

DATE June 21, 2017**PROJECT No.** 1773927-3000**TO** City of Ottawa and
Minto Communities - Canada**FROM** Loren Bekeris
Brian Byerley**EMAIL** Loren_Bekeris@golder.com
Brian_Byerley@golder.com**DESKTOP HYDROGEOLOGICAL ASSESSMENT
PROPOSED RESIDENTIAL SUBDIVISION
3311 GREENBANK ROAD, OTTAWA, ONTARIO**

This report presents the results of a desktop hydrogeological assessment carried out for the proposed residential subdivision development site at 3311 Greenbank Road, in Ottawa, Ontario. The hydrogeological assessment is required for draft plan approval.

The purpose of this hydrogeological assessment was to determine the general soil and groundwater conditions across this site, by means of existing on-site borehole information and data from nearby sites, and to address possible construction-related impacts to private water supply wells. The on-site information was enhanced with published mapping and publicly available information. The water well records in the Ministry of the Environment and Climate Change (MOECC) 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 being prepared for a proposed residential development to be located at 3311 Greenbank Road in Ottawa, Ontario (see Key Plan inset on Figure 1).

The following information is known about the site and the proposed development:

- The property is roughly rectangular in shape with a maximum length and width of approximately 400 and 120 metres, respectively.
- The site is bounded to the west by Greenbank Road, to the north by an existing high school, to the east by Jockvale Road, and to the south by undeveloped lands.
- The site has a relatively flat to gently sloping topography from about elevation 97 to 91 metres, decreasing in elevation towards the Jock River.
- The site primarily consists of undeveloped vacant and/or agricultural land, with some rows of trees.
- The property is to be developed as a residential subdivision consisting of townhomes.



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 the site is interpreted to predominantly consist of a thick deposit of glacial till. Published mapping indicates the bedrock surface to be at depths in the range of 5 to 15 metres below the ground surface in the vicinity of the site (Figure 3).

2.2 Bedrock Geology

The Ontario Geological Survey bedrock geology mapping indicates that the site is underlain by interbedded dolostone, shale and sandstone of the Oxford Formation (Figure 4).

2.3 Hydrogeology

2.3.1 Overburden Aquifer

The clay and glacial till deposits in the area are generally not capable of supplying sufficient quantities of groundwater to be considered an aquifer. As a result, the principal aquifer within the vicinity of the site is considered to be the underlying bedrock formations.

2.3.2 Bedrock Aquifers

The Oxford formation is considered to be a highly transmissive aquifer, and well yields in this formation have been reported between 45 and 115 L/min. Generally, the Oxford Formation provides an adequate resource for domestic water supplies. Groundwater flow in the Oxford formation is controlled predominately by fractures, as the primary porosity has been reduced by cementation.

2.3.3 Local Water Supply Wells

There are a total of 6 water wells identified in the MOECC Water Well Information System (WWIS), with a location accuracy of 300 metres or less, located within 100 metres of the site. The WWIS indicates that all of the wells were constructed to be used as water supply (domestic or livestock). The depths of the wells range from 20 to 72 metres, and the depth to the static water level water ranges from 2 to 3 metres (for wells where depth information is available in the WWIS).

3.0 SITE SPECIFIC GEOLOGY AND HYDROGEOLOGY

3.1 General

Golder Associates completed a geotechnical investigation at this site in 2017, which included eight boreholes advanced across the site.

Golder Associates also previously completed a geotechnical investigation for the South Nepean Collector sewer, which is being constructed to cross the site.

Based on a review of those previous studies and published geological mapping, the subsurface conditions at the site are interpreted to consist of topsoil and fill, overlying silty clay (within the eastern portion of the site), overlying bouldery glacial till, above bedrock. Available borehole logs are included in Attachment A, and borehole locations are indicated on Figure 1.

3.2 Site Specific Geology

Topsoil, Peat and Fill

Topsoil or peat exists at the ground surface at most of the borehole locations. Where encountered, the topsoil and peat ranges from about 80 to 600 millimetres in thickness. Fill was encountered at boreholes 17-01, 17-03, and 17-07. At these locations, the fill ranges from 1.1 to 2.8 metres thick. The fill consists of silty sand, sandy gravel, silty clay, and clayey silt.

Silty Clay

A deposit of silty clay exists below the topsoil in boreholes 17-04, 17-05, 15-3, 15-3A, and 15-4, towards the eastern portion of the site. The full thickness of the clay has been weathered to a grey brown crust and extends to depths ranging from about 1.5 to 2.3 metres below the existing ground surface.

Glacial Till and Interbedded Sand/Silt/Gravel

A deposit of glacial till, containing discontinuous interbedded sand, silt and gravel layers, exists below the topsoil, fill and silty clay (where present) in all of the boreholes from the previous investigations. The glacial till generally consists of a heterogeneous mixture of gravel, cobbles, and boulders in a matrix of silty sand, with variable amounts of silt, clay and gravel.

In boreholes 17-06, 15-2 and 15-4 to 15-7, the glacial till is interbedded with discontinuous layers of silt, sand, and gravel. The composition of the intermittently interbedded layers ranges from sandy silt, to silty sand, to sand, to gravelly sand, to sand and gravel. These layers would not typically be described as glacial till either due to the absence of fines (silt and clay) or gravel, cobbles and boulders.

The glacial till was proven to extend to depths varying from about 2.0 to 11.7 metres below the existing ground surface during the current investigation prior to the boreholes encountering practical refusal to augering or being terminated.

Auger Refusal and Bedrock

Practical refusal to augering was encountered at boreholes 15-1, 15-17A, 15-101, 17-01 through 17-04, 17-06, and 17-08, at depths varying between about 2.0 to 11.7 metres below the existing ground surface. Refusal may indicate the bedrock surface; however, it could also represent boulders within the glacial till.

Bedrock was encountered at boreholes 15-2, 15-7, 16-301 and 16-302. The boreholes were extended into the bedrock to depths of about 3.0 to 3.2 metres below the top of bedrock using rotary diamond drilling techniques while retrieving NQ sized core.

The following table summarizes the bedrock surface depths and elevations encountered at the borehole locations.

Borehole/ Test Pit Number	Ground Surface Elevation (masl)	Depth to Bedrock (m)	Bedrock Surface Elevation (masl)
15-2	91.59	11.58	80.01
15-7	92.84	6.20	86.64
16-301	93.16	9.80	83.36
16-302	93.06	8.02	85.04

The bedrock encountered in the boreholes consists of slightly weathered to fresh, thinly to thickly bedded, grey dolomite.

3.3 Hydrogeology

Monitoring wells were sealed into selected boreholes during previous investigations to allow for hydraulic response testing and measurements of the groundwater level. Estimates of hydraulic conductivity in monitoring wells where testing was completed as well as measured groundwater levels are provided in the following table.

Well ID	Geologic Unit of Screened Interval	Groundwater Level		Date of Measurement	Estimated Hydraulic Conductivity (m/s)
		Depth (m)	Elevation (m)		
17-01	Glacial Till	4.31	90.44	April 5, 2017	-
17-06	Glacial till and interbedded sand	1.57	91.71	April 5, 2017	-
15-2 screen 'A'	Bedrock	4.10	87.49	August 24, 2015	4×10^{-7}
15-2 screen 'B'	Sand and gravel (interbedded within glacial till)	3.17	88.42	August 24, 2015	3×10^{-5}
		2.18	89.41	April 7, 2016	
15-3A	Glacial till	2.98	88.36	August 24, 2015	-
15-5	Glacial till and interbedded sandy silt	3.19	89.60	August 24, 2015	5×10^{-8}
15-7	Bedrock	2.17	90.67	August 24, 2015	5×10^{-7}
		1.91	90.93	April 7, 2016	
15-101	Glacial till	3.57	88.86	August 24, 2015	-

Water levels across the area surrounding the site range from 1.57 to 4.31 metres depth. 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.

4.0 POTENTIAL IMPACTS TO EXISTING GROUNDWATER USERS

There are a total of 6 wells in the WWIS database that were constructed as water supply wells, located within 100 metres of the site. Details regarding the water supply wells are presented in the following table. Refer to Figure 1 for the well locations.

Well ID	Depth of Well (m)	Depth to Static Water Level (m)	Depth to Water Found (m)	Available Drawdown (m)	Type of Well
1506043	20.7	3.0	15.8	17.7	Bedrock
1509672	28.7	2.4	28.0	26.3	Bedrock
1509673	32.3	2.4	32.0	29.9	Bedrock
1516112	71.6	2.4	71.6	69.2	Bedrock
1517629	15.2	2.4	13.7	12.8	Bedrock
7165137	--	--	--	--	--

The well record associated with Well ID 7165137 is for an extension of the well casing (above ground). As such no details regarding the original construction of the well are available. The original well record for the well is not available. From the available well records, water supply wells in the area generally obtain water from the bedrock aquifer. As such it is likely that Well ID 7165137 is completed in a similar fashion.

Based on aerial photographs, there do not appear to be residences or buildings in the vicinity of Well ID 1516112 and Well ID 1517629. The well location sketches on the associated well records suggest that the locations of these water wells may have been incorrectly plotted.

The available drawdown in the wells, calculated as the difference between the static water level and the depth of the well) ranges from 12.8 to 69.2 metres. Considering that the overburden thickness in the area is mapped between 5 and 15 metres in thickness, a temporary drawdown, due to construction dewatering for the installation of services, could temporarily reduce the available drawdown in the wells but not likely to the degree that could 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).

Prior to construction at the site, it is recommended that a well survey be completed of the residences with wells located within approximately 100 metres of the property boundary. Information to be collected during the well survey could include the depth of the well, type of pump, and static water level. Water quality samples could be collected and analyzed for a typical suite of parameters (i.e. the 'subdivision package' as per MOECC Procedure D-5-5).

5.0 LIMITATIONS AND USE OF MEMORANDUM

This technical memorandum was prepared for the exclusive use of Minto Communities – Canada and the City of Ottawa. 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 proposed residential subdivision development at 3311 Greenbank Road, in Ottawa, Ontario. If you have any questions regarding this report, please contact the undersigned.

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LEB/BTB/hw

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Attachments: Figures 1 to 4
Attachment A – Borehole Logs



LEGEND

- APPROXIMATE BOREHOLE LOCATION, PREVIOUS INVESTIGATION
- APPROXIMATE TEST PIT LOCATION, PREVIOUS INVESTIGATION
- MOECC LISTED WATER WELL
- WATERCOURSE
- 100 metre BUFFER
- SITE BOUNDARY
- WATERBODY

KEY MAP

© OpenStreetMap (and) contributors, CC-BY-SA

0 25 50 100
1:2,500 METRES

REFERENCE(S)

1. LAND INFORMATION ONTARIO (LIO) DATA PRODUCED BY GOLDER ASSOCIATES LTD. UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 20142.
2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83
COORDINATE SYSTEM: MTM ZONE 9 VERTICAL DATUM: CGVD28

CLIENT
MINTO COMMUNITIES - CANADA

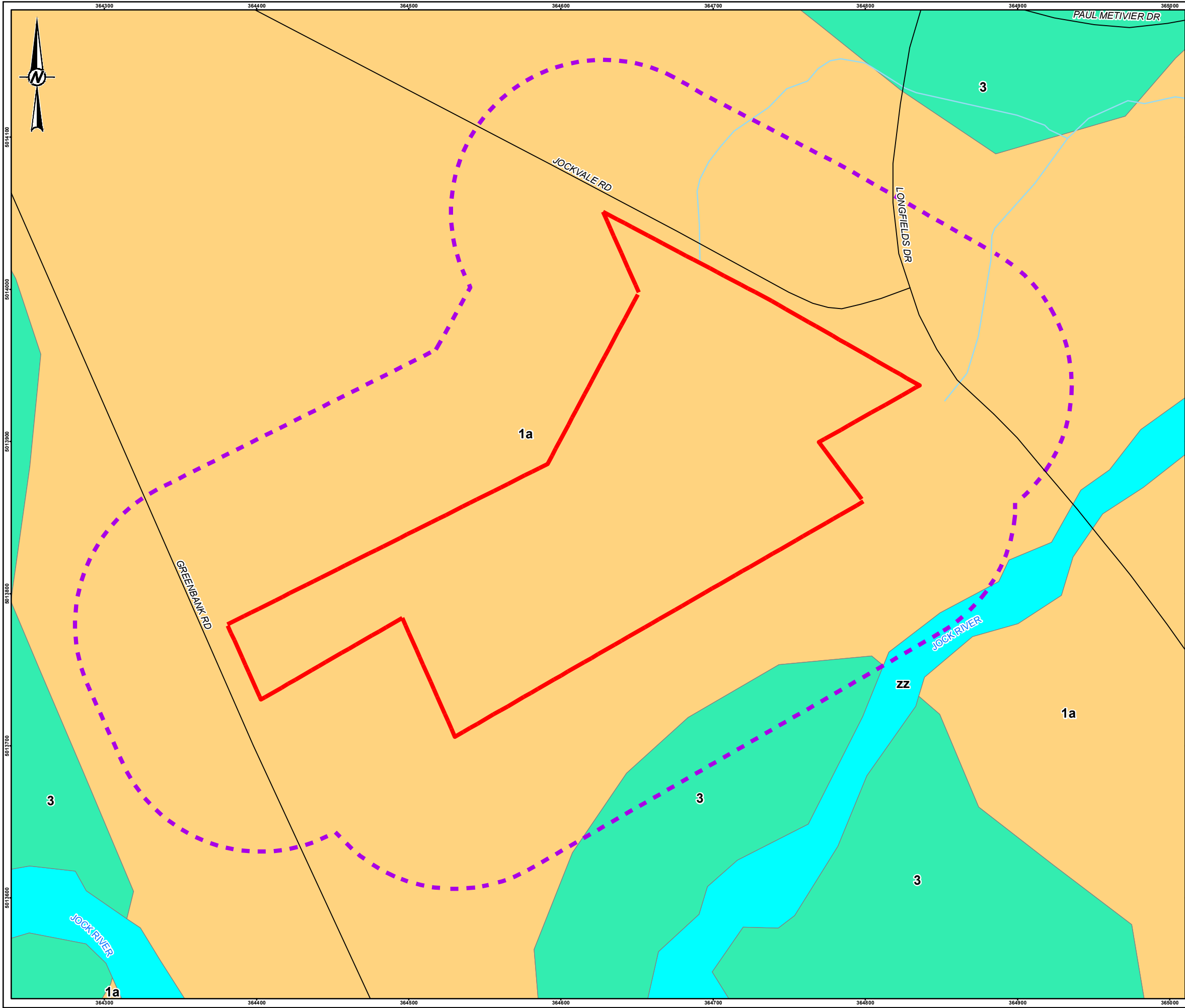
PROJECT
HYDROGEOLOGICAL ASSESSMENT
PROPOSED RESIDENTIAL DEVELOPMENT
3311 GREENBANK ROAD, OTTAWA, ONTARIO

TITLE
SITE PLAN

CONSULTANT	YYYY-MM-DD	2017-06-20
DESIGNED	---	
PREPARED	ABD	
REVIEWED	BH	
APPROVED	BTB	

PROJECT NO. 1773927	PHASE 3000	REV. 0	FIGURE 1
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LEGEND

- ROADWAY
- WATERCOURSE
- 100 meter BUFFER
- SITE BOUNDARY
- 3. OFFSHORE MARINE DEPOSITS: CLAY, SILTY CLAY & SILT
- 1a. TILL, PLAIN WITH LOCAL RELIEF <5 m
- zz. WATERBODY

KEY MAP

REFERENCE(S)

- BÉLANGER, J. R. 2008 URBAN GEOLOGY OF THE NATIONAL CAPITAL AREA, GEOLOGICAL SURVEY OF CANADA, OPEN FILE 5311, 1 DVD.
- LAND INFORMATION ONTARIO (LIO) DATA PRODUCED BY GOLDER ASSOCIATES LTD. UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2014
- PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83
- COORDINATE SYSTEM: MTM ZONE 9 VERTICAL DATUM: CGVD28

CLIENT		
MINTO COMMUNITIES - CANADA		
PROJECT		
HYDROGEOLOGICAL ASSESSMENT		
PROPOSED RESIDENTIAL DEVELOPMENT		
3311 GREENBANK ROAD, OTTAWA, ONTARIO		
TITLE		
SURFICIAL GEOLOGY		
CONSULTANT		
YYYY-MM-DD	2017-06-20	
DESIGNED	---	
PREPARED	ABD	
REVIEWED	BH	
APPROVED	BTB	

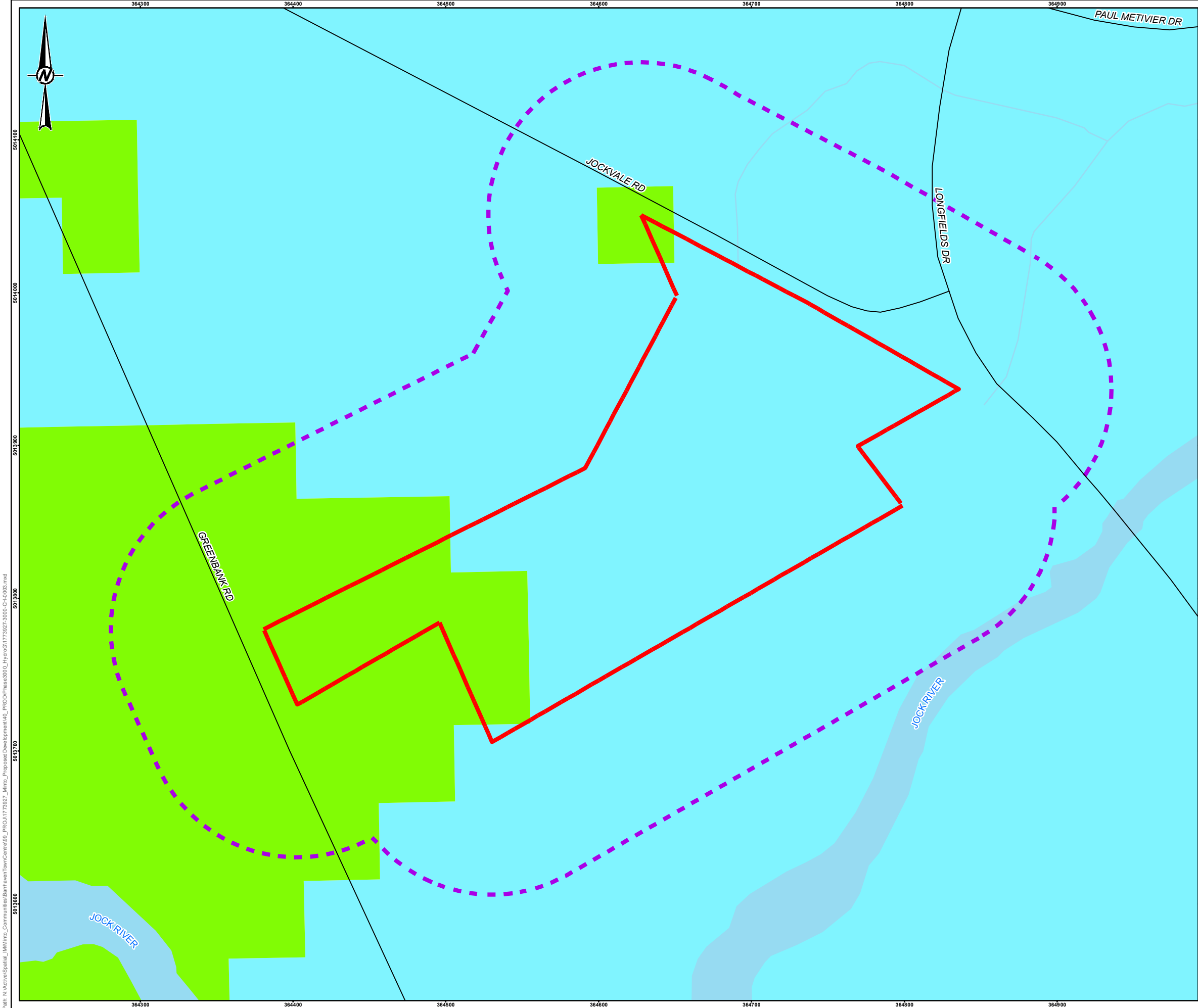
PROJECT NO.
1773927

PHASE
3000

REV.
0

FIGURE
2

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 28mm



LEGEND

- ROADWAY
- WATERCOURSE
- 100 meter BUFFER
- SITE BOUNDARY
- WATERBODY

TREND IN DEPTH TO BEDROCK (METRES)

0 to 1
1 to 2
2 to 3
3 to 5
5 to 10
10 to 15
15 to 25
25 to 50
50 to 100
100 to 200

KEY MAP

REFERENCE(S)

- 2010 BÉLANGER, J. R., URBAN GEOLOGY OF THE NATIONAL CAPITAL AREA, GEOLOGICAL SURVEY OF CANADA, OPEN FILE D3256, 2001
- LAND INFORMATION ONTARIO (LIO) DATA PRODUCED BY GOLDER ASSOCIATES LTD. UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2014
- PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83
- COORDINATE SYSTEM: MTM ZONE 9 VERTICAL DATUM: CGVD28

CLIENT

MINTO COMMUNITIES - CANADA

PROJECT

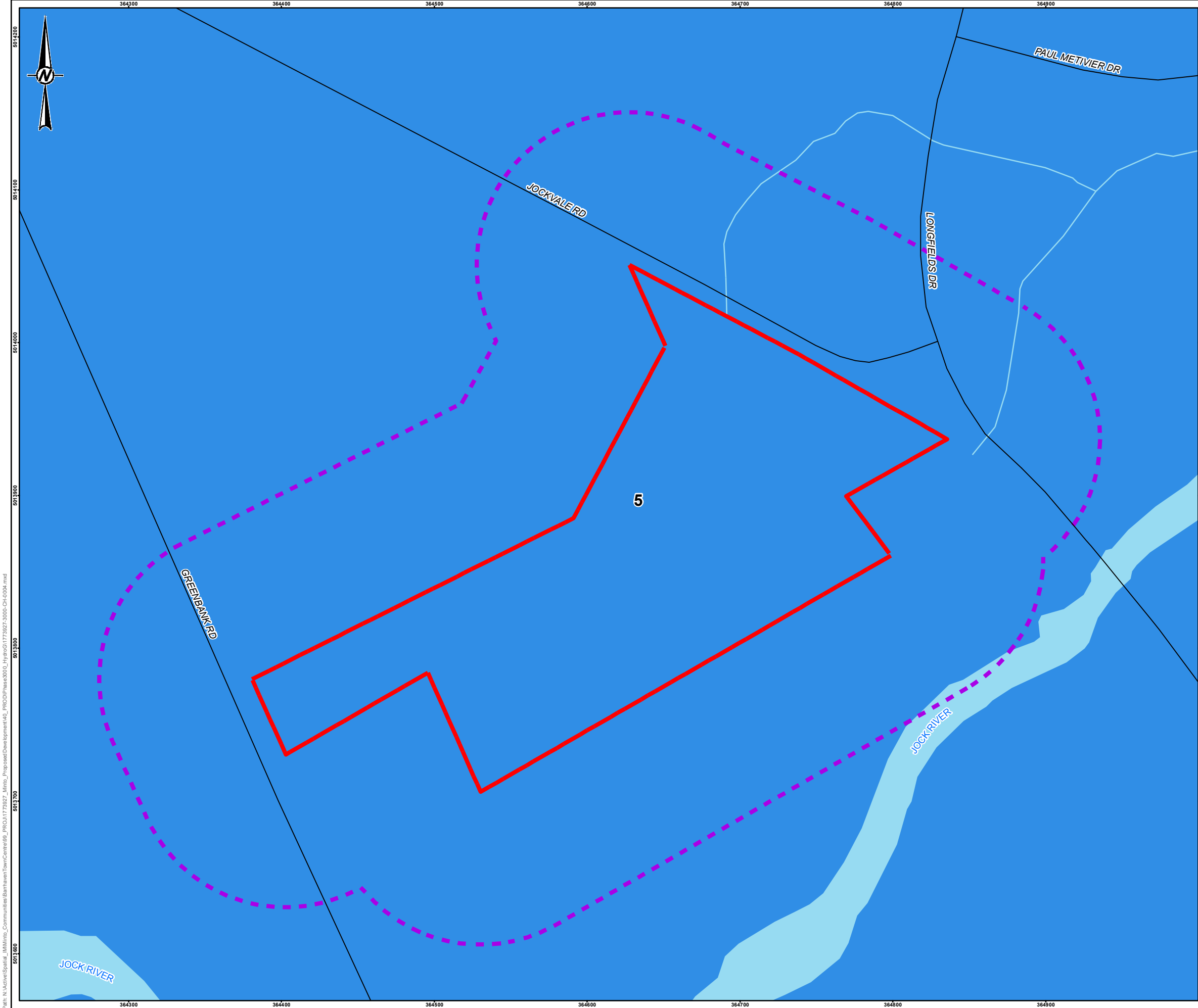
HYDROGEOLOGICAL ASSESSMENT
PROPOSED RESIDENTIAL DEVELOPMENT
3311 GREENBANK ROAD, OTTAWA, ONTARIO

TITLE

DRIFT THICKNESS

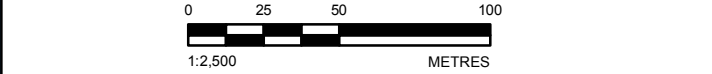
CONSULTANT	YYYY-MM-DD	2017-06-20
DESIGNED	---	
PREPARED	ABD	
REVIEWED	BH	
APPROVED	BTB	

PROJECT NO.	PHASE	REV.	FIGURE
1773927	3000	0	3



LEGEND

ROADWAY

WATERCOURSE

- REFERENCE(S)
1. ARMSTRONG, D.K. AND DODGE, J.E.P. 2007. PALEOZOIC GEOLOGY OF SOUTHERN ONTARIO; ONTARIO GEOLOGICAL SURVEY, MISCELLANEOUS RELEASE-DATA 219

2. LAND INFORMATION ONTARIO (LIO) DATA PRODUCED BY GOLDER ASSOCIATES LTD. UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2014

2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83

COORDINATE SYSTEM: MTM ZONE 9 VERTICAL DATUM: CGVD28

CLIENT			
MINTO COMMUNITIES - CANADA			
PROJECT			
HYDROGEOLOGICAL ASSESSMENT			
PROPOSED RESIDENTIAL DEVELOPMENT			
3311 GREENBANK ROAD, OTTAWA, ONTARIO			
TITLE			
BEDROCK GEOLOGY			
CONSULTANT		YYYY-MM-DD	2017-06-20
<div><div></div><div>Golder Associates</div></div>		DESIGNED	---
		PREPARED	ABD
		REVIEWED	BH
		APPROVED	BTB
PROJECT NO.	PHASE	REV.	FIGURE
1773927	3000	0	4

ATTACHMENT A

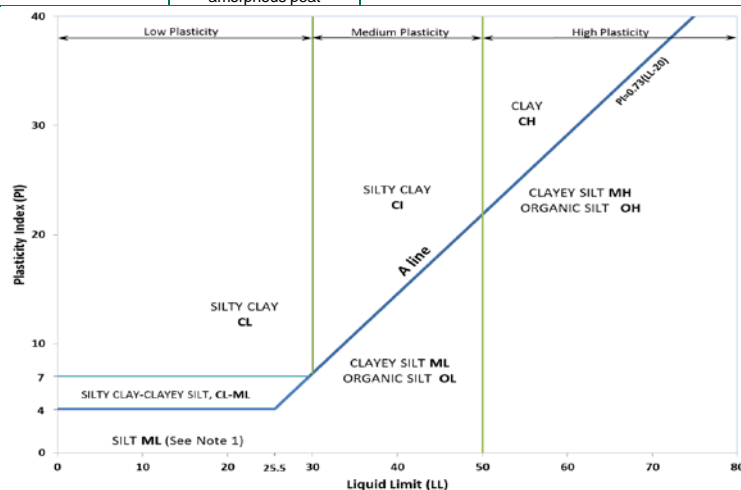
Borehole Logs



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
				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		
			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		
				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%	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, SAND and CLAY)
> 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 cm² 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
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, G_s)
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)
Y	unit weight

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

COHESIVE SOILS

NON-COHESIVE (COHESIONLESS) SOILS

Compactness²

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

- SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects.
- Definition of compactness descriptions based on SPT 'N' ranges from Terzaghi and Peck (1967) and correspond to typical average N_{60} values.

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.

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

- SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects; approximate only.
- 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.
$w \sim PL$	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
ν	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 $= \sigma'_p / \sigma'_{vo}$

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

Notes: 1
2

$\tau = c' + \sigma' \tan \phi'$
shear strength = (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	

PROJECT: 1773927

RECORD OF BOREHOLE: 17-01

SHEET 1 OF 1




LOCATION: See Site Plan

BORING DATE: March 14, 2017

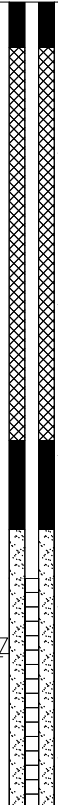
DATUM: Geodetic

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 ⁻⁶	10 ⁻⁵	10 ⁻⁴	10 ⁻³			
								nat V. rem V.	+ ⊕	Q - U -	● ○	Wp	W	Wi				
0		GROUND SURFACE		94.75														
	Power Auger 200 mm Diam. (Hollow Stem)	FILL - (SM) SILTY SAND; dark brown, contains rootlets; non-cohesive, moist, compact		0.00	1	SS	12										Bentonite Seal	
		FILL - (GP) sandy GRAVEL; brown; non-cohesive, moist, dense		0.61														
1					2	SS	>50											
		(SM) SILTY SAND, some gravel; grey brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist, compact to very dense		1.10														
2					3	SS	39										Native Backfill and Bentonite	
					4	SS	>50											
3																		
				5	SS	>50										Bentonite Seal		
4																		
				6	SS	28												
5																		
				7	SS	36												
				89.39														
				5.36														
		End of Borehole Auger Refusal																
6																		
7																		
8																		
9																		
10																		

WL in Screen at
Elev. 90.44 m on
April 5, 2017



DEPTH SCALE

1 : 50



LOGGED: DG

CHECKED: TMS

MIS-BHS 001 1773927.GPJ GAL-MIS.GDT 06/09/17 JM

PROJECT: 1773927

RECORD OF BOREHOLE: 17-02

SHEET 1 OF 1




LOCATION: See Site Plan

BORING DATE: March 13, 2017

DATUM: Geodetic

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				WATER CONTENT PERCENT					
								Cu, kPa		nat V. + rem V. ⊕		Q - U - ● - ○		Wp			W
							20	40	60	80		10 ⁻⁶	10 ⁻⁵	10 ⁻⁴	10 ⁻³		
0		GROUND SURFACE		97.94 0.00													
	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND; dark brown; moist			1	SS	12										
		(SM) SILTY SAND, some gravel; brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist, dense			2	SS	>50										
1																	
						3	SS	32									
2																	
						4	SS	30									
3																	
					5	SS	39										
4		(SM) SILTY SAND, some gravel; grey brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist, very dense		94.13 3.81	6	SS	>50										
5					7	SS	50										
6		End of Borehole Auger Refusal		92.30 5.64	8	SS	>50										
6																	
7																	
8																	
9																	
10																	

Open borehole dry
upon completion of
drilling

DEPTH SCALE

1 : 50



LOGGED: DG

CHECKED: TMS

MIS-BHS 001 1773927.GPJ GAL-MIS.GDT 06/09/17 JM

PROJECT: 1773927

RECORD OF BOREHOLE: 17-03

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: March 14, 2017

DATUM: Geodetic

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				WATER CONTENT PERCENT					
								Cu, kPa		nat V. + rem V.		Q - U		Wp			
								20	40	60	80	10 ⁻⁶	10 ⁻⁵	10 ⁻⁴	10 ⁻³		
								20	40	60	80	20	40	60	80		
0		GROUND SURFACE		97.75													
	Power Auger 200 mm Diam. (Hollow Stem)	FILL/TOPSOIL - (SM) SILTY SAND; dark brown; moist		0.00													
		FILL - (SM) SILTY SAND, some gravel; brown, contains cobbles and boulders; non-cohesive, moist, dense to very loose		0.08	1	SS	37										
1					2	SS	9										
					3	SS	28										
2																	
				4	SS	3											
3		(SM) SILTY SAND, some gravel; brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist, compact		94.92													
				2.83													
					5	SS	11										
4					6	SS	28										
		End of Borehole Auger Refusal		93.31													
				4.44													
5																	Open borehole dry upon completion of drilling
6																	
7																	
8																	
9																	
10																	

Open borehole dry
upon completion of
drilling

DEPTH SCALE

1 : 50



LOGGED: DG

CHECKED: TMS

MIS-BHS 001 1773927.GPJ GAL-MIS.GDT 06/09/17 JM

PROJECT: 1773927

RECORD OF BOREHOLE: 17-04

SHEET 1 OF 1





LOCATION: See Site Plan

BORING DATE: March 14, 2017

DATUM: Geodetic

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 ⁻⁶	10 ⁻⁵	10 ⁻⁴	10 ⁻³		
								20	40	60	80	20	40	60	80		
0		GROUND SURFACE		92.21													
	Power Auger 200 mm Diam. (Hollow Stem)	(PT) Fibrous PEAT; dark brown; non-cohesive		0.00													
		(CI/CH) SILTY CLAY; grey brown (WEATHERED CRUST); cohesive, w>PL, very stiff		92.01 0.20	1	SS	6								○		
1					2	SS	8							○			
					90.69												
		(SM) SILTY SAND, some gravel; brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist, compact		1.52	3	SS	15										
						4	SS	13									
					89.16												
3		(SM) SILTY SAND, some gravel; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet, compact		3.05	5	SS	15										
		End of Borehole Auger Refusal		88.52 3.69													
4																	
5																	
6																	
7																	
8																	
9																	
10																	

DEPTH SCALE

1 : 50



LOGGED: DG

CHECKED: TMS

MIS-BHS 001 1773927 GPJ GAL-MIS.GDT 06/09/17 JM

PROJECT: 1773927

RECORD OF BOREHOLE: 17-06

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: March 13, 2017

DATUM: Geodetic

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	RESISTANCE, BLOWS/0.3m				CONDUCTIVITY, k, cm/s					
								SHEAR STRENGTH Cu, kPa		nat V. + Q - rem V. ⊕ U - ●		WATER CONTENT PERCENT					
								20	40	60	80	10 ⁻⁶	10 ⁻⁵	10 ⁻⁴			10 ⁻³
0	Power Auger 200 mm Diam. (Hollow Stem)	GROUND SURFACE		93.28													
		TOPSOIL - (SM) SILTY SAND; dark brown; non-cohesive, moist		0.00	1	SS	5								Bentonite Seal		
				92.67													
		(SM) SILTY SAND, some gravel; brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist, compact to very dense		0.61	2	SS	11										
1																	
					3	SS	>50								Native Backfill and Bentonite		
2																	
					4	SS	17										
3																	
					5	SS	>50										
4		(SM) SILTY SAND, some gravel; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet, compact		89.47	6	SS	27							Bentonite Seal			
				3.81										Silica Sand			
		(SP) SAND, fine, trace to some non-plastic fines; grey; non-cohesive, wet, compact		88.71	7	SS	17										
5				4.57										32 mm Diam. PVC #10 Slot Screen			
		(SM) SILTY SAND, some gravel; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet, very dense		88.13	8	SS	>50										
				5.15													
6		End of Borehole Auger Refusal		87.54										WL in Screen at Elev. 91.71 m on April 5, 2017			
				5.74													
7																	
8																	
9																	
10																	

DEPTH SCALE

1 : 50



LOGGED: DG

CHECKED: TMS

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PROJECT: 1773927

RECORD OF BOREHOLE: 17-07

SHEET 1 OF 1




LOCATION: See Site Plan

BORING DATE: March 13, 2017

DATUM: Geodetic

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 ⁻⁶	10 ⁻⁵	10 ⁻⁴	10 ⁻³						
								SHEAR STRENGTH Cu, kPa				nat V. + Q - rem V. ⊕ U - ○						WATER CONTENT PERCENT			
								20	40	60	80	Wp	W	Wi	20			40	60	80	
0		GROUND SURFACE		93.66																	
	Power Auger 200 mm Diam. (Hollow Stem)	FILL/TOPSOIL - (CL/ML) SILTY CLAY to CLAYEY SILT; dark brown; cohesive, moist		0.00	1	SS	4														
1					2	SS	6														
			(SM) SILTY SAND, some gravel; brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist, compact to dense		92.44 1.22																
2					3	SS	32														
					4	SS	15														
3																					
			(SM) SILTY SAND, some gravel; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet, compact to dense		90.61 3.05	5	SS	12													
4					6	SS	10														
5					7	SS	40														
6					8	SS	13														
		End of Borehole		87.56 6.10																	
7																					
8																					
9																					
10																					

WL in open borehole at 4.88 m depth below ground surface upon completion of drilling



WL in open
borehole at 4.88 m
depth below
ground surface
upon completion of
drilling

DEPTH SCALE

1 : 50



LOGGED: DG

CHECKED: TMS

MIS-BHS 001 1773927.GPJ GAL-MIS.GDT 06/09/17 JM

PROJECT: 1773927

RECORD OF BOREHOLE: 17-08

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: March 13, 2017

DATUM: Geodetic

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	RESISTANCE, BLOWS/0.3m				k, cm/s					
								SHEAR STRENGTH Cu, kPa		nat V. + Q - ● rem V. ⊕ U - ○		WATER CONTENT PERCENT					
								20	40	60	80	10 ⁻⁶	10 ⁻⁵	10 ⁻⁴	10 ⁻³		
								20	40	60	80	20	40	60	80		
0	Power Auger 200 mm Diam. (Hollow Stem)	GROUND SURFACE		95.93													
		TOPSOIL - (SM) SILTY SAND; dark brown; moist		0.00	1	GRAB	-										
		(SM) SILTY SAND, some gravel; brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist, dense to very dense		95.62													
				0.31													
1					2	SS	>50										
					3	SS	47										
2		End of Borehole Auger Refusal		93.92													
				2.01													
3																	
4																	
5																	
6																	
7																	
8																	
9																	
10																	

MH

Open borehole dry
upon completion of
drilling

DEPTH SCALE

1 : 50



LOGGED: DG

CHECKED: TMS

MIS-BHS 001 1773927.GPJ GAL-MIS.GDT 06/09/17 JM

PROJECT: 1523645

RECORD OF BOREHOLE: 15-1

SHEET 1 OF 1

LOCATION: N 5013950.9 ; E 364883.8

BORING DATE: August 20, 2015

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				WATER CONTENT PERCENT					
								Cu, kPa		nat V. + Q - rem V. ⊕ U - ○		Wp ——— W ——— I WI					
								20	40	60	80	10 ⁻⁸	10 ⁻⁶			10 ⁻⁴	10 ⁻²
0	Power Auger 200 mm Diam. (Hollow Stem)	GROUND SURFACE		91.69													
		FILL - (SM) SILTY SAND, some gravel; brown, presence of organic matter; non-cohesive, moist		0.00	1	AS	-										
		FILL - (SM) gravelly SILTY SAND; grey brown to grey, presence of cobbles and boulders inferred from auger resistance (RE-WORKED GLACIAL TILL); non-cohesive, moist, dense to loose		0.21													
1					2	SS	31										
2					3	SS	14										
3					4	SS	9										
4					5	SS	6										
		FILL - (SC) gravelly CLAYEY SAND; grey brown (RE-WORKED GLACIAL TILL); cohesive, w-PL		88.34													
				3.35													
4				6	SS	4									MH		
5				7	SS	9											
6			(SM/SC) gravelly SILTY SAND to gravelly CLAYEY SAND; grey, contains sand seams (GLACIAL TILL); non-cohesive, wet, loose		86.05												
				5.64													
				9	SS	6											
7																	
			8	SS	4												
8		(SM) gravelly SILTY SAND; grey, contains sand layers up to 150 mm in thickness, presence of cobbles and boulders inferred from auger resistance (GLACIAL TILL); non-cohesive, wet, compact to very dense		84.07													
			7.62														
			11	SS	17												
9																	
			12	SS	44									MH			
10																	
			13	SS	53												
11																	
			14	SS	130									M			
12		End of Borehole Auger Refusal		79.98													
				11.71													
13																	
14																	
15																	

MIS-BHS 001 1523645.GPJ GAL-MIS.GDT 05/13/16 JM

DEPTH SCALE

1 : 75



LOGGED: PAH

CHECKED: SD

PROJECT: 1523645

RECORD OF BOREHOLE: 15-2

SHEET 1 OF 2

LOCATION: N 5013925.3 ; E 364835.3

BORING DATE: August 14-17, 2015

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				WATER CONTENT PERCENT							
								Cu, kPa		nat V. + rem V. ⊕		Q - ● U - ○				Wp ——— W ——— WI			
								20	40	60	80	20	40			60	80		
0	Power Auger 200 mm Diam. (Hollow Stem)	GROUND SURFACE		91.59	1	AS	-												
		FILL - (SM) SILTY SAND, trace to some gravel, trace organic matter; dark brown; non-cohesive, moist		0.10	2	AS	-												
		TOPSOIL - (SM) SILTY SAND, trace gravel; dark brown; moist		0.34															
1		(SM) gravelly SILTY SAND; grey brown, with oxidation staining, presence of cobbles and boulders inferred from auger resistance (GLACIAL TILL); non-cohesive, moist to wet, dense to compact			3	SS	39												
2					4	SS	18												
					5	SS	25												
					6	SS	21												
4		(SW/GW and SM) SAND and GRAVEL and gravelly SILTY SAND; grey brown, interbedded, presence of cobbles and boulders inferred from observations in adjacent test pit excavations; non-cohesive, wet, compact		87.78	7	SS	16												
5				3.81	8	SS	25												
					9	SS	26												
6				85.49	10	SS	38												
			(SM and SP) gravelly SILTY SAND and gravelly SAND; grey brown to grey, interbedded, presence of cobbles and boulders inferred from auger resistance (GLACIAL TILL); non-cohesive, wet, dense to very dense		6.10	11	SS	45											
7					12	SS	114												
					13	SS	132												
9				14	SS	>120													
10	Wash Boring NW Casing				15	SS	>150												
					16	RC	DD												
					17	SS	>250												
12		Borehole continued on RECORD OF DRILLHOLE 15-2		80.01															
				11.58															

DEPTH SCALE

1 : 75



LOGGED: PAH

CHECKED: SD

MIS-BHS 001 1523645.GPJ GAL-MIS.GDT 05/13/16 JM

PROJECT: 1523645

RECORD OF DRILLHOLE: 15-2

SHEET 2 OF 2

LOCATION: N 5013925.3 ; E 364835.3

DRILLING DATE: August 14-17, 2015

DATUM: CGVD28

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 850

DRILLING CONTRACTOR: Marathon Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV.																		COLOUR										FLUSH										RECOVERY										R.Q.D.										FRACT.										DISCONTINUITY DATA										HYDRAULIC										Diameter										Point Load										RMC																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
				DEPTH (m)																		RETURN										CORRECTION										TOTAL										SOLID										PER										INDEX										B Angle										DIP w.r.t.										TYPE AND SURFACE										CONDUCTIVITY										Index										LO										Q										AVG.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											

MIS-RCK 004 1523645.GPJ GAL-MISS.GDT 05/13/16 JM

DEPTH SCALE

1 : 75



LOGGED: PAH

CHECKED: SD

PROJECT: 1523645

RECORD OF BOREHOLE: 15-3

SHEET 1 OF 1

LOCATION: N 5013871.5 ;E 364762.7

BORING DATE: August 13, 2015

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	RESISTANCE, BLOWS/0.3m				k, cm/s							
								SHEAR STRENGTH Cu, kPa		nat V. + rem V. ⊕		Q - ● U - ○		WATER CONTENT PERCENT					
								20	40	60	80	10 ⁻⁸	10 ⁻⁶	10 ⁻⁴			10 ⁻²		

DEPTH SCALE

1 : 75



LOGGED: PAH

CHECKED: SD

MIS-BHS 001 1523645.GPJ GAL-MIS.GDT 05/13/16 JM

PROJECT: 1523645

RECORD OF BOREHOLE: 15-3A

SHEET 1 OF 1

LOCATION: N 5013899.3 ; E 364793.3

BORING DATE: August 17, 2015

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				WATER CONTENT PERCENT								
								Cu, kPa		nat V. + rem V. ⊕		Q - ● U - ○					Wp — W — WI			
								20	40	60	80	10 ⁻⁸	10 ⁻⁶				10 ⁻⁴	10 ⁻²	20	40
0	Power Auger 200 mm Diam. (Hollow Stem)	GROUND SURFACE		91.34																
		FILL - (SM) SILTY SAND; dark brown, contains organic matter; non-cohesive, moist		0.00																
				0.21	1	AS	-													
		FILL - (SM/GM) SILTY SAND and GRAVEL; red brown and grey brown, contains organic matter; non-cohesive, moist, compact		90.63																
				0.71																
1				0.91	2	SS	11													
		TOPSOIL - (ML) CLAYEY SILT; dark brown; moist																		
		(Cl) sandy SILTY CLAY; grey brown, with oxidation staining, contains rootlets and silty sand seams (WEATHERED CRUST); cohesive, w>PL, very stiff		89.51	3	SS	5													
				1.83																
2					4	SS	15													
		(SM/SC) gravelly SILTY SAND to gravelly CLAYEY SAND; grey brown to grey, presence of cobbles and boulders inferred from auger resistance (GLACIAL TILL); non-cohesive, wet, compact to very loose			5	SS	2													
3				6	SS	3														
4				7	SS	23														
		(SM/GM) SILTY SAND and GRAVEL; grey, presence of cobbles inferred from auger resistance (GLACIAL TILL); non-cohesive, wet, compact		86.77																
				4.57																
5				8	SS	15														
6				9	SS	31														
				84.63																
				6.71																
7		(SM/GM and SP) SILTY SAND and GRAVEL and gravelly SAND; grey, interbedded, presence of cobbles and boulders inferred from auger resistance (GLACIAL TILL); non-cohesive, wet, very dense			10	SS	67													
8					11	SS	306													
9		End of Borehole		82.35																
				8.99																
10																				
11																				
12																				
13																				
14																				
15																				

DEPTH SCALE

1 : 75



LOGGED: PAH

CHECKED: SD

MIS-BHS 001 1523645.GPJ GAL-MIS.GDT 05/13/16 JM

PROJECT: 1523645

RECORD OF BOREHOLE: 15-4

SHEET 1 OF 1

LOCATION: N 5013779.2; E 364691.4

BORING DATE: August 18, 2015

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 ⁻⁸	10 ⁻⁶			10 ⁻⁴	10 ⁻²
0	Power Auger 200 mm Diam. (Hollow Stem)	GROUND SURFACE		92.00													
		TOPSOIL - (ML) CLAYEY SILT; dark brown; moist		0.00 91.72	1	AS	-										
		(CI) SILTY CLAY, some sand; grey brown (WEATHERED CRUST); cohesive, w>PL, very stiff		0.28													
1					2	SS	9										
				90.55													
				1.45	3	SS	2										
2			(SC) gravelly CLAYEY SAND; grey brown to grey, presence of cobbles and boulders inferred from auger resistance (GLACIAL TILL); non-cohesive, wet, loose to compact			4	SS	13									
						5	SS	4									
3						6	SS	4									
4																	
5			(SM/GM) SILTY SAND and GRAVEL; grey, presence of cobbles and boulders inferred from auger resistance and auger refusal (GLACIAL TILL); non-cohesive, wet, very dense		87.43 4.57	7	SS	65									
						8	SS	>50									
6		- 175 mm limestone cobble encountered at 5.79 m		85.90	9	RC	DD										
		(ML/SM) sandy SILT to SILTY SAND, trace to some gravel; grey; non-cohesive, wet, dense to very dense		6.10	10	SS	42						M				
7																	
8					11	SS	60										
9		(SM) gravelly SILTY SAND; grey, contains sand layers, presence of cobbles and boulders inferred from auger resistance (GLACIAL TILL); non-cohesive, wet, very dense		83.31 8.69	12	SS	>50										
10		End of Borehole		81.94 10.06													
11																	
12																	
13																	
14																	
15																	

DEPTH SCALE

1 : 75



LOGGED: PAH

CHECKED: SD

MIS-BHS 001 1523645.GPJ GAL-MIS.GDT 05/13/16 JM

PROJECT: 1523645

RECORD OF BOREHOLE: 15-5

SHEET 1 OF 1

LOCATION: N 5013703.6 ; E 364564.8

BORING DATE: August 18-19, 2015

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				WATER CONTENT PERCENT													
								20		40		60				80		10 ⁻⁶		10 ⁻⁵		10 ⁻⁴		10 ⁻³	
								SHEAR STRENGTH Cu, kPa		nat V. + rem V. ⊕		Q - ● U - ○				Wp		W		WI					
								20	40	60	80	20	40	60	80										
0	Power Auger 200 mm Diam. (Hollow Stem)	GROUND SURFACE		92.79																					
		TOPSOIL - (SM) SILTY SAND; dark brown; moist		92.51																					
		(SM/GM/SC) SILTY SAND and GRAVEL to CLAYEY SAND, some gravel; grey brown, presence of cobbles inferred from auger resistance (GLACIAL TILL); non-cohesive, moist, compact		0.28																					
1				91.42	1	SS	20																		
		(SM) gravelly SILTY SAND; grey brown, presence of cobbles and boulders inferred from auger resistance (GLACIAL TILL); non-cohesive, moist to wet, compact		1.37																					
2					2	SS	21																		
3					3	SS	11																		
4					4	SS	13																		
5			(SC) gravelly CLAYEY SAND; grey brown to grey, presence of cobbles inferred from auger resistance (GLACIAL TILL); non-cohesive, wet, very loose to loose		88.98	5	SS	9																	
					3.81																				
6					6	SS	2																		
		(SM/GM and SP) SILTY SAND and GRAVEL and SAND; grey, interbedded, presence of cobbles inferred from auger resistance (GLACIAL TILL); non-cohesive, wet, compact		87.15	7	SS	11																		
				5.64																					
7					8	SS	16																		
8					9	SS	22																		
		(ML) sandy SILT, trace gravel; grey, contains clayey silt seams; non-cohesive, wet, compact		85.17																					
				7.62	10	SS	25																		
9		(ML and SM) sandy SILT and SILTY SAND, some gravel; grey, interbedded (GLACIAL TILL); non-cohesive, wet, very dense		84.41	11	SS	55																		
				8.38																					
10					12	SS	51																		
11		End of Borehole		82.12	13	SS	76																		
				10.67																					
12																									
13																									
14																									
15																									

DEPTH SCALE

1 : 75



LOGGED: PAH

CHECKED: SD

MIS-BHS 001 1523645.GPJ GAL-MIS.GDT 05/13/16 JM

PROJECT: 1523645

RECORD OF BOREHOLE: 15-6A

SHEET 1 OF 1

LOCATION: N 5013619.9; E 364467.1

BORING DATE: August 20, 2015

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				WATER CONTENT PERCENT							
								Cu, kPa		nat V. + rem V. ⊕		Q - ● U - ○				Wp ——— W ——— I WI			
								20	40	60	80	10 ⁻⁸	10 ⁻⁶			10 ⁻⁴	10 ⁻²	20	40
0		GROUND SURFACE		94.09															
	Power Auger 200 mm Diam. (Hollow Stem)	FILL - Mixture of (SW/GW) SAND and GRAVEL and (SM) SILTY SAND; brown, contains organic matter and fragments of concrete and mortar; non-cohesive, moist		0.00															
			1	AS	-														
1				2	SS	22													
				3	SS	39													
2		(SM/GM) SILTY SAND and GRAVEL; grey brown to grey, with oxidation staining, contains sandy silt seams, presence of cobbles and boulders inferred from auger resistance (GLACIAL TILL); non-cohesive, moist to wet, compact to very dense																	
				4	SS	43													
			5	SS	57														
3																			
4																			
5																			
6																			
7																			
		(ML and SM) gravelly sandy SILT and SILTY SAND, trace gravel; grey, laminated; non-cohesive, wet, dense to compact		87.08															
				7.01															
8																			
9																			
10																			
		(SW/GW) SAND and GRAVEL, medium to coarse; grey, presence of cobbles and boulders inferred from auger resistance; non-cohesive, wet, very dense		84.34															
				9.75															
11																			
		(ML) sandy SILT; grey; non-cohesive, wet, very dense		83.12															
				10.97															
		End of Borehole		11.13															
12		Note:																	
		The lead auger and cutting head (a 1.5 m long hollow-stem auger) became dislodged during extraction. The auger is likely located at the bottom of the hole (about 11 m depth).																	
13																			
14																			
15																			

DEPTH SCALE

1 : 75



LOGGED: PAH

CHECKED: SD

MIS-BHS 001 1523645.GPJ GAL-MIS.GDT 05/13/16 JM

PROJECT: 1523645

RECORD OF BOREHOLE: 15-6B

SHEET 1 OF 1

LOCATION: N 5013655.3 ; E 364419.6

BORING DATE: August 21, 2015

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				WATER CONTENT PERCENT													
								20		40		60				80		10 ⁻⁸		10 ⁻⁶		10 ⁻⁴		10 ⁻²	
								Cu, kPa		nat V. + rem V. ⊕		Q - ● U - ○				Wp		W		WI					
								20	40	60	80			20	40	60	80								
0	Power Auger 200 mm Diam. (Hollow Stem)	GROUND SURFACE		94.06																					
		ASPHALTIC CONCRETE		0.00																					
		FILL - (GW) sandy GRAVEL, angular; grey (PAVEMENT STRUCTURE)		0.15	1	AS	-																		
		FILL - (SP) gravelly SAND; brown (PAVEMENT STRUCTURE)		0.33	2	AS	-																		
				0.54	3	AS	-																		
1			TOPSOIL - (SM/ML) SILTY SAND to sandy SILT, trace gravel; dark brown to black; wet		93.20																				
			(ML) sandy SILT, trace gravel; brown, contains clayey silt seams; non-cohesive, moist, loose		0.86																				
2					92.23	4	SS	7																	
			(SM) gravelly SILTY SAND; grey brown, presence of cobbles and boulders inferred from auger resistance (GLACIAL TILL); non-cohesive, moist to wet, compact to dense		1.83	5	SS	22																	
3																									
						6	SS	37																	
4																									
				89.64																					
5		(SP) SAND, trace gravel; grey brown, contains silty sand layers; non-cohesive, wet, dense		4.42															M						
					7	SS	34																		
6		(ML and SM) sandy SILT and SILTY SAND; grey brown, interbedded; non-cohesive, wet, very dense		88.42																					
				5.64																					
7					8	SS	67																		
		(ML/SM) gravelly sandy SILT to gravelly SILTY SAND; grey, presence of cobbles inferred from auger resistance (GLACIAL TILL); non-cohesive, wet, very dense		87.35																					
				6.71																					
8					9	SS	50												MH						
9																									
10					10	SS	102																		
11																									
					11	SS	162																		
		End of Borehole		82.78																					
				11.28																					
12																									
13																									
14																									
15																									

DEPTH SCALE

1 : 75



LOGGED: PAH

CHECKED: SD

MIS-BHS 001 1523645.GPJ GAL-MIS.GDT 05/13/16 JM

PROJECT: 1523645

RECORD OF BOREHOLE: 15-7

SHEET 1 OF 2

LOCATION: N 5013739.7 ; E 364291.3

BORING DATE: August 12, 2015

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				WATER CONTENT PERCENT							
								Cu, kPa		nat V. + rem V. ⊕		Q - U - ● - ○				Wp ———— W ———— WI			
								20	40	60	80	10 ⁻⁸	10 ⁻⁶			10 ⁻⁴	10 ⁻²	20	40
0	Power Auger 200 mm Diam. (Hollow Stem)	GROUND SURFACE		92.84															
		TOPSOIL - (ML/SM) sandy SILT to SILTY SAND; dark brown; moist		0.00 92.56 0.28	1	AS	-												
		(SM) gravelly SILTY SAND; grey brown, with oxidation staining, presence of cobbles and boulders inferred from auger resistance (GLACIAL TILL); non-cohesive, moist to wet, compact to very dense			2	SS	>50												
1					3	SS	17												
2					4	SS	46												
3					5	SS	12												
		(SM) SILTY SAND, fine, trace gravel; brown; non-cohesive, wet, compact		89.64 3.20	6	SS	22												
4				88.72 4.12	7	SS	21												
		(SM) gravelly SILTY SAND; grey, presence of cobbles and boulders inferred from auger resistance (GLACIAL TILL); non-cohesive, wet, compact			87.81 5.03	8	SS	11											
5					86.64 6.2	9	SS	>50											
6		Borehole continued on RECORD OF DRILLHOLE 15-7																	
7																			
8																			
9																			
10																			
11																			
12																			
13																			
14																			
15																			

DEPTH SCALE

1 : 75



LOGGED: PAH

CHECKED: SD

MIS-BHS 001 1523645.GPJ GAL-MIS GDT 05/13/16 JM

PROJECT: 1523645

RECORD OF DRILLHOLE: 15-7

SHEET 2 OF 2

LOCATION: N 5013739.7 ; E 364291.3

DRILLING DATE: August 12, 2015

DATUM: CGVD28

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 850

DRILLING CONTRACTOR: Marathon 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				DISCONTINUITY DATA	HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC JQ AVG.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
							RECOVERY		R.Q.D. %	FRACT. INDEX PER 0.25 m	DISCONTINUITY DATA				DISCONTINUITY DATA				DISCONTINUITY DATA				DISCONTINUITY DATA																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
							TOTAL CORE %	SOLID CORE %			DISCONTINUITY DATA				DISCONTINUITY DATA				DISCONTINUITY DATA				DISCONTINUITY DATA																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
							FLUSH	FLUSH			DISCONTINUITY DATA				DISCONTINUITY DATA				DISCONTINUITY DATA				DISCONTINUITY DATA																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
		BEDROCK SURFACE		86.64																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									

Peltonite Seal

Granitic Sand

32 mm Diam. PVC
#10 Slot Screen

Cave

WL in Screen at
Elev. 90.93 m on
April 7, 2016

DEPTH SCALE

1 : 75



LOGGED: PAH

CHECKED: SD

MIS-ROK 004 1523645.GPJ CAL-MISS.GDT 05/13/16 JM

PROJECT: 1523645

RECORD OF BOREHOLE: 15-17

SHEET 1 OF 1

LOCATION: N 5013731.1 ; E 364221.7

BORING DATE: August 11, 2015

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				WATER CONTENT PERCENT							
								Cu, kPa		nat V. + rem V. ⊕		Q - ● U - ○				Wp ——— W ——— WI			
								20	40	60	80	10 ⁻⁸	10 ⁻⁶			10 ⁻⁴	10 ⁻²	20	40
0		GROUND SURFACE		93.79															
	Power Auger 200 mm Diam. (Hollow Stem)	FILL - (ML) gravelly sandy SILT; dark brown and red brown, contains organic matter; non-cohesive, moist, compact		0.00	1	SS	15												
					2	SS	15												
1				92.57															
		FILL - (ML) CLAYEY SILT, some gravel; dark grey; cohesive, w>PL		1.22	3	SS	7												
2				91.75															
		TOPSOIL - (OL) ORGANIC SILT; black; moist		2.04	4	SS	11												
				2.23															
3		(ML) gravelly sandy SILT; grey brown, presence of cobbles and boulders inferred from auger resistance (GLACIAL TILL); non-cohesive, wet, compact			5	SS	24												
					6	SS	29												
4		(SM) gravelly SILTY SAND; grey, presence of cobbles and boulders inferred from auger resistance (GLACIAL TILL); non-cohesive, wet, compact		90.13															
				3.66	7	SS	20												
					8	SS	13												
5		End of Borehole		88.91															
				4.88															
6																			
7																			
8																			
9																			
10																			
11																			
12																			
13																			
14																			
15																			

DEPTH SCALE

1 : 75



LOGGED: PAH

CHECKED: SD

MIS-BHS 001 1523645.GPJ GAL-MIS.GDT 05/13/16 JM

PROJECT: 1523645


RECORD OF PROBEHOLE: 15-17A

SHEET 1 OF 1

LOCATION: N 5013728.8 ;E 364221.0

BORING DATE: August 12, 2015

DATUM: CGVD28

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	RESISTANCE, BLOWS/0.3m				k, cm/s							
								SHEAR STRENGTH Cu, kPa		nat V. + rem V. ⊕		Q - ● U - ○				WATER CONTENT PERCENT			
								20	40	60	80	10 ⁻⁸	10 ⁻⁶			10 ⁻⁴	10 ⁻²		
0	Power Auger 200 mm Diam. (Hollow Stem)	GROUND SURFACE		93.62															
		Refer to Record of Borehole 15-17 for stratigraphy		0.00															
1																			
2																			
3																			
4																			
5		Probable Glacial Till		88.74 4.88															
6		End of Probehole Auger Refusal		88.08 5.54															
7																			
8																			
9																			
10																			
11																			
12																			
13																			
14																			
15																			

DEPTH SCALE

1 : 75



LOGGED: PAH

CHECKED: SD

MIS-BHS 001 1523645.GPJ CAL-MIS.GDT 05/13/16 JM

PROJECT: 1523645

RECORD OF BOREHOLE: 15-101

SHEET 1 OF 1

LOCATION: N 5013821.4 ; E 364747.3

BORING DATE: August 19, 2015

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				WATER CONTENT PERCENT													
								20		40		60				80		10 ⁻⁶		10 ⁻⁵		10 ⁻⁴		10 ⁻²	
								SHEAR STRENGTH Cu, kPa		nat V. + rem V. ⊕		Q - ● U - ○				Wp		W		Wi					
								20	40	60	80														
0		GROUND SURFACE		92.43																					
		FILL - (SM/GM) SILTY SAND and GRAVEL; red brown and brown, contains organic matter, presence of cobbles and boulders inferred from auger resistance; non-cohesive, moist		0.00																					
1		TOPSOIL - (SM) SILTY SAND; black; moist		91.36	1	SS	12																		
		(SM) gravelly SILTY SAND; grey brown, presence of cobbles and boulders inferred from auger resistance (GLACIAL TILL); non-cohesive, moist to wet, compact to dense		1.07																					
2				1.22	2	SS	20																		
					3	SS	36																		
3					4	SS	12																		
4		(SM/GM) gravelly SILTY SAND to SILTY SAND and GRAVEL; grey, contains sand layers, presence of cobbles inferred from auger resistance (GLACIAL TILL); wet, loose to dense		88.62	5	SS	12																		
				3.81	6	SS	12																		
5					7	SS	8																		
6					8	SS	24																		
7					9	SS	43																		
8					10	SS	22																		
9		(ML) sandy SILT, some gravel; grey, contains clayey silt seams (GLACIAL TILL); non-cohesive, wet, compact		83.74	11	SS	>50																		
				8.69																					
10		End of Borehole Sampler Refusal		82.42																					
				10.01																					
11																									
12																									
13																									
14																									
15																									

MIS-BHS 001 1523645.GPJ GAL-MIS.GDT 05/13/16 JM

DEPTH SCALE

1 : 75



LOGGED: PAH

CHECKED: SD

PROJECT: 1523645

RECORD OF BOREHOLE: 16-301

SHEET 1 OF 2

LOCATION: N 5013712.6 ;E 364379.1

BORING DATE: March 4-7, 2016

DATUM: CGVD28

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 ⁻⁸	10 ⁻⁶		
0		GROUND SURFACE		93.16											
		Probable Sand		0.00											
1		Probable Glacial Till		92.25 0.91											
2															
3															
4															
5	Wash Boring NW Casing														
6															
7															
8															
9															
10		Borehole continued on RECORD OF DRILLHOLE 16-301		83.36 9.8											
11															
12															
13															
14															
15															

WL in open
borehole at 0.78 m
depth below
ground surface
upon completion of
drilling

MIS-BHS 001 1523645.GPJ GAL-MIS.GDT 05/13/16 JM

DEPTH SCALE

1 : 75



LOGGED: DWM

CHECKED:

PROJECT: 1523645

RECORD OF BOREHOLE: 16-302

SHEET 1 OF 2

LOCATION: N 5013746.6 ; E 364217.4

BORING DATE: March 4, 2016

DATUM: CGVD28

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/0.3m	SHEAR STRENGTH Cu, kPa		WATER CONTENT PERCENT					
								20	40	60	80	10 ⁻⁶	10 ⁻⁵		
0		GROUND SURFACE		93.06											
		Probable Sand		0.00											
1		Probable Glacial Till		92.15											
				0.91											
2															
3															
4	Wash Boring NW Casing														
5															
6															
7															
8		Borehole continued on RECORD OF DRILLHOLE 16-302		85.04											
				8.02											
9															
10															
11															
12															
13															
14															
15															

DEPTH SCALE

1 : 75



LOGGED: DWM

CHECKED:

MIS-BHS 001 1523645.GPJ GAL-MIS GDT 05/13/16 JM

PROJECT: 1523645

RECORD OF DRILLHOLE: 16-302

SHEET 2 OF 2

LOCATION: N 5013746.6 ; E 364217.4

DRILLING DATE: March 4, 2016

DATUM: CGVD28

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 850

DRILLING CONTRACTOR: CCC

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																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
							RECOVERY				R.Q.D. %	FRACT. INDEX PER 0.25 m	DISCONTINUITY DATA				HYDRAULIC CONDUCTIVITY				Diametral Point Load Index (MPa)	RMC I-Q AVG.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
							FLUSH	TOTAL CORE %	SOLID CORE %	TYPE AND SURFACE DESCRIPTION			Joon	Jr	Ja	K ₁	K ₂	K ₃	K ₄																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
9	Rotary Drill NQ Core	BEDROCK SURFACE		85.04																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			

DEPTH SCALE

1 : 75



LOGGED: DWM

CHECKED:

MIS-RCK 004 1523645.GPJ CAL-MISS.GDT 05/13/16 JM

RECORD OF TEST PIT

<u>Test Pit Number</u> <u>(Elevation)</u>	<u>Depth</u> <u>(metres)</u>	<u>Description</u>
TP 16-401 (~91.6)	0.0 – 0.3	TOPSOIL/FILL - (ML) Clayey sandy SILT; brown to black, non-cohesive, moist
	0.3 – 1.0	FILL - (SM) SILTY SAND, some gravel to gravelly; dark brown, with organics, metal, plastic, glass, rubber, wood, cobbles and boulders up to 600 mm; non-cohesive, moist
	1.0 – 3.7	(SM) Gravelly SILTY SAND; brown to grey brown, with cobbles and boulders up to 1400 mm (GLACIAL TILL); non-cohesive, moist
	3.7 – 4.7	(SM) Gravelly SILTY SAND; grey, with cobbles and boulders up to 400 mm (GLACIAL TILL); non-cohesive, moist to wet
	4.7 – 6.0	(SP-GP) SAND and GRAVEL, some non-plastic fines; grey brown, with cobbles and boulders up to 500 mm; non-cohesive, wet
	6.0 – 8.2	(SM) Gravelly SILTY SAND; grey, with cobbles and boulders (GLACIAL TILL); non-cohesive, wet
	8.2	END OF TEST PIT

Notes:

- 1) Water seepage noted at about 4.0 m below ground surface.
- 2) Significant groundwater inflow observed between about 4.7 and 6.0 m below ground surface (from sand and gravel layer).
- 3) Test pit walls sloughing within sand and gravel layer (between about 4.7 and 6.0 m below ground surface).

<u>Sample</u>	<u>Depth (m)</u>
1	5.0