Soil Engineers Ltd.
CONSULTING ENGINEERS
GEOTECHNICAL • ENVIRONMENTAL • HYDROGEOLOGICAL • BUILDING SCIENCE
90 WEST BEAVER CREEK ROAD, SUITE #100, RICHMOND HILL, ONTARIO L4B 1E7 · TEL (416) 754-8515 · FAX (905) 881-8335

BARRIE	MISSISSAUGA	OSHAWA	NEWMARKET	GRAVENHURST	PETERBOROUGH	HAMILTON
TEL: (705) 721-7863	TEL: (905) 542-7605	TEL: (905) 440-2040	TEL: (905) 853-0647	TEL: (705) 684-4242	TEL: (905) 440-2040	TEL: (905) 777-7956
FAX: (705) 721-7864	FAX: (905) 542-2769	FAX: (905) 725-1315	FAX: (905) 881-8335	FAX: (705) 684-8522	FAX: (905) 725-1315	FAX: (905) 542-2769

A REPORT TO
LAW DEVELOPMENT GROUP

A GEOTECHNICAL INVESTIGATION FOR PROPOSED RESORT

CRANBERRY HARBOUR CASTLE
15 HARBOUR STREET EAST AND 300 BALSAM STREET

TOWN OF COLLINGWOOD

REFERENCE NO. 1803-S101

JUNE 2018

DISTRIBUTION

3 Copies - Law Development Group
1 Copy - Soil Engineers Ltd. (Barrie)
1 Copy - Soil Engineers Ltd. (Richmond Hill)

TABLE OF CONTENTS

TABLES

DIAGRAM

ENCLOSURES

1.0 INTRODUCTION

In accordance with written authorization dated March 22, 2018, from Mr. Larry Law of Law Development Group, a geotechnical investigation was carried out at 15 Harbour Street East and 300 Balsam Street, in the Town of Collingwood, for a proposed Resort.

The purpose of the investigation was to reveal the subsurface conditions and determine the engineering properties of the disclosed soils for the design and construction of the proposed project.

The geotechnical findings and resulting recommendations are presented in this Report.

It should be noted that Soil Engineers Ltd. has completed a previous borehole investigation at this site (Soil Engineers Ltd. report, Reference No. 0608-S050, dated November 2006); the findings for select boreholes from the 2006 investigation have been incorporated into this report.

2.0 SITE AND PROJECT DESCRIPTION

The Town of Collingwood is situated in the Simcoe Lowlands bordering the Niagara Escarpment where lacustrine sand, silt and clay deposits, outwash sands and glacial till have bedded onto undulated Black River and Trenton Group of bedrock.

The investigated site is located at the north portion of 15 Harbour Street East and at 300 Balsam Street, in the Town of Collingwood. An existing resort, the Living Water Resort & Residences, is located on the south portion of the property at 15 Harbour Street East, and an existing banquet hall, the Bear Estate, is located at 300 Balsam Street within the northeast portion of the investigated site. The area north of the existing resort is generally grass-, weed- and tree-covered, with an asphalt paved parking lot located to the southeast. The site is located on the southwest shoreline of Nottawasaga Bay. The ground surface throughout the majority of the investigated area is relatively flat; however, the site slopes upwards in the west portion of the site.

It is understood that the proposed project will consist of a new 5-storey addition to the existing resort, with on-grade and above-ground parking. In addition, it is understood that a 4-storey addition is proposed above the existing Bear Estate banquet hall. The development will be provided with municipal services and an access roadway meeting current urban standards.

3.0 FIELD WORK

The current field work, consisting of 9 boreholes to depths of 3.8 to 5.5 m, was performed on April 17 and 18, 2018, at the locations shown on the Borehole Location Plan, Drawing No. 1. The boreholes carried out for this investigation have been labelled in the 100-series to differentiate the boreholes from the boreholes carried out during the 2006 investigation.

The holes were advanced at intervals to the sampling depths by a track-mounted, continuous-flight power-auger machine equipped for soil sampling. Standard Penetration Tests, using the procedures described on the enclosed “List of Abbreviations and Terms”, were performed at the sampling depths. The test results are recorded as the Standard Penetration Resistance (or ‘N’ values) of the subsoil. The relative density of the granular strata and the consistency of the cohesive strata are inferred from the ‘N’ values. Split-spoon samples were recovered for soil classification and laboratory testing.

The field work was supervised and the findings were recorded by a Geotechnical Technician.

The elevation at each of the borehole locations was determined with reference to the site bench mark, a catch basin manhole (CBMH11) located near the front entrance to the Bear Estate banquet hall, as shown on Drawing No. 1. It has a geodetic elevation of 178.39 m.

4.0 SUBSURFACE CONDITIONS

Detailed descriptions of the encountered subsurface conditions at the boreholes are presented on the Borehole Logs, comprising Figures 1 to 9, inclusive. The revealed stratigraphy is plotted on the Subsurface Profile, Drawing No. 2. In addition, 2 of the boreholes conducted in 2006 are within the area of the currently proposed development. The Borehole Logs for these boreholes, Boreholes 7 and 8, are included in the Appendix. The engineering properties of the disclosed soils are discussed herein.

The investigations have disclosed that generally beneath a layer of topsoil or topsoil fill, a layer of granular/earth fill in places, the site is primarily underlain by strata of silty sand till and gravelly sand, with layers of sandy silt till, fine and fine to coarse grained sand, silty fine sand and silt encountered at various locations and depths. In addition, organic layers and a flood deposit closer to the water were encountered in places.

4.1 **Topsoil** (Boreholes 102, 105, 107 and 108) and **Topsoil Fill** (Boreholes 101, 103, 104, 106 and 109)

The topsoil veneer found at various locations throughout the site is approximately 20 to 23 cm thick, with a thicker topsoil fill layer encountered in the remaining areas throughout the site. The topsoil fill extends to depths of 0.5± to 2.0± m from the prevailing ground surface. The topsoil and topsoil fill are dark brown in colour, indicating that they contain appreciable amounts of roots and humus. These materials are compressible under loads; therefore, the topsoil and topsoil fill are considered to be void of engineering value. Due to their humus content, the topsoil and topsoil fill will generate an offensive odour and may produce volatile gases under anaerobic conditions. Therefore, the topsoil and topsoil fill must not be buried below any structures or deeper than 1.2 m below the exterior finished grade so they will not have an adverse impact on the environmental well-being of the developed area.

Topsoil or topsoil fill thicker than that found in the boreholes may occur in places. In order to prevent overstripping, diligent control of the stripping operation will be required.

Since the topsoil and topsoil fill are void of engineering value, they can only be used for general landscape contouring purposes. Their suitability for planting and sodding purposes can be further assessed by fertility testing.

4.2 **Organics** (Borehole 105) and **Flood Deposit** (Borehole 109)

An organic layer consisting of wood debris and material that appears to be cinder was encountered at Borehole 105 at a depth of 1.5± m below the prevailing ground surface; it was found interstratified with the silty sand till. In addition, a water-laid sand deposit containing some organics and wood debris was encountered in Borehole 109, near to the shoreline, at a depth of 1.8± m below the prevailing ground surface, indicating this appears to be a flood deposit.

The natural water content of the samples was determined and the results are plotted on the Borehole Logs; the values are 42% for the organic deposit consisting of wood and cinder, and 55% for the flood deposit, indicating the samples are in a wet condition and/or contain organics.

The soils containing roots and humus, particularly the organic deposit, are highly compressible under loading conditions with low shear strength. They will likely generate volatile gases under anaerobic conditions. They are void of engineering value.

A test pit programme can be carried out to determine the extent of the organics and flood deposit prior to and/or during the construction of the project.

4.3 **Earth Fill** (Boreholes 103, 104, 106, 107 and 108)

The earth fill was found beneath the topsoil or topsoil fill layers and extend to depths of 1.0± to 1.5± m below the prevailing ground surface. The earth fill consists of sand with varying amounts of silt and gravel; the fill contains organics, including wood and cinder, in places.

The obtained ‘N’ values range from 4 to 44, with a median of 12 blows per 30 cm of penetration, indicating that the earth fill was placed with some compaction effort at various locations.

The natural water content of the samples was determined and the results are plotted on the Borehole Logs; the values range from 10% to 30%, with a median of 20%, indicating that the earth fill is in a moist to wet condition.

Due to the unknown history of the earth fill, its non-uniform density, and the presence of organic inclusions, the fill is unsuitable for supporting any structures in its current condition. In using the fill for structural backfill, or in pavement or slab-on-grade construction, it should be subexcavated, inspected, sorted free of topsoil inclusions and any deleterious materials, aerated and properly recompacted in thin lifts. If it is impractical to sort the topsoil and other deleterious materials from the fill, the fill must be wasted and replaced with properly compacted inorganic earth fill.

The fill is amorphous in structure; it will ravel and is susceptible to collapse in steep cuts, particularly if the fill is in a wet condition.

A test pit programme can be carried out to determine the extent of the earth fill prior to and/or during the construction of the project.

One must be aware that the samples retrieved from boreholes 10 cm in diameter may not be truly representative of the geotechnical and environmental quality of the fill, and do not indicate whether the topsoil beneath the earth fill was completely stripped. This should be further assessed by laboratory testing and/or test pits.

4.4 **Silty Sand Till** (All Boreholes) and **Sandy Silt Till** (Borehole 109)

The silty sand till was encountered at varying depths throughout the site; it extends to the maximum investigated depth at all boreholes except Boreholes 105 and 107. In addition, a layer of sandy silt till was encountered overlying the silty sand till at Borehole 109. The tills consist of a random mixture of soils; the particle sizes range from clay to gravel, with the either the sand or silt fraction exerting the dominant influence on their soil properties. The tills are heterogeneous and amorphous, in places, with occasional wet sand and silt seams and layers, cobbles and boulders, showing they are glacial deposits which have been partially reworked by the past glaciation.

The obtained ‘N’ values for the silty sand till range from 22 per 30 cm to 50 per 0 cm, with a median of 50 per 15 cm, indicating that its relative density is compact to very dense, being generally very dense. The obtained ‘N’ value for the sandy silt till is 34 per 30 cm, indicating that its relative density is dense.

The natural water content of the samples was determined and the results are plotted on the Borehole Logs; the values for the silty sand till range from 6% to 14%, with a median of 11%, and the value for the sandy silt till is 16%. This indicates that the tills are in a damp to very moist, generally moist condition.

A grain size analysis was performed on the sandy silt till sample; the result is plotted on Figure 10.

Based on the above findings, the deduced engineering properties pertaining to the project are given below:

- High frost susceptibility and moderately low water erodibility.
- Medium to low permeability, with an estimated coefficient of permeability of 10^{-4} to 10^{-6} cm/sec, and runoff coefficients of:

Slope	
0% - 2%	0.07 to 0.15
2% - 6%	0.12 to 0.20
6% +	0.18 to 0.28

- Frictional soils, their shear strength is primarily derived from internal friction and is augmented by cementation. Therefore, their strength is primarily soil density dependent.
- In steep cuts, they will be stable; however, under prolonged exposure, localized sheet collapse will occur, particularly where the wet sand and silt layers are prevalent.
- Fair pavement-supportive materials, with an estimated California Bearing Ratio (CBR) value of 8% to 10%.
- Moderate to moderately low corrosivity to buried metal, with an estimated electrical resistivity of 4500 to 5000 ohm·cm.

4.5 **Gravelly Sand** (Boreholes 102, 104, 105, 107, 108 and 109) and **Sand** (Boreholes 101 and 103)

The sand deposits were encountered at varying depths. The gravelly sand particles are subangular in shape and contain a trace to some silt. The sand is fine to coarse grained and contains some silt and gravel with a trace of clay in places. The sorted structure shows that the sands are glaciolacustrine deposits. The gravelly sand within the upper 0.6± to 1.5± m, in places, has been loosened by the weathering process.

The obtained 'N' values for the gravelly sand range from 6 per 30 cm to 50 per 0 cm, with a median of 27 per 30 cm, and the 'N' value for the fine to coarse sand is 34 per 30 cm. This indicates that the relative density of the gravelly sand is loose to very dense, being generally compact, while the relative density of the fine to coarse sand is dense. The loose gravelly sand occurred within the weathered zone.

The natural water content of the samples was determined and the results are plotted on the Borehole Logs; the values for the gravelly sand range from 7% to 38%, with a median of 12%, and the values for the fine to coarse sand are 10% and 18%. This indicates that the sands are in a moist to wet, generally very moist condition. The high water content value of 38% in the gravelly sand at Borehole 108 is indicative of the wood and cinder encountered in the gravelly sand at this location. Due to the pervious nature of the sands, some of the water may have drained during sample retrieval and, therefore, the determined values may not represent the actual water content.

Grain size analyses were performed on 1 representative sample each of the gravelly sand and fine to coarse sand; the results are plotted on Figure 11.

Based on the above findings, the deduced engineering properties pertaining to the project are given below:

- Low frost susceptibility and high water erodibility.
- Susceptible to migration through small openings under seepage pressure.
- Pervious, with an estimated coefficient of permeability of 10^{-2} to 10^{-3} cm/sec, and runoff coefficients of:

Slope	
0% - 2%	0.04
2% - 6%	0.09
6% +	0.13

- Frictional soils, their shear strength is derived from internal friction and is soil density dependent.
- In steep cuts, the sands will slough; they will run with seepage and boil under a piezometric head of 0.4 m.
- Good pavement-supportive materials, with an estimated CBR value of 25% to 30%.
- Low corrosivity to buried metal, with an estimated electrical resistivity of 6500 to 7000 ohm·cm.

4.6 **Silty Fine Sand and Silt** (Borehole 106)

The silty fine sand and silt were found overlying the silty sand till at Borehole 106. The silty fine sand contains a trace of clay, while the silt contains traces of clay and sand. The sorted structure indicates that the silty fine sand and sandy silt are glaciolacustrine deposits. These soils were only found in one borehole; therefore, their occurrence is likely to be localized.

The obtained 'N' value for the silty fine sand and silt is 50 per 15 cm, indicating that their relative density is very dense.

The natural water content of the samples was determined and the results are plotted on the Borehole Log; the value for the silty fine sand is 19%, and the value for the silt is 13%. This indicates that the silty fine sand and silt are in a very moist to wet condition; they displayed dilatancy when wetted and shaken by hand.

Based on the above findings, the deduced engineering properties pertaining to the project are given below:

- High frost susceptibility and high soil-adfreezing potential.
- High water erodibility; they are susceptible to migration through small openings under seepage pressure.
- Soils of high capillarity and water retention capacity.
- Relatively pervious, with an estimated coefficient of permeability of 10^{-4} cm/sec, and runoff coefficients of:

Slope	
0% - 2%	0.07
2% - 6%	0.12
6% +	0.18

- Frictional soils, their shear strength is primarily derived from internal friction and is soil density dependent. Due to their dilatancy, the strength of the wet sand and silt is susceptible to impact disturbance; i.e., the disturbance will induce a build-up of pore pressure within the soil mantle, resulting in soil dilation and a reduction of shear strength.
- In excavation, the wet sand and silt will slough in steep cuts, run slowly with water seepage, and boil under a piezometric head of 0.4 m.

- Fair pavement-supportive materials, with an estimated CBR value of 8%.
- Moderately low corrosivity to buried metal, with an estimated electrical resistivity of 5000 ohm·cm.

4.7 **Soils from 2006 Geotechnical Investigation** (Boreholes 7 and 8)

The subsurface soils from Boreholes 7 and 8 of the 2006 investigation were utilized in this report preparation as they were conducted within the areas of the proposed development.

The subsurface soil information from previous borehole investigation shows that beneath a layer of fill, consisting of granular/sand extending to a depth of 1.2± to 1.5± m below the prevailing ground surface, the area of Boreholes 7 and 8 is underlain by compact to very dense silty sand till, and very dense fine and fine to coarse grained sand. The soils contain rock fragments.

4.8 **Interpretation of Refusal to Augering** (All Boreholes, and Boreholes 7 and 8)

Refusal to augering or Standard Penetration Tests (SPT) was encountered in all boreholes at depths ranging from 3.8 to 5.8 m below the prevailing ground surface, or elevations 174.6 to 173.4 m. It is inferred that boulders, or bedrock, occur at these levels.

4.9 **Compaction Characteristics of the Revealed Soils**

The obtainable degree of compaction is primarily dependent on the soil moisture and, to a lesser extent, on the type of compactor used and the effort applied. As a general guide, the typical water content values of the revealed soils for Standard Proctor compaction are presented in Table 1.

Table 1 - Estimated Water Content for Compaction

Soil Type	Determined Natural Water Content (%)	Water Content (%) for Standard Proctor Compaction	
		100% (optimum)	Range for 95% or +
Earth Fill	10 to 30 (median 20)	11	5 to 16
Silty Sand Till	6 to 14 (median 11)	10	6 to 15
Sandy Silt Till	16	11	6 to 16
Gravelly Sand	7 to 38 (median 12)	8	4 to 13
Sand	10 and 18	11	5 to 16
Silty Fine Sand	19	11	6 to 16
Silt	13	13	8 to 17

The above values show that the majority of the in situ soils are suitable for a 95% or + Standard Proctor compaction. However, portions of the earth fill and sands are too wet and will require aeration or mixing with drier soils prior to structural compaction. Aeration of these materials can be achieved by spreading them thinly on the ground in the dry, warm weather.

The earth fill should be sorted free of organic inclusions and any deleterious material prior to structural compaction.

The tills should be compacted using a heavy-weight, kneading-type roller. The inorganic earth fill, sands and silt can be compacted by a smooth roller with or without vibration, depending on the moisture content of the soils being compacted.

The lifts for compaction should be limited to 20 cm, or to a suitable thickness as assessed by test strips performed by the equipment which will be used at the time of construction.

When compacting the cemented, dense to very dense tills on the dry side of the optimum, the compactive energy will frequently bridge over the chunks in the soils and be transmitted laterally into the soil mantle. Therefore, the lifts must be limited to 20 cm or less (before compaction). It is difficult to monitor the lifts of backfill placed in deep trenches; therefore, it is preferable that the compaction of backfill at depths over 1.0 m below the subgrade be carried out on the wet side of the optimum. This would allow a wider latitude of lift thickness.

If the compaction of the soils is carried out with the water content within the range for 95% Standard Proctor dry density but on the wet side of the optimum, the surface of the compacted soil mantle will roll under the dynamic compactive load. This is unsuitable for road construction since each component of the pavement structure is to be placed under dynamic conditions which will induce the rolling action of the subgrade surface and cause structural failure of the new pavement. The slab-on-grade, foundations or bedding of the underground services will be placed on a subgrade which will not be subjected to impact loads. Therefore, the structurally compacted soil mantle with the water content on the wet side or dry side of the optimum will provide adequate subgrade strength for the project construction.

The presence of boulders will prevent transmission of the compactive energy into the underlying material to be compacted. If an appreciable amount of boulders over 15 cm in size is mixed with the material, it must either be sorted or must not be used for structural backfill and/or construction of engineered fill.

5.0 GROUNDWATER CONDITIONS

The boreholes were checked for the presence of groundwater and the occurrence of cave-in upon their completion. The data are plotted on the Borehole Logs and summarized in Table 2.

Table 2 - Groundwater Levels

BH No.	Borehole Depth (m)	Soil Colour Changes Brown to Grey Depth (m)	Measured Groundwater/ Cave-in* Level On Completion	
			Depth (m)	El. (m)
Current Investigation				
101	5.5	2.0	1.8/2.3*	178.2/177.7*
102	4.0	1.5	0.3/0.6*	177.9/177.6*
103	3.8	1.5	0.7/0.9*	177.7/177.5*
104	3.8	1.5	0.5/0.9*	177.8/177.4*
105	3.8	1.7	0.9/1.1*	177.5/177.3*
106	4.0	1.7	0.7/0.8*	177.7/177.6*
107	4.6	2.3	0.9/0.9*	177.6/177.6*
108	5.2	3.0	1.7/2.1*	176.9/176.5*
109	4.3	2.3	1.4/2.1*	177.0/176.3*
Report Reference No. 0608-S050				
7	5.8	2.3	2.7/2.7*	176.7/176.7*
8	5.2	2.0	2.7*	176.6*

* Cave-in level (In wet sand and silt layers, the level generally represents the groundwater at the time of investigation.)

As shown above, groundwater levels were detected at depths ranging from 0.3± to 1.8± m below the prevailing ground surface in the boreholes during the current investigation conducted in Spring, and at a depth of 2.7± m during the 2006 investigation conducted in Autumn. In addition, all boreholes caved at depths ranging from 0.6± to 2.7± m below the prevailing ground surface. The groundwater level will fluctuate with the seasons, and will likely be influenced by the water level in the nearby Nottawasaga Bay. It appears that the groundwater level lies at El. 178.0± to 177.0± m.

The soil colour changes from brown to grey at depths of 1.5± to 3.0± m below the prevailing ground surface. The brown colour indicates that the soils have oxidized.

The groundwater yield from the tills will be slight to some, while the yield from the sands and silt will be moderate to appreciable and persistent.

6.0 DISCUSSION AND RECOMMENDATIONS

The investigations have disclosed that generally beneath a layer of topsoil or topsoil fill, a layer of granular/earth fill in places, the site is primarily underlain by strata of compact to very dense, generally very dense silty sand till and loose to very dense, generally compact gravelly sand, with layers of dense sandy silt till, dense to very dense fine and fine to coarse grained sand, and very dense silty fine sand and silt encountered at various locations and depths. In addition, organic layers and a flood deposit closer to the water were encountered in places. The gravelly sand within a depth of 0.6± to 1.5± m below the prevailing ground surface in places has been weathered. Refusal to augering or SPT was encountered at depths of 3.8 to 5.8 m from the prevailing ground surface; it is inferred that boulders, or bedrock, occurs at these levels.

Groundwater/cave-in levels were observed in all boreholes upon completion of the field work at depths ranging from 0.3± to 2.7± m below the prevailing ground surface. The groundwater level will fluctuate with the seasons, and will likely be influenced by the water level in the nearby Nottawasaga Bay. The groundwater lies at El. 178.0± to 177.0± m.

The groundwater yield from the tills will be slight to some, while the yield from the sands and silt will be moderate to appreciable and persistent.

The geotechnical findings which warrant special consideration are presented below:

1. The topsoil and topsoil fill are unsuitable for engineering applications and must be removed. For the environmental as well as the geotechnical well-being of the future development, they should not be buried below any

structures or deeper than 1.2 m below the exterior finished grade. Fertility testing can be carried out to assess the suitability of the topsoil and topsoil fill as landscaping material.

2. Due to its unknown history, non-uniform density and the presence of organic inclusions, the earth fill is unsuitable for supporting any structures in its current condition. In using the fill for structural backfill, or in pavement or slab-on-grade construction, it should be subexcavated, inspected, sorted free of topsoil inclusions and any deleterious materials, aerated and properly recompacted in thin lifts. If it is impractical to sort the topsoil and other deleterious materials from the fill, the fill must be wasted and replaced with properly compacted inorganic earth fill.
3. The sound natural soils below the topsoil, topsoil fill, earth fill, organics, flood deposit and weathered sand are suitable for normal spread and strip footing construction. The footing subgrade must be inspected by a geotechnical engineer, or a geotechnical technician under the supervision of a geotechnical engineer, to ensure that its condition is compatible with the design of the foundation.
4. For footing construction, the new footings should be flush with the adjacent, existing foundation. Where the appropriate new footing subgrade lies below the adjacent existing footings, the existing footings should be underpinned to the same new founding level, or the distance between the new footing and the existing footing must be such that they do not impact each other.
5. Extended footings and/or cut and fill may be required for the site grading. It is generally more economical to place engineered fill for normal footing, sewer and road construction.
6. For slab-on-grade construction, the slab should be constructed on a granular base, 20 cm thick, consisting of 20-mm Crusher-Run Limestone, or equivalent, compacted to its maximum Standard Proctor dry density.

7. A Class 'B' bedding, consisting of compacted 20-mm Crusher-Run Limestone, is recommended for the construction of the underground services. Where extensive dewatering is required, a Class 'A' bedding should be considered. The pipe joints should be leak-proof, or wrapped with an appropriate waterproof membrane.
8. Where the proposed services are to be constructed adjacent to and/or beneath the existing services, the existing services must be properly secured.
9. Excavation should be carried out in accordance with Ontario Regulation 213/91.
10. The inferred bedrock lies at depths ranging from 3.8 to 5.8 m from the prevailing ground surface, and its excavation will be costly. Substantial savings can be realized by proper manipulation of the site grading so as to minimize rock excavation.
11. For underground services construction in areas where the bedrock lies at a shallow depth, excavation into the bedrock will require blasting which is expected to be costly. In addition, extra effort will be required to excavate the very dense soils containing boulders and rock debris. Therefore, there are economic advantages to be gained by careful control of the site grading or raising of the grade, and selection of types of residences which will minimize rock excavation.
12. A test pit programme can be carried out to determine the extent of the earth fill, organics and flood deposit prior to and/or during the construction of the project.

The recommendations appropriate for the project described in Section 2.0 are presented herein. One must be aware that the subsurface conditions may vary between boreholes. Should subsurface variances become apparent during construction, a geotechnical engineer must be consulted to determine whether the following recommendations require revision.

6.1 Foundations

For the proposed development, it is recommended that the normal spread and strip footings be placed below the topsoil, topsoil fill, earth fill, organics, flood deposit and weathered sand onto the sound natural soils or engineered fill. As a general guide, the recommended soil pressures for use in the design, together with the corresponding suitable founding levels, are presented in Table 3.

Table 3 - Founding Levels

BH No.	**Recommended Maximum Allowable Soil/Rock Pressure (SLS)/ Factored Ultimate Soil Bearing Pressure (ULS) and Suitable Founding Level**				**Inferred Groundwater Level**
	300 kPa (SLS) 480 kPa (ULS)		**500 kPa (SLS) 800 kPa (ULS)**		
	Depth (m)	**El. (m)**	**Depth (m)**	**El. (m)**	**El. (m)**
Current Investigation					
101	2.5 or +	177.5 or -	3.2 or +	176.8 or -	178.2
102	1.5 or +	176.7 or -	1.8 or +	176.4 or -	177.9
103	1.3 or +	177.1 or -	1.8 or +	176.6 or -	177.7
104	1.8 or +	176.5 or -	2.0 or +	176.3 or -	177.8
105	2.0 or +	176.4 or -	2.5 or +	175.9 or -	177.5
106	1.8 or +	176.6 or -	2.0 or +	176.4 or -	177.7
107	1.6 or +	176.9 or -	1.8 or +	176.7 or -	177.6
108	3.2 or +	175.4 or -	3.4 or +	175.2 or -	176.9
109	2.5 or +	175.9 or -	3.2 or +	175.2 or -	177.0
Report Reference No. 0608-S050					
7*	3.0 or +	176.4 or -	3.2 or +	176.2 or -	176.7
8*	1.3 or +	178.0 or -	1.5 or +	177.8 or -	176.6

* If construction/earth works has occurred at the locations of Boreholes 7 and 8 after the 2006 investigation and prior to this current investigation, the above recommended bearing pressures and founding levels at these borehole locations should be verified during construction.

In areas where foundations are to be extended, it may be more cost effective to subexcavate to a size 30% larger than the designed footing width and fill with lean concrete up to the normal footing elevation immediately after the suitable founding soil is exposed.

The existing earth fill, organics, flood deposit and weathered sand can be subexcavated and replaced with engineered fill. Furthermore, where fill is required to raise the grade, or if extended footings and/or cut and fill is required for the site grading, engineered fill suitable for normal footing construction can be considered. A Maximum Allowable Soil Pressure (SLS) of 150 kPa and a Factored Ultimate Soil Bearing Pressure (ULS) of 250 kPa is recommended for footings founded on engineered fill. The fill must be certified by the geotechnical consultant that supervised and inspected the fill placement. Details of engineered fill are provided in Section 6.2 of this report.

Where drilled footings are considered, the recommended bearing pressures and founding levels provided in Table 3 will apply. The slab within the area of the drilled footings should be structurally supported.

Due to the presence of adjacent buildings, the foundation details of the adjacent structures must be investigated and incorporated into the design and construction of the proposed project. It is recommended that a pre-construction survey and a monitoring program be carried out for all adjacent structures in order to verify any potential future liability claims.

Where footings are considered, the new footings should be flush with the adjacent, existing foundation. Where the appropriate new footing subgrade lies below the adjacent existing footings, the existing footings should be underpinned to the same founding level, or the distance between the new footing and the existing footing must be such that they do not impact each other. The structural and geotechnical engineers for the project must be consulted for the appropriate founding levels beside existing footings.

A slip-joint should be provided at the interface of the new structure and the existing building to allow for abrupt differential settlement to occur at the interface without imposing structural distress on the existing foundations.

The recommended bearing pressures (SLS) for normal footings incorporate a safety factor of 3. The total and differential settlements of the footings are estimated to be 25 mm and 15 mm, respectively.

The foundation subgrade must be inspected by a geotechnical engineer, or a geotechnical technician under the supervision of a geotechnical engineer, to assess its suitability for bearing the designed foundations.

Footings and grade beams exposed to weathering, and in unheated areas, should have at least 1.5 m of earth cover for protection against frost action.

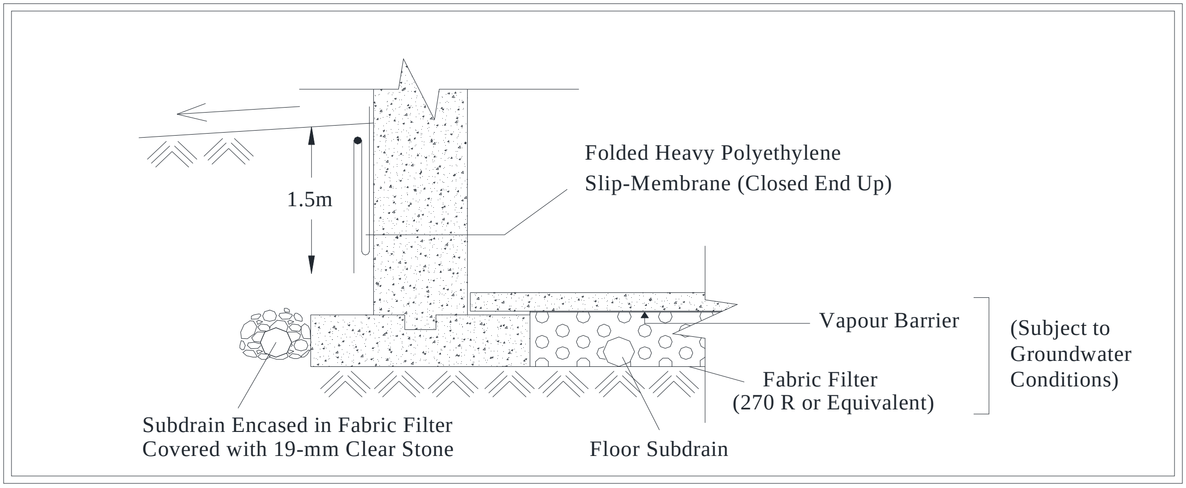
Perimeter subdrains and dampproofing of the foundation walls will be required. All the subdrains should be encased in a fabric filter to protect them against blockage by silting.

It should be noted that if groundwater or seepage is encountered during the footing excavations, or where the subgrade of the normal foundations is found to be wet, the subgrade should be protected by a concrete mud-slab immediately after exposure. This will prevent construction disturbance and costly rectification.

Where the basements or foundations of the proposed development are founded within the water-bearing soils, the basement walls and floor slabs will need to be waterproofed and designed to resist hydrostatic pressure and buoyancy uplift forces.

The in situ soils with a high silt content are high in frost susceptibility. In order to alleviate the risk of frost damage, the basement and foundation walls must be constructed of concrete and either backfilled with non-frost-susceptible pit-run granular, or should be properly shielded with a polyethylene slip-membrane extending below the frost depth. Where groundwater seepage is detected at the time of foundation excavation, floor subdrains must be installed and they must be connected to sump-wells, or to foundation drains which have a positive outlet. Also, a vapour barrier should be installed to prevent upfiltration of soil moisture that may wet the floor. The recommended measures are schematically presented in Diagram 1.

Diagram 1 - Frost Protection Measures (Foundation)



The necessity to implement the above measures should be assessed at the time of construction.

The foundations should meet the requirements specified in the latest Ontario Building Code, and the structure should be designed to resist an earthquake force using Site Classification ‘C’ (very dense soil).

6.2 **Engineered Fill**

The existing earth fill and weathered sand can be upgraded to or replaced with engineered fill, and where earth fill is required to raise the site or extended footings are required, it is generally more economical to place engineered fill for normal footing, underground services and pavement construction. The engineering requirements for a certifiable fill for pavement construction, municipal services, slab-on-grade, and footings designed with a Maximum Allowable Soil Pressure (SLS) of 150 kPa and a Factored Ultimate Soil Bearing Pressure (ULS) of 250 kPa are presented below:

1. All the existing topsoil, topsoil fill, organics and flood deposit must be removed, and the subgrade must be inspected and proof-rolled prior to any fill placement. The existing earth fill and weathered sand must be subexcavated, sorted free of topsoil inclusions and deleterious materials, if any, aerated and properly compacted.
2. Inorganic soils must be used, and they must be uniformly compacted in lifts of 20 cm thick to 98% or + of their maximum Standard Proctor dry density, up to the proposed finished grade and/or slab-on-grade subgrade. The soil moisture must be properly controlled on the wet side of the optimum. If the foundations are to be built soon after the fill placement, the densification process for the engineered fill must be increased to 100% of the maximum Standard Proctor compaction.
3. If imported fill is to be used, it should be inorganic soils, free of deleterious or any material with environmental issue (contamination). Any potential

imported earth fill from off site must be reviewed for geotechnical and environmental quality by the appropriate personnel as authorized by the developer or agency, before it is hauled to the site.

4. If the engineered fill is to be left over the winter months, adequate earth cover, or equivalent, must be provided for protection against frost action.
5. The engineered fill must extend over the entire graded area; the engineered fill envelope and finished elevations must be clearly and accurately defined in the field, and they must be precisely documented by qualified surveyors. Foundations partially on engineered fill must be reinforced and designed by a structural engineer, to properly distribute the stress induced by the abrupt differential settlement (estimated to be 15± mm) between the natural soils and engineered fill.
6. The engineered fill must not be placed during the period from late November to early April, when freezing ambient temperatures occur either persistently or intermittently. This is to ensure that the fill is free of frozen soils, ice and snow.
7. Where the ground is wet due to subsurface water seepage, an appropriate subdrain scheme must be implemented prior to the fill placement, particularly if it is to be carried out on sloping ground or a bank.
8. Where fill is to be placed on a bank steeper than 1 vertical:3 horizontal, the face of the bank must flattened to 3+ so that it is suitable for safe operation of the compactor and the required compaction can be obtained.
9. The fill operation must be inspected on a full-time basis by a technician under the direction of a geotechnical engineer.
10. The footing and underground services subgrade must be inspected by the geotechnical consulting firm that inspected the engineered fill placement. This is to ensure that the foundations are placed within the engineered fill envelope,

and the integrity of the fill has not been compromised by interim construction, environmental degradation and/or disturbance by the footing excavation.

11. Any excavation carried out in certified engineered fill must be reported to the geotechnical consultant who inspected the fill placement in order to document the locations of the excavation and/or to inspect reinstatement of the excavated areas to engineered fill status. If construction on the engineered fill does not commence within a period of 2 years from the date of certification, the condition of the engineered fill must be assessed for re-certification.
12. Despite stringent control in the placement of the engineered fill, variations in soil type and density may occur in the engineered fill. Therefore, the foundations must be properly reinforced and designed by the structural engineer for the project. The total and differential settlements of 25 mm and 15 mm, respectively, should be considered in the design of the foundations founded on engineered fill. In sewer construction, the engineered fill is considered to have the same structural proficiency as a natural inorganic soil.

6.3 **Slab-On-Grade**

The subgrade for the slab-on-grade must consist of sound natural soils or properly compacted inorganic fill. In preparation of the subgrade, it must be inspected and assessed by proof-rolling. The topsoil, topsoil fill, organics and flood deposit must be removed; the existing earth fill, weathered sand or any loose soils should be subexcavated, sorted free of any deleterious material, aerated and uniformly compacted to 98% or + of its maximum Standard Proctor dry density. If the deleterious materials cannot be sorted, the soils should be replaced by properly compacted, organic-free earth fill.

Any new material for raising the grade should consist of organic-free soil compacted to at least 98% of its maximum Standard Proctor dry density.

If the subgrade has been loosened due to construction traffic, it must be proof-rolled before placement of the granular base.

The slab should be constructed on a granular base, 20 cm thick, consisting of 20-mm Crusher-Run Limestone, or equivalent, compacted to its maximum Standard Proctor dry density.

A Modulus of Subgrade Reaction of 35 MPa/m can be used for the design of the floor slab.

It is understood that the proposed building will generally be heated. Accordingly, the slab at the entrance doors should be insulated with 65-mm Styrofoam, or its thermal equivalent, extending 1.5 m internally. This measure is to prevent cold drafts in the winter from inducing frost action in the subgrade and causing damage to the floor slab.

The slab-on-grade in open areas should be designed to tolerate frost heave, and the grading around the slab-on-grade and building structures must be such that it directs runoff away from the structures.

6.4 **Underground Services**

The subgrade for the underground services should consist of sound natural soils or properly compacted organic-free earth fill. Where topsoil, topsoil fill, organics, flood deposit or badly weathered sand is encountered, it should be subexcavated and replaced with bedding material compacted to at least 95% or + of its Standard Proctor compaction.

A Class ‘B’ bedding is recommended for the underground services construction. The bedding material should consist of compacted 20-mm Crusher-Run Limestone, or equivalent. In the areas where extensive dewatering is required, a Class ‘A’ bedding will be required. The pipe joints should be leak-proof, or the joints should be wrapped with a waterproof membrane, to prevent subgrade upfiltration through the joints.

In order to prevent pipe floatation when the sewer trench is deluged with water, a soil cover at least equal in thickness to the diameter of the pipe should be in place at all times after completion of the pipe installation.

Openings to subdrains and catch basins should be shielded with a fabric filter to prevent blockage by silting.

Since the silty sand till and sandy silt till have moderate to moderately low corrosivity to buried metal, all metal fittings for the underground services should be protected against soil corrosion. In determining the mode of protection, an electrical resistivity of 4500 to 5000 ohm·cm should be used. This, however, should be confirmed by testing the soil along the water main alignment at the time of services construction.

6.5 **Backfilling in Trenches and Excavated Areas**

The on-site inorganic soils are generally suitable for use as trench backfill. However, the soils should be sorted free of any topsoil inclusions and other deleterious materials prior to the backfilling.

The backfill in trenches and excavated areas should be compacted to at least 95% of its maximum Standard Proctor dry density. In the zone within 1.0 m below the pavement subgrade, the materials should be compacted with the water content 2% to

3% drier than the optimum, and the compaction should be increased to at least 98% of the respective maximum Standard Proctor dry density. This is to provide the required stiffness for pavement construction. In the lower zone, the compaction should be carried out on the wet side of the optimum; this allows a wider latitude of lift thickness. Backfill below any floor slab which is sensitive to settlement must be compacted to at least 98% of its maximum Standard Proctor dry density.

In normal underground services construction practice, the problem areas of settlement largely occur adjacent to manholes, catch basins, services crossings, foundation walls and columns. In areas which are inaccessible to a heavy compactor, imported sand backfill should be used. Unless compaction of the backfill is carefully performed, the interface of the native soils and the sand backfill will have to be flooded for a period of several days.

The narrow trenches for services crossings should be cut at 1 vertical:
2 or + horizontal so that the backfill can be effectively compacted. Otherwise, soil arching will prevent the achievement of proper compaction. The lift of each backfill layer should either be limited to a thickness of 20 cm, or the thickness should be determined by test strips.

One must be aware of the possible consequences during trench backfilling and exercise caution as described below:

- When construction is carried out in freezing winter weather, allowance should be made for these following conditions. Despite stringent backfill monitoring, frozen soil layers may inadvertently be mixed with the structural trench backfill. Should the in situ soils have a water content on the dry side of the optimum, it would be impossible to wet the soils due to the freezing condition, rendering difficulties in obtaining uniform and proper compaction.

Furthermore, the freezing condition will prevent flooding of the backfill when it is required, such as in a narrow vertical trench section, or when the trench box is removed. The above will invariably cause backfill settlement that may become evident within 1 to several years, depending on the depth of the trench which has been backfilled.

- In areas where the construction is carried out during the winter months, prolonged exposure of the trench walls will result in frost heave within the soil mantle of the walls. This may result in some settlement as the frost recedes, and repair costs will be incurred prior to final surfacing of the new pavement and the slab-on-grade construction.
- To backfill a deep trench, one must be aware that future settlement is to be expected, unless the side of the cut is flattened to at least 1 vertical: 1.5+ horizontal, and the lifts of the fill and its moisture content are stringently controlled; i.e., lifts should be no more than 20 cm (or less if the backfilling conditions dictate) and uniformly compacted to achieve at least 95% of the maximum Standard Proctor dry density, with the moisture content on the wet side of the optimum.
- It is often difficult to achieve uniform compaction of the backfill in the lower vertical section of a trench which is an open cut or is stabilized by a trench box, particularly in the sector close to the trench walls or the sides of the box. These sectors must be backfilled with sand. In a trench stabilized by a trench box, the void left after the removal of the box will be filled by the backfill. It is necessary to backfill this sector with sand, and the compacted backfill must be flooded for 1 day, prior to the placement of the backfill above this sector; i.e., in the upper sloped trench section. This measure is necessary in order to prevent consolidation of inadvertent voids and loose backfill which will compromise the compaction of the backfill in the upper section. In areas where groundwater movement is expected in the sand fill mantle, anti-seepage collars should be provided.

6.6 Sidewalks, Interlocking Stone Pavement and Landscaping

Interlocking stone pavement, sidewalks and landscaping structures in areas which are sensitive to frost-induced ground movement must be constructed on a free-draining, non-frost-susceptible granular material such as Granular 'B'. The material must extend to 0.3 to 1.5 m below the sidewalk, slab or pavement surface, depending on the degree of tolerance for settlement, and be provided with positive drainage, such as weeper subdrains connected to manholes or catch basins. Alternatively, the landscaping structures, sidewalks and interlocking stone pavement should be properly insulated with 65-mm Styrofoam, or equivalent.

6.7 Pavement Design

The recommended pavement design for the parking lot is presented in Table 4.

Table 4 - Pavement Design

Course	Thickness (mm)	OPS Specifications
Asphalt Surface	40	HL-3
Asphalt Binder	50	HL-8
Granular Base	150	Granular 'A' or equivalent
Granular Sub-base		Granular 'B' or equivalent
Parking	350	
Fire Route and Loading Dock	450	

In preparation of the subgrade, the topsoil, topsoil fill, organics and flood deposit should be removed, and the subgrade surface must be proof-rolled. The existing earth fill, weathered sand and any loose subgrade must be subexcavated, sorted free of any deleterious materials, aerated and properly compacted. If the deleterious materials cannot be sorted, the soils should be replaced by properly compacted, organic-free earth fill or granular materials. Earth fill used to raise the grade for pavement construction should consist of organic-free soil uniformly compacted to 95% or + of its maximum Standard Proctor dry density.

All the granular bases should be compacted to 100% of their maximum Standard Proctor dry density.

In the zone within 1.0 m below the road subgrade, the backfill should be compacted to at least 98% of its maximum Standard Proctor dry density, with the water content 2% to 3% drier than the optimum. In the lower zone, a 95% or + Standard Proctor compaction is considered adequate.

Along the perimeter where surface runoff may drain onto the pavement, a swale or an intercept subdrain system should be installed to prevent infiltrating precipitation from seeping into the granular bases (since this may inflict frost damage on the flexible pavement). The subdrains should consist of filter-wrapped weepers, and they should be connected to the catch basins and storm manholes in the paved areas. The subdrains should be backfilled with free-draining granular material.

6.8 Soil Parameters

The recommended soil parameters for the project design are given in Table 5.

Table 5 - Soil Parameters

Unit Weight and Bulk Factor

	Unit Weight (kN/m^3)		Estimated Bulk Factor	
	Bulk	**Submerged**	**Loose**	**Compacted**
Earth Fill	20.0	10.8	1.20	0.98
Silty Sand Till and Sandy Silt Till	22.5	12.5	1.33	1.05
Sands	20.0	10.8	1.25	0.98
Silty Fine Sand	20.5	10.5	1.20	1.00
Silt	21.0	10.5	1.20	1.00

Lateral Earth Pressure Coefficients

	Active K_a	At Rest K_0	Passive K_p
Earth Fill	0.40	0.50	2.50
Silty Sand Till, Sandy Silt Till, Sands and Silt	0.32	0.48	3.12

Coefficients of Friction

Between Concrete and Granular Base	0.60
Between Concrete and Sound Natural Soils	0.40

Maximum Allowable Soil Pressure (SLS) For Thrust Block Design (kPa)

Engineered Fill	75
Sound Natural Soils	100

6.9 Excavation

Where the new services are to be cut close to any existing underground services, one must be aware that the backfill for the existing underground services is amorphous in structure and is susceptible to sloughing and sudden side collapse. Extreme caution must be exercised when excavating the existing backfilled

services trenches; the sides of the cuts in the backfill will readily slough and may collapse suddenly. The existing services must be properly secured for the new/replacement services construction. The stability of the new trench and the existing services must be ensured by flattening the slope of the cut, by shoring or by the use of a trench box.

Excavation should be carried out in accordance with Ontario Regulation 213/91.

Excavations in excess of 1.2 m should be sloped at 1 vertical:1 horizontal for stability. Where earth fill, weathered sand or groundwater is encountered, the sides of excavations may need to be flattened to 1 vertical:1.5 or + horizontal for stability.

For excavation purposes, the types of soils are classified in Table 6.

Table 6 - Classification of Soils for Excavation

Material	**Type**
Sound Natural Tills	2
Earth Fill, weathered Sand and dewatered Sands and Silt	3
Saturated Sands and Silt	4

Excavation into the soils containing boulders may require extra effort and the use of a heavy-duty backhoe. Boulders larger than 15 cm in size are not suitable for structural backfill and/or construction of engineered fill. Where bedrock is encountered, excavation into the bedrock may require the aid of pneumatic hammering and/or rock blasting. A blasting specialist must be consulted to devise a safe blasting sequence.

The groundwater yield from the tills will be slight to some, while the yield from the sands and silt will be moderate to appreciable and persistent.

Where excavation is to be carried out in the wet or water-bearing sands or silt, the possibility of flowing sides and bottom boiling dictates that the ground be predrained by pumping from closely spaced sump-wells or, if necessary, by the use of a well-point dewatering system. This should be assessed by test pumping prior to the project construction when the intended bottom of excavation is determined. In order to provide a stable subgrade for the services or foundation construction, the groundwater should be depressed at least 1.0 m below the subgrade level.

Alternatively, sheeting structures can be installed around the excavation. The sheeting structure should be driven to a depth below the bottom of the excavation at least equal to the height of water above the bed of excavation. The sheeting structure must be properly designed to sustain the earth pressure, hydrostatic pressure and applicable surcharge loads.

Prospective contractors must be asked to assess the in situ subsurface conditions for soil cuts by digging test pits to at least 0.5 m below the intended bottom of excavation. These test pits should be allowed to remain open for a period of at least 4 hours to assess the trenching conditions.

7.0 LIMITATIONS OF REPORT

This report was prepared by Soil Engineers Ltd. for the account of Law Development Group and for review by their designated consultants and government agencies. Use of the report is subject to the conditions and limitations of the contractual agreement. The material in the report reflects the judgement of Mumta Mistry, B.A.Sc., and Daniel Man, P.Eng., in light of the information available to it at the time of preparation. Any use which a Third Party makes of this report, or any reliance on decisions to be made based on it, are the responsibility of such Third Parties. Soil Engineers Ltd. accepts no responsibility for damages, if any, suffered by any Third Party as a result of decisions made or actions based on this report.

SOIL ENGINEERS LTD.

Mumta Mistry, B.A.Sc.

Daniel Man, P.Eng.
MM/DM:dd

LICENSED PROFESSIONAL ENGINEER
D.S.C. MAN
28853117
June 5/18
PROVINCE OF ONTARIO

LIST OF ABBREVIATIONS AND DESCRIPTION OF TERMS

The abbreviations and terms commonly employed on the borehole logs and figures, and in the text of the report, are as follows:

SAMPLE TYPES

AS	Auger sample
CS	Chunk sample
DO	Drive open (split spoon)
DS	Denison type sample
FS	Foil sample
RC	Rock core (with size and percentage recovery)
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

PENETRATION RESISTANCE

Dynamic Cone Penetration Resistance:

A continuous profile showing the number of blows for each foot of penetration of a 2-inch diameter, 90° point cone driven by a 140-pound hammer falling 30 inches.

Plotted as '—•—'

Standard Penetration Resistance or 'N' Value:

The number of blows of a 140-pound hammer falling 30 inches required to advance a 2-inch O.D. drive open sampler one foot into undisturbed soil.

Plotted as '○'

WH	Sampler advanced by static weight
PH	Sampler advanced by hydraulic pressure
PM	Sampler advanced by manual pressure
NP	No penetration

SOIL DESCRIPTION

Cohesionless Soils:

'N' (blows/ft)	Relative Density
0 to 4	very loose
4 to 10	loose
10 to 30	compact
30 to 50	dense
over 50	very dense

Cohesive Soils:

Undrained Shear Strength (ksf)	'N' (blows/ft)	Consistency
less than 0.25	0 to 2	very soft
0.25 to 0.50	2 to 4	soft
0.50 to 1.0	4 to 8	firm
1.0 to 2.0	8 to 16	stiff
2.0 to 4.0	16 to 32	very stiff
over 4.0	over 32	hard

Method of Determination of Undrained Shear Strength of Cohesive Soils:

x 0.0 Field vane test in borehole; the number denotes the sensitivity to remoulding

△ Laboratory vane test

□ Compression test in laboratory

For a saturated cohesive soil, the undrained shear strength is taken as one half of the undrained compressive strength

METRIC CONVERSION FACTORS

1 ft = 0.3048 metres

1lb = 0.454 kg

1 inch = 25.4 mm

1ksf = 47.88 kPa

Soil Engineers Ltd.
CONSULTING ENGINEERS
GEOTECHNICAL • ENVIRONMENTAL • HYDROGEOLOGICAL • BUILDING SCIENCE

JOB NO.: 1803-S101

LOG OF BOREHOLE NO.: 101

FIGURE NO.: 1

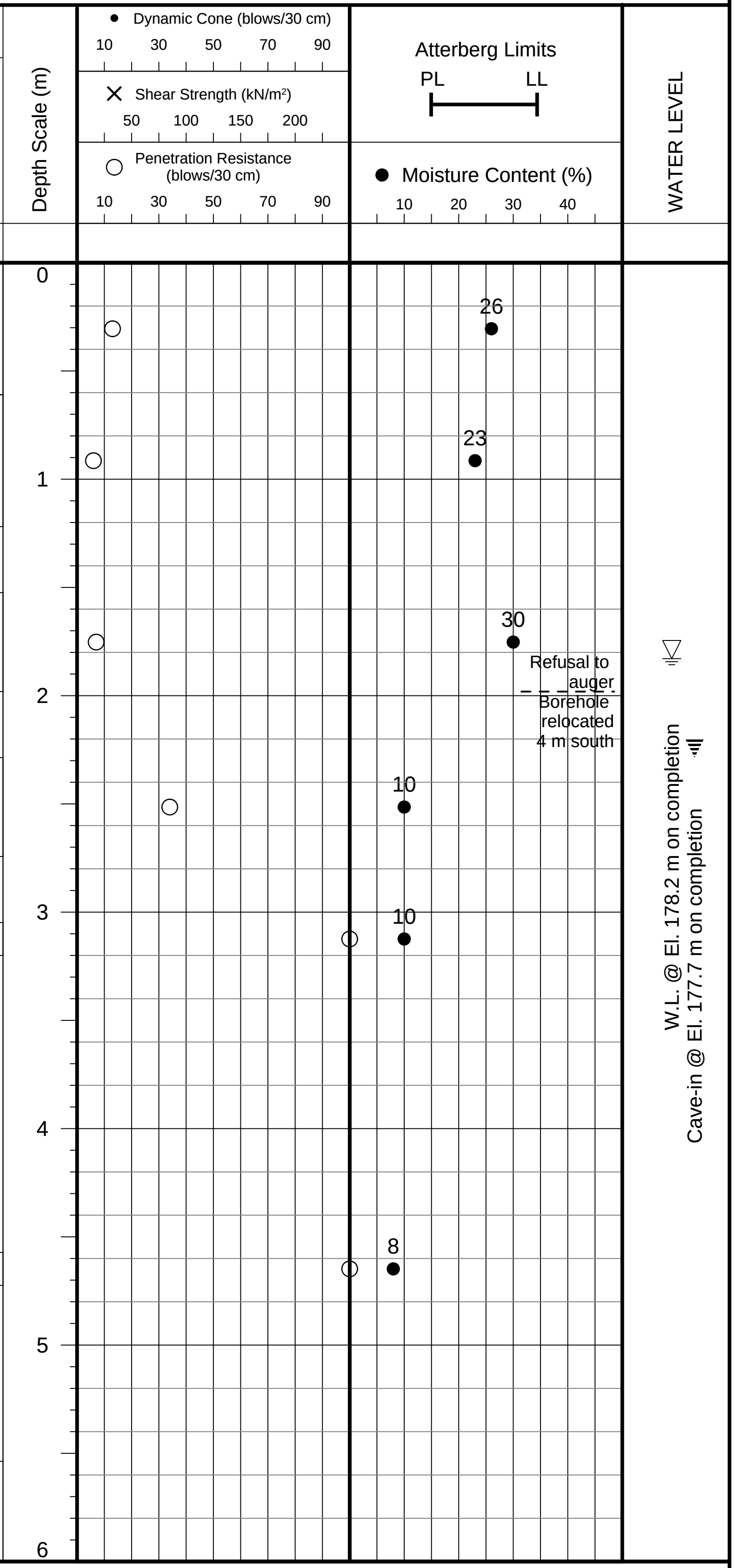
PROJECT DESCRIPTION: Proposed Resort

METHOD OF BORING: Solid Stem Flight-Auger

PROJECT LOCATION: Cranberry Harbour Castle
15 Harbour Street East and 300 Balsam Street
Town of Collingwood

DRILLING DATE: April 18, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
180.0	Ground Surface			
0.0	**TOPSOIL FILL**	1	DO	13
		2	DO	6
		3	DO	7
	Grey, dense **SAND** fine to coarse grained a trace of clay some silt and gravel	4	DO	34
177.0 3.0	Grey, very dense **SILTY SAND TILL** a trace of clay a trace to some gravel occ. wet sand and silt seams and layers, cobbles and boulders	5	DO	50/15
		6	DO	52/15
174.5 5.5	**END OF BOREHOLE** Refusal to auger at a depth of 5.5 m			



JOB NO.: 1803-S101

LOG OF BOREHOLE NO.: 102

FIGURE NO.: 2

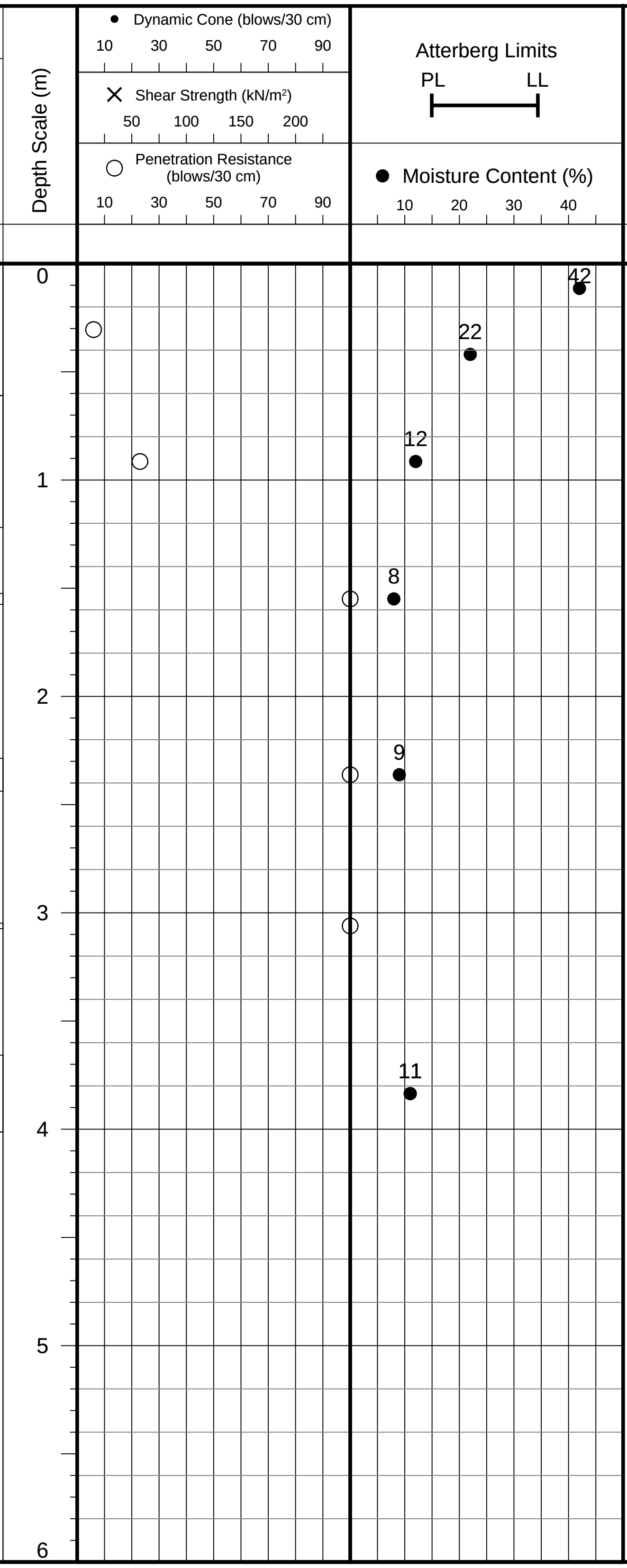
PROJECT DESCRIPTION: Proposed Resort

METHOD OF BORING: Solid Stem Flight-Auger

PROJECT LOCATION: Cranberry Harbour Castle
15 Harbour Street East and 300 Balsam Street
Town of Collingwood

DRILLING DATE: April 18, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
178.2	Ground Surface			
0.0	**23 cm TOPSOIL**	1A	DO	6
	Brown, loose to compact **GRAVELLY SAND** weathered a trace of silt	1B		
		2	DO	23
176.7 1.5	Grey, very dense **SILTY SAND TILL** a trace of clay a trace to some gravel occ. wet sand and silt seams and layers, cobbles and boulders	3	DO	50/5
		4	DO	55/15
		5	DO	50/3
		6	AS	-
174.2 4.0	**END OF BOREHOLE** Refusal to auger at a depth of 4.0 m			



WATER LEVEL

W.L. @ El. 177.9 m on completion

Cave-in @ El. 177.6 m on completion

JOB NO.: 1803-S101

LOG OF BOREHOLE NO.: 103

FIGURE NO.: 3

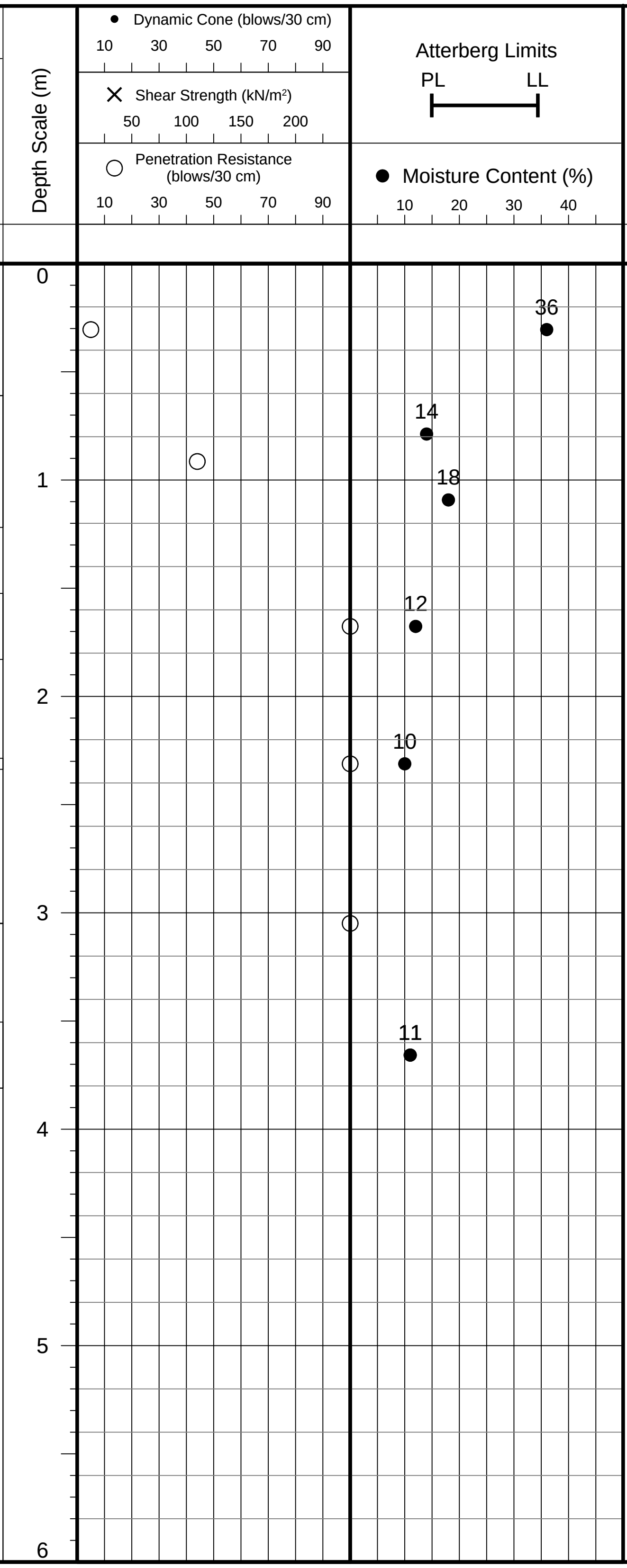
PROJECT DESCRIPTION: Proposed Resort

METHOD OF BORING: Solid Stem
Flight-Auger

PROJECT LOCATION: Cranberry Harbour Castle
15 Harbour Street East and 300 Balsam Street
Town of Collingwood

DRILLING DATE: April 18, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
178.4	Ground Surface			
0.0	**TOPSOIL FILL**	1	DO + AS	5
	Dark brown **EARTH FILL** **(Gravelly Sand)** a trace of silt	2A	DO	44
177.4 1.0	Brown, dense **SAND** fine to coarse grained some silt and gravel	2B		
176.9 1.5	Grey, very dense clay seams	3	DO	53/15
	SILTY SAND TILL	~~4~~	~~DO~~	~~50/5~~
	a trace of clay a trace to some gravel occ. wet sand and silt seams and layers, cobbles and boulders	~~5~~	~~DO~~	~~50/0~~
		6	AS	-
174.6 3.8	**END OF BOREHOLE** Refusal to auger at a depth of 3.8 m			



WATER LEVEL

W.L. @ El. 177.7 m on completion

Cave-in @ El. 177.5 m on completion

Soil Engineers Ltd.

JOB NO.: 1803-S101

LOG OF BOREHOLE NO.: 104

FIGURE NO.: 4

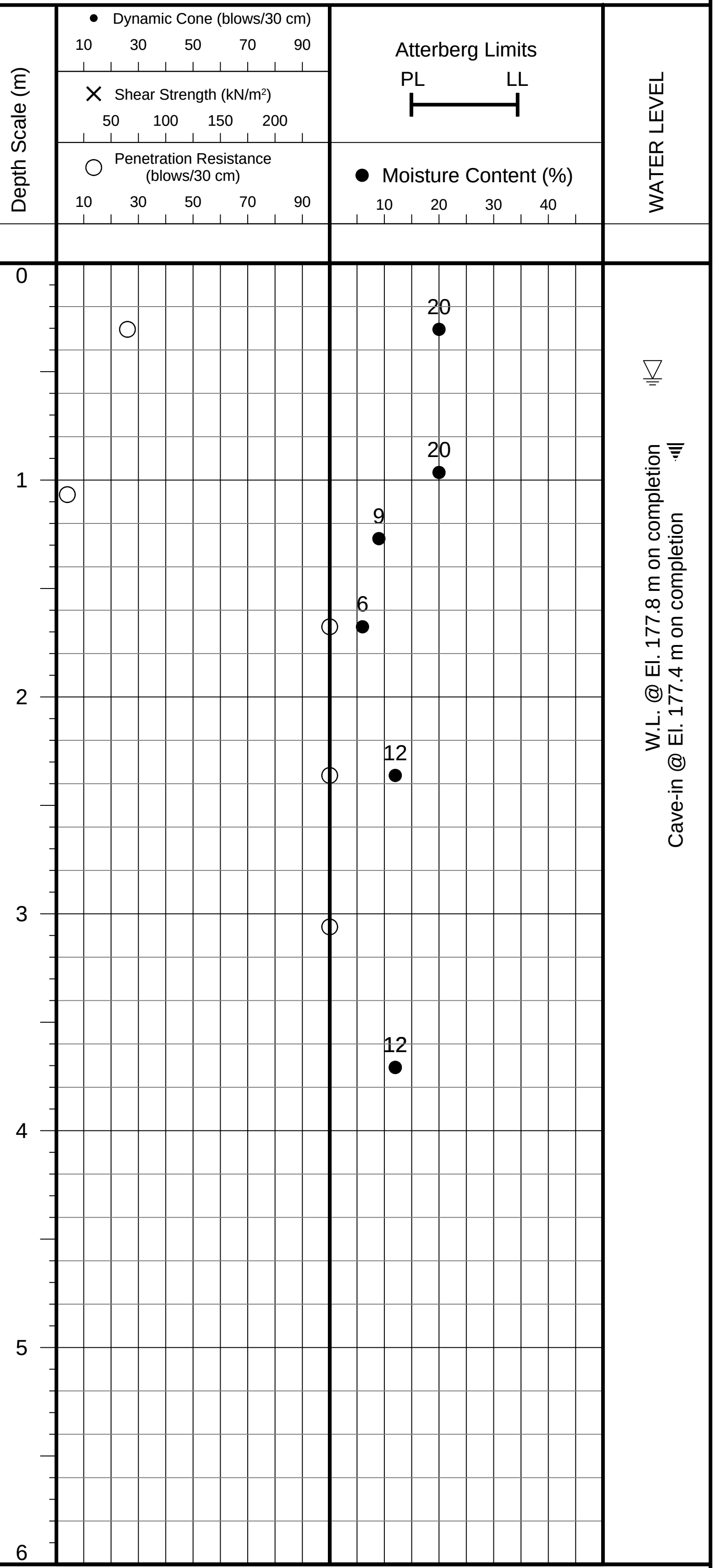
PROJECT DESCRIPTION: Proposed Resort

METHOD OF BORING: Solid Stem Flight-Auger

PROJECT LOCATION: Cranberry Harbour Castle
15 Harbour Street East and 300 Balsam Street
Town of Collingwood

DRILLING DATE: April 17, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
178.3	Ground Surface			
0.0	**TOPSOIL FILL**	1	DO	26
	Dark brown **EARTH FILL** **(Gravelly Sand)** a trace of silt with organic inclusions	2A	DO	4
177.1 1.2	Brown, very loose, weathered **GRAVELLY SAND** a trace of silt	2B		
176.8 1.5	Grey, very dense	3	DO	50/15
	SILTY SAND TILL	4	DO	60/15
	a trace of clay a trace of gravel to gravelly occ. wet sand and silt seams and layers, cobbles and boulders	5	DO	50/3
		6	AS	-
174.5 3.8	**END OF BOREHOLE** Refusal to auger at a depth of 3.8 m			



Soil Engineers Ltd.

Page: 1 of 1

JOB NO.: 1803-S101

LOG OF BOREHOLE NO.: 105

FIGURE NO.: 5

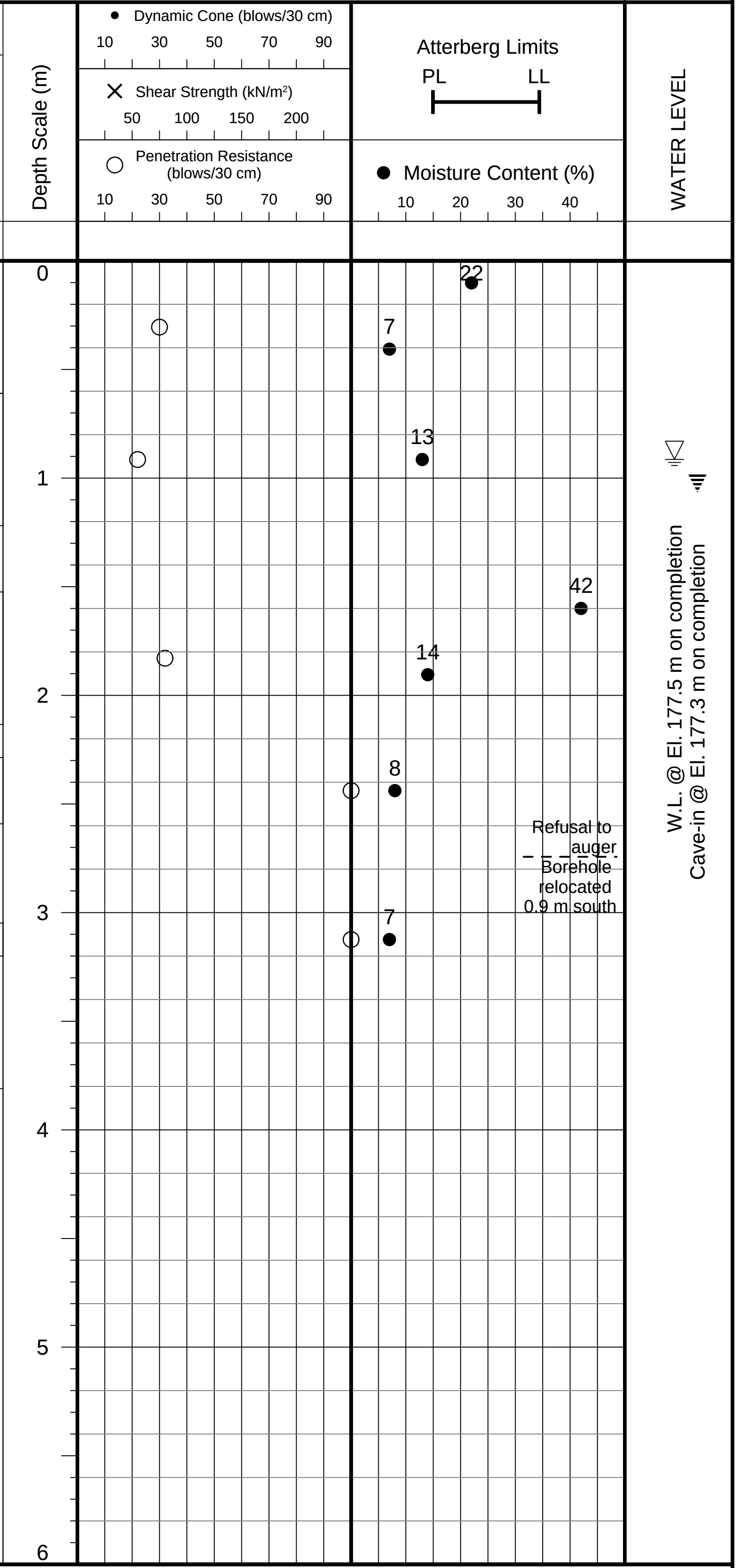
PROJECT DESCRIPTION: Proposed Resort

METHOD OF BORING: Solid Stem Flight-Auger

PROJECT LOCATION: Cranberry Harbour Castle
15 Harbour Street East and 300 Balsam Street
Town of Collingwood

DRILLING DATE: April 17, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value
178.4	Ground Surface			
0.0	**20 cm TOPSOIL**	1A	DO	30
	Brown, compact **SILTY SAND TILL** a trace of clay a trace of gravel to gravelly occ. wet sand and silt seams and layers, cobbles and boulders	1B		
		2	DO	22
176.9 1.5	Black **ORGANIC** wood and cinder	3A	DO	32
176.7 1.7	Grey, dense **SILTY SAND TILL** traces of clay and gravel occ. wet sand and silt seams and layers, cobbles and boulders silt layers	3B		
176.1 2.3	Grey, very dense **GRAVELLY SAND** a trace to some silt	4	DO	50/15
		5	DO	70/15
174.6 3.8	**END OF BOREHOLE** Refusal to auger at a depth of 3.8 m			



Soil Engineers Ltd.

JOB NO.: 1803-S101

LOG OF BOREHOLE NO.: 106

FIGURE NO.: 6

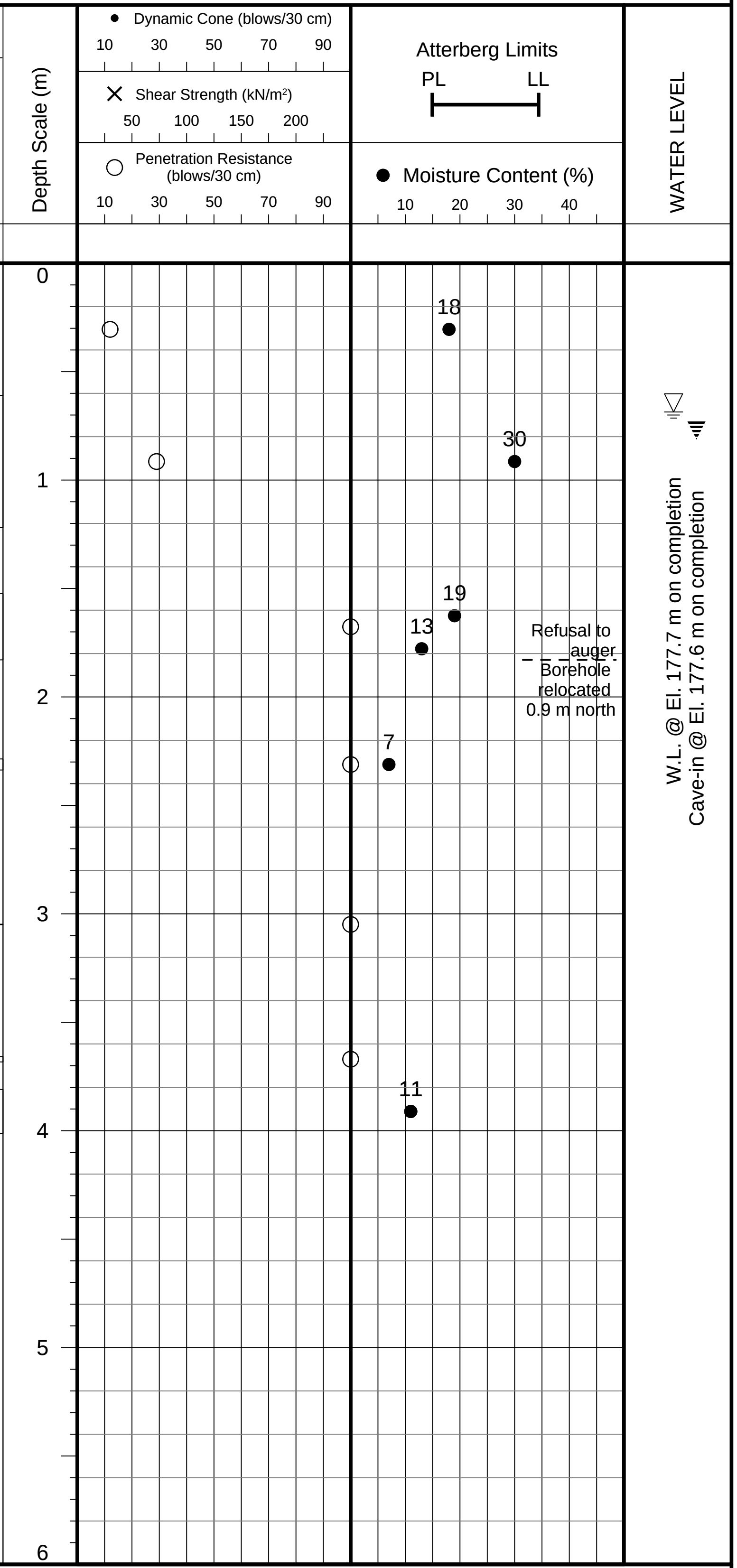
PROJECT DESCRIPTION: Proposed Resort

METHOD OF BORING: Solid Stem Flight-Auger

PROJECT LOCATION: Cranberry Harbour Castle
15 Harbour Street East and 300 Balsam Street
Town of Collingwood

DRILLING DATE: April 18, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
178.4	Ground Surface			
0.0	**TOPSOIL FILL**	1	DO	12
	Black **EARTH FILL** **(Gravelly Sand)** a trace of silt with wood and cinder	2	DO	29
176.9 1.5	Brown, very dense **SILTY FINE SAND** a trace of clay	3A	DO	50/15
176.7 1.7	Grey, very dense **SILT** traces of clay and sand	3B		
176.1 2.3	Grey, very dense **SILTY SAND TILL** a trace of clay a trace of gravel to gravelly occ. wet sand and silt seams and layers, cobbles and boulders	4 5 6 7	DO DO DO AS	50/5 50/0 50/3 -
174.4 4.0	**END OF BOREHOLE** Refusal to auger at a depth of 4.0 m			



W.L. @ El. 177.7 m on completion
Cave-in @ El. 177.6 m on completion

Soil Engineers Ltd.

JOB NO.: 1803-S101

LOG OF BOREHOLE NO.: 107

FIGURE NO.: 7

PROJECT DESCRIPTION: Proposed Resort

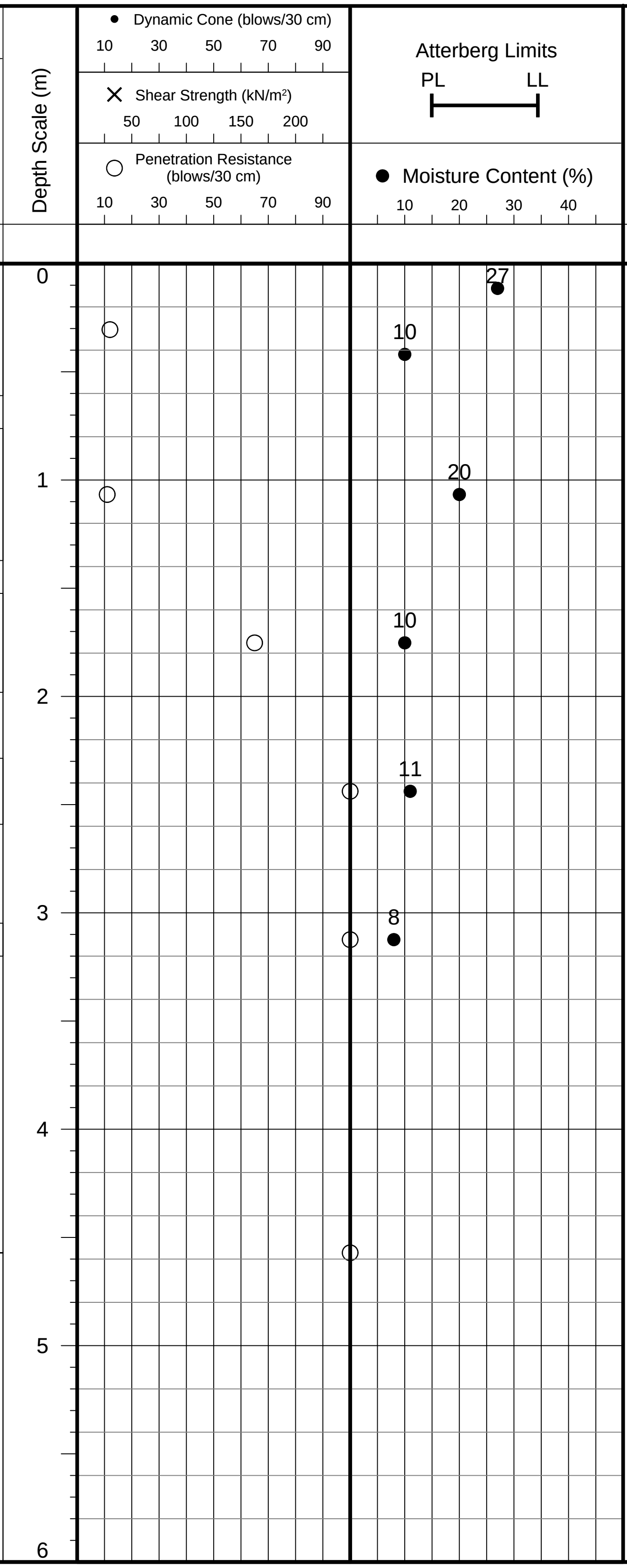
METHOD OF BORING: Solid Stem
Flight-Auger

PROJECT LOCATION: Cranberry Harbour Castle
15 Harbour Street East and 300 Balsam Street
Town of Collingwood

DRILLING DATE: April 17, 2018

El. (m) Depth (m)	SOIL DESCRIPTION
178.5	Ground Surface
0.0	**23 cm TOPSOIL**
	Brown **EARTH FILL (Sand)** fine to coarse grained and gravelly sand some silt
177.2 1.3	Very dense **SILTY SAND TILL** silt layers a trace of clay a trace to some gravel occ. wet sand and silt seams and layers, cobbles and boulders brown grey
175.5 3.0	Grey, very dense **GRAVELLY SAND** a trace of silt
173.9 4.6	**END OF BOREHOLE** Refusal to auger at a depth of 4.6 m

SAMPLES		
Number	Type	N-Value
1A	DO	12
1B		
2	DO	11
3	DO	65
4	DO	50/15
5	DO	55/15
6	DO	50/0



WATER LEVEL

W.L. @ El. 177.6 m on completion
Cave-in @ El. 177.6 m on completion

Soil Engineers Ltd.

JOB NO.: 1803-S101

LOG OF BOREHOLE NO.: 108

FIGURE NO.: 8

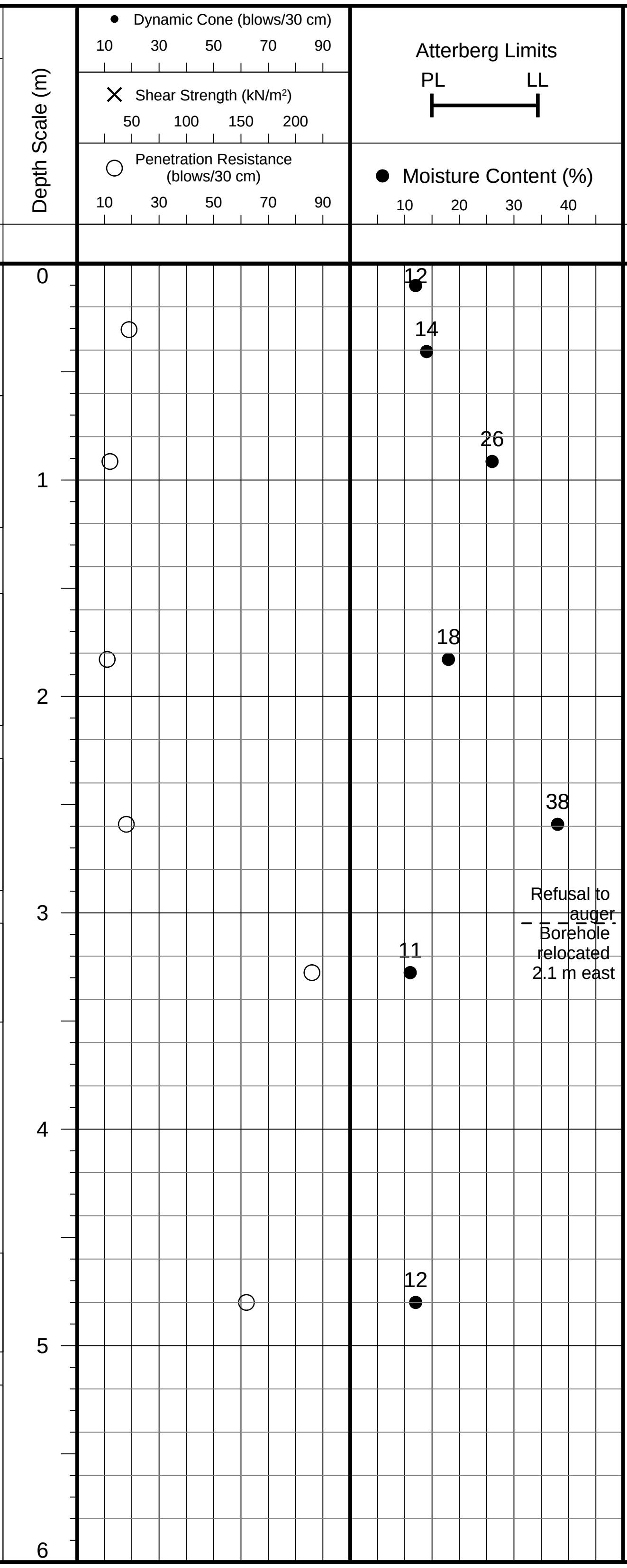
PROJECT DESCRIPTION: Proposed Resort

METHOD OF BORING: Hollow Stem Auger

PROJECT LOCATION: Cranberry Harbour Castle
15 Harbour Street East and 300 Balsam Street
Town of Collingwood

DRILLING DATE: April 17, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value
178.6	Ground Surface			
0.0	**20 cm TOPSOIL**	1A	DO	19
	Brown **EARTH FILL** **(Silty Sand)** traces of clay and gravel with organic inclusions	1B		
		2	DO	12
177.1 1.5	Brown, compact **GRAVELLY SAND** a trace of silt	3	DO	11
	wood/ cinder	4	DO	18
175.6 3.0	Grey, very dense **SILTY SAND TILL** a trace of clay a trace to some gravel occ. wet sand and silt seams and layers, cobbles and boulders	5	DO	86
		6	DO	62
173.4 5.2	**END OF BOREHOLE** Refusal to auger at a depth of 5.2 m			



Refusal to auger
Borehole relocated 2.1 m east

WATER LEVEL

W.L. @ El. 176.9 m on completion

Cave-in @ El. 176.5 m on completion

Soil Engineers Ltd.

JOB NO.: 1803-S101

LOG OF BOREHOLE NO.: 109

FIGURE NO.: 9

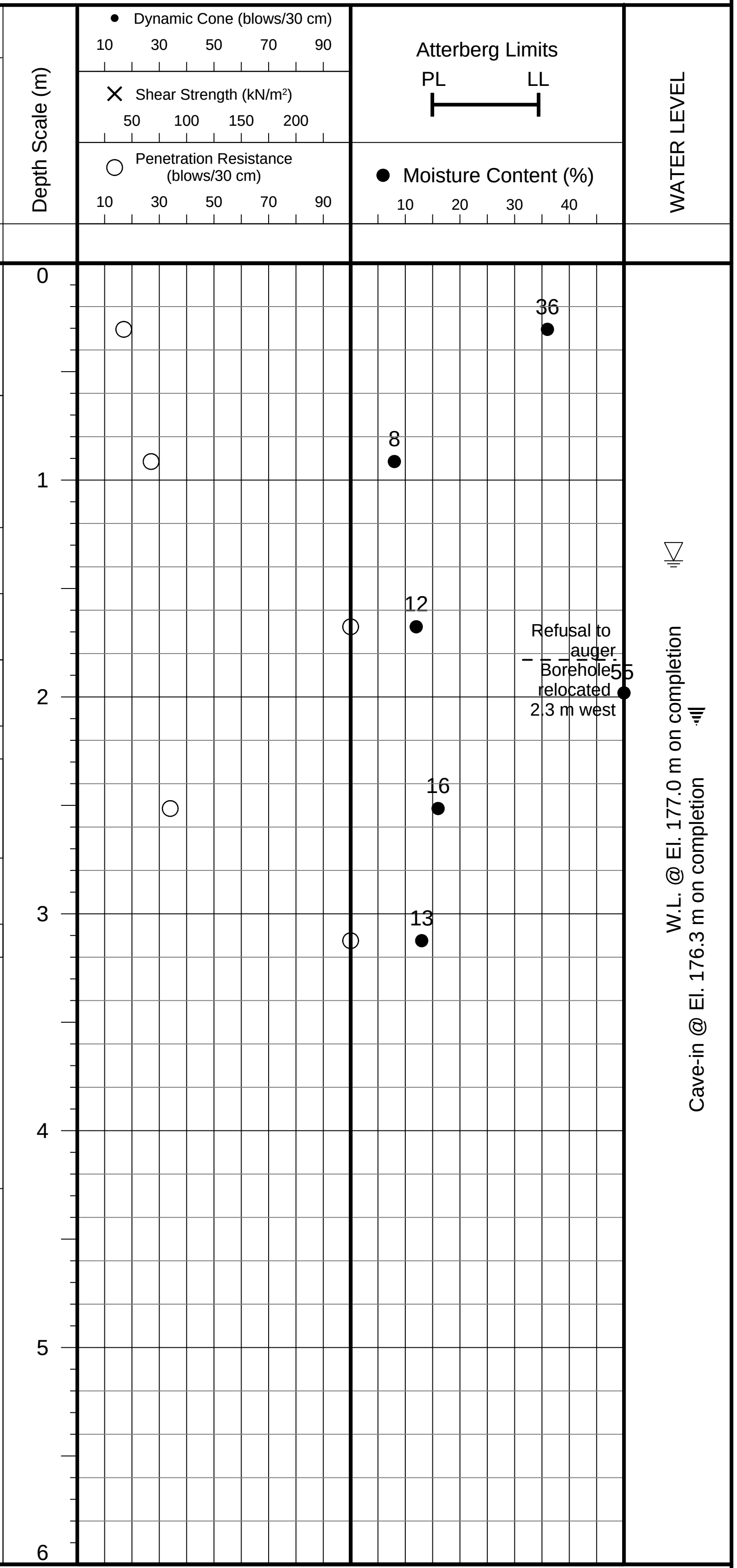
PROJECT DESCRIPTION: Proposed Resort

METHOD OF BORING: Solid Stem Flight-Auger

PROJECT LOCATION: Cranberry Harbour Castle
15 Harbour Street East and 300 Balsam Street
Town of Collingwood

DRILLING DATE: April 17, 2018

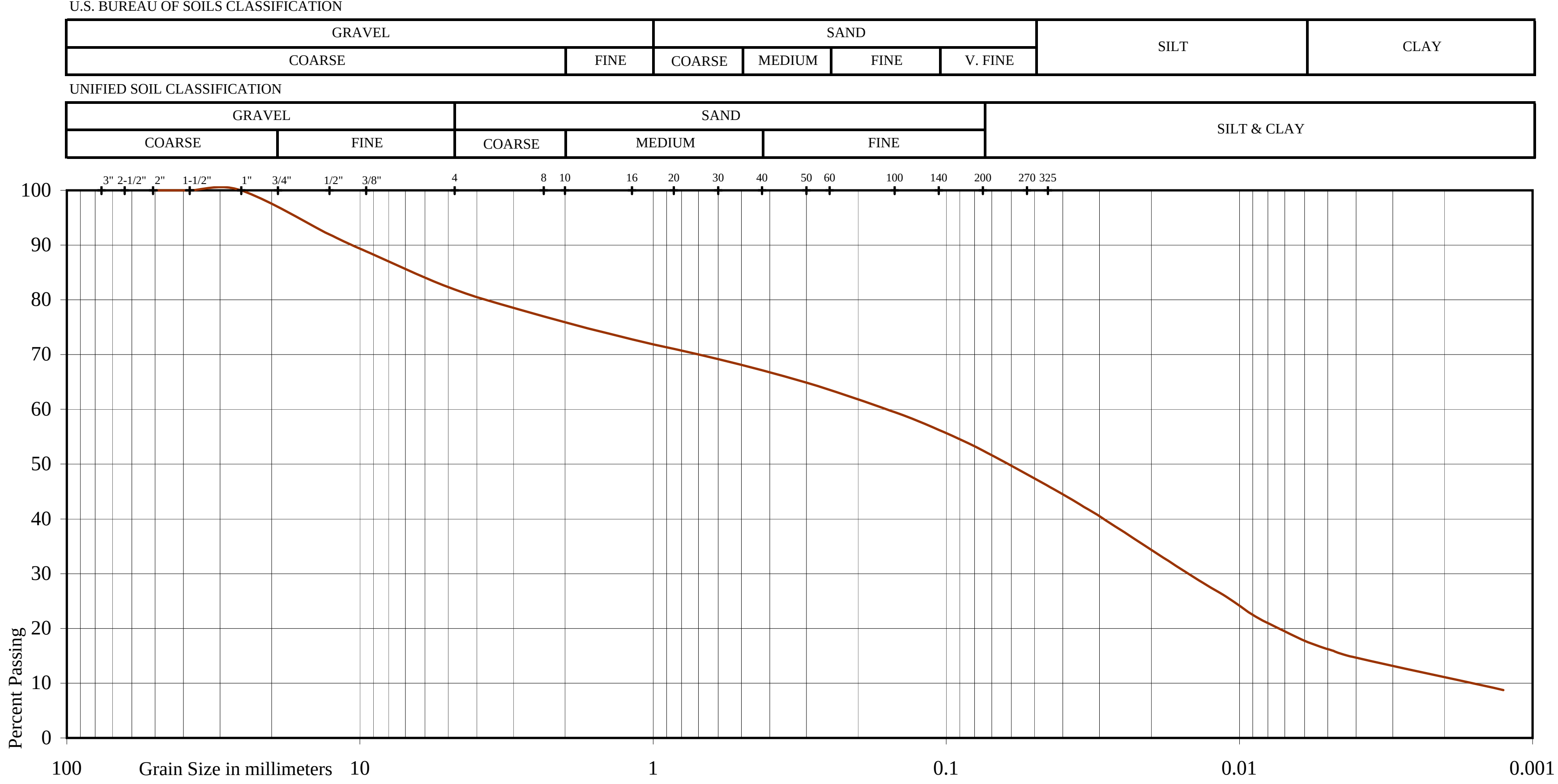
El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
178.4	Ground Surface			
0.0	**TOPSOIL FILL**	1	DO	17
	Brown, compact to very dense **GRAVELLY SAND** a trace to some silt	2	DO	27
		3	DO + AS	40/15
176.6 1.8	Black **FLOOD DEPOSIT** fine to medium grained sand with organic inclusions and wood debris	4	AS	-
176.1 2.3	Grey, dense **SANDY SILT TILL** some clay and gravel occ. wet sand and silt seams and layers, cobbles and boulders	5	DO	34
175.4 3.0	Grey, very dense **SILTY SAND TILL** a trace of clay a trace to some gravel occ. wet sand and silt seams and layers, cobbles and boulders	6	DO	50/15
174.1 4.3	**END OF BOREHOLE** Refusal to auger at a depth of 4.3 m			



Soil Engineers Ltd.

GRAIN SIZE DISTRIBUTION

Reference No: 1803-S101



Project:	Proposed Resort		
Location:	Cranberry Harbour Castle	Liquid Limit (%) =	-
	15 Harbour Street East and 300 Balsam Street, Town of Collingwood	Plastic Limit (%) =	-
Borehole No:	109	Plasticity Index (%) =	-
Sample No:	5	Moisture Content (%) =	16
Depth (m):	2.5	Estimated Permeability	
Elevation (m):	175.9	(cm./sec.) =	10^{-6}

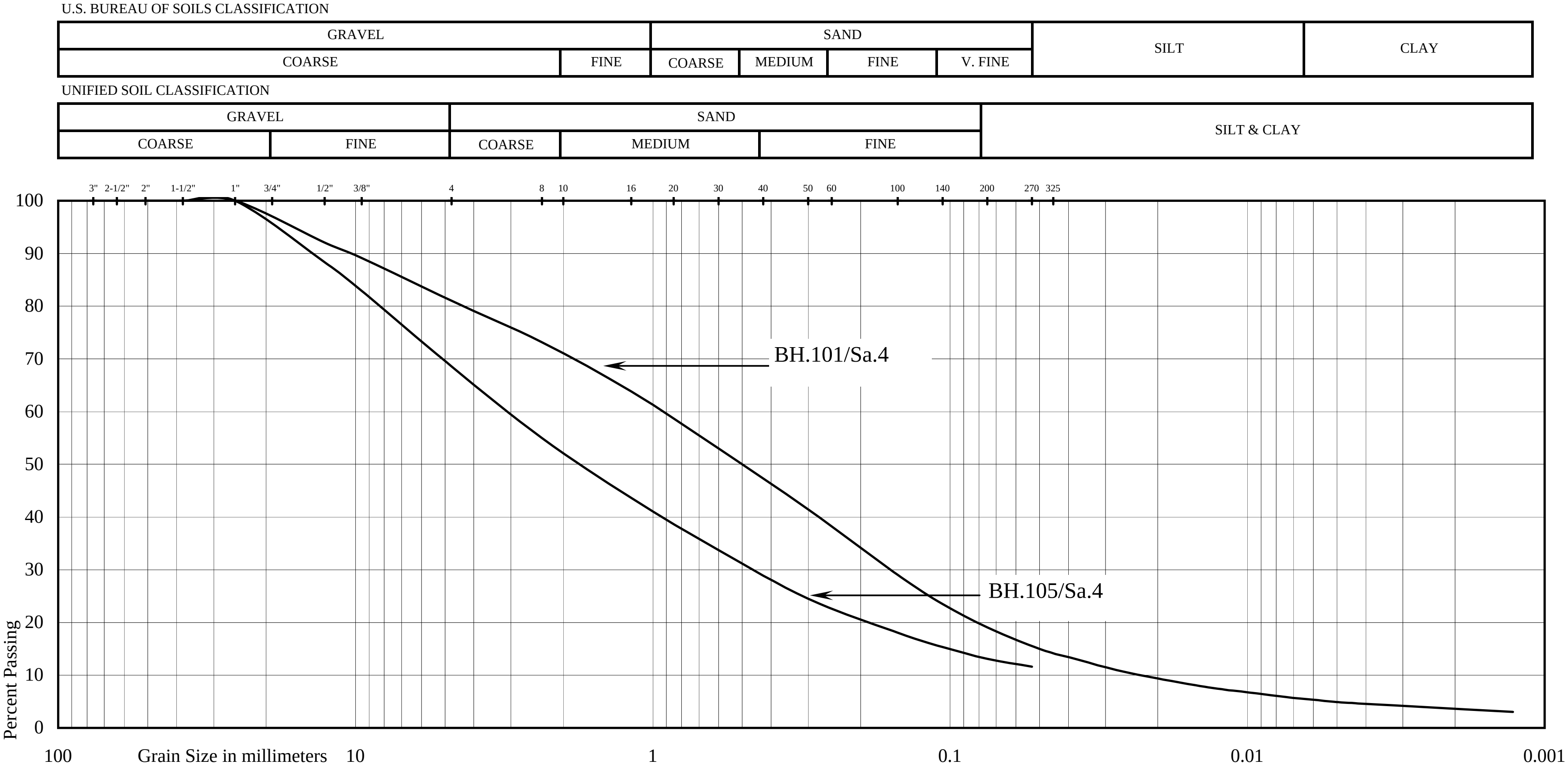
Classification of Sample [& Group Symbol]: SANDY SILT TILL, some clay and gravel

Figure: 10

Soil Engineers Ltd.

GRAIN SIZE DISTRIBUTION

Reference No: 1803-S101



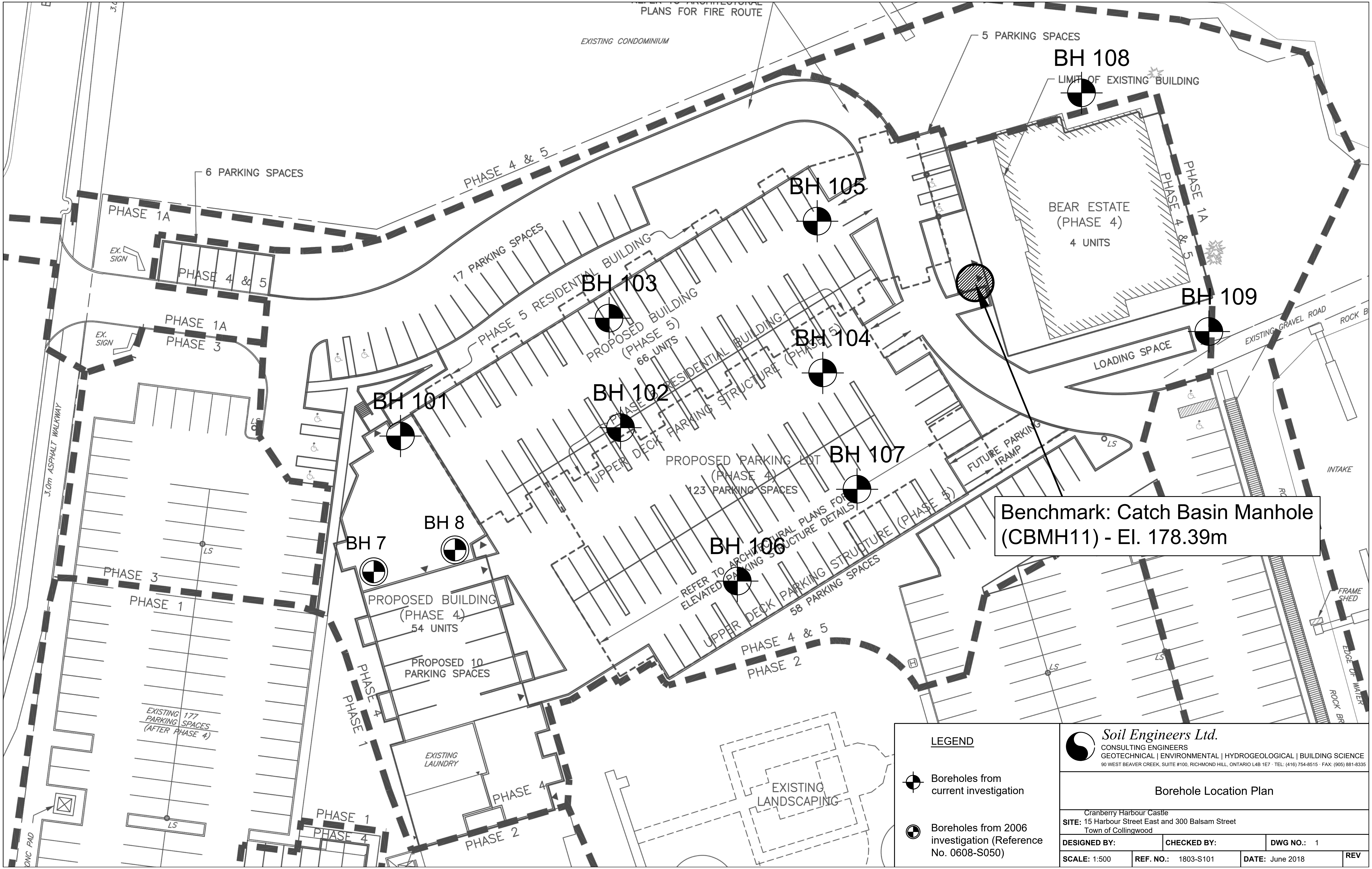
Project:	Proposed Resort	
Location:	Cranberry Harbour Castle	
	15 Harbour Street East and 300 Balsam Street, Town of Collingwood	
Borehole No:	101	105
Sample No:	4	4
Depth (m):	2.5	2.5
Elevation (m):	177.5	175.9

BH./Sa.	101/4	105/4
Liquid Limit (%) =	-	-
Plastic Limit (%) =	-	-
Plasticity Index (%) =	-	-
Moisture Content (%) =	10	8
Estimated Permeability (cm./sec.) =	10^{-3}	10^{-3}

Classification of Sample [& Group Symbol]: BH.101/Sa.4 - SAND, fine to coarse grained, some silt and gravel, a trace of clay

BH.105/Sa.4 - GRAVELLY SAND, some silt

Figure: 11



Benchmark: Catch Basin Manhole (CBMH11) - El. 178.39m

LEGEND

⊕ Boreholes from current investigation

⊕ Boreholes from 2006 investigation (Reference No. 0608-S050)

Soil Engineers Ltd.
CONSULTING ENGINEERS
GEOTECHNICAL | ENVIRONMENTAL | HYDROGEOLOGICAL | BUILDING SCIENCE
90 WEST BEAVER CREEK, SUITE #100, RICHMOND HILL, ONTARIO L4B 1E7 · TEL: (416) 754-8515 · FAX: (905) 881-8335

Borehole Location Plan

SITE: Cranberry Harbour Castle
15 Harbour Street East and 300 Balsam Street
Town of Collingwood

DESIGNED BY:
CHECKED BY:
DWG NO.: 1
SCALE: 1:500
REF. NO.: 1803-S101
DATE: June 2018
REV

Soil Engineers Ltd.
CONSULTING ENGINEERS
GEOTECHNICAL | ENVIRONMENTAL | HYDROGEOLOGICAL | BUILDING SCIENCE

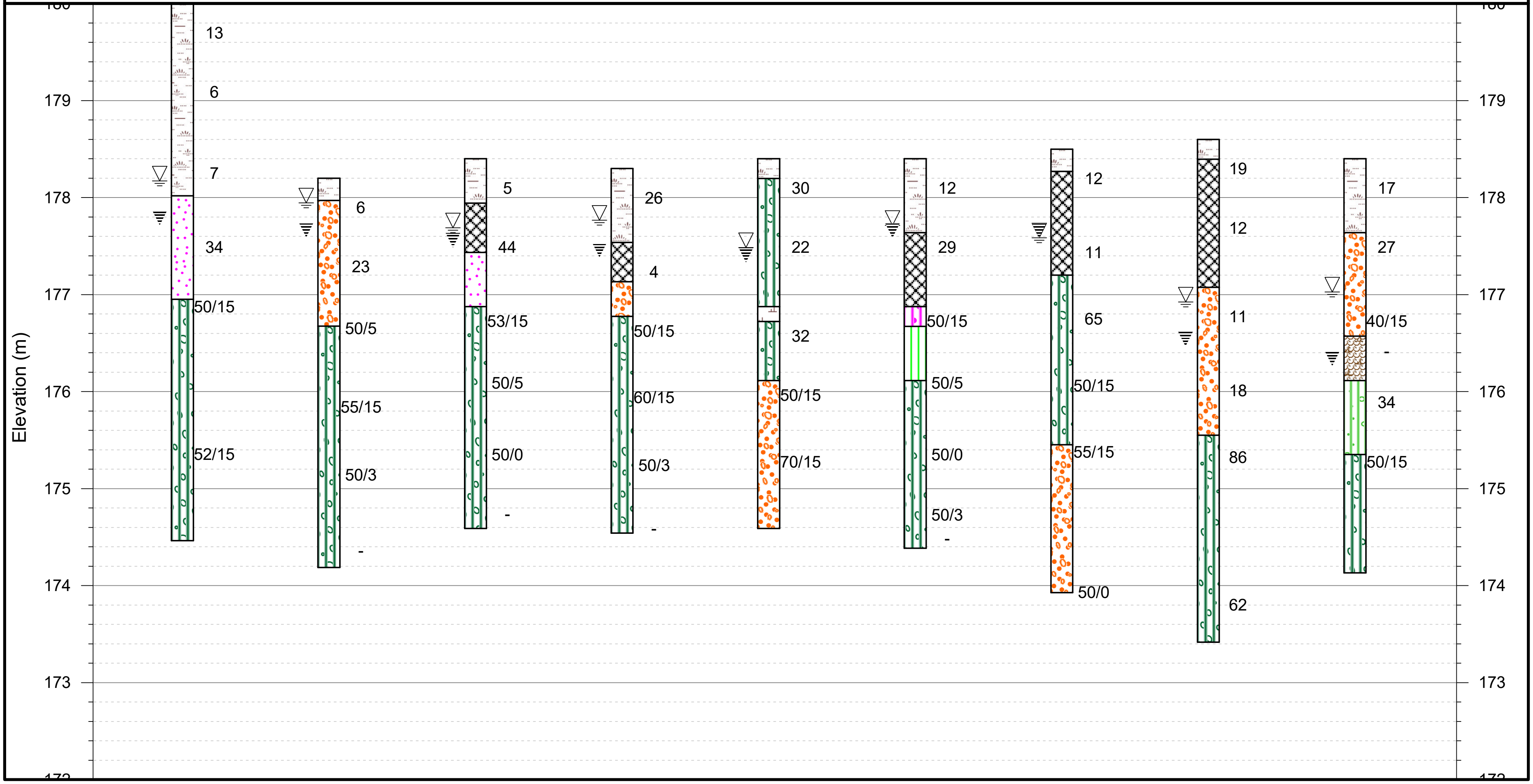
SUBSURFACE PROFILE
DRAWING NO. 2
SCALE: AS SHOWN

JOB NO.:	1803-S101
REPORT DATE:	June 2018
PROJECT DESCRIPTION:	Proposed Resort
PROJECT LOCATION:	Cranberry Harbour Castle 15 Harbour Street East and 300 Balsam Street Town of Collingwood

LEGEND

- ▨ TOPSOIL
- ▨ FILL
- ▨ SAND
- ▨ SILTY FINE SAND
- ▨ SILTY SAND TILL
- ▨ SANDY SILT TILL
- ▨ SILT
- ▨ ORGANIC
- ▨ FLOOD DEPOSIT
- ▨ GRAVELLY SAND
- ▽ WATER LEVEL (END OF DRILLING)
- ≡ CAVE-IN

BH No.:	101	102	103	104	105	106	107	108	109
El. (m):	180	178.2	178.4	178.3	178.4	178.4	178.5	178.6	178.4



Soil Engineers Ltd.
CONSULTING ENGINEERS
GEOTECHNICAL • ENVIRONMENTAL • HYDROGEOLOGICAL • BUILDING SCIENCE
90 WEST BEAVER CREEK ROAD, SUITE #100, RICHMOND HILL, ONTARIO L4B 1E7 · TEL (416) 754-8515 · FAX (905) 881-8335

BARRIE	MISSISSAUGA	OSHAWA	NEWMARKET	GRAVENHURST	PETERBOROUGH	HAMILTON
TEL: (705) 721-7863	TEL: (905) 542-7605	TEL: (905) 440-2040	TEL: (905) 853-0647	TEL: (705) 684-4242	TEL: (905) 440-2040	TEL: (905) 777-7956
FAX: (705) 721-7864	FAX: (905) 542-2769	FAX: (905) 725-1315	FAX: (905) 881-8335	FAX: (705) 684-8522	FAX: (905) 725-1315	FAX: (905) 542-2769

APPENDIX

BOREHOLE LOGS FOR BOREHOLES 7 AND 8 (FIGURES 7 AND 8)
FROM
SOIL INVESTIGATION REPORT REFERENCE NO. 0608-S050,
DATED NOVEMBER 2006

REFERENCE NO. 1803-S101

JOB NO.: 0608-S050

LOG OF BOREHOLE NO.: 7

FIGURE NO.: 7

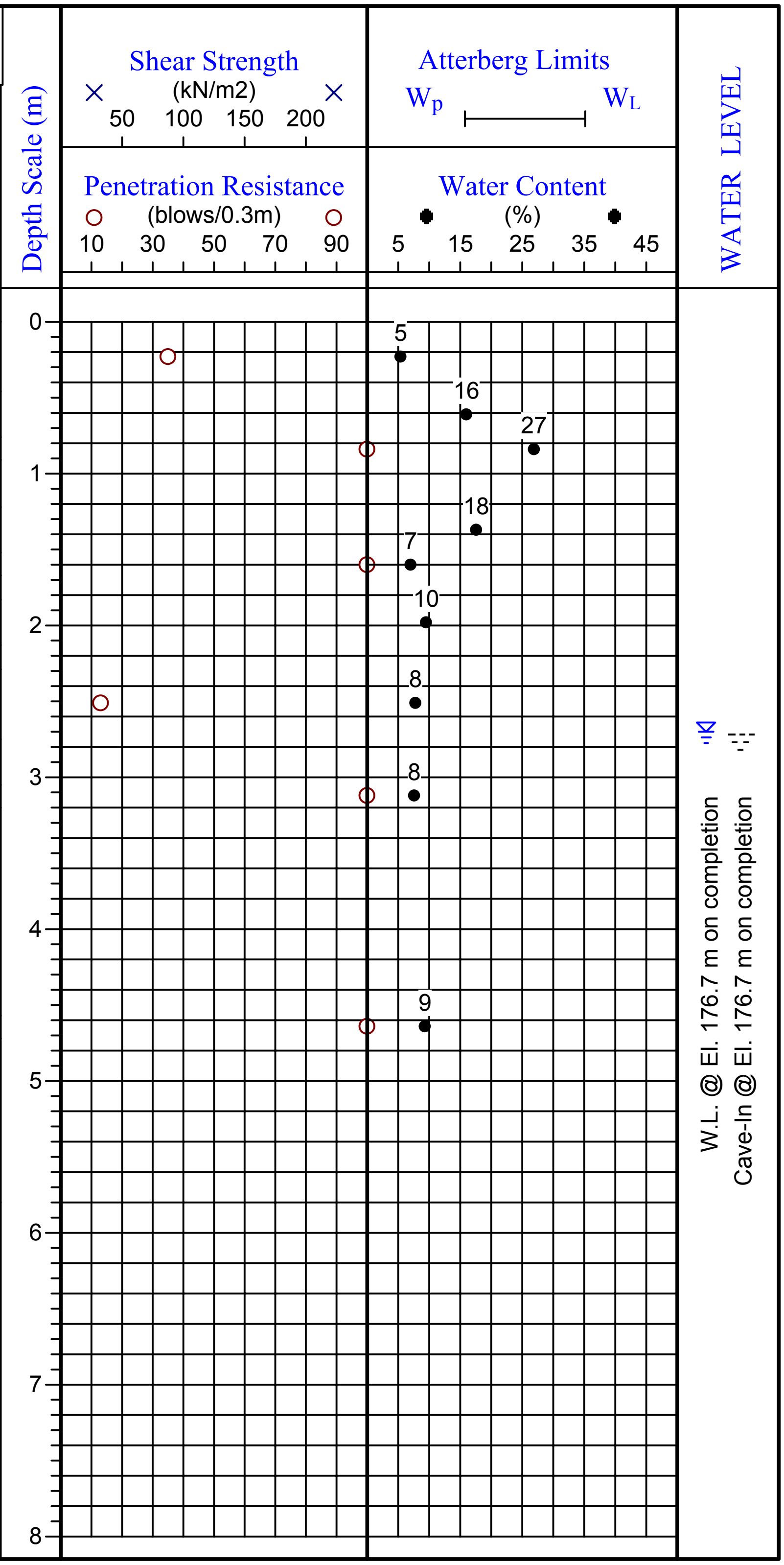
JOB DESCRIPTION: Proposed Hotel Development

JOB LOCATION: 15 Harbour Street East, Town of Collingwood

METHOD OF BORING: Flight-Auger

DATE: September 13, 2006

Elev. Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value
179.4	Ground Surface			
0.0	**GRANULAR, Fill**	1	DO	35
178.8 0.6	Brown **SAND, Fill** with wood debris ---- silty clay fill layer	2	AS	-
		3	DO	100+
		4	AS	-
177.9 1.5	Compact to very dense **SILTY SAND, Till** brown ---- grey a trace of gravel and clay occ. sand and silt seams and layers, cobbles, boulders and rock fragments ---- boulders and rock debris ----	5	DO	100+
		6	AS	-
		7	DO	13
		8	DO	100+
175.4 4.0	Grey, very dense **FINE SAND** some silt	9	DO	100+
173.6 5.8	**END OF BOREHOLE** Refusal to augering Inferred bedrock.			



Soil Engineers Ltd.

JOB NO.: 0608-S050

LOG OF BOREHOLE NO.: 8

FIGURE NO.: 8

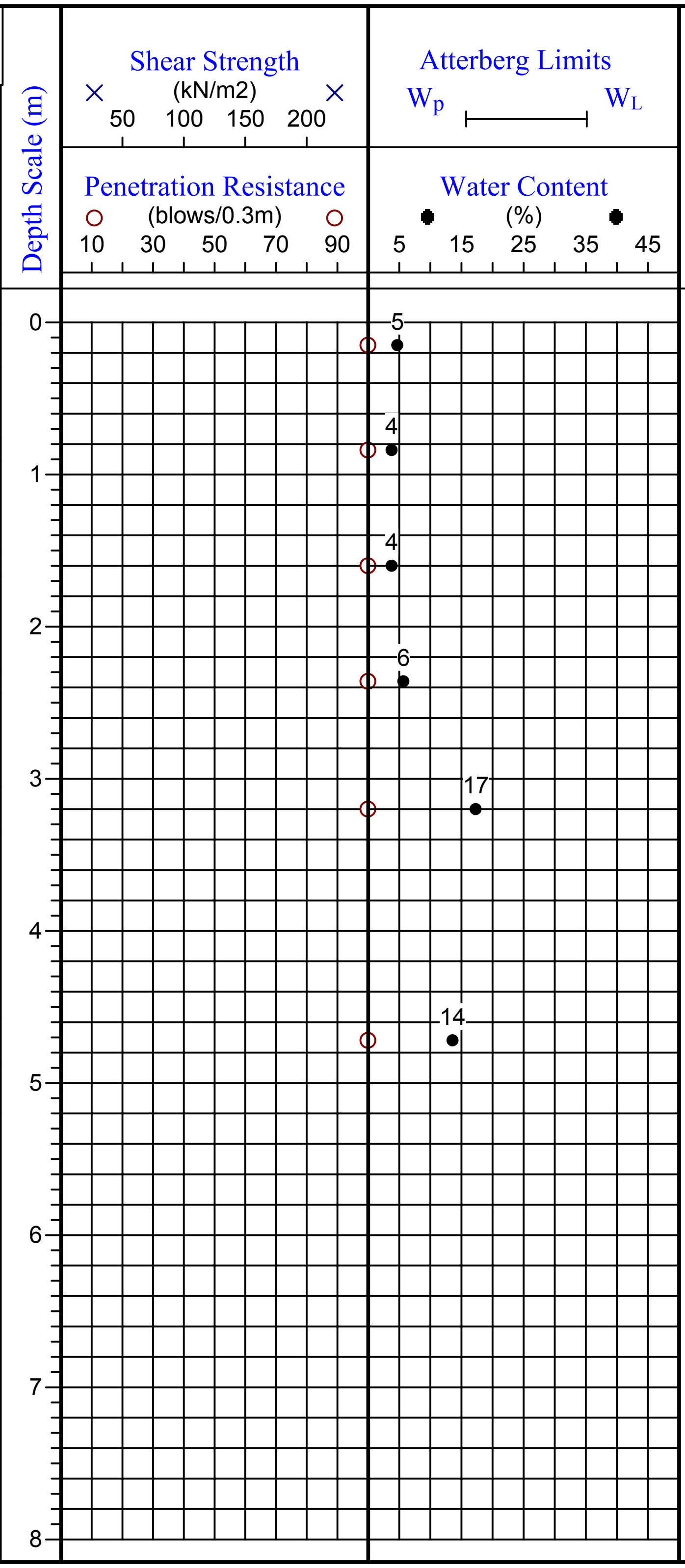
JOB DESCRIPTION: Proposed Hotel Development

JOB LOCATION: 15 Harbour Street East, Town of Collingwood

METHOD OF BORING: Flight-Auger

DATE: September 13, 2006

Elev. Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value
179.3	Ground Surface			
0.0	**SAND, Fill** with rock fragments	1 2	DO DO	100+ 100+
178.1 1.2	Brown, very dense **FINE TO COARSE SAND** a trace of gravel and clay occ. cobbles, boulders and rock slabs rock slab	3	DO	100+
177.3 2.0	Grey, very dense **SILTY SAND, Till** a trace of gravel and clay occ. sand and silt seams and layers, cobbles and boulders	4	DO	100+
176.6 2.7	Grey, very dense **FINE SAND** some silt occ. gravel, cobbles and rock fragments	5 6	DO DO	100+ 100+
174.1 5.2	**END OF BOREHOLE** Refusal to augering Inferred bedrock.			



WATER LEVEL

Cave-In @ El. 176.6 m on completion

Soil Engineers Ltd.