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A REPORT TO
HIGHGLEN HOMES LIMITED

A GEOTECHNICAL INVESTIGATION FOR PROPOSED RESIDENTIAL DEVELOPMENT

230 FINCH AVENUE
(PART 4, PLAN #40 R-29767)

CITY OF PICKERING

REFERENCE NO. 1911-S057

FEBRUARY 2020

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1.0 INTRODUCTION

In accordance with written authorization dated November 11, 2019, from Mr. John Perciasepe, of Highglen Homes Limited, a geotechnical investigation was carried out at a parcel of land located at 230 Finch Avenue, in the City of Pickering, for a proposed Residential Development.

The purpose of this 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.

2.0 SITE AND PROJECT DESCRIPTION

The City of Pickering is situated on Iroquois (glacial lake) plain where, in places, the glacial till stratigraphy has been partly eroded by the water action of the glacial lake and filled with lacustrine sands, silts, clays and reworked till.

The subject site is an open field situated at the northwest sector of Finch Avenue and Altona Road, in the City of Pickering. The site area is weed covered and was snow covered at the time of field investigation. The area fronting Finch Avenue is treed. The ground surface is relatively flat and level, with the overall topography descending gently towards the south.

The proposed project consists of the construction of a new residential subdivision, which will be provided with municipal services and roadways meeting the municipal standards.

3.0 FIELD WORK

The field work, consisting of 5 boreholes to a depth of 6.6 m, was performed on December 12, 2019 at the locations shown on the Borehole Location Plan, Drawing No. 1. A total of 5 monitoring wells were also installed for hydrogeological assessment.

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 from the spot elevations on the site plan provided by the client.

4.0 SUBSURFACE CONDITIONS

Detailed descriptions of the encountered subsurface conditions are presented on the Borehole Logs, comprising Figures 1 to 5, inclusive. The revealed stratigraphy is plotted on the Subsurface Profile, Drawing No. 2, and the engineering properties of the disclosed soils are discussed herein.

The investigation has disclosed that beneath a veneer of topsoil and a layer of earth fill, the site is underlain by strata of sandy silt, silty sand till and sands.

4.1 **Topsoil** (All Boreholes)

The revealed topsoil is 25 to 36 cm thick; it is dark brown in colour, indicating that it contains appreciable amounts of roots and humus. These materials are unstable and compressible under loads; therefore, the topsoil is considered to be void of engineering value. Due to its humus content, it will generate an offensive odour and may produce volatile gases under anaerobic conditions. Therefore, the topsoil must not be buried below any structures or deeper than 1.2 m below the finished grade so it will not have an adverse impact on the environmental well-being of the developed areas.

Since the topsoil is considered void of engineering value, it can only be used for general landscaping and landscape contouring purposes. A fertility analysis can be performed to determine the suitability of the topsoil as a planting material.

4.2 **Disturbed/Weathered Soil** (All Boreholes)

The disturbed/weathered soil encountered extends to depths of 0.7 m and 1.4 m from the prevailing ground surface. Sample examinations show that the soil contains sand, with gravel, cobbles and rock fragments.

The obtained ‘N’ values of the earth fill range from 3 to 22, with a median of 5 blows per 30 cm of penetration, indicating that the soil is generally loose.

The natural water content values of the soil are 6% and 18%, indicating that it is in a moist to wet condition.

A grain size analysis was performed on 1 representative sample of the soil and the result is plotted on Figure 6.

Due to the non-uniform and loose density, it is considered unsuitable for supporting structural loads. For structural use, the soil must be subexcavated, inspected, sorted free of any deleterious material, and properly compacted.

4.3 **Sandy Silt** (Borehole 5)

The sandy silt deposit was found below a layer of fine to coarse sand and it is embedded with seams and layers of silty clay and fine sand and contains a trace of clay. The laminated structure shows that the silt is a glaciolacustrine deposit.

The natural water content values of the sandy silt sample is 21%, indicating it is in a wet condition and is water bearing. The wet sample became highly dilatant under tactile examinations, showing the shear strength of the sandy silt will be subject to dynamic disturbance.

The obtained ‘N’ value is 6 blows per 30 cm of penetration, indicating that the relative density of the sandy silt is loose.

A grain size analysis was performed on the sandy silt sample and the result is plotted on Figure 7.

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

- Highly frost susceptible, with high soil-adfreezing potential.
- Highly water erodible; it is susceptible to migration through small openings under seepage pressure.
- Relatively pervious, with an estimated coefficient of permeability of 10^{-4} cm/sec, an estimated percolation rate of 20 min/cm, and runoff coefficients of:

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

- The soil has a high capillarity and water retention capacity.
- A frictional soil, its shear strength is density dependent. Due to the dilatancy, the strength of the wet 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 in shear strength.
- In excavation, the moist silt will be stable in relatively steep cuts, while the wet silt will slough and run slowly with seepage bleeding from the cut face, and the bottom will boil under a piezometric head of 0.3 m.
- A poor pavement-supportive material, with an estimated California Bearing Ratio (CBR) value of 6%.
- Moderate corrosivity to buried metal, with an estimated electrical resistivity of 4500 ohm·cm.

4.4 **Silty Sand Till** (All Boreholes)

The silty sand till was encountered below the sand layer and extends to the maximum investigated depth at all boreholes. The till consists of a random mixture of soil particle sizes ranging from clay to gravel, with the sand being the dominant fraction. It is heterogeneous in structure, showing that it is a glacial deposit.

The obtained ‘N’ values range from 11 to 49, with a median of 30 blows per 30 cm of penetration, indicating that the relative density of the silty sand till is compact to dense, being generally compact.

Intermittent hard resistance to augering was encountered, indicating the presence of cobbles and boulders in the stratum.

The natural water content values of the samples were determined and the results are plotted on the Borehole Logs; the values range from 9% to 14%, with a median of 10%, indicating the till is in a moist to very moist condition.

A grain size analysis was performed on 1 representative sample of the silty sand till; the results are plotted on Figure 8.

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

- High frost susceptibility and moderate water erodibility.
- Low permeability, with an estimated coefficient of permeability of 10^{-6} cm/sec and runoff coefficients of:

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

- A frictional soil, its shear strength is primarily derived from internal friction and is augmented by cementation. Therefore, its strength is primarily soil density dependent.
- In steep cuts, it will be stable; however, under prolonged exposure, localized sheet collapse will occur, particularly in the zone where the wet sand layers are prevalent.
- A fair pavement-supportive material, with an estimated CBR value of 8%.
- Moderately low corrosivity to buried metal, with an estimated electrical resistivity of 5000 ohm·cm.

4.5 **Sands** (All Boreholes)

The sand deposit was encountered below the surficial disturbed soil a layer of earth fill and sample examinations show that it is non-cohesive, consisting of fine to coarse sand particles, gravelly in places, and with some silt to being silty. The laminated structure shows the deposit was derived from a lacustrine environment.

The obtained ‘N’ values range from 7 to 60, with a median of 28 blows per 30 cm of penetration. This shows the relative density of the sand is loose to very dense, being generally compact.

The natural water content was determined and the results are plotted on the Borehole Logs. The values range from 3% to 21%, with a median of 5%; show that the sand deposit is in a damp to wet condition. The wet samples are water bearing and displayed appreciable dilatancy when shaken by hand.

A grain size analysis was performed on one of the sand samples and the result is plotted on Figure 9.

Accordingly, the following engineering properties are deduced:

- The sand with high silt content is highly frost susceptible with high soil-adfreezing potential.
- Highly water erodible.
- Pervious, with an estimated coefficient of permeability of 10^{-3} cm/sec, an estimated percolation rate of 10 min/cm, and runoff coefficients of:

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

- A frictional soil, its shear strength is derived from internal friction and is density dependent. Due to its dilatancy, the shear strength of the wet sand 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 relatively steep cuts, the sand will be stable in a damp to moist condition, but will slough if it is wet and run with water seepage. The bottom will boil under a piezometric head of 0.3 m.
- A fair material to support pavement, with an estimated CBR value of at least 8%.
- Moderately low corrosivity to buried metal, with an estimated electrical resistivity of 5000 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 +**
Sandy Silt	21	12	8 to 16
Silty Sand Till	9 to 14 (median 10)	11	7 to 16
Sands	3 to 21 (median 5)	10	5 to 15

Based on the above findings, a majority of the in situ soils are generally suitable for a 95% or + Standard Proctor compaction. However, the sandy silt and portions of the sands are too wet or on the wet side of the optimum. The wet soils will require prior aeration in dry, warm weather or mixing with drier inorganic soils for proper compaction.

The silty sand till should be compacted using a heavy-weight, kneading-type roller. The silt and sands can be compacted by a smooth 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.

When compacting the dense silty sand till on the dry side of the optimum, the compactive energy will frequently bridge over the chunks in the soil and be transmitted laterally into the soil mantle. Therefore, the lifts of this soil 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 pavement subgrade be carried out on the wet side of the optimum. This would allow a wider latitude of lift thickness.

One should be aware that with considerable effort, a 90%± Standard Proctor compaction of the wet silt and sands 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.

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 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 adequate subgrade strength for the project construction.

The presence of boulders in the till 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

Groundwater was detected at a depth of 5.5 m below the ground surface at Boreholes 4 and 5; all other boreholes remained dry upon completion of field work. The measured groundwater level is considered to represent the groundwater conditions at the site at the time of investigation. The groundwater level will fluctuate with the seasons.

The yield of groundwater from the silty sand till, due to its relatively low permeability, is expected to be slow to moderate and limited. The yield of groundwater, if encountered, from the sandy silt and sands will likely be moderate to appreciable and may be persistent.

6.0 DISCUSSION AND RECOMMENDATIONS

The investigation has disclosed that beneath a veneer of topsoil and a layer of disturbed/weathered soil, the site is underlain by strata of loose sandy silt, compact to dense, generally compact silty sand till and loose to very dense, generally compact sands.

Groundwater was detected at a depth of 5.5 m below the ground surface at Boreholes 4 and 5; all other boreholes remained dry upon completion of field work. The measured groundwater level is considered to represent the groundwater conditions at the site at the time of investigation. The groundwater level will fluctuate with the seasons.

The geotechnical findings which warrant special consideration are presented below:

1. The topsoil must be stripped for the project construction. This material is unsuitable for structural applications, and should only be placed in the landscaped areas. The topsoil should not be buried beneath the building envelope or deeper than 1.2 m below the finished grade.
2. The disturbed/weathered soil is not suitable for engineering applications. For structural use, it should be subexcavated, inspected, assessed, sorted free of organic matter and any deleterious materials, and properly compacted.
3. The natural soils are suitable for normal spread and strip footing construction. Due to the presence of topsoil and weathered soil, 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 slab-on-grade construction, any soft or loose soils should be subexcavated, aerated and properly compacted prior to the placement of the slab. 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. 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.
5. A Class ‘B’ bedding, consisting of compacted 20-mm Crusher-Run Limestone, is recommended for the construction of the underground services. Where water-bearing silt and sands occur, the sewer joints should be leak-proof, or wrapped with an appropriate waterproof membrane, to prevent subgrade migration. Where extensive dewatering is required, a Class ‘A’ bedding can be considered.
6. Some of the revealed soils are highly frost susceptible with high soil-adfreezing potential. Where they are used to backfill against foundation walls, special measures must be incorporated into the building construction to prevent serious damage due to soil adfreezing.
7. The till contains occasional boulders and cobbles. Boulders over 15 cm in size must not be used for structural backfill and/or construction of engineered fill. Excavation into the till containing boulders will require extra effort and the use of a heavy-duty backhoe.

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 **Foundations**

As a general guide for the design of house foundations, the recommended soil pressures and suitable founding levels, based on the borehole findings, are presented in Table 2.

Table 2 - Founding Levels

BH No.	Recommended Maximum Allowable Soil Pressure (SLS)/ Factored Ultimate Soil Bearing Pressure (ULS) and Suitable Founding Level					
	75 kPa (SLS) 120 kPa (ULS)		100 kPa (SLS) 160 kPa (ULS)		200 kPa (SLS) 320 kPa (ULS)	
	Depth (m)	El. (m)	Depth (m)	El. (m)	Depth (m)	El. (m)
1	-	-	-	-	1.6 or +	140.0 or -
2	-	-	1.0 or +	140.5 or -	4.6 or +	136.9 or -
3	-	-	1.0 or +	138.7 or -	4.6 or +	135.1 or -
4	-	-	1.0 or +	138.1 or -	4.6 or +	134.5 or -
5	1.0 or +	138.3 or -	-	-	4.6 or +	134.7 or -

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

Foundations exposed to weathering or in unheated areas should be protected against frost action by a minimum of 1.2 m of earth cover, or must be properly insulated.

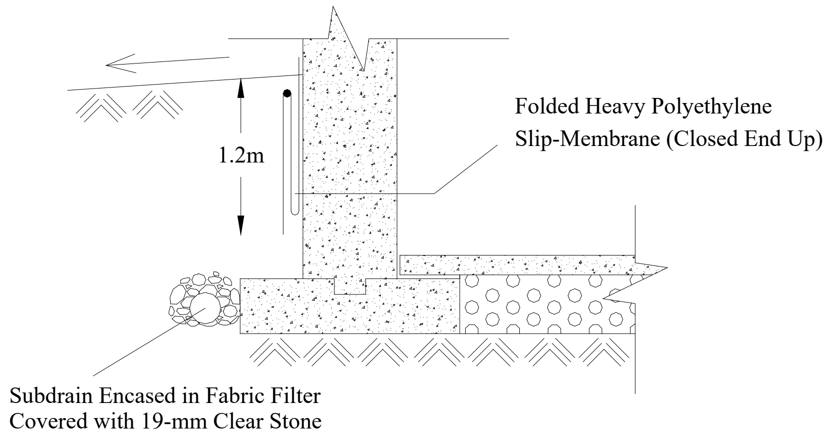
The footing subgrade should be inspected by a geotechnical engineer, or a geotechnical technician under the supervision of a geotechnical engineer, to ensure that the revealed conditions are compatible with the foundation design requirements.

Perimeter subdrains and dampproofing of the basement walls will be required. All the subdrains must be encased in a fabric filter to protect them against blockage by silting, and they must be connected to a positive outlet.

The foundations must meet the requirements specified by the latest Ontario Building Code, and the buildings must be designed to resist a minimum earthquake force using Site Classification ‘D’ (stiff soil).

Some of the occurring soils are high in frost heave and soil-adfreezing potential. If these soils are to be used for the foundation backfill, the foundation walls should be shielded by a polyethylene slip-membrane for protection against soil adfreezing. The recommended measures are schematically illustrated in Diagram 1.

Diagram 1 - Frost Protection Measures (Foundations)



The necessity to implement the above recommendations should be further assessed by a geotechnical engineer at the time of construction.

6.2 Engineered Fill

Where earth fill is required to raise the site, the engineering requirements for a certifiable fill for road construction, municipal services, slab-on-grade, and footings designed with a Maximum Allowable Soil Pressure (SLS) of 100 kPa and a Factored Ultimate Soil Bearing Pressure (ULS) of 160 kPa for normal footings are presented below:

1. The topsoil must be removed. The badly weathered soils must be inspected and proof-rolled prior to any fill placement, in order to assess any subexcavation requirements. The stripped surface must be surface compacted. The wet silt and sands, if any, should be stabilized by gravel prior to surface compaction.
2. Inorganic soils must be used, and they must be uniformly compacted in lifts 20 cm thick to 98% or + of their maximum Standard Proctor dry density up to the proposed finished grade. The soil moisture must be properly controlled near the optimum. If the house 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 the engineered fill is compacted with the moisture content on the wet side of the optimum, the underground services and pavement construction should not begin until the pore pressure within the fill mantle has completely dissipated. This must be further assessed at the time of the engineered fill construction.

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. 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.
6. 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 by two 15-mm steel reinforcing bars in the footings and upper section of the foundation walls, or be designed by a structural engineer, to properly distribute the stress induced by the abrupt differential settlement (about 15 mm) between the natural soil and engineered fill.
7. 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.
8. 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.
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. The fill operation must be inspected on a full-time basis by a technician under the direction of a geotechnical engineer.
11. The footing and underground services subgrade must be inspected by the geotechnical consulting firm that supervised 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.
12. Any excavation carried out in certified engineered fill must be reported to the geotechnical consultant who supervised the fill placement in order to document the locations of excavation and/or to supervise 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.
13. Despite stringent control in the placement of the 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.

6.3 **Slab-On-Grade**

For slab-on-grade construction, the subgrade must consist of sound natural soils, or properly compacted inorganic soils, compacted to at least 98% of its maximum Standard Proctor dry density. 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.

The sound natural soils are suitable for slab-on-grade construction. The weathered soils should be aerated and surface compacted for slab-on-grade construction.

A Modulus of Subgrade Reaction of 25 MPa/m is recommended for the design of the floor slab on sound native soils or on engineered fill.

The ground around the buildings must be graded to direct water away from the structures to minimize the frost heave phenomenon generally associated with the disclosed soils.

6.4 **Underground Services**

The subgrade for the underground services should consist of natural soils or compacted organic-free earth fill. Where topsoil, earth fill and soft soil are encountered, these materials must be subexcavated and replaced with properly compacted bedding material.

A Class ‘B bedding, consisting of compacted 20-mm Crusher-Run Limestone, is recommended for the construction of the underground services. The sewer joints should be leak-proof or wrapped with an appropriate waterproof membrane to prevent subgrade migration. Where extensive dewatering is required, a Class ‘A’ bedding can be considered.

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.

6.5 **Trench Backfilling**

The on-site inorganic soils are suitable for trench backfill and the wet soils must be aerated before backfilling. In the zone within 1.0 m below the pavement subgrade, the backfill should be compacted to at least 98% of its maximum Standard Proctor dry density with the moisture content 2% to 3% drier than the optimum. In the lower zone, a 95% or + Standard Proctor compaction is considered to be adequate; however, the material should be compacted on the wet side of the optimum.

In normal underground services construction practice, the problem areas of road settlement largely occur adjacent to manholes, catch basins, services crossings, foundation walls and columns, and it is recommended that a sand backfill be used. The areas at the interface of the native soil and the sand backfill should preferably be flooded for several days.

The narrow trenches 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 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 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 deep 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 Pavement Design

Based on the borehole findings, the recommended pavement design for local roads is presented in Table 3.

Table 3 - 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	300	Granular ‘B’ or equivalent

In preparation of the subgrade, the subgrade surface should be proof-rolled; any soft subgrade, organics and deleterious materials within 1.0 m below the underside of the granular sub-base should be subexcavated and replaced by properly compacted organic-free earth fill or granular material.

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

In the zone within 1.0 m below the pavement 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.

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

- If the 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 roads should be properly graded to prevent the ponding of large amounts of water during the interim construction period.
- Curb subdrains will be required. The subdrains should consist of filter-sleeved weepers to prevent blockage by silting.
- If the roads are to be constructed during the wet seasons and extensively soft subgrade occurs, the granular sub-base may require thickening. This can be assessed during construction.

6.7 Soil Parameters

The recommended soil parameters for the project design are given in Table 4.

Table 4 - Soil Parameters

Unit Weight and Bulk Factor

	Unit Weight (kN/m^3)	**Estimated Bulk Factor**	
	Bulk	**Loose**	**Compacted**
Weathered Soil	20.5	1.20	0.95
Sound Till	22.0	1.33	1.03
Silt and Sands	20.5	1.20	0.98

Table 4 - Soil Parameters (cont'd)

Lateral Earth Pressure Coefficients	**Active** **K_a**	**At Rest** **K_o**	**Passive** **K_p**
Sound Till	0.30	0.40	3.33
Silt and Sands	0.33	0.43	3.00

6.8 Excavation

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

Excavation into the till containing boulders will require extra effort and the use of a heavy-duty, properly equipped backhoe.

For excavation purposes, the types of soils are classified in Table 5.

Table 5 - Classification of Soils for Excavation

Material	**Type**
Sound Till	2
Silt and Sands above groundwater	3
Silt and Sands below groundwater	4

The groundwater yield from the silty sand till, due to its relatively low permeability, will be small to moderate and limited and can be controlled by pumping from sumps. The yield of groundwater, if encountered in the silt and sands is expected to be moderate to appreciable and may be persistent, and the groundwater may be controllable by pumping from closely spaced sumps or, if necessary, by the use of a well-point dewatering system. The appropriate method of dewatering should be assessed by a hydrogeological study.

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 Highglen Homes Limited, 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 Frank Lee, P. Eng. and Bernard Lee, 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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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

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JOB NO.: 1911-S057

LOG OF BOREHOLE NO.: 1

FIGURE NO.: 1

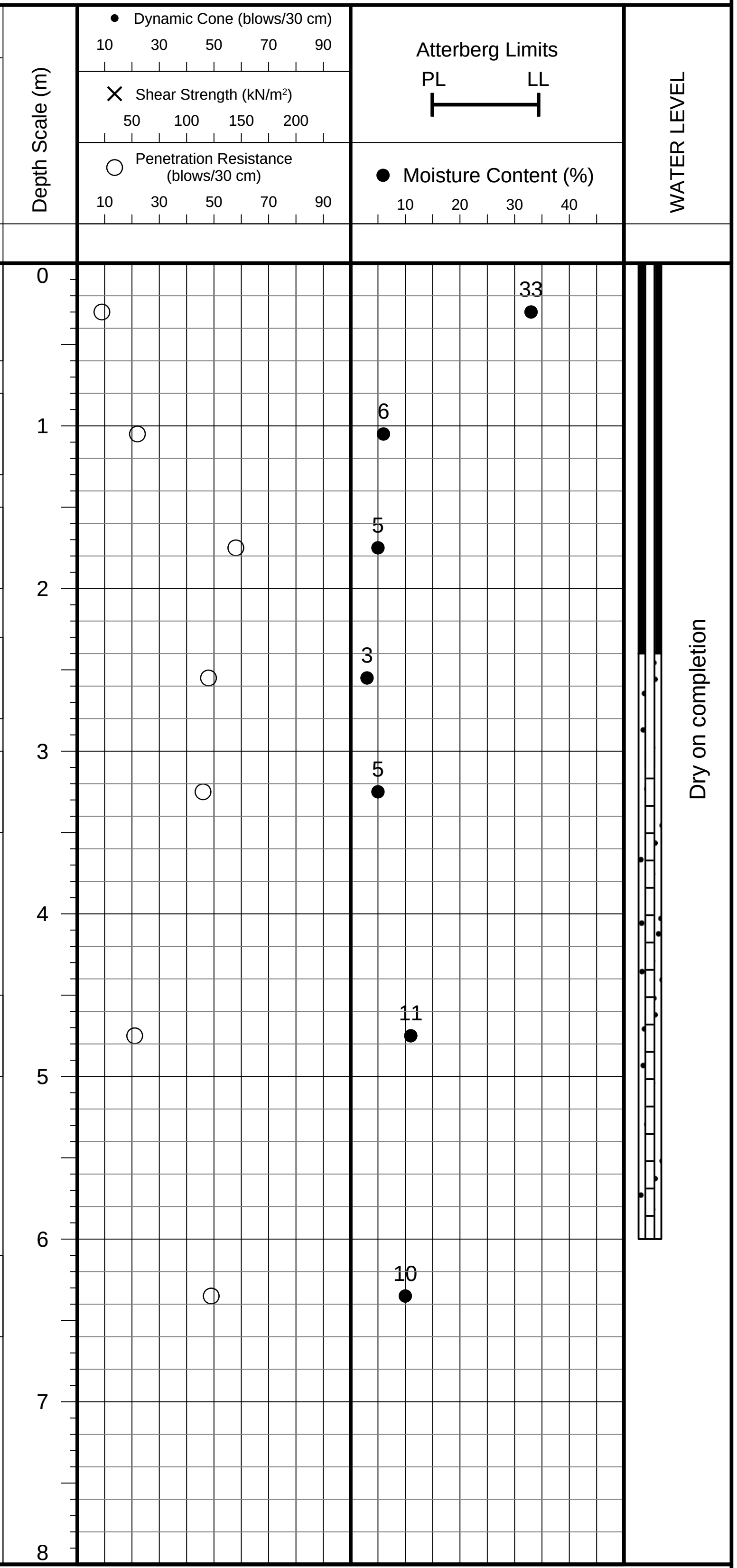
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight-Auger

PROJECT LOCATION: 230 Finch Avenue
(Part 4, Plan #40 R-29767)
City of Pickering

DRILLING DATE: December 12, 2019

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
141.6	Ground Surface			
0.0	**30 cm TOPSOIL**	1	DO	9
	Brown **DISTURBED/WEATHERED SOIL** sand with gravel and rock fragments	2	DO	22
140.2 1.4	Brown, dense to very dense **GRAVELLY SAND**	3 4	DO DO	58 48
138.7 2.9	Brown, dense **MEDIUM TO COARSE SAND** some silt	5	DO	46
137.6 4.0	Grey, compact to dense **SILTY SAND TILL** occ. wet sand and silt seams and layers cobbles and boulders	6 7	DO DO	21 49
135.0 6.6	**END OF BOREHOLE** Installed 50 mm Ø monitoring well to 6.0 m sand backfill from 2.4 to 6 m Bentonite from 0 to 2.4 m provided with a steel protective casing			



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JOB NO.: 1911-S057

LOG OF BOREHOLE NO.: 2

FIGURE NO.: 2

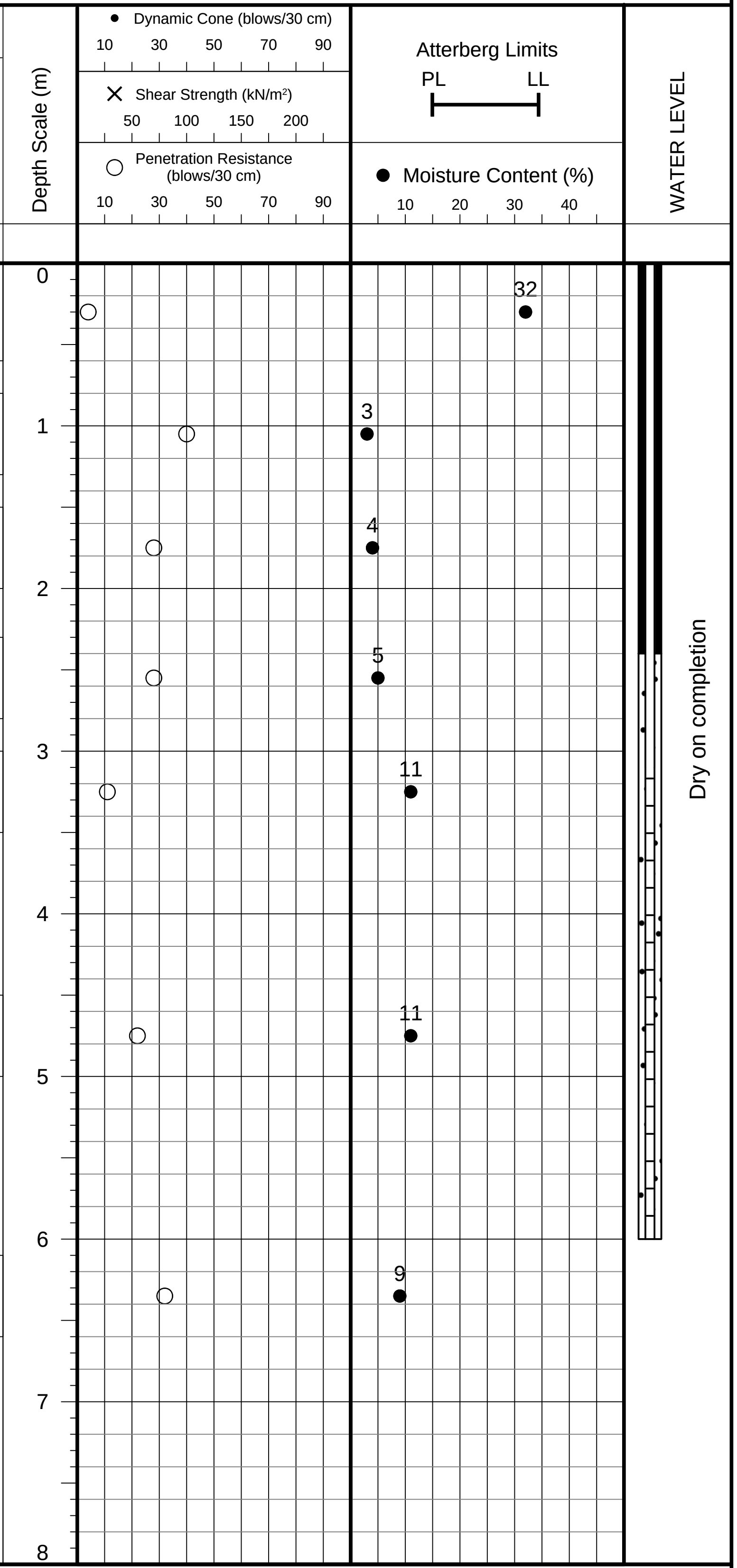
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight-Auger

PROJECT LOCATION: 230 Finch Avenue
(Part 4, Plan #40 R-29767)
City of Pickering

DRILLING DATE: December 12, 2019

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value
141.5	Ground Surface			
0.0	**36 cm TOPSOIL**	1	DO	4
	Brown **DISTURBED/WEATHERED SOIL** sand with gravel and cobbles			
140.8 0.7	Brown, compact to dense **GRAVELLY SAND**	2	DO	40
		3	DO	28
139.4 2.1	Brown, compact **FINE TO COARSE SAND** some silt	4	DO	28
138.6 2.9	Compact to dense **SILTY SAND TILL** occ. wet sand and silt seams and layers cobbles and boulders — brown / grey	5	DO	11
		6	DO	22
		7	DO	32
134.9 6.6	**END OF BOREHOLE** Installed 50 mm Ø monitoring well to 6.0 m sand backfill from 2.4 to 6 m Bentonite from 0 to 2.4 m provided with a steel protective casing			



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Page: 1 of 1

JOB NO.: 1911-S057

LOG OF BOREHOLE NO.: 3

FIGURE NO.: 3

PROJECT DESCRIPTION: Proposed Residential Development

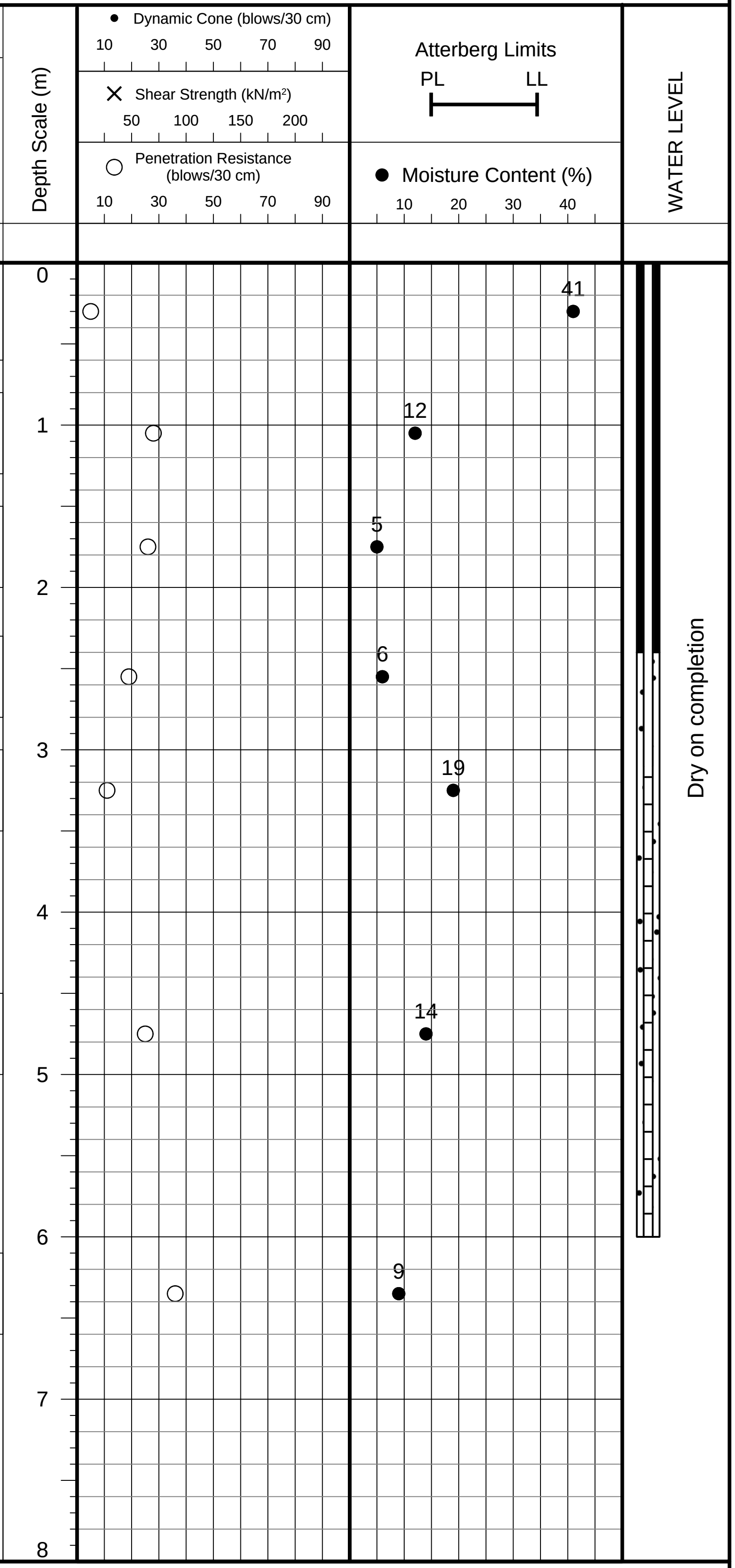
METHOD OF BORING: Flight-Auger

PROJECT LOCATION: 230 Finch Avenue
(Part 4, Plan #40 R-29767)
City of Pickering

DRILLING DATE: December 12, 2019

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value
139.7	Ground Surface			
0.0	**36 cm TOPSOIL**	1	DO	5
	Brown **DISTURBED/WEATHERED SOIL** sand with gravel			
139.0 0.7	Brown, compact **FINE TO COARSE SAND** some silt	2	DO	28
		3	DO	26
		4	DO	19
136.8 2.9	Brown, compact **SILTY FINE SAND**	5	DO	11
135.7 4.0	Compact to dense **SILTY SAND TILL** occ. wet sand and silt seams and layers cobbles and boulders	6	DO	25
	brown grey	7	DO	36
133.1 6.6	**END OF BOREHOLE**			

Installed 50 mm Ø monitoring well
to 6.0 m sand backfill from 2.4 to 6 m
Bentonite from 0 to 2.4 m
provided with a steel protective casing



JOB NO.: 1911-S057

LOG OF BOREHOLE NO.: 4

FIGURE NO.: 4

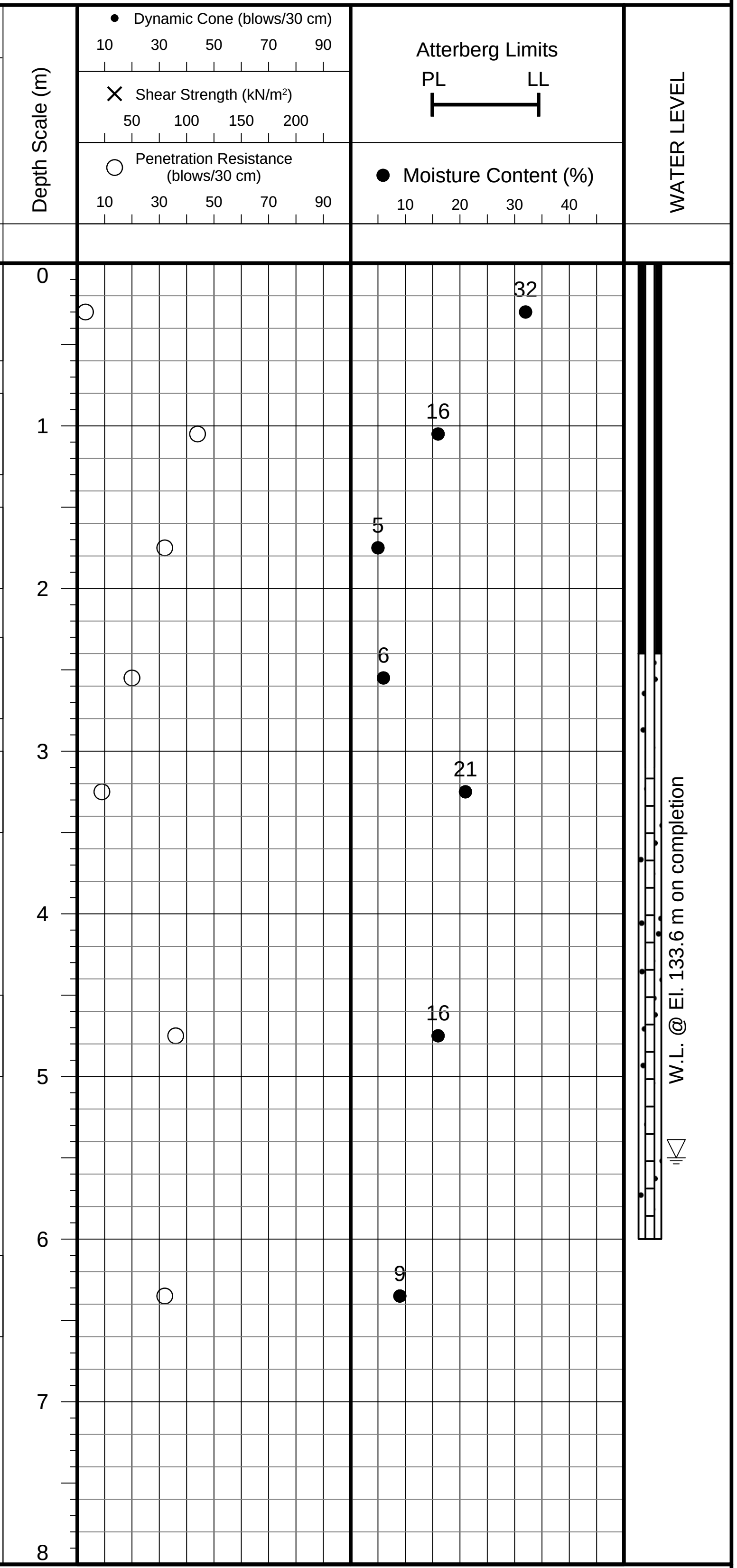
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight-Auger

PROJECT LOCATION: 230 Finch Avenue
(Part 4, Plan #40 R-29767)
City of Pickering

DRILLING DATE: December 12, 2019

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
139.1	Ground Surface			
0.0	**30 cm TOPSOIL** Brown **DISTURBED/WEATHERED SOIL** sand a trace of gravel	1	DO	3
138.4 0.7	Brown, compact to dense **FINE TO COARSE SAND** some silt	2	DO	44
		3	DO	32
		4	DO	20
136.2 2.9	Brown, loose **SILTY FINE SAND**	5	DO	9
135.1 4.0	Grey, dense **GRAVELLY SAND**	6	DO	36
133.6 5.5	Grey, dense **SILTY SAND TILL**	7	DO	32
132.5 6.6	**END OF BOREHOLE** Installed 50 mm Ø monitoring well to 6.0 m sand backfill from 2.4 to 6 m Bentonite from 0 to 2.4 m provided with a steel protective casing			



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JOB NO.: 1911-S057

LOG OF BOREHOLE NO.: 5

FIGURE NO.: 5

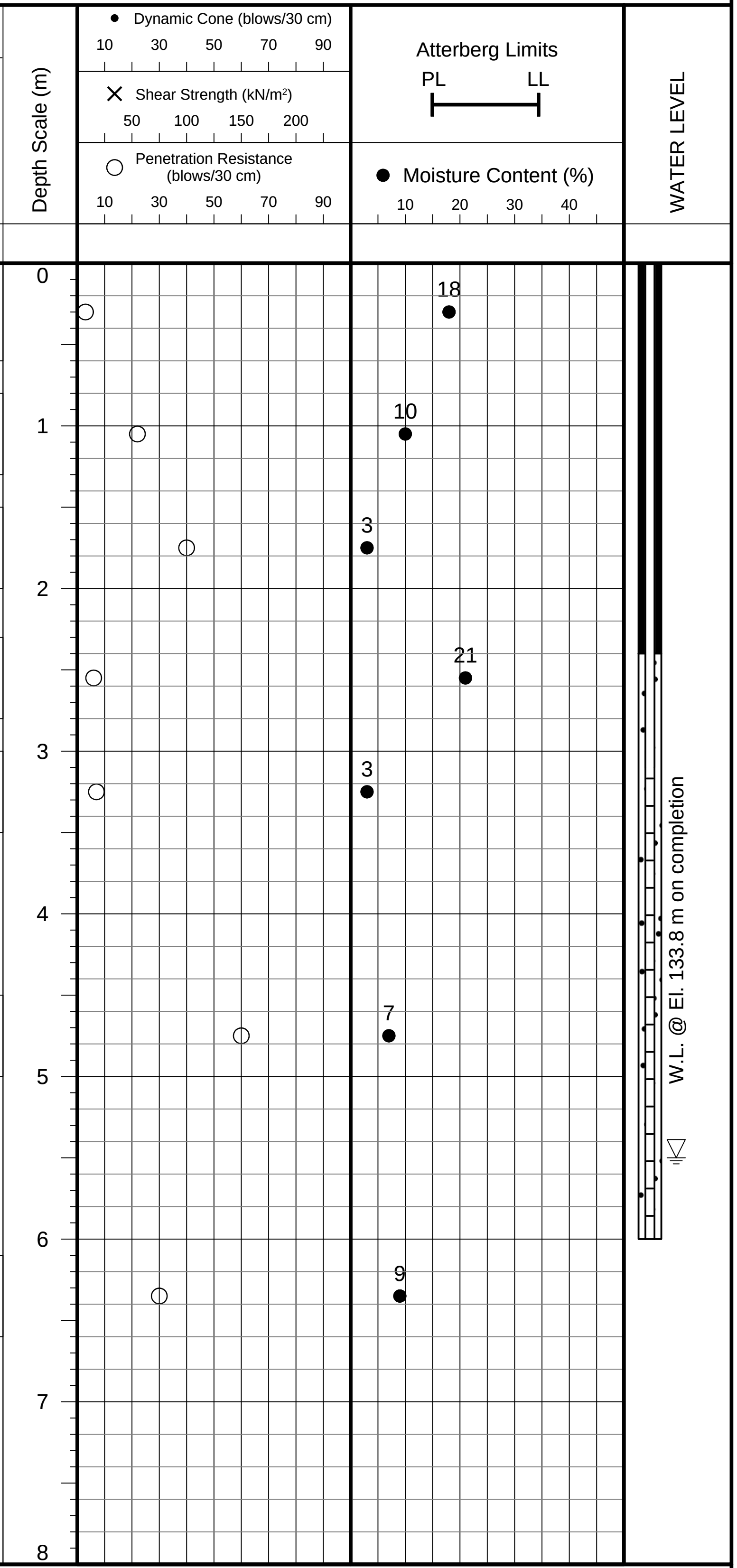
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight-Auger

PROJECT LOCATION: 230 Finch Avenue
(Part 4, Plan #40 R-29767)
City of Pickering

DRILLING DATE: December 12, 2019

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value
139.3	Ground Surface			
0.0	**25 cm TOPSOIL**			
	Brown **DISTURBED/WEATHERED SOIL** sand a trace of gravel	1	DO	3
138.6 0.7	Brown, compact to dense **FINE TO COARSE SAND** some silt	2	DO	22
		3	DO	40
137.2 2.1	Brown, loose **SANDY SILT**	4	DO	6
136.4 2.9	Brown, loose **FINE TO COARSE SAND** some silt	5	DO	7
135.3 4.0	Brown, very dense **GRAVELLY SAND**	6	DO	60
133.8 5.5	Grey, compact **SILTY SAND TILL**	7	DO	30
132.7 6.6	**END OF BOREHOLE** Installed 50 mm Ø monitoring well to 6.0 m sand backfill from 2.4 to 6 m Bentonite from 0 to 2.4 m provided with a steel protective casing			



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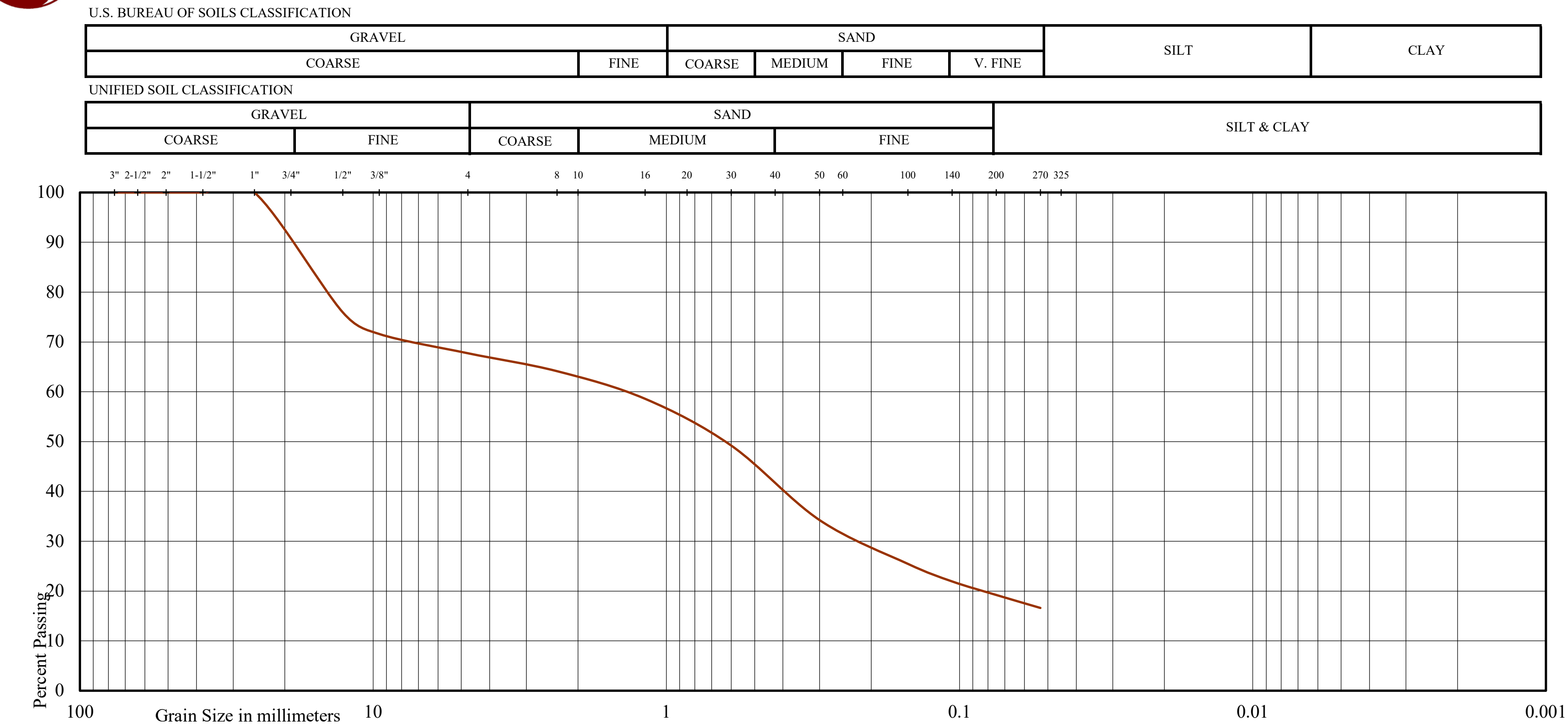
GRAIN SIZE DISTRIBUTION

Reference No: 1911-S057



Project:	Proposed Residential Development		
Location:	230 Finch Avenue (Part 4, Plan #40 R-29767), City of Pickering	Liquid Limit (%) =	-
		Plastic Limit (%) =	-
Borehole No:	1	Plasticity Index (%) =	-
Sample No:	1	Moisture Content (%) =	33
Depth (m):	0.3	Estimated Permeability	
Elevation (m):	141.3	(cm./sec.) =	10^{-3}

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

Figure: 6

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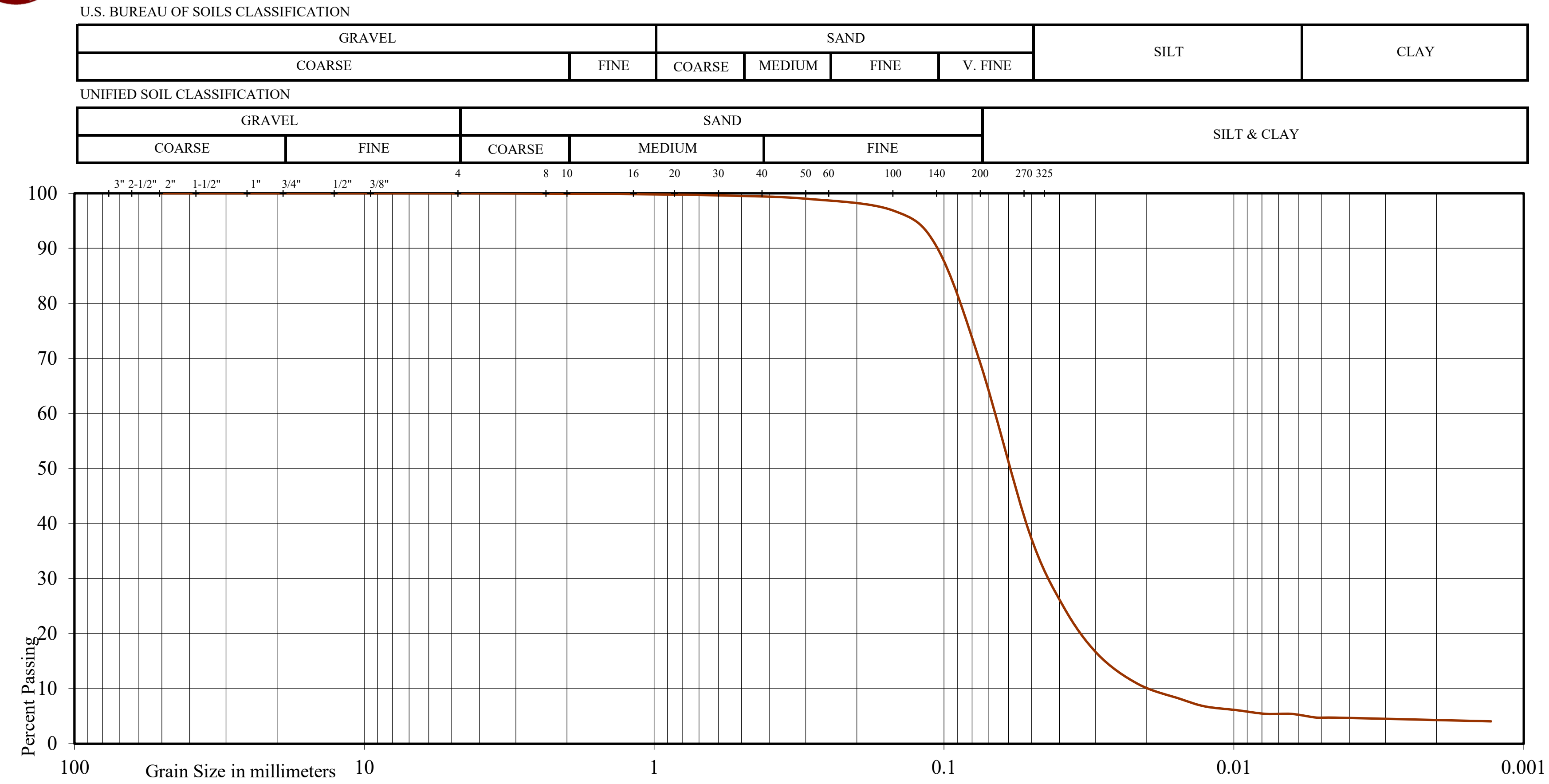
GRAIN SIZE DISTRIBUTION

Reference No: 1911-S057



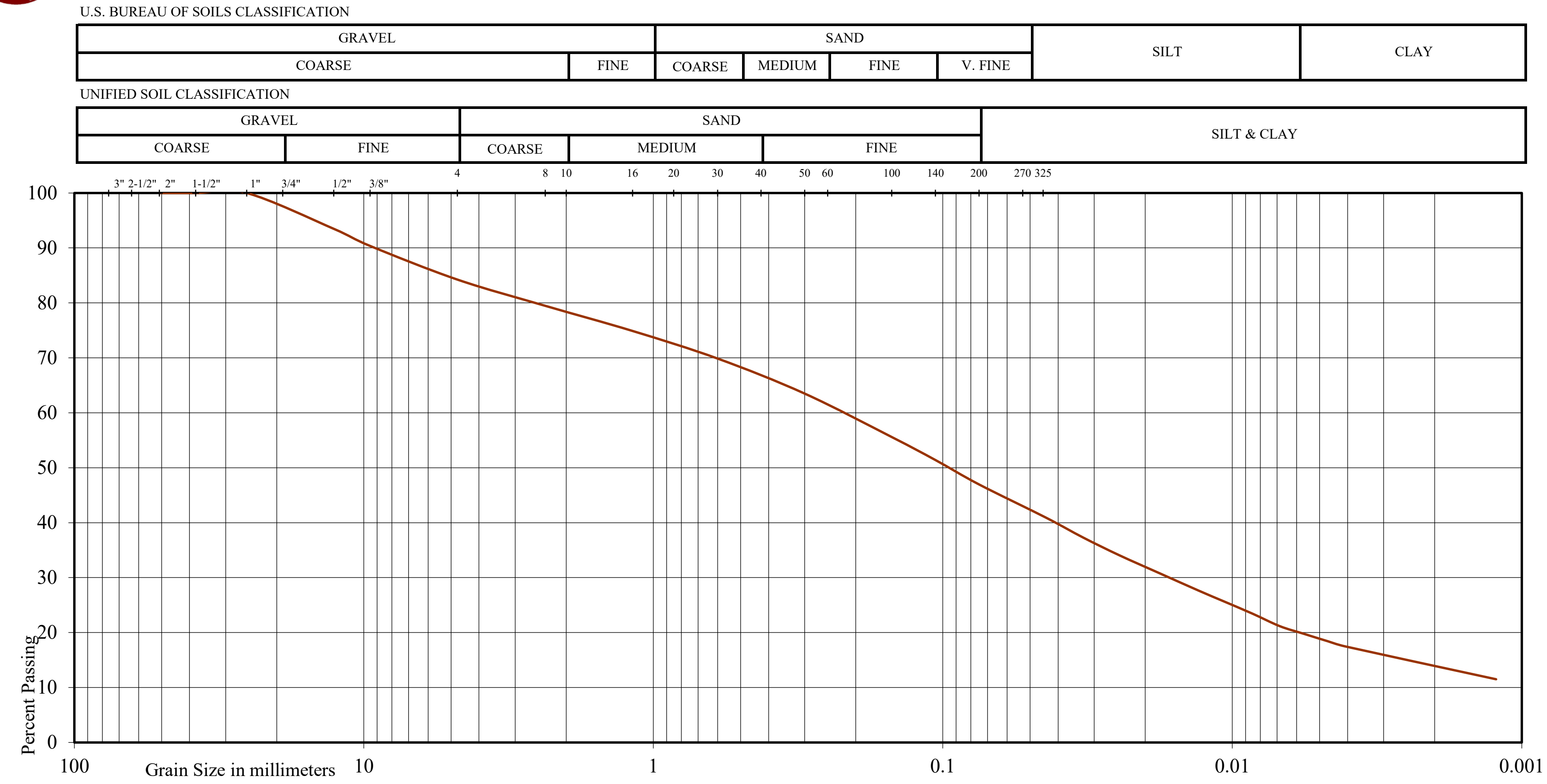
Project:	Proposed Residential Development		
Location:	230 Finch Avenue (Part 4, Plan #40 R-29767), City of Pickering	Liquid Limit (%) =	-
		Plastic Limit (%) =	-
Borehole No:	5	Plasticity Index (%) =	-
Sample No:	4	Moisture Content (%) =	21
Depth (m):	2.5	Estimated Permeability	
Elevation (m):	136.8	(cm./sec.) =	10^{-4}

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

Figure: 7

GRAIN SIZE DISTRIBUTION

Reference No: 1911-S057



Project:	Proposed Residential Development
Location:	230 Finch Avenue (Part 4, Plan #40 R-29767), City of Pickering

Borehole No: 1

Sample No: 7

Depth (m): 6.3

Elevation (m): 135.3

Liquid Limit (%) = -

Plastic Limit (%) = -

Plasticity Index (%) = -

Moisture Content (%) = 10

Estimated Permeability

(cm./sec.) = 10^{-6}

Classification of Sample [& Group Symbol]: SILTY SAND TILL, some clay and gravel

Figure: 8

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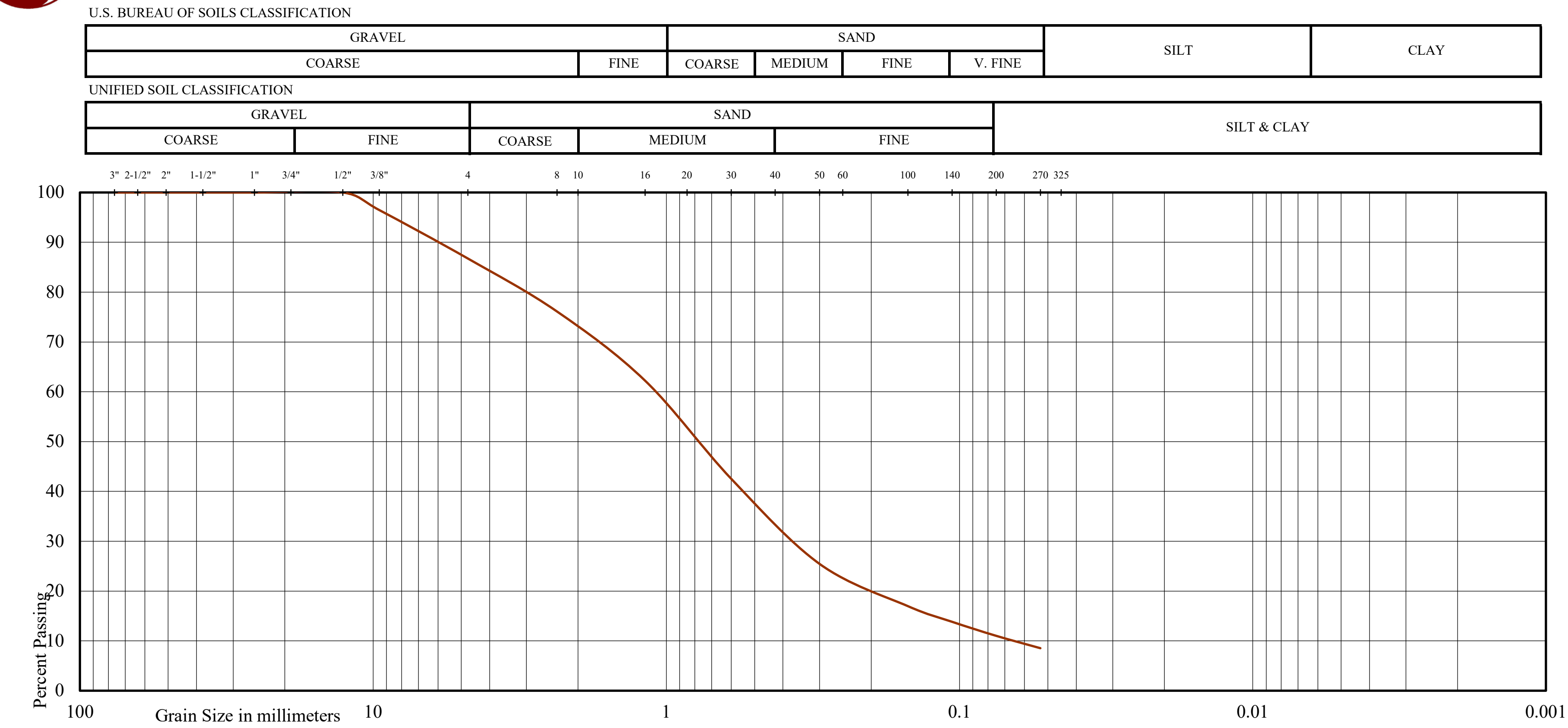
GRAIN SIZE DISTRIBUTION

Reference No: 1911-S057



Project: Proposed Residential Development

Location: 230 Finch Avenue (Part 4, Plan #40 R-29767), City of Pickering

Liquid Limit (%) = -

Plastic Limit (%) = -

Plasticity Index (%) = -

Borehole No: 2

Sample No: 4

Depth (m): 2.5

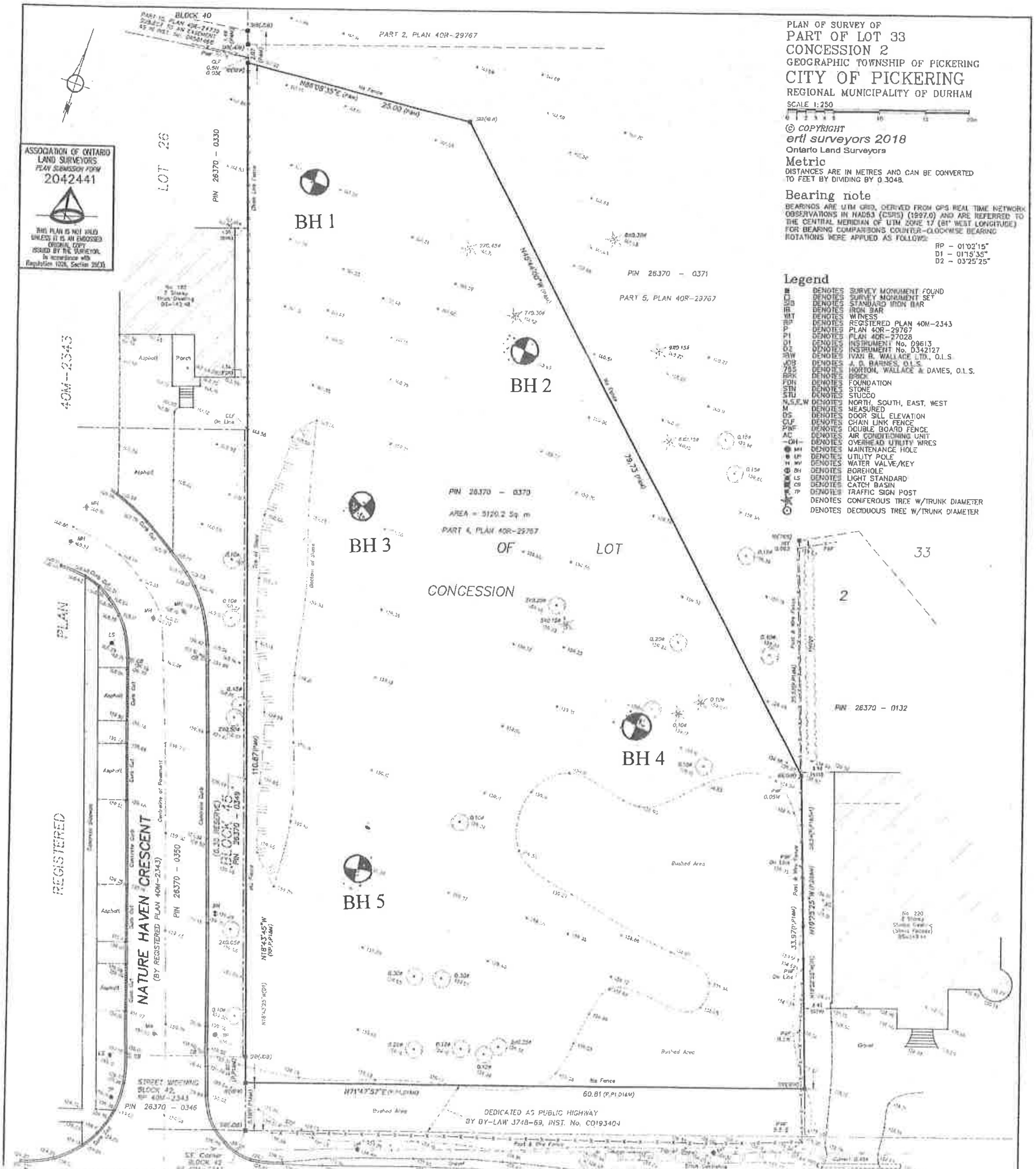
Elevation (m): 139.0

Moisture Content (%) = 5

Estimated Permeability (cm./sec.) = 10^{-2}

Classification of Sample [& Group Symbol]: FINE TO COARSE SAND, some silt and gravel

Figure: 9



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90 West Beaver Creek Road, Richmond Hill, Ontario L4B 1E7 Tel:(416) 754-8515 Fax: (905) 881-8335

BOREHOLE LOCATION PLAN

DESIGNED	CHECKED	DWG NO. 1		REV	
SCALE	As Shown	REF. NO.	1911-S057	DATE	February 2020

or's Certificate
HAT :
VEY AND PLAN ARE CORRECT AND IN ACCORDANCE WITH THE
T, THE SURVEYORS ACT AND THE REGULATIONS MADE UNDER THEM.
VEY WAS COMPLETED ON THE 22nd DAY OF JANUARY, 2018.

23, 2018

Lawrence O. Ertl
Ontario Land Surveyor

ertl surveyors
Ontario Land Surveyors
www.es-ols.com
1234 REID STREET, UNIT 10, RICHMOND HILL L4B 1C1
TELEPHONE (905) 731-7834 FAX (905)731-7852 EMAIL info@es-ols.com
DRAWING : 18011-NatureHaven Finch-T0.DWG PROJECT : 18011
CALC. BY CL. DRAWN BY DH. CHECKED BY CL.

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SUBSURFACE PROFILE
DRAWING NO. 2
SCALE: AS SHOWN

JOB NO.:	1911-S057
REPORT DATE:	February 2020
PROJECT DESCRIPTION:	Proposed Residential Development
PROJECT LOCATION:	230 Finch Avenue (Part 4, Plan #40 R-29767) City of Pickering

LEGEND

- TOPSOIL
- FILL
- SAND
- SILTY SAND
- SILTY SAND TILL
- SANDY SILT
- ∇ WATER LEVEL (END OF DRILLING)