

## TECHNICAL MEMORANDUM

**DATE** May 29, 2019

**Project No.** 18111310

**TO** Pauline Dicaire, Senior Project Manager of Capital Projects  
Ottawa Police Service  
c/o Jenna Wood, Senior Project Manager, Colliers Project Leaders

**FROM** Loren Bekeris and Brian Byerley

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**DESKTOP WATER WELL IMPACT STUDY  
PROPOSED OTTAWA POLICE SERVICE SOUTH FACILITY  
55 LODGE ROAD, OTTAWA, ONTARIO**

This report presents the results of a desktop water well impact study carried out by Golder Associates Ltd. (Golder) for the proposed Ottawa Police Service South Facility site that is to be located at 55 Lodge Road in Ottawa, Ontario. It is understood that this study is required for site plan approval.

The purpose of this study was to determine the general soil and groundwater conditions across the site and to address possible construction-related impacts to private water supply wells. The soil and groundwater conditions were assessed by means of existing data from on-site boreholes, published mapping and publicly available information. The water well records in the Ministry of the Environment, Conservation and Parks (MECP) Water Well Information System (WWIS) for nearby water wells were used to provide further information regarding hydrogeological conditions in the area and identify where nearby water well users are taking their water.

### 1.0 DESCRIPTION OF PROJECT AND SITE

Plans are currently being prepared for the proposed Ottawa Police Service South Facility to be located at 55 Lodge Road in Ottawa, Ontario (see Site Plan, Figure 1). From the preliminary drawings provided to Golder, it is understood that the new station will be located in the northern part of the site and consist of a three-storey main office building attached to another two-storey building and a two-storey parking structure, with a total footprint of approximately 12,000 square metres. All structures will be of slab on grade construction (i.e., no basement). It is understood that the structures will be founded on shallow foundations or pile foundations.

The following is known about the site:

- The site is located to the northeast of the intersection of Prince of Wales Drive and Lodge Road.
- The site is approximately triangular in shape and measures about 420 metres by 190 metres in plan.
- The ground surface is gently sloping down to the east, with ground surface elevations ranging from about 89 metres at Prince of Wales Drive to about 83 metres at the Rideau River.
- The site was the former location of the previous Carleton Lodge building.
- This site is currently vacant, is grass covered, and contains some tree coverage.

## **2.0 GEOLOGY AND HYDROGEOLOGY**

The following sections describe the published local geology and hydrogeology in the vicinity of the site.

### **2.1 Surficial Geology**

Based on published mapping (Figure 2), the surficial geology at and surrounding the site is interpreted to consist of marine silt and clay deposits. Published mapping indicates the bedrock surface to be at depths in the range of 15 to 50 metres below the ground surface across the site (Figure 3).

### **2.2 Bedrock Geology**

The Ontario Geological Survey bedrock geology mapping indicates that the site is underlain by the sandstone and dolostone of the March Formation.

### **2.3 Hydrogeology**

#### **2.3.1 Overburden Aquifer**

The fine-grained overburden deposits in the area are generally not capable of supplying sufficient quantities of groundwater to be considered an aquifer. As a result, the principal water supply aquifer within the vicinity of the site is considered to be the underlying bedrock formations. However, as discussed in Section 4.1, some local wells are completed in a deep gravel layer.

#### **2.3.2 Bedrock Aquifers**

The March formation and, where present, the overlying Oxford formation form the widely used Dolostone aquifer, which generally supplies adequate yields for domestic water supplies. Well yields in the Dolostone aquifer have been reported between 45 and 680 L/min. Groundwater flow within the Dolostone aquifer is controlled predominantly by fractures. In addition, the March formation, which contains sandstone interbeds, tends to yield more water than the Oxford formation, which contains shale interbeds (MRSPR, 2008), although the upper Oxford can be highly transmissive.

## **3.0 SITE SPECIFIC GEOLOGY AND HYDROGEOLOGY**

### **3.1 General**

Golder completed a geotechnical investigation at this site in 2016, which included 15 boreholes advanced across the site. Golder subsequently completed an additional geotechnical investigation at the site in 2018 and 2019 in order to provide geotechnical input to the detailed design; this investigation included 4 boreholes advanced across the site.

Based on a review of the geotechnical investigation results and published geological mapping, the subsurface conditions at the site are interpreted to consist of a layer of topsoil/fill, overlying a thick deposit of sensitive silty clay, extending to about 8 to 15 metres depth. The clay deposit is underlain by a deposit of glacial till, followed by dolostone bedrock. Borehole logs from both Golder investigations are provided as Attachment 1, and borehole locations are indicated on Figure 1. Note that no soil sampling was carried out in boreholes 19-01 and 19-02 which were advanced to confirm the bedrock depth at these locations.

## **3.2 Site Specific Geology**

### **Topsoil and Fill**

Topsoil exists at the ground surface at all of the borehole locations. At the borehole locations, the topsoil thickness ranges from about 50 to 760 millimetres, but more typically between 80 and 150 millimetres.

A layer of fill exists below the topsoil at all of the borehole locations, except boreholes BH16-12 and BH16-15. The fill extends down to depths ranging from about 0.6 to 2.3 metres, but more typically between 0.6 to 0.8 metres, below the existing ground surface. The fill generally consists of silty sand to sandy silt with varying amounts of gravel, cobbles, rootlets, and organic matter.

### **Silty Clay to Clay**

At all of the borehole locations, the topsoil and fill are underlain by a deposit of sensitive marine silty clay from the previous Champlain Sea that covered much of the Ottawa area.

The upper portion of the silty clay has generally been weathered to a grey brown crust and extends to depths ranging from about 4.6 to 7.6 metres below the existing ground surface. The full depth of the silty clay in boreholes 16-09 and 16-12 has been weathered to a grey brown crust and extends to depths of about 4.0 and 5.3 metres below the ground surface, respectively.

The silty clay below the depth of weathering is grey in colour. Where fully penetrated, the unweathered silty clay extends to depths ranging from about 8.5 to 15.3 metres below the existing ground surface.

### **Glacial Till**

At all of the borehole locations, there exists a thick deposit of glacial till beneath the silty clay. The glacial till typically consists of a heterogeneous mixture of gravel, cobbles, and boulders in a matrix of sandy silt to silty sand with trace to some clay. This deposit was fully penetrated only in borehole 18-02, where it extends to a depth of about 25.9 metres below the existing ground surface. Where not fully penetrated, the glacial till was proven to depths ranging from about 5.9 to 29 metres below the existing ground surface.

### **Clayey Silt**

A thin deposit of clayey silt was encountered below the glacial till at the location of borehole 18-02. The layer is 0.6 metre in thickness and extends down to a depth of 26.5 metres below the ground surface.

### **Gravel**

A deposit of gravel was encountered below the clayey silt at the location of borehole 18-02. The layer is 1.5 metre in thickness and extends down to a depth of about 28 metres below the ground surface.

### **Bedrock**

Practical refusal to augering was encountered in boreholes 16-01, 16-03, and 16-06 at depths ranging from about 19.0 to 26.4 metres below the existing ground surface. Auger refusal could indicate boulders within the glacial till or the bedrock surface.

Boreholes 18-02, 19-01, and 19-02 were extended into the underlying bedrock using rotary diamond drilling techniques. These boreholes were extended to about 2.1 to 5.2 metres into the bedrock. The recovered bedrock cores from these locations consist of fresh, thinly to medium bedded, light to medium grey, sandy dolostone or dolostone bedrock. The following table summarizes the auger refusal and bedrock depths and elevations encountered at the site.

Borehole Number	Ground Surface Elevation (metres)	Elevation of Bedrock or Auger Refusal (metres)	Depth of Bedrock or Auger Refusal (metres)
16-01	88.54	65.71 <sup>1</sup>	22.83 <sup>1</sup>
16-03	84.80	58.44 <sup>1</sup>	26.36 <sup>1</sup>
16-06	87.67	68.65 <sup>1</sup>	19.02 <sup>1</sup>
18-02	84.90	56.88	28.02
19-01	87.09	51.84	35.25
19-02	85.48	53.32	32.16

**Notes:**

<sup>1</sup> Auger Refusal

### 3.3 Hydrogeology

Standpipe piezometers were sealed into boreholes 16-04, 16-07, 16-10, 16-12, and 16-15 to allow for subsequent measurement of the groundwater level at the site. The groundwater levels in these standpipe piezometers were measured on February 2, 2017 and December 19, 2018. The following table summarizes the measured groundwater levels.

Borehole Number	Ground Surface Elevation (metres)	Strata	Groundwater Level Depth on 02/02/2017 (metres)	Groundwater Level Elevation on 02/02/2017 (metres)	Groundwater Level Depth on 19/12/2018 (metres)	Groundwater Level Elevation on 19/12/2018 (metres)
16-04	83.65	Silty Clay	1.14	82.51	1.05	82.60
16-07	84.57	Silty Clay	1.27	83.30	0.28	84.29
16-10	86.31	Glacial Till	2.78	83.53	0.73	85.58
16-12	87.91	Silty Clay / Glacial Till	0.71	87.20	0.74	87.17
16-15	86.75	Silty Clay	3.22	83.53	-	-

It should be noted that groundwater levels are expected to fluctuate seasonally. Higher groundwater levels are expected during wet periods of the year, such as spring and fall.

### 4.0 POTENTIAL IMPACTS TO EXISTING GROUNDWATER USERS

It is understood that all structures will be of slab on grade construction (i.e., no basement). The excavations for shallow foundations, if used, will either be within the engineered fill or through the engineered fill and into the very stiff to stiff weathered silty clay crust. Excavations for site services may extend slightly into the glacial till in the area around boreholes 16-09 and 16-12. Minimal dewatering is anticipated to be required for pile foundations.

The maximum depth of excavations for site servicing and shallow foundations is assumed to be approximately 5 metres below ground surface. The water table was found to be at an average of 1.3 metres below ground surface; therefore, dewatering during construction of site services and shallow foundations will require approximately 3.7 metres of dewatering. Assuming the maximum hydraulic conductivity of the dewatered silty clay

to clay is  $10^{-6}$  metres/second, the maximum radius of influence associated with this dewatering is approximately 40 metres (at a distance of 40 metres, less than 0.1 metre of water level drawdown would occur after 30 days of dewatering). To ensure a conservative assessment of potential impacts to groundwater users, existing groundwater users within 200 metres of the site were considered.

#### 4.1 Nearby Groundwater Supply Wells

There are a total of 27 well records in the WWIS database located within 200 metres of the site (see Figure 1). Of these, 17 well records correspond to water supply wells, 7 to well abandonment records and 3 to test holes. Details regarding the water supply wells are presented in the following table.

Well ID	Depth of Well (m)	Depth to Static Water Level (m)	Depth to Water Found (m)	Available Drawdown (m)	Type of Well
1504662	57.9	2.4	57.3	55.5	Bedrock
1504663	90.8	2.4	42.6; 59.7; 89.9	88.4	Bedrock
1504664	53.3	2.1	53.3	51.2	Bedrock
1504665	23.8	7.6	18.3	16.2	Overburden (Gravel from 18.3 – 23.8 m)
1505930	42.7	6.4	38.1; 41.1	36.3	Bedrock
1505934	82.0	5.2	82.0	76.8	Bedrock
1505936	41.1	10.4	40.5	30.8	Bedrock
1512146	79.2	Not provided	24.3; 52.4; 78.6	Not calculated	Bedrock
1513522	15.2	3.7	14.3	11.6	Overburden (Gravel from 11.6 – 15.2 m)
1515365	83.2	6.1	54.9; 67.1	77.1	Bedrock
1516589	115.8	3.6	61.0; 67.1	112.2	Bedrock
1517095	68.0	9.1	24.4; 67.1	58.8	Bedrock
1519100	68.6	6.1	56.3; 67.1	62.5	Bedrock
1519500	36.6	9.1	35.1	27.4	Bedrock
1522199	19.2	2.5	16.2	16.7	Overburden (Gravel from 14.6 – 19.2 m)
1530599	25.0	4.0	24.7	21.0	Overburden (Sand and Gravel from 19.8 – 25.0 m)
7163245	152.4	2.3	102.4; 130.5; 138.7	150.1	Bedrock

Based on the well record information, there are 3 water supply wells located in the vicinity of the Carleton Lodge Long Term Care Home (Well IDs 1504664, 1505930 and 1516589, the last of which was drilled in 1978 to supply water to the lodge). However, the Carleton Lodge is now serviced by municipal water supply, and there are no residences corresponding to the other two well records. Therefore, these three well records are interpreted to no longer correspond to active water supply wells.

The remaining water supply wells are primarily located near the intersection of Woodroffe Avenue and Prince of Wales Drive, and along the southern half of Lodge Road. Based on aerial photographs, there are approximately 12 residences in these two areas that are likely served by private water supply wells. City of Ottawa infrastructure maps indicate that these areas are not serviced by municipal water supply. These wells include both bedrock wells and overburden wells, ranging in depth from 15.2 to 152.4 metres. At all of the wells (except Well ID 1505934), there is an extensive layer of clay and/or glacial till measuring at least 7 metres thick overlying the gravel or bedrock aquifer. The available drawdown in the wells, calculated as the difference between the static water level and the depth of the well, ranges from 11.6 to 150.1 metres. As previously mentioned, construction dewatering associated with typical site servicing and shallow foundations could temporarily lower the shallow water table by up to 3.7 metres; however, given the protective clay layer and the available drawdown in the supply wells, it is interpreted that this lowering would not negatively impact water supply. It is understood that there are no structures or land uses planned for the site that would permanently lower the groundwater levels in the area surrounding the site (i.e., deep drained foundations).

Based on the lack of anticipated impacts to water supply wells in the vicinity of the site during construction activities, a groundwater monitoring program is not recommended.

## **5.0 LIMITATIONS AND USE OF MEMORANDUM**

This technical memorandum was prepared for the exclusive use of the Ottawa Police Service and Colliers Project Leaders. The technical memorandum, which specifically includes all tables, figures and appendices, is based on data gathered by Golder Associates Ltd., and information provided to Golder Associates Ltd. by others.

The information provided by others has not been independently verified or otherwise examined by Golder Associates Ltd. to determine the accuracy or completeness. Golder Associates Ltd. has relied in good faith on this information and does not accept responsibility for any deficiency, misstatements, or inaccuracies contained in the information as a result of omissions, misinterpretation or fraudulent acts.

The services performed as described in this technical memorandum were conducted in a manner consistent with that level of care and skill normally exercised by other members of the engineering and science professions currently practicing under similar conditions, subject to the time limits and financial and physical constraints applicable to the services.

Any use which a third party makes of this technical memorandum, or any reliance on, or decisions to be made based on it, are the responsibilities of such third parties. Golder Associates Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made, or actions taken based on this technical memorandum.

## 6.0 CLOSURE

We trust this submission satisfies the requirements for a desktop hydrogeological assessment of the Ottawa Police Service South Facility site that is to be located at 55 Lodge Road in Ottawa, Ontario. If you have any questions regarding this report, please contact the undersigned.

Loren Bekeris, M.Sc., P.Eng.  
*Environmental Engineer*

Brian Byerley, M.Sc., P.Eng.  
*Principal, Senior Hydrogeologist*

LEB/BTB/mvrd

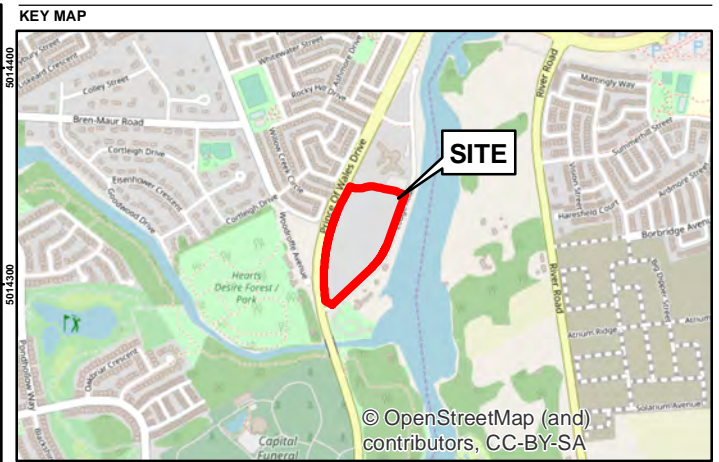
[https://golderassociates.sharepoint.com/sites/34624g/deliverables/hydrogeology/desktop water well impact study/18111310-001-tm-reva-water well impact study-2905\\_19.docx](https://golderassociates.sharepoint.com/sites/34624g/deliverables/hydrogeology/desktop%20water%20well%20impact%20study/18111310-001-tm-reva-water%20well%20impact%20study-2905_19.docx)

Attachments: Figure 1 – Site Plan  
Figure 2 – Surficial Geology  
Figure 3 – Drift Thickness  
Attachment 1 – Borehole Logs

## References

Mississippi-Rideau Source Protection Region. 2008. Water Characterization Report, Preliminary Draft. March 2008.



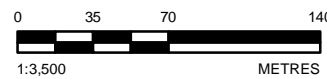


- LEGEND**
- MECP WWIS WATER WELL LOCATION (SUPPLY WELL)
  - MECP WWIS WATER WELL LOCATION (TESTHOLE OR ABANDONMENT)
  - APPROXIMATE BOREHOLE LOCATION
  - ROADWAY
  - PROPOSED BUILDING FOOTPRINT
  - PROPOSED ROAD AND PARKING LOT
  - APPROXIMATE SITE BOUNDARY
  - 200 m BUFFER

**NOTE(S)**  
1. ALL LOCATIONS ARE APPROXIMATE

**REFERENCE(S)**  
1. LAND INFORMATION ONTARIO (LIO) DATA PRODUCED BY GOLDER ASSOCIATES LTD. UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2016  
2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83  
COORDINATE SYSTEM: MTM ZONE 9 VERTICAL DATUM: CGVD28

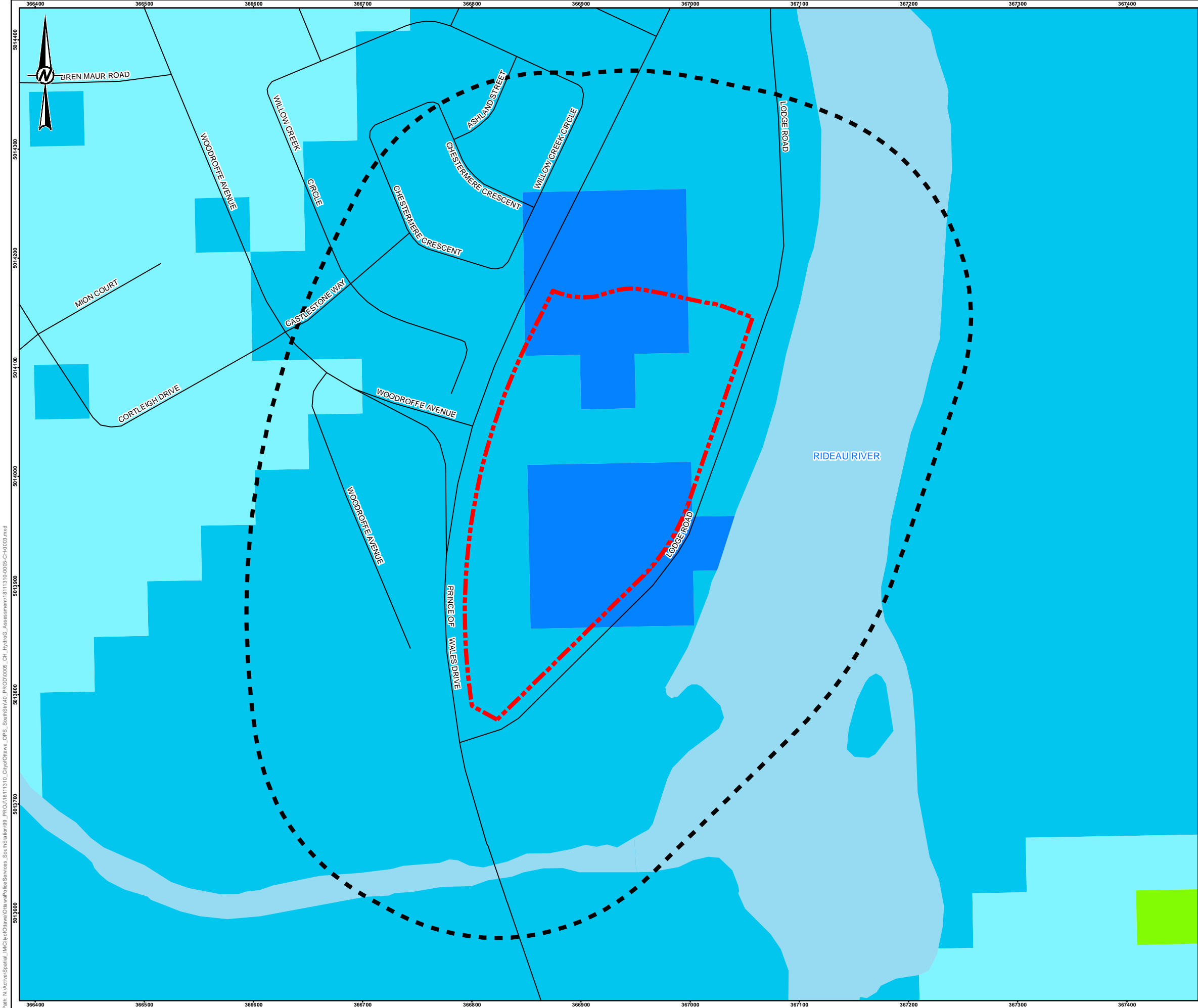
**DRAFT**



CLIENT OTTAWA POLICE SERVICE			
PROJECT HYDROGEOLOGICAL ASSESSMENT PROPOSED OTTAWA POLICE SERVICE SOUTH FACILITY 55 LODGE ROAD, OTTAWA, ONTARIO			
TITLE SITE PLAN			
	CONSULTANT	YYYY-MM-DD	2019-05-27
	DESIGNED	----	
	PREPARED	BR/JEM	
	REVIEWED	----	
	APPROVED	----	
PROJECT NO. 18111310	CONTROL 0005	REV. A	FIGURE 1







**LEGEND**

ROADWAY

WATERBODY

APPROXIMATE SITE BOUNDARY

200 m BUFFER

**TREND IN DEPTH TO BEDROCK (METRES)**

5 to 10

10 to 15

15 to 25

25 to 50

**NOTE(S)**

1. ALL LOCATIONS ARE APPROXIMATE

**REFERENCE(S)**

1. 2010 BÉLANGER, J. R., URBAN GEOLOGY OF THE NATIONAL CAPITAL AREA, GEOLOGICAL SURVEY OF CANADA, OPEN FILE D3256, 2001

2. LAND INFORMATION ONTARIO (LIO) DATA PRODUCED BY GOLDER ASSOCIATES LTD. UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2016

3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83

COORDINATE SYSTEM: MTM ZONE 9 VERTICAL DATUM: CGVD28

**DRAFT**

0 35 70 140

1:3,500 METRES

CLIENT

OTTAWA POLICE SERVICE

PROJECT

HYDROGEOLOGICAL ASSESSMENT

PROPOSED OTTAWA POLICE SERVICE SOUTH FACILITY

55 LODGE ROAD, OTTAWA, ONTARIO

TITLE

DRIFT THICKNESS

CONSULTANT	YYYY-MM-DD	2019-05-27
DESIGNED	----	
PREPARED	BR/JEM	
REVIEWED	----	
APPROVED	----	

PROJECT NO. 18111310

CONTROL 0005

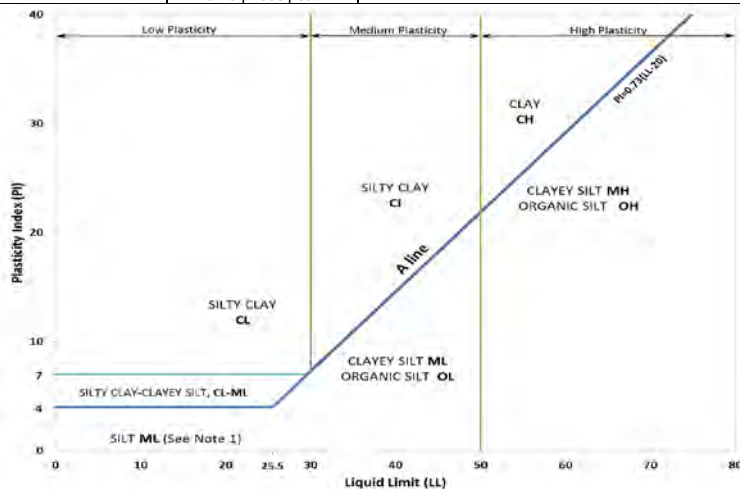
REV. A

FIGURE 3

# 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	$Cu = \frac{D_{60}}{D_{10}}$		$Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$			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 Pl 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		
			Liquid Limit ≥50	Slow to very slow	Low to medium	Dull to slight	3mm to 6 mm	Low	5% to 30%	OL	ORGANIC SILT		
				Slow to very slow	Low to medium	Slight	3mm to 6 mm	Low to medium	<5%	MH	CLAYEY SILT		
		CLAYS (Pl 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%	CL	SILTY CLAY		
			Liquid Limit 30 to 50	None	Medium to high	Slight to shiny	1 mm to 3 mm	Medium	(see Note 2)	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 BOREHOLES 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.). Values reported are as recorded in the field and are uncorrected.

#### Cone Penetration Test (CPT)

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

#### Dynamic Cone Penetration Resistance (DCPT); N<sub>d</sub>:

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
GS	Grab Sample
MC	Modified California Samples
MS	Modified Shelby (for frozen soil)
RC	Rock core
SC	Soil core
SS	Split spoon sampler – note size
ST	Slotted tube
TO	Thin-walled, open – note size (Shelby tube)
TP	Thin-walled, piston – note size (Shelby tube)
WS	Wash sample

### SOIL TESTS

w	water content
PL , w <sub>p</sub>	plastic limit
LL , w <sub>L</sub>	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test <sup>1</sup>
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement <sup>1</sup>
D <sub>R</sub>	relative density (specific gravity, G <sub>s</sub> )
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 <sub>4</sub>	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<sup>2</sup>

Term	SPT 'N' (blows/0.3m) <sup>1</sup>
Very Loose	0 to 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 the effects of overburden pressure.

2. Definition of compactness terms are based on SPT 'N' ranges as provided in Terzaghi, Peck and Mesri (1996). Many factors affect the recorded SPT 'N' value, including hammer efficiency (which may be greater than 60% in automatic trip hammers), overburden pressure, groundwater conditions, and grain size. As such, the recorded SPT 'N' value(s) should be considered only an approximate guide to the soil compactness. 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' <sup>1,2</sup> (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

$\pi$	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

$\gamma$	shear strain
$\Delta$	change in, e.g. in stress: $\Delta \sigma$
$\varepsilon$	linear strain
$\varepsilon_v$	volumetric strain
$\eta$	coefficient of viscosity
$\nu$	Poisson's ratio
$\sigma$	total stress
$\sigma'$	effective stress ( $\sigma' = \sigma - u$ )
$\sigma'_{vo}$	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
$\sigma_{oct}$	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
$\tau$	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
$\gamma'$	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 = $(w_l - w_p)$
NP	non-plastic
$w_s$	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
$C_\alpha$	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
$\sigma'_p$	pre-consolidation stress
OCR	over-consolidation ratio = $\sigma'_p / \sigma'_{vo}$

#### (d) Shear Strength

$\tau_p, \tau_r$	peak and residual shear strength
$\phi'$	effective angle of internal friction
$\delta$	angle of interface friction
$\mu$	coefficient of friction = $\tan \delta$
$c'$	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

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

Notes: 1  
2

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

$$\text{shear strength} = (\text{compressive strength})/2$$

# LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

## WEATHERINGS STATE

**Fresh:** no visible sign of rock material weathering.

**Faintly weathered:** weathering limited to the surface of major discontinuities.

**Slightly weathered:** penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material.

**Moderately weathered:** weathering extends throughout the rock mass but the rock material is not friable.

**Highly weathered:** weathering extends throughout rock mass and the rock material is partly friable.

**Completely weathered:** rock is wholly decomposed and in a friable condition but the rock and structure are preserved.

## BEDDING THICKNESS

<u>Description</u>	<u>Bedding Plane Spacing</u>
Very thickly bedded	Greater than 2 m
Thickly bedded	0.6 m to 2 m
Medium bedded	0.2 m to 0.6 m
Thinly bedded	60 mm to 0.2 m
Very thinly bedded	20 mm to 60 mm
Laminated	6 mm to 20 mm
Thinly laminated	Less than 6 mm

## JOINT OR FOLIATION SPACING

<u>Description</u>	<u>Spacing</u>
Very wide	Greater than 3 m
Wide	1 m to 3 m
Moderately close	0.3 m to 1 m
Close	50 mm to 300 mm
Very close	Less than 50 mm

## GRAIN SIZE

<u>Term</u>	<u>Size*</u>
Very Coarse Grained	Greater than 60 mm
Coarse Grained	2 mm to 60 mm
Medium Grained	60 microns to 2 mm
Fine Grained	2 microns to 60 microns
Very Fine Grained	Less than 2 microns

Note: \* Grains greater than 60 microns diameter are visible to the naked eye.

## CORE CONDITION

### Total Core Recovery (TCR)

The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

### Solid Core Recovery (SCR)

The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

### Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, as measured along the centerline axis of the core, relative to the length of the total core run. RQD varies from 0% for completely broken core to 100% for core in solid segments.

## DISCONTINUITY DATA

### Fracture Index

A count of the number of naturally occurring discontinuities (physical separations) in the rock core. Mechanically induced breaks caused by drilling are not included.

### Dip with Respect to Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90° angle is horizontal.

### Description and Notes

An abbreviation description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

## Abbreviations

JN Joint	PL Planar
FLT Fault	CU Curved
SH Shear	UN Undulating
VN Vein	IR Irregular
FR Fracture	K Slickensided
SY Stylolite	PO Polished
BD Bedding	SM Smooth
FO Foliation	SR Slightly Rough
CO Contact	RO Rough
AXJ Axial Joint	VR Very Rough
KV Karstic Void	
MB Mechanical Break	



SHEET 1 OF 3

DATUM: CGVD28

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES			DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION				
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m	SHEAR STRENGTH Cu, kPa		nat V. + rem V. ⊕		Q - ● U - ○		WATER CONTENT PERCENT						
								20	40	60	80	10 <sup>-5</sup>	10 <sup>-5</sup>	10 <sup>-4</sup>			10 <sup>-3</sup>	Wp	W	WI
								20	40	60	80	20	40	60			80			
0		GROUND SURFACE		88.54																
	Power Auger 200 mm Diam. (Hollow Stem)	FILL/TOPSOIL - (ML) sandy SILT; brown; moist		0.00																
		FILL - (SM) SILTY SAND, some gravel; brown, contains roots; non-cohesive, moist, loose		0.15	1	SS	8													
1		FILL - (SP/SM) gravelly SAND to SILTY SAND; brown; non-cohesive, moist, compact		87.78 0.76	2	SS	14													
		FILL - (SM/GM) SILTY SAND and GRAVEL; brown; non-cohesive, wet, compact		87.02 1.52	3	SS	14													
2		(CI/CH) SILTY CLAY to CLAY, trace sand; brown (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff		86.26 2.28	4	SS	10													
3																				
						5	SS	4												
4									⊕			+								
5						6	SS	4			⊕		126							
6									⊕			+								
7		(CI/CH) SILTY CLAY to CLAY, trace sand; grey; cohesive, w>PL, firm		82.44 6.10	7	SS	1				+									
8		(CI/CH) SILTY CLAY to CLAY, some sand; grey, contains silt seams; cohesive, w>PL, firm		80.92 7.62	8	SS	PH				+									
9		(SM) gravelly SILTY SAND; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet, compact		80.08 8.46	9	SS	17													
10		CONTINUED NEXT PAGE																		

DEPTH SCALE

1 : 50



LOGGED: DWM

CHECKED: EDW

MIS-BHS 001 1537295.GPJ GAL-MIS.GDT 5/18/17 JEM/TB

PROJECT: 1537295

**RECORD OF BOREHOLE: 16-01**

SHEET 2 OF 3

LOCATION: N 5014141.2 ; E 366882.1

BORING DATE: December 2, 2017

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				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m	SHEAR STRENGTH Cu, kPa		WATER CONTENT PERCENT					
								20	40	60	80	10 <sup>-6</sup>	10 <sup>-5</sup>		
		--- CONTINUED FROM PREVIOUS PAGE ---													
10		(SM) gravelly SILTY SAND; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet, compact													
11															
12															
13															
14															
15	Power Auger 200 mm Diam. (Hollow Stem)														
16															
17															
18															
19															
20															
		CONTINUED NEXT PAGE													

DEPTH SCALE

1 : 50



LOGGED: DWM

CHECKED: EDW

MIS-BHS 001 1537295.GPJ GAL-MIS.GDT 5/18/17 JEM/TB

PROJECT: 1537295

**RECORD OF BOREHOLE: 16-01**

SHEET 3 OF 3


LOCATION: N 5014141.2 ; E 366882.1

BORING DATE: December 2, 2017

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				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m	SHEAR STRENGTH Cu, kPa		nat V. + Q - rem V. ⊕ U -		WATER CONTENT PERCENT Wp — W — Wi			
								20	40	60	80	10 <sup>-6</sup>	10 <sup>-5</sup>		
20	Power Auger 200 mm Diam. (Hollow Stem)	--- CONTINUED FROM PREVIOUS PAGE --- (SM) gravelly SILTY SAND; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet, compact		65.71 22.83											
21															
22															
23															
23		End of Borehole Auger Refusal													
24															
25															
26															
27															
28															
29															
30															

DEPTH SCALE

1 : 50



LOGGED: DWM

CHECKED: EDW

MIS-BHS 001\_1537295.GPJ GAL-MIS.GDT 5/18/17 JEM/TB





PROJECT: 1537295

**RECORD OF BOREHOLE: 16-02**

SHEET 2 OF 2

LOCATION: N 5014138.6 ; E 366933.0

BORING DATE: December 2, 2017

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				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	SHEAR STRENGTH Cu, kPa		nat V. + Q - rem V. ⊕ U - ⊙		WATER CONTENT PERCENT Wp — W — Wi					
							20	40	60	80	20	40	60			80
10		--- CONTINUED FROM PREVIOUS PAGE --- (CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, firm to stiff		75.50				+								
		End of Borehole		10.36				+								
11																
12																
13																
14																
15																
16																
17																
18																
19																
20																

DEPTH SCALE

1 : 50



LOGGED: DWM

CHECKED: EDW

MIS-BHS 001 1537295.GPJ GAL-MIS.GDT 5/18/17 JEM/TB





PROJECT: 1537295

**RECORD OF BOREHOLE: 16-03**

SHEET 2 OF 3

LOCATION: N 5014136.8 ; E 366990.0

BORING DATE: December 5, 2017

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				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION		
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m	SHEAR STRENGTH Cu, kPa		nat V. + Q - rem V. ⊕ U - ⊙		WATER CONTENT PERCENT Wp ——— W ——— WI					
								20	40	60	80	10 <sup>-6</sup>	10 <sup>-5</sup>			10 <sup>-4</sup>	10 <sup>-3</sup>
10	Power Auger 200 mm Diam. (Hollow Stem)	--- CONTINUED FROM PREVIOUS PAGE --- (CI/CH) SILTY CLAY to CLAY; grey with black mottling; cohesive, w>PL, firm															
11				9	SS	PH											
12																	
13																	
14																	
15																	
16		(ML/SM) gravelly sandy SILT to SILTY SAND; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet, loose		69.46 15.34													
17					10	SS	5										
18																	
19																	
20																	
		CONTINUED NEXT PAGE															

DEPTH SCALE

1 : 50



LOGGED: DWM

CHECKED: EDW

MIS-BHS 001\_1537295.GPJ GAL-MIS.GDT 5/18/17 JEM/TB

PROJECT: 1537295

**RECORD OF BOREHOLE: 16-03**

SHEET 3 OF 3

LOCATION: N 5014136.8 ;E 366990.0

BORING DATE: December 5, 2017

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				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION		
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m	SHEAR STRENGTH Cu, kPa		nat V. + Q - rem V. ⊕ U - ⊙		WATER CONTENT PERCENT Wp — W — Wi					
								20	40	60	80	10 <sup>-6</sup>	10 <sup>-5</sup>			10 <sup>-4</sup>	10 <sup>-3</sup>
20	Power Auger 200 mm Diam. (Hollow Stem)	--- CONTINUED FROM PREVIOUS PAGE --- (ML/SM) gravelly sandy SILT to SILTY SAND; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet, loose															
21																	
22																	
23																	
24																	
25																	
26																	
27																	
28																	
29																	
30		End of Borehole Auger Refusal															

DEPTH SCALE

1 : 50



LOGGED: DWM

CHECKED: EDW

MIS-BHS 001 1537295.GPJ GAL-MIS.GDT 5/18/17 JEM/TB

PROJECT: 1537295

**RECORD OF BOREHOLE: 16-04**

SHEET 1 OF 1



LOCATION: N 5014129.8 ; E 367031.1

BORING DATE: December 6, 2017

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				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION		
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m												
								SHEAR STRENGTH Cu, kPa		nat V. + rem V. ⊕		Q - ● U - ○		WATER CONTENT PERCENT					
								20	40	60	80	10 <sup>-6</sup>	10 <sup>-5</sup>	10 <sup>-4</sup>	10 <sup>-3</sup>			Wp	W
								20	40	60	80	20	40	60	80				
0		GROUND SURFACE		83.65															
	Power Auger 200 mm Diam. (Hollow Stem)	FILL/TOPSOIL - (ML) sandy SILT; brown; non-cohesive, moist		0.00															
				0.12	1	SS	6												
		(CI/CH) SILTY CLAY to CLAY, some sand; brown with red mottling, contains silty sand seams (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff		82.89															
1				0.76	2	SS	8												
2					3	SS	6												
3																			
4																			
5																			
6																			
		(CI/CH) SILTY CLAY to CLAY; grey, contains sand seams; cohesive, w>PL, firm to stiff		77.55															
				6.10	6	SS	PH												
7																			
8																			
9		End of borehole		74.81															
				8.84															
10																			

Native Backfill

Bentonite Seal

Standpipe

Cave

W.L. in Screen at  
Elev. 82.51 m on  
Feb. 2, 2017

DEPTH SCALE

1 : 50



LOGGED: DWM

CHECKED: EDW

MIS-BHS 001\_1537295.GPJ GAL-MIS.GDT 5/18/17 JEM/TB

PROJECT: 1537295

**RECORD OF BOREHOLE: 16-05**

SHEET 1 OF 1

LOCATION: N 5014078.8 ;E 366857.1

BORING DATE: December 6, 2017

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				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m										
								SHEAR STRENGTH Cu, kPa				WATER CONTENT PERCENT					
								20	40	60	80	nat V. $\oplus$ rem V. $\ominus$	Q - $\bullet$ U - $\circ$	10 <sup>-6</sup>	10 <sup>-5</sup>		
0		GROUND SURFACE		88.04													
	Power Auger 200 mm Diam. (Hollow Stem)	FILL/TOPSOIL - (ML) sandy SILT; brown; moist		87.86													
		FILL - (SM) SILTY SAND, trace gravel; brown, contains organic matter; non-cohesive, moist, loose		0.18	1	SS	4										
1		(CI/CH) SILTY CLAY to CLAY, some sand; brown (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff		87.13	2	SS	12										
				0.91													
2						3	SS	7									
3																	
						4	SS	5									
4																	
5		(CI/CH) SILTY CLAY to CLAY; brown, contains silt seams; w>PL, firm to stiff		83.47	5	SS	1										
				4.57													
6																	
7		(CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, stiff		81.94	6	SS	PH										
				6.10													
8																	
					7	SS	PH										
9		(ML) sandy CLAYEY SILT, some gravel; grey, contains cobbles and boulders (GLACIAL TILL); cohesive, wet, very loose		79.31													
				8.73	8	SS	3										
10		End of Borehole		78.29													
				9.75													

DEPTH SCALE

1 : 50



LOGGED: DWM

CHECKED: EDW

MIS-BHS 001 1537295.GPJ GAL-MIS.GDT 5/18/17 JEM/TB





PROJECT: 1537295

**RECORD OF BOREHOLE: 16-06**

SHEET 2 OF 2


LOCATION: N 5014063.2 ; E 366910.7

BORING DATE: December 7, 2017

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				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION		
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m	SHEAR STRENGTH Cu, kPa		nat V. + Q - rem V. ⊕ U - ⊙		WATER CONTENT PERCENT					
								20	40	60	80	10 <sup>-6</sup>	10 <sup>-5</sup>			10 <sup>-4</sup>	10 <sup>-3</sup>
10	Power Auger 200 mm Diam. (Hollow Stem)	--- CONTINUED FROM PREVIOUS PAGE --- (CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, stiff to firm		74.67 13.00	9	SS	7	20	40	60	80	20	40	60	80		
11																	
12																	
13																	
14																	
15																	
16																	
17																	
18																	
19																	
20	End of Borehole Auger Refusal	68.65 19.02															

DEPTH SCALE

1 : 50



LOGGED: DWM

CHECKED: EDW

MIS-BHS 001 1537295.GPJ GAL-MIS.GDT 5/18/17 JEM/TB

PROJECT: 1537295

**RECORD OF BOREHOLE: 16-07**

SHEET 1 OF 1

LOCATION: N 5014050.8 ; E 366967.0

BORING DATE: December 7, 2017

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				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m										
								SHEAR STRENGTH Cu, kPa				WATER CONTENT PERCENT					
								20	40	60	80	10 <sup>-6</sup>	10 <sup>-5</sup>	10 <sup>-4</sup>	10 <sup>-3</sup>		
								nat V. + ⊕ - ● rem V. ⊕ U - ○				Wp   — W —   Wl					
								20	40	60	80	20	40	60	80		
0		GROUND SURFACE		84.57													
	Power Auger 200 mm Diam. (Hollow Stem)	FILL/TOPSOIL - (ML) sandy SILT; brown; moist		0.00													
		FILL - (SM) SILTY SAND, trace gravel; dark brown, contains rootlets; non-cohesive, moist, loose		0.10	1	SS	8										
1			(CI/CH) SILTY CLAY to CLAY, some sand; brown, contains roots; cohesive, w>PL, very stiff to stiff		83.81	2	SS	11									
					0.76												
2						3	SS	8					○				
3																	
					4	SS	5						○				
4								⊕									
									⊕								
										+							
											+						
5					5	SS	2						○				
6								⊕									
								⊕									
										+							
7								⊕		+							
								⊕		+							
8					7	SS	WR						○				
								⊕		+							
								⊕		+							
9								⊕		+							
		End of Borehole		75.43													
				9.14													
10																	

DEPTH SCALE

1 : 50



LOGGED: DWM

CHECKED: EDW

MIS-BHS 001 1537295.GPJ GAL-MIS.GDT 5/18/17 JEM/TB

SHEET 1 OF 1

DATUM: CGVD28

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

[illegible]

MIS-BHS 001 1537295.GPJ GAL-MIS.GDT 5/18/17 JEM/TB

DEPTH SCALE

1 : 50



LOGGED: DWM

CHECKED: EDW







PROJECT: 1537295

**RECORD OF BOREHOLE: 16-10**

SHEET 2 OF 2

LOCATION: N 5013992.4 ; E 366898.2

BORING DATE: December 8, 2017

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				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION		
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m												
								SHEAR STRENGTH Cu, kPa		nat V. + rem V. ⊕		Q - ● U - ○		WATER CONTENT PERCENT					
								20	40	60	80	20	40	60	80			10 <sup>-6</sup>	10 <sup>-5</sup>
10	Power Auger 200 mm Diam. (Hollow Stem)	--- CONTINUED FROM PREVIOUS PAGE --- (CI/CH) SILTY CLAY to CLAY; grey with black mottling; cohesive, w>PL, firm to stiff																	
11		(SM) gravelly SILTY SAND; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet, compact		75.52 10.79															
12					8	SS	16												
13																			
14		End of Borehole		72.33 13.98															
15																			
16																			
17																			
18																			
19																			
20																			

DEPTH SCALE

1 : 50



LOGGED: DWM

CHECKED: EDW

MIS-BHS 001\_1537295.GPJ GAL-MIS.GDT 5/18/17 JEM/TB

PROJECT: 1537295

**RECORD OF BOREHOLE: 16-11**

SHEET 1 OF 1

LOCATION: N 5013966.7 ; E 366959.7

BORING DATE: December 8, 2017

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				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION		
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m												
								SHEAR STRENGTH Cu, kPa		nat V. + rem V. ⊕		Q - ● U - ○		WATER CONTENT PERCENT					
								20	40	60	80	10 <sup>-6</sup>	10 <sup>-5</sup>	10 <sup>-4</sup>	10 <sup>-3</sup>			Wp	W
								20	40	60	80	20	40	60	80				
0		GROUND SURFACE		84.22															
	Power Auger 200 mm Diam. (Hollow Stem)	FILL/TOPSOIL - (SM) sandy SILT; brown; moist		0.00															
		FILL - (SM) SILTY SAND; dark brown, contains rootlets; non-cohesive, moist, loose		0.10	1	SS	6												
		(CI/CH) SILTY CLAY to CLAY, some sand; brown (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff		83.61															
				0.61															
1					2	SS	5												
2					3	SS	6												
									⊕			+							
									⊕			+							
3																			
					4	SS	2												
4								⊕			+								
								⊕			+								
5					5	SS	3												
								⊕			+								
								⊕			+								
6		(CI/CH) SILTY CLAY to CLAY; grey; cohesive; w>PL, stiff		78.12															
				6.10	6	SS	1												
7								⊕		+									
								⊕		+									
8					7	SS	PH												
								⊕		+									
								⊕		+									
9		End of Borehole		75.38				⊕		+									
				8.84															
10																			

DEPTH SCALE

1 : 50



LOGGED: DWM

CHECKED: EDW

MIS-BHS 001\_1537295.GPJ GAL-MIS.GDT 5/18/17 JEM/TB

PROJECT: 1537295

**RECORD OF BOREHOLE: 16-12**

SHEET 1 OF 1

LOCATION: N 5013936.2 ; E 366820.0

BORING DATE: December 13, 2017

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				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION		
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m	SHEAR STRENGTH Cu, kPa		nat V. + rem V. ⊕		Q - ● U - ○		WATER CONTENT PERCENT					
								20	40	60	80	10 <sup>-6</sup>	10 <sup>-5</sup>	10 <sup>-4</sup>	10 <sup>-3</sup>				
																		Wp   ———— W ————   Wl	
								20	40	60	80	20	40	60	80				
0	Power Auger 200 mm Diam. (Hollow Stem)	GROUND SURFACE		87.91															
		TOPSOIL - (ML) sandy SILT; brown; moist		0.00															
		(CI/CH) SILTY CLAY to CLAY, some sand; brown (WEATHERED CRUST); cohesive, w>PL, very stiff		0.13	1	SS	3												
1																			
						2	SS	5											
2																			
						3	SS	7											
3									⊕			115							
						4	SS	6				143							
4			(CL/CI) SILTY CLAY, trace sand and gravel; brown, contains silt seams (WEATHERED CRUST); w>PL, very stiff to stiff		83.92 3.99							143							
5					5	SS	3												
		(SM) gravelly SILTY SAND; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet, compact		82.58 5.33															
6					6	SS	16												
		End of Borehole		81.81 6.10															
7																			
8																			
9																			
10																			

DEPTH SCALE

1 : 50



LOGGED: DWM

CHECKED: EDW

MIS-BHS 001\_1537295.GPJ GAL-MIS.GDT 5/18/17 JEM/TB





PROJECT: 1537295

## RECORD OF BOREHOLE: 16-13

SHEET 2 OF 3

LOCATION: N 5013919.6 ; E 366870.5

BORING DATE: December 12, 2017

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				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m	SHEAR STRENGTH Cu, kPa		nat V. + Q - rem V. ⊕ U - ⊙		WATER CONTENT PERCENT Wp — W — Wi				
								20	40	60	80	10 <sup>-6</sup>	10 <sup>-5</sup>			10 <sup>-4</sup>
10	Power Auger 200 mm Diam. (Hollow Stem)	--- CONTINUED FROM PREVIOUS PAGE ---		9.98												
		(SM) gravelly SILTY SAND; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist														
11																
12																
13																
14																
15																
16																
17																
18																
19																
20																
		CONTINUED NEXT PAGE														

DEPTH SCALE

1 : 50



LOGGED: DWM

CHECKED: EDW

MIS-BHS 001 1537295.GPJ GAL-MIS.GDT 5/18/17 JEM/TB

PROJECT: 1537295

**RECORD OF BOREHOLE: 16-13**

SHEET 3 OF 3


LOCATION: N 5013919.6 ; E 366870.5

BORING DATE: December 12, 2017

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				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION		
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m	SHEAR STRENGTH Cu, kPa		nat V. + Q - rem V. ⊕ U - ○		WATER CONTENT PERCENT Wp ——— W ——— WI					
								20	40	60	80	10 <sup>-6</sup>	10 <sup>-5</sup>			10 <sup>-4</sup>	10 <sup>-3</sup>
20	Power Auger 200 mm Diam. (Hollow Stem)	--- CONTINUED FROM PREVIOUS PAGE --- (SM) gravelly SILTY SAND; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist		63.75 22.86	9	AS											
21																	
22																	
23		End of Borehole Auger Refusal															
24																	
25																	
26																	
27																	
28																	
29																	
30																	

DEPTH SCALE

1 : 50



LOGGED: DWM

CHECKED: EDW

MIS-BHS 001\_1537295.GPJ GAL-MIS.GDT 5/18/17 JEM/TB

PROJECT: 1537295

**RECORD OF BOREHOLE: 16-14**

SHEET 1 OF 1

LOCATION: N 5013898.3 ; E 366924.6

BORING DATE: December 9, 2017

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				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION			
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m													
								SHEAR STRENGTH Cu, kPa		nat V.	+ rem V.	+ ⊕	Q - U -	● ○	WATER CONTENT PERCENT					
								20	40	60	80	10 <sup>-6</sup>	10 <sup>-5</sup>	10 <sup>-4</sup>	10 <sup>-3</sup>			Wp	W	Wi
		GROUND SURFACE		84.83																
0	Power Auger 200 mm Diam. (Hollow Stem)	FILL/TOPSOIL - (ML) sandy SILT; brown; moist		0.00																
		FILL - (SM/ML) sandy SILT to SILTY SAND; dark brown, contains rootlets; non-cohesive, moist, loose		0.10	1	SS	5													
				84.07																
1		(CI/CH) SILTY CLAY to CLAY; brown with red motting, contains silty sand seams (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff		0.76	2	SS	6						○							
2					3	SS	5						○							
					4	SS	5						○							
3																				
				5	SS	4							○							
4								⊕												
								⊕												
5				6	SS	4							○							
								⊕			+									
6		(CI/CH) SILTY CLAY to CLAY; grey with black motting; cohesive, w>PL, firm to stiff		79.04 5.79				⊕	+											
					7	SS	PH							○						
7								⊕			+									
								⊕			+									
8					8	SS	PH													
								⊕			+									
9		End of Borehole		75.99 8.84				⊕			+									
10																				

DEPTH SCALE

1 : 50



LOGGED: DWM

CHECKED: EDW

MIS-BHS 001 1537295.GPJ GAL-MIS.GDT 5/18/17 JEM/TB

PROJECT: 1537295

**RECORD OF BOREHOLE: 16-15**

SHEET 1 OF 1

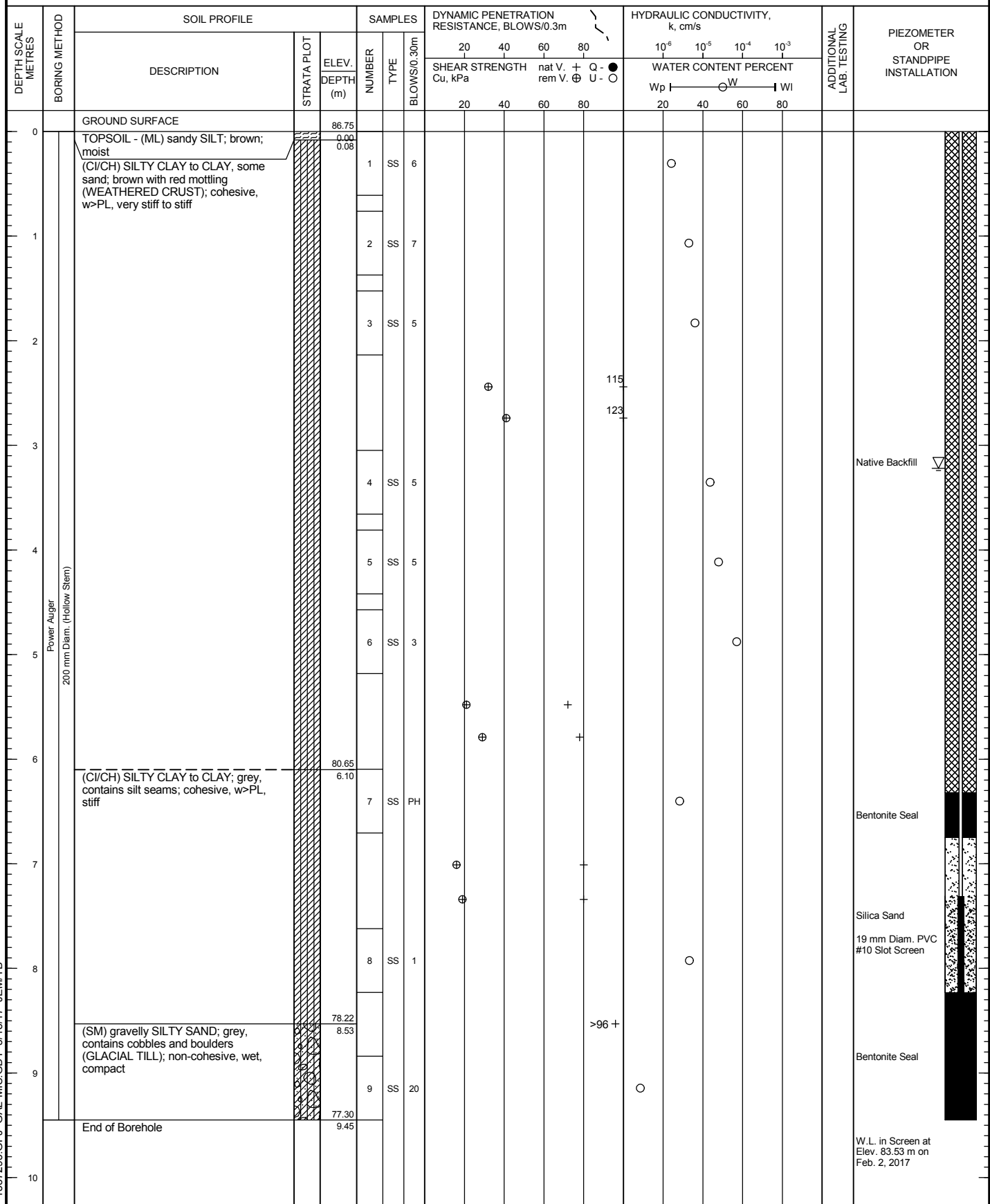
LOCATION: N 5013834.4 ; E 366824.6

BORING DATE: December 13, 2017

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm



DEPTH SCALE

1 : 50



LOGGED: DWM

CHECKED: EDW

MIS-BHS 001\_1537295.GPJ GAL-MIS.GDT 5/18/17 JEM/TB

SHEET 1 OF 3

DATUM: CGVD28

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

[illegible]

DEPTH SCALE

1 : 50



# GOLDER

LOGGED: KM

CHECKED: CRG

MIS-BHS 001 18111310.GPJ GAL-MIS.GDT 11/3/19 JEM

PROJECT: 18111310

**RECORD OF BOREHOLE: 18-01**

SHEET 2 OF 3

LOCATION: N 5014098.5 ;E 366864.7

BORING DATE: December 5, 6, 7 &amp; 10, 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				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	SHEAR STRENGTH Cu, kPa		nat V. + Q - rem V. ⊕ U -		WATER CONTENT PERCENT Wp ——— W ——— WI					
							20	40	60	80	10 <sup>-6</sup>	10 <sup>-5</sup>	10 <sup>-4</sup>			10 <sup>-3</sup>
		--- CONTINUED FROM PREVIOUS PAGE --- (ML/SM) sandy SILT to SILTY SAND, some gravel to gravelly; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet, loose to dense														
10	Wash Bore HW Casing															
11				10	SS	41										
12																
13				11	SS	13									MH	
14				12	SS	15										
15																
16				13	SS	6										
17				14	SS	>50										
18																
19				15	SS	7									MH	
20																
		CONTINUED NEXT PAGE														

DEPTH SCALE

1 : 50

**GOLDER**

LOGGED: KM

CHECKED: CRG

MIS-BHS 001\_18111310.GPJ GAL-MIS.GDT 11/3/19 JEM



PROJECT: 18111310

**RECORD OF BOREHOLE: 18-01**

SHEET 3 OF 3

LOCATION: N 5014098.5 ;E 366864.7

BORING DATE: December 5, 6, 7 &amp; 10, 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				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION		
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m	SHEAR STRENGTH Cu, kPa		nat V. + Q - rem V. ⊕ U - ○		WATER CONTENT PERCENT Wp — W — Wi					
								20	40	60	80	10 <sup>-6</sup>	10 <sup>-5</sup>			10 <sup>-4</sup>	10 <sup>-3</sup>
20	Wash Bore HW Casing	--- CONTINUED FROM PREVIOUS PAGE --- (ML/SM) sandy SILT to SILTY SAND, some gravel to gravelly; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet, loose to dense															
21																	
22																	
23																	
24																	
25																	
26																	
27																	
28																	
29																	
30		End of Borehole															

DEPTH SCALE

1 : 50

**GOLDER**

LOGGED: KM

CHECKED: CRG

MIS-BHS 001\_18111310.GPJ GAL-MIS.GDT 11/3/19 JEM

SHEET 1 OF 4

DATUM: CGVD28

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

[illegible]

DEPTH SCALE

1 : 50



# GOLDER

LOGGED: KM

CHECKED: CRG

MIS-BHS 001 18111310.GPJ GAL-MIS.GDT 11/3/19 JEM

PROJECT: 18111310

**RECORD OF BOREHOLE: 18-02**

SHEET 2 OF 4

LOCATION: N 5014098.6 ;E 366965.6

BORING DATE: Nov. 28, 29 &amp; Dec. 4, 5, 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				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION				
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m	20      40      60      80				10 <sup>-6</sup> 10 <sup>-5</sup> 10 <sup>-4</sup> 10 <sup>-3</sup>									
								SHEAR STRENGTH Cu, kPa				nat V.   +   Q - ● rem V.   ⊕   U - ○						WATER CONTENT PERCENT			
								20      40      60      80				Wp   ————   WI									
10	Power Auger 200 mm Diam. (Hollow Stem)	--- CONTINUED FROM PREVIOUS PAGE --- (CL/CH) SILTY CLAY; grey to dark grey, contains silt seams; cohesive, w>PL, firm to stiff						⊕		+											
11						10	SS	WH		⊕											
									⊕		+										
									⊕		+										
12									⊕		+										
14	Wash Bore HW Casing	(SM/ML) gravelly SILTY SAND to gravelly sandy SILT; grey, contains cobbles (GLACIAL TILL); non-cohesive, wet, compact to very loose		71.18 13.72	12	SS	8														
15																					
17																					
18																					
19																					
20																					

DEPTH SCALE

1 : 50

**GOLDER**

LOGGED: KM

CHECKED: CRG

MIS-BHS 001 18111310.GPJ GAL-MIS.GDT 11/3/19 JEM

PROJECT: 18111310

**RECORD OF BOREHOLE: 18-02**

SHEET 3 OF 4

LOCATION: N 5014098.6 ; E 366965.6

BORING DATE: Nov. 28, 29 &amp; Dec. 4, 5, 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				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m											
								SHEAR STRENGTH Cu, kPa		nat V.	+ rem V.	Q - U -	WATER CONTENT PERCENT					
								20	40	60	80	10 <sup>-6</sup>	10 <sup>-5</sup>	10 <sup>-4</sup>	10 <sup>-3</sup>			Wp
								20	40	60	80	20	40	60	80			
20	Wash Bore HW Casing	--- CONTINUED FROM PREVIOUS PAGE ---																
		(SM) gravelly SILTY SAND; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet, compact to very dense			20	SS	29											
21					21	SS	13											
					22	SS	36											
22					23	SS	57											
					24	SS	55											
23		(ML) CLAYEY SILT ; grey, contains sand seams; cohesive, w>PL, very Stiff		58.99														
				25.91	26	SS	73											
26				58.38														
		(GP) GRAVEL, some sand, trace non-plastic fines; grey, contains cobbles and boulders; non-cohesive, wet, very dense		26.52														
27				27	SS	>50												
28	Borehole Continued on RECORD OF DRILLHOLE 18-02		56.88															
			28.02															
29																		
30																		

DEPTH SCALE

1 : 50

**GOLDER**

LOGGED: KM

CHECKED: CRG

MIS-BHS 001 18111310.GPJ GAL-MIS.GDT 11/3/19 JEM

PROJECT: 18111310

**RECORD OF DRILLHOLE: 18-02**

SHEET 4 OF 4

LOCATION: N 5014098.6 ;E 366965.6

DRILLING DATE: Nov. 28, 29 &amp; Dec. 4, 5, 2018

DATUM: CGVD28

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 850

DRILLING CONTRACTOR: CCC Geotechnical &amp; Environmental Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	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.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
							RECOVERY		R.Q.D. %	FRACT. INDEX PER 0.3 m	DIP w.r.t. CORE AXIS	DISCONTINUITY DATA				HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -Q AVG.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
							TOTAL CORE %	SOLID CORE %				TYPE AND SURFACE DESCRIPTION																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
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		BEDROCK SURFACE		56.88																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			</

DEPTH SCALE

1 : 50

**GOLDER**

LOGGED: KM

CHECKED: CRG

MIS-RCK 004 18111310.GPJ GAL-MISS.GDT 11/3/19 JEM

PROJECT: 18111310

**RECORD OF BOREHOLE: 19-01**

SHEET 1 OF 5

LOCATION: N 5014031.0 ;E 366869.9

BORING DATE: February 19-20, 2019

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				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	SHEAR STRENGTH Cu, kPa		nat V. + Q - rem V. ⊕ U - ○		WATER CONTENT PERCENT Wp ——— W ——— WI					
							20	40	60	80	10 <sup>-6</sup>	10 <sup>-5</sup>	10 <sup>-4</sup>			10 <sup>-3</sup>
0		GROUND SURFACE		87.09												
		Unsampled Overburden		0.00												
1																
2																
3																
4																
5																
6																
7																
8																
9																
10																
		CONTINUED NEXT PAGE														

DEPTH SCALE

1 : 50

**GOLDER**

LOGGED: PAH

CHECKED: CRG

MIS-BHS 001 18111310.GPJ GAL-MIS.GDT 11/3/19 JEM



PROJECT: 18111310

**RECORD OF BOREHOLE: 19-01**

SHEET 2 OF 5

LOCATION: N 5014031.0 ;E 366869.9

BORING DATE: February 19-20, 2019

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				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	SHEAR STRENGTH Cu, kPa		nat V. + Q - rem V. ⊕ U - ○		WATER CONTENT PERCENT Wp — W — Wi					
							20	40	60	80	20	40	60			80
10	Power Auger 200 mm Diam. (Hollow Stem)	--- CONTINUED FROM PREVIOUS PAGE ---														
		Unsampled Overburden														
11																
12																
13																
14																
15																
16																
17																
18																
19	Wash Bore NW Casing															
20																
		CONTINUED NEXT PAGE														

DEPTH SCALE

1 : 50

**GOLDER**

LOGGED: PAH

CHECKED: CRG

MIS-BHS 001\_18111310.GPJ GAL-MIS.GDT 11/3/19 JEM

PROJECT: 18111310

**RECORD OF BOREHOLE: 19-01**

SHEET 3 OF 5

LOCATION: N 5014031.0 ; E 366869.9

BORING DATE: February 19-20, 2019

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				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m	SHEAR STRENGTH Cu, kPa		nat V. + Q - ● rem V. ⊕ U - ○		WATER CONTENT PERCENT Wp — W — Wi			
								20	40	60	80	10 <sup>-6</sup>	10 <sup>-5</sup>		
20	Wash Bore NW Casing	--- CONTINUED FROM PREVIOUS PAGE ---													
21		Unsampled Overburden													
22	Wash Bore NQ Core														
23															
24															
25															
26															
27															
28															
29															
30															
31															

CONTINUED NEXT PAGE

DEPTH SCALE

1 : 50

**GOLDER**

LOGGED: PAH

CHECKED: CRG

MIS-BHS 001 18111310.GPJ GAL-MIS.GDT 11/3/19 JEM

PROJECT: 18111310

**RECORD OF BOREHOLE: 19-01**

SHEET 4 OF 5

LOCATION: N 5014031.0 ;E 366869.9

BORING DATE: February 19-20, 2019

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				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m	SHEAR STRENGTH Cu, kPa		nat V. + Q - rem V. ⊕ U -		WATER CONTENT PERCENT Wp — W — Wi			
								20	40	60	80	10 <sup>-6</sup>	10 <sup>-5</sup>		
30	Wash Bore NQ Core	--- CONTINUED FROM PREVIOUS PAGE ---													
		Unsampled Overburden													
31															
32															
33															
34															
35															
36															
37															
38															
39															
40															

DEPTH SCALE

1 : 50

**GOLDER**

LOGGED: PAH

CHECKED: CRG

MIS-BHS 001 18111310.GPJ GAL-MIS.GDT 11/3/19 JEM

PROJECT: 18111310

**RECORD OF DRILLHOLE: 19-01**

SHEET 5 OF 5

LOCATION: N 5014031.0 ; E 366869.9

DRILLING DATE: February 19-20, 2019

DATUM: CGVD28

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME-850

DRILLING CONTRACTOR: CCC Geotechnical &amp; Environmental Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH	RECOVERY				FRACT. INDEX PER 0.3 m	DIP w.r.t CORE AXIS	DISCONTINUITY DATA				HYDRAULIC CONDUCTIVITY		Diametral Point Load Index (MPa)	RMC -Q AVG.
							TOTAL CORE %	SOLID CORE %	R.Q.D. %	TYPE AND SURFACE DESCRIPTION			Joon	Jr	Ja	K, cm/sec				
		BEDROCK SURFACE		51.84																
	Rotary Drill NQ Core	Fresh, light to medium grey, fine grained, faintly porous, medium bedded DOLOSTONE BEDROCK, with some calcite nodules and occasional thin shale partings		35.25	R1	100														
36					R2	50														
37																				
		End of Drillhole		49.74 37.35																
38																				
39																				
40																				
41																				
42																				
43																				
44																				
45																				

DEPTH SCALE

1 : 50

**GOLDER**

LOGGED: PAH

CHECKED: CRG

MIS-RCK 004 18111310.GPJ GAL-MISS.GDT 11/3/19 JEM

PROJECT: 18111310

**RECORD OF BOREHOLE: 19-02**

SHEET 1 OF 5

LOCATION: N 5014028.0 ;E 366929.9

BORING DATE: February 21-22, 2019

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				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m	SHEAR STRENGTH Cu, kPa		nat V. + Q - rem V. U -		WATER CONTENT PERCENT Wp — W — Wi			
								20	40	60	80	10 <sup>-6</sup>	10 <sup>-5</sup>		
0		GROUND SURFACE		85.48											
		Unsampled Overburden		0.00											
1															
2															
3															
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8															
9															
10															
		CONTINUED NEXT PAGE													

DEPTH SCALE

1 : 50

**GOLDER**

LOGGED: PAH

CHECKED: CRG

MIS-BHS 001 18111310.GPJ GAL-MIS.GDT 11/3/19 JEM

PROJECT: 18111310

**RECORD OF BOREHOLE: 19-02**

SHEET 2 OF 5

LOCATION: N 5014028.0 ;E 366929.9

BORING DATE: February 21-22, 2019

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				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m	SHEAR STRENGTH Cu, kPa		nat V. + Q - rem V. U -		WATER CONTENT PERCENT Wp — W — Wi			
								20	40	60	80	10 <sup>-6</sup>	10 <sup>-5</sup>		
10	Wash Bore NW Casing	--- CONTINUED FROM PREVIOUS PAGE ---													
		Unsampled Overburden													
11															
12															
13															
14															
15															
16															
17															
18															
19															
20															
		CONTINUED NEXT PAGE													

DEPTH SCALE

1 : 50

**GOLDER**

LOGGED: PAH

CHECKED: CRG

MIS-BHS 001 18111310.GPJ GAL-MIS.GDT 11/3/19 JEM

PROJECT: 18111310

**RECORD OF BOREHOLE: 19-02**

SHEET 3 OF 5

LOCATION: N 5014028.0 ;E 366929.9

BORING DATE: February 21-22, 2019

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				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	SHEAR STRENGTH Cu, kPa		nat V. + Q - rem V. U -		WATER CONTENT PERCENT Wp — W — Wi					
							20	40	60	80	10 <sup>-6</sup>	10 <sup>-5</sup>	10 <sup>-4</sup>			10 <sup>-3</sup>
20	Wash Bore NW Casing	--- CONTINUED FROM PREVIOUS PAGE ---														
		Unsampled Overburden														
21																
22																
23																
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27																
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30																
		CONTINUED NEXT PAGE														

DEPTH SCALE

1 : 50

**GOLDER**

LOGGED: PAH

CHECKED: CRG

MIS-BHS 001 18111310.GPJ GAL-MIS.GDT 11/3/19 JEM

PROJECT: 18111310

**RECORD OF BOREHOLE: 19-02**

SHEET 4 OF 5

LOCATION: N 5014028.0 ;E 366929.9

BORING DATE: February 21-22, 2019

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				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	SHEAR STRENGTH Cu, kPa		nat V. + Q - rem V. ⊕ U - ○		WATER CONTENT PERCENT Wp — W — Wi					
							20	40	60	80	10 <sup>-6</sup>	10 <sup>-5</sup>	10 <sup>-4</sup>			10 <sup>-3</sup>
30	Wash Bore NW Casing	--- CONTINUED FROM PREVIOUS PAGE ---														
		Unsampled Overburden														
		Borehole Continued on RECORD OF DRILLHOLE 19-02														
31																
32																
33																
34																
35																
36																
37																
38																
39																
40																

DEPTH SCALE

1 : 50

**GOLDER**

LOGGED: PAH

CHECKED: CRG

MIS-BHS 001 18111310.GPJ GAL-MIS.GDT 11/3/19 JEM



SHEET 5 OF 5

DATUM: CGVD28

DRILLING CONTRACTOR: CCC Geotechnical &amp; Enviromental Drilling

CHECKED: CRG

MIS-RCK 004 18111310.GPJ GAL-MISS.GDT 11/3/19 JEM