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A REPORT TO
BALLYMORE BUILDING (BARRIE) CORP.

A GEOTECHNICAL INVESTIGATION FOR PROPOSED RESIDENTIAL DEVELOPMENT

750 LOCKHART ROAD

CITY OF BARRIE

REFERENCE NO. 1810-S159

MARCH 2019

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1.0 INTRODUCTION

In accordance with written authorization from Ms. Sharon Dionne of Ballymore Building (Barrie) Corp. dated October 30, 2018, a geotechnical investigation was carried out on a parcel of land located at 750 Lockhart Road in the City of Barrie.

A preliminary geotechnical investigation of ten (10) boreholes was completed as part of the due diligence for land acquisition and the findings have been presented in a report dated September 5, 2017 (our Reference No. 1706-S080). The purpose of the current investigation was to evaluate the subsurface information from additional boreholes for the design and construction of the proposed residential development.

The geotechnical findings from both investigations and the resulting recommendations of the proposed development are presented in this Report.

2.0 SITE AND PROJECT DESCRIPTION

The City of Barrie is located within the periphery of Lake Simcoe basin where the glacial till has been partly eroded in places, by glacial Lake Algonquin and filled with lacustrine silts, sands and clay.

The subject property, approximately 13 hectares in area, is irregular in shape. It is located on the north side of Lockhart Road, approximately 350 m east of Yonge Street and immediately east of the Canadian National (CN) Railway in the City of Barrie. The property is currently a farm field with farmhouses and barns at the south portion. The centre portion is a treed area, having a watercourse known as the Hewitt's Creek bisecting the land and draining from the north to the east direction. The existing site gradient drops towards the creek, having a grade difference of almost 7 m across the property.

We understand that the property will be developed into a residential subdivision with townhouse blocks in the north portion, medium to high density residential blocks in the south portion, with a stormwater management facility in the mid portion. The existing treed area in the centre portion, however, will stay as a woodland. In addition, an earth berm will be constructed in the railway buffer along the CN Rail. The subdivision will be connected with municipal services and roadways meeting urban standards.

3.0 FIELD WORK

The field work of the current investigation, consisting of fifteen (15) sampled boreholes extending to depths of 6.4 to 9.6 m, was performed between November 27 and December 3, 2018. These boreholes are numbered in 100-series to distinguish them from the preliminary boreholes (Boreholes 1 to 10) completed in 2017.

The preliminary investigation has installed six (6) 50 mm diameter PVC monitoring wells in selected boreholes to facilitate groundwater monitoring by another consultant. Two (2) additional monitoring wells have been installed in the current investigation, upon completion of drilling and sampling. The locations of boreholes and monitoring wells are shown on the Location Plan, Drawing No. 1.

The boreholes 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 ground elevation at each borehole or monitoring well location was interpolated from the contours and spot elevations as shown on the Topographic Survey Plan, prepared by J.D. Barnes Ltd. dated January 15, 2018.

4.0 SUBSURFACE CONDITIONS

The investigation revealed that beneath the topsoil and ploughed soil, with a layer earth fill in places, the site is underlain by strata of sandy silt till and sand, with layers of silt and sandy silt. Detailed descriptions of the encountered subsurface conditions are presented on the Logs of Boreholes, comprising Figures 1 to 25, inclusive.

The revealed stratigraphy is plotted on the Subsurface Profile, Drawing Nos. 2 and 3. The engineering properties of the disclosed soils are discussed herein.

4.1 Topsoil/Ploughed Soil (All Boreholes, except Borehole 3)

In the farm field, a mixture of topsoil and ploughed soils extending to a depth of 0.6 to 1.4 m was contacted. In the other area, the existing ground surface was generally covered with topsoil in a variable thickness of 18 to 30 cm. Thicker topsoil layers can occur beyond or between the borehole locations, especially in the treed area and the low-lying area.

Another layer of topsoil or organic peat was encountered below the earth fill at a depth of 1.1 to 3.1 m from grade, at the location of Boreholes 5, 107 and 114. Its thickness ranges from 20 to 80 cm.

The topsoil and peat are dark brown in colour, and permeated with roots and humus. Similarly, the ploughed soil contains topsoil which is unstable and compressible under loads. They must be removed for site development. Alternatively, they can be reused in landscaped areas only. The topsoil fill must not be buried within the building envelope or deeper than 1.2 m below the finished grade, as it may have an adverse impact on the environmental well-being of the development.

4.2 **Earth Fill** (Boreholes 2, 3, 5, 6, 106, 107, 113, 114 and 115)

The earth fill consists of a mixture of sand, silt and clay. Due to the presence of organics and topsoil, the earth fill is not suitable to support any structure sensitive to movement.

For reuse as structural backfill, the earth fill must be sub-excavated, sorted free of organics and other deleterious materials, prior to placement and compaction in layers. If segregation is not feasible due to excessive amount of topsoil and organics, the fill should be disposed off site or reused for landscape purposes only.

4.3 **Sandy Silt Till** (Boreholes 1, 2, 5, 6, 7, 8, 9, 104, 105, 107, 108, 110, 111 and 112)

The sandy silt till consists of a random mixture of particle sizes ranging from clay to gravel, with sand and silt being the dominant fraction. It is heterogeneous and amorphous in structure, part of which has been reworked by the glacial lake. Grain size analyses were performed on two representative samples; the results are plotted on Figure 26.

Tactile examinations of the soil samples indicated that the till is slightly cemented. Intermittent hard resistance to augering was encountered, indicating the presence of cobbles and boulders in the till deposit. The obtained 'N' values range from 5 to over 100, with a median of 23 blows per 30 cm of penetration, indicating its relative density is loose to very dense, being generally compact.

The natural water content values of the till samples were determined; the results are plotted on the Borehole Logs. The values range from 5% to 23%, with a median of 10%, showing generally moist conditions, with occasional wet sand seams.

According to the above findings, the following engineering properties are deduced:

- High frost susceptibility and soil-adfreezing potential.
- Low permeability, with an estimated coefficient of permeability of 10^{-7} cm/sec, a percolation rate of 60 minutes/cm, and runoff coefficients of:

Slope	
0% - 2%	0.15
2% - 6%	0.20
6% +	0.28

- A frictional soil, the shear strength is primarily derived from internal friction and is augmented by cementation. The strength is density dependent.
- The till will be stable in steep cuts; however, under prolonged exposure, localized sheet collapse may occur.
- A fair pavement-supportive material, with an estimated California Bearing Ratio (CBR) value of 10%.
- Moderately low corrosivity to buried metal, with an estimated electrical resistivity of 5000 ohm·cm.

4.4 **Sand** (All Boreholes, except Boreholes 5 and 8)

The sand deposit is fine or fine to medium grained. Grain size analyses were performed on 4 representative samples; the results are plotted on Figures 27 and 28.

Sample examinations show that the sand deposit is in damp to wet conditions. This is confirmed by the natural water content of 3% to 24%, having a median of 18%.

The obtained 'N' values range from 3 to 100+, with a median of 50 blows per 30 cm of penetration, indicating loose to very dense, generally very dense in relative density.

The low ‘N’ value of 3 blows per 30 cm of penetration (at Borehole 9 location) may represent a disturbance by the hydrostatic pressure below the saturation level.

The following engineering properties of the sand deposit are deduced:

- Low frost susceptibility and soil-adfreezing potential.
- Highly water erodible, it is susceptible to migration through small openings under seepage pressure.
- Pervious, with an estimated coefficient of permeability of 10^{-3} to 10^{-4} cm/sec, a percolation rate of 8 to 15 minutes/cm and runoff coefficients of:

Slope	
0% - 2%	0.05
2% - 6%	0.10
6% +	0.15

- A frictional soil, the shear strength is derived from its internal friction angle and is soil density dependent.
- In excavation, the sand will slough and run slowly with seepage bleeding from the cut face. It will boil with a piezometric head of 0.3 m.
- A fair pavement-supportive material, with an estimated CBR value of 15%.
- Moderately low corrosivity to buried metal, with an estimated electrical resistivity of 6000 ohm·cm.

4.5 **Silt/Sandy Silt** (Boreholes 1, 4, 5, 8, 10, 110 and 113)

Deposits of silt and sandy silt were encountered in some of the boreholes at various depths. It is fine grained, with occasional sand seams and a trace of clay. Grain size analyses were performed on four representative samples; the results are plotted on Figures 29 and 30.

The natural water content of the soil samples ranges from 13% to 23%, with a median of 19%, indicating moist to wet conditions.

The obtained 'N' values range from 7 to over 100, with a median of 37 blows per 30 cm of penetration, indicating loose to very dense, being generally dense in relative density.

The engineering properties of the silt and sandy silt deposits are given below:

- Highly frost susceptible, with high soil-adfreezing potential.
- High water erodibility; it is susceptible to migration through small openings under seepage pressure.
- They have a high capillarity and water retention capacity.
- Semi-pervious, with an estimated coefficient of permeability of 10^{-5} cm/sec, a percolation rate of 30 minutes/cm and runoff coefficients of:

Slope	
0% - 2%	0.11
2% - 6%	0.16
6% +	0.23

- Frictional soils, the shear strength are density dependent. Due to their dilatancy, the strength of the wet silts 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 in shear strength.
- In excavation, the silts will slough and run slowly with seepage bleeding from the cut face. They will boil with a piezometric head of 0.4 m.
- Poor pavement-supportive material, with an estimated CBR value of 3%.
- Moderately corrosive to buried metal, with an estimated electrical resistivity of 4500 ohm·cm.

4.6 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	4 to 31	14	9 to 18
Sandy Silt Till	5 to 23 (median 10)	12	7 to 15
Sand	3 to 24 (median 18)	10	6 to 13
Silt/Sandy Silt	3 to 23 (median 19)	12	8 to 15

Based on the above findings, the silt till is generally suitable for 95% or + Standard Proctor compaction. However, the sand and silt are mostly on the wet side, and will require aeration prior to compaction. Aeration can be achieved by spreading the wet soil thinly on the ground during the dry and warm weather. Saturated sand can also be stockpiled on site to drain the excess water prior to placement and compaction.

The existing earth fill must be sub-excavated, sorted free of organics and other deleterious materials, prior to placement and compacted in layers.
The till and earth fill should be compacted using a heavy-weight kneading-type roller. The sand and silt can be compacted by a smooth drum roller, with or without vibration, depending on the water content of the soil 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.

One should be aware that with considerable effort, a 90%± Standard Proctor compaction of the wet sand and silt is achievable. Further densification is prevented by the pore pressure induced by the compactive effort; however, large random voids will have been expelled, and with time, the pore pressure will dissipate and the percentage of compaction will increase. There are many cases on record where after a few months of rest, the density of the compacted mantle has increased to over 95% of its maximum Standard Proctor dry density (SPDD).

If the compaction of the soils is carried out with the water content within the range for 95% SPDD 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 foundations or bedding of the sewer and slab-on-grade 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 an adequate subgrade for the 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 is mixed with the material, it must either be sorted or the material must not be used for construction of engineered fill and/or structural backfill.

5.0 GROUNDWATER CONDITIONS

The boreholes were checked for the presence of groundwater and the occurrence of cave-in upon completion of the field work. These records are summarized in Table 2.

Table 2 - Groundwater Record upon Completion

Borehole No.	**Ground Elevation (m)**	**Groundwater/Cave-In* Upon Completion**	
		Depth (m)	**Elevation (m)**
1	266.2	Monitoring well installed	
2	266.2	3.9*	262.3*
3	264.5	2.7*	261.8*
4	266.6	3.9*	262.7*
5	259.6	Monitoring well installed	
6	261.1	0.9	260.2
7	263.3	Monitoring well installed	
8	255.6	Monitoring well installed	
9	260.8	Monitoring well installed	
10	263.0	Monitoring well installed	
101	262.6	2.6/2.7*	260.0/259.9*
102	262.3	2.1/2.2*	260.2/260.1*
103	261.6	Monitoring well installed	
104	259.9	1.7*	258.2*
105	258.3	1.5/1.7*	256.8/256.6*
106	261.6	3.3*	258.3*
107	260.5	Monitoring well installed	
108	264.6	3.3	261.3

Table 2 - Groundwater Record upon Completion (cont'd)

Borehole No.	Ground Elevation (m)	Groundwater/Cave-In* Upon Completion	
		Depth (m)	Elevation (m)
109	263.9	2.3/2.4*	261.6/261.5*
110	267.1	5.1*	262.0*
111	265.8	3.3/3.5*	262.5/262.3*
112	263.3	3.6*	259.7*
113	265.0	5.1/5.4*	259.9/259.6*
114	261.8	2.1	259.7
115	262.3	1.0	261.3

Groundwater and cave-in were recorded between El. 256.6 m and 262.7 m in the open boreholes upon completion. In addition, groundwater records in the monitoring wells between August 2017 and February 2019 are provided by R.J. Burnside & Associates Limited, as summarized in Table 3.

Table 3 - Groundwater Level in Monitoring Wells

Borehole/ Monitoring Well No.	Ground El. (m)	August 30, 2017		November 24, 2017		April 24, 2018	
		Depth (m)	El. (m)	Depth (m)	El. (m)	Depth (m)	El. (m)
1	266.2	3.7	262.5	4.1	262.1	3.3	262.9
5	259.6	2.2	257.4	2.2	257.4	1.5	258.1
7	263.3	1.0	262.3	1.1	262.2	0.4	262.9
8	255.6	0.0	255.6	0.0	255.6	0.0	255.6
9	260.8	1.9	258.9	1.6	259.2	1.0	259.8
10	263.0	2.0	261.0	2.0	261.0	1.4	261.6

Table 3 - Groundwater Level in Monitoring Wells (cont'd)

Borehole/ Monitoring Well No.	**Ground El. (m)**	**August 14, 2018**		**December 17, 2018**		**February 1, 2019**	
		Depth (m)	**El. (m)**	**Depth (m)**	**El. (m)**	**Depth (m)**	**El. (m)**
1	266.2	4.1	262.1	4.0	262.2	4.0	262.2
5	259.6	2.7	256.9	2.0	257.6	2.2	257.4
7	263.3	1.3	262.0	1.2	262.1	1.3	262.0
8	255.6	0.0	255.6	0.0	255.6	0.0	255.6
9	260.8	2.0	258.8	1.7	259.1	1.9	258.9
10	263.0	2.2	260.8	1.9	261.1	2.1	260.9
103	261.6	-	-	-	-	2.8	258.8
107	260.5	-	-	-	-	1.5	259.0

The water level in the monitoring wells represents the groundwater regime in the area between August 2017 and February 2019. The highest groundwater level was recorded between El. 255.6 m and 262.9 m in April 2018. It is subject to seasonal fluctuation and the groundwater appears to drop in the east direction.

An artesian pressure is evident in Boreholes 1, 5, 6, 7, 8, 9, 104, 105, 107, 108 and 112, due to a confined aquifer below the low permeable till deposit. Depressurization of groundwater will be necessary before commencement of excavation below the stabilized water level in these areas.

Depending on the groundwater levels, the basement floor elevation of the development and the safe depth of excavation will have to be established.

6.0 DISCUSSION AND RECOMMENDATIONS

The investigation revealed that beneath the topsoil and ploughed soil, with a layer earth fill in places, the site is underlain by strata of sandy silt till and sand, with layers of silt and sandy silt.

Groundwater and cave-in were recorded between El. 256.6 m and El. 262.7 m in the open boreholes upon completion. The water level in the monitoring wells, representing the groundwater regime in the area, was recorded between August 2017 and February 2019, having the highest level between El. 255.6 m and El. 262.9 m in April 2018. It is subject to seasonal fluctuation and the groundwater appears to drop in the east direction.

An artesian pressure is evident in Boreholes 1, 5, 6, 7, 8, 9, 104, 105, 107, 108 and 112, due to a confined aquifer below the low permeable till deposit. Depressurization of groundwater will be necessary before commencement of excavation below the stabilized water level in these areas.

Based on the conceptual plans, the property will be developed into a residential subdivision with townhouse blocks in the north portion and medium to high density residential blocks in the south portion. A stormwater management facility is also proposed in the mid portion. The subdivision will be connected with municipal services and roadways meeting urban standards. In addition, an earth berm will be constructed in the railway buffer along the CN Rail.

The geotechnical findings which warrant special consideration are presented below:

1. The topsoil and ploughed soil must be removed for the development. The thickness may vary or becomes thicker in some areas. In order to prevent overstripping, a diligent control of the stripping operation will be required.
2. Topsoil and organic soils must not be buried within the building envelope or deeper than 1.2 m below the exterior finished grade of the development. It can only be used for landscaping and landscape contouring purposes.
3. Due to the high groundwater conditions, the site will have to be regraded with the addition of earth fill so that the proposed basement of the house structures will be above the groundwater level at all times. It is generally more economical to place an engineered fill for construction.
4. The basement floor should be at least 0.5 m above the highest detected groundwater level. Underfloor subdrains may be required in individual basement structures, having the basement floor less than 1.0 m from the highest detected groundwater level to prevent any hydrostatic uplift and groundwater upfiltration due to the seasonal fluctuation.
5. The existing earth fill is not suitable to support any structure sensitive to movement. It must be subexcavated, sorted free of topsoil inclusions or deleterious materials, before it is reused as engineered fill or structural backfill.
6. The native subsoil and the engineered fill are suitable for conventional footing construction. The footing subgrade must be inspected by a geotechnical engineer, or a geotechnical technician under the supervision of a geotechnical engineer.
7. An artesian pressure is evident in Boreholes 1, 5, 6, 7, 8, 9, 104, 105, 107, 108 and 112. Depressurization of groundwater will be necessary before commencement of excavation below the stabilized water level in these areas.
8. A Class ‘B’ bedding, consisting of compacted 20-mm Crusher-Run Limestone or equivalent, is recommended for the construction of the underground services. In water-bearing sand and silt or in areas where dewatering is necessary, a

Class ‘A’ concrete bedding should be used.

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 this become apparent during construction, a geotechnical engineer must be consulted to determine whether the following recommendations require revision.

6.1 Site Preparation

Due to the groundwater conditions, the site will have to be regraded with the addition of earth fill so that the proposed basement of the house structures will be above the groundwater level at all times. Any basement structure founded below the groundwater level will have to be water-proofed and designed as a tank structure to resist the hydrostatic pressure. It is generally more economical to place an engineered fill for the house foundations, underground services and pavement construction. The engineering requirements for a certifiable fill are presented below:

1. All topsoil, ploughed soil and earth fill must be removed and the subgrade must be inspected and proof-rolled prior to any fill placement. Badly weathered soils should also be subexcavated.
2. The existing earth fill and weathered soils can be sorted free of organics or deleterious material, aerated and properly compacted in layers.
3. Inorganic soils must be used for the engineered fill. They must be uniformly compacted in lifts 20 cm thick to 98% or + of their maximum SPDD up to the proposed finished grade. 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 SPDD.

4. If imported fill is to be used, it should be inorganic soils, free of any deleterious 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.
5. In areas where significant engineered fill (fill more than 3.0 m) is to be placed, settlement plates must be installed and monitored on a weekly basis to assess any consolidation progress in the fill and the underlying strata. No construction of site services or house foundations can commence in these areas until the settlement records have confirmed that the settlement is reduced to a tolerable level and there is no risk of long-term settlement. Where the readings remain the same for a period of 3 consecutive months, no further monitoring will be required and there is no risk for long-term settlement. The settlement of the engineered fill is anticipated to be reduced to a tolerable limit of 25 mm.
6. 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.
7. The engineered fill must extend over the entire graded area; the engineered fill envelope and the finished elevations must be clearly and accurately defined in the field, and must be precisely documented by qualified surveyors.
8. 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.
9. 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.

10. Where the fill is to be placed on a bank steeper than 1 vertical:3 horizontal, the face of the bank must be flattened to 3+ so that it is suitable for safe operation of the compactor and the required compaction can be obtained.
11. The fill operation must be inspected on a full-time basis by a technician under the direction of a geotechnical engineer. In this case, the effect of long-term settlement is expected to be negligible as the fill material will be compacted to achieve an appropriate strength and capacity for structural support.
12. 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.
13. Once the engineered fill is certified, any excavation carried out in the certified fill area must be reported to the geotechnical consultant who inspected the fill placement, in order to document the locations of 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 status must be assessed for re-certification.
14. Despite stringent control in the placement of engineered fill, variations in soil type and density may occur in the engineered fill. Therefore, the strip footings and the upper section of the foundation walls constructed on the engineered fill may require continuous reinforcement with steel bars, depending on the uniformity of the soils in the engineered fill and the thickness of the engineered fill underlying the foundations. Should the footings and/or walls require reinforcement, the required number and size of reinforcing bars must be assessed by considering the uniformity as well as the thickness of the engineered fill beneath the foundations. In sewer construction, the engineered fill is considered to have the same structural proficiency as a natural inorganic soil.

6.2 **Foundations**

It is assumed that the site will be regraded with an engineered fill for development. Recommended soil bearing pressures of 100 kPa (SLS) and 160 kPa (ULS) are recommended for the design of conventional spread and strip footings founded on the engineered fill or sound native soil stratum. The total and differential settlements of footings are estimated to be 25 mm and 15 mm, respectively.

Higher design bearing pressures may be provided for the foundation design of special structure at particular location, once the details and the founding elevation of the structure are finalized.

One must be aware that the recommended bearing pressures are given as a guide for foundation design and the footing subsoil must be confirmed by a geotechnical engineer at the time of construction.

If groundwater seepage is encountered during excavations, or where the subgrade of the footing is saturated, the subgrade should be protected by a concrete mud-slab immediately after exposure. This will prevent construction disturbance and costly rectification.

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

The building foundation must meet the requirements specified in the latest Ontario Building Code. As a guide, the structure should be designed to resist an earthquake force using Site Classification ‘D’ (stiff soil).

6.3 **Basement and Slab-On-Grade**

In order to minimize the impact of hydrostatic pressure and uplift, the basement floor should be at a depth at least 0.5 m above the highest detected groundwater elevation. In conventional design, perimeter subdrains and dampproofing of the foundation walls will be required in order to provide a dry basement. All the subdrains should be encased in a fabric filter to protect them against blockage by silting.

If the basement floor is less than 1.0 m above the highest detected groundwater elevation, underfloor subdrains should be provided in the granular bedding below the basement floor. The subdrains should be connected to the drainage or sump pits where water can be removed. In addition, vapour barrier of 6 mil polyethylene sheet should be placed above the granular bedding to alleviate wetting of the basement floor due to moisture upfiltration. A typical design of the bedding and the underfloor weepers is provided in Drawing No. 4.

The soil parameters outlined in Section 6.9 can be used for calculating the lateral earth pressure imposed on the basement walls.

The slab should be constructed on a granular base of 20 cm thick, consisting of 20-mm Crusher-Run Limestone, or equivalent, compacted to 100% of its maximum SPDD. Where underfloor weepers are required, the bedding should be increased to 30 cm and a 6-mil polyethylene membrane should be provided between the concrete slab and the bedding to prevent the migration of vapours into the structure.

The subgrade for slab-on-grade must consist of sound natural soil or properly compacted inorganic engineered fill. The subgrade should be inspected and assessed by proof-rolling prior to slab-on-grade construction. Where the subgrade consists of soft or weathered soils, it should be subexcavated, sorted free of topsoil inclusions, if any, aerated and uniformly compacted to 98% or + of its maximum SPDD.

6.4 **Underground Services**

The subgrade for underground services should consist of natural soils or engineered fill. In areas where the subgrade consists of unsuitable material, it should be subexcavated and replaced with properly compacted inorganic soil and/or bedding material compacted to at least 95% or + of SPDD.

Excavation for service trenches must be carried out in accordance with Ontario Regulation 213/91. In areas where a vertical cut is necessary, the use of a trench box is appropriate. The recommended lateral earth pressure coefficients presented in Section 6.9 can be used for the design of trench box or shoring.

A Class ‘B’ bedding is recommended for construction of the underground services. The bedding material should consist of compacted 20-mm Crusher-Run Limestone, or equivalent, as approved by a geotechnical engineer. Where saturated soils are present or extensive dewatering is required, a Class ‘A’ bedding will likely be required. The pipe joints and the pipe connections to manholes or catch basins should be leak-proof or wrapped with a waterproof membrane and backfilled with lean mix concrete.

In order to prevent pipe floatation when the sewer trench is deluged with water, a soil cover with a thickness equal 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.

The underground services should be protected against soil corrosion. For estimation of anode weight requirements, the estimated electrical resistivity of 4500 ohm·cm can be used. This should be confirmed by testing the soil along the water main alignment at the time of construction.

6.5 **Backfilling in Trenches and Excavated Areas**

The backfill in service trenches should be compacted to at least 95% of the maximum SPDD. In the zone within 1.0 m below the road subgrade, the material should be compacted with the water content 2% to 3% drier than the optimum; and the compaction should be increased to 98% of the respective maximum SPDD to provide the required stiffness for road construction.

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

Narrow trenches for services crossings should be cut at 1V:2H, so that the backfill in the trenches can be effectively compacted. Otherwise, soil arching in the trenches will prevent the achievement of proper compaction. The lift of each backfill layer should be limited to a thickness of 20 cm.

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

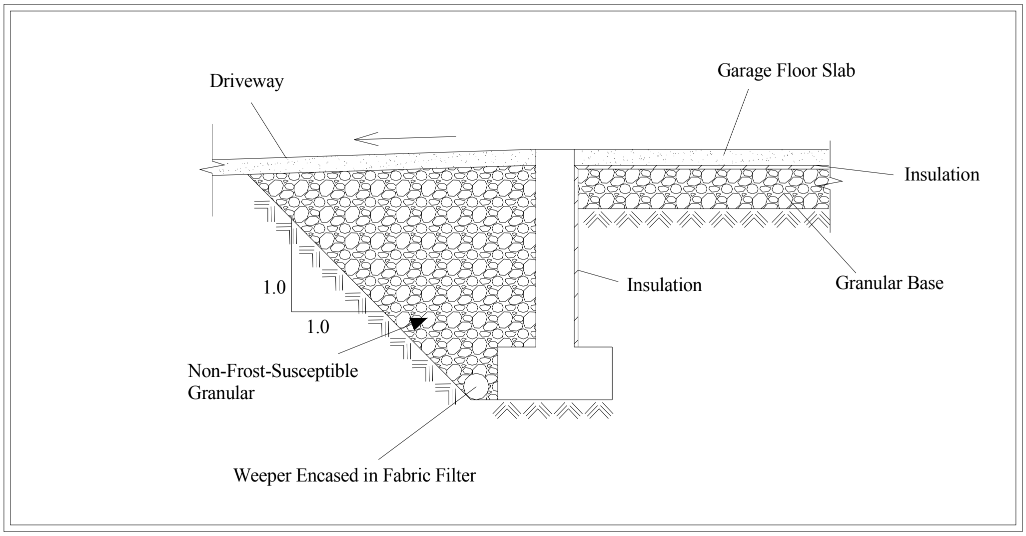
- When construction is carried out in freezing winter weather, allowance should be made for these following conditions. Despite stringent backfill monitoring, frozen soil layers may inadvertently be mixed with the structural trench backfill. Should the in situ soil have a water content on the dry side of the optimum, it would be impossible to wet the soil 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 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 underground services construction is carried out during 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.
- 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 1V:1.5+H, 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 SPDD, 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 Garages, Driveways and Landscaping

The subgrade soils can be frost susceptible. The ground is expected to heave during the freezing season. In order to minimize frost heaving, the driveway at the entrance to the garage should be backfilled with non-frost-susceptible granular material, with a frost taper at a slope of 1V:1H. The garage floors and the interior of the foundation walls should be insulated by 50-mm Styrofoam (or its equivalent), or a Granular 'B' backfill should be used for the garage construction. The recommended scheme is illustrated in Diagram 1.

Diagram 1 - Frost Protection Measures (Garage)



The slab-on-grade or sidewalk in open areas should be designed to tolerate frost heave. The grading around the slab-on-grade and house structures must be such that it directs runoff away from the structures. In areas where ground movement due to frost heave cannot be tolerated, the slab-on-grade or sidewalks must be constructed on a free-draining granular base, 0.3 to 1.5 m thick, depending on the degree of tolerance for settlement. These measures, with proper drainage, will prevent water from accumulating in the granular base. Alternatively, they can be insulated with 50-mm Styrofoam, or equivalent.

6.7 Pavement Design

The recommended pavement design for local roads and collectors is presented in Table 4.

Table 4 - Pavement Design

Course	Thickness (mm)	OPS Specifications
Asphalt Surface	40	HL-3
Asphalt Binder Local Roads Collectors	 50 65	HL-8
Granular Base	150	OPSS Granular ‘A’ or equivalent
Granular Sub-base Local Roads Collectors	 300 400	OPSS Granular ‘B’ or equivalent

In preparation of road subgrade, the topsoil and compressible material must be removed. Any new fill should consist of organic free material, compacted to 95% or + of the maximum SPDD. In the zone within 1.0 m below the pavement subgrade, the backfill should be compacted to at least 98% of the maximum SPDD, with the water content 2% to 3% drier than the optimum. The final subgrade should be inspected and proof-rolled. Any soft spots should be subexcavated, and replaced by properly compacted inorganic earth fill.

All the granular bases should be compacted to the maximum SPDD.

The pavement subgrade will suffer a strength regression if water is allowed to infiltrate prior to paving. The following measures should therefore be incorporated into the construction and road design:

- If road construction does not immediately follow the trench backfilling, the subgrade should be properly crowned and smooth-rolled to allow interim precipitation to be properly drained.
- Lot areas adjacent to the road structure should be properly graded to prevent the ponding of large amounts of water during the interim construction period.
- If the road is to be constructed during the wet seasons and extremely soft subgrade occurs, the granular sub-base may require thickening. This can be further assessed during construction.
- Fabric filter-encased curb subdrains are required to meet the Municipal road requirements.

6.8 **Stormwater Management Facility** (Boreholes 5, 6 and 107)

A Stormwater Management (SWM) facility will be constructed in the mid portion of the site, in the area of Boreholes 5, 6 and 107. The subsoil consists of sandy silt till of low permeability, overlying saturated sand or silt which may be under subterranean artesian pressure. The design of the pond, thus, should consist of an impermeable layer to resist the uplift pressure, having a factor of safety not less than 1.3 when the pond is empty for maintenance.

A drainage blanket can be used beneath the pond liner to release the hydrostatic pressure so that the thickness of the impermeable liner can be minimized. The design of the drainage blanket, the type of material and the thickness of liner depends on the pond location and the invert elevation of the pond.

For the construction of earth berm and access road, topsoil must be removed and the subgrade must be proof-rolled. Inorganic on-site material can be used, compacted to at least 98% of the maximum SPDD. A granular course consisting of 300 mm of 50-mm Crusher-Run Limestone, topped with 50 mm of limestone screening should be provided on the access road.

The preparation of bearing subsoil and the design soil capacities listed in Sections 6.1 and 6.2 can be used for the design of control structures. The inlet and outlet of the pond must be lined with gabion mats or equivalent for protection against scouring and erosion.

6.9 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	10.0	1.33	0.98
Sandy Silt Till	22.0	12.0	1.30	1.05
Sand/Silt	21.0	11.0	1.20	1.00

Table 5 - Soil Parameters (continued)

Lateral Earth Pressure Coefficients	**Active** K_a	**At Rest** K_o	**Passive** K_p
Compacted Earth Fill	0.40	0.55	4.00
Native Till, Sand or Silt	0.35	0.50	3.00
Coefficients of Friction			
Between Concrete and Granular Base			0.50
Between Concrete and Sound Native Soils			0.35

6.10 Excavation

Excavation should be carried out in accordance with Ontario Regulation 213/91. For excavation purposes, the types of soils are classified in Table 6.

Table 6 - Classification of Soils for Excavation

Material	Type
Sound Native Till	2
Weathered Soils, Earth Fill, drained Sand and Silt	3
Saturated Soils	4

In excavation, groundwater yield from the till at shallow depth will be slow in rate and limited in quantity. If the excavation extends to the deeper level, basal heaving may occur due to the artesian pressure. Depressurization of groundwater from the pressure relief wells or well points will be necessary before commencement of excavation below the stabilized water level in the areas of Boreholes 1, 5, 6, 7, 8, 9, 104, 105, 107, 108 and 112. 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 sewer subgrade. 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 Ballymore Building (Barrie) Corp., for review by its designated consultants, financial institutions, and government agencies. Use of this report is subject to the conditions and limitations of the contractual agreement.

The material in the report reflects the judgment of Kin Fung Li, P.Eng., and Bennett Sun, 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.

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March 22, 2019

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.: 1810-S159

LOG OF BOREHOLE NO.: 101

FIGURE NO.: 1

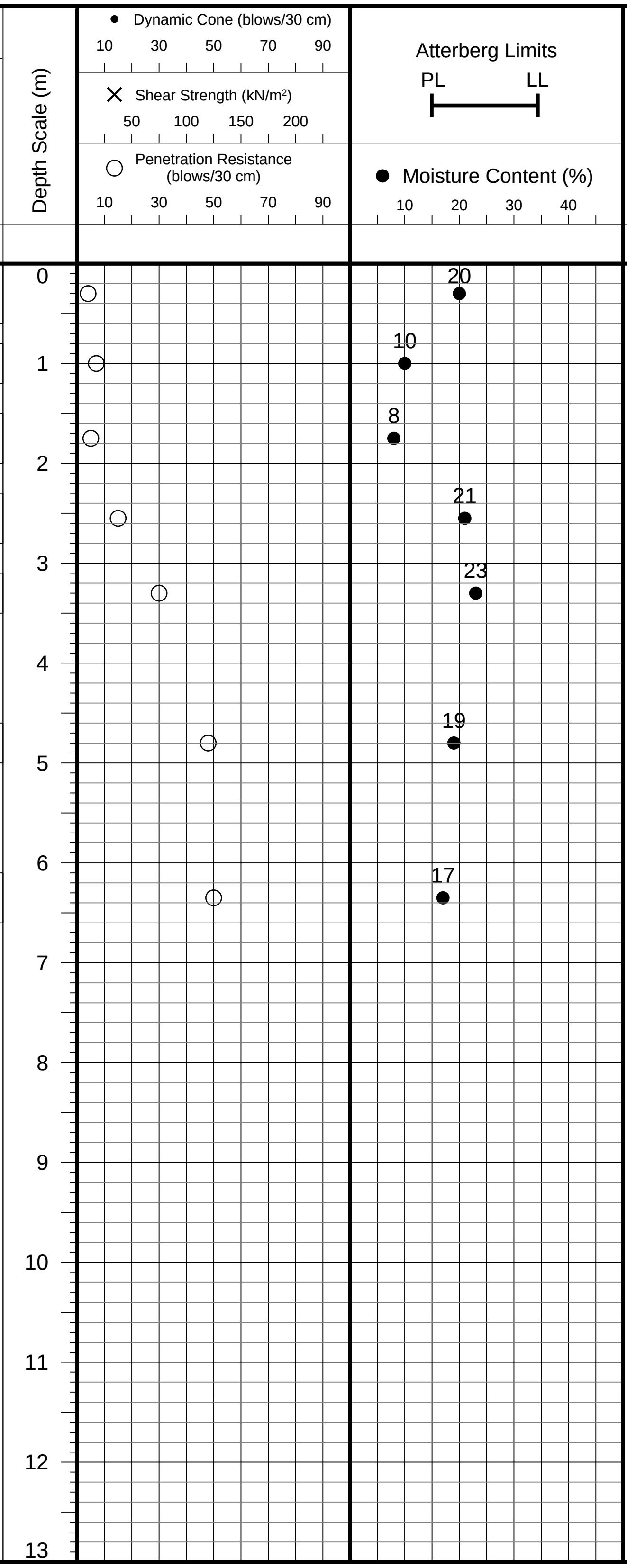
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 750 Lockhart Road, City of Barrie

DRILLING DATE: November 27, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES		
		Number	Type	N-Value
262.6	Ground Surface			
0.0	**30 cm TOPSOIL**			
	PLOUGHED SOIL brown sand and some silt, mixed with topsoil and clay	1	DO	4
261.6 1.0	Brown, loose to dense **SAND** fine grained to well graded some silt to silty wet below 2.3 m	2	DO	7
		3	DO	5
		4	DO	15
		5	DO	30
		6	DO	48
		7	DO	50
256.0 6.6	**END OF BOREHOLE**			



WATER LEVEL

W.L. @ El. 260.0 m upon completion

Cave-In @ El. 259.9 m upon completion

JOB NO.: 1810-S159

LOG OF BOREHOLE NO.: 102

FIGURE NO.: 2

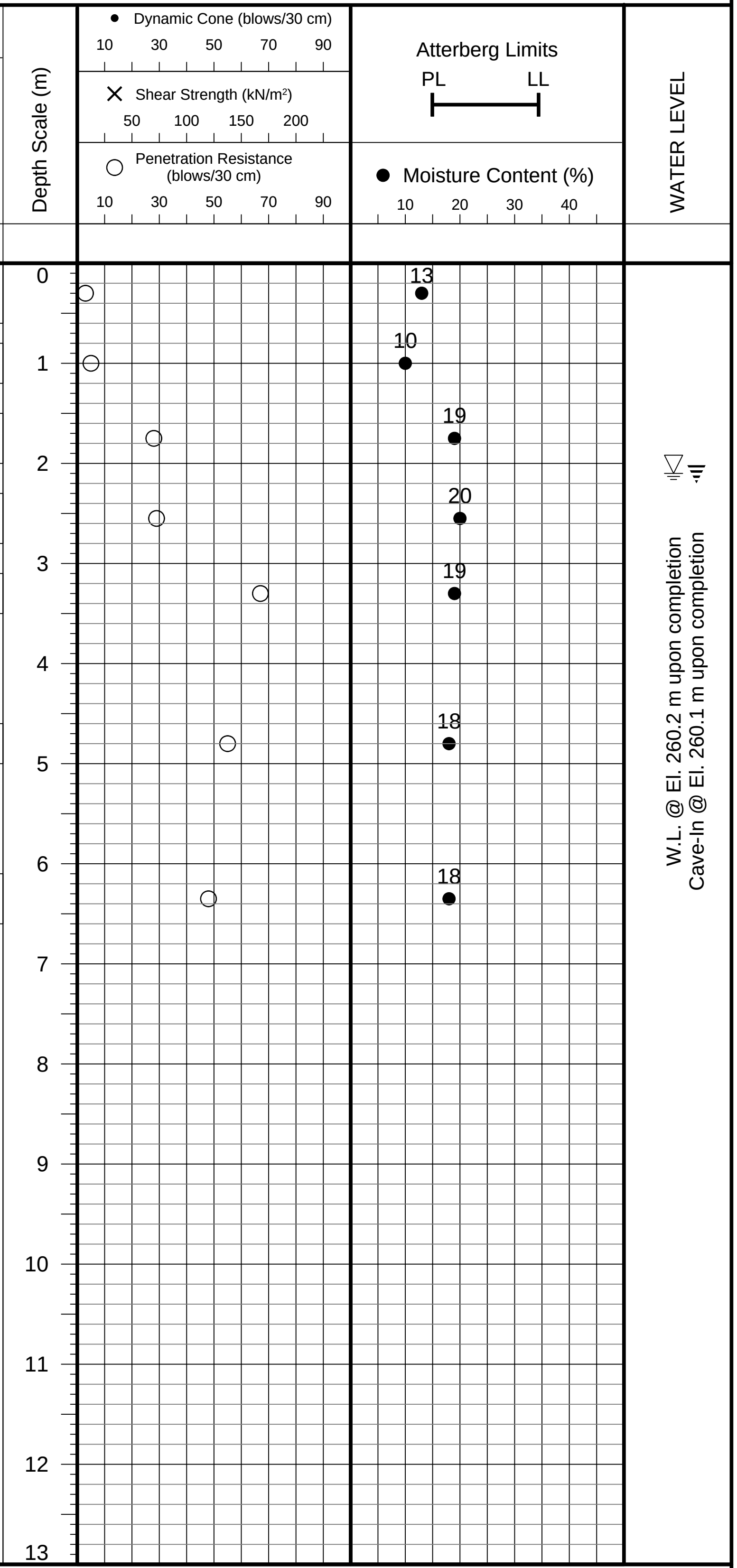
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 750 Lockhart Road, City of Barrie

DRILLING DATE: November 27, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
262.3	Ground Surface			
0.0	**30 cm TOPSOIL**	1	DO	3
	PLOUGHED SOIL brown sand and some silt, mixed with topsoil and clay	2	DO	5
261.1 1.2	Brown, compact to very dense, wet **SAND** fine grained to well graded some silt to silty	3	DO	28
		4	DO	29
		5	DO	67
		6	DO	55
		7	DO	48
255.7 6.6	**END OF BOREHOLE**			



W.L. @ El. 260.2 m upon completion

Cave-In @ El. 260.1 m upon completion

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JOB NO.: 1810-S159

LOG OF BOREHOLE NO.: 103

FIGURE NO.: 3

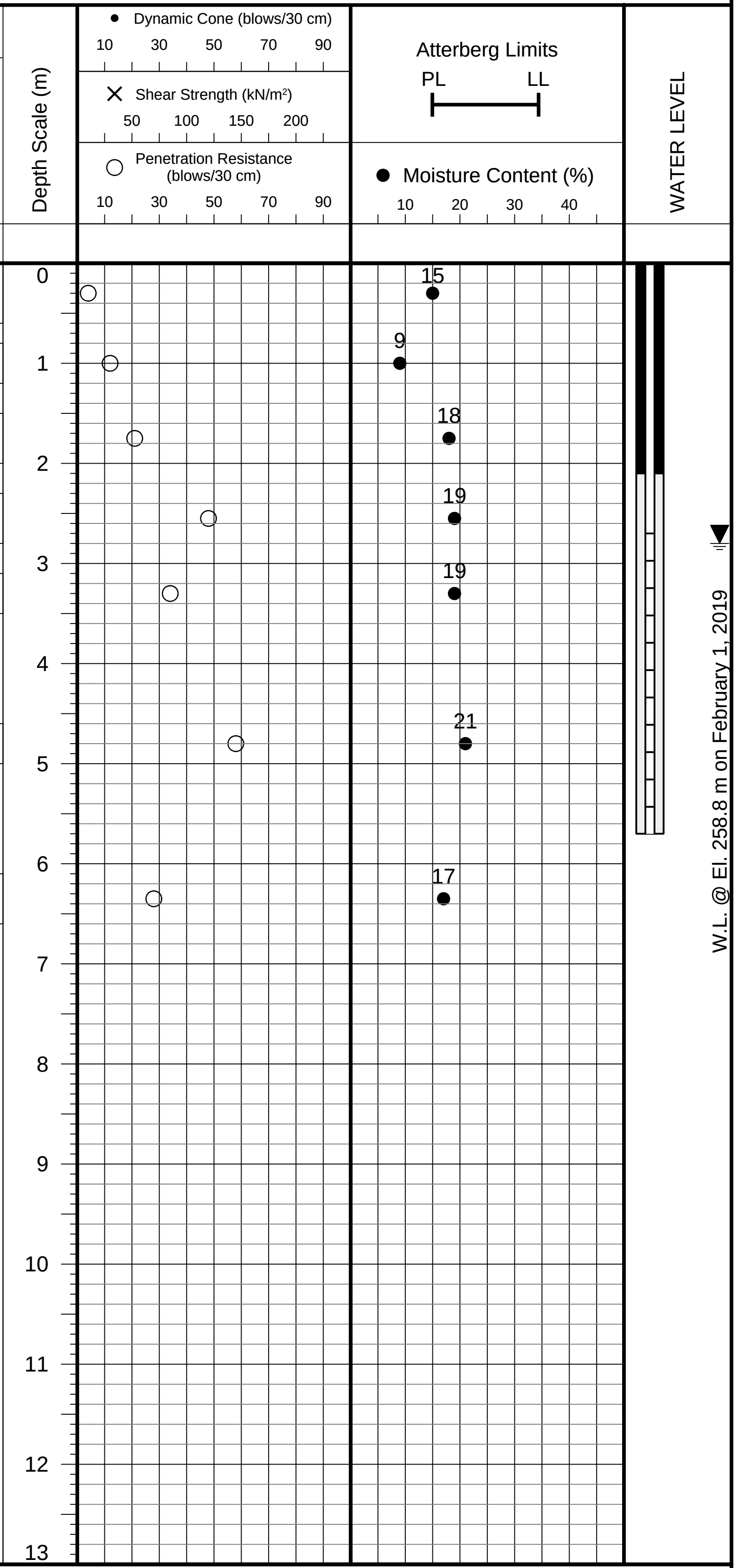
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 750 Lockhart Road, City of Barrie

DRILLING DATE: November 27, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
261.6	Ground Surface			
0.0	**25 cm TOPSOIL** **PLOUGHED SOIL** brown sand and some silt, mixed with topsoil and clay	1	DO	4
260.6 1.0	Brown, compact to very dense **SAND** fine to coarse grained a trace of silt wet below 1.5 m	2	DO	12
		3	DO	21
		4	DO	48
		5	DO	34
		6	DO	58
		7	DO	28
255.0 6.6	**END OF BOREHOLE** Installed 50 mm diameter PVC monitoring well with riser from 0 to 2.7 m and slotted screen from 2.7 to 5.7 m, backfilled with bentonite from 0 to 2.1 m and sand from 2.1 to 5.7 m			



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Page: 1 of 1

JOB NO.: 1810-S159

LOG OF BOREHOLE NO.: 104

FIGURE NO.: 4

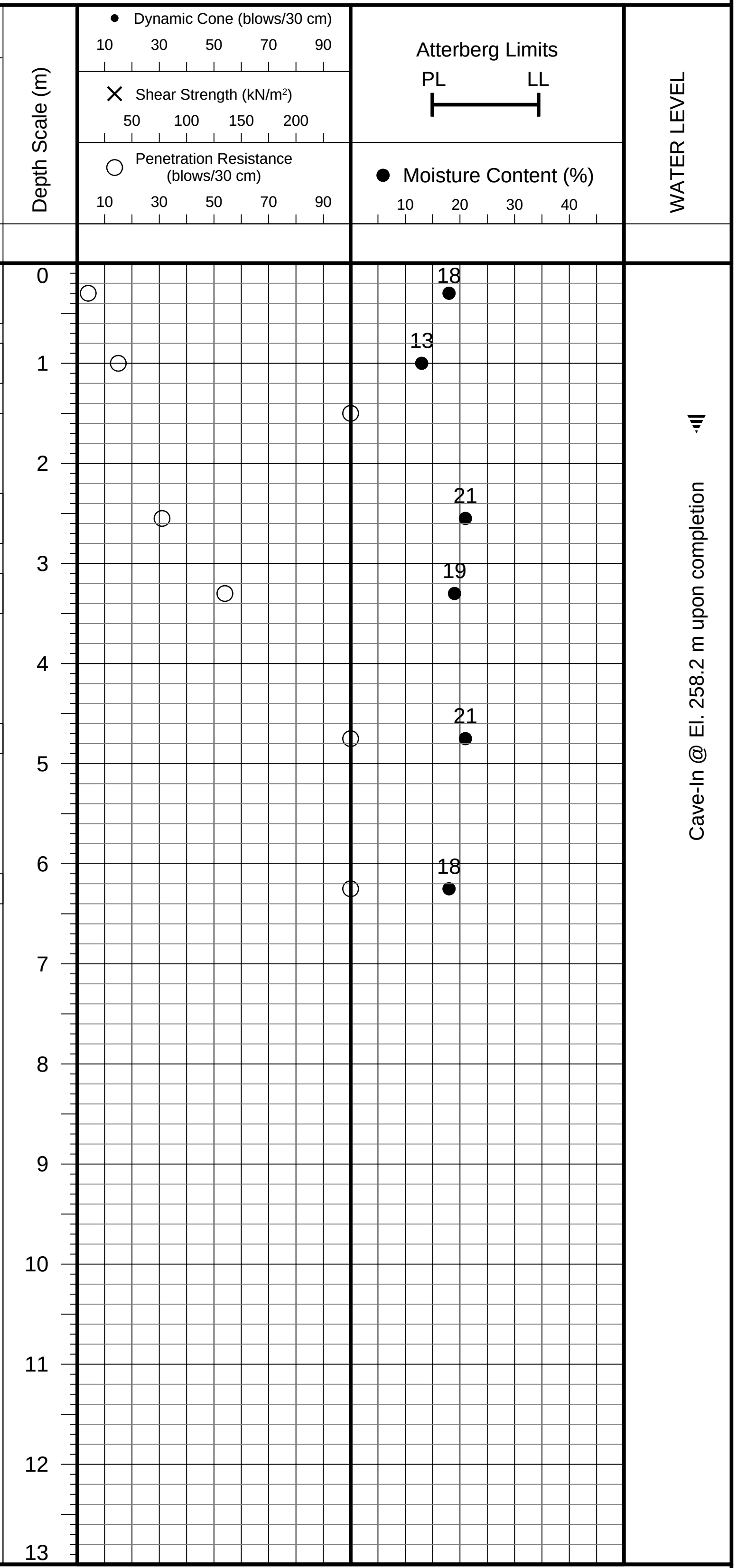
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 750 Lockhart Road, City of Barrie

DRILLING DATE: November 27, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
259.9	Ground Surface			
0.0	**25 cm TOPSOIL** **PLOUGHED SOIL** brown silty sand, mixed with topsoil and clay	1	DO	4
258.9 1.0	Brown, compact to very dense boulder **SANDY SILT TILL** traces of clay and gravel occ. cobbles and boulders	2 3	DO DO	15 50/0
257.6 2.3	Brown, compact to very dense, wet **SAND** fine grained some silt to silty	4 5 6 7	DO DO DO DO	31 54 50/15 50/15
253.5 6.4	**END OF BOREHOLE**			



Cave-In @ El. 258.2 m upon completion

JOB NO.: 1810-S159

LOG OF BOREHOLE NO.: 105

FIGURE NO.: 5

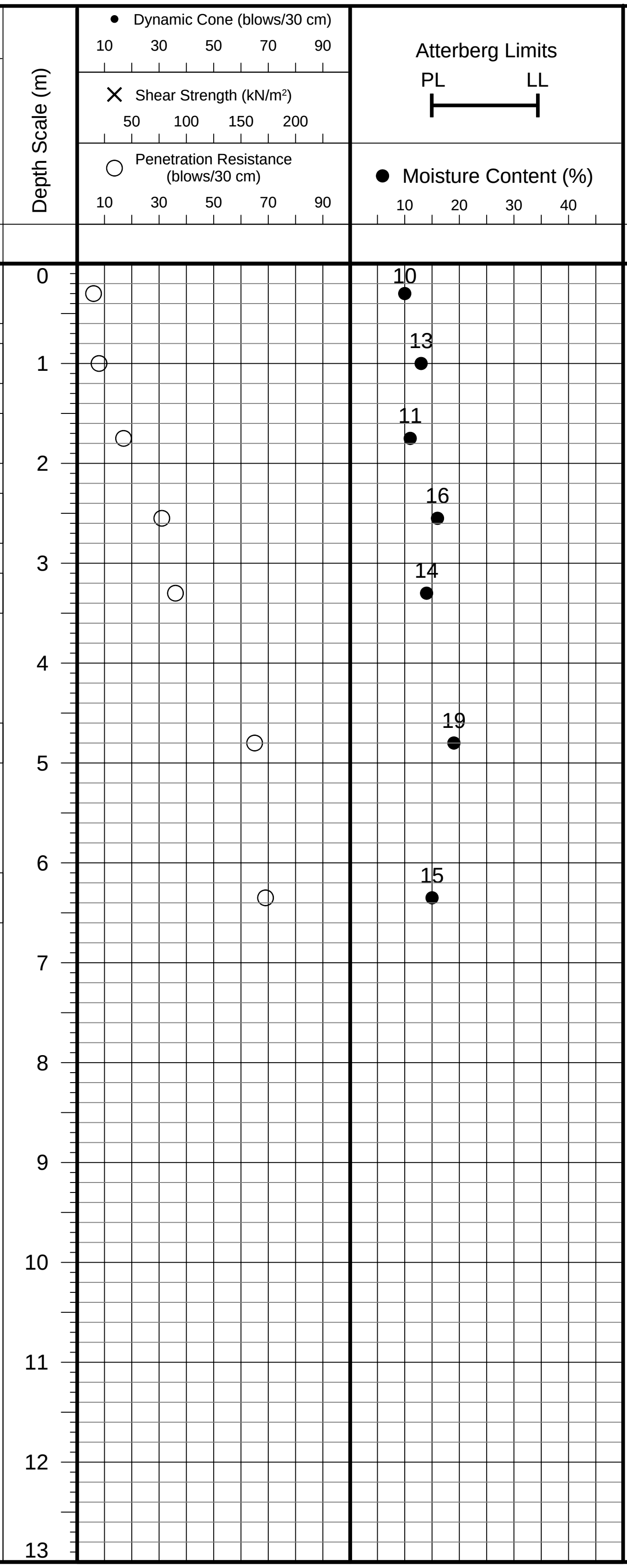
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 750 Lockhart Road, City of Barrie

DRILLING DATE: November 27, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
258.3	Ground Surface			
0.0	**23 cm TOPSOIL**			
	PLOUGHED SOIL brown silty sand traces of clay and gravel occ. topsoil inclusions	1	DO	6
		2	DO	8
257.1 1.2	Brown, compact **SANDY SILT TILL** traces of clay and gravel occ. cobbles and boulders	3	DO	17
255.8 2.5	Brown, dense to very dense, wet **SAND** fine to coarse grained a trace to some silt	4	DO	31
		5	DO	36
		6	DO	65
		7	DO	69
251.7 6.6	**END OF BOREHOLE**			



WATER LEVEL

W.L. @ El. 256.8 m upon completion

Cave-In @ El. 256.6 m upon completion

Soil Engineers Ltd.

JOB NO.: 1810-S159

LOG OF BOREHOLE NO.: 106

FIGURE NO.: 6

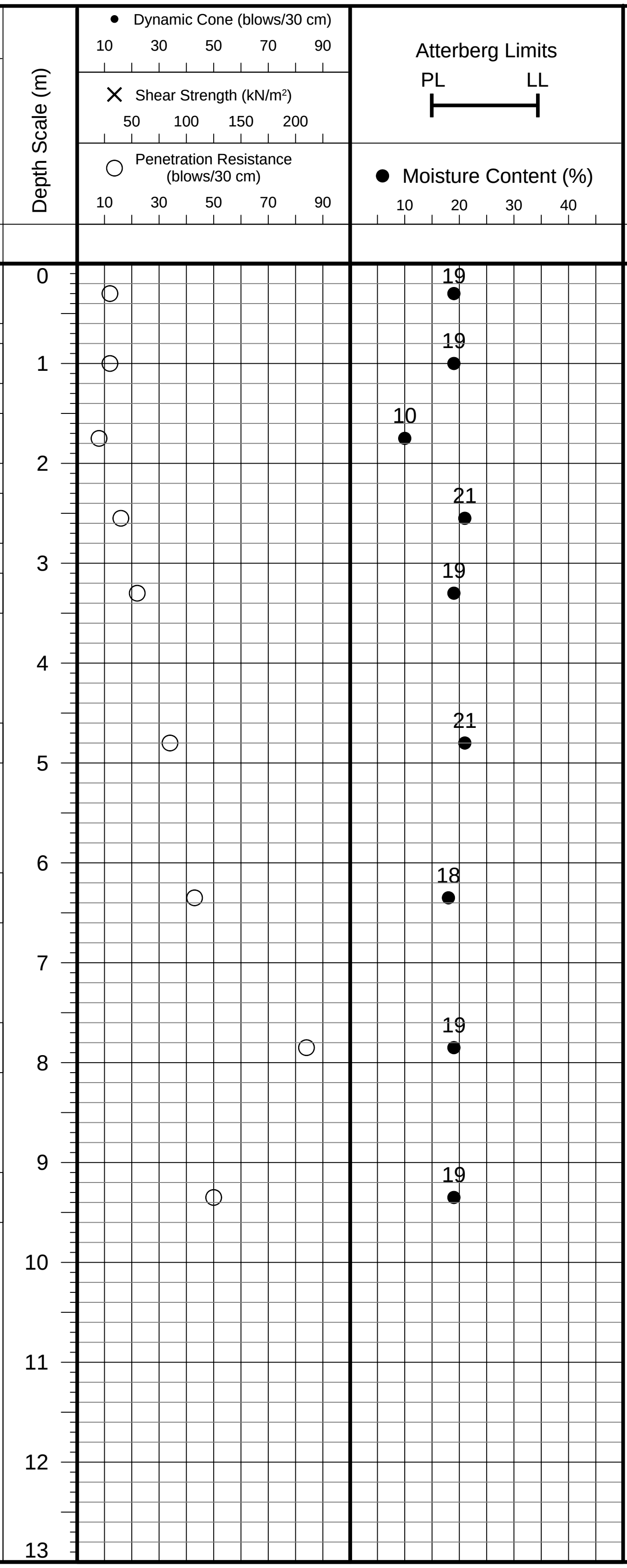
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 750 Lockhart Road, City of Barrie

DRILLING DATE: November 30, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
261.6	Ground Surface			
0.0	**30 cm TOPSOIL**	1	DO	12
	EARTH FILL dark brown silty sand mixed with topsoil and organics	2	DO	12
260.1 1.5	Brown, loose to very dense, wet **SAND** fine to coarse grained a trace of silt to silty	3	DO	8
	weathered	4	DO	16
		5	DO	22
		6	DO	34
		7	DO	43
		8	DO	84
		9	DO	50
252.0 9.6	**END OF BOREHOLE**			



WATER LEVEL

Cave-In @ El. 258.3 m upon completion

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JOB NO.: 1810-S159

LOG OF BOREHOLE NO.: 107

FIGURE NO.: 7

PROJECT DESCRIPTION: Proposed Residential Development

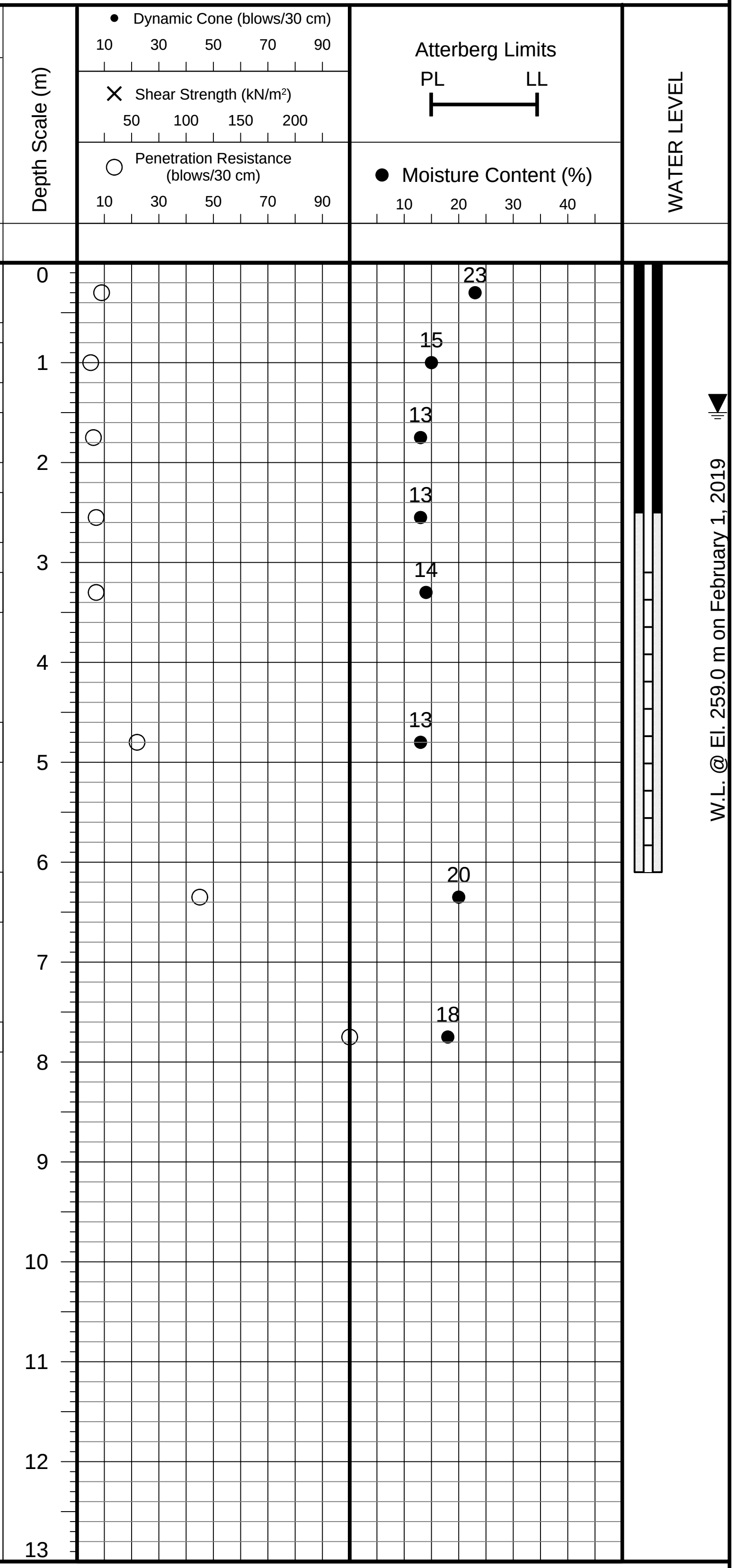
METHOD OF BORING: Flight Auger

PROJECT LOCATION: 750 Lockhart Road, City of Barrie

DRILLING DATE: December 3, 2018

El. (m) Depth (m)	SOIL DESCRIPTION
260.5	Ground Surface
0.0	**30 cm TOPSOIL**
	EARTH FILL brown to dark brown silty sand to silty clay mixed with topsoil and organics
259.4 259.2	**TOPSOIL**
1.3	Brown, loose to compact, wet **SANDY SILT TILL** weathered traces of clay and gravel occ. cobbles and boulders
255.0 5.5	Brown, dense to very dense, wet **SAND** fine grained a trace to some silt
252.6 7.9	**END OF BOREHOLE** Installed 50 mm diameter PVC monitoring well with riser from 0 to 3.1 m and slotted screen from 3.1 to 6.1 m, backfilled with bentonite from 0 to 2.5 m and sand from 2.5 to 6.1 m

SAMPLES		
Number	Type	N-Value
1	DO	9
2	DO	5
3	DO	6
4	DO	7
5	DO	7
6	DO	22
7	DO	45
8	DO	50/15



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JOB NO.: 1810-S159

LOG OF BOREHOLE NO.: 108

FIGURE NO.: 8

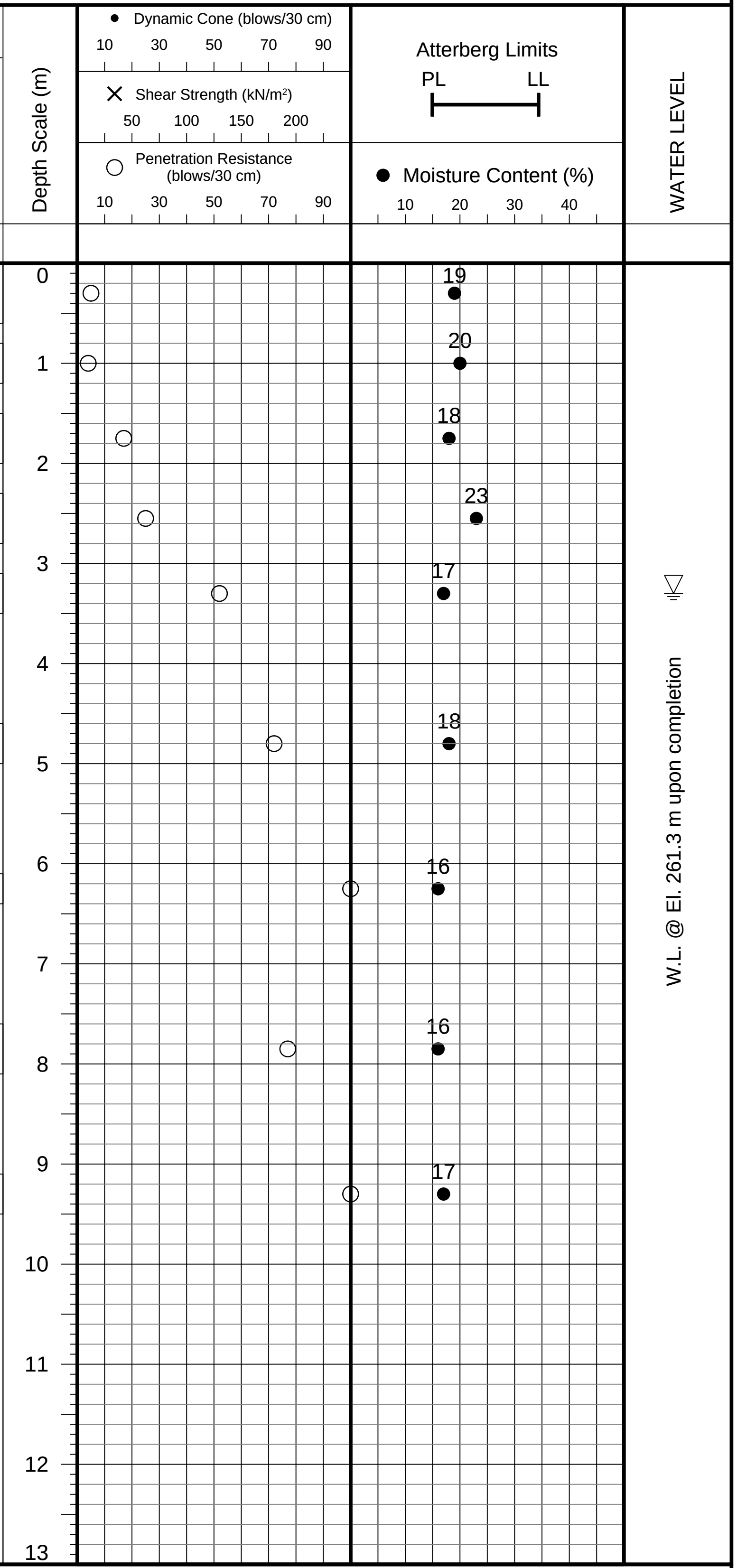
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 750 Lockhart Road, City of Barrie

DRILLING DATE: November 29, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value
264.6	Ground Surface			
0.0	**15 cm TOPSOIL**	1	DO	5
	PLOUGHED SOIL brown sandy silt mixed with topsoil and clay	2	DO	4
263.4 1.2	Brown, compact **SANDY SILT TILL** some clay a trace of gravel occ. sand seams and layers, cobbles and boulders	3	DO	17
		4	DO	25
261.5 3.1	Brown, very dense, wet **SAND** well graded a trace to some silt	5	DO	52
		6	DO	72
		7	DO	50/13
		8	DO	77
		9	DO	80/20
255.1 9.5	**END OF BOREHOLE**			



JOB NO.: 1810-S159

LOG OF BOREHOLE NO.: 109

FIGURE NO.: 9

PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

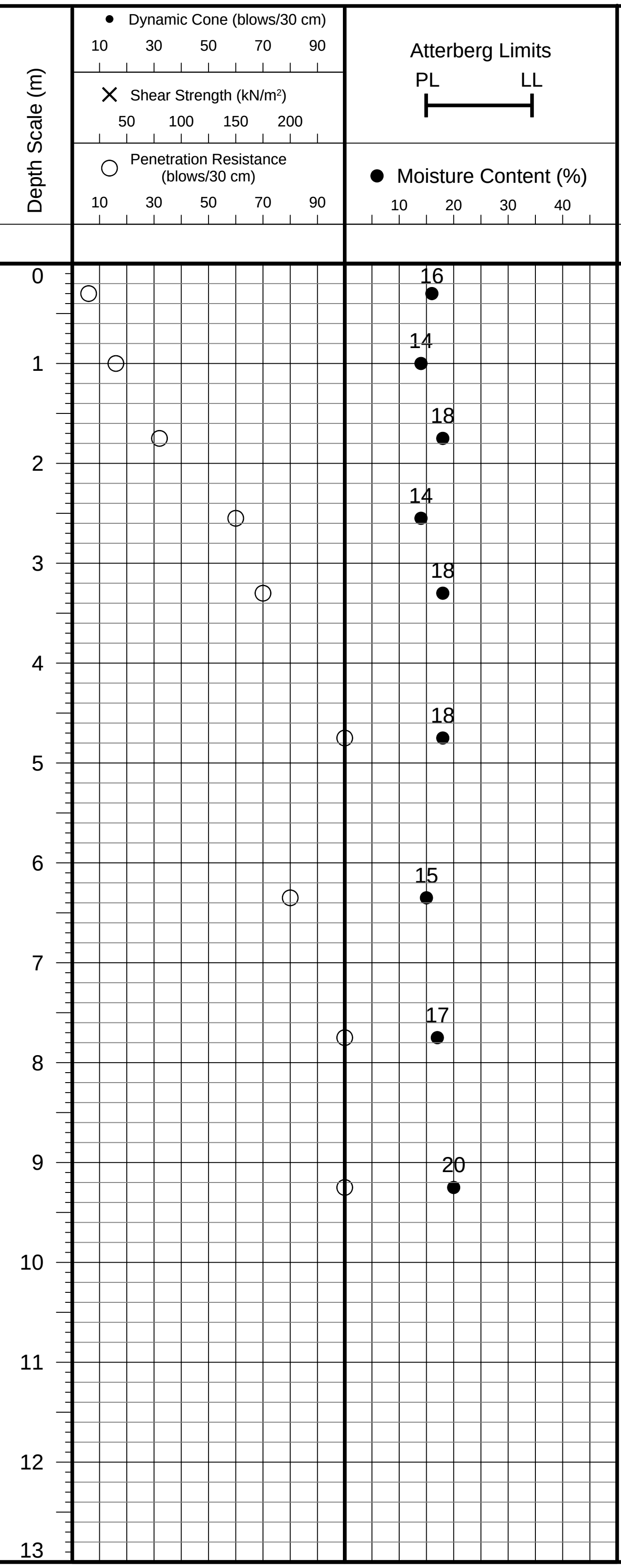
PROJECT LOCATION: 750 Lockhart Road, City of Barrie

DRILLING DATE: November 28, 2018

El. (m) Depth (m)	SOIL DESCRIPTION
263.9	Ground Surface
0.0	**33 cm TOPSOIL**
263.1 0.8	**PLOUGHED SOIL** brown sandy silt mixed with topsoil and clay
	Brown, compact to very dense **SAND** fine to coarse grained a trace to some silt fine grained and silty below 8 m wet below 2.3 m
254.5 9.4	**END OF BOREHOLE**

SAMPLES Number	Type	N-Value
1	DO	6
2	DO	16
3	DO	32
4	DO	60
5	DO	70
6	DO	50/15
7	DO	80
8	DO	60/15
9	DO	50/15

Depth Scale (m)



WATER LEVEL

W.L. @ El. 261.6 m upon completion

Cave-In @ El. 261.5 m upon completion

Soil Engineers Ltd.

JOB NO.: 1810-S159

LOG OF BOREHOLE NO.: 110

FIGURE NO.: 10

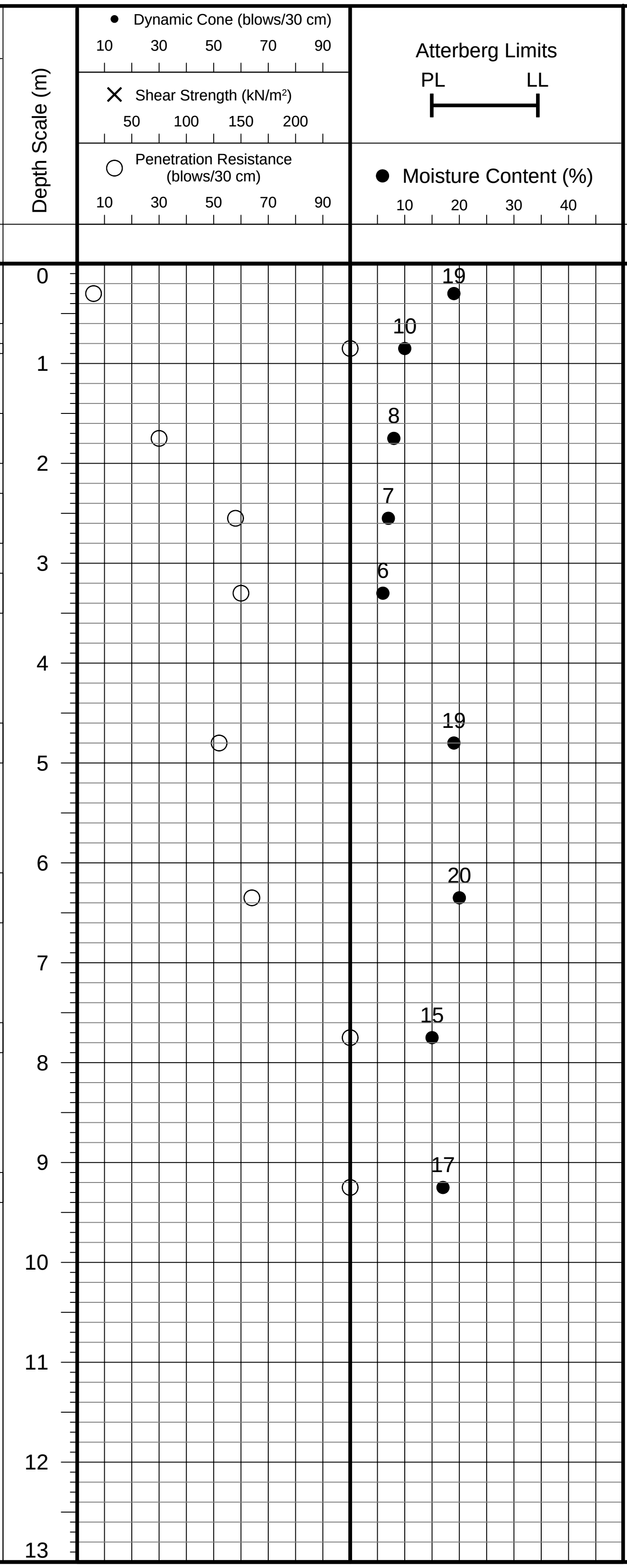
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 750 Lockhart Road, City of Barrie

DRILLING DATE: November 28, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
267.1	Ground Surface			
0.0	**25 cm TOPSOIL**	1	DO	6
266.3 0.8	**PLOUGHED SOIL** brown sandy silt mixed with topsoil and clay boulder	2	DO	50/3
	Brown, dense to very dense **SANDY SILT TILL** some clay a trace of gravel occ. sand seams and layers, cobbles and boulders	3	DO	30
		4	DO	58
264.0 3.1	Brown, very dense, wet **SAND** fine to medium grained some silt to silty	5	DO	60
		6	DO	52
		7	DO	64
		8	DO	50/15
258.6 8.5	Brown, very dense, wet **SILT** some sand to sandy	9	DO	55/15
257.7 9.4	**END OF BOREHOLE**			



WATER LEVEL

Cave-In @ El. 262.0 m upon completion

JOB NO.: 1810-S159

LOG OF BOREHOLE NO.: 111

FIGURE NO.: 11

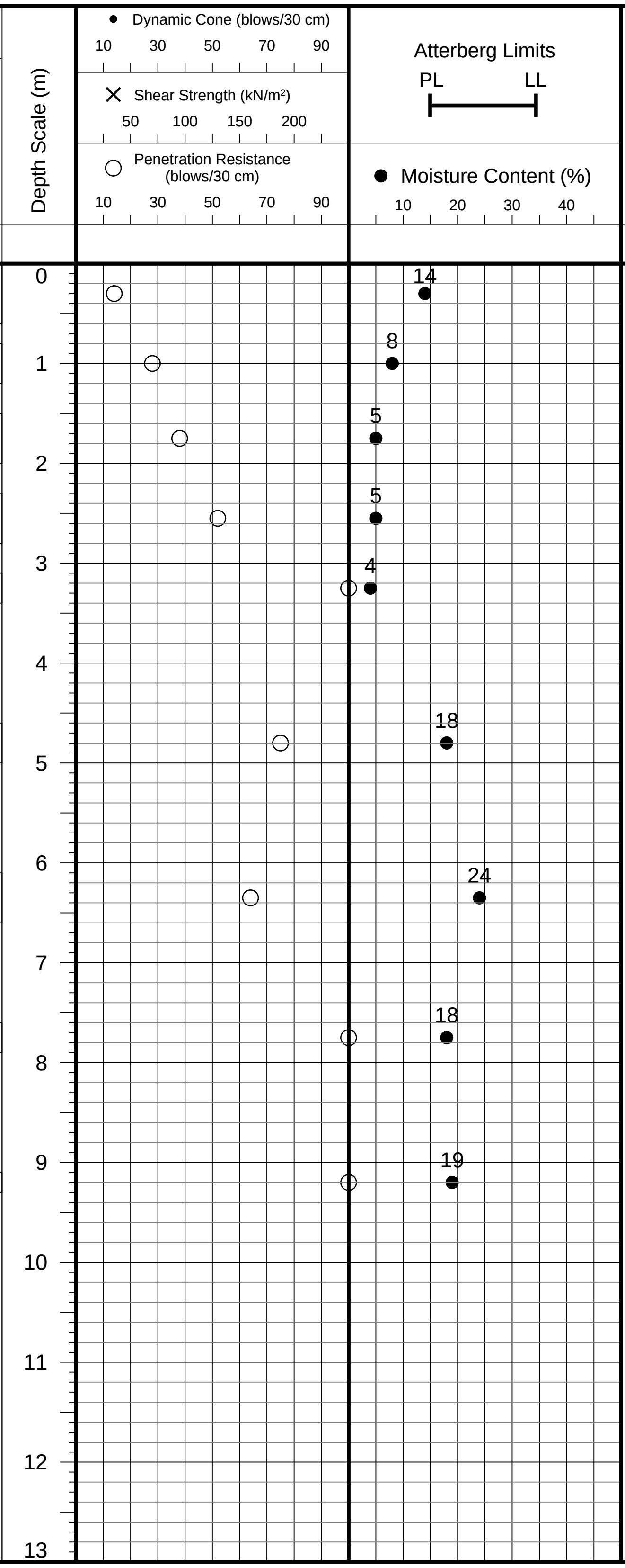
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 750 Lockhart Road, City of Barrie

DRILLING DATE: November 28, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value
265.8	Ground Surface			
0.0	**35 cm TOPSOIL**	1	DO	14
265.2 0.6	**PLOUGHED SOIL** brown silty sand mixed with topsoil and clay			
	Brown, compact to dense **SANDY SILT TILL** some clay a trace of gravel occ. sand seams and layers	2	DO	28
		3	DO	38
263.5 2.3	Brown, very dense, wet **SAND** fine to coarse grained a trace to some silt	4	DO	52
		5	DO	50/15
		6	DO	75
		7	DO	64
		8	DO	50/15
		9	DO	60/15
256.5 9.3	**END OF BOREHOLE**			



WATER LEVEL

W.L. @ El. 262.5 m upon completion

Cave-In @ El. 262.3 m upon completion

Soil Engineers Ltd.

JOB NO.: 1810-S159

LOG OF BOREHOLE NO.: 112

FIGURE NO.: 12

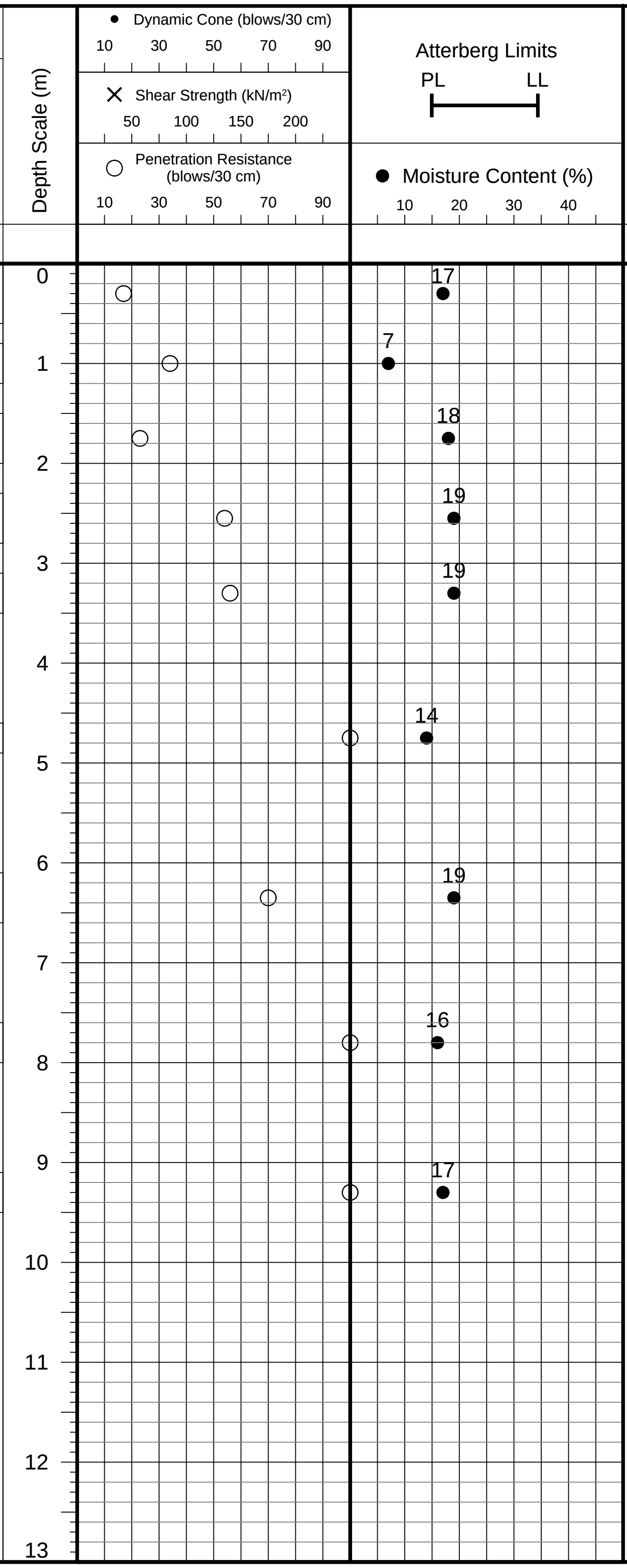
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 750 Lockhart Road, City of Barrie

DRILLING DATE: November 29, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
263.3	Ground Surface			
0.0	**8 cm TOPSOIL**			
	PLOUGHED SOIL brown silty sand mixed with topsoil and clay	1	DO	17
262.5 0.8	Brown, compact to dense **SANDY SILT TILL** some clay a trace of gravel occ. sand seams and layers, cobbles and boulders	2 3	DO DO	34 23
261.0 2.3	Brown, very dense, wet **SAND** fine to coarse grained a trace to some silt	4 5 6 7 8 9	DO DO DO DO DO DO	54 56 50/15 70 92/25 95/25
253.8 9.5	**END OF BOREHOLE**			



WATER LEVEL

Cave-In @ El. 259.7 m upon completion

JOB NO.: 1810-S159

LOG OF BOREHOLE NO.: 113

FIGURE NO.: 13

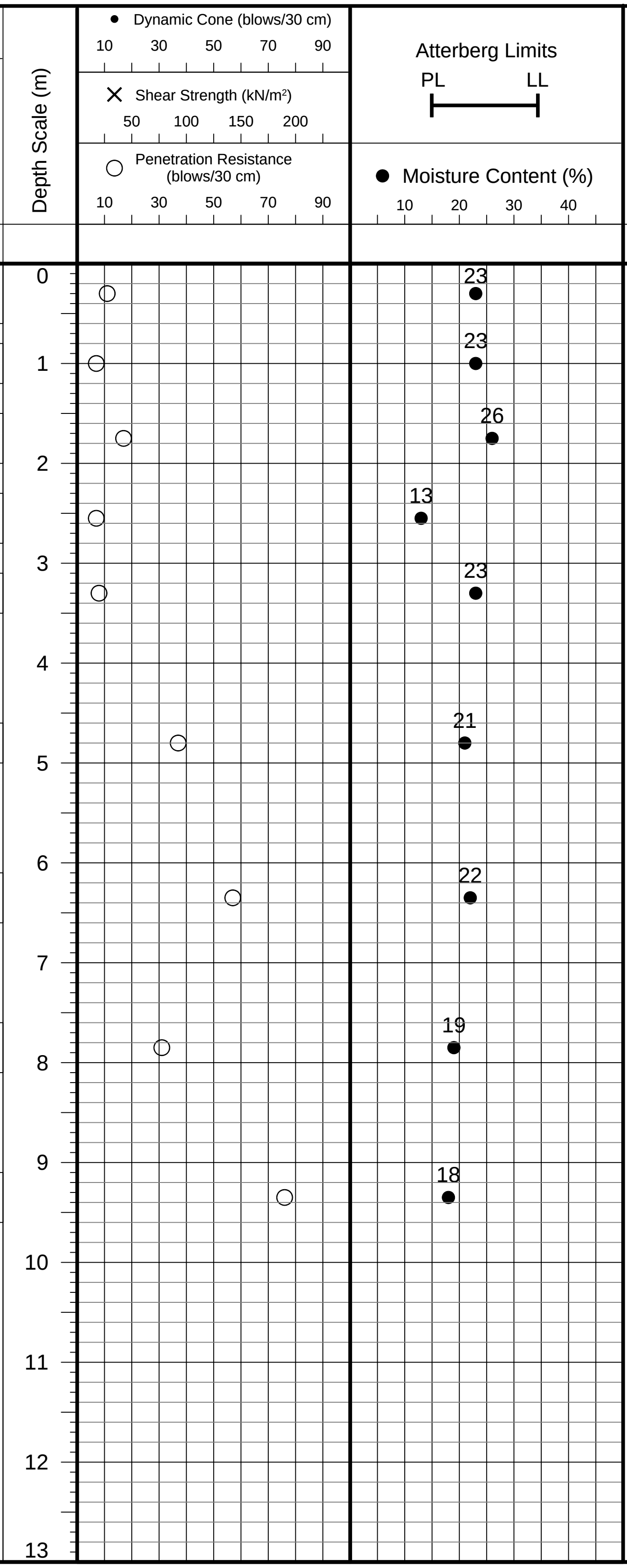
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 750 Lockhart Road, City of Barrie

DRILLING DATE: November 30, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
265.0 0.0	Ground Surface **23 cm TOPSOIL**			
	EARTH FILL dark brown silty clay mixed with organics and topsoil	1	DO	11
		2	DO	7
		3	DO	17
262.7 2.3	Brown, loose to very dense **SILT** fine grained occ. sand seams	4	DO	7
		5	DO	8
		6	DO	37
		7	DO	57
258.0 7.0	Brown, dense to very dense, wet **SAND** fine to medium grained a trace to some silt	8	DO	31
		9	DO	76
255.4 9.6	**END OF BOREHOLE**			



WATER LEVEL

W.L. @ El. 259.9 m upon completion

Cave-In @ El. 259.6 m upon completion

JOB NO.: 1810-S159

LOG OF BOREHOLE NO.: 114

FIGURE NO.: 14

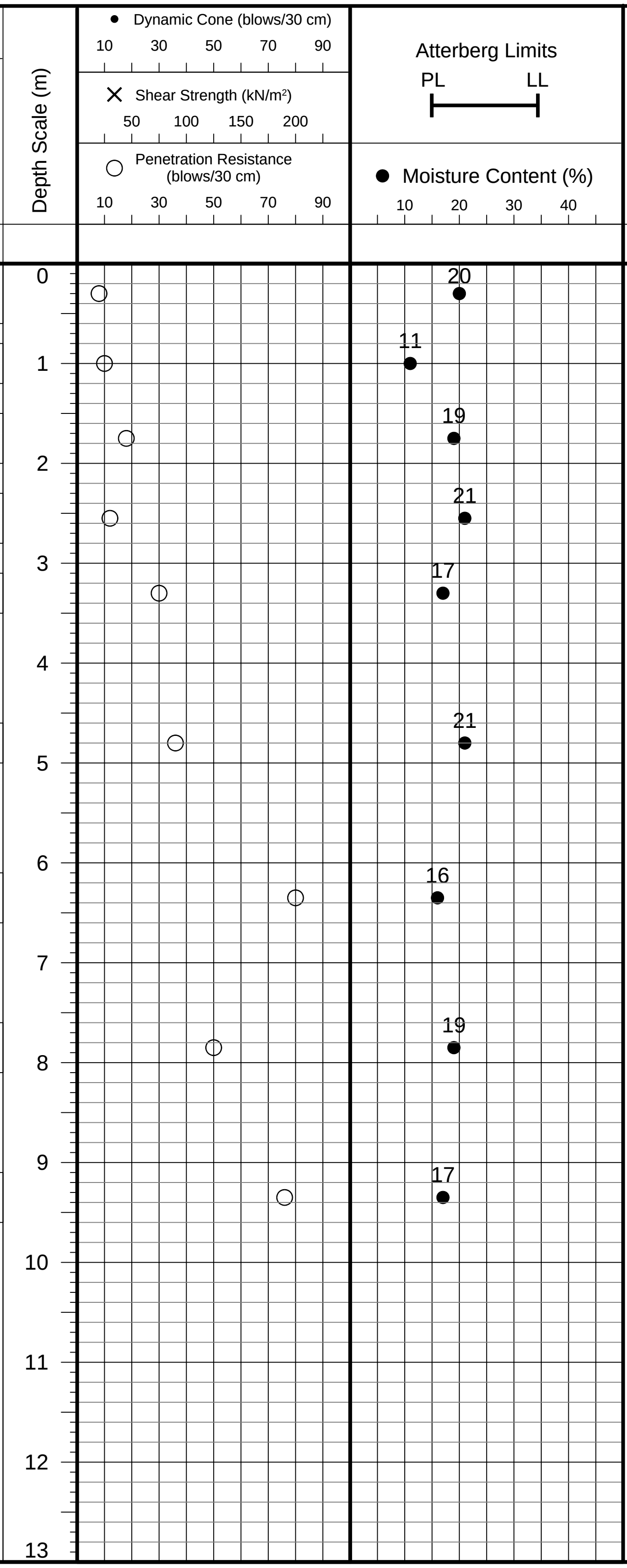
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 750 Lockhart Road, City of Barrie

DRILLING DATE: November 30, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value
261.8	Ground Surface			
0.0	**EARTH FILL** dark brown silty clay mixed with organics and topsoil	1	DO	8
		2	DO	10
260.3 1.5	**TOPSOIL**	3	DO	18
259.5 2.3	Brown, compact to very dense, wet silty sand layer **SAND** fine to meidum grained a trace to some silt	4	DO	12
		5	DO	30
		6	DO	36
		7	DO	80
		8	DO	50
		9	DO	76
252.2 9.6	**END OF BOREHOLE**			



WATER LEVEL

W.L. @ El. 259.7 m upon completion

Soil Engineers Ltd.

JOB NO.: 1810-S159

LOG OF BOREHOLE NO.: 115

FIGURE NO.: 15

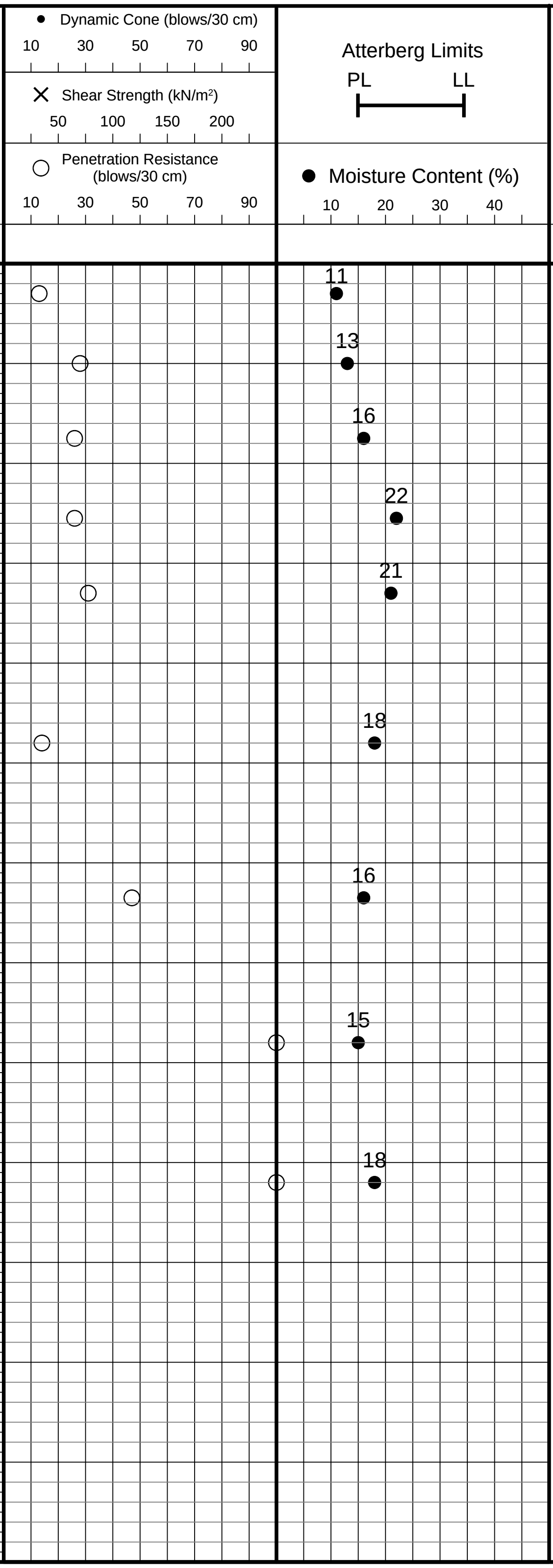
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 750 Lockhart Road, City of Barrie

DRILLING DATE: November 29, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	Depth Scale (m)
262.3	Ground Surface				
0.0	**18 cm TOPSOIL** **EARTH FILL**	1	DO	13	0
261.3 1.0	dark brown silty clay to silty sand occ. organics and topsoil inclusions	2	DO	28	1
	Brown, compact to very dense, wet **SAND**	3	DO	26	2
	fine to meidum grained a trace to some silt silty sand layer	4	DO	26	
		5	DO	31	3
		6	DO	14	4
		7	DO	47	6
		8	DO	83/25	7
253.0 9.3	**END OF BOREHOLE**	9	DO	50/8	9



WATER LEVEL

W.L. @ El. 261.3 m upon completion

Soil Engineers Ltd.

JOB NO.: 1706-S080

LOG OF BOREHOLE NO.: 1

FIGURE NO.: 16

PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

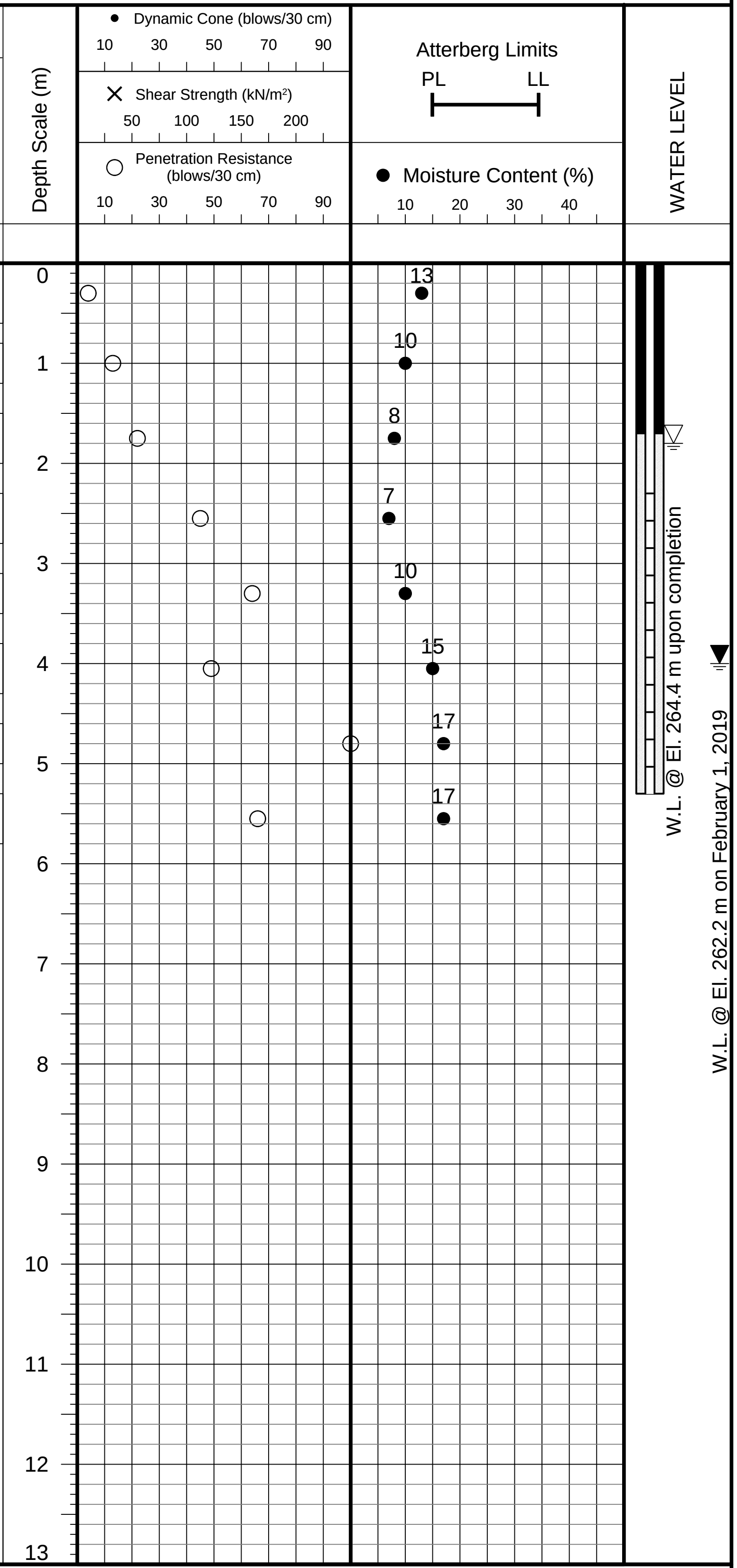
PROJECT LOCATION: 750 Lockhart Road, City of Barrie

DRILLING DATE: July 27, 2017

El. (m) Depth (m)	SOIL DESCRIPTION
266.2	Ground Surface
0.0	**33 cm TOPSOIL**
	PLOUGHED SOIL brown sandy silt mixed with topsoil
265.2 1.0	Brown, compact to very dense **SANDY SILT TILL** some clay a trace of gravel occ. sand seams and layers, cobbles and boulders
262.4 3.8	Brown, dense, wet **SAND** well graded traces of silt and fine gravel
261.5 4.7	Brown, very dense, wet **SILT** some sand to sandy
260.4 5.8	**END OF BOREHOLE**

Installed 50 mm diameter PVC monitoring well with riser from 0 to 2.3 m and slotted screen from 2.3 to 5.3 m, backfilled with bentonite from 0 to 1.7 m and sand from 1.7 to 5.3 m

SAMPLES		
Number	Type	N-Value
1	DO	4
2	DO	13
3	DO	22
4	DO	45
5	DO	64
6	DO	49
7	DO	85/23
8	DO	66



Soil Engineers Ltd.

Page: 1 of 1

JOB NO.: 1706-S080

LOG OF BOREHOLE NO.: 2

FIGURE NO.: 17

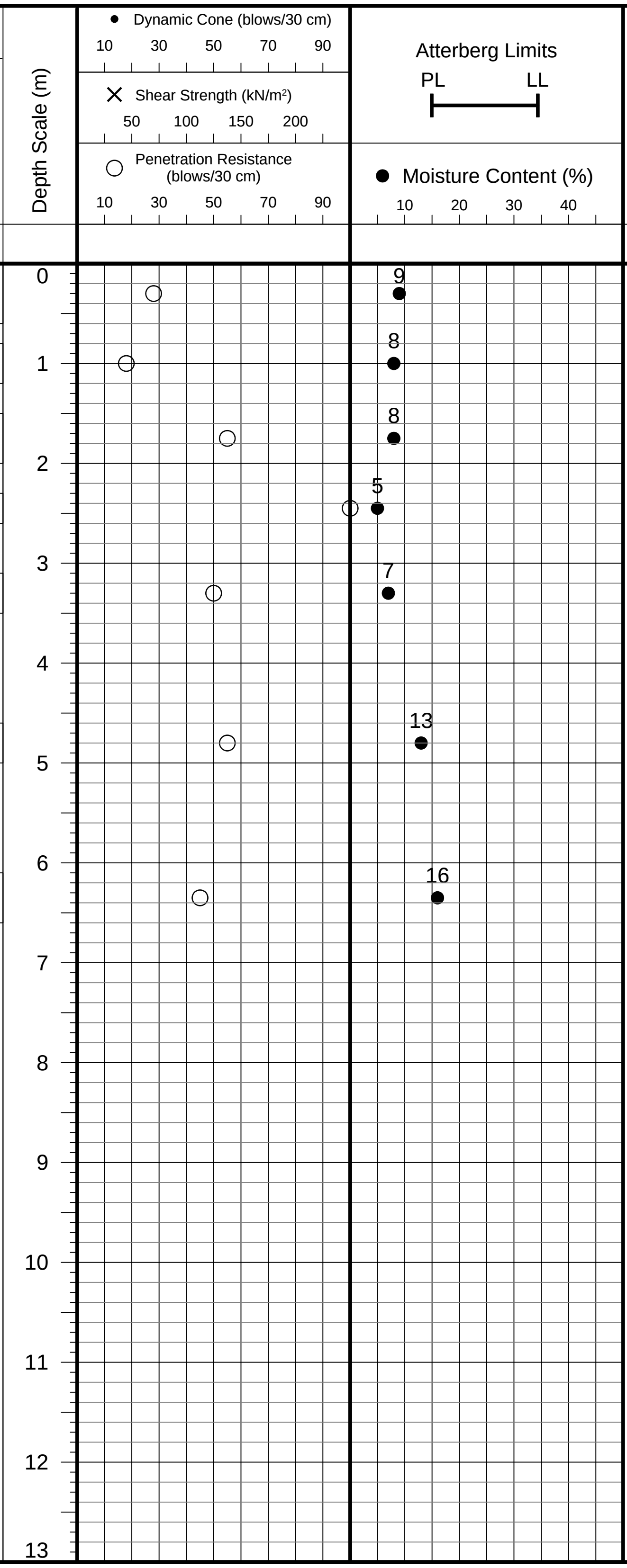
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 750 Lockhart Road, City of Barrie

DRILLING DATE: July 21, 2017

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
266.2 0.0	Ground Surface **23 cm TOPSOIL** **EARTH FILL** brown sand occ. gravel and rock fragments	1	DO	28
265.4 0.8	Brown, compact to very dense **SANDY SILT TILL** some clay a trace of gravel occ. sand seams and layers, cobbles and boulders	2 3 4	DO DO DO	18 55 50/15
263.1 3.1	Brown, dense to very dense **SAND** fine to medium grained some silt a trace of fine gravel wet below 4.6 m	5 6 7	DO DO DO	50 55 45
259.6 6.6	**END OF BOREHOLE**			



WATER LEVEL

Cave-In @ El. 262.3 m upon completion

Soil Engineers Ltd.

JOB NO.: 1706-S080

LOG OF BOREHOLE NO.: 3

FIGURE NO.: 18

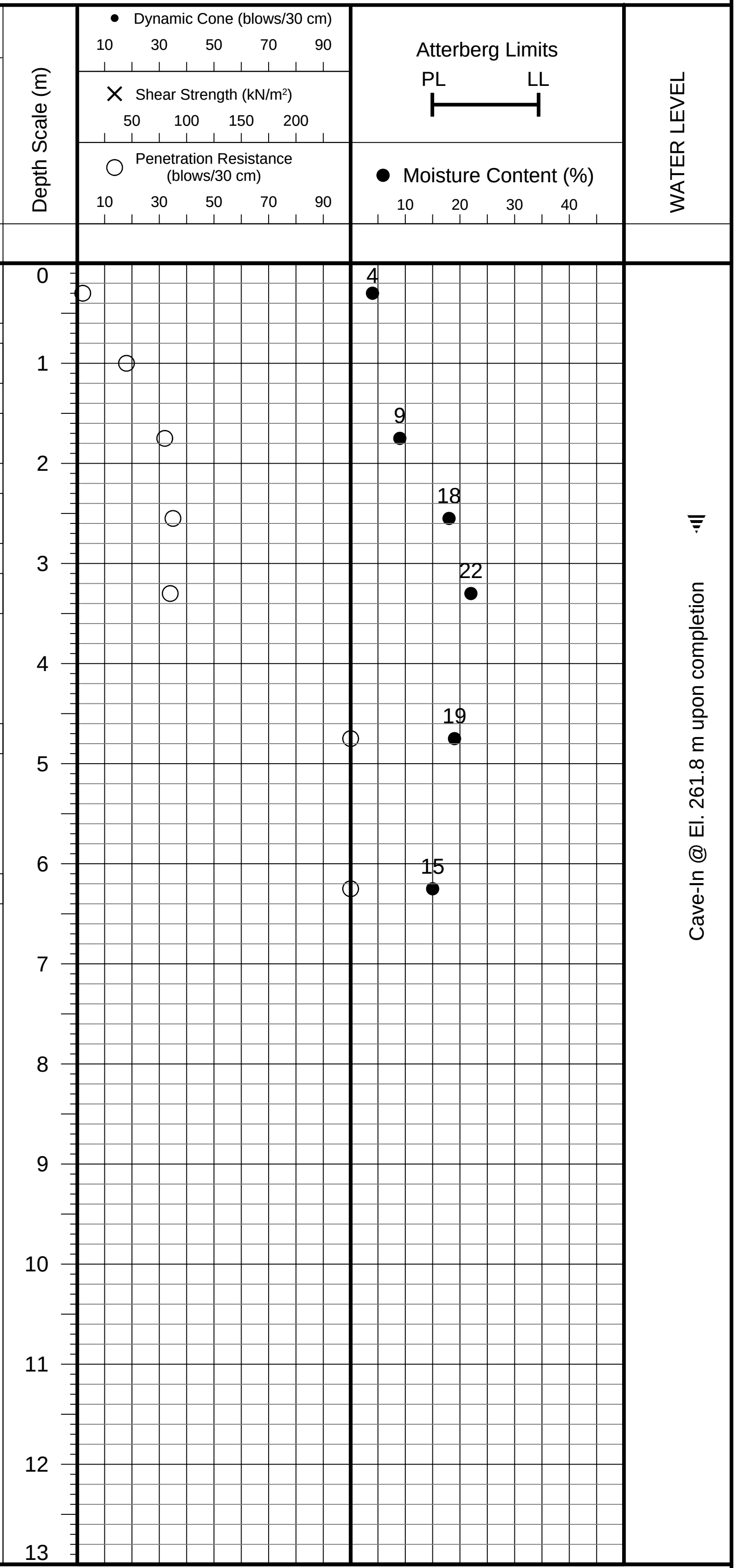
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 750 Lockhart Road, City of Barrie

DRILLING DATE: July 21, 2017

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value
264.5	Ground Surface			
0.0	**EARTH FILL** dark brown silty sand occ. topsoil inclusions and rock fragments	1	DO	2
263.7 0.8	Brown, compact to very dense **SAND** well graded some silt a trace of gravel wet below 2.3 m	2	DO	18
		3	DO	32
		4	DO	35
		5	DO	34
		6	DO	50/15
		7	DO	50/15
258.1 6.4	**END OF BOREHOLE**			



Cave-In @ El. 261.8 m upon completion

JOB NO.: 1706-S080

LOG OF BOREHOLE NO.: 4

FIGURE NO.: **19**

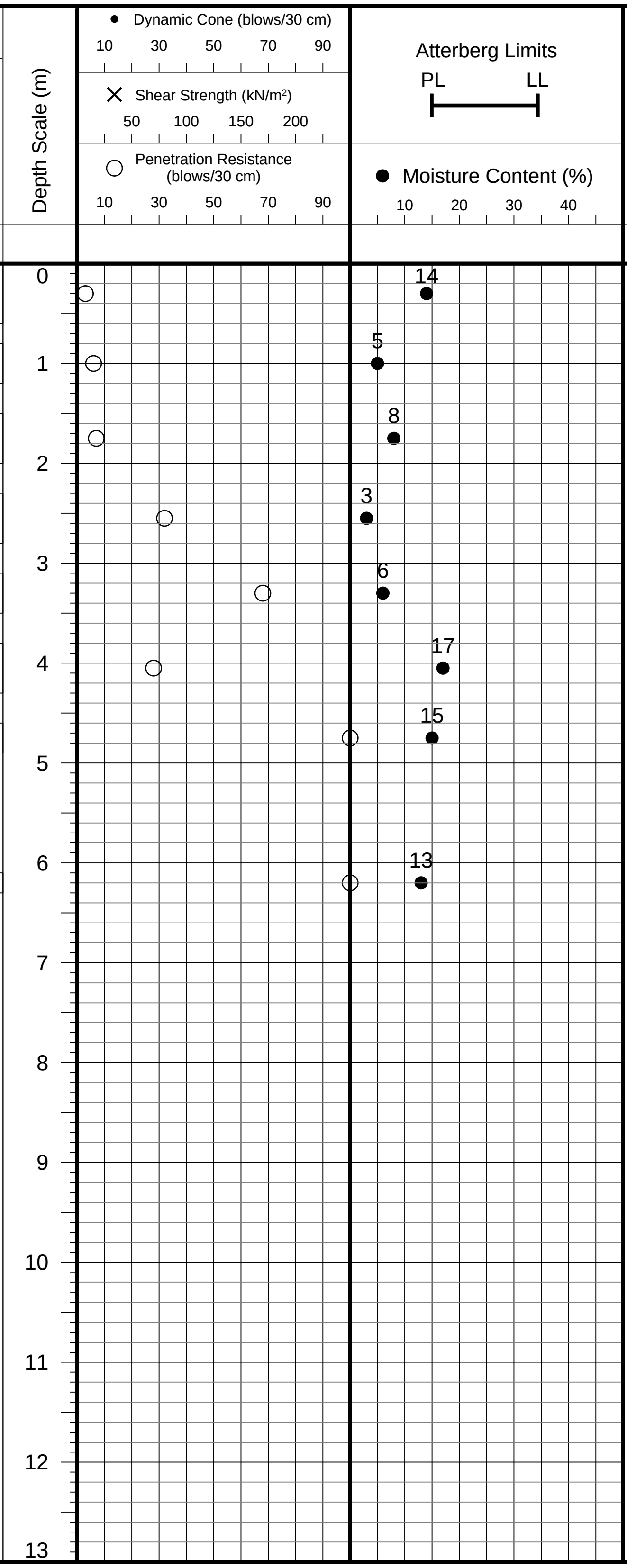
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 750 Lockhart Road, City of Barrie

DRILLING DATE: July 27, 2017

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
266.6	Ground Surface			
0.0	**35 cm TOPSOIL**	1	DO	3
265.8 0.8	**PLOUGHED SOIL** brown sandy silt mixed with topsoil	2	DO	6
	Brown, loose to very dense weathered **SAND** fine to medium grained traces of silt and fine gravel wet below 3.8 m	3	DO	7
		4	DO	32
		5	DO	68
		6	DO	28
		7	DO	50/15
261.3 5.3	Brown, very dense, wet **SANDY SILT**	8	DO	50/15
260.3 6.3	**END OF BOREHOLE**			



WATER LEVEL

Cave-In @ El. 262.7 m upon completion

Soil Engineers Ltd.

JOB NO.: 1706-S080

LOG OF BOREHOLE NO.: 5

FIGURE NO.: 20

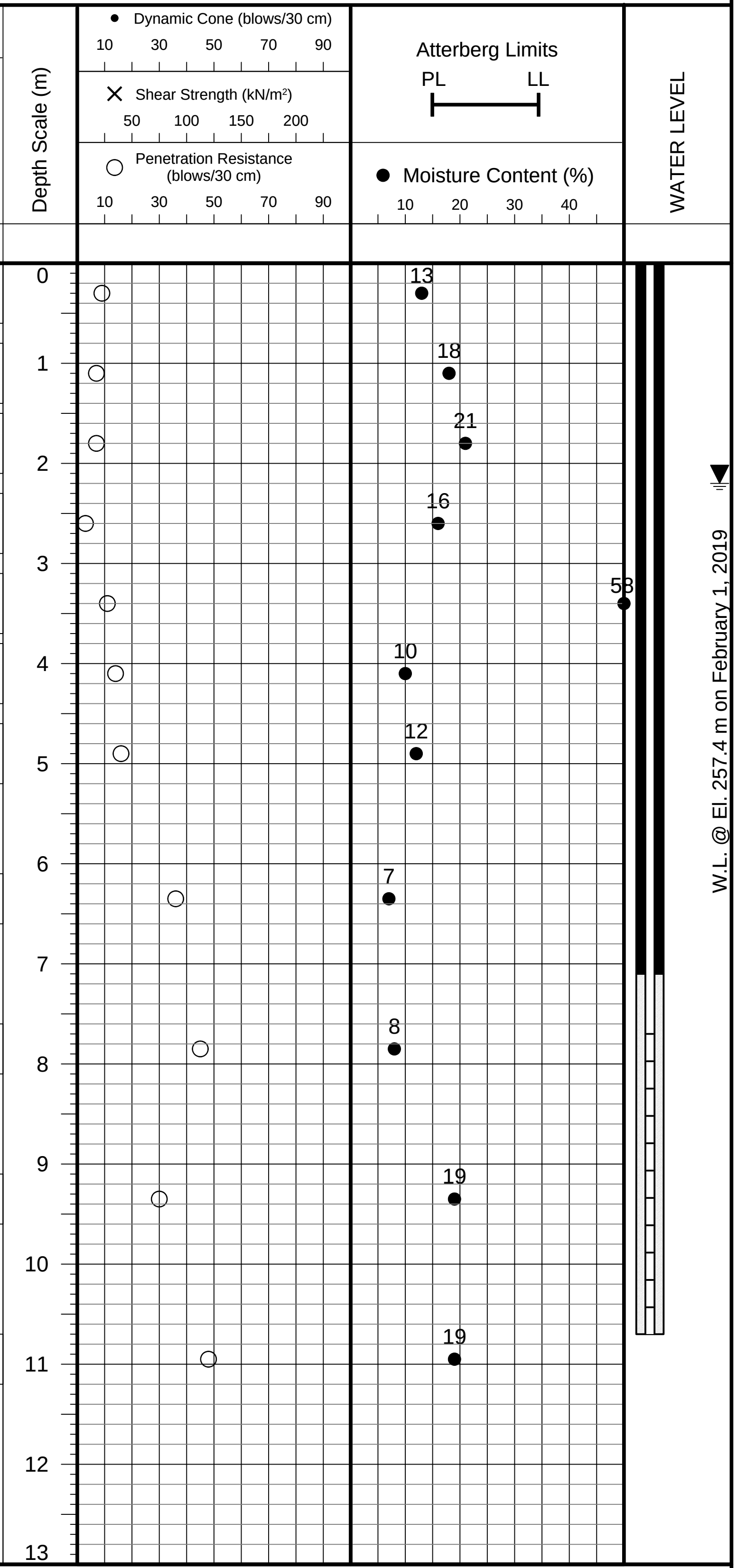
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 750 Lockhart Road, City of Barrie

DRILLING DATE: July 24, 2017

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value
259.6	Ground Surface			
0.0	**30 cm TOPSOIL**	1	DO	9
	EARTH FILL brown to grey sand and clay mixed with topsoil	2	DO	7
		3	DO	7
		4	DO	3
256.5 3.1	**TOPSOIL AND ORGANIC PEAT**	5	DO	11
256.2 3.4	Brown, compact to dense **SANDY SILT TILL** some clay a trace of gravel occ. sand seams and layers, cobbles and boulders	6	DO	14
		7	DO	16
	grey	8	DO	36
		9	DO	45
250.3 9.3	Dense, wet **SILT** occ. sand seams	10	DO	30
	brown grey	11	DO	48
248.4 11.2	**END OF BOREHOLE** Installed 50 mm diameter PVC monitoring well with riser from 0 to 7.7 m and slotted screen from 7.7 to 10.7 m, backfilled with bentonite from 0 to 7.1 m and sand from 7.1 to 10.7 m			



W.L. @ El. 257.4 m on February 1, 2019

Soil Engineers Ltd.

JOB NO.: 1706-S080

LOG OF BOREHOLE NO.: 6

FIGURE NO.: 21

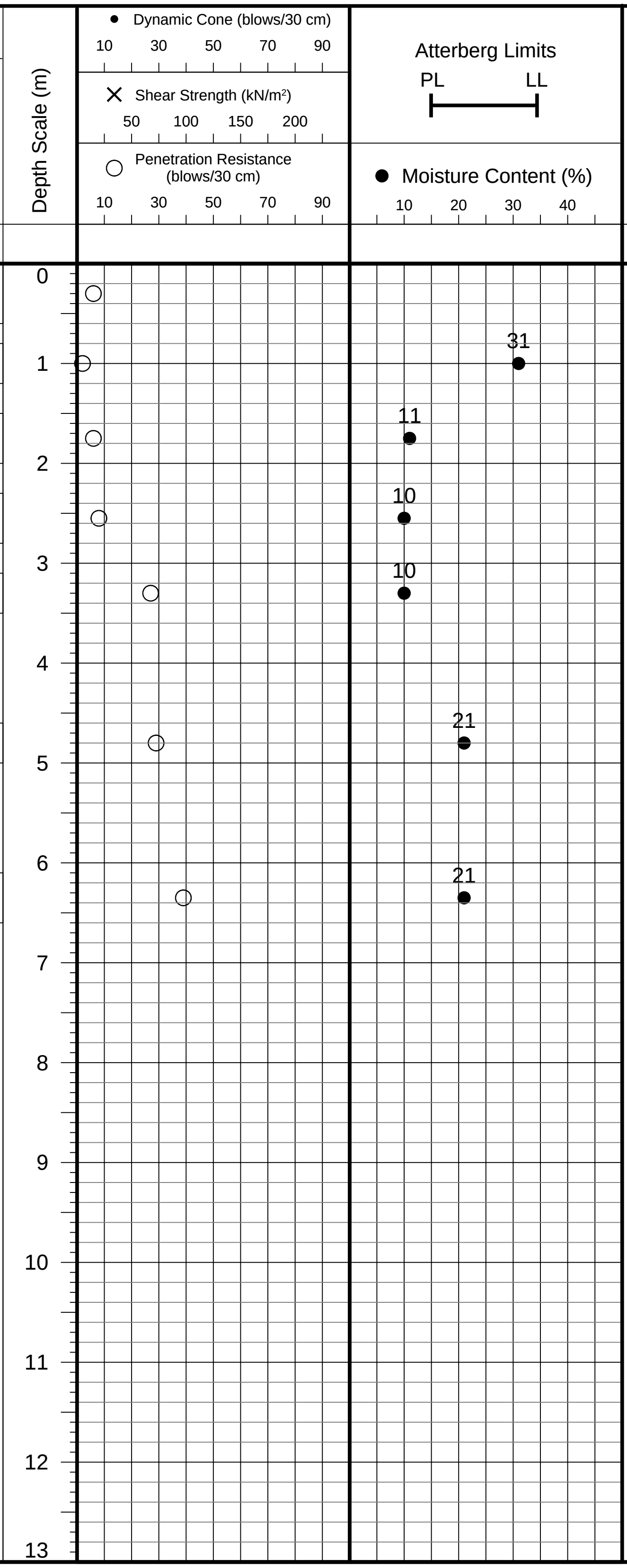
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 750 Lockhart Road, City of Barrie

DRILLING DATE: July 21, 2017

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value
261.1	Ground Surface			
0.0	**30 cm TOPSOIL**	1	DO	6
	EARTH FILL brown to grey sand and clay mixed with topsoil	2	DO	2
259.6 1.5	Brown, loose to compact **SANDY SILT TILL** some clay a trace of gravel occ. sand seams and layers, cobbles and boulders	3	DO	6
		4	DO	8
		5	DO	27
257.1 4.0	Brown, compact to dense, wet **SAND** fine grained a trace of silt	6	DO	29
		7	DO	39
254.5 6.6	**END OF BOREHOLE**			



WATER LEVEL

W.L. @ El. 260.2 m upon completion

Soil Engineers Ltd.

JOB NO.: 1706-S080

LOG OF BOREHOLE NO.: 7

FIGURE NO.: 22

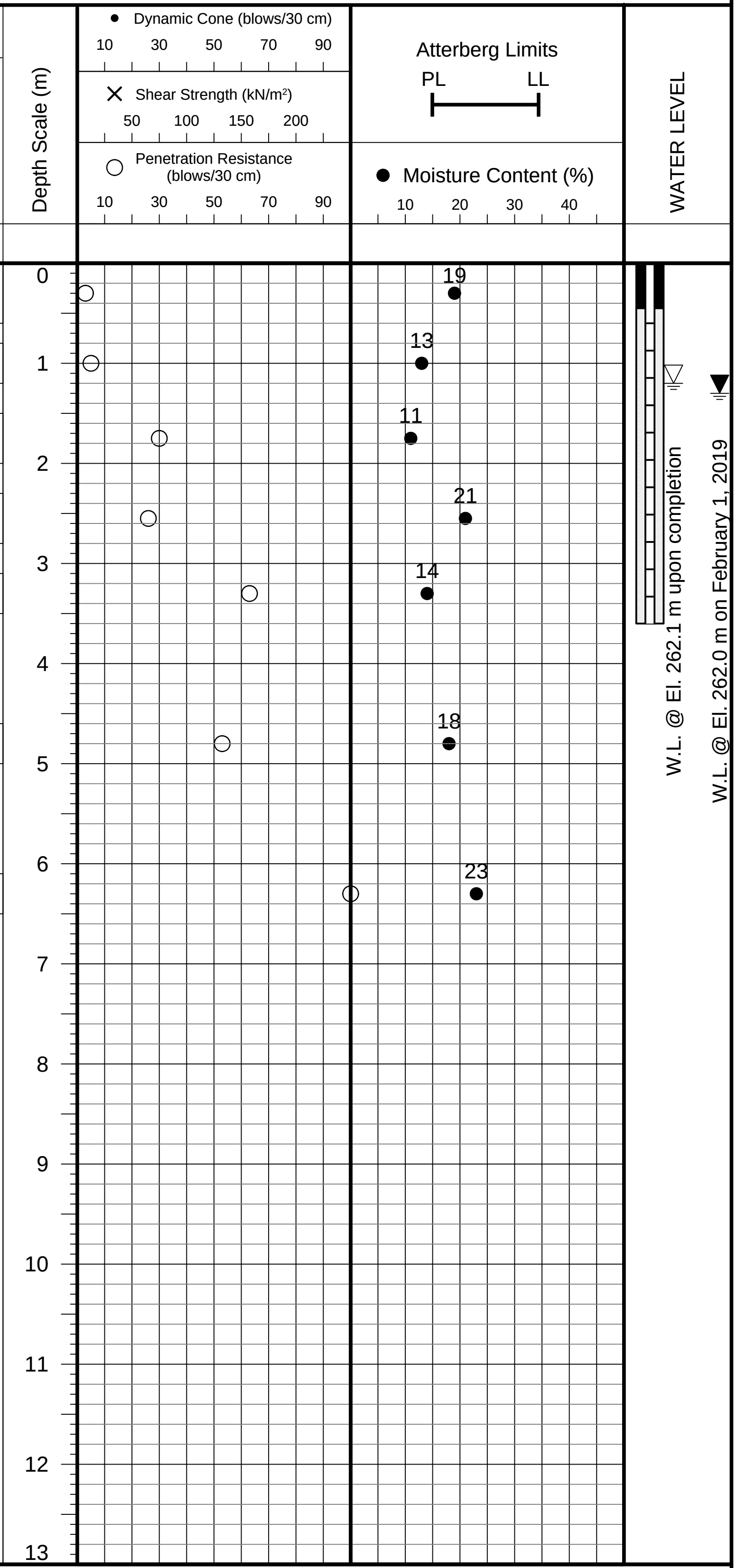
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 750 Lockhart Road, City of Barrie

DRILLING DATE: July 27, 2017

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
263.3	Ground Surface			
0.0	**13 cm TOPSOIL**			
	PLOUGHED SOIL brown sandy silt mixed with topsoil	1	DO	3
262.3 1.0	Brown, very loose to compact, wet weathered **SANDY SILT TILL** some clay a trace of gravel	2 3	DO DO	5 30
261.0 2.3	Brown, compact to very dense, wet **SAND** silt layers well graded a trace of silt	4 5 6 7	DO DO DO DO	26 63 53 84/25
256.8 6.5	**END OF BOREHOLE** Installed 50 mm diameter PVC monitoring well with riser from 0 to 0.6 m and slotted screen from 0.6 to 3.6 m, backfilled with bentonite from 0 to 0.5 m and sand from 0.5 to 3.6 m			



JOB NO.: 1706-S080

LOG OF BOREHOLE NO.: 8

FIGURE NO.: 23

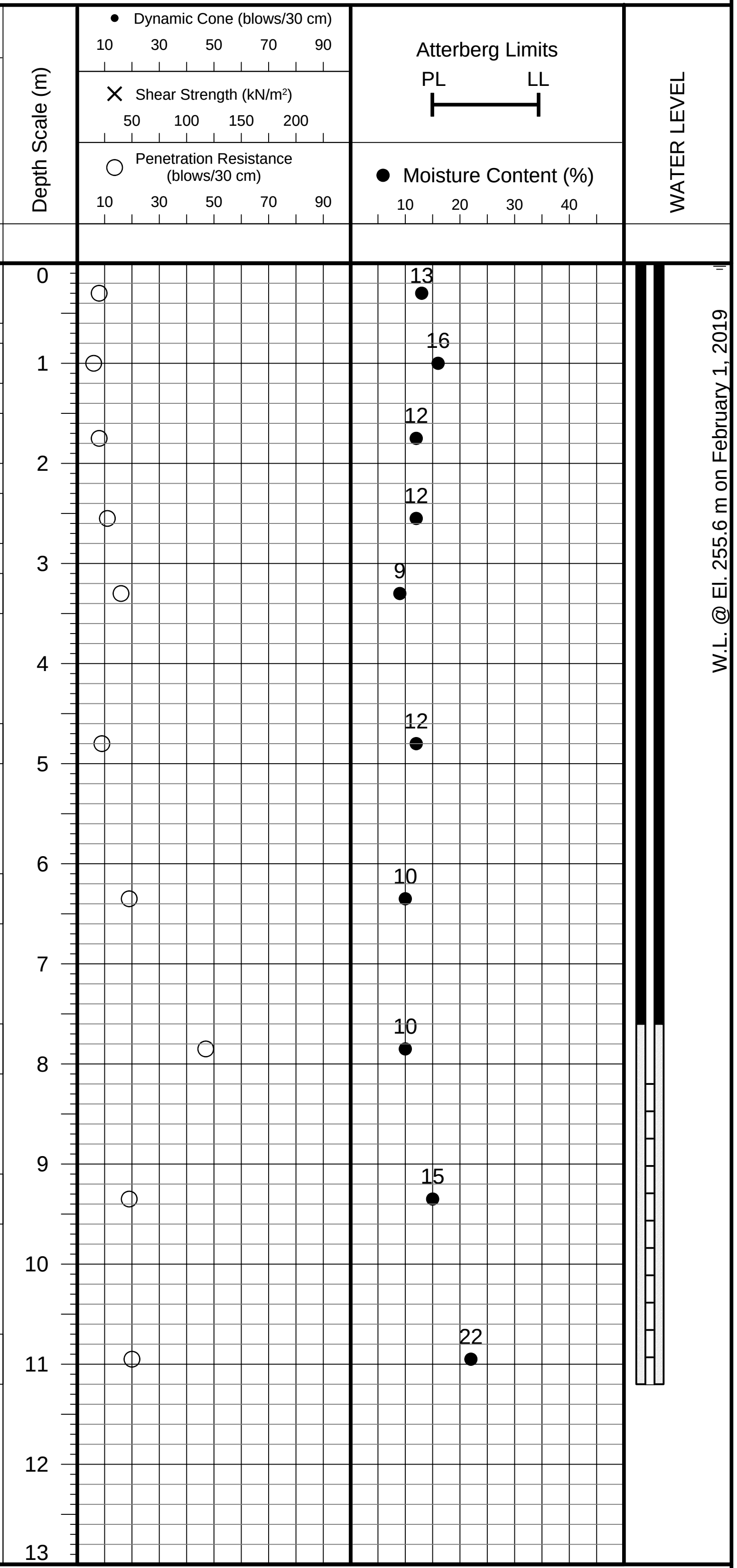
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 750 Lockhart Road, City of Barrie

DRILLING DATE: July 25, 2017

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value
255.6	Ground Surface			
0.0	**60 cm TOPSOIL**	1	DO	8
	PLOUGHED SOIL brown sandy silt mixed with topsoil	2	DO	6
254.2 1.4	Loose to dense **SANDY SILT TILL** some clay a trace of gravel occ. sand seams and layers, cobbles and boulders	3	DO	8
		4	DO	11
		5	DO	16
	brown grey	6	DO	9
		7	DO	19
		8	DO	47
246.5 9.1	Brown, compact, wet **SANDY SILT** fine grained occ. sand seams	9	DO	19
		10	DO	20
244.4 11.2	**END OF BOREHOLE** Installed 50 mm diameter PVC monitoring well with riser from 0 to 8.2 m and slotted screen from 8.2 to 11.2 m, backfilled with bentonite from 0 to 7.6 m and sand from 7.6 to 11.2 m			



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JOB NO.: 1706-S080

LOG OF BOREHOLE NO.: 9

FIGURE NO.: 24

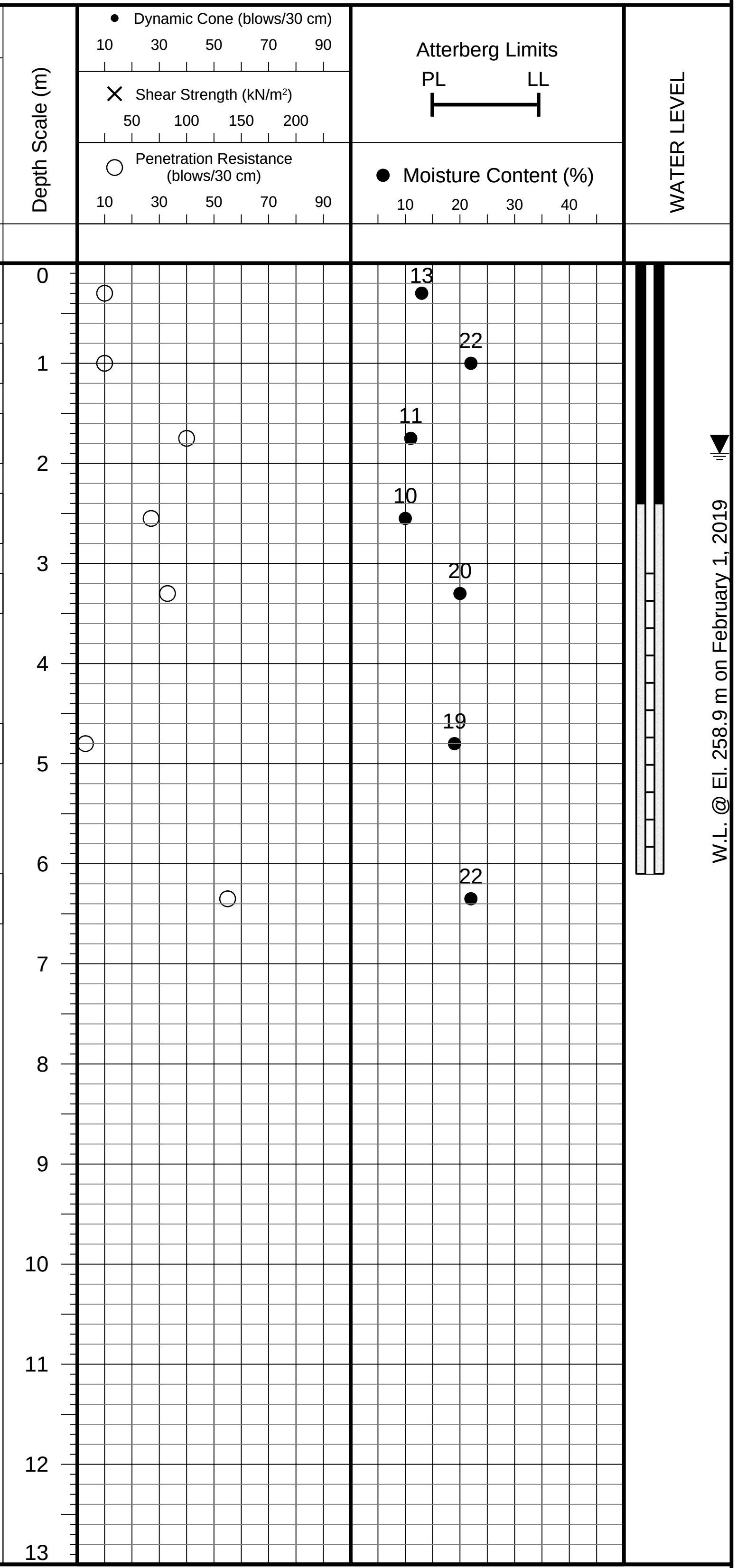
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 750 Lockhart Road, City of Barrie

DRILLING DATE: July 26, 2017

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
260.8	Ground Surface			
0.0	**35 cm TOPSOIL**	1	DO	10
	PLOUGHED SOIL brown sandy silt mixed with topsoil and clay	2	DO	10
259.7 1.1	Brown, compact to dense **SANDY SILT TILL** some clay a trace of gravel occ. sand seams and layers, cobbles and boulders	3	DO	40
		4	DO	27
257.7 3.1	Brown, loose to very dense, wet **SAND** fine grained some silt occ. sand seams and layers	5	DO	33
	disturbed	6	DO	3
		7	DO	55
254.2 6.6	**END OF BOREHOLE** Installed 50 mm diameter PVC monitoring well with riser from 0 to 3.1 m and slotted screen from 3.1 to 6.1 m, backfilled with bentonite from 0 to 2.4 m and sand from 2.4 to 6.1 m			



JOB NO.: 1706-S080

LOG OF BOREHOLE NO.: 10

FIGURE NO.: 25

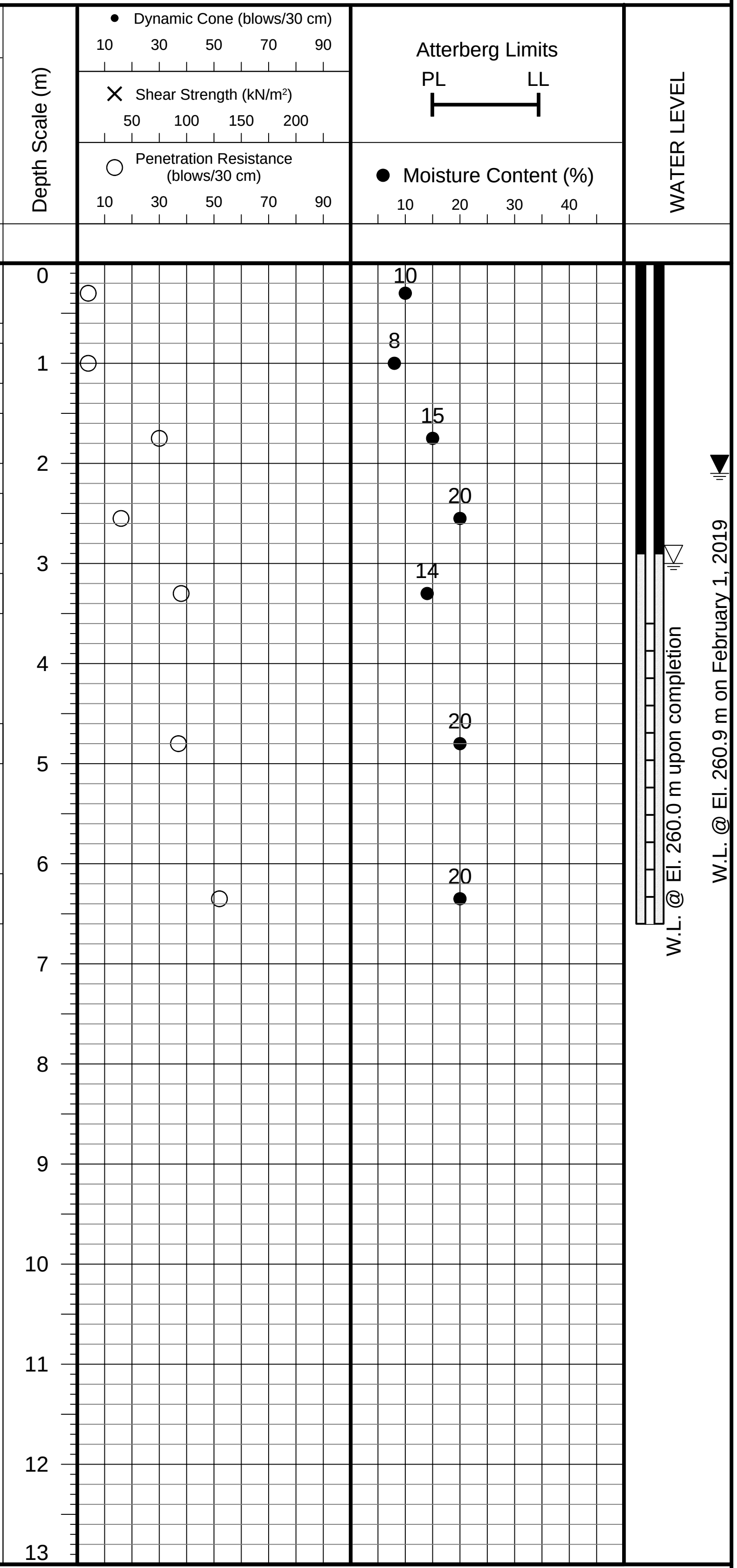
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 750 Lockhart Road, City of Barrie

DRILLING DATE: July 26, 2017

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES		
		Number	Type	N-Value
263.0	Ground Surface			
0.0	**20 cm TOPSOIL**	1	DO	4
	PLOUGHED SOIL brown sand and silt mixed with topsoil	2	DO	4
262.0 1.0	Brown, loose to compact weathered **SAND** fine grained some silt occ. topsoil and rootlet inclusions	3	DO	30
260.7 2.3	Brown, compact, wet **SILT** a trace of clay	4	DO	16
259.9 3.1	Brown, dense to very dense, wet **SAND** fine to medium grained a trace to some silt occ. silt seams and layers	5	DO	38
		6	DO	37
		7	DO	52
256.4 6.6	**END OF BOREHOLE** Installed 50 mm diameter PVC monitoring well with riser from 0 to 3.6 m and slotted screen from 3.6 to 6.6 m, backfilled with bentonite from 0 to 2.9 m and sand from 2.9 to 6.6 m			



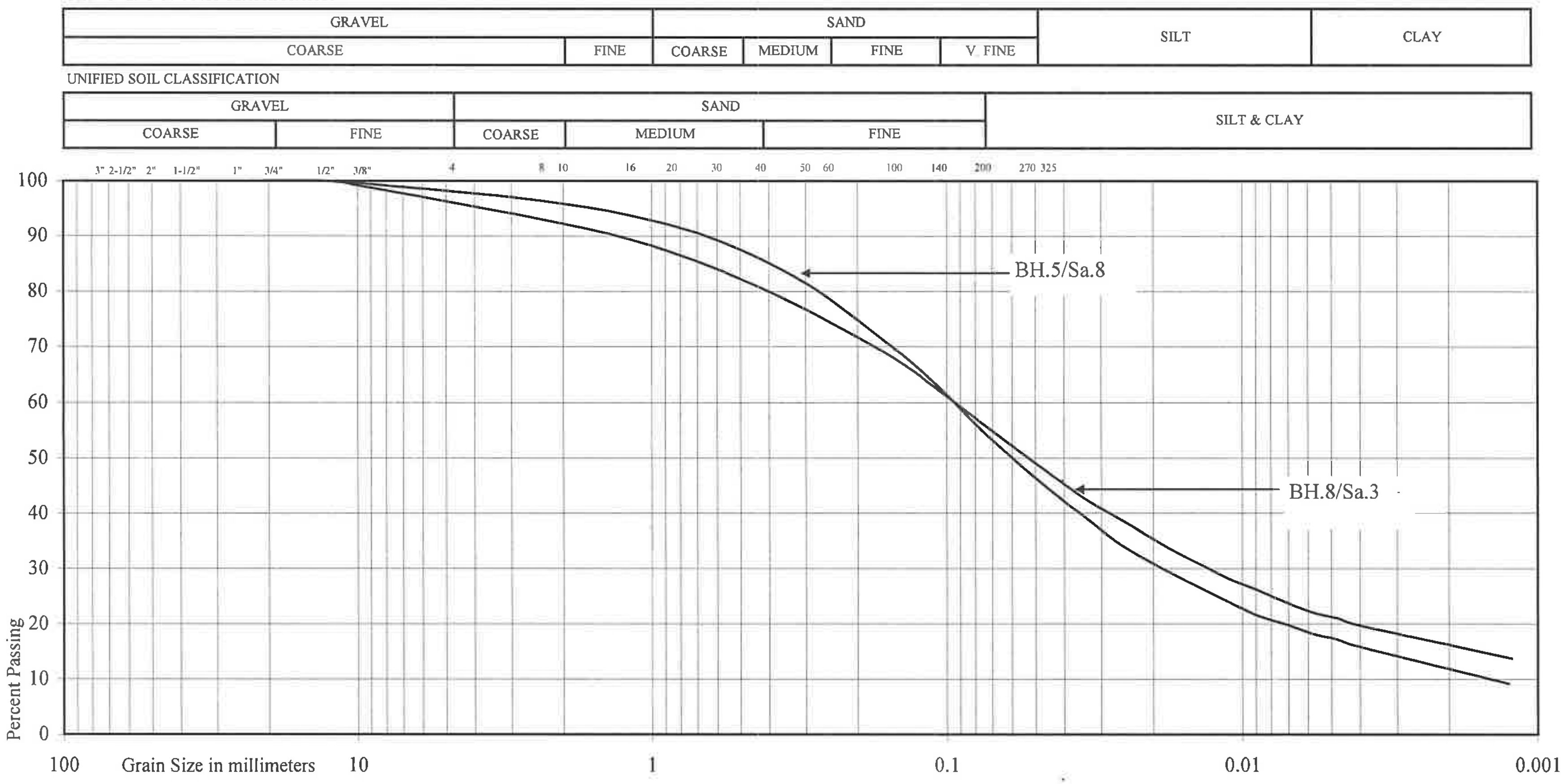
W.L. @ El. 260.0 m upon completion

W.L. @ El. 260.9 m on February 1, 2019

Soil Engineers Ltd.

GRAIN SIZE DISTRIBUTION

Reference No: 1810-S159
(Related Ref. No. 1706-S080)



Project: Proposed Residential Development
Location: 750 Lockhart Road, City of Barrie

Borehole No:	5	8
Sample No:	8	3
Depth (m):	6.3	1.8
Elevation (m):	253.3	253.8

BH./Sa.	5/8	8/3
Liquid Limit (%) =	-	-
Plastic Limit (%) =	-	-
Plasticity Index (%) =	-	-
Moisture Content (%) =	7	12
Estimated Permeability (cm./sec.) =	10^{-7}	10^{-7}

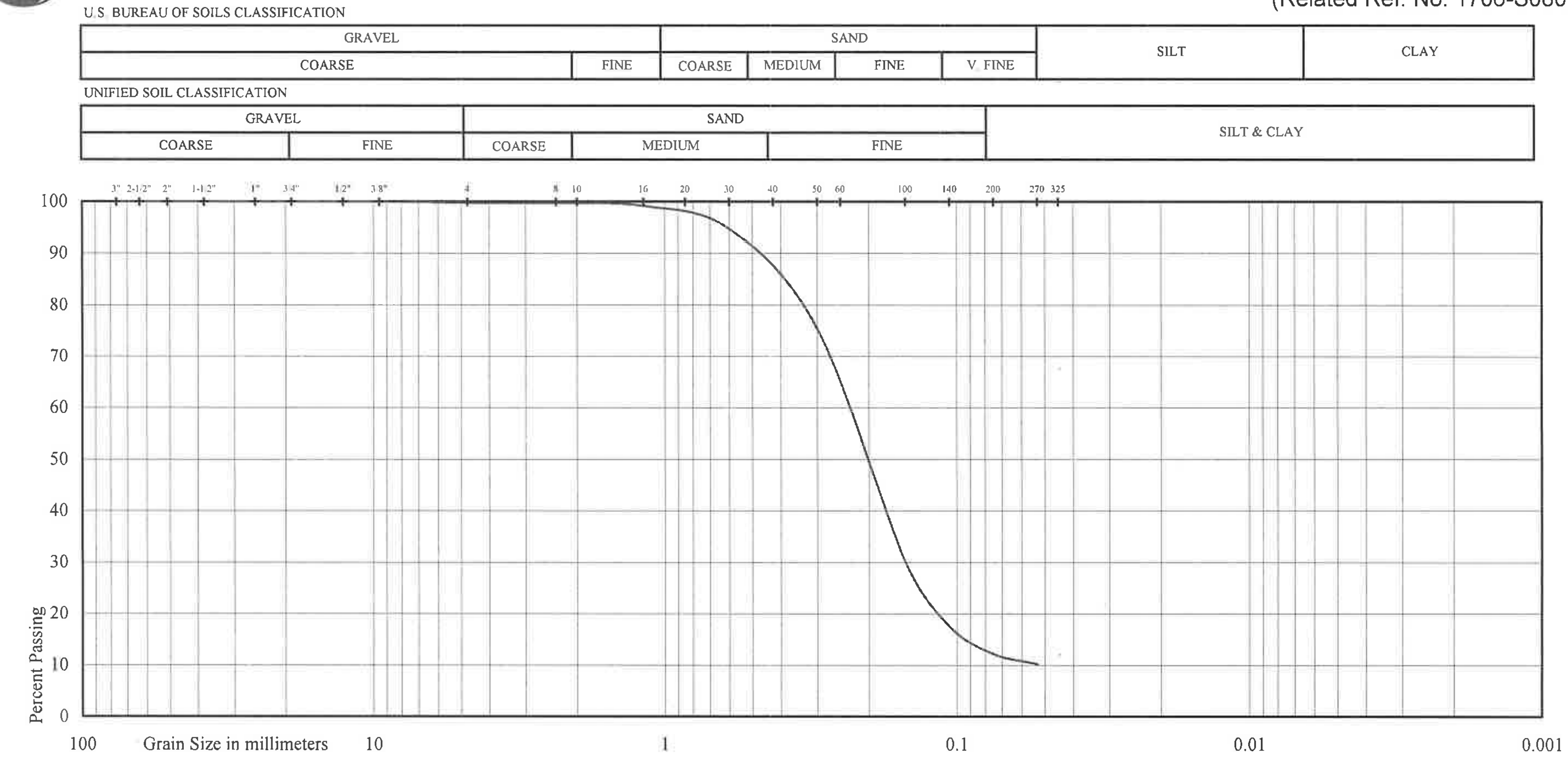
Classification of Sample [& Group Symbol]: SANDY SILT TILL
some clay, a trace of gravel

Figure: 26

Soil Engineers Ltd.

GRAIN SIZE DISTRIBUTION

Reference No: 1810-S159
(Related Ref. No. 1706-S080)



Project: Proposed Residential Development

Location: 750 Lockhart Road, City of Barrie

Borehole No: 108

Sample No: 8

Depth (m): 7.8

Elevation (m): 256.8

Liquid Limit (%) = -

Plastic Limit (%) = -

Plasticity Index (%) = -

Moisture Content (%) = 16

Estimated Permeability (cm./sec.) = 10^{-3}

Classification of Sample [& Group Symbol]: FINE SAND, some silt

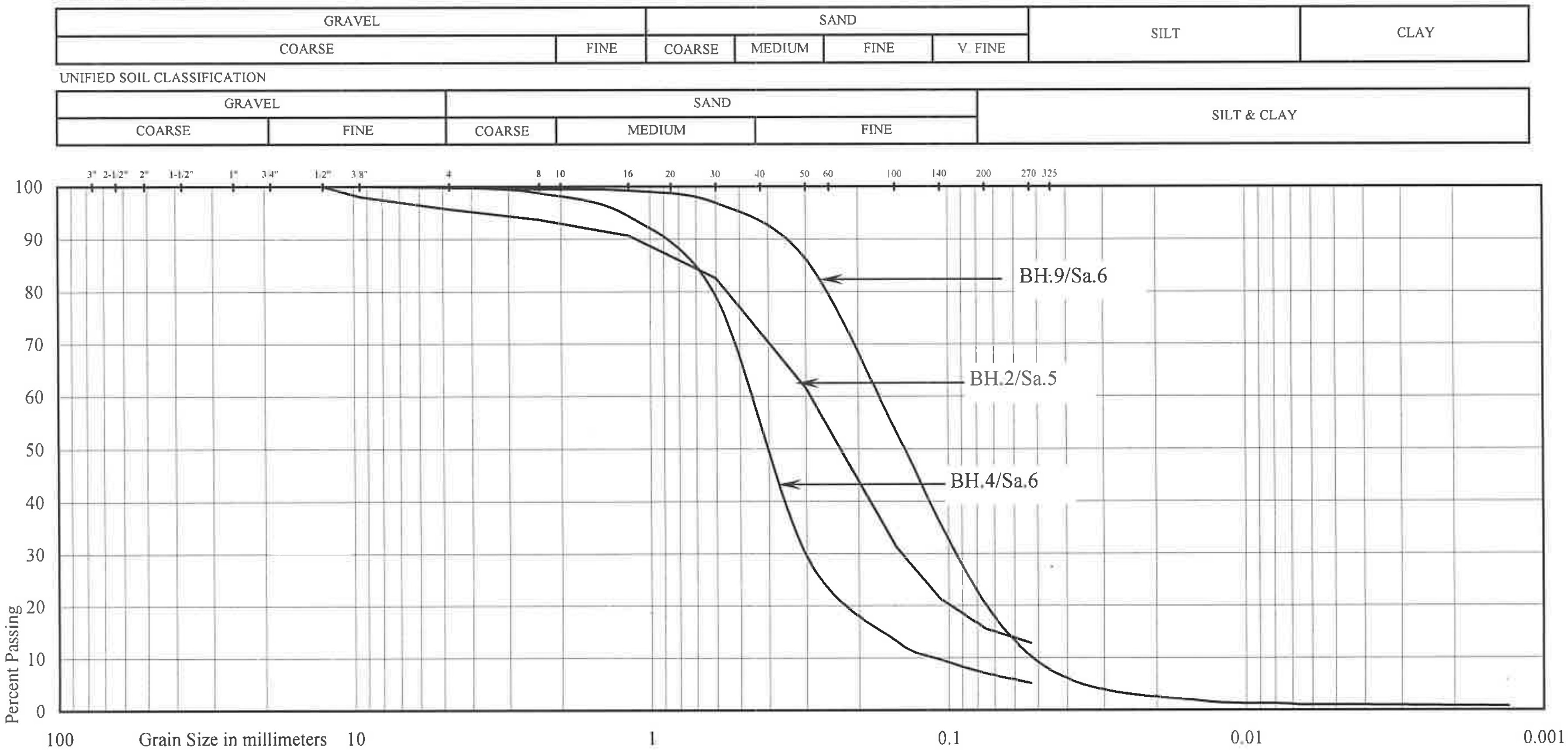
Figure: 27

Soil Engineers Ltd.

GRAIN SIZE DISTRIBUTION

Reference No: 1810-S159

(Related Ref. No. 1706-S080)



Project:	Proposed Residential Development		
Location:	750 Lockhart Road, City of Barrie		
Borehole No:	2	4	9
Sample No:	5	6	6
Depth (m):	3.3	4.0	4.8
Elevation (m):	262.9	262.6	256.0

BH./Sa.	2/5	4/6	9/6
Liquid Limit (%) =	-	-	-
Plastic Limit (%) =	-	-	-
Plasticity Index (%) =	-	-	-
Moisture Content (%) =	7	17	19
Estimated Permeability (cm./sec.) =	10^{-3}	10^{-2}	10^{-3}

Classification of Sample [& Group Symbol]: SAND

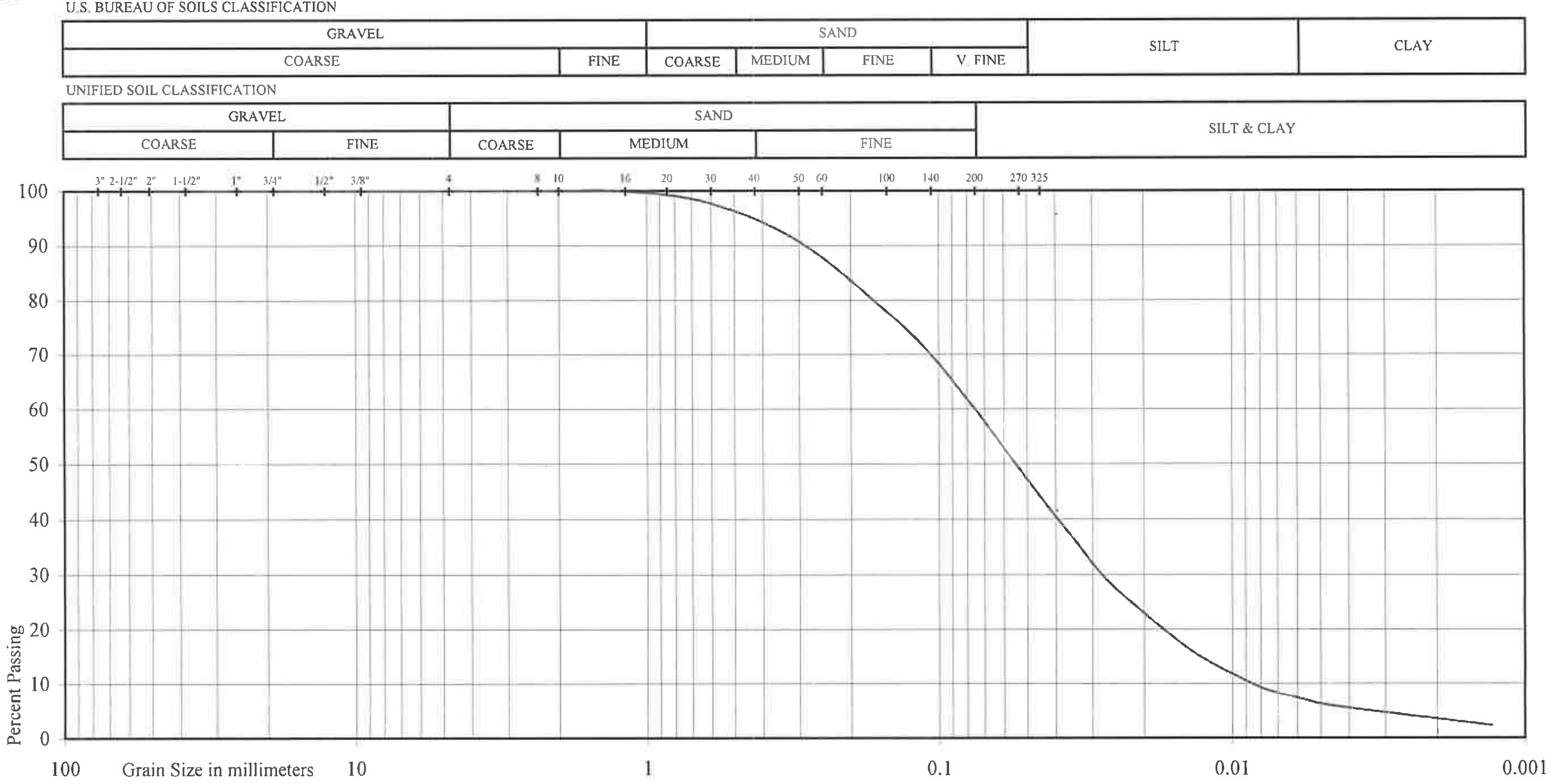
fine or fine to medium grained, a trace to some silt

Figure: 28

Soil Engineers Ltd.

GRAIN SIZE DISTRIBUTION

Reference No: 1810-S159



Project: Proposed Residential Development

Location: 750 Lockhart Road, City of Barrie

Borehole No: 8

Sample No: 9

Depth (m): 9.3

Elevation (m): 246.3

Liquid Limit (%) = -

Plastic Limit (%) = -

Plasticity Index (%) = -

Moisture Content (%) = 15

Estimated Permeability (cm./sec.) = 10^{-5}

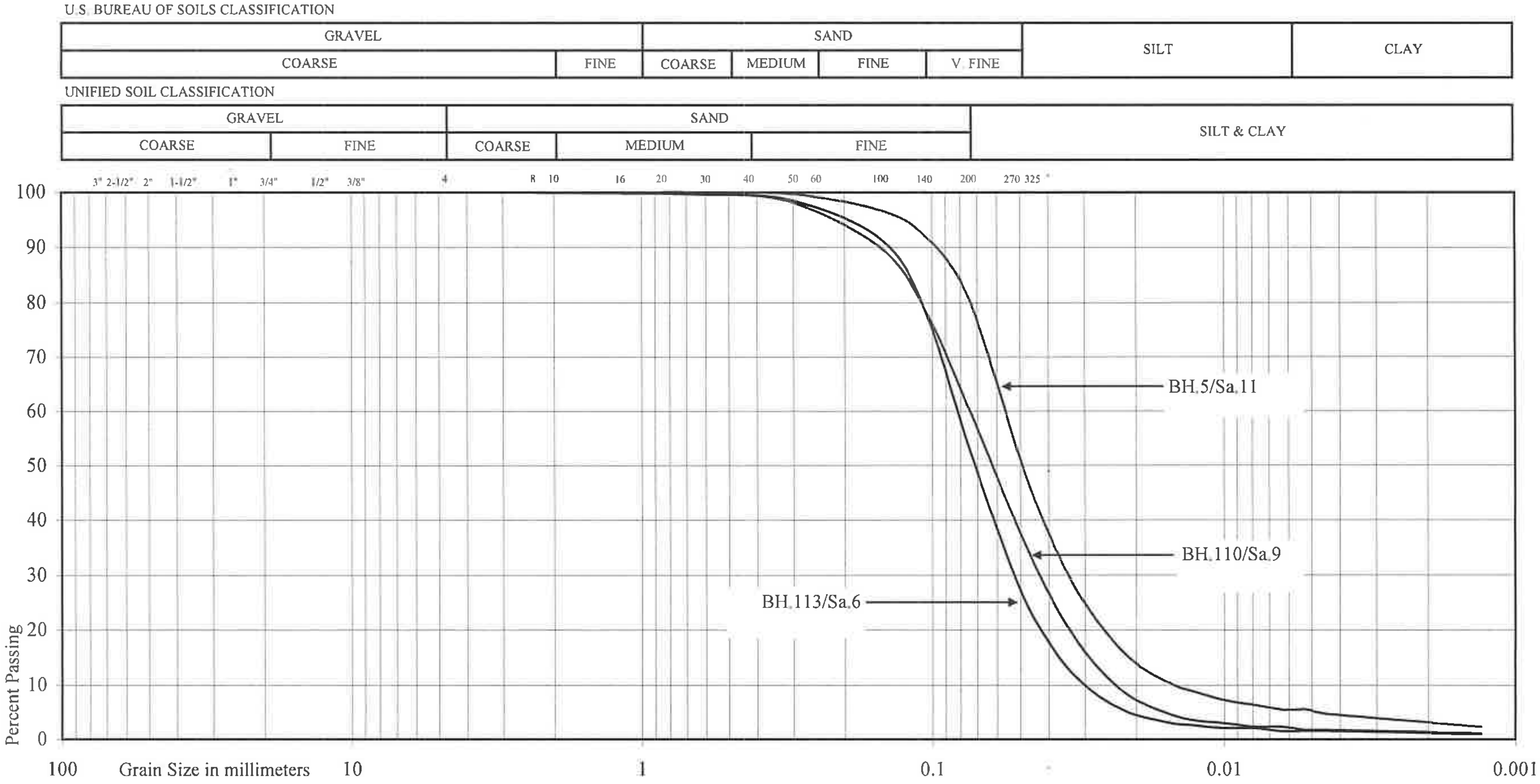
Classification of Sample [& Group Symbol]: SANDY SILT, a trace of clay

Figure: 29

Soil Engineers Ltd.

GRAIN SIZE DISTRIBUTION

Reference No: 0310-S142



Project: Proposed Residential Development

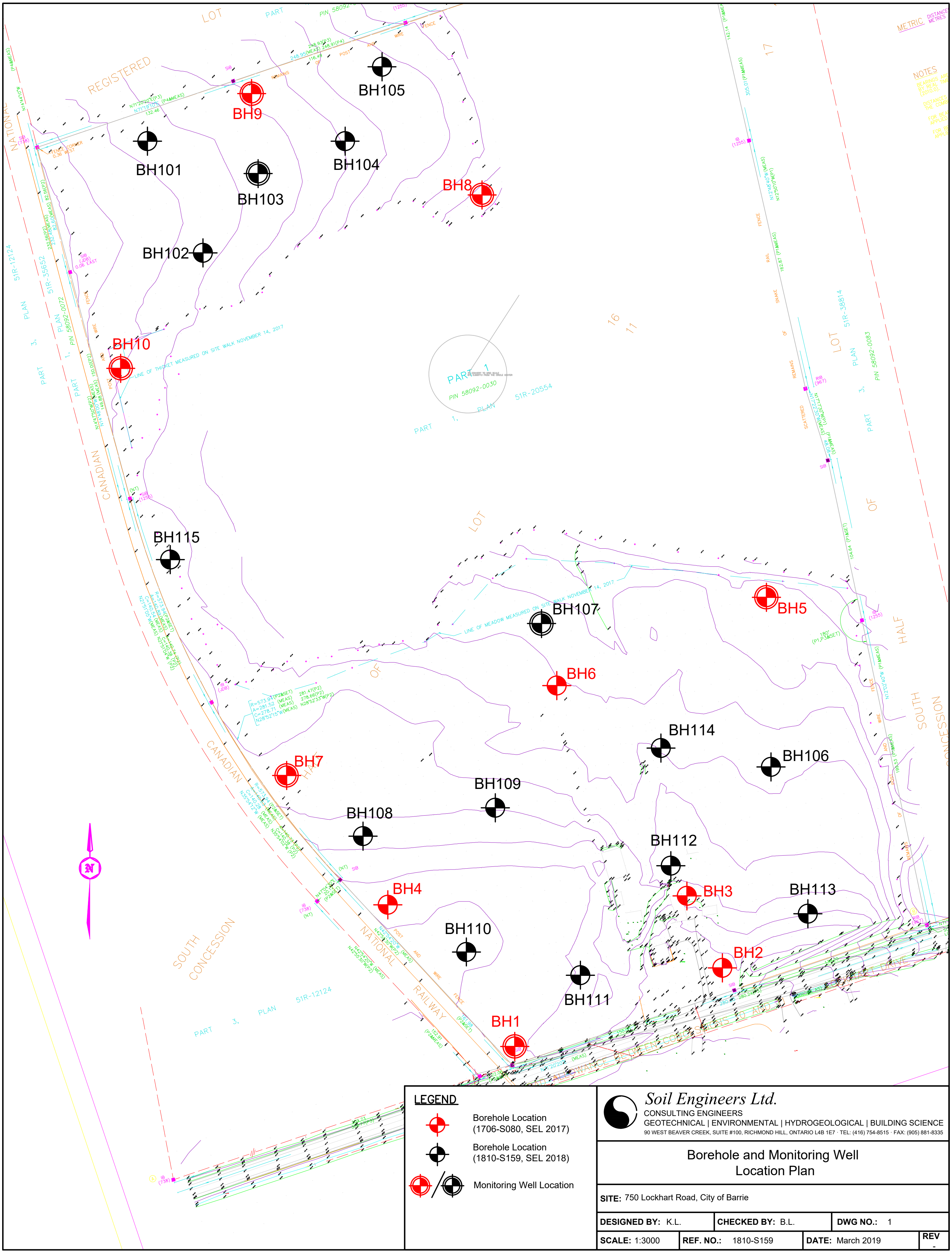
Location: 750 Lockhart Road, City of Barrie

Borehole No:	5	110	113
Sample No:	11	9	6
Depth (m):	11.0	9.3	4.8
Elevation (m):	248.6	257.8	260.2

BH./Sa.	5/11	110/9	113/6
Liquid Limit (%) =	-	-	-
Plastic Limit (%) =	-	-	-
Plasticity Index (%) =	-	-	-
Moisture Content (%) =	-	-	-
Estimated Permeability (cm./sec.) =	10^{-5}	10^{-6}	10^{-7}

Classification of Sample [& Group Symbol]: SILT
some fine sand, a trace of clay

Figure: 30



LEGEND

🟥 Borehole Location (1706-S080, SEL 2017)

● Borehole Location (1810-S159, SEL 2018)

🟥/● Monitoring Well Location

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90 WEST BEAVER CREEK, SUITE #100, RICHMOND HILL, ONTARIO L4B 1E7 · TEL: (416) 754-8515 · FAX: (905) 881-8335

Borehole and Monitoring Well Location Plan

SITE: 750 Lockhart Road, City of Barrie

DESIGNED BY: K.L.	**CHECKED BY:** B.L.	**DWG NO.:** 1	
SCALE: 1:3000	**REF. NO.:** 1810-S159	**DATE:** March 2019	**REV** -

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SUBSURFACE PROFILE
DRAWING NO. 2
SCALE: AS SHOWN

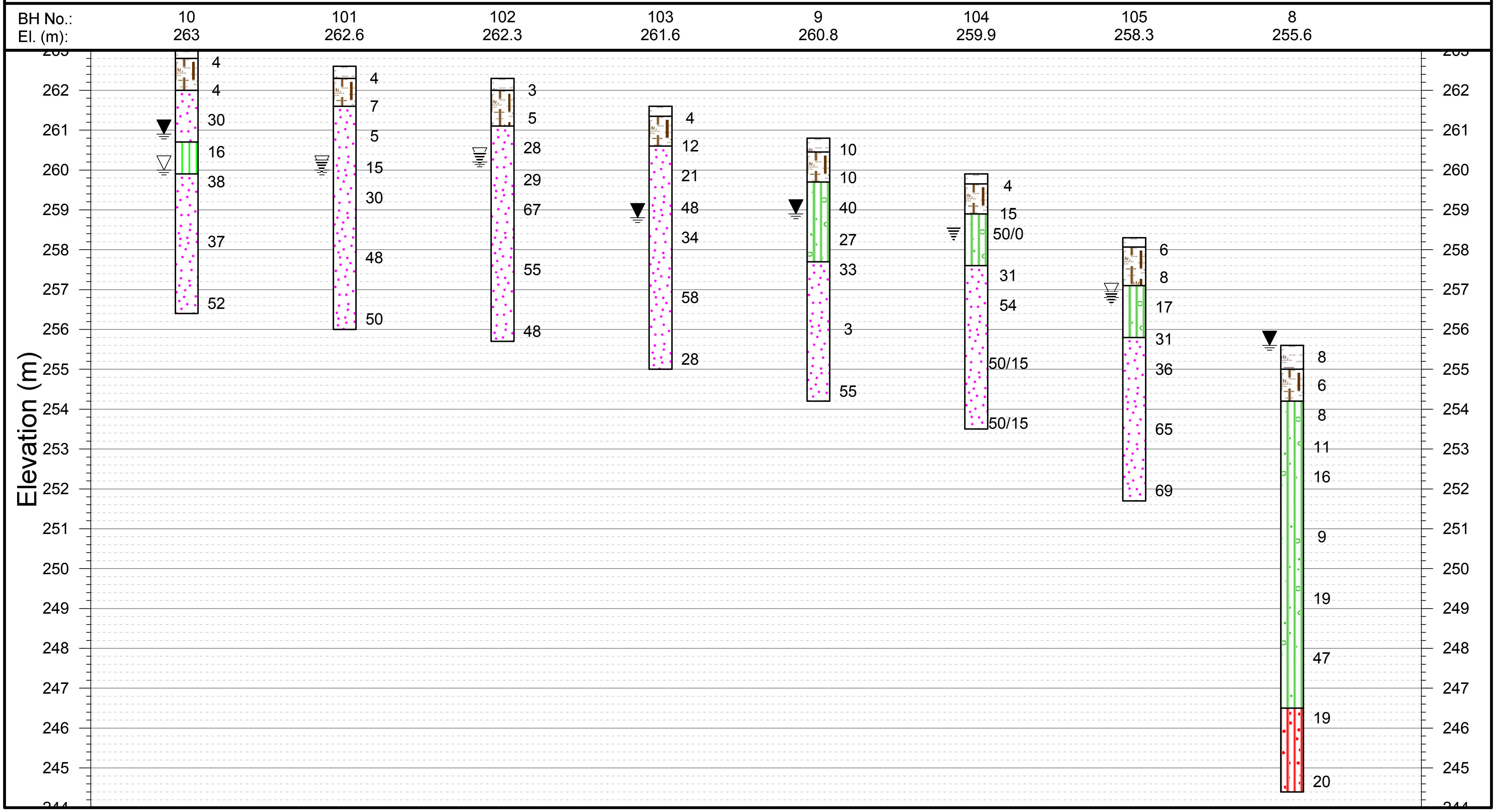
JOB NO.: 1810-S159
REPORT DATE: March 2019
PROJECT DESCRIPTION: Proposed Residential Development

PROJECT LOCATION: 750 Lockhart Road, City of Barrie

LEGEND

- TOPSOIL
- PLOUGHED SOIL
- SAND
- SANDY SILT
- SANDY SILT TILL
- SILT

▽ WATER LEVEL (END OF DRILLING) ≡ CAVE-IN ▼ WATER LEVEL (STABILIZED)



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SUBSURFACE PROFILE
DRAWING NO. 3
SCALE: AS SHOWN

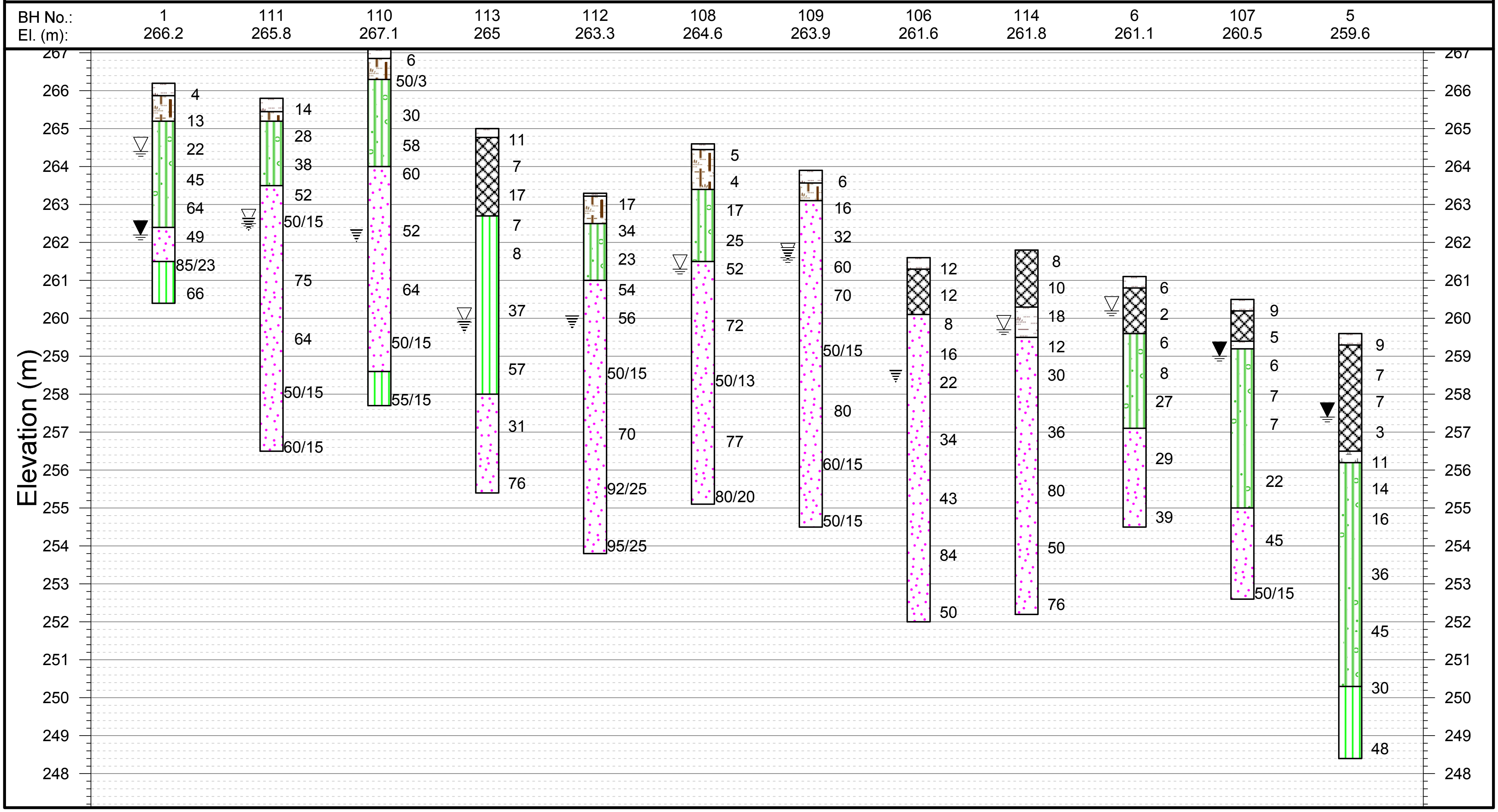
JOB NO.: 1810-S159
REPORT DATE: March 2019
PROJECT DESCRIPTION: Proposed Residential Development

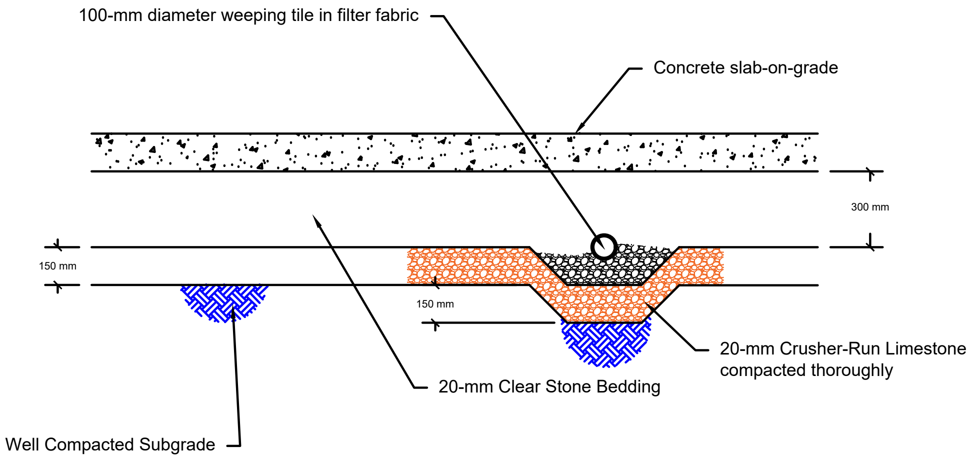
PROJECT LOCATION: 750 Lockhart Road, City of Barrie

LEGEND

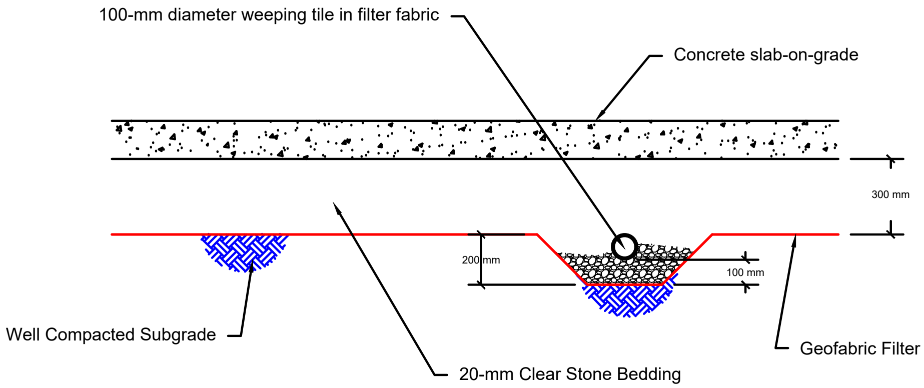
TOPSOIL
PLOUGHED SOIL
FILL
SAND
SANDY SILT TILL
SILT
PEAT

▽ WATER LEVEL (END OF DRILLING)
≡ CAVE-IN
▼ WATER LEVEL (STABILIZED)

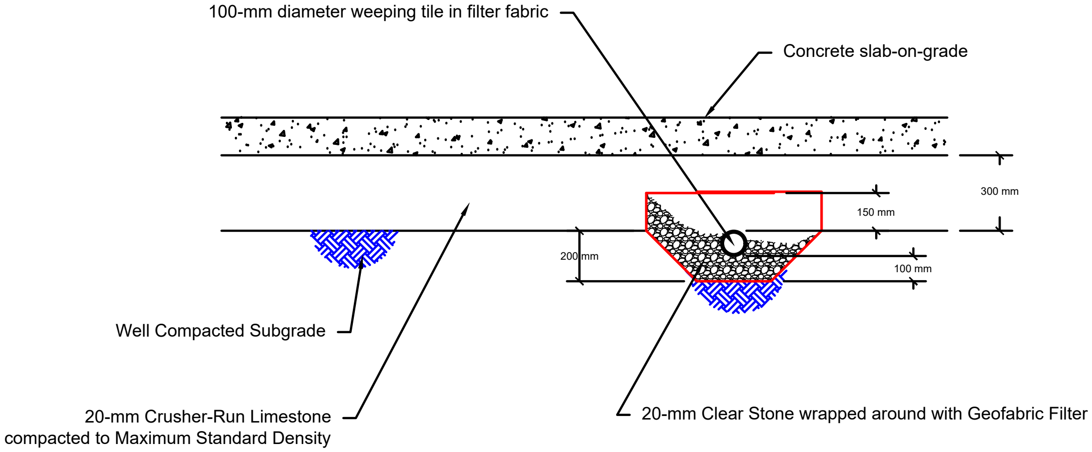




Option 'A'



Option 'B'



Option 'C'

Note:

1. Weepers should be placed in 6 m grids, draining in a positive gradient towards an outlet or a sump pit for removal by pumping.
2. A 10-mil polyethylene sheet should be specified between the gravel bedding and concrete slab.

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100 NUGGET AVENUE, TORONTO, ONTARIO M1S 3A7 · TEL: (416) 754-8515 · FAX: (416) 754-8516

Typical Design for Underfloor Weepers

SITE: 750 Lockhart Road, City of Barrie

DESIGNED BY: K.L. **CHECKED BY:** B.S. **DWG NO.:** 4

SCALE: N.T.S. **REF. NO.:** 1810-S159 **DATE:** March 2019 **REV** -