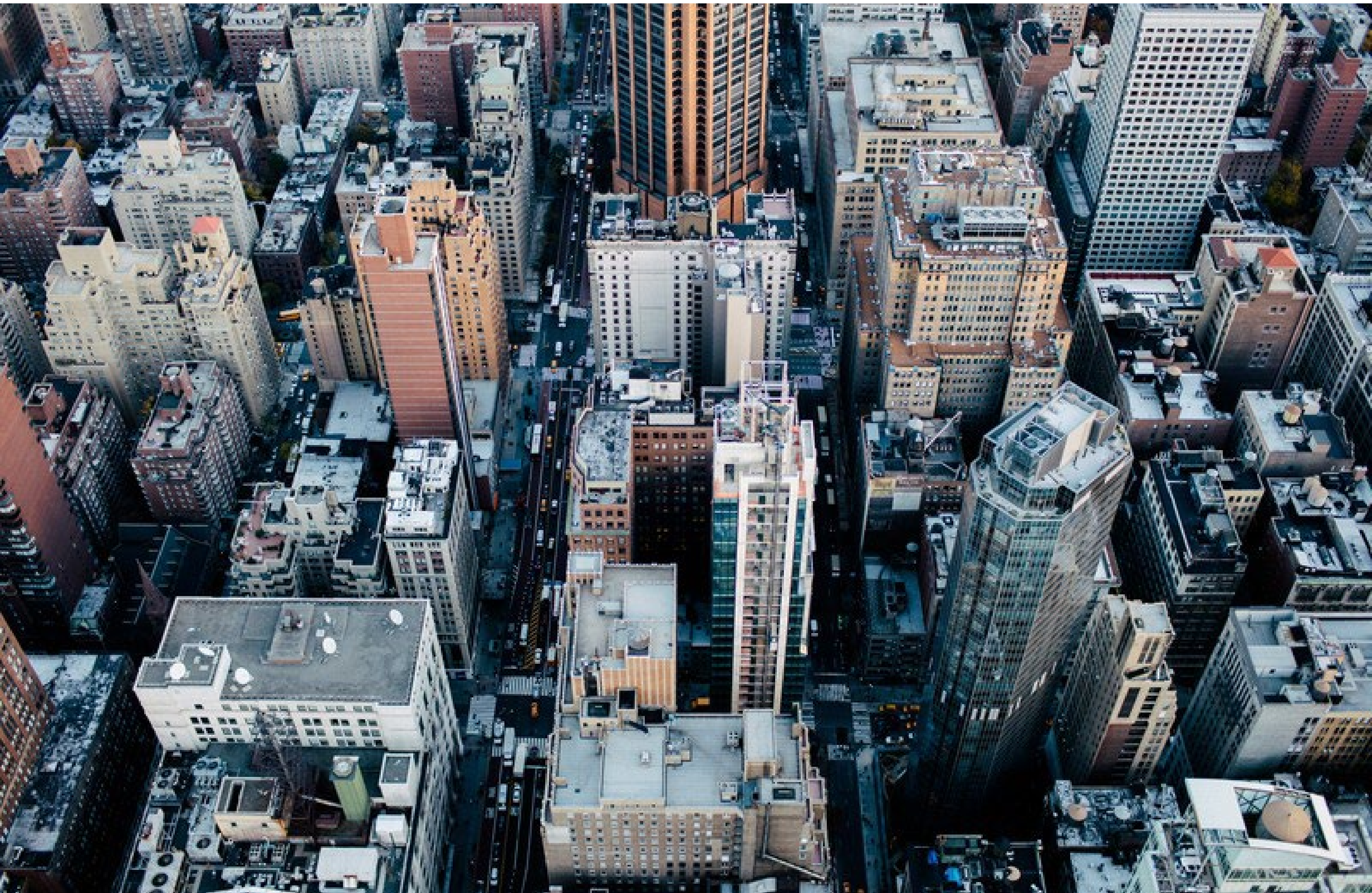
Geotechnical Investigation

Proposed Mixed Use Condominium Development - 1012 Yonge Street, Barrie, Ontario

Crown Barrie Developments Inc.

9 February 2022

→ **The Power of Commitment**



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1. Introduction

GHD Limited (GHD) has been retained by Crown Barrie Developments Inc. to undertake a geotechnical investigation in support of the proposed mix use condominium development at the property located at 1012 Yonge Street, in Barrie, Ontario (Site). A site location plan is provided in the attached **Figure 1.**

The subject property is located on the west side of Yonge Street, north of Lockhart Road in the City of Barrie. The existing site is currently occupied by an orchard and an associated farmhouse and barn structures within the future development area. The surrounding areas of the proposed development consist of agricultural land to the north, west and south, with the Yonge Street right of way forming the east boundary. The property has approximately 152 m of frontage along Yonge Street. The property is 4.94 hectares (ha) in gross area, with net development area of 4.76 ha due to the road widening and new right of way.

It is our understanding that the proposed development at the site will consist of the construction of a three to nine storey building with one level of underground parking to an approximate depth ranging from 5.2 to 6.7 metres below ground surface (mBGS) with the area surrounding the buildings to be covered with paved driveways, parking and landscaping.

The objective of the geotechnical investigation was to assess the subsurface soil and groundwater conditions within the area of the proposed development and to determine the ground suitability to support the proposed development. The geotechnical investigation was conducted by means of a limited number of boreholes and laboratory tests of select representative soil samples.

At the time of conducting this field investigation, final building layout plans were not provided to GHD and this report should be considered preliminary in nature. Based on the available final building layout plans, a detailed geotechnical investigation consisting of additional boreholes may be required.

The data and their interpretation presented in this report may not be sufficient to assess all of the factors that may have an effect upon the construction. Prospective contractors, therefore, should evaluate the factual information, obtain additional subsurface data as they might deem necessary and select their construction methods, sequencing and equipment based on their own experience on similar projects.

On-going liaison with GHD during the final design and construction phase of the project is recommended to ensure that the recommendations in this report are applicable and/or correctly interpreted and implemented.

The recommendations and opinions in this report are applicable only to the proposed development as described above and the Limitations of the Investigation found in Section 6 is an integral part of this report.

2. Background Information

A previous geotechnical investigation was completed by Soil Engineers Ltd. in February 2021 and a copy of the geotechnical investigation report was provided to GHD by Crown Barrie Developments Inc. (Crown) for review and comments. The investigation included the advancement of seven boreholes (denoted as Borehole 1 to Borehole 7) to a maximum depth of 9.3 m below ground surface (mBGS). Four monitoring wells (BH1, BH2, BH4, and BH5) were installed to depths ranging from 6.0 to 7.6 mBGS. BH1 has been dry for 2 of the 4 monitoring events and BH2 has been consistently dry.

In general, the ground stratigraphy at the Site, as described in that report, consisted of surficial topsoil underlain by native sandy silt till and sand deposits that extended to the termination depths of the boreholes. A concurrent hydrogeological investigation utilizing the four monitoring wells was also completed by another consultant, also dated February 2021.

A review of the available geotechnical and hydrogeological reports, suggests the previous investigations were insufficient for final design due to following reasons:

- The wells installed appear to be too shallow and the water level in BH1 may not be representative of the water table. BH1 and BH2 should be replaced with wells installed to 9.3 mBGS to ensure representative water levels and water quality samples should be collected. Also, a single well response test should be completed at these locations to confirm hydraulic conductivity values and water taking estimates.
- The geotechnical investigation should extend to such depths so that the soils within the zone of influence can be adequately assessed. The borehole depth for the previous geotechnical investigation is considered insufficient for the proposed development i.e., 3 to 9 storey building with one level of underground parking.
- This requires extending some of the boreholes for the proposed development to a deeper depth of 15 mBGS to ensure that soft/loose soils are not present within the foundations influence zones of the proposed buildings.

3. Field and Laboratory Work Procedures

Due to the above-mentioned reasons an additional geotechnical investigation consisting of the following scope of fieldwork was carried out. The current geotechnical investigation was conducted in accordance with the approved GHD work plan dated March 23, 2021, and continued discussion with the Client. A borehole location plan is provided in the attached **Figure 2**.

The fieldwork included the following key tasks:

- Advancement of five (5) boreholes within the area of the proposed buildings to an approximate depth of 16.0 mBGS.
- Instrumentation of four (4) drilled boreholes with a 50 mm diameter monitoring wells to determine the stabilized groundwater level.
- In-situ field testing and collection of soil samples for geotechnical laboratory testing.
- Collection of two (2) select soil samples for corrosivity analysis.
- Completion of one (1) round of water level readings approximately one (1) week following the installation of monitoring wells to obtain a stabilized water level across the site.

The field investigation protocols and methodologies are presented below:

3.1 Health & Safety Plan

Upon project initiation, a Site-specific Health and Safety Plan (HASP) was prepared in accordance with the requirements of the Occupational Health and Safety Act for implementation during the field investigation program. The HASP presents the visually observed Site conditions to identify potential physical hazards to field personnel. Required personal protective equipment was also listed in the HASP. It is mandatory for all GHD personnel involved in the field program, to read the HASP and have a copy of the HASP available at the Site during the investigative work. Health and Safety requirements in the HASP were implemented during the field investigation program and the HASP was maintained on the Site during all field activities. In addition to HASP, all field personnel also adhered to the COVID-19 protocols which require that all staff maintain a 2-metre separation distance.

3.2 Borehole Location Clearance

Prior to initiating the subsurface investigation activities, all applicable utility companies (gas, bell, cable, fiber, hydro, water and wastewater) were contacted through Ontario One-Call to demarcate the location of their respective underground utilities to ensure the lines are not damaged during the investigation work. In addition, a private utility locator (Landshark Group) was retained to demarcate the location of the privately owned utilities within the area of the boreholes to ensure that the private utilities are not damaged during the investigation work.

GHD also carried out a precondition survey to document the current condition of the ground surface at and in the vicinity of the boreholes and also along the proposed travel pathway of the drilling equipment in order to establish a baseline condition prior to the fieldwork. The precondition survey consisted of a visual, walk-through inspection of the Site and documentation using photographs.

3.3 Exploration and Testing Procedures

The drilling program for this geotechnical investigation was carried out between July 6th and July 14th, 2021 and involved the drilling of five (5) boreholes at the site. All five (5) boreholes were terminated at an approximate depth ranging from 15.5 to 15.8 m BGS. To measure the long-term ground water elevations, boreholes MW1-21, MW2-21, MW4-21, and MW5-21 were instrumented with 50 mm monitoring wells upon completion.

A summary of the borehole identification, survey information and the depth of each borehole is presented in the table below.

Table 3.1 Summary of Advanced Boreholes

Borehole Identification	Location – UTM Coordinate System		Ground Elevation (mAMSL)	Total Depth (mBGS) / Elevation	Well Depth (mBGS)
	Northing	Easting			
MW1-21	4910545.39	609712.088	268.23	15.85 / 252.38	10.67
MW2-21	4910481.407	609652.447	268.24	15.85 / 252.39	10.37
BH3-21	4910514.329	609567.975	270.66	15.64 / 255.02	N/A
MW4-21	4910426.121	609478.918	270.91	15.49 / 255.42	10.67
MW5-21	4910490.177	609448.749	271.10	15.85 / 255.24	10.67

Notes:
mBGS: meters below ground surface
mAMSL: meters above mean sea level

The drilling work was carried out utilizing a track-mounted drill rig (B57) supplied and operated by Landshark Drilling under the full-time supervision of GHD technical representative. The locations of the drilled boreholes are shown on **Figure 2**.

All the boreholes were advanced using solid / hollow stem augers. Soil samples were generally collected every 0.75 m intervals to 6.0 m BGS and at 1.5 m intervals thereafter to the termination depth of the boreholes. All sampling was conducted using a 50 mm outside diameter split spoon sampler in general accordance with the specifications of the Standard Penetration Test Method (ASTM D1587-8). In addition, at each borehole location the relative density or consistency of the subsurface soil layers were measured using the Standard Penetration Test (SPT) method, by counting the number of blows ('N') required to drive a conventional split-barrel soil sampler 0.3 m depth. Soil samples were retrieved from each borehole location to verify strata boundaries and soil properties.

The GHD technical representative logged the material encountered in the boreholes and examined the samples as they were obtained. The recovered samples were sealed in clean, airtight containers and transferred to the GHD laboratory, where they were reviewed by a senior geotechnical engineer. The detailed results of the individual boreholes are recorded on the accompanying borehole logs presented in **Appendix A.**

Upon completion of the field work, the drilled boreholes that did not contain monitoring wells were backfilled and sealed in accordance with Ontario Regulation 903. Excess soil cuttings were distributed evenly on the ground surface in the area of the borehole locations.

Ground level elevations as well as subsurface stratigraphy and the groundwater levels at the borehole locations are based on geodetic measurements and GPS coordinates are based on UTM-17, NAD 83. Measured ground elevations are noted for each borehole stratigraphic log presented in **Appendix A.**

3.4 Geotechnical Laboratory Testing

Prior to conducting geotechnical laboratory testing, the soil samples extracted from the Site were subjected to tactile examination by an experienced GHD geotechnical engineer who confirmed the field descriptions and selected representative samples for detailed testing.

Geotechnical laboratory testing included moisture content determination on all recovered soil samples. The results of water content tests on the extracted soil samples are reported at the corresponding depths in the log of the drilled boreholes presented in **Appendix A.**

In addition, particle size distribution tests (gradation analysis), using sieve analysis (ASTM D6913) and hydrometer testing (ASTM D422), were completed on twelve (12) select soil samples from the boreholes. Atterberg index testing was also completed on two (2) of the soil samples selected for gradation analysis. The geotechnical laboratory testing was conducted in accordance with ASTM Standards.

The results of moisture content determination tests are recorded on the related borehole logs at the corresponding depths. The results of the grain size analyses, and Atterberg Limits are provided in **Appendix B-1 and B-2**. The collected soil samples were classified/described in general accordance with the ASTM D2487 - Standard Practice for Classification of Soils for engineering purposes (Unified Soil Classification System-USCS).

4. Subsurface Conditions

4.1 Stratigraphy

The subsurface conditions encountered at the Site are summarized below and are also presented on the accompanying borehole logs in **Appendix A**. It should be noted that the subsurface conditions are confirmed at the borehole locations only and may vary at other locations. The boundaries between the various strata as shown on the borehole log are generally based on non-continuous sampling. These boundaries represent an inferred transition between the various strata, rather than a precise plane of geological change.

The stratigraphy at the borehole locations generally consists of topsoil underlain by fill of varying thickness followed by native deposits of silty sand to sandy silt to silt with sand, except at Borehole MW5-21 location, where fill material was underlain by native silty clay. This native silty clay deposit was followed by native deposits of silty sand trace clay trace to some gravel.

A brief description of the major soil stratum encountered at the Site is summarized below:

4.1.1 Topsoil

Topsoil approximately 200 to 350 mm thick was encountered at the ground surface in all the boreholes. Topsoil was underlaid by fill material consisting sandy silt to silty sand trace clay to sand some silt.

4.1.2 Fill Material

Underlying the topsoil in all boreholes, fill material consisting of sandy silt to silty sand trace clay to sand some silt with trace to some rootlets was encountered which extended to an approximate depth of 0.76 to 2.3 m BGS. Fill materials were generally underlain by native non-cohesive soil deposits consisting of silty sand to sandy silt to sand some silt except in Borehole MW5-21, where a layer of native cohesive clay with silt was encountered below the fill material. A summary of the fill depth and elevation are provided in the table below:

Table 4.1 Depth of Fill material

Borehole	Ground Surface Elev.	Depth of Fill material (m)	Bottom of Fill Elevation (mAMSL)
MW1-21	268.23	2.29	265.94
MW2-21	268.24	1.52	266.72
BH3-21	270.66	0.76	269.90
MW4-21	270.91	1.52	269.39
MW5-21	271.09	1.52	269.57

Note: Fill material was encountered below the topsoil

SPT ‘N’ values within the fill material generally ranged from 2 to 5 blows per 300 mm penetration of the split spoon sampler indicating the fill material to be in a very loose to loose condition.

The moisture content values of the fill varied between 4 and 34 percent by weight, associated with a moist to wet condition. The relatively wide range of water content values are indicative of variable organic content within the fill layer.

4.1.3 Native Silty Sand, Sand, Sandy Silt, Silt

Below the fill material, native deposits of non cohesive soils consisting of silty sand to sand to sandy silt to silt trace to some sand trace clay were encountered in all the boreholes except in borehole MW5-21. In Borehole MW5-21, native cohesive soil consisting of silty clay trace sand was encountered below the fill material underlain by native sandy soil deposits. These native non cohesive soil deposits extended to the termination depth of all the boreholes. For a detailed description of encountered subsoil conditions, please refer to the Borehole logs as provided in **Appendix A** of this report.

In general SPT ‘N’ values within the non cohesive soil deposits generally ranged from 30 to more than 50 bows per 300 mm penetration of split spoon sampler indicating soil to be in dense to very dense condition. However, lower SPT N values in the range of 10 to 15 blows per 300 mm penetration of split spoon sampler indicating the soil to be loose to compact conditions were encountered at depths ranging from 9 to 12.2 mbgs (i.e., at approximate elevations of 258.46 to 259.91mAMSL (metre above mean sea level)

Moisture contents of samples extracted from the native non cohesive soil deposits were measured in the laboratory and the calculated moisture contents ranged from 2 to 26 percent by weight, associated with a moist to wet condition.

Gradation analysis (sieve and hydrometer testing) was conducted on eleven (11) select representative samples of the native soil deposit. The obtained results are reported in the respective borehole logs and are tabulated in the following table. The gradation analysis curves are presented in **Appendix B-1.**

Table 4.2 Particle Size Distribution Analyses

Borehole	Sample ID	Sample Depth (m)	Particle Size Distribution (ASTM D422, and ASTM D421)				Soil Description
			Gravel %	Sand %	Silt %	Clay %	
MW1-21	SS4	2.3 – 3.0	22	63	13	2	Silty sand with gravel (SM)
MW1-21	SS9	6.1 – 6.7	0	91	9	0	Poorly graded sand with silt (SP-SM)
MW1-21	SS13	12.2 – 12.8	0	24	73	3	Silt with sand (ML)
MW2-21	SS7	4.6 – 5.2	0	39	58	3	Sandy silt (ML)
MW2-21	SS12	10.6 – 11.3	0	61	35	4	Silty sand (SM)
BH3-21	SS5	3.0 – 3.6	0	26	59	15	Silt with sand (ML)

Borehole	Sample ID	Sample Depth (m)	Particle Size Distribution (ASTM D422, and ASTM D421)				Soil Description
			Gravel %	Sand %	Silt %	Clay %	
BH3-21	SS10	7.6 – 8.2	1	90	6	3	Well graded sand with silt (SW-SM)
BH3-21	SS13	12.2 – 12.8	1	92	5	2	Poorly graded sand with silt (SP-SM)
MW4-21	SS3	1.5 – 2.1	22	52	17	9	Silty sand with gravel (SM)
MW4-21	SS9	6.1 – 6.7	4	25	63	8	Silt with sand (ML)
MW5-21	SS10	10.6 – 11.3	0	91	7	2	Poorly graded sand with silt (SP-SM)

Atterberg limits test was also performed on one of the samples (i.e., BH3-21, SS5) due to the relatively elevated clay content and the results are presented in the following table and are also presented in **Appendix B-2.**

Table 4.3 Atterberg Limits Test Results

Borehole	Sample ID	Sample Depth (m)	Natural Moisture Content (ASTM D2216) (%)	Atterberg Limits (ASTM D4318)			Soil Description
				LL	PL	PI	
BH3-21	SS5	3.0 – 3.6	8	-	-	NP	Non-Plastic

Notes:
LL : liquid limit
PL : plastic limit
PI : plasticity index

Based on the Atterberg Limits test result, the native soil deposits encountered in BH3-21 was a non plastic soil.

4.1.4 Native Lean Clay

Below the fill material in borehole MW5-21, a layer of native soil consisting of silty clay (Lean Clay) trace sand was encountered extending to an approximate depth of 2.3 m BGS. This native clayey soil was underlain by silty sand trace gravel deposits.

SPT ‘N’ value within the clay with silt deposit was 6 blows per 300 mm penetration of split spoon sampler indicating a firm soil consistency.

Moisture content for the sample extracted from the native clay with silt soil layer was measured in the laboratory and the calculated moisture content was 30 percent by weight, associated with a very moist condition.

Gradation analysis (sieve and hydrometer testing) was also conducted on a selected representative sample of this native soil layer. The obtained result is reported in the respective borehole log and also tabulated in the following table. The gradation analysis curve is presented in **Appendix B-1.**

Table 4.4 Particle Size Distribution Analyses

Borehole	Sample ID	Sample Depth (m)	Particle Size Distribution (ASTM D422, and ASTM D421)				Soil Description
			Gravel %	Sand %	Silt %	Clay %	
MW5-21	SS3	1.5 – 2.1	0	10	32	58	Lean Clay (CL)

Atterberg limits test was also performed on the same soil sample selected for grain size analysis. The result of this test is presented in the following table and also presented in **Appendix B-2.**

Table 4.5 Atterberg Limits Test Results

Borehole	Sample ID	Sample Depth (m)	Natural Moisture Content (ASTM D2216) (%)	Atterberg Limits (ASTM D4318)			Soil Description
				LL	PL	PI	
MW5-21	SS3	1.5 – 2.1	30	49	22	27	Lean Clay (CL)

Notes:
LL : liquid limit
PL : plastic limit
PI : plasticity index

Based on the Atterberg Limits test and the Gradation Analyses result, the native soil deposit encountered in MW5-21 at 1.52 m to 2.29 m bgs can be classified as Lean Clay (CL).

4.2 Groundwater Conditions

Details of the measured water levels in the open boreholes at the completion of drilling are presented on the borehole records in **Appendix A.** Where monitoring wells were installed, the observed conditions are also reflected in the borehole records presented in **Appendix A**. A round of water level measurements was conducted in the installed monitoring wells on August 18, 2021, approximately 1 week following drilling. The observed/inferred groundwater levels at the borehole locations during the site investigation, as well as the groundwater levels recorded in the monitoring wells during the follow up visit are tabulated below:

Table 4.6 Summary of Groundwater Readings

Borehole / Well ID	Elevation	Borehole Completion / Well Installation Date	Well Depth (m)	Groundwater Level Depth (mbgs) / Elevation	
				Upon Completion of Borehole / Installation of Well	August 18, 2021
MW1-21	268.23	July 14, 2021	10.67	4.30	4.40
MW2-21	268.24	July 11, 2021	10.37	4.60	4.20
BH3-21	270.66	July 9, 2021	No monitoring well was installed	4.12	N/A
MW4-21	270.91	July 8, 2021	10.67	3.05	6.60
MW5-21	271.09	July 6, 2021		6.40	6.88

It should be noted that the groundwater level in the area is subject to seasonal fluctuations and precipitation events and should be expected to be higher during wet periods of the year. Perched water table condition could develop in the shallower soils after heavy precipitation and/or during spring thaw.

5. Engineering Discussion and Recommendations

Based on the scope of work as mentioned in the GHD proposal Reference No. 11177797 dated March 23, 2021, it is our understanding that the proposed development at the site will consist of constructing a three to nine storey building with one level of underground parking to 5.2 to 6.7 mBGS with the area surrounding the buildings to be covered with paved driveways, parking, and landscaping.

At the time of conducting this field investigation, final building layout plans and information related to proposed development activities such as finished floor elevations and footing / slab loading conditions were not provided to GHD so this report should be considered preliminary in nature.

It is to be noted that the information herein is intended to provide general guidance for the detailed design stage and construction phases. Discussions pertaining to construction methods or considerations are provided to highlight aspects of the proposed development that may have a bearing on design.

The following sections provide comments and recommendations for the proposed development as well as other geotechnical related design and construction issues.

5.1 Site Preparation and Grading

Based on the conditions encountered in the boreholes, the Site was underlain by topsoil followed by fill material consisting of non cohesive sandy silty soils trace clay with trace to some rootlets. In few of the boreholes, organic material other than the rootlets was also encountered in the fill material. The fill material was underlain by native soils generally consisting of silty sand to sandy silt to silt except at MW5-21 location, where native silty clay layer was encountered below the fill material. This native clay soil layer was underlain by native silty sand.

At the time of fieldwork, the Site was generally flat, sloping gently towards the northeast with the highest measured elevation of 271.09 at MW5-21 and lowest elevation of 268.23 at MW1-21. The Site was generally covered with an orchard with occasional clusters of heavy mature vegetation. As a result, Site grading activities will likely include removal of the surficial vegetative cover and some cut and fill. The fill materials were found to contain rootlets and organic material. These fill materials containing organics as well as any organics if found in the native soils should be removed from the footprint of the proposed building and pavement areas prior to site grading activities and should not be used as backfill.

Earth fill materials found to be generally free of topsoil and /or organics can remain in place provided the material is reviewed and approved by the Engineer as described below. The subgrade soils exposed after the removal of the unsuitable fill material and unsuitable reworked native soils containing organics will consist of competent native silty sand to sandy silt to sandy silt soils.

Prior to Site grading activity and earth filling, the exposed subgrade soils should be visually inspected, compacted, and proof rolled using large axially loaded equipment. Any soft, organic, or unacceptable areas should be removed as directed by the Engineer and replaced with suitable fill materials compacted to a minimum of 98 percent Standard Proctor Maximum Dry Density (SPMDD). Clean earth fill used to raise grades in the proposed building and pavement areas should be placed in thin layers (200 mm thick or less) and compacted by a heavy sheep-foot type roller to 98 percent SPMDD. The native soil, free of topsoil/organic and rootlets, encountered at the Site are generally suitable for reuse as backfill to raise site grades, where required, or to be used to backfill against foundation walls or as trench backfill during installation of buried services, provided they are free of organic material, and are within the optimum moisture content.

If imported materials are required to raise Site grades to design levels, then potential source Sites should be evaluated for geotechnical and environmental quality prior to acceptance. It is recommended that any proposed fill considered for reuse on the Site comprise of clean earth material, free of topsoil and building rubble, and is at a moisture content ±2% of the laboratory optimum for compaction.

5.2 Foundations

Based on the information as provided in GHD proposal as well as the discussions with the client, it is our understanding that the proposed three to nine storey buildings will be constructed with one level of underground parking up to 5.2 to 6.7 m BGS. As per the soil stratigraphy as observed at the borehole locations, the following foundation options can be adopted for the proposed construction.

5.2.1 Foundation Design – Shallow Foundation

Footings on Native Soil

The common practice for the Serviceability Limit State (SLS) design of most structure and building foundations is to limit the total and differential foundation settlements to 25 mm and 19 mm, respectively. Other serviceability criteria for the proposed buildings may be determined by the structural engineer considering tolerable settlement that would not restrict the use or operation of the facilities. Spread and strip footings placed below any existing earth fill or reworked / disturbed native soils on the underlying undisturbed native sandy silt to silty sand soils may be considered suitable to support the proposed building. At the time of preparation of this report the exact building orientation as well as the location of the proposed buildings was not known.

As per the information provided by the client, it is our understanding that the depth of the proposed floor slab for one level of underground parking will be in the range of 5.2 to 6.7 mBGS. Based on the geotechnical findings obtained from borehole locations advanced at the site the spread footings (3 x 3 m in size or less) placed at the minimum founding depth as shown in the table below can be designed for a Serviceability Limit State (SLS) of 200 kPa and a factored Ultimate Limit State (ULS) of 300 kPa (subject to on site verification during construction).

Table 5.1 Recommended Footing Depths and Soil Bearing Capacities

Borehole	Minimum Founding Depth Below Existing Grade (m)	Elevation	Bearing Capacity at Serviceability Limit State (kPa)	Bearing Capacity at Factored Ultimate Limit State (kPa)	Founding Soil
MW1-21	5.2	263.03	200	300	Native Sandy Silt to Silty Sand
MW2-21		263.04			
BH3-21		265.46			
MW4-21		265.71			
MW5-21		265.89			

The perimeter foundations and those foundations within unheated areas should be protected from frost effects by at least 1.5 m of earth cover according to OPSD 3090.101 or equivalent insulation.

In this report, geotechnical parameters for Ultimate Limit State (ULS) and Serviceability Limit State (SLS) conditions have been provided for conventional footings of size not exceeding 3.0 m in dimension.

Adjacent footings at different elevations should be stepped at a slope not steeper than ten (10) Horizontal to seven (7) Vertical. As well, footings close to underground services should be set back from services. It is also recommended that the lowest footing be constructed first in order to avoid undermining the footings at higher elevations.

Footings on Engineered Fill

In case if the Site grades are to be raised, engineered fill could be considered to support structures foundations. A maximum geotechnical bearing pressure of 225 kPa at ULS and 150 kPa at SLS could be considered for footings placed on engineered fill.

The following placement procedure is recommended.

- Engineered fill should be placed after stripping the ground surface cover (topsoil if encountered) and the earth fill materials found to contain significant amounts of topsoil/organics or rootlets from the footprint of the proposed building area as described in Section 4.1. The sub-excavation should laterally extend at least 2 m beyond the perimeter of the footprint of the proposed structure.

- The area to receive the engineered fill should be inspected, compacted, and approved by the geotechnical engineer. Spongy, wet or soft/loose spots should be sub-excavated to expose stable subgrade and replaced with competent approved soil, compatible with subgrade conditions, as directed by the geotechnical engineer.
- The fill soil must be a uniform, homogeneous material, and should be placed in thin layers not exceeding approximately 200 mm when loose. Oversize particles (cobbles and boulders) larger than 120 mm should be discarded. The material for backfilling the excavation and raising the grades should consist of approved earth fill materials. For engineered fill below foundations, each fill layer should be uniformly compacted with heavy compactors, suitable for the type of fill used, to at least 98% percent of its Standard Proctor Maximum Dry Density. The engineered fill should be placed at water contents ± 2% of the optimum value for maximum compaction.
- Full-time geotechnical inspection and quality control (by means of frequent field density and laboratory testing) are necessary for the construction of a certifiable engineered fill pad. The compaction procedure and efficiency should be controlled by the geotechnical engineer.

The engineered fill should not be placed during winter months when freezing ambient temperatures occur persistently or intermittently

5.2.2 Foundation Design – Raft Foundations

Based on the geotechnical findings obtained from borehole locations advanced at the site the Raft foundation (approximately 25 x 75 m in size) placed at the minimum founding depth of 5.2 mBGS can be designed for a Serviceability Limit State (SLS) of 130 kPa (subject to on site verification during construction to limit the total settlement to 50 mm.

Where required, a raft/mat foundation (concrete pad/structural slab) can be considered to support the proposed structures. The structural slab (mat/raft) should be installed on native ground or as an alternative, the mat could be established on engineered fill constructed to raise grades on native ground.

For the design of a raft foundation placed on native deposit, the modulus of vertical subgrade reaction can be taken as k_v = 30 MPa/m when the structural slab is installed on native silty sand / sandy silt soils. For the design of a rectangular mat foundation of width "B" (m), the modulus of subgrade reaction (k_{vb}) can be calculated using one of the following equations:

$K_{vb} = k_v/B\ [(m + 0.15)/1.5m]$ for fine grained silty clay soil

$K_{vb} = k_v\ [(B + 0.3)/2B]^2$ for granular soil

where;

k_{vb}= modulus of subgrade reaction for actual footing dimension B
k_v= modulus of subgrade reaction (for a 0.3m x 0.3m square plate)
B= width of the raft (m)
L= length of raft (m)
m= L/B

The modulus of subgrade reaction will be used by the structural engineer to model the deformation and stiffness response of the raft on soil to assess the suitability of this foundation option. The ultimate limit state ULS value generally does not govern the design of raft / mat foundations.

The exposed foundation grade on which the proposed structure will be supported should be inspected and approved by a geotechnical engineer prior to the construction of the mat foundation.

In consideration of the proposed design elevation of the mat foundation at an approximate elevation of 263.0 mAMSL (metre above mean sea level) it is anticipated that the water level will be at an approximate elevation of 264.0 mAMSL (i.e., one metre above the underside of mat foundation). Therefore, the slab design should consider hydrostatic uplift pressures. For details regarding the long-term groundwater management, refer to the Hydrogeological report which is provided as a separate cover.

5.2.3 Foundation Design – Deep Foundations

Alternatively, deep foundations such as caissons may be used if higher bearing capacities are required. However, based on the ground water levels encountered in the monitoring wells installed at the Site, there is a high potential for groundwater seepage and sloughing conditions during caisson installation. If conventional bored piles are used, casing should be provided during pile construction to provide sidewall stability and seal off zones where soil sloughs may occur. A mud slurry within the liner will be required in case water seepage is encountered to provide basal stability during caisson advancement. The level of slurry in the excavation shall be sufficient to prevent the intrusion of water and to maintain a stable wall with no cave-in, sloughing, or basal heave. Alternatively, a dewatering system could be used instead of mud drilling to maintain the water level 1 m below the invert elevation of the proposed caisson such that no disturbance to the base founding material occurs.

If mud / slurry drilling is employed, then tremie or pumped concrete will need to be employed to construct the caisson. The tremie or pumping operation shall be a continuous flow of concrete that prevents the inflow of water or slurry. Where tremie is placed under slurry, the caisson shall be filled with concrete entirely by tremie and the method of deposition shall not be changed part way up the caisson. During withdrawal, the bottom of the liner shall have a minimum embedment into the concrete being placed and a sufficient head of concrete shall be maintained above the bottom of the liner at all times to prevent intrusion of soil and water into the hole.

OPSS 903 standard for the construction of deep foundation provides details for caisson installation and the use of liners and mud slurry to prevent sloughing and basal instability. Section 903.07.03.02 titled "Excavation" presents a description of the method of augering and the use of liners and slurry to provide excavation and basal stability and section 903.07.03.07.03 titled "Concrete Placed Under Water or Under Slurry" describes the method of concrete placement and Section 903.07.03.07.04 titled "Withdrawal of Liners" describes the procedure for the liner withdrawl.

The pile contractor should make his own estimate of temporary casing requirements, considering such factors as construction procedures and bore diameters. Bell piles are not recommended due to presence of sloughing soil at the pile base (i.e., wet sand). There may be occasional presence of cobbles and boulders within the native deposits and it should be recognised in the contract specifications by contractors bidding on this work.

The diameter of caissons should be at least 760 mm to allow safe passage for the cleaning and inspection of the base of each caisson prior to pouring concrete. At the time of geotechnical investigation, cobbles or boulders were not encountered in any of the boreholes, however, there may be a possibility that cobbles and boulders could be encountered at locations between boreholes and the contractor should be advised to follow proper construction methodology if encountered. The concrete for the bored piles should be placed immediately after drilling.

Where drilled caissons are founded within the overburden soils (competent sandy silt / silty sand materials), the caissons may be designed using the following relationships with SPT values (suggested by Decourt 1995):

$$q_{su} = \grave{\alpha} \times (2.8\ N' + 10)\ (\text{kPa})$$
$$q_{tu} = K_b \times N_b\ (\text{kPa})$$

where:

qsu = ultimate shaft resistance

qtu = ultimate toe resistance

$\grave{\alpha}$ = 1 for displacement piles in any soil and non-displacement piles in clays, and 0.5 to 0.6 for non-displacement piles in granular soils

N' = average SPT index along the pile shaft

Nb = average SPT index in the vicinity of the pile toe

Kb = is a base factor given in the table below:

Kb Base Factor Values based on Soil Type and Pile Type

Table 5.2

Soil Type	Displacement piles	Non-Displacement Piles
Sand	325	165
Sandy silt	205	115
Clayey silt	165	100
Clay	100	80

To develop full toe resistances, the piles should penetrate the bearing stratum a minimum three times the pile diameter. The minimum required diameter of the augured footings is 760 mm to allow for adequate access and cleaning prior to placing concrete.

The factored ULS would then be obtained by multiplying the ultimate capacity by the geotechnical resistance factor of 0.3 for both uplift and compression as recommended in the CFEM.

It is recommended that full-time geotechnical monitoring be provided during the installation of the bored piles so that an accurate record of drilled shaft sizes, alignment, locations, lengths, cut-off elevations, and installation procedures can be kept.

Sampling and testing of concrete compressive strength cylinders to the requirements of CSA A23.1 and A23.2 is recommended. At least one set of concrete cylinders should be taken for each day caissons are poured. The tops of the bored piles should be protected against cold weather in accordance with the requirements of CSA A23.1.

Bored pile construction must be carried out in conformance with Ontario Occupational Health and Safety Act and Regulations for Construction projects, O.Reg. 213/91, s. 243 to 247.

5.3 Basement Slab and Foundation Walls

The basement walls should be designed to resist the lateral earth pressure. For calculating the lateral earth pressure, the at rest coefficient of earth pressure (K_0) as provided in Section 5.9 for sandy silty / silty sand soils may be used. Where the groundwater table is not lowered below the footing founding depth, the hydrostatic pressures must be considered in addition to earth pressure. The bulk unit weight of the retained backfill may be taken 22kN/m^3 for well compacted soil. An appropriate factor of safety should be employed.

It is our understanding that the basement slab will be approximately 6.1 m BGS and based on the groundwater level readings taken in the monitoring wells the water table is expected to be encountered at an approximate depth of 4 to 6 m BGS. As per the anticipated site conditions the basement will be subjected to hydrostatic forces and a perimeter drainage system and a subfloor system will be required. Alternatively, the basement slab and walls can be constructed as a bathtub to prevent water infiltration and design for full hydrostatic forces.

The subgrade for the floor slab should comprise undisturbed native soil or well-compacted fill. A minimum 200 mm thick layer of granular base materials consisting of 19 mm crusher run with not more than 10% material that will pass a 4 mm sieve be placed beneath basement slab. If the subgrade soil is wet, we strongly recommend that subfloor weeping tiles be placed and connected to the sump pit. If a permanent dewatering system is not implemented, the basement slab may need to be designed as a structural slab to provide adequate resisting pressures against the hydrostatic uplift pressures anticipated to be acting against the base of the slab.

If a moisture sensitive floor finish is to be applied to the slab, then we recommend that a 15mil polyethylene moisture vapour barrier be installed directly beneath the slab as per subsection 9.13.2.7 of the Ontario Building Code. The purpose of the vapour barrier is to reduce moisture transfer by diffusion as per section 5.5.1.2 of the Ontario Building Code. Joints in the vapour barrier should be lapped not less than 100 mm.

Concrete testing should be performed onsite to determine the slump, temperature, and air entertainment and concrete cylinders should be cast for compressive strength testing.

As the basement level is anticipated to be founded below the natural ground water table, a perimeter wall drainage system will need to be installed for the basement structure to collect groundwater from within the surficial earth fill and native soil layers. The perimeter drainage system should consist of Terrafix Terradrain™ 200, Mirafi Miradrain™ 5000, and/or similar products. A waterproofing membrane such as Mirafi Miradri™ and/or similar product compatible with the drainage system is also recommended. The perimeter drainage system should be provided with a collector pipe at the base of the foundation wall and a sump/pump system which shall include an uninterruptible power supply.

It is recommended that subfloor drainage pipes be installed below the basement slab at a level of 300 mm below the slab with pipes placed at 5 m spacing. The drain pipes should be surrounded by a 150 mm thick layer of 19 mm clear crushed stone that is fully wrapped with a non-woven geotextile filter fabric, having a filtration opening size (F.O.S.) of 80 microns or less.

For a watertight or ‘bathtub’ design option, hydrostatic pressures need to be considered in designing a structural slab and foundation / basement walls to resist both the hydrostatic and lateral earth pressures. A waterproofing membrane such as the Mirafi product or similar (noted above) will be required for the underside of slab and foundation walls for the submerged depths.

The roof runoff should be collected and directed through solid pipes, separate from the perimeter drainage system to a positive outlet. The surfaces surrounding the structure should be graded to direct water away from the structure.

The water collected by the perimeter drain pipes and subfloor drainage should be directed into a positive outlet such as a sump from where the water is removed by pumping. For the design of the sump and pump, the rate of groundwater flow into the drainage system should be assessed at the time of construction.

5.4 Seismic Site Classification

The latest Ontario Building Code (OBC) requires the assignment of a Seismic Site Class for calculations of earthquake design forces and the structural design based on a two percent probability of exceedance in 50 years. According to the latest OBC, the Seismic Site Class is a function of soil profile and is based on the average properties of the subsoil strata to a depth of 30 m below the ground surface. The OBC provides the following three methods to obtain the average properties for the top 30 m of the subsoil strata:

- Average shear wave velocity.
- Average Standard Penetration Test (SPT) values (uncorrected for overburden).
- Average undrained shear strength.

Based on the results of the conducted geotechnical investigation, the Site can be classified as Class ‘D’ in accordance with Table 4.1.8.4.A of the Ontario Building Code. However, it is anticipated that the seismic site class can be improved to class C following the completion of MASW survey.

5.5 Depth of Frost Penetration

The design depth of frost penetration in the area is 1.5 m as per the OPSD 3090.101. A permanent soil cover of 1.5 m or its thermal equivalent synthetic insulation is required for frost protection of foundations (foundations in unheated areas). During winter construction, exposed surfaces to support foundations must be protected against freezing by means of loose straw and tarpaulins.

5.6 Site Servicing

The native soils encountered in the boreholes are suitable for the support of proposed Site services. The bedding and sand cover materials for the pipes should be adequately compacted to provide support and protection. Provided the base area of the sewer pipes and watermains are free of all loose and deleterious materials, the pipe bedding should comply with a Class B bedding configuration as per the requirements of OPSD 802.030 (rigid pipe) and/or OPSD 802.010 (flexible pipe).

Where disturbance of the trench base has occurred, due to the presence of soft cohesive soils (if any), groundwater seepage and the like, the disturbed soils should be sub-excavated and replaced with suitably compacted granular fill. If the native soil at pipe founding level is wet, clear stone may be used as bedding material, but must be wrapped with a suitable filter fabric.

If fill material is found at the pipe inert level, the fill material should be visually inspected. Any wet, soft, highly organic or otherwise unsuitable fills should be sub-excavated and replaced with bedding materials or clean fills compacted to minimum of 95% SPMDD.

5.7 Excavation

The Occupational Health and Safety Act (OHSA) regulations require that if workmen must enter an excavation deeper than 1.2 m, the excavation must be suitably sloped and/or braced in accordance with the OHSA requirements. OHSA specifies maximum slope of the excavations for four broad soil types as summarized in the following table:

Table 5.3 Recommended Excavation Slopes (OHSA)

Soil Type	Base of Slope	Maximum Slope Inclination
1	Within 1.2 metre of bottom	1 horizontal to 1 vertical
2	Within 1.2 metre of bottom of trench	1 horizontal to 1 vertical
3	From bottom of excavation	1 horizontal to 1 vertical
4	From bottom of excavation	3 horizontal to 1 vertical

OHSA Section 226 (Current - July 1, 2021) defines the four soil types as follows:

Type 1 soil:

a) hard, very dense and only able to be penetrated with difficulty by a small sharp object;
b) has a low natural moisture content and a high degree of internal strength;
c) has no signs of water seepage; and
d) can be excavated only by mechanical equipment.

Type 2 soil:

a) very stiff, dense and can be penetrated with moderate difficulty by a small sharp object;
b) has a low to medium natural moisture content and a medium degree of internal strength; and
c) has a damp appearance after it is excavated.

Type 3 soil:

a) stiff to firm and compact to loose in consistency or is previously excavated soil;
b) exhibits signs of surface cracking;
c) exhibits signs of water seepage;
d) if it is dry, may run easily into a well-defined conical pile; and

e) has a low degree of internal strength.

Type 4 soil:

a) soft to very soft and very loose in consistency, very sensitive and upon disturbance is significantly reduced in natural strength;

b) runs easily or flows, unless it is completely supported before excavating procedures;

c) has almost no internal strength;

d) wet or muddy; and e) exerts substantial fluid pressure on its supporting system. Ontario Regulation 213/91, s. 226 (5)

The native sandy silt to silty sand soils underlying the Site can be considered Type 2 soils above groundwater level, and Type 3 below groundwater table. If the above recommended excavation side slopes cannot be maintained due to lack of space or any other reason, the excavation side slopes must be supported by an engineered shoring system. The shoring system should be designed in accordance with Canadian Engineering Foundation Manual (4th Edition) and the OHSA Regulations for Construction Projects. It is anticipated that foundation and utility excavations can be made with conventional equipment.

Surface water should be directed away from open excavations and spoil piles should be kept a minimum of 1.0 m away from the top of any excavation to prevent excess loading on excavation sidewalls.

5.8 Temporary Groundwater Control

At the time of field work, the groundwater level was measured in each borehole before completion. The water level in the open borings generally varied between 3.05 m BGS and 6.40 m BGS. Also, to measure the long-term stable ground water levels, monitoring wells were installed in four boreholes MW1-21, MW2-21, MW4-21 and MW5-21 and the groundwater levels were measured on August 18, 2021. The water level measured in the monitoring wells ranged from 4.21 to 6.88 m BGS.

The encountered groundwater levels in all the boreholes during drilling and the measured ground water levels in the installed monitoring wells are provided in Section 4.4 and are shown in the borehole logs provided in **Appendix A.**

Based on the proposed excavation depths of 5.2 to 6.7 m BGS it is anticipated that excavations for the construction of the underground parking level will extend below the natural groundwater table. Moderate to high groundwater inflow is expected where the excavations extend less than 0.5 m below the groundwater table, as such, a positive dewatering system installed by a dewatering specialist will likely be required to lower the ground water level prior to excavation in order to maintain a safe and adequately dry excavation. The groundwater level should be drawn down at least 1 m below the base of the excavation to avoid basal instability. Care should also be taken to divert surface water away from excavations. Sump pits, if utilized, should be lined with suitable geotextile filter fabric and pump inlet should be set in clear stone, which must fill the sump pit completely. Unfiltered pumping can cause excessive migration of soil fines which will loosen the soil deposits that may subsequently result in ground surface settlement.

It is recommended that several test pits be dug during the tendering stage of the project in order for prospective contractors to familiarize themselves with the soil and groundwater conditions.

5.9 Lateral Earth Pressures

Structures subject to unbalanced earth pressures such as, shoring systems, and other similar structures must be designed to resist lateral earth and hydraulic pressures. Based on the subsurface conditions encountered, the soil parameters provided in the table may be used to calculate lateral earth pressures:

Table 5.4 Lateral Earth Pressures

Soil Type	Bulk Unit Weight	Effective Angle of Internal Friction (°)	Coefficient of Lateral Earth Pressure		
	γ (kN/m3)	ϕ	K_a	K_o	K_p
Fill –Sandy silt to silty sand	18	28	0.35	0.51	2.88
Native - Silty Clay (firm)	20	26	0.39	0.56	2.56
Native – Sandy Silt to Silty Sand (dense to very dense)	21	34	0.28	0.44	3.53

Where lateral wall movements are to be resisted, the coefficient of lateral earth pressure at rest K_0 should be used.

For the design of shoring system, the groundwater level should be assumed at the ground surface in the design of shoring systems and other design purposes.

5.10 Backfilling and Reuse of Excavated Material

Backfilling of trenches and excavations can be accomplished by reusing the excavated soils or similar fill material or imported granular soil, provided the moisture content of the material is maintained within ±2 percent of optimum and the fill is free of topsoil, organics, and any deleterious material. The lift thickness of fill placed in excavated trenches should not exceeding 200 mm and compacted to not less than 98 percent of its Standard Proctor Maximum Dry Density (SPMDD).

The soils encountered at the Site may be geotechnically suitable for reuse as backfill to raise site grades (where required) or to be used as trench backfill provided and be free of organic material and is within the optimum moisture content. The native soils above the groundwater level are likely to be near their optimum water content for compaction, whereas those below the groundwater level will likely be wet and well above their optimum water content for compaction.

In some of the boreholes advanced at the Site, a high percentage of silt within the native sandy silt soil deposits were encountered at this Site. These silty soils are sensitive to small changes in moisture content and thus may be difficult to compact, unless they are allowed to dry to around their optimum moisture content (which may require significant time). Therefore, if the soils are to be reused as a structural fill, it should be anticipated that reworking of the materials will be necessary to facilitate compaction through drying or slight wetting and use of heavy dynamic roller compactors. Re-compaction of the native fine-grained soils to an adequate density will be possible only if the natural moisture contents are within ±2% of the optimum moisture content of the materials.

Control of moisture content during placement and compaction will also be essential for maintaining adequate compaction. If any materials are found to be wet, they may be left aside to dry, or mixed with drier material that is to be used as backfill. All backfill materials should be placed in thin layers (200 mm thick or less) and compacted by a heavy smooth type roller to 98 percent SPMDD.

All backfill operations and materials should be inspected and tested by qualified geotechnical personnel to confirm that proper material is utilized, and that adequate compaction is attained.

5.11 Pavement Design

5.11.1 Subgrade Preparation

After topsoil stripping, the exposed soil subgrade in the proposed pavement area, should be heavily proof rolled in conjunction with an inspection by a qualified geotechnical personnel. Loose or soft areas and presence of any organic material identified by proof rolling should be sub-excavated and replaced with approved earth fill materials and compacted to provide a stable uniform subgrade to meet the requirements of OPSS.MUNI 501 (November 2014). After proof rolling, Site grades should be adjusted (cut/fill) to the design subgrade profile with appropriate crossfall.

Fill placed to raise Site grades should be compacted to a minimum of 98 percent SPMDD. Where new fill is required to raise the grade, selected on-site earth materials could be used, provided it is free of any organic material. The fill should be placed in large areas where it can be compacted by a heavy roller. Any fill placed to increase or level the grade must be compacted to a minimum 98 percent SPMDD in lifts not exceeding 200 mm.

In-situ density testing to monitor the effectiveness of the compaction equipment in achieving the required densities is also recommended. The most severe loading conditions on pavement areas and the subgrade may occur during construction. Consequently, special provisions such as end dumping and forward spreading of subbase fills, restricted construction lanes, and half-loads during paving may be required, especially if construction is carried out during inclement weather conditions.

5.11.2 Recommended Pavement Structure

The recommended pavement structures provided below are based on an estimate of the subgrade soil properties determined from the field tests, and visual examination/textural classification of the soil samples. The following asphaltic concrete and granular pavement thickness may be used for the design of the proposed local driveways and parking areas.

Table 5.5 Recommended Pavement Structure

Pavement Structure	Compaction	Pavement Structure	
		Light Duty (Car Parking Areas)	Heavy Duty (Delivery Trucks)
HL3 Hot Mix HL8 Hot Mix	OPSS 310, Table 8	40 50	40 80
Granular A Base (19 mm crusher run limestone or crushed concrete)	100% SPMDD	150	150
Granular B Tyle II Subbase (50 mm crusher run limestone or crushed concrete)	100 % SPMDD	250	350

It is noted that the pavement granular base and subbase layers can consist of sand and gravel, crushed limestone, or crushed concrete materials. The material gradation and durability requirements of the selected granular courses should meet OPSS 101 specifications.

The pavement design considers that construction will be carried out during dry periods of the year and that the subgrade is competent. If the subgrade becomes excessively wet or rutted during construction activities, additional subbase material may be required. The need for additional subbase material is best determined during construction.

A program of geotechnical/material inspection and testing must be carried out during construction of the pavements to confirm that the subgrade conditions exposed are consistent with those encountered in the boreholes and the design assumptions, as well as to confirm that the various project specifications and materials requirements are being met.

5.11.3 Drainage

To maintain the integrity of the pavement at the Site, subdrains should be installed at all catchbasins (3m stubs in the upgradient direction) and along the perimeter of the parking lot. The invert of the subdrains should be at least 250 mm below the bottom of the subbase and should be sloped to drain to adjacent catchbasins. The subdrains should be installed in a 300 mm by 300 mm trench lined by suitable geotextile and consist of a 150 mm diameter perforated pipe wrapped in a suitable geotextile and surrounded with a minimum thickness of 50 mm of free draining clear stone or concrete sand.

Grading adjacent to pavement areas should be designed so that water is not allowed to pond adjacent to the outside edges of the pavement

5.12 Corrosivity Testing

Corrosivity testing was carried out for two (2) select samples by Caduceon Environmental Laboratories, in accordance with ASTM and CSA Standards. Analytical results received from the laboratory are provided in Appendix C. The analytical results were compared with CSA A23.1 Standards to determine the potential of sulphate attack on concrete and with the American Water Works Association (AWWA) C105 to assess soil corrosivity potential of ductile iron pipes and fittings. Corrosivity testing as described by the American Water Works Association (AWWA) includes soil resistivity, pH, sulphide indication, redox potential, and moisture content. Points are assigned to the sample based on the results of the test. A soil that has a total point score of 10 or more is considered to be potentially corrosive to ductile iron pipe. The potential for sulphate attack on concrete (class of exposure) is determined using Table 3 provided in CSA A23.1.

The following table summarizes the laboratory test results for the two (2) soil samples collected from the boreholes to assess soil potential for sulphate attack on concrete structures:

Table 5.6 Summary of Sulphate Results Attack

Borehole ID	Sample Depth (m)	Sulphate (%)	Class of Exposure (Ref. Table 3 of CSA A23.1)	Potential for Sulphate Attack (Ref. Table 3 of CSA A23.1)	Cementing Materials to be used (Ref. Table 3 of CSA A23.1)
MW2-21 / SS9	6.1 – 6.7	0.002	Below S-3	Negligible	Not specified
MW5-21 / SS7	6.1 – 6.7	<0.001	Below S-3	Negligible	Not specified

In general, the results of sulphate ion content analysis indicate that the soil samples contain low levels of sulphate ion, which are below the class of exposure levels outlined in CSA A23.1. No additional precautions are required to provide protection against sulphate attack such as special cements or mixtures.

In regard to soil corrosivity potential against ductile iron pipes and fittings, it is noted that sulphide analysis presented in AWWA is a qualitative test where a positive, trace, or negative determination is based on the presence of bubbles as a result of a chemical reaction. Such testing has not been conducted as the laboratory defines sulfides concentration that is unrelated to the scale provided by AWWA. As a result, it was assumed that the result was positive and a maximum score of 3.5 was selected (most conservative assumption). Also, for moisture content determination, the value obtained from the geotechnical laboratory tests were used for this analysis and soil poor drainage condition has been considered to obtain more conservative values. The table below summarizes the ANSI/AWWA rating of the tested soil samples on their potential for corrosion towards buried ductile cast iron pipes/fittings. A score of ten (10) points or more indicates the soil is corrosive to ductile iron pipes and protection will be needed.

Table 5.7 Assessment of Corrosive Potential

Borehole ID	Sample Depth (m)	Relevant Parameters				Total Points	Corrosivity Potential
		Resistivity (ohm/cm)	pH	Redox Potential (mV)	Moisture (%)		
MW2-21 / SS9	6.1 – 6.7	18200	8.22	260	18	5.5	No
MW5-21 / SS7	6.1 – 6.7	7350	8.34	270	16	5.5	No

Based on the results obtained for the samples submitted, special provisions will not be required for corrosion protection of any metallic pipe components in the area of borehole MW2-21 and MW5-21.

6. Limitations of the Investigation

This report is intended solely for Crown Communities Development (the Client) and is prohibited for use by others without GHD's prior written consent. Any unauthorized reuse, redistribution of or reliance on the report shall be at the Client and recipient's sole risk, without liability to GHD. No portion of this report may be used as a separate entity; it is to be read in its entirety and shall include all supporting drawings and appendices.

The recommendations made in this report are in accordance with our present understanding of the project, the current site use, ground surface elevations and conditions, and are based on the work scope approved by the Client and described in the report. The services were performed in a manner consistent with that level of care and skill ordinarily exercised by members of geotechnical engineering professions currently practicing under similar conditions in the same locality. No other representations, and no warranties or representations of any kind, either expressed or implied, are made. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties.

All details of design and construction are rarely known at the time of completion of a geotechnical study. The recommendations and comments made in the study report are based on our subsurface investigation and resulting understanding of the project, as defined at the time of the study.

It is important to emphasize that a soil investigation is, in fact, a random sampling of a site and the comments included in this report are based on the results obtained at the test locations only. The subsurface conditions confirmed at the test locations may vary at other locations. The subsurface conditions can also be significantly modified by the construction activities on site (i.e. excavation, dewatering and drainage, pile driving, etc.). These conditions can also be modified by exposure of soils or bedrock to humidity, dry periods or frost. Soil and groundwater conditions between and beyond the test locations may differ both horizontally and vertically from those encountered at the test locations and conditions may become apparent during construction which could not be detected or anticipated at the time of our investigation. Should any conditions at the site be encountered which differ from those found at the test locations, we request that we be notified immediately in order to permit a reassessment of our recommendations.

All of Which is Respectfully Submitted,

GHD

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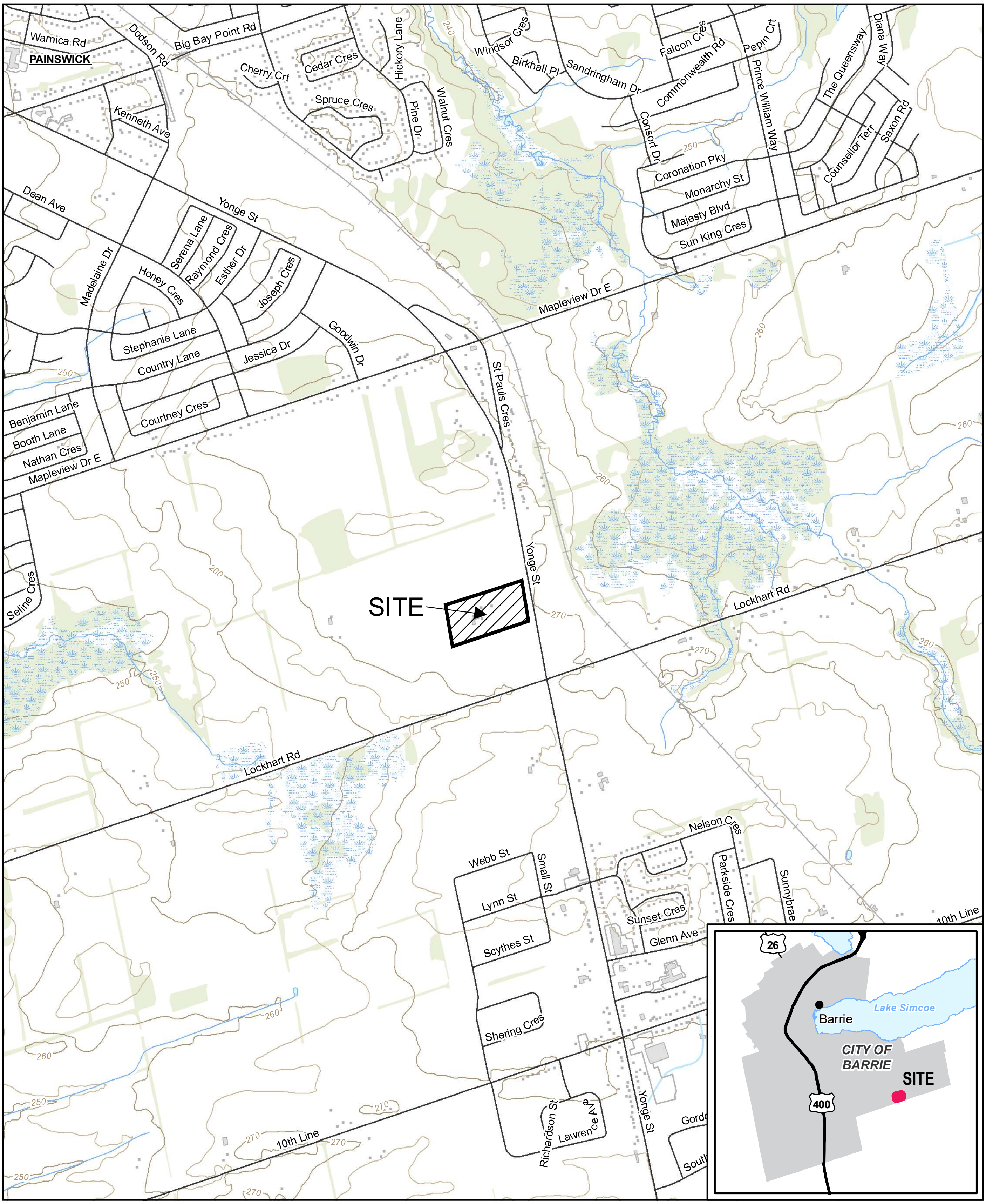
2/9/2022
PROVINCE OF ONTARIO

Figures



Paper Size ANSI A

0 200 400 600

Meters

Map Projection: Transverse Mercator
Horizontal Datum: North American 1983
Grid: NAD 1983 UTM Zone 17N

N

CROWN BARRIE DEVELOPMENTS INC.
PROPOSED MIX USE CONDOMINIUM
1012 YONGE STREET, BARRIE, ONTARIO

Project No. **11226647**
Revision No. **-**
Date **Feb 8, 2022**

SITE LOCATION MAP

FIGURE 1

Q:\GIS\PROJECTS\11226000s\11226647\Layouts\RPT001\11226647_RPT001_GIS001.mxd
Print date: 08 Feb 2022 - 15:10

Data source: MNRF NRVIS, 2018. Produced by GHD under licence from Ontario Ministry of Natural Resources and Forestry, © Queen's Printer 2022.

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LEGEND

■	BOREHOLE LOCATION
(268.23)	GROUND ELEVATION

0 10 20 30m
1:1000
Coordinate System:
UTM ZONE 17
NAD83 METRES

N

CROWN BARRIE DEVELOPMENTS INC.
PROPOSED MIX USE CONDOMINIUM
1012 YONGE STREET, BARRIE, ONTARIO

BOREHOLE LOCATION PLAN

Project No. **11226647**
Date **February 2022**

FIGURE 2

Filename: N:\CA\Mississauga\Projects\662\11226647\Digital_Design\ACAD\Figures\RPT002\11226647-GHD-0000-RPT-EN-0101_WA-002.dwg
Plot Date: 08 February 2022 2:04 PM

Appendices

Appendix A

Borehole Stratigraphic Logs

REFERENCE No.: 11226647

ENCLOSURE No.: 1

GHD

BOREHOLE No.: **MW1-21**

ELEVATION: 268.23 m

BOREHOLE REPORT

Page: 1 of 2

CLIENT: Crown Barrie Developments Inc.

PROJECT: Geotechnical Investigation - Hydrogeological Investigation

LOCATION: 1012 Yonge Street, Barrie, Ontario

DESCRIBED BY: C. Radway CHECKED BY: P. Verma

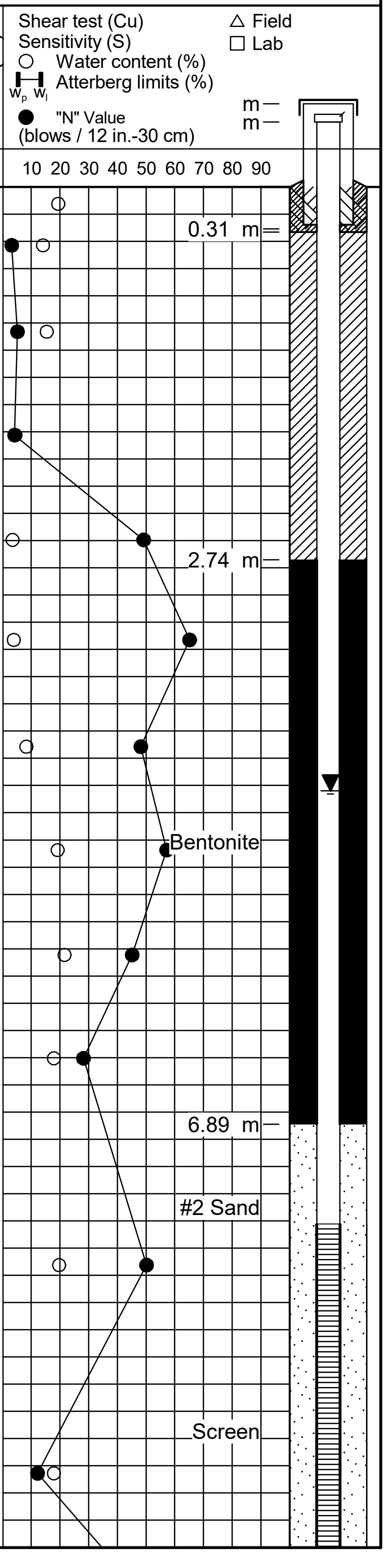
DATE (START): July 13, 2021 DATE (FINISH): July 14, 2021

LEGEND

☒	SS	- SPLIT SPOON
▨	ST	- SHELBY TUBE
◫	AU	- AUGER PROBE
▼		- WATER LEVEL

NORTHING: 4910545.39 EASTING: 609712.088

Depth (Metres)	Elevation (m) BGS	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	State	Type and Number	Recovery/ TCR(%)	Moisture Content %	Blows per 15cm/ RQD(%)	'N' Value/ SCR(%)
	268.23		GROUND SURFACE						
0.25	267.98		TOPSOIL : 250 mm	☒	SS1A		19	--	--
			FILL : SANDY SILT, trace clay, rootlets, brown, moist, very loose to loose	☒	SS1B	100	14	1-1-2-2	3
				☒	SS2	92	15	2-3-2-3	5
				☒	SS3	83	4	2-2-2-4	4
2.29	265.94		NATIVE : SM-SILTY SAND with gravel, light brown, moist, dense Gravel : 22%, Sand : 63%, Clay : 2%, Silt : 13%	☒	SS4	75	3	8-14-35-40	49
			very dense	☒	SS5	100	4	20-30-35-50/ 100mm	65
			moist to wet, dense	☒	SS6	75	8	12-20-28-40	48
			very dense	☒	SS7	83	19	10-22-35-45	57
5.34	262.89		SP-SM-SAND with silt, poorly graded, trace gravel, light brown, wet, dense	☒	SS8	83	21	10-20-25-28	45
			compact Gravel : 0%, Sand : 91%, Clay : 0%, Silt : 9%	☒	SS9		18	3-8-20-45	28
7.62	260.61		SM-SILTY SAND, trace clay, light brown, wet, very dense	☒	SS10	75	20	15-20-30-35	50
			trace gravel, wet, compact	☒	SS11		18	2-4-8-16	12



REFERENCE No.: 11226647 ENCLOSURE No.: 1

BOREHOLE REPORT

BOREHOLE No.: **MW1-21**
ELEVATION: 268.23 m

Page: 2 of 2

CLIENT: Crown Barrie Developments Inc.
PROJECT: Geotechnical Investigation - Hydrogeological Investigation
LOCATION: 1012 Yonge Street, Barrie, Ontario
DESCRIBED BY: C. Radway CHECKED BY: P. Verma
DATE (START): July 13, 2021 DATE (FINISH): July 14, 2021

LEGEND

☒	SS	- SPLIT SPOON
▨	ST	- SHELBY TUBE
◫	AU	- AUGER PROBE
▼		- WATER LEVEL

NORTHING: 4910545.39 EASTING: 609712.088

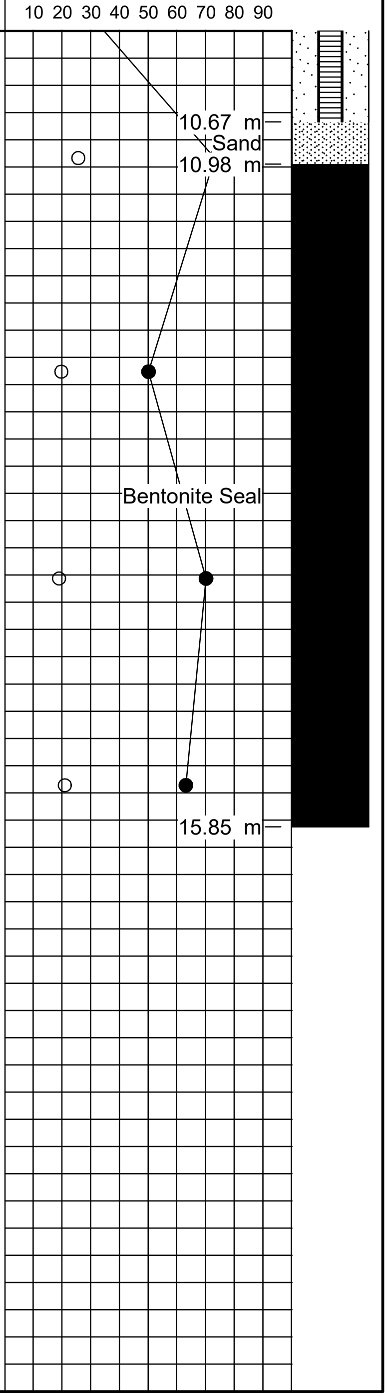
Shear test (Cu) △ Field
Sensitivity (S) ☐ Lab
○ Water content (%)
W_p W_l Atterberg limits (%)
● "N" Value (blows / 12 in.-30 cm)

Depth (Feet)	Depth (Metres)	Elevation (m) BGS	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	State	Type and Number	Recovery/ TCR(%)	Moisture Content (%)	Blows per 15cm/ RQD(%)	'N' Value/ SCR(%)
Feet	Metres	268.23		GROUND SURFACE				%		
33–40	11.0–12.0			brown, very dense	☒	SS12	67	26	14-25-48-50/ 75mm	73
40	12.20	256.03		ML-SILT with sand, trace clay, wet, very dense Gravel : 0%, Sand : 24%, Clay : 3%, Silt : 73%	☒	SS13	75	20	10-20-30-48	50
	14.0			very dense	☒	SS14	67	19	20-30-40-50/ 50mm	70
	15.0			trace clay, grey	☒	SS15		21	15-28-35-48	63
52	15.85	252.38								

END OF BOREHOLE :

NOTE :

- End of Borehole at 15.85 m bgs
- 50 mm diameter monitoring well installed at 10.67 m bgs
- Ground water level found at 4.27 m bgs
- Groundwater level found at 4.44 m on Aug 18, 2021
- bgs denotes 'below ground surface'



File: I:\LOG DATABASE\8-CHAR\11------\1122---\112266--\11226647\11226647.GPJ Library File: GHD_GEOTECH_V05.GLB Report: SOIL LOG WITH GRAPH+WELL Date: 8/23/21

REFERENCE No.: 11226647 ENCLOSURE No.: 2

BOREHOLE No.: **MW2-21**
ELEVATION: 268.24 m

BOREHOLE REPORT

Page: 1 of 2

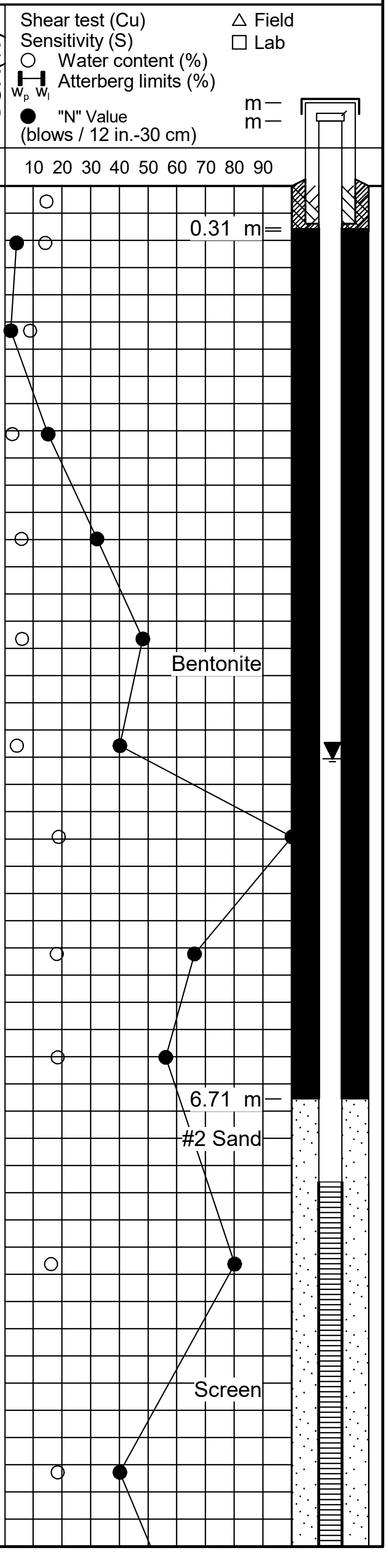
CLIENT: Crown Barrie Developments Inc.
PROJECT: Geotechnical Investigation - Hydrogeological Investigation
LOCATION: 1012 Yonge Street, Barrie, Ontario
DESCRIBED BY: C. Radway CHECKED BY: P. Verma
DATE (START): July 10, 2021 DATE (FINISH): July 11, 2021

LEGEND

☒	SS	- SPLIT SPOON
▨	ST	- SHELBY TUBE
◫	AU	- AUGER PROBE
▼		- WATER LEVEL

NORTHING: 4910481.407 EASTING: 609652.447

Depth (Metres)	Elevation (m) BGS	DESCRIPTION OF SOIL AND BEDROCK	Type and Number	Recovery/ TCR(%)	Moisture Content (%)	Blows per 15cm/ RQD(%)	'N' Value/ SCR(%)
	268.24	GROUND SURFACE					
0.23	268.01	TOPSOIL : 225 mm	SS1A		14	--	--
		FILL : SANDY SILT, trace clay, occasional rootlets, brown, moist, loose	SS1B	83	14	1-2-2-2	4
0.76	267.48	SAND, some silt, light brown, moist, very loose	SS2	83	9	1-1-1-1	2
		compact	SS3	75	3	2-7-8-8	15
		dense	SS4	75	6	3-12-20-40	32
			SS5	100	6	10-18-30-35	48
			SS6	75	4	10-20-20-30	40
4.57	263.67	NATIVE : ML-SANDY SILT, trace clay, brown, wet, very dense Gravel : 0%, Sand : 39%, Clay : 3%, Silt : 58%	SS7	94	19	15-35-50/ 125mm	100
5.34	262.90	SP-SAND, trace to some silt, brown, wet, very dense	SS8	79	18	20-28-38-45	66
			SS9	83	18	10-12-44-50/ 150mm	56
			SS10	75	16	28-38-42-45	80
		dense	SS11	75	18	15-20-20-55	40



REFERENCE No.: 11226647 ENCLOSURE No.: 2

BOREHOLE No.: **MW2-21**
ELEVATION: 268.24 m

BOREHOLE REPORT

Page: 2 of 2

CLIENT: Crown Barrie Developments Inc.
PROJECT: Geotechnical Investigation - Hydrogeological Investigation
LOCATION: 1012 Yonge Street, Barrie, Ontario
DESCRIBED BY: C. Radway CHECKED BY: P. Verma
DATE (START): July 10, 2021 DATE (FINISH): July 11, 2021

LEGEND

☒	SS	- SPLIT SPOON
▨	ST	- SHELBY TUBE
◫	AU	- AUGER PROBE
▼		- WATER LEVEL

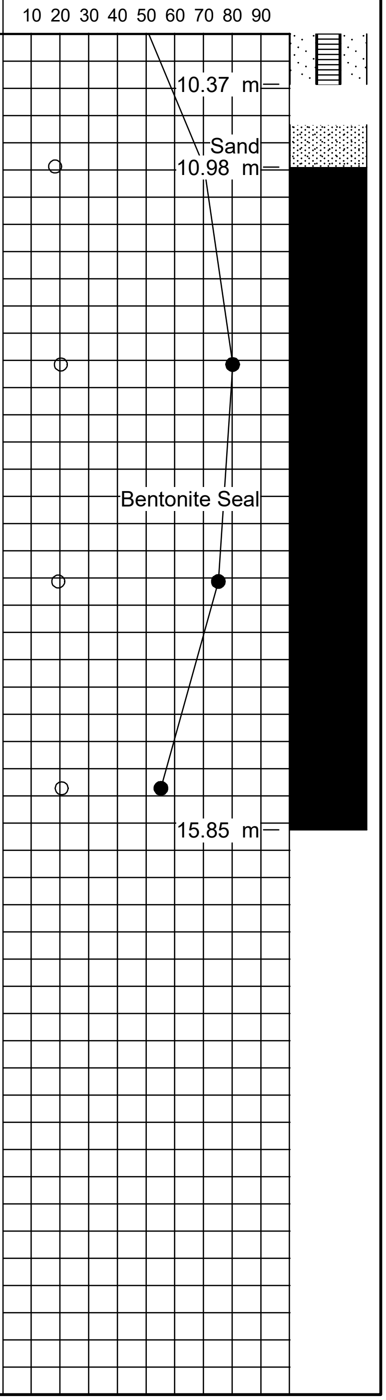
NORTHING: 4910481.407 EASTING: 609652.447

Depth Feet	Depth Metres	Elevation (m) BGS	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	State	Type and Number	Recovery/ TCR(%)	Moisture Content %	Blows per 15cm/ RQD(%)	'N' Value/ SCR(%)
		268.24		GROUND SURFACE						
35	10.67	257.57		SM-SILTY SAND, trace clay, brown, wet, very dense Gravel : 0%, Sand : 61%, Clay : 4%, Silt : 35%	☒	SS12	83	18	15-30-40-50	70
					☒	SS13	75	20	20-30-50/ 150mm	80
					☒	SS14	75	19	15-35-40-50/ 150mm	75
					☒	SS15	67	20	16-25-30-50/ 150mm	55
52	15.85	252.39		**END OF BOREHOLE :**						

NOTE :

- End of Borehole at 15.85 m bgs
- 50 mm diameter monitoring well installed at 10.37 m bgs
- Ground water level found at 4.57 m bgs
- Groundwater level found at 4.21 m on Aug 18, 2021
- bgs denotes 'below ground surface'

Shear test (Cu) △ Field
Sensitivity (S) ☐ Lab
○ Water content (%)
Atterberg limits (%) W_p W_l
● "N" Value (blows / 12 in.-30 cm)



REFERENCE No.: 11226647

ENCLOSURE No.: 3

GHD

BOREHOLE No.: **BH3-21**

ELEVATION: 270.66 m

BOREHOLE REPORT

Page: 1 of 2

CLIENT: Crown Barrie Developments Inc.

PROJECT: Geotechnical Investigation - Hydrogeological Investigation

LOCATION: 1012 Yonge Street, Barrie, Ontario

DESCRIBED BY: C. Radway

CHECKED BY: P. Verma

DATE (START): July 9, 2021

DATE (FINISH): July 9, 2021

LEGEND

☒ SS - SPLIT SPOON

▨ ST - SHELBY TUBE

◫ AU - AUGER PROBE

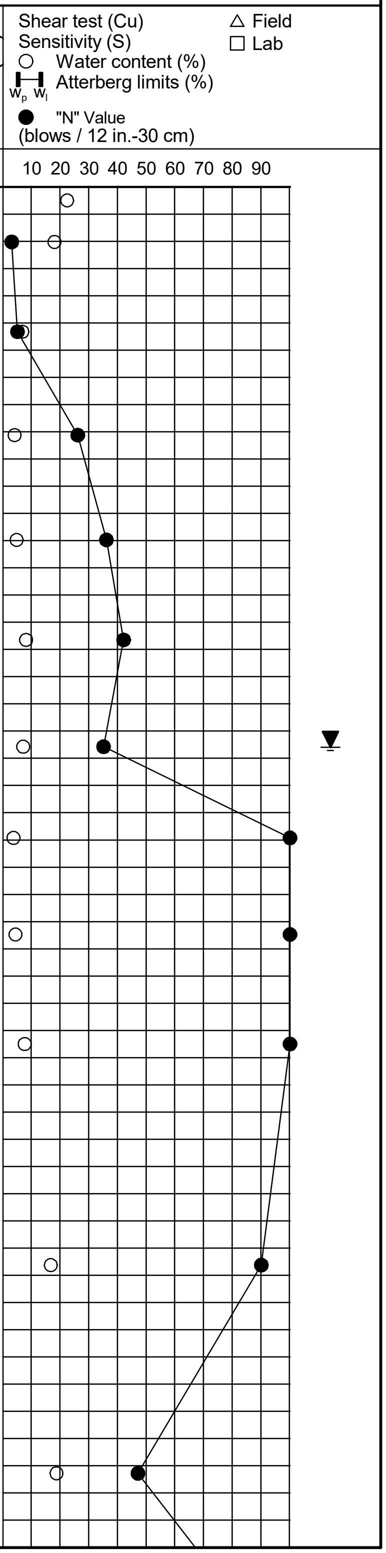
▼ - WATER LEVEL

NORTHING: 4910514.329

EASTING: 609567.975

Depth (Metres)	Elevation (m) BGS	DESCRIPTION OF SOIL AND BEDROCK	Type and Number	Recovery/ TCR(%)	Moisture Content (%)	Blows per 15cm/ RQD(%)	'N' Value/ SCR(%)
	270.66	GROUND SURFACE					
		TOPSOIL : 200 mm	SS1A		22	--	--
0.20	270.46	FILL : SANDY SILT, trace clay, trace rootlets, brown, moist, loose	SS1B	92	18	1-1-2-1	3
0.76	269.90	NATIVE : SM-SILTY SAND, trace to some gravel, trace clay, light brown, moist, loose	SS2	92	7	1-2-3-4	5
1.52	269.14	SM-SILTY SAND, trace to some gravel, trace clay, brown, moist, compact	SS3	83	4	3-10-16-20	26
		dense	SS4	83	5	4-16-20-45	36
3.05	267.61	ML-SILT with sand, some clay, brown, moist, dense Gravel : 0%, Sand : 26%, Clay : 15%, Silt : 59%; NP	SS5	79	8	16-20-22-36	42
3.81	266.85	SM-SILTY SAND, trace clay and gravel, brown, moist, dense	SS6	92	7	6-15-20-26	35
		very dense	SS7	94	4	10-40-50/ 125mm	100
5.34	265.32	SP-SAND, trace silt and gravel, brown, moist, very dense	SS8	100	4	20-40-50/ 0mm	100
			SS9	100	8	20-30-50/ 100mm	100
7.62	263.04	SW-SM-SAND with silt, well graded, trace clay and gravel, brown, moist, very dense Gravel : 1%, Sand : 90%, Clay : 3%, Silt : 6%	SS10	75	17	15-55-35-48	90
		dense	SS11	79	19	12-13-34-45	47

Depth scale: Feet 0–32; Metres 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0



REFERENCE No.: 11226647

ENCLOSURE No.: 3

BOREHOLE No.: **BH3-21**

ELEVATION: 270.66 m

BOREHOLE REPORT

Page: 2 of 2

CLIENT: Crown Barrie Developments Inc.

PROJECT: Geotechnical Investigation - Hydrogeological Investigation

LOCATION: 1012 Yonge Street, Barrie, Ontario

DESCRIBED BY: C. Radway

CHECKED BY: P. Verma

DATE (START): July 9, 2021

DATE (FINISH): July 9, 2021

LEGEND

☒	SS	- SPLIT SPOON
▨	ST	- SHELBY TUBE
◧	AU	- AUGER PROBE
▼		- WATER LEVEL

NORTHING: 4910514.329

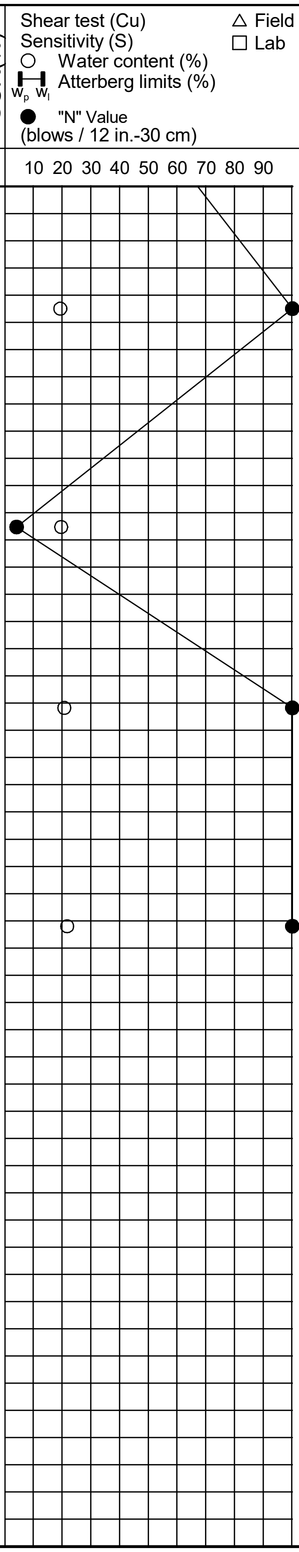
EASTING: 609567.975

Depth (Feet)	Depth (Metres)	Elevation (m) BGS	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	State	Type and Number	Recovery/ TCR(%)	Moisture Content (%)	Blows per 15cm/ RQD(%)	'N' Value/ SCR(%)
		270.66		GROUND SURFACE						
35	10.67	259.99		SM-SILTY SAND, trace gravel, brown, wet, very dense	☒	SS12		19	8-25-50/ 150mm	100
40	12.20	258.46		SP-SM-SAND with silt, poorly graded, trace clay and gravel, brown, wet, loose Gravel : 1%, Sand : 92%, Clay : 2%, Silt : 5%	☒	SS13	75	20	1-2-2-6	4
45				very dense	☒	SS14	100	21	20-50/ 75mm	100
51					☒	SS15	100	22	22-40-50/ 100mm	100
51	15.64	255.02		**END OF BOREHOLE :**						

Depth scale: Feet 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65; Metres 11.0 12.0 13.0 14.0 15.0 16.0 17.0 18.0 19.0

NOTE :

- End of Borehole at 15.64 m bgs
- Ground water level found at 4.12 m bgs
- bgs denotes 'below ground surface'
- NP denotes 'non-plastic'



REFERENCE No.: 11226647

ENCLOSURE No.: 4

GHD

BOREHOLE No.: **MW4-21**

ELEVATION: 270.91 m

BOREHOLE REPORT

Page: 1 of 2

CLIENT: Crown Barrie Developments Inc.

PROJECT: Geotechnical Investigation - Hydrogeological Investigation

LOCATION: 1012 Yonge Street, Barrie, Ontario

DESCRIBED BY: C. Radway CHECKED BY: P. Verma

DATE (START): July 7, 2021 DATE (FINISH): July 8, 2021

LEGEND

☒ SS - SPLIT SPOON

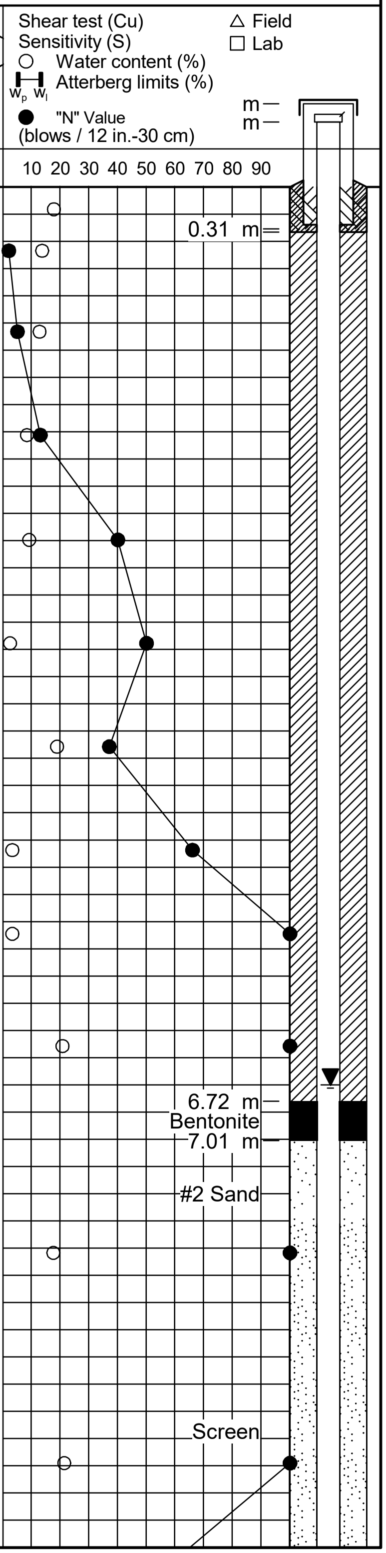
▨ ST - SHELBY TUBE

◫ AU - AUGER PROBE

▼ - WATER LEVEL

NORTHING: 4910426.121 EASTING: 609478.918

Depth (Metres)	Elevation (m) BGS	DESCRIPTION OF SOIL AND BEDROCK	Type and Number	Recovery/ TCR(%)	Moisture Content	Blows per 15cm/ RQD(%)	'N' Value/ SCR(%)
	270.91	GROUND SURFACE			%		
		TOPSOIL : 325 mm	SS1A		18	--	--
0.33	270.58	FILL : SANDY SILT, trace clay, trace rootlets, brown, moist, very loose occasional organic matter, loose	SS1B	58	14	0-1-1-1	2
			SS2	75	13	1-2-3-3	5
1.52	269.39	NATIVE : SM-SILTY SAND with gravel, trace clay, light brown, moist, compact Gravel : 22%, Sand : 52%, Clay : 9%, Silt : 17% dense	SS3	67	8	2-5-8-15	13
			SS4	67	9	16-20-20-22	40
3.05	267.86	SP-SM-SAND, some silt, trace gravel, brown, moist, dense	SS5	75	2	10-20-30-40	50
3.81	267.10	SM-SILTY SAND, trace clay, brown, wet, dense	SS6	75	19	20-22-15-15	37
4.57	266.34	SP-SAND, trace silt and gravel, brown, moist to wet, very dense	SS7		3	10-30-36-58/ 150mm	66
			SS8	55	3	17-50/ 150mm	100
6.10	264.81	ML-SILT with sand, trace clay and gravel, brown, moist to wet, very dense Gravel : 4%, Sand : 25%, Clay : 8%, Silt : 63%	SS9	100	21	22-29-50/ 125mm	100
			SS10	75	18	22-29-50/ 125mm	100
			SS11	75	21	20-30-50/ 150mm	100



REFERENCE No.: 11226647

ENCLOSURE No.: 4

BOREHOLE No.: **MW4-21**

ELEVATION: 270.91 m

BOREHOLE REPORT

Page: 2 of 2

CLIENT: Crown Barrie Developments Inc.

PROJECT: Geotechnical Investigation - Hydrogeological Investigation

LOCATION: 1012 Yonge Street, Barrie, Ontario

DESCRIBED BY: C. Radway

CHECKED BY: P. Verma

DATE (START): July 7, 2021

DATE (FINISH): July 8, 2021

LEGEND

☒	SS	- SPLIT SPOON
▨	ST	- SHELBY TUBE
◫	AU	- AUGER PROBE
▼		- WATER LEVEL

NORTHING: 4910426.121

EASTING: 609478.918

Depth (Feet)	Depth (Metres)	Elevation (m) BGS	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	State	Type and Number	Recovery/ TCR(%)	Moisture Content	Blows per 15cm/ RQD(%)	'N' Value/ SCR(%)
Feet	Metres	270.91		GROUND SURFACE				%		
33–40	11.0, 12.0			compact	☒	SS12	67	23	2-4-6-12	10
40	12.20	258.71		SP-SAND, some silt, trace gravel, brown, wet, dense	☒	SS13	75	16	10-18-20-36	38
	13.0, 14.0			very dense	☒	SS14	100	18	12-48-50/ 100mm	100
	15.0				☒	SS15	100	18	35-50/ 100mm	100
51	15.49	255.42		**END OF BOREHOLE :**						

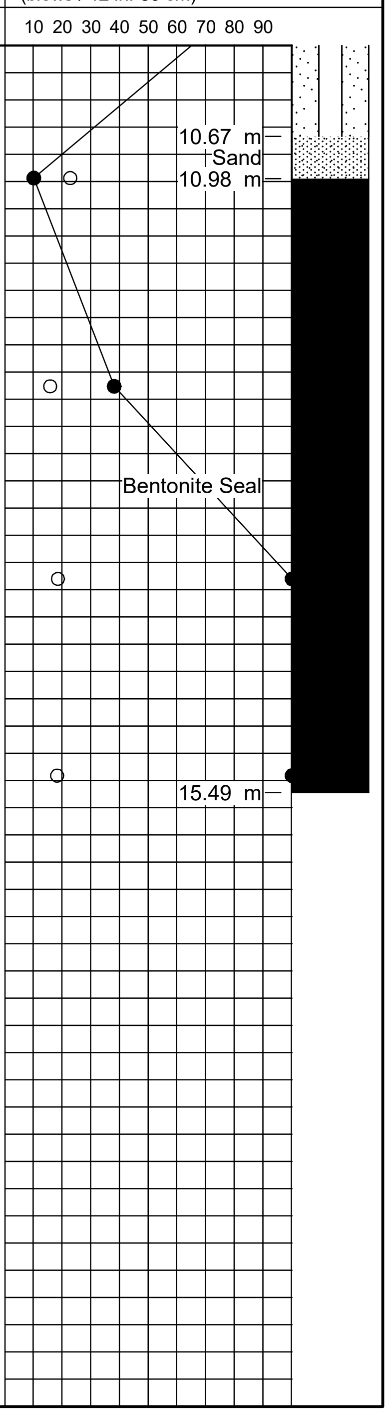
Depth scale: Feet 33 to 65; Metres 11.0, 12.0, 13.0, 14.0, 15.0, 16.0, 17.0, 18.0, 19.0

END OF BOREHOLE :

NOTE :

- End of Borehole at 15.49 m bgs
- 50 mm diameter monitoring well installed at 10.67 m bgs
- Ground water level found at 3.05 m bgs
- Groundwater level found at 6.60 m on Aug 18, 2021
- bgs denotes 'below ground surface'

Shear test (Cu) △ Field
Sensitivity (S) ☐ Lab
○ Water content (%)
Atterberg limits (%) W_p W_l
● "N" Value (blows / 12 in.-30 cm)



REFERENCE No.: 11226647

ENCLOSURE No.: 5

GHD

BOREHOLE No.: **MW5-21**

ELEVATION: 271.09 m

BOREHOLE REPORT

Page: 1 of 2

CLIENT: Crown Barrie Developments Inc.

PROJECT: Geotechnical Investigation - Hydrogeological Investigation

LOCATION: 1012 Yonge Street, Barrie, Ontario

DESCRIBED BY: C. Radway

CHECKED BY: P. Verma

DATE (START): July 6, 2021

DATE (FINISH): July 6, 2021

LEGEND

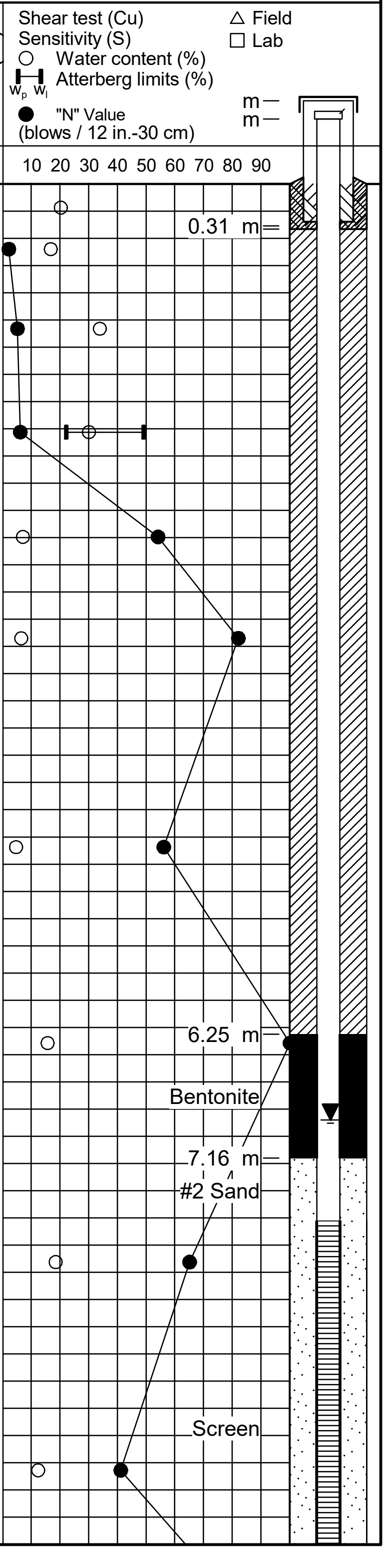
- ☒ SS - SPLIT SPOON
- ▨ ST - SHELBY TUBE
- ◫ AU - AUGER PROBE
- ▼ - WATER LEVEL

NORTHING: 4910490.177

EASTING: 609448.749

Depth (Metres)	Elevation (m) BGS	DESCRIPTION OF SOIL AND BEDROCK	Type and Number	Recovery/ TCR(%)	Moisture Content (%)	Blows per 15cm/ RQD(%)	'N' Value/ SCR(%)
	271.09	GROUND SURFACE					
		TOPSOIL : 350 mm	SS1A		20	--	--
0.35	270.74	FILL : SANDY SILT, trace gravel, trace rootlets, brown, moist, very loose	SS1B	83	17	1-1-1-1	2
		trace clay, loose	SS2	75	34	1-2-3-4	5
1.52	269.57	NATIVE : CL- Silty Clay (Lean Clay) trace sand, brown, moist, firm Gravel : 0%, Sand : 10%, Clay : 58%, Silt : 32%	SS3	83	30	1-2-4-5	6
2.29	268.80	SM-SILTY SAND, trace gravel, brown, moist, very dense	SS4	83	7	6-24-30-45	54
			SS5	92	6	20-38-44-50/ 125mm	82
			SS6	83	5	12-18-38-50	56
			SS7	94	16	17-20-50/ 125mm	100
7.62	263.47	SP-SM-SAND, some silt, trace gravel, brown, moist, very dense	SS8	83	18	25-30-35-35	65
		trace silt and clay, wet, dense	SS9	83	12	10-16-25-50/ 125mm	41

Depth scale: Feet 0–32; Metres 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0



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REFERENCE No.: 11226647

ENCLOSURE No.: 5

BOREHOLE No.: MW5-21

ELEVATION: 271.09 m

BOREHOLE REPORT

Page: 2 of 2

CLIENT: Crown Barrie Developments Inc.

PROJECT: Geotechnical Investigation - Hydrogeological Investigation

LOCATION: 1012 Yonge Street, Barrie, Ontario

DESCRIBED BY: C. Radway CHECKED BY: P. Verma

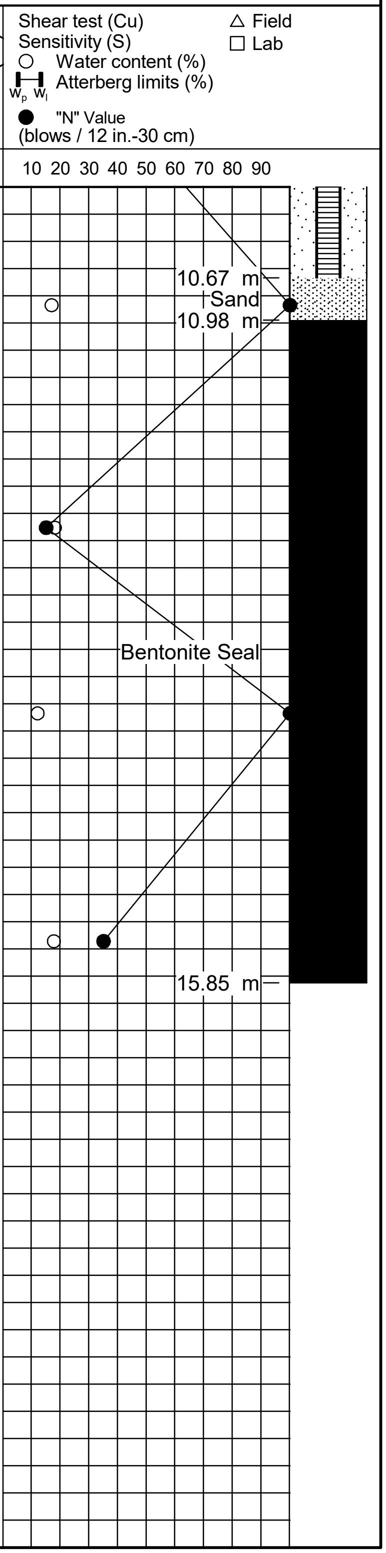
DATE (START): July 6, 2021 DATE (FINISH): July 6, 2021

LEGEND

☒	SS	- SPLIT SPOON
▨	ST	- SHELBY TUBE
◫	AU	- AUGER PROBE
▼		- WATER LEVEL

NORTHING: 4910490.177 EASTING: 609448.749

Depth Feet	Depth Metres	Elevation (m) BGS	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	State	Type and Number	Recovery/ TCR(%)	Moisture Content	Blows per 15cm/ RQD(%)	'N' Value/ SCR(%)
Feet	Metres	271.09		GROUND SURFACE				%		
35	10.67	260.42		SM-SILTY SAND, trace clay, brown, moist, very dense Gravel : 0%, Sand : 91%, Clay : 2%, Silt : 7%	☒	SS10	75	17	15-40-50/ 100mm	100
41				compact	☒	SS11		18	5-7-8-10	15
46				some gravel, very dense	☒	SS12		12	28-50/ 150mm	100
51				dense	☒	SS13		18	10-15-20-21	35
52	15.85	255.24		**END OF BOREHOLE :**						



NOTE :

- End of Borehole at 15.85 m bgs
- 50 mm diameter monitoring well installed at 10.67 m bgs
- Ground water level found at 6.40 m bgs
- Groundwater level found at 6.88 m on Aug 18, 2021
- bgs denotes 'below ground surface'

Appendix B1

Laboratory Gradation Results

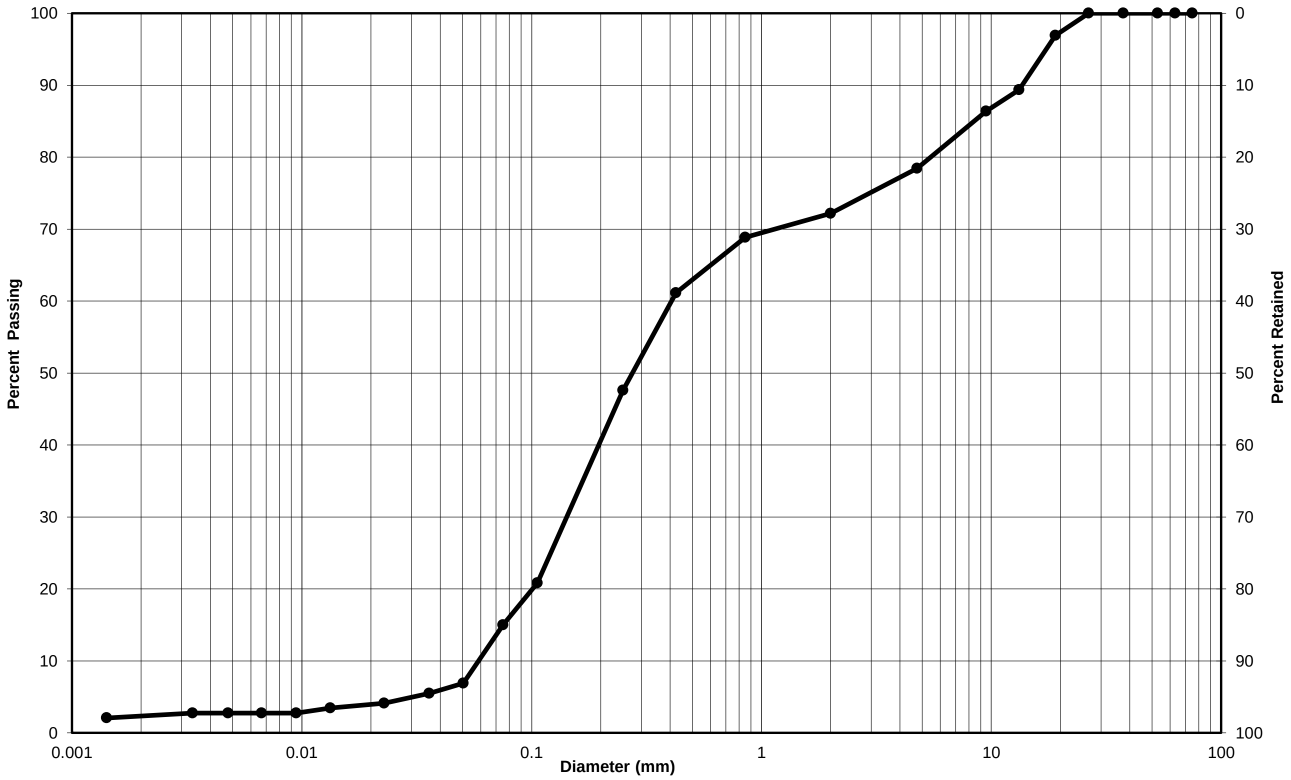
Particle-Size Analysis of Soils (Geotechnical)
(USCS) (ASTM D422)

Client: Crown Barrie Developments Inc.
Lab No.: SS-D-21-23

Project/Site: Proposed Mix Use Condominium Development
Project No.: 11226647

Borehole no.: BH1
Sample no.: SS4

Depth: 7.5'-9.5'
Enclosure:



<table>
<tr><td rowspan="2">Clay & Silt</td><td colspan="3">Sand</td><td colspan="2">Gravel</td></tr>
<tr><td>Fine</td><td>Medium</td><td>Coarse</td><td>Fine</td><td>Coarse</td></tr>
<tr><td colspan="6">Unified Soil Classification System</td></tr>
</table>

Soil Description	Gravel (%)	Sand (%)	Clay & Silt (%)
Silty sand with gravel (SM)	22	63	15
Silt-size particles (%):	13		
Clay-size particles (%) (<0.002mm):	2		

Remarks:

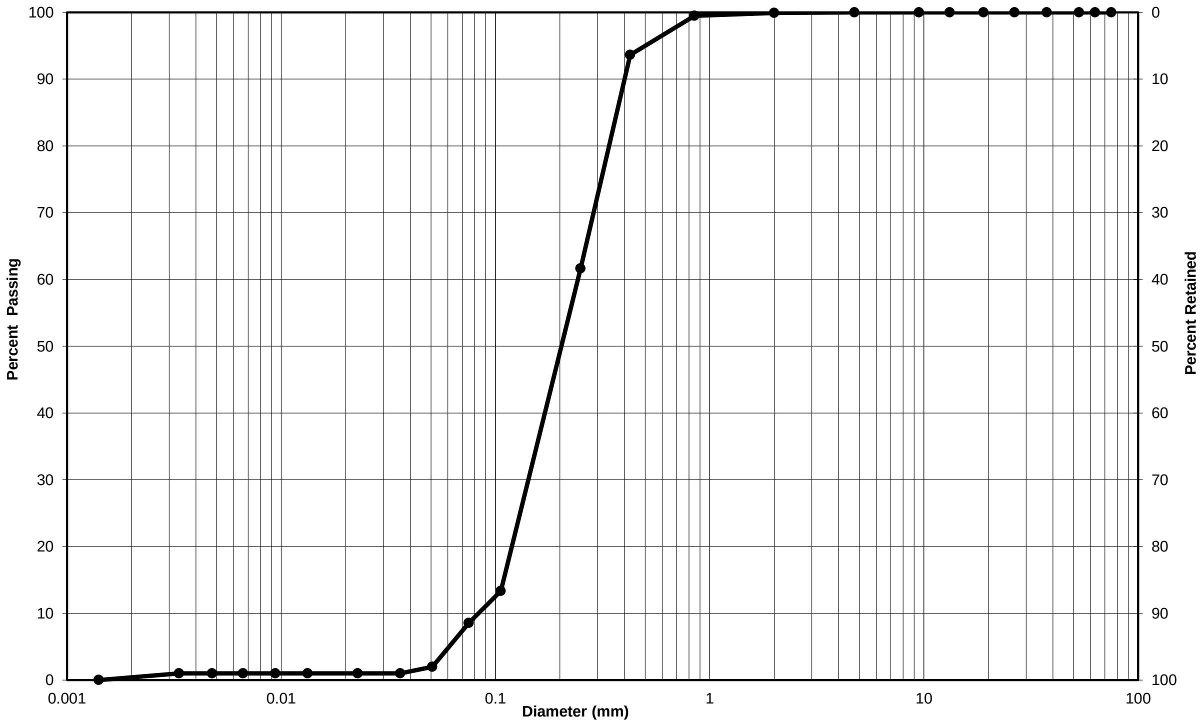
Performed by: M.Chan
Date: July 26, 2021

Verified by: Joe Sullivan
Date: August 5, 2021

Particle-Size Analysis of Soils (Geotechnical) (USCS) (ASTM D422)

Client:	Crown Barrie Developments Inc.	**Lab No.:**	SS-D-21-23
Project/Site:	Proposed Mix Use Condominium Development	**Project No.:**	11226647

Borehole no.:	BH1	Sample no.:	SS9
Depth:	20'-22'	Enclosure:	



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse
Unified Soil Classification System					

Soil Description	Gravel (%)	Sand (%)	Clay & Silt (%)
Poorly graded sand with silt (SP-SM)	0	91	9
Silt-size particles (%):	9		
Clay-size particles (%) (<0.002mm):	0		

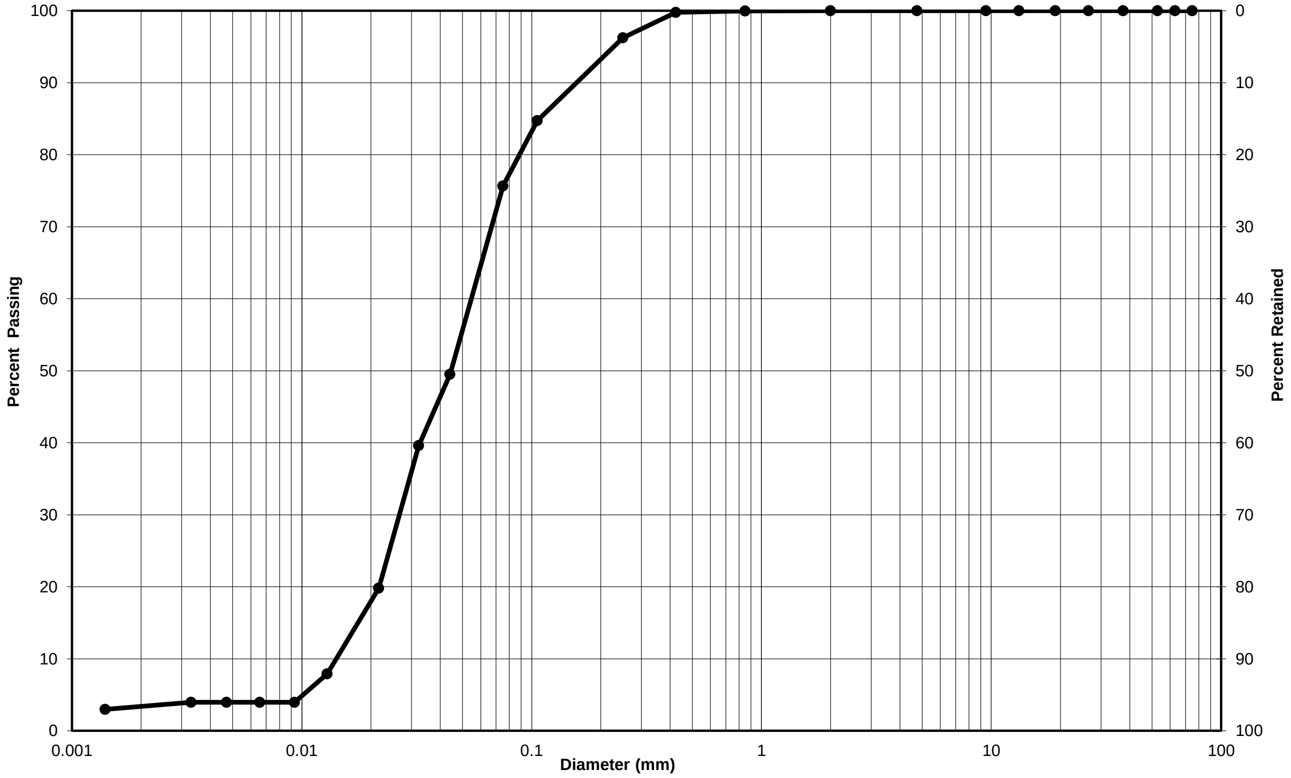
Remarks:

Performed by:	M.Chan	**Date:**	July 26, 2021
Verified by:	Joe Sullivan	**Date:**	August 5, 2021

Particle-Size Analysis of Soils (Geotechnical)
(USCS) (ASTM D422)

Client:	Crown Barrie Developments Inc.	**Lab No.:**	SS-D-21-23
Project/Site:	Proposed Mix Use Condominium Development	**Project No.:**	11226647

Borehole no.:	BH1	Sample no.:	SS13
Depth:	40'-42'	Enclosure:	



<table>
<tr><td rowspan="2">Clay & Silt</td><td colspan="3">Sand</td><td colspan="2">Gravel</td></tr>
<tr><td>Fine</td><td>Medium</td><td>Coarse</td><td>Fine</td><td>Coarse</td></tr>
<tr><td colspan="6">Unified Soil Classification System</td></tr>
</table>

Soil Description	**Gravel (%)**	**Sand (%)**	**Clay & Silt (%)**
Silt with sand (ML)	0	24	76
Silt-size particles (%):	73		
Clay-size particles (%) (<0.002mm):	3		

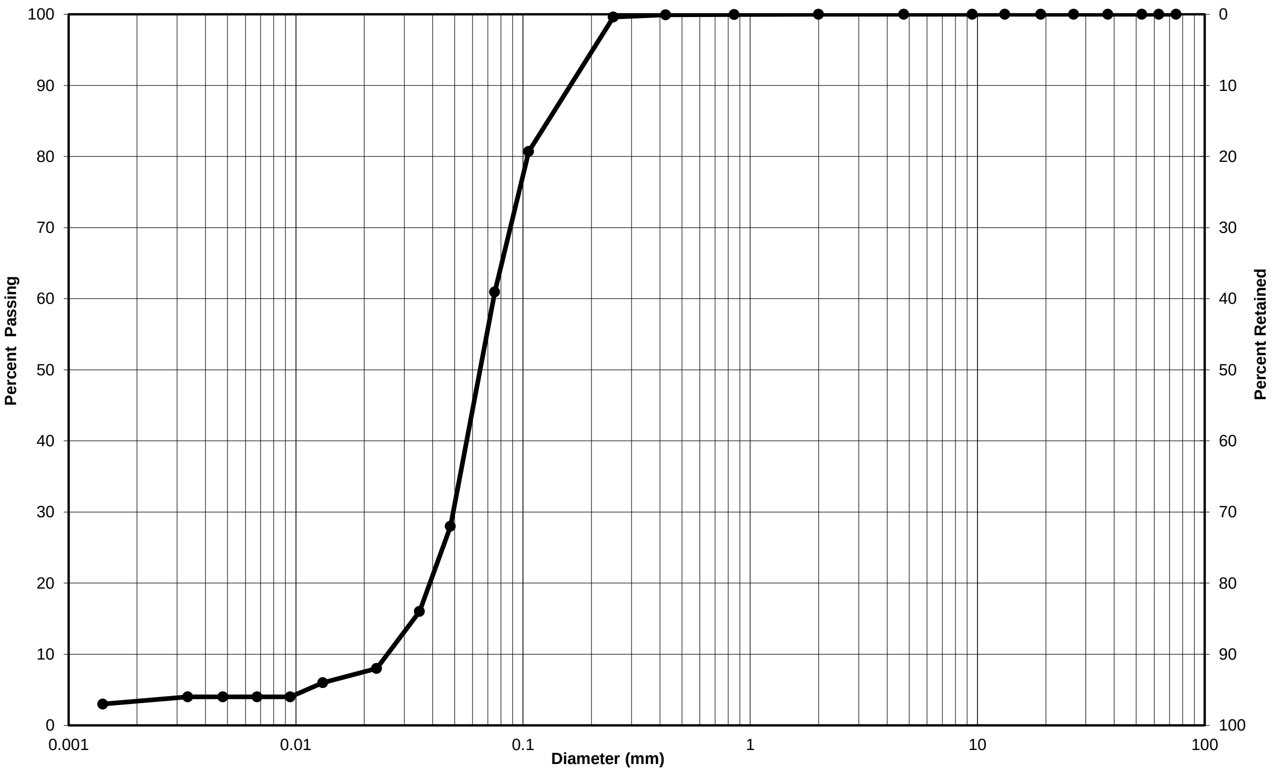
Remarks:

Performed by:	M.Chan	**Date:**	July 26, 2021
Verified by:	Joe Sullivan	**Date:**	August 5, 2021

Particle-Size Analysis of Soils (Geotechnical) (USCS) (ASTM D422)

Client:	Crown Barrie Developments Inc.	**Lab No.:**	SS-D-21-23
Project/Site:	Proposed Mix Use Condominium Development	**Project No.:**	11226647

Borehole no.:	BH2	Sample no.:	SS7
Depth:	15'-17'	Enclosure:	



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse
Unified Soil Classification System					

Soil Description	Gravel (%)	Sand (%)	Clay & Silt (%)
Sandy silt (ML)	0	39	61
Silt-size particles (%):	58		
Clay-size particles (%) (<0.002mm):	3		

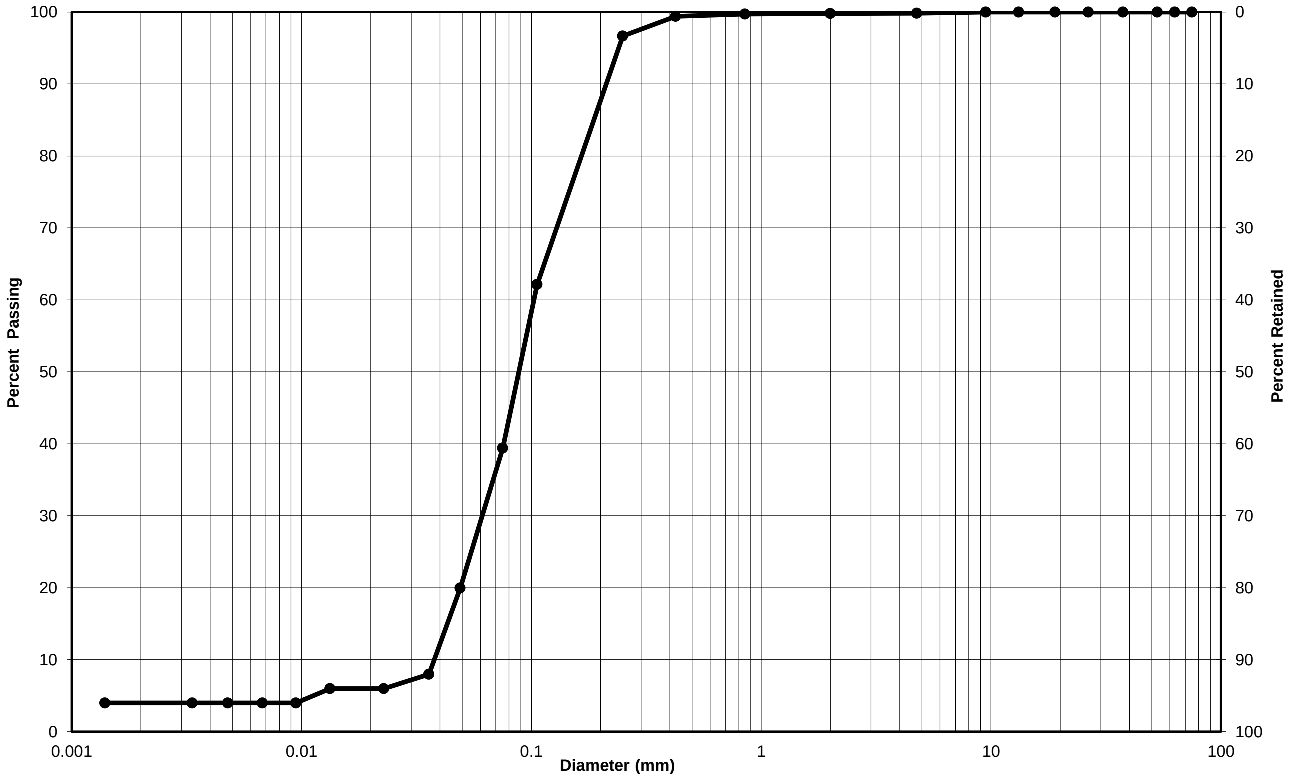
Remarks:

Performed by:	M.Chan	**Date:**	July 26, 2021
Verified by:	Joe Sullivan	**Date:**	August 5, 2021

Particle-Size Analysis of Soils (Geotechnical) (USCS) (ASTM D422)

Client:	Crown Barrie Communities Development Inc.	**Lab No.:**	SS-D-21-23
Project/Site:	Proposed Mix Use Condominium Development	**Project No.:**	11226647

Borehole no.:	BH2	Sample no.:	SS12
Depth:	35'-37'	Enclosure:	



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse
Unified Soil Classification System					

Soil Description	Gravel (%)	Sand (%)	Clay & Silt (%)
Silty sand (SM)	0	61	39
Silt-size particles (%):	35		
Clay-size particles (%) (<0.002mm):	4		

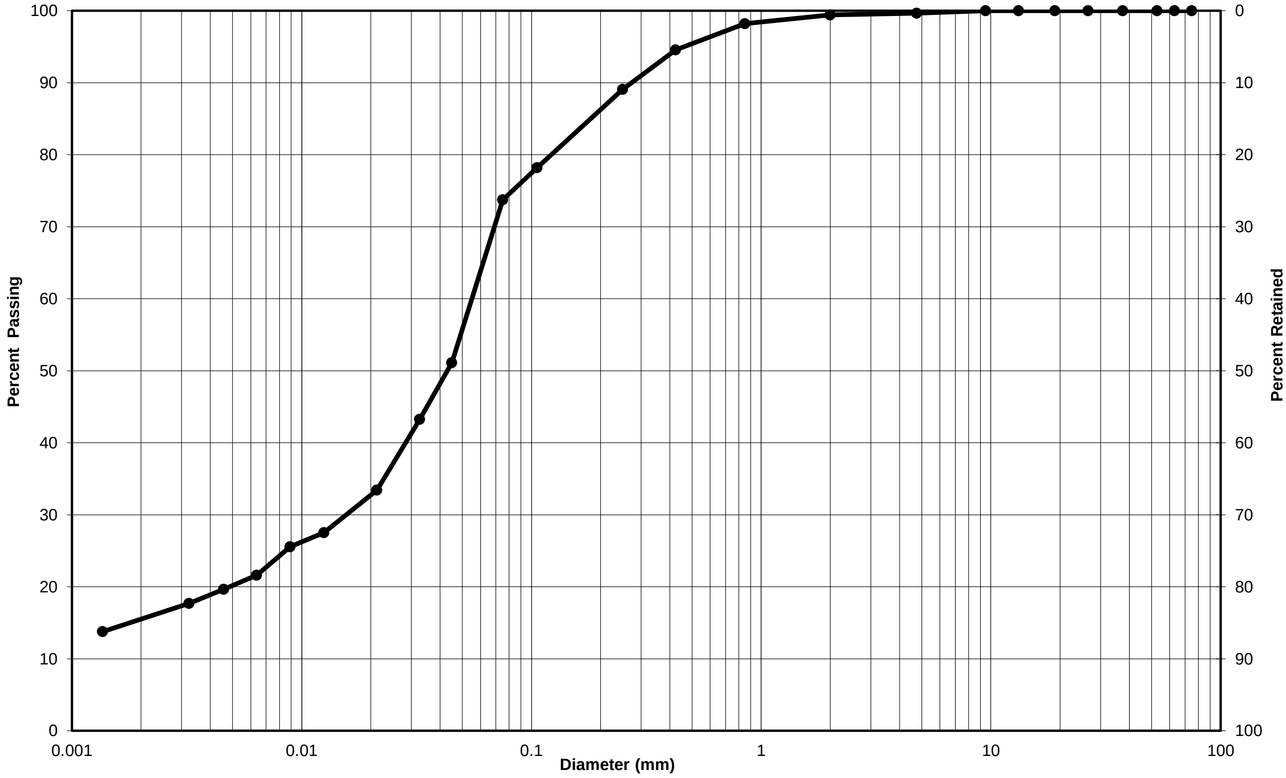
Remarks:

Performed by:	M.Chan	**Date:**	July 26, 2021
Verified by:	Joe Sullivan	**Date:**	August 5, 2021

Particle-Size Analysis of Soils (Geotechnical)
(USCS) (ASTM D422)

Client:	Crown Barrie Developments Inc.	**Lab No.:**	SS-D-21-23
Project/Site:	Proposed Mix Use Condominium Development	**Project No.:**	11226647

Borehole no.:	BH3	Sample no.:	SS5
Depth:	10'-12'	Enclosure:	



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse
Unified Soil Classification System					

Soil Description	Gravel (%)	Sand (%)	Clay & Silt (%)
Silt with sand (ML)	0	26	74
Silt-size particles (%):	59		
Clay-size particles (%) (<0.002mm):	15		

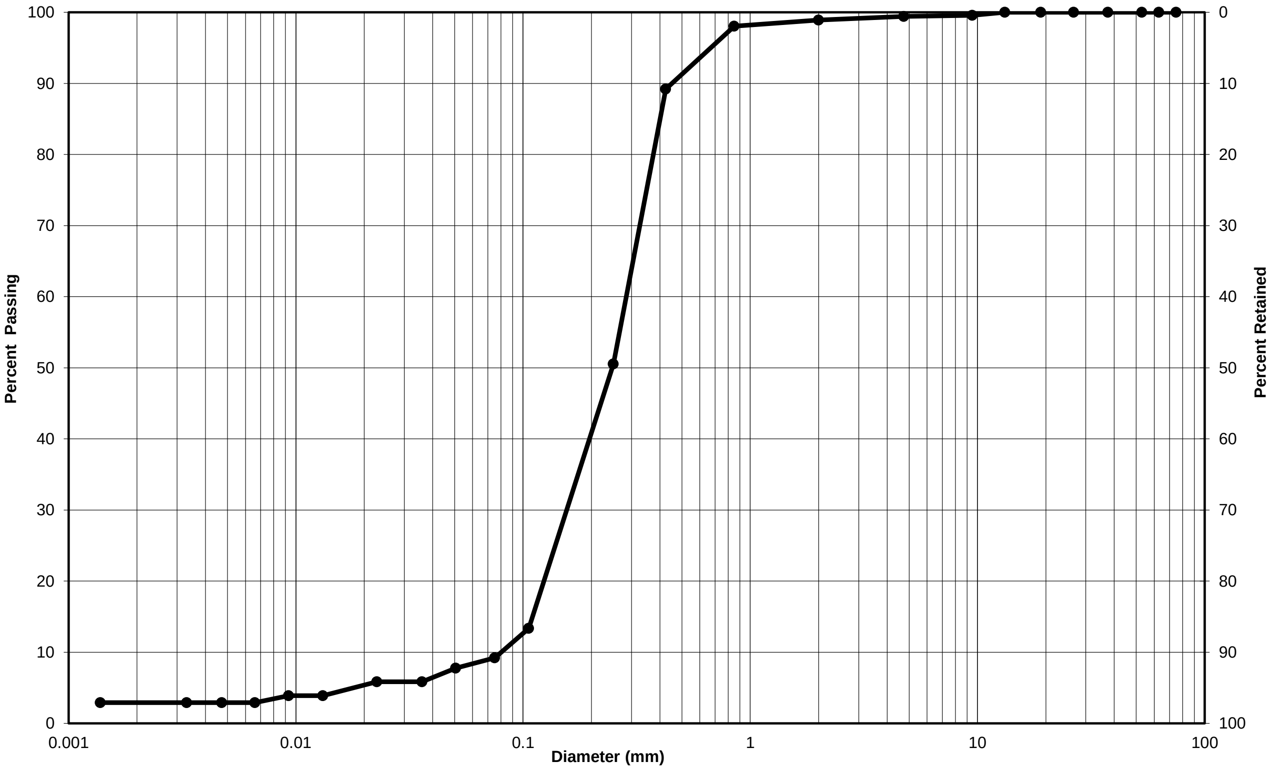
Remarks:

Performed by:	M.Chan	**Date:**	July 27, 2021
Verified by:	Joe Sullivan	**Date:**	August 5, 2021

Particle-Size Analysis of Soils (Geotechnical) (USCS) (ASTM D422)

Client: Crown Barrie Developments Inc.
Lab No.: SS-D-21-23
Project/Site: Proposed Mix Use Condominium Development
Project No.: 11226647

Borehole no.: BH3
Sample no.: SS10
Depth: 25'-27'
Enclosure:



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse
Unified Soil Classification System					

Soil Description	Gravel (%)	Sand (%)	Clay & Silt (%)
Well graded sand with silt (SW-SM)	1	90	9
Silt-size particles (%):	6		
Clay-size particles (%) (<0.002mm):	3		

Remarks:

Performed by: M.Chan
Date: July 27, 2021
Verified by: Joe Sullivan
Date: August 5, 2021

Particle-Size Analysis of Soils (Geotechnical)
(USCS) (ASTM D422)

Client: Crown Barrie Developments Inc.

Lab No.: SS-D-21-23

Project/Site: Proposed Mix Use Condominium Development

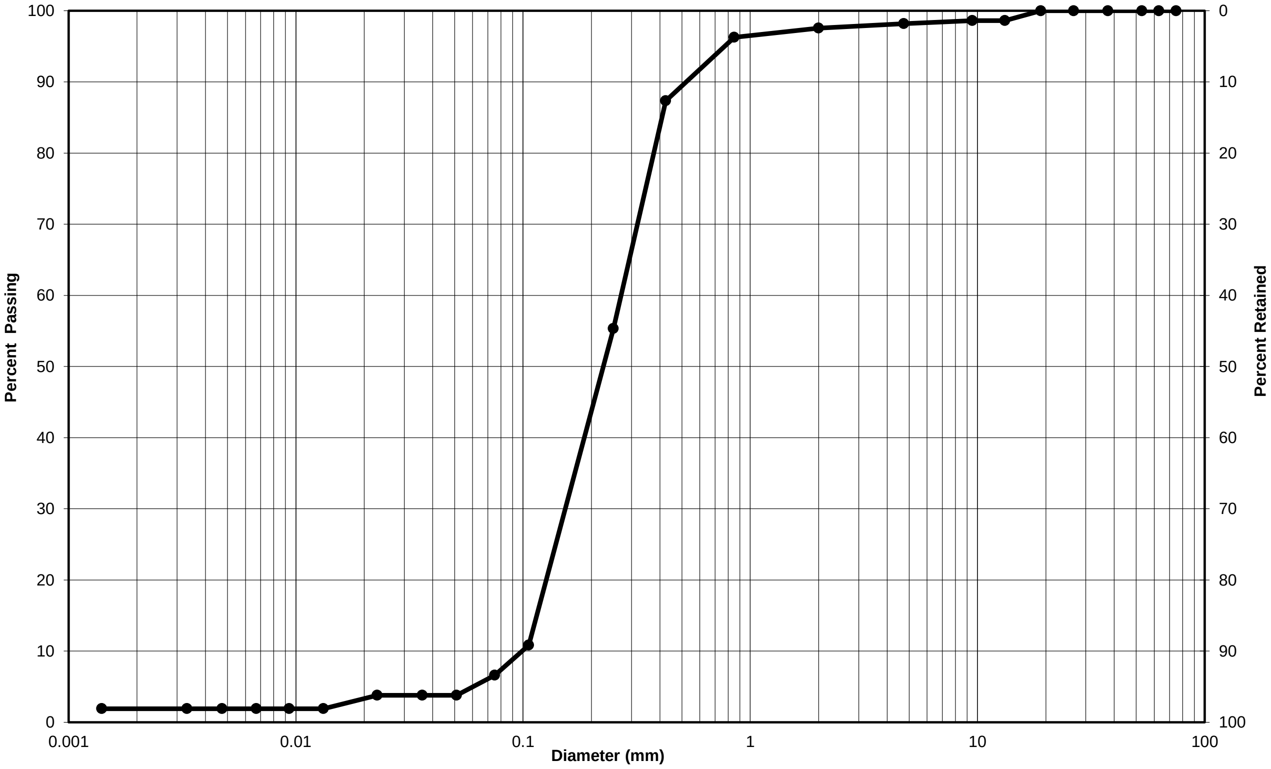
Project No.: 11226647

Borehole no.: BH3

Sample no.: SS13

Depth: 40'-42'

Enclosure:



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse
Unified Soil Classification System					

Soil Description	Gravel (%)	Sand (%)	Clay & Silt (%)
Poorly graded sand with silt (SP-SM)	1	92	7
Silt-size particles (%):	5		
Clay-size particles (%) (<0.002mm):	2		

Remarks:

Performed by: M.Chan

Date: July 27, 2021

Verified by: Joe Sullivan Joe Sullivan

Date: August 5, 2021

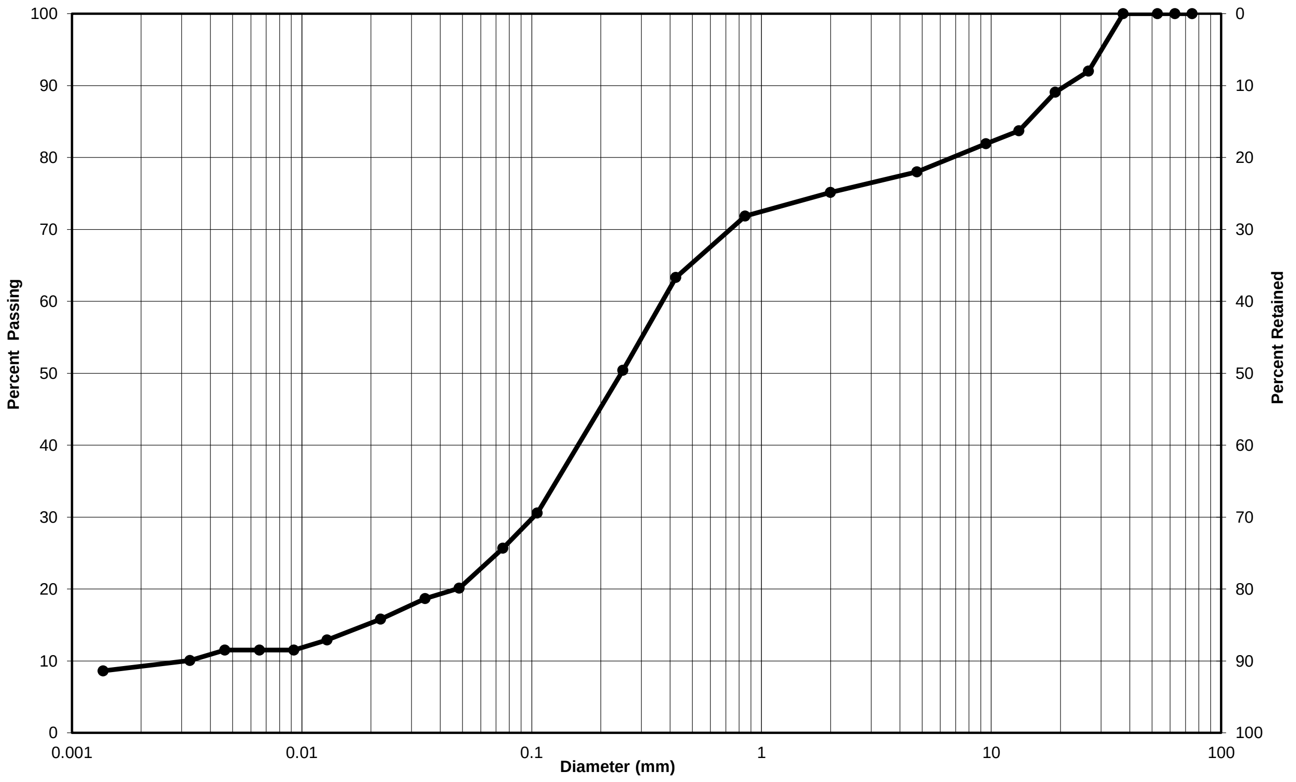
Particle-Size Analysis of Soils (Geotechnical) (USCS) (ASTM D422)

Client: Crown Barrie Developments Inc.
Lab No.: SS-D-21-23

Project/Site: Proposed Mix Use Condominium Development
Project No.: 11226647

Borehole no.: BH4
Sample no.: SS3

Depth: 5'-7'
Enclosure:



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse
Unified Soil Classification System					

Soil Description	Gravel (%)	Sand (%)	Clay & Silt (%)
Silty sand with gravel (SM)	22	52	26
Silt-size particles (%):	17		
Clay-size particles (%) (<0.002mm):	9		

Remarks:

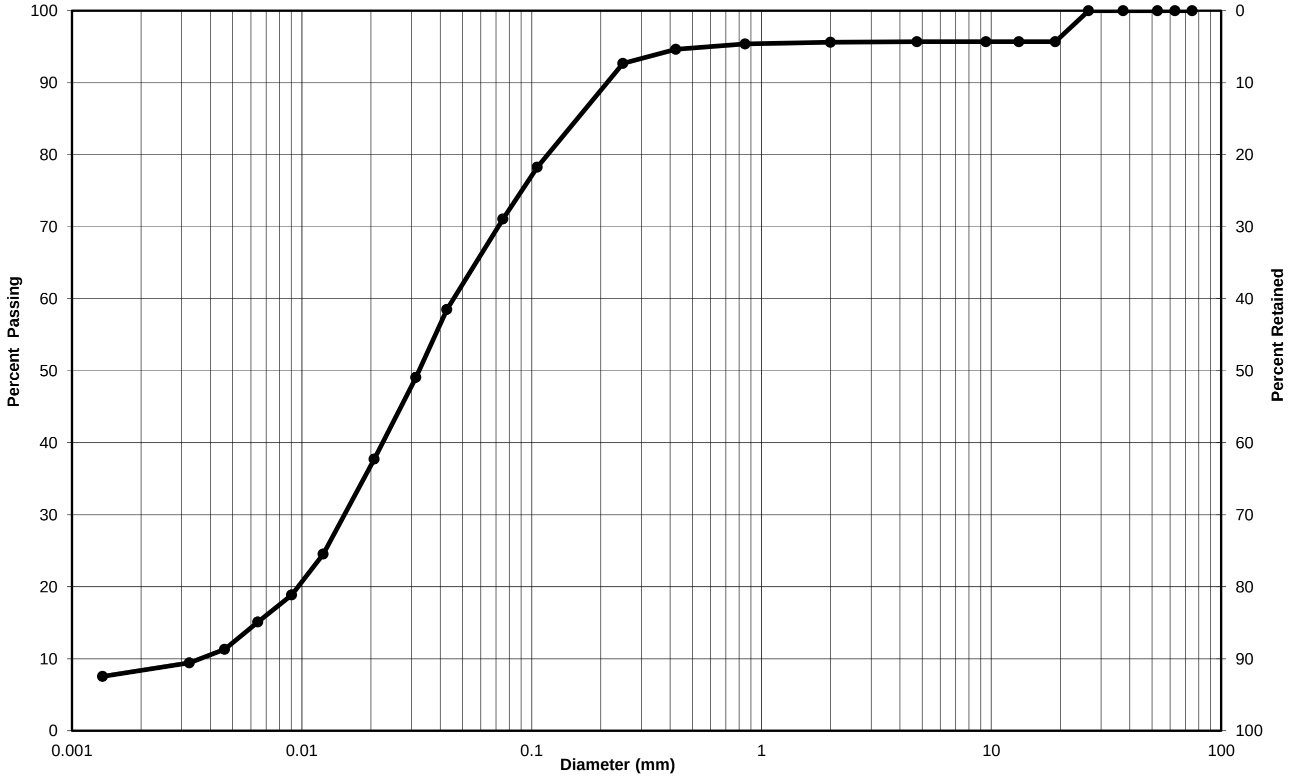
Performed by: M.Chan
Date: July 27, 2021

Verified by: Joe Sullivan
Date: August 5, 2021

Particle-Size Analysis of Soils (Geotechnical)
(USCS) (ASTM D422)

Client: Crown Barrie Developments Inc.
Lab No.: SS-D-21-23
Project/Site: Proposed Mix Use Condominium Development
Project No.: 11226647

Borehole no.: BH4
Sample no.: SS9
Depth: 20'-22'
Enclosure:



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse
Unified Soil Classification System					

Soil Description	Gravel (%)	Sand (%)	Clay & Silt (%)
Silt with sand (ML)	4	25	71
Silt-size particles (%):	63		
Clay-size particles (%) (<0.002mm):	8		

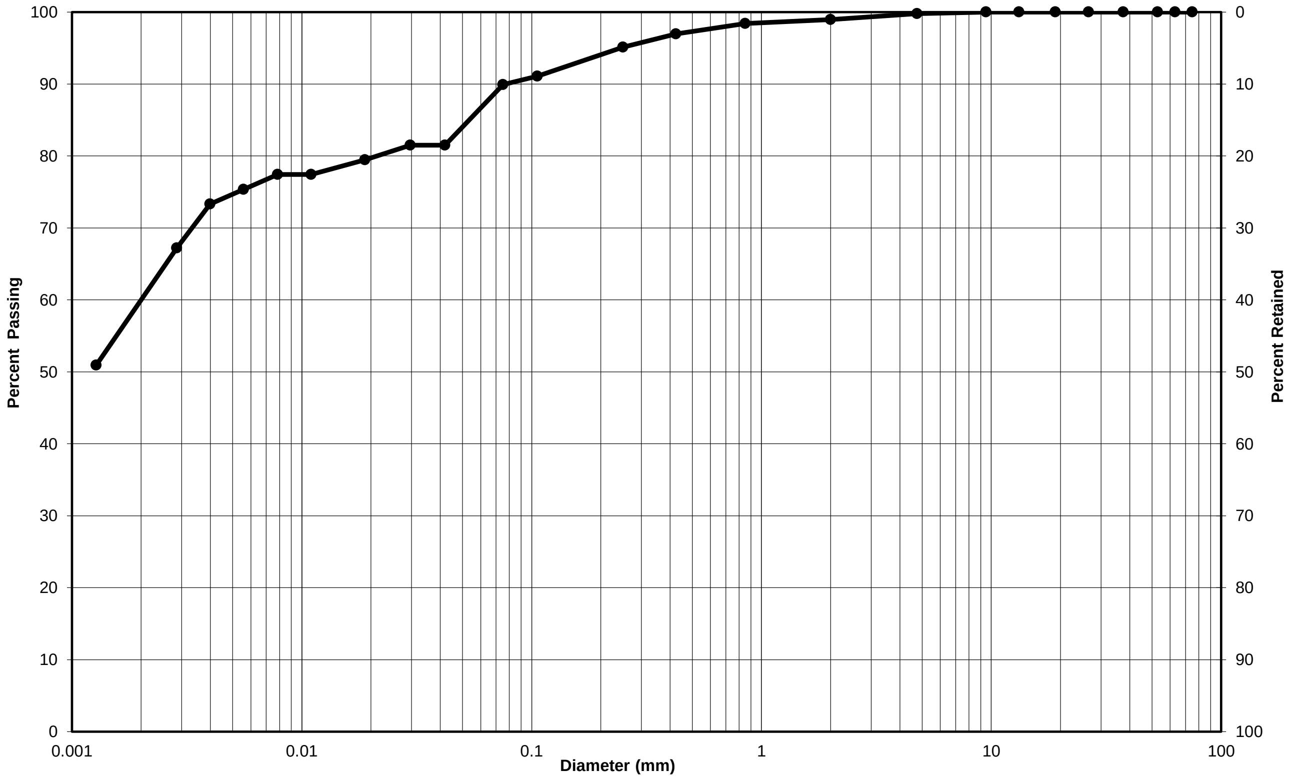
Remarks:

Performed by: M.Chan
Date: July 27, 2021
Verified by: Joe Sullivan
Date: August 5, 2021

Particle-Size Analysis of Soils (Geotechnical)
(USCS) (ASTM D422)

Client:	Crown Barrie Development Inc.	**Lab No.:**	SS-D-21-23
Project/Site:	Proposed Mix Use Condominium Development	**Project No.:**	11226647

Borehole no.:	BH5	Sample no.:	SS3
Depth:	5'-7'	Enclosure:	



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse
Unified Soil Classification System					

Soil Description	Gravel (%)	Sand (%)	Clay & Silt (%)
Silty Clay trace Sand	0	10	90
Silt-size particles (%):	32		
Clay-size particles (%) (<0.002mm):	58		

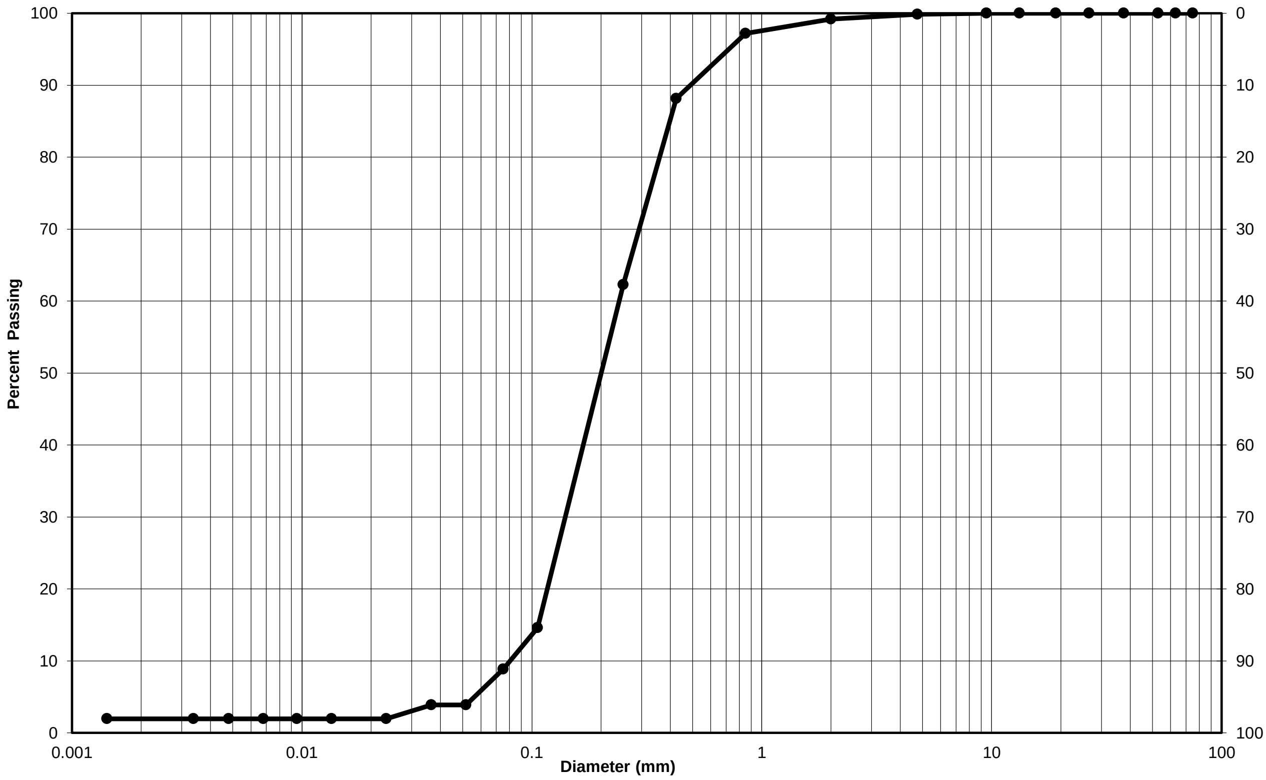
Remarks:

Performed by:	M.Chan	**Date:**	July 27, 2021
Verified by:	Joe Sullivan	**Date:**	August 5, 2021

Particle-Size Analysis of Soils (Geotechnical)
(USCS) (ASTM D422)

Client:	Crown Barrie Developments Inc.	**Lab No.:**	SS-D-21-23
Project/Site:	Proposed Mix Use Condominium Development	**Project No.:**	11226647

Borehole no.:	BH5	Sample no.:	SS10
Depth:	35'-37'	Enclosure:	



<table>
<tr><td rowspan="2">Clay & Silt</td><td colspan="3">Sand</td><td colspan="2">Gravel</td></tr>
<tr><td>Fine</td><td>Medium</td><td>Coarse</td><td>Fine</td><td>Coarse</td></tr>
<tr><td colspan="6">Unified Soil Classification System</td></tr>
</table>

Soil Description	**Gravel (%)**	**Sand (%)**	**Clay & Silt (%)**
Poorly graded sand with silt (SP-SM)	0	91	9
Silt-size particles (%):	7		
Clay-size particles (%) (<0.002mm):	2		

Remarks:

Performed by:	M.Chan	**Date:**	July 27, 2021
Verified by:	Joe Sullivan	**Date:**	August 5, 2021

Appendix B2

Laboratory Atterberg Limit Test Results

Liquid Limit, Plastic Limit and Plasticity Index of Soils
(ASTM D4318)

Client: Crown Barrie Devlopments Inc. **Lab no.:** SS-D-21-23

Project/Site: Proposed Mix Use Condominium Development **Project no.:** 11226647-02

Borehole no.: BH3 Sample no.: SS5 Depth: 10'-12'
Soil Description: Date sampled:

Apparatus: Hand Crank Balance no.: 1 Porcelain bowl no.: 1
Liquid limit device no.: 1 Oven no.: WH-1031 Spatula no.: 1
Sieve no.: n/a Glass plate no.: 1

Liquid Limit (LL):

	Test No. 1	Test No. 2	Test No. 3
Number of blows			
Water Content:			
Tare no.			
Wet soil+tare, g			
Dry soil+tare, g			
Mass of water, g			
Tare, g			
Mass of soil, g			
Water content %			

Plastic Limit (PL) - Water Content:

Tare no.		
Wet soil+tare, g		
Dry soil+tare, g		
Mass of water, g		
Tare, g		
Mass of soil, g		
Water content %		
Average water content %		

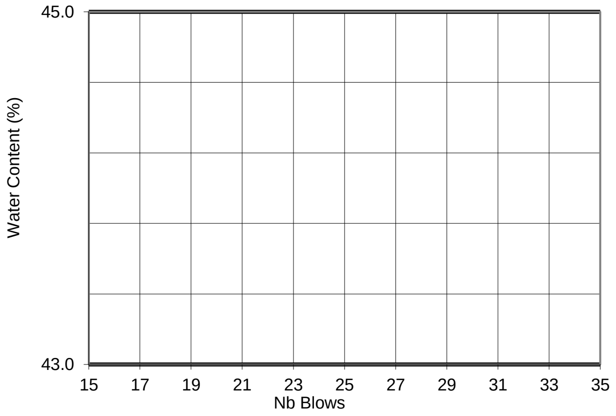
Natural Water Content (W^n):

Tare no.	118	
Wet soil+tare, g	103.50	
Dry soil+tare, g	97.30	
Mass of water, g	6.20	
Tare, g	19.70	
Mass of soil, g	77.60	
Water content %	8.0%	

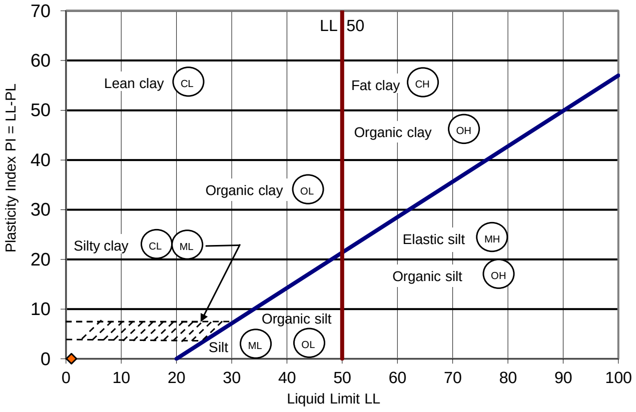
Soil Preparation:

☑ Cohesive <425 µm
☐ Cohesive >425 µm
☐ Non-cohesive
☑ Dry preparation
☐ Wet preparation

Results



Soil Plasticity Chart ASTM D2487



Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	Natural Water Content W^n
-	-	NP	8.0

Remarks:

Performed by: T.Watkins **Date:** August 12, 2021

Verified by: Joe Sullivan **Date:** August 13, 2021

Liquid Limit, Plastic Limit and Plasticity Index of Soils
(ASTM D4318)

Client: Crown Barrie Devlopments Inc. **Lab no.:** SS-D-21-23

Project/Site: Proposed Mix Use Condominium Development **Project no.:** 11226647-02

Borehole no.: BH5 Sample no.: SS3 Depth: 5'-7'

Soil Description: Lean Clay (CL) Date sampled:

Apparatus: Hand Crank Balance no.: 1 Porcelain bowl no.: 1

Liquid limit device no.: 1 Oven no.: WH-1031 Spatula no.: 1

Sieve no.: n/a Glass plate no.: 1

Soil Preparation:

☑ Cohesive <425 µm ☑ Dry preparation

☐ Cohesive >425 µm ☐ Wet preparation

☐ Non-cohesive

Liquid Limit (LL):

	Test No. 1	Test No. 2	Test No. 3
Number of blows	27	23	19
Water Content:			
Tare no.	22	23	25
Wet soil+tare, g	26.39	23.08	25.92
Dry soil+tare, g	22.50	20.16	22.03
Mass of water, g	3.89	2.92	3.89
Tare, g	14.48	14.33	14.53
Mass of soil, g	8.02	5.83	7.50
Water content %	48.5%	50.1%	51.9%

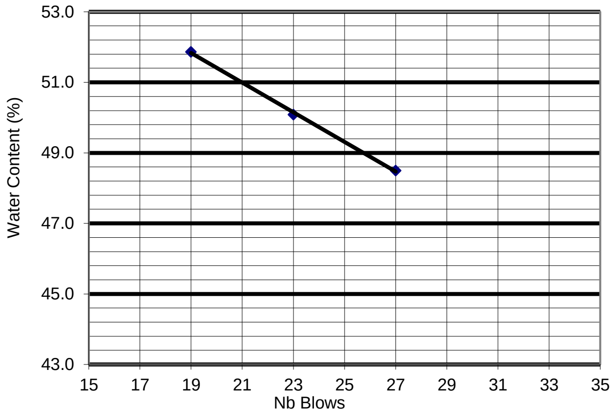
Plastic Limit (PL) - Water Content:

Tare no.	H	7
Wet soil+tare, g	19.07	20.78
Dry soil+tare, g	18.23	19.60
Mass of water, g	0.84	1.18
Tare, g	14.36	14.24
Mass of soil, g	3.87	5.36
Water content %	21.7%	22.0%
Average water content %	21.9%	

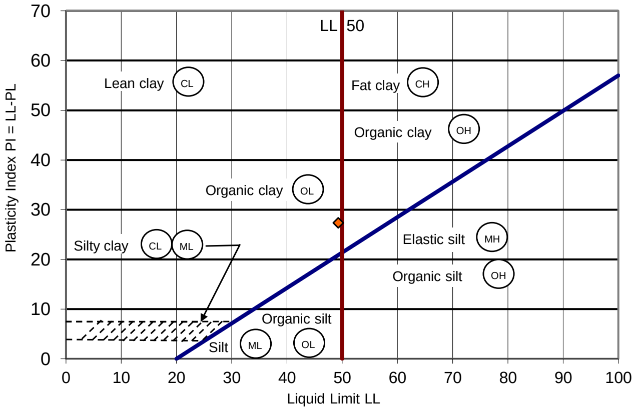
Natural Water Content (W^n):

Tare no.	128	
Wet soil+tare, g	61.70	
Dry soil+tare, g	52.60	
Mass of water, g	9.10	
Tare, g	22.20	
Mass of soil, g	30.40	
Water content %	29.9%	

Results



Soil Plasticity Chart ASTM D2487



Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	Natural Water Content W^n
49	22	27	29.9

Remarks:

Performed by: T.Watkins **Date:** August 12, 2021

Verified by: Joe Sullivan **Date:** August 13, 2021

Appendix C

Corrosivity Testing Laboratory Certificates

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: ---

REPORT No. B21-25509

Report To:

GHD Limited
455 Phillip Street,
Waterloo Ontario N2L 3X2 Canada
Attention: Puneet Verma

Caduceon Environmental Laboratories
110 West Beaver Creek Rd Unit 14
Richmond Hill ON L4B 1J9
Tel: 289-475-5442
Fax: 289-562-1963

DATE RECEIVED: 12-Aug-21

DATE REPORTED: 18-Aug-21

SAMPLE MATRIX: Soil

JOB/PROJECT NO.: 1012 Yonge St/11226647-02

P.O. NUMBER:

WATERWORKS NO.

Parameter	Qty	Site Analyzed	Analyst Initials	Date Analyzed	Lab Method	Reference Method
Conductivity	2	Holly Lane	ST	17-Aug-21	A-COND-01 (o)	SM 2510B
Anions	2	Holly Lane	pcu	17-Aug-21	A-IC-01 (o)	SM4110C
pH	2	Richmond Hill	HAZ	12-Aug-21	A-pH-02 (rh)	MOEE3530
Physical	2	Richmond Hill	HAZ	13-Aug-21	A-REDOX	In-House
A - Wet Chem	2	Default Site	TES	17-Aug-21	S-Sulphide	In-House

µg/g = micrograms per gram (parts per million) and is equal to mg/Kg
F1 C6-C10 hydrocarbons in µg/g, (F1-btex if requested)
F2 C10-C16 hydrocarbons in µg/g, (F2-napth if requested)
F3 C16-C34 hydrocarbons in µg/g, (F3-pah if requested)
F4 C34-C50 hydrocarbons in µg/g
This method complies with the Reference Method for the CWS PHC and is validated for use in the laboratory.
Any deviations from the method are noted and reported for any particular sample.
nC6 and nC10 response factor is within 30% of response factor for toluene:
nC10,nC16 and nC34 response factors within 10% of each other:
C50 response factors within 70% of nC10+nC16+nC34 average:
Linearity is within 15%:
All results expressed on a dry weight basis.
Unless otherwise noted all chromatograms returned to baseline by the retention time of nC50.

Unless otherwise noted all extraction, analysis, QC requirements and limits for holding time were met.
If analyzed for F4 and F4G they are not to be summed but the greater of the two numbers are to be used in application to the CWS PHC
QC will be made available upon request.

O. Reg 406/19 - Ontario Regulation 406/19
Tbl. 2.1 - Res/Park/Insti - Bulk - Residental/Parkland/Institutional
Tbl. 3.1 - Res/Park/Insti - Bulk - Residental/Parkland/Institutional

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

Steve Garrett
Director of Laboratory Services

CADUCEON
ENVIRONMENTAL LABORATORIES
Client committed. Quality assured.

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: ---

REPORT No. B21-25509

Report To:
GHD Limited
455 Phillip Street,
Waterloo Ontario N2L 3X2 Canada
Attention: Puneet Verma

Caduceon Environmental Laboratories
110 West Beaver Creek Rd Unit 14
Richmond Hill ON L4B 1J9
Tel: 289-475-5442
Fax: 289-562-1963

DATE RECEIVED: 12-Aug-21
DATE REPORTED: 18-Aug-21
SAMPLE MATRIX: Soil

JOB/PROJECT NO.: 1012 Yonge St/11226647-02
P.O. NUMBER:
WATERWORKS NO.

	Client I.D.		BH#2/SS#9	BH#5/SS#7			**O. Reg 406/19**	
	Sample I.D.		B21-25509-1	B21-25509-2			**Tbl. 2.1 - Res/Park/Insti**	**Tbl. 3.1 - Res/Park/Insti**
	Date Collected		11-Aug-21	06-Aug-21				
Parameter	**Units**	**R.L.**						
pH @25°C	pH Units		8.22	8.34				
Resistivity	ohms·cm		18200	7350				
REDOX potential	mV		260	270				
Chloride	µg/g	5	27	34				
Sulphate	µg/g	10	20	< 10				
Sulfide	µg/g	0.3	< 0.3 [1]	< 0.3 [1]				

1. Subcontracted to Testmark Labs

O. Reg 406/19 - Ontario Regulation 406/19
Tbl. 2.1 - Res/Park/Insti - Bulk - Residental/Parkland/Institutional
Tbl. 3.1 - Res/Park/Insti - Bulk - Residental/Parkland/Institutional

Steve Garrett
Director of Laboratory Services

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: --- **REPORT No. B21-25509**

Report To:

GHD Limited
455 Phillip Street,
Waterloo Ontario N2L 3X2 Canada
Attention: Puneet Verma

Caduceon Environmental Laboratories
110 West Beaver Creek Rd Unit 14
Richmond Hill ON L4B 1J9
Tel: 289-475-5442
Fax: 289-562-1963

DATE RECEIVED: 12-Aug-21
DATE REPORTED: 18-Aug-21
SAMPLE MATRIX: Soil

JOB/PROJECT NO.: 1012 Yonge St/11226647-02
P.O. NUMBER:
WATERWORKS NO.

Summary of Exceedances

O. Reg 406/19 - Ontario Regulation 406/19
Tbl. 2.1 - Res/Park/Insti - Bulk - Residental/Parkland/Institutional
Tbl. 3.1 - Res/Park/Insti - Bulk - Residental/Parkland/Institutional

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

Steve Garrett
Director of Laboratory Services

ghd.com

→ The Power of Commitment