REPORT

Geotechnical Report

Laffin Parcel

Submitted to:

Caivan Communities
2934 Baseline Road, Suite 302
Ottawa, ON
K2H 1B2

Submitted by:

Golder Associates Ltd.
1931 Robertson Road,
Ottawa, Ontario
K2H 5B7

+1 613 592 9600

20144864-3000-02

July 23, 2020

Distribution List

1 e-copy: Caivan Communities

1 e-copy: Golder Associates Ltd.

Table of Contents

TABLES

FIGURES

APPENDICES

1.0 INTRODUCTION

Golder Associates Limited (Golder) has been retained by Caivan Communities (Caivan) to complete a geotechnical investigation for a parcel of property known as the “Laffin Parcel”. The parcel is located west of Queen Charlotte Street and north of Ottawa Street West in Richmond (see Figure 1).

The purpose of the investigation is to assess the anticipated general soil and groundwater conditions across the parcels by means of a number of boreholes, as well as associated field and laboratory testing. The results of the field and laboratory investigations are used to complete a variety of geotechnical analyses and prepare this geotechnical report. This report is intended to review potential geotechnical issues, including construction considerations that might affect development planning and provided discussion and recommendations related to the design and construction of the development.

This report is based on information obtained from the June 2020 investigation, as well as results of previous investigations in, and our general understanding of, the general area.

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 BACKGROUND

2.1 General

The location of the Laffin parcel is shown on the Key Plan on Figure 1.

Two previous investigations were carried out by Golder; a borehole and auger hole investigation carried out in 1992 for the Laffin Subdivision and a hydrogeological investigation completed in 2010 for the Mattamy Homes Development. The subsurface information and results of the previous investigations are contained in the reports titled:

- *Geotechnical Investigation Proposed Laffin Subdivision, Queen Street, Richmond, Ontario*, dated November 1992 (Golder Report No. 921-2357).
- *Technical Memorandum Proposed Mattamy Homes Development, Richmond (Ottawa), Ontario*, dated July 2010 (Golder Report No. 08-1122-0078).

Portions of these previous investigations are relevant to the currently investigated parcel (i.e. borehole and test pit locations are adjacent to or within the footprint of the current subject site and are expected to be have similar subsurface conditions). The locations of these test holes are shown on Figure 1.

2.2 Summary of Previous Investigations

Six test holes (3 auger holes and 3 boreholes) were advanced as part of the 1992 investigation and were labelled BH1, BH1A, BH2, AH1, AH2 and AH3. The subsurface conditions encountered generally consisted of topsoil or asphaltic concrete over glacial till underlain by what was inferred to be bedrock based on auger refusal. Auger refusal was observed between 0.5 and 2.2 m below ground surface. A thin layer of fill was encountered beneath the topsoil in BH1 and pavement fill (base and subbase material) was encountered beneath the asphaltic concrete in AH2 and AH3. A thin layer of sandy silt was encountered above the till in BH1A, AH1 and AH2.

Eight boreholes labelled 10-1 to 10-8 were advanced as part of the 2010 hydrogeological investigation. One borehole (MW10-6) was advanced within the proposed Laffin parcel and two boreholes (MW10-5 and MW10-7) were advanced in proximity to the proposed Laffin parcel footprint. At the location of MW10-6 the subsurface conditions consisted of about 250 mm of topsoil over loose to compact, sandy silt to silty sand, which extended to a depth of 1.8 m; over dense to very dense sandy silt till to about 3.1 m depth; over sandstone and dolostone bedrock. The Rock Quality Designation (RQD) of the bedrock ranged from about 70 to 85% indicating a fair to good rock quality.

In borehole MW10-5 located approximately 40 m from the northwest boundary of the development, the subsurface conditions consisted of 100 mm topsoil over compact silty sand to about 2 m depth over very dense sandy silt till which extended to the termination depth of the borehole at 4 m. At MW10-7, located approximately 200 m to the west of the proposed development, the subsurface conditions consisted of 80 mm topsoil, sandy silt to about 2.3 m depth underlain by loose silty sand which extended to the termination depth of the borehole at about 4 m.

Groundwater levels measured in the three monitoring wells indicated groundwater levels ranging from 0.5 m (El. 94.9 m) to 1.2 m (El. 94.3 m) below ground surface.

It should be noted that cobbles and boulders were observed in the till material.

3.0 CURRENT INVESTIGATION (JUNE 2020)

3.1 Procedure

The fieldwork for this investigation was carried out on June 23 and 24, 2020. During that time, a total of 12 boreholes (numbered 20-301 to 20-312) were advanced at the approximate locations shown on the attached Site Plan (Figure 1).

The boreholes were advanced using a truck-mounted hollow-stem auger drill rig supplied and operated by Marathon Drilling of Ottawa, Ontario. The boreholes were advanced to depths ranging from 2 to 6.3 m below the existing ground surface.

Standard Penetration Tests (SPTs) were carried out within the overburden at regular intervals of depth. Samples of the soils encountered were recovered using 35 mm diameter split-spoon sampling equipment.

Monitoring wells were installed in the glacial till in boreholes 20-304 and 20-310.

The fieldwork was supervised by technicians from our staff who located the boreholes, directed the drilling and in situ testing operations, logged the boreholes and samples, and took custody of the soil and bedrock samples retrieved. On completion of the drilling operations, the soil samples were transported to our Ottawa laboratory for further examination and laboratory testing, which included natural water content and grain size distribution tests on selected soil samples.

Two samples of soil, one from each of boreholes 20-305 and 20-309 was submitted to Eurofins Environment Testing for basic chemical analyses related to potential sulphate attack on buried concrete elements and potential corrosion of buried ferrous elements.

The results of the laboratory testing program are included in Appendix C.

The borehole locations were selected, marked in the field, and subsequently surveyed by Golder Associates personnel. The coordinates and ground surface elevations of the boreholes were measured using a Trimble R8 GPS survey unit. The geodetic reference system used for the survey is the North American datum of 1983 (NAD83). The coordinates are based on the Modified Transverse Mercator (MTM Zone 9) coordinate system. The elevations are referenced to Geodetic datum (CGVD28).

3.2 Subsurface Conditions

The following sections provide a general overview of the subsurface conditions at the site.

3.2.1 Topsoil

Topsoil was encountered at ground surface at all borehole locations with the exception of boreholes 20-304, 20-306, 20-307 and 20-310. The topsoil ranges in thickness from about 100 to 610 mm at the borehole locations.

3.2.2 Fill

Fill was encountered beneath the topsoil and at surface in most boreholes except for boreholes 20-301 and 20-309. The silty sand fill ranged in thickness from 500 to 800 mm. SPT tests carried out within the silty sand fill measured ‘N’ values ranging from 5 to 7 blows per 0.3 metres of penetration. The results of this in situ testing indicate a loose state of packing.

3.2.3 Sandy Silty Clay

A sandy silty clay deposit was encountered beneath the fill in boreholes 20-306 and 20-307. The layer ranged in thickness from 1.9 to 2.3 m and extended to depths of between 2.7 and 2.9 m below ground surface. The SPT ‘N’ values generally ranged from 3 to 12 blows per 0.3 m of penetration, indicating a firm to stiff consistency. One sample of the silty clay from borehole 20-307 measured an SPT ‘N’ value of greater than 50 blows per 0.3 m which may be indicative of refusal on bedrock or boulder.

Three samples of the clay were selected for moisture content testing. The moisture content of the samples of silty clay ranged from 26 to 34%. The results of Atterberg Limits testing completed on a sample of the silty clay indicate a plasticity index value of 10% and liquid limit value of 30%, which is indicative of a low plasticity clay (CL). The results of the Atterberg Limit test are shown on the plasticity chart on Figure C1.

3.2.4 Sandy Silt and Silt

A sandy silt layer was encountered below the topsoil and fill in all boreholes with the exception of boreholes 20-307 and 20-312. A silt layer was encountered beneath the silty clay in borehole 20-306. The layer ranged in thickness from 0.8 to 2.5 m. The SPT ‘N’ values generally ranged from 3 to 30 blows per 0.3 m of penetration, indicating a very loose to compact state of packing. One sample of the silt from borehole 20-303 measured a SPT ‘N’ value of greater than 50 blows per 0.3 m which was likely indicative of refusal on bedrock or a boulder.

The results of grain size distribution testing carried out on five samples of the silt deposit are presented on Figure C2. Several samples of the silt were selected for moisture content testing. The moisture content of the silt samples ranged from 18 to 25%.

3.2.5 Glacial Till

A glacial till layer comprising predominantly of silty sand to gravelly sand and silt was encountered below the silty sand layer in all boreholes with the exception of boreholes 20-307 and 20-309. The till was encountered beneath the topsoil/fill layer in borehole 20-312. The layer generally ranged in thickness from 0.2 to 1.2 m. For boreholes 20-304 and 20-310, the boreholes were terminated in the till layer and indicated thickness of more than 3.1 and 3.8 m, respectively. The SPT ‘N’ values generally ranged from 4 to greater than 50 blows per 0.3 m of penetration, indicating a loose to very dense state of packing. It should be noted that cobbles and boulders were observed in the till layer in some boreholes.

The results of grain size distribution testing carried out on three samples of the till deposit are presented on Figure C3. Several samples of the till were selected for moisture content testing. The moisture content of the till samples ranged from 8 to 12%.

3.2.6 Auger Refusal

Practical refusal to augering was encountered below glacial till in boreholes 20-301, 20-302, 20-305, 20-306, 20-308, 20-311 and 20-312 at depths ranging between 1.8 and 4.3 m below the ground surface. Refusal to augering was also encountered below the silty sand layer in boreholes 20-303 at a depth of 2 m below ground surface. Refusal could represent the bedrock surface or cobbles/boulders in the glacial till.

3.2.7 Bedrock

Bedrock was encountered in boreholes 20-307 and 20-309 at depths of 2.7 and 3.1 m below ground surface, respectively. The bedrock was described as slightly weathered to fresh, grey limestone. Bedrock was cored to about 4.3 m depth in borehole 20-307 and 6.3 m in borehole 20-309.

3.2.8 Groundwater

Monitoring wells were installed in boreholes 20-304 and 20-310 to observe the stabilized groundwater level across the site.

A summary of the groundwater levels measured in the previous monitoring wells is presented in Table 1.

It is expected that the groundwater level will be subject to fluctuations both seasonally and as a result of precipitation events.

Table 1: Summary of Ground Conditions

Borehole	Geologic Unit at Screened Interval	Depth to Groundwater (m)	Hydraulic Conductivity (cm/s)	Date of Reading
20-304	Sandy Silt and Gravelly Sand and Silt Till	2.46	1×10^{-5}	July 6, 2020
20-310	Silt and Gravelly Sand and Silt Till	2.27	-	July 3, 2020

4.0 DISCUSSION

4.1 General

This section of the report provides preliminary engineering guidelines on the geotechnical design aspects of the project based on our interpretation of the existing information from investigations carried out on the Laffin parcel development, as well as our understanding of the current project requirements.

It should be emphasized that the laboratory testing, as well as portions of the field work which are being undertaken as part of this investigation are being completed concurrently with the preparation of this preliminary report. The laboratory test results will be included in subsequent versions of this report and may necessitate revisions to the discussion and recommendations provided herein.

In general, the subsurface conditions within the Laffin parcel are expected to consist of topsoil and fill overlying native sandy silt and silt, glacial till containing cobbles and boulders, over limestone bedrock which is anticipated to be encountered between depths of 1.8 and 4.3 m below ground surface. A 1.9 to 2.3 m thick layer of silty clay was encountered in boreholes 20-306 and 20-307.

4.2 Site Grading

As a general guideline regarding the site grading, the preparation for filling of the site should include stripping the topsoil for predictable performance of structures and services.

The site is generally underlain by loose to very dense native sandy silt and gravelly sand and silt till and therefore, grade raises typical for low-rise sub-divisions should not be an issue for this site.

4.3 Foundations

It is considered that conventional houses could be supported on shallow foundations founded on or within the native sandy silt or the glacial till deposit.

Strip footing foundations may be designed using a maximum allowable bearing pressure of 125 kPa. As such, the house footings may be sized in accordance with Part 9 of the Ontario Building Code (OBC).

For the Laffin parcel, selection of the founding levels (in relation to the groundwater level) is also impacted by City of Ottawa requirements associated with the use of sump pumps. The underside of footing (USF) elevations for all structures should be at or above the elevation of the springline of the storm sewer installed in the adjacent roadways, and at or above the groundwater level.

Following servicing of the site (as will typically occur in advance of house construction), some lowering of the groundwater level is expected.

4.4 Frost Protection

The native subgrade soils on this site are considered to be 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.

4.5 Excavations

Excavation for the installation of site services and house basements will likely be made into and potentially through the native silty sand and into the underlying glacial till.

No unusual problems are anticipated with excavating in the overburden materials using conventional hydraulic excavating equipment, recognizing that cobbles and boulders should be expected within the glacial till.

The glacial till would generally be classified as a Type 3 soil in accordance with the Occupational Health and Safety Act of Ontario (OHSA) for Construction Activities. As such, excavations within these materials may be made with side slopes at 1 horizontal to 1 vertical (1H:1V).

Some groundwater inflow into the excavations should be expected. 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 of the excavation, and the time of year at which the excavation is carried out. 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 pumps are used. A permit to take water may be required depending on proposed construction plan and timing of construction.

4.6 Material Reuse

Any topsoil removed during site grading or excavation activities is not considered suitable as engineered fill and should be stockpiled separately for re-use in landscaping applications only.

The overburden soils at the site should not be used as backfill directly against exterior, unheated or well insulated foundation elements.

Any clayey soils or wet silty soils are not considered suitable for reuse as structural/engineered fill but could be reused in non-structural areas (i.e., landscaping).

4.7 Basement and Garage Floor Slabs

In preparation for the construction of the basement/garage floor slabs, all loose, wet, and disturbed material 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 floor slabs.

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 Standard Proctor Maximum Dry Density (SPMDD).

The recommended type of drainage system required (perimeter drains and/or underfloor drains; damp-proofing or waterproofing) 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.

The founding depths should be set above the groundwater level. The groundwater level was observed to be depths ranging between 2.3 and 2.5 m below existing grade in the monitoring wells installed as part of the June 2020 investigation.

However, if/where the groundwater level is encountered above subgrade level, a geotextile could be required between the clear stone underslab fill and the silty 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. 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 Ontario Provincial Standard Specification (OPSS) 1860.

4.8 Bedding and Pipe Cover for Services

Assuming similar hydrogeological and drainage conditions as the previous development phases, at least 250 mm of 19 mm nominal size clear crushed stone should be used as pipe bedding for the storm sewers to allow for drainage. The clear stone must be fully wrapped in a suitable non-woven geotextile.

At least 150 mm of OPSS Granular A should be used as pipe bedding for sanitary sewer and water pipes, and for the storm sewer laterals to the houses. Unless fully wrapped in a non-woven geotextile, the use of clear crushed stone as a bedding layer should not be permitted anywhere for bedding and backfill of sanitary sewer and water pipes 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. 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.

Cover material, from spring line of the pipe to at least 300 mm above the top of 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.

4.9 Excavation Backfill

Site Services

It should generally be possible to re-use the silty sand 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.

Impervious Cut-Offs

Impervious dikes or cut-offs should be constructed in the service trenches for sanitary sewers, water pipes and service laterals to each house to reduce additional groundwater lowering at the site due to the “french drain” effect. It is important that these barriers extend from trench wall to trench wall and that they fully penetrate the granular materials to the trench bottom. The dikes should be at least 1.5 m wide.

Clay cut-offs should not be constructed in the service trenches for the storm sewer pipes (assuming the same drainage requirements apply as for previous phases of the development).

4.10 Basements and Garages

To avoid problems with frost adhesion and heaving, foundation elements should be backfilled with non-frost susceptible sand or sand and gravel. The backfill should be placed in maximum 300 mm thick lifts and be compacted to at least 95% of the material’s SPMDD.

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 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

H =The height of the basement wall in metres

4.11 Pavement Design

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

Pavement areas requiring grade raises to proposed subgrade level should be filled using acceptable (compactable and inorganic) earth borrow or OPSS Select Subgrade Material.

For planning purposes, Table 2 outlines the City of Ottawa’s minimum recommended pavement structure for residential streets.

Table 2: Preliminary Pavement Design Residential Streets

Pavement Component	Thickness (mm)	Materials
Asphaltic Concrete Pavement	Surface course – 40 Base course – 50	SP 12.5 SP 19.0
Base	150	OPSS Granular A
Subbase	400	OPSS Granular B Type II

For collector roadways, the subbase thickness should be increased to 600 mm. The asphaltic concrete thickness should be assumed to be at least 140 mm for bus routes and the subbase thickness should also be increased to 600 mm.

4.12 Corrosion and Cement Type

Two samples of soil from boreholes 20-305 and 20-309 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 summarized below:

Table 3: Summary of Chemical Analyses Results

BH No. / Sa No.	Sample Depth (m)	Chloride (%)	SO4 (%)	Electrical Conductivity (mS/cm)	pH	Resistivity (ohm-cm)
20-305 / Sa 2	0.8 – 1.4	<0.002	0.09	0.08	8.23	12000
20-309 / Sa 3	1.5 – 2.1	0.002	<0.01	0.08	8.29	11900

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

4.13 Pools, Decks and Additions

4.13.1 Above Ground and In Ground Pools

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

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

A permit application will have to be submitted for City’s approval for pool enclosures.

4.13.2 Additions

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

5.0 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).

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

Golder Associates should be retained to review the final grading plan and specifications for this project prior to construction to ensure that the guidelines in this report have been adequately interpreted.

Ontario Regulation 903 (Wells) would ultimately require abandonment of the monitoring wells installed within the test holes on this site (wells from both the current and previous geotechnical investigations); however, these devices may be useful during construction, and may be used as part of the groundwater level monitoring following servicing of the site. It is therefore proposed that decommissioning of these devices be undertaken following City approval. Wells should be decommissioned in accordance with the procedures outlined in Ontario Regulation 903.

6.0 CLOSURE

We trust this report satisfies your current requirements. If you have any questions regarding this report, please contact the undersigned.

Golder Associates Ltd.

LICENSED PROFESSIONAL ENGINEER
Bridgit F. Bocage
100185750
July 27, 2020
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
C. G. HENDRY
100011328
PROVINCE OF ONTARIO

Bridgit Bocage, M.Eng., P.Eng.
Geotechnical Engineer

Chris Hendry, M.Eng., P.Eng.
Senior Geotechnical Engineer

BB/CH/hdw

https://golderassociates.sharepoint.com/sites/128209/project files/6 deliverables/laffin parcel final/20144864 geotech draft report laffin 20200722.docx

Important Information and Limitations of This Report

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, **Caivan Communities.** 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.

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.

LEGEND

⊕	APPROXIMATE BOREHOLE LOCATION
◆	EXISTING BOREHOLE LOCATION
—	ROADWAY
🟥	APPROXIMATE SITE BOUNDARY

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
CAIVAN (RICHMOND NORTH) LIMITED

PROJECT
PRELIMINARY GEOTECHNICAL REPORT
LAFFIN PARCEL

TITLE
SITE PLAN, PREVIOUS AND PROPOSED TESTHOLE LOCATIONS

CONSULTANT

GOLDER

YYYY-MM-DD	2020-07-01
DESIGNED	----
PREPARED	JEM
REVIEWED	KM
APPROVED	CH

PROJECT NO.	CONTROL	REV.	FIGURE
20144864	0006	0	1

Path: N:\Active\Spatial_IM\Caivan\RichmondProposedSWMP\99_PROJ\20144864_Caivan_Enviro\0006_Geotech_Prelim_Report_LaffinParcel\20144864-0006-BG-0001.mxd

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

25mm

APPENDIX A

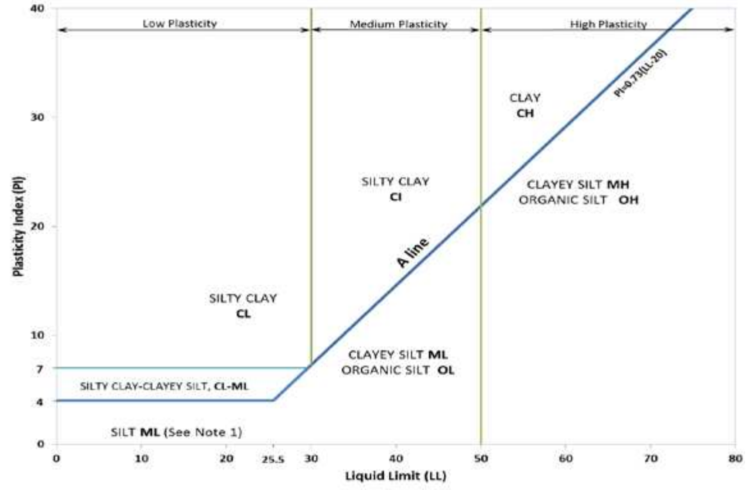
Record of Previous Investigations

METHOD OF SOIL CLASSIFICATION

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

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

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



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

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

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

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

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

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

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

ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS

PARTICLE SIZES OF CONSTITUENTS

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

MODIFIERS FOR SECONDARY AND MINOR CONSTITUENTS

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

PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

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

Cone Penetration Test (CPT)

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

Dynamic Cone Penetration Resistance (DCPT); N_d:

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

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

SAMPLES

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

SOIL TESTS

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

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

NON-COHESIVE (COHESIONLESS) SOILS

Compactness[2]

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

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

Field Moisture Condition

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

COHESIVE SOILS

Consistency

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

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

Water Content

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

LIST OF SYMBOLS

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

I. GENERAL

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

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

(a) Index Properties

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

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

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

Notes:

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

2 shear strength = (compressive strength)/2

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERINGS STATE

Fresh: no visible sign of rock material weathering.

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

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

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

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

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

BEDDING THICKNESS

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

JOINT OR FOLIATION SPACING

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

GRAIN SIZE

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

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

CORE CONDITION

Total Core Recovery (TCR)

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

Solid Core Recovery (SCR)

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

Rock Quality Designation (RQD)

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

DISCONTINUITY DATA

Fracture Index

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

Dip with Respect to Core Axis

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

Description and Notes

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

Abbreviations

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

PROJECT: 08-1122-0078

RECORD OF BOREHOLE: 10-5

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: Apr. 30, 2010

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m
0		GROUND SURFACE	94.82			
	Power Auger 200mm Diam. (Hollow Stem)	TOPSOIL	0.00			
		Compact grey brown SILTY fine SAND	0.10			
1				1	50 DO	15
				2	50 DO	5
2		Compact to very dense grey SANDY SILT, some gravel, trace clay (GLACIAL TILL)	92.84 1.98			
				3	50 DO	15
3				4	50 DO	>100
4		End of Borehole	90.86 3.96			

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

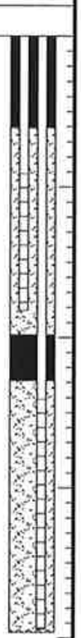
SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ ; 20 40 60 80

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

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

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION



DEPTH SCALE

1 : 50

Golder Associates

LOGGED: J.D.

CHECKED:

MIS-BHS 001 0811220078-9500.GPJ GAL-MIS.GDT 5/19/10 JM

PROJECT: 08-1122-0078

RECORD OF BOREHOLE: 10-6

SHEET 1 OF 2

LOCATION: See Site Plan

BORING DATE: Apr. 30, 2010

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

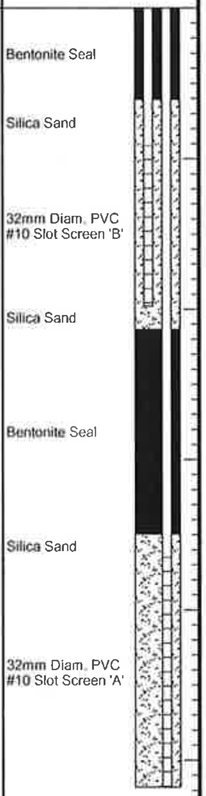
HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}

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

ADDITIONAL LAB. TESTING

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m
		GROUND SURFACE	95.67			
0	Power Auger 200mm Diam. (Hollow Stem)	TOPSOIL	0.00			
		Loose to compact grey brown SANDY SILT to SILTY SAND, trace clay	95.42 0.25			
1				1	50 DO	6
2		Dense to very dense grey brown SANDY SILT, some gravel, cobbles and boulders (GLACIAL TILL)	93.84 1.83	2	50 DO	27
				3	50 DO	68
3	Rotary Drill NQ Core	Thinly to medium bedded light grey intebedded SANDSTONE and DOLOSTONE BEDROCK	92.60 3.07	4	50 DO	>100
4				C1	NQ RC	DD
5				C2	NQ RC	DD
		End of Borehole	90.49 5.18			
6						
7						
8						
9						
10						

PIEZOMETER OR STANDPIPE INSTALLATION



DEPTH SCALE

1 : 50

LOGGED: J.D.

CHECKED: bb

MIS-BHS 001 0811220078-9500.GPJ GAL-MIS.GDT 5/19/10 JM

PROJECT: 08-1122-0078

RECORD OF DRILLHOLE: 10-6

SHEET 2 OF 2

LOCATION: See Site Plan

DRILLING DATE: Apr. 30, 2010

DATUM:

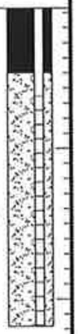
DRILL RIG: CME 55

INCLINATION: -90° AZIMUTH: ---

DRILLING CONTRACTOR: Marathon Drilling

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

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE (m/min)	FLUSH COLOUR % RETURN	RECOVERY TOTAL CORE % 80 60 40 20	RECOVERY SOLID CORE % 80 60 40 20	R.Q.D. % 80 60 40 20	FRACT. INDEX PER 0.3 5 10 15 20	DISCONTINUITY DATA DIP w.r.t. CORE AXIS 0 30 60 90	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	HYDRAULIC CONDUCTIVITY K, cm/sec 10^{-6} 10^{-5} 10^{-4} 10^{-3}	DIAMETRAL POINT LOAD INDEX (MPa) 2 4 6	NOTES WATER LEVELS INSTRUMENTATION
		BEDROCK SURFACE		92.60												
4 5	Rotary Drill NQ Core	Thinly to medium bedded light grey intebedded SANDSTONE and DOLOSTONE BEDROCK		3.07	1											Bentonite Seal Silica Sand 32mm Diam. PVC #10 Slot Screen 'A'
6 7 8 9 10 11 12 13		End of Borehole		90.49 5.18												



DEPTH SCALE
1 : 50

Golder Associates

LOGGED: J.D.
CHECKED:

PROJECT: 08-1122-0078

RECORD OF BOREHOLE: 10-7

SHEET 1 OF 1

LOCATION: See Site Plan

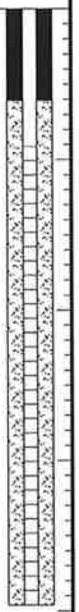
BORING DATE: Apr. 29, 2010

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	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		95.36							
0	Power Auger 200mm Diam. (Hollow Stem)	TOPSOIL		0.00							Bentonite Seal
		Stiff grey to brown SILT, trace to some clay, trace fine sand		0.08							Silica Sand
1					1	50 DO	5				
2					2	50 DO	9				
		Loose grey brown SILTY fine SAND		93.07 2.29							32mm Diam. PVC #10 Slot Screen
3					3	50 DO	8				
					4	50 DO	9				
4		End of Borehole		91.40 3.96							
5											
6											
7											
8											
9											
10											



DEPTH SCALE
1 : 50

Golder Associates

LOGGED: J.D.
CHECKED:

TABLE 1

RECORD OF BOREHOLES AND AUGERHOLES
PROPOSED LAFFIN SUBDIVISION
QUEEN STREET, RICHMOND, ONTARIO

Borehole/ Augerhole Number	Depth (metres)	Soil Description
BH 1 Elev. 99.30 metres	0.0 - 0.06	**TOPSOIL**
	0.06 - 0.30	Brown sand and gravel **(FILL)**
	0.30 - 0.73	Brown **GLACIAL TILL**
	0.73	End of Hole Auger Refusal
		Hole dry on October 24, 1992
BH 1A Elev. 99.34 metres	0.0 - 0.18	**TOPSOIL**
	0.18 - 0.43	Brown **SANDY SILT**
	0.43 - 0.49	Brown **GLACIAL TILL**
	0.49	End of Hole Auger Refusal
		Hole dry on October 24, 1992
BH 2 Elev. 98.82 metres	0.00 - 0.30	Dark brown silty **TOPSOIL**
	0.30 - 2.19	Compact brown **GLACIAL TILL** N = 24, 29 blows per 0.3 metre
	2.19	End of Hole Auger Refusal
		Water level at 1.4 metre depth on October 24, 1992

TABLE 1 (cont'd)

RECORD OF BOREHOLES AND AUGERHOLES
PROPOSED LAFFIN SUBDIVISION
QUEEN STREET, RICHMOND, ONTARIO

Borehole/ Augerhole Number	Depth (metres)	Soil Description
AH 1 Elev. 98.90 metres	0.0 - 0.24	Dark brown silty **TOPSOIL**
	0.24 - 0.37	Brown **SANDY SILT**
	0.37 - 1.13	Brown **GLACIAL TILL**
	1.13	End of Hole Auger Refusal Hole dry on October 24, 1992
AH 2 Elev. 99.53 metres	0.0 - 0.06	**ASPHALTIC CONCRETE**
	0.06 - 0.15	Grey crushed stone (**BASE**)
	0.15 - 0.58	Brown sand and gravel, trace to some silt (**SUBBASE**)
	0.58 - 0.73	Brown sandy silt (**FILL**)
	0.73 - 0.88	**TOPSOIL**
	0.88 - 1.16	Brown **SANDY SILT**
	1.16 - 1.58	Brown **GLACIAL TILL**
	1.58	End of Hole Auger Refusal Hole dry on October 24, 1992

TABLE 1 (cont'd)

RECORD OF BOREHOLES AND AUGERHOLES
PROPOSED LAFFIN SUBDIVISION
QUEEN STREET, RICHMOND, ONTARIO

Borehole/ Augerhole Number	Depth (metres)	Soil Description
AH 3 Elev. 99.56 metres	0.00 - 0.05	**ASPHALTIC CONCRETE**
	0.05 - 0.18	Grey crushed stone (**BASE**)
	0.18 - 0.52	Brown sand and gravel, trace silt (**SUBBASE**)
	0.52 - 0.61	**TOPSOIL**
	0.61 - 0.88	Brown **SANDY SILT**
	0.88 - 0.98	Brown **GLACIAL TILL**
	0.98	End of Hole Auger Refusal Hole dry on October 24, 1992

APPENDIX B

Current Investigation - Record of Boreholes

PROJECT: 20144864

RECORD OF BOREHOLE: 20-301

SHEET 1 OF 1

LOCATION: N 5004877.5 ;E 356671.0

BORING DATE: June 23, 2020

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	ELEV. DEPTH (m)	SAMPLES: NUMBER	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	94.79							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND; dark brown, contains organic matter; moist	0.00							
		(ML) sandy SILT; grey brown; non-cohesive, moist, very loose to compact	0.11	1	SS	5				
1				2	SS	8				
				3	SS	24				
2		(SM) gravelly SILTY SAND; grey (GLACIAL TILL); non-cohesive, moist, compact	92.66 2.13							
		End of Borehole Auger Refusal	2.28							Open borehole dry upon completion of drilling
3										
4										
5										
6										
7										
8										
9										
10										

MIS-BHS 001 20144864.GPJ GAL-MIS.GDT 7/24/20 JM/JEM

DEPTH SCALE

1 : 50

GOLDER

LOGGED: KM

CHECKED: BB

PROJECT: 20144864

RECORD OF BOREHOLE: 20-302

SHEET 1 OF 1

LOCATION: N 5004929.5 ;E 356765.7

BORING DATE: June 23, 2020

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80; SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3}; WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		94.80							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND; dark brown; moist		0.00							
		FILL - (SM) SILTY SAND; red brown; non-cohesive, moist, loose		0.11	1	SS	7				
1		(ML) sandy SILT; grey brown; non-cohesive, moist, compact		94.04 0.76	2	SS	23				
2					3	SS	30				
		(SM) gravelly SILTY SAND; grey (GLACIAL TILL); non-cohesive, moist, compact to dense		92.51 2.29	4	SS	35				
3		End of Borehole Auger Refusal		92.03 2.77							Open borehole dry upon completion of drilling
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: KM

CHECKED: BB

PROJECT: 20144864

RECORD OF BOREHOLE: 20-303

SHEET 1 OF 1

LOCATION: N 5004993.5 ;E 356803.7

BORING DATE: June 23, 2020

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		94.78					
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND; dark brown, contains organic matter; moist		0.00					
		FILL - (SM) SILTY SAND; grey brown, mottled, contains organic matter; non-cohesive, moist, loose		0.11	1	SS	5		
1		(ML) sandy SILT, trace fines; grey brown; non-cohesive, moist, compact to very dense		94.17 0.61	2	SS	16		
					3	SS	57/ 0.28	MH	
2		End of Borehole Auger Refusal		92.82 1.96					Open borehole dry upon completion of drilling
3									
4									
5									
6									
7									
8									
9									
10									

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

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

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

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

DEPTH SCALE

1 : 50

GOLDER

LOGGED: KM

CHECKED: BB

PROJECT: 20144864

RECORD OF BOREHOLE: 20-304

SHEET 1 OF 1

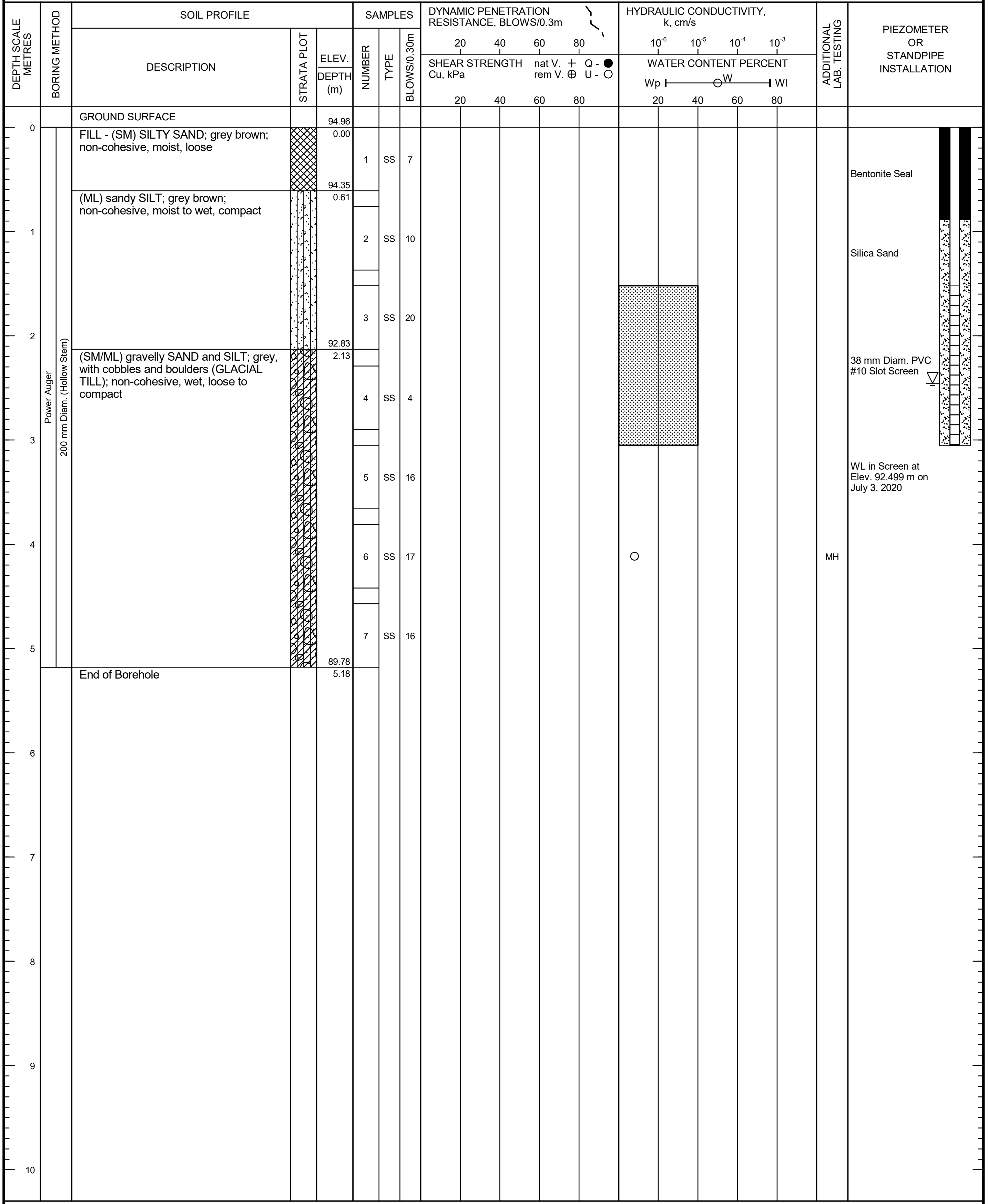
LOCATION: N 5004804.3 ;E 356738.0

BORING DATE: June 24, 2020

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm



SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	94.96
FILL - (SM) SILTY SAND; grey brown; non-cohesive, moist, loose	0.00
(ML) sandy SILT; grey brown; non-cohesive, moist to wet, compact	94.35 0.61
(SM/ML) gravelly SAND and SILT; grey, with cobbles and boulders (GLACIAL TILL); non-cohesive, wet, loose to compact	92.83 2.13
End of Borehole	89.78 5.18

NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
1	SS	7	
2	SS	10	
3	SS	20	
4	SS	4	
5	SS	16	
6	SS	17	MH
7	SS	16	

Bentonite Seal

Silica Sand

38 mm Diam. PVC #10 Slot Screen

WL in Screen at Elev. 92.499 m on July 3, 2020

DEPTH SCALE
1 : 50

GOLDER

LOGGED: DG
CHECKED: BB

PROJECT: 20144864

RECORD OF BOREHOLE: 20-305

SHEET 1 OF 1

LOCATION: N 5004849.3 ;E 356780.6

BORING DATE: June 23, 2020

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	94.92							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND; dark brown, contains organic; moist	0.00							
		FILL - (SM) SILTY SAND; brown, mottled, contains organic matter; non-cohesive, moist, loose	0.10	1	SS	6				
1		(ML) sandy SILT, some fines; grey brown; non-cohesive, moist, compact to loose	94.16 0.76	2	SS	10			CHEM	
2				3	SS	9		○	MH	
		(SM) gravelly SILTY SAND; grey (GLACIAL TILL); non-cohesive, moist, loose	92.63 2.29	4	SS	6				
3				5	SS	50/ 0.03				
		End of Borehole Auger Refusal	91.85 3.07							Open borehole dry upon completion
4										
5										
6										
7										
8										
9										
10										

MIS-BHS 001 20144864.GPJ GAL-MIS.GDT 7/24/20 JM/JEM

DEPTH SCALE

1 : 50

GOLDER

LOGGED: KM

CHECKED: BB

PROJECT: 20144864

RECORD OF BOREHOLE: 20-306

SHEET 1 OF 1

LOCATION: N 5004723.1 ;E 356802.1

BORING DATE: June 24, 2020

DATUM: Geodetic

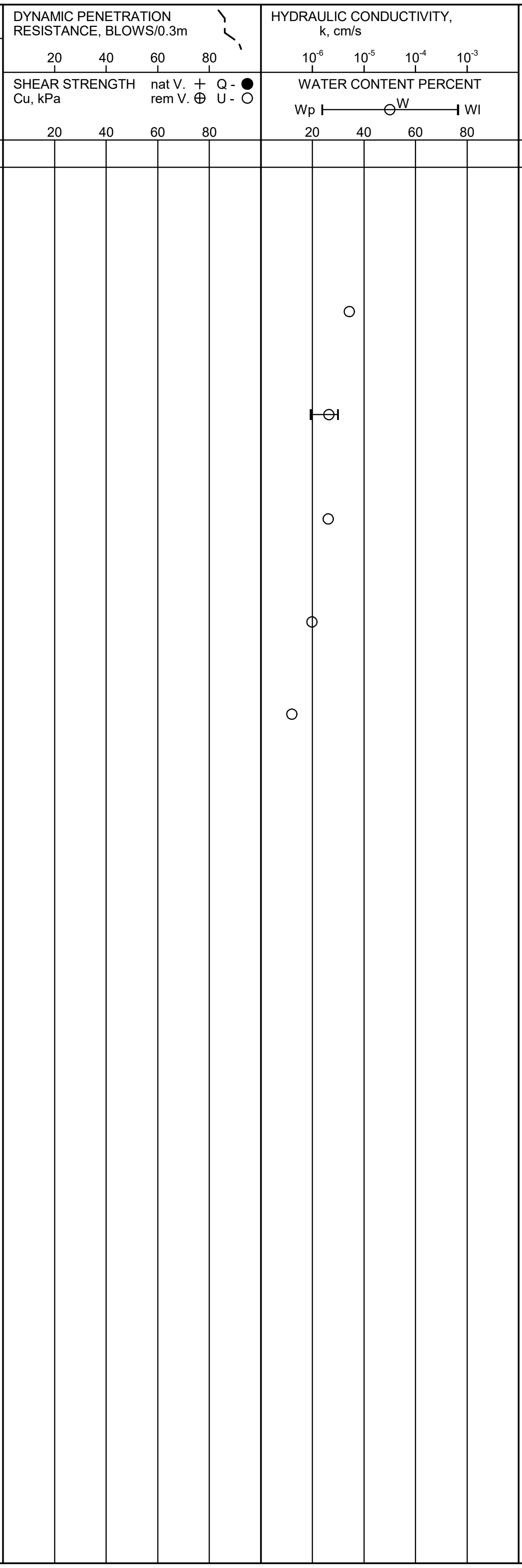
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	94.99
FILL - (SM) SILTY SAND; grey brown; non-cohesive, moist, loose	0.00
(CL) sandy SILTY CLAY; grey brown, contains silty sand layers; cohesive, w~PL, stiff	94.38 0.61
(ML) SILT, some sand; grey brown; non-cohesive, wet, compact	92.09 2.90
(SM/ML) gravelly SAND and SILT; grey, with cobbles and boulders (GLACIAL TILL); non-cohesive, wet	91.33 3.66
End of Borehole Auger Refusal	90.73 4.26

SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
1	SS	6	
2	SS	3	
3	SS	10	
4	SS	7	
5	SS	14	MH
6	SS	51	MH



PIEZOMETER OR STANDPIPE INSTALLATION

∇

WL in open borehole at 3.55 m depth below ground surface upon completion of drilling

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

DEPTH SCALE

1 : 50

GOLDER

LOGGED: DG

CHECKED: BB

PROJECT: 20144864

RECORD OF BOREHOLE: 20-307

SHEET 1 OF 1

LOCATION: N 5004759.0 ;E 356875.7

BORING DATE: June 24, 2020

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 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
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m				
		GROUND SURFACE		95.19							
0	Power Auger 200 mm Diam. (Hollow Stem)	FILL - (SM) SILTY SAND; grey brown; non-cohesive, moist, loose		0.00	1	SS	5				
1		(CL) sandy SILTY CLAY; grey brown, contains silty sand layers; cohesive, w~PL, very stiff		94.43 0.76	2	SS	4				
2					3	SS	12				
					4	SS	55/ 0.23				
3	Rotary Drill NQ Core	Fresh, medium bedded, grey, medium to strong LIMESTONE BEDROCK		92.53 2.66	5	RC	DD				
4		End of Borehole		90.88 4.31							
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: DG

CHECKED: BB

PROJECT: 20144864

RECORD OF BOREHOLE: 20-308

SHEET 1 OF 1

LOCATION: N 5004825.9 ;E 356907.6

BORING DATE: June 23, 2020

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	SOIL PROFILE: STRATA PLOT	SOIL PROFILE: ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80); SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}); WATER CONTENT PERCENT Wp ├──○W──┤ Wl (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		95.33							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL/FILL - (SM) SILTY SAND; dark brown, contains organic matter; non-cohesive, moist		0.00							
		(ML) SILT, some sand, trace gravel; grey; non-cohesive, moist, loose to compact		95.03 0.30	1	SS	6				
1					2	SS	4				
					3	SS	16		○	MH	
2		(SM) gravelly SILTY SAND; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist, very dense		93.20 2.13	4	SS	50/ 0.25				
		End of Borehole Auger Refusal		92.82 2.51							
3											WL in open borehole dry upon completion of drilling
4											
5											
6											
7											
8											
9											
10											

MIS-BHS 001 20144864.GPJ GAL-MIS.GDT 7/24/20 JM/JEM

DEPTH SCALE

1 : 50

GOLDER

LOGGED: KM

CHECKED: BB

PROJECT: 20144864

RECORD OF BOREHOLE: 20-309

SHEET 1 OF 1

LOCATION: N 5004667.6 ;E 356880.1

BORING DATE: June 24, 2020

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 / SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} / WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		95.28							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND; dark brown, with rootlets; non-cohesive, moist		0.00	1	SS	8				
1		(ML) SILT, some sand; grey brown; non-cohesive, moist to wet, loose to compact		94.67 0.61	2	SS	3				
2					3	SS	12			CHEM	
					4	SS	10				▽
3					5	SS	50/ 0.05				
	Rotary Drill NQ Core	Slightly weathered to fresh, medium bedded, grey, medium to strong LIMESTONE BEDROCK		92.19 3.09	6	RC	DD				
4					7	RC	DD				
5 6					8	RC	DD				
7 8 9 10		End of Borehole		88.96 6.32							WL in open borehole at 2.50 m depth below ground surface upon completion of drilling

DEPTH SCALE

1 : 50

GOLDER

LOGGED: DG

CHECKED: BB

PROJECT: 20144864

RECORD OF BOREHOLE: 20-310

SHEET 1 OF 1

LOCATION: N 5004599.5 ;E 356935.2

BORING DATE: June 24, 2020

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	95.71
FILL - (SM) SILTY SAND; brown; non-cohesive, moist, loose	0.00
(ML) SILT, some sand, fine; grey brown, contains silt layers; non-cohesive, moist to wet, compact	94.95 0.76
(SM/ML) gravelly SAND and SILT; grey, with cobbles and boulders (GLACIAL TILL); non-cohesive, wet, loose to very dense	93.42 2.29
End of Borehole	89.62 6.09

NUMBER	TYPE	BLOWS/0.30m	WATER CONTENT PERCENT	ADDITIONAL LAB. TESTING
1	SS	6		
2	SS	15		
3	SS	15		
4	SS	9	○	MH
5	SS	15		
6	SS	21		
7	SS	92		
8	SS	58		

PIEZOMETER OR STANDPIPE INSTALLATION

- Bentonite Seal
- Silica Sand
- 38 mm Diam. PVC #10 Slot Screen ▽
- WL in Screen at Elev. 93.436 m on July 3, 2020

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

DEPTH SCALE

1 : 50

GOLDER

LOGGED: DG

CHECKED: BB

PROJECT: 20144864

RECORD OF BOREHOLE: 20-311

SHEET 1 OF 1

LOCATION: N 5004680.7 ;E 356947.0

BORING DATE: June 23, 2020

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80; SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3}; WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	95.69							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL/FILL - (SM) SILTY SAND; dark brown, contains organic matter; moist	0.00							
		(ML) SILT, trace sand; grey brown to grey, contains layers of clayey silt; non-cohesive, moist, very loose to loose	95.39 0.30	1	SS	3				
1				2	SS	5		○	MH	
		(SM) gravelly SILTY SAND; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist, compact to very dense	94.17 1.52	3	SS	26				
2				4	SS	50/ 0.03				
		End of Borehole Auger Refusal	93.23 2.46							
3										Open borehole dry upon completion of drilling
4										
5										
6										
7										
8										
9										
10										

MIS-BHS 001 20144864.GPJ GAL-MIS.GDT 7/24/20 JM/JEM

DEPTH SCALE

1 : 50

GOLDER

LOGGED: KM

CHECKED: BB

PROJECT: 20144864

RECORD OF BOREHOLE: 20-312

SHEET 1 OF 1

LOCATION: N 5004719.6 ;E 357006.5

BORING DATE: June 23, 2020

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	SOIL PROFILE: STRATA PLOT	SOIL PROFILE: ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ├──○W──┤ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		96.19							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL/FILL - (SM) SILTY SAND; dark brown, contains organic matter; non-cohesive, moist, very loose	▩	0.00	1	SS	4				
1		(SM) gravelly SILTY SAND; grey brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist, compact to very dense	▨	95.58 0.61	2	SS	19				
					3	SS	50/ 0.10				
2		End of Borehole Auger Refusal		94.41 1.78							Open borehole dry upon completion of drilling
3											
4											
5											
6											
7											
8											
9											
10											

MIS-BHS 001 20144864.GPJ GAL-MIS.GDT 7/24/20 JM/JEM

DEPTH SCALE

1 : 50

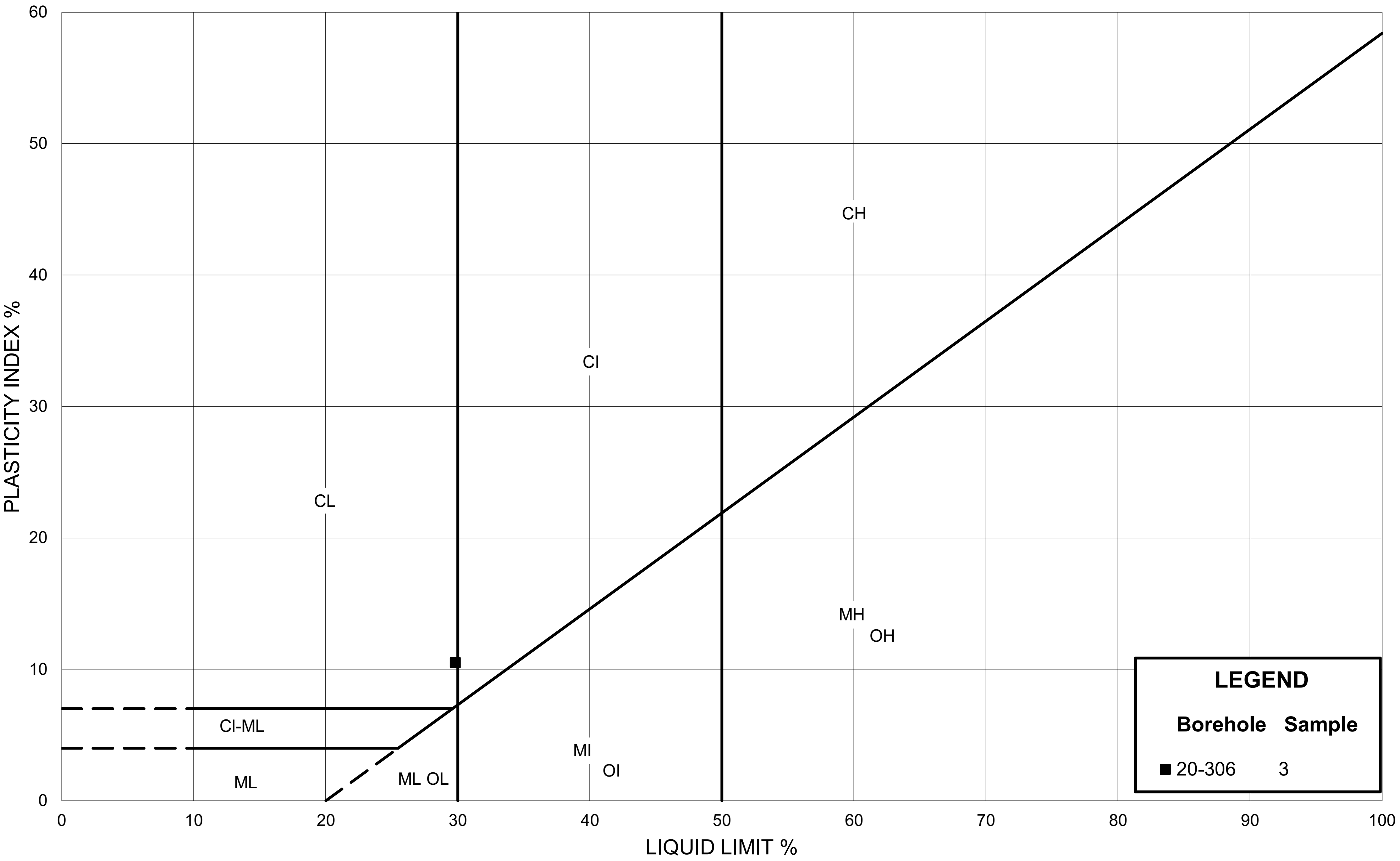
GOLDER

LOGGED: KM

CHECKED: BB

APPENDIX C

Laboratory Test Results



GOLDER

PLASTICITY CHART

Figure: C1

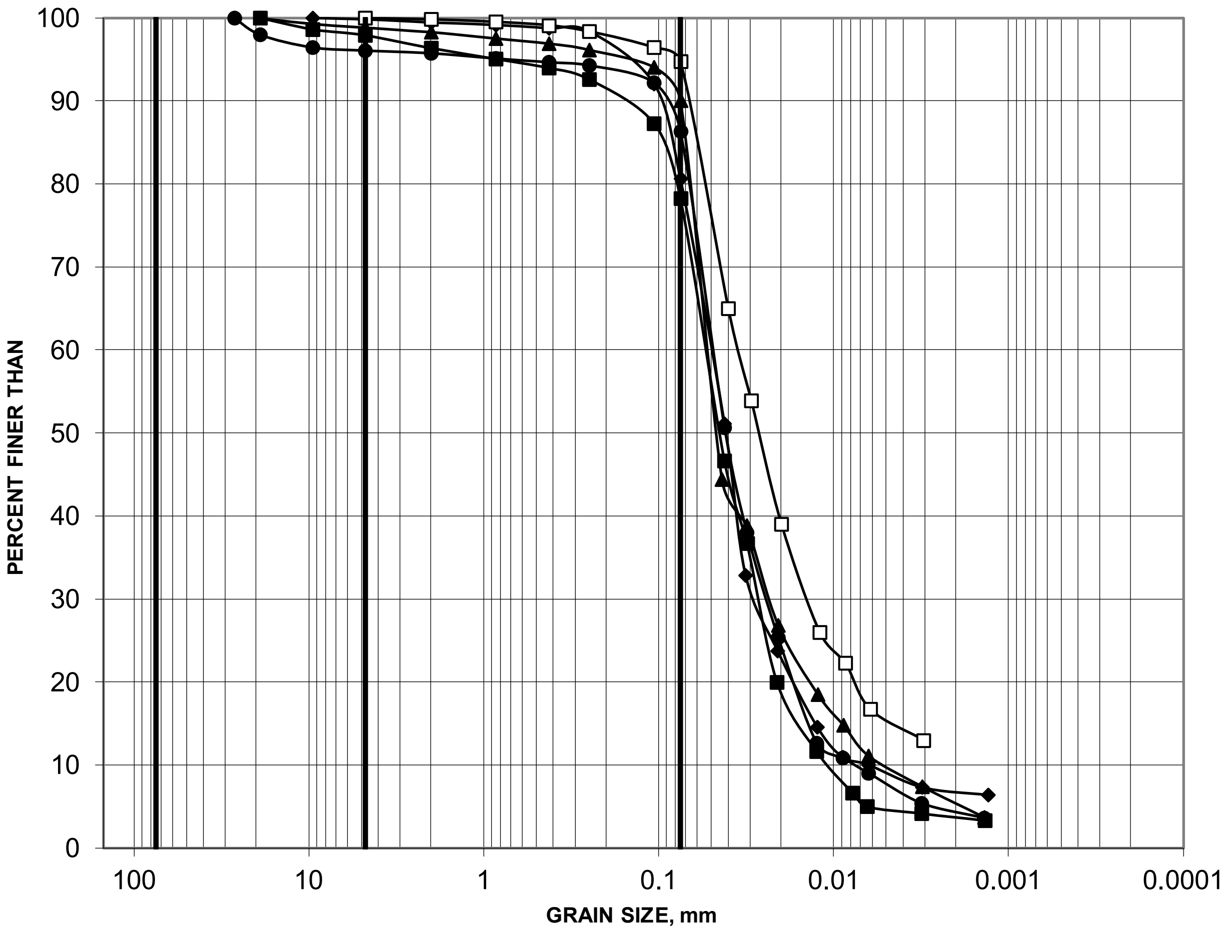
Project: 20144864/2000

Created By: MI Checked By: CW

GRAIN SIZE DISTRIBUTION

FIGURE C2

SILT



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

	Borehole	Sample	Depth (m)	Constituents (%)			
				Gravel	Sand	Silt	Clay
■	20-303	3	1.52-1.98	2	20	74	4
◆	20-305	3	1.52-2.13	0	19	74	7
▲	20-306	5	3.05-3.66	1	9	85	5
●	20-308	3	1.52-2.13	4	10	82	4
□	20-311	2	0.76-1.37	0	5	84	11

Project: 20144864/2000

GOLDER

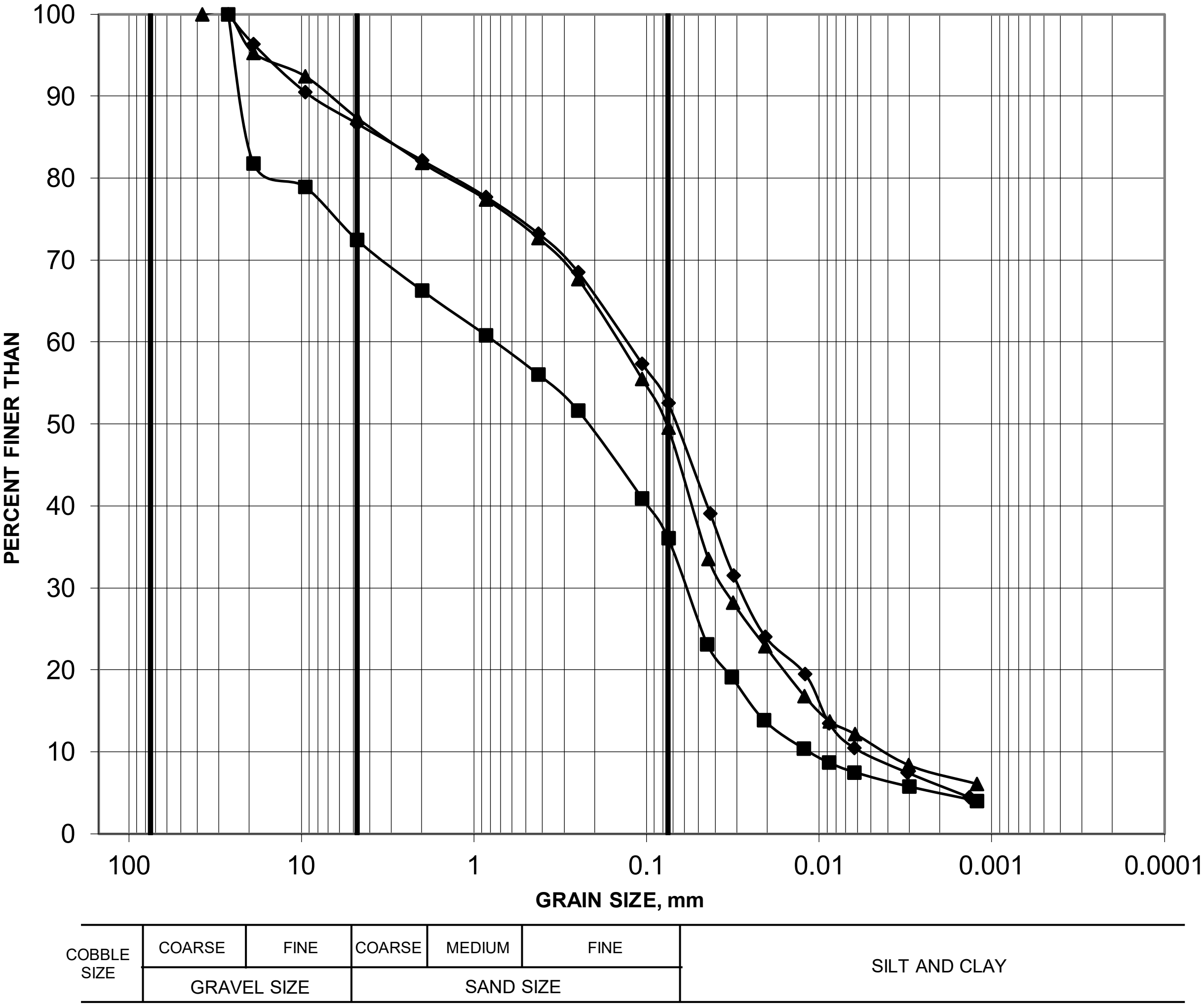
Created by: MI
Checked by: CW

https://golderassociates.sharepoint.com/sites/35409g/Shared Documents/Active/2020/20144864/Phase 2000/Figures/

GRAIN SIZE DISTRIBUTION

FIGURE C3

TILL



				Constituents (%)			
	Borehole	Sample	Depth (m)	Gravel	Sand	Silt	Clay
■	20-304	6	3.81-4.42	28	36	31	5
◆	20-306	6	3.81-4.27	13	34	47	6
▲	20-310	4	2.29-2.90	13	37	43	7

Project: 20144864/2000

GOLDER

Created by: MI
Checked by: CW

https://golderassociates.sharepoint.com/sites/35409g/Shared Documents/Active/2020/20144864/Phase 2000/Figures/

APPENDIX D

Chemical Testing Results

Certificate of Analysis

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

Report Number:	1933382
Date Submitted:	2020-07-02
Date Reported:	2020-07-08
Project:	20144864 / 2000
COC #:	859510

				Lab I.D. Sample Matrix Sample Type Sampling Date Sample I.D.	1501966 Soil 2020-06-23 20-305 sa2 / 2.5-4.5'	1501967 Soil 2020-06-24 20-309 sa3 / 5-7'
Group	**Analyte**	**MRL**	**Units**	**Guideline**		
Anions	Cl	0.002	%		<0.002	0.002
	SO4	0.01	%		0.09	<0.01
General Chemistry	Electrical Conductivity	0.05	mS/cm		0.08	0.08
	pH	2.00			8.23	8.29
	Resistivity	1	ohm-cm		12000	11900

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

GOLDER

golder.com