Terraprobe

Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

GEOTECHNICAL INVESTIGATION
PROPOSED LONG TERM CARE HOME
6360 REGIONAL ROAD 25
MILTON, ONTARIO

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1 INTRODUCTION

Terraprobe Inc. (Terraprobe) was retained by Thomas Robert Colbeck to conduct a geotechnical investigation for a proposed Long Term Care Home Structure at a site located at 6360 Regional Road25, Milton, Ontario.

This report encompasses the results of the geotechnical investigation conducted for the proposed development to determine the prevailing subsurface soil and groundwater conditions, and on this basis, provides geotechnical design advice and engineering recommendations for the foundations, basement floor slab and drainage, pavement design, seismic site classification, and lateral earth pressure design parameters. Geotechnical comments pertinent to the site construction aspects including excavation, bedding/embedment, backfill and groundwater control are also included in this report.

2 SITE AND PROJECT DESCRIPTION

The project site is located in the southwest quadrant of the intersection of Louis St. Laurent Ave and Regional Road 25 in the Town of Milton, with a municipal address of 6360 Regional Road25, Milton, Ontario. The general location of the site is presented in Figure 1 - Site Location Plan.

The site consists of an approximately rectangular-shaped parcel of land. The site comprises of a dwelling, a gravel driveway, sparse trees and landscaped areas. It is proposed that the dwelling would be demolished to facilitate the redevelopment.

According to the email sent by the client on January 20, 2023, the proposed development would include a 8 storey Long Term Care Home building. It is understood from the same email, the proposed structure may have 1 underground parking level and the projects site will also include at-grade parking lot, fire routes, driveways and landscaped areas.

3 INVESTIGATION PROCEDURE

The field investigation was conducted on June 13 to 17, 2022 and consisted of drilling a total of sixteen (16) boreholes to depths ranging from 9.2 to 9.4 m below grade. The approximate locations of the boreholes are shown on the enclosed Figure 2A - Borehole Location Plan (Existing Condition) and Figure 2B – Borehole Location Plan (Proposed Condition). Records of the individual boreholes are provided on the Borehole Logs in Appendix A.

The boreholes were drilled by a specialist drilling contractor using track-mounted drill rigs equipped with a power auger. The boreholes were advanced using continuous flight solid stem augers and were sampled at 0.75 m (up to 3.0 m depth) and 1.5 m (below 3.0 m depth) intervals with a conventional 50-mm diameter split barrel sampler when the Standard Penetration Test (SPT) was carried out (ASTM D1586). The field work (drilling, sampling, and testing) was observed and recorded by a member of our field engineering staff, who logged the borings and examined the samples as they were obtained.

Groundwater levels were measured in open boreholes upon completion of drilling. Monitoring wells comprising 50-mm diameter PVC pipes were installed in eight (8) boreholes (Boreholes 1, 4, 7, 9, 10, 13, 15 and 16) to facilitate groundwater monitoring. The groundwater level measurements in the monitoring wells were taken on July 14, 2022 and are noted on the enclosed Borehole Logs.

The borehole coordinates (Universal Transverse Mercator, UTM, Zone 17T) were surveyed by Terraprobe using a Trimble R10® GNSS System. The Trimble R10® system uses the Global Navigation Satellite System and the Can-Net® reference system to determine target location and elevation. Ground surface elevations were obtained from the site topographic survey. It should be noted that the elevations provided on the Borehole Logs are approximate only, for the purpose of relating soil stratigraphy and should not be used or relied on for other purposes.

All samples obtained during the investigation were sealed into clean plastic jars, and transported to our geotechnical testing laboratory for detailed inspection and testing. All borehole samples were examined (tactile) in detail by a geotechnical engineer, and classified according to visual and index properties. In-house laboratory testing consisted of:

- Natural water content determination (ASTM D2216); and
- Particle size distribution (ASTM D6913 and D1140).

A summary of the geotechnical laboratory tests is provided in Appendix B.

4 SUBSURFACE CONDITIONS

The specific soil conditions encountered at each borehole location are described in greater detail on the Borehole Logs, with a summary of the general subsurface soil conditions outlined below. This summary is intended to correlate this data to assist in the interpretation of the subsurface conditions encountered at the site.

It should be noted that the subsurface conditions are confirmed at the borehole locations only and may vary between and beyond the borehole locations. The boundaries between the various strata as shown on the borehole logs are based on non-continuous sampling. These boundaries represent an inferred transition between the various strata, rather than a precise plane of geologic change.

4.1 Stratigraphy

The following stratigraphy is based on the borehole findings, as well as the geotechnical laboratory testing conducted on selected representative soil samples.

4.1.1 Topsoil

A layer of topsoil was encountered in each borehole to depths ranging from 90 mm to 150 mm below grade.

4.1.2 Earth Fill

Topsoil was underlain by earth fill materials consisting of clayey silt with trace amount of gravel, sand and organics in Boreholes 5, 6, 8, 9, 10, 11, 13 and 15 and the topsoil was underlain by weathered/disturbed native soil in Boreholes 1, 2, 3, 4, 7, 12, 14 and 16. The earth fill layer was found to extend to 0.8 m below grade.

Standard Penetration Testing (SPT) results (N-Values) of the earth fill materials ranged typically from 8 to 13 blows per 300 mm of penetration indicating a firm to stiff consistency. The moisture contents of the topsoil and earth fill samples ranged from 9 to 26 percent by mass, indicating a moist condition

4.1.3 Clayey Silt Till

Glacial till material consisting of clayey silt with varying amount of sand (some sand to sandy) and trace amounts of gravel was encountered below the fill material in each borehole. Clayey silt till extended to depths of about 3.0 to 6.1 m below grade.

N-values obtained from the cohesive till layer ranged from 15 to 38 blows per 300 mm of penetration, indicating a very stiff to hard consistency. The moisture contents of the glacial till samples ranged from 9 to 21 percent by mass, indicating a moist condition.

4.1.4 Sandy Silt to Sand and Silt Till

Glacial till material consisting of sandy silt to sand and silt with varying amount of clay and gravel (trace to some) was encountered below the clayey silt till layer in each borehole. The cohesionless till extended to the full depth of investigation.

N-values obtained from the cohesionless till layer ranged from 41 to 79 blows per 300 mm of penetration to 50 blows per 75 mm of penetration, indicating a dense to very dense relative density. The moisture contents of the glacial till samples ranged from 2 to 33 percent by mass, indicating a moist to wet condition.

4.2 Geotechnical Laboratory Test Results

The geotechnical laboratory testing consisted of natural moisture content determination for all samples, while Sieve and Hydrometer analysis were conducted on selected soil samples. The test results are plotted on the enclosed Borehole Logs at respective sampling depths.

The results (graphs) of the Sieve and Hydrometer (grain size) analysis are appended, and a summary of these results is presented as follow:

Borehole No. Sample No.	Sampling Depth below Grade (m)	Percentage (by mass)				Descriptions (MIT System)
		Gravel	Sand	Silt	Clay	
Borehole 1, Sample 8	7.7	13	32	42	13	SANDY SILT some clay, some gravel
Borehole 4, Sample 6	4.8	2	19	53	26	CLAYEY SILT Some sand, trace gravel
Borehole 10, Sample 5	3.4	3	31	44	22	SAND SILT clayey, trace gravel
Borehole 13, Sample 7	6.2	8	36	43	13	SAND AND SILT some clay, trace gravel
Borehole 16, Sample 9	9.2	13	49	32	6	SILTY SAND Some gravel, trace clay

4.3 Soil Corrosivity

A total of five (5) soil samples (Borehole 1, Sample 4; Borehole 4, Sample 3; Borehole 11, Sample 5; Borehole 14, Sample 5; Borehole 16, Sample 6) were submitted to SGS Laboratories for chemical analyses (corrosivity Package) consisting of pH, Resistivity, Electrical Conductivity, Redox Potential, Sulphide, Sulphate and Chloride. A copy of the Certificates of Analyses is included in Appendix C.

Concrete material embedded in soil may be subjected to potential sulphate attack depending upon the site-specific soil conditions. The test results indicated that the concentration of sulphate in soil were between 16 to 36 µg/g (0.0041 to 0.0054 percent by mass). The analytical results of soluble sulphate concentration were compared to the *Canadian Standard CAN3/CSA A23.1-M94 Table 3, Additional Requirements for Concrete Subjected to Sulphate Attack.* It is anticipated that these results would be used to determine the type of cementing materials to be used to produce concrete for this project. Comparison of the test results indicates that the water-soluble sulfide concentrations in soil are lower than 0.01 percent. Based on this result, there is a negligible potential for sulphate attack on the concrete, regardless of cementing material used.

Five (5) samples of soil (Borehole 1, Sample 4; Borehole 4, Sample 3; Borehole 11, Sample 5; Borehole 14, Sample 5; Borehole 16, Sample 6) were submitted to SGS Canada Inc. for chemical analyses (Corrosivity Package) consisting of pH, Resistivity, Electrical Conductivity, Redox Potential, Sulphate, Sulphide and Chloride. These parameters are used for assessing soil corrosivity applicable to cast iron alloys, according to the 10-points soil evaluation procedure described in AWWA C105. Typically, if the total points are 10 or more, the soil is considered potentially corrosive and warrants taking protective measures. A more recent study has suggested that soil with a resistivity of less than about 2000 ohm.cm should be considered aggressive. It should be noted that the analytical results only provide an indication of the potential for corrosion. A copy of the Certificate of Analysis is appended.

Severity Ranking	Borehole and Sample Number				
	BH1; SS4	BH4; SS3	BH11; SS5	BH14; SS5	BH16; SS6
Total Points	1	1	1	1	1

Concrete material embedded in soil may be subjected to potential sulphate attack depending upon the site-specific soil conditions. The test results indicated that the concentration of sulphate in soil were between 16 to 36 µg/g (0.0041 to 0.0054 percent by mass). The analytical results of soluble sulphate concentration were compared to the *Canadian Standard CAN3/CSA A23.1-M94 Table 3, Additional Requirements for Concrete Subjected to Sulphate Attack*. It is anticipated that these results would be used to determine the type of cementing materials to be used to produce concrete for this project. Comparison of the test results indicates that the water-soluble sulfide concentrations in soil are lower than 0.01 percent. Based on this result, there is a negligible potential for sulphate attack on the concrete, regardless of cementing material used.

4.4 Groundwater

Observations pertaining to the depth of groundwater level and caving were made in the open boreholes immediately after completion of drilling and are noted on the enclosed Borehole Logs. Boreholes 1, 4, 7, 9, 10, 13, 15 and 16. The groundwater level measurements in the monitoring wells were taken on July 14, 2022 and are noted on the enclosed Borehole Logs. A summary of these observations in the boreholes is provided as follows:

Borehole No	Ground Surface Elevation (m)	Depth of Borehole (m)	Upon Completion of Drilling		Groundwater Level in Well, Depth/Elev. (m) as on July 14, 2022
			Depth to Cave (m)	Unstabilized Water Level (m)	
BH 1	192.0	9.3	Open	Dry	6.6 / 185.5

Borehole No	Ground Surface Elevation (m)	Depth of Borehole (m)	Upon Completion of Drilling		Groundwater Level in Well, Depth/Elev. (m) as on July 14, 2022
			Depth to Cave (m)	Unstabilized Water Level (m)	
BH 2	192.6	9.2	Open	Dry	Monitoring well not installed
BH 3	192.5	9.2	Open	Dry	Monitoring well not installed
BH 4	192.6	9.3	Open	Dry	6.8 / 185.8
BH 5	192.6	9.4	Open	8.8	Monitoring well not installed
BH 6	192.7	9.4	7.9	7.9	Monitoring well not installed
BH 7	192.7	9.4	Open	Dry	7.2 / 185.5
BH 8	192.6	9.3	7.9	7.6	Monitoring well not installed
BH 9	192.5	9.2	Open	Dry	6.5 / 186.0
BH 10	192.9	9.3	Open	Dry	8.0 / 184.9
BH 11	192.5	9.3	8.8	7.9	Monitoring well not installed
BH 12	192.5	9.4	8.8	7.9	Monitoring well not installed
BH 13	192.4	9.3	Open	Dry	6.7 / 185.6
BH 14	192.2	9.2	Open	Dry	Monitoring well not installed
BH 15	192.2	9.3	Open	Dry	7.0 / 185.3
BH 16	192.2	9.2	Open	Dry	7.1 / 185.2

Groundwater levels may fluctuate with time, and seasonally, depending on the amount of precipitation and surface runoff.

5 DISCUSSIONS AND RECOMMENDATIONS

The following discussion and recommendations are based on the factual data obtained from this investigation and are intended for the use of the owner and the design engineer. Contractors bidding or providing services on this project should review the factual data and determine their own conclusions regarding construction methods and scheduling.

This report is provided on the basis of these terms of reference and on the assumption that the design features relevant to the geotechnical analyses will be in accordance with applicable codes, standards and guidelines of practice. The Ontario Building Code may require additional considerations beyond the recommendations provided in this report, and must be followed. If there are any changes to the site development features or there is any additional information relevant to the interpretations made of the subsurface information with respect to the geotechnical analyses or other recommendations, then Terraprobe should be retained to review the implications of these changes with respect to the contents of this report.

5.1 Foundation

Boreholes 5, 6, 7, 9, 10, 11, 13, 14 and 15 advanced in the close proximity of the proposed building footprint encountered the topsoil underlain by the earth fill zone and/or weathered/disturbed soil, extending to Elev. 191.4 to 192.1 m, which is in turn underlain by the clayey silt till, extending to Elev. 186.1 to 189.5 m. which in turn underlain by cohesionless glacial till, extending to the full depth of investigation.

The proposed development would include a 8 storey Long Term Care Home building resting on one level of underground parking structure, at-grade parking lot, fire routes, driveways, and landscaped areas.

The information regarding the finished floor elevations (FFE) for the first floor and the basement floor is not available at the time of issuance of this report. The average existing site grade may be at Elev. 192.5 m±. For the one-level underground parking structure (P1), the FFE would be generally set at about 4.0 m depth below grade, implying the P1 FFE at Elev. 188.5 m±.

The undisturbed glacial till soils are considered suitable to support the proposed building foundations. A maximum net geotechnical reaction of 300 kPa at Serviceability Limit States (SLS) and a factored geotechnical resistance of 450 kPa at Ultimate Limit States (ULS) may be used for preliminary design of conventional spread footing foundations (for vertical and concentric loads) supported on the underlying competent undisturbed clayey silt till soils of very stiff to hard consistency. The final grading plan and design drawings should be reviewed by Terraprobe to better assess the design foundation elevations and to provide updated foundation bearing pressure (geotechnical reaction and resistance) recommendations prior to the industrial development.

Following table demonstrates the minimum depth of footing which provides the bearing capacity recommended:

BH No.	Minimum Depth of Footing below Existing Ground Surface (m)	Highest Elevation to support the footing (m)	Geotechnical Reaction at SLS (kPa)	Factored Geotechnical Resistance at ULS (kPa)	Bearing Stratum
5	1.2 m	191.4	300	450	Clayey Silt Till
6	1.5 m	191.2	300	450	Clayey Silt Till
7	1.5 m	191.2	300	450	Clayey Silt Till
9	1.5 m	191.0	300	450	Clayey Silt Till
10	1.5 m	191.4	300	450	Clayey Silt Till
11	1.5 m	191.0	300	450	Clayey Silt Till
13	1.5 m	190.9	300	450	Clayey Silt Till
14	1.5 m	190.7	300	450	Clayey Silt Till
15	1.2 m	191.0	300	450	Clayey Silt Till

All foundations must be designed to bear at least a minimum of 0.3 m into the undisturbed native soil stratum. The minimum foundation width to be used in conjunction with the above bearing pressure shall be 450 mm, and the minimum size of individual column footings shall be 900 mm × 900 mm. The footing sizes for housing and small buildings are stipulated in the Ontario Building Code (2012), Division 2, Part 9, and must be followed.

5.1.1 Foundation Installation

The foundation installations must be reviewed in the field by Terraprobe. The on-site review of the condition of the foundation subgrade, as the foundations are constructed, is an integral part of the geotechnical engineering design function and is not to be considered as third-party inspection services. If Terraprobe is not retained to carry out all of the foundation evaluations during construction, then Terraprobe accepts no responsibility for the performance of the foundations.

All exterior foundations and foundations in unheated areas must be provided with a minimum soil cover of 1.2 m or equivalent insulation for frost protection.

It is recommended that all excavated footing base must be evaluated by a qualified geotechnical engineer to ensure that the founding soils exposed at the excavation base are consistent with the design bearing pressure intended by the geotechnical engineer.

Prior to pouring foundation concrete, the foundation subgrade should be cleaned of all deleterious materials such as topsoil, fill, softened, disturbed or caved materials, as well as any standing water. If construction proceeds during freezing weather conditions, adequate temporary frost protection for the foundation subgrade and concrete must be provided.

It is noted that the native soils tend to weather rapidly and deteriorate on exposure to the atmosphere or surface water. Hence, foundation bases which remain open for an extended period of time should be protected by a skim coat of lean concrete (mud slab). Provisions should be made to minimize disturbance to the exposed foundation subgrade.

5.2 Lateral Earth Pressure Design Parameters

Walls or bracings subject to unbalanced earth pressures must be designed to resist a pressure that can be calculated based on the following equation:

$$P = K [\gamma (h-h_w) + \gamma' h_w + q] + \gamma_w h_w$$

Where:

P = the horizontal pressure (kPa)
K = the earth pressure coefficient
h = the depth below the ground surface (m)
h_w = the depth below the groundwater level (m)
γ = the bulk unit weight of soil (kN/m^3)
γ_w = the bulk unit weight of water (9.8 kN/m^3)
γ' = the submerged unit weight of the exterior soil, (γ_{sat} - γ_w)
q = the complete surcharge loading (kPa)

Where the wall backfill can be drained effectively to eliminate hydrostatic pressures on the wall, this equation can be simplified to:

$$P = K[\gamma h + q]$$

This equation assumes that free-draining granular backfill is used and positive drainage is provided to ensure that there is no hydrostatic pressure acting in conjunction with the earth pressure.

Resistance to sliding of retaining structures is developed by friction between the base of the footing and the soil. This friction **(R)** depends on the normal load on the soil contact (**N**) and the frictional resistance of the soil (**tan ϕ**) expressed as **R = N tan ϕ**. The factored geotechnical resistance at ULS is **0.8 R**.

Passive earth pressure resistance is generally not considered as a resisting force against sliding for conventional retaining structure design because a structure must deflect significantly to develop the full passive resistance.

The average values for use in the design of structures subject to unbalanced earth pressures at this site are tabulated as follow:

Parameter	**Definition**	**Units**
ϕ	angle of internal friction	degrees
γ	bulk unit weight of soil	kN/ m^3
K_a	active earth pressure coefficient (Rankine)	dimensionless
K_o	at-rest earth pressure coefficient (Rankine)	dimensionless
K_p	passive earth pressure coefficient (Rankine)	dimensionless

Stratum/Parameter	**Φ (degree)**	**γ (kN/m^3)**	**K_a**	**K_o**	**K_p**
Earth Fill	28	19.0	0.36	0.53	2.77
Clayey Silt Glacial Till	32	21.0	0.31	0.47	3.25
Sandy Silt to Sand and Silt Glacial Till	36	21.5	0.26	0.41	3.85

The above values of the earth pressure coefficients are for the horizontal backfill grade behind the wall. The earth pressure coefficients for inclined grade will vary based on the inclination of the retained ground surface.

5.3 Site Classification for Seismic Site Response

Under Ontario Regulation 88/19, the ministry amended Ontario’s Building Code (O. Reg 332/12) to further harmonize Ontario’s Building Code with the 2015 National Codes. These changes will help reduce red tape for businesses and remove barriers to interprovincial trade throughout the country. The amendments are based on code change proposals the ministry consulted in 2016 and 2017. The majority of the amendments came into effect on January 1, 2020, which includes structural sufficiency of buildings to withstand external forces and improve resilience.

Seismic hazard is defined in the 2012 Ontario Building Code (OBC 2012) by uniform hazard spectra (UHS) at spectral coordinates of 0.2 s, 0.5 s, 1.0 s and 2.0 s and a probability of exceedance of 2% in 50 years. The OBC method uses a site classification system defined by the average soil/bedrock properties (e.g. shear wave velocity (v_s), Standard Penetration Test (SPT) resistance, and undrained shear strength (s_u)) in the top 30 meters of the site stratigraphy below the foundation level, as set out in Table 4.1.8.4A of the Ontario Building Code (2012). There are 6 site classes from A to F, decreasing in ground stiffness from A, hard rock, to E, soft soil; with site class F used to denote problematic soils (e.g. sites underlain by thick peat deposits and/or liquefiable soils). The site class is then used to obtain peak ground acceleration (PGA), peak ground velocity (PGV) site coefficients F_a and F_v, respectively, used to modify the UHS to account for the effects of site-specific soil conditions.

Geophysics was retained by Terraprobe to conduct a site-specific MASW test on January 9th, 2023 to establish the site seismic classification based on the direct measurement of the shear wave velocity. Geophysics conducted site specific shear wave velocity soundings in the area. The test results measuring the minimum, maximum, and average shear wave velocity in the upper 30 m (V_s 30) are provided in the Geophysics report provided in Appendix D and summarized in the following table:

Depth Range (m)	Minimum Vs 30 (m/s)	Average Vs 30 (m/s)	Maximum Vs 30 (m/s)	Site Class
0 to 30	607	664	726	C

As per Ontario Building Code (2012), when the average shear wave velocity is between 360 m/s and 760 m/s, the site is designated as Site Class C. The average shear wave velocity measured at the site was 664 m/s (0 to 30 m depth below grade). Therefore, based on the direct measurement of the shear wave velocities, the site classification for seismic analysis is **Class C**, according to Table 4.1.8.4.A of the Ontario Building Code 2012 (Refer to Geophysics report in Appendix D, GPR File: F-23089, dated January 10, 2023). Tables 4.1.8.4.B. and 4.1.8.4.C. of the Ontario Building Code (2012) provide the applicable acceleration and velocity-based site coefficients.

The values of the site coefficient for design spectral acceleration at period T, F(T), and of similar coefficients F(PGA) and F(PGV) shall conform to Tables 4.1.8.4.B. to 4.1.8.4.I. using linear interpolation for intermediate values of PGA.

5.4 Basement Floor Slab

The excavated subgrade surface should be assessed by a qualified geotechnical engineer. The modulus of subgrade reaction appropriate for the slab design constructed on undisturbed Glacial Till material is 30,000 kPa/m.

The basement floor slab should be provided with a capillary moisture barrier and drainage layer. This can be made by placing the slab on a minimum 200 mm thick 19 mm clear stone layer (OPSS.MUNI 1004) compacted by vibration to a dense state. This material also serves as the drainage media for the subfloor drainage system. Provision of subfloor drainage is recommended in conjunction with the perimeter drainage of the structure.

The subfloor drainage system is an important building element and helps prevent hydrostatic pressure acting on the floor slabs, as such the storm sumps which ensure the performance of this system must have a duplexed pump arrangement for 100 percent pumping redundancy and these pumps must be provided with emergency power as needed. Basement and subfloor drainage provisions are further discussed in Section 5.5 of this report.

5.5 Basement Drainage

The ground water levels measured in the piezometers were between 6.5 m (Borehole 9) and 8.1 m (Borehole 10) depth below grade (Elev. 184.9 m and Elev. 186.0 m).

To assist in maintaining basement dry from seepage, it is recommended that exterior grades around the building be sloped away at a 2 percent gradient or more, for a distance of at least 1.2 m. As well, perimeter foundation drains should be provided, consisting of perforated pipe with filter fabric (minimum 100 mm diameter) surrounded by a granular filter (minimum 150 mm thick), and freely outletting. The granular filter should consist of 19 mm Clear Stone (OPSS.MUNI 1004) surrounded by a filter fabric (Terrafix 270R or equivalent), see Figure 3 Basement Drainage Detail.

The basement wall (for basements) in case of open excavation must be provided with damp-proofing provisions in conformance to the Section 9.13.2 of the Ontario Building Code (2012). The basement wall backfill for a minimum lateral distance of 0.6 m out from the wall should consist of free-draining granular material (OPSS.MUNI 1010 Granular B), or provided with a prefabricated drain material (for instance, CCW MiraDRAIN 6000 series or Terrafix Terradrain 600), see Figure 3 Basement Drainage Detail. The perimeter drain installation and outlet provisions must conform to the plumbing code requirements.

A subfloor drainage system is recommended. The sub-floor drainage system should consist of perforated pipes (minimum 100 mm diameter) located at a maximum spacing of 5.0 m centre to centre (Refer to Fig 4 Basement Subdrain Detail). The subdrain system should be outlet to a suitable discharge point under gravity flow, or connected to a sump located in the lowest level of the basement. The water from the sump must be pumped out to a suitable discharge point/positive outlet. The installation of the drains as well as the outlet must conform to the applicable plumbing code requirements.

The size of the sump should be adequate to accommodate the anticipated water seepage. An industrial duplex pumping arrangement (main pump with a provision of a backup pump) on emergency backup power is recommended. The pump capacity must be adequate to accommodate peak flow conditions expected during the wet seasons (i.e., spring melt and fall). The sub-drain installation and outlet must conform to the plumbing code requirements. The subfloor drainage system is an important building element at this site, as such the storm sump that ensures the performance of this system must have an industrial duplexed pump arrangement on emergency power, as noted above, for 100 percent pumping redundancy.

5.6 Pavement

The paved areas at the project site would include passenger car parking lots, driveway, and fire routes.

5.6.1 Pavement Design

The following flexible pavement thickness designs are provided in the following table.

Pavement Layers	Parking Lot	Fire Route/ Driveway/Access Road
Hot Mix Asphalt Surface Course OPSS 1150 HL 3	40 mm	40 mm
Hot Mix Asphalt Binder Course OPSS 1150 HL 8	50 mm	80 mm
Base Course OPSS MUNI 1010 Granular A	150 mm	150 mm
Subbase Course OPSS MUNI 1010 Granular B Type II	300 mm	400 mm

Alternatively, consideration may also be given to the use of Portland cement concrete pavement where there is intense truck use, and turning of transport vehicles in conjunction with the waste handling, loading docks or delivery facilities. The following table provides the minimum recommended rigid pavement structures:

Pavement Layers	Minimum Component Thickness
Portland Cement Concrete, CAN/CSA A23.1- Class C-2	210 mm
Subbase Course, OPSS MUNI 1010 Granular A	150 mm

It should be noted that in addition to the adherence to the above pavement design recommendations, a close control on the pavement construction process will also be required in order to obtain the desired pavement life. It is recommended that regular inspection and testing be conducted during the pavement construction to confirm material quality, thickness, and to ensure adequate compaction.

5.6.2 Drainage

Control of water is an important factor in achieving a good pavement life. The need for adequate subgrade drainage cannot be over-emphasized. The subgrade must be free of depressions and sloped (preferably at a minimum grade of three percent) to provide effective drainage toward subgrade drains.

Grading adjacent to the pavement areas should be designed to ensure that water is not allowed to pond adjacent to the outside edges of the pavement. Continuous pavement subdrains should be provided along both sides of the driveway and drained into respective catchbasins to facilitate drainage of the subgrade and granular materials. The subdrain should be installed in accordance with Town's *STD No. E-24 Subdrains*. The subdrain invert should be maintained at least 0.3 m below subgrade level. Continuous subdrains should be provided for the access road/driveway pavement areas along the curb-lines/sidewalk and at all catchbasins within the parking areas. Two lengths of subdrain (each minimum of about 3 m long) should be installed at each catchbasin over the parking lot area.

5.6.3 General Pavement Recommendations

HL 3 and HL 8 hot mix asphalt mixes should be designed, produced and placed in conformance with OPSS 1150 and OPSS 310 requirements and relevant Town's standards.

Portland cement concrete should be design, produced and placed in conformation with CAN/CSA A23.1, OPSS MUNI 1350 and OPSS 350 requirements and relevant Town's standards.

Granular A and Granular B Type II should meet the requirements of OPSS MUNI 1010 and relevant Town's standards. Granular materials should be compacted to 100 percent SPMDD at ±2 percent of the optimum moisture content.

PG 58-28, conforming to OPSS MUNI 1101 is recommended in the HMA surface and binder courses.

Tack coat SS-1 should be applied between hot mix asphalt binder course and surface course.

5.6.4 Subgrade Preparation

All topsoil, organics and soft/loose fill materials should be stripped from the subgrade areas. The subgrade soil is expected to consist of fill materials or clayey silt till and these fine-grained soils will be weakened by construction traffic when wet; especially if site work is carried out during the periods of wet weather. An adequate granular working surface would be likely required in order to minimize subgrade disturbance and protect its integrity in wet periods.

Immediately prior to placing the granular subbase, the exposed subgrade should be compacted and then proofrolled with a heavy rubber tired vehicle (such as a loaded gravel truck). The subgrade should be inspected for signs of rutting or displacement. Areas displaying signs of rutting or displacement should be recompacted and retested or, the material should be excavated and replaced with well-compacted clean fill.

The fill may consist of either granular material or local inorganic soils provided that its moisture content is within ±2 percent of optimum moisture content. Fill should be placed and compacted in accordance with OPSS MUNI 501 and the subgrade should be compacted to 98 percent of SPMDD. The final subgrade surface should be sloped at least 3 percent to provide positive drainage.

5.7 Pipe Bedding and Cover/Embedment

The design information of the underground services was not available at the time of preparation of this report. The following subsections provide preliminary geotechnical engineering information for the design of underground services with relatively shallow inverts. Trench excavation should be carried out in accordance with the Occupational Health and Safety Act (OHSA) and Regulations for Construction Projects (O.Reg. 213/91 with recent amendments).

The site stratigraphy generally consists of earth fill material extending to about 0.8 depth below grade, underlain by clayey silt till deposit extending to about 3.0 to 6.1 m depth below grade, which was in turn underlain by Sandy Silt to Sand and Silt glacial till, extending to the full depth of the investigation.

The following sections provide preliminary geotechnical engineering information for the design of the sewers. Trench excavation should be carried out in accordance with the Occupational Health and Safety Act (OHSA) and Regulations for Construction Projects (O.Reg. 213/91 with recent amendments), while trench bedding, backfilling and compaction should be carried out in accordance with OPSD 802.010, OPSD 802.013, OPSD 802.030, OPSD 802.031, OPSD 802.032, OPSD 802.33 and /or OPSS MUNI 401 as appropriate.

The undisturbed glacial till deposit will be suitable for support of buried services that are properly bedded. Where disturbance of the trench base has occurred, due to ground water seepage, or construction traffic, the disturbed soils should be sub-excavated and replaced with suitably compacted granular material. Any accumulation of water at the base of the excavation and any soft/loose soils should be removed prior to placement of the pipe bedding/embankment. Placement of the pipe bedding/embedment must be done in dry condition.

Concrete sewer pipe should be installed in conformance with the OPSD 802.030, OPSD 802.031, OPSD 802.032 or OPSD 802.033 requirements, while PVC or HDPE sewer pipe should be installed in conformance with the OPSD 802.010 or OPSD 802.013 requirements. The bedding and embedment materials as specified in OPSS MUNI 401would include OPSS MUNI 1010 Granular A, Granular B with 100 percent passing 26.5 mm sieve and unshrinkable fill. The cover materials for rigid pipes include OPSS MUNI 1010 Granular A and Granular B with 100 percent passing 26.5 mm sieve.

The bedding, embedment and cover materials should be placed in layers not exceeding 200 mm in thickness and compacted to a minimum of 95 percent SPMDD or vibrated into a dense state in the case of clear stone type bedding.

5.8 Infiltration Rate

The results of the Sieve and Hydrometer analysis tests and corresponding hydraulic conductivity and infiltration rate are summarized in the following table. Note that the hydraulic conductivity is obtained only based on the result of sieve and hydrometer test.

Borehole No. Sample No.	Sampling Depth below Grade (m)	Percentage (MIT)				Description	Hydraulic Conductivity (cm/sec)	Infiltration Rate (mm/hr)
		Gravel	Sand	Silt	Clay			
Borehole 1, Sample 8	7.7	13	32	42	13	SANDY SILT some clay, some gravel	10^{-6}	14
Borehole 10, Sample 5	3.4	3	31	44	22	CLAYEY SILT sandy, trace gravel	10^{-7}	6
Borehole 4, Sample 6	4.8	2	19	53	26	CLAYEY SILT some sand, trace gravel	10^{-7}	6

The hydraulic conductivity of the sandy silt till deposit is on the order of 10^{-6} cm/sec. and of the clayey silt till deposit is on the order of 10^{-7} cm/sec. As per the TRCA *Low Impact Development Stormwater Management Planning and Design Guide*, Table C1, an infiltration rate of about 14 mm/hour corresponds to the estimated values of the hydraulic conductivity for sandy silt till and 6 mm/hour for clayey silt till portions. The design infiltration rate should be evaluated based on applicable safety correction factor(s), as per the above referenced document.

5.9 Excavations and Ground Water Control

The boreholes data indicate that the fill materials and undisturbed native soils would be encountered in the excavations. Excavations must be carried out in accordance with the *Occupational Health and Safety Act and Regulations for Construction Projects*. These regulations designate four (4) broad classifications of soils to stipulate appropriate measures for excavation safety.

TYPE 1 SOIL

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

TYPE 2 SOIL

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

TYPE 3 SOIL

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

TYPE 4 SOIL

a. is soft to very soft and very loose in consistency, very sensitive and upon disturbance is significantly reduced in natural strength;
b. runs easily or flows, unless it is completely supported before excavating procedures;
c. has almost no internal strength;
d. is wet or muddy; and
e. exerts substantial fluid pressure on its supporting system.

The fill material encountered in the boreholes are classified as Type 3 Soil, while glacial till deposit would be classified as Type 2 Soil above and Type 3 below the prevailing groundwater level, under these regulations.

Where workmen must enter excavations advanced deeper than 1.2 m, the trench walls should be suitably sloped and/or braced in accordance with the Ontario Occupational Health and Safety Act (OHSA) and Regulations for Construction Projects. The regulation stipulates the steepest slopes of excavation by soil type as follows:

Soil Type	Base of Slope	Steepest Slope Inclination
1	within 1.2 m of bottom of trench	1 horizontal to 1 vertical
2	within 1.2 m of bottom of trench	1 horizontal to 1 vertical
3	from bottom of trench	1 horizontal to 1 vertical
4	from bottom of trench	3 horizontal to 1 vertical

Minimum support system requirements for steeper excavations are stipulated in the Occupational Health and Safety Act and Regulations for Construction Projects, and include provisions for timbering, shoring and moveable trench boxes.

It should be noted that the glacial till deposit may contain larger particles (cobbles and boulders) that are not specifically identified in the Borehole Logs. The size and distribution of such obstructions cannot be predicted with borings, because the borehole sampler size is insufficient to secure representative samples of the particles of this size. Provision should be made in excavation contracts to allocate risks associated with time spent and equipment utilized to remove or penetrate such obstructions when encountered.

The groundwater levels measured July 14, 2022 in the monitoring wells installed within the site indicated that the groundwater levels are between 6.5 and 8.0 m below grade (Elev. 184.9 m to Elev. 186.0 m).

There should be limited seepage from the overburden, as the overburden comprises relatively low permeability glacial till. However, perched groundwater seepage emanating from relatively permeable silt/sand lenses typically found within the glacial till due to its mode of deposition and the earth fill zone. The amount of perched water seepage can be controlled by continuous pumping from filtered sumps at the base of the excavation.

For excavations extending near or below the prevailing groundwater level (e.g. elevator pit), it may be necessary to lower the groundwater level and maintain it at least 1 m below the excavation base prior to and during the subsurface construction.

5.10 Backfill

The native soils are considered suitable for backfill provided the moisture content of these soils is within 2 percent of the Optimum Moisture Content (OMC). It should be noted that there may be wet zones within the subsurface soils (particularly soils excavated from below the prevailing groundwater level) which could be too wet to compact. Any soil material with 3% or higher in-situ moisture content than its OMC, could be put aside to dry or be tilled to reduce the moisture content so that it can be effectively compacted. Alternatively, materials of higher moisture content could be wasted and replaced with imported material which can be readily compacted.

In settlement sensitive areas, the backfill should consist of clean earth and should be placed in lifts of 150 mm thickness or less, and heavily compacted to a minimum of 98% SPMDD at a water content close to optimum (within 2%). The upper 1.2 m of the pavement subgrade must be compacted to a minimum of 100% SPMDD.

It should be noted that the soils encountered on the site are generally not free draining, and will be difficult to handle and compact should they become wetter as a result of inclement weather or seepage. Hence, it can be expected that the earthworks will be difficult and may incur additional costs if carried out during wet periods (i.e. spring and fall) of the year.

5.11 Quality Control

Excavations on this site must be shored to preserve the integrity of the surrounding properties and structures. The Ontario Building Code stipulates that engineering review of the subsurface conditions is required on a continuous basis during the installation of earth retaining structures. Terraprobe should be retained to provide this review, which is an integral part of the geotechnical design function as it relates to the shoring design considerations. Terraprobe can provide detailed shoring design services for the project, if requested. All foundations must be monitored by the geotechnical engineer on a continuous basis as they are constructed. The on-site review of the condition of the foundation soil as the foundations are constructed is an integral part of the geotechnical design function and is required by Section 4.2.2.2 of the Ontario Building Code. If Terraprobe is not retained to carry out foundation evaluations during construction, then Terraprobe accepts no responsibility for the performance or non-performance of the foundations, even if they are ostensibly constructed in accordance with the conceptual design advice provided in this report.

Concrete for this structure will be specified in accordance with the requirements of CAN3 - CSA A23.1. Terraprobe maintains a CSA certified concrete laboratory and can provide concrete sampling and testing services for the project as necessary.

The requirements for fill placement on this project should be stipulated relative to SPMDD, as determined by ASTM D698. In-situ determinations of density during fill placement by Procedure Method B of ASTM D2922 are recommended to demonstrate that the contractor is achieving the specified soil density. Terraprobe is a CNSC licensed operator of appropriate nuclear density gauges for this work and can provide sampling and testing services for the project as necessary.

Terraprobe can provide thorough in-house resources, quality control services for Building Envelope, Roofing and Structural Steel in accordance with CSA W178, as necessary, for the Structural and Architectural quality control requirements of the project. Terraprobe is certified by the Canadian Welding Bureau under W178.1-1996.

6 LIMITATIONS AND RISK

6.1 Procedures

This investigation has been carried out using investigation techniques and engineering analysis methods consistent with those ordinarily exercised by Terraprobe and other engineering practitioners, working under similar conditions and subject to the time, financial and physical constraints applicable to this project. The discussions and recommendations that have been presented are based on the factual data obtained by Terraprobe.

It must be recognized that there are special risks whenever engineering or related disciplines are applied to identify subsurface conditions. Even a comprehensive sampling and testing programme implemented in accordance with the most stringent level of care may fail to detect certain conditions. Terraprobe has assumed for the purposes of providing design parameters and advice, that the conditions that exist between sampling points are similar to those found at the sample locations. The conditions that Terraprobe has interpreted to exist between sampling points can differ from those that actually exist.

It may not be possible to drill a sufficient number of boreholes or sample and report them in a way that would provide all the subsurface information that could affect construction costs, techniques, equipment and scheduling. Contractors bidding on or undertaking work on the project should be directed to draw their own conclusions as to how the subsurface conditions may affect them, based on their own investigations and their own interpretations of the factual investigation results, cognizant of the risks implicit in the subsurface investigation activities so that they may draw their own conclusions as to how the subsurface conditions may affect them.

6.2 Changes in Site and Scope

It must also be recognized that the passage of time, natural occurrences, and direct or indirect human intervention at or near the site have the potential to alter subsurface conditions. Groundwater levels are particularly susceptible to seasonal fluctuations.

The discussion and recommendations are based on the factual data obtained from this investigation made at the site by Terraprobe and are intended for use by the owner and its retained designers in the design phase of the project. If there are changes to the project scope and development features, the interpretations made of the subsurface information, the geotechnical design parameters and comments relating to constructability issues and quality control may not be relevant or complete for the revised project. Terraprobe should be retained to review the implications of such changes with respect to the contents of this report.

This report was prepared for the express use of Thomas Robert Colbeck and their retained design consultants and is not for use by others. This report is copyright of Terraprobe Inc. and no part of this report may be reproduced by any means, in any form, without the prior written permission of Terraprobe Inc. and Thomas Robert Colbeck who are the authorized users.

It is recognized that the regulatory agencies in their capacities as the planning and building authorities under Provincial statues, will make use of and rely upon this report, cognizant of the limitations thereof, both expressed and implied.

We trust the foregoing information is sufficient for your present requirements. If you have any questions, or if we can be of further assistance, please do not hesitate to contact us.

Yours truly,

Terraprobe Inc.

LICENSED PROFESSIONAL ENGINEER
M.R.
M. RASHID
100534732
2023-03-06
PROVINCE OF ONTARIO

Md Hasanur Rashid, M.Eng., P.Eng.
Geotechnical Engineer

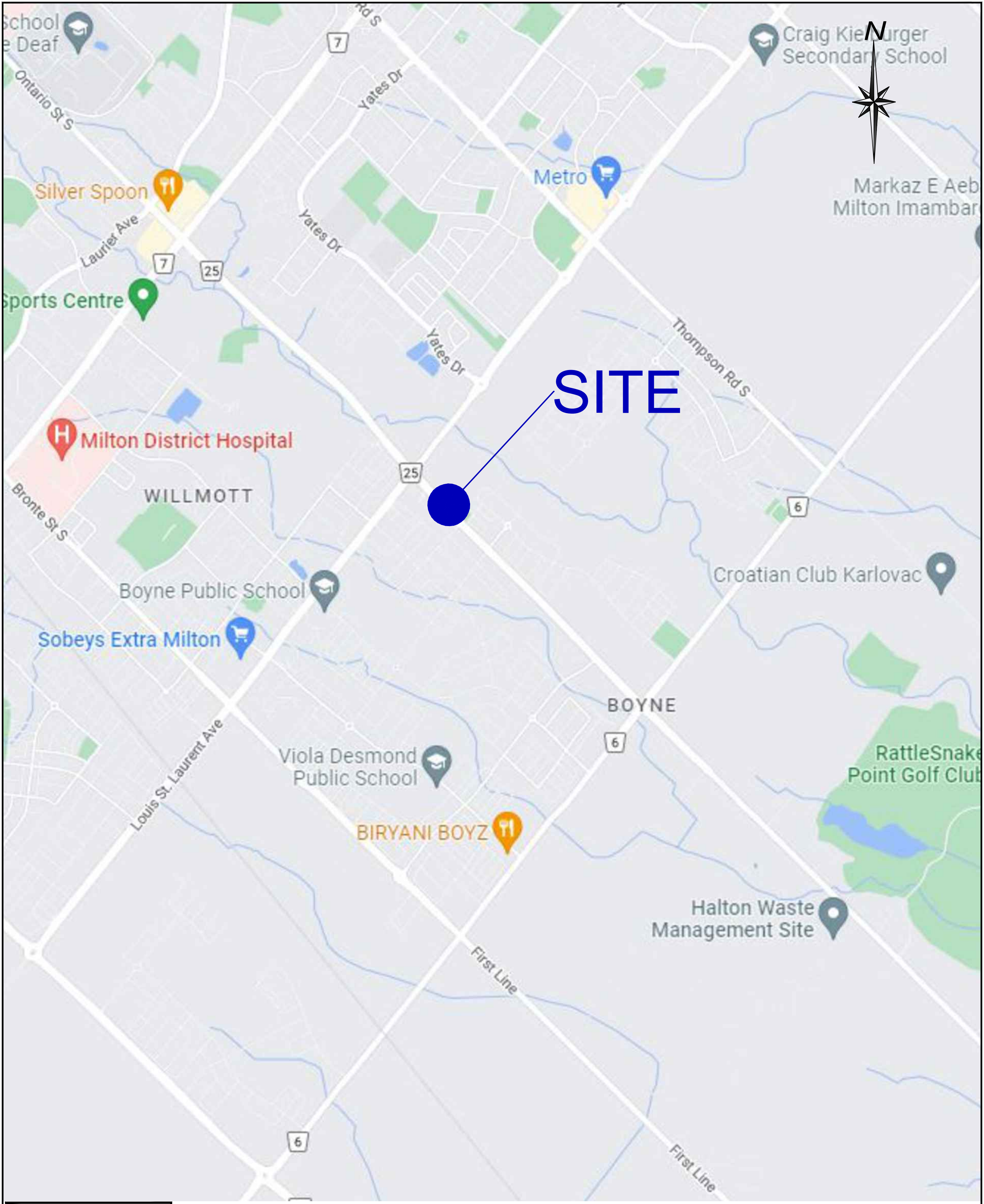
Mike Tanos, P.Eng.
Review/Consulting Principal

ENCLOSURES

TERRAPROBE INC.

FIGURES

TERRAPROBE INC.



REFERENCE
Image © 2022 Google

SCALE 32 0 80m

Terraprobe
11 Indell Lane, Brampton, Ontario, L6T 3Y3
Tel: (905) 796-2650 Fax: (905) 796-2250

Title: **SITE LOCATION PLAN**

File. No.: 1-22-0209-01

FIGURE : 1

REFERENCE
Image © 2022 Google Earth

LEGEND
⌖ Approximate Borehole Location

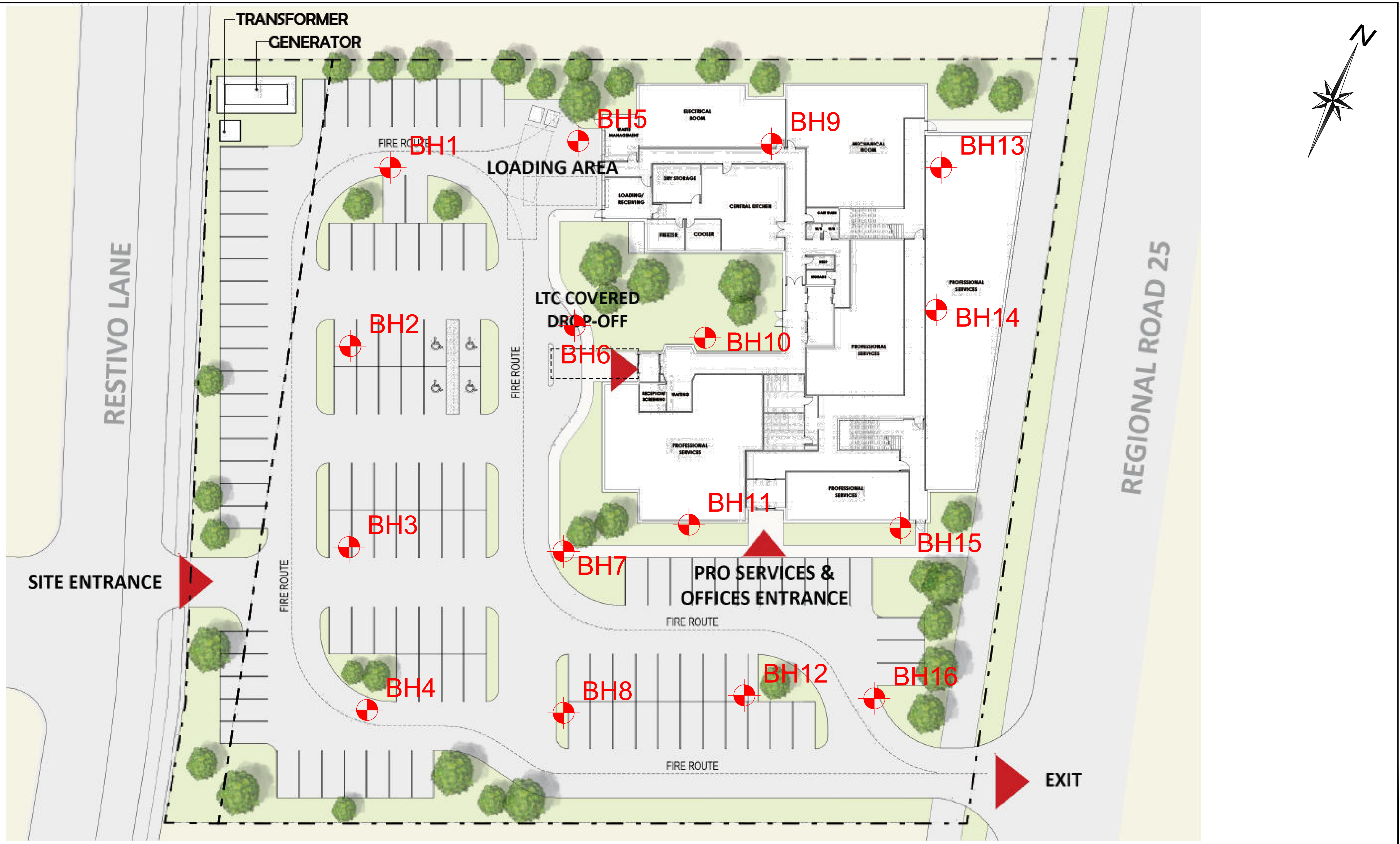
SCALE
1:600

Terraprobe
11 Indell Lane, Brampton, Ontario, L6T 3Y3
Tel: (905) 796-2650 Fax: (905) 796-2250

Title:
BOREHOLE LOCATION PLAN

File No.
EXISTING CONDITION

FIGURE :
2A



REFERENCE
Date: January 20, 2023
Email By: Abdulkader kadernani

LEGEND
⌖ Approximate Borehole Location

SCALE
1:600

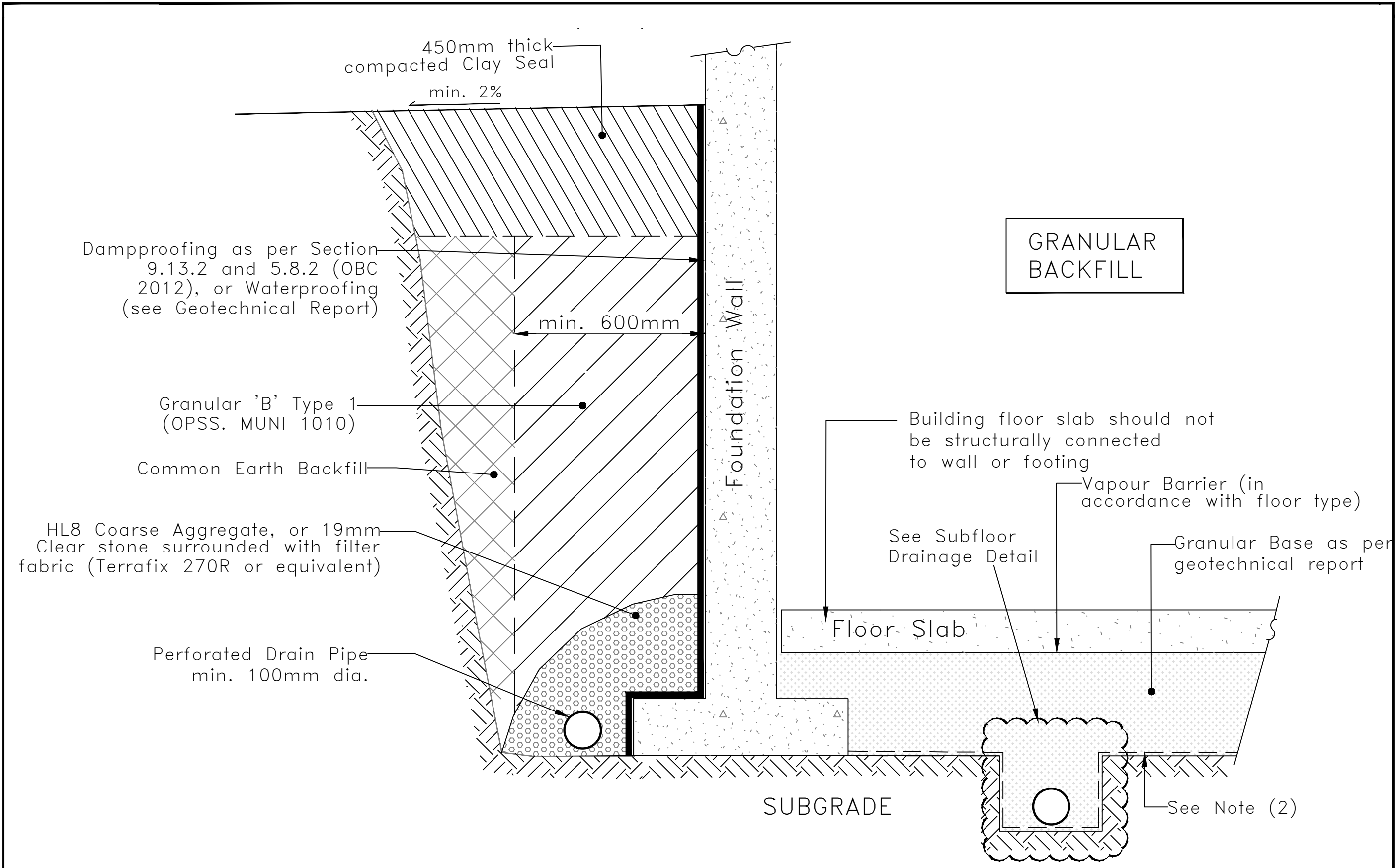
8 0 20m

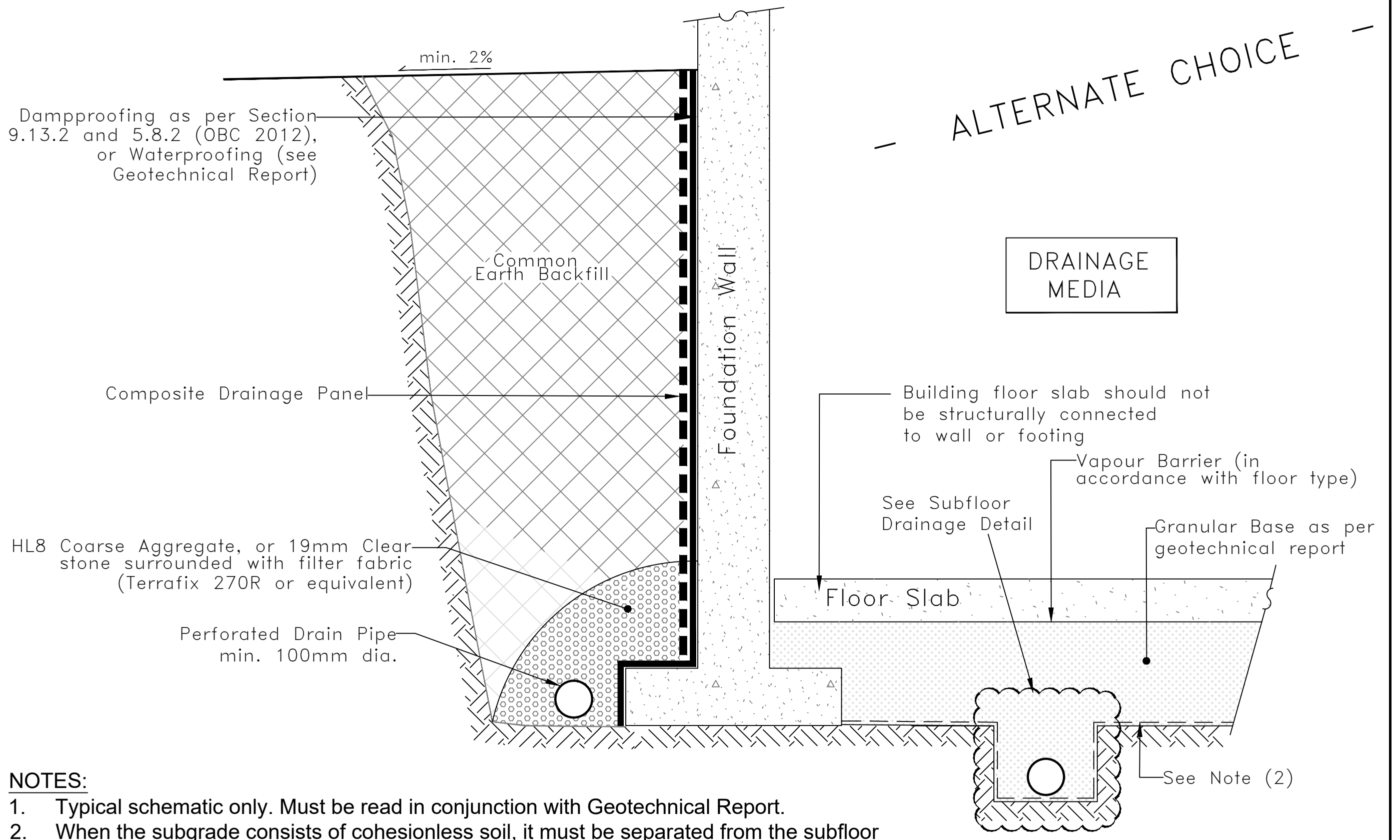
Terraprobe
11 Indell Lane, Brampton, Ontario, L6T 3Y3
Tel: (905) 796-2650 Fax: (905) 796-2250

Title:
BOREHOLE LOCATION PLAN
PROPOSED CONDITION

File No.
1-22-0209-01

FIGURE :
2B





NOTES:

1. Typical schematic only. Must be read in conjunction with Geotechnical Report.
2. When the subgrade consists of cohesionless soil, it must be separated from the subfloor drainage layer using a non-woven geotextile (Terrafix 360R or approved equivalent).
3. Not to Scale

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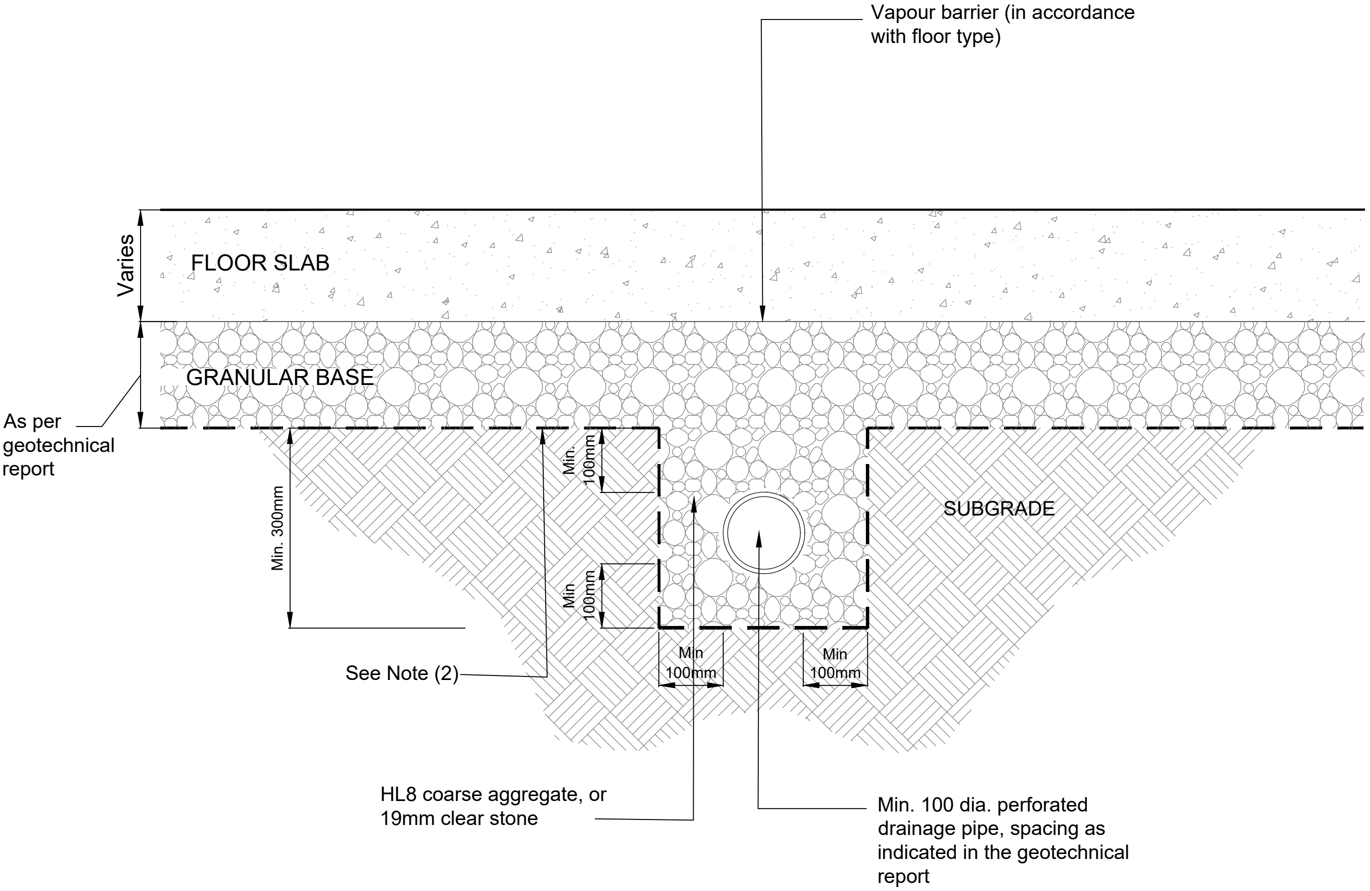
11 Indell Lane, Brampton, Ontario, L6T 3Y3
Tel: (905) 796-2650 Fax: (905) 796-2250

Title:

TYPICAL BASEMENT DRAINAGE SCHEMATIC
(OPEN EXCAVATION)



NOTES:

1. Typical schematic only. Must be read in conjunction with Geotechnical Report.
2. When the subgrade consists of cohesionless soil, it must be separated from the subfloor drainage layer using a non-woven geotextile (Terrafix 360R or approved equivalent).
3. Not to Scale

Terraprobe
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Title:

TYPICAL BASEMENT SUBDRAIN DETAIL

APPENDIX A

TERRAPROBE INC.

ABBREVIATIONS AND TERMINOLOGY

SAMPLING METHODS

AS	auger sample
CORE	cored sample
DP	direct push
FV	field vane
GS	grab sample
SS	split spoon
ST	shelby tube
WS	wash sample

PENETRATION RESISTANCE

Standard Penetration Test (SPT) resistance ('N' values) is defined as the number of blows by a hammer weighing 63.6 kg (140 lb.) falling freely for a distance of 0.76 m (30 in.) required to advance a standard 50 mm (2 in.) diameter split spoon sampler for a distance of 0.3 m (12 in.).

Dynamic Cone Test (DCT) resistance is defined as the number of blows by a hammer weighing 63.6 kg (140 lb.) falling freely for a distance of 0.76 m (30 in.) required to advance a conical steel point of 50 mm (2 in.) diameter and with 60° sides on 'A' size drill rods for a distance of 0.3 m (12 in.)."

COHESIONLESS SOILS

Compactness	'N' value
very loose	< 4
loose	4 – 10
compact	10 – 30
dense	30 – 50
very dense	> 50

COHESIVE SOILS

Consistency	'N' value	Undrained Shear Strength (kPa)
very soft	< 2	< 12
soft	2 – 4	12 – 25
firm	4 – 8	25 – 50
stiff	8 – 15	50 – 100
very stiff	15 – 30	100 – 200
hard	> 30	> 200

COMPOSITION

Term (e.g)	% by weight
trace silt	< 10
some silt	10 – 20
silty	20 – 35
sand *and* silt	> 35

TESTS AND SYMBOLS

MH	mechanical sieve and hydrometer analysis
w, w_c	water content
w_L, LL	liquid limit
w_P, PL	plastic limit
I_P, PI	plasticity index
k	coefficient of permeability
γ	soil unit weight, bulk
G_s	specific gravity
φ'	internal friction angle
c'	effective cohesion
c_u	undrained shear strength

▽	Unstabilized water level
▼	1st water level measurement
▼	2nd water level measurement
▼	Most recent water level measurement
3.0 +	Undrained shear strength from field vane (with sensitivity)
C_c	compression index
c_v	coefficient of consolidation
m_v	coefficient of compressibility
e	void ratio

FIELD MOISTURE DESCRIPTIONS

Damp	refers to a soil sample that does not exhibit any observable pore water from field/hand inspection.
Moist	refers to a soil sample that exhibits evidence of existing pore water (e.g. sample feels cool, cohesive soil is at or close to plastic limit) but does not have visible pore water
Wet	refers to a soil sample that has visible pore water

Terraprobe

LOG OF BOREHOLE 1

Project No. : 1-22-0209-01
Client : Thomas Robert Colbeck
Originated by : DH

Date started : June 13, 2022
Project : 6360 Regional Road 25
Compiled by : HR

Sheet No. : 1 of 1
Location : Milton, Ontario
Checked by : MMT

Position : E: 593189, N: 4816392 (UTM 17T)
Elevation Datum : Geodetic

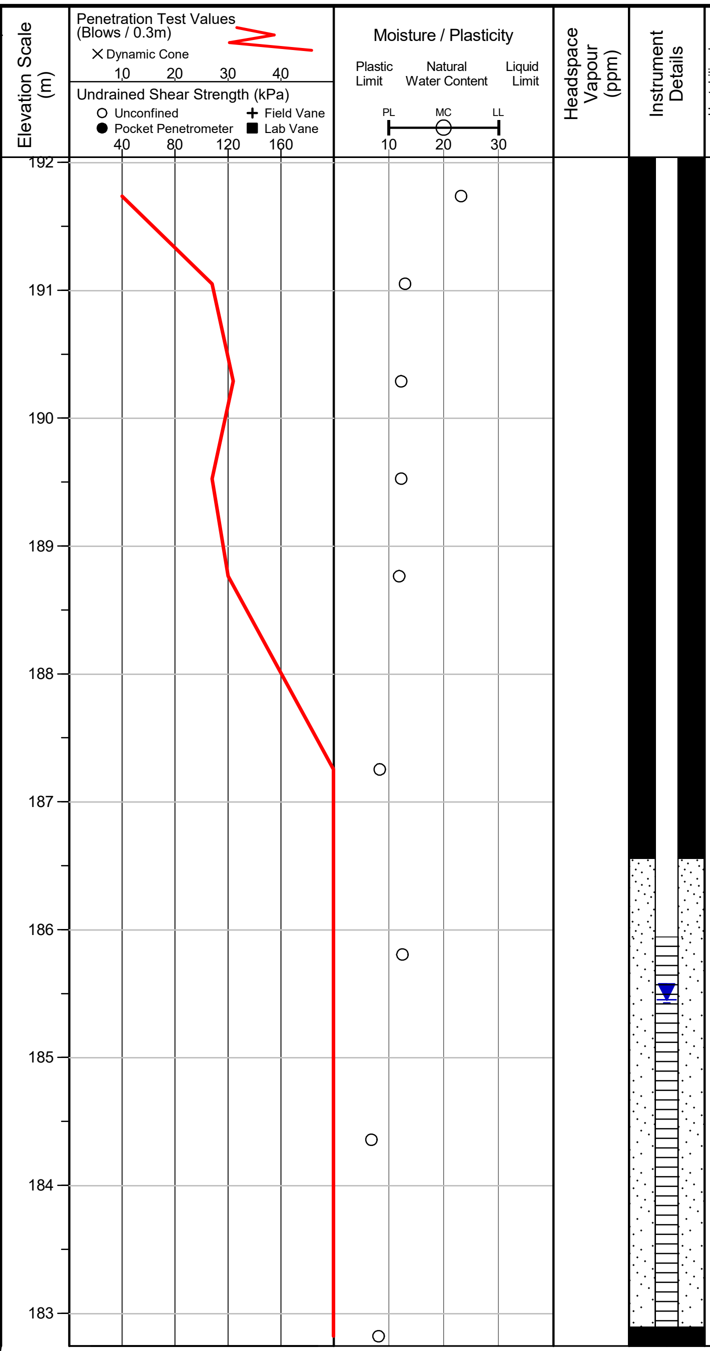
Rig type : Track-mounted
Drilling Method : Solid stem augers

Depth Scale (m)	Elev Depth (m)	SOIL PROFILE Description	SAMPLES Number	Type	SPT 'N' Value	Lab Data and Comments GRAIN SIZE DISTRIBUTION (%) (MIT) GR SA SI CL
0	192.0	**GROUND SURFACE**				
		100mm **TOPSOIL**				
		(WEATHERED/DISTURBED), trace organics	1	SS	10	
	191.2 0.8	**CLAYEY SILT**, some sand to sandy, trace gravel, very stiff to hard, brown to reddish brown, moist (GLACIAL TILL)	2	SS	27	
1						
			3	SS	31	
2						
			4	SS	27	
3			5	SS	30	
4						
	187.4 4.6	**SANDY SILT to SAND AND SILT**, trace to some clay, trace to some gravel, very dense, reddish brown, moist to wet (GLACIAL TILL)	6	SS	76 / 275mm	
5						
6			7	SS	50 / 125mm	
7			8	SS	50 / 125mm	13 32 42 13
8						
9	182.7 9.3		9	SS	50 / 150mm	

END OF BOREHOLE

Borehole was dry and open upon completion of drilling.

50 mm dia. monitoring well installed.



WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Jul 14, 2022	6.6	185.5

Terraprobe

LOG OF BOREHOLE 2

Project No. : 1-22-0209-01	Client : Thomas Robert Colbeck		Originated by : DH
Date started : June 17, 2022	Project : 6360 Regional Road 25		Compiled by : HR
Sheet No. : 1 of 1	Location : Milton, Ontario		Checked by : MMT

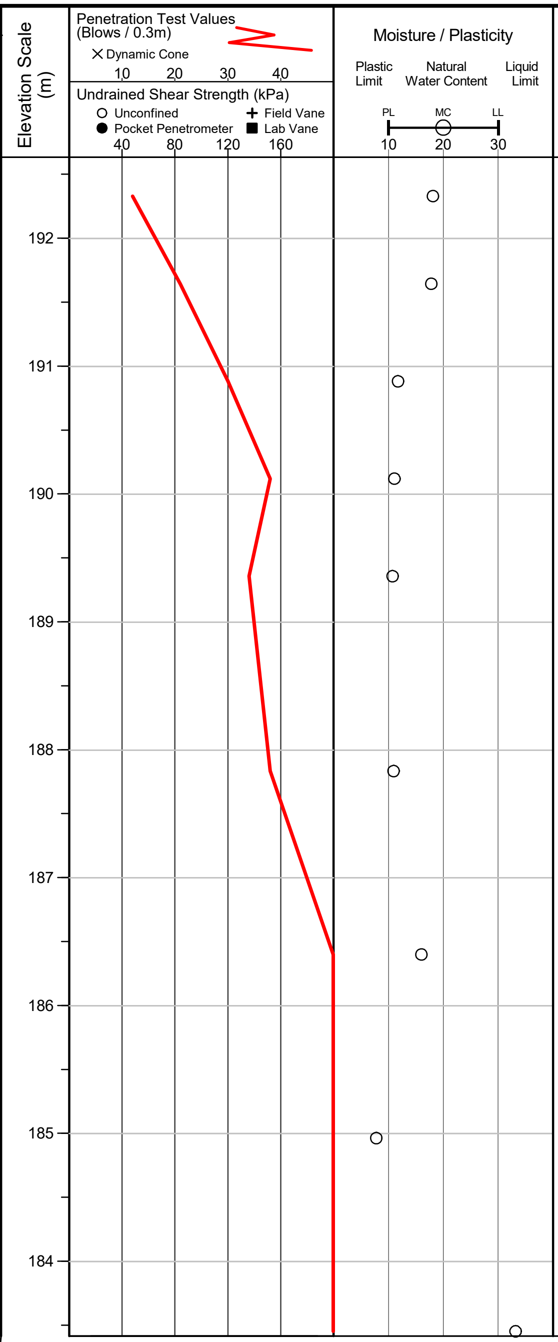
Position : E: 593164, N: 4816428 (UTM 17T)
Elevation Datum : Geodetic
Rig type : Track-mounted
Drilling Method : Solid stem augers

SOIL PROFILE

Elev Depth (m)	Description
192.6	**GROUND SURFACE**
192.4 0.2	150mm **TOPSOIL**
	(WEATHERED/DISTURBED), trace organics
191.8 0.8	**CLAYEY SILT**, some sand to sandy, trace gravel, very stiff to hard, brown to reddish brown, moist (GLACIAL TILL)
186.5 6.1	**SANDY SILT to SAND AND SILT**, trace to some clay, trace to some gravel, very dense, moist to wet (GLACIAL TILL)
183.4 9.2	**END OF BOREHOLE**

SAMPLES

Number	Type	SPT 'N' Value
1	SS	12
2	SS	21
3	SS	30
4	SS	38
5	SS	34
6	SS	38
7	SS	50 / 125mm
8	SS	50 / 100mm
9	SS	50 / 75mm



Headspace Vapour (ppm)

Instrument Details

Unstabilized Water Level

Lab Data and Comments
GRAIN SIZE DISTRIBUTION (%) (MIT)
GR SA SI CL

Borehole was dry and open upon completion of drilling.

Terraprobe

LOG OF BOREHOLE 3

Project No. : 1-22-0209-01
Client : Thomas Robert Colbeck
Originated by : DH

Date started : June 17, 2022
Project : 6360 Regional Road 25
Compiled by : HR

Sheet No. : 1 of 1
Location : Milton, Ontario
Checked by : MMT

Position : E: 593178, N: 4816411 (UTM 17T)
Elevation Datum : Geodetic

Rig type : Track-mounted
Drilling Method : Solid stem augers

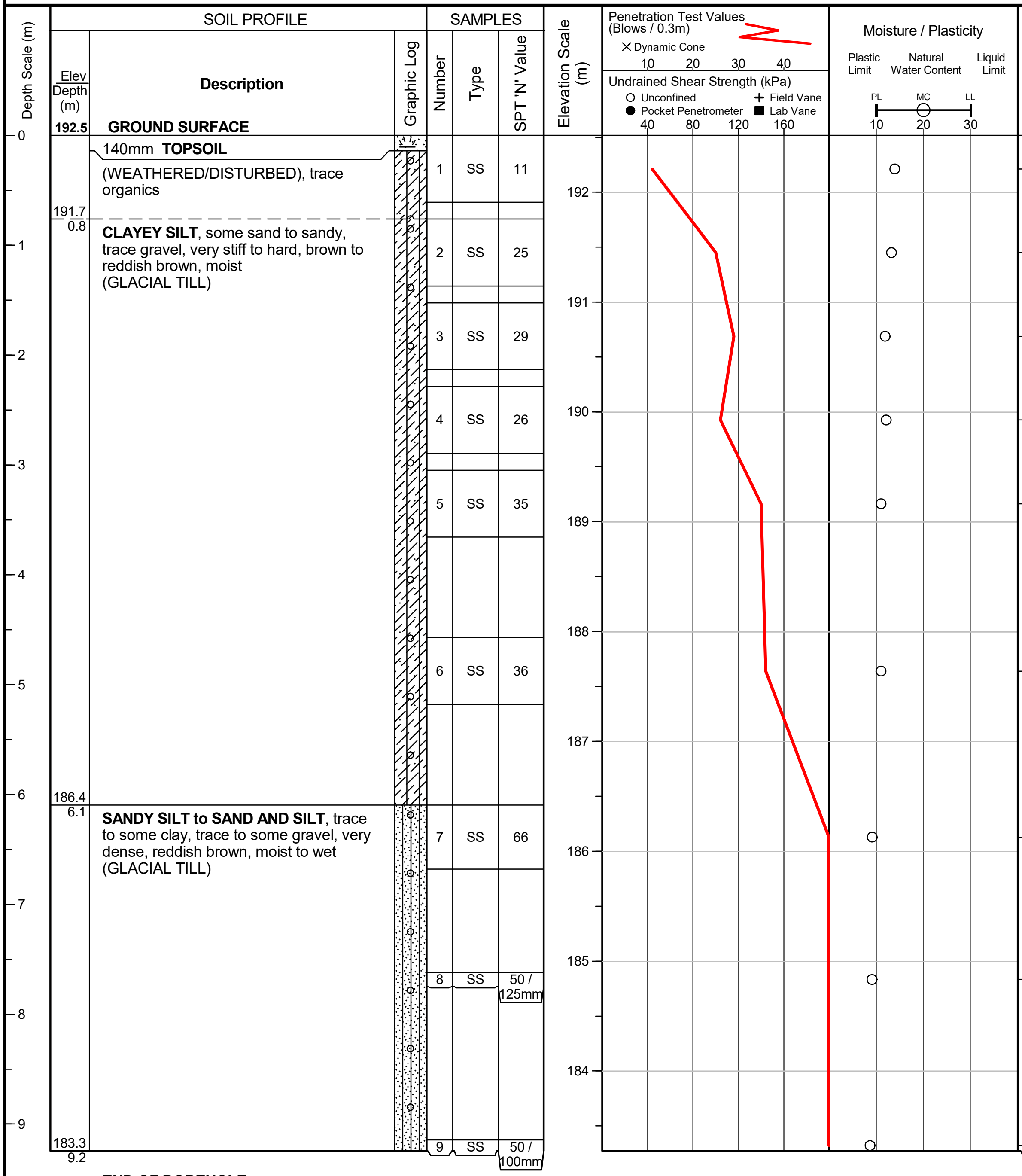
SOIL PROFILE

Elev Depth (m)	Description
192.5	**GROUND SURFACE**
	140mm **TOPSOIL**
	(WEATHERED/DISTURBED), trace organics
191.7 0.8	**CLAYEY SILT**, some sand to sandy, trace gravel, very stiff to hard, brown to reddish brown, moist (GLACIAL TILL)
186.4 6.1	**SANDY SILT to SAND AND SILT**, trace to some clay, trace to some gravel, very dense, reddish brown, moist to wet (GLACIAL TILL)
183.3 9.2	**END OF BOREHOLE**

Borehole was dry and open upon completion of drilling.

SAMPLES

Number	Type	SPT 'N' Value	Headspace Vapour (ppm)
1	SS	11	PID: 0 FID: 0
2	SS	25	PID: 0 FID: 0
3	SS	29	PID: 0 FID: 0
4	SS	26	PID: 0 FID: 0
5	SS	35	PID: 0 FID: 0
6	SS	36	PID: 0 FID: 0
7	SS	66	PID: 0 FID: 0
8	SS	50 / 125mm	PID: 0 FID: 0
9	SS	50 / 100mm	PID: 0 FID: 0



Instrument Details

Unstabilized Water Level

Lab Data and Comments

GRAIN SIZE DISTRIBUTION (%) (MIT)

GR SA SI CL

Terraprobe

LOG OF BOREHOLE 4

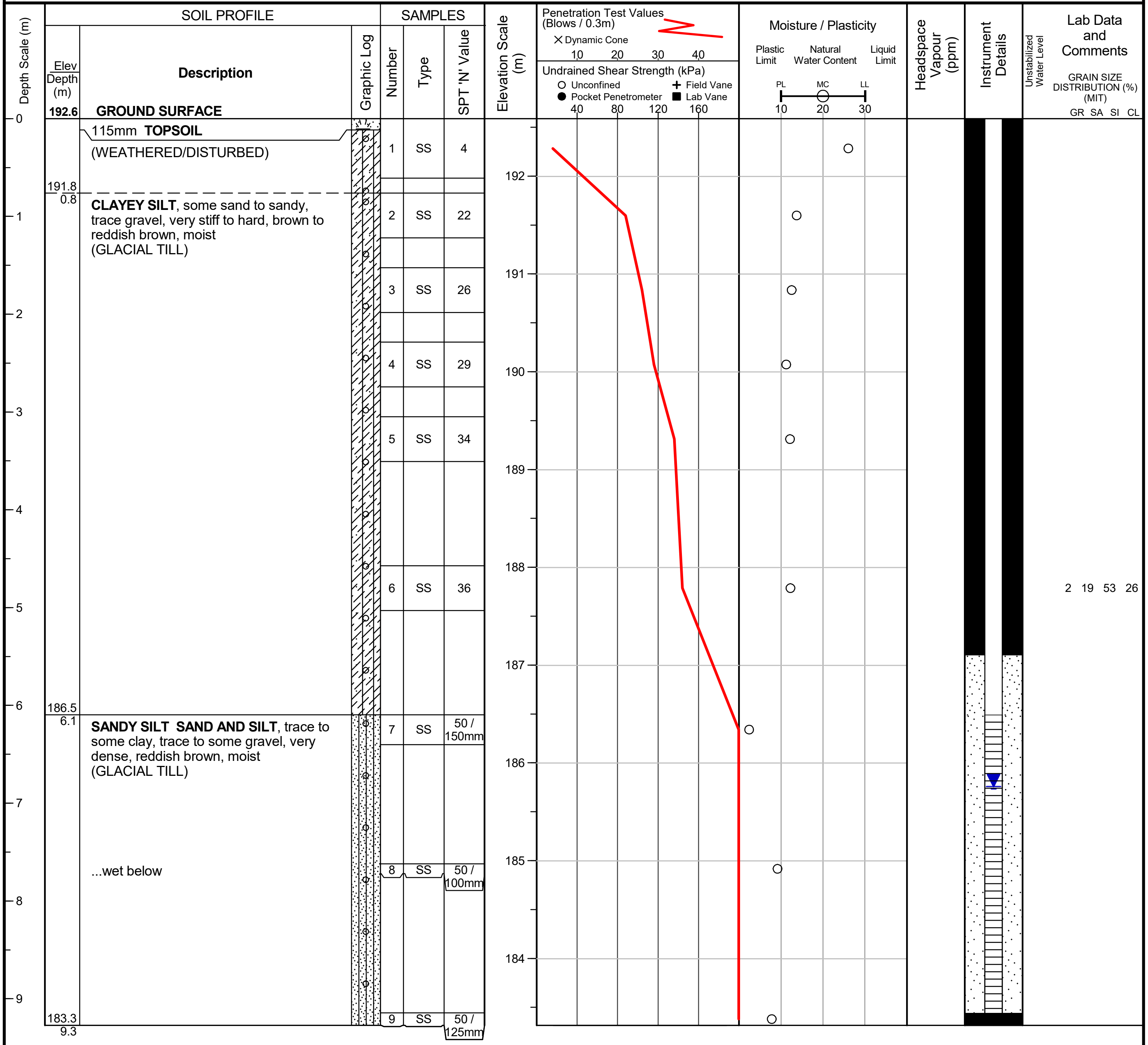
Project No. : 1-22-0209-01
Date started : June 17, 2022
Sheet No. : 1 of 1

Client : Thomas Robert Colbeck
Project : 6360 Regional Road 25
Location : Milton, Ontario

Originated by : DH
Compiled by : HR
Checked by : MMT

Position : E: 593136, N: 4816448 (UTM 17T)
Rig type : Track-mounted

Elevation Datum : Geodetic
Drilling Method : Solid stem augers



Elev / Depth (m)	Description
192.6	**GROUND SURFACE**
	115mm **TOPSOIL**
	(WEATHERED/DISTURBED)
191.8 0.8	**CLAYEY SILT**, some sand to sandy, trace gravel, very stiff to hard, brown to reddish brown, moist (GLACIAL TILL)
186.5 6.1	**SANDY SILT SAND AND SILT**, trace to some clay, trace to some gravel, very dense, reddish brown, moist (GLACIAL TILL) ...wet below
183.3 9.3	**END OF BOREHOLE**

Number	Type	SPT 'N' Value	Lab Data and Comments
1	SS	4	
2	SS	22	
3	SS	26	
4	SS	29	
5	SS	34	
6	SS	36	2 19 53 26
7	SS	50 / 150mm	
8	SS	50 / 100mm	
9	SS	50 / 125mm	

Borehole was dry and open upon completion of drilling.

50 mm dia. monitoring well installed.

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Jul 14, 2022	6.8	185.8

file: 1-22-0209-01 bh logs.gpj

LOG OF BOREHOLE 5

Project No. : 1-22-0209-01
Date started : June 13, 2022
Sheet No. : 1 of 1

Client : Thomas Robert Colbeck
Project : 6360 Regional Road 25
Location : Milton, Ontario

Originated by : DH
Compiled by : HR
Checked by : MMT

Position : E: 593158, N: 4816475 (UTM 17T)
Rig type : Track-mounted

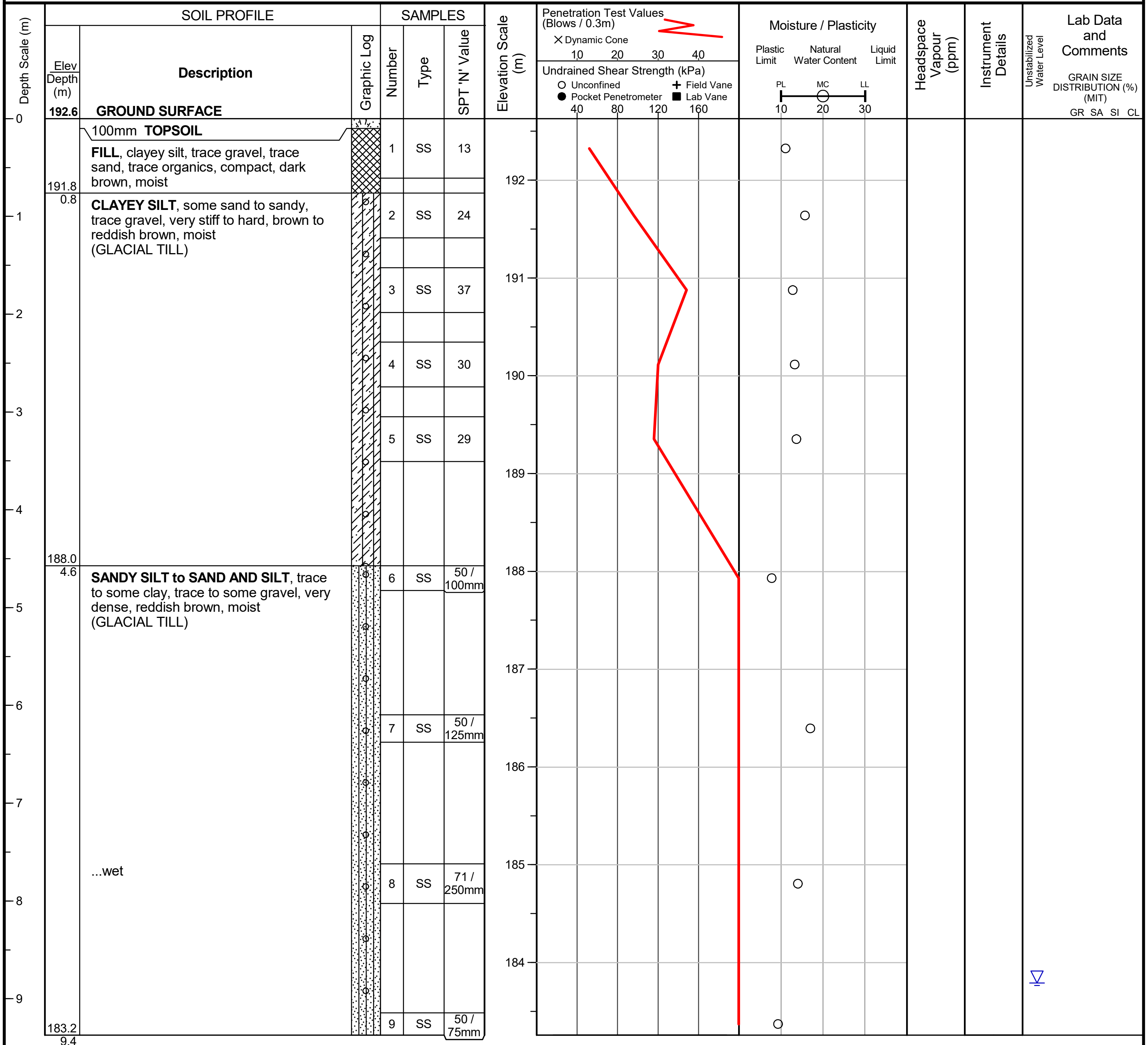
Elevation Datum : Geodetic
Drilling Method : Solid stem augers

SOIL PROFILE

Elev Depth (m)	Description
192.6	**GROUND SURFACE**
	100mm **TOPSOIL**
	FILL, clayey silt, trace gravel, trace sand, trace organics, compact, dark brown, moist
191.8 0.8	**CLAYEY SILT**, some sand to sandy, trace gravel, very stiff to hard, brown to reddish brown, moist (GLACIAL TILL)
188.0 4.6	**SANDY SILT to SAND AND SILT**, trace to some clay, trace to some gravel, very dense, reddish brown, moist (GLACIAL TILL) ...wet
183.2 9.4	**END OF BOREHOLE**

SAMPLES

Number	Type	SPT 'N' Value
1	SS	13
2	SS	24
3	SS	37
4	SS	30
5	SS	29
6	SS	50 / 100mm
7	SS	50 / 125mm
8	SS	71 / 250mm
9	SS	50 / 75mm



Unstabilized water level measured at 8.8 m below ground surface; borehole was open upon completion of drilling.

LOG OF BOREHOLE 6

Project No. : 1-22-0209-01
Date started : June 14, 2022
Sheet No. : 1 of 1

Client : Thomas Robert Colbeck
Project : 6360 Regional Road 25
Location : Milton, Ontario

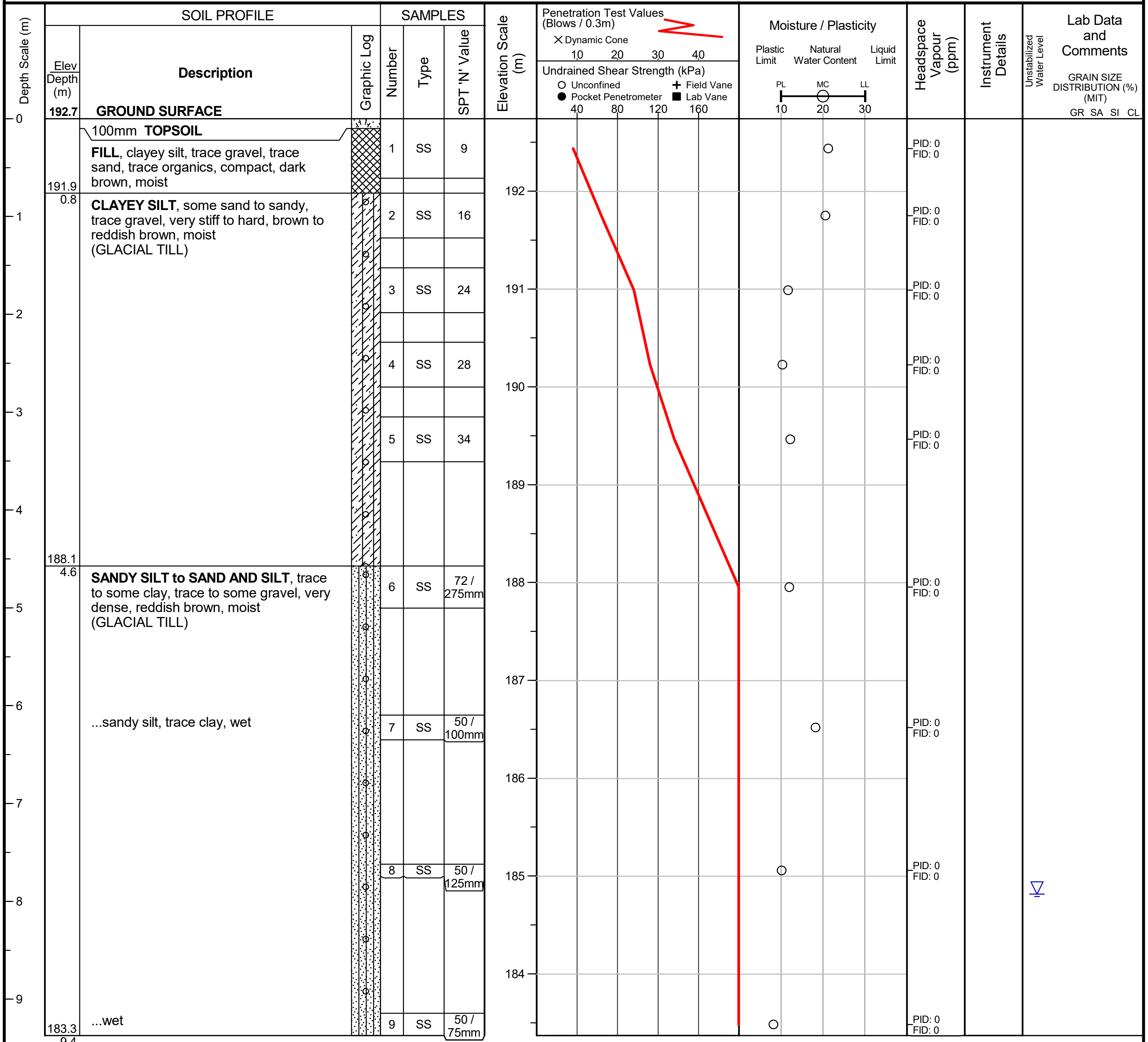
Originated by : DH
Compiled by : HR
Checked by : MMT

Position : E: 593175, N: 4816456 (UTM 17T)
Rig type : Track-mounted

Elevation Datum : Geodetic
Drilling Method : Solid stem augers

Elev Depth (m)	Description
192.7	**GROUND SURFACE**
	100mm **TOPSOIL**
191.9 0.8	**FILL**, clayey silt, trace gravel, trace sand, trace organics, compact, dark brown, moist
188.1 4.6	**CLAYEY SILT**, some sand to sandy, trace gravel, very stiff to hard, brown to reddish brown, moist (GLACIAL TILL)
183.3 9.4	**SANDY SILT to SAND AND SILT**, trace to some clay, trace to some gravel, very dense, reddish brown, moist (GLACIAL TILL) ...sandy silt, trace clay, wet ...wet

Number	Type	SPT 'N' Value	Headspace Vapour (ppm)
1	SS	9	PID: 0 FID: 0
2	SS	16	PID: 0 FID: 0
3	SS	24	PID: 0 FID: 0
4	SS	28	PID: 0 FID: 0
5	SS	34	PID: 0 FID: 0
6	SS	72 / 275mm	PID: 0 FID: 0
7	SS	50 / 100mm	PID: 0 FID: 0
8	SS	50 / 125mm	PID: 0 FID: 0
9	SS	50 / 75mm	PID: 0 FID: 0



END OF BOREHOLE

Unstabilized water level measured at 7.9 m below ground surface; borehole caved to 7.9 m below ground surface upon completion of drilling.

file: 1-22-0209-01 bh logs.gpj

Terraprobe

LOG OF BOREHOLE 7

Project No. : 1-22-0209-01
Client : Thomas Robert Colbeck
Originated by : DH

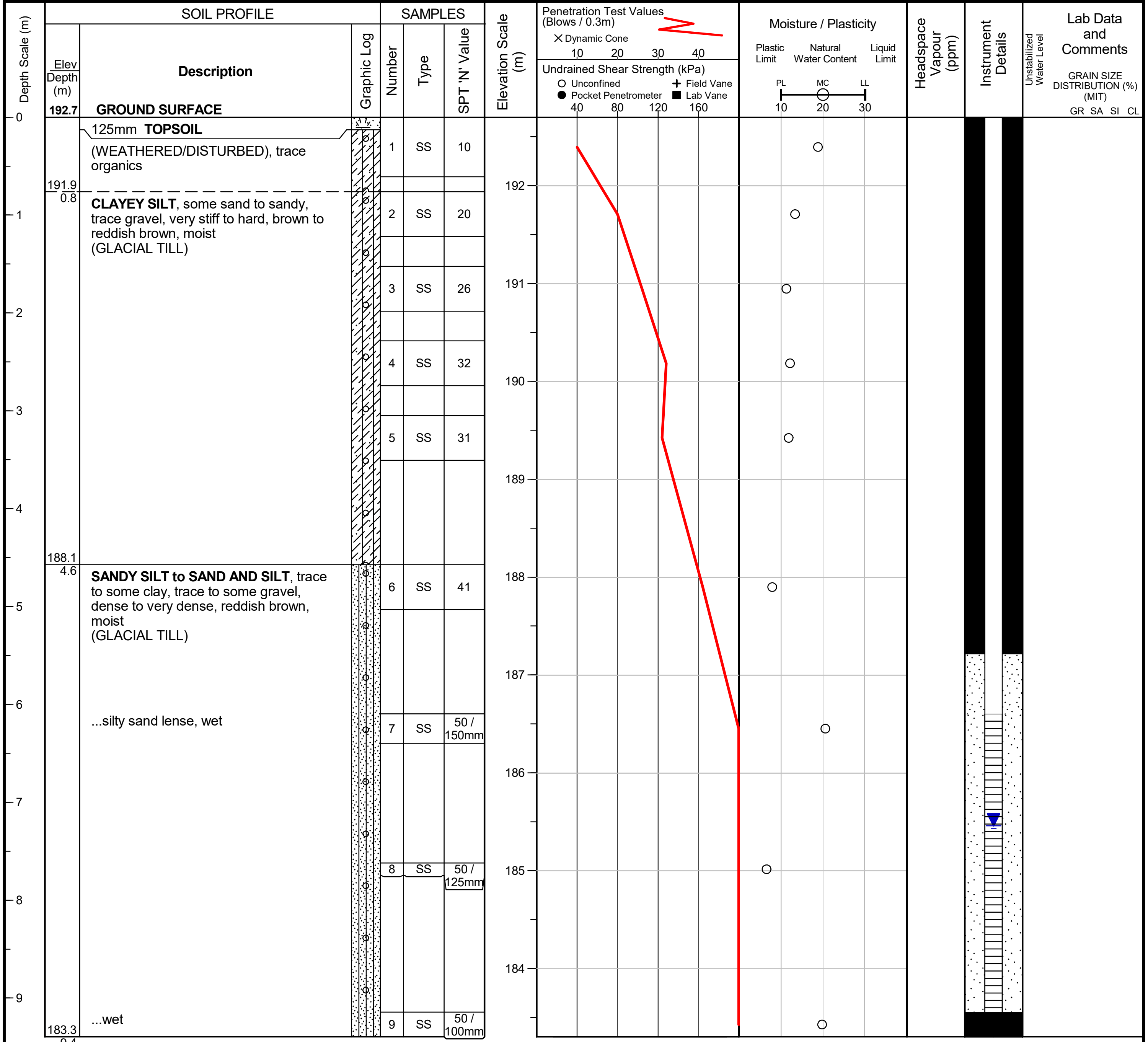
Date started : June 14, 2022
Project : 6360 Regional Road 25
Compiled by : HR

Sheet No. : 1 of 1
Location : Milton, Ontario
Checked by : MMT

Position : E: 593197, N: 4816435 (UTM 17T)
Elevation Datum : Geodetic

Rig type : Track-mounted
Drilling Method : Solid stem augers

Elev Depth (m)	Description	Sample Number	Type	SPT 'N' Value
192.7	**GROUND SURFACE**			
	125mm **TOPSOIL**			
	(WEATHERED/DISTURBED), trace organics	1	SS	10
191.9 0.8	**CLAYEY SILT**, some sand to sandy, trace gravel, very stiff to hard, brown to reddish brown, moist (GLACIAL TILL)	2	SS	20
		3	SS	26
		4	SS	32
		5	SS	31
188.1 4.6	**SANDY SILT to SAND AND SILT**, trace to some clay, trace to some gravel, dense to very dense, reddish brown, moist (GLACIAL TILL)	6	SS	41
	...silty sand lense, wet	7	SS	50 / 150mm
		8	SS	50 / 125mm
183.3 9.4	...wet	9	SS	50 / 100mm



END OF BOREHOLE

Borehole was dry and open upon completion of drilling.

50 mm dia. monitoring well installed.

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Jul 14, 2022	7.2	185.5

Terraprobe

LOG OF BOREHOLE 8

Project No. : 1-22-0209-01
Date started : June 14, 2022
Sheet No. : 1 of 1

Client : Thomas Robert Colbeck
Project : 6360 Regional Road 25
Location : Milton, Ontario

Originated by : DH
Compiled by : HR
Checked by : MMT

Position : E: 593216, N: 4816419 (UTM 17T)
Rig type : Track-mounted

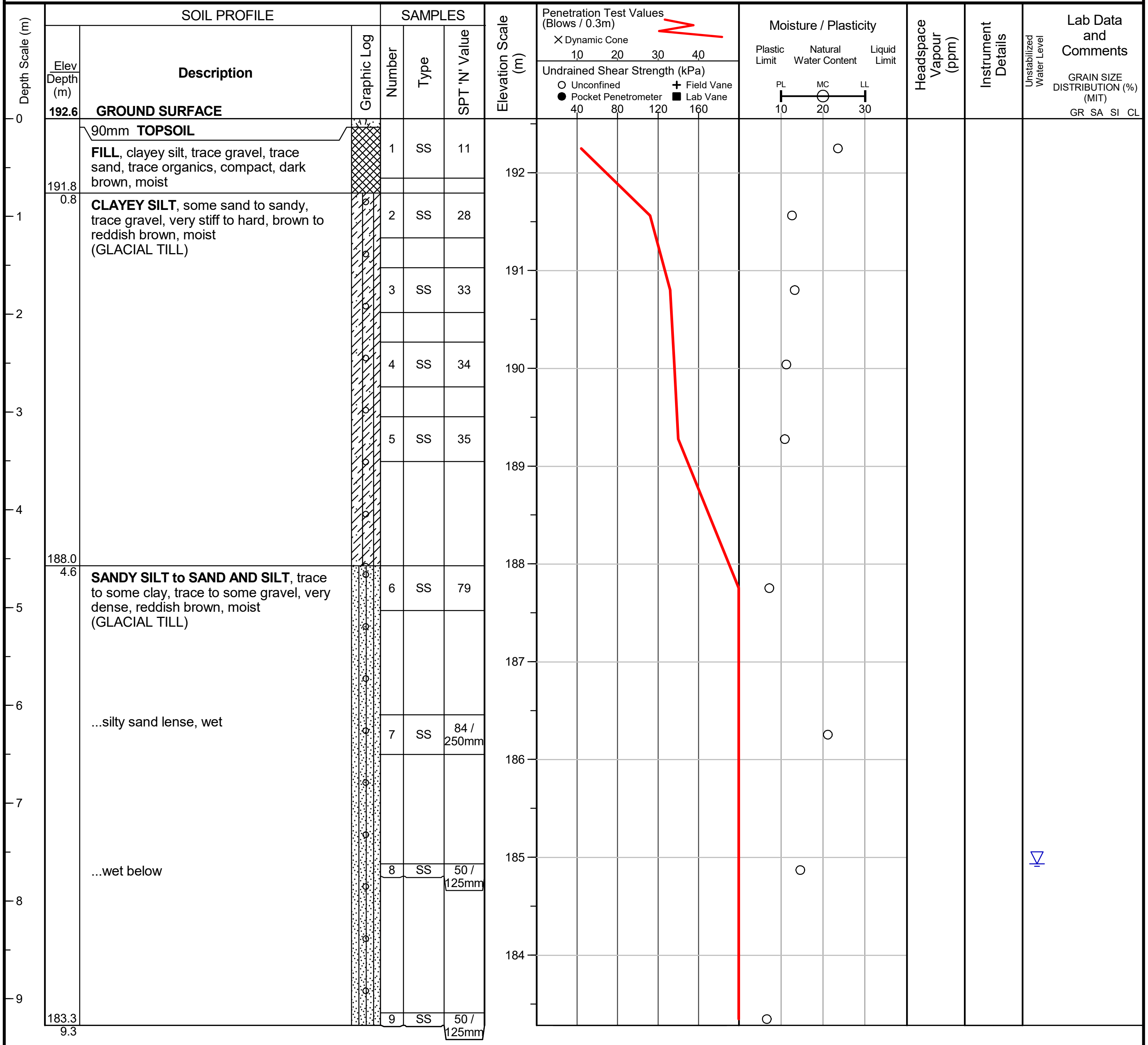
Elevation Datum : Geodetic
Drilling Method : Solid stem augers

SOIL PROFILE

Elev Depth (m)	Description
192.6	**GROUND SURFACE**
	90mm **TOPSOIL**
	FILL, clayey silt, trace gravel, trace sand, trace organics, compact, dark brown, moist
191.8 0.8	**CLAYEY SILT**, some sand to sandy, trace gravel, very stiff to hard, brown to reddish brown, moist (GLACIAL TILL)
188.0 4.6	**SANDY SILT to SAND AND SILT**, trace to some clay, trace to some gravel, very dense, reddish brown, moist (GLACIAL TILL) ...silty sand lense, wet ...wet below
183.3 9.3	**END OF BOREHOLE**

SAMPLES

Number	Type	SPT 'N' Value
1	SS	11
2	SS	28
3	SS	33
4	SS	34
5	SS	35
6	SS	79
7	SS	84 / 250mm
8	SS	50 / 125mm
9	SS	50 / 125mm



Unstabilized water level measured at 7.6 m below ground surface; borehole caved to 7.9 m below ground surface upon completion of drilling.

LOG OF BOREHOLE 9

Project No. : 1-22-0209-01
Date started : June 15, 2022
Sheet No. : 1 of 1

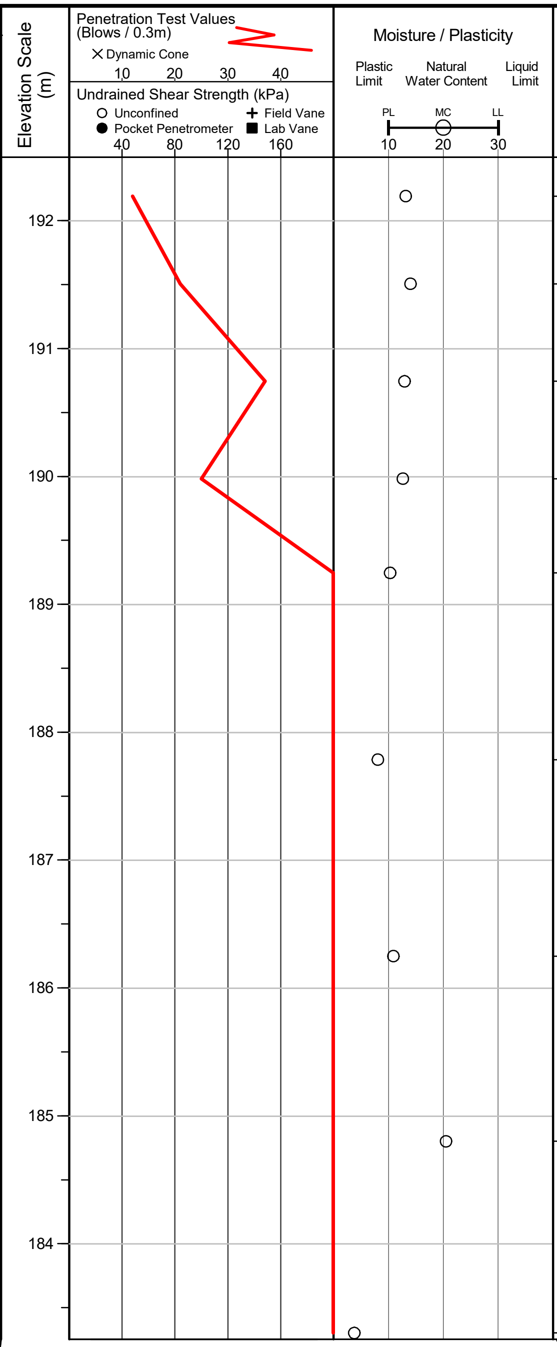
Client : Thomas Robert Colbeck
Project : 6360 Regional Road 25
Location : Milton, Ontario

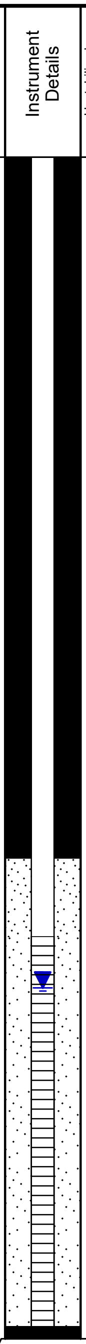
Originated by : DH
Compiled by : HR
Checked by : MMT

Position : E: 593172, N: 4816498 (UTM 17T)
Rig type : Track-mounted

Elevation Datum : Geodetic
Drilling Method : Solid stem augers

Elev Depth (m)	Description	Sample Number	Type	SPT 'N' Value	Headspace Vapour (ppm)
192.5	**GROUND SURFACE**				
	125mm **TOPSOIL**				
191.7 0.8	**FILL**, clayey silt, trace gravel, trace sand, trace organics, stiff, dark brown, moist	1	SS	12	PID: 0 FID: 0
189.5 3.0	**CLAYEY SILT**, some sand to sandy, trace gravel, very stiff to hard, brown to reddish brown, moist (GLACIAL TILL)	2	SS	21	PID: 0 FID: 0
		3	SS	37	PID: 0 FID: 0
		4	SS	25	PID: 0 FID: 0
	SANDY SILT to SAND AND SILT, trace to some clay, trace to some gravel, very dense, reddish brown, moist (GLACIAL TILL)	5	SS	62	PID: 0 FID: 0
		6	SS	50 / 125mm	PID: 0 FID: 0
	...wet below	7	SS	50 / 150mm	PID: 0 FID: 0
	...sand and silt lense	8	SS	50 / 150mm	PID: 0 FID: 0
183.3 9.2		9	SS	50 / 100mm	PID: 0 FID: 0





Lab Data and Comments
GRAIN SIZE DISTRIBUTION (%) (MIT)
GR SA SI CL

END OF BOREHOLE

Borehole was dry and open upon completion of drilling.

50 mm dia. monitoring well installed.

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Jul 14, 2022	6.5	186.0

Terraprobe

LOG OF BOREHOLE 10

Project No. : 1-22-0209-01
Date started : June 16, 2022
Sheet No. : 1 of 1

Client : Thomas Robert Colbeck
Project : 6360 Regional Road 25
Location : Milton, Ontario

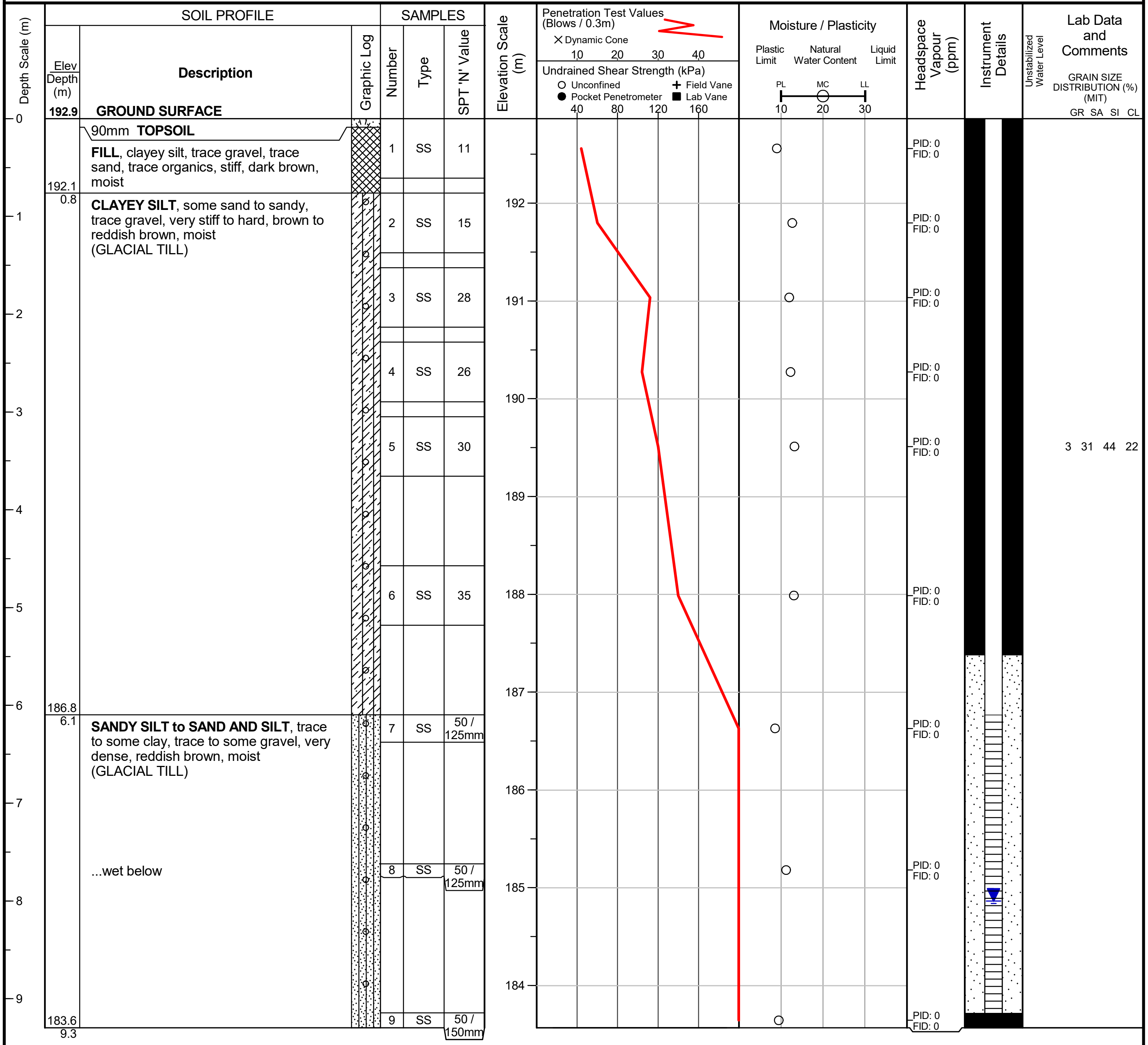
Originated by : DH
Compiled by : HR
Checked by : MMT

Position : E: 593184, N: 4816470 (UTM 17T)
Rig type : Track-mounted

Elevation Datum : Geodetic
Drilling Method : Solid stem augers

Elev Depth (m)	SOIL PROFILE – Description
192.9	**GROUND SURFACE**
	90mm **TOPSOIL**
	FILL, clayey silt, trace gravel, trace sand, trace organics, stiff, dark brown, moist
192.1 0.8	**CLAYEY SILT**, some sand to sandy, trace gravel, very stiff to hard, brown to reddish brown, moist (GLACIAL TILL)
186.8 6.1	**SANDY SILT to SAND AND SILT**, trace to some clay, trace to some gravel, very dense, reddish brown, moist (GLACIAL TILL) ...wet below
183.6 9.3	

Number	Type	SPT 'N' Value	Headspace Vapour (ppm)	Lab Data and Comments – GRAIN SIZE DISTRIBUTION (%) (MIT) GR SA SI CL
1	SS	11	PID: 0 FID: 0	
2	SS	15	PID: 0 FID: 0	
3	SS	28	PID: 0 FID: 0	
4	SS	26	PID: 0 FID: 0	
5	SS	30	PID: 0 FID: 0	3 31 44 22
6	SS	35	PID: 0 FID: 0	
7	SS	50 / 125mm	PID: 0 FID: 0	
8	SS	50 / 125mm	PID: 0 FID: 0	
9	SS	50 / 150mm	PID: 0 FID: 0	



END OF BOREHOLE

Borehole was dry and open upon completion of drilling.

50 mm dia. monitoring well installed.

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Jul 14, 2022	8.0	184.9

LOG OF BOREHOLE 11

Project No. : 1-22-0209-01
Date started : June 15, 2022
Sheet No. : 1 of 1

Client : Thomas Robert Colbeck
Project : 6360 Regional Road 25
Location : Milton, Ontario

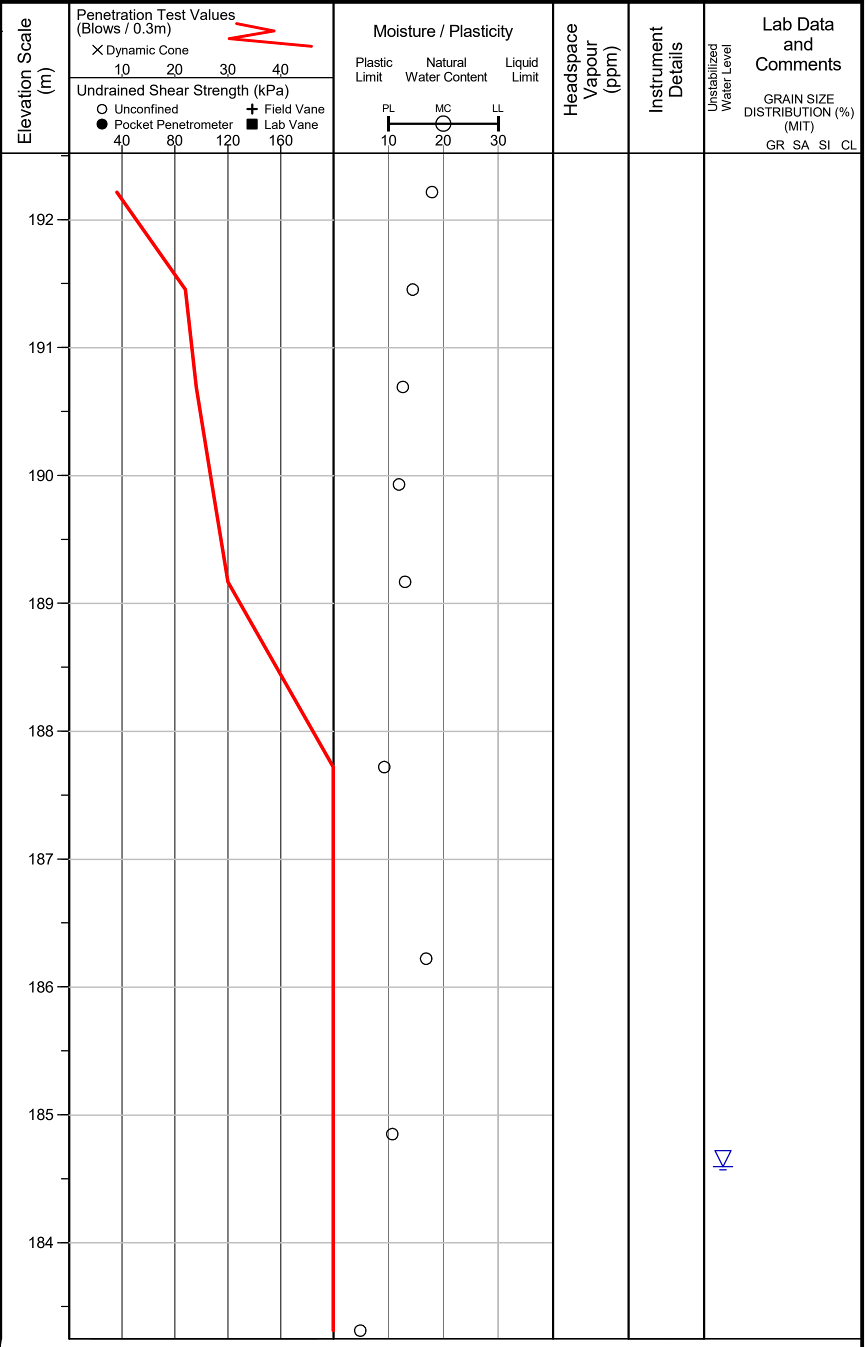
Originated by : DH
Compiled by : HR
Checked by : MMT

Position : E: 593207, N: 4816449 (UTM 17T)
Rig type : Track-mounted
Elevation Datum : Geodetic
Drilling Method : Solid stem augers

Elev Depth (m)	Description	Number	Type	SPT 'N' Value
192.5	**GROUND SURFACE**			
	115mm **TOPSOIL**			
	FILL, clayey silt, trace gravel, trace sand, trace organics, stiff, dark brown, moist	1	SS	9
191.7 0.8	**CLAYEY SILT**, some sand to sandy, trace gravel, very stiff to hard, brown to reddish brown, moist (GLACIAL TILL)	2	SS	22
		3	SS	24
		4	SS	27
		5	SS	30
187.9 4.6	**SANDY SILT to SAND AND SILT**, trace to some clay, trace to some gravel, very dense, reddish brown, moist (GLACIAL TILL)	6	SS	74
	...wet	7	SS	82 / 250mm
	...wet below	8	SS	50 / 100mm
183.2 9.3		9	SS	50 / 125mm

END OF BOREHOLE

Unstabilized water level measured at 7.9 m below ground surface; borehole caved to 8.8 m below ground surface upon completion of drilling.



LOG OF BOREHOLE 12

Project No. : 1-22-0209-01
Date started : June 14, 2022
Sheet No. : 1 of 1

Client : Thomas Robert Colbeck
Project : 6360 Regional Road 25
Location : Milton, Ontario

Originated by : DH
Compiled by : HR
Checked by : MMT

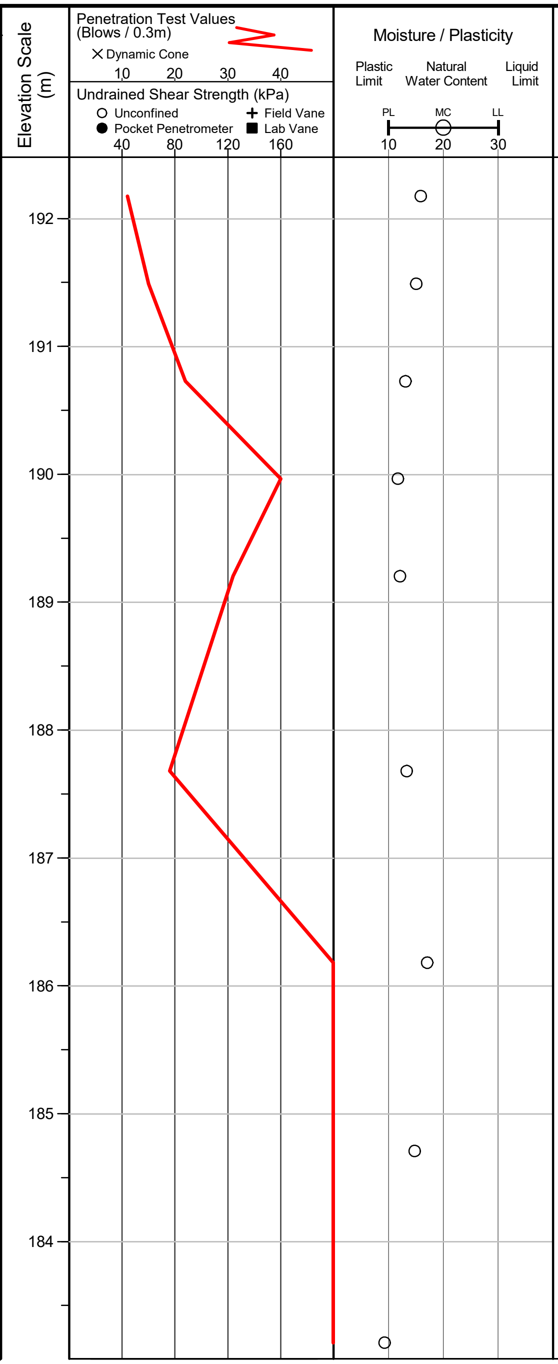
Position : E: 593228, N: 4816434 (UTM 17T)
Rig type : Track-mounted
Elevation Datum : Geodetic
Drilling Method : Solid stem augers

SOIL PROFILE

Elev (m)	Depth (m)	Description
192.5	0	**GROUND SURFACE**
		100mm **TOPSOIL**
		(WEATHERED/DISTURBED)
191.7	0.8	**CLAYEY SILT**, some sand to sandy, trace gravel, very stiff to hard, brown to reddish brown, moist (GLACIAL TILL)
186.4	6.1	**SAND**, trace silt, trace clay, very dense, brown, wet
184.9	7.6	**SANDY SILT to SAND AND SILT**, trace to some clay, trace to some gravel, very dense, reddish brown, wet (GLACIAL TILL)
183.1	9.4	**END OF BOREHOLE**

SAMPLES

Number	Type	SPT 'N' Value
1	SS	11
2	SS	15
3	SS	22
4	SS	40
5	SS	31
6	SS	19
7	SS	26 / 250mm
8	SS	50 / 150mm
9	SS	50 / 100mm



Headspace Vapour (ppm)

Instrument Details

Unstabilized Water Level: ∇ at 7.6 m

Lab Data and Comments
GRAIN SIZE DISTRIBUTION (%) (MIT)
GR SA SI CL

Unstabilized water level measured at 7.6 m below ground surface; borehole caved to 8.8 m below ground surface upon completion of drilling.

LOG OF BOREHOLE 13

Project No. : 1-22-0209-01
Date started : June 16, 2022
Sheet No. : 1 of 1

Client : Thomas Robert Colbeck
Project : 6360 Regional Road 25
Location : Milton, Ontario

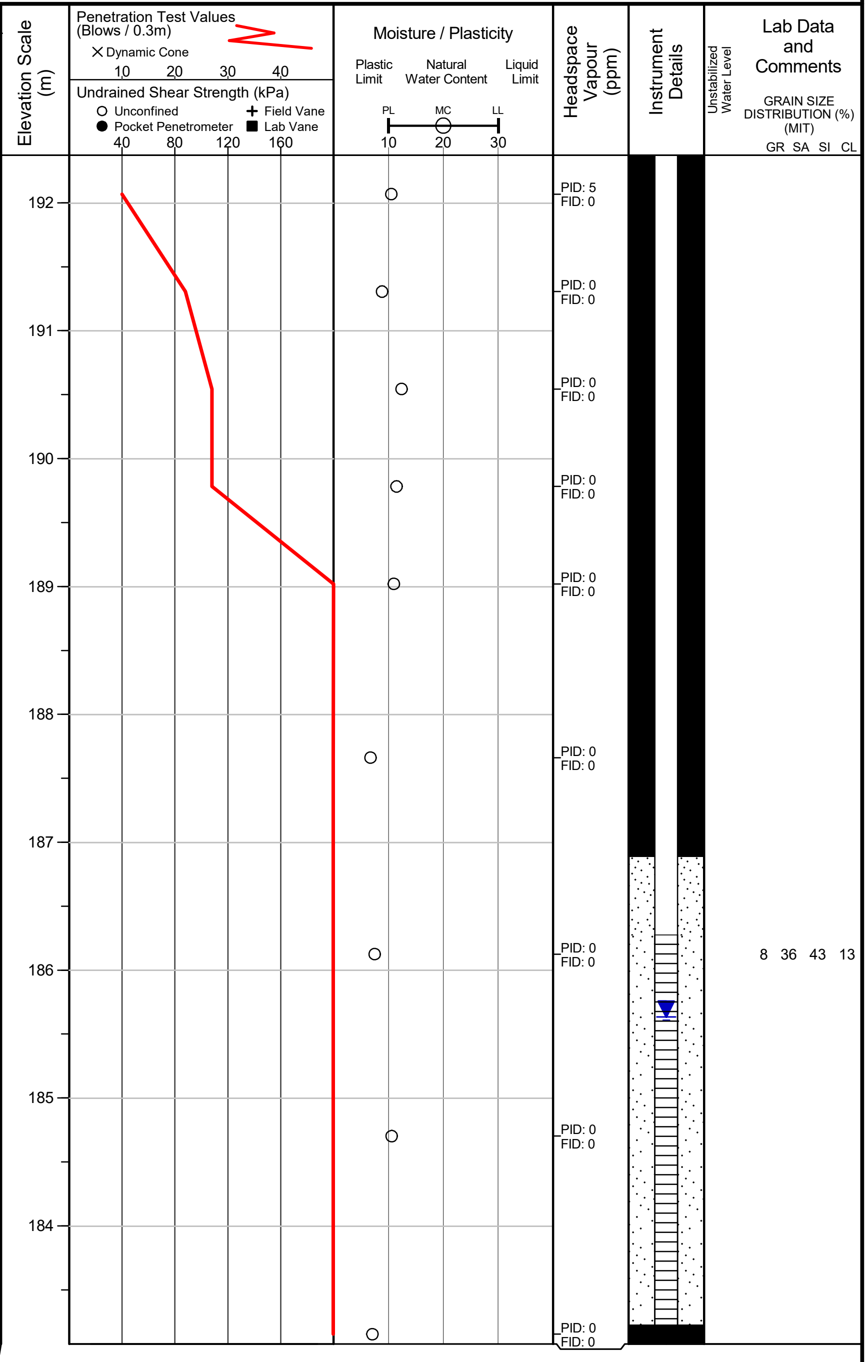
Originated by : DH
Compiled by : HR
Checked by : MMT

Position : E: 593188, N: 4816515 (UTM 17T)
Rig type : Track-mounted

Elevation Datum : Geodetic
Drilling Method : Solid stem augers

Elev Depth (m)	Description
192.4	**GROUND SURFACE**
	90mm **TOPSOIL**
191.6 0.8	**FILL**, clayey silt, trace gravel, trace sand, trace organics, stiff, dark brown, moist
189.4 3.0	**CLAYEY SILT**, some sand to sandy, trace gravel, very stiff, brown to reddish brown, moist (GLACIAL TILL)
183.1 9.3	**SANDY SILT to SAND AND SILT**, trace to some clay, trace to some gravel, very dense, reddish brown, moist (GLACIAL TILL) ...wet below

Number	Type	SPT 'N' Value	Headspace Vapour (ppm)	Lab Data and Comments GRAIN SIZE DISTRIBUTION (%) (MIT) GR SA SI CL
1	SS	10	PID: 5 FID: 0	
2	SS	22	PID: 0 FID: 0	
3	SS	27	PID: 0 FID: 0	
4	SS	27	PID: 0 FID: 0	
5	SS	50	PID: 0 FID: 0	
6	SS	50 / 125mm	PID: 0 FID: 0	
7	SS	50 / 150mm	PID: 0 FID: 0	8 36 43 13
8	SS	50 / 100mm	PID: 0 FID: 0	
9	SS	50 / 150mm	PID: 0 FID: 0	



Depth Scale (m): 0 – 9

END OF BOREHOLE

Borehole was dry and open upon completion of drilling.

50 mm dia. monitoring well installed.

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Jul 14, 2022	6.7	185.6

file: 1-22-0209-01 bh logs.gpj

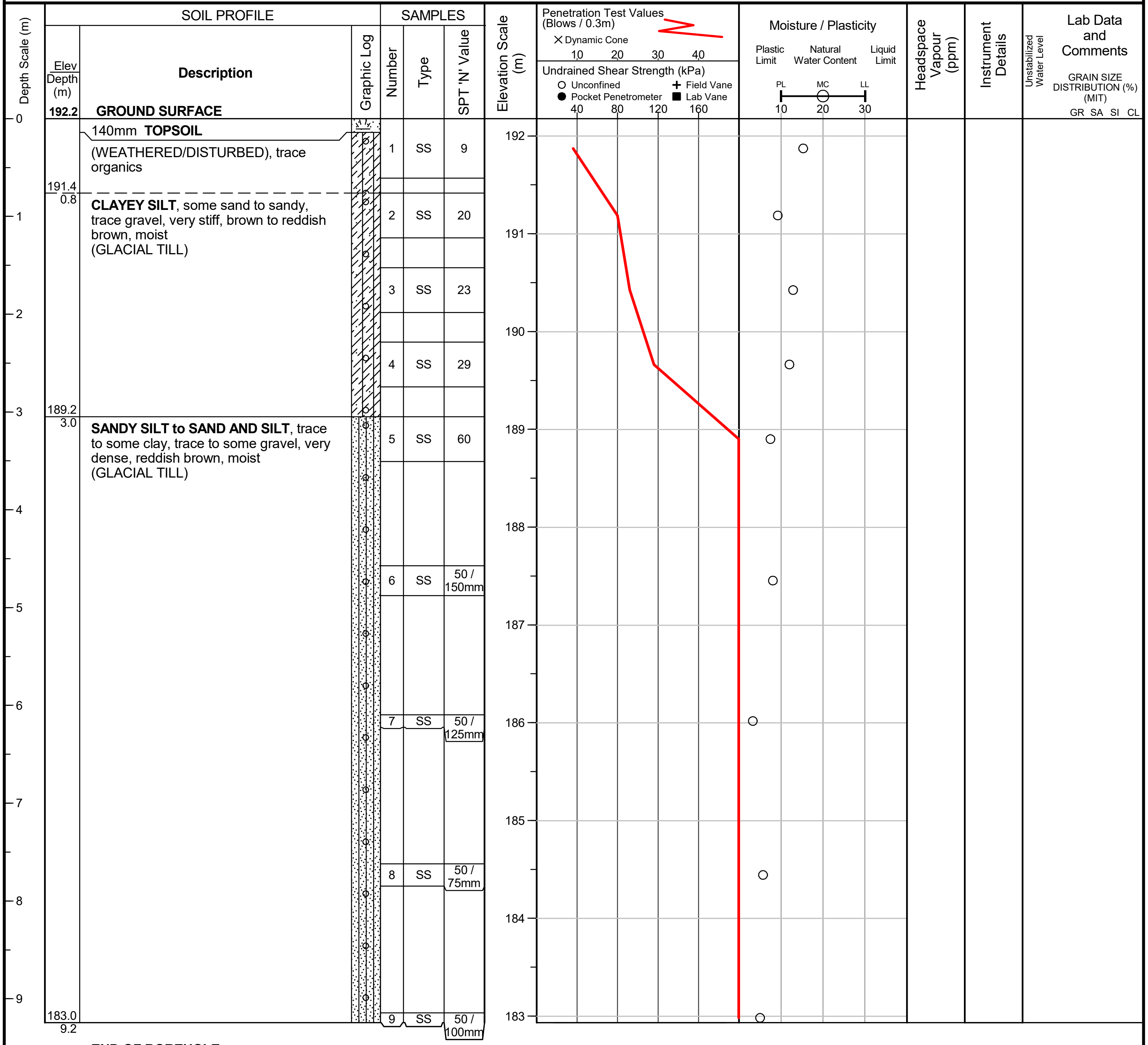
Terraprobe

LOG OF BOREHOLE 14

Project No.	: 1-22-0209-01	Client	: Thomas Robert Colbeck	Originated by	: DH
Date started	: June 16, 2022	Project	: 6360 Regional Road 25	Compiled by	: HR
Sheet No.	: 1 of 1	Location	: Milton, Ontario	Checked by	: MMT

Position	: E: 593207, N: 4816494 (UTM 17T)	Elevation Datum	: Geodetic
Rig type	: Track-mounted	Drilling Method	: Solid stem augers

Elev Depth (m)	Description	Number	Type	SPT 'N' Value
192.2	**GROUND SURFACE**			
	140mm **TOPSOIL**			
	(WEATHERED/DISTURBED), trace organics	1	SS	9
191.4 0.8	**CLAYEY SILT**, some sand to sandy, trace gravel, very stiff, brown to reddish brown, moist (GLACIAL TILL)	2	SS	20
		3	SS	23
		4	SS	29
189.2 3.0	**SANDY SILT to SAND AND SILT**, trace to some clay, trace to some gravel, very dense, reddish brown, moist (GLACIAL TILL)	5	SS	60
		6	SS	50 / 150mm
		7	SS	50 / 125mm
		8	SS	50 / 75mm
183.0 9.2		9	SS	50 / 100mm



END OF BOREHOLE

Borehole was dry and open upon completion of drilling.

file: 1-22-0209-01 bh logs.gpj

Terraprobe

LOG OF BOREHOLE 15

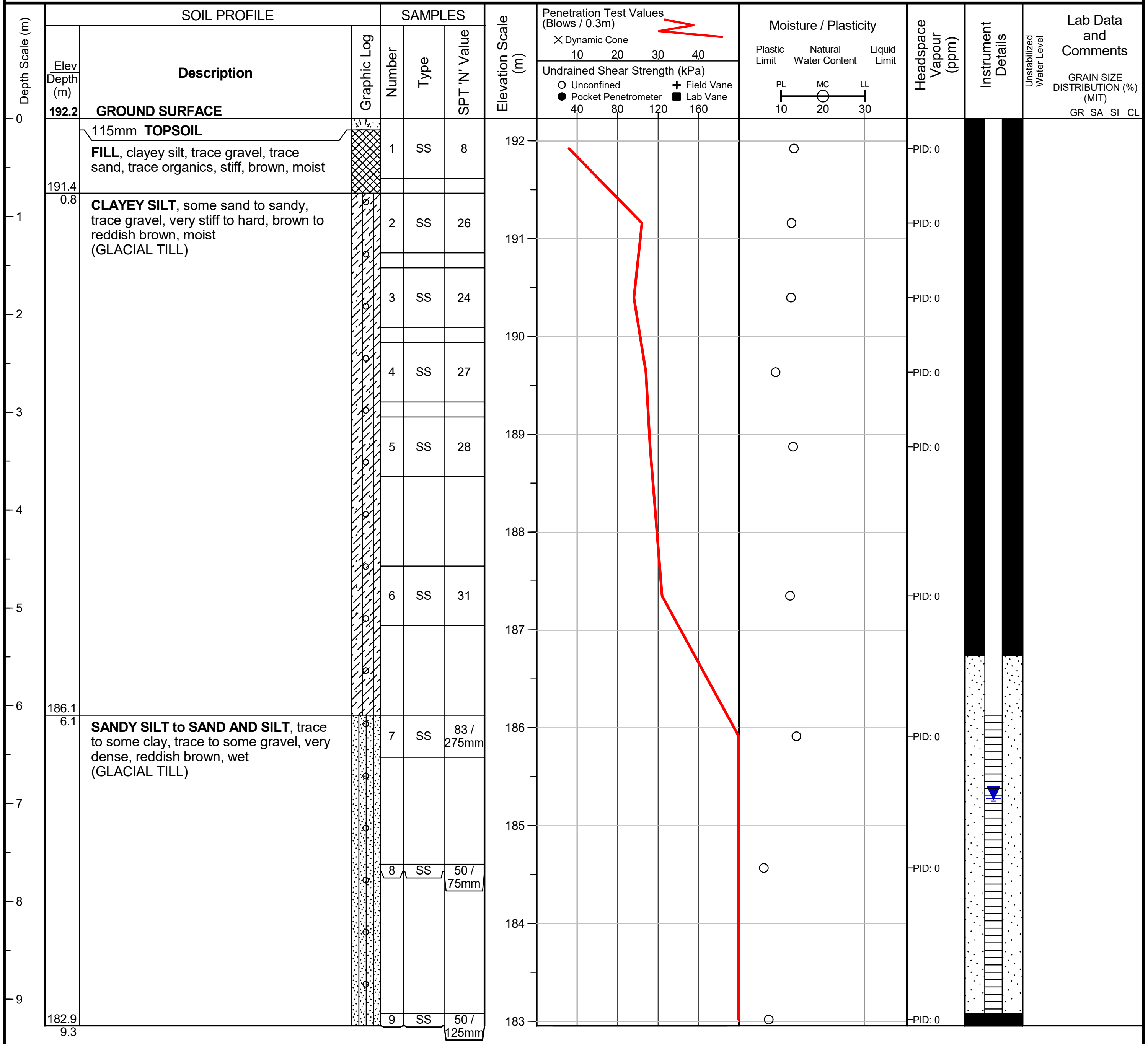
Project No. : 1-22-0209-01
Date started : June 16, 2022
Sheet No. : 1 of 1

Client : Thomas Robert Colbeck
Project : 6360 Regional Road 25
Location : Milton, Ontario

Originated by : DH
Compiled by : HR
Checked by : MMT

Position : E: 593225, N: 4816475 (UTM 17T)
Rig type : Track-mounted

Elevation Datum : Geodetic
Drilling Method : Solid stem augers



Elev Depth (m)	Description
192.2	**GROUND SURFACE**
	115mm **TOPSOIL**
	FILL, clayey silt, trace gravel, trace sand, trace organics, stiff, brown, moist
191.4 0.8	**CLAYEY SILT**, some sand to sandy, trace gravel, very stiff to hard, brown to reddish brown, moist (GLACIAL TILL)
186.1 6.1	**SANDY SILT to SAND AND SILT**, trace to some clay, trace to some gravel, very dense, reddish brown, wet (GLACIAL TILL)
182.9 9.3	

Number	Type	SPT 'N' Value	Headspace Vapour (ppm)
1	SS	8	PID: 0
2	SS	26	PID: 0
3	SS	24	PID: 0
4	SS	27	PID: 0
5	SS	28	PID: 0
6	SS	31	PID: 0
7	SS	83 / 275mm	PID: 0
8	SS	50 / 75mm	PID: 0
9	SS	50 / 125mm	PID: 0

END OF BOREHOLE

Borehole was dry and open upon completion of drilling.

50 mm dia. monitoring well installed.

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Jul 14, 2022	7.0	185.3

file: 1-22-0209-01 bh logs.gpj

Terraprobe

LOG OF BOREHOLE 16

Project No. : 1-22-0209-01
Date started : June 15, 2022
Sheet No. : 1 of 1

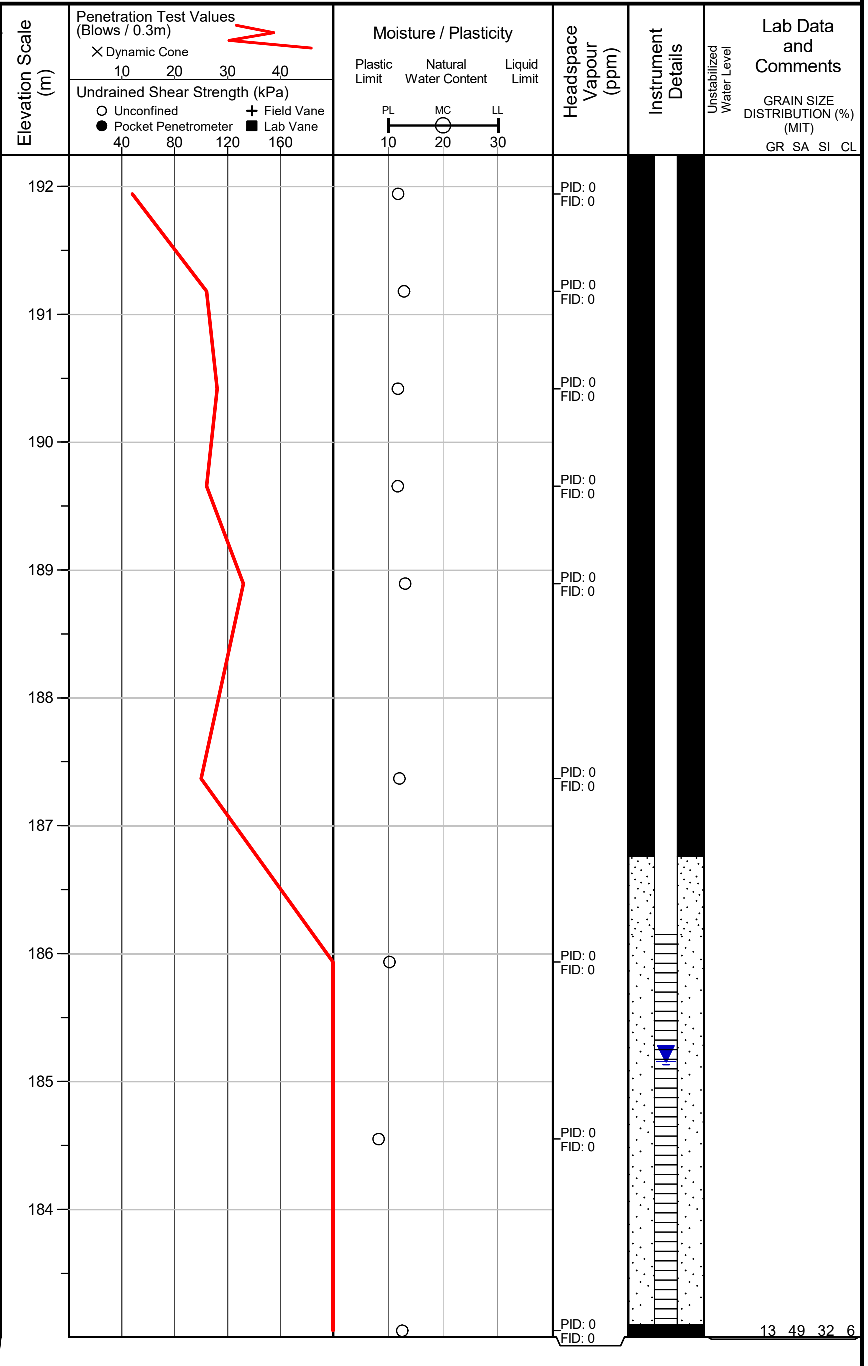
Client : Thomas Robert Colbeck
Project : 6360 Regional Road 25
Location : Milton, Ontario

Originated by : DH
Compiled by : HR
Checked by : MMT

Position : E: 593246, N: 4816455 (UTM 17T)
Rig type : Track-mounted

Elevation Datum : Geodetic
Drilling Method : Solid stem augers

Elev Depth (m)	Description	Number	Type	SPT 'N' Value
192.2	**GROUND SURFACE**			
	125mm **TOPSOIL**			
	(WEATHERED/DISTURBED), trace organics	1	SS	12
191.4 0.8	**CLAYEY SILT**, some sand to sandy, trace gravel, very stiff to hard, brown to reddish brown, moist (GLACIAL TILL)	2	SS	26
		3	SS	28
		4	SS	26
		5	SS	33
		6	SS	25
186.1 6.1	**SANDY SILT to SAND AND SILT**, trace to some clay, trace to some gravel, very dense, reddish brown, moist (GLACIAL TILL)	7	SS	84 / 275mm
	...wet below	8	SS	50 / 150mm
183.0 9.2		9	SS	50 / 100mm



END OF BOREHOLE

Borehole was dry and open upon completion of drilling.

50 mm dia. monitoring well installed.

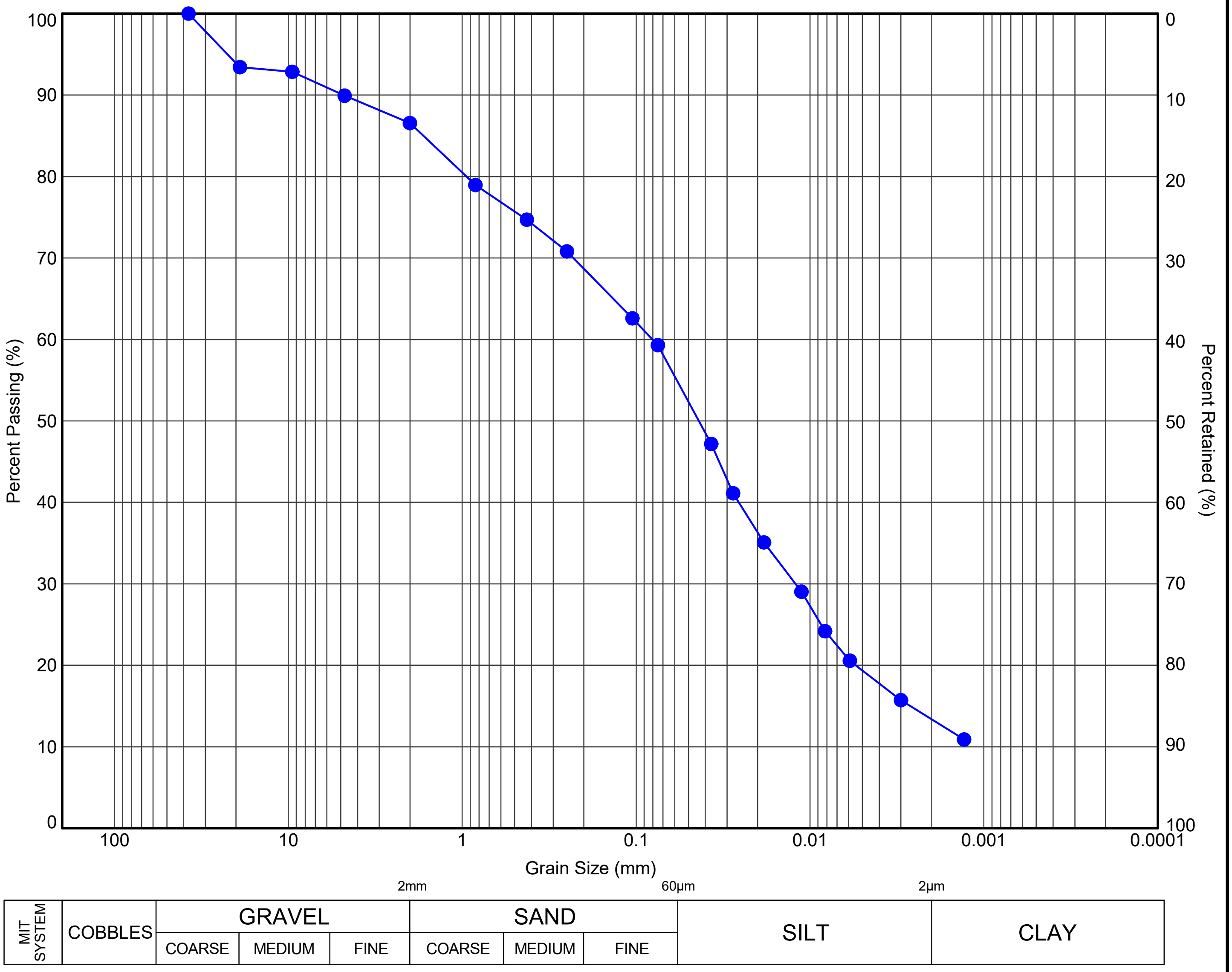
WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Jul 14, 2022	7.1	185.2

file: 1-22-0209-01 bh logs.gpj

APPENDIX B

TERRAPROBE INC.



MIT SYSTEM

	Hole ID	Sample	Depth (m)	Elev. (m)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	*(Fines, %)*
●	**1**	SS8	7.7	184.4	13	32	42	13	

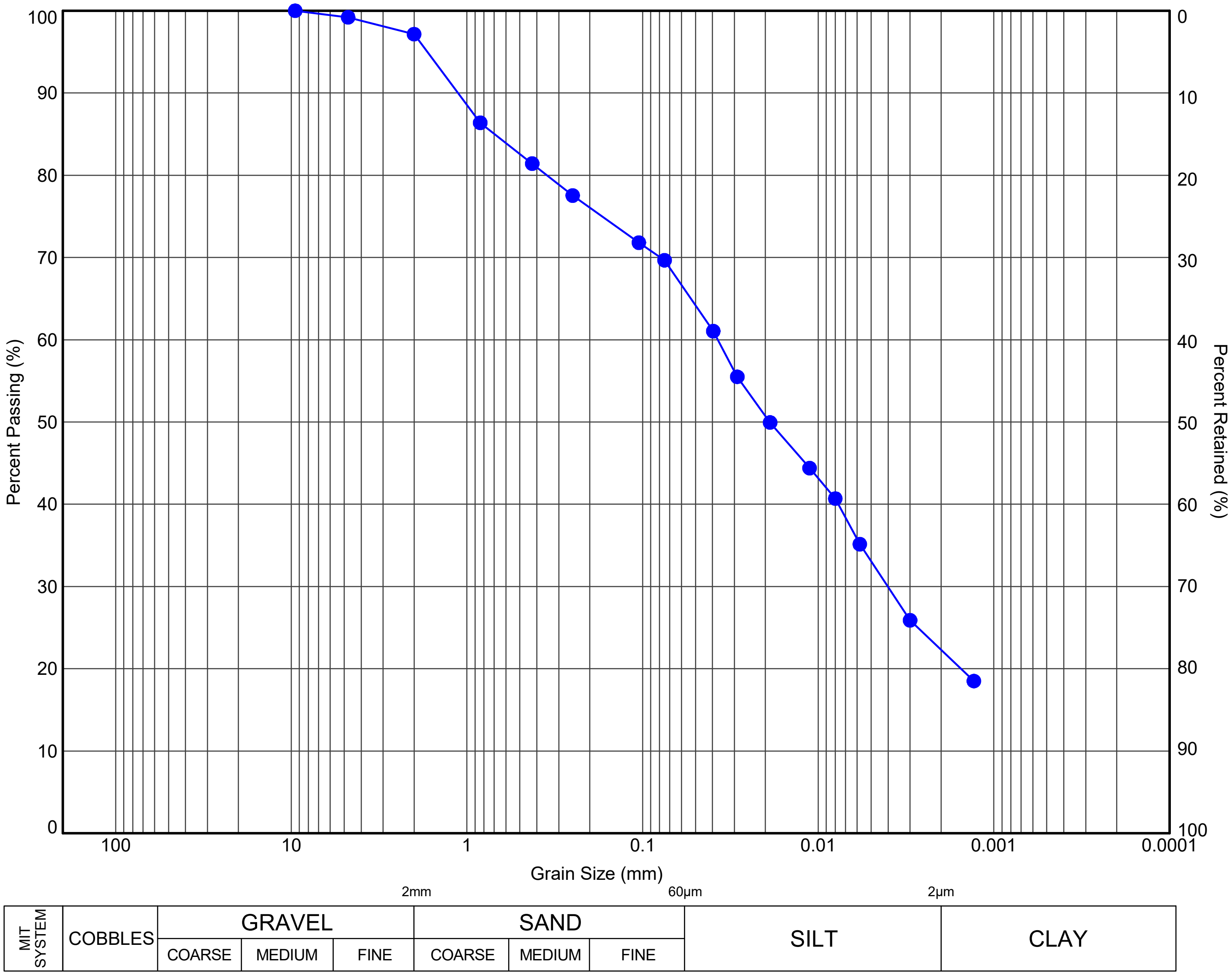
Terraprobe

11 Indell Lane, Brampton Ontario L6T 3Y3
(905) 796-2650

Title:

GRAIN SIZE DISTRIBUTION
SANDY SILT, SOME GRAVEL, SOME CLAY

File No.: **1-22-0209-01**



	Hole ID	Sample	Depth (m)	Elev. (m)	MIT SYSTEM Gravel (%)	Sand (%)	Silt (%)	Clay (%)	*(Fines, %)*
●	**10**	SS5	3.4	189.5	3	31	44	22	

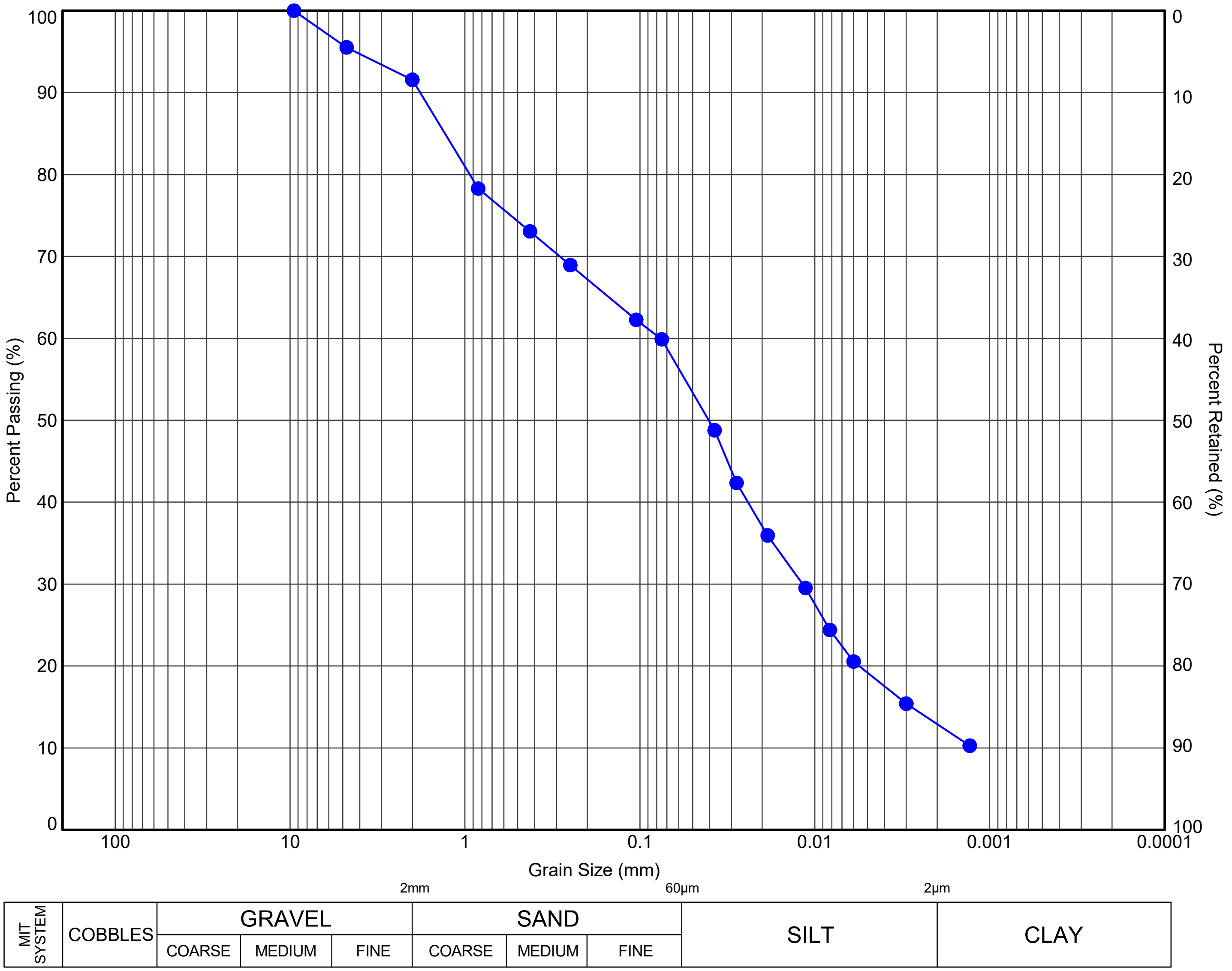
Terraprobe

11 Indell Lane, Brampton Ontario L6T 3Y3
(905) 796-2650

Title:

GRAIN SIZE DISTRIBUTION
SANDY SILT, CLAYEY, TRACE GRAVEL

File No.: **1-22-0209-01**



MIT SYSTEM

	Hole ID	Sample	Depth (m)	Elev. (m)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	*(Fines, %)*
●	**13**	SS7	6.2	186.1	8	36	43	13	

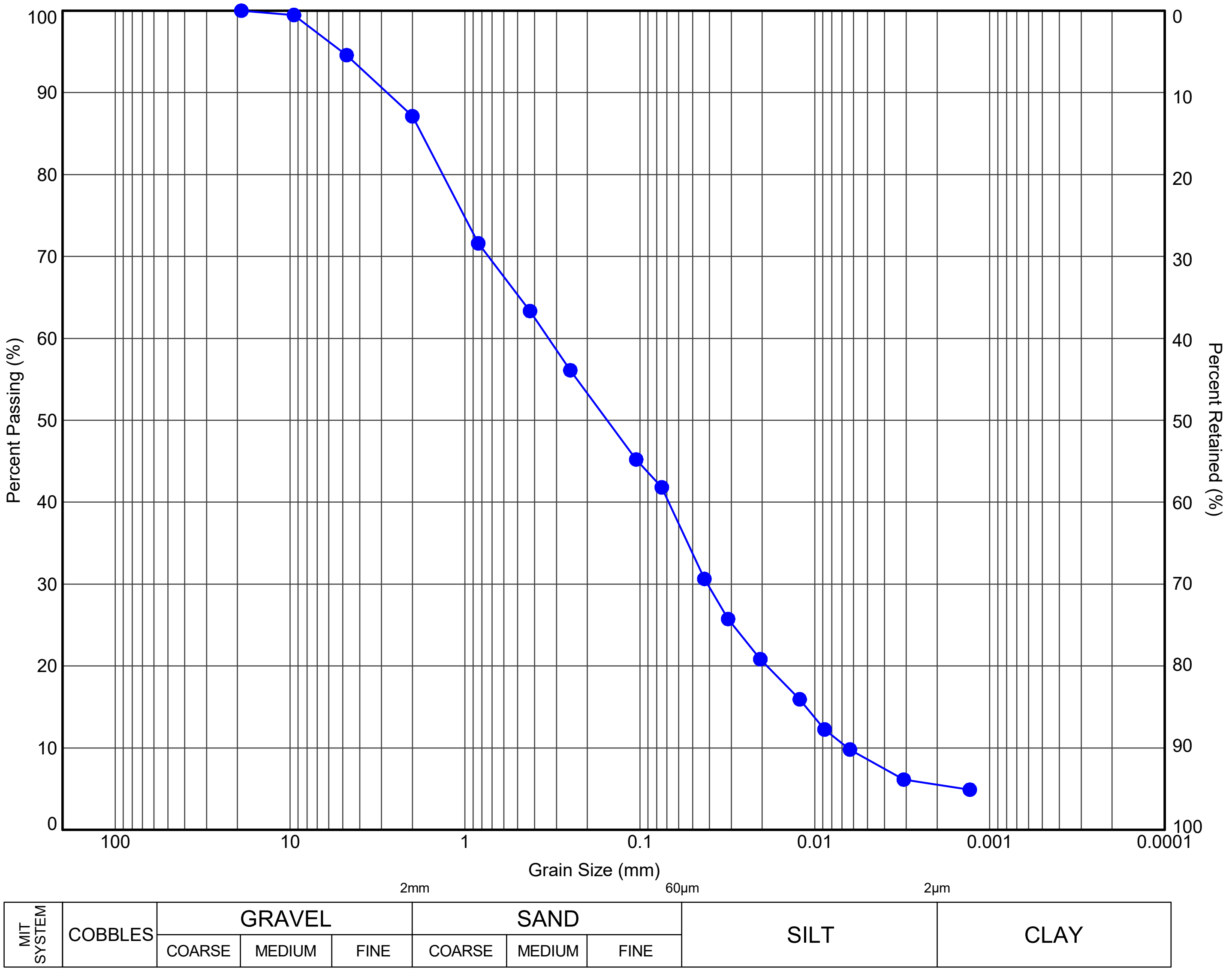
Terraprobe

11 Indell Lane, Brampton Ontario L6T 3Y3
(905) 796-2650

Title:

GRAIN SIZE DISTRIBUTION
SAND AND SILT, SOME CLAY, TRACE GRAVEL

File No.: **1-22-0209-01**



					MIT SYSTEM				
	Hole ID	Sample	Depth (m)	Elev. (m)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	*(Fines, %)*
●	**16**	SS9	9.2	183.1	13	49	32	6	

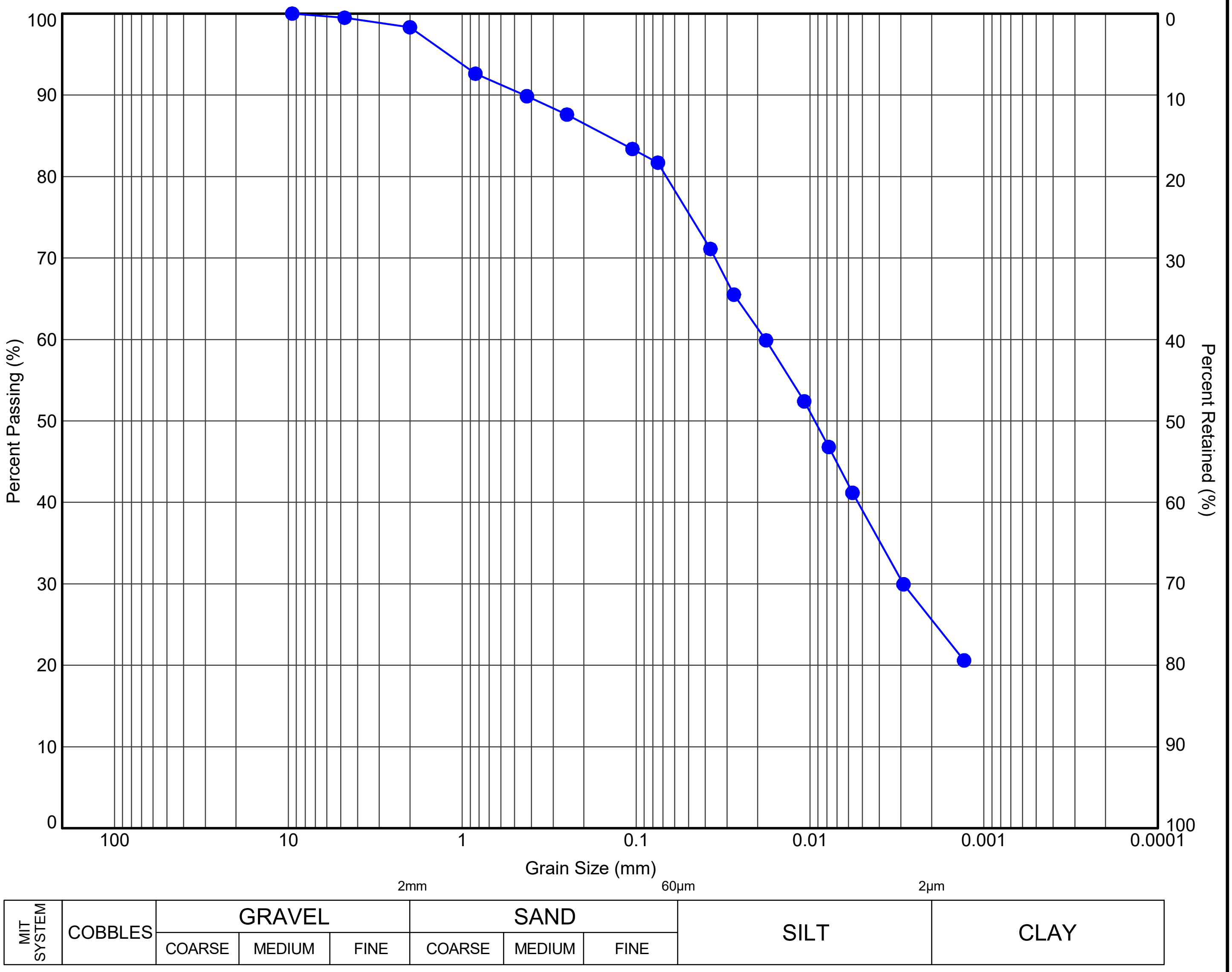
Terraprobe

11 Indell Lane, Brampton Ontario L6T 3Y3
(905) 796-2650

Title:

GRAIN SIZE DISTRIBUTION
SILTY SAND, SOME GRAVEL, TRACE CLAY

File No.: **1-22-0209-01**



	Hole ID	Sample	Depth (m)	Elev. (m)	MIT SYSTEM Gravel (%)	Sand (%)	Silt (%)	Clay (%)	*(Fines, %)*
●	**4**	SS6	4.8	187.8	2	19	53	26	

Terraprobe

11 Indell Lane, Brampton Ontario L6T 3Y3
(905) 796-2650

Title:

GRAIN SIZE DISTRIBUTION
CLAYEY SILT, SOME SAND, TRACE GRAVEL

File No.: **1-22-0209-01**

APPENDIX C

TERRAPROBE INC.

2910 12TH STREET NE
CALGARY, ALBERTA
CANADA T2E 7P7
TEL (403)735-2005
FAX (403)735-2771
http://www.agatlabs.com

CLIENT NAME: **TERRAPROBE INC.**
11 INDELL LANE
BRAMPTON, ON L6T3Y3
(905) 796-2650

ATTENTION TO: **Hasanus Rashid**

PROJECT: **1-22-0209-01**

AGAT WORK ORDER: **22T912723**

ROCK ANALYSIS REVIEWED BY: **Jewel Shibu, Lab Supervisor**

SOIL ANALYSIS REVIEWED BY: **Amanjot Bhela, Inorganic Lab Manager**

DATE REPORTED: **Jul 14, 2022**

PAGES (INCLUDING COVER): **7**

VERSION*: **2**

Should you require any information regarding this analysis please contact your client services representative at (403) 735-2005

*Notes

VERSION 2:Version 1: July 04, 2022 excluding Sulphide
Version 2 supersedes Version 1, July 14, 2022- Complete.

Disclaimer:

- *All work conducted herein has been done using accepted standard protocols, and generally accepted practices and methods. AGAT test methods may incorporate modifications from the specified reference methods to improve performance.*
- *All samples will be disposed of within 30 days after receipt unless a Long Term Storage Agreement is signed and returned. Some specialty analysis may be exempt, please contact your Client Project Manager for details.*
- *AGAT's liability in connection with any delay, performance or non-performance of these services is only to the Client and does not extend to any other third party. Unless expressly agreed otherwise in writing, AGAT's liability is limited to the actual cost of the specific analysis or analyses included in the services.*
- *This Certificate shall not be reproduced except in full, without the written approval of the laboratory.*
- *The test results reported herewith relate only to the samples as received by the laboratory.*
- *Application of guidelines is provided "as is" without warranty of any kind, either expressed or implied, including, but not limited to, warranties of merchantability, fitness for a particular purpose, or non-infringement. AGAT assumes no responsibility for any errors or omissions in the guidelines contained in this document.*
- *All reportable information as specified by ISO/IEC 17025:2017 is available from AGAT Laboratories upon request.*

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Western Enviro-Agricultural Laboratory Association (WEALA)
Environmental Services Association of Alberta (ESAA)

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Certificate of Analysis

AGAT WORK ORDER: 22T912723

PROJECT: 1-22-0209-01

2910 12TH STREET NE
CALGARY, ALBERTA
CANADA T2E 7P7
TEL (403)735-2005
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http://www.agatlabs.com

CLIENT NAME: TERRAPROBE INC.

SAMPLING SITE:6360 Regional Rd 25, Milton

ATTENTION TO: Hasanus Rashid

SAMPLED BY:

(283-042) Sulfide (CGY)

DATE RECEIVED: 2022-06-24

DATE REPORTED: 2022-07-14

			SAMPLE DESCRIPTION:	BH14 (SS5)	BH16 (SS6)	BH11 (SS5)	BH1 (SS4)	BH4 (SS3)
			SAMPLE TYPE:	Soil	Soil	Soil	Soil	Soil
			DATE SAMPLED:	2022-06-16	2022-06-15	2022-06-15	2022-06-15	2022-06-17
Parameter	**Unit**	**G / S**	**RDL**	4021067	4021068	4021069	4021070	4021071
Sulfide	%		0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

Analysis performed at AGAT Calgary (unless marked by *)

Certified By: Jewel Shibu

Certificate of Analysis

AGAT WORK ORDER: 22T912723

PROJECT: 1-22-0209-01

2910 12TH STREET NE
CALGARY, ALBERTA
CANADA T2E 7P7
TEL (403)735-2005
FAX (403)735-2771
http://www.agatlabs.com

CLIENT NAME: TERRAPROBE INC.

ATTENTION TO: Hasanus Rashid

SAMPLING SITE:6360 Regional Rd 25, Milton

SAMPLED BY:

Corrosivity Package

DATE RECEIVED: 2022-06-24

DATE REPORTED: 2022-07-14

			SAMPLE DESCRIPTION:	BH14 (SS5)	BH16 (SS6)	BH11 (SS5)	BH1 (SS4)	BH4 (SS3)
			SAMPLE TYPE:	Soil	Soil	Soil	Soil	Soil
			DATE SAMPLED:	2022-06-16	2022-06-15	2022-06-15	2022-06-15	2022-06-17
Parameter	**Unit**	**G / S**	**RDL**	**4021067**	**4021068**	**4021069**	**4021070**	**4021071**
Chloride (2:1)	µg/g	NA	2	33	37	37	23	23
Sulphate (2:1)	µg/g		2	36	25	30	26	16
pH (2:1)	pH Units		NA	7.86	7.65	8.49	8.10	8.17
Electrical Conductivity (2:1)	mS/cm	0.57	0.005	0.200	0.200	0.243	0.172	0.176
Resistivity (2:1) (Calculated)	ohm.cm		1	5000	5000	4120	5810	5680
Redox Potential 1	mV		NA	328	354	296	318	282
Redox Potential 2	mV		NA	353	335	297	311	282
Redox Potential 3	mV		NA	352	341	298	327	289

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: Refers to Table 1: Full Depth Background Site Condition Standards - Soil - Residential/Parkland/Institutional/Industrial/Commercial/Community Property Use
Guideline values are for general reference only. The guidelines provided may or may not be relevant for the intended use. Refer directly to the applicable standard for regulatory interpretation.

4021067-4021071 EC, pH, Chloride and Sulphate were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil). Resistivity is a calculated parameter.
Redox potential measured on as received sample. Due to the potential for rapid change in sample equilibrium chemistry with exposure to oxidative/reduction conditions laboratory results may differ from field measured results.
Redox potential measurement in soil is quite variable and non reproducible due in part, to the general heterogeneity of a given soil. It is also related to the introduction of increased oxygen into the sample after extraction. The interpretation of soil redox potential should be considered in terms of its general range rather than as an absolute measurement.

Analysis performed at AGAT Toronto (unless marked by *)

Certified By: Amanjot Bhela

AMANJOT BHELA

Quality Assurance

CLIENT NAME: TERRAPROBE INC.

PROJECT: 1-22-0209-01

SAMPLING SITE:6360 Regional Rd 25, Milton

AGAT WORK ORDER: 22T912723

ATTENTION TO: Hasanus Rashid

SAMPLED BY:

Rock Analysis

RPT Date: Jul 14, 2022			DUPLICATE				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
(283-042) Sulfide (CGY)															
Total Sulfur	1	3968261	0.10	0.12	18.2%	< 0.01	98%	90%	110%						
Sulfate	4021067	4021067	<0.01	<0.01	0.0%	< 0.01	100%	80%	120%						
(283-042) Sulfide (CGY)															
Sulfate	3					< 0.01		80%	120%						

Certified By: Jewel Shibu

Quality Assurance

CLIENT NAME: TERRAPROBE INC.

PROJECT: 1-22-0209-01

SAMPLING SITE:6360 Regional Rd 25, Milton

AGAT WORK ORDER: 22T912723

ATTENTION TO: Hasanus Rashid

SAMPLED BY:

Soil Analysis

RPT Date: Jul 14, 2022			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
Corrosivity Package															
Chloride (2:1)	4021067	4021067	33	34	3.0%	< 2	96%	70%	130%	101%	80%	120%	110%	70%	130%
Sulphate (2:1)	4021067	4021067	36	36	0.0%	< 2	101%	70%	130%	100%	80%	120%	102%	70%	130%
pH (2:1)	4021067	4021067	7.86	8.10	3.0%	NA	98%	80%	120%	NA			NA		
Electrical Conductivity (2:1)	4021067	4021067	0.200	0.211	5.4%	< 0.005	103%	80%	120%	NA			NA		
Redox Potential 1	4021067						100%	90%	110%	NA			NA		

Comments: NA signifies Not Applicable.
pH duplicates QA acceptance criteria was met relative as stated in Table 5-15 of Analytical Protocol document.

Duplicate NA: results are under 5X the RDL and will not be calculated.

Certified By: Amanjot Bhela

ASSOCIATION OF THE CHEMICAL PROFESSION OF ONTARIO
CHARTERED
AMANJOT BHELA
CHEMIST

Method Summary

CLIENT NAME: TERRAPROBE INC.
PROJECT: 1-22-0209-01
SAMPLING SITE:6360 Regional Rd 25, Milton

AGAT WORK ORDER: 22T912723
ATTENTION TO: Hasanus Rashid
SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Chloride (2:1)	INOR-93-6004	modified from SM 4110 B	ION CHROMATOGRAPH
Sulphate (2:1)	INOR-93-6004	modified from SM 4110 B	ION CHROMATOGRAPH
pH (2:1)	INOR 93-6031	modified from EPA 9045D and MCKEAGUE 3.11	PH METER
Electrical Conductivity (2:1)	INOR-93-6075	modified from MSA PART 3, CH 14 and SM 2510 B	PC TITRATE
Resistivity (2:1) (Calculated)	INOR-93-6036	McKeague 4.12, SM 2510 B,SSA #5 Part 3	CALCULATION
Redox Potential 1	INOR-93-6066	G200-20, SM 2580 B	REDOX POTENTIAL ELECTRODE
Redox Potential 2	INOR-93-6066	G200-20, SM 2580 B	REDOX POTENTIAL ELECTRODE
Redox Potential 3	INOR-93-6066	G200-20, SM 2580 B	REDOX POTENTIAL ELECTRODE

APPENDIX D

TERRAPROBE INC.

FRONTWAVE
GEOPHYSICS

January 10, 2023 File No. F-23089

Hasanur Rashid, M.Eng., P.Eng. Email: hrashid@terraprobe.ca
Geotechnical Engineer
Terraprobe Inc.
11 Indell Lane
Brampton, Ontario
L6T 3Y3

Re: Shear wave velocity test for seismic site classification at 6360 Regional Road 25, Milton, Ontario.

Dear Mr. Rashid:

Frontwave Geophysics Inc. was retained by Terraprobe Inc. to carry out a geophysical investigation at a site located at 6360 Regional Road 25, Milton, Ontario.

The objective of the survey was to determine site class for seismic site response based on average shear wave velocity value measured in the upper 30 m (V_S30). The multi-channel analysis of surface waves (MASW) method was used to obtain shear wave velocity profile.

The fieldwork was conducted on January 9th, 2023. The location of the MASW survey line is shown in Figure 1.

This report describes the basic principles of MASW, survey design, interpretation method, and presents the results of the investigation in chart and table format.

Frontwave Geophysics Inc.
Brampton, ON
(647) 514-4724
www.frontwave.ca

Legend				
MASW Approximate location of MASW survey line (69 m geophone spread)	**Date:**	2023-01-10	FRONTWAVE GEOPHYSICS	
	File No:	F-23089		
	Title:	Survey Location Plan		
	Location:	6360 Regional Road 25, Milton, ON	Figure: **1**	

MASW Survey

Overview

The Multi-channel Analysis of Surface Waves (MASW) is a seismic method widely applied to produce shear wave velocity (V_S) profiles. It is based on the dispersive nature of Rayleigh surface waves in layered media. Surface waves with longer wavelengths propagate deeper in the subsurface, hence, their phase velocity is more influenced by the elastic properties of deeper layers. The velocity of Rayleigh waves depends mainly on the shear wave velocity of the medium. Distribution of Rayleigh waves phase velocities as a function of wavelength (or frequency) can be visualized as a dispersion curve. The inverse problem is then solved by modelling the experimental data with a theoretical dispersion curve; the model parameters are typically limited to layer thickness and shear wave velocity with an assumption of horizontally layered strata. As a result of the inversion, a shear wave velocity depth profile is obtained. Figure 2 illustrates the overall procedure of the MASW method.

Two approaches different in data acquisition and processing can be implemented. The active method involves using artificial sources (e.g., sledgehammer, drop weight) to generate seismic energy, whereas the passive method utilizes energy generated by natural sources (wind, waves, microseismicity) and human activities (mostly vehicle traffic). The energy that can be generated with easily accessible active sources such as sledgehammers is typically concentrated within a relatively high frequency range, and the maximum depth of penetration for active surveys is limited to approximately 15-30 m, depending on the mass of the source and geology of the site. Ambient vibrations registered with the passive acquisition are usually of lower frequency and provide better resolution at greater depths. When survey logistics allow, the active and passive source methods are combined for obtaining well-resolved dispersion images over a wide frequency range, thus increasing the depth of investigation while retaining high resolution at shallow depths.

Survey Design

The acquisition layout consisted of 24 receivers in a linear array (spread), connected with two 12-channel cables to P.A.S.I. Gea-24 seismograph. 4.5 Hz natural frequency vertical geophones were used for this survey. To optimize sampling of different wavelengths, two sets of measurements were conducted with spread lengths of 23 m and 69 m (1 m and 3 m spacing between geophones, respectively). Data collected with longer spreads provide a greater depth of investigation, whereas data collected with shorter geophone spacings ensure better resolution in the uppermost few meters of the subsurface.

8-kg sledgehammer was used as an energy source for active acquisition. Shots were executed at three to five locations per spread: two shots close to the ends of the spread, and one to three shots within the spread. A total of 8 shot records was collected. The record length was set to 1500 ms with a 0.05 ms sampling interval.

For passive acquisition, a linear 24-channel array with 3 m spacing between geophones was used. Ambient wavefield was recorded for 10 minutes with a sampling interval of 2 ms.

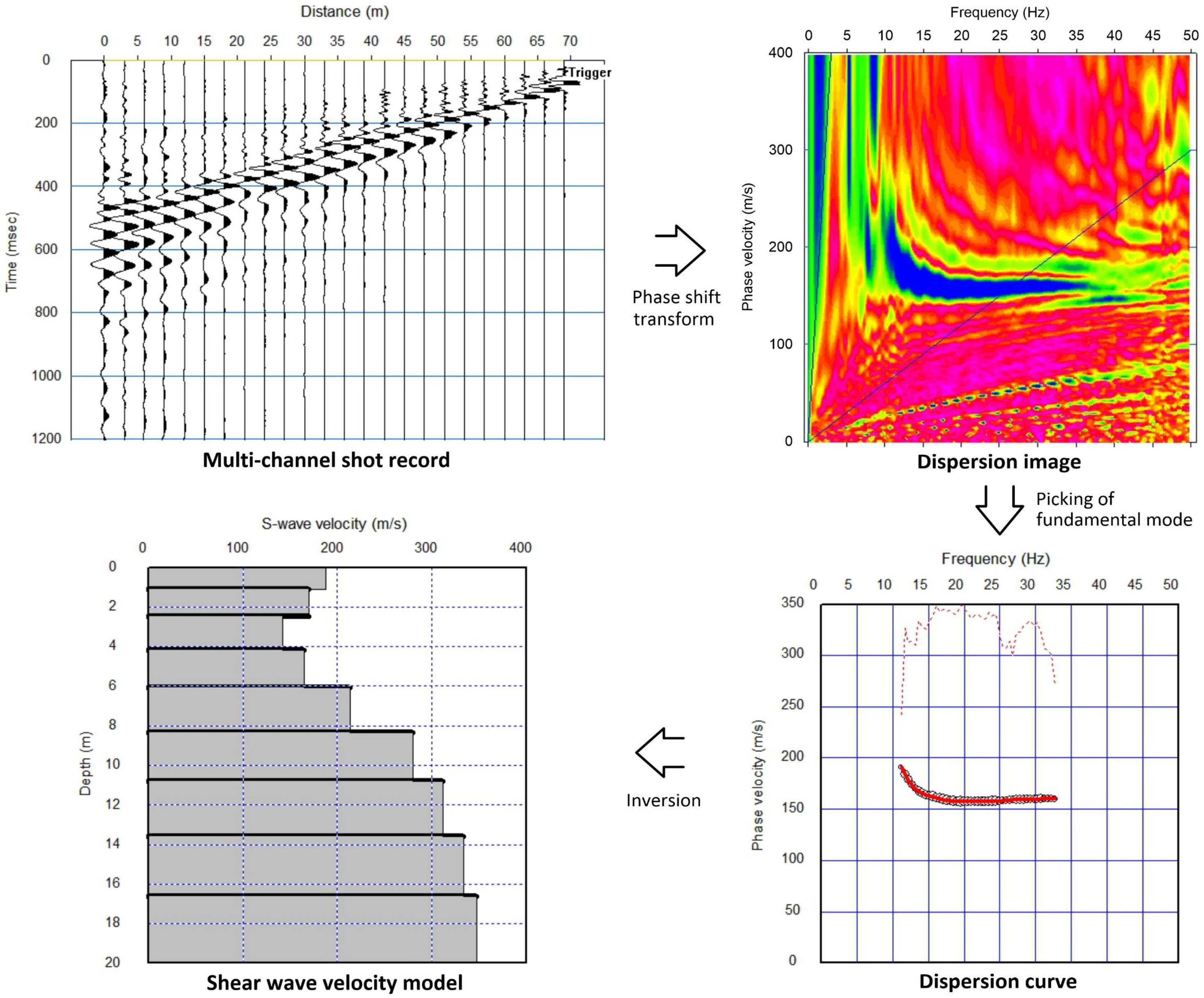

Figure 2. The procedure of MASW data processing using the SeisImager SW software package.

Interpretation

A dispersion curve is obtained from each field record by converting the shot gather into a dispersion image and then identifying and picking the fundamental mode. A shear wave velocity profile is obtained through inversion of the dispersion curve by modelling the subsurface as a horizontally layered medium with the model parameters limited to the number of layers, their thickness and shear-wave velocity.

SeisImager SW software package was used for processing, picking and inversion of the MASW data.

Some variability among the dispersion curves and resulting models obtained from different shot records is always observed due to lateral velocity variations, near and far field effects, different signal-to-noise ratio, etc. Combining independent inversion results from multiple shot records improves the estimation of the actual shear wave velocity and provides an assessment of uncertainty. The results of the interpretation are presented in the form of the average shear wave velocity profile; the observed variability of the MASW data is reported as upper and lower bound velocity profiles.

The solution of the inverse problem is non-unique (many different models can equally fit the experimental dispersion curve). To limit the non-uniqueness, P-wave refraction analysis of the collected dataset is implemented and the results are used to constrain the S-wave velocity model during the inversion process. The refraction technique allows to calculate the depth and give an estimate of S-wave velocity of high velocity contrast layers such as bedrock. Introducing the high-velocity layer into inherently smooth initial MASW models allows to produce higher resolution, higher confidence inversion results.

Accuracy of the results

The accuracy of MASW generally depends on the complexity of the subsurface and specific site conditions (noise levels, topography, etc.). Lateral velocity variations and steeper bedrock topography increase the dispersion uncertainty. The presence of high velocity contrast layers such as bedrock will require the use of a-priory information to optimize model parameters for more accurate results. Hence, if the a-priory information is not available (e.g., when the data are overly noisy to carry out refraction analysis), the accuracy decreases.

Conventional opinion based on decades of experience estimates the error margin of V_S30 value determined from MASW to be within +/-10%. In practice, it means that the MASW data can be used to provide reliable site classification if the calculated V_S30 value is not within 10% of a site class boundary.

RESULTS

The collected surface wave data were of very good quality; the dispersion images showed good resolution and covered a frequency range of approximately 15 to 55 Hz. Example shot record and MASW dispersion images obtained at this site are presented in Figure 4 at the end of the report.

Seismic refraction analysis indicated that the depth to shale bedrock was approximately 13 m below ground surface. Compressional (P) wave velocity measured in the bedrock was approximately 2800 m/s. The refraction data was used for parameterization of the initial inversion model.

The results of the MASW sounding are presented in Figure 3. The average shear wave velocity profile from the active shot records and passive data is plotted in the chart as a solid line. The dashed lines represent the upper and lower bound S-wave velocity profiles.

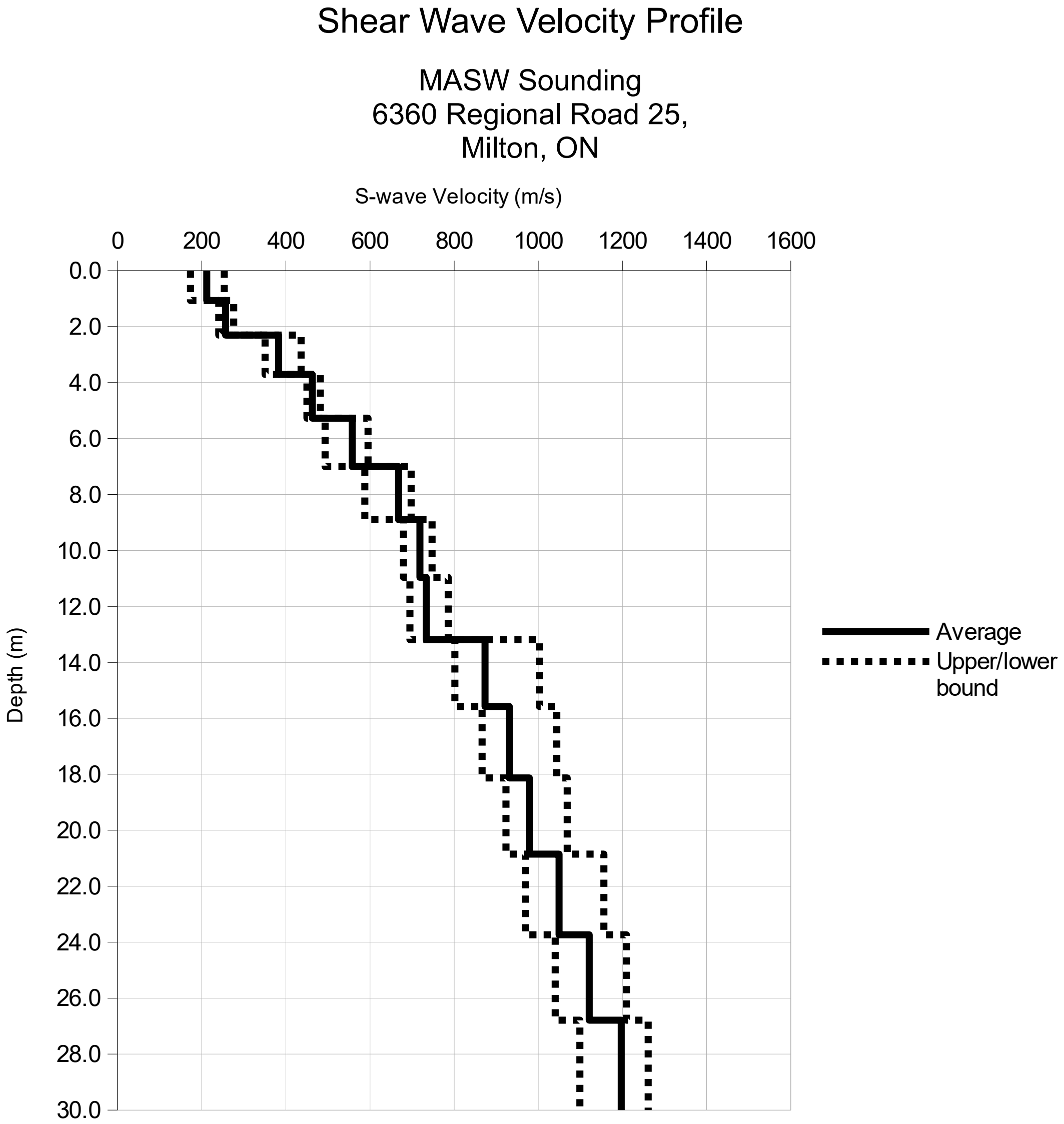

Figure 3. Shear wave velocity profile from MASW sounding.

The tabulated shear wave velocity model is presented in Table 1.

Table 1. Shear wave velocities from MASW sounding.

Depth Interval (m)		S-wave Velocity (m/s)
From	To	
0.0	1.1	212
1.1	2.3	257
2.3	3.7	383
3.7	5.3	463
5.3	7.0	558
7.0	8.9	668
8.9	11.0	719
11.0	13.2	734
13.2	15.6	873
15.6	18.1	931
18.1	20.9	979
20.9	23.7	1049
23.7	26.8	1121
26.8	30.0	1197

For seismic site classification, the average shear wave velocity within the upper 30 meters (V_S30) is defined as the travel-time weighted average velocity from surface to a depth of 30 m and calculated using the following formula:

$$V_S30 = 30 / \Sigma (d/V_S),$$

where d is the thickness of any layer and V_S is the layer S-wave velocity. In other words, V_S30 is calculated as 30 m divided by the sum of the S-wave travel times for each layer within the topmost 30 m.

The calculated V_S30 values are presented in Table 2.

Table 2. V_S30 values from MASW sounding.

Depth Range (m)	Minimum V_S30 (m/s)	Average V_S30 (m/s)	Maximum V_S30 (m/s)	NBC 2015 Seismic Site Class
0 to 30	607	**664**	726	**C**

The V_S30 values obtained from the MASW sounding varied from 607 m/s to 726 m/s with an average of 664 m/s.

Based on the Site Classification for Seismic Site Response (Table 4.1.8.4.-A) of the National Building Code of Canada 2015 (NBC), the investigated area is in **Site Class C** ($360 < V_S30 \leq 760$ m/s).

We hope you find this report satisfactory. Should you have any questions or require additional information, please do not hesitate to contact the undersigned.

Frontwave Geophysics Inc.

Ilia Gusakov, P.Geo.
Geophysicist
(647) 514-4724
ilia.gusakov@frontwave.ca

PROFESSIONAL GEOSCIENTIST
ILIA GUSAKOV
PRACTISING MEMBER
3161
ONTARIO

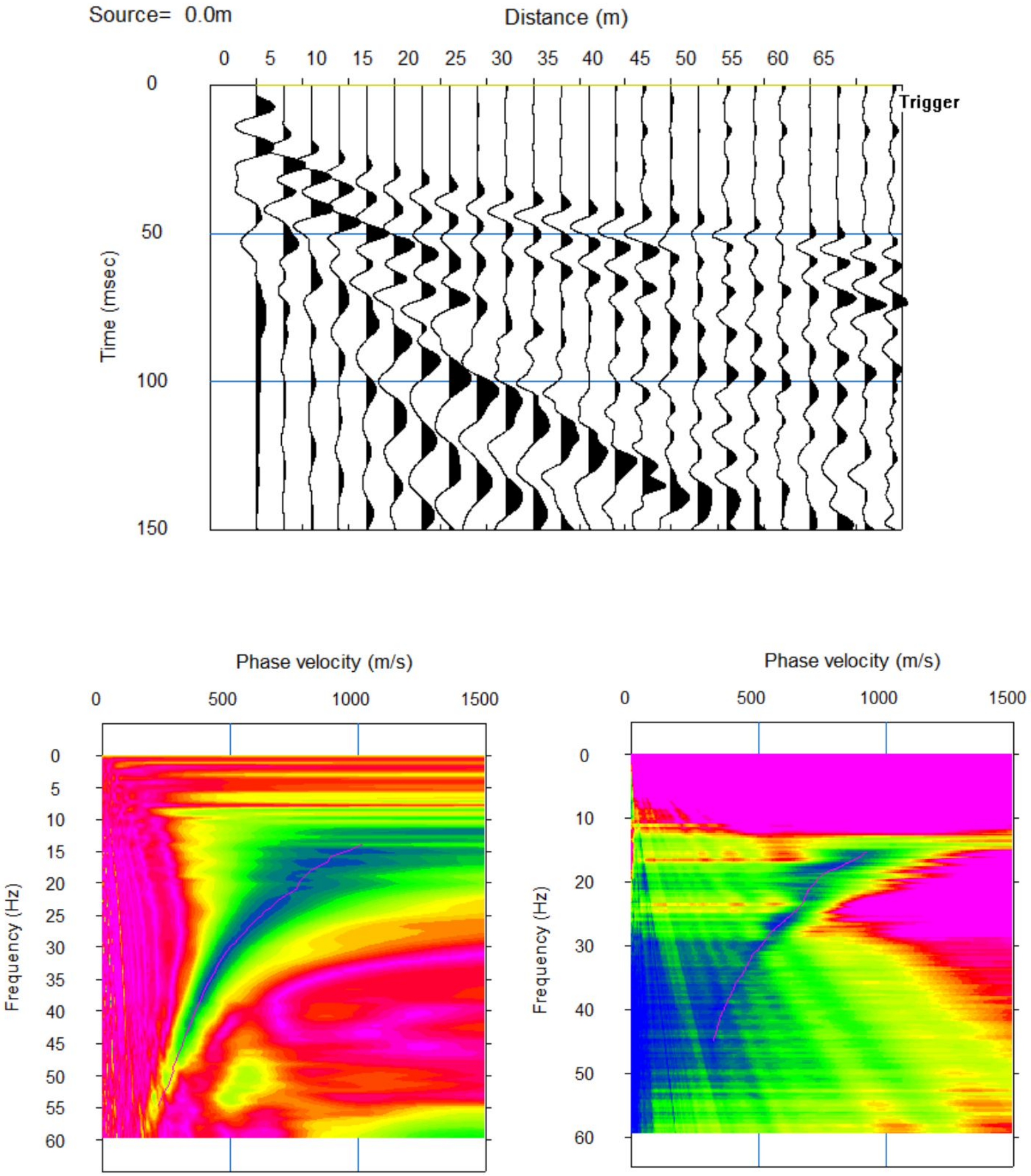

Figure 4. Example shot record (top) and dispersion images from active (bottom left) and passive (bottom right) acquisition.