



Terraprobe

*Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing*

**FOUNDATION INVESTIGATION AND DESIGN REPORT
HAINES CREEK CULVERT REPLACEMENT
HIGHWAY 518, 2.5 KM EAST OF THE HIGHWAYS 518/400 INTERCHANGE
AGREEMENT NUMBER: 5012-E-0001
G.W.P. 5446-09-00, W.P. 5446-09-01, SITE 44-283/C
GEOCRES No. 31E-324
MINISTRY OF TRANSPORTATION, ONTARIO
NORTHEASTERN REGION**

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted at the Haines Creek Culvert site where a culvert replacement is proposed. The Haines Creek Culvert is located on Highway 518, 2.5 km east of the Highway 518/Highway 400 near Parry Sound, Ontario.

The purpose of this investigation was to explore the subsurface conditions at the site and, based on the data obtained, to provide borehole location plans, records of boreholes, stratigraphic profiles, laboratory test results and descriptions of the subsurface conditions. Models of the subsurface conditions were developed from the data obtained.

Terraprobe Inc. ("Terraprobe") conducted the investigation as a sub-consultant to G. D. Jewell Engineering Inc. ("G. D. Jewell") under the Ministry of Transportation Ontario ("MTO") Northeastern Region Agreement Number 5012-E-0001.

For reporting purposes the investigated site is identified as:

- Haines Creek Culvert, MTO Site #44-283/C ("Haines site"), Highway 518, 2.5 km east of the Highway 518/Highway 400 Interchange, 4.0 x 2.9 x 24.3 m (span x rise x length) corrugated steel arched pipe culvert with approximately 1.1 m of cover.

2 SITE DESCRIPTION & PHYSIOGRAPHY

Haines Creek Culvert was located around 2.5 km east of the interchange of Highways 518 and 400. Highway 518 crossed Haines Creek which links Haines Lake on the north with McNutt Lake on the south, via the existing culvert. Haines Creek flowed from south to north. At this site Highway 518 was a two-lane highway with gravel shoulders carrying generally east and west bound traffic.

The study area is located in the Precambrian Laurentian peneplane in north-eastern Ontario. The topography is generally irregular. Recent deposits consist of peat, gravel, sand, clay and till soils. Soil cover on both sides of the creek is generally sparse and represented by sand/silt with cobbles and boulders. The mineral soil cover is typically less than 1 m and may vary greatly over short distances. Locally, the depth of soil cover may extend to depths of around 20 m in the area of the site.



The soil deposits are underlain by metasedimentary rocks of the Huronian Supergroup and gneisses of the Grenville Province and their intrusive equivalents. The areas have undergone considerable folding, intrusive activity, regional metamorphism and faulting. Bedrock predominantly comprises pink granitic gneiss and dark grey migmatite. The bedrock in the immediate vicinity of the site is at various depths. Bedrock outcrops were observed in many locations in the area of the site.

3 SITE INVESTIGATION AND FIELD TESTING

The field investigation at Haines Creek was conducted from November 12 to December 6, 2012, and consisted of drilling and sampling a total of sixteen test holes comprising eight boreholes, HC1 to HC8, two auger probes, HC1-P and HC2-P and six dynamic cone penetration tests HC3-cone to HC8-cone. The test holes were advanced to depths from 2.0 to 24.8 m at the locations as shown on attached Borehole Locations and Soil Strata Drawings in Appendix C. The details of the work plan are summarized in Table 3.1.

Table 3.1 – Test Hole Details

Test Hole No.		Purpose of the Borehole	Location	Depth (m)		
				SPT/Cone/Auger	Rock coring	Total
Borehole	HC1	Foundation	Midpoint	15.9	0	15.9
	HC2	Roadway protection	Midpoint	24.8	0	24.8
	HC3	Foundation	In front of the north end of the new culvert	22.3	0	22.3
	HC4	Cofferdam	Within/close to the proposed cofferdam location	21.3	0	21.3
	HC5	Cofferdam	Within/close to the proposed cofferdam location	22.5	0	22.5
	HC6	Cofferdam	Within/close to the proposed cofferdam location	11.3	1.5	12.8
	HC7	Foundation	In front of the south end of the new culvert	15.7	0.9	16.6
	HC8	Cofferdam	Within/close to the proposed cofferdam location	13.6	1.5	15.1
Auger Probe	HC1-P	Foundation	Beside Borehole HC-1	2.0	-	2.0
	HC2-P	Roadway protection	Beside Borehole HC-2	2.0	-	2.0
Dynamic Cone Penetration Test	HC3-cone	Foundation	Beside Borehole HC-3	19.8	-	19.8
	HC4-cone	Cofferdam	Beside Borehole HC-4	19.8	-	19.8
	HC5-cone	Cofferdam	Beside Borehole HC-5	19.8	-	19.8
	HC6-cone	Cofferdam	Beside Borehole HC-6	9.9	-	9.9
	HC7-cone	Foundation	Beside Borehole HC-7	10.5	-	10.5
	HC8-cone	Cofferdam	Beside Borehole HC-8	12.4	-	12.4

Tulloch Geomatics Inc. ("Tulloch") established survey control points at the Haines Creek site. Terraprobe utilized the control points to survey the test holes at the Haines site and to establish ground surface elevations at the test hole locations.



Terraprobe marked the borehole locations on the site. Access to some of the borehole locations was difficult due to the two existing lakes. These boreholes were therefore relocated to be as close as feasible to the proposed locations while allowing safe operation of the drill rig. Utility clearances were obtained by Terraprobe prior to the field drilling.

Samples of the overburden soils were obtained at selected intervals of depth using a split spoon sampler in conjunction with Standard Penetration Testing ("SPT") as specified in ASTM Method D1586. The in-situ undrained shear strength was measured in the softer cohesive soil using an MTO type field vane. Relatively undisturbed soil samples were also collected with thin-walled Shelby Tube samplers. Boreholes HC6 to HC8 were also advanced into bedrock using NQ size diamond coring techniques in general accordance with ASTM D2113.

In addition to the testing outlined above, Dynamic Cone Penetration Test (DCPT) was conducted at selected locations. This test consists of continuously driving into undisturbed ground a 50 mm diameter cone (60 vertex angle) attached to a drill rod, with a driving energy of 475 J per blow (63.5 kg hammer dropping freely a vertical distance of 0.76 m). The number of blows for each 300 mm of penetration is recorded and this provides an indication of the relative changes in the soil density/consistency with depth.

The ground water conditions in the open boreholes were observed throughout the drilling operations. One borehole HC1 was also instrumented with standpipe piezometers consisting of 25 mm diameter PVC pipe with a slotted screen enclosed in sand to permit longer term ground water level monitoring. The locations and completion details of the piezometers are summarized in Table 3.2.

Table 3.2 – Piezometer Installation Details

Piezometer Location	Piezometer Details	
	Tip Depth/ Elevation (m)	Completion Details
HC1	15.2/181.2	Piezometer with 3.0 m slotted screen installed with filter sand to 11.6 m, bentonite seal from 11.6 m to 0.6 m and a concrete encased flush mount cover from 0.6 m to ground surface.

The remaining boreholes were abandoned in accordance with MOE Regulation 903.

Two drill rigs were used for the drilling, sampling and in-situ testing operations and the installation of piezometers. A truck mounted drill rig was used to drill Boreholes HC1 and HC2, and a small D-25 drill rig mounted on a raft was used to drill Boreholes HC3 to HC8 in the lake.

The drilling, sampling and coring operations were observed on a full time basis by a member of Terraprobe's technical staff who logged the boreholes and rock cores and prepared the recovered soil and rock samples for transport to Terraprobe's Brampton laboratory for further examination and testing. Rock core samples were preserved and transported in accordance with ASTM D 5079.



4 LABORATORY TESTING

Soils were identified in the field in accordance with the MTO Soil Classification procedures. The recovered soil samples were transported to Terraprobe's Brampton laboratory where the field soil classifications were verified and water content determinations were completed. Selected samples were also subjected to a laboratory testing programme consisting of gradation analysis and Atterberg Limits tests. The results of this testing program are shown on the Record of Borehole sheets in Appendix A and on the various figures in Appendix B.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets in Appendix A. Details of the encountered soil and rock stratigraphy are also presented on the "Borehole Locations and Soil Strata" drawings in Appendix C. The stratigraphic boundaries shown have been inferred from non-continuous samples and observations of drilling resistance and typically represent a transition from one soil or rock type to another. These boundaries should not be interpreted to represent exact planes of geological change. The subsurface conditions are confirmed at the borehole locations only, and will vary between and beyond the locations investigated. The following discussion has been simplified in terms of the major stratigraphic units.

The subsurface stratigraphy encountered in Boreholes HC1 and HC2 drilled on the existing roadway, generally comprised flexible pavement (asphaltic concrete and aggregate), sand fill, rock fill and deposits of silt, clayey silt, silt and sand, sand and sandy gravel. A peat deposit was also contacted in Borehole HC2.

Boreholes HC3 to HC8 were drilled in Haines Lake and McNutt Lake at the proposed cofferdam and at the upstream and downstream ends of the new culvert. The soil stratigraphy consisted of peat, sand, silt and sand, cobbles, sandy gravel, silt with clay and clayey silt. The overburden soils were underlain by metamorphic gneiss at depths of 11.3 to 15.7 m (Elev. 179.2 to 183.5 m) in Boreholes HC6 to HC8.

The major soil strata encountered are described below.

5.1 Flexible Pavement

Flexible pavement comprising of 50 to 55 mm thick asphaltic concrete underlain by 400 and 850 mm of granular base and subbase was encountered in Boreholes HC1 and HC2. The granular fill extended to elevations of 195.5 and 195.9 m and was inferred to be in a compact state.

5.2 Fill – Sand

Fill consisting of sand was encountered beneath the flexible pavement in Boreholes HC1 and HC2 and to depths of 7.6 m (Elev. 188.8 m) and 5.2 m (Elev. 191.3 m) below the existing ground surface respectively. Obstructions, inferred to be large pieces of rock were encountered within the fill at 3.8 and 1.5 m depths (Elev. 192.6 and 194.9 m) in the two boreholes.



The grain size distribution plots of samples of the sand fill recovered from the boreholes are presented in Figure B2-1. These results show a grain size distribution consisting about of 95% sand and 5% silt and clay size particles.

N-values in the range of 4 to 57 blows for 0.3 m were determined in the SPT test carried out in the sand fill, inferring a loose to very dense relative density, with a typically loose to compact state. Higher N-values of 155 blows for 200 mm and 100 blows for 50 mm were measured at 1.5 m depth in Borehole HC2 and 3.8 m depth in Borehole HC1 respectively, possibly due to large pieces of rock. The water content of samples of the sand fill recovered from the penetration testing ranged from 5 to 32%.

5.3 Peat

A deposit of peat was present in Boreholes HC2 to HC8. The deposit was 1.7 to 4.6 m thick and penetrated at elevations 189.1 to 190.3 m. The peat was described as coarse fibrous and had organic contents of 19 to 31% in four determinations. The water content of the peat ranged from 32 to 512%, and was typically above 120%.

5.4 Sandy/Silty Soils

Cohesionless sandy/silty soils of various compositions (silt, silt and sand, sand) were encountered below the sand fill in Borehole HC1, beneath clayey silt in Boreholes HC1 to HC3, HC5, HC7 and HC8, and under silt with clay in Boreholes HC4 and HC6. The sandy/silty soil deposits were approximate 0.8 to 10.7 m in thickness and extended to depths of 11.3 to 23.9 m (Elev. 172.3 to 183.5 m).

The results of grain size distribution analysis of samples recovered from these deposits are shown in Figure B2-3. These results show a grain size distribution consisting of 0% gravel, 9-88% sand, 12-74% silt and 1-17% clay size particles.

N-values determined in these deposits ranged from WH (static hammer weigh) to greater than 100 blows per 0.3 m indicating a very loose to very dense relative density. The moisture contents of the sandy/silty samples ranged from 14 to 35%.

5.5 Silt with Clay/Clayey Silt

Silt with clay/clayey silt was penetrated below the silt in Borehole HC1 and beneath the peat deposit in Boreholes HC2 to HC8. The silt with clay/clayey silt deposits were approximate 1.8 to 7.6 m in thickness and extended to depths of 10.5 to 14.5 m (Elev. 182.0 to 184.4 m). The split spoon sampler penetrated the silt with clay/clayey silt deposits under the static weight of the hammer in some locations. N-values of 2 and 1 blows per 0.3 m were recorded with the lower portions of the deposits in Boreholes HC2 and HC4. Undrained shear strengths ranging from 5 to 72 kPa, indicating a very soft to stiff consistency were indicated in situ field vane testing carried out in the clayey silt.

The results of grain size distribution analysis of samples recovered from these deposits are shown in Figure B2-2. These results show a grain size distribution consisting of 0% gravel, 7-15% sand, 58-68% silt and 21-35% clay size particles.



Atterberg Limits tests carried out on selected samples of the clayey silt showed liquid limit and plastic limit of 25 to 32 and 14 to 16 per cent respectively as shown in Figure B2-5. The moisture contents of the soil samples were in range of 30 to 100%.

5.6 Sandy Gravel/Cobbles

Sandy gravel was contacted below the sand in Borehole HC2 and beneath the lake bed in Borehole HC5. The sandy gravel extended to the termination depth of Borehole HC2 and to a depth of 1.9 m (Elev. 192.9 m) in Borehole HC5. N-values of 1 and 57 blows per 0.3 m were determined in these deposits. The results of grain size distribution analysis of samples recovered from these deposits are shown in Figure B2-4. The results show a grain size distribution consisting of 52% gravel, 37% sand and 11% silt and clay size particles. The moisture contents of the sandy gravel were 9 and 25%.

Cobbles were contacted below the sand and to the depth explored in Borehole HC3. N-values of 19 and greater than 100 for 0.3 m were determined in the cobbles.

5.7 Bedrock

Biotite gneiss bedrock was contacted below the overburden soils at depths ranging from 11.3 to 15.7 m below the existing grade (Elev. 179.2 to 183.5 m) in Boreholes HC6 to HC8. The gneiss bedrock was proved by coring at the three borehole locations and the bedrock depth and elevations to the top of bedrock are summarized in Table 5.1.

Table 5.1 – Depth to Bedrock

Borehole Number	Depth to Bedrock (m)	Top of Bedrock Elevation (m)
HC6	11.3	183.5
HC7	15.7	179.2
HC8	13.6	181.2

Inferred bedrock was contacted at 22.4 m depth (Elev. 172.4 m) in Borehole HC5.

The gneiss was light grey to pink, fine to medium grained, with close to moderate spaced flat to dipping cross joints. The bedrock was unweathered and massive to strongly foliated.

The gneiss bedrock exhibited moderate to high strength with biotite rich layers. Total core recovery in this bedrock ranged from 98 to 100% and the RQD values ranged from 0% to 79% however the RQD values were typically above 50%. Based on these results the rock quality is considered to be fair to good with occasional zones of very poor to poor quality rock.

5.8 Groundwater Level

A standpipe piezometer was installed in Borehole HC1 and the groundwater level readings were measured on separate visits made after the completion of drilling. The groundwater level records are presented in Table 5.2.



Table 5.2 – Groundwater Level Measurements

Borehole	Date	Water Levels	
		Depth (m)	Elevation (m)
HC1	December 13, 2012	1.3	195.1
	January 10, 2013	1.4	195.0

Based on General Arrangement Drawing provided by G. D. Jewell, the water level in the creek was recorded at Elev.194.9 m in October, 2012 indicating that the groundwater table exists at or just above the creek water level.

All groundwater observations at this site were short term and the levels are expected to fluctuate seasonally and with precipitation conditions. The ground water level may also be affected by the free water level in the creek.

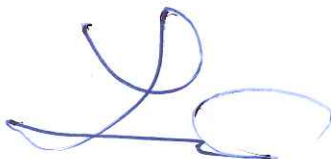
5.9 Miscellaneous

The drilling, sampling and in-situ testing operations and the installation of piezometers were conducted with various drill rigs owned and operated by Walker Drilling Ltd. of Utopia, Ontario. A truck mounted drill rig was used to drill Boreholes HC1 and HC2, and a small D-25 drill rig mounted on a raft was used to drill Boreholes HC3 to HC8 in the lake. Traffic control was provided by Jackson Trademark Services Ltd. of Aurora, Ontario.

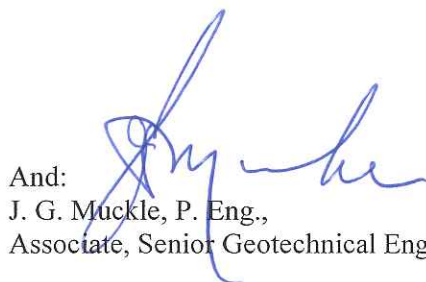
The boreholes were advanced using hollow-stem augers and casing and washboring methods. Rock cores were retrieved by NQ size diamond coring techniques.

Mr. Wen Zhu, E.I.T. carried out the field work and the laboratory testing was performed at Terraprobe's Brampton laboratory. The report was written by Mr. W. Lei, P. Eng. and Mr. J. G. Muckle, Senior Geotechnical Engineer. Mr. Michael Tanos, P. Eng., MTO Designated Principal Contact carried out an independent review of the report.





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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

6 GENERAL

This report presents interpretation of the geotechnical data in the factual report and provides geotechnical design recommendations for the Haines Creek Culvert replacement (MTO Site # 44-283/C) on Highway 518, Northeastern Region, Ontario.

The existing Haines Creek Culvert ("Haines site") is located on Highway 518, about 2.5 km east of Highway 400, District of Huntsville. The existing culvert consists of a corrugated steel arched pipe culvert measuring 24.3 m in length, with a 4.0 m span and a height of 2.9 m. The culvert carries Highway 518 east bound and west bound traffic over Haines Creek which links Haines Lake to the north and McNutt Lake to the south. Based on information provided by G. D. Jewell the creek flow is northerly from McNutt Lake into Haines Lake.

Several replacement options are proposed for the new Haines Creek Culvert. These options include a precast concrete box culvert, a CSPA culvert and a sheet pile/prestressed slab structure. All options could be used to replace the culvert at the existing location or at a new location, i.e., 10 m east of the existing culvert.

7 STRUCTURE FOUNDATIONS

7.1 Structure Foundations

The subsurface stratigraphy encountered in the Boreholes HC1 and HC2 drilled on the roadway adjacent to the existing culvert generally comprised flexible pavement, sand fill and deposits of silt, clayey silt, silt and sand, and sandy gravel. Groundwater was measured in the standpipe piezometer installed in Borehole HC1 at depths of 1.3 m (Elev. 195.1 m). The groundwater level approximately coincided with the creek water level (i.e. Elev. 194.9 m).

The remaining boreholes penetrated a deposit of peat overlying strata of sands and silts, cobbles, sandy gravel, silt and clayey silt. Bedrock was confirmed at depths of 11.3 to 15.7 m (Elev. 179.2 to 183.5 m) in Boreholes HC6 to HC8.

Based on the results of Borehole HC1 it is considered that the possible that peat was removed to construct the existing culvert. The results of Borehole HC2 indicate that the peat was probably left in place beneath the embankment fill outside of the limits of the culvert construction.



It is proposed to locate the new structure about 10 m east of the existing structure. It is understood that four replacement options including sheet pile/prestressed slab structure, precast concrete rigid frame on cast-in-place footings, CSPA culvert and precast concrete box culvert, have been considered for the new Haines Creek Culvert. Accordingly three foundation options including Driven Piles, Spread Footings and Granular A Pad have been considered for the support of the culvert replacement.

The presence of highly compressible soil, the relatively low bearing resistance of the underlying strata, and the high ground water levels result in potentially difficult conditions that impact the design of the culvert.

7.1.1 Granular A Pad

If CSPA culvert or precast concrete box culvert is selected for the new Haines Creek Culvert, a properly prepared Granular A pad can be considered to support the new culvert structure. Based on the General Arrangement drawings provided by G. D. Jewell, the founding level for the new culvert would be at elevations of 192.5 m at the inlet and 192.3 m at the outlet of the new culvert. Loose sand fill (existing embankment fill) was encountered at these grades in Boreholes HC1 and HC2, and highly compressible peat was encountered at and below elevation 192 m in all of the boreholes except Borehole HC1.

Although the peat beneath the existing road embankment fill has consolidated to some degree, a high risk of structural distress due to post construction settlement will exist for a rigid structure that is underlain by the peat. For this reason the excavation for culvert should extend to at least elevation 189.0 m to ensure that all of the peat has been removed from within the footprint of the new culvert. It is possible that additional excavation will be needed in some areas for complete removal of the peat. Engineered fill consisting of additional Granular A can be used to restore the grade. A minimum thickness of 500 mm Granular A pad to be compacted to 100% Standard Proctor Maximum Dry Density ("SPMDD") can be placed on the sand fill or engineered fill. A non-woven geotextile should be placed between the Granular A pad and subgrade soils to prevent fine particles from migrating into the granular material.

A CSPA culvert or closed box cell culvert and wing walls supported on a Granular A pad constructed as outlined above may be designed using factored geotechnical resistance at Ultimate Limit States (ULS) of 225 kPa and a geotechnical reaction of 150 kPa at Serviceability Limit States (Type II). In the case of pre-cast units of closed cell box culvert, it may be necessary to place a 100 mm thick leveling course of uncompacted Granular A base material beneath the culvert sections.

Prior to placing the levelling course, the founding subgrade must be cleaned of all deleterious materials such as softened or disturbed soil as well as any standing water. The founding subgrade must be inspected and approved by the geotechnical engineer prior to proceeding with further construction work. If construction proceeds during freezing weather conditions, adequate temporary frost protection for the founding subgrade must be provided. At the both ends of the new culvert, the founding subgrade of the culvert should be provided with a minimum of 2.0 m of earth cover or equivalent thermal protection.



The sliding resistance of mass concrete on the subgrade surfaces may be computed based on ultimate coefficients of friction of 0.7 for a Granular A pad.

Passive earth pressure resistance is generally not considered as a resisting force against sliding for conventional structure design because a structure must deflect significantly to develop the full passive resistance.

7.1.2 Spread Footings

If the option of precast concrete rigid frame is selected, then cast-in-place spread footings will be needed to support the new culvert. The new culvert will be located at about 10 m east of the existing culvert.

Based on the General Arrangement drawing provided by G. D. Jewell, the elevations at inlet and outlet of the concrete frame culvert would be 192.5 and 192.3 m respectively. Accordingly the recommended founding depths can be estimated to be 0.5 m below the inlet and outlet elevations, i.e., at elevations of about 192.0 and 191.8 m.

The weak and highly compressible soils encountered in Boreholes HC1, HC2, HC3 and HC7 at the founding level would result in excessive footing width for the precast rigid frame, and possible significant total and differential settlements. From a foundation engineering perspective, the option of precast concrete rigid frame on cast-in-place footing may not be feasible. Alternatively a rigid frame type structure could be supported on a system of end bearing piles supported on the bedrock.

Adequate control of the ground water is essential to the effectiveness of this type of construction. The underlying soil strata are fine grained and highly susceptible to disturbance. For this reason vibratory compaction equipment should only be used with great caution.

7.1.3 Sheet Piles

If the sheet pile/prestressed slab design alternative is selected, the sheet piles are likely to be driven to practical refusal on gneiss bedrock at a depth of 15.7 m (Elev. 179.2 m) at the location of Borehole HC7 and deeper than 24.8 m at the locations of Boreholes HC1 to HC3. The existing embankment fill may contain large pieces of rock and the piles may encounter obstructions. Based on the General Arrangement provided by G.D. Jewell, it is recommended that the upper portion of sheet piles (Elev. 195.75 to 192.3 m) be designed to resist lateral earth pressure from the embankment fill.

Sheet piles can be driven to effective refusal in the competent soils or the underlying bedrock. Additional boreholes are required at the site to further explore the soil conditions for pile foundations.

7.1.4 Recommended Foundation Alternative

From a foundation engineering perspective, it is considered that either a CSPA culvert or precast concrete box culvert supported on a Granular A pad is the preferred option for the Haines Creek Culvert replacement.



7.2 Frost Cover

The frost penetration for the site is 2.0 m. Therefore, all footings should have at least 2.0 m of earth cover or equivalent synthetic insulation for frost protection.

A 125 mm thick Dow Styrofoam insulation or equivalent can be placed underneath the culvert for frost protection. The manufacturer should be consulted regarding the installation details.

8 EXCAVATION

All excavations must be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the soils at Haines site may be classified as Type 3 soils above the water table and Type 4 soils below the water table. Excavations within Type 3 soils may be sloped at 1H:1V and excavations in Type 4 soils must be sloped at 3H:1V or flatter.

Where workers must enter excavations extending deeper than 1.2 m, the trench walls must be suitably sloped and/or braced in accordance with the Occupational Health and Safety Act and Regulations for Construction Projects.

Surface drainage should be designed to prevent the flow of surface water into excavations. Excavation to several meters below the water table will be required to construct the culverts and it is possible that the sand fill contains large pieces of rock. Excavations should be undertaken in accordance with OPSS 902.

9 GROUNDWATER CONTROL

The groundwater levels were measured in the standpipe piezometer installed in Borehole HC1 at depths of 1.3 m (Elev. 195.1 m) and 1.4 m (Elev. 195.0 m) below the ground surface on December 13, 2012 and January 10, 2013 respectively. The excavations will extend several meters below the measured water levels and excess hydrostatic pressure exists in the underlying sandy layer.

It is understood that the flow of water would be temporarily diverted away from the construction area so that construction will proceed in sufficiently dry conditions as per OPSD 221.010, OPSD 221.020 or OPSD 221.030 as appropriate. An interceptor trench on the existing embankment is also recommended to prevent surface water from entering the excavation.

The design of the dewatering system should be the responsibility of the Contractor. If excavations are extended into the sandy layer, it is recommended that the groundwater level be temporarily lowered to 1.0 m below the elevation of the deepest excavation. The contract documents should contain a NSSP alerting the contractor of the need for adequate ground water control at the site. A suggested wording for this NSSP is included in Appendix E.

A Permit To Take Water (PTTW) is required for any water taking if the volume exceeds 50,000 L/day. A PTTW for groundwater control will most likely be required for the site where the excavations are below the water table and are made within the high permeability sandy/silty soils. The rate and volume required for dewatering will be dependent on the construction methods and staging chosen by the contractor.



Any accumulation of water from the base of the excavation should be removed prior to culvert installation or compacting granular fill. Culvert installation or compacting engineered fill must be done in the dry.

10 BEDDING

All disturbed, loosened or softened soils and deleterious material must be removed from the base of the excavation before bedding material is placed. It is anticipated that the final grades and geometries of the existing embankments of the Haines site will be kept unchanged. It is recommended that the fill material in these areas consist of OPSS Granular A material.

Bedding material should consist of OPSS Granular A material. Additional bedding requirements that may be imposed by the supplier must also be followed.

11 CAMBER

Flexible culverts on compressible soils, especially under high embankments, should be longitudinally cambered to counteract the effects of differential settlement, and so avoid ponding inside the culvert.

The peat encountered at the location of Borehole HC 2 will be excavated and replaced with the engineered fill. The existing road embankments have been in place for many years and no grade changes or embankment widening is proposed. On this basis differential settlement of a CSPA culvert is expected to be relatively minor and cambering would not be warranted.

12 BACKFILLING

Backfill around the culvert should be carried out as per OPSD 803.010 (concrete culvert), or OPSD 802.010 (Flexible Pipe) and the backfill should consist of free-draining, non-frost susceptible granular materials in accordance with OPSS 1010. The excavated material comprising the sand fill at the site can be used for backfilling purposes provided it is free of organics and other deleterious material. This material will also require moisture conditioning prior to its placement. All granular fill (meeting OPSS 1010 specifications) should be placed in loose lifts not exceeding 200 mm thick and be compacted to at least 95% of its SPMDD.

For fills below the ground water level or immediately below the roadway, it is recommended that Granular A material be used. Where necessary, proper tapering should be provided as shown in OPSD 803.031. The design should also incorporate a subdrain.

Heavy compaction equipment should not be used adjacent to the walls and roof of the culvert. The height of the backfill to the culvert walls should be maintained equal on both sides of the structure during all stages of backfill placement. Compaction equipment to be used adjacent to retaining structures should be restricted in accordance with Special Provision 105S10. Backfilling operations should be undertaken in accordance with OPSS 902.



13 EARTH PRESSURE

Earth pressures acting on the structure should be computed in accordance with Clause 6.9 of the CHBDC but generally are given by the expression:

$$P_h = K(\gamma h + q)$$

P_h = horizontal pressure on the wall (kPa)

K = earth pressure coefficient (see Table 13.1)

γ = unit weight of retained soil (see Table 13.1)

h = depth below top of fill where pressure is computed (m)

q = value of any surcharge (kPa)

In accordance with Clause 6.9.3 of the CHBDC, a compaction surcharge should be added. The magnitude should be 12 kPa at the top of fill and decreasing to 0 kPa at a depth of 1.7 m for Granular B Type I or at a depth of 2.0 m for Granular A or Granular B Type II.

Earth pressure coefficients for backfill to the headwall and wingwall are dependent on the material used as backfill. Typical values are given in Table 13.1.

Table 13.1 – Earth Pressure Coefficients

Wall Condition	Earth Pressure Coefficient (K)					
	OPSS Granular A or OPSS Granular B Type II $\phi = 35^\circ$; $\gamma = 22.8 \text{ kN/m}^3$		OPSS Granular B Type I $\phi = 32^\circ$; $\gamma = 21.2 \text{ kN/m}^3$		Rock Fill $\phi = 42^\circ$; $\gamma = 19.0 \text{ kN/m}^3$	
	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)
Active (Unrestrained Wall)	0.27	0.40*	0.31	0.48*	0.20	0.28*
At rest (Restrained Wall)	0.43	-	0.47	-	0.33	-
Passive (Movement Towards Soil Mass)	3.70	-	3.30	-	5.0	-

* For wing walls.

The factors in the table above are “ultimate” values and require certain movements for the respective conditions to be mobilized. The values to use in design can be estimated from Figure C6.16 in the Commentary to the CHBDC, 2006.

14 ROADWAY PROTECTION

A roadway protection system should be put in place to retain the existing embankment in the event that a staged construction is carried out. A road protection system or a temporary shoring system should be constructed in accordance with the Occupational Health and Safety Act of Ontario (OHSA). The shape of the soil pressure distribution diagram behind a shoring system depends upon the type of soil to be encountered and the amount of movement that can be permitted. The



Stage 1 and Stage 2 would be temporary lane diversions which involve temporary detour of traffic to a single lane as well as the installation of Performance Level 2 roadway protection. Upon the completion of staged construction, the embankment foreslopes should be reinstated to the original state.

Based on the information provided by G. D. Jewell, the road widening is not required during the staged construction. Otherwise the widening area may overload the weak/soft subgrade soils, resulting in excessive settlement and slumping.

16 APPROACH EMBANKMENTS

Staged construction may be required for the culvert construction. It is understood that road widening is not required for the staged construction. The final grade and geometry is anticipated to be the same as the existing embankment.

16.1 Stability

The local and global stability of the embankment fill will depend on the slope geometry and also to a large degree on the material used to construct the embankment. The existing embankment side slopes at the Haines site have performed satisfactorily for many years. Therefore, the same geometry of the embankments will have a high probability of providing stable performance and the risk will be low.

The specifications with respect to placement water content, lift thicknesses and degree of compaction must be consistently achieved to ensure that the embankments will perform satisfactorily.

16.2 Settlement

Clayey soils were encountered in Boreholes HC1 and HC2 however some sections of the existing roadway embankment may be underlain by peat. Considering that the existing embankment at this site has been stable for many years, the rate of consolidation settlement is probably very low at this stage. Therefore the post-construction settlement due to the consolidation of the underlying clayey soils is also expected to be minimal (less than 25 mm), provided that the existing grades are maintained.

It has been assumed that the shallow peat deposits would be removed in preparation for the new culvert construction and that the new embankment fill would be benched into the existing embankment.

17 EMBANKMENT CONSTRUCTION

To preserve continuity of drainage of the existing roadway embankment, Granular B material has been recommended for the embankment fill. Embankment construction should be in accordance with OPSS 501 and OPSS 206. Benching between existing fill and new fill should be established by benching in accordance with OPSD 208.010.

Proper erosion control measures should be implemented both during construction and permanently. Temporary erosion and sediment control must be provided in accordance with OPSS 577 and



embankment slopes must be reinstated with permanent erosion protection in accordance with OPSS 511.

It is also imperative that the construction include provisions for preventing the flow of surface water down the face of the unprotected slopes. Surface water must be directed to protected outfalls/outlets designed to drain away from the embankment.

18 EROSION PROTECTION

Erosion protection should be provided at the culvert inlet and outlet (including the slopes and sides).

18.1 Clay Seal

Erosion protection at the inlet and outlet areas could consist of a clay seal. The purpose of the clay seal is to ensure that water flow is channelled through the culvert and does not seep through the backfill around and underneath the structure. It should be ensured that the clay seal extends to cover all the granular backfill materials to prevent seepage through them. The clay seal should therefore be continuous around the culvert and have a minimum compacted thickness of 0.6 m and should extend at least 1 m above the high water level or the top of granular backfill. The clay seal should be protected by a layer of rip-rap. The material used for the clay seal should conform to the requirements stipulated in OPSS 1205.

18.2 Cut-off and Head Walls

Alternatively, concrete cut-off and head walls can be constructed to protect the granular backfill and prevent seepage around the culvert. Alternatively it may be feasible to utilize steel sheet piling for cut-off walls.

Concrete cut-off walls and head walls can also be used to protect the granular fill around the culvert outlet against erosion and scour. In this case, however, filtered erosion protection such as rip-rap should be provided along the channel and the sides beyond the concrete cut-off and head walls at the outlet. The rip-rap layer should cover all surfaces on the embankment slopes with which creek or lake water is likely to be in contact. The rip-rap treatment at the inlet and outlet of the culverts should conform to OPSD 810.010, OPSD 810.020, OPSS 511 and SP511S01.

The above recommendations are suggestions only. The design of erosion protection schemes for the stream bed in the inlet and outlet areas will depend on hydrologic, hydraulic and/or other concerns. We recommend that a qualified geomorphologist be consulted as to design the specifics of the channel, culvert outlet and inlet protection (i.e. thickness and extent of protection) and scour depth. Footings must also be placed below the scour depth.

19 COFFERDAM

Cofferdams are temporary enclosures to keep out water and soil so as to permit dewatering and construction of the permanent structure in the dry.

Considering the high water level, a sheet piling cofferdam may provide better control of groundwater and lake water. The loads such as hydrostatic pressure, wave forces, current forces



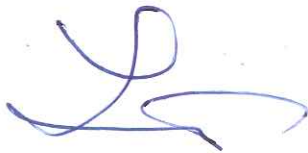
must be considered for the design of the cofferdam. The contractor has responsibility for the design of the cofferdam.

20 CONSTRUCTION CONCERNS

During construction, the Contract Administrator should employ experienced geotechnical staff to observe construction activities related to foundation construction.

Potential construction concerns include, but are not necessarily limited to:

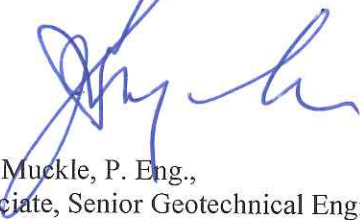
- The potential for encountering soft/weak soils at the founding grade that would necessitate sub-excavation and replacement with engineered fill;
- The susceptibility of the subgrade soil to disturbance from construction activity and the requirement to remove and replace disturbed soil that is not required in the design;
- The potential for erosion and undermining of exposed soil due to seepage of groundwater or lake water from underneath cofferdam;
- Potential for disturbance of the underlying saturated sandy soils due to the effects of construction;
- The sheet piles may encounter obstacles in the sand fill at the site; and
- The potential for damage during construction resulting from increased run-off from storm events.



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TABLE

TERRAPROBE INC.

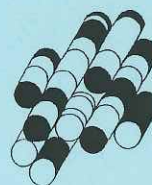


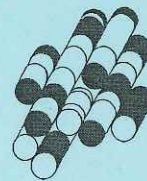
TABLE 1

DOCUMENT	TITLE
OPSS 206	Construction Specification for Grading
OPSS 501	Construction Specification for Compacting
OPSS 511	Construction Specification for Rip-Rap, Rock Protection and Granular Sheeting
OPSS 517	Construction Specification for Dewatering of Pipeline, Utility, and Associated Structure Excavation
OPSS 539	Construction Specification for Temporary Protection Systems
OPSS 571	Construction Specification for Sodding
OPSS 572	Construction Specification for Seed and Cover
OPSS 577	Construction Specification for Temporary Erosion and Sediment Control Measures
OPSS 902	Construction Specification for Excavation & Backfilling of Structures
OPSS 1010	Material Specifications for Aggregates - Base, Subbase, Select Subgrade, and Backfill Material
OPSS 1205	Material Specification for Clay Seal
OPSD 208.010	Benching of Earth Slopes
OPSD 221.010	Temporary Water Passage System, Culvert in Watercourse
OPSD 221.020	Temporary Water Passage System, Pumping and Piping
OPSD 221.030	Temporary Water Passage System, Temporary Channel or Culvert Outside Watercourse
OPSD 802.010	Flexible Pile Embedment and Backfill, Earth Excavation
OPSD 803.010	Backfill and Cover for Concrete Culverts
OPSD 803.031	Frost Treatment-Pipe Culverts, Frost Penetration Line between Top of Pipe and Bedding Grade
OPSD 810.010	Rip-Rap Treatment for Sewer and Culvert Outlets
OPSD 810.020	Rip-Rap Treatment for Ditch Inlets
SP105S10	Amendment to OPSS 501, February 1996
SP110S13	Amendment to OPSS 1010
SP112S06	Amendment to OPSS 1205
SP511S01	Placement of Rip Rap, Rock Protection and Gravel Sheeting
NSSP	Non Standard Special Provision for Ground Water Control



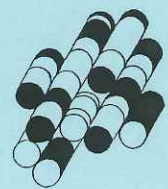
APPENDICES

TERRAPROBE INC.



APPENDIX A

TERRAPROBE INC.



LIMITATIONS AND RISK

Procedures

The soil conditions were confirmed at the borehole locations only and conditions may vary between and beyond the boreholes. The boundaries between the various strata as shown on the logs are based on non-continuous sampling. These boundaries represent an inferred transition between the various strata, rather than a precise plane of stratigraphic change.

This investigation has been carried out using investigation techniques and engineering analysis methods consistent with those ordinarily exercised by Terraprobe and other engineering practitioners, working under similar conditions and subject to the time, financial and physical constraints applicable to this project. The discussions and recommendations that have been presented are based on the factual data obtained.

It must be recognized that there are special risks whenever engineering or related disciplines are applied to identify subsurface conditions. Even a comprehensive sampling and testing programme implemented in accordance with the most stringent level of care may fail to detect certain conditions. Terraprobe has assumed for the purposes of providing design parameters and advice, that the conditions that exist between sampling points are similar to those found at the sample locations. The conditions that Terraprobe has interpreted to exist between sampling points can differ from those that actually exist.

It may not be possible to drill a sufficient number of boreholes or sample and report them in a way that would provide all the subsurface information that could affect construction costs, techniques, equipment and scheduling. Contractors bidding on or undertaking work on the project should be directed to draw their own conclusions as to how the subsurface conditions may affect them, based on their own investigations and their own interpretations of the factual investigation results, cognizant of the risks implicit in the subsurface investigation activities.

Changes In Site And Scope

It must be recognized that the passage of time, natural occurrences, and direct or indirect human intervention at or near the site have the potential to alter subsurface conditions. Groundwater levels are particularly susceptible to seasonal fluctuations.

The design advice is based on the factual data obtained from this investigation made at the site by Terraprobe and are intended for use by the owner and its retained designers in the design phase of the project. If there are changes to the project scope and development features, or there is any additional information relevant to the interpretations made of the subsurface information, the geotechnical design parameters and comments relating to constructibility issues and quality control may not be relevant or complete for the revised project. Terraprobe should be retained to review the implications of such changes with respect to the contents of this report.

This report was prepared for the express use of the Ministry of Transportation, its retained design consultants and G. D. Jewell Engineering Inc. It is not for use by others. This report is copyright of Terraprobe Inc. and no part of this report may be reproduced by any means, in any form, without the prior written permission of Terraprobe Inc. The Ministry of Transportation, its retained design consultants and G. D. Jewell Engineering Inc. are authorized users.

EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS \bar{N} .

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

c_u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	>200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	>50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND/OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINTING AND BEDDING:

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	>3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

SS	SPLIT SPOON	TP	THINWALL PISTON
WS	WASH SAMPLE	OS	OSTERBERG SAMPLE
ST	SLOTTED TUBE SAMPLE	RC	ROCK CORE
BS	BLOCK SAMPLE	PH	TW ADVANCED HYDRAULICALLY
CS	CHUNK SAMPLE	PM	TW ADVANCED MANUALLY
TW	THINWALL OPEN	FS	FOIL SAMPLE

STRESS AND STRAIN

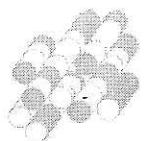
u	kPa	PORE WATER PRESSURE
u_o	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

m_v	kPa ⁻¹	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_a	1	RATE OF SECONDARY CONSOLIDATION
C_v	m ² /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_r	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_r	1	SENSITIVITY = c_u / τ_r

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m ³	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	kN/m ³	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_w	kg/m ³	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kN/m ³	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m ³	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kN/m ³	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m ³	DENSITY OF DRY SOIL	w_c	%	SHRINKAGE LIMIT	q	m ² /s	RATE OF DISCHARGE
γ_d	kN/m ³	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $(w_L - w_p)$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m ³	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $(w - w_p)/I_p$	i	1	HYDRAULIC GRADIENT
γ_{sat}	kN/m ³	UNIT WEIGHT OF SATURATED SOIL	I_c	1	CONSISTENCY INDEX = $(w_c - w)/I_p$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m ³	DENSITY OF SUBMERGED SOIL	e_{max}	1, %	VOID RATIO IN LOOSEST STATE	j	kN/m ²	SEEPAGE FORCE
γ'	kN/m ³	UNIT WEIGHT OF SUBMERGED SOIL						



RECOVERY

- TCR** **Total Core Recovery** is the total length of core pieces, irrespective of their individual lengths obtained in a core run, and expressed as a percentage of the length of that core run.
- SCR** **Solid Core Recovery** is the total length of sound full-diameter core pieces obtained in a core run, expressed as a percentage of the length of that core run
- RQD** **Rock Quality Designation** pertains to the sum of those pieces of sound core which are 10 cm or greater in length obtained in a core run, expressed as a percentage of the length of that core run.

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
QUALITY	very poor	poor	fair	good	excellent

JOINT CHARACTERISTICS

Joint Spacing (adapted from Bieniawski 1989, ISRM 1981)

Classification	Spacing
very close	< 60 mm
close	60 – 200 mm
moderately close	0.2 to 0.6 m
wide	0.6 to 2 m
very wide	> 2 m

Natural Fracture Frequency (per 0.3 m)

Refers to the number of natural fractures (joints, faults, etc.) which are present per 0.3m. Ignores mechanical or drill-induced breaks, and closed discontinuities (e.g. bedding planes).

Orientation

Orientation	Angle from horiz.
horizontal/flat	0 - 20°
dipping	20 - 50°
vertical	50 - 90°

Joint Filling

Description	Approx. ϕ
tight, hard, non-softening	25 - 35
oxidation, surface staining only	25 - 30
slightly altered, clay-free	25 - 30
sandy particles, clay-free	2 - 25
sandy and silty, minor clay	1 - 24
non-softening clays	6 - 12
swelling clay fillings	n/a

Joint Aperture

Classification	Aperture
closed / tight	< 0.5 mm
gapped	0.5 to 10 mm
open	> 10 mm

Planarity

- Planar
- Undulating
- Stepped
- Irregular
- Discontinuous

Roughness

- Very rough
- Rough
- Smooth
- Slickensided
- Polished

Coating	Description
clean	no filling
veneer	< 1 mm filling
coating / infill	> 1 mm filling

GENERAL

Degree of Weathering (after MTO, RR229 Evaluation of Shales for Construction Projects)

Zone	Degree	Description
Z1	unweathered	shale, regular jointing
Z2	partially weathered	angular blocks of unweathered shale, no matrix, with chemically weathered but intact shale
Z3		soil-like matrix with frequent angular shale fragments < 25mm diameter
Z4a		soil-like matrix with occasional shale fragments < 3mm diameter
Z4b	fully weathered	soil-like matrix only

Strength classification (after Marinos and Hoek, 2001)

Grade	Term	UCS (MPa)	Field Estimate (Description)
R6	extremely strong	> 250	can only be chipped by geological hammer
R5	very strong	100 - 250	requires many blows from geological hammer
R4	strong	50 - 100	requires more than one blow from geological hammer
R3	medium strong	25 - 50	can't be scraped, breaks under one blow from geological hammer
R2	weak	5 - 25	can be peeled / scraped with knife with difficulty
R1	very weak	1 - 5	easily scraped / peeled, crumbles under firm blow of geo. hammer
R0	extremely weak	< 1	indented by thumbnail

Bedding Thickness (Quarterly Journal of Engineering Geology, Vol 3, 1970)

Very thickly bedded	> 2 m	Medium bedded	200 – 600mm	Very thinly bedded	20 – 60mm	Thinly Laminated < 6mm
Thickly bedded	0.6 – 2m	Thinly bedded	60 – 200mm	Laminated	6 – 20mm	

Bedrock Graphic Legend



Inferred bedrock



Shale



Limestone

RECORD OF BOREHOLE No HC1

1 of 2

METRIC

G.W.P. 5446-09-00 LOCATION Coords: E:270840.7 N:5022382 ORIGINATED BY WZ
DIST HWY 518 BOREHOLE TYPE HOLLOW STEM AUGERS / WASH BORING COMPILED BY SS
DATUM GEODETIC DATE 2012-12-5 - 2012-12-6 CHECKED BY HA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100	w_p	w	w_L		
196.4	GROUND SURFACE															
	50mm ASPHALTIC CONCRETE															
195.9	400mm AGGREGATE		1	SS		196										
0.5	FILL, sand, trace to some gravel, trace silt and clay; loose to compact, brown, moist to wet		2	SS												
			3	SS		195										...at 1.5m, commence casing and wash boring
			4	SS		194										
	...at 3.8m, rock fill obstruction		5	SS		193										...at 3.0m, Auger grinding, spoon wet
						192										
	...at 4.9m, some organics		6	SS		191										0 95 (5)
			7	SS		190										
						189										
188.8	SILT, some clay, trace sand, firm, grey, wet		8	SS	WH	188										Dec. 5, 2012 Dec. 6, 2012 0 9 74 17
			9	ST		187										...at 9.1m, - no sample recovered in ST9
						186										
185.7	CLAYEY SILT, trace sand, soft, grey, moist		10	ST		185										0 7 58 35
10.7																

Continued Next Page

+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Library: library - mto gnt.gib report: mto-terraprobe soil path: \\pdoserver11-project\files\11-geotechnical\2012\11-12-2100 - 2100\11-12-2130\haines creek bh logs (new temp).gib

RECORD OF BOREHOLE No HC1

2 of 2

METRIC

G.W.P. 5446-09-00 LOCATION Coords: E:270840.7 N:5022382 ORIGINATED BY WZ
DIST HWY 518 BOREHOLE TYPE HOLLOW STEM AUGERS / WASH BORING COMPILED BY SS
DATUM GEODETIC DATE 2012-12-5 - 2012-12-6 CHECKED BY HA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	SPT 'N' VALUE						
	(continued)										
183.9	CLAYEY SILT, trace sand, soft, grey, moist (continued)		11A	SS	WH		184			54	
12.5	SILT AND SAND, trace clay, loose, grey, wet		11B								
			12	SS	4		183				
							182				
180.5			13	SS	6		181				
15.9											

END OF BOREHOLE

Borehole contained drill water upon completion of drilling. Unstabilized water level and cave not measured.

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
December 13, 2012	1.3	195.1
January 10, 2013	1.4	195.0

RECORD OF BOREHOLE No HC1-P

1 of 1

METRIC

G.W.P. 5446-09-00 LOCATION Coords: E:270839.3 N:5022384.3 ORIGINATED BY WZ
DIST HWY 518 BOREHOLE TYPE SOLID STEM AUGERS COMPILED BY SS
DATUM GEODETIC DATE 2012-12-4 CHECKED BY HA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	SPT 'N' VALUE			20	40	60	80	100					
196.4	GROUND SURFACE																
196.1	40mm ASPHALTIC CONCRETE		1	AS			196										
0.4	330mm AGGREGATE		2	SS	31												
	FILL, sand, some gravel, trace silt; compact to dense, brown, damp																
	...wet		3	SS	12		195										
194.4																	
2.0																	

END OF BOREHOLE

Borehole was dry and open upon
completion of drilling.

RECORD OF BOREHOLE No HC2

1 of 3

METRIC

G.W.P. 5446-09-00 LOCATION Coords: E:270844.9 N:5022393.8 ORIGINATED BY WZ
DIST HWY 518 BOREHOLE TYPE HOLLOW STEM AUGERS / WASH BORING COMPILED BY SS
DATUM GEODETIC DATE 2012-11-29 - 2012-12-3 CHECKED BY HA

Library: library - mto gnt.glb report: mto-terraprobe soil path: \\pdc\server11-project files\11-geotechnical\2012\11-12-2100 - 2190\11-12-2130\haines creek bh logs (new temp).gpl

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	SPT 'N' VALUE			SHEAR STRENGTH (kPa)								WATER CONTENT (%)	
								○ UNCONFINED	● QUICK TRIAXIAL	+ FIELD VANE							X LAB VANE
196.4	GROUND SURFACE					20	40	60	80	100	10	20	30		GR SA SI CL		
195.5 0.9	55mm ASPHALTIC CONCRETE		1	SS	37												
	850mm AGGREGATE		2	SS	30												
	FILL, sand, some gravel, trace silt and clay; compact, brown, moist to wet		3	SS	155 / 200mm												
	...at 1.5m, rock fill obstruction		4	SS	13										...at 2.3m, commence casing and wash boring		
			5	SS	10										...at 3.0m, spoon wet		
			6	SS	10												
191.3 5.2	PEAT, coarse fibrous, dark grey		7	SS	5												
189.6 6.9	CLAYEY SILT, trace sand, firm to stiff, grey, moist		8	SS	3												
			9	SS	WH												
			10	ST													
			11	SS	WH												
			12	SS	WH												

Continued Next Page

+ 3, X 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

Nov. 29, 2012
Dec. 3, 2012

RECORD OF BOREHOLE No HC2

2 of 3

METRIC

G.W.P. 5446-09-00 LOCATION Coords: E:270844.9 N:5022393.8 ORIGINATED BY WZ
DIST HWY 518 BOREHOLE TYPE HOLLOW STEM AUGERS / WASH BORING COMPILED BY SS
DATUM GEODETIC DATE 2012-11-29 - 2012-12-3 CHECKED BY HA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	SPT 'N' VALUE			20 40 60 80 100	20 40 60 80 100	w_p	w	w_L		
	(continued)							○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE X LAB VANE	WATER CONTENT (%)				GR SA SI CL
182.0	CLAYEY SILT, trace sand, firm to stiff, grey, moist (continued)		13	SS	2		184	2						
14.5	SILT AND SAND, trace clay, loose, grey, wet		14	SS	6		183	3					70	
			15	SS	4		182							
			16	SS	6		181							
			17	SS	6		180							
			18	SS	8		179							
175.1	SAND, trace silt, loose, grey, moist to wet		19	SS	7		178							
21.3			20	SS	7		177							
							176							
							175							
							174							
							173							
172.5														

Continued Next Page

+ 3, X 3, Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No HC2

3 of 3

METRIC

G.W.P. 5446-09-00 LOCATION Coords: E:270844.9 N:5022393.8 ORIGINATED BY WZ
DIST HWY 518 BOREHOLE TYPE HOLLOW STEM AUGERS / WASH BORING COMPILED BY SS
DATUM GEODETIC DATE 2012-11-29 - 2012-12-3 CHECKED BY HA

SOIL PROFILE		SAMPLES				GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	SPT 'N' VALUE								
23.9	(continued)												
171.6	SANDY GRAVEL, some silt and clay, very dense, grey, moist (continued)		21	SS	57		172						52 37 (11)
24.8													

END OF BOREHOLE

Borehole contained drill water upon
completion of drilling. Unstabilized
water level and cave not measured.

library: library - mto gint.glb report: mto-terraprobe soil path: \\pdclserver\11-project files\11-geotechnical\2012\11-12-2100 - 2199\11-12-2130\gint\haines creek bh logs (new temp).gpl

RECORD OF BOREHOLE No HC2-P

1 of 1

METRIC

G.W.P. 5446-09-00 LOCATION Coords: E:270845.8 N:5022392.3 ORIGINATED BY WZ
DIST HWY 518 BOREHOLE TYPE SOLID STEM AUGERS COMPILED BY SS
DATUM GEODETIC DATE 2012-12-4 CHECKED BY HA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	SPT 'N' VALUE			20	40	60	80	100					
196.4	GROUND SURFACE																
	60mm ASPHALTIC CONCRETE																
195.9	520mm AGGREGATE		1	AS			196										
0.6	FILL, sand, some gravel, trace silt; dense, brown, damp		2	SS	43												
	...wet		3	SS	31		195										
194.5																	
2.0																	

END OF BOREHOLE

Borehole was dry and open upon
completion of drilling.

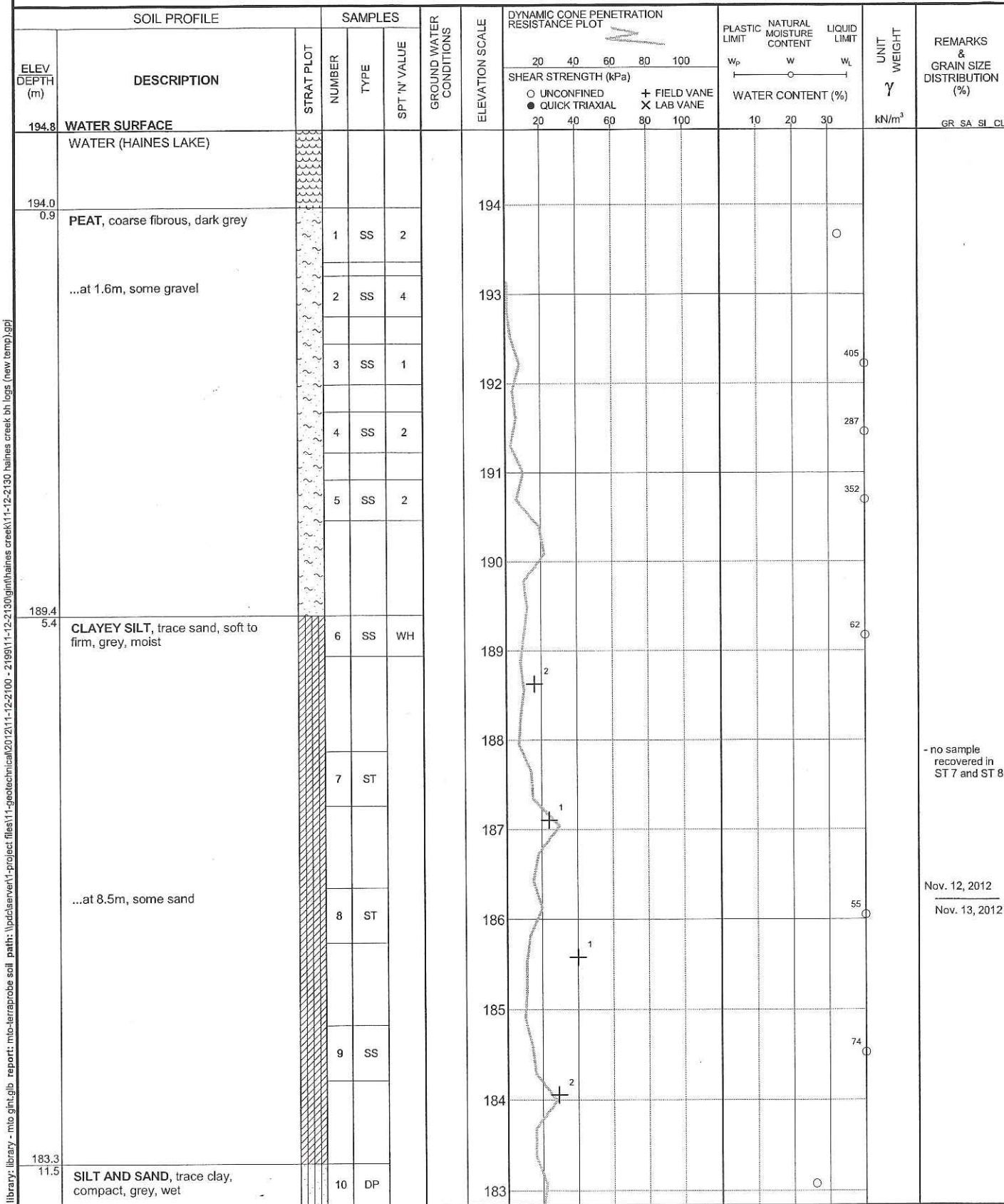
library: library - mto gint.glb report: mto-terraprobe soil path: \\pdc\server1\project files\11-geotechnical\2012\11-12\2100 - 2199\11-12\2130 haines creek bh logs (new temp).gpl

RECORD OF BOREHOLE No HC3

1 of 2

METRIC

G.W.P. 5446-09-00 LOCATION Coords: E:270831.7 N:5022396.5 ORIGINATED BY WZ
DIST HWY 518 BOREHOLE TYPE WASH BORING & CONE TEST COMPILED BY SS
DATUM GEODETIC DATE 2012-11-12 - 2012-11-13 CHECKED BY HA



Continued Next Page

+ 3, X 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No HC3

2 of 2

METRIC

G.W.P. 5446-09-00 LOCATION Coords: E:270831.7 N:5022396.5 ORIGINATED BY WZ
DIST HWY 518 BOREHOLE TYPE WASH BORING & CONE TEST COMPILED BY SS
DATUM GEODETTIC DATE 2012-11-12 - 2012-11-13 CHECKED BY HA

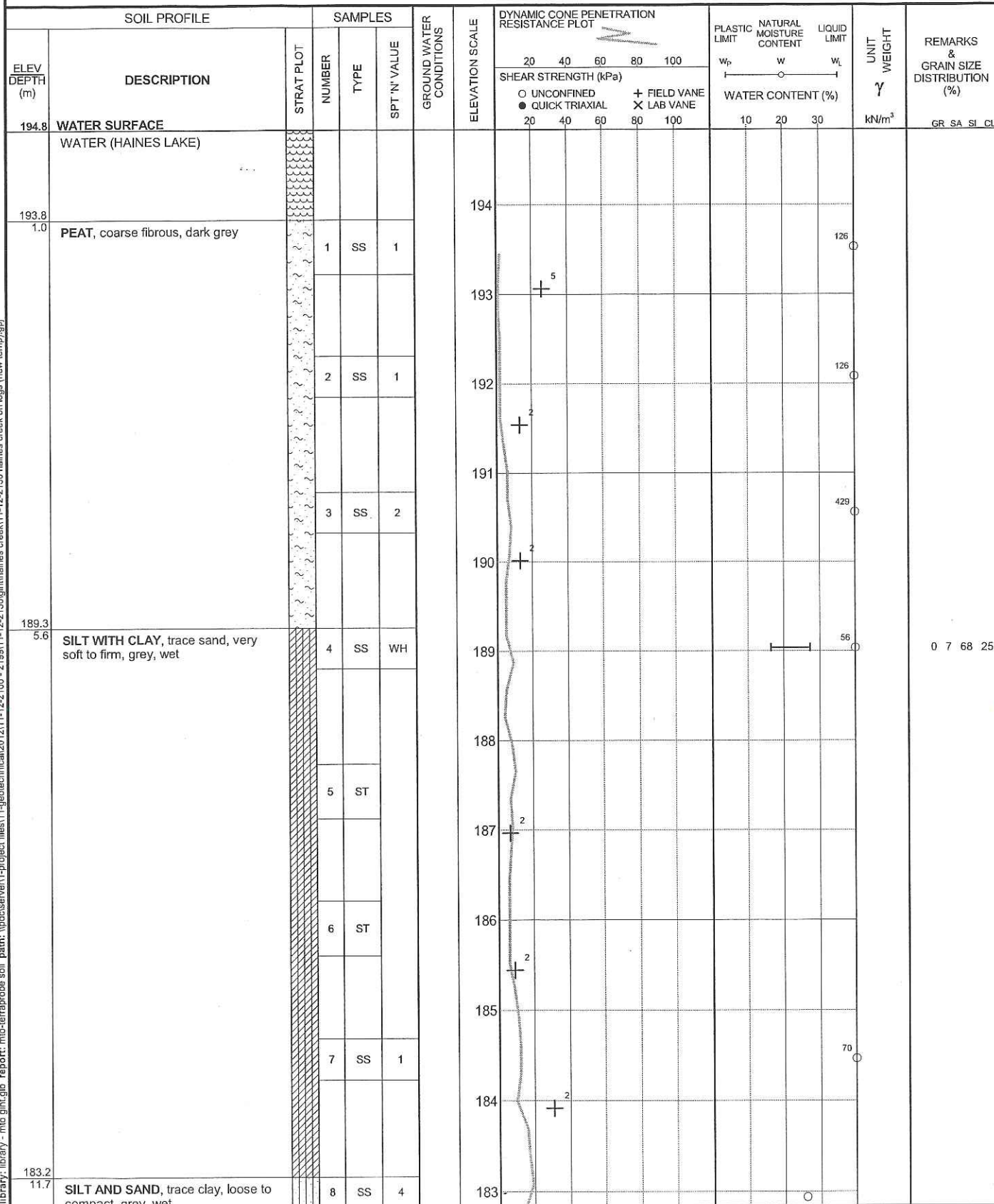
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			SPT 'N' VALUE	SHEAR STRENGTH (kPa)		WATER CONTENT (%)			
	(continued)						○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE X LAB VANE	W _p W W _L					
	SILT AND SAND, trace clay, compact, grey, wet (continued)		11	SS	25			20 40 60 80 100	10 20 30				
			12	SS	11								
178.7 16.1	SAND, trace silt, loose to compact, grey, wet		13	SS	5								
			14	SS	11								
			15	SS	6								
174.2 20.7	COBBLES, compact to very dense, grey, damp		16	SS	19								
172.6 22.3			17	SS	100 / 25mm								

RECORD OF BOREHOLE No HC4

1 of 2

METRIC

G.W.P. 5446-09-00 LOCATION Coords: E:270829.5 N:5022403.5 ORIGINATED BY WZ
DIST HWY 518 BOREHOLE TYPE WASH BORING & CONE TEST COMPILED BY SS
DATUM GEODETIC DATE 2012-11-15 - 2012-11-16 CHECKED BY HA



Continued Next Page

+ 3, X 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No HC4

2 of 2

METRIC

G.W.P. 5446-09-00 LOCATION Coords: E:270829.5 N:5022403.5 ORIGINATED BY WZ
DIST HWY 518 BOREHOLE TYPE WASH BORING & CONE TEST COMPILED BY SS
DATUM GEODETIC DATE 2012-11-15 - 2012-11-16 CHECKED BY HA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIMIT MOISTURE CONTENT		UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	SPT 'N' VALUE			20 40 60 80 100	20 40 60 80 100	w _p	w	w _L	
	(continued)							SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X LAB VANE		WATER CONTENT (%)			
								20 40 60 80 100		10 20 30			GR SA SI CL
177.1	SILT AND SAND, trace clay, loose to compact, grey, wet (continued)		9	SS	10		182						
178							181						
			10	SS	6		180						
							179						
			11	SS	5		178						
							177						
173.6	SAND, trace silt, loose to very dense, grey, wet		12	SS	6		176						
21.3							175						
			13	SS	19		174						
			14	SS	141								

END OF BOREHOLE

Borehole contained drill water upon completion of drilling. Unstabilized water level and cave not measured.

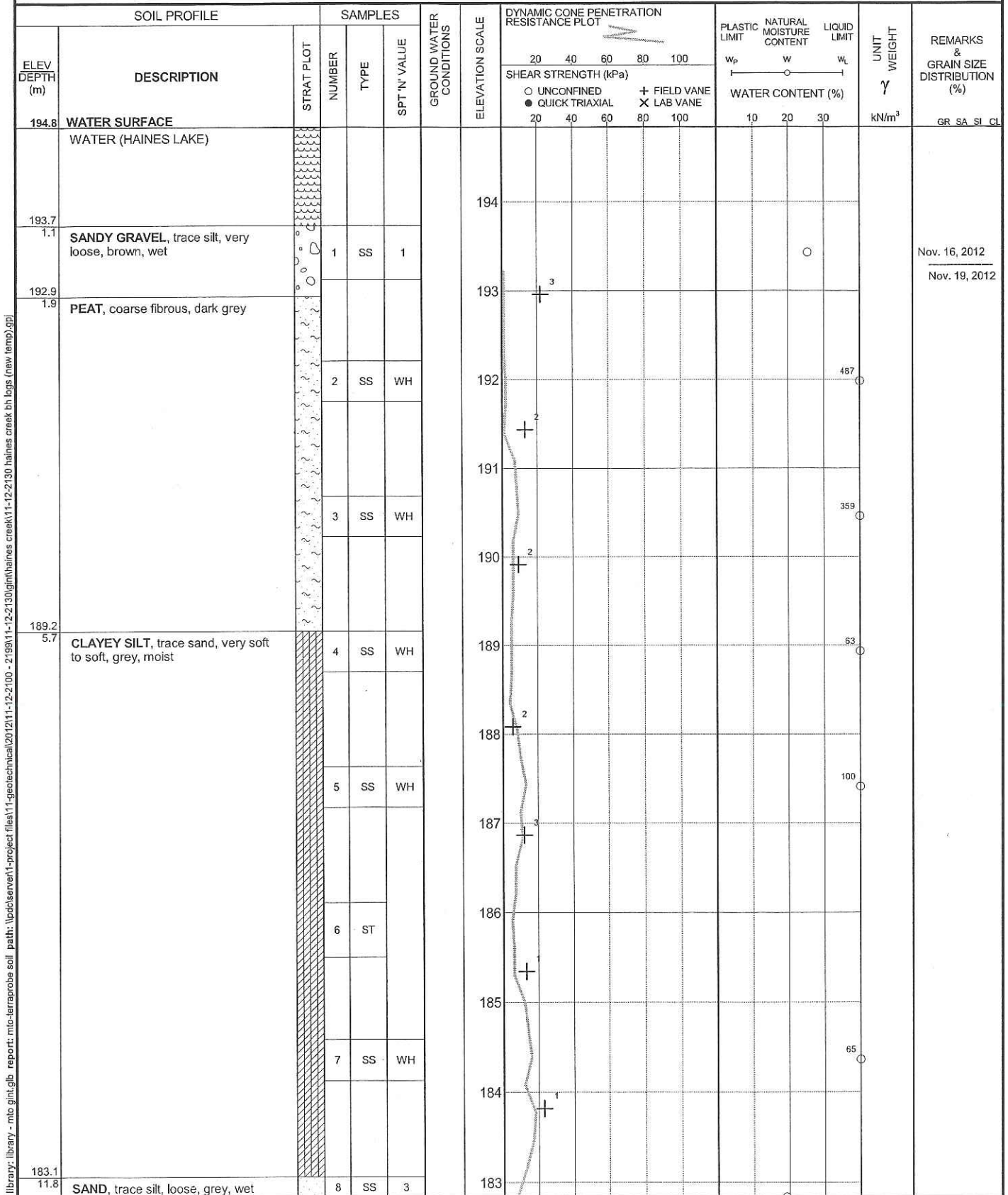
Nov. 15, 2012
Nov. 16, 2012
0 48 51 1

RECORD OF BOREHOLE No HC5

1 of 2

METRIC

G.W.P. 5446-09-00 LOCATION Coords: E:270825.1 N:5022400.6 ORIGINATED BY WZ
DIST HWY 518 BOREHOLE TYPE WASH BORING & CONE TEST COMPILED BY SS
DATUM GEODETIC DATE 2012-11-16 - 2012-11-19 CHECKED BY HA



Continued Next Page

+ 3, X 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

library: library - mto.gint.glb report: mto-terraprobe soil path: \\pds\server\1-project\files\11-geotechnical\2012\11-12-2100 - 2199\11-12-2130\gin\haines creek\11-12-2130 haines creek bh logs (new temp).gpl

RECORD OF BOREHOLE No HC5

2 of 2

METRIC

G.W.P. 5446-09-00 LOCATION Coords: E:270825.1 N:5022400.6 ORIGINATED BY WZ
DIST HWY 518 BOREHOLE TYPE WASH BORING & CONE TEST COMPILED BY SS
DATUM GEODETTIC DATE 2012-11-16 - 2012-11-19 CHECKED BY HA

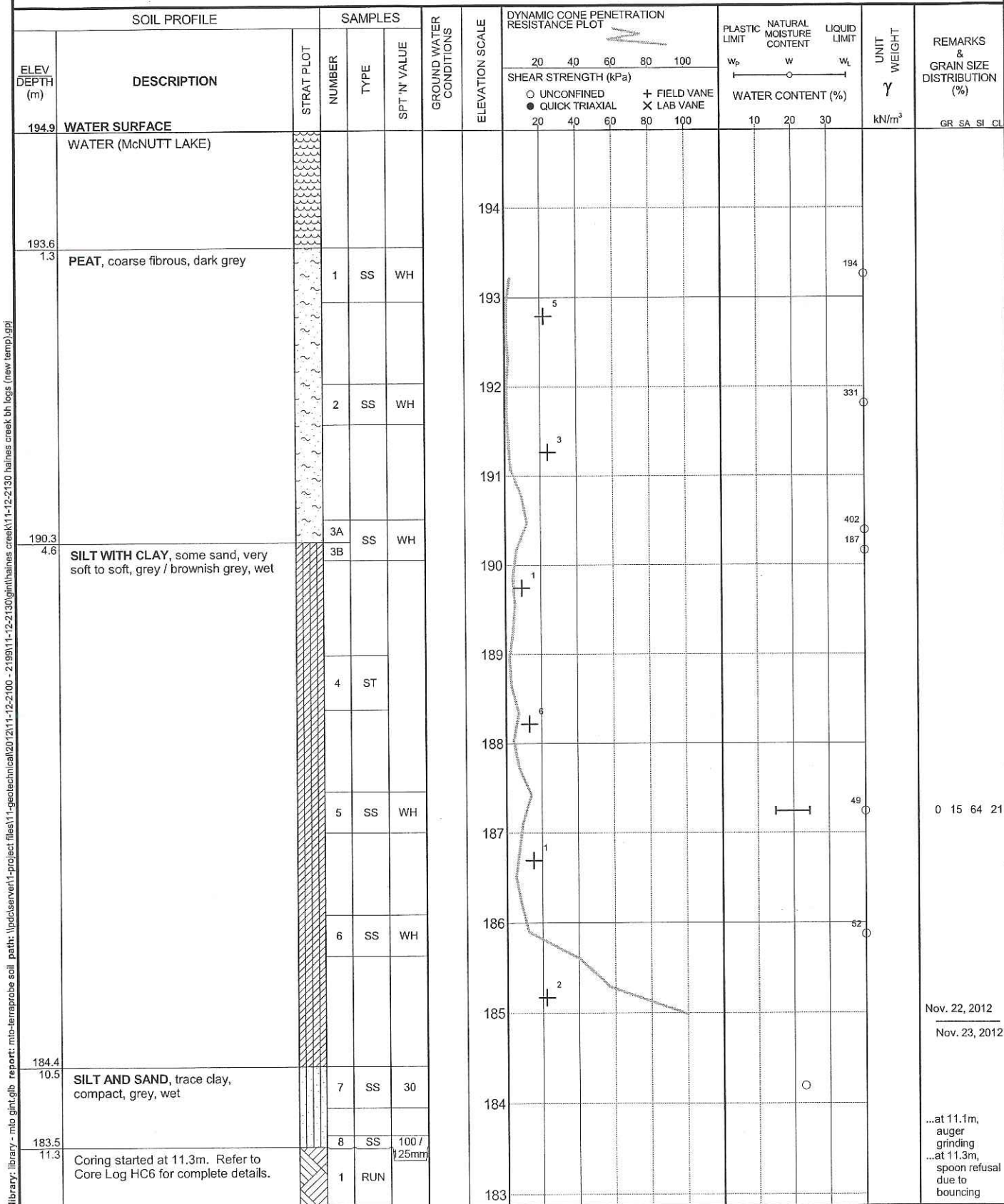
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	SPT 'N' VALUE								
	(continued)		8	SS	3								
	SAND, trace silt, loose, grey, wet (continued)		9	SS	9								
			10	SS	5								
			11	SS	5								
			12	SS	7								
	...compact to dense		13	SS	17								
			14	SS	35								
172.3 22.5	...at 22.4m, inferred bedrock		15	SS	100 / 75mm								...at 22.4m, Spoon refusal due to spoon bouncing
<p>END OF BOREHOLE</p> <p>Borehole contained drill water upon completion of drilling. Unstabilized water level and cave not measured.</p>													

RECORD OF BOREHOLE No HC6

1 of 2

METRIC

G.W.P. 5446-09-00 LOCATION Coords: E:270848.7 N:5022364.5 ORIGINATED BY WZ
DIST HWY 518 BOREHOLE TYPE WASH BORING & CONE TEST, NQ ROCK CORING COMPILED BY SS
DATUM GEODETIC DATE 2012-11-22 - 2012-11-23 CHECKED BY HA



Continued Next Page

+ 3, X 3: Numbers refer to Sensitivity
○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No HC6

2 of 2

METRIC

G.W.P. 5446-09-00 LOCATION Coords: E:270848.7 N:5022364.5 ORIGINATED BY WZ
DIST HWY 518 BOREHOLE TYPE WASH BORING & CONE TEST, NQ ROCK CORING COMPILED BY SS
DATUM GEODETIC DATE 2012-11-22 - 2012-11-23 CHECKED BY HA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	SPT 'N' VALUE			20	40	60	80	100					
	(continued)																
	Coring started at 11.3m. Refer to Core Log HC6 for complete details. (continued)		2	RUN													
182.1 12.8			3	RUN													

END OF BOREHOLE

Borehole contained drill water upon
completion of drilling. Unstabilized
water level and cave not measured.

library: library - mto gintglib report: mto-terrprobe soil path: \\pdcserver\1-project files\11-geotechnical\2012\11-12-2100 - 2198\11-12-2130\gint\haines creek bh logs (new temp).gpi

RECORD OF ROCK CORE No HC6

1 of 1

METRIC

G.W.P. 5446-09-00 LOCATION Coords: E:270848.7 N:5022364.5 ORIGINATED BY WZ
DIST HWY 518 BOREHOLE TYPE WASH BORING & CONE TEST, NQ ROCK CORING COMPILED BY SS
DATUM GEODETIC DATE 2012-11-22 - 2012-11-23 CHECKED BY HA

Depth (m)	Graphic Log	GENERAL DESCRIPTION	Run Elev Depth	Recovery	Elevation (m)	Weathering Zones	UCS (MPa)				Natural Fractures		Laboratory Testing	Comments	Elevation (m)
							5	25	50	100	250	Frequency	Spacing		
		Rock coring started at 11.3m below grade	11.3m												
		Gneiss, light, thinly bedded, very strong; joints are dipping; biotite to quartzofeldspathic, unweathered, massive to strongly foliated / gneissic	183.5m	R1 TCR = 100% SCR = 56% RQD = 42%	183									— 11.4-11.5m: localized rubble zones — 11.7-12.8m: localized rubble zones	183
12			12.0m	R2 TCR = 100% SCR = 0% RQD = 0%											
			12.4m	R3 TCR = 100% SCR = 43% RQD = 0%											

END OF BOREHOLE

Borehole contained drill water upon completion of drilling. Unstabilized water level and cave not measured.

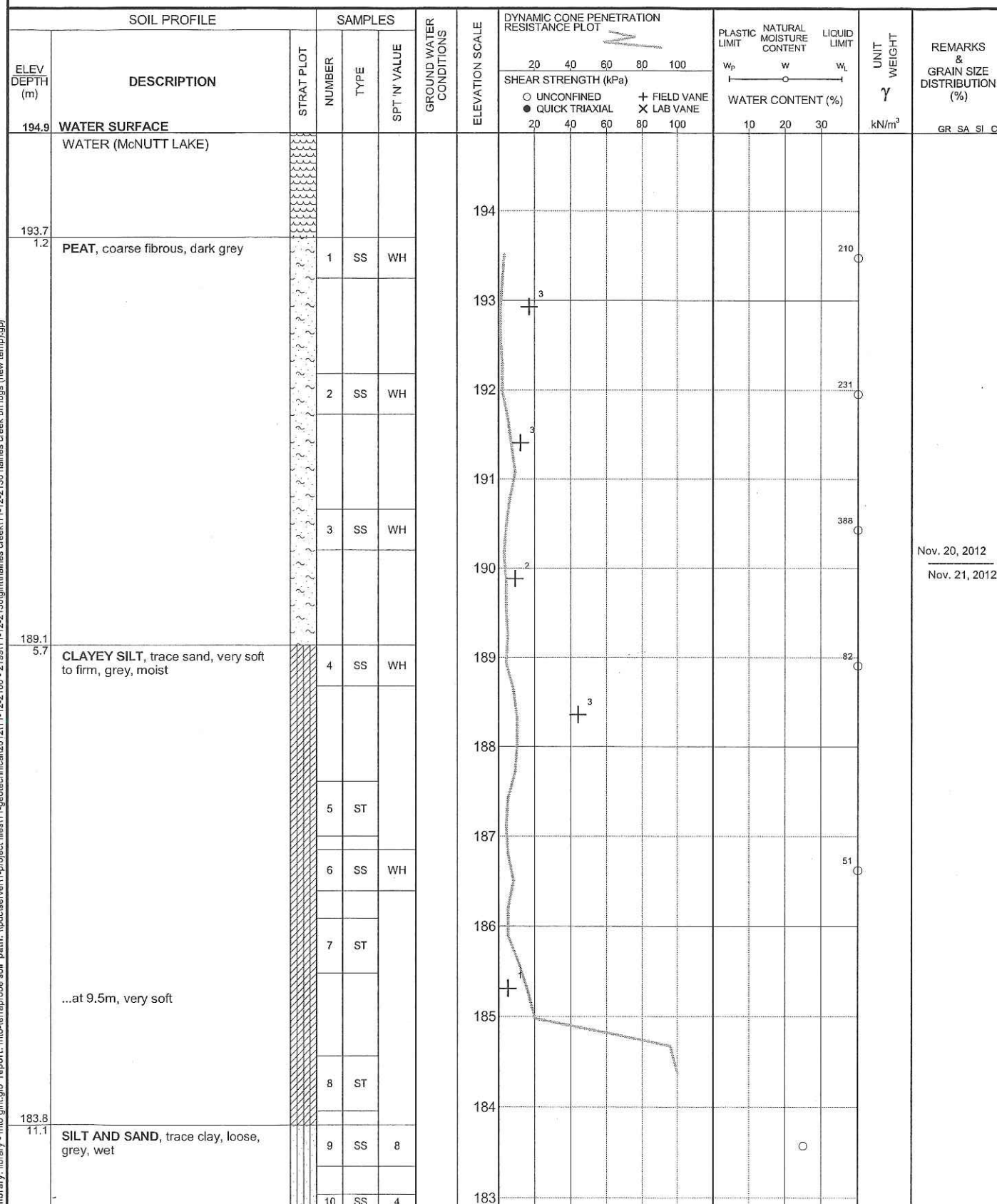
RECORD OF BOREHOLE No HC7

1 of 2

METRIC

G.W.P. 5446-09-00 LOCATION Coords: E:270848.1 N:5022373.7 ORIGINATED BY WZ
 DIST HWY 518 BOREHOLE TYPE WASH BORING & CONE TEST, NQ ROCK CORING COMPILED BY SS
 DATUM GEODETIC DATE 2012-11-20 - 2012-11-22 CHECKED BY HA

library: library - mto gint.glb report: mto-terraprobe soil path: \pdc\server1\project files\1-geotechnical\2012\11-12-2000 - 2199\11-12-2013\gint\haines creek bh logs (new temp).gpl



Continued Next Page

+³, X³: Numbers refer to Sensitivity
○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No HC7

2 of 2

METRIC

G.W.P. 5446-09-00 LOCATION Coords: E:270848.1 N:5022373.7 ORIGINATED BY WZ
 DIST HWY 518 BOREHOLE TYPE WASH BORING & CONE TEST, NQ ROCK CORING COMPILED BY SS
 DATUM GEODETIC DATE 2012-11-20 - 2012-11-22 CHECKED BY HA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	SPT 'N' VALUE		20	40	60	80	100					
	(continued)															
	SILT AND SAND, trace clay, loose, grey, wet (continued)		10	SS	4											
	...at 13.4m, very dense		11	SS	66											
	...at 14.0m, boulder obstruction															
			12	SS	100 / 50mm											
179.2 15.7	Coring started at 15.7m. Refer to Core Log HC7 for complete details.		1	RUN												
178.3 16.6																

END OF BOREHOLE

Borehole contained drill water upon completion of drilling. Unstabilized water level and cave not measured.

library: library - mto gint.glb report: mto-terraprobe soil path: \\pdc\server\1-project files\11-geotechnical\2012\11-12-2100 - 2109\11-12-2130\in\haines creek bh logs (new temp).gpl

RECORD OF ROCK CORE No HC7

1 of 1

METRIC

G.W.P. 5446-09-00 LOCATION Coords: E:270848.1 N:5022373.7 ORIGINATED BY WZ
DIST HWY 518 BOREHOLE TYPE WASH BORING & CONE TEST, NQ ROCK CORING COMPILED BY SS
DATUM GEODETTIC DATE 2012-11-20 - 2012-11-22 CHECKED BY HA

Depth (m)	Graphic Log	GENERAL DESCRIPTION	Rin Elev Depth	Recovery	Elevation (m)	Weathering Zones	UCS (MPa) ● 5 25 50 100 250 Estimated Strength	Natural Fractures Frequency Spacing	Laboratory Testing	Comments	Elevation (m)
		Rock coring started at 15.7m below grade	179.2m								
15		Gneiss, light, thinly bedded, very strong; joints are dipping; biotite to quartzofeldspatic, unweathered, massive to strongly foliated / gneissic	15.7m	TCR = 98% SCR = 94% RQD = 79%	179					15.6-15.8m: localized rubble zones	179
			178.3m								

END OF BOREHOLE

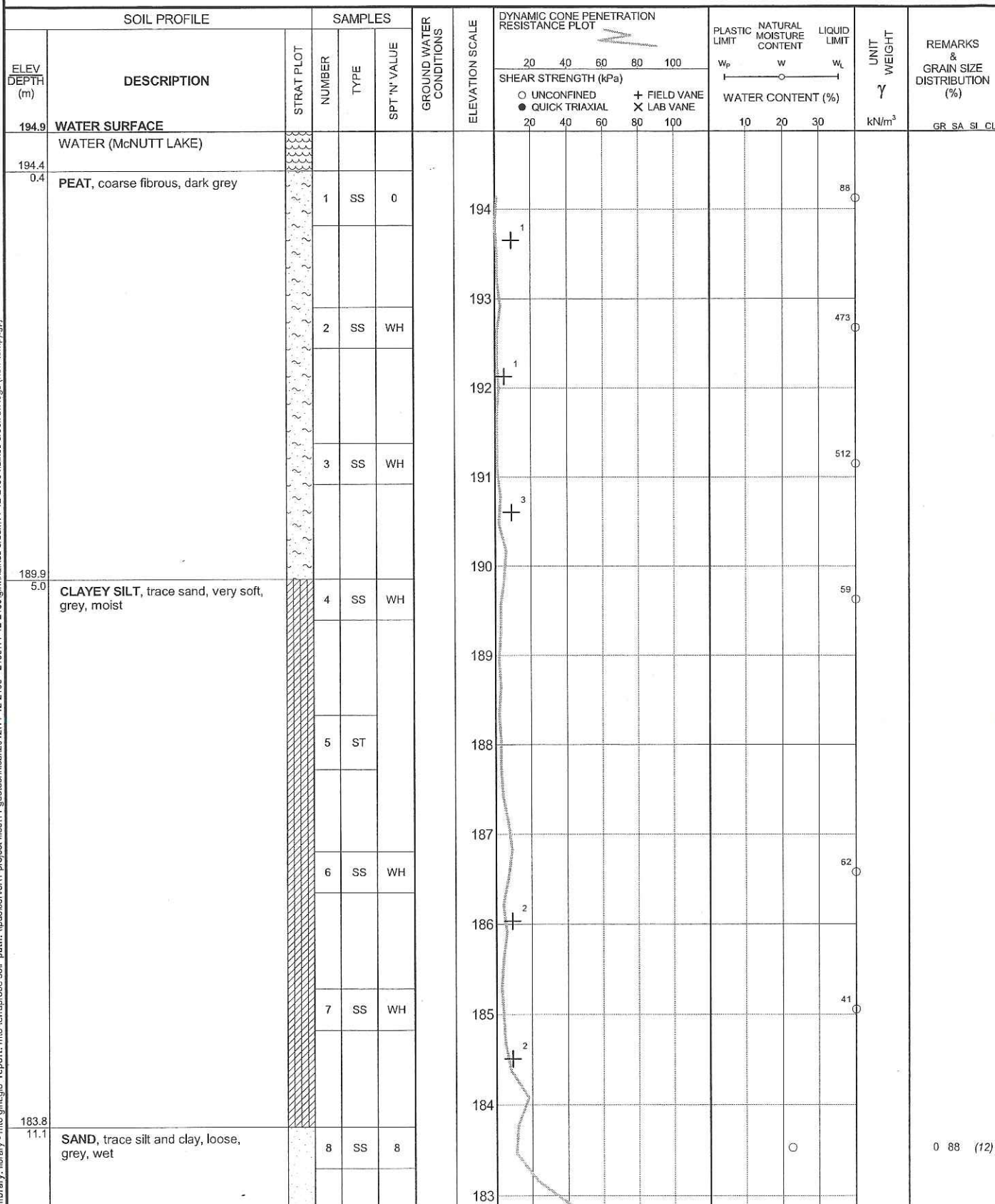
Borehole contained drill water upon completion of drilling. Unstabilized water level and cave not measured.

RECORD OF BOREHOLE No HC8

1 of 2

METRIC

G.W.P. 5446-09-00 LOCATION Coords: E:270853.7 N:5022367.9 ORIGINATED BY WZ
DIST HWY 518 BOREHOLE TYPE WASH BORING & CONE TEST, NQ ROCK CORING COMPILED BY SS
DATUM GEODETIC DATE 2012-11-24 CHECKED BY HA



Continued Next Page

+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

library: library - mto gint.glb report: mto-terraprobe soil path: \\pdciserv1-project files\11-geotechnical\2012\11-12-2100 - 2199\11-12-2130\haines creek bh logs (new temp).spl

RECORD OF BOREHOLE No HC8

2 of 2

METRIC

G.W.P.	5446-09-00	LOCATION	Coords: E:270853.7 N:5022367.9	ORIGINATED BY	WZ
DIST	HWY 518	BOREHOLE TYPE	WASH BORING & CONE TEST , NQ ROCK CORING	COMPILED BY	SS
DATUM	GEODETIC	DATE	2012-11-24	CHECKED BY	HA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV. DEPTH (m)	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE			SPT 'N' VALUE						20 40 60 80 100	
													SHEAR STRENGTH (kPa)	WATER CONTENT (%)
							20 40 60 80 100	10 20 30						
(continued)														
	SAND, trace silt and clay, loose, grey, wet (continued)		9	SS	4									
181.2 13.6	Coring started at 13.6m. Refer to Core Log HC8 for complete details.		10	SS	100 / 75mm									
			1	RUN										
			2	RUN										
179.8 15.1												...at 13.5m, auger grinding ...at 13.6m, spoon refusal		

END OF BOREHOLE

Borehole contained drill water upon completion of drilling. Unstabilized water level and cave not measured.

RECORD OF ROCK CORE No HC8

1 of 1

METRIC

G.W.P. 5446-09-00 LOCATION Coords: E:270853.7 N:5022367.9 ORIGINATED BY WZ
DIST HWY 518 BOREHOLE TYPE WASH BORING & CONE TEST, NQ ROCK CORING COMPILED BY SS
DATUM GEODETTIC DATE 2012-11-24 CHECKED BY HA

Depth (m)	Graphic Log	GENERAL DESCRIPTION	Run Elev Depth	Recovery	Elevation (m)	Weathering Zones	UCS (MPa) Estimated Strength	Natural Fractures Frequency Spacing	Laboratory Testing	Comments	Elevation (m)
		Rock coring started at 13.6m below grade	181.2m								
14		Gneiss, light, thinly bedded, very strong; joints are dipping; biotite to quartzofeldspathic, unweathered, massive to strongly foliated / gneissic	13.6m R1	TCR = 100% SCR = 85% RQD = 69%	181					13.6-13.7m: localized rubble zones	181
15			180.3m 14.5m R2	TCR = 100% SCR = 100% RQD = 57%	180					14.1-14.2m: localized rubble zones	180

END OF BOREHOLE

Borehole contained drill water upon completion of drilling. Unstabilized water level and cave not measured.

Haines Creek Culvert Replacement
Agreement No. 5012-E-0001, GWP No. 5446-09-00, SITE 44-283/C



Bedrock Core Sample
Borehole: HC6
Runs: 1, 2 & 3
Depth: 11.3m – 12.8m



Terraprobe Inc.

Project # 11-12-2130

Haines Creek Culvert Replacement
Agreement No. 5012-E-0001, GWP No. 5446-09-00, SITE 44-283/C



Bedrock Core Sample
Borehole: HC7
Run: 1
Depth: 15.7m – 16.6m



Terraprobe Inc.

Project # 11-12-2130

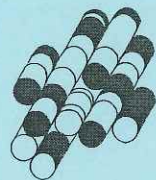


Bedrock Core Sample
Borehole: HC8
Runs: 1 & 2
Depth: 13.6m – 15.1m



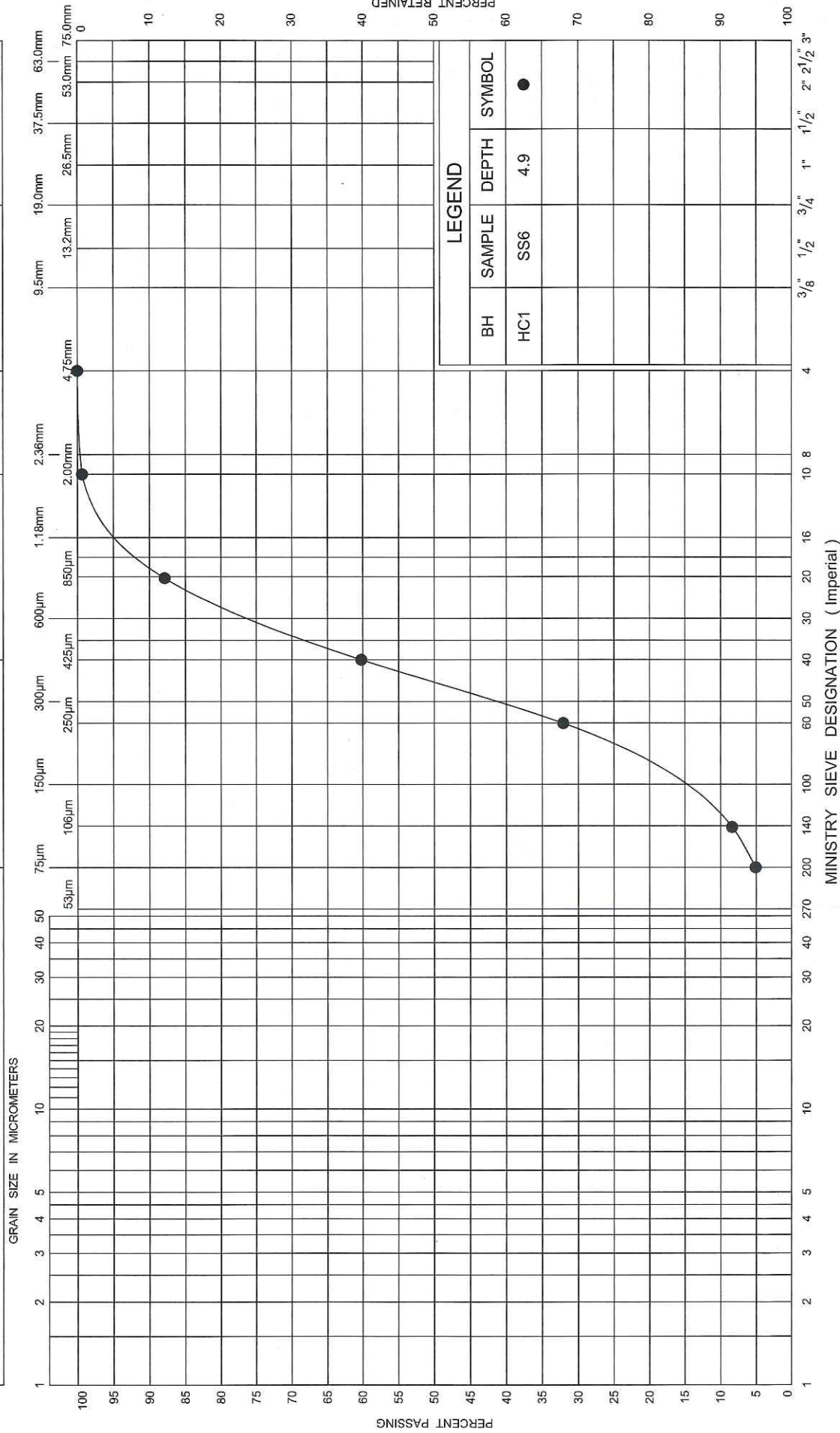
APPENDIX B

TERRAPROBE INC.



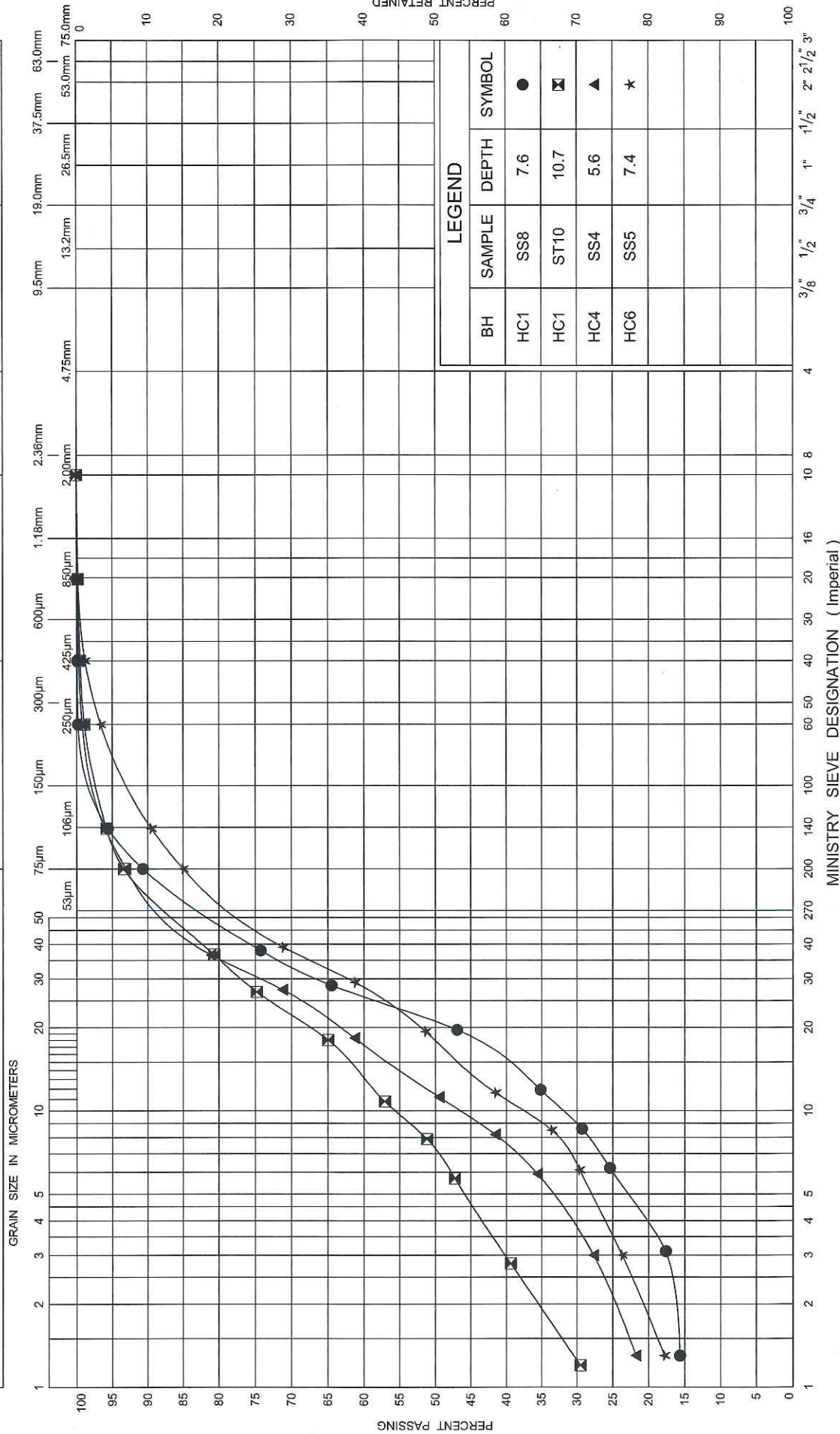
UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND			GRAVEL		
	Fine	Medium	Coarse	Fine	Coarse	



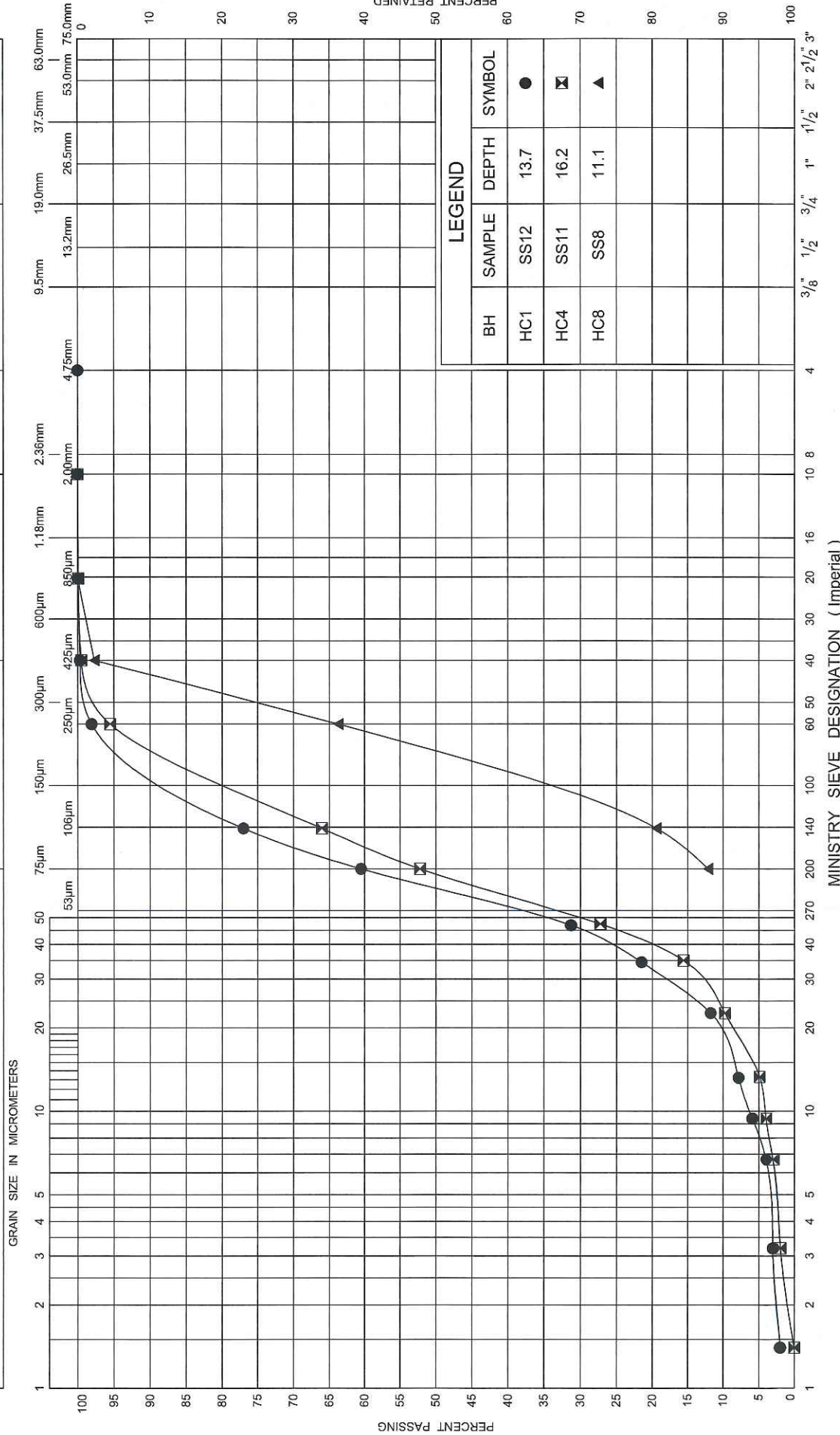
UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND			GRAVEL		
	Fine	Medium	Coarse	Fine	Coarse	



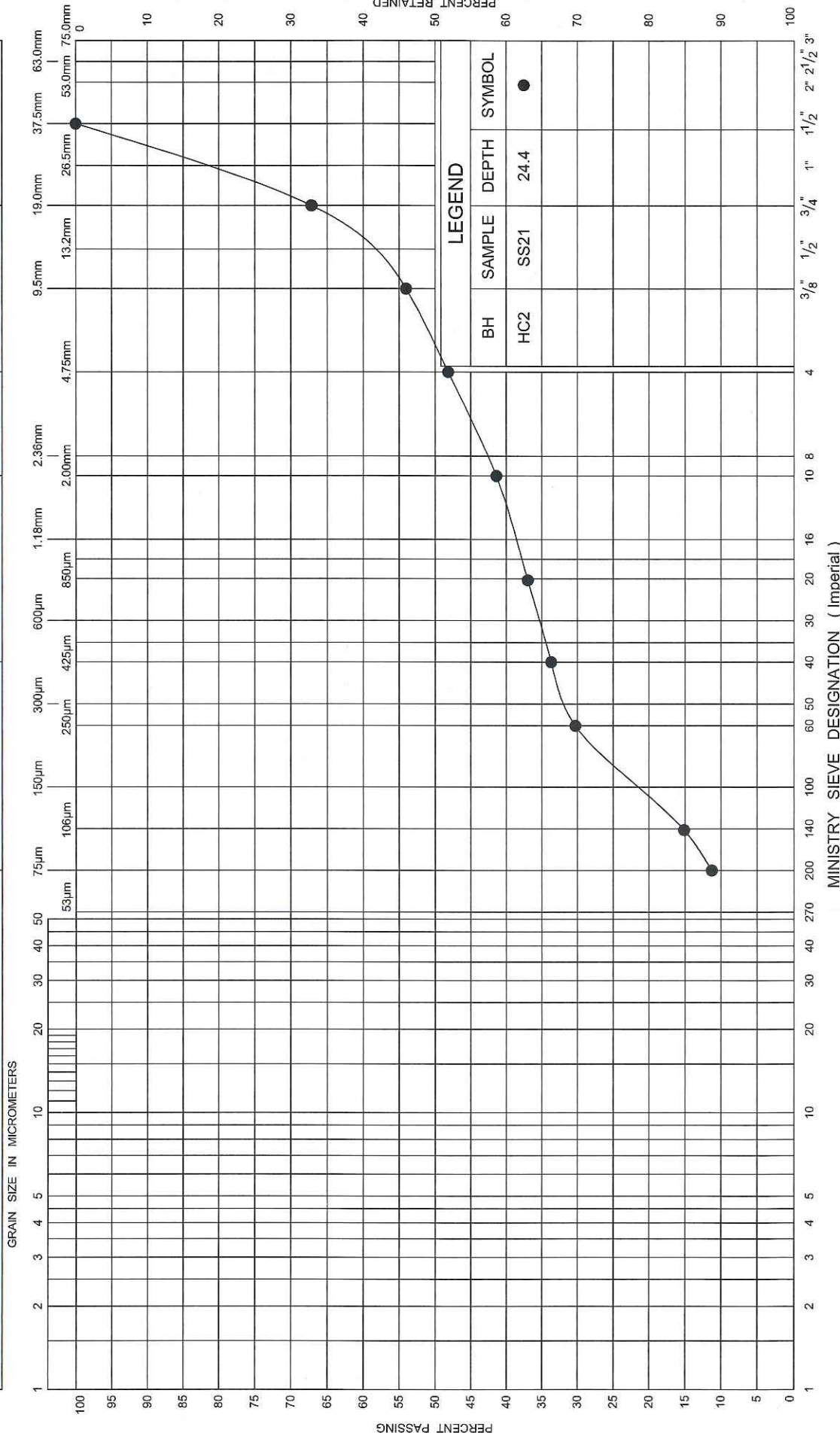
UNIFIED SOIL CLASSIFICATION SYSTEM

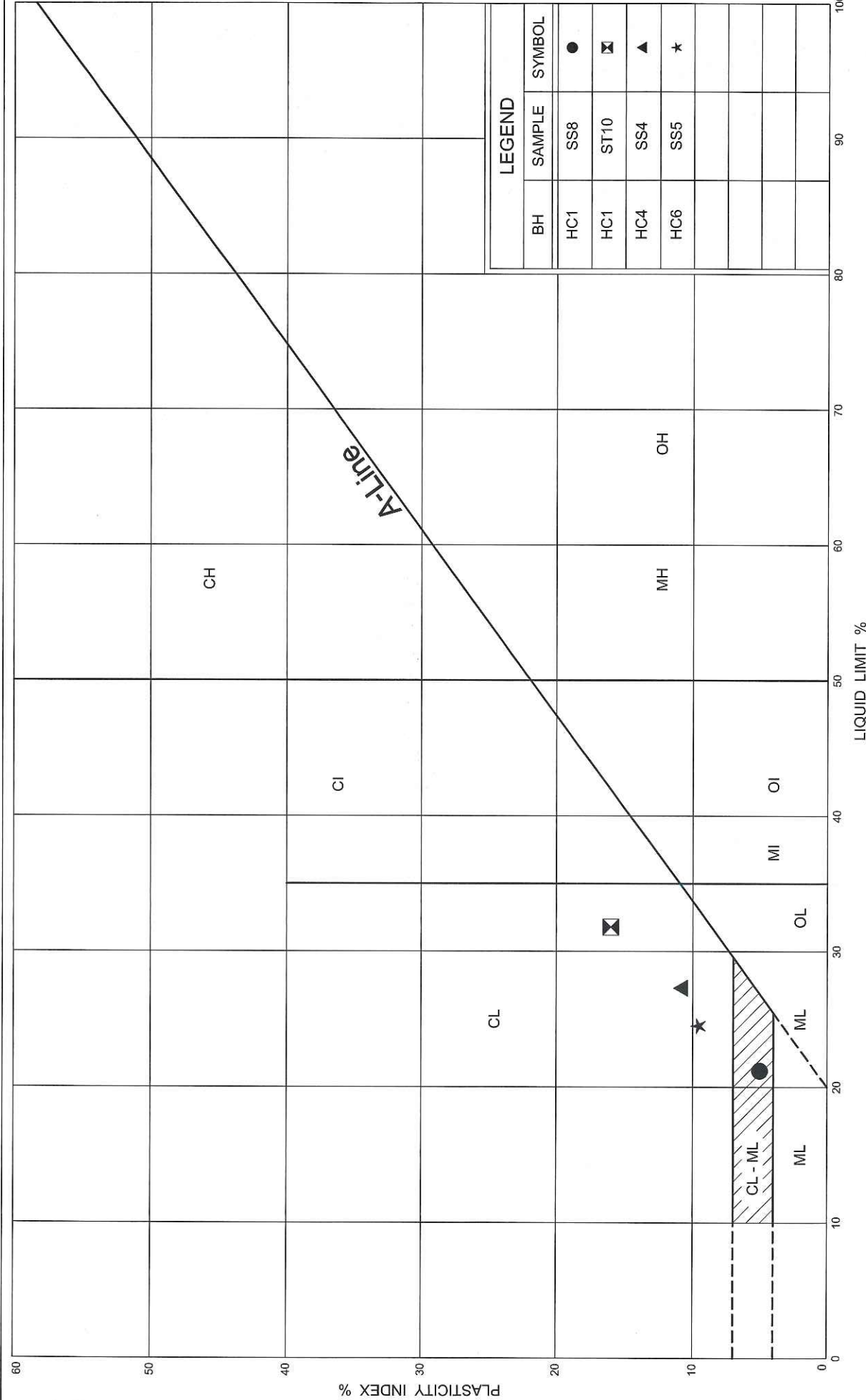
CLAY & SILT	SAND			GRAVEL		
	Fine	Medium	Coarse	Fine	Coarse	



UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT		SAND			GRAVEL	
		Fine	Medium	Coarse	Fine	Coarse





LEGEND		
BH	SAMPLE	SYMBOL
HC1	SS8	●
HC1	ST10	⊠
HC4	SS4	▲
HC6	SS5	★

PLASTICITY CHART CLAYEY SILT TO SILT

FIG No B2-5

GW P 5446-09-00

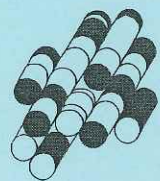
Haines Creek Culvert Replacement

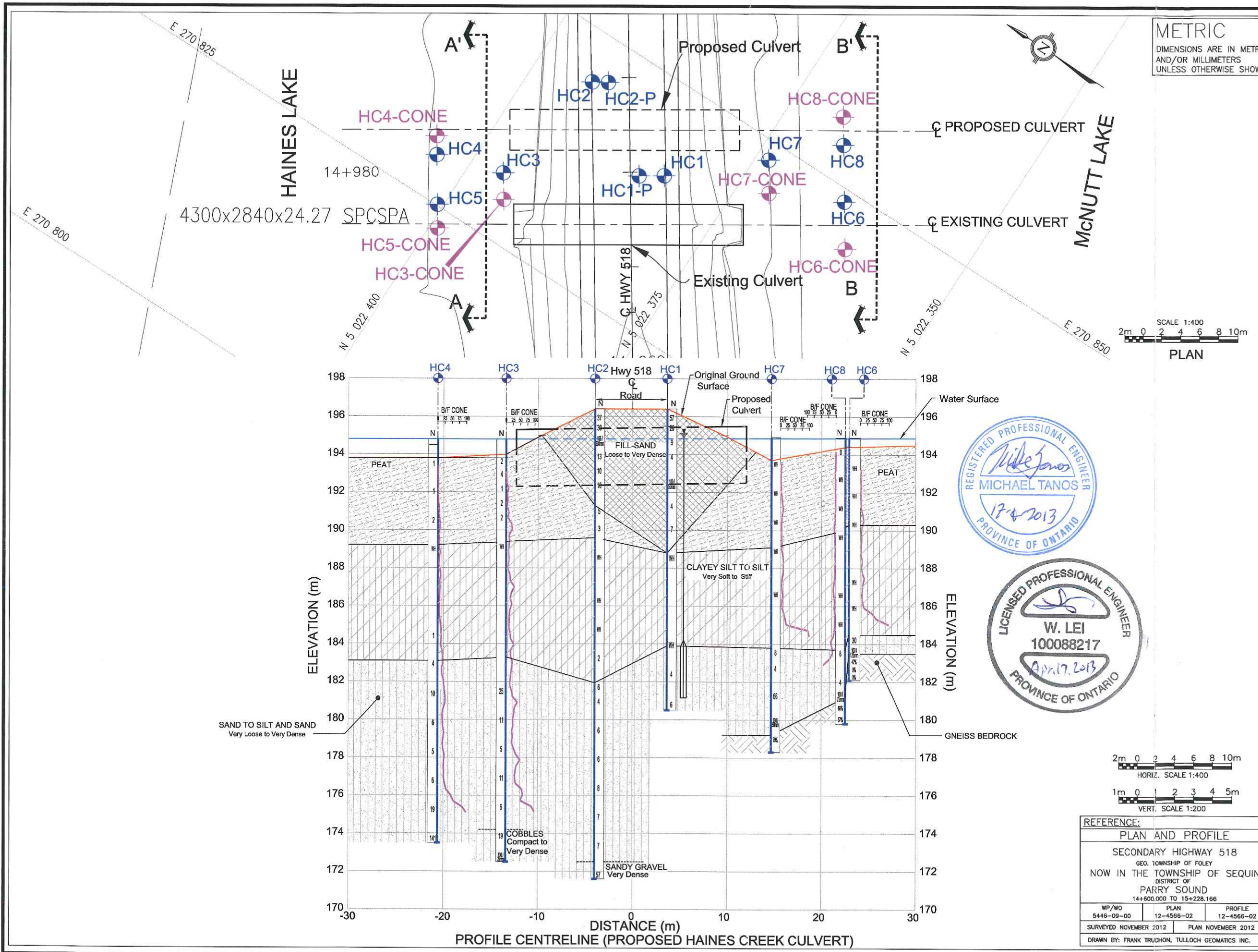
Ministry of
Transportation



APPENDIX C

TERRAPROBE INC.





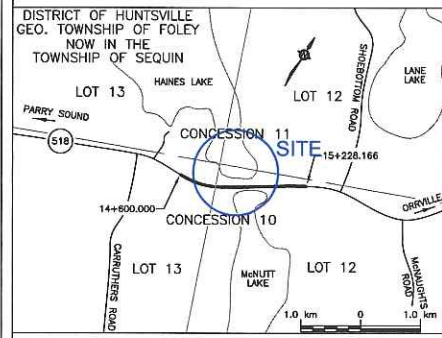
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETERS
UNLESS OTHERWISE SHOWN

CONT. No. 2013-5115
GWP No. 5446-09-00

HAINES CREEK CULVERT
REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

G.D. Jewell
ENGINEERING Inc.

Terraprobe Inc.
Consulting Geotechnical & Environmental Engineering
Construction Materials Engineering, Inspection & Testing
11 Indell Lane - Brampton Ontario L6T 3Y3 (905) 798-2850



LEGEND

	Bore Hole
	Dynamic Cone Penetration Test
	Blows/0.3m (Std Pen Test, 475 J/blow)
	Blows/0.3m (60' Cone, 475 J/blow)
	WL at Time of Investigation
	WL in Piezometer (JAN. 2013)
	Piezometer
	90% Rock Quality Designation
	Auger Refusal

No	ELEV.	MTM COORDINATES	
		NORTHING	EASTING
HC1	196.4	5022382.0	270840.7
HC1-P	196.4	5022384.3	270839.3
HC2	196.4	5022393.8	270844.9
HC2-P	196.4	5022392.3	270845.8
HC3	194.8	5022396.5	270831.7
HC3-CONE	194.8	5022394.9	270829.4
HC4	194.8	5022403.5	270829.5
HC4-CONE	194.8	5022404.6	270831.2
HC5	194.8	5022400.6	270825.1
HC5-CONE	194.8	5022399.2	270823.0
HC6	194.9	5022364.5	270848.7
HC6-CONE	194.9	5022361.8	270844.5
HC7	194.9	5022373.7	270848.1
HC7-CONE	194.9	5022371.8	270845.1
HC8	194.9	5022367.9	270853.7
HC8-CONE	194.9	5022369.5	270856.2

NOTE
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.
This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

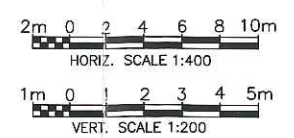
REVISIONS

DATE	BY	DESCRIPTION

DESIGN HA CODE CHBDC2006 LOAD DATE MARCH 2013
DRAWN KC CHK WL STRUCT GEOPRES 31E-324

REGISTERED PROFESSIONAL ENGINEER
MICHAEL TANOS
17-4-2013
PROVINCE OF ONTARIO

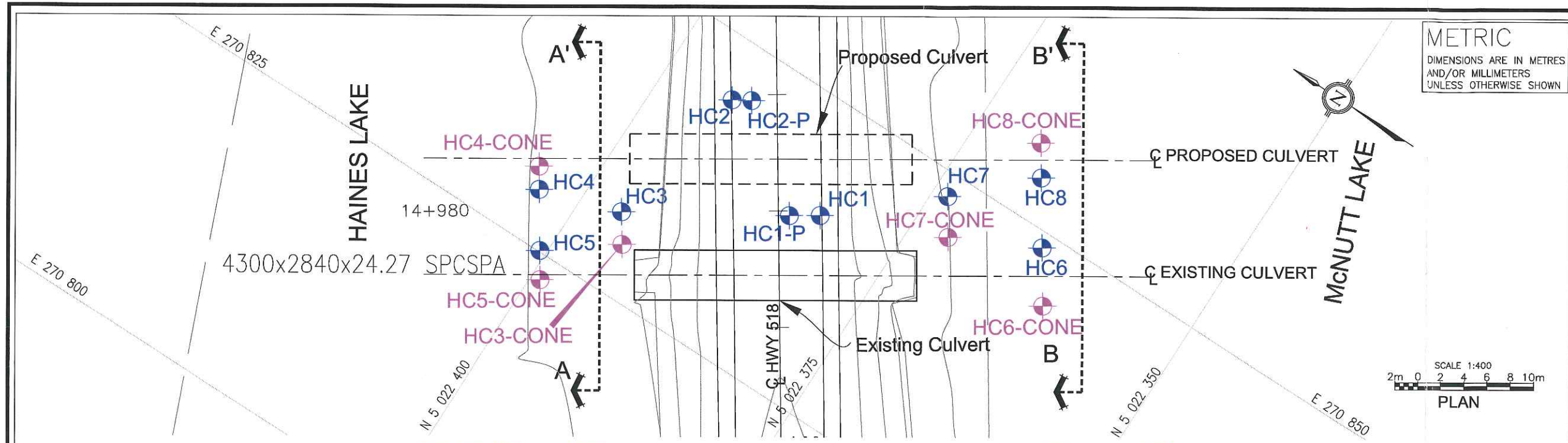
LICENSED PROFESSIONAL ENGINEER
W. LEI
100088217
Apr. 17, 2013
PROVINCE OF ONTARIO



REFERENCE:

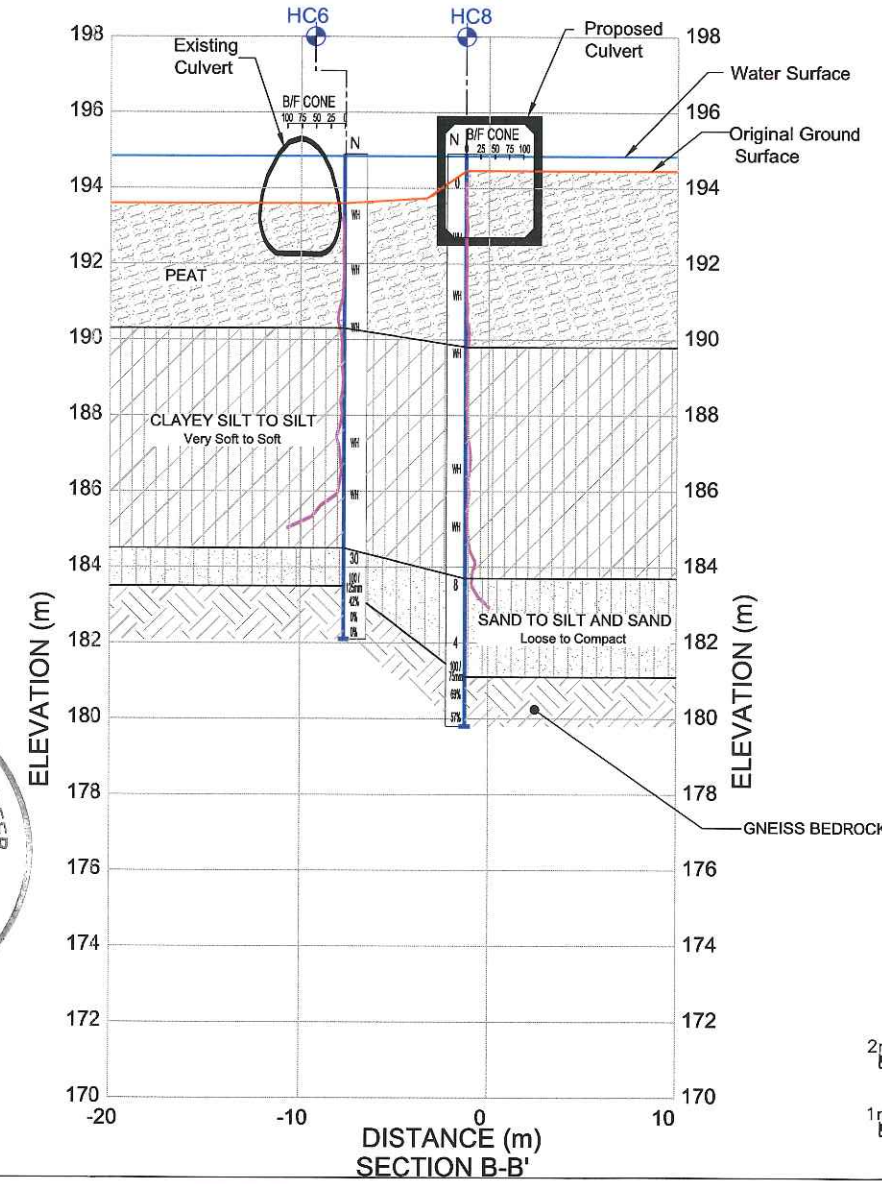
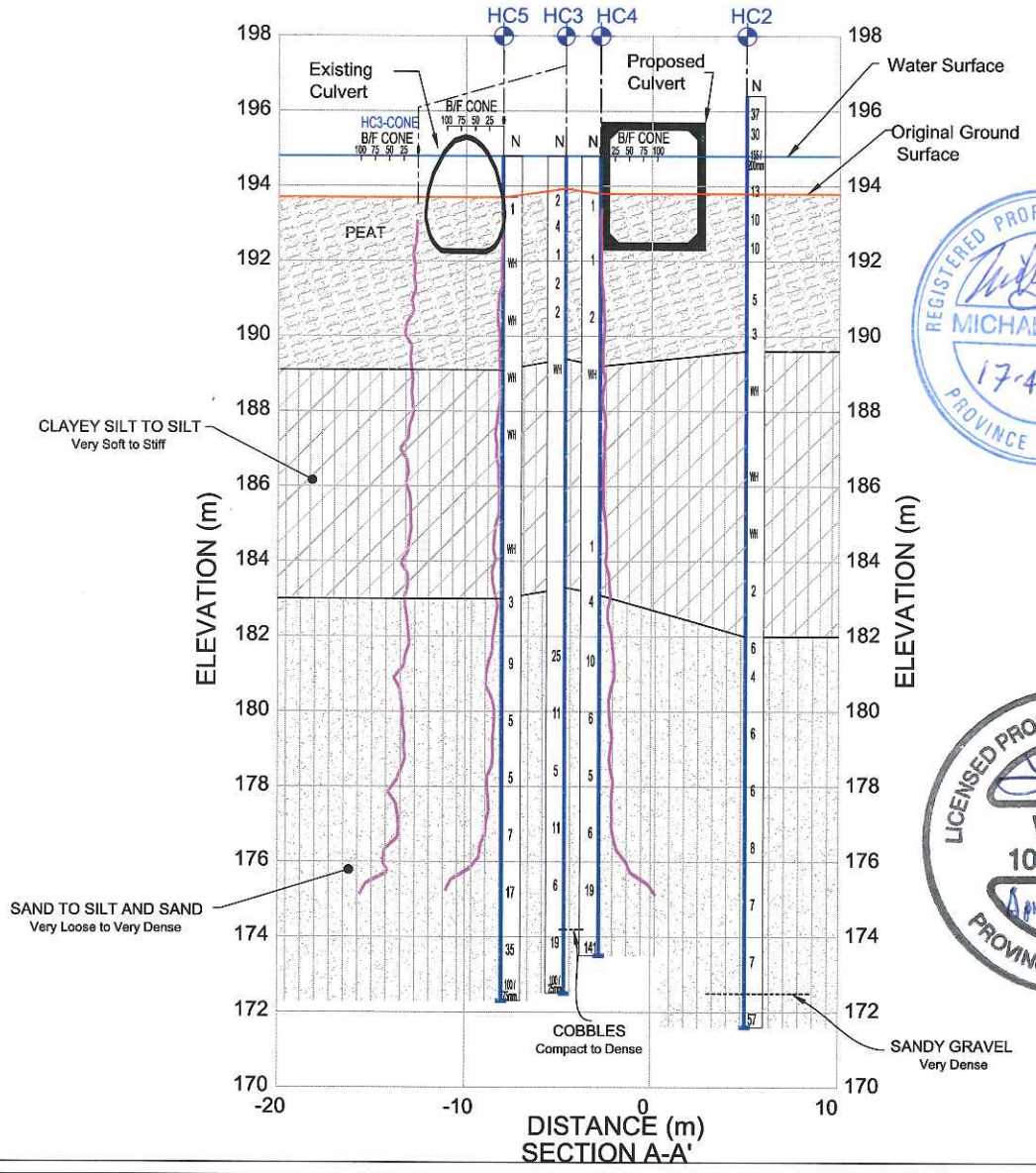
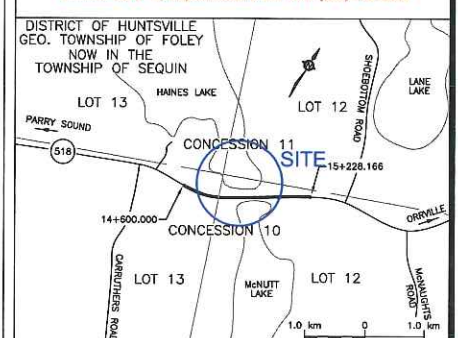
PLAN AND PROFILE
SECONDARY HIGHWAY 518
GEO. TOWNSHIP OF FOLEY
NOW IN THE TOWNSHIP OF SEQUIN
DISTRICT OF
PARRY SOUND
14+600.000 TO 15+228.166

WP/NO 5446-09-00	PLAN 12-4566-02	PROFILE 12-4566-02
SURVEYED NOVEMBER 2012	DATE NOVEMBER 2012	
DRAWN BY: FRANK TRUCHON, TULLOCH GEOMATICS INC.		



METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETERS
UNLESS OTHERWISE SHOWN

CONT. No. 2013-5115
GWP No. 5446-09-00
HAINES CREEK CULVERT
REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA
SHEET
2 OF 2



- LEGEND
- Bore Hole
 - Dynamic Cone Penetration Test
 - 'N' Blows/0.3m (Std Pen Test, 475 J/blow)
 - CONE Blows/0.3m (60° Cone, 475 J/blow)
 - WL at Time of Investigation
 - WL in Piezometer (JAN. 2013)
 - Piezometer
 - 90% Rock Quality Designation
 - A/R Auger Refusal

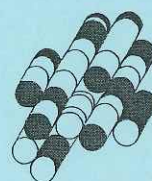
No	ELEV.	MTM COORDINATES	
		NORTHING	EASTING
HC1	196.4	5022382.0	270840.7
HC1-P	196.4	5022384.3	270839.3
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HC7	194.9	5022373.7	270848.1
HC7-CONE	194.9	5022371.8	270845.1
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HC8-CONE	194.9	5022369.5	270856.2

NOTE
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.
This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

REVISIONS						
	DATE	BY	DESCRIPTION			
DESIGN	HA	CODE	CH8DC2006	LOAD	DATE	MARCH 2013
DRAWN	KC	CHK	WL	STRUCT	GEODRES 31E-324	

APPENDIX D

TERRAPROBE INC.



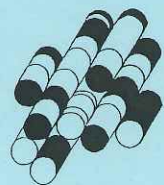
**COMPARISON OF FOUNDATION ALTERNATIVES FOR EACH FOUNDATION
ELEMENT**

Foundation Element	Granular A Pad	Spread Footing	Driven Piles
	<p><i>Advantages:</i></p> <ul style="list-style-type: none">i. Can be placed on low geotechnical resistance of soils.ii. Relatively short construction period. <p><i>Disadvantages:</i></p> <ul style="list-style-type: none">i. Potential for unacceptable settlements and differential settlementsii. Requires relatively large and deep excavations in order to found the Granular A pad on competent soils.	<p><i>Advantages:</i></p> <p>None</p> <p><i>Disadvantages:</i></p> <ul style="list-style-type: none">ii. Uneconomically large footings due to low geotechnical resistance of soils.iii. Unreliable performance and high risk due to settlement sensitive soils. Potential for unacceptable settlements and differential settlements.	<p><i>Advantages:</i></p> <ul style="list-style-type: none">i. High geotechnical resistances available by driving piles to effective refusal.ii. Readily installed.iii. Reliable performance and low risk. <p><i>Disadvantages:</i></p> <ul style="list-style-type: none">i. Construction concerns related to the possibility of piles being obstructed by obstacles or boulders during driving.



APPENDIX E

TERRAPROBE INC.



DEWATERING – Item No.

Non-Standard Special Provision

SCOPE

The work under this item includes the design, installation, operation, maintenance and removal of temporary dewatering systems to facilitate the Jenkins Creek culvert replacement.

Foundations for the replacement culvert will require excavation below the groundwater level. Cohesionless soils below the groundwater table will be subjected to conditions of unbalanced hydrostatic head and can slough, boil and cave in during temporary excavation work.

REFERENCES

- OPSS 517 Construction Specification for Dewatering of Pipeline, Utility, and Associated Structure Excavation
- OPSS 518 Construction Specification for Control of Water from Dewatering Operations

SUBMISSION AND DESIGN REQUIREMENTS

Written details for the proposed dewatering system shall be submitted to the Contract Administrator for information purposes a minimum of ten business days prior to commencing dewatering operations. The Contractor shall reference borehole logs included in the Contract Documents as a guide in determining requirements.

CONSTRUCTION

Dewatering System

The Contractor is responsible for the design, installation, operation and maintenance of an adequate dewatering system to lower the groundwater level to at least 1.0 m below the founding level for the replacement culvert, to allow excavation, subgrade preparation and construction in dry conditions.

Operation

A continuous dewatering operation shall be provided to facilitate the installation of the replacement culvert at all times during the work. All components of the dewatering system shall be maintained in an effective, functioning and stable condition at all times during the work. Notwithstanding the above, the work shall be completed in accordance with the environmental and operational constraints specified elsewhere in the contract.

Restoration

All equipment and materials placed shall be removed from the right-of-way upon the completion of the work and all areas disturbed as part of this work shall be restored to their preconstruction conditions, unless specified otherwise.

BASIS OF PAYMENT

Payment at the contract price for the above tender item shall be full compensation for all labour, equipment and material to do the work.

