REPORT

Geotechnical Investigation Access Property Developments

864 Lady Ellen Place, Ottawa, ON

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1.0 INTRODUCTION

This report presents the results of a geotechnical investigation carried out in support of the site redevelopment of the subject property located at 864 Lady Ellen Place in Ottawa, Ontario. The approximate location of the site is shown on the Key Map inset on the attached Site Plan (Figure 1). The investigation and reporting were carried out in general accordance with the scope of work provided in our initial proposal dated March 17, 2022.

The purpose of the investigation was to assess the general subsurface and groundwater conditions within the study area by means of seven boreholes, and associated laboratory testing. Based on an interpretation of the factual information obtained during the current investigation, as well as existing information from previous investigations at the site, a general description of the soil and groundwater conditions is presented. These interpreted subsurface conditions and available project details were used to prepare 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 PROJECT DESCRIPTION

Plans are being prepared for the redevelopment of site located at 864 Lady Ellen Place in Ottawa, Ontario (see Site Plan, Figure 1).

Based on the information provided, the property is a 3.3-acre lot with an existing three-story commercial building on the west side of the site. Based on the site plan dated August 11, 2020, as a part of site redevelopment, the existing building will be demolished and a new 1-storey, approximately 23,000 sq. ft. single-storey building will be constructed on the west side of the site. A 4-storey building, of approximately 170,000 sq. ft. will also be constructed on the east side of the site. It is understood the buildings will not have basements.

Previous geotechnical investigations were carried out at the Site by Golder in 2019 and G.C. McRostie Consulting Engineers in 1955. The results of those investigations are contained in the following reports:

- Golder Associates Report No. 18110987-1000 submitted to J.L. Richards Associates Ltd., titled "Geotechnical Investigation, Proposed New Office Building-Phase 1, Ottawa, Ontario", dated March 2019
- G.C. McRostie Consulting Engineers Report No. SF169 submitted to Producers Dairy Limited, titled "Report on Foundation Investigation at Laperriere Avenue, Ottawa Property" dated 11 February 1955.

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

Published geological mapping and the results of previous investigations indicate that the subsurface conditions at this site generally consist of a surficial layer of topsoil/fill overlying a deposit of glacial till underlain by shallow bedrock. The underlying bedrock is comprised of interbedded limestone and dolostone of the Gull River formation.

3.0 PROCEDURE

The fieldwork for this investigation was carried out between July 18 and 21, 2022. During that time, a total of seven boreholes (numbered 22-01 to 22-07) 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 George Downing Estate Drilling Limited. The boreholes were advanced to depths ranging from 5.0 to 10.2 m below the existing ground surface. Practical refusal to auger advancement was encountered in all of the boreholes, and boreholes 22-01, 22-03, 22-04, 22-05 and 22-07 were extended into the bedrock using rotary diamond drilling technique while retrieving NQ sized core.

Standard Penetration Tests (SPTs) were carried out in the boreholes within the overburden at regular intervals of depth where possible. Samples of the soils encountered were recovered using 35 mm inside diameter split-spoon sampling equipment in general accordance with ASTM D1586-18.

The fieldwork was supervised by a member of 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 and bedrock samples were transported to our laboratory for further examination by the project engineer and for laboratory testing, which included natural water content, Atterberg limits and grain size distribution tests on selected soil samples, and Uniaxial Compressive Strength (UCS) testing on selected bedrock core specimens.

Two samples of soil (from boreholes 22-01 and 22-04) were 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 borehole locations were selected in consultation with client, marked in the field, and subsequently surveyed by Golder Associates personnel. The borehole coordinates and existing ground surface elevations were measured using a Trimble R10 GPS survey unit. The geodetic reference system used for the survey is the North American datum of 1983 (CSRS: CBNV6-2010.0 NAD83). The borehole coordinates are based on the Universal Transverse Mercator (UTM Zone 18 North) coordinate system. The elevations are referenced to Geodetic datum (CGVD28).

4.0 SUBSURFACE CONDITIONS

4.1 General

Information on the subsurface conditions is provided as follows:

- The Borehole Records from the current investigation are provided in Appendix A.
- The Borehole, Augerhole and Test Pit records from the previous investigations are provided in Appendix B.
- Results of laboratory test results is provided in Appendix C.
- Core photographs are provided in Appendix D.
- Results of the basic chemical analyses is provided in Appendix E.
- Golder Associates Technical Memorandum No. 18110987/1000, dated January 04, 2018, is provided in Appendix F.

The Borehole Records describe the subsurface conditions at the particular borehole locations only.
The stratigraphic boundaries shown on the borehole records are inferred from non-continuous sampling in some cases, observations of drilling progress as well as results of Standard Penetration Tests and, therefore, represent transitions between soil types rather than exact planes of geological change. Furthermore, subsurface soil, bedrock, and groundwater conditions will vary between and beyond the test pit and borehole locations.

The following sections present a detailed overview of the subsurface conditions encountered in the boreholes advanced during the current investigation as well as boreholes and augerholes advanced during 2019 investigation (Report No. 18110987-1000). It should be noted that the shallow subsurface conditions noted on the borehole and test pit logs from the previous investigations carried out in 1955 (Report No. SF169) may have changed significantly since the boreholes and the test pit were advanced, as such only auger refusal/bedrock depths from this previous drilling are discussed herein.

4.2 Overview of Subsurface Conditions

In general, the subsurface stratigraphy within the area of the investigation consists of pavement structure as well as topsoil and fill, underlain by silty sand, underlain by deposits of silty clay to clay, underlain by clayey silt, underlain by sand and gravel, underlain by glacial till over bedrock. The following sections present a detailed overview of the subsurface conditions encountered in the test pits and boreholes advanced during the current investigation.

4.2.1 Pavement Structure

Boreholes 22-01, 22-04 and 22-05 were advanced on the existing parking lots at the site. The pavement structure at these locations consists of a 50 to 100 mm thick layer of asphaltic concrete overlying 360 to 810 mm of granular base/subbase.

Previous augerholes 18-101, 18-104, 18-105 and 18-108 to 18-115 were advanced on existing parking lots at the site. The pavement structure at these locations consisted of up to 100 mm thick layer of asphaltic concrete overlying 50 to 910 mm of granular base/subbase. The pavement structure in previous augerholes 18-106 and 18-107 consisted of a layer of granular surface/base.

4.2.2 Topsoil

Topsoil was encountered at the ground surface in current boreholes 22-03 and 22-06 (which were drilled in grassed areas). The thickness of topsoil at boreholes 22-03 and 22-06 was found to be 50 mm and 100 mm, respectively.

Topsoil was encountered within or below the fill at boreholes 22-02, 22-05, 22-07, previous boreholes 18-02, 18-03, and augerholes 18-102, 18-103, and 18-106. The topsoil at these locations has a thickness of about 120 to 300 mm. The presence of this layer suggests that portions of the site were not completely stripped prior to previous filling and paving.

4.2.3 Fill

Fill was encountered at the ground surface in boreholes 22-02, 22-07 and all previous boreholes. Fill was also encountered below the topsoil or pavement in boreholes 22-03, 22-05, 22-06 and previous augerholes 18-108, 18-111, 18-112, and 18-113.

The fill generally consists of varying proportions of silt, sand, and gravel with varying amounts of cobbles, organic matter, and debris (for example pieces of asphaltic concrete). The fill at the borehole locations extends to depths ranging from about 0.7 to 1.5 m below the existing ground surface (Elevation of 75.90 to 76.84 m). Fill was not fully penetrated in the 2018 augerholes (which were terminated at shallow depth).

SPT “N” values measured within the fill ranged from about 2 to 45 blows per 0.3 m of penetration, indicating a highly variable, very loose to dense state of packing: typically compact.

The measured water content of two samples of the fill obtained from boreholes 22-01 and 22-07 was about 8 and 12 %

The result of grain size distribution testing carried out on two samples of the fill is shown on Figure C-1 in Appendix C.

4.2.4 Silty Sand to Sandy Silt

A silty sand to sandy silt deposit (about 0.5 to 0.7 m in thickness) was encountered below the fill or topsoil at the locations of current borehole 22-02 and previous augerholes 18-101, 18-106, and 18-107. The silty sand to sandy silt at these locations extends to a depth of about 1.4 to 1.5 m (elevation of 75.2 to 76.2 m) below the existing ground surface. This deposit was not fully penetrated in augerholes, where encountered.

SPT “N” value measured within the silty sand was 9 blows per 0.3 m of penetration, indicating a loose state of packing.

The measured water content of a single sample of sandy silt obtained from borehole 22-02 was 17%.

The result of grain size distribution testing carried out on a single sample of the sandy silt is shown on Figure C-2 in Appendix C.

4.2.5 Silty Clay to Clay (Weathered Crust)

At the locations of current boreholes 22-01, 22-02, 22-03 and previous boreholes 18-02 and 18-03, the topsoil and silty sand to sandy silt is underlain by a silty clay to clay deposit. The silty clay to clay has been entirely weathered to a grey-brown crust. At the borehole locations, the weathered silty clay to clay crust extends to depths of approximately 1.0 to 2.3 m (elevation of 74.63 to 75.65 m) below the existing ground surface.

SPT “N” values measured within the silty clay to clay ranged from about 5 to 18 blows per 0.3 m of penetration, indicating firm to very stiff consistency; more typically firm to stiff. The results of the previous in-situ testing indicate a very stiff consistency.

The measured water content of two samples of the silty clay to clay crust obtained from boreholes 22-02 and 22-03 was 31 and 33%.

The result of grain size distribution testing carried out on a single sample of the weathered silty clay to clay is shown on Figure C-3 in Appendix C. The result of Atterberg limit testing carried out on a single sample from this deposit gave plasticity index value of about 28 and liquid limit value of 50, indicating an intermediate to high plasticity soil. The results of the Atterberg limit testing are provided on Figure C-4 in Appendix C.

4.2.6 Clayey Silt

A thin deposit of clayey silt with varying amounts of sand was encountered below the weathered silty clay crust at the location of previous borehole 18-03. Clayey silt was also encountered below the fill or topsoil at the locations of augerholes 18-102, 18-103 and 18-110. At these locations, the clayey silt layer extends to a depth of about 0.7 to 2.7 m (elevation of 74.35 to 76.14 m) below the existing ground surface. The clayey silt was not fully penetrated in augerhole 18-103.

The SPT “N” values within the clayey silt ranged from 8 to 32 blows per 0.3 m of penetration, indicating stiff to very stiff consistency.

4.2.7 Sand and Gravel

A thin deposit of sand and gravel was encountered below the weathered silty clay crust at the location of previous borehole 18-02. The layer is 0.5 m in thickness and extends to a depth of about 2.7 m (elevation of 74.3 m) below the existing ground surface.

SPT “N” values measured within the sand and gravel deposit was 46 blows per 0.3 m of penetration, indicating a dense state of packing.

4.2.8 Glacial Till

Glacial till was encountered in all current and previous boreholes below fill, weathered silty clay to clay, clayey silt or sand and gravel deposits. Glacial till was also encountered beneath the silty sand, clayey silt, or fill material at previous augerholes 18-101, 18-104, 18-105, 18-109, 18-110, 18-114, and 18-115. These augerholes were terminated within this deposit at a depth of about 1.5 m below the existing ground surface.

The glacial till typically consists of a heterogeneous mixture of gravel, cobbles, and boulders in a matrix of sandy silt to silty sand with trace to some clay. The glacial till layer was encountered at depths of 0.3 to 3.8 m (elevation of 74.3 to 77.9 m) in the various boreholes. This deposit was fully penetrated in all current and previous boreholes, except 22-02, 22-06 and 18-01. This deposit extends to a depth of about 3.1 to 7.1 m (elevation of 70.1 to 74.2 m) below existing ground surface. Where not fully penetrated (i.e., in current borehole 22-02, 22-06 and previous borehole 18-01), the glacial till was proven to depths ranging from about 3.5 to 6.1 m (elevation of 71.3 to 73.6 m) below the existing ground surface. In current borehole 22-06, a thin layer of very dense silty sand was encountered below the glacial till deposit.

The SPT “N” values within the glacial till layer ranged from 5 to greater than 50 blows per 0.3 m of penetration, indicating a loose to very dense state of packing; typically compact-to-very dense. The higher blow counts could be indicative of boulders and cobbles in the till rather than the state of packing.

The measured water content of nine samples of the glacial till ranged from 3 to 8%

The results of grain size distribution testing carried out on four samples of the glacial till are shown on Figure C-5 in Appendix C.

The table below summarizes the top of glacial till depth and elevations at each borehole locations.

Investigation	Borehole Number	Ground Surface Elevation (m)	Top of Glacial till Depth (m)	Top of Glacial till Elevation (m)
Current Investigation	22-01	76.62	0.97	75.65
	22-02	76.92	1.83	75.09
	22-03	76.92	2.29	74.63
	22-04	77.20	0.41	76.79
	22-05	78.06	1.52	76.54
	22-06	77.84	0.89	76.95
	22-07	77.48	1.17	76.31
Previous Investigation (Report No. 18110987-1000)	18-01	77.02	0.69	76.33
	18-02	77.01	2.74	74.27
	18-03	77.09	2.74	74.35

4.2.9 Refusal and Bedrock

Practical refusal to augering was encountered in current boreholes 22-02, 22-06 and previous borehole 18-01 at a depth of about 3.5 to 6.1 m (elevation of 71.3 to 73.6 m) below the existing ground surface. Auger refusal could indicate boulders within the glacial till or the bedrock surface.

All boreholes from current and previous investigation, except 22-02, 22-06 and 18-01 were extended through the glacial till deposit into the underlying bedrock using rotary diamond drilling technique and bedrock was confirmed at depths of 3.1 and 7.4 m (elevations of 70.1 and 74.2 m) below the existing ground surface. The recovered bedrock cores from these locations consist of slightly to moderately weathered to fresh, thin to medium bedded, medium grey, limestone and dolostone bedrock with interbedded shale.

In borehole 22-04, and previous borehole 18-03, the upper 0.5 to 0.8 m of the bedrock is slightly weathered at the top. The weathered portion of the bedrock at this location extends to a depth of 4.3 to 4.6 m below the existing ground surface (elevation of about 72.6 to 72.7 m).

The Total Core Recovery (TCR) of bedrock ranged from 77 to 100% and the Rock Quality Designation (RQD) ranged from 51 to 100%, indicating a fair to excellent quality rock.

The results of the UCS testing on three samples of the bedrock completed in 2018 indicate values ranging from 143 to 179 MPa, which indicates a very strong bedrock.

Photographs of the recovered bedrock cores are presented in Appendix D.

Table below summarizes the refusal or top of bedrock depths and elevations for each borehole.

Investigation	Borehole Number	Ground Surface Elevation (m)	Refusal / Top of Bedrock Depth (m)	Core Length (m)	Refusal / Top of Bedrock Elevation (m)
Current Investigation	22-01	76.62	3.81	3.4	72.81
	22-02	76.92	5.01^R	-	71.91 ^R
	22-03	76.92	3.13	2.5	73.79
	22-04	77.20	4.57	4.0	72.63
	22-05	78.06	3.89	3.3	74.17
	22-06	77.84	6.50^R	-	71.34 ^R
	22-07	77.48	7.36	3.2	70.12
Previous Investigation (Report No. 18110987-1000)	18-01	77.02	3.45^R	-	73.57 ^R
	18-02	77.01	4.83	3.8	72.18
	18-03	77.09	4.75	3.8	72.34

Note: R denotes Auger Refusal

4.3 Groundwater

The groundwater levels in the monitoring wells installed at this site were measured on July 22, 2022. During that time, the water levels ranged from 3.99 to 4.16 m below existing ground surface. The measured water levels are summarized as follows:

Monitoring Well Number	Geologic Unit	July 22, 2022	
		Ground Water Level Depth (m)	Ground Water Level Elevation (m)
22-03	Bedrock	4.00	72.92
22-05	Glacial Till/ Bedrock	3.99	74.07
22-06	Glacial Till	4.16	73.68

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 and fall.

4.4 Corrosion Testing

Two samples of soil from boreholes 22-01 and 22-04 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 E and are summarized below:

Borehole Number	Sample Number	Depth Intervals (m)	Chlorides (%)	Sulphates (%)	pH	Resistivity (Ohm-cm)
22-01	2B	0.98-1.37	0.056	0.01	8.27	847
22-04	3	1.52-2.13	0.035	0.01	7.89	1163

5.0 DESIGN AND CONSTRUCTION CONSIDERATIONS

5.1 General

This section of the report provides engineering guidelines on the geotechnical design aspects of the proposed development based on our interpretation of the borehole information and project requirements.

The information in this portion of the report is provided for planning and design purposes for the guidance of the design engineers and architects. Where comments are made on construction, they are provided only to highlight aspects of construction which could affect the design of the project. 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, costs, sequencing and the like.

Pursuant to the following recommendations, the subsurface conditions encountered during the investigations indicate that there are no concerns from a geotechnical standpoint for the site development that cannot be managed using routine and accepted design and construction approaches for similar developments.

5.2 Site Grading

The subsurface conditions on this site generally consist of pavement structure and topsoil and fill, underlain by silty sand, underlain by deposits of silty clay to clay, underlain by clayey silt, underlain by sand and gravel, underlain by glacial till over bedrock.

No practical restrictions apply to the thickness of grade raise fill which may be placed on the site from a geotechnical design perspective.

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

Ground water levels were measured as shallow as around 4.0 m below the ground surface in the monitoring wells installed at site. More significant groundwater flow should be expected for excavations that extend below the groundwater level. Therefore, consideration should be given (but is not necessary from a geotechnical perspective) to setting the grading to limit the required depths of excavation (particularly for basements) since groundwater management requirements and costs increase with excavation depth below the groundwater level.

5.3 Excavations

It is understood the proposed buildings will not have basements. Localized excavations for foundations will be made through overburden deposits. Bedrock was encountered at depths of approximately 3 m to 7m at various locations. Bedrock excavation is not likely to be required for foundations, but localized bedrock excavation could be required in the base of utility trenches, depending on the depths required.

5.3.1 Excavations in Overburden

No unusual problems are anticipated in excavating the overburden using conventional hydraulic excavating equipment, recognizing that cobbles and boulders could be present in the overburden. Boulders larger than 0.3 m in diameter should be removed from the excavation side slopes for worker safety.

In accordance with the Occupational Health and Safety Act (OHSA) of Ontario, the soils that will be encountered within the excavations above the groundwater level would generally be classified as Type 3 soils. The side slopes in the overburden above the water table could be sloped no steeper than 1 horizontal to 1 vertical. If the excavations extend below the groundwater level, the soils would be classified as Type 4 soil. Accordingly, the excavations below the groundwater level in this deposit would likely require flatter side slopes (e.g., 3 horizontals to 1 vertical) to remain stable. If the groundwater level is lowered below the base of the excavation prior to excavation, the sides may be sloped at 1 horizontal to 1 vertical.

Where site conditions (such as proximity of existing structures and utilities, or space restrictions) do not allow for the above noted side slopes then suitable safety and support measures must be undertaken according to the requirements of the OSHA. These measures include installation of a suitable shoring system to create and maintain positive support to the sidewalls of the excavation.

It should be noted that the silty and sandy overburden at this site may be sensitive to disturbance. This would not typically be an issue for excavations above the groundwater table unless there is excessive construction traffic, particularly during periods of wet weather. Any disturbed soil will need to be removed and replaced, or recompacted, prior to placing foundations. New granular fill materials or concrete should be placed immediately following inspection and approval of the subgrade by geotechnical personnel. The duration between exposure of the subgrade and covering with the protective layer should be limited to as brief as possible and, in the interim, no construction traffic should be permitted on the subgrade.

5.3.2 Excavations in Bedrock

The bedrock encountered at this site, in general, consists of slightly weathered to fresh limestone. The thin upper portion of the bedrock may be highly weathered in some areas (as encountered in boreholes 21-02 and 21-04). It will likely be possible to carry out the bedrock removal using mechanical methods (such as hydraulic excavators and hoe ramming) for the removal of the highly weathered portion of the bedrock or for shallow, localized excavations into bedrock (such as could be required in the base of utility trenches). Large-scale bedrock excavation is more economically done with controlled blasting. This is not likely to be required based on our understanding of the current development plans.

Near vertical and unsupported excavation walls in the bedrock should be feasible for the construction period. However, the exposed bedrock should be inspected regularly (as the bedrock excavation proceeds) by qualified geotechnical personnel to assess the exposed bedrock surface for potential localized instabilities. All loose rock should be removed from the sidewalls during excavation to ensure the safety of workers. Line drilling may be required to define the edges of rock excavation and prevent inadvertent over-excavation due to overbreak of the rock.

If required, blasting 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. 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 excavation contractor should be required to submit a complete and detailed blasting design and monitoring proposal prepared by a blasting/vibrations specialist prior to commencing blasting. This would have to be reviewed and accepted in relation to the requirements of the blasting specifications.

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 as typical vibration criteria commonly adopted for construction projects. If unusually sensitive receptors are identified during construction planning, then specific criteria may need to be adopted for those receptors.

Frequency Range (Hertz)	Vibration Limits (mm/second)
< 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 practical, bedrock removal should commence at the furthest points from the closest structure or service to assess the ground vibration attenuation characteristics and to confirm the anticipated ground vibration levels.

Vibration monitoring should be carried out throughout all bedrock removal operations.

5.4 Groundwater Management

Based on the groundwater conditions observed in the monitoring wells, excavations deeper than approximately 4 m below ground surface will likely be below the groundwater level, depending on the time of year that construction occurs. The rate of groundwater inflow to excavations will depend on many factors, including: the contractor’s schedule and rate of excavation, the size of the excavation, the number of working areas being excavated at one time, and the time of year at which the excavation is made. Also, there may be instances where precipitation collects in an open excavation and must be rapidly pumped out.

According to O.Reg 63/16 and O.Reg 387/04, if the volume of water to be pumped from excavations for the purpose of construction dewatering is greater than 50,000 litres per day and less than 400,000 litres per day, the water taking will need to be registered as a prescribed activity in the Environmental Activity and Sector Registry (EASR) and requires the completion of a “Water Taking Plan”. Alternatively, 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 to be pumped from an excavation.

Dewatering systems are the Contractor's responsibility and the rate and volume required for dewatering is dependent on the construction methods and staging chosen by the contractor. In general, however, it is anticipated that the volume of dewatering required in the excavations can be handled, as required, by pumping from properly constructed and filtered sumps located within the excavations. For typical foundation excavations (on the order of 2 m depth and above the groundwater table) it is unlikely that an EASR or PTTW would be required. If extensive excavations for site services are required below the water table, then this assumption should be reviewed during detailed design.

5.5 Foundations

The native undisturbed glacial till may be used to found the existing buildings. The top of glacial till elevation in this area ranges from 74.3 to 77.0 m (where elevations are confirmed). All fill material, organic soil, disturbed soil, etc. should be removed from below the foundation locations down to the glacial till. If desired, the foundations could be placed at a higher level, with the material below the foundations removed down to the glacial till and replaced with compacted engineered granular fill. If this approach is adopted, the material should be removed and replaced below a 1:1 line extending outwards and down from the edge of the foundation.

The SLS net bearing resistance and factored ULS bearing resistance values for pad and strip footing foundations of various sizes in glacial till deposit or compacted engineered fill is provided in table below:

Type of Footing	Width or Size of Footing (m)	Net Bearing Resistance at SLS (kPa)	Factored Bearing Resistance at ULS (kPa)
Pad Footing	1.5	200	175
	2.0		205
	2.5		230
	3.0		260
	3.5		290
	4.0		320
Strip Footing	1.0	200	160
	2.0		230
	2.5		270
	3.0		300

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

The glacial till at the site contains cobbles and boulders. Any cobbles or boulders in footing areas which have been loosened by the excavation process should be removed and the cavity filled with lean concrete or compacted granular fill.

If higher foundation bearing resistances are required, it may be feasible to found the structure on bedrock, though this would almost certainly require additional excavation and so is likely not economical unless high foundation loads are anticipated. The top of bedrock elevation in this area ranges from 70.1 to 74.2 m. As the top of bedrock elevation varies across the site, and is below a typical shallow foundation depth of 1.8 m, the following two options can be considered:

- Lower the foundation elevation to the as-found rock surface and adjust the column length. This option uses less material, but may require adjusting the design, rebar, formwork, etc. of the columns for each location.
- Construct a concrete pier to fill in the gap between the rock surface and the design underside of footing (essentially thickening the concrete). This option requires more material, and likely two stages of construction – one to construct the pier, followed by a second to form and construct the footing. It does, however, allow for a single design for all the foundations (i.e., the underside of footing is constant, only the concrete quantity varies) and so this option is more versatile and easier to manage on site.

For a footing founded on or within bedrock, a factored bearing resistance at ULS of 5 MPa may used. The bedrock should not be excessively disturbed, and any loose/broken rock should be removed. The water table must be drawn down below the bottom of the excavation and should be maintained at that level throughout the placement of concrete. There is no practical limit on the size of footings on rock.

The above values are based on the bearing resistance of the rock (i.e., the geotechnical resistance of the foundation). If the option to place additional concrete between the as-found rock surface and the underside of the footing is adopted, it will have no impact on the bearing resistance of the rock (and the values above may be used). The capacity of the mass concrete pier itself should, however, be assessed the structural engineer.

Settlement of footings on bedrock is typically negligible under services loads and SLS conditions do not govern the design of foundations on rock for typical building foundation loads.

For lateral sliding resistance, an unfactored interface friction coefficient of 0.7 may be used for the design of foundations (or other concrete elements) placed on competent bedrock, and 0.45 may be used for foundations placed on soil. A resistance factor of 0.8 should be applied to the sliding resistance.

It is understood the existing building on the west side of the site will be demolished, and the western building of the current development will be constructed overtop. It is further understood that the existing building has a basement which will need to be backfilled. At the time of demolition, the existing building and any existing fill material (including any foundations, services, etc.) should be removed. The below-grade area can then be backfilled with compacted granular fill (such as OPSS Granular B Type 2).

5.6 Seismic Design

Multichannel Analysis of Surface Waves (MASW) test was carried out on December 11, 2018, during a previous investigation (Report No. 18110987-1000) at the site to evaluate the average shear wave velocity of the upper 30 m of soil/bedrock at the site. The shear wave velocities measured at the site are presented in a technical memorandum No. 18110987/ 1000 (attached in Appendix F) and indicate that the average shear wave velocity in the upper 30 m of the subsurface stratigraphy at the MASW location was 877 m/s.

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 rock below founding level. Using that methodology, a Site Classification C can be used for design of the proposed building since it appears that more than 3 m of soils will be present between the underside of foundations and the bedrock surface.

A Seismic Site Classification of B could be used for design of the proposed building if less than 3 m of overburden is present between the underside of the footing and the bedrock. If more than 3 m of soil will remain below the foundations, then a Seismic Site Classification of C should be assumed.

5.7 Frost Protection

The soils at this site maybe frost susceptible. Therefore, all exterior foundation elements of heated structures should be provided with a minimum of 1.5 m of earth cover for frost protection purposes. Isolated footings of unheated structures should be provided with a minimum of 1.8 m of earth cover.

Consideration could also be given to insulating the bearing surface with high density insulation as an alternative to earth cover. Further geotechnical input can be provided in this regard, if required.

5.8 Foundation Wall Backfill

The soils at this site are frost susceptible and should not be used as backfill directly against exterior, unheated, or well insulated foundation elements. To avoid problems with frost adhesion and heaving, these foundation elements should be backfilled with non-frost susceptible granular fill conforming to the requirements of OPSS Granular B Type I materials.

To avoid ground settlements around the foundation elements, which could affect site grading and drainage, all of the backfill materials should be placed in maximum 300 mm thick lifts, compacted to at least 95 % of the material’s Standard Proctor Maximum Dry Density (SPMDD) using suitable compaction equipment.

In areas where pavement or other hard surfacing will abut the building, differential frost heaving could occur between the granular fill and the adjacent areas. To reduce this differential heaving, the backfill adjacent to the wall should be placed to form a frost taper. The frost taper should be brought up to pavement subgrade level from 1.8 m below finished exterior grade at a slope of 3 horizontal to 1 vertical, or flatter, away from the wall.

It is understood the buildings will not include basement levels, and therefore drainage of the basement walls is not required.

Portions of the existing soils present on the site may be suitable for re-use and should be carefully reviewed during excavation. Suitable soils may be stockpiled on site for re-use in site grading, backfilling, trench backfill, landscaping, etc.

5.9 Site Servicing

At least 150 mm of OPSS Granular A should be used as pipe bedding for sewer and water pipes. Where unavoidable disturbance to the subgrade surface occurs below the invert of the pipe, it will be necessary to remove the disturbed material, and place a sub-bedding layer consisting of compacted OPSS Granular B Type II beneath the Granular A. 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 surrounding soil could potentially migrate into the voids in the clear crushed stone and cause loss of lateral pipe support.

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 standard Proctor maximum dry density.

It should generally be possible to re-use the existing inorganic fill, silty sand, weathered silty clay, sand and gravel, clayey silt, and glacial till as trench backfill, provided that they are not too wet to handle, place, and compact. Where the trench will be covered with hard surfaced areas, the type of 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 standard Proctor maximum dry density using suitable vibratory compaction equipment.

It should be possible to use the bedrock as trench backfill, provided the bedrock is well broken and broadly graded (maximum size of 300 mm). The rock fill, however, should only be placed from at least 300 mm above the pipes to minimize damage due to impact or point load. The rock fill should be limited to a maximum of 300 mm in size.

5.10 Pavement Design

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

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

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

The pavement structure for new car parking areas should consist of:

Pavement Component	Thickness (mm)
Asphaltic Concrete	50
OPSS Granular A Base	150
OPSS Granular B Type II Subbase	300

The pavement structure for new access roadways and truck traffic areas should consist of:

Pavement Component	Thickness (mm)
Asphaltic Concrete	90
OPSS Granular A Base	150
OPSS Granular B Type II Subbase	400

The granular base and subbase used on this site should consist of Granular A and B Type II, respectfully, in conformance with OPSS.MUNI 1010 or City of Ottawa specification F-3147. The granular base and subbase materials should be uniformly compacted to 100 percent of the material's standard Proctor maximum dry density using suitable vibratory compaction equipment. The asphaltic concrete should be compacted in accordance with Table 10 of OPSS.MUNI 310.

The composition of the asphaltic concrete pavement in car parking areas should be as follows:

- Superpave 12.5 Surface Course – 50 mm.

The composition of the asphaltic concrete pavement in access roadways and truck traffic areas should be as follows:

- Superpave 12.5 Surface Course – 40 mm.
- Superpave 19.0 Binder Course – 50 mm.

The pavement design should be based on a Traffic Category of Level B. The asphalt cement used on this project should be made with PG 58-34 asphalt cement on all lifts.

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

At the limits of construction or the end of the curb “return” (i.e., the start of the constant width portion of the access road, the asphaltic concrete should be milled back an additional 300 mm to a depth of 40 or 50 mm to accept the surface course asphaltic concrete.

The granular courses and subbase level should be tapered between the new and existing pavements by using 10 horizontal to 1 vertical tapers up or down as required, starting from beyond the limits of construction. Butt joints can be used along joints of new and existing parking areas.

5.11 Corrosion and Cement Type

Two samples of soil from boreholes 22-01 and 22-04 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.

The concentration of soluble sulphate provides an indication of the degree of sulphate attack that is expected for concrete in contact with soil and groundwater at the site. The sulphate results were compared with Table 3 of Canadian Standards Association Standards A23.1-14 (CSA A23.1) and generally indicate a low degree of sulphate attack potential on concrete structures at this site. Accordingly, Type GU Portland cement should be acceptable for buried concrete substructures.

The pH, resistivity and chloride concentration provide an indication of the degree of corrosiveness of the sub-surface environment. Generally, the test results indicate an elevated potential for corrosion of exposed ferrous metal at the site which should be considered in the design of substructures.

6.0 ADDITIONAL CONSIDERATIONS

The soils at this site are sensitive to disturbance from ponded water, construction traffic, and frost. Cobbles and boulders are present in the fill and the glacial till.

All footing and subgrade areas should be inspected by experienced geotechnical personnel of Golder Associates prior to filling or concreting to document that the correct/expected strata exist and that 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.

The groundwater level monitoring devices (i.e., monitoring wells) installed at the site will require decommissioning at the time of construction in accordance with Ontario Regulation 903. It is therefore proposed that decommissioning of these devices be made part of the construction contract. Some of those devices may be useful during the initial stages of dewatering, if required, for monitoring the progress of the groundwater level lowering.

At the time of the writing of this report, only preliminary details for the proposed redevelopment were available. Golder Associates should review the final drawings and specifications for this project prior to tendering to confirm that the guidelines in this report have been adequately interpreted and to review some of our preliminary recommendations.

In particular, at the time of the investigation, the proposed development included a building on the east side of the site. At the time of demolition of the building on the western side of the site, the area should be reviewed by Golder following removal of the building, and prior to backfilling. This will allow confirmation of the subsurface conditions below the existing building, as well as localized test pitting (if required) in the area.

Signature Page

Golder Associates Ltd.

LICENSED PROFESSIONAL ENGINEER
C. G. HENDRY
100011328
Dec. 15, 2022
PROVINCE OF ONTARIO

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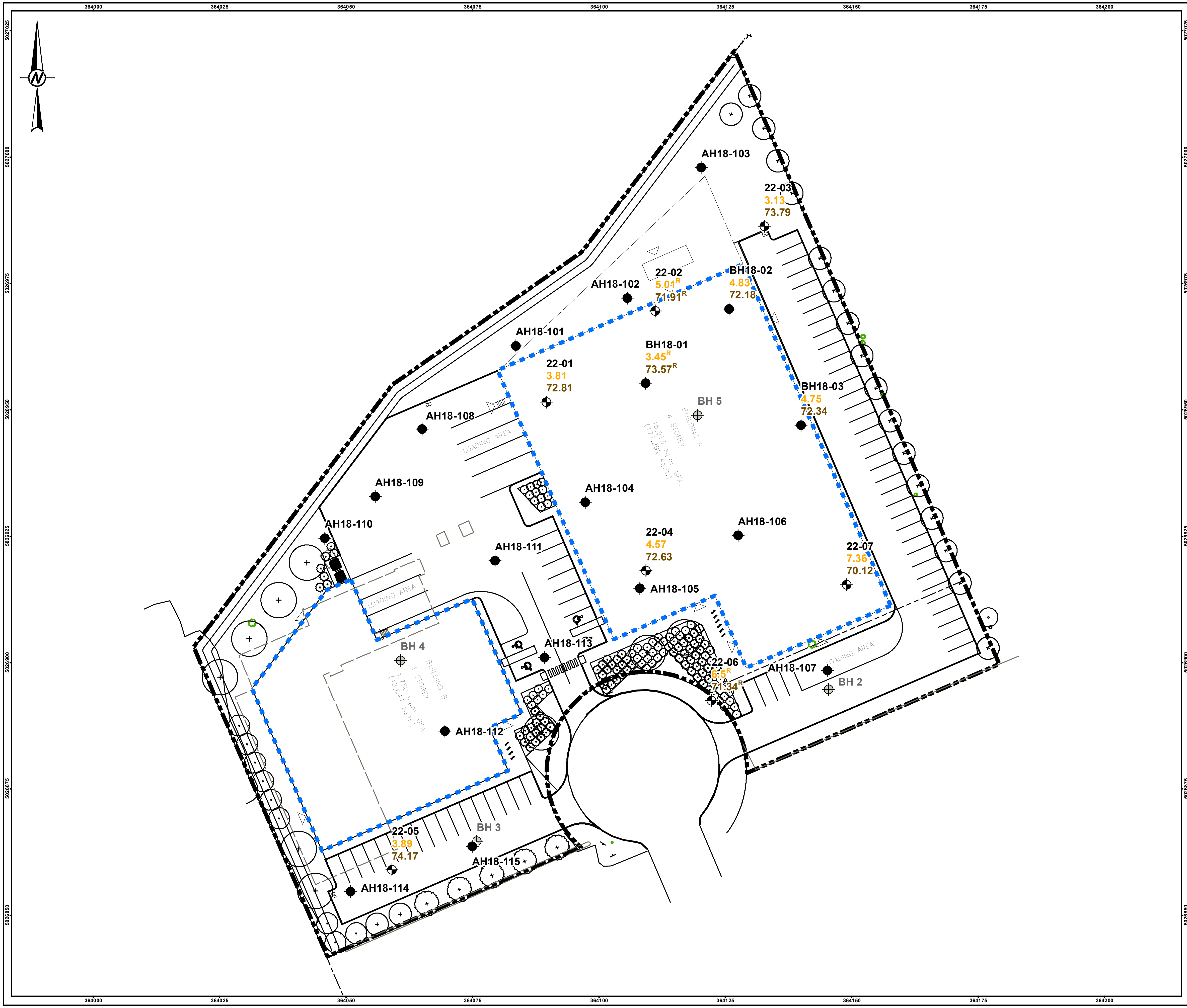
Geotechnical Consultant

Chris Hendry, P.Eng.
Senior Principal Geotechnical Engineer

KG/CH/hdw/ljv

https://golderassociates.sharepoint.com/sites/162763/project files/6 deliverables/geotechnical/final/22524317 rpt rev0 2022'12'15 - geotech investigation-864 lady ellen place.docx



KEY MAP

SCALE 1:25,000

LEGEND

⊕	BOREHOLE LOCATION, CURRENT INVESTIGATION
●	BOREHOLE AND AUGERHOLE LOCATION, PREVIOUS INVESTIGATION (REPORT NO. 18110987-1000, DATED MARCH 2019)
⊕	BOREHOLE LOCATION, PREVIOUS INVESTIGATION (REPORT NO. SF169, DATED FEBRUARY 1955)
2.5	DEPTH TO BEDROCK (mbgs)
72.34	BEDROCK SURFACE ELEVATION mASL
R	AUGER REFUSAL
▭	PROPOSED BUILDING FOOTPRINT

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 10 20 40

1:750 METRES

CLIENT

ACCESS PROPERTY DEVELOPMENT

PROJECT

GEOTECHNICAL INVESTIGATION, 864 LADY ELLEN PLACE, OTTAWA, ONTARIO

TITLE

SITE PLAN

CONSULTANT

WSP GOLDER

YYYY-MM-DD	2019-01-18
DESIGNED	----
PREPARED	BR
REVIEWED	KG
APPROVED	CH

PROJECT NO.	CONTROL	REV.	FIGURE
22524317	0002	0	1

Path: S:\Clients\City_of_Ottawa\Lady_Ellen_Place\99_PROJ\22524317\40_PROD\0002_Geotech_Investigation\22524317-0002-BG-0001.mxd

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

25mm

0

APPENDIX A

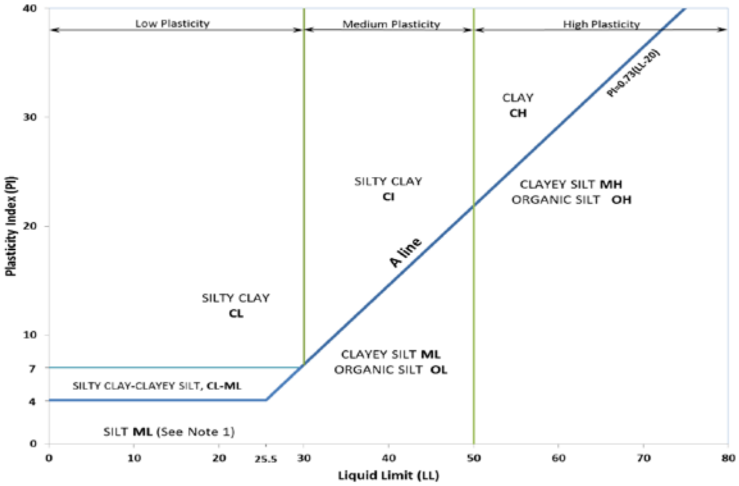
Record of Borehole Logs – Current Investigation

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	$Cu = \frac{D_{60}}{D_{10}}$	$Cc = \frac{(D_{30})^2}{D_{10}xD_{60}}$	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 $= \sigma'_p / \sigma'_{vo}$

(d) Shear Strength

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

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

PROJECT: 22524317

RECORD OF BOREHOLE: 22-01

SHEET 1 OF 2

LOCATION: N 5025433.0 ;E 441833.0

BORING DATE: July 20, 2022

DATUM: Geodetic

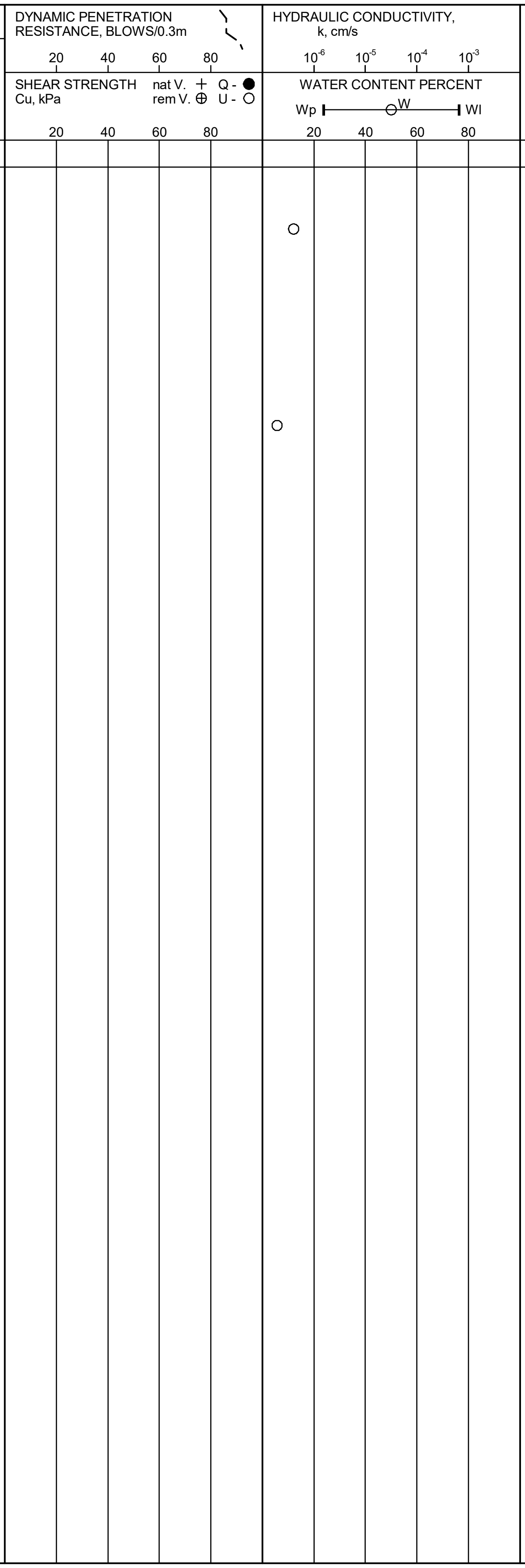
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

ELEV. DEPTH (m)	SOIL PROFILE DESCRIPTION
76.62	GROUND SURFACE
0.00	ASPHALTIC CONCRETE
0.15	FILL - (SW) gravelly SAND, pavement sturture, some silt, angular; grey; non-cohesive, moist
	FILL - (SM) gravelly SILTY SAND, pavement sturture, trace clay; brown to dark brown, contains cobbles; non-cohesive, moist, loose
75.76 0.86 0.97	(CI/CH) SILTY CLAY to CLAY, some sand, trace gravel; brown, highly fissured (WEATHERED CRUST); cohesive, w~PL, very stiff to stiff
74.94 1.68	(SM) gravelly SILTY SAND, trace clay; brown, trace organic matter, possible cobbles and boulders (GLACIAL TILL); non-cohesive, moist to wet, loose to compact
	(SM) gravelly SILTY SAND, trace clay; grey brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist, dense to compact
73.57 3.05	(SM/GM) gravelly SILTY SAND to sandy SILTY GRAVEL, trace clay; grey brown, possible cobbles and boulders (GLACIAL TILL to WEATHERED BEDROCK); non-cohesive, moist to wet, very dense
72.81 3.81	Borehole continued on RECORD OF DRILLHOLE 22-01

SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
1	SS	6	M
2	SS	5	
3	SS	46	M
4	SS	16	
5	SS	64	



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

PIEZOMETER OR STANDPIPE INSTALLATION

MIS-BHS 001 22524317_GEOTECH.GPJ GAL-MIS.GDT 12/8/22 JEM

DEPTH SCALE
1 : 50

LOGGED: RI
CHECKED: KG

PROJECT: 22524317

RECORD OF DRILLHOLE: 22-01

SHEET 2 OF 2

LOCATION: N 5025433.0 ;E 441833.0

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: July 20, 2022

DRILL RIG: CME-55

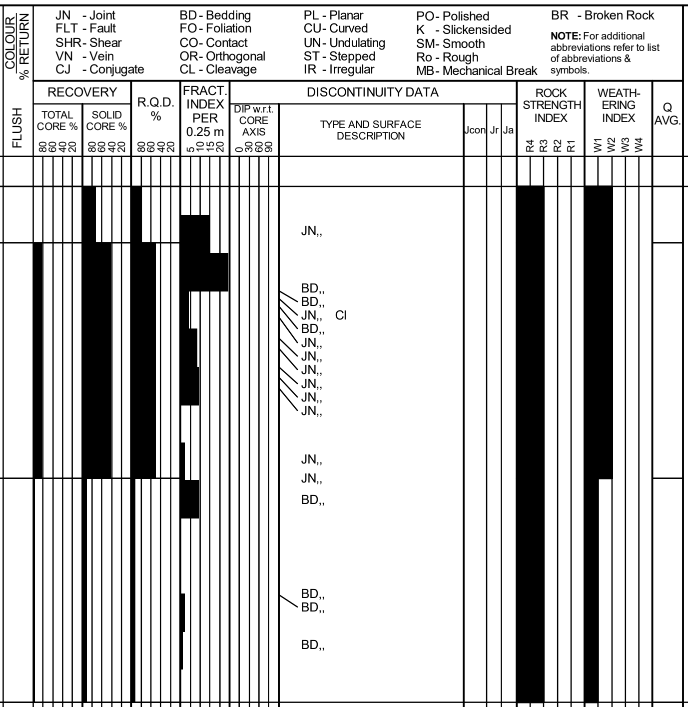
DRILLING CONTRACTOR: Downing Drilling

DATUM: Geodetic

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

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

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.
		BEDROCK SURFACE		72.81	
4	Rotary Drill NQ Core	Slighty weathered to fresh, thinly to medium bedded, medium grey, fine grained, faintly porous, medium strong DOLOSTONE, with interlaminations and interbeds of shale - broken core/lost core from 4.10 to 4.48 m depth - clay seam from 4.60 to 4.67 m depth		3.81	1
5		- broken core from 4.81 to 4.88 m depth - clay seam from 4.81 to 4.88 m depth - broken core/lost core from 5.00 to 5.07 m depth - silty clay seam from 5.00 to 5.07 m depth - silty clay seam at 5.14 m depth			2
6		- broken core/lost core from 5.74 to 5.88 m depth			
7		- broken core from 6.50 to 6.51 m depth		69.40	3
		End of Drillhole		7.22	
8					
9					
10					
11					
12					
13					



DEPTH SCALE
1 : 50

LOGGED: RI
CHECKED: KG

PROJECT: 22524317

RECORD OF BOREHOLE: 22-02

SHEET 1 OF 1

LOCATION: N 5025450.6 ;E 441854.8

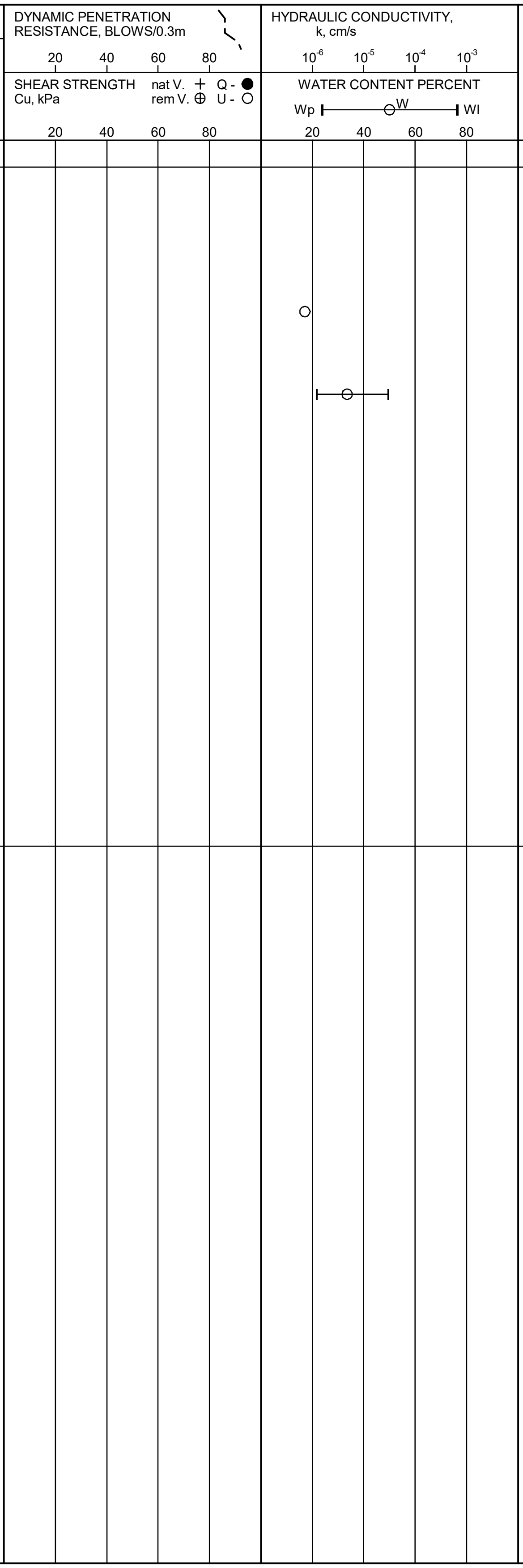
BORING DATE: July 18, 2022

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
		GROUND SURFACE	76.92				
0	Power Auger 200 mm Diam. (Hollow Stem)	FILL - (SM) gravelly SILTY SAND, angular; grey; non-cohesive, moist, compact	0.00				
		FILL - (SM) gravelly SILTY SAND; brown, contains asphalt freagments; non-cohesive, moist, compact to loose	0.15	1	SS	20	
1		TOPSOIL - (SM) SILTY SAND, fine, trace clay; dark brown to black, contains organic matter; non-cohesive, moist, loose	75.90 1.02 1.14	2	SS	9	M
		(ML) sandy SILT, trace gravel; greyish brown, orange mottled; non-cohesive, moist, loose	75.40 1.52	3	SS	9	M
2		(CI/CH) SILTY CLAY to CLAY, trace to some sand; greyish brown, highly fissured (WEATHERED CRUST); cohesive, w~PL, very stiff	75.09 1.83				
		(SM) gravelly SILTY SAND, trace clay; brown to greyish brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist, compact to dense		4	SS	28	
3				5	SS	>50	
4		(SM/ML) gravelly SILTY SAND to sandy SILT, trace clay; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet, dense	72.80 4.12	6	SS	39	
				7	SS	>50	
5		End of Borehole Auger Refusal	71.91 5.01				
6							
7							
8							
9							
10							



PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE

1 : 50

LOGGED: RI

CHECKED: KG

PROJECT: 22524317

RECORD OF BOREHOLE: 22-03

SHEET 1 OF 2

LOCATION: N 5025467.0 ;E 441876.7

BORING DATE: July 19, 2022

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES: 0 to 10

BORING METHOD: Power Auger, 200 mm Diam. (Hollow Stem) (0 to 3.13 m)

SOIL PROFILE – DESCRIPTION	ELEV. / DEPTH (m)
GROUND SURFACE	76.92
TOPSOIL - (SM) SILTY SAND, trace gravel; dark brown, contains organic matter; non-cohesive, moist, compact	0.05
FILL - (SM) gravelly SILTY SAND, angular; grey; non-cohesive, moist, compact	76.62 0.30
FILL - (SM) gravelly SILTY SAND; brown to dark brown, contains asphalt fragments and ash; non-cohesive, moist, compact	75.98 0.94
TOPSOIL/FILL - (SM) SILTY SAND, trace gravel; dark brown to black, contains organic matter and rootlets; non-cohesive, moist, compact	75.40 1.52
(CI/CH) SILTY CLAY to CLAY, trace sand; greyish brown, highly fissured (WEATHERED CRUST); cohesive, w<PL, very stiff	74.63 2.29
(SM) gravelly SILTY SAND, trace clay; greyish brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist, very dense	73.79 3.13
Borehole continued on RECORD OF DRILLHOLE 22-03	

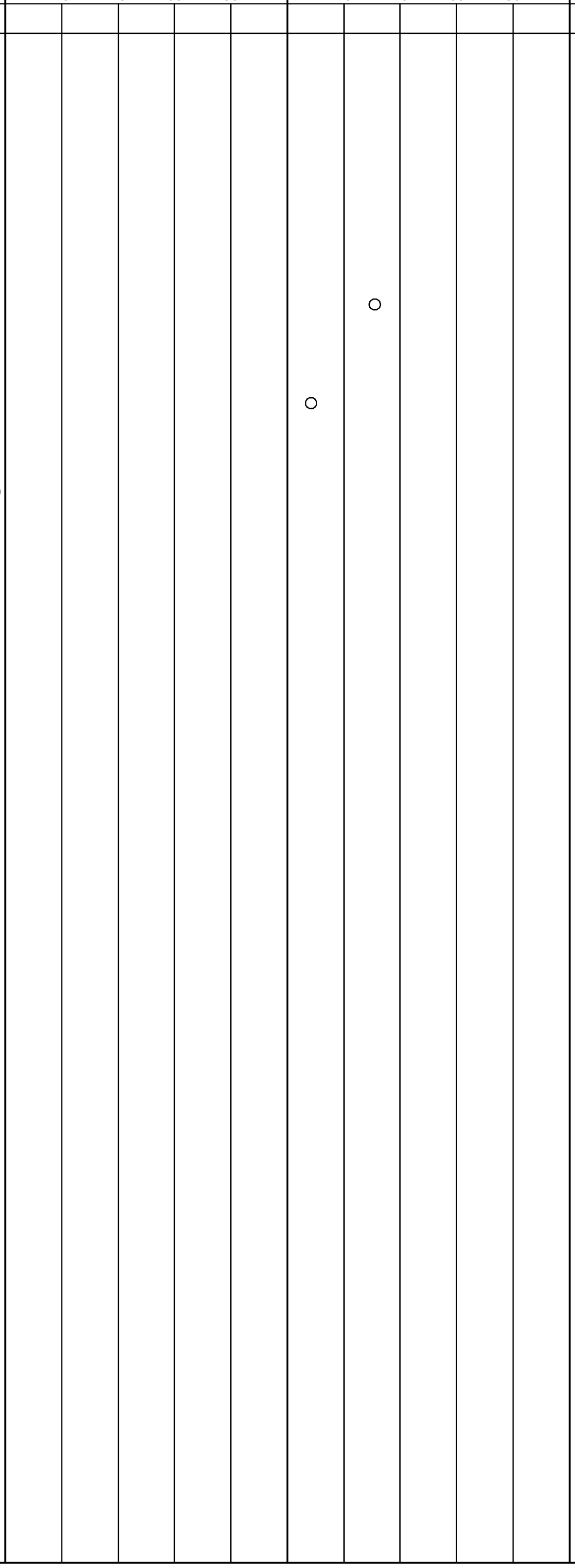
SAMPLES – NUMBER	TYPE	BLOWS/0.30m
1	SS	27
2	SS	18
3	SS	18
4	SS	69
5	SS	>50

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:
- Flush Mount Casing
- Bentonite Seal
- Cuttings
- Bentonite Seal

DEPTH SCALE

1 : 50

LOGGED: RI

CHECKED: KG

PROJECT: 22524317

RECORD OF DRILLHOLE: 22-03

SHEET 2 OF 2

LOCATION: N 5025467.0 ;E 441876.7

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: July 19, 2022

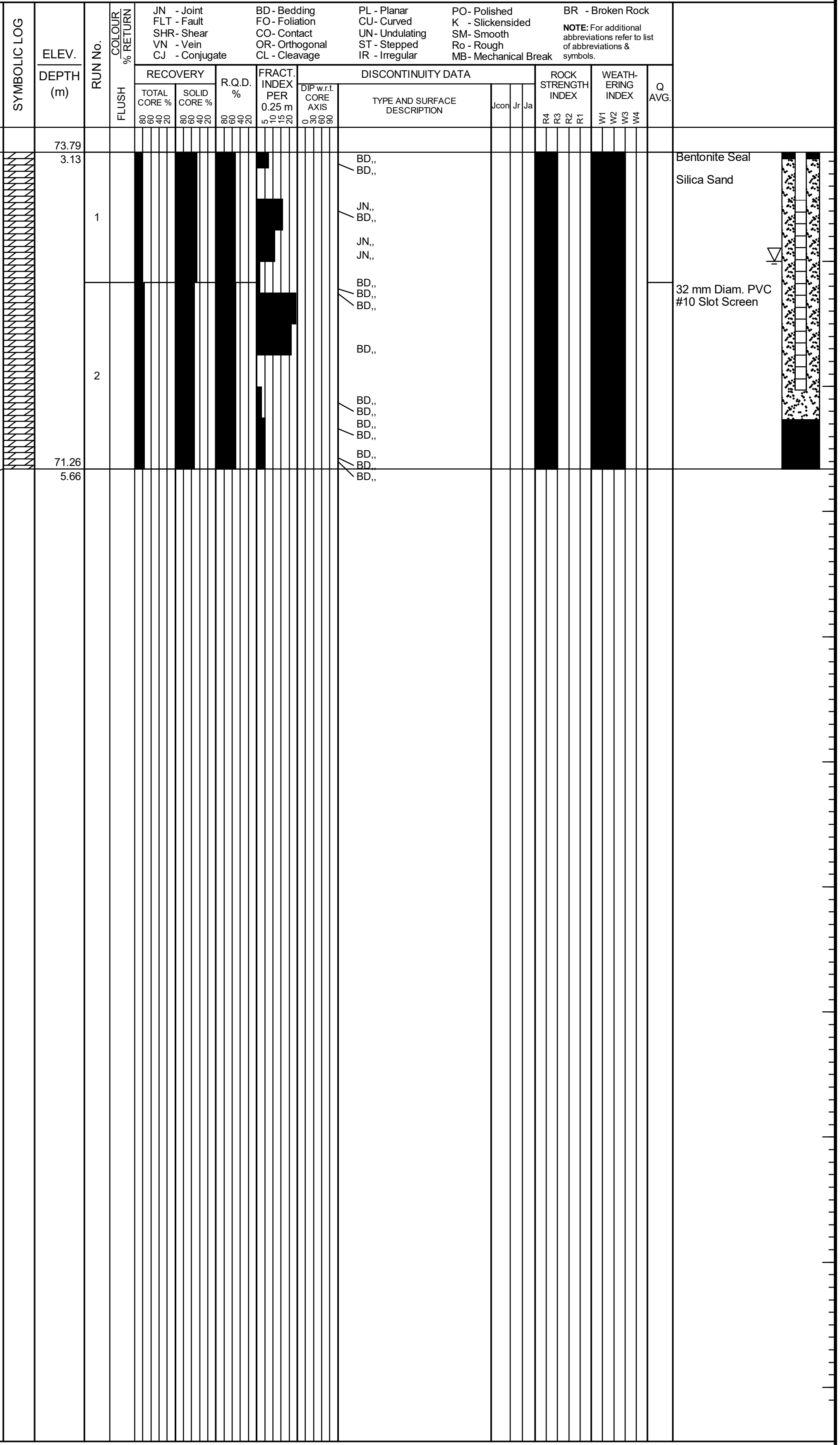
DRILL RIG: CME-55

DRILLING CONTRACTOR: Downing Drilling

DATUM: Geodetic

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

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. / DEPTH (m)
		BEDROCK SURFACE	73.79
	Rotary Drill NQ Core	Slightly to moderately weathered, thinly to medium bedded, medium grey, fine grained, faintly porous, medium strong DOLOSTONE, with interlaminations and interbeds of shale - broken core from 3.13 to 3.18 m depth - broken core/lost core from 3.60 to 3.84 m depth	3.13
4		- broken core/lost core from 4.26 to 4.70 m depth	
5		- broken core from 5.11 to 5.13 m depth - broken core from 5.30 to 5.34 m depth - broken core from 5.54 to 5.57 m depth	71.26 5.66
		End of Drillhole	
6		Note: Water level in screen at 4.00 m depth (72.92 mASL) on July 22, 2022	
7			
8			
9			
10			
11			
12			
13			



DEPTH SCALE

1 : 50

LOGGED: RI

CHECKED: KG

MIS-RCK 004 22524317_GEOTECH.GPJ GAL-MISS.GDT 12/8/22 JEM

PROJECT: 22524317

RECORD OF BOREHOLE: 22-04

SHEET 1 OF 2

LOCATION: N 5025399.3 ;E 441852.0

BORING DATE: July 21, 2022

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	77.20
ASPHALTIC CONCRETE	0.05
FILL - (SM) gravelly SILTY SAND, pavement structure, contains cobbles; dark brown; non-cohesive, moist, compact	76.79 0.41
(SM) gravelly SILTY SAND, trace clay; dark brown to brown, oxidation in upper portion, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist, compact to dense	75.07 2.13
(SM) gravelly SILTY SAND, trace clay; grey brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist, dense to very dense	73.39 3.81
(GM/SM) gravelly SILTY SAND to SILTY sandy GRAVEL; grey brown, possible cobbles and boulders (GLACIAL TILL to WEATHERED BEDROCK); non-cohesive, moist, very dense	72.63 4.57
Borehole continued on RECORD OF DRILLHOLE 22-04	

SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
1	SS	13	
2	SS	11	M
3	SS	36	
4	SS	46	
5	SS	54	
6	SS	59	

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

PIEZOMETER OR STANDPIPE INSTALLATION

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

DEPTH SCALE

1 : 50

LOGGED: RI

CHECKED: KG

PROJECT: 22524317

RECORD OF DRILLHOLE: 22-04

SHEET 2 OF 2

LOCATION: N 5025399.3 ;E 441852.0

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: July 21, 2022

DRILL RIG: CME-55

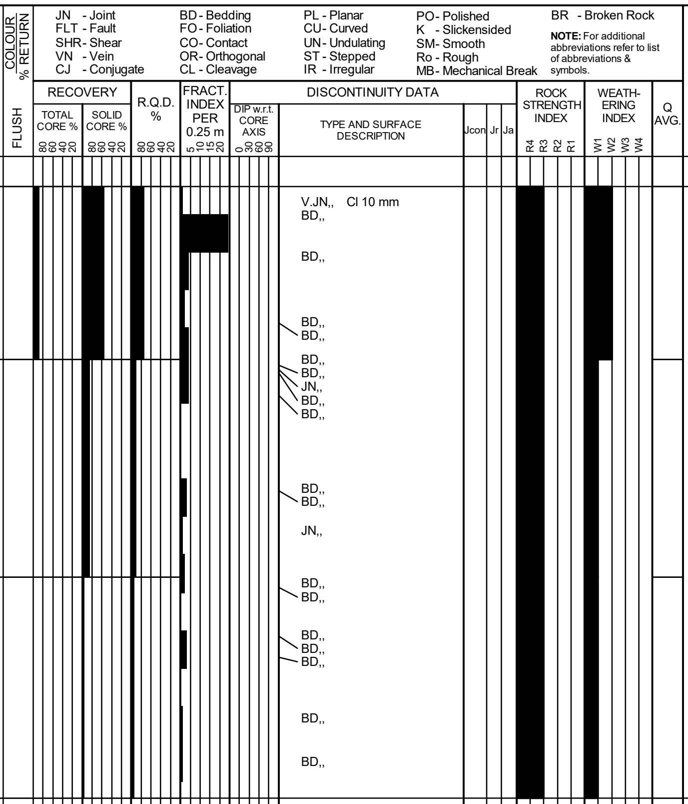
DRILLING CONTRACTOR: Downing Drilling

DATUM: Geodetic

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

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

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. DEPTH (m)	RUN No.	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION
		BEDROCK SURFACE	72.63 4.57		
5 6 7 8	Rotary Drill NQ Core	Slightly weathered to fresh, thinly to medium bedded, medium grey, fine grained, faintly porous, medium strong DOLOSTONE, with interlaminations and interbeds of shale - broken core/lost core from 4.76 to 5.03 m depth - broken core from 5.46 to 5.47 m depth - broken core from 5.71 to 5.75 m depth - clay seam, weathered shale from 5.71 to 5.75 m depth - broken core from 6.56 to 6.58 m depth - broken core from 7.53 to 7.54 m depth	68.59 8.61	1 2 3	V.JN,, CI 10 mm BD,, BD,, BD,, BD,, BD,, BD,, JN,, BD,, BD,, BD,, BD,, JN,, BD,, BD,, BD,, BD,, BD,, BD,, BD,,
9 10 11 12 13 14		End of Drillhole			



DEPTH SCALE

1 : 50

WSP GOLDER

LOGGED: RI

CHECKED: KG

PROJECT: 22524317

RECORD OF BOREHOLE: 22-05

SHEET 1 OF 2

LOCATION: N 5025341.1 ;E 441800.7

BORING DATE: July 20, 2022

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}

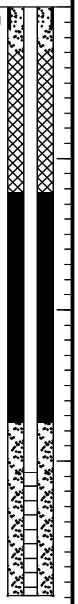
WATER CONTENT PERCENT: Wp ⊢—○W—⊣ Wl 20 40 60 80

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

SOIL PROFILE – DESCRIPTION	ELEV.	DEPTH (m)
GROUND SURFACE	78.06	
ASPHALTIC CONCRETE		0.00
FILL - (SW) gravelly SAND, pavement structure, trace silt, angular; grey; non-cohesive, moist, loose		0.10
FILL - (SP) SAND, pavement structure, fine to medium, some silt; brown; non-cohesive, moist, loose	77.63	0.43
FILL - (SM) gravelly SILTY SAND, trace clay; dark brown, contains cobbles; non-cohesive, moist to wet, very loose	77.15	0.91
(TOPSOIL-ML) sandy CLAYEY SILT, trace gravel; dark brown, contains organic matter; cohesive, w>PL, fine	76.84	1.22
(SM/GM) gravelly SILTY SAND to SILTY sandy GRAVEL; brown to grey brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist, very dense	76.54	1.52
Borehole continued on RECORD OF DRILLHOLE 22-05	74.17	3.89

SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING
1	SS	8	
2	SS	2	
3	SS	55	M
4	SS	91	
5	SS	57	
6	SS	>50	

PIEZOMETER OR STANDPIPE INSTALLATION



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

DEPTH SCALE
1 : 50

LOGGED: RI
CHECKED: KG

PROJECT: 22524317

RECORD OF DRILLHOLE: 22-05

SHEET 2 OF 2

LOCATION: N 5025341.1 ;E 441800.7

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: July 20, 2022

DRILL RIG: CME-55

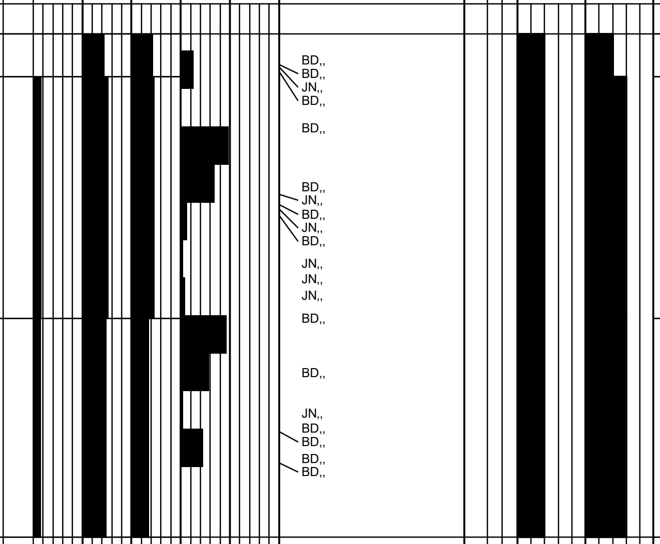
DRILLING CONTRACTOR: Downing Drilling

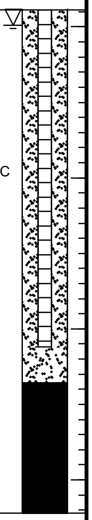
DATUM: Geodetic

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

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

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION
		BEDROCK SURFACE		74.17 3.89		
4 5 6 7	Rotary Drill NQ Core	Slightly to moderately weathered, thinly to medium bedded, medium grey, fine grained, faintly porous, medium strong DOLOSTONE, with interlaminations and interbeds of shale - broken core from 4.00 to 4.09 m depth - broken core/lost core from 4.51 to 4.9 m depth - broken core/lost core from 5.77 to 6.13 m depth - broken core from 6.50 to 6.58 m depth		70.84 7.22	1 2 3	BD,, BD,, JN,, BD,, BD,, BD,, JN,, BD,, JN,, BD,, JN,, JN,, JN,, BD,, BD,, JN,, BD,, BD,, BD,, BD,,
8 9 10 11 12 13		End of Drillhole Note: Water level in screen at 3.99 m depth (74.07 mASL) on July 22, 2022				





32 mm Diam. PVC #10 Slot Screen

DEPTH SCALE

1 : 50

LOGGED: RI

CHECKED: KG

PROJECT: 22524317

RECORD OF BOREHOLE: 22-06

SHEET 1 OF 1

LOCATION: N 5025373.4 ;E 441864.5

BORING DATE: July 19, 2022

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

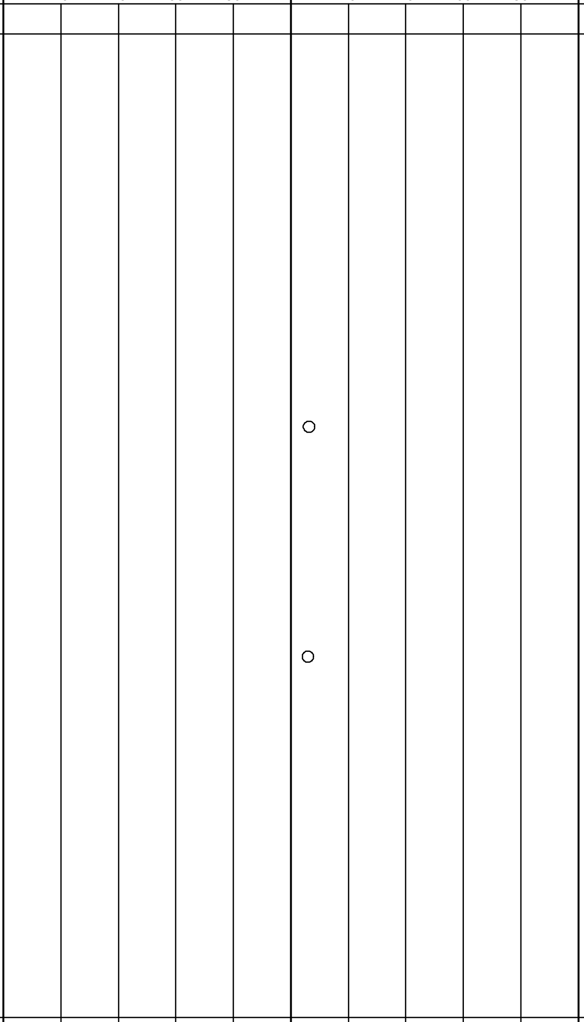
PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

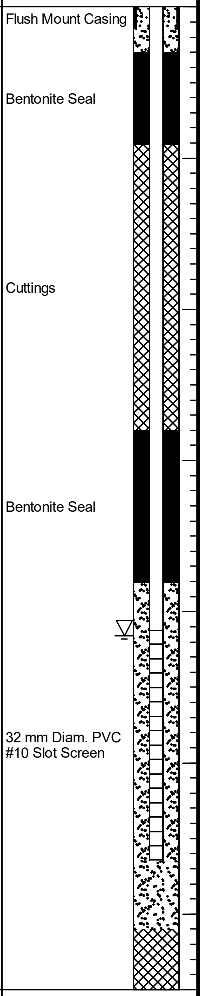
SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m
GROUND SURFACE	77.84			
TOPSOIL - (SM) SILTY SAND, trace gravel; dark brown to black, contains organic matter and rootlets; non-cohesive, moist, loose	0.00 0.10 0.25	1	SS	19
FILL - (SM) gravelly SILTY SAND, angular; grey; non-cohesive, moist, compact	77.25 0.59			
FILL - (SM) gravelly SILTY SAND; brown, contains organic matter and rootlets; non-cohesive, moist, compact	76.95 0.89	2	SS	10
FILL/TOPSOIL - (SM) SILTY SAND, trace gravel; dark brown, contains organic matter and rootlets; non-cohesive, moist, compact				
(SM) gravelly SILTY SAND, trace clay; brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist, compact to dense		3	SS	18
(SM) gravelly SILTY SAND, trace clay; brownish grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist to wet, compact to dense	75.25 2.59	4	SS	46
		5	SS	28
		6	SS	36
		7	SS	>50
(SM) gravelly SILTY SAND, trace clay; grey brown to grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist to wet, dense	72.50 5.34	8	SS	>50
(SM) SILTY SAND, fine to medium, trace gravel; grey; non-cohesive, wet, very dense	71.74 6.10	9	SS	82
End of Borehole Auger Refusal	71.34 6.50			

Note: Water level in screen at 4.16 m depth (73.68 mASL) on July 22, 2022

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

LOGGED: RI
CHECKED: KG

MIS-BHS 001 22524317_GEOTECH.GPJ GAL-MIS.GDT 12/8/22 JEM

PROJECT: 22524317

RECORD OF BOREHOLE: 22-07

SHEET 1 OF 2

LOCATION: N 5025395.8 ;E 441891.7

BORING DATE: July 18, 2022

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

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

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

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

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

DEPTH SCALE METRES	DESCRIPTION	ELEV. / DEPTH (m)
	GROUND SURFACE	77.48
0	FILL - (SM) gravelly SILTY SAND, angular; grey; non-cohesive, moist, compact	0.00
	FILL - (SM) gravelly SILTY SAND; brown; non-cohesive, moist, compact	0.15
1	TOPSOIL - (SM) SILTY SAND; dark brown to black, contains organic matter; non-cohesive, moist, compact	76.57 0.91
	(SM) gravelly SILTY SAND, trace clay; brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist, compact to very dense	76.31 1.17
3	(SM/ML) gravelly SILTY SAND to sandy SILT, trace clay; grey brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist to wet, compact to very dense	74.43 3.05
5	(GM/SM) gravelly SILTY SAND to SILTY sandy GRAVEL, trace clay; grey brown to grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet, compact to very dense	72.15 5.33
7	Borehole continued on RECORD OF DRILLHOLE 22-07	70.42 7.06

SAMPLES NUMBER	TYPE	BLOWS/0.3m	WATER CONTENT PERCENT	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
1	SS	15	○	M	
2	SS	11			
3	SS	35	○		
4	SS	52			
5	SS	23	○	M	
6	SS	14			
7	SS	71			
8	SS	71			
9	SS	28			
10	SS	>50			

MIS-BHS 001 22524317_GEOTECH.GPJ GAL-MIS.GDT 12/8/22 JEM

DEPTH SCALE

1 : 50

LOGGED: RI

CHECKED: KG

PROJECT: 22524317

RECORD OF DRILLHOLE: 22-07

SHEET 2 OF 2

LOCATION: N 5025395.8 ;E 441891.7

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: July 18, 2022

DRILL RIG: CME-55

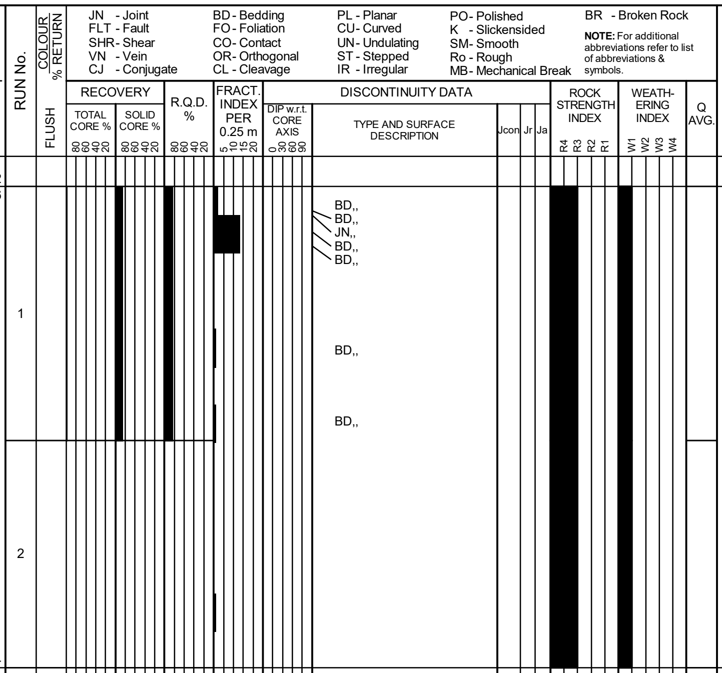
DRILLING CONTRACTOR: Downing Drilling

DATUM: Geodetic

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

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

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. DEPTH (m)	RUN No.	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION
		BEDROCK SURFACE	70.42		
	Rotary Drill NQ Core	Fresh, thinly to medium bedded, medium grey, fine grained, faintly porous, medium strong DOLOSTONE, with interlaminations and interbeds of shale - weathered bedrock from 7.06 to 7.36 m depth - broken core/lost core from 7.25 to 7.36 m depth	7.06	1	BD,, BD,, JN,, BD,, BD,,
8					BD,,
					BD,,
9				2	
10			67.24 10.24		
		End of Drillhole			



DEPTH SCALE

1 : 50

LOGGED: RI

CHECKED: KG

APPENDIX B

Record of Augerhole, Borehole and Test Pit Logs – Previous Investigation

PROJECT: 18110987

RECORD OF BOREHOLE: 18-01

SHEET 1 OF 1

LOCATION: N 364109.2 ;E 5026955.3

BORING DATE: January 3, 2019

DATUM:

SAMPLER HAMMER, 64kg; DROP, 760mm

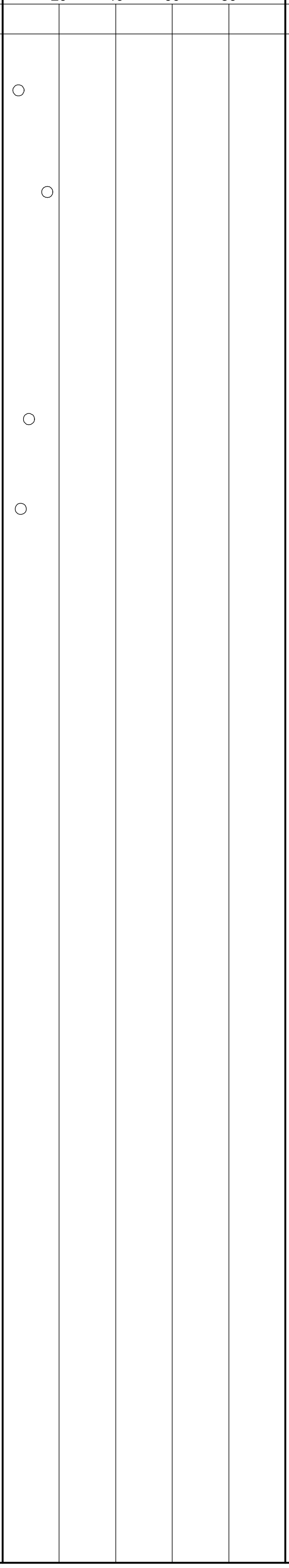
PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.30m
		GROUND SURFACE	77.02			
0	Power rAuger 200 mm Diam. (Hollow Stem)	FILL - (SW) gravelly SAND, angular; grey; non-cohesive, frozen	0.00			
		FILL - (SW/GW) SAND and GRAVEL, angular and subrounded, some silt; brown, contains asphaltic concrete pieces; non-cohesive, frozen	0.13	1	AS	-
1		(SM) SILTY SAND, some gravel; brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist, compact	76.33 0.69	2	SS	16
2				3	SS	13
				4	SS	26
3				5	SS	>50
		End of Borehole Auger Refusal on boulders or inferred bedrock	73.57 3.45			
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}



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE

1 : 50

GOLDER

LOGGED: PAH

CHECKED: AG

PROJECT: 18110987

RECORD OF BOREHOLE: 18-02

SHEET 1 OF 2

LOCATION: N 364125.8 ;E 5026970.0

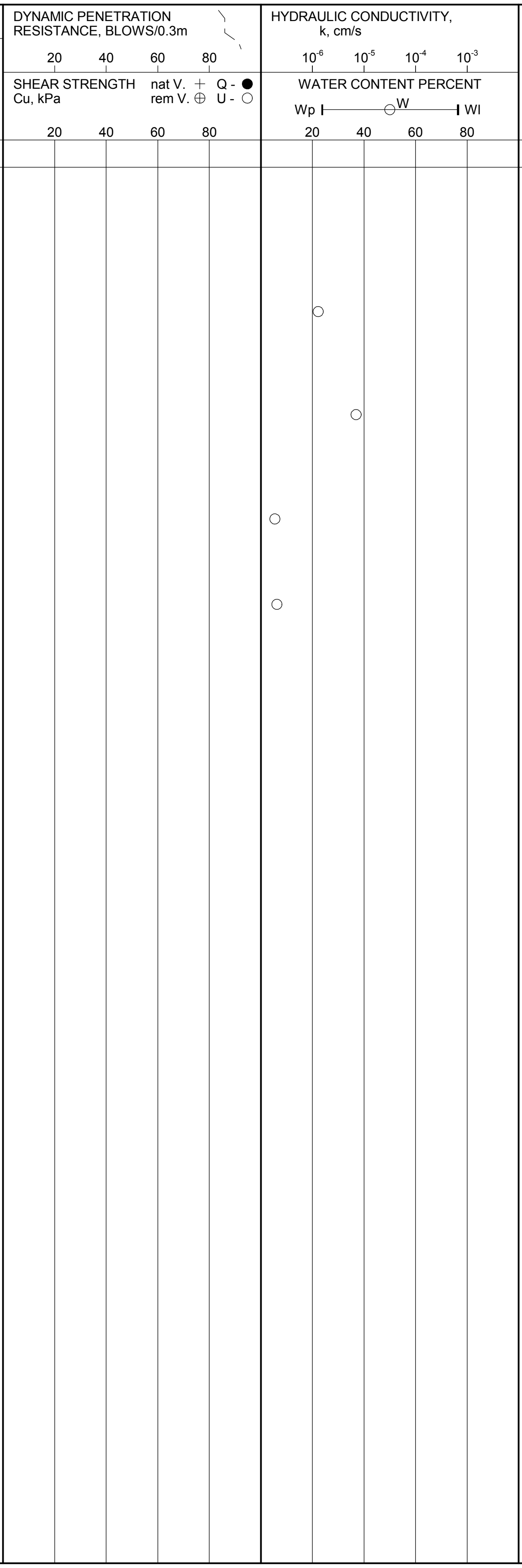
BORING DATE: January 3-4, 2019

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/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		77.01					
0	Power Auger 200 mm Diam. (Hollow Stem)	FILL - (GW) sandy GRAVEL, angular; grey (PAVEMENT STRUCTURE)		0.00	1	AS	-		
		FILL - (SM,ML) SILTY SAND and sandy SILT, some gravel; brown; non-cohesive, moist, loose		76.78 0.23					
1		TOPSOIL- (ML) CLAYEY SILT; dark brown; moist		76.00 1.01	2	SS	8		
2		(CI/CL) SILTY CLAY; grey brown, contains silty fine sand seams, fissured (WEATHERED CRUST); cohesive, w<PL, very stiff		1.17	3	SS	9		
		(SW/GW) SAND and GRAVEL, trace to some silt; brown; non-cohesive, moist, dense		74.78 2.23	4	SS	46		
3		(SM) Gravelly SILTY SAND; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist, very dense		74.27 2.74	5	SS	>50		
4	Rotary Drill HQ3 Core				R1	RC	DD		∇
					R2	RC	DD		
5 6 7 8 9 10		Borehole continued on RECORD OF DRILLHOLE 18-02		72.18 4.83					



DEPTH SCALE

1 : 50

LOGGED: PAH

CHECKED: AG

PROJECT: 18110987

RECORD OF DRILLHOLE: 18-02

SHEET 2 OF 2

LOCATION: N 364125.8 ;E 5026970.0

DRILLING DATE: January 3-4, 2019

DATUM:

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55

DRILLING CONTRACTOR: CCC Geotechnical and Enviromental Drilling

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

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

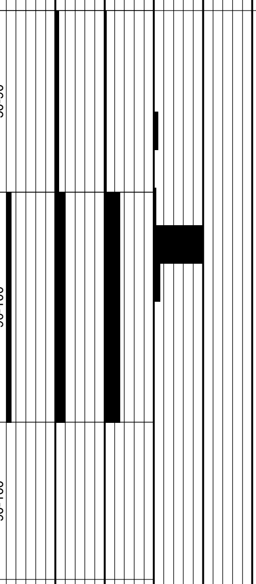
PL - Planar
CU- Curved
UN- Undulating
ST - Stepped
IR - Irregular

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

BR - Broken Rock

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

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH COLOUR % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.3 m	DIP w.r.t. CORE AXIS	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jcon	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -Q' AVG.	
		BEDROCK SURFACE		72.18															
5–8	Rotary Drill HQ3 Core	Fresh, medium grey, fine grained, non-porous, thin to medium bedded, strong LIMESTONE, with interbedded dolomite and shale seams		4.83	1	50-90													
					2	90-100													
				68.42	3	90-100													
9–14		End of Drillhole		8.59															WL in open borehole measured at 4.04 m depth upon completion of drilling



DEPTH SCALE
1 : 50

GOLDER

LOGGED: PAH
CHECKED: AG

PROJECT: 18110987

RECORD OF BOREHOLE: 18-03

SHEET 1 OF 2

LOCATION: N 364139.9 ;E 5026947.0

BORING DATE: January 4, 2019

DATUM:

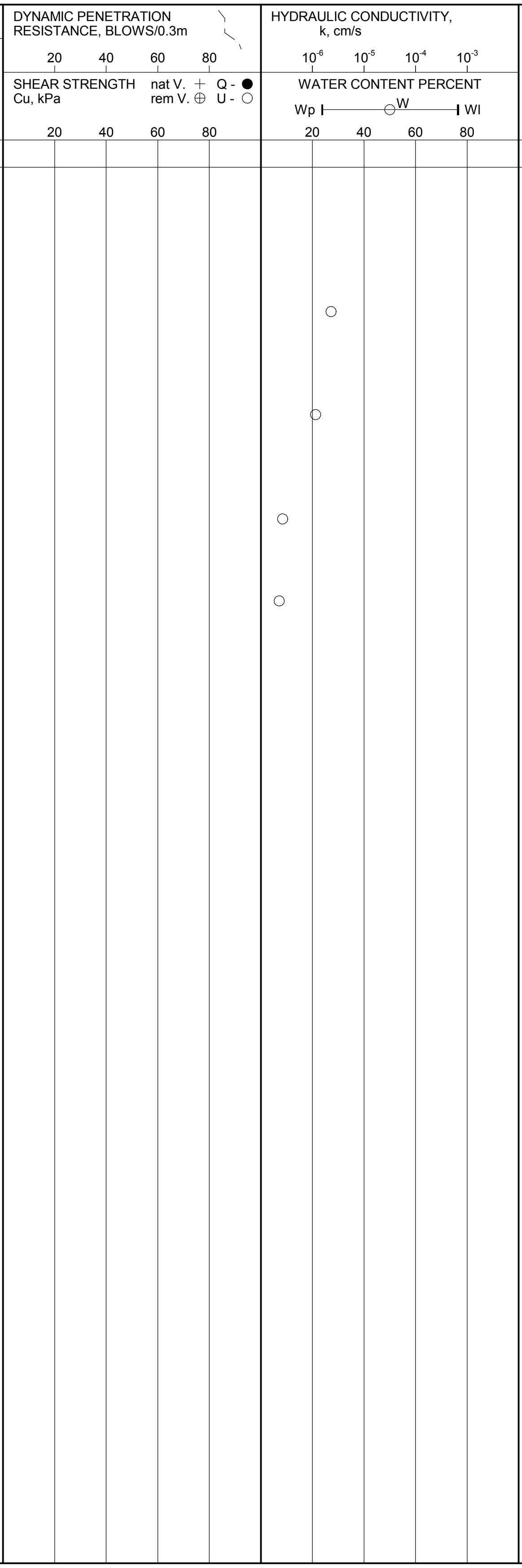
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

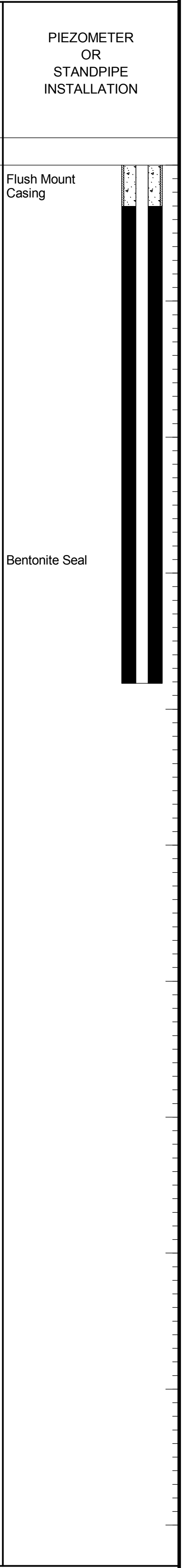
BORING METHOD: Power Auger, 200 mm Diam. (Hollow Stem)

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	77.09
FILL - (SW/GW) gravelly SAND to sandy GRAVEL, angular; grey; non-cohesive, frozen	0.00
FILL - (SM) SILTY SAND, some gravel; brown; non-cohesive, moist, compact	76.63 0.46
TOPSOIL - (SM) SILTY SAND; dark brown; moist	76.02 1.07
(CI/CL) SILTY CLAY; grey brown, contains silty fine sand seams, fissured (WEATHERED CRUST); cohesive, w<PL, very stiff	1.22
(ML) CLAYEY SILT and SAND, some gravel; brown; non-cohesive, moist, compact	75.26 1.83
(SM) Gravelly SILTY SAND; brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist, compact to dense	74.35 2.74
Borehole continued on RECORD OF DRILLHOLE 18-03	73.28 3.81

SAMPLES NUMBER	TYPE	BLOWS/0.3m
1	SS	45
2	SS	11
3	SS	8
4	SS	32
5	SS	>50



ADDITIONAL LAB. TESTING



DEPTH SCALE

1 : 50

LOGGED: PAH

CHECKED: AG

PROJECT: 18110987

RECORD OF DRILLHOLE: 18-03

SHEET 2 OF 2

LOCATION: N 364139.9 ;E 5026947.0

DRILLING DATE: January 4, 2019

DATUM:

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55

DRILLING CONTRACTOR: CCC Geotechnical and Enviromental Drilling

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

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

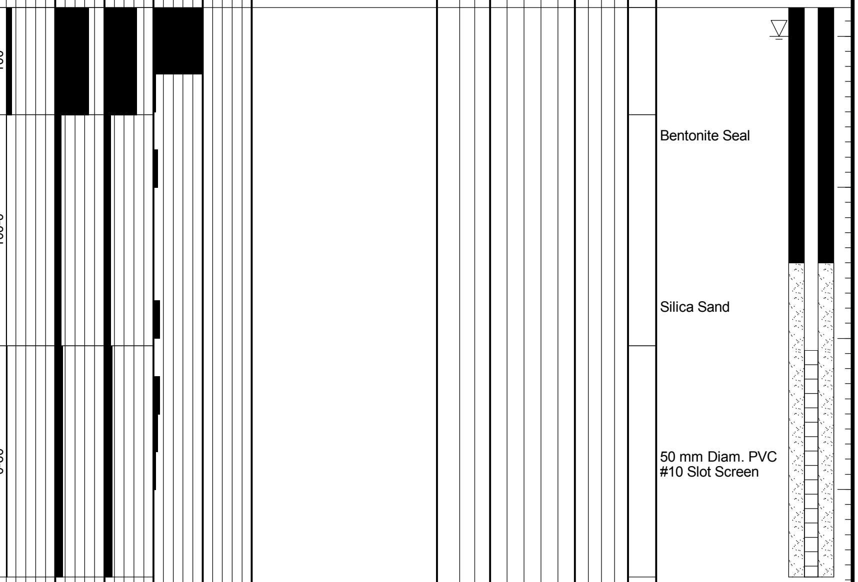
PL - Planar
CU- Curved
UN- Undulating
ST - Stepped
IR - Irregular

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

BR - Broken Rock

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

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. DEPTH (m)	RUN No.	FLUSH COLOUR % RETURN
		BEDROCK SURFACE	73.28		
4	Rotary Drill HQ3 Core	Slightly weathered, grey LIMESTONE	3.81	1	100
		Fresh, medium grey, fine grained, non-porous, thin to medium bedded, strong LIMESTONE, with interbedded dolomite and shale seams	72.74 4.35		
5				2	100-0
6					
7				3	0-60
		End of Drillhole	69.51 7.58		
8					
9					
10					
11					
12					
13					



Bentonite Seal

Silica Sand

50 mm Diam. PVC
#10 Slot Screen

WL in Screen at
Elev. 43.09 m on
Jan. 7, 2019

DEPTH SCALE
1 : 50

GOLDER

LOGGED: PAH
CHECKED: AG

APPENDIX A – RECORD OF AUGERHOLES

Table 1: Record of Augerholes

<table>
<tr><th>Augerhole Number (Elevation)</th><th>Depth (metres)</th><th>Description</th></tr>
<tr><td>AH 18-101</td><td>0 – 0.08</td><td>Asphaltic Concrete</td></tr>
<tr><td>(76.53 m)</td><td>0.08 – 0.16</td><td>Fill – (SW) gravelly SAND, angular; grey (PAVEMENT STRUCTURE)</td></tr>
<tr><td></td><td>0.16 – 0.75</td><td>Fill – (SW–GW) SAND and GRAVEL, angular and sub-rounded gravel, some silt; brown; non-cohesive, moist, compact to dense</td></tr>
<tr><td></td><td>0.75 – 1.35</td><td>(SM) SILTY SAND; brown; non-cohesive, moist, compact</td></tr>
<tr><td></td><td>1.35 – 1.5</td><td>(SM) SILTY SAND, some gravel; brown to grey brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist, compact</td></tr>
<tr><td></td><td></td><td>End of Augerhole;</td></tr>
<tr><td></td><td></td><td>Note: Augerhole dry upon completion.</td></tr>
<tr><td></td><td></td><td><table><tr><th>Sample No.</th><th>Depth (m)</th><th>Lab Testing</th></tr><tr><td>1</td><td>0.3 – 0.9</td><td>–</td></tr><tr><td>2</td><td>0.9 – 1.35</td><td>W_n=17%</td></tr></table></td></tr>
<tr><td>AH 18-102</td><td>0 – 0.25</td><td>Fill – (GW) sandy GRAVEL; grey; non-cohesive, frozen</td></tr>
<tr><td>(76.96 m)</td><td>0.25 – 0.9</td><td>Fill – (SW–GW) SAND and GRAVEL, angular and sub-rounded gravel, some silt; brown; non-cohesive, moist</td></tr>
<tr><td></td><td>0.91 – 1.1</td><td>TOPSOIL – (SM) SILTY SAND; moist</td></tr>
<tr><td></td><td>1.1 – 1.5</td><td>(ML) sandy CLAYEY SILT, trace gravel; brown; non-cohesive, moist, loose</td></tr>
<tr><td></td><td></td><td>End of Augerhole;</td></tr>
<tr><td></td><td></td><td>Note: Augerhole dry upon completion.</td></tr>
<tr><td></td><td></td><td><table><tr><th>Sample</th><th>Depth (m)</th><th>Lab Testing</th></tr><tr><td>1</td><td>0 – 0.25</td><td>–</td></tr><tr><td>2</td><td>1.1 – 1.5</td><td>W_n=25%</td></tr></table></td></tr>
<tr><td>AH 18-103</td><td>0 – 0.45</td><td>Fill – (SW) gravelly SAND; grey; non-cohesive, frozen</td></tr>
<tr><td>(76.83 m)</td><td>0.5 – 1.2</td><td>Fill – (SW–GW) SAND and GRAVEL, angular and sub-rounded gravel, some silt; grey brown; non-cohesive, moist</td></tr>
<tr><td></td><td>1.2 – 1.3</td><td>TOPSOIL – (ML) sandy SILT; dark brown; moist</td></tr>
<tr><td></td><td>1.3 – 1.5</td><td>(ML) CLAYEY SILT, some sand; grey brown, contains root penetrations; cohesive, w<PL</td></tr>
<tr><td></td><td></td><td>End of Augerhole;</td></tr>
<tr><td></td><td></td><td>Note: Augerhole dry upon completion.</td></tr>
<tr><td></td><td></td><td><table><tr><th>Sample</th><th>Depth (m)</th></tr><tr><td>1</td><td>0.6 – 1.2</td></tr><tr><td>2</td><td>1.3 – 1.5</td></tr></table></td></tr>
</table>

APPENDIX A – RECORD OF AUGERHOLES

Augerhole Number (Elevation)	Depth (metres)	Description
AH 18-104	0 – 0.07	Asphaltic Concrete
(76.91 m)	0.07 – 0.12	Fill - (SW) gravelly SAND, angular; grey (PAVEMENT STRUCTURE)
	0.12 – 0.6	Fill – (SW–GW) SAND and GRAVEL, angular and sub-rounded gravel, some silt; brown; non-cohesive, moist
	0.6 – 1.5	(SM) SILTY SAND, some gravel; brown to grey brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist
		End of Augerhole;
		Note: Augerhole dry upon completion.

Sample	Depth (m)	Lab Testing
1	0.15 – 0.5	–
2	0.6 – 1	W_n=13%

AH 18-105	0 – 0.05	Asphaltic Concrete
(77.23 m)	0.05 – 0.12	Fill – (SW) gravelly SAND, angular; grey (PAVEMENT STRUCTURE)
	0.12 – 0.5	Fill – (SW–GW) SAND and GRAVEL, angular and sub-rounded gravel, trace silt; brown; non-cohesive, moist
	0.5 – 1.5	(SM) SILTY SAND, some gravel; brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist
		End of Augerhole;
		Note: Augerhole dry upon completion.

Sample	Depth (m)	Lab Testing
1	0.15 – 0.5	–
2	0.6 – 1	W_n=10%

AH 18-106	0 – 0.9	Fill – (SW) gravelly SAND, angular; grey (PAVEMENT STRUCTURE)
(77.35 m)	0.9 – 1	TOPSOIL (SM) SILTY SAND; dark brown; moist
	1 – 1.5	(SM) SILTY SAND, ~40% to 45% low plasticity fine, some gravel; yellow brown; non-cohesive, moist
		End of Augerhole;
		Note: Augerhole dry upon completion.

Sample	Depth (m)	Lab Testing
1	0 – 0.3	–
2	0.9 – 1	–
3	1 – 1.5	W_n=13%

APPENDIX A – RECORD OF AUGERHOLES

Augerhole Number (Elevation)	Depth (metres)	Description
AH 18-107	0 – 0.2	Fill – (SW) gravelly SAND, angular; grey (PAVEMENT STRUCTURE)
(77.70 m)	0.2 – 0.8	Fill – (SM–GM) SILTY SAND and GRAVEL, angular and sub-rounded gravel; brown, contains cobbles and brick fragments; non-cohesive, moist
	0.8 – 1.5	(SM) SILTY SAND; brown; non-cohesive, moist, compact
		End of Augerhole;
		Note: Augerhole dry upon completion.

Sample	Depth (m)	Lab Testing
1	0.3 – 0.8	–
2	0.9 – 1.5	W_n=14%

AH 18-108	0 – 0.1	Asphaltic Concrete
(76.34 m)	0.1 – 0.3	Fill – (SW) gravelly SAND, angular; grey (PAVEMENT STRUCTURE)
	0.3 – 1.5	Fill – (SW–GW) SAND and GRAVEL, angular and sub-rounded gravel; brown, contains silty sand pockets; non-cohesive, moist
		End of Augerhole;
		Note: Augerhole dry upon completion.

Sample	Depth (m)
1	0.1 – 0.3
2	0.5 – 1

AH 18-109	0 – 0.04	Asphaltic Concrete
(76.58 m)	0.04 – 0.2	Fill – (SW) gravelly SAND, angular; grey (PAVEMENT STRUCTURE)
	0.2 – 0.6	Fill – (SM) SILTY SAND, some gravel; light to dark brown; non-cohesive, frozen
	0.6 – 1.5	(SM) SILTY SAND, some gravel; brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist, dense
		End of Augerhole;
		Note: Augerhole dry upon completion.

Sample	Depth (m)	Lab Testing
1	0.3 – 0.6	–
2	0.9 – 1.5	W_n=6%

APPENDIX A – RECORD OF AUGERHOLES

<table>
<tr><th>Augerhole Number (Elevation)</th><th>Depth (metres)</th><th>Description</th></tr>
<tr><td>AH 18-110</td><td>0 – 0.05</td><td>Asphaltic Concrete</td></tr>
<tr><td>(76.84 m)</td><td>0.05 – 0.2</td><td>Fill – (SW) gravelly SAND; angular; grey (PAVEMENT STRUCTURE)</td></tr>
<tr><td></td><td>0.2 – 0.7</td><td>(ML) CLAYEY SILT, some sand; brown; cohesive, w<PL</td></tr>
<tr><td></td><td>0.7 – 1.5</td><td>(SM) SILTY SAND, some gravel; brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist</td></tr>
<tr><td></td><td></td><td>End of Augerhole;</td></tr>
<tr><td></td><td></td><td>Note: Augerhole dry upon completion.</td></tr>
<tr><td></td><td></td><td><table>
<tr><th>Sample</th><th>Depth (m)</th><th>Lab Testing</th></tr>
<tr><td>1</td><td>0.1 – 0.2</td><td>–</td></tr>
<tr><td>2</td><td>0.3 – 0.6</td><td>–</td></tr>
<tr><td>3</td><td>0.9 – 1.2</td><td>W_n=8%</td></tr>
</table></td></tr>
<tr><td>AH 18-111</td><td>0 – 0.06</td><td>Asphaltic Concrete</td></tr>
<tr><td>(76.48 m)</td><td>0.06 – 0.75</td><td>Fill – (GW) sandy Gravel, angular; grey, contains cobbles (PAVEMENT STRUCTURE)</td></tr>
<tr><td></td><td>0.75 – 1.5</td><td>Fill – (SW–GW) SAND and GRAVEL, angular and sub-rounded gravel, some silt; brown; non-cohesive, moist</td></tr>
<tr><td></td><td></td><td>End of Augerhole;</td></tr>
<tr><td></td><td></td><td>Note: Augerhole dry upon completion.</td></tr>
<tr><td></td><td></td><td><table>
<tr><th>Sample</th><th>Depth (m)</th></tr>
<tr><td>1</td><td>0.1 – 0.4</td></tr>
<tr><td>2</td><td>1.2 – 1.5</td></tr>
</table></td></tr>
<tr><td>AH 18-112</td><td>0 – 0.07</td><td>Asphaltic Concrete</td></tr>
<tr><td>(77.7 m)</td><td>0.07 – 0.1</td><td>Fill - (SW) gravelly SAND, angular; grey (PAVEMENT STRUCTURE)</td></tr>
<tr><td></td><td>0.1 – 0.2</td><td>Asphaltic Concrete</td></tr>
<tr><td></td><td>0.2 – 0.3</td><td>Fill - (GW) sandy GRAVEL, angular; grey (PAVEMENT STRUCTURE)</td></tr>
<tr><td></td><td>0.3 – 1.5</td><td>Fill – (SM) gravely SILTY SAND; brown; non-cohesive, moist</td></tr>
<tr><td></td><td></td><td>End of Augerhole;</td></tr>
<tr><td></td><td></td><td>Note: Augerhole dry upon completion.</td></tr>
<tr><td></td><td></td><td><table>
<tr><th>Sample</th><th>Depth (m)</th><th>Lab Testing</th></tr>
<tr><td>1</td><td>0.2 – 0.3</td><td>–</td></tr>
<tr><td>2</td><td>0.5 – 0.9</td><td>W_n=9%</td></tr>
</table></td></tr>
</table>

APPENDIX A – RECORD OF AUGERHOLES

Augerhole Number (Elevation)	Depth (metres)	Description
AH 18-113	0 – 0.09	Asphaltic Concrete
(77.15 m)	0.09 – 0.2	Fill – (GW) sandy GRAVEL, angular; grey (PAVEMENT STRUCTURE)
	0.2 – 1.5	Fill – (SW–GW) SAND and GRAVEL, angular and sub-rounded gravel, some silt; brown; non-cohesive, moist
		End of Augerhole;
		Note: Augerhole dry upon completion.

Sample	Depth (m)	Lab Testing
1	0.1 – 0.2	–
2	0.3 – 0.9	W_n=10%

Augerhole Number (Elevation)	Depth (metres)	Description
AH 18-114	0 – 0.08	Asphaltic Concrete
(78.18 m)	0.08 – 0.3	Fill – (GW) sandy GRAVEL, angular; grey (PAVEMENT STRUCTURE)
	0.3 – 1.5	(SM) SILTY SAND, some gravel; brown to grey brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist
		End of Augerhole;
		Note: Augerhole dry upon completion; Augered through a 350 mm diameter boulder at a depth of about 500 – 850 mm.

Sample	Depth (m)	Lab Testing
1	0 – 0.8	–
2	1 – 1.5	W_n=6%

Augerhole Number (Elevation)	Depth (metres)	Description
AH 18-115	0 – 0.075	Asphaltic Concrete
(77.92 m)	0.075 – 0.4	Fill – (GW) sandy GRAVEL, angular; grey (PAVEMENT STRUCTURE)
	0.4 – 1.5	(SM) SILTY SAND, some gravel; brown to grey brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist
		End of Augerhole;
		Note: Augerhole dry upon completion.

Sample	Depth (m)	Lab Testing
1	0.1 – 0.4	–
2	1 – 1.5	W_n=9%

G.C. M^c ROSTIE

CONSULTING CIVIL ENGINEERS

OTTAWA CANADA

SOIL PROFILE & SUMMARY OF LABORATORY TESTS

PRODUCERS DAIRY
LAPERRIERE AVE., OTTAWA.

ELEVATION OF GROUND SURFACE (ZERO DEPTH) 254.2 GEODETIC

REMARKS (SF 169)

HOLE Nº 2

~~BORINGS~~ PIT BY Mc ROSTIE TESTING BY Mc ROSTIE DATE JAN 26/55

UNCONFINED COMPRESSIVE STRENGTH KIPS/FT²	WATER CONTENT %	NUMBER OF BLOWS/FT	SAMPLE Nº	DESCRIPTION OF SOIL	DEPTH IN FEET	ELEVATION	WATER CONTENT %
				GROUND SURFACE			
		2		TOP SOIL 0.8	0	254.2	(77.5)
		3		LOOSE GRAVELLY SAND	1		
		6			2	252.2	
		5		3.2	3		
		16		DENSE SILT, SAND & GRAVEL	4	250.2	
				5.0 BOTTOM OF PIT	5	(76)	
					6	248.2	
					7		
		140 LB. HAMMER 30 INCH DROP – PROBING TEST 1½ INCH ROD			8	246.2	
					9		
					10	244.2	
					11		
					12		

○ NATURAL WATER CONTENT
□ PLASTIC LIMIT
△ LIQUID LIMIT

PLATE 3

G.C. McROSTIE

CONSULTING CIVIL ENGINEERS
OTTAWA CANADA

SOIL PROFILE & SUMMARY OF LABORATORY TESTS

PRODUCERS DAIRY
LAPERRIERE AVE., OTTAWA

ELEVATION OF GROUND SURFACE (ZERO DEPTH) 256.0 GEODETIC

REMARKS (SF 169)

BORINGS BY McROSTIE TESTING BY McROSTIE DATE JAN. 24/55

HOLE No 3

UNCONFINED COMPRESSIVE STRENGTH KIPS/FT²	WATER CONTENT %	NUMBER OF BLOWS/FT.	SAMPLE No	DESCRIPTION OF SOIL	DEPTH IN FEET	ELEVATION	WATER CONTENT %
				GROUND SURFACE	0	256 (78)	
				TOP SOIL			
				0.8			
				LOOSE GRAVELLY SAND	1		
	13	1	☒		2	254	
				3.0	3		
	75	2	☒	DENSE SILT, SAND, & GRAVEL			
FOR 4"	48	3	☒		4	252	
					5		
					6	250	
BOULDER REQUIRED BLASTING				6.9	7	759	2 DAY WATER LEVEL
				DENSE SAND GRAVEL & BOULDERS	8	248	
					9		
					10	246	
					11		
		140 LB. HAMMER 30" DROP 2" SPLIT SPOON			12		
				BOTTOM OF HOLE 13.3 (74)	13		

⊙ NATURAL WATER CONTENT
▫ PLASTIC LIMIT
△ LIQUID LIMIT

PLATE 4

G. C. M^{c}ROSTIE

CONSULTING CIVIL ENGINEERS
OTTAWA CANADA

SOIL PROFILE & SUMMARY OF LABORATORY TESTS

PRODUCERS DAIRY
LAPERRIERE AVE., OTTAWA

ELEVATION OF GROUND SURFACE (ZERO DEPTH) 254.1

REMARKS (SF 169)

HOLE NO 4

BORINGS BY McROSTIE TESTING BY McROSTIE DATE JAN 25/55

UNCONFINED COMPRESSIVE STRENGTH KIPS/FT²	WATER CONTENT %	NUMBER OF BLOWS/FT.	SAMPLE NO	DESCRIPTION OF SOIL	DEPTH IN FEET	ELEVATION	WATER CONTENT %
				GROUND SURFACE			
				TOP SOIL	0	254.1	
				0.8			
				LOOSE SILTY SAND	1		
		3	1		2	252.1	
				2.5			
				DENSE SILT, SAND & GRAVEL	3		
		72	2		4	250.1	
		85	3	5.0	5		OVERNIGHT WATER LEVEL
				DENSE SILT, SAND, GRAVEL, & BOULDERS			WATER LEVEL FEB. 8/55
					6	248.1	[illegible] at 6' Oct 3/56
					7		
				8.0 BOTTOM OF HOLE	8	246.1	
					9		
					10	244.1	
					11		
					12		

JETTING REQUIRED TO ADVANCE CASING

140 LB. HAMMER
30 INCH DROP
2 INCH SPLIT SPOON

- ∘ NATURAL WATER CONTENT
- □ PLASTIC LIMIT
- △ LIQUID LIMIT

PLATE 5

G. C. McROSTIE

CONSULTING CIVIL ENGINEERS
OTTAWA CANADA

SOIL PROFILE & SUMMARY OF LABORATORY TESTS

PRODUCERS DAIRY
LAPERRIERE AVE., OTTAWA

ELEVATION OF GROUND SURFACE (ZERO DEPTH) 251.5

REMARKS (SF 169)

BORINGS BY McROSTIE TESTING BY McROSTIE DATE JAN. 20/55

HOLE No 5

UNCONFINED COMPRESSIVE STRENGTH KIPS/FT²	WATER CONTENT %	NUMBER OF BLOWS/FT.	SAMPLE No	DESCRIPTION OF SOIL	DEPTH IN FEET	ELEVATION	WATER CONTENT %
				GROUND SURFACE			
				TOPSOIL	0	251.5	(76.7)
				0.8			
				LOOSE SILTY SAND OCCASIONAL STONES	1		
		6	1		2	249.5	
					3		
				3.5			
		42	2	DENSE SILT SAND & GRAVEL	4	247.5	
							OVERNIGHT WATER LEVEL
		53	3		5		
					6	245.5	WATER LEVEL FEB 8/55
					7		
		(24" FOR 7")	4		8	243.5	
							w.c. Oct 3/56
				8.9			
				DENSE SAND, GRAVEL & BOULDERS	9	(73.9)	
		140 LB. HAMMER 30 INCH DROP 2 INCH SPLIT-SPOON	DIAMOND DRILLED 5.5' CORE RECOVERY 4.1'		10	241.5	
					11		
					12	239.5	
				BOTTOM OF HOLE AT 14.4 FT. (72.2)	13		

○ NATURAL WATER CONTENT
□ PLASTIC LIMIT
△ LIQUID LIMIT

PLATE 6

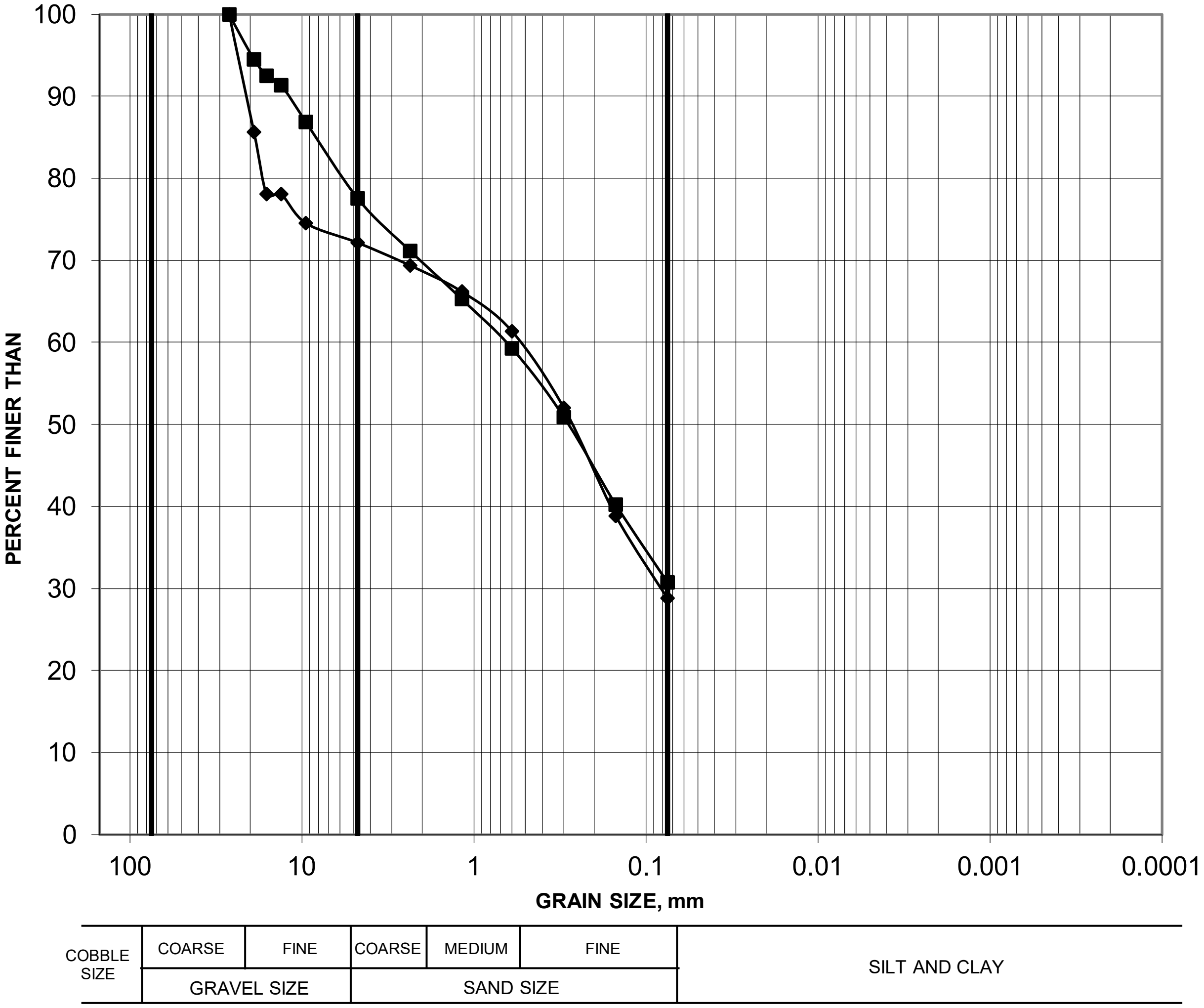
APPENDIX C

Results of Laboratory Testing

GRAIN SIZE DISTRIBUTION

FIGURE C-1

FILL



				Constituents (%)			
	Borehole	Sample	Depth (m)	Gravel	Sand	Silt	Clay
■	22-01	1	0.15-0.76	22	47	31	
◆	22-07	1B	0.00-0.61	28	43	29	

GOLDER
MEMBER OF WSP

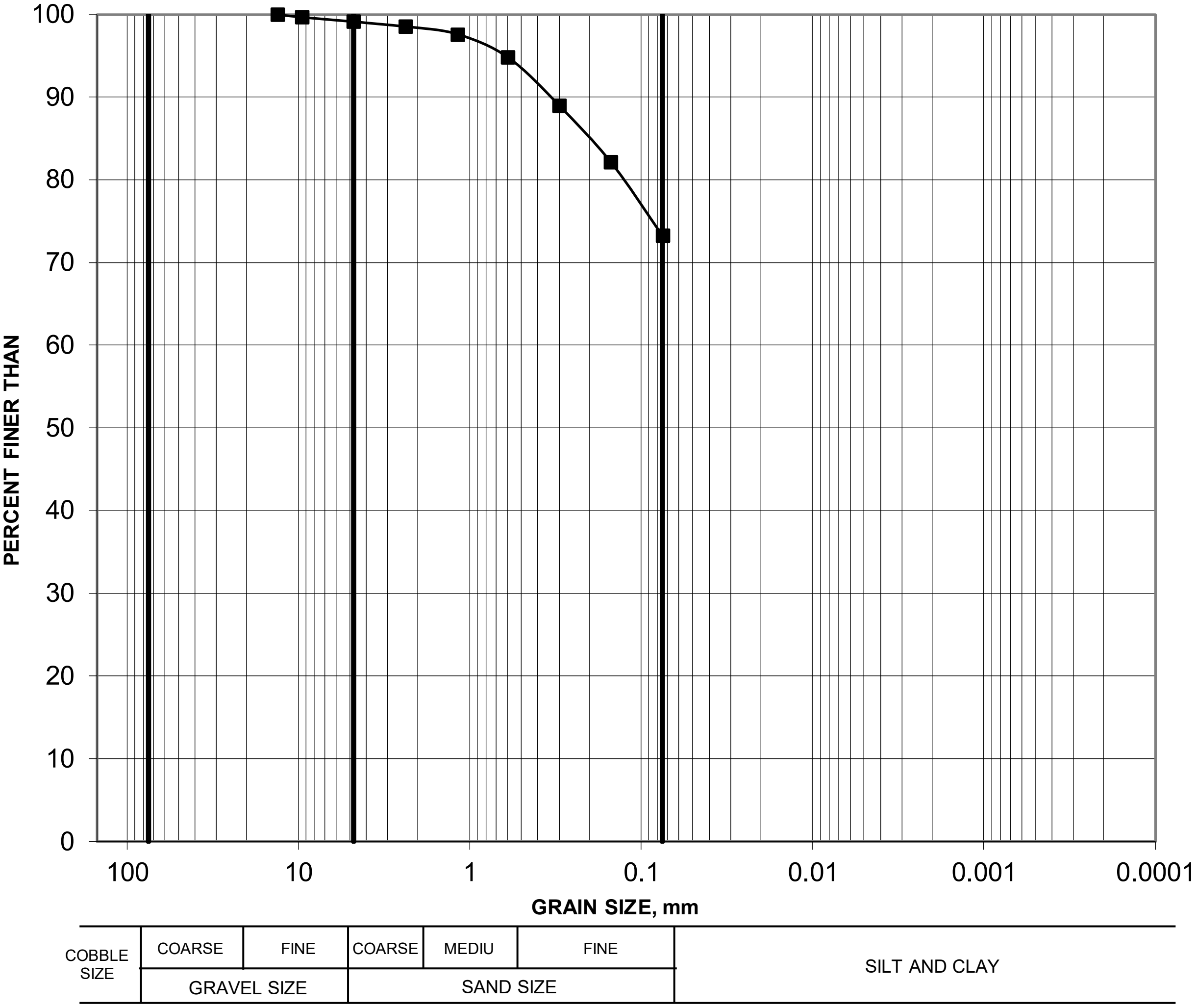
Project: 22524317

Created by: MI
Checked by: JB

https://golderassociates.sharepoint.com/sites/35409g/Shared Documents/Active/2022/22524317/Figures/

GRAIN SIZE DISTRIBUTION	FIGURE C-2

SANDY SILT



			Constituents (%)			
Borehole	Sample	Depth (m)	Gravel	Sand	Silt	Clay
■ 22-02	2C	0.76-1.37	1	26	73	

Project: 22524317

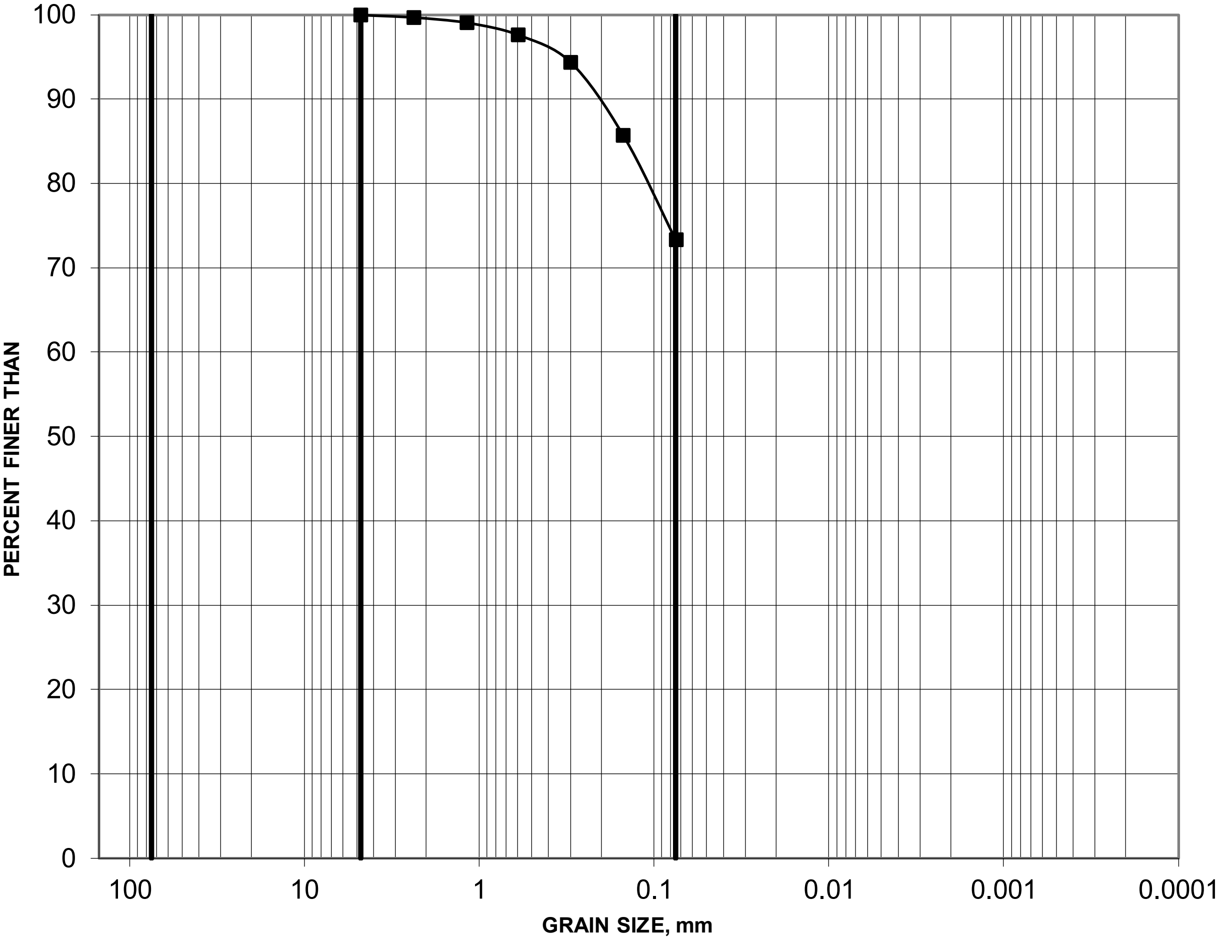
GOLDER
MEMBER OF WSP

Created by:	MI
Checked by:	JB

GRAIN SIZE DISTRIBUTION

FIGURE C-3

SILTY CLAY TO CLAY (WEATHERED CRUST)



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

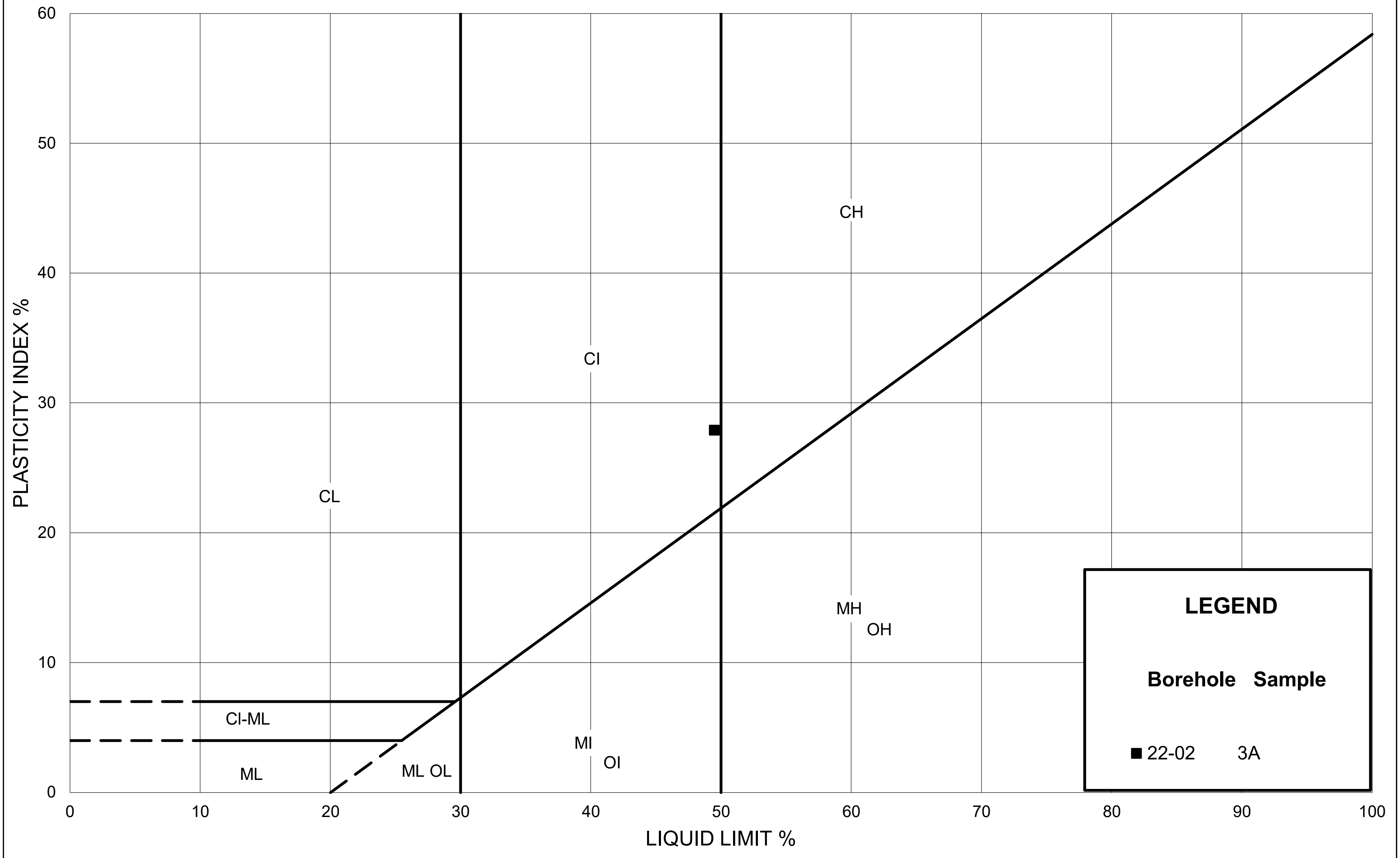
				Constituents (%)			
	Borehole	Sample	Depth (m)	Gravel	Sand	Silt	Clay
■	22-02	3A	1.52-1.83	0	27	73	

Project: 22524317

GOLDER
MEMBER OF WSP

Created by: MI

Checked by: JB



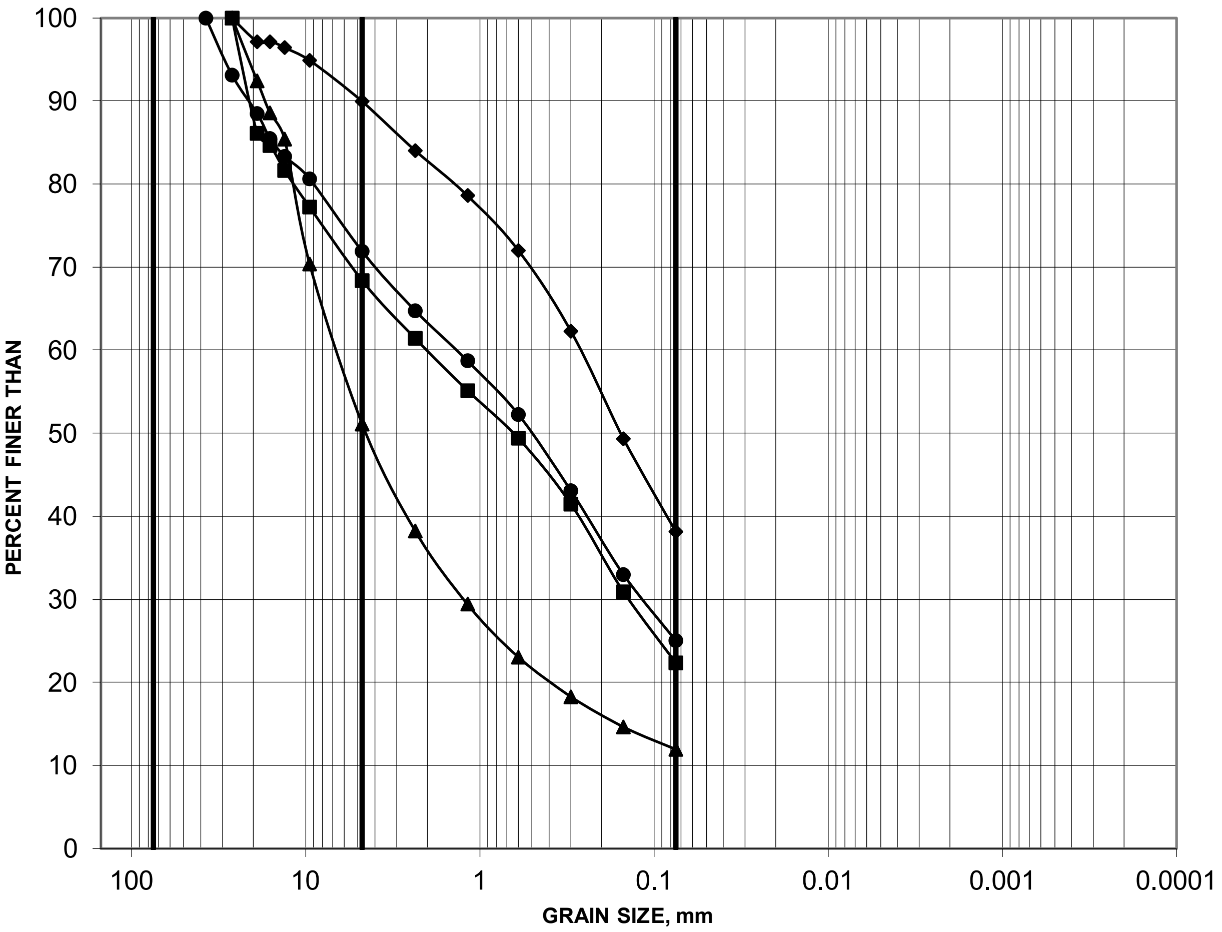
GOLDER
MEMBER OF WSP

PLASTICITY CHART
SILTY CLAY TO CLAY (WEATHERED CRUST)

Figure:	C-4
Project:	22524317
Created By: MI	Checked By: JB

GRAIN SIZE DISTRIBUTION	FIGURE C-5

GLACIAL TILL



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

				Constituents (%)			
Borehole		Sample	Depth (m)	Gravel	Sand	Silt	Clay
■	22-01	3B	1.68-2.13	32	46	22	
◆	22-04	2	0.76-1.37	10	52	38	
▲	22-05	3	1.52-2.13	49	39	12	
●	22-07	5	3.05-3.66	28	47	25	

Project: 22524317

GOLDER
MEMBER OF WSP

Created by: MI
Checked by: JB

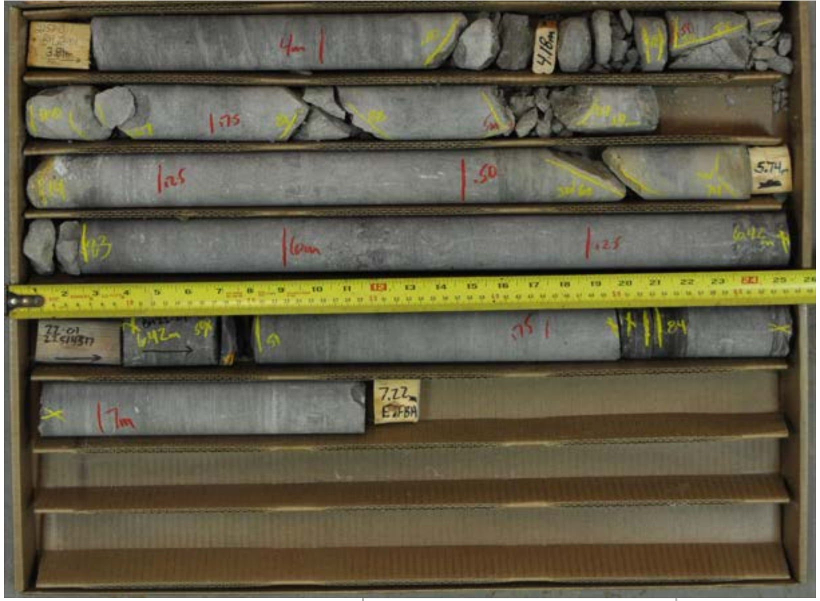
https://golderassociates.sharepoint.com/sites/35409g/Shared Documents/Active/2022/22524317/Figures/

APPENDIX D

Core Photographs

BH 22-01 (Dry)
Rock core from a depth of 3.81 m to 7.22 m
Core Box 1 to 2 of 2

Depth 3.81 m Top of Bedrock



Depth 7.22 m EOH

wsp GOLDER

Access Property Developments

Geotechnical and Environmental Investigation

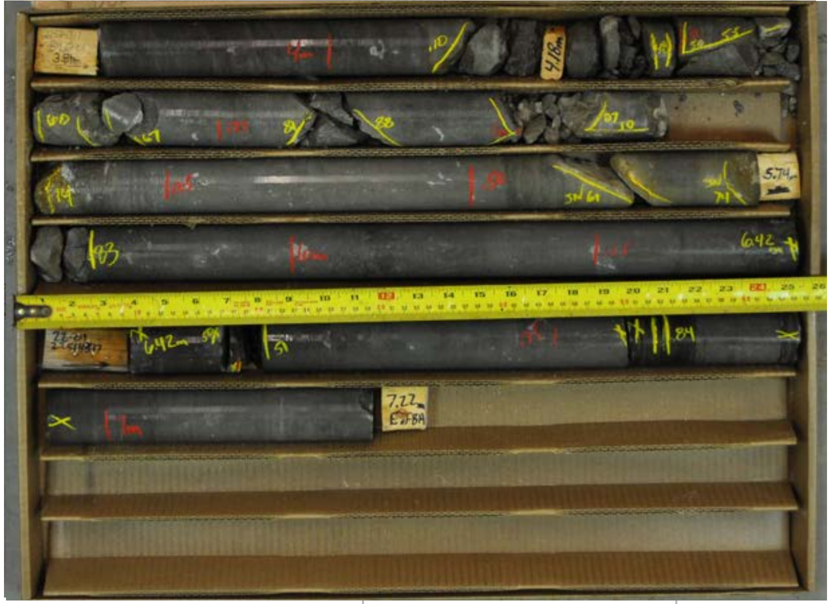
864 Lady Ellen Place, Ottawa, Ontario

Project No.	22524317
Drawn:	PAK
Date:	2022-07-26
Checked:	KG
Review:	CH

BH 22-01
1 to 2 of 2

BH 22-01 (Dry)
Rock core from a depth of 3.81 m to 7.22 m
Core Box 1 to 2 of 2

Depth 3.81 m Top of Bedrock



Depth 7.22 m EOH

WSP GOLDER

Access Property Developments

Geotechnical and Environmental Investigation

864 Lady Ellen Place, Ottawa, Ontario

Project No.	22524317
Drawn:	PAK
Date:	2022-07-26
Checked:	KG
Review:	CH

BH 22-01
1 to 2 of 2

BH 21-01 (Dry)
Rock core from a depth of 3.13 m to 5.66 m
Core Box 1 to 2 of 2

Depth 3.13 m Top of Bedrock

Depth 5.66 m EOH

WSP GOLDER

Access Property Developments

Geotechnical and Environmental Investigation

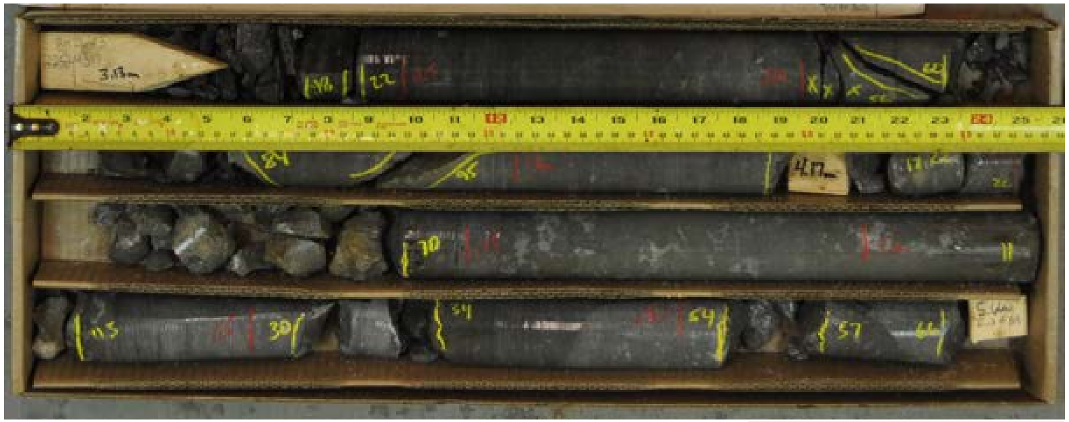
864 Lady Ellen Place, Ottawa, Ontario

Project No.	22524317
Drawn:	PAK
Date:	2022-07-26
Checked:	KG
Review:	CH

BH 22-03
1 to 2 of 2

BH 22-03 (Wet)
Rock core from a depth of 3.13 m to 5.66 m
Core Box 1 to 1 of 1

Depth 3.13 m Top of Bedrock



Depth 5.66 m EOH

Access Property Developments

Geotechnical and Environmental Investigation

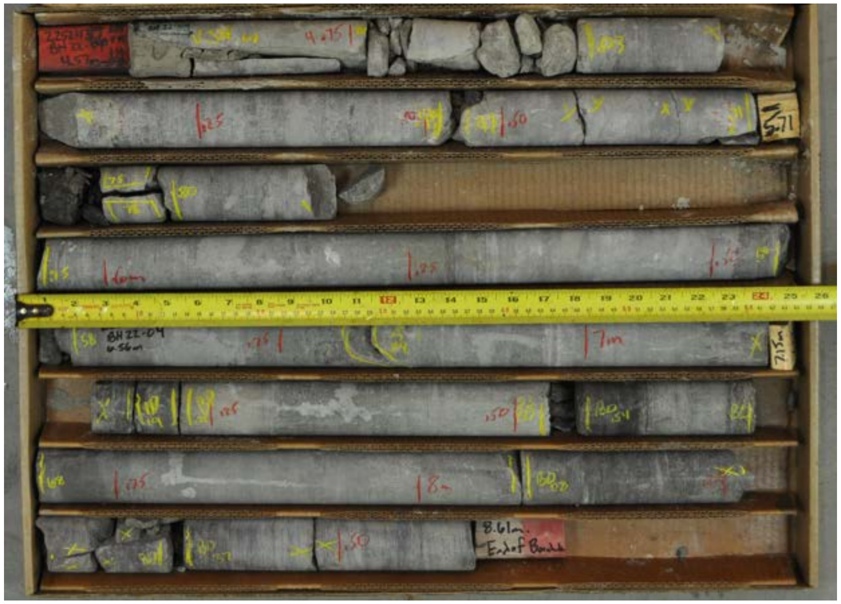
864 Lady Ellen Place, Ottawa, Ontario

Project No.	22524317
Drawn:	PAK
Date:	2022-07-26
Checked:	KG
Review:	CH

BH 22-03
1 to 1 of 1

BH 21-04(Wet)
Rock core from a depth of 4.50 m to 8.61 m
Core Box 1 to 2 of 2

Depth 4.50 m Top of Bedrock



Depth 8.61 m EOH

Access Property Developments

Geotechnical and Environmental Investigation

864 Lady Ellen Place, Ottawa, Ontario

Project No.	22524317
Drawn:	PAK
Date:	2022-07-26
Checked:	KG
Review:	CH

BH 22-04
1 to 2 of 2

BH 22-04(Dry)
Rock core from a depth of 4.50 m to 8.61 m
Core Box 1 to 2 of 2

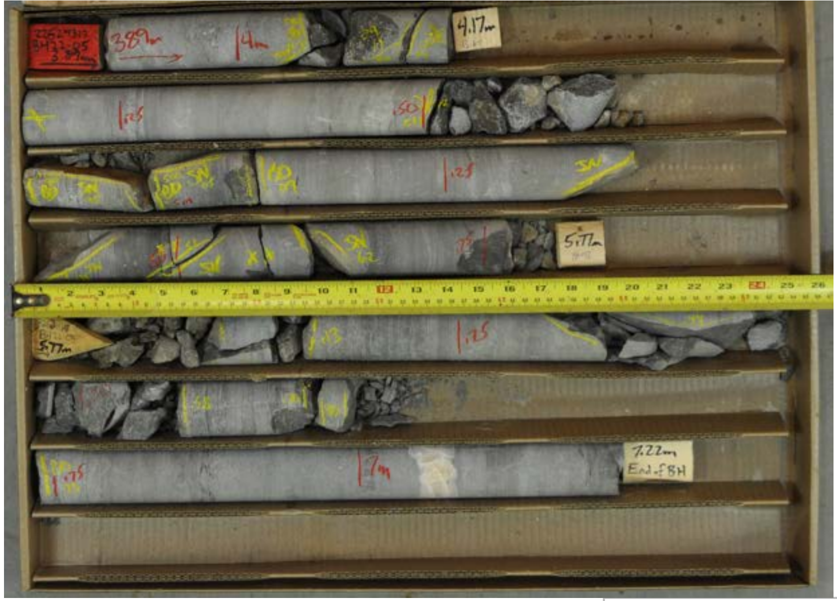
Depth 4.50 m Top of Bedrock

Depth 8.61 m EOH

WSP GOLDER	**Access Property Developments** **Geotechnical and Environmental Investigation** **864 Lady Ellen Place, Ottawa, Ontario**	Project No. Drawn: Date: Checked: Review:	22524317 PAK 2022-07-26 KG CH	**BH 22-04** **1 to 2 of 2**

BH 21-01 (Dry)
Rock core from a depth of 3.89 m to 7.22 m
Core Box 1 to 2 of 2

Depth 3.89 m Top of Bedrock



Depth 7.22 m EOH

WSP GOLDER	**Access Property Developments** **Geotechnical and Environmental Investigation** **864 Lady Ellen Place, Ottawa, Ontario**	Project No. 22524317 Drawn: PAK Date: 2022-07-26 Checked: KG Review: CH	**BH 22-05** **1 to 2 of 2**

BH 22-05 (Wet)
Rock core from a depth of 3.89 m to 7.22 m
Core Box 1 to 2 of 2

Depth 3.89 m Top of Bedrock

Depth 7.22 m EOH

WSP GOLDER

Access Property Developments

Geotechnical and Environmental Investigation

864 Lady Ellen Place, Ottawa, Ontario

Project No.	22524317
Drawn:	PAK
Date:	2022-07-26
Checked:	KG
Review:	CH

BH 22-05
1 to 2 of 2

BH 22-07 (Dry)
Rock core from a depth of 7.06 m to 10.24 m
Core Box 1 to 2 of 2

Depth 7.06 m Top of Bedrock

Depth 10.24 m EOH

WSP GOLDER

Access Property Developments

Geotechnical and Environmental Investigation

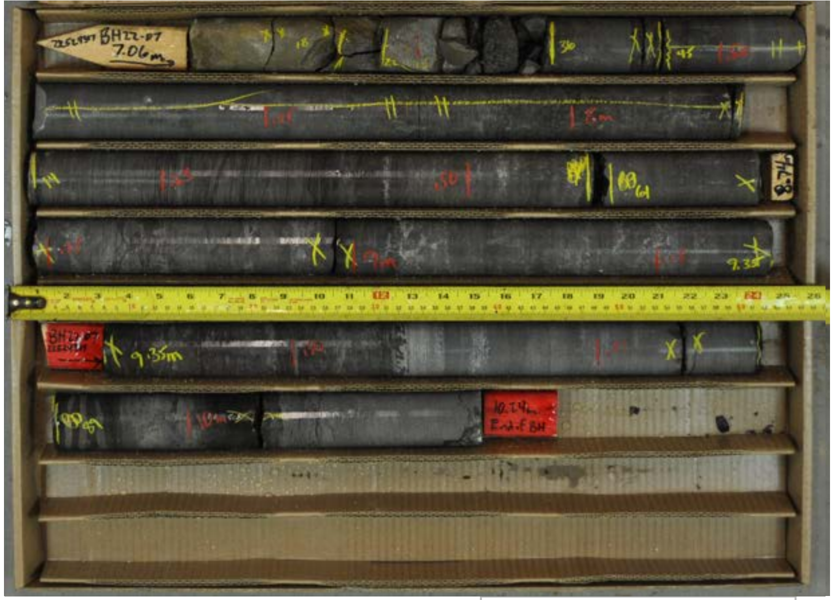
864 Lady Ellen Place, Ottawa, Ontario

Project No.	22524317
Drawn:	PAK
Date:	2022-07-26
Checked:	KG
Review:	CH

BH 22-07
1 to 2 of 2

BH 22-07 (Wet)
Rock core from a depth of 7.06 m to 10.24 m
Core Box 1 to 2 of 2

Depth 7.06 m Top of Bedrock



Depth 10.24 m EOH

Access Property Developments

Geotechnical and Environmental Investigation

864 Lady Ellen Place, Ottawa, Ontario

Project No.	22524317
Drawn:	PAK
Date:	2022-07-26
Checked:	KG
Review:	CH

BH 22-07
1 to 2 of 2

APPENDIX E

Results of Chemical Analysis

Certificate of Analysis

Client:	Golder Associates Ltd (Ottawa) 1931 Robertson Road, Ottawa, Ontario K2E	Report Number:	1983542
		Date Submitted:	2022-08-09
		Date Reported:	2022-08-16
		Project:	22524317
		COC #:	894691
Attention:	Ms. Mel Ireland		
PO#:			
Invoice to:	Golder Associates Ltd		

Dear Mel Ireland:

Please find attached the analytical results for your samples. If you have any questions regarding this report, please do not hesitate to call (613-727-5692).

Report Comments:

Revised report to fix sample id

APPROVAL: ______________________________

Rebecca Koshy, Project Manager

All analysis is completed at Eurofins Environment Testing Canada Inc. (Ottawa, Ontario) unless otherwise indicated.

Eurofins Environment Testing Canada Inc. (Ottawa, Ontario) is accredited by CALA, Canadian Association for Laboratory Accreditation to ISO/IEC 17025 for tests which appear on the scope of accreditation. The scope is available at: https://directory.cala.ca/.

Eurofins Environment Testing Canada Inc. (Ottawa, Ontario) is licensed by the Ontario Ministry of the Environment, Conservation, and Parks (MECP) for specific tests in drinking water (license #2318). A copy of the license is available upon request.

Eurofins Environment Testing Canada Inc. (Ottawa, Ontario) is accredited by the Ontario Ministry of Agriculture, Food, and Rural Affairs for specific tests in agricultural soils.

Please note: Field data, where presented on the report, has been provided by the client and is presented for informational purposes only. Guideline values listed on this report are provided for ease of use (informational purposes) only. Eurofins recommends consulting the official provincial or federal guideline as required. Unless otherwise stated, measurement uncertainty is not taken into account when determining guideline or regulatory exceedances.

Environment Testing

Certificate of Analysis

Client: Golder Associates Ltd (Ottawa)
1931 Robertson Road,
Ottawa, Ontario
K2E
Attention: Ms. Mel Ireland
PO#:
Invoice to: Golder Associates Ltd

Report Number: 1983542
Date Submitted: 2022-08-09
Date Reported: 2022-08-16
Project: 22524317
COC #: 894691

				Lab I.D.	1643329	1643330
				Sample Matrix	Soil	Soil
				Sample Type		
				Sampling Date	2022-07-20	2022-07-21
				Sample I.D.	22-01 SA2B / 3.2'-4.5'	22-04 sa3 / 5-7'
Group	**Analyte**	**MRL**	**Units**	**Guideline**		
Anions	Cl	0.002	%		0.056	0.035
	SO4	0.01	%		0.01	0.01
General Chemistry	Electrical Conductivity	0.05	mS/cm		1.18	0.86
	pH	2.00			8.27	7.89
	Resistivity	1	ohm-cm		847	1163

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 eurofins | Environment Testing

Certificate of Analysis

Client: Golder Associates Ltd (Ottawa)
1931 Robertson Road,
Ottawa, Ontario
K2E
Attention: Ms. Mel Ireland
PO#:
Invoice to: Golder Associates Ltd

Report Number: 1983542
Date Submitted: 2022-08-09
Date Reported: 2022-08-16
Project: 22524317
COC #: 894691

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Run No 427483 **Analysis/Extraction Date** 2022-08-16 **Analyst** IP **Method** AG SOIL			
SO4	<0.01 %	108	70-130
Run No 427520 **Analysis/Extraction Date** 2022-08-16 **Analyst** IP **Method** Cond-Soil			
Electrical Conductivity	<0.05 mS/cm	105	90-110
pH	5.41	100	90-110
Resistivity			
Run No 427534 **Analysis/Extraction Date** 2022-08-16 **Analyst** AsA **Method** C CSA A23.2-4B			
Chloride	<0.002 %		90-110

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 F

Golder Associates Technical Memorandum No. 18110987/1000, dated January 04, 2018

TECHNICAL MEMORANDUM

DATE January 4, 2018

Project No. 18110987/1000

TO Chaitanya Goyal, Golder Associates Ltd.

FROM Stephane Sol, Christopher Phillips

EMAIL ssol@golder.com; cphillips@golder.com

NBCC SEISMIC SITE CLASS TESTING RESULTS LADY ELLEN PLACE, OTTAWA, ONTARIO

This technical memorandum presents the results of a Multichannel Analysis of Surface Waves (MASW) test performed for the National Building Code (NBCC 2015). The seismic testing was carried out within a parking lot located on Lady Ellen Place, in Ottawa, Ontario (Figure 1). The geophysical testing was performed by Golder Associates Ltd. (Golder) personnel on December 11, 2018.

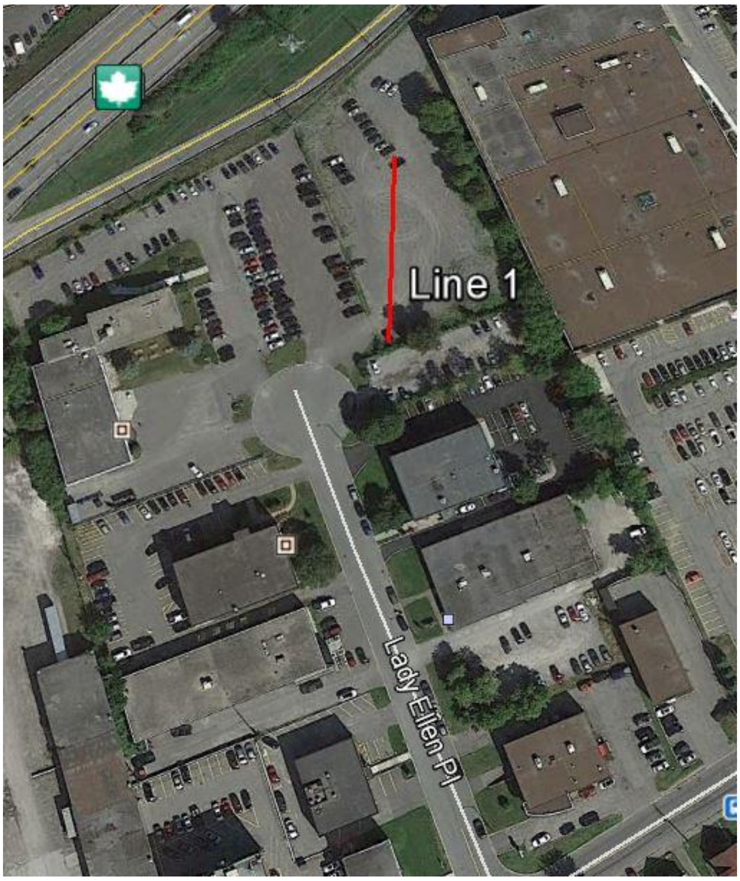


Figure 1: MASW Location Site Map (MASW Line in red)

Methodology

The MASW method measures variations in surface-wave velocity with increasing distance and wavelength and can be used to infer the rock/soil types, stratigraphy and soil conditions.

A typical MASW survey requires a seismic source, to generate surface waves, and a minimum of two geophone receivers, to measure the ground response at some distance from the source. Surface waves are a special type of seismic wave whose propagation is confined to the near surface medium.

The depth of penetration of a surface wave into a medium is directly proportional to its wavelength. In a non-homogeneous medium, surface waves are dispersive, i.e., each wavelength has a characteristic velocity owing to the subsurface heterogeneities within the depth interval that particular wavelength of surface wave propagates through. The relationship between surface-wave velocity and wavelength is used to obtain the shear-wave velocity and attenuation profile of the medium with increasing depth.

The seismic source used can be either active or passive, depending on the application and location of the survey. Examples of active sources include explosives, weight-drops, sledge hammer and vibrating pads. Examples of passive sources are road traffic, micro-tremors, and water-wave action (in near-shore environments).

The geophone receivers measure the wave-train associated with the surface wave travelling from a seismic source at different distances from the source.

The participation of surface waves with different wavelengths can be determined from the wave-train by transforming the wave-train results into the frequency domain. The surface-wave velocity profile with respect to wavelength (called the ‘dispersion curve’) is determined by the delay in wave propagation measured between the geophone receivers. The dispersion curve is then matched to a theoretical dispersion curve using an iterative forward-modelling procedure. The result is a shear-wave velocity profile of the tested medium with depth, which can be used to estimate the dynamic shear-modulus of the medium as a function of depth.

Field Work

The MASW field work was conducted on December 11, 2018, by a geophysicist from the Golder Mississauga office. For the MASW line, a series of 24 low frequency (4.5 Hz) geophones were laid out at 3 metre intervals. Both active and passive readings were recorded along the MASW line. For the active investigation, a seismic drop of 45 kg and a 9.9 kg sledge hammer were used as seismic sources. Active seismic records were collected with seismic sources located 5, 10, and 15 metres from and collinear to the geophone array. An example of active seismic record collected along the MASW line is shown in Figure 2 below.

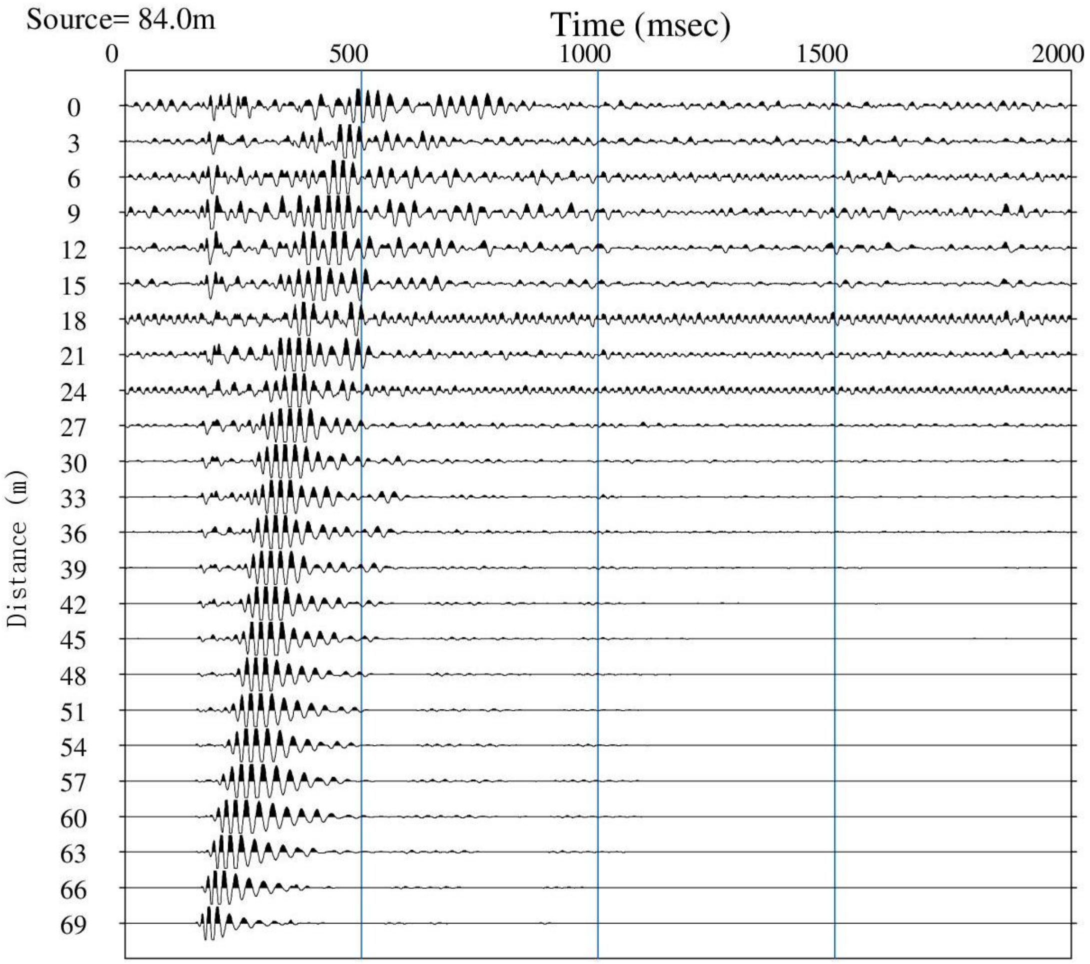


Figure 2: Typical seismic record collected at the site of the MASW line.

Data Processing

Processing of the MASW test results consisted of the following main steps:

1) Transformation of the time domain data into the frequency domain using a Fast-Fourier Transform (FFT) for each source location;

2) Calculation of the phase for each frequency component;

3) Linear regression to calculate phase velocity for each frequency component;

4) Filtering of the calculated phase velocities based on the Pearson correlation coefficient (r2) between the data and the linear regression best fit line used to calculate phase velocity;

5) Generation of the dispersion curve by combining calculated phase velocities for each shot location of a single MASW test; and,

6) Generation of the stiffness profile, through forward iterative modelling and matching of model data to the field collected dispersion curve.

Processing of the MASW data was completed using the SeisImager/SW software package (Geometrics Inc.). The calculated phase velocities for a seismic shot point were combined and the dispersion curve generated by choosing the minimum phase velocity calculated for each frequency component as shown on Figure 3. Shear wave velocity profiles were generated through inverse modelling to best fit the calculated dispersion curves. The active survey provided a dispersion curve with a suitable frequency range (11 to 60 Hz). The minimum measured surface wave frequency with sufficient signal-to-noise ratio to accurately measure phase velocity was approximately 11 Hz.

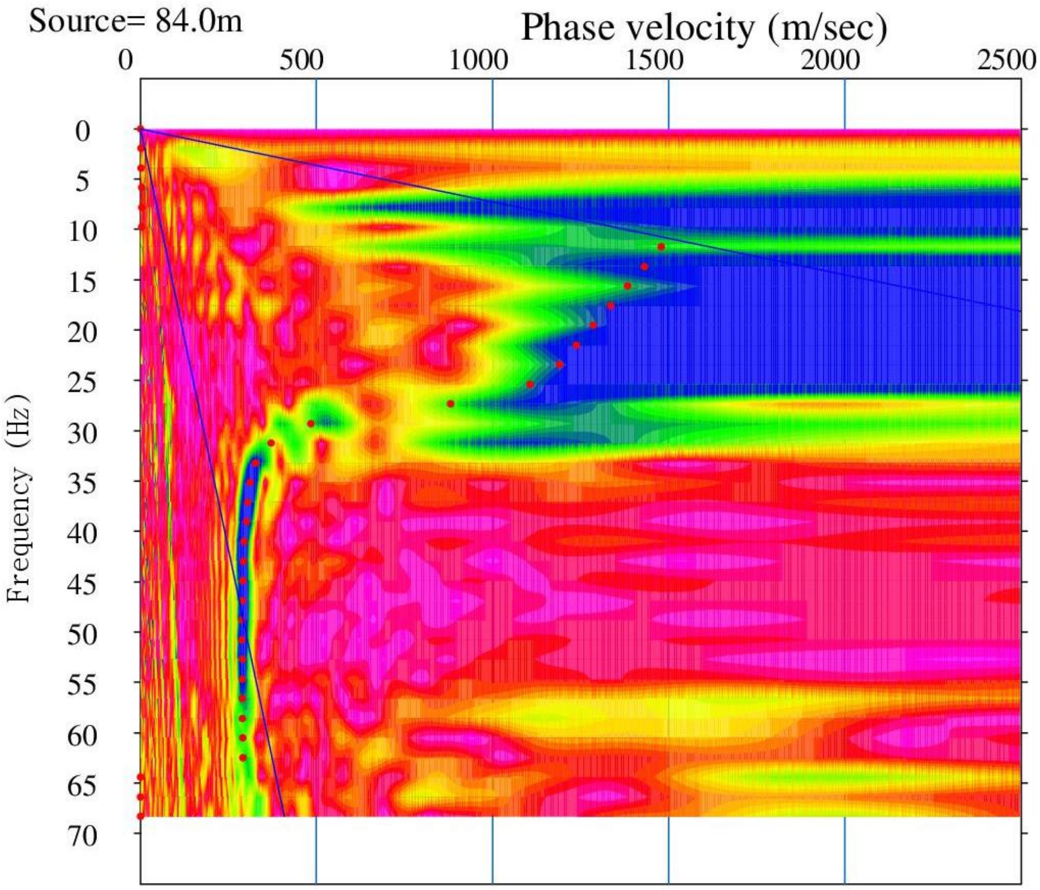


Figure 3: Active MASW Dispersion Curve Picks (red dots) along the MASW line

Results

The MASW test results are presented in Figure 4, which present the calculated shear wave velocity profile derived from the field testing along the MASW line. The results along the MASW line have been calculated using weight-drop located at 10 metres from the last geophone. The field collected dispersion curves are compared with the model generated dispersion curves on Figure 5 for the MASW line. There is a satisfactory correlation between the field collected and model calculated dispersion curves, with a root mean squared error of less than 7% along the MASW line.

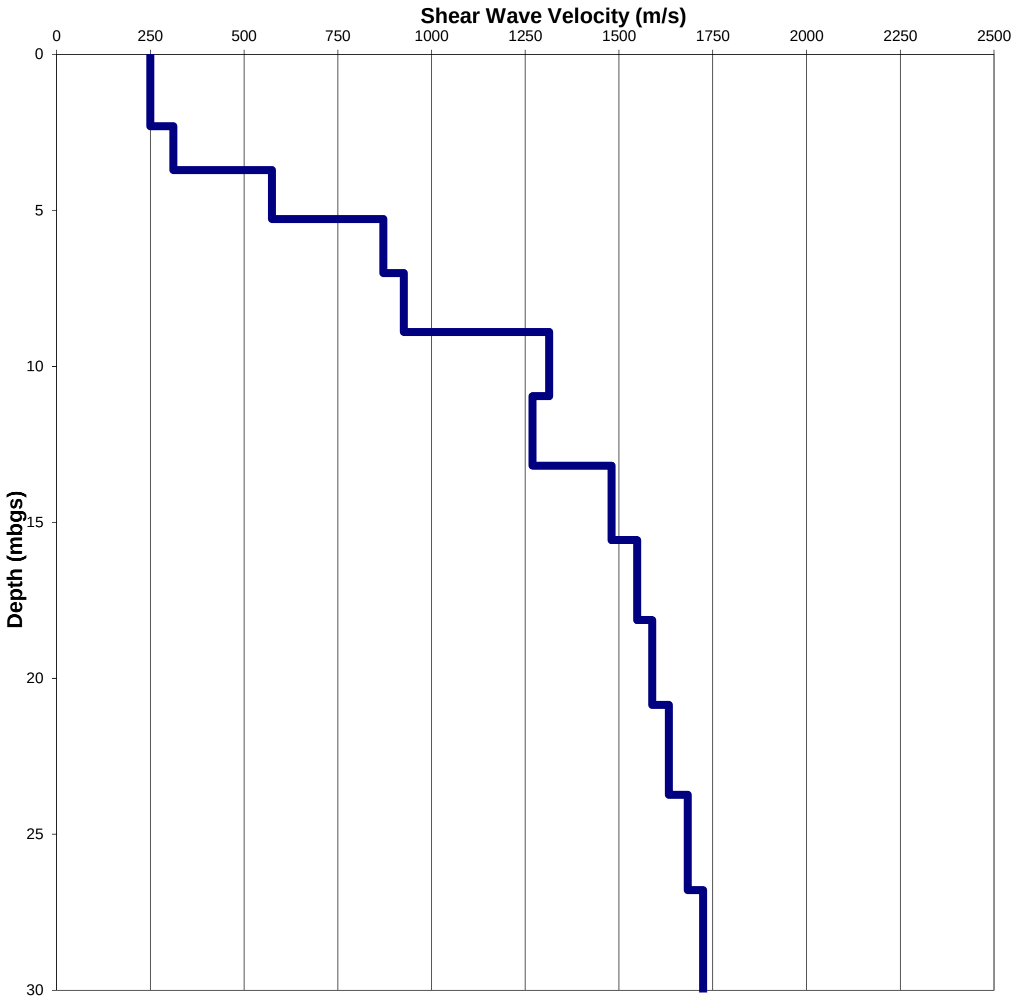


Figure 4: MASW Modelled Shear-Wave Velocity Depth profile along the MASW Line

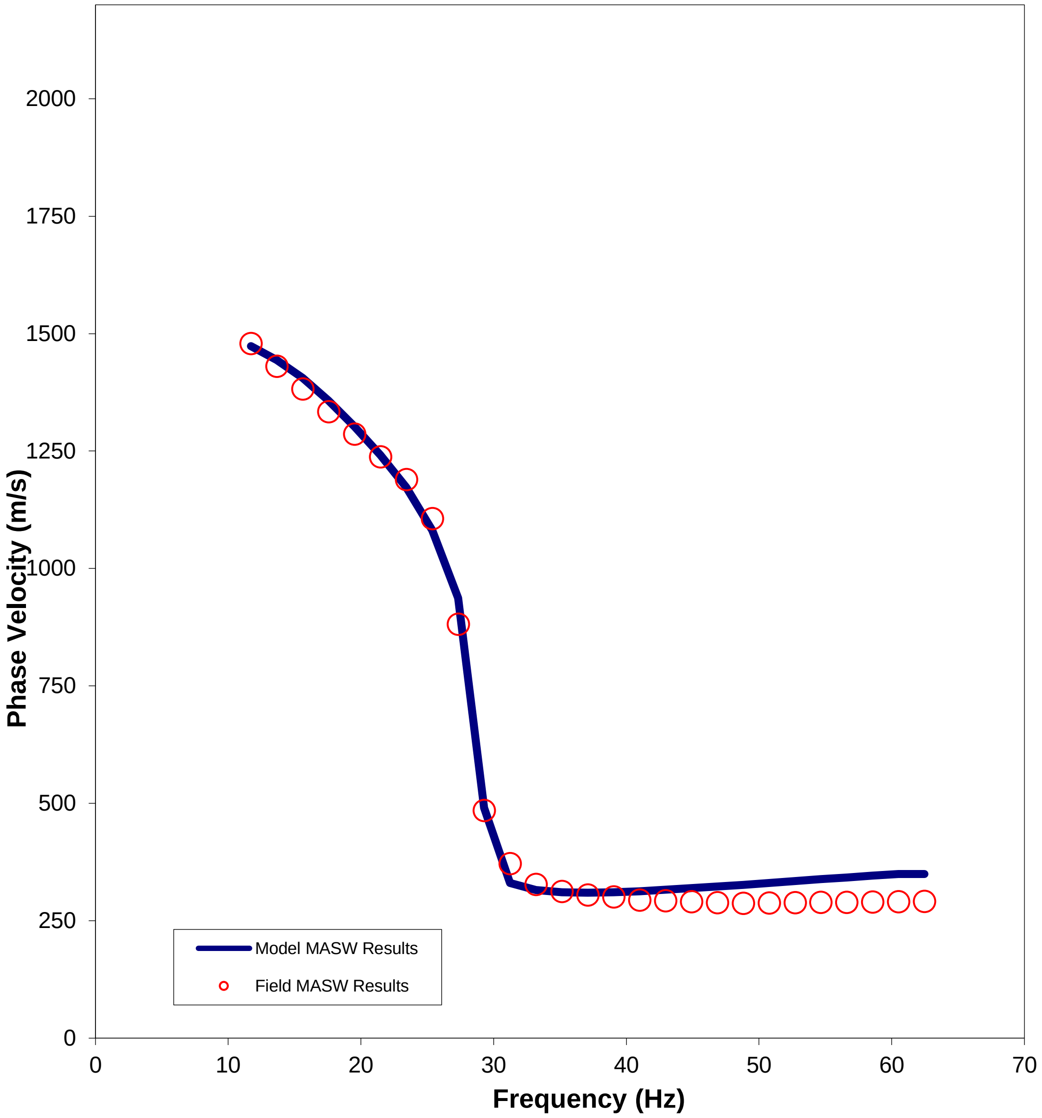


Figure 5: Comparison of Field (red dots) vs. Modelled Data (blue line) along the MASW Line

To calculate the average shear-wave velocity as required by the NBCC 2015, the results were modelled to 30 metres below ground surface. The average shear-wave velocity along the MASW line was found to be 877 m/s (Table 1). The NBCC 2015 requires special site specific evaluation if certain soil types are encountered on the site, so the site classification stated here should be reviewed, and modified if necessary, according to borehole stratigraphy, standard penetration resistance results, and undrained shear strength measurements, if available for this site.

Table 1: Shear-Wave Velocity Profile along the MASW line

Model Layer (mbgs)		Layer Thickness (m)	Shear Wave Velocity (m/s)	Shear Wave Travel Time Through Layer (s)
Top	Bottom			
0.00	1.07	1.07	250	0.004286
1.07	2.31	1.24	250	0.004945
2.31	3.71	1.40	312	0.004495
3.71	5.27	1.57	574	0.002728
5.27	7.01	1.73	872	0.001986
7.01	8.90	1.90	926	0.002047
8.90	10.96	2.06	1313	0.001569
10.96	13.19	2.23	1269	0.001753
13.19	15.58	2.39	1480	0.001615
15.58	18.13	2.55	1548	0.001650
18.13	20.85	2.72	1588	0.001712
20.85	23.74	2.88	1633	0.001766
23.74	26.79	3.05	1684	0.001811
26.79	30.00	3.21	1725	0.001864
			Vs Average to 30 mbgs (m/s)	**877**

Limitations

This technical memorandum is based on data and information collected by Golder Associates Ltd. and is based solely on the conditions of the properties at the time of the work, supplemented by historical information and data obtained by Golder Associates Ltd. as described in this memo.

Golder Associates Ltd. has relied in good faith on all information provided and does not accept responsibility for any deficiency, misstatements, or inaccuracies contained in the reports as a result of omissions, misinterpretation, or fraudulent acts of the persons contacted or errors or omissions in the reviewed documentation.

The services performed, as described in this memo, were conducted in a manner consistent with that level of care and skill normally exercised by other members of the engineering and science professions currently practicing under similar conditions, subject to the time limits and financial and physical constraints applicable to the services.

Any use which a third party makes of this memo, or any reliance on, or decisions to be made based on it, are the responsibilities of such third parties. Golder Associates Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this memo.

The findings and conclusions of this memo are valid only as of the date of this memo. If new information is discovered in future work, including excavations, borings, or other studies, Golder Associates Ltd. should be requested to re-evaluate the conclusions of this memo, and to provide amendments as required.

Closure

We trust that this technical memorandum meets your needs at the present time. If you have any questions or require clarification, please contact the undersigned at your convenience.

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