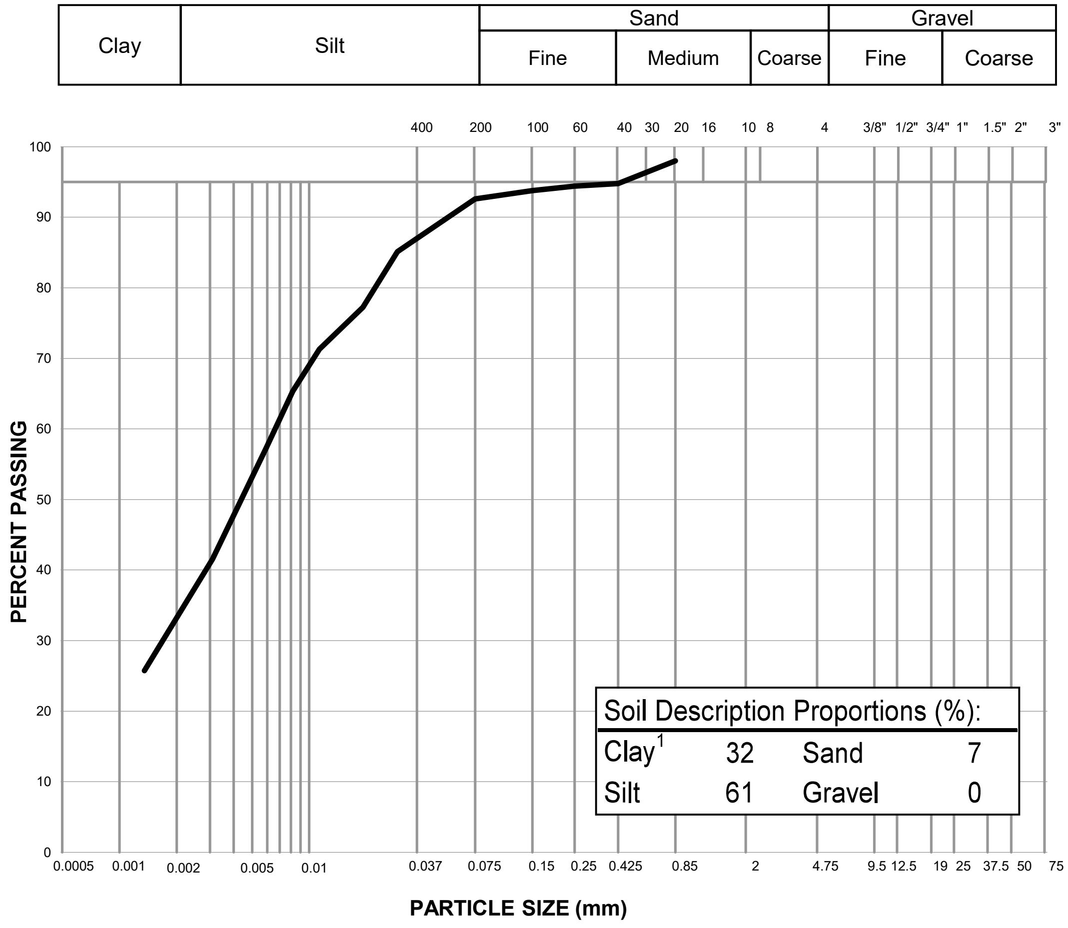
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928 & C136

Project:	2019 Geotechnical Drilling Program	Sample No.:	SA07
Project No.:	ENW.WENW03031-10	Material Type:	-
Site:	Venus TSF	Sample Loc.:	BH19-01
Client:	CIRNAC	Sample Depth:	4.5 - 5.0 m
Client Rep.:	Ron Gee	Sampling Method:	Grab
Date Tested:	December 20, 2019 By: BW	Date Sampled:	November 9, 2019
Soil Description[2]:	SILT - some clay, trace sand	Sampled By:	IM
		USC Classification:	ML Cu: #N/A
Moisture Content:	43.3%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
38	
25	
19	
12.5	
10	
5	
2	
0.85	98
0.425	95
0.25	94
0.15	94
0.075	92.6
0.0292	85.1
0.0192	77.2
0.0113	71.3
0.0082	65.3
0.0060	57.4
0.0031	41.6
0.0014	25.7



Soil Description Proportions (%):

Clay[1]	32	Sand	7
Silt	61	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 Tetra Tech description protocols

Specification: ____________________

Remarks: ____________________

Reviewed By: ____________________ P.Eng.

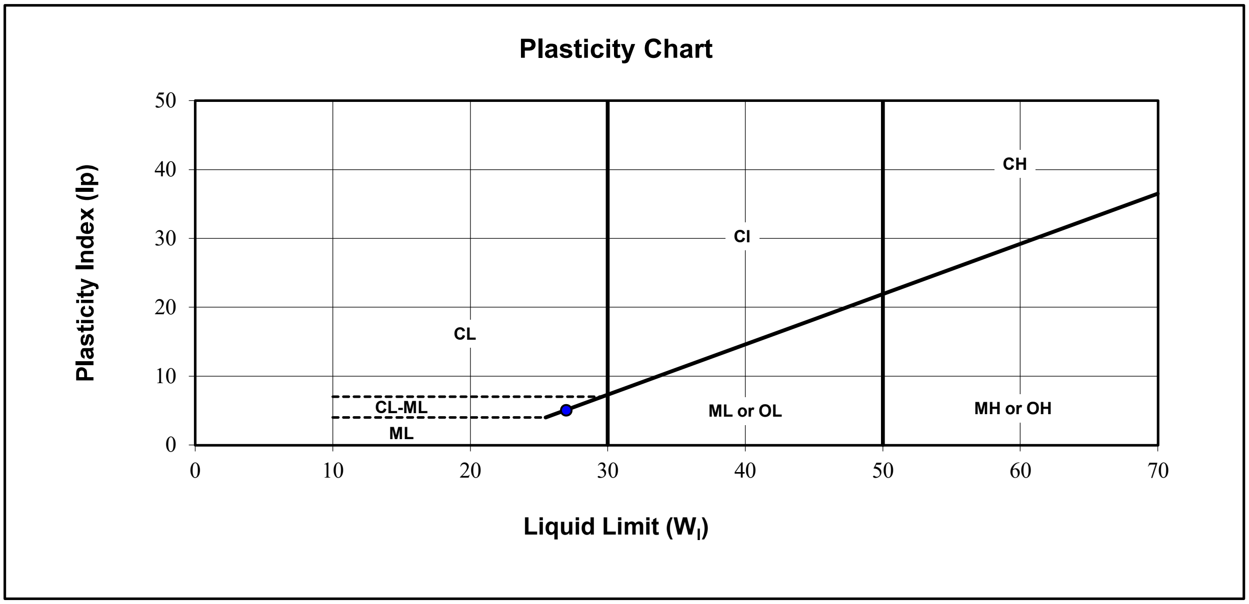
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Venus Tailings Storage Facility	Sample Number:	SA15
	2019 Geotechnical Drilling Program	Borehole Number:	19-01
Project No:	ENW.WENW03031-10	Source:	-
Client:	CIRNAC	Sampled By:	IM Tested By: BW
Attention:	Ron Gee	Date Sampled:	November 9, 2019
Email:	ron.gee@canada.ca	Date Tested:	January 23, 2020

Sample Description: CLAY - silty, trace sand



Liquid Limit (W$_{1)}$:	27	Natural Moisture (%)	28.5
Plastic Limit :	22	Soil Plasticity:	Low
Plasticity Index (Ip) :	**5**	Mod.USCS Symbol:	CL-ML

Remarks:

Reviewed By: P.Eng.

TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

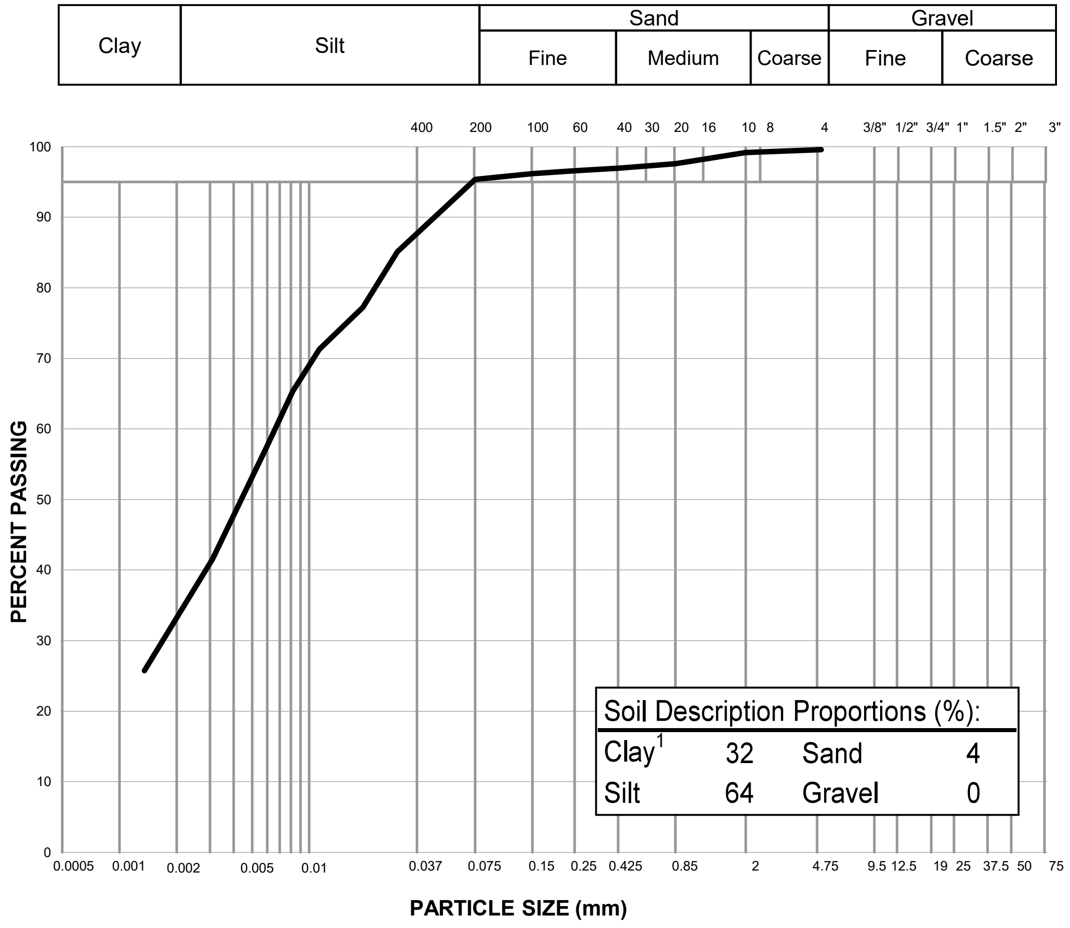
ASTM D7928 & C136

Project: 2019 Geotechnical Drilling Program
Project No.: ENW.WENW03031-10
Site: Venus TSF
Client: CIRNAC
Client Rep.: Ron Gee
Date Tested: December 20, 2019 By: BW
Soil Description[2]: CLAY - silty, trace sand

Sample No.: SA15
Material Type: -
Sample Loc.: BH19-01
Sample Depth: 9.1 - 9.5 m
Sampling Method: Grab
Date Sampled: November 9, 2019
Sampled By: IM
USC Classification: CL-ML Cu: #N/A
Cc: #N/A

Moisture Content: 28.5%

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	97
0.15	96
0.075	95.4
0.0292	85.1
0.0192	77.2
0.0113	71.3
0.0082	65.3
0.0060	57.4
0.0031	41.6
0.0014	25.7



Soil Description Proportions (%):

Clay[1]	32	Sand	4
Silt	64	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 Tetra Tech description protocols

Specification: ______________________

Remarks: ______________________

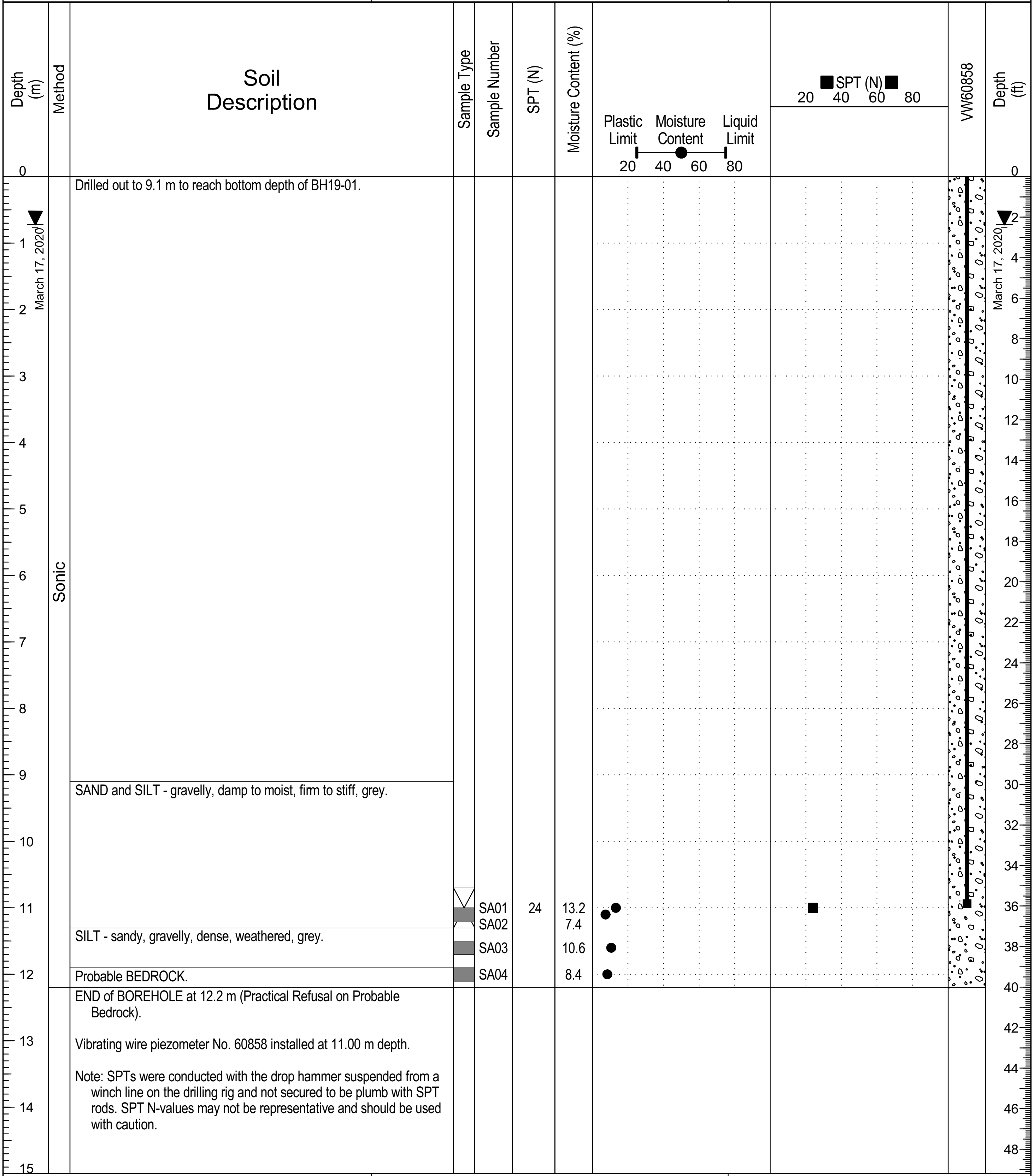
Reviewed By: ______________________ P.Eng.

TETRA TECH

Crown-Indigineous Relations and Northern Affairs Canada

Borehole No: **BH19-01A**

Project: Venus TSF - Geotechnical Drilling Program	Project No: ENW.EENW03031-10
Location: South Klondike Highway KM 86	
Carcross, Yukon	UTM: 522522.279 E; 6656023.356 N; Z 8 NAD83



Drilled out to 9.1 m to reach bottom depth of BH19-01.

SAND and SILT - gravelly, damp to moist, firm to stiff, grey.

SILT - sandy, gravelly, dense, weathered, grey.

Probable BEDROCK.

END of BOREHOLE at 12.2 m (Practical Refusal on Probable Bedrock).

Vibrating wire piezometer No. 60858 installed at 11.00 m depth.

Note: SPTs were conducted with the drop hammer suspended from a winch line on the drilling rig and not secured to be plumb with SPT rods. SPT N-values may not be representative and should be used with caution.

Sample Number	SPT (N)	Moisture Content (%)
SA01	24	13.2
SA02		7.4
SA03		10.6
SA04		8.4

TETRA TECH

Contractor: Metro Drilling	Completion Depth: 12.2 m
Drilling Rig Type: Fraste RS2 Sonic	Start Date: November 12, 2019
Logged By: IM	Completion Date: November 13, 2019
Reviewed By: AWW	Page 1 of 1

PARTICLE SIZE ANALYSIS REPORT

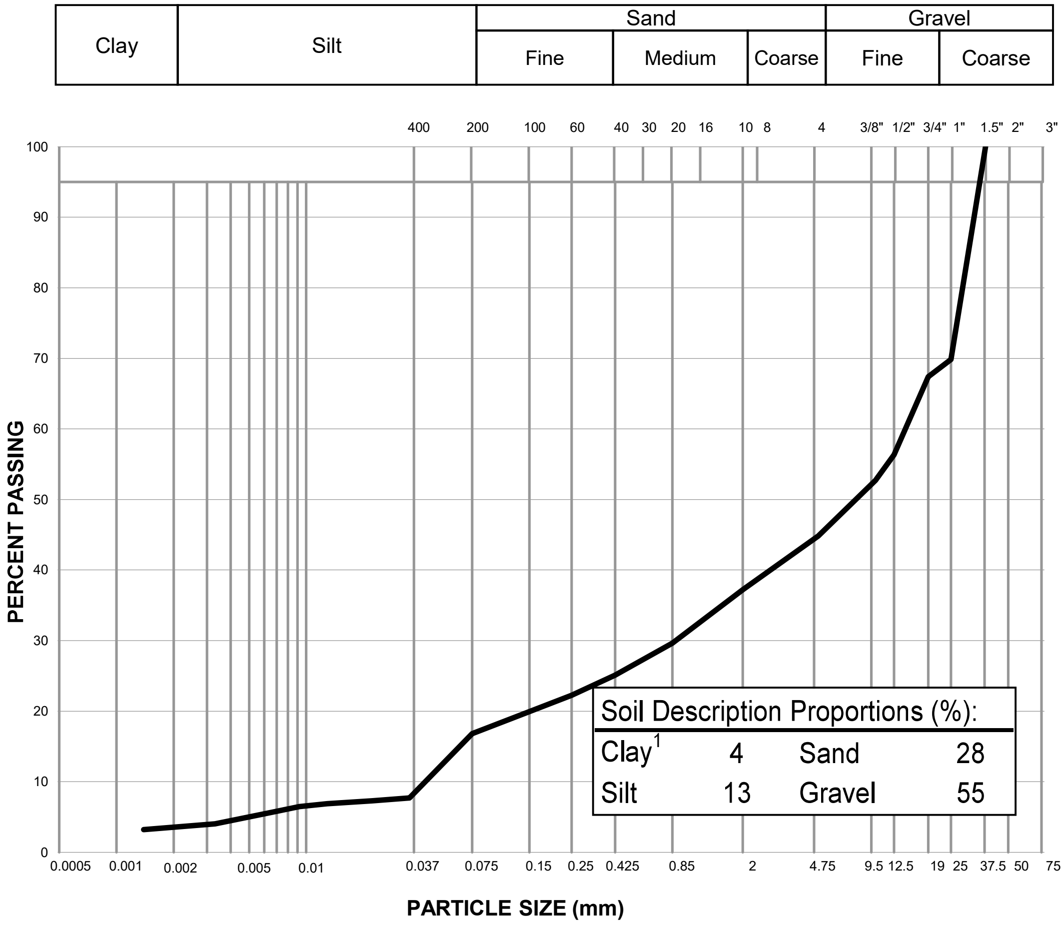
ASTM D7928 & C136

Project: 2019 Geotechnical Drilling Program
Project No.: ENW.WENW03031-10
Site: Venus TSF
Client: CIRNAC
Client Rep.: Ron Gee
Date Tested: December 20, 2019 By: BW
Soil Description[2]: GRAVEL - sandy, some silt, trace clay

Moisture Content: 8.4%

Sample No.: SA04
Material Type: -
Sample Loc.: BH19-01A
Sample Depth: 11.9 - 12.1 m
Sampling Method: Grab
Date Sampled: November 12, 2019
Sampled By: IM
USC Classification: GM Cu: 324.5
Cc: 1.2

Particle Size (mm)	Percent Passing
75	
50	
38	100
25	70
19	67
12.5	56
10	53
5	45
2	37
0.85	30
0.425	25
0.25	22
0.15	20
0.075	16.8
0.0350	7.7
0.0222	7.3
0.0129	6.9
0.0092	6.5
0.0066	5.7
0.0033	4.0
0.0014	3.2



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

Specification: ______________________________

Remarks: ______________________________

Reviewed By: ______________________________ P.Eng.

TETRA TECH

Crown-Indigineous Relations and Northern Affairs Canada

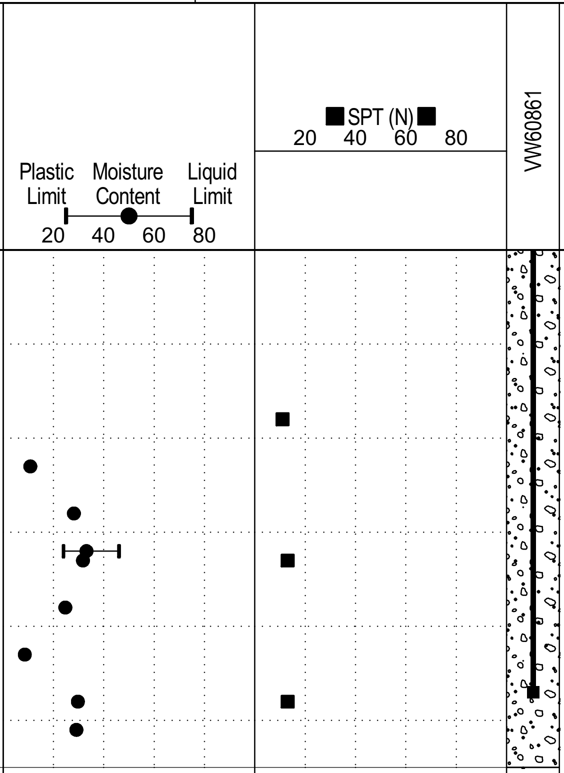
Borehole No: **BH19-06**

Project: Venus TSF - Geotechnical Drilling Program	Project No: ENW.EENW03031-10
Location: South Klondike Highway KM 86	
Carcross, Yukon	UTM: 522584.907 E; 6655992.547 N; Z 8 NAD83

Method: Sonic

▼ March 17, 2020

Soil Description	Sample Number	SPT (N)	Moisture Content (%)
SAND and GRAVEL (Fill used to build drill pad).			
GRAVEL and SAND (Toe Buttress Fill) - coarse sand, angular, gravel up to 75 mm diameter, well graded, moist, loose to compact.			
Poor recovery in sonic core.		11	
Probable original ground consisting of organic topsoil over sand and gravel (SA01).	SA01		10.8
CLAY (CI) - silty, traces of sand and gravel, organic inclusions, damp, firm, medium plastic, light grey-brown.	SA02		28.1
	SA04	13	33.1
	SA03		31.7
- moist, tan-brown below 3.7 m	SA05		24.7
SAND - gravelly, gravel angular up to 50 mm diameter, moist, compact, dark grey.	SA06		8.6
SAND and SILT.	SA07	13	29.7
GRAVEL - trace of sand, possible weathered bedrock.	SA08		29.1



END of BOREHOLE at 5.5 m (Practical Refusal on Probable Bedrock).

Vibrating wire piezometer No. 60861 installed at 4.76 m depth.

Note: SPTs were conducted with the drop hammer suspended from a winch line on the drilling rig and not secured to be plumb with SPT rods. SPT N-values may not be representative and should be used with caution.

Depth (m) 0–15; Depth (ft) 0–48

TETRA TECH

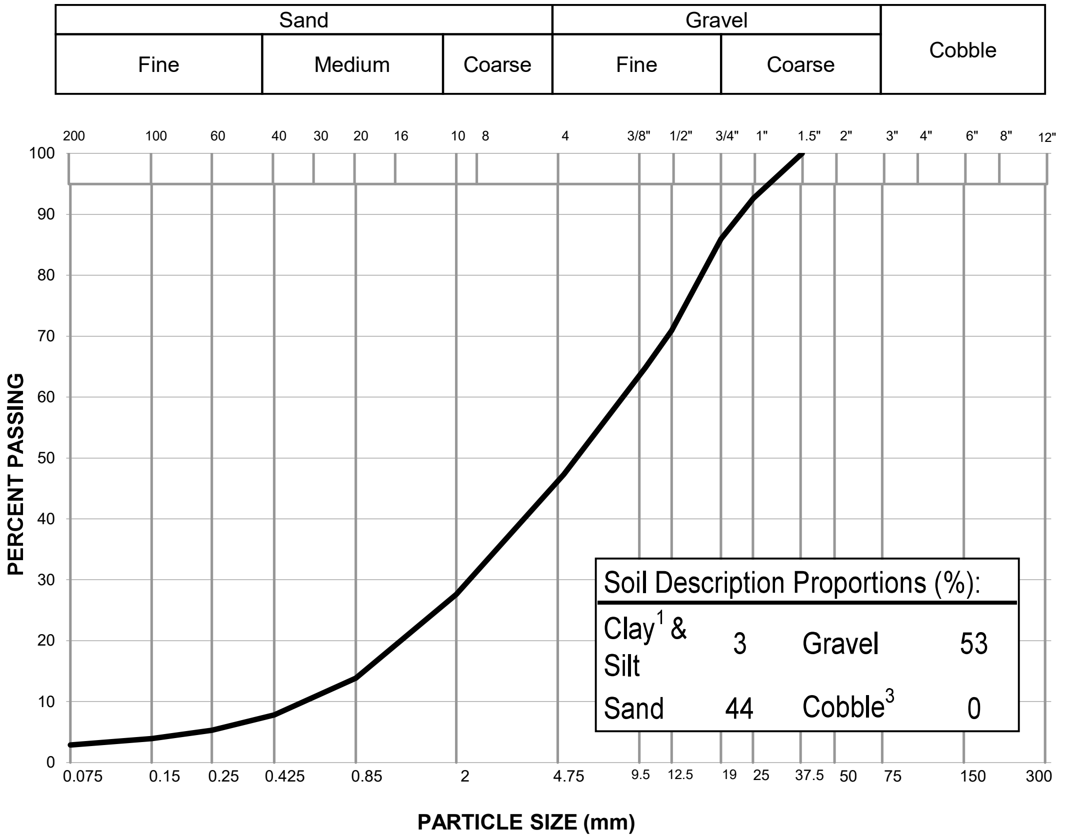
Contractor: Metro Drilling	Completion Depth: 5.5 m
Drilling Rig Type: Fraste RS2 Sonic	Start Date: November 8, 2019
Logged By: IM	Completion Date: November 8, 2019
Reviewed By: AWW	Page 1 of 1

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928 & C136

Project:	2019 Geotechnical Drilling Program	Sample No.:	SA01
Project No.:	ENW.WENW03031-10	Material Type:	-
Site:	Venus TSF	Sample Loc.:	BH19-06
Client:	CIRNAC	Sample Depth:	2.2 - 2.4 m
Client Rep.:	Ron Gee	Sampling Method:	Grab
Date Tested:	December 17, 2019 By: DK	Date Sampled:	November 8, 2019
Soil Description[2]:	GRAVEL and SAND - trace silt	Sampled By:	IM
		USC Classification:	GW Cu: 14.9
Moisture Content:	10.8%		Cc: 1.1

Particle Size (mm)	Percent Passing
300	
200	
150	
100	
75	
50	
38	100
25	93
19	86
12.5	71
10	65
5	47
2	28
0.85	14
0.425	8
0.25	5
0.15	4
0.075	2.9



Soil Description Proportions (%):

Clay[1] & Silt	3	Gravel	53
Sand	44	Cobble[3]	0

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

[2] The description is visually based & subject to Tt WM4400 description protocols

[3] If cobbles are present, sampling procedure may not meet ASTM C702 & D75

Specification: ______________________

Remarks: ______________________

Reviewed By: ______________________ P.Eng.

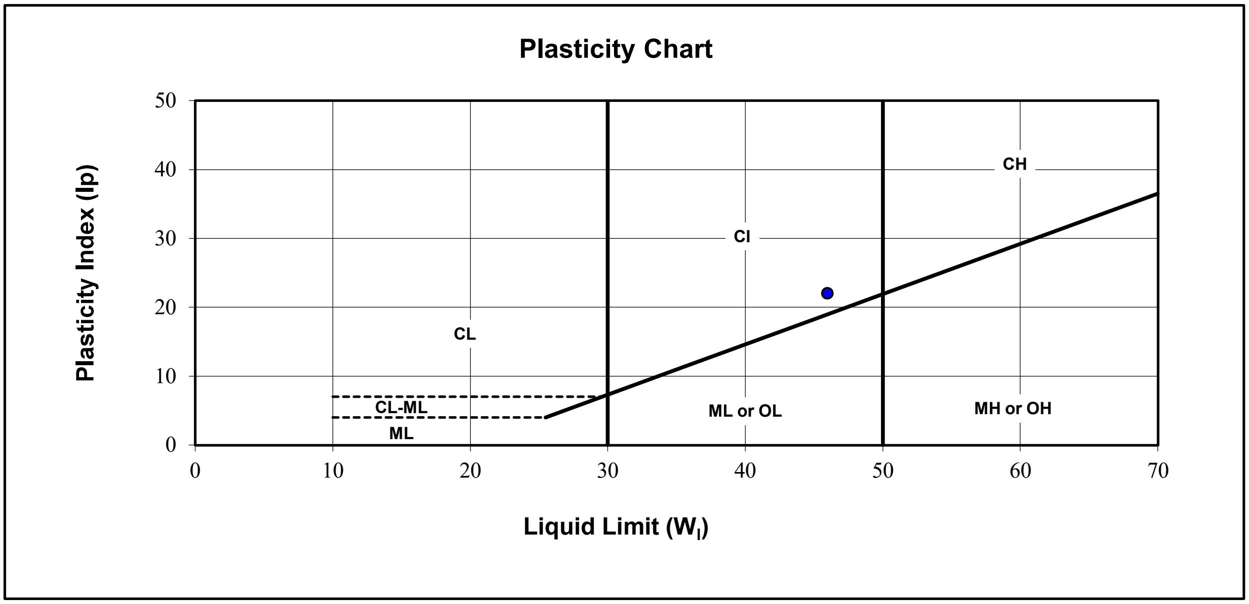
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	2019 Geotechnical Drilling Program Venus Tailings Storage Facility	Sample Number:	SA04
		Borehole Number:	BH19-06
Project No:	ENW.WENW03031-10	Source:	-
Client:	CIRNAC	Sampled By:	IM Tested By: BW
Attention:	Ron Gee	Date Sampled:	November 8, 2019
Email:	ron.gee@canada.ca	Date Tested:	January 23, 2020

Sample Description: CLAY, silty, traces of sand and gravel



Liquid Limit ($W_{1)}$:	46	Natural Moisture (%)	33.1
Plastic Limit :	24	Soil Plasticity:	Medium
Plasticity Index (Ip) :	**22**	Mod.USCS Symbol:	CI

Remarks:

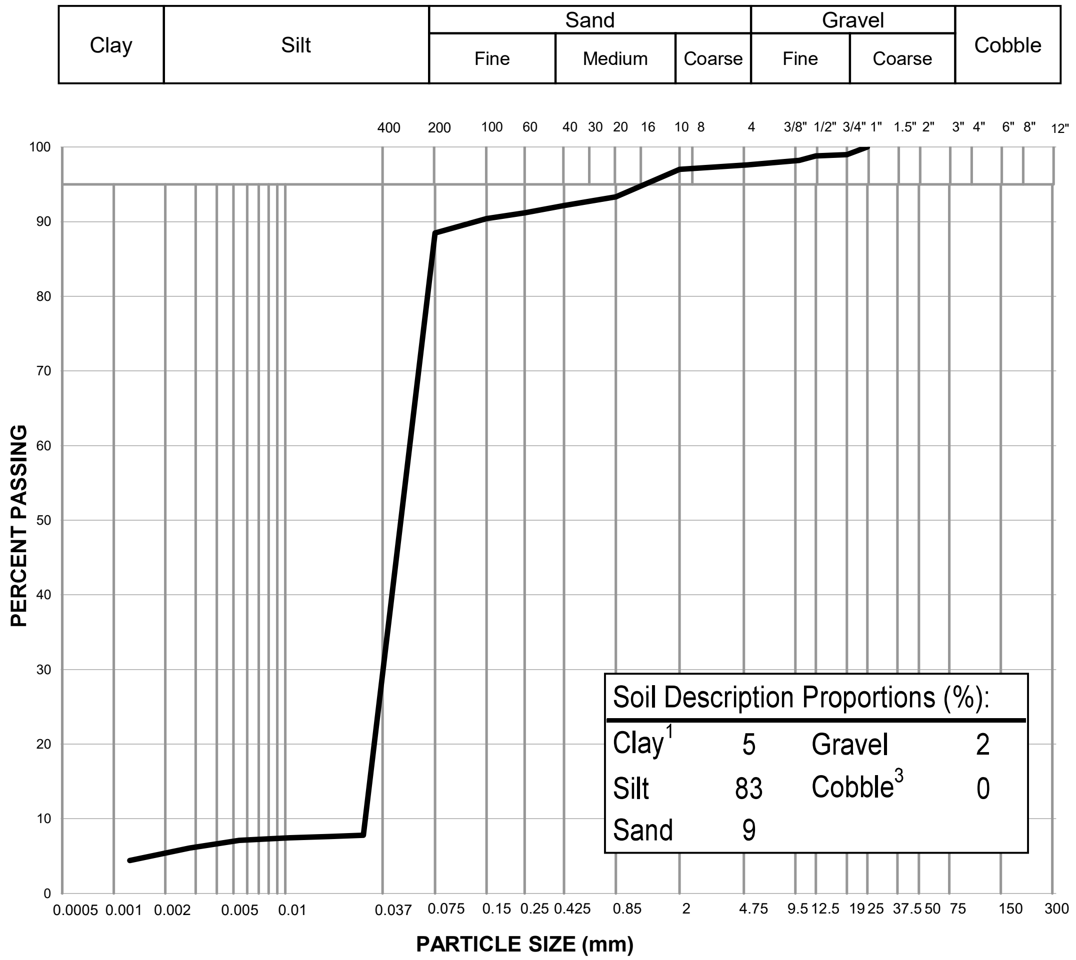
Reviewed By: P.Eng.

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928 & C136

Project:	2019 Geotechnical Drilling Program	Sample No.:	SA04
Project No.:	ENW.WENW03031-10	Material Type:	-
Site:	Venus TSF	Sample Loc.:	BH19-06
Client:	CIRNAC	Sample Depth:	3.1 - 3.3 m
Client Rep.:	Ron Gee	Sampling Method:	Grab
Date Tested:	December 20, 2019 By: BW	Date Sampled:	November 8, 2019
Soil Description[2]:	CLAY - silty, traces of sand and gravel	Sampled By:	IM
		USC Classification:	CI Cu: 2.0
Moisture Content:	33.1%		Cc: 1.0

Particle Size (mm)	Percent Passing
300	
200	
150	
100	
75	
50	
38	
25	100
19	99
12.5	99
10	98
5	98
2	97
0.85	93
0.425	92
0.25	91
0.15	90
0.075	88.5
0.0285	7.8
0.0182	7.6
0.0106	7.4
0.0075	7.3
0.0054	7.1
0.0028	6.1
0.0012	4.4



Soil Description Proportions (%):			
Clay[1]	5	Gravel	2
Silt	83	Cobble[3]	0
Sand	9		

Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual [2] The description is visually based & subject to Tetra Tech description protocols [3] If cobbles are present, sampling procedure may not meet ASTM C702 & D75

Specification: ______________________________

Remarks: ______________________________

Reviewed By: ____________________ P.Eng.

TETRA TECH

Crown-Indigineous Relations and Northern Affairs Canada

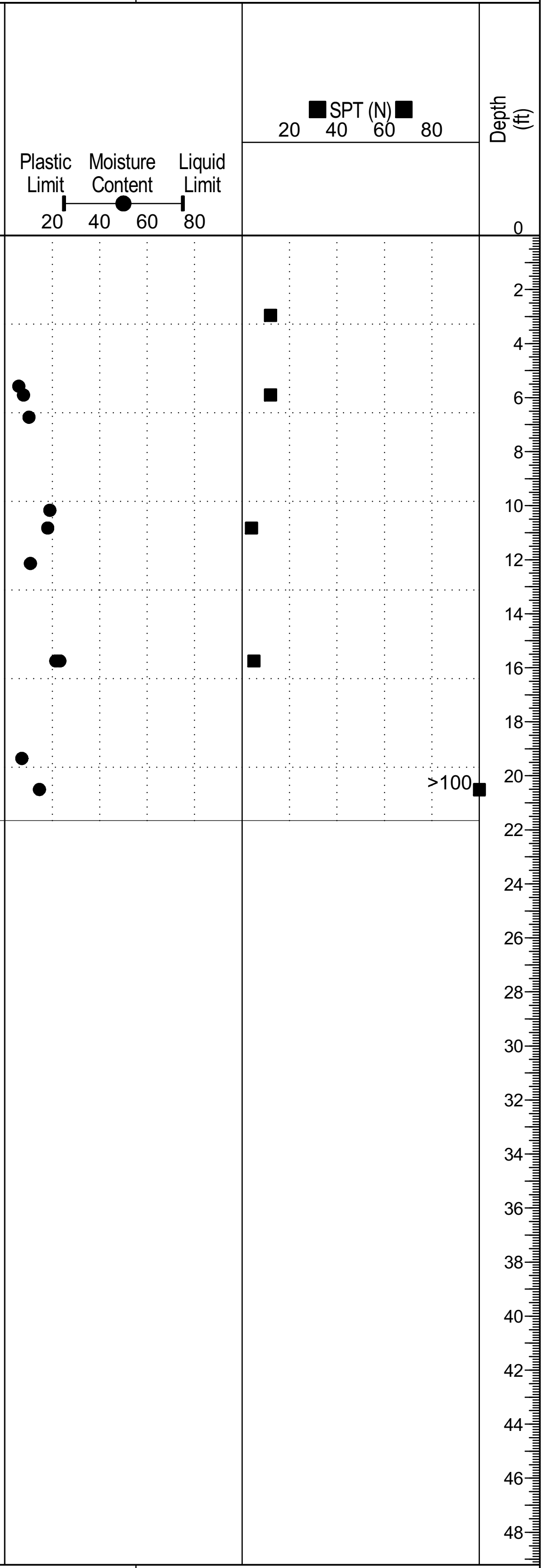
Borehole No: **BH19-07**

Project: Venus TSF - Geotechnical Drilling Program	Project No: ENW.EENW03031-10
Location: South Klondike Highway KM 86	
Carcross, Yukon	UTM: 522601.38 E; 6655984.68 N; Z 8 NAD83

Method	Soil Description	Sample Number	SPT (N)	Moisture Content (%)
Sonic	SAND and GRAVEL (Fill used to build drill pad).			
	SAND and GRAVEL (Toe Buttress Fill) - trace of silt, well graded, moist, compact, brown.		12	
		SA02	12	5.9
		SA01		7.9
		SA03		10.2
	SILT - some sand to sandy, wet, soft, grey.			
	GRAVEL (Till-like) - sandy, silty, trace of clay, gravel up to 35 mm diameter.	SA05		19
		SA04	4	18.1
		SA06		10.8
		SA07	5	21.5
		SA08		23.2
	Probable weathered BEDROCK.	SA09		7.2
	Probable BEDROCK.	SA10	13/ 150mm	14.6

END of BOREHOLE at 6.6 m (Practical Refusal on Probable Bedrock).

Note: SPTs were conducted with the drop hammer suspended from a winch line on the drilling rig and not secured to be plumb with SPT rods. SPT N-values may not be representative and should be used with caution.



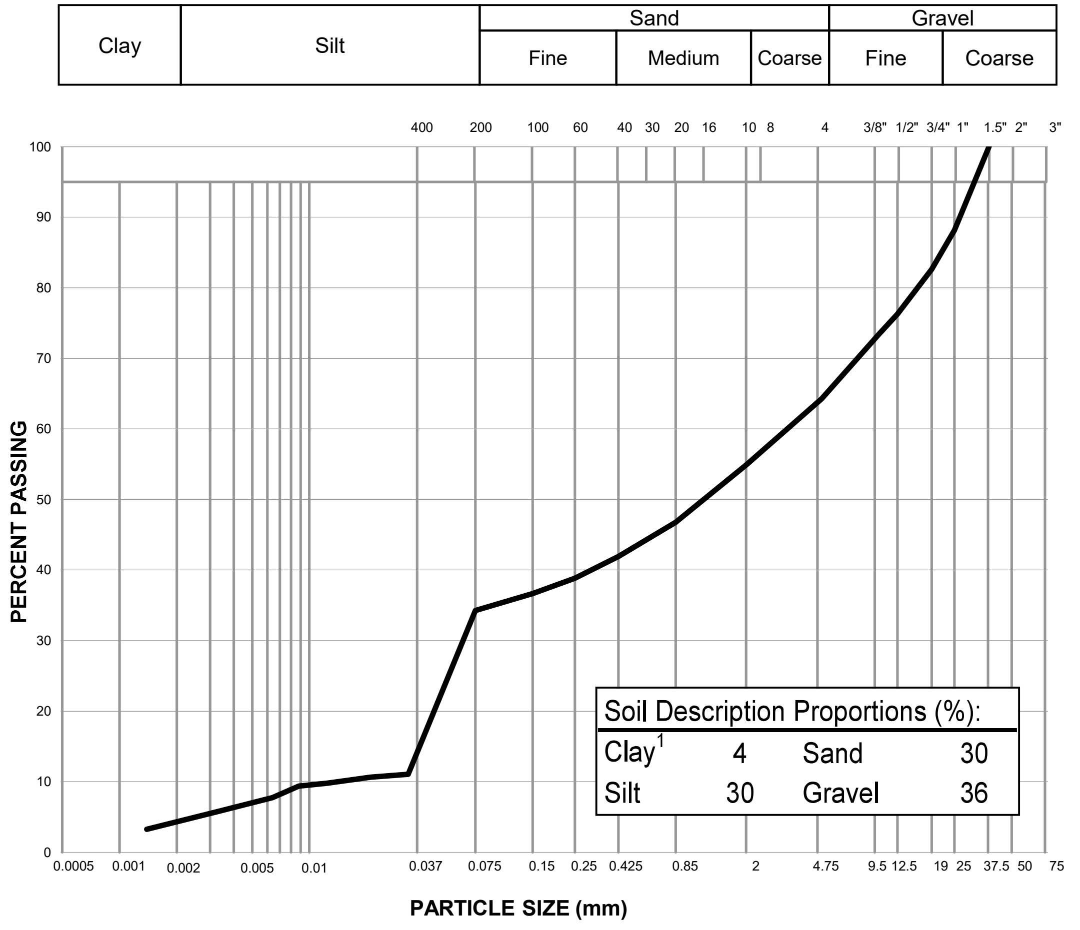
Contractor: Metro Drilling	Completion Depth: 6.6 m
Drilling Rig Type: Fraste RS2 Sonic	Start Date: November 7, 2019
Logged By: IM	Completion Date: November 7, 2019
Reviewed By: AWW	Page 1 of 1

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928 & C136

Project:	2019 Geotechnical Drilling Program	Sample No.:	SA06
Project No.:	ENW.WENW03031-10	Material Type:	-
Site:	Venus TSF	Sample Loc.:	BH19-07
Client:	CIRNAC	Sample Depth:	3.6 - 3.7 m
Client Rep.:	Ron Gee	Sampling Method:	Grab
Date Tested:	December 20, 2019 By: BW	Date Sampled:	November 7, 2019
Soil Description[2]:	GRAVEL - sandy, silty, trace clay	Sampled By:	IM
		USC Classification:	GM Cu: 251.6
Moisture Content:	10.8%		Cc: 0.1

Particle Size (mm)	Percent Passing
75	
50	
38	100
25	88
19	83
12.5	76
10	73
5	64
2	55
0.85	47
0.425	42
0.25	39
0.15	37
0.075	34.2
0.0332	11.0
0.0211	10.6
0.0124	9.8
0.0088	9.4
0.0064	7.8
0.0032	5.7
0.0014	3.3



Soil Description Proportions (%):

Clay[1]	4	Sand	30
Silt	30	Gravel	36

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

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

Specification: ______

Remarks: ______

Reviewed By: ______ P.Eng.

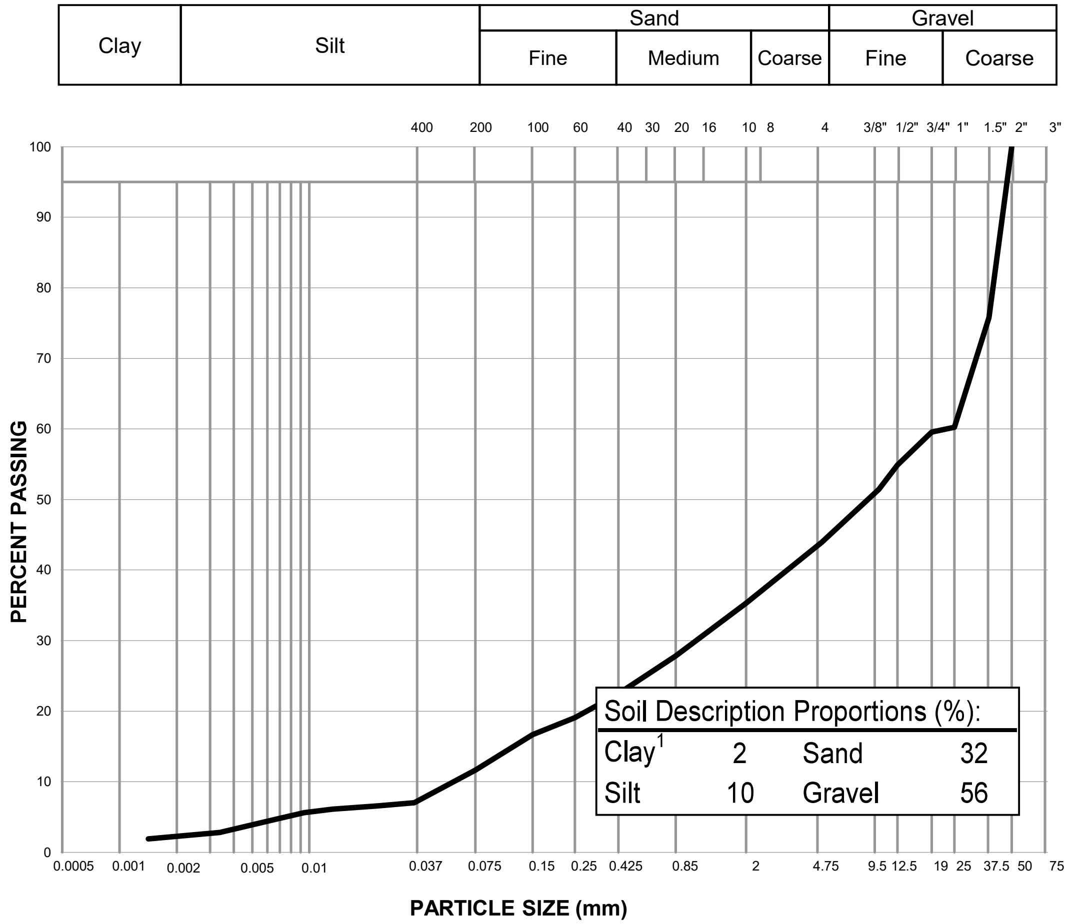
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928 & C136

Project:	2019 Geotechnical Drilling Program	Sample No.:	SA09
Project No.:	ENW.WENW03031-10	Material Type:	-
Site:	Venus TSF	Sample Loc.:	BH19-07
Client:	CIRNAC	Sample Depth:	5.8 - 6.0 m
Client Rep.:	Ron Gee	Sampling Method:	Grab
Date Tested:	December 20, 2019 By: BW	Date Sampled:	November 7, 2019
Soil Description[2]:	GRAVEL - sandy, some silt, trace clay	Sampled By:	IM
		USC Classification:	GW-GM Cu: 377.1
Moisture Content:	7.2%		Cc: 1.0

Particle Size (mm)	Percent Passing
75	
50	100
38	76
25	60
19	60
12.5	55
10	51
5	44
2	35
0.85	28
0.425	22
0.25	19
0.15	17
0.075	11.7
0.0358	7.0
0.0228	6.6
0.0132	6.1
0.0094	5.6
0.0067	4.7
0.0034	2.8
0.0014	1.9



Soil Description Proportions (%):

Clay[1]	2	Sand	32
Silt	10	Gravel	56

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

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

Specification: __________

Remarks: __________

Reviewed By: __________ P.Eng.

TETRA TECH

APPENDIX C

CPT REPORT (GREGG DRILLING)

Site Investigation Summary

Cone Penetration Testing Report

GREGG DRILLING AND TESTING CANADA LTD.

2019
Authored by: Shane Kelly, M.Eng., P.Eng. & Sara Szeto, M.Sc.
Prepared for: Tetra Tech
Site: Venus Mine, Carcross, Yukon

Table of Contents

GREGG
GEOTECH DRILLING · GROUP OF COMPANIES

December 12, 2019

Tetra Tech
Attn: Mr. Ian MacIntyre

Subject: CPT Site Investigation
Venus Mine
Carcross, Yukon
Gregg Drilling Project Number: GRG190104

Dear Mr. MacIntyre,

The following report presents the results of Gregg Drilling and Testing Canada Ltd. site investigation for the above referenced site. The following testing services were performed:

1	Cone Penetration Tests	(CPTU)	☒
2	Pore Pressure Dissipation Tests	(PPDT)	☒
3	Seismic Cone Penetration Tests	(SCPTU)	☒
4	UVOST Laser Induced Fluorescence	(UVOST)	☐
5	Groundwater Sampling	(GWS)	☐
6	Soil Sampling	(SS)	☐
7	Vapor Sampling	(VS)	☐
8	Pressuremeter Testing	(PMT)	☐
9	Vane Shear Testing	(VST)	☐
10	Dilatometer Testing	(DMT)	☐

A list of reference papers providing additional background on the specific tests conducted is provided in the bibliography following the text of the report. If you would like a copy of any of these publications or should you have any questions or comments regarding the contents of this report, please do not hesitate to contact our office at 1.844.848.8684.

Sincerely,

Shane Kelly
Vice President, Gregg Drilling and Testing Canada Ltd.

Cone Penetration Testing Description

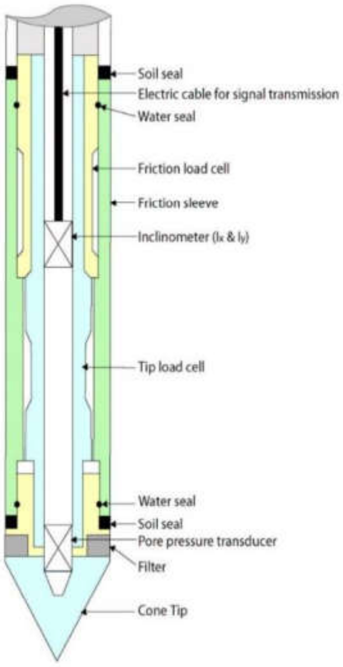


Figure CPT

Gregg Drilling carries out all Cone Penetration Tests (CPT) using an integrated electronic cone system, *Figure CPT*. The cone takes measurements of tip resistance (q_c), sleeve resistance (f_s), and penetration pore water pressure (u_2). Measurements are taken at either 1.0, 2.0, 2.5 or 5.0 cm intervals during penetration to provide a nearly continuous profile. CPT data reduction and basic interpretation is performed in real time facilitating on-site decision making. The CPT parameters are stored electronically for further analysis and reference. All CPT soundings are performed in accordance with revised ASTM standards (D 5778-12).

The Pore pressure transducer is located directly behind the cone tip in the u_2 location. A new saturated filter element is used on each sounding to measure both penetration pore pressures as well as measurements during a dissipation test (*PPDT*). Prior to each test, the filter element is fully saturated with oil under vacuum pressure to improve accuracy.

When the sounding is completed, the test hole is backfilled according to client specifications. If grouting is used, the procedure generally consists of pushing a hollow tremie pipe with a “knock out” plug to the termination depth of the CPT hole. Grout is then pumped under pressure as the tremie pipe is pulled from the hole. Disruption or further contamination to the site is therefore minimized.

Gregg Drilling Cone (GDC) 15cm^2 Standard Cone Specifications:

Dimensions			
Cone base area		**Sleeve surface area**	**Cone net area ratio**
15 cm^2		225 cm^2	0.85
Specifications			
	Cone load cell	**Sleeve load cell**	**Pore pressure transducer**
Full scale range	180 kN (20 tons)	31 kN (3.5 tons)	7,000 kPa (1,000 psi)
Overload capacity	150%	150%	150%
Full scale tip/sleeve stress	120 MPa (1,200 tsf)	1,400 kPa (15 tsf)	
Repeatability	120 kPa (1.2 tsf)	1.4 kPa (0.015 tsf)	7 kPa (1 psi)

A.P. van den Berg (APV) 15cm^2 Standard Cone Specifications:

Dimensions			
Cone base area		**Sleeve surface area**	**Cone net area ratio**
15 cm^2		225 cm^2	0.75
	Cone load cell	**Sleeve load cell**	**Pore pressure transducer**
Max load	150 MPa	1.5 MPa	3.0 MPa

Note: The repeatability during field use will depend somewhat on ground conditions, abrasion, maintenance and zero load stability.

Cone Penetration Data & Interpretation

The Cone Penetration Test (CPT) data collected are presented in graphical and electronic form in the report. The plots include interpreted Soil Behavior Type (SBT) based on the charts described by Robertson (2009 & 2010). Typical plots display SBT based on the non-normalized charts of Robertson (2010). For CPT soundings deeper than 30m, we recommend the use of the normalized charts of Robertson (2009) which can be displayed as SBTn, upon request. The report can also include spreadsheet output of computer calculations of basic interpretation in terms of SBT and SBTn and various geotechnical parameters using current published correlations based on the comprehensive review by Lunne, Robertson and Powell (1997), as well as recent updates by Robertson and Cabal (Guide to Cone Penetration Testing, 2015). The interpretations are presented only as a guide for geotechnical use and should be carefully reviewed. Gregg Drilling does not warranty the correctness or the applicability of any of the geotechnical parameters interpreted by the software and does not assume any liability for use of the results in any design or review. The user should be fully aware of the techniques and limitations of any method used in the software. Some interpretation methods require input of the groundwater level to calculate vertical effective stress. An estimate of the in-situ groundwater level has been made based on field observations and/or CPT results, but should be verified by the user.

A summary of locations and depths is available in Table 1. Note that all penetration depths referenced in the data are with respect to the existing ground surface. Note that it is not always possible to clearly identify a soil type based solely on qt, fs, and u2. In these situations, experience, judgment, and an assessment of the pore pressure dissipation data should be used to infer the correct soil behavior type.

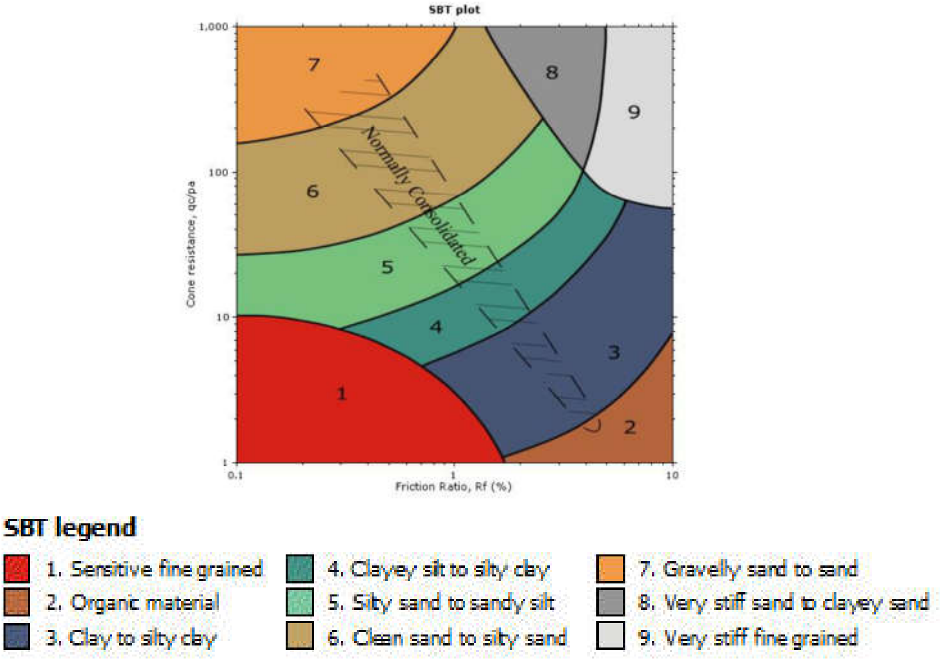


Figure SBT (after Robertson, 2010) – Note: Colors may vary slightly compared to plots.

Cone Penetration Data & Interpretation

Gregg uses a commercial CPT interpretation and plotting software CPeT-IT (https://geologismiki.gr/products/cpet-it/). The software takes the CPT data and performs basic interpretation in terms of soil behavior type (SBT) and various geotechnical parameters using current published empirical correlations based on the comprehensive review by Lunne, Robertson and Powell (1997) and updated by Robertson and Cabal (2015). The interpretation is presented in tabular format. The interpretations are presented only as a guide for geotechnical use and should be carefully reviewed. Gregg does not warranty the correctness or the applicability of any of the geotechnical parameters interpreted by the software and does not assume any liability for any use of the results in any design or review. The user should be fully aware of the techniques and limitations of any method used in the software.

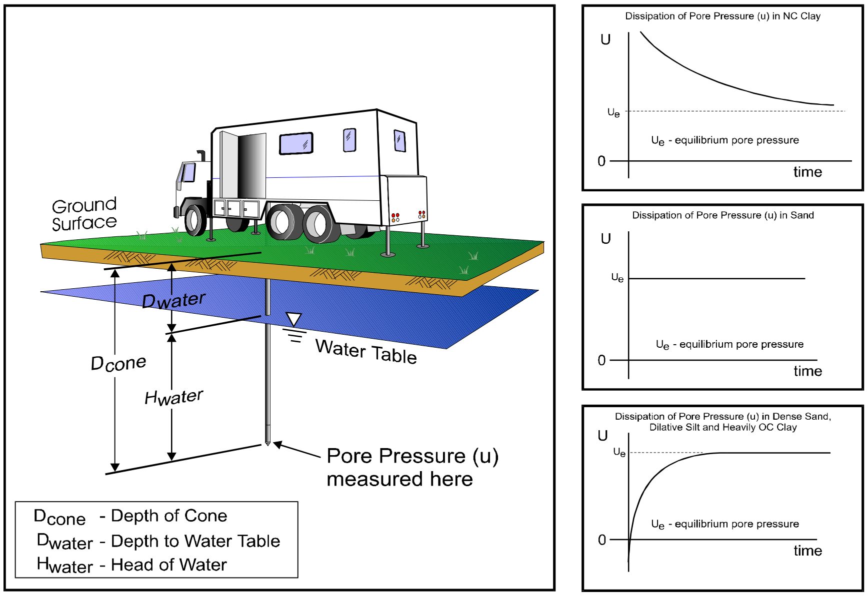
Pore Pressure Dissipation Testing Description

Pore Pressure Dissipation Tests (PPDT's) conducted at various intervals can be used to measure equilibrium water pressure (at the time of the CPT). If conditions are hydrostatic, the equilibrium water pressure can be used to determine the approximate depth of the ground water table. A PPDT is conducted when penetration is halted at specific intervals determined by the field representative. The variation of the penetration pore pressure (*u)* with time is measured behind the tip of the cone and recorded.

Pore pressure dissipation data can be interpreted to provide estimates of:

- Equilibrium piezometric pressure
- Phreatic surface
- In situ horizontal coefficient of consolidation (c_h)
- In situ horizontal coefficient of permeability (k_h)

In order to correctly interpret the equilibrium piezometric pressure and/or the phreatic surface, the pore pressure must be monitored until it reaches equilibrium, *Figure PPDT*. This time is commonly referred to as t_{100}, the point at which 100% of the excess pore pressure has dissipated.



Water Table Calculation

$$D_{water} = D_{cone} - H_{water}$$

where $H_{water} = U_e$ (depth units)

Useful Conversion Factors:
1psi = 0.704m = 2.31 feet (water)
1tsf = 0.958 bar = 13.9 psi
1m = 3.28 feet

Figure PPDT

A complete reference on pore pressure dissipation testing is presented by Robertson et al. 1992 and Lunne et al. 1997.

A summary of the pore pressure dissipation tests can be found in Table 1.

Groundwater Sampling

Gregg Drilling conducts groundwater sampling using a sampler as shown in *Figure GWS*. The groundwater sampler has a retrievable stainless steel or disposable PVC screen with steel drop off tip. This allows for samples to be taken at multiple depth intervals within the same sounding location. In areas of slower water recharge, provisions may be made to set temporary PVC well screens during sampling to allow the pushing equipment to advance to the next sample location while the groundwater is allowed to infiltrate.

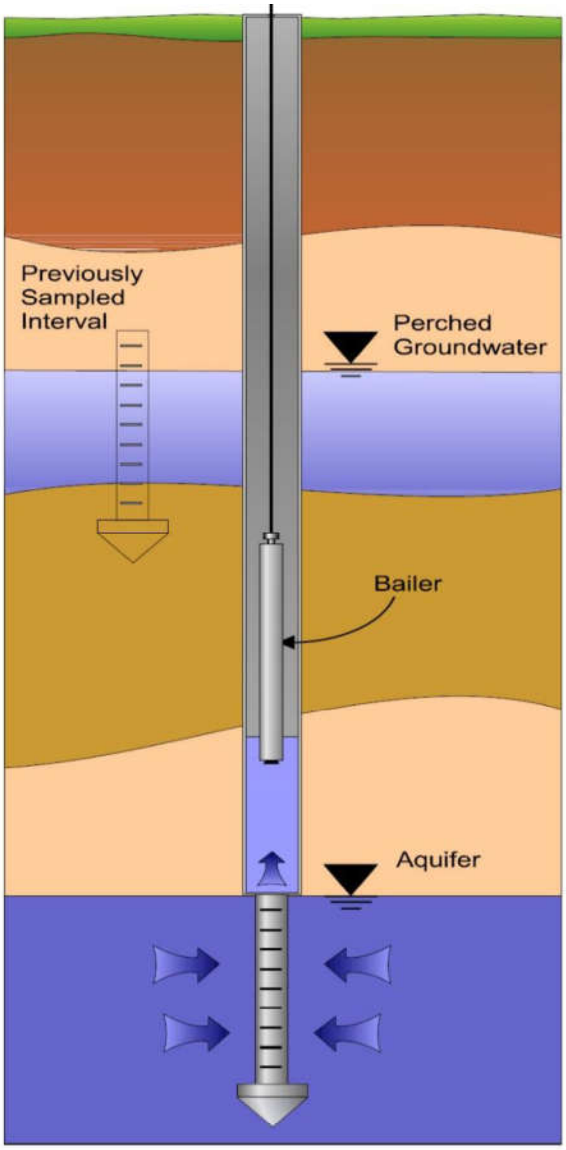


Figure GWS

The groundwater sampler operates by advancing 44.5mm (1¾ inch) hollow push rods with the filter tip in a closed configuration to the base of the desired sampling interval. Once at the desired sample depth, the push rods are retracted; exposing the encased filter screen and allowing groundwater to infiltrate hydrostatically from the formation into the inlet screen. A small diameter bailer (approximately ½ or ¾ inch) is lowered through the push rods into the screen section for sample collection. The number of downhole trips with the bailer and time necessary to complete the sample collection at each depth interval is a function of sampling protocols, volume requirements, and the yield characteristics and storage capacity of the formation. Upon completion of sample collection, the push rods and sampler, with the exception of the PVC screen and steel drop off tip are retrieved to the ground surface, decontaminated and prepared for the next sampling event.

For a detailed reference on direct push groundwater sampling, refer to Zemo et al., 1992.

Soil Sampling

Gregg Drilling uses a piston-type push-in sampler to obtain small soil samples without generating any soil cuttings, *Figure SS*. Two different types of samplers (12 and 18 inch) are used depending on the soil type and density. The soil sampler is initially pushed in a "closed" position to the desired sampling interval using the CPT pushing equipment. Keeping the sampler closed minimizes the potential of cross contamination. The inner tip of the sampler is then retracted leaving a hollow soil sampler with inner 1¼" diameter sample tubes. The hollow sampler is then pushed in a locked "open" position to collect a soil sample. The filled sampler and push rods are then retrieved to the ground surface. Because the soil enters the sampler at a constant rate, the opportunity for 100% recovery is increased. For environmental analysis, the soil sample tube ends are sealed with Teflon and plastic caps. Often, a longer "split tube" can be used for geotechnical sampling.

For a detailed reference on direct push soil sampling, refer to Robertson et al, 1997.

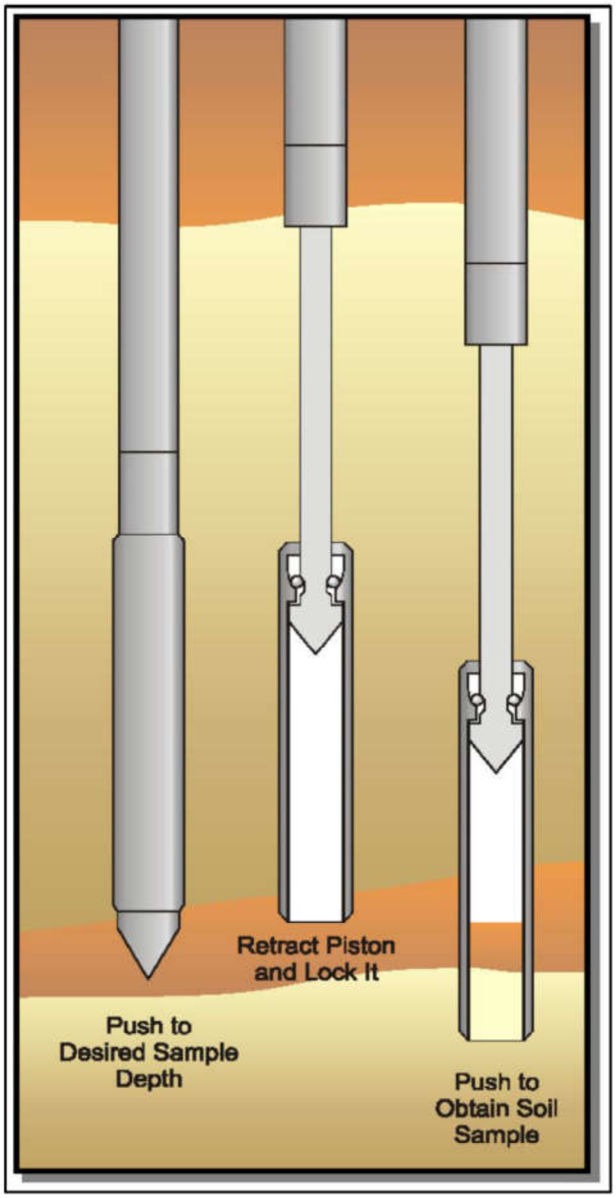


Figure SS

Seismic Cone Penetration Testing

Seismic Cone Penetration Testing (SCPT) can be conducted at various intervals during the Cone Penetration Test. Shear wave velocity (Vs) can then be calculated over a specified interval with depth. A small interval for seismic testing, such as 1-1.5m (3-5ft) allows for a detailed look at the shear wave profile with depth. Conversely, a larger interval such as 3-6m (10-20ft) allows for a more average shear wave velocity to be calculated. Gregg Drilling's cones have a horizontally active geophone located 0.2m (0.66ft) behind the tip.

To conduct the seismic shear wave test, the penetration of the cone is stopped and the rods are decoupled from the rig. An automatic hammer is triggered to send a shear wave into the soil. The distance from the source to the cone is calculated knowing the total depth of the cone and the horizontal offset distance between the source and the cone. To calculate an interval velocity, a minimum of two tests must be performed at two different depths. The arrival times between the two wave traces are compared to obtain the difference in time (Δt). The difference in depth is calculated (Δd) and velocity can be determined using the simple equation: v = Δd/Δt

Multiple wave traces can be recorded at the same depth to improve quality of the data.

A complete reference on seismic cone penetration tests is presented by Robertson et al. 1986 and Lunne et al. 1997.

A summary the shear wave velocities, arrival times and wave traces are provided with the report.

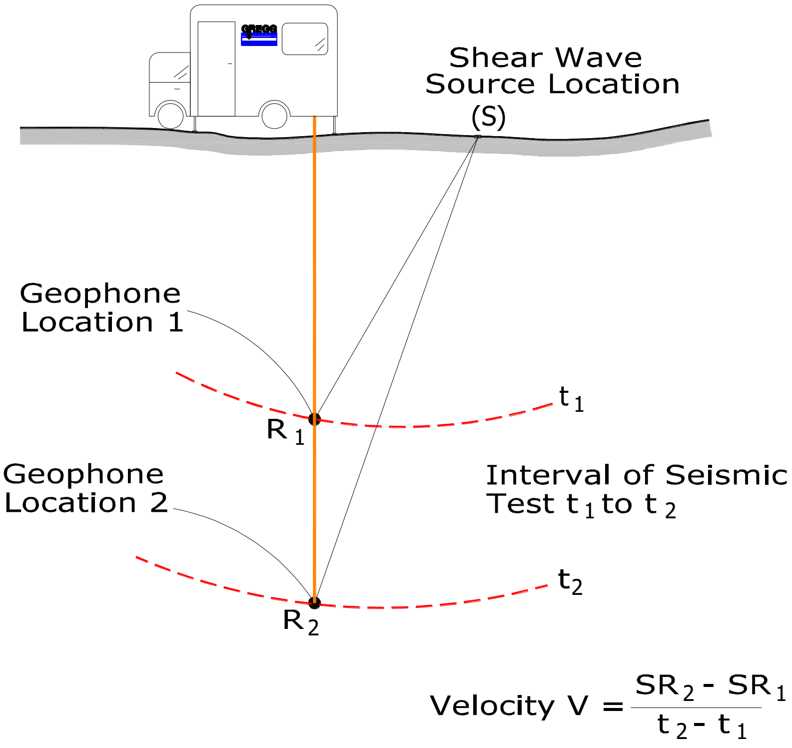


Figure SCPT

iVane Shear Testing

Gregg Drilling operates a digital iVane from A.P. van den Berg, in compliance with ASTM D2573, to measure undrained shear strengths in soft clays. It can be used in soft clays as well as other fine-grained soils such as silts, organic soils, fine-grained tailings and other soft fine-grained materials where a prediction of the peak and remolded undrained shear strength is required.

The iVane is digital and has a torque motor and measuring torque load cell down-hole for improved accuracy and elimination of torque effects associated with the rod string between surface and the test depth. The digital readout displays undrained shear strength and torque versus rotation to provide a detailed record of the test. The iVane can measure a range of undrained shear strength values using different vane sizes. The rate of rotation of the vane can be varied from a slow 0.1 degrees/s up to 6 degrees/s.

The iCone Vane consists of four rectangular blades fixed at 90° angels that are pushed into the ground to the desired depth. Once this depth is reached, the blades are rotated at a constant speed through ranges of the test sequence. The resistance of the soil, and consequently the required torque, will increase until the soil shears. From the point the soil is shearing, the torque value will generally decrease. The highest measured value to shear the soil, is a measure for the undrained shear strength. After the first test to measure the peak undrained shear strength, the soil is remolded by rotating (between 5 and 10 rotations) the vane at a high speed. Then the rate of rotation is slowed to the rate used at peak strength determination to continue the test to measure the remolded shear strength.

The relationship between the undrained shear strength Su, torque T and vane diameter D is given in the following equation:

$S_u = (6T / 7\pi D^3)K$

where:
S_u = peak undrained shear strength in kPa
T = maximum value of measured torque (T_{max}) or residual torque (T_R) corrected for apparatus and rod friction in Nm
D = vane diameter in mm
K = 1×10^6 (SI units)

Figure Gregg Drilling iVane

References

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TABLE 1: CPT Summary

CPT Sounding Identification	Date (mm-dd-year)	Start Depth (m)	Termination Depth (m)	Cone ID	Depth of Pore Pressure Dissipation Tests (m)
CPT19-01	11-14-2019	1.60	5.800	GDC-59	-
CPT19-02B	11-13-2019	1.50	14.125	GDC-59	9.20
CPT19-04	11-14-2019	1.60	7.650	GDC-59	4.625
CPT19-06	11-14-2019	1.45	4.175	GDC-59	3.35, 4.150

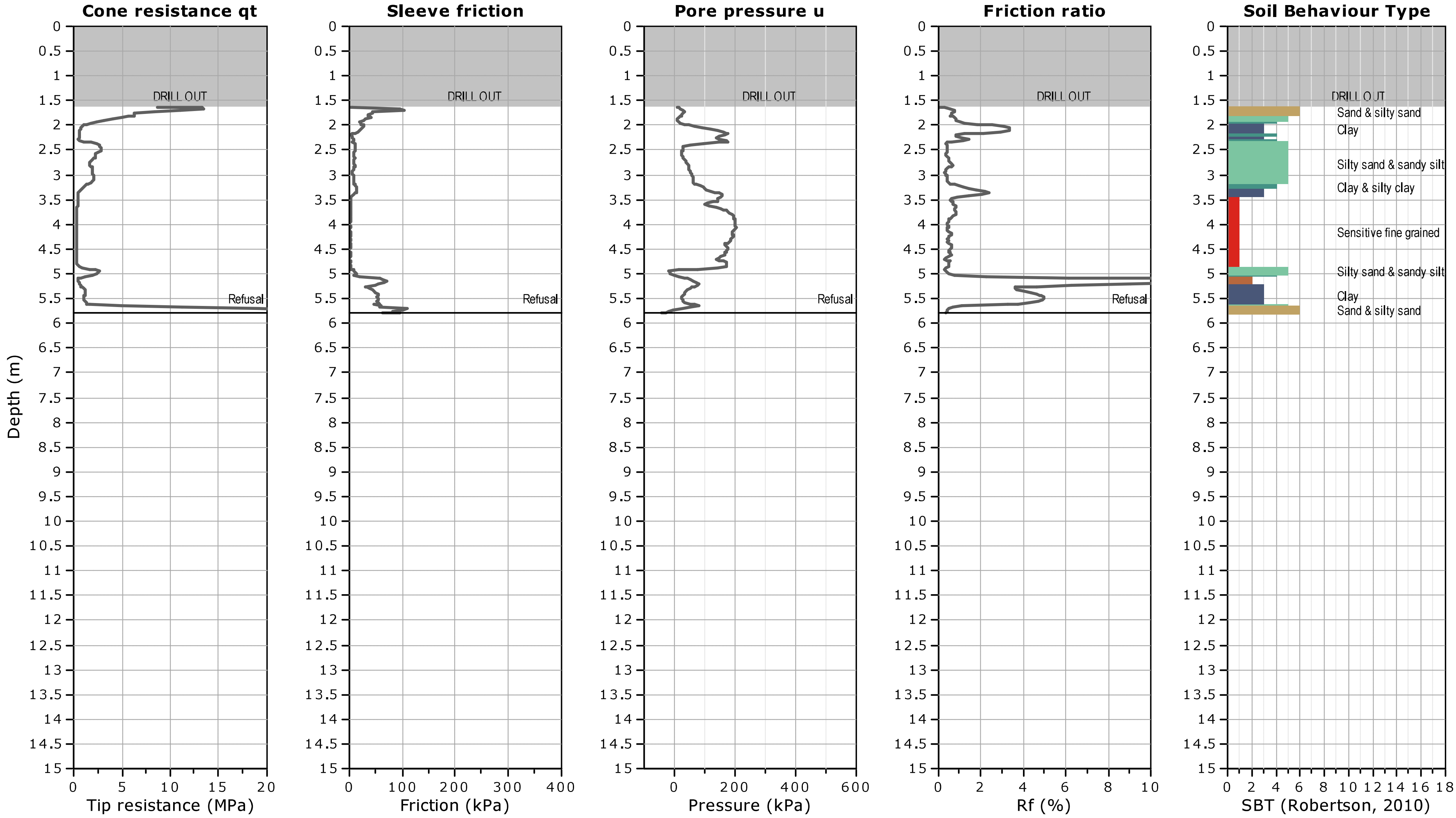
Note that all penetration depths are with respect to the existing ground surface.

APPENDIX A – CPT Plots – Standard

Project: **Tetra Tech - Venus Mine**
Location: **Carcross, Yukon**

CPT19-01

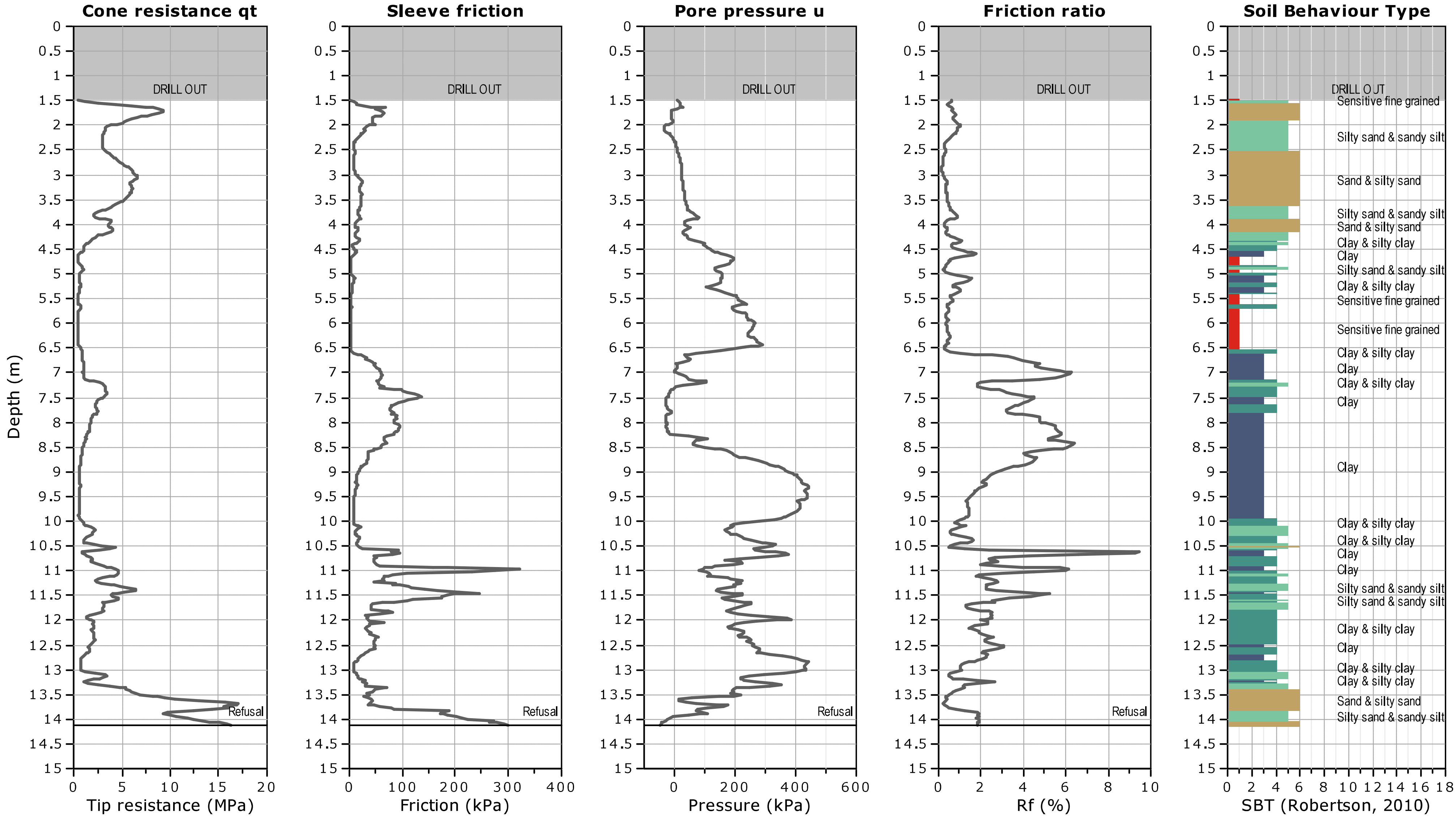
Total depth: 5.80 m, Date: 11/14/2019
Cone Operator: Josh Ellis



Project: **Tetra Tech - Venus Mine**
Location: **Carcross, Yukon**

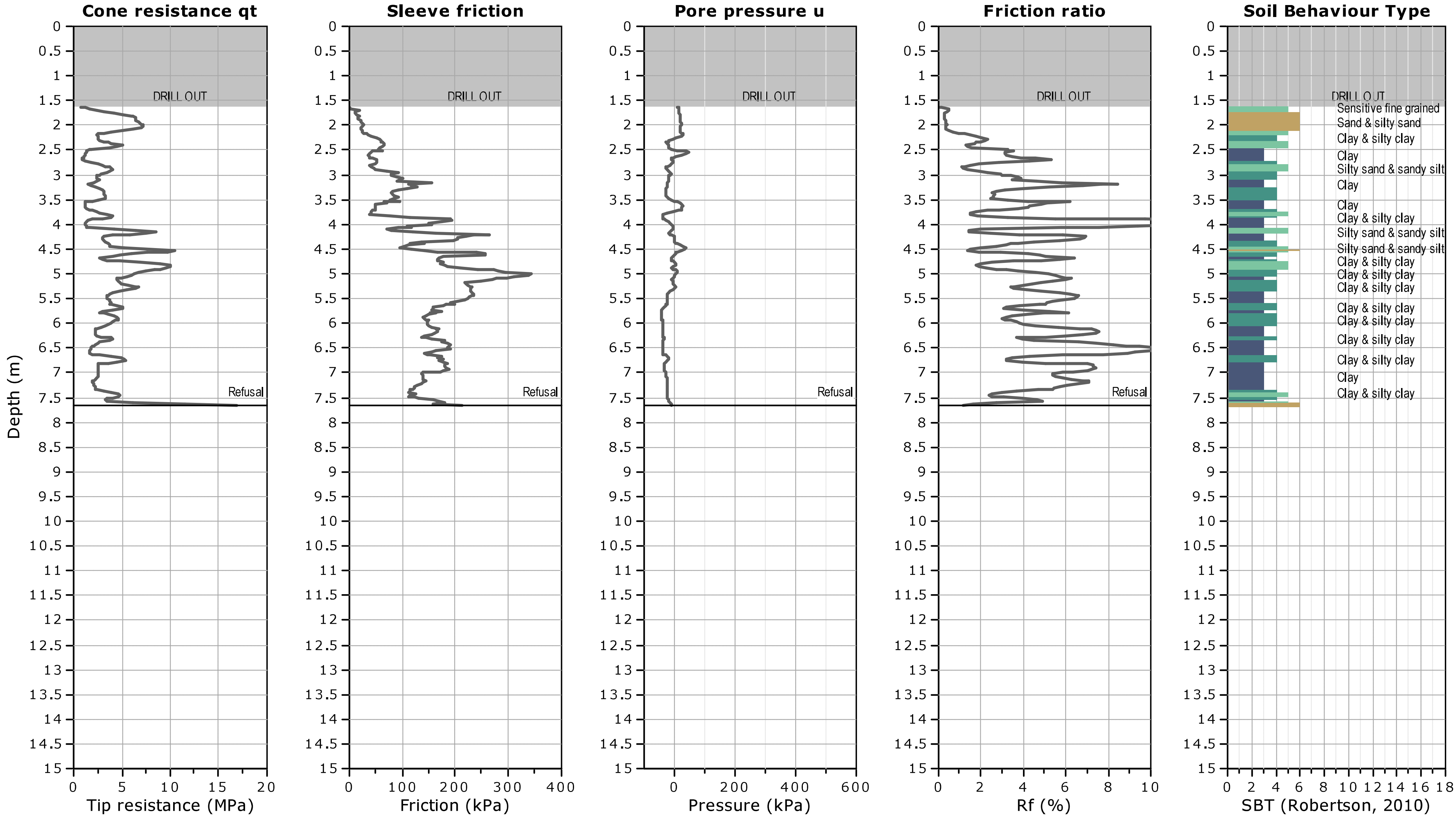
CPT19-02B

Total depth: 14.13 m, Date: 11/13/2019
Cone Operator: Josh Ellis



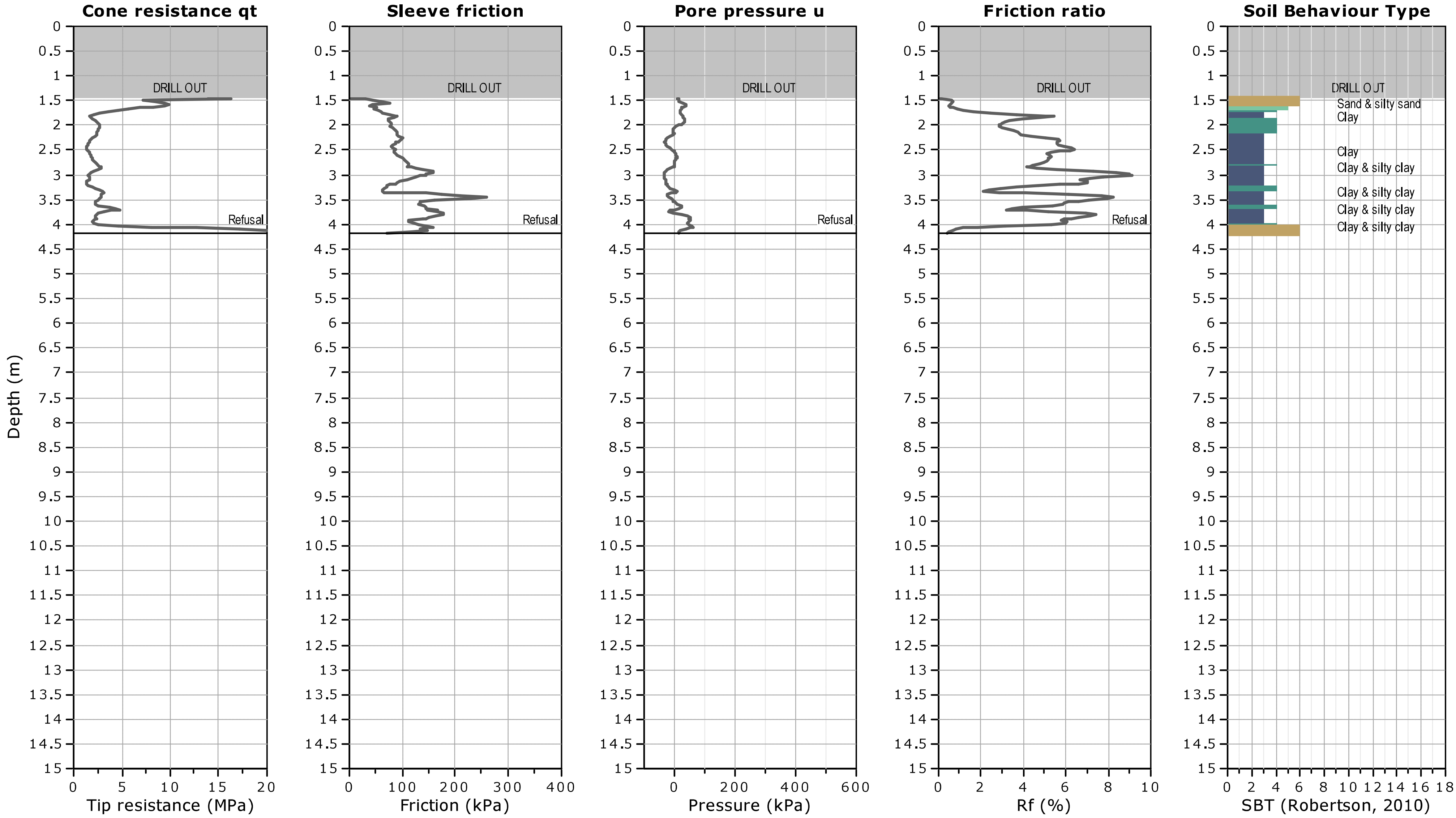
Project: **Tetra Tech - Venus Mine**
Location: **Carcross, Yukon**

CPT19-04
Total depth: 7.65 m, Date: 11/14/2019
Cone Operator: Josh Ellis



Project: **Tetra Tech - Venus Mine**
Location: **Carcross, Yukon**

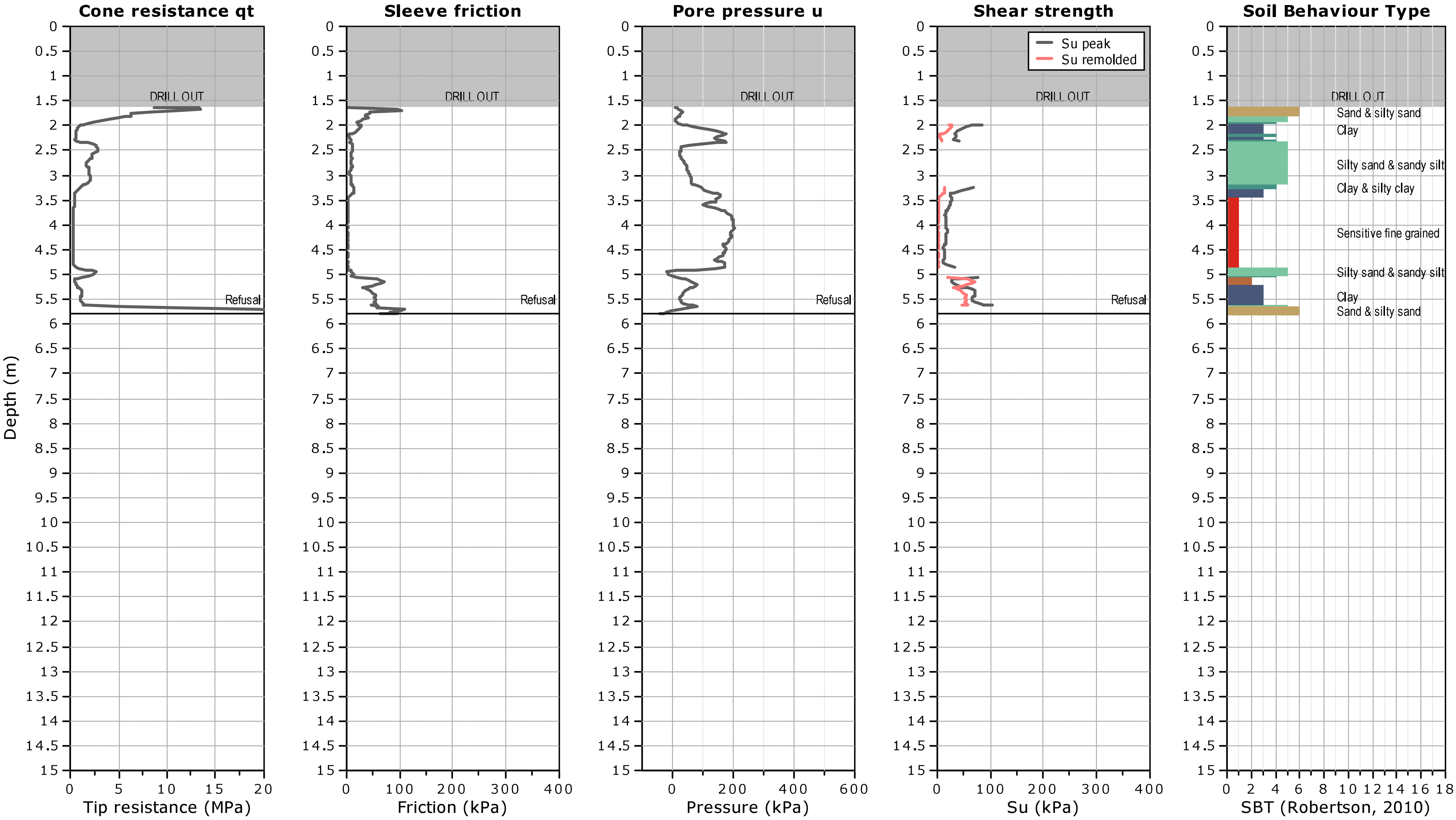
CPT19-06
Total depth: 4.18 m, Date: 11/14/2019
Cone Operator: Josh Ellis



APPENDIX B – CPT Plots – S_u

Project: **Tetra Tech - Venus Mine**
Location: **Carcross, Yukon**

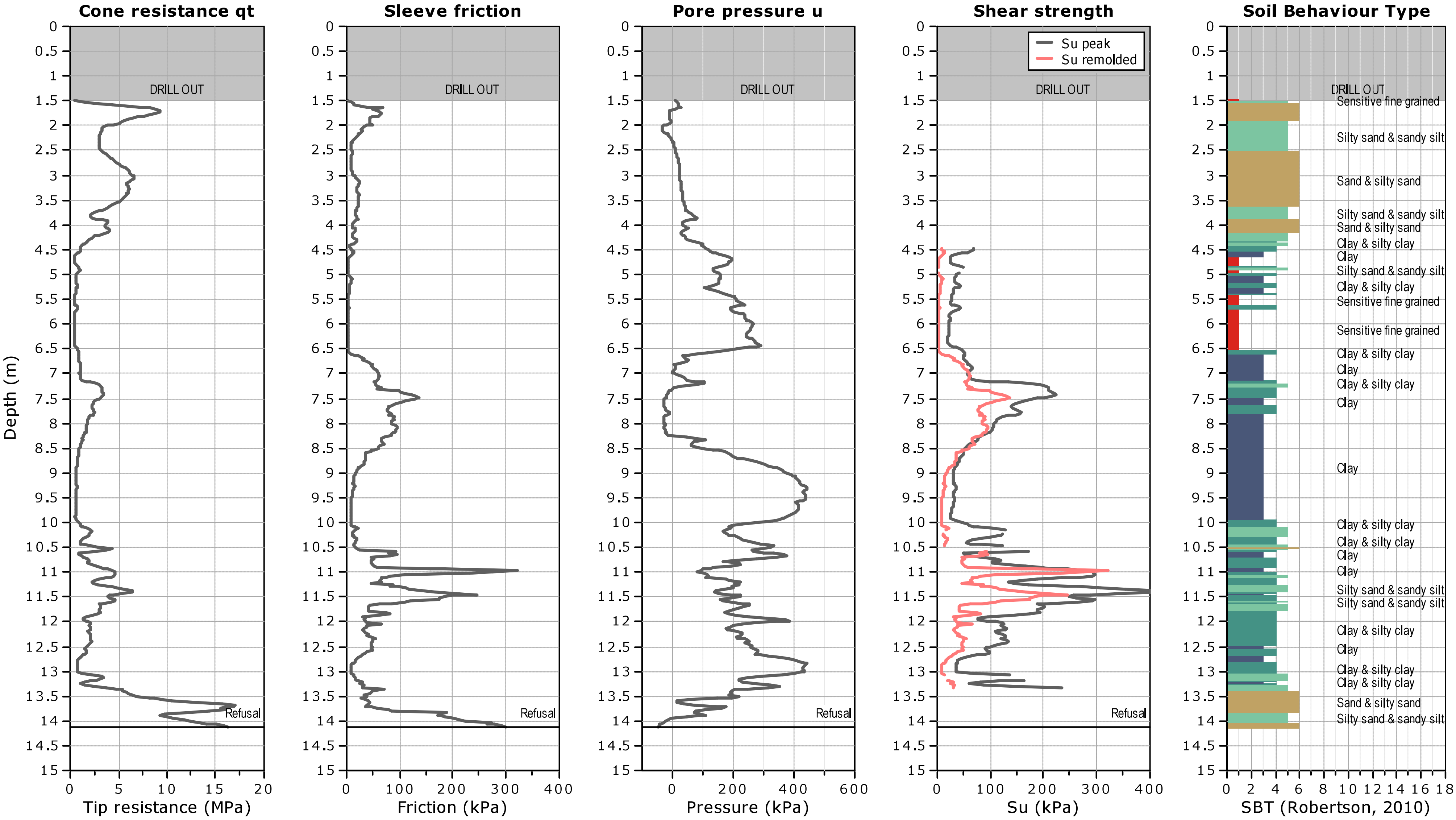
CPT19-01
Total depth: 5.80 m, Date: 11/14/2019
Cone Operator: Josh Ellis



Project: Tetra Tech - Venus Mine
Location: Carcross, Yukon

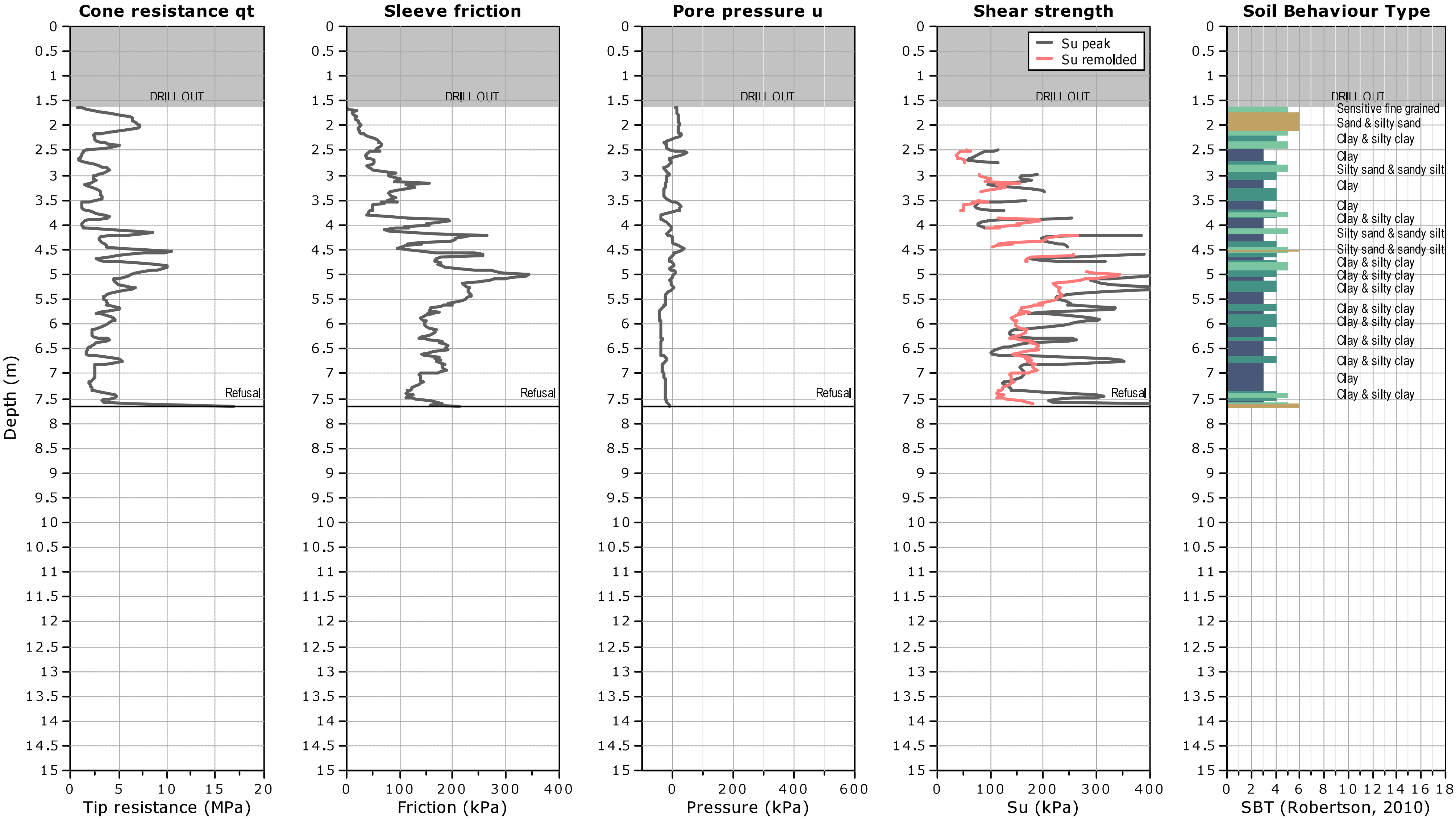
CPT19-02B

Total depth: 14.13 m, Date: 11/13/2019
Cone Operator: Josh Ellis



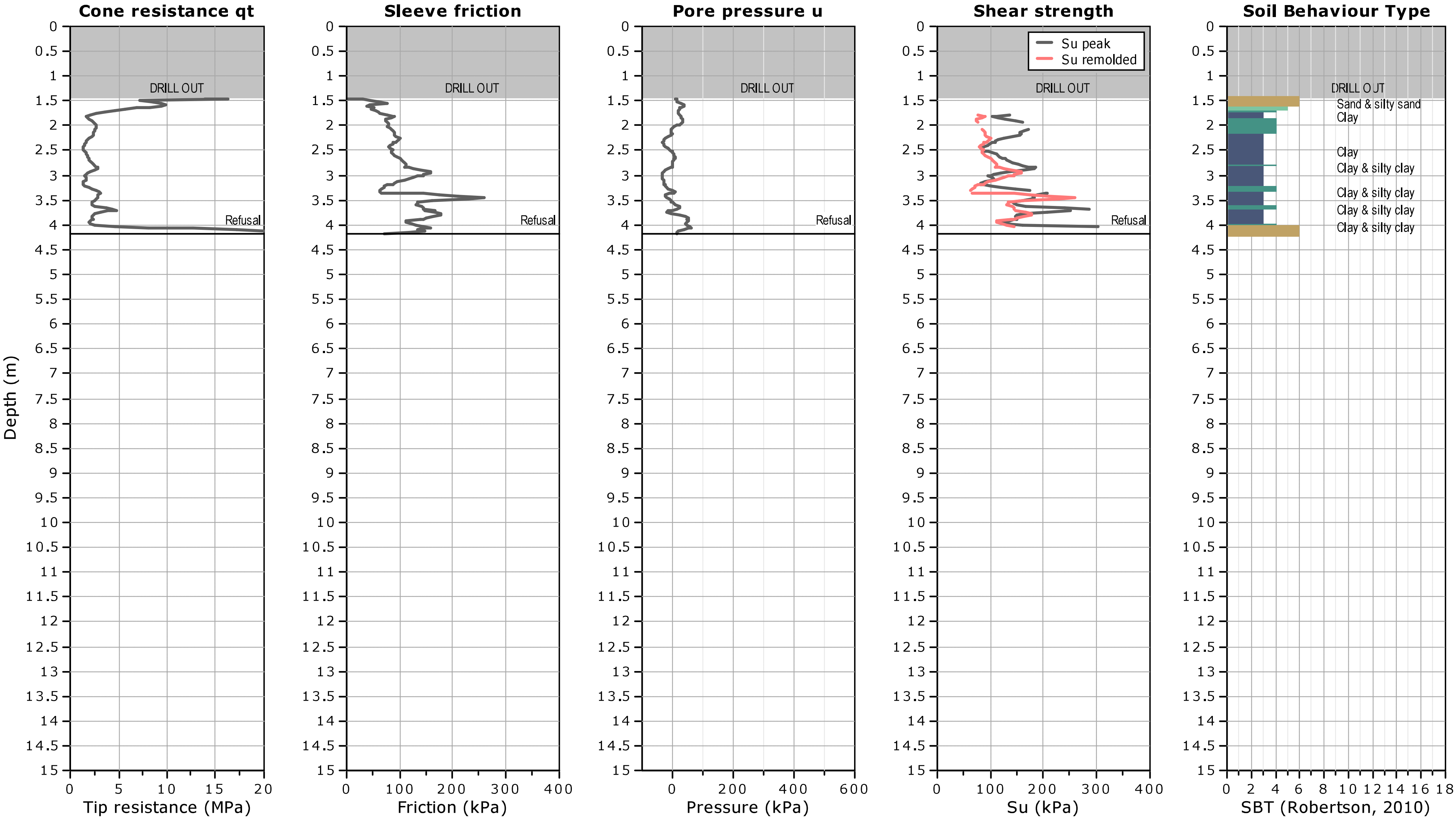
Project: **Tetra Tech - Venus Mine**
Location: **Carcross, Yukon**

CPT19-04
Total depth: 7.65 m, Date: 11/14/2019
Cone Operator: Josh Ellis



Project: **Tetra Tech - Venus Mine**
Location: **Carcross, Yukon**

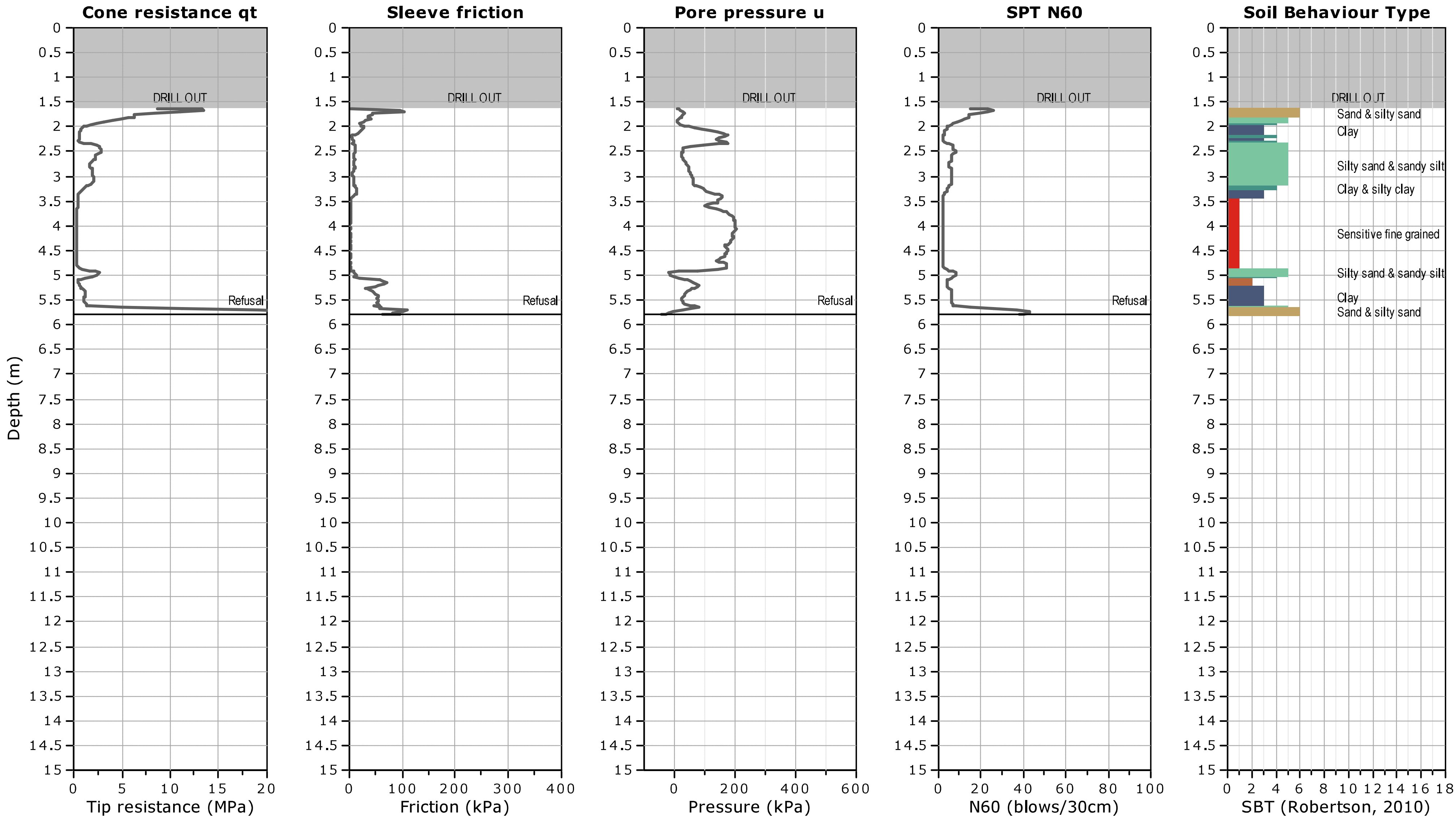
CPT19-06
Total depth: 4.18 m, Date: 11/14/2019
Cone Operator: Josh Ellis



APPENDIX C – CPT Plots – N_{60}

Project: **Tetra Tech - Venus Mine**
Location: **Carcross, Yukon**

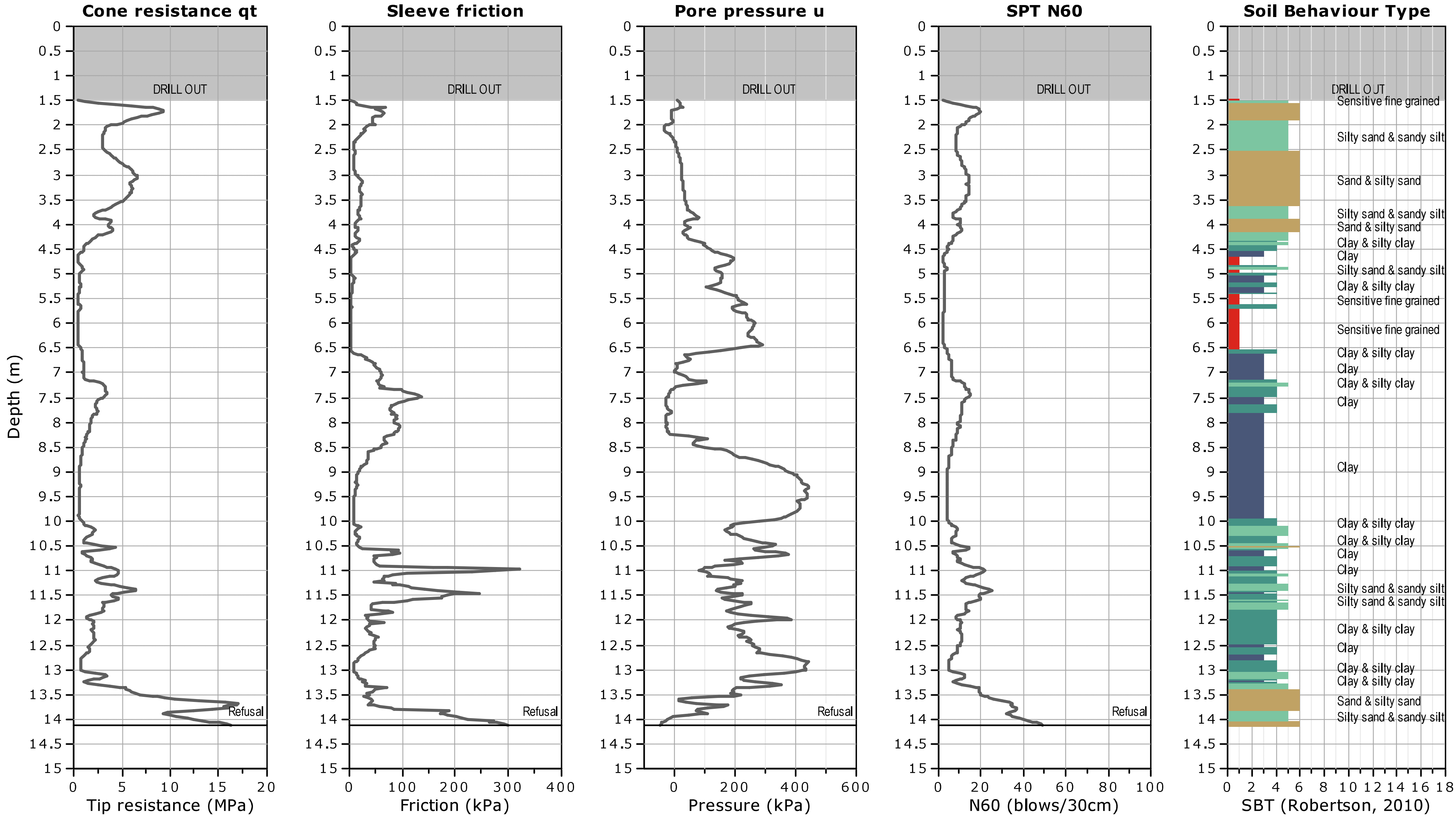
CPT19-01
Total depth: 5.80 m, Date: 11/14/2019
Cone Operator: Josh Ellis



Project: **Tetra Tech - Venus Mine**
Location: **Carcross, Yukon**

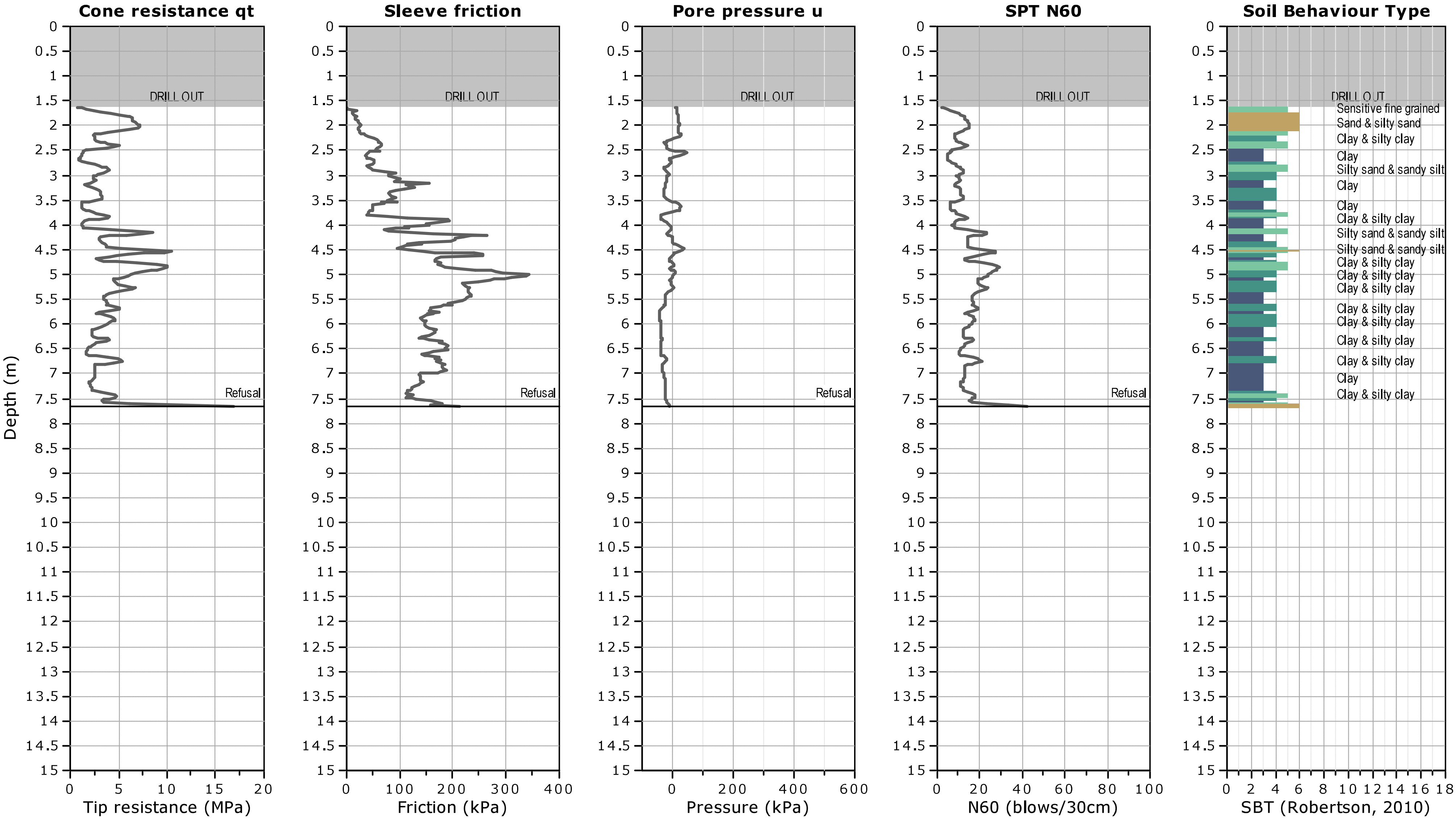
CPT19-02B

Total depth: 14.13 m, Date: 11/13/2019
Cone Operator: Josh Ellis



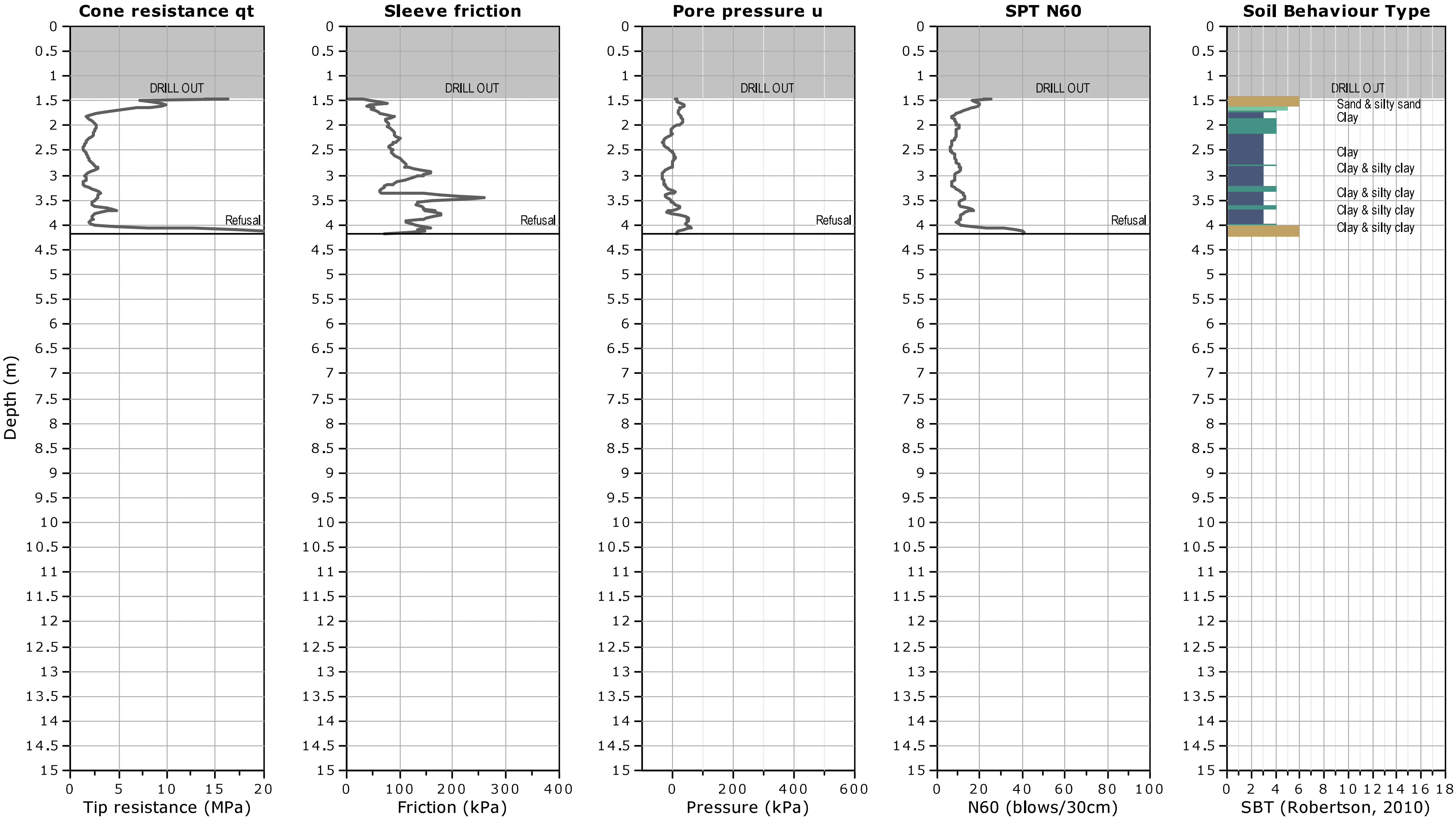
Project: **Tetra Tech - Venus Mine**
Location: **Carcross, Yukon**

CPT19-04
Total depth: 7.65 m, Date: 11/14/2019
Cone Operator: Josh Ellis



Project: **Tetra Tech - Venus Mine**
Location: **Carcross, Yukon**

CPT19-06
Total depth: 4.18 m, Date: 11/14/2019
Cone Operator: Josh Ellis

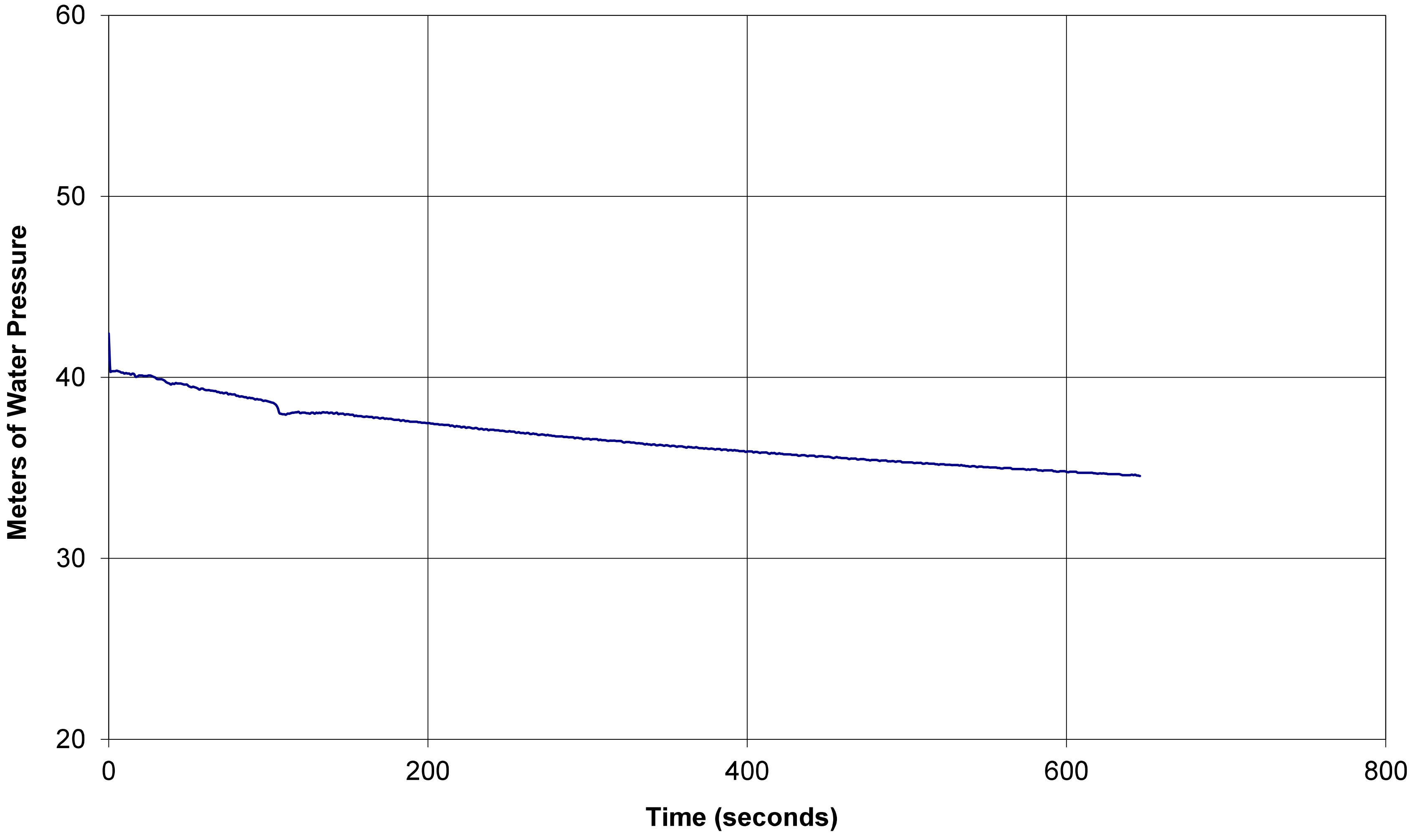


APPENDIX D – Pore Pressure Dissipation Testing Plots

GREGG DRILLING & TESTING

Pore Pressure Dissipation Test

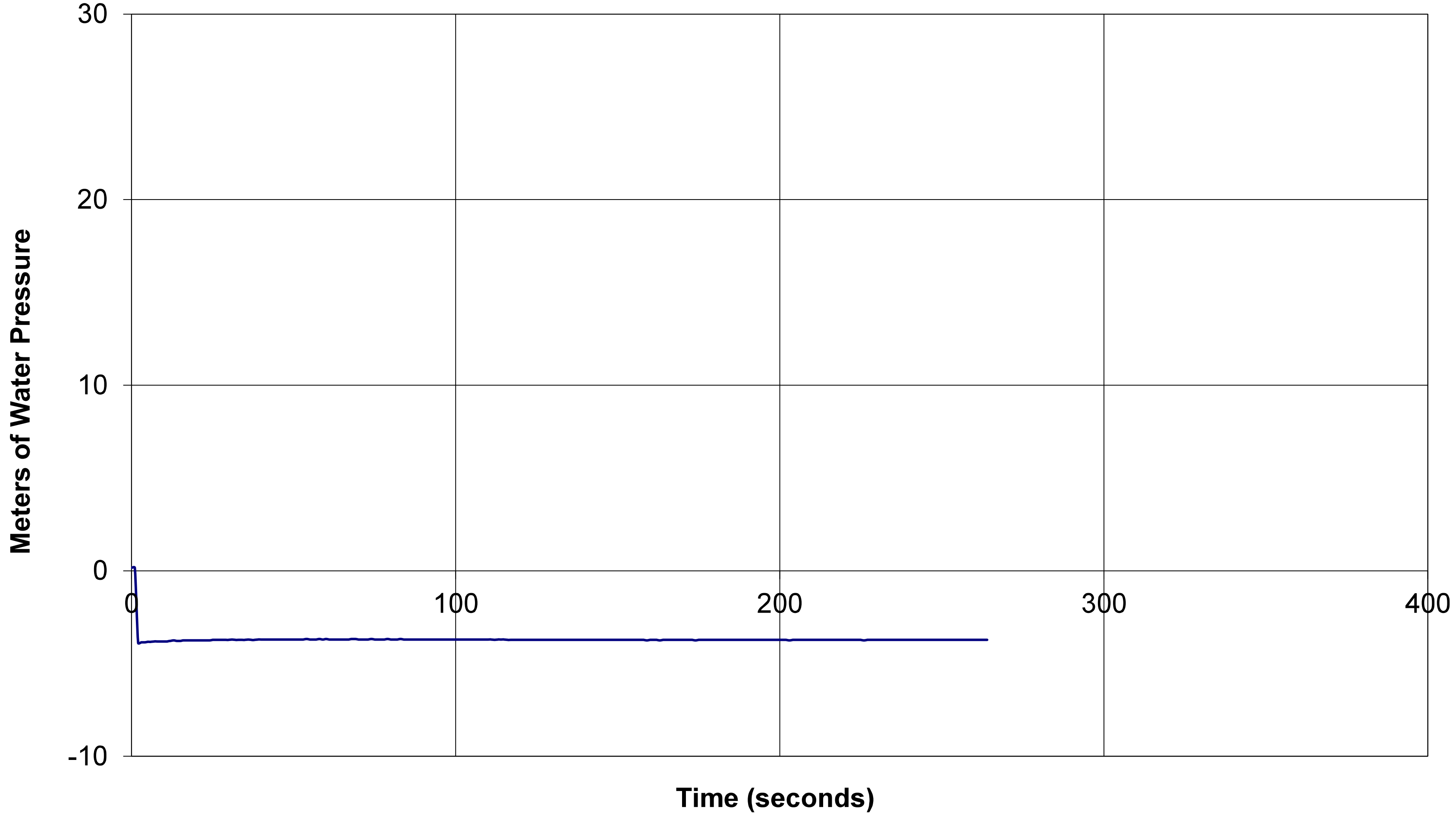
Sounding: CPT19-02B
Depth (m): 9.2
Site: Venus Mine
Engineer: Ian MacIntyre



GREGG DRILLING & TESTING

Pore Pressure Dissipation Test

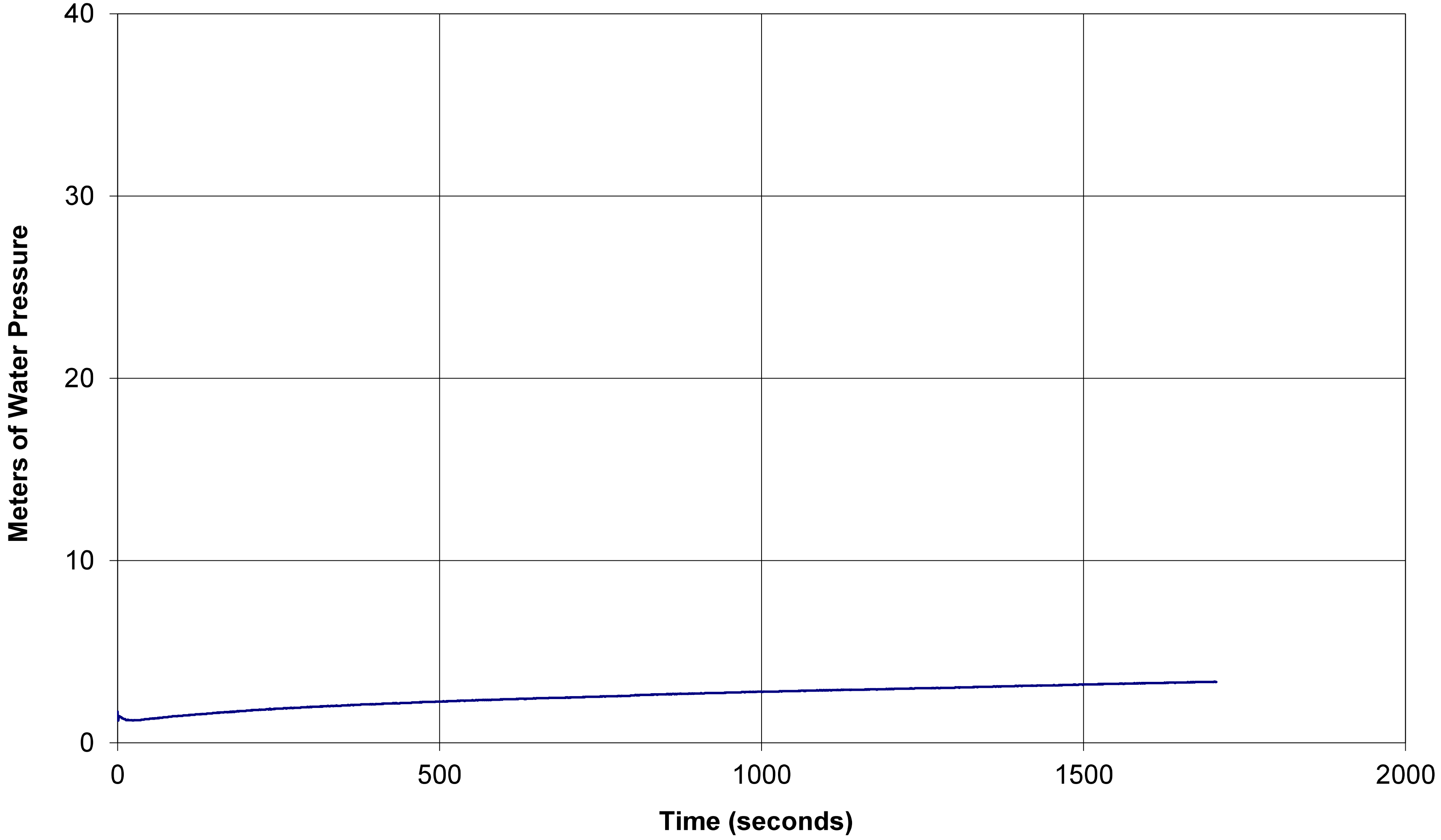
Sounding: CPT19-04
Depth (m): 4.625
Site: Venus Mine
Engineer: Ian MacIntyre



GREGG DRILLING & TESTING

Pore Pressure Dissipation Test

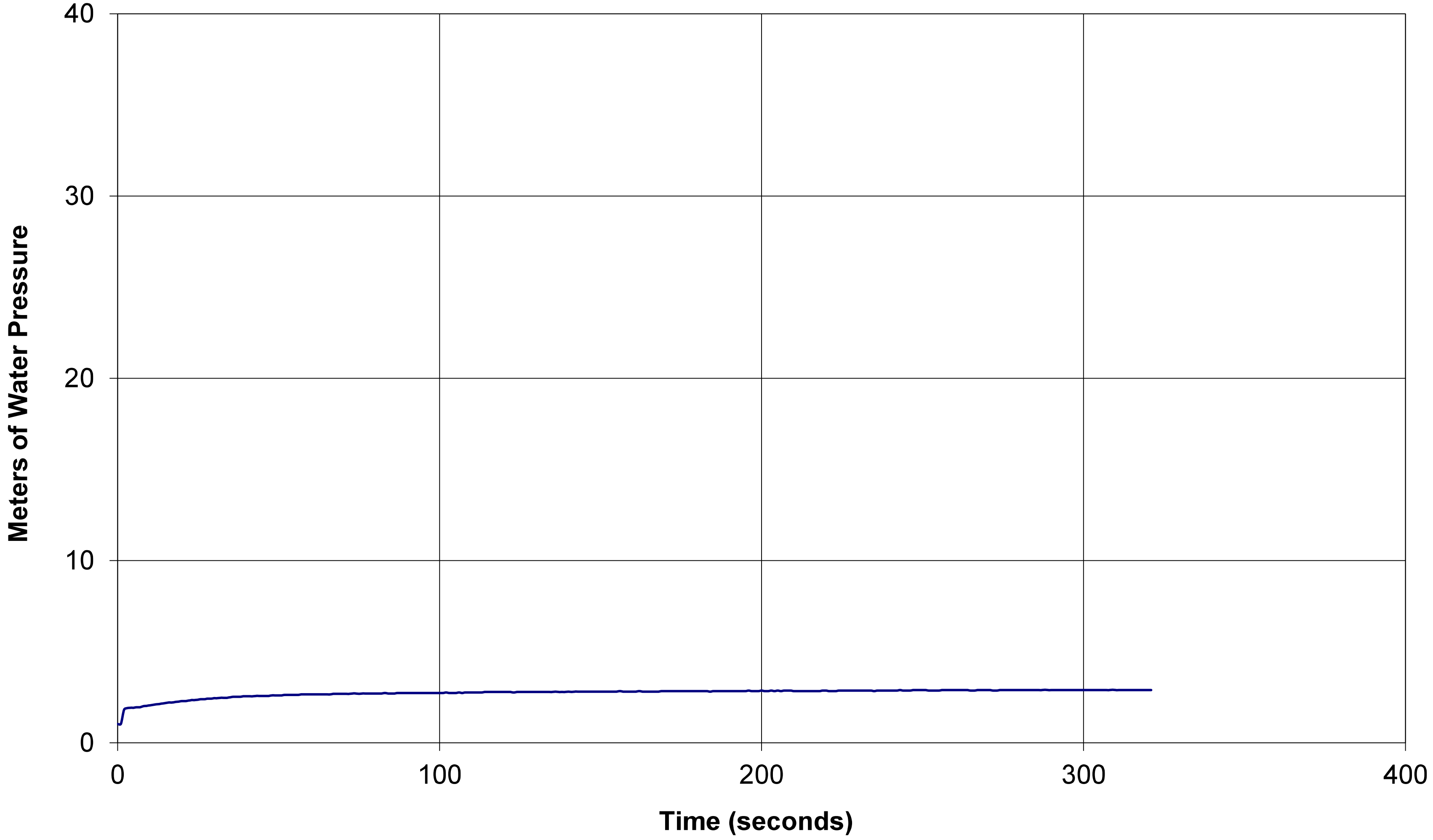
Sounding: CPT19-06
Depth (m): 3.35
Site: Venus Mine
Engineer: Ian MacIntyre



GREGG DRILLING & TESTING

Pore Pressure Dissipation Test

Sounding: CPT19-06
Depth (m): 4.15
Site: Venus Mine
Engineer: Ian MacIntyre



APPENDIX E – Shear Wave Velocity Calculations & Waveforms

Shear Wave Velocity Calculations

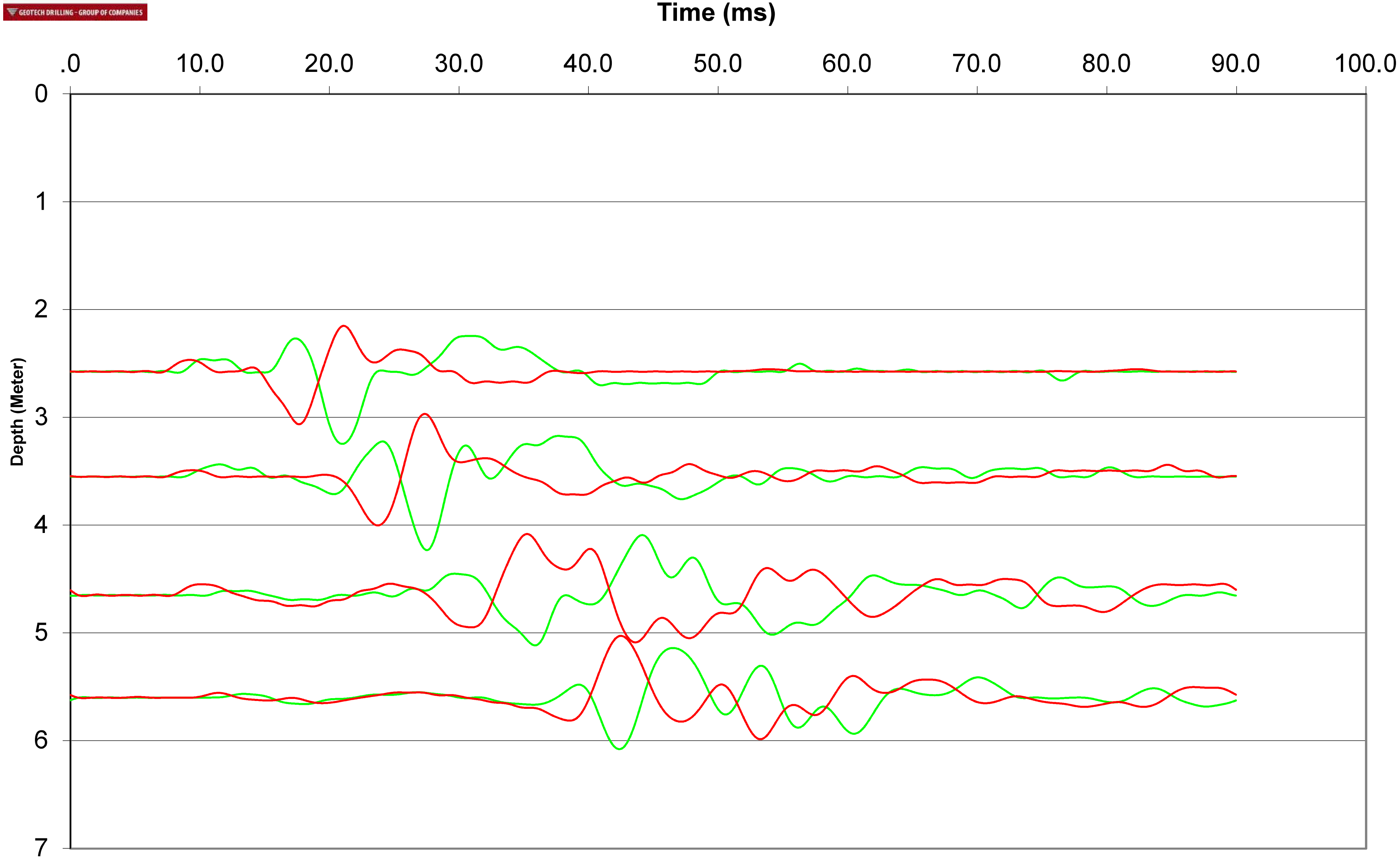
Venus Mine
Carcross, Yukon
CPT19-01

Geophone Offset: 0.20 Meters
Source Offset: 1.50 Meters

11/14/19

Test Depth (Meter)	Geophone Depth (Meter)	Waveform Ray Path (Meter)	Incremental Distance (Meter)	Characteristic Arrival Time (ms)	Incremental Time Interval (ms)	Interval Velocity (M/Sec)	Interval Depth (Meter)
2.58	2.38	2.81	2.81	19.1500			
3.55	3.35	3.67	0.86	25.5000	6.3500	135.7	2.86
4.65	4.45	4.70	1.03	32.5500	7.0500	145.5	3.90
5.60	5.40	5.60	0.91	40.1500	7.6000	119.5	4.93

Waveforms for Sounding CPT19-01



Shear Wave Velocity Calculations

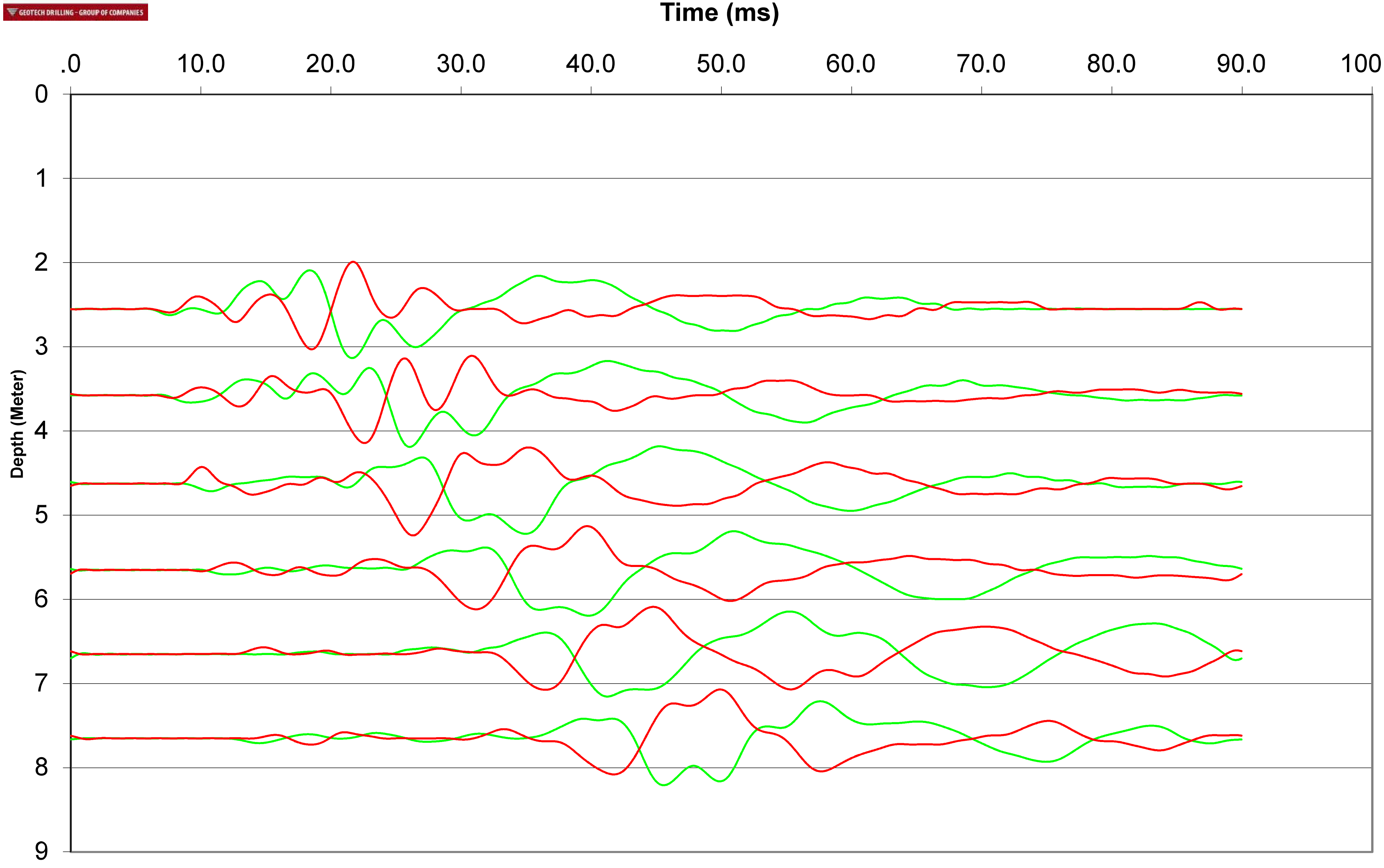
Venus Mine
Carcross, Yukon
CPT19-04

Geophone Offset: 0.20 Meters
Source Offset: 1.50 Meters

11/14/19

Test Depth (Meter)	Geophone Depth (Meter)	Waveform Ray Path (Meter)	Incremental Distance (Meter)	Characteristic Arrival Time (ms)	Incremental Time Interval (ms)	Interval Velocity (M/Sec)	Interval Depth (Meter)
2.55	2.35	2.79	2.79	20.0000			
3.58	3.38	3.69	0.91	24.2000	4.2000	215.6	2.86
4.63	4.43	4.67	0.98	28.6000	4.4000	222.5	3.90
5.65	5.45	5.65	0.98	33.6500	5.0500	194.1	4.94
6.65	6.45	6.62	0.97	38.7500	5.1000	190.1	5.95
7.65	7.45	7.60	0.98	43.6500	4.9000	199.5	6.95

Waveforms for Sounding CPT19-04



APPENDIX D

SLOPE STABILITY FIGURES

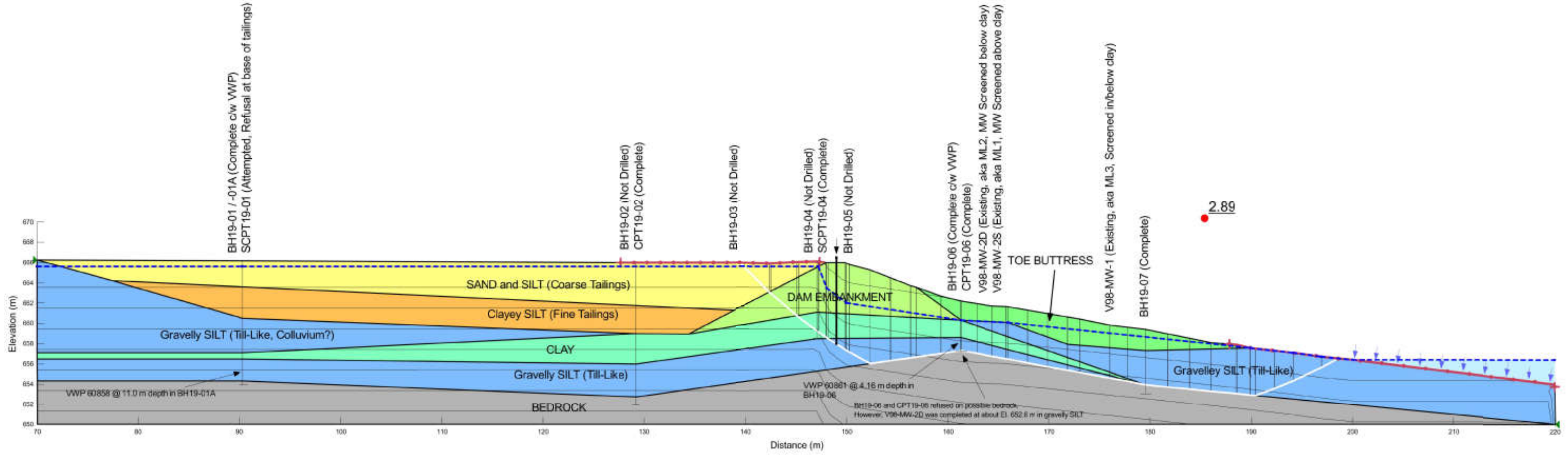
Venus Tailings Storage Facility Slope Stability Update
Tetra Tech File: ENW.EENW03031-10

Date: 4/1/2020

Slope Stability Case: Static

Horz Seismic Coef. (100% PGA): 0g

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line	C-Top of Layer (kPa)	C-Rate of Change ((kN/m²)/m)	C-Maximum (kPa)	Cohesion (kPa)
🟨	SAND and SILT (Coarse Tailings)	Mohr-Coulomb	20	0	35	0	1				
🟩	Dam Embankment (Fill)	Mohr-Coulomb	19	0	32	0	1				
🟩	GRAVEL (Toe Buttress Fill)	Mohr-Coulomb	21	0	34	0	1				
🟩	CLAY	S=f(depth)	19				1	150	-60	30	
🟦	Gravelly SILT (Till-Like)	Mohr-Coulomb	20	0	34	0	1				
⬜	BEDRCCK	Bedrock (Impenetrable)					1				
🟧	Clayey SILT (Fine Tailings)	Undrained (Phi=0)	20				1				30



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TETRA TECH

2019 GEOTECHNICAL DRILLING PROGRAM
VENUS TAILINGS STORAGE FACILITY, YUKON

SLOPE STABILITY MODELING RESULTS

PROJECT NO.	DWN	CKD	REV	
ENW.EENW03031-10	CB	AW	0	D-1
OFFICE	DATE			
EBA-WHSE	April 2, 2020			

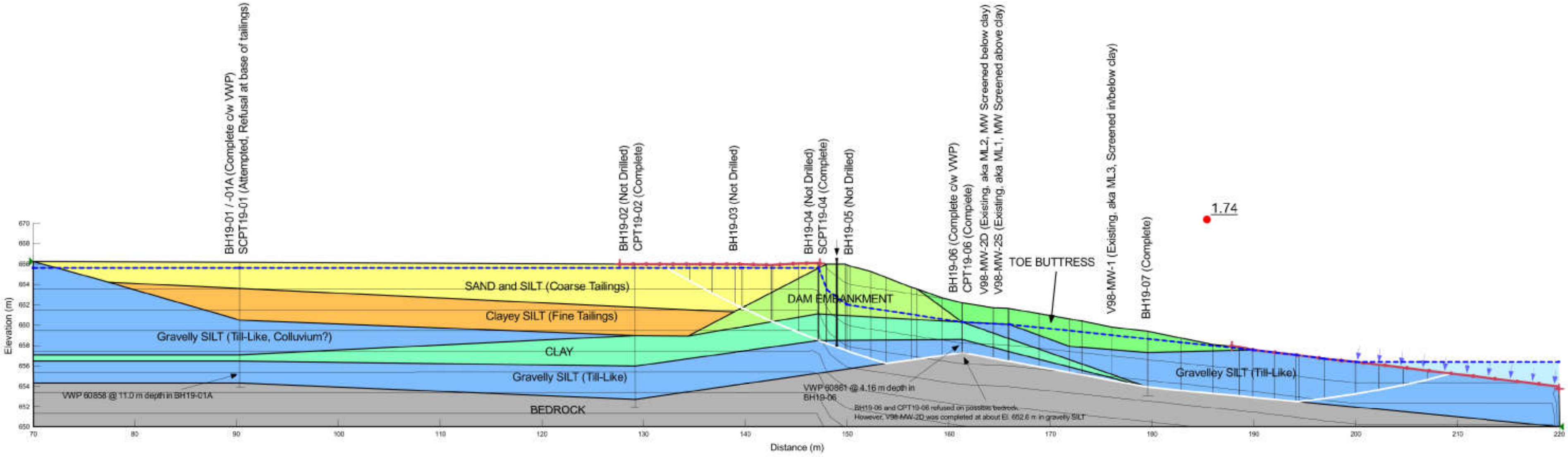
Venus Tailings Storage Facility Slope Stability Update
Tetra Tech File: ENW.EENW03031-10

Date: 4/1/2020

Slope Stability Case: Pseudostatic (1:475 Year EQ)

Horz Seismic Coef. (100% PGA): 0.108g

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line	C-Top of Layer (kPa)	C-Rate of Change ((kN/m²)/m)	C-Maximum (kPa)	Cohesion (kPa)
🟨	SAND and SILT (Coarse Tailings)	Mohr-Coulomb	20	0	35	0	1				
🟩	Dam Embankment (Fill)	Mohr-Coulomb	19	0	32	0	1				
🟩	GRAVEL (Toe Buttress Fill)	Mohr-Coulomb	21	0	34	0	1				
🟩	CLAY	S=f(depth)	19				1	150	-60	30	
🟦	Gravelly SILT (Till-Like)	Mohr-Coulomb	20	0	34	0	1				
⬜	BEDROCK	Bedrock (Impenetrable)					1				
🟧	Clayey SILT (Fine Tailings)	Undrained (Phi=0)	20				1				30



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2019 GEOTECHNICAL DRILLING PROGRAM
VENUS TAILINGS STORAGE FACILITY, YUKON

SLOPE STABILITY MODELING RESULTS

PROJECT NO.	DWN	CKD	REV	
ENW.EENW03031-10	CB	AW	0	D-2
OFFICE	DATE			
EBA-WHSE	April 2, 2020			

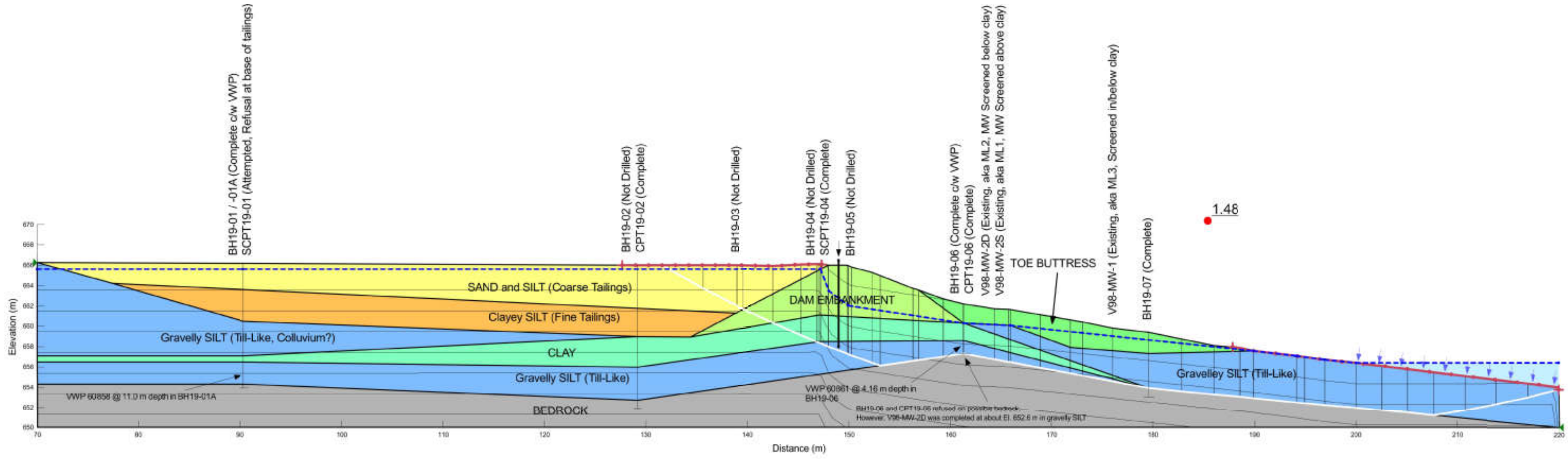
Venus Tailings Storage Facility Slope Stability Update
Tetra Tech File: ENW.EENW03031-10

Date: 4/1/2020

Slope Stability Case: Pseudostatic (1:975 Year EQ)

Horz Seismic Coef. (100% PGA): 0.155g

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line	C-Top of Layer (kPa)	C-Rate of Change ((kN/m²)/m)	C-Maximum (kPa)	Cohesion (kPa)
🟨	SAND and SILT (Coarse Tailings)	Mohr-Coulomb	20	0	35	0	1				
🟩	Dam Embankment (Fill)	Mohr-Coulomb	19	0	32	0	1				
🟩	GRAVEL (Toe Buttress Fill)	Mohr-Coulomb	21	0	34	0	1				
🟩	CLAY	S=f(depth)	19				1	150	-60	30	
🟦	Gravelly SILT (Till-Like)	Mohr-Coulomb	20	0	34	0	1				
⬜	BEDROCK	Bedrock (Impenetrable)					1				
🟧	Clayey SILT (Fine Tailings)	Undrained (Phi=0)	20				1				30



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2019 GEOTECHNICAL DRILLING PROGRAM
VENUS TAILINGS STORAGE FACILITY, YUKON

SLOPE STABILITY MODELING RESULTS

PROJECT NO.	DWN	CKD	REV
ENW.EENW03031-10	CB	AW	0

OFFICE	DATE
EBA-WHSE	April 2, 2020

D-3

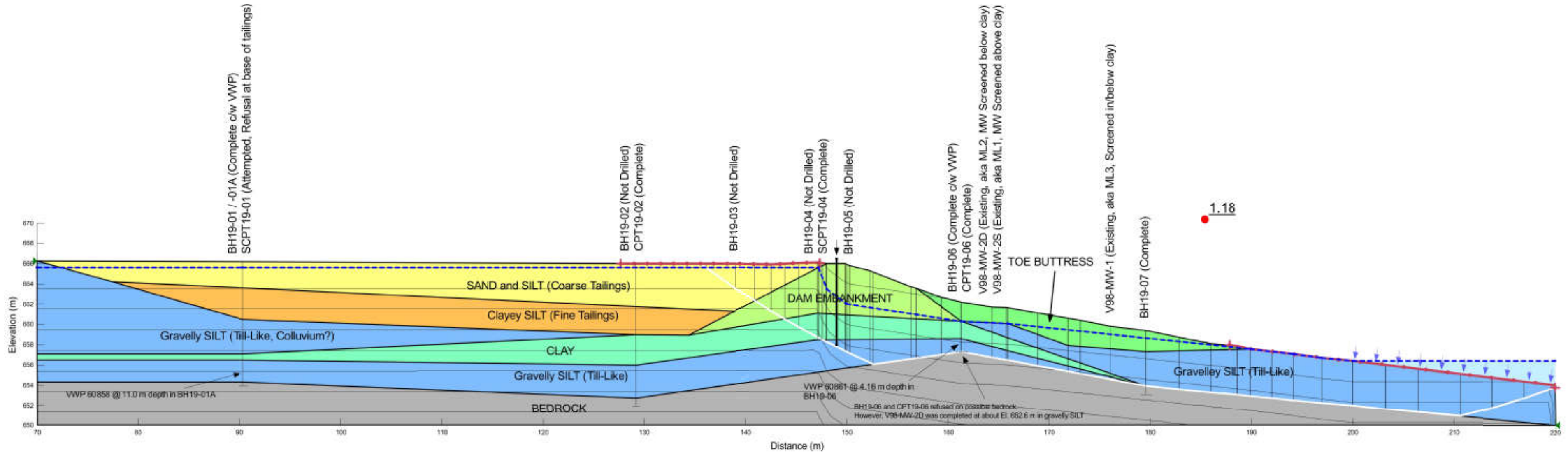
Venus Tailings Storage Facility Slope Stability Update
Tetra Tech File: ENW.EENW03031-10

Date: 4/1/2020

Slope Stability Case: Pseudostatic (1:2,475 Year EQ)

Horz Seismic Coef. (100% PGA): 0.236g

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line	C-Top of Layer (kPa)	C-Rate of Change ((kN/m²)/m)	C-Maximum (kPa)	Cohesion (kPa)
🟨	SAND and SILT (Coarse Tailings)	Mohr-Coulomb	20	0	35	0	1				
🟩	Dam Embankment (Fill)	Mohr-Coulomb	19	0	32	0	1				
🟩	GRAVEL (Toe Buttress Fill)	Mohr-Coulomb	21	0	34	0	1				
🟩	CLAY	S=f(depth)	19				1	150	-60	30	
🟦	Gravelly SILT (Till-Like)	Mohr-Coulomb	20	0	34	0	1				
⬜	BEDROCK	Bedrock (Impenetrable)					1				
🟧	Clayey SILT (Fine Tailings)	Undrained (Phi=0)	20				1				30



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2019 GEOTECHNICAL DRILLING PROGRAM
VENUS TAILINGS STORAGE FACILITY, YUKON

SLOPE STABILITY MODELING RESULTS

PROJECT NO.	DWN	CKD	REV	
ENW.EENW03031-10	CB	AW	0	**D-4**
OFFICE	DATE			
EBA-WHSE	April 2, 2020			

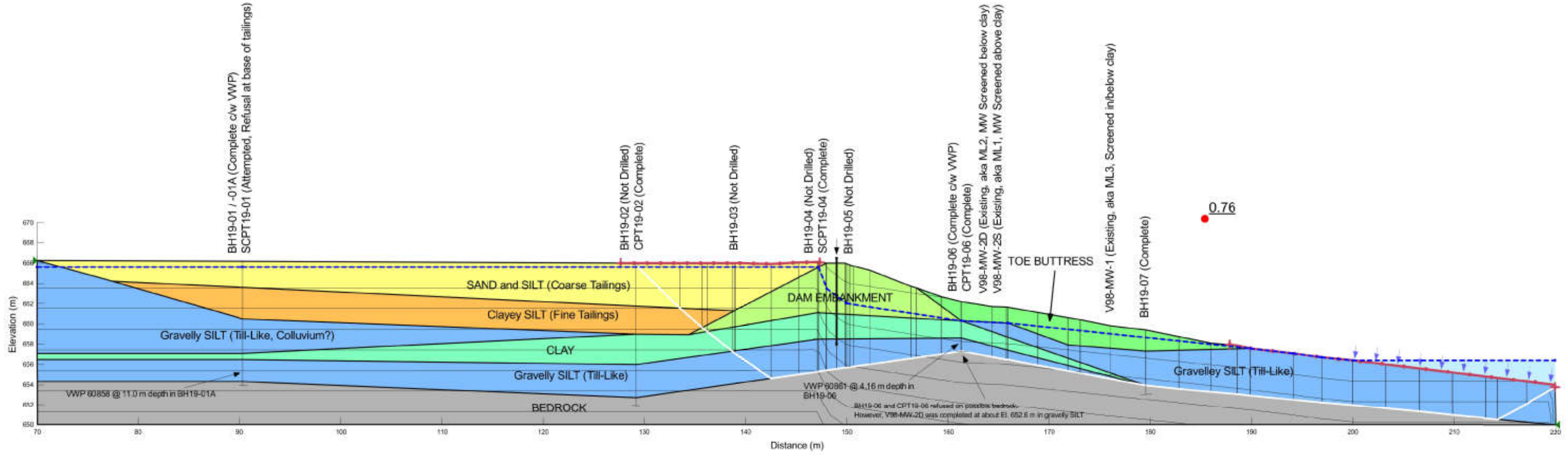
Venus Tailings Storage Facility Slope Stability Update
Tetra Tech File: ENW.EENW03031-10

Date: 4/1/2020

Slope Stability Case: Pseudostatic (Design EQ - 50% Between 1:2,475 and 1:10,000)

Horz Seismic Coef. (100% PGA): 0.347g

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line	C-Top of Layer (kPa)	C-Rate of Change ((kN/m²)/m)	C-Maximum (kPa)	Cohesion (kPa)
🟨	SAND and SILT (Coarse Tailings)	Mohr-Coulomb	20	0	35	0	1				
🟩	Dam Embankment (Fill)	Mohr-Coulomb	19	0	32	0	1				
🟩	GRAVEL (Toe Buttress Fill)	Mohr-Coulomb	21	0	34	0	1				
🟩	CLAY	S=f(depth)	19				1	150	-60	30	
🟦	Gravelly SILT (Till-Like)	Mohr-Coulomb	20	0	34	0	1				
⬛	BEDROCK	Bedrock (Impenetrable)					1				
🟧	Clayey SILT (Fine Tailings)	Undrained (Phi=0)	20				1				30



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2019 GEOTECHNICAL DRILLING PROGRAM
VENUS TAILINGS STORAGE FACILITY, YUKON

SLOPE STABILITY MODELING RESULTS

PROJECT NO.	DWN	CKD	REV
ENW.EENW03031-10	CB	AW	0

OFFICE	DATE
EBA-WHSE	April 2, 2020

D-5

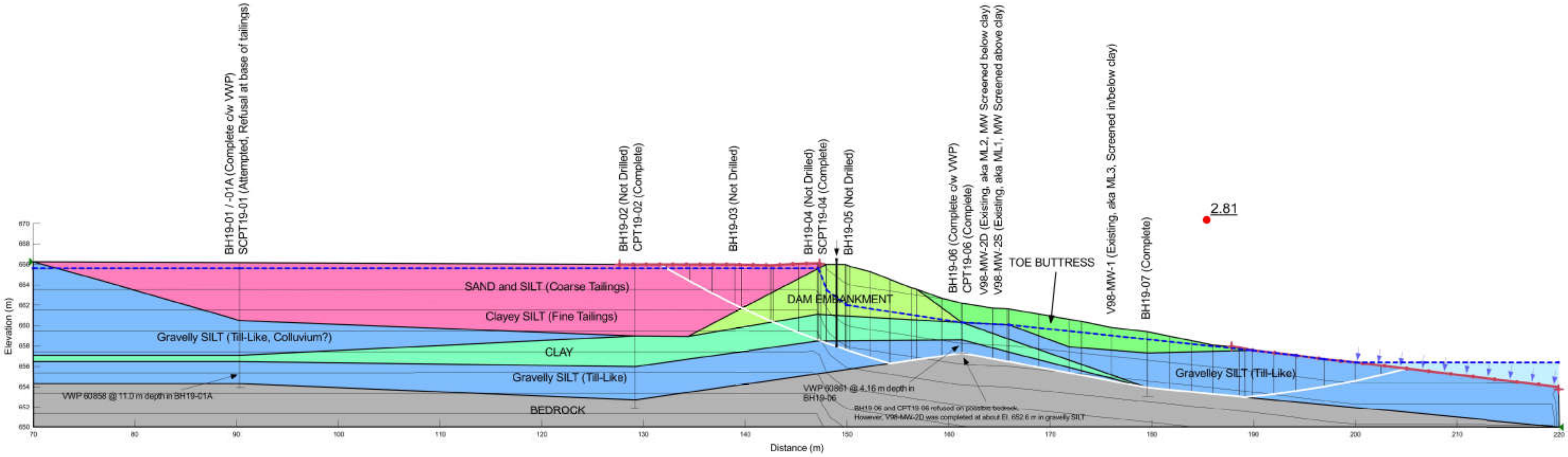
Venus Tailings Storage Facility Slope Stability Update
Tetra Tech File: ENW.EENW03031-10

Date: 4/1/2020

Slope Stability Case: Post-Seismic (Liquefied Tailings)

Horz Seismic Coef. (100% PGA): 0g

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line	C-Top of Layer (kPa)	C-Rate of Change ((kN/m²)/m)	C-Maximum (kPa)	Tau/Sigma Ratio	Minimum Strength (kPa)
🟩	Dam Embankment (Fill)	Mohr-Coulomb	19	0	32	0	1					
🟩	GRAVEL (Toe Buttress Fill)	Mohr-Coulomb	21	0	34	0	1					
🟩	CLAY	S=f(depth)	19				1	150	-60	30		
🟦	Gravelly SILT (Till-Like)	Mohr-Coulomb	20	0	34	0	1					
⬜	BEDROCK	Bedrock (Impenetrable)					1					
🟥	Liquefied Tailings	S=f(overburden)	20				1				0.05	0



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TETRA TECH

**2019 GEOTECHNICAL DRILLING PROGRAM
VENUS TAILINGS STORAGE FACILITY, YUKON**

SLOPE STABILITY MODELING RESULTS

PROJECT NO.	DWN	CKD	REV
ENW.EENW03031-10	CB	AW	0

OFFICE	DATE
EBA-WHSE	April 2, 2020

D-6

Q:\Whitehorse\Data\0201drawings\S.Klondike-Haines Juntion Hwy\ENW.EENW03031-10 Arctic Gold & Silver Mine Environmental Monitoring\ENW.EENW03031-10 Venus Slope Stability.dwg [D-6] April 20, 2020 - 11:08:06 am (BY: BUCHAN, CAMERON)

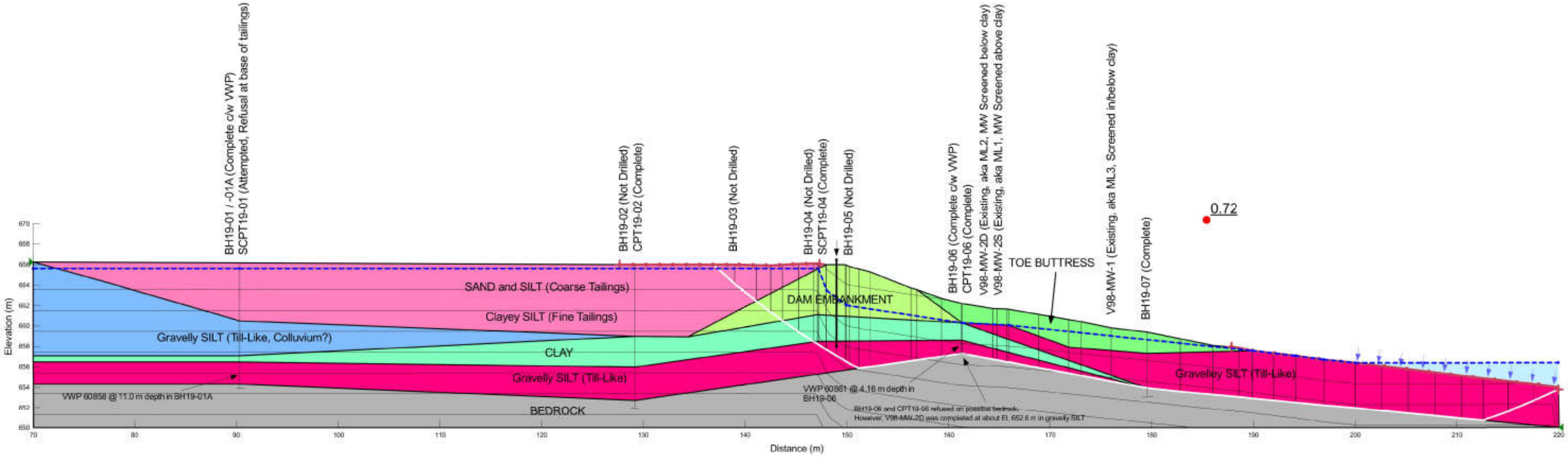
Venus Tailings Storage Facility Slope Stability Update
Tetra Tech File: ENW.EENW03031-10

Date: 4/1/2020

Slope Stability Case: Post-Seismic (Liquefied Tailings and Foundation)

Horz Seismic Coef. (100% PGA): 0g

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line	C-Top of Layer (kPa)	C-Rate of Change ((kN/m²)/m)	C-Maximum (kPa)	Tau/Sigma Ratio	Minimum Strength (kPa)
🟩	Dam Embankment (Fill)	Mohr-Coulomb	19	0	32	0	1					
🟩	GRAVEL (Toe Buttress Fill)	Mohr-Coulomb	21	0	34	0	1					
🟩	CLAY	S=f(depth)	19				1	150	-60	30		
🟦	Gravelly SILT (Till-Like)	Mohr-Coulomb	20	0	34	0	1					
⬜	BEDROCK	Bedrock (Impenetrable)					1					
🟪	Liquefied Tailings	S=f(overburden)	20				1				0.05	0
🟥	Liquefied Foundation Soil	S=f(overburden)	20				1				0.1	0



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