REPORT ON

Additional Geotechnical Investigation Program Capital Region Resource Recovery Centre (CRRRC) Ottawa, Ontario

Submitted to:

Taggart Miller Environmental Services

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1.0 INTRODUCTION

This report presents the results of a geotechnical investigation carried out for the proposed buildings/facilities to be located at the north end of the Capital Region Resource Recovery Centre (CRRRC) site (Site), south of Highway 417 and west of Frontier Road in Ottawa, Ontario.

The purpose of the geotechnical investigation was to assess the general soil and groundwater conditions across the site. Based on an interpretation of the factual information obtained, along with existing data available for the site, engineering guidelines on developing this portion of the site, including (but not limited to) the feasible foundation systems (and associated design parameters) for the various proposed structures, the permissible grade raises as well as the various proposed infrastructure (i.e., pavements, site servicing) are provided. In addition, the geotechnical investigation was undertaken to meet the requirements for Site Plan Control approval and building permit applications for the various structures, where the level of investigation meets the requirements of City of Ottawa's "*Geotechnical Investigation and Reporting Guidelines for Development Applications in the City of Ottawa*".

The reader is referred to the "Important Information and Limitations of This Report", which follows the text but forms an integral part of this document.

2.0 DESCRIPTION OF PROJECT AND SITE

2.1 General

The proposed CRRRC Site is located east of Boundary Road, just southeast of the Highway 417/Boundary Road interchange, on Lots 22 through 25, Concession XI, in the former Township of Cumberland. The property is east of an existing industrial park, north of Devine Road and west of Frontier Road and totals approximately 192 hectares in area.

The land use surrounding the CRRRC Site is primarily a mixture of commercial/industrial and agricultural. The agricultural land use is found immediately east of the CRRRC Site, as well as to the southeast, south and southwest; however, areas of undeveloped (i.e., heavily vegetated) land generally exists between the CRRRC Site and the agricultural lands in these directions. The industrial land use is found to the west and northwest of the CRRRC Site. Residential development in the vicinity of the CRRRC Site is limited to some houses mixed in with the commercial/industrial uses along Boundary Road.

The area of the current investigation is located in the northern portion of the CRRRC Site, where numerous buildings/facilities are being proposed, and covers an area of about 55 hectares (see Site Grading Plan, Figure 1). The area is currently undeveloped and relatively flat with existing elevations varying from about 75.0 to 77.5 metres.

The proposed development shown on Figure 1 consists of numerous buildings and infrastructure including the following:

- Heavily loaded structures: The proposed C&D processing facility, materials recovery facility, leachate pre-treatment building/geotube shelter (greenhouse), and secondary digester. These structures are expected to be heavily loaded and will likely need to be supported on deep/piled foundations with structural slabs;
- Moderately loaded structures: The proposed organic pre-processing building and maintenance garage. These structures are expected to be moderately loaded and will likely need to be supported on either deep/piled foundations or raft slab foundations;

- Lightly loaded buildings: The proposed administration building, scale houses, PHC soil storage building, and flare power generation building. These structures are expected to be relatively lightly loaded and could likely be supported on shallow spread footing foundations or raft foundations;
- Large pads for processing compost and PHC soils;
- A retaining wall for the clean load and small vehicle drop off area;
- Site servicing and surface water ponds; and,
- Road widening and pavement design for various access roadways within the facility.

2.2 Previous Geotechnical Investigation

Golder Associates Ltd. (Golder) completed an overall broad-scale geotechnical and hydrogeological investigation for the proposed CRRRC facility in 2013. The primary focus of that investigation was to assess the general characteristics of the subsurface conditions that underlie the CRRRC Site, provide geotechnical and hydrogeological input for the preliminary facility design, and to assist with the MOECC environmental permitting/approvals. The results of that investigations are summarized in the following report:

- "*Volume III, Geology, Hydrogeology and Geotechnical Report Capital Region Resource Recovery Centre*", dated December 2014 (Report No. 12-1125-0045/4500).

Based on the existing subsurface information, the subsurface conditions across the CRRRC Site consist of about 0.05 to 0.3 metres of topsoil/peat underlain by about 0.3 to 2.7 metres of surficial sand and silt, overlying between about 26 to 37 metres of compressible and soft silty clay. The upper 0.1 to 1.3 metres of the clay deposit at most locations has been weathered to a red brown crust and has a stiffer consistency. Within the upper portion of the underlying unweathered silty clay, to depths of about 2.7 to 5.5 metres below ground surface, a 0.1 to 0.6 metre thick continuous silty layer crosses the CRRRC Site. The unweathered silty clay generally has a soft consistency to about 9 to 10 metres depth, followed by a firm consistency to about 15 to 18 metres depth, and is stiff to very stiff below that. The silty clay is underlain by loose to very dense glacial till that ranges from about 2 to 9 metres in thickness. The bedrock surface (Carlsbad Formation limestone and shale) was encountered beneath the glacial till deposit at depths between about 33 and 41 metres.

2.3 Test Fill Program

A geotechnical test fill program was implemented in 2015 for the purposes of validating the compressibility of the underlying silty clay soils.The test fill program included construction of two test fill pads on the compressible silty clay soil within the northern portion of the CRRRC Site (see Figure 2) and monitoring of the test fill settlements. Monitoring the actual settlements due to fill placement provided additional data on the compressibility of the silty clay deposit underlying the CRRRC Site at a much larger scale than possible on laboratory specimens.

The information obtained allowed for the refined assessment of the allowable grade raises for site development, refinement of numerical settlement models, and design of the preload/surcharge measures. The material used to construct the test fill pads was silty clay soil from nearby sources (i.e., 82 Range Road in Ottawa). The test fill pads were constructed in stages with side slopes of approximately 2 horizontal to 1 vertical (2H:1V) with square base dimensions of about 36.0 and 39.2 metres at Test Fill Pads 1 and 2, respectively. The following table indicates the maximum thicknesses of fill for each stage of test fill pad construction and the date of fill placement. At each stage the wet unit weight of the silty clay fill was measured at various locations across the newly placed fill. The average unit wet weight of each stage is summarized in the following table:

Table 2.1: Summary of Test Fill Pad Construction Staging

Embankment / Base Elevation (m)	Stage No.	Average Wet Unit Weight (kN/m^3)	Lift Thickness (m)	Maximum Test Fill Pad Elevation (m) / Height (m)	Date of placing the fill
Test Fill Pad 1 / 76.20	1	17.4	0.5	76.70 / 0.50	February 4, 2015
	2	17.6	0.41	77.11 / 0.91	February 6, 2015
	3	17.6	0.54	77.65 / 1.45	February 9, 2015
	4	17.3	0.05	77.70 / 1.50	February 11, 2015
	5	17.2	0.30	77.73 / 1.53	January 29, 2016
Test Fill Pad 2 / 76.15	1	18.4	0.40	76.55 / 0.40	December 15, 2014
	2	17.0	0.80	77.35 / 1.20	February 3, 2015
	3	17.9	0.38	77.73 / 1.58	February 5, 2015
	4	19.2	0.54	78.27 / 2.12	February 10, 2015
	5	17.4	0.14	78.41 / 2.26	February 11, 2015

In each test fill pad, three settlement plates (SP) were installed within the fill. Baseline measurements were taken prior to the fill placement, and subsequently at periodic intervals of time after completion of the fill placement for Stage Nos.4 and 5 for Test Fill Pads 1 and 2, respectively.

The SP's were installed on the native soil below frost level, one in the center and two at 5 metres offset from the center of each test fill pad. Figure 4 provides a summary of the settlement monitoring results.

2.4 Regional Seismicity

As delineated in "*The Physiography of Southern Ontario*[1]", this section of Highway 417 lies on the boundary of the minor physiographic regions known as the Ottawa Valley Clay Plain and the Russell and Prescott Sand plain, which lies within the major physiographic region of the Ottawa-St. Lawrence Lowland.

The Ottawa Valley Clay Plain region is characterized by relatively thick deposits of sensitive marine clay, silt and silty clay that were deposited within the Champlain Sea basin. These deposits, known as the Champlain Sea clay or Leda clay, overlie relatively thin, commonly reworked glacial till and glaciofluvial deposits, that in turn overlie bedrock[2].The Russell and Prescott Sand Plains are generally characterized by a sand mantle about 3 to 5 m thick overlying an extensive deposit of sensitive marine clay deposited within the Champlain Sea basin, underlain by glacial till and shale bedrock.

This region is underlain by a series of sedimentary rocks, consisting of sandstones, dolostones, limestones and shales that are, in turn, underlain at depth by bedrock of Carlsbad Formation.

The site falls within the Western Québec (WQ) seismic zone according to the Geological Survey of Canada. The WQ seismic zone constitutes a large area which encompasses the urban areas of Montreal, Ottawa-Hull and

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[1] Chapman, L. J. and Putnam, D. F., 1984. *The Physiography of Southern Ontario*, Ontario Geological Survey. Special Volume 2, Third Edition. Accompanied by Map P.2715, Scale 1:600,000. Ontario Ministry of Natural Resources.

[2] Belanger, J.R. "Urban Geology of Canada's National Capital Area", in *Urban Geology of Canadian Cities*, Geological Association of Canada Special Paper 42, Ed. P.F. Karrow and O.L. White, 1998.

Cornwall. Within the WQ seismic zone recent seismic activity has been concentrated in two subzones; one along the Ottawa River and another more active subzone along the Montreal-Maniwaki axis. The two major earthquakes in the WQ seismic zone includes the 1935 Témiscaming event which had a magnitude (i.e., a measure of the intensity of the earthquake) of 6.2, and the 1944 Cornwall-Massena event which had a magnitude of 5.6.

3.0 PROCEDURE

The fieldwork for the current investigation was carried out between December 18, 2017 and February 8, 2018. At that time, 40 test holes were advanced within the building/facility and infrastructure areas, as shown on the attached Test Hole Location Plan, Figure 2. The CRRRC Site investigation methodology applied during the current subsurface investigation is outlined below:

- Four boreholes were advanced along the proposed main access roadway at approximately 150 metre spacings to depths of about 4.3 to 4.9 metres below present ground surface. Six deep boreholes and eight very deep boreholes were also put down across the site. The deep boreholes were advanced through the overburden soils to depths of about 10 metres below the existing ground surface. The very deep boreholes were advanced through the overburden to the bedrock surface at depths of about 29.2 to 40.0 metres below the existing ground surface. The bedrock was then cored in the very deep boreholes an additional 1.6 to 3.4 metres using HQ-size coring equipment.

- The boreholes were advanced using a track-mounted continuous flight hollow-stem auger drill rig, supplied and operated by Forage Greenville Drilling of Ottawa, Ontario. Wash boring techniques were used to advance the very deep boreholes into bedrock. Standard penetration tests (SPTs) were carried out in the boreholes at regular intervals of depth and samples of the soils encountered were recovered using split spoon sampling equipment. In situ vane testing was carried out where possible in the cohesive deposits to assess the undrained shear strength of these soils. In addition, fifteen relatively undisturbed 73 millimetre diameter thin walled Shelby tube samples of the silty clay were obtained from the boreholes using a fixed piston sampler. The very deep boreholes were backfilled with bentonite-cement grout within the bedrock and bentonite mixed with soil cuttings in the overburden.

- Nilcon *in situ* vane profiles were completed at nine borehole locations within the study area. At these locations the boreholes were first drilled through the surficial silty sand and/or upper silty clay to depths of between about 1.0 and 2.1 metres, to reach the native unweathered silty clay. Below that depth, an electric Nilcon *in situ* vane testing apparatus was advanced, with measurements taken at either 0.5 or 1.0 metre depth intervals. This vane testing was carried out under conditions of a constant rate of rotation (consistent with ASTM D2573). The undrained shear strength of remoulded silty clay was also typically measured (to assess sensitivity of the clay) at approximately one of every three to five test intervals. The Nilcon vane testing was typically advanced to a depth of about 10 metres below the existing ground surface. In the remaining boreholes and at greater depths, in situ vane testing was completed using the MTO ‘N’ vane.

- Thirteen Cone Penetration Tests (CPTs) were advanced within the study area. The CPT consists of a probe with a cone shaped tip that is equipped with electronic sensing elements to continuously measure tip resistance and local side friction on a sleeve behind the tip, as well as pore water pressure (Type I). The cone is pushed at a constant rate into the ground using a drill rig (consistent with ASTM D5778-12). A continuous stratigraphic profile together with engineering properties, such as strength, behaviour stress history and density, can be interpreted from the results of the CPT. The CPTs were advanced through the upper silty clay to up to depths of about 10 metres. The CPTs were advanced using a drill rig supplied and operated by the Stratum CPT of Grenville, Quebec and the data obtained interpreted by Golder staff.

The field work was supervised by members of engineering staff who located the test holes in the field, directed the drilling, sampling, and in situ testing operations, and logged the test holes and took custody of the soil and bedrock samples retrieved. Upon completion of the drilling operations, samples of the soil and bedrock obtained in the boreholes were transported to our laboratory for future examination by the project engineer and for laboratory testing. The testing included water content determinations, Atterberg Limit testing, grain size distribution tests, and oedometer consolidation testing. Unconfined compressive strength (UCS) testing was also carried out on four samples of the bedrock core.

Four soil samples were selected and submitted to Eurofins Environment Testing for basic chemical analyses related to potential sulphate attack on buried concrete elements and corrosion of buried ferrous elements.

The test hole locations were selected, picketed, and surveyed in the field by Golder. The test hole locations and elevations were surveyed using a Trimble R8 Global Positioning System (GPS) unit. The test hole locations in Universal Transverse Mercator (UTM) NAD 83, Zone 18 ground surface elevations referenced to geodetic datum (CGVD28) and drilled depths are summarized in the following table. Northing and easting grid coordinates are also summarized below as well as shown on the Record of Borehole sheets.

Table 3-1: Summary of Test Hole Locations - Current Investigation

Test Hole Number	UTM ZONE 18 Northing (m)	UTM ZONE 18 Easting (m)	Ground Surface Elevation (m) (CGVD28)	Test hole Depth (m)	Description Of Test Hole Type			
					Very Deep Borehole	Deep Borehole	Nilcon Vane Test Hole	CPT Test Hole
17-01	5020936.4	465673.3	77.3	4.9		x		
17-02	5020989.8	465813.1	77.5	4.9		x		
17-03	5021042.5	465953.7	77.5	4.3		x		
17-04	5021108.2	466090.6	76.3	4.4		x		
17-05	5021093.1	465937.9	76.3	9.6		x	x	
17-06	5021145.7	465895.4	76.5	10.0				x
17-07	5021228.9	465864.4	76.3	32.5	x			
17-08	5021301.7	465837.2	76.1	9.8		x	x	x
17-09	5021391.2	466055.7	76.6	33.1	x			
17-10	5021315.6	466081.9	76.5	10.0				x
17-11	5021417.6	466129.1	76.6	10.0				x
17-12	5021345.5	466151.3	76.6	10.0			x	
17-13	5021450.3	466217.9	76.4	10.0			x	
17-14	5021390.9	466243.5	76.6	36.9	x			
17-15	5021504.2	466348.8	76.0	10.0				x
17-16	5021443.0	466364.6	76.1	10.0				x
17-17	5021538.5	466440.9	76.3	38.5	x			
17-18	5021496.1	466456.3	76.0	9.8		x	x	x
17-19	5021502.5	466517.0	76.0	10.0		x		
17-20	5021491.3	466569.2	76.0	10.0			x	

Test Hole Number	UTM ZONE 18 Northing (m)	UTM ZONE 18 Easting (m)	Ground Surface Elevation (m) (CGVD28)	Test hole Depth (m)	Description Of Test Hole Type			
					Very Deep Borehole	Deep Borehole	Nilcon Vane Test Hole	CPT Test Hole
17-21	5021375.1	466666.3	76.5	10.0	x			
17-22	5021314.9	466705.5	76.5	39.9				x
17-23	5021218.7	466509.0	76.4	9.8	x			
17-24	5021172.5	466473.4	76.0	9.7		x	x	x
17-25	5021082.8	466539.8	76.3	10.0				x
17-26	5021036.3	466558.2	76.3	10.0	x			-
17-27	5021055.7	466466.9	76.3	41.5			x	-
17-28	5021008.7	466486.9	76.0	10.0				x
17-29	5021029.1	466400.2	76.2	41.9	x			
17-30	5020966.5	466404.0	76.0	10.0		x	x	x
17-31	5020957.7	466330.6	76.0	10.0				x

In addition, eleven test holes were advanced within the current investigation area as part of the previous investigation in 2014. The locations of the previous test holes are shown on Figure 2. The northing and easting grid coordinates, ground surface elevation, and drilled depth are summarized in the table below as well as shown on the Record of Borehole sheets in Appendix B.

Table 3-2: Summary of Test Hole Locations - Previous Investigation

Test Hole Number	UTM ZONE 18 Northing (m)	UTM ZONE 18 Easting (m)	Ground Surface Elevation (m) (CGVD28)	Test hole Depth (m)	Description Of Test Hole Type							
					Very Deep Borehole	Deep Borehole	Nilcon Vane Test	CPT Test Hole	Monitoring Well	VSP	Direct Push	Shelby Tube
12-3	5021578.5	466670.9	76.1/76.3	1.5/45.4	x	x	x	x	x		x	x
12-4	5020872.7	466523.2	75.9/76.0	1.6/43.6	x	x	x	x	x		x	x
13-5	5021083.2	466176.3	76.4/76.5	1.5/40.3	x	x	x	x	x			
13-8	5021436.7	466032.3	76.4	1.5/7.6		x		x	x			
13-9	5021536.1	466347.6	76.1	1.5/7.6		x		x	x			
13-10	5021244.4	466453.0	76.4/76.5	1.5/7.6		x		x	x			
13-11	5021059.0	466865.2	76.0	1.5		x		x	x			
13-12	5020785.0	466278.4	76.2/76.3	1.5/7.6		x		x	x			

Test Hole Number	UTM ZONE 18 Northing (m)	UTM ZONE 18 Easting (m)	Ground Surface Elevation (m) (CGVD28)	Test hole Depth (m)	Description Of Test Hole Type							
					Very Deep Borehole	Deep Borehole	Nilcon Vane Test	CPT Test Hole	Monitoring Well	VSP	Direct Push	Shelby Tube
13-13	5021366.3	466752.5	76.2	1.5		x		x	x			
13-1 (A13-1)	5020863.8	465500.4	77.2	3.1		x						
13-2 (A13-2)	5020876.6	465535.5	77.5	3.1		x						

Vertical Seismic Profile (VSP) testing was completed as part of the previous investigation at the CRRRC Site in 2014. The results of that testing are summarized in a technical memorandum provided in Appendix H.

4.0 SUBSURFACE CONDITIONS

4.1 General

Information on the subsurface conditions is provided as follows:

- The subsurface conditions encountered in the boreholes along with the results of the in situ vane testing are shown on the Record of Borehole sheets in Appendix A. The results of the water content and Atterberg limit testing are also indicated on the Record of Borehole sheets.
- The Record of Borehole sheets from the previous 2014 investigation in area of the current investigation are provided in Appendix B.
- The CPT profiles for normalized cone resistance with an interpreted profile of the stratigraphy are provided in Appendix C.
- The results of grain size distribution testing carried out on selected soil samples are shown on Figures D1 to D3 provided in Appendix D.
- The results of Atterberg limit tests carried out on selected silty clay samples are shown on Figure D4 in Appendix D
- The results of oedometer consolidation tests on selected silty clay samples are provided on Figures D5 to D12 in Appendix D.
- The UCS test results on selected bedrock core samples are shown on Figure D13, also in Appendix D.
- The results of the basic chemical analyses are provided in Appendix E.
- A summary of the undrained shear strength profiles interpreted from the CPTs as well as the measured undrained shear strength from the Nilcon vane testing are provided on Figures 5 and 6, respectively.
- A summary of the sensitivity of the silty clay is provided on Figure 7.
- A summary of the undrained shear strength profiles interpreted from the CPTs based on correlation with the measured undrained shear strengths measured from the Nilcon vane testing are provided on Figures F1 to F13 in Appendix F.
- Photographs of the core recovered from underlying bedrock are shown in Appendix G.

The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from observations of drilling progress, non-continuous sampling and CPT measurements and, therefore, represent transitions between soil and rock types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the test hole locations. In general, the subsurface conditions on this site consist of topsoil/peat/fill underlain by a thin layer of surficial sand, overlying a thick deposit of compressible and soft silty clay. The silty clay is underlain by glacial till, followed by interbedded shale and limestone bedrock.

The following sections present a more detailed overview of the subsurface conditions on this site. In the following discussion, emphasis is placed on the subsurface conditions indicated in the boreholes from the present investigation. The relevant boreholes from 2014 investigations were, in some cases, advanced beyond the structure/facility footprints of the current investigation area. The results of relevant boreholes from the 2014 investigation are referenced herein only in regard to the bedrock surface elevation and groundwater conditions.

4.2 Overburden Summary

The general overview of the overburden condition encountered in the boreholes from the additional geotechnical investigation on the site is summarized in the following table. In addition, a more detailed description is provided in the following sections.

Table 4-1: Summary of Overburden Conditions

Deposit/ Structure Description	Boreholes	Deposit/ Structure Thickness (m)	Deposit/ Structure Surface Elevation (m)	N Values or Su	Laboratory Testing
				Relative Density or Consistency[1]	
Fill-Silty Sand and Clayey Silt, some gravel, contains organic matter	17-01 to 17-03	2.3 to 3.1	77.3 to 77.5	N= 2-37; Very loose to dense	w = 10 to 16%
Topsoil	17-05,17-08,17-09, 17-17, 17-18, 17-19, 17-21, 17-23, 17-24, 17-26, 17-29, and 17-30	0.08 to 0.3	76.0 to 76.6	-	-
Surficial Sand, Silty Sand, and Sandy Silt	17-04, 17-05, 17-07, 17-08, 17-09, 17-14, 17-17, 17-18, 17-19, 17-21, 17-23, 17-24, 17-26, 17-29,17-30	0.6 to 3.1	75.7 to 76.6	N= WH-18; Very loose to compact	w = 17 to 61% 4 – M (Fig. D1) 1 – CHEM (App. E)
Silty Clay to Clay	All deep 2 and very deep boreholes	1.8 to 34.7	76.0 to 73.5	Su=9 to >96 kPa (Figures 5 – 6) Very soft to stiff	w = 34 to 105% 18 – AT (Fig. D4) 8 – Oed (Fig.D5 to D12) 1 – CHEM (App. E)

Deposit/ Structure Description	Boreholes	Deposit/ Structure Thickness (m)	Deposit/ Structure Surface Elevation (m)	N Values or Su	Laboratory Testing
				Relative Density or Consistency¹	
Glacial Till	17-07, 17-09, 17-14, 17-17, 17-21, 17-23, 17-26, 17-29	1.1 to 6.8	38.8 to 53.7	N= 11 to >50; Compact to very dense	w = 7% to 16% 3 – M (Fig. D3) 2 – CHEM (App. E)

Notes:

[1] = For the upper 10 metres of the clay deposit, the consistency results are representative of in situ Nilcon vane testing, where the lower 10 metres results are representative of the in situ N vane testing

[2] = The clay deposit was not fully penetrated in the deep boreholes

N = SPT ‘N’-value; number of blows for 0.3 m of penetration; WH = Weight of hammer.
Su = Undrained shear Strength (kPa)
w = Natural Moisture Content (%)
AT = Atterberg limit testing
Oed = Oedometer Consolidation tests
M = Sieve analysis
CHEM = Basic Chemical Analyses

4.2.1 Fill

Fill exists at the ground surface at boreholes 17-01 to 17-03 advanced along the proposed main access roadway. The fill consists of silty sand, sandy silt and clayey silt, some gravel and contains organic matter. The fill was fully penetrated in these boreholes and varies from about 2.3 to 3.1 metres in thickness (i.e., elevations 74.2 to 75.2 metres). SPT ‘N’ values obtained within this material generally range from about 1 to 37 blows per 0.3 metres of penetration indicating a very loose to dense state of packing. The measured water content on selected samples of the fill ranges from approximately 10 to 16 percent.

4.2.2 Topsoil

Topsoil exists at ground surface at boreholes 17-05, 17-08, 17-09, 17-17, 17-18, 17-19, 17-21, 17-23, 17-24, 17-26, 17-29, and 17-30, with thicknesses of about 80 to 300 millimetres.

4.2.3 Surficial Silty Sand

Surficial silty sand was encountered at the ground surface or beneath the topsoil at all the boreholes with the exception of boreholes 17-01 to 17-03. This deposit extends to about 0.7 to 3.1 metres depth below the existing ground surface (i.e., elevations 73.5 to 75.8 metres). SPT ‘N’ values obtained within the silty sandy soils generally range from weight of hammer to 18 blows per 0.3 metres of penetration indicating a very loose to compact state of packing.

The measured natural water contents on selected samples of this deposit range from about 17 to 61 percent. The results of grain size distribution testing on four samples of this material are shown on Figure D1 in Appendix D.

4.2.4 Silty Clay

The fill and surficial silty sand are underlain by a thick deposit of sensitive silty clay to clay. The silty clay deposit was fully penetrated at all the very deep boreholes (17-07, 17-09, 17-14, 17-17, 17-21, 17-23, 17-26, and 17-29) and is about 21.8 to 34.7 metres in thickness, extending to about 22.6 to 37.5 metres depth below the existing ground surface (i.e., elevations 38.8 to 53.7 metres). At the deep boreholes (17-01, 17-02, 17-03,17-04, 17-05, 17-08, 17-09, 17-18, 17-19, 17-24, and 17-30) the clay deposit was not fully penetrated but was proven to extend to depth up to about 9.1 metres below the ground surface.

The upper 0.6 metres to 1.1 metres of the silty clay at boreholes 17-01, 17-03, 17-05, 17-07, 17-08, 17-09, and 17-30 has been weathered to a red brown crust (referred to as ‘weathered crust’). Layers and seams of silty sand, sand and clayey silt were also encountered within the weathered portion of the silty clay deposit. SPT ‘N’ values obtained within the weathered material generally range from weight of hammer to 5 blows per 0.3 metres of penetration indicating a stiff to firm consistency (based on local experience with correlations to undrained shear strength).

The measured natural water contents of selected samples of the weathered crust ranged from about 40 to 87 percent.

The silty clay below the surficial silty sand or weathered crust (where present) is unweathered. The results of *in situ* Nilcon vane testing in the upper 10 metres of this unweathered material gave undrained shear strengths ranging from about 9 to 50 kilopascals (kPa), generally increasing with depth. These results indicate a generally very soft to firm consistency to about 10 metres depth in the deposit. One higher undrained shear strength of 74 kPa was measured in borehole 17-08N within this deposit a depth of about 3 metres below the existing ground surface. However, this value likely reflects the presence of a sand and silt layer, rather than the stiffness of the silty clay. The results of the Nilcon vane testing are summarized on the Record of Borehole sheets in Appendix A as well as provided on Figure 6.

Undrained shear strength profiles of the upper 10 metres of silty clay have also been evaluated from the results of the CPTs, using the following equation:

$$S_u = (q_t - \sigma_{vo}) / N_{kt}$$

Where: S_u = Calculated undrained shear strength (kPa);

q_t = Measured net tip resistance (kPa);

σ_{vo} = Calculated total vertical stress (kPa);

N_{kt} = Correlation factor, a value of 15 to 20 was used based on correlations with Nilcon vane testing results.

The undrained shear strength profiles for the silty clay, interpreted from the results of the CPTs, as described above, are summarized on Figure 5. In general, the assumed N_{kt} correlation factors increase with depth.
The interpreted undrained shear strength profiles from the CPTs along with the results of the Nilcon vane testing are also shown on Figures F1 to F13 in Appendix F. The CPT results indicate undrained shear strengths that are generally consistent with the *in situ* Nilcon vane testing results.

In situ shear vane testing carried out where possible in the very deep cored boreholes within this deposit measured undrained shear strengths of 9 to greater than 95 kPa, indicating generally a very soft to stiff consistency, generally increasing with depth. The higher undrained shear strengths within the upper portion of this deposit may reflect the presence of sand and silty layers.

The calculated sensitivity ratio, based on remoulded shear strengths of 1 to 36 kPa in this deposit, from range about 1 to 25, indicating a very sensitive material in accordance with the CFEM[3].

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[3] Canadian Geotechnical Society., 2006. Canadian foundation Engineering Manual. Richmond, B.C., Fourth Edition.

The measured water contents of samples of the unweathered silty clay were between about 34 and 105 percent. However, more generally, the following observations are made:

- The water content above about 20 metre depth is typically in the range of 50 to 85 percent; and,
- The water content below about 20 metre depth is slightly less (i.e., typically in the range of 40 to 65 percent).

The results of Atterberg limit testing carried out on several samples of the unweathered silty clay gave plasticity index values generally ranging from about 25 to 59 percent and liquid limits values from about 41 to 85 percent. These results indicate an intermediate but more typically high plasticity deposit. These values are summarized on Figure D4 in Appendix D. The natural water content is generally at or above the measured liquid limit.

Oedometer consolidation testing was carried out on eight thin-walled Shelby tube samples of the unweathered silty clay. The results of that testing are provided on Figures D11 to D18 in Appendix D and are summarized in Table 4-2 below.

Table 4-2: Summary of Oedometer Consolidation Tests

Borehole/ Sample Number	Sample Depth/Elevation (m)	Unit Weight (kN/m^3)	σ_P' (kP)	Cc	Cr	e_o	OCR	Wn (%)	WL %)	PI (%)
17-05/3	2.4/73.9	14.2	65	4.45	0.0183	2.87	2.6	105	74	53
17-05/6	6.4/69.9	15.2	80	3.00	0.0166	2.24	1.7	82	60	40
17-08/5[1]	5.0/71.1	17.3	60	0.72	0.0083	1.29	1.3	47	85	59
17-08/7	7.5/68.6	15.1	80	2.73	0.0100	2.24	1.4	81	67	41
17-19/7	6.2/69.8	16.0	67	1.32	0.0100	1.76	1.3	64	62	42
17-24/4	3.1/73.3	15.6	64	1.67	0.0066	1.93	1.9	70	51	35
17-30/5	4.7/71.3	15.7	65	1.17	0.0149	1.93	1.6	70	41	25
17-30/9	9.9/66.1	16.0	112	2.33	0.0050	1.78	1.5	64	70	47

Notes:
[1] – Probability of a silty layer in sample
σ_P' – Apparent preconsolidation pressure
σ_{VO}' - Computed existing vertical effective stress
Cc - Compression index
Cr - Recompression index
e_o - Initial void ratio
OCR - Overconsolidation ratio
Wn - Natural moisture content
WL - Liquid limit
PI - Plasticity index

A continuous layer of sandy silt to silty sand was encountered within the upper portion of the silty clay at depths between about 2.7 and 5.5 metres (referred to as the silty layer). This layer was observed both within the sampled boreholes as well as from the results of the CPTs and varies in thickness from about 0.1 to 0.6 metres.

The results of grain size distribution testing carried out on one sample of this silty layer were shown on Figure D2 in Appendix D.

4.2.5 Glacial Till

A deposit of glacial till was encountered below the silty clay at the very deep borehole locations (17-07, 17-09, 17-14, 17-17, 17-21, 17-23, 17-26, 17-29) at depths between about 22.6 to 37.5 metres below the existing ground surface (i.e., elevations 38.8 to 53.7 metres). The till consists of a heterogeneous mixture of gravel, cobbles, and boulders in a matrix of sandy silt with some clay. This deposit was fully penetrated to depths between about 29.4 and 40.5 metres below the existing ground surface with the thickness ranging from about 1.1 to 6.8 metres.

SPT 'N' values obtained within the glacial till generally range from 11 to greater than 50 blows per 0.3 metres of penetration indicating a compact to very dense state of packing. However, the higher SPT 'N' values encountered in the glacial till may reflect the presence of cobbles and boulders in the deposit.

The measured natural water content on selected samples of the glacial till ranges from approximately 7 to 16 percent. The results of grain size distribution testing carried out on three samples of this deposit are shown on Figure D3 in Appendix D. However, it should be noted that the samples were retrieved using a 35-millimetre inside diameter sampler and therefore the results do not reflect the boulder, cobble or full gravel content.

4.3 Bedrock

The bedrock encountered at site consists of the shaley member of the Carslbad formation consisting of grey to dark grey, thinly to medium bedded shale with dolomite, limestone and calcareous shale interbeds.

The bedrock surface was encountered at depths ranging from about 29.4 to 40.5 metres below the existing ground surface (i.e., elevations 46.9 to 35.6 metres) at the very deep boreholes (17-07, 17-09, 17-14, 17-17, 17-21, 17-23, 17-26, 17-29). These boreholes were advanced 1.6 to 3.4 metres into the bedrock using diamond drilling techniques.

Photos of the bedrock core obtained during the current investigation are provided on Figures G1 to G18 in Appendix G.

The following table summarizes the bedrock surface depths and elevations as encountered at the boreholes as part of the current and previous investigations.

Table 4-3: Summary of Cored Bedrock Boreholes

Borehole Number	Ground Surface Elevation (m)	Depth to Bedrock Surface (m)	Bedrock Surface Elevation (m)
17-07	76.3	29.4	46.9
17-09	76.6	30.0	46.6
17-14	76.6	35.3	41.3
17-17	76.3	35.1	41.2
17-21	76.1	40.5	35.7
17-23	76.5	37.8	38.7
17-26	76.3	38.6	37.7
17-29	76.2	40.0	36.2
12-3	76.2	39.8	36.4
12-4	75.9	37.8	38.1
13-5	76.5	34.2	42.3

Surface elevation contours of the Carlsbad Formation bedrock within the study area using data from the current and 2014 investigations are shown on Figure 3.

Rock Quality Designation (RQD) values measured on the recovered bedrock core samples ranged from about 0 to 100 percent but more generally between 40 to 75 percent indicating a poor to good quality rock. The lowest RQD value was measured within the upper 0.35 metres of the bedrock in borehole 17-17. The result of four unconfined compressive strength tests on selected samples of the bedrock are presented on Figure D13 in Appendix D. The results range from about 97 to 229 MPa and indicate a strong to very strong bedrock.

4.4 Groundwater

Monitoring wells and standpipe piezometers were not installed as part of the current investigation. However, a groundwater level monitoring program was instituted within selected on-site boreholes as part of the previous investigations starting in January 2013. Reference should be made to the previous investigation (i.e., Report No. 12-1125-0045/4500/vol III) for details regarding the monitoring well installations and the groundwater level monitoring program. The initial and the most recent groundwater level measurement in the monitoring wells located within current investigation area are summarized in the table below.

Table 4-4: Summary of Ground Water Elevations in Monitoring Wells in the Current Study Area

Well Location	Ground Surface Elevation (m)	Material	Groundwater Elevation (m)							
			09-Jan-13	29-Apr-13	17-May-13	06-Jul-15	02-Oct-15	20-Apr-16	26-Nov-16	20-Nov-17
12-3-3	76.2	Bedrock	-	74.48	74.46	74.6	74.59	74.63	74.5	74.67
12-3-4A	76.2	Glacial Till	74.6	74.5	74.5	74.7	74.7	74.8	74.6	74.8
12-3-4B	76.2	Deep Clay	75.8	75.4	75.4	75.3	75.3	75.3	75.3	75.3
12-3-5A	76.2	Middle Clay	frozen	75.5	75.5	75.4	75.4	75.5	75.3	75.5
12-3-5B	76.2	Shallow Clay with Silty Layer	75.6	75.8	75.8	75.8	75.8	75.9	75.7	75.9
12-3-6	76.3	Surficial Sand	75.9	75.8	75.7	75.7	75.6	75.9	76.0	76.0
12-4-3	75.9	Upper Bedrock	-	74.2	74.2	74.4	74.3	74.3	74.2	74.8
12-4-4A	75.9	Glacial Till	-	74.5	74.5	74.6	74.6	74.6	74.5	74.3
12-4-4B	75.9	Deep Clay	-	75.1	75.1	75.5	75.2	75.5	75.4	75.3
12-4-5A	75.9	Middle Clay	-	75.4	75.4	75.4	75.3	75.5	75.2	75.3
12-4-5B	75.9	Shallow Clay with Silty Layer	-	75.7	75.6	75.8	75.6	75.8	75.4	75.6
12-4-6	75.9	Surficial Sand	-	75.8	75.5	75.9	75.6	75.8	75.8	75.8
13-5-3	76.5	Bedrock	-			74.6	74.5	74.6	74.5	74.6
13-5-4A	76.4	Glacial Till	-	74.5	74.5	74.6	74.6	74.5	74.3	74.4
13-5-4B	76.4	Mid Clay	-	74.8	74.7	74.9	74.8	74.9	74.3	75.0
13-5-5	76.4	Shallow Clay with Silty Layer	-	76.1	75.9	75.7	75.6	76.1	75.8	76.1
13-5-6	76.5	Surficial Sand	-	76.0	75.4	75.4	75.7	76.2	75.7	76.3
13-8-2	76.4	Surficial Sand	-	76.4	76.2	75.6	75.6	-	-	-
13-8-3	76.4	Shallow Clay with Silty Layer	-	76.0	76.0	75.9	75.9	-	-	-
13-9-2	76.1	Surficial Sand	-	75.9	75.2	75.2	75.2	75.9	77.2	77.2
13-9-3	76.1	Shallow Clay with Silty Layer	-	75.8	75.6	75.6	75.4	75.9	77.1	77.1
13-10-2	76.4	Surficial Sand	-	75.9	75.3	75.4	75.5	76.0	77.5	77.5

Well Location	Ground Surface Elevation (m)	Material	Groundwater Elevation (m)							
			09-Jan-13	29-Apr-13	17-May-13	06-Jul-15	02-Oct-15	20-Apr-16	26-Nov-16	20-Nov-17
13-10-3	76.5	Shallow Clay with Silty Layer	-	75.8	75.7	75.5	75.8	76.0	77.5	77.5
13-11-2	76.0	Surficial Sand	-	75.9	75.6	75.4	75.3	-	-	-
13-12-2	76.2	Surficial Sand	-	76.1	75.8	75.6	75.6	-	-	-
13-12-3	76.3	Shallow Clay with Silty Layer	-	75.9	75.9	75.9	75.7	-	-	-
13-13-2	76.2	Surficial Sand	-	75.8	75.7	75.6	75.5	-	-	-

As indicated in the table above, the groundwater level varies between about elevations of 74.2 and 77.5 metres. It should be noted that the groundwater levels measurements were not limited to the table above and that a groundwater level monitoring program for on-site monitoring wells is being carried out to further characterize the long-term hydrogeological conditions present at the CRRRC Site. In addition, groundwater levels are expected to fluctuate seasonally. Higher and lower groundwater levels are expected during wet and dry periods of the year.

4.5 Corrosion

Samples of soil from boreholes 17-07, 17-26, and 17-29 were submitted to Eurofins Environment Testing for basic chemical analyses related to potential corrosion of buried steel elements and potential sulphate attack on buried concrete elements. The results of this testing are provided in Appendix E and are summarized below.

Table 4-5: Result of Basic Chemical Analyses

Borehole Number / Sample Number	Sample Depth (m)	Chloride (%)	SO_4 (%)	pH	Resistivity (Ohm-cm)	Material
17-07 / 18	25.9 – 26.5	0.015	0.09	8.8	813	Glacial Till
17-26 / 2	0.76 – 1.4	< 0.002	<0.01	8.8	12,500	Surficial Silty Sand
17-29 / 3	3.0 – 3.7	0.018	0.01	8.6	20,000	Silty Clay
17-29 / 20	35.1 – 35.7	0.157	0.04	9.0	5,880	Silty Clay

5.0 DISCUSSION

5.1 General

This section of the report provides engineering guidelines and recommendations on the geotechnical design aspects of the proposed buildings/facilities at the CRRRC Site to support an application to the City of Ottawa for Site Plan Control approval and building permit applications for the various structures. The recommendations are based on our interpretation of the factual data obtained from the test hole information advanced during the current subsurface investigation as well as the project requirements. The discussion and recommendations presented are intended to provide the building design team with sufficient information to assess the feasible foundation alternatives and to carry out the detail design of the foundations for the individual buildings/facilities. The results and guidelines presented herein are subject to the limitations in the “Important Information and Limitations of this Report” which follows the text of this report. The following guidelines are provided on the basis that the buildings/facilities will be designed in accordance with the 2012 Ontario Building Code (OBC).

5.2 Site Grading

The subsurface conditions on the site generally consist of topsoil/peat/ fill underlain by a thin layer of surficial sand, overlying a thick deposit of compressible sensitive very soft to stiff silty clay extending to at least 23 to 38 metres depth. The upper 0.6 to 1.1 metres of the silty clay deposit at some locations has been weathered to a red brown crust and has a stiff consistency. The underlying silty clay generally has a soft consistency to about 10 to 12 metres depth, followed by a firm consistency to about 16 to 19 metres depth, and is stiff below that.

The “soft to firm” grey silty clay has limited capacity to accept additional load from the weight of grade raise fill and from the foundations of the buildings/facilities without undergoing long-term consolidation settlements. Therefore, to leave sufficient remaining capacity for the silty clay to support these foundations, the thicknesses of grade raise fill will need to be limited to no more than about 1.0 metre based largely on the observations from the test fill program described in Section 2.3.

The results of test fill program indicate the following:

- Less than 25 milimetres of settlement for a 23 kPa loading placed over an area of 36 metres squared (i.e., Pad 1).
- Settlements expected to exceed 50 milimetres for a 28 kPa loading placed over an area of 36 metres squared (i.e., Pad 1).
- Settlements upwards of 120 milimetres for a 34 kPa loading placed over an area of about 39 metres squared (i.e., Pad 2).

The current grading plan shown on Figure 1 indicates grade raises generally consistent with the 1.0 restriction, with only a few areas requiring mitigation (e.g. EPS or surcharge) as outlined below. Grade raise fill should be sands or gravels with a unit weight not exceeding 18 kN/m^3.

If the grading restriction given above cannot be accommodated, the following two options could be considered to lessen the applied load on the silty clay and limit the expected settlements:

- The additional required grade raising (above the limit given above) in some applications/locations on the CRRRC site could be accomplished using expanded polystyrene (EPS) light weight fill. Further discussion of this option is presented in Sections 5.4.3 and 5.4.4.
- The area could be pre-loaded/surcharged and allowed to settle in advance of structure construction. The subgrade settlements would need to be monitored to establish when sufficient settlements had occurred such that structure construction could proceed. To reduce the time required for the pre-loading, it is likely that a temporary surcharge above the existing grade would need to be considered, however in either case the pre-load time could be months or years in duration, but could be reduced with the use of wick drains. Some discussion of this option is presented in Section 5.4.6.

Additional geotechnical guidelines would need to be provided if any of the above options are selected.

As a general guideline regarding the site grading, the preparation for filling of the site should include stripping the topsoil and fill for predictable performance of structures and services. The topsoil is not suitable as engineered fill and should be stockpiled separately for re-use in landscaping applications only. In areas with no proposed structures, services, or roadways, the fill may be left in place provided some settlement of the ground surface following filling can be tolerated.

5.3 Seismic Site Class and Hazards

OBC 2012 requires the use of a time-averaged (harmonic) shear wave velocity (V_S) in the upper 30 metres for determining the appropriate seismic Site Class. The measured shear wave velocities are to be averaged over 30 metres immediately below the bottom of the basement, spread footing foundation or pile caps.

As part of the previous investigation at the CRRRC Site carried out by Golder in 2014, shear wave velocities were measured at two locations across the site. The results of that testing are summarized in technical memorandum provided in Appendix H.

The results indicate average shear wave velocities in the upper 30 metres of subsurface stratigraphy of less than 180 metres per second. In accordance with Section 4.1.8 of the OBC 2012 a Site Class E would be applicable for the seismic design of the buildings at the CRRRC Site. The Site is also underlain by more than 3 metres of clay meeting the criteria listed in Table 4.1.8.4.A of OBC 2012, further reinforcing the Site Class E designation.

In accordance with Table 1.2 of Supplementary Standard SB-1 of the OBC 2012 and based on the location of the Site, the reference Site Class C seismic hazard values modified to the site-specific seismic site classification (i.e., Site Class E) are summarized in the table below.

Table 5-1: Seismic Hazard Values

Seismic Hazard Values	2% Exceedance in 50 years (2,475 return period) (Site Class C)	2% Exceedance in 50 years (2,475 return period) (Site Class E)
PGA (g)	0.320	0.365
Sa (0.2) (g)	0.640	0.788
Sa (0.5) (g)	0.310	0.382
Sa (1.0) (g)	0.140	0.288
Sa (2.0) (g)	0.046	0.095
Sa (10.0) (g)	0.046	0.047

The soils on this site are not considered to be susceptible to liquefaction during seismic events.

5.4 Building Foundations

5.4.1 Overview

As discussed in the preceding section, the silty clay deposit has limited capacity to accept the combined load from site grading fill and foundation loads. Although the surficial sand layer was observed at most of the locations on the site and the upper portion of the silty clay deposit has been weathered to a stiff crust in some locations, the underlying unweathered portions of the deposit are compressible. For these subsurface conditions, the Serviceability Limit States (SLS) bearing resistances for the design of foundations is based on limiting the stress increases on the soft to firm, compressible, grey silty clay at depth to an acceptable level so that foundation settlements do not become excessive. The potential stress increase on the compressible unweathered silty clay is primarily affected by:

- The applied pressures on the foundations and the size (i.e., dimensions) of the footings;
- The thickness of the surficial sand and weathered crust below the underside of the foundations and above the compressible silty clay, through which the foundation loads are distributed;

- The amount of net surcharge in the vicinity of the foundations due to landscape fill, underslab fill, floor loads, etc.; and,
- The effects of groundwater lowering caused by this or other construction.

As indicated previously, it is understood that the overall site development will include the construction of several buildings subjected to various loading conditions. The building loads for the various structures are summarized in Table 5-2 below.

Table 5-2: Summary of Building Foundation Details

Building	Finished Floor Elevation (m)	Proposed Grade Raise (m)	Expected Floor Load (kPa)	Column Load (kN)	Raft Slab Load (kPa) (where an option)
Admin Building	77.50	1.1	< 5	-	~30
Materials Recovery Facility	77.40	0.9	< 25	1,600	N/A
C&D Processing Facility	77.40	1.4	<25	1,600	N/A
Maintenance Garage	76.90	1.0	< 15	-	-
Leachate Treatment Facility	77.00	1.0	< 7	-	-
In-Bound Scale Houses	77.35	1.1	< 5	-	~15
Out- Bound Scale Houses	77.70	0.6	< 5	-	~15
Secondary Scale Houses	77.15	1.0	< 5	-	~15
Truck Tire Wash Facility	76.65	0.5	< 5	-	-
Compost Processing Facility and Storage	77.10	0.9	~ 7	N/A	N/A
Organics Pre-Processing Facility	77.40	1.0	< 15	-	~50
Petroleum Hydrocarbon (PHC) Treatment and Storage Facility	76.90	1.0	~ 30	N/A	-
Clean Load & Small Vehicles Drop-off (Lower Level)	76.60	0.4	N/A	N/A	N/A

Further discussion of the foundation design alternatives is provided in the following sections.

5.4.2 Pile Foundations

It is considered that the heavily and moderately loaded structures will need to be supported on steel pipe piles or H-piles driven to refusal on the bedrock. A piled foundation would transfer the foundation loads through the silty clay and the compact to very dense glacial till deposit, and down to the bedrock surface which appears to range from about 35.7 to 46.9 metres elevation as shown on the bedrock surface contour map (Figure 3). The use of a piled foundation would avoid the structures experiencing any significant total or differential settlement (for both static and seismic loading conditions).

A suitable pile type would be concrete filled steel pipe piles (closed-ended) or H-piles, with the piles end-bearing on bedrock.

A minimum 0.75 metre thick granular working mat should be provided for pile driving equipment to protect the subgrade. The granular pad should consist of 300 millimetres of OPSS Granular B Type II underlain by 450 millimetres of 150 millimetre minus crushed stone. The granular pad should also be underlain by a Class II nonwoven geotextile having an FOS not exceeding 100 microns placed on the subgrade, with overlaps of at least 0.5 metres between rolls.

5.4.2.1 Axial Resistance

As one possible design example, based on a 245 millimetres diameter close-ended steel pipe pile with a wall thickness of 12 millimetres driven to bedrock, an unfactored Ultimate Limit State (ULS) resistance of 2,200 kilonewtons can be developed based on prior PDA testing of similar piles on similar bedrock. The ULS unfactored resistance of a HP 310 x 110 pile driven to bedrock may be taken as 3,000 kilonewtons. In accordance with the 2012 OBC the ULS values given above should be factored using a resistance factor of either 0.4 or 0.5 if PDA testing is carried out or 0.6 with static load testing.

The ULS factored geotechnical resistance of the pile should equal or exceed the structural resistance if the piles are driven to the bedrock, and are installed using an appropriate set criteria and using a hammer of sufficient energy.

For piles end-bearing on or within the bedrock, Serviceability Limit States (SLS) conditions generally do not govern the design since the stresses required to induce 25 millimetres of movement (i.e., the typical SLS criteria) exceed those at ULS. Accordingly, the post-construction settlement of structural elements which derive their support from piles bearing on bedrock should be negligible.

Pipe piles should be equipped with a base plate having a thickness of at least 20 millimetres to limit damage to the pile tip during driving.

Due to their smaller cross section, H-piles might have more success in penetrating the glacial till and reaching the bedrock surface. Pipe piles offer the advantage of creating more lateral stiffness by infilling with concrete but will be more challenging to drive through cobbles/boulders in the glacial till compared to H-Piles, and their stiffness in flexure is less dependent on the direction of loading. However, the integrity of pipe piles following driving may be more readily inspected (by visual examination of the pile interiors) than for H-piles, and therefore damaged piles can be more easily identified.

To avoid reductions in vertical capacity the piles should be driven no closer than 2.5 diameters centre to centre.

The pile termination or set criteria will be dependent on the pile driving hammer type, helmet, selected pile, and length of pile; the criteria must therefore be established at the time of construction and after the piling equipment is known. All of these factors must be taken into consideration in establishing the driving criteria to ensure that the piles will have adequate capacity, but are also not overdriven and damaged. In this regard, it is a generally accepted practice to reduce the hammer energy after abrupt peaking is met on the bedrock surface, and then to gradually increase the energy over a series of blows to seat the pile. If battered piles are considered, the contractor will need to be careful in driving battered piles through the glacial till which consists of cobble/boulders. Therefore, the piles should be reinforced at the tip with standard bearing points to improve seating of the piles on the bedrock and to reduce the potential for damage to the piles during driving through soils that contain boulders. However, it should be expected that some of the piles, both vertical and battered, will be out of allowable tolerance and require assessment.

Relaxation of the piles following the initial set could result from several processes, including:

- Softening of the shale bedrock into which the piles are driven;
- The dissipation of negative excess pore water pressures in the overburden material above the bedrock surface; and,
- The driving of adjacent piles.

Provision should therefore be made for restriking all of the piles at least once to confirm the design set and/or the permanence of the set and to check for upward displacement due to driving adjacent piles. Piles that do not meet the design set criteria on the first restrike should receive additional restriking until the design set is met. All restriking should be performed after 48 hours of the previous set.

Since the piles would be founded on shale bedrock, it is expected that several rounds of restriking could be required. The need for multiple restrikes could be reduced by using a lesser geotechnical capacity for the piles.

It is recommended that dynamic monitoring and capacity testing (known as PDA testing) be carried out (by the contractor) at an early stage in the piling operation to verify both the transferred energy from the pile driving equipment and the load carrying capacity of the piles. As a preliminary guideline, the specification should require that at least 10 percent of the piles be included in the dynamic testing program. CASE method estimates of the capacities should be provided for all piles tested. These estimates should be provided by means of a field report on the day of testing. As well, CAPWAP analyses should be carried out for at least one third of the piles tested, with the results provided no later than one week following testing. The final report should be stamped by a professional engineer licensed in the province of Ontario.

The purpose of the PDA testing will be to confirm that the contractor’s proposed set criteria is appropriate and that the required pile geotechnical capacity is being achieved. It will therefore be necessary for the pile to have sufficient structural capacity to survive that testing, which could require a stronger pile section than would otherwise be required by the design loading.

The foundation and piling specifications should be reviewed by Golder prior to tender and the contractor’s submission (i.e., shop drawings, equipment, procedures, and set criteria) should be reviewed by the geotechnical consultant prior to the start of piling. That submission should include a WEAP (Wave Equation Analysis of Piles) analysis of the driveability of the pile, to the design depth, using the contractor’s selected hammer.

Vibration monitoring should be carried out during pile installation to ensure that the vibration levels at nearby existing structures, if present, are maintained below tolerable levels. A maximum peak particle velocity of 50 millimetres per second is recommended for structures.

Piling operations should be inspected on a full time basis by geotechnical personnel to monitor the pile locations and plumbness, initial sets, penetrations on restrike, and to check the integrity of the piles following installation.

5.4.2.2 Downdrag

Downdrag forces will also be applied to the piles as a result of consolidation settlement of the compressible silty clay layer due to the additional loading imposed from the 1.0 metre grade raise and apply negative skin friction to the pile shaft. The resulting unfactored downdrag loads may be taken as 160 kilonewtons for a 245 millimetre diameter pipe pile and 260 kilonewtons for a HP 310 x 110 pile.

5.4.2.3 Resistance to Lateral Loading-Driven Piles

Lateral loading could be resisted fully or partially by the use of battered piles sloped at 1 horizontal to 12 vertical (1H:12V).

The resistance to lateral loading could also be derived from the soil resistance in front of the piles, and it may be assumed that this resistance will be nearly the same for vertical and inclined piles.

The SLS lateral geotechnical response of the soil in front of the piles under lateral loading may be calculated using subgrade reaction theory where the coefficient of horizontal subgrade reaction, k_h, is based on the equation given below, as described by Terzaghi[4]

For cohesionless soils:

$$k_h = \frac{n_h z}{B}$$

Where: n_h = the constant of horizontal subgrade reaction, as given below;

z = the depth (m); and,

B = the pile diameter/width (m).

For cohesive soils: (Terzaghi, 1955)

$$k_h = \frac{67\, s_u}{B}$$

Where: s_u = the undrained shear strength of the soil (kPa); and,

B = the pile diameter/width (m).

The constant of horizontal subgrade reaction depends on the soil type and soil density/consistency around the pile shaft. For the design of resistance to lateral loads, the values indicated in the table below may be used. The values provided are unfactored geotechnical parameters.

Table 5-3: Pile Foundation Horizontal Subgrade Reaction Parameters

Range of Elevations to Bottom of Soil Layer[1] (m)	Soil Type	n_h (kPa/m)	s_u (kPa)
Pile cap to 73.5	Very loose to compact surficial sand	1.3	-
66.0	Soft silty clay	-	15
61.0	Firm silty clay	-	30
38.8 to 53.7	Firm to stiff silty clay	-	50
35.7 to 46.9	Compact to very dense glacial till	4.4	-

Notes:

[1] The bottom of layer elevations is variable and therefore the most critical combination should be considered, or be evaluated on a location-by-location basis using the nearest borehole record.

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[4] 4Terzaghi, K. “Elevation of Coefficient of Subgrade Reaction”, Geotechnique, V.D. 5, No. 4, 1995, pp.297-326

Group action for lateral loading should be considered when the pile spacing in the direction of the loading is less than six to eight pile diameters. Group action can be evaluated by reducing the coefficient of lateral subgrade reaction or ULS resistance in the direction of loading by a reduction factor as follows:

Table 5-4: Reduction Factors for Pile Group Action under Lateral Loading

Pile Spacing in Direction of Loading (d = Pile Diameter)	Reduction Factor
8d	1.0
6d	0.7
4d	0.4
3d	0.25

The coefficient of horizontal subgrade reaction values calculated as described above may then be used to calculate the lateral deflection of the pile (i.e., the SLS response of the pile), taking into the account the soil-structure interaction.

For establishing the ULS factored *structural* resistance, the shear force and bending moment distribution in the piles under factored loading can be established using these same procedures and parameters for evaluating the SLS response of the pile.

The unfactored ULS static geotechnical resistance to lateral loading for a single pile can be taken as 100 kilonewtons for a 245 millimetres pipe pile and 320 kilonewtons for a HP 310 x 110 pile driven to refusal on bedrock.

The ULS resistance given above are unfactored values. In accordance with the 2012 OBC with a resistance factor of 0.5 should be applied in calculating horizontal resistance. The ULS lateral resistance of a pile group may be estimated as the sum of the individual resistances across the face of the pile group, perpendicular to the direction of the applied lateral force, adjusted for group action as indicated above.

5.4.2.4 Resistance to Lateral Loading - Foundation Walls and Grade Beams

Resistance to lateral loading can also be generated along buried structural elements such as foundation walls and grade beams, as their lateral displacement mobilizes passive resistances. However, soils exposed to freeze-thaw conditions (as discussed in Section 5.7) should not be relied upon to generate passive resistances. Further details related to passive resistances along buried elements is provided in Section 5.5.

5.4.2.5 Resistance to Lateral Loading - Structural Slabs

Resistance to lateral loading can also be generated by the friction between the base and the subgrade of foundation elements subjected to dead and sustained live loads. For structural slabs, the extent of loading will be materially offered by the degree to which the slab deflects and engages with the soil. It should be noted that in such cases any load applied may lead to stresses being transmitted to the underlying compressible silty clay at depth.

The following friction factors can be used in conjunction with dead and sustained live loads.

Table 5-5: Unfactored Friction Coefficient for Slabs

Interface and Loading Condition	Coefficient of Friction
Concrete – Granular A base	0.60
EPS	0.40

The values given above should be factored with a resistance factor of 0.8 as specified in the 2012 OBC.

5.4.3 Raft Foundations

It also considered that certain structures with relatively low floor loads could be supported on a raft slab foundation which would have at least 1.0 metre of EPS lightweight fill under and around the structures. For the Administration Building and Scale Houses, a raft foundation could be designed with a gross SLS bearing resistance of 35 kPa and a factored ULS bearing resistance of 50 kPa. The above SLS resistance should be consistent with total and differential settlements not exceeding about 50 and 25 millimetres.

The SLS resistance corresponds to a settlement resulting from consolidation of the silty clay. Consolidation of silty clay is a process which takes months or longer and, as such, results from sustained loading. Therefore, the foundation loads to be used in conjunction with the SLS resistance given above should be the full dead load plus sustained live load. The factored dead load plus full factored live load should be used in conjunction with the ULS factored bearing resistance.

The raft foundations will need to be sufficiently rigid so that the structure loads will be uniformly distributed over the entire structure footprint, which depends on the relative stiffness between the raft slab and the underlying subgrade. The distribution of the contact stress, the raft slab deflections, and the resulting forces and bending moments in the slab to be used in its structural design could be determined by structural analysis using a modulus of subgrade reaction, k_s, for the subgrade. It should be noted however that the modulus of subgrade reaction is not a fundamental soil property and its value depends, in part, on the size and shape of the loaded area. For the analysis of the contact stress distribution beneath a raft foundation, its value would depend on the size of the areas over which increased/concentrated contact stresses are anticipated (analogous to equivalent footings beneath the walls and columns) and the size of these areas is in turn related to the value the modulus of subgrade reaction, i.e., they are inter-related. Accordingly, the analysis of the raft slabs should ideally involve an iterative analysis between the determination of the contact stress distribution by the structural engineer and the geotechnical determination of the modulus of subgrade reaction value, until the two are consistent with each other.

The permissible SLS gross contact stress given above assumes a relatively uniform contact stress under the raft. Areas of higher contact stress could lead to localized overstressing of the silty clay with some resulting higher settlements and unanticipated raft slab deflections and forces. Given this requirement for a relatively uniform contact stress, the width of the loaded area will essentially be the width of an individual structure. The modulus of subgrade reaction may therefore be assumed to be 10 megapascals per metre for a raft slab underlain by EPS lightweight fill or native sand.

The raft should be designed not only to resist the forces and moments calculated in this manner, but should also be designed to resist the *hydrostatic uplift pressures* on the raft. A groundwater level at about 0.5 metres below the existing ground surface should be considered in that analysis.

The SLS resistance and corresponding settlement estimates are dependent upon the soil at or below founding level not being disturbed during construction. Where the subgrade consists of silty clay this material will be very sensitive to disturbance and should therefore be protected with a mud slab of lean concrete, which should be placed immediately following inspection and approval of the subgrade.

5.4.4 Spread Footing

It is considered that some of the more lightly loaded structures may generally be supported on spread footings founded on or within the native sand or silty clay, at depths of less than about 1.0 metre below the finished exterior grades. Shallow foundations at such depths would require insulation as describe in Section 5.7. Spread footing foundations at depths greater than 1.0 metre are not considered feasible.

As discussed in the preceding sections, the silty clay has limited capacity to accept the combined load from site grading fill and foundation loads. The bearing resistance for spread footing foundations at this site are therefore based on limiting the stress increases on the soft, compressible, grey silty clay to an acceptable level so that foundation settlements do not become excessive. Four important parameters in calculating the stress increase on the grey silty clay are:

- The thickness of soil below the underside of the footings and above the compressible silty clay;
- The size (dimensions) of the footings;
- The amount of surcharge in the vicinity of the foundation due to grade raise/landscape fill, underslab fill, floor loads, etc.; and,
- The effects of groundwater lowering caused by this or other construction (assumed to be about 0.5 metres).

The following table summarizes the permissible bearing resistance and grade raises for the Administration Building and Maintenance Garage. It should be noted that spread footing foundations at depths of 1.8 metres below finished grade and at other structures are not considered feasible.

Table 5-6: Permissible Bearing Resistance and Grade Raises for Spread Footing Foundations

Structure	SLS Bearing Resistance (kPa)	ULS Bearing Resistance (kPa)	Type of Footing	Corresponding Maximum Footing Width (metres)	Maximum Permissible Grade Raise (metres)
Administration Building	60	150	Pad	≤ 1.0	1.1
	60	150	Strip	≤ 0.5	1.1
Maintenance Garage	50	150	Pad	≤ 1.0	1.0
	35	150	Strip	≤ 0.5	1.0

Notes:
Requires insulation of footings for frost protection (see Section 5.7)

The above allowable bearing resistances are based on the criteria of limiting the stress level within the silty clay at an acceptable margin below the deposit's preconsolidation pressure. However, in assessing the needed level of margin, and noting that the total thickness of the clay deposit at this site is significant, it is considered that the post construction total and differential settlements of footings sized using the above permissible bearing resistances and grading restrictions should be less than about 40 and 20 millimetres, respectively, provided that the soil at or below founding level is not disturbed during construction. Further, the SLS resistances correspond to a settlement resulting from consolidation of the silty clay. Consolidation of the silty clay is a process which takes months or longer and, as such, results from sustained loading. Therefore, the foundation loads to be used in conjunction with the SLS resistances given above should be full dead load plus sustained live load. The factored dead load plus full factored live load should be used in conjunction with the ULS factored bearing resistances.

Where the surficial sand is exposed at footing/subgrade level, prior to construction of footings, the surface of the native sandy material should be proof-rolled to provide surficial densification of any loose or disturbed material.

The bearing resistance values given above could be increased by replacing some of the grade raise fill and native sand with EPS lightweight fill (e.g., 1.0 metre of EPS would increase the bearing values by about 20 kPa). Additional details on this option can be provided if needed.

5.4.5 Slab on Grade

Slab on grade are considered feasible where floor loads are less than 7 kPa. In preparation for construction of the floor slab, all loose, wet, and disturbed material (including all of the fill and topsoil) should be removed from within the building footprints.

Provision should be made for at least 150 millimetres of OPSS. Granular A to form the base of the floor slab. Any bulk fill required to raise the grade to the underside of the Granular A should consist of OPSS. Granular B Type II. The underslab fill should be placed in maximum 300 millimetre thick lifts and should be compacted to at least 95 percent of the material’s standard Proctor maximum dry density using suitable vibratory compaction equipment.

To support slab design, a modulus of subgrade reaction of 10 megapascals per metre can be used.

Where floor loads exceed 7 kPa, structural slabs (i.e. supported on piles) or the use of surcharge, pre-load and/or lightweight fill can be considered. Further details on the latter option can be provided if needed.

5.4.6 Surcharge and Pre-load Options

In the area of the Compost Processing and Storage area, Petroleum Hydrocarbon (PHC) Soil Treatment Biopile area and the Clean Load and Small Vehicles Drop-off area, larger loads may lead to settlement that could impact the performance of these facilities. A description of these facilities is provided herein:

1) Compost Processing and Storage area: A paved area with about 1.5 metres of grade raise is proposed. The facility covers an area of about 3.5 hectares and is expected to store about 20,400 tonnes of material in windrows which are about 3 to 4 metres high and 5 to 8 metres wide. Thus, the average loading in this area is expected to be less than about 5 kPa.

2) PHC Soil Treatment Biopile area: This area covers about 1,200 square metres and will be lined with a geomembrane. The biopiles will have a total volume of about 2,000 cubic metres, resulting in an average loading of up to about 50 kPa.

3) Clean Load and Small Vehicle Drop-Off area: This area covers a footprint of about 800 square metres with an initial grade raise of about 0.4 metres at the lower level, and a 1.8 metre grade raise at the upper level. The Drop-Off area is higher than the waste containers below. This area will also be paved and require a 1.5 metre high retaining wall at the western edge of the facility.

For the Compost Processing and Storage area where the loading is limited, pre-loading/surcharging is not considered necessary. Therefore, the pad can be constructed using the pavement structure given in Section 5.10 for parking areas.

For the PHC Soil Treatment Biopile area, the much higher fill and pad loadings will likely induce long-term consolidation settlements which may impact performance of the geomembrane barrier/drainage system. In this case, a surcharge and pre-load of the area would provide a reasonable option to improve performance. Without a surcharge and pre-load, settlements in the order of 800 to 900 millimetres can be expected over a 20 year period. The surcharge and pre-load should be 2.5 metres in height above the proposed finished grade and extend about 5 metres beyond the limit of the biopile footprint. The surcharge and pre-load should be monitored with 6 to 10 settlement plates over a period of 12 to 18 months. Following this, removal of the surcharge and pre-load can be undertaken to allow construction of the biopile cells. During biopile operations, further settlements are expected to range from about 30 to 90 millimetres over a 20 year period.

For the Clean Load and Small Vehicle Drop-Off area, the much higher fill loadings will likely induce long-term consolidation settlements that will affect performance of the facility and of the retaining wall. In this case, a surcharge and pre-load of the area would provide a reasonable option to improve performance. Without a pre-load and surcharge, settlements on the order of 500 to 600 millimetres can be expected over a 20 year period, impacting performance of the pad and retaining wall. The surcharge and pre-load should be 2.5 metres in height above the proposed finished grade and extend about 3 metres beyond the limit of the retaining wall and any fill areas exceeding a grade raise of 1.0 metre. The surcharge and pre-load should be monitored with 4 to 6 settlement plates over a period of 9 to 12 months. Following this, removal of the surcharge and pre-load can be undertaken as needed and 1.0 metre of EPS lightweight fill placed behind the retaining wall over a width of 4 metres to provide for acceptable performance of the pad and wall. Under these conditions, further settlements after the pre-load and surcharge should be less than 50 millimetres at the upper level, and less than 25 millimetres along the retaining wall foundation (lower level).

5.5 Retaining Wall, Foundation Wall and Grade Beam Backfill

The soils at this site are highly frost susceptible and should not be used as backfill against exterior unheated, or uninsulated foundation elements (e.g., pile caps, grade beams, and retaining walls). To avoid problems with frost adhesion and heaving, these foundation elements should either be backfilled with non-frost susceptible sand or sand and gravel conforming to the requirements for OPSS Granular B Type I or, alternatively, a bond break such as the Platon system sheeting on thermal insulation could be placed against the foundation walls and grade beams.

In areas where pavement or other hard surfacing will abut the proposed structures, differential frost heaving could occur between the granular fill and the adjacent areas. To reduce this differential heaving, the backfill adjacent to the wall should be placed to form a frost taper. The frost taper should be brought up to pavement subgrade level from 1.5 metres below finished exterior grade at a slope of 3 horizontal to 1 vertical, or flatter, away from the wall. The granular fill should be placed in maximum 300 millimetre thick lifts and should be compacted to at least 95 percent of the material’s standard Proctor maximum dry density using suitable vibratory compaction equipment.

The pavement or hard surfacing could be expected to perform better in the long term if the granular backfill against the foundation walls is drained by means of a perforated pipe subdrain in a surround of 19 millimetre clear stone, fully wrapped in a geotextile, which leads by gravity drainage to a positive outlet.

5.6 Lateral Earth Pressures

The magnitude of the lateral earth pressures will depend on the type and method of placement of the backfill materials, the nature of the soils behind the backfill, the magnitude of surcharge including construction loadings, the freedom of lateral movement of the structure, and the drainage conditions behind the walls. Seismic (earthquake) loading must also be taken into account in the design.

It should be noted that all of the lateral earth pressure equations are given in an unfactored format and will need to be factored for ULS design purposes.

It should also be noted that the below lateral earth pressure equations assume that the foundation walls will be drained. If the walls are design to be water-tight, the walls will have to be designed to resist the additional hydro-static pressure.

5.6.1 Static Lateral Earth Pressures

The following guidelines and recommendations are provided regarding the lateral earth pressures for static (i.e., not earthquake) loading conditions. These lateral earth pressures assume that the ground above the wall will be flat, not sloping. If the inclination of the slope above the wall changes then new lateral earth pressures will need to be calculated. If the backfill materials consist of compacted sand or sand and gravel (OPSS Granular B Type I) then the following parameters (unfactored) may be used:

Table 5-7: Static Lateral Earth Pressure Parameters

Soil Unit Weight (kN/m3)	20
Yielding, K_a	0.33
Non- Yielding, K_o	0.50

- If the structure does not allow lateral yielding (i.e., restrained structure where the rotational or horizontal movement is not sufficient to mobilize an active earth pressure condition), at-rest earth pressures (plus any compaction surcharge) should be assumed for the foundation design. If the structure allows for lateral yielding, active earth pressures should be used in the foundation design.
- The lateral earth pressures may be taken as:

$$\sigma_h(z) = K (\gamma z + q)$$

Where: $\sigma_h(z)$ = Lateral earth pressure on the wall at depth z, kPa;

K = At-rest or active earth pressure coefficient;

γ = Unit weight of retained soil;

z = Depth below top of wall, metres; and

q = Uniform surcharge at ground surface to account for traffic and equipment (not less than 15 kilopascals), plus any surcharge due to adjacent foundation loads.

5.6.2 Seismic Lateral Earth Pressures

Seismic (earthquake) loading must be taken into account in the design in accordance with OBC 2012. In this regard, the following should be included in the assessment of lateral earth pressures:

- Seismic loading will result in increased lateral earth pressures acting on the wall. The wall should be designed to withstand the combined lateral loading for the appropriate static pressure conditions given in Section 5.5.2, above, plus the earthquake-induced dynamic earth pressure.
- The following unfactored seismic active pressure coefficients (K_{AE}) for OPSS Granular B Type I may be used in design. It should be noted that these seismic earth pressure coefficients assume that the back of the wall is vertical and the ground surface behind the wall is flat. Where sloping backfill is present above the top of the wall, the lateral earth pressures under seismic loading conditions should be calculated by treating the weight of the backfill located above the top of the wall as a surcharge.

Table 5-8: Seismic Lateral Earth Pressure Coefficients

Wall Type	Design Earthquake	Site PGA for Site Class E	Seismic Active Pressure Coefficients, K_{AE}
Yielding Wall	2,475 Yr	0.365 g	0.49
Non-Yielding Wall	2,475 Yr	0.365 g	0.68

- The earthquake-induced dynamic pressure distribution, which is to be added to the static earth pressure distribution, is a linear distribution with maximum pressure at the top of the wall and minimum pressure at its toe (i.e., an inverted triangular pressure distribution). The total pressure distribution (static plus seismic) may be determined as follows:

$$\sigma_h(d) = K_a \gamma d + (K_{AE} - K_a) \gamma (H\text{-}d)\text{, yielding walls}$$

$$\sigma_h(d) = K_o \gamma d + (K_{AE} - K_a) \gamma (H\text{-}d)\text{, non-yielding walls}$$

Where:

$\sigma_h(d)$ is the (static plus seismic) lateral earth pressure at depth, d, (kPa);

K_a is the static active earth pressure coefficient;

K_o is the static at-rest earth pressure coefficient;

K_{AE} is the seismic active earth pressure coefficient;

γ is the unit weight of the backfill soil (kN/m^3), as given previously;

d is the depth below the top of the wall (m); and,

H is the total height of the wall (m).

Lateral passive resistance can be developed along buried foundation walls and grade beams that displace sufficiently. The following unfactored passive resistance would develop:

- For a 1.0 metre high wall or grade beam, 22 kilonewtons per metre;
- For a 2.0 metres high wall or grade beam, 102 kilonewtons per metre;
- For a 2.5 metres high wall or grade beam, 142 kilonewtons per metre; and,
- For a 3.0 metres high wall or grade beam, 232 kilonewtons per metre.

A geotechnical resistance factor of 0.5 should be used with the values above.

The wall deflection needed to mobilize these maximum passive lateral resistances is about 3 percent of the wall height. Deflection of about 1.3 percent of the wall height would be needed to develop 85 percent of the maximum passive resistance, with the passive resistances developing linearly over this range. The values provided herein assume that the walls and grade beams are backfilled with OPSS Granular B Type I.

5.7 Frost Protection

The soils at this site are considered to be frost susceptible and will expand/heave if allowed to freeze. All exterior perimeter foundation elements for buildings/facilities that are heated should be provided with a minimum of 1.5 metres of earth cover. However, the exterior and interior foundation elements (e.g., footings, pile caps, and grade beams) of the unheated buildings/facilities should be provided with a minimum of 1.8 metres of earth cover for frost protection purposes.

Rigid insulation could be considered as an alternative to the above earth cover requirements particularly where the slab subgrade will already need to be insulated, that insulation could be extended beneath the pile caps and grade beams to also insulate the subgrade beneath those foundation elements. Further details can be provided for the perimeter footings, if insulation of the subgrade is preferred alternative to earth cover.

5.8 Excavation and Shoring

Excavations depths of about 2 to 3 metres will be required for the construction of the foundations and servicing. The excavations will be made through the existing topsoil, fill, and surficial sand, where present, and into the underlying silty clay below the groundwater level. No unusual problems are anticipated in excavating in the overburden materials using conventional hydraulic excavating equipment. In accordance with the Occupational Health and Safety Act of Ontario (OHSA), the overburden soils below the water table (i.e., sand and soft silty clay) would generally be classified as Type 4 soils. Accordingly, side slopes in the short term in these soils should slopped at a minimum of 4 horizontal to 1 vertical (4H:1V).

Alternatively, the excavations could be carried out using steeper side slopes with all manual labour carried out within a fully braced, steel trench box for worker safety.

Stockpiling of soil beside the excavations made in the silty clay should be avoided; the weight of the stockpiled soil could lead to basal instability of braced excavations or slope instability for unsupported excavations. In addition, the shoring system should be designed to account for the additional surcharge loading from any adjacent any building foundations. Excavations will extend below the groundwater level and therefore ground water inflow into the excavations should be expected. It should be possible to handle the groundwater inflow into the excavation by pumping from well filtered sumps within the excavations. The rate of groundwater inflow from the silty clay is expected to be low, with moderate inflows occurring from the overlying fill and surficial sand.
The actual rate of groundwater inflow to the excavations will depend on many factors including the contractor’s schedule and rate of excavation, the size of the excavation, the number of working areas being excavated at one time, and the time of year at which the excavation is made. Also, there may be instances where volumes of precipitation, surface runoff and/or groundwater collects in an open excavation, and must be pumped out. The groundwater level should be lowered to at least 0.5 metres below the excavation level.

According to Ontario Regulation 63/16 and Ontario Regulation 387/04, a Permit to Take Water (PTTW) is required from the Ministry of the Environment and Climate Change (MOECC) if a volume of water greater than 400,000 L/day is pumped from the excavations. If the volume of water to be pumped will be less than 400,000 L/day, but more than 50,000 L/day, the water taking will not require a PTTW, but will need to be registered in the Environmental Activity and Sector Registry (EASR) as a prescribed activity.

Where the subgrade is found to be wet and sensitive to disturbance (i.e., for sandy soils below the water table or sensitive silty clay), consideration should be given to placing a mud slab of lean concrete over the subgrade (following inspection and approval by geotechnical personnel) to protect the subgrade from construction traffic. Surface water should be directed away from the excavation areas, to prevent ponding of water that could result in disturbance and weakening of the subgrade.

If the above open-cut excavation side slopes cannot be accommodated, then a shoring system would need to be considered. The excavation contractor should be made responsible for the detailed design of the shoring.

The shoring method(s) chosen to support the excavation sides must take into account the soil stratigraphy, the groundwater conditions, the methods adopted to manage the groundwater, the permissible ground movements associated with the excavation and construction of the shoring system, and potential impacts on adjacent structures and utilities. The selection of the type of temporary shoring system, and the method of lateral restraint should be entirely the choice/responsibility of the contractor. The contractor should be required to submit the shoring system design, including details on the design lateral earth pressures, expected movements, and a monitoring plan, for review prior to the start of shoring construction.

Some unavoidable inward horizontal deformation and vertical settlement of the adjacent ground may occur as a result of excavation, installation of the shoring and deflection of the ground support system (including bending of the walls and compression of the struts).

The construction documents should not specify the specific shoring system that should be used, but rather the permissible deflection level (i.e., ‘Performance Level’) should be specified, in accordance with OPSS.MUNI 539. With the above design approach, it is considered that Performance Level 2 would be specified.

5.9 Site Servicing

5.9.1 Pipelines

It is expected that excavations for the installation of site services will extend to no more than 2 metres depth. These excavations will be made through the surficial fill, sand (where present), and into the underlying soft silty clay.

At least 150 millimetres of OPSS Granular A should be used as pipe bedding for sewer and water pipes. Where unavoidable disturbance to the subgrade surface does occur, it may be necessary to place a sub-bedding layer consisting of compacted OPSS Granular B Type II beneath the Granular A or to thicken the Granular A bedding. The bedding material should in all cases extend to the spring line of the pipe and should be compacted to at least 95 percent of the material’s standard Proctor maximum dry density. The use of clear crushed stone as a bedding layer should not be permitted anywhere on this project since fine particles from the sandy backfill materials or sandy soils on the trench walls could potentially migrate into the voids in the clear crushed stone and cause loss of lateral pipe support.

Cover material, from spring line of the pipe to at least 300 millimetres above the top of pipe, should consist of OPSS Granular A or Granular B Type I with a maximum particle size of 25 millimetres. The cover material should be compacted to at least 95 percent of the material’s standard Proctor maximum dry density.

It should generally be possible to re-use surficial sandy soils or drier weather silty clay as trench backfill.

The high moisture content of the unweathered grey silty clay makes this soil difficult to handle and compact. If grey silty clay is excavated during installation of the site services, this material should be wasted or should only be used as backfill in the lower portion of the trenches to limit the amount of long term settlement of the roadway surface. If the grey silty clay is used in trenches under roadways, some long term settlement of the pavement surface should be expected. Where the trench will be covered with hard surfaced areas, the type of native material placed in the frost zone (between subgrade level and 1.8 metres depth) should match the soil exposed on the trench walls for frost heave compatibility. Trench backfill should be placed in maximum 300 millimetre thick lifts and should be compacted to at least 95 percent of the material’s standard Proctor maximum dry density using suitable compaction equipment.

Impervious dykes or cut-offs should be constructed at 100 metre intervals in the service trenches to reduce groundwater lowering at the site due to the “french drain” effect of the granular bedding and surround for the service pipes. It is important that these barriers extend from trench wall to trench wall and that they fully penetrate the granular materials to the trench bottom. The dykes should be at least 1.5 metres wide and could be constructed using relatively dry (i.e., compactable) grey brown silty clay from the weathered zone or beam concrete.

5.9.2 Surface Ponds

Several stormwater management ponds are proposed within the facility, with depths in the order of 2 to 3 metres. The excavations for the ponds will be through grade raise fill and surficial sand. As such, excavation side slopes of 4H: 1H should be used. Erosion protection of the excavated slopes should also be provided.

5.10 Pavements Design

Site access to the facility is proposed directly from Boundary Road approximately 1,130 metres south of Highway 417 and approximately 600 metres south of the Thunder Road.

In preparation for pavement construction, all topsoil, disturbed, or otherwise deleterious material (i.e., those materials containing organic material) should be removed from the roadway areas.

The existing fill, and any native subgrade within the proposed site access road way, should be proof rolled prior to the placement of new fill. The purpose of the proof rolling is to provide surficial densification of the existing subgrade and to identify any isolated areas of soft or loose subgrade soil, which would require subexcavation and replacement with suitable fill.

Sections requiring backfilling of existing ditches to the proposed subgrade level (i.e., following subexcavation of loose/soft soil) should be carried out using acceptable OPSS Select Subgrade Material (SSM). All fill should be placed in maximum 300 millimetre thick lifts and should be compacted to at least 95 percent of the material’s standard Proctor maximum dry density using suitable vibratory compaction equipment.

The granular base and subbase should be compacted to 100 percent of the material’s standard Proctor maximum dry density using suitable compaction equipment unless otherwise noted.

Below the pavement structure, frost compatibility must be maintained across any pavement tie-ins. The depth of frost penetration (from the profile grade) on this project should be 1.8 metres. This depth should be used when designing frost tapers in accordance with the OPSD 803 series. Transition zones should be treated in accordance with the applicable OPSD 205 series. The transition treatment depth, "t", should be taken as 1.8 metres and the depth of organic, leached and accumulated layers, "D_a", taken as 300 millimetres.

The subsoil should be inspected by qualified geotechnical personnel to make sure that there is no potential for differential frost heaving.

In preparation for the pavement structure for the new paved site access road the following pavement construction should be carried out:

- Remove all organic material and topsoil;
- Provide 150 millimetres (40+50+50) HMA;
  - 50 millimetres SP 12.5 FC 2, Traffic Category D, PGAC 64-34; and,
  - 100 (50+50) millimetres SP 19.0, Traffic Category D, PGAC 64-34.
- Provide 150 millimetres of new Granular A; and,

- Provide 500 millimetres of new Granular B Type II.

If all or parts of the access road will be used as a gravel surfaced haul road during or after construction, the following pavement construction should be carried out:

- Remove all organic material and topsoil;
- Provide 200 millimetres of new Granular A, compacted to 100 percent of the material's standard Proctor maximum dry density (SPMDD);
- Provide 400 millimetres of upper subbase Granular B Type II compacted to 100 percent of the material's SPMDD;
- Provide a biaxial geogrid such as, Tensar BX1200 XMD, or equivalent; and,
- Provide 300 millimetres of lower subbase Granular B Type II compacted to 95 percent SPMDD. The lower subbase should be spread with dozer only and not compacted prior to placement of the geogrid.

The granular base and subbase for new construction should consist of OPSS Granular A and Granular B Type II, respectfully. Subgrade fill, if required could consist of SSM in accordance with OPSS.MUNI 1010.

The composition of the Hot Mix and Granular Conversion Factors should be as follows:

- Superpave 12.5 FC2 – 2.390 t/m^3 ;
- Superpave 19.0 – 2.460 t/m^3;
- Granular A – 2.4 t/m$^{3;}$ and,
- Granular B Type II – 2.4 t/m^3.

Based on the pavement profile at Boundary Road where it will intersect with the proposed site access roadway, there will be an approximately 1.8 metres difference in grade. Therefore, a 10H:1V taper for tie in of the granular materials will be required at this intersection.

5.11 Trees

The silty clay soils at this site are potentially sensitive to water depletion by trees of high water demand during periods of dry weather. When trees draw water from the silty clay, the silty clay undergoes shrinkage which can result in settlement of adjacent structures founded at shallow depth. Some restrictions could therefore need to be imposed on the planting of trees of higher water demand in close proximity to the foundations structures founded at shallow depth (i.e., shallow spread footings or shallow raft foundations). It is therefore recommended that trees with high water demand not be planted closer to any buildings with shallow foundations than the ultimate height of the tree. However, these restrictions do not apply to structures founded on deep pile foundations supported on bedrock.

The table below provides a list of common trees in decreasing order of water demand and, accordingly, decreasing risk of potential effects on structures.

Table 5-9: Some Common Trees in Decreasing Order of Water Demand

Tree Species	List of Trees
Broad Leaved Deciduous	Poplar Alder Aspen Willow Elm Maple Birch Ash Beech Oak
Deciduous Conifer	Larch
Evergreen Conifers	Spruce Fir Pine

5.12 Corrosion and Cement Type

Four samples of soil from boreholes 17-07, 17-26, and 17-29 were submitted to Eurofins Environment Testing for basic chemical analyses related to potential corrosion of buried steel elements and potential sulphate attack on buried concrete elements. The results of this testing are provided in Appendix E.

The results indicate that concrete made with Type GU Portland cement should be acceptable for substructures. The results also indicate a mild to very high potential for corrosion of exposed ferrous metals within the silty clay deposit and a high potential for corrosion of exposed ferrous metal within the glacial till deposit.

6.0 ADDITIONAL CONSIDERATIONS

The soils at this site are sensitive to disturbance from ponded water, construction traffic and frost.

Piling operations should be inspected on a full time basis by geotechnical personnel to monitor the pile locations and plumbness, initial sets, penetrations on restrike, and to check the integrity of the piles following installation.

All raft foundation bearing areas should be inspected by geotechnical personnel to ensure that a suitable subgrade has been reached and that it has been properly prepared. In order to avoid disturbance of the sensitive clay subgrade, it is recommended that the silty clay subgrade be protected by a mud slab of lean concrete as soon as each portion of the excavation has been completed and inspected.

All footing and subgrade areas should be inspected by experienced geotechnical personnel prior to filling or concreting to ensure that soil having adequate bearing capacity has been reached and that the bearing surfaces have been properly prepared.

The placing and compaction of engineered fill as well as sewer bedding and backfill should be inspected to ensure that the materials used conform to specifications from both a grading and compaction point of view.

Two test pads from previous investigation were constructed to about 2.5 metre height within the proposed building area. These test pads should be removed before construction.

Regardless of season, granular pads will be required to be constructed before any heavy equipment can be sent out to site. It is understood that the client is planning to do some pre-construction drainage improvements to better promote and manage the runoff, especially in the spring, which can render the site challenging to access.

It is recommended that the final shoring design be reviewed and accepted by a geotechnical engineer prior to construction and that periodic inspection of the shoring installation procedures be carried out to ensure compatibility with the building design.

At the time of the writing of this report, only conceptual details for the proposed structures were available. Golder should be retained to review the final drawings and specifications for this project prior to tendering to ensure that the guidelines in this report have been adequately interpreted.

7.0 CLOSURE

We trust that this report meets your current needs. If you have any questions, or if we may be of further assistance, please do not hesitate to contact the undersigned.

Signature Page

Golder Associates Ltd.

LICENSED PROFESSIONAL ENGINEER
18
M.S. SNOW
6/13/2018
PROVINCE OF ONTARIO

Shokouh Meshkinfar, EIT
Junior Geotechnical Engineer-in-Training

Michael Snow, P.Eng.
Principal, Senior Geotechnical Engineer

SM/SAT/MSS/mvrd
https://golderassociates.sharepoint.com/sites/18733g/deliverables/phase 400 tsk 4.4 report/reports/1787048-400-4.4-rev0-final-crrrc geotechnical report-june 2018.docx

IMPORTANT INFORMATION AND LIMITATIONS
OF THIS REPORT

Standard of Care: Golder Associates Ltd. (Golder) has prepared this report in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering and science professions currently practicing under similar conditions in the jurisdiction in which the services are provided, subject to the time limits and physical constraints applicable to this report. No other warranty, expressed or implied is made.

Basis and Use of the Report: This report has been prepared for the specific site, design objective, development and purpose described to Golder by the Client, **Taggart Miller Environmental Services.** The factual data, interpretations and recommendations pertain to a specific project as described in this report and are not applicable to any other project or site location. Any change of site conditions, purpose, development plans or if the project is not initiated within eighteen months of the date of the report may alter the validity of the report. Golder cannot be responsible for use of this report, or portions thereof, unless Golder is requested to review and, if necessary, revise the report.

The information, recommendations and opinions expressed in this report are for the sole benefit of the Client. No other party may use or rely on this report or any portion thereof without Golder's express written consent. If the report was prepared to be included for a specific permit application process, then the client may authorize the use of this report for such purpose by the regulatory agency as an Approved User for the specific and identified purpose of the applicable permit review process, provided this report is not noted to be a draft or preliminary report, and is specifically relevant to the project for which the application is being made. Any other use of this report by others is prohibited and is without responsibility to Golder. The report, all plans, data, drawings and other documents as well as all electronic media prepared by Golder are considered its professional work product and shall remain the copyright property of Golder, who authorizes only the Client and Approved Users to make copies of the report, but only in such quantities as are reasonably necessary for the use of the report by those parties. The Client and Approved Users may not give, lend, sell, or otherwise make available the report or any portion thereof to any other party without the express written permission of Golder. The Client acknowledges that electronic media is susceptible to unauthorized modification, deterioration and incompatibility and therefore the Client cannot rely upon the electronic media versions of Golder's report or other work products.

The report is of a summary nature and is not intended to stand alone without reference to the instructions given to Golder by the Client, communications between Golder and the Client, and to any other reports prepared by Golder for the Client relative to the specific site described in the report. In order to properly understand the suggestions, recommendations and opinions expressed in this report, reference must be made to the whole of the report. Golder cannot be responsible for use of portions of the report without reference to the entire report.

Unless otherwise stated, the suggestions, recommendations and opinions given in this report are intended only for the guidance of the Client in the design of the specific project. The extent and detail of investigations, including the number of test holes, necessary to determine all of the relevant conditions which may affect construction costs would normally be greater than has been carried out for design purposes. Contractors bidding on, or undertaking the work, should rely on their own investigations, as well as their own interpretations of the factual data presented in the report, as to how subsurface conditions may affect their work, including but not limited to proposed construction techniques, schedule, safety and equipment capabilities.

Soil, Rock and Groundwater Conditions: Classification and identification of soils, rocks, and geologic units have been based on commonly accepted methods employed in the practice of geotechnical engineering and related disciplines. Classification and identification of the type and condition of these materials or units involves judgment, and boundaries between different soil, rock or geologic types or units may be transitional rather than abrupt. Accordingly, Golder does not warrant or guarantee the exactness of the descriptions.

IMPORTANT INFORMATION AND LIMITATIONS
OF THIS REPORT (cont'd)

Special risks occur whenever engineering or related disciplines are applied to identify subsurface conditions and even a comprehensive investigation, sampling and testing program may fail to detect all or certain subsurface conditions. The environmental, geologic, geotechnical, geochemical and hydrogeologic conditions that Golder interprets to exist between and beyond sampling points may differ from those that actually exist. In addition to soil variability, fill of variable physical and chemical composition can be present over portions of the site or on adjacent properties. **The professional services retained for this project include only the geotechnical aspects of the subsurface conditions at the site, unless otherwise specifically stated and identified in the report.** The presence or implication(s) of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this project and have not been investigated or addressed.

Soil and groundwater conditions shown in the factual data and described in the report are the observed conditions at the time of their determination or measurement. Unless otherwise noted, those conditions form the basis of the recommendations in the report. Groundwater conditions may vary between and beyond reported locations and can be affected by annual, seasonal and meteorological conditions. The condition of the soil, rock and groundwater may be significantly altered by construction activities (traffic, excavation, groundwater level lowering, pile driving, blasting, etc.) on the site or on adjacent sites. Excavation may expose the soils to changes due to wetting, drying or frost. Unless otherwise indicated the soil must be protected from these changes during construction.

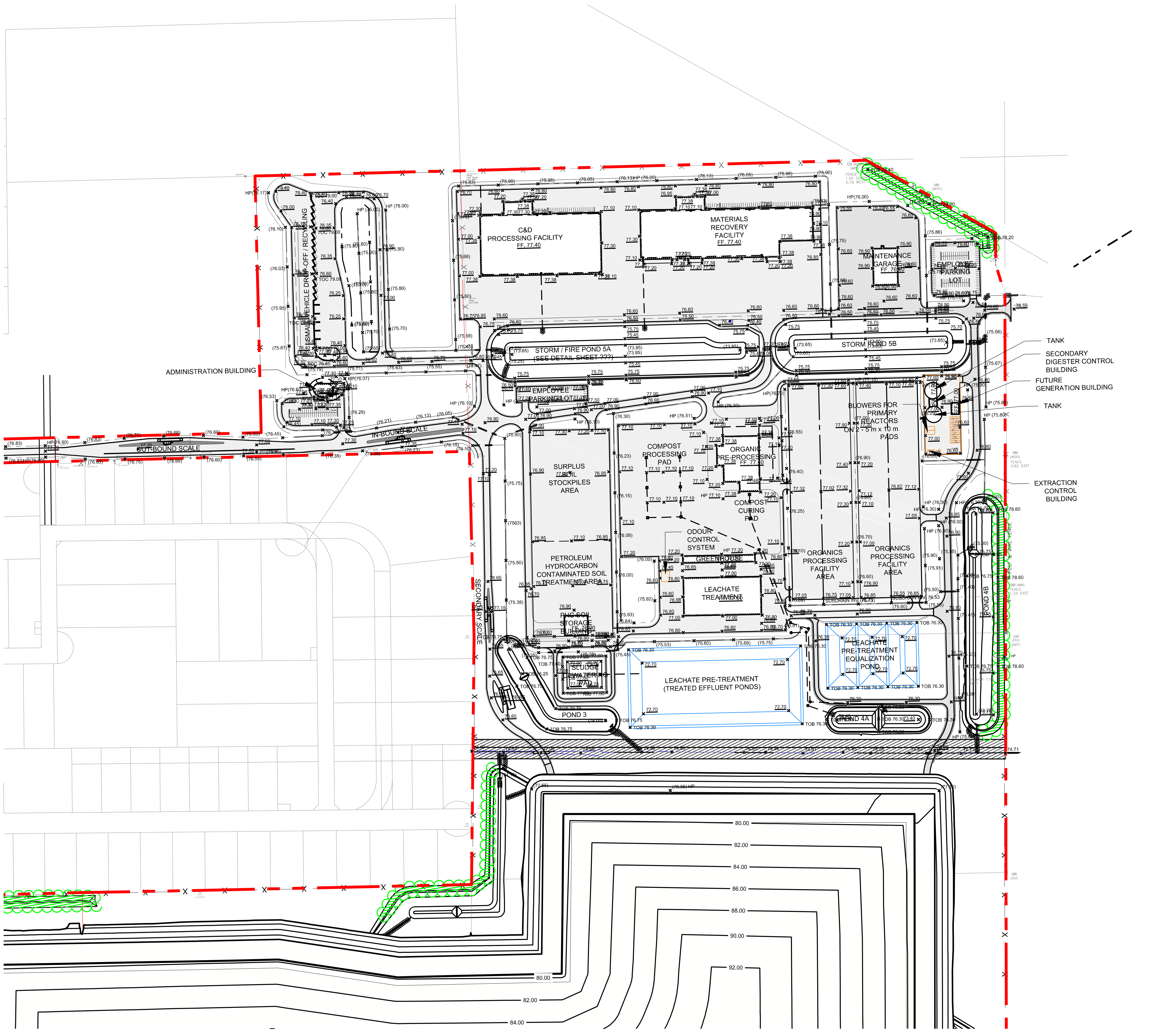
Sample Disposal: Golder will dispose of all uncontaminated soil and/or rock samples 90 days following issue of this report or, upon written request of the Client, will store uncontaminated samples and materials at the Client's expense. In the event that actual contaminated soils, fills or groundwater are encountered or are inferred to be present, all contaminated samples shall remain the property and responsibility of the Client for proper disposal.

Follow-Up and Construction Services: All details of the design were not known at the time of submission of Golder's report. Golder should be retained to review the final design, project plans and documents prior to construction, to confirm that they are consistent with the intent of Golder's report.

During construction, Golder should be retained to perform sufficient and timely observations of encountered conditions to confirm and document that the subsurface conditions do not materially differ from those interpreted conditions considered in the preparation of Golder's report and to confirm and document that construction activities do not adversely affect the suggestions, recommendations and opinions contained in Golder's report. Adequate field review, observation and testing during construction are necessary for Golder to be able to provide letters of assurance, in accordance with the requirements of many regulatory authorities. In cases where this recommendation is not followed, Golder's responsibility is limited to interpreting accurately the information encountered at the borehole locations, at the time of their initial determination or measurement during the preparation of the Report.

Changed Conditions and Drainage: Where conditions encountered at the site differ significantly from those anticipated in this report, either due to natural variability of subsurface conditions or construction activities, it is a condition of this report that Golder be notified of any changes and be provided with an opportunity to review or revise the recommendations within this report. Recognition of changed soil and rock conditions requires experience and it is recommended that Golder be employed to visit the site with sufficient frequency to detect if conditions have changed significantly.

Drainage of subsurface water is commonly required either for temporary or permanent installations for the project. Improper design or construction of drainage or dewatering can have serious consequences. Golder takes no responsibility for the effects of drainage unless specifically involved in the detailed design and construction monitoring of the system.



LEGEND

🟥	PROPERTY BOUNDARY
	EXISTING CONTOUR (0.25 m INTERVAL)
	TERRACING (SLOPE AS INDICATED)
	DITCH
	600 mmØ CULVERT OR AS NOTED
	EXISTING CULVERT AS NOTED

REFERENCE(S)

1. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83, COORDINATE SYSTEM: UTM ZONE 18, VERTICAL DATUM: CGVD28

0 100 200
1:5,000 METRES

CLIENT
TAGGART MILLER ENVIRONMENTAL SERVICES

PROJECT
CAPITAL REGION RESOURCE RECOVERY CENTRE

TITLE
OVERALL SITE PLAN

CONSULTANT

GOLDER

YYYY-MM-DD	2018-01-19
DESIGNED	MK
PREPARED	ABD
REVIEWED	SAT
APPROVED	MSS

PROJECT NO.	CONTROL	REV.	DRAWING
1787048	0009	0	1

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25 mm
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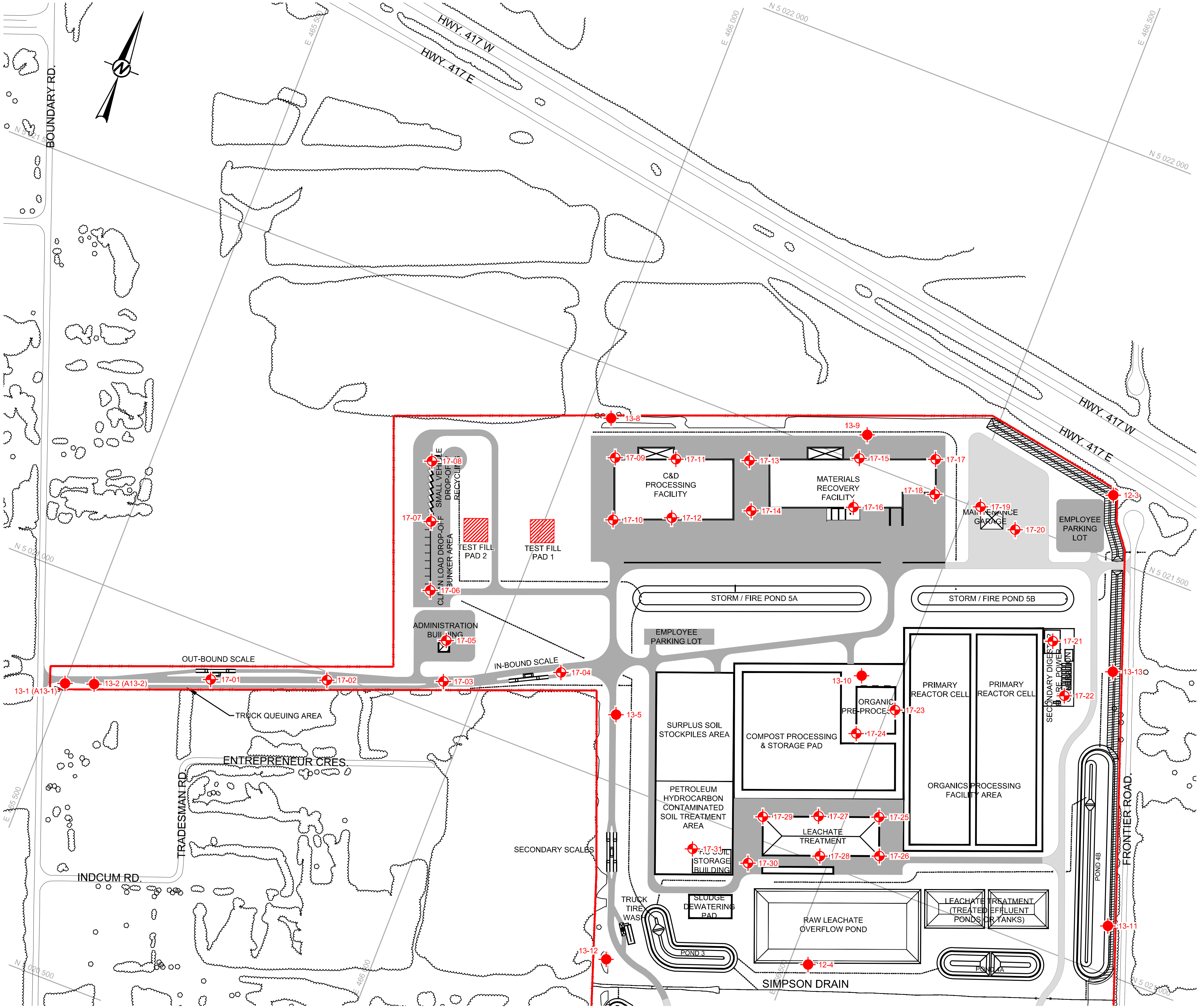

KEY MAP

SCALE 1:30000

LEGEND

⌖	APPROXIMATE TEST HOLE LOCATION, CURRENT INVESTIGATION
●	APPROXIMATE TEST HOLE LOCATION, PREVIOUS INVESTIGATION BY GOLDER ASSOCIATES LTD, REPORT NO. 12-1125-0045
▨	APPROXIMATE TEST FILL LOCATIONS

REFERENCE(S)

1. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83, COORDINATE SYSTEM: UTM ZONE 18, VERTICAL DATUM: CGVD28

0 100 200
1:5,000 METRES

CLIENT
TAGGART MILLER ENVIRONMENTAL SERVICES

PROJECT
GEOTECHNICAL INVESTIGATION
CAPITAL REGION RESOURCE RECOVERY CENTRE

TITLE
TEST HOLE LOCATION PLAN

CONSULTANT
GOLDER

YYYY-MM-DD	2018-06-12
DESIGNED	----
PREPARED	JM
REVIEWED	SAT
APPROVED	MSS

PROJECT NO.	CONTROL	REV.	FIGURE
1787048	0009	0	2

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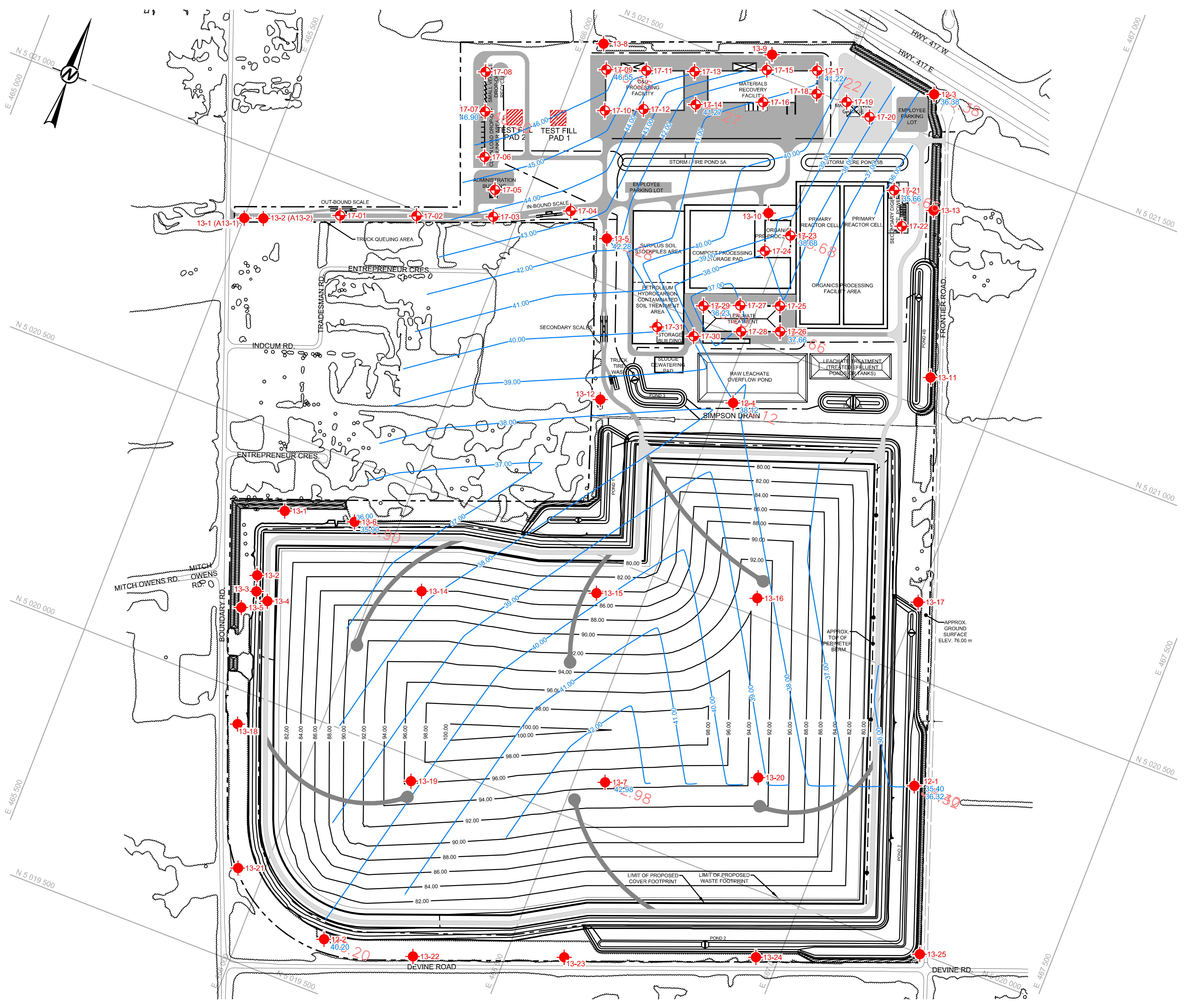
25 mm
0



LEGEND

⌖	APPROXIMATE TEST HOLE LOCATION, CURRENT INVESTIGATION
●	APPROXIMATE TEST HOLE LOCATION, PREVIOUS INVESTIGATION BY GOLDER ASSOCIATES LTD, REPORT NO. 12-1125-0045
46.90	BEDROCK ELEVATION IN TEST HOLE, metres ABOVE SEA LEVEL
—39.00—	INTERPRETED BEDROCK ELEVATION CONTOUR, metres ABOVE SEA LEVEL
▨	APPROXIMATE TEST FILL LOCATIONS

REFERENCE(S)

1. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83, COORDINATE SYSTEM: UTM ZONE 18, VERTICAL DATUM: CGVD28

CLIENT
TAGGART MILLER ENVIRONMENTAL SERVICES

PROJECT
GEOTECHNICAL INVESTIGATION
CAPITAL REGION RESOURCE RECOVERY CENTRE

TITLE
BEDROCK SURFACE CONTOUR PLAN

CONSULTANT

GOLDER

YYYY-MM-DD	2018-06-12
DESIGNED	----
PREPARED	JM
REVIEWED	SAT
APPROVED	MSS

PROJECT NO.	CONTROL	REV.	FIGURE
1787048	0009	0	3

25 mm

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

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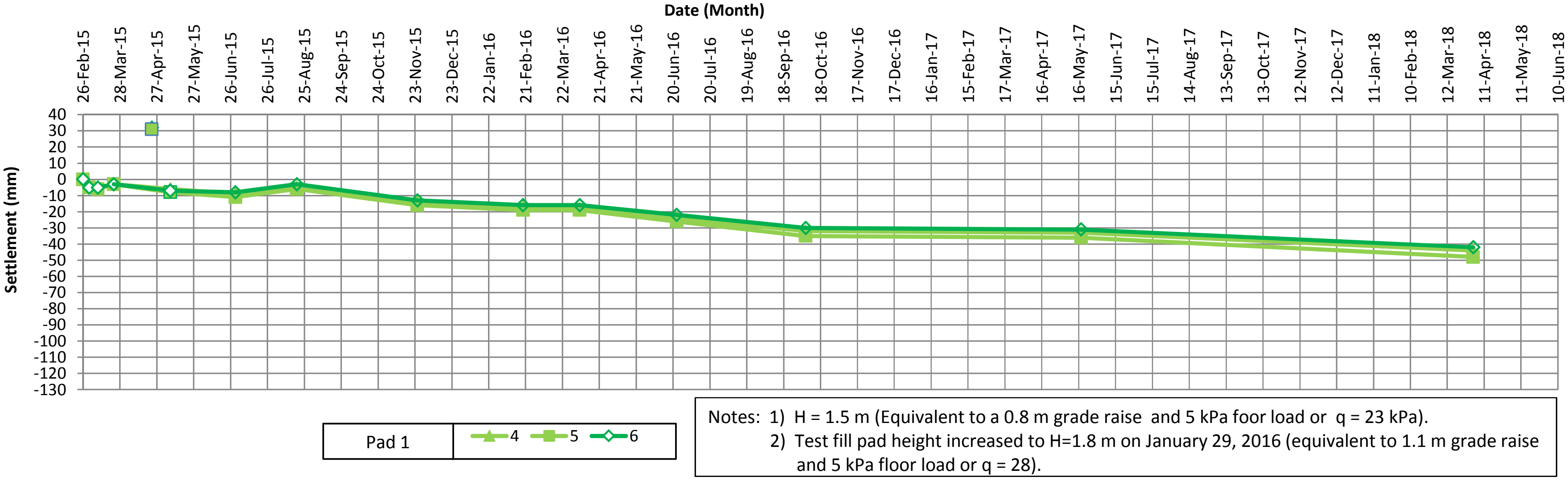
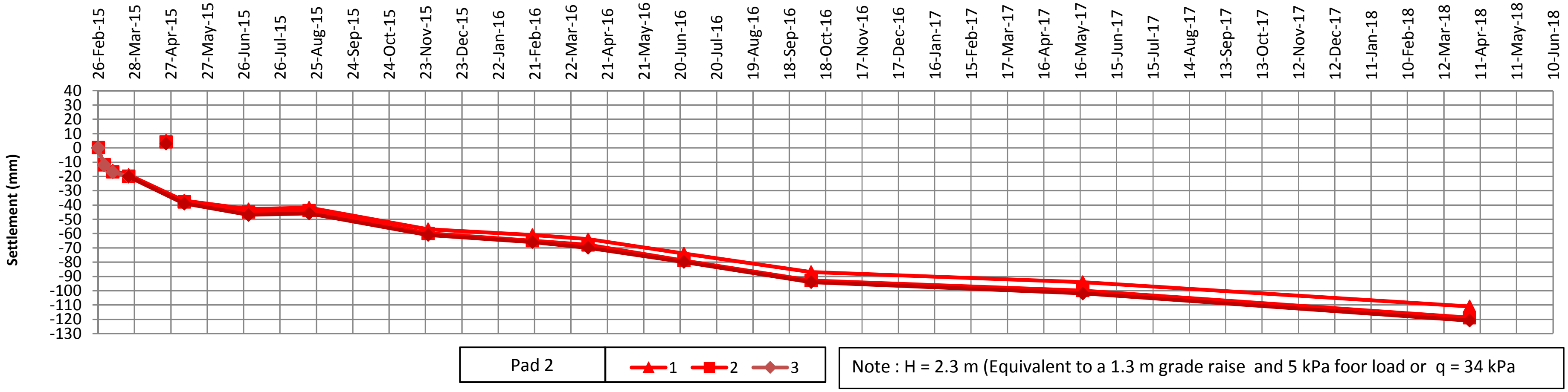
C:\Users\SMeshkinfar\Desktop\CRRRC\Settlement\[12-1125-0045 Test Fill Monitoring Summary_M1.xlsx]Figure 1B



Notes: 1) H = 1.5 m (Equivalent to a 0.8 m grade raise and 5 kPa foor load or q = 23 kPa).
2) Test fill pad height increased to H=1.8 m on January 29, 2016 (equivalent to 1.1 m grade raise and 5 kPa floor load or q = 28).



Note : H = 2.3 m (Equivalent to a 1.3 m grade raise and 5 kPa foor load or q = 34 kPa

CRRRC

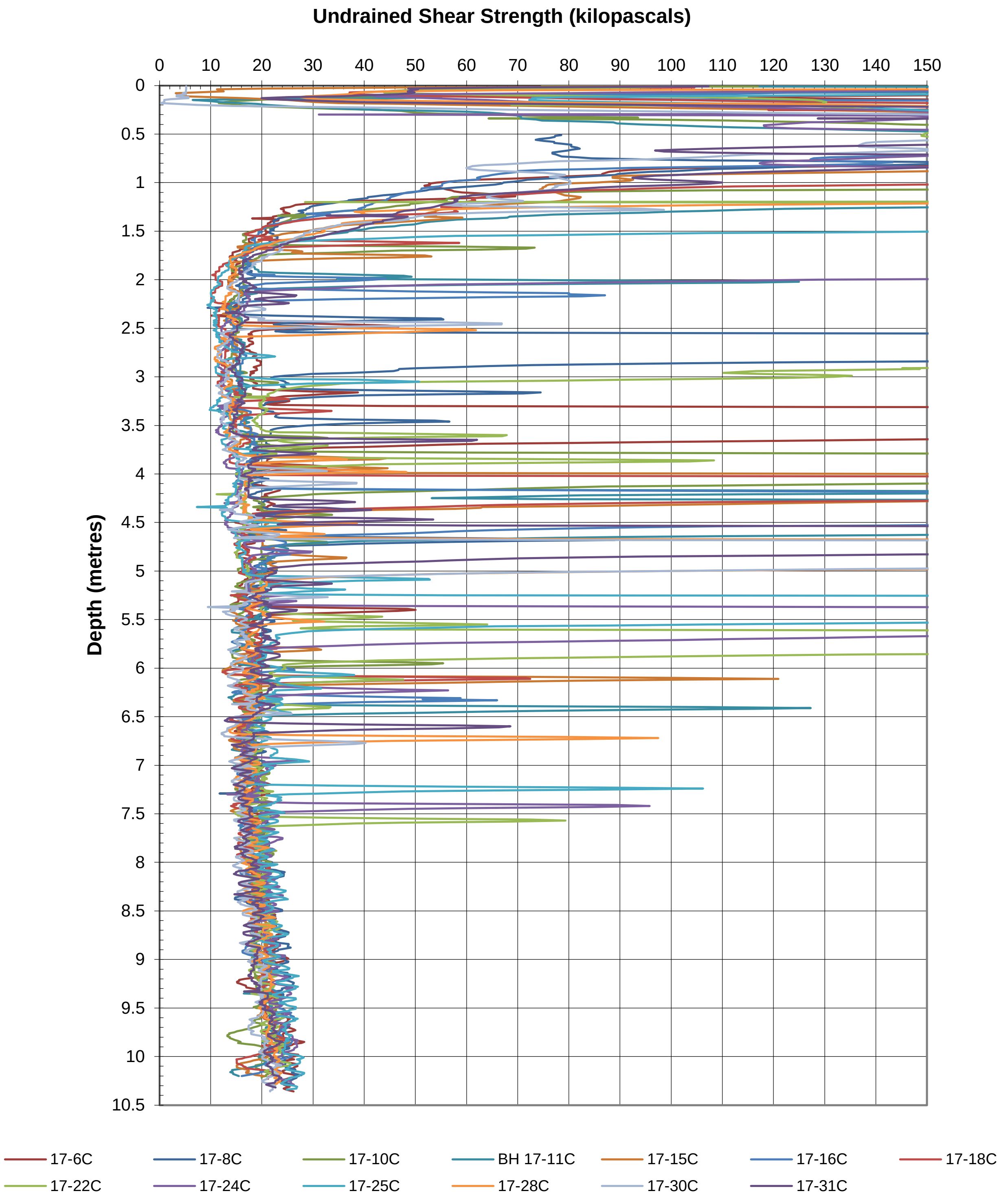
TEST FILL PAD SETTLEMENT MONITORING RESULTS

Golder Associates

PROJECT No.	1787048		PHASE No. 400/4.4	
DESIGN	SM	24/04/2018	SCALE: NTS	REV.
CADD			**FIGURE 4**	
CHECK	MSS			
REVIEW				

SUMMARY OF UNDRAINED SHEAR STRENGTHS PROFILES - CPTS

FIGURE 5



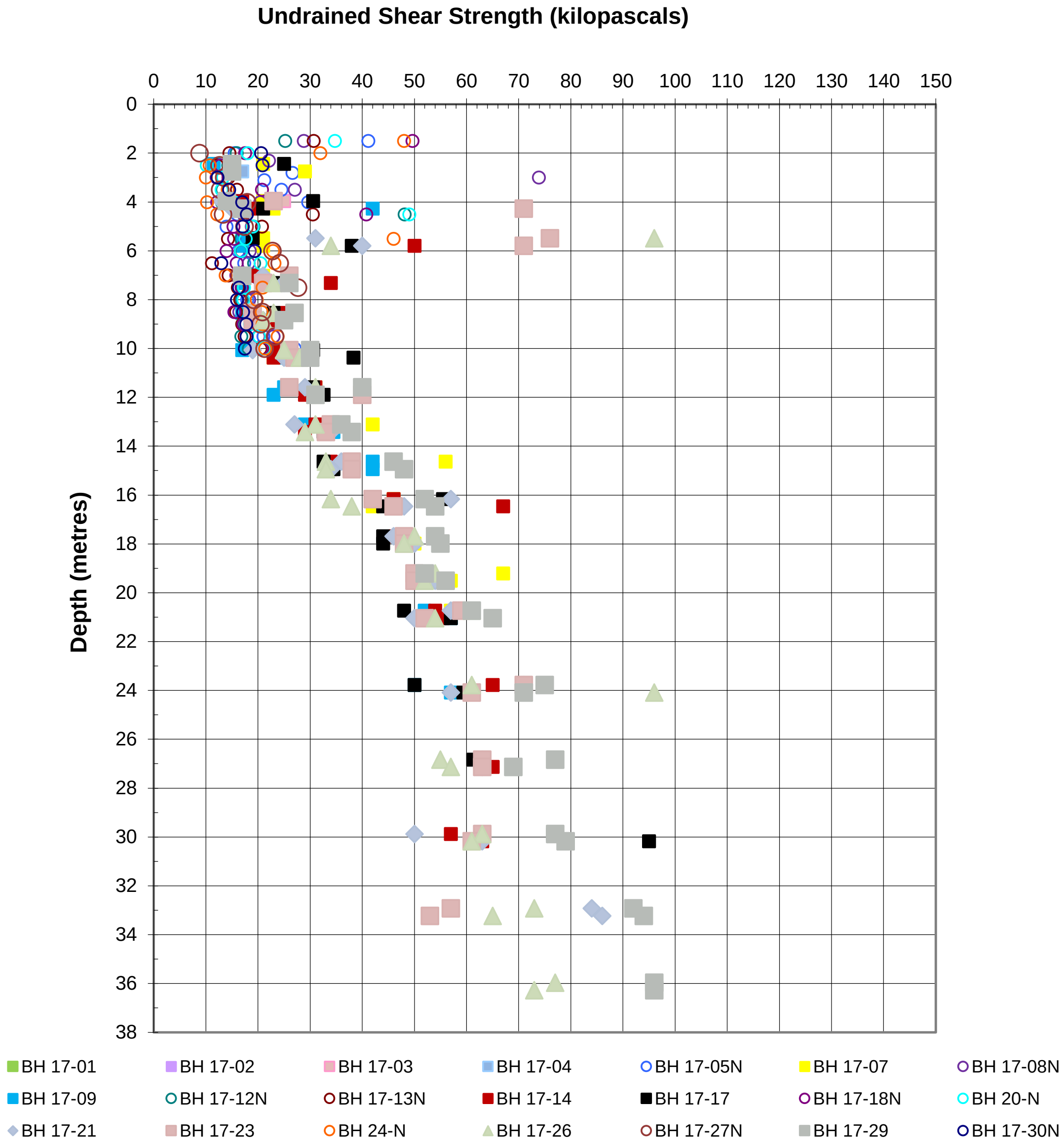
Date June 11, 2018
Project 1787048/400/4.4

Golder Associates

Drawn SM
Chkd MSS

SUMMARY OF UNDRAINED SHEAR STRENGTHS PROFILES - BOREHOLES

FIGURE 6



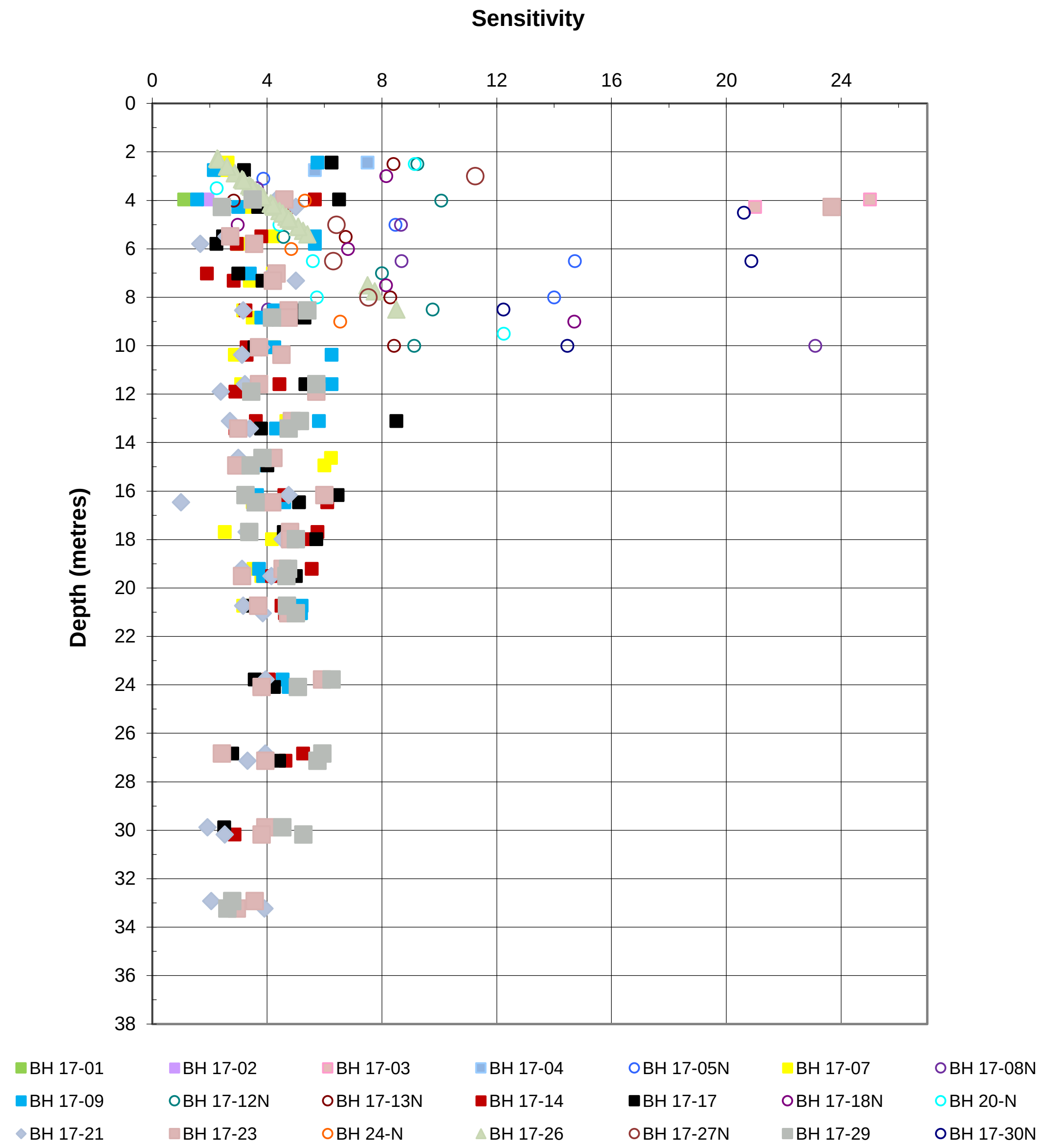
Date June 07, 2018
Project 1787048/400/4.4

Golder Associates

Drawn SM
Chkd MSS

SUMMARY OF SILTY CLAY SENSITIVITY - BOREHOLES

FIGURE 7



Date June 11, 2018
Project 1787048/400/4.4

Golder Associates

Drawn SM
Chkd MSS

APPENDIX A

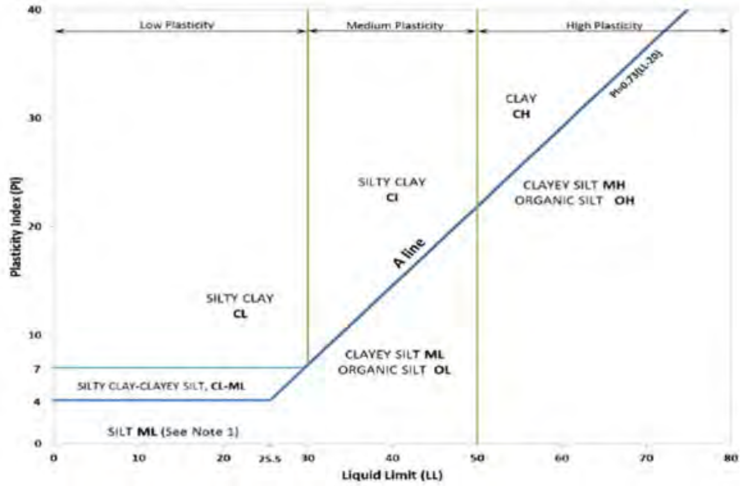
List of Abbreviations and Symbols Record of Boreholes – Current Investigation

METHOD OF SOIL CLASSIFICATION

The Golder Associates Ltd. Soil Classification System is based on the Unified Soil Classification System (USCS)

Organic or Inorganic	Soil Group	Type of Soil		Gradation or Plasticity	$Cu = \frac{D_{60}}{D_{10}}$	$Cc = \frac{(D_{30})^2}{D_{10}xD_{60}}$	Organic Content	USCS Group Symbol	Group Name
INORGANIC (Organic Content ≤30% by mass)	COARSE-GRAINED SOILS (>50% by mass is larger than 0.075 mm)	GRAVELS (>50% by mass of coarse fraction is larger than 4.75 mm)	Gravels with ≤12% fines (by mass)	Poorly Graded	<4	≤1 or ≥3	≤30%	GP	GRAVEL
				Well Graded	≥4	1 to 3		GW	GRAVEL
			Gravels with >12% fines (by mass)	Below A Line	n/a			GM	SILTY GRAVEL
				Above A Line	n/a			GC	CLAYEY GRAVEL
		SANDS (≥50% by mass of coarse fraction is smaller than 4.75 mm)	Sands with ≤12% fines (by mass)	Poorly Graded	<6	≤1 or ≥3		SP	SAND
				Well Graded	≥6	1 to 3		SW	SAND
			Sands with >12% fines (by mass)	Below A Line	n/a			SM	SILTY SAND
				Above A Line	n/a			SC	CLAYEY SAND

Organic or Inorganic	Soil Group	Type of Soil	Laboratory Tests	Field Indicators					Organic Content	USCS Group Symbol	Primary Name
				Dilatancy	Dry Strength	Shine Test	Thread Diameter	Toughness (of 3 mm thread)			
INORGANIC (Organic Content ≤30% by mass)	FINE-GRAINED SOILS (≥50% by mass is smaller than 0.075 mm)	SILTS (Non-Plastic or PI and LL plot below A-Line on Plasticity Chart below)	Liquid Limit <50	Rapid	None	None	>6 mm	N/A (can't roll 3 mm thread)	<5%	ML	SILT
				Slow	None to Low	Dull	3mm to 6 mm	None to low	<5%	ML	CLAYEY SILT
				Slow to very slow	Low to medium	Dull to slight	3mm to 6 mm	Low	5% to 30%	OL	ORGANIC SILT
			Liquid Limit ≥50	Slow to very slow	Low to medium	Slight	3mm to 6 mm	Low to medium	<5%	MH	CLAYEY SILT
				None	Medium to high	Dull to slight	1 mm to 3 mm	Medium to high	5% to 30%	OH	ORGANIC SILT
		CLAYS (PI and LL plot above A-Line on Plasticity Chart below)	Liquid Limit <30	None	Low to medium	Slight to shiny	~ 3 mm	Low to medium	0% to 30% **(see Note 2)**	CL	SILTY CLAY
			Liquid Limit 30 to 50	None	Medium to high	Slight to shiny	1 mm to 3 mm	Medium		CI	SILTY CLAY
			Liquid Limit ≥50	None	High	Shiny	<1 mm	High		CH	CLAY
HIGHLY ORGANIC SOILS (Organic Content >30% by mass)		Peat and mineral soil mixtures							30% to 75%	PT	SILTY PEAT, SANDY PEAT
		Predominantly peat, may contain some mineral soil, fibrous or amorphous peat							75% to 100%		PEAT



Note 1 – Fine grained materials with PI and LL that plot in this area are named (ML) SILT with slight plasticity. Fine-grained materials which are non-plastic (i.e. a PL cannot be measured) are named SILT.

Note 2 – For soils with <5% organic content, include the descriptor "trace organics" for soils with between 5% and 30% organic content include the prefix "organic" before the Primary name.

Dual Symbol — A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC and CL-ML.

For non-cohesive soils, the dual symbols must be used when the soil has between 5% and 12% fines (i.e. to identify transitional material between "clean" and "dirty" sand or gravel.

For cohesive soils, the dual symbol must be used when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart (see Plasticity Chart at left).

Borderline Symbol — A borderline symbol is two symbols separated by a slash, for example, CL/CI, GM/SM, CL/ML.

A borderline symbol should be used to indicate that the soil has been identified as having properties that are on the transition between similar materials. In addition, a borderline symbol may be used to indicate a range of similar soil types within a stratum.

ABBREVIATIONS AND TERMS USED ON RECORDS OF BORHEOLES AND TEST PITS

PARTICLE SIZES OF CONSTITUENTS

Soil Constituent	Particle Size Description	Millimetres	Inches (US Std. Sieve Size)
BOULDERS	Not Applicable	>300	>12
COBBLES	Not Applicable	75 to 300	3 to 12
GRAVEL	Coarse Fine	19 to 75 4.75 to 19	0.75 to 3 (4) to 0.75
SAND	Coarse Medium Fine	2.00 to 4.75 0.425 to 2.00 0.075 to 0.425	(10) to (4) (40) to (10) (200) to (40)
SILT/CLAY	Classified by plasticity	<0.075	< (200)

MODIFIERS FOR SECONDARY AND MINOR CONSTITUENTS

Percentage by Mass	Modifier
>35	Use 'and' to combine major constituents (*i.e.,* SAND and GRAVEL)
> 12 to 35	Primary soil name prefixed with "gravelly, sandy, SILTY, CLAYEY" as applicable
> 5 to 12	some
≤ 5	trace

PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) split-spoon sampler for a distance of 300 mm (12 in.).

Cone Penetration Test (CPT)

An electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm^2 pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (q_t), porewater pressure (u) and sleeve frictions are recorded electronically at 25 mm penetration intervals.

Dynamic Cone Penetration Resistance (DCPT); N_d:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH:	Sampler advanced by hydraulic pressure
PM:	Sampler advanced by manual pressure
WH:	Sampler advanced by static weight of hammer
WR:	Sampler advanced by weight of sampler and rod

SAMPLES

AS	Auger sample
BS	Block sample
CS	Chunk sample
DD	Diamond Drilling
DO or DP	Seamless open ended, driven or pushed tube sampler – note size
DS	Denison type sample
FS	Foil sample
GS	Grab Sample
RC	Rock core
SC	Soil core
SS	Split spoon sampler – note size
ST	Slotted tube
TO	Thin-walled, open – note size
TP	Thin-walled, piston – note size
WS	Wash sample

SOIL TESTS

w	water content
PL , w_p	plastic limit
LL , w_L	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test[1]
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement[1]
D_R	relative density (specific gravity, Gs)
DS	direct shear test
GS	specific gravity
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V (FV)	field vane (LV-laboratory vane test)
γ	unit weight

1. Tests anisotropically consolidated prior to shear are shown as CAD, CAU.

NON-COHESIVE (COHESIONLESS) SOILS

Compactness[2]

Term	SPT 'N' (blows/0.3m)[1]
Very Loose	0 - 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	>50

1. SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects.
2. Definition of compactness terms are based on SPT-'N' ranges as provided in Terzaghi, Peck and Mesri (1996) and correspond to typical average N_{60} values. Many factors affect the recorded SPT-'N' value, including hammer efficiency (which may be greater than 60% in automatic trip hammers), groundwater conditions, and grainsize. As such, the recorded SPT-'N' value(s) should be considered only an approximate guide to the compactness term. These factors need to be considered when evaluating the results, and the stated compactness terms should not be relied upon for design or construction.

Field Moisture Condition

Term	Description
Dry	Soil flows freely through fingers.
Moist	Soils are darker than in the dry condition and may feel cool.
Wet	As moist, but with free water forming on hands when handled.

COHESIVE SOILS

Consistency

Term	Undrained Shear Strength (kPa)	SPT 'N'[1,2] (blows/0.3m)
Very Soft	<12	0 to 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	>200	>30

1. SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects; approximate only.
2. SPT 'N' values should be considered ONLY an approximate guide to consistency; for sensitive clays (e.g., Champlain Sea clays), the N-value approximation for consistency terms does NOT apply. Rely on direct measurement of undrained shear strength or other manual observations.

Water Content

Term	Description
w < PL	Material is estimated to be drier than the Plastic Limit.
w ~ PL	Material is estimated to be close to the Plastic Limit.
w > PL	Material is estimated to be wetter than the Plastic Limit.

LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. GENERAL

π	3.1416
ln x	natural logarithm of x
$\log_{10}$	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta\ \sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

(a) Index Properties (continued)

w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	plasticity index = $(w_l - w_p)$
w_s	shrinkage limit
I_L	liquidity index = $(w - w_p) / I_p$
I_C	consistency index = $(w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_α	secondary compression index
m_v	coefficient of volume change
c_v	coefficient of consolidation (vertical direction)
c_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio = σ'_p / σ'_{vo}

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = tan δ
c'	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p′	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

Notes:
1 $\tau = c' + \sigma' \tan \phi'$
2 shear strength = (compressive strength)/2

---

* Density symbol is ρ. Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density multiplied by acceleration due to gravity)

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-01

SHEET 1 OF 1

LOCATION: N 5020936.4 ;E 465673.3

BORING DATE: December 18, 2017

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80; SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3}; WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		77.26							
0	Power Auger 200 mm Diam. (Hollow Stem)	FILL - (SM) SILTY SAND, fine to medium sand, trace gravel, some low plastic fines; brown, contains organic matter and clayey silt seams; non-cohesive, moist, dense to very loose	▩	0.00	1	SS	37				
1					2	SS	28				
2					3	SS	13				
					4	SS	2				
3		(CI/CH) SILTY CLAY to CLAY; grey brown, contains silt seams (WEATHERED CRUST); cohesive, w>PL, soft	▨	74.21 3.05	5	SS	WH				
4								⊕+			
		(SM/ML) SILTY SAND to sandy SILT, fine sand; grey; non-cohesive, wet		73.25 4.01							
		(CI/CH) SILTY CLAY to CLAY; grey with reddish brown mottling, contains silt seams; cohesive, w>PL, soft	▨	72.99 4.27	6	SS	WH				
5		End of Borehole		72.38 4.88							
6											
7											
8											
9											
10											

DEPTH SCALE
1 : 50

GOLDER

LOGGED: DWM
CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-02

SHEET 1 OF 1

LOCATION: N 5020989.8 ;E 465813.1

BORING DATE: December 18, 2017

DATUM: CGVD28

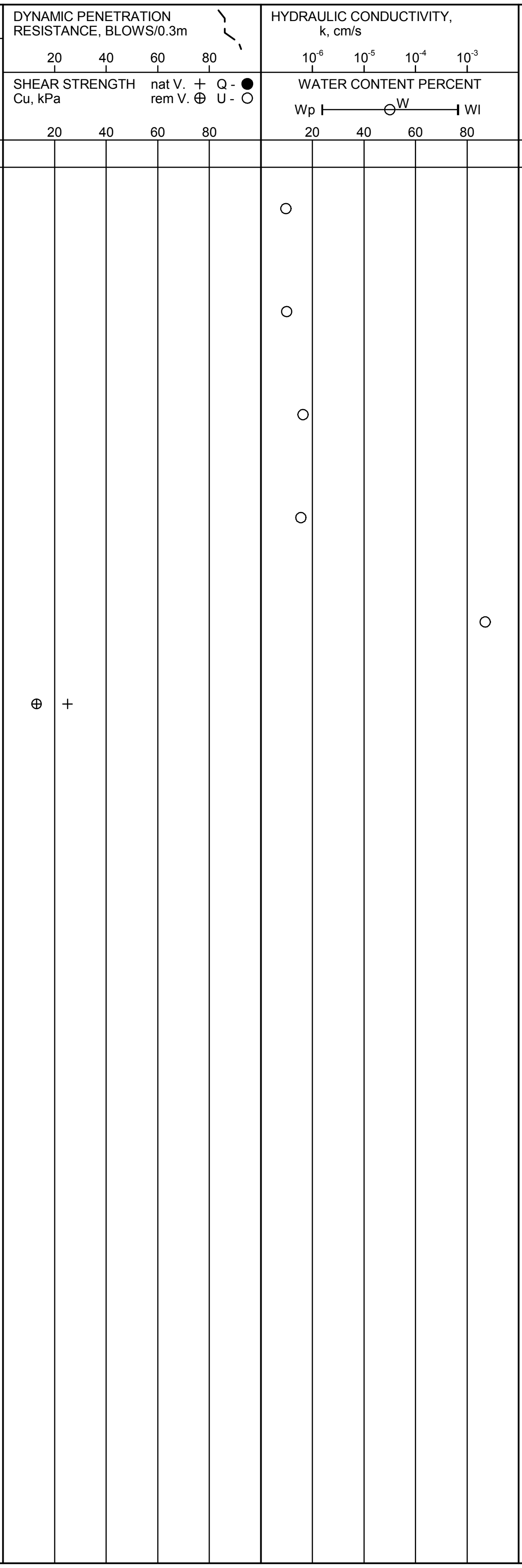
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: Power Auger, 200 mm Diam. (Hollow Stem)

SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)
GROUND SURFACE		77.46
FILL - (SM) SILTY SAND, some gravel; grey to blackish to brown, contains asphalt, organic matter and brick fragments; non-cohesive, moist, compact	▩	0.00
FILL - (ML) CLAYEY SILT and sandy SILT, some gravel; grey brown, contains organic matter; non-cohesive, moist, loose to very loose	▩	75.94 1.52
(CI/CH) SILTY CLAY to CLAY; grey brown, contains silt seams; cohesive, w>PL, soft	▨	74.41 3.05
(SM/ML) SILTY SAND to sandy SILT, fine to medium sand; grey; non-cohesive, wet	░	73.27 4.19
(CI/CH) SILTY CLAY to CLAY; grey with reddish brown mottling, contains silt seams; cohesive, w>PL, soft	▨	4.27
End of Borehole		72.58 4.88

SAMPLES NUMBER	TYPE	BLOWS/0.30m
1	SS	25
2	SS	19
3	SS	9
4	SS	3
5	SS	WH
6	SS	WH



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE METRES: 0 1 2 3 4 5 6 7 8 9 10

DEPTH SCALE

1 : 50

GOLDER

LOGGED: DWM

CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-03

SHEET 1 OF 1

LOCATION: N 5021042.5 ;E 465953.7

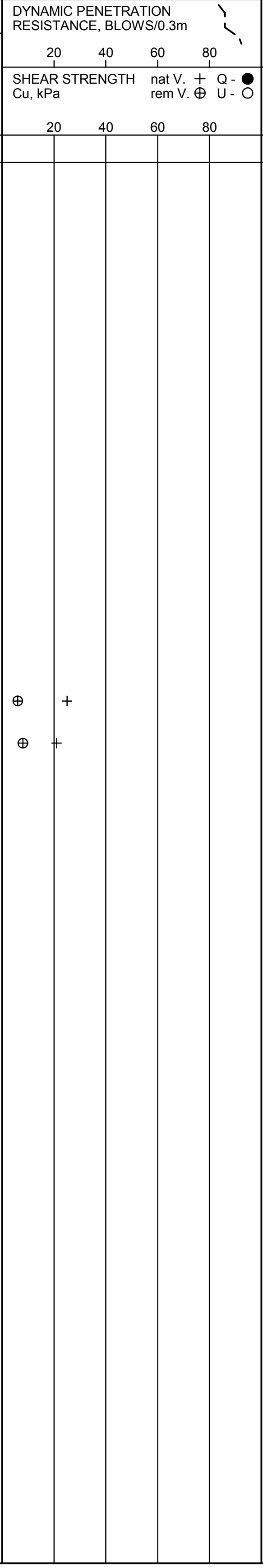
BORING DATE: December 18, 2017

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m
		GROUND SURFACE		77.47			
0	Power Auger 200 mm Diam. (Hollow Stem)	FILL - (SM) SILTY SAND, some gravel to gravelly, some low plastic fines; brown to black, contains organic matter; non-cohesive, moist, compact	▨	0.00	1	SS	24
1					2	SS	22
2					3	SS	15
		(CI/CH) SILTY CLAY to CLAY; grey brown (WEATHERED CRUST), contains silt seams; cohesive, w>PL, stiff	▨	75.19 2.28	4	SS	3
3		(CI/CH) SILTY CLAY to CLAY; grey with reddish brown mottling, contains silt seams; cohesive, w>PL, soft	▨	74.58 2.89	5	SS	WH
4							
		End of Borehole		73.20 4.27			
5							
6							
7							
8							
9							
10							



HYDRAULIC CONDUCTIVITY, k, cm/s

10^{-6} 10^{-5} 10^{-4} 10^{-3}

WATER CONTENT PERCENT

Wp ⊢—○W—⊣ Wl

20 40 60 80

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

MIS-BHS 001 1787048.GPJ GAL-MIS.GDT 4/12/18 ZS

DEPTH SCALE

1 : 50

GOLDER

LOGGED: DWM

CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-04

SHEET 1 OF 1

LOCATION: N 5021108.2 ;E 466090.6

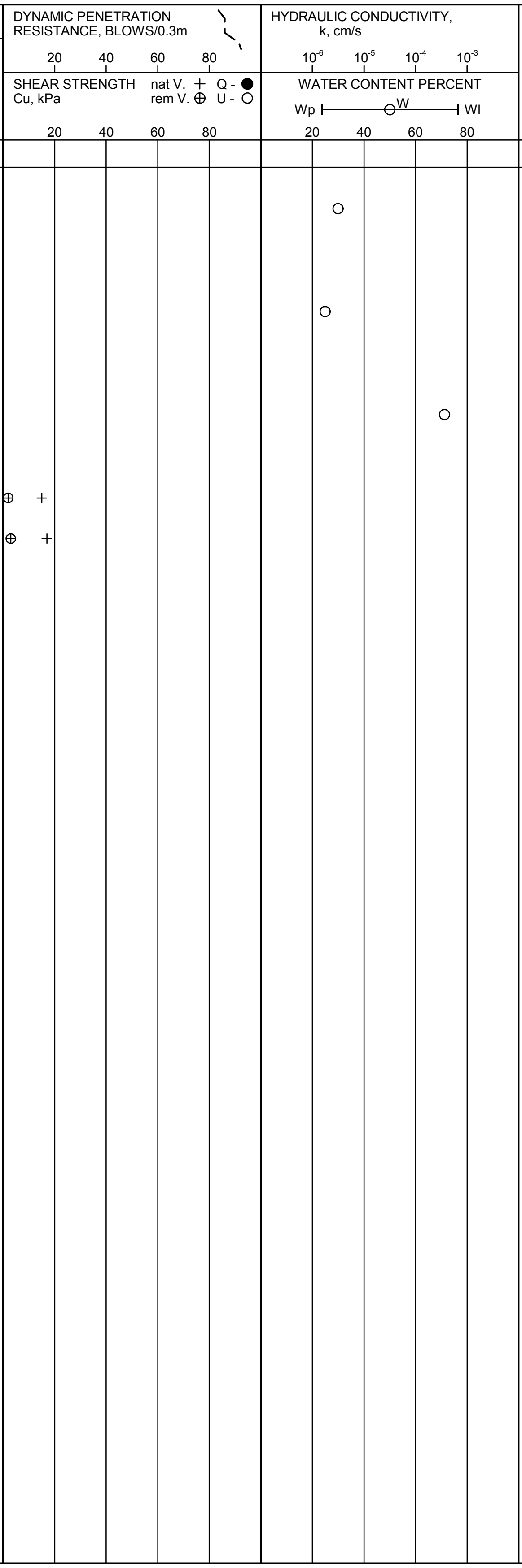
BORING DATE: December 18, 2017

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		76.30					
0	Power Auger 200 mm Diam. (Hollow Stem)	(SP/SM) SAND to SILTY SAND, trace gravel; non-cohesive, wet, loose		0.00	1	SS	9		
1					2	SS	7		
		(CI/CH) SILTY CLAY to CLAY; grey brown, contains silt seams: cohesive, w>PL, soft		74.78 1.52	3	SS	WH		
3					4	SS	WH		
4		(ML) sandy SILT, SILT and CLAYEY SILT, layered; grey; non-cohesive, wet, very loose		72.49 3.81	5	SS	2		
		End of Borehole		71.88 4.42					



DEPTH SCALE
1 : 50

GOLDER

LOGGED: DWM
CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-05

SHEET 1 OF 1

LOCATION: N 5021093.1 ;E 465937.9

BORING DATE: January 30, 2018

DATUM: CGVD28

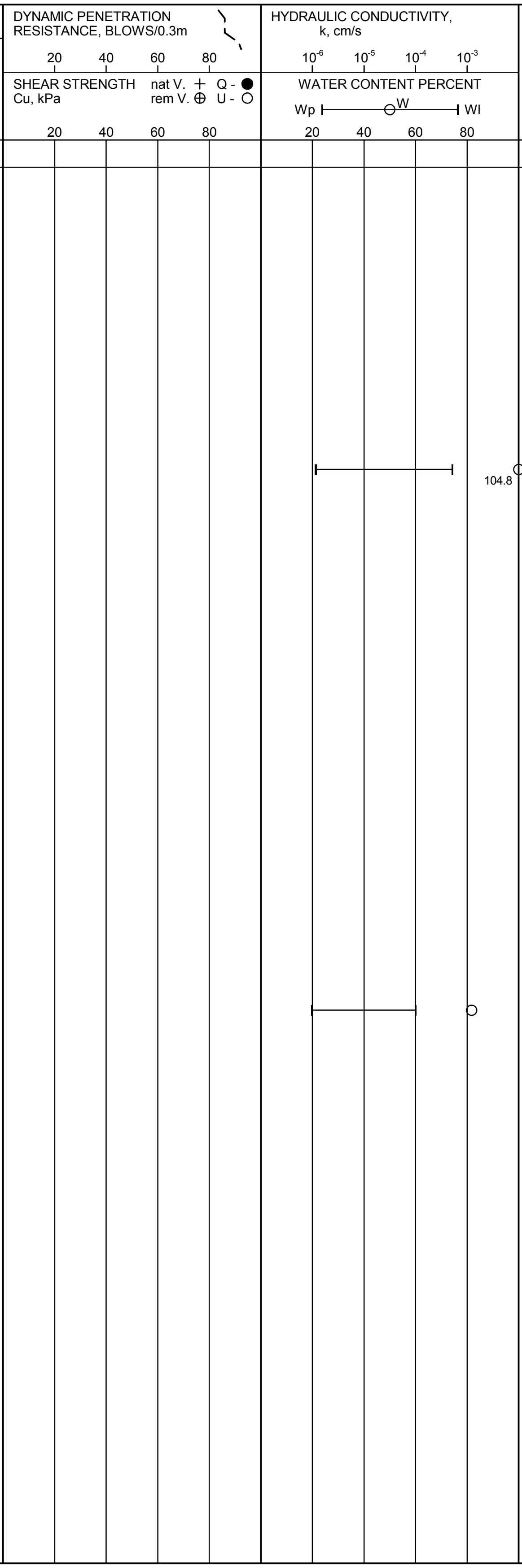
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: Wash Boring, HW Casing

SOIL PROFILE DESCRIPTION	ELEV.	DEPTH (m)
GROUND SURFACE	76.35	
TOPSOIL - (SM) SILTY SAND; dark brown; non-cohesive, moist		0.00
(SP/SM) SAND to SILTY SAND; brown; non-cohesive, moist, loose		0.08
(CI/CH) SILTY CLAY to CLAY; grey brown, contains silt seams (WEATHERED CRUST); cohesive, w>PL, stiff	75.59	0.76
(CI/CH) SILTY CLAY to CLAY; grey, contains silt seams; cohesive, w>PL, soft	75.01	1.34
(SM/ML) SILTY SAND to sandy SILT; grey; non-cohesive, wet	72.84	3.51
(CI/CH) SILTY CLAY to CLAY; grey, contains silt seams; cohesive, w>PL, firm to soft		3.66
End of Borehole	66.80	9.55

NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
1	SS	7	
2	SS	3	
3	TP	PH	C
4	SS	WH	
5	SS	WR	
6	TP	PH	C
7	SS	WR	
8	TP	PH	



PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE 1 : 50

LOGGED: DG

CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-05N

SHEET 1 OF 2

LOCATION: N 5021093.1 ;E 465937.9

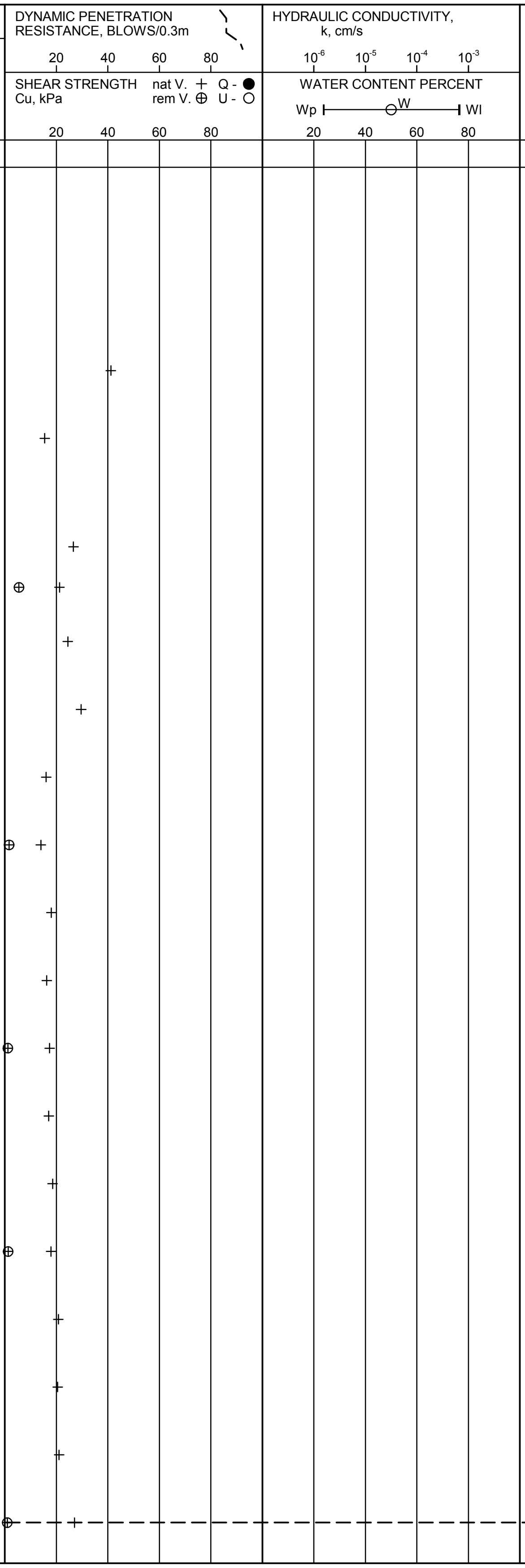
BORING DATE: January 11, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		76.35					
0	Power Auger 200 mm Diam. (H.S)	TOPSOIL - (SM) SILTY SAND; dark brown; non-cohesive, moist							
		(SP/SM) SAND to SILTY SAND; brown; non-cohesive, moist, loose		0.05	1	SS	7		
1		(CI/CH) SILTY CLAY to CLAY; grey brown, contains silt seams (WEATHERED CRUST); cohesive, w>PL, stiff		75.59 0.76	2	SS	3		
2 – 9	Nilcon Vanes Clutch	For soil stratigraphy refer to Record of Borehole 17-05		75.01 1.34					
10				66.35					
		CONTINUED NEXT PAGE							



DEPTH SCALE

1 : 50

GOLDER

LOGGED: DG

CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-05N

SHEET 2 OF 2

LOCATION: N 5021093.1 ;E 465937.9

BORING DATE: January 11, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---									
10		End of Borehole		10.00							
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											

MIS-BHS 001 1787048.GPJ GAL-MIS.GDT 4/12/18 ZS

DEPTH SCALE

1 : 50

GOLDER

LOGGED: DG

CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-07

SHEET 1 OF 4

LOCATION: N 5021228.9 ;E 465864.4

BORING DATE: December 19-21, 2017

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

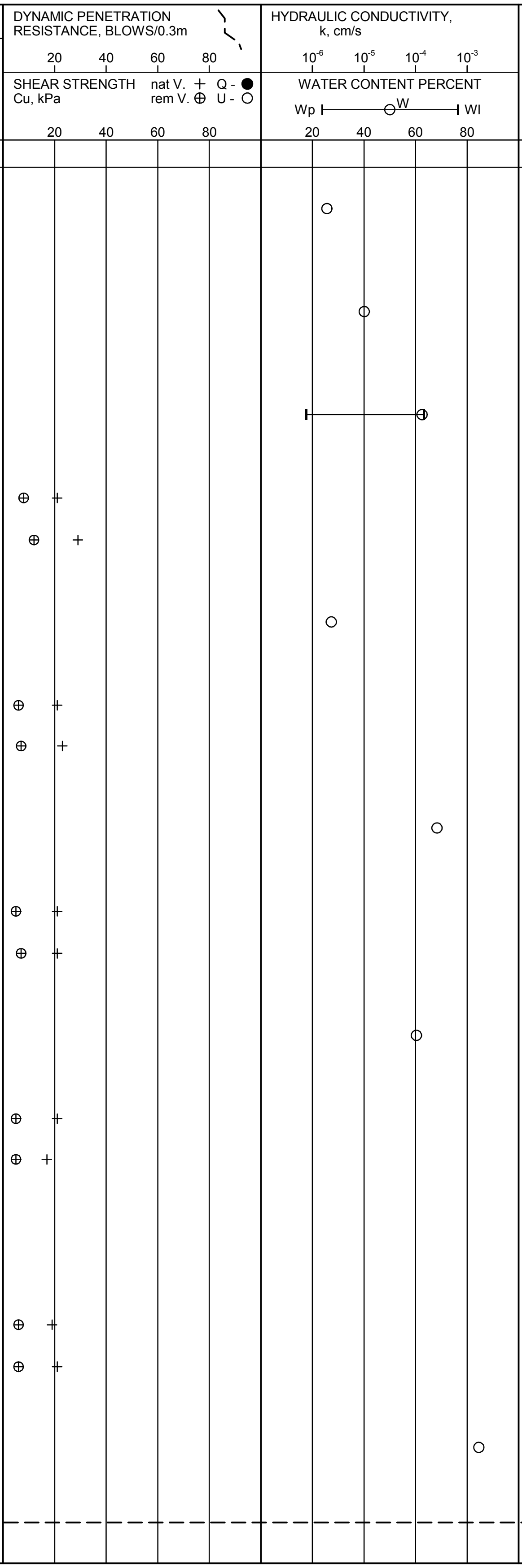
PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: Wash Boring
HW Casing

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	76.29
(SM) SILTY SAND, fine; grey brown, contains organic matter; non-cohesive, moist, very loose	0.00
(CI/CH) SILTY CLAY to CLAY, trace sand; grey brown, contains silt layers and organic matter (rootlets) (WEATHERED CRUST); cohesive, w>PL, stiff	75.53 0.76
(CI/CH) SILTY CLAY to CLAY; grey with reddish brown mottling, contains silt seams; cohesive, w>PL, soft to firm	74.77 1.52
(ML) sandy SILT; grey; non-cohesive, wet, compact to loose	73.24 3.05
(CI/CH) SILTY CLAY to CLAY; grey with reddish brown to black mottling, contains silt seams; cohesive, w>PL, soft	72.63 3.66

CONTINUED NEXT PAGE

NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
1	SS	WH	
2	SS	3	
3	SS	WH	
4	SS	10	M
5	SS	WH	
6	SS	WH	
7	SS	WR	
8	SS	WR	



PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE METRES: 0 – 10

DEPTH SCALE
1 : 50

GOLDER

LOGGED: DWM
CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-07

SHEET 2 OF 4

LOCATION: N 5021228.9 ;E 465864.4

BORING DATE: December 19-21, 2017

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

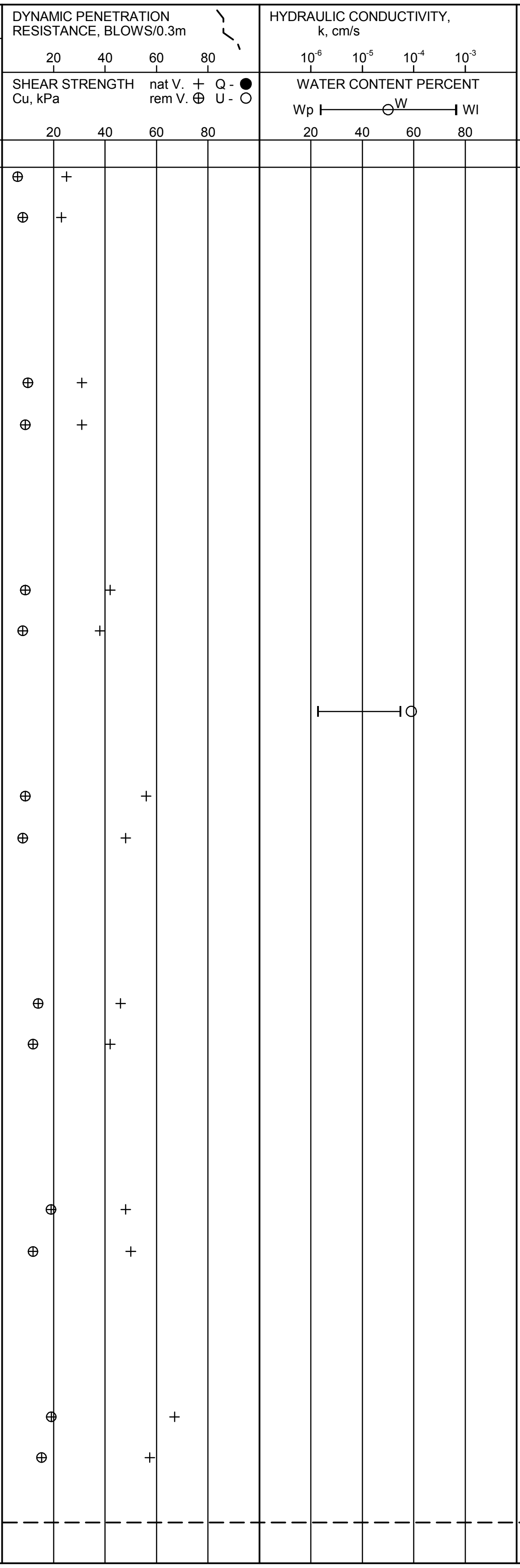
PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: Wash Boring, HW Casing

--- CONTINUED FROM PREVIOUS PAGE ---

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
(CI/CH) SILTY CLAY to CLAY; grey with reddish brown to black mottling, contains silt seams; cohesive, w>PL, soft	
(CI/CH) SILTY CLAY to CLAY; grey with black mottling, contains silt seams; cohesive, w>PL, firm	65.01 11.28
(CI/CH) SILTY CLAY to CLAY; grey with black mottling, contains silt seams; cohesive, w>PL, stiff	61.97 14.32
(CI/CH) SILTY CLAY to CLAY; grey with black mottling, contains silt seams; cohesive, w>PL, firm	61.51 14.78
(CI/CH) SILTY CLAY to CLAY; grey with black mottling, contains silt seams; cohesive, w>PL, stiff	58.00 18.29

SAMPLES NUMBER	TYPE	BLOWS/0.30m
9	SS	WR
10	SS	WH
11	SS	WR
12	SS	WR
13	SS	WR
14	SS	WR
15	SS	WR



DEPTH SCALE METRES: 10 – 20

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

GOLDER

LOGGED: DWM
CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-07

SHEET 3 OF 4

LOCATION: N 5021228.9 ;E 465864.4

BORING DATE: December 19-21, 2017

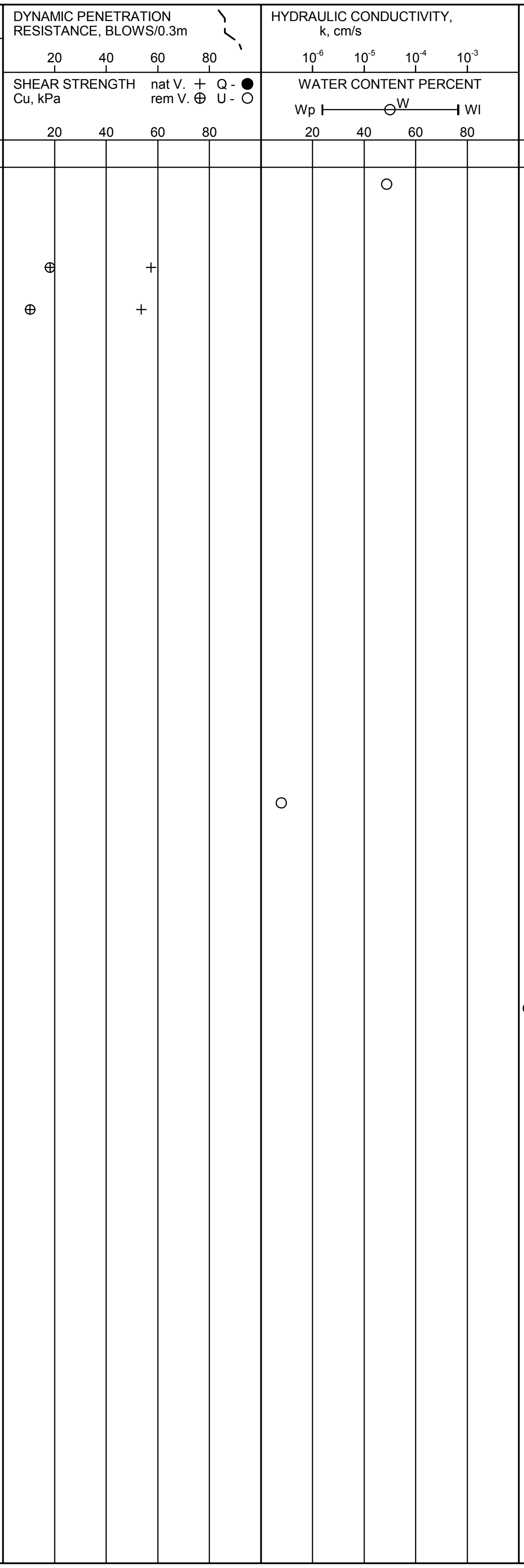
DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

--- CONTINUED FROM PREVIOUS PAGE ---

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
20	Wash Boring HW Casing	(CI/CH) SILTY CLAY to CLAY; grey with black mottling, contains silt seams; cohesive, w>PL, stiff		15	SS	WR		
22.56		(SM/ML) SILTY SAND to sandy SILT, some low plastic fines, some gravel to gravelly; grey, contains rock fragments (GLACIAL TILL); non-cohesive, wet, dense to very dense	53.73 22.56	16	SS	39		
				17	SS	54		
				18	SS	87	CHEM	
				19	SS	50		
				20	SS	>50		
29.39		Borehole continued on RECORD OF DRILLHOLE 17-07	46.90 29.39					



DEPTH SCALE 1 : 50

GOLDER

LOGGED: DWM

CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF DRILLHOLE: 17-07

SHEET 4 OF 4

LOCATION: N 5021228.9 ;E 465864.4

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: December 19-21, 2017

DRILL RIG: LC 55

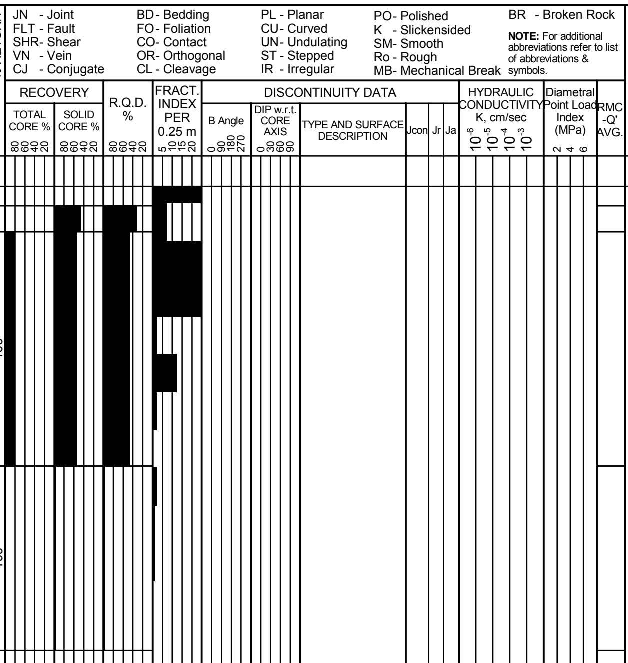
DRILLING CONTRACTOR: Grenville Drilling

DATUM: CGVD28

JN - Joint
FLT - Fault
SHR- Shear
VN - Vein
CJ - Conjugate
BD- Bedding
FO- Foliation
CO- Contact
OR- Orthogonal
CL - Cleavage
PL - Planar
CU- Curved
UN- Undulating
ST - Stepped
IR - Irregular
PO- Polished
K - Slickensided
SM- Smooth
Ro - Rough
MB- Mechanical Break
BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN FLUSH	RMC -Q' AVG.	
		BEDROCK SURFACE		46.90				
		Possible weathered rock, till infilling		29.39				
	Rotary Drill HQ Core	Slightly weathered to fresh, thinly to medium bedded, grey to dark grey, fine grained, slightly to non-porous SHALE, with limestone and calcareous shale interbeds CARLSBAD FORMATION - Broken core from 29.69 m to 30.00 m - Broken core from 30.00 m to 30.19 m - Broken core from 30.59 m to 30.70 m - Broken core from 30.86 m to 30.88 m		29.52	1			
30 31					2	100		UCS = 135.8 MPa
32				43.83	3	100		
		End of Drillhole		32.46				
33 34 35 36 37 38 39								



DEPTH SCALE
1 : 50

LOGGED: DWM
CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-08

SHEET 1 OF 1

LOCATION: N 5021301.7 ;E 465837.2

BORING DATE: January 10, 2018

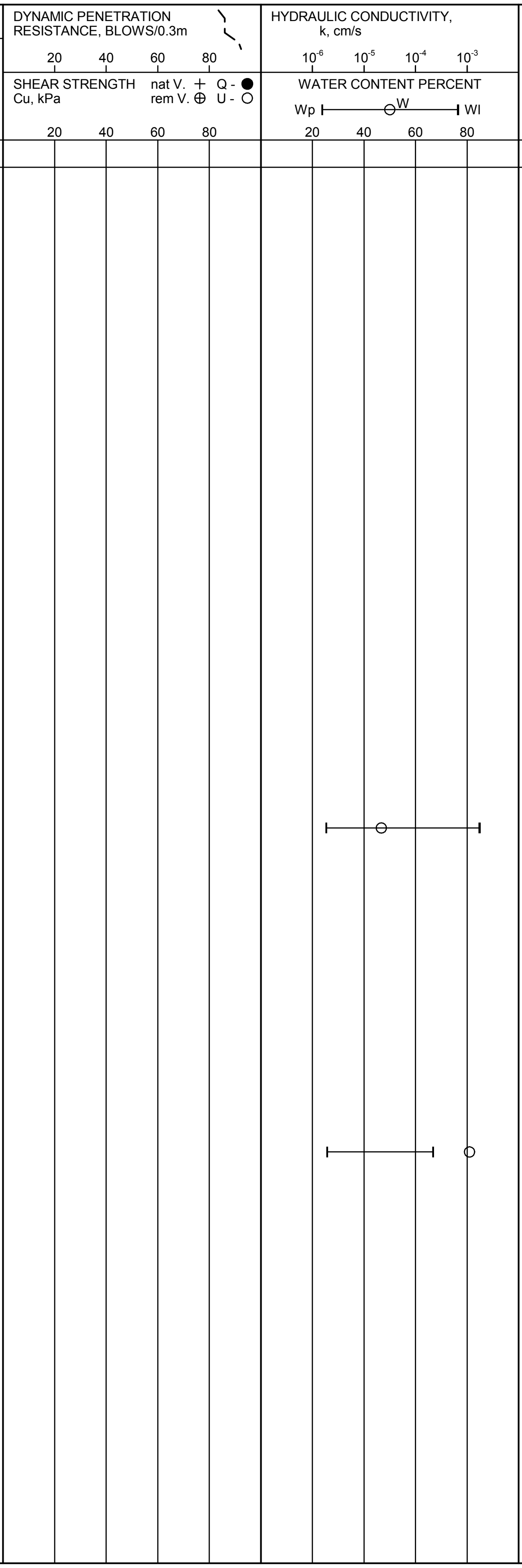
DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
	GROUND SURFACE	76.12
Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND; dark brown; non-cohesive, moist	0.00
	(SM) SILTY SAND; brown; non-cohesive, moist, loose	0.08
	(CI/CH) SILTY CLAY to CLAY; grey brown, contains silt seams (WEATHERED CRUST); cohesive, w>PL, stiff	75.39 0.73
	(CI/CH) SILTY CLAY to CLAY; grey with reddish brown mottling, contains silt seams; cohesive, w>PL, firm to soft	74.78 1.34
	(SP/SM) SAND to SILTY SAND, fine sand; grey; non-cohesive, wet, very loose	73.38 2.74
Wash Boring HW Casing	(CI/CH) SILTY CLAY to CLAY; grey with occasional reddish brown mottling, contains silt seams; cohesive, w>PL, soft	72.84 3.28
	End of Borehole	66.37 9.75

SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
1	SS	7	
2	SS	2	
3	SS	WH	
4	SS	2	
5	TP	PH	C
6	SS	WH	
7	TP	PH	C
8	SS	WH	
9	SS	WH	



PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE METRES: 0 1 2 3 4 5 6 7 8 9 10

DEPTH SCALE
1 : 50

GOLDER

LOGGED: DG
CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-08N

SHEET 1 OF 2

LOCATION: N 5021301.7 ;E 465837.2

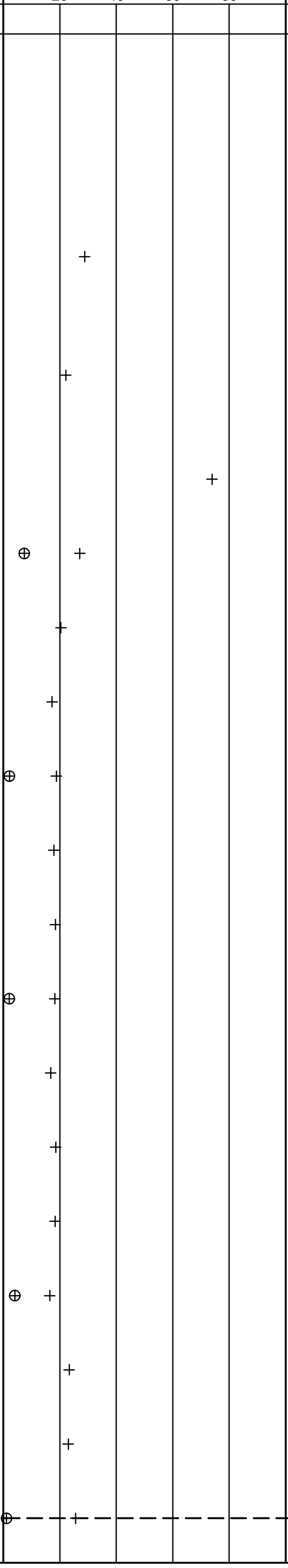
BORING DATE: January 9, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		76.12							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND; dark brown; non-cohesive, moist		0.00							
		(SM) SILTY SAND; brown; non-cohesive, moist, loose		0.09	1	SS	7				
		(CI/CH) SILTY CLAY to CLAY; grey brown, contains silt seams (WEATHERED CRUST); cohesive, w>PL, stiff		75.57 0.55							
1					2	SS	2				
	Nilcon Vanes Clutch	For soil stratigraphy refer to Record of Borehole 17-08		74.77 1.35							
2											
3											
4											
5											
6											
7											
8											
9											
10				66.12							
		CONTINUED NEXT PAGE									



DEPTH SCALE

1 : 50

GOLDER

LOGGED: DG

CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-08N

SHEET 2 OF 2

LOCATION: N 5021301.7 ;E 465837.2

BORING DATE: January 9, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	SOIL PROFILE: STRATA PLOT	SOIL PROFILE: ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20, 40, 60, 80); SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20, 40, 60, 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6}, 10^{-5}, 10^{-4}, 10^{-3}); WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl (20, 40, 60, 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---									
10		End of Borehole		10.00							
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: DG

CHECKED: SM

MIS-BHS 001 1787048.GPJ GAL-MIS.GDT 4/12/18 ZS

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-09

SHEET 1 OF 5

LOCATION: N 5021391.2 ;E 466055.7

BORING DATE: January 3-9, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: Wash Boring, HW Casing

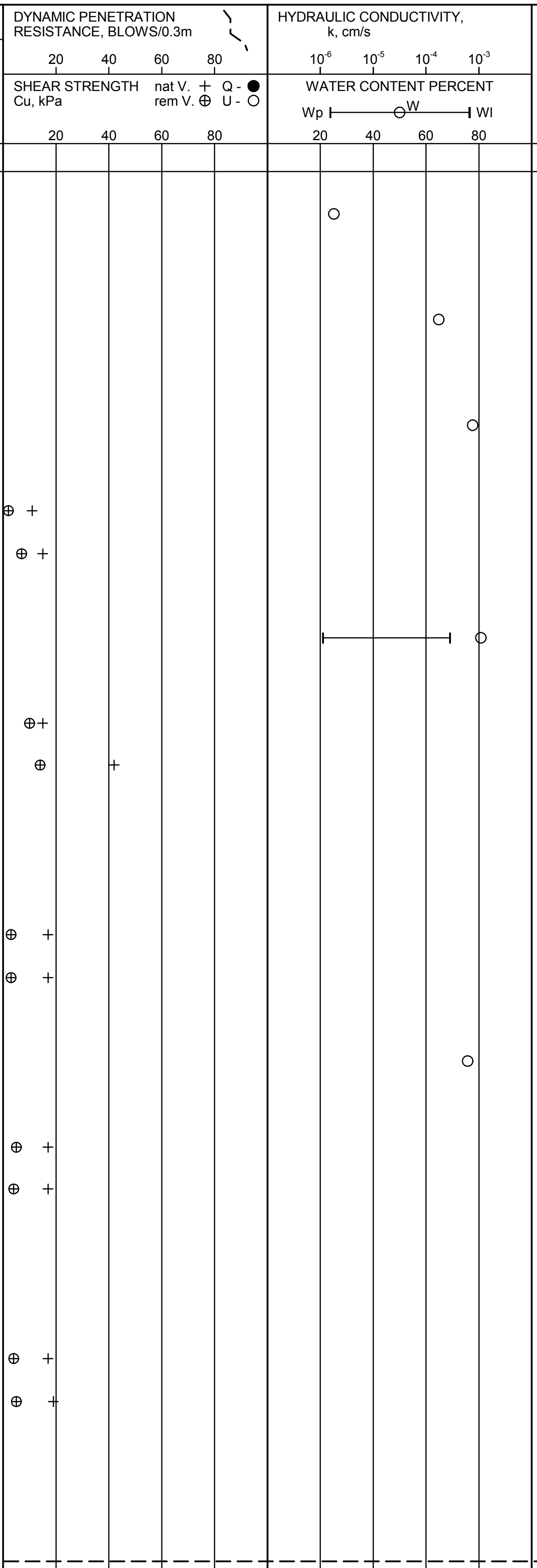
DEPTH SCALE METRES: 0 – 10

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	76.56
TOPSOIL - (SM) SILTY SAND; black; non-cohesive, wet	0.00
(SM) SILTY SAND; grey brown; non-cohesive, moist, very loose	76.26 0.30
(CI/CH) SILTY CLAY to CLAY; grey brown, contains silt seams and organic matter (roots) (WEATHERED CRUST); cohesive, w>PL, stiff to firm	75.80 0.76
(CI/CH) SILTY CLAY to CLAY; grey with reddish brown mottling, contains silt seams; cohesive, w>PL, very soft to soft - Possible silt layer	74.73 1.83
	66.56

CONTINUED NEXT PAGE

SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
1	SS	2	M
2	SS	2	
3	SS	WH	
4	SS	WR	
5	SS	WH	
6	SS	WH	
7	SS	WR	
8	SS	WR	

PIEZOMETER OR STANDPIPE INSTALLATION



DEPTH SCALE
1 : 50

GOLDER

LOGGED: DWM
CHECKED: SM

MIS-BHS 001 1787048.GPJ GAL-MIS.GDT 4/12/18 ZS

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-09

SHEET 2 OF 5

LOCATION: N 5021391.2 ;E 466055.7

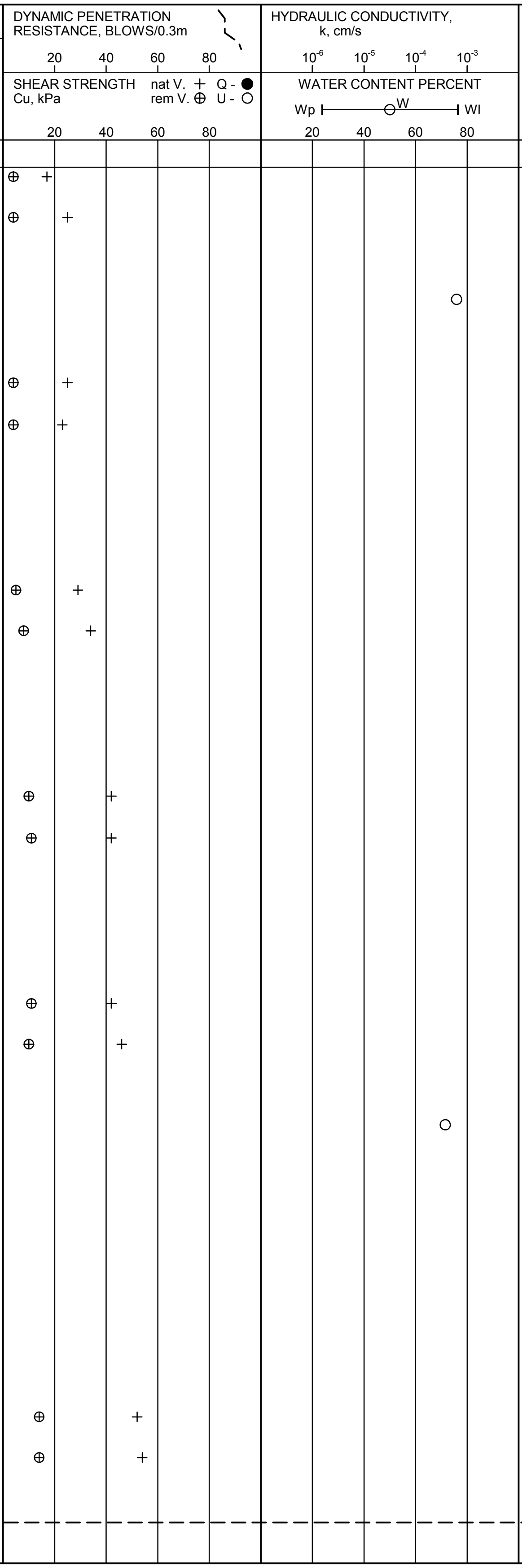
BORING DATE: January 3-9, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---							
10	Wash Boring HW Casing	(CI/CH) SILTY CLAY to CLAY; grey with reddish brown to black mottling, contains silt seams; cohesive, w>PL, soft to firm	▨	10.00					
11					9	SS	WR		
12		(CI/CH) SILTY CLAY to CLAY; grey with black mottling, contains silt seams; cohesive, w>PL, firm	▨	64.37 12.19	10	SS	WR		
13									
14					11	SS	WR		
15					12	SS	WR		
16									
17					13	SS	WR		
18		(CI/CH) SILTY CLAY to CLAY; grey with black mottling, contains silt seams; cohesive, w>PL, stiff	▨	58.27 18.29	14	SS	WR		
19									
20					15	SS	WR		
		CONTINUED NEXT PAGE							



DEPTH SCALE

1 : 50

GOLDER

LOGGED: DWM

CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-09

SHEET 3 OF 5

LOCATION: N 5021391.2 ;E 466055.7

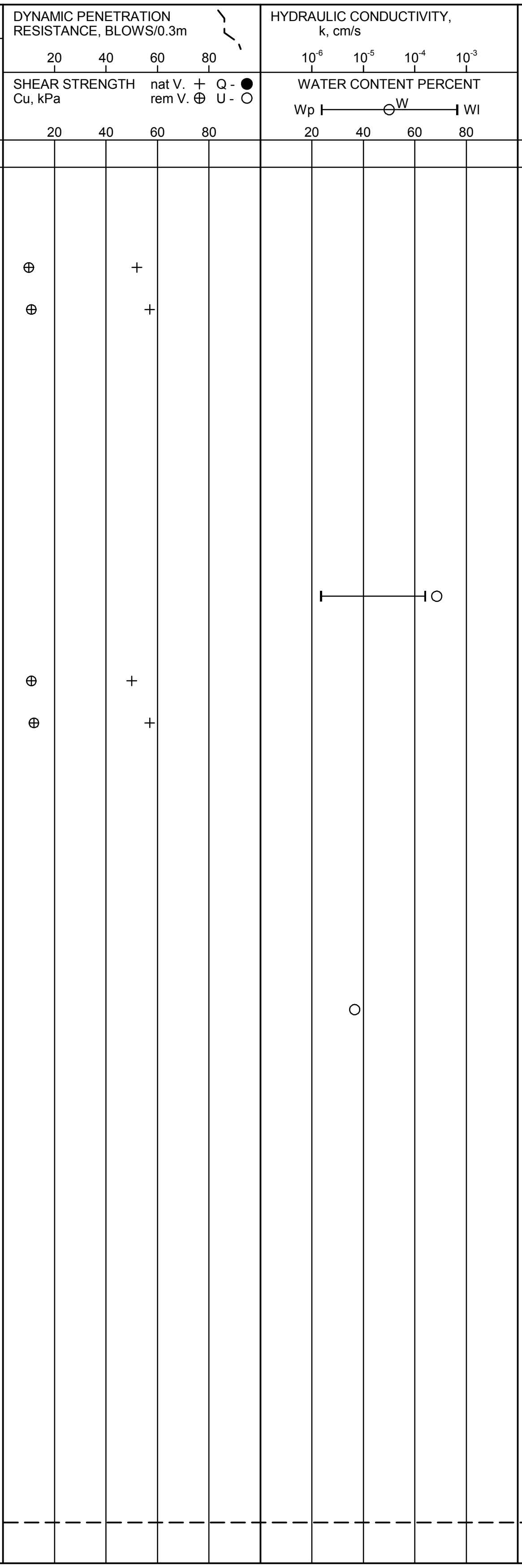
BORING DATE: January 3-9, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m
		--- CONTINUED FROM PREVIOUS PAGE ---					
20	Wash Boring HW Casing	(CI/CH) SILTY CLAY to CLAY; grey with black mottling, contains silt seams; cohesive, w>PL, stiff			15	SS	WR
21							
22							
23					16	SS	WR
24							
25							
26					17	SS	1
		(SM/ML) SILTY SAND to sandy SILT, some low plastic fines, some gravel to gravelly; grey, contains rock fragments and cobbles (GLACIAL TILL); non-cohesive, wet, very dense		49.89 26.67	18	SS	55
27							
28					19	SS	56
29					20	SS	>50
					21	SS	>50
30				46.55			
		CONTINUED NEXT PAGE					



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE
1 : 50

GOLDER

LOGGED: DWM
CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-09

SHEET 4 OF 5

LOCATION: N 5021391.2 ;E 466055.7

BORING DATE: January 3-9, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m				
		--- CONTINUED FROM PREVIOUS PAGE ---									
30		Borehole continued on RECORD OF DRILLHOLE 17-09		30.01							
31											
32											
33											
34											
35											
36											
37											
38											
39											
40											

MIS-BHS 001 1787048.GPJ GAL-MIS.GDT 4/12/18 ZS

DEPTH SCALE

1 : 50

GOLDER

LOGGED: DWM

CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF DRILLHOLE: 17-09

SHEET 5 OF 5

LOCATION: N 5021391.2 ;E 466055.7

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: January 3-9, 2018

DRILL RIG: LC 55

DRILLING CONTRACTOR: Grenville Drilling

DATUM: CGVD28

JN - Joint
FLT - Fault
SHR- Shear
VN - Vein
CJ - Conjugate

BD- Bedding
FO- Foliation
CO- Contact
OR- Orthogonal
CL - Cleavage

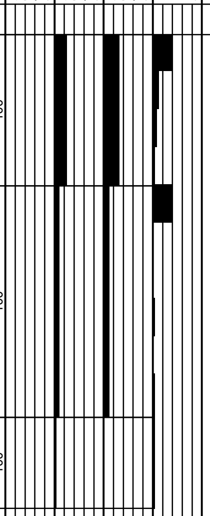
PL - Planar
CU- Curved
UN- Undulating
ST - Stepped
IR - Irregular

PO- Polished
K - Slickensided
SM- Smooth
Ro - Rough
MB- Mechanical Break

BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. / DEPTH (m)	RUN No.	FLUSH COLOUR % RETURN
		BEDROCK SURFACE	46.55		
31 32 33	Rotary Drill HQ Core	Slightly weathered to fresh, thinly to medium bedded, grey to dark grey, fine grained, slightly to non-porous SHALE, with limestone and calcareous shale interbeds CARLSBAD FORMATION - Silt seam from 30.15 m to 30.24 m - Silt seam from 31.03 m to 31.08 m	30.01 43.42	1 2 3	100 100 100
34 35 36 37 38 39 40		End of Drillhole	33.14		



DISCONTINUITY DATA						HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -Q' AVG.
B Angle	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jcon	Jr	Ja	10^{-6} 10^{-5} 10^{-4} 10^{-3}	2 4 6	
0 90 180 270	0 30 60 90							

DEPTH SCALE

1 : 50

GOLDER

LOGGED: DWM

CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-12N

SHEET 1 OF 2

LOCATION: N 5021345.5 ;E 466151.3

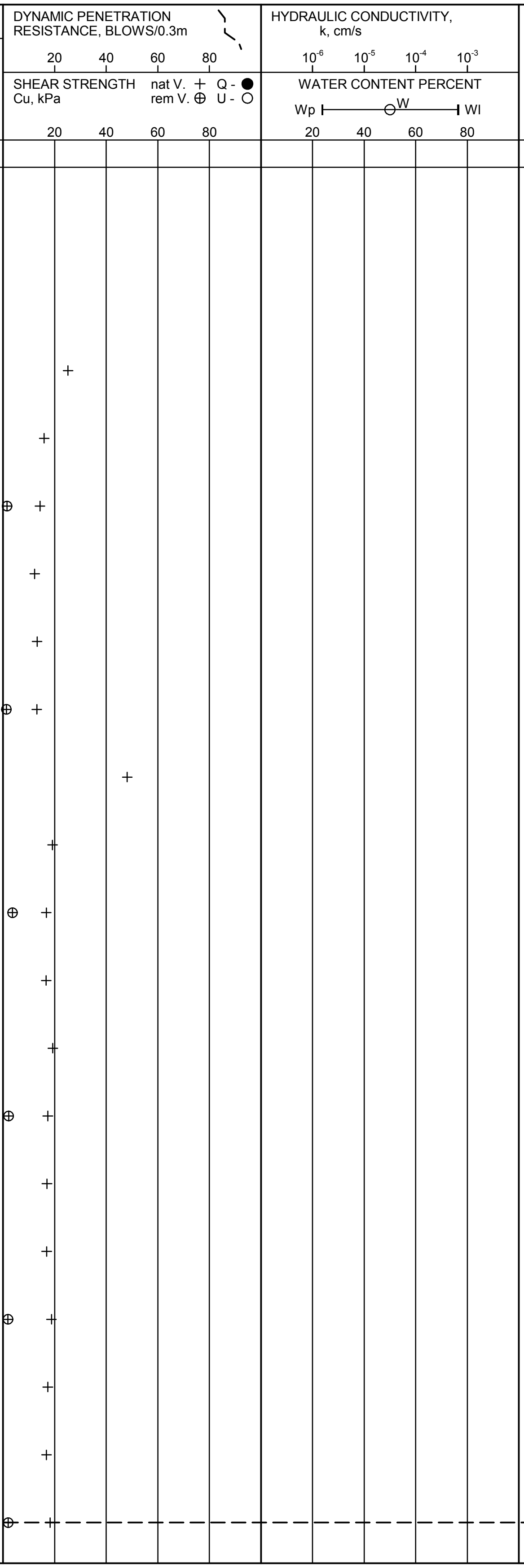
BORING DATE: January 17, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		76.57					
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND; dark brown; non-cohesive, moist		0.00					
		(SM) SILTY SAND; brown; non-cohesive, wet, loose		76.34 0.23	1	SS	6		
1		(CI/CH) SILTY CLAY to CLAY; grey brown, contains silt seams (WEATHERED CRUST): cohesive, w>PL, stiff		75.96 0.61	2	SS	3		
	Nilcon Vanes Clutch			75.32 1.25					
10				66.57					
		CONTINUED NEXT PAGE							



DEPTH SCALE
1 : 50

GOLDER

LOGGED: DG
CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-12N

SHEET 2 OF 2

LOCATION: N 5021345.5 ;E 466151.3

BORING DATE: January 17, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m				
		--- CONTINUED FROM PREVIOUS PAGE ---									
10		End of Borehole		10.00							
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											

DEPTH SCALE
1 : 50

GOLDER

LOGGED: DG
CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-13N

SHEET 1 OF 2

LOCATION: N 5021450.3 ;E 466217.9

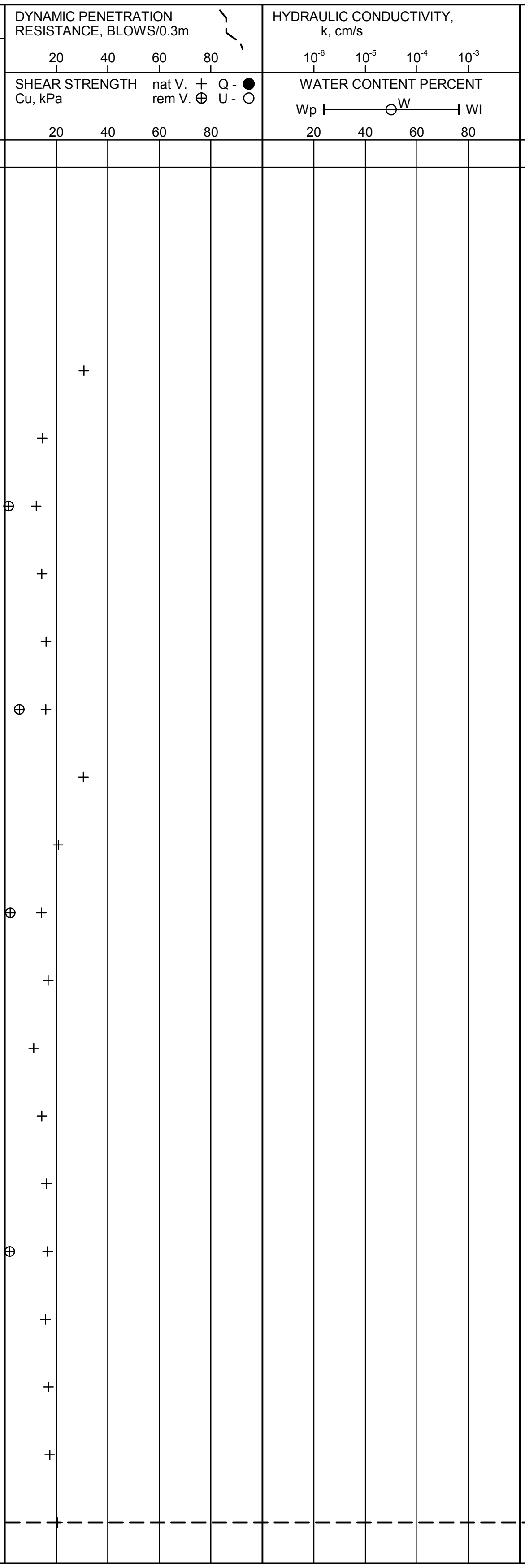
BORING DATE: January 17, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		76.43					
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND; dark brown; non-cohesive, moist		0.00					
		(SM) SILTY SAND; brown; non-cohesive, wet, very loose		76.20 0.23	1	SS	4		
1		(CI/CH) SILTY CLAY to CLAY; grey brown, contains silt seams (WEATHERED CRUST); cohesive, w>PL, stiff		75.67 0.76	2	SS	3		
	Nilcon Vanes Clutch			75.21 1.22					
10				66.43					



CONTINUED NEXT PAGE

DEPTH SCALE

1 : 50

GOLDER

LOGGED: DG

CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-13N

SHEET 2 OF 2

LOCATION: N 5021450.3 ;E 466217.9

BORING DATE: January 17, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---									
10		End of Borehole		10.00							
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: DG

CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-14

SHEET 1 OF 5

LOCATION: N 5021390.9 ;E 466243.5

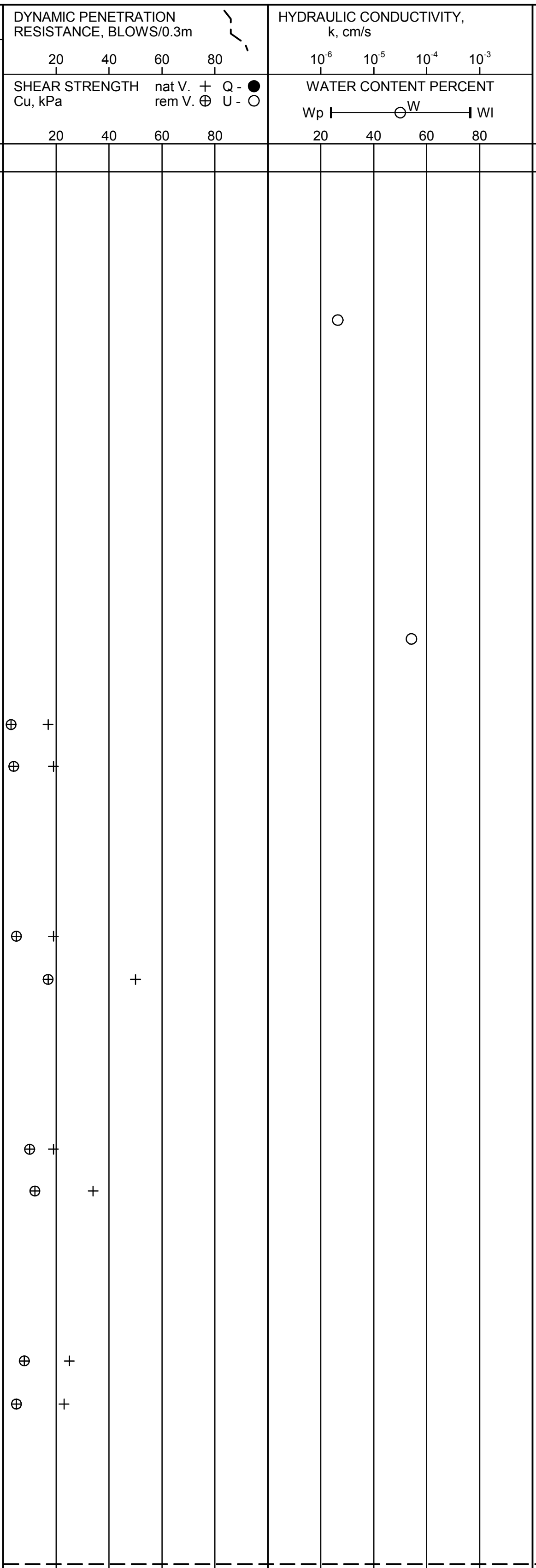
BORING DATE: January 10-16, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		76.60					
0	Wash Boring HW Casing	(SM) SILTY SAND; brown; non-cohesive, wet, very loose to loose		0.00	1	SS	4		
1					2	SS	3	M	
2					3	SS	9		
					4	SS	PH		
3		(CI/CH) SILTY CLAY to CLAY; grey with reddish brown to black mottling, contains silt seams; cohesive, w>PL, soft		73.55 3.05	5	SS	WR		
4									
5					6	SS	WR		
6					7	SS	WR		
7									
8					8	SS	WR		
9					9	SS	WR		
10		CONTINUED NEXT PAGE							



DEPTH SCALE

1 : 50

GOLDER

LOGGED: DWM

CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-14

SHEET 2 OF 5

LOCATION: N 5021390.9 ;E 466243.5

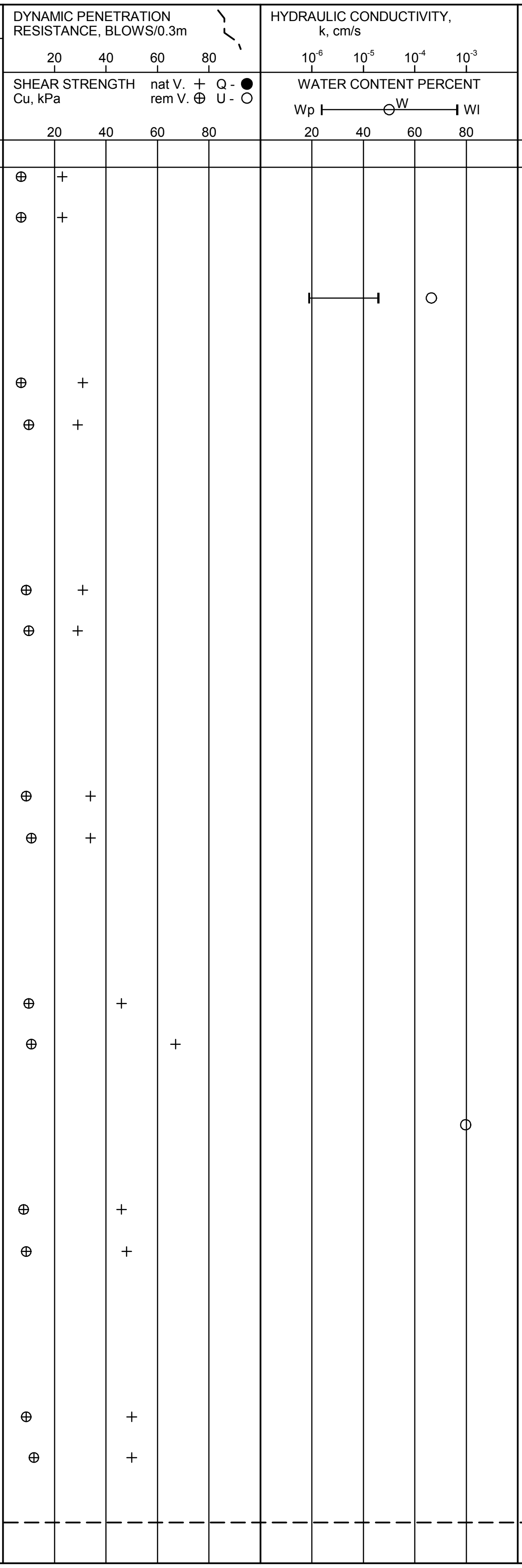
BORING DATE: January 10-16, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---							
10		(CI/CH) SILTY CLAY to CLAY; grey with reddish brown to black mottling, contains silt seams; cohesive, w>PL, soft	▨						
		(CI/CH) SILTY CLAY to CLAY; grey with reddish brown to black mottling, contains silt seams; cohesive, w>PL, firm	▨	65.94 10.66					
11					10	SS	WR		
12					11	SS	WR		
13									
14					12	SS	WR		
15	Wash Boring HW Casing				13	SS	WR		
16		- Possible silt layer							
17					14	SS	WR		
18					15	SS	WR		
19		(CI/CH) SILTY CLAY to CLAY; grey with black mottling, contains silt seams; cohesive, w>PL, stiff	▨	57.71 18.89					
20					16	SS	WR		
		CONTINUED NEXT PAGE							



DEPTH SCALE

1 : 50

GOLDER

LOGGED: DWM

CHECKED: SM

MIS-BHS 001 1787048.GPJ GAL-MIS.GDT 4/12/18 ZS

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-14

SHEET 3 OF 5

LOCATION: N 5021390.9 ;E 466243.5

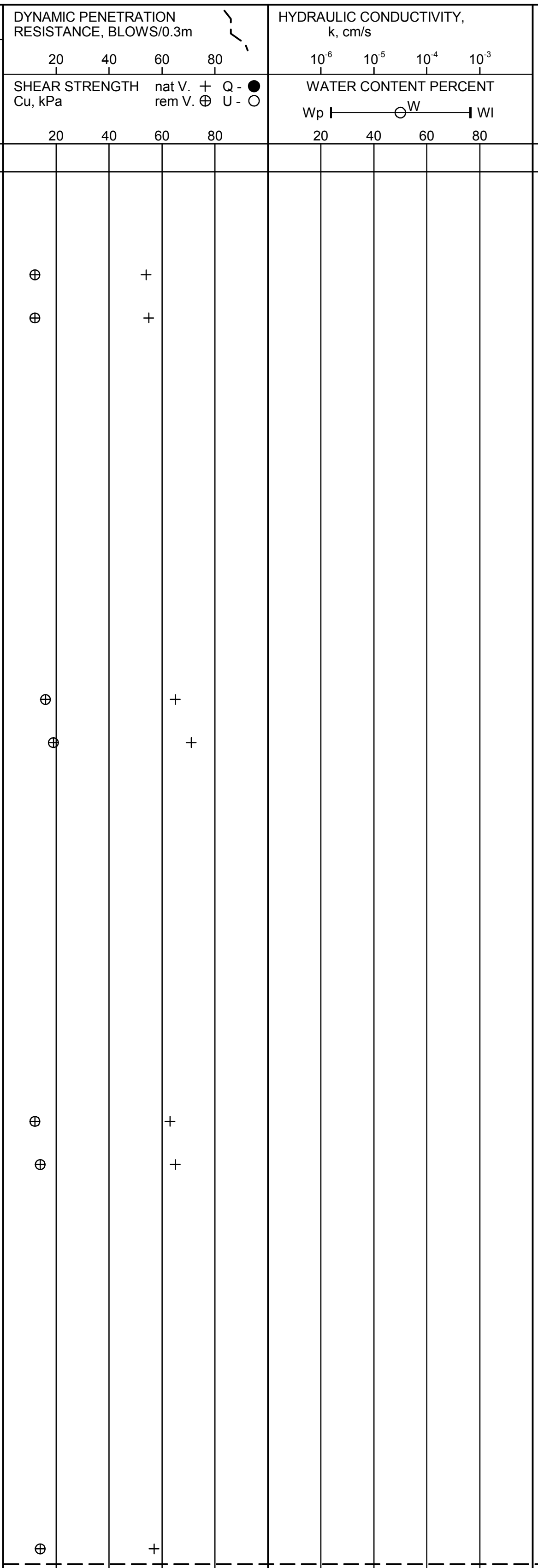
BORING DATE: January 10-16, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---							
20	Wash Boring HW Casing	(CI/CH) SILTY CLAY to CLAY; grey with black mottling, contains silt seams; cohesive, w>PL, stiff	▨		16	SS	WR		
23					17	SS	WR		
26					18	SS	2		
29					19	SS	WR		
30		*CONTINUED NEXT PAGE*							



DEPTH SCALE
1 : 50

GOLDER

LOGGED: DWM
CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-14

SHEET 4 OF 5

LOCATION: N 5021390.9 ;E 466243.5

BORING DATE: January 10-16, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

--- CONTINUED FROM PREVIOUS PAGE ---

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80); SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}); WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
30	Wash Boring HW Casing	(CI/CH) SILTY CLAY to CLAY; grey with black mottling, contains silt seams; cohesive, w>PL, stiff	45.05 31.55				⊕ +			
31.55		(SM/ML) SILTY SAND to sandy SILT, some low plastic fines, some gravel to gravelly; grey, contains cobbles (GLACIAL TILL); non-cohesive, wet, very dense		20	SS	61				
33				21	SS	58		○	M	
34				22	SS	51				
			42.11 34.49	23	SS	>50				
34.49	Rotary Drill HQ Core	COBBLES and BOULDERS	41.27 35.33	24	RC	DD				
35.33		Borehole continued on RECORD OF DRILLHOLE 17-14								

DEPTH SCALE

1 : 50

GOLDER

LOGGED: DWM

CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF DRILLHOLE: 17-14

SHEET 5 OF 5

LOCATION: N 5021390.9 ;E 466243.5

DRILLING DATE: January 10-16, 2018

DATUM: CGVD28

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: LC 55

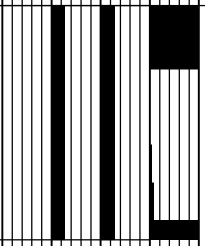
DRILLING CONTRACTOR: Grenville Drilling

JN - Joint FLT - Fault SHR- Shear VN - Vein CJ - Conjugate	BD- Bedding FO- Foliation CO- Contact OR- Orthogonal CL - Cleavage	PL - Planar CU- Curved UN- Undulating ST - Stepped IR - Irregular	PO- Polished K - Slickensided SM- Smooth Ro - Rough MB- Mechanical Break

BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN FLUSH	RECOVERY TOTAL CORE % (80 60 40 20)	RECOVERY SOLID CORE % (80 60 40 20)	R.Q.D. % (80 60 40 20)	FRACT. INDEX PER 0.25 m (5 10 15 20)	DISCONTINUITY DATA B Angle (0 90 180 270)	DIP w.r.t. CORE AXIS (0 30 60 90)	TYPE AND SURFACE DESCRIPTION	Jcon	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec (10^{-6} 10^{-5} 10^{-4} 10^{-3})	Diametral Point Load Index (MPa) (2 4 6)	RMC -Q' AVG.	
		BEDROCK SURFACE		41.27																
36	Rotary Drill HQ Core	Slightly weathered to fresh, thinly to medium bedded, grey to dark grey, fine grained, slightly to non-porous SHALE, with limestone and calcareous shale interbeds CARLSBAD FORMATION - Clay mud seams from 35.37 m to 35.46 m - Broken core from 35.63 m to 35.71 m		35.33 39.72	1	100														UCS = 110.9 MPa
37		End of Drillhole		36.88																
38																				
39																				
40																				
41																				
42																				
43																				
44																				
45																				



DEPTH SCALE

1 : 50

GOLDER

LOGGED: DWM

CHECKED: SM

MIS-RCK 004 1787048.GPJ GAL-MISS.GDT 4/12/18 ZS

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-17

SHEET 1 OF 5

LOCATION: N 5021538.5 ;E 466440.9

BORING DATE: January 17-19, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

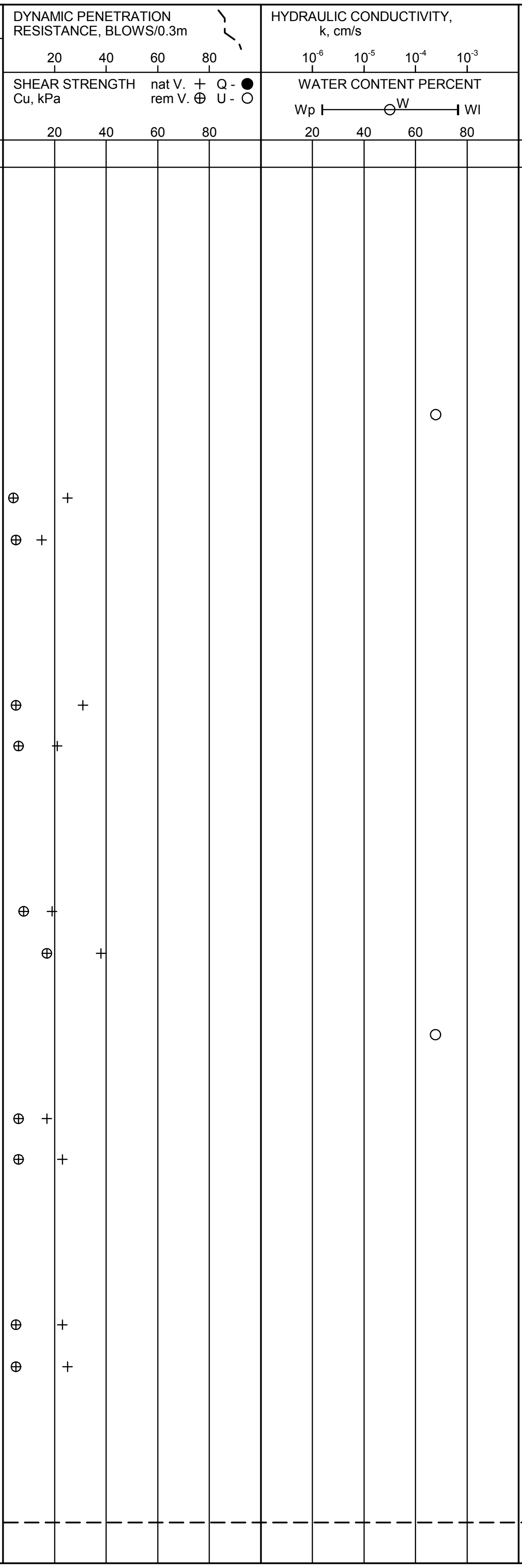
PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES: 0 – 10

BORING METHOD: Wash Boring, HW Casing

SOIL PROFILE – DESCRIPTION	ELEV. / DEPTH (m)
GROUND SURFACE	76.32
TOPSOIL - (SM) SILTY SAND; brown; non-cohesive, moist	0.00
(SM/ML) SILTY SAND to sandy SILT; brown; non-cohesive, moist to wet, loose	0.08
(CI/CH) SILTY CLAY to CLAY; grey brown, contains silt seams; cohesive, w>PL, soft to firm	74.65 1.67
(CI/CH/ML) SILTY CLAY to CLAY and sandy SILT, layered; grey brown; cohesive, w>PL, stiff	71.75 4.57
(CI/CH) SILTY CLAY to CLAY; grey with reddish brown to black mottling, contains silt seams; cohesive, w>PL, soft to firm	71.14 5.18
(CI/CH) SILTY CLAY to CLAY; grey with reddish brown to black mottling, contains silt seams; cohesive, w>PL, firm to stiff	68.09 8.23

SAMPLES NUMBER	TYPE	BLOWS/0.30m
1	SS	6
2	SS	6
3	SS	5
4	SS	WR
5	SS	8
6	SS	WR
7	SS	WR
8	SS	WR



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

GOLDER

LOGGED: DWM
CHECKED: SM

MIS-BHS 001 1787048.GPJ GAL-MIS.GDT 4/12/18 ZS

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-17

SHEET 2 OF 5

LOCATION: N 5021538.5 ;E 466440.9

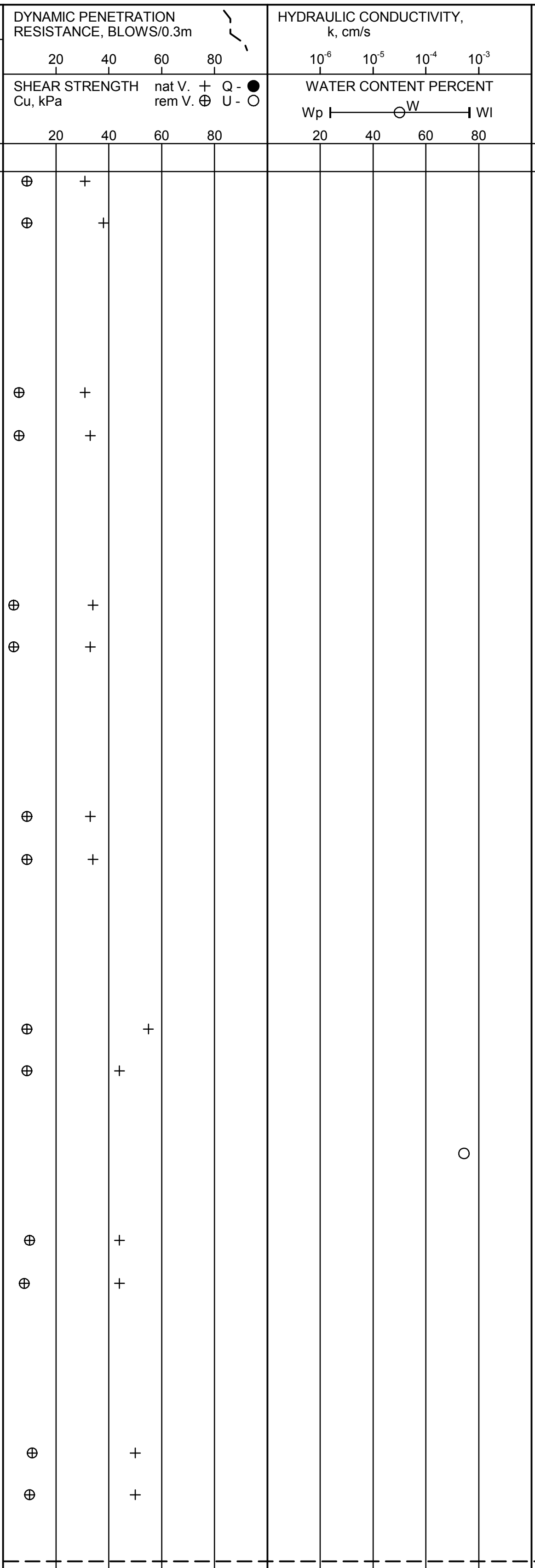
BORING DATE: January 17-19, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---							
10	Wash Boring HW Casing	(CI/CH) SILTY CLAY to CLAY; grey with reddish brown to black mottling, contains silt seams; cohesive, w>PL, firm to stiff	▨						
11					9	SS	WR		
12					10	SS	WR		
13									
14					11	SS	WR		
15					12	SS	WR		
16									
17					13	SS	WR		
18					14	SS	WR		
19									
20					15	SS	WR		
		CONTINUED NEXT PAGE							



DEPTH SCALE

1 : 50

GOLDER

LOGGED: DWM

CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-17

SHEET 3 OF 5

LOCATION: N 5021538.5 ;E 466440.9

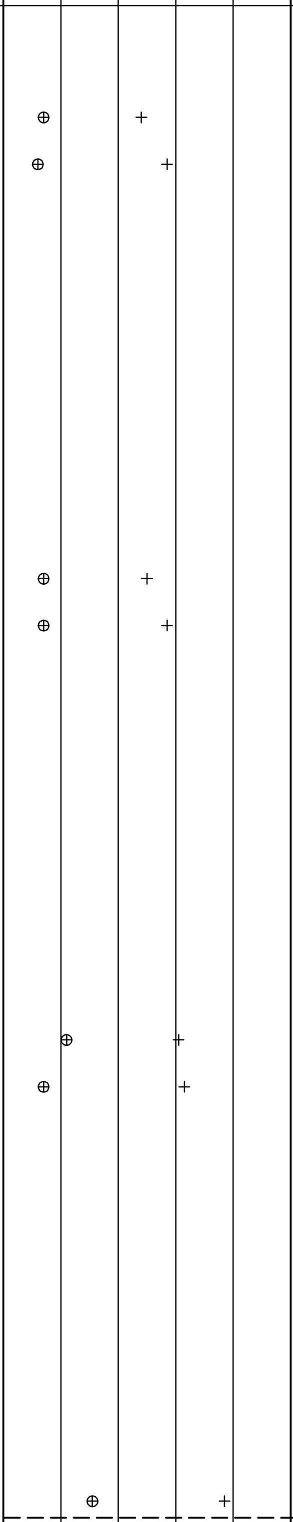
BORING DATE: January 17-19, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80; SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3}; WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---									
20	Wash Boring HW Casing	(CI/CH) SILTY CLAY to CLAY; grey with reddish brown to black mottling, contains silt seams; cohesive, w>PL, firm to stiff	▨		15	SS	WR				
21											
22											
23					16	SS	WR				
24											
25											
26					17	SS	WR				
27											
28											
29					18	SS	WR				
30		*CONTINUED NEXT PAGE*									



DEPTH SCALE

1 : 50

GOLDER

LOGGED: DWM

CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-17

SHEET 4 OF 5

LOCATION: N 5021538.5 ;E 466440.9

BORING DATE: January 17-19, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80); SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}); WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---								
30	Wash Boring HW Casing	(CI/CH) SILTY CLAY to CLAY; grey with reddish brown to black mottling, contains silt seams; cohesive, w>PL, firm to stiff					>96+			
31										
32										
		(ML-CI) CLAYEY SILT and SILTY CLAY, layered; grey; cohesive, w>PL, stiff	44.01 32.31	19	SS	2		○		
33										
		(SM/ML) SILTY SAND to sandy SILT, some low plastic fines, some gravel to gravelly; grey, contains shale fragments (GLACIAL TILL); non-cohesive, wet, compact to very dense	42.79 33.53							
34				20	SS	29				
35		Borehole continued on RECORD OF DRILLHOLE 17-17	41.27 35.05							
36										
37										
38										
39										
40										

DEPTH SCALE
1 : 50

GOLDER

LOGGED: DWM
CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF DRILLHOLE: 17-17

SHEET 5 OF 5

LOCATION: N 5021538.5 ;E 466440.9

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: January 17-19, 2018

DRILL RIG: LC 55

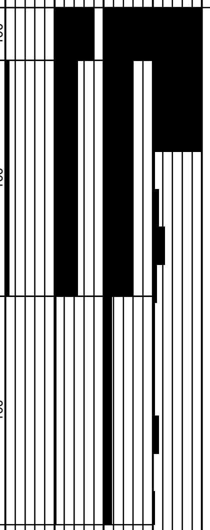
DRILLING CONTRACTOR: Grenville Drilling

DATUM: CGVD28

JN - Joint
FLT - Fault
SHR- Shear
VN - Vein
CJ - Conjugate
BD- Bedding
FO- Foliation
CO- Contact
OR- Orthogonal
CL - Cleavage
PL - Planar
CU- Curved
UN- Undulating
ST - Stepped
IR - Irregular
PO- Polished
K - Slickensided
SM- Smooth
Ro - Rough
MB- Mechanical Break
BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH COLOUR % RETURN
		BEDROCK SURFACE		41.27 35.05		
36 37	Rotary Drill NQ Core	Slightly weathered to fresh, thinly to medium bedded, grey to dark grey, fine grained, slightly to non-porous SHALE, with limestone and calcareous shale interbeds CARLSBAD FORMATION - Broken/lost core from 35.40 m to 35.82 m - Broken core from 35.75 m to 35.82 m - Weathered/broken core from 36.70 m to 36.81 m			1 2	100 100
38				37.85	3	100
39 40 41 42 43 44 45		End of Drillhole		38.47		



DISCONTINUITY DATA: B Angle (0 90 180 270) · DIP w.r.t. CORE AXIS (0 30 60 90) · TYPE AND SURFACE DESCRIPTION · Jcon · Jr · Ja

HYDRAULIC CONDUCTIVITY K, cm/sec 10^{-6} 10^{-5} 10^{-4} 10^{-3}

Diametral Point Load Index (MPa) 2 4 6

RMC -Q' AVG.

DEPTH SCALE
1 : 50

GOLDER

LOGGED: DWM
CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-18

SHEET 1 OF 1

LOCATION: N 5021496.1 ;E 466456.3

BORING DATE: January 19, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	76.01							
0	Wash Boring HW Casing	TOPSOIL - (SM) SILTY SAND; dark brown; non-cohesive, moist	0.00							
		(SM) SILTY SAND; brown; non-cohesive, moist to wet, loose	75.71 0.30	1	SS	5				
1				2	SS	6				
		(CI/CH) SILTY CLAY to CLAY; grey with reddish brown mottling, contains silt seams; cohesive, w>PL, soft	74.49 1.52	3	SS	1				
3				4	SS	WH				
4				5	TP	PH				
6				6	SS	WH				
8				7	TP	PH				
9				8	SS	WH				
		End of Borehole	66.26 9.75							

DEPTH SCALE

1 : 50

GOLDER

LOGGED: DG

CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-18N

SHEET 1 OF 2

LOCATION: N 5021496.1 ;E 466456.3

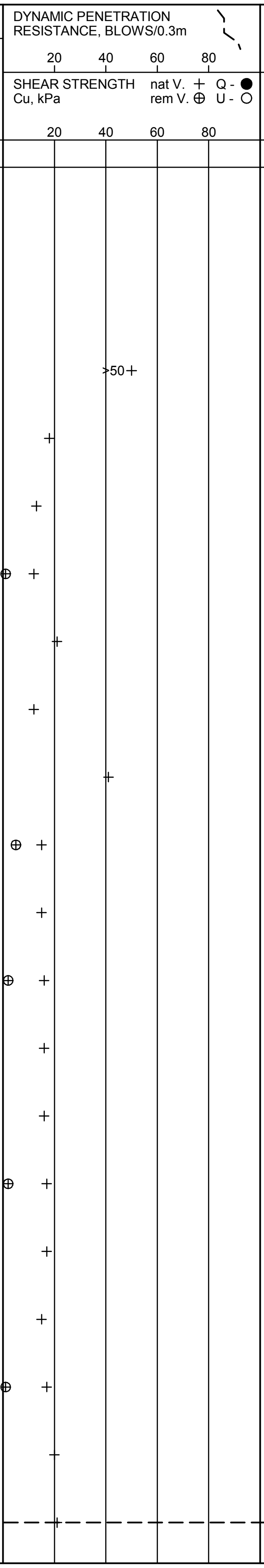
BORING DATE: January 18, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m / SHEAR STRENGTH Cu, kPa	HYDRAULIC CONDUCTIVITY, k, cm/s / WATER CONTENT PERCENT	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		76.01							
0	Power Auger 200 mm Diam. (H.S)	For soil stratigraphy refer to Record of Borehole 17-18		0.00							
1	Nilcon Vanes Clutch										
10				66.01							
		CONTINUED NEXT PAGE									



HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}

WATER CONTENT PERCENT: Wp ⊢—○W—⊣ Wl: 20 40 60 80

DEPTH SCALE

1 : 50

GOLDER

LOGGED: DG

CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-18N

SHEET 2 OF 2

LOCATION: N 5021496.1 ;E 466456.3

BORING DATE: January 18, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 / SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} / WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---									
10		End of Borehole		10.00							
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: DG

CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-19

SHEET 1 OF 1

LOCATION: N 5021502.5 ;E 466517.0

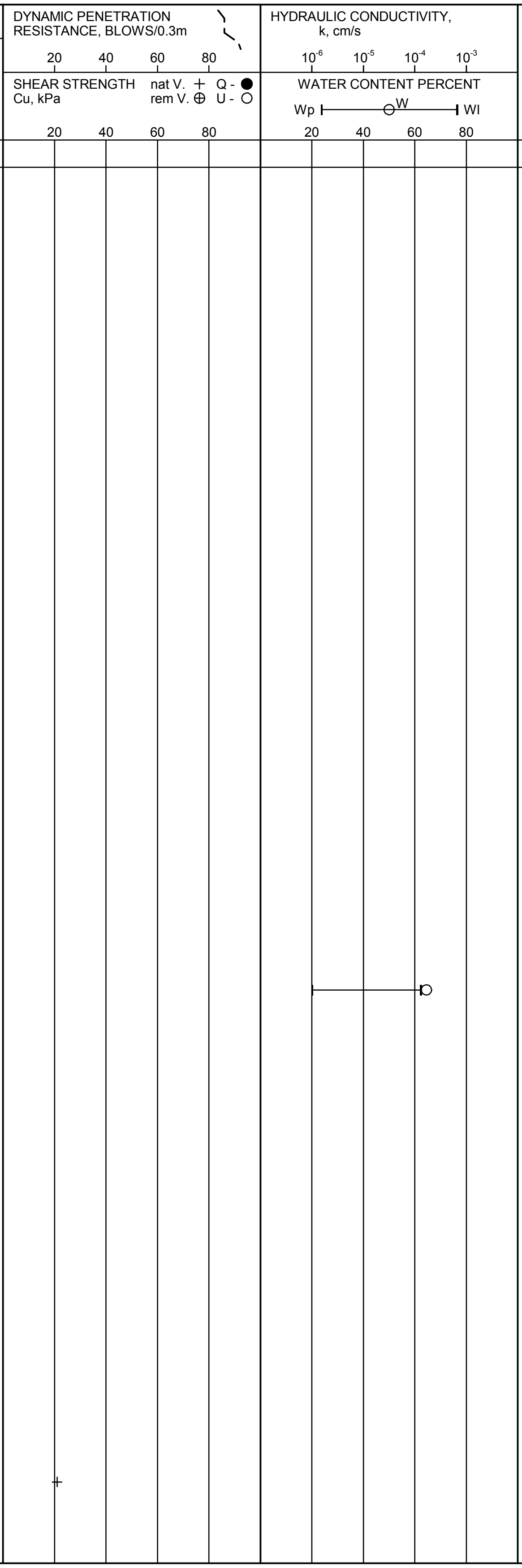
BORING DATE: January 19, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	75.98					
0	Wash Boring HW Casing	TOPSOIL - (SM) SILTY SAND; dark brown; non-cohesive, moist	0.00					
		(SM/ML) SILTY SAND to sandy SILT; brown; non-cohesive, moist to wet, loose	75.73 0.25	1	SS	5		
1				2	SS	7		
		(CI/CH) SILTY CLAY to CLAY; grey brown and reddish brown, contains silt seams; cohesive, w>PL, firm	74.46 1.52	3	SS	2		
2		(CI/CH) SILTY CLAY to CLAY; grey, contains silt seams; cohesive, w>PL, very soft to soft	74.15 1.83					
				4	TP	PH		
3								
4				5	SS	WH		
		(SM/ML) sandy SILT to SILTY SAND; brown; non-cohesive, wet	71.56 4.42					
5		(CI/CH) SILTY CLAY to CLAY; grey, contains silt seams; cohesive, w>PL, soft	71.26 4.72	6	SS	WH		
6				7	TP	PH	C	
7								
8				8	SS	WH		
9				9	TP	PH		
		End of Borehole	66.28 9.70					
10								



MIS-BHS 001 1787048.GPJ GAL-MIS.GDT 4/12/18 ZS

DEPTH SCALE

1 : 50

GOLDER

LOGGED: DG

CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-20N

SHEET 1 OF 2

LOCATION: N 5021491.3 ;E 466569.2

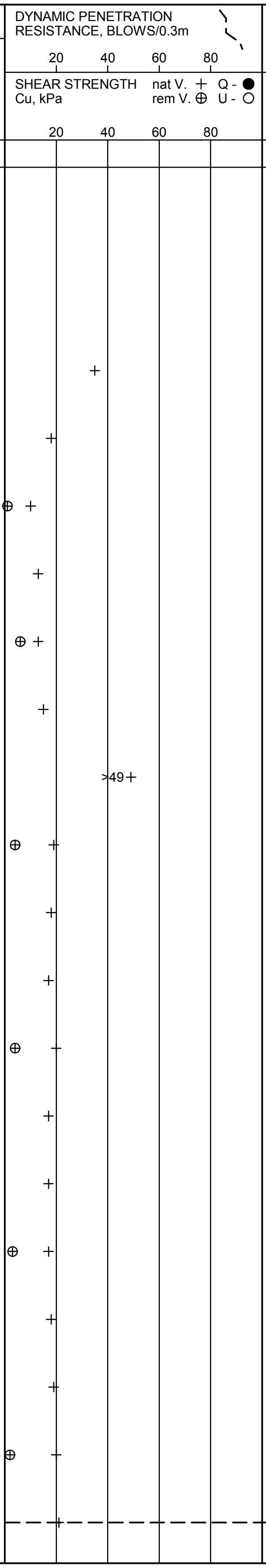
BORING DATE: January 18, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m / SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○	HYDRAULIC CONDUCTIVITY, k, cm/s / WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		76.03							
0	Power Auger 200 mm Diam. (H.S)	For soil stratigraphy refer to Record of Borehole 17-19		0.00							
1	Nilcon Vanes Clutch										
10				66.03							
		CONTINUED NEXT PAGE									



DEPTH SCALE

1 : 50

GOLDER

LOGGED: DG

CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-20N

SHEET 2 OF 2

LOCATION: N 5021491.3 ;E 466569.2

BORING DATE: January 18, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m				
		--- CONTINUED FROM PREVIOUS PAGE ---									
10		End of Borehole		10.00							
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: DG

CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-21

SHEET 1 OF 6

LOCATION: N 5021375.1 ;E 466666.3

BORING DATE: January 24-29, 2018

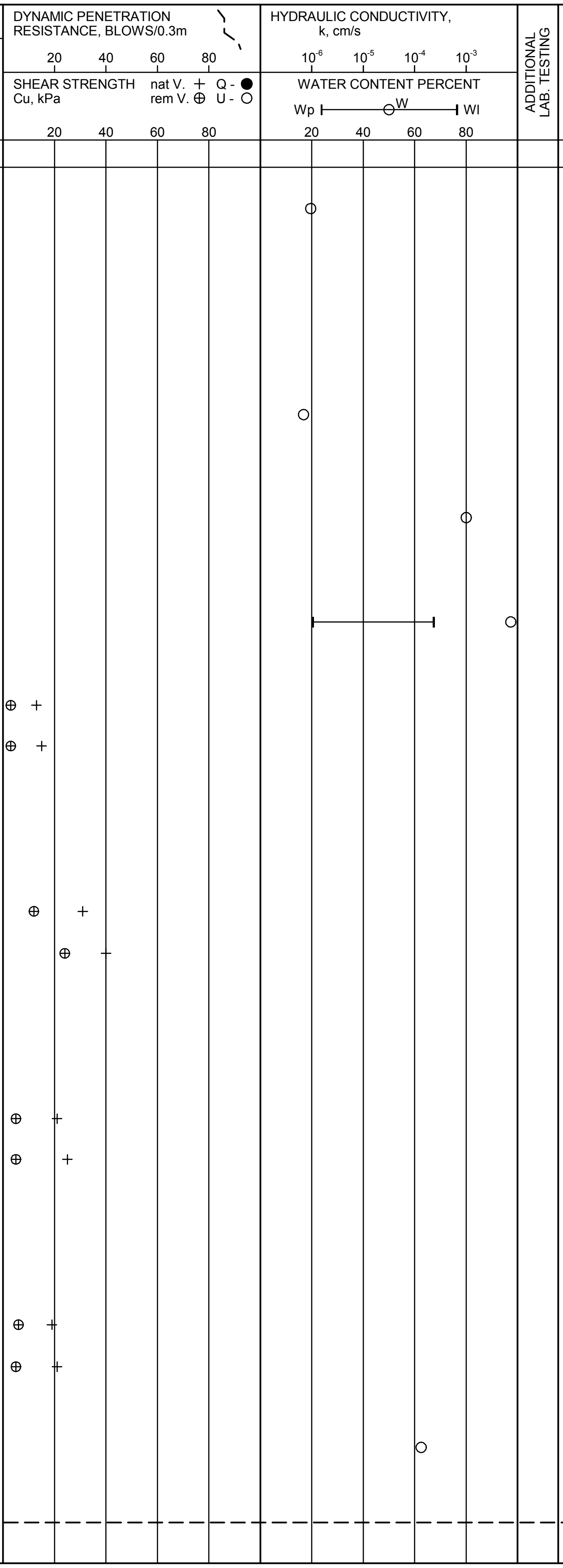
DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: Wash Boring, HW Casing

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m
	GROUND SURFACE	76.14			
0	TOPSOIL - (SM) SILTY SAND; brown; non-cohesive, moist	0.00			
	(SM) SILTY SAND; grey brown; non-cohesive, wet, loose to compact	0.15	1	SS	6
1			2	SS	14
2			3	SS	10
	(CI/CH) SILTY CLAY to CLAY; grey with reddish brown mottling, contains silt seams; cohesive, w>PL, stiff	73.86 2.28	4	SS	2
3	(CI/CH) SILTY CLAY to CLAY; grey with reddish brown to black mottling, contains silt seams; cohesive, w>PL, soft	73.09 3.05	5	SS	WR
5			6	SS	WR
	(CI/CH) SILTY CLAY to CLAY; grey with reddish brown to black mottling, contains silt seams; cohesive, w>PL, firm	70.96 5.18			
6	(CI/CH) SILTY CLAY to CLAY; grey with reddish brown to black mottling, contains silt seams; cohesive, w>PL, soft	70.04 6.10	7	SS	WR
8			8	SS	WR
9			9	SS	WR
10					



PIEZOMETER OR STANDPIPE INSTALLATION

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

GOLDER

LOGGED: DWM
CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-21

SHEET 2 OF 6

LOCATION: N 5021375.1 ;E 466666.3

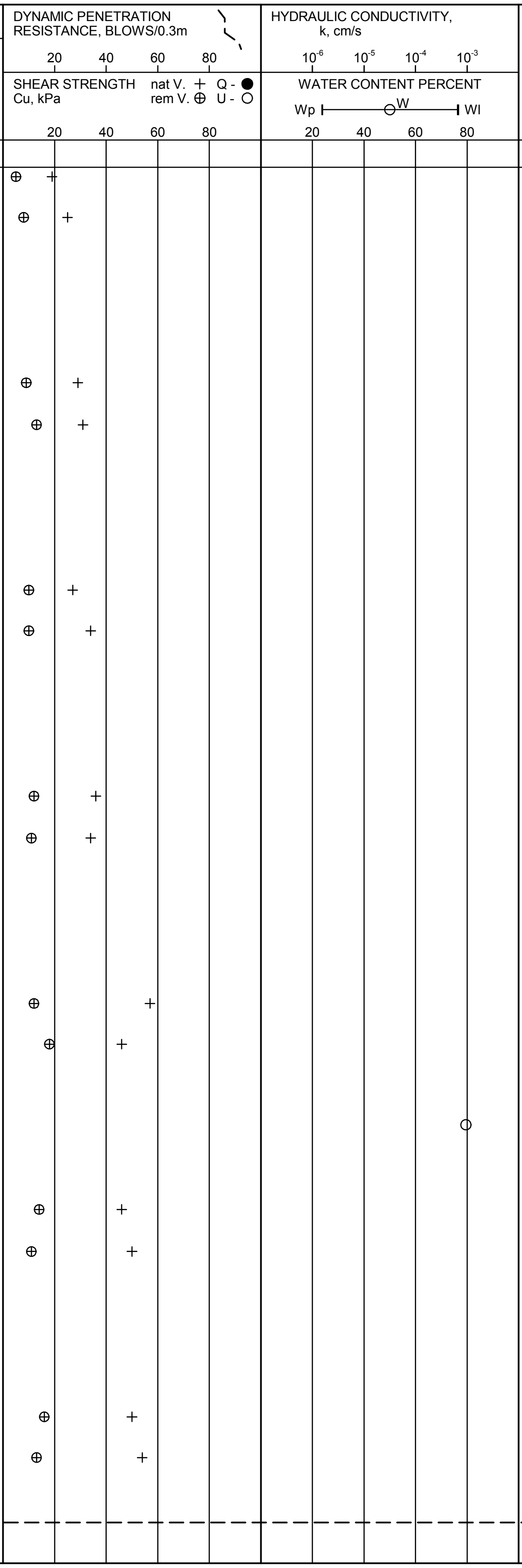
BORING DATE: January 24-29, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---							
10	Wash Boring HW Casing	(CI/CH) SILTY CLAY to CLAY; grey with reddish brown to black mottling, contains silt seams; cohesive, w>PL, soft	▨						
11					10	SS	WR		
12					11	SS	WR		
13									
14					12	SS	WR		
15		(CI/CH) SILTY CLAY to CLAY; grey with black mottling, contains silt seams; cohesive, w>PL, firm to stiff	▨	60.90 15.24	13	SS	WR		
16									
17					14	SS	WR		
18					15	SS	WR		
19									
20					16	SS	WR		
		CONTINUED NEXT PAGE							



DEPTH SCALE
1 : 50

GOLDER

LOGGED: DWM
CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-21

SHEET 3 OF 6

LOCATION: N 5021375.1 ;E 466666.3

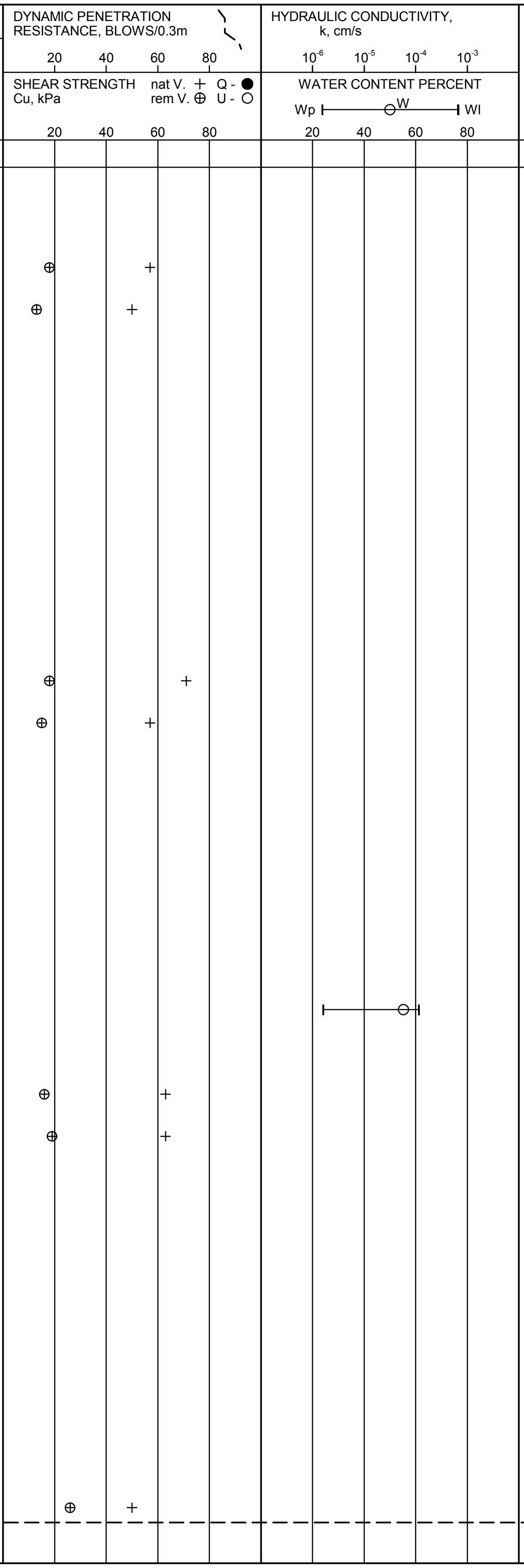
BORING DATE: January 24-29, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---							
20	Wash Boring HW Casing	(CI/CH) SILTY CLAY to CLAY; grey with black mottling, contains silt seams; cohesive, w>PL, firm to stiff	▨		16	SS	WR		
21									
22									
23		(CI-CH) SILTY CLAY to CLAY; grey with black mottling, contains silt seams; cohesive, w>PL, stiff	▨	53.28 22.86	17	SS	WR		
24									
25									
26					18	SS	WR		
27									
28									
29					19	SS	WR		
30		*CONTINUED NEXT PAGE*							



DEPTH SCALE

1 : 50

GOLDER

LOGGED: DWM

CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-21

SHEET 4 OF 6

LOCATION: N 5021375.1 ;E 466666.3

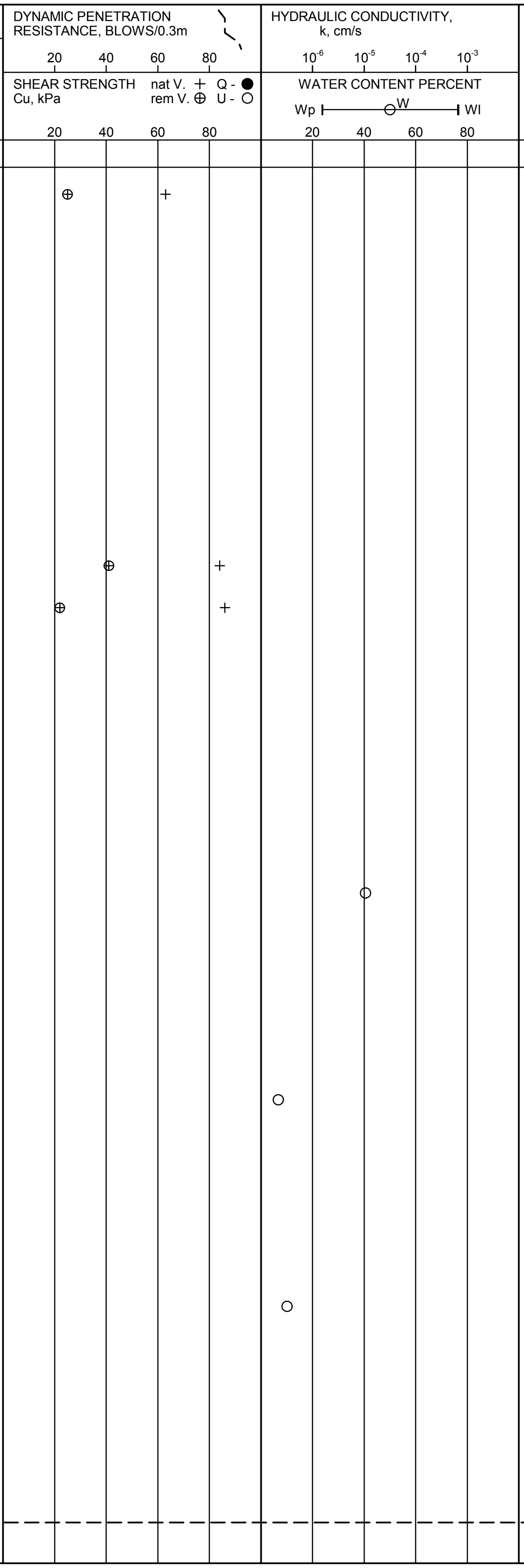
BORING DATE: January 24-29, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
		--- *CONTINUED FROM PREVIOUS PAGE* ---					
30	Wash Boring HW Casing	(CI-CH) SILTY CLAY to CLAY; grey with black mottling, contains silt seams; cohesive, w>PL, stiff					
31							
32				20	SS	WR	
33							
34							
35				21	SS	WR	
36							
		(ML-SM) SILTY SAND and sandy SILT, some low plastic fines, some gravel to gravelly; grey, contains rock fragments (GLACIAL TILL); wet, compact to very dense	39.41 36.73	22	SS	11	
37							
38				23	SS	31	M
39							
				24	SS	80	
40							
		CONTINUED NEXT PAGE					



PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE

1 : 50

GOLDER

LOGGED: DWM

CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-21

SHEET 5 OF 6

LOCATION: N 5021375.1 ;E 466666.3

BORING DATE: January 24-29, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	SOIL PROFILE: STRATA PLOT	SOIL PROFILE: ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---									
40	HW Casing		▨	35.66 40.48							
		Borehole continued on RECORD OF DRILLHOLE 17-21									
41											
42											
43											
44											
45											
46											
47											
48											
49											
50											

DEPTH SCALE
1 : 50

GOLDER

LOGGED: DWM
CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF DRILLHOLE: 17-21

SHEET 6 OF 6

LOCATION: N 5021375.1 ;E 466666.3

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: January 24-29, 2018

DRILL RIG: LC 55

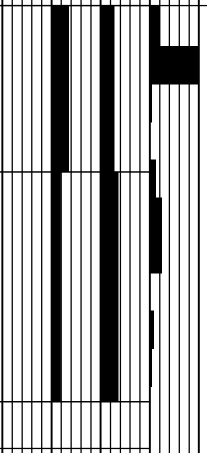
DRILLING CONTRACTOR: Grenville Drilling

DATUM: CGVD28

JN - Joint
FLT - Fault
SHR- Shear
VN - Vein
CJ - Conjugate
BD- Bedding
FO- Foliation
CO- Contact
OR- Orthogonal
CL - Cleavage
PL - Planar
CU- Curved
UN- Undulating
ST - Stepped
IR - Irregular
PO- Polished
K - Slickensided
SM- Smooth
Ro - Rough
MB- Mechanical Break
BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. DEPTH (m)	RUN No.	FLUSH COLOUR % RETURN	RECOVERY TOTAL CORE % / SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.25 m	DISCONTINUITY DATA (B Angle, DIP w.r.t. CORE AXIS, TYPE AND SURFACE DESCRIPTION, Jcon, Jr, Ja)	HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -Q' AVG.	
		BEDROCK SURFACE	35.66										
41 42 43	Rotary Drill NQ Core	Slightly weathered to fresh, thinly to medium bedded, grey to dark grey, fine grained, slightly to non-porous SHALE, with limestone and calcareous shale interbeds CARLSBAD FORMATION - Broken core from 40.61 m to 40.63 m - Broken core from 40.74 m to 40.93 m - Possible mud seams from 40.80 m to 40.82 m - Possible mud seams from 41.70 m to 41.72 m - Broken core from 41.92 m to 41.95 m - Weathered/broken core from 42.01 m to 42.07 m - Broken core from 42.66 m to 42.96 m	40.48 32.73	1 2 3	100 100 100								UCS = 97.4 MPa
		End of Drillhole	43.41										



44

45

46

47

48

49

50

DEPTH SCALE

1 : 50

GOLDER

LOGGED: DWM

CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-23

SHEET 1 OF 5

LOCATION: N 5021218.7 ;E 466509.0

BORING DATE: January 30-February 6, 2018

DATUM: CGVD28

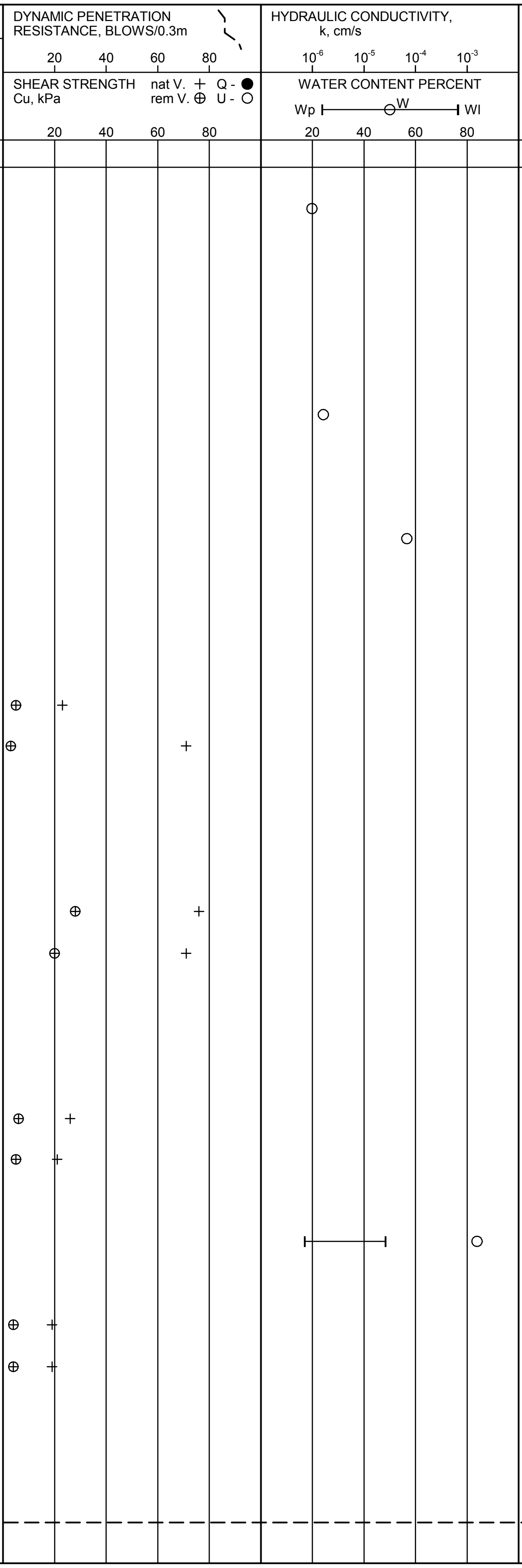
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: Wash Boring, HW Casing

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (m)
	GROUND SURFACE	76.50
0	TOPSOIL - (ML) sandy SILT; brown; non-cohesive, moist	0.00
	(SM) SILTY SAND; grey brown; cohesive, moist to wet, loose to compact	0.15
	(CI/CH) SILTY CLAY to CLAY; grey brown, contains silt seams; cohesive, w>PL, soft to stiff	73.91 2.59
	(CI/CH) SILTY CLAY to CLAY; grey with reddish brown to black mottling, contains silt seams; cohesive, w>PL, firm	70.40 6.10
10	*CONTINUED NEXT PAGE*	

SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
1	SS	6	
2	SS	14	
3	SS	5	M
4	SS	2	
5	SS	WH	
6	SS	WR	
7	SS	WR	
8	SS	WR	
9	SS	WR	



PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE

1 : 50

GOLDER

LOGGED: DWM

CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-23

SHEET 2 OF 5

LOCATION: N 5021218.7 ;E 466509.0

BORING DATE: January 30-February 6, 2018

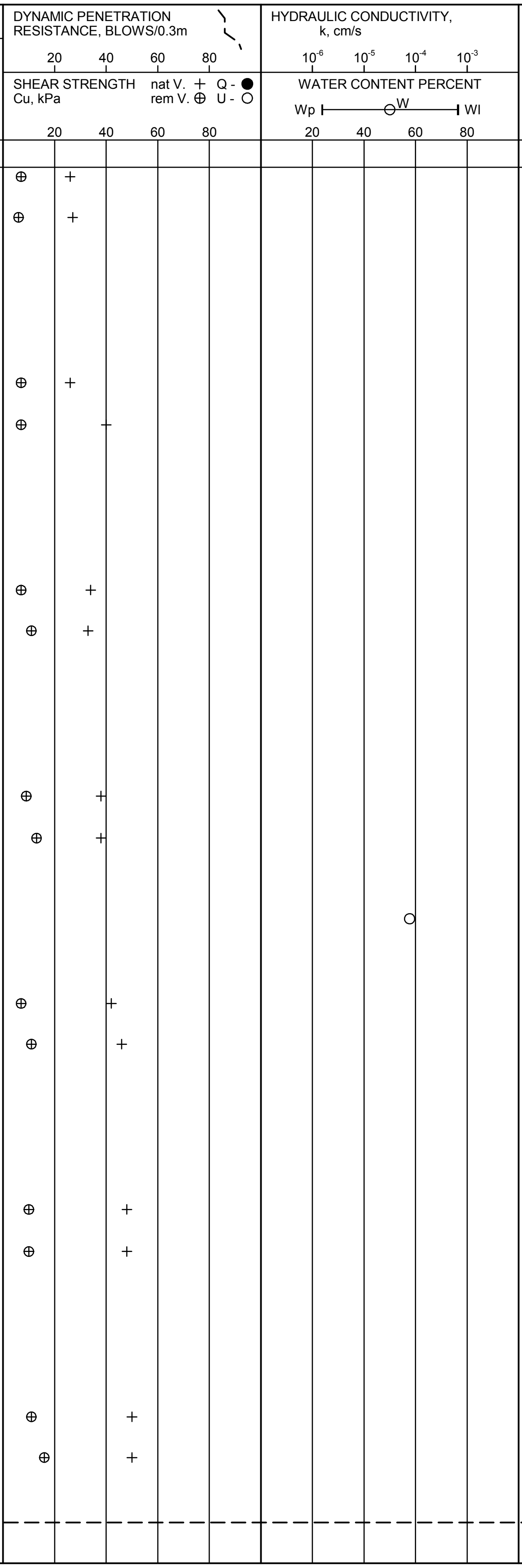
DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: Wash Boring, HW Casing

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m
	--- *CONTINUED FROM PREVIOUS PAGE* ---				
10	(CI/CH) SILTY CLAY to CLAY; grey with reddish brown to black mottling, contains silt seams; cohesive, w>PL, firm				
11			10	SS	WR
12			11	SS	WR
13					
14			12	SS	WR
15			13	SS	WR
16					
17			14	SS	WR
18		58.21 18.29			
	(CI/CH) SILTY CLAY to CLAY; grey with black mottling, contains silt seams; cohesive, w>PL, firm to stiff		15	SS	WR
19					
20			16	SS	WR
	CONTINUED NEXT PAGE				



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE

1 : 50

LOGGED: DWM

CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-23

SHEET 3 OF 5

LOCATION: N 5021218.7 ;E 466509.0

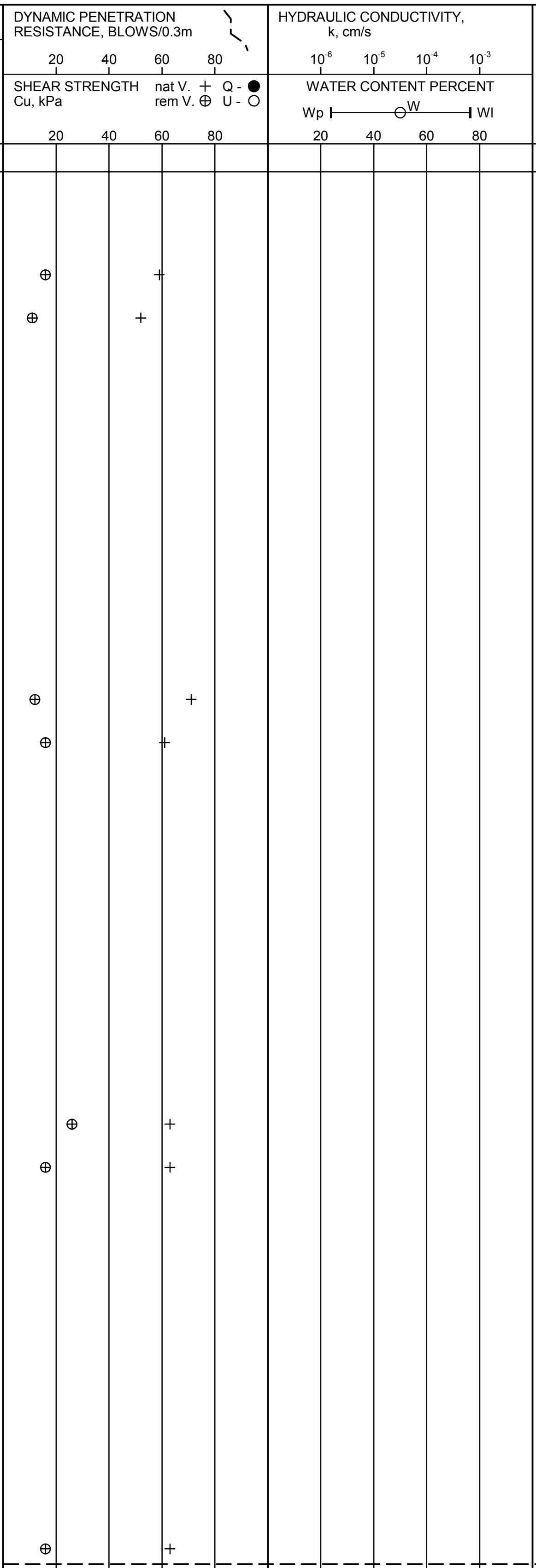
BORING DATE: January 30-February 6, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---							
20	Wash Boring HW Casing	(CI/CH) SILTY CLAY to CLAY; grey with black mottling, contains silt seams; cohesive, w>PL, firm to stiff	▨		16	SS	WR		
		(CI/CH) SILTY CLAY to CLAY; grey with black mottling, contains silt seams; cohesive, w>PL, stiff	▨	56.08 20.42					
21									
22									
23					17	SS	WR		
24									
25									
26					18	SS	WR		
27									
28									
29					19	SS	WR		
30									
		CONTINUED NEXT PAGE							



DEPTH SCALE
1 : 50

GOLDER

LOGGED: DWM
CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-23

SHEET 4 OF 5

LOCATION: N 5021218.7 ;E 466509.0

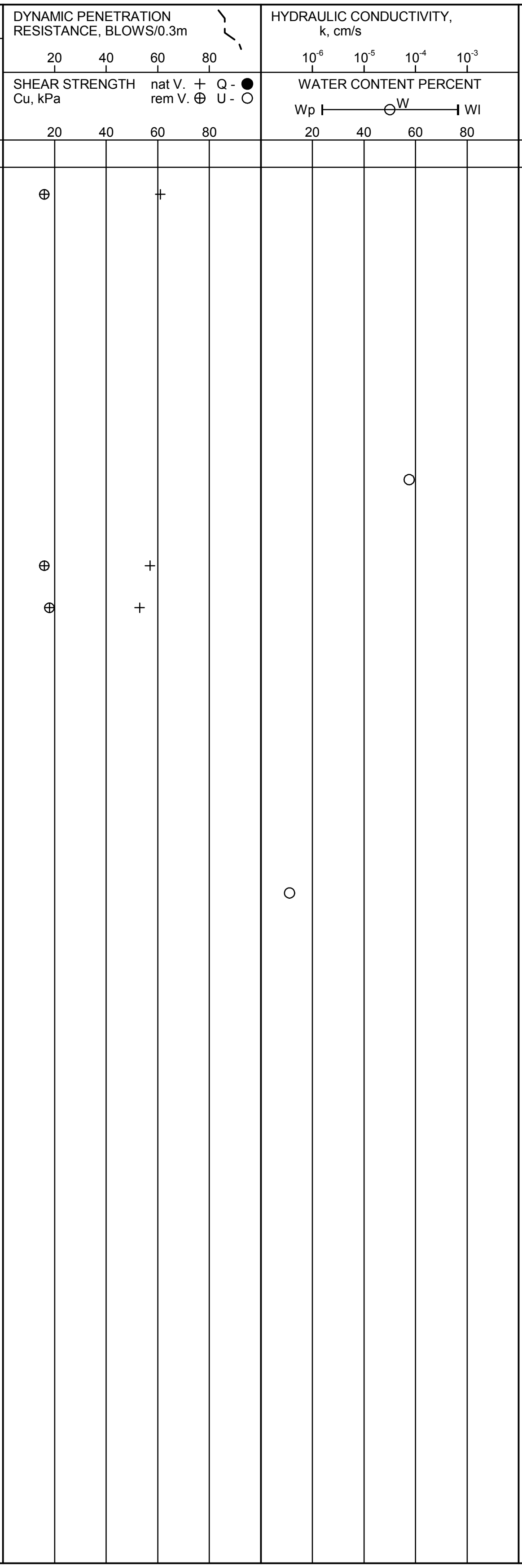
BORING DATE: January 30-February 6, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- *CONTINUED FROM PREVIOUS PAGE* ---							
30	Wash Boring HW Casing	(CI/CH) SILTY CLAY to CLAY; grey with black mottling, contains silt seams; cohesive, w>PL, stiff							
31									
32					20	SS	WR		
33									
34				42.06 34.44					
35		(SM-ML) sandy SILT to SILTY SAND, some low plastic fines, some gravel to gravelly; grey, contains rock fragments and cobbles (GLACIAL TILL); non-cohesive, wet, compact to dense			21	SS	16		
36									
37					22	SS	34		
38				38.68 37.82					
		Borehole continued on RECORD OF DRILLHOLE 17-23							
39									
40									



DEPTH SCALE

1 : 50

LOGGED: DWM

CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF DRILLHOLE: 17-23

SHEET 5 OF 5

LOCATION: N 5021218.7 ;E 466509.0

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: January 30-February 6, 2018

DRILL RIG: LC 55

DRILLING CONTRACTOR: Grenville Drilling

DATUM: CGVD28

JN - Joint
FLT - Fault
SHR- Shear
VN - Vein
CJ - Conjugate

BD- Bedding
FO- Foliation
CO- Contact
OR- Orthogonal
CL - Cleavage

PL - Planar
CU- Curved
UN- Undulating
ST - Stepped
IR - Irregular

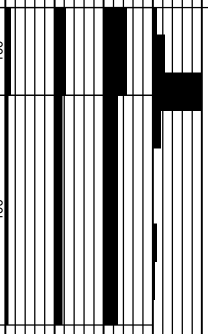
PO- Polished
K - Slickensided
SM- Smooth
Ro - Rough
MB- Mechanical Break

BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN FLUSH	
		BEDROCK SURFACE		38.68			
38 39	Rotary Drill NQ Core	Slightly weathered to fresh, thinly to medium bedded, grey to dark grey, fine grained, slightly to non-porous SHALE, with limestone and calcareous shale interbeds CARLSBAD FORMATION - Broken core from 38.27 m to 38.32 m - Broken core from 38.40 m to 38.52 m - Broken core from 38.62 m to 38.66 m		37.82 36.58	1 2	100 100	UCS = 229.3 MPa
40		End of Drillhole		39.92			
41							
42							
43							
44							
45							
46							
47							

RECOVERY: TOTAL CORE % (80 60 40 20); SOLID CORE % (80 60 40 20) | R.Q.D. % (80 60 40 20) | FRACT. INDEX PER 0.25 m (5 10 15 20) | DISCONTINUITY DATA: B Angle (0 90 180 270); DIP w.r.t. CORE AXIS (0 30 60 90); TYPE AND SURFACE DESCRIPTION; Jcon; Jr; Ja | HYDRAULIC CONDUCTIVITY K, cm/sec (10^{-6} 10^{-5} 10^{-4} 10^{-3}) | Diametral Point Load Index (MPa) (2 4 6) | RMC -Q' AVG.



DEPTH SCALE

1 : 50

LOGGED: DWM

CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-24

SHEET 1 OF 1

LOCATION: N 5021172.5 ;E 466473.4

BORING DATE: January 25, 2018

DATUM: CGVD28

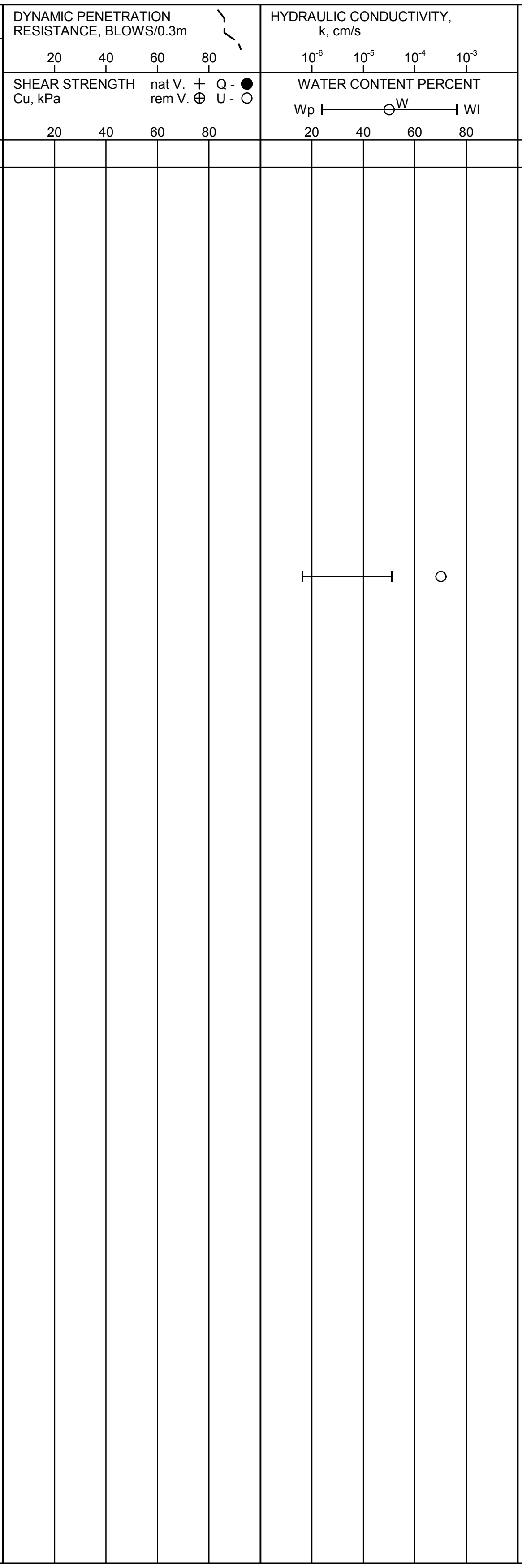
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: Wash Boring, HW Casing

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	76.44
TOPSOIL - (SM) SILTY SAND; dark brown; non-cohesive, moist	0.00
(SM) SILTY SAND; brown; non-cohesive, moist to wet, very loose to loose	76.14 0.30
(CI/CH) SILTY CLAY to CLAY; grey brown, contains silt seams; cohesive, w>PL, very soft to soft	74.31 2.13
(SM/ML) SILTY SAND to sandy SILT; grey; non-cohesive, wet	70.95 5.49
(CI/CH) SILTY CLAY to CLAY; grey with reddish brown mottling, contains silt seams; cohesive, w>PL, soft	5.66
End of Borehole	66.69 9.75

SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
1	SS	4	
2	SS	6	
3	SS	3	
4	TP	PH	C
5	SS	WH	
6	SS	3	
7	TP	PH	
8	SS	WH	



PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE 1 : 50

GOLDER

LOGGED: DG

CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-24N

SHEET 1 OF 2

LOCATION: N 5021172.5 ;E 466473.4

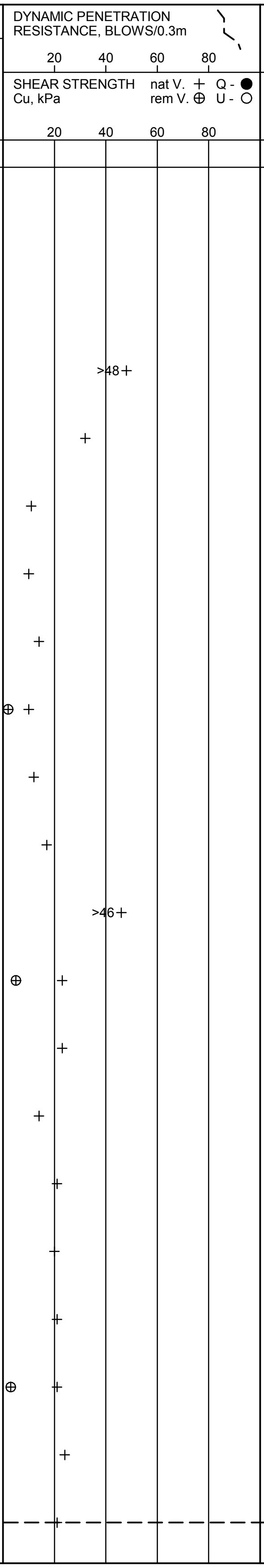
BORING DATE: January 25, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m / SHEAR STRENGTH Cu, kPa	HYDRAULIC CONDUCTIVITY, k, cm/s / WATER CONTENT PERCENT	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		76.44							
0	Power Auger 200 mm Diam. (H.S)	For soil stratigraphy refer to Record of Borehole 17-24		0.00							
1											
2											
3											
4											
5	Nilcon Vanes Clutch										
6											
7											
8											
9											
10				66.44							
		CONTINUED NEXT PAGE									



HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}

WATER CONTENT PERCENT: Wp ⊢—○W—⊣ Wl; 20 40 60 80

DEPTH SCALE

1 : 50

GOLDER

LOGGED: DG

CHECKED: SM

MIS-BHS 001 1787048.GPJ GAL-MIS.GDT 4/12/18 ZS

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-24N

SHEET 2 OF 2

LOCATION: N 5021172.5 ;E 466473.4

BORING DATE: January 25, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---									
10		End of Borehole		10.00							
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: DG

CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-26

SHEET 1 OF 5

LOCATION: N 5021036.3 ;E 466558.2

BORING DATE: February 8-13, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: Wash Boring, HW Casing

DEPTH SCALE METRES	SOIL PROFILE: DESCRIPTION	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
	GROUND SURFACE	76.26				
0	TOPSOIL - (SM) SILTY SAND; brown; non-cohesive, moist	0.00				
	(SM) SILTY SAND; brown; non-cohesive, wet, compact to very loose	0.15	1	SS	11	M
1			2	SS	8	CHEM
2			3	SS	18	
			4	SS	WH	
3	(CI/CH) SILTY CLAY to CLAY; grey brown, contains silt seams; w>PL, soft	73.42 2.84	5	SS	1	
5			6	SS	WR	
	- Possible silt layer					
6	(CI/CH) SILTY CLAY to CLAY; grey with reddish brown to black mottling, contains silt seams; cohesive, w>PL, soft to firm	70.16 6.10	7	SS	WR	
8			8	SS	WR	
9			9	SS	WR	
10						

CONTINUED NEXT PAGE

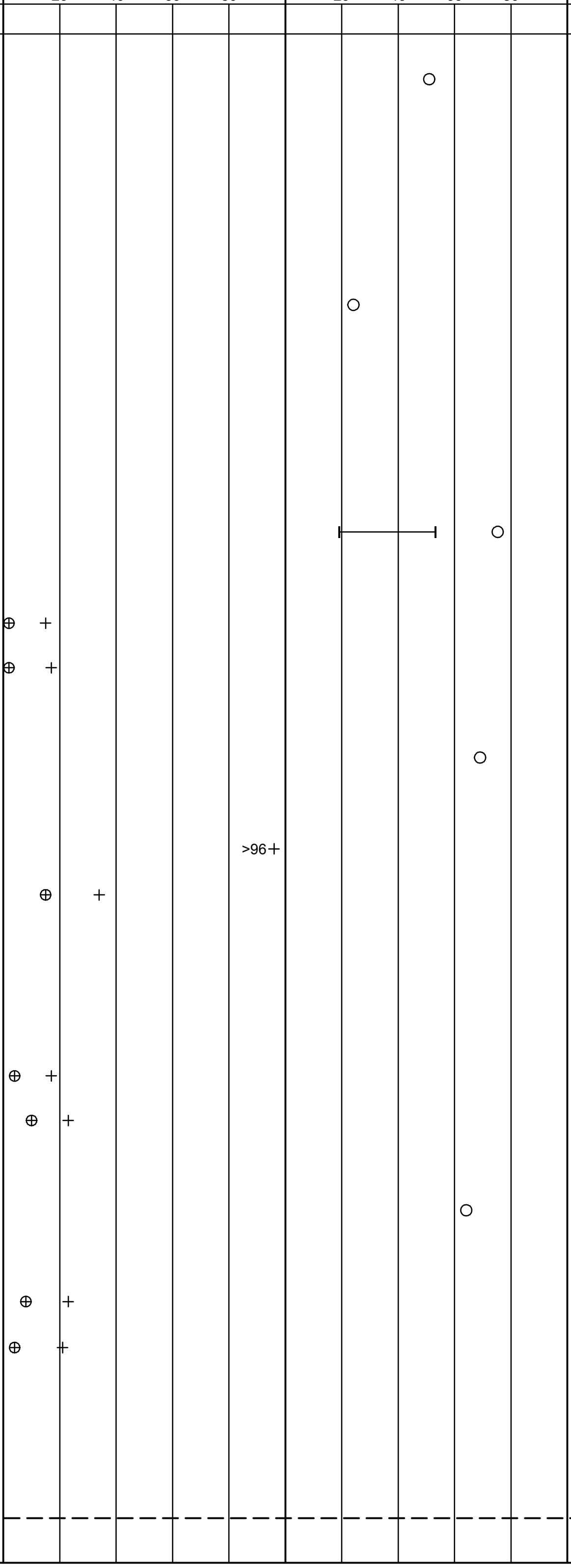
DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ : 20 40 60 80

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}

WATER CONTENT PERCENT: Wp ⊢—○W—⊣ Wl : 20 40 60 80

PIEZOMETER OR STANDPIPE INSTALLATION



DEPTH SCALE

1 : 50

GOLDER

LOGGED: DWM

CHECKED: SM

MIS-BHS 001 1787048.GPJ GAL-MIS.GDT 4/13/18 ZS

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-26

SHEET 2 OF 5

LOCATION: N 5021036.3 ;E 466558.2

BORING DATE: February 8-13, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

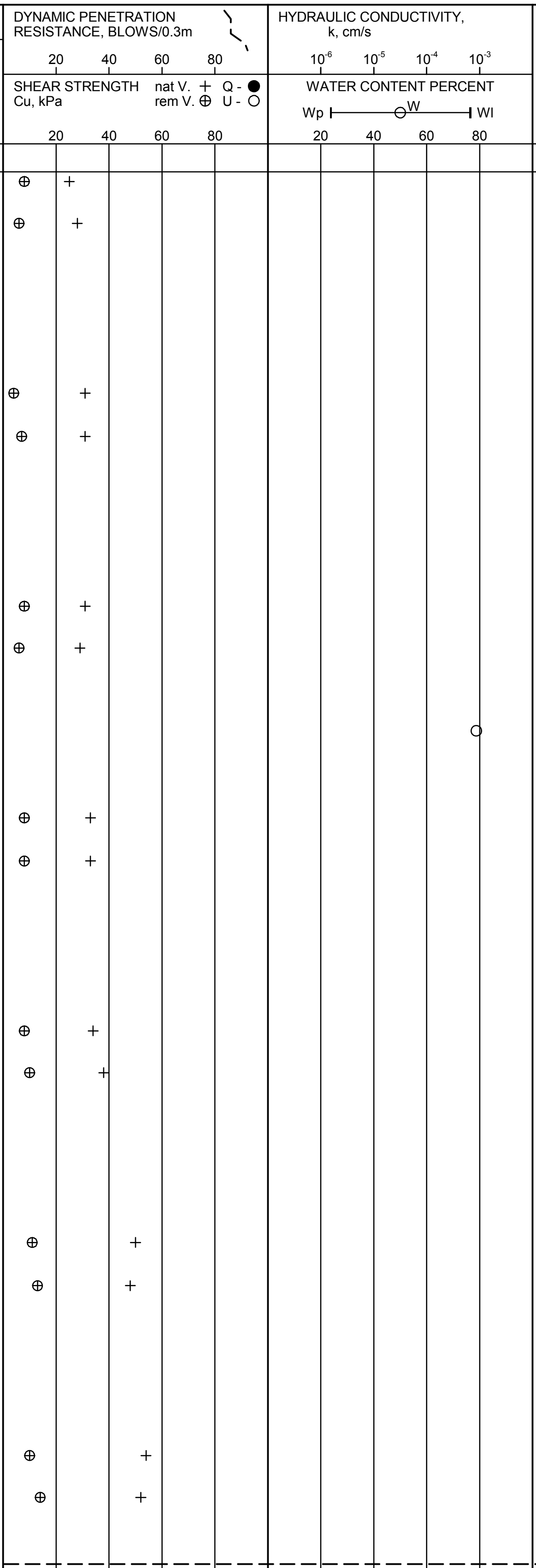
PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: Wash Boring, HW Casing

--- CONTINUED FROM PREVIOUS PAGE ---

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
10	(CI/CH) SILTY CLAY to CLAY; grey with reddish brown to black mottling, contains silt seams; cohesive, w>PL, soft to firm	
12	(CI/CH) SILTY CLAY to CLAY; grey with black mottling, contains silt seams; cohesive, w>PL, firm	64.07 12.19
17	(CI/CH) SILTY CLAY to CLAY; grey with black mottling, contains silt seams; cohesive, w>PL, firm to stiff	58.89 17.37
20	CONTINUED NEXT PAGE	

SAMPLES NUMBER	TYPE	BLOWS/0.30m
10	SS	WR
11	SS	WR
12	SS	WR
13	SS	WR
14	SS	WR
15	SS	WR
16	SS	WR



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE
1 : 50

GOLDER

LOGGED: DWM
CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-26

SHEET 3 OF 5

LOCATION: N 5021036.3 ;E 466558.2

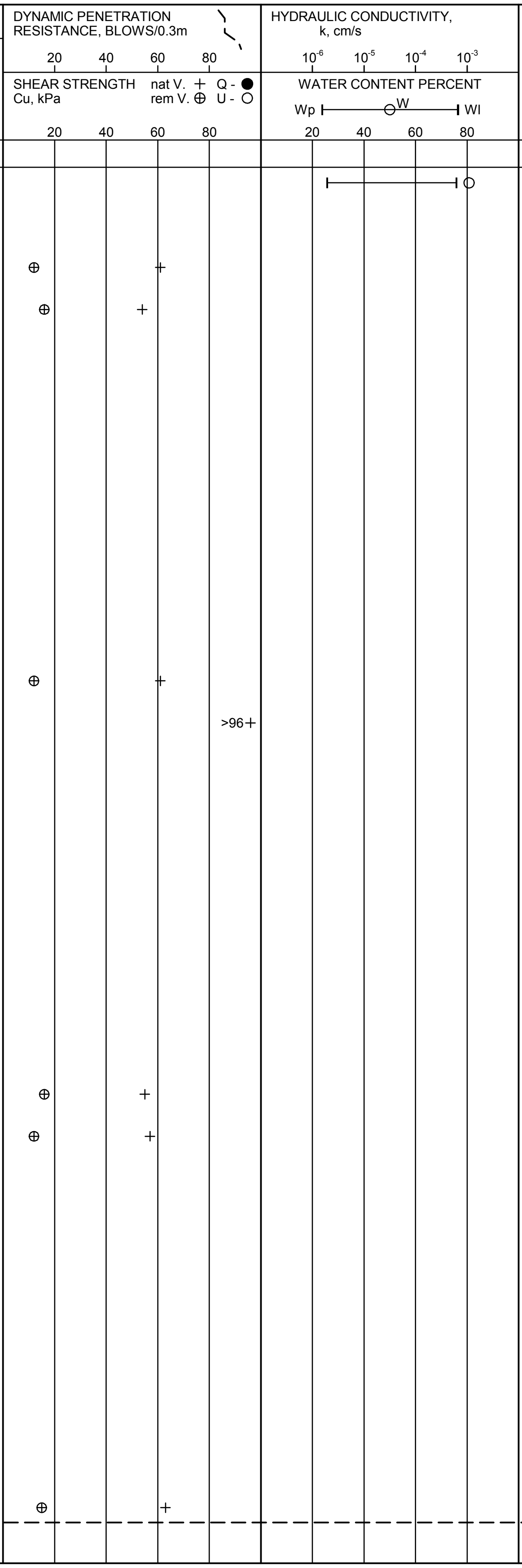
BORING DATE: February 8-13, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---							
20	Wash Boring HW Casing	(CI/CH) SILTY CLAY to CLAY; grey with black mottling, contains silt seams; cohesive, w>PL, firm to stiff	▨		16	SS	WR		
		(CI/CH) SILTY CLAY to CLAY; grey with black mottling, contains silt seams; cohesive, w>PL, stiff	▨	55.84 20.42					
21									
22									
23					17	SS	WR		
24									
25									
26					18	SS	WR		
27									
28									
29					19	SS	WR		
30		*CONTINUED NEXT PAGE*							



DEPTH SCALE

1 : 50

GOLDER

LOGGED: DWM

CHECKED: SM

MIS-BHS 001 1787048.GPJ GAL-MIS.GDT 4/13/18 ZS

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-26

SHEET 4 OF 5

LOCATION: N 5021036.3 ;E 466558.2

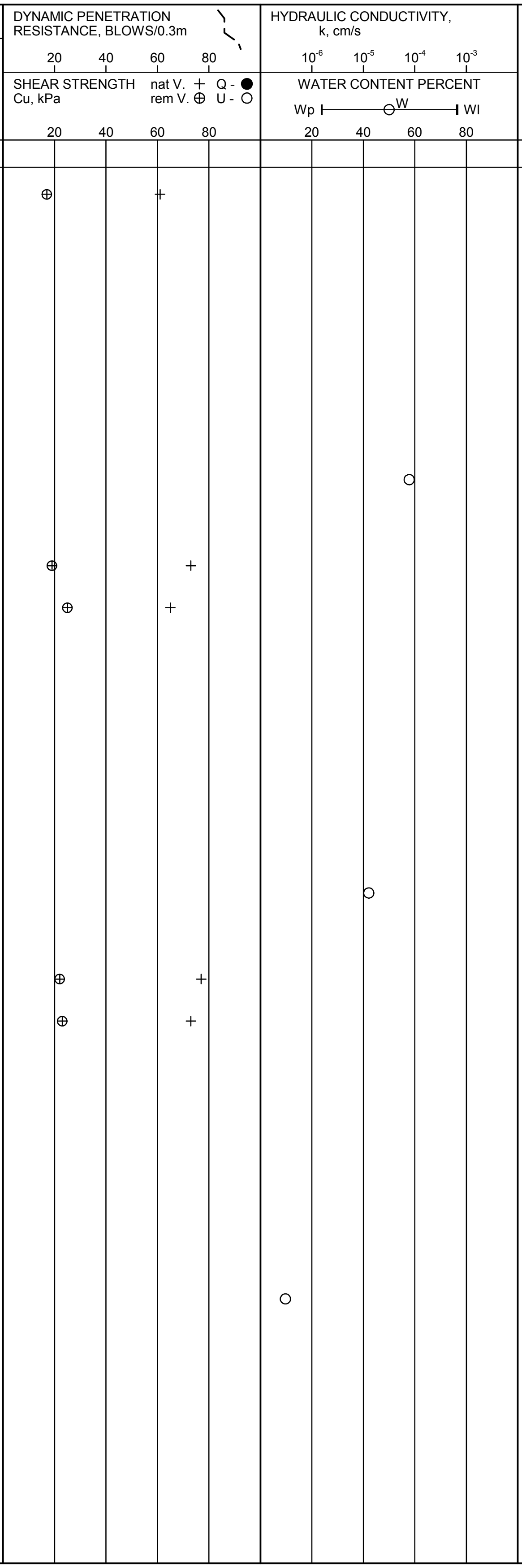
BORING DATE: February 8-13, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---							
30	Wash Boring HW Casing	(CI/CH) SILTY CLAY to CLAY; grey with black mottling, contains silt seams; cohesive, w>PL, stiff	▨						
32					20	SS	WR		
35					21	SS	WR		
37		(SM) gravelly SILTY SAND, some low plastic fines; grey (GLACIAL TILL); non-cohesive, wet, very dense		38.77 37.49					
38					22	SS	56	M	
		Borehole continued on RECORD OF DRILLHOLE 17-26		37.66 38.60					



DEPTH SCALE
1 : 50

GOLDER

LOGGED: DWM
CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF DRILLHOLE: 17-26

SHEET 5 OF 5

LOCATION: N 5021036.3 ;E 466558.2

DRILLING DATE: February 8-13, 2018

DATUM: CGVD28

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: LC 55

DRILLING CONTRACTOR: Grenville Drilling

JN - Joint
FLT - Fault
SHR- Shear
VN - Vein
CJ - Conjugate

BD- Bedding
FO- Foliation
CO- Contact
OR- Orthogonal
CL - Cleavage

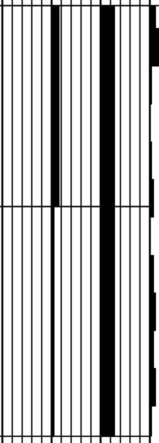
PL - Planar
CU- Curved
UN- Undulating
ST - Stepped
IR - Irregular

PO- Polished
K - Slickensided
SM- Smooth
Ro - Rough
MB- Mechanical Break

BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH	COLOUR % RETURN	RECOVERY TOTAL CORE % (80 60 40 20)	RECOVERY SOLID CORE % (80 60 40 20)	R.Q.D. % (80 60 40 20)	FRACT. INDEX PER 0.25 m (5 10 15 20)	DISCONTINUITY DATA B Angle (0 90 180 270)	DIP w.r.t. CORE AXIS (0 30 60 90)	TYPE AND SURFACE DESCRIPTION	Jcon	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec (10^{-6} 10^{-5} 10^{-4} 10^{-3})	Diametral Point Load Index (MPa) (2 4 6)	RMC -Q' AVG.
		BEDROCK SURFACE		37.66																
39 40 41	Rotary Drill NQ Core	Slightly weathered to fresh, thinly to medium bedded, grey to dark grey, fine grained, slightly to non-porous SHALE, with limestone and calcareous shale interbeds CARLSBAD FORMATION - Broken core from 38.96 m to 39.00 m		38.60 34.81	1 2		100 100-75													
42 43 44 45 46 47 48		End of Drillhole		41.45																



DEPTH SCALE
1 : 50

GOLDER

LOGGED: DWM
CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-27N

SHEET 1 OF 2

LOCATION: N 5021055.7 ;E 466466.9

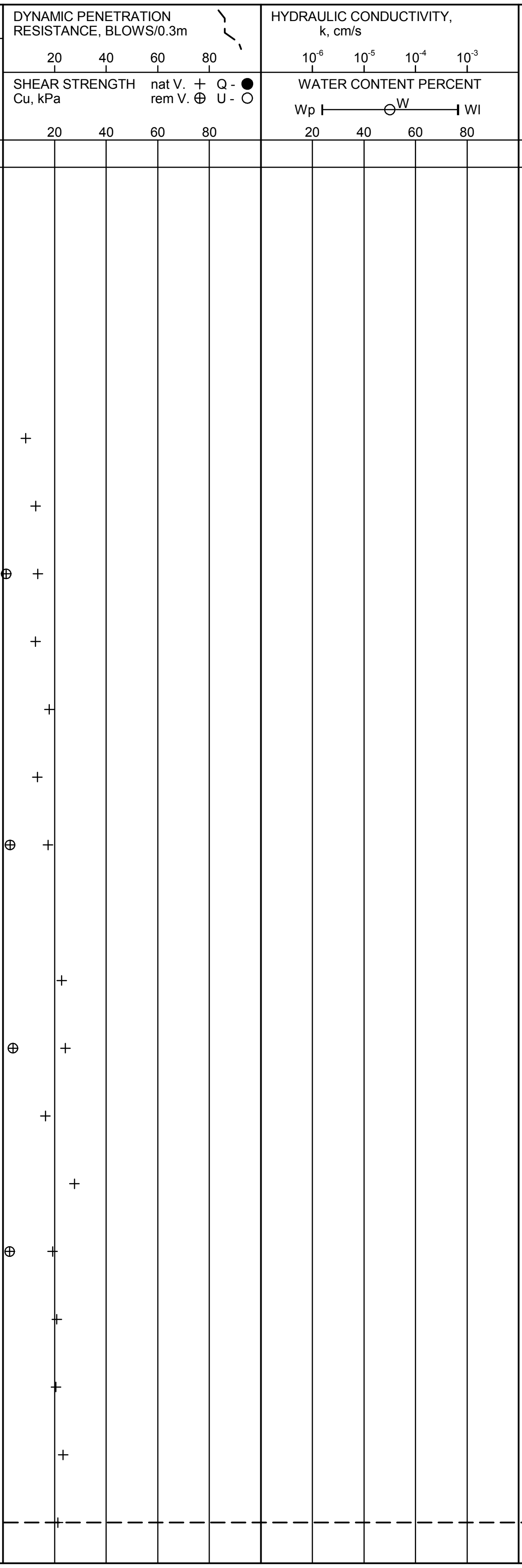
BORING DATE: January 26, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		76.26					
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND; dark brown; non-cohesive, wet		0.00					
		(SM) SILTY SAND; brown; non-cohesive, wet, loose to compact		75.96 0.30	1	SS	6		
1					2	SS	12		
				75.04 1.22					
2	Nilcon Vanes Clutch								
3									
4									
5									
6									
7									
8									
9									
10				66.26					
		CONTINUED NEXT PAGE							



DEPTH SCALE

1 : 50

GOLDER

LOGGED: DG

CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-27N

SHEET 2 OF 2

LOCATION: N 5021055.7 ;E 466466.9

BORING DATE: January 26, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---									
10		End of Borehole		10.00							
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											

MIS-BHS 001 1787048.GPJ GAL-MIS.GDT 4/12/18 ZS

DEPTH SCALE

1 : 50

GOLDER

LOGGED: DG

CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-29

SHEET 1 OF 5

LOCATION: N 5021029.1 ;E 466400.2

BORING DATE: January 30-February 5, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

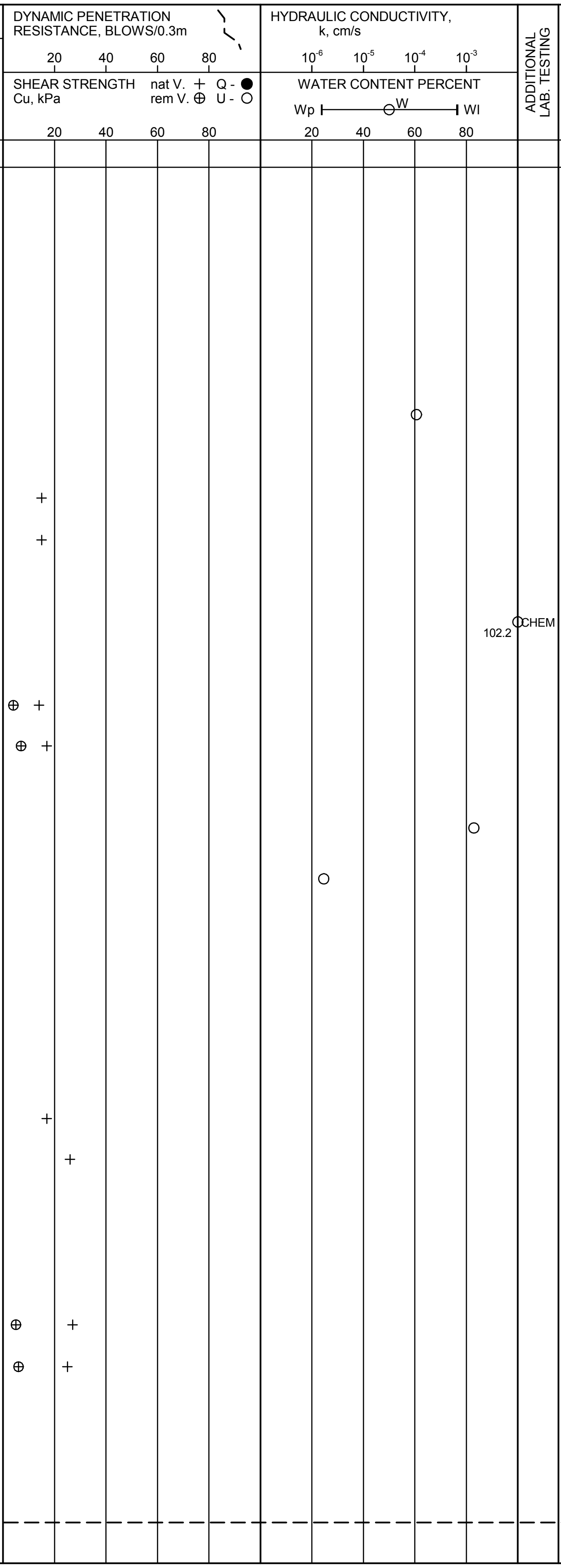
PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: Wash Boring, HW Casing

DEPTH SCALE METRES: 0 to 10

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	76.21
TOPSOIL - (SM) SILTY SAND; dark brown; non-cohesive, moist	0.00
(SP/SM) SAND to SILTY SAND; grey brown; non-cohesive, wet, compact to very loose	75.96 0.25
(CI/CH) SILTY CLAY to CLAY; grey with reddish brown mottling, contains silt seams; cohesive, w>PL, soft	74.11 2.10
(SP/SM) SAND to SILTY SAND, fine sand; grey; non-cohesive, wet	71.06 5.15
(CI/CH) SILTY CLAY to CLAY; grey with reddish brown mottling, contains silt seams; cohesive, w>PL, soft	70.88 5.33
(CL/CH) SILTY CLAY to CLAY; grey with black mottling, contains silt seams; cohesive, w>PL, firm	69.20 7.01

SAMPLES NUMBER	TYPE	BLOWS/0.30m
1	SS	13
2	SS	1
3	SS	WR
4	SS	WH
5	SS	1
6	SS	WH
7	SS	WR
8	SS	WR



PIEZOMETER OR STANDPIPE INSTALLATION

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

GOLDER

LOGGED: DG
CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-29

SHEET 2 OF 5

LOCATION: N 5021029.1 ;E 466400.2

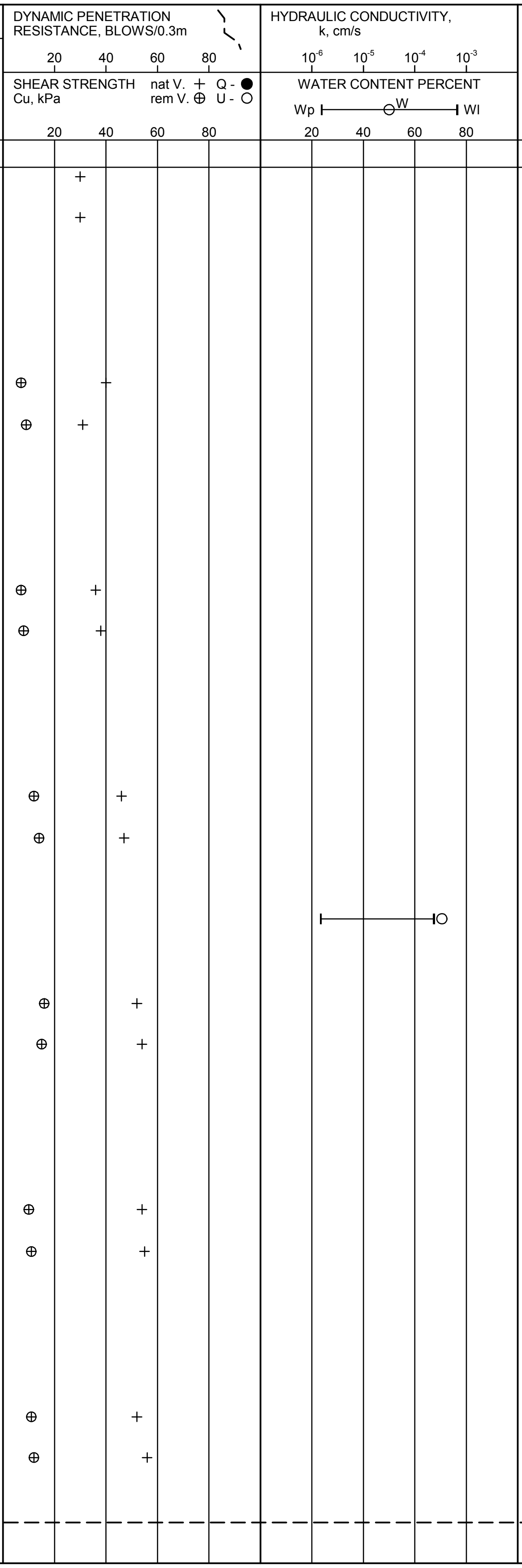
BORING DATE: January 30-February 5, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---							
10	Wash Boring HW Casing	(CL/CH) SILTY CLAY to CLAY; grey with black mottling, contains silt seams; cohesive, w>PL, firm	▨						
11					9	SS	WR		
12					10	SS	WR		
13									
14					11	SS	WR		
15					12	SS	WR		
16		(CL/CH) SILTY CLAY to CLAY; grey with black mottling, contains silt seams; cohesive, w>PL, stiff	▨	60.36 15.85					
17					13	SS	WR		
18									
19					14	SS	WR		
20					15	SS	WR		
		CONTINUED NEXT PAGE							



DEPTH SCALE

1 : 50

GOLDER

LOGGED: DG

CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-29

SHEET 3 OF 5

LOCATION: N 5021029.1 ;E 466400.2

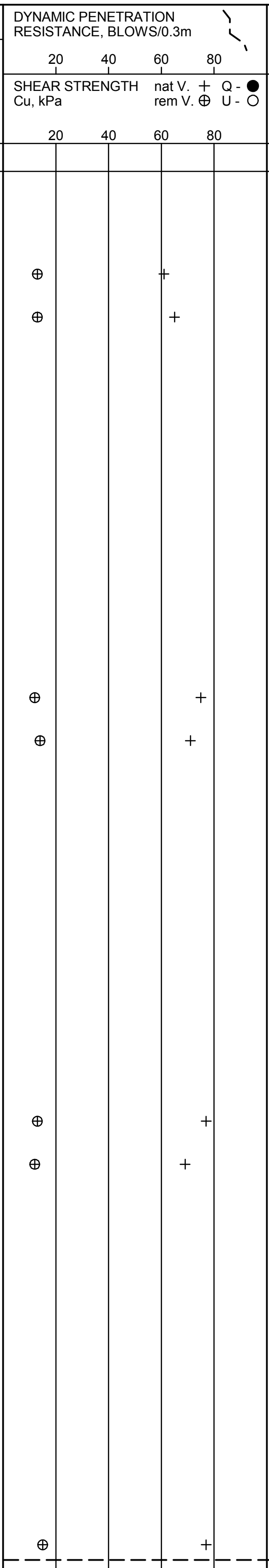
BORING DATE: January 30-February 5, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---							
20	Wash Boring HW Casing	(CL/CH) SILTY CLAY to CLAY; grey with black mottling, contains silt seams; cohesive, w>PL, stiff	▨		15	SS	WR		
21									
22									
23					16	SS	WR		
24									
25									
26					17	SS	WH		
27									
28									
29					18	SS	WR		
30		*CONTINUED NEXT PAGE*							



HYDRAULIC CONDUCTIVITY, k, cm/s

10^{-6} 10^{-5} 10^{-4} 10^{-3}

WATER CONTENT PERCENT

Wp ⊢—○W—⊣ Wl

20 40 60 80

DEPTH SCALE
1 : 50

GOLDER

LOGGED: DG
CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-29

SHEET 4 OF 5

LOCATION: N 5021029.1 ;E 466400.2

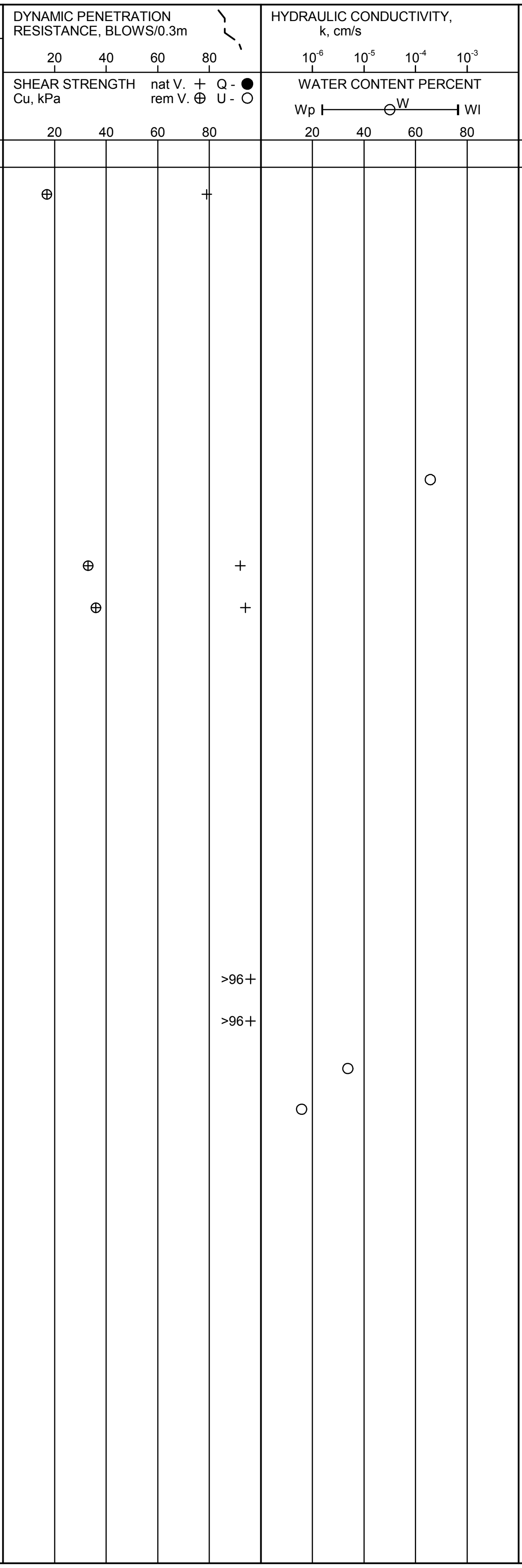
BORING DATE: January 30-February 5, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---							
30	Wash Boring HW Casing	(CL/CH) SILTY CLAY to CLAY; grey with black mottling, contains silt seams; cohesive, w>PL, stiff							
32					19	SS	WR		
35					20	SS	WH	CHEM	
37		(SM/ML) SILTY SAND to sandy SILT, some gravel to gravelly, some low plastic fines; grey (GLACIAL TILL); non-cohesive, wet, dense to very dense		39.51 36.70	21	SS	35		
					22	SS	>50		
40		Borehole continued on RECORD OF DRILLHOLE 17-26		36.23 39.98					



DEPTH SCALE

1 : 50

LOGGED: DG

CHECKED: SM

MIS-BHS 001 1787048.GPJ GAL-MIS.GDT 4/12/18 ZS

PROJECT: 1787048/400/4.4

RECORD OF DRILLHOLE: 17-29

SHEET 5 OF 5

LOCATION: N 5021029.1 ;E 466400.2

DRILLING DATE: January 30-February 5, 2018

DATUM: CGVD28

INCLINATION: -90° AZIMUTH: ---

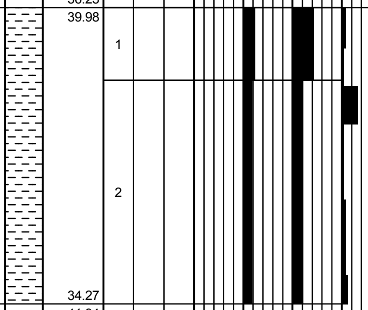
DRILL RIG: CME 75

DRILLING CONTRACTOR: Grenville Drilling

JN - Joint
FLT - Fault
SHR- Shear
VN - Vein
CJ - Conjugate
BD- Bedding
FO- Foliation
CO- Contact
OR- Orthogonal
CL - Cleavage
PL - Planar
CU- Curved
UN- Undulating
ST - Stepped
IR - Irregular
PO- Polished
K - Slickensided
SM- Smooth
Ro - Rough
MB- Mechanical Break
BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	FLUSH	RECOVERY TOTAL CORE % 80 60 40 20	RECOVERY SOLID CORE % 80 60 40 20	R.Q.D. % 80 60 40 20	FRACT. INDEX PER 0.25 m 5 10 15 20	DISCONTINUITY DATA B Angle 0 90 180 270	DIP w.r.t. CORE AXIS 0 30 60 90	TYPE AND SURFACE DESCRIPTION	Jcon	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec 10^{-6} 10^{-5} 10^{-4} 10^{-3}	Diametral Point Load Index (MPa) 2 4 6	RMC -Q' AVG.
		BEDROCK SURFACE		36.23																
40	Rotary Drill HQ Core	Slightly weathered to fresh, thinly to medium bedded, grey to dark grey, fine grained, slightly to non-porous SHALE, with limestone and calcareous shale interbeds CARLSBAD FORMATION		39.98	1															
41					2															
				34.27																
42		End of Drillhole		41.94																
43																				
44																				
45																				
46																				
47																				
48																				
49																				



MIS-RCK 004 1787048.GPJ GAL-MISS.GDT 4/12/18 ZS

DEPTH SCALE
1 : 50

GOLDER

LOGGED: DG
CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-30

SHEET 1 OF 2

LOCATION: N 5020966.5 ;E 466404.0

BORING DATE: January 28, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES: 0 – 10

BORING METHOD: Wash Boring, HW Casing

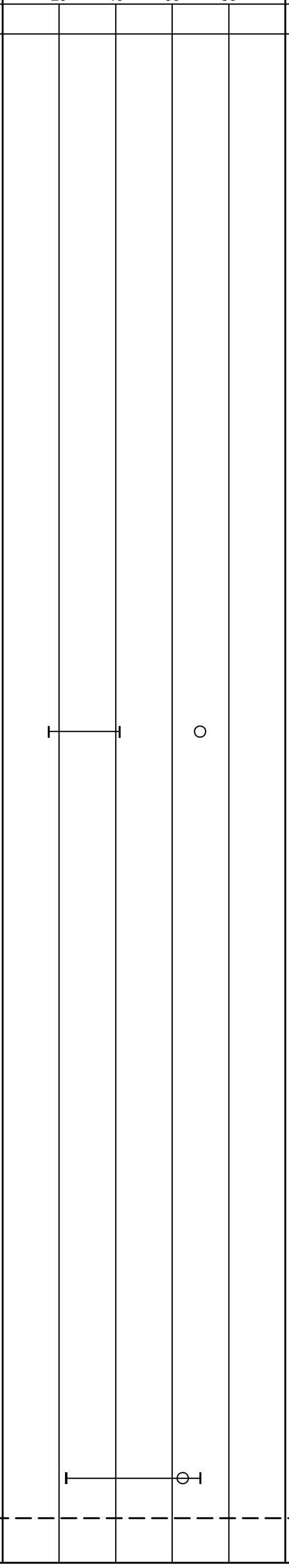
SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	75.99
TOPSOIL - (SM) SILTY SAND; dark brown; non-cohesive, moist	0.00
(SM) SILTY SAND; brown; non-cohesive, moist to wet, very loose	75.69 0.30
(CL/CH) SILTY CLAY to CLAY; grey brown, contains silt seams (WEATHERED CRUST); cohesive, w>PL, stiff	75.08 0.91
(CL/CH) SILTY CLAY to CLAY; grey with reddish brown mottling, contains silt seams; cohesive, w>PL, soft	74.31 1.68
(SM/ML) SILTY SAND to sandy SILT, fine sand; grey; non-cohesive, wet	70.59 5.40
(CL/CH) SILTY CLAY to CLAY; grey with reddish brown mottling, contains silt seams; cohesive, w>PL, soft	70.38 5.61
	65.98

SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
1	SS	4	
2	SS	5	
3	SS	2	
4	SS	WH	
5	TP	PH	C
6	SS	WH	
7	SS	WR	
8	SS	WR	
9	TP	PH	C

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}



PIEZOMETER OR STANDPIPE INSTALLATION

CONTINUED NEXT PAGE

DEPTH SCALE

1 : 50

GOLDER

LOGGED: DG

CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-30

SHEET 2 OF 2

LOCATION: N 5020966.5 ;E 466404.0

BORING DATE: January 28, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---									
10		End of Borehole		10.01							
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: DG

CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-30N

SHEET 1 OF 2

LOCATION: N 5020966.5 ;E 466404.0

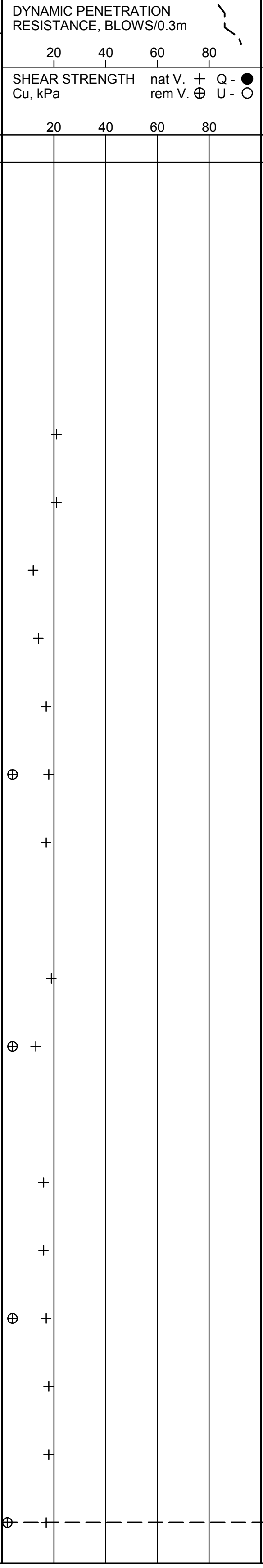
BORING DATE: January 28, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		75.99					
0	Power Auger 200 mm Diam. (H.S)	For soil stratigraphy refer to Record of Borehole 17-30		0.00					
1 – 10	Nilcon Vanes Clutch								
10				65.99					
		CONTINUED NEXT PAGE							



HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}

WATER CONTENT PERCENT: Wp ⊢—○W—⊣ Wl; 20 40 60 80

DEPTH SCALE
1 : 50

GOLDER

LOGGED: DG
CHECKED: SM

PROJECT: 1787048/400/4.4

RECORD OF BOREHOLE: 17-30N

SHEET 2 OF 2

LOCATION: N 5020966.5 ;E 466404.0

BORING DATE: January 28, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) WATER CONTENT PERCENT Wp ├──○W──┤ Wl (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---									
10		End of Borehole		10.00							
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											

MIS-BHS 001 1787048.GPJ GAL-MIS.GDT 4/12/18 ZS

DEPTH SCALE

1 : 50

GOLDER

LOGGED: DG

CHECKED: SM

APPENDIX B

Record of Boreholes - Previous Investigation

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 12-3-2

SHEET 1 OF 3

LOCATION: N 5021570.68 ;E 466665.61

BORING DATE: November 27-28, 2012

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING
		GROUND SURFACE	76.24				
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL	0.00				
		Loose to compact grey brown to grey SILTY SAND, trace clay	0.20	1	50 DO	9	
1				2	50 DO	10	MH
		Grey SANDY SILT, trace clay	75.10 1.14				
		Soft grey and red brown CLAY to SILTY CLAY, with silt seams	74.72 1.52	3	50 DO	WH	
2							
3	Electric Nilcon						
4							
5		Grey SILT, trace clay	71.36 4.88				
		Grey SILTY SAND	5.03				
		Soft grey and red brown CLAY to SILTY CLAY, with black staining and silt seams	5.15				
6		Grey SILT	69.84 6.46				
		Soft grey and red brown CLAY to SILTY CLAY, with black staining	69.35				
7		Grey SILT	6.95				
		Soft grey and red brown CLAY to SILTY CLAY, with black staining and clayey silt seams					
8		Soft to stiff grey and grey brown CLAY to SILTY CLAY, with black staining	67.65 8.59				
9							
10							
11							
12							
13							
14							
15							

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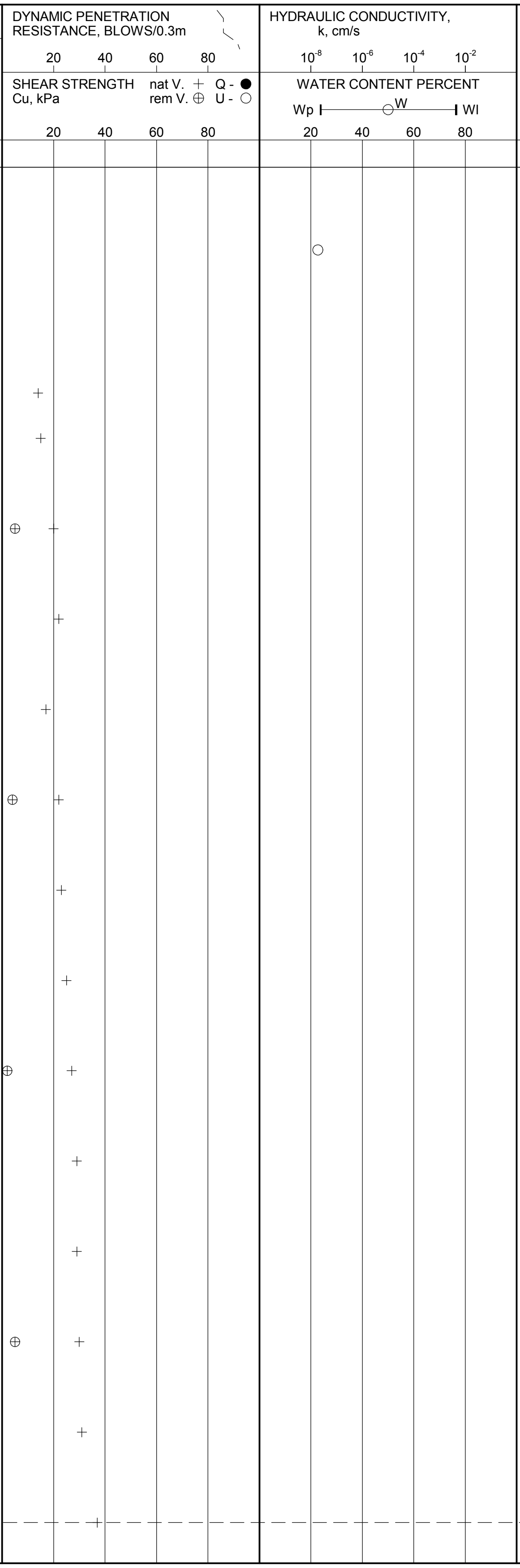


PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE
1 : 75

Golder Associates

LOGGED: DG
CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 12-3-2

SHEET 2 OF 3

LOCATION: N 5021570.68 ;E 466665.61
INCLINATION: -90° AZIMUTH: ---
SAMPLER HAMMER, 64kg; DROP, 760mm

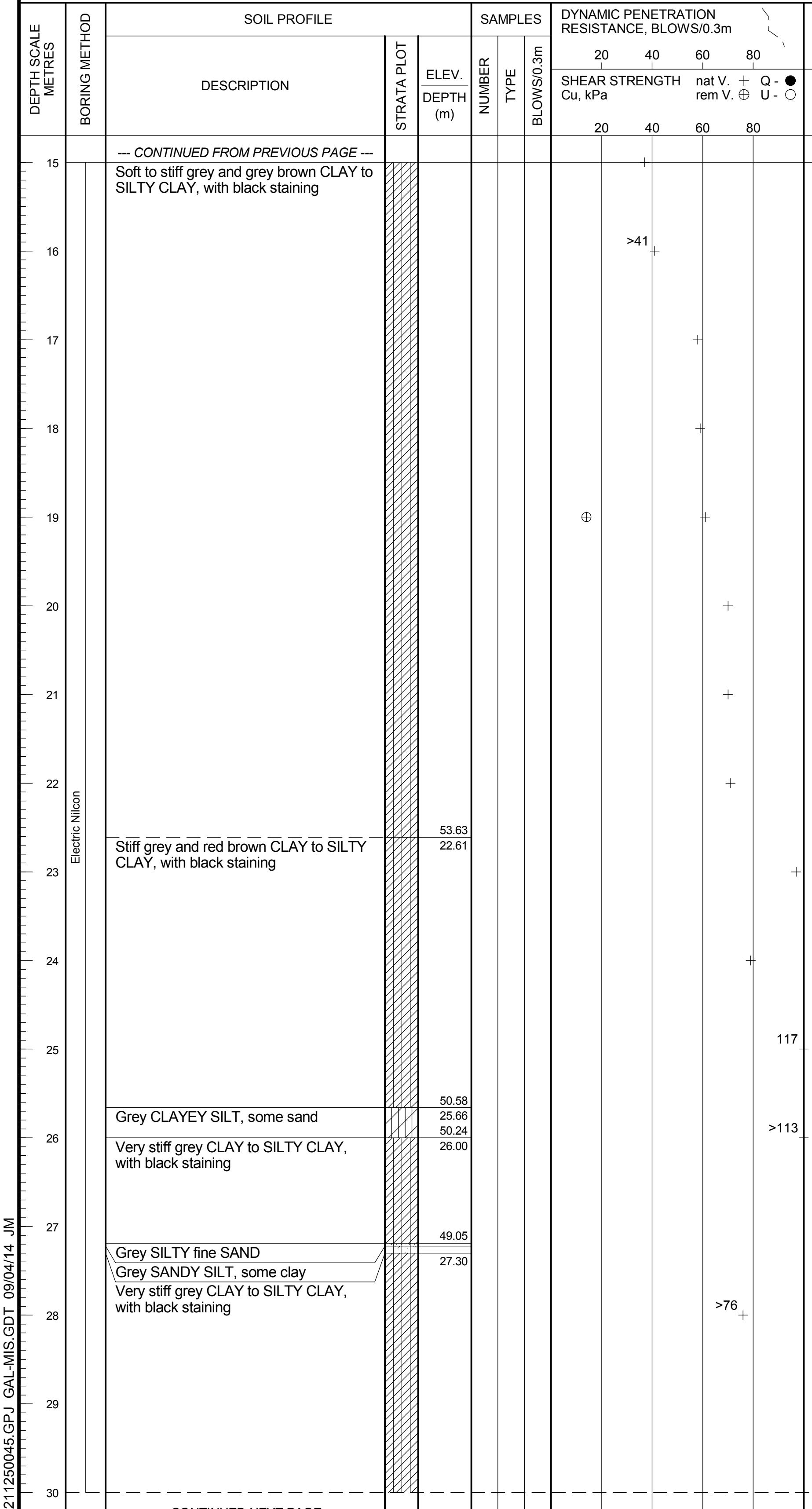
BORING DATE: November 27-28, 2012

DATUM: Geodetic

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

--- CONTINUED FROM PREVIOUS PAGE ---

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
15	Electric Nilcon	Soft to stiff grey and grey brown CLAY to SILTY CLAY, with black staining	▨						
22.61		Stiff grey and red brown CLAY to SILTY CLAY, with black staining	▨	53.63 22.61					
25.66		Grey CLAYEY SILT, some sand	▥	50.58 25.66					
26.00		Very stiff grey CLAY to SILTY CLAY, with black staining	▨	50.24 26.00					
		Grey SILTY fine SAND		49.05					
		Grey SANDY SILT, some clay		27.30					
		Very stiff grey CLAY to SILTY CLAY, with black staining	▨						
30									



HYDRAULIC CONDUCTIVITY, k, cm/s
10^{-8} 10^{-6} 10^{-4} 10^{-2}
WATER CONTENT PERCENT
Wp ⊢—○W—⊣ Wl
20 40 60 80

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 75

Golder Associates

LOGGED: DG
CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 12-3-2

SHEET 3 OF 3

LOCATION: N 5021570.68 ;E 466665.61

INCLINATION: -90° AZIMUTH: ---

BORING DATE: November 27-28, 2012

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 / SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-8} 10^{-6} 10^{-4} 10^{-2} / WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---									
30	Electric Nilcon	Brown SILTY SAND	▨	45.94 30.33							
		Very stiff grey CLAY to SILTY CLAY, with black staining	▨								
31				45.11 31.13				>76 +			
		End of Borehole									
		Note: Soil stratigraphy inferred from various soil sampling methods and CPT.									
32											
33											
34											
35											
36											
37											
38											
39											
40											
41											
42											
43											
44											
45											

CRRRC-SOIL 1211250045.GPJ GAL-MIS.GDT 09/04/14 JM

DEPTH SCALE

1 : 75

Golder Associates

LOGGED: DG

CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 12-3-3

SHEET 1 OF 3

LOCATION: N 5021578.47 ;E 466670.90

BORING DATE: December 3-5, 2012

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-8} 10^{-6} 10^{-4} 10^{-2} WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	76.22							
0	Wash Boring HW Casing	TOPSOIL	0.00							Protective Casing Bentonite Seal
		Loose to compact grey brown to grey SILTY SAND, trace clay	0.20							
1		Grey SANDY SILT, trace clay	75.08 1.14							
		Soft grey and red brown CLAY to SILTY CLAY, with silt seams	74.70 1.52							
2				1	73 TP	PH				
5		Grey SILT, trace clay	71.34 4.88							
		Grey SILTY SAND	5.03							
		Soft grey and red brown CLAY to SILTY CLAY, with black staining and silt seams	5.15							
6				2	73 TP	PH				
		Grey SILT	69.82 6.46							
		Soft grey and red brown CLAY to SILTY CLAY, with black staining	69.33							
7		Grey SILT	6.95							
		Soft grey and red brown CLAY to SILTY CLAY, with black staining and clayey silt seams								Bentonite-Cement Grout
8		Soft to stiff grey and grey brown CLAY to SILTY CLAY, with black staining	67.63 8.59							
12				3	73 TP	PH				
15										

CONTINUED NEXT PAGE

DEPTH SCALE

1 : 75

LOGGED: DG

CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 12-3-3

SHEET 2 OF 3

LOCATION: N 5021578.47 ;E 466670.90

BORING DATE: December 3-5, 2012

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

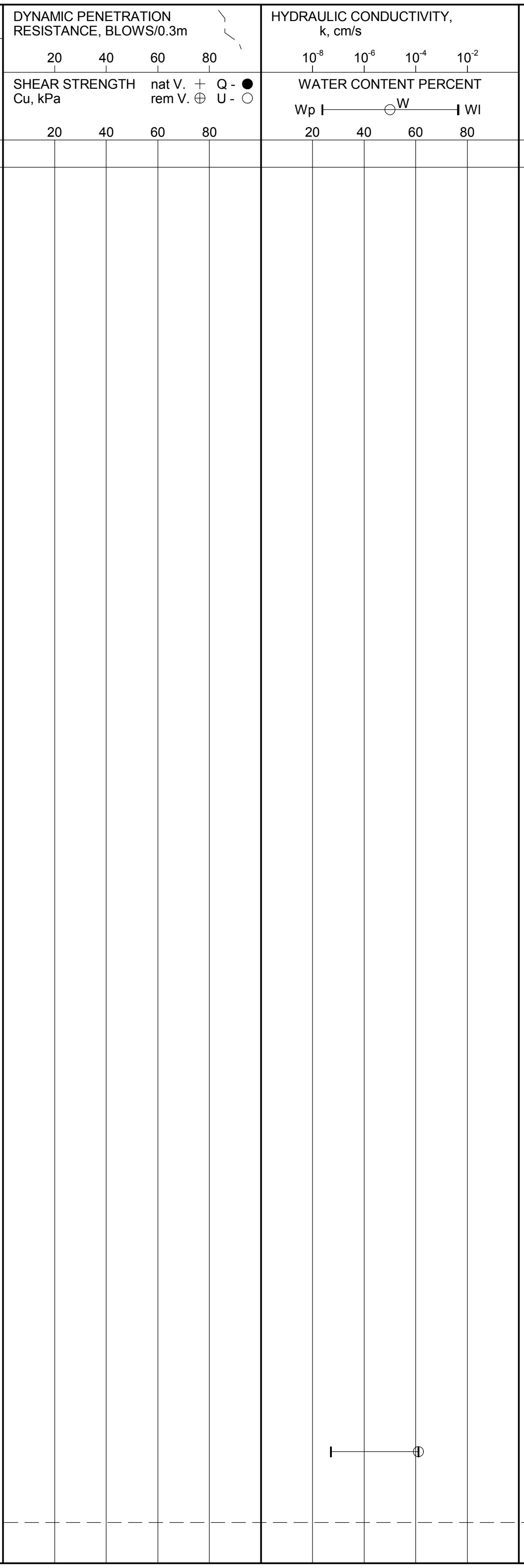
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: Wash Boring, HW Casing

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
	--- *CONTINUED FROM PREVIOUS PAGE* ---	
15	Soft to stiff grey and grey brown CLAY to SILTY CLAY, with black staining	
22.61	Stiff grey and red brown CLAY to SILTY CLAY, with black staining	53.61 22.61
25.66	Grey CLAYEY SILT, some sand	50.56 25.66
26.00	Very stiff grey CLAY to SILTY CLAY, with black staining	50.22 26.00
27.30	Grey SILTY fine SAND Grey SANDY SILT, some clay Very stiff grey CLAY to SILTY CLAY, with black staining	49.03 27.30
30	*CONTINUED NEXT PAGE*	

SAMPLES NUMBER	TYPE	BLOWS/0.3m
4	73 TP	PH
5	73 TP	PH
6	73 TP	PH



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION: Bentonite-Cement Grout

DEPTH SCALE

1 : 75

Golder Associates

LOGGED: DG

CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 12-3-3

SHEET 3 OF 3

LOCATION: N 5021578.47 ;E 466670.90

BORING DATE: December 3-5, 2012

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○: 20 40 60 80

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-8} 10^{-6} 10^{-4} 10^{-2}

WATER CONTENT PERCENT: Wp ⊢—○W—⊣ Wl: 20 40 60 80

--- CONTINUED FROM PREVIOUS PAGE ---

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	ELEV. / DEPTH (m)
30	Wash Boring HW Casing	Brown SILTY SAND	45.92 30.33
		Very stiff grey CLAY to SILTY CLAY, with black staining	
31			
32		Very stiff grey SILTY CLAY, some sand	44.37 31.85
		Very stiff grey and red CLAY to SILTY CLAY	32.10
33		Compact to very dense grey SILTY SAND to SANDY SILT, some gravel, trace to some clay, with cobbles and boulders (GLACIAL TILL)	43.15 33.07
34–39	Rotary Drill HQ Core		
40		Borehole continued on RECORD OF DRILLHOLE 12-3-3	36.38
41–45			

Note:
Soil stratigraphy inferred from various soil sampling methods and CPT.

SAMPLES: NUMBER	TYPE	BLOWS/0.3m	WATER CONTENT PERCENT	ADDITIONAL LAB. TESTING
7	50 DO	6		
8	50 DO	20		
9	50 DO	21		
10	50 DO	44		
11	50 DO	55		
12	50 DO	97		
13	50 DO	88	○	MH
14	50 DO	>50		
15	50 DO	90		
16	50 DO	90		

PIEZOMETER OR STANDPIPE INSTALLATION:

Bentonite-Cement Grout

Peltonite

CRRRC-SOIL 1211250045.GPJ GAL-MIS.GDT 09/04/14 JM

DEPTH SCALE

1 : 75

Golder Associates

LOGGED: DG

CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF DRILLHOLE: 12-3-3

SHEET 1 OF 3

LOCATION: N 5021578.47 ;E 466670.90

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: December 3-5, 2012

DRILL RIG: CME 55

DRILLING CONTRACTOR: Marathon Drilling

DATUM: Geodetic

JN - Joint
FLT - Fault
SH - Shear
VN - Vein
CJ - Conjugate

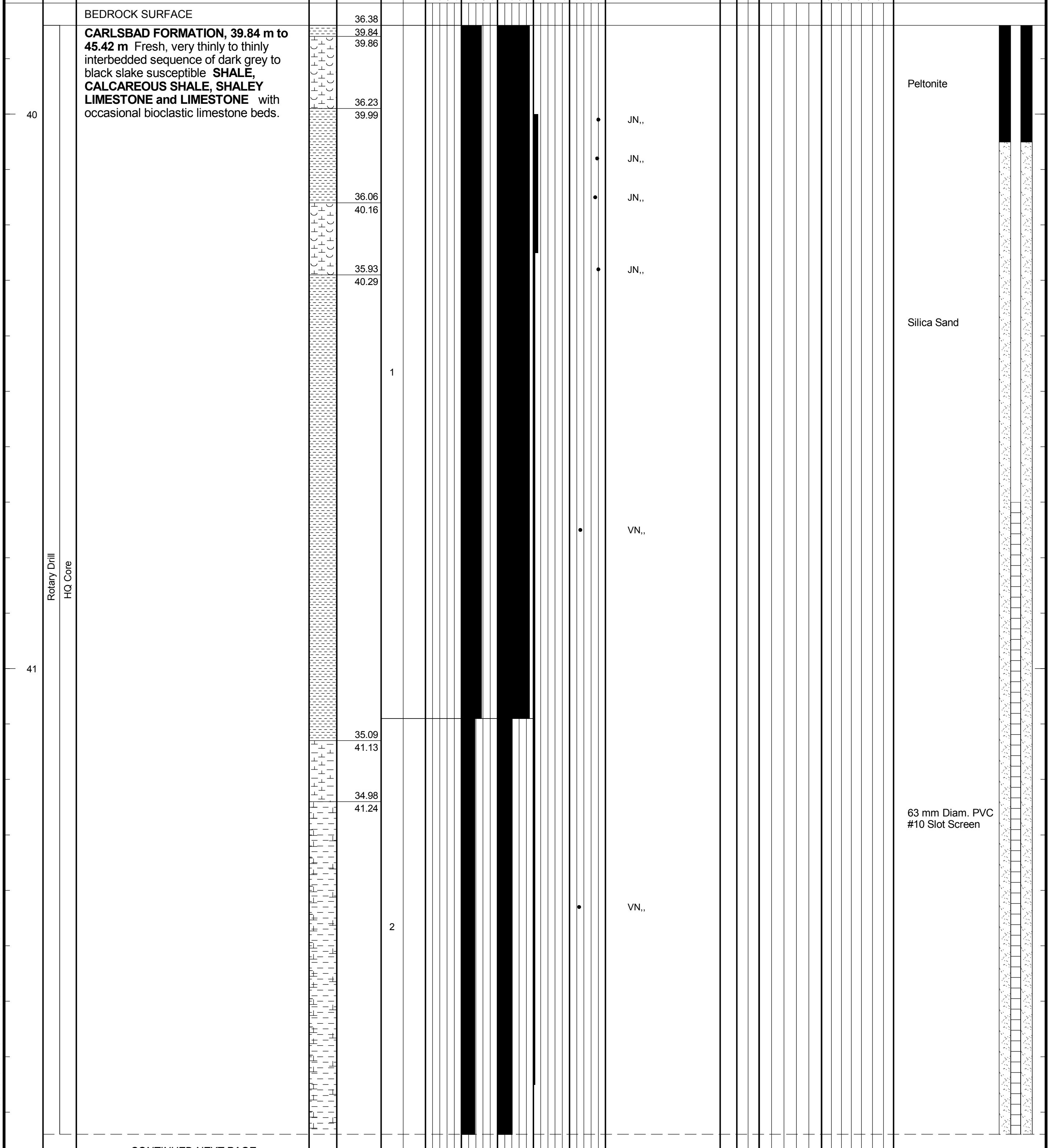
BD - Bedding
FO - Foliation
CO - Contact
OR - Orthogonal
CL - Clean

PL - Planar
CU - Curved
UN - Undulating
ST - Stepped
IR - Irregular

PO - Polished
K - Slickensided
SM - Smooth
RO - Rough
MB - Mechanical Break

BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.



BEDROCK SURFACE

CARLSBAD FORMATION, 39.84 m to 45.42 m Fresh, very thinly to thinly interbedded sequence of dark grey to black slake susceptible **SHALE, CALCAREOUS SHALE, SHALEY LIMESTONE and LIMESTONE** with occasional bioclastic limestone beds.

ELEV.	DEPTH (m)
36.38	
39.84	
	39.86
36.23	39.99
36.06	40.16
35.93	40.29
35.09	41.13
34.98	41.24

RUN No.	TYPE AND SURFACE DESCRIPTION
1	JN,,
1	JN,,
1	JN,,
1	JN,,
1	VN,,
2	VN,,

NOTES

Peltonite

Silica Sand

63 mm Diam. PVC
#10 Slot Screen

CONTINUED NEXT PAGE

DEPTH SCALE

1 : 10

LOGGED: DG

CHECKED: SAT

RECORD OF DRILLHOLE: 12-3-3

PROJECT: 12-1125-0045

LOCATION: N 5021578.47 ;E 466670.90

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: December 3-5, 2012

DRILL RIG: CME 55

DRILLING CONTRACTOR: Marathon Drilling

SHEET 2 OF 3

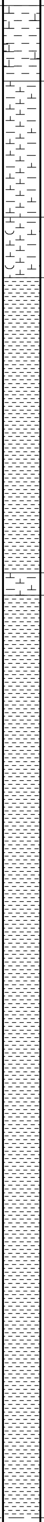
DATUM: Geodetic

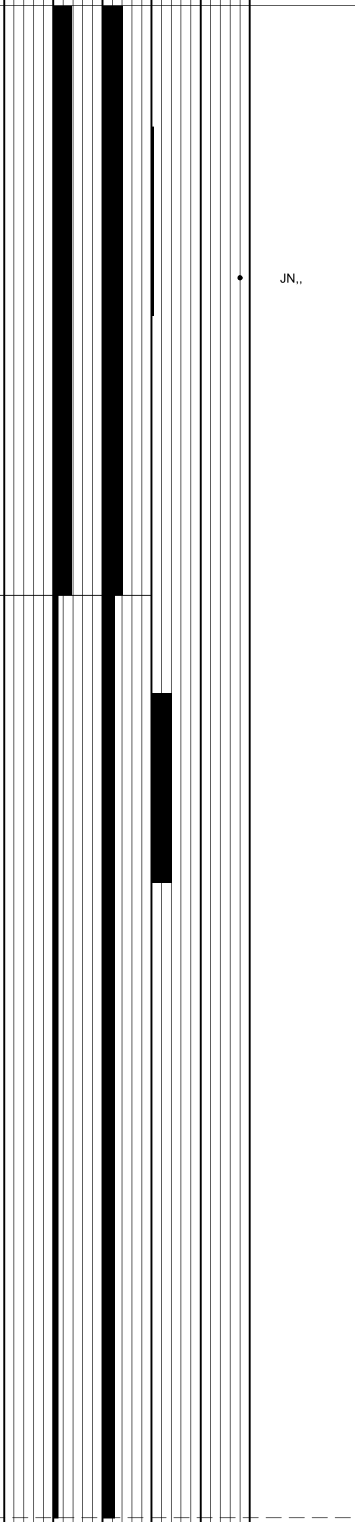
JN - Joint, FLT - Fault, SH - Shear, VN - Vein, CJ - Conjugate
BD - Bedding, FO - Foliation, CO - Contact, OR - Orthogonal, CL - Clean
PL - Planar, CU - Curved, UN - Undulating, ST - Stepped, IR - Irregular
PO - Polished, K - Slickensided, SM - Smooth, RO - Rough, MB - Mechanical Break
BR - Broken Rock

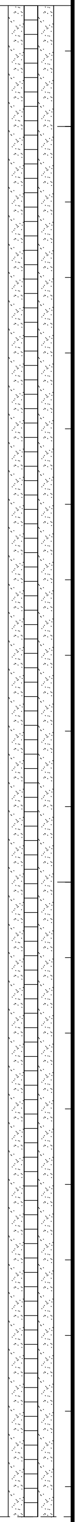
NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. DEPTH (m)	RUN No.	NOTES
		--- CONTINUED FROM PREVIOUS PAGE ---			
	Rotary Drill HQ Core	**CARLSBAD FORMATION, 39.84 m to 45.42 m** Fresh, very thinly to thinly interbedded sequence of dark grey to black slake susceptible **SHALE, CALCAREOUS SHALE, SHALEY LIMESTONE and LIMESTONE** with occasional bioclastic limestone beds.	34.28 41.94		
42			34.10 42.12		
			34.02 42.20	2	
			33.63 42.59		
			42.62		
					63 mm Diam. PVC #10 Slot Screen
43				3	
		CONTINUED NEXT PAGE			

Columns: SYMBOLIC LOG; FLUSH RETURN; RECOVERY (TOTAL CORE %, SOLID CORE %; 80 60 40 20); R.Q.D. % (80 60 40 20); FRACT. INDEX PER 0.25m (5 10 15 20); DIP w.r.t. CORE AXIS (0 30 60 90); DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION, Jcon, Jr, Ja; HYDRAULIC CONDUCTIVITY K, cm/sec (10^{-8} 10^{-6} 10^{-4} 10^{-2}); WEATHERING INDEX (W1 W2 W3 W4 W5 W6)







DEPTH SCALE

1 : 10

LOGGED: DG

CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF DRILLHOLE: 12-3-3

SHEET 3 OF 3

LOCATION: N 5021578.47 ;E 466670.90

DRILLING DATE: December 3-5, 2012

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55

DRILLING CONTRACTOR: Marathon Drilling

JN - Joint
FLT - Fault
SH - Shear
VN - Vein
CJ - Conjugate

BD - Bedding
FO - Foliation
CO - Contact
OR - Orthogonal
CL - Clean

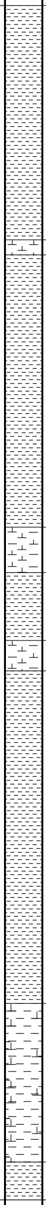
PL - Planar
CU - Curved
UN - Undulating
ST - Stepped
IR - Irregular

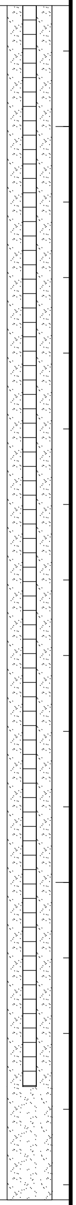
PO - Polished
K - Slickensided
SM - Smooth
RO - Rough
MB - Mechanical Break

BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY TOTAL CORE % / SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.25m	DIP w.r.t. CORE AXIS	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jcon	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec	WEATHERING INDEX	NOTES
		--- CONTINUED FROM PREVIOUS PAGE ---															
44	Rotary Drill HQ Core	**CARLSBAD FORMATION, 39.84 m to 45.42 m** Fresh, very thinly to thinly interbedded sequence of dark grey to black slake susceptible **SHALE, CALCAREOUS SHALE, SHALEY LIMESTONE and LIMESTONE** with occasional bioclastic limestone beds.		32.07 44.15 44.17	3												
										●	VN,,						
				31.69 44.53 31.63 44.59 31.54 44.68 31.50 44.72	4												63 mm Diam. PVC #10 Slot Screen
45				31.06 45.16 30.85 45.37 30.80													Silica Sand
		End of Drillhole		45.42													





DEPTH SCALE
1 : 10

Golder Associates

LOGGED: DG
CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 12-3-4

SHEET 1 OF 3

LOCATION: N 5021576.05 ;E 466672.49

INCLINATION: -90° AZIMUTH: ---

BORING DATE: December 11-14, 2012

DATUM: Geodetic

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ : 20 40 60 80

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-8} 10^{-6} 10^{-4} 10^{-2}

WATER CONTENT PERCENT: Wp ⊢—○W—⊣ Wl : 20 40 60 80

BORING METHOD: Wash Boring, HW Casing

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	76.23
TOPSOIL	0.00
Loose to compact grey brown to grey SILTY SAND, trace clay	0.20
Grey SANDY SILT, trace clay	75.09 1.14
Soft grey and red brown CLAY to SILTY CLAY, with silt seams	74.71 1.52
Grey SILT, trace clay	71.35 4.88
Grey SILTY SAND	5.03
Soft grey and red brown CLAY to SILTY CLAY, with black staining and silt seams	5.15
Grey SILT	69.83 6.46
Soft grey and red brown CLAY to SILTY CLAY, with black staining	
Grey SILT	69.34 6.95
Soft grey and red brown CLAY to SILTY CLAY, with black staining and clayey silt seams	
Soft to stiff grey and grey brown CLAY to SILTY CLAY, with black staining	67.64 8.59

PIEZOMETER OR STANDPIPE INSTALLATION: 'B' 'A'

Protective Casing

Bentonite-Cement Grout

CONTINUED NEXT PAGE

DEPTH SCALE 1 : 75

Golder Associates

LOGGED: DG

CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 12-3-4

SHEET 2 OF 3

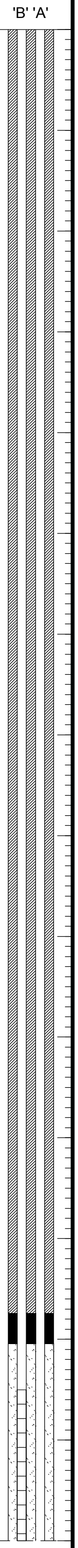
LOCATION: N 5021576.05 ;E 466672.49

INCLINATION: -90° AZIMUTH: ---

BORING DATE: December 11-14, 2012

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-8} 10^{-6} 10^{-4} 10^{-2} WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---									'B' 'A'
15		Soft to stiff grey and grey brown CLAY to SILTY CLAY, with black staining									
16											
17											
18											
19											
20											
21											Bentonite-Cement Grout
22	Wash Boring HW Casing										
		Stiff grey and red brown CLAY to SILTY CLAY, with black staining		53.62 22.61							
23											
24											
25											
		Grey CLAYEY SILT, some sand		50.57 25.66							
26		Very stiff grey CLAY to SILTY CLAY, with black staining		50.23 26.00							
27											
		Grey SILTY fine SAND		49.04							
		Grey SANDY SILT, some clay		27.30							
		Very stiff grey CLAY to SILTY CLAY, with black staining									
28											Peltonite Silica Sand
29											25 mm Diam. PVC #10 Slot Screen 'B'
30											
		CONTINUED NEXT PAGE									



DEPTH SCALE

1 : 75

Golder Associates

LOGGED: DG

CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 12-3-4

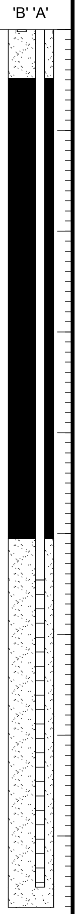
SHEET 3 OF 3

LOCATION: N 5021576.05 ;E 466672.49
INCLINATION: -90° AZIMUTH: ---

BORING DATE: December 11-14, 2012

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80; SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-8} 10^{-6} 10^{-4} 10^{-2}; WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
30	Wash Boring HW Casing	--- CONTINUED FROM PREVIOUS PAGE ---								
		Brown SILTY SAND	45.93 30.33							
		Very stiff grey CLAY to SILTY CLAY, with black staining								
32		Very stiff grey SILTY CLAY, some sand	44.38 31.85							
		Very stiff grey and red CLAY to SILTY CLAY	32.10							
33		Compact to very dense grey SILTY SAND to SANDY SILT, some gravel, trace to some clay, with cobbles and boulders (GLACIAL TILL)	43.16 33.07							
38		End of Borehole Note: Soil stratigraphy inferred from various soil sampling methods and CPT.	37.52 38.71							



Silica Sand	30.0 – 30.5
Peltonite	30.5 – 35.0
Silica Sand	35.0 – 38.7
38 mm Diam. PVC #10 Slot Screen 'A'	35.4 – 38.5
Silica Sand	38.7

DEPTH SCALE
1 : 75

Golder Associates

LOGGED: DG
CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 12-3-5

SHEET 1 OF 2

LOCATION: N 5021577.15 ;E 466668.45

BORING DATE: December 7, 2012

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m
		GROUND SURFACE	76.23			
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL	0.00			
		Loose to compact grey brown to grey SILTY SAND, trace clay	0.20			
1		Grey SANDY SILT, trace clay	75.09 1.14			
		Soft grey and red brown CLAY to SILTY CLAY, with silt seams	74.71 1.52			
5		Grey SILT, trace clay	71.35 4.88			
		Grey SILTY SAND	5.03			
		Soft grey and red brown CLAY to SILTY CLAY, with black staining and silt seams	5.15	1	73 TP	PH
6		Grey SILT	69.83 6.46			
		Soft grey and red brown CLAY to SILTY CLAY, with black staining				
7		Grey SILT	69.34 6.95			
		Soft grey and red brown CLAY to SILTY CLAY, with black staining and clayey silt seams				
8		Soft to stiff grey and grey brown CLAY to SILTY CLAY, with black staining	67.64 8.59			
15						

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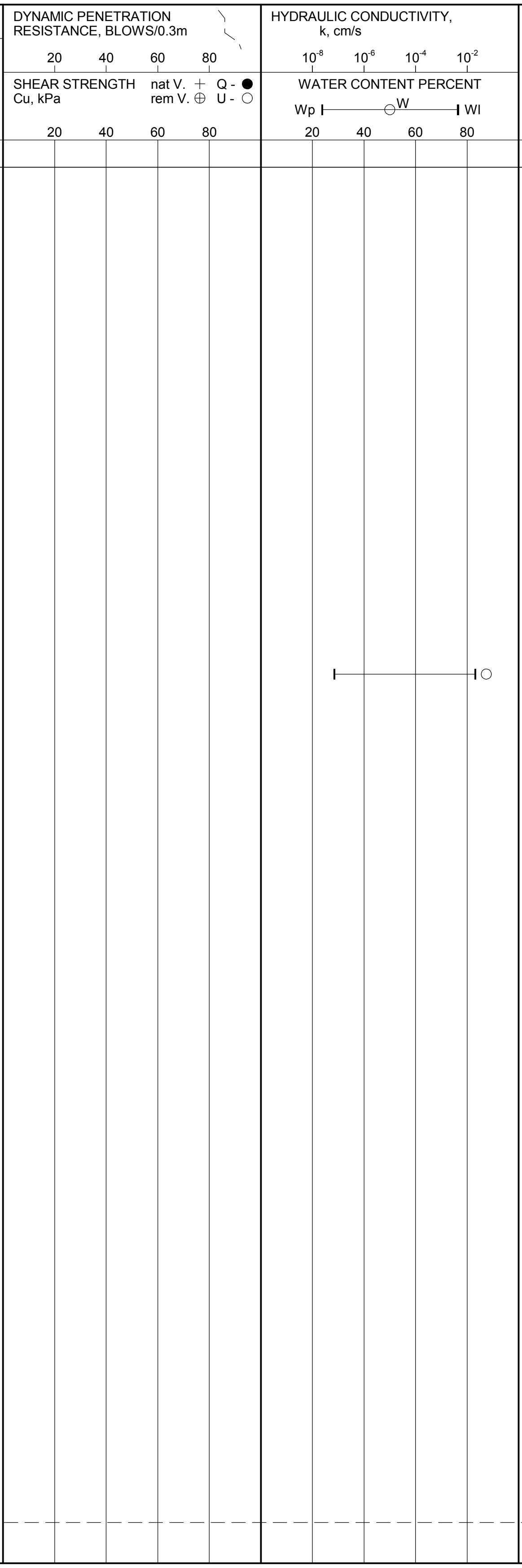
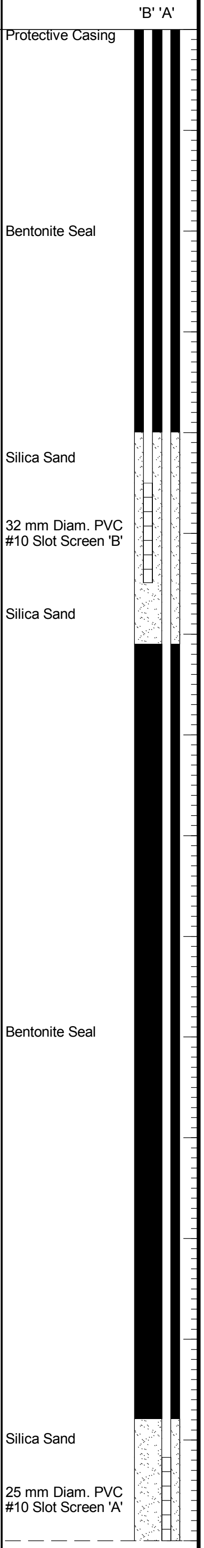


PIEZOMETER OR STANDPIPE INSTALLATION



DEPTH SCALE

1 : 75

Golder Associates

LOGGED: DG

CHECKED: SAT

CRRRC-SOIL 1211250045.GPJ GAL-MIS.GDT 09/04/14 JM

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 12-3-5

SHEET 2 OF 2

LOCATION: N 5021577.15 ;E 466668.45

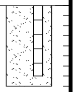
BORING DATE: December 7, 2012

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80); SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-8} 10^{-6} 10^{-4} 10^{-2}); WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---									'B' 'A'
15	Power Auger	Soft to stiff grey and grey brown CLAY to SILTY CLAY, with black staining	▨		2	73 TP	PH				25 mm Diam. PVC #10 Slot Screen 'A' Silica Sand 
		End of Borehole Note: Soil stratigraphy inferred from various soil sampling methods and CPT.		60.43 15.80							
16											
17											
18											
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26											
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28											
29											
30											

CRRRC-SOIL 1211250045.GPJ GAL-MIS.GDT 09/04/14 JM

DEPTH SCALE

1 : 75

Golder Associates

LOGGED: DG

CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 12-3-6

SHEET 1 OF 1

LOCATION: N 5021574.40 ;E 466669.89

INCLINATION: -90° AZIMUTH: ---

BORING DATE: December 7, 2012

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80; SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-8} 10^{-6} 10^{-4} 10^{-2}; WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		76.27							MON. WELL
0	Power Auger 200 mm Diam. (HS)	TOPSOIL		0.00							Protective Casing Bentonite Seal
		Loose to compact grey brown to grey SILTY SAND, trace clay		0.20							Silica Sand
1		Grey SANDY SILT, trace clay		75.13 1.14							50 mm Diam. PVC #10 Slot Screen
		End of Borehole Note: Soil stratigraphy inferred from various soil sampling methods and CPT.		74.75 1.52							
2											
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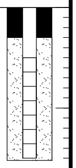
13											
14											
15											



DEPTH SCALE

1 : 75

Golder Associates

LOGGED: DG

CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 12-3-7

SHEET 1 OF 3

LOCATION: N 5021565.88 ;E 466661.37

INCLINATION: -90° AZIMUTH: ---

BORING DATE: March 11, 2013

DATUM: Geodetic

BORING METHOD: Geoprobe

SOIL PROFILE

DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	76.09
TOPSOIL	0.00
Loose to compact grey brown to grey SILTY SAND, trace clay	0.20
Grey SANDY SILT, trace clay	74.95 1.14
Soft grey and red brown CLAY to SILTY CLAY, with silt seams	74.57 1.52
Grey SILT, trace clay	71.21 4.88
Grey SILTY SAND	5.03
Soft grey and red brown CLAY to SILTY CLAY, with black staining and silt seams	5.15
Grey SILT	69.69 6.46
Soft grey and red brown CLAY to SILTY CLAY, with black staining	
Grey SILT	69.20 6.95
Soft grey and red brown CLAY to SILTY CLAY, with black staining and clayey silt seams	
Soft to stiff grey and grey brown CLAY to SILTY CLAY, with black staining	67.50 8.59

SAMPLES

NUMBER	TYPE	BLOWS/0.3m
1	53 mm TUBE	-
2	53 mm TUBE	-
3	53 mm TUBE	-
4	53 mm TUBE	-
5	53 mm TUBE	-
6	53 mm TUBE	-
7	53 mm TUBE	-
8	53 mm TUBE	-
9	53 mm TUBE	-
10	53 mm TUBE	-

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

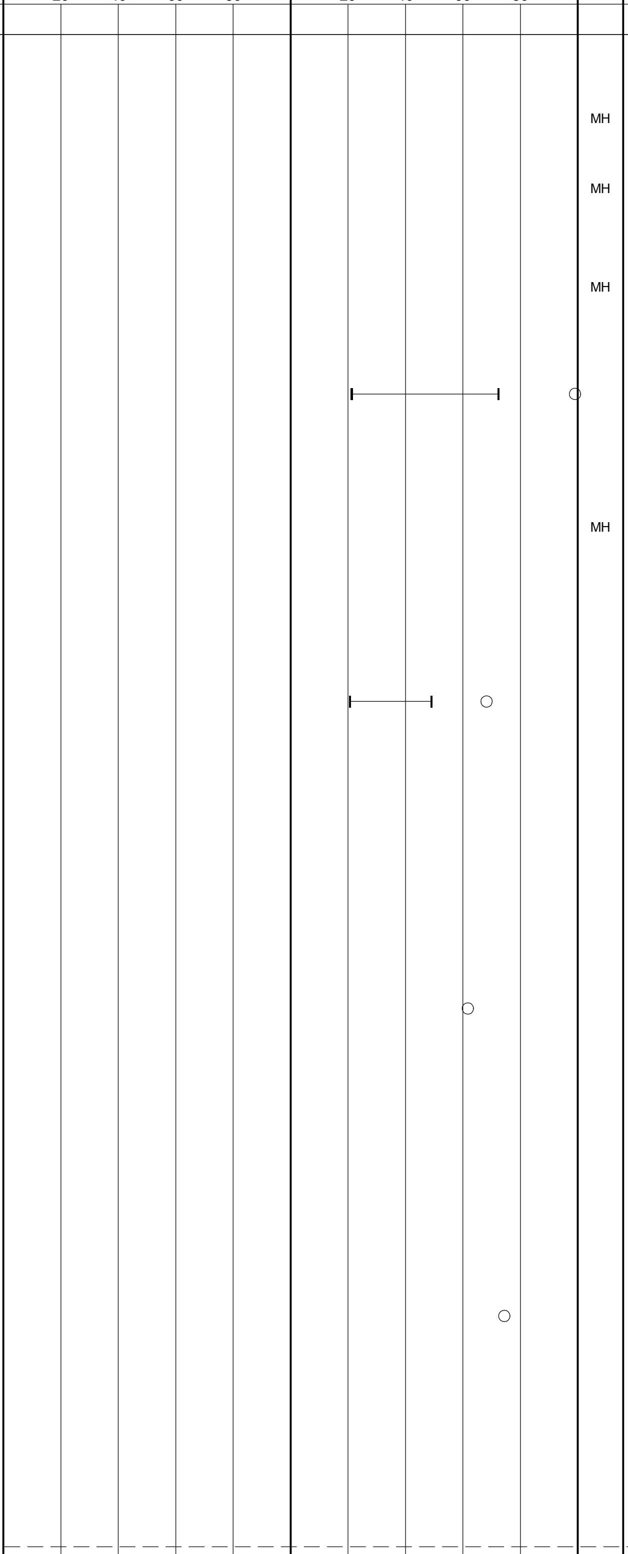
SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-8} 10^{-6} 10^{-4} 10^{-2}

WATER CONTENT PERCENT: Wp ⊢—○W—⊣ Wl 20 40 60 80

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION



DEPTH SCALE METRES: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

CONTINUED NEXT PAGE

DEPTH SCALE

1 : 75

Golder Associates

LOGGED: KE

CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 12-3-7

SHEET 2 OF 3

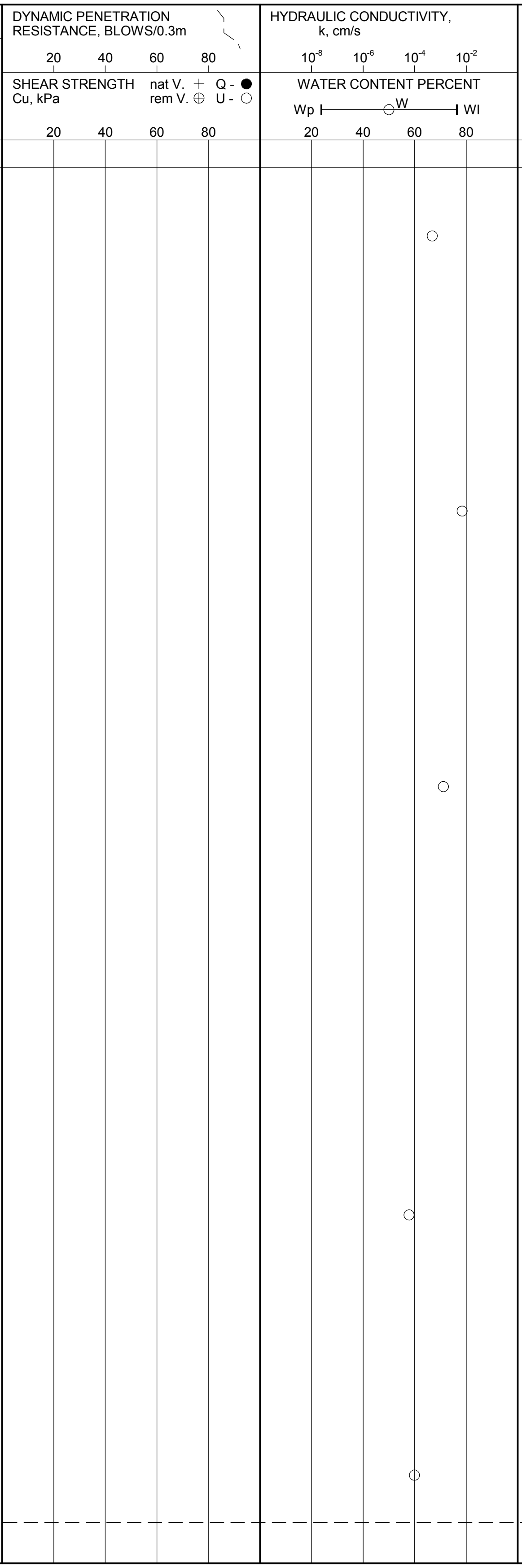
LOCATION: N 5021565.88 ;E 466661.37

INCLINATION: -90° AZIMUTH: ---

BORING DATE: March 11, 2013

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m
		--- CONTINUED FROM PREVIOUS PAGE ---					
15	Geoprobe	Soft to stiff grey and grey brown CLAY to SILTY CLAY, with black staining	▨		11	53 mm TUBE	-
17					12	53 mm TUBE	-
18					13	53 mm TUBE	-
20					14	53 mm TUBE	-
21					15	53 mm TUBE	-
22		Stiff grey and red brown CLAY to SILTY CLAY, with black staining	▨	53.48 22.61	16	53 mm TUBE	-
24					17	53 mm TUBE	-
25		Grey CLAYEY SILT, some sand		50.43 25.66			
26		Very stiff grey CLAY to SILTY CLAY, with black staining	▨	50.09 26.00	18	38 mm TUBE	-
27		Grey SILTY fine SAND Grey SANDY SILT, some clay Very stiff grey CLAY to SILTY CLAY, with black staining	▨	48.90 27.30	19	38 mm TUBE	-
29					20	38 mm TUBE	-
30		*CONTINUED NEXT PAGE*					



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE

1 : 75

Golder Associates

LOGGED: KE

CHECKED: SAT

CRRRC-SOIL 1211250045.GPJ GAL-MIS.GDT 09/04/14 JM

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 12-3-7

SHEET 3 OF 3

LOCATION: N 5021565.88 ;E 466661.37

INCLINATION: -90° AZIMUTH: ---

BORING DATE: March 11, 2013

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.3m	WATER CONTENT PERCENT (Wp, W, Wl)
30	Geoprobe	*--- CONTINUED FROM PREVIOUS PAGE ---*		20		-	
		Brown SILTY SAND	45.79 30.33				
31		Very stiff grey CLAY to SILTY CLAY, with black staining		21	38 mm TUBE	-	
32		Very stiff grey SILTY CLAY, some sand	44.24 31.85				
		Very stiff grey and red CLAY to SILTY CLAY	32.10	22	38 mm TUBE	-	○
33		Compact to very dense grey SILTY SAND to SANDY SILT, some gravel, trace to some clay, with cobbles and boulders (GLACIAL TILL)	43.02 33.07				
		End of Borehole	33.28				
34		Note: Soil stratigraphy inferred from various soil sampling methods and CPT.					
35							
36							
37							
38							
39							
40							
41							
42							
43							
44							
45							

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-8} 10^{-6} 10^{-4} 10^{-2}

WATER CONTENT PERCENT: Wp ⊢—○W—⊣ Wl 20 40 60 80

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE
1 : 75

Golder Associates

LOGGED: KE
CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 12-3-7-1

SHEET 1 OF 1

LOCATION: N 5021565.89 ;E 466667.46
INCLINATION: -90° AZIMUTH: ---

BORING DATE: March 11, 2013

DATUM: Geodetic

DEPTH SCALE METRES | BORING METHOD | SOIL PROFILE | SAMPLES | DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 | SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80 | HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-8} 10^{-6} 10^{-4} 10^{-2} | WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 20 40 60 80 | ADDITIONAL LAB. TESTING | PIEZOMETER OR STANDPIPE INSTALLATION

Boring method: Geoprobe

DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	76.06
TOPSOIL	0.00
Loose to compact grey brown to grey SILTY SAND, trace clay	0.20
Grey SANDY SILT, trace clay	74.92 1.14
Soft grey and red brown CLAY to SILTY CLAY, with silt seams	74.54 1.52
Grey SILT, trace clay	71.18 4.88
Grey SILTY SAND	5.03
Soft grey and red brown CLAY to SILTY CLAY, with black staining and silt seams	5.15
Grey SILT	69.66 6.46
Soft grey and red brown CLAY to SILTY CLAY, with black staining	
Grey SILT	69.17 6.95
Soft grey and red brown CLAY to SILTY CLAY, with black staining and clayey silt seams	
Soft to stiff grey and grey brown CLAY to SILTY CLAY, with black staining	67.47 8.59
End of Borehole	67.15 8.91

Note:
Soil stratigraphy inferred from various soil sampling methods and CPT.

NUMBER	TYPE	BLOWS/0.3m
1	53 mm TUBE	-
2	53 mm TUBE	-
3	53 mm TUBE	-
4	53 mm TUBE	-
5	53 mm TUBE	-
6	53 mm TUBE	-

Depth scale (m): 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

DEPTH SCALE
1 : 75

Golder Associates

LOGGED: WAM
CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 12-4-2

SHEET 1 OF 3

LOCATION: N 5020868.09 ;E 466519.28

INCLINATION: -90° AZIMUTH: ---

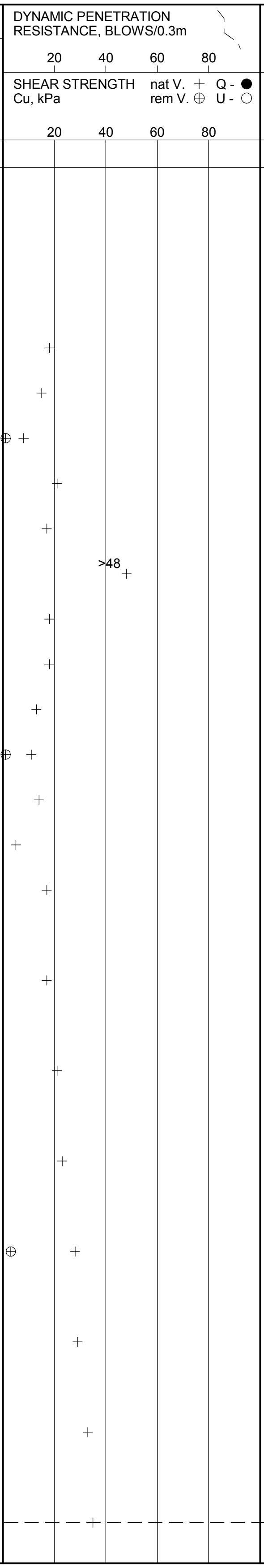
BORING DATE: January 23-28, 2013

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m
	GROUND SURFACE	75.92			
Power Auger 200 mm Diam. (HS)	TOPSOIL	0.00			
	Grey brown SANDY SILT, trace clay, with black staining	75.62 0.30	1	50 DO	
	Red brown SILTY CLAY, with silty sand seams (Weathered Crust)	75.22 0.70	2	50 DO	
Electric Nilcon	Soft red grey CLAY to SILTY CLAY, with silty sand and silt seams	74.70 1.22			
	Red grey and grey CLAY to SILTY CLAY, with silt seams	72.95 2.97			
	Grey SILTY SAND, trace clay, with black staining	71.20 4.72			
	Grey SILT, some sand	4.95			
	Soft red grey and grey CLAY to SILTY CLAY, with black staining and silt seams	5.18			
	Grey SILT, some sand	68.76			
	Soft to firm red grey and grey CLAY to SILTY CLAY, with black staining	7.26			
	Firm to stiff grey and red CLAY to SILTY CLAY, with black staining	62.36 13.56			



HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-8} 10^{-6} 10^{-4} 10^{-2}

WATER CONTENT PERCENT: Wp ⊢ ○W ⊣ Wl — 20 40 60 80

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

CONTINUED NEXT PAGE

DEPTH SCALE

1 : 75

LOGGED: DG

CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 12-4-2

SHEET 2 OF 3

LOCATION: N 5020868.09 ;E 466519.28

BORING DATE: January 23-28, 2013

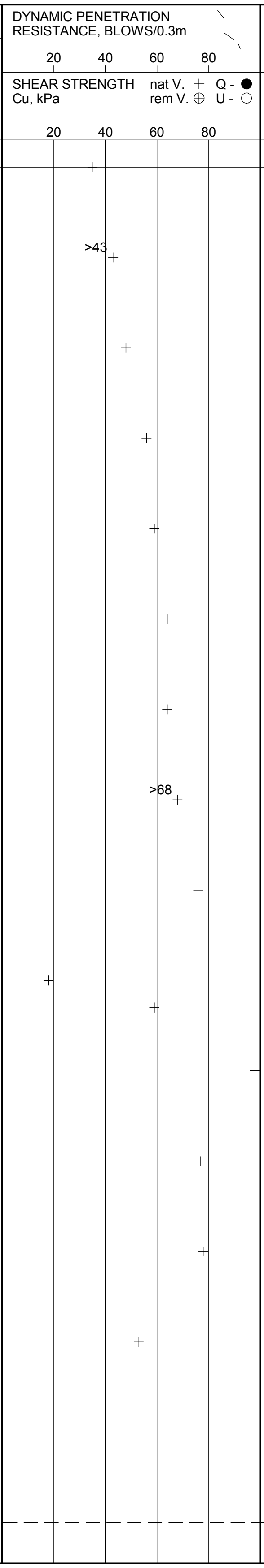
DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---							
15	Electric Nilcon	Firm to stiff grey and red CLAY to SILTY CLAY, with black staining	▨						
22.76		Stiff grey to dark grey CLAY to SILTY CLAY, with black staining	▨	53.16 22.76					
30		*CONTINUED NEXT PAGE*							



HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-8} 10^{-6} 10^{-4} 10^{-2}

WATER CONTENT PERCENT: Wp ⊢—○W—⊣ Wl; 20 40 60 80

DEPTH SCALE

1 : 75

Golder Associates

LOGGED: DG

CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 12-4-2

SHEET 3 OF 3

LOCATION: N 5020868.09 ;E 466519.28

BORING DATE: January 23-28, 2013

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-8} 10^{-6} 10^{-4} 10^{-2} WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m				
		--- CONTINUED FROM PREVIOUS PAGE ---									
30 31 32 33	Electric Nilcon	Stiff grey to dark grey CLAY to SILTY CLAY, with black staining	▨								
34 35 36 37 38 39 40 41 42 43 44 45		End of Borehole Note: 1. Soil stratigraphy inferred from various soil sampling methods and CPT. 2. Vane pushed to 33.8 m depth.		42.12 33.80							

DEPTH SCALE

1 : 75

Golder Associates

LOGGED: DG

CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 12-4-3

SHEET 1 OF 3

LOCATION: N 5020872.72 ;E 466523.18

BORING DATE: January 31 - February 15, 2013

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: Wash Boring, HW Casing

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m
GROUND SURFACE	75.92			
TOPSOIL	0.00			
Grey brown SANDY SILT, trace clay, with black staining	75.62 0.30			
Red brown SILTY CLAY, with silty sand seams (Weathered Crust)	75.22 0.70			
Soft red grey CLAY to SILTY CLAY, with silty sand and silt seams	74.70 1.22			
Red grey and grey CLAY to SILTY CLAY, with silt seams	72.95 2.97	1	73 TP	PH
Grey SILTY SAND, trace clay, with black staining	71.20 4.72			
Grey SILT, some sand	4.95			
Soft red grey and grey CLAY to SILTY CLAY, with black staining and silt seams	5.18			
Grey SILT, some sand	68.76	2	73 TP	PH
Soft to firm red grey and grey CLAY to SILTY CLAY, with black staining	7.26			
		3	73 TP	PH
Firm to stiff grey and red CLAY to SILTY CLAY, with black staining	62.36 13.56			

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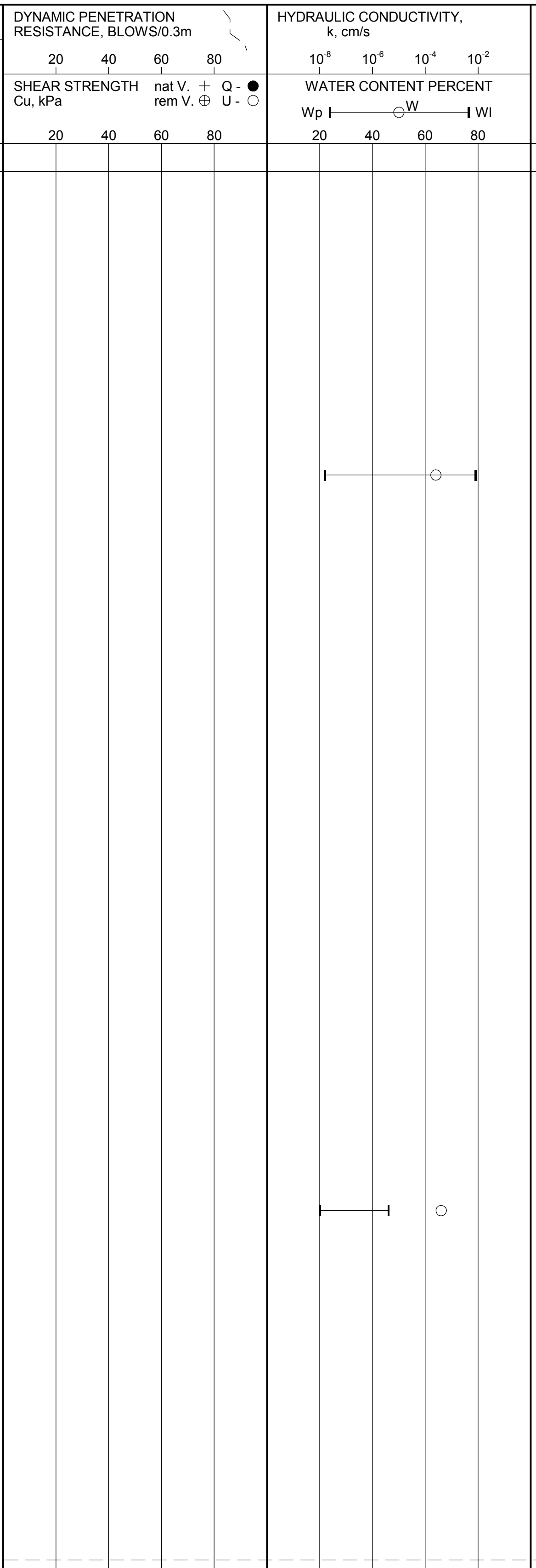


ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

Protective Casing

Bentonite Seal

Bentonite-Cement Grout

DEPTH SCALE

1 : 75

LOGGED: DG

CHECKED: SAT

CRRRC-SOIL 1211250045.GPJ GAL-MIS.GDT 09/04/14 JM

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 12-4-3

SHEET 2 OF 3

LOCATION: N 5020872.72 ;E 466523.18

INCLINATION: -90° AZIMUTH: ---

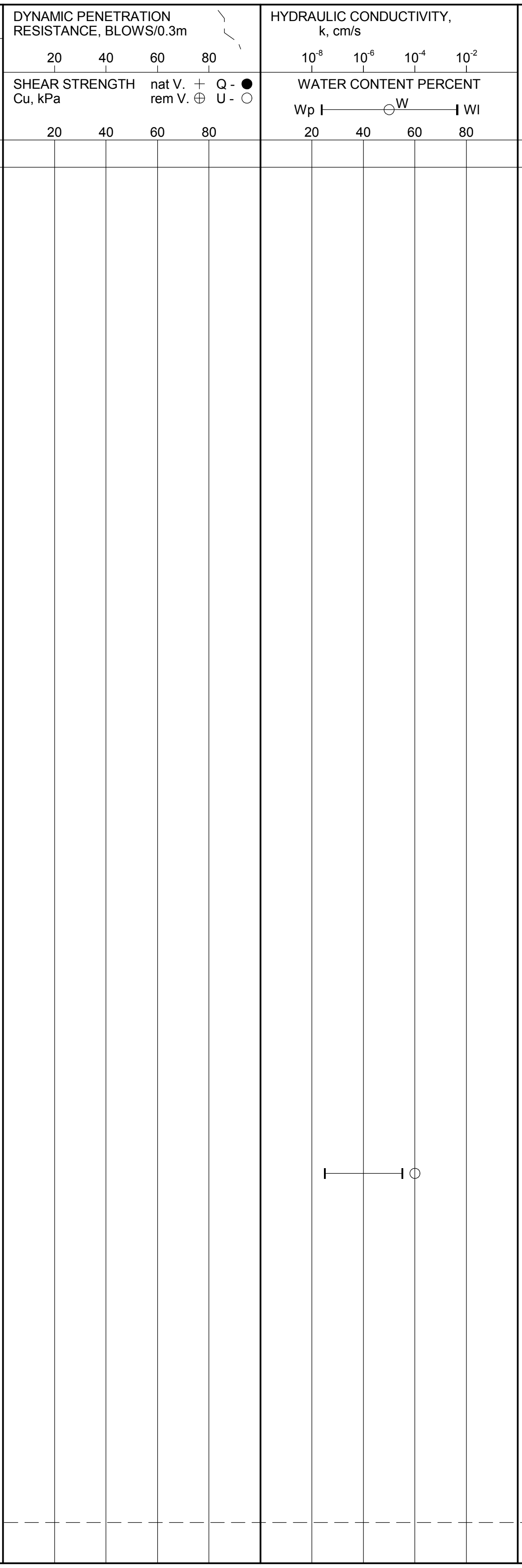
SAMPLER HAMMER, 64kg; DROP, 760mm

BORING DATE: January 31 - February 15, 2013

DATUM: Geodetic

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---							
15	Wash Boring HW Casing	Firm to stiff grey and red CLAY to SILTY CLAY, with black staining	▨						
17.5					4	73 TP	PH		
18.5					5	73 TP	PH		
22.8		Stiff grey to dark grey CLAY to SILTY CLAY, with black staining	▨	53.16 22.76					Bentonite-Cement Grout
26					6	73 TP	WR		
30		*CONTINUED NEXT PAGE*							



DEPTH SCALE

1 : 75

LOGGED: DG

CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 12-4-3

SHEET 3 OF 3

LOCATION: N 5020872.72 ;E 466523.18

INCLINATION: -90° AZIMUTH: ---

BORING DATE: January 31 - February 15, 2013

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80); SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-8} 10^{-6} 10^{-4} 10^{-2}); WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---									
30	Wash Boring HW Casing	Stiff grey to dark grey CLAY to SILTY CLAY, with black staining									
31					7	73 TP	WR				
33				42.16	8	50 DO	11				
34		Dense grey SILTY SAND, some gravel, trace clay (GLACIAL TILL)		33.76	9	50 DO	60				Bentonite-Cement Grout
38				38.12							
		Borehole continued on RECORD OF DRILLHOLE 12-4-3 Note: 1. Soil stratigraphy inferred from various soil sampling methods and CPT. 2. Soil stratigraphy from 0.0 m to 33.8 m based on 12-4-2									

Depth scale: 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45

DEPTH SCALE

1 : 75

Golder Associates

LOGGED: DG

CHECKED: SAT

RECORD OF DRILLHOLE: 12-4-3

PROJECT: 12-1125-0045

SHEET 1 OF 3

LOCATION: N 5020872.72 ;E 466523.18

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: January 31 - February 15, 2013

DRILL RIG: CME 55

DRILLING CONTRACTOR: Marathon Drilling

DATUM: Geodetic

JN - Joint
FLT - Fault
SH - Shear
VN - Vein
CJ - Conjugate
BD - Bedding
FO - Foliation
CO - Contact
OR - Orthogonal
CL - Clean
PL - Planar
CU - Curved
UN - Undulating
ST - Stepped
IR - Irregular
PO - Polished
K - Slickensided
SM - Smooth
RO - Rough
MB - Mechanical Break
BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. DEPTH (m) | RUN No. | FLUSH RETURN | RECOVERY (TOTAL CORE % 80 60 40 20, SOLID CORE % 80 60 40 20) | R.Q.D. % 80 60 40 20 | FRACT. INDEX PER 0.25m 5 10 15 20 | DISCONTINUITY DATA (DIP w.r.t. CORE AXIS 0 30 60 90; TYPE AND SURFACE DESCRIPTION; Jcon Jr Ja) | HYDRAULIC CONDUCTIVITY K, cm/sec 10^{-8} 10^{-6} 10^{-4} 10^{-2} | WEATHERING INDEX W1 W2 W3 W4 W5 W6 | NOTES

BEDROCK SURFACE 38.12

CARLSBAD FORMATION, 37.80 m to 43.61 m Fresh, very thinly to thinly interbedded sequence of dark grey to black slake susceptible **SHALE, CALCAREOUS SHALE, SHALEY LIMESTONE and LIMESTONE** with occasional bioclastic limestone beds.

Drilling record: Rotary Drill, HQ Core

Depth scale: 38, 39

ELEV. / DEPTH (m):

37.80
38.08
37.84
37.99
37.93
37.94
37.98
38.01
37.79
38.13
37.74
38.18
37.37
38.55
37.32
38.60
37.19
38.73
37.10
38.82
37.00
38.92
36.95
38.97
36.89
39.03
36.83
39.09
36.68
39.24
39.26
39.29
36.59
39.33
36.35
39.57
36.26
39.66
36.22
39.70
36.16
39.76

RUN No.: 1, 2

TYPE AND SURFACE DESCRIPTION	Jcon	Jr	Ja
BD,PL,SM	12	1	1
BD,IR,SM	16	1.5	1
BD,PL,SM	12	1	1
BD,PL,SM	12	1	1

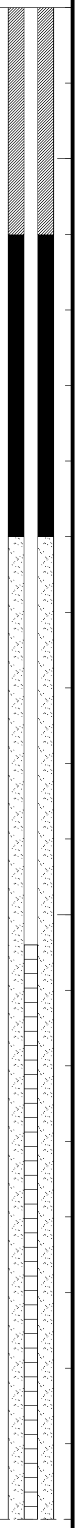
NOTES:

Bentonite-Cement Grout

Bentonite Seal

Silica Sand

63 mm Diam. PVC #10 Slot Screen



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DEPTH SCALE

1 : 10

Golder Associates

LOGGED: DG

CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF DRILLHOLE: 12-4-3

SHEET 2 OF 3

LOCATION: N 5020872.72 ;E 466523.18

DRILLING DATE: January 31 - February 15, 2013

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55

DRILLING CONTRACTOR: Marathon Drilling

JN - Joint
FLT - Fault
SH - Shear
VN - Vein
CJ - Conjugate

BD - Bedding
FO - Foliation
CO - Contact
OR - Orthogonal
CL - Clean

PL - Planar
CU - Curved
UN - Undulating
ST - Stepped
IR - Irregular

PO - Polished
K - Slickensided
SM - Smooth
RO - Rough
MB - Mechanical Break

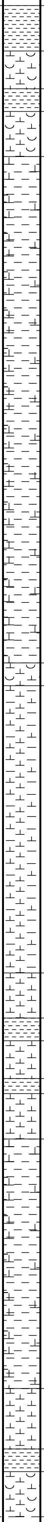
BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. DEPTH (m) | RUN No. | FLUSH RETURN | RECOVERY: TOTAL CORE % 80 60 40 20; SOLID CORE % 80 60 40 20 | R.Q.D. % 80 60 40 20 | FRACT. INDEX PER 0.25m 5 10 15 20 | DIP w.r.t. CORE AXIS 0 30 60 90 | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION, Jcon, Jr, Ja | HYDRAULIC CONDUCTIVITY K, cm/sec 10^{-8} 10^{-6} 10^{-4} 10^{-2} | WEATHERING INDEX W1 W2 W3 W4 W5 W6 | NOTES

--- CONTINUED FROM PREVIOUS PAGE ---

CARLSBAD FORMATION, 37.80 m to 43.61 m Fresh, very thinly to thinly interbedded sequence of dark grey to black slake susceptible **SHALE, CALCAREOUS SHALE, SHALEY LIMESTONE and LIMESTONE** with occasional bioclastic limestone beds.

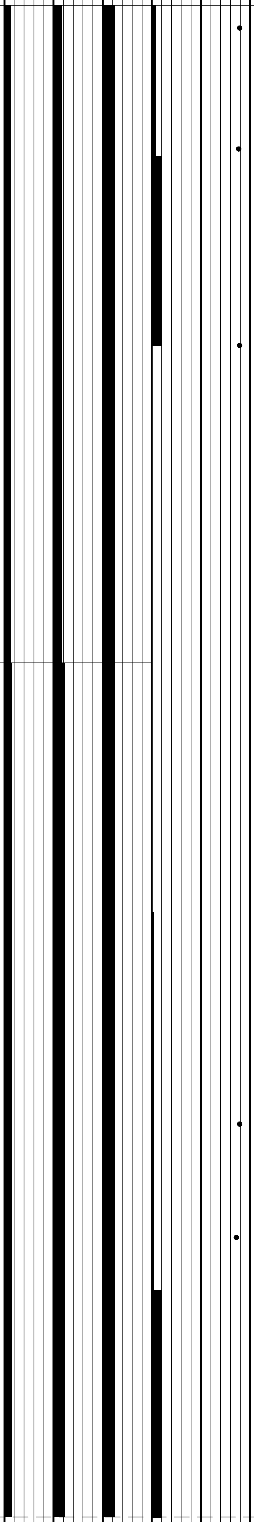


ELEV.	DEPTH (m)
36.06	39.86
36.01	39.91
	39.94
35.92	40.00
35.25	40.67
	40.70
34.84	41.08
34.78	41.14
	41.17
34.70	41.22
	41.24
34.62	41.30
34.29	41.63
34.21	41.71
	41.74

Depth scale: 40, 41

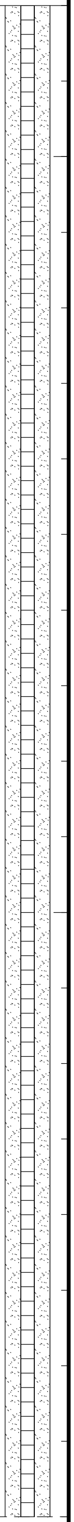
DRILLING RECORD: Rotary Drill, HQ Core

RUN No.: 2, 3



TYPE AND SURFACE DESCRIPTION	Jcon	Jr	Ja
BD,PL,SM	12	1	1
JN,PL,SM	12	1	1
JN,PL,SM	12	1	1
BD,PL,SM	12	1	1
BD,CU,SM	12	2	1

NOTES: 63 mm Diam. PVC #10 Slot Screen



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DEPTH SCALE
1 : 10

Golder Associates

LOGGED: DG
CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF DRILLHOLE: 12-4-3

SHEET 3 OF 3

LOCATION: N 5020872.72 ;E 466523.18

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: January 31 - February 15, 2013

DRILL RIG: CME 55

DRILLING CONTRACTOR: Marathon Drilling

DATUM: Geodetic

JN - Joint	BD - Bedding	PL - Planar	PO - Polished	BR - Broken Rock
FLT - Fault	FO - Foliation	CU - Curved	K - Slickensided	**NOTE:** For additional abbreviations refer to list of abbreviations & symbols.
SH - Shear	CO - Contact	UN - Undulating	SM - Smooth	
VN - Vein	OR - Orthogonal	ST - Stepped	RO - Rough	
CJ - Conjugate	CL - Clean	IR - Irregular	MB - Mechanical Break	

DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. DEPTH (m) | RUN No. | FLUSH RETURN | RECOVERY: TOTAL CORE % (80 60 40 20), SOLID CORE % (80 60 40 20) | R.Q.D. % (80 60 40 20) | FRACT. INDEX PER 0.25m (5 10 15 20) | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS (0 30 60 90), TYPE AND SURFACE DESCRIPTION, Jcon, Jr, Ja | HYDRAULIC CONDUCTIVITY K, cm/sec (10^{-8} 10^{-6} 10^{-4} 10^{-2}) | WEATHERING INDEX (W1 W2 W3 W4 W5 W6) | NOTES

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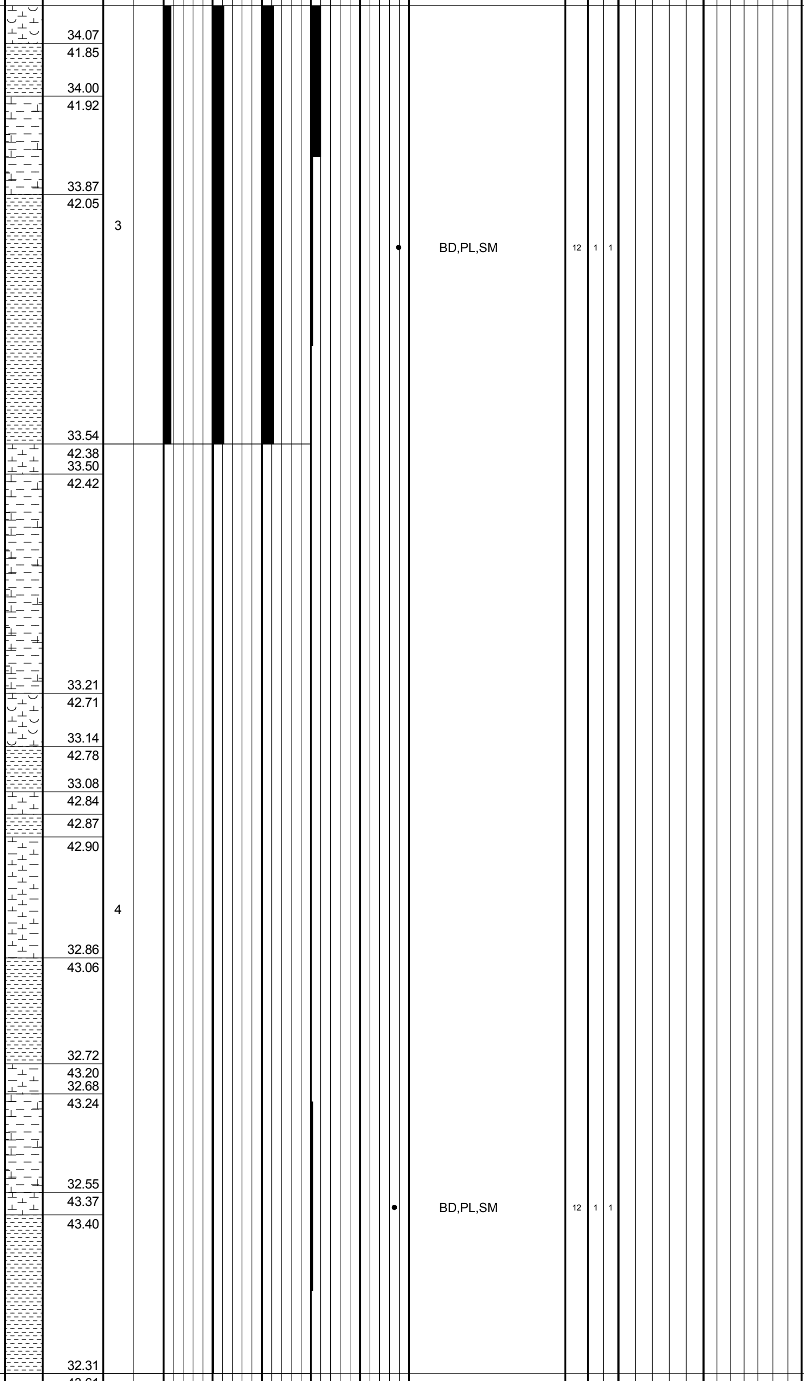
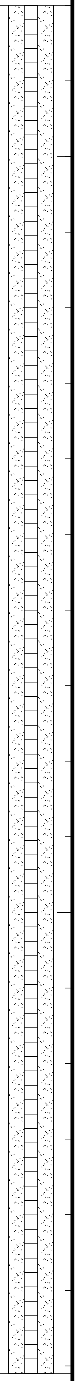


CARLSBAD FORMATION, 37.80 m to 43.61 m Fresh, very thinly to thinly interbedded sequence of dark grey to black slake susceptible **SHALE, CALCAREOUS SHALE, SHALEY LIMESTONE and LIMESTONE** with occasional bioclastic limestone beds.

ELEV.	DEPTH (m)
34.07	41.85
34.00	41.92
33.87	42.05
33.54	42.38
33.50	42.42
33.21	42.71
33.14	42.78
33.08	42.84
	42.87
	42.90
32.86	43.06
32.72	43.20
32.68	43.24
32.55	43.37
	43.40
32.31	43.61

RUN No.	TYPE AND SURFACE DESCRIPTION	Jcon	Jr	Ja
3	BD,PL,SM	12	1	1
4	BD,PL,SM	12	1	1

End of Drillhole



63 mm Diam. PVC #10 Slot Screen

CRRC-ROCK 1211250045.GPJ GAL-MISS.GDT 09/04/14 JM

DEPTH SCALE

1 : 10

Golder Associates

LOGGED: DG

CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 12-4-4

SHEET 1 OF 3

LOCATION: N 5020875.53 ;E 466521.56

INCLINATION: -90° AZIMUTH: ---

BORING DATE: February 22-25, 2013

DATUM: Geodetic

DEPTH SCALE METRES | BORING METHOD | SOIL PROFILE | SAMPLES: NUMBER, TYPE, BLOWS/0.3m | DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80 | SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○: 20 40 60 80 | HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-8} 10^{-6} 10^{-4} 10^{-2} | WATER CONTENT PERCENT: Wp ⊢—○W—⊣ Wl: 20 40 60 80 | ADDITIONAL LAB. TESTING | PIEZOMETER OR STANDPIPE INSTALLATION

BORING METHOD: Wash Boring, HW Casing

DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	75.88
TOPSOIL	0.00
Grey brown SANDY SILT, trace clay, with black staining	75.58 0.30
Red brown SILTY CLAY, with silty sand seams (Weathered Crust)	75.18 0.70
Soft red grey CLAY to SILTY CLAY, with silty sand and silt seams	74.66 1.22
Red grey and grey CLAY to SILTY CLAY, with silt seams	72.91 2.97
Grey SILTY SAND, trace clay, with black staining	71.16 4.72
Grey SILT, some sand	4.95
Soft red grey and grey CLAY to SILTY CLAY, with black staining and silt seams	5.18
Grey SILT, some sand	68.72
Soft to firm red grey and grey CLAY to SILTY CLAY, with black staining	7.26
Firm to stiff grey and red CLAY to SILTY CLAY, with black staining	62.32 13.56

PIEZOMETER OR STANDPIPE INSTALLATION: 'B' 'A'

Protective Casing

Bentonite Seal

Bentonite-Cement Grout

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DEPTH SCALE

1 : 75

Golder Associates

LOGGED: DG/DWM

CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 12-4-4

SHEET 2 OF 3

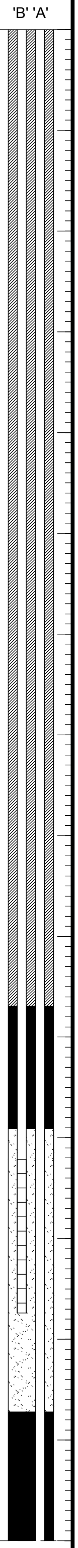
LOCATION: N 5020875.53 ;E 466521.56

INCLINATION: -90° AZIMUTH: ---

BORING DATE: February 22-25, 2013

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-8} 10^{-6} 10^{-4} 10^{-2} WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---									'B' 'A'
15	Wash Boring HW Casing	Firm to stiff grey and red CLAY to SILTY CLAY, with black staining	▨								
20											Bentonite-Cement Grout
22.76		Stiff grey to dark grey CLAY to SILTY CLAY, with black staining	▨	53.12 22.76							
25											Bentonite Seal
26											Silica Sand
27											25 mm Diam. PVC #10 Slot Screen 'B'
28											Silica Sand
29											Bentonite Seal
30		*CONTINUED NEXT PAGE*									



DEPTH SCALE

1 : 75

Golder Associates

LOGGED: DG/DWM

CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 12-4-4

SHEET 3 OF 3

LOCATION: N 5020875.53 ;E 466521.56

INCLINATION: -90° AZIMUTH: ---

BORING DATE: February 22-25, 2013

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-8} 10^{-6} 10^{-4} 10^{-2} WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---									'B' 'A'
30	Wash Boring HW Casing	Stiff grey to dark grey CLAY to SILTY CLAY, with black staining									Bentonite Seal
34		Dense grey SILTY SAND, some gravel, trace clay (GLACIAL TILL)		42.12 33.76							Silica Sand 32 mm Diam. PVC #10 Slot Screen 'A'
37		End of Borehole Note: Soil stratigraphy inferred from various soil sampling methods and CPT.		39.23 36.65							

CRRRC-SOIL 1211250045.GPJ GAL-MIS.GDT 09/04/14 JM

DEPTH SCALE

1 : 75

Golder Associates

LOGGED: DG/DWM

CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 12-4-5

SHEET 1 OF 2

LOCATION: N 5020871.62 ;E 466520.35

INCLINATION: -90° AZIMUTH: ---

BORING DATE: February 26, 2013

DATUM: Geodetic

Boring method: Wash Boring, HW Casing

DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	75.90
TOPSOIL	0.00
Grey brown SANDY SILT, trace clay, with black staining	75.60 0.30
Red brown SILTY CLAY, with silty sand seams (Weathered Crust)	75.20 0.70
Soft red grey CLAY to SILTY CLAY, with silty sand and silt seams	74.68 1.22
Red grey and grey CLAY to SILTY CLAY, with silt seams	72.93 2.97
Grey SILTY SAND, trace clay, with black staining	71.18 4.72
Grey SILT, some sand	4.95
Soft red grey and grey CLAY to SILTY CLAY, with black staining and silt seams	5.18
Grey SILT, some sand	68.74
Soft to firm red grey and grey CLAY to SILTY CLAY, with black staining	7.26
Firm to stiff grey and red CLAY to SILTY CLAY, with black staining	62.34 13.56

SAMPLES: NUMBER | TYPE | BLOWS/0.3m

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

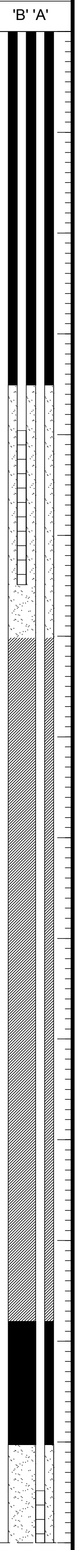
SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-8} 10^{-6} 10^{-4} 10^{-2}

WATER CONTENT PERCENT: Wp ⊢ ○W ⊣ Wl 20 40 60 80

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION



DEPTH SCALE METRES: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

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DEPTH SCALE 1 : 75

LOGGED: DG

CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 12-4-5

SHEET 2 OF 2

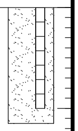
LOCATION: N 5020871.62 ;E 466520.35

INCLINATION: -90° AZIMUTH: ---

BORING DATE: February 26, 2013

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80); SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-8} 10^{-6} 10^{-4} 10^{-2}); WATER CONTENT PERCENT Wp ⊢ W ⊣ Wl (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---									'B' 'A'
15	Wash Boring HW Casing	Firm to stiff grey and red CLAY to SILTY CLAY, with black staining	▨								25 mm Diam. PVC #10 Slot Screen 'A'
16				59.75 16.15							Silica Sand
		End of Borehole Note: Soil stratigraphy inferred from various soil sampling methods and CPT.									
17											
18											
19											
20											
21											
22											
23											
24											
25											
26											
27											
28											
29											
30											



DEPTH SCALE

1 : 75

Golder Associates

LOGGED: DG

CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 12-4-6

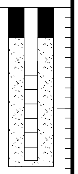
SHEET 1 OF 1

LOCATION: N 5020874.33 ;E 466518.97
INCLINATION: -90° AZIMUTH: ---

BORING DATE: February 27, 2013

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-8} 10^{-6} 10^{-4} 10^{-2} WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		75.89							MON. WELL
0	Wash Boring HW Casing	TOPSOIL		0.00							Protective Casing Bentonite Seal
		Grey brown SANDY SILT, trace clay, with black staining		75.59 0.30							Silica Sand
1		Red brown SILTY CLAY, with silty sand seams (Weathered Crust)		75.19 0.70							50 mm Diam. PVC #10 Slot Screen
		Soft red grey CLAY to SILTY CLAY, with silty sand and silt seams		74.67 1.22							
		End of Borehole Note: Soil stratigraphy inferred from various soil sampling methods and CPT.		74.31 1.58							
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											



DEPTH SCALE
1 : 75

Golder Associates

LOGGED: DG
CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 12-4-7

SHEET 1 OF 3

LOCATION: N 5020849.96 ;E 466535.91

INCLINATION: -90° AZIMUTH: ---

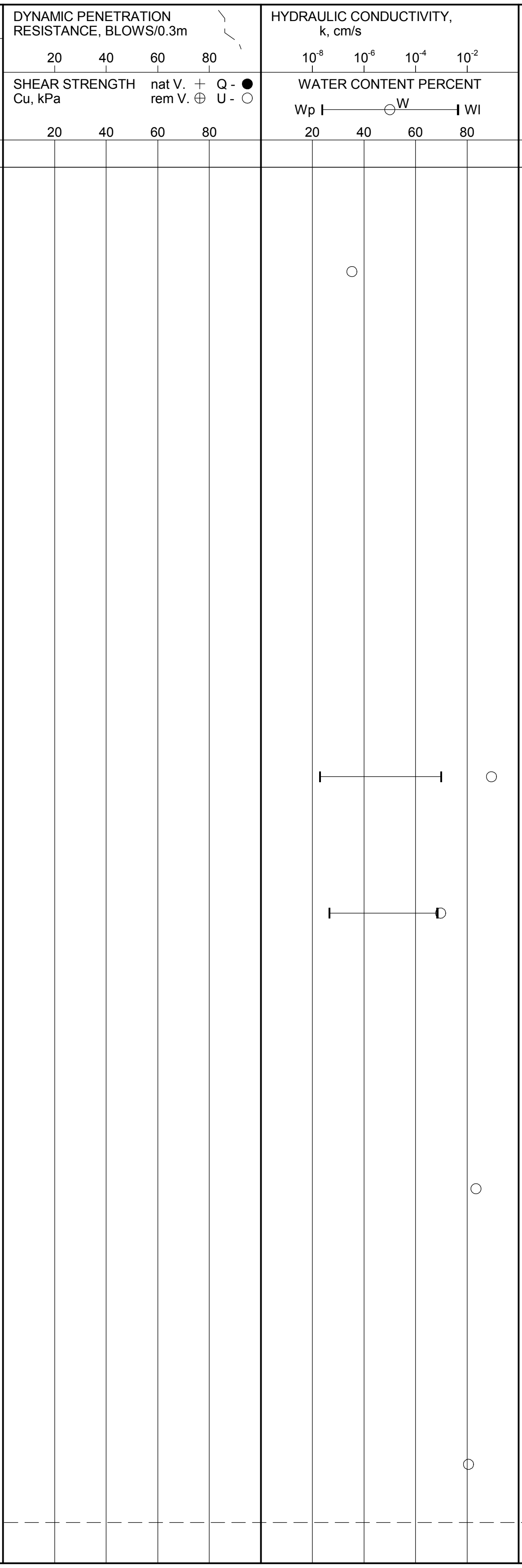
BORING DATE: April 2-3, 2013

DATUM: Geodetic

BORING METHOD: Geoprobe

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
	GROUND SURFACE	75.95
0	TOPSOIL	0.00
	Grey brown SANDY SILT, trace clay, with black staining	75.65 0.30
	Red brown SILTY CLAY, with silty sand seams (Weathered Crust)	75.25 0.70
1	Soft red grey CLAY to SILTY CLAY, with silty sand and silt seams	74.73 1.22
3	Red grey and grey CLAY to SILTY CLAY, with silt seams	72.98 2.97
	Grey SILTY SAND, trace clay, with black staining	71.23 4.72
5	Grey SILT, some sand	4.95
	Soft red grey and grey CLAY to SILTY CLAY, with black staining and silt seams	5.18
7	Grey SILT, some sand	68.79
	Soft to firm red grey and grey CLAY to SILTY CLAY, with black staining	7.26
13	Firm to stiff grey and red CLAY to SILTY CLAY, with black staining	62.39 13.56
15	CONTINUED NEXT PAGE	

SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING
1	53 mm TUBE	-	MH
2	53 mm TUBE	-	
3	53 mm TUBE	-	
4	53 mm TUBE	-	MH
5	53 mm TUBE	-	
6	53 mm TUBE	-	
7	53 mm TUBE	-	
8	53 mm TUBE	-	
9	53 mm TUBE	-	
10	53 mm TUBE	-	



PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE 1 : 75

LOGGED: DG

CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 12-4-7

SHEET 2 OF 3

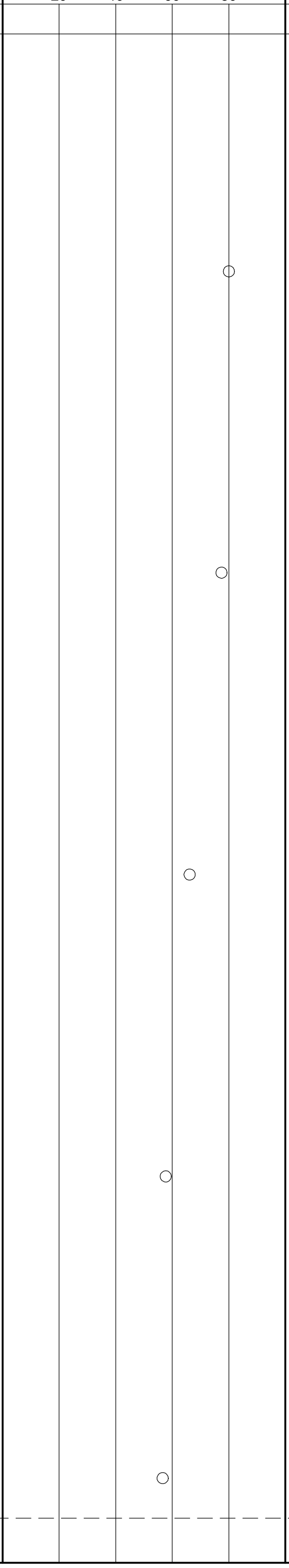
LOCATION: N 5020849.96 ;E 466535.91

INCLINATION: -90° AZIMUTH: ---

BORING DATE: April 2-3, 2013

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80; SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-8} 10^{-6} 10^{-4} 10^{-2}; WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---									
15	Geoprobe	Firm to stiff grey and red CLAY to SILTY CLAY, with black staining	▨								
16					11	53 mm TUBE	-				
17					12	53 mm TUBE	-				
18											
19					13	53 mm TUBE	-				
20					14	53 mm TUBE	-				
21											
22					15	53 mm TUBE	-				
23		Stiff grey to dark grey CLAY to SILTY CLAY, with black staining	▨	53.19 22.76	16	53 mm TUBE	-				
24											
25					17	53 mm TUBE	-				
26					18	53 mm TUBE	-				
27											
28					19	53 mm TUBE	-				
29					20	53 mm TUBE	-				
30		*CONTINUED NEXT PAGE*									



DEPTH SCALE

1 : 75

LOGGED: DG

CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 12-4-7

SHEET 3 OF 3

LOCATION: N 5020849.96 ;E 466535.91

BORING DATE: April 2-3, 2013

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-8} 10^{-6} 10^{-4} 10^{-2} WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---									
30			▨	45.62 30.33	20		-				
		End of Borehole Note: Soil stratigraphy inferred from various soil sampling methods and CPT.									
31											
32											
33											
34											
35											
36											
37											
38											
39											
40											
41											
42											
43											
44											
45											

DEPTH SCALE

1 : 75

Golder Associates

LOGGED: DG

CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 13-5-2

SHEET 1 OF 3

LOCATION: N 5021087.76 ;E 466180.49

BORING DATE: February 28 - March 1, 2013

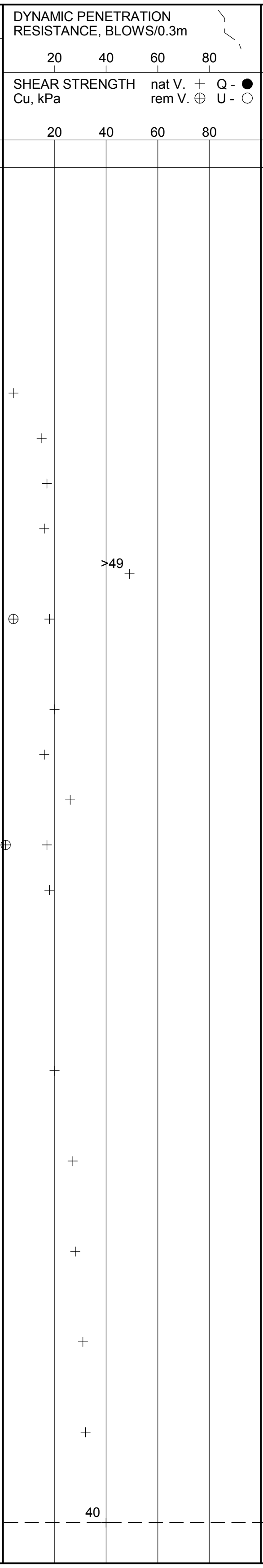
DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m
		GROUND SURFACE		76.43			
0	Power Auger 200 mm Diam. (HS)	TOPSOIL		0.00 76.13	1	50 DO	5
		Loose brown to grey brown SAND, some silt		0.30	2	50 DO	10
1					3	50 DO	6
2	Electric Nilcon	Soft CLAY to SILTY CLAY		74.60 1.83			
4		Compact grey SAND		72.16 4.27			
5		Soft CLAY to SILTY CLAY		71.55 4.88			
11		Firm CLAY to SILTY CLAY		65.43 11.00			
15		*CONTINUED NEXT PAGE*					



HYDRAULIC CONDUCTIVITY, k, cm/s

10^{-8} 10^{-6} 10^{-4} 10^{-2}

WATER CONTENT PERCENT

Wp ⊢—○W—⊣ Wl

20 40 60 80

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE

1 : 75

Golder Associates

LOGGED: DG

CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 13-5-2

SHEET 2 OF 3

LOCATION: N 5021087.76 ;E 466180.49

BORING DATE: February 28 - March 1, 2013

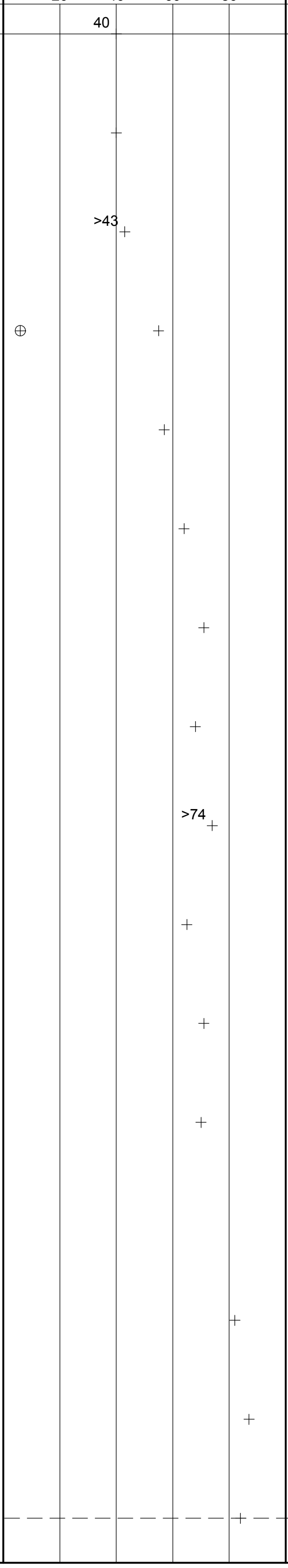
DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-8} 10^{-6} 10^{-4} 10^{-2}) WATER CONTENT PERCENT Wp ├──○W──┤ Wl (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---						40			
15	Electric Nilcon	Firm CLAY to SILTY CLAY	▨								
18		Stiff CLAY to SILTY CLAY	▨	58.43 18.00							
30		*CONTINUED NEXT PAGE*									



DEPTH SCALE

1 : 75

LOGGED: DG

CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 13-5-2

SHEET 3 OF 3

LOCATION: N 5021087.76 ;E 466180.49

INCLINATION: -90° AZIMUTH: ---

BORING DATE: February 28 - March 1, 2013

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-8} 10^{-6} 10^{-4} 10^{-2} WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---									
30	Electric Nilcon	Stiff CLAY to SILTY CLAY	▨								
31			▨								
32			▨								
33			▨								
34			▨								
35			▨								
36			▨								
37			▨								
38			▨	38.23							
		End of Borehole Note: 1. Soil stratigraphy inferred from various soil sampling methods and CPT. 2. Vane pushed to 38.20 m depth. 3. Different stratigraphy relative to boreholes 13-5-3 and 13-5-4.		38.20							
39											
40											
41											
42											
43											
44											
45											

DEPTH SCALE

1 : 75

Golder Associates

LOGGED: DG

CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 13-5-3

SHEET 1 OF 3

LOCATION: N 5021083.24 ;E 466176.27

BORING DATE: June 14-18, 2013

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES | BORING METHOD | SOIL PROFILE | SAMPLES (NUMBER, TYPE, BLOWS/0.3m) | DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) | SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80) | HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-8} 10^{-6} 10^{-4} 10^{-2}) | WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl (20 40 60 80) | ADDITIONAL LAB. TESTING | PIEZOMETER OR STANDPIPE INSTALLATION

BORING METHOD: Wash Boring, NW Casing

DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)
GROUND SURFACE		76.51
TOPSOIL		0.00
Loose brown to grey brown SAND, some silt		76.21 0.30
Soft CLAY to SILTY CLAY		74.68 1.83
Compact grey SAND		72.24 4.27
Soft CLAY to SILTY CLAY		71.63 4.88
Firm CLAY to SILTY CLAY		65.51 11.00

MON. WELL

Protective Casing

Bentonite Seal

Bentonite-Cement Grout

CONTINUED NEXT PAGE

DEPTH SCALE

1 : 75

Golder Associates

LOGGED: DWM

CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 13-5-3

SHEET 2 OF 3

LOCATION: N 5021083.24 ;E 466176.27

BORING DATE: June 14-18, 2013

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80); SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-8} 10^{-6} 10^{-4} 10^{-2}); WATER CONTENT PERCENT Wp ├──○W──┤ Wl (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---									MON. WELL
15	Wash Boring NW Casing	Firm CLAY to SILTY CLAY									
18		Stiff CLAY to SILTY CLAY		58.51 18.00							
22											Bentonite-Cement Grout
27.40		Compact to very dense grey SILTY SAND and SANDY SILT, some gravel, trace clay (GLACIAL TILL)		49.11 27.40	1	50 DO	>100				
30		*CONTINUED NEXT PAGE*									

DEPTH SCALE

1 : 75

Golder Associates

LOGGED: DWM

CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 13-5-3

SHEET 3 OF 3

LOCATION: N 5021083.24 ;E 466176.27

BORING DATE: June 14-18, 2013

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-8} 10^{-6} 10^{-4} 10^{-2} WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---									MON. WELL
30	Wash Boring NW Casing	Compact to very dense grey SILTY SAND and SANDY SILT, some gravel, trace clay (GLACIAL TILL)									
					2	50 DO	70				
31					3	50 DO	94				
32											Bentonite-Cement Grout
33					4	50 DO	80				
34		COBBLES		42.45 34.06							
		Borehole continued on RECORD OF DRILLHOLE 12-5-3 Note: 1. Soil stratigraphy inferred from various soil sampling methods and CPT. 2. Different stratigraphy relative to borehole 13-5-2.									Peltonite
35											
36											
37											
38											
39											
40											
41											
42											
43											
44											
45											

DEPTH SCALE

1 : 75

Golder Associates

LOGGED: DWM

CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF DRILLHOLE: 13-5-3

SHEET 1 OF 4

LOCATION: N 5021083.24 ;E 466176.27

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: June 14-18, 2013

DRILL RIG: CME 55

DRILLING CONTRACTOR: Marathon Drilling

DATUM: Geodetic

JN - Joint	BD - Bedding	PL - Planar	PO - Polished	BR - Broken Rock
FLT - Fault	FO - Foliation	CU - Curved	K - Slickensided	**NOTE:** For additional abbreviations refer to list of abbreviations & symbols.
SH - Shear	CO - Contact	UN - Undulating	SM - Smooth	
VN - Vein	OR - Orthogonal	ST - Stepped	RO - Rough	
CJ - Conjugate	CL - Clean	IR - Irregular	MB - Mechanical Break	

Column headings: DEPTH SCALE METRES; DRILLING RECORD; DESCRIPTION; SYMBOLIC LOG; ELEV. DEPTH (m); RUN No.; FLUSH RETURN; RECOVERY (TOTAL CORE % 80 60 40 20; SOLID CORE % 80 60 40 20); R.Q.D. % 80 60 40 20; FRACT. INDEX PER 0.25m 5 10 15 20; DISCONTINUITY DATA (DIP w.r.t. CORE AXIS 0 30 60 90; TYPE AND SURFACE DESCRIPTION; Jcon; Jr; Ja); HYDRAULIC CONDUCTIVITY K, cm/sec 10^{-8} 10^{-6} 10^{-4} 10^{-2}; WEATHERING INDEX W1 W2 W3 W4 W5 W6; NOTES

BEDROCK SURFACE — 42.28

CARLSBAD FORMATION, 34.23 m to 40.33 m Fresh, very thinly to thinly interbedded sequence of dark grey to black slake susceptible **SHALE, CALCAREOUS SHALE, SHALEY to ARGILLACEOUS LIMESTONE and LIMESTONE** with occasional bioclastic limestone beds (35.85-.91 m and 37.59-.82 m). Shale and calcareous shale comprises approximately 78% of section.

Drilling record: Rotary Drill, NQ Core

Depth scale: 35, 36

ELEV.	DEPTH (m)
	34.23
42.22	34.29
41.83	34.68
41.73	34.78
41.56	34.95
	34.97
41.46	35.06
41.17	35.34
	35.37
40.83	35.68
40.76	35.75
	35.77
	35.79
40.66	35.85
40.60	35.91
40.41	36.10
40.36	36.15
40.29	

RUN No.	FLUSH RETURN
1	100
2	100

TYPE AND SURFACE DESCRIPTION	Jcon	Jr	Ja
JN,CU,SM	16	2	1
BD,PL,SM	12	1	1
BD,PL,SM	12	1	1
BD,CU,SM	16	2	1
FR,,			
BD,PL,SM	12	1	2
BD,CU,SM	12	2	2

NOTES — MON. WELL

Peltonite

Silica Sand

32 mm Diam. PVC #10 Slot Screen

CONTINUED NEXT PAGE

DEPTH SCALE

1 : 10

Golder Associates

LOGGED: DWM

CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF DRILLHOLE: 13-5-3

SHEET 2 OF 4

LOCATION: N 5021083.24 ;E 466176.27

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: June 14-18, 2013
DRILL RIG: CME 55
DRILLING CONTRACTOR: Marathon Drilling

DATUM: Geodetic

JN - Joint
FLT - Fault
SH - Shear
VN - Vein
CJ - Conjugate

BD - Bedding
FO - Foliation
CO - Contact
OR - Orthogonal
CL - Clean

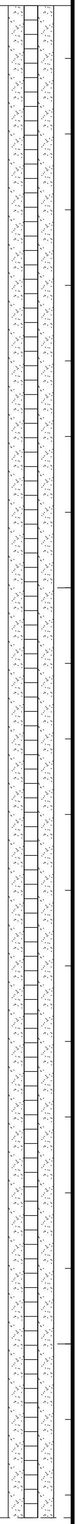
PL - Planar
CU - Curved
UN - Undulating
ST - Stepped
IR - Irregular

PO - Polished
K - Slickensided
SM - Smooth
RO - Rough
MB - Mechanical Break

BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY TOTAL CORE % 80 60 40 20	RECOVERY SOLID CORE % 80 60 40 20	R.Q.D. % 80 60 40 20	FRACT. INDEX PER 0.25m 5 10 15 20	DISCONTINUITY DATA DIP w.r.t. CORE AXIS 0 30 60 90	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jcon	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec 10^{-8} 10^{-6} 10^{-4} 10^{-2}	WEATHERING INDEX W1 W2 W3 W4 W5 W6	NOTES
		--- *CONTINUED FROM PREVIOUS PAGE* ---																MON. WELL
	Rotary Drill NQ Core	**CARLSBAD FORMATION, 34.23 m to 40.33 m** Fresh, very thinly to thinly interbedded sequence of dark grey to black slake susceptible **SHALE, CALCAREOUS SHALE, SHALEY to ARGILLACEOUS LIMESTONE and LIMESTONE** with occasional bioclastic limestone beds (35.85-.91 m and 37.59-.82 m). Shale and calcareous shale comprises approximately 78% of section.		36.22 40.23														
				36.28	2	100												
				39.97 36.54														
				36.57								BD,PL,SM	16	1	2			
				39.84 36.67														
				36.69														
				39.75 36.76 39.71								BD,PL,SM	12	1	1			
				36.80														
				39.62 36.89														
				36.91														
37				36.94														
				39.47 37.04	3	100												
				37.07														
				37.09								BD,PL,SM	12	1	1			
				37.11														32 mm Diam. PVC #10 Slot Screen
												BD,CU,SM	16	2	1			
				39.06 37.45														
				38.99 37.52														
				38.92 37.59														
				38.69 37.82	4	100												
38																		
		CONTINUED NEXT PAGE																



DEPTH SCALE
1 : 10

LOGGED: DWM
CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF DRILLHOLE: 13-5-3

SHEET 3 OF 4

LOCATION: N 5021083.24 ;E 466176.27

DRILLING DATE: June 14-18, 2013

DATUM: Geodetic

DRILL RIG: CME 55

INCLINATION: -90° AZIMUTH: ---

DRILLING CONTRACTOR: Marathon Drilling

JN - Joint
FLT - Fault
SH - Shear
VN - Vein
CJ - Conjugate

BD - Bedding
FO - Foliation
CO - Contact
OR - Orthogonal
CL - Clean

PL - Planar
CU - Curved
UN - Undulating
ST - Stepped
IR - Irregular

PO - Polished
K - Slickensided
SM - Smooth
RO - Rough
MB - Mechanical Break

BR - Broken Rock

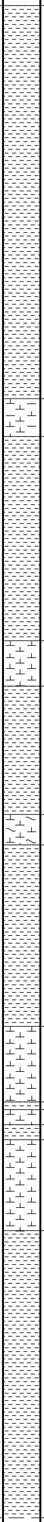
NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. DEPTH (m) | RUN No. | FLUSH RETURN | RECOVERY: TOTAL CORE % 80 60 40 20, SOLID CORE % 80 60 40 20 | R.Q.D. % 80 60 40 20 | FRACT. INDEX PER 0.25m 5 10 15 20 | DIP w.r.t. CORE AXIS 0 30 60 90 | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION, Jcon, Jr, Ja | HYDRAULIC CONDUCTIVITY K, cm/sec 10^{-8} 10^{-6} 10^{-4} 10^{-2} | WEATHERING INDEX W1 W2 W3 W4 W5 W6 | NOTES

--- CONTINUED FROM PREVIOUS PAGE ---

MON. WELL

CARLSBAD FORMATION, 34.23 m to 40.33 m Fresh, very thinly to thinly interbedded sequence of dark grey to black slake susceptible **SHALE, CALCAREOUS SHALE, SHALEY to ARGILLACEOUS LIMESTONE and LIMESTONE** with occasional bioclastic limestone beds (35.85-.91 m and 37.59-.82 m). Shale and calcareous shale comprises approximately 78% of section.



ELEV.	DEPTH (m)
37.76	38.75
37.71	38.80
37.44	39.07
37.38	39.13
37.21	39.30
37.17	39.34
36.93	39.58
36.83	39.69
	39.71
	39.73
36.66	39.85

RUN No.	FLUSH RETURN
4	100
5	100

TYPE AND SURFACE DESCRIPTION	Jcon	Jr	Ja
BD,PL,SM	16	1	2
BD,PL,SM	16	1	2
BD,CU,SM	16	2	2
BD,PL,SM	12	1	1

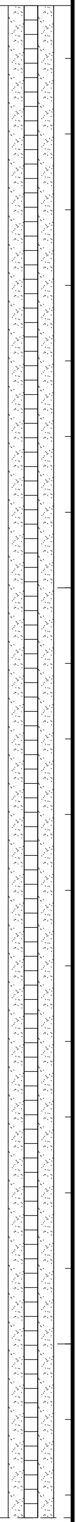
39

40

Rotary Drill

NQ Core

32 mm Diam. PVC
#10 Slot Screen



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DEPTH SCALE
1 : 10

Golder Associates

LOGGED: DWM
CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF DRILLHOLE: 13-5-3

SHEET 4 OF 4

LOCATION: N 5021083.24 ;E 466176.27

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: June 14-18, 2013

DRILL RIG: CME 55

DRILLING CONTRACTOR: Marathon Drilling

DATUM: Geodetic

JN - Joint	BD - Bedding	PL - Planar	PO - Polished
FLT - Fault	FO - Foliation	CU - Curved	K - Slickensided
SH - Shear	CO - Contact	UN - Undulating	SM - Smooth
VN - Vein	OR - Orthogonal	ST - Stepped	RO - Rough
CJ - Conjugate	CL - Clean	IR - Irregular	MB - Mechanical Break

BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY TOTAL CORE % 80 60 40 20	RECOVERY SOLID CORE % 80 60 40 20	R.Q.D. % 80 60 40 20	FRACT. INDEX PER 0.25m 5 10 15 20	DISCONTINUITY DATA DIP w.r.t. CORE AXIS 0 30 60 90	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jcon	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec 10^{-8} 10^{-6} 10^{-4} 10^{-2}	WEATHERING INDEX W1 W2 W3 W4 W5 W6	NOTES
		--- CONTINUED FROM PREVIOUS PAGE ---																MON. WELL
	Rotary Drill NQ Core			36.23 40.28 40.30 36.18	5	100											■	Silica Sand
		End of Drillhole		40.33														
41																		
42																		

DEPTH SCALE

1 : 10

Golder Associates

LOGGED: DWM

CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 13-5-4

SHEET 1 OF 3

LOCATION: N 5021083.81 ;E 466178.65

BORING DATE: March 4-5, 2013

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES | BORING METHOD | SOIL PROFILE: DESCRIPTION, STRATA PLOT, ELEV. DEPTH (m) | SAMPLES: NUMBER, TYPE, BLOWS/0.3m | DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 | SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80 | HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-8} 10^{-6} 10^{-4} 10^{-2} | WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 20 40 60 80 | ADDITIONAL LAB. TESTING | PIEZOMETER OR STANDPIPE INSTALLATION

Boring method: Wash Boring, HW Casing

DESCRIPTION	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	PIEZOMETER OR STANDPIPE INSTALLATION ('B' 'A')
GROUND SURFACE	76.43				
TOPSOIL	0.00				Protective Casing
Loose brown to grey brown SILTY SAND	76.13 0.30				
Grey SILTY CLAY, with black staining	74.60 1.83				
Compact grey SAND	72.16 4.27	1	50 DO	14	
Grey SILTY CLAY, with black staining	71.55 4.88				
		2	50 DO	WR	
					Bentonite Seal
					Silica Sand
					25 mm Diam. PVC #10 Slot Screen 'B'

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DEPTH SCALE

1 : 75

Golder Associates

LOGGED: DG

CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 13-5-4

SHEET 2 OF 3

LOCATION: N 5021083.81 ;E 466178.65
INCLINATION: -90° AZIMUTH: ---
SAMPLER HAMMER, 64kg; DROP, 760mm

BORING DATE: March 4-5, 2013

DATUM: Geodetic

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80
SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ : 20 40 60 80
HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-8} 10^{-6} 10^{-4} 10^{-2}
WATER CONTENT PERCENT: Wp ⊢—○W—⊣ Wl : 20 40 60 80

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION 'B' 'A'
		--- *CONTINUED FROM PREVIOUS PAGE* ---						
15	Wash Boring HW Casing	Grey SILTY CLAY, with black staining						25 mm Diam. PVC #10 Slot Screen 'B'
16								Silica Sand
17								
18								
19								
20								
21								
22								Bentonite Seal
23								
24								
25								
26								
27			49.03 27.40					
		Compact to very dense grey SILTY SAND and SANDY SILT, some gravel, trace clay (GLACIAL TILL)						
28				3	50 DO	29		
29				4	50 DO	61		Silica Sand
				5	50 DO	53		38 mm Diam. PVC #10 Slot Screen 'A'
30				6		96		
		CONTINUED NEXT PAGE						

DEPTH SCALE
1 : 75

Golder Associates

LOGGED: DG
CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 13-5-4

SHEET 3 OF 3

LOCATION: N 5021083.81 ;E 466178.65

BORING DATE: March 4-5, 2013

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-8} 10^{-6} 10^{-4} 10^{-2}) WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---									'B' 'A'
30	Wash Boring HW Casing	Compact to very dense grey SILTY SAND and SANDY SILT, some gravel, trace clay (GLACIAL TILL)			6	50 DO	96				38 mm Diam. PVC #10 Slot Screen 'A'
31		End of Borehole Note: 1. Soil stratigraphy inferred from various soil sampling methods and CPT. 2. Different stratigraphy relative to borehole 13-5-2.		45.34 31.09							
32											
33											
34											
35											
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41											
42											
43											
44											
45											

DEPTH SCALE

1 : 75

Golder Associates

LOGGED: DG

CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 13-5-5

SHEET 1 OF 1

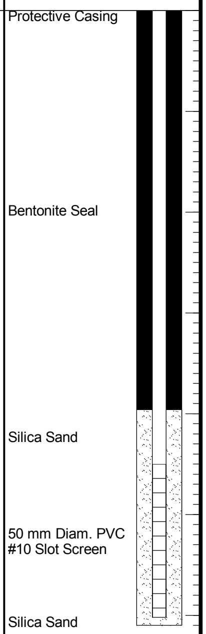
LOCATION: N 5021081.04 ;E 466176.45

INCLINATION: -90° AZIMUTH: ---

BORING DATE: March 6, 2013

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-8} 10^{-6} 10^{-4} 10^{-2}) / WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		76.38							MON. WELL
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL		0.00							
		Loose brown to grey brown SILTY SAND		76.08 0.30							
2		Grey SILTY CLAY, with black staining		74.55 1.83							
4		Compact grey SAND		72.11 4.27							
5		Grey SILTY CLAY, with black staining		71.50 4.88							
6		End of Borehole Note: Soil stratigraphy inferred from various soil sampling methods and CPT.		70.28 6.10							



DEPTH SCALE
1 : 75

Golder Associates

LOGGED: DG
CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 13-5-6

SHEET 1 OF 1

LOCATION: N 5021081.45 ;E 466178.88

BORING DATE: March 6, 2013

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-8} 10^{-6} 10^{-4} 10^{-2} WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		76.45							MON. WELL
0	Power Auger 200 mm Diam. (HS)	TOPSOIL		0.00							Protective Casing Bentonite Seal
		Loose brown to grey brown SILTY SAND		76.15 0.30							Silica Sand
1											50 mm Diam. PVC #10 Slot Screen
		End of Borehole		74.93 1.52							
2		Note: Soil stratigraphy inferred from various soil sampling methods and CPT.									
3											
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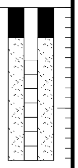

DEPTH SCALE

1 : 75

Golder Associates

LOGGED: DG

CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 13-8-2

SHEET 1 OF 1

LOCATION: N 5021436.71 ;E 466032.27

INCLINATION: -90° AZIMUTH: ---

BORING DATE: April 9, 2013

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80); SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-8} 10^{-6} 10^{-4} 10^{-2}); WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	76.41							
0	Geoprobe	TOPSOIL	0.00							Protective Casing Bentonite Seal
		Grey to grey brown SILTY SAND to SANDY SILT	0.20							Silica Sand
			75.50	1	53 mm TUBE	-				
1		Grey brown CLAYEY SILT, some sand	1.01 75.11							32 mm Diam. PVC #10 Slot Screen
		Grey brown SILTY SAND to SANDY SILT, trace gravel	1.30							
		Red brown SILTY CLAY, with silt seams (Weathered Crust)	1.52							
2		End of Borehole								
		Note: Soil stratigraphy inferred from various soil sampling methods and CPT.								
3										
4										
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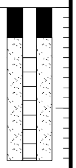
15										



DEPTH SCALE

1 : 75

Golder Associates

LOGGED: DG

CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 13-8-3

SHEET 1 OF 1

LOCATION: N 5021438.32 ;E 466036.25

INCLINATION: -90° AZIMUTH: ---

BORING DATE: April 9, 2013

DATUM: Geodetic

BORING METHOD: Geoprobe

DESCRIPTION	ELEV. / DEPTH (m)	ADDITIONAL LAB. TESTING
GROUND SURFACE	76.43	
TOPSOIL	0.00	
Grey to grey brown SILTY SAND to SANDY SILT	0.20 75.52	
Grey brown CLAYEY SILT, some sand		
Grey brown SILTY SAND to SANDY SILT, trace gravel	1.01 75.13 1.30	
Red brown SILTY CLAY, with silt and silty sand seams (Weathered Crust)	74.54	
Red grey and grey CLAY to SILTY CLAY	1.89 72.24	
Grey SILT	4.23	
Red grey SILTY CLAY	4.37 71.76	MH
Grey SILTY SAND, trace clay	4.67	
Red grey to grey CLAY to SILTY CLAY, with black staining and silt seams	68.81	
End of Borehole	7.62	

Note:
Soil stratigraphy inferred from various soil sampling methods and CPT.

SAMPLES NUMBER	TYPE	BLOWS/0.3m
1	53 mm TUBE	-
2	53 mm TUBE	-
3	53 mm TUBE	-
4	53 mm TUBE	-
5	53 mm TUBE	-

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-8} 10^{-6} 10^{-4} 10^{-2}

WATER CONTENT PERCENT: Wp ⊢ ○W ⊣ Wl 20 40 60 80

PIEZOMETER OR STANDPIPE INSTALLATION

- Protective Casing
- Bentonite Seal
- Silica Sand
- 32 mm Diam. PVC #10 Slot Screen
- Silica Sand
- Cave

DEPTH SCALE METRES: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

DEPTH SCALE
1 : 75

Golder Associates

LOGGED: DG

CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 13-9-2

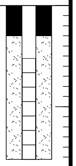
SHEET 1 OF 1

LOCATION: N 5021532.90 ;E 466350.22

INCLINATION: -90° AZIMUTH: ---

BORING DATE: March 20, 2013

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	SOIL PROFILE: STRATA PLOT	SOIL PROFILE: ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-8} 10^{-6} 10^{-4} 10^{-2}) WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		76.05							
0	Geoprobe	TOPSOIL		0.00							Protective Casing Bentonite Seal Silica Sand 32 mm Diam. PVC #10 Slot Screen 
		Grey brown to brown SILTY SAND, trace clay		0.12 74.82	1	53 mm TUBE	-			MH	
1		Red brown SILTY CLAY, with black staining (Weathered Crust)		1.23 74.53							
		End of Borehole Note: Soil stratigraphy inferred from various soil sampling methods and CPT.		1.52							
2											
3											
4											
5											
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7											
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12											
13											
14											
15											

DEPTH SCALE

1 : 75

Golder Associates

LOGGED: KE

CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 13-9-3

SHEET 1 OF 1

LOCATION: N 5021536.14 ;E 466347.26

INCLINATION: -90° AZIMUTH: ---

BORING DATE: March 20, 2013

DATUM: Geodetic

BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.3m
	GROUND SURFACE	76.08			
Geoprobe	TOPSOIL	0.00			
	Grey brown to brown SILTY SAND, trace clay	0.12	1	53 mm TUBE	-
	Red brown SILTY CLAY, with black staining and sand seams (Weathered Crust)	74.85 1.23			
	Red grey CLAY to SILTY CLAY, with silt seams	74.15 1.93	2	53 mm TUBE	-
			3	53 mm TUBE	-
	Grey SILTY SAND	71.79			
	Red grey SILTY CLAY	4.40			
	Grey SILTY SAND, with black staining	71.36			
	Red grey to grey CLAY to SILTY CLAY - Grey silt layer from 4.95 m to 5.00 m - Grey silt layer from 5.41 m to 5.46 m	4.72	4	53 mm TUBE	-
	Grey SILT	69.83			
	Red grey to grey SILTY CLAY, with silt seams - Grey silt layer from 6.79 m to 6.82 m	6.35	5	53 mm TUBE	-
	End of Borehole	68.46 7.62			

Note:
Soil stratigraphy inferred from various soil sampling methods and CPT.

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

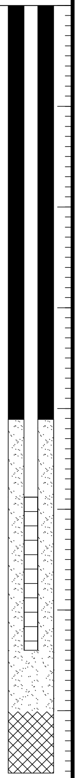
SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-8} 10^{-6} 10^{-4} 10^{-2}

WATER CONTENT PERCENT: Wp ⊢ ○W ⊣ Wl 20 40 60 80

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION



- Protective Casing
- Bentonite Seal
- Silica Sand
- 32 mm Diam. PVC #10 Slot Screen
- Silica Sand
- Cave

DEPTH SCALE METRES: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

DEPTH SCALE

1 : 75

LOGGED: KE

CHECKED: SAT

Golder Associates

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 13-10-2

SHEET 1 OF 1

LOCATION: N 5021245.94 ;E 466456.29

BORING DATE: March 14, 2013

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-8} 10^{-6} 10^{-4} 10^{-2} WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m				
		GROUND SURFACE		76.41							
0	Geoprobe	TOPSOIL		0.00							Protective Casing Bentonite Seal
		Grey brown to grey SAND, trace silt		0.12							Silica Sand
1					1	53 mm TUBE	-				32 mm Diam. PVC #10 Slot Screen
		End of Borehole Note: Soil stratigraphy inferred from various soil sampling methods and CPT.		74.89 1.52							
2											
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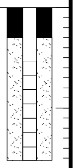


DEPTH SCALE

1 : 75

LOGGED: DG

CHECKED: SAT

CRRRC-SOIL 1211250045.GPJ GAL-MIS.GDT 09/04/14 JM

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 13-10-3

SHEET 1 OF 1

LOCATION: N 5021244.40 ;E 466452.99

BORING DATE: March 13, 2013

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-8} 10^{-6} 10^{-4} 10^{-2}

WATER CONTENT PERCENT: Wp ⊢—○W—⊣ Wl 20 40 60 80

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
		GROUND SURFACE	76.46 0.00
0	Geoprobe	TOPSOIL	
		Grey brown to grey SAND, trace silt	0.12
2		Grey brown SAND, trace to some silt	74.08 2.38
		Red grey to grey CLAY to SILTY CLAY, with black staining - Grey silt layer from 3.30 m to 3.33 m - Grey silt layer from 3.58 m to 3.63 m - Grey silt layer from 5.77 m to 5.80 m	73.75 2.71
6		Grey SILTY SAND, with black staining	70.59 5.87
		Grey SILT, some sand to CLAYEY SILT	70.31 6.15
		Red grey to grey CLAY to SILTY CLAY, with black staining - Clayey silt layer from 6.81 m to 6.83 m - Clayey silt layer from 7.11 m to 7.14 m - Clayey silt layer from 7.32 m to 7.34 m	70.01 6.45
		End of Borehole Note: Soil stratigraphy inferred from various soil sampling methods and CPT.	68.84 7.62

SAMPLES NUMBER	TYPE	BLOWS/0.3m
1	53 mm TUBE	-
2	53 mm TUBE	-
3	53 mm TUBE	-
4	53 mm TUBE	-
5	53 mm TUBE	-

ADDITIONAL LAB. TESTING: MH (at 1 m)

PIEZOMETER OR STANDPIPE INSTALLATION:
- Protective Casing
- Bentonite Seal
- Silica Sand
- 32 mm Diam. PVC #10 Slot Screen
- Silica Sand
- Cave

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

DEPTH SCALE
1 : 75

Golder Associates

LOGGED: KE

CHECKED: SAT

PROJECT: 12-1125-0045

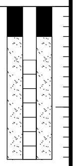
RECORD OF BOREHOLE: 13-11-2

SHEET 1 OF 1

LOCATION: N 5021059.00 ;E 466865.18
INCLINATION: -90° AZIMUTH: ---

BORING DATE: March 21, 2013

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-8} 10^{-6} 10^{-4} 10^{-2} WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		76.03							
0	Geoprobe	TOPSOIL *(0.00 m - 0.05 m)*		0.00 0.05							Protective Casing Bentonite Seal Silica Sand 32 mm Diam. PVC #10 Slot Screen
1		Grey brown to grey SAND, trace to some silt		74.51 1.52	1	53 mm TUBE	-				
		End of Borehole Note: Soil stratigraphy inferred from various soil sampling methods and CPT.									
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9											
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11											
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13											
14											
15											

DEPTH SCALE
1 : 75

Golder Associates

LOGGED: KE
CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 13-12-2

SHEET 1 OF 1

LOCATION: N 5020785.00 ;E 466278.43

INCLINATION: -90° AZIMUTH: ---

BORING DATE: April 10, 2013

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80; SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-8} 10^{-6} 10^{-4} 10^{-2}; WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		76.19							
0	Geoprobe	TOPSOIL		0.00							Protective Casing Bentonite Seal
1		Grey brown to red brown SILTY SAND, trace gravel		75.89 0.30	1	53 mm TUBE	-				Silica Sand 32 mm Diam. PVC #10 Slot Screen
		Red brown SILTY CLAY (Weathered Crust)		75.00 1.19							
		End of Borehole Note: Soil stratigraphy inferred from various soil sampling methods and CPT.		74.67 1.52							
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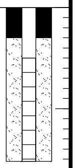


DEPTH SCALE

1 : 75

Golder Associates

LOGGED: DG

CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 13-12-3

SHEET 1 OF 1

LOCATION: N 5020781.01 ;E 466283.81

INCLINATION: -90° AZIMUTH: ---

BORING DATE: April 10, 2013

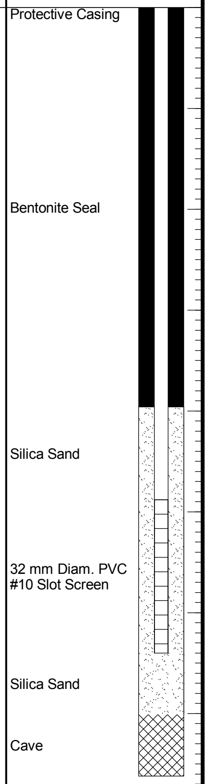
DATUM: Geodetic

BORING METHOD: Geoprobe

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING
GROUND SURFACE	76.27				
TOPSOIL	0.00				
Grey brown to red brown SILTY SAND, trace gravel	75.97 0.30	1	53 mm TUBE	-	
Red brown SILTY CLAY (Weathered Crust)	75.08 1.19				
Red grey to grey CLAY to SILTY CLAY, with clayey silt and silt seams	74.75 1.52	2	53 mm TUBE	-	
		3	53 mm TUBE	-	
Grey SILT, trace sand and clay	71.49 4.78				MH
Red grey to grey CLAY to SILTY CLAY, with silt seams	70.88 5.39	4	53 mm TUBE	-	
		5	53 mm TUBE	-	
Grey SILT	69.21				
Red grey to grey SILTY CLAY, with silt seams	7.16				
End of Borehole	68.65 7.62				

Note:
Soil stratigraphy inferred from various soil sampling methods and CPT.

PIEZOMETER OR STANDPIPE INSTALLATION



DEPTH SCALE
1 : 75

Golder Associates

LOGGED: DG
CHECKED: SAT

PROJECT: 12-1125-0045

RECORD OF BOREHOLE: 13-13-2

SHEET 1 OF 1

LOCATION: N 5021366.28 ;E 466752.54

INCLINATION: -90° AZIMUTH: ---

BORING DATE: March 13, 2013

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-8} 10^{-6} 10^{-4} 10^{-2} WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		76.21							
0	Geoprobe	TOPSOIL		0.00							Protective Casing Bentonite Seal
1		Grey and brown SAND, some silt		0.12	1	53 mm TUBE	-			MH	Silica Sand 32 mm Diam. PVC #10 Slot Screen
				74.69 1.52							
2		End of Borehole Note: Soil stratigraphy inferred from various soil sampling methods and CPT.									
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10											
11											
12											
13											
14											
15											

DEPTH SCALE

1 : 75

Golder Associates

LOGGED: KE

CHECKED: SAT

PROJECT: 12-1125-0045/8100

RECORD OF BOREHOLE: 13-1 (A13-1)

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: June 5, 2013

DATUM: Geodetic

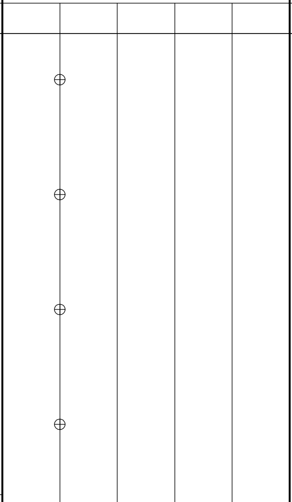
INCLINATION: -90° AZIMUTH: ---

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: Power Auger, 200 mm Diam. (Hollow Stem)

DEPTH SCALE METRES	DESCRIPTION	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m
	GROUND SURFACE	77.22			
0	Compact dark brown to black SILTY SAND, trace gravel and shale fragments	0.00	1	SS	15
	Compact brown SILTY fine SAND	76.46 0.76	2	SS	15
1	Brown SILTY CLAY, trace thin silty sand seams (Weathered Crust)	75.70 1.52	3	SS	3
2	Grey brown SILTY CLAY	74.93 2.29	4	SS	PH
3	End of Borehole	74.17 3.05			

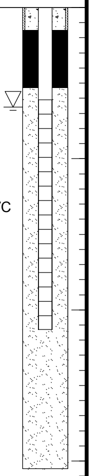


HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}

WATER CONTENT PERCENT: Wp ⊢—○W—⊣ Wl; 20 40 60 80

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION: MON. WELL



- Flush Mount Casing
- Bentonite Seal
- Silica Sand
- 32 mm Diam. PVC #10 Slot Screen
- Silica Sand

W.L. in Screen at Elev. 76.564 on June 7, 2013

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: DWM

CHECKED: HLRF

PROJECT: 12-1125-0045/8100

RECORD OF BOREHOLE: 13-2 (A13-2)

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: June 5, 2013

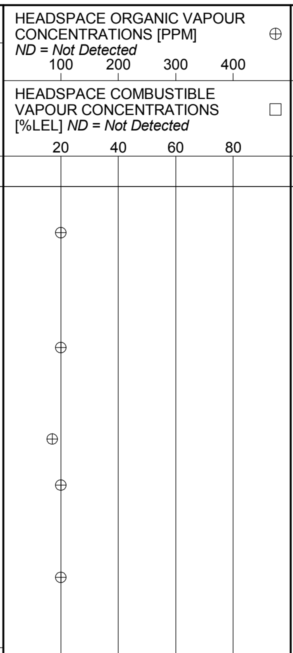
DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m
		GROUND SURFACE		77.48			
0	Power Auger 200 mm Diam. (Hollow Stem)	Compact brown to black sandy clayey silt, trace gravel, shale fragments, and organic matter (FILL)		0.00	1	SS	11
1					2	SS	11
		Loose brown SILTY fine SAND		76.11 1.37	3	SS	5
2		Brown SILTY CLAY (Weathered Crust)		75.65 1.83	3A	SS	5
		Grey brown SILTY CLAY		75.20 2.28	4	SS	1
3		End of Borehole		74.43 3.05			

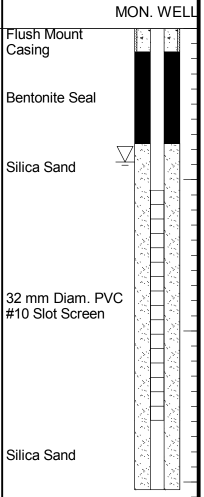


HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}

WATER CONTENT PERCENT: Wp ⊢—○W—⊣ Wl — 20 40 60 80

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION



W.L. in Screen at Elev. 76.60 on June 7, 2013

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DWM

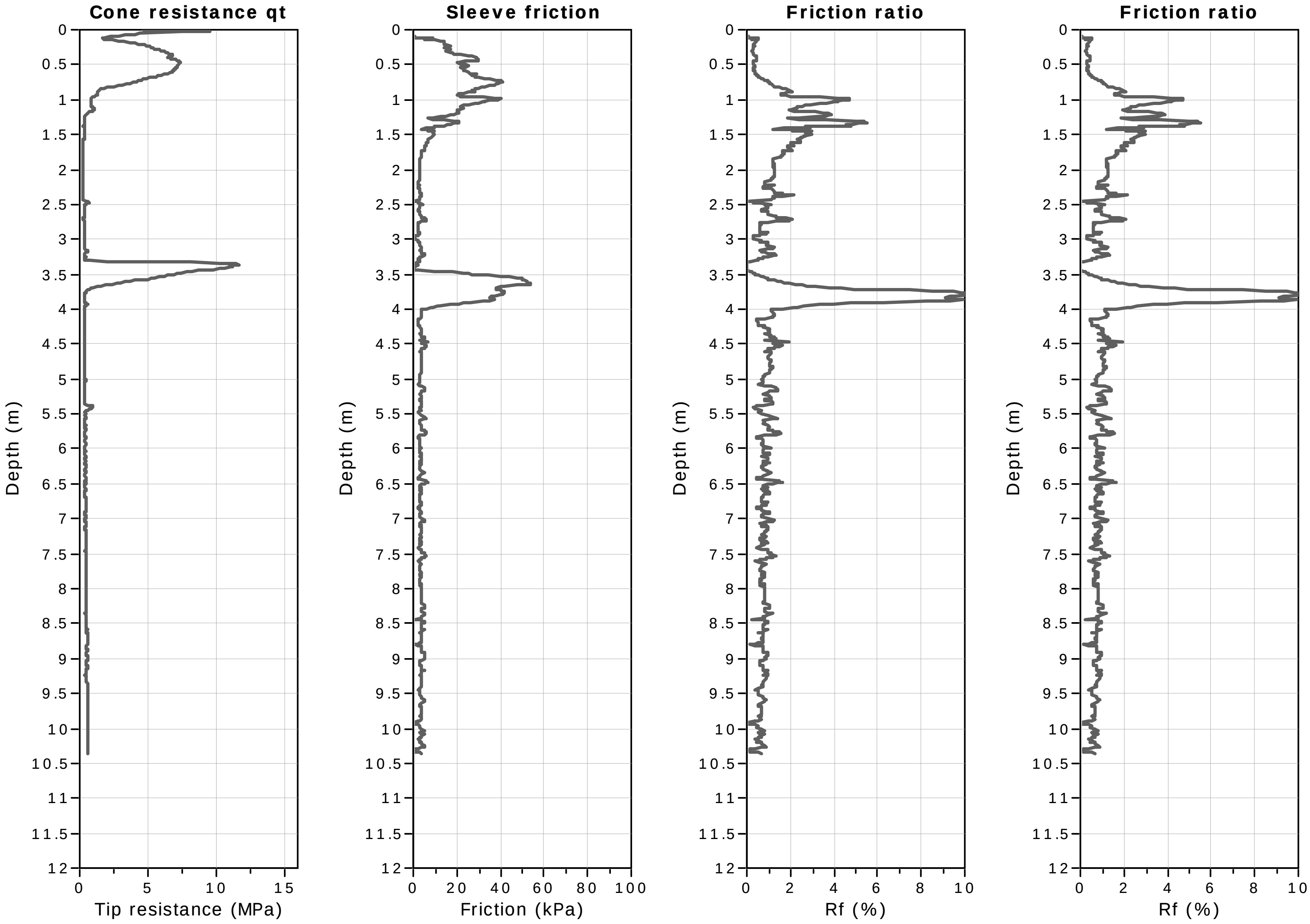
CHECKED: HLRF

APPENDIX C

Cone Penetration Test (CPT) Results - Current Investigation

Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**

CPT17-06_RevA
Total depth: 10.36 m, Date: 03/01/2018
Cone Type: I-CFTXYP20-10
Cone Operator: M. Roy - Stratum CPT



Golder Associates Ltd.
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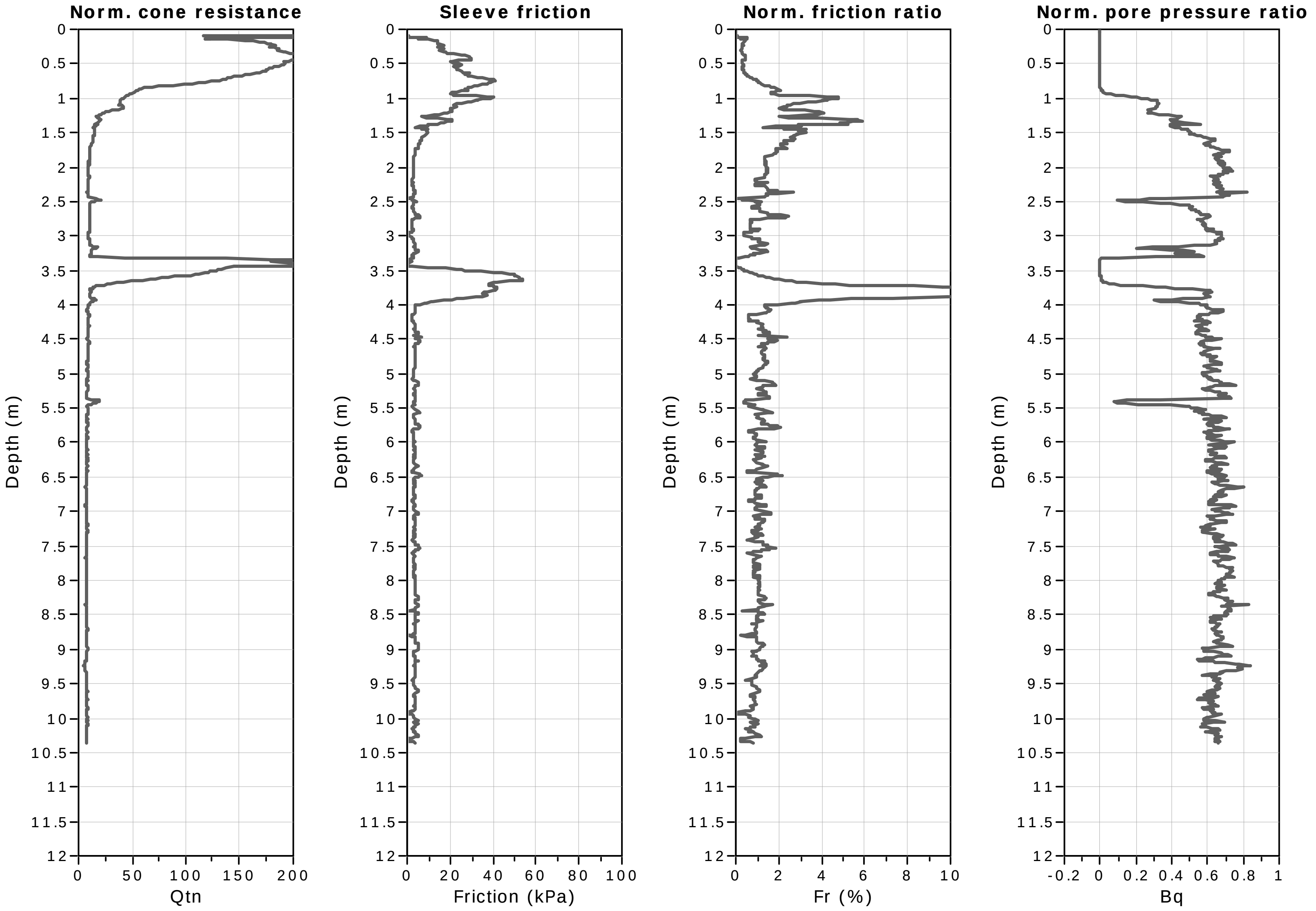
Project: CRRRC - 1787048-400-4.4
Location: Ottawa, ON, Canada

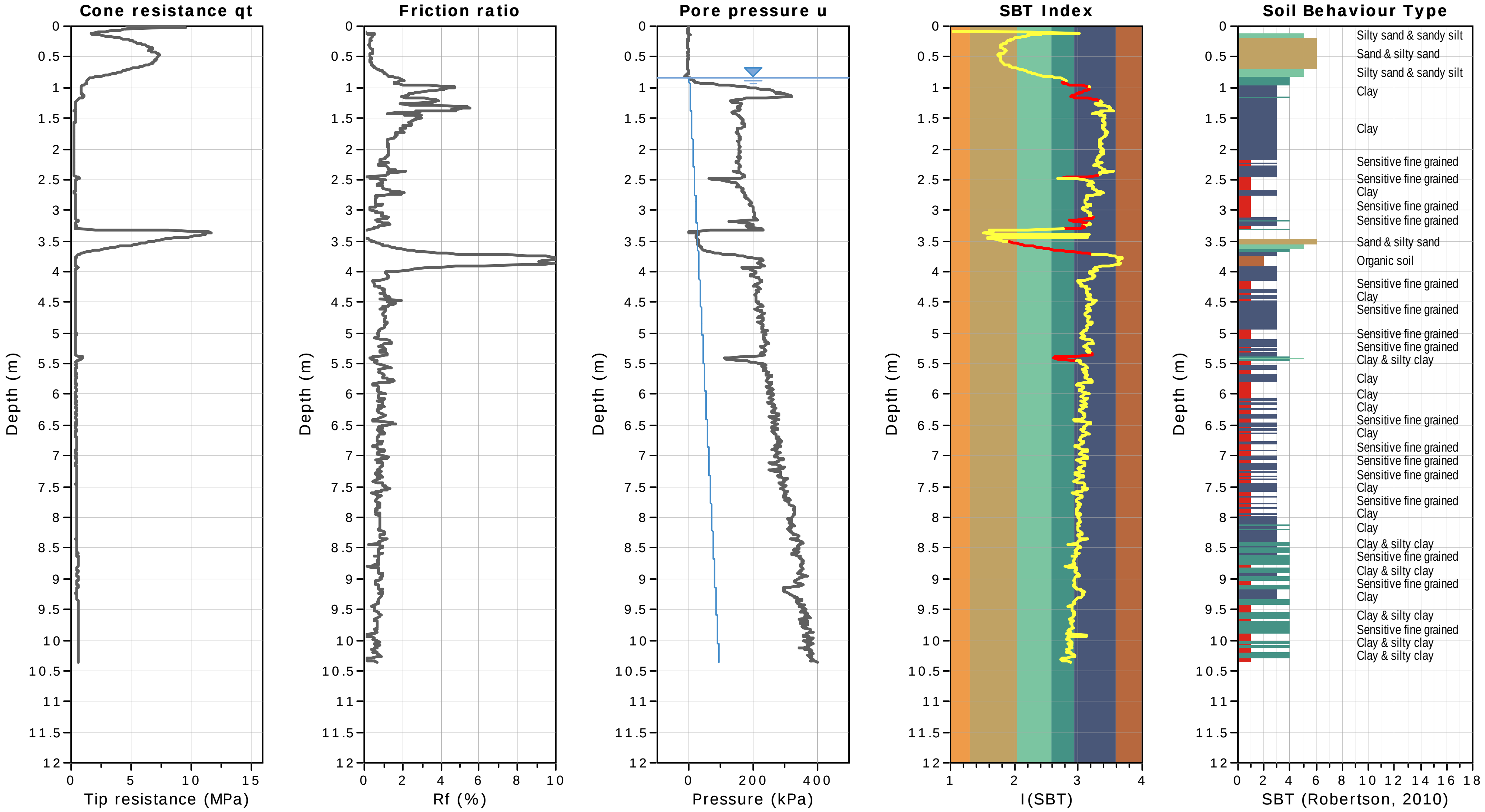
CPT17-06_RevA
Total depth: 10.36 m, Date: 03/01/2018
Cone Type: I-CFTXYP20-10
Cone Operator: M. Roy - Stratum CPT



Golder Associates Ltd.
www.golder.com

Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**

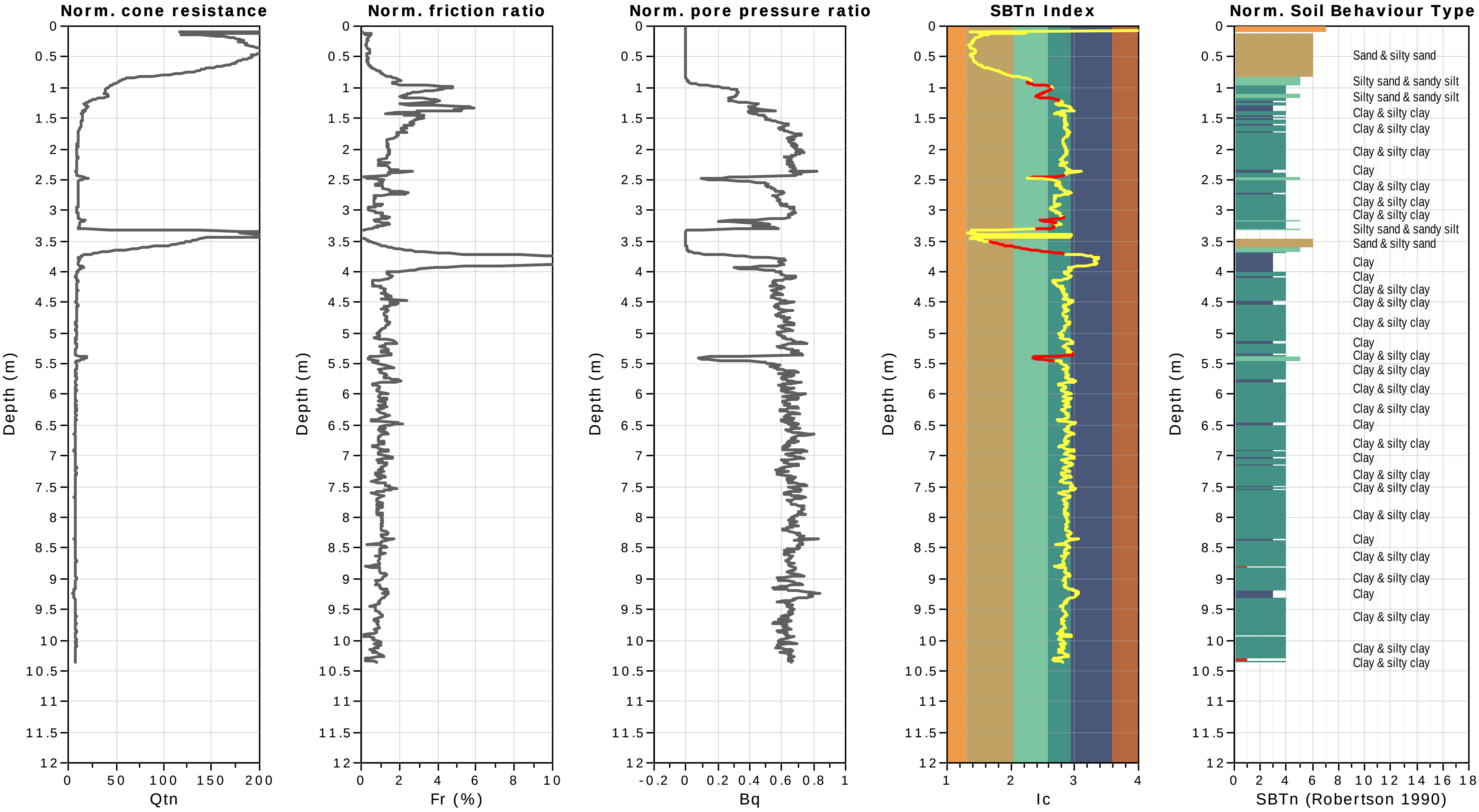
CPT17-06_RevA
Total depth: 10.36 m, Date: 03/01/2018
Cone Type: I-CFTXYP20-10
Cone Operator: M. Roy - Stratum CPT



Golder Associates Ltd.
www.golder.com

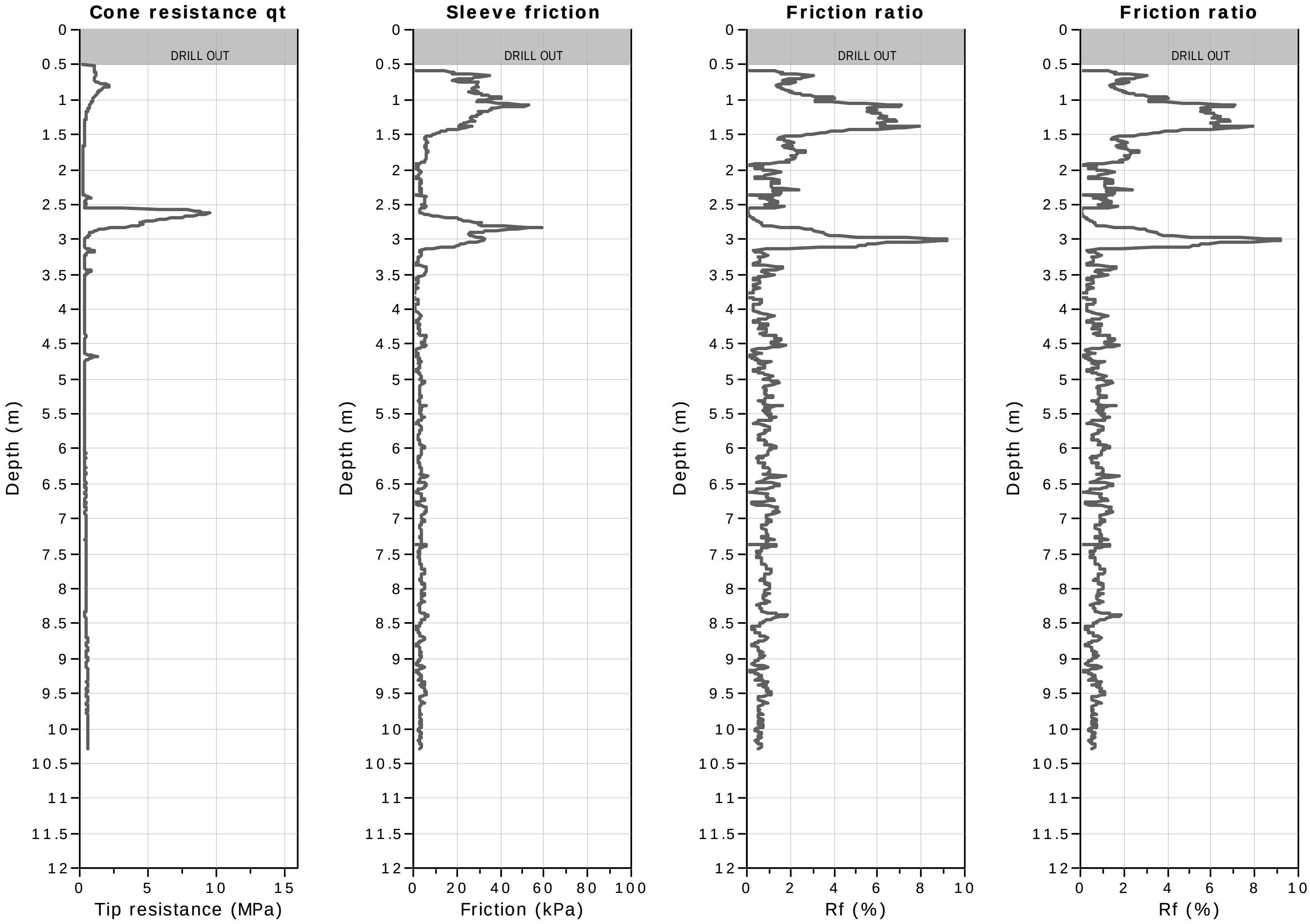
CPT17-06_RevA
Total depth: 10.36 m, Date: 03/01/2018
Cone Type: I-CFTXYP20-10
Cone Operator: M. Roy - Stratum CPT

Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**



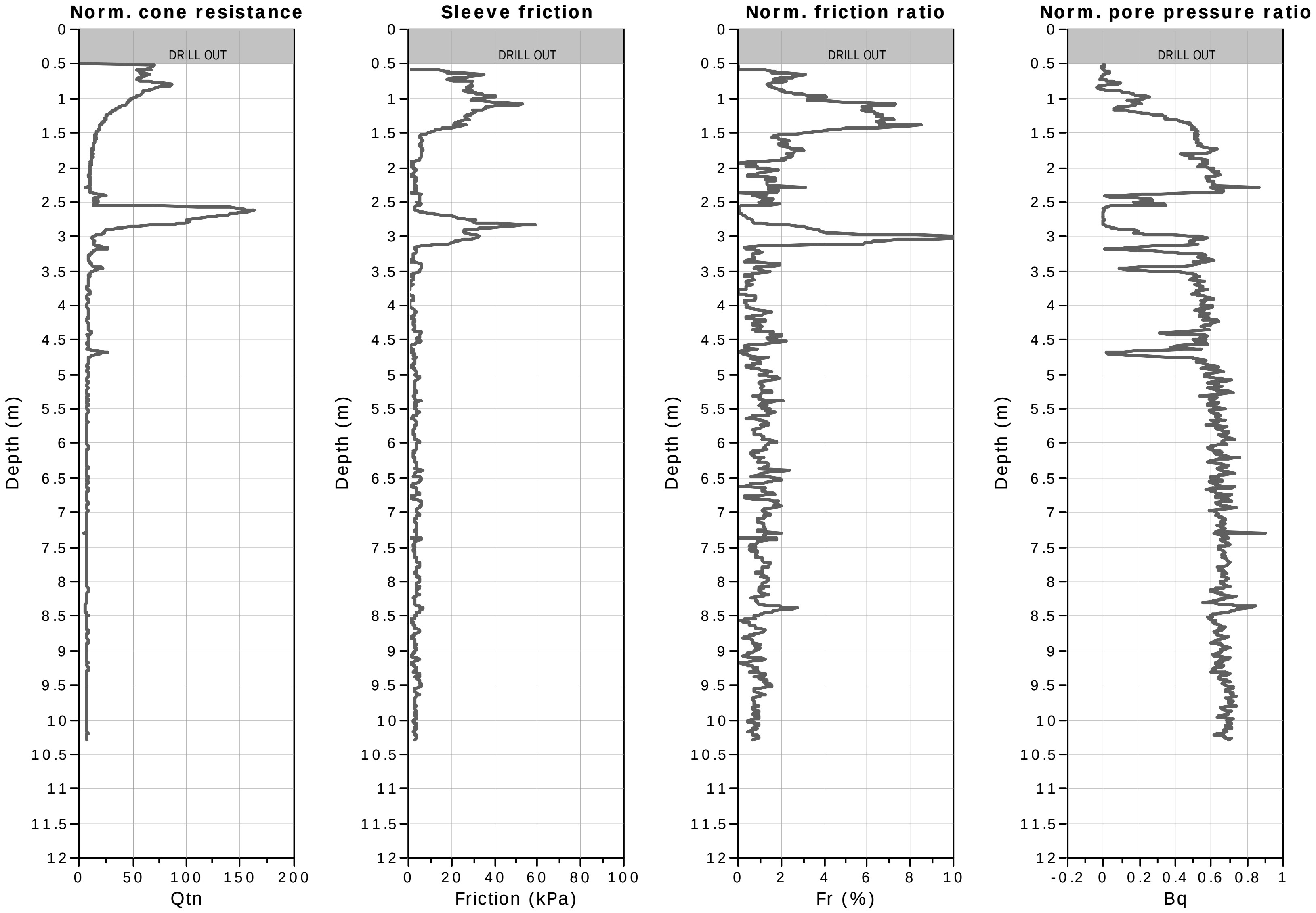
Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**

CPT17-08_RevA
Total depth: 10.29 m, Date: 03/01/2018
Cone Type: I-CFXYP20-10 171029
Cone Operator: M. Roy - Stratum CPT



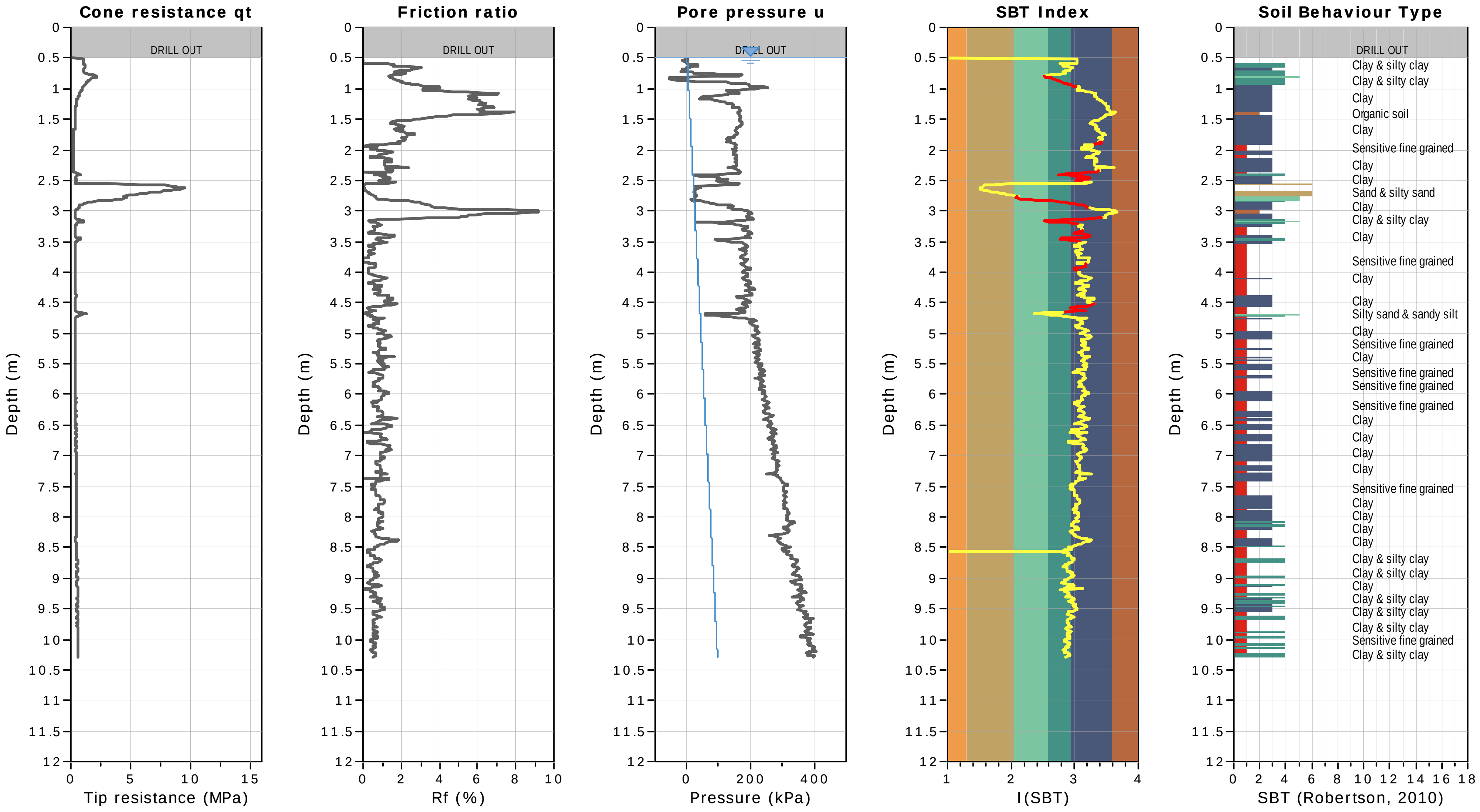
Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**

CPT17-08_RevA
Total depth: 10.29 m, Date: 03/01/2018
Cone Type: I-CFXYP20-10 171029
Cone Operator: M. Roy - Stratum CPT



Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**

CPT17-08_RevA
Total depth: 10.29 m, Date: 03/01/2018
Cone Type: I-CFXYP20-10 171029
Cone Operator: M. Roy - Stratum CPT



Project: CRRRC - 1787048-400-4.4

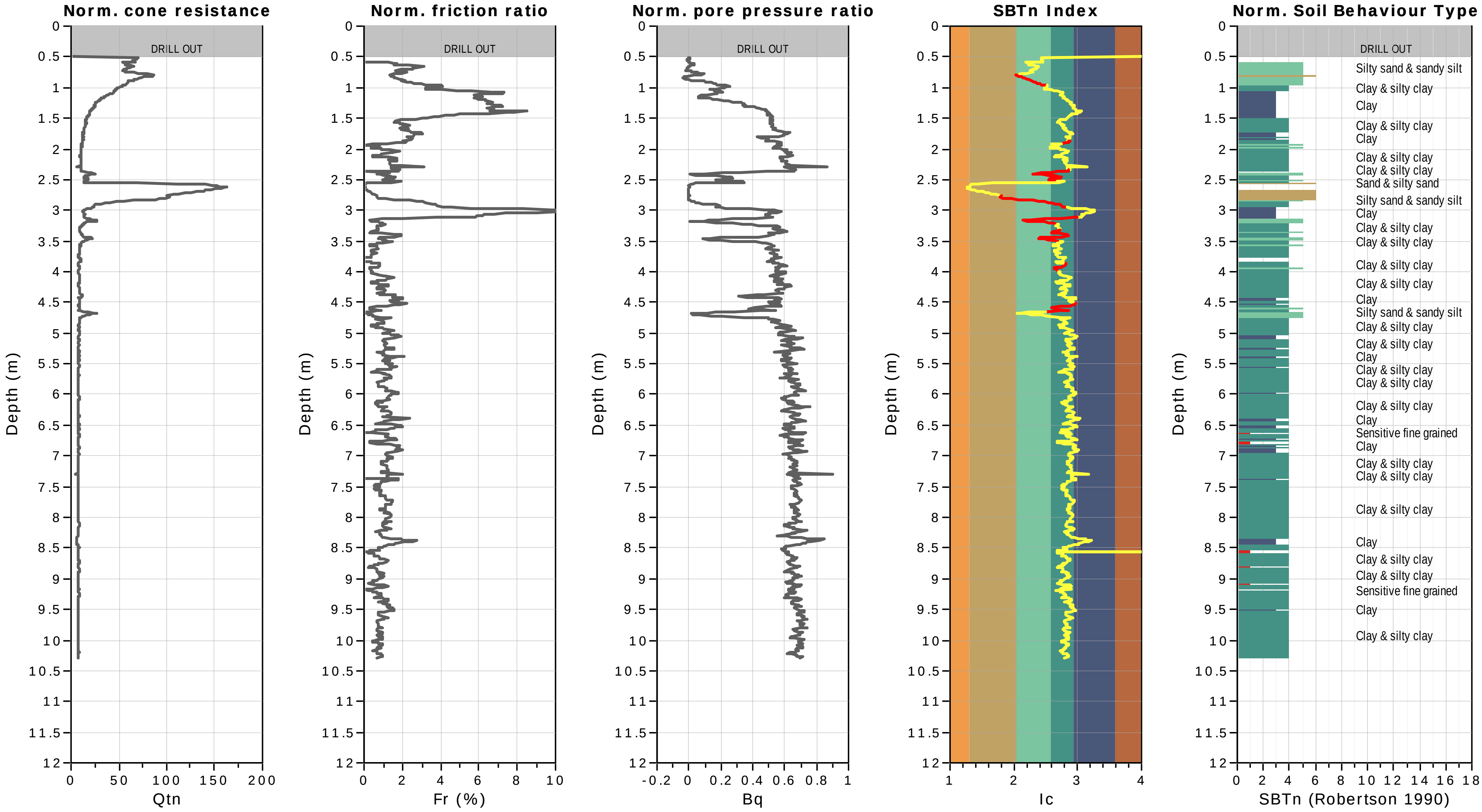
Location: Ottawa, ON, Canada

CPT17-08_RevA

Total depth: 10.29 m, Date: 03/01/2018

Cone Type: I-CFXYP20-10 171029

Cone Operator: M. Roy - Stratum CPT



CPT17-10_RevA

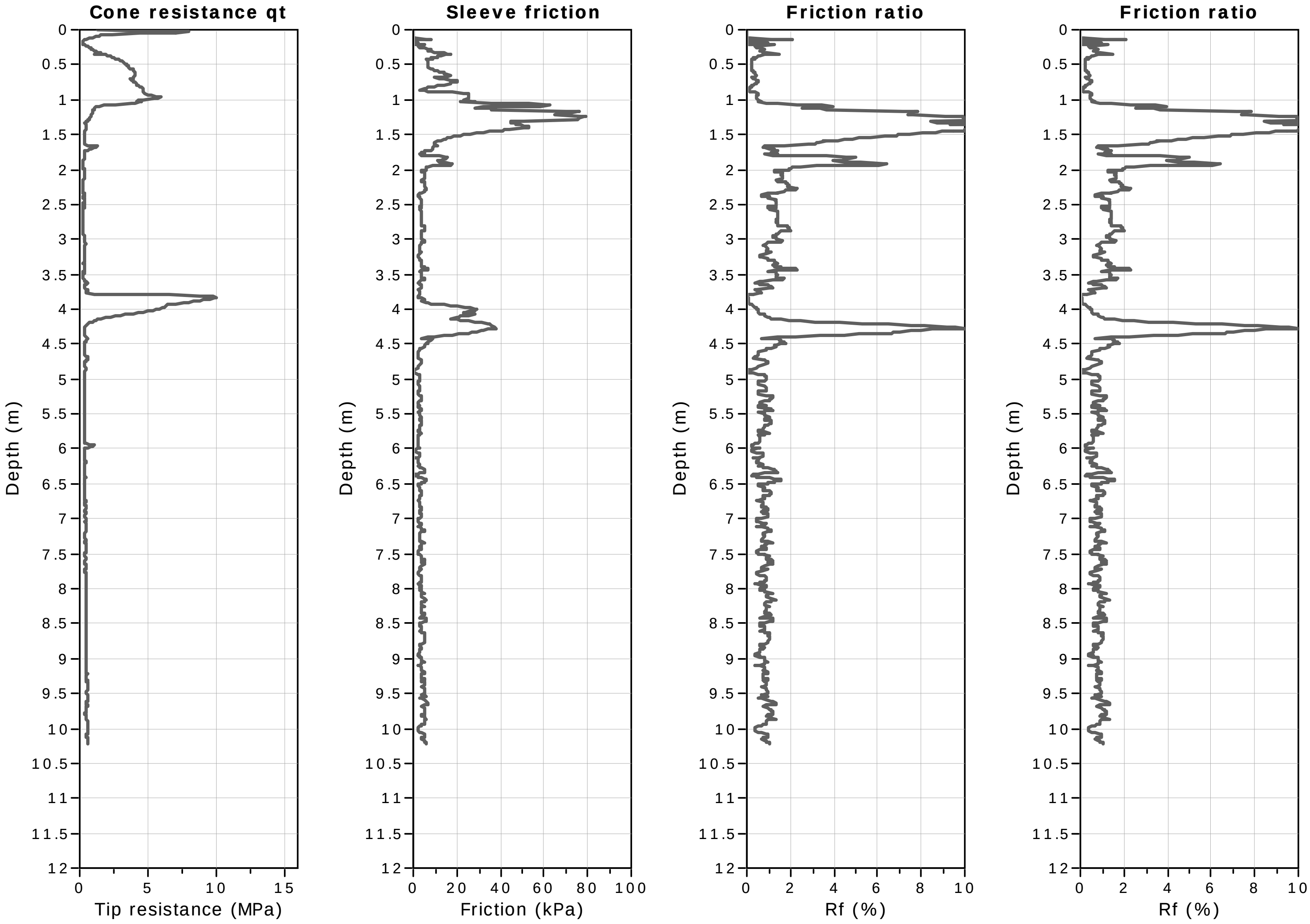
Total depth: 10.22 m, Date: 03/01/2018

Cone Type: I-CFXYP20-10 171029

Cone Operator: M. Roy - Stratum CPT

Project: **CRRRC - 1787048-400-4.4**

Location: **Ottawa, ON, Canada**



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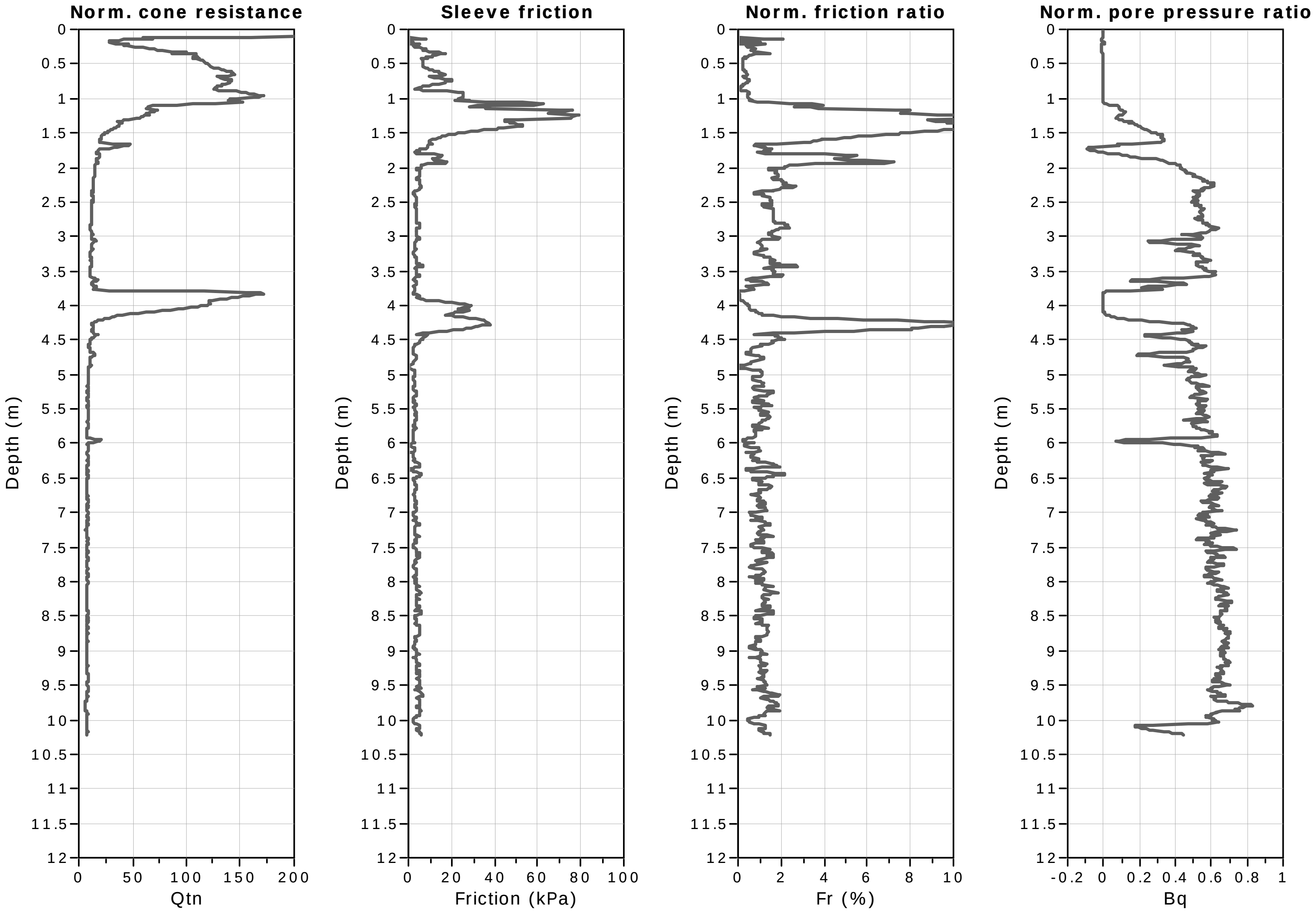
Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**

CPT17-10_RevA
Total depth: 10.22 m, Date: 03/01/2018
Cone Type: I-CFXYP20-10 171029
Cone Operator: M. Roy - Stratum CPT



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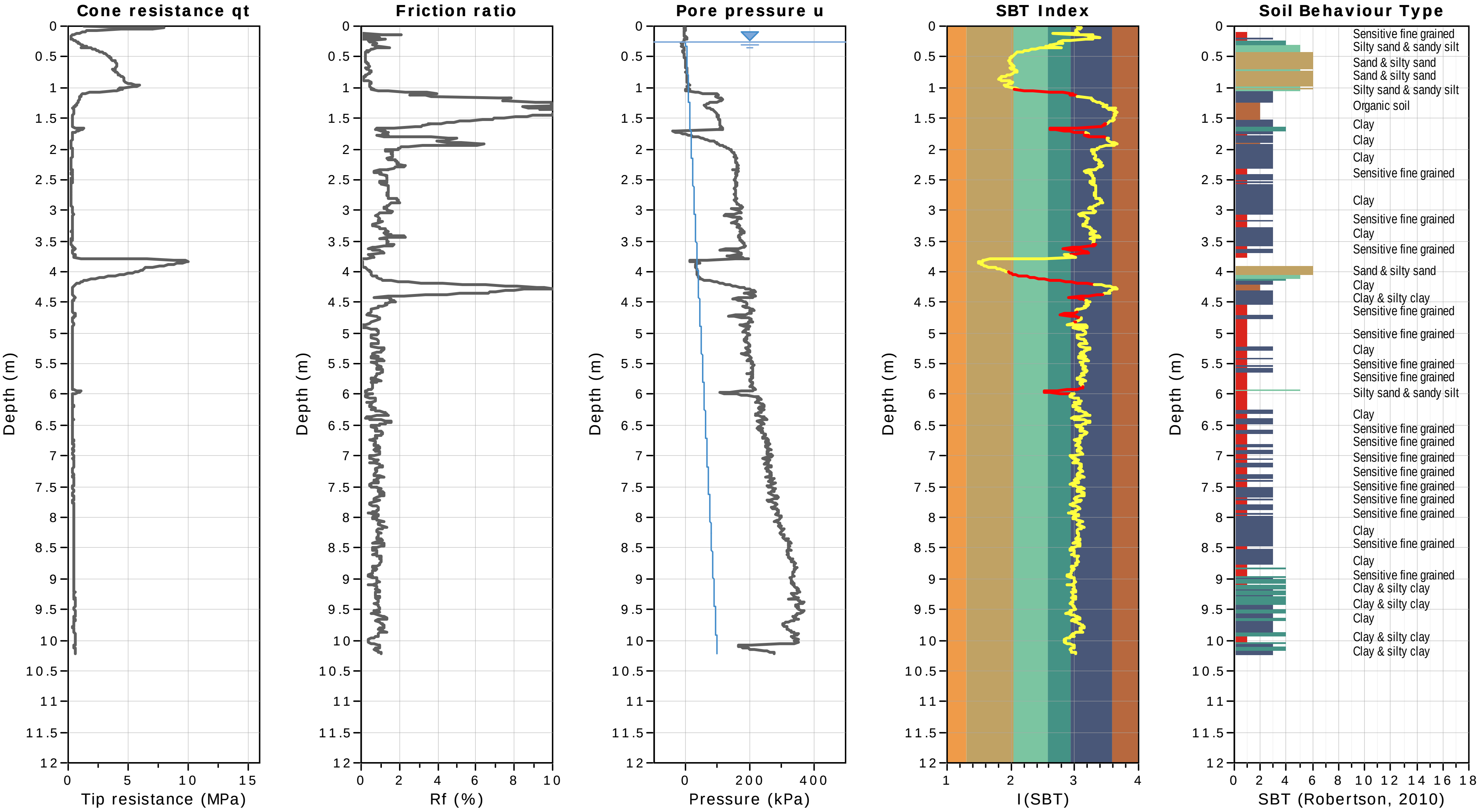
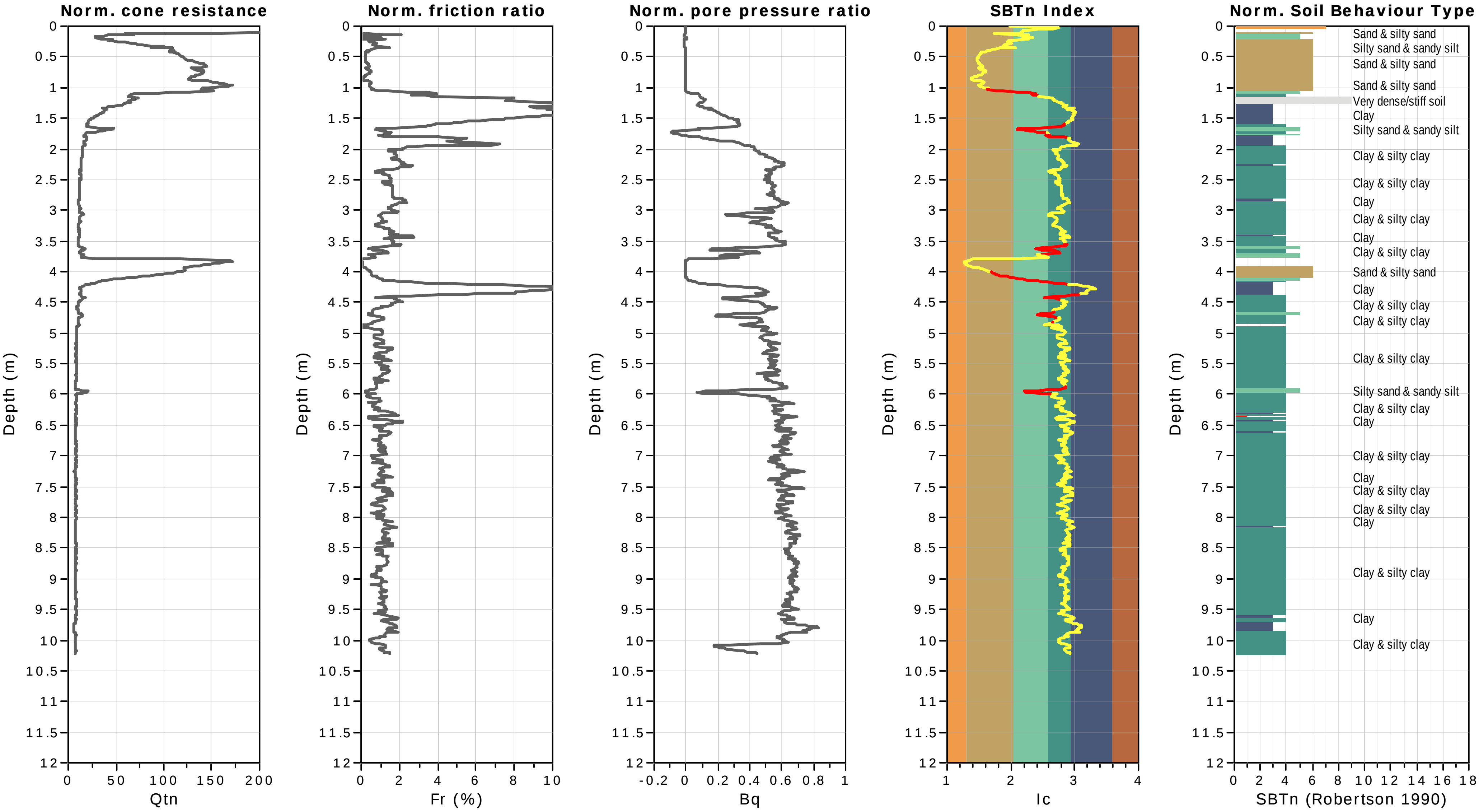
Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**

CPT17-10_RevA
Total depth: 10.22 m, Date: 03/01/2018
Cone Type: I-CFXYP20-10 171029
Cone Operator: M. Roy - Stratum CPT



Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**

CPT17-10_RevA
Total depth: 10.22 m, Date: 03/01/2018
Cone Type: I-CFXYP20-10 171029
Cone Operator: M. Roy - Stratum CPT



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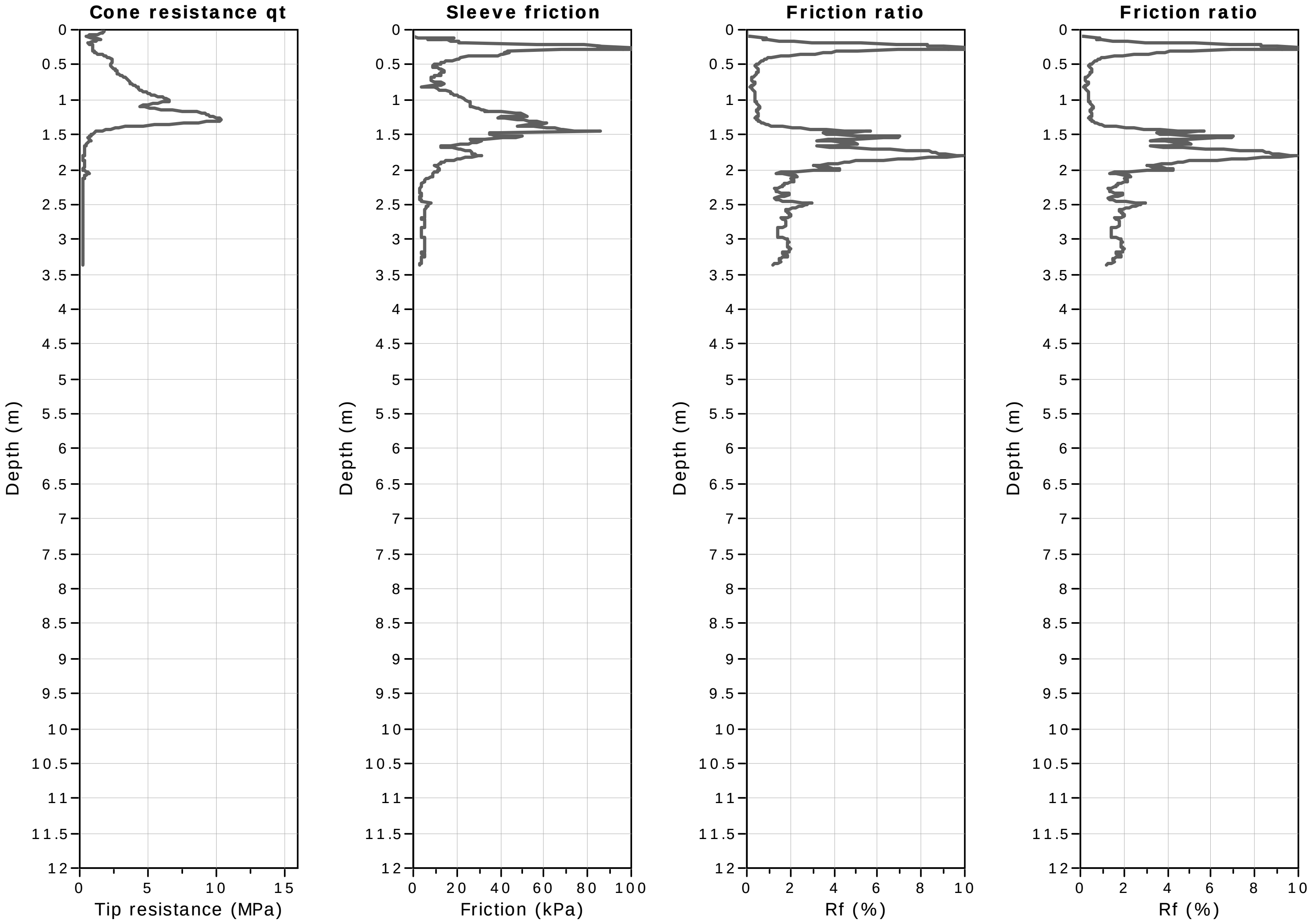
CPT17-11_RevA

Total depth: 3.38 m, Date: 03/01/2018
Cone Type: I-CFXYP20-10 171029
Cone Operator: M. Roy - Stratum CPT

Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**

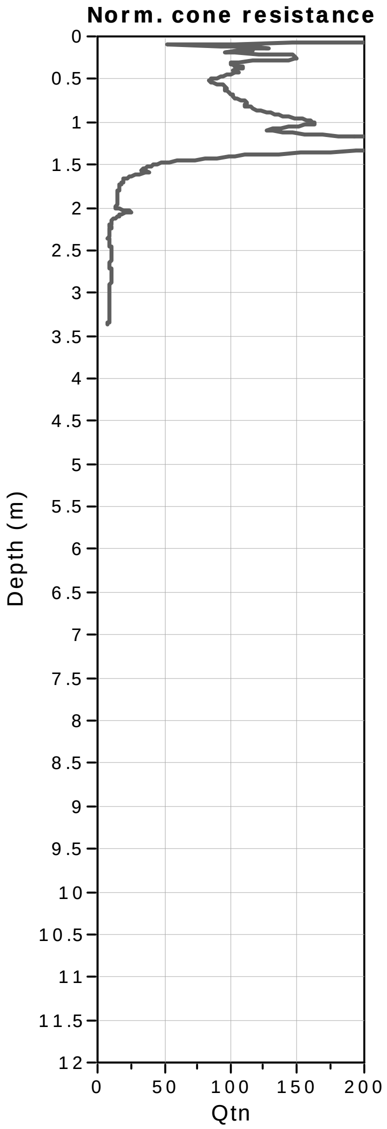


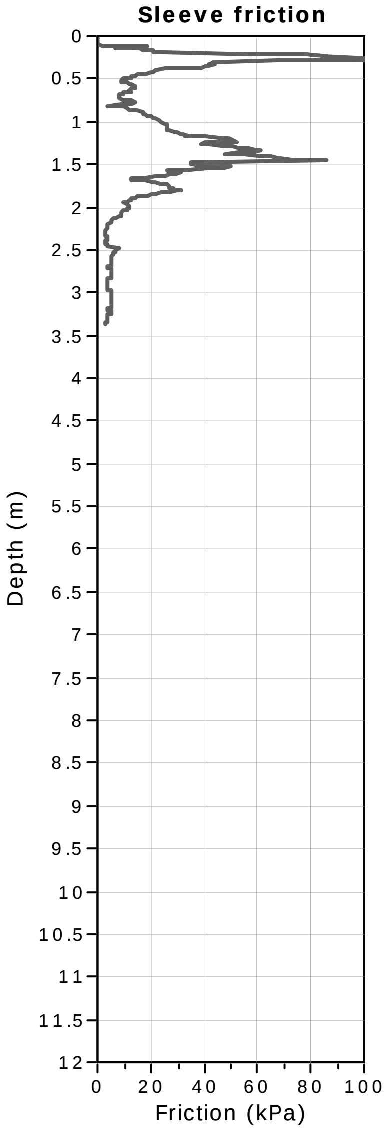
CPeT-IT v.2.0.1.12 - CPTU data presentation & interpretation software - Report created on: 26/01/2018, 3:40:58 PM
Project file: C:\Users\JBrunswickwerner\Desktop\Ottawa CPT\CRRRC_Ottawa_20JAN2018.cpt

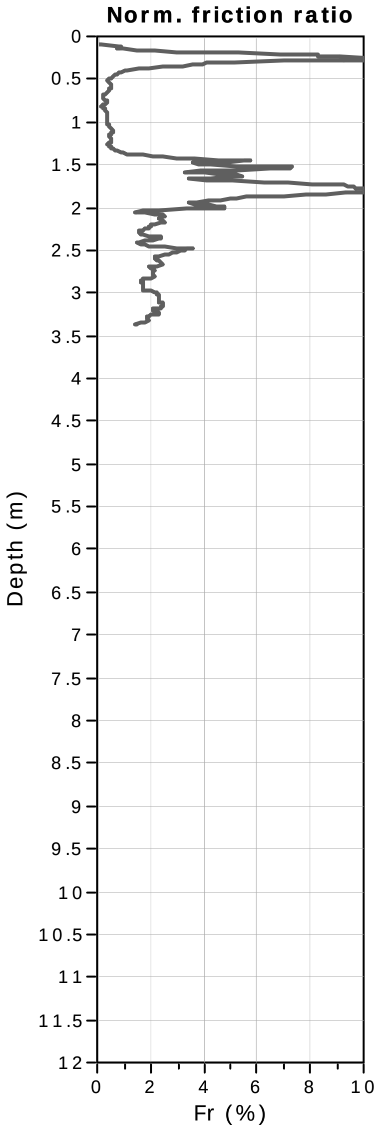
Golder Associates Ltd.
www.golder.com

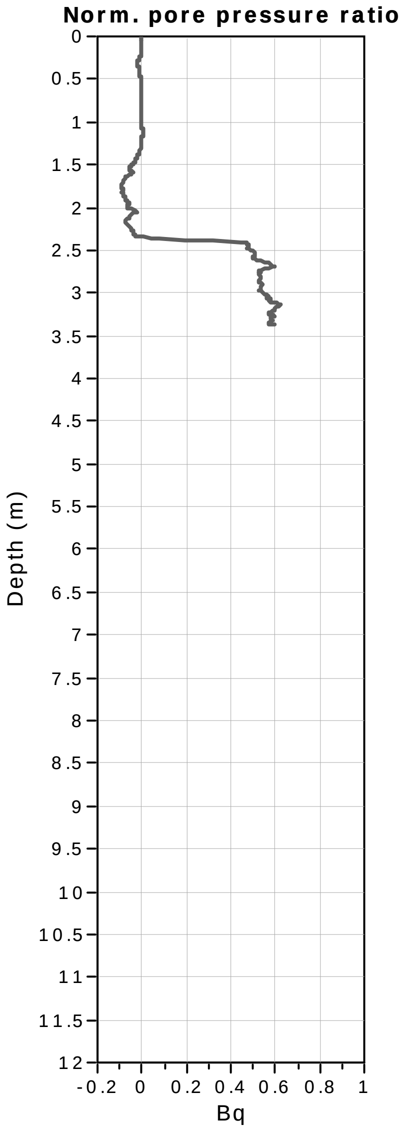
Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**

CPT17-11_RevA
Total depth: 3.38 m, Date: 03/01/2018
Cone Type: I-CFXYP20-10 171029
Cone Operator: M. Roy - Stratum CPT


Norm. cone resistance


Sleeve friction


Norm. friction ratio


Norm. pore pressure ratio

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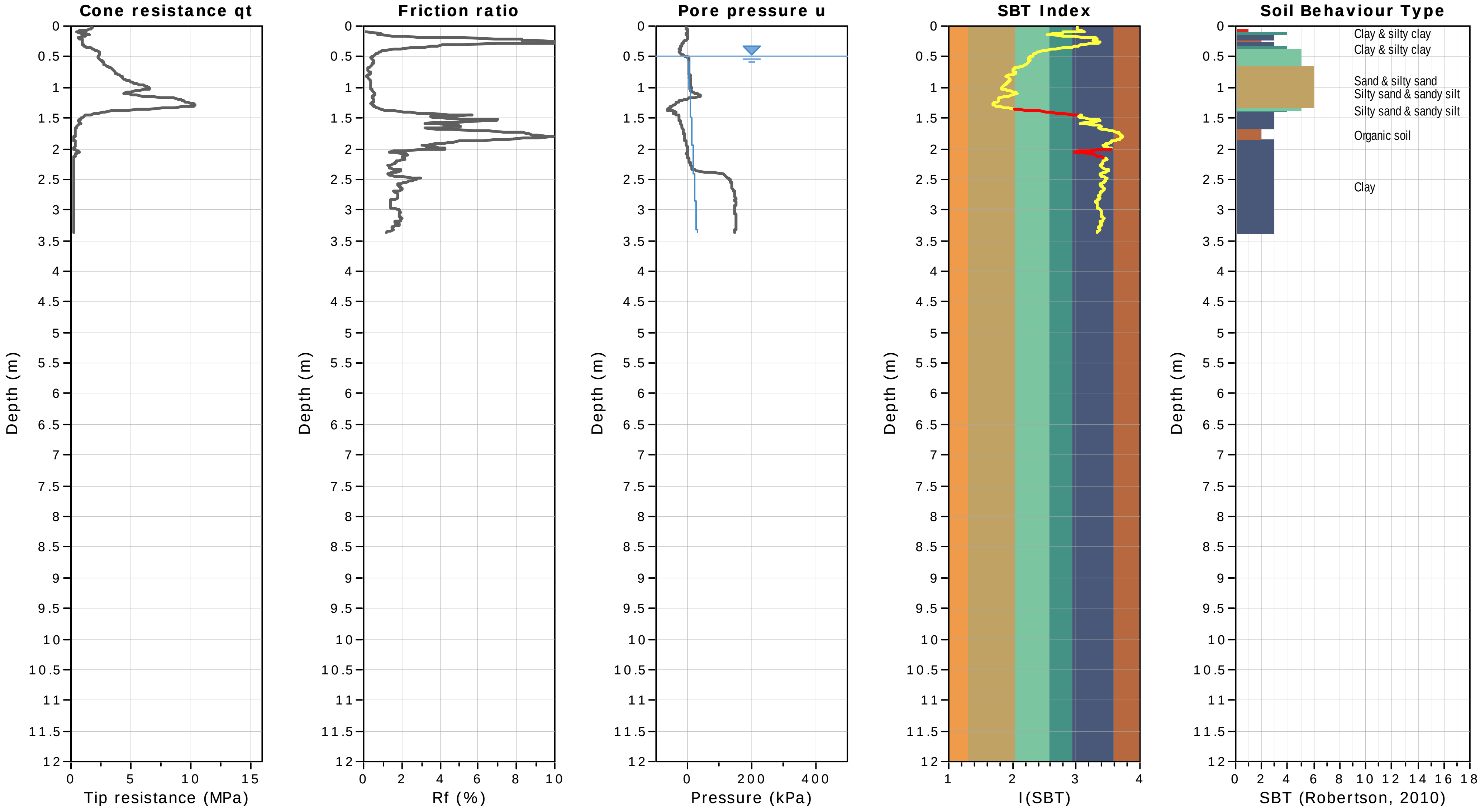
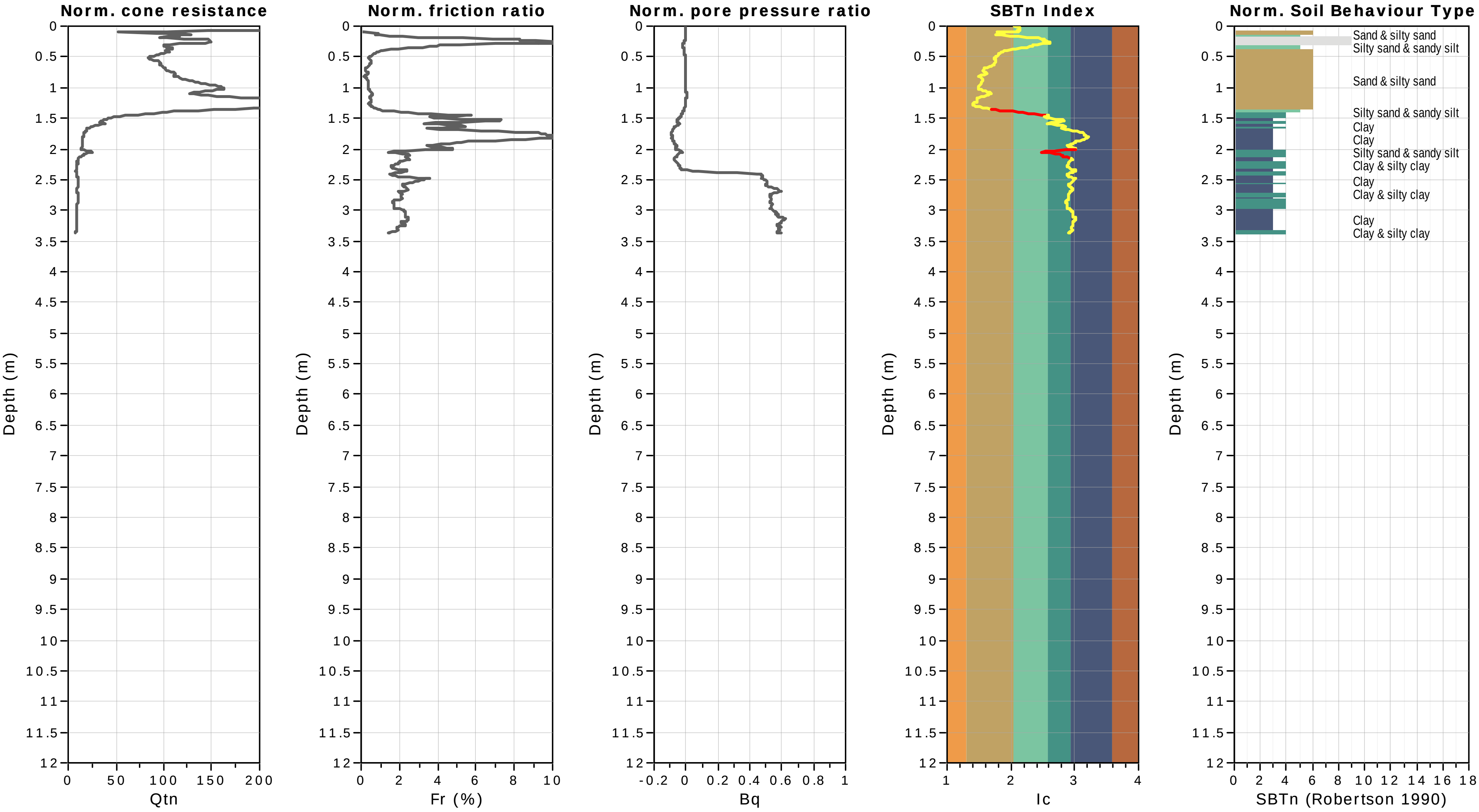
Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**

CPT17-11_RevA
Total depth: 3.38 m, Date: 03/01/2018
Cone Type: I-CFXYP20-10 171029
Cone Operator: M. Roy - Stratum CPT



Project: CRRRC - 1787048-400-4.4
Location: Ottawa, ON, Canada

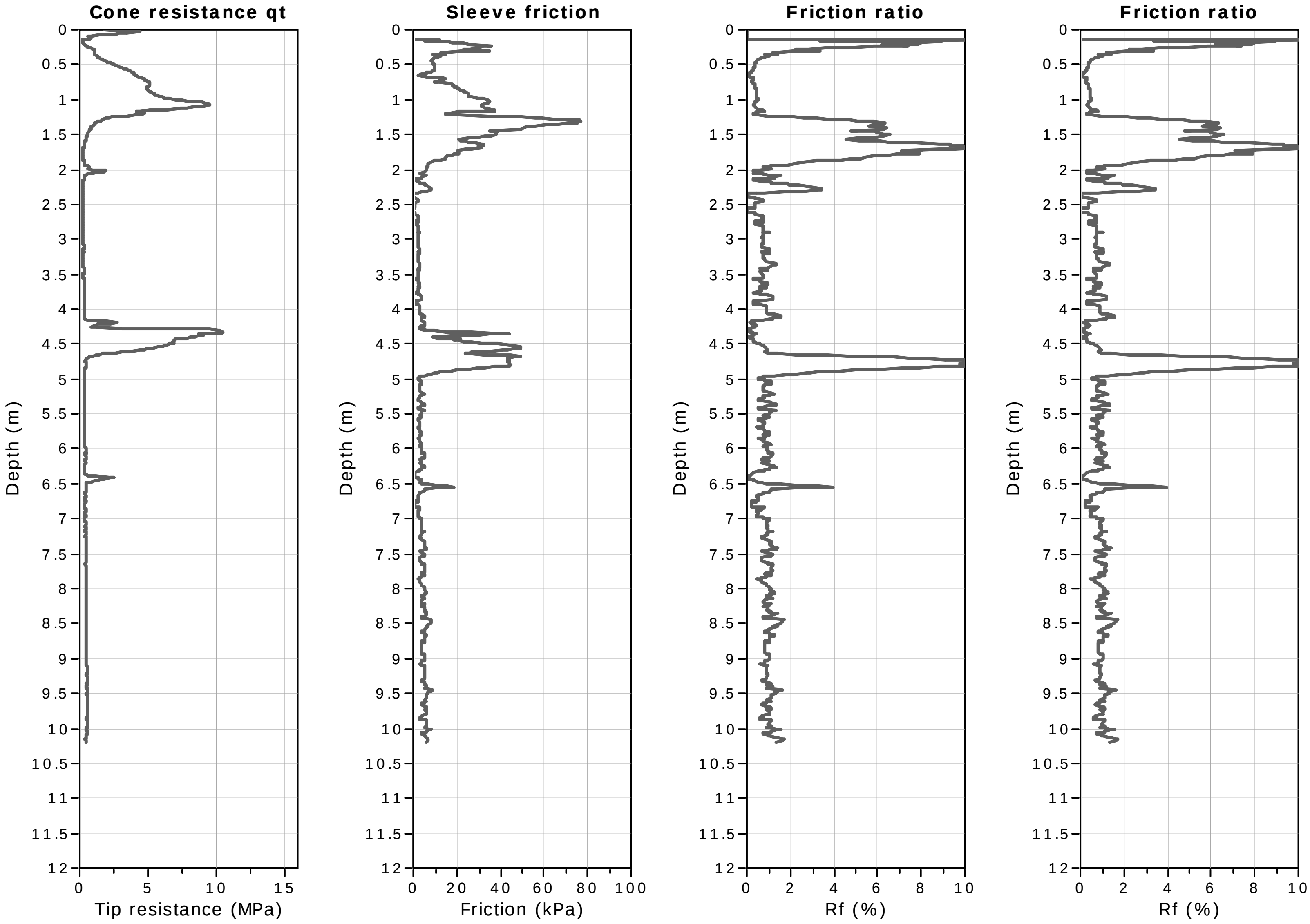
CPT17-11_RevA
Total depth: 3.38 m, Date: 03/01/2018
Cone Type: I-CFXYP20-10 171029
Cone Operator: M. Roy - Stratum CPT



Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**

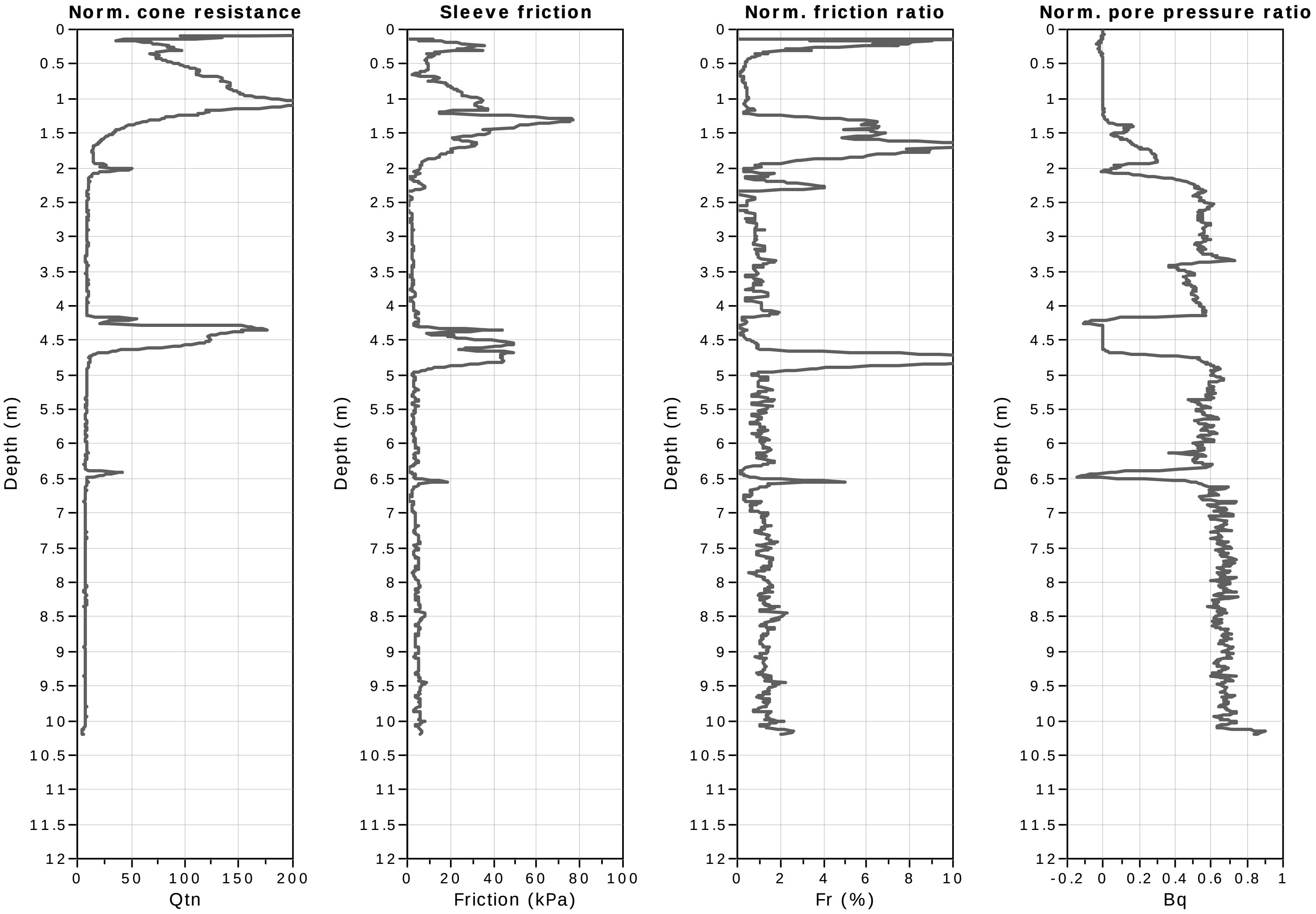
CPT17-11R_RevA

Total depth: 10.20 m, Date: 03/01/2018
Cone Type: I-CFXYP20-10 171029
Cone Operator: M. Roy - Stratum CPT



Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**

CPT17-11R_RevA
Total depth: 10.20 m, Date: 03/01/2018
Cone Type: I-CFXYP20-10 171029
Cone Operator: M. Roy - Stratum CPT



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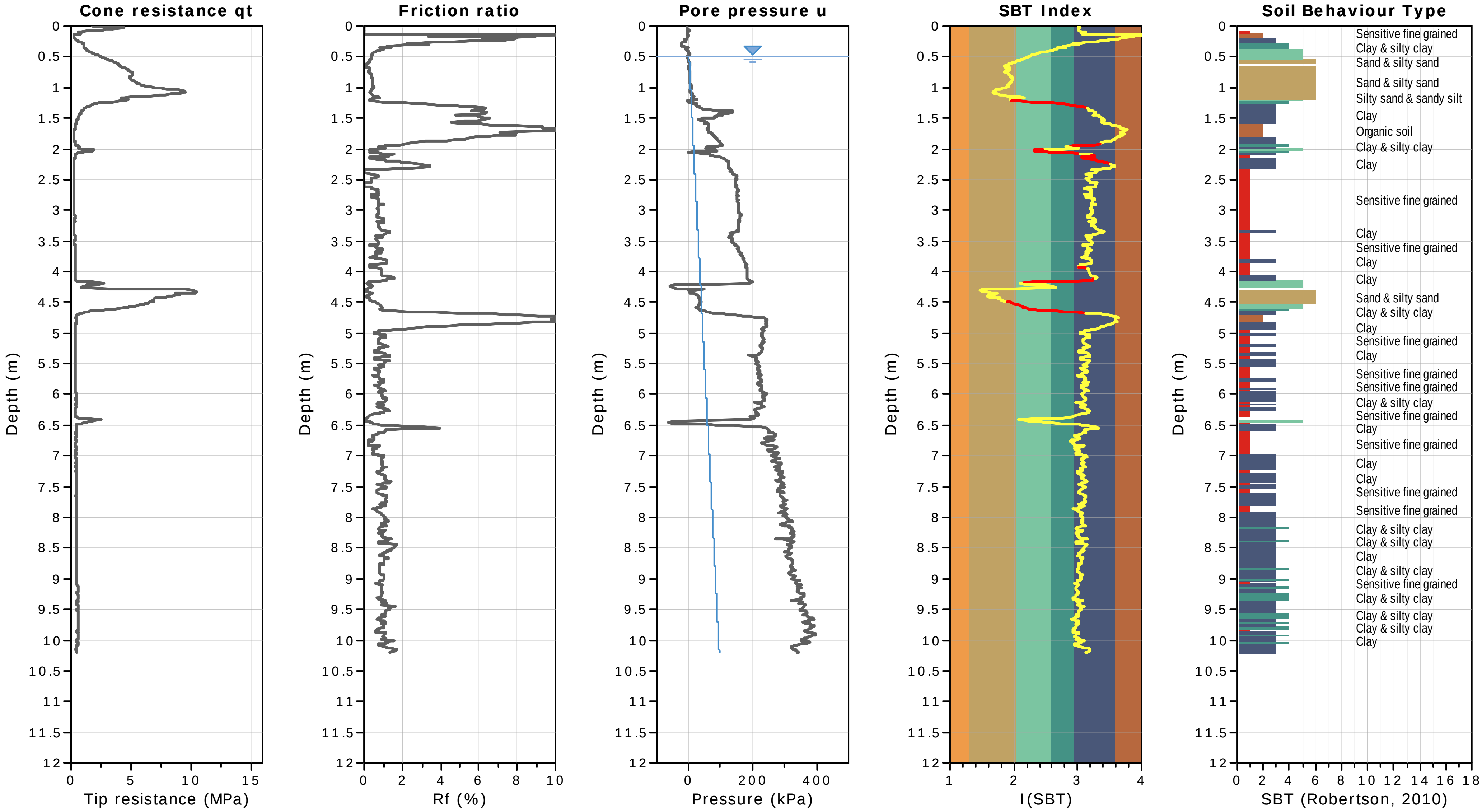
Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**

CPT17-11R_RevA
Total depth: 10.20 m, Date: 03/01/2018
Cone Type: I-CFXYP20-10 171029
Cone Operator: M. Roy - Stratum CPT



Golder Associates Ltd.
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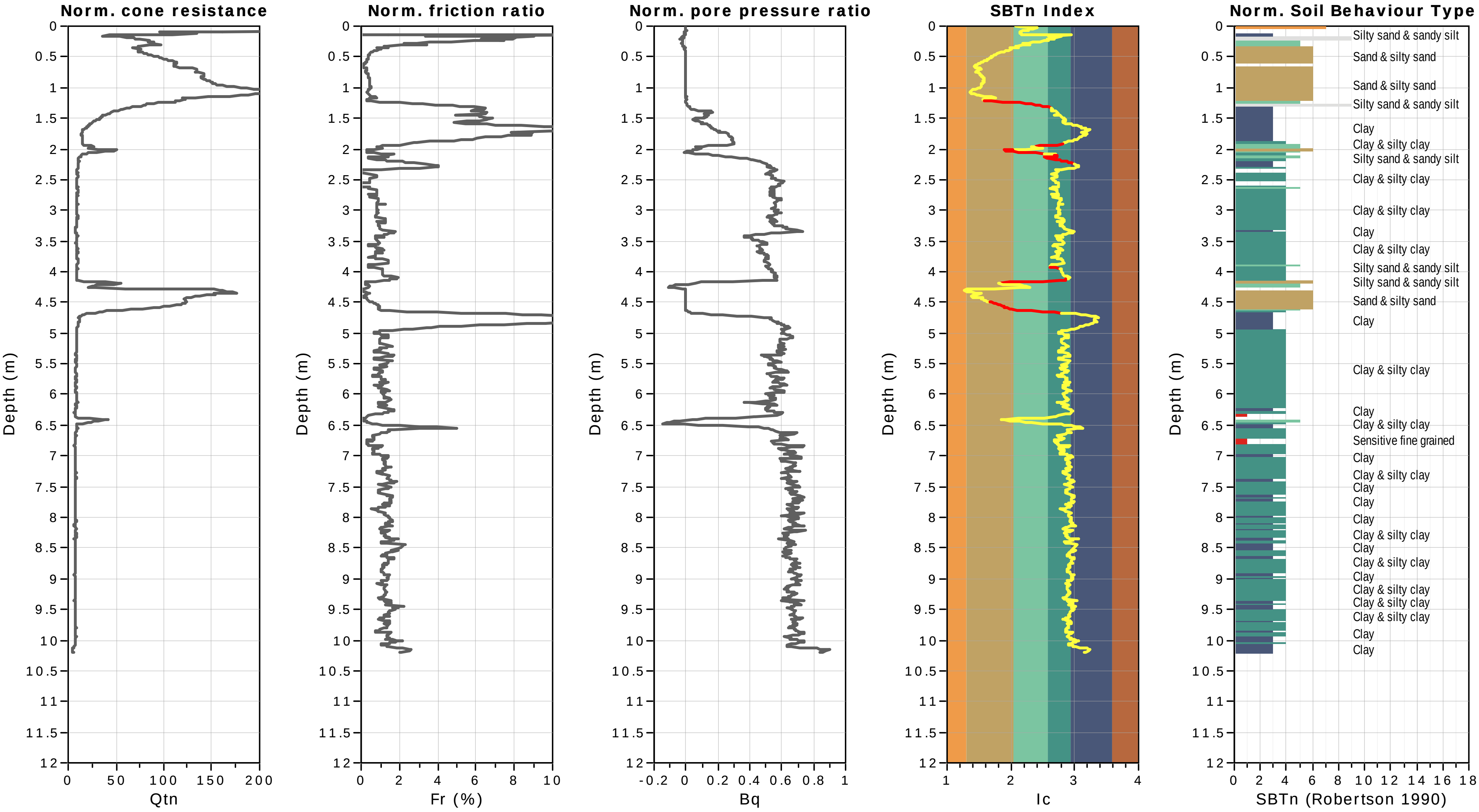
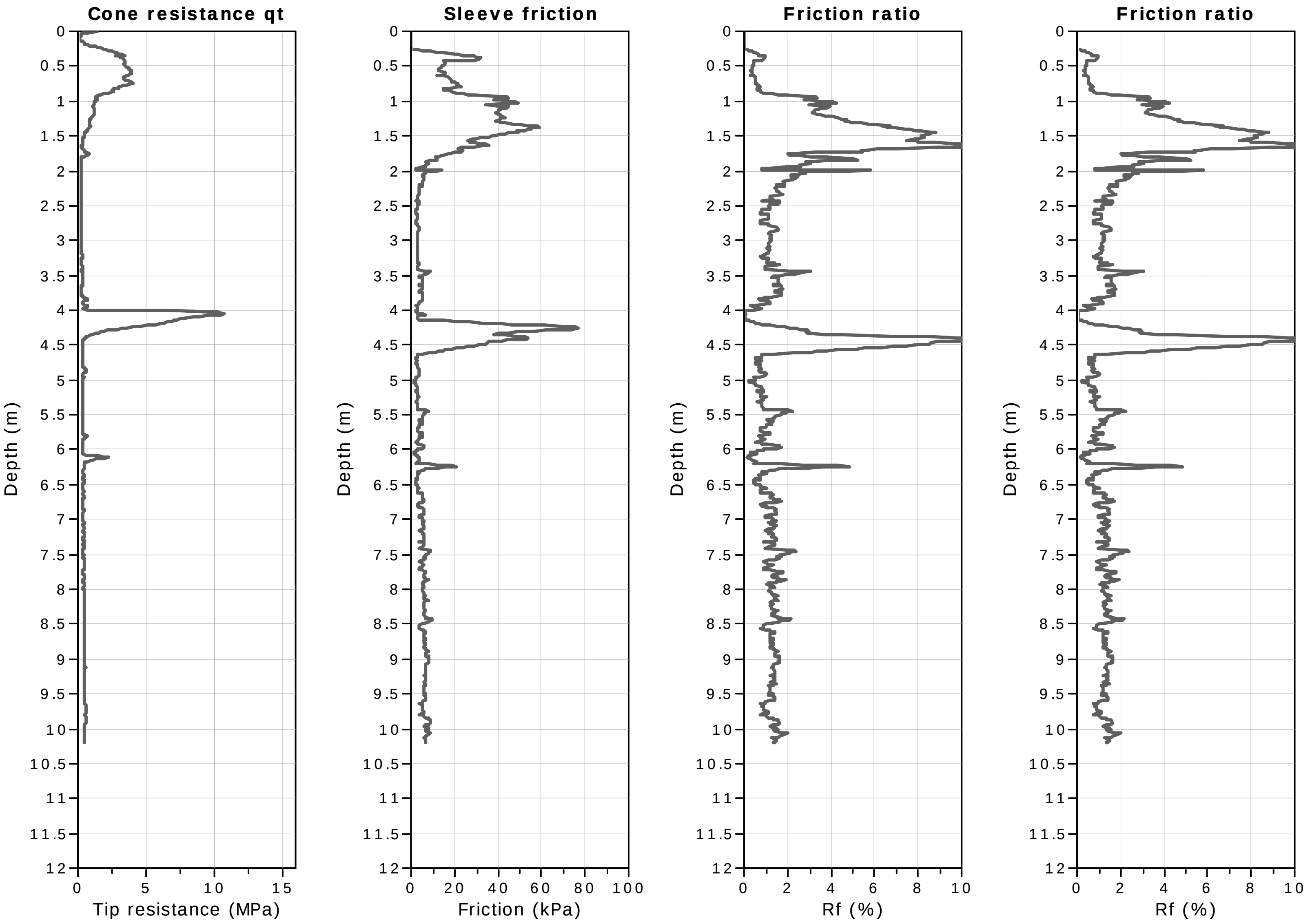
Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**

CPT17-11R_RevA
Total depth: 10.20 m, Date: 03/01/2018
Cone Type: I-CFXYP20-10 171029
Cone Operator: M. Roy - Stratum CPT



Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**

CPT17-15_RevA
Total depth: 10.20 m, Date: 03/01/2018
Cone Type: I-CFXYP20-10 171029
Cone Operator: M. Roy - Stratum CPT



Golder Associates Ltd.
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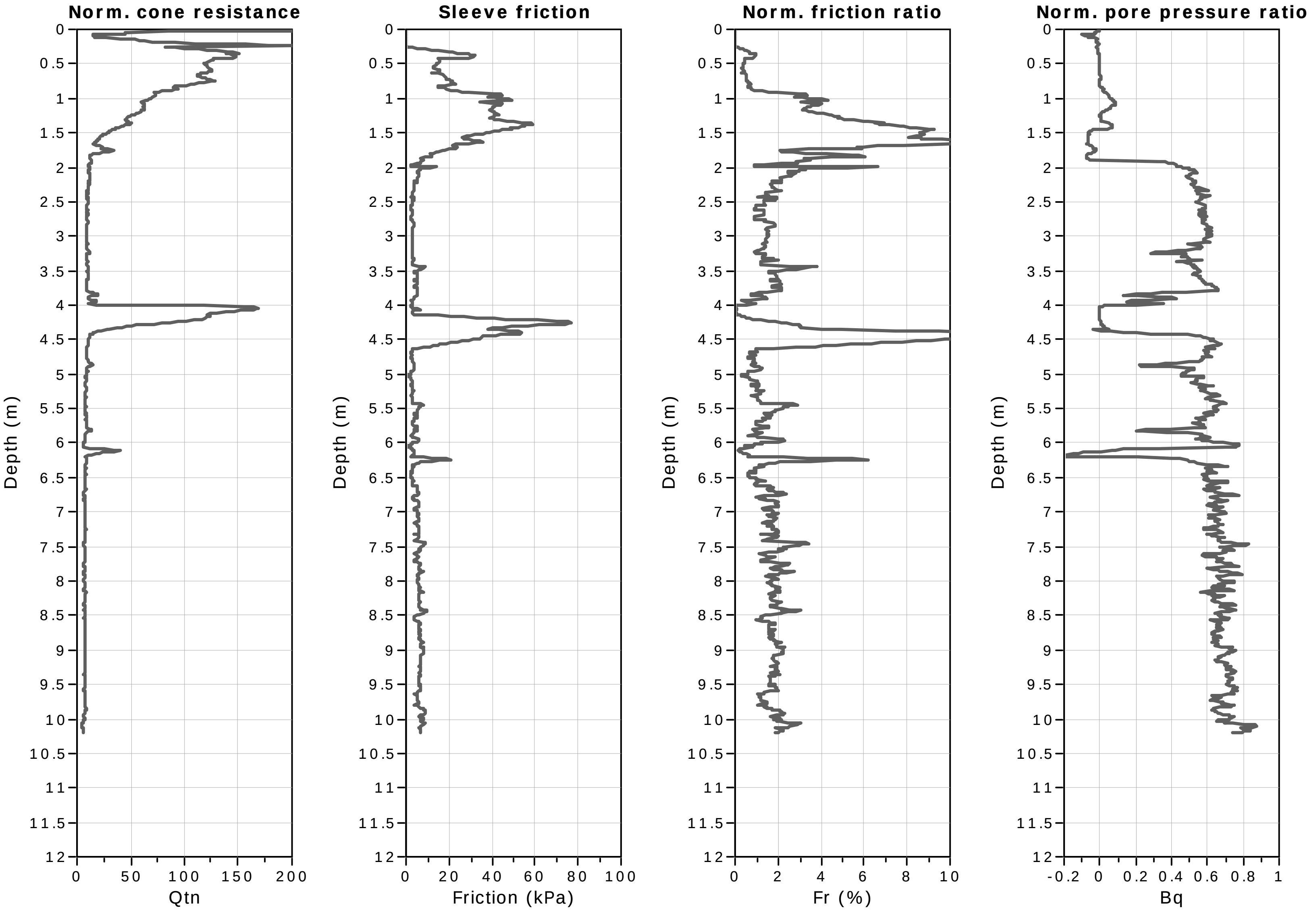
Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**

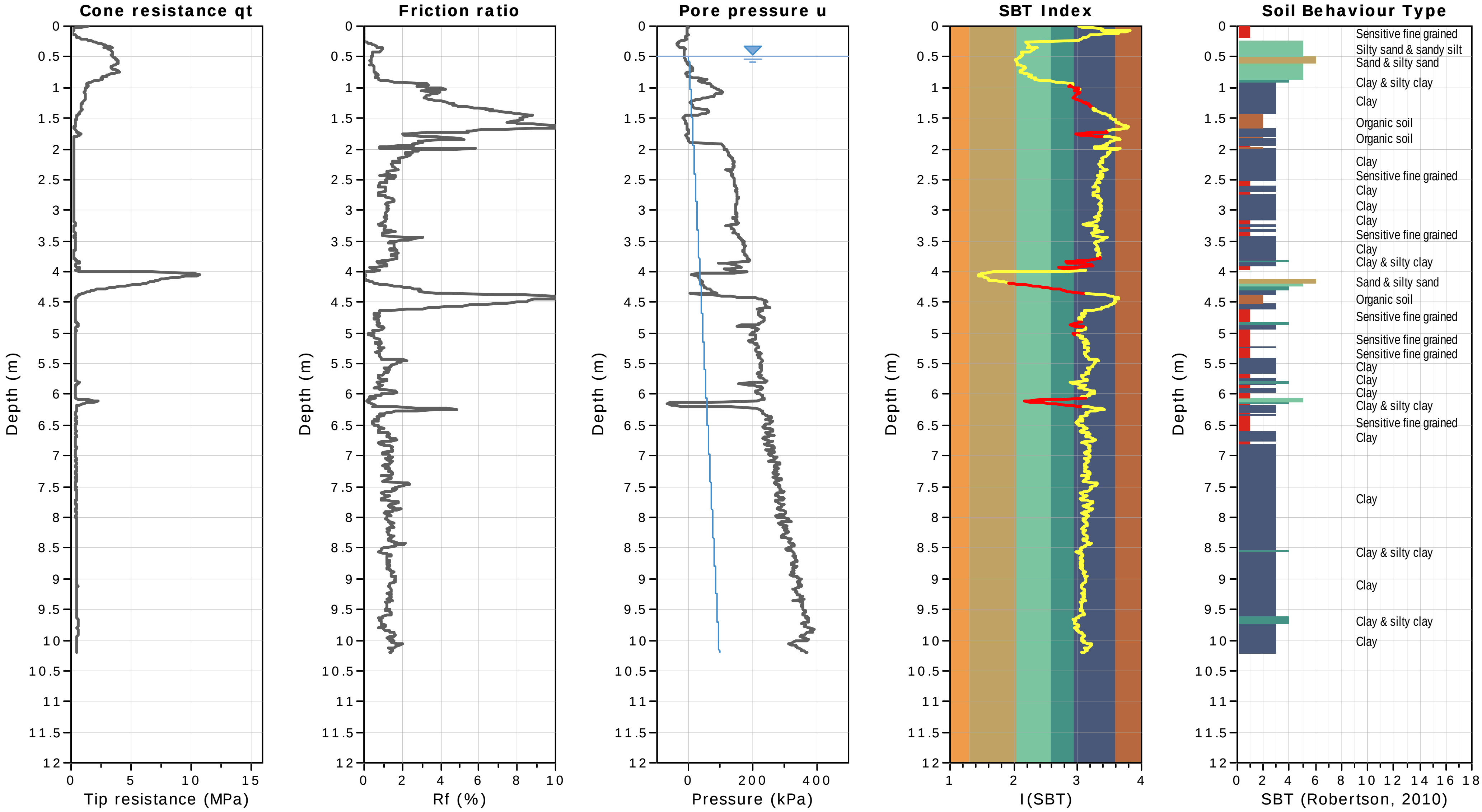
CPT17-15_RevA
Total depth: 10.20 m, Date: 03/01/2018
Cone Type: I-CFXYP20-10 171029
Cone Operator: M. Roy - Stratum CPT



Golder Associates Ltd.
www.golder.com

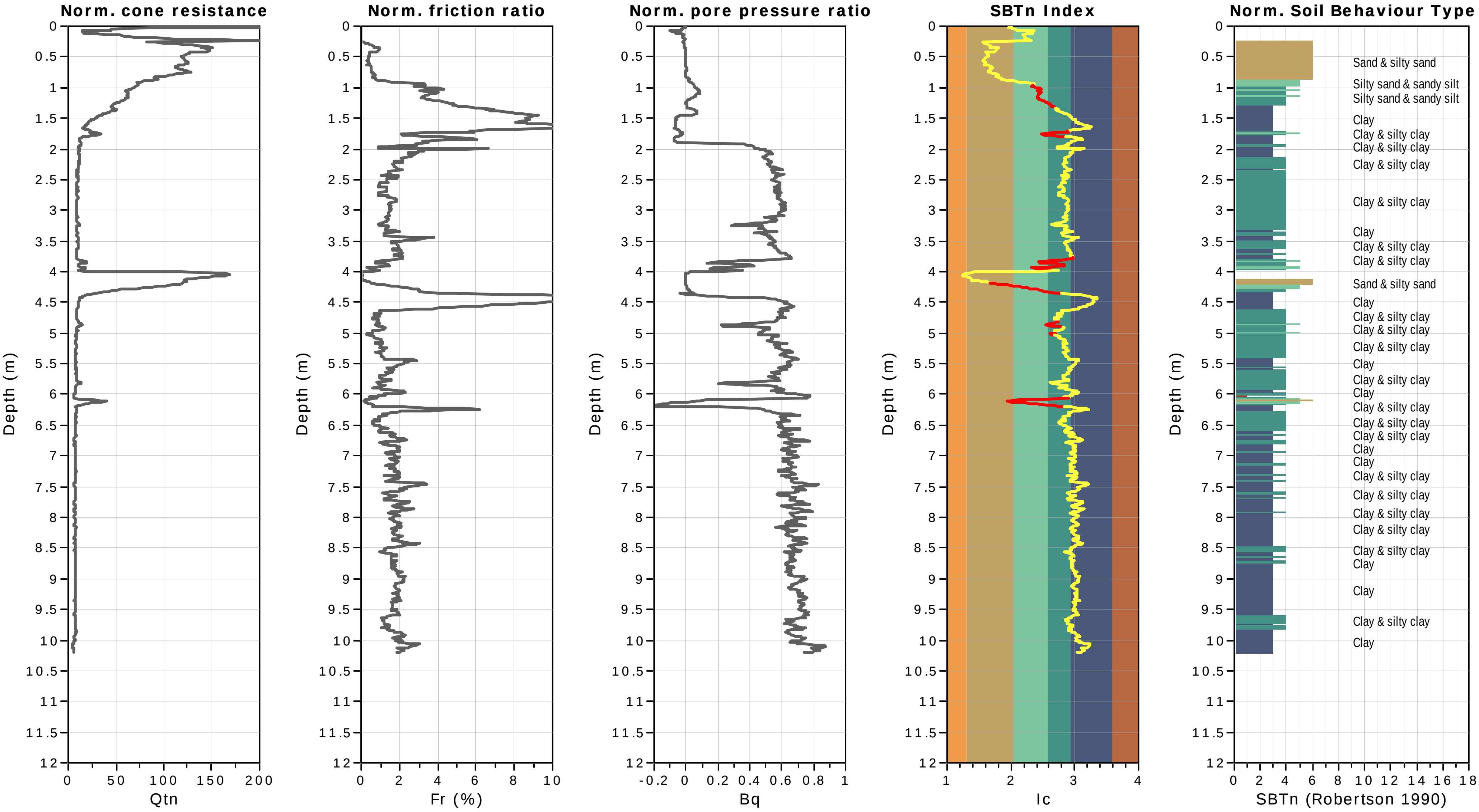
CPT17-15_RevA
Total depth: 10.20 m, Date: 03/01/2018
Cone Type: I-CFXYP20-10 171029
Cone Operator: M. Roy - Stratum CPT

Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**



Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**

CPT17-15_RevA
Total depth: 10.20 m, Date: 03/01/2018
Cone Type: I-CFXYP20-10 171029
Cone Operator: M. Roy - Stratum CPT



Golder Associates Ltd.
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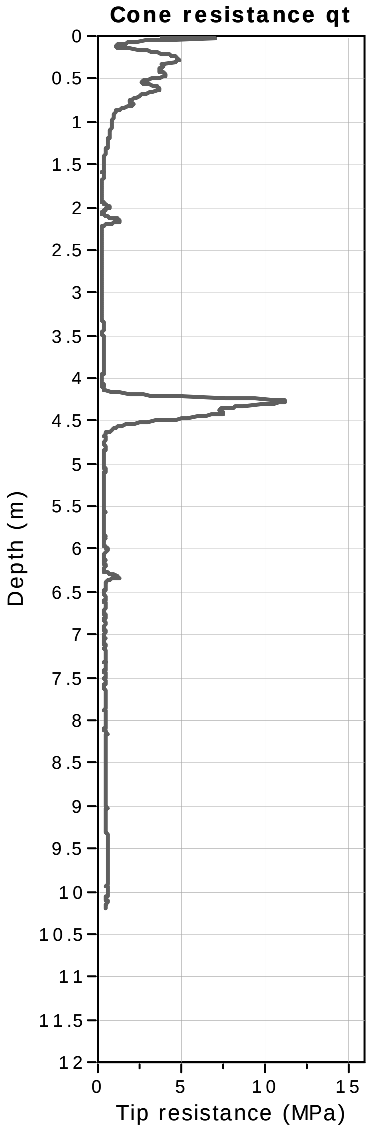
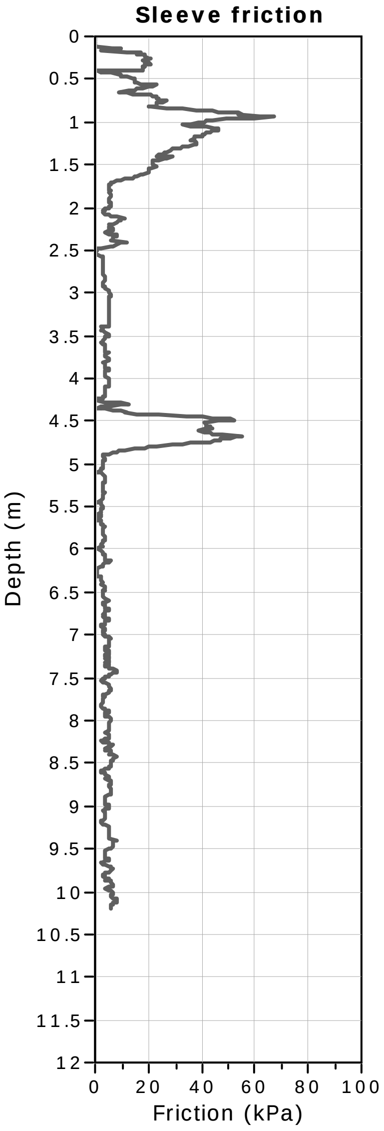
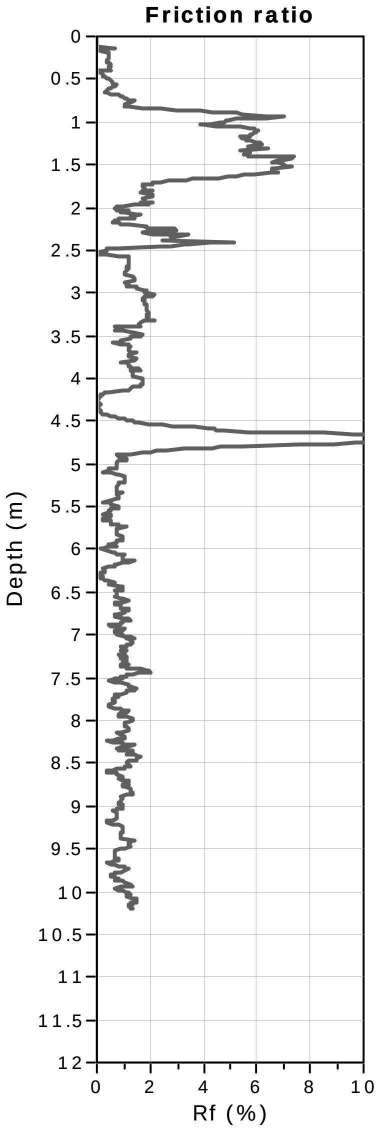
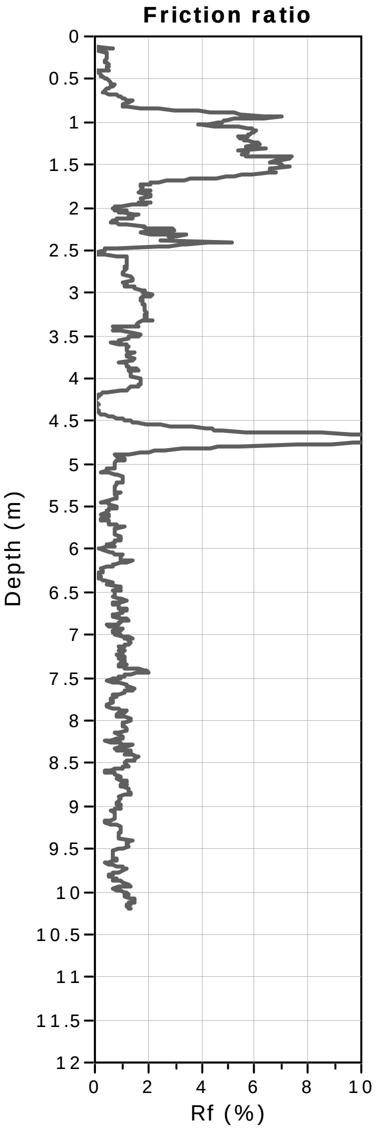
Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**

CPT17-16_RevA
Total depth: 10.20 m, Date: 03/01/2018
Cone Type: Uknown
Cone Operator: Uknown


Cone resistance qt

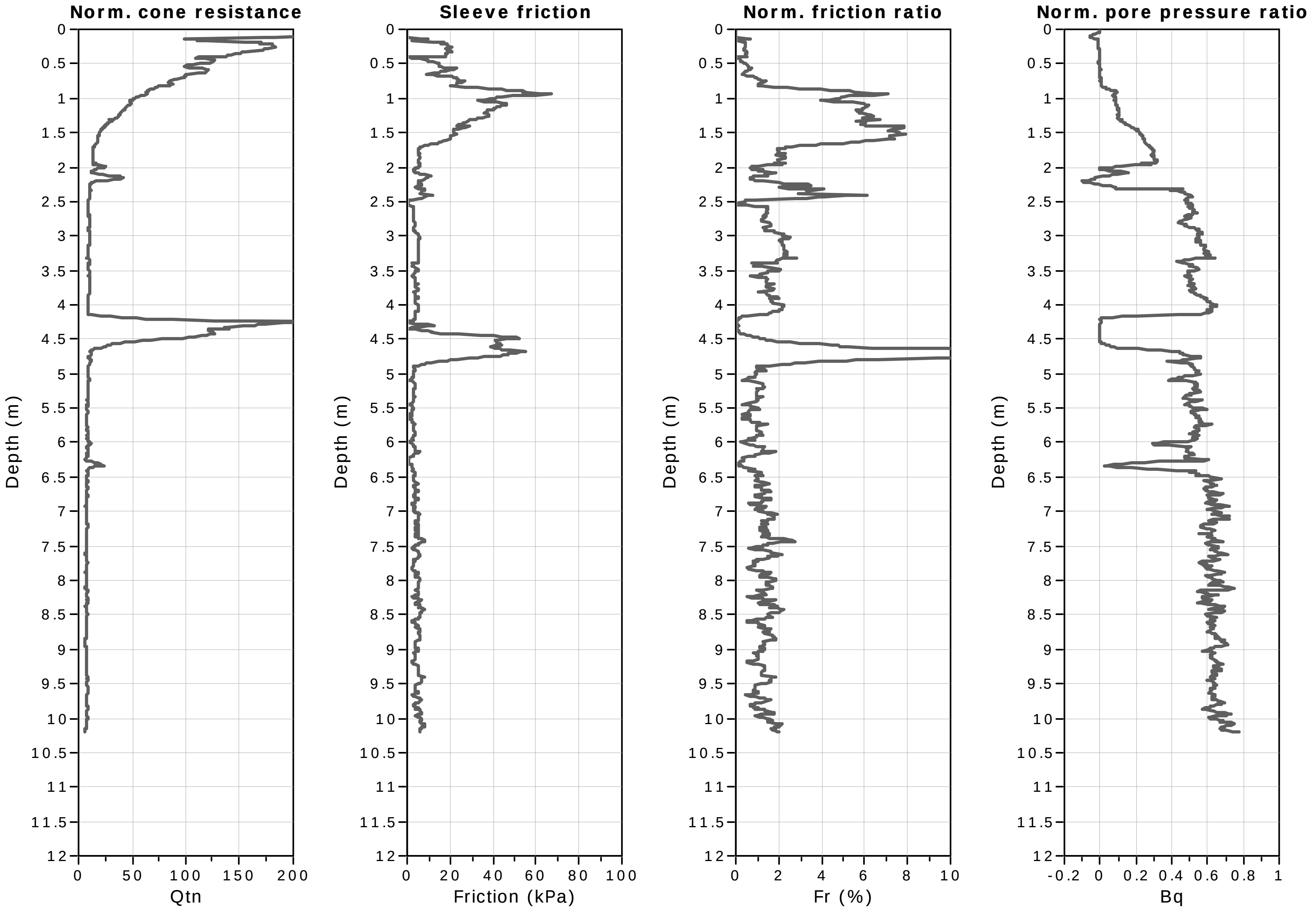

Sleeve friction


Friction ratio


Friction ratio

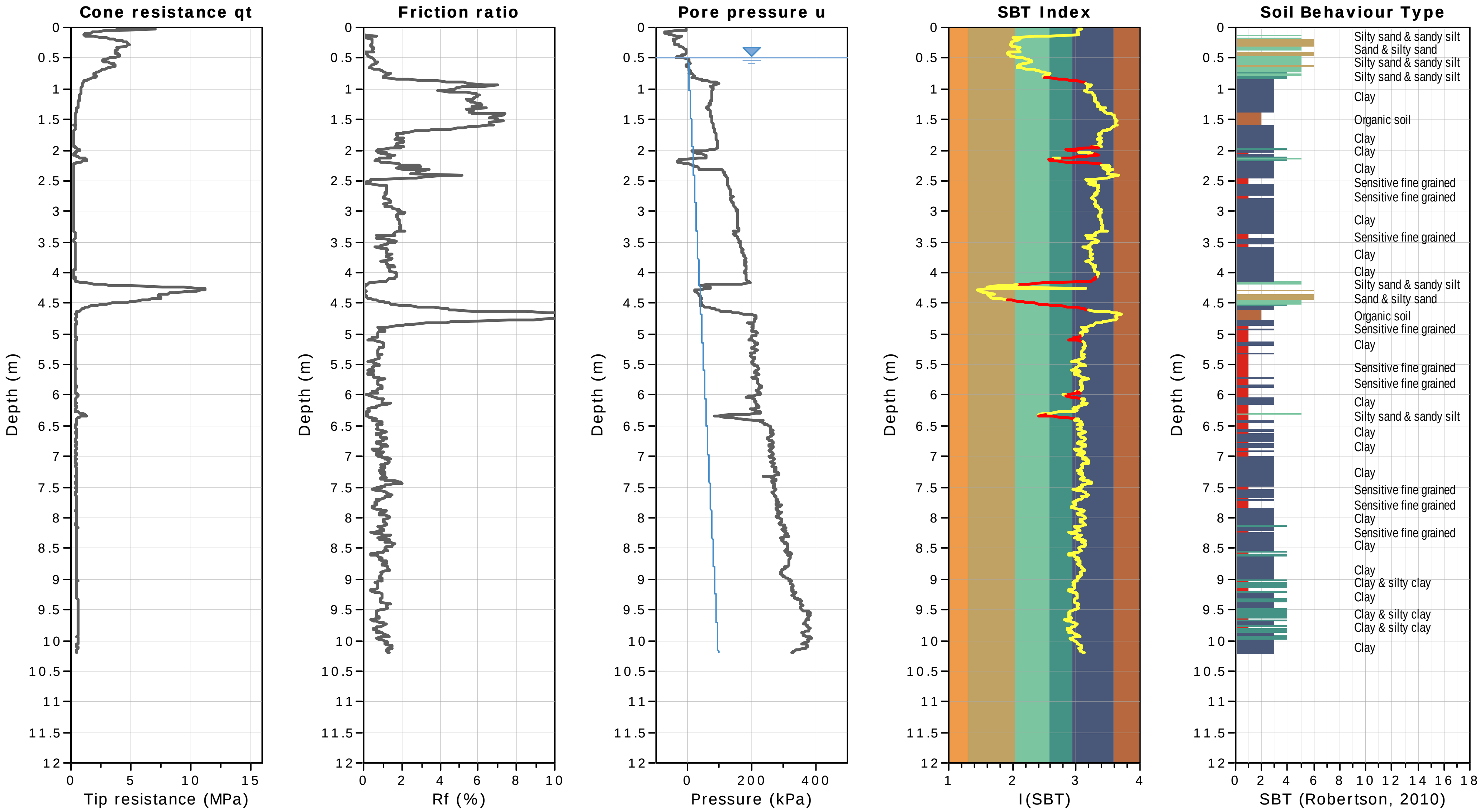
Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**

CPT17-16_RevA
Total depth: 10.20 m, Date: 03/01/2018
Cone Type: Uknown
Cone Operator: Uknown



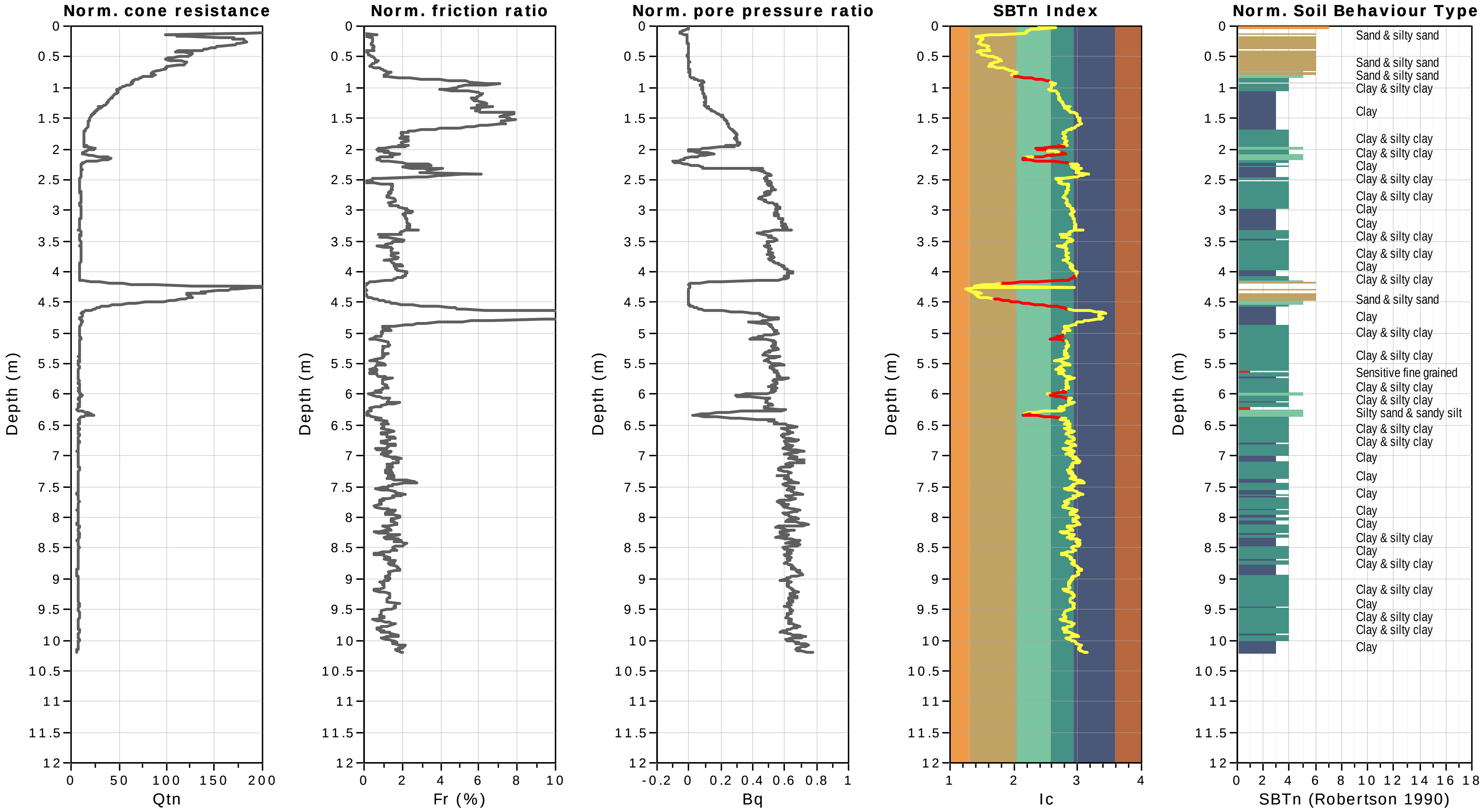
CPT17-16_RevA
Total depth: 10.20 m, Date: 03/01/2018
Cone Type: Uknown
Cone Operator: Uknown

Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**



CPT17-16_RevA
Total depth: 10.20 m, Date: 03/01/2018
Cone Type: Uknown
Cone Operator: Uknown

Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**



Golder Associates Ltd.
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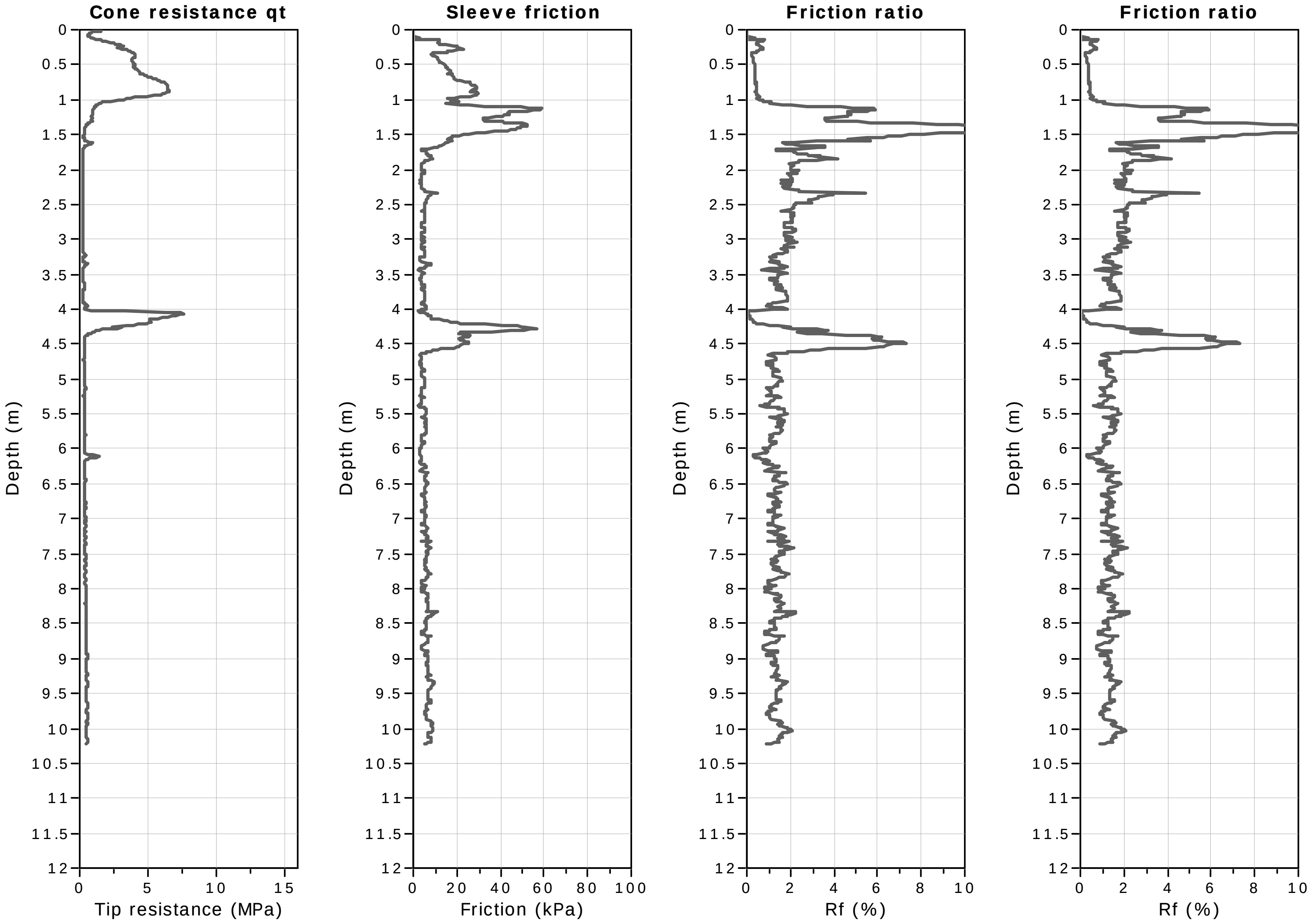
Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**

CPT17-18_RevA
Total depth: 10.23 m, Date: 03/01/2018
Cone Type: I-CFXYP20-10 171029
Cone Operator: M. Roy - Stratum CPT



Golder Associates Ltd.
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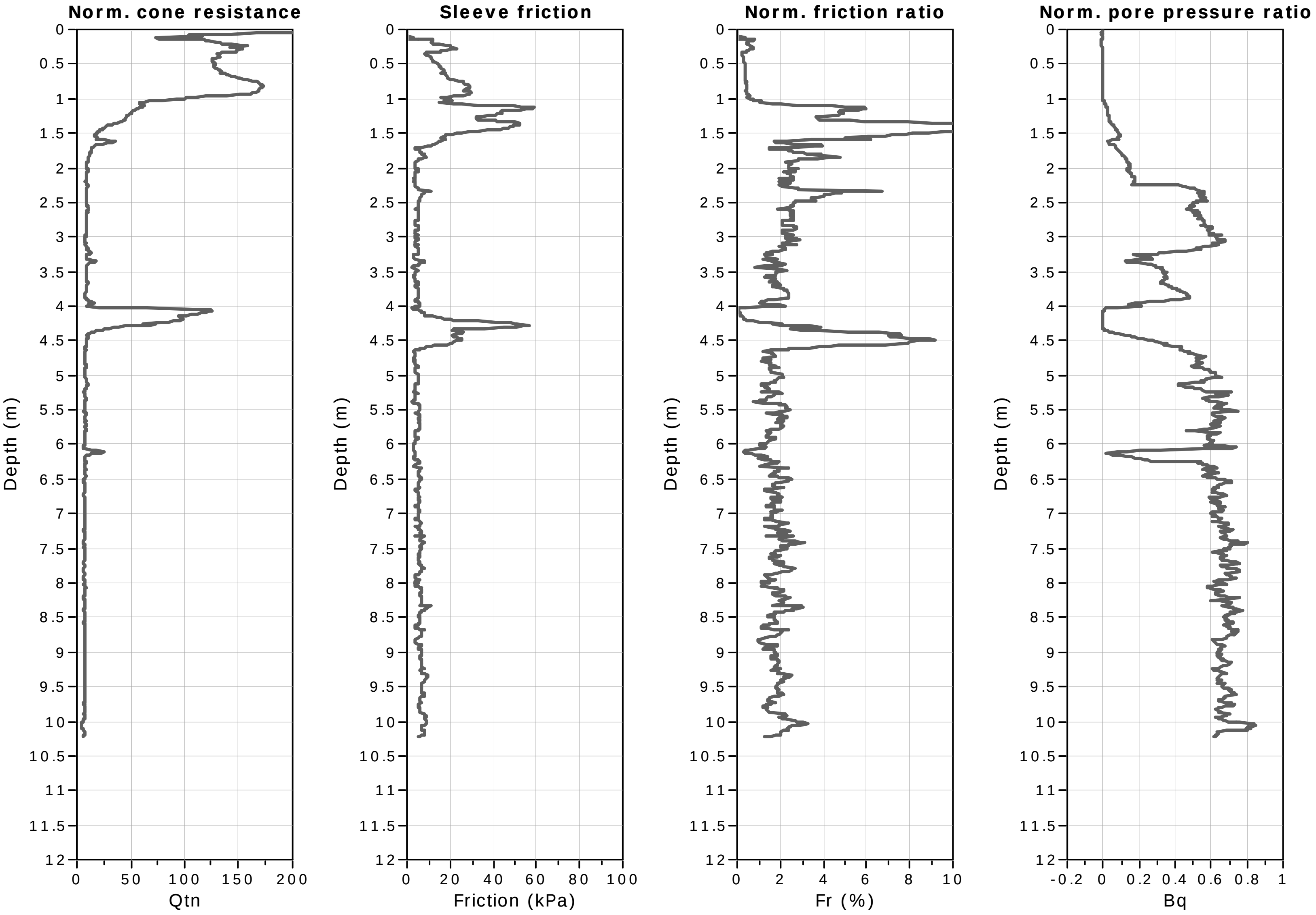
Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**

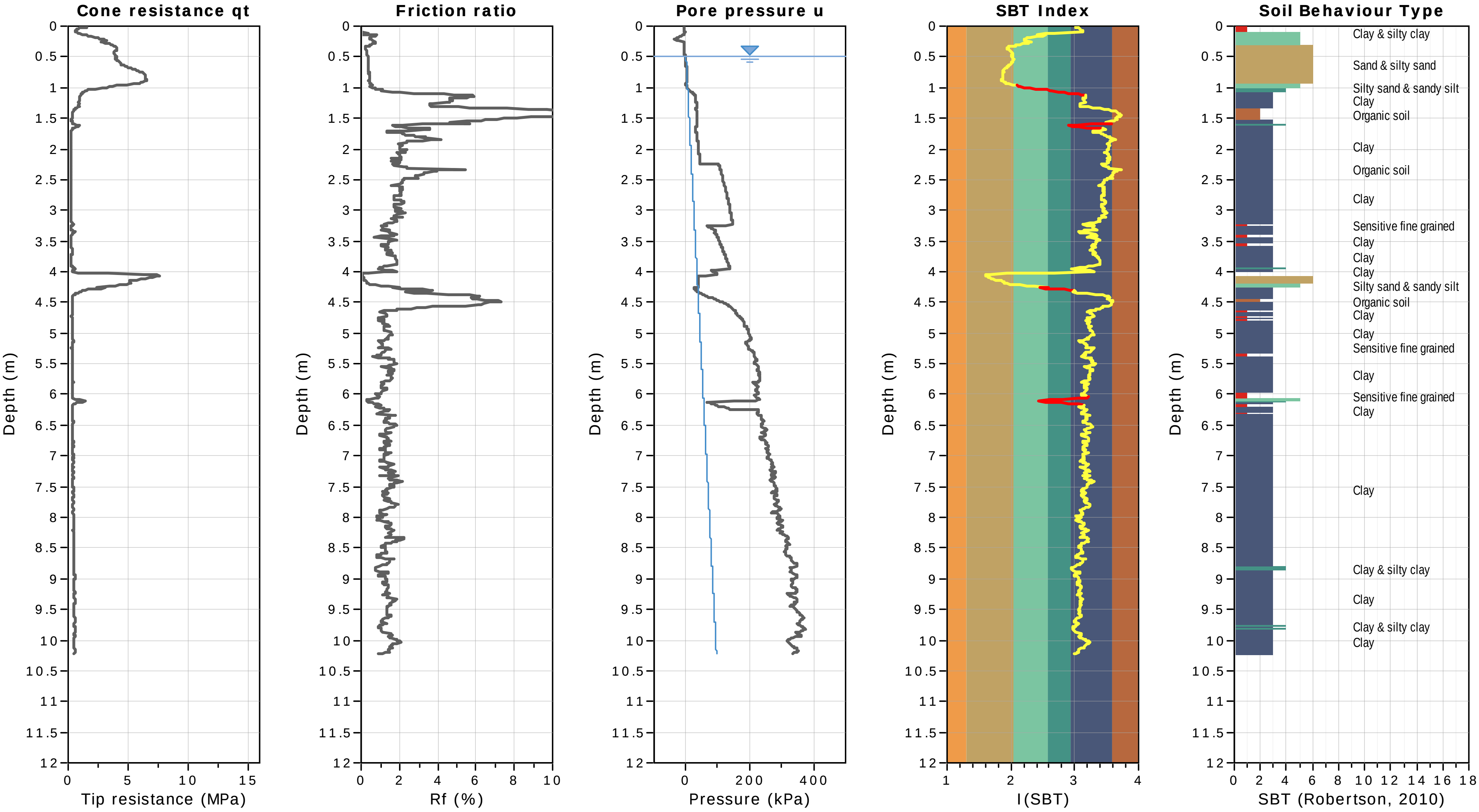
CPT17-18_RevA
Total depth: 10.23 m, Date: 03/01/2018
Cone Type: I-CFXYP20-10 171029
Cone Operator: M. Roy - Stratum CPT



Golder Associates Ltd.
www.golder.com

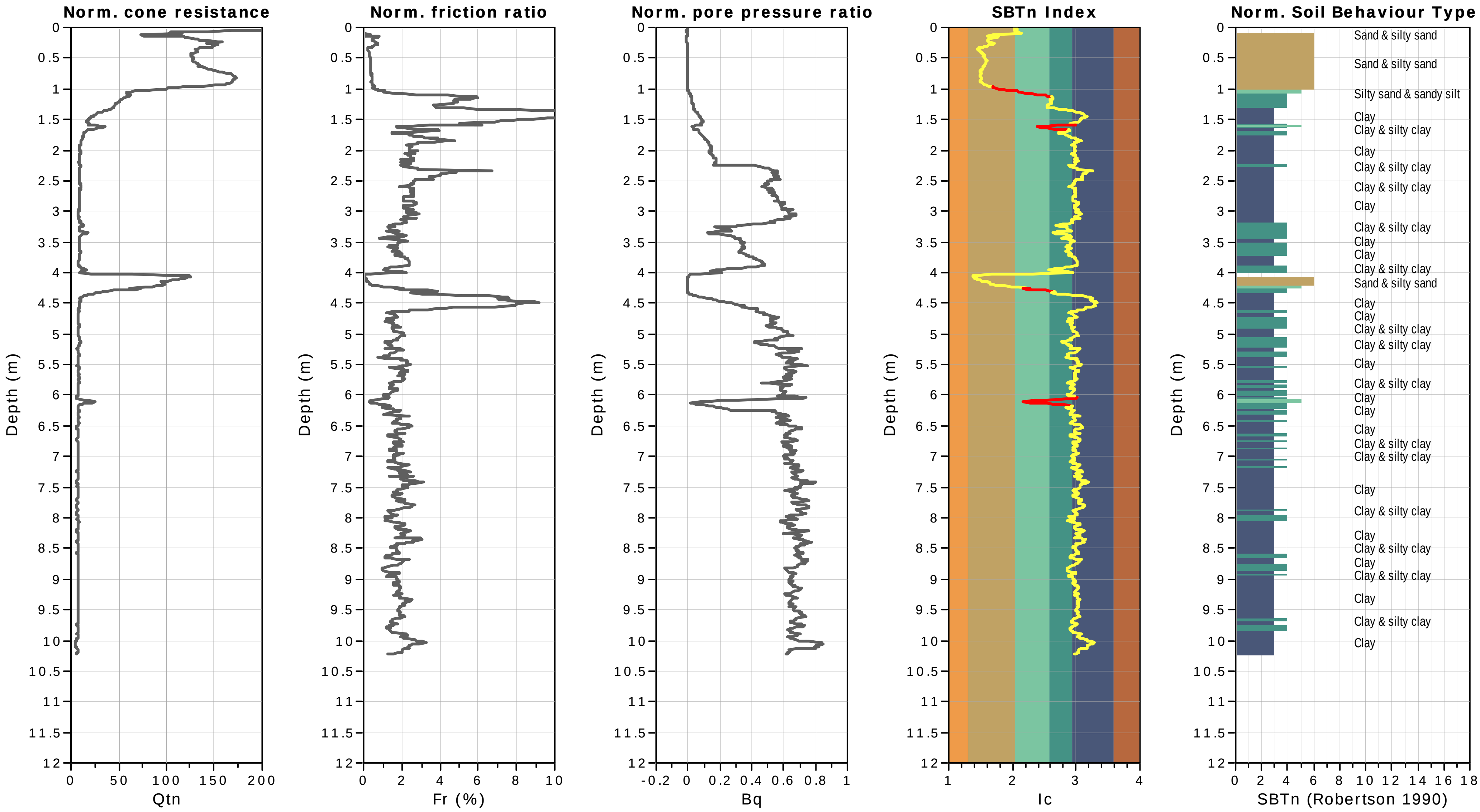
Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**

CPT17-18_RevA
Total depth: 10.23 m, Date: 03/01/2018
Cone Type: I-CFXYP20-10 171029
Cone Operator: M. Roy - Stratum CPT



Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**

CPT17-18_RevA
Total depth: 10.23 m, Date: 03/01/2018
Cone Type: I-CFXYP20-10 171029
Cone Operator: M. Roy - Stratum CPT



Project: **CRRRC - 1787048-400-4.4**

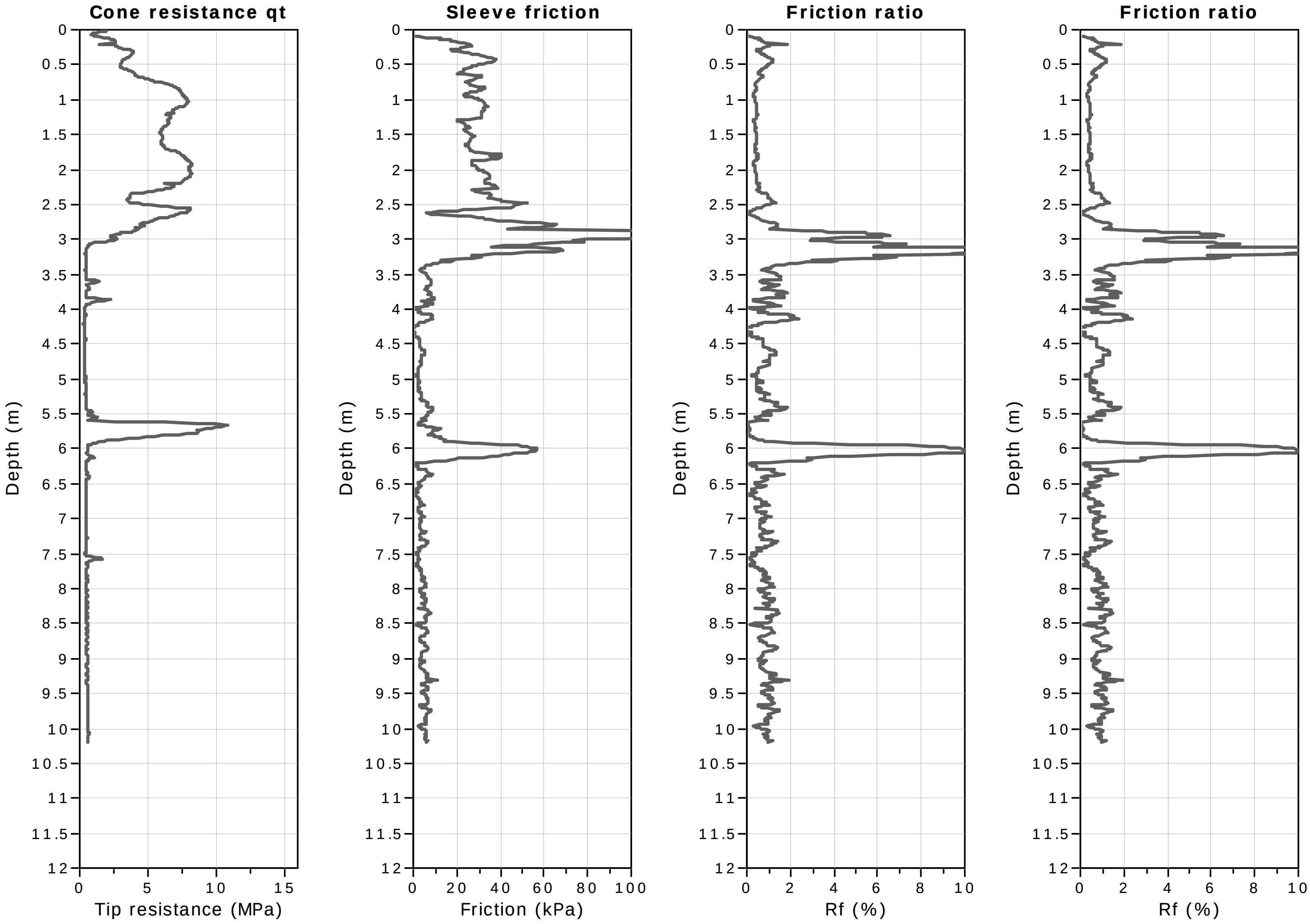
Location: **Ottawa, ON, Canada**

CPT17-22_RevA

Total depth: 10.20 m, Date: 04/01/2018

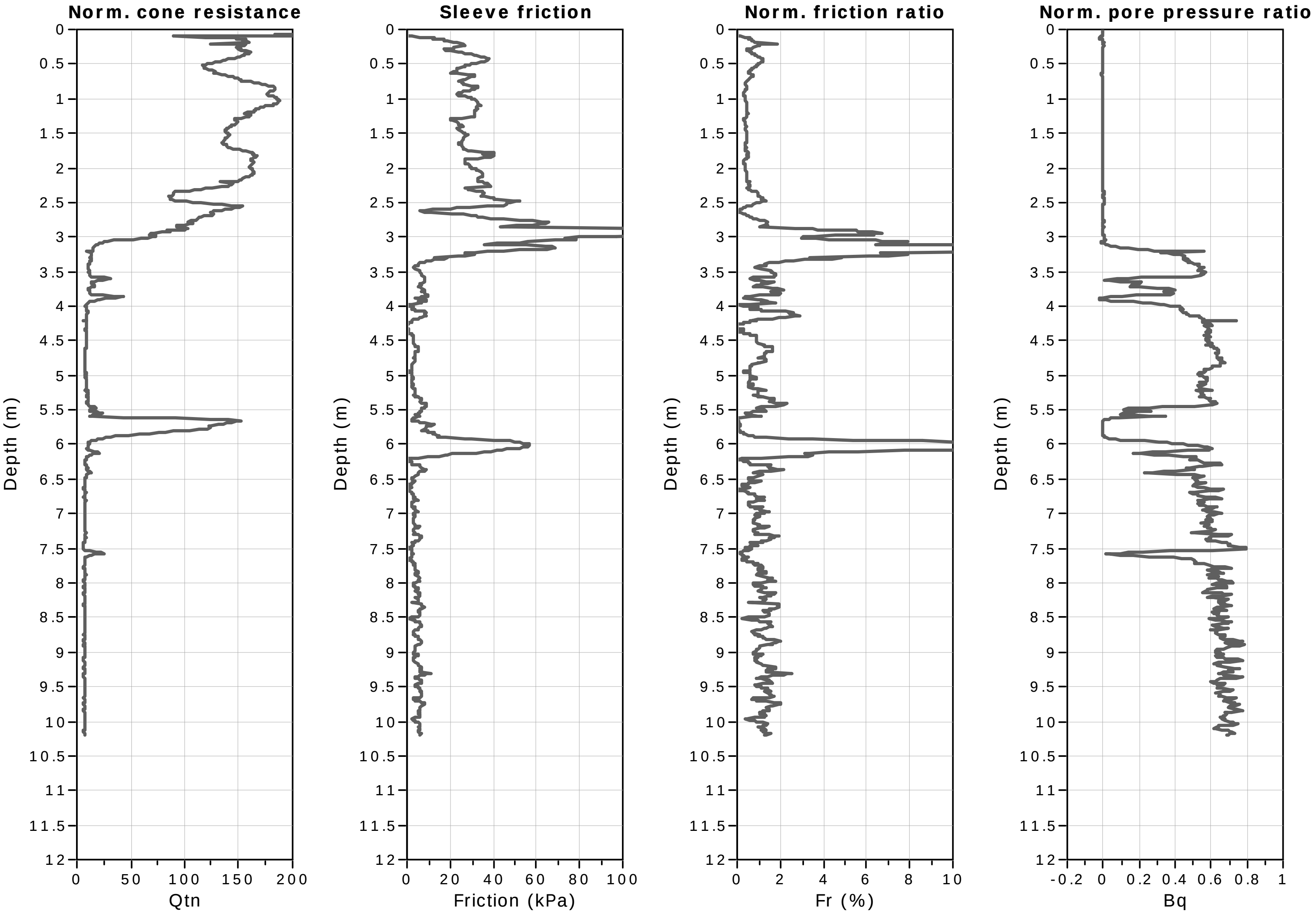
Cone Type: I-CFXYP20-10 171029

Cone Operator: M. Roy - Stratum CPT



Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**

CPT17-22_RevA
Total depth: 10.20 m, Date: 04/01/2018
Cone Type: I-CFXYP20-10 171029
Cone Operator: M. Roy - Stratum CPT



Golder Associates Ltd.
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CPT17-22_RevA

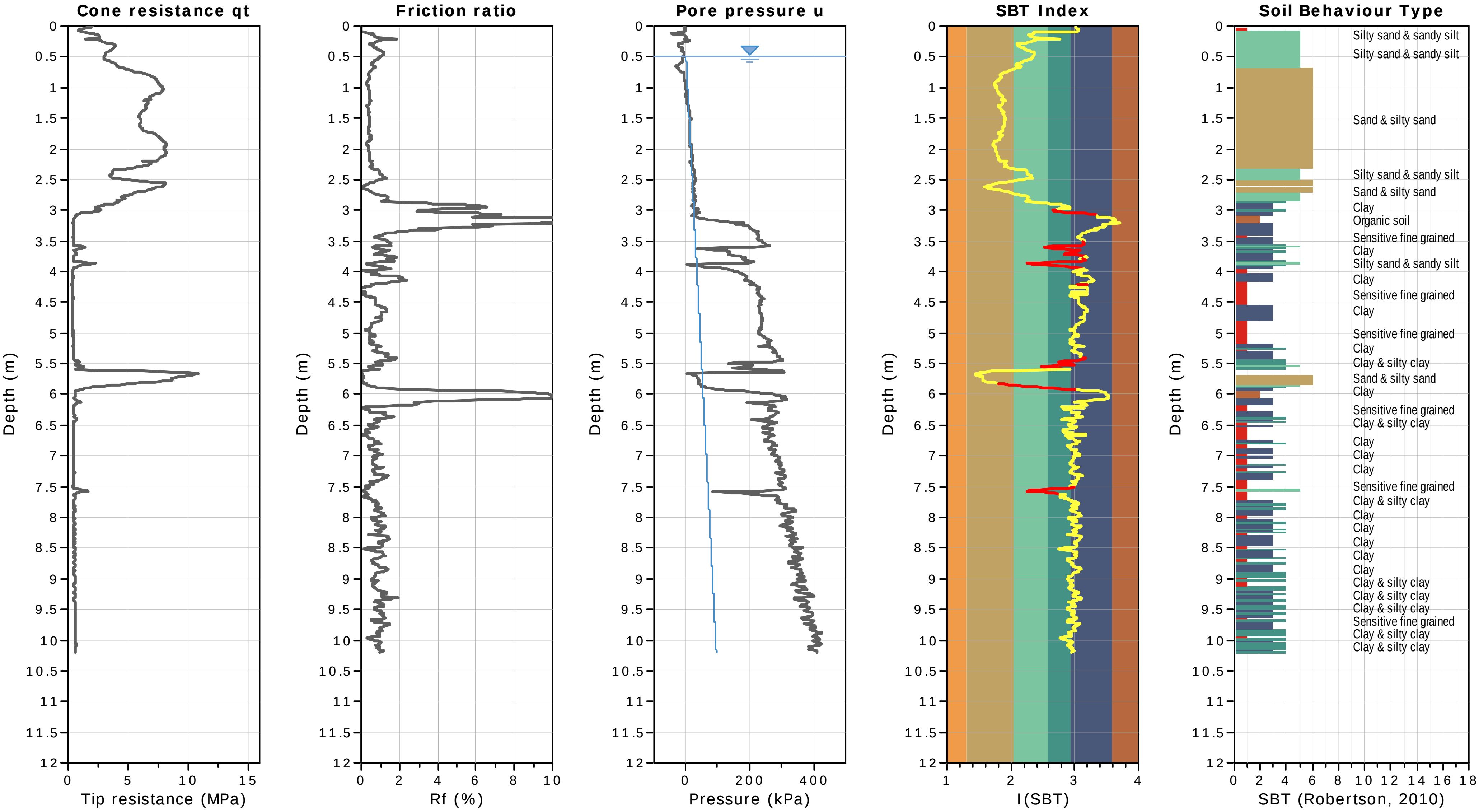
Total depth: 10.20 m, Date: 04/01/2018

Cone Type: I-CFXYP20-10 171029

Cone Operator: M. Roy - Stratum CPT

Project: **CRRRC - 1787048-400-4.4**

Location: **Ottawa, ON, Canada**



Golder Associates Ltd.
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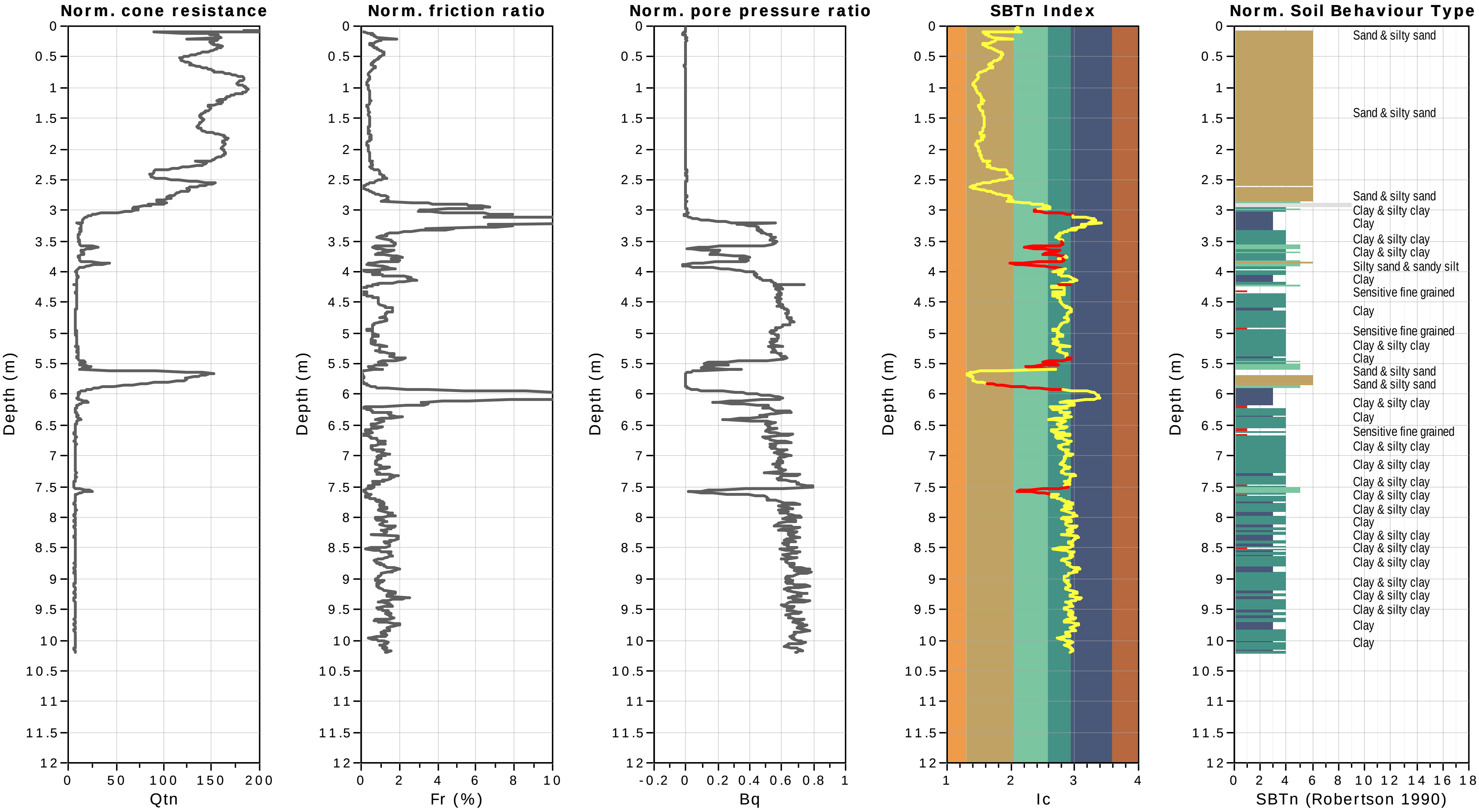
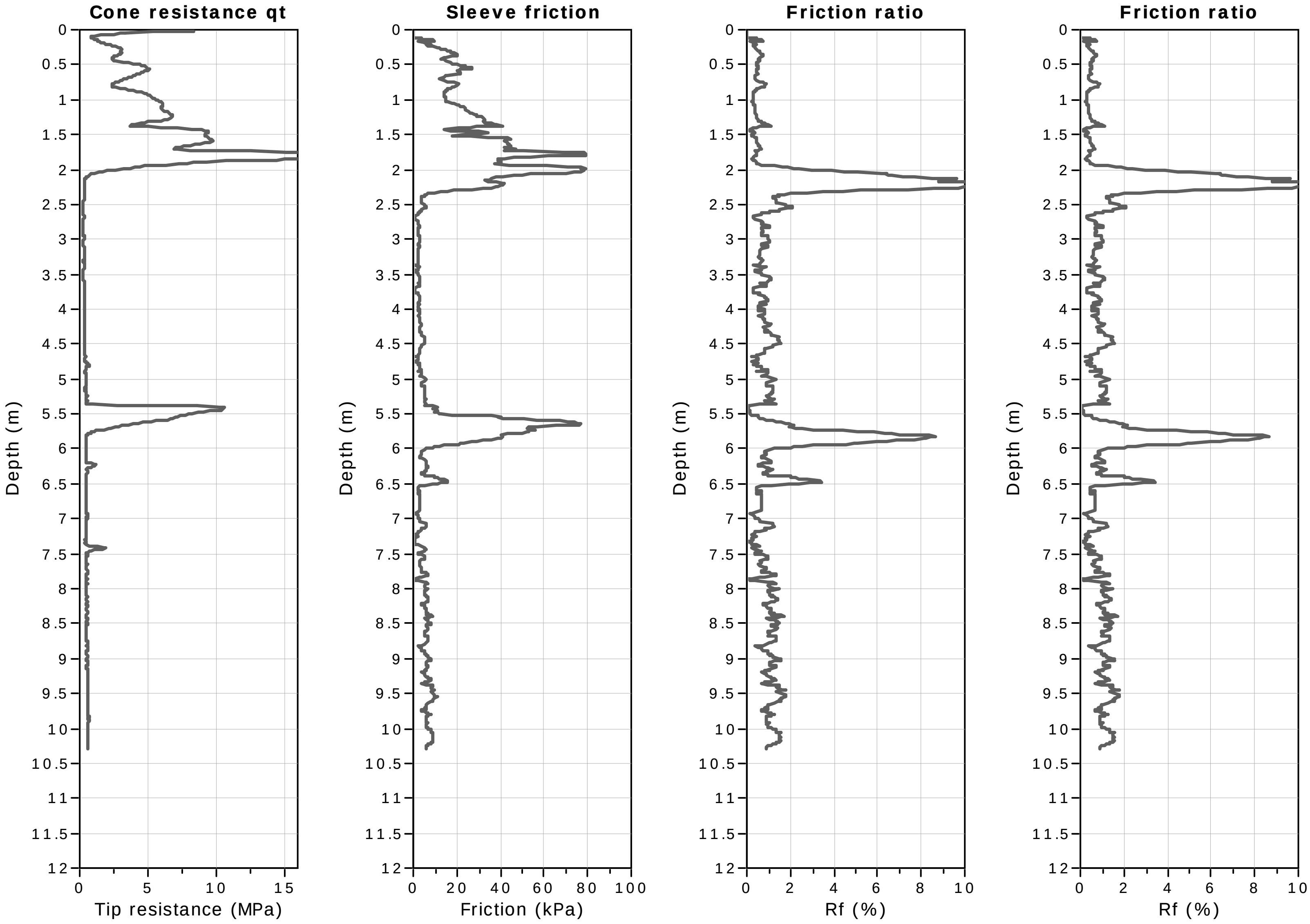
CPT17-22_RevA
Total depth: 10.20 m, Date: 04/01/2018
Cone Type: I-CFXYP20-10 171029
Cone Operator: M. Roy - Stratum CPT

Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**



Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**

CPT17-24_RevA
Total depth: 10.29 m, Date: 04/01/2018
Cone Type: I-CFXYP20-10 171029
Cone Operator: M. Roy - Stratum CPT



Golder Associates Ltd.
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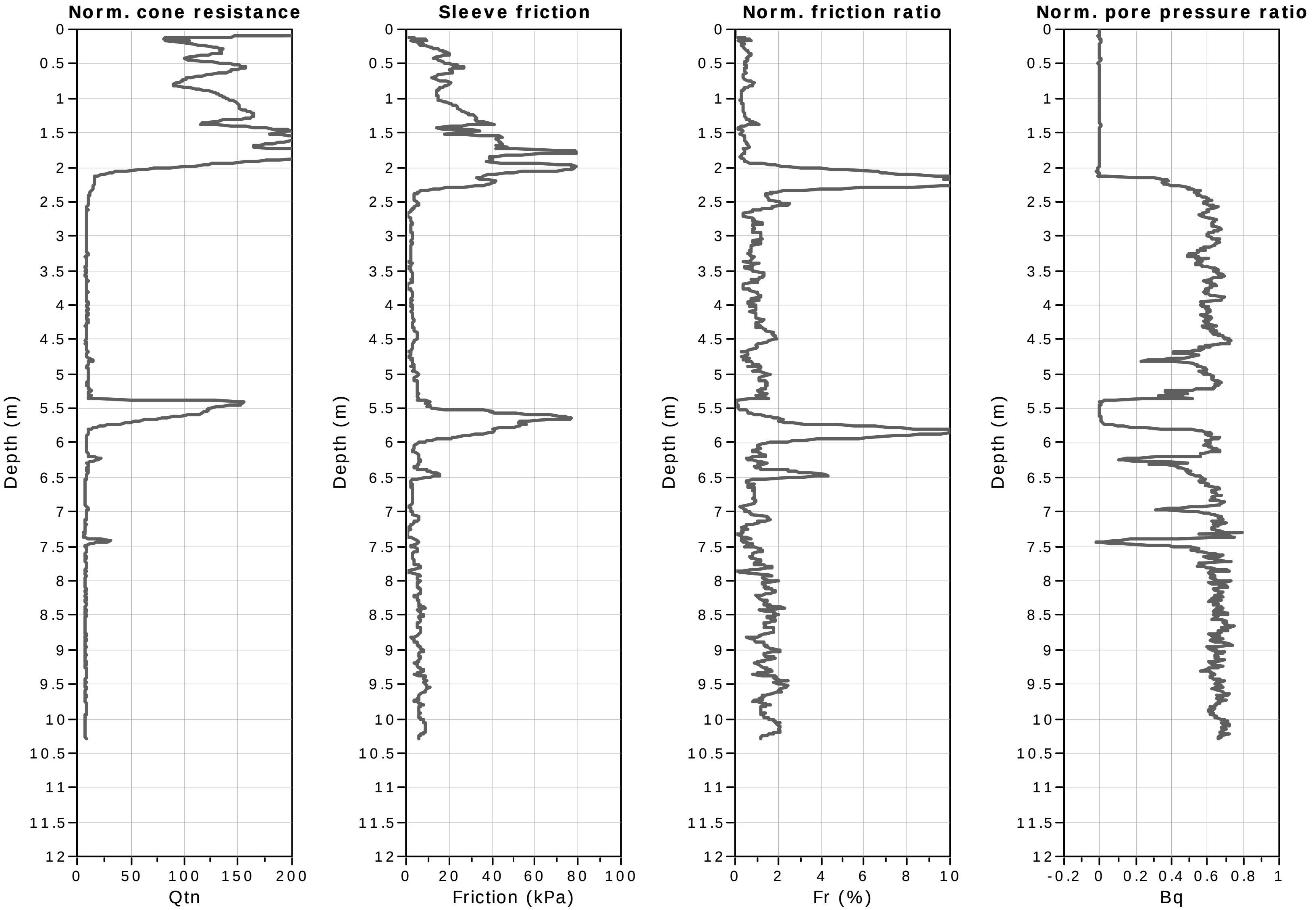
Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**

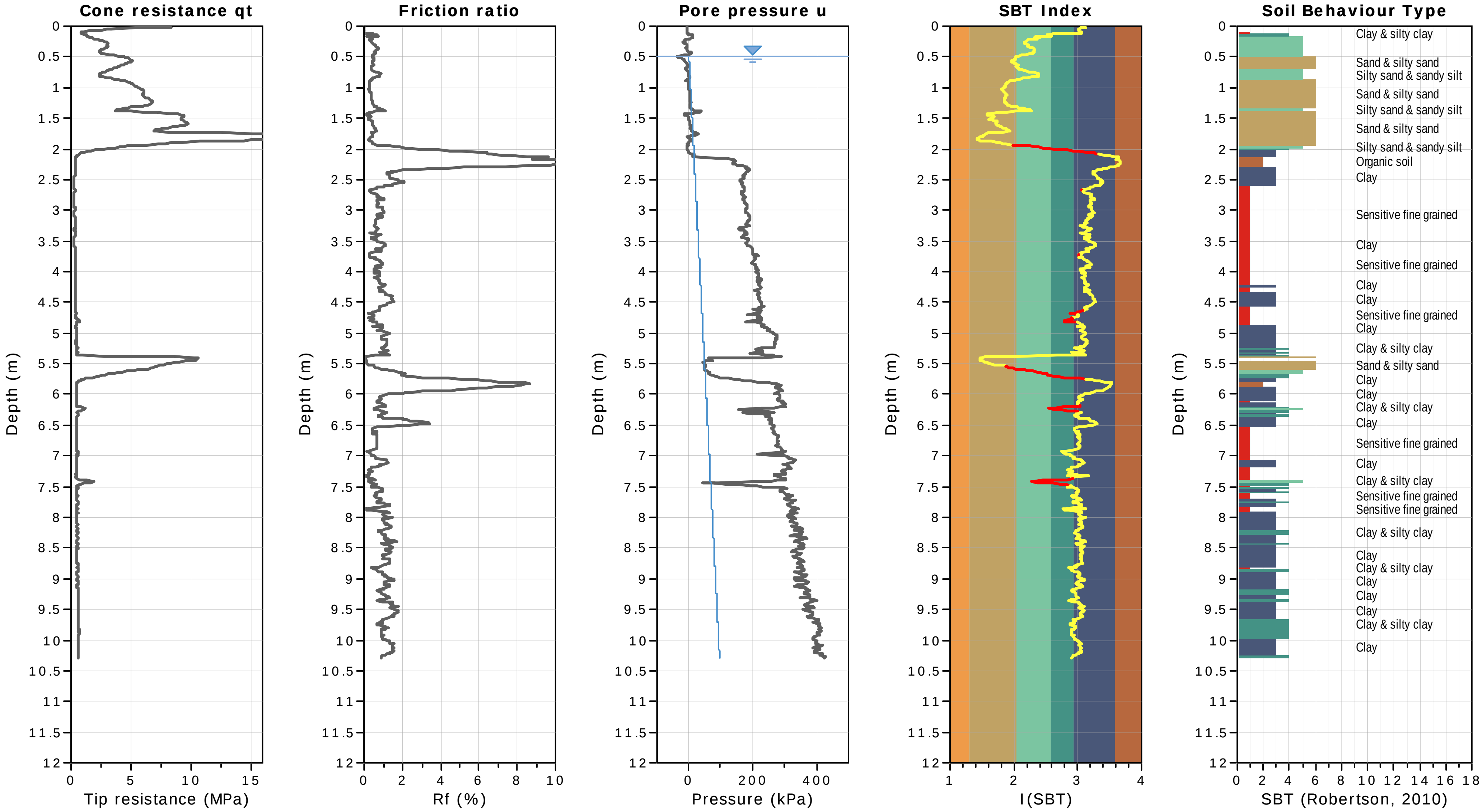
CPT17-24_RevA
Total depth: 10.29 m, Date: 04/01/2018
Cone Type: I-CFXYP20-10 171029
Cone Operator: M. Roy - Stratum CPT



Golder Associates Ltd.
www.golder.com

Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**

CPT17-24_RevA
Total depth: 10.29 m, Date: 04/01/2018
Cone Type: I-CFXYP20-10 171029
Cone Operator: M. Roy - Stratum CPT



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Golder Associates Ltd.
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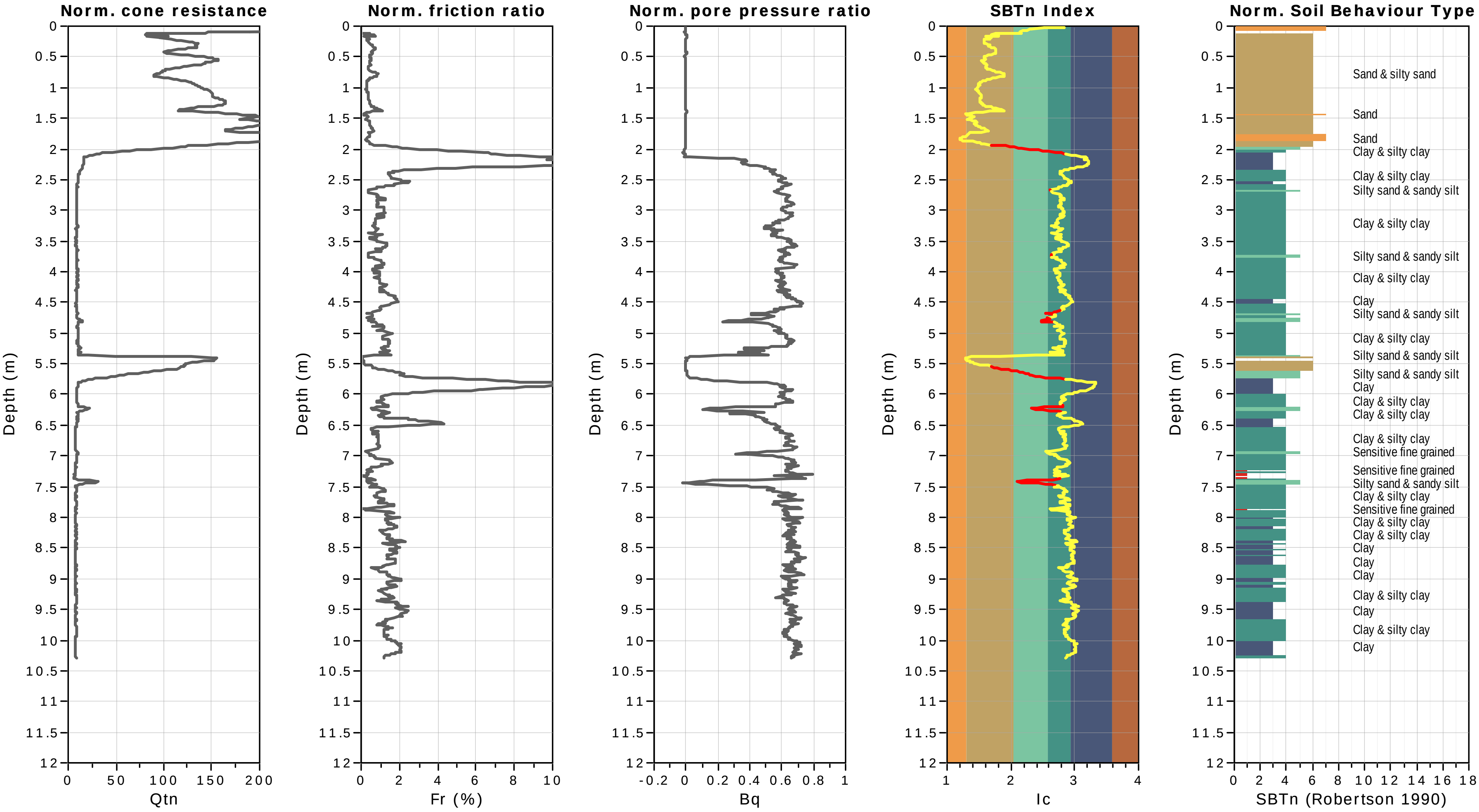
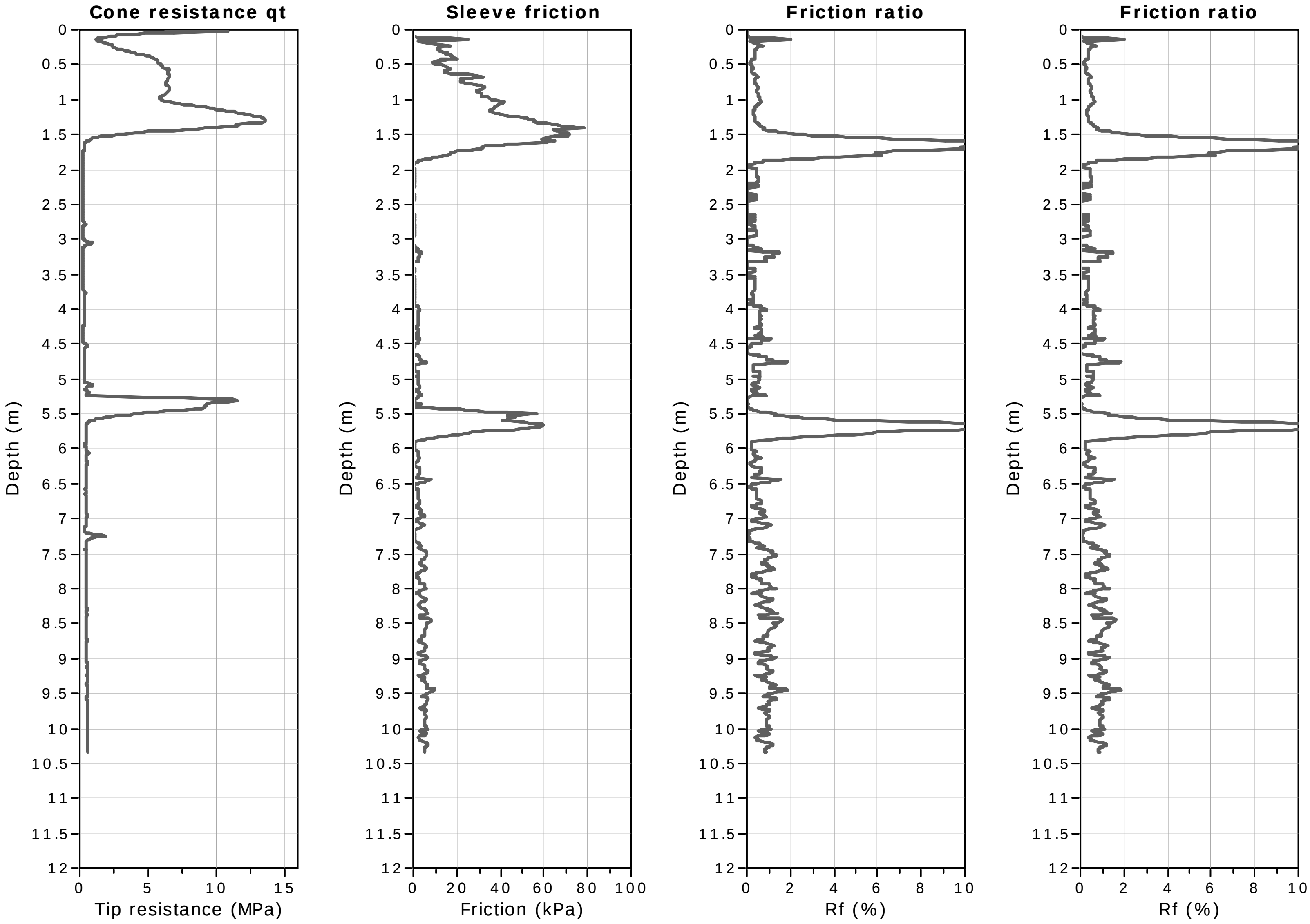
Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**

CPT17-24_RevA
Total depth: 10.29 m, Date: 04/01/2018
Cone Type: I-CFXYP20-10 171029
Cone Operator: M. Roy - Stratum CPT



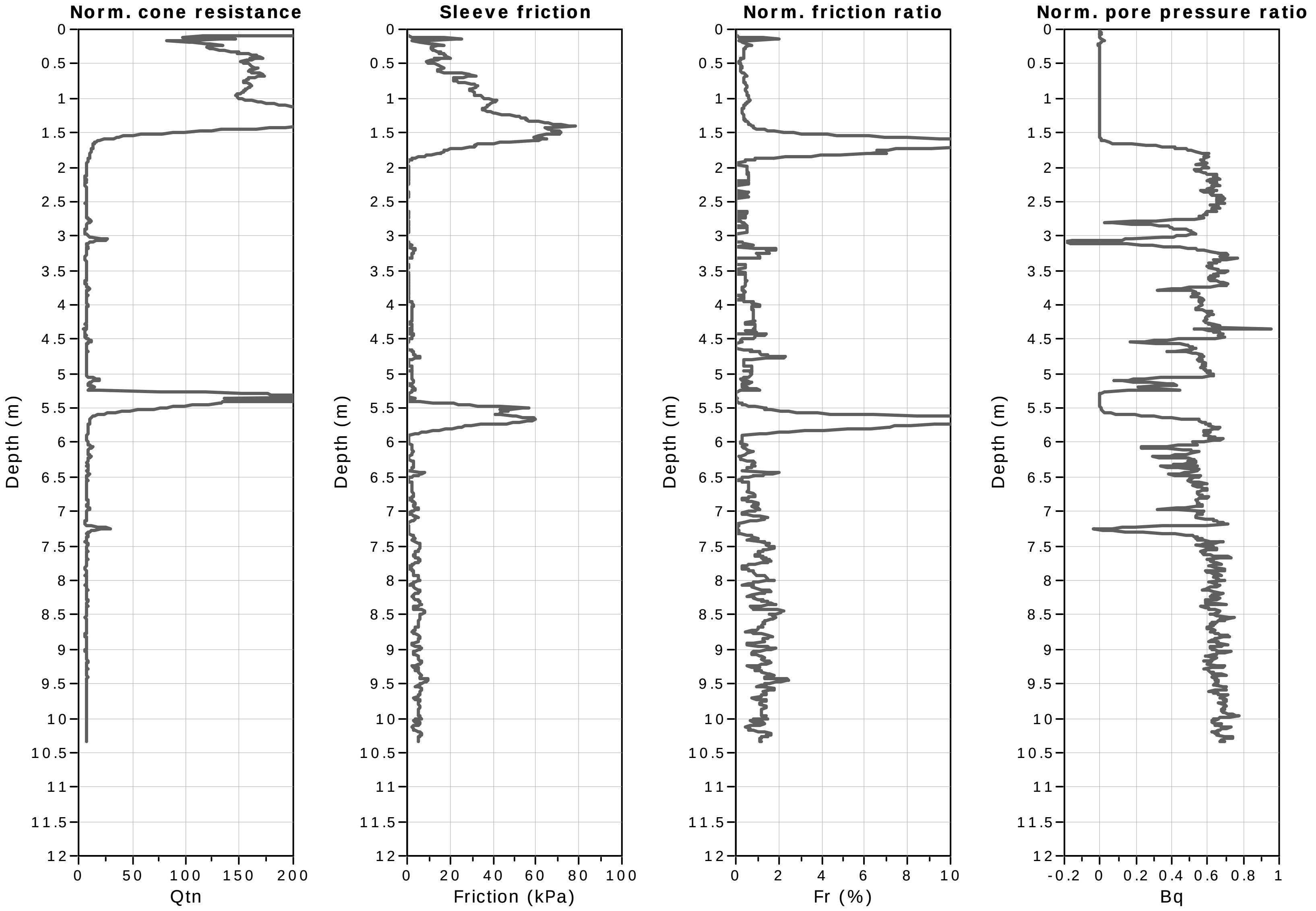
Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**

CPT17-25_RevA
Total depth: 10.34 m, Date: 04/01/2018
Cone Type: Uknown
Cone Operator: Uknown



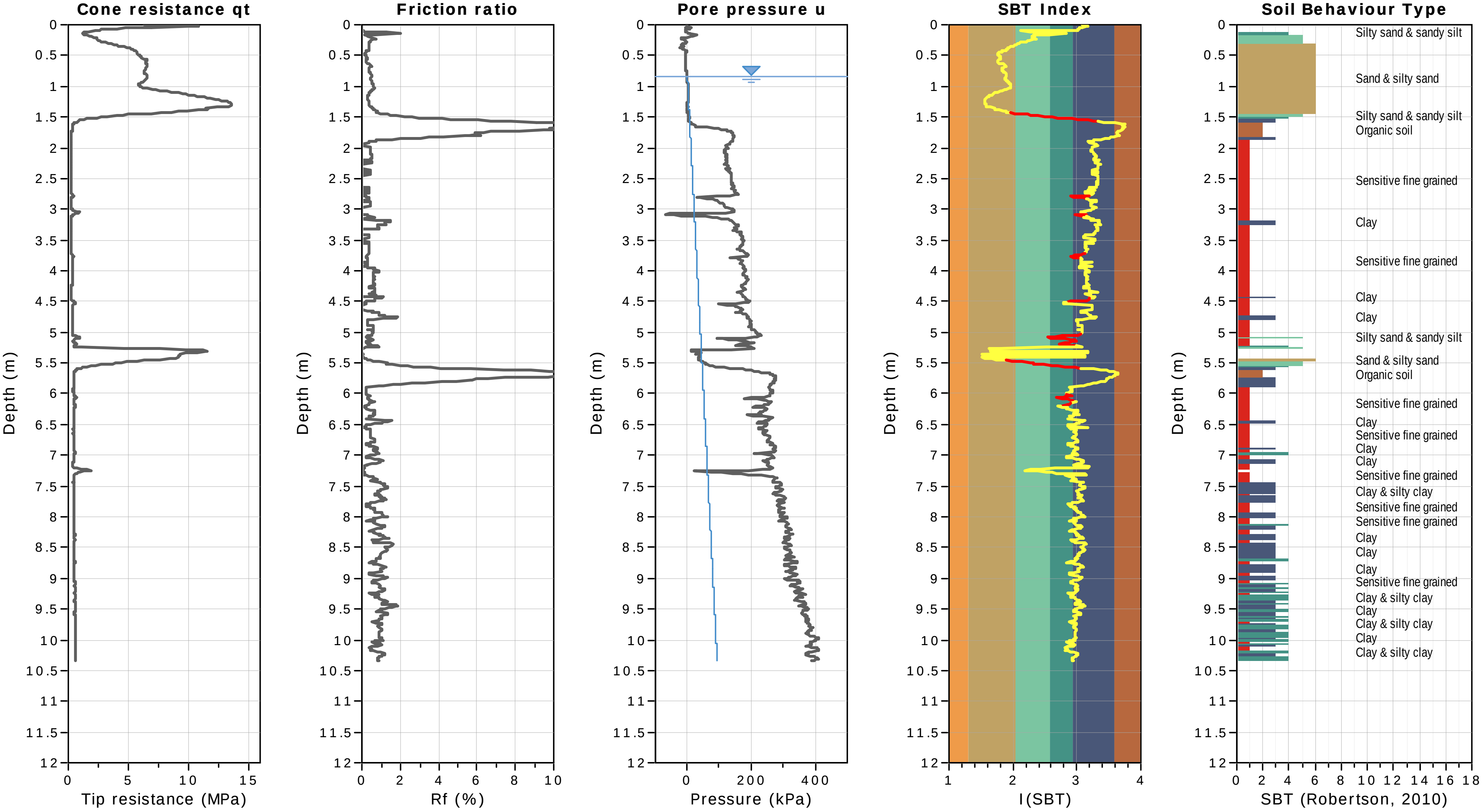
Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**

CPT17-25_RevA
Total depth: 10.34 m, Date: 04/01/2018
Cone Type: Uknown
Cone Operator: Uknown



Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**

CPT17-25_RevA
Total depth: 10.34 m, Date: 04/01/2018
Cone Type: Uknown
Cone Operator: Uknown



Golder Associates Ltd.
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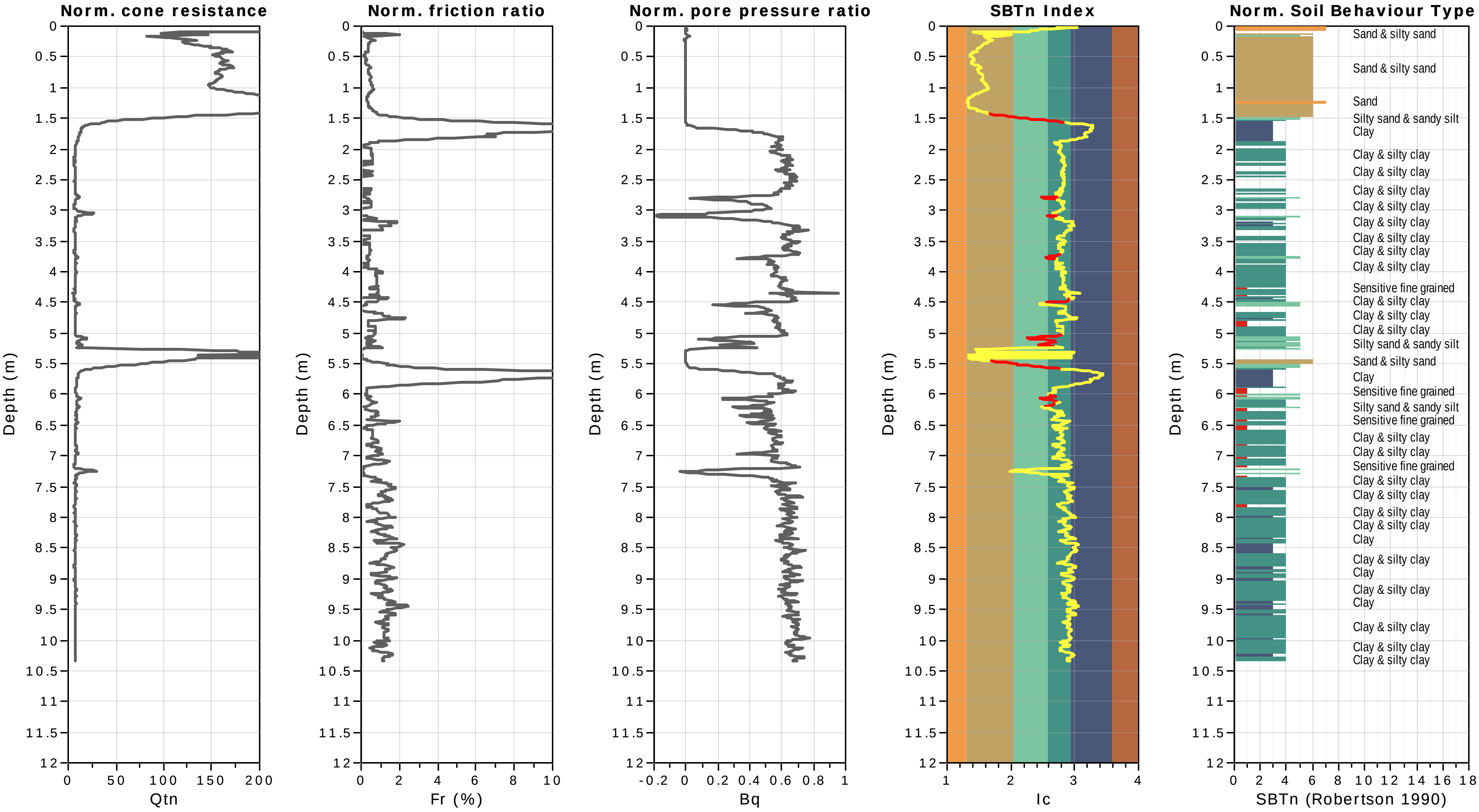
Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**

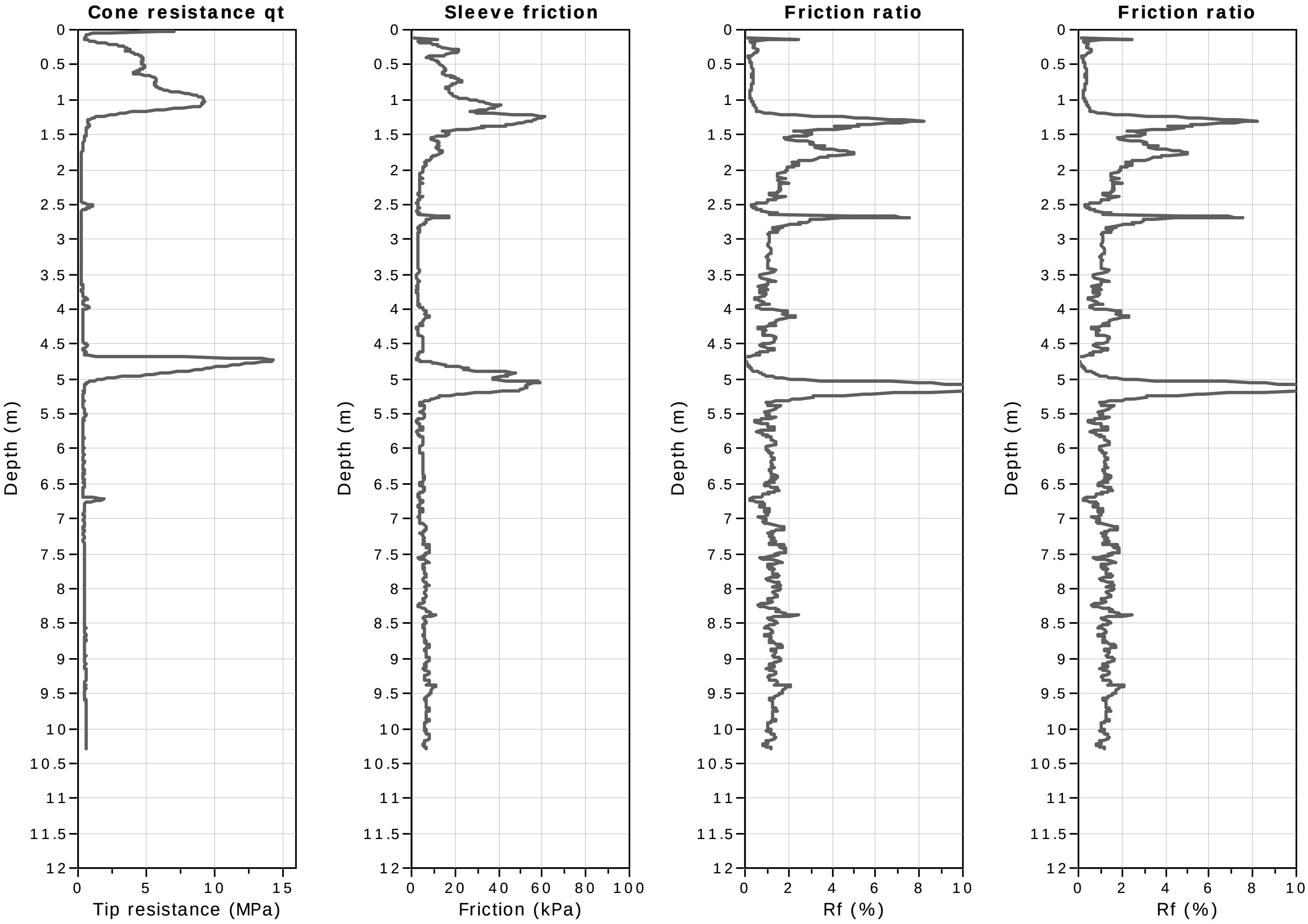
CPT17-25_RevA
Total depth: 10.34 m, Date: 04/01/2018
Cone Type: Uknown
Cone Operator: Uknown



CPT17-28_RevA

Total depth: 10.29 m, Date: 04/01/2018
Cone Type: I-CFXYP20-10 171029
Cone Operator: M. Roy - Stratum CPT

Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**



Golder Associates Ltd.
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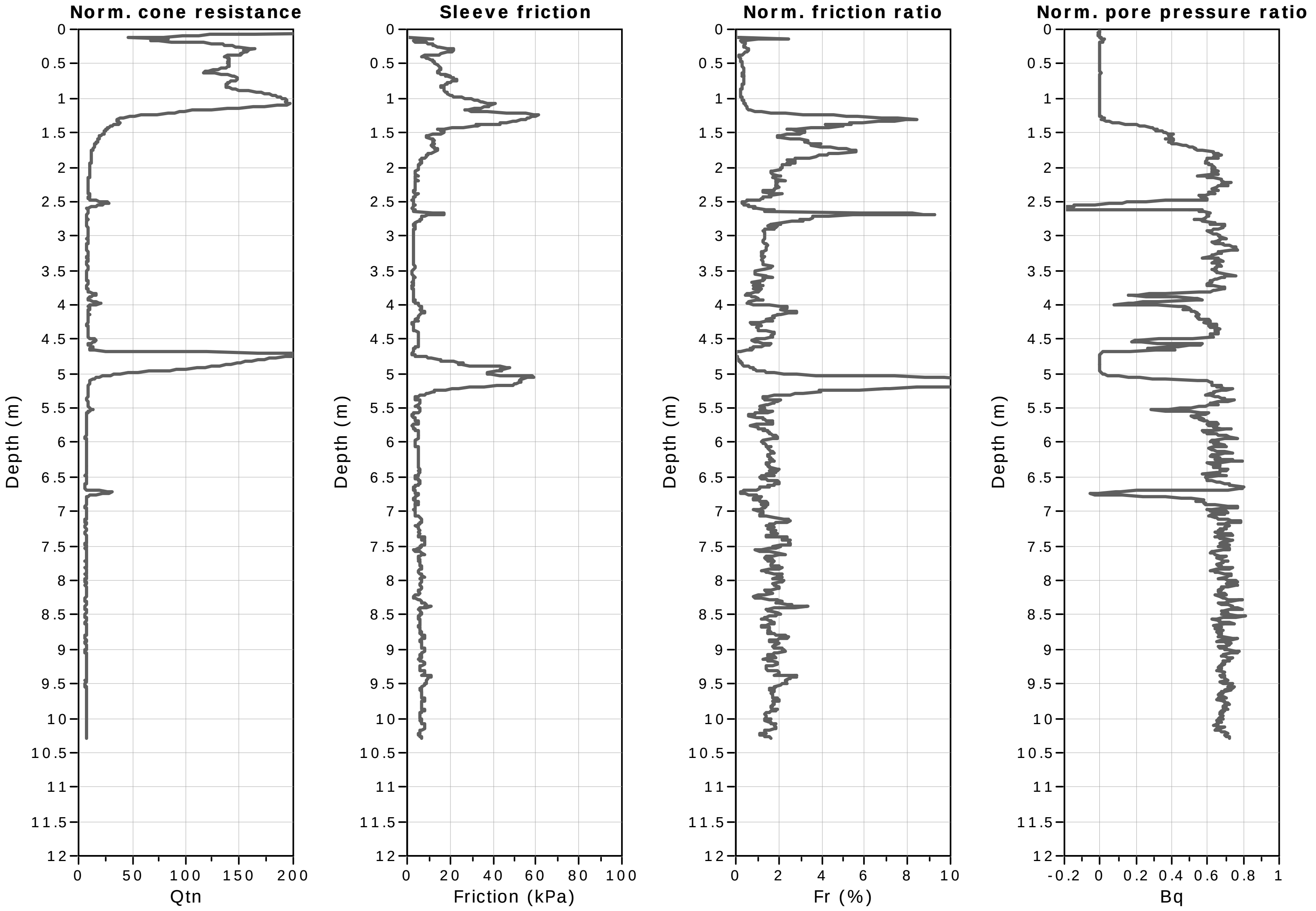
Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**

CPT17-28_RevA
Total depth: 10.29 m, Date: 04/01/2018
Cone Type: I-CFXYP20-10 171029
Cone Operator: M. Roy - Stratum CPT



Golder Associates Ltd.
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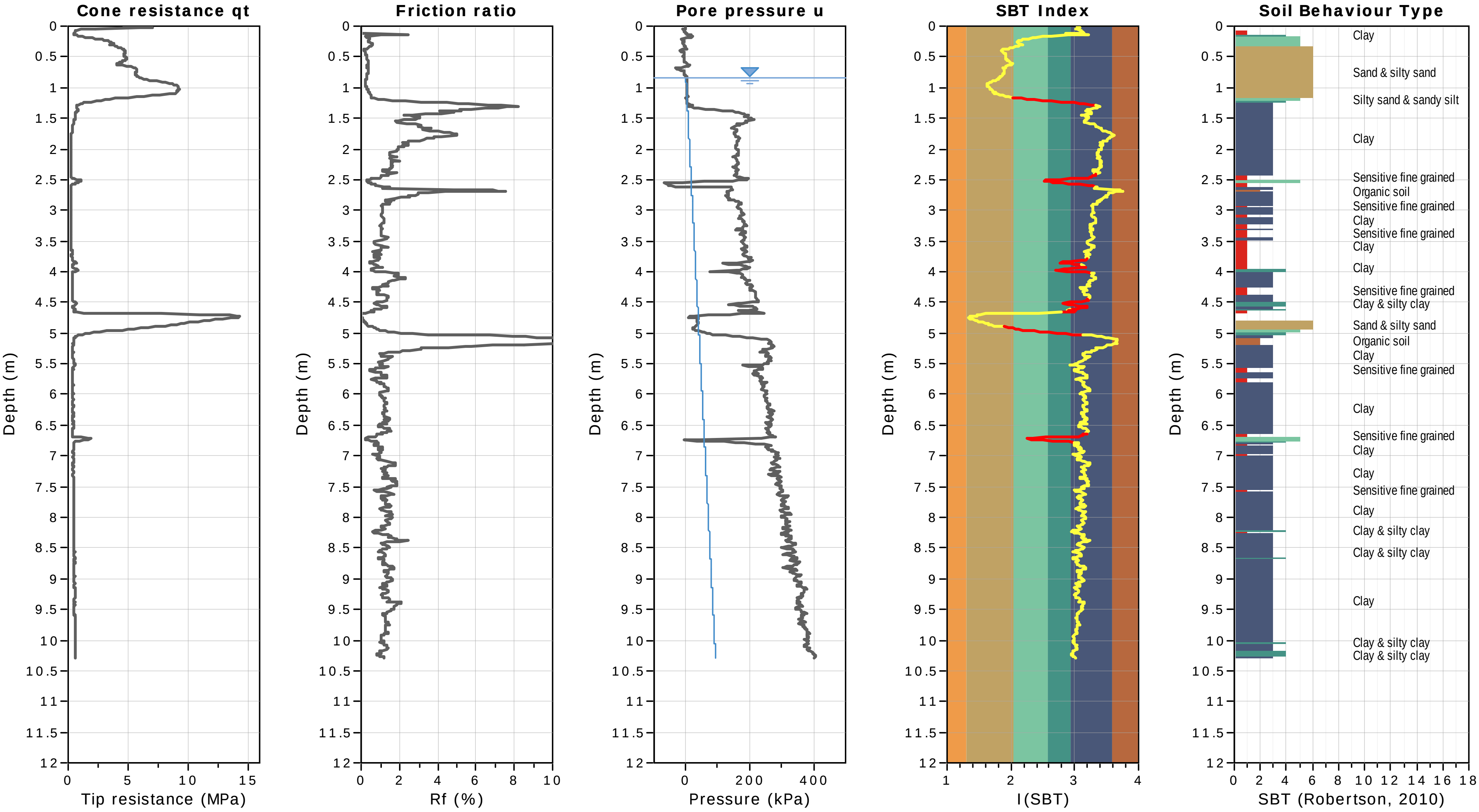
CPT17-28_RevA

Total depth: 10.29 m, Date: 04/01/2018
Cone Type: I-CFXYP20-10 171029
Cone Operator: M. Roy - Stratum CPT

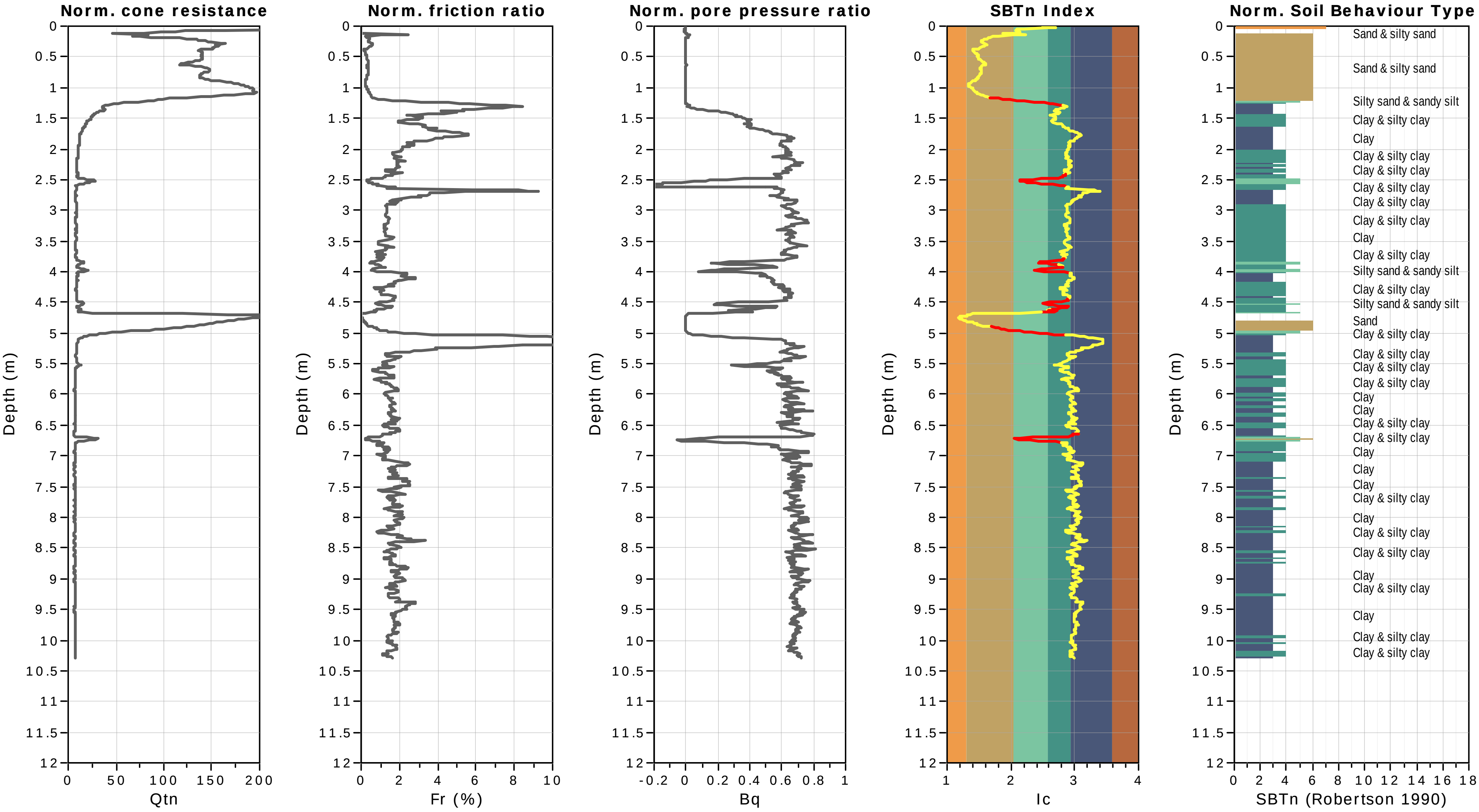
Project: CRRRC - 1787048-400-4.4
Location: Ottawa, ON, Canada



Project: CRRRC - 1787048-400-4.4
Location: Ottawa, ON, Canada

CPT17-28_RevA

Total depth: 10.29 m, Date: 04/01/2018
Cone Type: I-CFXYP20-10 171029
Cone Operator: M. Roy - Stratum CPT



CPT17-30_RevA

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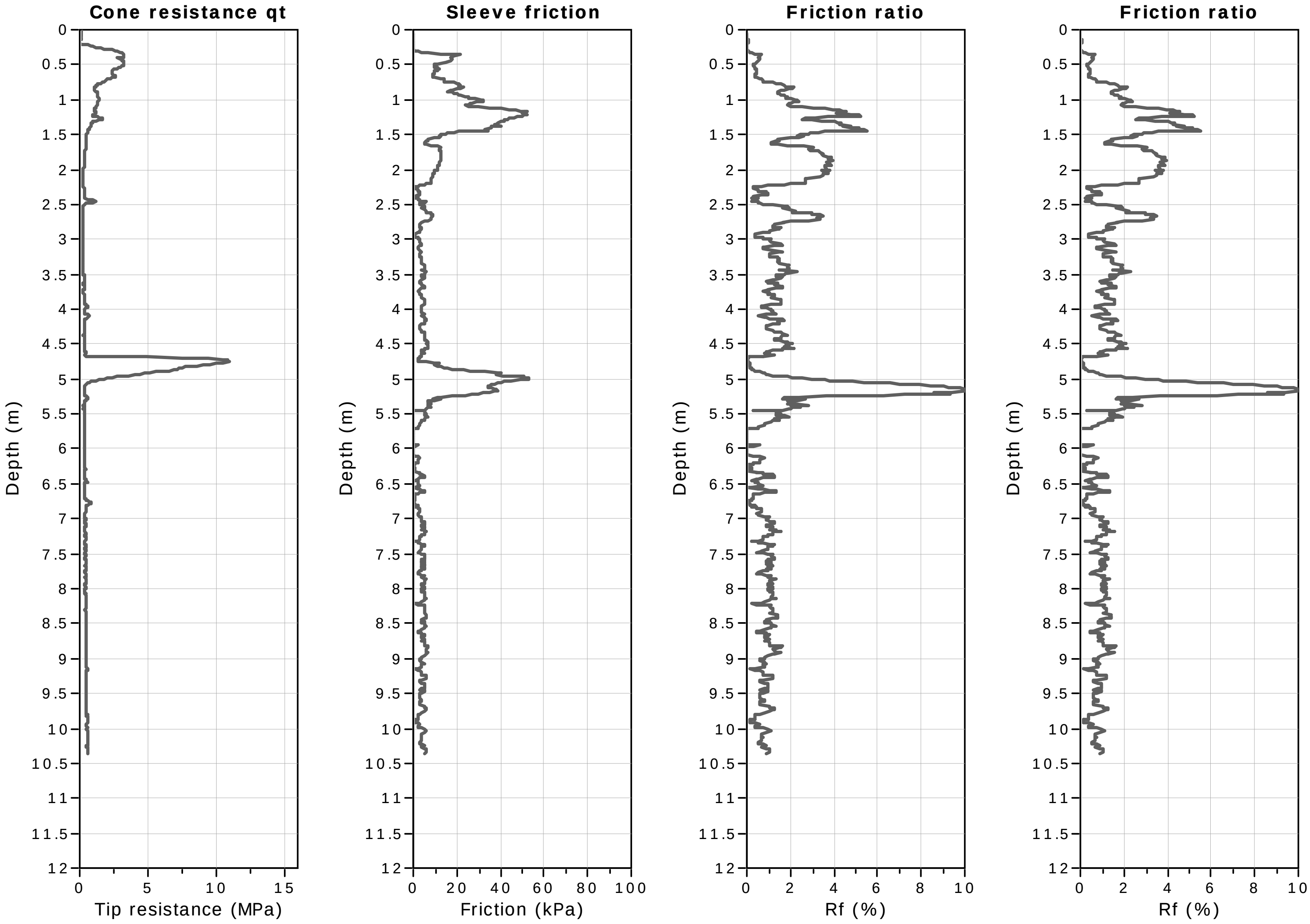
Cone Type: I-CFXYP20-10 171029
Cone Operator: M. Roy - Stratum CPT

Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**



Project: CRRRC - 1787048-400-4.4

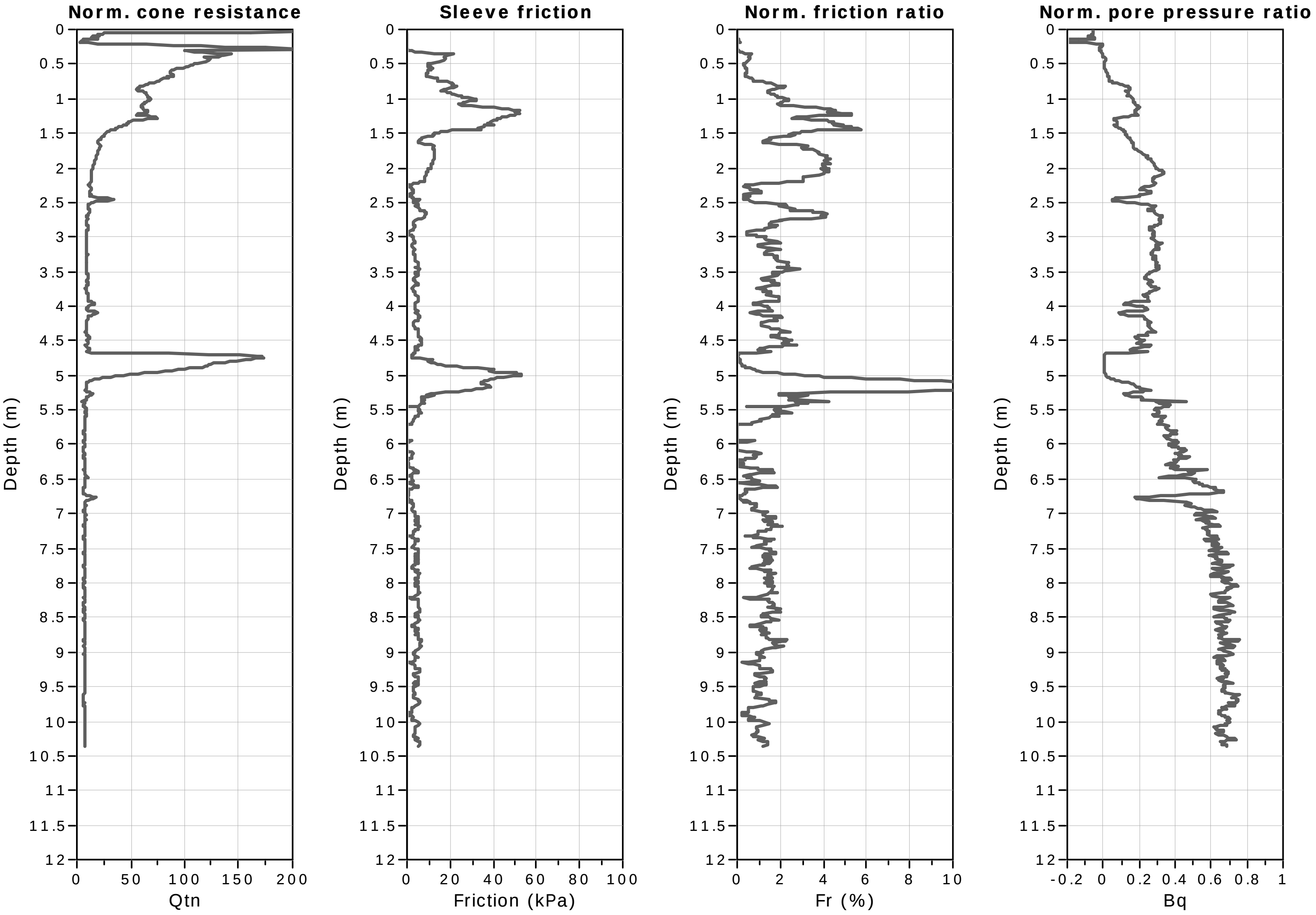
Location: Ottawa, ON, Canada

CPT17-30_RevA

Total depth: 10.36 m, Date: 04/01/2018

Cone Type: I-CFXYP20-10 171029

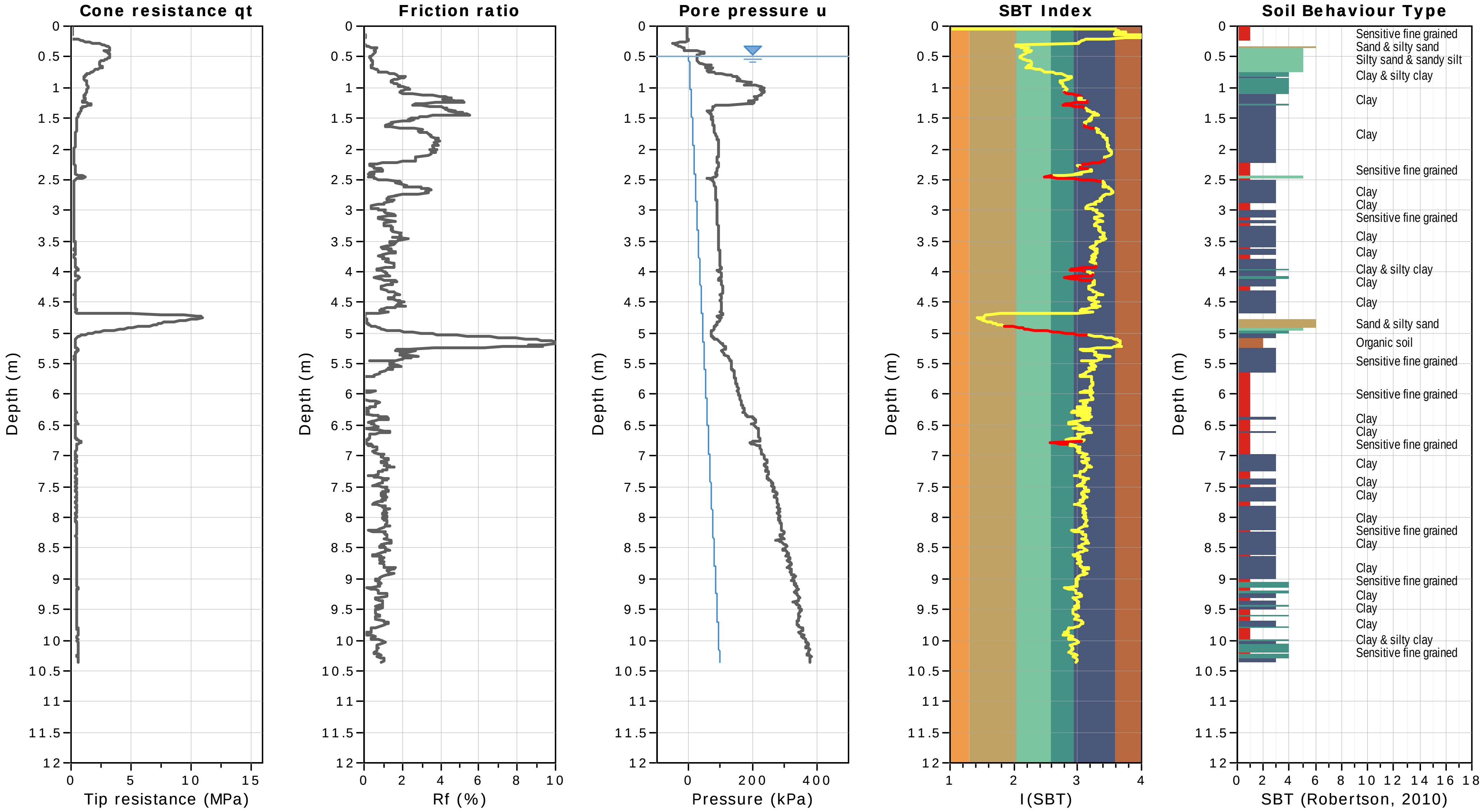
Cone Operator: M. Roy - Stratum CPT



CPT17-30_RevA

Total depth: 10.36 m, Date: 04/01/2018
Cone Type: I-CFXYP20-10 171029
Cone Operator: M. Roy - Stratum CPT

Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**



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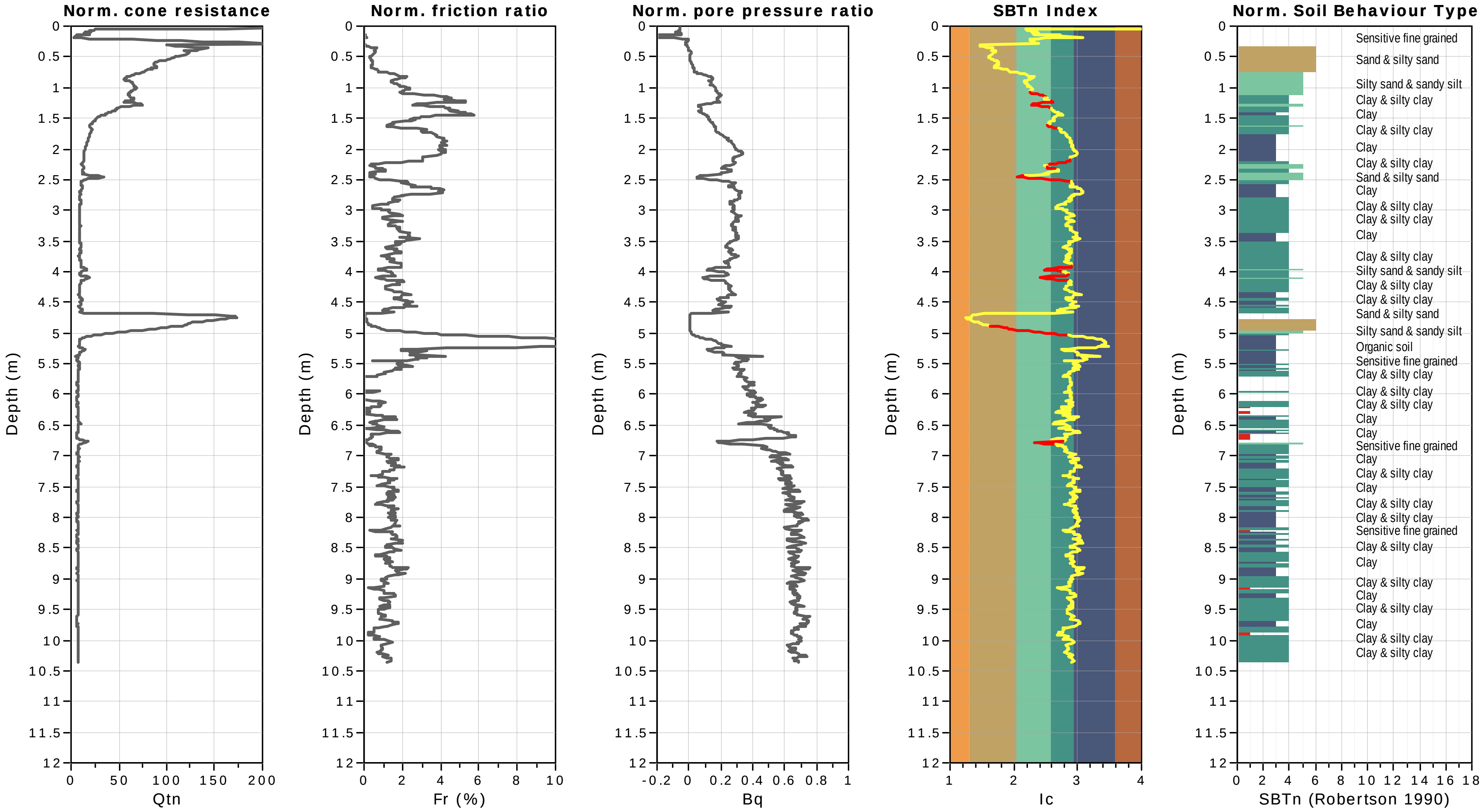
Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**

CPT17-30_RevA
Total depth: 10.36 m, Date: 04/01/2018
Cone Type: I-CFXYP20-10 171029
Cone Operator: M. Roy - Stratum CPT



Golder Associates Ltd.
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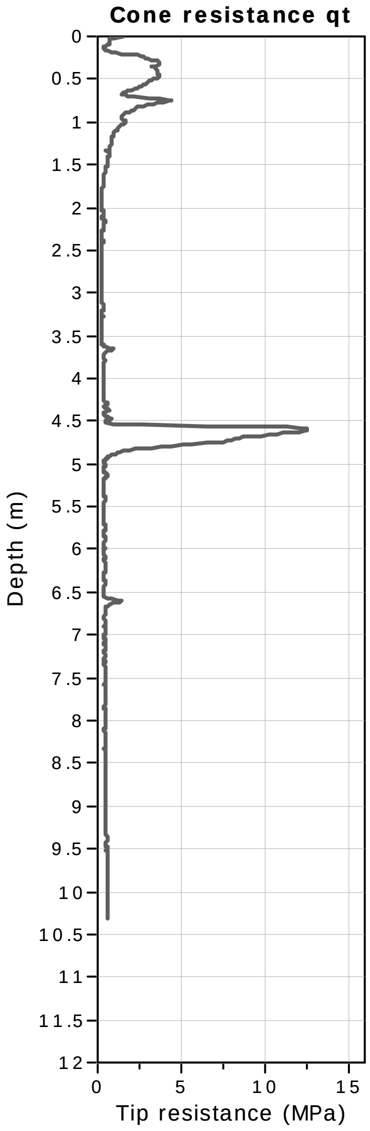
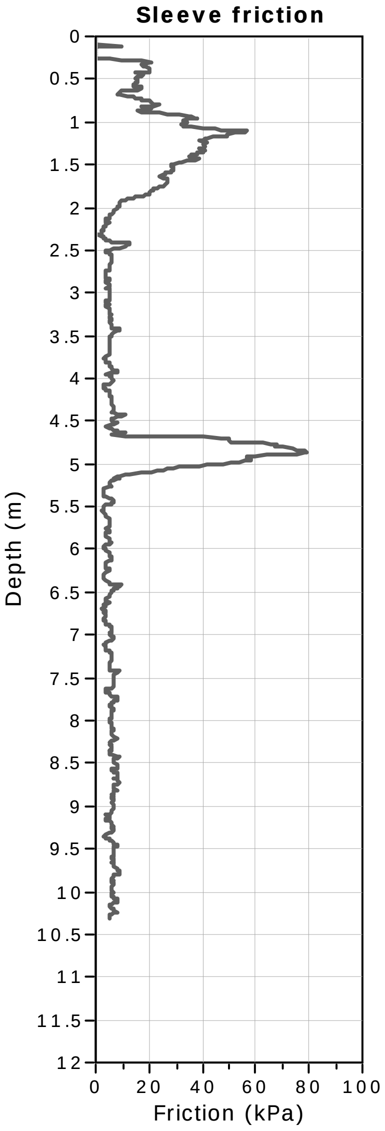
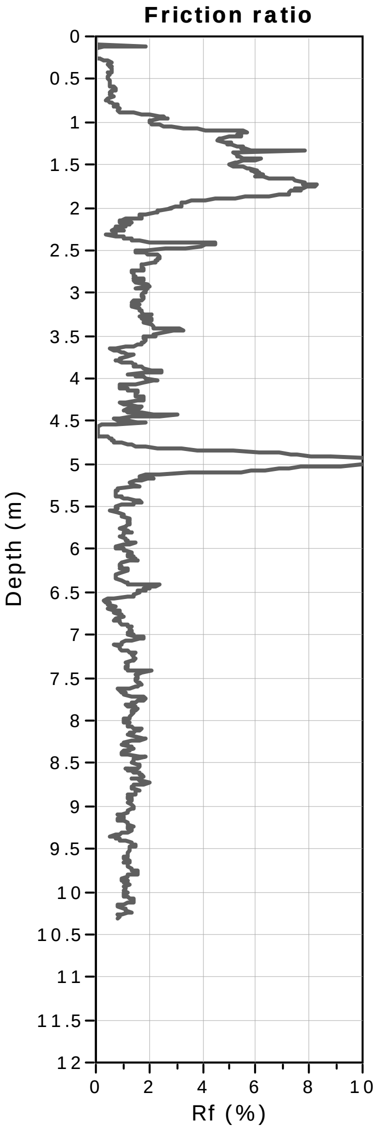
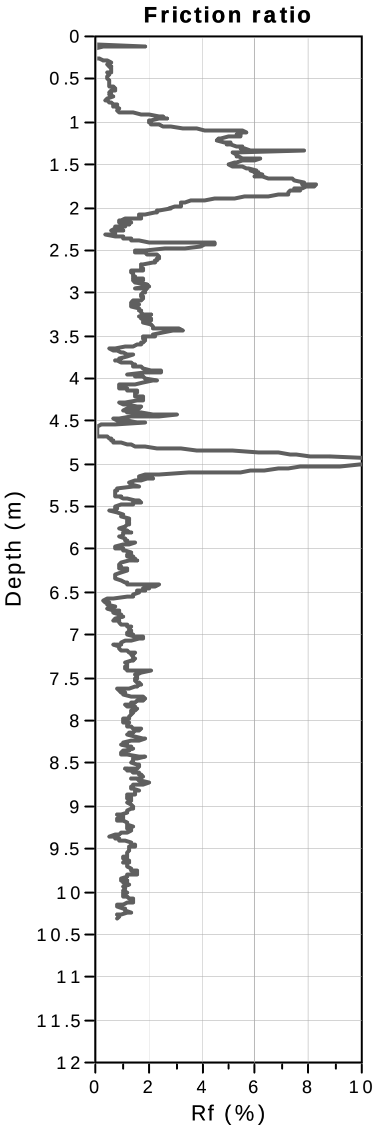
Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**

CPT17-31_RevA
Total depth: 10.32 m, Date: 04/01/2018
Cone Type: I-CFXYP20-10 171029
Cone Operator: M. Roy - Stratum CPT



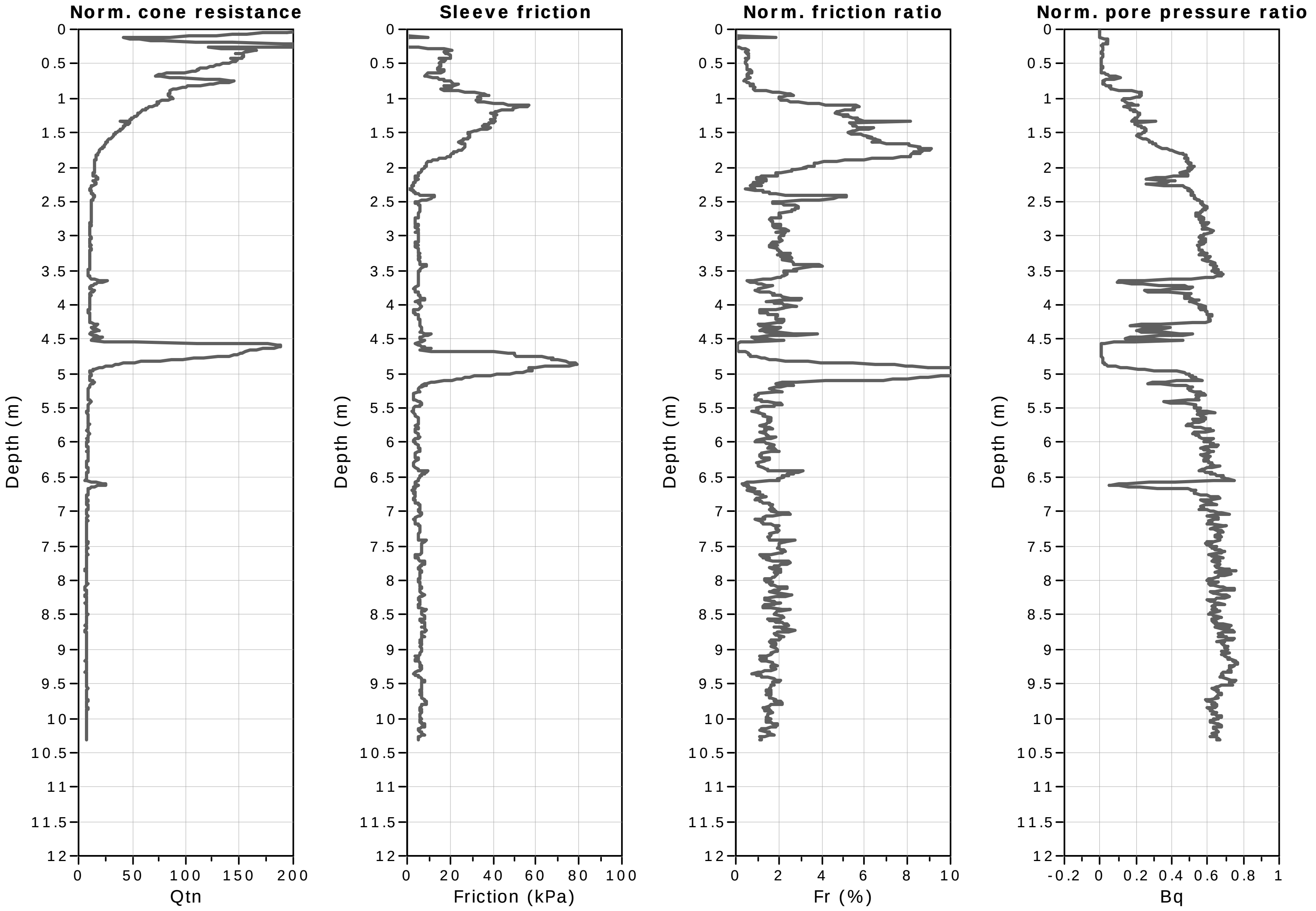






Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**

CPT17-31_RevA
Total depth: 10.32 m, Date: 04/01/2018
Cone Type: I-CFXYP20-10 171029
Cone Operator: M. Roy - Stratum CPT



Golder Associates Ltd.
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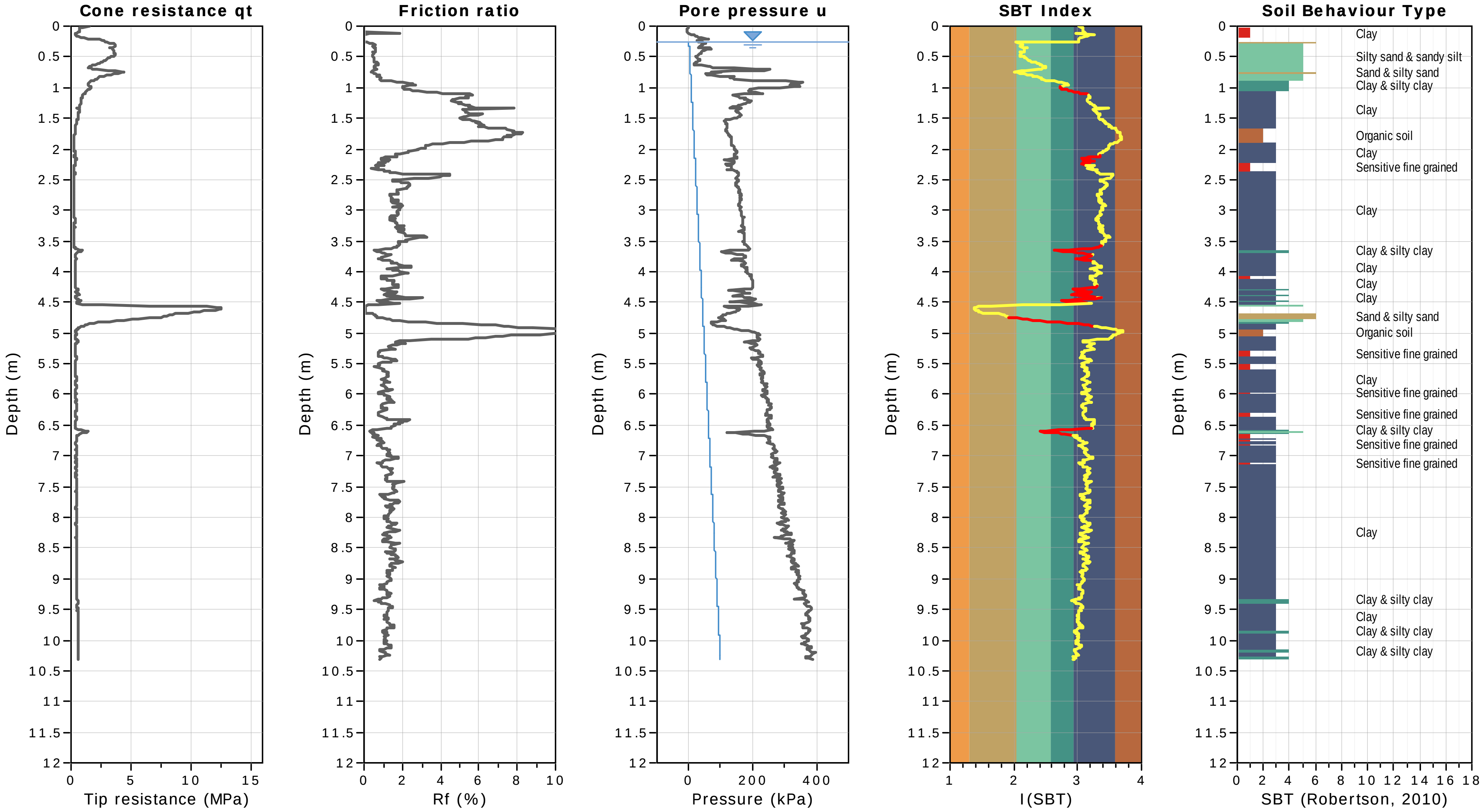
Project: **CRRRC - 1787048-400-4.4**
Location: **Ottawa, ON, Canada**

CPT17-31_RevA
Total depth: 10.32 m, Date: 04/01/2018
Cone Type: I-CFXYP20-10 171029
Cone Operator: M. Roy - Stratum CPT



Golder Associates Ltd.
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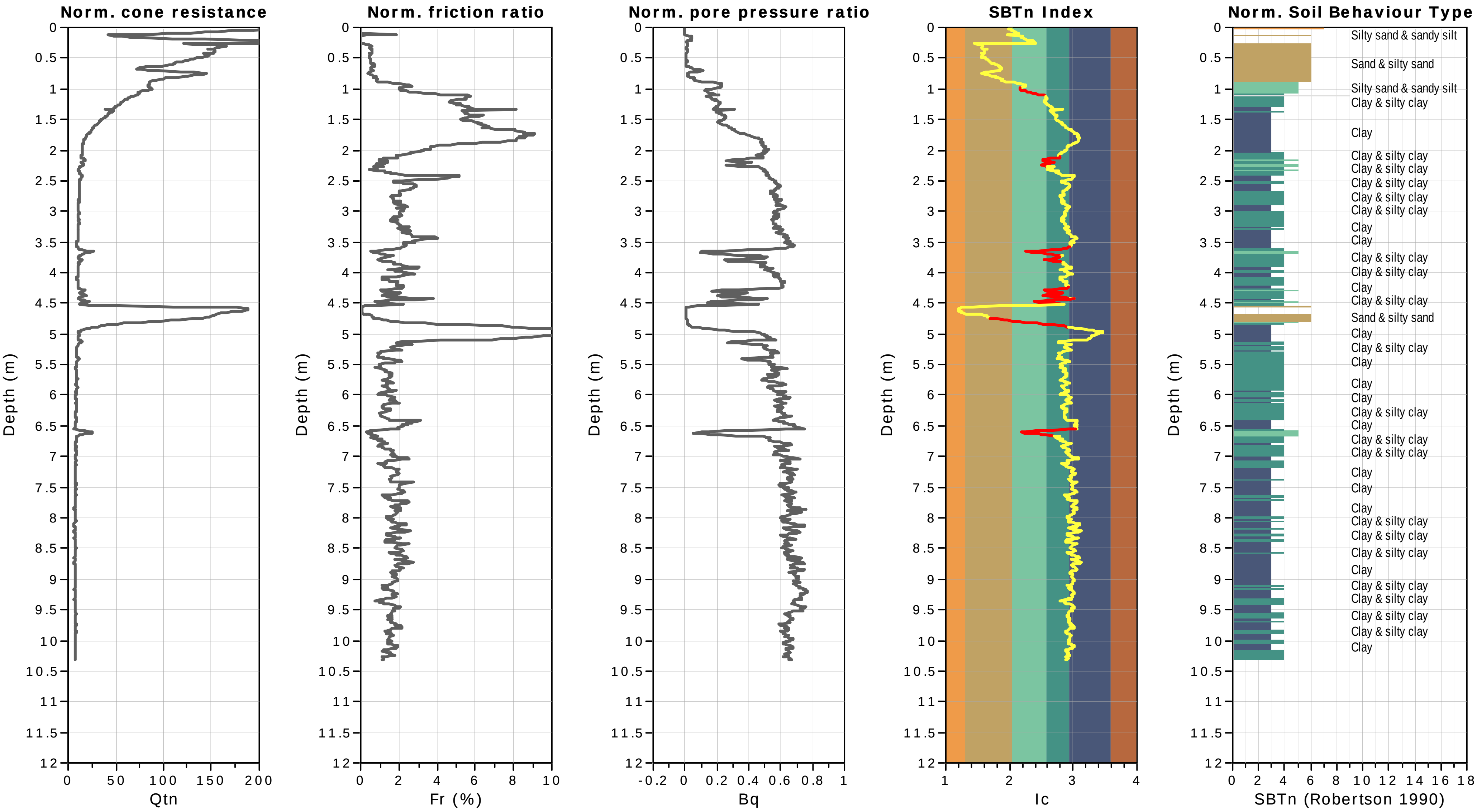
CPT17-31_RevA
Total depth: 10.32 m, Date: 04/01/2018
Cone Type: I-CFXYP20-10 171029
Cone Operator: M. Roy - Stratum CPT

Project: CRRRC - 1787048-400-4.4
Location: Ottawa, ON, Canada



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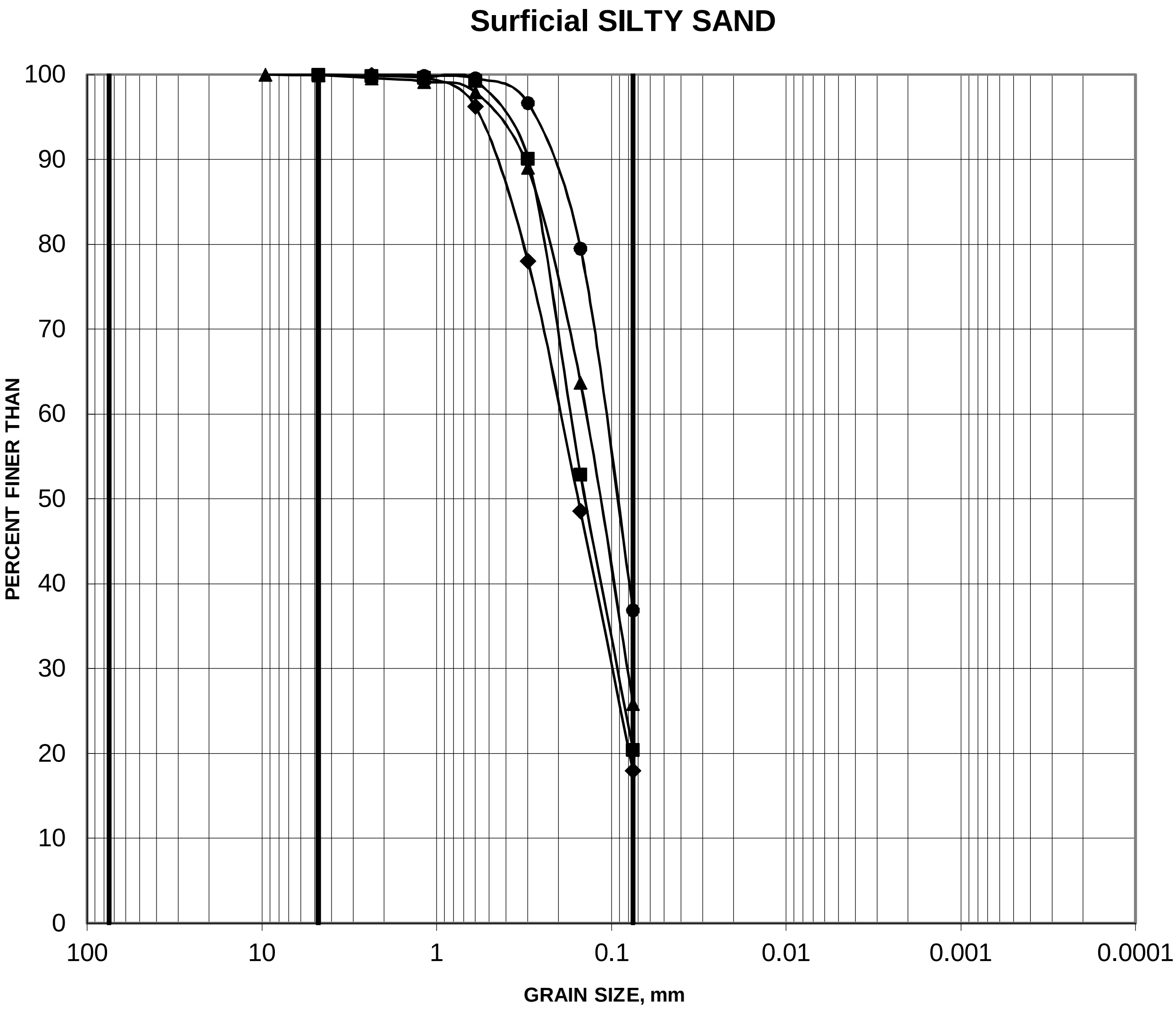
APPENDIX D

Laboratory Testing Results on Soil Samples and Bedrock Cores

GRAIN SIZE DISTRIBUTION

FIGURE D1



Cobble	coarse	fine	coarse	medium	fine	SILT AND CLAY
Size	GRAVEL SIZE		SAND SIZE			

Borehole	Sample	Depth (m)
■ 17-09	1	0.00-0.61
◆ 17-14	2	0.76-1.37
▲ 17-23	3	1.52-2.13
● 17-26	1	0.00-0.61

Created by: MI
Checked by: CNM

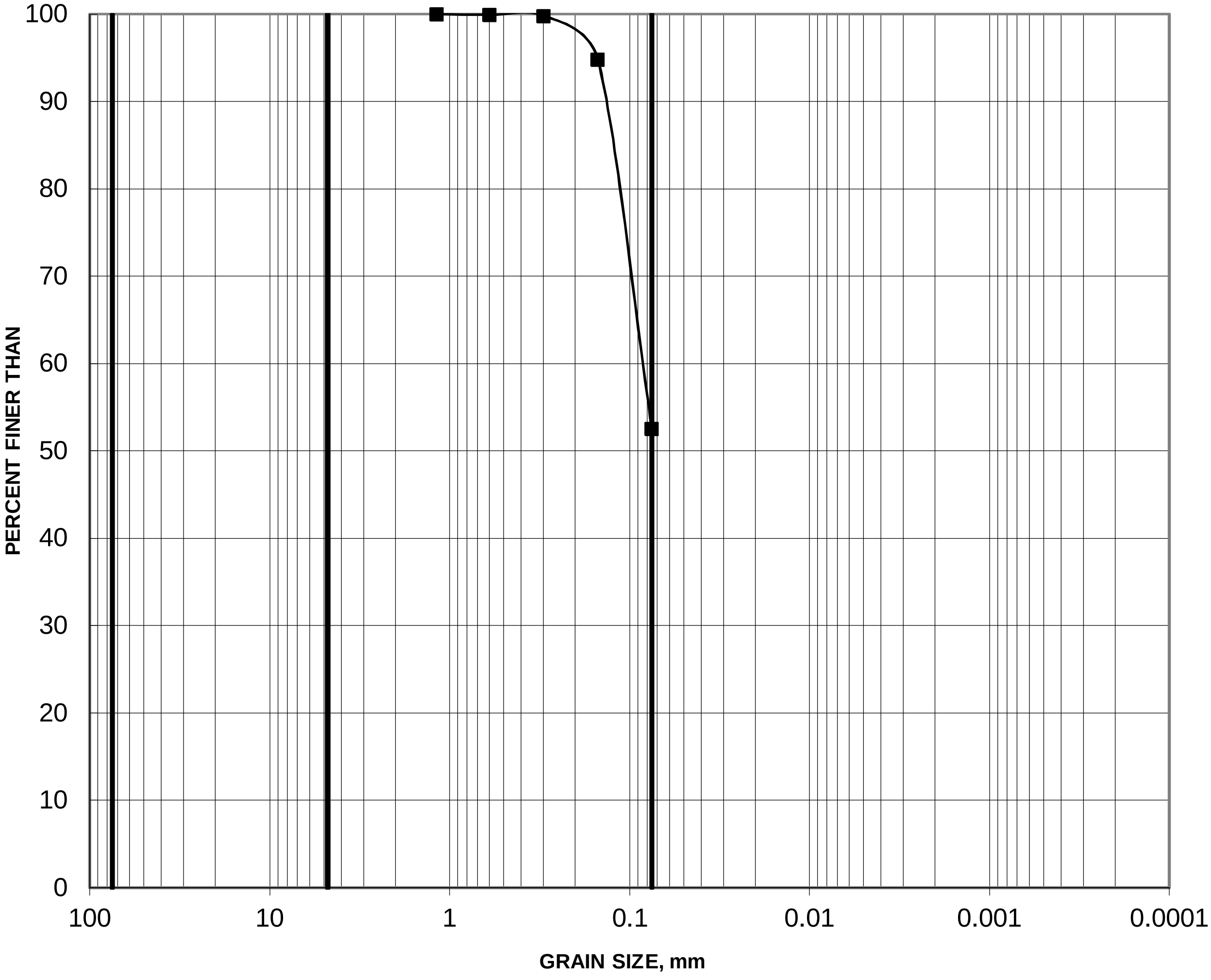
Project: 1787048 /400 /4.4

Golder Associates

GRAIN SIZE DISTRIBUTION

FIGURE D2

Silty layer within the SILTY CLAY



Cobble	coarse	fine	coarse	medium	fine	SILT AND CLAY
Size	GRAVEL SIZE		SAND SIZE			

Borehole	Sample	Depth (m)
─■─ 17-07	4	3.05-3.66

Project: 1787048 /400 /4.4

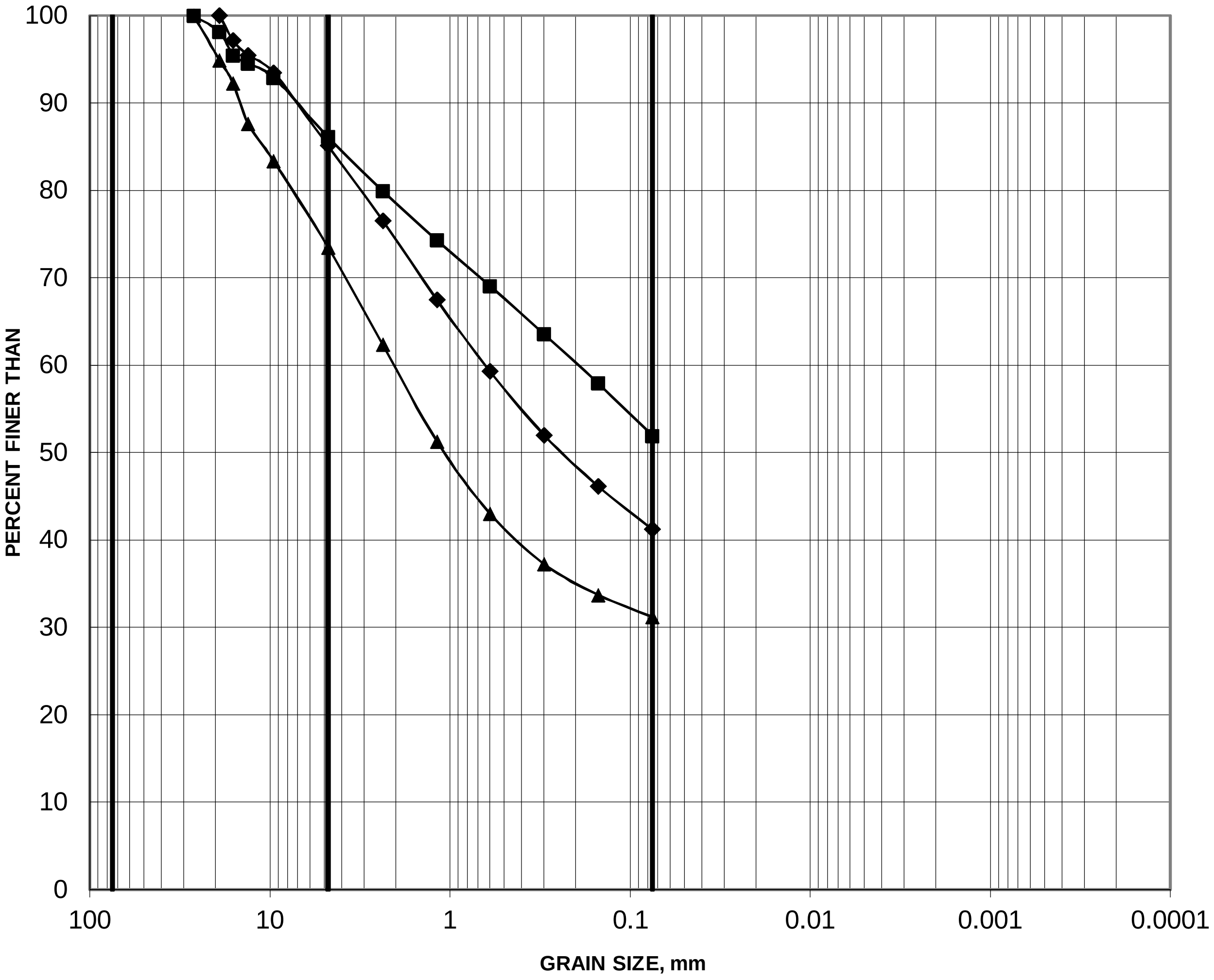
Golder Associates

Created by: MI
Checked by: CNM

GRAIN SIZE DISTRIBUTION

FIGURE D3

GLACIAL TILL



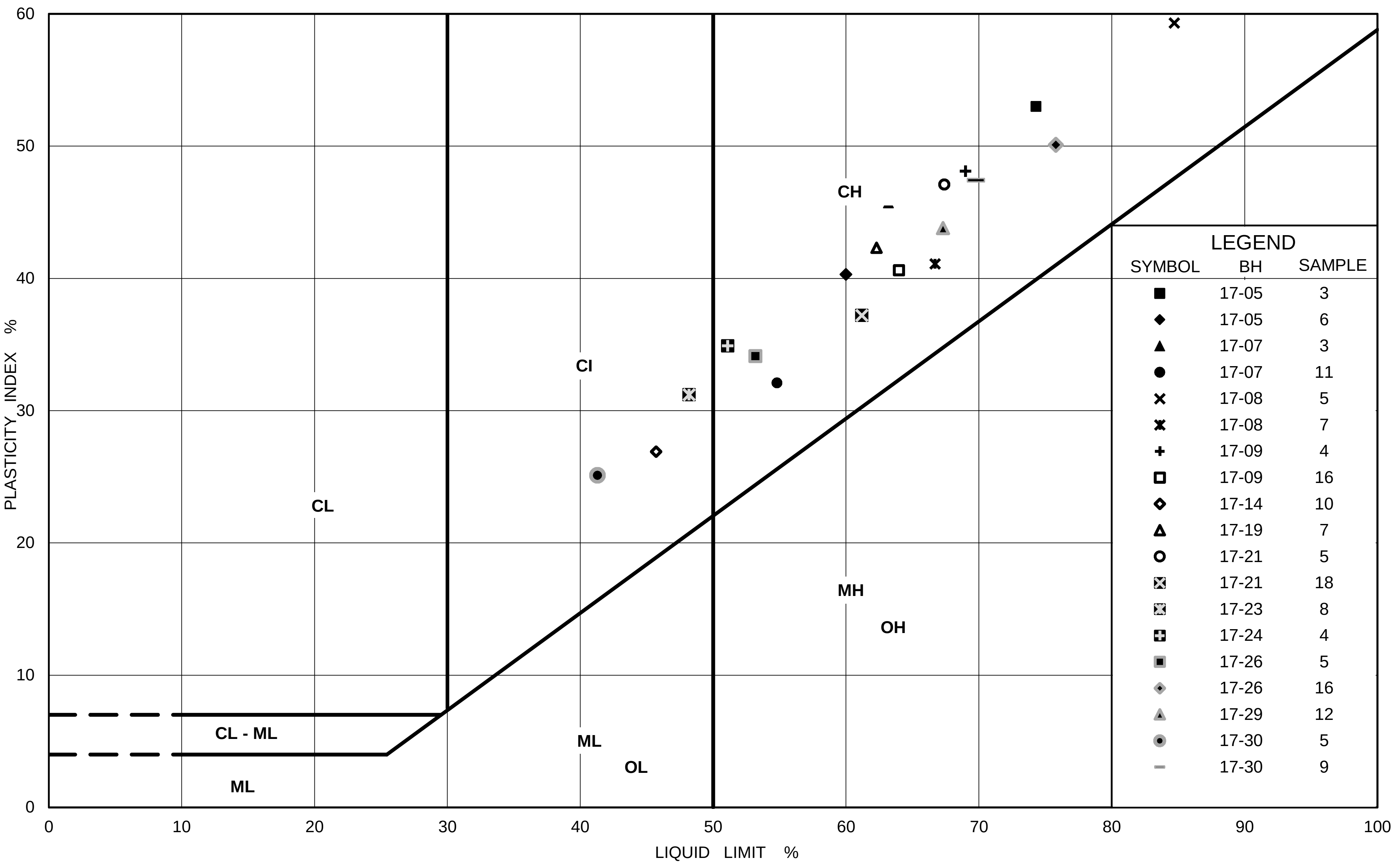
Cobble	coarse	fine	coarse	medium	fine	SILT AND CLAY
Size	GRAVEL SIZE		SAND SIZE			

Borehole	Sample	Depth (m)
■ 17-14	21	32.77-33.38
◆ 17-21	23	38.11-38.72
▲ 17-26	22	38.11-38.57

Project: 1787048 /400 /4.4

Golder Associates

Created by: MI
Checked by: CNM



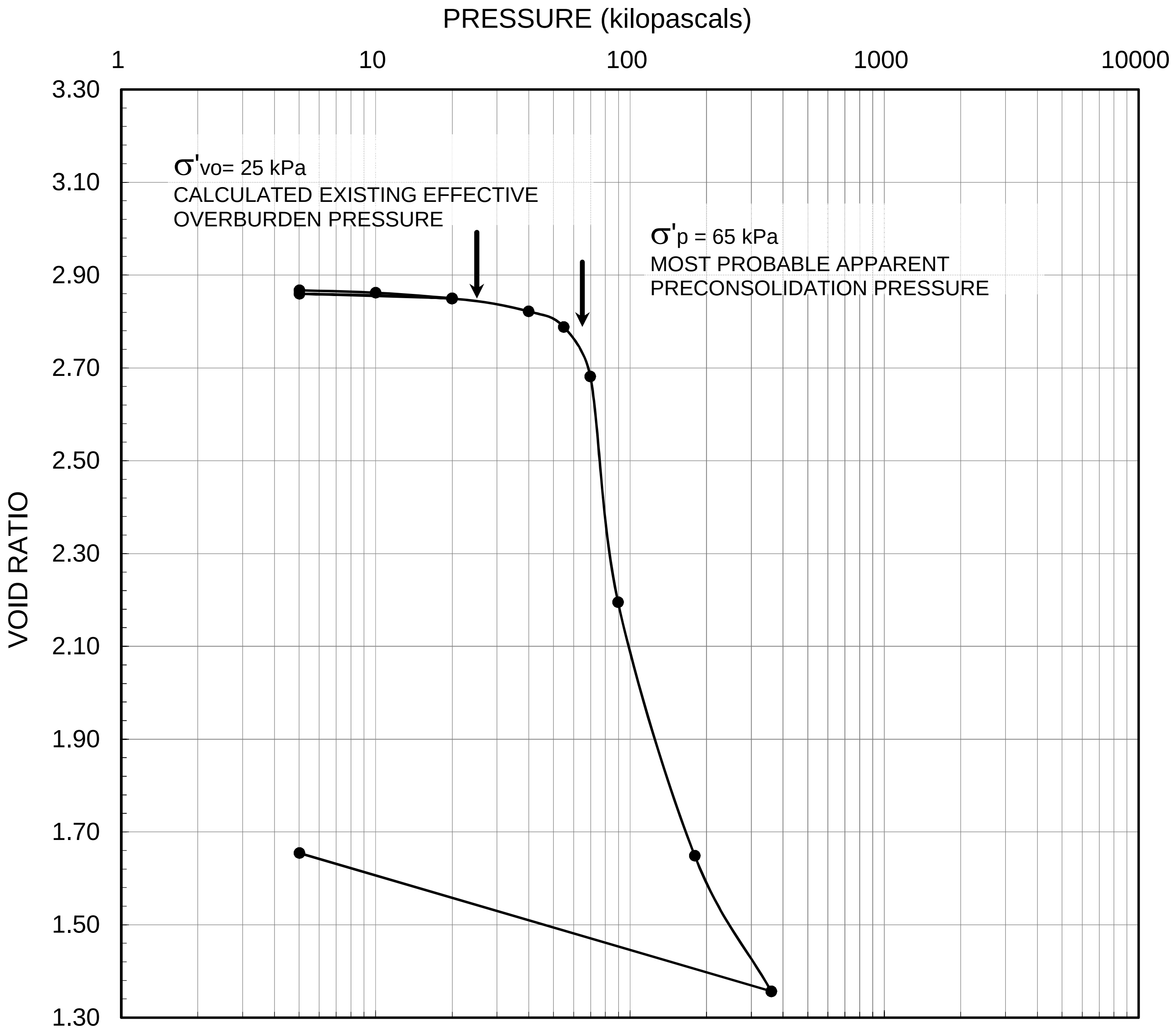
GOLDER

PLASTICITY CHART
Unweathered SILTY CLAY to CLAY

Figure : D4

Project No.: 1787048 /400 /4.4

Compiled By : MI Checked By : CNM

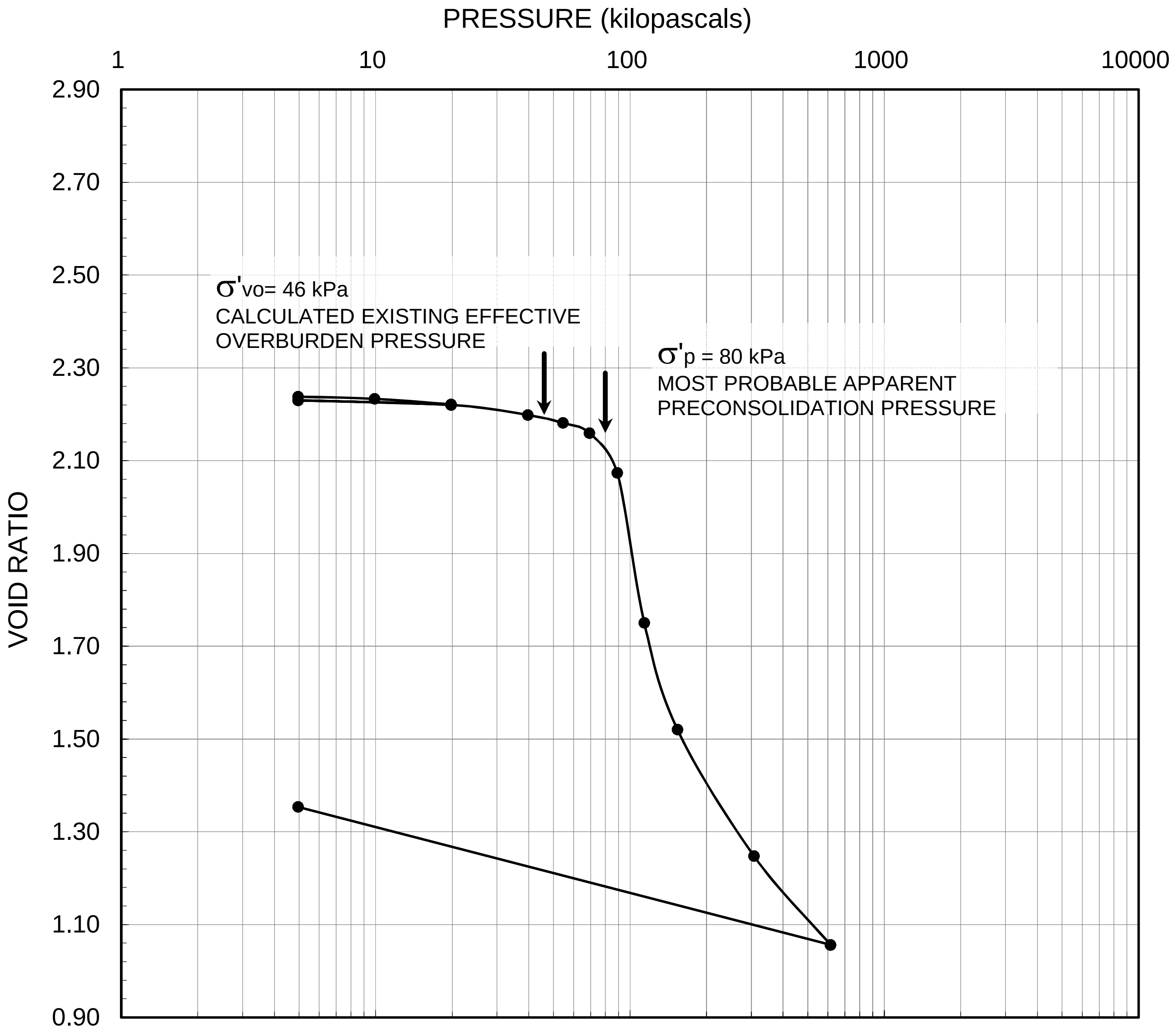


LEGEND

Borehole:	17-05	w_i = 105%	S_o = 100%	γ = 14.2 kN/m³
Sample:	3	w_f = 62%	e_o = 2.87	G_s = 2.75
Depth (m):	2.4	w_l = 74%	C_c = 4.45	
Elevation (m):	74.0	w_p = 21%	C_r = 0.018	

GOLDER

SCALE	AS SHOWN	TITLE	
DATE	04/13/18		
CADD	N/A		**CONSOLIDATION TEST RESULTS**
ENTERED	MI		
FILE No.	Consolidation summary	CHECK	CNM
PROJECT No.	1787048 /400 /4.4	REV.	1
REVIEW	SM	FIGURE	**D5**



LEGEND

Borehole:	17-05	w_i	= 82%	S_o	= 100%	γ	= 15.2 kN/m³
Sample:	6	w_f	= 50%	e_o	= 2.24	G_s	= 2.76
Depth (m):	6.4	w_l	= 60%	C_c	= 3.00		
Elevation (m):	70.0	w_p	= 20%	C_r	= 0.017		

GOLDER

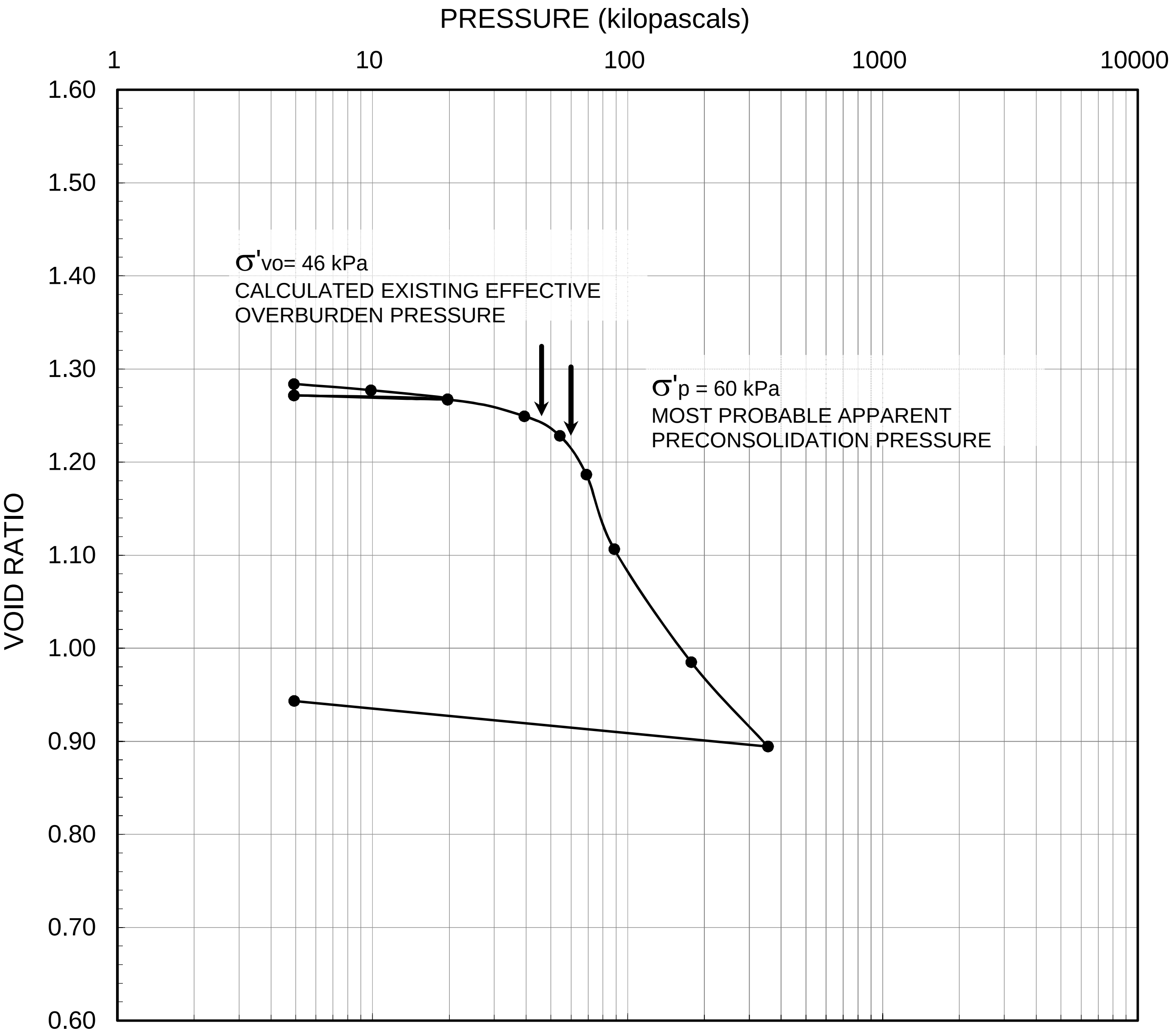
SCALE AS SHOWN
DATE 04/13/18
CADD N/A
ENTERED MI
CHECK CNM
REVIEW SM

FILE No. Consolidation summary
PROJECT No. 1787048 /400 /4.4 REV. 1

TITLE

CONSOLIDATION TEST RESULTS

FIGURE **D6**

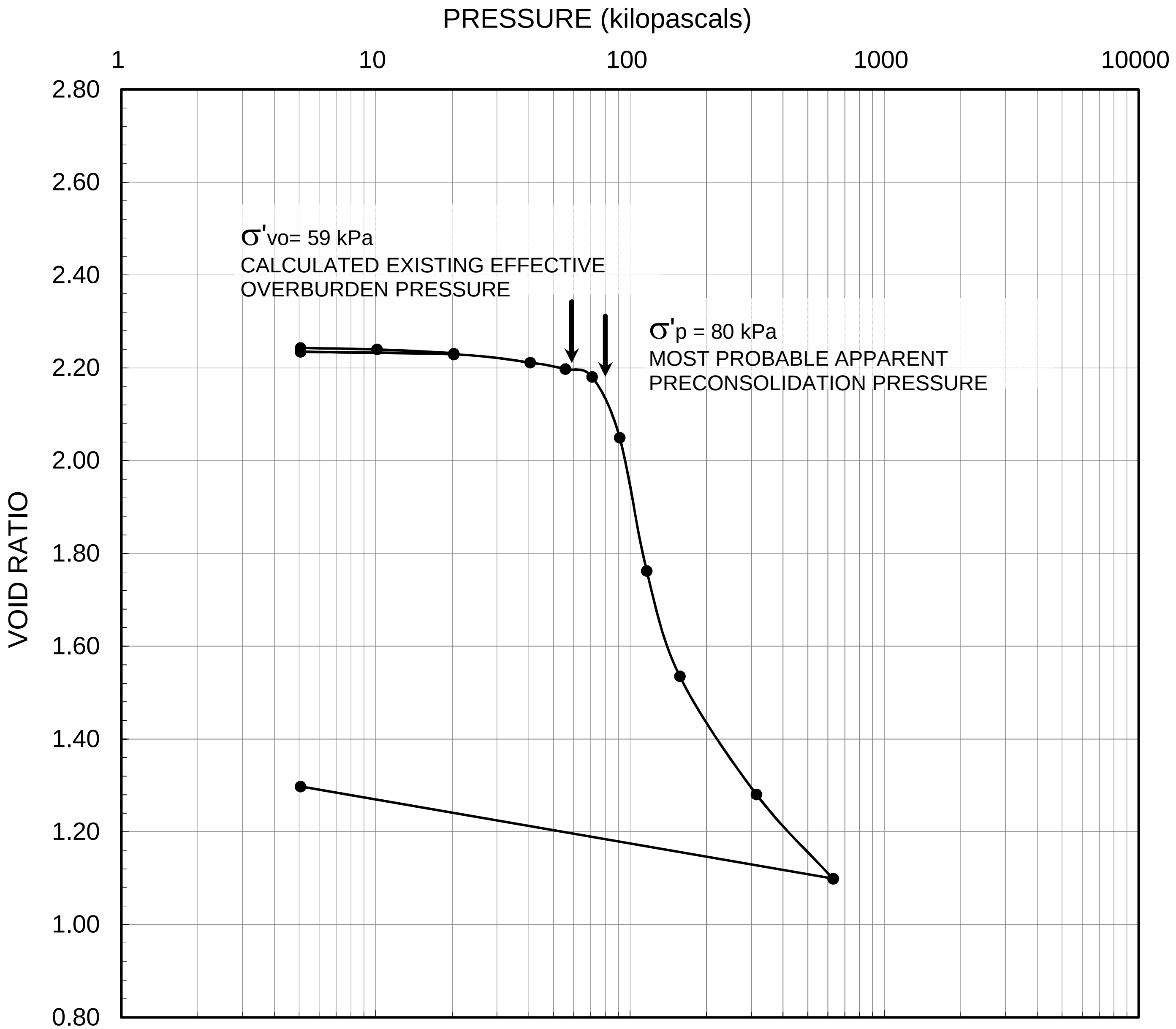


LEGEND

Borehole:	17-08	w_i = 47%	S_o = 100%	γ = 17.3 kN/m³
Sample:	5	w_f = 34%	e_o = 1.29	G_s = 2.76
Depth (m):	5.0	w_l = 85%	C_c = 0.72	
Elevation (m):	71.1	w_p = 25%	C_r = 0.008	

GOLDER

SCALE	AS SHOWN	TITLE	CONSOLIDATION TEST RESULTS
DATE	04/13/18		
CADD	N/A		
ENTERED	MI		
FILE No.	Consolidation summary	CHECK	CNM
PROJECT No.	1787048 /400 /4.4	REV.	1
REVIEW	SM	FIGURE	D7



LEGEND

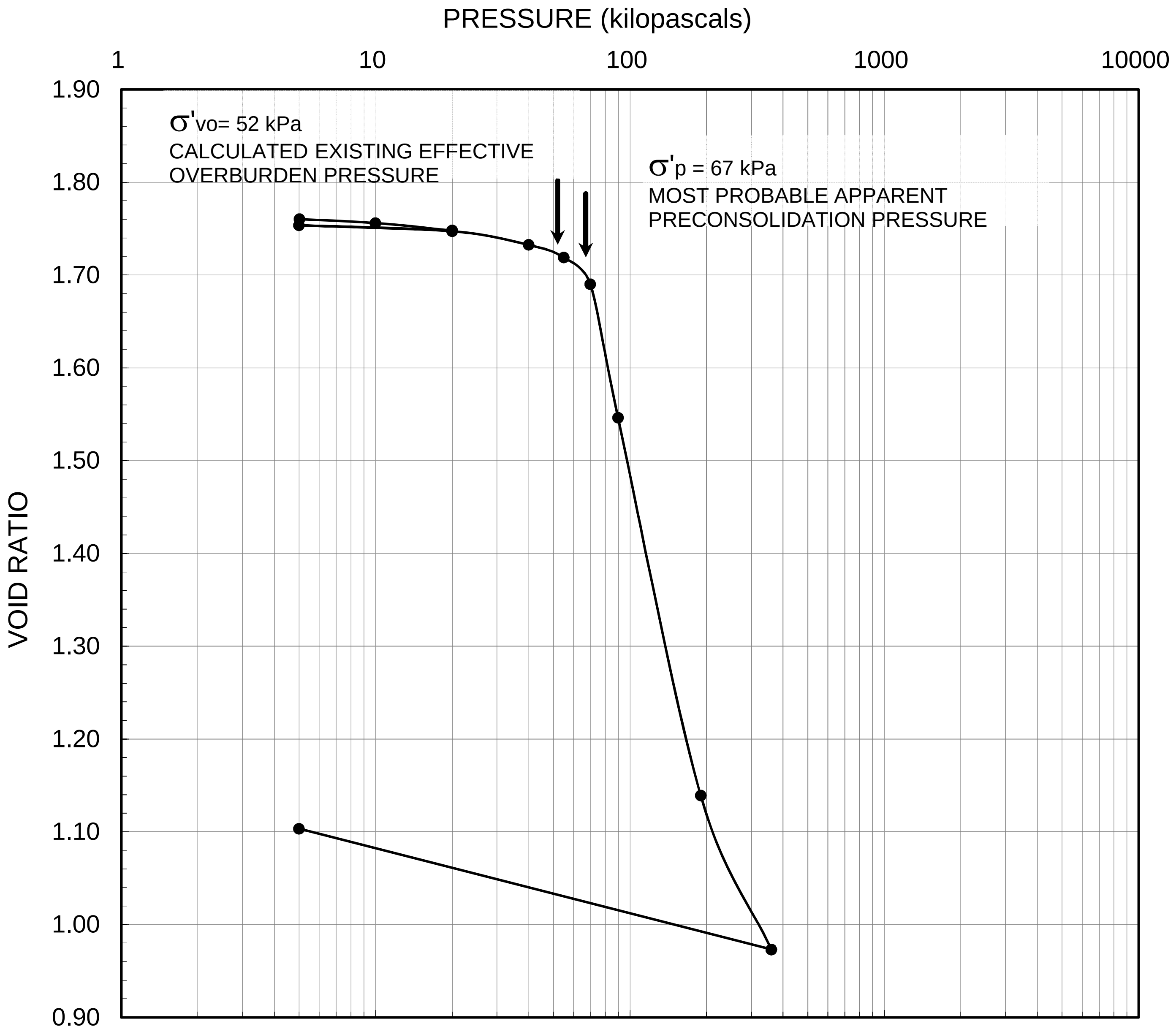
Borehole: 17-08
Sample: 7
Depth (m): 7.5
Elevation (m): 68.6

w_i = 81%
w_f = 47%
w_l = 67%
w_p = 26%

S_o = 100%
e_o = 2.24
C_c = 2.73
C_r = 0.010

γ = 15.1 kN/m³
G_s = 2.76

GOLDER	SCALE AS SHOWN	TITLE	
	DATE 04/13/18	**CONSOLIDATION TEST RESULTS**	
	CADD N/A		
	ENTERED MI		
FILE No. Consolidation summary	CHECK CNM		
PROJECT No. 1787048 /400 /4.4 REV. 1	REVIEW SM		FIGURE **D8**



LEGEND

Borehole:	17-19	w_i = 64%	S_o = 100%	γ = 16 kN/m³
Sample:	7	w_f = 41%	e_o = 1.76	G_s = 2.74
Depth (m):	6.2	w_l = 62%	C_c = 1.32	
Elevation (m):	69.8	w_p = 20%	C_r = 0.010	

GOLDER

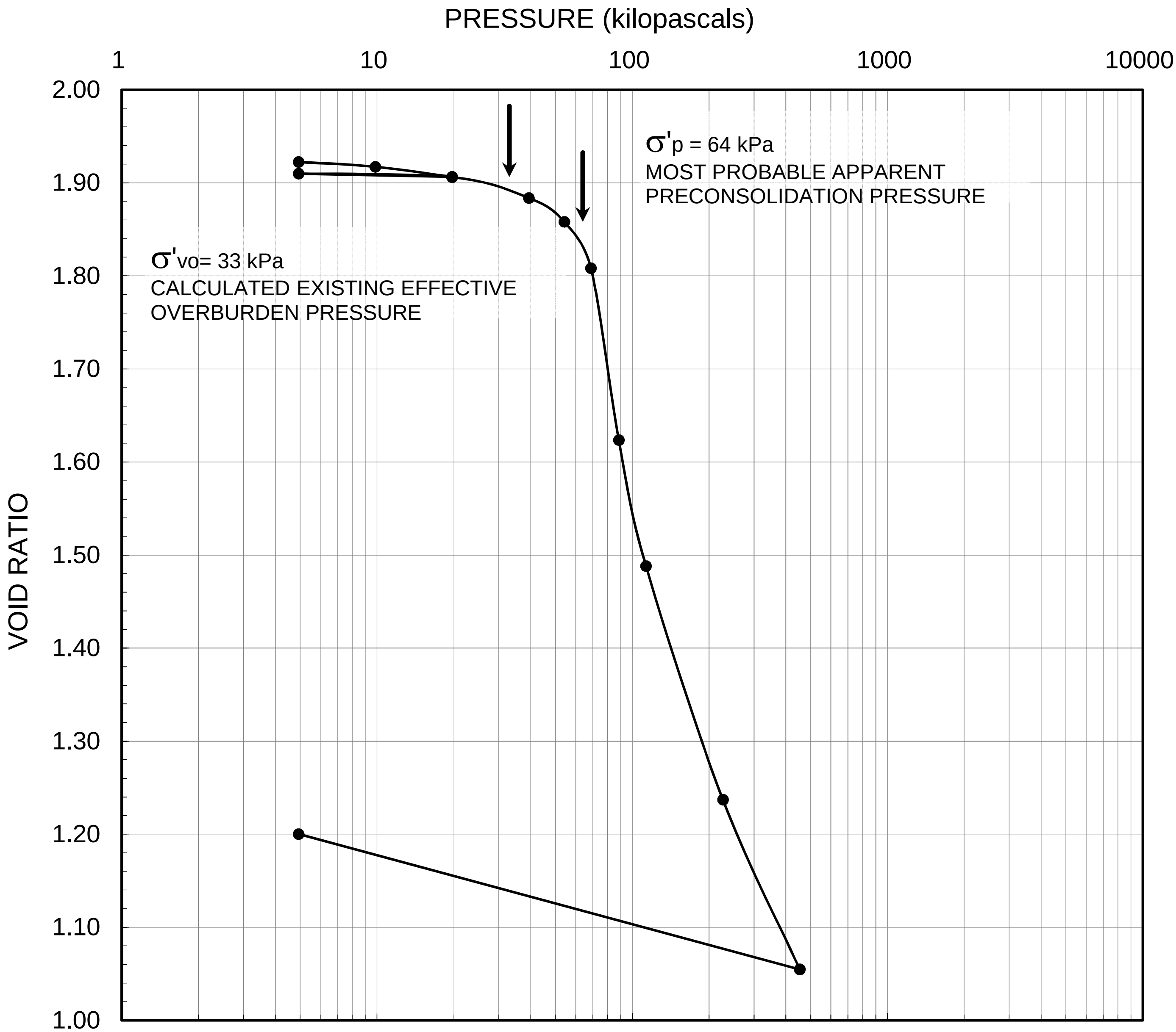
SCALE AS SHOWN
DATE 04/13/18
CADD N/A
ENTERED MI
CHECK CNM
REVIEW SM

FILE No. Consolidation summary
PROJECT No. 1787048 /400 /4.4
REV. 1

TITLE

CONSOLIDATION TEST RESULTS

FIGURE **D9**



LEGEND

Borehole:	17-24	w_i = 70%	S_o = 100%	γ = 15.6 kN/m³
Sample:	4	w_f = 45%	e_o = 1.93	G_s = 2.75
Depth (m):	3.1	w_l = 51%	C_c = 1.67	
Elevation (m):	73.3	w_p = 16%	C_r = 0.007	

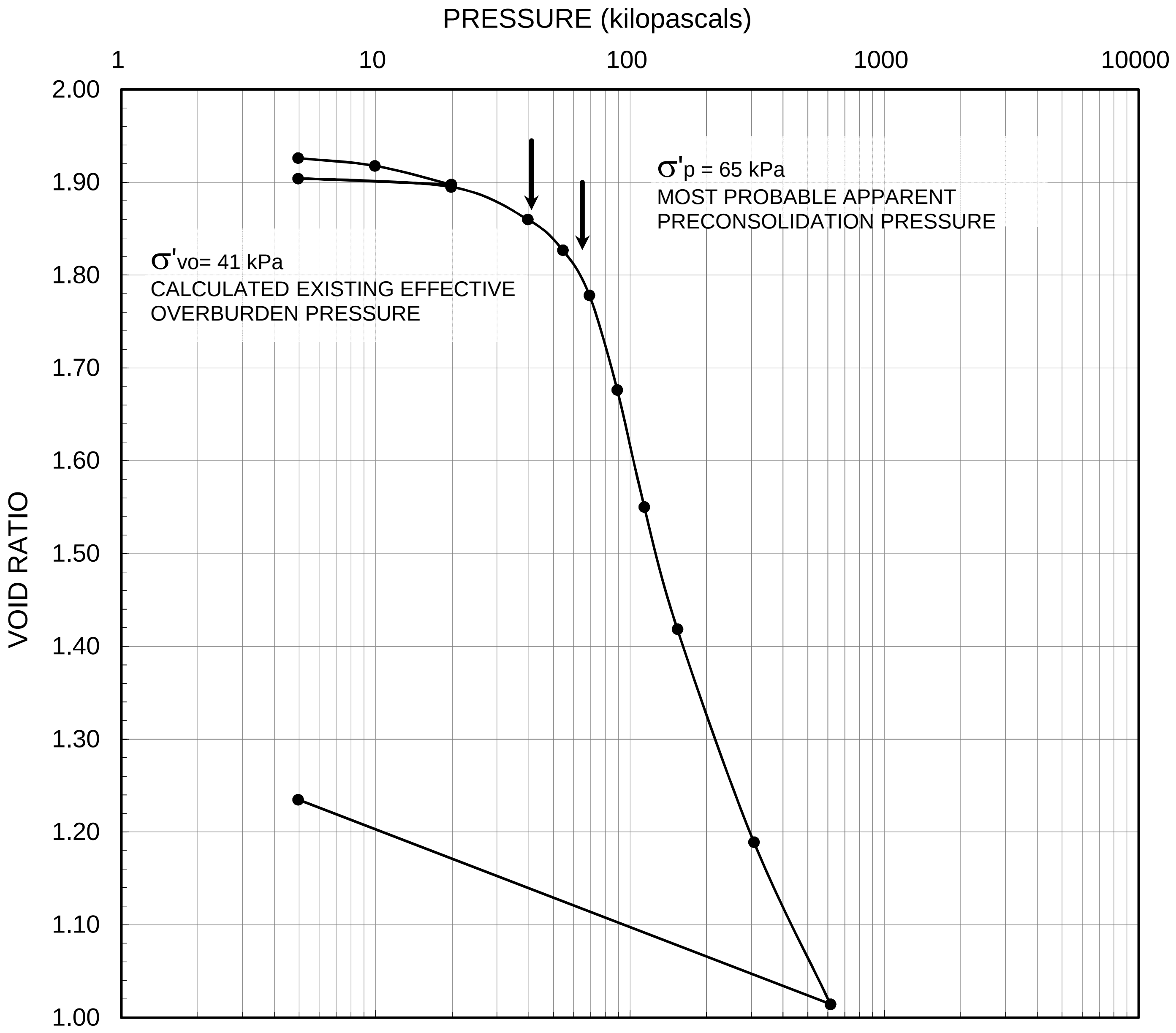
GOLDER

SCALE	AS SHOWN
DATE	04/13/18
CADD	N/A
ENTERED	MI
CHECK	CNM
REVIEW	SM
FILE No.	Consolidation summary
PROJECT No.	1787048 /400 /4.4
REV.	1

TITLE

CONSOLIDATION TEST RESULTS

FIGURE D10



LEGEND

Borehole: 17-30 w_i = 70% S_o = 100% γ = 15.7 kN/m³

Sample: 5 w_f = 45% e_o = 1.93 G_s = 2.76

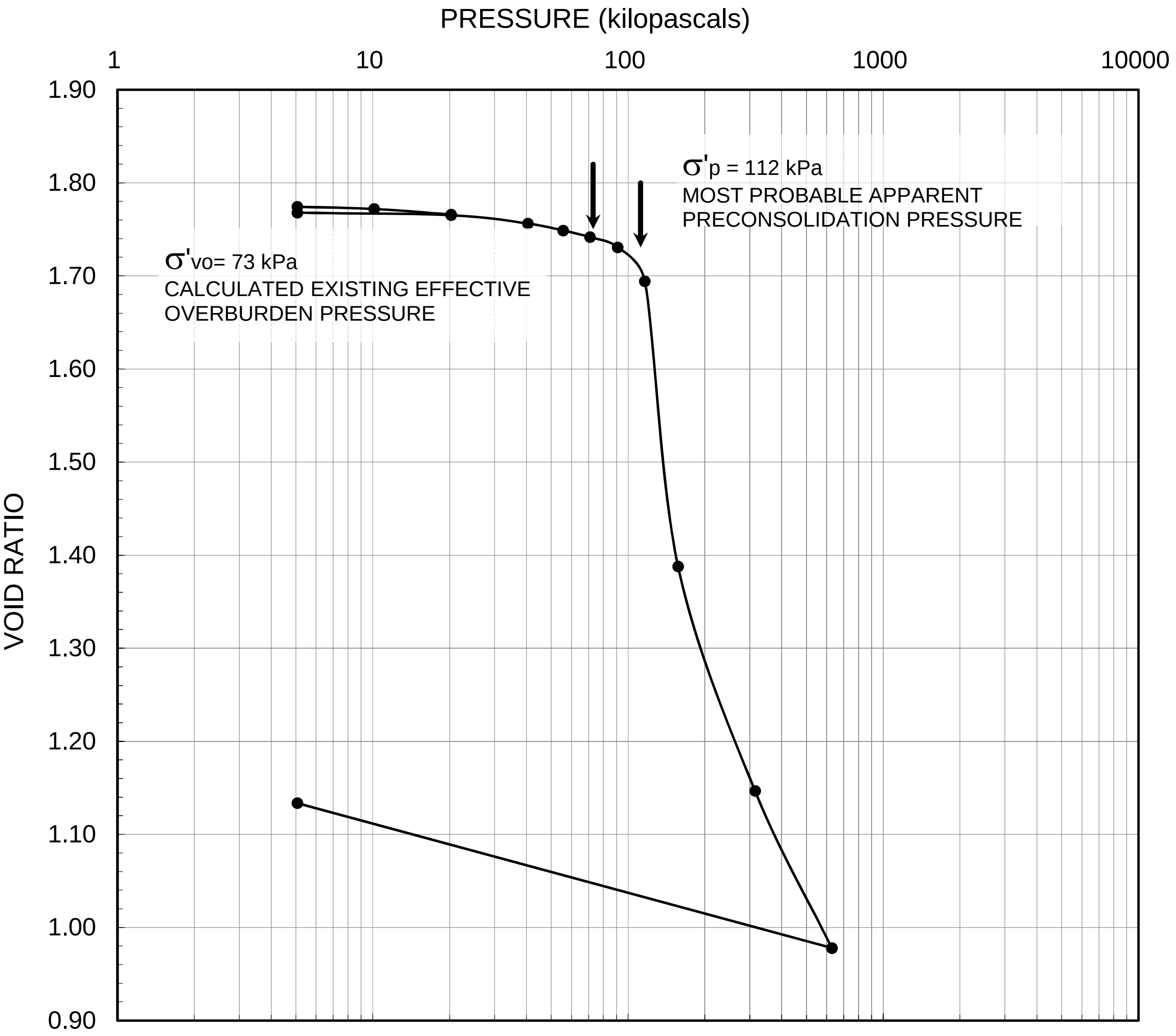
Depth (m): 4.7 w_l = 41% C_c = 1.17

Elevation (m): 71.3 w_p = 16% C_r = 0.015

GOLDER

SCALE	AS SHOWN	TITLE	
DATE	04/13/18		
CADD	N/A		
ENTERED	MI		
FILE No.	Consolidation summary	CHECK	CNM
PROJECT No.	1787048 /400 /4.4	REV.	1
REVIEW	SM	FIGURE	D11

CONSOLIDATION TEST RESULTS



LEGEND

Borehole:	17-30	w_i = 64%	S_o = 99%	γ = 16 kN/m³
Sample:	9	w_f = 42%	e_o = 1.78	G_s = 2.76
Depth (m):	9.9	w_l = 70%	C_c = 2.33	
Elevation (m):	66.1	w_p = 22%	C_r = 0.005	

GOLDER

SCALE AS SHOWN
DATE 04/13/18
CADD N/A
ENTERED MI
CHECK CNM
REVIEW SM

TITLE

CONSOLIDATION TEST RESULTS

FILE No. Consolidation summary
PROJECT No. 1787048 /400 /4.4
REV. 1

FIGURE **D12**

FIGURE D13

Golder Associates Ltd.
1931 Robertson Road
Ottawa, Ontario
K2H 5B7

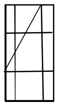
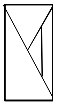
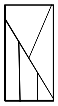
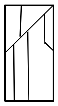
UNCONFINED COMPRESSIVE STRENGTH OF ROCK CORE

Project: CRRRC - Post EA Approval Activities

Project No.: 1787048 /400 /4.4

Date: March 9, 2018

Location(s): See Table Below

Bore Hole No.	Depth (m)	Date Tested	Core Size	Diameter (mm)	Density (kg/m³)	Compressive Strength (MPa)	Failure Mode
17-07	31.06-31.24	Mar 1/18	HQ	60.6	2675	135.8	
17-14	35.72-35.94	Mar 1/18	HQ	60.8	2677	110.9	
17-21	42.69-42.85	Mar 1/18	HQ	60.9	2713	97.4	
17-23	37.82-38.00	Mar 1/18	HQ	60.6	2676	229.3	

REMARKS :
- Cores tested in vertical direction.
- Cores tested in air-dry condition.
- Specimen ends prepared with high-strength plaster, but un-restrained.
- L/D ratio's between 2.2:1 and 2.5:1
- Time to failure > 2 and < 15 minutes.

TESTING WAS CARRIED OUT IN GENERAL ACCORDANCE WITH ASTM D7012 - Method C

SIGNED: ______________________

C.N.Mangione P.Eng.

APPENDIX E

Results of Chemical Analyses

Certificate of Analysis

Client: Golder Associates Ltd. (Ottawa)
1931 Robertson Road
Ottawa, ON
K2H 5B7
Attention: Ms. Susan Trickey
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1802569
Date Submitted: 2018-02-22
Date Reported: 2018-02-27
Project: 1787048
COC #: 188724

				Lab I.D.	1346173	1346174	1346175	1346176
				Sample Matrix	Soil	Soil	Soil	Soil
				Sample Type				
				Sampling Date	2018-01-30	2018-02-08	2018-02-08	2018-02-08
				Sample I.D.	17-7 Sa18/85-87	17-26 Sa2/2.5-4.5	17-29 Sa3/10-12	17-29 Sa20/115-117
Group	**Analyte**	**MRL**	**Units**	**Guideline**				
Agri. - Soil	pH	2.00			8.76	8.84	8.58	8.98
	SO4	0.01	%		0.09	<0.01	0.01	0.04
General Chemistry	Cl	0.002	%		0.015	<0.002	0.018	0.157
	Electrical Conductivity	0.05	mS/cm		1.23	0.08	<0.05	0.17
	Resistivity	1	ohm-cm		813	12500	20000	5880

Guideline = *** = Guideline Exceedence**

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

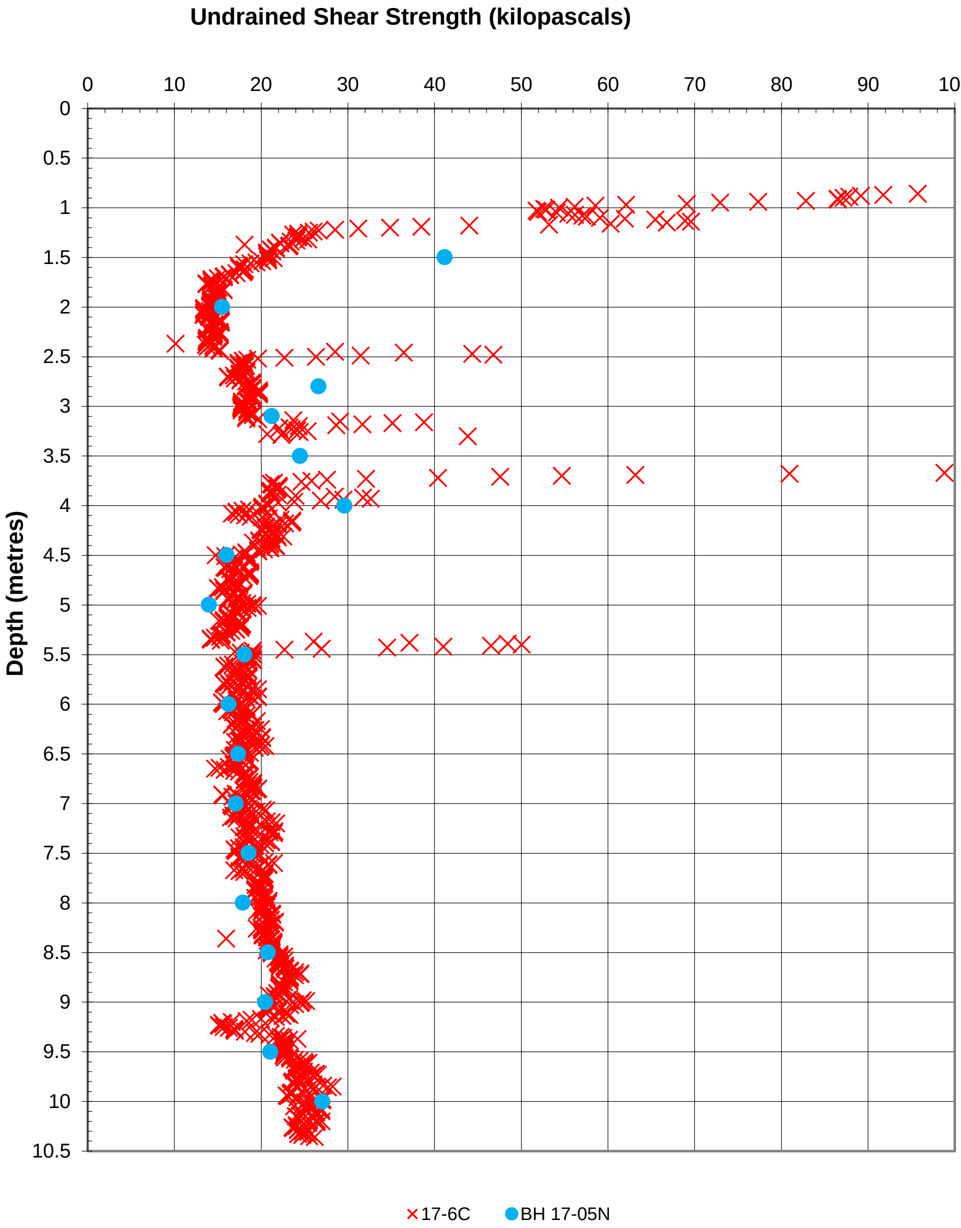
MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

APPENDIX F

Correlation of Undrained Shear Strengths from CPT and Nilcon Vane Testing

CORRELATION OF UNDRAINED SHEAR STRENGTHS - CPT AND NILCON VANE TESTING

FIGURE F1



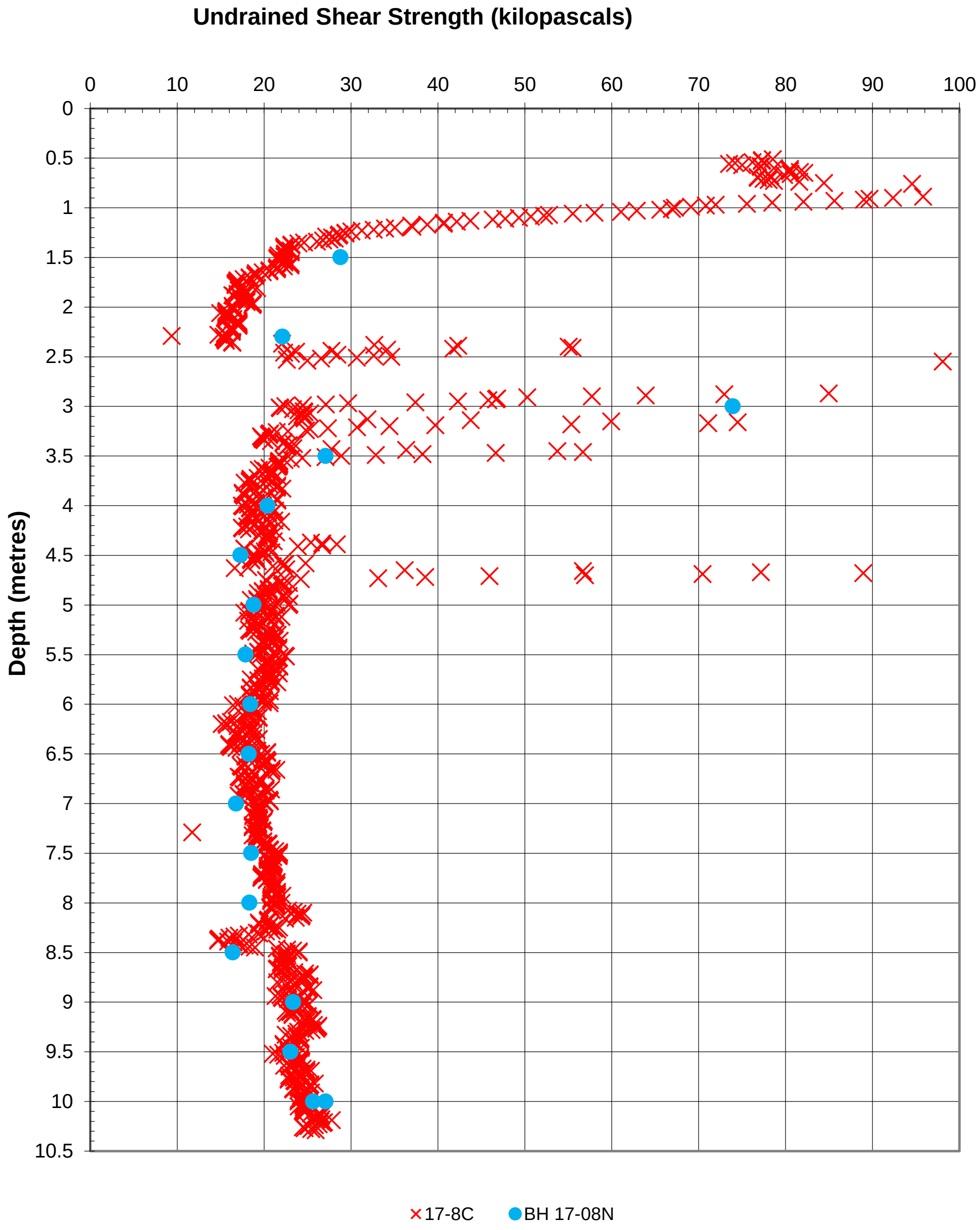
Date June 12, 2018
Project 1787048/400/4.4

Golder Associates

Drawn SM
Chkd MSS

CORRELATION OF UNDRAINED SHEAR STRENGTHS - CPT AND NILCON VANE TESTING

FIGURE F2

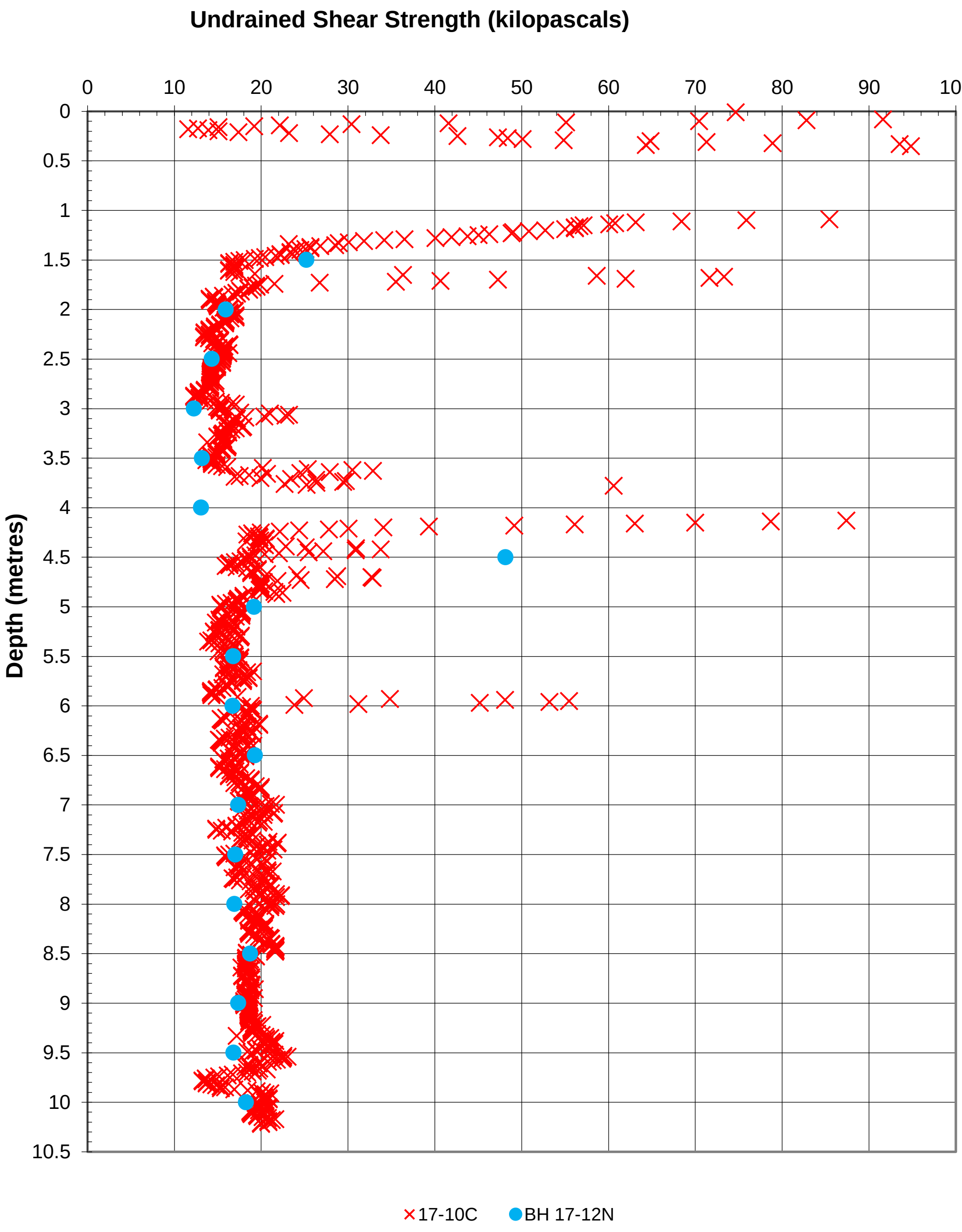


Date June 12, 2018
Project 1787048/400/4.4

Golder Associates

Drawn SM
Chkd MSS

STRENGTHS - CPT AND NILCON VANE TESTING



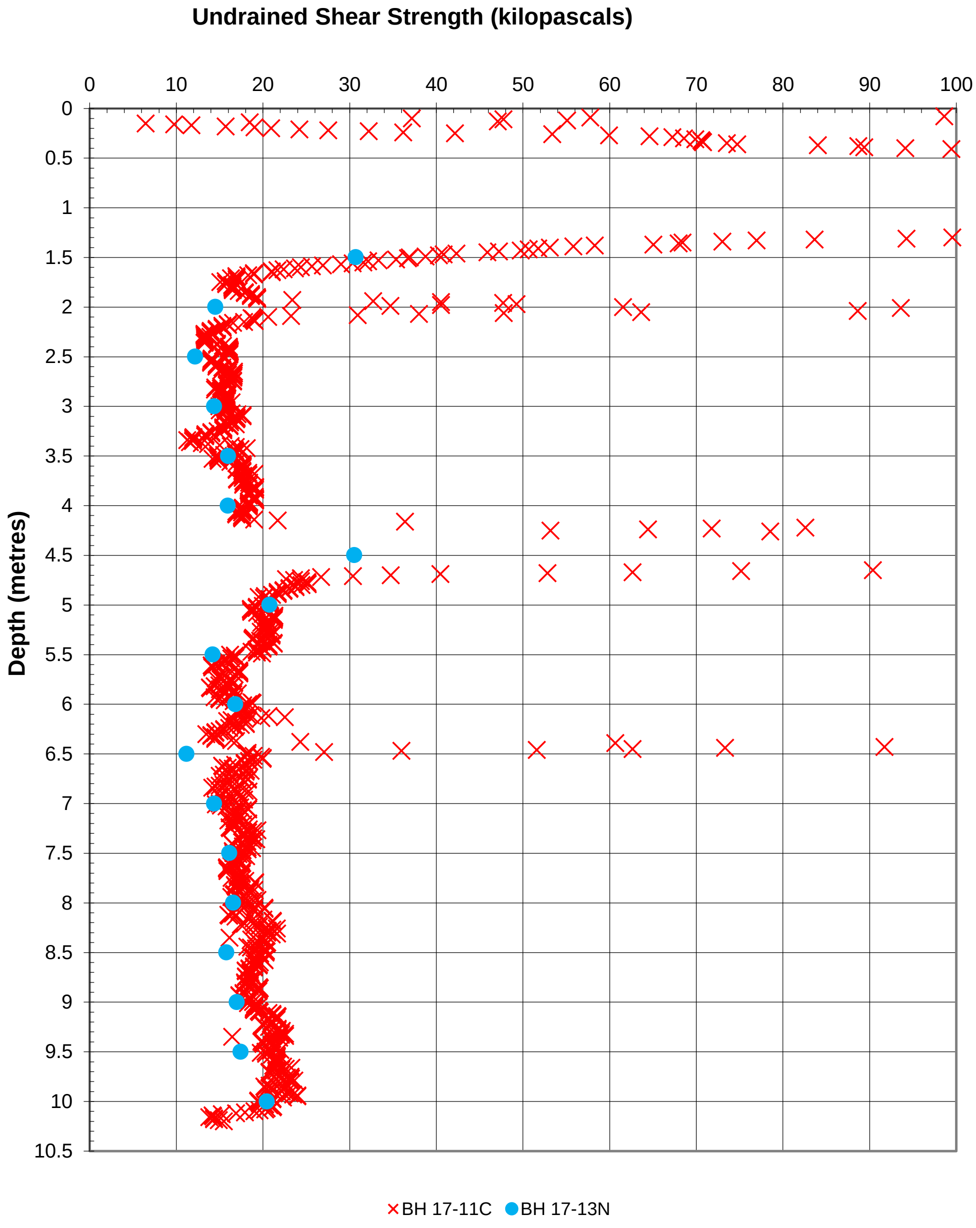
Date June 12, 2018
Project 1787048/400/4.4

Golder Associates

Drawn SM
Chkd MSS

CORRELATION OF UNDRAINED SHEAR STRENGTHS - CPT AND NILCON VANE TESTING

FIGURE F4



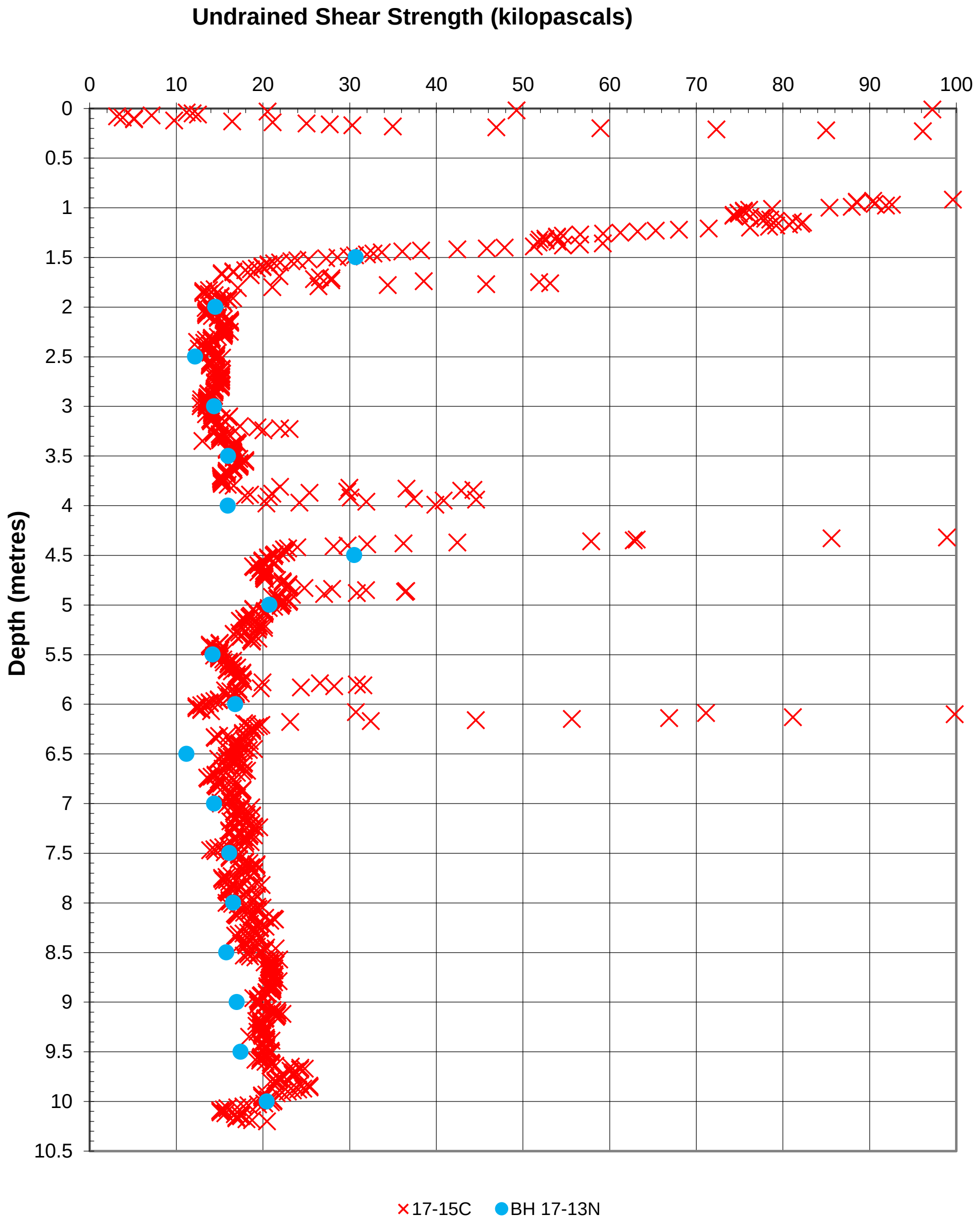
Date June 12, 2018
Project 1787048/400/4.4

Golder Associates

Drawn SM
Chkd MSS

CORRELATION OF UNDRAINED SHEAR STRENGTHS - CPT AND NILCON VANE TESTING

FIGURE F5



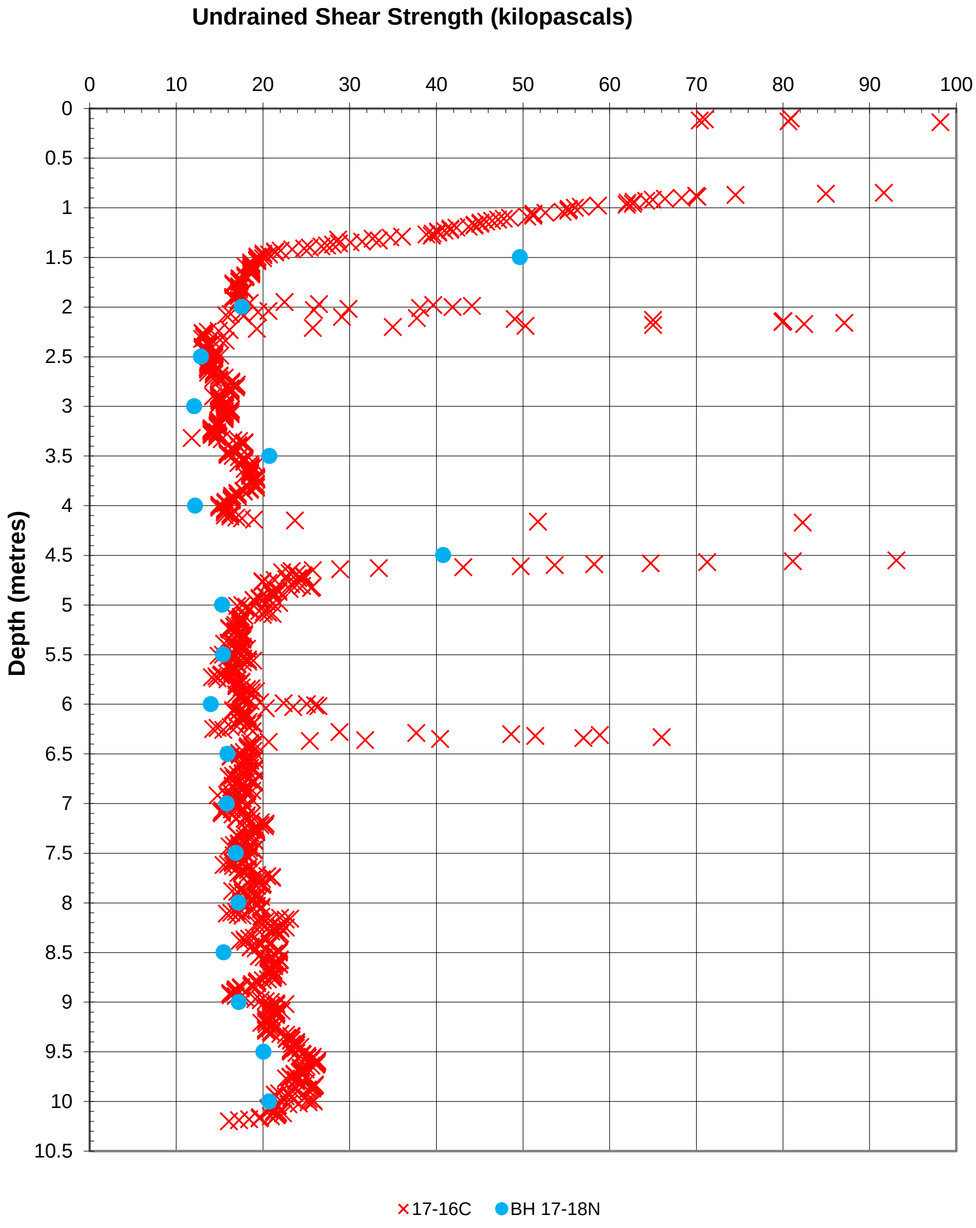
Date June 12, 2018
Project 1787048/400/4.4

Golder Associates

Drawn SM
Chkd MSS

CORRELATION OF UNDRAINED SHEAR STRENGTHS - CPT AND NILCON VANE TESTING

FIGURE F6



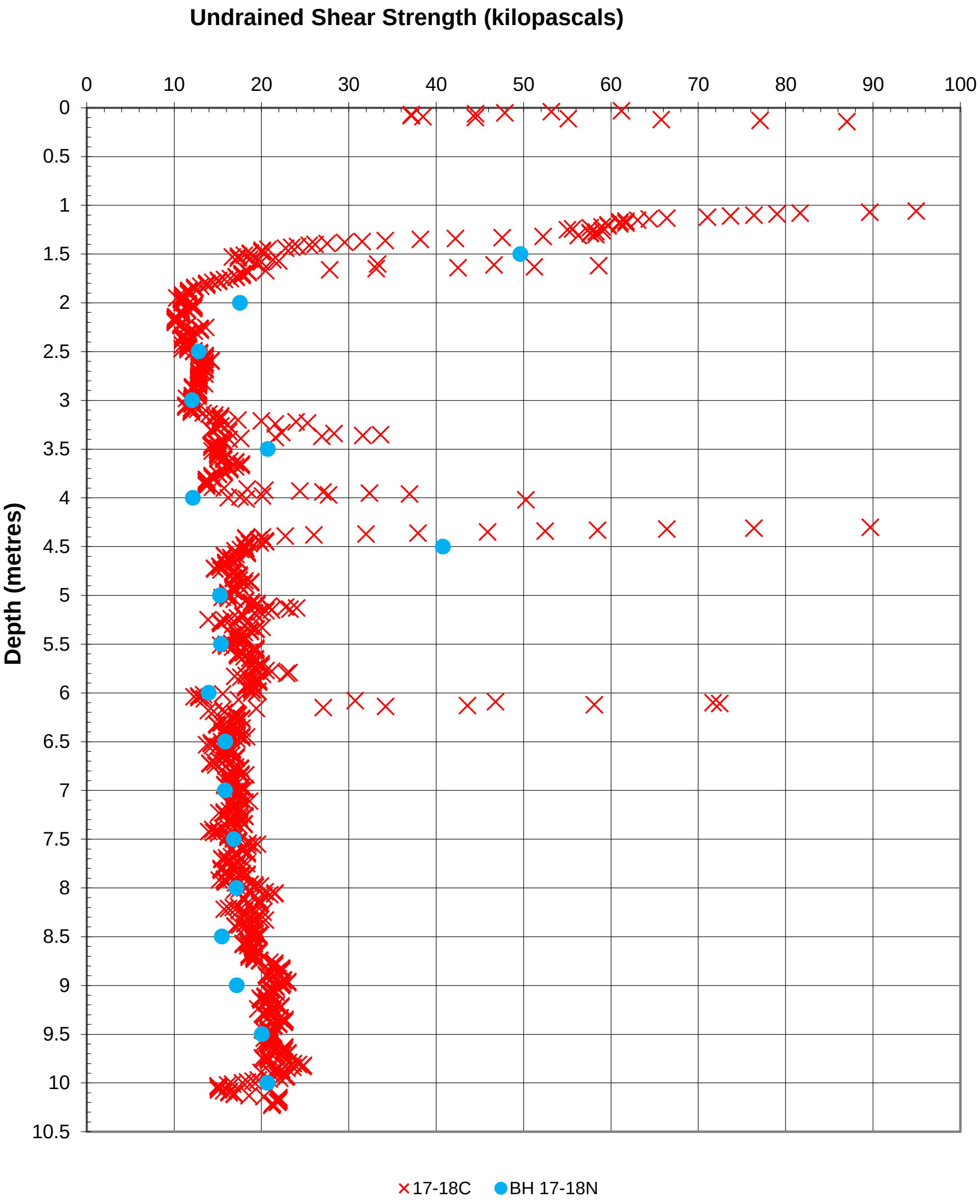
Date June 12, 2018
Project 1787048/400/4.4

Golder Associates

Drawn SM
Chkd MSS

CORRELATION OF UNDRAINED SHEAR STRENGTHS - CPT AND NILCON VANE TESTING

FIGURE F7



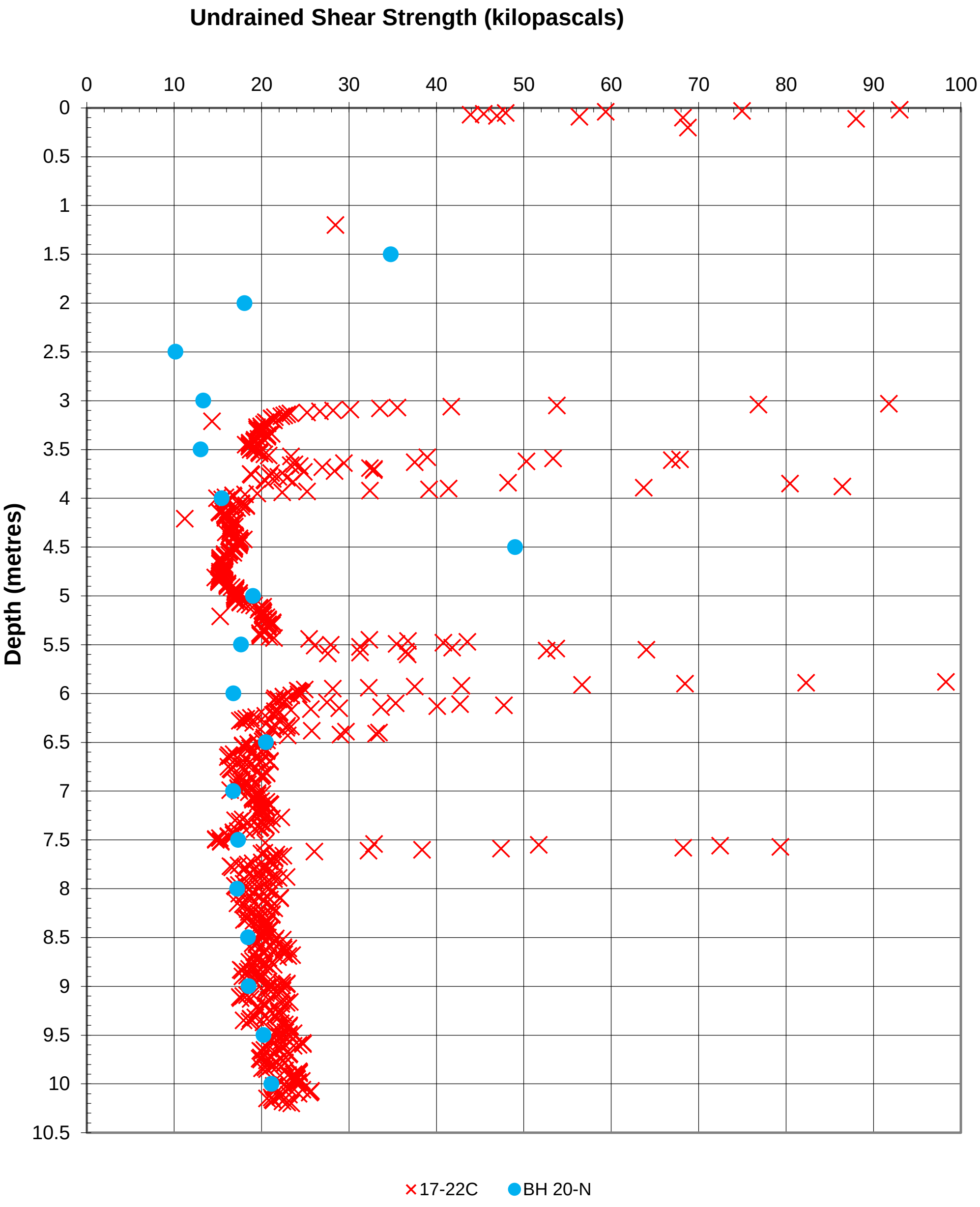
Date June 12, 2018
Project 1787048/400/4.4

Golder Associates

Drawn SM
Chkd MSS

CORRELATION OF UNDRAINED SHEAR STRENGTHS - CPT AND NILCON VANE TESTING

FIGURE F8



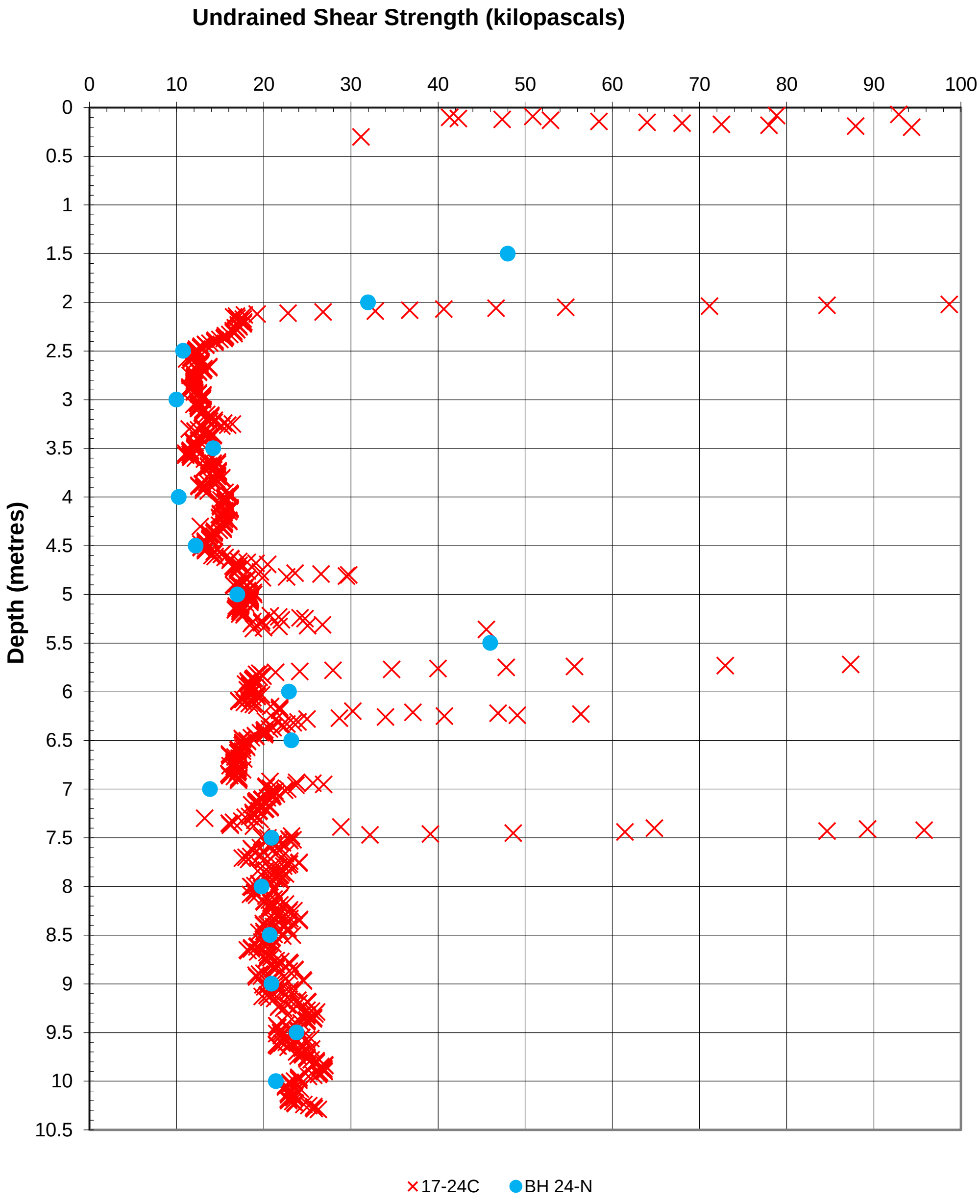
Date June 12, 2018
Project 1787048/400/4.4

Golder Associates

Drawn SM
Chkd MSS

CORRELATION OF UNDRAINED SHEAR STRENGTHS - CPT AND NILCON VANE TESTING

FIGURE F9



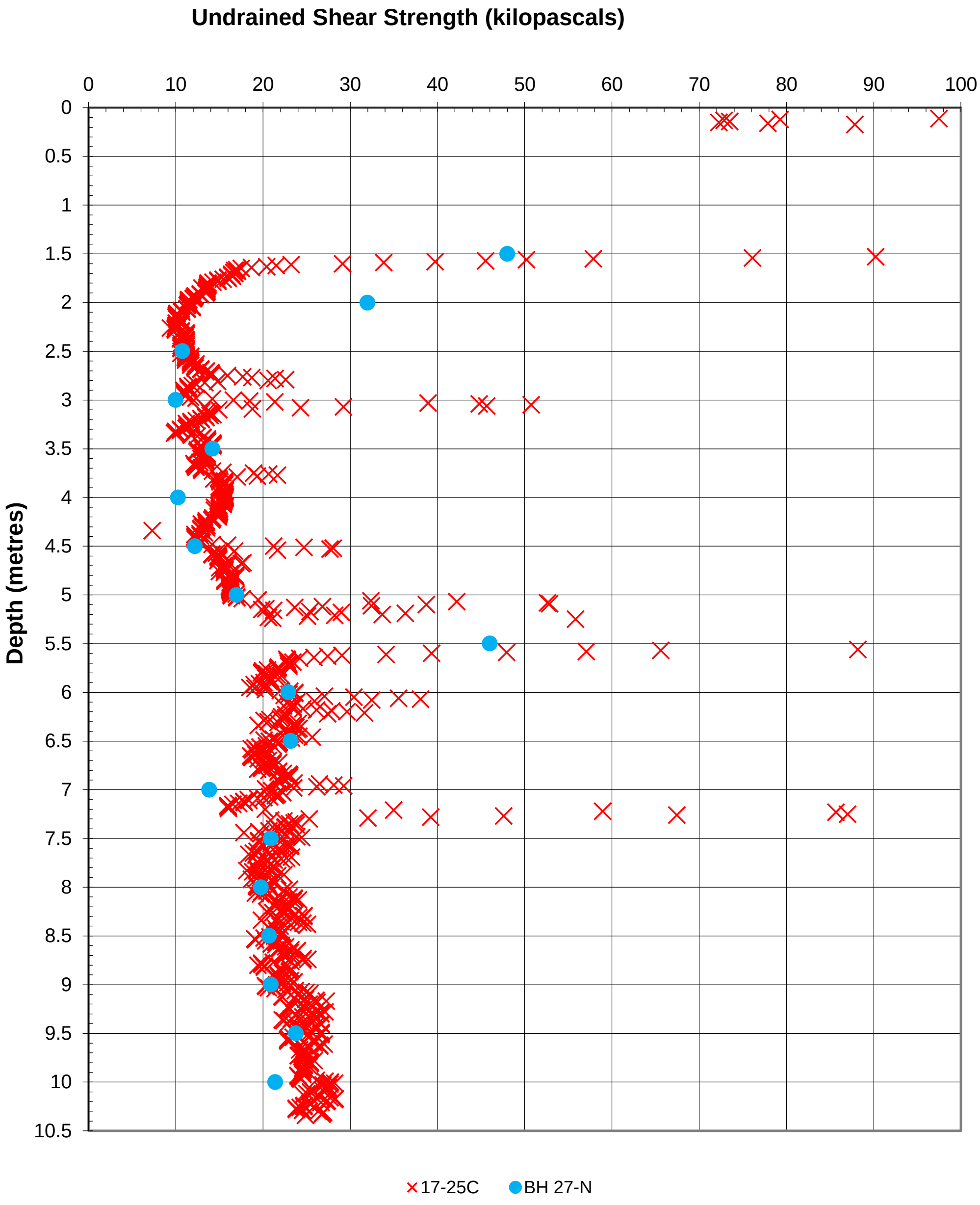
Date June 12, 2018
Project 1787048/400/4.4

Golder Associates

Drawn SM
Chkd MSS

CORRELATION OF UNDRAINED SHEAR STRENGTHS - CPT AND NILCON VANE TESTING

FIGURE F10



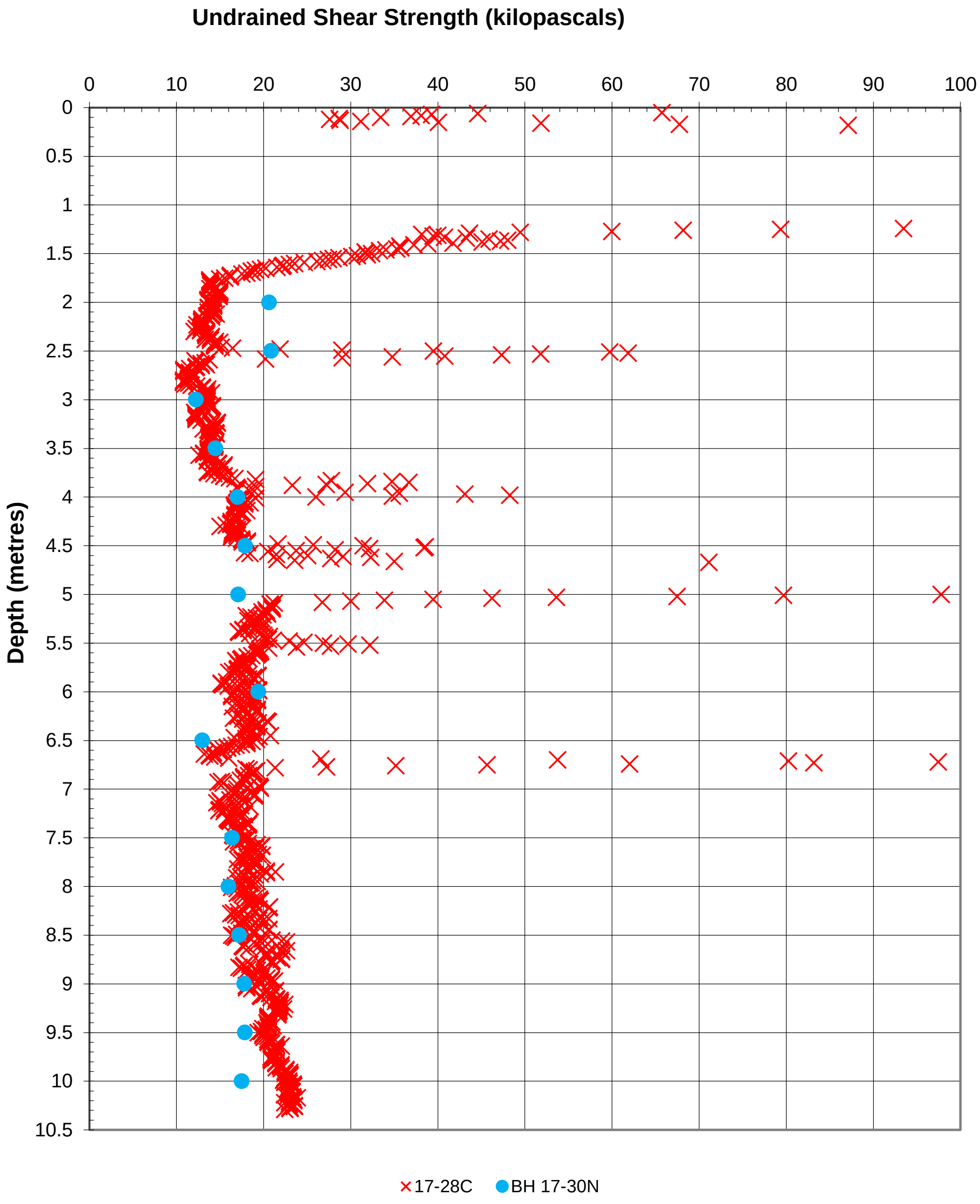
Date June 12, 2018
Project 1787048/400/4.4

Golder Associates

Drawn SM
Chkd MSS

CORRELATION OF UNDRAINED SHEAR STRENGTHS - CPT AND NILCON VANE TESTING

FIGURE F11



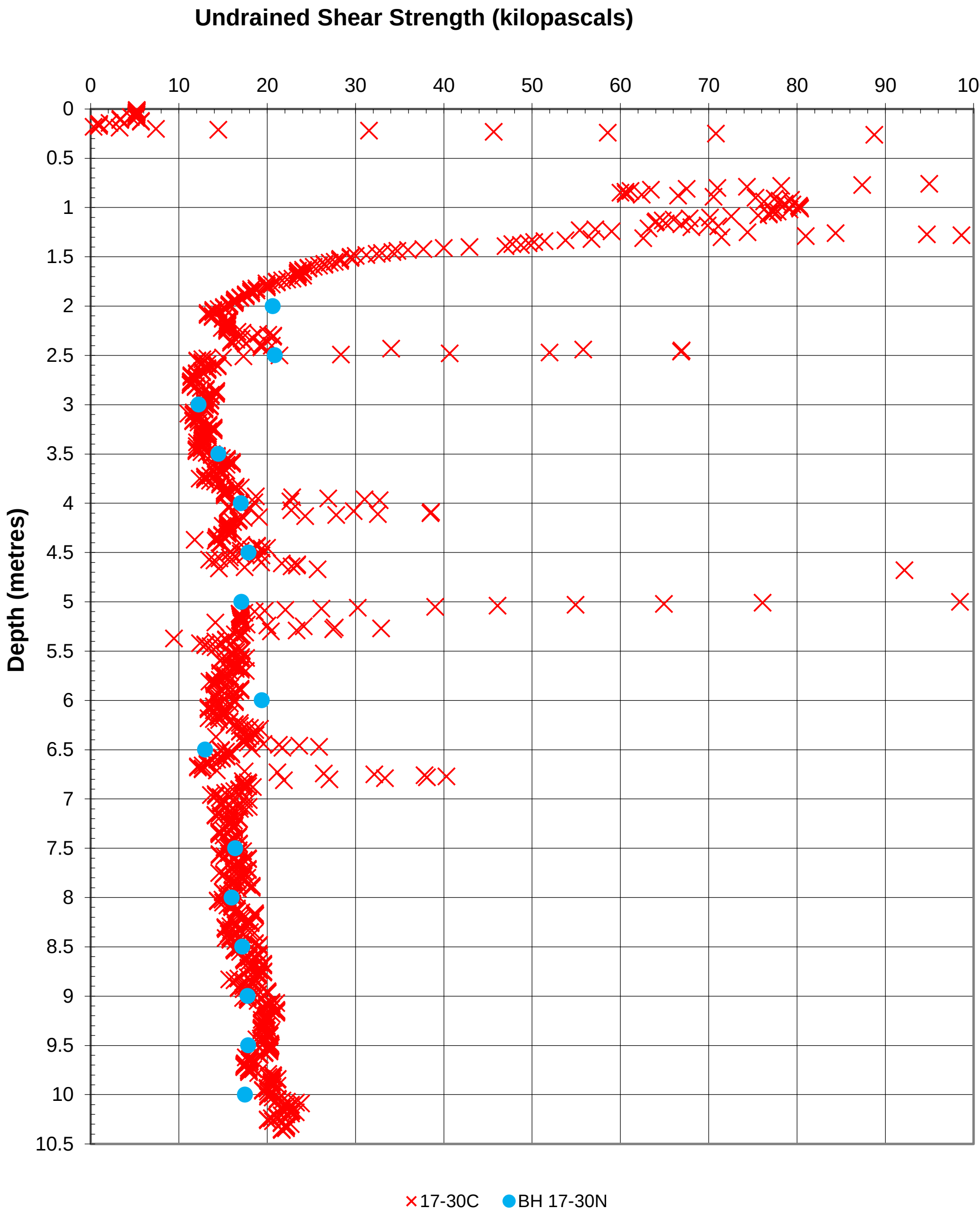
Date June 12, 2018
Project 1787048/400/4.4

Golder Associates

Drawn SM
Chkd MSS

CORRELATION OF UNDRAINED SHEAR STRENGTHS - CPT AND NILCON VANE TESTING

FIGURE F12



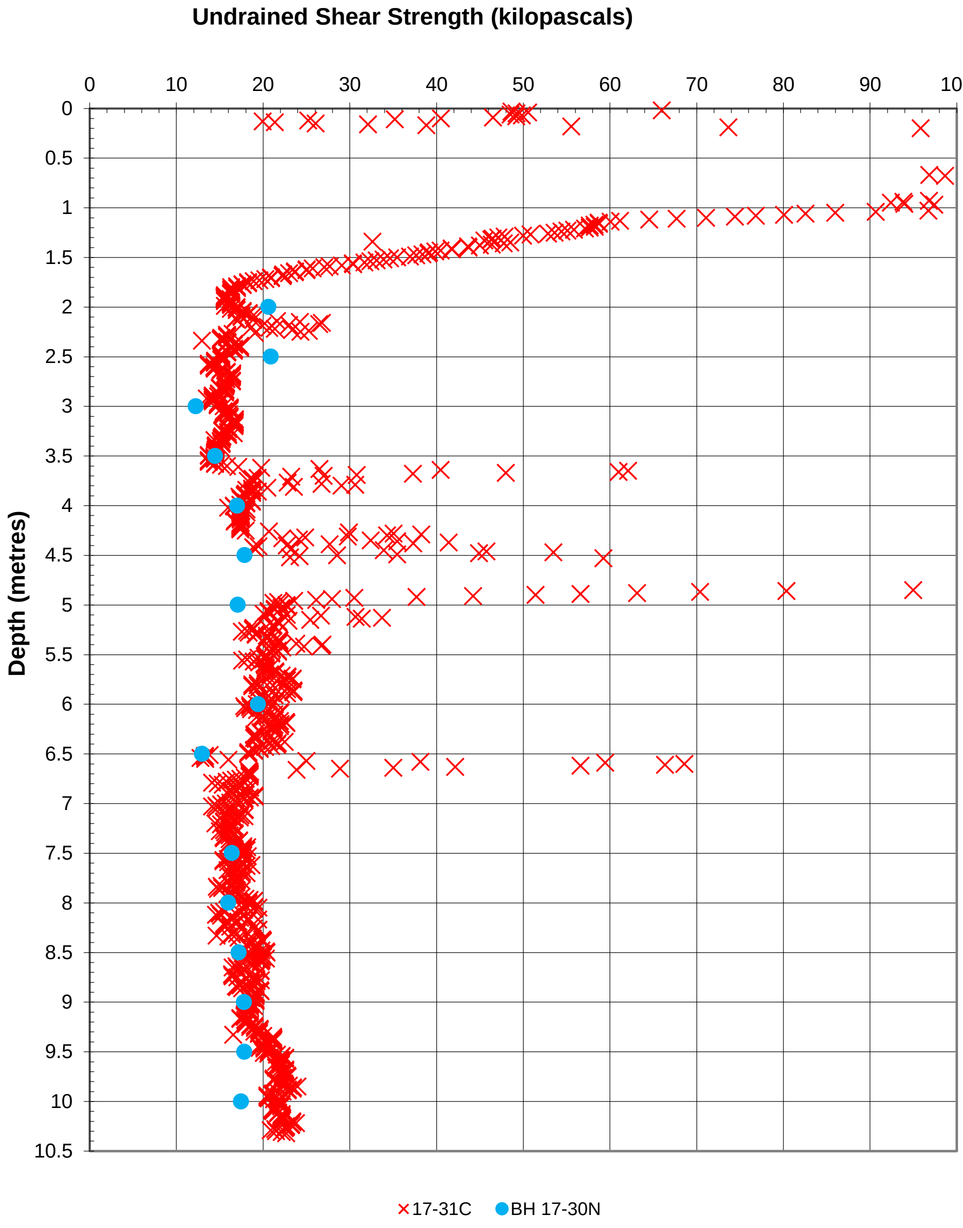
Date June 12, 2018
Project 1787048/400/4.4

Golder Associates

Drawn SM
Chkd MSS

CORRELATION OF UNDRAINED SHEAR STRENGTHS - CPT AND NILCON VANE TESTING

FIGURE F13



Date June 12, 2018
Project 1787048/400/4.4

Golder Associates

Drawn SM
Chkd MSS

APPENDIX G

Photographs of Bedrock Core Samples

BH 17-07 (Dry)
Cored Length of 29.39 to 32.41 metres
Core Box 1 to 1 of 1

29.39 m Top of bedrock

32.41 m *

* End of Hole is 32.46 m

CLIENT
TAGGART MILLER ENVIRONMENTAL SERVICES

PROJECT
CRRRC SITE

CONSULTANT

GOLDER

DD/MM/YYYY	05/04/2018
PREPARED	SM
DESIGN	SM
REVIEW	
APPROVED	MSS

TITLE
BOREHOLE 17-07 (DRY)
CORE PHOTOGRAPHS

PROJECT No.	PHASE	Rev.	FIGURE
1787048	400/4.4	0	G1

BH 17-07 (Wet)
Cored Length of 29.39 to 32.41 metres
Core Box 1 to 1 of 1

29.39 m Top of bedrock

32.41 m *

* End of Hole is 32.46 m

CLIENT TAGGART MILLER ENVIRONMENTAL SERVICES	PROJECT CRRRC SITE

CONSULTANT

GOLDER

DD/MM/YYYY	05/04/2018
PREPARED	SM
DESIGN	SM
REVIEW	
APPROVED	MSS

TITLE
BOREHOLE 17-07 (WET)
CORE PHOTOGRAPHS

PROJECT No.	PHASE	Rev.	FIGURE
1787048	400/4.4	0	G2

BH 17-09 (Dry)
Cored Length of 30.01 to 32.86 metres
Core Box 1 to 1 of 2

30.01 m Top of bedrock

32.86 m

CLIENT
TAGGART MILLER ENVIRONMENTAL SERVICES

PROJECT
CRRRC SITE

CONSULTANT

GOLDER

DD/MM/YYYY	05/04/2018
PREPARED	SM
DESIGN	SM
REVIEW	
APPROVED	MSS

TITLE
BOREHOLE 17-09 (DRY)
CORE PHOTOGRAPHS

PROJECT No.	PHASE	Rev.	FIGURE
1787048	400/4.4	0	G3

BH 17-09 (Dry)
Cored Length of 32.86 to 33.14 metres
Core Box 2 to 2 of 2

32.86 m

33.14 m EOH

CLIENT
TAGGART MILLER ENVIRONMENTAL SERVICES

PROJECT
CRRRC SITE

CONSULTANT

DD/MM/YYYY	05/04/2018
PREPARED	SM
DESIGN	SM
REVIEW	
APPROVED	MSS

GOLDER

TITLE
BOREHOLE 17-09 (DRY)
CORE PHOTOGRAPHS

PROJECT No.	PHASE	Rev.	FIGURE
1787048	400/4.4	0	G4

BH 17-09 (Wet)
Cored Length of 30.01 to 32.86 metres
Core Box 1 to 1 of 2

30.01 m Top of bedrock

32.86 m

CLIENT
TAGGART MILLER ENVIRONMENTAL SERVICES

PROJECT
CRRRC SITE

CONSULTANT

DD/MM/YYYY	05/04/2018
PREPARED	SM
DESIGN	SM
REVIEW	
APPROVED	MSS

TITLE
BOREHOLE 17-09 (WET)
CORE PHOTOGRAPHS

PROJECT No.	PHASE	Rev.	FIGURE
1787048	400/4.4	0	G5

BH 17-09 (Wet)
Cored Length of 32.86 to 33.14 metres
Core Box 2 to 2 of 2

CLIENT
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PROJECT
CRRRC SITE

CONSULTANT

DD/MM/YYYY	05/04/2018
PREPARED	SM
DESIGN	SM
REVIEW	
APPROVED	MSS

TITLE
BOREHOLE 17-09 (WET)
CORE PHOTOGRAPHS

PROJECT No.	PHASE	Rev.	FIGURE
1787048	400/4.4	0	G6

BH 17-14 (Dry)
Cored Length of 34.52 to 36.88 metres
Core Box 1 to 1 of 1

34.52 m Cobbles &

35.33 m Top of bedrock

36.88 m EOH

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CONSULTANT
GOLDER

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PREPARED SM
DESIGN SM
REVIEW
APPROVED MSS

TITLE
BOREHOLE 17-14 (DRY)
CORE PHOTOGRAPHS

PROJECT No.	PHASE	Rev.	FIGURE
1787048	400/4.4	0	G7

BH 17-14 (Wet)
Cored Length of 34.52 to 36.88 metres
Core Box 1 to 1 of 1

34.52 m Cobbles & Boulders

35.33 m Top of bedrock

36.88 m EOH

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TITLE
BOREHOLE 17-14 (WET)
CORE PHOTOGRAPHS

PROJECT No.	PHASE	Rev.	FIGURE
1787048	400/4.4	0	G8

BH 17-17 (Dry)
Cored Length of 35.05 to 38.47 metres
Core Box 1 to 2 of 2

35.05 m Top of bedrock

38.47 m EOH

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DESIGN	SM
REVIEW	
APPROVED	MSS

TITLE
BOREHOLE 17-17 (DRY)
CORE PHOTOGRAPHS

PROJECT No.	PHASE	Rev.	FIGURE
1787048	400/4.4	0	G9

1 in

0

BH 17-17 (Wet)
Cored Length of 35.05 to 38.47 metres
Core Box 1 to 2 of 2

35.05 m Top of bedrock

38.47 m EOH

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DESIGN	SM
REVIEW	
APPROVED	MSS

TITLE
BOREHOLE 17-17 (WET)
CORE PHOTOGRAPHS

PROJECT No.	PHASE	Rev.	FIGURE
1787048	400/4.4	0	G10

BH 17-21 (Dry)
Cored Length of 40.48 to 43.41 metres
Core Box 1 to 1 of 1

40.48 m Top of bedrock

43.41 m EOH

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PROJECT
CRRRC SITE

CONSULTANT
GOLDER

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PREPARED	SM
DESIGN	SM
REVIEW	
APPROVED	MSS

TITLE
BOREHOLE 17-21 (DRY)
CORE PHOTOGRAPHS

PROJECT No.	PHASE	Rev.	FIGURE
1787048	400/4.4	0	G11

BH 17-21 (Wet)
Cored Length of 40.48 to 43.41 metres
Core Box 1 to 1 of 1

40.48 m Top of bedrock

43.41 m EOH

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PROJECT
CRRRC SITE

CONSULTANT

DD/MM/YYYY	05/04/2018
PREPARED	SM
DESIGN	SM
REVIEW	
APPROVED	MSS

TITLE
BOREHOLE 17-21 (WET)
CORE PHOTOGRAPHS

PROJECT No.	PHASE	Rev.	FIGURE
1787048	400/4.4	0	G12

BH 17-23 (Dry)
Cored Length of 37.49 to 39.92 metres
Core Box 1 to 1 of 1

37.49 m Top of bedrock

39.92 m EOH

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PROJECT
CRRRC SITE

CONSULTANT
GOLDER

DD/MM/YYYY	05/04/2018
PREPARED	SM
DESIGN	SM
REVIEW	
APPROVED	MSS

TITLE
BOREHOLE 17-23 (DRY)
CORE PHOTOGRAPHS

PROJECT No.	PHASE	Rev.	FIGURE
1787048	400/4.4	0	G13

BH 17-23 (Wet)
Cored Length of 37.49 to 39.92 metres
Core Box 1 to 1 of 1

37.49 m Top of bedrock

39.92 m EOH

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PROJECT
CRRRC SITE

CONSULTANT

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PREPARED	SM
DESIGN	SM
REVIEW	
APPROVED	MSS

TITLE
BOREHOLE 17-23 (WET)
CORE PHOTOGRAPHS

PROJECT No.	PHASE	Rev.	FIGURE
1787048	400/4.4	0	G14

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A

1 in

0

BH 17-26 (Dry)
Cored Length of 38.60 to 41.45 metres
Core Box 1 to 1 of 1

38.60 m Top of bedrock

41.45 m EOH

CLIENT
TAGGART MILLER ENVIRONMENTAL SERVICES

PROJECT
CRRRC SITE

CONSULTANT

DD/MM/YYYY 05/04/2018
PREPARED SM
DESIGN SM
REVIEW
APPROVED MSS

TITLE
BOREHOLE 17-26 (DRY)
CORE PHOTOGRAPHS

PROJECT No.	PHASE	Rev.	FIGURE
1787048	400/4.4	0	G15

BH 17-26 (Wet)
Cored Length of 38.60 to 41.45 metres
Core Box 1 to 1 of 1

38.60 m Top of bedrock

41.45 m EOH

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PROJECT
CRRRC SITE

CONSULTANT
GOLDER

DD/MM/YYYY	05/04/2018
PREPARED	SM
DESIGN	SM
REVIEW	
APPROVED	MSS

TITLE
BOREHOLE 17-26 (WET)
CORE PHOTOGRAPHS

PROJECT No.	PHASE	Rev.	FIGURE
1787048	400/4.4	0	G16

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BH 17-29 (Dry)
Cored Length of 39.98 to 41.94 metres
Core Box 1 to 1 of 1

39.98 m Top of bedrock

41.94 m EOH

CLIENT
TAGGART MILLER ENVIRONMENTAL SERVICES

PROJECT
CRRRC SITE

CONSULTANT
GOLDER

DD/MM/YYYY	05/04/2018
PREPARED	SM
DESIGN	SM
REVIEW	
APPROVED	MSS

TITLE
BOREHOLE 17-29 (DRY)
CORE PHOTOGRAPHS

PROJECT No.	PHASE	Rev.	FIGURE
1787048	400/4.4	0	G17

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BH 17-29 (Wet)
Cored Length of 39.98 to 41.94 metres
Core Box 1 to 1 of 1

39.98 m Top of bedrock

41.94 m EOH

CLIENT
TAGGART MILLER ENVIRONMENTAL SERVICES

PROJECT
CRRRC SITE

CONSULTANT

DD/MM/YYYY	05/04/2018
PREPARED	SM
DESIGN	SM
REVIEW	
APPROVED	MSS

TITLE
BOREHOLE 17-29 (WET)
CORE PHOTOGRAPHS

PROJECT No.	PHASE	Rev.	FIGURE
1787048	400/4.4	0	G18

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A

1 in

0

APPENDIX H

Technical Memorandum – Results of VSP Testing

TECHNICAL MEMORANDUM

DATE March 2013 **PROJECT No.** 12-1125-0045

VSP TEST RESULTS – CRRRC SITE, OTTAWA, ONTARIO

This memorandum presents the results of the vertical seismic profile (VSP) testing performed at the Capital Region Resource Recovery Centre (CRRRC) Site (Site) located in the eastern portion of the City of Ottawa. VSP testing was completed in BH-12-2-3 and BH-12-3-3 on February 20 and 21, 2013. Both boreholes were cased with a PVC pipe grouted in place, which extended above ground surface. Borehole BH-12-2-3 consists of about 36.7 metres of overburden overlying limestone bedrock. The overburden consists of approximately 34.6 metres of clay to silty clay overlying about 2.2 metres of sand and silt. Borehole BH-12-3-3 consists of approximately 39.8 metres of overburden overlying shale bedrock. The overburden consists of about 34.1 metres of clay to silty clay overlying about 5.7 metres of sand to sandy silt.

Methodology

For the VSP method, seismic energy is generated at the ground surface by an active seismic source and recorded by a geophone located in a nearby borehole at a known depth (Figure 1). The methodology can be applied using an active seismic source that produces either compression or shear waves. The time required for the energy to travel from the source to the receiver (geophone) provides a measurement of the average compression or shear wave seismic velocity of the medium between the source and the receiver. Data obtained from different geophone depths are used to calculate a detailed vertical seismic velocity profile of the subsurface in the immediate vicinity of the test borehole.

The high resolution results of a VSP survey are often used for earthquake engineering site classification, as per the National Building Code of Canada, 2010.

Field Work

The field work was completed on February 20th and 21st, 2013, by personnel from the Golder Ottawa offices.

Both compression and shear wave seismic sources were measured using a source located in close vicinity to the borehole. The seismic source for the compression wave test consisted of a 9.9 kilogram sledge hammer vertically impacted on a metal plate, located 2 metres from the borehole. The seismic source for the shear wave test consisted of a 3.0 metres long, 150 millimetres by 150 millimetres wooden beam, weighted down by a vehicle and horizontally struck with a 9.9 kilogram sledge hammer on alternate ends of the beam to induce polarized shear waves. The shear sources were located 2 metres from the borehole. Test measurements started at ground surface and were recorded in the borehole with a 3-component receiver spaced at 1-metre intervals below the ground surface, to a maximum depth of the borehole (40.2 metres in borehole BH-12-2-3 and 44.3 metres in borehole BH-12-3-3).

The seismic records collected for each source location were stacked a minimum of ten times to minimize the effects of ambient background seismic noise on the collected data. The data was sampled at 0.020833 millisecond intervals and a total time window of 0.341 seconds was collected for each seismic shot.

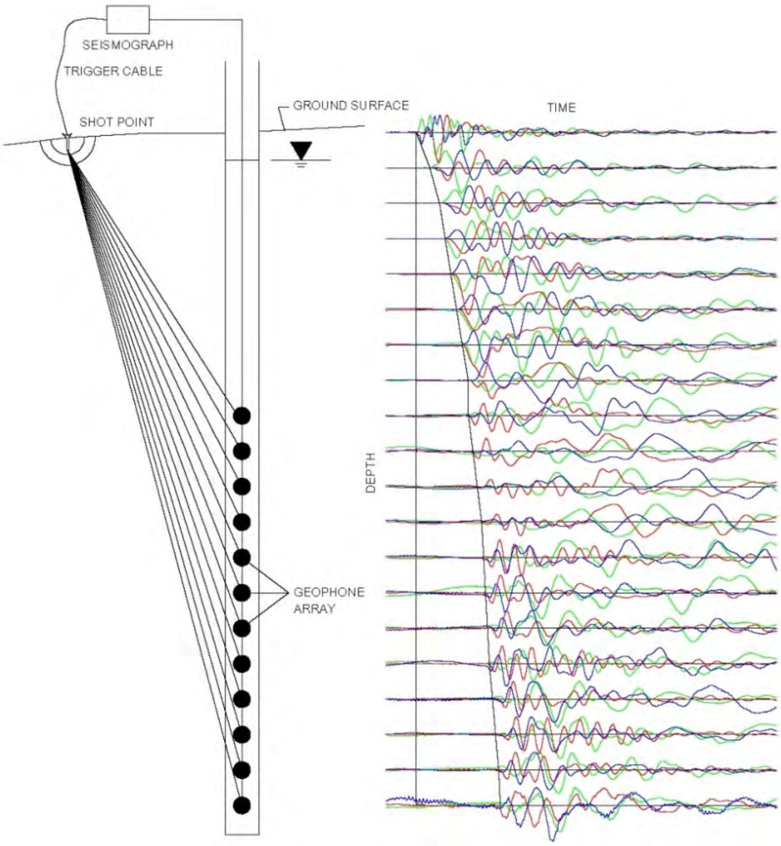

Figure 1: Example of Layout and resulting time traces from a VSP survey

Data Processing

Processing of the VSP test results consisted of the following main steps:

1) Combination of seismic records to present seismic traces for all depth intervals on a single plot for each seismic source and for each component;

2) Low Pass Filtering of data to remove spurious high frequency noise;

3) First break picking of the compression and shear wave arrivals; and,

4) Calculation of the average compression and shear wave velocity to each tested depth interval.

Processing of the VSP data was completed using the SeisImager/SW software package (Geometrics Inc.). The seismic records are presented on the following four plots and show the first break picks of the compression wave and shear wave arrivals for both boreholes overlaid on the seismic waveform traces recorded at the different geophone depths (Figures 2 to 5). The arrivals were picked on the vertical component for the compression source and on the two horizontal components for the shear source.

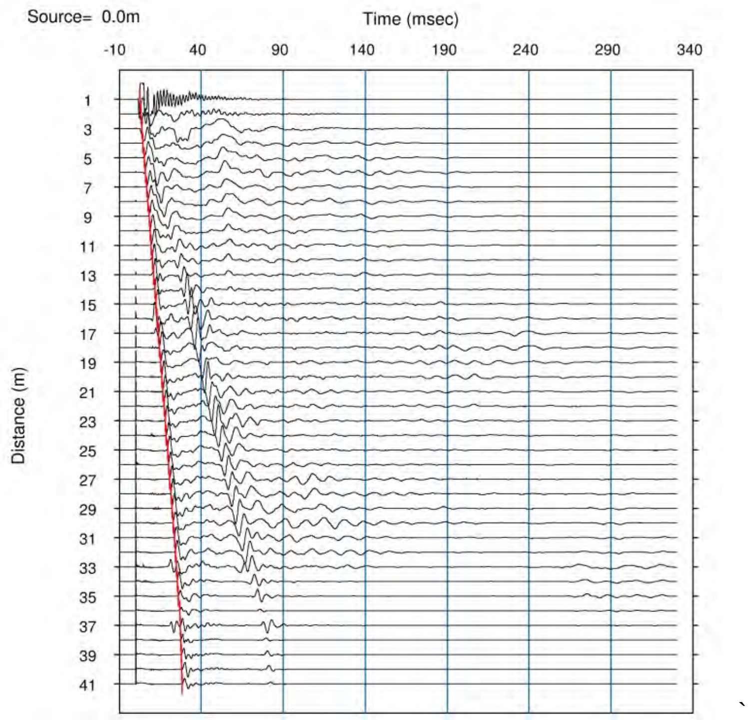

Figure 2: BH-12-2-3, first break picking of compression wave arrivals (red) along the seismic traces recorded at each receiver depth

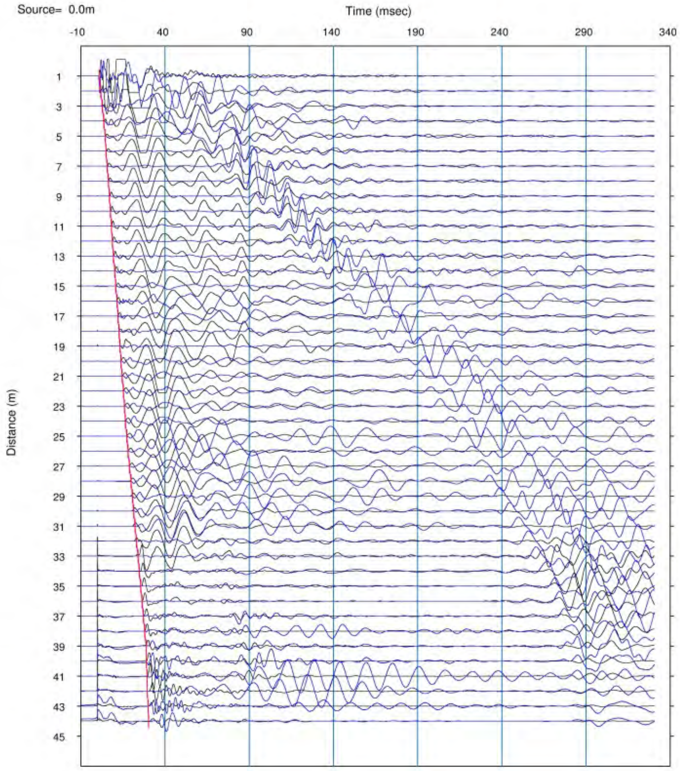

Figure 3: BH-12-3-3, first break picking of compression wave arrivals (red) along the seismic traces recorded at each receiver depth

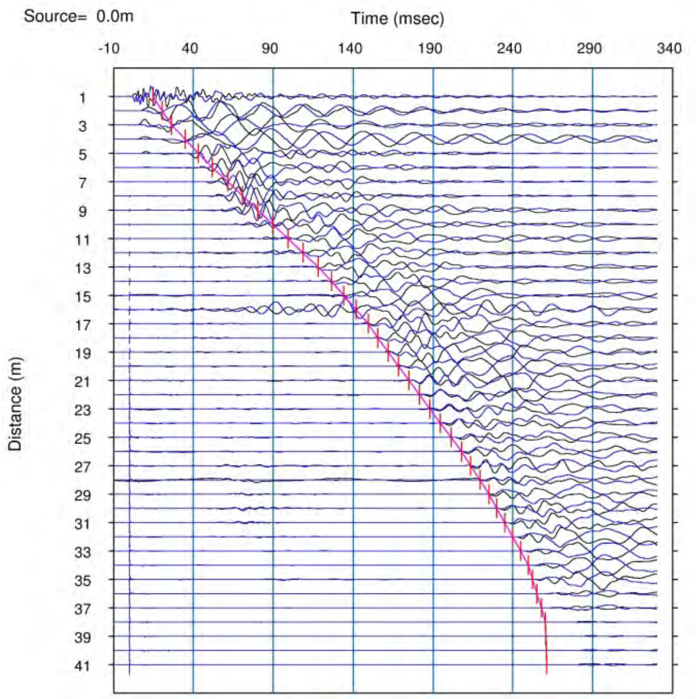

Figure 4: BH-12-2-3, first break picking of shear wave arrivals (red) along the seismic traces recorded at each receiver depth

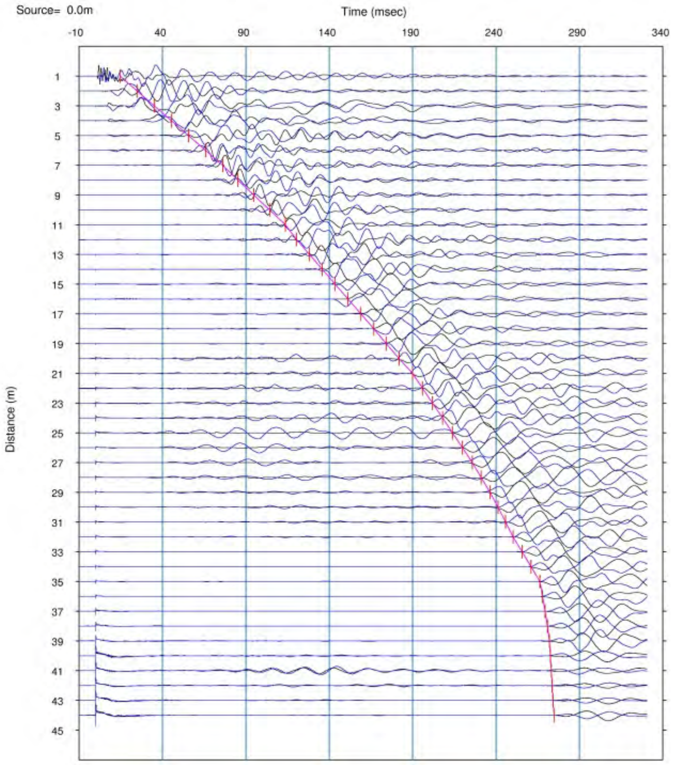

Figure 5: BH-12-3-3, first break picking of shear wave arrivals (red) along the seismic traces recorded at each receiver depth

Results

The VSP results are summarized in Table 1 for BH-12-2-3 and Table 2 for BH-12-3-3. The shear wave and compression wave layer velocities, at the field collected one-metre intervals, were calculated by best fitting a theoretical travel time model to the field data collected at either half or one metre intervals. The depths presented on the tables are relative to ground surface.

The estimated dynamic engineering moduli, based on the calculated wave velocities, are also presented on Table 1 and 2. The engineering moduli were calculated using an estimated bulk density, based on the borehole log, but a more detailed geotechnical investigation would be necessary to determine a more exact density for each layer. For the topsoil down to a depth of approximately 36 metres in BH-12-2-3 and 38 metres in BH-12-3-3, a bulk density of 1,750 kg/m^3 was estimated. Further down, to a depth of the bottom of the hole, the bulk density for the bedrock was estimated at 2,300 kg/m^3.

The first layer of both boreholes is likely frozen, which is why a relatively high velocity is measured for both the compressional and shear wave velocity.

The average shear wave velocity from ground surface to a depth of 30 metres was measured to be 117 m/s for BH-12-2-3 and 112 m/s for BH-12-3-3.

Closure

We trust that these results meet your current needs. If you have any questions or require clarification, please contact the undersigned at your convenience.

Yours truly,

GOLDER ASSOCIATES LTD.

Stephane Sol, Ph.D. Geophysics Group	Brian Byerley, M. Sc., P. Eng. Senior Hydrogeologist, Principal

SS/PF/BTB/sg
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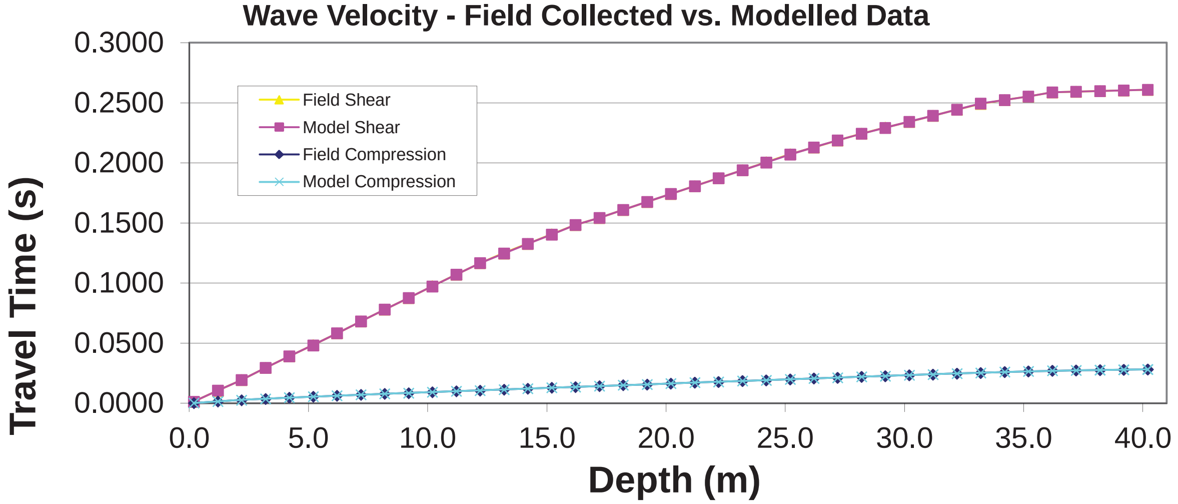
Attachments: Tables 1 and 2

TABLE 1
SHEAR WAVE VELOCITY PROFILE AT BH 12-2-3

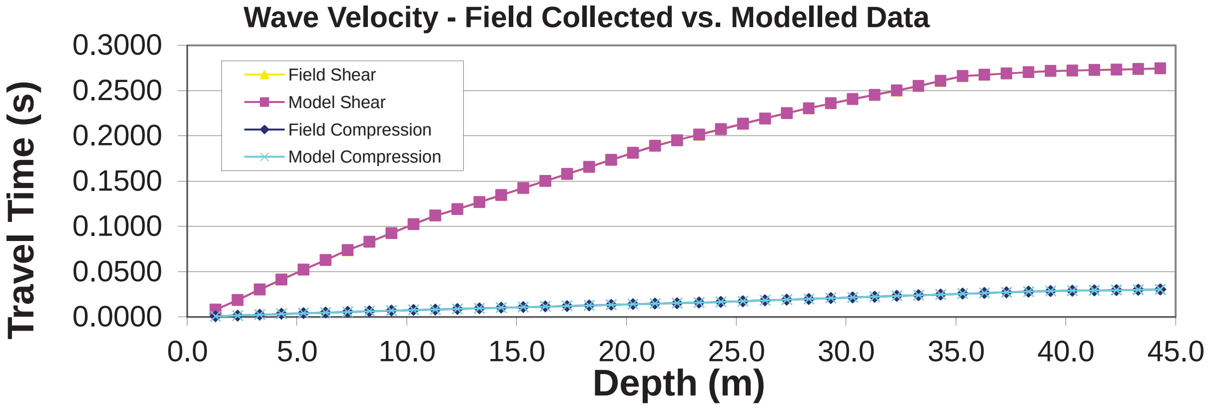
Layer Depth (m)				Estimated Bulk Density (kg/m^3)	Dynamic Engineering Properties			
Top	Bottom	Compressional Wave (m/s)	Shear Wave (m/s)		Poissons Ratio	Shear Modulus (MPa)	Deformation Modulus (MPa)	Bulk Modulus (MPa)
0.0	0.2	872	138	1750	0.49	33	99	1286
0.0	1.2	747	110	1750	0.49	21	63	948
1.2	2.2	820	113	1750	0.49	22	67	1147
2.2	3.2	985	99	1750	0.49	17	51	1675
3.2	4.2	1115	104	1750	0.50	19	57	2150
4.2	5.2	1210	108	1750	0.50	20	61	2535
5.2	6.2	1260	99	1750	0.50	17	51	2755
6.2	7.2	1230	102	1750	0.50	18	54	2623
7.2	8.2	1345	102	1750	0.50	18	55	3142
8.2	9.2	1350	104	1750	0.50	19	57	3164
9.2	10.2	1370	103	1750	0.50	19	56	3260
10.2	11.2	1380	103	1750	0.50	19	56	3308
11.2	12.2	1390	105	1750	0.50	19	58	3355
12.2	13.2	1390	122	1750	0.50	26	78	3346
13.2	14.2	1390	125	1750	0.50	27	82	3345
14.2	15.2	1400	130	1750	0.50	30	88	3391
15.2	16.2	1400	128	1750	0.50	29	86	3392
16.2	17.2	1400	165	1750	0.49	48	142	3366
17.2	18.2	1400	150	1750	0.49	39	118	3378
18.2	19.2	1420	152	1750	0.49	40	121	3475
19.2	20.2	1410	152	1750	0.49	40	121	3425
20.2	21.2	1405	152	1750	0.49	40	121	3401
21.2	22.2	1400	152	1750	0.49	40	121	3376
22.2	23.2	1410	152	1750	0.49	40	121	3425
23.2	24.2	1490	152	1750	0.49	40	121	3831
24.2	25.2	1450	150	1750	0.49	39	118	3627
25.2	26.2	1450	170	1750	0.49	51	151	3612
26.2	27.2	1430	175	1750	0.49	54	160	3507
27.2	28.2	1350	180	1750	0.49	57	169	3114
28.2	29.2	1520	200	1750	0.49	70	209	3950
29.2	30.2	1520	200	1750	0.49	70	209	3950
30.2	31.2	1520	200	1750	0.49	70	209	3950
31.2	32.2	1520	200	1750	0.49	70	209	3950
32.2	33.2	1520	200	1750	0.49	70	209	3950
33.2	34.2	1520	340	1750	0.47	202	596	3773
34.2	35.2	1520	320	1750	0.48	179	529	3804
35.2	36.2	1900	300	1750	0.49	158	468	6108
36.2	37.2	3700	1900	2300	0.32	8303	21935	20416
37.2	38.2	3700	1900	2300	0.32	8303	21935	20416
38.2	39.2	3700	1900	2300	0.32	8303	21935	20416
39.2	40.2	3700	1900	2300	0.32	8303	21935	20416



Notes
1. Depth Presented relative to ground surface.
2. This Table to be analyzed in conjunction with the accompanying report.

TABLE 2
SHEAR WAVE VELOCITY PROFILE AT BH 12-3-3

Layer Depth (m)				Estimated Bulk Density (kg/m^3)	Dynamic Engineering Properties			
Top	Bottom	Compressional Wave (m/s)	Shear Wave (m/s)		Poissons Ratio	Shear Modulus (MPa)	Deformation Modulus (MPa)	Bulk Modulus (MPa)
0.0	1.3	2385	165	1750	0.50	48	143	9891
0.0	2.3	1110	92	1750	0.50	15	44	2136
2.3	3.3	1020	88	1750	0.50	14	41	1803
3.3	4.3	1022	90	1750	0.50	14	42	1809
4.3	5.3	1260	92	1750	0.50	15	44	2759
5.3	6.3	1480	93	1750	0.50	15	45	3813
6.3	7.3	1500	93	1750	0.50	15	45	3917
7.3	8.3	1520	108	1750	0.50	20	61	4016
8.3	9.3	1530	103	1750	0.50	19	56	4072
9.3	10.3	1550	103	1750	0.50	19	56	4180
10.3	11.3	1550	103	1750	0.50	19	56	4180
11.3	12.3	1560	145	1750	0.50	37	110	4210
12.3	13.3	1560	125	1750	0.50	27	82	4222
13.3	14.3	1340	130	1750	0.50	30	88	3103
14.3	15.3	1550	130	1750	0.50	30	89	4165
15.3	16.3	1600	128	1750	0.50	29	86	4442
16.3	17.3	1550	128	1750	0.50	29	86	4166
17.3	18.3	1600	128	1750	0.50	29	86	4442
18.3	19.3	1600	130	1750	0.50	30	89	4441
19.3	20.3	1580	130	1750	0.50	30	89	4329
20.3	21.3	1580	125	1750	0.50	27	82	4332
21.3	22.3	1580	165	1750	0.49	48	142	4305
22.3	23.3	1580	165	1750	0.49	48	142	4305
23.3	24.3	1400	165	1750	0.49	48	142	3366
24.3	25.3	1250	165	1750	0.49	48	142	2671
25.3	26.3	1280	170	1750	0.49	51	151	2800
26.3	27.3	1250	170	1750	0.49	51	151	2667
27.3	28.3	1150	185	1750	0.49	60	178	2235
28.3	29.3	1250	185	1750	0.49	60	178	2655
29.3	30.3	1200	210	1750	0.48	77	229	2417
30.3	31.3	1200	215	1750	0.48	81	240	2412
31.3	32.3	1250	215	1750	0.48	81	240	2627
32.3	33.3	1200	190	1750	0.49	63	188	2436
33.3	34.3	1220	185	1750	0.49	60	178	2525
34.3	35.3	1220	190	1750	0.49	63	188	2520
35.3	36.3	1220	650	1750	0.30	739	1925	1619
36.3	37.3	1250	680	1750	0.29	809	2087	1655
37.3	38.3	1260	680	2300	0.29	1064	2754	2233
38.3	39.3	1500	800	1750	0.30	1120	2915	2444
39.3	40.3	3000	1800	2300	0.22	7452	18164	10764
40.3	41.3	3100	1900	2300	0.20	8303	19913	11032
41.3	42.3	3200	1800	2300	0.27	7452	18907	13616
42.3	43.3	3200	1800	2300	0.27	7452	18907	13616
43.3	44.3	3200	1800	2300	0.27	7452	18907	13616



Notes

1. Depth Presented relative to ground surface.
2. This Table to be analyzed in conjunction with the accompanying report.

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