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A REPORT TO
HUNTINGWOOD TRAILS (COLLINGWOOD) LTD.

A GEOTECHNICAL INVESTIGATION FOR PROPOSED RESIDENTIAL DEVELOPMENT

5 SILVER CREEK DRIVE

TOWN OF COLLINGWOOD

REFERENCE NO. 2207-S205

AUGUST 2023
(Revision of Report Dated August 2022)

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1.0 INTRODUCTION

In 2011, a Geotechnical Investigation, consisting of 16 boreholes extending to depths of 0.5 to 4.3 m, was carried out at 5 Silver Creek Drive in the Town of Collingwood for a proposed residential development. In accordance with written authorization dated July 27, 2022, from Mr. Edward Weisz of Huntingwood Trails (Collingwood) Ltd., an update to the report (Reference No. 1104-S041, dated June 2011) was carried out to focus solely on the proposed development at the south-eastern portion of the subject site. The associated Borehole Logs and Grain Size Analyses are attached in the Appendix for reference.

The purpose of this Report is to reveal the subsurface conditions and to determine the engineering properties of the disclosed soils for the design and construction of a residential development.

2.0 SITE AND PROJECT DESCRIPTION

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

The subject property is trapezoidal in shape and is bounded by Highway 26 and Silver Creek Drive to the north and Georgian Trail to the south, with residential developments to the west and east. The property is divided into two halves by a creek in the middle of the property running from south to north. The east half of the property was occupied by wooded areas at the time of investigation whereas the west half was an open field covered with weeds.

Based on the Draft Plan of Subdivision prepared by KLM Planning Partners Inc., the subject development, which is approximately 29.163 hectares in size, consists of forty-eight (48) street townhouse units and fourteen (14) semi-detached units east of Silver Creek and seven (7) single detached units on the west side of Silver Creek.

3.0 FIELD WORK

The fieldwork for Boreholes 8 to 12, extending to depths ranging from 0.8 to 4.3 m, was performed on May 9, 2011, at the locations shown on the Borehole Location Plan, Drawing No. 1. The client has confirmed that no earthworks have been conducted on the subject site since 2011. As such, the subsurface conditions remain the same.

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 non-cohesive 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 recorded by a Geotechnical Technician.

The elevation at each of the borehole locations was interpolated from the topographic map provided by CF Crozier & Associates.

4.0 SUBSURFACE CONDITIONS

Detailed descriptions of the encountered subsurface conditions are presented on the Borehole Logs attached in the Appendix, comprising of Figures 8 to 12, inclusive. The engineering properties of the disclosed soils are discussed herein.

Beneath a layer of topsoil, the site is underlain by silty sand till, silt, fine sand and fine to coarse sand deposits, bedding onto Dolomitic Limestone Bedrock.

4.1 **Topsoil** (All Boreholes)

The revealed topsoil veneer ranged from 15 to 53 cm in thickness. The topsoil 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. The topsoil can only be used for general landscaping and landscape contouring purposes, and must not be buried deeper than 1.2 m below the finished grade or below any structures. A fertility analysis can be carried out to determine the suitability of the topsoil for general planting material.

4.2 **Silty Sand Till** (Borehole 8)

The silty sand till stratum was encountered beneath the topsoil. It consists of a random mixture of soil particle sizes ranging from clay to gravel, with the silt and sand being the predominant fractions. These structures are heterogeneous, indicating that it is a glacial till.

Tactile examinations of the soil samples indicated that the till displayed some cohesion, indicating that the soils contain some clay and gravel. The samples were also found to contain a trace of rock fragments and occasional wet sand seams and layers.

Hard resistance to augering was encountered in places, indicating the presence of cobbles and boulders embedded in the till mantle.

The natural water content values were determined, and the results are plotted on the Borehole Log. The values are 8% and 11%, indicating that the till is in a moist condition.

The obtained 'N' value is 100+ blows per 30 cm of penetration, indicating that the relative density of the sand till is very dense.

Grain size analysis was performed on one (1) representative sample; the results are plotted on Figure 18 in the Appendix.

The engineering properties of the till are listed below:

- Moderate frost susceptibility and moderate water erodibility.
- Low permeability, with an estimated coefficient of permeability of 10^{-6} cm/sec and a percolation time of 50 min/cm.
- A frictional-cohesive soil, its shear strength is density dependent and is augmented by cementation and cohesion.
- The till will be relatively stable in excavation; however, with prolonged exposure, localized sheet collapse will likely occur.
- A fair pavement-supportive material, with an estimated California Bearing Ratio (CBR) value of 8%.
- Moderately low corrosivity to buried metal, with an estimated electrical resistivity of 5000 ohm·cm.

4.3 **Silt** (Boreholes 9 and 10)

The silt was encountered beneath the topsoil, overlying the bedrock at depths of 0.7 and 1.4 m below grade. The silt contains some clay and sand. The sorted structure indicates that it is a glaciolacustrine deposit.

The natural water content of the silt samples was determined to be 14% and 17%, indicating that the silt is in a very moist to wet condition.

The obtained 'N' values are 18 and 100+ blows per 30 cm of penetration, indicating that the relative density of the silt is compact to very dense.

A grain size analysis was performed on one (1) representative sample; the result is plotted on Figure 19 in the Appendix.

Accordingly, the engineering properties of the silt are listed below:

- The silt has high capillarity and water retention capability.
- High frost susceptibility and soil-adfreezing potential.
- High water erodibility; it will migrate through small openings under low to moderate seepage pressure.
- Relatively low permeability, with an estimated coefficient of permeability of 10^{-5} cm/sec and a percolation time of 20 min/cm.
- Its shear strength is derived from internal friction, thus being density dependent.
- 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. It will boil with a piezometric head of 0.4 m.
- A poor pavement-supportive material, with an estimated CBR value of less than 3%.
- Moderately low corrosivity to buried metal, with an estimated electrical resistivity of 5000 ohm·cm.

4.4 **Fine Sand** (Boreholes 11 and 12) and **Fine to Coarse Sand** (Borehole 11)

The sands were encountered beneath the topsoil, overlying the bedrock at depths of 4.1 and 2.1 m below grade. They contain a trace of silt.

The obtained 'N' values of the sands ranged from 3 to 100+, with a median of 13 blows per 30 cm of penetration, showing the relative density of the sands is very loose to very dense, generally being compact.

The loose fine sand occurs in the surficial layers within depths ranging from 1.1 to 1.7± m below the prevailing ground surface, where the sand has been weakened by the weathering process.

The natural water content of the samples was determined and the results are plotted on the Borehole Logs in the Appendix. The natural water values ranged from 6% to 26%, with a median of 18%, indicating that the sands are in a moist to wet, generally wet condition. Sample examinations showed that the sands are generally in a saturated condition.

Grain size analyses were performed on one (1) representative sample each of the fine sand and fine to coarse sand; the results are plotted on Figures 20 and 21 in the Appendix, respectively.

The engineering properties of the sands are listed below:

- Moderately low frost susceptibility with high water erodibility.
- Susceptible to migration through small openings under seepage pressure.
- Pervious, with an estimated coefficient of permeability of 10^{-2} cm/sec and a percolation time of 4 min/cm.
- Frictional soils, their shear strength is dependent on their internal friction angle and soil density.
- In excavation, the wet sands will slough, run with seepage and boil with a piezometric head of 0.3 m.
- Good pavement-supportive materials, with an estimated CBR value of 21%.
- Low corrosivity to buried metal, with an estimated electrical resistivity of 6000 ohm·cm.

4.5 **Dolomitic Limestone Bedrock** (All Boreholes)

Refusal to augering was encountered in all of the boreholes. Based on the general geological information for the region, the depths of refusal are in the (inferred) limestone bedrock. The refusal depth ranges from 0.8 to 4.3 m or at El. 184.5 m in the southwest portion of the site, dropping to El. 180.8 m in the north and east, indicating that the (inferred) bedrock depth varies within the property.

The Black River and Trenton Group bedrock is thin to medium bedded, consisting of limestone slabs. The limestone is highly competent to support a heavily-loaded foundation. It is hard to excavate by mechanical means. Effective removal from rock excavation will require blasting which requires a specialist to devise an appropriate scheme to limit the shock waves of the blasting from damaging nearby structures below or above ground.

Groundwater is often trapped in the crevices of the limestone. It may be under minor artesian pressure, in places. However, the limestone bedrock is considered to be a poor aquifer. The encountered groundwater can be readily controlled by pumping from sumps.

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 +**
Silty Sand Till	8 and 11	10	6 to 15
Silt	14 and 17	13	8 to 17
Sands	6 to 26 (median 18)	10 and 11	5 to 16

Based on the above findings, the silt and till are generally suitable for a 95% or + Standard Proctor compaction. However, a portion of the sands are too wet and will require aeration or mixing with drier soils prior to Standard Proctor compaction. The sands can be aerated by spreading them thinly on the ground in the dry, warm weather. The sands can also be properly stockpiled to drain the excess water.

The till should be compacted using a heavy-weight, kneading-type roller. The sands and silt can be compacted by a smooth roller with or without vibration, depending on the water content of the soils being compacted. The lifts for compaction should be limited to 20 cm, or to a suitable thickness as assessed by test strips performed by the equipment which will be used at the time of construction.

5.0 GROUNDWATER CONDITION

Groundwater seepage encountered during augering was recorded on the field logs. The boreholes were checked for the presence of groundwater and the occurrence of cave-in upon their completion. The data are plotted on the Borehole Logs in the Appendix and summarized in Table 2.

Table 2 - Groundwater and Cave-in Levels Upon Completion

	Borehole	**Soil Colour Changes Brown to Grey**	**Seepage Encountered During Augering**		**Measured Groundwater/Cave-In On Completion**	
BH No.	**Depth (m)**	**Depth (m)**	**Depth (m)**	**Amount**	**Depth (m)**	**El. (m)**
8	1.7	1.7+	0.3	Some	0.5	185.8
9	0.8	0.7	-	-	Dry	-
10	1.6	1.4	-	-	Dry	-
11	4.3	2.1	1.7	Appreciable	1.5*	183.6*
12	2.3	2.1	1.6	Appreciable	1.5/2.1*	181.6/181.0*

*In wet sand, the cave-in level generally represents the groundwater level at the time of investigation.

Groundwater and cave-in levels were encountered at depths ranging from 0.3 to 2.1 m below the prevailing ground surface the boreholes. The remaining boreholes were dry upon completion of the field work.

The colour of the soils changed from brown to grey at depths ranging from 0.7 to 2.1 m, showing the upper layer of some of the soils has oxidized. The encountered groundwater is likely a result of infiltrated precipitation which is trapped in the soils above the (inferred) bedrock and is expected to fluctuate with the seasons.

The yield of groundwater from the till and silt will be small to moderate. The groundwater yield from the sands is expected to be appreciable and persistent. This is generally dependent on the seasonal weather conditions and the continuity and extent of the deposits.

6.0 DISCUSSION AND RECOMMENDATIONS

The investigation has disclosed that beneath a layer of topsoil, approximately 15 to 53 cm in thickness, the site is underlain by deposits of very dense silty sand till, compact to very dense silt, and generally compact sand overlying Dolomitic Limestone Bedrock or inferred bedrock.

Groundwater and cave-in levels were encountered at depths ranging from 0.3 to 2.1 m below the prevailing ground surface in the boreholes. The encountered groundwater is likely a result of infiltrated precipitation trapped in the soils, creating perched groundwater above the (inferred) bedrock, and is expected to fluctuate with the seasons.

The yield of groundwater from the till and silt will be small to moderate. The groundwater yield from the sands is expected to be appreciable and persistent, depending on seasonal weather conditions and the continuity and extent of the deposits.

Based on the Draft Plan of Subdivision, the site will be subdivided into residential lots and will be provided with municipal services and a connecting roadway meeting municipal standards. The geotechnical findings which warrant special consideration are presented below:

1. The revealed topsoil, 15 to 53 cm in thickness, is unsuitable for engineering applications and must be stripped. For the environmental as well as the geotechnical well-being of the future development, it should not be buried over 1.2 m below the proposed finished grade or below any structures. A fertility analysis may be performed to determine the suitability of the topsoil for planting and sodding purposes.
2. The native soils are weathered in the zone extending to depths ranging from 1.1 to 1.7± m below the prevailing ground surface. This condition warrants caution in construction of foundations; therefore, the footing subgrade must be inspected by a geotechnical engineer, or a geotechnical technician under the supervision of a geotechnical engineer, or a building inspector who has geotechnical experience, to assess its suitability for bearing the designed foundations.
3. As noted, the silt is high in soil-adfreezing potential. Special measures must be implemented to minimize the risk of damage of the foundations caused by frost action.
4. For slab-on-grade construction, any weathered or very loose to loose soils should be subexcavated, aerated and properly compacted prior to the placement of the slab. 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 (SPDD).
5. Due to the shallow bedrock condition, it may be more economical to raise the site for the development as compared to extensive rock excavation which will require blasting. Where the site needs to be raised, it is generally economical to place engineered fill for normal footing, sewer and pavement construction.
6. Where in-ground services are to be constructed in saturated sands, the pipe joints must be leak-proof, or the joints should be wrapped with a waterproof membrane. The bedding material for the underground services should consist of 20-mm Crusher-Run

(graded) Limestone. If extensive dewatering is required, it may be necessary to use a concrete Class 'A' bedding for support.

7. For excavation below the groundwater level in the sand deposits, vigorous pumping from closely spaced sump-wells or, if necessary, a well-point dewatering system, may be required. This should be assessed by test pumping prior to project construction.
8. Excavation into the very dense till containing boulders may require extra effort and the use of a heavy-duty backhoe. Boulders larger than 15 cm in size are not suitable for structural backfill. Excavation into the bedrock will require blasting. This should be carried out after a pre-construction survey of the nearby structures and the blasting should be supervised and carried out by a blasting expert.

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

6.1 Foundations

Based on the borehole findings, the footing must be placed below the topsoil onto the sound native soils, engineered fill or bedrock. Maximum Allowable Soil Pressures (SLS) of 150 and 1000 kPa, with Factored Ultimate Soil Bearing Pressures (ULS) of 250 and 2000 kPa, can be used for the design of the normal spread and strip foundations on sound native soil or bedrock, respectively. The corresponding founding levels are given in Table 3.

Table 3 - Founding Levels

	Recommended Maximum Allowable Soil Pressure (SLS)/ Factored Ultimate Soil Bearing Pressure (ULS) and Corresponding Founding Level			
	150 kPa (SLS) 250 kPa (ULS) (On Native Soil)		**1000 kPa (SLS) 2000 kPa (ULS) (On Bedrock)**	
BH No.	**Depth (m)**	**El. (m)**	**Depth (m)**	**El. (m)**
8	0.8	185.5	1.7	184.6
9	-	-	0.8	184.5
10	0.5	185.6	1.6	184.5
11	1.8	183.3	4.3	180.8
12	1.2	181.9	2.3	180.8

As noted, (inferred) bedrock occurs in the investigated areas. Where basements are to be constructed, raising the site grade through the placement of earth fill will be necessary in order to minimize rock excavation and to provide sufficient earth cover to protect the foundations against frost action.

The total and differential settlements of the footings founded on soil are estimated to be 25 mm and 15 mm, respectively, and will be negligible on bedrock.

Foundations exposed to weathering, and in unheated areas, should have at least 1.5 m of earth cover for protection against frost action, or must be properly insulated.

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

Due to the occurrence of shallow groundwater and shallow bedrock, it is recommended that engineered fill should be considered to raise the grade of the site and that the basement level should remain at least 0.5 m above the detected groundwater level. To provide a dry floor, subdrains consisting of filter-wrapped weepers must be installed beneath the floor slabs and connected to a positive outlet. A vapour barrier must be placed in the granular base of the floor above the crown of the subdrain.

As noted, the silt is high in soil-adfreezing potential. Where this soil is used for foundation backfill, the foundations must be properly sealed with polyethylene slip-membrane extending below the frost depth, or properly insulated. The slip-membrane will allow vertical movement of the heaving soil (due to frost) without imposing structural distress on the foundation. Alternatively, a prefabricated drainage board can be installed over the entire wall below grade. The ground must be graded to direct water away from the structure to minimize the frost heave phenomenon generally associated with the disclosed soil.

The building foundations should meet the requirements specified in the latest Ontario Building Code. Structures founded on bedrock should be designed to resist an earthquake force using Site Classification ‘C’ (soft rock). However, structures founded on the native soil or engineered fill should be designed to resist an earthquake force using Site Classification ‘D’ (stiff soil).

Due to the presence of topsoil and weathered soils, the footing subgrade must be inspected by a geotechnical engineer, or a geotechnical technician under the supervision of a geotechnical engineer, or a building inspector who has geotechnical experience, to ensure that the subgrade conditions are compatible with the foundation design requirements.

6.2 Engineered Fill

Due to the occurrence of shallow bedrock, extensive rock excavation can be expected during basement and underground services construction. Therefore, it may be more economical to raise the grade of the site for the development.

Where earth fill is required to raise the site, it is generally economical to place engineered fill for normal footing, sewer and road construction.

The engineering requirements for a certifiable fill for road construction, municipal services, slab-on-grade, and footings designed with a 150 kPa SLS and a 250 kPa ULS are presented below:

1. All of the topsoil must be removed, and the subgrade surface must be inspected and proof-rolled prior to any fill placement. Badly weathered soils must be subexcavated, aerated, sorted free of topsoil inclusions and deleterious materials, if necessary, and properly compacted to at least 98% SPDD.
2. Inorganic soils must be used, and they must be uniformly compacted in lifts 20 cm thick to 98% or + SPDD up to the proposed finished grade and/or slab-on-grade subgrade. The soil moisture must be properly controlled near the optimum. If the building foundations are to be built soon after the fill placement, the densification process for the engineered fill must be increased to 100% SPDD.
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, the hauler is responsible for its environmental quality and must provide a document to certify that it is free of hazardous contaminants.
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 must be precisely documented by qualified surveyors. Foundations partially on engineered fill must be reinforced 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 (estimated to be 15± mm) between the natural soils 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 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.
9. The fill operation must be inspected on a full-time basis by a technician under the direction of a geotechnical engineer.
10. The footing and underground services subgrade must be inspected by the geotechnical consulting firm that inspected the engineered fill placement. This is to ensure that the foundations are placed within the engineered fill envelope, and the integrity of the fill has not been compromised by interim construction, environmental degradation and/or disturbance by the footing excavation.
11. Any excavation carried out in the certified engineered fill must be reported to the geotechnical consultant who inspected the fill placement in order to document the locations of the excavation and/or to inspect reinstatement of the excavated areas to engineered fill status. If construction on the engineered fill does not commence within a period of 2 years from the date of certification, the condition of the engineered fill must be assessed for re-certification.
12. Despite stringent control in the placement of the engineered fill, variations in soil type and density may occur in the engineered fill. Therefore, the strip footings and upper section of the foundation walls constructed on the engineered fill may require continuous reinforcement with steel bars. The required number and size of the reinforcing bars must be assessed by considering the uniformity as well as the thickness of the engineered fill beneath the foundations.
13. In sewer construction, the engineered fill is considered to have the same structural proficiency as a natural inorganic soil.

6.3 **Underground Services**

The subgrade for the underground services should consist of sound native soils or properly compacted inorganic soils. In areas where the subgrade consists of topsoil, badly weathered soils or very loose to loose soils, they should be subexcavated and replaced with bedding material compacted to at least 95% of its Standard Proctor compaction.

Excavation for underground services construction may require removal of the underlying limestone bedrock, which can be effectively removed by blasting. A rock blasting specialist must be consulted so that disturbance to the surrounding areas is minimized. The condition of the existing structures close to the blasting area should be surveyed prior to rock blasting. This is to avoid potential liability as a result of the blasting.

A Class 'B' bedding is recommended for the underground services construction. The bedding material should consist of compacted 20-mm Crusher-Run Limestone, or equivalent.

Where water-bearing sands and silt occur, the sewer joints should be leak-proof, or wrapped with an appropriate waterproof membrane to prevent subgrade migration. If subgrade stabilization is required, the stone immersion technique may be applied. In areas where more extensive dewatering in sands is required for sewer construction, a Class 'A' bedding should be considered.

In order to prevent pipe floatation in a runoff deluged trench, a soil cover with a thickness two times the diameter of the pipe should be in place at all times after completion of the pipe installation.

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

Since the soils have moderately low corrosivity to buried metal, the underground services should be protected against corrosion. For estimation of anode weight requirements, the estimated electrical resistivity of the disclosed soil can be used. This, however, should be confirmed by testing the soil along the sewer alignment at the time of construction. The proposed anode weight requirement must meet the minimum requirement as specified by the Town Standard.

6.4 Backfilling in Trenches and Excavated Areas

The on-site organic-free native soils are suitable for trench backfill. In the zone within 1.0 m below the pavement subgrade and below the slab-on-grade, the backfill should be compacted to at least 98% SPDD with the moisture content 2% to 3% drier than the optimum. In the lower zone, a 95% or + SPDD compaction is considered to be adequate.

The natural water content of the soils, as determined, indicates that the silt and till are generally suitable for a 95% or + Standard Proctor compaction. However, a portion of the sands are too wet and will require aeration or mixing with drier soils prior to Standard Proctor compaction.

In normal underground services and slab-on-grade construction practice, the problem areas of road settlement largely occur adjacent to manholes, catch basins, services crossings, foundation walls and columns. In areas which are inaccessible to a heavy compactor, sand backfill should be used with a smaller vibratory compactor.

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 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 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 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.

6.5 Garages and Driveways

Due to the frost susceptible characteristics of the subgrade soils, one must realize that the ground will heave during the cold weather. The driveways at the entrances to the garages should be backfilled with non-frost-susceptible granular materials, with a recommended frost taper at a slope of 1 vertical:1 horizontal. The garage floor slab and interior garage foundation walls can be insulated with 50-mm Styrofoam, or equivalent.

6.6 Pavement Design

The subgrade generally consists of sand till, silt and sands. Based on the borehole findings, the recommended pavement design for the local residential road is provided in Table 4.

Table 4 - Pavement Design

Course	Thickness (mm)	OPS Specifications
Asphalt Surface	40	HL 3
Asphalt Binder	50	HL 8
Granular Base	150	Granular 'A' or equivalent
Granular Sub-base	300	Granular 'B' or equivalent

In preparation of the subgrade, the subgrade surface should be proof-rolled; any soft subgrade, organics and deleterious materials should be subexcavated and replaced by properly compacted, organic-free earth fill or granular materials.

The earth fill used to raise the grade for pavement construction should be organic-free and be compacted to 95% or + SPDD. All granular bases and sub-bases should be compacted to 100% or + SPDD. In the zone within 1.0 m below the pavement subgrade, the backfill should be compacted to at least 98% SPDD, with the water content 2% to 3% drier than the optimum. In the lower zone, a 95% or + SPDD 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.
- 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 wet seasons, the granular sub-base should be thickened in order to compensate for the inadequate strength of the subgrade

6.7 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/m3)		**Estimated Bulk Factor**	
	Bulk	**Submerged**	**Loose**	**Compacted**
Silty Sand Till	22.0	12.5	1.33	1.05
Silt and Sands	20.0	10.5	1.20	1.00

Lateral Earth Pressure Coefficients

	Active K_a	**At Rest K_o**	**Passive K_p**
Compacted Earth Fill	0.40	0.50	2.50
Silty Sand Till, Silt and Sands	0.33	0.45	3.33

Coefficients of Friction

Between Concrete and sound native Soil	0.35
Between Concrete and Granular Base	0.50

6.8 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
Bedrock	1
Silty Sand Till	2
Weathered/reworked Soils, Silt and Sands above groundwater	3
Water-bearing Silt and Sands	4

The yield of groundwater from the till and silt, will be small to moderate and limited in quantity. The groundwater yield from the sands is expected to be appreciable and persistent, depending on the seasonal weather conditions and the continuity and extent of the sands.

Where excavations are to be carried out in the water-bearing sands, the possibility of flowing sides and bottom boiling dictates that the ground be predrained, either by pumping from closely spaced sump-wells (excavations shallower than 0.3 m below the groundwater) or if necessary by the use of a well-point dewatering system (excavations deeper than 0.3 m into the groundwater). In order to provide a stable subgrade for the services or foundation construction, the groundwater should be depressed to at least 0.5 m below the subgrade. As noted, the groundwater yield from the sand deposits will likely be appreciable and persistent; however, this can be further assessed by test pumping prior to the project construction.

The very dense till contains occasional boulders. Extra effort and a properly equipped backhoe will be required for excavation. Boulders larger than 15 cm in size are not suitable for structural backfill.

Prospective contractors must assess the in situ conditions for excavation by performing test cuts to at least 0.5 m below the intended bottom of excavation. These test pits should remain open for a period of at least 4 hours to assess the trench conditions.

Excavations into bedrock will require blasting. An expert in rock blasting must be consulted to determine the charge and blasting sequences, so that shock waves from blasting will have a minimal impact on the surrounding structures.

A pre-construction survey must be completed for all structures within the potential zone of influence, as assessed by the blasting contractor. The survey will provide a baseline of data for assessing any future claims for damages. The survey at a minimum should include, but not be limited to, photographs, videos and visual inspections.

Vibration monitoring should be carried out during blasting to aid in setting charges and confirm that the vibrations are within tolerances. The results of the vibration monitoring, together with the pre-construction survey, can also be used to evaluate any damage claims which may arise.

7.0 LIMITATIONS OF REPORT

It should be noted that no tests have been carried out to determine whether environmental contaminants are present in the soils. Therefore, this report deals only with a study of the geotechnical aspects of the proposed project.

This report was prepared by Soil Engineers Ltd. for the account of Huntingwood Trails (Collingwood) Ltd., and for review by their designated consultants and government agencies. The material in it reflects the judgement of Cedric Ramos, B.A.Sc., Hui Wing Yang, P.Eng., and Bernard Lee, P.Eng. in light of the information available to them 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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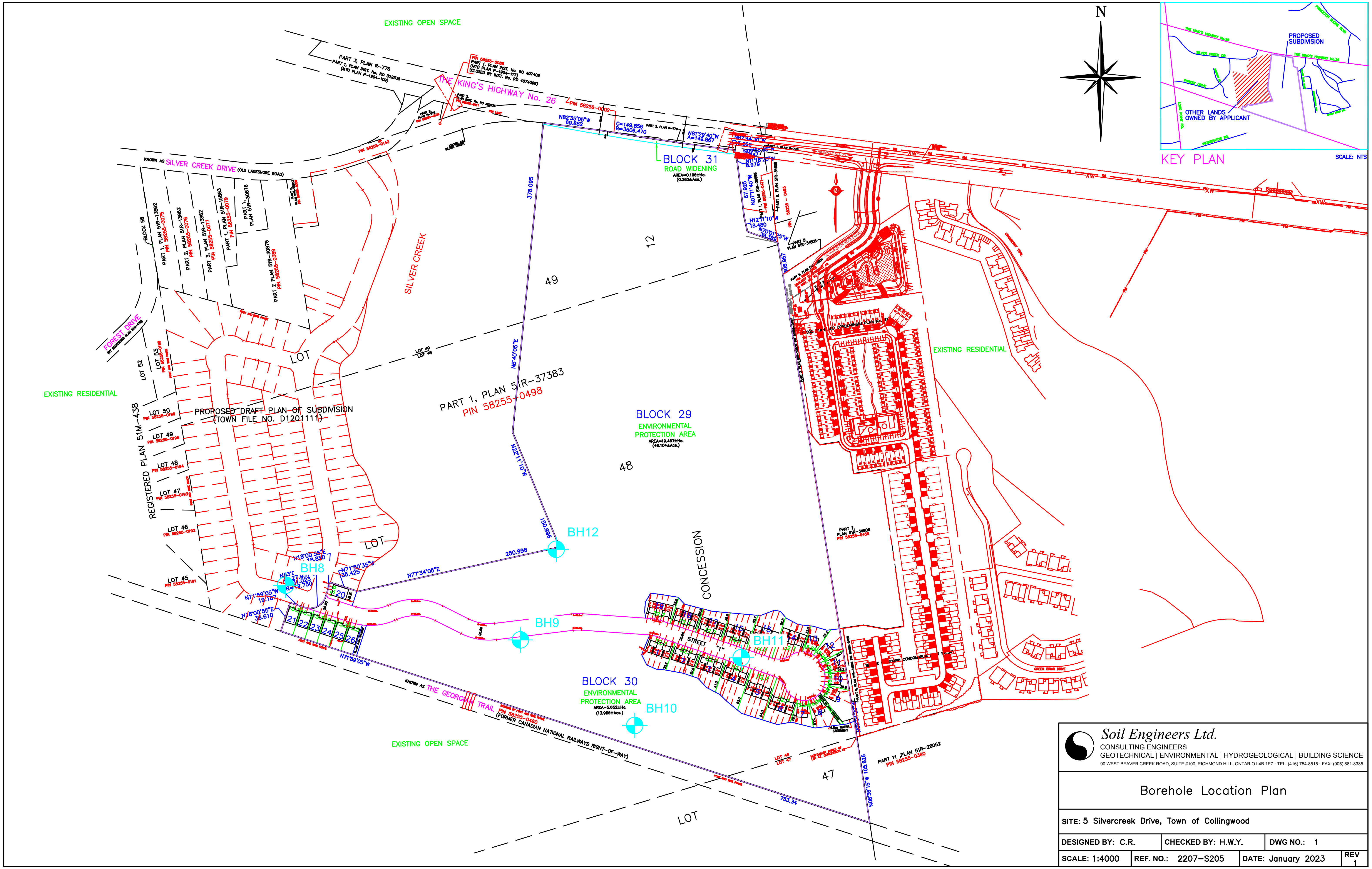

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90 WEST BEAVER CREEK ROAD, SUITE #100, RICHMOND HILL, ONTARIO L4B 1E7 · TEL: (416) 754-8515 · FAX: (905) 881-8335

Borehole Location Plan

SITE: 5 Silvercreek Drive, Town of Collingwood

DESIGNED BY: C.R.
CHECKED BY: H.W.Y.
DWG NO.: 1
SCALE: 1:4000
REF. NO.: 2207–S205
DATE: January 2023
REV 1

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

APPENDIX

1104-S041 BOREHOLE LOGS AND GRAIN SIZES

REFERENCE NO. 2207-S205

JOB NO: 1104-S041

LOG OF BOREHOLE NO: 8

FIGURE NO: 8

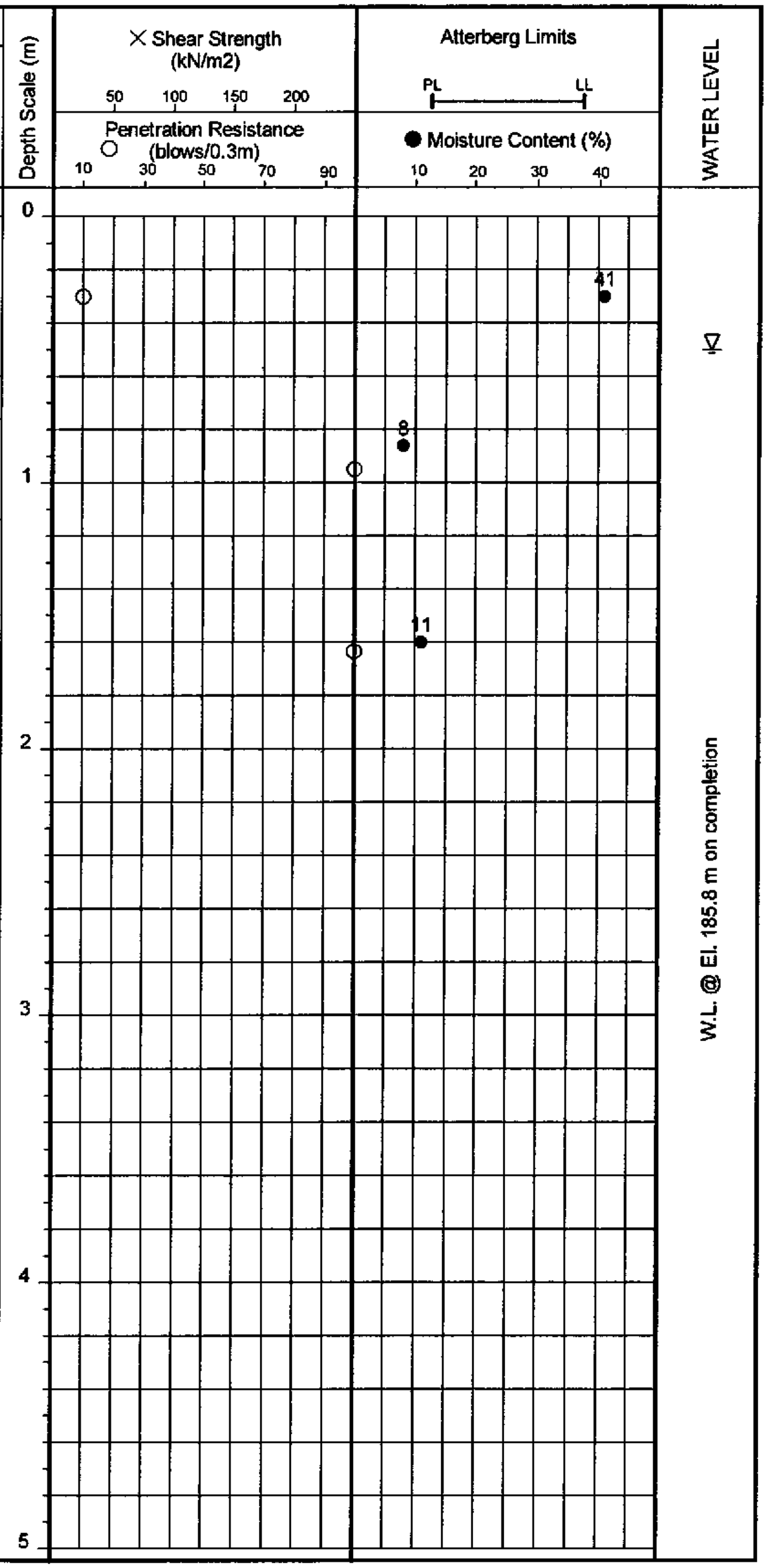
JOB DESCRIPTION: Proposed Residential Development

JOB LOCATION: 5 Silver Creek Drive, Town of Collingwood

METHOD OF BORING: Flight-Auger

DATE: May 9, 2011

Depth Elev. (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value
0.0 186.3	Ground Surface **53 cm TOPSOIL**			
		1	DO	10
	Brown, very dense **SILTY SAND, Till** some clay and some gravel with a trace of bedrock fragments occ. wet sand seams and layers boulder	2	DO	100+
1.7 184.6	**END OF BOREHOLE** Refusal to augering Inferred bedrock	3	DO	100+



W.L. @ El. 185.8 m on completion

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JOB NO: 1104-S041

LOG OF BOREHOLE NO: 9

FIGURE NO: 9

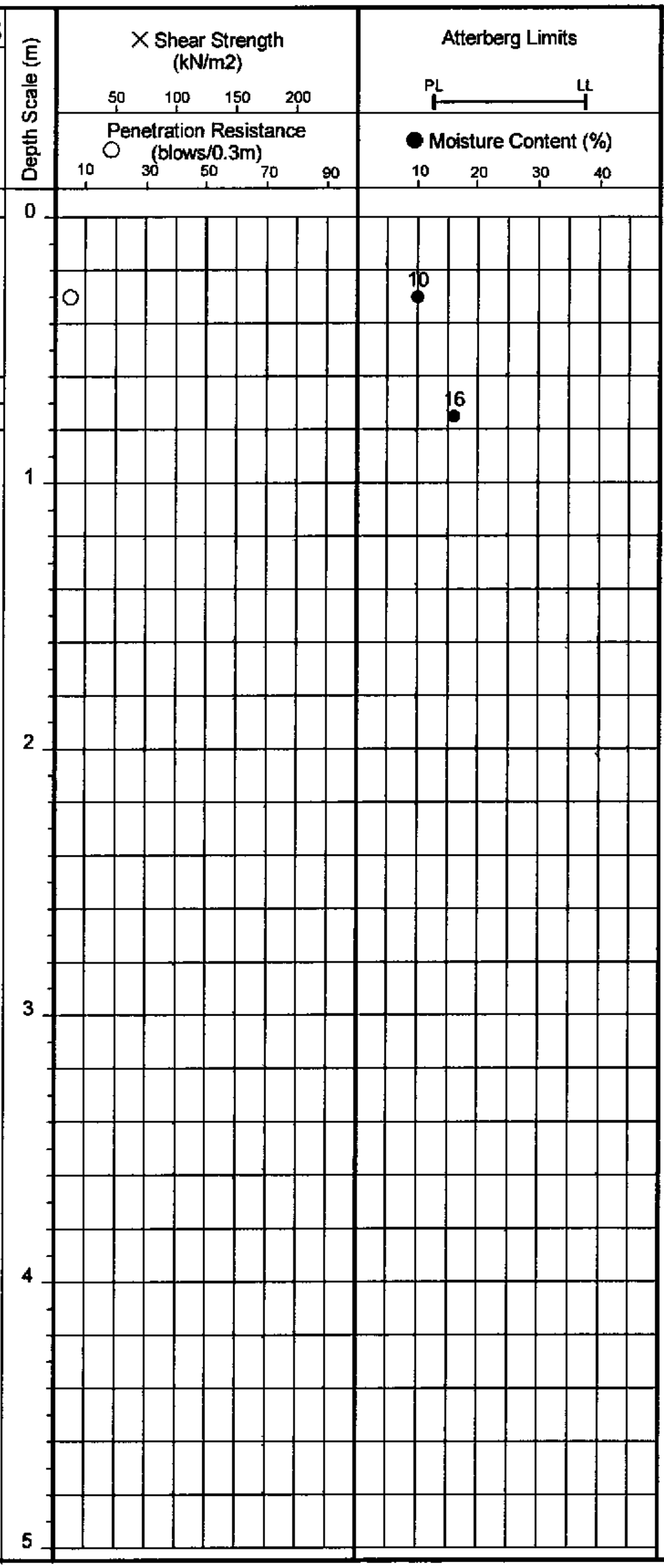
JOB DESCRIPTION: Proposed Residential Development

JOB LOCATION: 5 Silver Creek Drive, Town of Collingwood

METHOD OF BORING: Flight-Auger

DATE: May 9, 2011

Depth Elev. (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	WATER LEVEL
0.0	Ground Surface				
185.3	**41 cm TOPSOIL**	1	DO	5	
	Brown **SILT** some clay				
0.7					
184.6 0.8	Grey, weathered **BEDROCK**	2	AS	-	
184.5	**END OF BOREHOLE** Refusal to augering				
					Dry on completion



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JOB NO: 1104-S041

LOG OF BOREHOLE NO: 10

FIGURE NO: 10

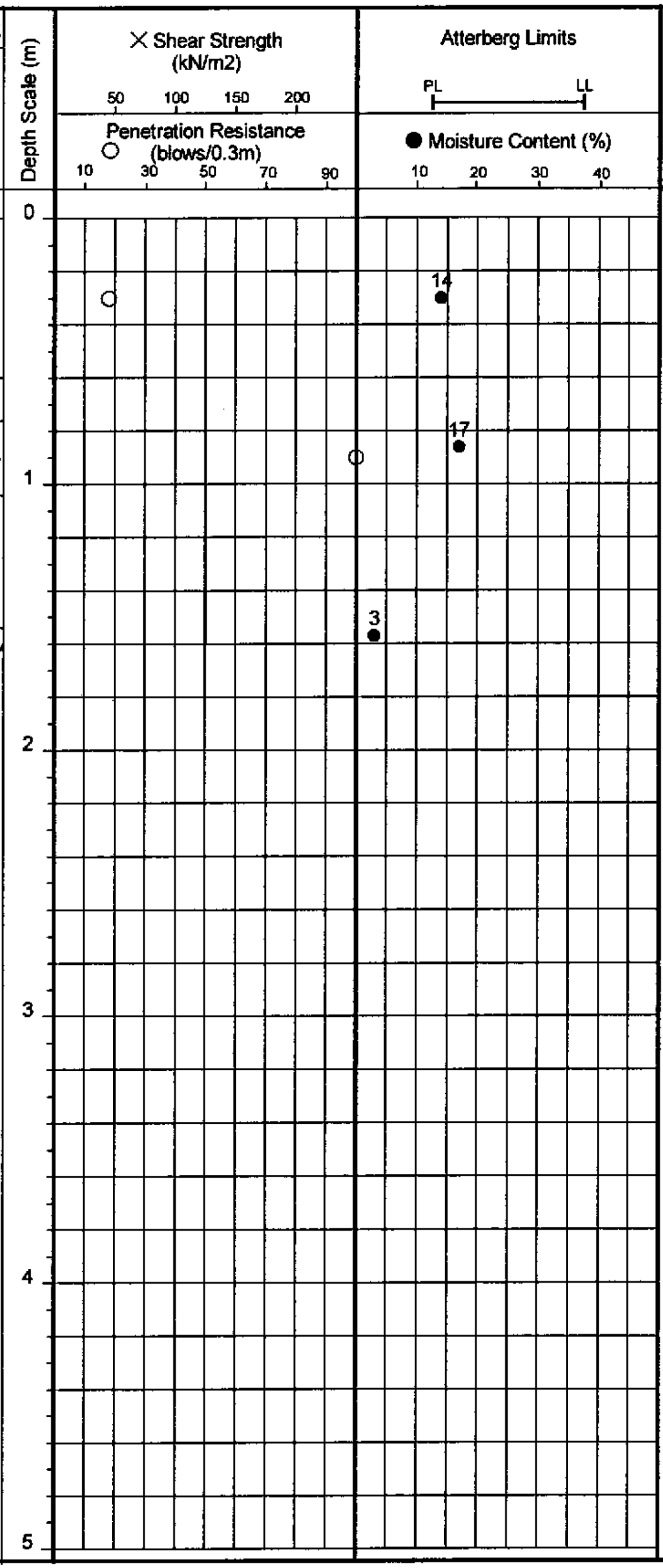
JOB DESCRIPTION: Proposed Residential Development

JOB LOCATION: 5 Silver Creek Drive, Town of Collingwood

METHOD OF BORING: Flight-Auger

DATE: May 9, 2011

Depth Elev. (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	WATER LEVEL
0.0 186.1	Ground Surface **15 cm TOPSOIL**				
	Brown, compact to very dense **SILT** some sand and clay	1	DO	18	
		2	DO	100+	
1.4 184.7	Grey, weathered **BEDROCK**	3	AS	-	
1.6 184.5	**END OF BOREHOLE** Refusal to augering				Dry on completion



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JOB NO: 1104-S041

LOG OF BOREHOLE NO: 11

FIGURE NO: 11

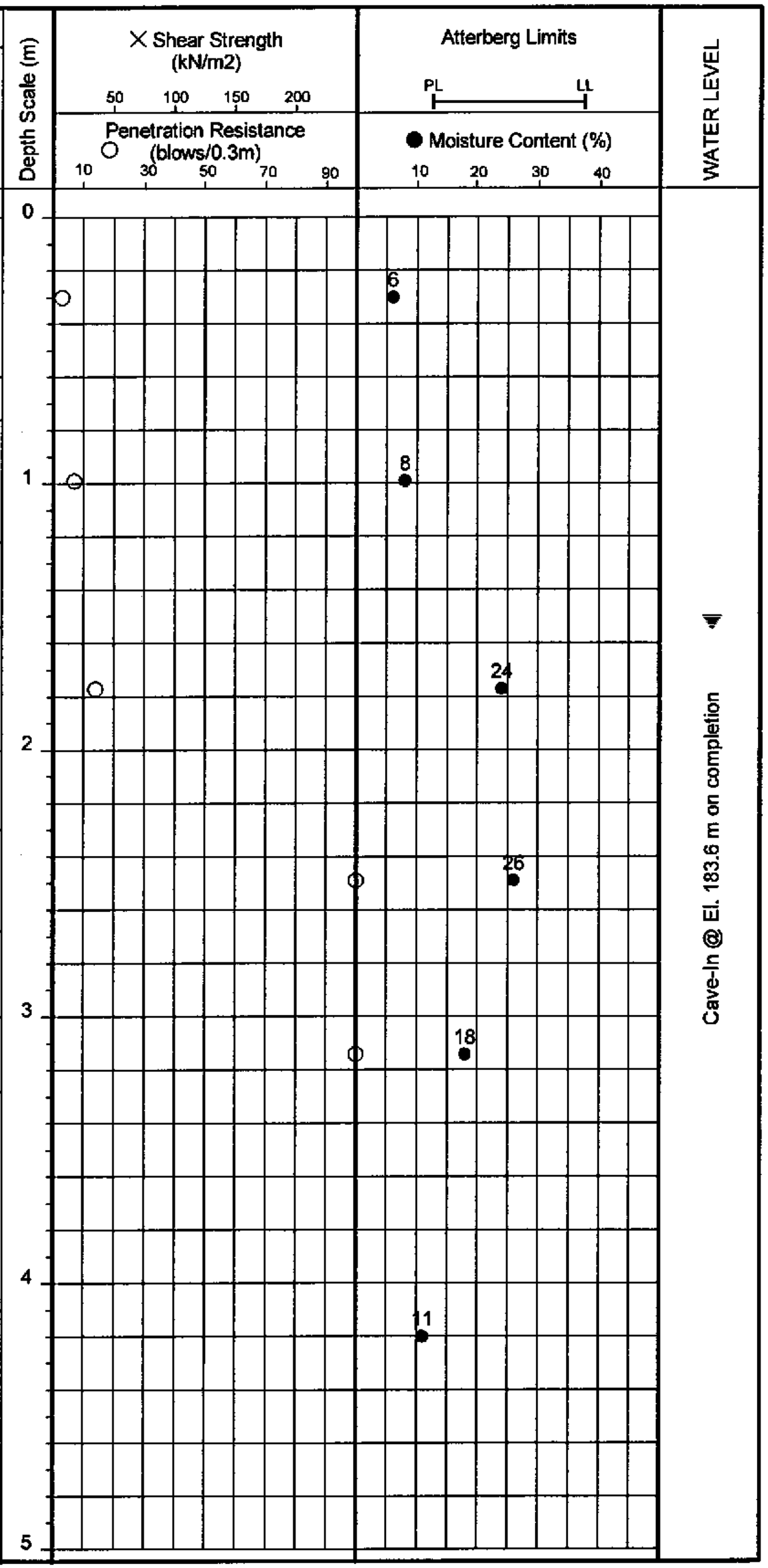
JOB DESCRIPTION: Proposed Residential Development

JOB LOCATION: 5 Silver Creek Drive, Town of Collingwood

METHOD OF BORING: Flight-Auger

DATE: May 9, 2011

Depth Elev. (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
0.0 185.1	Ground Surface **25 cm TOPSOIL**			
	Brown, very loose to compact	1	DO	3
	FINE SAND			
	a trace of silt	2	DO	7
	weathered	3	DO	14
2.1 183.0	Grey, very dense			
	FINE TO COARSE SAND	4	DO	100+
	a trace of silt some bedrock fragments			
		5	DO	100+
4.1 181.0	Grey **BEDROCK**	6	AS	-
4.3 180.8	**END OF BOREHOLE** Refusal to augering			



Soil Engineers Ltd.

JOB NO: 1104-S041

LOG OF BOREHOLE NO: 12

FIGURE NO: 12

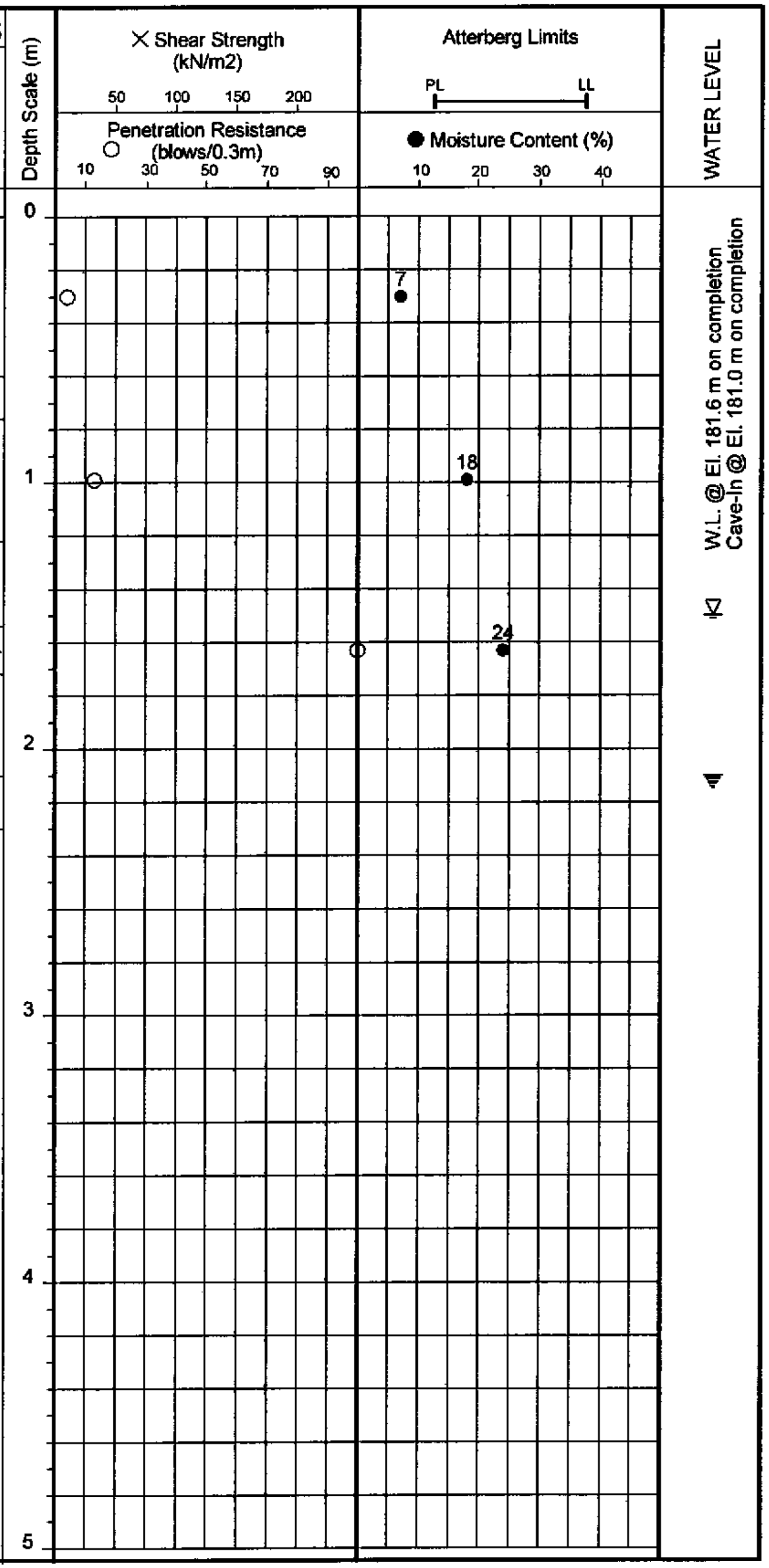
JOB DESCRIPTION: Proposed Residential Development

JOB LOCATION: 5 Silver Creek Drive, Town of Collingwood

METHOD OF BORING: Flight-Auger

DATE: May 9, 2011

Depth Elev. (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
0.0 183.1	Ground Surface **23 cm TOPSOIL**			
	Brown, loose to very dense	1	DO	4
	FINE SAND			
	a trace of silt weathered	2	DO	13
		3	DO	100+
2.1 181.0	Grey **BEDROCK**	4	AS	-
2.3 180.8	**END OF BOREHOLE** Refusal to augering			



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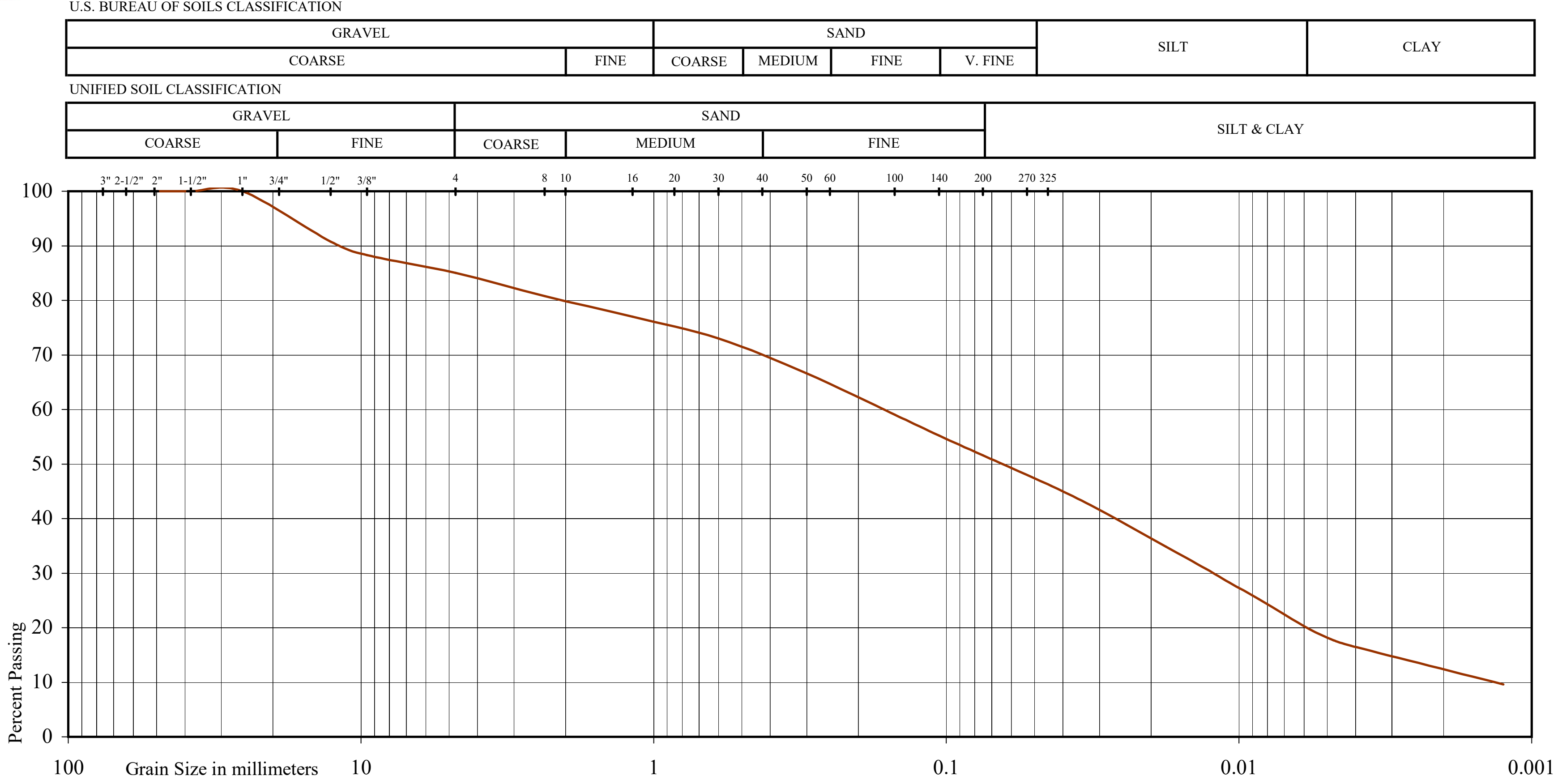
GRAIN SIZE DISTRIBUTION

Reference No: 1104-S041



Project: Proposed Residential Development

Location: 5 Silver Creek Drive, Town of Collingwood

Liquid Limit (%) = -

Plastic Limit (%) = -

Plasticity Index (%) = -

Moisture Content (%) = 8

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

Borehole No: 8

Sample No: 2

Depth (m): 1.0

Elevation (m): 185.3

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

Figure: 18

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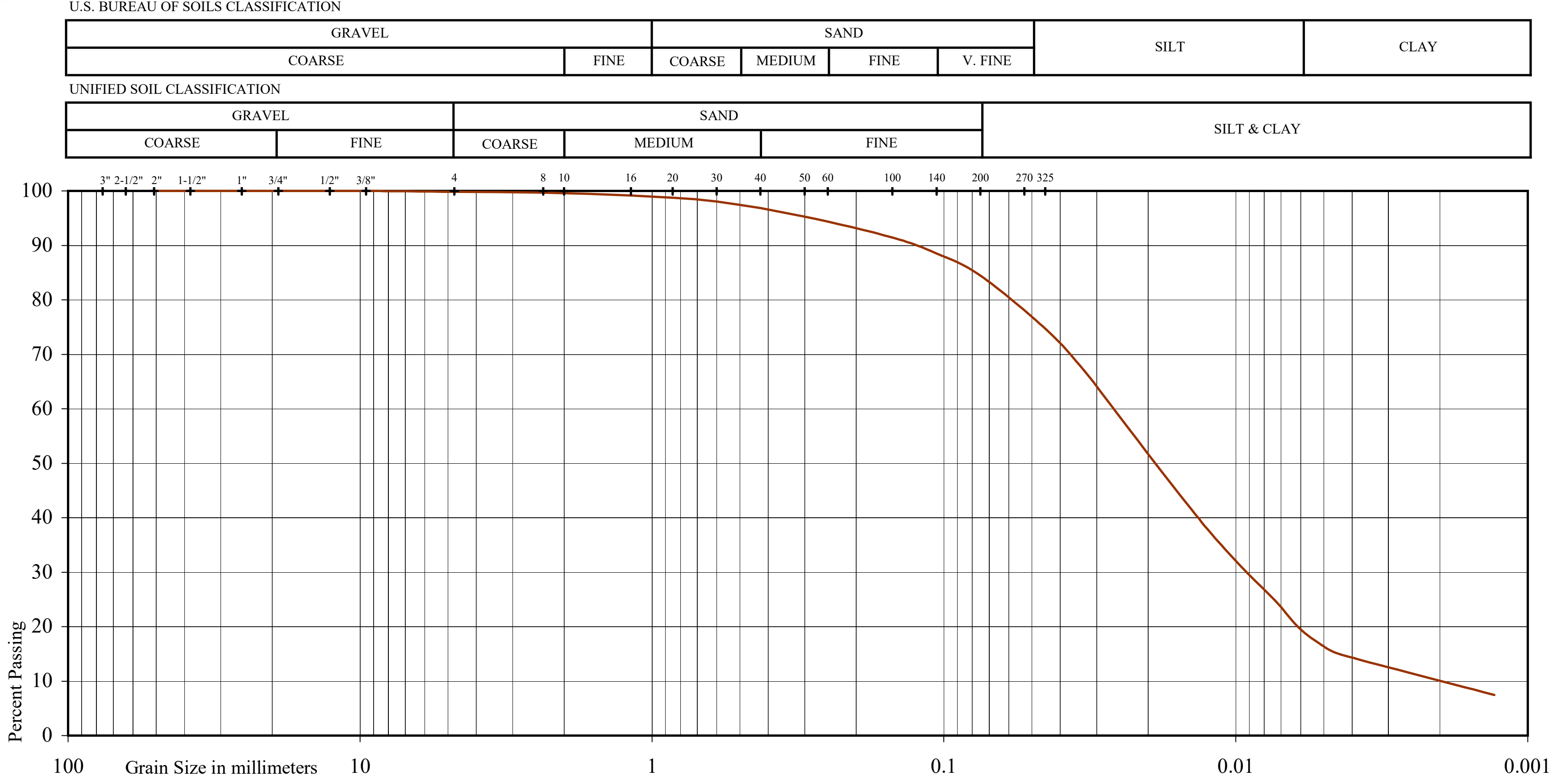
GRAIN SIZE DISTRIBUTION

Reference No: 1104-S041



Project:	Proposed Residential Development
Location:	5 Silver Creek Drive, Town of Collingwood

Borehole No:	10
Sample No:	2
Depth (m):	0.9
Elevation (m):	185.2

Liquid Limit (%) =	-
Plastic Limit (%) =	-
Plasticity Index (%) =	-
Moisture Content (%) =	17
Estimated Permeability (cm./sec.) =	10^{-5}

Classification of Sample [& Group Symbol]: SILT
some sand and clay

Figure: 19

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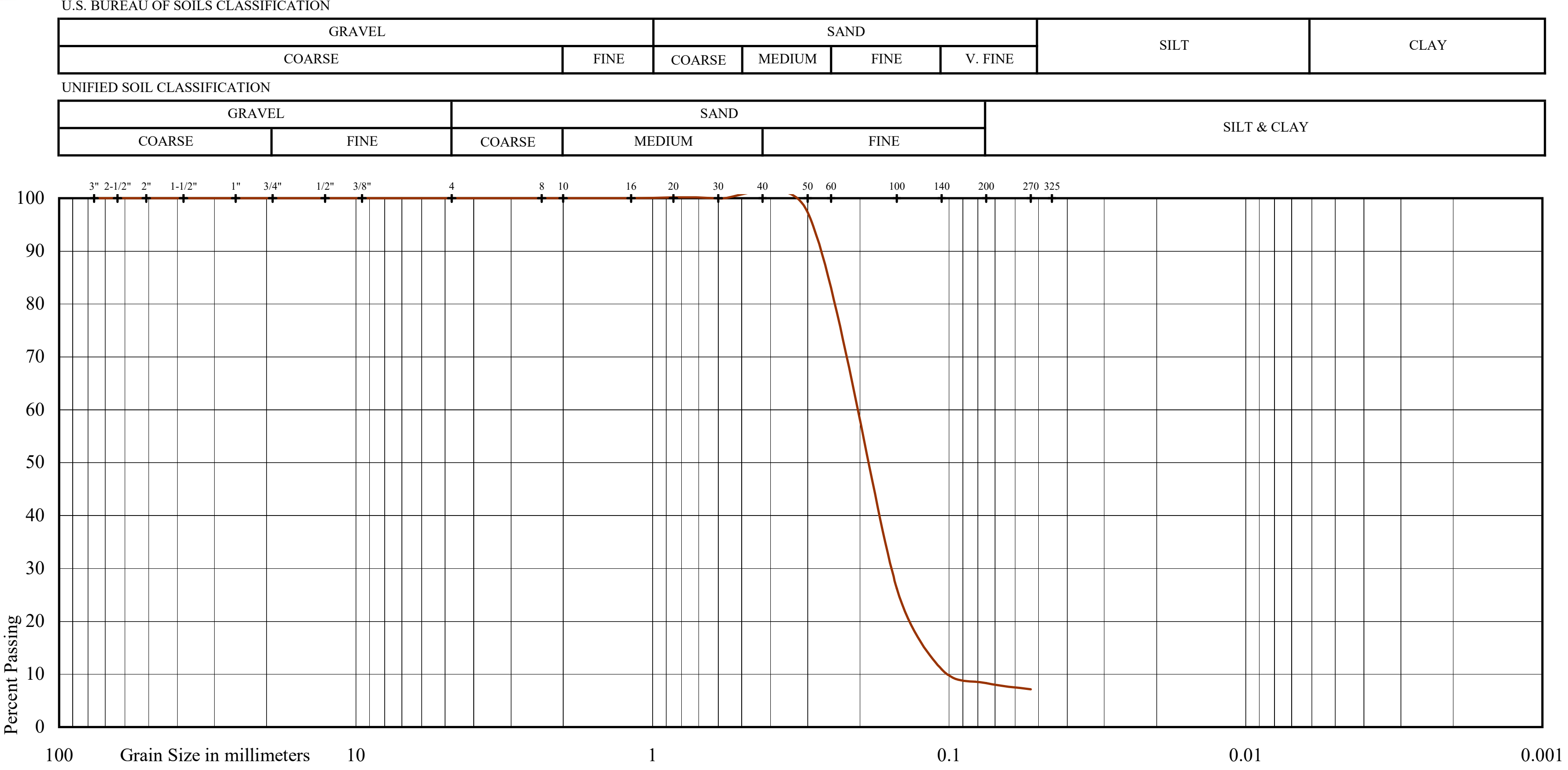
GRAIN SIZE DISTRIBUTION

Reference No: 1104-S041



Project: Proposed Residential Development

Location: 5 Silver Creek Drive, Town of Collingwood

Liquid Limit (%) = -

Plastic Limit (%) = -

Plasticity Index (%) = -

Moisture Content (%) = 24

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

Borehole No: 11

Sample No: 3

Depth (m): 1.8

Elevation (m): 183.3

Classification of Sample [& Group Symbol]: FINE SAND
a trace of silt

Figure: 20

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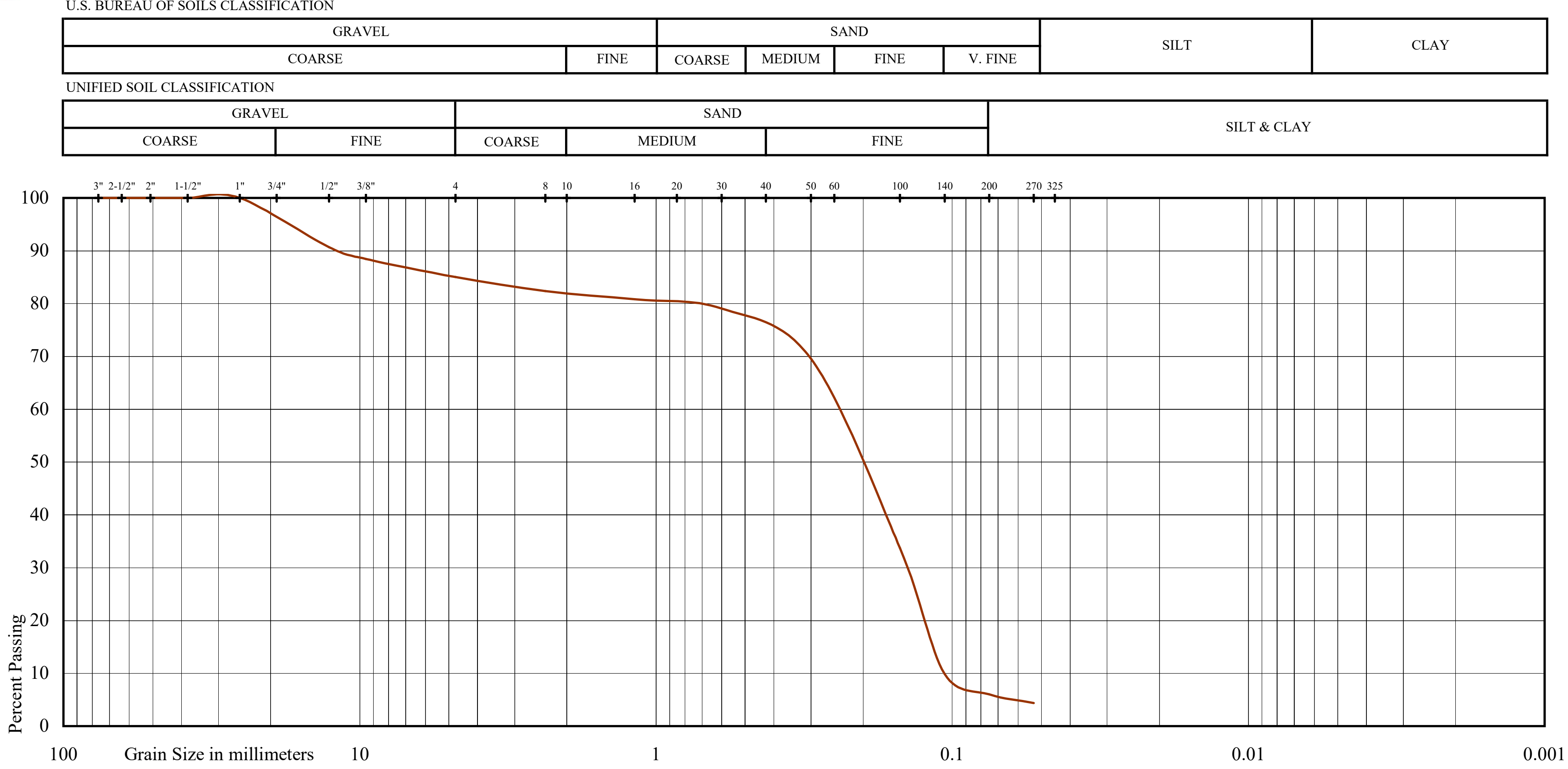
GRAIN SIZE DISTRIBUTION

Reference No: 1104-S041



Project: Proposed Residential Development

Location: 5 Silver Creek Drive, Town of Collingwood

Borehole No: 11

Sample No: 5

Depth (m): 3.2

Elevation (m): 181.9

Liquid Limit (%) = -

Plastic Limit (%) = -

Plasticity Index (%) = -

Moisture Content (%) = 18

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

Classification of Sample [& Group Symbol]: FINE TO COARSE SAND

a trace of silt, some rock fragments

Figure: 21