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REPORT ON

Geotechnical Investigation Proposed Residential Development Burnett Lands Greenbank Road at the Jock River Ottawa, Ontario

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REPORT

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1.0 INTRODUCTION

This report presents the results of a geotechnical investigation carried out for the proposed residential development site to be located west of Greenbank Road, adjacent to the Jock River, in Ottawa, Ontario.

The purpose of this geotechnical investigation was to determine the general soil and groundwater conditions across this site by means of seven boreholes. Based on an interpretation of the factual information obtained during this current investigation, along with the existing data available for the area from the previous investigations, engineering guidelines are provided on the geotechnical design aspects of the project, including construction considerations which could affect design decisions.

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

2.0 DESCRIPTION OF PROJECT AND SITE

Consideration is being given to developing a residential subdivision on a site located west of Greenbank Road, adjacent to the Jock River, 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:

- The site is located immediately west of Greenbank Road, approximately 400 metres south of the intersection with Jockvale Road. The southwest boundary of the site is adjacent to the Jock River and consists of a low-lying flood plain.
- The site is trapezoid-shaped and measures approximately 500 metres by up to 400 metres long.
- The site topography is relatively flat with a gentle downward slope from east to west. A shallow ditch (Burnett Municipal Drain) running north-south crosses the middle of the site.
- The majority of the site is currently undeveloped and predominately consists of agricultural land with localized vegetation and trees.
- It is understood that the proposed development will include conventional residential dwellings (semi-detached and townhouse) as well as access roads and services within the subdivision.
- Greenbank Road will be shifted to the west and will cross the eastern portion of the site.

Golder Associates completed a preliminary geotechnical investigation at this site in 2011, as part of the “due diligence” process associated with Claridge Homes acquiring this property. That investigation included a limited number of very widely spaced testholes.

Golder Associates also previously completed several geotechnical investigations within or in the vicinity of the site, including a preliminary investigation for a residential development to be located immediately north of this property and for the proposed South Nepean Collector sewer, which is proposed to cross the site.

Based on a review of those previous studies and published geological mapping, the subsurface conditions on northern and western portions of the site are expected to consist of a thick deposit of clay, but the clay is expected to thin towards the central and southern portions of the site where glacial till is expected at shallow depths.

Published geological mapping indicates that the depth to the bedrock surface on this site should be in the order of 5 to 15 metres.

3.0 PROCEDURE

The fieldwork for this investigation was carried out on February 18 through February 23, 2016. At that time, the following boreholes were put down at the approximate locations shown on the Site Plan, Figure 1.

- Seven boreholes (numbered BH16-101 to 16-107) were put down across the site.
- Two additional boreholes (numbered 16-102A and 16-104A) were put down adjacent to boreholes 16-102 and 16-104 to retrieve a Shelby tube sample of the “softer” silty clay.
- One additional borehole (numbered 16-107A) was put down adjacent to borehole 16-107 due to shallow refusal to augering.

All of the boreholes were advanced to depths ranging from about 1.7 (practical refusal to augering) to 8.2 metres below the existing ground surface. The boreholes were advanced using a track-mounted continuous flight hollow-stem auger drill rig, supplied and operated by CCC Geotechnical and Environmental Drilling Ltd. of Ottawa, Ontario.

Standard Penetration Tests (SPTs) were carried out in the boreholes at regular intervals of depth and samples of the soils encountered were recovered using split spoon sampling equipment. In situ vane testing was carried out, where possible, in the cohesive deposits to determine the undrained shear strength of these soils. Four relatively undisturbed 73 millimetre diameter thin walled Shelby tube samples of the silty clay were obtained from boreholes 16-102, 16-102A, 16-104, and 16-104A using a fixed piston sampler.

Groundwater monitoring wells were installed into boreholes 16-101 and 16-103 to allow for subsequent measurement of the groundwater level across the site. The groundwater levels in these monitoring wells were measured on March 7, 2016.

The fieldwork was supervised by an experienced technician from our staff who located the boreholes, directed the drilling operations and in situ testing, logged the boreholes and samples, and took custody of the soil samples retrieved.

Upon completion of the drilling operations, samples of the soils encountered in the boreholes were transported to our laboratory for further examination by the project engineer and for laboratory testing. The laboratory testing included natural water content determinations, Atterberg limit testing, grain size distribution testing, and oedometer consolidation testing.

Two samples of soil, one each from boreholes 16-105 and 16-107, were submitted to EXOVA Environmental Ontario for basic chemical analysis related to potential sulphate attack on buried concrete element and corrosion of buried ferrous elements.

The borehole locations were selected, picketed, and surveyed in the field by Golder Associates personnel. The borehole locations and elevations were surveyed using a Trimble R8 Global Positioning System (GPS) unit. The elevations are referenced to Geodetic datum.

4.0 SUBSURFACE CONDITIONS

4.1 General

The subsurface conditions encountered in the boreholes put down for the current investigation are shown on the Record of Borehole Sheets in Appendix A. The results of the laboratory water content and Atterberg limit testing are provided on the Record of Borehole Sheets. The oedometer consolidation test results are provided on Figure 2. The results of grain size distribution testing on selected sample of soil are provided on Figure 3.

The subsurface conditions encountered in the relevant boreholes put down on this site for the previous investigations are provided on the Record of Borehole Sheets in Appendix B.

The results of the basic chemical analyses carried out on two soil samples, one each from boreholes 16-105 and 16-107, are provided in Appendix C.

Based on the results of the current and previous investigations, the site has been divided into two assessment areas (see Site Plan, Figure 2), and the subsurface conditions within each area generally consist of:

- Area A (western and northern portions of the site): A thick deposit of silty clay which extends to depths of up to more than 8.2 metres below the existing ground surface.
- Area B (central and eastern portions of the site): Very stiff to stiff layer of silty clay overlying glacial till, or glacial till near the ground surface.

The following sections present a more detailed overview of the subsurface conditions for each assessment area.

4.2 Area A

Area A includes the northern and western portions of the site. Boreholes 16-101, 16-102/16-102A and 16-104/16-104A for the current investigation and boreholes 11-1/11-1A, 11-2/11-2A, 11-5, 11-6, and 15-9/15-9A from the previous investigation were put down within this area.

Topsoil

Topsoil exists at the ground surface at all of the borehole locations. The topsoil varies from about 150 to 300 millimetres in thickness.

Sensitive Silty Clay

The topsoil is underlain by a deposit of silty clay.

The upper 1.3 to 3.1 metres of the silty clay deposit have been weathered to a grey brown crust. SPT “N” values within the weathered crust ranged from 1 to 7 blows per 0.3 metres of penetration. In situ vane testing measured undrained shear strengths of about 59 to greater than 96 kilopascals. The results of this in situ testing indicate the crust to have a stiff to very stiff consistency.

The measured water contents of the weathered deposit were about 32 to 56 percent.

The silty clay below the depth of weathering is grey in colour. The silty clay deposit in boreholes 16-102, 11-2, 11-5, and 15-9/15-9A was fully penetrated and extends to depths ranging from about 3.1 to 4.3 metres below the existing ground surface. The unweathered grey silty clay in the remaining boreholes was not fully penetrated but was proven to depths of about 3.4 to 8.2 metres below the ground surface prior to the boreholes being terminated.

The undrained shear strength within the unweathered deposit is typically in the range of 30 to 50 kilopascals, which indicates a firm consistency.

The sensitivity of the silty clay was measured to predominantly vary between about 5 and 14, indicating this clay to be sensitive to extra-sensitive in accordance with the Canadian Foundation Engineering Manual (CFEM).

The results of Atterberg limit testing carried out on three samples of the grey silty clay indicate plasticity index values between 30 and 50 percent and liquid limit values between 51 and 75 percent, which indicates a high plasticity soil. The measured water content of the samples from the unweathered soils ranged from about 48 to 86 percent, except one sample at the bottom of borehole 16-104, which measured water content of 24 percent. This silty clay sample contains a trace to some sand and gravel and is likely near surface of the glacial till.

Oedometer consolidation testing was carried out on two Shelby tube samples of the grey silty clay. The results of this testing are provided on Figure 2 and on Figure 3 in Appendix B, as well as summarized below.

Borehole/ Sample No.	**Sample Depth (m)**	**Unit Wt. (kN/m^3)**	**σ_P' (kPa)**	**σ_{VO}' (kPa)**	**C_c**	**C_r**	**e_o**	**OCR**
11-1A / 1	3.4	16.2	225	74	0.95	0.018	1.46	4.8
16-104A / 1	5.0	14.9	110	50	3.07	0.003	2.44	2.2

Notes:

σ_P' - Apparent preconsolidation pressure

C_c - Compression index

e_o - Initial void ratio

σ_{VO}' - Computed existing vertical effective stress

C_r - Recompression index

OCR - Overconsolidation ratio

Glacial Till

Glacial till was encountered beneath the silty clay deposit at boreholes 16-102, 11-2, 11-5 and 15-9 at depths of about 3.1 to 4.3 metres below the ground surface. The glacial till consists of a heterogeneous mixture of gravel, cobbles, and boulders in a matrix of silty sand to sandy silt. The glacial till was proven to depths of about 5.2 to 7.6 metres below the ground surface.

SPT "N" values of 1 to greater than 50 blows per 0.3 metres of penetration were measured in the glacial till, indicating a very loose to very dense state of packing. However the higher "N" values likely reflect the presence of cobbles and/or boulders within the glacial till, rather than actual state of packing of the soil matrix.

A layer of sandy soil was encountered below the glacial till in boreholes 11-2 and 15-9A. The sandy layer was proven to be at least about 0.3 and 1.7 metres thick, extending to depths of at least 5.5 and 9.1 metres below the ground surface respectively.

Groundwater

The groundwater levels in the monitoring well or piezometers sealed in the current and previous boreholes were measured at various times. The observed groundwater levels are summarized in the table below:

Borehole Number	Geological Unit	Ground Surface Elevation (m)	Groundwater Depth (m)	Groundwater Level (m)	Date of Measurement
16-101	Silty Clay	91.82	1.09	90.73	Mar 7, 2016
11-1A	Silty Clay	-	1.23	-	Feb 7, 2011
11-2A	Silty Clay	-	0.95	-	Feb 7, 2011

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.

4.3 Area B

Area B includes the central and eastern parts of the site. Boreholes 16-103, 16-105, 16-106, 16-107/16-107A from the current investigation and boreholes 11-3 and 11-4 from the previous investigation were put down within this part of the site. In addition, boreholes 15-7, 15-8, 15-17/15-17A, 15-103, 16-301, and 16-302 from the South Nepean Collector investigation were advanced on this portion of the site.

Fill and Topsoil

About 2.0 metres of fill exists at borehole 15-17. The fill consists of sandy silt and clayey silt, with varying amounts of gravel and organic matter.

SPT “N” values of 7 to 15 blows per 0.3 metres of penetration were measured within the fill, indicating a loose to compact state of packing.

Topsoil exists at the ground surface or below the fill. The topsoil varies from about 150 to 370 millimetres in thickness at the borehole locations.

Silty Clay

At most of the borehole locations, the fill and topsoil are underlain by a deposit of silty clay. Where encountered, the entire silty clay deposit has been weathered to a grey brown crust and extends to depths of about 0.6 to 2.5 metres below the existing ground surface.

SPT “N” values within the weathered silty clay ranged from 2 to 10 blows per 0.3 metres of penetration. The results of one in situ vane test measured an undrained shear strength of about 59 kilopascals. The results of the in situ testing indicate the crust to have a stiff to very stiff consistency.

The measured water content of two samples of the weathered silty clay was about 36 and 41 percent.

Upper Sandy Silt to Silty Sand

A layer of silty sand with some silt exists beneath the silty clay at borehole 16-103. A possible sand layer was also encountered at the ground surface at boreholes 16-301 and 16-302. The sandy soil is about 0.3 to 0.9 metres thick.

Glacial Till

Glacial till exists below the silty clay and silty sand deposits or below the topsoil in all boreholes, at depths varying from about 0.3 to 2.5 metres below the existing ground surface. The glacial till generally consists of a heterogeneous mixture of gravel, cobbles, and boulders in a matrix of silty sand to sandy silt.

SPT “N” values within the glacial till of 1 to greater than 100 blows per 0.3 metres of penetration indicates a very loose to very dense state of packing. However, the higher blow counts likely reflect the presence of cobbles and/or boulders within the glacial till, rather than the actual state of packing of the soil matrix.

The measured water content of samples from the glacial till ranged from about 9 to 14 percent

A layer of sandy soil was encountered within the glacial till deposit at boreholes 16-106, 11-3, and 15-7 at depths of about 3.2 to 4.6 metres below the ground surface. The sandy soil consists of sand and silty sand and was proven to be about 0.3 to 1.4 metres thick. SPT “N” values within the sandy soil of 9 to 22 blows per 0.3 metre of penetration indicates this sandy soil to have a loose to compact state of packing.

The results of grain size distribution on one sample of the sandy soil retrieved from the current and previous investigations are provided on Figure 3.

Auger Refusal and Bedrock

Refusal to auger advancement was encountered at boreholes 16-103, 16-105, 16-106, 16-107/16-107A, 15-17A, and 15-103 at depths of about 1.7 to 7.3 metres below the ground surface. Refusal may indicate the bedrock surface, but it likely reflects the presence of cobbles and/or boulders in the glacial till deposit.

Bedrock was encountered at boreholes 15-7, 15-8, 16-301 and 16-302. The boreholes were extended into the bedrock for depths of about 1.8 to 3.2 metres using rotary diamond drilling techniques while retrieving NQ or HQ sized core.

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

Borehole Number	Ground Surface Elevation (m)	Depth to Bedrock (m)	Bedrock Surface Elevation (m)
15-7	92.84	6.20	86.64
15-8	92.19	8.89	83.30
16-301	93.16	9.80	83.36
16-302	93.06	8.02	85.04

The bedrock encountered in the boreholes consists of grey limestone and dolomite, with black shale interbeds. The bedrock is fresh and thinly to medium bedded. The Rock Quality Designation (RQD) values measured on the recovered bedrock core samples generally ranged from about 50 to 100 percent, indicating a fair to excellent rock quality.

Groundwater

The groundwater levels in the monitoring well or piezometers sealed in the current and previous boreholes were measured at various times. The observed groundwater levels are summarized in the table below:

Borehole Number	Geologic Unit	Ground Surface Elevation (m)	Groundwater Depth (m)	Groundwater Level (m)	Date of Measurement	Estimated Hydraulic Conductivity (cm/s)
16-103	Silty Clay/ Clay/Silty Sand Till	93.51	0.91	92.60	Mar 7, 2016	-
15-7	Bedrock	92.84	2.17	90.67	Apr 24, 2015	5×10^{-5}
15-9A	Gravelly sand (interbedded within glacial till)	92.27	0.92	91.35	Aug 25, 2015	3×10^{-3}
11-3	Glacial Till	-	1.53	-	Feb 7, 2011	-

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.

5.0 DISCUSSION

5.1 General

This section of the report provides engineering guidelines on the geotechnical design aspects of the project based on our interpretation of the borehole information and the project requirements. The reader is referred to the "Important Information and Limitations of This Report" which follows the text but forms an integral part of this document.

5.2 Site Grading

The subsurface conditions on this site generally consist of silty clay overlying glacial till at depths varying from about 3.1 metres on the north part of the site and to more than 8.2 metres beneath the west part of the site. The lower portions of the deeper silty clay deposit are compressible beneath the northern and western parts of the site. On the central and eastern parts of the site, the subsurface conditions consist of very stiff weathered silty clay underlain by glacial till, or glacial till near the ground surface.

The "softer" grey silty clay deposit has limited capacity to accept additional load from the weight of grade raise fill and from the foundations of houses without undergoing consolidation settlements. This condition is particularly true for the northern and western portions of the site where the silty clay deposit is much thicker and more compressible. Therefore, to leave sufficient remaining capacity for the silty clay to support house foundations, with reasonable footing sizes, the thicknesses of grade raise fill will need to be limited.

The following table provides the maximum grade raises which are permitted for each of the assessment areas as indicated on Figure 1. These grade raise limitations have been assessed based on leaving sufficient remaining capacity in the silty clay deposit such that footings up to 0.6 metres in size can be designed using an allowable bearing pressure of at least 75 kilopascals, consistent with design in accordance with Part 9 of the Ontario Building Code (OBC).

Assessment Area	**Maximum Permissible Grade Raise (m)**
A	1.7
B	NA[1]

Note 1: NA = Not Applicable.

For Area B, there is no practical grade raise restriction since this area is underlain by very stiff weathered silty clay overlying glacial till deposit, or just glacial till.

The above maximum grade raise for Area A was selected based on the following considerations:

- The houses will have conventional depth basements, with founding levels in the range of 2.4 metres below finished grade.
- Any fill required for site grading (above original grade) and the backfill within the garages would have a unit weight of no more than 20 kilonewtons per cubic metre. Crushed clear stone, uniform fine sand, as well as silty clay (such as present on this site) may be suitable for this purpose. Sand and gravel, glacial till, and crushed stone typically have a higher unit weight and, if these materials are to be used, the maximum permissible grade raises would be reduced and would need to be re-evaluated.

If the grading restriction given for Area A cannot be accommodated, the following three options could be considered:

1) The additional required grade raising (above the limits given in the previous table) could be accomplished using expanded polystyrene (EPS) light weight fill.
2) The area could be pre-loaded and allowed to settle in advance of house construction. The subgrade settlements would need to be monitored to establish when sufficient settlements had occurred such that house construction could proceed. To reduce the time required for the pre-loading, it is likely that a temporary surcharge above the existing grade would need to be considered, however in either case the pre-load time could be months or years.
3) The houses could be supported on driven steel piles, which derive their support from more competent bearing soils (i.e., glacial till) below the “softer” layers of silty clay.

Additional geotechnical guidelines would need to be provided if any of the three above options are selected. Additional investigation could also be required (in particular for Options 2 and 3) before those guidelines could be finalized.

As a general guideline regarding the site grading, the preparation for filling of the site should include stripping the topsoil or buried topsoil (near borehole 15-17) for predictable performance of structures and services. The topsoil is not suitable as engineered fill and should be stockpiled separately for re-use in landscaping applications only. In areas with no proposed structures, services, or roadways, the topsoil may be left in-place provided some settlement of the ground surface following filling can be tolerated.

5.3 Foundations

It is considered that the proposed residences may be supported on spread footings founded on or within the weathered silty clay or glacial till (where the surface of the till is shallow).

For Area A, the unweathered silty clay deposit beneath this portion of the site has limited capacity to accept the combined load from site grading fill and foundation loads. The allowable bearing pressures for spread footing foundations are therefore based on limiting the stress increases on the unweathered compressible silty clay at depth to an acceptable level so that foundation settlements do not become excessive. Four important parameters in calculating the stress increase on the grey silty clay are:

- The thickness of soil below the underside of the footings and above the “softer” unweathered silty clay;
- The size (dimensions) of the footings;
- The amount of surcharge in the vicinity of the foundations due to landscape fill, underslab fill, floor loads, etc., as described in Section 5.2; and,
- The effects of groundwater lowering caused by this or other construction.

Provided that the grade raises are restricted to those indicated in Section 5.2, strip footing foundations up to 0.6 metre in width can be designed using a maximum allowable bearing pressure of 75 kilopascals. As such, the house footings may be sized in accordance with Part 9 of the OBC.

The post-construction total and differential settlements of footings sized using the above maximum allowable bearing pressure should be less than about 25 and 15 millimetres, respectively, provided that the subgrade at or below founding level is not disturbed during construction.

Further, the provided maximum allowable bearing pressure for footings founded within the silty clay corresponds to settlement resulting from consolidation of these deposits. Consolidation of the silty clay is a process which takes months or longer and, as such, results from sustained loading. Therefore, the foundation loads to be used in conjunction with the allowable bearing pressure should be the full dead load plus sustained live load.

The glacial till on this site contains cobbles and boulders. Any cobbles or boulders in the footing areas which have been loosened by the excavation process should be removed and the cavity filled with lean concrete (the cobble and boulders should not be pushed back in place).

5.4 Seismic Design

For design in accordance with Part 4 of the 2012 OBC, where required, a seismic site response classification of Site Class E could be assigned to the northern and western portions of the site, and a Site Class D could be assigned for the eastern portion of the site, acknowledging that this requirement does not apply to ground oriented residential structures designed per Part 9 of the OBC. The boundary between these two Site Class areas are shown on Figure 4.

This Site Class assessment was carried out using in situ testing data (as permitted by the OBC), and therefore it could be conservative. Geophysical measurement of the shear wave velocity for the upper 30 metres of soil and/or bedrock below founding level on this site would allow for a more accurate seismic Site Class to be specified, and to help assess whether more favourable Site Class values could be assigned to parts of the site.

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

5.5 Frost Protection

All exterior perimeter foundation elements or foundation elements in unheated areas should be provided with a minimum of 1.5 metres of earth cover for frost protection purposes. Isolated and/or unheated exterior footings adjacent to surfaces which are cleared of snow cover during winter months should be provided with a minimum of 1.8 metres of earth cover.

Insulating the bearing surface with high density insulation could be considered as an alternative to earth over for frost protection. Further details could be provide if required.

5.6 Basement Excavations

Excavations for basements will be through the fill, topsoil, sandy soil, silty clay, and glacial till (where the till surface is shallow). No unusual problems are anticipated in excavating in the overburden soils using conventional hydraulic excavating equipment, recognizing that large boulders will likely be encountered within the glacial till. Boulders larger than 0.3 metres in size should be removed from the walls of the excavations for worker safety.

Side slopes in the overburden materials should be stable in the short term at 1 horizontal to 1 vertical (1H:1V) in accordance with the Occupational Health and Safety Act (OHSA) of Ontario for Type 3 soils.

Some groundwater inflow into the excavations could be expected. However, for the planned basement excavation depths, it should be possible to handle the groundwater inflow by pumping from well filtered sumps in the excavations. Where the subgrade is found to be wet and sensitive to disturbance, consideration should be given to placing a mud slab of lean concrete over the subgrade (following inspection and approval by geotechnical personnel) or a 150 millimetre thick layer of OPSS Granular A underlain by a non-woven geotextile, to protect the subgrade from construction traffic.

5.7 Basement and Garage Floor Slabs

In preparation for the construction of the basement floor slabs, all loose, wet and disturbed materials should be removed from beneath the floor slabs. Provision should be made for at least 200 millimetres of 19 millimetre crushed clear stone to form the base of the basement floor slabs.

To prevent hydrostatic pressure build up beneath the basement floor slabs, it is suggested that the granular base material be positively drained. This could be achieved by providing a hydraulic link between the underslab fill material and the exterior drainage system.

The backfill material inside the garage should have a unit weight no greater than 20 kilonewtons per cubic metre (i.e., uniform fine sand or clear crushed stone). The garage backfill should be placed in maximum 300 millimetre thick lifts and be compacted to at least 95 percent of the material's standard Proctor maximum dry density using suitable compaction equipment. The granular base for the garage floor slab should consist of at least 150 millimetres of Granular A compacted to at least 95 percent of the material's Standard Proctor maximum dry density using suitable compaction equipment.

5.8 Basement Wall and Foundation Wall Backfill

The soils at this site are frost susceptible and should not be used as backfill directly against exterior, unheated, or well insulated foundation elements. To avoid problems with frost adhesion and heaving, a bond break such as Platon system sheeting should be placed against the foundation walls. Alternatively, these foundation elements could be backfilled with non-frost susceptible sand, provided it meets the unit weight restriction of 20 kilonewtons per cubic metre.

Drainage of the wall backfill should be provided by means of a perforated pipe subdrain in a surround of 19 millimetre clear stone, fully wrapped in geotextile, which leads by gravity drainage to an adjacent storm sewer or sump pit. Conventional damp proofing of the basement walls is appropriate with the above design approach.

Where design of basement walls in accordance with Part 4 of the 2012 OBC is required, walls backfilled with granular material and effectively drained as described above should be designed to resist lateral earth pressures calculated using a triangular distribution of the stress with a base magnitude of $K_o\gamma H$, where:

K_o = The lateral earth pressure coefficient in the 'at rest' state, use 0.5;

γ = The unit weight of the granular backfill, use 22 kilonewtons per cubic metre; and,

H = The height of the basement wall in metres.

If Platon System sheeting or similar water barrier product is used against the foundation walls, then hydrostatic groundwater pressures should also be considered in the calculation of the lateral earth pressures.

5.9 Site Servicing

Excavations for the installation of site services will be made through the fill, topsoil, sandy soil, silty clay, and glacial till (at least on parts of the site). No unusual problems are anticipated in excavating in the overburden using conventional hydraulic excavating equipment, recognizing that cobbles and boulders will likely be encountered within the glacial till. Boulders larger than 0.3 metres in size should be removed from the excavation side slopes for worker safety.

In accordance with the OHSA of Ontario, the silty clay and the sandy soils above the water table would generally be classified as Type 3 soils and side slopes in the entire deposit of silty clay as well as the sandy soils above the water table in the short term may be sloped at 1H:1V. Excavation side slopes in the sandy soil below the groundwater level would need to be cut back at 3H:1V (i.e., Type 4 soils). This includes the sandy deposits within the glacial till. Alternatively, excavations within the overburden could also be carried out within a fully braced steel trench box, which would minimize the width of the excavation.

Stockpiling of soil beside the excavations made in the silty clay should be avoided; the weight of the stock piled soil could lead to basal instability of braced excavations or slope instability for unsupported excavations.

Some groundwater inflow into the excavations should be expected from the grey clay and glacial till. However, it should generally be possible to handle the groundwater inflow by pumping from well filtered sumps in the excavations provided suitably sized pumps are used.

Higher groundwater inflows should be expected from the more permeable sandy layers within the glacial till, and some sloughing and subgrade disturbance should be expected. It is expected that passive dewatering will be required to prevent destabilization (i.e., disturbance) of the excavation base in areas where basal heave or subgrade disturbance will be potential issues (i.e., where high permeability sandy soils are present at or in close proximity to the base of the excavations such as borehole 15-9A). As a preliminary guideline, it is envisaged that passive relief wells could be installed at periodic intervals along the alignment of “deeper” site services alignment in advance of excavation to allow for lowering the piezometric level. Alternatively, pumping from sumps installed within pits just ahead (and off-line) of the sewer trenches could also be considered. If this option is chosen, pits should be located just off-line of the site services alignment to avoid the potential for disturbance of the subgrade below pipe bedding level. The design of the dewatering system should ultimately be the responsibility of the contractor.

The actual rate of groundwater inflow to the trench (or the required pumping from sumps) will depend on many factors, including: the contractor’s schedule and rate of excavation, the size of the excavation, the number of working areas being excavated at one time, and the time of year at which the excavation is made. Also, there may be instances where significant volumes of precipitation, surface runoff and/or groundwater collects in an open excavation, and must be pumped out. If the pumping volumes exceed 400,000 litres per day, a Category 3 Permit-To-Take-Water (PTTW) will be required from the Ministry of the Environment and Climate Change (MOECC). For expected groundwater inflows greater than 50,000 litres per day but less than 400,000 litres per day (equivalent to a formerly Category 2 PTTW), a registration in the Environmental Activity and Sector Registry (EASR) will be required under the new regulations, which came into force on March 29, 2016.

At least 150 millimetres of OPSS Granular A should be used as pipe bedding for sewer and water pipes. Where unavoidable disturbance to the subgrade surface does occur, it may be necessary to place a sub-bedding layer consisting of compacted OPSS Granular B Type II beneath the Granular A, or to thicken the Granular A bedding.

The bedding material should, in all cases, extend to the spring line of the pipe and should be compacted to at least 95 percent of the material's standard Proctor maximum dry density. The use of clear crushed stone as a bedding layer should not be permitted anywhere on this project since fine particles from the sandy backfill materials or sandy soils on the trench walls could potentially migrate into the voids in the clear crushed stone and cause loss of lateral pipe support.

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

It should generally be possible to re-use the drier silty clay and glacial till as trench backfill.

However, the high moisture content of the "deeper" silty clay deposits (i.e., below the weathered zone) makes these soils difficult to handle and compact. If these materials are excavated during installation of the site services, they should be wasted or should only be used as backfill in the lower portion of the trenches to limit the amount of long term settlement of the roadway surface. If the unweathered silty clay is used in trenches under roadways, long term settlement of the pavement surface should be expected.

Where the trench will be covered with hard surfaced areas, the type of native material placed in the frost zone (between subgrade level and 1.8 metres depth) should match the soil exposed on the trench walls for frost heave compatibility. Trench backfill should be placed in maximum 300 millimetre thick lifts and should be compacted to at least 95 percent of the material's standard Proctor maximum dry density using suitable compaction equipment.

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

5.10 Pavement Design

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

Pavement areas requiring grade raising to proposed subgrade level should be filled using acceptable (compactable and inorganic) earth borrow or OPSS Select Subgrade Material. These materials should be placed in maximum 300 millimetre thick lifts and should be compacted to at least 95 percent of the material's standard Proctor maximum dry density using suitable compaction equipment.

The surface of the pavement subgrade should be crowned to promote drainage of the roadway granular structure. Perforated pipe sub-drains should be provided at subgrade level extending from the catch basins for a distance of at least 3 metres longitudinally, parallel to the curb in two directions.

The pavement structure for local roads should consist of:

Pavement Component	Thickness (millimetres)
Asphaltic Concrete	90
OPSS Granular A Base	150
OPSS Granular B Type II Subbase	375

The pavement structure for collector roadways should consist of:

Pavement Component	Thickness (millimetres)
Asphaltic Concrete	90
OPSS Granular A Base	150
OPSS Granular B Type II Subbase	450

For arterial roadway, the subbase thickness should be increased to 600 millimetres.

The granular base and subbase materials should be uniformly compacted to at least 100 percent of the materials' standard Proctor maximum dry density using suitable vibratory compaction equipment. The asphaltic concrete should be compacted in accordance with Table 10 of OPSS 310.

The composition of the asphaltic concrete pavement should be as follows:

Superpave 12.5 mm Surface Course – 40 millimetres

Superpave 19 mm Base Course – 50 millimetres

The asphaltic cement should consist of PG 58-34 and the design of the mixes should be based on a Traffic Category B for local roads and Category D for collector roads.

The above pavement designs are based on the assumption that the pavement subgrade has been acceptably prepared (i.e., where the trench backfill and grade raise fill have been adequately compacted to the required density and the subgrade surface not disturbed by construction operations or precipitation). Depending on the actual conditions of the pavement subgrade at the time of construction, it could be necessary to increase the thickness of the subbase and/or to place a woven geotextile beneath the granular materials.

5.11 Pools, Decks and Additions

5.11.1 Above Ground and In Ground Pools

For Area A, no special geotechnical considerations are necessary for the installation of in-ground pools, provided that the pool (including piping) does not extend deeper than the house footing level. A geotechnical assessment will be required if the pool extends deeper than the house foundations.

For Area A, due to the additional loads that would be imposed by the construction of *above-ground pools*, these should be located no closer than 2 metres from the outside wall of the house. In addition, the installation of an above-ground pool should not be permitted to alter the existing grades within 3 metres of the house. Provided these restrictions are adhered to, no further geotechnical assessment should be required for above-ground pools.

For Area B, no special geotechnical considerations are necessary for the installation of in-ground or above ground pools.

5.11.2 Decks

For Area A, a geotechnical evaluation/assessment will be necessary for future decks that:

- are attached to the house;
- require changes to the existing grades; or,
- are heavily loaded and require spread footing or drilled pier foundations.

The geotechnical evaluation must consider the proposed grading, foundation types and sizes, depths of foundations, and design bearing pressures. Written approval from a geotechnical engineer should be required by the City of Ottawa prior to a building permit being issued.

For Area B, no special geotechnical considerations area necessary for decks.

5.11.3 Additions

For both Areas A and B, any proposed addition to a house (regardless of size) will require a geotechnical assessment. The geotechnical assessment must consider the proposed grading, foundation types and sizes, depths of foundations, and design bearing pressures. Written approval from a geotechnical engineer should be required by the City of Ottawa prior to the building permit being issued.

5.12 Corrosion and Cement Type

Two samples of soil, one each from boreholes 16-105 and 16-107, were submitted to EXOVA Environmental Ontario for basic chemical analysis related to potential corrosion of buried steel elements and potential sulphate attack on buried concrete elements. The results of this testing are provided in Appendix C. The results indicate that concrete made with Type GU Portland cement should be acceptable for substructures. The results also indicate a moderate to elevated potential for corrosion of exposed ferrous metal, which should be considered in the design of substructures.

5.13 Trees

The clayey soils encountered within portions of the site are highly sensitive to water depletion by trees of high water demand during periods of dry weather. When trees draw water from the clayey soil, the clay undergoes shrinkage which can result in settlement of adjacent structures. The zone of influence of a tree is considered to be approximately equal to the height of the tree. Therefore trees which have a high water demand should not be planted closer to structures than the ultimate height of the trees. Table 1 provides a list of the common trees in decreasing order of water demand and, accordingly, decreasing risk of potential effects on structures.

The restriction on trees can be waived in those areas where the footings are founded on glacial till.

6.0 ADDITIONAL CONSIDERATIONS

The guidelines in this report have been developed on the basis of the structures on this site being designed in accordance with Part 9 of the OBC. For any portions of the site where the structures will need to be designed in accordance with Part 4 of the OBC, additional geotechnical investigation may be required and additional guidelines would need to be provided.

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

All footing and subgrade areas should be inspected by experienced geotechnical personnel prior to filling or concreting to ensure that soil having adequate bearing capacity has been reached and that the bearing surfaces have been properly prepared. The placing and compaction of any engineered fill as well as sewer bedding and backfill should be inspected to ensure that the materials used conform to the specifications from both a grading and compaction point of view.

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

The groundwater level monitoring devices (i.e., standpipe piezometers or wells) installed at the site will require decommissioning at the time of construction in accordance with Ontario Regulation 128/03. However, it is expected that most of the wells will either be destroyed during construction or can be more economically abandoned as part of the construction. If that is not the case or is not considered feasible, abandonment of the monitoring wells can be carried out separately.

7.0 CLOSURE

We trust this report contains sufficient information for your present requirements. If you have any questions concerning this report, or if we can be of further service to you on this project, please call us.

Yours truly,

GOLDER ASSOCIATES LTD.

LICENSED PROFESSIONAL ENGINEER
P.E.C. KO
100103970
Dec 15/16
PROVINCE OF ONTARIO

Christine Ko, P.Eng.
Geotechnical Engineer

Troy Skinner, P.Eng.
Associate, Senior Geotechnical Engineer

KM/CK/TMS/ob

\\golder.gds\gal\ottawa\active\2015\3 proj\1523044 claridge burnett lands ottawa\08_reports\1000-geotech\final\1523044-1000 geotech report_final.docx

IMPORTANT INFORMATION AND LIMITATIONS
OF THIS REPORT

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

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

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

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

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

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

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

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

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

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

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

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

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

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

TABLE 1

SOME COMMON TREES
IN DECREASING ORDER OF WATER DEMAND

Broad Leaved Deciduous

Poplar

Alder

Aspen

Willow

Elm

Maple

Birch

Ash

Beech

Oak

Deciduous Conifer

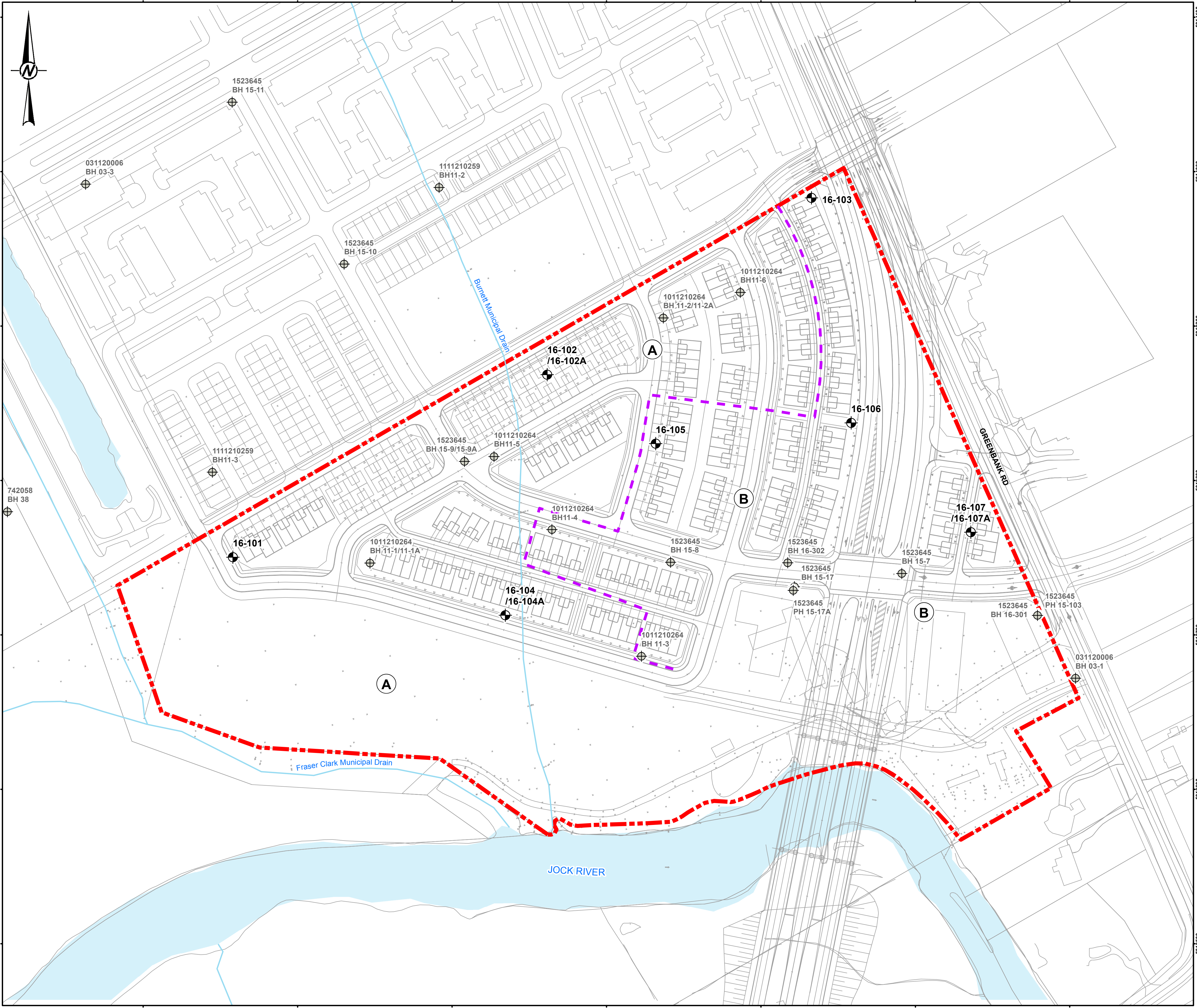
Larch

Evergreen Conifers

Spruce

Fir

Pine



LEGEND

⊕	APPROXIMATE BOREHOLE LOCATION, CURRENT INVESTIGATION
⊕	APPROXIMATE BOREHOLE LOCATION, PREVIOUS INVESTIGATION
—	WATERCOURSE
🟦	WATERBODY
🟥	SITE LIMIT
- -	APPROXIMATE BOUNDARY BETWEEN ASSESSMENT AREAS
Ⓐ	ASSESSMENT AREA

KEY MAP

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0 25 50 100

1:2,500 METRES

NOTE(S)

1. THIS FIGURE IS TO BE READ IN CONJUNCTION WITH THE ACCOMPANYING GOLDER ASSOCIATES LTD. REPORT NO. 1523044-1000.

REFERENCE(S)

1. BASE PLAN PROVIDED IN DIGITAL FORMAT BY NOVATECH ENGINEERING CONSULTANTS LTD.
2. LAND INFORMATION ONTARIO (LIO) DATA PRODUCED BY GOLDER ASSOCIATES LTD. UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2014
2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: MTM ZONE 9 VERTICAL DATUM: CGVD28

CLIENT
CLARIDGE HOMES CORPORATION

PROJECT
GEOTECHNICAL INVESTIGATION
BURNETT LANDS, OTTAWA, ONTARIO

TITLE
SITE PLAN

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-03-01
DESIGNED	----
PREPARED	JEM
REVIEWED	CK
APPROVED	TMS

PROJECT NO.	PHASE	REV.	FIGURE
1523044	1000	0	1

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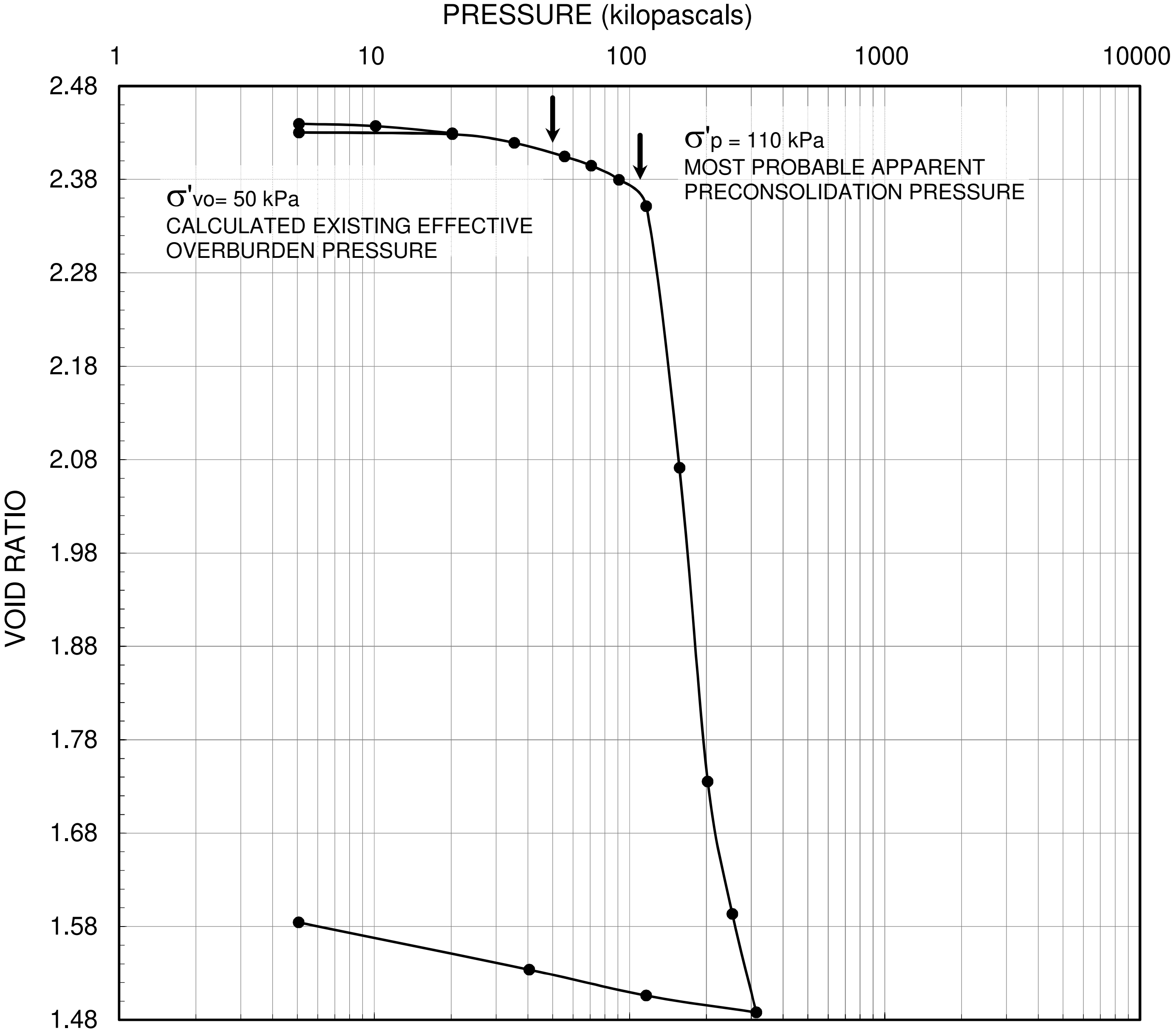
25mm



LEGEND

Borehole:	16-104A	w_i = 86%	S_o = 99%	γ = 14.9 kN/m³
Sample:	1	w_f = 57%	e_o = 2.44	G_s = 2.81
Depth (m):	5.0	w_l = 75%	C_c = 3.07	
Elevation (m):	86.3	w_p = 25%	C_r = 0.003	

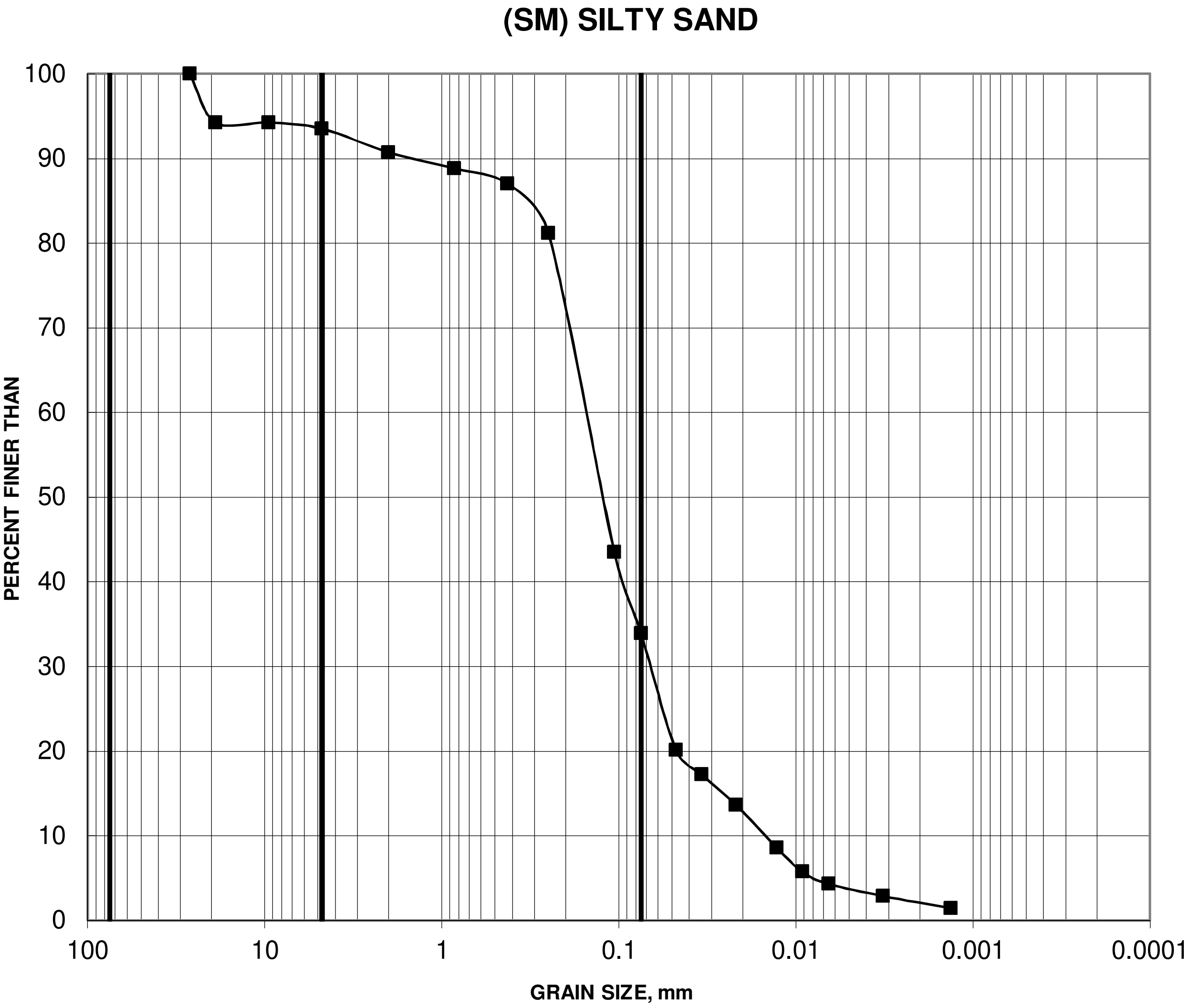
Golder Associates

SCALE	AS SHOWN	TITLE	
DATE	04/19/16		
CADD	N/A		CONSOLIDATION TEST RESULTS
ENTERED	CW		
CHECK	CNM		
REVIEW	CK	FIGURE	2

FILE No. Consolidation summary

PROJECT No. 1523044 REV. 1

GRAIN SIZE DISTRIBUTION	FIGURE 3



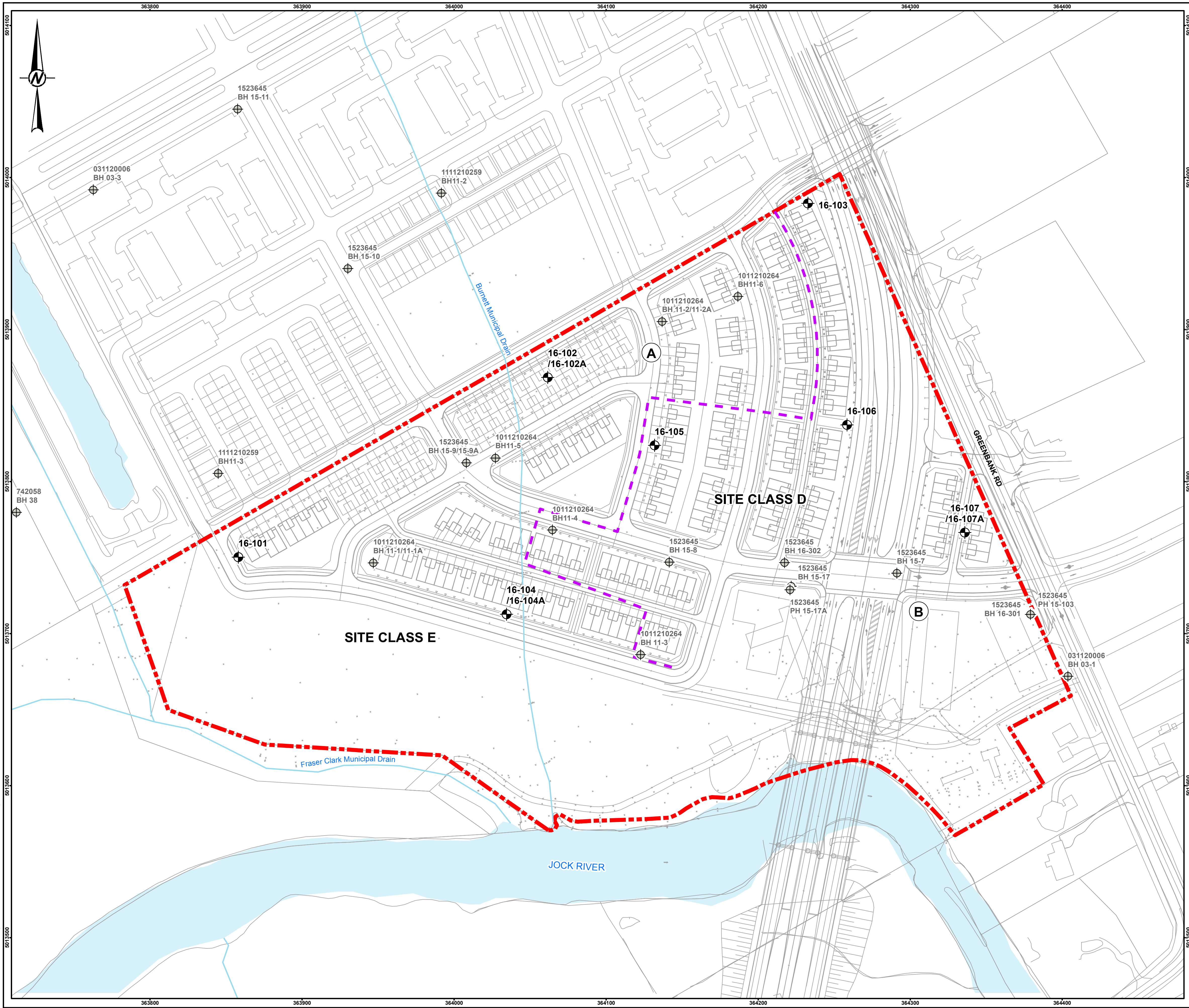
Cobble Size	coarse	fine	coarse	medium	fine	SILT AND CLAY
	GRAVEL SIZE		SAND SIZE			

Borehole	Sample	Depth (m)
■ 16-106	8	4.57-5.18

Project: 1523044/1000

Golder Associates

Created by: CW
Checked by: CNM



LEGEND

⊕	APPROXIMATE BOREHOLE LOCATION, CURRENT INVESTIGATION
⊕	APPROXIMATE BOREHOLE LOCATION, PREVIOUS INVESTIGATION
—	WATERCOURSE
▭	WATERBODY
▭	SITE LIMIT
- -	APPROXIMATE BOUNDARY BETWEEN SITE CLASS
Ⓐ	ASSESSMENT AREA

KEY MAP

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0 25 50 100

1:2,500 METRES

NOTE(S)

1. THIS FIGURE IS TO BE READ IN CONJUNCTION WITH THE ACCOMPANYING GOLDER ASSOCIATES LTD. REPORT NO. 1523044-1000.

REFERENCE(S)

1. BASE PLAN PROVIDED IN DIGITAL FORMAT BY NOVATECH ENGINEERING CONSULTANTS LTD.
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2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83
COORDINATE SYSTEM: MTM ZONE 9 VERTICAL DATUM: CGVD28

CLIENT
CLARIDGE HOMES CORPORATION

PROJECT
GEOTECHNICAL INVESTIGATION
BURNETT LANDS, OTTAWA, ONTARIO

TITLE
SEISMIC SITE CLASSIFICATION

CONSULTANT

Golder Associates

YYYY-MM-DD	2016-03-01
DESIGNED	----
PREPARED	JEM
REVIEWED	CK
APPROVED	TMS

PROJECT NO.	PHASE	REV.	FIGURE
1523044	1000	0	4

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

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APPENDIX A

List of Abbreviations and Symbols
Record of Borehole Sheets
Current Investigation

ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS

PARTICLE SIZES OF CONSTITUENTS

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

MODIFIERS FOR SECONDARY AND MINOR CONSTITUENTS

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

PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

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

Cone Penetration Test (CPT)

An electronic cone penetrometer with a 60° conical tip and a project end area of 10 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
DO or DP	Seamless open ended, driven or pushed tube sampler – note size
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split spoon sampler – note size
ST	Slotted tube
TO	Thin-walled, open – note size
TP	Thin-walled, piston – note size
WS	Wash sample

SOIL TESTS

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

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

NON-COHESIVE (COHESIONLESS) SOILS

Compactness[2]

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

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

Field Moisture Condition

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

COHESIVE SOILS

Consistency

Term	Undrained Shear Strength (kPa)	SPT 'N'[1] (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.

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
σ_1, σ_2, σ_3	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

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

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

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

PROJECT: 1523044-1000

RECORD OF BOREHOLE: 16-101

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: February 23, 2016

DATUM: Geodetic

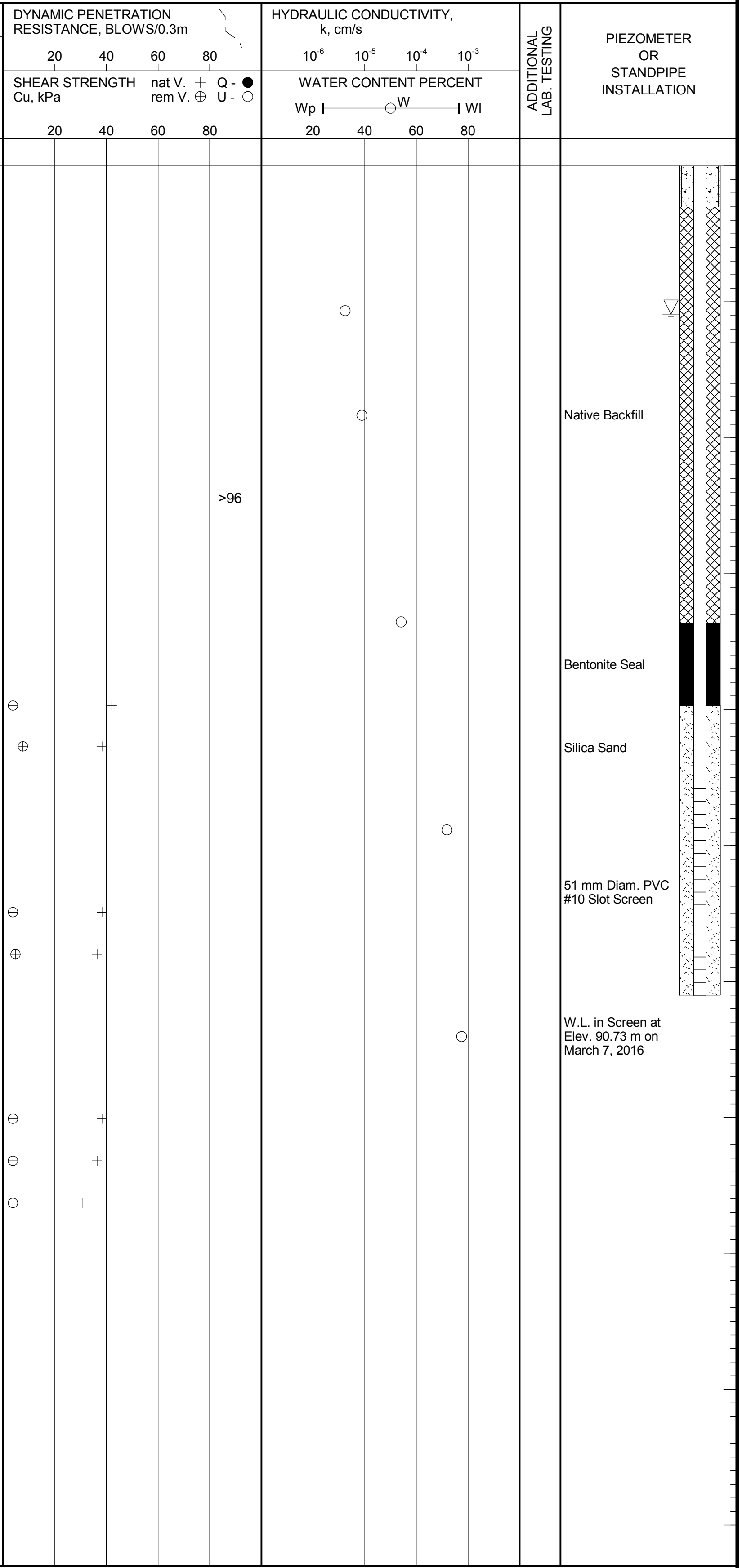
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES: 0 to 10

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

SOIL PROFILE: DESCRIPTION	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.30m
GROUND SURFACE	91.82			
TOPSOIL - (ML) sandy SILT; brown	0.00	1	GRAB	-
(CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (Weathered Crust); cohesive, w>PL, stiff to very stiff	0.15	2	GRAB	-
		3	SS	4
		4	SS	4
(CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, firm	88.77 3.05	5	SS	1
		6	SS	PH
		7	SS	WH
End of Borehole	84.20 7.62			



DEPTH SCALE

1 : 50

Golder Associates

LOGGED: CG

CHECKED: CK

PROJECT: 1523044-1000

RECORD OF BOREHOLE: 16-102

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: February 22, 2016

DATUM: Geodetic

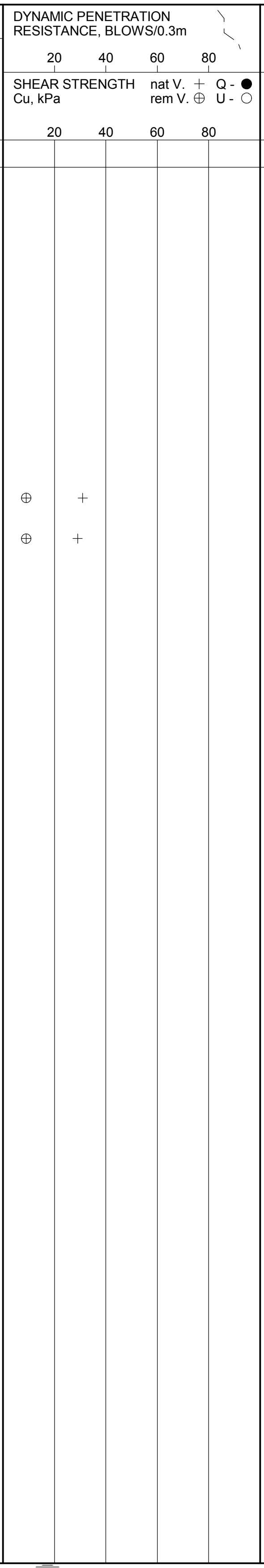
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (m)
GROUND SURFACE	92.01
TOPSOIL - (ML) CLAYEY SILT; dark brown	0.00
(CI/CH) SILTY CLAY to CLAY; grey brown (Weathered Crust); cohesive, w>PL, very stiff	91.78 0.23
(CI/CH) SILTY CLAY to CLAY; grey; cohesive, w~PL, firm	90.49 1.52
(SM) SILTY SAND, some gravel; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet, very loose to compact	88.96 3.05
End of Borehole	84.39 7.62

SAMPLES NUMBER	TYPE	BLOWS/0.30m
1	GRAB	-
2	GRAB	-
3	SS	6
4	SS	1
5	TP	PH
6	SS	7
7	SS	4
8	SS	8
9	SS	17
10	SS	2



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

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

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: DG

CHECKED: CK

PROJECT: 1523044-1000

RECORD OF BOREHOLE: 16-102A

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: February 22, 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. + 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		92.01							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) CLAYEY SILT; dark brown		0.00							
1		(CI/CH) SILTY CLAY to CLAY; grey brown (Weathered Crust); cohesive, w>PL, very stiff		91.78 0.23							
2		(CI/CH) SILTY CLAY to CLAY; grey; cohesive, w~PL, firm		90.49 1.52	1	TP	PH				
3		End of Borehole Note: Soil stratigraphy inferred from BH 16-102		89.27 2.74							
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DG

CHECKED: CK

PROJECT: 1523044-1000

RECORD OF BOREHOLE: 16-103

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: February 19, 2016

DATUM: Geodetic

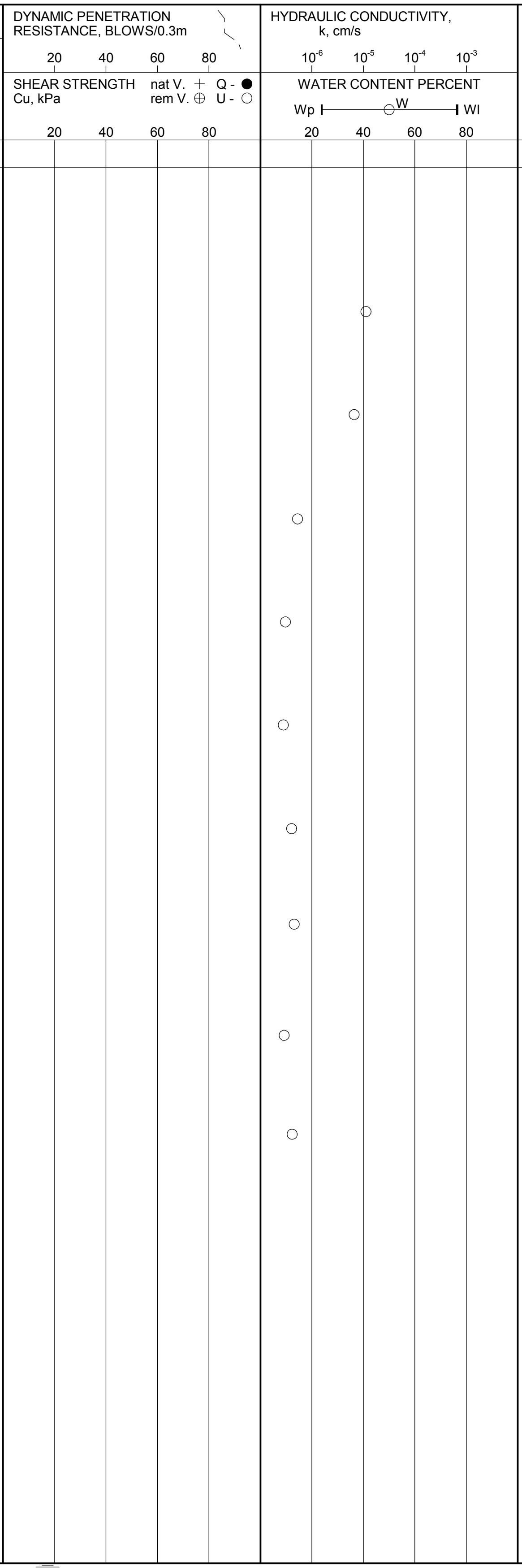
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

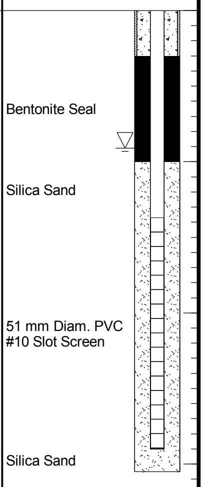
BORING METHOD: Power Auger, 200 mm Diam. (Hollow Stem)

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	93.51
TOPSOIL - (ML) CLAYEY SILT; dark brown	0.00
(CI/CH) SILTY CLAY to CLAY; grey brown (Weathered Crust); cohesive, w>PL, very stiff	0.15
(SM) SILTY SAND, some gravel; brown; non-cohesive, wet, loose	91.69 1.82
(SM) SILTY SAND, some gravel; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet, loose to very dense	91.38 2.13
End of Borehole Auger Refusal	86.25 7.26

SAMPLES NUMBER	TYPE	BLOWS/0.30m
1	GRAB	-
2	GRAB	-
3	SS	10
4	SS	4
5	SS	11
6	SS	4
7	SS	25
8	SS	33
9	SS	40
10	SS	58
11	SS	>50



ADDITIONAL LAB. TESTING



W.L. in Screen at Elev. 92.60 m on March 7, 2016

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: DG

CHECKED: CK

PROJECT: 1523044-1000

RECORD OF BOREHOLE: 16-104

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: February 23, 2016

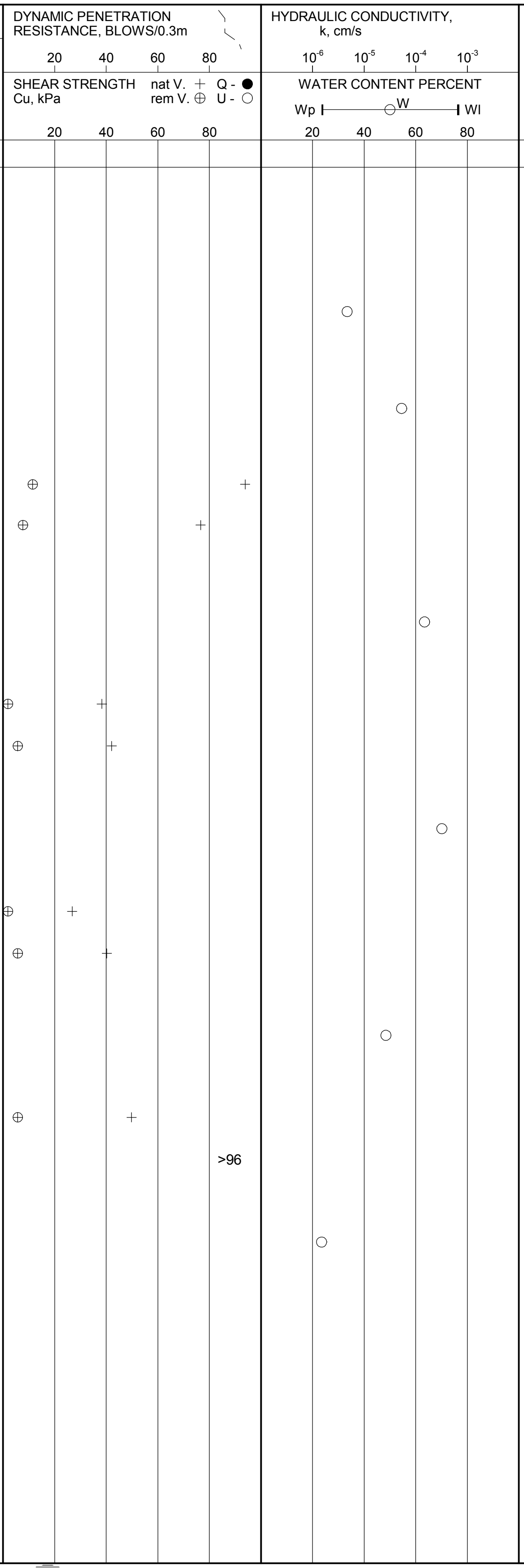
DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m
	GROUND SURFACE	91.25			
0	TOPSOIL - (ML) CLAYEY SILT to CLAY; dark brown	0.00	1	GRAB	-
	(CI/CH) SILTY CLAY, trace sand; grey brown, with red mottling (Weathered Crust); cohesive, w>PL, stiff to very stiff	90.95 0.30	2	GRAB	-
1			3	SS	4
			4	TP	PH
3	(CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, soft to firm	88.20 3.05	5	SS	PH
5			6	SS	PH
			7	SS	PH
	(CI/CH) SILTY CLAY, trace to some sand, trace gravel; grey; cohesive, w>PL, stiff to very stiff	84.54 6.71			
8			8	SS	PH
	End of Borehole	83.01 8.24			



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

MIS-BHS 001 1523044.GPJ GAL-MIS.GDT 05/24/16 JEM

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: CG

CHECKED: CK

PROJECT: 1523044-1000

RECORD OF BOREHOLE: 16-104A

SHEET 1 OF 1

LOCATION: See Site Plan

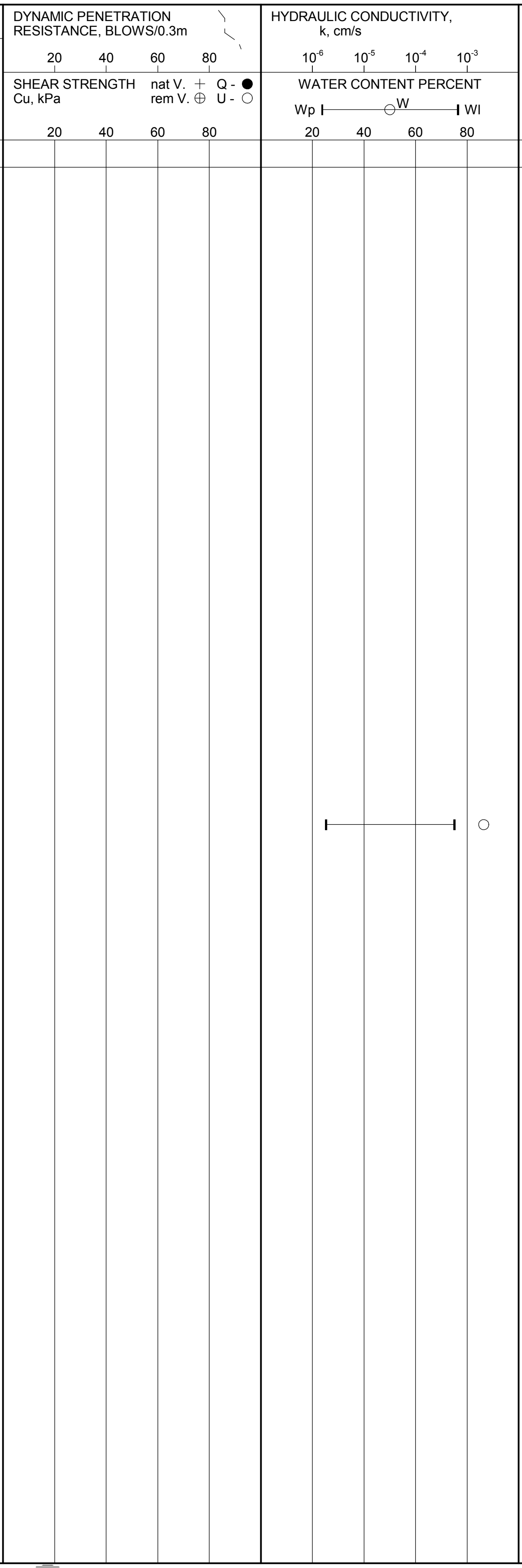
BORING DATE: February 23, 2016

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	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		91.25					
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) CLAYEY SILT to CLAY; dark brown		0.00					
		(CI/CH) SILTY CLAY, trace sand; grey brown, with red mottling (Weathered Crust); cohesive, w>PL, stiff to very stiff		90.95 0.30					
3		(CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, soft to firm		88.20 3.05					
					1	TP	PH	C	
5		End of Borehole Note: Soil stratigraphy inferred from BH 16-104		86.12 5.13					



DEPTH SCALE
1 : 50

Golder Associates

LOGGED: CG
CHECKED: CK

PROJECT: 1523044-1000

RECORD OF BOREHOLE: 16-105

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: February 22, 2016

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	SOIL PROFILE: STRATA PLOT	SOIL PROFILE: ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		92.39							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) CLAYEY SILT; dark brown		0.00	1	GRAB	-				
		(CL/CI) SILTY CLAY; grey brown (Weathered Crust); cohesive, w>PL, stiff to very stiff		0.15	2	GRAB	-				
1					3	SS	5				
					4	SS	3				
2											
		(SM) SILTY SAND, some gravel; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet, loose to compact		90.03 2.36	5	SS	7				
3											
					6	SS	3				
4					7	SS	6				
5					8	SS	7				
					9	SS	7				
6											
					10	SS	26				
7		End of Borehole Auger Refusal		85.38 7.01							
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: CG

CHECKED: CK

MIS-BHS 001 1523044.GPJ GAL-MIS.GDT 05/24/16 JEM

PROJECT: 1523044-1000

RECORD OF BOREHOLE: 16-106

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: February 18, 2016

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

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

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

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

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

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
	GROUND SURFACE	92.78					
0	TOPSOIL - (ML) CLAYEY SILT; dark brown	0.00	1	GRAB	-		
	(CL/CI) SILTY CLAY; grey brown (Weathered Crust); cohesive, w>PL, stiff to very stiff	0.15	2	GRAB	-		
1			3	SS	6		
2			4	SS	4		
	(SM) SILTY SAND, some gravel; grey brown to grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet, very loose	90.49 2.29	5	SS	2		
3			6	SS	1		
4	(ML) SANDY SILT, some gravel; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet, compact	88.97 3.81	7	SS	15		
	(SM) SILTY SAND, fine; grey; non-cohesive, wet, compact	88.21 4.57	8	SS	15	MH	
5			9	SS	19		
6	(SM) SILTY SAND, some gravel; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet	86.84 5.94					
	End of Borehole Auger Refusal	6.10					
7							
8							
9							
10							

MIS-BHS 001 1523044.GPJ GAL-MIS.GDT 05/24/16 JEM

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: CG

CHECKED: CK

PROJECT: 1523044-1000

RECORD OF BOREHOLE: 16-107

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: February 18, 2016

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.30m	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	93.14							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) CLAYEY SILT; dark brown	0.00	1	GRAB	-				
		(CL/CI) SILTY CLAY; grey brown (Weathered Crust); cohesive, w>PL, stiff to very stiff	0.15	2	GRAB	-				
1				3	SS	4				
		(SM) SILTY SAND; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet, very dense	91.77 1.37	5	SS	>50				
2		End of Borehole Auger Refusal	91.16 1.98							
3										
4										
5										
6										
7										
8										
9										
10										

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: CG

CHECKED: CK

PROJECT: 1523044-1000

RECORD OF BOREHOLE: 16-107A

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: February 18, 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. + 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		93.14							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) CLAYEY SILT; dark brown		0.00							
		(CL/CI) SILTY CLAY; grey brown (Weathered Crust); cohesive, w>PL, stiff to very stiff		0.15							
1											
		(SM) SILTY SAND; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet, very dense		91.77 1.37							
		End of Borehole Auger Refusal Note: Soil stratigraphy inferred from BH 16-107		91.46 1.68							
2											
3											
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: CG

CHECKED: CK

APPENDIX B

Record of Borehole Sheets and Laboratory Test Results Previous Investigations

PROJECT: 10-1121-0264

RECORD OF BOREHOLE: BH 11-1

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: January 25, 2011

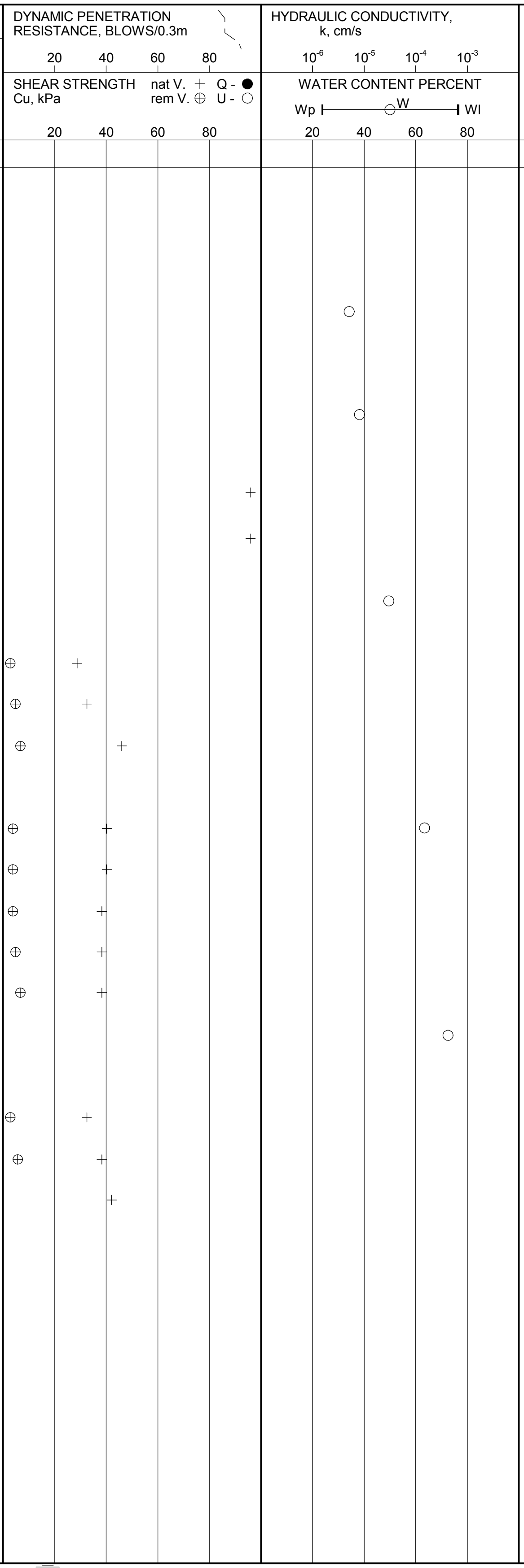
DATUM: Local

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m
	GROUND SURFACE					
0	TOPSOIL		0.00			
	Very stiff grey brown SILTY CLAY, some silty fine sand layers (Weathered Crust)		0.23			
1				1	50 DO	5
2				2	50 DO	3
3	Firm grey SILTY CLAY		3.05	3	50 DO	1
5				4	50 DO	
6				5	50 DO	WH
	End of Borehole		7.62			



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: PAH

CHECKED: ______

PROJECT: 10-1121-0264

RECORD OF BOREHOLE: BH 11-1A

SHEET 1 OF 1

LOCATION: See Site Plan

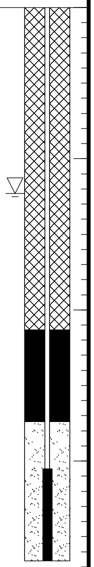
BORING DATE: January 25, 2011

DATUM: Local

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 / SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} / WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE									
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL		0.00							
		Very stiff grey brown SILTY CLAY, some silty fine sand layers (Weathered Crust)		0.23							Native Backfill
1											
2											Bentonite Seal
3											Silica Sand
		Firm grey SILTY CLAY		3.05	1	76 TP	PH				Standpipe
		End of Borehole Note: Soil profile inferred from RECORD OF BOREHOLE BH 11-1.		3.66							W.L. in Standpipe at 1.23 m depth below ground surface on February 7, 2011
4											
5											
6											
7											
8											
9											
10											



DEPTH SCALE
1 : 50

LOGGED: PAH
CHECKED: ______

PROJECT: 10-1121-0264

RECORD OF BOREHOLE: BH 11-2

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: January 28, 2011

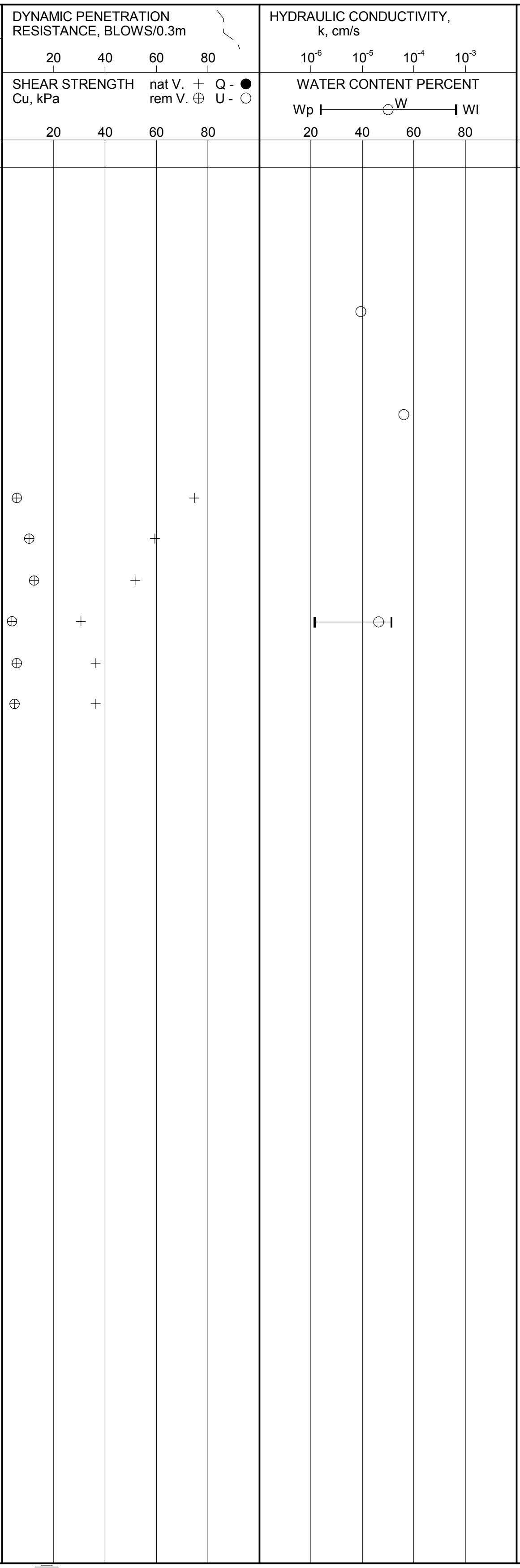
DATUM: Local

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m
GROUND SURFACE				
TOPSOIL	0.00			
Very stiff to stiff grey brown SILTY CLAY (Weathered Crust)	0.30	1	50 DO	7
		2	50 DO	4
Firm grey SILTY CLAY	3.05	3	50 DO	
Loose to compact grey SILTY SAND, some gravel, with cobbles (GLACIAL TILL)	3.96	4	50 DO	8
		5	50 DO	22
Loose grey fine to medium SAND	5.18	6	GRAB	-
End of Borehole	5.49			



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: PAH

CHECKED: ______

PROJECT: 10-1121-0264

RECORD OF BOREHOLE: BH 11-2A

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: January 28, 2011

DATUM: Local

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

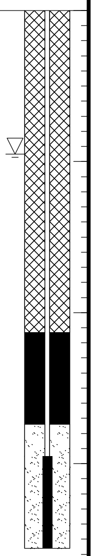
SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ : 20 40 60 80

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

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

ADDITIONAL LAB. TESTING

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE					
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL	0.00				
		Very stiff to stiff grey brown SILTY CLAY (Weathered Crust)	0.30				
1							Native Backfill
2							Bentonite Seal
3							Silica Sand
		Firm grey SILTY CLAY	3.05				Standpipe
				1	88 TP	PH	
		End of Borehole Note: Soil profile inferred from RECORD OF BOREHOLE BH 11-2.	3.56				W.L. in Standpipe at 0.95 m depth below ground surface on February 7, 2011
4							
5							
6							
7							
8							
9							
10							



DEPTH SCALE

1 : 50

LOGGED: PAH

CHECKED: ______

PROJECT: 10-1121-0264

RECORD OF BOREHOLE: BH 11-3

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: January 25, 2011

DATUM: Local

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES: 0 – 10

BORING METHOD: Power Auger, 200 mm Diam. (Hollow Stem) (0 – 5.79 m)

SOIL PROFILE

DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	
TOPSOIL	0.00
Very stiff grey brown SILTY CLAY (Weathered Crust)	0.25
Loose to compact grey brown SANDY SILT, some gravel, with cobbles (GLACIAL TILL)	1.22
Loose grey SANDY SILT, some gravel, with cobbles (GLACIAL TILL)	2.29
Loose grey fine to medium SAND	4.57
Loose to compact grey SANDY SILT, some gravel, with cobbles (GLACIAL TILL)	4.88
End of Borehole	5.79

SAMPLES

NUMBER	TYPE	BLOWS/0.30m
1	50 DO	6
2	50 DO	18
3	50 DO	8
4	50 DO	8
5	50 DO	9
6	50 DO	27

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

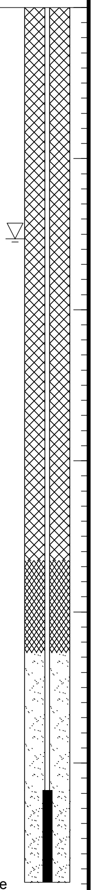
SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ : 20 40 60 80

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



Native Backfill

Bentonite Seal

Silica Sand

Standpipe

W.L. in Standpipe at 1.53 m depth below ground surface on February 7, 2011

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: PAH

CHECKED: _______

PROJECT: 10-1121-0264

RECORD OF BOREHOLE: BH 11-4

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: January 28, 2011

DATUM: Local

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									
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL		0.00							
		Very stiff to stiff grey brown SILTY CLAY (Weathered Crust)		0.22							
1					1	50 DO	6				
2					2	50 DO	2	⊕ +			
		Loose grey SANDY SILT, some gravel (GLACIAL TILL)		2.51	3	50 DO	7				
3					4	50 DO	5				
		End of Borehole		3.66							
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: PAH

CHECKED: ______

PROJECT: 10-1121-0264

RECORD OF BOREHOLE: BH 11-5

SHEET 1 OF 1

LOCATION: See Site Plan

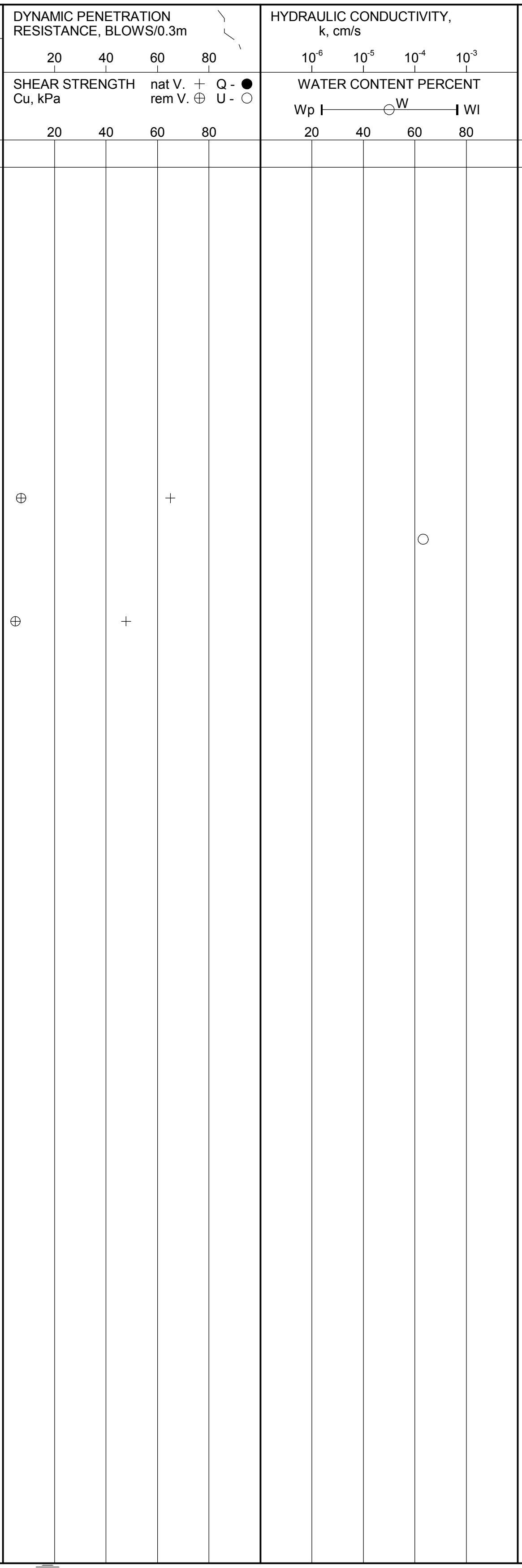
BORING DATE: January 25, 2011

DATUM: Local

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m
	GROUND SURFACE					
Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL		0.00			
	Very stiff to stiff grey brown SILTY CLAY, some sand seams (Weathered Crust)		0.25	1	50 DO	7
				2	50 DO	2
	Stiff grey SILTY CLAY, some silt seams		2.59	3	50 DO	WH
	Loose to very loose grey SANDY SILT, some gravel (GLACIAL TILL)		3.51	4	50 DO	5
				5	50 DO	2
	End of Borehole		5.18			



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

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

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: PAH

CHECKED: ______

PROJECT: 10-1121-0264

RECORD OF BOREHOLE: BH 11-6

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: January 28, 2011

DATUM: Local

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m
		GROUND SURFACE					
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL		0.00			
		Very stiff to stiff grey brown SILTY CLAY (Weathered Crust)	▨	0.25			
2					1	50 DO	5
		End of Borehole		3.35			

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

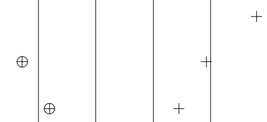
SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ : 20 40 60 80

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



DEPTH SCALE

1 : 50

Golder Associates

LOGGED: PAH

CHECKED: _______

PROJECT: 1523645

RECORD OF BOREHOLE: 15-7

SHEET 1 OF 2

LOCATION: N 5013739.7 ;E 364291.3

BORING DATE: August 12, 2015

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

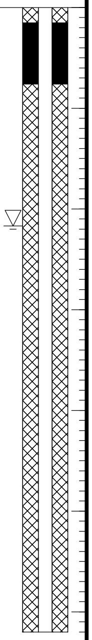
DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

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

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

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

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	92.84					
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML/SM) sandy SILT to SILTY SAND; dark brown; moist	0.00	1	AS	-		Native Backfill
		(SM) gravelly SILTY SAND; grey brown, with oxidation staining, presence of cobbles and boulders inferred from auger resistance (GLACIAL TILL); non-cohesive, moist to wet, compact to very dense	92.56 0.28					Bentonite Seal
1				2	SS	>50		
2				3	SS	17		▽
3				4	SS	46		
		(SM) SILTY SAND, fine, trace gravel; brown; non-cohesive, wet, compact	89.64 3.20	5	SS	12		Native Backfill
4		(SM) gravelly SILTY SAND; grey (GLACIAL TILL); non-cohesive, wet, compact	88.72 4.12	6	SS	22	M	
5				7	SS	21		
		(ML) gravelly sandy SILT; grey (GLACIAL TILL); non-cohesive, wet, compact	87.81 5.03	8	SS	11		
6			86.64	9	SS	>50		
		Borehole continued on RECORD OF DRILLHOLE 15-7	6.2					
7								
8								
9								
10								
11								
12								
13								
14								
15								



DEPTH SCALE

1 : 75

LOGGED: PAH

CHECKED: SD

PROJECT: 1523645

RECORD OF DRILLHOLE: 15-7

SHEET 2 OF 2

LOCATION: N 5013739.7 ;E 364291.3

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: August 12, 2015

DRILL RIG: CME 850

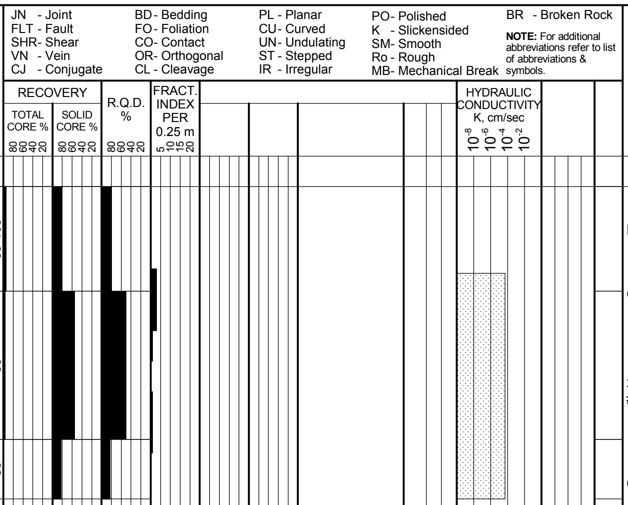
DRILLING CONTRACTOR: Marathon Drilling

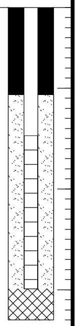
DATUM: CGVD28

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

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

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN FLUSH	
		BEDROCK SURFACE	86.64			
7	Rotary Drill NQ Core	Fresh, thinly to medium bedded, grey LIMESTONE	6.20	1	85-100	Peltonite Seal
						Granitic Sand
8				2	85	32 mm Diam. PVC #10 Slot Screen
9			83.54 9.30	3	85	Cave
		End of Drillhole				WL in Screen at Elev. 90.67 m on Aug. 24, 2015
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						





DEPTH SCALE

1 : 75

LOGGED: PAH

CHECKED: SD

PROJECT: 1523645

RECORD OF BOREHOLE: 15-8

SHEET 1 OF 2

LOCATION: N 5013747.0 ;E 364141.5

BORING DATE: August 11-12, 2015

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

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

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

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

PIEZOMETER OR STANDPIPE INSTALLATION

BORING METHOD	SOIL PROFILE – DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
	GROUND SURFACE	92.19				
Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (CL/ML) CLAYEY SILT; dark brown; moist	0.00	1	AS	-	
	(CI) sandy SILTY CLAY; grey brown, contains silty sand seams (WEATHERED CRUST); cohesive, w>PL, very stiff	0.20	2	SS	6	
	(SM) gravelly SILTY SAND; grey brown, presence of cobbles and boulders inferred from auger resistance (GLACIAL TILL); non-cohesive, wet, compact	90.88 1.31	3	SS	19	
	(SM) gravelly SILTY SAND; grey (GLACIAL TILL); non-cohesive, wet, very loose to compact	90.06 2.13	4	SS	2	
			5	SS	3	
			6	SS	1	MH
			7	SS	2	
			8	SS	5	
			9	SS	5	
			10	SS	10	
	(SM) gravelly SILTY SAND; dark grey, presence of cobbles and boulders inferred from auger resistance (GLACIAL TILL); non-cohesive, wet, dense to very dense	84.57 7.62	11	SS	48	M
			12	SS	90	
	Borehole continued on RECORD OF DRILLHOLE 15-8	83.30 8.89				

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

MIS-BHS 001 1523645.GPJ GAL-MIS.GDT 09/23/15 JM

DEPTH SCALE

1 : 75

Golder Associates

LOGGED: PAH

CHECKED: SD

PROJECT: 1523645

RECORD OF DRILLHOLE: 15-8

SHEET 2 OF 2

LOCATION: N 5013747.0 ;E 364141.5

DRILLING DATE: August 11-12, 2015

DATUM: CGVD28

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 850

DRILLING CONTRACTOR: Marathon Drilling

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

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

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN FLUSH	RECOVERY TOTAL CORE % 80 60 40 20	RECOVERY SOLID CORE % 80 60 40 20	R.Q.D. % 80 60 40 20	FRACT. INDEX PER 0.25 m 5 10 15 20	HYDRAULIC CONDUCTIVITY K, cm/sec 10^{-8} 10^{-6} 10^{-4} 10^{-2}
		BEDROCK SURFACE		83.30							
9	Rotary Drill NQ Core	Fresh, thinly to medium bedded, grey LIMESTONE		8.89	1	100					
10				81.52 10.67	2	100					
11		End of Drillhole									
12											
13											
14											
15											
16											
17											
18											
19											
20											
21											
22											
23											

MIS-RCK 004B 1523645.GPJ GAL-MISS.GDT 09/23/15 JM

DEPTH SCALE
1 : 75

Golder Associates

LOGGED: PAH
CHECKED: SD

PROJECT: 1523645

RECORD OF BOREHOLE: 15-9

SHEET 1 OF 1

LOCATION: N 5013812.4 ;E 364008.0

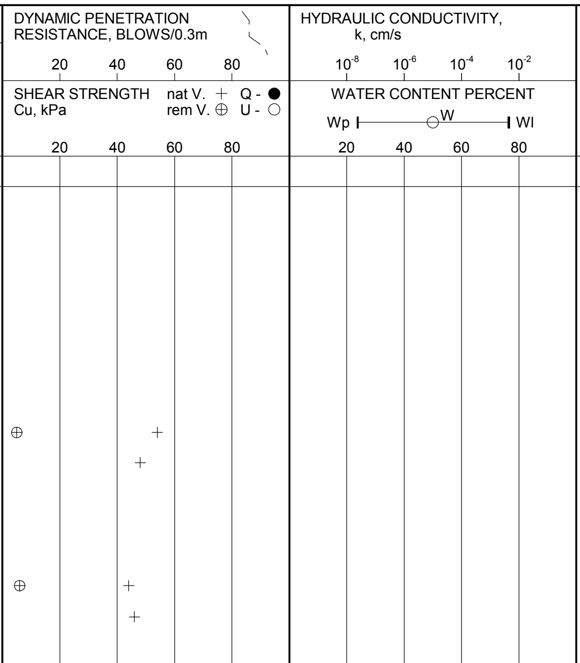
BORING DATE: August 10, 2015

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		92.27					
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) sandy SILT; dark brown; moist		0.00					
		(CI) sandy SILTY CLAY; grey brown, contains silty sand seams (WEATHERED CRUST); cohesive, w>PL, very stiff		0.22					
1					1	SS	4		
2					2	SS	1		
		(CI/ML) SILTY CLAY to CLAYEY SILT; grey; cohesive, w>PL, firm to stiff		89.83 2.44					
3					3	SS	2		
4		Probable Glacial Till		87.95 4.32					
		End of Borehole Auger Refusal on Probable Boulder		4.50	4	SS	>50		
5		Note:							
		Refer to Record of Borehole 15-9A for deeper stratigraphy.							
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									



DEPTH SCALE

1 : 75

Golder Associates

LOGGED: PAH

CHECKED: SD

MIS-BHS 001 1523645.GPJ GAL-MIS.GDT 09/23/15 JM

PROJECT: 1523645

RECORD OF BOREHOLE: 15-9A

SHEET 1 OF 1

LOCATION: N 5013812.4 ;E 364008.0

BORING DATE: August 10-11, 2015

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

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

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

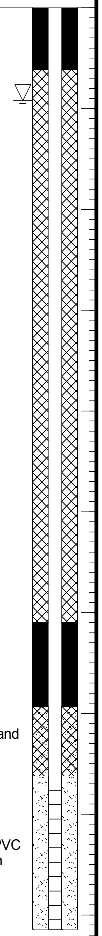
WATER CONTENT PERCENT: Wp ⊢—○W—⊣ Wl : 20 40 60 80

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

SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (m)
GROUND SURFACE	92.27
Refer to Record of Borehole 15-9 for stratigraphy	0.00
(ML) gravelly sandy SILT; grey, presence of cobbles and boulders inferred from auger refusal and auger resistance (GLACIAL TILL); non-cohesive, wet, very loose to compact	87.70 4.57
(SP) gravelly SAND; grey; non-cohesive, wet, loose	84.80 7.47
End of Borehole	83.13 9.14

SAMPLE NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
1	SS	1	
2	SS	2	
3	SS	2	
4	SS	17	
5	SS	6	M
6	AS	-	

PIEZOMETER OR STANDPIPE INSTALLATION



Bentonite Seal

Native Backfill

Bentonite Seal

Native Backfill and Granitic Sand

38 mm Diam. PVC #10 Slot Screen

WL in Screen at Elev. 91.35 m on Aug. 24, 2015

DEPTH SCALE 1 : 75

Golder Associates

LOGGED: PAH

CHECKED: SD

PROJECT: 1523645

RECORD OF BOREHOLE: 15-17

SHEET 1 OF 1

LOCATION: N 5013731.1 ;E 364221.7

BORING DATE: August 11, 2015

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)
		GROUND SURFACE		93.79
0	Power Auger 200 mm Diam. (Hollow Stem)	FILL - (ML) gravelly sandy SILT; dark brown and red brown, contains organic matter; non-cohesive, moist, compact		0.00
1		FILL - (ML) CLAYEY SILT, some gravel; dark grey; cohesive, w>PL		92.57 1.22
2		TOPSOIL - (OL) ORGANIC SILT; black; moist		91.75 2.04
		(ML) gravelly sandy SILT; grey brown, presence of cobbles and boulders inferred from auger resistance (GLACIAL TILL); non-cohesive, wet, compact		2.23
3		(SM) gravelly SILTY SAND; grey, presence of cobbles and boulders inferred from auger resistance (GLACIAL TILL); non-cohesive, wet, compact		90.13 3.66
5		End of Borehole		88.91 4.88

SAMPLES: NUMBER	TYPE	BLOWS/0.30m
1	SS	15
2	SS	15
3	SS	7
4	SS	11
5	SS	24
6	SS	29
7	SS	20
8	SS	13

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

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

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

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

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

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

DEPTH SCALE

1 : 75

Golder Associates

LOGGED: PAH

CHECKED: SD

PROJECT: 1523645

RECORD OF PROBEHOLE: 15-17A

SHEET 1 OF 1

LOCATION: N 5013728.8 ;E 364221.0

BORING DATE: August 12, 2015

DATUM: CGVD28

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	SOIL PROFILE STRATA PLOT	SOIL PROFILE ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-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		93.62							
0	Power Auger 200 mm Diam. (Hollow Stem)	Refer to Record of Borehole 15-17 for stratigraphy		0.00							
1											
2											
3											
4											
5		Probable Glacial Till	▨	88.74 4.88							
		End of Probehole Auger Refusal		88.08 5.54							
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											

DEPTH SCALE

1 : 75

LOGGED: PAH

CHECKED: SD

PROJECT: 1523645

RECORD OF PROBEHOLE: 15-103

SHEET 1 OF 1

LOCATION: N 5013713.1 ;E 364379.7

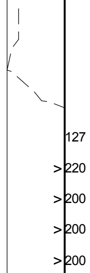
BORING DATE: August 13, 2015

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE 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		94.22							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL		0.00							
		Probable Silty Clay (Weathered Crust)		93.92 0.30							
1		Probable Glacial Till, presence of cobbles and boulders inferred from auger refusal and auger resistance		93.61 0.61							
3	DCPT	Probable Glacial Till		90.87 3.35							
								127			
5								>220			
								>200			
								>200			
6		End of Probehole Auger Refusal at 3.35 m Dynamic Cone Refusal at 5.79 m Note: The AW drill rods used to advance the DCPT were angled upon completion at an incline of about 10 degrees from vertical and were immovable/stuck. The top 1.5 metres was removed, but about 4.5 metres of the drill rods remain in the ground from about 1.5 to 6 metres depth.		88.43 5.79				>200			



DEPTH SCALE
1 : 75

Golder Associates

LOGGED: PAH
CHECKED: SD

PROJECT: 1523645

RECORD OF BOREHOLE: 16-301

SHEET 1 OF 2

LOCATION: N 5013712.6 ;E 364379.1

BORING DATE: March 4-7, 2016

DATUM: CGVD28

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE 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		93.16							
0	Wash Boring NW Casing	Probable Sand		0.00							▽
1		Probable Glacial Till		92.25 0.91							
9				83.36							WL in open borehole at 0.78 m depth below ground surface upon completion of drilling
10		Borehole continued on RECORD OF DRILLHOLE 16-301		9.8							

DEPTH SCALE

1 : 75

Golder Associates

LOGGED: DWM

CHECKED:

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

PROJECT: 1523645

RECORD OF DRILLHOLE: 16-301

SHEET 2 OF 2

LOCATION: N 5013712.6 ;E 364379.1

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: March 4-7, 2016

DRILL RIG: CME 850

DRILLING CONTRACTOR: CCC

DATUM: CGVD28

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

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

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	FLUSH	RECOVERY TOTAL CORE % 80 60 40 20	RECOVERY SOLID CORE % 80 60 40 20	R.Q.D. % 80 60 40 20	FRACT. INDEX PER 0.25 m 5 10 15 20	DISCONTINUITY DATA B Angle 0 90 180 270	DISCONTINUITY DATA DIP w.r.t. CORE AXIS 0 30 60 90	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jcon	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec 10^{-8} 10^{-6} 10^{-4} 10^{-2}	Diametral Point Load Index (MPa) 2 4 6	RMC -Q' AVG.	
		BEDROCK SURFACE		83.36																	
10	Rotary Drill NQ Core	Fresh, thinly to thickly bedded, grey DOLOMITE BEDROCK		9.80	1		100														
11					2		100														
12					3		100														
13		End of Drillhole		80.16 13.00																	WL in open borehole at 0.78 m depth below ground surface upon completion of drilling
14																					
15																					
16																					
17																					
18																					
19																					
20																					
21																					
22																					
23																					
24																					

DEPTH SCALE

1 : 75

Golder Associates

LOGGED: DWM

CHECKED:

PROJECT: 1523645

RECORD OF BOREHOLE: 16-302

SHEET 1 OF 2

LOCATION: N 5013746.6 ;E 364217.4

BORING DATE: March 4, 2016

DATUM: CGVD28

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE 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		93.06							
0	Wash Boring NW Casing	Probable Sand		0.00							
1		Probable Glacial Till		92.15 0.91							
2											
3											
4											
5											
6											
7											
8		Borehole continued on RECORD OF DRILLHOLE 16-302		85.04 8.02							
9											
10											
11											
12											
13											
14											
15											

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

DEPTH SCALE

1 : 75

Golder Associates

LOGGED: DWM

CHECKED:

PROJECT: 1523645

RECORD OF DRILLHOLE: 16-302

SHEET 2 OF 2

LOCATION: N 5013746.6 ;E 364217.4

DRILLING DATE: March 4, 2016

DATUM: CGVD28

DRILL RIG: CME 850

INCLINATION: -90° AZIMUTH: ---

DRILLING CONTRACTOR: CCC

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

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	COLOUR / % RETURN / FLUSH	RECOVERY TOTAL CORE % (80 60 40 20)	RECOVERY SOLID CORE % (80 60 40 20)	R.Q.D. % (80 60 40 20)	FRACT. INDEX PER 0.25 m (5 10 15 20)	DISCONTINUITY DATA B Angle (0 90 180 270)	DIP w.r.t. CORE AXIS (0 30 60 90)	TYPE AND SURFACE DESCRIPTION	Jcon	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec (10^{-8} 10^{-6} 10^{-4} 10^{-2})	Diametral Point Load Index (MPa) (2 4 6)	RMC -Q' AVG.
		BEDROCK SURFACE		85.04															
	Rotary Drill NQ Core	Fresh, thinly to thickly bedded, grey DOLOMITE BEDROCK		8.02	1	100													
9					2	0													
10					3	0													
11				81.86															
		End of Drillhole		11.20															
12																			
13																			
14																			
15																			
16																			
17																			
18																			
19																			
20																			
21																			
22																			
23																			

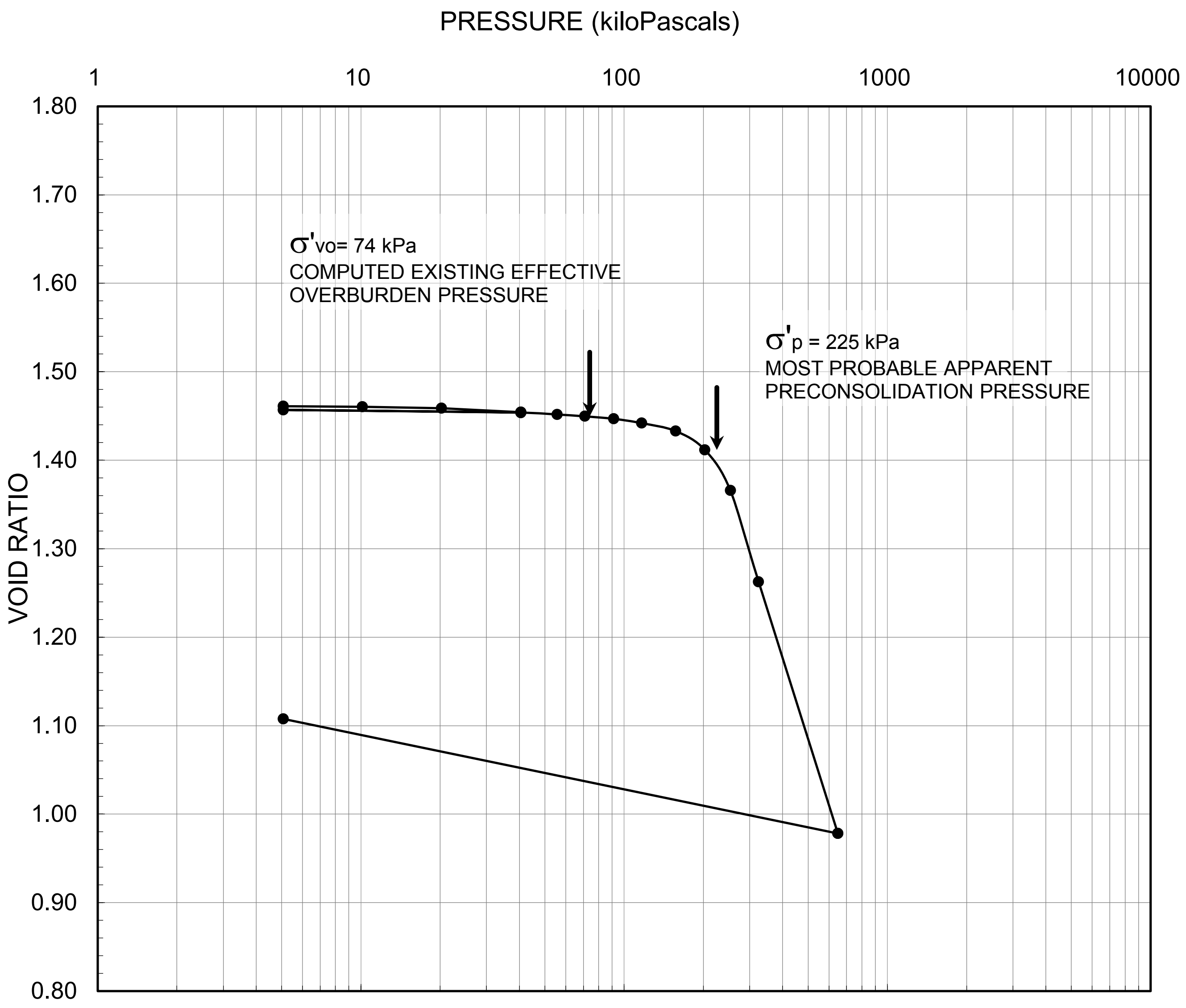
DEPTH SCALE

1 : 75

Golder Associates

LOGGED: DWM

CHECKED:



LEGEND

Borehole: 11-1A	w_i = 51%	S_o = 97%
Sample: 1	w_f = 39%	C_c = 0.95
Depth (m): 3.4	w_l = 61%	C_r = 0.018
	w_p = 23%	

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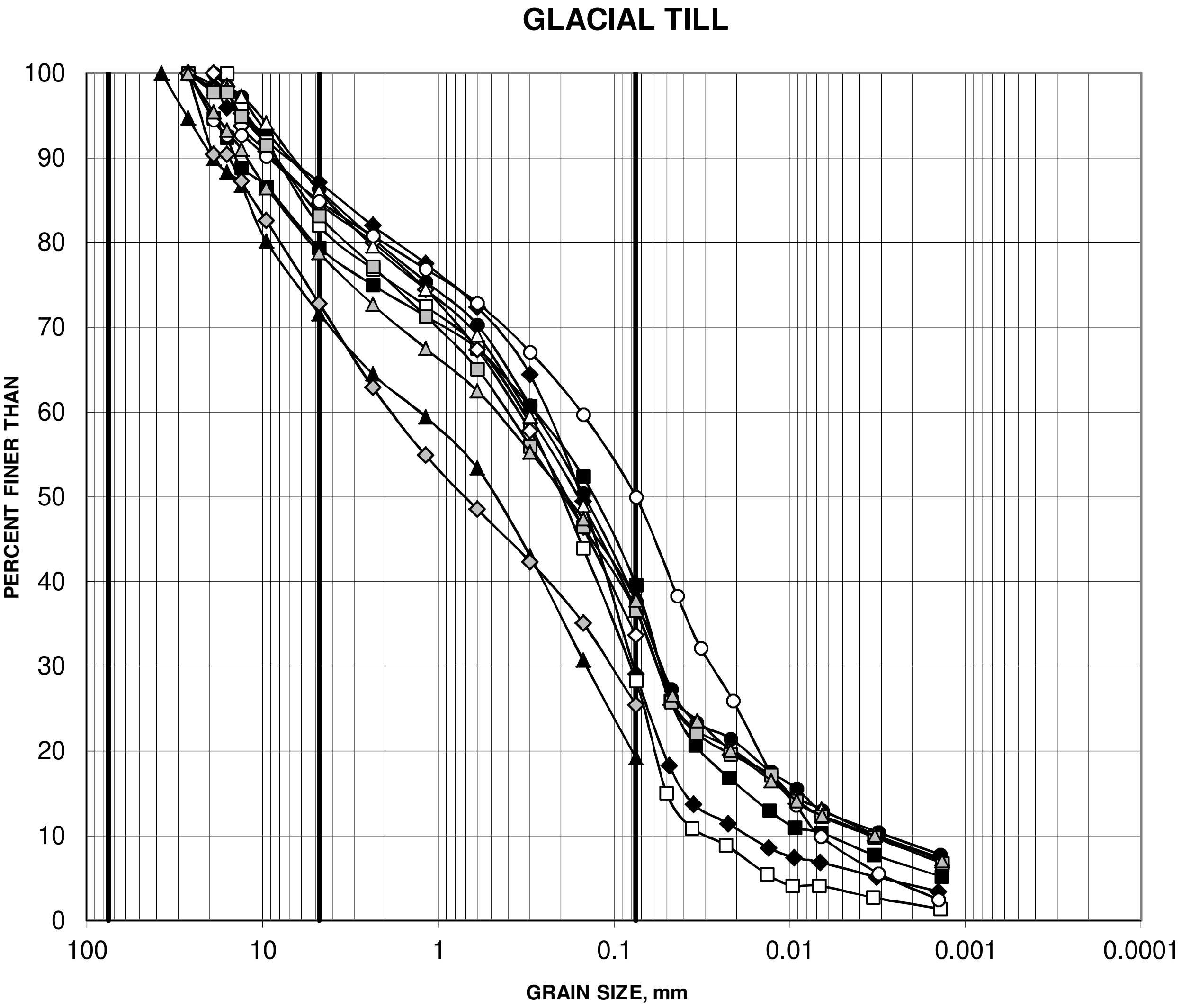
SCALE	AS SHOWN	TITLE	
DATE	04/15/16		
DESIGN	NA		**CONSOLIDATION TEST RESULTS**
CADD	NA		
FILE No.	Consolidation summary	CHECK	
PROJECT No.	10-1121-0264	REV. 0	REVIEW	FIGURE **3**

GRAIN SIZE DISTRIBUTION

FIGURE 5



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

Borehole	Sample	Depth (m)
■ 15-1	10	6.86-7.47
◆ 15-1	12	8.38-8.99
▲ 15-1	14	10.67-11.28
● 15-2	5	2.29-2.90
□ 15-2	12	7.62-7.77
◇ 15-3	7	4.57-5.18
△ 15-3A	5	3.05-3.66
○ 15-6B	9	7.62-8.23
▨ 15-8	6	3.81-4.42
◈ 15-8	11	7.62-8.23
▲ 15-12	13	12.20-12.96

Project: 1523645

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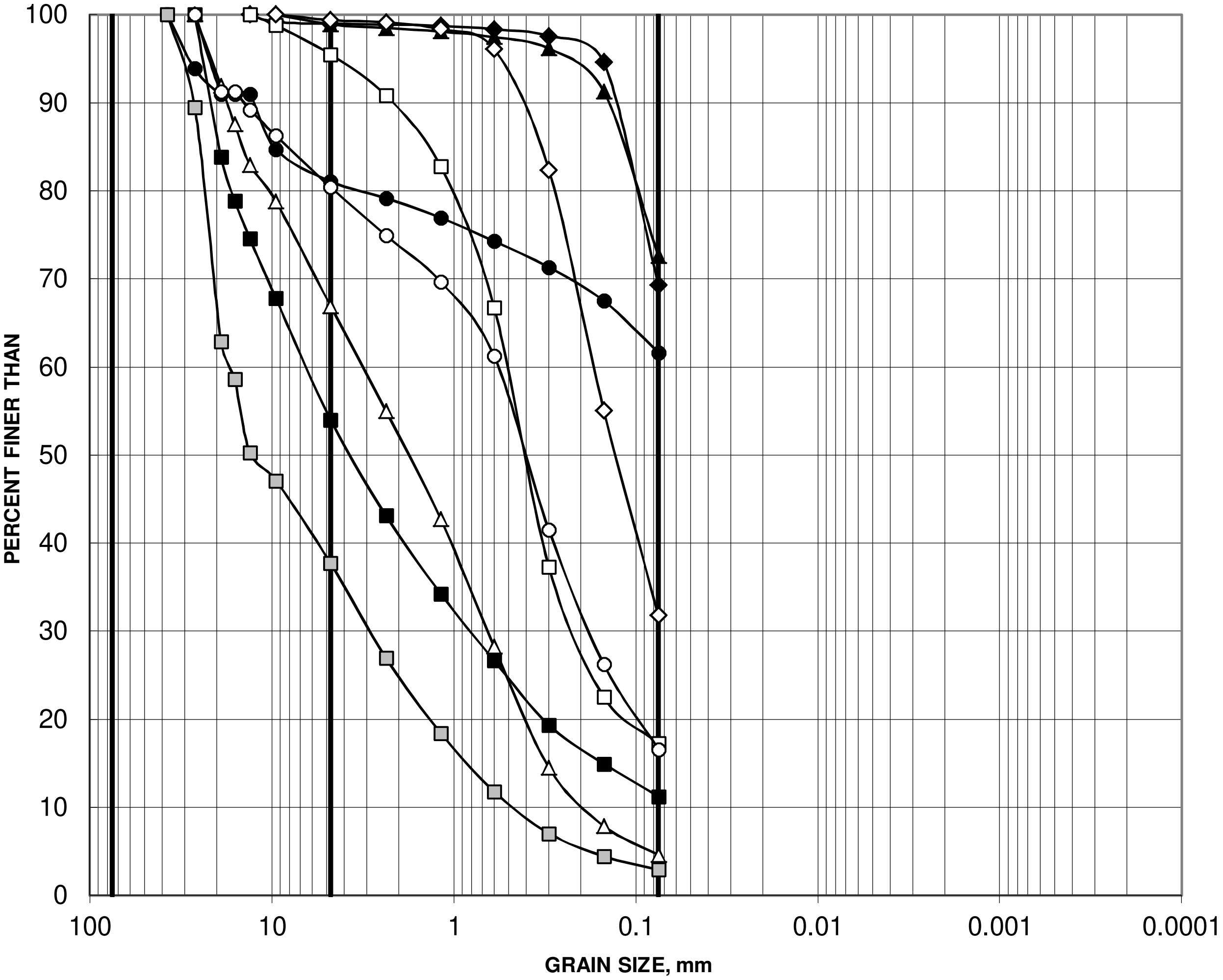
Created by: MI
Checked by: CNM

GRAIN SIZE DISTRIBUTION	FIGURE 6

Interbedded SAND/SILT within Glacial Till



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

Borehole	Sample	Depth (m)
■ 15-2	9	5.34-5.79
◆ 15-4	10	5.98-6.59
▲ 15-5	10	7.62-8.23
● 15-6A	9	7.62-8.23
□ 15-6B	7	4.57-5.18
◇ 15-7	6	3.81-4.12
△ 15-9A	5	7.62-8.23
○ 15-10	9	8.54-9.15
▨ 15-11	9	8.54-9.15

Project: 1523645

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Created by: MI
Checked by: CNM

APPENDIX C

Results of Basic Chemical Analysis
EXOVA Environmental Ontario Report No. 1603027

Certificate of Analysis

Client: Golder Associates Ltd. (Ottawa)
1931 Robertson Road
Ottawa, ON
K2H 5B7
Attention: Ms. Christine Ko
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1603027
Date Submitted: 2016-03-02
Date Reported: 2016-03-08
Project: 1523044/1000
COC #: 805851

				Lab I.D. Sample Matrix Sample Type Sampling Date Sample I.D.	1229119 Soil 2016-02-22 16-105 SA3/2.5-4.5	1229120 Soil 2016-02-22 16-107 SA4/5-6.4
Group	**Analyte**	**MRL**	**Units**	**Guideline**		
Agri. - Soil	pH	2.0			7.4	8.3
General Chemistry	Cl	0.002	%		0.010	0.004
	Electrical Conductivity	0.05	mS/cm		0.33	0.15
	Resistivity	1	ohm-cm		3030	6670
	SO4	0.01	%		<0.01	0.01

Guideline = *** = Guideline Exceedence**

All analysis completed in Ottawa, Ontario (unless otherwise indicated by ** which indicates analysis was completed in Mississauga, Ontario).
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

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