

GEOTECHNICAL SLOPE STABILITY AND STREAMBANK EROSION STUDY LONG TERM STABLE LSOPE CREST UPDATE **1300 BRONTE CREEK ROAD OAKVILLE, ONTARIO**

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Attention:

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1.0 INTRODUCTION

Terraprobe Inc. (Terraprobe) was retained by Bronte Rive LP c/o Argo Development Corporation to conduct a geotechnical slope stability and streambank erosion analysis update for the valley slope situated to the west of the properties generally located around 1300 Bronte Road, in the Town of Oakville, Ontario.

This report encompasses the results of a site specific detailed slope stability and streambank erosion analysis based on a borehole investigation, conducted to assess the long-term stability and erosion risks of the subject slope. The report provides an update to the previous Terraprobe Report (File No. 1-16-0035-01, dated May 19, 2016) as well as extending the study area further south along the slope crest; including geotechnical engineering recommendations for the long-term stability of the site slope and delineates the updated Long-Term Stable Slope Crest (LTSSC) location for the majority of the site based on the applicable stability and erosion setbacks.

2.0 SITE AND PROJECT DESCRIPTION

The subject site, is located on the west side of Bronte Road, at a short distance north of Queen Elizabeth Way (QEW), in the Town of Oakville, Ontario. For site description purposes, Bronte Road is assumed to be aligned in a north-south direction. The municipal address of the property is 1300 Bronte Road, while the legal description is Part of Lot 31, Concession 2, S.D.S, Geographic Township of Trafalgar, Town of Oakville, Regional Municipality of Halton. The general location of the subject property and portions of the adjacent lands are shown on the enclosed Site Location Plan (Figure 1) and Borehole Location and Site Features Plan (Figure 2).

The property is bounded by Bronte Road to the East (front), residential properties to the north, wood lot to the south and valley slope associated with Bronte Creek to the west (rear). The geotechnical study area currently includes a two-storey brick dwelling and a detached garage situated within the relatively wider (rear) portion of the property (#1300 Bronte Road) as well as adjacent land to the south. There is a relatively large man made pond situated to the east side of the existing dwelling and garage. The westerly tableland portion of the geotechnical study area is relatively flat and gently slopes towards the Bronte Creek valley slope. The slope within the study area is about 30 to 32 m high with inclination varying from about 0.6 to 2.1 horiz. to 1 vert. The watercourse (Bronte Creek) meanders within a well defined and deeply incised valley base. The creek meanders towards the subject slope as it progresses downstream with a relatively broad floodplain. In addition to the main branch of Bronte Creek, a tributary referred to as BCT-1 traverses the southern portion of the site. This tributary is contained within a gulley located on the larger Bronte Creek Slope prior to entering into the larger Bronte Creek valley and watercourse.



A geotechnical slope stability and streambank erosion study is required as the property abuts the valley land regulated by Conservation Halton. The study included an assessment of the long-term stability and erosion risks for the valley slope and delineation of the Long-term Stable Slope Crest (LTSSC) location for the subject site.

3.0 FIELD PROCEDURE

The field investigation was conducted on October 25 & 26, and November 3 to 5, 2021 and consisted of drilling and sampling a total of two (2) exploratory boreholes near the slope crest extending to depths of about 19.9 m (Borehole 21-1) and 27.5 m (Borehole 21-2) below existing ground surface.

The boreholes were staked out in the field by Terraprobe Inc. at approximate locations shown on the enclosed Borehole Location and Site Features Plan (Figure 2). Boreholes were located in a relatively close proximity of the slope crest to determine subsurface soil and ground water conditions comprising the valley slope. The ground surface elevations at the borehole locations were inferred from the topographic survey information (prepared by J.D. Barnes Limited, OLS, Reference No. 20-30-555-01, dated November 22, 2021) provided by the client, and are referenced to the Geodetic datum.

Utility agencies were contacted by Terraprobe to locate underground public utility lines present within the work area and to clear the borehole locations prior to drilling. The borings were drilled by a specialist drilling subcontractor using a track-mounted drill rig power auger. The boreholes were advanced using continuous flight hollow stem augers and mud-rotary, and were sampled at 0.75 m (up to 3.0 m below grade) 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 D 1586). The field work (drilling, sampling and testing) was observed and recorded by a member of our field engineering staff, who logged the boring and examined the soil samples as they were obtained. All samples obtained during the field investigation were sealed into plastic jars, and transported to our laboratory for detailed inspection and testing. Borehole soil samples were examined (tactile) in detail by a geotechnical engineer, and classified according to visual and index properties. Laboratory testing consisted of water content determination on all samples, and a Sieve and Hydrometer analysis on two (2) selected native soil samples (Borehole 21-1, Sample 3 and Borehole 21-2, Sample 6). Atterberg Limits tests was also conducted on one (1) selected native soil sample (Borehole 21-1, Sample 3). The results of the geotechnical laboratory testing are plotted on the enclosed Borehole Logs at respective sampling depths. The results of the Sieve and Hydrometer analysis as well as Atterberg Limits tests are summarized in Section 4.6 of this report, and appended.

Ground water levels were monitored in the boreholes upon completion of drilling. Monitoring wells consisting of 51 mm diameter PVC tubing were installed in both boreholes to facilitate ground water level measurement. The PVC tubing was fitted with a bentonite clay seal as shown on the enclosed Borehole Logs. Water levels in the monitoring wells were measured on November 30, 2021, about three



weeks following the installation. The results of ground water level monitoring are summarized in Section 4.7 of this report.

4.0 SUBSURFACE CONDITIONS

The results of the individual boreholes are summarized below and recorded on the accompanying Borehole Logs. This summary is intended to correlate this data to assist in the interpretation of the subsurface conditions encountered at the site. Refer to enclosed Borehole Logs for stratigraphic details.

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

In summary, the subsurface soil conditions encountered in the boreholes advanced across the site were fairly consistent. The 2021 Terraprobe boreholes encountered a topsoil layer at the ground surface underlain by weathered/disturbed native soil which was in turn underlain by undisturbed native soil deposit. The undisturbed native soil deposit was further underlain by weathered shale (inferred Bedrock of Queenston Formation) at both borehole locations.

4.1 Surficial Layer

A layer of topsoil was encountered at the ground surface in all boreholes, with thicknesses of about 150 mm (Borehole 21-1) and 200 mm (Borehole 21-2). The topsoil was dark brown in colour and predominantly consisted of a silt matrix.

The topsoil thicknesses were estimated from the borings and are approximate, and may vary between and beyond the boreholes. The topsoil thickness noted on the Borehole Logs refers to the distinct topsoil layer present at the borehole location, however, organic inclusions extended deeper than the topsoil thickness layer noted on the Borehole Logs. The topsoil thickness to be removed/stripped for the site development may differ from the topsoil thickness noted on the Borehole Logs. Therefore, this information is not sufficient for estimating topsoil quantities and/or associated costs. Consideration should be given to conduct a shallow test pit investigation to obtain a more precise topsoil thickness, if required.

4.2 Weathered/Disturbed Soils

A zone of weathered/disturbed soil was encountered in both boreholes beneath the surficial topsoil layer and extended to depths of about 0.8 m (Borehole 21-1) and 1.2 m (Borehole 21-2) below grade. The



weathered/disturbed soils predominantly consisted of clayey silt with variable sand (some sand to sandy), and trace gravel.

The Standard Penetration Test results ('N' Values) obtained from the weathered/disturbed soil varied from 2 to 6 blows per 300 mm of penetration, indicating a soft to firm consistency.

Measured moisture contents of weathered/disturbed soil samples ranged from 15 to 23 percent by weight, indicating a typically moist condition. The relatively high moisture contents of some of the weathered/disturbed soil samples are likely due the presence of topsoil or organics.

4.3 Native Soils

Undisturbed native soil deposit was encountered in all boreholes beneath the zone weathered/disturbed soil and extended to depths of about 19.8 m (Borehole 21-1) to 25.9 m (Borehole 21-2) below existing grade. The native soils are generally brown/reddish brown in colour and become grey at deeper depths.

Undisturbed native glacial clayey silt till with variable sand (some sand to sandy) and trace amounts of gravel was encountered in both boreholes at depths of about 0.8 m (Borehole 21-1) and 1.2 m (Borehole 21-2) and extended to depths of about 4.6 m and 2.4 m below grade, respectively.

The Standard Penetration Test results ('N' Values) obtained from clayey silt till deposit varied from 21 to 36 blows per 300 mm of penetration and 88 blows per 250 mm of penetration, indicating a very stiff to hard (typically hard) consistency.

Measured moisture contents of the native till soil samples varied form 8 to 12 percent by weight, indicating a moist condition.

A layer of silty sand with varying amounts of gravel (some gravel to gravelly) and trace amounts clay was encountered in Borehole 21-2 beneath the clayey silt till at a depth of about 2.3 m below grade, and extended to a depth of about 6.1 m below grade.

The Standard Penetration Test results ('N' Values) obtained from the silty sand layer were greater than 50 blows per 300 mm of penetration, indicating a very dense relative density.

The measured moisture content of these soil samples ranged from 9 to 10 percent by weight, indicating a generally moist condition.

A layer of sandy gravel to sand and gravel with some silt and trace amounts of clay was encountered in both boreholes beneath the clayey silt till deposit (Borehole 21-1) and below the silty sand deposit (Borehole 21-2) at depths of about 4.6 m and 6.1 m below grade, and extended to depths of about 12.2 and 25.9 m below grade, respectively.



The Standard Penetration Test results ('N' Values) obtained from these soil samples varied from 39 to 95 blows per 300 mm to 50 blows per 75 mm to 125 mm of penetration, indicating a dense to very dense (generally very dense) relative density.

The measured moisture content of these soil samples ranged from 6 to 19 percent by weight, indicating a moist to wet condition.

A layer of sand with some silt and trace amounts gravel was encountered in Borehole 21-1 beneath the sandy gravel to sand and gravel at a depth of about 12.2 m below grade, and extended to a depth of about 19.8 m below grade.

The Standard Penetration Test results ('N' Values) obtained from the sand layer varied from 25 to 32 blows per 300 mm of penetration, indicating a compact to dense relative density.

The measured moisture content of these soil samples ranged from 18 to 21 percent by weight, indicating a generally wet condition.

The glacial till and sandy gravel to sand and gravel deposits are likely to contain larger particles (cobbles and boulders) that are not specifically identified in the boreholes. The size and distribution of such obstructions cannot be predicted with borings, because the borehole sampler size is insufficient to secure representative samples for particles of this size.

4.4 Shale

The (inferred Bedrock of Queenston Formation) was encountered in all boreholes beneath the native soil (overburden) at depths of about 19.8 m (Borehole 21-1) and 25.9 m (Borehole 21-2) below grade. The shale (Bedrock of Queenston Formation) is a deposit predominantly comprising thin to medium bedded reddish calcareous shale with brown intermittent grey/green bands of 'harder' sandstone/dolostone/limestone stringers. Experience in larger excavations suggests that these limestone layers are discontinuous and nominally 50 to 300 mm thick. Thicker beds of limestone may also be encountered in some areas. The shale is typically of low strength while the 'harder' limestone layers are generally of medium strength.

The tri-cone borehole method used at this site is conventionally accepted investigative practice. However, the tri-cone and interval sampling method does not define the bedrock surface with precision, particularly where the surface of the rock is weathered, weaker and easily penetrated by the tri-cone. It should be noted that confirmation and characterization of the bedrock through rock coring was not included in our scope of work. The bedrock surface elevations at the borehole locations, as noted on the borehole logs, were inferred from the spoon samples, sampling spoon refusal and bouncing, therefore actual bedrock surface elevations may vary from the inferred elevations noted on the borehole logs and as summarized below.



Borehole No.	Borehole Surface Elevation (m)	Inferred Bedrock Elevation (m)	Depth of Inferred Bedrock Below Grade (m)
21-1	128.0	108.2	19.8
21-2	126.0	100.1	25.9

The following table summarizes the inferred bedrock elevations interpreted from the borehole data:

The coring and detailed characterization of the bedrock was beyond the current scope of our work

4.5 Previous Boreholes

In Summary, the subsurface soil conditions encountered in the 2016 Terraprobe boreholes advanced across the site were fairly consistent. The boreholes encountered a topsoil layer at the ground surface underlain by a zone of earth fill material which was in turn underlain by undisturbed native soil deposit. The undisturbed native soil deposit was in turn underlain by weathered shale (inferred Bedrock of Queenston Formation) at all borehole locations. The detailed borehole descriptions can be found in the 2016 report (File No. 1-16-0035-01) and the borehole logs have been appended to this report.

4.6 Geotechnical Laboratory Test Results

The geotechnical consisted of water content determination on all samples, while Sieve and Hydrometer analysis and Atterberg Limits tests were conducted on selected native soil samples. The laboratory test results are plotted on the enclosed Borehole Logs at respective sampling depths, and the results of the Sieve and Hydrometer analysis are appended and summarized as follows:

Borehole No.	Sampling Depth	Percentage				Description
Sample No.	Below Grade	Gravel	Sand	Silt	Clay	(MIT System)
Borehole 21-1; Sample 6	1.8 m	3	27	46	24	CLAYEY SILT, sandy, trace gravel
Borehole 21-2; Sample 6	4.7 m	22	49	21	8	SILTY GRAVELY SAND, trace clay



The results of the Atterberg Limits test were plotted on A-Line Graph (refer to enclosed figure, Atterberg Limits Test Results). The following table presents a summary of the Atterberg Limits test results:

Borehole No. Sample No.	Sampling Depth Below Grade	Liquid Limit (W∟)	Plastic Limit (W _P)	Plasticity Index (I _P)	Natural Water Content (W _N)	Plasticity
Borehole 1; Sample 3	1.8	27	16	11	12	Slightly Plastic

4.7 Groundwater

Observations pertaining to the depth of water level and borehole caving were made in the boreholes immediately after the completion of drilling, and are noted on the enclosed Borehole Logs. Monitoring wells consisting of 50 mm diameter PVC tubing were installed in both boreholes to facilitate ground water level monitoring. The details of the well installations are shown on the enclosed Borehole Logs. Ground water level measurements in the wells/piezometers were taken on November 30, 2021, (about three weeks following the installation) and are noted on the enclosed Borehole Logs. A summary of the measured ground water levels is provided as follows:

Borehole No.	Depth of Boring below Grade (m)	Depth to Cave below Grade (m)	Water Level Depth / Elevation at the time of drilling (m)	Water Level Depth/Elevation May 6, 2022
21-1	19.9	N/A	N/A	12.8/115.2
21-2	27.5	N/A	N/A	16.5/109.5

N/A = Not Measurable due to drilling mud and casing

It should be noted that the ground water levels may fluctuate seasonally depending on the amount of precipitation and surface runoff. Wet soils may be encountered to about 0.6 m higher than the water levels due to capillary rise in fine cohesionless silt/sand soils (where present).



5.0 DISCUSSION AND RECOMMENDATIONS

The following discussion and recommendations are based on the factual data obtained from the investigations in 2016 & 2021 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 geotechnical engineering practice. 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 Slope Stability

A detailed site specific slope stability and streambank erosion analysis was carried out based on the borehole investigation conducted for the site to assess the long-term stability and erosion risks of the subject valley slope. The study included a visual inspection of the site slope to assess existing slope conditions with respect to any obvious signs of instability and erosion concerns, as well as a detailed slope stability analysis by preparing slope models and using a computer software. This study includes the areas assessed in the 2016 report and an additional area to the south that was staked by Conservation Halton on August 18, 2021.

5.1.1 Slope Inspection and Mapping

For visual inspection of the slope was conducted on October 19, 2021. General information pertaining to existing slope features such as slope profile, slope drainage, watercourse features, vegetation cover, structures in the vicinity of the slope, as well as erosion and slope slide features, was obtained during the inspection. A brief summary of the results of the visual inspection as well as site topographic information is presented below.

The topographic survey of the property (prepared by J.D. Barnes Limited, OLS, Reference No. 20-30-555-01, dated November 22, 2021) and base maps of the adjacent slope area including the creek (Drawing Name: OAK023-1991 Format and OAK024-1991 Format) were provided by the client. A composite topographic map was inferred/prepared based on the above noted information and is enclosed as Figure 2 (Borehole Location and Site Features Plan). A total of five (5) slope cross-sections (Sections E-E' to I-I') were derived from the topographic information and our slope inspection for slope stability analysis in addition to the four cross sections derived in the previous report. The cross-section locations were selected on the basis of slope height and inclination to represent the critical slope conditions present



within the study area, and to obtain sufficient coverage of the subject slope. These sections extended through the tableland, across the slope surface extending down to the Bronte Creek floodplain and to the watercourse. The locations of the slope cross-sections are presented on Figure 2 (in plan), and the details of the slope profiles along with the floodplain (where applicable) and watercourse, are presented on Figures 3A to 3D.

The property abuts the valley slope associated with Bronte Creek. The tableland is followed by the prominent valley slope extending down to the bottom of the deeply incised valley associated with the Bronte Creek watershed. The tableland is relatively flat and gently slopes toward the valley slope.

The slope of the main Bronte Creek valley within the study area is about 30 to 32 m high with inclinations varying from about 0.6 to 2.1 horiz. (with locally steeper or flatter inclinations). A near vertical bare scarp was noted at the central portion of the slope (refer to Photographs 6 and 7) which extended upward from the slope toe/water edge covering approximately three-quarters of the slope height (refer to the attached Figure 2 for the approximate extent of the scarp). The near vertical bare scarp is likely created by slope toe/creek bank erosion due to the presence of the creek at the slope toe. This erosion results in an oversteepened slope which is then subjected to progressive slumping. The slope surface outside of the scarp area is generally vegetated with numerous young to mature trees and saplings (refer to Photographs 1 to 4 & 9 to 16). The slope surface (outside of the scarp area) was noted to be leaf littered at the time of our inspection. The tree trunk growth was generally straight and upright except for a few leaning and fallen trees. There were no obvious signs of any slope instability such as tension cracks, slump or scarp zones outside of the scarp area. Further, there was no evidence of any significant surface or rill erosion outside of the scarp area (refer to the enclosed photographs and Figure 2 for photo locations). There is a small ravine/gully (about 1 to 6 m deep) within the southerly portion of the site that extends from the slope crest to the floodplain and Bronte Creek (refer to photographs 11, 12 and 15) which is referred to as Bronte Creek Tributary-1 (BCT-1).

Within the main Bronte Creek valley there is an approximately 11 to 50 m wide vegetated flood plain located between a side tributary of the main Bronte Creek and the slope toe within the northerly and southerly portions of the slope (refer to Section A-A', B-B', F-F' and G-G' locations) within the study area. There was no evidence of active slope toe erosion and/or undercutting within the northerly or southerly portions of the slope toe. However, the creek takes a sharp meander towards the subject slope within the central portion of the site and flows at the slope toe resulting in active toe erosion at the central portion of the slope. No significant/noticeable changes to the slope condition from 2016 were noted in the 2021 inspection.

5.1.2 Slope Stability Analysis

Two boreholes were advanced on the tableland, in a relatively close proximity of the slope crest, to determine the subsurface soil and ground water conditions comprising the subject slope. The borehole



data indicates that the subject slope consists of a relatively thin layer (about 0.8 to 1.2 m) of weathered/disturbed soil underlain by native soil deposits which was further underlain by inferred shale bedrock (Queenston Formation).

A detailed engineering analysis of slope stability was carried out for the selected critical slope crosssections (Section E-E' and Section G-G') utilizing computer software Slide (version 7.036, developed by Rocscience) and several standard methods of limit equilibrium analysis (Bishop's, Janbu, and Spencer). These cross sections were selected based on the slope height and inclinations as the worst-case scenarios or "critical sections". These methods of analysis allow the calculation of Factors of Safety for hypothetical or assumed failure surfaces through the slope. The analysis method is used to assess potential for movements of large masses of soil (typically more than 2 m slip circle thickness) over a specific failure surface which is often curved or circular. The analysis involves dividing the sliding mass into many thin slices and calculating the forces on each slice. The normal and shear forces acting on the sides and base of each slice are calculated. It is an iterative process that converges on a solution.

For a specific failure surface, the Factor of Safety is defined as the ratio of the available soil strength resisting movement, divided by the gravitational forces tending to cause movement. The Factor of Safety of 1.0 represents a "limiting equilibrium" condition where the slope is at a point of pending failure since the soil resistance is equal to the forces tending to cause movement. It is usual to require a Factor of Safety greater than one (1) to ensure stability of the slope. The typical Factors of Safety used for engineering design of slopes for stability, ranges from about 1.3 to 1.5 for developments situated close to the slope crest. The most common design guidelines are based on a 1.5 minimum Factor of Safety.

The analysis was carried out by preparing a model of the slope geometry and subsurface conditions, and analyzing numerous potential failure surfaces through the slope in search of the minimum or critical Factor of Safety for site specific conditions. The pertinent data obtained from the topographic and borehole information were input into the slope stability analysis. Many calculations were carried out to examine the Factors of Safety for varying depths for potential failure surfaces.

Based on the borehole results, the following average soil properties were utilized for the overburden soil strata in the slope stability analysis:

Stratum	Unit Weight (kN/cu.m)	Angle of internal friction (φ')	Cohesion (c'), kPa
Clayey Silt Till	21.0	32°	6
Silty Sand	20.0	35°	0
Sandy Gravel to Sand and Gravel	21.5	36°	0
Sand	20.0	35°	0



The above soil strength parameters are based on the effective stress analysis for long-term slope stability. It is noted that the above soil parameters are conservative and actual site soils are stronger. The ground water levels as measured in the monitoring wells installed in Boreholes 21-1 and 21-2 were also incorporated in the slope stability analysis.

The bedrock was encountered in both boreholes at depths of about 19.8 m to 25.9 m below grade. Based on the overburden soil type comprising the slope and the slope configuration, the formation of high pore water pressure (elevated water table) within the overburden soils is unlikely. However, conservatively, the effect of a hypothetical elevated water level (water level assumed to be within about 1 to 2 m of the ground surface) on the slope stability was also analyzed to simulate short-term, temporary and infrequent ground water level condition.

The results of the slope stability analyses are presented on the enclosed figures and are summarized below:

	Approvimate Slope	Minimum Factor of Safety for Potential Slope Slides for Existing Condition		Type of	
Section	Inclination	Normal Ground Water (Normal Condition)	High Ground Water (Temporary Condition)	Slope Slide	
Section E-E'	± 0.9 H : 1 V	1.02	*	Overburden Slope Slide	
Section B-B'	± 0.7 H : 1 V Upper ± 1.3 H : 1 V Lower	1.01	*	Overburden Slope Slide	

* The minimum Factors of Safety for both sections for normal ground water level are lower than a 1.30 Factor of Safety which is required for elevated ground water condition, therefore, these sections were not analyzed for elevated (temporary) ground water condition as the slope at these locations is considered to be unstable even at normal ground water level condition

The minimum factors of safety for Sections E-E' and G-G' were 1.02 and 1.01 for normal ground water level condition. As noted above both sections were not analysed for high/elevated ground water level condition as the Factors of Safety obtained from the normal ground water level condition were lower than the required Factor of Safety, and therefore, these slopes are considered to be unstable in the long-term.

For an active land used, the MNR Policy Guidelines allow a minimum Factor of Safety range of 1.3 to 1.5 for slope stability, as follows:

TYPE	LAND-USES	DESIGN MINIMUM FACTOR OF SAFETY
A	PASSIVE: no buildings near slope; farm field, bush, forest, timberland, woods, wasteland, badlands, tundra	1.1
В	LIGHT: no habitable structures near slope; recreational parks, golf courses, buried small utilities, tile beds, barns, garages, swimming pools, sheds, satellite dishes, dog houses	1.20 to 1.30



TYPE	LAND-USES	DESIGN MINIMUM FACTOR OF SAFETY
С	ACTIVE: habitable or occupied structures near slopes; residential, commercial, and industrial buildings, retaining walls, storage/warehousing of non-hazardous substances	1.30 to 1.50
D	INFRASTRUCTURE and PUBLIC USE: public use structures and buildings (i.e. hospitals, schools, stadiums), cemeteries, bridges, high voltage power transmission lines, towers, storage/warehousing of hazardous materials, waste management areas	1.40 to 1.50

Conservation Halton's Policies, procedures and guidelines (based on the MNR Guidelines) require a 1.5 minimum Factor of Safety for slope stability for land development and planning over the long-term. A minimum factor of safety of 1.5 is required for normal ground water condition and a minimum factor of safety of 1.3 is required for elevated, short term and infrequent ground water condition.

The minimum factors of safety for Sections E-E' and G-G' were 1.02 and 1.01 for normal ground water level condition. Therefore, the minimum factors of safety obtained for both sections for the existing slope condition are lower than the minimum required factors of safety, and therefore are not considered adequate with respect to the long-term stability of the site slope.

Therefore, a number of representative trial profiles of the slope with flatter inclinations and similar slope height and subsurface conditions as those of Sections E-E' and G-G' were analyzed to obtain the minimum factors of safety in conformance to the policy guidelines. These two sections were selected to represent the most critical overburden slope conditions within the extended study area.

The results of the slope stability analysis conducted for a hypothetical slope profile with a flatter inclination of 1.8 horizontal to 1.0 vertical through the native soils for the subject slope with similar slope height and sub-surface conditions as those of Sections E-E' and G-G', for both normal and elevated ground water conditions, are presented on the enclosed figures, and summarized below:

		Minimum Factor of S Slope Slides for Ex	Safety for Potential disting Condition	Tuno of
Section	Stable Slope Inclination	Normal Ground Water (Normal Condition)	High Ground Water (Temporary Condition)	Slope Slide
Section E-E'	Native Soils 1.8 H to 1 V	1.53	1.34	Overburden Slope Slide
Section B-B'	± Native Soils 1.8 H to 1 V	1.67	1.32	Overburden Slope Slide

The above computed minimum factors of safety were 1.53 and 1.67 for long term (normal ground water condition) and 1.34 and 1.32 for temporary and infrequent condition (elevated ground water level) for Sections E-E' and G-G', respectively, which are considered to be adequate, and are in conformance to the Conservation Halton's Policies, procedures and guidelines and industry standards.



Therefore, a slope inclination of 1.8 to 1.0 (horizontal to vertical) or flatter is required for the long-term stability of the native overburden portion. It is noted that the calculated long-term stable slope inclination for this site is consistent with our previous studies conducted at this site (File No. 1-16-0035-01) and the general area which is about 1.8 to 1.0 (horizontal to vertical) for the native overburden in the general area. In addition the previous study established a slope inclination of 2.25 to 1 (horizontal to vertical) for the long term stability of the fill overburden portion, the analysis sheets establishing this inclination are included in Appendix F. While there were no significant/noticeable changes to the slope condition between the 2016 and 2021 inspections, the LTSSC from the 2016 report was updated to reflect the assumed position of side tributary of Bronte Creek (at the slope toe).

The Credit Valley Conservation - Slope Stability Definition and Determination Guidelines, February 2014 recommend a stable slope inclination of 1.4 horizontal to 1 vertical (Generalized Stability Setback Guidelines) for shale bedrock without rock coring and characterization. The topographic information indicates that the lower portion of the slope comprising shale is currently slightly steeper than the recommended stable slope inclination (for Section E-E'). Therefore, a stability setback should be applied to the slope by extending a line at 1.4 horz. to 1 vert. inclination through the shale portion of the slope, at 1.8 horz. to 1 vert. (stable) inclination through the native overburden soil. The stability setback line shall extend from the applicable toe erosion allowance (erosion component, see Section 5.2).

5.2 Toe Erosion Allowance

In addition to a stability set-back, a toe erosion allowance is also required where watercourse is located within 15 m of the slope toe. A guideline table (MNR) recommended for estimating the toe erosion allowance is presented as follows:

MINIMUM TOE EROSION ALLOWANCE - River within 15 m of Slope Toe *								
Type of Material	Evidence of Active Erosion** or	No evidence of	Active Erosion** of	or				
	Bankfull Flow Velocity > Competent Flow Velocity***	Flow Velocity <	< Competent Flor	w Velocity***				
Native Soil Structure		Bankf	ull Width					
		< 5 m	5 - 30 m	> 30 m				
1. Hard Rock (granite)	0 - 2 m	0 m	0 m	1 m				
2. Soft Rock (shale, limestone) Cobbles, Boulders	2 - 5 m	0 m	1 m	2 m				
3. Stiff/Hard Cohesive Soil	5 - 8 m	1 m	2 m	4 m				

Guideline Table



71

MINIMUM TOE EROSION ALLOWANCE - River within 15 m of Slope Toe *											
(clays, clayey silt) Coarse Granular (gravels) Tills											
4. Soft/Firm Cohesive Soil Fine Granular (sand, silt) Fill	8 - 15 m	1 - 2 m	5 m	7 m							
 If a valley floor is > 15 m width, sti 	Il may require study or inclusion of a	a toe erosion allov	vance.								

** Active Erosion is defined as: bank material is bare and exposed directly to stream flow under normal or flood flow conditions and, where undercutting, over steepening, slumping of a bank or high down stream sediment loading is

conditions and, where undercutting, over steepening, slumping of a bank or high down stream sediment loading is occurring. An area may be exposed to river flow but may not display Aactive erosion@ (i.e. is not bare or undercut) either as a result of well rooted vegetation or as a result of shifting of the channel or because flows are relatively low velocity. The toe erosion allowances presented in the right half of Table 2 are suggested for sites with this condition.

*** Competent Flow velocity; the flow velocity that the bed material in the stream can support without resulting in erosion or scour.
 Consideration must also be given to potential future meandering of the watercourse channel.

Source: Ontario Ministry of Natural Resources (2002), ATechnical Guide River & Stream Systems: Erosion Hazard Limit, pp38

The MNR "Geotechnical Principles for Stable Slopes" recommend an erosion setback where a watercourse is located within 15 m of the slope toe. The Guideline Table recommends different ranges of erosion setbacks based on the native soil structure comprising the slope, degree of erosion, and watercourse characteristics.

At this site the slope toe consists of shale bedrock. At the southerly portion of the site (Sections F-F' and G-G') of the slope toe is separated by a vegetated floodplain of about 20 to 50 m wide and there was no obvious evidence of active slope toe erosion in this area. However, at the central portion of the slope (Section E-E'), the creek is in direct contact with the valley wall resulting in active slope toe erosion. In comments on the Revision 1 report Conservation Halton noted that based on aerial photographs of the site it was estimated that the side tributary of Bronte Creek, passing through Sections A-A' and B-B', appeared to have migrated closer to the slope toe than shown in the 2003 base map data used in Figure 2. An updated base map was acquired through Conservation Halton's Request for Digital Mapping or Data Licensing program in order to check the current location of this tributary. The updated base map did not show a change in the location of side tributary of Bronte Creek. However, to ensure CH did not have any concerns with the final recommended LTSSC, it was decided to assume that the side tributary has migrated to the existing slope toe in order to determine the LTSSC based on the most conservative possible scenario. The change in the tributary location is show in section on Figure 3A but is not reflected in plan as there was no available mapping to support it. The MNR Guidelines require a toe erosion allowance of 2 to 5 m for a slope toe comprising shale for an active erosion condition. Conservatively, a to erosion setback of 5 m is recommended at this site (as per the MNR Guidelines) to be applied for the entire site slope within the study area, as applicable.



Therefore, the long-term stable slope crest location at this site can be determined by applying a toe erosion setback of 5 m at the slope toe (as applicable), and extending a stability setback line from the toe erosion setback drawn at 1.4 horz. to 1 vert. inclination through the shale (where applicable), at 1.8 horz. to 1 vert. inclination through the slope. The location of the estimated Long-term Stable Slope crest is shown on Figure 2 in plan, and Figures 3A to 3D in sections, respectively. For planning purposes the long-term refers to a 100 year planning horizon.

Section I-I' was cut through the gully occupied by BCT-1 toward the south end of the site to determine the potential impact of the gully and watercourse on the overall stability of the subject slope. While BCT-1 was noted to be intermittent and at a relatively low flow at the time of inspection a conservative toe erosion allowance of 8 m was applied (for soil overburden for the upper slope). The LTSSC for the gully was delineated based on an 8 m erosion allowance and the stable slope inclinations used for the site. The resultant LTSSC is located entirely within the hazard zone as defined by the full site LTSSC and will therefore have no long term impact on the position of the LTSSC for the overall valley slope over the long term.

It is understood that GEO Morphix Ltd. (GEO Morphix) is conducting a conceptual channel design and erosion assessment for BCT 1). This watercourse is proposed to receive outflows from the SWM facility following development. This watercourse is considered the main drainage feature within the subject lands and would be used as the outfall channel for the storm water management system. Terraprobe conducted a preliminary review of the conceptual channel design (provided by the client) and it appears that the proposed channel design works would include creekbank/bed improvements. The proposed improvements would be constructed in a way to be as "naturalized" as possible. The proposed improvements would include a combination of vegetated rock buttresses and brush mattresses to protect the creek bank/bed improvements/protection are further detailed in the Geo Morphix report (File No.: PN23026, Dated March, 2023). The conceptual channel design appears to be acceptable from a geotechnical engineering perspective. For clarity, the proposed erosion mitigation works were not factored into the determination of the LTSSC for BCT-1. Furthermore, it is understood that a detailed design should be reviewed be a qualified geotechnical engineer.

6.0 SUMMARY

The borehole data indicates that the site slope consists of a surficial layer of topsoil, underlain by a layer of earth fill materials/weathered/disturbed soil which was further underlain by undisturbed native soil overburden which graded into shale (inferred Bedrock of Queenston Formation) at depths of about 19.8 to 25.9 m below grade.



As noted before, the main valley slope is relatively steep (about 0.6 to 2.1 horiz. to 1 vert). Therefore, a stability setback of 1.4 horz. to 1 vert. is recommended for the slope portion comprising shale and 1.8 horz. to 1 vert. for the native soil overburden at this site. The main valley slope toe within the study area, consists of shale and evidence of active toe erosion was noted at the slope toe within the central portion of the main valley slope as the watercourse (Bronte Creek) is located at the slope toe in this area. Conservatively a toe erosion setback (Erosion Component) of 5 m is recommended for the main valley slope were considered, a conservative toe erosion setback was used along with the stable slope inclinations used for the main valley slope to determine the LTSSC with respect to these features. As the LTSSC associated with BCT-1 and the gully slope is located entirely within the hazard zone as determined by the main valley slope LTSSC it will not have an impact of the overall LTSSC position.

Therefore, the location of the Long-Term Stable Slope Crest (LTSSC) was calculated (according to the appended Long-Term Stable Slope Crest Model) by applying a toe erosion allowance of 5 m (for bedrock) at the slope toe (where applicable) and 8 m (for overburden) at the gully base, and extending a stability setback line at 1.4 horz. to 1 vert. inclination through the shale portion of the slope (where applicable) and 1.8 horz. to 1 vert. through the native overburden.

The location of the Long-Term Stable Slope Crest was determined in accordance with the Long-Term Stable Slope Crest model (see enclosed) and is presented on Figure 2 (in plan) and Figures 3A to 3D (in section) extending the existing LTSSC from the 2016 report. For planning purposes, the long-term refers to a 100 year planning horizon.

The following general constraints on any future development on the property, are recommended:

- a) site development and construction activities should be conducted in a manner which do not result in surface erosion of the slope. In particular, site grading and drainage should be designed to prevent direct concentrated or channelized surface runoff from flowing directly over the slope. Water drainage from down-spouts, sumps, swimming pools and the like should not be permitted to flow over the slope, but a minor sheet flow may be acceptable,
- b) the existing vegetation cover should be maintained on the slope,
- c) the configuration of the slope should not be altered without prior consultation with a geotechnical engineer and approval from concerned authorities. In particular, the slope should not be steepened,
- d) a silt fence should be erected and maintained downslope of the work area during construction, and



e) all necessary approvals and permits must be obtained from regulatory authorities/agencies prior to the commencement of site works.

7.0 LIMITATIONS AND USE OF REPORT

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 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 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.

The discussion and recommendations are based on the factual data obtained from the investigation and are intended for use by the owner and its retained designers.

The investigation at this site was conceived and executed to provide information for the slope stability study. 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 have an effect on construction costs, techniques, equipment, and scheduling. Contractors bidding on or undertaking work on this project should therefore, in this light, be directed to decide on their own investigations, as well as their own interpretations of the factual investigation results. They should be cognizant of the risks implicit in subsurface investigation activities so that they may draw their own conclusions as to how the subsurface conditions may affect them.

This report was prepared for the express use of Bronte River LP c/o Argo Development Corporation and their retained design consultants. It 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 Bronte River LP c/o Argo Development Corporation 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.

Terraprobe Inc.

Connor McCormick, P.Eng. Geotechnical Engineer



M=calukdar

Madan Talukdar, P.Eng. Associate









CROSS SECTION A-A'

CROSS SECTION B-B'

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SLOPE CROSS SECTIONS SECTION A-A' AND SECTION B-B'

1-16-0035-02

FIGURE :

3A

CROSS SECTION D-D'

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SLOPE CROSS SECTIONS SECTION C-C' AND SECTION D-D'

1-16-0035-02

FIGURE :

3B

CROSS SECTION F-F'

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SLOPE CROSS SECTIONS SECTION E-E' AND SECTION F-F'

1-16-0035-02

FIGURE : 3C

CROSS SECTION H-H'

CROSS SECTION I-I'

SCALE 1:600 2_0__5m

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1-16-0035-02

FIGURE :

3D

_	7	
	SAMPL	ING METHODS
	AS CORE DP FV CS	auger sample cored sample direct push field vane grab sample

split spoon

shelby tube

wash sample

SS

ST

WS

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.)."

COHESIONLE	SS SOILS	COHESIVE S	OILS		COMPOSITION	N
Compactness	'N' value	Consistency	'N' value	Undrained Shear Strength (kPa)	Term (e.g)	% by weight
very loose loose compact dense very dense	< 4 4 – 10 10 – 30 30 – 50 > 50	very soft soft firm stiff very stiff hard	< 2 2 – 4 4 – 8 8 – 15 15 – 30 > 30	< 12 12 – 25 25 – 50 50 – 100 100 – 200 > 200	<i>trace</i> silt some silt silt <i>y</i> sand <i>and</i> silt	< 10 10 – 20 20 – 35 > 35

TESTS AND SYMBOLS

МН	mechanical sieve and hydrometer analysis	∑ ■7	Unstabilized water level
W, Wc	water content	Ţ	1° water level measurement
w_L , LL	liquid limit	$\overline{\mathbf{\Lambda}}$	2 nd water level measurement
w_{P}, PL	plastic limit	▼	Most recent water level measurement
I _P , PI	plasticity index		
k	coefficient of permeability	3.0+	Undrained shear strength from field vane (with sensitivity)
γ	soil unit weight, bulk	Cc	compression index
Gs	specific gravity	Cv	coefficient of consolidation
φ'	internal friction angle	mv	coefficient of compressibility
C'	effective cohesion	е	void ratio
Cu	undrained shear strength		

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									LO	GΟ	F BC	DRE	HOL	E 21-1
Pro	ject N	lo. : 1-16-0035-02	Clie	nt	: E	Bronte	River	LP							Origin	ated by:RS
Dat	e sta	rted : November 4, 2021	Pro	ject	: 1	300 E	Bronte	Road							Com	piled by:CM
She	et No	p. :1 of 2	Loc	atio	n : C	Dakvill	e, Ont	ario							Che	cked by : MMT
Posi	tion	: E: 600943, N: 4807415 (UTM 17T)				Elevati	on Datu	m : Geodet	ic							
Rig t	ype	: Track-mounted				Drilling	Method	: Hollow	stem au	ugers / muo	d rotary ((tricone)				
Ê.		SOIL PROFILE			SAMP	LES v	cale	Penetration Te (Blows / 0.3m)	st Values	2	м	oisture / P	lasticity	e r	ent o	Lab Data
Depth Scale	<u>Elev</u> Depth (m)	Description	Braphic Lo	Number	Type	PT 'N' Valu	levation So (m)	1,0 Undrained She O Unconfine ● Pocket Pe	ar Streng) 4 <u>0</u> th (kPa) ✦ Field Vane ■ Lab Vane	Plasti Limit	c Natura Water Co	al Liquid Intent Limit	Headspa Vapou (ppm)	Instrume Detail	GRAIN SIZE DISTRIBUTION (%) (MIT)
- 0	128.0 127.8	GROUND SURFACE	<u></u>	-		S	ш 128-	40 8	30 12	0 160	1	0 20	30			GR SA SI CL
-	0.2	(WEATHERED/DISTURBED)		1	SS	2						0				
- 1	0.8	CLAYEY SILT, sandy, trace gravel, very stiff to hard, reddish brown, moist (GLACIAL TILL)		2	SS	21	127 -				_	0		-		
-				3	SS	35						o 🛏				3 27 46 24
-2							126 -									
-				4	SS	36						0				
-3				5	SS	88 / 250mm	125 -				0					
- 4							- 124 -									
-	123.4															
-5	4.0	SANDY GRAVEL to SAND AND GRAVEL some silt, trace clay, very dense, reddish brown, moist		6	SS	78	123 -				0			_		
-							-									
-6			0 19				122 -							-		
-				7	SS	95					0					
-7							121 -							_		
-						50 /	-									
-8				. 8	55	125mm	120 -							-		
-							-									
-9			0				119-							-		
<u>.</u>		at 9.1 m, wet below	0	9	<u>ss</u>	50 / 75mm	-					0				
02 bh logs.g				A			118 -							-		
: 1-16-0035-0																
file			. 0	10	SS	57										

(continued next page)

		Terraprobe						LOG OF BC	REHOLE 21-1
Proj	ect N	No. : 1-16-0035-02	Client	: B	Bronte	River	LP		Originated by : RS
Date	e star	rted : November 4, 2021	Projec	t :1	300 E	Bronte	Road		Compiled by : CM
She	et No	p. : 2 of 2	Locatio	on : C	Dakvill	le, Ont	ario		Checked by : MMT
Posit	ion :	: E: 600943, N: 4807415 (UTM 17T)			Elevati	on Datu	m : Geodetic		
Rig ty	ype :	: Track-mounted			Drilling	Method	Hollow stem augers /	/ mud rotary (tricone)	
(E)		SOIL PROFILE		SAMPI	_ES 	cale	Penetration Test Values (Blows / 0.3m)	Moisture / Plasticity	e t Lab Data
Depth Scale	<u>Elev</u> Depth (m)	Description	Graphic Loo Number	Type	SPT 'N' Valu	Elevation So (m)	10 20 30 4 Undrained Shear Strength (kPa) ○ Unconfined + Fiel ● Pocket Penetrometer ■ Lab 40 80 120	0)))dVane §0 Plastic Natural Liquid Limit Water Content Limit PL MC LL ↓ 0 0 10 20 30	doode builling doode do do do do do do do do dod
- 11 - - 12		SANDY GRAVEL to SAND AND GRAVEL, some silt, trace clay, very dense, reddish brown, moist (continued)		SS	57	117 - - 116 -		• • • • • • • • • • • • • • • • • • •	
-	<u>115.8</u> 12.2	SAND, some silt, trace gravel, compact to dense, brown, wet	11	SS	25	-		0	
- 13 -						115 -			
- 14 -			12	ss	32	- 114		0	
- 15			13	SS	30	113 -		0	
- 16 -						112 -			
- 17 -			14	SS	25	111 -		o	
- 18						110 -			
-			15	SS	31			0	
- 19 -	108.2					109 -			
	<u>108.1</u> 19.9	INFERRED BEDROCK, shale with intermittent sandstone, limestone / dolostone stringers, reddish brown (QLIEENSTON EORMATION)	16	<u>t</u> ss	50 / 100mm		L wa	TER LEVEL READINGS	
jdg.ggg							<u>Date</u> Nov 30, 2021	Water Depth (m) Elevation (m 12.8 115.2	ŋ
file: 1-16-0035-02 bh lc		END OF BOREHOLE Unstabilized water level and depth at cave could not be determined due to use mud rotary drilling technique. 50 mm dia. monitoring well installed.							

é			Terraprobe										L	-0	GC	DF	BC	RE	101	LE 21	-2
F	Proje	ect N	lo. : 1-16-0035-02	Clie	nt	: E	Bronte	River	LP										Origir	nated by :	OE/RS
D)ate	star	ted : October 26, 2021	Pro	ject	: 1	300 E	Bronte	Road										Com	piled by:	СМ
S	Shee	et No	o. :1 of 3	Loc	atio	n : C	Dakvill	e, Onta	ario										Che	cked by :	MMT
P	ositi	on	: E: 601025, N: 4807419 (UTM 17T)				Elevati	on Datur	n : G	eodeti	0									,	
R	lig ty	pe	: Track-mounted				Drilling	Method	: H	ollows	stem a	ugers	/ mud	rotary	(tricone	e)					
	Ê		SOIL PROFILE			SAMP	LES	<u>e</u>	Penetra (Blows	ation Tes / 0.3m)	t Values	·		N	loisture	/ Plastic	ity	υ	t	Lab	Data
	epth Scale (n	<u>Elev</u> Depth (m)	Description	aphic Log	Number	Type	T 'N' Value	evation Scal (m)	Undrain O U	namic Con 0 2 ned Shea nconfined	e <u>03</u> ar Strenç	0 4 gth (kPa + Fie	l <mark>0</mark>) eld Vane	Plast Limit	ic Na Water ⊃∟ №	Itural Content	Liquid Limit	Headspace Vapour (ppm)	Instrumen Details	IN Compare Compared C	nd ments N SIZE UTION (%)
- (126.0	GROUND SURFACE	0			R	ū	4	08	0 12	20 1	60	· ·		20 3	0			GR	SA SI CL
-		125.8 0.2	200mm TOPSOIL (WEATHERED/DISTURBED)		1	SS	2	-							0						
- 1	1	124.8			2	SS	6	125 -								0					
-		1.2	CLAYEY SILT, some sand to sandy, trace gravel, very stiff, reddish brown, moist (GLACIAL TILL)		3	SS	21	-		\backslash					0						
-2	2				_			124 -													
		123.7																			
-			SIL IY SAND, some gravel to gravelly, trace clay, very dense, reddish brown, moist		4	SS	57	-													
-3	3				5	SS	71	123 -						C	>						
- 2	1							- 122 –													
-					6	SS	50 / 75mm	-						¢	>					22 4	9 21 8
ŧ	5				•			121 -													
- 6	3	<u>119.9</u> 6.1	SANDY GRAVEL to SAND AND GRAVEL,		7	SS	50 / 125mm	120 -						c	>						
- 7	7		some silt, trace clay, very dense, reddish brown, moist		5		1231111	- 119 –													
-					8	SS	50 / 125mm	-						c	þ						
- 8 -	3							- 118													
-9	9							117 -													
gs.gpj					9	SS	59	-							0						
0035-02 bh lo	10							116 -													
file: 1-16-					10	SS	60	-													

		Terraprobe										L	.00	G C)F B	80	RE	101	_E 2	1-2
Pro	ject N	No. : 1-16-0035-02	Clie	nt	: E	Bronte	River	LP										Origir	ated by	: OE/R
Dat	e star	rted : October 26, 2021	Proj	ect	: 1	300 E	Bronte	Road										Com	piled by	: CM
She	et No	p. : 2 of 3	Loc	atio	n : C	Dakvil	le, Onta	ario										Che	cked by	: MMT
Posi	tion :	: E: 601025, N: 4807419 (UTM 17T)				Elevati	on Datur	n : Ge	eodetic	;										
Rig t	ype :	: Track-mounted			0.4.4.0	Drilling	Method	: Ho	bllow s	tem a	ugers	/ mud	rotary (†	ricone)					
e (m)			ŋ		SAMP	LES 9	scale	(Blows / X Dyna	0.3m) amic Con		Ž		Mo	oisture /	Plasticity) ur ace	ient Is	La ឆូត្	b Data and
Depth Scal	<u>Elev</u> Depth (m)	Description	Graphic Lo	Number	Type	SPT 'N' Val	Elevation S (m)	1,0 Undrain O Un ● Po 4,0	ed Shea confined cket Pene 8() 3 r Streng trometer) 12	0 gth (kPa + Fi ⊡ La 20	4 <u>0</u> a) ield Vane ab Vane 160	Plastic Limit PI	Nater (ural Lic Content L LL J 30	quid imit	Headsp Vapo (ppm	Instrum Detai	Col Custapilizi Custapilizi CR DISTR	MMENTS AIN SIZE IBUTION (%) (MIT) SA SI CI
- 11		SANDY GRAVEL to SAND AND GRAVEL	-,	10	SS	60	115 -						С							
- - 12		brown, moist <i>(continued)</i>					- 114 –													
-				11	SS	86	-						0							
- 13							113 -													
- 14				12	SS	39	112 -					(0						
- - 15							-													
-				13	SS	50	-							0						
- 16 -							110											Ţ		
- 17		at 16.8 m, grey below		14	SS	58	109 —						C							
- 18							108 -													
-				15	SS	58	_						0							
- 19 -							107													
- 20				16	SS	63	106 -							0						
							-													
				17	SS	54	- 105 -													

(continued next page)

	5	Terraprobe					LOG OF BOREHOLE 21-2
Proje	ect No	o. : 1-16-0035-02	Clien	t	: Bronte	e River	_P Originated by : OE/R
Date	start	ed : October 26, 2021	Proje	ect	: 1300	Bronte	Road Compiled by : CM
Shee	et No.	:3 of 3	Loca	tion	: Oakvi	lle, Ont	ario Checked by : MMT
Positi	on :	E: 601025, N: 4807419 (UTM 17T)			Elevat	ion Datu	n : Geodetic
Rig ty	pe :	Track-mounted			Drilling	g Method	: Hollow stem augers / mud rotary (tricone)
<u>(</u> ب		SOIL PROFILE		SAI	MPLES	e	Penetration Test Values (Blows / 0.3m) Moisture / Plasticity 9 + Lab Data
Depth Scale (r	<u>Elev</u> Depth (m)	Description	Graphic Log	Number	sPT 'N' Value	Elevation Sca (m)	XDynamic Cone Natural Liquid Liquid Indicator Indicato
- 22		SANDY GRAVEL to SAND AND GRAVEL, some silt, trace clay, very dense, reddish brown, moist (continued)		17 S	S 54	104 -	
-							
- 23				18 S	S 54	103 -	
- - 24						- 102 -	
-				19 S	S 53		o
- 25	100 1					- 101	
- 26	25.9	INFERRED BEDROCK, shale with intermittent sandstone, limestone / dolostone stringers, reddish brown (QUEENSTON FORMATION)		<u>20 S</u>	<u>S</u> , 50 / <u>75mm</u>	100 -	
-27	98.5					99 -	
- I	27.5	END OF BOREHOLE		<u>217 S</u>	<u>75mm</u>		

Unstabilized water level and depth at cave could not be determined due to use mud rotary drilling technique.

WATER LEVEL READINGS Date Water Depth (m) Elevation (m) Nov 30, 2021 16.5 109.5

50 mm dia. monitoring well installed.

m


























Photo 1. Looking north along the slope crest. The slope crest is well vegetated



Photo 2. Looking north along the slope crest. The slope crest is well vegetated and showns no sins of recent failure.





Photo 3. Looking south along the slope crest/upper slope. The slope is well vegetated and tree growth is generally upright and straight.



Photo 4. Looking south along the tableland/slope crest. The tablelland is relatively flat and the slope crest is well vegetated with mature trees.





Photo 5. Looking south toward the relatively steep scarp. The slope north of the scarp is speerated from the creek by a flood plain.



Photo 6. Looking south, a closer view of the relatively steep scarp located at the lower portion of the slpe. The creek is in direct contact with the slope resulting in active toe erosion.





Photo 7. Looking north toward the relatively steep scarp. The scarp is predominately comprised of bare shale.



Photo 8. Looking north along the creek south of the scarp. The slope is seperated from the creek by a floodplain and no active erosion was observed in this area.





Photo 9. Looking east up slope, the slope is generally well vegetated with mature trees. There are occasional fallen trees but typically tree growth is upright and straight.



Photo 10. Looking south across the large flood plain seperating the southern slope from the creek. The flood plain is well vegetated with young trees.





Photo 11. Looking west downslope along a small gully.



Photo 12. Looking west another veiw of the small gulley.





Photo 13. Looking north mid-slope toward the scarp. This section of the slope is well vegetated with young and mature trees.



Photo 14. Looking north mid-slope at the southern extent of the site. The slope is well vegetated with mature trees, whos growth is generally upright and sraight with some exceptions.





Photo 15. Looking south at the start of the small gulley containing intermitant drainage water flow.



Photo 16. Looking south along the tableland and slope crest at the south end of the site. The tableland is relatively flat and the slope crest is vegetated with young and mature trees.







Project : 1300 Bronte Road

Location : Oakville

LOG OF BOREHOLE 1

Project No.: 1-16-0035-01

Date started : February 11, 2016

Sheet No. : 1 of 2

	Posi	tion	: E: 600808, N: 4807676 (UTM 17T)	Elevati	ion Datu	m :G	eodetic	(NAD8	3)												
	Rig t	уре	: CME 55, track-mounted			[Drilling	Method	: S	olid ste	m auge	rs									
	(n		SOIL PROFILE			SAMPL	ES	ale	Penetra (Blows	ation Tes / 0.3m)	t Values	٨		м	oisture	/ Plastic	itv	e	ıt		Lab Data
	Scale (Elev	Description	iic Log	nber	be	' Value	ion Sca (m)	X Dyi	namic Con 1 <u>0</u> 2	e 20 : r Strengt	30 4 h.(kPa)	4,0	Plasti Limit	c Na Water	atural Content	Liquid Limit	adspac /apour	strumer Details	stabilized ter Level	and Comments
	Depth	(m)	Description	raph	Nun	L L	L L	levat	O U ● P	nconfined ocket Pene	etrometer	+ Field \	/ane ane	F	°∟ N		.L.	He	ű –	ч Ч	GRAIN SIZE DISTRIBUTION (%) (MIT)
	-0	131.0		U			ц З	Ξ	4	40 ε	30 1	20 1	60	1	0 2	20 3	0				GR SA SI CL
	-	0.2	FILL, sandy silt, trace to some gravel, trace to some clay, with sporadic organic presence, loose to compact, reddish		1	SS	5	-								с	>				
	-1		brown, moisi		2	SS	11	130 -							o						
	-				_																
	-2				3	SS	15	129 -							0						
		128.7						-													
	-	2.0	CLAYEY SILT, some sand to sandy, trace gravel,, very stiff to hard, brown, damp to moist (GLACIAL TILL)		4	SS	24	-			\rangle				0						
	-3				1			128 -													
	-				5	SS	18								•						6 27 42 25
	-4							127 -													
	-		till-shale complex, reddish brown		6	<u></u> SS,	50 / 75mm	-							0					hea	vy grinding
	-5 -							126 -													
	-6	<u>124.9</u> 6.1			7	SS /	. 100 /	125 -						0							
	-		intermittent sandstone / limestone / dolostone stringers, reddish brown (QUEENSTON FORMATION)				75mm	-													
	-7							124 -													
					8	<u></u> ss,	, 100 / 75mm	- 123 -						0							
	-							-													
s.gpj	-9				0	89	100 /	122 -						0					,		
3: 1-16-0035 bh logs	-						75mm	-						-							
ŧ	- 10			\mathbb{N}	1			121-											<u>.:⊨</u> .	• •	



Project : 1300 Bronte Road

Location : Oakville

LOG OF BOREHOLE 1

Project No.: 1-16-0035-01

Date started : February 11, 2016

Sheet No. : 2 of 2

													One	CUNU.	•	2	01 2	
Positi	on	: E: 600808, N: 4807676 (UTM 17T)			E	Elevati	on Datur	m : Geodetic	(NAD8	3)								
Rig ty	ре	: CME 55, track-mounted			[Drilling	Method	: Solid ste	m augei	rs								
â		SOIL PROFILE		SAMPLES D Penetration Test Values											0		Lab Data	
Depth Scale (m	<u>Elev</u> Depth (m)	Description	Graphic Log	Number	Type	SPT 'N' Value	Elevation Scal (m)	X Dynamic Con 10 Undrained Shea O Unconfined Pocket Pen 40	e 203 r Strength etrometer 3012	50 40 n (kPa) + Field Va ■ Lab Van 20 16	D ane ne 60	Plastic Limit PL	Nature / F Natu Water C	ral Li ontent L LL 30	quid imit	Headspace Vapour	Instrument Details	GRAIN SIZE GRAIN SIZE DISTRIBUTION (%) (MIT) GR SA SI CL
		INFERRED BEDROCK, shale with intermittent sandstone / limestone / dolostone stringers, reddish brown (QUEENSTON FORMATION) (continued)		10	SS ,	100 / 75mm	- 120 —					0						
- 12				11	SS ,	. 100 / 75mm	- 119 <i>-</i>					0						heavy grinding
- 13							- 118 –											
	END OF BOREHOLE Borehole was dry and caved to 12.8 m below ground surface upon completion of drilling. 25 mm dia, piozemeter installad								<u>Date</u> eb 24, 20	WATER <u>W</u> a 016	LEVEL ater Der 9.8	. READ	INGS <u>Elev</u>	<u>vation (r</u> 121.2	<u>n)</u>	LK	*****	



Project : 1300 Bronte Road

Location : Oakville

LOG OF BOREHOLE 2

Project No.: 1-16-0035-01

Date started : February 12, 2016

Sheet No. : 1 of 2

	Posit	ion	: E: 600872, N: 4807678 (UTM 17T)			I	Elevati	on Datu	m :G	eodetic	(NAD8	3)								
	Rig ty	/pe	: CME 55, track-mounted			I	Drilling	Method	: S	olid ster	n auge	rs								
Г	ĉ		SOIL PROFILE			SAMPI	ES	e	Penetra	ation Test	Values			М	oioturo	/ Plantic	oit (a)	t	Lab Data
	Jepth Scale (n	<u>Elev</u> Depth (m)	Description	raphic Log	Number	Type	PT 'N' Value	levation Scal (m)	Undrair O U	namic Cone 1,0 2 ned Shear nconfined ocket Pene	0 <u>3</u> Strength	30 4 h (kPa) + Field V ■ Lab Va	40 Yane	Plasti Limit	c N Wate	atural Content	Liquid Limit	Headspace Vapour	Instrument Details	and Deating and Comments GRAIN SIZE DISTRIBUTION (%) (MIT)
╞	-0	130.0	GROUND SURFACE	0	-		ц.	田 130-	4	10 8	0 1:	20 1	60	1	0	20 :	30			GR SA SI CL
		129.8 0.2	180mm TOPSOIL FILL, sandy silt, some gravel to gravelly, trace to some clay, with sporadic organic presence, loose, reddish brown, moist		1	SS	5	_								0				
	- 1		······, ·····, ·····		2	SS	9	129 -								0		_		
		<u>128.5</u> 1.5						_		$\left \right\rangle$										wet speen
	-2		SIL I, some sand to sandy, trace clay, trace gravel, compact, reddish brown, wet		3	SS	26	128 -			\rangle				(2 13 77 8
-					4	SS	19	-		(/				c)				
-	- 3	<u>127.0</u> 3.0	CLAYEY SILT , some sand to sandy, trace gravel, very stiff to hard, brown,		5	SS	26	127 –							0					
-			damp to moist (GLACIAL TILL)																	
	-4							126 -												
-	- 5				6	SS	50 / 100mm	125 -						0				_		
-	¢							-												
-	- 0	<u>123.9</u> 6.1	SANDY GRAVEL to SAND AND GRAVEL, some silt, trace clay, very dense, reddish brown, very moist		7	SS	50 / 100mm	124 -						0						
-	-7			000 C				123 -												
-			wet	0°0°	8	SS	100 / 125mm	-						0						grinding at 7.3m
	- 8			0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0				- 122												
t bh logs.gpj	-9	<u>120.9</u> 9.1	INFERRED BEDROCK, shale with intermittent sandstone / limestone / delestone stringers, raddisk brown		9	ss	100 / 100mm	121 –						0						Ā
file: 1-16-0035	- 10		(QUEENSTON FORMATION)					120 -										_		heavy grinding

(continued next page)



Project : 1300 Bronte Road

Location : Oakville

LOG OF BOREHOLE 2

Project No.: 1-16-0035-01

Date started : February 12, 2016

Sheet No. : 2 of 2

Posit	ion	um : Geodetic (NAD83)							
Rig t	ype	: CME 55, track-mounted				Drilling	Method	d : Solid stem augers	
Ê		SOIL PROFILE		5	Sampi	ES	le	Penetration Test Values (Blows / 0.3m) Moisture / Plasticity Q + Lab [Data
Scale (r	Elev		c Log	ber	e	Value	on Sca m)	× Dynamic Cone 10 20 30 40 Hint Water Content Liquid protection of the second of th	d ients
Depth	Depth (m)	Description	Graphi	Num	Ty	SPT 'N'	Elevati (Undrained Shear Strength (KPa) O Unconfined + Field Vane Pocket Penetrometer ■ Lab Vane 40 80 120 160 10 20 30	SIZE TION (%) T)
- - 11 -		INFERRED BEDROCK, shale with intermittent sandstone / limestone / dolostone stringers, reddish brown (QUEENSTON FORMATION) (continued)		10	SS	100 / 100mm	- 119 –		
- 12	<u>117.7</u> 12.3			11	SS	100 /	118 -		
		END OF BOREHOLE							

Unstabilized water level measured at 9.1 m below ground surface; borehole caved to 11.0 m below ground surface upon completion of drilling.



Project : 1300 Bronte Road

Location : Oakville

LOG OF BOREHOLE 3

Project No.: 1-16-0035-01

Date started : February 12, 2016

Sheet No. : 1 of 2

	Positi	on	: E: 600935, N: 4807669 (UTM 17T)	Elevation Datum : Geodetic (NAD83)																
Ľ	Rig ty	pe	: CME 55, track-mounted	Drilling Metho					d : Solid stem augers											
ſ	Ê		SOIL PROFILE			SAMPLES		ale	Penetra (Blows	ation Test / 0.3m)	Values	>		м	oisture	/ Plastic	citv	ę.	ŧ	Lab Data
	Depth Scale (r	Elev Depth (m) 129.5	Description GROUND SURFACE	Graphic Log	Number	Type	SPT 'N' Value	Elevation Sca (m)	X Dyr 1 Undrair 0 U	namic Cone 1,0 2 ned Shea nconfined ocket Pene 1,0 8	e 2 <u>03</u> r Strength trometer 3012	0 4 (kPa) ╋ Field V ■ Lab Va 20 1	40 Yane ane 60	Plasti Limit P	C Nater	atural r Content	Liquid Limit	Headspac Vapour	Instrumer Details	GRAIN SIZE DISTRIBUTION (%) (MIT) GR SA SI CL
	•0	120.2	250mm TOPSOIL	<u>x 1</u> /				-												
-		0.3 128.7	FILL, sandy silt, trace to some gravel, trace clay, trace organics, loose, reddish brown, moist		1	SS	5	129 –									0			
$\left \right $	·1	0.8	SANDY SILT, trace clay, trace gravel, compact, reddish brown, wet		2	SS	17	-		$\left \right\rangle$					С					
	-2			3 SS 10	128						0					∑ wet spoon				
					4	SS	13	127 –							—с)				
$\left \right $	3	<u>126.5</u> 3.0	CLAYEY SILT, some sand to sandy, trace gravel, very stiff to hard, brown,		5	SS	20	-							0					
F			damp to moist (GLACIAL TILL)					126 -												
-	•4				6	SS	50 / 100mm	- 125 –						0						
-	-5							- 124 -												
$\left \right $	6	<u>123.4</u> 6.1	SANDY GRAVEL to SAND AND GRAVEL, some silt, trace clay, very		7	SS	100 / 100mm	-						С						
	.7			。。。。。 。				-												
	.8				8	SS	100 / 125mm	122 -						0						
	5			0000				121 -												
i logs.gpj	9		 wet below	000 C	9	SS	100 / 150mm	-							0					
file: 1-16-0035 bf	10			0000				120 -												

(continued next page)



Project : 1300 Bronte Road

Location : Oakville

LOG OF BOREHOLE 3

Project No.: 1-16-0035-01

Date started : February 12, 2016

Sheet No. : 2 of 2

Posit	ion	: E: 600935, N: 4807669 (UTM 17T)			Elevati	on Datu	m : Geodetic (NA	(D83)				
Rig ty	уре	: CME 55, track-mounted			Drilling	Method	: Solid stem au	igers				
e (m)		SOIL PROFILE		SAN	IPLES	cale	Penetration Test Valu (Blows / 0.3m) X Dynamic Cone	ies	Moisture / Plasticity	ace ur	ient Is	Lab Data _{য় ত} and
Depth Scale	<u>Elev</u> Depth (m)	Description (continued)	Graphic Lo	Type	SPT 'N' Valı	Elevation S (m)	10 20 Undrained Shear Stre O Unconfined ● Pocket Penetrome 40 80	30 40 ength (kPa) + Field Vane ter ■ Lab Vane 120 160	Plastic Natural Liquid Limit Water Content Limit PL MC LL I O 20 30	Headsp Vapol	Instrum Detai	Comments GRAIN SIZE DISTRIBUTION (%) (MIT) GR SA SI CL
-		SANDY GRAVEL to SAND AND GRAVEL, some silt, trace clay, very dense, reddish brown, very moist (continued)	°°°°			119-						
- 11			• 0 10 	0 55	50/ 125mm	-			0			48 33 14 5
- 12) • •			118-						
-	<u>117.3</u> 12.2	INFERRED BEDROCK, shale with intermittent sandstone / limestone / dolostone stringers, reddish brown		<u>1, 55</u>	<u>3 100 /</u> 50mm	, 117 –			•			
- 13		(QUEENSTON FORMATION)				-						
-				-	50/	116 -						
- 14				2 58	125mm	-						
- 15						115-						
	<u>114.2</u> 15.3		<u>1</u> ;	3 55	3 100 / 75mm				0			heavy grinding

Unstabilized water level measured at 1.5 m below ground surface; borehole caved to 9.1 m below ground surface upon completion of drilling.

25 mm dia. piezometer installed.

WATER LEVEL READINGS <u>Date</u> <u>Water Depth (m)</u> <u>Elevation (m)</u> Feb 24, 2016 11.8 117.7

file: 1-16-0035 bh logs.gpj


















