APPENDIX C7

Geotechnical

Terraprobe

Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

PRELIMINARY
GEOTECHNICAL INVESTIGATION
CLASS ENVIRONMENTAL ASSESSMENT (EA) STUDY
KIRBY ROAD EXTENSION
DUFFERIN STREET TO BATHURST STREET
CITY OF VAUGHAN, ONTARIO

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1 INTRODUCTION

Terraprobe Inc. (Terraprobe) was retained by Rizmi Holdings Limited to conduct a preliminary geotechnical investigation for a Class Environmental Assessment (Class EA) Study for proposed Kirby Road extension from Dufferin Street to Bathurst Street, in the City of Vaughan, Region of York, Ontario. A site location plan is provided in Figure 1.

This report encompasses the results of the preliminary geotechnical investigation conducted along the proposed alignments to determine the prevailing subsurface soil and ground water conditions, and on this basis, to provide the preliminary geotechnical engineering recommendations for the project, including pavement design and a water-crossing structure (culvert or bridge), installation of underground utilities (sewers) and deep cut and high embankment sections required for the proposed road extension. In addition, comments are also included on pertinent construction aspects including excavations, backfill and ground water control.

Terraprobe has also completed a hydrogeological study for this project site. The findings of this investigation are reported under a separate cover.

2 SITE AND PROJECT DESCRIPTIONS

The City of Vaughan, in cooperation with the Region of York plans to undertake a Class EA Study that includes preliminary design for the Kirby Road extension from Dufferin Street to Bathurst Street. The proposed extension will tie in Dufferin Street and Bathurst Street at west and east ends, respectively. The design drawings provided by Schaeffer & Associates Ltd. (Schaeffer) indicate that a total of four alternative alignments (i.e. Alignments 4, 5, 6 and 6A) are under consideration for the proposed extension. The western portion of each alignment is generally located in relatively densely wooded and grassed area while the eastern portion traverses through an undulating fallow agricultural land. An alignment will cross a small creek (Patterson Creek). Alignments 4 and 5 would also traverse through the wetland associated with this creek.

Scheaffer provided Terraprobe with *Environmental Assessment Study Kirby Road Extension (from Dufferin Street to Bathurst Street), City of Vaughan, Transportation, Traffic and Active Transportation Need and Justification Assessment*, prepared by Poulos & Chung Limited. This report indicates that the proposed extension will consist of two through lanes in each direction of travel and be classified as “a primary arterial goods movement corridor”. It is understood that the extension will be open to traffic by 2021. Kirby Road is currently under the jurisdiction of the City of Vaughan, however, it may be transferred under the jurisdiction of the Region of York in the future as this road is contemplated to play an important role and function in the overall regional road network.

There is an existing corrugated steel pipe culvert at the Creek along the internal access road. A new water-crossing structure (culvert or bridge) will be required to provide the continuity of the new road across Patterson Creek. Sewer pipes will be installed along the selected alignment. The proposed alignments would traverse through significantly undulating terrain, resulting in high fill (embankment) and deep cut sections. A slope stability analysis is carried out for the selected high embankment and deep cut slope to provide preliminary guidance to help facilitate selection of the final alignment.

3 INVESTIGATION PROCEDURE

Borehole locations were staked out by Terraprobe generally in accordance with the borehole location plan provided by Scheaffer on October 26, 2017. Some borehole locations were adjusted based on the site access constraints and features. The field investigation was conducted during the period of October 31 to November 9 and December 7, 2017, and consisted of drilling and sampling a total of 21 boreholes to depths varying from about 6.6 to 20.3 m below grade. The approximate locations of the boreholes are shown on the enclosed Borehole Location Plans (Figures 2A, 2B and 2C).

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

All samples obtained during the investigation were sealed into clean plastic jars and transported to our geotechnical testing laboratory for detailed inspection and testing. All borehole samples were examined (tactile) in detail by a geotechnical engineer, and classified according to visual and index properties. Laboratory tests consisted of water content determination on all samples; and a Sieve and Hydrometer analysis on twelve (12) selected native soil samples (Borehole 1, Sample 5; Borehole 2, Sample 4; Borehole 3, Samples 7 and 14; Borehole 5, Sample 9; Borehole 8, Sample 4; Borehole 10, Sample 8; Borehole 13, Sample 6; Borehole 15, Sample 4; Borehole 18, Sample 5; Borehole 20, Sample 4; and Borehole 21, Sample 4) and Atterberg Limits test on one (1) selected native cohesive soil sample (Borehole 21, Sample 4). The measured natural water contents of individual samples and the results of the Sieve and Hydrometer analysis and Atterberg Limits tests are plotted on the enclosed Borehole Logs at respective sampling depths. The results of Sieve and Hydrometer analysis and Atterberg Limits tests are also summarized in Section 4.7 of this report and appended.

Water levels were measured in open boreholes upon completion of drilling. Monitoring wells comprising 50 mm diameter PVC pipes were installed in Boreholes 2, 3, 6, 8, 9, 10, 13, 14, 16 and 20 to facilitate ground water monitoring and for the purpose of the hydrogeological study. The PVC tubing was fitted with a bentonite clay seal as shown on the accompanying Borehole Logs. Water levels in the monitoring wells were measured on January 8 and 25, 2018. The results of ground water monitoring are presented in Section 4.8 of this report.

The borehole ground surface elevations were surveyed by Terraprobe using a Trimble R10 GNSS System. The Trimble R10 system uses the Global Navigation Satellite System and the Can-Net reference system to determine target location and elevation. The Trimble R10 system is reported to have an accuracy of up to 10 mm horizontally and up to 30 mm vertically.

We noted that significant borehole location and/or surface elevation discrepancies were noted particularly for Boreholes 1 to 17 when compared with the contour and plan data provided by Schaeffer (see Figures 2B and 2C). This issue was discussed with the design team. It is recommended that a detailed survey of the project site be carried out and the borehole locations and elevations be further confirmed.

It is should be noted that the elevations provided on the Borehole Log are approximate, for the purpose of relating soil stratigraphy and should not be used or relied on for other purposes.

4 SUBSURFACE CONDITIONS

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

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

4.1 Topsoil

A topsoil layer was encountered at the ground surface at each borehole location with the exceptions of Boreholes 1, 4, 20 and 21. The topsoil thickness ranged from about 150 to 350 mm.

The above topsoil thickness was measured from the borehole drilling and is approximate. We recommend that a shallow test pit investigation be carried out to determine precise topsoil thickness present across the site for quantity estimation and costing purposes if required.

4.2 Pavement

An asphalt pavement structure was encountered in Boreholes 1 and 21 and summarized in the following table.

Pavement Structural Components	Borehole 1 (Dufferin Street Intersection)	Borehole 21 (Bathurst Street Intersection)
Asphaltic Concrete (mm)	160	240
Granular Base/Subbase (mm)	640	200
Total Pavement Thickness (mm)	800	440

4.3 Earth Fill

Earth fill materials, consisting of the matrix of sand and silt, gravelly sand and clayey silt were encountered beneath the topsoil layer or at ground surface in all boreholes with exceptions of Boreholes 1 and 21 and extended to about 0.8 m to 6.1 m depths below grade. The relatively deep earth fill zones were encountered in Boreholes 10 and 17, extending to about 6.1 m and 4.6 m depth below grade, respectively. The earth fill materials generally consist of trace amounts of organic matters.

Standard Penetration Test results (N-values) obtained from the cohesionless earth fill zone ranged from 1 to 26 blows per 300 mm of penetration, indicating a very loose to compact relative density. The N-values obtained from the cohesive clayey silt earth fill zone ranged from 6 to 15 blows per 300 mm of penetration, indicating a firm to stiff consistency. The in-situ moisture contents of the earth fill samples ranged from 4 to 28 percent by mass, indicating a moist condition.

4.4 Sand/Sandy Silt to Silty Sand

The sand/sandy silt to silty sand, with trace to some gravel and clay were encountered beneath the earth fill zones or the asphalt pavement structure at depths ranging from 0.4 m (Borehole 21) to 6.1 m (Borehole 10) depths below grade and extended to depths varying from about 2.3 m (Borehole 21) to about 20.3 m (Borehole 3) below grade at each borehole location in each borehole.

The N-values obtained from the matrix of sand and silt ranged from 4 to 88 blows per 300 mm of penetration to 50 blows per 125 mm of penetration, indicating a very loose to very dense relative density. The in-situ moisture contents of the samples ranged from 1 to 26 percent by mass, indicating a damp to wet condition.

4.5 Silt

Silt with trace to some clay and sand was encountered beneath the sand/sandy silt to silty sand layers at depths ranging from about 6.1 to 12.2 m below grade and extended to depths of about 6.6 m to 14.2 m below grade (the full depths of the investigation) in Boreholes 5, 6, 10, 19 and 20.

The N-values obtained from the silt deposit ranged from 18 to 81 blows per 300 mm of penetration, indicating a compact to very dense relative density. The in-situ moisture contents of the silt samples ranged from 15 to 21 percent by mass, indicating a moist to wet condition.

4.6 Clayey Silt

Clayey silt deposit, with trace to some gravel and trace amounts of gravel was encountered beneath the silt layer, earth fill zone or sand layer at depths varying from about 1.5 to 10.7 m below grade and extended to depth ranging from about 4.6 m to 12.6 m (the full depth of the investigation) below grade in Boreholes 5, 18 and 21.

N-values obtained from the clayey silt deposit ranged from 18 to 59 blows per 300 mm of penetration, indicating a very stiff to hard consistency. The in-situ moisture contents of the clayey silt samples ranged from 11 to 23 percent by mass, indicating a moist condition.

4.7 Geotechnical Laboratory Test Results

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

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

Borehole No. Sample No.	Sampling Depth below Grade (m)	Percentage (by mass)				Descriptions (MIT System)
		Gravel	Sand	Silt	Clay	
Borehole 1, Sample 5	3.3	0	69	29	2	SILTY SAND trace clay
Borehole 2, Sample 4	2.5	1	22	70	7	SANDY SILT trace clay, trace gravel
Borehole 3, Sample 7	6.3	0	94	4	2	SAND trace silt, trace clay
Borehole 3, Sample 14	17.0	0	76	21	3	SILTY SAND trace clay
Borehole 5, Sample 9	9.4	0	1	84	15	SILT some clay, trace sand
Borehole 8, Sample 4	2.5	0	92	6	2	SAND trace silt, trace clay
Borehole 10, Sample 8	7.8	0	3	87	10	SILT some clay, trace sand

Borehole No. Sample No.	Sampling Depth below Grade (m)	Percentage (by mass)				Descriptions (MIT System)
		Gravel	Sand	Silt	Clay	
Borehole 13, Sample 6	4.8	0	93	5	2	SAND trace silt, trace clay
Borehole 15, Sample 4	2.5	5	22	54	19	SANDY SILT some clay, trace gravel
Borehole 18, Sample 5	3.3	1	17	48	34	CLAYEY SILT some sand, trace gravel
Borehole 20, Sample 4	2.5	10	67	20	3	SILTY SAND trace gravel, trace clay
Borehole 21, Sample 4	2.5	0	12	63	25	CLAYEY SILT some sand

Atterberg Limits Test was carried out on one selected soil sample. The result was plotted on A-Line Graph (refer to enclosed Figure, Atterberg Limits Test Results) and summarized as follows:

Borehole No. Sample No.	Sampling Depth below Grade (m)	Liquid Limit (W_L)	Plastic Limit (W_P)	Plasticity Index (I_P)	Natural Water Content (percent)	Plasticity
Borehole 21, Sample 4	2.5	25	17	8	20	Slightly Plastic

4.8 Ground Water

Observations pertaining to the depth of water level and caving were made in the open boreholes immediately after completion of drilling, and are noted on the enclosed Borehole Logs. Monitoring wells were installed in Boreholes 2, 3, 6, 8, 9, 10, 13, 14, 16 and 20 to facilitate ground water level monitoring and for the purpose of the hydrogeological study. As hollow stem augers were used to encase some boreholes, observations of borehole caving upon completion of the borehole drilling could not be done. Drilling mud was also added to stabilize the borehole wall in some boreholes, and the measurement of water level upon completion of borehole drilling could not be made. The ground water level measurements in the monitoring wells were taken on January 8 and 25, 2018 and are noted on the enclosed Borehole Logs. A summary of these observations is provided as follows:

Borehole No.	Depth of Boring below Grade	Depth to Cave below Grade	Water Level Depth/Elevation at the Time of Drilling	Water Level Depth/Elevation in Monitoring Well on January 8, 2018	Water Level Depth/Elevation in Monitoring Well on January 25, 2018
BH 1	6.6 m	Open	Dry	Monitoring Well not installed	Monitoring Well not installed

Borehole No.	**Depth of Boring below Grade**	**Depth to Cave below Grade**	**Water Level Depth/Elevation at the Time of Drilling**	**Water Level Depth/Elevation in Monitoring Well on January 8, 2018**	**Water Level Depth/Elevation in Monitoring Well on January 25, 2018**
BH 2	6.6 m	na	Dry	6.3 m/283.1 m	Dry
BH 3	20.3 m	na	16.8 m/284.2 m	17.9 m/283.1 m	17.9 m/283.1
BH 4	11.1 m	na	2.3 m/282.4 m	Monitoring Well not installed	Monitoring Well not installed
BH 5	12.6 m	na	na	Monitoring Well not installed	Monitoring Well not installed
BH 6	6.6 m	na	na	1.8 m/276.8 m	1.6 m/277.0 m
BH 7	11.1 m	Open	Dry	Monitoring Well not installed	Monitoring Well not installed
BH 8	12.6 m	na	Dry	na	Dry
BH 9	8.1 m	na	na	5.4 m/275.7 m	5.2 m/275.9 m
BH 10	8.1 m	na	na	3.1 m/272.6 m	3.0 m/272.7 m
BH 11	11.1 m	Open	Dry	Monitoring Well not installed	Monitoring Well not installed
BH 12	6.6 m	Open	Dry	Monitoring Well not installed	Monitoring Well not installed
BH 13	12.6 m	na	na	Dry	Dry
BH 14	18.7 m	na	na	17.9 m/281.4 m	Dry
BH 15	11.1 m	Open	Dry	Monitoring Well not installed	Monitoring Well not installed
BH 16	8.1 m	Open	Dry	Dry	Dry
BH 17	6.6 m	Open	Dry	Monitoring Well not installed	Monitoring Well not installed
BH 18	11.1 m	Open	Dry	Monitoring Well not installed	Monitoring Well not installed
BH 19	14.2 m	Open	Dry	Monitoring Well not installed	Monitoring Well not installed
BH 20	15.7 m	Open	Dry	not accessible	not accessible
BH 21	6.6 m	Open	Dry	Monitoring Well not installed	Monitoring Well not installed

The water levels noted above may fluctuate seasonally depending upon the precipitation and surface runoff. The water levels in boreholes in close proximity to Patterson Creek will be also affected by the creek water level.

5 DISCUSSIONS AND RECOMMENDATIONS

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

This report is provided on the basis of these terms of reference and on the assumption that the design features relevant to the geotechnical analyses will be in accordance with applicable codes, standards and guidelines of practice. 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.

The recommendations provided in the following sections are preliminary for the purpose of Class EA study and alignment feasibility review. Further geotechnical works and review will be required to provide final and updated geotechnical design recommendations for the selected alignment.

5.1 Pavement

5.1.1 Traffic Data Analysis

The traffic data was provided by Poulos & Chung Limited via the email dated January 17, 2018, and summarized in the following table.

2021 AADT*	2031 AADT*	2021 Commercial Vehicles	2031 Commercial Vehicles	Annual Growth Rate	ESALs* (2021 to 2141)
20,000	25,000	1.5%	10 to 12%	2.3%	7,006,600

*Note: AADT=Annual Average Daily Traffic; ESALs=Equivalent Single Axle Loads

The above traffic data was interpreted by Terraprobe to estimate the design Equivalent Single Axle Loads (ESALs) in accordance with the Appendix D of MTO *MI-183 Adaption and Verification of AASHTO Pavement Design Guide for Ontario Conditions*. It is understood that the extension will be open to traffic by 2021. The traffic volumes were determined for a 20 - year pavement design period (2021 to 2041) in accordance with York Region's *Road Design Guideline.* The total design ESALs anticipated over the 20-year design life period are also provided in the above table. The detailed traffic analysis and estimated ESALs are given in Appendix C.

5.1.2 Design Parameters

The following discussions on the design of flexible pavement are provided based on the results of the subsurface investigation and laboratory testing carried out and the traffic data provided. The pavement design parameters are summarized in the following table. The pavement designs were developed based on the following references and guideline,

- MTO's Adaptation and Verification of AASHTO Pavement Design Guide for Ontario Conditions, MI-183, March 19, 2008.
- American Association of State Highway and Transportation Officials, AASHTO Guide for Design of Pavement Structures, 1993.
- Region of York, Road Design Guidelines, Version 1.20, December 2016.

Design and Material Parameters	Values
Initial Serviceability Index	4.5
Terminal Serviceability Index	2.5
Serviceability Loss	2.0
Reliability Level, %	90
Overall Standard Deviation	0.49
Design Subgrade Resilient Modulus, MPa	30
Layer Coefficient of Hot Mix Asphalt Surface Course	0.42
Layer Coefficient of Granular Base Course	0.14
Layer Coefficient of Granular Subbase Course	0.09
Drainage Coefficients of Base and Subbase Courses	1.0

5.1.3 Pavement Design

Recommended pavement structure for the extension is given in the following table.

Pavement Structure	Kirby Road
HMA Surface Course, OPSS 1150 HL 1	50 mm
HMA Binder Course, OPSS 1150 HL 8 HS	100 mm
Granular Base Course, OPSS MUNI 1010 Granular A	150 mm
Granular Subbase Course, OPSS MUNI 1010 Granular B Type I	600 mm

Pavement Structure	Kirby Road
Total Thickness	900 mm
Constructed Pavement Structural Number	138
Design Structural Number	138

Pavement construction sequence should be carried out as follows,

- Remove the existing topsoil and any other obviously deleterious materials along the proposed road alignment;
- Fill and cut subgrade to design elevations in accordance with OPSS 206 to accommodate the new pavement structure; the prepared subgrade should be carefully proof-rolled in the presence of the geotechnical engineer, any soft or wet areas or other obviously deleterious materials excavated and properly replaced with suitable, approved material;
- Place 600 mm thick OPSS MUNI 1010 Granular B Type I subbase course in loose lifts not exceeding 150 mm thickness; compact to 100 percent of Standard Proctor Maximum Dry Density (SPMDD);
- Place 150 mm thick OPSS MUNI 1010 Granular A base course, compacted to 100 percent of SPMDD; and
- Place 100 mm thick 1150 HL 8 HS hot mix asphalt binder course (two lifts) followed by placing 50 mm thick OPSS 1150 HL 1 hot mix asphalt surface course. The surface of the completed pavement should be provided with a cross fall of 2 percent.

The constructed pavement Structural Number is 138, which is equal to the Design Structural Number (138). As such, the pavement is structurally adequate for the expected traffic loads within a 20-year design life period.

5.1.4 Drainage

Control of water is an important factor in achieving a good pavement life. Therefore, we recommend that provisions be made to drain the new pavement subgrade and its granular layers. Full-length subdrains should be installed beneath the curb in accordance with the OPSD 216.021 and the subdrain pipe should be connected to a positive outlet. Subdrains should consist of 150 mm diameter perforated plastic pipe wrapped with a knitted geotextile sock and placed in a trench excavated 300 mm wide and 300 mm deep in the subgrade. The backfill around the subdrain should consist of OPSS MUNI 1004 19 mm Clear Stone, provided that the clear stone is wrapped entirely in a geotextile fabric.

5.1.5 Subgrade Preparation

As the proposed alignment cross the uneven terrain, the subgrade preparation will result in fill and cut sections. For the cut sections, the subgrade will be excavated to the design elevation required to accommodate the new pavement structure. The subgrade should be properly prepared, shaped and graded for positive drainage.

The embankment fill should be placed on the approved and properly prepared subgrade in loose lifts not exceeding 300 mm thickness; and compacted to 95 percent of SPMDD in accordance with OPSS MUNI 501. The upper 1 m of the embankment, forming the pavement subgrade must be uniformly compacted to a minimum of 98 percent of SPMDD. Fill materials used for constructing the embankment should consist of local excavated earth material, select subgrade material or imported granular material. Embankments should be designed with a side slope inclination of 2 Horizontal to 1 Vertical (2H:1V) or flatter.

Transition zones from earth cut to earth fill and vice versa should conform to OPSD 205.010.

Immediately prior to placing the granular subbase, the exposed subgrade should be proof rolled with a heavy rubber tired vehicle (such as a loaded gravel truck). The subgrade should be inspected for signs of rutting or displacement. Areas displaying signs of rutting or displacement should be compacted and tested or the material should be excavated and replaced with compacted Granular B Type I. Backfill material should be placed and compacted to at least 100 percent of SPMDD. The final subgrade surface should be sloped at a grade of 3 percent to provide positive subgrade drainage.

5.1.6 Pavement Materials and Construction Features

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

5.1.6.1 Pavement Materials

HL 1 and HL 8 HS hot mix asphalt mixes should be designed, produced and placed in conformance with OPSS 1150 and OPSS 310 requirements and the Region’s requirements.

Both Granular A and Granular B Type I materials should meet the requirements of OPSS MUNI 1010 requirements. Granular materials should be compacted to 100 percent of SPMDD.

5.1.6.2 Padding

HL3 HS hot mix asphalt is recommended as padding. Padding should be placed in lifts not exceeding 50 mm.

5.1.6.3 Asphalt Cement Grade

Performance graded asphalt cement, PG 64-28, conforming to OPSS MUNI 1101 requirements, should be used in both HMA binder and surface courses.

5.1.6.4 Tack Coat

A tack coat (SS1) should be applied to all construction joints prior to placing hot mix asphalt to create an adhesive bond. SS1 tack coat should also be applied between hot mix asphalt binder and surface courses.

5.1.6.5 Frost Protection

For design purposes the frost penetration depth is estimated to 1.2 m below ground surface in accordance with OPSD 3090.101.

5.2 Watercourse Crossings

The proposed alignments under consideration will require watercourse crossings. The design information for these structure is not available at the time of preparation of this report therefore the geotechnical recommendations provided in the following sections are preliminary and intended for general design guidance. Additional location specific boreholes will need to be advanced during the detailed design stage once the final alignment has been selected to provide updated geotechnical design recommendations. In general, these structures may consist of culvert (CSP or precast concrete box culvert) and bridge.

5.2.1 Foundations

Boreholes 6, 7 and 10 are located in close proximity to the Creek Boreholes 6 and 7 encountered 150 mm and 250 mm thick topsoil at ground surface, respectively, underlain by earth fill materials extending to about 0.8 m depth below grade. The earth fill materials were in turn underlain by undisturbed native soil deposit extending to the full depth of investigation. Borehole 7 was dry upon the completion of drilling. Water levels measured in the monitoring well on January 8 and 25, 2018, installed in Borehole 6 were about at 1.8 m and 1.6 m depth below grade, respectively. Borehole 10 encountered 150 m thick topsoil at the ground surface, underlain by earth fill material extending to about 6.1 m depth below grade, underlain by undisturbed native soil deposit extending to the full depth of the investigation. Water levels measured in the monitoring well on January 8 and 25, 2018, installed in Borehole 10 were about 3.1 m and 3.0 m depths below grade, respectively.

The following table summarizes the recommended geotechnical reaction and geotechnical resistance available at the borehole locations.

Borehole No.	Highest (Bottom) of Footing below Grade	Highest (Bottom) of Footing Elevation	Max. Factored Geotechnical Resistance at ULS (kPa)	Max. Geotechnical Reaction at SLS (kPa)	Bearing Stratum
BH 6	Below 2.0 m	276.6 m	300	200	Compact and Wet Sand to Silty Sand
BH 7	2.0 to 6.0 m Below 6.0 m	286.9 to 282.9 m Below 282.9 m	300 750	200 500	Compact Sand Dense to Very Dense Sand
BH 10	6.5 to 7.6 m Below 7.6	269.2to 268.1 m Below 268.1 m	450 750	300 500	Dense Sand Had Silt, some clay

The relatively deep sand fill material was encountered in Borehole 10. In this area, the earth fill material should be excavated to the competent native soil and backfilled with OPSS MUNI 1010 Granular A material to the design foundation elevation. The Granular A material should be placed in lifts not exceeding 200 mm loose thickness and compacted to 100 percent of SPMDD at ±2 percent of Optimum Moisture Content (OMC). The sides of the granular pad should extend at least 1 m horizontally beyond the footing sides in every direction extending down to the native subgrade soil at a 1 Horizontal to 1 Vertical (1H:1V) side slope. This approach will require positive ground water control depending upon the prevailing ground water level at the time of construction.

A footing bearing on a compacted Granular A pad can be designed for a factored geotechnical resistance at Ultimate Limit State (ULS) of 450 kPa and a geotechnical reaction at Serviceability Limit State (SLS) of 300 kPa.

Alternatively, the watercourse crossing structures may also be supported on deep foundations. Additional deep boreholes will be required to obtain location specific subsurface soil and ground water information to provide geotechnical design recommendations for a deep foundation system (i.e., augered caissons and driven piles).

The ground water levels noted in particularly Boreholes 6 and 10 indicate that positive ground water control will be required foundation installation. Without prior positive groundwater control, the native soils will become disturbed upon excavation and lose their integrity to support.

5.2.2 Spread Footing Foundation Installation

Spread footings including any associated concrete wing walls/retaining walls, should be founded at a minimum depth of 1.2 m below permanent soil cover to provide adequate protection against frost penetration, as per OPSD 3090.101.

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

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

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

5.2.3 Scour Protection

Erosion protection should be provided at the structure inlet and outlet (including the slopes and sides). At the inlet area this could consist of a clay seal. The purpose of the clay seal is to ensure that water flow is channelled through the structure and does not seep through the backfill around and underneath the structure. It should be ensured that the clay seal extends to cover all the granular backfill materials to prevent seepage through them. The clay seal should therefore be continuous and have a minimum compacted thickness of 0.6 m and should extend above the high water level. The clay seal should be protected by a layer of rip-rap. The material used for the clay seal should conform to the requirements stipulated in OPSS 1205.

Alternatively, concrete cut-off and head walls can be constructed to protect the granular backfill and prevent seepage around the structure.

Concrete cut-off and head walls can also be used to protect the granular fill around the structure outlet against erosion. In this case, however, filtered erosion protection such as rip-rap should be provided along the channel and the sides beyond the concrete cut-off and head walls at the outlet.

Design of erosion protection schemes for the creek bed in the inlet and outlet areas will depend on hydrologic, hydraulic and/or other concerns. Typically, rip-rap protection is provided to these areas. The rip-rap layer should cover all surfaces on the embankment slopes with which creek water is likely to be in contact. A geomorphic consultant should prepare the scour protection design.

5.2.4 Lateral Earth Pressure

If the abutment is allowed to yield (unrestrained system) then, active horizontal earth pressure should be used for the design. If the abutment is not allowed to yield (restrained system) then, at-rest horizontal earth pressures should be used for the design. The amount of wall movement required to develop active, passive and at-rest earth pressures may be interpreted using Figure C6.9.1(a) in the Commentary to the CHBDC 2006.

Earth pressures are generally calculated using the following expression:

$$P = K(\gamma h + q)$$

Where:
P = the horizontal pressure (kPa)
K = the earth pressure coefficient
h = the depth below the ground surface (m)
γ = the bulk unit weight of soil (kN/m^3)
q = the complete surcharge loading (kPa)

The above equation is based on the assumption that free draining material is provided behind the abutment with a positive drainage and outlet system.

Earth pressures acting on the structure should be computed in accordance with Clause 6.9 of the CHBDC 2006. According to Clause 6.9.3 of the CHBDC 2006, a compaction surcharge should also be added. For soils with an angle of internal friction ranging from 30° to 35° the magnitude should be 12 kPa at the top of the fill decreasing linearly to 0 kPa at a depth of 1.7 m; or decreasing linearly to 0 kPa at a depth of 2.0 m for soils with an angle of internal friction that exceeds 35°. Compaction equipment including hand operated vibratory equipment should be in accordance with OPSS MUNI 501.

Earth pressure coefficients are dependent on the material used as backfill and typical values are provided in the following table.

Wall Condition	**Earth Pressure Coefficient (K)**			
	OPSS Granular A or OPSS Granular B Type II ϕ = 35°; g = 22.8 kN/m^3		**OPSS Granular B Type I ϕ = 32°; g = 21.2 kN/m^3**	
	Horizontal Surface Behind Wall	**Sloping Surface Behind Wall (2H:1V)**	**Horizontal Surface Behind Wall**	**Sloping Surface Behind Wall (2H:1V)**
Active (Unrestrained Wall)	0.27	0.40*	0.31	0.48*
At rest (Restrained Wall)	0.43	-	0.47	-
Passive (Movement Towards Soil Mass)	3.69	-	3.25	-

* For wing walls.

The earth pressure coefficients in the table above are Rankine “ultimate” values that require certain structural movements for the respective conditions to be mobilized. The values to use for design can be estimated from Figure C6.16 in the Commentary to the CHBDC, 2006.

5.2.5 Ultimate Coefficient of Friction

Resistance to lateral forces/sliding resistance between the concrete footing and the subgrade soils should be evaluated in accordance with the CHBDC 2006. The sliding resistance may be computed based on the following ultimate coefficients of friction:

- Sand to silty sand subgrade – 0.6;
- Compacted granular pad – 0.7.

5.2.6 Seismic Design Parameters

According to Table A.3.1.1 of the CHBDC the site is located in Seismic Zone 0 (Aurora) and therefore the following seismic parameters should be used for design:

• Velocity Related Seismic Zone	0
• Zonal Velocity Ratio	0.05
• Acceleration Related Seismic Zone	1
• Zonal Acceleration Ratio	0.05
• Peak Horizontal Acceleration	0.08

Based on borehole data, the soil profile type would be classified as Type II. According to Table 4.4 of the CHBDC, a Site Coefficient "S" (ground motion amplification factor) of 1.2 should be used in the seismic design.

5.3 Sewers

The design information of the underground services was not available at the time of preparation of this report. It is understood that the sewer will be installed at about 5.0 m depth below road grade using conventional open-cut techniques.

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

5.3.1 Excavation

All topsoil should be stripped from areas where underground services are to be located. Based on the results of the boreholes drilled along the proposed alignments, it is expected that excavations will generally penetrate topsoil, fill materials, native sand, sandy silt to silty sand, clayey silt and silt.

OHSA designates four broad classifications of soils to stipulate appropriate measures for excavation safety. The earth fill materials are classified as “Type 3 Soil” above and “Type 4 Soil” below the prevailing ground water level, while the native soils (sand, sandy silt to silty sand, clayey silt and silt) soils are classified as “Type 2 to 3 Soils” depending on consistency or relative density. As such, the above conditions should generally be regarded as "Type 3 Soil", provided that effective ground water control is achieved where required and surface water is directed away from open excavations. The soils encountered at this site are considered to be suitable for excavation using normal trenching and excavating equipment.

Where workmen must enter excavations advanced deeper than 1.2 m, the trench walls should be suitably sloped and/or braced in accordance with the OHSA. Minimum support system requirements for steeper excavations are stipulated in the OHSA, and include provisions for timbering, shoring and moveable trench boxes.

5.3.2 Pipe Bedding and Cover/Embedment

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

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

Further detail information on bedding/embedment and cover materials can be provided at the detailed design phase.

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

5.3.3 Backfill

The topsoil and earth fill materials containing excessive amounts of topsoil should not be reused as trench backfill. However, these materials may be stockpiled and reused for landscaping purposes. The selection and sorting of earth fill soils should be conducted under the direction of a geotechnical engineer.

The native soils free from vegetation, organic matter, excessively wet soil, oversized particles and other deleterious materials are considered suitable for backfilling purposes provided the moisture content of these soils is close to the OMC (within 3 percent). Any excessively wet soil must be separated and allowed to dry, or be tilled to reduce the moisture content so that it can be effectively compacted. Alternatively, materials of higher moisture content could be wasted and be replaced with imported material which can be more readily compacted.

Trench backfill material should be placed in uniform layers not exceeding 300 mm in thickness for the full width of the trench and each layer should be compacted to a minimum of 95 percent SPMDD. The backfill materials should be placed and compacted under the direction of a geotechnical engineer. The upper 1 m of the backfill, forming the pavement subgrade must be uniformly compacted to a minimum of 98 percent of SPMDD.

Post construction settlements on the order of 1 to 3 percent of the backfill depth is expected to occur over several months depending upon the backfill material type, and may have an effect on the overlying pavement structures if present. In the case of deep services, provisions should be included in the contract for remedial work such as padding and resurfacing where required.

5.4 High Fill and Deep Cut Sections

The profile drawings provided by Schaeffer indicate the high fill (embankment) and deep cut sections (> 5 m) along the proposed alignments (see Appendix E). The preliminary design and construction recommendations for the high embankment and deep cut sections are provided in the following sections based on the factual data.

5.4.1 High Embankment Sections

The maximum embankment height measured on the profile drawings from design elevation of the top of embankment to the toe of slope elevation is estimated to be about 14 m. The cross section at Sta. 0+195 along Alignment 4 was selected to represent the critical slope conditions for the high embankment sections. Borehole 2 advanced in a close proximity to this embankment penetrated 150 mm thick topsoil at ground surface, underlain by earth fill material extending to about 0.8 m depth below grade, which is in turn underlain by sandy silt to silty sand extending to the full depth of the investigation. The ground water levels in the monitoring well installed in Borehole 2 measured on January 8 and 25, 2018 were 6.3 m below grade (Elev. 283.1 m) and dry, respectively.

5.4.1.1 Settlement

The preliminary settlement of the underlying soil (under the proposed embankment fill weight) is estimated to vary from 90 to 180 mm depending on the embankment height. Due to cohesionless nature of the underlying soil, this settlement is expected to be immediate (short-term) as the load is applied and will essentially be completed by the end of construction. Further analysis is required to refine the settlement value during the detailed design sage for the final alignment.

In addition, the embankment constructed with local earth fill or granular material will also settle during construction (fill settlement). Generally, the magnitude of this settlement is expected to be about 1 percent of the embankment height. Most of this settlement should be immediate in nature and will be essentially complete shortly after construction in case of cohesionless fill used to construct the embankment. The internal settlement of the embankment may take weeks or a few months if it is constructed with cohesive fill. Nevertheless, we recommend deferring the surface course asphalt paving operations for a full construction season i.e. 1 year, to accommodate any remaining post construction settlement that may occur after construction.

5.4.1.2 Slope Stability Analysis

A detailed engineering analysis of slope stability was carried out for the embankment noted above (Sta. 0+195, Alignment 4) utilizing computer software SLIDE (version 6.0), developed by Rocscience Inc. The slope stability analysis is based on effective stress limit equilibrium method for analysing slope stability using Morgenstern-Price, Bishop, Janbu and Spencer methods. 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 (typically greater than 2 m thick) of soil 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. Based on the borehole results, the following average soil properties were utilized for the soil strata in the slope stability analysis:

Stratum	Unit Weight kN/m^3	Angle of Internal Friction (degrees)	Cohesion (kPa)
Compacted Embankment Fill	19.0	30	0
Sandy Silt to Silty Sand	21.0	32	0

The above soil strength parameters are based on the effective stress analysis for long term slope stability. It is noted that these soil properties are relatively conservative, and the site soils are actually stronger.

The traffic load on the embankment was modelled by a surcharge load of 12 kPa.

The standard industrial practice requires a minimum factor of safety of 1.3 for the design of embankment.

The analyses indicate that the embankment constructed at a minimum side slope geometry of 2 horizontal to 1 vertical (2H:1V) or flatter and provided with a mid-height bench of a minimum 2 m width, will have an acceptable factors of safety of 1.3 with respect to embankment stability. The slope stability results are included in Appendix D.

Based on the results of the above analyses, in order to maintain a minimum factor of safety of 1.3 or greater, a bench should be incorporated in the design at mid-height of the embankment where local earth fill embankment is equal to and greater than 8 m high. The bench should be designed as follows:

- Extend a bench at mid-height of the embankment;
- The bench must be at least 2 m wide; and
- Provide 2 percent cross fall along the bench for positive drainage.

In summary, for the preliminary design purpose, the embankment slope may be designed at 2 horizontal to 1 vertical or flatter provided with a mid-height bench of minimum 2 m wide for the embankment more than 8.0 m in height. A bench may not be required for the embankment less than 8.0 m in height.

5.4.1.3 Embankment Construction

It is recommended that any deleterious material and soft/loose and other unsuitable soils be removed within an envelope given by an imaginary slope not steeper than 1H:1V from the toe of the proposed embankment. The exposed subgrade should be inspected, approved, and properly compacted from the surface in accordance with OPSS.MUNI 501.

Materials used for embankment construction should meet the requirements of OPSS.MUNI 212. The embankment fill should be placed on the approved and properly prepared subgrade in loose lifts not exceeding 300 mm thickness; compact to 95 percent of SPMDD in accordance with OPSS MUNI 501. The upper 1 m of the embankment, forming the pavement subgrade must be uniformly compacted to a minimum of 98 percent of SPMDD. Embankment construction should be in accordance with OPSS.MUNI 206 and OPSS.MUNI 501.

Proper erosion control measures should be implemented both during construction and permanently. Temporary erosion and sediment control must be provided in accordance with OPSS.805. Embankment slopes should be provided with permanent erosion protection in accordance with OPSS.MUNI 804. It is also imperative that the designs include provisions for preventing the flow of surface water down the face of slopes. Consideration can be given to using a mountable curb and gutter arrangement to control and divert surface water away from the top of the slope. Surface water must be directed to armoured outfalls/outlets designed to drain into roadside ditches.

5.4.2 Deep Cut Sections

The maximum cut depth measured on the profile drawings from the design road elevation to the top of slope is estimated to be about 9.5 m. The cross section at Sta. 1+900 along Alignment 5 was selected to represent the critical slope conditions for the cut section. Borehole 20 is located in the general area of above noted cut section. Based on the borehole information, the excavation will be made in sandy silt to silty sand soil of generally dense to very dense relative density.

5.4.2.1 Slope Stability

The engineering analysis of the long-term (effective stress) slope stability for this section was conducted using Slide 6.0. Based on the nearest borehole results, the following average soil properties were utilized for the soil strata in the slope stability analysis:

Stratum	Unit Weight kN/m^3	Angle of Internal Friction (degrees)	Cohesion (kPa)
Earth Fill	19.0	28	0
Sandy Silt to Silty Sand	21.0	32	0
Silt, some clay	21.0	30	5

A side slope with an inclination of 2 horizontal to 1 vertical was analyzed. A long-term factor of safety of 1.3 against potential slope slide was obtained. Therefore, as a preliminary design guide, a cut slope inclination of 2 horizontal to 1 vertical may be used for the design of the cut slope geometry. Further location specific analysis is required during the detailed design stage to provide updated recommendations.

5.4.2.2 Slope Construction

Areas of cut, including slopes should be cleared and grubbed as outlined in OPSS 201. All topsoil and any excessively wet or otherwise deleterious soil should be removed and separated/stockpiled. The underlying native soils excavated from the cut areas may be reused as engineered fill.

Proper erosion control measures should be implemented both during construction and permanently in order to minimize surface erosion of the slopes. Temporary erosion and sediment control must be provided in accordance with OPSS 805. The tableland adjacent to the cut slopes should be shaped and graded to direct surface run-off away from the slopes. Surface water must be intercepted and managed via ditches, swales or other means.

Vegetation cover on the slopes should be established as soon as practicable after grading. There are a number of proprietary materials and techniques that can be considered for the application of mulch and seed mixtures that may be considered. The suitability of the materials used should be verified by a qualified horticulturalist as well as the geotechnical engineer. It is important that the work is staged appropriately in order that the surface treatment is placed during favourable growing conditions. A construction specification for seed and cover is provided in OPSS MUNI 804.

The excavation may potentially encounter bearing silt/sand seams and lenses. Typically large volumes of water and sustained flow would not be expected however in extreme cases there may be a need for remedial work to preserve the long term stability of the slopes. The requirements for the extent of such work can best be assessed by the geotechnical engineer during construction. The work would probably consist of the construction of a filter and shell system. The filter would consist of a suitable filter fabric placed against the slope and protected using a shell of well graded clear crushed stone. The requirements of the filter fabric and the size of the stone will depend on the conditions encountered during construction.

5.5 Earth Pressure Design Parameters

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

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

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

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

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

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

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

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

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

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

Stratum/Parameter	**Φ**	**γ**	**K_a**	**K_o**	**K_p**
Earth Fill/Weathered/Disturbed Soils	28	19.0	0.36	0.53	2.77
Undisturbed Sand and Sandy Silt to Silty Sand	32	21.0	0.31	0.47	3.25
Undisturbed Silt and Clayey Silt	30	21.0	0.33	0.50	3.00

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

5.6 Ground Water Control

Terraprobe has completed Hydrogeological Report (File No. 1-15-0700-54) for this site to provide ground water control measures and estimate ground water discharge volume (Refer to this report for detailed information).

Based on the borehole information and design information provided, it is likely that ground water seepage will be encountered in the excavation. The perched ground water seepage emanating from above the static ground water table should diminish slowly and can be controlled by continuous pumping from filtered sumps at the base of the excavation.

In general, wet cohesionless soil deposits were encountered in the boreholes at varying depths which were advanced along the proposed road alignments. For excavations extending through the wet cohesionless soils (silt/sand) and below the prevailing ground water level, it will be necessary to lower the ground water level and maintain it below the excavation base (at least 1.0 m) prior to and during the subsurface construction. A professional dewatering expert should review the subsurface information to assess the potential requirement of dewatering and establish appropriate dewatering methodology which will be responsibility of the dewatering contractor. Consideration should be given to install a skim coat of lean concrete (mud-slab) to preserve the subgrade integrity, and to provide a working platform as required based on site conditions.

6 LIMITATIONS AND RISK

6.1 Procedures

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

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

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

6.2 Changes in Site and Scope

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

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

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

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

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

Yours truly,

Terraprobe Inc.

Seth Zhang, P. Eng., M.Eng., M.Sc.
Associate

B. Singh, M.A. Sc., P. Eng.
Principal

ENCLOSURES

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FIGURES

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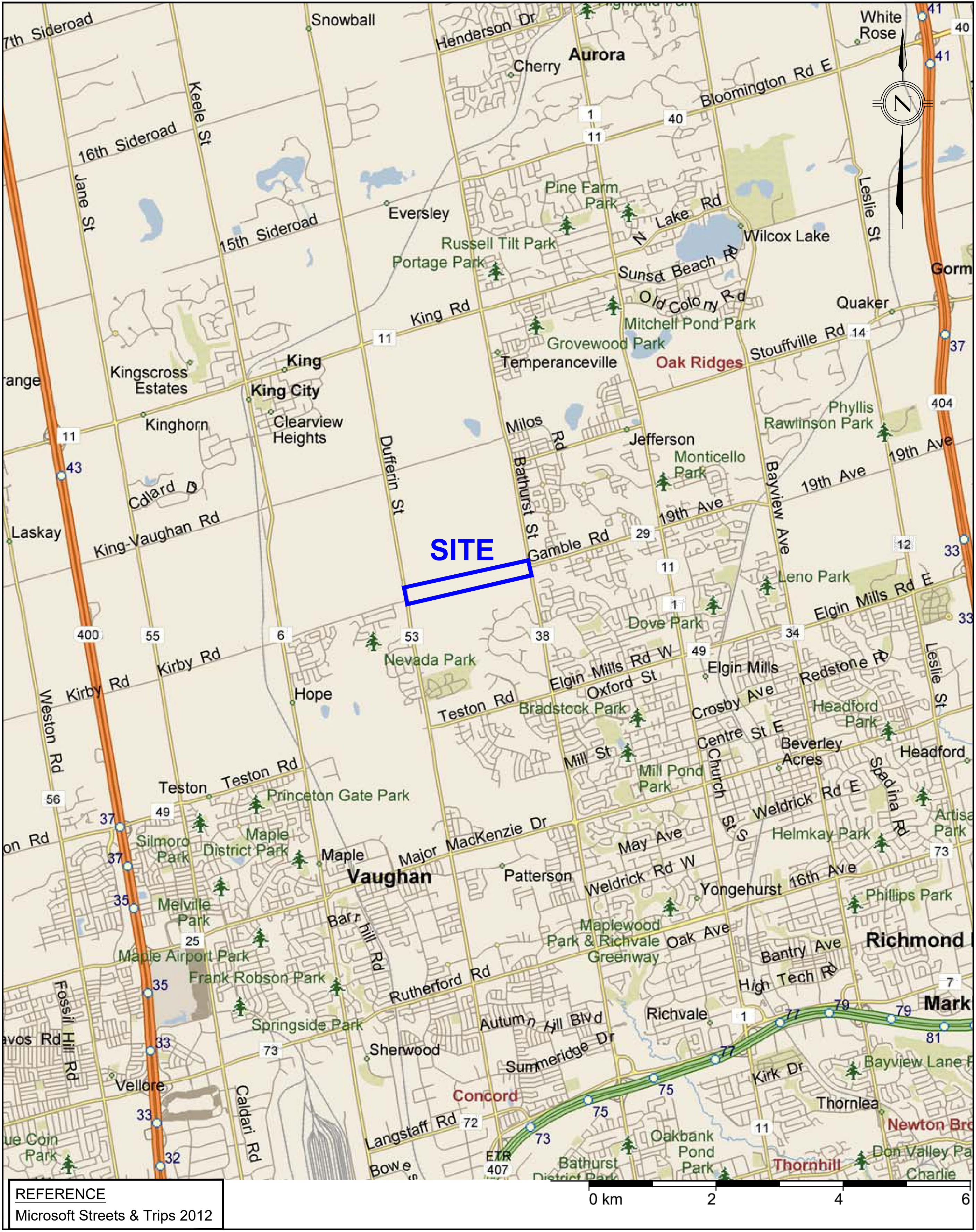

REFERENCE
Microsoft Streets & Trips 2012

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

Title:

SITE LOCATION PLAN

File No.

1-17-0700-01

FIGURE :

1

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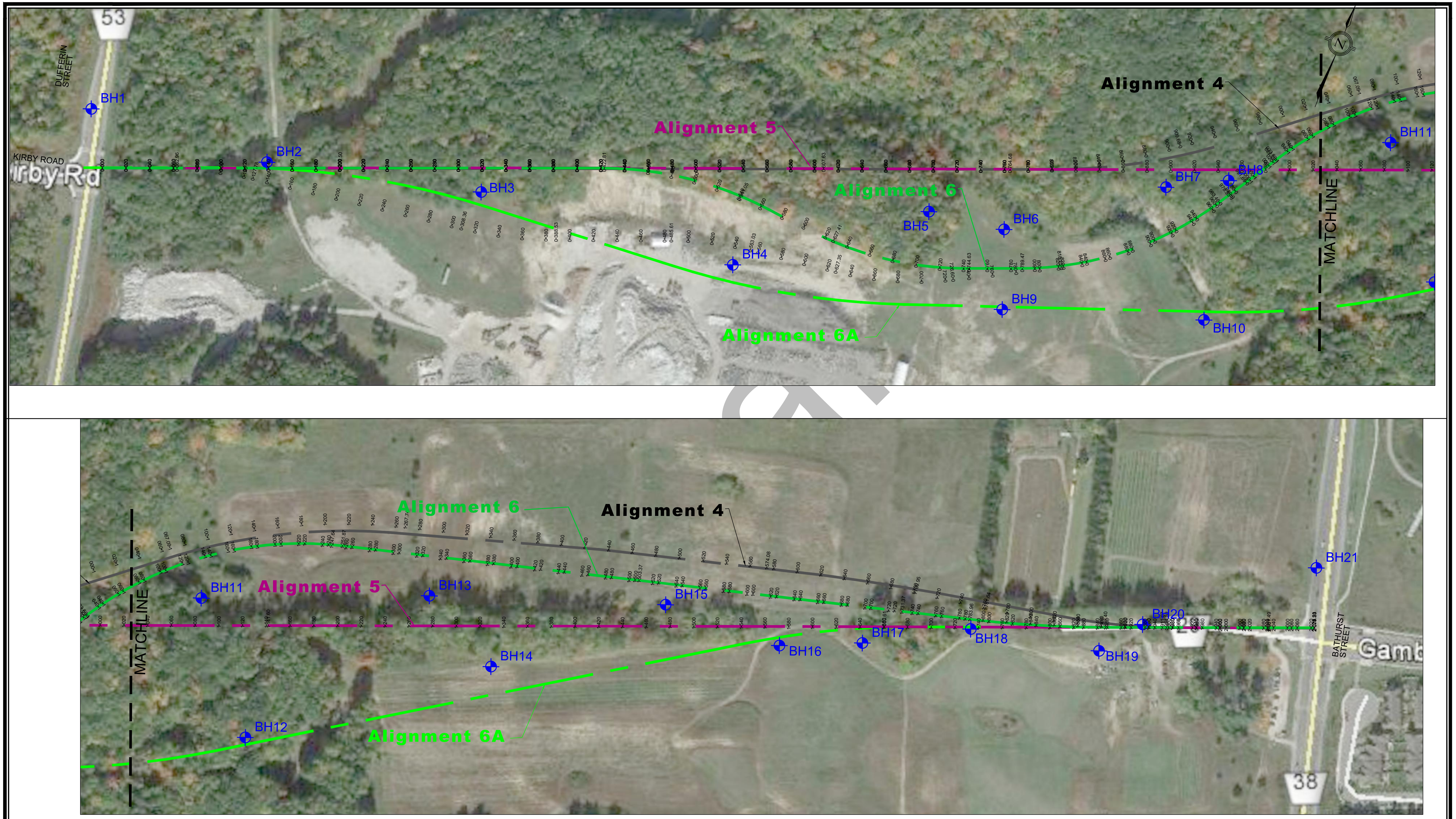

REFERENCE 1

Cad Drawings provided by Schaeffer & Associates Ltd. via email.

REFERENCE 2

Image ©2018 Google

LEGEND

⊕ Approximate Borehole Location

16 8 0 40m
SCALE 1:3000

Terraprobe

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Title:

BOREHOLE LOCATION PLAN

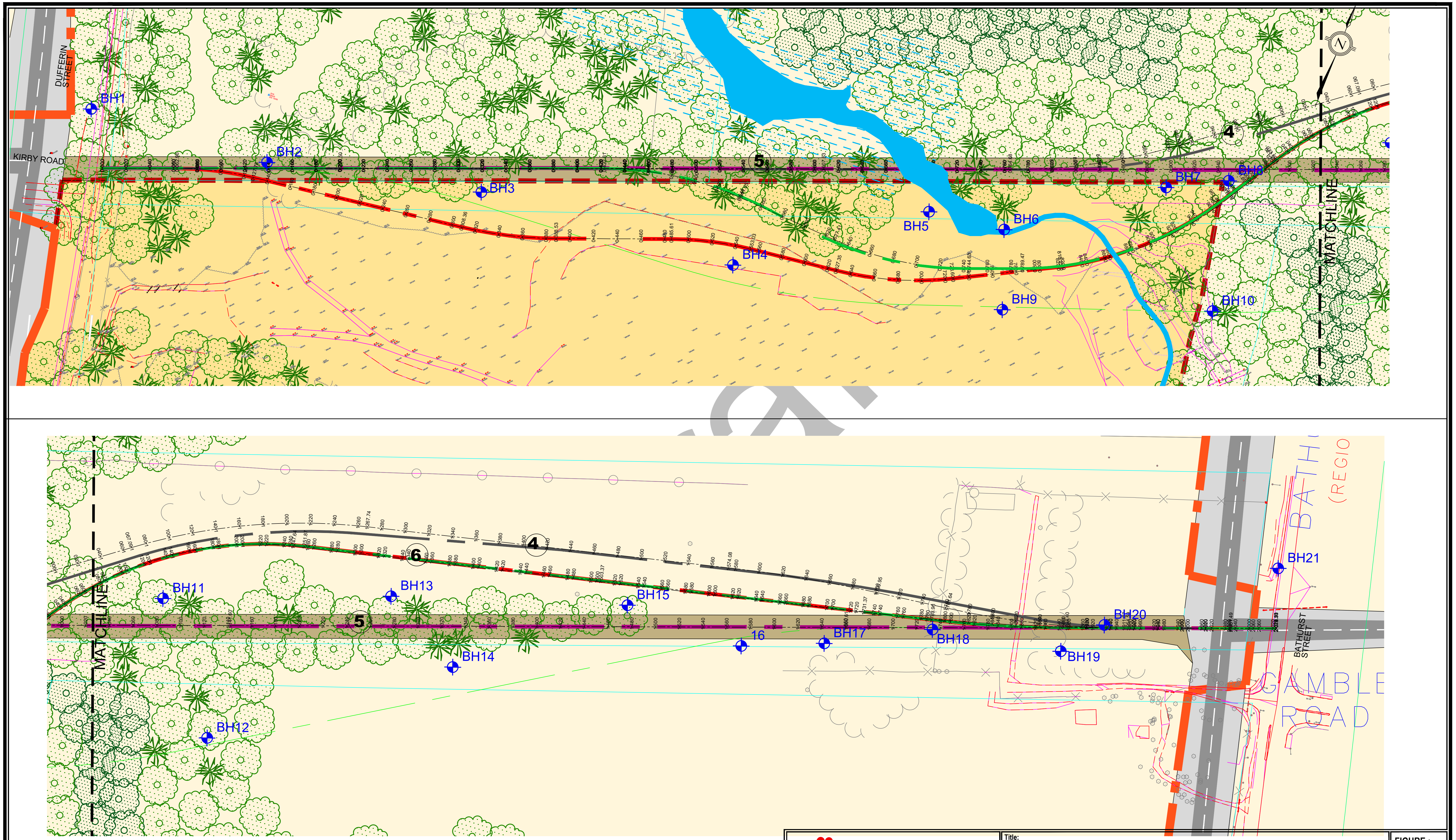
File No.

1-15-0700

FIGURE :

2A

T:\1-Project Files\2015\1-15-0700 - Kirby Road Extension, Vaughan\01-GEO Invest\A. Dwgs, Logs\AutoCAD\DRAWINGS\1-15-0700 FIGURE 2A Google Image-- (2018-01-30).dwg,
Kamal



LEGEND

⌖ Approximate Borehole Location

REFERENCE

Cad Drawings provided by Schaeffer & Associates Ltd. via email.

16 8 0 40m
SCALE 1:3000

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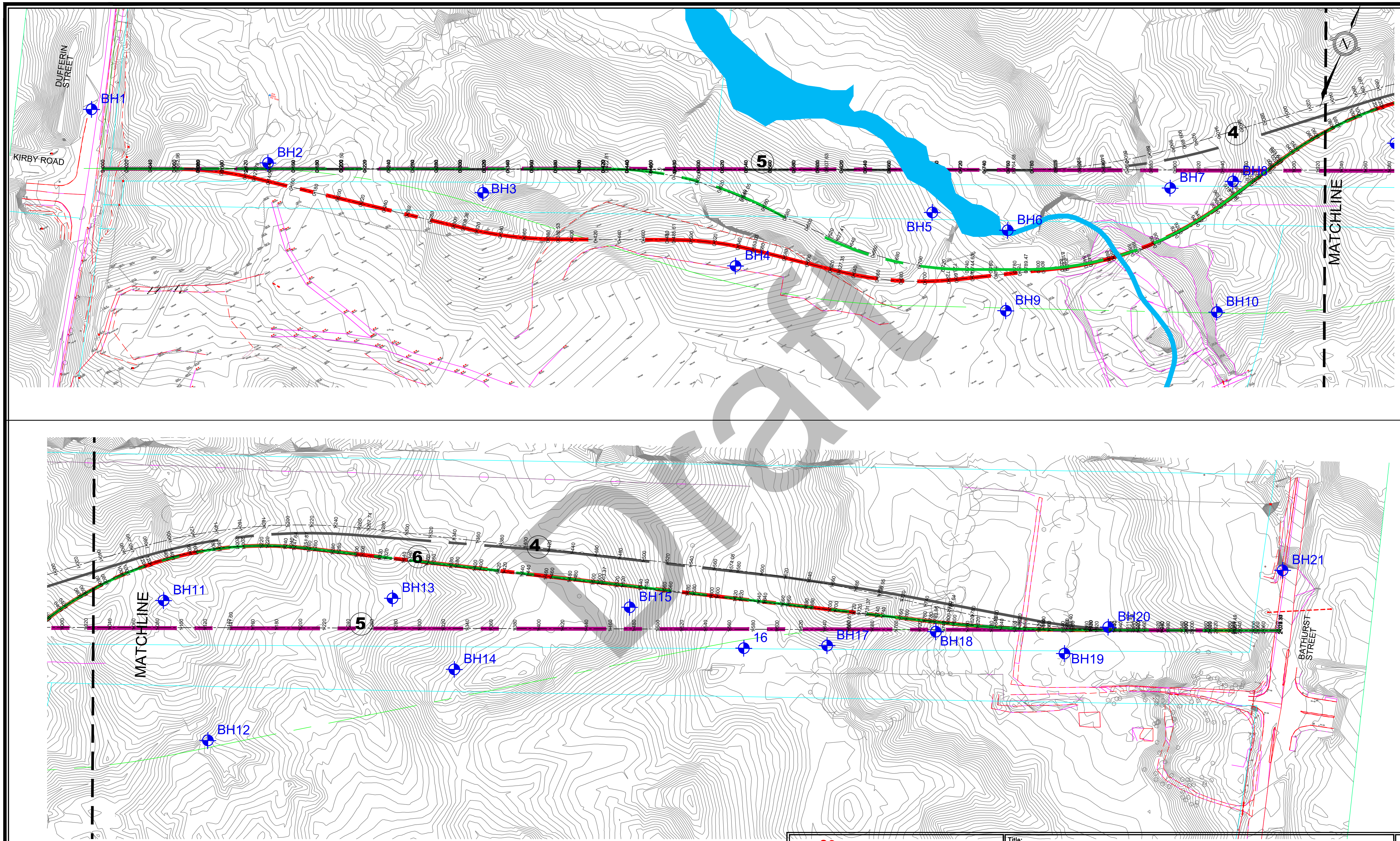
Title:
BOREHOLE LOCATION PLAN

File No.
1-15-0700

FIGURE :
2B

T:\1-Project Files\2015\1-15-0700 - Kirby Road Extension, Vaughan\01-GEO Invest\A. Dwgs. Logs\AutoCAD\DRAWINGS\1-15-0700 FIGURES - updated (2018-01-30).dwg
Kamal



LEGEND

⊕ Approximate Borehole Location

REFERENCE

Cad Drawings provided by Schaeffer & Associates Ltd. via email.

16 8 0 40m
SCALE 1:3000

Terraprobe
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Title:
BOREHOLE LOCATION PLAN

File No.
1-15-0700

FIGURE :
2C

T:\1-Project Files\2015\1-15-0700 - Kirby Road Extension, Vaughan\01-GEO Invest\A. Dwgs, Logs\AutoCAD\DRAWINGS\1-15-0700 FIGURES.- updated (2018-01-30).dwg,
Kamal

APPENDIX A

TERRAPROBE INC.

Terraprobe

ABBREVIATIONS AND TERMINOLOGY

SAMPLING METHODS

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

PENETRATION RESISTANCE

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

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

COHESIONLESS SOILS

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

COHESIVE SOILS

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

COMPOSITION

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

TESTS AND SYMBOLS

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

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

FIELD MOISTURE DESCRIPTIONS

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

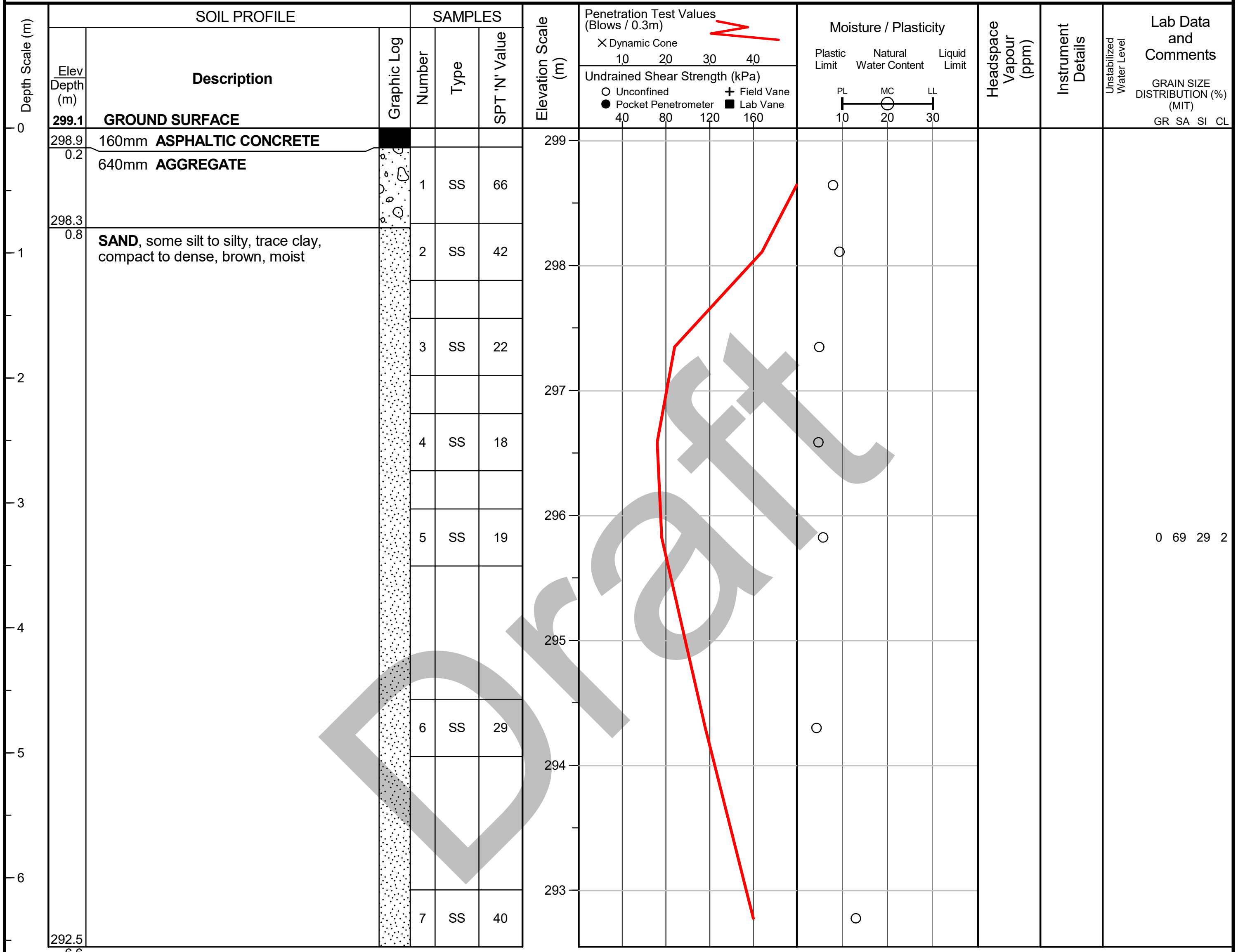
Terraprobe

LOG OF BOREHOLE 1

Project No. : 1-15-0700-01
Client : Rizmi Holdings Limited
Originated by : TG
Date started : December 7, 2017
Project : Kirby Road Extension
Compiled by : NNA
Sheet No. : 1 of 1
Location : Vaughan, Ontario
Checked by : SZ

Position : E: 620760, N: 4861627 (UTM 17T)
Elevation Datum : Geodetic
Rig type : CME 55, truck-mounted
Drilling Method : Solid stem augers

Elev Depth (m)	Description	Sample Number	Type	SPT 'N' Value	Lab Data and Comments: GRAIN SIZE DISTRIBUTION (%) (MIT) GR SA SI CL
299.1	**GROUND SURFACE**				
298.9 0.2	160mm **ASPHALTIC CONCRETE**				
	640mm **AGGREGATE**	1	SS	66	
298.3 0.8	**SAND**, some silt to silty, trace clay, compact to dense, brown, moist	2	SS	42	
		3	SS	22	
		4	SS	18	
		5	SS	19	0 69 29 2
		6	SS	29	
292.5 6.6		7	SS	40	



END OF BOREHOLE

Borehole was dry and open upon completion of drilling.

file: 1-15-0700-01_borehole_logs_coord updated 2018-01-30.gpj

LOG OF BOREHOLE 2

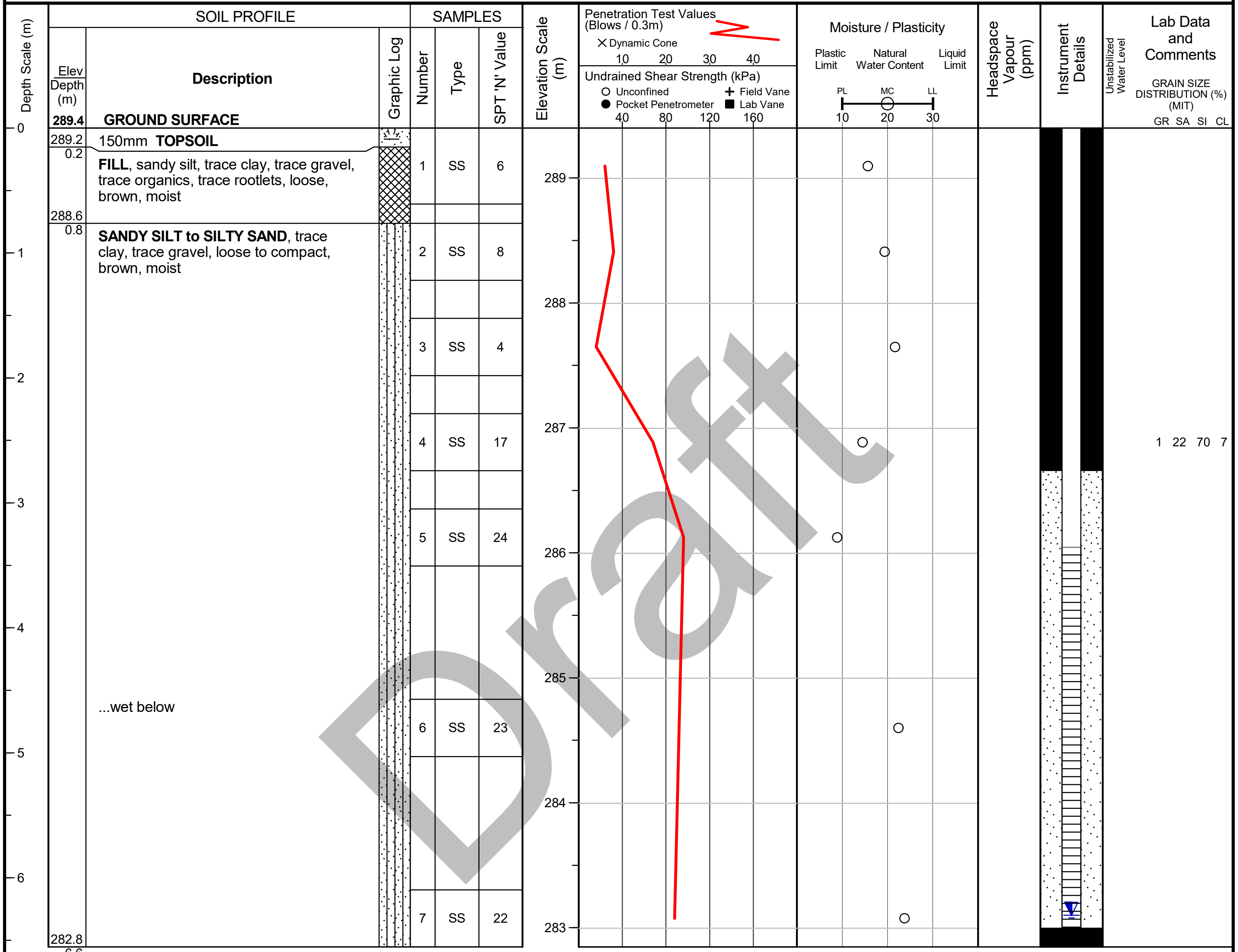
Project No. : 1-15-0700-01
Date started : October 31, 2017
Sheet No. : 1 of 1

Client : Rizmi Holdings Limited
Project : Kirby Road Extension
Location : Vaughan, Ontario

Originated by : SM
Compiled by : NNA
Checked by : SZ

Position : E: 620915, N: 4861628 (UTM 17T)
Rig type : Track-mounted
Elevation Datum : Geodetic
Drilling Method : Hollow stem augers

Elev Depth (m)	Description	Number	Type	SPT 'N' Value	Lab Data and Comments GRAIN SIZE DISTRIBUTION (%) (MIT) GR SA SI CL
289.4	**GROUND SURFACE**				
	150mm **TOPSOIL**				
289.2 0.2	**FILL**, sandy silt, trace clay, trace gravel, trace organics, trace rootlets, loose, brown, moist	1	SS	6	
288.6 0.8	**SANDY SILT to SILTY SAND**, trace clay, trace gravel, loose to compact, brown, moist	2	SS	8	
		3	SS	4	
		4	SS	17	1 22 70 7
		5	SS	24	
	...wet below	6	SS	23	
		7	SS	22	
282.8 6.6	**END OF BOREHOLE**				



Borehole was dry and encased during drilling.

50 mm dia. monitoring well installed.

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Jan 8, 2018	6.3	283.1
Jan 25, 2018	dry	n/a

Terraprobe

LOG OF BOREHOLE 3

Project No. : 1-15-0700-01	Client : Rizmi Holdings Limited	Originated by : SM
Date started : October 31, 2017	Project : Kirby Road Extension	Compiled by : NNA
Sheet No. : 1 of 2	Location : Vaughan, Ontario	Checked by : SZ

Position : E: 621095, N: 4861658 (UTM 17T)

Elevation Datum : Geodetic

Rig type : Track-mounted

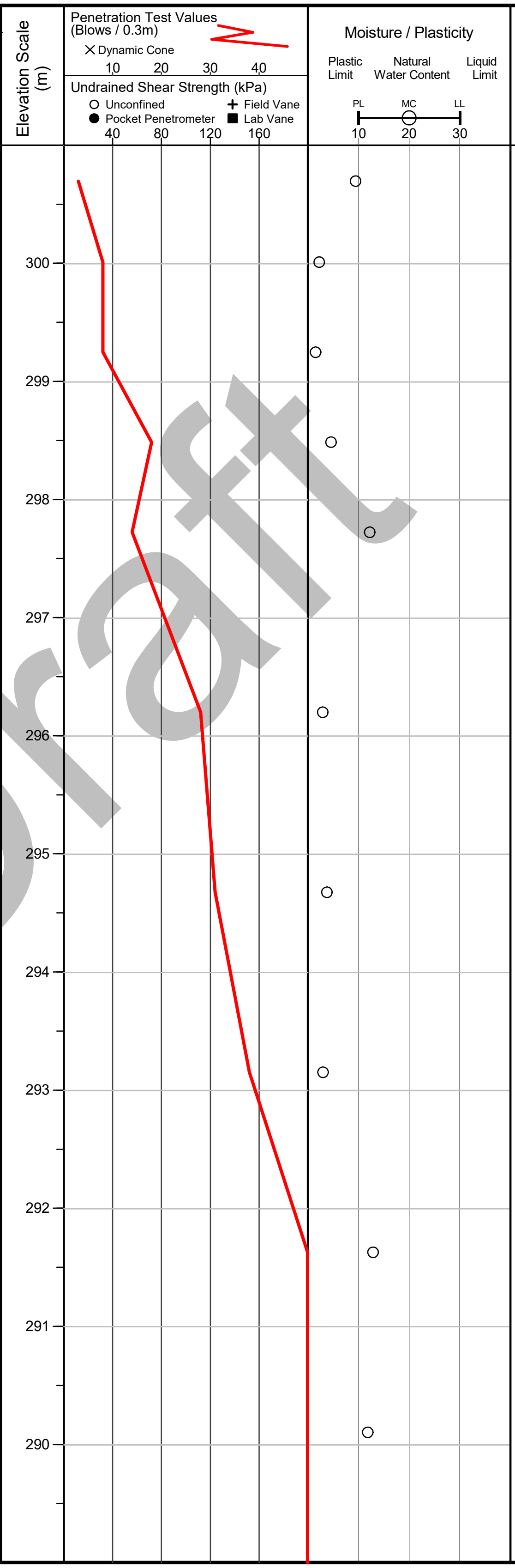
Drilling Method : Hollow stem augers

SOIL PROFILE

Elev Depth (m)	Description
301.0	**GROUND SURFACE**
300.7 0.3	300mm **TOPSOIL**
300.2 0.8	**FILL**, sandy silt, trace clay, trace gravel, trace organics, very loose, brown, moist
	SAND, some silt to silty, trace clay, loose to compact, brown, damp to moist
	...trace silt, dense to very dense below

SAMPLES

Number	Type	SPT 'N' Value	Depth (m)	Elevation (m)
1	SS	3	0.3	300.7
2	SS	8	1	300
3	SS	8	1.75	
4	SS	18	2.5	
5	SS	14	3.25	
6	SS	28	4.75	
7	SS	31	6.25	
8	SS	38	7.75	
9	SS	55	9.25	
10	SS	78	10.75	



Headspace Vapour (ppm)

Instrument Details

Unstabilized Water Level

Lab Data and Comments

GRAIN SIZE DISTRIBUTION (%) (MIT)

GR	SA	SI	CL
0	94	4	2

October 31, 2017

November 1, 2017

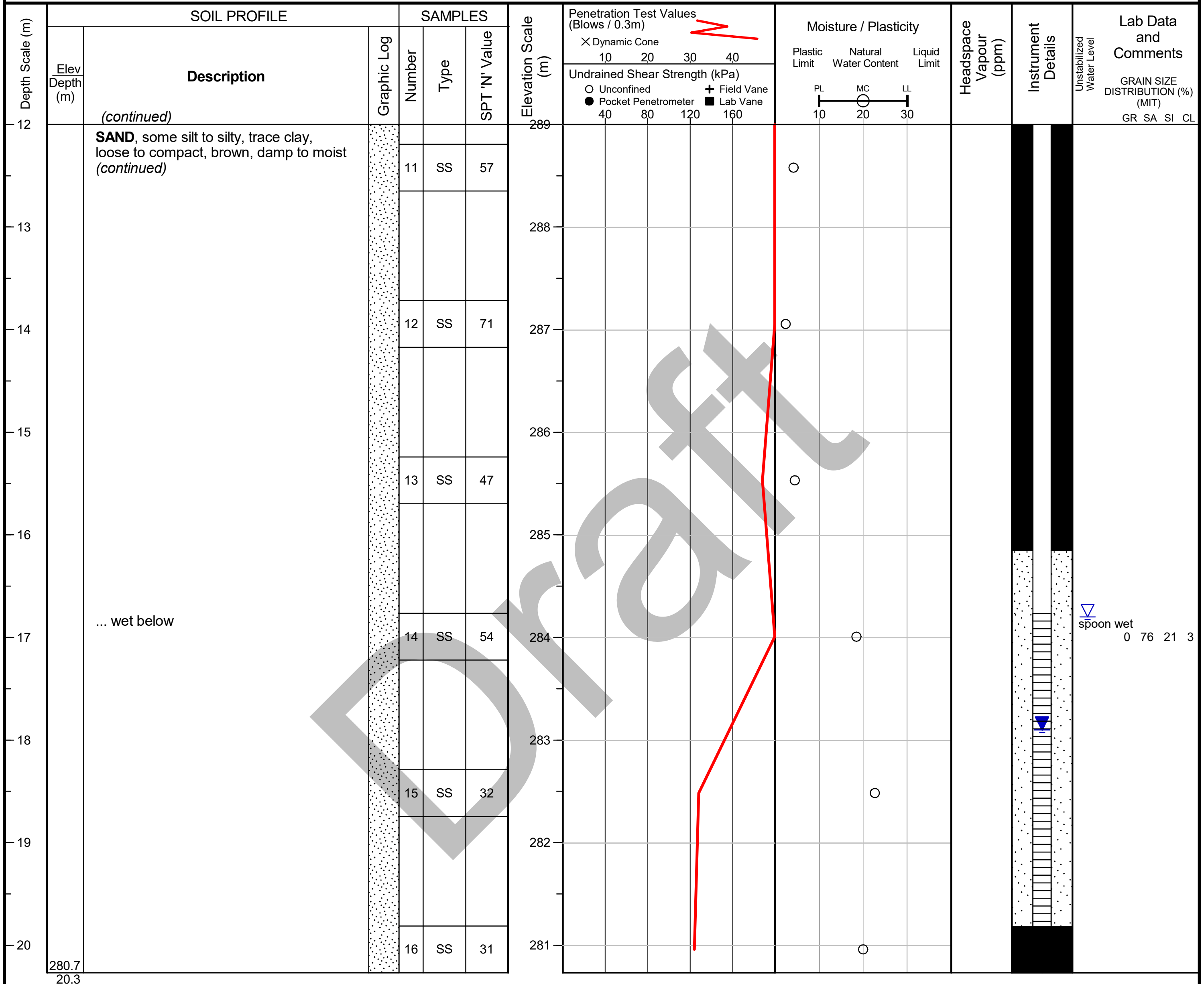
file: 1-15-0700-01_borehole_logs_coord updated 2018-01-30.gpj

(continued next page)

LOG OF BOREHOLE 3

Project No. : 1-15-0700-01
Client : Rizmi Holdings Limited
Originated by : SM
Date started : October 31, 2017
Project : Kirby Road Extension
Compiled by : NNA
Sheet No. : 2 of 2
Location : Vaughan, Ontario
Checked by : SZ

Position : E: 621095, N: 4861658 (UTM 17T)
Elevation Datum : Geodetic
Rig type : Track-mounted
Drilling Method : Hollow stem augers



(continued)

SAND, some silt to silty, trace clay, loose to compact, brown, damp to moist *(continued)*

... wet below

280.7
20.3

Number	Type	SPT 'N' Value	GR	SA	SI	CL
11	SS	57				
12	SS	71				
13	SS	47				
14	SS	54	0	76	21	3
15	SS	32				
16	SS	31				

END OF BOREHOLE

Unstabilized water level measured at 16.8 m below ground surface; borehole was encased during drilling.

50 mm dia. monitoring well installed.

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Jan 8, 2018	17.9	283.1
Jan 25, 2018	17.9	283.1

Terraprobe

LOG OF BOREHOLE 4

Project No. : 1-15-0700-01
Date started : October 31, 2017
Sheet No. : 1 of 2

Client : Rizmi Holdings Limited
Project : Kirby Road Extension
Location : Vaughan, Ontario

Originated by : SM
Compiled by : NNA
Checked by : SZ

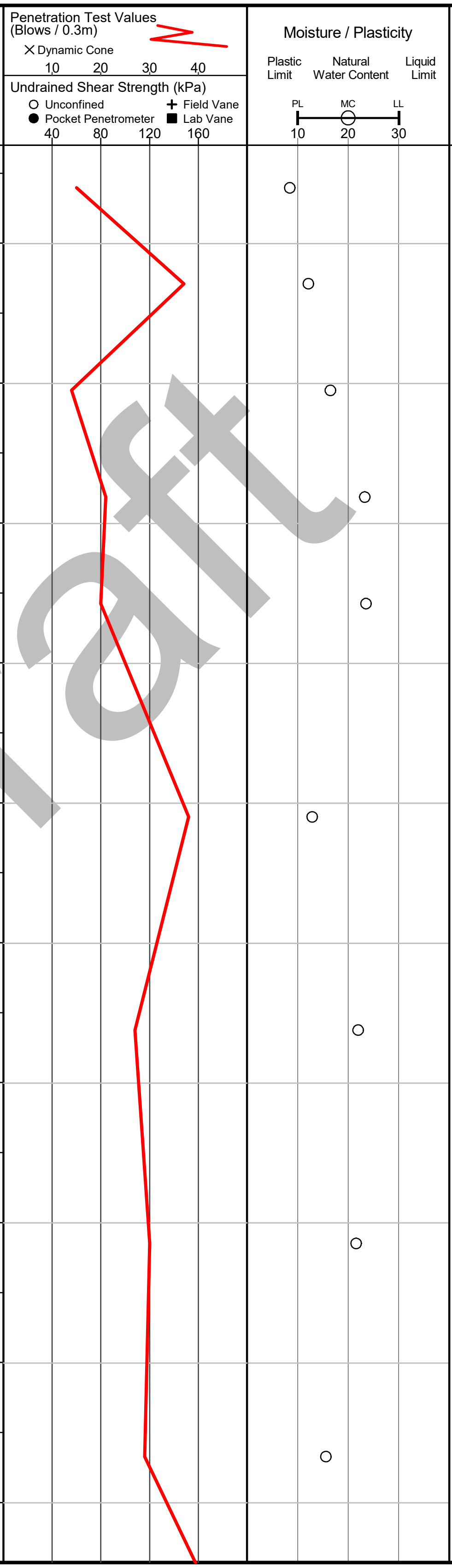
Position : E: 621315, N: 4861662 (UTM 17T)
Rig type : Track-mounted
Elevation Datum : Geodetic
Drilling Method : Hollow stem augers

SOIL PROFILE

Elev Depth (m)	Description
284.7	**GROUND SURFACE**
	FILL, sand, trace gravel, trace silt, construction debris, compact, brown, moist
283.9 0.8	**SAND**, trace to some silt, trace gravel, compact to dense, brown, moist ...wet below
280.1 4.6	**SANDY SILT to SILTY SAND**, trace clay, compact to dense, brown, wet ...grey below

SAMPLES

Number	Type	SPT 'N' Value
1	SS	15
2	SS	37
3	SS	14
4	SS	21
5	SS	20
6	SS	38
7	SS	27
8	SS	30
9	SS	29



Depth Scale (m): 0 1 2 3 4 5 6 7 8 9 10

Elevation Scale (m): 284 283 282 281 280 279 278 277 276 275

Headspace Vapour (ppm)

Instrument Details

Unstabilized Water Level: ∇

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

spoon wet

(continued next page)

Terraprobe

LOG OF BOREHOLE 4

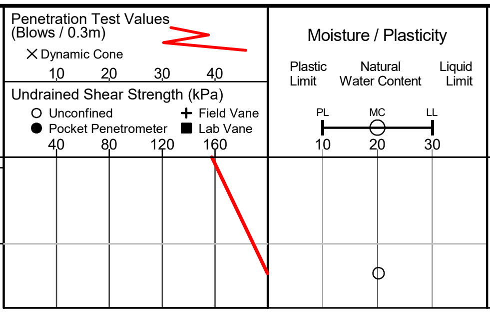
Project No. : 1-15-0700-01
Date started : October 31, 2017
Sheet No. : 2 of 2

Client : Rizmi Holdings Limited
Project : Kirby Road Extension
Location : Vaughan, Ontario

Originated by : SM
Compiled by : NNA
Checked by : SZ

Position : E: 621315, N: 4861662 (UTM 17T)
Rig type : Track-mounted
Elevation Datum : Geodetic
Drilling Method : Hollow stem augers

Depth Scale (m)	Elev Depth (m)	SOIL PROFILE Description	Graphic Log	SAMPLES Number	Type	SPT 'N' Value	Elevation Scale (m)	Headspace Vapour (ppm)	Instrument Details	Unstabilized Water Level	Lab Data and Comments GRAIN SIZE DISTRIBUTION (%) (MIT) GR SA SI CL
		(continued)									
		SANDY SILT to SILTY SAND, trace clay, compact to dense, brown, wet *(continued)*									
		...very dense					274				
11	273.6 11.1			10	SS	53					



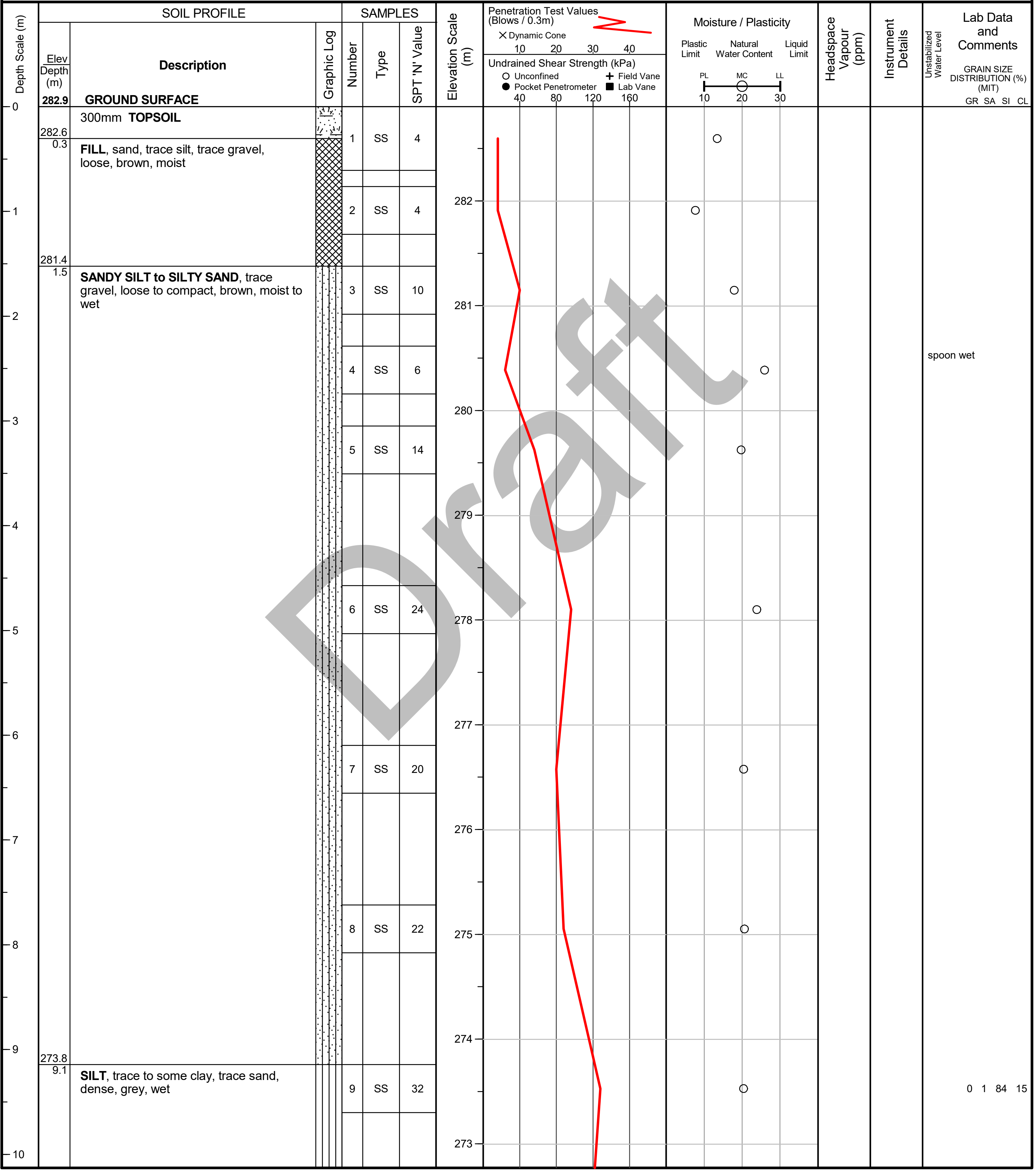
END OF BOREHOLE

Unstabilized water level measured at 2.3 m below ground surface; borehole was encased during drilling.

LOG OF BOREHOLE 5

Project No. : 1-15-0700-01	Client : Rizmi Holdings Limited	Originated by : SM
Date started : November 1, 2017	Project : Kirby Road Extension	Compiled by : NNA
Sheet No. : 1 of 2	Location : Vaughan, Ontario	Checked by : SZ

Position : E: 621460, N: 4861754 (UTM 17T)
Elevation Datum : Geodetic
Rig type : Track-mounted
Drilling Method : Hollow stem augers



Elev Depth (m)	Description
282.9	**GROUND SURFACE**
	300mm **TOPSOIL**
282.6 0.3	**FILL**, sand, trace silt, trace gravel, loose, brown, moist
281.4 1.5	**SANDY SILT to SILTY SAND**, trace gravel, loose to compact, brown, moist to wet
273.8 9.1	**SILT**, trace to some clay, trace sand, dense, grey, wet

Number	Type	SPT 'N' Value	Lab Data and Comments GRAIN SIZE DISTRIBUTION (%) (MIT) GR SA SI CL
1	SS	4	
2	SS	4	
3	SS	10	
4	SS	6	spoon wet
5	SS	14	
6	SS	24	
7	SS	20	
8	SS	22	
9	SS	32	0 1 84 15

(continued next page)

Terraprobe

LOG OF BOREHOLE 5

Project No. : 1-15-0700-01
Client : Rizmi Holdings Limited
Originated by : SM

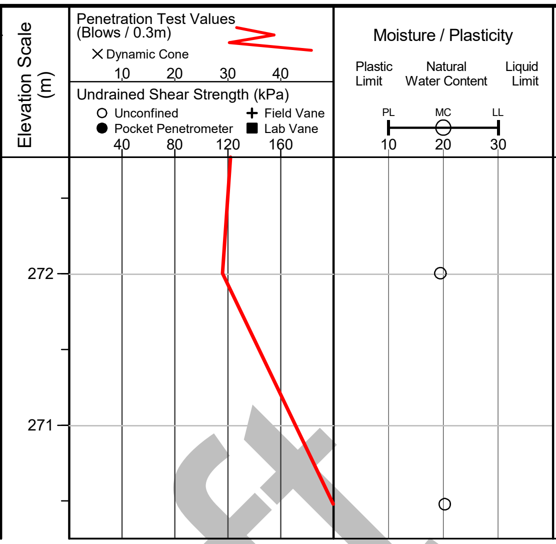
Date started : November 1, 2017
Project : Kirby Road Extension
Compiled by : NNA

Sheet No. : 2 of 2
Location : Vaughan, Ontario
Checked by : SZ

Position : E: 621460, N: 4861754 (UTM 17T)
Elevation Datum : Geodetic

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

Depth Scale (m)	Elev Depth (m)	SOIL PROFILE Description	Graphic Log	SAMPLES Number	Type	SPT 'N' Value
		(continued)				
		SILT, trace to some clay, trace sand, dense, grey, wet *(continued)*				
11	272.2 10.7	**CLAYEY SILT**, trace sand, trace gravel, very stiff to hard, grey, wet to wet		10	SS	29
12				11	SS	59
	270.3 12.6					



Headspace Vapour (ppm)

Instrument Details

Unstabilized Water Level

Lab Data and Comments

GRAIN SIZE DISTRIBUTION (%) (MIT)

GR SA SI CL

END OF BOREHOLE

Drilling mud was used during drilling. The borehole was encased during drilling.

Terraprobe

LOG OF BOREHOLE 6

Project No. : 1-15-0700-01
Date started : November 2, 2017
Sheet No. : 1 of 1

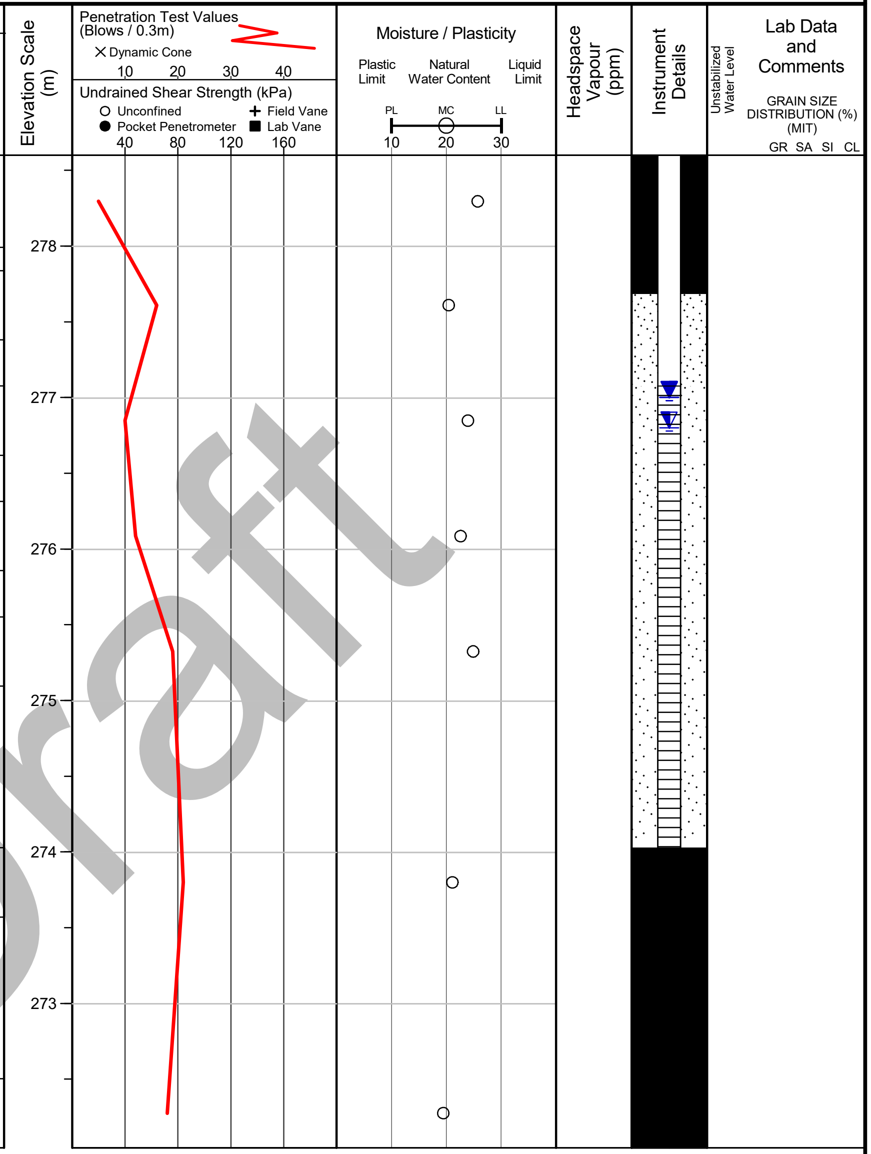
Client : Rizmi Holdings Limited
Project : Kirby Road Extension
Location : Vaughan, Ontario

Originated by : SM
Compiled by : NNA
Checked by : SZ

Position : E: 621525, N: 4861759 (UTM 17T)
Rig type : Track-mounted

Elevation Datum : Geodetic
Drilling Method : Hollow stem augers

Elev Depth (m)	SOIL PROFILE Description	SAMPLES Number	Type	SPT 'N' Value
278.6	**GROUND SURFACE**			
278.4 0.2	150mm **TOPSOIL**			
	FILL, silty sand, trace organics, loose, brown, moist	1	SS	5
277.8 0.8	**SAND**, trace to some silt, compact, brown, wet	2	SS	16
		3	SS	10
		4	SS	12
		5	SS	19
274.0 4.6	**SILTY SAND**, trace clay, compact, brown, wet	6	SS	21
272.5 6.1	**SILT**, trace sand, trace clay, compact, grey, wet	7	SS	18
272.0 6.6				



END OF BOREHOLE

Drilling mud was used during drilling. The borehole was encased during drilling.

50 mm dia. monitoring well installed.

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Jan 8, 2018	1.8	276.8
Jan 25, 2018	1.6	277.0

Terraprobe

LOG OF BOREHOLE 7

Project No. : 1-15-0700-01
Date started : November 10, 2017
Sheet No. : 1 of 2

Client : Rizmi Holdings Limited
Project : Kirby Road Extension
Location : Vaughan, Ontario

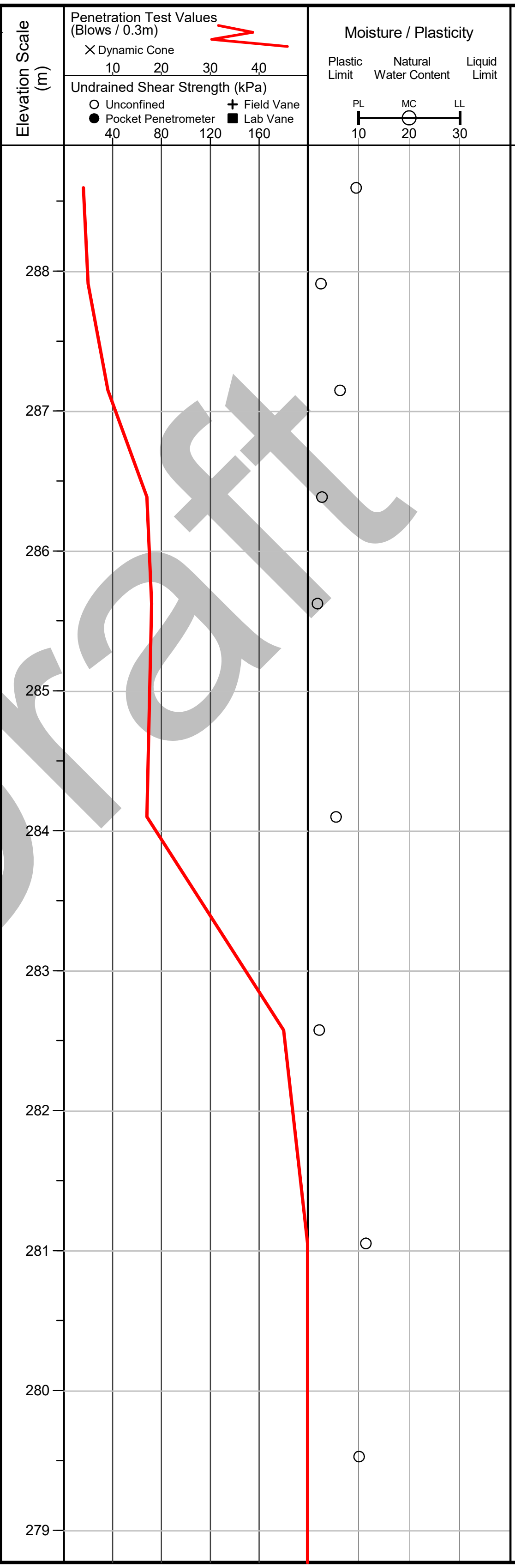
Originated by : SM
Compiled by : NNA
Checked by : SZ

Position : E: 621644, N: 4861833 (UTM 17T)
Rig type : Track-mounted

Elevation Datum : Geodetic
Drilling Method : Solid stem augers

Depth Scale (m)
0 1 2 3 4 5 6 7 8 9 10

SOIL PROFILE		SAMPLES		
Elev Depth (m)	Description	Number	Type	SPT 'N' Value
288.9	**GROUND SURFACE**			
	250mm **TOPSOIL**			
288.6 0.3	**FILL**, sand, some silt, very loose, brown, moist	1	SS	4
288.1 0.8	**SAND**, trace to some silt, trace gravel, loose to compact, brown, damp to moist	2	SS	5
		3	SS	9
		4	SS	17
	...trace rootlets	5	SS	18
		6	SS	17
	...dense to very dense below	7	SS	45
	...occasional silt partings	8	SS	56
		9	SS	86



Headspace Vapour (ppm)

Instrument Details

Unstabilized Water Level

Lab Data and Comments

GRAIN SIZE DISTRIBUTION (%) (MIT)

GR SA SI CL

(continued next page)

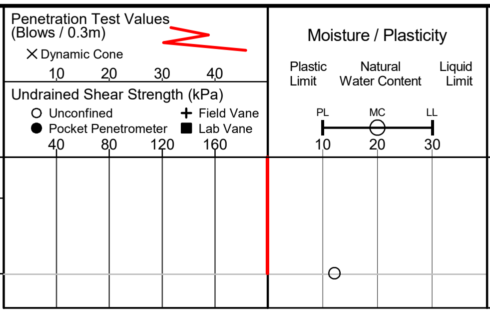
Terraprobe

LOG OF BOREHOLE 7

Project No. : 1-15-0700-01	Client : Rizmi Holdings Limited	Originated by : SM
Date started : November 10, 2017	Project : Kirby Road Extension	Compiled by : NNA
Sheet No. : 2 of 2	Location : Vaughan, Ontario	Checked by : SZ

Position : E: 621644, N: 4861833 (UTM 17T)
Elevation Datum : Geodetic
Rig type : Track-mounted
Drilling Method : Solid stem augers

Depth Scale (m)	SOIL PROFILE Elev Depth (m)	Description (continued)	Graphic Log	SAMPLES Number	Type	SPT 'N' Value	Elevation Scale (m)	Headspace Vapour (ppm)	Instrument Details	Unstabilized Water Level	Lab Data and Comments GRAIN SIZE DISTRIBUTION (%) (MIT) GR SA SI CL
11	277.8 11.1	**SAND**, trace to some silt, trace gravel, loose to compact, brown, damp to moist *(continued)*		10	SS	80	278				



END OF BOREHOLE

Borehole was dry and open upon completion of drilling.

LOG OF BOREHOLE 8

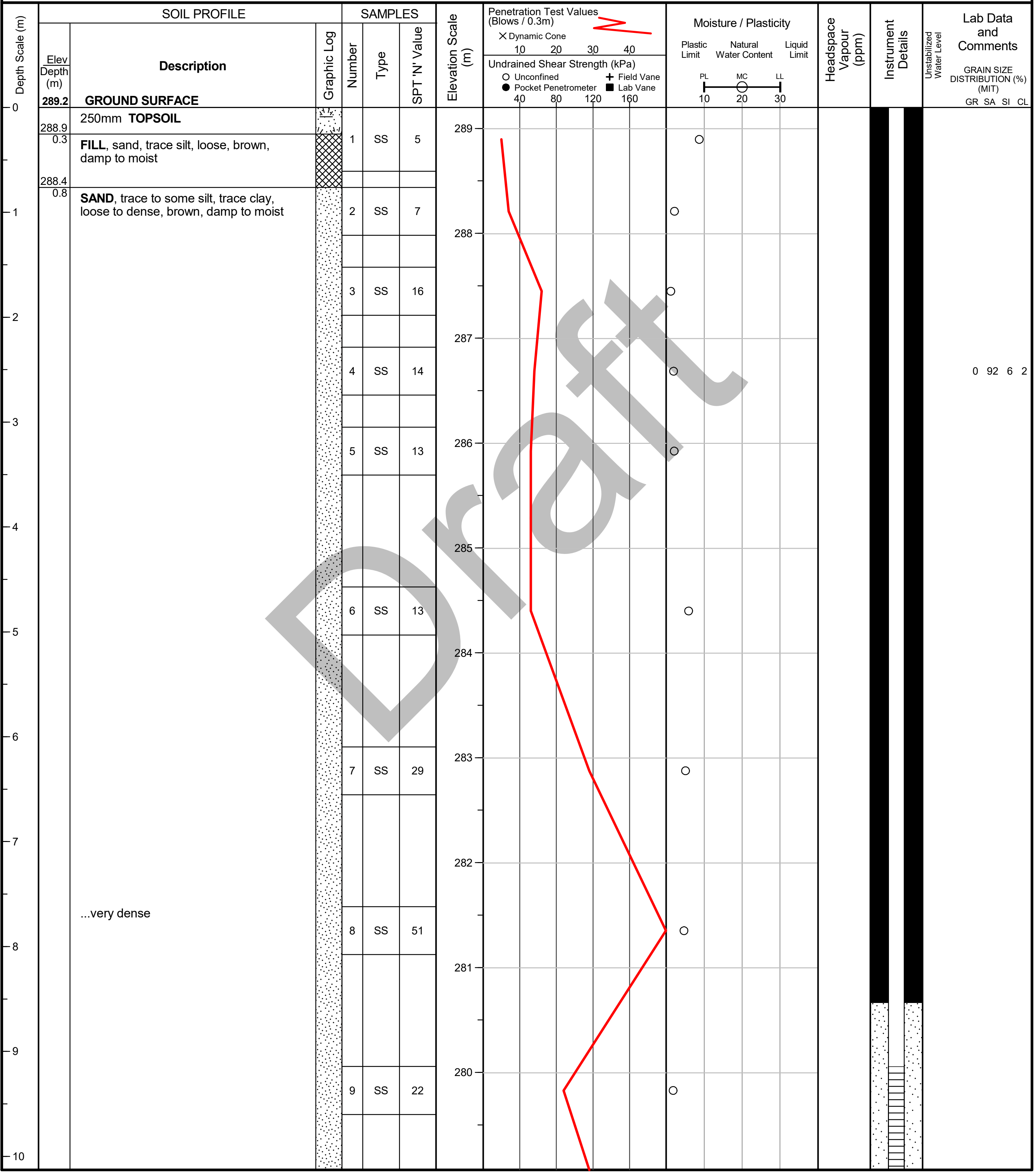
Project No. : 1-15-0700-01
Date started : November 10, 2017
Sheet No. : 1 of 2

Client : Rizmi Holdings Limited
Project : Kirby Road Extension
Location : Vaughan, Ontario

Originated by : SM
Compiled by : NNA
Checked by : SZ

Position : E: 621693, N: 4861854 (UTM 17T)
Rig type : Track-mounted

Elevation Datum : Geodetic
Drilling Method : Hollow stem augers



Elev Depth (m)	Description
289.2	**GROUND SURFACE**
	250mm **TOPSOIL**
288.9 0.3	**FILL**, sand, trace silt, loose, brown, damp to moist
288.4 0.8	**SAND**, trace to some silt, trace clay, loose to dense, brown, damp to moist
	...very dense

Number	Type	SPT 'N' Value	Lab Data and Comments (GR SA SI CL)
1	SS	5	
2	SS	7	
3	SS	16	
4	SS	14	0 92 6 2
5	SS	13	
6	SS	13	
7	SS	29	
8	SS	51	
9	SS	22	

(continued next page)

Terraprobe

LOG OF BOREHOLE 8

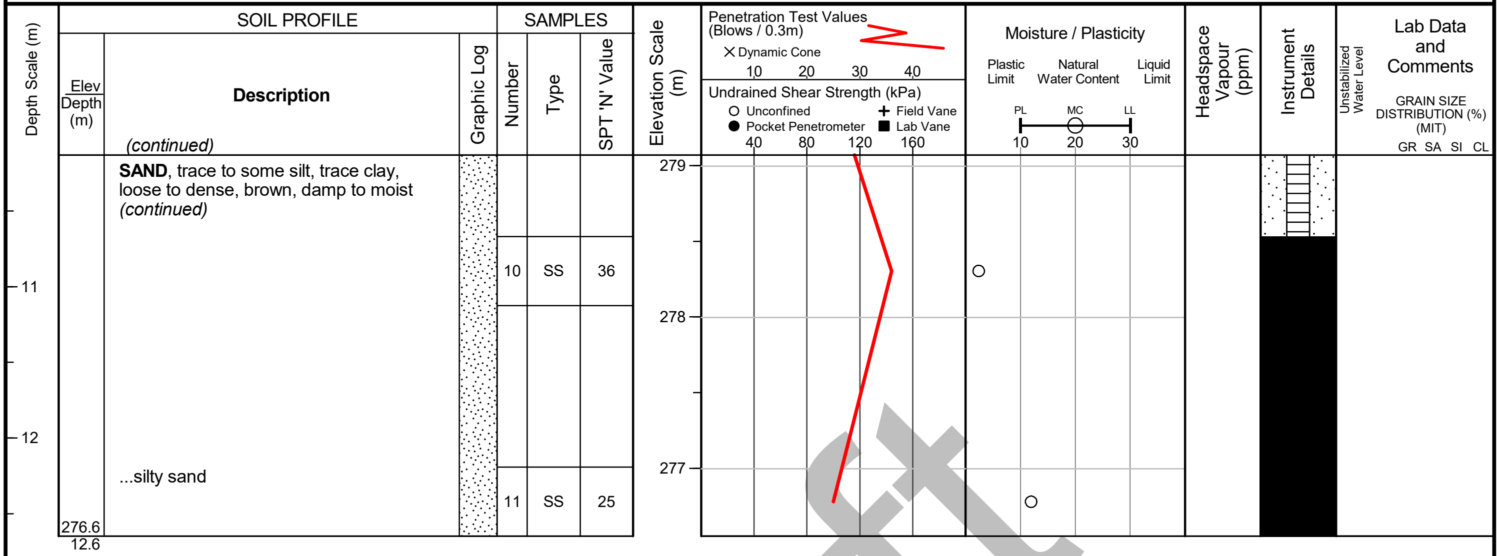
Project No. : 1-15-0700-01
Client : Rizmi Holdings Limited
Originated by : SM

Date started : November 10, 2017
Project : Kirby Road Extension
Compiled by : NNA

Sheet No. : 2 of 2
Location : Vaughan, Ontario
Checked by : SZ

Position : E: 621693, N: 4861854 (UTM 17T)
Elevation Datum : Geodetic

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



SAND, trace to some silt, trace clay, loose to dense, brown, damp to moist *(continued)*

...silty sand

Number	Type	SPT 'N' Value
10	SS	36
11	SS	25

276.6
12.6

END OF BOREHOLE

Borehole was dry and encased during drilling.

50 mm dia. monitoring well installed.

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Jan 25, 2018	dry	n/a

Terraprobe

LOG OF BOREHOLE 9

Project No. : 1-15-0700-01
Date started : November 2, 2017
Sheet No. : 1 of 1

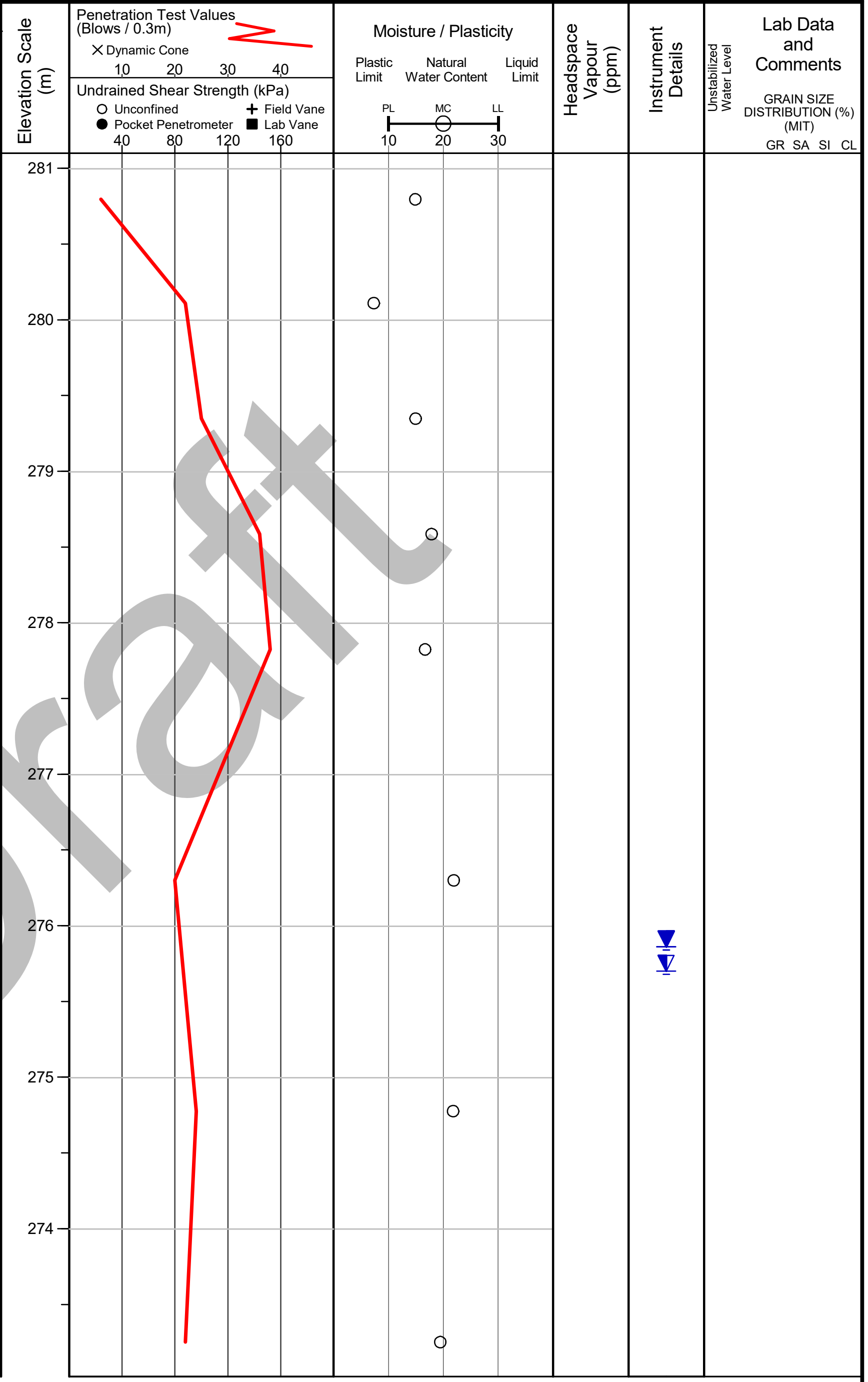
Client : Rizmi Holdings Limited
Project : Kirby Road Extension
Location : Vaughan, Ontario

Originated by : SM
Compiled by : NNA
Checked by : SZ

Position : E: 621543, N: 4861694 (UTM 17T)
Rig type : Track-mounted

Elevation Datum : Geodetic
Drilling Method : Hollow stem augers

Depth Scale (m)	Elev Depth (m)	Description	Sample Number	Sample Type	SPT 'N' Value
0	281.1	**GROUND SURFACE**			
	280.9 0.2	150mm **TOPSOIL**			
		FILL, sandy silt, trace clay, trace organics, loose, brown, moist	1	SS	6
1	280.3 0.8	**SANDY SILT to SILTY SAND**, compact to dense, brown, moist	2	SS	22
2			3	SS	25
			4	SS	36
3			5	SS	38
4					
5		...wet below	6	SS	20
6			7	SS	24
7					
8	273.0 8.1	...grey	8	SS	22



END OF BOREHOLE

Drilling mud was used during drilling. The borehole was encased during drilling.

50 mm dia. monitoring well installed.

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Jan 8, 2018	5.4	275.7
Jan 25, 2018	5.2	275.9

LOG OF BOREHOLE 10

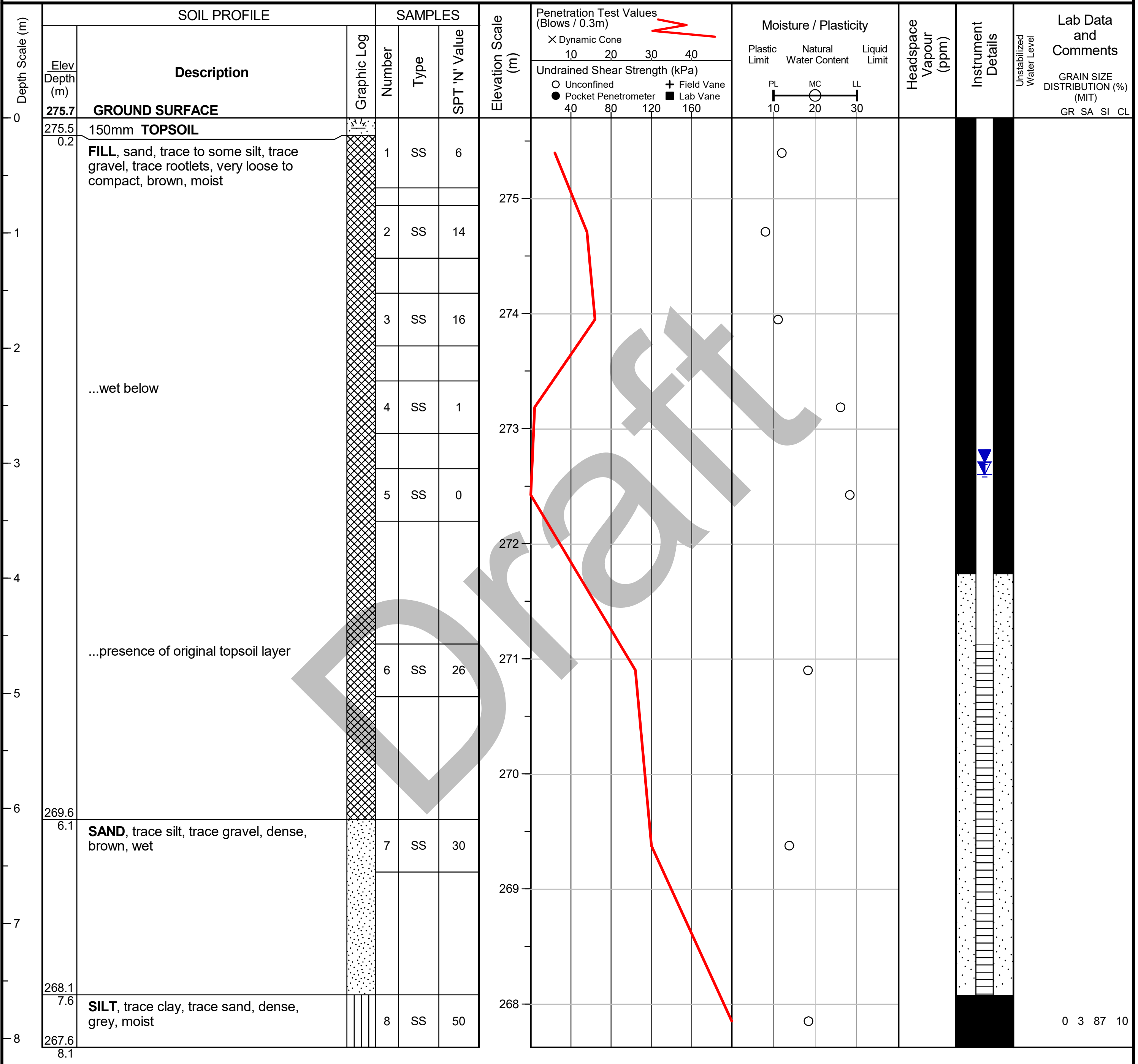
Terraprobe

Project No. : 1-15-0700-01
Date started : November 3, 2017
Sheet No. : 1 of 1

Client : Rizmi Holdings Limited
Project : Kirby Road Extension
Location : Vaughan, Ontario

Originated by : SM
Compiled by : NNA
Checked by : SZ

Position : E: 621731, N: 4861715 (UTM 17T)
Rig type : Track-mounted
Elevation Datum : Geodetic
Drilling Method : Hollow stem augers



Elev Depth (m)	Description
275.7	**GROUND SURFACE**
275.5 0.2	150mm **TOPSOIL**
	FILL, sand, trace to some silt, trace gravel, trace rootlets, very loose to compact, brown, moist ...wet below ...presence of original topsoil layer
269.6 6.1	**SAND**, trace silt, trace gravel, dense, brown, wet
268.1 7.6	**SILT**, trace clay, trace sand, dense, grey, moist
267.6 8.1	**END OF BOREHOLE**

Number	Type	SPT 'N' Value	GR	SA	SI	CL
1	SS	6				
2	SS	14				
3	SS	16				
4	SS	1				
5	SS	0				
6	SS	26				
7	SS	30				
8	SS	50	0	3	87	10

END OF BOREHOLE

Drilling mud was used during drilling. The borehole was encased during drilling.

50 mm dia. monitoring well installed.

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Jan 8, 2018	3.1	272.6
Jan 25, 2018	3.0	272.7

file: 1-15-0700-01_borehole_logs_coord updated 2018-01-30.gpj

Terraprobe

LOG OF BOREHOLE 11

Project No. : 1-15-0700-01
Date started : November 3, 2017
Sheet No. : 1 of 2

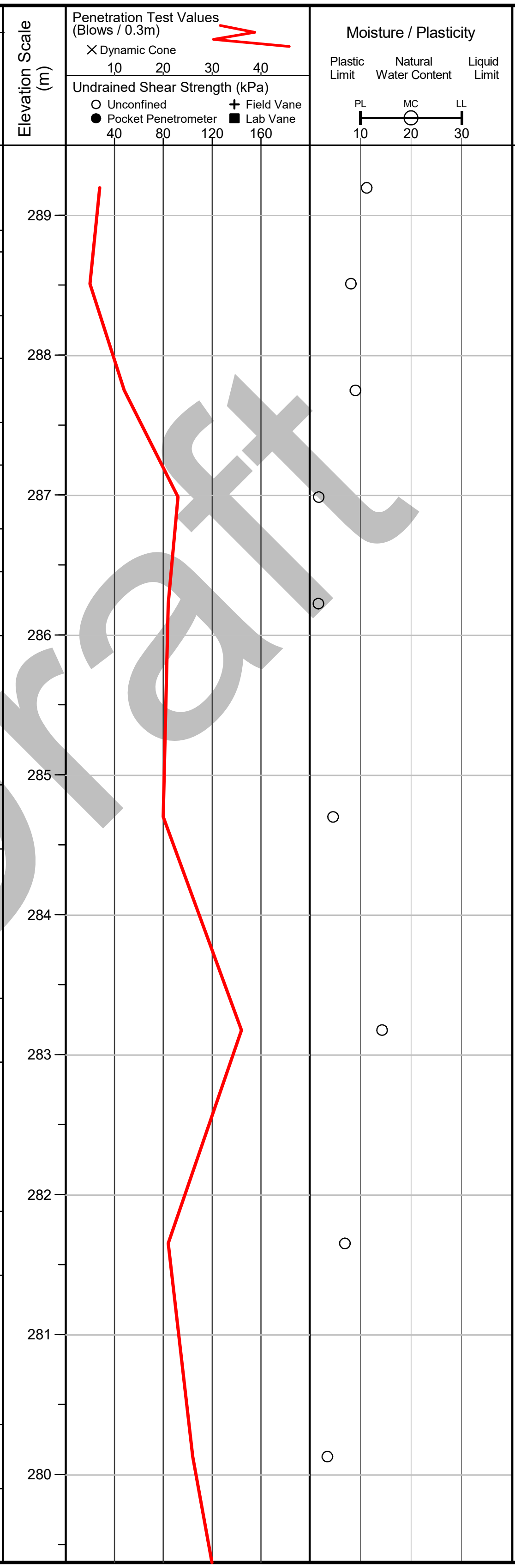
Client : Rizmi Holdings Limited
Project : Kirby Road Extension
Location : Vaughan, Ontario

Originated by : SM
Compiled by : NNA
Checked by : SZ

Position : E: 621814, N: 4861925 (UTM 17T)
Rig type : Track-mounted

Elevation Datum : Geodetic
Drilling Method : Solid stem augers

Elev Depth (m)	SOIL PROFILE Description	Graphic Log	SAMPLES Number	Type	SPT 'N' Value	Headspace Vapour (ppm)	Instrument Details	Unstabilized Water Level	Lab Data and Comments GRAIN SIZE DISTRIBUTION (%) (MIT) GR SA SI CL
289.5	**GROUND SURFACE**								
289.3 0.2	150mm **TOPSOIL**								
	FILL, sand, some silt to silty, loose, brown, moist		1	SS	7				
288.7 0.8	**SAND**, trace to some silt, loose to dense, brown, damp to moist		2	SS	5				
			3	SS	12				
			4	SS	23				
			5	SS	21				
			6	SS	20				
	...silty sand		7	SS	36				
			9	SS	21				
			10	SS	26				



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file: 1-15-0700-01_borehole_logs_coord updated 2018-01-30.gpj

Terraprobe

LOG OF BOREHOLE 11

Project No. : 1-15-0700-01
Date started : November 3, 2017
Sheet No. : 2 of 2

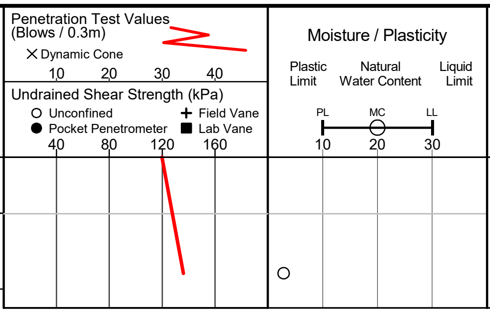
Client : Rizmi Holdings Limited
Project : Kirby Road Extension
Location : Vaughan, Ontario

Originated by : SM
Compiled by : NNA
Checked by : SZ

Position : E: 621814, N: 4861925 (UTM 17T)
Rig type : Track-mounted

Elevation Datum : Geodetic
Drilling Method : Solid stem augers

Depth Scale (m)	Elev Depth (m)	SOIL PROFILE Description *(continued)*	Graphic Log	SAMPLES Number	Type	SPT 'N' Value	Elevation Scale (m)	Unstabilized Water Level	Lab Data and Comments GRAIN SIZE DISTRIBUTION (%) (MIT) GR SA SI CL
		SAND, trace to some silt, loose to dense, brown, damp to moist *(continued)*							
							279		
11	278.4 11.1			11	SS	34			



Headspace Vapour (ppm)

Instrument Details

END OF BOREHOLE

Borehole was dry and open upon completion of drilling.

Terraprobe

LOG OF BOREHOLE 12

Project No. : 1-15-0700-01	Client : Rizmi Holdings Limited	Originated by : SM
Date started : November 3, 2017	Project : Kirby Road Extension	Compiled by : NNA
Sheet No. : 1 of 1	Location : Vaughan, Ontario	Checked by : SZ

Position : E: 621884, N: 4861824 (UTM 17T)

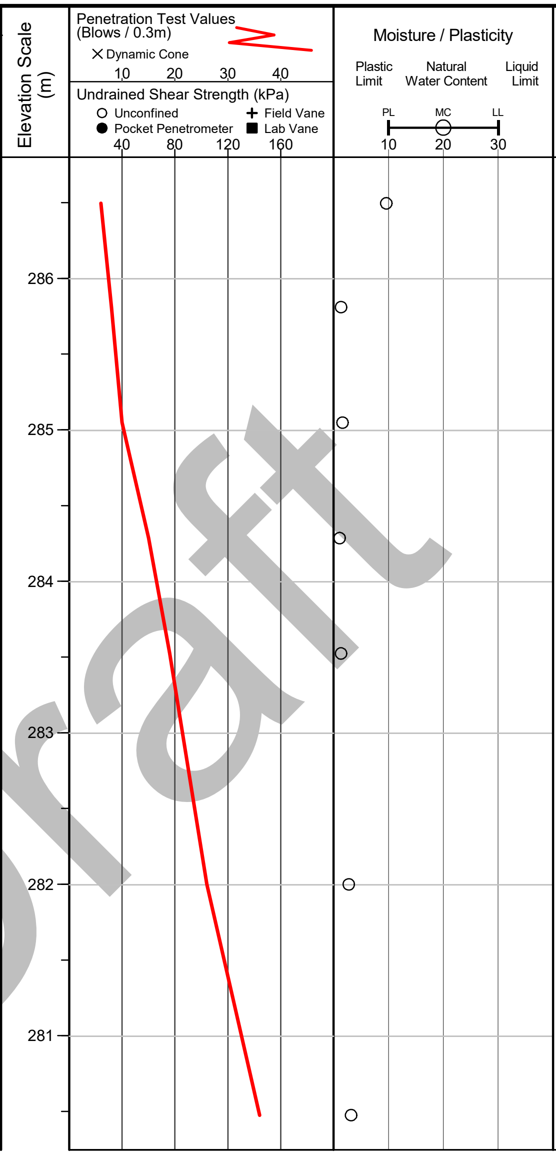
Elevation Datum : Geodetic

Rig type : Track-mounted

Drilling Method : Solid stem augers

Depth Scale (m)	Elev Depth (m)	Description	Graphic Log	Number	Type	SPT 'N' Value
0	286.8	**GROUND SURFACE**				
	286.6 0.2	150mm **TOPSOIL**				
		FILL, sand, some silt, trace rootlets, loose, brown, moist		1	SS	6
1	286.0 0.8	**SAND**, trace to some silt, loose to compact, brown, damp to moist		2	SS	8
2				3	SS	10
				4	SS	15
3				5	SS	19
5				6	SS	26
6		...dense		7	SS	36
	280.2 6.6	**END OF BOREHOLE**				

Borehole was dry and open upon completion of drilling.



Headspace Vapour (ppm)	Instrument Details	Unstabilized Water Level	Lab Data and Comments GRAIN SIZE DISTRIBUTION (%) (MIT) GR SA SI CL

file: 1-15-0700-01_borehole_logs_coord updated 2018-01-30.gpj

Terraprobe

LOG OF BOREHOLE 13

Project No. : 1-15-0700-01
Date started : November 6, 2017
Sheet No. : 1 of 2

Client : Rizmi Holdings Limited
Project : Kirby Road Extension
Location : Vaughan, Ontario

Originated by : SM
Compiled by : NNA
Checked by : SZ

Position : E: 621997, N: 4861984 (UTM 17T)
Rig type : Track-mounted

Elevation Datum : Geodetic
Drilling Method : Hollow stem augers

Elev Depth (m)	Description	Sample Number	Type	SPT 'N' Value	Lab Data and Comments GRAIN SIZE DISTRIBUTION (%) (MIT) GR SA SI CL
293.7	**GROUND SURFACE**				
	300mm **TOPSOIL**	1	SS	7	
293.4 0.3	**FILL**, sand, some silt, trace gravel, trace rootlets, loose, brown, moist				
292.9 0.8	**SAND**, trace to some silt, trace gravel, trace clay, compact, brown, damp to moist	2	SS	14	
		3	SS	19	
		4	SS	17	
		5	SS	13	
		6	SS	19	0 93 5 2
		7	SS	14	
		8	SS	22	
	...very dense	9	SS	56	

November 6, 2017
November 7, 2017

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file: 1-15-0700-01_borehole_logs_coord updated 2018-01-30.gpj

LOG OF BOREHOLE 13

Project No. : 1-15-0700-01
Date started : November 6, 2017
Sheet No. : 2 of 2

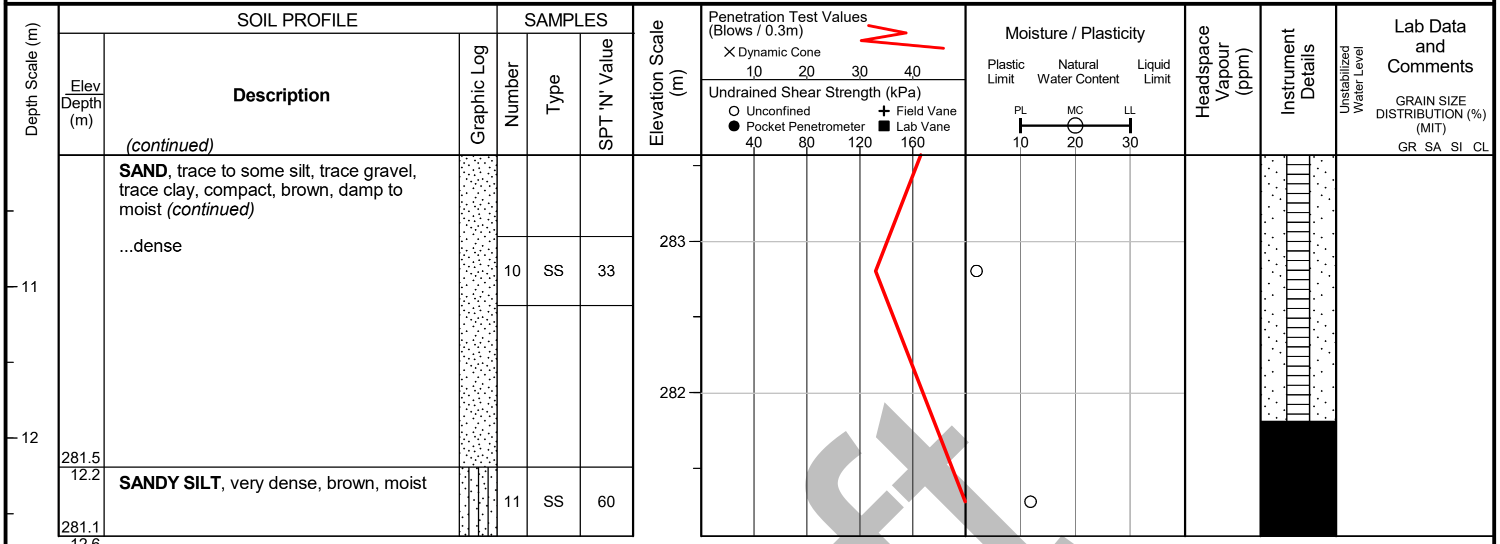
Client : Rizmi Holdings Limited
Project : Kirby Road Extension
Location : Vaughan, Ontario

Originated by : SM
Compiled by : NNA
Checked by : SZ

Position : E: 621997, N: 4861984 (UTM 17T)
Rig type : Track-mounted

Elevation Datum : Geodetic
Drilling Method : Hollow stem augers

Elev Depth (m)	Description *(continued)*	Number	Type	SPT 'N' Value
	SAND, trace to some silt, trace gravel, trace clay, compact, brown, damp to moist *(continued)* ...dense	10	SS	33
281.5 12.2	**SANDY SILT**, very dense, brown, moist	11	SS	60
281.1 12.6				



END OF BOREHOLE

Drilling mud was used during drilling. The borehole was encased during drilling.

50 mm dia. monitoring well installed.

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Jan 8, 2018	dry	n/a
Jan 25, 2018	dry	n/a

LOG OF BOREHOLE 14

Project No. : 1-15-0700-01	Client : Rizmi Holdings Limited		Originated by : SM
Date started : November 6, 2017	Project : Kirby Road Extension		Compiled by : NNA
Sheet No. : 1 of 2	Location : Vaughan, Ontario		Checked by : SZ

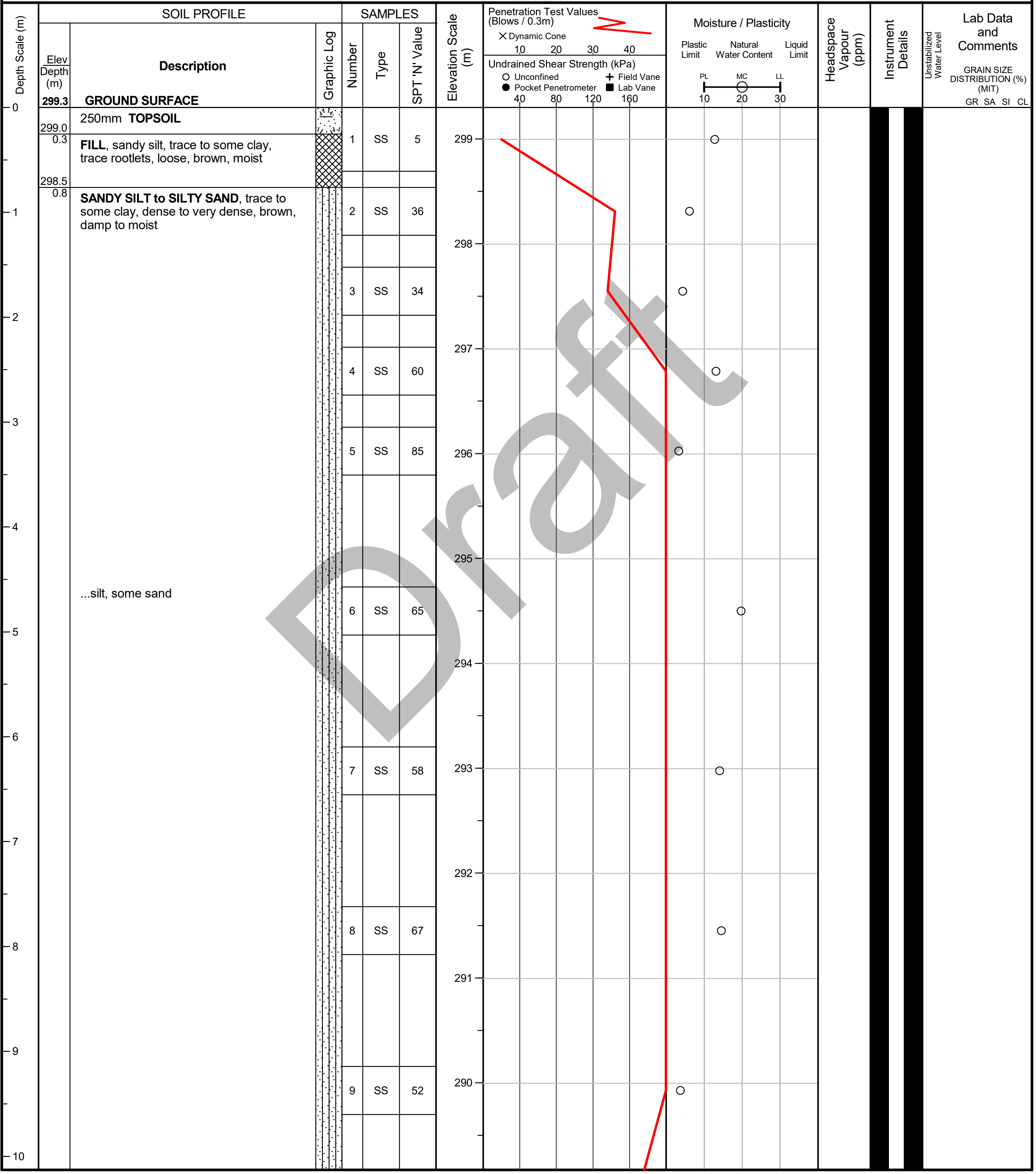
Position : E: 622064, N: 4861943 (UTM 17T)
Elevation Datum : Geodetic
Rig type : Track-mounted
Drilling Method : Solid stem augers

SOIL PROFILE

Elev Depth (m)	Description
299.3	**GROUND SURFACE**
299.0 0.3	250mm **TOPSOIL**
298.5 0.8	**FILL**, sandy silt, trace to some clay, trace rootlets, loose, brown, moist
	SANDY SILT to SILTY SAND, trace to some clay, dense to very dense, brown, damp to moist ...silt, some sand

SAMPLES

Number	Type	SPT 'N' Value
1	SS	5
2	SS	36
3	SS	34
4	SS	60
5	SS	85
6	SS	65
7	SS	58
8	SS	67
9	SS	52



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Terraprobe

LOG OF BOREHOLE 14

Project No. : 1-15-0700-01
Date started : November 6, 2017
Sheet No. : 2 of 2

Client : Rizmi Holdings Limited
Project : Kirby Road Extension
Location : Vaughan, Ontario

Originated by : SM
Compiled by : NNA
Checked by : SZ

Position : E: 622064, N: 4861943 (UTM 17T)
Rig type : Track-mounted

Elevation Datum : Geodetic
Drilling Method : Solid stem augers

Depth Scale (m): 11, 12, 13, 14, 15, 16, 17, 18

SOIL PROFILE		SAMPLES		
Elev Depth (m)	Description	Number	Type	SPT 'N' Value
	(continued)			
	SANDY SILT to SILTY SAND, trace to some clay, dense to very dense, brown, damp to moist *(continued)*	10	SS	38
		11	SS	36
285.6 13.7	**SAND**, trace to some silt, compact to very dense, brown, moist	12	SS	13
		13	SS	18
		14	SS	31
		15	SS	93 / 275mm
280.6 18.7				

END OF BOREHOLE

Drilling mud was used during drilling. The borehole was encased during drilling.

50 mm dia. monitoring well installed.

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Jan 8, 2018	17.9	281.4
Jan 25, 2018	dry	n/a

Terraprobe

LOG OF BOREHOLE 15

Project No. : 1-15-0700-01
Date started : November 7, 2017
Sheet No. : 1 of 2

Client : Rizmi Holdings Limited
Project : Kirby Road Extension
Location : Vaughan, Ontario

Originated by : SM
Compiled by : NNA
Checked by : SZ

Position : E: 622189, N: 4862036 (UTM 17T)
Rig type : Track-mounted

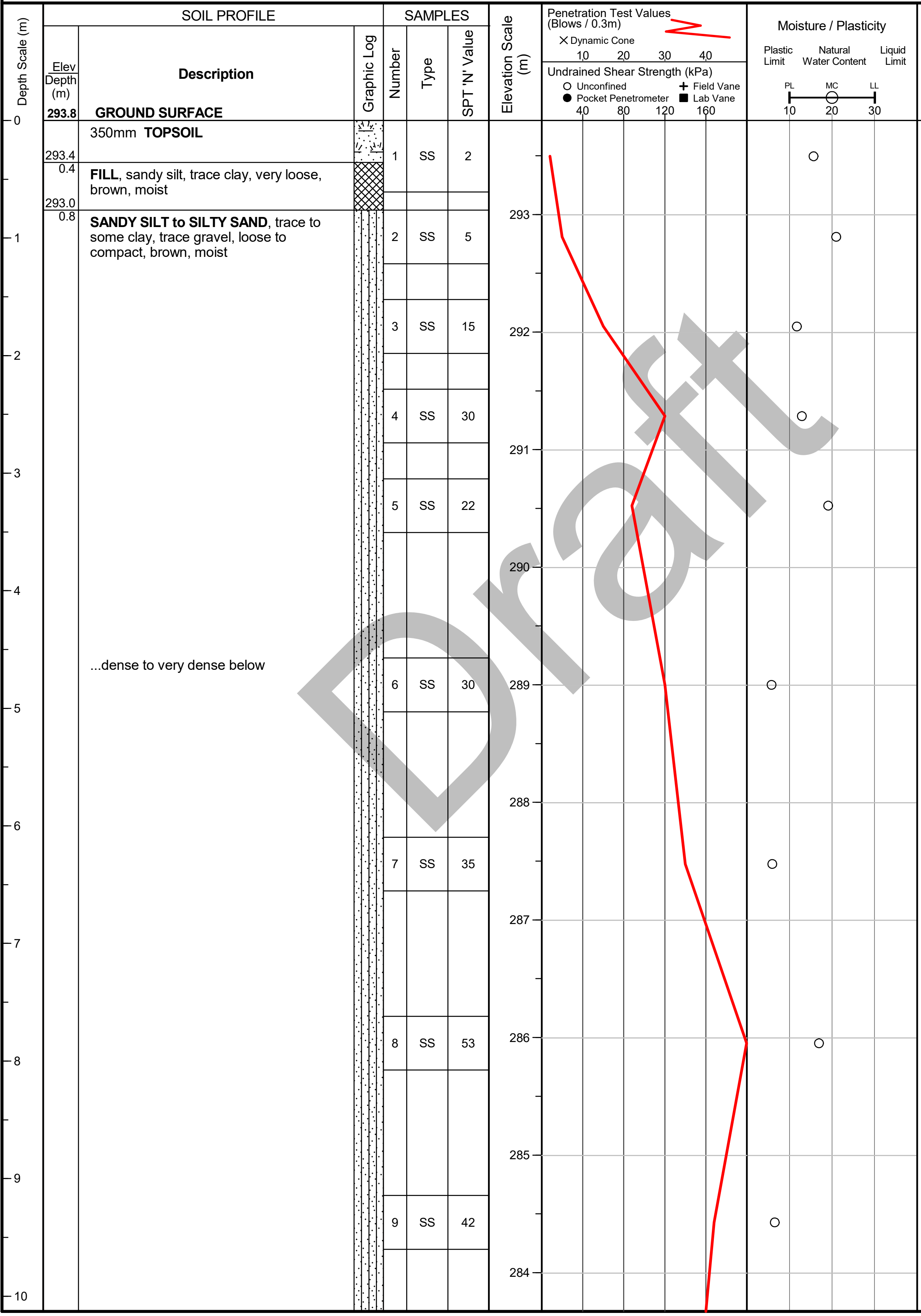
Elevation Datum : Geodetic
Drilling Method : Solid stem augers

SOIL PROFILE

Elev Depth (m)	Description
293.8	**GROUND SURFACE**
	350mm **TOPSOIL**
293.4 0.4	**FILL**, sandy silt, trace clay, very loose, brown, moist
293.0 0.8	**SANDY SILT to SILTY SAND**, trace to some clay, trace gravel, loose to compact, brown, moist
	...dense to very dense below

SAMPLES

Number	Type	SPT 'N' Value	Lab Data and Comments GRAIN SIZE DISTRIBUTION (%) (MIT) GR SA SI CL
1	SS	2	
2	SS	5	
3	SS	15	
4	SS	30	5 22 54 19
5	SS	22	
6	SS	30	
7	SS	35	
8	SS	53	
9	SS	42	



Headspace Vapour (ppm)

Instrument Details

Unstabilized Water Level

(continued next page)

file: 1-15-0700-01_borehole_logs_coord updated 2018-01-30.gpj

LOG OF BOREHOLE 15

Project No. : 1-15-0700-01
Date started : November 7, 2017
Sheet No. : 2 of 2

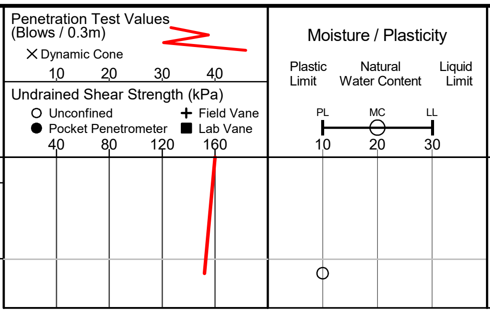
Client : Rizmi Holdings Limited
Project : Kirby Road Extension
Location : Vaughan, Ontario

Originated by : SM
Compiled by : NNA
Checked by : SZ

Position : E: 622189, N: 4862036 (UTM 17T)
Rig type : Track-mounted

Elevation Datum : Geodetic
Drilling Method : Solid stem augers

Depth Scale (m)	SOIL PROFILE Elev Depth (m)	Description	Graphic Log	SAMPLES Number	Type	SPT 'N' Value	Elevation Scale (m)	Headspace Vapour (ppm)	Instrument Details	Unstabilized Water Level	Lab Data and Comments GRAIN SIZE DISTRIBUTION (%) (MIT) GR SA SI CL
		(continued)									
11	282.7 11.1	**SANDY SILT to SILTY SAND**, trace to some clay, trace gravel, loose to compact, brown, moist *(continued)*		10	SS	38	283				



END OF BOREHOLE

Borehole was dry and open upon completion of drilling.

LOG OF BOREHOLE 16

Project No. : 1-15-0700-01
Date started : November 7, 2017
Sheet No. : 1 of 1

Client : Rizmi Holdings Limited
Project : Kirby Road Extension
Location : Vaughan, Ontario

Originated by : SM
Compiled by : NNA
Checked by : SZ

Position : E: 622300, N: 4862000 (UTM 17T)
Rig type : Track-mounted

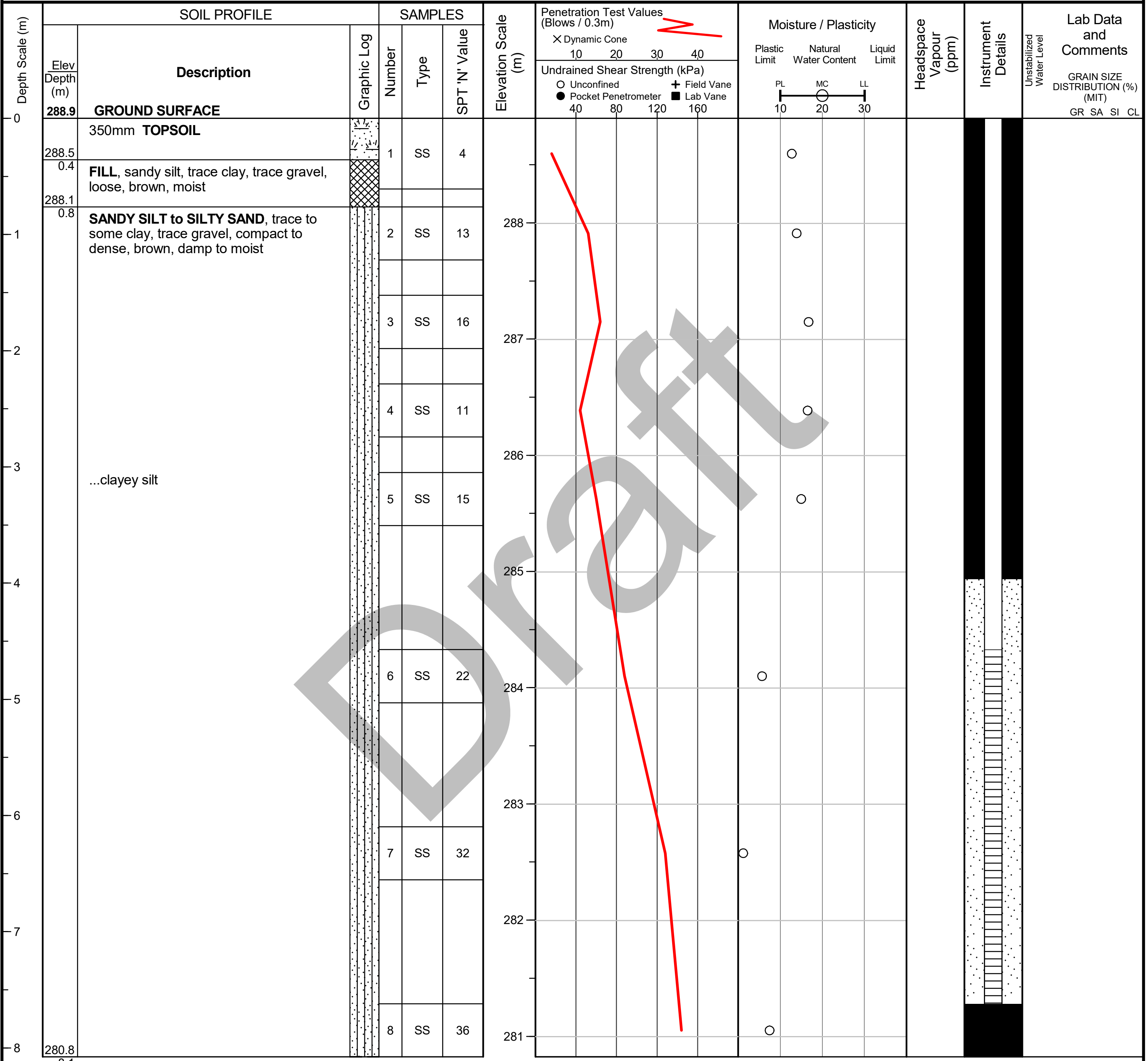
Elevation Datum : Geodetic
Drilling Method : Solid stem augers

SOIL PROFILE

Elev (m)	Depth (m)	Description
288.9	0	**GROUND SURFACE**
		350mm **TOPSOIL**
288.5	0.4	**FILL**, sandy silt, trace clay, trace gravel, loose, brown, moist
288.1	0.8	**SANDY SILT to SILTY SAND**, trace to some clay, trace gravel, compact to dense, brown, damp to moist
		...clayey silt
280.8	8.1	

SAMPLES

Number	Type	SPT 'N' Value
1	SS	4
2	SS	13
3	SS	16
4	SS	11
5	SS	15
6	SS	22
7	SS	32
8	SS	36



END OF BOREHOLE

Borehole was dry and open upon completion of drilling.

50 mm dia. monitoring well installed.

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Jan 8, 2018	dry	n/a
Jan 25, 2018	dry	n/a

Terraprobe

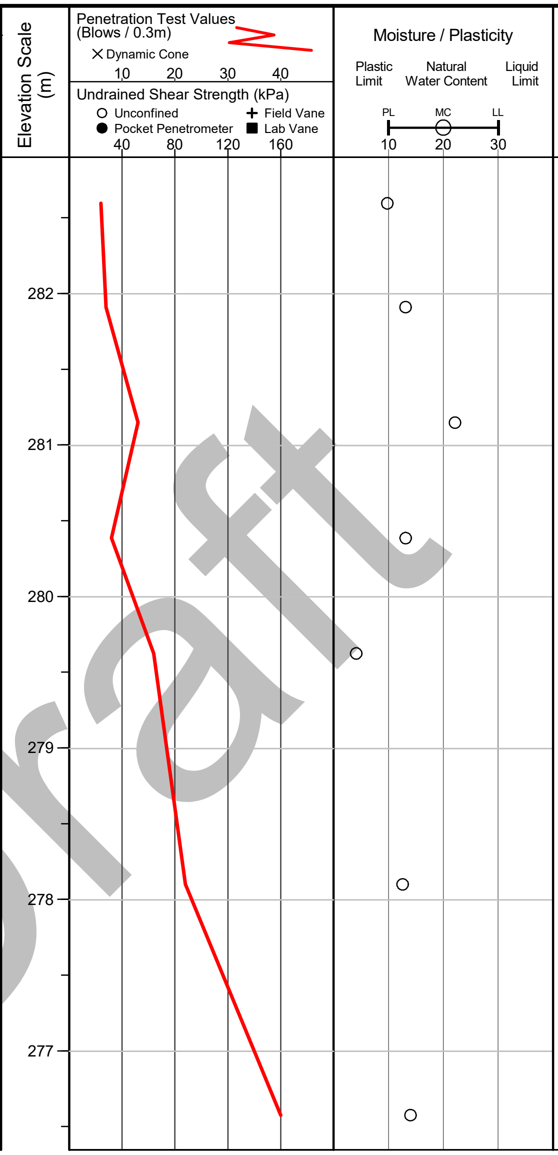
LOG OF BOREHOLE 17

Project No. : 1-15-0700-01
Client : Rizmi Holdings Limited
Originated by : SM
Date started : November 10, 2017
Project : Kirby Road Extension
Compiled by : NNA
Sheet No. : 1 of 1
Location : Vaughan, Ontario
Checked by : SZ

Position : E: 622357, N: 4862055 (UTM 17T)
Elevation Datum : Geodetic
Rig type : Track-mounted
Drilling Method : Solid stem augers

Depth Scale (m)	Elev Depth (m)	Description	Number	Type	SPT 'N' Value
0	**282.9**	**GROUND SURFACE**			
		300mm **TOPSOIL**			
	282.6 0.3	**FILL**, clayey silt, some sand, trace gravel, trace organics, firm to stiff, brown to dark brown, moist	1	SS	6
1			2	SS	7
2			3	SS	13
	280.6 2.3	**FILL**, sandy silt, trace clay, trace gravel, trace rootlets, loose, brown, moist	4	SS	8
3	279.9 3.0	**FILL**, gravelly sand, some silt, compact, brown, moist	5	SS	16
4					
	278.3 4.6	**SANDY SILT to SILTY SAND**, trace clay, trace gravel, compact to dense, brown, moist	6	SS	22
5					
6			7	SS	40
	276.3 6.6	**END OF BOREHOLE**			

Borehole was dry and open upon completion of drilling.



Headspace Vapour (ppm)	Instrument Details	Unstabilized Water Level	Lab Data and Comments GRAIN SIZE DISTRIBUTION (%) (MIT) GR SA SI CL

LOG OF BOREHOLE 18

Project No. : 1-15-0700-01
Client : Rizmi Holdings Limited
Originated by : SM

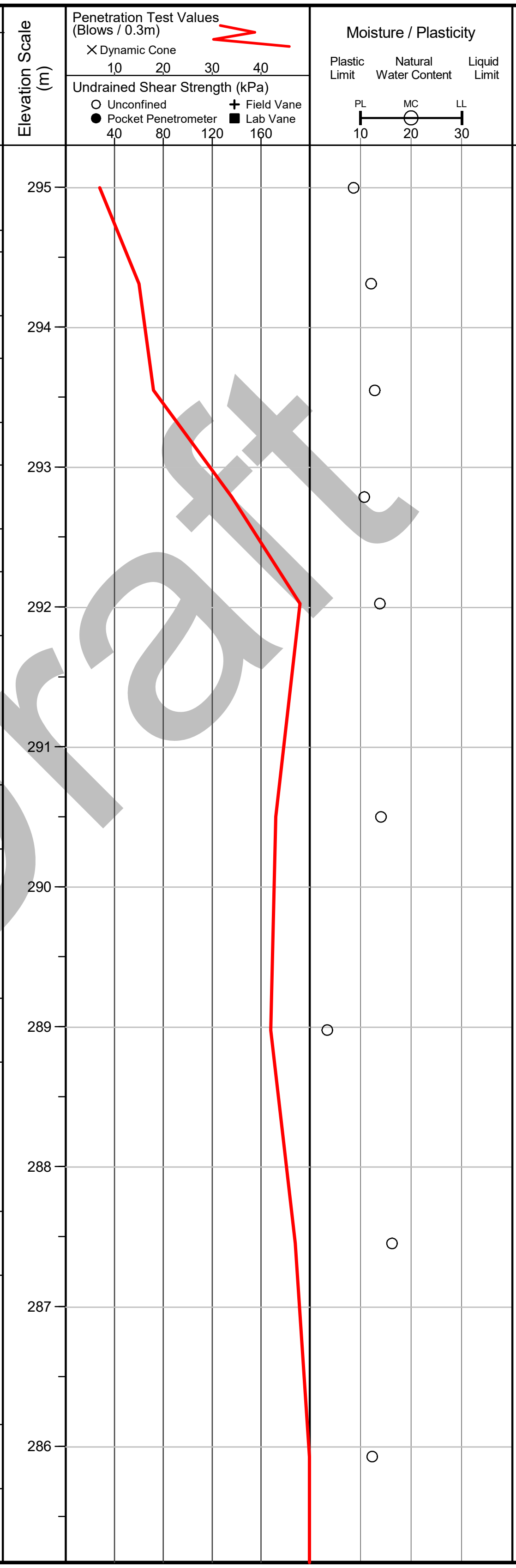
Date started : November 8, 2017
Project : Kirby Road Extension
Compiled by : NNA

Sheet No. : 1 of 2
Location : Vaughan, Ontario
Checked by : SZ

Position : E: 622440, N: 4862093 (UTM 17T)
Elevation Datum : Geodetic

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

SOIL PROFILE		SAMPLES			Lab Data and Comments GRAIN SIZE DISTRIBUTION (%) (MIT)
Elev Depth (m)	Description	Number	Type	SPT 'N' Value	GR SA SI CL
295.3	**GROUND SURFACE**				
	250mm **TOPSOIL**				
295.0 0.3	**FILL**, clayey silt, some sand, trace gravel, firm to stiff, brown, moist	1	SS	7	
		2	SS	15	
293.8 1.5	**CLAYEY SILT**, trace to some sand, trace gravel, very stiff to hard, brown, moist	3	SS	18	
		4	SS	34	
		5	SS	48	1 17 48 34
290.7 4.6	**SANDY SILT to SILTY SAND**, trace to some clay, trace gravel, dense to very dense, brown, moist	6	SS	43	
		7	SS	42	
	...clayey silt	8	SS	47	
		9	SS	85	



Depth Scale (m): 0 1 2 3 4 5 6 7 8 9 10

Headspace Vapour (ppm)

Instrument Details

Unstabilized Water Level

(continued next page)

Terraprobe

LOG OF BOREHOLE 18

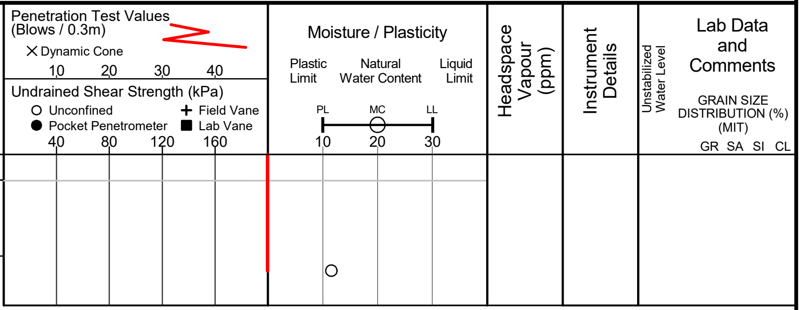
Project No. : 1-15-0700-01
Date started : November 8, 2017
Sheet No. : 2 of 2

Client : Rizmi Holdings Limited
Project : Kirby Road Extension
Location : Vaughan, Ontario

Originated by : SM
Compiled by : NNA
Checked by : SZ

Position : E: 622440, N: 4862093 (UTM 17T)
Rig type : Truck-mounted
Elevation Datum : Geodetic
Drilling Method : Solid stem augers

	SOIL PROFILE			SAMPLES			
Depth Scale (m)	Elev Depth (m)	Description *(continued)*	Graphic Log	Number	Type	SPT 'N' Value	Elevation Scale (m)
		SANDY SILT to SILTY SAND, trace to some clay, trace gravel, dense to very dense, brown, moist *(continued)*					285
11	284.2 11.1			10	SS	72	



END OF BOREHOLE

Borehole was dry and open upon completion of drilling.

Terraprobe

LOG OF BOREHOLE 19

Project No. : 1-15-0700-01	Client : Rizmi Holdings Limited	Originated by : SM
Date started : November 8, 2017	Project : Kirby Road Extension	Compiled by : NNA
Sheet No. : 1 of 2	Location : Vaughan, Ontario	Checked by : SZ

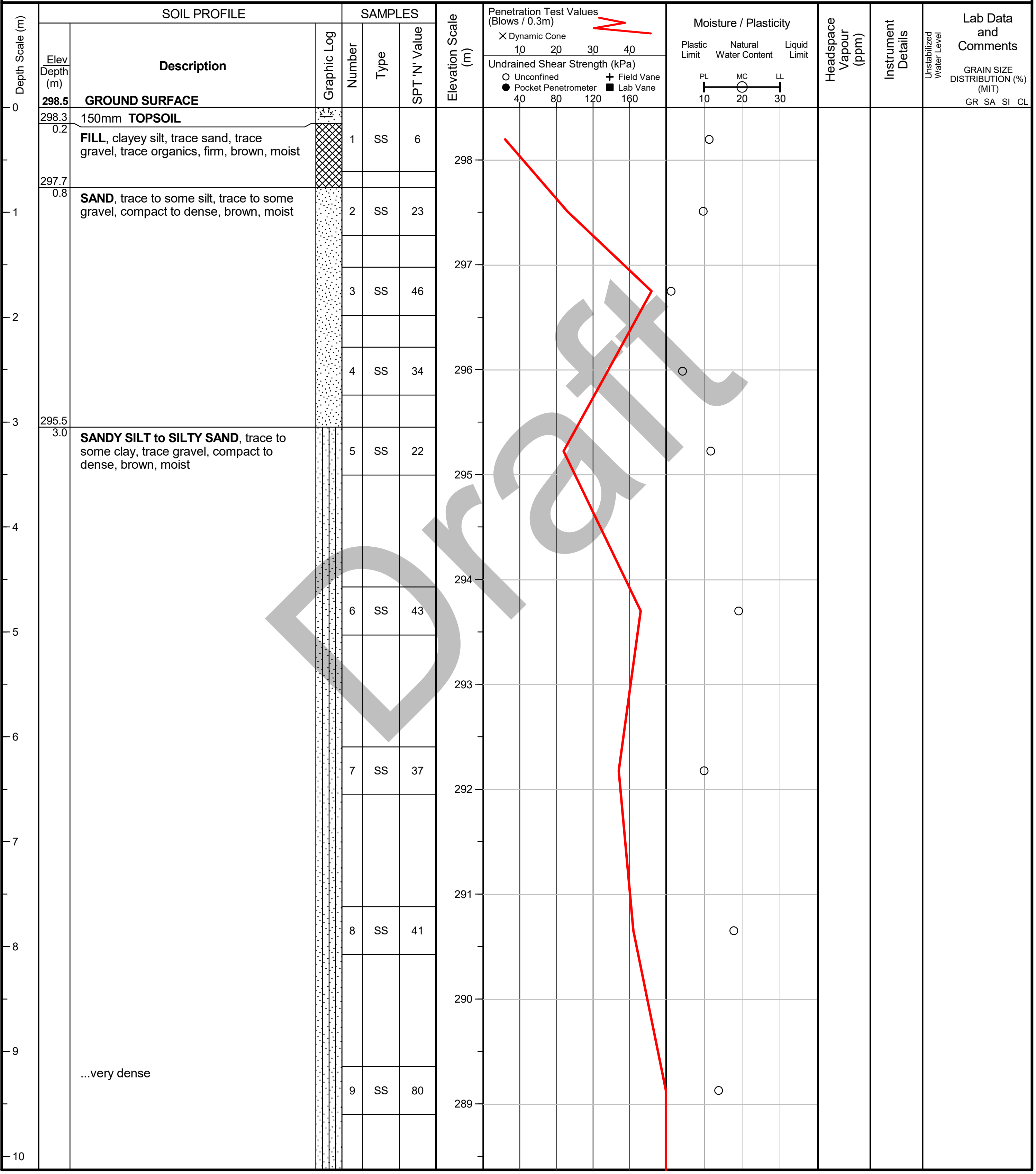
Position : E: 622549, N: 4862107 (UTM 17T)

Rig type : Truck-mounted

Elevation Datum : Geodetic

Drilling Method : Solid stem augers

Elev Depth (m)	SOIL PROFILE Description	SAMPLES Number	Type	SPT 'N' Value
298.5	**GROUND SURFACE**			
	150mm **TOPSOIL**			
298.3 0.2	**FILL**, clayey silt, trace sand, trace gravel, trace organics, firm, brown, moist	1	SS	6
297.7 0.8	**SAND**, trace to some silt, trace to some gravel, compact to dense, brown, moist	2	SS	23
		3	SS	46
		4	SS	34
295.5 3.0	**SANDY SILT to SILTY SAND**, trace to some clay, trace gravel, compact to dense, brown, moist	5	SS	22
		6	SS	43
		7	SS	37
		8	SS	41
	...very dense	9	SS	80



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LOG OF BOREHOLE 19

Project No. : 1-15-0700-01
Date started : November 8, 2017
Sheet No. : 2 of 2

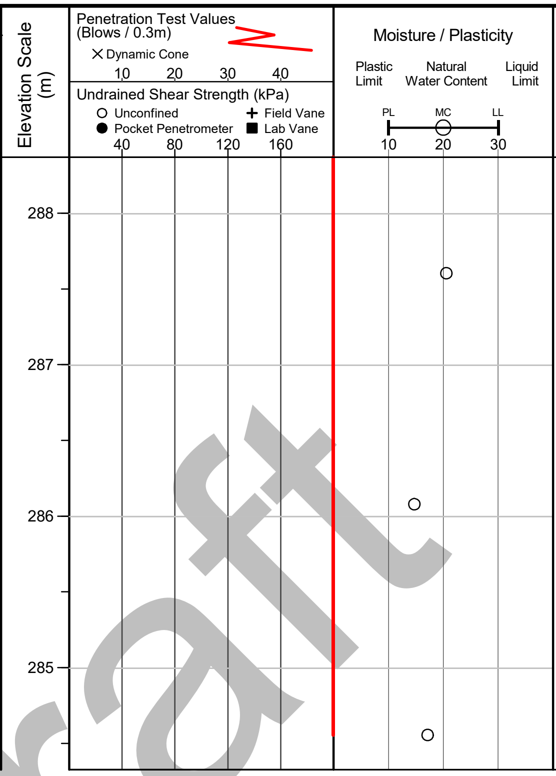
Client : Rizmi Holdings Limited
Project : Kirby Road Extension
Location : Vaughan, Ontario

Originated by : SM
Compiled by : NNA
Checked by : SZ

Position : E: 622549, N: 4862107 (UTM 17T)
Rig type : Truck-mounted
Elevation Datum : Geodetic
Drilling Method : Solid stem augers

Elev Depth (m)	Description *(continued)*	Graphic Log	Number	Type	SPT 'N' Value
	SANDY SILT to SILTY SAND, trace to some clay, trace gravel, compact to dense, brown, moist *(continued)*				
287.8 10.7	**SILT**, trace clay, trace sand, very dense, brown, moist		10	SS	53
			11	SS	53
284.3 14.2			12	SS	58

Depth Scale (m): 11, 12, 13, 14



Headspace Vapour (ppm)

Instrument Details

Unstabilized Water Level

Lab Data and Comments

GRAIN SIZE DISTRIBUTION (%) (MIT)

GR SA SI CL

END OF BOREHOLE

Borehole was dry and open upon completion of drilling.

Terraprobe

LOG OF BOREHOLE 20

Project No. : 1-15-0700-01
Date started : November 9, 2017
Sheet No. : 1 of 2

Client : Rizmi Holdings Limited
Project : Kirby Road Extension
Location : Vaughan, Ontario

Originated by : SM
Compiled by : NNA
Checked by : SZ

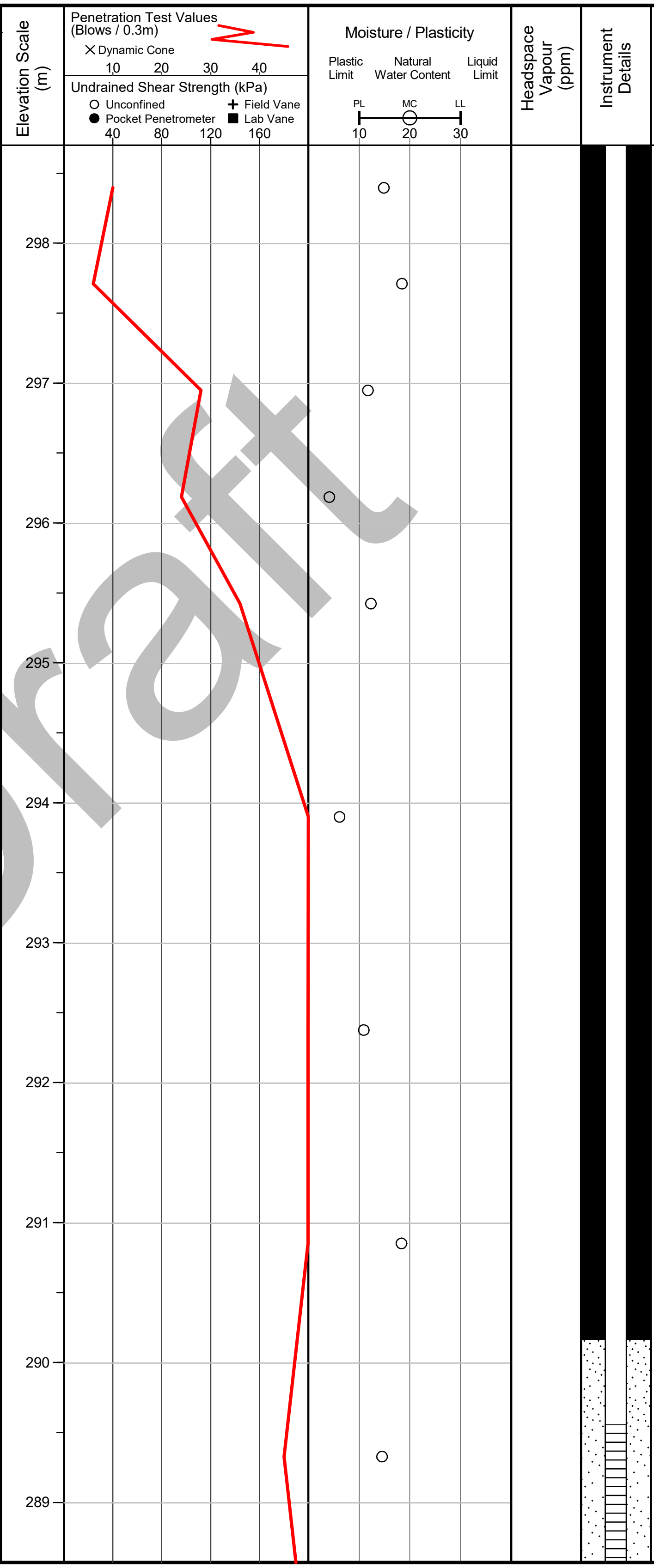
Position : E: 622577, N: 4862140 (UTM 17T)
Rig type : Truck-mounted
Elevation Datum : Geodetic
Drilling Method : Solid stem augers

SOIL PROFILE

Elev Depth (m)	Description
298.7	**GROUND SURFACE**
0	**FILL**, clayey silt, trace to some sand, trace gravel, firm to stiff, brown, moist
297.2 1.5	**SANDY SILT to SILTY SAND**, trace to some clay, trace to some gravel, compact to very dense, brown, moist
	...wet sand seams

SAMPLES

Number	Type	SPT 'N' Value	Lab Data and Comments GRAIN SIZE DISTRIBUTION (%) (MIT) GR SA SI CL
1	SS	10	
2	SS	6	
3	SS	28	
4	SS	24	10 67 20 3
5	SS	36	
6	SS	50	
7	SS	55	
8	SS	58	
9	SS	45	



Depth Scale (m): 0 1 2 3 4 5 6 7 8 9 10

(continued next page)

Terraprobe

LOG OF BOREHOLE 20

Project No. : 1-15-0700-01
Date started : November 9, 2017
Sheet No. : 2 of 2

Client : Rizmi Holdings Limited
Project : Kirby Road Extension
Location : Vaughan, Ontario

Originated by : SM
Compiled by : NNA
Checked by : SZ

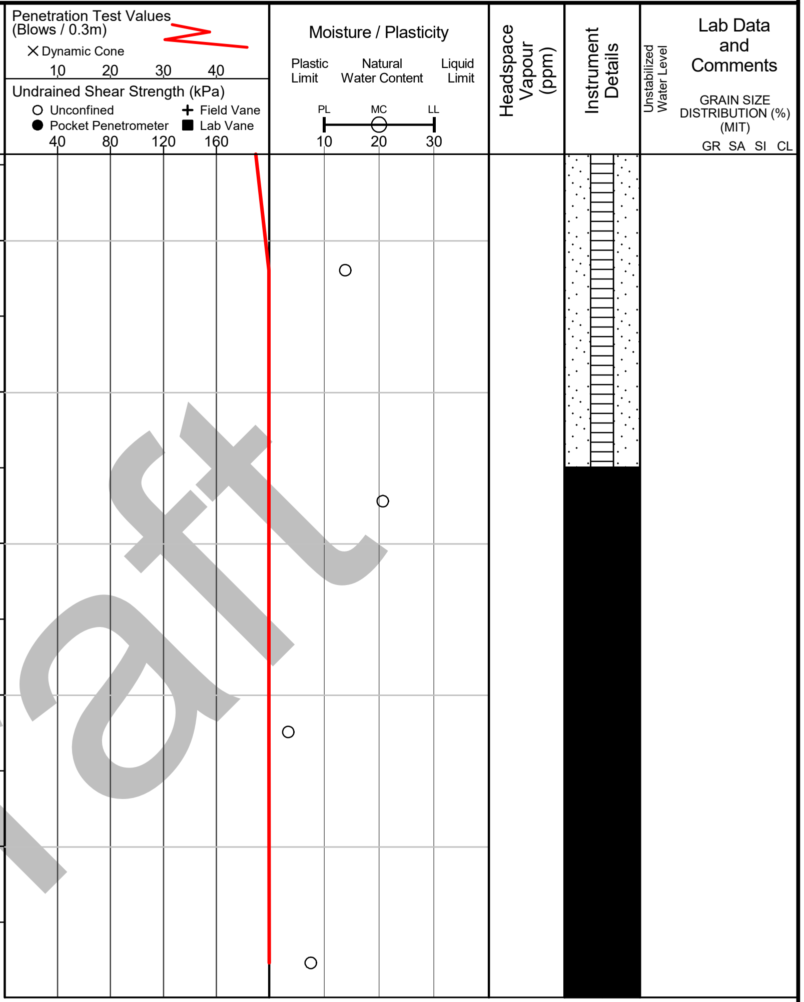
Position : E: 622577, N: 4862140 (UTM 17T)
Rig type : Truck-mounted

Elevation Datum : Geodetic
Drilling Method : Solid stem augers

Elev / Depth (m)	Description	Sample Number	Type	SPT 'N' Value
	(continued) **SANDY SILT to SILTY SAND**, trace to some clay, trace to some gravel, compact to very dense, brown, moist *(continued)*			
		10	SS	88
286.5 12.2	**SILT**, some sand, trace clay, very dense, brown, wet	11	SS	81
285.0 13.7	**SANDY SILT to SILTY SAND**, trace to some clay, trace to some gravel, compact to very dense, brown, moist	12	SS	73
		13	SS	50
283.0 15.7	**END OF BOREHOLE**			

Depth Scale (m): 11, 12, 13, 14, 15

Elevation Scale (m): 288, 287, 286, 285, 284



END OF BOREHOLE

The monitoring well is buried. The water level measurement could not be done.

Borehole was dry and open upon completion of drilling.

50 mm dia. monitoring well installed.

LOG OF BOREHOLE 21

Terraprobe

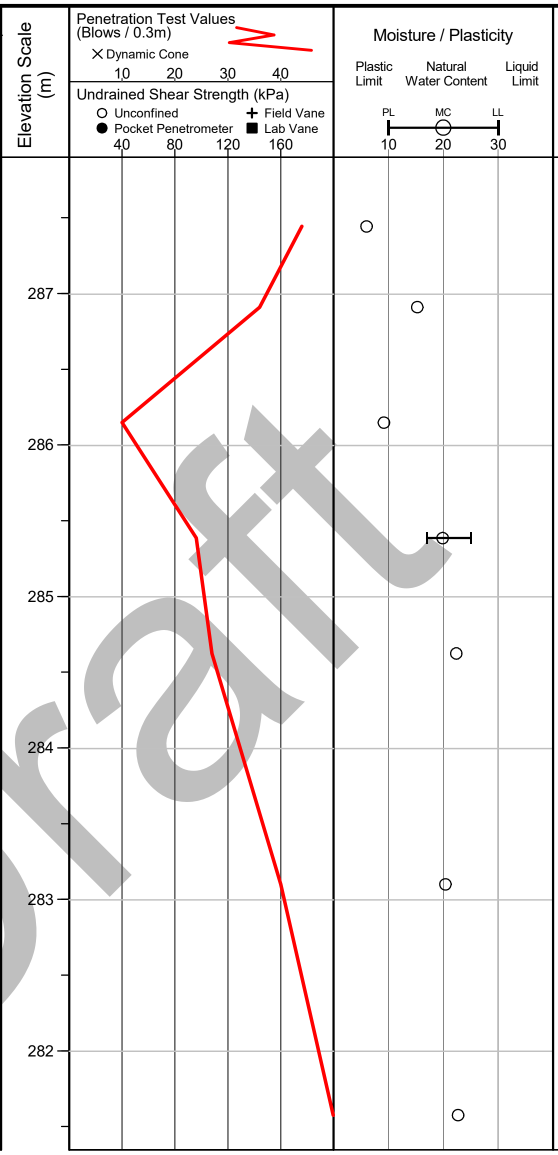
Project No. : 1-15-0700-01
Date started : December 7, 2017
Sheet No. : 1 of 1

Client : Rizmi Holdings Limited
Project : Kirby Road Extension
Location : Vaughan, Ontario

Originated by : TG
Compiled by : NNA
Checked by : SZ

Position : E: 622703, N: 4862229 (UTM 17T)
Rig type : CME 55, truck-mounted
Elevation Datum : Geodetic
Drilling Method : Solid stem augers

Elev / Depth (m)	Description (SOIL PROFILE)	Sample Number	Type	SPT 'N' Value	GRAIN SIZE DISTRIBUTION (%) (MIT) GR SA SI CL
287.9	**GROUND SURFACE**				
287.7 0.2	240mm **ASPHALTIC CONCRETE**				
287.5 0.4	200mm **AGGREGATE**				
	SAND, some silt to silty, compact to dense, brown, moist	1	SS	44	
		2	SS	36	
		3	SS	10	
285.6 2.3	**CLAYEY SILT**, trace to some sand, trace gravel, very stiff to hard, brown, moist	4	SS	24	0 12 63 25
		5	SS	27	
		6	SS	40	
		7	SS	51	
281.3 6.6					



Depth Scale (m): 0 1 2 3 4 5 6

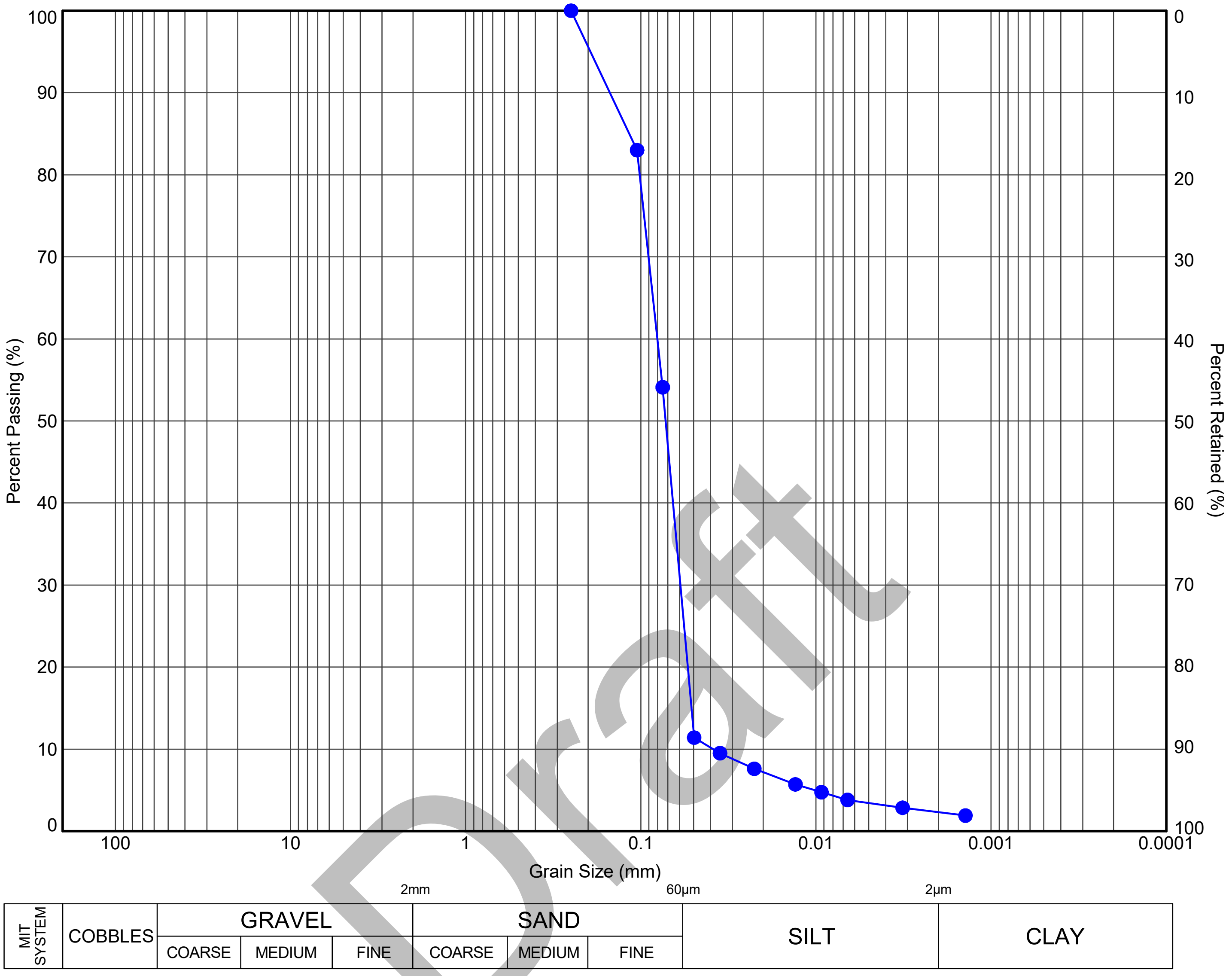
Headspace Vapour (ppm) | Instrument Details | Unstabilized Water Level | Lab Data and Comments

END OF BOREHOLE

Borehole was dry and open upon completion of drilling.

APPENDIX B

TERRAPROBE INC.



					MIT SYSTEM				
	Hole ID	Sample	Depth (m)	Elev. (m)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	*(Fines, %)*
●	**1**	SS5	3.3	295.8	0	69	29	2	

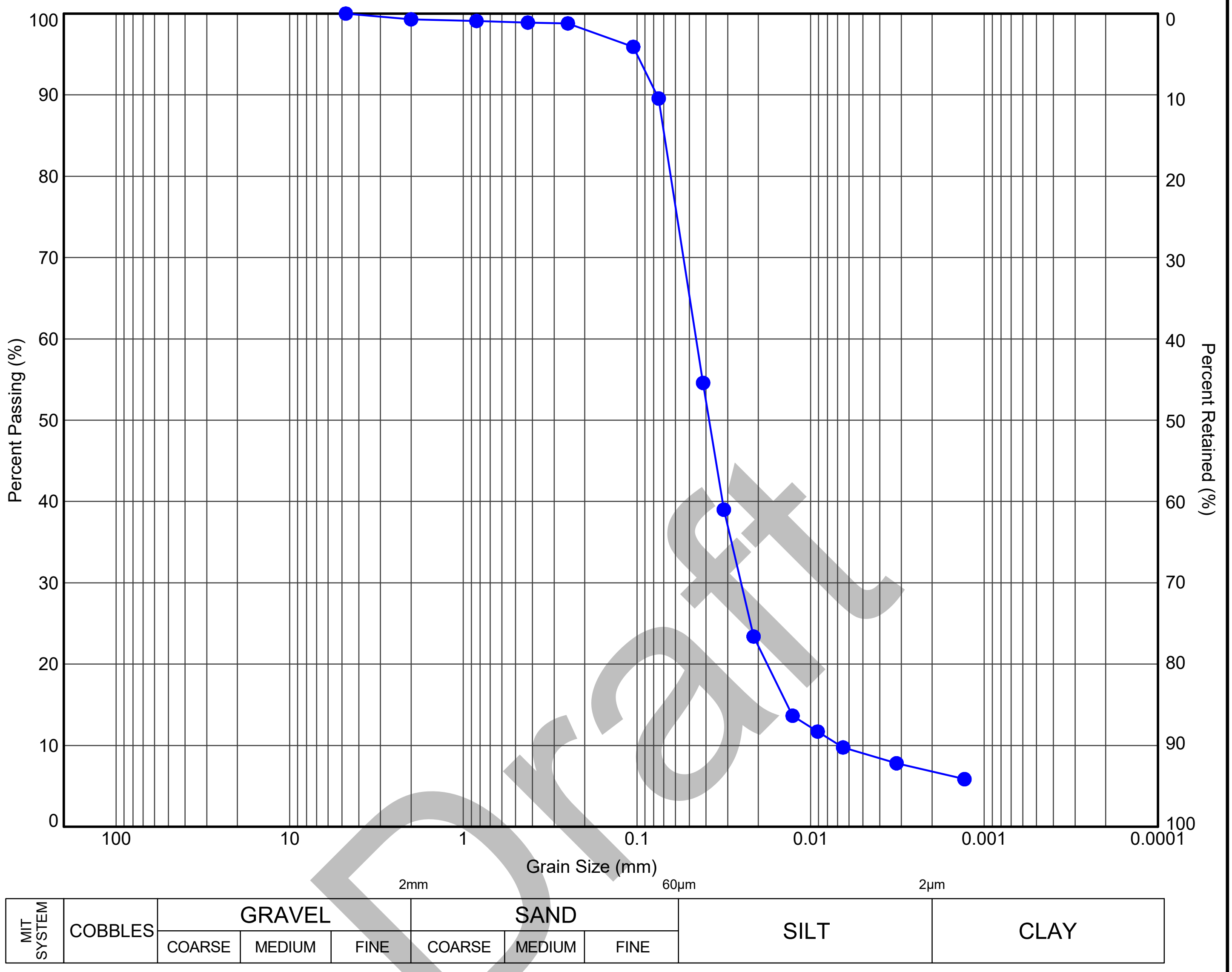
Terraprobe

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

Title:

GRAIN SIZE DISTRIBUTION
SILTY SAND, TRACE CLAY

File No.: **1-15-0700-01**



MIT SYSTEM

	Hole ID	Sample	Depth (m)	Elev. (m)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	*(Fines, %)*
●	**2**	SS4	2.5	286.9	1	22	70	7	

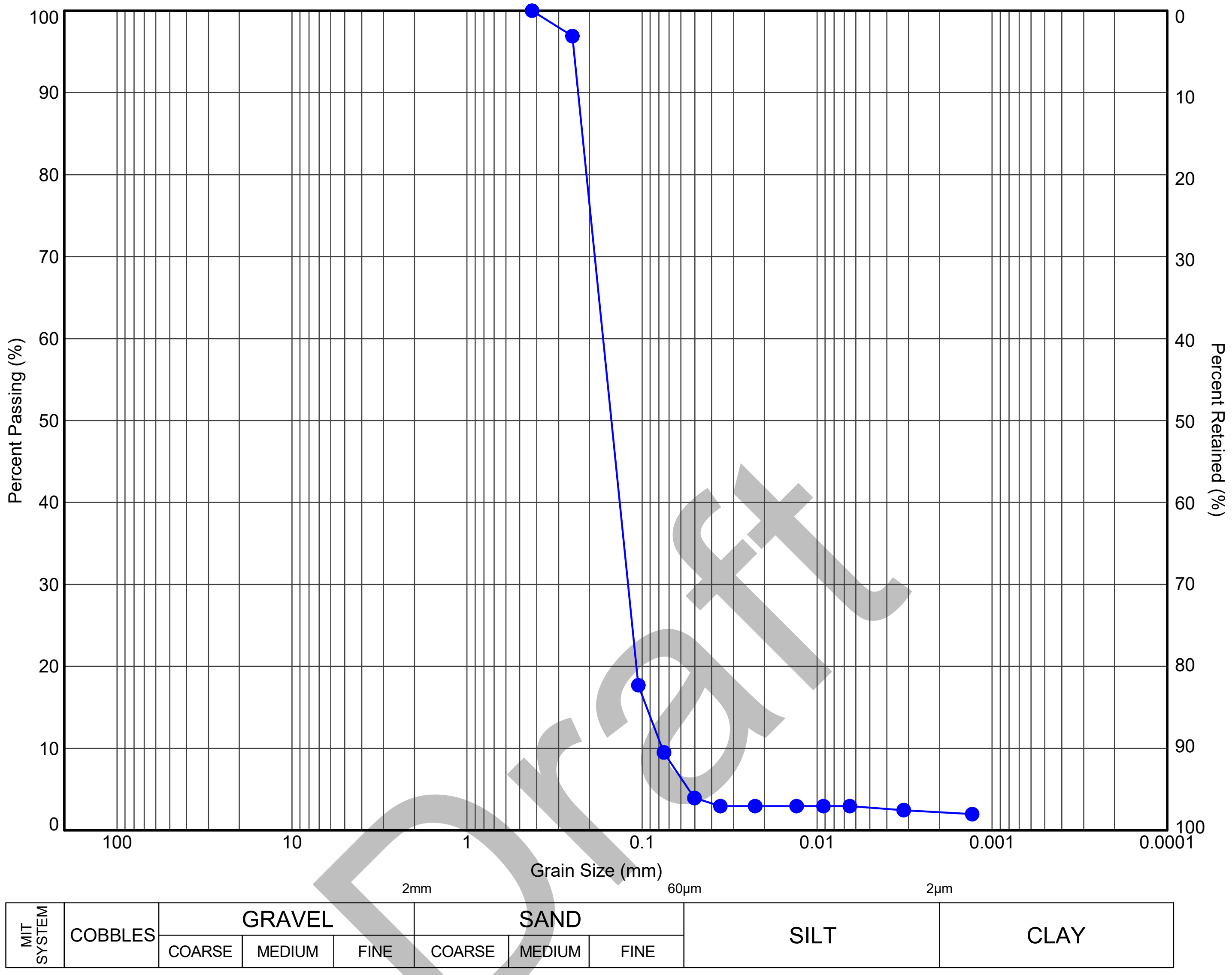
Terraprobe

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

Title:

GRAIN SIZE DISTRIBUTION
SANDY SILT, TRACE CLAY, TRACE GRAVEL

File No.: **1-15-0700-01**



MIT SYSTEM

	Hole ID	Sample	Depth (m)	Elev. (m)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	*(Fines, %)*
●	**3**	SS7	6.3	294.7	0	94	4	2	

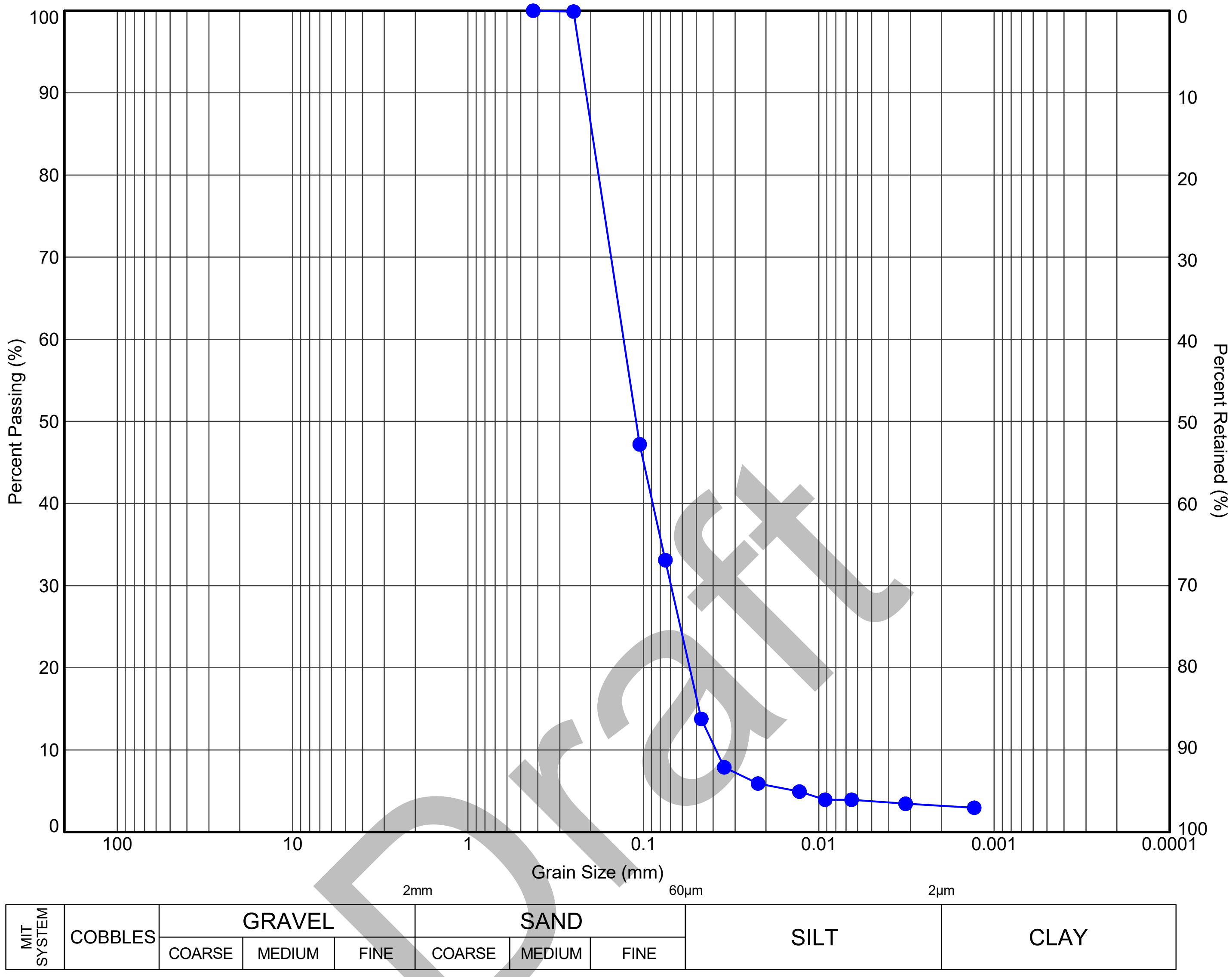
Terraprobe

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

Title:

GRAIN SIZE DISTRIBUTION
SAND, TRACE SILT, TRACE CLAY

File No.: **1-15-0700-01**



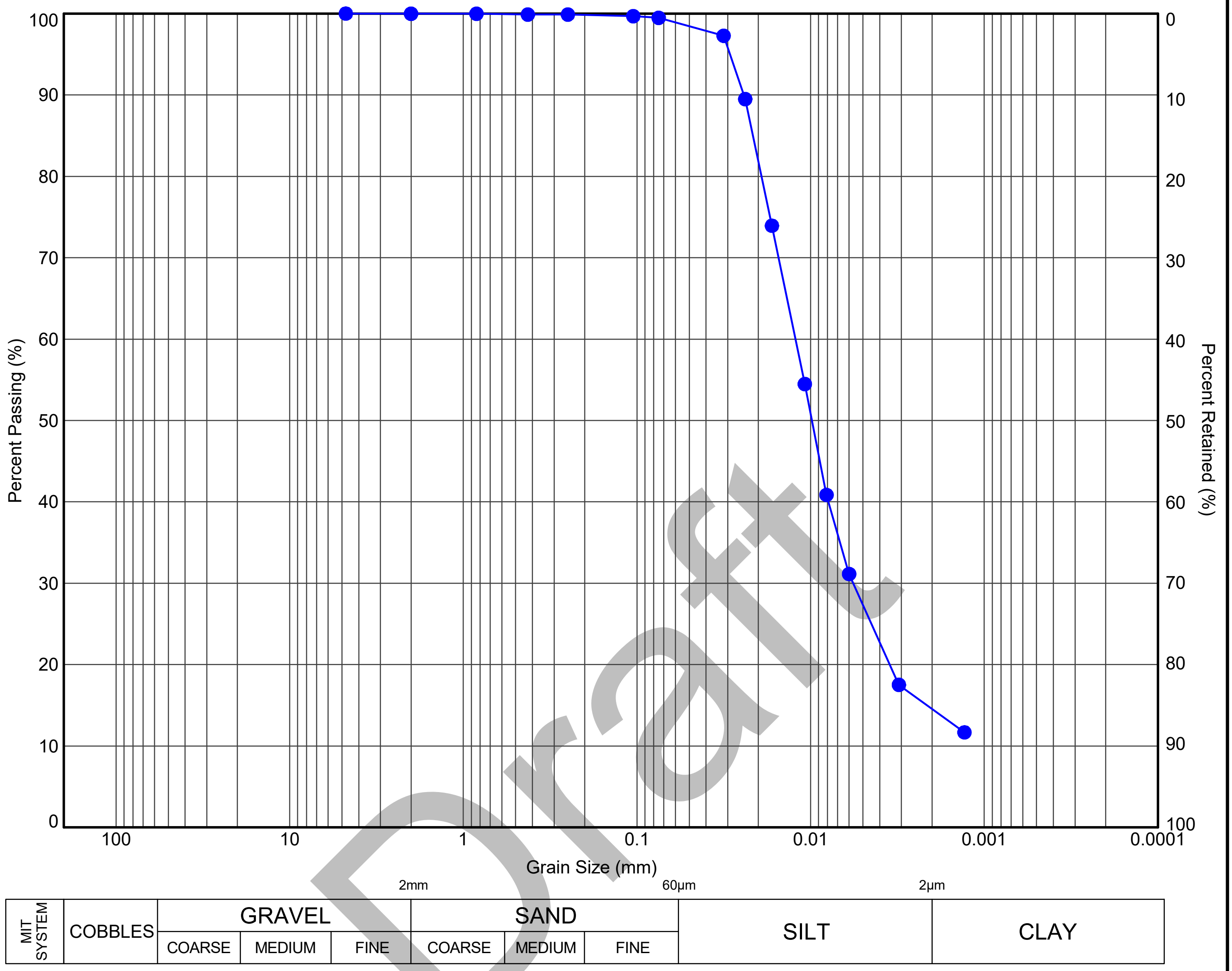
					MIT SYSTEM				
	Hole ID	Sample	Depth (m)	Elev. (m)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	*(Fines, %)*
●	**3**	SS14	17.0	284.0	0	76	21	3	

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

Title:

GRAIN SIZE DISTRIBUTION
SILTY SAND, TRACE CLAY

File No.: **1-15-0700-01**



				MIT SYSTEM				
	Hole ID	Sample	Depth (m)	Elev. (m)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	*(Fines, %)*
●	**5**	SS9	9.4	273.5	0	1	84	15	

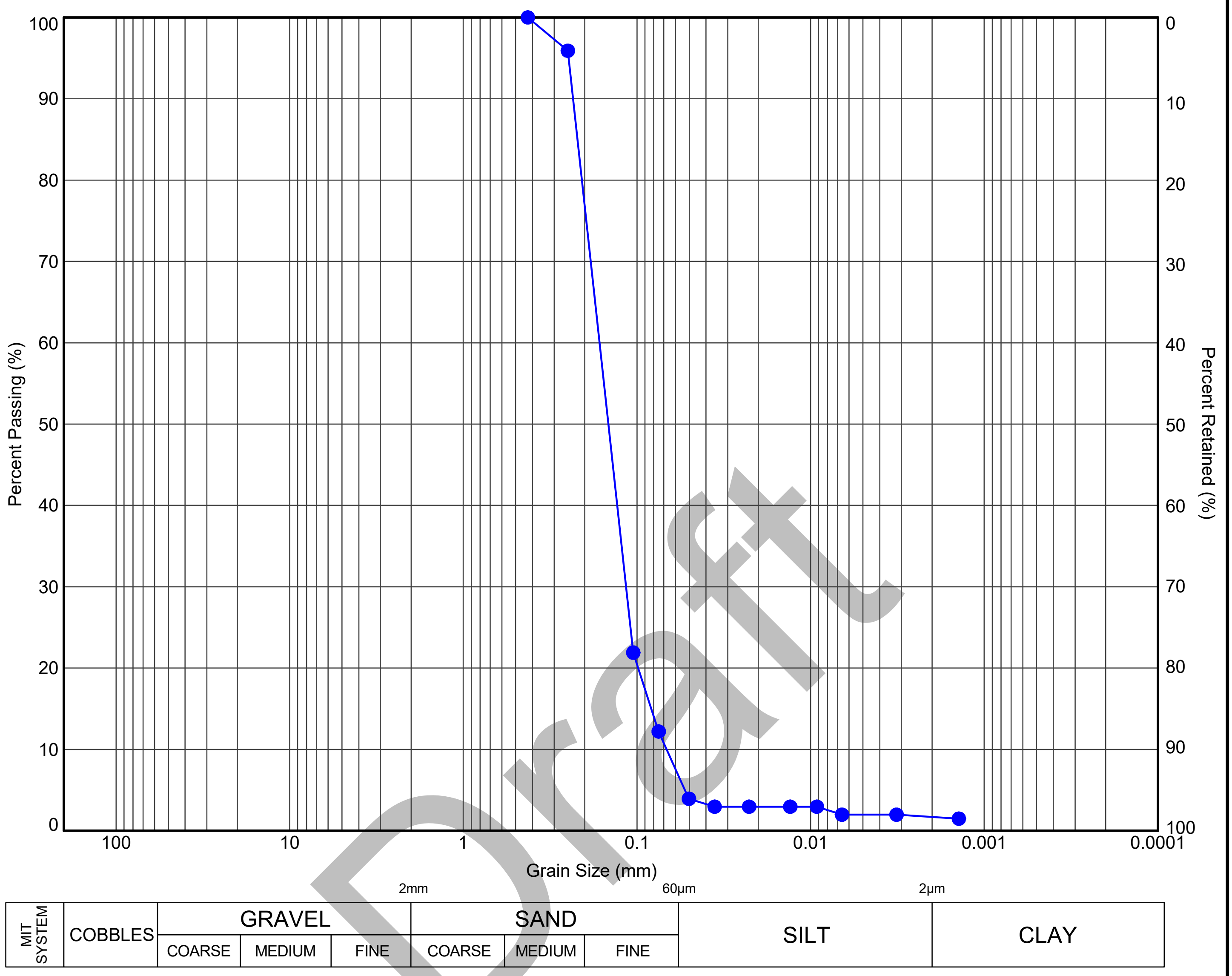
Terraprobe

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

Title:

GRAIN SIZE DISTRIBUTION
SILT, SOME CLAY, TRACE SAND

File No.: **1-15-0700-01**



	Hole ID	Sample	Depth (m)	Elev. (m)	MIT SYSTEM Gravel (%)	Sand (%)	Silt (%)	Clay (%)	*(Fines, %)*
●	**8**	SS4	2.5	286.7	0	92	6	2	

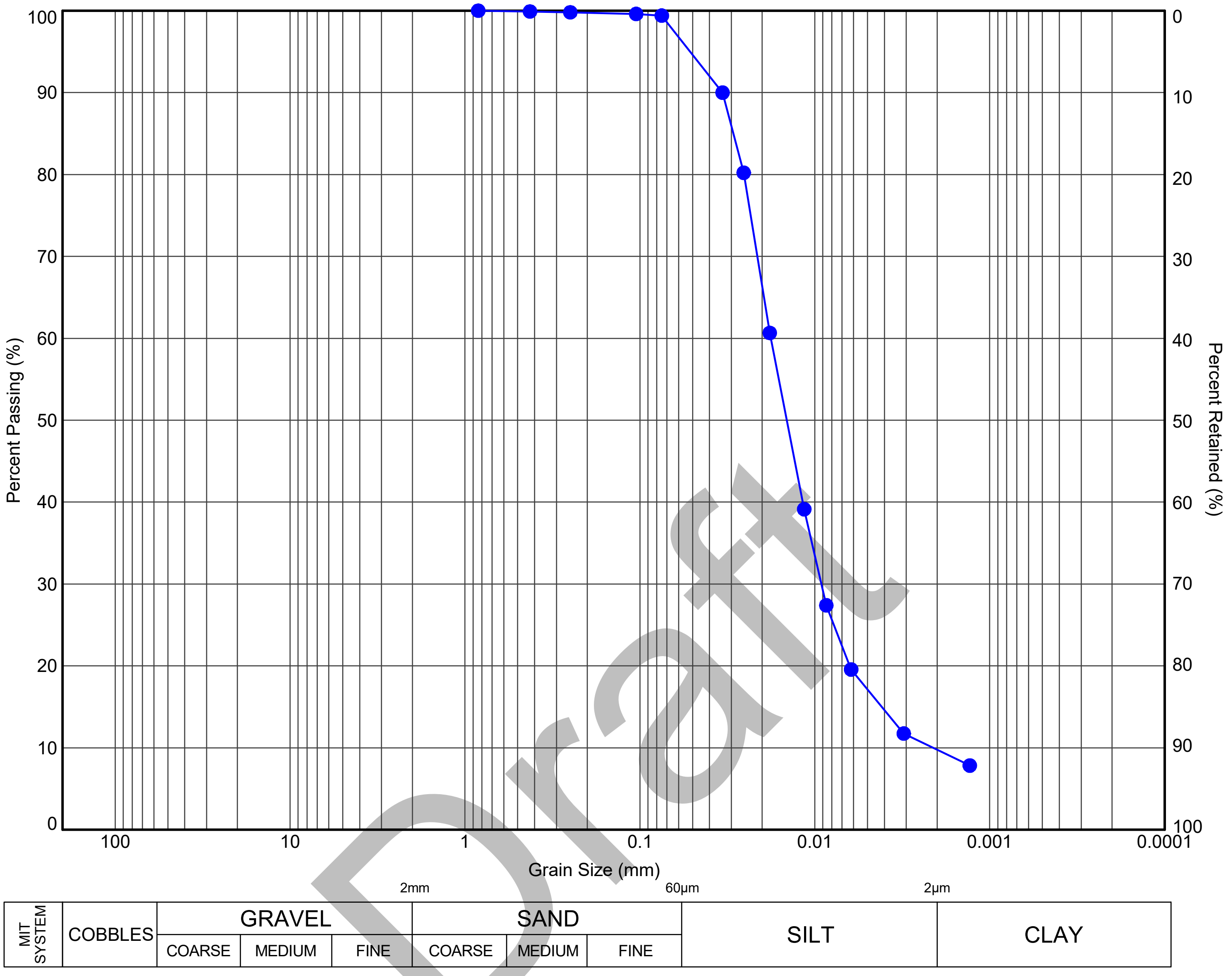
Terraprobe

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

Title:

GRAIN SIZE DISTRIBUTION
SAND, TRACE SILT, TRACE CLAY

File No.: **1-15-0700-01**



					MIT SYSTEM				
	Hole ID	Sample	Depth (m)	Elev. (m)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	*(Fines, %)*
●	**10**	SS8	7.8	267.9	0	3	87	10	

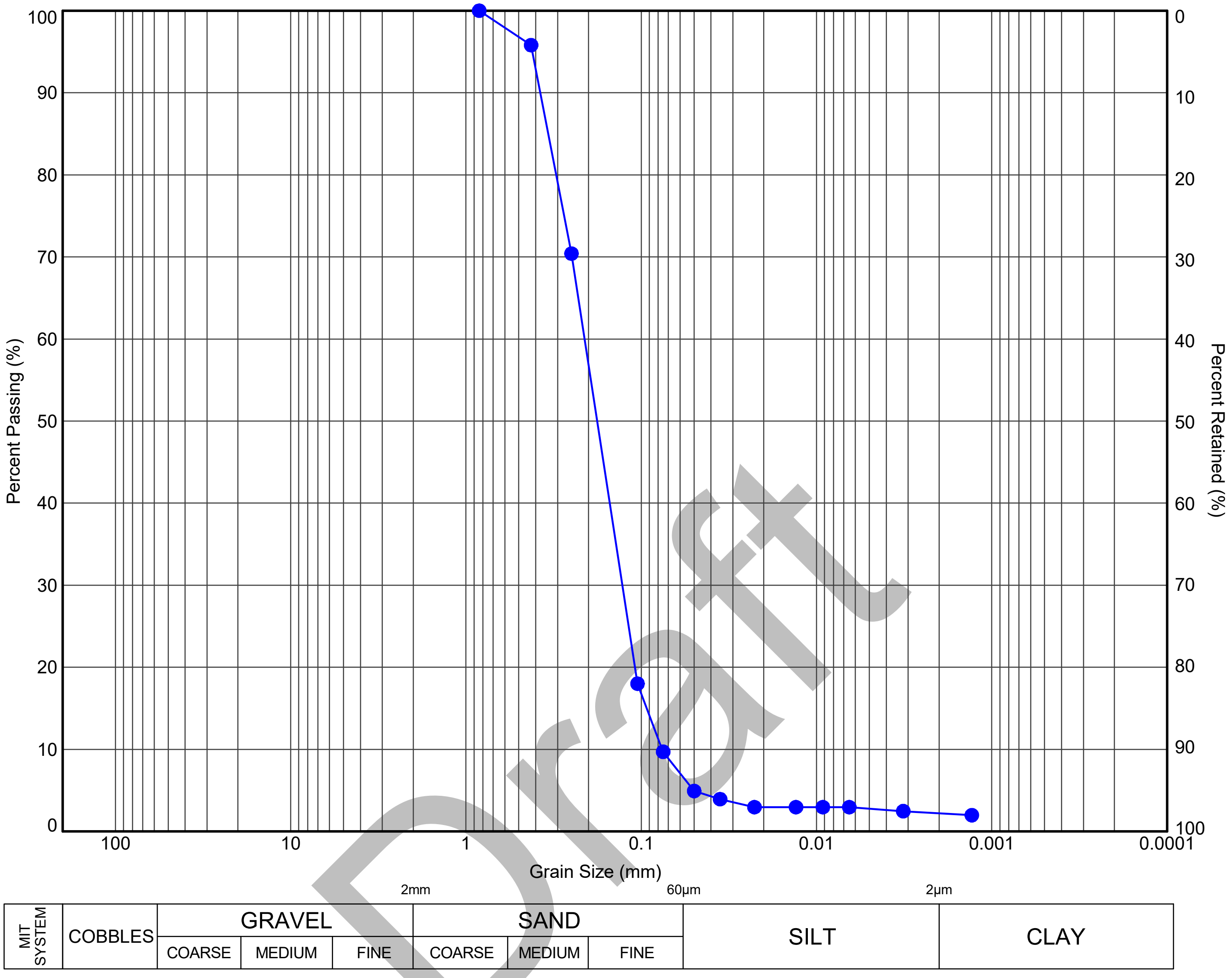
Terraprobe

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

Title:

GRAIN SIZE DISTRIBUTION
SILT, SOME CLAY, TRACE SAND

File No.: **1-15-0700-01**



					MIT SYSTEM				
	Hole ID	Sample	Depth (m)	Elev. (m)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	*(Fines, %)*
●	**13**	SS6	4.8	288.9	0	93	5	2	

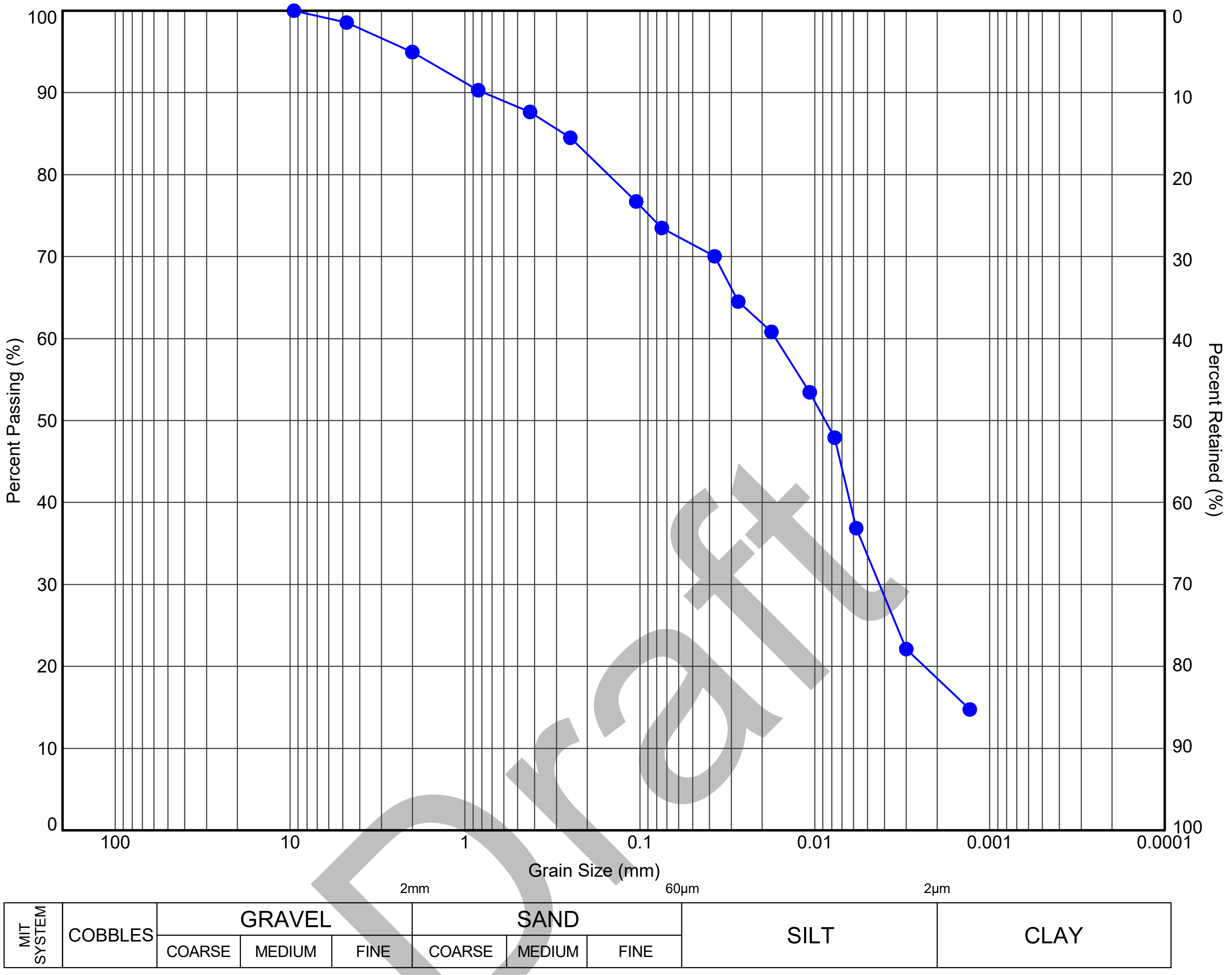
Terraprobe

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

Title:

GRAIN SIZE DISTRIBUTION
SAND, TRACE SILT, TRACE CLAY

File No.: **1-15-0700-01**



	Hole ID	Sample	Depth (m)	Elev. (m)	MIT SYSTEM Gravel (%)	Sand (%)	Silt (%)	Clay (%)	*(Fines, %)*
●	**15**	SS4	2.5	291.3	5	22	54	19	

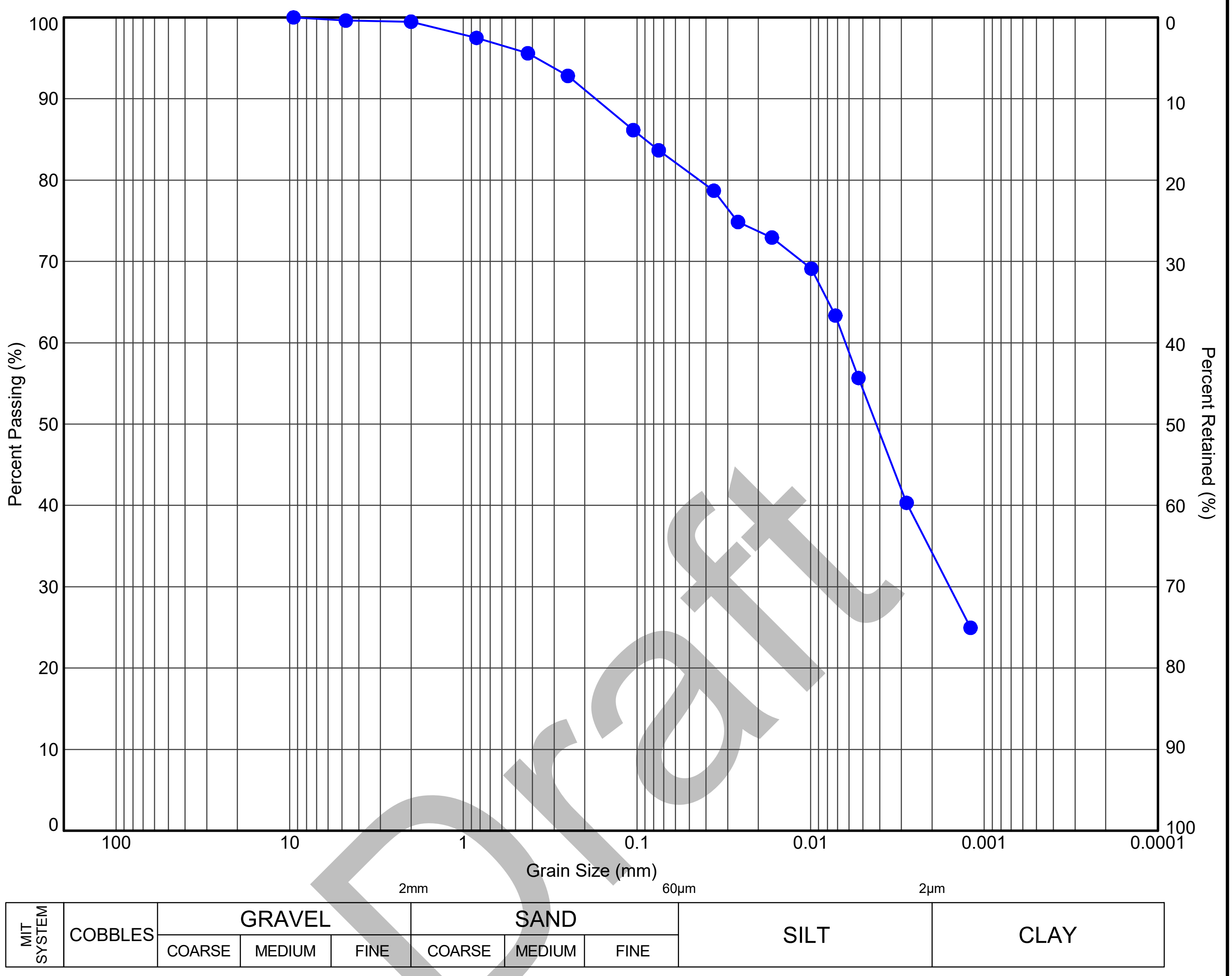
Terraprobe

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

Title:

GRAIN SIZE DISTRIBUTION
SANDY SILT, SOME CLAY, TRACE GRAVEL

File No.: **1-15-0700-01**



					MIT SYSTEM				
	Hole ID	Sample	Depth (m)	Elev. (m)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	*(Fines, %)*
●	**18**	SS5	3.3	292.0	1	17	48	34	

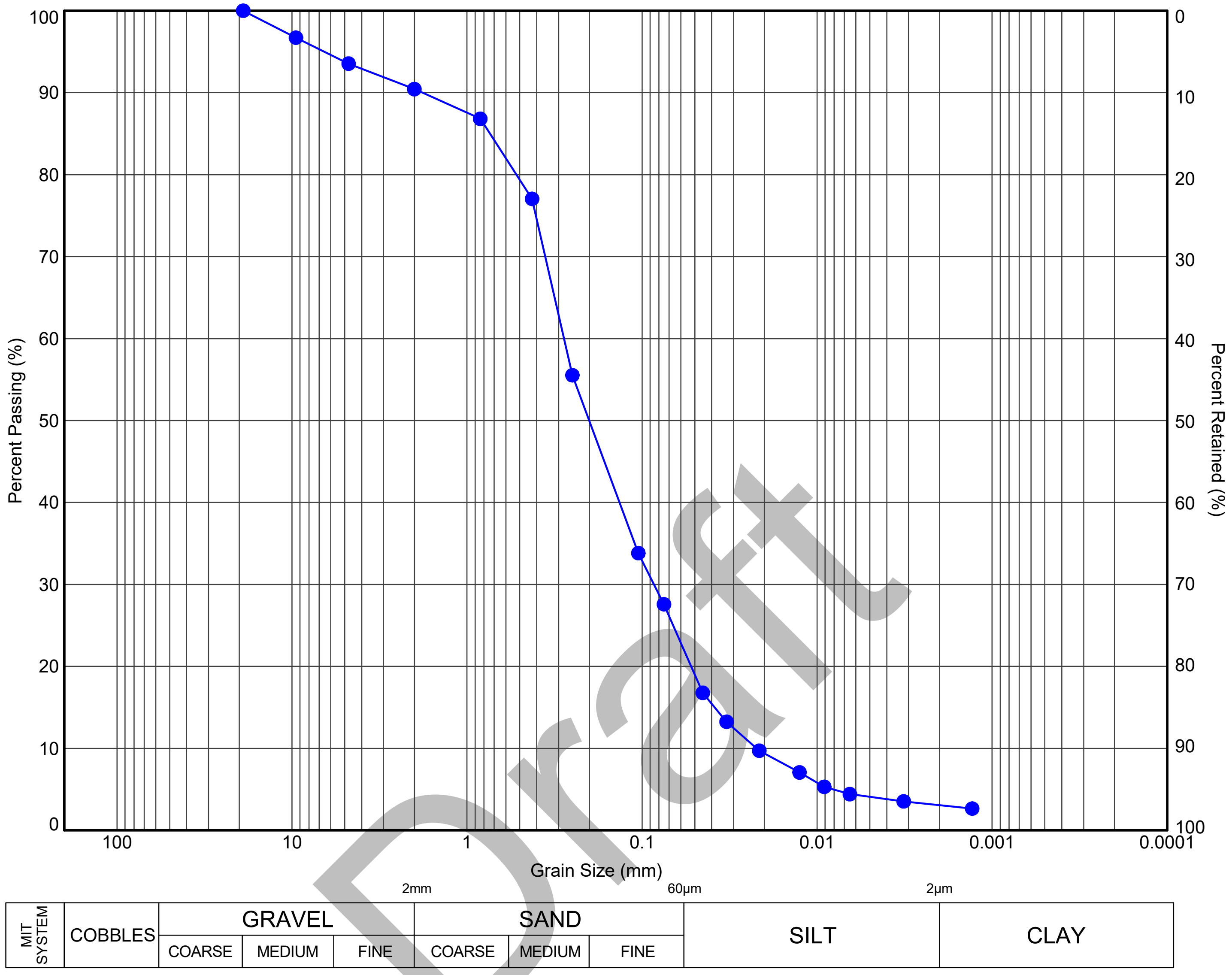
Terraprobe

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

Title:

GRAIN SIZE DISTRIBUTION
CLAYEY SILT, SOME SAND, TRACE GRAVEL

File No.: **1-15-0700-01**



MIT SYSTEM

	Hole ID	Sample	Depth (m)	Elev. (m)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	*(Fines, %)*
●	**20**	SS4	2.5	296.2	10	67	20	3	

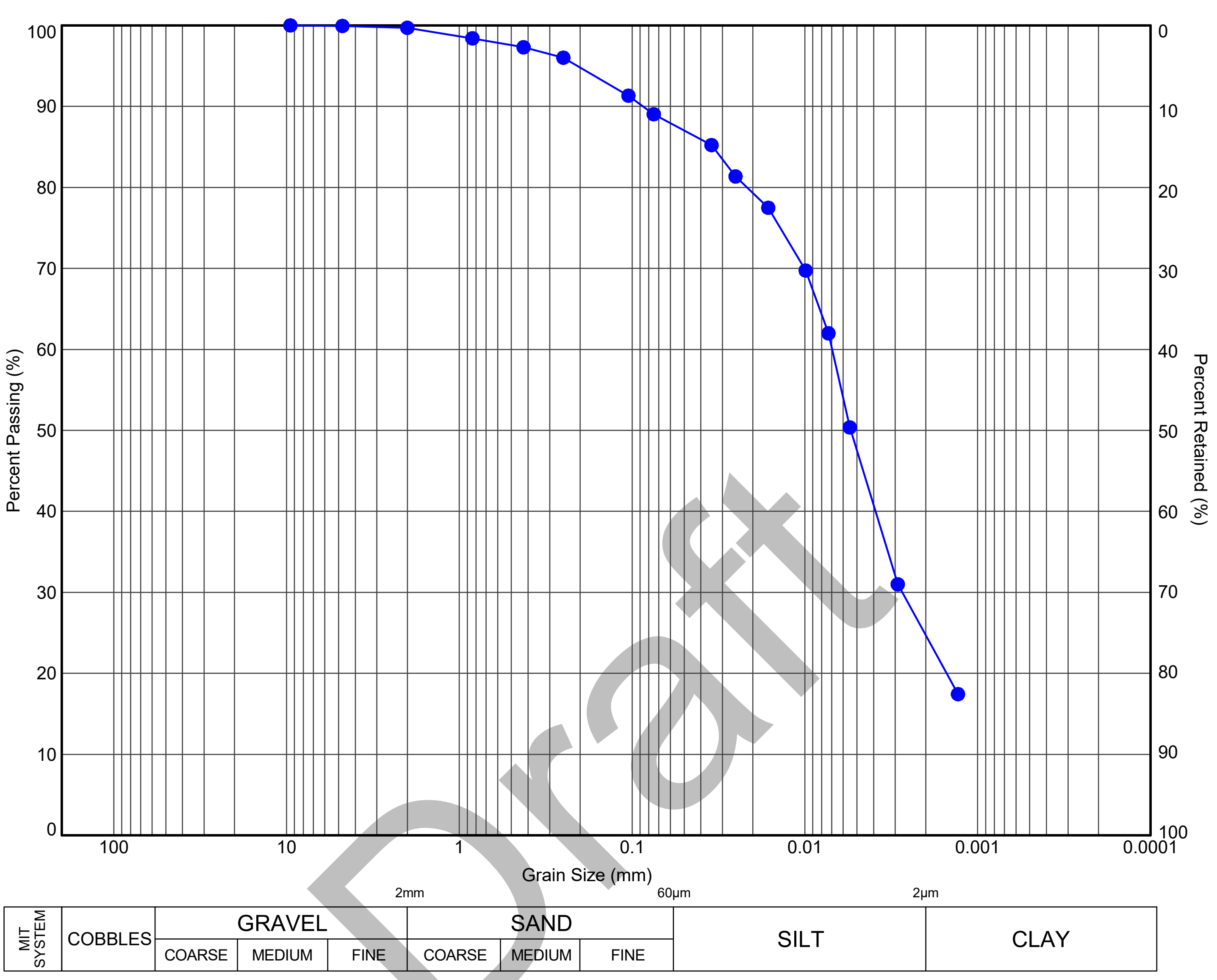
Terraprobe

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

Title:

GRAIN SIZE DISTRIBUTION
SILTY SAND, TRACE GRAVEL, TRACE CLAY

File No.: **1-15-0700-01**



MIT SYSTEM

	Hole ID	Sample	Depth (m)	Elev. (m)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	*(Fines, %)*
●	**21**	SS4	2.5	285.4	0	12	63	25	

Terraprobe

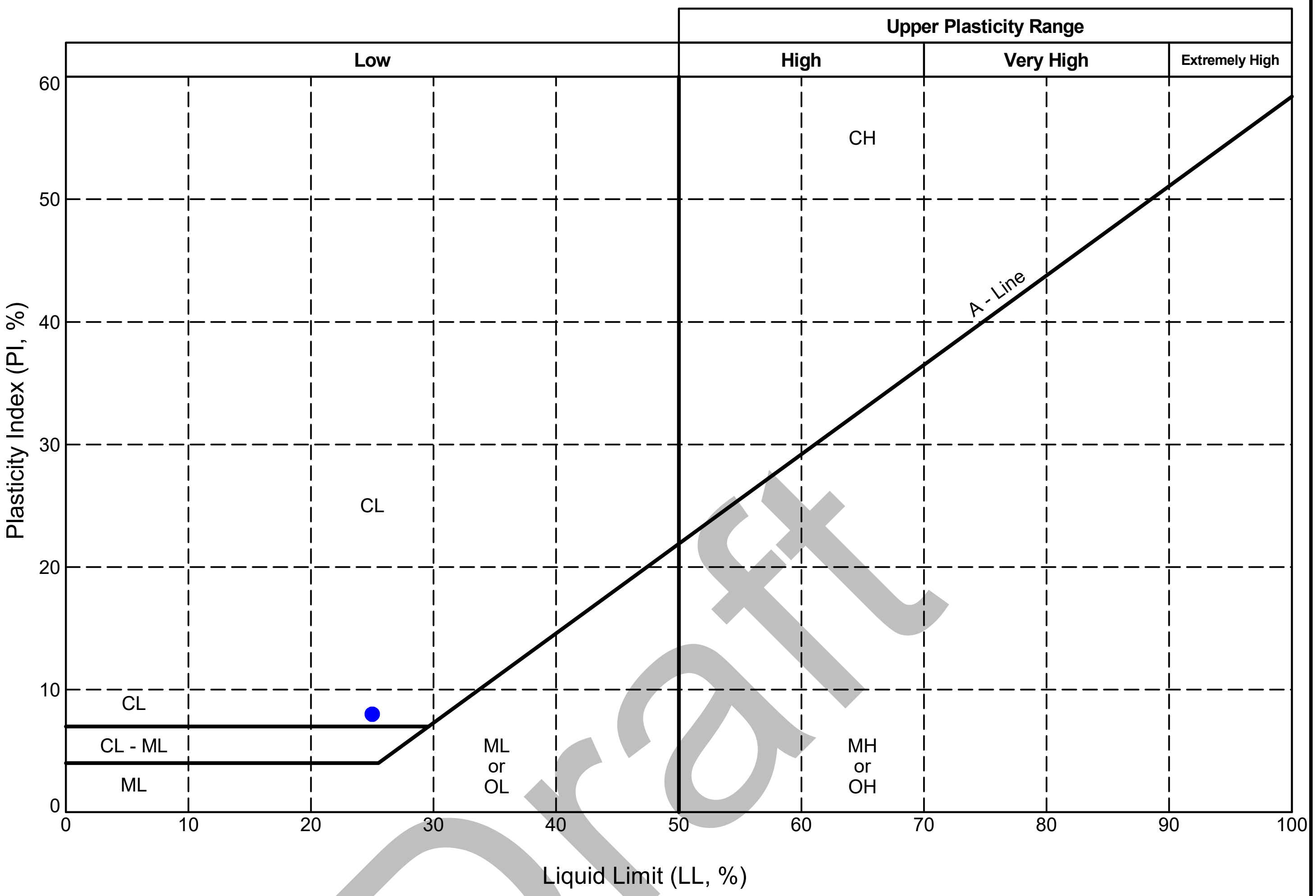
11 Indell Lane, Brampton Ontario L6T 3Y3
(905) 796-2650

Title:

GRAIN SIZE DISTRIBUTION
CLAYEY SILT, SOME SAND

File No.:

1-15-0700-01



	Borehole	Sample	Depth (m)	Elev. (m)	LL (%)	PL (%)	PI (%)	Description
●	21	SS4	2.5	285.4	25	17	8	SLIGHTLY PLASTIC

Terraprobe

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

Title:

ATTERBERG LIMITS CHART

File No.: **1-15-0700-01**

APPENDIX C

TERRAPROBE INC.

File No. 1-15-0700-01

KIRBY ROAD EXTENSION
DUFFERIN STREET TO BATHURST STREET
CITY OF VAUGHAN
Equivalent Single Axle Load Calculation (AADT)

Description - Kirby Road Extension			
Traffic Data Year		**2021**	**2031**
Design Year			
Analysis Period		**2021 to 2031**	**2031 to 2041**
1a) Annual Average Daily Traffic		20,000	25,000
Annual Growth Rate (%)		2.30%	2.30%
1b) Commerical Vehicle Fraction of Total Traffic		1.5%	12.0%
Number of lanes in one direction		2	2
1c) Directional Factor		0.5	0.5
1d) Lane distribution Factor		0.8	0.8
	Daily Truck Volume	**120**	**1200**
Road Classification		**Urban Minor Arterial**	
2) Breakdown of Truck Proportions			
	Class 1	0.65	0.65
	Class 2	0.05	0.05
	Class 3	0.20	0.20
	Class 4	0.10	0.10
3) Daily Truck Volumes (4 Classes)			
	Class 1	78	780
	Class 2	6	60
	Class 3	24	240
	Class 4	12	120
4) Truck Factors (4 Classes)			
	Class 1	0.5	0.5
	Class 2	2.3	2.3
	Class 3	1.6	1.6
	Class 4	5.5	5.5
5) Daily ESALs per Truck Class (4 Classes)			
	Class 1	39	390
	Class 2	14	138
	Class 3	38	384
	Class 4	66	660
6) Total Daily ESALs in Design Lane		**157**	**1572**
7) Total Base Year ESALs		**2021**	**2031**
Number of Days of Truck Traffic		365	365
	Total Base Year ESALs	**57,378**	**573,780**
8) Cumulative ESALs for Design Period			
Analysis Period		10	10
Annual Growth Rate (%)		2.30%	2.30%
Geometric Growth Factor		11.1	11.1
	Cumulative ESALs for the Analysis Period	**637,000**	**6,369,600**
	Cumulative ESALs for the Design Period		**7,006,600**

Note: ESALs calculations are based on traffic data obtained from MTO's Traffic Volume Information System (TVIS) and Adaption and Verification of AASHTO Pavement Design Guide for Ontario Conditions (MI-183), 2008.

1993 AASHTO FLEXIBLE PAVEMENT DESIGN

File No.:	1-15-0700
Project Name:	Kirby Road Extension

Design Structural Number for Future Traffic

Design ESALs:	7,006,600
Initial Serviceability:	4.5
Terminal Serviceability:	2.5
Level of Reliability (%):	90
Overall Standard Deviation:	0.49
Subgrade Resilient Modulus (MPa):	30
Design Structural Number:	**138**

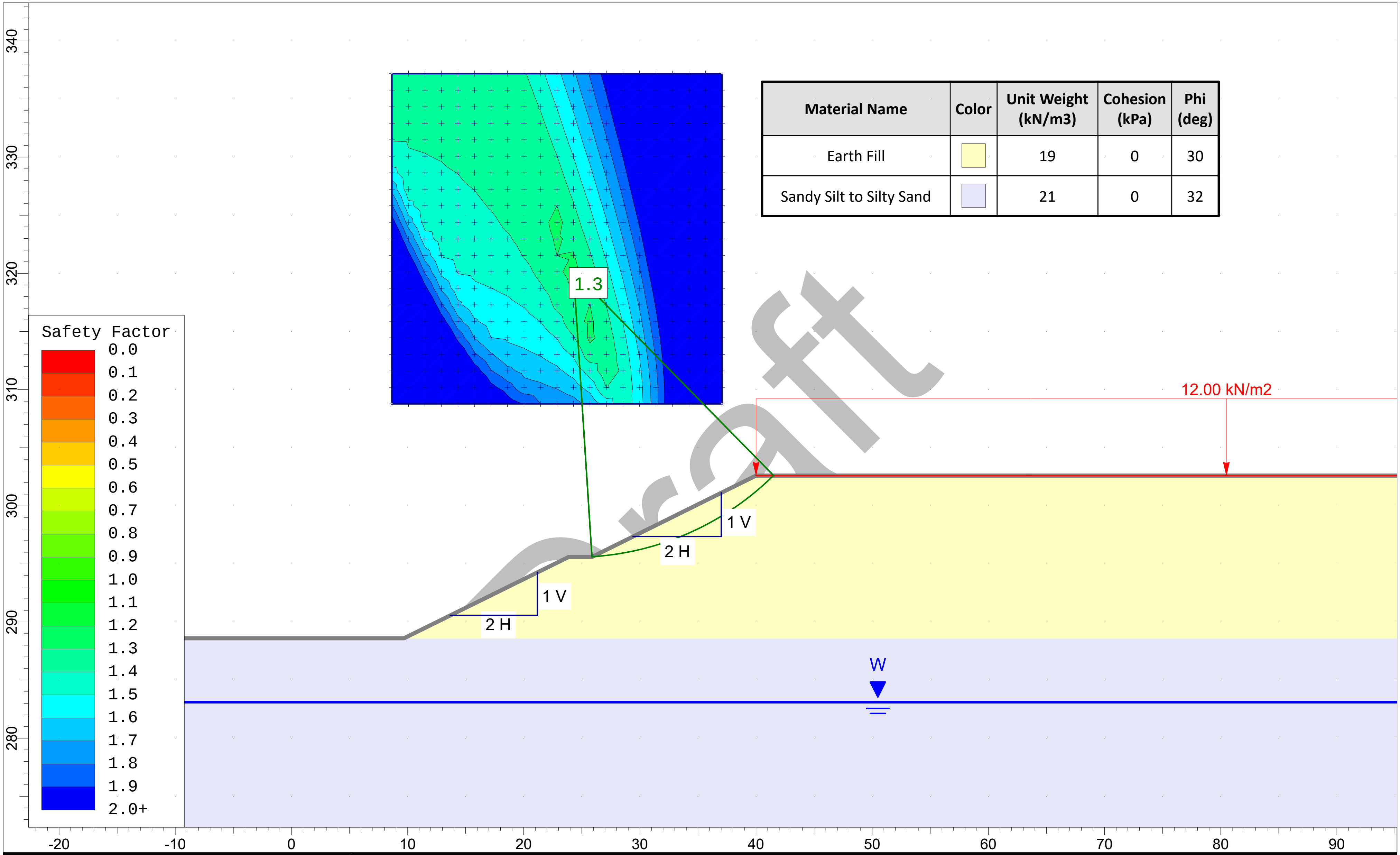
Pavement Structural Design

Pavement Components	**Thickness (mm)**	**Structural Coefficient**	**Drainage Coefficient**	**Structural Number**
HMA	150	0.42	1.0	63
Base Course	150	0.14	1.0	21
Subbase Course	600	0.09	1.0	54
Total	900			138

The designed pavement is structurally adequate.

APPENDIX D

TERRAPROBE INC.



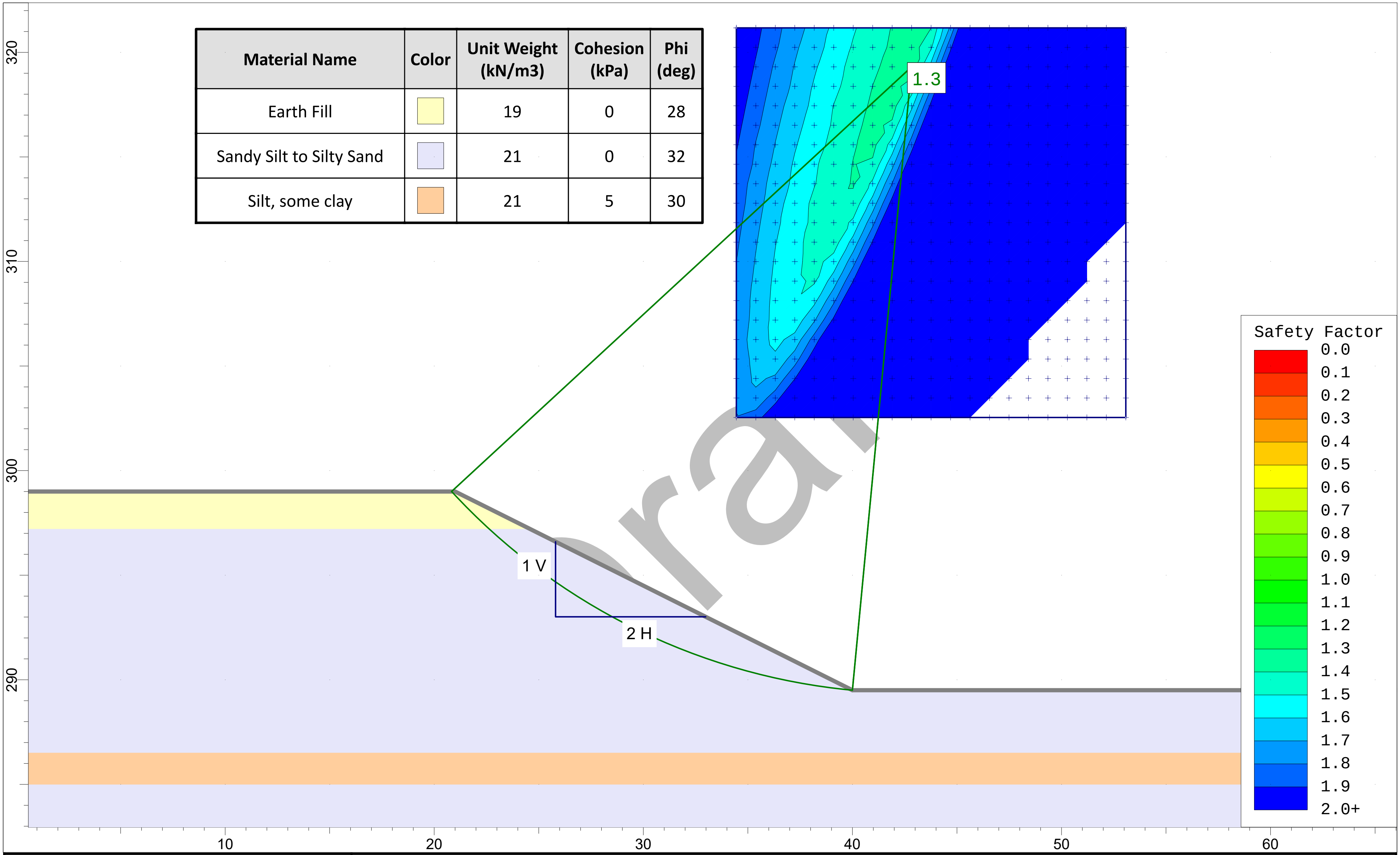
Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Earth Fill	🟨	19	0	30
Sandy Silt to Silty Sand	🟪	21	0	32

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 7.013

Project	**Kirby Road Extension**
Analysis Description	High Embankment

DB	SZ	*Scale*	1:450	*Reference*	Normal Ground Water Level, Circular Slip Surface
Date	2/16/2018			*File Name*	Embankment.slim



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Earth Fill	🟨	19	0	28
Sandy Silt to Silty Sand	🟪	21	0	32
Silt, some clay	🟧	21	5	30

Terraprobe

Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 7.013

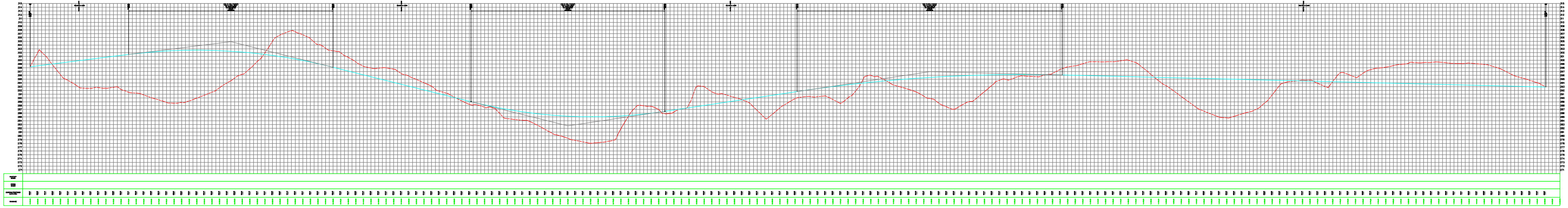
Project	**Kirby Road Extension**		
Analysis Description	Deep Cut		
DB SZ	*Scale* 1:250	*Reference*	Normal Ground Water Level, Circular Slip Surface
Date	2/16/2018	*File Name*	Cut.slim

APPENDIX E

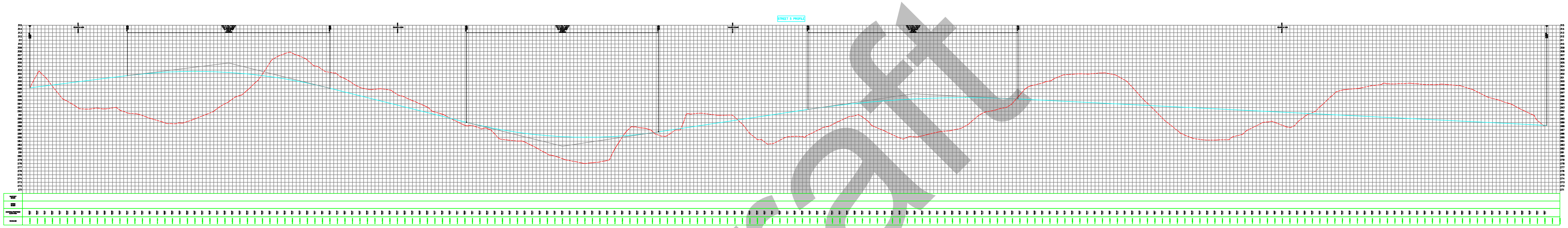
TERRAPROBE INC.

Cad Drawings provided by Schaeffer & Associates Ltd. via email.

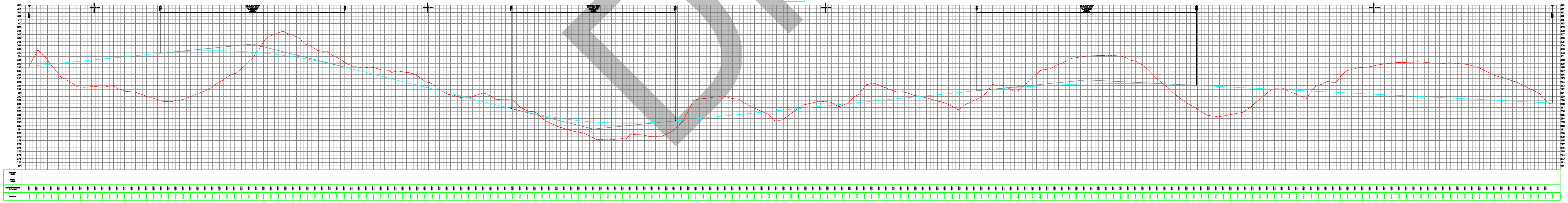
STREET 4 PROFILE



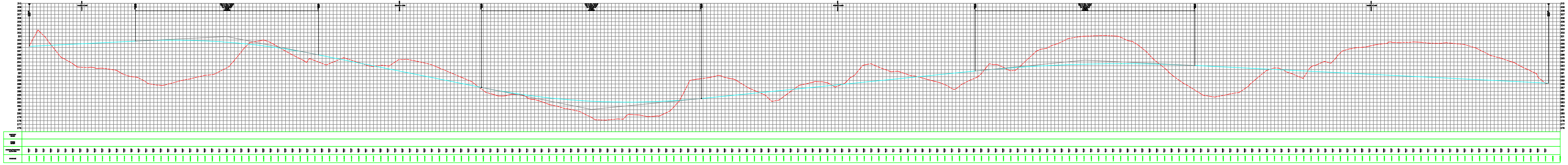
STREET 5 PROFILE



STREET 6 PROFILE



STREET 6A PROFILE



T:\1-Project Files\2015\1-15-0700 - Kirby Road Extension, Vaughan\01-GEO Invest\A. Dwgs, Logs\AutoCAD\DRAWINGS\4339_Profiles (Alignment 4 - 6A).dwg,
Kamal