REPORT (REV. 1)

Geotechnical Investigation Barrett Lands - Phase 3

Leitrim Development Area

3100 Leitrim Road, Ottawa, Ontario

Submitted to:

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Table of Contents

FIGURES

APPENDICES

1.0 INTRODUCTION

This report presents the results of a geotechnical investigation carried out for the Barrett Lands – Phase 3 development to be located in Findlay Creek Village at 3100 Leitrim Road in Ottawa, Ontario. It is understood that this geotechnical investigation report is required in support of a development application for the subject property.

The purpose of this geotechnical investigation was to assess the general subsurface conditions at the site by means of a limited number of boreholes and test pits. Based on an interpretation of the factual information obtained, a general description of the soil, bedrock, and groundwater conditions is presented. These interpreted subsurface conditions and available project details were used to provide engineering guidelines on the geotechnical design aspects of the project, including construction considerations which could influence 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

Plans are being prepared for a new residential development to be located at 3100 Leitrim Road in Ottawa, Ontario, referred to herein as Barrett Lands – Phase 3. The project limits for the proposed development are shown on Figure 1. The following information is known about the site and the proposed development:

- The site is bordered to the east by an existing salt dome and farmlands, to the west by Barrett Lands – Phase 2 development, to the north by Leitrim Road and to the south by Hope Cemetery.
- The site is flat and somewhat rectangular in shape and measures approximately 280 m by 400 m.
- The site is currently undeveloped and is used for agricultural purposes.
- Based on the provided preliminary site plan, a new access roadway (called Promenade Barrett Farm Drive) passes through the middle portion of the site in east-west direction, and then will be further extended toward the east of the site (for a total length of about 200 m). This new roadway will be connected to Rotary Way and Bank Street intersection. That 200 m portion of the road is also considered as part of the proposed development.
- The proposed site will be developed into conventional residential housing with the basement levels, along with access roadways.

Golder Associates Ltd. (Golder) carried out a geotechnical investigation for the initial phase of the Leitrim Road development in 2012, which covered the lands to the south of Leitrim Road, between Bank Street and Fenton Road. The results of that investigation were provided in the following report:

- Report to Tartan Development Corporation, titled "*Geotechnical Investigation, Proposed Development, Leitrim Road and Bank Street, Ottawa, Ontario*", dated January 2012 (report No. 11-1121-0198-1000).

Other previous geotechnical investigations were also carried out by Golder for the Barrett Lands – Phase 1, Phase 2 and Findlay Creek Village – Stage 5 developments that are located to the west of the current site. The results of those investigations are contained in the following reports:

- Report to IBI Group, titled "*Geotechnical Investigation, Proposed Residential Development, Barrett Lands, Ottawa, Ontario*", dated February 2018 (report No. 1774599-1000).

- Report to IBI Group, titled "*Geotechnical Investigation, Barrett Lands – Phase 2, 3100 Leitrim Road, Leitrim Development Area, Ottawa, Ontario*", dated December 2019 (report No. 19129142-1000).
- Report to IBI Group, titled "*Geotechnical Investigation, Findlay Creek Village - Stage 5, 3100 Leitrim Road, July* 2020 (report No. 19129142-6000).

The selected records of test pit and borehole from the previous investigations are provided in Appendix B and the corresponding test pit and borehole locations are shown on Figure 1.

Based on a review of the published geological mapping and the previous investigations carried out within and near proposed Phase 3 development, the subsurface conditions at this site are expected to consist of topsoil underlain by layered and variable deposits of clayey silt, silty sand and gravel overlying glacial till which is in turn underlain by bedrock. The depth to bedrock is anticipated to be about 5 to 10 m at this site. The bedrock is mapped as shale of the Carlsbad formation. The shale bedrock underlaying the site is not known to have expansive behaviour.

This interpretation is generally consistent with the results of previous investigations in the area.

3.0 PROCEDURE

The fieldwork for the current geotechnical investigation was carried out from January 11 to 19, 2021. During that time, 16 test pits (numbered TP20-01 to TP20-16) and four boreholes (numbered BH20-01 to BH20-04) were advanced at the approximate locations shown on Figure 1.

The test pits were advanced using a track mounted hydraulic excavator supplied and operated by Glenn Wright Excavating of Ottawa, Ontario. The test pits were excavated to depths ranging from about 2.0 m to 6.1 m below the existing ground surface. Refusal to excavating was encountered at three of the test pits including TP20-07, TP20-09 and TP20-12 at depths ranging from about 2.0 to 4.8 m below the existing ground surface.

The soils exposed on the sides of the test pits were classified by visual and tactile examination. Grab samples were obtained from the major soil strata encountered in the test pits. The groundwater seepage conditions were observed in the open test pits and the test pits were loosely backfilled upon completion of excavating and sampling.

The boreholes (i.e., BH20-01 to BH20-04) were advanced with a track-mounted hollow stem auger drill rig supplied and operated by CCC Geotechnical and Environmental Drilling of Ottawa, Ontario. The boreholes were advanced to refusal depths ranging between about 6.2 m to 6.7 m below the existing ground surface.

In all of the boreholes, Standard Penetration Tests (SPT) were carried out within the overburden at regular intervals of depth in general conformance with ASTM D1586. Soil samples were recovered using 35 mm inside diameter split-spoon sampling equipment.

Standpipe piezometers were installed in boreholes BH20-01 and BH20-03 to allow for subsequent monitoring of groundwater levels at the site as well as to carry out in-situ hydraulic conductivity testing. Groundwater level measurements and hydraulic conductivity testing were carried out on February 03, 2021.

The fieldwork was supervised by a member of our team who logged the boreholes and test pits, directed the in-situ testing, and collected the soil samples retrieved in the boreholes and test pits. The soil samples obtained during the fieldwork were brought to our laboratory for further examination by the project engineer. The laboratory testing included natural water content measurement, grain size distribution and Atterberg Limits tests.

Two samples of soil from test pits 20-06 and 20-10 were submitted to Eurofins Environment Testing for basic chemical analysis related to potential sulphate attack on buried concrete elements and corrosion of buried ferrous elements.

The test pit and borehole locations were selected by IBI Group and subsequently marked in the field and surveyed by Golder personnel. The positions and ground surface elevations at the borehole locations were determined using a Trimble R10 Model 2 Global Navigation Satellite System (GNSS) unit. The Geodetic reference system used for the survey is the North American Datum of 1983 (NAD83). The borehole coordinates are based on the Universal Transverse Mercator (UTM Zone 09) coordinate system. The elevations are referenced to Geodetic datum (CGVD28).

4.0 SUBSURFACE CONDITIONS

4.1 General

The following information on the subsurface conditions is provided in this report:

- Record of Test Pit and Borehole Sheets for the current investigation are provided in Appendix A.
- Record of Test Pit and Borehole Sheets for the previous investigations are provided in Appendix B.
- Laboratory test results for the current investigation are provided in Appendix C.
- Results of the basic chemical analyses are provided in Appendix D.
- Results of hydraulic conductivity testing are provided in Appendix E.

Results of the water content measurements are provided on the corresponding Record of Test Pit and Borehole Sheets.

In general, the subsurface conditions at this site consist of topsoil over layered sandy silt to clayey silt and silty sand, silty clay, silty sand to sandy silt and, sand and gravel, underlain by glacial till over bedrock.

The proposed site of the Barrett Land – Phase 3 project is currently used as a stockpile area to store fill and excavated materials from nearby developments. Several large soil stockpiles were observed across the site during the field investigation. The locations of the test pits and boreholes were selected to avoid these fill materials during the field investigation. Therefore, the quantity and quality of these fill materials were not investigated as part of the current investigation.

The following sections present a more detailed overview of the subsurface conditions encountered during the field investigation.

4.2 Topsoil

Topsoil exists at the ground surface at all of the borehole and test pit locations. The topsoil ranges from about 0.2 to 0.6 m in thickness.

4.3 Silty Clay / Silty Clay to Clayey Silt

Deposits of silty clay and silty clay to clayey silt exist below the layered silt and sand or sand and gravel deposits in test pits TP20-02, TP20-13 and TP20-14. The deposit is unweathered and is grey in colour. The silty clay and silty clay to clayey silt deposits extend to depths ranging from about 2.5 to 5.0 m below the existing ground surface.

The results of measured water content testing carried out on three samples of silty clay and silty clay to clayey silt were between about 27 to 28%. The results of Atterberg limit testing carried out on four samples of these deposits gave plasticity index values ranging from about 5 to 9% and liquid limit values between about 24 to 26%, indicating a low plasticity soil. The results of the Atterberg limit testing are provided on Figure C-1 in Attachment C.

4.4 Sand and Gravel

Sandy silty gravel to gravelly silty sand layers (called herein “Sand and Gravel”) exist below the topsoil in test pits TP20-01 to TP20-08, TP20-10, TP20-11 and TP20-16 and boreholes BH20-01 to BH20-04. The sand and gravel layers contain varying amounts of silt, cobbles and boulders. These deposits were generally encountered within the northern and eastern portions of the site.

The sand and gravel ranges in thickness between about 0.4 and 3.0 m and extend to depths ranging between about 0.7 and 3.3 m below the existing ground surface.

The results of standard penetration tests carried out within these layers gave SPT ‘N’ values ranging from 11 to 17 blows per 0.3 m of penetration, indicating a compact state of packing.

The measured natural water content of five samples of the sand and gravel ranged from about 11 to 17%.

The results of grain size distribution testing carried out on two samples of the sand and gravel are provided on Figure C-2 and C-3 in Appendix C.

4.5 Layered Sandy Silt to Clayey Silt and Silty Sand

Deposits of layered sandy silt to clayey silt, sandy silt to silty sand (called herein layered silt and sand) exist below the topsoil or sand and gravel deposits in all of the test pits and boreholes with the exception of test pit TP20-02. The layered deposits contain varying amounts of gravel, cobbles, and boulders. These deposits range in thickness from about 0.9 to 3.8 m and extend to depths ranging between about 1.5 and 5.5 m below the existing ground surface.

The results of standard penetration tests carried out within these deposits in boreholes BH20-01 to BH20-04 gave SPT ‘N’ values ranging from 10 to 40 blows per 0.3 m of penetration, indicating a loose to dense state of packing.

The measured water contents of seven samples from these deposits varied from 17 to 39%.

4.6 Glacial Till

A deposit of glacial till exists below the silty clay to clayey silt or layered sand and silt deposits in all of the boreholes and test pits with the exception of test pit TP20-12. The glacial till generally consists of a heterogeneous mixture of gravel, cobbles, and boulders in a matrix of sandy silt to silty sand. The glacial till was not penetrated at the test pit and borehole locations but was proven to extend to depths ranging between about 3.8 and 6.7 m beneath the existing ground surface prior to encountering refusal to excavating/augering or termination of the test pits.

The results of standard penetration tests carried out within the glacial till in boreholes BH20-01 to BH20-04 gave SPT ‘N’ values ranging from 12 to greater than 50 blows per 0.3 m of penetration, indicating a compact to very dense state of packing.

The measured natural water content of seven samples from the deposit of glacial till ranged from about 7 to 29%.

The result of grain size distribution testing carried out on one sample of the glacial till is provided on Figure C-4 in Appendix C.

4.7 Refusal

Refusal to excavating or augering was encountered at test pits TP20-07, TP20-09 and TP20-12 and all of the boreholes (i.e., BH20-01 to BH20-04), at depths ranging from about 2.0 to 6.7 m below the existing ground surface. Refusal to excavating or augering could indicate the bedrock surface, or it could have been encountered on large and/or nested boulders in the glacial till or overlying deposits.

The following table summarizes the ground surface, depth of test hole, depth to refusal, and refusal elevations as encountered at the test pit and borehole locations.

Test Pit/Borehole Number	Ground Surface Elevation (m)	Depth of Test hole (m)	End of Test hole Elevation (m)
TP 20-01	97.7	5.5	92.2
TP 20-02	99.5	5.0	94.5
TP 20-03	100.0	5.0	95.0
TP 20-04	97.3	5.0	92.3
TP 20-05	99.1	5.0	94.1
TP 20-06	100.1	5.1	95.0
TP 20-07	100.7	4.8 (refusal)	95.9 (refusal)
TP 20-08	100.4	6.2	94.2
TP 20-09	96.8	3.8 (refusal)	93.0 (refusal)
TP 20-10	97.6	4.0	93.6
TP 20-11	99.4	5.0	94.4
TP 20-12	96.3	2.0 (refusal)	94.3 (refusal)
TP 20-13	97.3	4.0	93.3
TP 20-14	98.5	5.1	93.4
TP 20-15	101.4	5.0	96.4
TP 20-16	104.1	5.0	99.1
BH 20-01	97.8	6.7 (refusal)	91.1 (refusal)
BH 20-02	98.9	6.2 (refusal)	92.7 (refusal)
BH 20-03	100.0	6.2 (refusal)	93.8 (refusal)
BH 20-04	100.7	6.3 (refusal)	94.4 (refusal)

4.8 Groundwater

The groundwater seepage conditions were observed in the test pits during the short time that they remained open. At the time of excavation, some groundwater seepage was observed in all of the test pits (with the exception of TP20-12 and TP20-15) at depths ranging from about 0.8 m to 3.6 m below the existing ground surface.

Groundwater levels were also measured at the monitoring wells installed within boreholes BH20-01 and BH20-03 at depths of about 3.1 m and 1.9 m, respectively.

A summary of the depths and elevations of the groundwater seepage levels observed during the field investigation, as well as monitoring well measurements is provided in the following table:

Test Pit/Borehole Number	Ground Surface Elevation (m)	Groundwater Seepage or Groundwater Depth (m)	Groundwater Seepage or Groundwater Elevation (m)
TP20-01	97.7	1.7	96.0
TP20-02	99.5	2.1	97.4
TP20-03	100.0	2.3	97.7
TP20-04	97.3	1.7	95.6
TP20-05	99.1	1.0	98.1
TP20-06	100.1	2.1	98.0
TP20-07	100.7	1.6	99.1
TP20-08	100.4	1.7	98.7
TP20-09	96.8	3.6	93.2
TP20-10	97.6	1.6	96.0
TP20-11	99.4	2.0	97.4
TP20-12	96.3	N/A[1]	–
TP20-13	97.3	0.8	96.5
TP20-14	98.5	1.5	97.0
TP20-15	101.4	N/A[1]	–
TP20-16	104.1	2.7	101.4
BH20-01	97.8	3.1[2]	94.7
BH20-02	98.9	Not measured	–
BH20-03	100.0	1.9[2]	98.1
BH20-04	100.7	Not measured	–

Note: [1] N/A means no groundwater seepage was observed during the test pit excavation; [2] Groundwater level measured in the monitoring well

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.

Single well hydraulic conductivity testing was completed in boreholes BH20-01 and BH20-03. The hydraulic response testing and groundwater level measurements were carried out on February 03, 2021. Results of the rising head and falling head hydraulic conductivity test analysis are provided in Appendix E. The hydraulic conductivity of the glacial till deposit within borehole BH20-01 was $1x10^{-4}$ cm/s, and in borehole BH20-03 was $9.8x10^{-3}$ cm/s.

4.9 Corrosion Testing

Samples of soils from test pits TP20-06 and PT20-10 were submitted to Eurofins Environment Testing for basic chemical analysis related to potential sulphate attack on buried concrete elements and corrosion of buried ferrous elements. The results of this testing are provided in Appendix D and are summarized below.

Borehole Number/ Sample Number	Sample Depth (m)	Chloride (%)	SO_4 (%)	pH	Resistivity (Ohm-cm)
TP20-06 / Sa 1	2.4 – 2.5	0.003	0.01	8.1	6,250
TP20-10 / Sa 2	1.5 – 1.6	0.003	0.02	8.0	2,860

5.0 DESIGN AND CONSTRUCTION CONSIDERATIONS

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 available information described herein and project requirements. Contractors bidding on or undertaking the works should examine the factual results of the investigation, satisfy themselves as to the adequacy of the factual information for construction, and make their own interpretation of the factual data as it affects their proposed construction techniques, schedule, safety, and equipment capabilities.

Reference should be made 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 at this site generally consist of topsoil over layered and variable deposits of clayey silt to silt clay, clayey silt to silt, silty sand, sandy gravel and gravely sand, underlain by glacial till over bedrock. Refusal to excavating (or augering) was encountered at a few of the test hole locations at depths ranging from about 2.0 m to 6.7 m below the existing ground surface.

No practical restrictions apply to the thickness of grade raise fill which may be placed on the site from a foundation design perspective. However, grade raises in excess of 3.5 m should be reviewed and approved by Golder.

As a general guideline regarding the site grading, the preparation for filling of the site should include stripping any topsoil, fill (if encountered), and organic matter to improve the settlement performance of structures and services. Topsoil, fill and organic matter are not suitable as general fill and should be stockpiled separately for re-use in landscaping applications only. In areas with no proposed structures, services, or roadways, these materials may be left in-place provided some settlements of the ground surface following filling can be tolerated.

Groundwater seepage was generally encountered at depths ranging from about 0.8 m to 3.6 m below the existing ground surface. Significant groundwater flow should be expected for excavations that extend below the groundwater level. Therefore, consideration should be given to setting the grading in order to limit the required depths of excavation (particularly for basements) since groundwater management requirements and costs increase with excavation depth below the groundwater level. It would be preferred from a geotechnical perspective to limit the depths of excavations to no more than about 1.0 m below the existing ground surface. Continuous significant groundwater inflow to the basement drainage system would also ideally be avoided.

The grading should also ideally be selected to avoid or limit excavations in bouldery glacial till and or bedrock during the basement construction, particularly along the southwestern extent of the site, where shallow refusal on large boulders or bedrock was encountered.

5.3 Material Reuse

The native soils are not considered to be generally suitable for reuse as structural/engineered fill. Within foundation areas, imported engineered fill should be used.

The native sand and gravel and coarse-grained glacial till may be suitable for use as controlled fill beneath pavement areas, provided they are not too fine grained and wet to place and compact. The native clayey silt to silty clay, silty clay, sandy silt to silty sand may be too fine grained and wet to feasibly be used as controlled fill. These materials could however be reused in non-structural areas (i.e., landscaping).

5.4 Foundations

5.4.1 Residential Buildings

The undisturbed, inorganic overburden soils encountered at the site are considered to be suitable for supporting conventional residential houses (with basements). Topsoil and fill (if encountered) would not be considered suitable to support the house foundations. The test pit locations as part of the current investigation were selected along the proposed future roadways throughout the site based on the provided preliminary site plan by IBI Group, and as such no loose and disturbed/reworked native materials are anticipated to present within the proposed residential house footprints.

As noted above, the site of the proposed Barrett Land – Phase 3 development is currently used as a stockpile area to store large volumes of fill materials. These materials should be removed from the underside of the future buildings and roadways to avoid post-construction settlements. If it is decided to use these materials as grade raise fill on this site, a qualified geotechnical engineer should be retained to assess the suitability of these materials for the grade raise fill application, and also to document the quantity, thickness and compaction process of such materials across the site.

Strip and pad footing foundations may be designed using a maximum allowable bearing pressure (i.e., Serviceability Limit States, SLS, bearing resistance) of 75 kPa. As such, the house footings may be sized in accordance with Part 9 of the Ontario Building Code (OBC). The Ultimate Limit States bearing resistance may be taken as 150 kPa, for footings up to 1.0 m in width, if needed for design.

Any unsuitable or disturbed material below the underside of the footing elevations should be removed and replaced with engineered fill. The engineered fill should consist of Ontario Provincial Standard Specification (OPSS) Granular B Type II, placed in maximum 300 mm thick lifts, and compacted to at least 95% of the material’s Standard Proctor Maximum Dry Density (SPMDD) using suitable vibratory compaction equipment. The engineered fill material must be placed within the full zone of influence of the building foundations. The zone of influence is considered to extend out and down from the edge of the perimeter footings at a slope of 1 horizontal to 1 vertical (1H:1V).

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

The overburden materials on this site, in particular the glacial till deposit, contain cobbles and boulders. Any cobbles or boulders in footing areas which are loosened by the excavation process should be removed (and not pushed back into place) and the cavity filled with lean concrete or compacted engineered fill. Otherwise, recompression of the disturbed soils could lead to larger than expected post-construction settlements.

5.4.2 Thrust Restraint

Concrete thrust block structures (for the watermain construction) are anticipated to be founded on silty clay to clayey silt, layered silt and sand, sand and gravel deposit or glacial till, depending on the founding elevation of the watermain invert.

Thrust restraint for the watermain could be provided either by means of friction between the watermain pipe and the granular bedding (restrained joints) or by thrust blocks.

For design purposes, a coefficient of friction of 0.25 may be used between the granular pipe bedding and the watermain, assuming that the pipe bedding and surround are adequately compacted in place and in intimate contact with the pipe.

The allowable bearing pressure for thrust blocks installed within compacted granular backfill and/or bearing on the native soils (i.e., silty clay to clayey silt, layered silt and sand, sand and gravel deposit or glacial till) may be taken as 100 kPa. Thrust blocks should not be designed to bear against uncompacted fill materials.

Due to the low tolerance for pipe movement, the grade raise fill materials that will be placed on the site are not considered suitable to provide adequate lateral resistance for the thrust blocks. If encountered, these materials should be excavated from behind the thrust block and replaced with engineered fill. The extent of the material replacement will depend on the size of the block, required lateral resistance, and allowable movement. It should be noted that the extent of the material replacement could be in the order of 5 to 6 m beyond the thrust block, which may not be feasible and is likely impractical. Alternatively, the thrust block could be keyed into the underlying competent native glacial till or bedrock. The dimension of the key will depend on the location, depth, size, and design load of the block. Further guidelines on thrust block design can be provided if required.

6.0 SEISMIC DESIGN CONSIDERATIONS

The seismic design provisions of the 2012 Ontario Building Code (OBC) depend, in part, on the shear wave velocity of the upper 30 m of soil and/or bedrock below the founding level. Based on the 2012 Ontario Building Code methodology, this site can be assigned a Site Class of D.

Although the seismic Site Class is not directly applicable to structures designed in accordance with Part 9 of the OBC (i.e., conventional housing), this assessment is provided to address City of Ottawa requirements that relate to housing on Site Class E sites.

A more favourable Site Class value (i.e., C or B) could potentially be assigned for the site if shear wave velocity testing were carried out.

The soils at this site are not considered to be liquefiable.

6.1 Foundation Excavations

Excavations for basements and foundations will be made through the overburden deposits, glacial till and/or bedrock. Depending on the final grading plan for the proposed development, bedrock might be encountered during basement excavations, likely along the southwestern extent of the site. Practical refusal to excavating was encountered at depths varying from approximately 2.0 to 6.7 m below the existing ground surface at a few of the test pit and borehole locations.

No unusual problems are anticipated with excavating the overburden materials using large hydraulic excavating equipment, recognizing that significant cobble and boulder removal should be expected in the glacial till and some of the overlaying silt and sand deposits. Boulders larger than 0.3 m in diameter should be removed from the excavation side slopes for worker safety.

If required, shallow depths of bedrock removal could be accomplished using mechanical methods (such as hoe ramming in conjunction with line drilling). Deeper excavations into bedrock would likely require blasting. Further details on blasting are provided in Section 5.11.1 of this report.

Above the water table, side slopes should be stable in the short term at 1 horizontal to 1 vertical (Type 3 soil in accordance with the Occupational Health and Safety Act of Ontario (OHSA)). Below the water table, side slopes of 3 horizontal to 1 vertical or flatter (Type 4 soil in accordance with the OHSA) will be required to prevent sloughing of the sandier soils.

Near-vertical excavation side slopes in the bedrock, if encountered, should be feasible.

It is expected that it should be possible to handle the groundwater inflow by pumping from well filtered sumps in the excavations, provided that the excavations extend no deeper than about 1.0 m to 1.5 m below the existing ground surface, particularly within the eastern portion of the site.

For excavations that need to be carried out below the groundwater level, some sloughing of excavation side slopes and/or disturbance of the base of the excavations can be anticipated. Pre-drainage of the site using ditching or several shallow wells to lower the groundwater level to at least 0.5 m below the base of the excavations would assist in reducing the potential for side slope instability and subgrade disturbance.

Consideration will also need to be given to providing a working pad over the native subgrade to protect it from disturbance (e.g., a mud slab of lean concrete or a 0.3 m thick pad of OPSS Granular A or B Type II, possibly underlain by a geotextile).

Consideration should be given at the time of tender of the basement excavation work to carrying out test excavations in the presence of bidders so that the actual excavation conditions and days of groundwater inflow can be assessed.

A Permit-To-Take-Water (PTTW) is required from the Ministry of the Environment, Conservation and Parks (MECP) if a volume of water greater than 400,000 litres per day is pumped from the excavations. If the volume of water to be pumped will be less than 400,000 litres per day, but more than 50,000 litres per day, the water taking will not require a PTTW, but will need to be registered in the Environmental Activity and Sector Registry (EASR) as a prescribed activity.

PTTW No. 3480-AQ5Q7R (expiring August 31, 2027) has been obtained from the MECP for this development.

6.2 Basement and Garage Floor Slabs

In preparation for the construction of the basement floor slabs, all loose, wet, and disturbed materials as well as fill materials (if encountered) should be removed from beneath the floor slab. Provision should be made for at least 200 mm of 19 mm crushed clear stone to form the base of the basement floor slabs. The underslab fill should be compacted to at least 95% of the material's SPMDD.

The recommended type of drainage system required (perimeter drains and/or underfloor drains; damp-proofing or water-proofing) depends upon the proposed basement founding elevations, soil types in the area and actual stabilized groundwater levels. As a general guideline, to prevent hydrostatic pressure build up beneath the basement floor slabs, it is suggested that the granular base for the floor slabs be positively drained. This can be achieved by providing a hydraulic link between the underfloor fill and the exterior drainage system.

The groundwater level was observed to be at about 0.8 m to 3.6 m below the existing ground surface. From a constructability perspective, excavations below the groundwater level should ideally be limited/avoided. Raising of site grades in areas with a high water table would be beneficial in reducing the water control measures for foundation construction. Similarly, since significant and sustained groundwater inflow into the foundation drainage system would ideally be avoided, the founding depths should be set above the groundwater level.

However, if/where the groundwater level is encountered above subgrade level, a geotextile could be required between the clear stone underslab fill and the sandy subgrade soils, to avoid loss of fine soil particles from the subgrade soil into the voids in the clear stone and ultimately into the drainage system. In the extreme case, loss of fines into the clear stone could cause ground loss beneath the slab and plugging of the drainage system. Where a geotextile is required, it should consist of a Class II non-woven geotextile with a Filtration Opening Size (FOS) not exceeding about 100 microns, in accordance with OPSS 1860.

The garage backfill should be placed in maximum 300 mm thick lifts and be compacted to at least 95% of the material's SPMDD using suitable compaction equipment.

The granular base for the garage floor slabs should consist of at least 150 mm of Granular A compacted to at least 95% of the material's SPMDD using suitable compaction equipment.

6.3 Frost Protection

The native subgrade soils on this site are considered to be highly frost susceptible. Therefore, all exterior perimeter foundation elements or foundation elements in unheated areas should be provided with a minimum of 1.5 m of earth cover for frost protection purposes. Isolated, unheated exterior footings adjacent to surfaces which are cleared of snow cover during winter months should be provided with a minimum of 1.8 m of earth cover. Houses with conventional depth basements would satisfy these requirements.

6.4 Basement Walls and Foundation Wall Backfill

The soils at this site are highly frost susceptible and should not be used as a backfill directly against exterior, unheated or well insulated foundation elements. To avoid problems with frost adhesion and heaving, these foundation elements should be backfilled with non-frost susceptible sand or sand and gravel conforming to the requirements for OPSS Granular B Type I or, alternatively, a bond break such as the Platon system sheeting could be placed against the foundation walls.

Drainage of the basement wall backfill should be provided by means of a perforated pipe subdrain in a surround of 19 mm 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 the design of basement walls in accordance with Part 4 of the 2012 Ontario Building Code 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 21.5 kN/m^3; and,

H = The height of the basement wall in metres.

If Platon System sheeting or a 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.

6.5 Sewers, Watermains and Site Servicing

It is understood that the future sewers, watermains and site serving will be located along the future residential streets within the development as well as Promenade Barrett Farm Drive at depths ranging typically between 4.5 and 6.5 m below the existing ground surface.

For the general site servicing along the future residential streets, the subsurface conditions within the development generally consist of topsoil over layered and variable deposits of sandy silt to clayey silt, silty clay, silty sand, sandy gravel and gravely sand, underlain by glacial till over bedrock. Refusal to excavating or augering was encountered at a few of the test hole locations at depths ranging from about 2.0 to 6.7 m below the existing ground surface.

Groundwater seepage in the test pits and groundwater levels in boreholes were observed at depths ranging between about 0.8 m and 3.6 m below the existing ground surface.

6.5.1 Excavations

Excavations for the installation of the site servicing would be generally through topsoil, overburden deposits, glacial till and/or bedrock.

No unusual problems are anticipated with trenching in the overburden using conventional hydraulic excavating equipment, recognizing that cobbles and boulders should be expected within the overburden soils. Boulders larger than 0.3 m in size should be removed from excavation side slopes for worker safety.

The soils above the groundwater table would generally be classified as a Type 3 soil in accordance with the OHSA. As such, these excavations may be made with side slopes at 1 horizontal to 1 vertical. Where trenches for the installation of services extend into the wet silt and sand deposits, the excavation side slopes would need to be no steeper than 3H:1V (Type 4 soil). Alternatively, the excavations could be carried out using steeper side slopes with all manual labour carried out within a fully braced, steel trench box for worker safety.

Based on the results of hydraulic conductivity testing, some groundwater inflow into the trenches should be expected. Higher groundwater seepage is anticipated from the glacial till and upper portion of the bedrock.

However, it should be possible to handle the groundwater inflow by pumping from well filtered sumps established in the floor of the excavations, provided suitably sized and multiple pumps are used.

The actual rate of groundwater inflow into the trench will depend on many factors including the contractor's schedule and rate of excavation, the size and depth of the excavation, and the time of year at which the excavation is carried out. There may also be instances where significant volumes of precipitation collect in an open excavation and must be pumped out.

If required, it is expected that the bedrock removal for this project will be carried out using drill and blast techniques. Mechanical methods of rock removal (such as hoe ramming) can likely be carried out for depths of about one metre; however, this work would likely be slow and tedious.

Near vertical trench walls in the bedrock should stand unsupported for the construction period.

If blasting is used, it should be controlled to limit the peak particle velocities at all adjacent structures or services such that blast induced damage will be avoided. This will require blast designs by a specialist in this field.

A pre-blast survey should be carried out of all of the surrounding structures and services. Selected existing interior and exterior cracks in the structures should be identified during the pre-blast survey and should be monitored for lateral or shear movements by means of pins, glass plate telltales and/or movement telltales.

The contractor should be limited to only small controlled shots. The following frequency-dependent peak vibration limits at the nearest structures and services are suggested.

Frequency Range (Hertz)	Vibration Limits (mm/s)
< 10	5
10 to 40	5 to 50 (sliding scale)
> 40	50

These limits should be practical and achievable on this project.

It is recommended that the monitoring of ground vibration intensities (peak ground vibrations and accelerations) from the blasting operations be carried out both in the ground adjacent to the closest structures and within the structures themselves.

If excavations are made through the bedrock, the groundwater inflow from the bedrock will at first be relatively significant. That inflow may potentially diminish with time and continued pumping, but some form of active dewatering could be required (such as pumping from wells) and the groundwater level lowered in advance of excavation and construction. For example, pumping from several sumps which are excavated into the bedrock and to below the invert level should be considered (in advance of construction).

6.5.2 Bedding and Backfill

At least 150 mm of OPSS Granular A should be used as pipe bedding for sewer and water pipes. Where bedrock is present at the invert level, the bedding should be thickened to 300 mm. 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% of the material's SPMDD. 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 silty/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 mm above the top of the pipe, should consist of OPSS Granular A or Granular B Type I with a maximum particle size of 25 mm. The cover material should be compacted to at least 95% of the material’s SPMDD.

It should generally be possible to re-use the native overburden materials and glacial till as trench backfill. 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 m depth) should match the soil exposed on the trench walls for frost heave compatibility. Trench backfill should be placed in maximum 300 mm thick lifts and should be compacted to at least 95% of the material’s SPMDD using suitable compaction equipment.

The high moisture content of the layered sandy silt to clayey silt, clayey silt to silty clay and silty clay materials below the water table makes these soils difficult to handle and compact. If wet clayey and silty materials are excavated during installation of the site services, these materials should be wasted or should only be used as a backfill in the lower portion of the trenches to limit the amount of long-term settlement of the roadway surface.

Impervious dykes or cut-offs should be constructed in the service trenches at 100 m intervals to reduce groundwater lowering at the site due to the “french drain” effect of the granular bedding and surround for the service pipes. The dykes should extend from the base of the sewer trench and fully penetrate the bedding from trench wall to trench wall. Also, they should be at least 1.5 m in width and extend to the top of the cover material or the top of bedrock (whichever is higher). Dykes partly or wholly within bedrock should be constructed of low strength concrete; dykes entirely within native soil may be constructed using relatively dry (i.e., compactable) grey-brown silty clay from the weathered zone, where it exists, or imported clay.

6.6 Pavement Design

The following provides guidelines for the subdivision pavements.

6.6.1 Profile Grade

It is anticipated that some filling will be carried out to achieve profile grade within the development. Raising the grade within the development is acceptable from a geotechnical point of view.

6.6.2 Subgrade Preparation

The pavement subgrade will generally consist of native subsoil and reworked native subsoil after the installation of services within the subdivision.

As a general guideline, in preparation for pavement construction, all deleterious material (i.e., loose, or disturbed soil or soil containing organic material) should be removed from all pavement areas. Also, all topsoil and fill (if encountered) materials should be removed from underneath the pavement structure. Subgrade then should be proof rolled prior to the placement of any new fill. The purpose of the proof rolling is to provide surficial densification of the existing native subgrade and to locate any isolated areas of soft or loose soil, which would require subexcavation and replacement with suitable fill. This is particularly important where test pits were excavated within the roadway right-of-way. To minimize the potential for disturbance, the general grade should not be cut to the final subgrade level until all services have been installed.

Sections requiring grade raising to the proposed subgrade level should be filled using acceptable (compactable and inorganic) earth borrow (OPSS.MUNI 206/212) or Select Subgrade Material (SP F-3147). All fill should be placed in maximum 300 mm thick lifts and should be compacted to at least 95% of the material's SPMDD using suitable vibratory compaction equipment.

6.6.3 Pavement Drainage

The subgrade surface should be crowned or sloped to promote drainage of the roadway granular structure. Perforated pipe subdrains should be provided along the low sides of the roadway, at each catchbasin, extending a minimum of 3 m from the catchbasin. The subdrains should be installed in accordance with the City of Ottawa Specification F-4050 "Pipe Subdrain" and as per the City of Ottawa Drawing No. R1. The geotextile should consist of a Class I nonwoven geotextile to OPSS 1860. The geotextile should have a maximum Apparent Opening Size (A.O.S.) of 212 µm.

For these urban sections of roadway, the granular base and subbase courses should extend full width to at least 500 mm beyond the back of the curb line. Backfilling of catch basin laterals located below subgrade level should be completed using acceptable native soils or fill that match the material types exposed on the lateral trench walls. This will reduce potential problems associated with differential frost heaving.

6.6.4 Granular Pavement Materials

The granular base and subbase for new construction should consist of Granular A and Granular B Type II (City of Ottawa F-3147), respectfully.

6.6.5 Pavement Design Residential Streets

Traffic volume data was not provided this project. The minimum pavement structure for the residential street as per the City of Ottawa is as follows:

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

The composition of the hot mix asphaltic concrete and the appropriate traffic category levels should be as follows:

- Surface Course: 40 mm Superpave 12.5
- Base Course: 50 mm Superpave 19

The asphaltic concrete should meet the requirements of City of Ottawa specification F-3106. As such, the Performance Graded Asphalt Cement (PGAC) should consist of PG 54-34 and both mixes should be based on Traffic Category B for local roadways and Category C for collector roadways.

The above pavement design is based on the assumption that the pavement subgrade has been acceptably prepared (i.e., where the bottom of the excavation has 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.

6.6.6 Promenade Barrett Farm Drive

The following preliminary pavement design is recommended as a minimum for the Promenade Barrett Farm Drive, in the absence of the design traffic volume. Since this road will be an eastern extension of the Barrett Farm Drive in Barrett Lands – Phase 2 project (which is currently under construction on the west side of the current site), the pavement design for the section of the road in Phase 3 will then need to be reviewed and necessary adjustments to the following pavement design recommendations should be made, if required:

Pavement Component	Thickness (mm)
Asphaltic Concrete	130
Granular O or A Base	150
Granular B Type II Subbase	600

The composition of the hot mix asphaltic concrete and the appropriate traffic category levels should be as follows:

- Surface Course: 40 mm Superpave 12.5
- Base Course: 40 mm + 50 mm Superpave 19

The base course asphaltic concrete should be specified as fine graded in order to place the 40 mm thickness. A tack coat consisting of SS-1 emulsified asphalt diluted with an equal amount of water should be provided between all lifts. The undiluted and emulsified asphalt shall be in conformance with OPSS 1103.

6.6.7 Pavement Structure Compaction

Adequate compaction of the granular roadway materials will be essential to the continued acceptable performance of the roadway. Compaction should be carried out in conformance with procedures outlined in OPSS 501 “Construction Specification for Compacting” with compacted densities of the various materials being in accordance with Subsection 501.08.02 Method A. The granular base and subbase material should be uniformly compacted to at least 100% of the material’s SPMDD using suitable vibratory compaction equipment. Compaction of the asphaltic concrete should be carried out in accordance with OPSS 310, Table 10.

The placement and compaction of any engineered fill, as well as sewer and watermain bedding and backfill, should be inspected to ensure that the materials used conform to the specifications from both grading and compaction viewpoint. In addition, compaction testing and sampling of the asphaltic concrete used on site should be carried out to make sure that the materials used, and level of compaction achieved during construction meet the project requirements.

6.7 Corrosion & Cement Type

One soil sample from each of the test pits TP20-06 and TP20-10 were submitted to Eurofins Environment Testing for basic chemical analysis related to elevated potential sulphate attack on buried concrete elements and corrosion of buried ferrous elements. The results of this testing are provided in Appendix D.

The results indicate that concrete made with Type GU Portland cement should be acceptable for substructures. The results also indicate a moderate potential for corrosion of exposed ferrous metal, which should be considered in the design of substructures.

6.8 Trees

Silty clay or clay soils in some areas in Ottawa are highly sensitive to water depletion by trees of high water demand during periods of dry weather. When trees draw water from the silty clay or clay, the soil undergoes a significant amount of volume change (i.e., shrinkage) which can result in settlement of adjacent structures.

Based on the results of the field investigation, isolated areas of silty clay and silty clay to clayey silt deposits were encountered in test pits TP20-02, TP20-13 and TP20-14.

Results of the Atterberg limit testing are provided on Figure C-1 in Appendix C, and also presented below:

Test Pit No.	Sample No.	Depth (m)	Liquid Limit (%)	Plastic Index (%)	Water Content (%)
TP20-02	2	2.8 – 3.0	24	5	27
TP20-13	2	1.7 – 1.8	26	7	28
TP20-14	3	2.0 – 2.1	25	9	28

The results of Atterberg limit testing carried out on three samples of the silty clay from shallow depth (i.e., presumably near or below the underside of the footings) gave an average plasticity index and liquid limit values of 7% and 25%, respectively. Based on the results of Atterberg limit testing, the silty clay and silty clay to clayey silt layers (where encountered) have low plasticity. Therefore, these materials are not likely to undergo significant volume changes as a result of variations in water content. As such, no restrictions on the types or sizes of trees that may be planted or tree to foundation setback distances need to be considered for this development.

6.9 Pools, Decks and Additions

6.9.1 Above Ground and In Ground Pools

No special geotechnical considerations are necessary for the installation of above-ground or in-ground pools.

1.1.1 Decks

There are no special geotechnical considerations for decks on this site.

1.1.2 Additions

Any proposed addition to a house (regardless of size) will require a geotechnical assessment. Written approval from a geotechnical engineer should be required by the City prior to the building permit being issued.

7.0 ADDITIONAL CONSIDERATIONS

The soils at this site are sensitive to disturbance from ponded water, construction traffic and frost. If construction is carried out during periods of sustained below freezing temperatures, all subgrade areas should be protected from freezing (e.g., by using insulated tarps and/or heating).

The test pits excavated and filled on site constitute zones of disturbance to the surficial soils. These could affect the performance of surface structures should such be planned for the zone of influence of those locations. In such cases, the excavated soil should be removed and replaced with engineered fill.

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

All footing and subgrade areas should be inspected by experienced geotechnical personnel prior to filling or concreting to ensure that bearing surfaces have been properly prepared. The placing and compaction of any engineered fill should be inspected to ensure that the materials used conform to the specifications from both grading and compaction viewpoint.

8.0 CLOSURE

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

Yours truly,

Golder Associates Ltd.

AGhirian

LICENSED PROFESSIONAL ENGINEER
A.Ghirian
A. GHIRIAN
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04-02-2022
PROVINCE OF ONTARIO

Ali Ghirian, P.Eng.
Geotechnical Engineer

Bill Cavers, P.Eng.
Associate, Senior Geotechnical Engineer

AG/WC/hdw

https://golderassociates.sharepoint.com/sites/138166/project files/6 deliverables/final report - rev 1/20442530-1000-001-r-rev1-rpt-barrett co-tenancy geotech investigation-barrett lands phase 3-jan 20221.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 **Barrett Co-Tenancy.** The factual data, interpretations and recommendations pertain to a specific project as described in this report and are not applicable to any other project or site location. Any change of site conditions, purpose, development plans or if the project is not initiated within eighteen months of the date of the report may alter the validity of the report. Golder cannot be responsible for use of this report, or portions thereof, unless Golder is requested to review and, if necessary, revise the report.

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

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

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

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

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

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

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

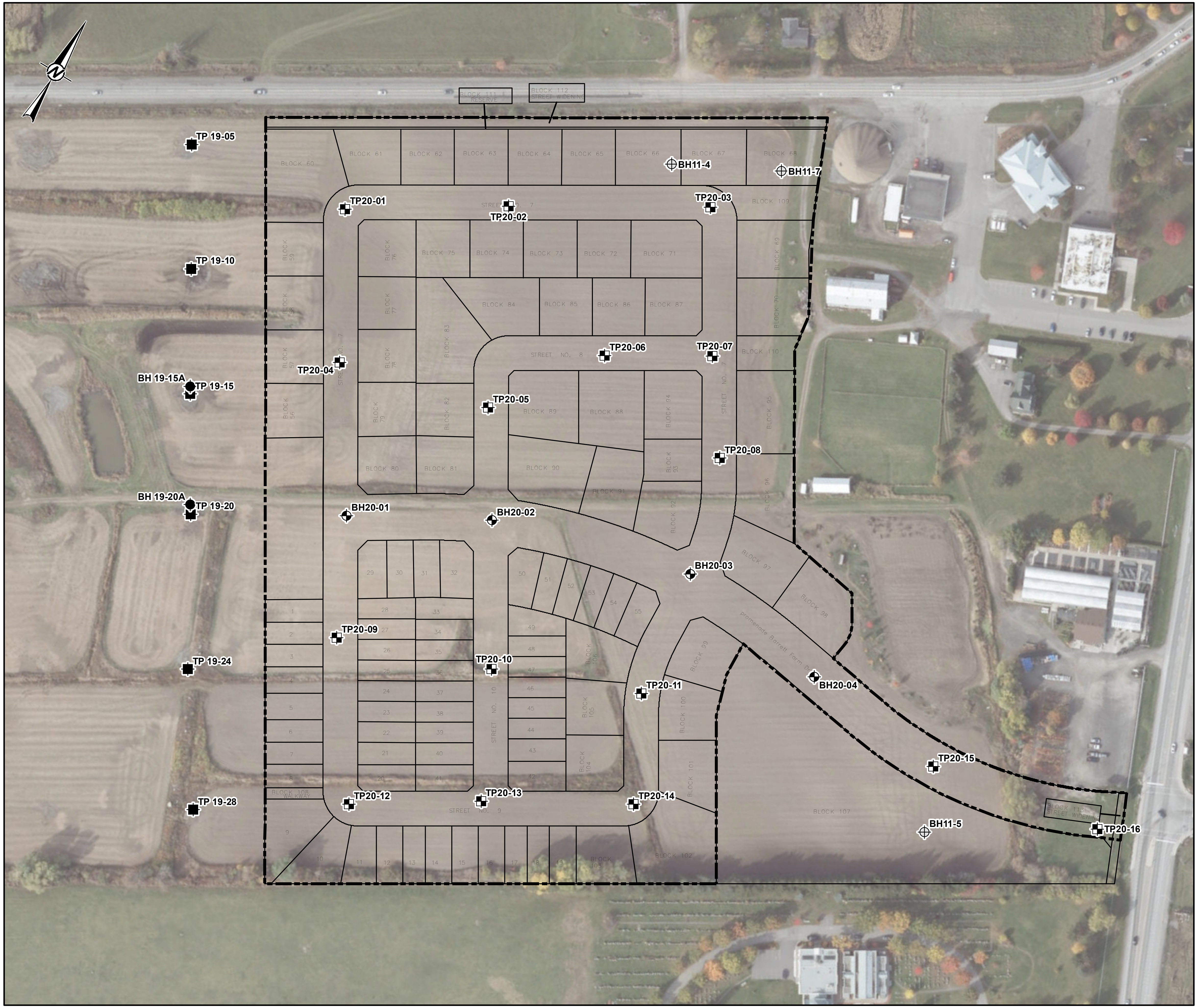
Sample Disposal: Golder will dispose of all uncontaminated soil and/or rock samples 90 days following issue of this report or, upon written request of the Client, will store uncontaminated samples and materials at the Client's expense. In the event that actual contaminated soils, fills or groundwater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

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

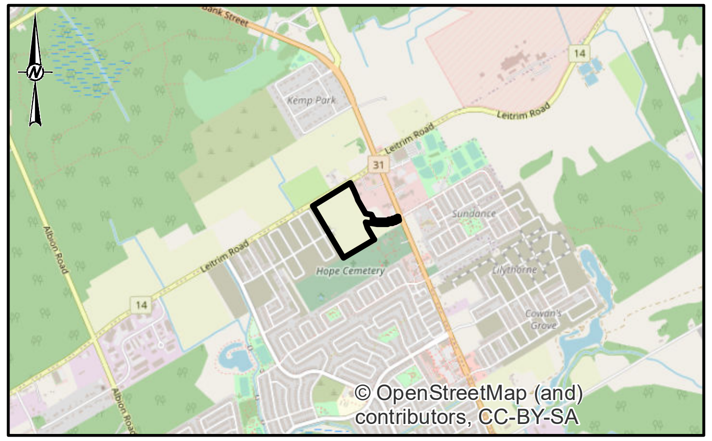
During construction, Golder should be retained to perform sufficient and timely observations of encountered conditions to confirm and document that the subsurface conditions do not materially differ from those interpreted conditions considered in the preparation of Golder's report and to confirm and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

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

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



KEY MAP



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SCALE 1:50,000

LEGEND

⊕ APPROXIAMTE BOREHOLE LOCATION, CURRENT INVESTIGATION

▣ APPROXIMATE TEST PIT LOCATION, CURRENT INVESTIGATION

● APPROXIMATE BOREHOLE LOCATION, PREVIOUS INVESTIGATION
(GOLDER ASSOCIATES REPORT No. 19129142)

■ APPROXIMATE TEST PIT LOCATION, PREVIOUS INVESTIGATION
(GOLDER ASSOCIATES REPORT No. 19129142)

⊕ APPROXIMATE TESTHOLE LOCATION, PREVIOUS INVESTIGATION
(GOLDER ASSOCIATES REPORT No. 1111210198)

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

1. PROJECTION: TRANSVERSE MERCATOR, DATUM: NAD 83,
COORDINATE SYSTEM: MTM ZONE 9, VERTICAL DATUM: CGVD28

0 20 40 80
1:2,000 METRES

CLIENT
BARRETT CO-TENANCY

PROJECT
BARRETT LANDS PHASE 3
OTTAWA, ONTARIO

TITLE
SITE PLAN

CONSULTANT

GOLDER

YYYY-MM-DD	2019-09-18
DESIGNED	AG
PREPARED	JEM
REVIEWED	AG
APPROVED	WC

PROJECT NO.	CONTROL	REV.	FIGURE
20442530	0001	A	1

Path: N:\Active\Spatial_IM\BarrettCo_Tenancy\Barrett Lands\99_PROJ\20442530_BCT_Geotech\40_PROD\0001_Geotech_Investigation\20442530-0001-BG-0001.mxd

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

25mm

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APPENDIX A

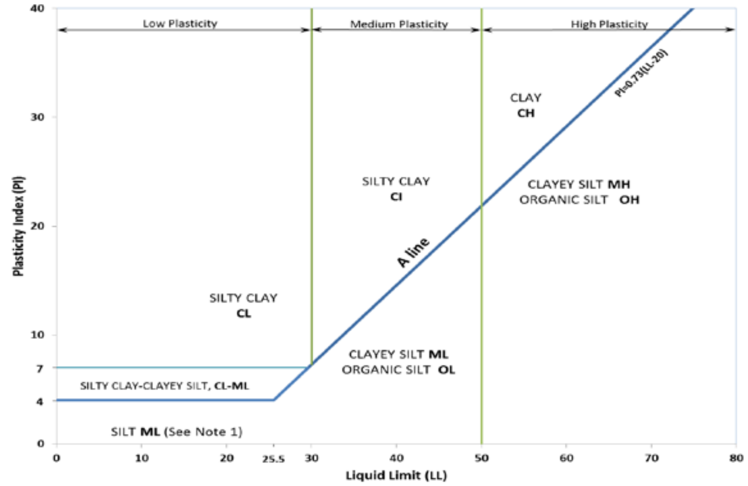
Test Pit and Borehole Sheets Current Investigation

METHOD OF SOIL CLASSIFICATION

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

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

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



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

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

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

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

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

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

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

ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS

PARTICLE SIZES OF CONSTITUENTS

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

MODIFIERS FOR SECONDARY AND MINOR CONSTITUENTS

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

PENETRATION RESISTANCE

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

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

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

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

SAMPLES

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

SOIL TESTS

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

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

NON-COHESIVE (COHESIONLESS) SOILS

Compactness[2]

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

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

Field Moisture Condition

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

COHESIVE SOILS

Consistency

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

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

Water Content

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

LIST OF SYMBOLS

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

I. GENERAL

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

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

(a) Index Properties

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = $\tan \delta$
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

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

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

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERINGS STATE

Fresh: no visible sign of rock material weathering.

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

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

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

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

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

BEDDING THICKNESS

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

JOINT OR FOLIATION SPACING

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

GRAIN SIZE

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

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

CORE CONDITION

Total Core Recovery (TCR)

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

Solid Core Recovery (SCR)

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

Rock Quality Designation (RQD)

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

DISCONTINUITY DATA

Fracture Index

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

Dip with Respect to Core Axis

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

Description and Notes

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

Abbreviations

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

TABLE 1

RECORD OF TEST PITS

Test Pit Number Elevation (Metres)	Depth (metres)	Description
TP 20-01 (97.7 m) N: 5021279.675 E: 375001.247	0.0 – 0.5	TOPSOIL (SM) SILTY SAND, some gravel; dark brown; contains organic matter and rootles, non-cohesive, moist
	0.5 – 1.7	SW/GW SAND and GRAVEL, some silt; grey-brown; non-cohesive, moist to wet
	1.7 – 5.5	(ML/SM) Layered Sandy SILT, Clayey SILT and Silty Sand; grey; non-cohesive, wet
	5.5	END OF TEST PIT

Note: Water seepage at 1.7 m

Sample	Depth (m)	Water Content (%)
1	0.7 – 0.9	
2	1.9 – 2.0	20
3	4.9 – 5.0	
4	5.4 – 5.5	

TABLE 1

RECORD OF TEST PITS

Test Pit Number Elevation (Metres)	Depth (metres)	Description
TP 20-02 (99.5 m)	0.0 – 0.3	TOPSOIL (SM) SILTY SAND, some gravel; dark brown; contains organic matter and rootles, non-cohesive, moist
N: 5021324.306 E: 375073.373	0.3 – 2.1	(SM/GW) SILTY SAND and GRAVEL; brown, non-cohesive, moist to wet
	2.1 – 3.6	(CL-ML) SILTY CLAY to Clayey SILT; grey; cohesive, w>PL
	3.6 – 4.5	(SM) SILTY SAND, grey, contains cobbles and boulders (GLACIAL TILL), non-cohesive, wet
	4.5 – 5.0	(SM) Gravelly SILTY SAND; grey, contains cobbles and boulders (GLACIAL TILL), non-cohesive, wet
	5.0	END OF TEST PIT

Note: Water seepage at 2.1 m

Sample	Depth (m)	Water Content (%)	Water Content (%)
1	1.30 – 1.4	13	
2	2.8 – 3.0	28	LL=24; PI=5
3	4.1 – 4.2		
4	4.9 – 5.0		

TABLE 1

RECORD OF TEST PITS

Test Pit Number Elevation (Metres)	**Depth (metres)**	**Description**
TP 20-03 (100.0 m) N: 5021208.447 E: 375251.839	0.0 – 0.2	TOPSOIL - (SM) SILTY SAND; dark brown, contains organic matter and rootless; non-cohesive, moist
	0.2 – 2.4	(SW/GW) Silty SAND and GRAVEL; brown, non-cohesive, moist
	2.4 – 4.8	(ML/SM) Layered Sandy SILT, Clayey SILT and Silty Sand; grey, non – cohesive, moist to wet
	4.8 – 5.0	(SM) SILTY SAND, trace to some gravel; grey, contains cobbles and boulders (GLACIAL TILL), non – cohesive, wet
	5.0	END OF TEST PIT Note: Water seepage at 2.3 m

Sample	Depth (m)	Water Content (%)
1	0.8 – 0.9	
2	2.4 – 2.5	
3	4.9 – 5.0	29

TABLE 1

RECORD OF TEST PITS

Test Pit Number Elevation (Metres)	Depth (metres)	Description
TP 20-04 (97.3 m) N: 5021209.820 E: 375039.489	0.0 – 0.4	TOPSOIL - (SM) SILTY SAND; dark brown, contains organic matter and rootlets; non-cohesive, moist
	0.4 – 1.7	(SW/GW) SAND and GRAVEL, some silt; brown; non-cohesive, moist
	1.7 – 3.8	(ML/SM) Layered Sandy SILT, Clayey SILT and Silty Sand; grey, non-cohesive, wet
	3.8 – 5.0	(SM/GM) Gravelly SILTY SAND; grey, contains cobbles and boulders (GLACIAL TILL), non-cohesive, wet
	5.0	END OF TEST PIT Note: Water Seepage at 1.7 m

Sample	Depth (m)	Water Content (%)
1	0.7 – 0.8	
2	2.6 – 2.7	39
3	4.0 – 4.2	

TABLE 1

RECORD OF TEST PITS

Test Pit Number Elevation (Metres)	Depth (metres)	Description
TP 20-05 (99.1 m) N: 5021229.118 E: 375117.488	0.0 – 0.3	TOPSOIL – (SM) SILTY SAND; dark brown, contains organic matter and rootlets; non-cohesive, moist
	0.3 – 1.9	(SW) Gravelly Sand, some silt; brown, non-cohesive, moist to wet
	1.9 – 4.5	(ML/SM) Layered Sandy SILT, Clayey SILT and Silty Sand; grey, non-cohesive, wet
	4.5 – 5.0	(SM/ML) Silty Sand to Clayey SILT, grey; contains cobbles and boulders (GLACIAL TILL), wet
	5.0	END OF TEST PIT
		Note: Water seepage at 1.0 m

Sample	Depth (m)	Water Content (%)
1	1.1 – 1.20	
2	2.1 – 2.2	17
3	4.9 – 5.0	

TABLE 1

RECORD OF TEST PITS

Test Pit Number Elevation (Metres)	Depth (metres)	Description
TP 20-06 (100.1 m)	0.0 – 0.3	TOPSOIL – (SM) SILTY SAND to sandy SILT; dark brown, contains organic matter and rootlets; non-cohesive, moist
N: 5021283.159 E: 375155.888	0.3 – 2.1	(SW/GW) SAND and GRAVEL, some silt, brown, non-cohesive, moist
	2.1 – 3.4	(ML/SM) Layered Sandy SILT, Clayey SILT and Silty Sand; grey, non-cohesive, moist to wet
	3.4 – 5.1	(SM) Gravelly SILTY SAND, grey; contains cobbles and boulders (GLACIAL TILL), wet
		Note: cobbles and boulders were observed at 4.6 m
	5.1	END OF TEST PIT
		Note: Water seepage at 2.1 m

Sample	Depth (m)	Water Content (%)
1	2.4 – 2.5	22
2	3.5 – 3.6	

TABLE 1

RECORD OF TEST PITS

Test Pit Number Elevation (Metres)	**Depth (metres)**	**Description**
TP 20-07 (100.7 m) N: 5021311.525 E: 375203.917	0.0 – 0.3	TOPSOIL – (SM) SILTY SAND, some clay; dark brown, Contains organic matter and rootlets; non-cohesive, moist
	0.3 – 1.6	(SW/GW) SAND and GRAVEL, some silt; brown, non-cohesive, moist
	1.6 – 1.9	(SM) SILTY SAND; grey-brown, non-cohesive, moist
	1.9 – 3.9	(ML/SM) Layered Sandy SILT, Clayey SILT and Silty Sand; grey, non-cohesive, wet
	3.9 – 4.8	(SM) Gravelly SILTY SAND; grey, contains cobbles and boulders (GLACIAL TILL), non-cohesive, wet
	4.8	END OF TEST PIT (*Refusal to excavation*)

Note: Water seepage at 1.6 m

Sample	Depth (m)	Water Content (%)
1	0.4 – 0.5	11
2	2.4 – 2.5	17
3	3.9 – 4.0	

TABLE 1

RECORD OF TEST PITS

Test Pit Number Elevation (Metres)	Depth (metres)	Description
TP 20-08 (100.4 m) N: 5021268.013 E: 375234.326	0.0 – 0.3	TOPSOIL – (SM) SILTY SAND, some clay; dark brown, contains organic matter and rootlets; non-cohesive, moist
	0.3 – 1.7	(SW/GW) SAND and GRAVEL, some silt; brown, non-cohesive, moist
	1.7 – 3.0	(ML/SM) Layered Sandy SILT, Clayey SILT and Silty Sand; grey, non-cohesive, wet
	3.0 – 6.2	(SM) Gravelly SILTY SAND to SAND; grey, contains cobbles and boulders (GLACIAL TILL), non-cohesive, wet
	6.2	END OF TEST PIT

Note: Water seepage at 1.7 m

Sample	Depth (m)	Water Content (%)
1	1.2 – 1.3	
2	1.7 – 1.8	33
3	3.2 – 3.3	
4	6.0 – 6.2	

TABLE 1

RECORD OF TEST PITS

Test Pit Number Elevation (Metres)	**Depth (metres)**	**Description**
TP 20-09 (96.8 m) N: 5021086.408 E: 375111.219	0.0 – 0.4	TOPSOIL – (SM) SILTY SAND; dark brown, contains organic matter and rootlets; non-cohesive, moist
	0.4 – 0.8	(SM) SILTY SAND, some gravel, contains cobbles and boulders; brown, non-cohesive, moist
	0.8 – 2.0	(ML/SM) Layered Sandy SILT, Clayey SILT and Silty Sand; grey, non-cohesive, moist
	2.0 – 3.8	(SM/GM) SILTY SAND and GRAVEL; grey, contains cobbles and boulders (GLACIAL TILL), non-cohesive, moist to wet
	3.8	END OF TEST PIT (*Refusal to excavation*)
		Note: Water seepage was observed at 3.6 m

Sample	Depth (m)	Water Content (%)
1	0.8 – 1.0	
2	2.0 – 2.1	
3	3.6 – 3.8	16

TABLE 1

RECORD OF TEST PITS

Test Pit Number Elevation (Metres)	Depth (metres)	Description
TP 20-10 (97.6 m) N: 5021113.515 E: 375188.436	0.0 – 0.3	TOPSOIL – (SM) SILTY SAND; dark brown, contains organic matter and rootlets; non-cohesive, moist
	0.3 – 0.7	(SW/GW) SAND and GRAVEL, some silt; brown, non-cohesive, moist
	0.7 – 1.8	(ML/SM) Layered Sandy SILT, Clayey SILT and Silty Sand, some gravel; brown, non-cohesive, moist to wet
	1.8 – 4.0	(SM) Gravelly SILTY SAND, some clay; grey, contains cobbles and boulders (GLACIAL TILL), non-cohesive, wet
	4.0	END OF TEST PIT

Note: Water seepage was observed at 1.6 m

Sample	Depth (m)	Water Content (%)
1	0.6 – 0.7	12
2	1.5 – 1.6	30
3	3.6 – 3.7	17

TABLE 1

RECORD OF TEST PITS

Test Pit Number Elevation (Metres)	Depth (metres)	Description
TP 20-11 (99.4 m) N: 5021142.342 E: 375261.792	0.0 – 0.2	TOPSOIL – (SM) SILTY SAND, some clay; dark brown, contains organic matter and rootlets; non-cohesive, moist
	0.2 – 2.0	(SW/GW) SAND and GRAVEL, some silt; brown, non-cohesive, moist to wet
	2.0 – 4.5	(ML/SM) Layered Sandy SILT, Clayey SILT and Silty Sand; grey, non-cohesive, wet
	4.5 – 5.0	(SM) gravelly SILTY SAND, some clay; grey, contains cobbles and boulders (GLACIAL TILL), non-cohesive, wet
	5.0	END OF TEST PIT
		Note: Water seepage observed at 2.0 m

Sample	Depth (m)	Water Content (%)
1	1.0 – 1.10	
2	3.3 – 3.4	
3	4.5 – 4.6	29

TABLE 1

RECORD OF TEST PITS

Test Pit Number Elevation (Metres)	**Depth (metres)**	**Description**
TP 20-12 (96.3 m) N: 5021015.486 E: 375160.728	0.0 – 0.4	TOPSOIL – (SM) SILTY SAND, some gravel; dark brown, contains organic matter and rootlets, non-cohesive, moist
	0.4 – 1.5	(SM) SILTY SAND, some gravel, contains cobbles and boulders; grey, non-cohesive, moist
	1.5 – 2.0	(ML/SM) Layered Sandy SILT, Clayey SILT and Silty Sand; grey, non-cohesive, moist
	2.0	END OF TEST PIT (*Refusal to excavation*) Note: Water seepage was not observed

Sample	Depth (m)	Water Content (%)
1	1.3 – 1.5	
2	1.9 – 2.0	

TABLE 1

RECORD OF TEST PITS

Test Pit Number Elevation (Metres)	Depth (metres)	Description
TP 20-13 (97.3 m) N: 5021051.763 E: 375218.836	0.0 – 0.3	TOPSOIL – (SM) SILTY SAND; dark brown, contains organic matter and rootlets; non-cohesive, moist
	0.3 – 1.5	(SM) Gravelly SILTY SAND; grey, non-cohesive, moist to wet
	1.5 – 2.5	(CL-ML) SILTY CLAY to Clayey SILT; grey, cohesive, w>PL
	2.5 – 4.0	(SM) SILTY SAND, some gravel; grey, contains cobbles and boulders (GLACIAL TILL), non-cohesive, wet
	4.0	END OF TEST PIT Significant caving in and therefore test pit was terminated due to unsafe condition Note: Water seepage observed at 0.8 m

Sample	Depth (m)	Water Content (%)	Atterberg Limits (%)
1	0.9 – 1.0		
2	1.7 – 1.8	28	LL=26; PI=7
3	2.8 – 3.0		

TABLE 1

RECORD OF TEST PITS

Test Pit Number Elevation (Metres)	Depth (metres)	Description
TP 20-14 (98.5 m) N: 5021090.769 E: 375287.642	0.0 – 0.3	TOPSOIL – (SM) SILTY SAND; dark brown, contains organic matter and rootlets, non-cohesive, moist
	0.3 – 1.0	(SM) Gravelly SILTY SAND; grey, non-cohesive, moist
	1.0 – 2.0	(ML/SM) Layered Sandy SILT, Clayey SILT and Silty Sand; brown, non-cohesive, moist to wet
	2.0 – 5.0	(CL) SILTY CLAY; grey, cohesive, W>PL
	5.0 – 5.1	(SM) Gravelly SILTY SAND; grey, contains cobbles and boulders (GLACIAL TILL), non-cohesive, wet
	5.1	END OF TEST PIT Note: Water seepage observed at 1.5 m

Sample	Depth (m)	Water Content (%)	Atterberg Limits (%)
1	0.2 – 1.0		
2	1.2 – 1.3		
3	2.0 – 2.1	28	LL=25; PI=9
4	3.0 – 3.1		
5	3.6 – 3.7		
6	5.0 – 5.1		

TABLE 1

RECORD OF TEST PITS

Test Pit Number Elevation (Metres)	Depth (metres)	Description
TP 20-15 (101.4 m) N: 5021187.299 E: 375411.292	0.0 – 0.3	TOPSOIL – (SM) SILTY SAND; contains organic matter and rootlets, dark brown, non-cohesive, moist
	0.3 – 0.8	(SM) SILTY SAND, some gravel; brown, non-cohesive, moist
	0.8 – 1.2	(GW-GM) Silty Sandy GRAVEL; grey, non-cohesive, moist
	1.2 – 2.6	(ML/SM) Layered Sandy SILT, Clayey SILT and Silty Sand, trace gravel; brown, contains boulders, non-cohesive, moist
	2.6 – 5.0	(SM) Gravelly SILTY SAND; grey, contains cobbles and boulders (GLACIAL TILL), non-cohesive, moist
	5.0	END OF TEST PIT Note: Water seepage not observed.

Sample	Depth (m)	Water Content (%)
1	1.0 – 1.1	
2	1.4 – 1.5	
3	3.2 – 3.3	
4	4.9 – 5.0	

TABLE 1

RECORD OF TEST PITS

Test Pit Number Elevation (Metres)	Depth (metres)	Description
TP 20-16 (104.1 m) N: 5021202.773 E: 375501.078	0.0 – 0.3	TOPSOIL – (SM) SILTY SAND, trace gravel; dark brown, contains organic matter and rootlets, non-cohesive, moist
	0.3 – 1.8	(SM) SILTY SAND, trace to some gravel; brown, non-cohesive, moist
	1.8 – 3.3	(SW/GW) SAND and GRAVEL, some silt; brown, non-cohesive, moist to wet
	3.3 – 4.5	(ML/SM) Layered Sandy SILT, Clayey SILT and Silty Sand; grey, non-cohesive, moist
	4.5 – 5.0	(SM) gravelly SILTY SAND, some clay; grey, contains cobbles and boulders (GLACIAL TILL), non-cohesive, wet
	5.0	END OF TEST PIT Note: Water seepage observed at 2.7 m

Sample	Depth (m)	Water Content (%)
1	0.8 – 0.9	
2	1.8 – 1.9	15
3	3.9 – 4.0	
4	4.9 – 5.0	14

PROJECT: 20442530

RECORD OF BOREHOLE: 20-01

SHEET 1 OF 1

LOCATION: N 5021143.5 ;E 375083.2

BORING DATE: January 19, 2021

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}

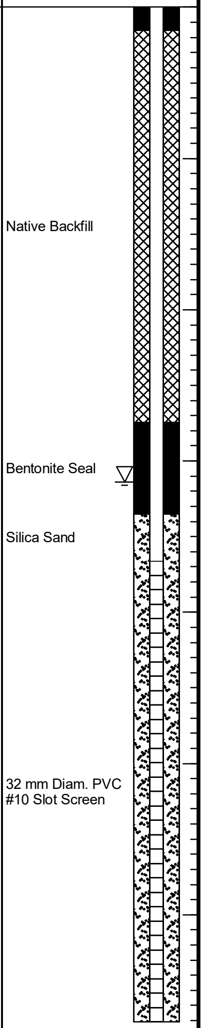
WATER CONTENT PERCENT: Wp ⊢—○W—⊣ Wl : 20 40 60 80

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

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	97.78
TOPSOIL - (SM) SILTY SAND; dark brown, contains rootlets and organics; non-cohesive, moist	0.00
(SM) sandy SILT to CLAYEY SILT; brown; non-cohesive, wet to moist, compact	97.17 0.61
(ML) sandy SILT to clayey SILT; brown; non-cohesive, moist, dense	96.26 1.52
(SM/GM) SILTY SAND and GRAVEL, angular; brown, contains cobbles and boulders (GLACIAL TILL); moist to wet, dense to very dense	95.49 2.29
End of Borehole Auger Refusal	91.07 6.71

NUMBER	TYPE	BLOWS/0.30m
1	SS	93
2	SS	17
3	SS	37
4	SS	>50
5	SS	42
6	SS	57
7	SS	>50
8	SS	68
9	SS	>50

PIEZOMETER OR STANDPIPE INSTALLATION



WL in Screen at Elev. 94.64 m on February 3, 2021

DEPTH SCALE 1 : 50

GOLDER

LOGGED: RA

CHECKED: AG

PROJECT: 20442530

RECORD OF BOREHOLE: 20-02

SHEET 1 OF 1

LOCATION: N 5021179.8 ;E 375149.2

BORING DATE: January 19, 2021

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)	SAMPLES: NUMBER	TYPE	BLOWS/0.30m
GROUND SURFACE	98.86			
TOPSOIL - (CL/CI) SILTY CLAY, some sand; dark brown, contains rootlets and organics; cohesive, w~PL, hard	0.00	1	SS	28
(SM) gravelly SILTY SAND; brown, contains cobbles; non-cohesive, moist, compact	98.25 0.61	2	SS	15
(ML) sandy SILT to CLAYEY SILT, trace clay; grey brown; non-cohesive, wet, compact	97.34 1.52	3	SS	13
(SM/GM) SILTY SAND and GRAVEL, angular; grey, contains cobbles and boulders (GLACIAL TILL); wet, compact to very dense	96.61 2.25	4	SS	12
		5	SS	27
		6	SS	56
		7	SS	74
		8	SS	>50
		9	SS	>50
End of Borehole Auger Refusal	92.66 6.20			

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

MIS-BHS 001 20442530.GPJ GAL-MIS.GDT 3-17-21 JEM

DEPTH SCALE

1 : 50

GOLDER

LOGGED: RA

CHECKED: AG

PROJECT: 20442530

RECORD OF BOREHOLE: 20-03

SHEET 1 OF 1

LOCATION: N 5021208.4 ;E 375251.8

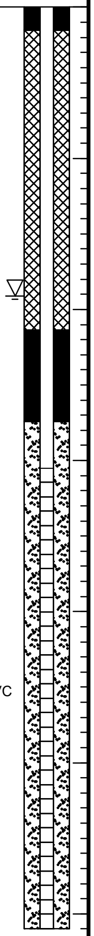
BORING DATE: January 18, 2021

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	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	99.99							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND, some gravel; brown, contains rootlets and organics; non-cohesive, moist, compact	0.00	1	SS	12				
1		(SW/GW) SAND and GRAVEL; brown; non-cohesive, moist, compact	99.38 0.61	2	SS	16				Native Backfill
2		(ML) sandy SILT to SILT; brown; non-cohesive, wet, loose	98.62 1.37	3	SS	10				
3		(SM) gravelly SILTY SAND; grey, contains cobbles (GLACIAL TILL); non-cohesive, wet, dense	97.70 2.29	4	SS	32				Bentonite Seal
				5	SS	>50				Silica Sand
4				6	SS	34				
5		(SM) gravelly SILTY SAND; grey; non-cohesive, wet, compact	95.42 4.57	7	SS	28				32 mm Diam. PVC #10 Slot Screen
6		(SM) gravelly SILTY SAND, angular; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet	94.35 5.64	8	SS	37				
				9	SS	>50				
		End of Borehole Auger Refusal	93.79 6.20							WL in Screen at Elev. 98.08 m on February 3, 2021
7										
8										
9										
10										



DEPTH SCALE

1 : 50

GOLDER

LOGGED: RA

CHECKED: AG

PROJECT: 20442530

RECORD OF BOREHOLE: 20-04

SHEET 1 OF 1

LOCATION: N 5021195.7 ;E 375334.4

BORING DATE: January 18, 2021

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m
GROUND SURFACE	100.69			
TOPSOIL - (SM) SILTY SAND, trace gravel; brown; non-cohesive, moist, compact	0.00	1	SS	13
(SM) SILTY SAND, some gravel; brown; non-cohesive; moist	100.08 0.61	2	SS	11
(ML) sandy SILT, trace clay; brown; non-cohesive, moist, compact	99.17 1.52	3	SS	11
(SM) SILTY SAND, some gravel; brown grey; non-cohesive, wet, dense	98.40 2.29	4 5	SS SS	30 31
(SP/SM) SILTY SAND to SAND, some gravel; brown; non-cohesive, wet, dense	97.03 3.66	6	SS	40
(SM/GM) SILTY SAND and GRAVEL, angular; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet, compact to dense	96.27 4.42	7 8 9	SS SS SS	14 33 >50
End of Borehole Auger Refusal	94.39 6.30			

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, k, cm/s	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
20 40 60 80	10^{-6} 10^{-5} 10^{-4} 10^{-3}		
SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○	WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl		
20 40 60 80	20 40 60 80		

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

DEPTH SCALE

1 : 50

GOLDER

LOGGED: RA

CHECKED: AG

APPENDIX B

Test Pit and Borehole Sheets Previous Investigations

TABLE 1

RECORD OF TEST PITS

Test Pit Number Elevation (Metres)	Depth (metres)	Description
TP 19-05 (97.0 metres)	0.0 – 0.27	TOPSOIL – (ML) clayey SILT, trace sand and gravel; black; contains organic matter and rootlets, cohesive, w~PL
	0.27 – 0.45	(SM/ML) gravelly SILTY SAND to sandy SILT; brown to dark brown; non-cohesive, moist
	0.45 – 1.5	(GM) silty SANDY GRAVEL; dark brown; contains cobbles and boulders, non-cohesive, wet
	1.5 – 1.8	(ML/SM/CL) layered SILTY SAND, sandy SILT and SILTY CLAY; grey; non-cohesive, wet
	1.8 – 5.0	(SM) gravelly SILTY SAND; grey; contains cobbles and boulders (GLACIAL TILL), non-cohesive, wet
	5.0	END OF TEST PIT

Note: water seepage at 1.15 m depth upon completion

Sample	Depth (m)	Water Content (%)
1	0.27 – 0.45	
2	0.5 – 1.0	
3	1.5 – 1.8	21
4	2.5 – 3.0	9
5	3.9 – 4.0	
6	4.9 – 5.0	

TABLE 1

RECORD OF TEST PITS

Test Pit Number Elevation (Metres)	Depth (metres)	Description
TP 19-10 (96.6 metres)	0.0 – 0.25	TOPSOIL – (ML) SILT; black; contains organic matter and rootlets, non-cohesive, moist
	0.25 – 0.9	(SM/ML/CL) layered SILTY SAND, SILT and SILTY CLAY; grey; contains cobble and boulders, cohesive, w>PL
	0.9 – 1.8	(GM) silty sandy GRAVEL; dark brown to dark grey; contains cobbles and boulders, non-cohesive, wet
	1.8 – 3.6	(SM/ML) layered SILTY SAND and SILT; grey; some gravel, non-cohesive, wet
	3.6 – 5.0	(SP) SAND, fine to medium; grey; some gravel, contains cobbles and boulders, non-cohesive, wet
	5.0	END OF TEST PIT

Note: water seepage at depth of 0.8 m upon completion.

Sample	Depth (m)	Water Content (%)
1	0.4 – 0.6	
2	1.1 – 1.4	
3	1.8 – 1.9	
4	2.5 – 2.6	
5	3.3 – 3.4	
6	3.6 – 3.7	
7	4.9 – 5.0	

TABLE 1

RECORD OF TEST PITS

Test Pit Number Elevation (Metres)	Depth (metres)	Description
TP 19-15 (96.5 metres)	0.0 – 0.55	TOPSOIL – (ML) SANDY SILT, trace gravel; black; contains organic matter and rootlets, non-cohesive, moist
	0.55 – 1.7	(ML/CL) layered SILT and SILTY CLAY; grey to brown; cohesive, wet, w>PL
	0.9 – 1.7	(SM/ML/CL) layered SILTY SAND, SILT and SILTY CLAY, trace gravel; grey brown; cohesive, w>PL
	1.7 – 3.5	(GM) SANDY GRAVEL; dark grey to black; non-cohesive, wet
	3.5	END OF TEST PIT
		Note: water seepage at about 1.4 m upon completion; significant caving in walls of excavation

Sample	Depth (m)	Water Content (%)
1	0.55 – 0.8	
2	1.0 – 1.3	
3	1.7 – 2.0	

TABLE 1

RECORD OF TEST PITS

Test Pit Number Elevation (Metres)	Depth (metres)	Description
TP 19-20 (96.0 metres)	0.0 – 0.1	TOPSOIL – (ML) SILT, trace gravel; black; contains organic matter and rootlets, cohesive, w<PL
	0.1 – 0.5	(SM/ML) SILTY SAND to sandy SILT, trace gravel; grey to grey brown; non-cohesive, moist
	0.5 – 1.2	(SM/ML/CL) layered SILTY SAND, SILT and SILTY CLAY, trace gravel; grey to grey brown; non-cohesive, moist to wet
	1.2 – 2.0	(GW) silty sandy GRAVEL; grey; non-cohesive, wet
	2.0 – 4.0	(ML/CL) layered SILT and SILTY CLAY; grey; non-cohesive, wet
	4.0	END OF TEST PIT (Refusal to excavation)
		Note: water seepage at about 1.1 m upon completion; caving in walls of excavation

Sample	Depth (m)	Water Content (%)
1	0.1 – 0.5	
2	0.9 – 1.3	
3	1.2 – 1.5	
4	2.0 – 2.3	24
5	3.0 – 3.2	

TABLE 1

RECORD OF TEST PITS

Test Pit Number Elevation (Metres)	Depth (metres)	Description
TP 19-24 (96.2 metres)	0.0 – 0.20	TOPSOIL – (ML) CLAYEY SILT, trace sand; dark brown to black; contains organic matter and rootlets, cohesive, w<PL
	0.2 – 0.4	(CL/ML) SILTY CLAY to CLAYEY SILT, trace gravel; grey brown; contains rootless, highly fissured, cohesive, w<PL
	0.4 – 1.0	(GM) SILTY sandy GRAVEL; dark grey to brown; contains cobbles and boulders, non-cohesive, moist
	1.0 – 1.25	(SM/ML/CL) layered SILTY SAND, SILT and SILTY CLAY, trace gravel; brown; non-cohesive to cohesive, moist / w~PL
	1.25 – 2.8	(ML/SM) sandy SILT Y to SILTY SAND; grey; contains cobbles and boulders (GLACIAL TILL), non-cohesive, moist to wet
	2.8	END OF TEST PIT (Refusal to excavation)

Note: water seepage at about 1.9 m upon completion

Sample	Depth (m)	Water Content (%)
1	0.0 – 0.2	
2	0.2 – 0.4	
3	0.4 – 1.0	
4	1.0 – 1.25	
5	1.25 – 1.5	15
6	2.2 – 2.3	

TABLE 1

RECORD OF TEST PITS

Test Pit Number Elevation (Metres)	Depth (metres)	Description
TP 19-28 (95.8 metres)	0.0 – 0.25	TOPSOIL – (ML) gravelly sandy SILT; dark brown; contains organic matter and rootlets, non-cohesive, moist
	0.25 – 1.0	(SM) gravelly SILTY SAND; brown to grey brown; contains cobbles and boulders, non-cohesive, moist
	1.0 – 2.0	Weathered bedrock (inferred) slabs
	2.0	END OF TEST PIT (Refusal to excavation)
		Note: No water seepage upon completion

Sample	Depth (m)	Water Content (%)
1	0.45 – 0.6	
2	0.85 – 1.0	

PROJECT: 19129142-1000

RECORD OF BOREHOLE: 19-15A

SHEET 1 OF 1

LOCATION: N 5021159.6 ;E 374979.2

BORING DATE: October 8, 2019

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

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

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

BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
	GROUND SURFACE	96.51					
Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND; dark brown, contains organic matter (rootlets); moist, very loose	0.00	1	SS	3		
	(CL/ML) CLAYEY SILT to SILTY CLAY; grey brown; cohesive, wet, stiff to very stiff	95.91 0.60	2	SS	2		∇
			3	SS	5		WL measured at a depth of 1.2 m upon completion of drilling
	(SM/GM) SILTY SAND and GRAVEL, fine to coarse; brown, contains shells; non-cohesive, wet, loose	94.53 1.98	4	SS	8		
	(ML) sandy SILT, non-plastic; grey; non-cohesive, wet, loose to very loose	93.62 2.89	5	SS	4		
			6	SS	WH		
	(CL/ML) CLAYEY SILT, SILTY CLAY; grey; non-cohesive, wet, very loose	92.09 4.42	7	SS	WH		
			8	SS	WH		
			9	SS	3		
	End of Borehole	89.81 6.70					

MIS-BHS 001 19129142.GPJ GAL-MIS.GDT 12/9/19 ZS

DEPTH SCALE

1 : 50

GOLDER

LOGGED: DJG

CHECKED: AG

PROJECT: 19129142-1000

RECORD OF BOREHOLE: 19-20A

SHEET 1 OF 1

LOCATION: N 5021106.8 ;E 375010.7

BORING DATE: October 8, 2019

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		95.96							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND, trace gravel and rootlets; dark brown; non-cohesive, moist, loose		0.00	1	SS	7				
1		(ML) sandy SILT, fine, non-plastic fines; grey; non-cohesive, wet, very loose		95.36 0.60	2	SS	2				
2		(SM/GM) SILTY SAND and GRAVEL, fine to coarse; brown; non-cohesive, wet, loose		94.59 1.37	3	SS	9				∇ WL measured at a depth of 1.5 m upon completion of drilling
		(ML) sandy SILT, fine, non-plastic fines; grey; non-cohesive, wet, loose		93.83 2.13	4	SS	9				
3		Limestone		93.07 2.89	5	SS	>50				
		End of Borehole Auger Refusal		92.84 3.12							
4											
5											
6											
7											
8											
9											
10											

MIS-BHS 001 19129142.GPJ GAL-MIS.GDT 12/9/19 ZS

DEPTH SCALE

1 : 50

GOLDER

LOGGED: DJG

CHECKED: AG

PROJECT: 11-1121-0198-1000

RECORD OF BOREHOLE: 11-4

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: September 9, 2011

DATUM:

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE									
0	Power Auger 200 mm Diam. (Hollow Stem)	Topsoil (FILL)		0.00							
		Brown silty sand (FILL)		0.23							
		Loose to compact brown sand, some gravel, trace silt (FILL)		0.70							
1					1	50 DO	13				
2					2	50 DO	19				
											∇
					3	50 DO	7				
		Loose brown SILT, trace sand, gravel, and clay		2.68							
3					4	50 DO	9			MH	
4		Compact grey SILT, trace clay and sand		3.81	5	50 DO	17				
5					6	50 DO	10				
		Compact grey SILTY SAND, some gravel, trace clay, with cobbles and boulders (GLACIAL TILL)		5.03	7	50 DO	21				
6					8	50 DO	26				
7					9	50 DO	27				
		End of Borehole Auger Refusal		7.47							
8											W.L. in open hole at 2.4 m depth at time of drilling
9											
10											

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

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: PH

CHECKED: C.K.

PROJECT: 11-1121-0198-1000

RECORD OF BOREHOLE: 11-5

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: September 9, 2011

DATUM:

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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}

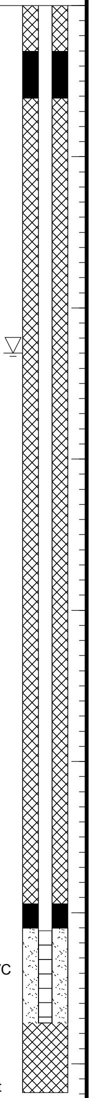
WATER CONTENT PERCENT: Wp ⊢—○W—⊣ Wl : 20 40 60 80

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

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	
Topsoil (FILL)	0.00
Brown sand, trace gravel and silt (FILL)	0.21
Compact brown silty sand, some gravel (FILL)	0.82
Compact brown SILT, trace to some sand	1.52
Loose grey SILT, trace to some sand	2.77
Compact to very dense grey SILTY SAND, some gravel, trace clay, with cobbles and boulders (GLACIAL TILL)	4.63
End of Borehole Auger Refusal	7.19

SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING
1	GRAB		
2	50 DO	11	
3	50 DO	28	
4	50 DO	16	
5	50 DO	8	
6	50 DO	6	MH
7	50 DO	16	
8	50 DO	19	
9	50 DO	14	
10	50 DO	>50	

PIEZOMETER OR STANDPIPE INSTALLATION



W.L. in Screen at 2.3 m depth at time of drilling

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

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

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: PH
CHECKED: C.K.

PROJECT: 11-1121-0198-1000

RECORD OF BOREHOLE: 11-7

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: September 27, 2011

DATUM:

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m
		GROUND SURFACE				
0	Power Auger 200 mm Diam. (Hollow Stem)	Topsoil (FILL)	0.00			
		Compact to dense brown sand, some gravel, trace silt, some brick pieces, organics, and peat (FILL)	0.15	1	50 DO	10
1				2	50 DO	14
2				3	50 DO	21
				4	50 DO	34
3				5	50 DO	33
4				6	50 DO	20
		Compact grey SILT, trace sand	4.37			
5				7	50 DO	15
				8	50 DO	12
6		End of Borehole	6.10			
7						
8						
9						
10						

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

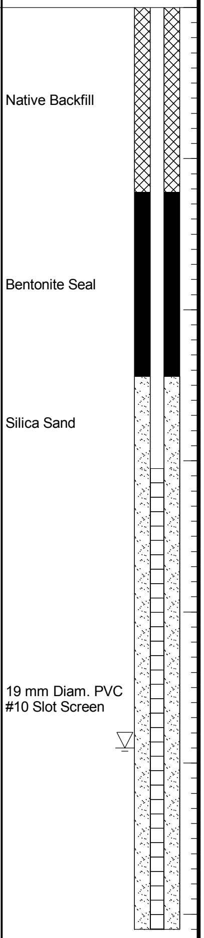
SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80

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

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

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION



W.L. in Screen at 4.9 m depth on September 28, 2011

DEPTH SCALE

1 : 50

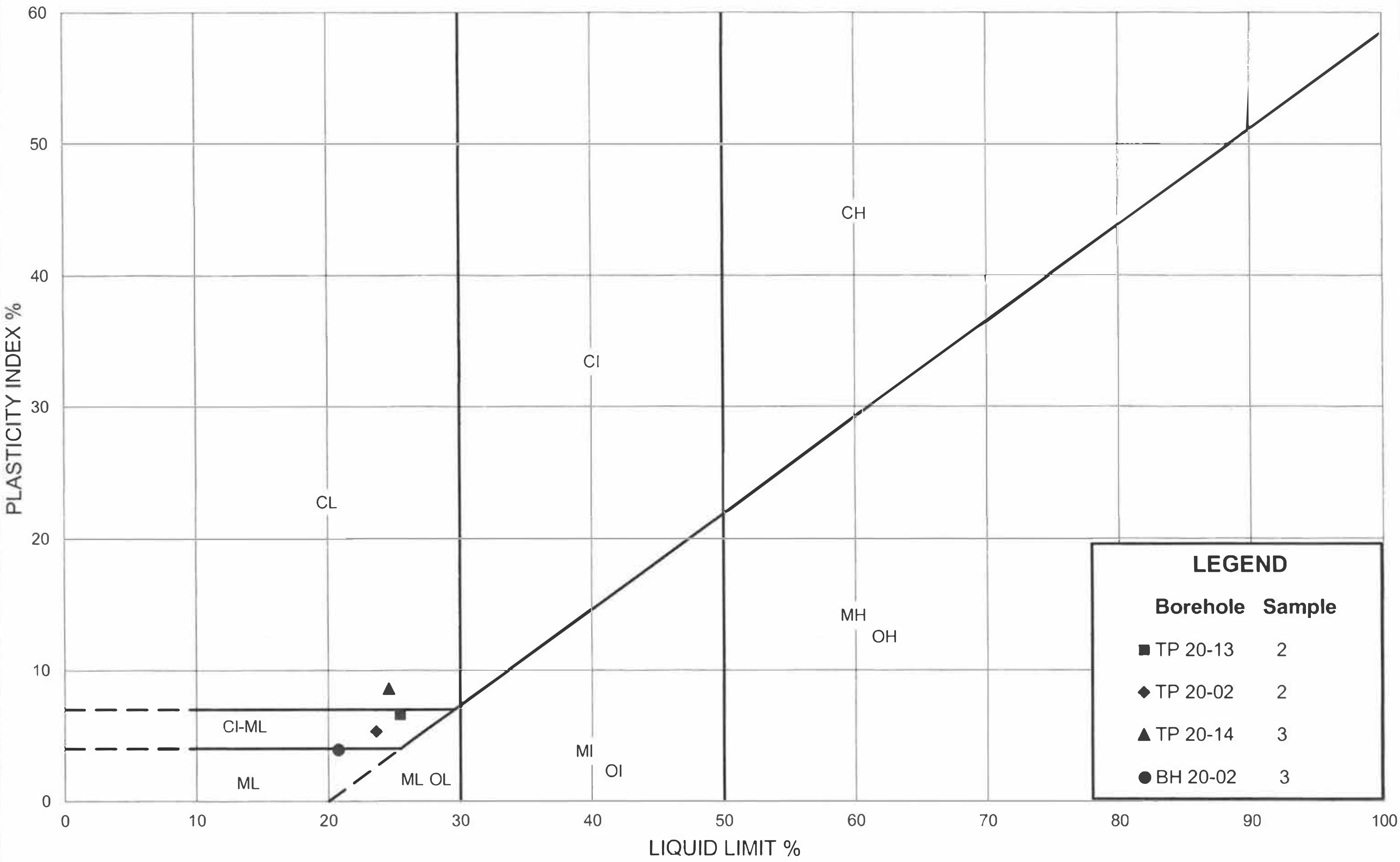
Golder Associates

LOGGED: DK

CHECKED: C.K.

APPENDIX C

Results of Laboratory Testing



GOLDER

PLASTICITY CHART

Figure: C-1

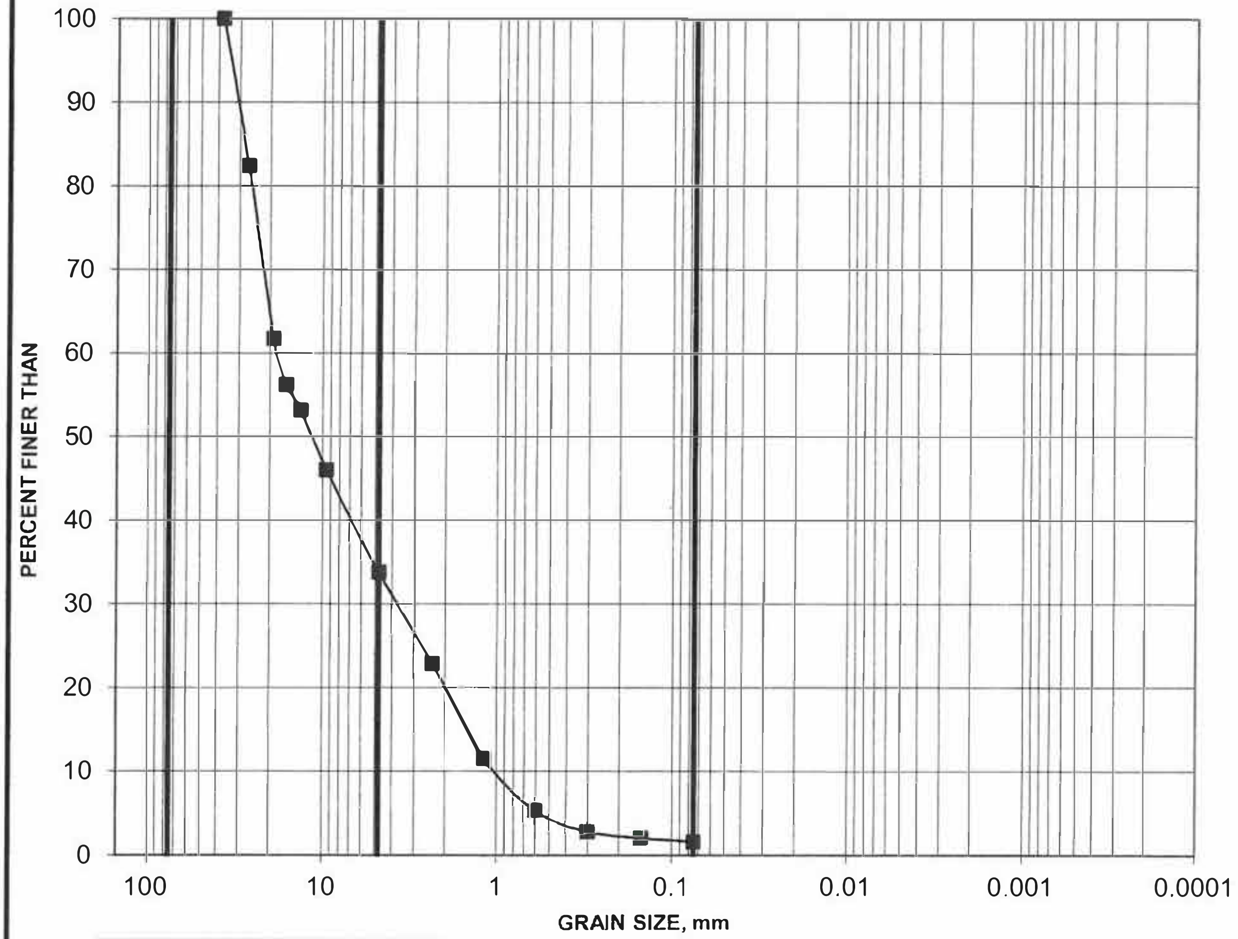
Project: 20442530

Created By: CW Checked By: MI

GRAIN SIZE DISTRIBUTION

C-2

GRAVELLY SAND



COBBLE SIZE	COARSE	FINE	COARSE	MEDIU	FINE	SILT AND CLAY
	GRAVEL SIZE		SAND SIZE			

	Testpit	Sample	Depth (m)	Constituents (%)			
				Gravel	Sand	Silt	Clay
─■─	20-05	1	1.10-0.20	66	32		2

GOLDER

Project: 20442530

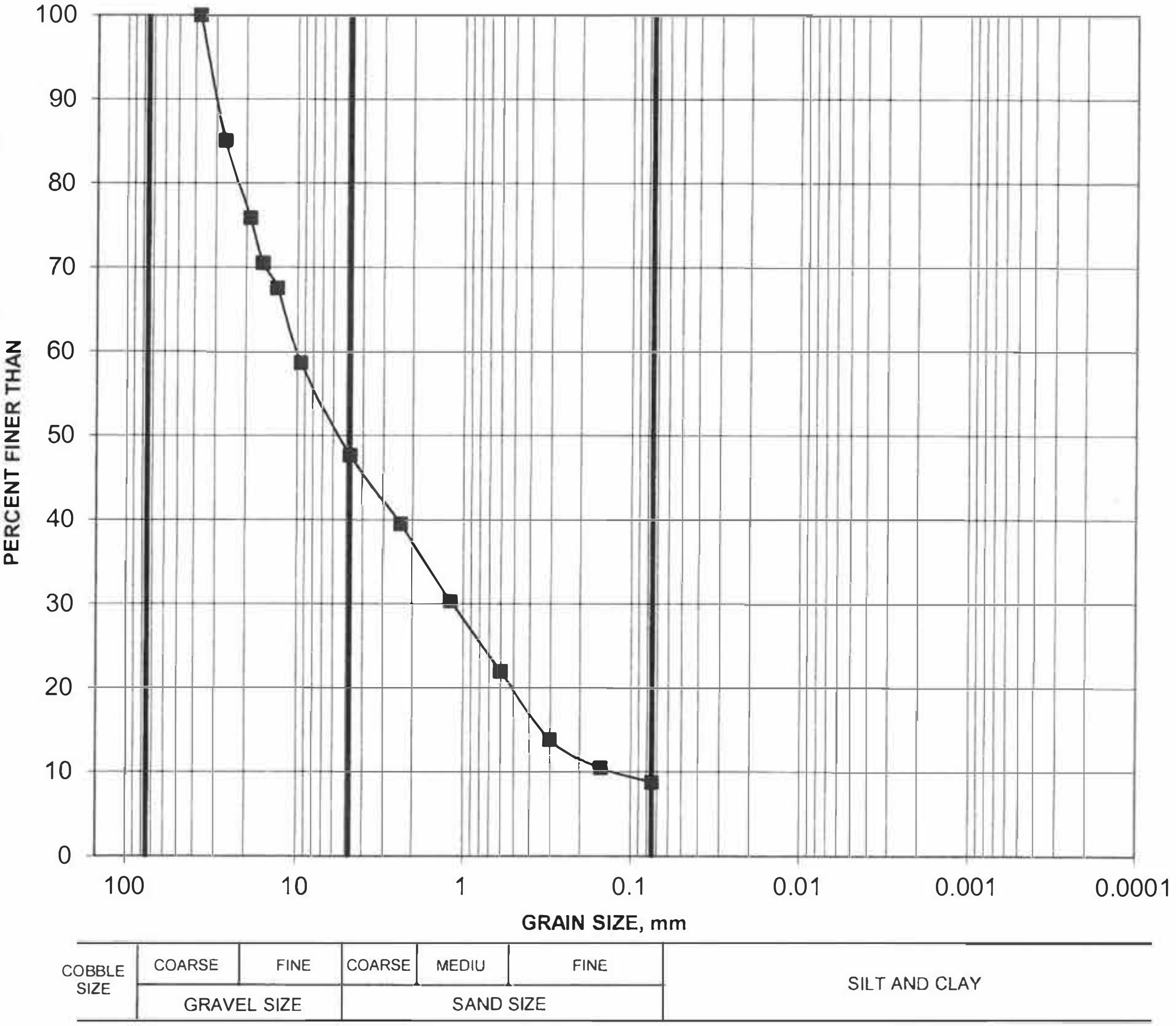
Created by:

Checked by:

GRAIN SIZE DISTRIBUTION

C-3

SANDY SILTY GRAVEL



				Constituents (%)			
	Testpit	Sample	Depth (m)	Gravel	Sand	Silt	Clay
━■━	20-15	1	1.00-1.10	52	39	9	

GOLDER

Project: 20442530

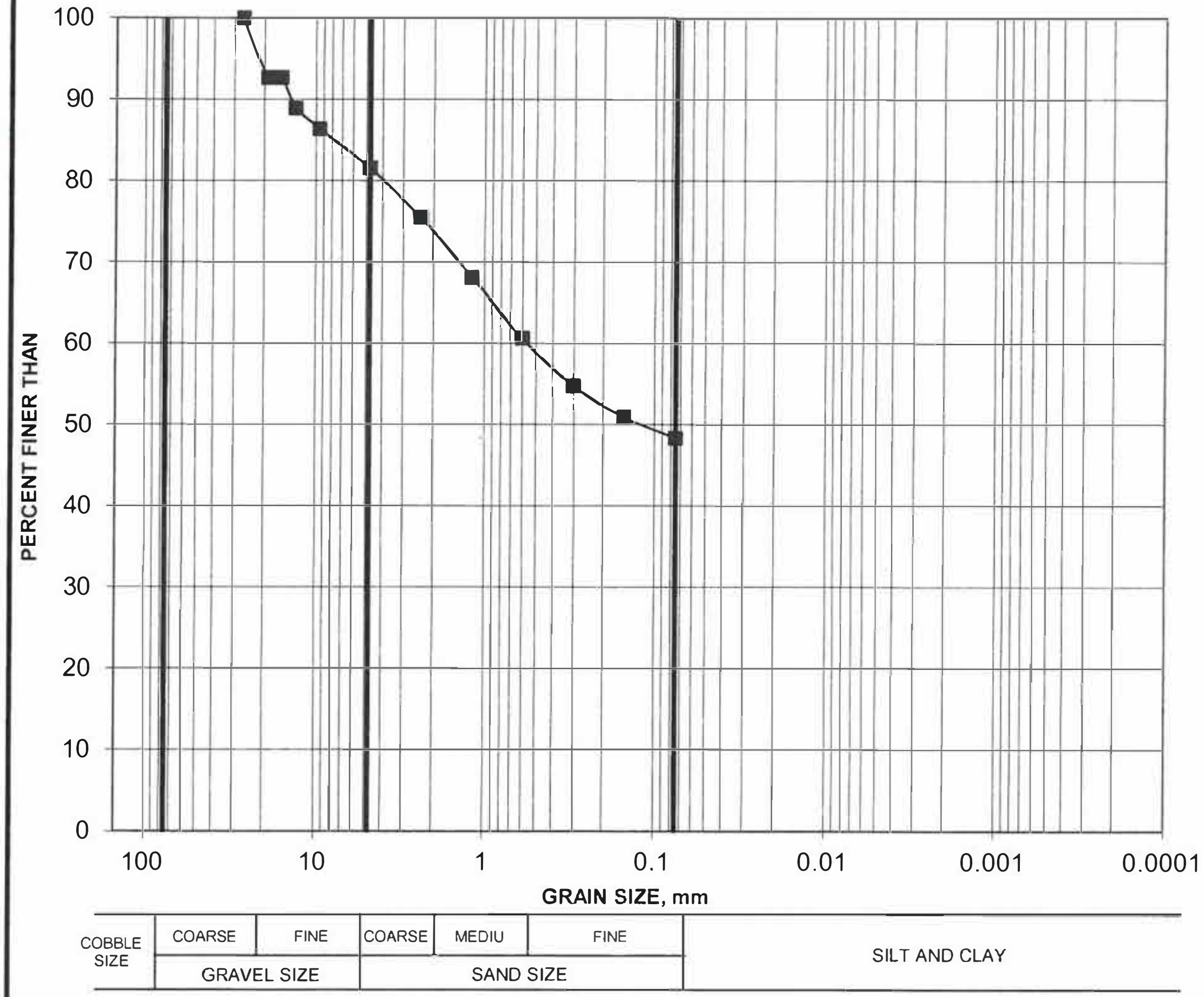
Created by: CW

Checked by: MI

GRAIN SIZE DISTRIBUTION

C-4

GLACIAL TILL



				Constituents (%)			
	Testpit	Sample	Depth (m)	Gravel	Sand	Silt	Clay
■	20-09	3	3.60-3.80	18	34	48	

GOLDER

Project: 20442530

Created by:

Checked by:

APPENDIX D

Results of Chemical Analysis

eurofins | Environment Testing

Certificate of Analysis

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

Report Number: 1947300
Date Submitted: 2021-02-02
Date Reported: 2021-02-09
Project: 20442530 ph 1000
COC #: 869640

				Lab I.D.	1540754	1540755
				Sample Matrix	Soil	Soil
				Sample Type		
				Sampling Date	2021-01-12	2021-01-12
				Sample I.D.	TP20-06 sa1	TP20-10 sa2
Group	**Analyte**	**MRL**	**Units**	**Guideline**		
Anions	SO4	0.01	%		0.01	0.02
Cl in Concrete	Cl	0.002	%		0.003	0.003
General Chemistry	Electrical Conductivity	0.05	mS/cm		0.16	0.35
	pH	2.00			8.05	8.03
	Resistivity	1	ohm-cm		6250	2860

Guideline = *** = Guideline Exceedence**

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

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

APPENDIX E

Results of Hydraulic Conductivity Testing

BOUWER AND RICE SLUG TEST ANALYSIS
RISING HEAD TEST BH20-01

INTERVAL (metres below ground surface)

Top of Interval = 3.66
Bottom of Interval = 6.71

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

where:

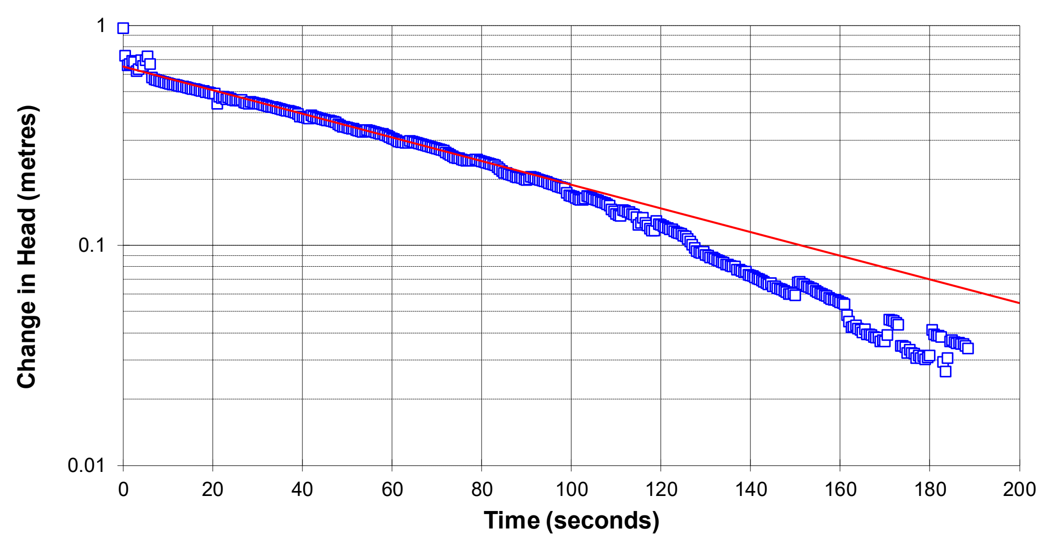
r_c = casing radius (metres);
R_e = effective radius (metres);
L_e = length of screened interval (metres);
r_w = radial distance to undisturbed aquifer (metres)
y_0 = initial drawdown (metres)
y_t = drawdown (metres) at time t (seconds)

INPUT PARAMETERS

r_c =	**0.02**
r_w =	**0.10**
L_e =	**3.05**
$ln(R_e/r_w)$	**2.38**
y_0 =	**0.65**
y_t =	**0.35**
t =	**50**

RESULTS

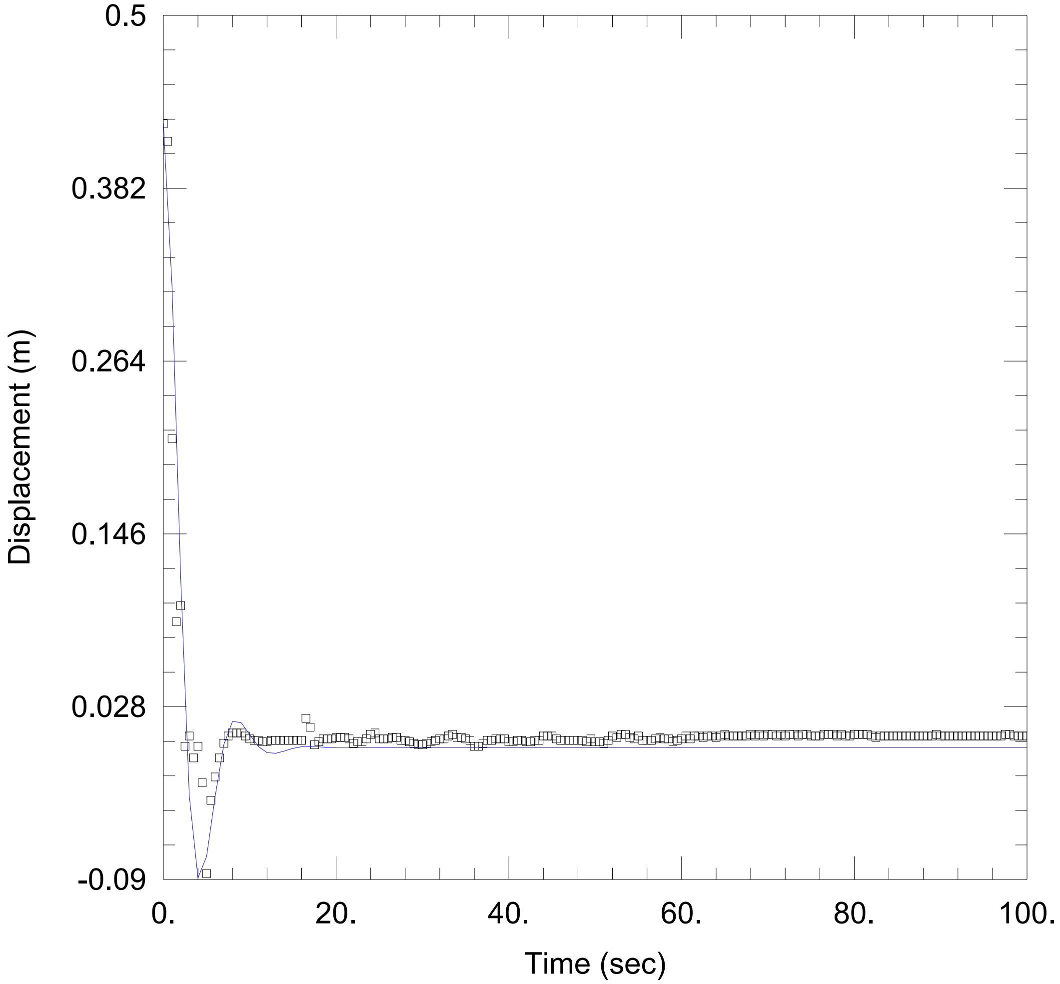
K=	**1E-06**	**m/sec**
K=	**1E-04**	**cm/sec**



Project Name: Barrett Co-Tenancy/Barrett Lands Phase 3
Project No.: 20442530
Test Date: 03-Feb-21

Analysis By: CAMC
Checked By: BH
Analysis Date: 08-Feb-21

Golder Associates Ltd.



WELL TEST ANALYSIS

Data Set: C:\...\BH20-03.aqt
Date: 02/18/21 Time: 10:26:39

PROJECT INFORMATION

Project: 20442530
Location: Barrett Lands Phase 3
Test Date: Analysis: CAMC; Checked by: BH

AQUIFER DATA

Saturated Thickness: 5. m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (BH20-03)

Initial Displacement: 0.426 m
Static Water Column Height: 4.2 m
Total Well Penetration Depth: 4.195 m
Screen Length: 3.05 m
Casing Radius: 0.016 m
Well Radius: 0.102 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Springer-Gelhar

K = 9.795E-5 m/sec
Le = 14.11 m

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