Terraprobe

Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

GEOTECHNICAL ENGINEERING REPORT
535-551 BRANT STREET
BURLINGTON, ONTARIO

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File No. 1-18-0718-02
Issued: April 22, 2019
Revision 1: November 12, 2020
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1.0 THE PROJECT

Terraprobe was retained by Renimmob Properties Limited to conduct a subsurface investigation and provide geotechnical engineering design advice for a proposed development at 535-551 Brant Street in Burlington, Ontario. The development consists of a new high-rise tower, resting on a four (P4) level underground parking structure. A site location plan is provided as Figure 1.

For the purposes of this report, the current site elevation is approximately at 87.5 ±m. The lowest P4 finished floor elevation (FFE) is assumed at Elev. 74.5 ±m. The field investigation consisted of:

- Eight (8) boreholes advanced to depths of approximately 2.0 to 18.5 m below grade, with three (3) of the boreholes receiving bedrock cores to below proposed P4 elevation.
    - Boreholes 101-103 on John St. for separate pavement report
    - Boreholes 104-108 on the site for geotechnical and hydrogeological purposes

The locations of the boreholes are provided on the Borehole Location Plan as Figure 2. The results of the individual boreholes are recorded on the Borehole Logs in Appendix A. A summary of the geotechnical laboratory tests is provided in Appendix B.

Interpretation, analysis and advice with respect to the geotechnical engineering aspects of the proposed development are provided, based on the information secured from this investigation. The anticipated construction conditions pertaining to excavation, foundation construction, seismic site classification, slab design, basement drainage, and ground water control are discussed.

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.

Terraprobe prepared a hydrogeological report under separate cover (File No. 1-18-0718-46). The soil chemistry samples noted on the Borehole Logs in Appendix A was reported in Terraprobe's Phase Two ESA (File No. 1-18-0718-42). A pavement design letter based on Boreholes 101, 102, and 103 for the John St. realignment is also reported under a separate cover (File No. 1-18-0718-03).

2.0 SUBSURFACE CONDITIONS

The field investigation was performed during the period of November 26, 2018 and January 25, 2019. The borehole elevations and coordinates are provided relative to geodetic datum (NAD 83). The

horizontal coordinates are reported relative to the Universal Transverse Mercator geographic coordinate system (UTM Zone 17T). It should be noted that the subsurface conditions are confirmed at the borehole locations only and may vary at other locations. The boundaries between the various strata represent an inferred transition rather than a precise plane of geological change. This summary is intended to correlate the data to assist in the interpretation of the subsurface conditions at the site. Refer to the enclosed Borehole Logs in Appendix A and geotechnical laboratory results in Appendix B for more specific subsurface details.

The surficial material and topsoil thicknesses provided in the report were obtained at individual borehole locations, as measured through the collar of the open borehole. Thicknesses may vary between and beyond borehole locations.

2.1 Stratigraphy

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

2.1.1 Surficial and Earth Fill Materials

At surface, Boreholes 101 to 107 encountered a pavement structure consisting of 50 to 120 mm of asphalt overlying 50 to 260 mm of aggregate. Borehole 108 encountered a 150 mm thick concrete slab.

Underlying the pavement structure and surficial material, earth fill was encountered in all the boreholes extending to a depth of 1.5 to 2.3 m below grade (Elev. 85.1 to 86.3 m). The earth fill consists of clayey silt to sandy silt with trace to some gravel. Trace rock fragments, trace asphalt, trace wood fragments, and trace brick fragments were also observed. It is typically brown to dark brown, and moist. Standard Penetration Test (SPT) results (N-Values) measured in the earth fill range from 2 to 34 blows per 300 mm of penetration, suggesting a soft/very loose to hard/compact state. The earth fill is, on average, stiff/compact.

2.1.2 Glacial Till (Halton Till)

Underlying the earth fill, a glacial till was encountered in all the boreholes at a depth of 1.5 to 2.3 m below grade (Elev. 85.1 to 86.3 m). The glacial till stratum extends to a depth of 2.0 to 3.0 m below grade (Elev. 84.4 to 85.5 m). The glacial till is composed of silt, some clay, trace sand, and trace gravel. It is typically reddish brown and moist. Standard Penetration Test (SPT) results (N-Values) measured in the sand range from 6 to over 50 blows per 300 mm of penetration, indicating a firm to hard consistency, on average hard.

2.1.3 Bedrock (Queenston Formation)

The bedrock that underlies the site belongs to the Queenston Formation which predominantly consists of thinly bedded reddish brown calcareous shale with grey green bands of interbedded argillaceous limestone. A summary of properties with respect to the shale within the Queenston Formation was presented in the Ontario Ministry of Transportation and Communications document RR229, *Evaluation of Shales for Construction Projects* (March 1983), as follows:

	Uniaxial Compressive Strength (MPa)	Young's Modulus (GPa)	Poisson's Ratio
Average	8.7	1.3	0.32
Range	7.2 to 9.6	0.5 to 2.3	0.28 to 0.35

There is typically a zone of weathering at the contact between the rock of the Queenston Formation and the glacial soil overburden. In the Ontario Ministry of Transportation and Communications document RR229, *Evaluation of Shales for Construction Projects,* there is a *typical weathering profile of a low durability shale,* reproduced from Kempton, Davis and Chandler, that characterizes the shale surface into three grades of weathering and four zones described as follows:

	Zone	Description	Notes
Fully Weathered	IVb	soil like matrix only	indistinguishable from glacial drift deposits, slightly clayey, may be fissured
Partially Weathered	IVa	soil like matrix with occasional pellets of shale less than 3 mm dia.	little or no trace of rock structure, although matrix may contain relic fissures
	III	soil like matrix with frequent angular shale particles up to 25 mm dia.	moisture content of matrix greater than the shale particles
	II	angular blocks of unweathered shale with virtually no matrix separated by weaker chemically weathered but intact shale	spheroidal chemical weathering of shale pieces emanating from relic joints and fissures, and bedding planes
Unweathered (Sound)	I	shale	regular fissuring

The augering and interval sampling method used to explore the overburden at the site is conventionally accepted investigative practice. However, this method does not define the bedrock surface with precision, particularly in this instance where the overlying soil consists of a glacial till possibly containing cobbles and boulders, and where the surficial zone of the bedrock is typically highly weathered. The change in resistance to augering in between Zones III and II in the shale profile is not profound. The top of rock as indicated on the Borehole Logs from this investigation is to be consistently interpreted as the surface of Zone II in the profile. In this regard, bedrock was inferred in Borehole 108 by split spoon samples and auger resistance observation at a depth of about 3.0 m below grade (Elev. 84.7 ±m).

Bedrock was confirmed by rock coring in Boreholes 104, 106, and 107, at 3.1 m to 3.3 m below grade (Elev. 84.1 to 84.7 ±m), and extended to the depth of the investigation at 18.0 to 18.5 m below grade (Elev. 68.9 to 69.7 ±m). Rock Core Logs are provided in Appendix A. Photographs of recovered rock core are provided in Appendix C. Borehole 105 did not encounter bedrock as it was only for Phase Two ESA purposes and was terminated at 2.6 m below grade.

Borehole	Surface Elevation (m)	Top of Weathered (Zone II) Bedrock		Unweathered/Sound (Zone I) Bedrock		Method of Observation/Notes
		Depth (m)	Elevation (m)	Depth (m)	Elevation (m)	
104	87.4	3.0	84.4	3.5	83.9	Rock Coring
106	87.7	3.0	84.7	3.2	84.5	Rock Coring
107	87.8	3.0	84.8	3.6	84.2	Rock Coring
108	87.7	3.0	84.7	n/a*		Drilling observations, SPT samples

**rock coring not conducted*

The TCR (total core recovery), SCR (solid core recovery), and RQD (rock quality designation) values for the core runs of the shale bedrock are summarized in the following table along with the range in uniaxial compressive strengths of samples of the cored rock.

Borehole	Total Core Recovery (TCR) %	Solid Core Recovery (SCR) %	Rock Quality Designation (RQD) %
104	93 - 100	94 - 100	45 - 100
106	95 - 100	88 - 100	66 - 100
107	95 - 100	72 - 100	43 - 100

Rock Quality Designation (RQD) refers to the total length of those pieces of sound core which are 100 mm or greater in length in a core run, expressed as a percentage of the total length of that core run. Sound pieces of rock are those pieces separated by natural fractures or bedding, and not machine induced or subsequent artificial breaks. The RQD of the recovered rock core ranged from approximately 43 to 100%. While the RQD for some runs in the sound bedrock may seem to be low, it is not indicative of the actual good strength and bearing capacity of the Queenston Formation. Since the bedding is horizontal in this formation, and there are many bedding layers within this rock mass, the RQD is typically low and is a function of the regular repeating bedding planes, not of stress induced fractures leading to a weaker rock mass. The results of this investigation in this regard are typical of the deposit.

The discontinuities observed in the rock cores were typically horizontal and generally associated with the bedding planes. The joints were generally filled with softening clay deposit and the joint spacing was

generally close to moderately close. These parameters indicate that the bedrock can generally be considered to be fairly sound to sound below about elevation 89.0 metres.

2.2 Ground Water

The ground water conditions were observed in the boreholes during and upon completion of drilling. The water levels in the monitoring wells were measured by a member of our staff on March 15 and 22, 2019, as summarized in the following table.

Borehole	Surface elevation (m)	Depth of borehole (m)	Depth to cave (m)	Unstabilized water level upon completion of drilling (m)	Water Level in Well – Depth/Elevation (m)	
					Mar. 15, 2019	Mar. 22, 2019
101	87.5	2.0	Open	Dry	n/a	n/a
102	87.3	2.0	0.9	0.3	n/a	n/a
103	87.3	2.0	Open	Dry	n/a	n/a
104	87.4	18.5	n/a	n/a	3.3 / 84.2	3.3 / 84.2
105	87.6	2.6	Open	Dry	Dry	Dry
106	87.7	18.0	n/a	n/a	4.5 / 83.2	4.5 / 83.2
107	87.8	18.1	n/a	n/a	4.3 / 83.5	4.1 / 83.7
108	87.7	3.3	Open	Dry	Dry	2.6 / 85.2

For design purposes, the ground water table is near the till/rock interface at Elev. 84.0± m and appears hydraulically connected with the bedrock based on the deep wells. The fill and glacial till deposit contains a high percentage of fines and is considered to be a low permeability material, and will typically preclude the free-flow of water when wet. Ground water levels may fluctuate with time and seasonally depending on the amount of precipitation and surface runoff.

3.0 GEOTECHNICAL ENGINEERING DESIGN

The following discussion and recommendations are based on the factual data obtained from the Terraprobe investigation and are intended for 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. If there are any changes to the site development features or 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.

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.

Overall grade in the area is at approximate Elev. 87.5 ±m. The proposed structure will rest on a four (P4) level underground parking structure across the site. The P4 finished floor elevation (FFE) is anticipated to be set approximately 13 m below existing grade (Elev. 74.5± m). Footings will be set approximately 1 m below FFE (at Elev. 73.5 ± m). The borehole locations with respect to the proposed development are shown on Figure 3.

3.1 Foundation Design Parameters

The top of weathered bedrock was encountered at depths of about 3.0 ± m below exterior grade (Elev. 84.5± m). Top of unweathered (sound) bedrock was identified in the Terraprobe rock cores at 3.2 to 3.6 m below exterior grade (Elev. 83.9 to 84.5± m).

The lowest FFE is at Elev. 74.5± m for four levels of underground parking. Based on the factual data from the borehole logs, it is expected that all foundations will be made as spread footings in sound bedrock of the Queenston Formation. Spread footings on sound Queenston Formation bedrock may be designed using a maximum factored geotechnical resistance at ULS of 5000 kPa. The maximum net geotechnical reaction at SLS is 4000 kPa, for an estimated total settlement of 25 mm. The settlement of foundations made on the sound bedrock is elastic, linear and non-recoverable. The settlement occurs as load is applied.

Footings stepped from one elevation to another should be offset at a slope not exceeding 7 vertical to 10 horizontal. All foundations exposed to ambient outside temperatures must have a minimum 1.2 meters of soil cover or equivalent to protect against frost heave, as is the case for the one level of the underground parking prepared for the medical tower. Experience suggests that the temperature in “unheated” underground parking levels two or more levels below grade with normal ventilation provisions is not as severe as the ambient open air condition. In our experience, the earth cover required to prevent frost effects on foundations in the lower parking levels need not be any greater than 1.2 metres, and unmonitored experience in a number of structures has shown that perimeter foundations provided with 600 mm of cover perform adequately as do interior isolated foundations with 900 mm of cover as will be the case with the 4 level parking structure. At locations adjacent ventilation shafts, it is normal practise to provide insulation to ensure that foundations are not affected by the cold air flow.

Prior to pouring concrete for the footings, the footing subgrade must be cleaned of all deleterious materials such as softened, disturbed, or caved material, as well as any weathered bedrock or standing

water. Terraprobe must inspect and approve the proposed footing subgrades to confirm sound bedrock is encountered at the founding elevations. If construction proceeds during freezing weather conditions, temporary frost protection for the footing bases and concrete must be provided. It should be noted that the bedrock surface can weather and deteriorate on exposure to the atmosphere or surface water. Therefore, foundation bases that will remain open and exposed for an extended period of time should be protected by applying a skim coat of lean concrete.

3.2 Earthquake Design Parameters

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 are intended to 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 Fa and Fv, respectively, used to modify the UHS to account for the effects of site-specific soil conditions.

Based on the above noted information, it is recommended that the site designation for seismic analysis be 'Site Class B', as per Table 4.1.8.4.A of the Ontario Building Code (2012). Consideration may be given to conducting a site specific Multichannel Analysis of Surface Waves (MASW) at this site to determine the average shear wave velocity in the top 30 metres of the site stratigraphy. An improved seismic site designation (Site Class A) may be possible.

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 of the OBC 2012, as amended January 1, 2020, using linear interpolation for intermediate values of PGA.

3.3 Earth Pressure Design Parameters

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

Stratum/Parameter	γ	φ	K_a	K_o	K_p
Compact Granular Fill Granular 'B' (OPSS 1010)	21	32	0.31	0.47	3.26
Existing Earth Fill	30	19.0	0.33	0.50	3.00
Glacial Till	21	34	0.28	0.44	3.54
Queenston Formation (Bedrock)	26	28	n/a	n/a	n/a

where: γ = internal angle of friction (degrees)

φ = bulk unit weight of soil (kN/m^3)

K_a = Rankine active earth pressure coefficient (dimensionless)

K_o = Rankine at-rest earth pressure coefficient (dimensionless)

K_p = Rankine passive earth pressure coefficient (dimensionless)

The above earth pressure parameters pertain to a horizontal grade condition behind a retaining structure. Values of earth pressure parameters for an inclined retained grade condition will vary.

Walls 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 at depth, **h** (m)

K = the earth pressure coefficient

$\mathbf{h_w}$ = the depth below the groundwater level (m)

γ = the bulk unit weight of soil, (kN/m^3)

γ' = the submerged unit weight of the exterior soil, (γ - 9.8 kN/m^3)

q = the complete surcharge loading (kPa)

Where the wall backfill can be drained effectively to eliminate hydrostatic pressures on the wall that would otherwise act in conjunction with the earth pressure, this equation can be simplified to:

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

Where the structure is made directly against a shored excavation, drainage is provided by forming a drained cavity with prefabricated drain core material covering the excavation face and designed to discharge collected water into an underfloor drainage system. This is discussed in Section 3.5.

The factored geotechnical resistance to sliding of foundation elements is developed by friction between the base of the footing and the soil. This friction (**R**) depends on the normal load at the soil contact (**N**) and the frictional resistance of the soil (**tan φ**) expressed as $\boldsymbol{R_f = N\,tan\varphi}$, which is the unfactored resistance. The factored geotechnical resistance at ULS is $\boldsymbol{R_f = 0.8\,N\,tan\varphi}$.

The empirical approach for the design of foundation walls below bedrock level has been to use a uniform pressure distribution for the design of the basement walls below the top of bedrock elevation, which is consistent with the maximum earth pressure calculated for the lowest level of soil in the profile. This approach is likely conservative but it recognizes the practical requirement to have a foundation wall of a consistent width through the lower reach of the building.

Time-dependant rock swell will become an issue once excavations are extended to more than 1 m into bedrock. The upper 1 m of bedrock (as measured from the top of Zone II weathered bedrock) is sufficiently weathered/unconfined that locked in horizontal stresses are not present to the same degree as they are in the deeper sound bedrock, and therefore does not present a swelling/movement issue. If any basement structures are more than 1 m below top of weathered rock and open for less than 120 days prior to casting foundation walls, provision for a minimum of 50 mm of crushable foam separating the rock from concrete must be provided.

Where pits are made for sumps and elevators or other such features which are incorporated within the major excavation, there must be careful consideration of the potential for rock squeeze effects if the pits are to be cast directly against the rock face. For such structures, a crushable layer can be placed between the rock and the concrete. Ethafoam is typically used in this application and the walls are designed for 25% to 50% compressive strength of the foam. At 50% compression 220 Ethafoam plank material will provide a resistance of 18 psi (124 kPa). At 25% compression 220 Ethafoam plank material will provide a resistance of 9 psi (65 kPa). The 10% crush compressive strength of this material is 7 psi (50 kPa), which will allow for concrete placement.

In the case of sumps, elevators, etc., if the rock is over excavated by at least 600 mm and the pits and sumps are backfilled with 19 mm clear stone (OPSS 1004), then there is sufficient give in the backfill to accommodate the rock swell.

3.4 Slab on Grade Design Parameters

The basement level slab is to be made at an FFE of 74.5 ±m. The modulus of subgrade reaction appropriate for design of the slab resting on unweathered Queenston Formation bedrock is 80,000 kPa/m.

It is necessary that P4 floor slabs be provided with a capillary moisture barrier and drainage layer. This is made by placing the slab on a minimum 300 mm layer of HL-8 Coarse Aggregate or 19 mm clear stone (OPSS 1004) compacted by vibration to a dense state. Cohesionless soils will be encountered at the subgrade for the slab on grade.

3.5 Basement Drainage

A separate hydrogeological report was prepared by Terraprobe for this site (File No. 1-18-0718-46), which provides the approximate amount of daily temporary (construction) and permanent ground water collection and discharge.

To assist in maintaining dry basements and preventing seepage, it is recommended that exterior grades around the buildings be sloped away at a 2 percent gradient or more, for a distance of at least 1.2 metres. Provision of nominal subfloor drainage is required in conjunction with the perimeter drainage of the structure, to collect and remove the water that infiltrates at the building perimeter and under the floor. Perimeter and subfloor drainage are required throughout the below grade area.

It is recommended that the subfloor drainage system consists of minimum 100 mm diameter perforated pipes spaced at max 9 metres on centre. The pipes must be surrounded on all sides by a minimum of 100 mm of HL-8 Course Aggregate or 19 mm clear stone, and the pipe inverts should be a minimum 300 mm below the base of the slab. The elevator pits can be drained separately with an independent lower pumping sump or can be designed as water proof structures which are below the drainage level. A typical basement subdrain detail is provided in Appendix D. Terraprobe recommends to cut the rock subgrade neat to 300 mm beneath the floor slab and place subdrains directly on the subgrade. The subfloor drainage layer is then comprised of 300 mm of 19 mm clear stone (OPSS 1004).

Foundation walls must be damp-proofed in conformance to Section 5.8.2 of the Ontario Building Code (2012). Prefabricated drainage composites, such as Miradrain 2000 (Mirafi) or Terradrain 200 (Terrafix), should be incorporated between the shoring wall or rock face and the cast-in-place concrete foundation wall to make a drained cavity. Drainage from the cavity must be collected at the base of the wall in non-perforated pipes and conveyed directly to the sumps. The flow to the building storm water sump from the subsurface drainage will be governed largely by the building perimeter drainage collection during rainfall and runoff events. Typical shored excavation drainage details are provided in Appendix D.

The drainage system is a critical structural element, since it keeps water pressure from acting on the basement floor slab or on the foundation walls. As such, the sump that ensures the performance of this system must have a duplexed pump arrangement for 100% pumping redundancy and these pumps must be on emergency power. Buildings of this size are normally provided with duplex pumps at 200 litres/minute capacity to address infiltration from storm events. Such events exceed nominal subsurface flows.

4.0 DESIGN CONSIDERATION FOR CONSTRUCTABILITY

4.1 Excavations

Excavations must be carried out in accordance with the *Occupational Health and Safety Act and Regulations for Construction Projects, November 1993 (Part III - Excavations, Section 222 through 242).* These regulations designate four (4) broad classifications of soils to stipulate appropriate measures for excavation safety. For practical purposes, the earth fill is considered a Type 3 soil, and the glacial till and weathered bedrock are Type 2 soils.

Where workmen must enter a trench or excavation deeper than 1.2 m, the soil must be suitably sloped and/or braced in accordance with the regulation requirements. The regulation stipulates safe excavation slopes by soil type as follows:

Soil Type	Base of Slope	Steepest Slope Inclination
1	within 1.2 metres of bottom of trench	1 horizontal to 1 vertical
2	within 1.2 metres 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 Sections 235 through 238 and 241 of the Act and Regulations and include provisions for timbering, shoring and moveable trench boxes.

4.1.1 Overburden Soils

The need for shoring to support adjacent property will depend on the proximity of the building footprint to the property line. For preliminary consideration temporary unsupported excavations should be cut to an overall inclination of 1 horizontal to 1 vertical or flatter. If this minimum geometry cannot be achieved then consideration will need to be given to the use of shoring. Shoring design recommendations are discussed in Section 4.2.

It is possible that large particles (rubble, cobbles and boulders) may be found in the earth fill material. Similarly, larger size particles (cobbles and boulders) that are not specifically identified in the boreholes may be present in the underlying native soils. The size and distribution of such obstructions cannot be predicted with boreholes, as the sampler size is insufficient to secure representative samples of particles of this size. Provision must be made in excavation contracts to allocate risks associated with the time spent and equipment utilized to remove or penetrate such obstructions when encountered.

It should be noted that surplus excavated soil resulting from the construction that is to be disposed of off-site, will require chemical analyses to assess the disposal site requirements. Chemical analyses of soil were carried out as part of this assignment and have been report under separate cover. It should be noted, however that sites accepting fill usually have aesthetic, or engineering property requirements, as well as chemical requirements for soil acceptance. Such requirements are site specific, so assessment of the appropriateness of the soil from this site for use at other locations was beyond the scope of the investigation.

4.1.2 Shale Bedrock

Queenston Formation bedrock is not considered a "soil" under the act. Excavations into the shale bedrock can be vertical to near-vertical, but not overhanging. The face of the excavation must be scaled of any loose rock to protect the workers working in the excavation. Where this is not possible, protective mesh can be draped over the rock face when work is required in the area immediately beside the cut rock face. The shale (as well as the limestone, sandstone and siltstone interbeds) are transected by sub-vertical fractures, typically oriented at right angles to one another, and these fractures may preferentially cause the formation of slabs, wedges or blocks of loose unstable rock which will require removal and can often lead to 'over-break' beyond the intended excavation 'cut line'.

Past experience in bedrock belonging to the Queenston Formation indicates that the till-shale transition zone and the underlying rock can be removed without blasting. The upper weathered portion of the shale bedrock can be removed with powerful excavators equipped with rock teeth. The removal of the underlying bedrock and the interbedded limestone and siltstone layers, however, will be more arduous and time consuming, and will require specialized rock buckets, with the assistance of hoe rams and other similar tools. Line drilling may be required, but likely only in sensitive areas such as where excavations are in close proximity to existing structures where it is necessary to limit over-break and vibrations. The relative ease/difficulty in excavation of bedrock will also depend on the size (width) and depth of the excavation. For example, excavation of narrow trenches into the shale will obviously be more difficult than forming large open cuts for structures in which excavators can operate from the base of the cut to 'pry' up hard layers. Some of the thicker "hard" layers may require additional hoe-ramming effort to remove, but this is not considered unusual for rock excavations in this area. The risk and responsibility for these issues must be addressed in the contract documents for foundations, excavation, and shoring contractors.

In the bedrock, ground water seepage is expected to occur continuously through bedding planes, fractures, and along the more pervious sandstone and limestone interbeds. It should be possible to handle the infiltration by means of ditches and filtered sumps, fitted with appropriately sized pumps within the base of the excavation, as the excavation progresses. Be aware that fouling of pumps by powdery shale fines is sometimes a problem as is accumulation of suspended soil and rock fine particles in the ponded seepage water.

During excavation, gas monitoring should be carried out to ensure that any natural gas detected emanating from the bedrock has been adequately vented and dissipated.

4.2 Shoring Design

The site is immediately bounded by existing low-rise commercial structures to the east, John Street the north, Brant Street to the south, and a parking lot to the west. No excavation shall extend below the foundations of existing adjacent structures without adequate alternative support being provided. Underpinning guidelines are provided as Appendix E. The excavations will be supported using conventional soldier pile and lagging walls. The east wall of the excavation must be constructed as a rigid shoring system to preserve the integrity and support of the soil beneath existing foundations of the adjacent buildings, in a state approximating the at-rest condition. This is to be achieved using continuous interlocking caisson wall shoring.

4.2.1 Earth Pressure Distribution

If the shoring is supported with a single level of earth anchor or bracing, a triangular earth pressure distribution similar to that used for the basement wall design is appropriate. Where multiple supports are used to support the excavation, research has shown that a distributed pressure diagram more realistically approximates the earth pressure on a shoring system of this type, when restrained by pre-tensioned anchors.

The multi-level supported shoring can be designed based on an earth pressure distribution consisting of a trapezoidal pressure distribution with a maximum pressure defined by:

$$\boldsymbol{P = 0.8\,K[\gamma H + q]}$$

In this distribution, the earth pressure is taken as zero at the grade level, uniformly increasing to a maximum pressure within 1/4H. Similarly, from a depth 3/4H, the maximum design pressure can be decreased to zero pressure at the base of the excavation.

Conventional soldier pile and lagging do not experience the ground water pressures, as water is allowed to drain freely through the wall. The ground water pressure distribution is only applicable where an

impermeable boundary condition is created along the perimeter of the excavation, as is the case with a continuous interlocking caisson wall.

4.2.2 Soldier Pile Toe Design

Caisson pile toes will be made in bedrock of the Queenston Formation. The factored vertical bearing capacity at ULS for the design of a pile, embedded in the sound bedrock, is 8 MPa. The factored lateral bearing capacity of the sound rock at ULS is 1 MPa.

The exposed Queenston Formation deteriorates with time. Exposed excavation faces have been found to flake and recede as much as 300 mm with 12 months exposure. This recession generally takes the form of coin-size shale particles dropping from the face on a constant basis. The deteriorated rock loses internal integrity and bearing capability. Typically the soldier piles advanced as part of the caisson wall are advanced at least 1 metre below the base of the excavation to accommodate this weathering, to ensure the lateral and vertical provided can be utilized.

4.2.3 Shoring Support

Where the excavation penetrates the bedrock, the rock excavation is nominally self-supporting in a vertical face, provided the rock bedding is horizontally oriented. Anchors made in bedrock of the Queenston Formation may be designed using a working adhesion of 550 kPa. A proto-type anchor must be made to demonstrate the anchor capacity (performance tested). All production anchors must be proof-tested to 133% of the design load, to validate the design assumptions.

Raker footings established in the weathered shale at an inclination of 45 degrees can be designed for a maximum factored geotechnical resistance at ULS of 500 kPa

4.3 Site Work

The earth fill, native soils, and bedrock at this site will become disturbed and may lose their integrity to support when subjected to traffic, particularly when wet. It can be expected that a subgrade made in the native soils will be disturbed unless an adequate granular working surface is provided to protect the integrity of the subgrade soils from construction traffic, especially during periods of wet weather. Subgrade preparation works cannot be adequately accomplished during wet weather and the project must be scheduled accordingly. The disturbance caused by the traffic can result in the removal of disturbed soil and use of granular fill material for site restoration or underfloor fill that is not intrinsic to the project requirements.

If construction proceeds during freezing weather conditions, adequate temporary frost protection for the founding subgrade and concrete must be provided. The soil and rock at this site is susceptible to frost damage. Consideration must be given to frost effects, such as heave or softening, on exposed soil surfaces in the context of this particular project development.

4.4 Quality Control

4.4.1 Shoring

The City of Burlington will require that the shoring installations be monitored during the period of construction to demonstrate that the shoring is performing adequately. Terraprobe has considerable experience in the provision of shoring instrumentation and monitoring services for a number of similar sites.

The provisions of the Ontario Building Code require that the construction of the earth retaining structures be monitored on a continuous basis. The shoring system constitutes an earth retaining structure as provided in Section 4.2.2.3 of the Ontario Building Code 2012. Terraprobe should be retained to provide this review as the shoring installations are made. It is an integral part of the geotechnical design function as it relates to shoring design considerations.

Assuming soil and/or rock anchors will be used to support the shoring system on this site, a minimum of one anchor as each target anchorage level must be performance tested to verify the design adhesion used for the anchorages. This performance test anchor shall be consistent dimension in anchor and free stressing zones with the proposed production anchors and be provided with adequate tendon steel capacity to test the anchor to twice the design working load. The performance tests shall be monitored and evaluated by the geotechnical engineer. Production anchorages should not be installed until the performance test at each level has adequately demonstrated the design adhesion value. All production anchorages shall be monitored during stressing and evaluated by a geotechnical engineer.

4.4.2 Foundations

The proposed structures will be founded on spread footing foundations made on unweathered (sound) bedrock of the Queenston Formation. The foundation installations must be reviewed in the field by Terraprobe as they are constructed. The on-site review of the condition of the foundation rock 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 2012. 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 contained in this report.

4.4.3 Slabs on Grade

The long term performance of the slab on grade is highly dependent upon the subgrade support conditions. Stringent construction control procedures should be maintained to ensure that uniform subgrade moisture and density conditions are achieved as much as practically possible. The design advice in this report is based on an assessment of the subgrade support capabilities as indicated by the boreholes. These conditions may vary across the site depending on the final design grades and therefore, the preparation of the subgrade and the compaction of all fill should be monitored by Terraprobe at the time of construction to confirm material quality, thickness, and to ensure adequate compaction.

4.4.4 General

The requirements for fill placement on this project have been stipulated relative to Standard Proctor Maximum Dry Density (SPMDD). In situ determinations of density during fill and asphaltic pavement placement on site are required to demonstrate that the specified placement density is achieved. Terraprobe is a CNSC certified operator of appropriate nuclear density gauges for this work and can provide sampling and testing services for the project as necessary, with our qualified technical staff.

Concrete 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.

Terraprobe staff can also provide quality control services for Building Envelope, Roofing and Structural Steel, as necessary, for the Structural and Architectural quality control requirements of the project. Terraprobe is certified by the Canadian Welding Bureau under W178.1.

5.0 LIMITATIONS AND USE OF REPORT

5.1 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 from this investigation.

The drilling work was carried out by a drilling contractor and was observed and recorded by Terraprobe on a full time basis. All boreholes were made by a continuous flight power auger machine using solid and hollow stem augers, with the ability to record SPT-N values. A Terraprobe technician logged the boreholes and examined the samples as they were obtained. The samples obtained were sealed in clean, air-tight containers and transferred to the Terraprobe laboratory, where they were reviewed for

consistency of description by a geotechnical engineer. Ground water observations were made in the borehole as drilling proceeded and were measured at a later date in the installed ground monitoring wells. Continuous rock core samples were also obtained.

The samples of the strata penetrated were obtained using the Split-Barrel Method technique (ASTM D1586). The samples were taken at intervals. The conventional interval sampling procedure used for this investigation does not recover continuous samples of soil at any borehole location. There is consequently some interpolation of the borehole layering between samples and indications of changes in stratigraphy as shown on the borehole logs are approximate.

It must be recognized that there are special risks whenever engineering or related disciplines are applied to identify subsurface conditions. 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.

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 and geotechnical advice to completely identify all aspects of the site and works that could affect construction costs, techniques, equipment and scheduling. Contractors bidding on or undertaking work on the project must 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, and their approach to the construction works, cognizant of the risks implicit in the subsurface investigation activities.

5.2 Changes in Site and Scope

The passage of time, natural occurrences, and direct or indirect human intervention at or near the site have the potential to alter subsurface conditions. In particular, caution should be exercised in the consideration of contractual responsibilities as they relate to control of seepage, disturbance of soils, and frost protection.

The design parameters provided and the engineering advice offered in this report 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 design consultants 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, advice and comments relating to constructability issues and quality control may not be relevant or complete for the project. Terraprobe should be retained to review the implications of such changes with respect to the contents of this report.

5.3 Use of Report

This report is prepared for the express use of Renimmob Properties Limited, and their retained design consultants and is not intended 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.

It is recognized that the City of Burlington, in their capacity as the planning and building authority under Provincial statues, will make use of and rely upon this report, cognizant of the limitations thereof, both as are expressed and implied.

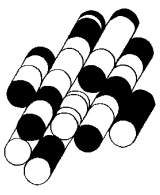
Terraprobe Inc.

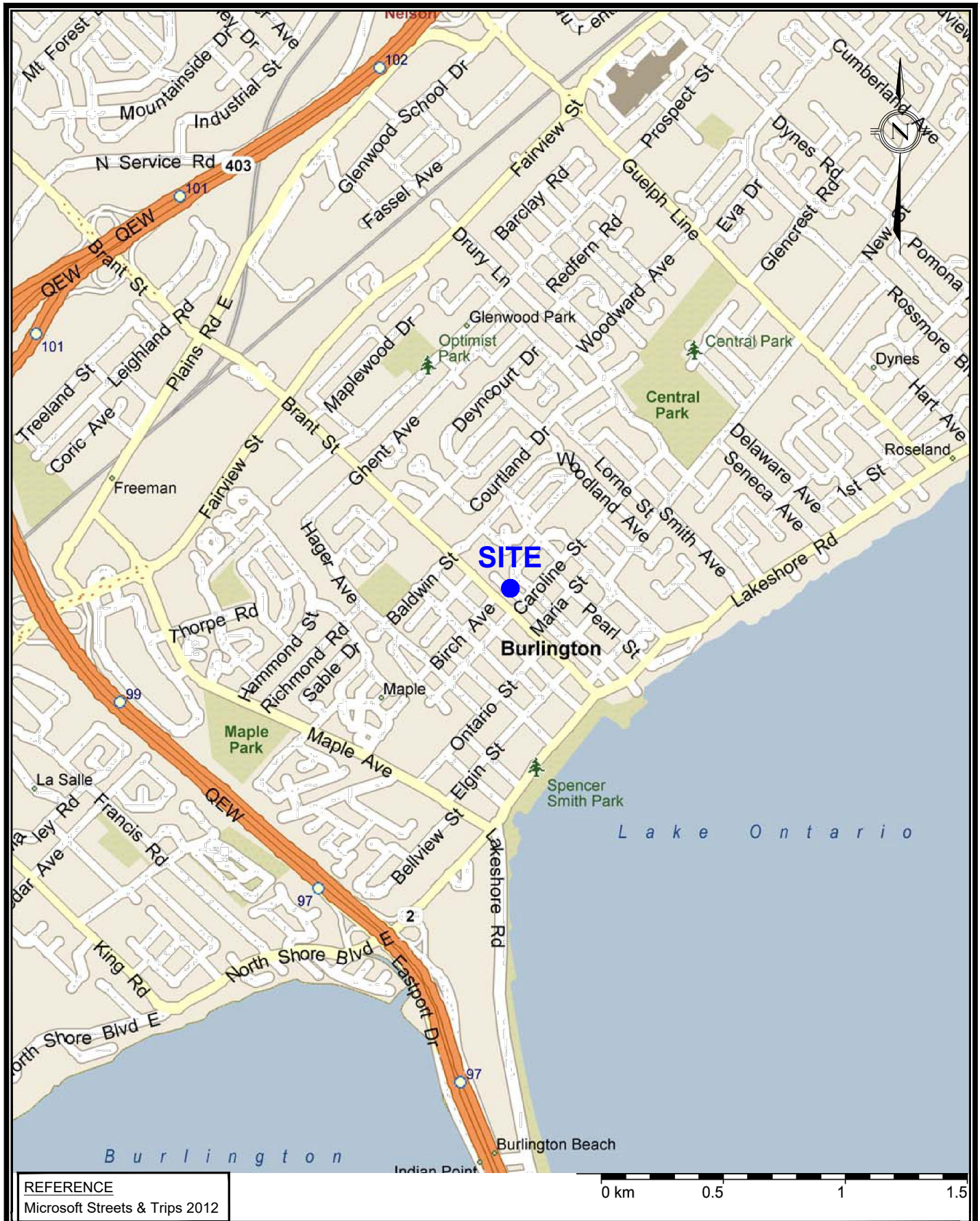


Patrick Cannon, P.Eng.
Principal

FIGURES

TERRAPROBE INC.





REFERENCE
Microsoft Streets & Trips 2012

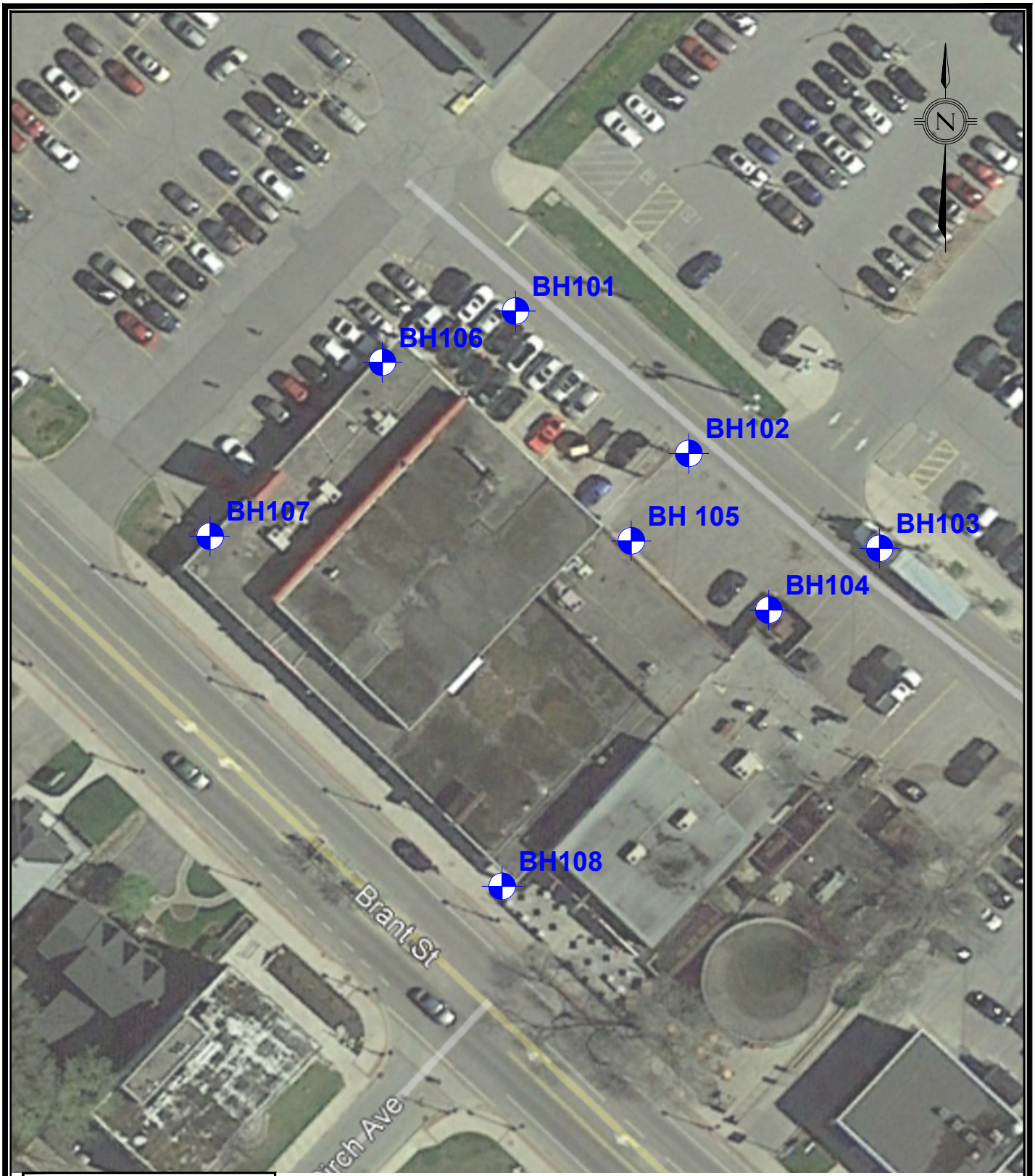
Terraprobe
11 Indell Lane, Brampton, Ontario, L6T 3Y3
Tel: (905) 796-2650 Fax: (905) 796-2250

Title: SITE LOCATION PLAN

File No. 1-18-0718-01

FIGURE : 1

Z:\1-Project Files\2018\1-18-0718 - 535 - 551 Brant Street, Burlington\01-Subsurface Investigation\A. Dwgs, Logs\AutoCAD\1-18-0718-01 FIG.dwg, Sandy



LEGEND

Approximate Borehole Location

SCALE 1:750

0 2 4 6 8 10 20m

REFERENCE
Google Earth 2018

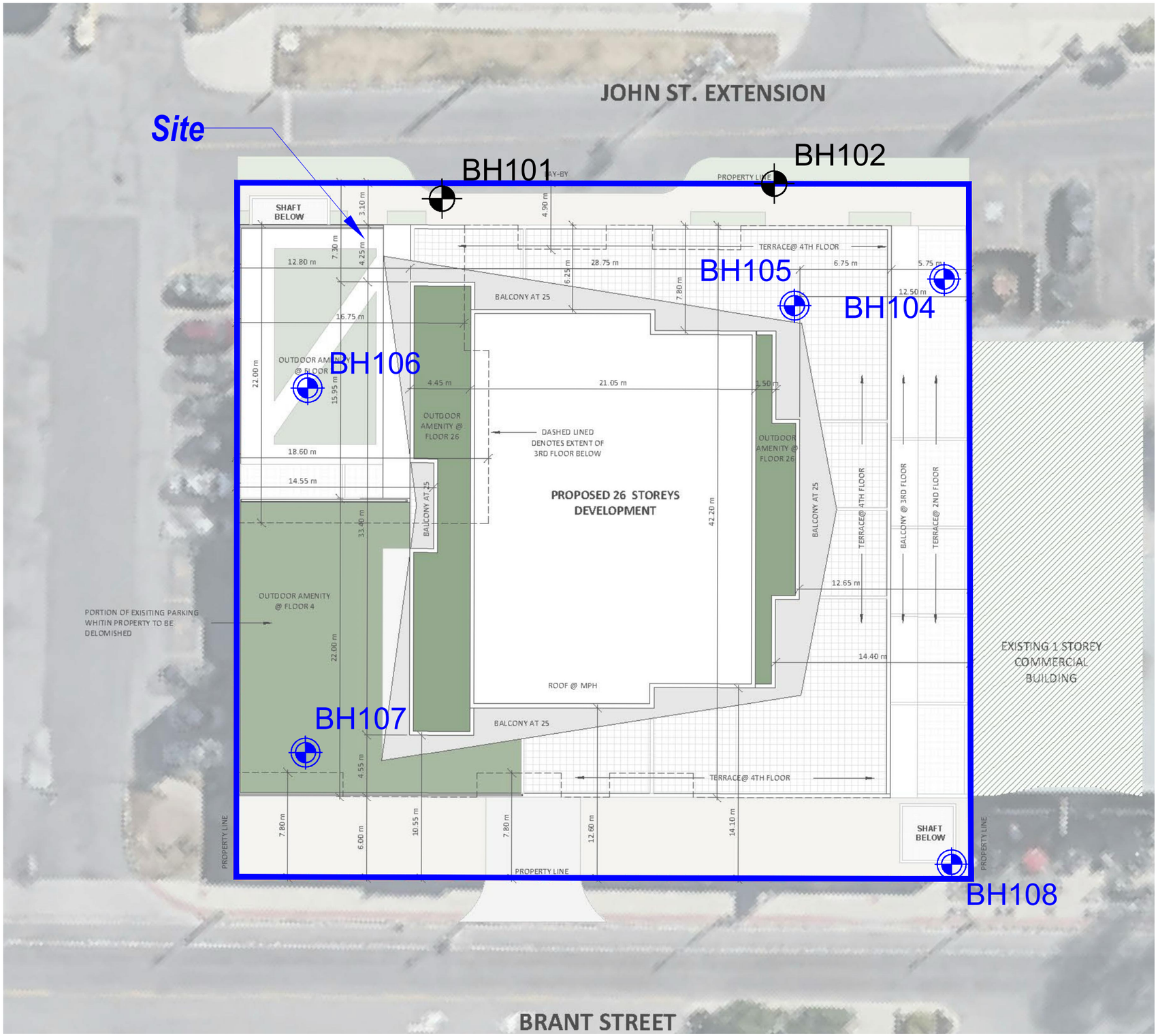
Terraprobe
11 Indell Lane, Brampton, Ontario, L6T 3Y3
Tel: (905) 796-2650 Fax: (905) 796-2250

Title: BOREHOLE LOCATION PLAN

File No. 1-18-0718-01

FIGURE : 2

Z:\1-Project Files\2018\1-18-0718 - 535 - 551 Brant Street, Burlington\01-Subsurface Investigation\A. Dwgs, Logs\AutoCAD\1-18-0718-01 FIG.dwg, Sandy



Terraprobe Inc.
Consulting Geotechnical & Environmental Engineering
Construction Materials, Inspection & Testing
11 Indell Lane - Brampton Ontario L6T 3Y3 (905) 796-2650

Reference:
Site Plan
535-551 Brant Street, Burlington, ON
Dwg No: A1.02
Project No: 18.069
By: Turner Fleischer

Notes:

Legend:

- Site Boundary
- Approximate Borehole with Monitoring Well Location
- Approximate Geotechnical Pavement Investigation Borehole Location

Project Title:
Geotechnical Engineering Report

Site Location:
535 to 551 Brant Street, Burlington, Ontario

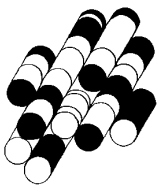
Figure Title:
BOREHOLE LOCATION PLAN-
PROPOSED CONDITION

Designed By: TW	***File No.:*** 1-18-0718-46
Drawn By: AA	***Scale:*** As Shown
Reviewed By: PC	***Figure No.:*** 3
Date: April 2020	

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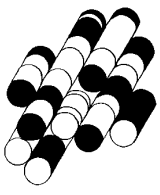
APPENDICES

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APPENDIX A

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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 plastic limit) but does not have visible pore water
Wet	refers to a soil sample that has visible pore water

Terraprobe

ROCK CORE TERMINOLOGY

RECOVERY

TCR **Total Core Recovery** is the total length of core pieces, irrespective of their individual lengths obtained in a core run, and expressed as a percentage of the length of that core run.

SCR **Solid Core Recovery** is the total length of sound full-diameter core pieces obtained in a core run, expressed as a percentage of the length of that core run .

RQD **Rock Quality Designation** pertains to the sum of those pieces of sound core which are 10 cm or greater in length obtained in a core run, expressed as a percentage of the length of that core run.

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
QUALITY	**very poor**	**poor**	**fair**	**good**	**excellent**

JOINT CHARACTERISTICS

Joint Spacing (adapted from *Bieniawski 1989*, *ISRM 1981*)

Classification	Spacing
very close	< 60 mm
close	60 – 200 mm
moderately close	0.2 to 0.6 m
wide	0.6 to 2 m
very wide	> 2 m

Natural Fracture Frequency (per 0.3 m)
Refers to the number of natural fractures (joints, faults, etc.) which are present per 0.3m. Ignores mechanical or drill-induced breaks, and closed discontinuities (e.g. bedding planes).

Orientation

Orientation	Angle from horiz.
horizontal/flat	0 - 20°
dipping	20 - 50°
vertical	50 - 90°

Joint Filling

Description	Approx. φ`
tight, hard, non-softening	25 - 35
oxidation, surface staining only	25 - 30
slightly altered, clay-free	25 - 30
sandy particles, clay-free	2 - 25
sandy and silty, minor clay	1 - 24
non-softening clays	6 - 12
swelling clay fillings	n/a

Joint Aperture

Classification	Aperture
closed / tight	< 0.5 mm
gapped	0.5 to 10 mm
open	> 10 mm

Planarity
- Planar
- Undulating
- Stepped
- Irregular
- Discontinuous

Roughness
- Very rough
- Rough
- Smooth
- Slickensided
- Polished

Coating	Description
clean	no filling
veneer	< 1 mm filling
coating / infill	> 1 mm filling

GENERAL

Degree of Weathering (*after MTO, RR229 Evaluation of Shales for Construction Projects*)

Zone	Degree	Description
Z1	unweathered	shale, regular jointing
Z2	partially weathered	angular blocks of unweathered shale, no matrix, with chemically weathered but intact shale
Z3		soil-like matrix with frequent angular shale fragments < 25mm diameter
Z4a		soil-like matrix with occasional shale fragments < 3mm diameter
Z4b	fully weathered	soil-like matrix only

Strength classification (*after Marinos and Hoek, 2001*)

Grade	Term	UCS (MPa)	Field Estimate (Description)
R6	extremely strong	> 250	can only be chipped by geological hammer
R5	very strong	100 - 250	requires many blows from geological hammer
R4	strong	50 - 100	requires more than one blow from geological hammer
R3	medium strong	25 - 50	can't be scraped, breaks under one blow from geological hammer
R2	weak	5 - 25	can be peeled / scraped with knife with difficulty
R1	very weak	1 - 5	easily scraped / peeled, crumbles under firm blow of geo. hammer
R0	extremely weak	< 1	indented by thumbnail

Bedding Thickness (*Quarterly Journal of Engineering Geology, Vol 3, 1970*)

Very thickly bedded	> 2 m	Medium bedded	200 – 600mm	Very thinly bedded	20 – 60mm	Thinly Laminated < 6mm
Thickly bedded	0.6 – 2m	Thinly bedded	60 – 200mm	Laminated	6 – 20mm	

LOG OF BOREHOLE 101

Terraprobe

Project No. : 1-18-0718	Client : Carriage Gate Homes	Originated by : TG
Date started : November 26, 2018	Project : 535-551 Brant Street	Compiled by : JK
Sheet No. : 1 of 1	Location : Burlington, ON	Checked by : MD

Position : E: 597162, N: 4798043 (UTM 17T) Elevation Datum : Geodetic

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

Depth Scale (m)	Elev Depth (m)	Description	Graphic Log	Number	Type	SPT 'N' Value	Elevation Scale (m)	Penetration Test Values (Blows / 0.3m) / Undrained Shear Strength (kPa)	Moisture / Plasticity	Headspace Vapour (ppm)	Instrument Details	Lab Data and Comments
0	**87.5**	**GROUND SURFACE**										
	87.2	115mm **ASPHALTIC CONCRETE**										
	0.3	150mm **AGGREGATE**										
		FILL, clayey silt, trace sand, trace gravel, trace asphalt, stiff, red with black pockets, moist		1	SS	15	87					SS1 Analysis: M&I
1				2	SS	12						SS2 Analysis: PAH
	86.0						86					
	1.5	**SILT**, some clay, trace sand, trace gravel, hard, reddish brown, moist (HALTON TILL)		3	SS	92 / 275mm						SS3 Analysis: PHC
	85.5											
	2.0	**END OF BOREHOLE**										

Penetration Test Values (Blows / 0.3m): Dynamic Cone — 10, 20, 30, 40

Undrained Shear Strength (kPa): Unconfined, Pocket Penetrometer, Field Vane, Lab Vane — 40, 80, 120, 160

Moisture / Plasticity: Plastic Limit, Natural Water Content, Liquid Limit — PL, MC, LL — 10, 20, 30

Unstabilized Water Level

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

Borehole was dry and open upon completion of drilling.

file: 1-18-0718 bh logs.gpj

LOG OF BOREHOLE 102

Terraprobe

Project No. : 1-18-0718	Client : Carriage Gate Homes	Originated by : TG
Date started : November 26, 2018	Project : 535-551 Brant Street	Compiled by : JK
Sheet No. : 1 of 1	Location : Burlington, ON	Checked by : MD

Position : E: 597181, N: 4798028 (UTM 17T) Elevation Datum : Geodetic

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

Depth Scale (m)	Elev Depth (m)	Description	Graphic Log	Number	Type	SPT 'N' Value	Elevation Scale (m)	Penetration Test Values (Blows / 0.3m) / Undrained Shear Strength (kPa)	Moisture / Plasticity	Headspace Vapour (ppm)	Instrument Details	Unstabilized Water Level	Lab Data and Comments
0	87.3	**GROUND SURFACE**					87	Dynamic Cone 10 20 30 40; Unconfined / Pocket Penetrometer / Field Vane / Lab Vane 40 80 120 160	Plastic Limit / Natural Water Content / Liquid Limit PL MC LL 10 20 30				GRAIN SIZE DISTRIBUTION (%) (MIT) GR SA SI CL
		120mm **ASPHALTIC CONCRETE**											
	86.9	260mm **AGGREGATE**											
	0.4	**FILL**, clayey silt, some sand, trace to some gravel, trace asphalt, trace rock fragments, firm to stiff, dark brown, moist		1	SS	7						▽	SS1 Analysis: PAH
1		...at 0.6 m, red, stiff		2	SS	13	86						SS2 Analysis: VOC, PHC
	85.8												
	1.5	**SILT**, some silt, trace sand, trace gravel, hard, reddish brown, moist		3	SS	59							SS3 Analysis: M&I
	85.3	(HALTON TILL)											
	2.0	**END OF BOREHOLE**											

Unstabilized water level measured at 0.3 m below ground surface; borehole caved to 0.9 m below ground surface upon completion of drilling.

LOG OF BOREHOLE 103

Terraprobe

Project No. : 1-18-0718	Client : Carriage Gate Homes	Originated by : TG
Date started : November 26, 2018	Project : 535-551 Brant Street	Compiled by : JK
Sheet No. : 1 of 1	Location : Burlington, ON	Checked by : MD

Position : E: 597202, N: 4798017 (UTM 17T) Elevation Datum : Geodetic

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

Depth Scale (m)	Elev Depth (m)	Description	Graphic Log	Number	Type	SPT 'N' Value	Elevation Scale (m)	Penetration Test Values (Blows / 0.3m) / Undrained Shear Strength (kPa)	Moisture / Plasticity (PL, MC, LL)	Headspace Vapour (ppm)	Instrument Details	Unstabilized Water Level	Lab Data and Comments
0	87.3	**GROUND SURFACE**											
	87.0	95mm **ASPHALTIC CONCRETE**											
	0.3	240mm **AGGREGATE**											
		FILL, clayey silt, some sand, trace to some gravel, trace asphalt, trace rock fragments, stilff to very stiff, red with black pockets, moist		1	SS	26	87						SS1 Analysis: VOC, PHC
1				2	SS	12							SS2 Analysis: M&I
	85.8						86						
	1.5	**SILT**, some clay, trace sand, trace gravel, very stiff, reddish brown, moist (HALTON TILL)		3	SS	17							SS3 Analysis: PAH
	85.3												
	2.0	**END OF BOREHOLE**											

Penetration Test Values (Blows / 0.3m): Dynamic Cone — 10, 20, 30, 40

Undrained Shear Strength (kPa): Unconfined, Pocket Penetrometer, Field Vane, Lab Vane — 40, 80, 120, 160

Moisture / Plasticity: Plastic Limit (PL) 10, Natural Water Content (MC) 20, Liquid Limit (LL) 30

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

Borehole was dry and open upon completion of drilling.

file: 1-18-0718 bh logs.gpj

LOG OF BOREHOLE 104

Terraprobe

Project No. : 1-18-0718	Client : Carriage Gate Homes	Originated by : TG
Date started : January 22, 2019	Project : 535-551 Brant Street	Compiled by : JK
Sheet No. : 1 of 2	Location : Burlington, ON	Checked by : MD

Position : E: 597190, N: 4798010 (UTM 17T) | Elevation Datum : Geodetic | Core Diameter : **HQ**, OD=96mm, ID=64mm

Rig type : Truck-mounted | Drilling Method : Hollow stem augers, HQ rock coring

Depth Scale (m)	Elev Depth (m)	Description	Graphic Log	Sample Number	Sample Type	SPT 'N' Value	Elevation Scale (m)	Penetration Test Values (Blows / 0.3m) / Undrained Shear Strength (kPa)	Moisture / Plasticity	Headspace Vapour (ppm)	Instrument Details	Lab Data and Comments
0	**87.4**	**GROUND SURFACE**					87					
	87.2	80mm **ASPHALTIC CONCRETE**										
	0.2	80mm **AGGREGATE**										
		FILL, clayey silt, trace to some gravel, trace sand, trace asphalt, hard, red with grey and black pockets, moist		1	SS	34				PID: <5		SS1 Analysis: M&I
1		...at 0.8 m, some sand, trace concrete, dark brown to black, firm		2	SS	5	86			PID: 5		SS2 Analysis: PAH
		...at 1.5 m, brown with red staining		3	SS	6				PID: 10		SS3 Analysis: VOC, PHC
2	85.1						85			PID: <5		
	2.3	**SILT**, some clay, trace sand, trace gravel, firm, reddish brown, moist (HALTON TILL)		4A	SS	6				PID: <5		17 11 47 25
		...at 2.6 m, silty clay, trace shale fragments		4B								4B Analysis: M&I, PAH, VOC, PHC
3	84.4											
	3.0			5	SS	50 / 125mm				PID: <5		
	84.1	**INFERRED BEDROCK**, shale, red					84					
	3.3	**QUEENSTON FORMATION** (See rock core log for details)		1	RUN							
		...at 3.5 m, transition to sound bedrock		2	RUN		83					
5												
				3	RUN		82					
6												
							81					
7				4	RUN							
							80					
8												
							79					
9				5	RUN							
							78					
10												
							77					
				6	RUN							
11							76					
				7	RUN							

(continued next page)

LOG OF BOREHOLE 104

Terraprobe

Project No. : 1-18-0718	Client : Carriage Gate Homes	Originated by : TG
Date started : January 22, 2019	Project : 535-551 Brant Street	Compiled by : JK
Sheet No. : 2 of 2	Location : Burlington, ON	Checked by : MD

Position : E: 597190, N: 4798010 (UTM 17T) | Elevation Datum : Geodetic | Core Diameter : **HQ**, OD=96mm, ID=64mm

Rig type : Truck-mounted | Drilling Method : Hollow stem augers, HQ rock coring

Depth Scale (m)	Elev Depth (m)	Description	Graphic Log	Sample Number	Sample Type	SPT 'N' Value
		(continued)				
12		**QUEENSTON FORMATION** (See rock core log for details) *(continued)*		7	RUN	
13				8	RUN	
14						
15				9	RUN	
16						
17				10	RUN	
18				11	RUN	
	68.9 18.5	**END OF BOREHOLE**				

Elevation Scale (m): 75, 74, 73, 72, 71, 70, 69

Penetration Test Values (Blows / 0.3m): Dynamic Cone 10 20 30 40

Undrained Shear Strength (kPa): Unconfined, Pocket Penetrometer, Field Vane, Lab Vane — 40 80 120 160

Moisture / Plasticity: Plastic Limit, Natural Water Content, Liquid Limit — PL MC LL — 10 20 30

Headspace Vapour (ppm)

Instrument Details

Unstabilized Water Level

Lab Data and Comments

GRAIN SIZE DISTRIBUTION (%) (MIT) — GR SA SI CL

Borehole contained drill water upon completion of drilling. Unstabilized water level and cave not measured.

50 mm dia. monitoring well installed.

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Mar 15, 2019	3.3	84.2
Mar 22, 2019	3.2	84.2

file: 1-18-0718 bh logs.gpj

ROCK CORE LOG 104

Terraprobe

Project No. : 1-18-0718 | Client : Carriage Gate Homes | Originated by : TG

Date started : January 22, 2019 | Project : 535-551 Brant Street | Compiled by : JK

Sheet No. : 1 of 1 | Location : Burlington, ON | Checked by : MD

Position : E: 597190, N: 4798010 (UTM 17T) | Elevation Datum : Geodetic | Core Diameter : **HQ**, OD=96mm, ID=64mm

Rig type : Truck-mounted | Drilling Method : Hollow stem augers, HQ rock coring

Rock coring started at 3.3m below grade

QUEENSTON FORMATION

calcareous Shale, red, medium bedded, weak; joints are horizontal, closed to gapped, clean;

interbedded with **limestone**, grey, thinly bedded, medium strong

...at 3.5m, transition to sound bedrock

Run 1 : 0% limestone, 100% shale

Run 2 : 10% limestone, 90% shale

Run 3 : 7% limestone, 93% shale

Run 4 : 16% limestone, 84% shale

Run 5 : 29% limestone, 71% shale

Run 6 : 17% limestone, 83% shale

Run 7 : 8% limestone, 92% shale

Run 8 : 9% limestone, 91% shale

Run 9 : 9% limestone, 91% shale

Run 10 : 6% limestone, 94% shale

Run 11 : 4% limestone, 96% shale

END OF COREHOLE

Run	Elev Depth (m)	Recovery	Elevation (m)
	84.1		
R1	3.3 / 83.3	TCR = **103**% SCR = **87**% RQD = **45**%	84
R2	4.1 / 81.8	TCR = **100**% SCR = **97**% RQD = **83**%	83
R3	5.6 / 80.2	TCR = **100**% SCR = **93**% RQD = **68**%	82
R4	7.2 / 78.7	TCR = **98**% SCR = **98**% RQD = **95**%	81
R5	8.7 / 77.2	TCR = **93**% SCR = **88**% RQD = **60**%	80
R6	10.2 / 75.7	TCR = **100**% SCR = **97**% RQD = **85**%	79
R7	11.7 / 74.3	TCR = **98**% SCR = **98**% RQD = **98**%	78
R8	13.1 / 72.7	TCR = **100**% SCR = **100**% RQD = **100**%	77
R9	14.7 / 71.2	TCR = **97**% SCR = **97**% RQD = **97**%	76
R10	16.2 / 69.6	TCR = **95**% SCR = **94**% RQD = **87**%	75
R11	17.8 / 68.9	TCR = **100**% SCR = **96**% RQD = **96**%	74
	18.5m		73
			72
			71
			70
			69

Natural Fractures: Frequency / Spacing

Frequency
5
2
6
2
2
1
2
2
WZ
3
1
0
1
1
1
0
1
1
>10
3
1
5
2
1
0
1
1
0
0
1
0
0
0
0
1
1
1
0
0
0
0
0
1
0
2
0
0
0
2
0
0
0
0

Comments

- **3.3m:** *highly weathered*
- **3.8m:** *dipping joint, closed, clean, smooth, planar*
- **4.1m:** *vertilcal joint, closed, clean, smooth, planar*
- **5.6-5.7m:** *50mm rubblized*
- **8.8-8.8m:** *rubble*
- **8.9m:** *dipping joint, clean, smooth, closed, planar*
- **9.6-9.7m:** *horizontal joint, clay infilled, gapped, smooth, planar*
- **10.3m:** *dipping joint, closed, smooth, planar, clean*
- **13.0m:** *cacium deposits*
- **16.5m:** *vertical joint, clean, closed, smooth, undulating*

file: 1-18-0718 bh logs.gpj

LOG OF BOREHOLE 105

Terraprobe

Project No. : 1-18-0718	Client : Carriage Gate Homes	Originated by : TG
Date started : January 25, 2019	Project : 535-551 Brant Street	Compiled by : JK
Sheet No. : 1 of 1	Location : Burlington, ON	Checked by : MD

Position : E: 597175, N: 4798018 (UTM 17T) Elevation Datum : Geodetic

Rig type : Big Beaver Drilling Method : Solid stem augers

Depth Scale (m)	Elev Depth (m)	Description	Graphic Log	Number	Type	SPT 'N' Value	Elevation Scale (m)	Penetration Test Values (Blows / 0.3m) / Undrained Shear Strength (kPa)	Moisture / Plasticity (PL, MC, LL)	Headspace Vapour (ppm)	Instrument Details	Lab Data and Comments
0	87.6	**GROUND SURFACE**					87					
		50mm **ASPHALTIC CONCRETE**										
		50mm **AGGREGATE**										
		FILL, clayey silt, trace to some sand, trace to some gravel, trace asphalt, trace wood fragments, trace rock fragments, stiff, reddish brown, moist		1	SS	9				PID: <5		SS1 Analysis: M&I
1				2	SS	13				PID: <5		SS2 Analysis: PAH, VOC, PHC
	86.1						86					
	1.5	**SILT**, some clay, trace sand, trace gravel, very stiff, reddish brown, moist (HALTON TILL)		3	SS	28				PID: <5		SS3 Analysis: M&I, PAH, VOC, PHC
2		...at 2.3 m, trace shale fragments, hard, grey with red		4	SS	81 / 200mm				PID: <5		14 22 46 18 / 21 18 41 20
	85.0						85					
	2.6	**END OF BOREHOLE**										

Penetration Test Values (Blows / 0.3m): Dynamic Cone (10, 20, 30, 40)

Undrained Shear Strength (kPa): Unconfined, Pocket Penetrometer, Field Vane, Lab Vane (40, 80, 120, 160)

Moisture / Plasticity: Plastic Limit (PL), Natural Water Content (MC), Liquid Limit (LL) (10, 20, 30)

Unstabilized Water Level

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

Borehole was dry and open upon completion of drilling.

50 mm dia. monitoring well installed.

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Mar 15, 2019	dry	n/a
Mar 22, 2019	dry	n/a

file: 1-18-0718 bh logs.gpj

LOG OF BOREHOLE 106

Terraprobe

Project No. : 1-18-0718	Client : Carriage Gate Homes	Originated by : TG
Date started : January 23, 2019	Project : 535-551 Brant Street	Compiled by : JK
Sheet No. : 1 of 2	Location : Burlington, ON	Checked by : MD

Position : E: 597147, N: 4798038 (UTM 17T) | Elevation Datum : Geodetic | Core Diameter : **HQ**, OD=96mm, ID=64mm

Rig type : Truck-mounted | Drilling Method : Hollow stem augers, HQ rock coring

Depth Scale (m)	Elev Depth (m)	Description	Graphic Log	Sample Number	Sample Type	SPT 'N' Value
0	87.7	**GROUND SURFACE**				
	87.5 / 0.2	80mm **ASPHALTIC CONCRETE**				
		80mm **AGGREGATE**		1	SS	7
		FILL, sandy silt, trace gravel, trace asphalt, loose, brown to dark brown, moist		2	SS	7
1	86.2					
	1.5	**SILT**, some clay, trace sand, trace gravel, very stiff to hard, reddish brown, moist (HALTON TILL)		3	SS	24
2				4	SS	54
	84.7					
3	3.0	**INFERRED BEDROCK**, shale, red		5	SS	50 / 125mm
	84.5 / 3.2	**QUEENSTON FORMATION** (See rock core log for details)		1	RUN	
4		..at 3.2 m, transition to sound bedrock				
5				2	RUN	
6				3	RUN	
7						
8				4	RUN	
9				5	RUN	
10						
11				6	RUN	
				7	RUN	

Elevation Scale (m): 87, 86, 85, 84, 83, 82, 81, 80, 79, 78, 77, 76

Penetration Test Values (Blows / 0.3m): Dynamic Cone 10 20 30 40

Undrained Shear Strength (kPa): Unconfined, Pocket Penetrometer, Field Vane, Lab Vane — 40 80 120 160

Moisture / Plasticity: Plastic Limit (PL) 10, Natural Water Content (MC) 20, Liquid Limit (LL) 30

Headspace Vapour (ppm): PID: <5 (SS1), PID: <5 (SS2), PID: <5 (SS3), PID: <5 (SS4), PID: <5 (RUN)

Instrument Details: Unstabilized Water Level

Lab Data and Comments

GRAIN SIZE DISTRIBUTION (%) (MIT)

GR SA SI CL

SS1 Analysis: PAH

SS2 Analysis: M&I, VOC, PHC

SS3 Analysis: M&I, PAH

0 10 74 16

SS4 Analysis: VOC, PHC

(continued next page)

LOG OF BOREHOLE 106

Terraprobe

Project No. : 1-18-0718	Client : Carriage Gate Homes	Originated by : TG
Date started : January 23, 2019	Project : 535-551 Brant Street	Compiled by : JK
Sheet No. : 2 of 2	Location : Burlington, ON	Checked by : MD

Position : E: 597147, N: 4798038 (UTM 17T) | Elevation Datum : Geodetic | Core Diameter : **HQ**, OD=96mm, ID=64mm

Rig type : Truck-mounted | Drilling Method : Hollow stem augers, HQ rock coring

Depth Scale (m)	Elev / Depth (m)	Description	Graphic Log	Sample Number	Sample Type	SPT 'N' Value
12		*(continued)*				
		QUEENSTON FORMATION (See rock core log for details) *(continued)*		7	RUN	
13						
				8	RUN	
14						
				9	RUN	
15						
				10	RUN	
16						
17	69.7 / 18.0	**END OF BOREHOLE**				

Elevation Scale (m): 75, 74, 73, 72, 71, 70

Penetration Test Values (Blows / 0.3m): Dynamic Cone 10 20 30 40

Undrained Shear Strength (kPa): Unconfined, Pocket Penetrometer, Field Vane, Lab Vane — 40 80 120 160

Moisture / Plasticity: Plastic Limit (PL) | Natural Water Content (MC) | Liquid Limit (LL) — 10 20 30

Headspace Vapour (ppm)

Instrument Details

Unstabilized Water Level

Lab Data and Comments

GRAIN SIZE DISTRIBUTION (%) (MIT) — GR SA SI CL

Borehole contained drill water upon completion of drilling. Unstabilized water level and cave not measured.

50 mm dia. monitoring well installed.

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Mar 15, 2019	4.5	83.2
Mar 22, 2019	4.5	83.3

file: 1-18-0718 bh logs.gpj

ROCK CORE LOG 106

Terraprobe

Project No. : 1-18-0718 | Client : Carriage Gate Homes | Originated by : TG

Date started : January 23, 2019 | Project : 535-551 Brant Street | Compiled by : JK

Sheet No. : 1 of 1 | Location : Burlington, ON | Checked by : MD

Position : E: 597147, N: 4798038 (UTM 17T) | Elevation Datum : Geodetic | Core Diameter : **HQ**, OD=96mm, ID=64mm

Rig type : Truck-mounted | Drilling Method : Hollow stem augers, HQ rock coring

Depth (m)	Graphic Log	GENERAL DESCRIPTION	Run / Elev / Depth (m)	Recovery	Elevation (m)	Shale Weathering Zones (Z1 Z2 Z3 Z4)	UCS (MPa) / Estimated Strength (R1 R2 R3 R4 R5 R6)	Natural Fractures: Frequency	Natural Fractures: Spacing	Laboratory Testing	Comments	Elevation (m)
		Rock coring started at 3.2m below grade	**84.5**									
		QUEENSTON FORMATION **calcareous Shale**, red, medium bedded, weak; joints are horizontal, closed to gapped, clean;	3.2 R1 83.4	TCR = **98%** SCR = **88%** RQD = **77%**	84			4 0 1 1			**3.4m:** *dipping joint, clean, smooth, planar, closed*	84
4		interbedded with **limestone**, grey, thinly bedded, medium strong ...at 3.2m, transition to sound bedrock	4.3 R2 81.9	TCR = **95%** SCR = **93%** RQD = **92%**	83			2 2 1 2				83
5		*Run 1 : 16% limestone* *84% shale*	5.8 R3 80.4	TCR = **100%** SCR = **95%** RQD = **92%**	82			0 >10 1 1			**5.8m:** *approx. 75mm core loss* **6.1-6.2m:** *approx. 25mm rubblized* **6.2m:** *orange colour in joint (oxidation)*	82
6		*Run 2 : 16% limestone* *84% shale*										
7		*Run 3 : 21% limestone* *79% shale*	7.3 R4 78.9	TCR = **100%** SCR = **100%** RQD = **100%**	81			0 1 1 1 1				81
8		*Run 4 : 32% limestone* *68% shale*			80			0 5 4 2				80
9			8.8 R5 77.3	TCR = **97%** SCR = **90%** RQD = **62%**	79			3 0 0 0				79
10		*Run 5 : 17% limestone* *83% shale*			78			1 0 0 0				78
11		*Run 6 : 3% limestone* *97% shale*	10.4 R6 75.8	TCR = **95%** SCR = **95%** RQD = **95%**	77			0 0 0 2				77
12			11.9 R7 74.3	TCR = **100%** SCR = **98%** RQD = **94%**	76			0 0 0 0				76
13		*Run 7 : 18% limestone* *82% shale*			75			4 1 3 0			**14.2-14.3m:** *approx. 25mm dipping joint, clean*	75
14		*Run 8 : 8% limestone* *92% shale*	13.4 R8 72.8	TCR = **100%** SCR = **100%** RQD = **87%**	74			0 0 0 1				74
15			14.9 R9 71.2	TCR = **100%** SCR = **100%** RQD = **100%**	73			0 0 0 1				73
16		*Run 9 : 17% limestone* *83% shale*			72			0 0 0 1				72
17		*Run 10 : 5% limestone* *95% shale*	16.5 R10 69.7	TCR = **98%** SCR = **98%** RQD = **98%**	71			0 0 1 0				71
			18.0m		70			0				70
		END OF COREHOLE										

file: 1-18-0718 bh logs.gpj

LOG OF BOREHOLE 107

Terraprobe

Project No. : 1-18-0718	Client : Carriage Gate Homes	Originated by : TG
Date started : January 24, 2019	Project : 535-551 Brant Street	Compiled by : JK
Sheet No. : 1 of 2	Location : Burlington, ON	Checked by : MD

Position : E: 597128, N: 4798019 (UTM 17T) | Elevation Datum : Geodetic | Core Diameter : **HQ**, OD=96mm, ID=64mm

Rig type : Truck-mounted | Drilling Method : Hollow stem augers, HQ rock coring

Depth Scale (m)	Elev Depth (m)	Description	Graphic Log	Number	Type	SPT 'N' Value
0	87.8	**GROUND SURFACE**				
	87.6	75mm **ASPHALTIC CONCRETE**				
	0.2	75mm **AGGREGATE**		1	SS	11
		FILL, clayey silt, sandy, trace to some gravel, trace asphalt, trace concrete fragments, trace brick, very loose/very soft to stiff/compact, black to dark brown, moist		2	SS	2
	86.3					
2	1.5	**SILT**, some clay, trace sand, trace gravel, very stiff to hard, reddish brown, moist (HALTON TILL)		3	SS	16
				4	SS	50 / 125mm
3	84.8					
	3.0	**INFERRED BEDROCK**, shale, red		5	SS	50 / 25mm
	84.7	**QUEENSTON FORMATION** (See rock core log for details)		1	RUN	
	3.1	...at 3.6 m, transition to sound bedrock		2	RUN	
4				3	RUN	
5				4	RUN	
6				5	RUN	
7				6	RUN	
8				7	RUN	
9						
10						
11						

Elevation Scale (m): 87, 86, 85, 84, 83, 82, 81, 80, 79, 78, 77, 76

Penetration Test Values (Blows / 0.3m): Dynamic Cone 10 20 30 40

Undrained Shear Strength (kPa): Unconfined, Pocket Penetrometer, Field Vane, Lab Vane — 40 80 120 160

Moisture / Plasticity: Plastic Limit, Natural Water Content, Liquid Limit — PL MC LL — 10 20 30

Headspace Vapour (ppm)

Instrument Details

Unstabilized Water Level

Lab Data and Comments

GRAIN SIZE DISTRIBUTION (%) (MIT) GR SA SI CL

SS1 Analysis: M&I, PAH

SS2 Analysis: VOC, PHC

SS3 Analysis: M&I, PAH

SS4 Analysis: VOC, PHC

(continued next page)

LOG OF BOREHOLE 107

Terraprobe

Project No. : 1-18-0718	Client : Carriage Gate Homes	Originated by : TG
Date started : January 24, 2019	Project : 535-551 Brant Street	Compiled by : JK
Sheet No. : 2 of 2	Location : Burlington, ON	Checked by : MD

Position : E: 597128, N: 4798019 (UTM 17T) | Elevation Datum : Geodetic | Core Diameter : **HQ**, OD=96mm, ID=64mm

Rig type : Truck-mounted | Drilling Method : Hollow stem augers, HQ rock coring

Depth Scale (m)	Elev / Depth (m)	Description	Graphic Log	Sample Number	Sample Type	SPT 'N' Value
12		*(continued)*				
		QUEENSTON FORMATION (See rock core log for details) *(continued)*		7	RUN	
13				8	RUN	
14						
15				9	RUN	
16				10	RUN	
17						
18	69.7 / 18.1			11	RUN	

Elevation Scale (m): 75, 74, 73, 72, 71, 70

Penetration Test Values (Blows / 0.3m): Dynamic Cone 10 20 30 40

Undrained Shear Strength (kPa): Unconfined, Pocket Penetrometer, Field Vane, Lab Vane — 40 80 120 160

Moisture / Plasticity: Plastic Limit (PL) | Natural Water Content (MC) | Liquid Limit (LL) — 10 20 30

Headspace Vapour (ppm)

Instrument Details

Unstabilized Water Level

Lab Data and Comments

GRAIN SIZE DISTRIBUTION (%) (MIT) — GR SA SI CL

END OF BOREHOLE

Borehole contained drill water upon completion of drilling. Unstabilized water level and cave not measured.

50 mm dia. monitoring well installed.

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Mar 15, 2019	4.3	83.5
Mar 22, 2019	4.1	83.7

file: 1-18-0718 bh logs.gpj

Terraprobe

ROCK CORE LOG 107

Project No. : 1-18-0718	Client : Carriage Gate Homes	Originated by : TG
Date started : January 24, 2019	Project : 535-551 Brant Street	Compiled by : JK
Sheet No. : 1 of 1	Location : Burlington, ON	Checked by : MD

Position : E: 597128, N: 4798019 (UTM 17T) — Elevation Datum : Geodetic — Core Diameter : **HQ**, OD=96mm, ID=64mm

Rig type : Truck-mounted — Drilling Method : Hollow stem augers, HQ rock coring

Column headings: Depth (m) | Graphic Log | GENERAL DESCRIPTION | Run / Elev Depth (m) | Recovery | Elevation (m) | Shale Weathering Zones (Z1 Z2 Z3 Z4) | UCS (MPa) ● 5 25 50 100 250 / Estimated Strength (R1 R2 R3 R4 R5 R6) | Natural Fractures: Frequency, Spacing | Laboratory Testing | Comments | Elevation (m)

Rock coring started at 3.1m below grade (84.7)

QUEENSTON FORMATION
calcareous Shale, red, medium bedded, weak; joints are horizontal, closed to gapped, clean;

interbedded with **limestone**, grey, thinly bedded, medium strong
...at 3.6m, transition to sound bedrock

Run 1 : 9% limestone, 91% shale
Run 2 : 33% limestone, 67% shale
Run 3 : 10% limestone, 90% shale
Run 4 : 19% limestone, 81% shale
Run 5 : 30% limestone, 70% shale
Run 6 : 28% limestone, 72% shale
Run 7 : 25% limestone, 75% shale
Run 8 : 9% limestone, 91% shale
Run 9 : 19% limestone, 81% shale
Run 10 : 0% limestone, 100% shale
Run 11 : 8% limestone, 92% shale

Run	Depth from (m)	Elev to (m)	TCR	SCR	RQD
R1	3.1	83.5	**100%**	**72%**	**43%**
R2	4.3	82.0	**97%**	**92%**	**68%**
R3	5.8	80.5	**100%**	**98%**	**97%**
R4	7.3	79.6	**100%**	**89%**	**78%**
R5	8.2	78.0	**100%**	**97%**	**93%**
R6	9.8	76.5	**95%**	**95%**	**90%**
R7	11.3	75.0	**95%**	**95%**	**92%**
R8	12.8	73.6	**100%**	**100%**	**100%**
R9	14.2	72.0	**98%**	**98%**	**81%**
R10	15.8	70.4	**100%**	**100%**	**100%**
R11	17.4	69.7	**100%**	**100%**	**100%**

Bottom: 18.1m

Natural fracture frequency (top to bottom): >10, >10, 2, 2, 1, 4, 6, >10, 2, 0, 12, 3, 2, 1, >10, 1, 2, 1, 1, 1, 0, 4, 0, 2, 2, 1, 0, 0, 0, 0, 1, 2, 0, 0, 0, 1, 0, 0, 0, 3, 2, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0

Comments

3.1-3.3m: *approx. 200mm rubble*
3.4-3.5m: *approx. 25mm rubblized zone*
3.5m: *vertical joint, clean, gapped, smooth, planar*
3.5-3.6m: *approx. 100mm weathered zone, clay with angular blocks*
7.3-7.4m: *approx. 100mm rubblized zone probably caved material*
12.5-12.6m: *approx. 150mm calcium layer*
13.4m: *calcium deposits*
15.0m: *dipping joint, gapped, smooth, planar, clean*
15.1-15.1m: *approx. 40mm dipping joint, smooth, undulating, open, clay infilled*

END OF COREHOLE

LOG OF BOREHOLE 108

Terraprobe

Project No. : 1-18-0718	Client : Carriage Gate Homes	Originated by : TG
Date started : January 25, 2019	Project : 535-551 Brant Street	Compiled by : JK
Sheet No. : 1 of 1	Location : Burlington, ON	Checked by : MD

Position : E: 597160, N: 4797980 (UTM 17T) Elevation Datum : Geodetic

Rig type : Big Beaver Drilling Method : Solid stem augers

Depth Scale (m)	Elev Depth (m)	Description	Graphic Log	Number	Type	SPT 'N' Value
	87.7	**GROUND SURFACE**				
0	87.5	150mm **PC CONCRETE**				
	0.2	**FILL**, sandy silt, trace gravel, trace rock fragments, loose to compact, dark brown, moist		1	SS	8
1				2	SS	10
	86.2					
	1.5	**SILT**, some clay, trace sand, trace gravel, hard, reddish brown, moist (HALTON TILL)		3	SS	39
2				4	SS	78 / 275mm
	84.7					
3	3.0	**INFERRED BEDROCK**, shale, red		5	SS	50 / 125mm
	84.4					
	3.3	**END OF BOREHOLE**				

Elevation Scale (m): 87, 86, 85

Penetration Test Values (Blows / 0.3m) — Dynamic Cone: 10, 20, 30, 40

Undrained Shear Strength (kPa) — Unconfined, Pocket Penetrometer, Field Vane, Lab Vane: 40, 80, 120, 160

Moisture / Plasticity — Plastic Limit (PL), Natural Water Content (MC), Liquid Limit (LL): 10, 20, 30

Headspace Vapour (ppm)

Instrument Details

Unstabilized Water Level

Lab Data and Comments

GRAIN SIZE DISTRIBUTION (%) (MIT) — GR SA SI CL

SS1 Analysis: M&I

SS2 Analysis: PAH, VOC, PHC

SS3 Analysis: M&I

0 14 73 13

SS4 Analysis: PAH

SS5 Analysis: VOC, PHC

Borehole was dry and open upon completion of drilling.

50 mm dia. monitoring well installed.

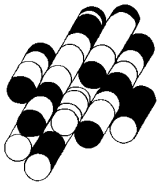
WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Mar 15, 2019	dry	n/a
Mar 22, 2019	2.6	85.2

file: 1-18-0718 bh logs.gpj

APPENDIX B

TERRAPROBE INC.



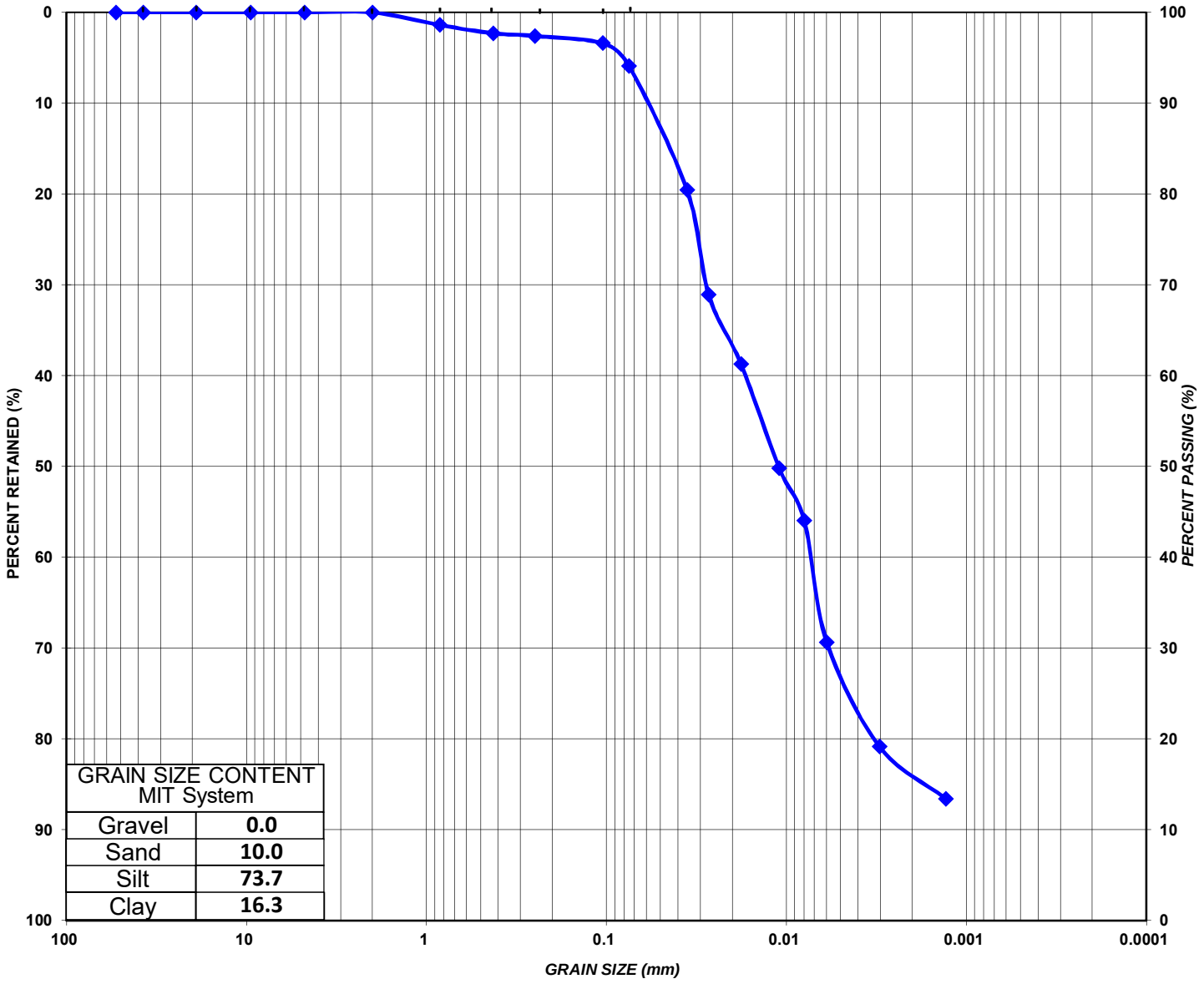
Terraprobe

SIEVE AND HYDROMETER ANALYSIS TEST REPORT

PROJECT: **535 - 551 Brant Street, Burlington, Ontario**
LOCATION: **Burlington, On.**
CLIENT: **Carriage Gate Homes**
BOREHOLE: **106**
SAMPLE NUMBER: **4**
SAMPLE DEPTH: **7'**
SAMPLE DESCRIPTION: **SILT, some clay, trace sand**

FILE NO.: **1-18-0718**
LAB NO.: **1057**
SAMPLE DATE: **Jan 27, 2019**
SAMPLED BY: **TG**

GRAIN SIZE DISTRIBUTION



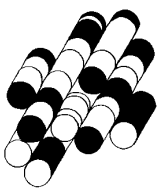
GRAIN SIZE CONTENT MIT System	
Gravel	**0.0**
Sand	**10.0**
Silt	**73.7**
Clay	**16.3**

MIT SYSTEM	GRAVEL	COARSE	MEDIUM	FINE	SILT	CLAY
		SAND				

UNIFIED SYSTEM ASTM D2487	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY
	GRAVEL		SAND			

APPENDIX C

TERRAPROBE INC.



Borehole 104



Bedrock Core Sample
Borehole: 104
Runs: 1, 2, 3
Depth: 3.3 to 6.2 meters below grade (Elev. 84.1 to 81.2 m)



Bedrock Core Sample
Borehole: 104
Runs: 3, 4, 5
Depth: 6.2 to 9.0 meters below grade (Elev. 81.2 to 78.4 m)



Bedrock Core Sample
Borehole: 104
Runs: 5, 6
Depth: 9.0 to 11.7 meters below grade (Elev. 78.4 to 75.7 m)



Bedrock Core Sample
Borehole: 104
Runs: 7, 8
Depth: 11.7 to 14.5 meters below grade (Elev. 75.7 to 72.9 m)



Bedrock Core Sample
Borehole: 104
Runs: 8, 9, 10
Depth: 14.5 to 17.5 meters below grade (Elev. 72.9 to 69.9 m)



Bedrock Core Sample
Borehole: 104
Runs: 10, 11
Depth: 17.5 to 18.5 meters below grade (Elev. 67.9 to 68.9 m)

Borehole 106



Bedrock Core Sample
Borehole: 106
Runs: 1, 2, 3
Depth: 3.2 to 6.2 meters below grade (Elev. 84.5 to 81.5 m)



Bedrock Core Sample
Borehole: 106
Runs: 3, 4, 5
Depth: 6.2 to 9.0 meters below grade (Elev. 81.5 to 78.7 m)



Bedrock Core Sample
Borehole: 106
Runs: 5, 6, 7
Depth: 9.0 to 12.1 meters below grade (Elev. 78.7 to 75.6 m)



Bedrock Core Sample
Borehole: 106
Runs: 7, 8
Depth: 12.1 to 14.9 meters below grade (Elev. 75.6 to 72.8 m)



Bedrock Core Sample
Borehole: 106
Runs: 9, 10
Depth: 14.9 to 18.0 meters below grade (Elev. 72.8 to 69.7 m)

Borehole 107



Bedrock Core Sample
Borehole: 107
Runs: 1, 2
Depth: 3.1 to 5.8 meters below grade (Elev. 84.7 to 82.0 m)



Bedrock Core Sample
Borehole: 107
Runs: 3, 4, 5
Depth: 5.8 to 8.7 meters below grade (Elev. 82.0 to 79.1 m)



Bedrock Core Sample
Borehole: 107
Runs: 5, 6
Depth: 8.7 to 11.3 meters below grade (Elev. 79.1 to 76.5 m)



Bedrock Core Sample
Borehole: 107
Runs: 7, 8
Depth: 11.3 to 14.2 meters below grade (Elev. 76.5 to 73.6 m)



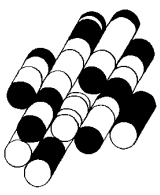
Bedrock Core Sample
Borehole: 107
Runs: 9
Depth: 14.2 to 15.8 meters below grade (Elev. 73.6 to 72.0 m)

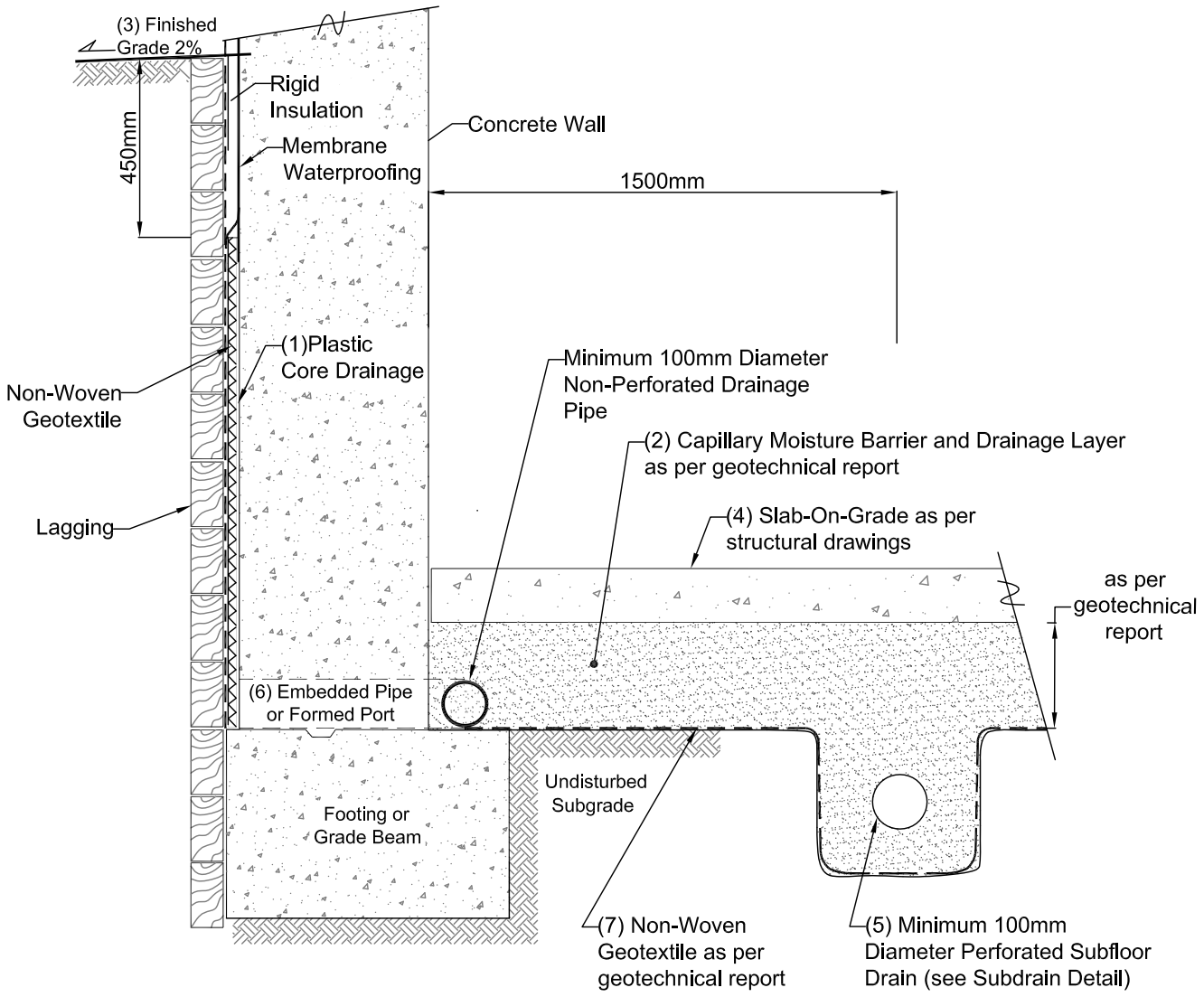


Bedrock Core Sample
Borehole: 107
Runs: 10, 11
Depth: 15.8 to 18.1 meters below grade (Elev. 72.0 to 69.7 m)

APPENDIX D

TERRAPROBE INC.





NOTES

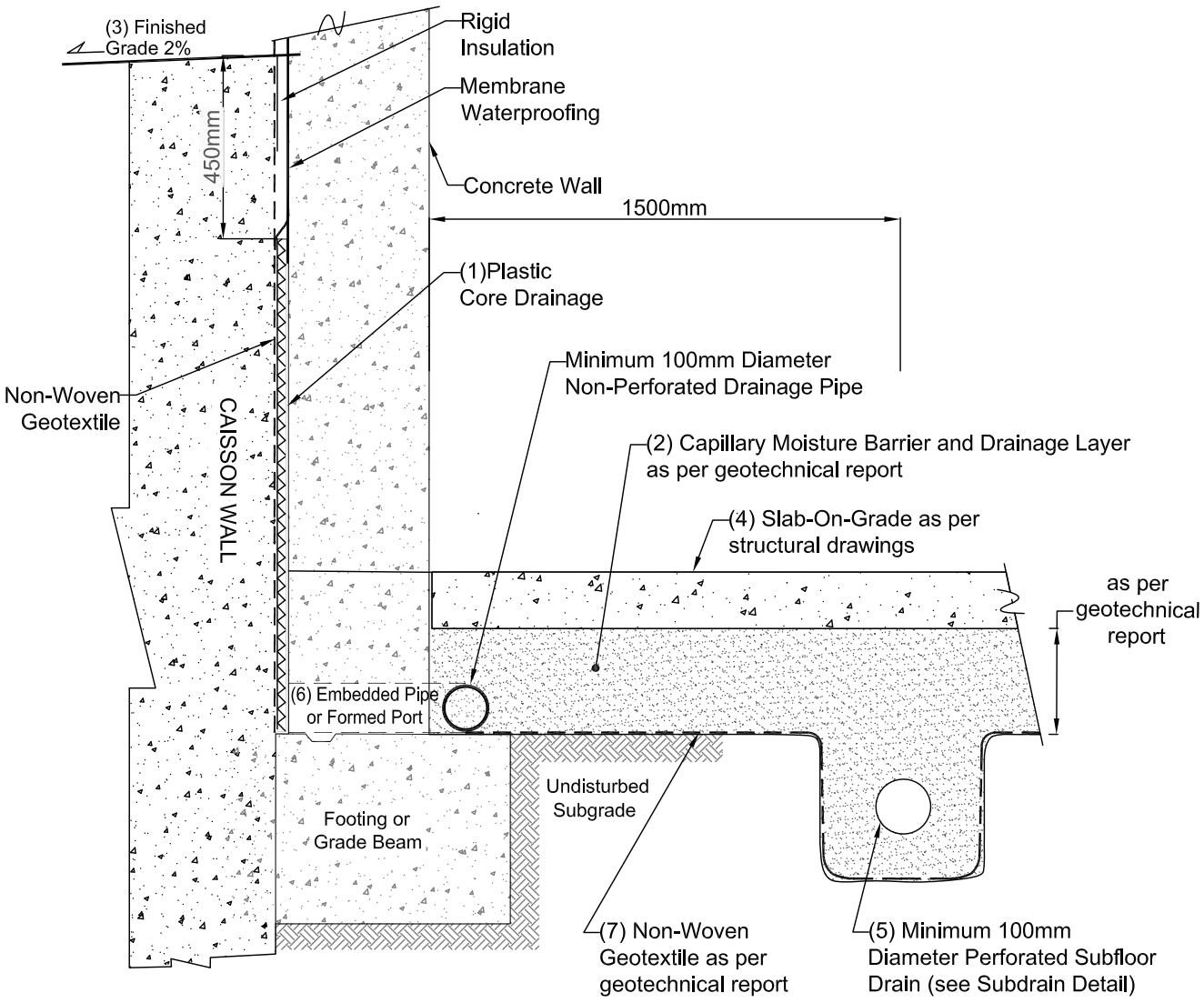
1) Prefabricated drainage panels to consist of Terrafix - TERRADRAIN 200, Mirafi - Miradrain 6000, or approved equivalent. Panels should provide continuous cover with a minimum overlap of 300mm.
2) Capillary moisture barrier/drainage layer to consist of a minimum 200mm layer of 19mm clear stone (OPSS 1004), or as indicated in geotechnical report, compacted to a dense state. Upper 50mm can be replaced with Granular "A" (OPSS 1010) compacted to 98% SPMDD where vehicular traffic is required.
3) Exterior finished grade away from wall at a minimum grade of 2% for min. 1.2m.
4) Building floor slab-on-grade shall not be structurally connected to foundation wall or footing.
5) Subfloor drain invert to be a minimum of 300mm below underside of floor slab, to be set in parallel rows, one way, and at the spacing specified in the geotechnical report.
6) Embedded pipes/formed ports to be set a distance of maximum 3m on-centre. Each port to have a minimum cross-sectional area of 1500mm². Perimeter drainage must be collected and conveyed directly to the building sumps in non-perforated pipe.
7) When the subgrade consists of a cohesionless soil, the subgrade must be separated from the subfloor drainage layer using a non-woven geotextile (Terrafix 360R or approved equivalent).

N.T.S.

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

Title:

SCHEMATIC DRAINAGE DETAIL
SOLDIER PILE & LAGGING SHORING SYSTEM



NOTES

1) Prefabricated drainage panels to consist of Terrafix - TERRADRAIN 200, Mirafi - Miradrain 6000, or approved equivalent. Panels should provide continuous cover with a minimum overlap of 300mm.

2) Capillary moisture barrier/drainage layer to consist of a minimum 200mm layer of 19mm clear stone (OPSS 1004), or as indicated in geotechnical report, compacted to a dense state. Upper 50mm can be replaced with Granular "A" (OPSS 1010) compacted to 98% SPMDD where vehicular traffic is required.

3) Exterior finished grade away from wall at a minimum grade of 2% for min. 1.2m.

4) Building floor slab-on-grade shall not be structurally connected to foundation wall or footing.

5) Subfloor drain invert to be a minimum of 300mm below underside of floor slab, to be set in parallel rows, one way, and at the spacing specified in the geotechnical report.

6) Embedded pipes/formed ports to be set a distance of maximum 3m on-centre. Each port to have a minimum cross-sectional area of 1500mm². Perimeter drainage must be collected and conveyed directly to the building sumps in non-perforated pipe.

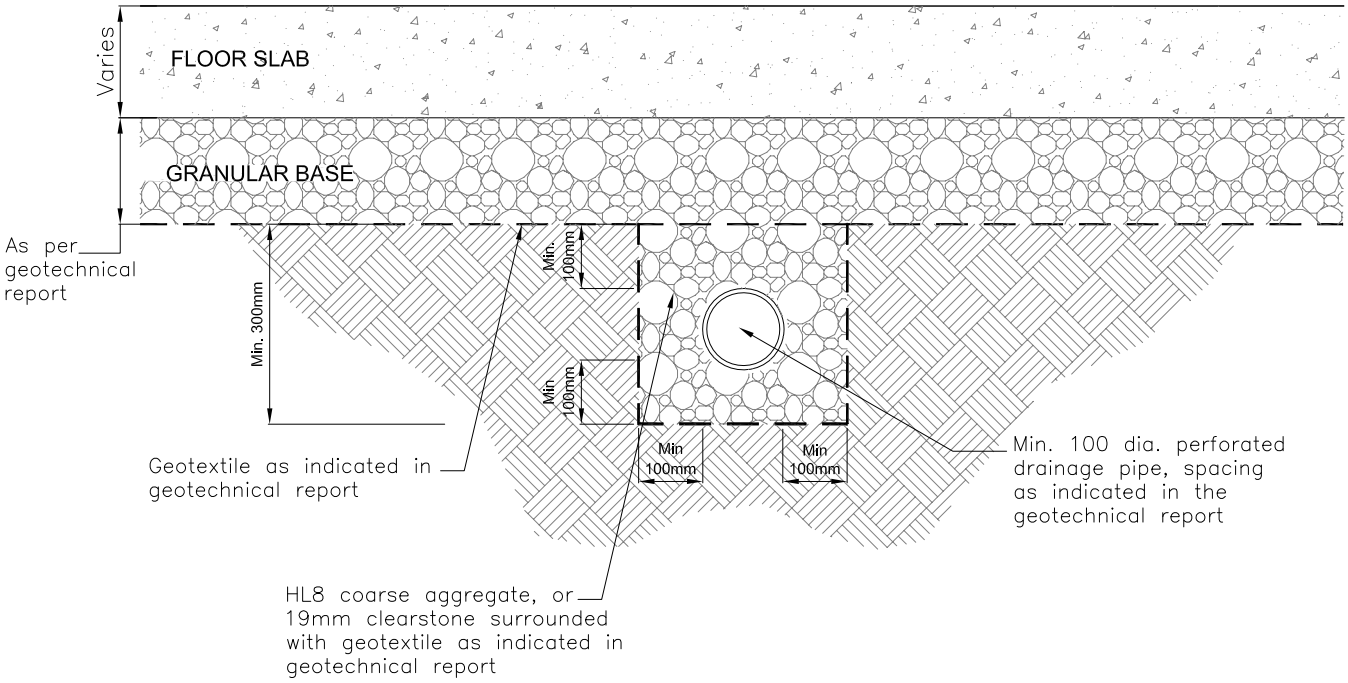
7) When the subgrade consists of a cohesionless soil, the subgrade must be separated from the subfloor drainage layer using a non-woven geotextile (Terrafix 360R or approved equivalent).

N.T.S.

Terraprobe
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Title:

SCHEMATIC DRAINAGE DETAIL
CAISSON WALL SHORING SYSTEM



Schematic Only
Not to Scale

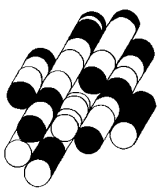
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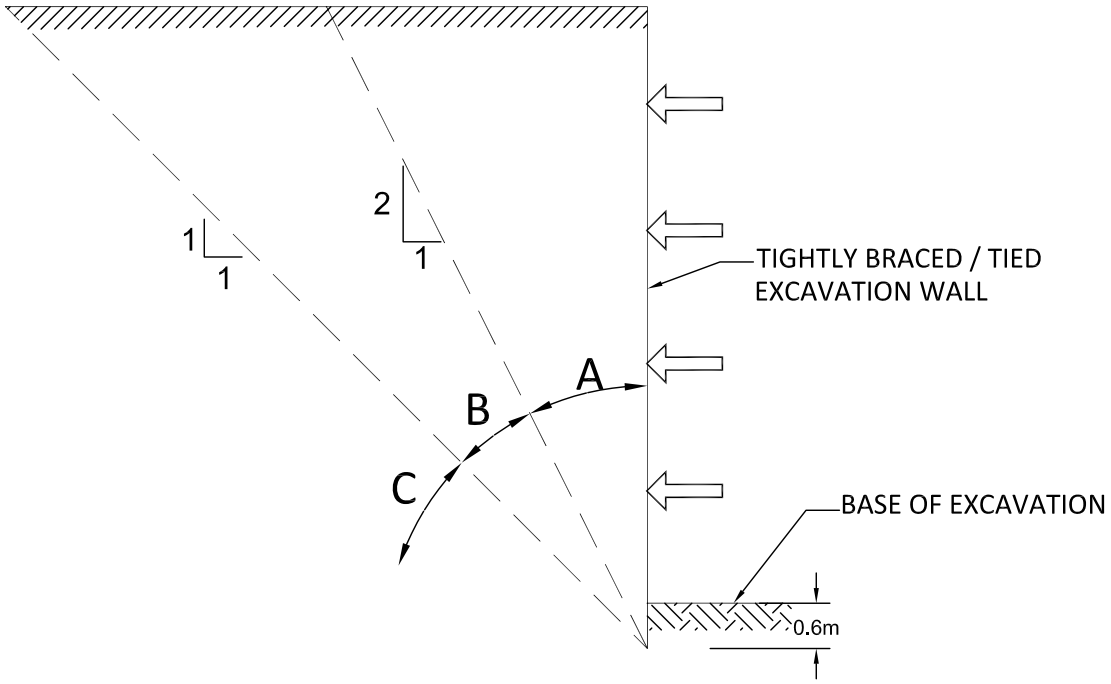
Title:

BASEMENT SUBDRAIN DETAIL

APPENDIX E

TERRAPROBE INC.





Zone A: Foundations within this zone often require underpinning. Horizontal and vertical pressures on excavation wall of non-underpinned foundations must be considered.

Zone B: Foundation within this zone often do not require underpinning. Horizontal and vertical pressures on excavation wall of non-underpinned foundations must be considered.

Zone C: Foundations within this zone usually do not require underpinning.

REFERENCE:

User's Guide - NBC 2005 Structural Commentaries
(Part 4 of Division B) - Commentary K

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

Title:

GUIDELINES FOR UNDERPINNING SOILS