TECHNICAL MEMORANDUM

DATE January 8, 2020 **Project No.** 19129142/3000

TO Pierre Dufresne
Tartan Land Development

CC Jim Moffatt, IBI Group

FROM Caitlin Cooke **EMAIL** ccooke@golder.com

GROUNDWATER IMPACT STUDY
RESIDENTIAL DEVELOPMENT, FINDLAY CREEK VILLAGE, STAGE 5
OTTAWA, ONTARIO

This report presents the results of a groundwater impact study carried out for Stage 5 of the Findlay Creek Village residential development site at 3100 Leitrim Road, in Ottawa, Ontario. The groundwater impact study is required by the City of Ottawa (City) prior to draft plan approval.

The purpose of this groundwater impact study was to determine the general soil and groundwater conditions across this site, by means of existing on-site borehole information and subsurface 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, Conservation and Parks (MECP) Water Well Information System (WWIS) for nearby water wells were used to provide further information regarding hydrogeological conditions in the area and identify where nearby water well users are taking their water.

1.0 DESCRIPTION OF PROJECT AND SITE

Stage 5 of the Findlay Creek Village residential development site is planned to be developed between Kelly Farm Drive and Fenton Road and to the south of Leitrim Road in Ottawa, Ontario. The approximate location of the site is shown on the Key Map insert provided on the Site Plan, Figure 1.

The following is known about the site and project (Figure 1):

- The site is somewhat rectangular in shape and measures approximately 550 m by 600 m.
- The overall site topography is relatively flat, but the ground surface elevation slopes down from northwest to southeast.
- The majority of the site is currently undeveloped and is used for agricultural purposes.
- The majority of the site will be developed as a conventional residential development and the balance, toward the west, as future employment uses.
- The development will be serviced with municipal sewer and water.

It is understood that trenches for installation of site services are anticipated to have depths ranging from 3.5 to 5.5 metres below existing ground surface. Trench depths are anticipated to be deepest where connections are made to the existing sewers on Kelly Farm Drive, and at the southwestern corner of the site where a connection will be made to the storm sewer where it outlets to a stormwater pond (Leitrim Pond 2).

2.0 GEOLOGY

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

2.1 Surficial Geology

The surficial geology in the vicinity of the site is shown on Figure 2. The upper overburden material mapped within the development is nearshore deposits of fine- to medium-grained sand (Unit 5b). This generally agrees with the site-specific data gathered by Golder Associates from test pits and boreholes completed within and near the development site (Golder Associates, 2019). These investigations found that the subsurface conditions on the site generally consist of fill material overlying variable deposits of sand and silt, overlying glacial till, with the bedrock surface at about 2 to 7 metres depth.

The locations of the test pits and boreholes is shown on Figure 1 and the test pit and borehole logs are provided in Attachment A.

Based on the data collected by Golder Associates, the bedrock surface typically exists at depths ranging from about 1.9 to 6.5 metres below the existing ground surface. The shallowest depths to bedrock were found in the vicinity of BH 4 and BH11-8 in the southwest of the site, and at BH11-2 and TP17-101 near the intersection of Kelly Farm Drive and Leitrim Road. Published mapping indicates the bedrock surface to be at depths in the range of 3 to 10 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 Nepean and March Formations are present in the area of the site (Figure 4). The Nepean Formation consists of quartz sandstone and the March Formation consists of interbedded sandstone, sandy dolostone and dolostone (Williams, 1991). Although not shown on Figure 4, the Oxford Formation, consisting of dolostone with subordinate shaley and sandy interbeds, has also been found near the site.

The site-specific bedrock geology in the vicinity of the site has been interpreted based on test pit and borehole information gathered for the site, nearby phases of the Findlay Creek Village Subdivision, and the installation of Leitrim Pond 2 south of the site. All boreholes completed into the bedrock in the vicinity of the site encountered an upper bedrock unit consisting of dolostone or dolomitic limestone. This bedrock unit is interpreted to be the Oxford Formation.

3.0 HYDROGEOLOGY

3.1 Regional Hydrogeology

The clay and glacial till deposits in the area of the development 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.

The Nepean, March and Oxford Formations are considered to be highly transmissive aquifers, and generally provide an adequate resource for domestic water supplies. Groundwater flow in these formations is controlled predominately by fractures, as the primary porosity has been reduced by cementation.

3.2 Site Specific Hydrogeology

A number of hydrogeological investigations have been completed on and nearby the site. Monitoring wells were sealed into various boreholes 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 and included in Attachment A.

Borehole Number	Geologic Unit	Ground Surface Elevation (masl)	Groundwater Depth (m)	Groundwater Elevation (masl)	Date of Measurement	Estimated Hydraulic Conductivity (m/s)
BH 11-1	Silt	Not measured	2.0	Not calculated	Sept 28, 2011	Not measured
BH 11-8	Bedrock	Not measured	3.5	Not calculated	Sept 28, 2011	Not measured
BH 6	Glacial Till	Not measured	0.3	Not calculated	Oct 28, 1993	Not measured
BH 16-6	Glacial Till/Bedrock	93.8	2.2	91.6	Aug 18, 2016	$3x10^{-4}$
BH 16-7	Glacial Till	94.1[1]	2.3	91.8	Aug 18, 2016	$2x10^{-3}$
BH 16-8	Bedrock	93.7[1]	2.3	91.4	Aug 18, 2016	$6x10^{-5}$
BH 17-05	Silty Sand/ Glacial Till	96.0	1.8	94.2	June 9, 2017	$8x10^{-5}$
BH 17-08	Sand/Glacial Till	97.8	1.7	96.1	June 9, 2017	$5x10^{-4}$

Notes: [1] Ground surface elevations were estimated based on adjacent ground surface elevations from the topographic mapping provided by IBI Group.

Water levels across the area surrounding the site range from 0.3 to 3.5 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

The greatest potential impacts to private wells could occur when groundwater control occurs from trenches that extend into the dolomitic limestone bedrock. The maximum depth of the proposed trenches will be approximately 5.5 metres below ground surface in this area of the site. The highest measured water levels near the site were found to be approximately 0.3 metres below ground surface; therefore, dewatering during construction of site services could require up to 5.2 metres of dewatering. The radius of influence of groundwater level drawdown during construction dewatering can be estimated using the modified Sichart and Kryieleis equation (Cashman and Preene, 2013[1], equation 7.15):

$$R_o = 1750(H - h)\sqrt{K}$$

where R_o represents the radius of influence in metres, H-h represents the amount of groundwater level drawdown in metres and K represents the hydraulic conductivity of the aquifer in metres per second (m/s). Using the highest hydraulic conductivity measured in the bedrock near the site (i.e., 3 x 10^{-4} m/s) and assuming a maximum drawdown of 5.2 metres, the radius of influence is estimated to be about 160 metres from the service trench.

[1] Groundwater Lowering in Construction: A Practical Guide to Dewatering" By P.M. Cashman, Martin Preene. 2013.

4.1 Groundwater Quantity

It is considered that the only potential for the proposed development to affect the water quantity of any wells that are in use near the site would be in association with temporary pumping from service trenches (potential for short term impact). The maximum radius of influence associated with dewatering was estimated to be 160 metres; however, to provide a conservative assessment of potential impacts to groundwater users, groundwater use within 200 metres of the site has been reviewed.

Municipal water service within 200 metres of the site is provided along Leitrim Road, Fenton Road and Southclark Place. Based on recent available aerial imagery, no well users are located on Leitrim Road within 200 metres of the site. The City of Ottawa was contacted to request the addresses on Fenton Road and Southclark Place that do not have water meters (indicating likely well users). For the three identified addresses that do not have water meters, the MECP Water Well Information System (WWIS) database was reviewed to identify probable wells records for these properties. The following table summarizes the well construction details for those wells. These properties are identified on Figure 1.

Address	Probable Well ID	Depth of Well (m)	Depth to Static Water Level (m)	Depth to Water Found (m)	Available Drawdown (m)	Type of Well
2790 Fenton Road	1515428	11.3	1.2	10.4	10.1	Bedrock
4534 Southclark Place	1514660	21.3	3.0	7.0	18.3	Bedrock
4543 Southclark Place	1513618	14.6	1.8	13.7	12.8	Bedrock

From the available well records, the water supply wells obtain water from the bedrock aquifer. The available drawdown in the wells, calculated as the difference between the static water level and the depth of the well) ranged from about 10 to 18 metres. A temporary drawdown due to construction dewatering from service trenches at the site could temporarily reduce the available drawdown in the well, but not likely to the degree that could negatively impact water supply. It is noted that these addresses are for small industrial properties, and the daily water demands are likely limited to washroom and kitchenette use by employees. It is understood that there are no structures or land uses planned for the site that would permanently lower the groundwater levels in the area surrounding the site (i.e., deep drained foundations).

Based on the comparatively small amount of drawdown that would be required in service trenches compared to the available drawdown in the wells, the installation of site services is not expected to adversely affect performance of any wells in service within 200 metres of the site (or further away), and impacts to existing groundwater users associated with temporary pumping from service trenches are not anticipated.

Prior to construction at the site, it is recommended that a well survey be completed at 2790 Fenton Road, 4534 Southclark Place and 4543 Southclark Place. 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 MECP Procedure D-5-5).

4.2 Groundwater Quality

As discussed in the geotechnical report (Golder, 2019), for shallow depths of excavation, bedrock removal in trenches in Stage 5 could be accomplished using mechanical methods (such as hoe ramming). Hoe ramming was used during the installation of sewers along Kelly Farm Drive in 2019; therefore, it is likely that connections to these existing sewers from Stage 5 can also be accomplished using the same methods and blasting will not be required.

Excavations deeper into the bedrock will likely require drill and blast procedures. These areas are likely to be where trench depths are anticipated to be deepest and the depth to bedrock is shallowest (i.e., where connections are made to the existing sewers on Kelly Farm Drive, and at the southwestern corner of the site where a connection will be made to the storm sewer where it outlets to Leitrim Pond 2). It is possible that vibration from blasting might cause well water in nearby wells to become turbid (cloudy) as vibrations re-suspend rock flour or other loose material from the base or sides of the well bore into the water column. If this were to occur, it is a very temporary situation that would rectify itself. It is considered that pre-construction monitoring and pre-construction sampling of any existing wells are matters for the contractor to normally consider as part of their pre-construction surveys. If there are any effects on a well due to the site development, it is typically the responsibility of the developer and/or the contractor to mitigate (as is standard practice).

The temporary nature of the proposed construction dewatering will not result in long-term changes in groundwater flow patterns; as a result, long-term impacts to water quality at active water supply wells are not anticipated.

5.0 LIMITATIONS AND USE OF MEMORANDUM

This technical memorandum was prepared for the exclusive use of Tartan Land Corporation. 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 groundwater impact study of the proposed Stage 5 of the Findlay Creek Village residential development, in Ottawa, Ontario. If you have any questions regarding this report, please contact the undersigned.

Golder Associates Ltd.

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Hydrogeologist

PROFESSIONAL GEOSCIENTIST
CAITLIN A. MARTIN COOKE
PRACTISING MEMBER
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Jan. 10/20
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Principal

CAMC/PAS/sg
https://golderassociates.sharepoint.com/sites/114268/project files/5 deliverables/phase 3000 - hydrogeological study/19129142-tm-hydrogeological study-2020-01-08.docx

Attachments: Figures 1 to 4
Attachment A – Borehole and Test Pit Logs and Hydraulic Conductivity Testing Results

References

Golder Associates Ltd., 2019. Geotechnical Investigation, Findlay Creek Village – Stage 5, 3100 Leitrim Road, Leitrim Development Area, Ottawa, Ontario. Report No. 19129142-2000, November 2019.

Williams, D.A., 1991. Paleozoic Geology of the Ottawa-St Lawrence Lowland, Southern Ontario; Ontario Geological Survey, Open File Report 5770, 292p.

374000

375000

6021000

5020000

TP17-9
BH11-3
TP17-8
TP17-104
1512247
1502168
1502169
7119814
BH17-07
TP17-103
TP17-108
1512275
TP17-102
1514163
TP17-101
TP17-107
BH17-06
BH11-2
TP17-106
TP17-112
BH11-6
TP17-105
TP17-111
LEITRIM ROAD
BH17-05
1515625
1515627
TP17-110
TP17-115
TP17-109
TP17-114
BH17-04
1512385
1514378
BH11-1
TP17-113
1515428
7179335
2790 Fenton Road
BH.6
TP17-116
1513729
1516413
TP17-117
1513676
1513618
1520518
FENTON ROAD
SOUTHCLARK PLACE
WIDGEON WAY
BULRUSH CRESCENT
MANGROVE CRESCENT
WHITE ALDER AVENUE
LONG POINT CIRCLE
4534 Southclark Place
4543 Southclark Place
1513593
BH11-8
BH.4
TP16-3
BH 16-8
TP16-4
TP16-1
BH16-1
BH16-3
TP16-6
TP16-5
TP16-2
TP16-8
TP16-7
BH16-2
BRADWELL WAY
SHEPODY CIRCLE
KELLY FARM DRIVE
TP16-12
TP16-10
BH16-7
TP16-9
7250130
TP16-11
BH16-4
BH16-5
TP16-13
BH17-1
TP16-14
BH16-6
BH17-3
TP16-15
BUFFLEHEAD WAY
GOLDEN SEDGE WAY
CRESTON VALLEY WAY
BH17-2
ALBION ROAD

KEY MAP

SCALE 1:60,000

LEGEND

- MOECC LISTED WATER WELL
- EXISTING GOLDER BOREHOLE LOCATION FROM PREVIOUS 931-2396 REPORT
- EXISTING GOLDER BOREHOLE OR TEST PIT LOCATION FROM PREVIOUS 1774599 REPORT
- EXISTING GOLDER BOREHOLE LOCATION FROM PREVIOUS 11-1121-0198 REPORT
- EXISTING GOLDER BOREHOLE OR TEST PIT LOCATION FROM PREVIOUS 12-1121-0053 REPORT
- 200m SITE BUFFER
- STAGE 5 SITE BOUNDARY

NOTE(S)

ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

1. LAND INFORMATION ONTARIO (LIO) DATA PRODUCED BY GOLDER ASSOCIATES LTD. UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2014
2. BASE PLAN PROVIDED IN ELECTRONIC BY IBI GROUP, OCTOBER 22, 2019
3. PROJECTION: TRANSVERSE MERCATOR, DATUM: NAD 83, COORDINATE SYSTEM: UTM ZONE 18, VERTICAL DATUM: CGVD28

0 50 100 200

1:5,000 METRES

CLIENT

TARTAN LAND DEVELOPMENT

PROJECT

GROUNDWATER IMPACT STUDY
RESIDENTIAL DEVELOPMENT,
FINDLAY CREEK VILLAGE, STAGE 5, OTTAWA, ONTARIO

TITLE

SITE PLAN

CONSULTANT

GOLDER

YYYY-MM-DD	2019-11-22
DESIGNED	----
PREPARED	ABD
REVIEWED	CAMC
APPROVED	PAS

PROJECT NO.	CONTROL	REV.	FIGURE
19129142	0003	A	1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm 0

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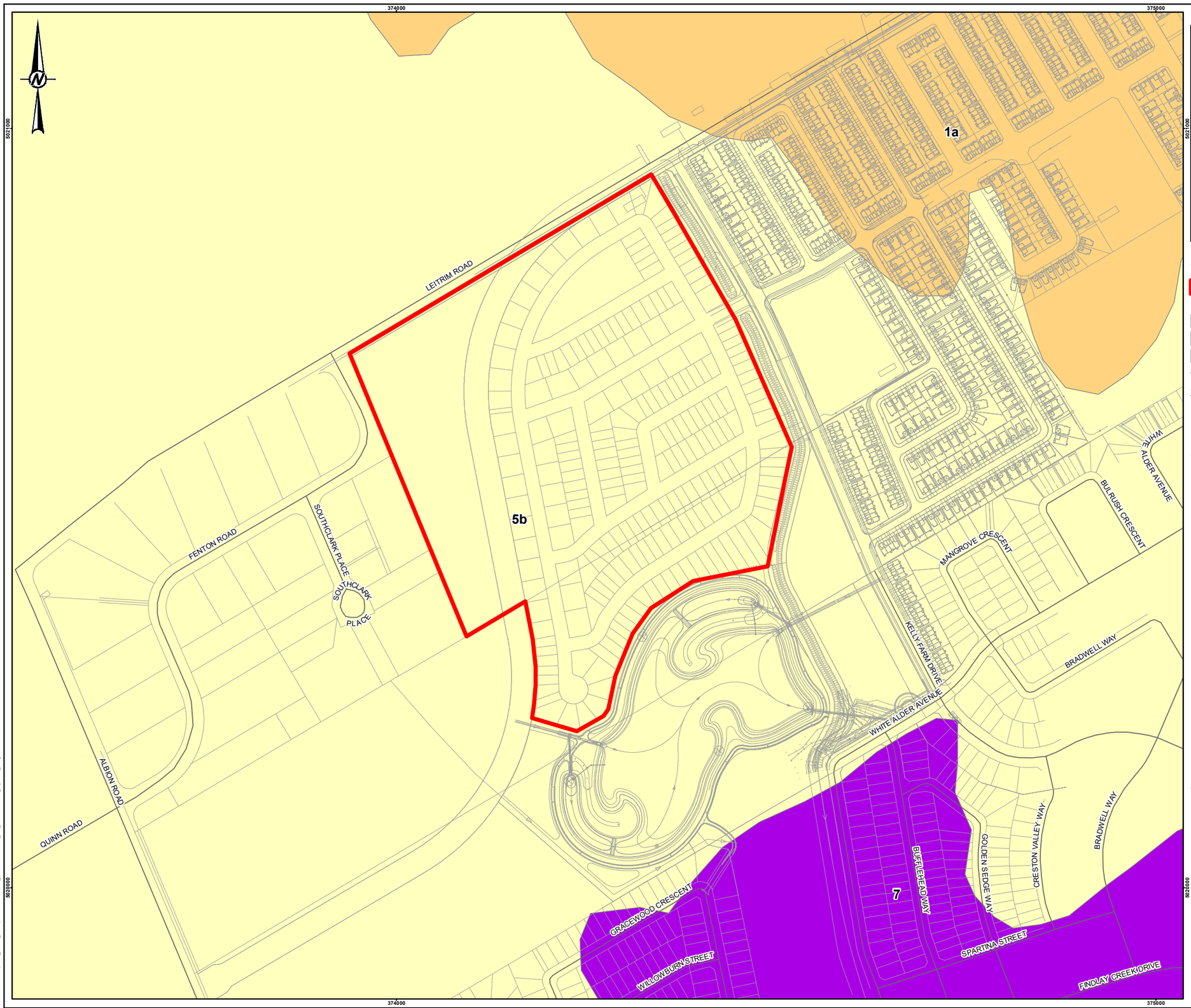

KEY MAP

SCALE 1:50,000

LEGEND

STAGE 5 SITE BOUNDARY

GSC SURFICIAL GEOLOGY

- 7. ORGANIC DEPOSITS: MUCK & PEAT
- 5b: NEARSHORE SEDIMENTS: FINE TO MEDIUM GRAINED SAND
- 1a. TILL, PLAIN WITH LOCAL RELIEF <5 m

NOTE(S)

ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

1. LAND INFORMATION ONTARIO (LIO) DATA PRODUCED BY GOLDER ASSOCIATES LTD. UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES. © QUEENS PRINTER 2014
2. BASE PLAN PROVIDED IN ELECTRONIC BY IBI GROUP, OCTOBER 22, 2019
3. BÉLANGER, J. R. 2008 URBAN GEOLOGY OF THE NATIONAL CAPITAL AREA, GEOLOGICAL SURVEY OF CANADA, OPEN FILE 5311, 1 DVD.
4. PROJECTION: TRANSVERSE MERCATOR, DATUM: NAD 83, COORDINATE SYSTEM: UTM ZONE 18, VERTICAL DATUM: CGVD28

0 50 100 200
1:5,000 METRES

CLIENT
TARTAN LAND DEVELOPMENT

PROJECT
GROUNDWATER IMPACT STUDY
RESIDENTIAL DEVELOPMENT,
FINDLAY CREEK VILLAGE, STAGE 5, OTTAWA, ONTARIO

TITLE
SURFICIAL GEOLOGY

CONSULTANT
GOLDER

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APPROVED	PAS

PROJECT NO.	CONTROL	REV.	FIGURE
19129142	0003	A	2

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0 25mm

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6021000

6020000

LEITRIM ROAD

FENTON ROAD

SOUTHCLARK PLACE

SOUTHCLARK PLACE

ALBION ROAD

QUINN ROAD

GRACEWOOD CRESCENT

WILLOWBURN STREET

BULRUSH CRESCENT

MANGROVE CRESCENT

KELLY FARM DRIVE

BRADWELL WAY

WHITE ALDER AVENUE

BUFFLEHEAD WAY

GOLDEN SEDGE WAY

CRESTON VALLEY WAY

BRADWELL WAY

SPARTINA STREET

374000

KEY MAP

SCALE 1:50,000

LEGEND

STAGE 5 SITE BOUNDARY

GSC TREND IN DEPTH TO BEDROCK (METRES)

- 2 to 3
- 3 to 5
- 5 to 10
- 10 to 15

NOTE(S)

ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

1. LAND INFORMATION ONTARIO (LIO) DATA PRODUCED BY GOLDER ASSOCIATES LTD. UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2014
2. BASE PLAN PROVIDED IN ELECTRONIC BY IBI GROUP, OCTOBER 22, 2019
3. 2010 BÉLANGER, J. R., URBAN GEOLOGY OF THE NATIONAL CAPITAL AREA, GEOLOGICAL SURVEY OF CANADA, OPEN FILE D3256, 2001
4. PROJECTION: TRANSVERSE MERCATOR, DATUM: NAD 83, COORDINATE SYSTEM: UTM ZONE 18, VERTICAL DATUM: CGVD28

0 50 100 200

1:5,000 METRES

CLIENT

TARTAN LAND DEVELOPMENT

PROJECT

GROUNDWATER IMPACT STUDY
RESIDENTIAL DEVELOPMENT,
FINDLAY CREEK VILLAGE, STAGE 5, OTTAWA, ONTARIO

TITLE

DEPTH TO BEDROCK SURFACE

CONSULTANT

GOLDER

YYYY-MM-DD	2019-11-22
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PREPARED	ABD
REVIEWED	CAMC
APPROVED	PAS

PROJECT NO.	CONTROL	REV.	FIGURE
19129142	0003	A	3

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm

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374000

375000

5021000

5020000

LEITRIM ROAD

FENTON ROAD

SOUTHCLARK PLACE

SOUTHCLARK PLACE

ALBION ROAD

QUINN ROAD

GRACEWOOD CRESCENT

WHITE ALDER AVENUE

BULRUSH CRESCENT

MANGROVE CRESCENT

KELLYFARM DRIVE

BRADWELL WAY

BUFFLEHEAD WAY

GOLDEN SEDGE WAY

CRESTON VALLEY WAY

BRADWELL WAY

SPARTINA STREET

WHITE ALDER AVENUE

8

3

2

KEY MAP

SCALE 1:50,000

LEGEND

FAULT

STAGE 5 SITE BOUNDARY

GSC BEDROCK GEOLOGY

8. VERULAM FORMATION: INTERBEDDED BIOCLASTIC LIMESTONE, SUBLITHOGRAPHIC TO FINE CRYSTALLINE LIMESTONE

3. MARCH FORMATION: INTERBEDDED QUARTZ SANDSTONE, SANDY DOLOSTONE, AND DOLOSTONE

2. NEPEAN FORMATION: FINE TO COARSE GRAINED QUARTZ SANDSTONE, PARTIALLY CALCAREOUS IN UPPER PART

NOTE(S)

ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

1. LAND INFORMATION ONTARIO (LIO) DATA PRODUCED BY GOLDER ASSOCIATES LTD. UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2014
2. BASE PLAN PROVIDED IN ELECTRONIC BY IBI GROUP, OCTOBER 22, 2019
3. ARMSTRONG, D.K. AND DODGE, J.E.P. 2007. PALEOZOIC GEOLOGY OF SOUTHERN ONTARIO; ONTARIO GEOLOGICAL SURVEY, MISCELLANEOUS RELEASE–DATA 219
4. PROJECTION: TRANSVERSE MERCATOR, DATUM: NAD 83, COORDINATE SYSTEM: UTM ZONE 18, VERTICAL DATUM: CGVD28

0 50 100 200

1:5,000 METRES

CLIENT
TARTAN LAND DEVELOPMENT

PROJECT
GROUNDWATER IMPACT STUDY
RESIDENTIAL DEVELOPMENT,
FINDLAY CREEK VILLAGE, STAGE 5, OTTAWA, ONTARIO

TITLE
BEDROCK GEOLOGY

CONSULTANT
GOLDER

YYYY-MM-DD	2019-11-22
DESIGNED	----
PREPARED	ABD
REVIEWED	CAMC
APPROVED	PAS

PROJECT NO.	CONTROL	REV.	FIGURE
19129142	0003	A	4

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm 0

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ATTACHMENT A

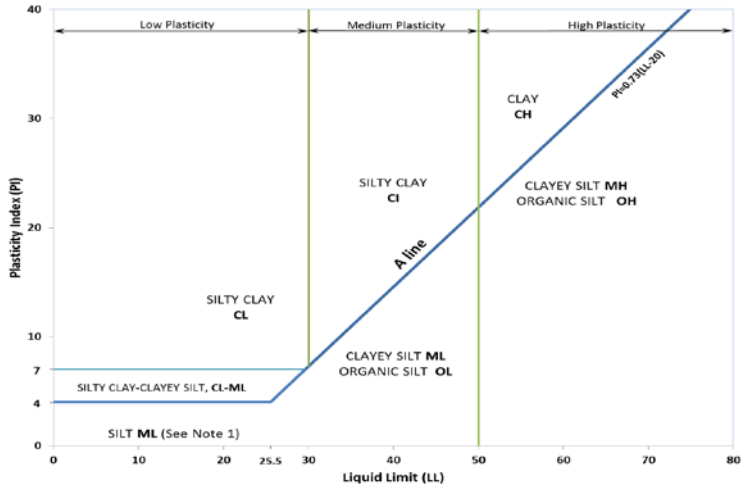
Borehole and Test Pit Logs and Hydraulic Conductivity Testing Results

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

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



Note 1 – Fine grained materials with PI and LL that plot in this area are named (ML) SILT with slight plasticity. Fine-grained materials which are non-plastic (i.e. a PL cannot be measured) are named SILT.
Note 2 – For soils with <5% organic content, include the descriptor "trace organics" for soils with between 5% and 30% organic content include the prefix "organic" before the Primary name.

Dual Symbol — A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC and CL-ML.
For non-cohesive soils, the dual symbols must be used when the soil has between 5% and 12% fines (i.e. to identify transitional material between "clean" and "dirty" sand or gravel.
For cohesive soils, the dual symbol must be used when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart (see Plasticity Chart at left).

Borderline Symbol — A borderline symbol is two symbols separated by a slash, for example, CL/CI, GM/SM, CL/ML.
A borderline symbol should be used to indicate that the soil has been identified as having properties that are on the transition between similar materials. In addition, a borderline symbol may be used to indicate a range of similar soil types within a stratum.

ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS

PARTICLE SIZES OF CONSTITUENTS

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

MODIFIERS FOR SECONDARY AND MINOR CONSTITUENTS

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

PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) split-spoon sampler for a distance of 300 mm (12 in.). Values reported are as recorded in the field and are uncorrected.

Cone Penetration Test (CPT)

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

Dynamic Cone Penetration Resistance (DCPT); N_d:

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

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

SAMPLES

AS	Auger sample
BS	Block sample
CS	Chunk sample
DD	Diamond Drilling
DO or DP	Seamless open ended, driven or pushed tube sampler – note size
DS	Denison type sample
GS	Grab Sample
MC	Modified California Samples
MS	Modified Shelby (for frozen soil)
RC	Rock core
SC	Soil core
SS	Split spoon sampler – note size
ST	Slotted tube
TO	Thin-walled, open – note size (Shelby tube)
TP	Thin-walled, piston – note size (Shelby tube)
WS	Wash sample

SOIL TESTS

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

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

NON-COHESIVE (COHESIONLESS) SOILS

Compactness[2]

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

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

Field Moisture Condition

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

COHESIVE SOILS

Consistency

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

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

Water Content

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

LIST OF SYMBOLS

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

I. GENERAL

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

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

(a) Index Properties

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

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

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

Notes: 1 $\tau = c' + \sigma' \tan \phi'$

2 shear strength = (compressive strength)/2

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

Description	Bedding Plane Spacing
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

Description	Spacing
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

Term	Size*
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 occuring 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^{o} 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: 931-2396

RECORD OF BOREHOLE 4

SHEET 1 OF 1

LOCATION: See Plan

BORING DATE: Oct.25&26,1993

DATUM:

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, k, cm/s	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		Ground Surface									
0	Power Auger 200mm Diam (Hollow Stem)	Brown SANDY SILT, scattered trace gravel with depth		0.00							
1		Loose to compact brown to grey sandy silt to silty sand, some gravel and clay occasional boulder (GLACIAL TILL)		0.88	1	50 DO	12				
2					2	50 DO	9				
2		End of Hole Auger Refusal		2.19							W.L in open hole at 0.06m depth on completion of drilling Oct. 26, 1993
3		NOTE : AH 4A - 1.5m East Auger Refusal at 1.98m AH 4B - 7.0m South Auger Refusal at 2.19m									
4											
5											
6											
7											
8											
9											
10											

SHEAR STRENGTH Cu, kPa — nat.V - + O - ● rem.V - ⊕ U - O

WATER CONTENT, PERCENT: Wp — W — Wl (20, 40, 60, 80)

DATA INPUT: Disk 17, S.Leighton

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: R.A.M

CHECKED:

PROJECT: 931-2396

RECORD OF BOREHOLE 6

SHEET 1 OF 1

LOCATION: See Plan

BORING DATE: Oct.26,1993

DATUM:

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m / SHEAR STRENGTH Cu, kPa (nat.V - +, Q - ●, rem.V - ⊕, U - O)	HYDRAULIC CONDUCTIVITY, k, cm/s / WATER CONTENT, PERCENT (Wp, W, Wl; 20, 40, 60, 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		Ground Surface									
		Dark brown silty TOPSOIL		0.00							
				0.24							
1		Stiff to very stiff grey brown SILTY CLAY, trace to some sand seams (Weathered Crust)			1	50 DO	2		O		Bentonite Seal
2	Power Auger 200mm Diam (Hollow Stem)				2	50 DO	WH 5		O		Native Backfill
				1.83							
		Very loose to loose dark grey to grey SILT, some sand, scattered trace gravel			3	50 DO	WH		O	MH	
3											
				2.99	4	50 DO	17				
		Compact grey sandy silt to silty sand, some gravel and clay, occasional boulders (GLACIAL TILL)									
4					5	50 DO	17				Standpipe
		End of Hole		4.57							
5											W.L in Standpipe at 0.30m depth Oct.28, 1993
6											
7											
8											
9											
10											

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: R.A.M

CHECKED:

PROJECT: 11-1121-0198-1000

RECORD OF BOREHOLE: 11-1

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: September 12, 2011

DATUM:

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp, W, Wl) (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE											
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL		0.00									Native Backfill
		Brown SAND, trace silt		0.21	1	GRAB							Bentonite Seal
		Compact brown SILT, trace sand and clay		0.56	2	50 DO	12						Native Backfill
1					3	50 DO	16						Bentonite Seal
													Silica Sand
2		Loose to compact grey SILT, trace sand and clay		1.95	4	50 DO	6					MH	51 mm Diam. PVC #10 Slot Screen
3					5	50 DO	>50						
		Very dense grey SILTY SAND, some gravel, trace clay, with cobbles and boulders (GLACIAL TILL)		3.26									Native Backfill
		End of Borehole Auger Refusal		3.44									W.L. in Screen at 2.0 m depth on September 28, 2011
4													
5													
6													
7													
8													
9													
10													

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: PH

CHECKED: C.K.

MIS-BHS 001 1111210198-1000.GPJ GAL-MIS.GDT 01/27/12 JEM

PROJECT: 11-1121-0198-1000

RECORD OF BOREHOLE: 11-2

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: September 12, 2011

DATUM:

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp — W — Wl) (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE											
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL		0.00									
		Brown CLAYEY SILT, trace sand		0.15	1	GRAB							
1					2	50 DO	7					MH	
		Very dense brown SILTY SAND, trace gravel and clay, with cobbles and boulders (GLACIAL TILL)		1.37	3	50 DO	>50						
2					4	50 DO	>50						
		End of Borehole Auger Refusal		2.59									
3													
4													
5													
6													
7													
8													
9													
10													

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: PH

CHECKED: C.K.

MIS-BHS 001 1111210198-1000.GPJ GAL-MIS.GDT 01/27/12 JEM

PROJECT: 11-1121-0198-1000

RECORD OF BOREHOLE: 11-3

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: September 12, 2011

DATUM:

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp, W, Wl) (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE											
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL		0.00									
		Brown SILTY SAND		0.09									
		Brown SILT, trace gravel, clay, and sand		0.61									
1		Compact to very dense brown SAND, some gravel, trace silt and clay, with cobbles and boulders (GLACIAL TILL)		0.98	1	50 DO	15						▽
					2	50 DO	37						
2					3	50 DO	20						
3					4	50 DO	57						
					5	50 DO	>50						
4		End of Borehole Auger Refusal		4.10									W.L. in open hole at 1.3 m depth at time of drilling
5													
6													
7													
8													
9													
10													

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: PH

CHECKED: C.K.

MIS-BHS 001 1111210198-1000.GPJ GAL-MIS.GDT 01/27/12 JEM

PROJECT: 11-1121-0198-1000

RECORD OF BOREHOLE: 11-6

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: September 9, 2011

DATUM:

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl) (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE									
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL		0.00							
		Loose brown SILT, trace to some sand and clay		0.15							
1					1	50 DO	5				
		Loose grey brown SILT, trace to some gravel		1.14							
		Loose grey SILT, trace to some sand		1.74	2	50 DO	5				
2											
		Loose to very dense grey SILTY SAND, some gravel, trace clay, with cobbles and boulders (GLACIAL TILL)		2.29	3	50 DO	29				
3					4	50 DO	14				
4					5	50 DO	25				
					6	50 DO	9				
5					7	50 DO	>50				
		End of Borehole Auger Refusal		5.64							
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: PH

CHECKED: C.K.

MIS-BHS 001 1111210198-1000.GPJ GAL-MIS.GDT 01/27/12 JEM

PROJECT: 11-1121-0198-1000

RECORD OF BOREHOLE: 11-8

SHEET 1 OF 2

LOCATION: See Site Plan

BORING DATE: September 27 & 28, 2011

DATUM:

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE						SHEAR STRENGTH Cu, kPa: nat V. + Q - ●; rem V. ⊕ U - ○ (20 40 60 80)	WATER CONTENT PERCENT: Wp — W — Wl (20 40 60 80)		
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL		0.00							
		Grey brown SILT, trace gravel and sand		0.10	1	50 DO	10				
1					2	50 DO	24				Bentonite Seal
					3	50 DO					
2		Highly weathered grey DOLOMITIC LIMESTONE BEDROCK		1.88							
	Rotary Drill HQ Core	Fresh, fine grained, thinly bedded, grey DOLOMITIC LIMESTONE BEDROCK		2.13	C1	HQ RC	DD				Silica Sand
3											
4					C2	HQ RC	DD				19 mm Diam. PVC #10 Slot Screen
5											
					C3	HQ RC	DD				
6				6.00							W.L. in Screen at 3.5 m depth on September 28, 2011
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DK

CHECKED: C.K.

MIS-BHS 001 1111210198-1000.GPJ GAL-MIS.GDT 01/27/12 JEM

PROJECT: 11-1121-0198-1000

RECORD OF DRILLHOLE: 11-8

SHEET 2 OF 2

LOCATION: See Site Plan

DRILLING DATE: September 27 & 28, 2011

DATUM:

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55

DRILLING CONTRACTOR: Downing Drilling

FR/FX-FRACTURE F-FAULT SM-SMOOTH FL-FLEXURED BC-BROKEN CORE
CL-CLEAVAGE J-JOINT R-ROUGH UE-UNEVEN MB-MECH. BREAK
SH-SHEAR P-POLISHED ST-STEPPED W-WAVY B-BEDDING
VN-VEIN S-SLICKENSIDED PL-PLANAR C-CURVED

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY: TOTAL CORE %	RECOVERY: SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.3	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	HYDRAULIC CONDUCTIVITY K, cm/sec	DIAMETRAL POINT LOAD INDEX (MPa)	NOTES WATER LEVELS INSTRUMENTATION
		BEDROCK SURFACE															
2	Rotary Drill HQ Core	Highly weathered grey DOLOMITIC LIMESTONE BEDROCK		1.88													
		Fresh, fine grained, thinly bedded, grey DOLOMITIC LIMESTONE BEDROCK		2.13	C1												Bentonite Seal
3																	Silica Sand
4					C2												19 mm Diam. PVC #10 Slot Screen
5					C3												
6				6.00													W.L. in Screen at 3.5 m depth on September 28, 2011
7																	
8																	
9																	
10																	
11																	

MIS-RCK 001 1111210198-1000 ROCK.GPJ GAL-MISS.GDT 01/27/12 JEM

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DK

CHECKED: C.K.

PROJECT: 12-1121-0053

RECORD OF BOREHOLE: 16-1

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: June 30, 2016

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-8} 10^{-6} 10^{-4} 10^{-2}) / WATER CONTENT PERCENT (Wp, W, Wl) (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		93.63							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND; brown to dark brown; non-cohesive		0.00							
		(SM) sandy SILT; grey brown, contains clayey silt interbeds; non-cohesive; moist to wet, compact		0.15	1	SS	5				
1					2	SS	11				
2					3	SS	13				
					4	SS	4				
3				90.58							
		(SM) SILTY SAND, some gravel; grey, contains cobbles (GLACIAL TILL); non-cohesive, wet, compact		3.05	5	SS	11				
				90.02							
		End of Borehole Auger Refusal		3.61							
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: JD

CHECKED: KSL

MIS-BHS 001 1211210053.GPJ GAL-MIS.GDT 02/21/17 ZS

PROJECT: 12-1121-0053

RECORD OF BOREHOLE: 16-2

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: June 29, 2016

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-8} 10^{-6} 10^{-4} 10^{-2}) / WATER CONTENT PERCENT (Wp — W — Wl) (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		93.20							
0	Power Auger 200 mm Diam. (Hollow Stem)	(SM) sandy SILT; grey to brown, contains clayey silt interbeds; non-cohesive, moist to wet, loose to very loose		0.00	1	SS	3				
1					2	SS	7				
2					3	SS	2				
				90.92							
		(SM/ML) SILTY SAND to sandy SILT, trace gravel; grey, contains clayey silt interbeds; non-cohesive, wet, very loose to loose		2.28	4	SS	1				
3					5	SS	WH				
4					6	SS	WH				
5					7	SS	8				
				87.87							
		(SM) SILTY SAND, some gravel; grey (GLACIAL TILL); non-cohesive, wet, very dense		5.33	8	SS	>50				
6				87.10							
		Probable Dolostone Bedrock		6.10	9	SS	50				
				86.39							
7		End of Borehole Auger Refusal		6.81							
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: JD

CHECKED: KSL

MIS-BHS 001 1211210053.GPJ GAL-MIS.GDT 02/21/17 ZS

PROJECT: 12-1121-0053

RECORD OF BOREHOLE: 16-3

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: June 30, 2016

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-8} 10^{-6} 10^{-4} 10^{-2}) / WATER CONTENT PERCENT (Wp, W, Wl) (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		93.96							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND; brown to dark brown; non-cohesive		0.00 93.73							
		(SM) sandy SILT; grey brown, contains clayey silt interbeds; non-cohesive, moist to wet, compact to loose		0.23	1	SS	4				
1					2	SS	10				
2					3	SS	8				
					4	SS	5				
				91.06							
3		(SM) SILTY SAND, trace gravel; grey (GLACIAL TILL); non-cohesive, wet, loose		2.90	5	SS	4				
				90.15							
4		Probable Dolostone Bedrock		3.81	6	SS	53				
				89.46							
		End of Borehole Auger Refusal		4.50							
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: JD

CHECKED: KSL

MIS-BHS 001 1211210053.GPJ GAL-MIS.GDT 02/21/17 ZS

PROJECT: 12-1121-0053

RECORD OF BOREHOLE: 16-4

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: June 29, 2016

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-8} 10^{-6} 10^{-4} 10^{-2}) / WATER CONTENT PERCENT (Wp, W, Wl) (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		93.60							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND; brown to dark brown; non-cohesive		0.00							
		(SM) sandy SILT; grey to brown, contains clayey silt interbeds; non-cohesive, moist to wet, loose to very loose		0.10	1	SS	6				
1					2	SS	9				
2					3	SS	3				
					4	SS	2				
3					5	SS	2				
4				89.56							
		(SM/ML) SILTY SAND to sandy SILT, some gravel; grey (GLACIAL TILL); non-cohesive, wet, very loose		4.04	6	SS	3				
5					7	SS	1				
				88.27							
		(SM) SILTY SAND; some gravel; grey (GLACIAL TILL); non-cohesive, wet, dense to very dense		5.33	8	SS	43				
6					9	SS	>50				
				87.10							
		End of Borehole Auger Refusal		6.50							
7											
8											
9											
10											

DEPTH SCALE

1 : 50

LOGGED: JD

CHECKED: KSL

Golder Associates

MIS-BHS 001 1211210053.GPJ GAL-MIS.GDT 02/21/17 ZS

PROJECT: 12-1121-0053

RECORD OF BOREHOLE: 16-5

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: June 29, 2016

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-8} 10^{-6} 10^{-4} 10^{-2}) / WATER CONTENT PERCENT (Wp, W, Wl) (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		94.03							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND; brown to dark brown; non-cohesive		0.00							
		(SM) sandy SILT; grey brown, with clayey silt interbeds; non-cohesive, moist to wet, loose to compact		0.12	1	SS	8				
1					2	SS	18				
2					3	SS	11				
				91.59							
		(SM) SILTY SAND, some gravel; grey (GLACIAL TILL); non-cohesive, wet, compact to very dense		2.44	4	SS	>50				
3					5	SS	12				
4					6	SS	>50				
				89.61							
		End of Borehole Auger Refusal		4.42							
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: JD

CHECKED: KSL

MIS-BHS 001 1211210053.GPJ GAL-MIS.GDT 02/21/17 ZS

PROJECT: 12-1121-0053

RECORD OF BOREHOLE: 16-6

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: June 29, 2016

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-8} 10^{-6} 10^{-4} 10^{-2}) / WATER CONTENT PERCENT (Wp, W, Wl) (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		93.80							
0	Power Auger 200 mm Diam. (Hollow Stem)	(SM) sandy SILT; grey brown; non-cohesive, moist to wet, loose to compact		0.00	1		8				Bentonite Seal
1					2		12				
2					3		7				Cuttings
					4		7				
3					5		6				Bentonite Seal
				90.14							Silica Sand
		(SM) SILTY SAND, trace gravel; grey (GLACIAL TILL); non-cohesive, wet, loose		3.66	6		8				
4											
					7		7				32 mm Diam. PVC #10 Slot Screen
5				88.47							
		Probable Dolostone Bedrock		5.33	8		>50				Native Backfill
				87.93							
6		End of Borehole Auger Refusal		5.87							W.L. in Screen at 2.21 m depth on Aug. 18, 2016
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: JD

CHECKED: KSL

MIS-BHS 001 1211210053.GPJ GAL-MIS.GDT 02/21/17 ZS

PROJECT: 12-1121-0053

RECORD OF BOREHOLE: 16-7

SHEET 1 OF 2

LOCATION: See Site Plan

BORING DATE: August 10, 2016

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-8} 10^{-6} 10^{-4} 10^{-2}) / WATER CONTENT PERCENT (Wp, W, Wl) (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		94.10							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) sandy SILT; brown; non-cohesive		0.00							
		(ML) sandy SILT, trace clay; brown; non-cohesive, moist, loose to compact		0.08	1	SS	6				
1					2	SS	12				
				92.58							
		(ML) SILT, some sand; grey, contains cobbles and clayey silt interbeds; cohesive, moist to wet, compact		1.52	3	SS	10				Bentonite and Cuttings
2				91.81							
		(SM) SILTY SAND, some gravel; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet, compact to dense		2.29	4	SS	35				
3					5	SS	11				
											Silica Sand
4					6	SS	14				
				89.53							32 mm Diam. PVC #10 Slot Screen
	Wash Boring NQ Core	(SP/GP) SAND and GRAVEL, some non-plastic fines; contains cobbles and boulders (GLACIAL TILL); wet, compact		4.57	7	SS	24				
5											Silica Sand
				88.72	8	SS	>50				
		Borehole continued on RECORD OF DRILLHOLE 16-7		5.38							
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: KM

CHECKED: KSL

MIS-BHS 001 1211210053.GPJ GAL-MIS.GDT 02/21/17 ZS

PROJECT: 12-1121-0053

RECORD OF DRILLHOLE: 16-7

SHEET 2 OF 2

LOCATION: See Site Plan

DRILLING DATE: August 10, 2016

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55

DRILLING CONTRACTOR: Downing Drilling

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

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

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	COLOUR % RETURN / FLUSH	RECOVERY: TOTAL CORE %	RECOVERY: SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.25 m	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jcon	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -Q' AVG.	
		BEDROCK SURFACE		88.72																
6	Rotary Drill, NQ Core	Slightly weathered to fresh, medium to thinly bedded, grey, fine grained, crystalline, non-porous DOLOSTONE, with thin shale interbeds		5.38	1	10														
7					2	5														Bentonite Seal
8					3	5														
				85.82																
		End of Drillhole		8.28																W.L. in Screen at 2.30 m depth on Aug. 18, 2016
9																				
10																				
11																				
12																				
13																				
14																				
15																				

DEPTH SCALE

1 : 50

LOGGED: KM

CHECKED: KSL

Golder Associates

MIS-RCK 004 1211210053.GPJ GAL-MISS.GDT 02/21/17 ZS

PROJECT: 12-1121-0053

RECORD OF BOREHOLE: 16-8

SHEET 1 OF 2

LOCATION: See Site Plan

BORING DATE: August 10, 2016

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-8} 10^{-6} 10^{-4} 10^{-2}) WATER CONTENT PERCENT Wp W Wl (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		93.70							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) sandy SILT; brown; non-cohesive		0.00							
		(SM) SILTY SAND; light brown to brown; non-cohesive, dry, loose		0.08	1	SS	6				
				92.94							
1		(ML) sandy SILT, fine; grey brown to grey, contains oxidation staining; non-cohesive, moist, loose		0.76	2	SS	7				
					3	SS	9				
2				91.62							
		(ML) sandy SILT; grey, contains cobbles; non-cohesive, moist, loose		2.08	4	SS	7				Bentonite and Cuttings
3				90.65							
		(SM) SILTY SAND, some gravel; grey, contains cobbles, boulders, and sand seams (GLACIAL TILL); non-cohesive, moist to wet, loost to compact		3.05	5	SS	9				
4					6	SS	23				
				89.31							
		Borehole continued on RECORD OF DRILLHOLE 16-8		4.39							
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: KM

CHECKED: KSL

MIS-BHS 001 1211210053.GPJ GAL-MIS.GDT 02/21/17 ZS

PROJECT: 12-1121-0053

RECORD OF DRILLHOLE: 16-8

SHEET 2 OF 2

LOCATION: See Site Plan

DRILLING DATE: August 10, 2016

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55

DRILLING CONTRACTOR: Downing Drilling

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

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	COLOUR % RETURN / FLUSH	RECOVERY: TOTAL CORE %	RECOVERY: SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.25 m	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jcon	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -Q' AVG.	
		BEDROCK SURFACE		89.31																
5	Rotary Drill NQ Core	Slightly weathered to fresh, medium to thinly bedded, grey, fine grained, crystalline, non-porous DOLOSTONE, with thin shale interbeds		4.39	1	5														Bentonite and Cuttings
6					2	5														Silica Sand
7					3	5														32 mm Diam. PVC #10 Slot Screen
				86.08																
		End of Drillhole		7.62																W.L. in Screen at 2.30 m depth on Aug. 18, 2016
8																				
9																				
10																				
11																				
12																				
13																				
14																				

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: KM
CHECKED: KSL

MIS-RCK 004 1211210053.GPJ GAL-MISS.GDT 02/21/17 ZS

TABLE 1

RECORD OF TEST PITS

Test Pit Number Elevation (Metres)	Depth (metres)	Description
TP 16-1	0.00 – 0.25	TOPSOIL – (ML) Sandy SILT; dark brown; non-cohesive
(93.49 metres)	0.25 – 0.70	(ML) Sandy SILT, some sand, trace gravel; brown grey; non-cohesive, moist
	0.70 – 1.20	(ML) SILT, some sand to sandy; grey brown; non-cohesive, moist
	1.20 – 3.10	(ML) SILT to CLAYEY SILT, trace sand; brown; non-cohesive, moist to wet
	3.10 – 4.70	(SM) SILTY SAND, some gravel; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet
	4.70	END OF TEST PIT – Refusal to excavation
		Note: Water seepage at 2.2 metres
		Side walls caving in at 3.1 metres depth

Sample	Depth (m)
1	0.25 – 0.70
2	0.70 – 1.20
3	1.20 – 3.10
4	3.10 – 4.10

TABLE 1

RECORD OF TEST PITS

Test Pit Number Elevation (Metres)	Depth (metres)	Description
TP 16-2	0.00 – 0.21	TOPSOIL – (ML) Sandy SILT; dark brown; non-cohesive
(93.36 metres)	0.21 – 0.61	(SM) SILTY SAND; brown; non-cohesive, moist
	0.61 – 1.00	(SM) SILTY SAND; non-cohesive, wet
	1.00 – 1.40	(ML) SILTY CLAY; grey brown; cohesive, w>PL
	1.40 – 3.70	(ML) SILT, some sand; grey brown; non-cohesive, moist to wet
	3.70 – 5.80	(ML) Sandy SILT, some gravel; grey brown to grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet
	5.80	End of Test Pit – Side walls of test pit sloughing
		Note: Water seepage at 2.0 metres depth

Sample	Depth (m)	Lab Testing
1	0.21 – 0.61	
2	0.61 – 1.00	
3	1.00 – 1.40	w_n=40%, w_L=43%, w_P=20%
4	1.40 – 3.70	
5	3.70 – 5.80	

TABLE 1

RECORD OF TEST PITS

Test Pit Number Elevation (Metres)	Depth (metres)	Description
TP 16-3	0.00 – 0.30	TOPSOIL – (ML) sandy SILT; dark brown; non-cohesive
(93.78 metres)	0.30 – 0.95	(ML) Sandy SILT; brown; non-cohesive, moist
	0.95 – 1.30	(ML) Sandy SILT; grey brown; non-cohesive, moist
	1.30 – 2.60	(ML) CLAYEY SILT; grey; cohesive, w>PL
	2.60 – 3.90	(ML) sandy SILT, some gravel; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet
	3.90	END OF TEST PIT – Refusal to excavation
		Note: Water seepage at 2.6 metres depth

Sample	Depth (m)
1	0.30 – 0.95
2	0.95 – 1.30
3	1.30 – 2.60
4	2.60 – 3.90

TP 16-4	0.00 – 0.22	TOPSOIL – (ML) Sandy SILT; dark brown; non-cohesive, moist
(93.74 metres)	0.22 – 0.80	(ML) SILT, some sand to sandy, trace gravel; brown grey; non-cohesive, moist
	0.80 – 3.10	(ML) SILT trace sand; grey; non-cohesive, moist
	3.10 – 4.40	(ML) Sandy SILT, some gravel; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet
	4.40	END OF TEST PIT – Refusal to excavation
		Note: Water seepage at 2.3 metres

Sample	Depth (m)	Lab Testing
1	0.22 – 0.80	
2	0.80 – 1.70	
3	1.70 – 3.10	Gr (0) Sa (2) Si/Cl (98)
4	3.10 – 4.40	

TABLE 1

RECORD OF TEST PITS

Test Pit Number Elevation (Metres)	Depth (metres)	Description
TP 16-5	0.00 – 0.18	TOPSOIL – (ML) sandy SILT; dark brown; non-cohesive
(93.44 metres)	0.18 – 0.85	(ML) SILT, some sand to sandy; grey brown; non-cohesive, moist
	0.85 – 1.30	(ML) SILT, some sand; grey brown; non-cohesive, moist
	1.30 – 3.10	(ML) SILT to CLAYEY SILT, some sand; grey; non-cohesive, moist to wet
	3.10 – 6.00	(ML) sandy SILT, some gravel; grey (GLACIAL TILL); non-cohesive, wet
	6.00	END OF TEST PIT
		Note: Water seepage at 2.7 metres

Sample	Depth (m)
1	0.18 – 0.85
2	0.85 – 1.30
3	1.30 – 3.10
4	3.10 – 4.30

TABLE 1

RECORD OF TEST PITS

Test Pit Number Elevation (Metres)	Depth (metres)	Description
TP 16-6 (93.95 metres)	0.00 – 0.26	TOPSOIL – (ML) Sandy SILT, some gravel; dark brown; non-cohesive
	0.26 – 0.60	(SM/ML) SILTY SAND to sandy SILT; brown, contains rootlets; non-cohesive, moist
	0.60 – 1.00	(SM) SILTY SAND, some gravel; grey brown, contains cobbles; non-cohesive, moist
	1.00 – 2.90	(ML) SILT to CLAYEY SILT, some sand; grey brown; non-cohesive, w>PL
	2.90 – 3.40	(ML) SILT, some sand to sandy; grey; non-cohesive, moist to wet
	3.40 – 6.00	(ML) Sandy SILT, some gravel; grey, contains cobbles and boulders up to 750 millimetres in diameter (GLACIAL TILL), non-cohesive, wet
	6.00	END OF TEST PIT
		Note: Water seepage at 3.1 metres Side walls sloughing at 3.9 metres depth

Sample	Depth
1	0.26 – 0.60
2	0.60 – 1.00
3	1.00 – 1.50
4	1.50 – 2.90
5	2.90 – 3.40
6	3.40 – 6.00

TABLE 1

RECORD OF TEST PITS

Test Pit Number Elevation (Metres)	Depth (metres)	Description
TP 16-7	0.00 – 0.17	TOPSOIL – (ML) Sandy SILT; brown; non-cohesive
(93.35 metres)	0.17 – 1.30	(ML) SILT, some sand, trace gravel; brown; non-cohesive, moist
	1.30 – 2.40	(ML) Sandy SILT; grey; non-cohesive, moist
	2.40 – 4.30	(ML) SILT, some sand to sandy; grey; non-cohesive, moist
	4.30 – 6.00	(ML) Sandy SILT, some gravel; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist
	6.00	END OF TEST PIT
		Note: Water seepage at 4.4 metres.

Sample	Depth
1	0.17 – 0.70
2	0.70 – 1.30
3	1.30 – 2.40
4	2.40 – 4.30
5	4.30 – 6.00

TABLE 1

RECORD OF TEST PITS

Test Pit Number Elevation (Metres)	Depth (metres)	Description
TP 16-8	0.00 – 0.27	TOPSOIL – (ML) Sandy SILT; dark brown; non-cohesive
(93.98 metres)	0.27 – 1.20	(ML) SILT, some sand, trace gravel; brown, contains rootlets; non-cohesive, moist
	1.20 – 2.10	(ML) SILT, some sand to sandy; grey-brown; non-cohesive, moist
	2.10 – 2.80	(ML) SILT to CLAYEY SILT, trace sand; grey; non-cohesive, moist
	2.80 – 6.00	(SM) SILTY SAND, some gravel; grey, contains cobbles and boulders up to 870 millimetres in diameter (GLACIAL TILL); non-cohesive
	6.00	END OF TEST PIT

Note: Water seepage at 3.3 metres

Side walls sloughing at 3.5 metres depth

Sample	Depth	Lab Testing
1	0.20 – 0.75	
2	0.75 – 1.20	
3	1.20 – 2.10	
4	2.10 – 2.80	Gr (0) Sa (4) Si/Cl (96)
5	2.80 – 6.00	

TABLE 1

RECORD OF TEST PITS

Test Pit Number / Elevation (Metres)	Depth (metres)	Description
TP 16-9	0.00 – 0.20	TOPSOIL – (ML) Sandy SILT; dark brown; non-cohesive
(93.54 metres)	0.20 – 0.70	(SM) SILTY SAND; brown, contains rootlets; non-cohesive, moist
	0.70 – 1.50	(ML) Sandy SILT; grey brown, contains cobbles; non-cohesive, moist
	1.50 – 3.60	(ML) SILT, trace sand; grey; non-cohesive, moist to wet
	3.60 – 6.00	(ML) Sandy SILT, some gravel to gravelly; grey, contains cobbles and boulders up to 780 millimetres in diameter (GLACIAL TILL); non-cohesive, wet
	6.00	END OF TEST PIT
		Note: Water seepage at 2.7 metres Side walls sloughing at 4.8 metres depth

Sample	Depth (m)	Lab Testing
1	0.20 – 0.70	
2	0.70 – 1.50	
3	1.50 – 3.60	Gr (0) Sa (3) Si/Cl (97) w_n=20%
4	3.60 – 6.00	

TABLE 1

RECORD OF TEST PITS

Test Pit Number Elevation (Metres)	Depth (metres)	Description
TP 16-10	0.00 – 0.23	TOPSOIL – (ML) Sandy SILT; dark brown; non-cohesive
(94.14 metres)	0.23 – 0.37	(ML) Sandy SILT; red brown; non-cohesive, moist
	0.37 – 1.45	(ML) CLAYEY SILT to sandy SILT; brown grey; non-cohesive, moist
	1.45 – 3.40	(ML) Sandy SILT; grey; non-cohesive, moist
	3.40 – 6.00	(SM) SILTY SAND, some gravel; grey, contains cobbles and boulders up to 510 millimetres in diameter (GLACIAL TILL); non-cohesive, moist to wet
	6.00	END OF TEST PIT
		Note: Water seepage at 4.0 metres Walls caving at 6.0 metres depth

Sample	Depth (m)
1	0.23 – 0.37
2	0.37 – 1.45
3	1.45 – 3.40
4	3.40 – 4.90
5	4.90 – 6.00

TABLE 1

RECORD OF TEST PITS

Test Pit Number Elevation (Metres)	Depth (metres)	Description
TP 16-11	0.00 – 0.21	TOPSOIL – (ML) Sandy SILT; brown; non-cohesive
(93.77 metres)	0.21 – 0.38	(SM) SILTY SAND; brown, contains rootlets; non-cohesive, moist
	0.38 – 2.30	(ML) SILT to CLAYEY SILT, some sand; grey brown; non-cohesive, moist to wet
	2.30 – 4.40	(ML) SILT, trace sand; grey; non-cohesive, wet
	4.40 – 6.00	(SM) SILTY SAND, some gravel to gravelly; grey, contains cobbles and boulders up to 530 millimetres in diameter (GLACIAL TILL); non-cohesive, wet
	6.00	END OF TEST PIT –
		Note: Water seepage at 2.0 meters depth Side walls sloughing

Sample	Depth (m)	Lab Testing
1	0.21 – 3.80	
2	3.80 – 2.30	
3	2.30 – 4.40	Gr (0) Sa (2) Si/Cl (98)
4	4.40 – 6.00	

TABLE 1

RECORD OF TEST PITS

Test Pit Number Elevation (Metres)	Depth (metres)	Description
TP 16-12	0.00 – 0.23	TOPSOIL – (ML) sandy SILT; dark brown; non-cohesive
(94.17 metres)	0.23 – 1.80	(ML) Sandy SILT, trace gravel; brown; non-cohesive, moist
	1.80 – 2.40	(ML) SILT to CLAYEY SILT; grey; non-cohesive, moist
	2.40 – 4.60	(ML/SM) Sandy SILT to SILTY SAND, some gravel; grey, contains cobbles and boulders up to 710 millimetres in diameter (GLACIAL TILL); non-cohesive
	4.60	END OF TEST PIT – Refusal to excavation
		Note: Test pit dry upon completion of excavating

Sample	Depth
1	0.23 – 0.70
2	0.70 – 1.80
3	1.80 – 2.40
4	2.40 – 4.60

TP 16-13	0.00 – 0.18	TOPSOIL – (ML) Sandy SILT; brown; non-cohesive
(94.10 metres)	0.18 – 1.40	(ML) SILT, some sand; brown, contains rootlets; non-cohesive, moist
	1.40 – 2.40	(ML) SILT some sand to sandy; grey; non-cohesive, moist
	2.40 – 6.10	(SM) SILTY SAND, some gravel; grey, contains cobbles and boulders up to 780 millimetres in diameter (GLACIAL TILL); non-cohesive, moist to wet
	6.10	END OF TEST PIT – side walls sloughing at 5.0 metres
		Note: Water seepage at 4.9 metres.
		Side walls sloughing at 5.0 metres depth

Sample	Depth (m)
1	0.18 – 1.40
2	1.40 – 2.40
3	2.40 – 6.10

TABLE 1

RECORD OF TEST PITS

Test Pit Number Elevation (Metres)	Depth (metres)	Description
TP 16-14	0.00 – 0.21	TOPSOIL – (ML) Sandy SILT; brown; non-cohesive
(93.66 metres)	0.21 – 2.10	(ML) SILT; grey brown; non-cohesive, moist
	2.10 – 3.50	(ML) SILT, trace sand; grey; non-cohesive, wet
	3.50 – 6.00	(SM) SILTY SAND, some gravel; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet
	6.00	END OF TEST PIT
		Note: Water seepage at 1.6 metres Side walls sloughing at 4.6 metres depth

Sample	Depth (m)	Lab Testing
1	0.21 – 2.10	
2	2.10 – 3.50	Gr (0) Sa (7) Si/Cl (93)
3	3.50 – 6.00	

TP 16-15	0.00 – 0.19	TOPSOIL – (ML) Sandy SILT; brown; non-cohesive
(94.19 metres)	0.19 – 2.10	(SM/ML) SILTY SAND to sandy SILT; brown; non-cohesive, moist
	2.10 – 3.00	(ML) SILT, some sand to sandy; grey brown; non-cohesive, moist
	3.00 – 5.60	(ML) SILTY SAND, some gravel; grey; contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet
	5.60 – 6.00	(SM) SILTY SAND, trace gravel; grey; non-cohesive, wet
	6.00	END OF TEST PIT
		Note: Water seepage at 2.4 metres Side walls sloughing

Sample	Depth
1	0.19 – 2.10
2	2.10 – 3.00
3	3.00 – 5.60
4	5.60 – 6.00

HVORSLEV SLUG TEST ANALYSIS
FALLING HEAD TEST 16-6

INTERVAL (metres below ground surface)

Top of Interval =	**3.66**
Bottom of Interval =	**5.49**

$$K = \frac{r_c^2}{2L_e} \ln\left[\frac{L_e}{2R_e} + \sqrt{1 + \left(\frac{L_e}{2R_e}\right)^2}\right] \left[\frac{\ln\left(\frac{h_1}{h_2}\right)}{(t_2 - t_1)}\right]$$ where K = (m/sec)

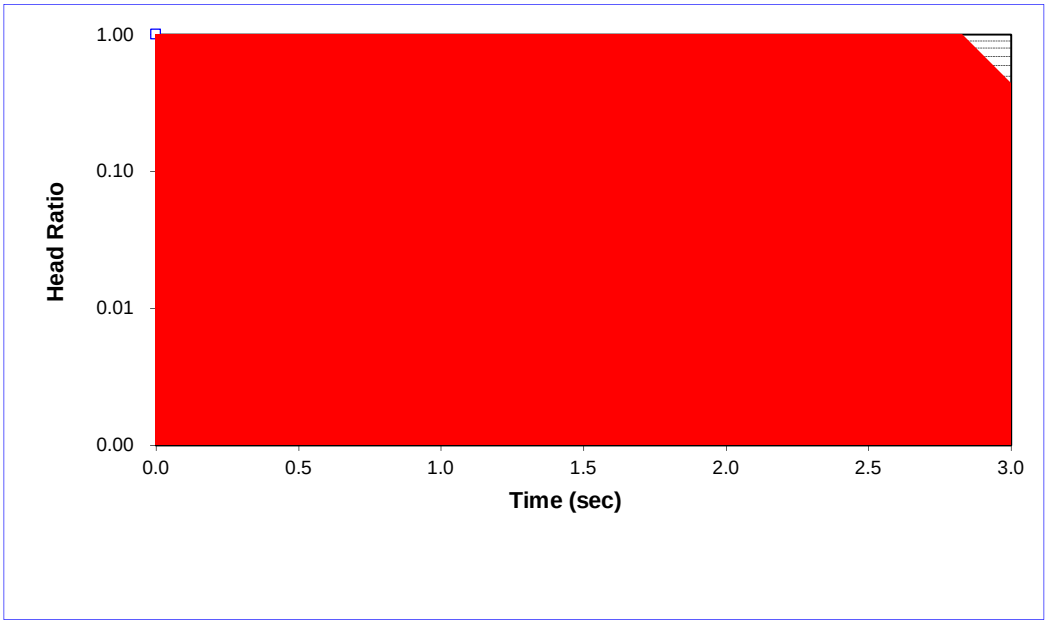
where:

r_c = casing radius (metres)
R_e = filter pack radius (metres)
L_e = length of screened interval (metres)
t = time (seconds)
h_t = head at time t (metres)

INPUT PARAMETERS	
r_c =	1.6E-02
R_e =	1.0E-01
L_e =	1.8
t_1 =	0
t_2 =	2
h_1/h_0 =	1.00
h_2/h_0 =	0.06

RESULTS

K=	**3E-04**	**m/sec**
K=	**3E-02**	**cm/sec**



Project Name: IBI/Leitrim SWMP
Project No.: 12-1121-0053
Test Date: 8/18/2016

Analysis By: CWT
Checked By: JPAO
Analysis Date: 8/19/2016

Golder Associates Ltd.

HVORSLEV SLUG TEST ANALYSIS
FALLING HEAD TEST 16-7

INTERVAL (metres below ground surface)

Top of Interval =	**3.35**
Bottom of Interval =	**5.18**

$$K = \frac{r_c^2}{2L_e} \ln\left[\frac{L_e}{2R_e} + \sqrt{1 + \left(\frac{L_e}{2R_e}\right)^2}\right] \left[\frac{\ln\left(\frac{h_1}{h_2}\right)}{(t_2 - t_1)}\right]$$ where K = (m/sec)

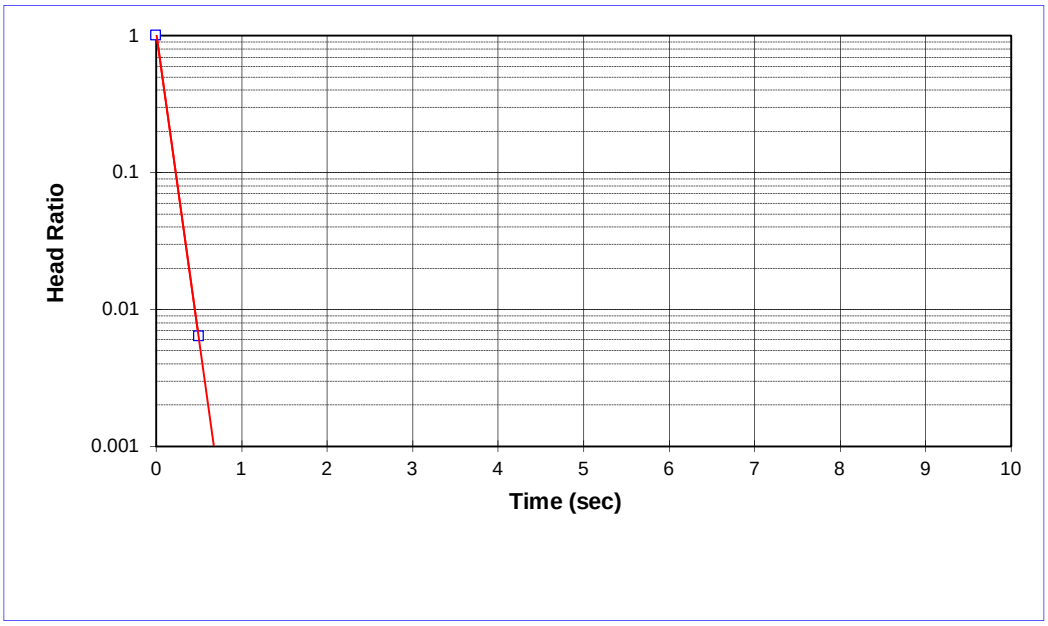
where:
- r_c = casing radius (metres)
- R_e = filter pack radius (metres)
- L_e = length of screened interval (metres)
- t = time (seconds)
- h_t = head at time t (metres)

INPUT PARAMETERS

r_c =	1.6E-02
R_e =	1.0E-01
L_e =	1.8
t_1 =	0
t_2 =	0.5
h_1/h_0 =	1.05
h_2/h_0 =	0.01

RESULTS

K=	**2E-03**	**m/sec**
K=	**2E-01**	**cm/sec**



Project Name: IBI/Leitrim SWMP
Project No.: 12-1121-0053
Test Date: 8/18/2016

Analysis By: CWT
Checked By: JPAO
Analysis Date: 8/19/2016

Golder Associates Ltd.

HVORSLEV SLUG TEST ANALYSIS
RISING HEAD TEST 16-8

INTERVAL (metres below ground surface)

Top of Interval =	**5.74**
Bottom of Interval =	**7.62**

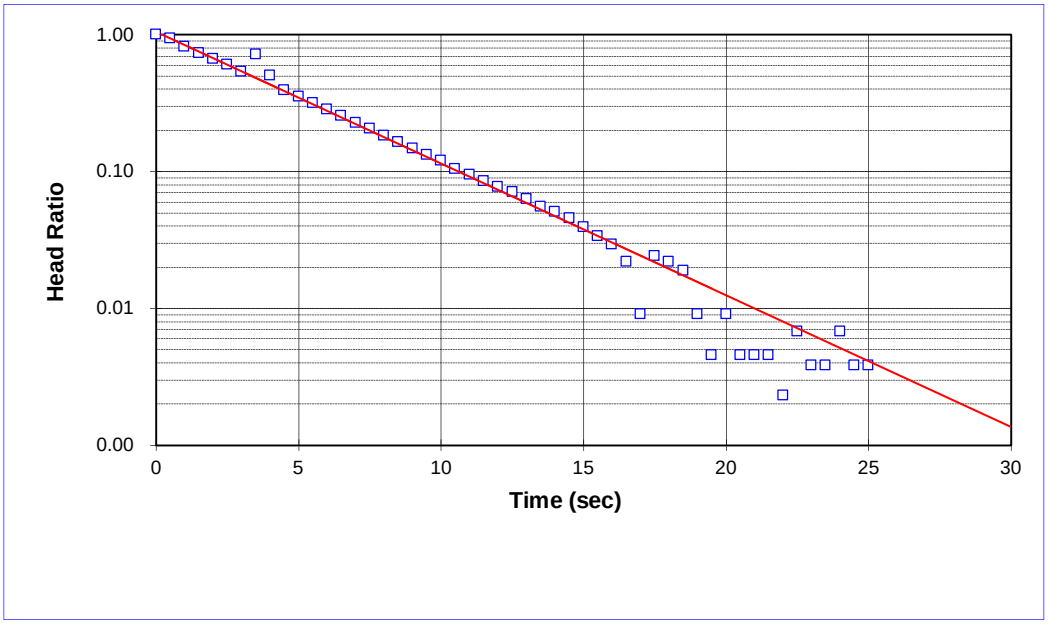
$$K = \frac{r_c^2}{2L_e} \ln\left[\frac{L_e}{2R_e} + \sqrt{1 + \left(\frac{L_e}{2R_e}\right)^2}\right] \left[\frac{\ln\left(\frac{h_1}{h_2}\right)}{(t_2 - t_1)}\right]$$ where K = (m/sec)

where:
- r_c = casing radius (metres)
- R_e = filter pack radius (metres)
- L_e = length of screened interval (metres)
- t = time (seconds)
- h_t = head at time t (metres)

INPUT PARAMETERS	
r_c =	1.6E-02
R_e =	3.8E-02
L_e =	1.9
t_1 =	0.5
t_2 =	19.5
h_1/h_0 =	0.94
h_2/h_0 =	0.01

RESULTS

K=	**6E-05**	**m/sec**
K=	**6E-03**	**cm/sec**



Project Name: IBI/Leitrim SWMP
Project No.: 12-1121-0053
Test Date: 8/18/2016

Analysis By: CWT
Checked By: JPAO
Analysis Date: 8/19/2016

Golder Associates Ltd.

PROJECT: 1774599

RECORD OF BOREHOLE: 17-01

SHEET 1 OF 2

LOCATION: N 5020094.6 ;E 374165.9

BORING DATE: April 25, 2017

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ●, rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp — W — Wl) (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		94.14							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL		0.00							
		(ML) sandy SILT; grey brown to grey, contains clay seams; non-cohesive, wet, compact		0.15	1	GRAB	-				
1					2	SS	25				
				92.31	3	SS	35				
2		(ML-SM) sandy SILT to gravelly SILTY SAND; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet, compact to very dense		1.83							
					4	SS	71			MH	
3					5	SS	>50				
	Rotary Drill NW Casing				6	NQ RC	DD				
4					7	SS	16				
5	Rotary Drill NQ Core				8	NQ RC	DD				
				88.78							
		Borehole continued on RECORD OF DRILLHOLE 17-01		5.36							
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

LOGGED: PAH

CHECKED: WAM

Golder Associates

MIS-BHS 001 1774599.GPJ GAL-MIS.GDT 2/2/18 JEM

PROJECT: 1774599

RECORD OF DRILLHOLE: 17-01

SHEET 2 OF 2

LOCATION: N 5020094.6 ;E 374165.9

DRILLING DATE: April 25, 2017

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.	FLUSH	COLOUR % RETURN	RECOVERY: TOTAL CORE %	RECOVERY: SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.25 m	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jcon	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -Q' AVG.
		BEDROCK SURFACE		88.78																
6	Rotary Drill / NQ Core	Fresh, medium to thinly bedded, grey, fine grained, non-porous DOLOSTONE with thin shale interbeds		5.36 / 87.97	1															
		End of Drillhole		6.17																
7																				
8																				
9																				
10																				
11																				
12																				
13																				
14																				
15																				

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

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

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

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

BR - Broken Rock

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

DEPTH SCALE

1 : 50

LOGGED: PAH

CHECKED: WAM

Golder Associates

MIS-RCK 004 1774599.GPJ GAL-MISS.GDT 2/2/18 JEM

PROJECT: 1774599

RECORD OF BOREHOLE: 17-02

SHEET 1 OF 1

LOCATION: N 5019993.3 ;E 374282.6

BORING DATE: April 25, 2017

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp — W — Wl; 20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		94.21							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL		0.00 / 94.01							
		(SM) SILTY SAND; yellow brown to grey brown; non-cohesive, wet, compact		0.20	1	GRAB	-				
1					2	SS	17				
		(SP) SAND, some non-plastic fines; grey; non-cohesive, wet, dense		92.84 / 1.37							
2					3	SS	35		○		
		(SM/ML) SILTY SAND to sandy SILT; grey, contains fine sand and clay seams; non-cohesive, wet, dense to compact		92.08 / 2.13	4	SS	46				
3					5	SS	25		○		
		(SM) gravelly SILTY SAND; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet, compact to very dense		90.70 / 3.51	6	SS	59				
4											
					7	SS	27		○		
5											
					8	SS	45				
6											
					9	SS	10				
		End of Borehole Auger Refusal		87.96 / 6.25							
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: PAH

CHECKED: WAM

MIS-BHS 001 1774599.GPJ GAL-MIS.GDT 2/2/18 JEM

PROJECT: 1774599

RECORD OF BOREHOLE: 17-03

SHEET 1 OF 1

LOCATION: N 5020064.9 ;E 374395.5

BORING DATE: April 25, 2017

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp — W — Wl)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		93.57							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL		0.00 / 93.37							
		(SM) SILTY SAND; grey brown, contains boulders; non-cohesive, wet, compact		0.20	1	GRAB	-				
1					2	SS	20				
				92.20							
		(ML, CL & SM) layered SILT, CLAYEY SILT, and SILTY SAND; grey; non-cohesive, wet, very loose to compact		1.37							
2					3	SS	2				
					4	SS	2			MH	
3					5	SS	2				
4					6	SS	17				
				89.15							
		(ML) sandy SILT, some gravel; grey (GLACIAL TILL); non-cohesive, wet, loose to very dense		4.42							
5					7	SS	4				
					8	SS	>50				
				88.01							
		End of Borehole Auger Refusal		5.56							
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

LOGGED: PAH

CHECKED: WAM

Golder Associates

MIS-BHS 001 1774599.GPJ GAL-MIS.GDT 2/2/18 JEM

PROJECT: 1774599

RECORD OF BOREHOLE: 17-04

SHEET 1 OF 1

LOCATION: N 5020717.6 ;E 373941.1

BORING DATE: May 4, 2017

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp — W — Wl) (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		96.32							
0	Power Auger 200 mm Diam. (Hollow Stem)	ASPHALTIC CONCRETE		0.00							
		FILL - (SP) gravelly SAND, angular; grey (PAVEMENT STRUCTURE)		0.10 96.04							
		FILL - (GP) sandy GRAVEL, angular; grey (PAVEMENT STRUCTURE)		0.28 95.66							
		FILL - (SM) gravelly SILTY SAND; brown to dark brown; non-cohesive, moist		0.66 95.46							
1		TOPSOIL (ML) sandy CLAYEY SILT; black; cohesive, w>PL		0.86 1.02	1	SS	13				
		(SM/ML) SILTY SAND to sandy SILT, trace gravel; grey brown, contains silty clay layers; non-cohesive, moist to wet, compact			2	SS	18				
2					3	SS	15				
3					4	SS	12				
				92.66							
		(ML) sandy SILT; grey, contains silty clay layers; non-cohesive, wet, very loose		3.66	5	SS	4				
4				91.90							
		End of Borehole		4.42							
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: RI

CHECKED: WAM

MIS-BHS 001 1774599.GPJ GAL-MIS.GDT 2/2/18 JEM

PROJECT: 1774599

RECORD OF BOREHOLE: 17-05

SHEET 1 OF 1

LOCATION: N 5020818.2 ;E 374110.5

BORING DATE: May 4, 2017

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) WATER CONTENT PERCENT Wp W Wl (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		95.96							
0	Power Auger 200 mm Diam. (Hollow Stem)	ASPHALTIC CONCRETE		0.00 95.71							Flush Mount Casing
		FILL - (SM) gravelly SILTY SAND; brown to dark brown (PAVEMENT STRUCTURE)		0.25 95.17							Cuttings
1		FILL - (SM/ML) SILTY SAND to sandy SILT, trace gravel; grey, contains organic matter; non-cohesive, moist, compact		0.79 94.89	1	SS	11				Bentonite Seal
		TOPSOIL - (ML) sandy SILT; black; non-cohesive, moist		1.07 1.20							
2		(SM/ML) SILTY SAND to sandy SILT, trace gravel; grey brown, contains silty clay layers; non-cohesive, moist to wet, compact		93.83	2	SS	14				Silica Sand
		(SM) gravelly SILTY SAND; grey brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist to wet, compact to very dense		2.13	3	SS	12				32 mm Diam. PVC #10 Slot Screen
3					4	SS	>50				
		End of Borehole Auger Refusal		92.61 3.35							WL in Screen at Elev. 94.19 m on June 9, 2017
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: RI

CHECKED: WAM

MIS-BHS 001 1774599.GPJ GAL-MIS.GDT 2/2/18 JEM

PROJECT: 1774599

RECORD OF BOREHOLE: 17-06

SHEET 1 OF 1

LOCATION: N 5020920.5 ;E 374282.2

BORING DATE: May 8, 2017

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl) (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		95.86							
0	Power Auger 200 mm Diam. (Hollow Stem)	ASPHALTIC CONCRETE		0.00 / 95.61							
		FILL - (SP) gravelly SAND; grey (PAVEMENT STRUCTURE)		0.25 / 95.25	1	GRAB	-			M	
1		FILL - (SP) gravelly SAND; grey brown; non-cohesive, moist, compact to loose		0.61 / 94.34	2	SS	10				
2		(ML) CLAYEY SILT, some sand; grey brown; cohesive, w>PL, stiff		1.52 / 93.57	3	SS	5				
		(ML) SILT, some sand to sandy; grey brown; non-cohesive, wet, loose		2.29 / 93.12	4	SS	8				
3		(SM) gravelly SILTY SAND; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist, dense to very dense		2.74 / 92.15	5	SS	36				
					6	SS	>50				
		End of Borehole Auger Refusal		3.71							
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: SN

CHECKED: WAM

MIS-BHS 001 1774599.GPJ GAL-MIS.GDT 2/2/18 JEM

PROJECT: 1774599

RECORD OF BOREHOLE: 17-07

SHEET 1 OF 1

LOCATION: N 5021023.8 ;E 374455.8

BORING DATE: May 8, 2017

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp, W, Wl) (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		97.64									
0	Power Auger 200 mm Diam. (Hollow Stem)	ASPHALTIC CONCRETE		0.00 / 97.39									
		FILL - (SP/GP) sandy GRAVEL to gravelly SAND; grey brown (PAVEMENT STRUCTURE)		0.25 / 96.88	1	GRAB	-						
1		FILL - (SM) SILTY SAND, some gravel; grey brown, contains cobbles and boulders; non-cohesive, moist, very dense		0.76 / 96.42	2	SS	>50						
		End of Borehole Auger Refusal		1.22									
2													
3													
4													
5													
6													
7													
8													
9													
10													

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: SN

CHECKED: WAM

MIS-BHS 001 1774599.GPJ GAL-MIS.GDT 2/2/18 JEM

PROJECT: 1774599

RECORD OF BOREHOLE: 17-08

SHEET 1 OF 1

LOCATION: N 5021128.4 ;E 374632.6

BORING DATE: May 8, 2017

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		97.84					
0	Power Auger 200 mm Diam. (Hollow Stem)	ASPHALTIC CONCRETE		0.00 97.61					Flush Mount Casing
		FILL - (GP) sandy GRAVEL; brown (PAVEMENT STRUCTURE)		0.23 97.08	1	GRAB	-		Cuttings
1		FILL - (ML) gravelly sandy SILT; grey brown; non-cohesive, moist to wet, compact		0.76 96.32	2	SS	30	MH	Bentonite Seal Silica Sand
2		(SP) SAND, some gravel; brown; non-cohesive, moist to wet, compact		1.52 95.55	3	SS	18		
		(SM) gravelly SILTY SAND; brown grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist to wet, dense		2.29	4	SS	37		32 mm Diam. PVC #10 Slot Screen
3				94.74	5	SS	>50		
		End of Borehole Auger Refusal		3.10					WL in Screen at Elev. 96.10 m on June 9, 2017
4									
5									
6									
7									
8									
9									
10									

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

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

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

WATER CONTENT PERCENT: Wp — W — Wl (20 40 60 80)

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: SN

CHECKED: WAM

MIS-BHS 001 1774599.GPJ GAL-MIS.GDT 2/2/18 JEM

PROJECT: 1774599

RECORD OF BOREHOLE: 17-09

SHEET 1 OF 1

LOCATION: N 5021231.4 ;E 374806.7

BORING DATE: May 9, 2017

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl) (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		97.58							
0	Power Auger 200 mm Diam. (Hollow Stem)	ASPHALTIC CONCRETE		0.00 / 97.35							
		FILL - (SP/GP) gravelly SAND to sandy GRAVEL; grey brown (PAVEMENT STRUCTURE)		0.23 / 96.82	1	GRAB	-				
1		FILL - (SP) gravelly SAND; grey brown (PAVEMENT STRUCTURE); non-cohesive, moist, dense		0.76 / 96.06	2	SS	38				
		(ML) SANDY SILT, some gravel; grey (GLACIAL TILL); non-cohesive, moist, compact		1.52 / 95.14	3	SS	13				
2		(ML) SILT, some sand and gravel; grey (GLACIAL TILL); non-cohesive, wet, loose		2.44 / 94.53	4	SS	8				
3		(SW) gravelly SILTY SAND; grey (GLACIAL TILL); non-cohesive, wet, compact to very dense		3.05	5	SS	20				
					6	SS	>50				
4		End of Borehole Auger Refusal		4.10							
5											
6											
7											
8											
9											
10											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: SN

CHECKED: WAM

MIS-BHS 001 1774599.GPJ GAL-MIS.GDT 2/2/18 JEM

TABLE 1

RECORD OF TEST PITS

Test Pit Number (Elevation)	Depth (metres)	Description
17-101 (95.58 metres)	0.00 – 0.40	TOPSOIL – (CL) SILTY CLAY, trace to some sand, some gravel; dark brown; cohesive, w>PL
	0.40 – 0.65	(ML) sandy CLAYEY SILT, trace gravel; grey brown; cohesive, w>PL
	0.65 – 2.10	(SM) gravelly SILTY SAND; grey brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist to wet
	2.10 – 2.55	(ML) gravelly sandy SILT; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet
	2.55	END OF TEST PIT – Refusal on BEDROCK

Notes: Water seepage at 0.9 metres depth upon completion.

Sample	Depth (m)
1	0.15 – 0.40
2	0.40 – 0.65
3	0.85 – 1.00
4	2.20 – 2.40

17-102 (95.50 metres)	0.00 – 0.15	TOPSOIL – (CL/ML) SILTY CLAY to CLAYEY SILT, trace to some sand, trace gravel; black; cohesive, w>PL
	0.15 – 0.85	(CI/CH) sandy SILTY CLAY, trace to some gravel; grey brown, contains cobbles and boulders; cohesive, w>PL
	0.85 – 2.15	(SM) gravelly SILTY SAND; grey brown to grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist to wet
	2.15	END OF TEST PIT – Refusal on BEDROCK

Notes: Water seepage at 0.8 metres depth upon completion.

Sample	Depth (m)
1	0.00 – 0.15
2	0.40 – 0.60
3	0.85 – 1.15
4	1.90 – 2.15

TABLE 1

RECORD OF TEST PITS

Test Pit Number (Elevation)	Depth (metres)	Description
17-103 (95.52 metres)	0.00 – 0.25	TOPSOIL – (CL) SILTY CLAY, trace gravel, trace to some sand; dark brown, contains cobbles; cohesive, w>PL
	0.25 – 0.55	(CI/CH) sandy SILTY CLAY, trace to some gravel; grey brown, contains cobbles and boulders; cohesive, w>PL
	0.55 – 2.40	(SM) gravelly SILTY SAND; grey brown to grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist to wet
	2.40	END OF TEST PIT – Refusal on BEDROCK

Notes: Water seepage at 0.8 metres depth upon completion.

Sample	Depth (m)	Lab Testing
1	0.15 – 0.25	
2	0.40 – 0.50	W_n = 18%
3	0.70 – 0.85	W_n = 9%
4	2.00 – 2.40	W_n = 8%

17-104 (97.17 metres)	0.00 – 0.15	TOPSOIL – (CL) SILTY CLAY, trace to some sand and gravel; dark brown; cohesive, w>PL
	0.15 – 0.28	(ML) sandy CLAYEY SILT, trace to some gravel; brown to grey brown, contains cobbles; cohesive, w>PL
	0.28 – 0.65	(ML) gravelly sandy SILT; grey brown, contains cobbles and boulders (GLACIAL TILL); cohesive, w>PL
	0.65 – 3.10	(SM) gravelly SILTY SAND; grey brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist to wet
	3.10	END OF TEST PIT – Refusal on BEDROCK

Notes: Water seepage at 1.8 metres depth upon completion.

Sample	Depth (m)
1	0.00 – 0.15
2	0.15 – 0.28
3	0.40 – 0.55
4	0.75 – 0.90
5	3.00 – 3.10

TABLE 1

RECORD OF TEST PITS

Test Pit Number (Elevation)	Depth (metres)	Description
17-105 (94.75 metres)	0.00 – 0.20	TOPSOIL – (CL) SILTY CLAY, trace to some sand, trace gravel; dark brown; cohesive, w>PL
	0.20 – 0.62	(CL/CI) sandy SILTY CLAY, trace gravel; grey brown (WEATHERED CRUST); cohesive, w>PL
	0.62 – 0.90	(ML) sandy SILT, trace gravel; grey brown, contains cobbles and boulders; non-cohesive, moist to wet
	0.90 – 1.70	(SM) gravelly SILTY SAND; grey brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist
	1.70 – 3.50	(SM) gravelly SILTY SAND; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet
	3.50	END OF TEST PIT – Refusal on BEDROCK

Notes: Water seepage at 0.8 metres depth upon completion.

Sample	Depth (m)
1	0.00 – 0.20
2	0.40 – 0.55
3	0.62 – 0.90
4	0.90 – 1.00
5	1.90 – 2.10

17-106 (95.41 metres)	0.00 – 0.20	TOPSOIL – (CL) SILTY CLAY, trace to some sand; black; cohesive, w>PL
	0.20 – 1.40	(ML) sandy CLAYEY SILT, trace to some gravel; grey brown, contains cobbles and boulders; cohesive, w>PL
	1.40 – 2.40	(SL) gravelly SILTY SAND; grey brown to grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist to wet
	2.40	END OF TEST PIT – Refusal on BEDROCK

Notes: Water seepage at 0.8 metres depth upon completion.

Sample	Depth (m)	Lab Testing
1	0.00 – 0.20	
2	0.40 – 0.50	
3	0.60 – 0.80	W_n = 33% MH – See Figure 4
4	1.70 – 1.80	
5	1.80 – 1.90	W_n = 14%

TABLE 1

RECORD OF TEST PITS

Test Pit Number (Elevation)	Depth (metres)	Description
17-107 (94.93 metres)	0.00 – 0.25	TOPSOIL – (CL) SILTY CLAY, trace to some sand; black to dark brown; cohesive, w>PL
	0.25 – 0.85	(CL/CI) sandy SILTY CLAY, trace gravel; grey brown, contains cobbles and boulders; cohesive, w>PL
	0.85 – 1.70	(SM) gravelly SILTY SAND; grey brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist to wet
	1.70 – 2.40	(SM) gravelly SILTY SAND; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet
	2.40	END OF TEST PIT – Refusal on BEDROCK

Notes: Water seepage at 1.0 metres depth upon completion.

Sample	Depth (m)
1	0.00 – 0.25
2	0.55 – 0.65
3	1.00 – 1.15
4	2.00 – 2.40

TABLE 1

RECORD OF TEST PITS

Test Pit Number (Elevation)	Depth (metres)	Description
17-108 (95.14 metres)	0.00 – 0.23	TOPSOIL – (CL) SILTY CLAY, trace gravel, trace to some sand; dark brown; cohesive, w>PL
	0.23 – 0.85	(CI/CH) sandy SILTY CLAY; grey brown, contains cobbles and boulders; cohesive, w>PL
	0.85 – 1.00	(SM) gravelly SILTY SAND; brown, contains cobbles and boulders; non-cohesive, wet
	1.00 – 1.25	(CI/CH) SILTY CLAY to CLAY, trace to some sand; grey brown, contains cobbles and boulders; cohesive, w>PL
	1.25 – 2.65	(SM) gravelly SILTY SAND; grey brown to grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist to wet
	2.65	END OF TEST PIT – Refusal on BEDROCK

Notes: Water seepage at 1.0 metres depth upon completion.

Sample	Depth (m)
1	0.00 – 0.23
2	0.30 – 0.45
3	0.55 – 0.80
4	0.85 – 1.00
5	1.00 – 1.10
6	1.30 – 1.60
7	1.75 – 2.00

TABLE 1

RECORD OF TEST PITS

Test Pit Number (Elevation)	Depth (metres)	Description
17-109 (94.03 metres)	0.00 – 0.18	TOPSOIL – (CL) SILTY CLAY, trace to some sand; dark brown; cohesive, w>PL
	0.18 – 1.20	(CI/CH) SILTY CLAY to CLAY, some sand to sandy; grey brown (WEATHERED CRUST); cohesive, w>PL
	1.20 – 1.30	(SM) gravelly SILTY SAND; brown, contains cobbles and boulders; non-cohesive, wet
	1.30 – 4.50	(CL/ML/SM) interbedded SILTY CLAY, SILT, and SILTY SAND; grey with brown layers, contains cobbles and boulders; non-cohesive, wet
	4.50	END OF TEST PIT – Refusal on BEDROCK

Notes: Water seepage at 0.9 metres depth upon completion.

Sample	Depth (m)	Lab Testing
1	0.00 – 0.18	
2	0.30 – 0.50	
3	0.85 – 1.00	
4	1.20 – 1.30	
5	1.50 – 1.60	W_n = 30% MH – See Figure 6
6	3.00 – 3.20	W_n = 43%

TABLE 1

RECORD OF TEST PITS

Test Pit Number (Elevation)	Depth (metres)	Description
17-110 (94.30 metres)	0.00 – 0.20	TOPSOIL – (CL) SILTY CLAY, trace to some sand, trace gravel; dark brown; cohesive, w>PL
	0.20 – 1.75	(CL/CI) sandy SILTY CLAY, trace gravel; grey brown, contains silty sand layers; cohesive, w>PL
	1.75 – 4.00	(SM) gravelly SILTY SAND; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet
	4.00	END OF TEST PIT – Refusal on BEDROCK

Notes: Water seepage at 0.8 metres depth upon completion.

Sample	Depth (m)
1	0.00 – 0.20
2	0.45 – 0.55
3	0.95 – 1.10
4	1.75 – 2.00
5	3.50 – 3.75

TABLE 1

RECORD OF TEST PITS

Test Pit Number (Elevation)	Depth (metres)	Description
17-111 (94.81 metres)	0.00 – 0.23	TOPSOIL – (CL) SILTY CLAY, trace to some sand, trace gravel; dark brown; cohesive, w>PL
	0.23 – 0.48	(CL/CI) sandy SILTY CLAY; grey brown, contains cobbles and boulders; cohesive, w>PL
	0.48 – 1.30	(ML) sandy CLAYEY SILT, some gravel; grey brown, contains cobbles, boulders, and silty sand layers (GLACIAL TILL); non-cohesive, moist to wet
	1.30 – 1.40	(SM) gravelly SILTY SAND; grey brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist
	1.40 – 3.80	(SM) gravelly SILTY SAND; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist to wet
	3.80 – 4.30	(ML) gravelly sandy SILT; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet
	4.30	END OF TEST PIT – Refusal on BEDROCK

Notes: Water seepage at 0.6 metres depth upon completion.

Sample	Depth (m)	Lab Testing
1	0.00 – 0.23	
2	0.25 – 0.35	W_n = 28%
3	0.45 – 0.75	W_n = 22% MH – See Figure 7
4	1.30 – 1.90	W_n = 12%
5	2.00 – 2.20	
6	4.20 – 4.30	

TABLE 1

RECORD OF TEST PITS

Test Pit Number (Elevation)	Depth (metres)	Description
17-112 (94.68 metres)	0.00 – 0.25	TOPSOIL – (CL) SILTY CLAY, some sand, trace gravel; dark brown; cohesive, w>PL
	0.25 – 1.60	(CI/CH) sandy SILTY CLAY to CLAY; grey brown, contains silty sand layers (WEATHERED CRUST); cohesive, w>PL
	1.60 – 1.70	(SM) gravelly SILTY SAND; brown, contains shells and sand layers; non-cohesive, wet
	1.70 – 2.20	(ML) CLAYEY SILT, some sand and gravel; grey brown, contains cobbles and boulders (GLACIAL TILL); cohesive, moist to wet
	2.20 – 3.60	(SM) gravelly SILTY SAND; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist to wet
	3.60	END OF TEST PIT – Refusal on BEDROCK

Notes: Water seepage at 1.1 metres depth upon completion.

Sample	Depth (m)
1	0.00 – 0.25
2	0.45 – 0.65
3	0.95 – 1.05
4	1.60 – 1.70
5	1.70 – 1.80
6	2.30 – 2.40

TABLE 1

RECORD OF TEST PITS

Test Pit Number (Elevation)	Depth (metres)	Description
17-113 (93.62 metres)	0.00 – 0.40	TOPSOIL – (CL) SILTY CLAY, trace to some sand; dark brown; cohesive, w>PL
	0.40 – 1.45	(CI/CH) SILTY CLAY to CLAY, some sand; grey brown, contains silty sand layers (WEATHERED CRUST); cohesive, w>PL
	1.45 – 1.50	(SM) gravelly SILTY SAND; dark brown; non-cohesive, wet
	1.50 – 3.30	(ML/CL/SM) interbedded SILTY CLAY, SILT, and SILTY SAND; grey with brown layering, contains cobbles and boulders; non-cohesive, wet
	3.30 – 4.70	(SM/ML) gravelly SILTY SAND to sandy SILT; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet
	4.70	END OF TEST PIT – Refusal on BEDROCK

Notes: Water seepage at 1.0 metres depth upon completion.

Sample	Depth (m)	Lab Testing
1	0.25 – 0.40	
2	0.45 – 0.55	W_n = 25%
3	1.55 – 1.30	
4	2.30 – 2.50	W_n = 27% MH – See Figure 6
5	4.50 – 4.70	

TABLE 1

RECORD OF TEST PITS

Test Pit Number (Elevation)	Depth (metres)	Description
17-114 (94.04 metres)	0.00 – 0.23	TOPSOIL – (CL) SILTY CLAY, trace to some sand; dark brown; cohesive, w>PL
	0.23 – 1.80	(CI/CH) SILTY CLAY to CLAY, some sand; grey brown, contains silty sand seams (WEATHERED CRUST); cohesive, w>PL
	1.80 – 2.00	(SP) gravelly SAND; black, contains cobbles; non-cohesive, wet
	2.00 – 4.00	(CI/CH-ML) SILTY CLAY to CLAYEY SILT, some sand; grey, contains cobbles and boulders; cohesive, w>PL
	4.00 – 4.65	(SM) gravelly SILTY SAND; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet
	4.65	END OF TEST PIT – Refusal on BEDROCK

Notes: Water seepage at 0.8 metres depth upon completion.

Sample	Depth (m)
1	0.00 – 0.23
2	1.10 – 1.30
3	1.80 – 2.00
4	2.00 – 2.20
5	4.50 – 4.65

TABLE 1

RECORD OF TEST PITS

Test Pit Number (Elevation)	Depth (metres)	Description
17-115 (94.27 metres)	0.00 – 0.20	TOPSOIL – (CL) SILTY CLAY, trace sand; dark brown; cohesive, w>PL
	0.20 – 1.60	(CI/CH) SILTY CLAY to CLAY, some sand; grey brown, contains silty sand seams (WEATHERED CRUST); cohesive, w>PL
	1.60 – 1.80	(SM) gravelly SILTY SAND; grey, contains shells, cobbles and boulders; non-cohesive, wet
	1.80 – 2.00	(CI/CH-ML) SILTY CLAY to CLAYEY SILT, trace sand; grey, contains cobbles and boulders; cohesive, w>PL
	2.00 – 4.55	(SM) gravelly SILTY SAND; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet
	4.55	END OF TEST PIT – Refusal on BEDROCK

Notes: Water seepage at 0.9 metres depth upon completion.

Sample	Depth (m)	Lab Testing
1	0.00 – 0.20	
2	0.35 – 0.45	W_n = 29%
3	0.75 – 0.90	
4	1.60 – 1.80	W_n = 22% MH – See Figure 5
5	1.80 – 2.00	W_n = 22%
6	2.00 – 2.20	
7	4.50 – 4.55	

TABLE 1

RECORD OF TEST PITS

Test Pit Number (Elevation)	Depth (metres)	Description
17-116 (93.76 metres)	0.00 – 0.30	FILL – (CI/CH) sandy SILTY CLAY, trace gravel; grey brown; contains rootlets; cohesive, w>PL
	0.30 – 0.40	TOPSOIL – (CL) sandy SILTY CLAY; black; cohesive, w>PL
	0.40 – 1.25	(CI/CH) SILTY CLAY to CLAY, some sand; grey brown, contains silty sand seams (WEATHERED CRUST); cohesive, w>PL
	1.25 – 1.50	(SM) SILTY SAND; dark brown, contains cobbles and boulders; non-cohesive, wet
	1.50 – 4.90	(CL/ML/SM) interbedded SILTY CLAY, SILT, and SILTY SAND; grey brown, contains cobbles and boulders; non-cohesive, wet to moist
	4.90 – 5.20	(SM) gravelly SILTY SAND; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet
	5.20	END OF TEST PIT – Refusal on BEDROCK

Notes: Water seepage at 1.0 metres depth upon completion.

Sample	Depth (m)	Lab Testing
1	0.00 – 0.30	
2	0.30 – 0.40	
3	0.90 – 1.10	W_n = 42%
4	1.25 – 1.35	
5	1.60 – 1.80	W_n = 23% MH – See Figure 6
6	2.70 – 3.30	W_n = 30%
7	4.90 – 5.20	W_n = 10%

TABLE 1

RECORD OF TEST PITS

Test Pit Number (Elevation)	Depth (metres)	Description
17-117 (93.57 metres)	0.00 – 0.40	FILL – (SM) gravelly SILTY SAND; dark brown; contains cobbles; non-cohesive, moist
	0.40 – 0.50	TOPSOIL – (CL) sandy SILTY CLAY; dark brown to black; cohesive, w>PL
	0.50 – 1.30	(CI/CH) SILTY CLAY to CLAY, some sand; grey brown, contains silty sand seams (WEATHERED CRUST); cohesive, w>PL
	1.30 – 1.40	(SM) SILTY SAND, some gravel to gravelly; dark brown, contains cobbles; non-cohesive, wet
	1.40 – 4.00	(CL/ML/SM) interbedded SILTY CLAY, SILT, and SILTY SAND; grey brown, contains cobbles and boulders; non-cohesive, wet
	4.00 – 4.90	(SM) gravelly SILTY SAND; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet
	4.90	END OF TEST PIT – Refusal on BEDROCK

Notes: Water seepage at 1.3 metres depth upon completion.

Sample	Depth (m)
1	0.00 – 0.40
2	0.40 – 0.50
3	0.90 – 1.00
4	1.30 – 1.40
5	1.40 – 1.60
6	2.10 – 2.30
7	3.10 – 3.30
8	4.10 – 4.20

HVORSLEV SLUG TEST ANALYSIS
FALLING HEAD TEST 17-5

INTERVAL (metres below ground surface)

Top of Interval =	**1.83**
Bottom of Interval =	**3.35**

$$K = \frac{r_c^2}{2L_e} \ln\left[\frac{L_e}{2R_e} + \sqrt{1 + \left(\frac{L_e}{2R_e}\right)^2}\right] \left[\frac{\ln\left(\frac{h_1}{h_2}\right)}{(t_2 - t_1)}\right]$$ where K = (m/sec)

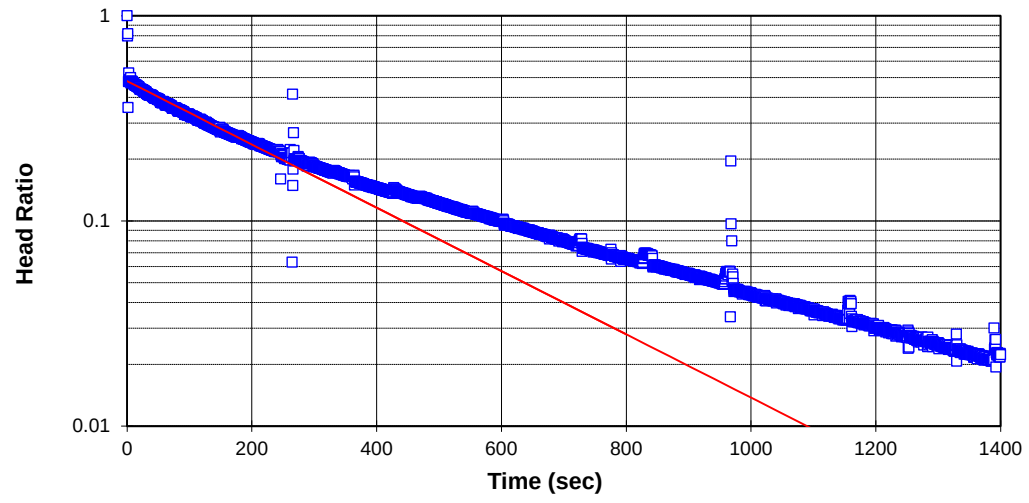
where:

r_c = casing radius (metres)
R_e = filter pack radius (metres)
L_e = length of screened interval (metres)
t = time (seconds)
h_t = head at time t (metres)

INPUT PARAMETERS	
r_c =	**0.02**
R_e =	**0.10**
L_e =	**1.5**
t_1 =	**0**
t_2 =	**800**
h_1/h_0 =	**0.48**
h_2/h_0 =	**0.03**

RESULTS

K=	**8E-07**	**m/sec**
K=	**8E-05**	**cm/sec**



Project Name: IBI Barrett Lands
Project No.: 1774599
Test Date: 6/9/2017

Analysis By: DH
Checked By: SRW
Analysis Date: 6/23/2017

Golder Associates Ltd.

BOUWER AND RICE SLUG TEST ANALYSIS
RISING HEAD TEST 17-8

INTERVAL (metres below ground surface)

Top of Interval =	**1.58**
Bottom of Interval =	**3.10**

$$K = \frac{r_c^2 \ln\left(\frac{R_e}{r_w}\right)}{2L_e} \frac{1}{t} \ln\frac{y_0}{y_t}$$

where K=m/sec

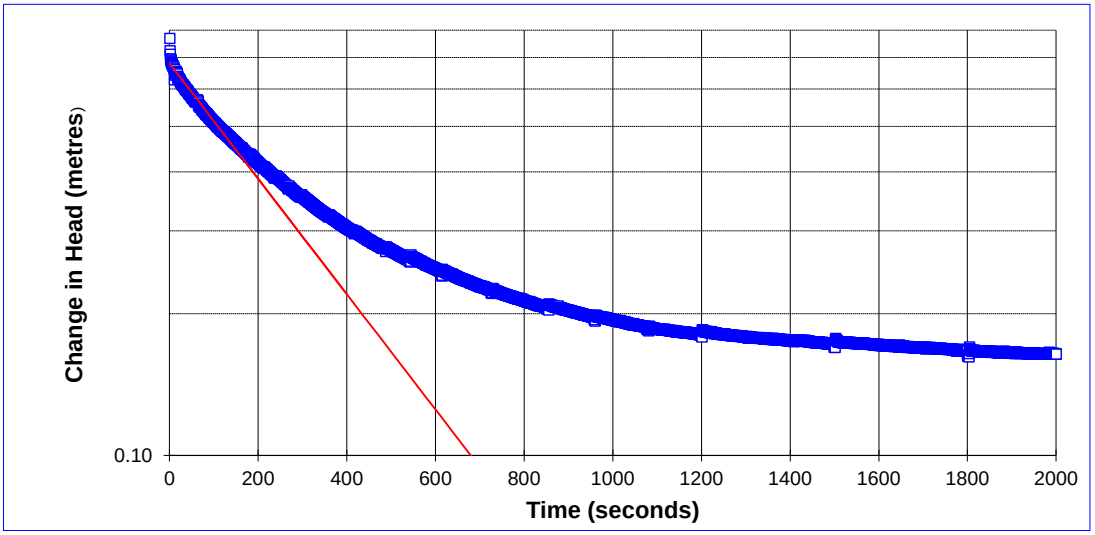
where:

r_c = casing radius (metres);
R_e = effective radius (metres);
L_e = length of screened interval (metres);
r_w = radial distance to undisturbed aquifer (metres)
y_0 = initial drawdown (metres)
y_t = drawdown (metres) at time t (seconds)

INPUT PARAMETERS	
r_c =	**0.06**
r_w =	**0.10**
L_e =	**1.48**
$\ln(R_e/r_w)$	**1.66**
y_0 =	**0.68**
y_t =	**0.22**
t =	**400.0**

RESULTS

K=	**5E-06**	**m/sec**
K=	**5E-04**	**cm/sec**



Project Name: IBI Barrett Lands
Project No.: 1774599
Test Date: 06/09/17

Analysis By: DH
Checked By: SRW
Analysis Date: 6/23/2017