Terraprobe

Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

GEOTECHNICAL INVESTIGATION
PROPOSED RESIDENTIAL SUBDIVISION
WALDEMAR DEVELOPMENT
TOWNSHIP OF AMARANTH, ONTARIO

Prepared for: Sarah Properties Ltd. Developments
2 Prince Edward Road
Woodstock, Ontario
N4V 1G7

Attention: Mr. Walter Broos

File No. 11-14-4090
April 15, 2015

Distribution:

4 Copies - Sarah Properties Ltd. Developments
1 Copy - Terraprobe Inc., Brampton

Terraprobe Inc.

Greater Toronto
11 Indell Lane
Brampton, Ontario L6T 3Y3
(905) 796-2650 Fax: 796-2250
brampton@terraprobe.ca

Hamilton – Niagara
903 Barton Street, Unit 22
Stoney Creek, Ontario L8E 5P5
(905) 643-7560 Fax: 643-7559
stoneycreek@terraprobe.ca

Central Ontario
220 Bayview Drive, Unit 25
Barrie, Ontario L4N 4Y8
(705) 739-8355 Fax: 739-8369
barrie@terraprobe.ca

Northern Ontario
1012 Kelly Lake Rd., Unit 1
Sudbury, Ontario P3E 5P4
(705) 670-0460 Fax: 670-0558
sudbury@terraprobe.ca

www.terraprobe.ca

TABLE OF CONTENTS

APPENDIX

1. INTRODUCTION

Terraprobe Inc. was retained by Sarah Properties Ltd. Developments to conduct a geotechnical investigation for a property located in the Township of Amaranth, Ontario. The property is currently undeveloped vacant fallow agricultural fields. It is understood that the property would be developed as a residential subdivision comprising single family lots serviced by a municipal water system, a communal sewer system and internal local paved roads.

This report encompasses the geotechnical investigation of the subject site to assess its geotechnical suitability and provides geotechnical engineering recommendations for the intended development. The field investigation consisted of advancing a total of eighteen (18) boreholes and ten (10) test pits. The borehole investigation was conducted to determine the prevailing subsurface soil and ground water conditions. This information is used to provide geotechnical engineering recommendations for the design of proposed house foundations, basement drainage, earthworks, pipe bedding, earth pressure design parameters and pavement structure. In addition, comments are also included on pertinent construction aspects including excavation, backfill, ground water control and installation of underground utilities.

Terraprobe has also conducted Hydrogeologic Study and a Phase One Environmental Site Assessment for the site. The findings of these investigations are reported under separate covers.

2. SITE AND PROJECT DESCRIPTION

The property is located on the west side of the Village of Waldemar and to the north of Highway 9 between 10th Line and Amaranth East Luther Townline. The property is generally bounded by undeveloped rural lands except to the east where it abuts existing estate residential development. The general location of the subject property is presented on Figure 1.

The property is irregular in shape covering an area of about 35 hectares. The property currently consists of open agricultural fields with relatively flat to gently rolling topography. It is proposed to develop the property as a residential subdivision comprising approximately 334 single family residential lots. The development would include municipal paved roadways and be serviced with a municipal water system and a communal sewage system.

3. FIELD PROCEDURE

The field investigation was conducted on March 10 and April 9 to 15, 2014, and consisted of drilling and sampling a total of eighteen (18) boreholes extending to depths ranging from about 4.6 to 12.3 m of below existing ground surface. The field works also included five (5) shallow boreholes for Hydrogeologic Study and ten (10) test pits for sanitary tile bed area. The information of shallow boreholes and test pits are reported and included in the Hydrogeological Investigation report under a separate cover. The boreholes were staked out in the field by Terraprobe Inc. The approximate locations of boreholes are shown on the enclosed Borehole Location Plan (Figure 2).

The ground surface elevations at the borehole locations were obtained from the contour drawing (BASE TOPO - MOD) provided by the client and are assumed to be referenced to the Geodetic Datum. The elevations noted on the borehole logs are approximate, and provided only for the purpose of relating borehole soil stratigraphy, and should not be used or relied on for other purposes.

The borings were drilled by a specialist drilling contractor using a track-mounted drill rig power auger. The borings were advanced using continuous flight solid stem augers, and were sampled at 0.75 m (up to 3.0 m depth) and 1.5 m (below 3.0 m depth) intervals with a conventional 50 mm diameter split barrel samplers 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 testing consisted of water content determination on all samples; and a Sieve and Hydrometer analysis on seven (7) selected native soil samples (Borehole 1, Samples 2 and 9; Borehole 6, Sample 3; Borehole 16, Sample 5; Borehole 17, Samples 3 and 6; and Borehole 18, Sample 5). The measured natural water contents of individual samples and the results of the Sieve and Hydrometer analysis tests are plotted on the enclosed borehole logs at respective sampling depths. The results of laboratory tests (Sieve and Hydrometer analysis tests) are also summarized in Section 4.4 of this report, and appended.

Water levels were monitored in open boreholes upon completion of drilling. Monitoring wells comprising 50 mm diameter PVC tubing were installed in all boreholes to facilitate ground water level monitoring. 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 June 5 and July 3, 2014, respectively (about two and three months following the installation). The results of ground water level monitoring are presented in Section 4.5 of this report.

4. SUBSURFACE CONDITIONS

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

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

In summary, the boreholes encountered a topsoil layer at the ground surface underlain by a zone of weathered/disturbed soils which was in turn underlain by undisturbed native soil deposits extending to the full depth of investigation at all borehole locations.

4.1 Topsoil

A topsoil layer was encountered in all boreholes at the ground surface varying in thickness from about 150 mm (Boreholes, 5, 11, 17 and 18) to 500 mm (Boreholes 3, 4, 7, 8 and 14). The topsoil was dark brown to black in colour and predominately consisted of silt matrix.

It should be noted that the site was ploughed and the upper (surficial zone) of the soil was noted to be mixed/disturbed. Therefore, the topsoil thicknesses noted on the borehole logs are approximate, estimated from the boreholes. The above data is not sufficient for estimating topsoil quantities and/or associated costs. A shallow test pit investigation should be carried out to measure accurate topsoil thickness across the site for topsoil quantity estimation, if required.

4.2 Weathered/Disturbed Soil Zone

A zone of weathered/disturbed soil was encountered beneath the surficial topsoil layer in all boreholes. The weathered/disturbed soil extended to depths varying from about 0.5 m (Boreholes 6 and 16) to as much as 3.0 m (Borehole 3) below grade. The composition of weathered/disturbed soils was generally similar to that of the underlying undisturbed native soils, and included a trace amount of organics/topsoil.

The Standard Penetration Test results (‘N’ Values) obtained from weathered/disturbed materials generally varied from 4 to 24 blows per 300 mm of penetration, indicating a loose to compact relative density (cohesionless soils) and soft to very stiff consistency (cohesive soils). Some of the high ‘N’ Values obtained from the weathered/disturbed soil may likely be due to partially frozen ground condition and may not necessarily represent the state of compactness of the materials tested.

The measured moisture contents of the weathered/disturbed soil sample typically ranged between 15 to 39 percent by mass, indicating a typically moist to very moist to locally wet condition.

4.3 Native Soils

Undisturbed native soil deposit was encountered in all boreholes beneath the zone of weathered/disturbed materials and extended to the full depths of investigation varying from 4.6 to 12.3 m below grade. The composition of native soil deposits is relatively consistent across the site, generally consisting of clayey silt to sandy silt and sand and silt tills.

It must be noted that the undisturbed native soil deposit is likely to contain larger size particles (cobbles and boulders) that are not specifically identified in the boreholes. The size and distribution of such obstructions cannot be predicted with borings, because the borehole sampler size is insufficient to secure representative samples for the particles of this size.

4.3.1 Clayey Silt Till

Undisturbed native clayey silt till deposit was encountered at all boreholes with exceptions of Boreholes 6, 12 and 14 beneath the weathered/disturbed soil zone. The glacial till predominately consisted of clayey silt matrix with varying amounts of sand (trace sand to sandy) and trace to some gravel. The clayey silt till soils extended to the depths of about 1.5 m (Borehole 16) to 9.1 m (Borehole 3) below grade.

The Standard Penetration Test results (‘N’ Values) obtained from the clayey silt till soils generally varied from 10 to 94 blows per 300 mm of penetration and to 50 blows per 50 to 150 mm of penetration, indicating a stiff to hard (typically very stiff to hard) consistency. The measured moisture contents of the clayey silt till soil samples generally ranged from 8 to 30 percent by mass, indicating a typically moist condition.

4.3.2 Sandy Silt to Sand and Silt Till

Undisturbed native sandy silt to sand and silt till deposit was encountered in Boreholes 1, 3, 6 and 11 to 17 beneath gravel and sand, clayey silt till and weathered/disturbed soil zone at depths varying from about 0.6 m (Borehole 12) to 10.7 m (Borehole 1) below grade. The glacial till deposit included trace to some clay and gravel. This deposit extended to the full depth of the investigation varying from about 4.6 m (Borehole 6) to 12.3 m (Borehole 3) below grade.

The Standard Penetration Test results (‘N Values) obtained from the cohesionless till deposit generally varied from 15 to 85 blows per 300 mm of penetration and 50 blow per 0 to 150 mm penetration, indicating a compact to very dense relative density (predominately very dense). The measured moisture contents of these soil samples typically ranged from 3 to 19 percent by mass, indicating a damp to moist condition.

4.3.3 Sand/Sand and Gravel

A layer of sand/sand and gravel was encountered beneath embedded within the glacial till deposit at depths of about 7.6 m and 2.7 m below grade in Boreholes 1 and 7 respectively, and extended to depths of about 4.6 m (Borehole 7) and 10.7 m (Borehole 1) below grade.

The Standard Penetration Test results ('N' Values) obtained from these soils were 29 and 68 blows per 300 mm of penetration, indicating a compact to very dense relative density. The measured moisture contents of these soil samples ranged from 10 to 17 percent by mass, indicating a typically wet condition.

4.4 Geotechnical Laboratory Test Results

The geotechnical laboratory testing consisted of water content determination for all samples, while a Sieve and Hydrometer analysis test was conducted on selected soil samples. The measured natural water contents of individual samples and the results of the Sieve and Hydrometer analysis tests 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 below:

Borehole No. Sample No.	Sampling Depth below Grade	Percentage				Description (MIT System)
		Gravel	Sand	Silt	Clay	
Borehole 1 Sample 2	0.8 m	0	9	54	37	CLAYEY SILT, trace sand
Borehole 1 Sample 9	9.1 m	47	42	11		GRAVEL AND SAND, some silt
Borehole 6 Sample 3	1.5 m	10	41	40	9	SAND AND SILT, some gravel, trace clay
Borehole 16 Sample 5	3.0 m	14	38	37	11	SAND AND SILT, some gravel, some clay
Borehole 17 Sample 3	1.5 m	3	26	47	24	CLAYEY SILT, sandy, trace gravel
Borehole 17 Sample 6	4.6 m	11	37	37	15	SAND AND SILT, some clay, some gravel
Borehole 18 Sample 5	3.0 m	3	26	49	22	CLAYEY SILT, sandy, trace gravel

4.5 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 all boreholes to facilitate ground water level monitoring. The ground water level measurements in the monitoring wells were taken on June 5 and July 3, 2014, (about two and three months following the installation) and are noted on the enclosed borehole logs. A summary of measured ground water level is provided below:

Borehole No.	Depth of Boring	Depth to Cave	Water Level Depth/Elevation at Time of Drilling	Water Level Depth/Elevation in Monitoring Well June 5, 2014	Water Level Depth/Elevation in Monitoring Well July 3, 2014
1	12.2 m BG	Open	3.0 m BG/471.2 m	-0.9 m BG/475.1 m	1.3 m BG/472.9 m
2	6.6 m BG	Open	4.6 m BG/466.2 m	1.5 m BG/469.3 m	3.4 m BG/467.5 m
3	12.3 m BG	Open	Dry	5.4 m BG/ 464.7 m	8.2 m BG/ 461.9 m
4	6.6 m BG	Open	Dry	4.3 m BG/ 466.1 m	4.9 m BG/ 465.5 m
5	6.2 m BG	Open	Dry	5.8 m BG/ 462.7 m	6.0 m BG/ 462.5 m
6	4.6 m BG	Open	Dry	1.1 m BG/ 465.6 m	1.9 m BG/ 464.8 m
7	6.6 m BG	Open	3.7 m BG/ 469.1 m	1.5 m BG/ 471.3 m	1.8 m BG/ 471.0 m
8	6.6 m BG	Open	Dry	1.6 m BG/ 467.4 m	2.2 m BG/ 466.8 m
9	5.0 m BG	Open	Dry	1.1 m BG/ 464.9 m	1.5 m BG/ 464.5 m
10	5.0 m BG	Open	Dry	2.2 m BG/ 467.5 m	2.6 m BG/ 467.0 m
11	12.2 m BG	Open	Dry	5.3 m BG/ 463.0 m	5.6 m BG/ 462.7 m
12	4.6 m BG	Open	3.7 m BG/ 462.5 m	1.9 m BG/ 464.3 m	2.5 m BG/ 463.7 m
13	4.7 m BG	Open	4.0 m BG/ 458.8 m	2.8 m BG/ 460.0 m	3.3 m BG/ 459.5 m
14	5.5 m BG	Open	4.6 m BG/ 458.6 m	1.7 m BG/ 461.5 m	2.3 m BG/ 460.9 m
15	12.2 m BG	Open	9.1 m BG/ 461.3 m	6.2 m BG/ 464.2 m	7.1 m BG/ 463.3 m
16	5.0 m BG	Open	4.3 m BG/ 461.2 m	1.5 m BG/ 464.0 m	2.2 m BG/ 463.3 m
17	4.8 m BG	Open	Dry	1.7 m BG/ 466.1 m	2.2 m BG/ 465.6 m
18	5.0 m BG	Open	Dry	1.7 m BG/ 461.8 m	2.1 m BG/ 461.4 m

BG = Below Grade

It should be noted that the ground water levels indicated above may fluctuate seasonally depending on the amount of precipitation and surface runoff. Wet soils may be encountered up to about 0.6 m above measured water level due to capillary rise in fine cohesionless silt/sand soils.

5. DISCUSSION AND RECOMMENDATIONS

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

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

5.1 Foundations

The boreholes encountered a topsoil layer at the ground surface generally underlain by a weathered/disturbed soil zone extending to depths varying from about 0.5 to 3.0 m below grade, which was in turn underlain by undisturbed native soil deposit extending to the full depth of investigation.

The existing topsoil and weathered/disturbed soils are unsuitable for the support of proposed house foundations. All foundations must be supported on the underlying competent undisturbed native soils or on engineered fill, if applicable.

It is understood that the proposed houses would be supported on conventional spread footing foundations. The following subsections provide geotechnical design recommendations for the house foundations.

5.1.1 Spread Foundations on Native Soils

The undisturbed native soils are considered suitable to support the proposed house foundations. The development details (including site grading plan) were not available at the time of preparation of this report. However, it is understood that the proposed houses would likely include a basement. A nominal net geotechnical reaction of 150 kPa (Serviceability Limit States, SLS) and factored geotechnical resistance of

225 kPa (Ultimate Limit States, ULS) may be used for preliminary design of conventional spread footing foundations (for vertical and concentric loads) supported on the underlying competent undisturbed native till soils of very stiff to hard consistency or compact to very dense relative density.

It should be noted that the foundations at Borehole 3 will have to be extended deeper (about 3.3 m below existing grade) to support them on underlying competent glacial till soil. We understand that the proposed houses will have a basement, and therefore based on the final site grading details, the design foundation elevations may already have to be designed deeper at the levels of underlying competent undisturbed native till soils. Regardless, the final site grading and house foundation elevations should be reviewed by Terraprobe to assess the design founding levels and corresponding soil bearing pressures available at the design foundation depths.

All foundations must be designed to bear at least a minimum of 0.3 m into the competent undisturbed native soil stratum. The minimum width of continuous strip footing should be 500 mm, and the minimum size of isolated footings should be 900 mm x 900 mm, in conjunction with the above bearing pressure. Footing width for houses and small building are stipulated in Division 2, Part 9 of Ontario Building Code (2006) and must be followed regardless of the foundation recommendation provided in this report.

5.1.2 Foundations on Engineered Fill

The design grading may require ambient site grades to be raised in some areas. If site grades are required to be raised, consideration should be given to construction of engineered fill which may also support house foundations at normal depths, if needed. The engineered fill refers to earth fill designed and constructed under full-time inspection and testing supervision of a geotechnical engineer to support the house foundations without excessive settlement.

Prior to the placement of the engineered fill, it is recommended that the topsoil and/or weathered and disturbed native soils be stripped from beneath and beyond the proposed house footprints (minimum of 2 m beyond), and that the subgrade be proof-rolled. Any soft or wet areas which deflect excessively during the proof roll, should be sub-excavated and replaced with suitably compacted clean earth fill placed in maximum 150 mm thick lifts. It should be noted that localized subgrade stabilization measures may be required, based on the proof-roll assessment. The selection and sorting of the existing weathered/disturbed soils present on the site should be conducted under the supervision of a geotechnical engineer. These materials may be utilized as engineered fill, provided these soils are not too wet to achieve specified compaction, and do not contain excessive organic inclusion. The moisture content of the engineered fill material must be within 2 percent of its optimum moisture content.

The engineered fill should consist of clean earth fill or imported granular materials (OPSS 1010), and should be placed in lifts of 150 mm thicknesses or less, and compacted to a minimum of 98 percent Standard Proctor Maximum Dry Density (SPMDD). The engineered fill should extend for a distance of at least 2 m beyond the house footprint as measured at the founding level, and should extend downwards from this point at a 1 to 1 (horizontal to vertical) slope, to the approved subgrade. In addition, the engineered fill should extend at least 0.6 m above the proposed foundation elevation. This is to ensure that the foundations are placed on the engineered fill both in plan and elevation.

The placement and inspection of the engineered fill must be conducted under the full time supervision of a qualified geotechnical engineer. Provided the engineered fill is placed and compacted as indicated above, a maximum net allowable geotechnical reaction of up to 150 kPa (Serviceability Limit States, S.L.S.) and 225 kPa (factored geotechnical resistance at Ultimate Limit States, U.L.S.) may be utilized for the design of conventional spread footing foundations supported on engineered fill. Site grading plan should be reviewed by Terraprobe to better assess the suitability and requirements for engineered fill.

In case of footings supported on engineered fill, the minimum width for the conventional spread strip footing must be 600 mm, and the minimum size of the individual column footing must be 1000 mm x 1000 mm, regardless of loading considerations.

It should be noted that for houses placed on engineered fill, nominal reinforcing steel is recommended in the foundation walls. The reinforcing steel should consist of two (2) continuous 15 M bars at the top of the foundation wall and two (2) continuous 15 M bars at the bottom (Figure 3). A draft copy of "Engineered Fill Earthworks Specifications" is append for reference.

5.1.3 Placement of Footings

All exterior foundations and foundations in unheated areas must be provided with a minimum soil cover of 1.2 m or equivalent insulation for frost protection. All footings must be designed and constructed to bear at least 0.3 m into the undisturbed native soil/engineered fill stratum.

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

Prior to pouring concrete for the footings, the footing 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 footing bases and concrete must be provided.

Native soils and engineered fill materials tend to weather rapidly and deteriorate on exposure to the atmosphere and surface water. Hence, foundation bases which remain open for an extended period of time should be protected by a skim coat of lean concrete.

It should be noted that wet/dilatant soils may be encountered at the design foundation elevation at some borehole locations. Foundation subgrade comprising wet/dilatant soil will become weak and unstable due to disturbance, and will loose its integrity to support foundation. Consideration should be given to minimize disturbance to the foundation subgrade in these areas and the subgrade may need to be protected by a skim coat of lean concrete. For foundation excavations extending below the ground water level, it will be necessary to lower and maintain the ground water level below the excavation base. Further comments on the ground water control are presented in Section 5.5 of this report.

5.2 Basement Floor Slab

Concrete floor slab should be placed on at least 150 mm of granular base (OPSS 1010 Granular “A” or 19 mm crusher run limestone or OPSS 1004 19 mm Clear Stone) compacted to a minimum of 98 percent SPMDD or vibrated into a dense state in case of a clearstone material. The subgrade should be assessed and approved by a geotechnical engineer prior to the placement of granular base. Any incompetent, soft and wet subgrade areas identified must be subexcavated and backfilled with suitable compacted clean earth fill or imported granular materials. The granular base should be placed either on undisturbed native subgrade or clean earth fill compacted to at least 98 percent SPMDD.

5.3 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 at depth h (kPa)
K = the earth pressure coefficient
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 $R = N \tan \phi$. The factored geotechnical resistance at ULS is **0.8 R**.

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

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

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

Stratum/Parameter	ϕ	γ	K_a	K_o	K_p
Weathered/Disturbed Soil	30	19.5	0.33	0.50	3.00
Clayey Silt Till	30	21.5	0.33	0.50	3.00
Sandy Silt to Sand and Silt Till Sand and Gravel/Sand	32	21.5	0.31	0.47	3.25

The values of the earth pressure coefficients noted above are for the horizontal ground surface/backfill. The earth pressure coefficients for inclined ground surface/backfill behind the retaining structure will vary based on the inclination of the retained ground surface.

5.4 Basement Drainage

As noted before, all boreholes remained open and water levels upon completion of drilling ranged from 3.0 to 9.1 m (or dry) below grade. Water levels measured in the monitoring wells on June 5 and July 3, 2014 indicated that the water levels generally varied from 1.1 to 8.2 m below grade. Therefore, varying amounts of ground water seepage may be encountered in the excavation in some areas (depending upon the depth of excavation) .

To assist in maintaining basements dry from seepage, it is recommended that exterior grades around the house be sloped away at a 2 percent gradient or more, for a distance of at least 1.2 m. As well, perimeter foundation drains should be provided, consisting of perforated pipe with filter fabric (minimum 100 mm diameter) surrounded by a granular filter (minimum 150 mm thick), and freely outletting. The granular filter should consist of OPSS 1004 19 mm Clear Stone (Figure 4 Basement Drainage Detail).

The basement wall (for basements) must be provided with damp-proofing provisions in conformance to the Section 9.13.2 of the Ontario Building Code. The basement wall backfill for a minimum lateral distance of 0.6 m out from the wall should consist of free-draining granular material (OPSS 1010 Granular 'B'), or provided with a suitable alternative drainage cellular media. The perimeter drain installation and outlet provisions must conform to the plumbing code requirements.

A provision of a sub-floor drainage system installed beneath the basement floor slab is recommended in addition to the above recommended perimeter drainage. The sub-floor drainage system should consist of perforated pipes located at a maximum spacing of 5.0 m centre to centre (Figure 4 Basement Drainage Detail and Figure 5 Basement Subdrain Detail). The perimeter foundations and sub-floor drains may be outlet to a suitable discharge point under gravity flow, or connected to a sump located in the lowest level of the basement and the water be pumped to a suitable discharge point. The perimeter and sub-drain installation and outlet should conform to the applicable (plumbing) code requirements.

The size of the sump should be adequate to accommodate the water seepage. The sub-floor drainage system should be designed to prevent the possibility of back-flow. A duplex pumping arrangement (main pump with a provision of a backup pump) on emergency backup power is recommended. The pumps should have sufficient capacity to accommodate a maximum peak flow of water of about 6 to 8 gallons per minute. This flow is not anticipated to be a sustained flow, but could be achieved under certain peak flow conditions.

5.5 Excavations and Ground Water Control

The borehole data indicate that topsoil, weathered/disturbed and undisturbed native soils would be encountered in the excavations. Excavations must be carried out in accordance with the Occupational Health and Safety Act and Regulations for Construction Projects. These regulations designate four broad classifications of soils to stipulate appropriate measures for excavation safety.

TYPE 1 SOIL

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

TYPE 2 SOIL

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

TYPE 3 SOIL

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

TYPE 4 SOIL

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

The weathered/disturbed native soils encountered in the boreholes are classified as Type 3 Soil above and Type 4 Soil below the prevailing groundwater level, while undisturbed native soils are classified as Type 1 to Type 3 soil based on soil's consistency or relative density and ground water level under these regulation.

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 Occupational Health and Safety Act and Regulations for Construction Projects. The regulation stipulates steepest slopes of excavation by soil type as follows:

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

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

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

Ground water levels upon completion of drilling ranged from 3.0 to 9.1 m below grade, while some boreholes remained dry. The ground water levels measured in the monitoring wells June 5 and July 3, 2014 indicated that the water level generally ranged from 1.1 to 8.2 m below grade. It must be noted that the ground water levels noted in the boreholes may fluctuate seasonally and wet soil may be found as much as 600 mm above the measured ground water levels where there is capillary rise in fine, cohesionless silt/sand soils.

Based on the borehole information, it is understood that there may be some ground water seepage in the excavation in some areas (depending upon the depth of excavation). This seepage will likely emanate from very moist to wet cohesionless sand and gravel/sand/silt lenses encountered within the glacial till deposit. The perched groundwater 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. The amount of water seepage is expected to increase with the depth of excavation. For excavations extending into the underlying very moist and wet sand/silt/sand and gravel zones, and/or 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. Without positive ground water control and lowering the prevailing ground water level, the subgrade in wet permeable soil zones will become weak and lose its integrity to support. 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.

It should be noted that excavations carried through and below the water bearing cohesionless soil deposit (silt, sand, gravel) will experience loosening and sloughing of the base and sides, unless the ground water level is lowered first. Consideration should be given to conduct test pit excavation to further assess the ground water influx, excavation stability and to provide updated ground water control recommendations once the site servicing and other developments details are finalized. Dewatering of more than 50,000 litres/day would require a permit from the Ministry of Environment.

5.6 Backfill

The existing topsoil and weathered/disturbed soils containing excessive amounts of organics should not be reused as backfill in settlement sensitive areas (beneath the floor slabs, trench backfill and pavement areas). However, these materials may be stockpiled and reused for landscaping purposes. The weathered/disturbed materials with only trace amounts of organic inclusion may be utilized as backfill. The selection and sorting of weathered/disturbed materials should be conducted under the supervision of a geotechnical engineer.

The approved weathered/disturbed and native soils are considered suitable for backfill provided these soils are within 3 percent of the optimum moisture content. It should be noted that there will likely be wet zones within the subsurface soils which could be too wet to compact. Any soil material with 3 percent or higher in-situ moisture content than its optimum moisture content, could be put aside to dry or be tilled to reduce the moisture content so that it can be effectively compacted. Alternatively, materials of higher moisture content could be wasted and be replaced with imported material which can be readily compacted. The site soils would be best compacted with a heavy sheepsfoot type roller.

In settlement sensitive areas (beneath the floor slabs, trench backfill and pavement areas), the backfill should consist of approved clean earth and should be placed in lifts of 150 mm thicknesses or less, and heavily compacted to a minimum of 95 percent SPMDD at a water content close to optimum. The soils encountered on the site will be best compacted with a heavy sheepsfoot type roller.

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

5.7 Pipe Bedding

The design details and invert elevations of the underground utilities were not available at the time of preparation of this report. The site stratigraphy predominantly consists of an upper weathered/disturbed soil zone underlain by undisturbed native soil deposit extending to the full depths of investigation. The undisturbed native materials and approved compacted earth fill will be suitable for support of buried services on a conventional well graded granular base material. It is recommended that the utility subgrade be inspected by a geotechnical engineer or its representative during construction. The utility subgrade may require stabilization as deemed necessary based on the subgrade assessment, particularly if it consists of weathered/disturbed soils and/or wet dilatant materials. When the disturbance of the trench base has occurred, such as due to ground water seepage, or construction traffic, the disturbed soils should be subexcavated and replaced with suitably compacted granular fill.

Granular bedding material should consist of a well graded, free draining soil, such as OPSS 1010 Granular "A" or 19 mm crusher-run limestone or as approved by the Town/County. A clear stone type bedding may also be considered if approved by the regulatory agencies. The bedding material should be placed in maximum 150 mm thick lifts and compacted to a minimum of 95 percent SPMDD or vibrated/tamped to a dense state in case of a clear stone material.

The clear stone bedding on cohesionless soil (silt/sand/sand and gravel) subgrade may be considered but only in conjunction with a suitable geotextile filter (Terrafix 270 R or equivalent); otherwise without proper filtering, there may be entry of fines from the surrounding soils into the bedding. This loss of ground could result in loss of support to the pipes and in possible future settlements.

5.8 Pavement Design

The proposed development would include construction of paved internal local roads.

The boreholes encountered a surficial layer of topsoil underlain by a zone of weathered/disturbed materials below grade. The weathered/disturbed materials were underlain by undisturbed native soil deposit which extended to the full depths of investigation.

Although the final design grades were not available at the time of preparation of this report, however, based on the existing site conditions and currently available information, it is understood that both cut and fill may be required for site grading, therefore, the pavement subgrade may consist of undisturbed native soil and compacted earth fill. The pavement subgrade should be proof-rolled with a heavy rubber tire vehicle (such as a grader) and any loose, soft, wet or unstable areas should be sub-excavated, and backfilled with clean earth fill material placed in 150 mm thick lifts and compacted to a minimum of 98 percent SPMDD. Local subexcavation in some areas may be required due to incompetent subgrade conditions (loose/soft, wet and/or excessive topsoil/organic presence) as identified during proof roll.

The existing weathered/disturbed soils encountered on the site may be utilized for subgrade preparation provided they do not contain excessive amounts of organics and deleterious materials, as well as their in-situ moisture content is within 3 percent of the optimum moisture content. The selection and sorting of the weathered/disturbed soils for reuse should be conducted under the supervision of a geotechnical engineer. Pavement subgrade (consisting of fill material) should be compacted to a minimum of 95 percent SPMDD, while the upper zone (within 1.2 m of the design subgrade) should be compacted to a minimum of 98 percent SPMDD.

The following pavement thicknesses for the internal local roadways are recommended. These pavement component design thicknesses should be compared with the Township Standards which should be followed if the Township Standards are higher or more stringent than the pavement design noted below.

Pavement Layers	Minimum Component Thickness	Compaction Requirements
Hot Mix Asphalt Surface Course, OPSS 1150 HL 3	40 mm	as per OPSS 310
Hot Mix Asphalt Binder Course, OPSS 1150 HL 8	60 mm	
Base Course, OPSS 1010 Granular A	150 mm	a minimum of 100 percent Standard Proctor Maximum Dry Density (ASTM D698)
Subbase Course, OPSS 1010 Granular B Type I	350 mm	

The granular materials should be placed in lifts 150 mm thick or less, and compacted to a minimum of 100 percent SPMDD for granular base and subbase. Hot mix asphalt mixes should be produced and placed in accordance with OPSS 310, OPSS 1150 and pertinent Town specifications. The granular base and subbase materials and their placement should conform to OPSS 501, OPSS MUNI 1010 and pertinent Town specifications. Performance graded asphalt cement PG 58-28, conforming to OPSS MUNI 1101 requirements, is recommended for the HMA binder and surface courses.

The need for adequate subgrade drainage cannot be over-emphasized. The subgrade must be free of depressions and sloped (a minimum grade of 3 percent) to provide effective drainage toward subgrade drains. Grading adjacent to the pavement areas should be designed to ensure that water is not allowed to pond adjacent to the outside edges of the pavement. Continuous pavement subdrains should be provided along both sides of the roadway and drained into respective catchbasins to facilitate drainage of the subgrade and granular materials. The subdrain invert should be maintained at least 0.3 m below subgrade level (Figure 6 Pavement Drainage Alternatives). Alternatively, side drainage ditches should be provided if a rural road cross-section is to be employed.

The above pavement design thicknesses are considered adequate for the design traffic. However, if the pavement construction occurs in wet, winter or inclement weather; it may be necessary to provide additional subgrade support for heavy construction traffic by increasing the thickness of the granular subbase, base or both. Traffic areas for construction equipment may experience unstable subgrade conditions. These areas may be stabilized utilizing additional thickness of granular materials.
The long-term performance of the pavement structure is highly dependent upon the subgrade support conditions. Stringent construction control procedures must be maintained to ensure that uniform subgrade moisture and density conditions are achieved as much as possible when fill is placed, and the natural subgrade is not disturbed or weakened after it is exposed.

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 desired pavement life. Therefore, it is recommended that regular inspection and testing should be conducted during pavement construction to confirm material quality, thickness, and to ensure adequate compaction.

6. LIMITATIONS AND RISK

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

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

The discussion and recommendations are based on the factual data obtained from the investigation and are intended for use by the owner and its retained designers in the design phase of the project. Since the project is still in the design stage, all aspects of the project relative to the subsurface conditions cannot be anticipated. Terraprobe should review the design drawings and specifications prior to the construction of this work. 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 constructibility issues and quality control may not be relevant to the revised project in part or complete. Terraprobe should be retained to review the implications of these changes with respect to the contents of this report.

The investigation at this site was conceived and executed to provide information for project design. It may not be possible to drill a sufficient number of boreholes or samples and report them in a way that would provide all the subsurface information that could have an effect on construction costs, techniques, equipment, and scheduling. Contractors bidding on or undertaking work on this project should therefore, in this light, be directed to decide on their own investigations, as well as their own interpretations of the factual investigation results. They should be cognizant of the risks implicit in subsurface investigation activities so that they may draw their own conclusions as to how the subsurface conditions may affect them.

This report was prepared for the express use of Sarah Properties Ltd. Developments and its retained design consultants. It is not for use by others. This report is copyright of Terraprobe Inc. and no part of this report may be reproduced by any means, in any forms, without the prior written permission of Terraprobe Inc. and Sarah Properties Ltd. Developments, who are the authorized users.

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

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

Yours truly,

Terraprobe Inc.

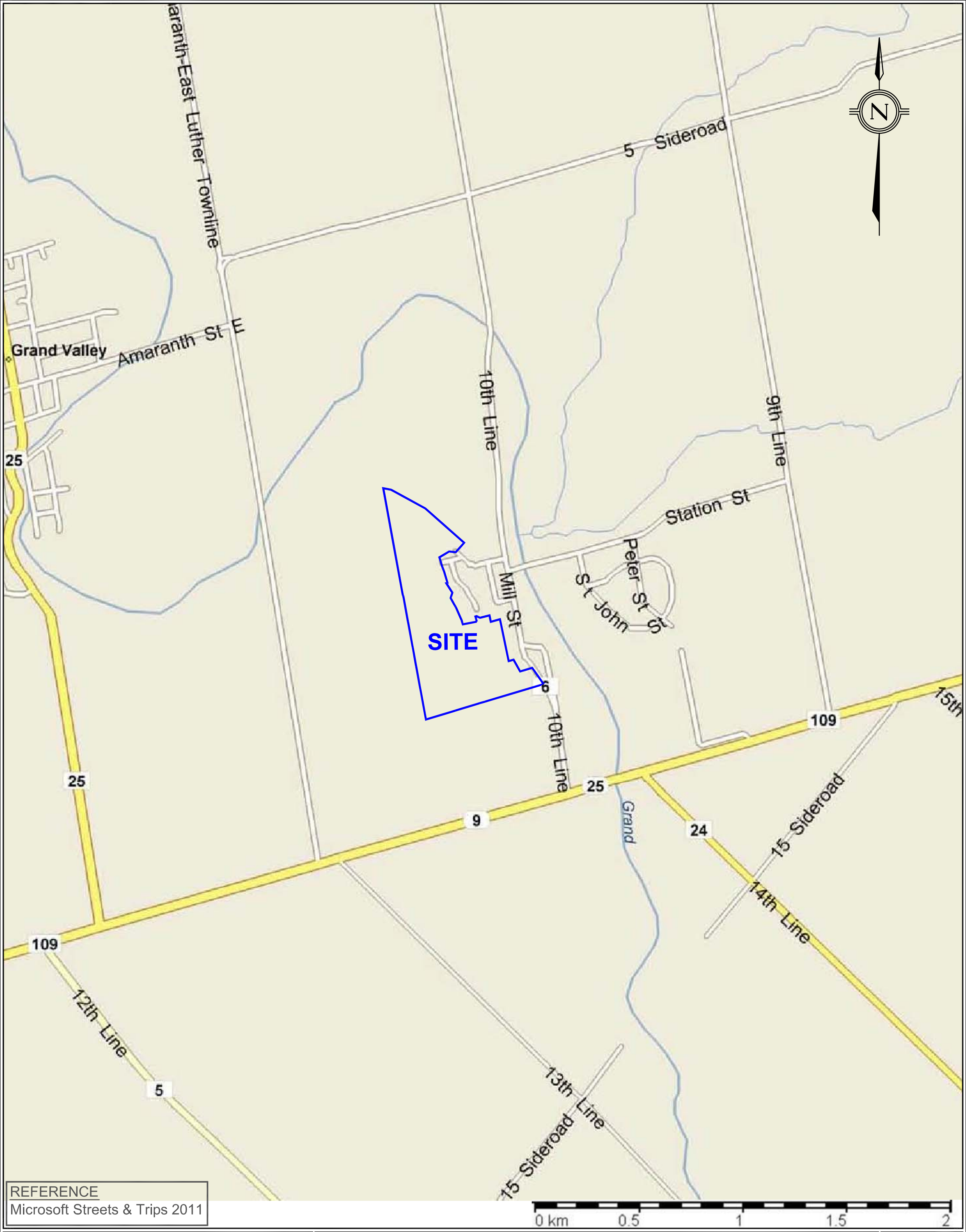
LICENSED PROFESSIONAL ENGINEER
L. ZHANG
100108586
2015-04-15
PROVINCE OF ONTARIO

Seth Zhang, P. Eng.
Geotechnical Engineer

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

FIGURES

TERRAPROBE INC.



REFERENCE
Microsoft Streets & Trips 2011

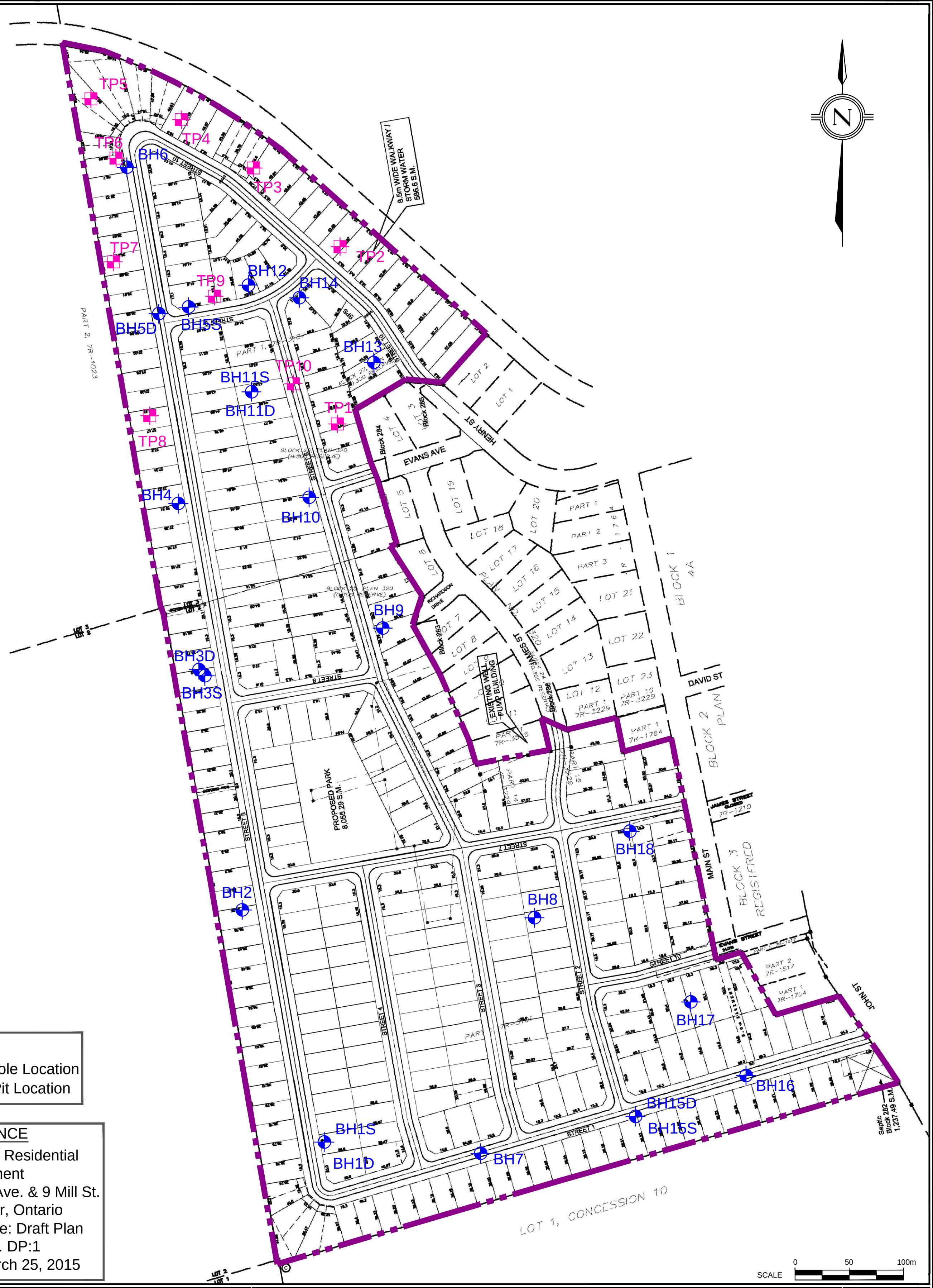
Terraprobe
11 Indell Lane, Brampton, Ontario, L6T 3Y3
Tel: (905) 796-2650 Fax: (905) 796-2250

Title:

SITE LOCATION PLAN

File No. 11-14-4090

FIGURE : 1



LEGEND

- Borehole Location
- Test Pit Location

REFERENCE

Proposed Residential Development
1 Evans Ave. & 9 Mill St.
Waldemar, Ontario
Sheet Title: Draft Plan
Sheet No. DP:1
Date: March 25, 2015

Terraprobe

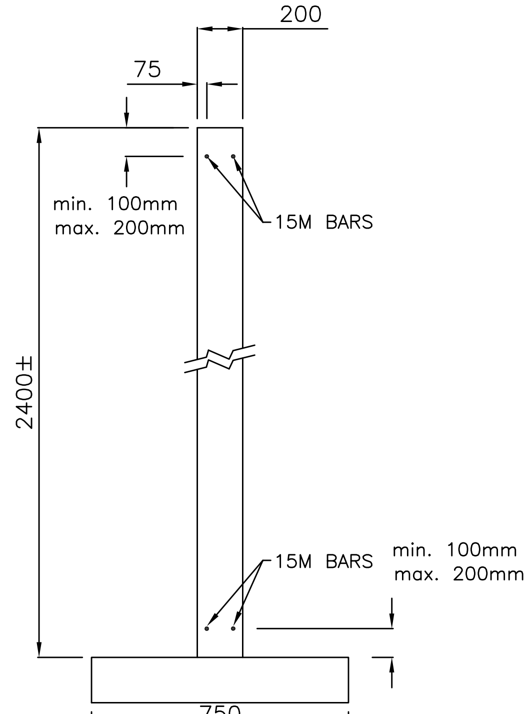
11 Indell Lane, Brampton, Ontario, L6T 3Y3
Tel: (905) 796-2650 Fax: (905) 796-2250

Title: BOREHOLE LOCATION PLAN

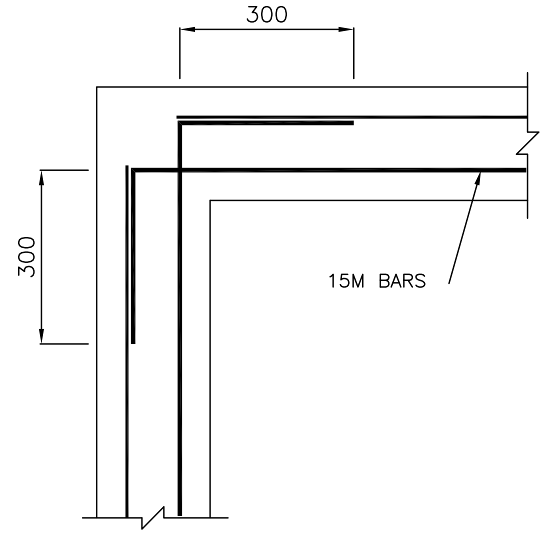
File No. 11-14-4090

FIGURE : 2

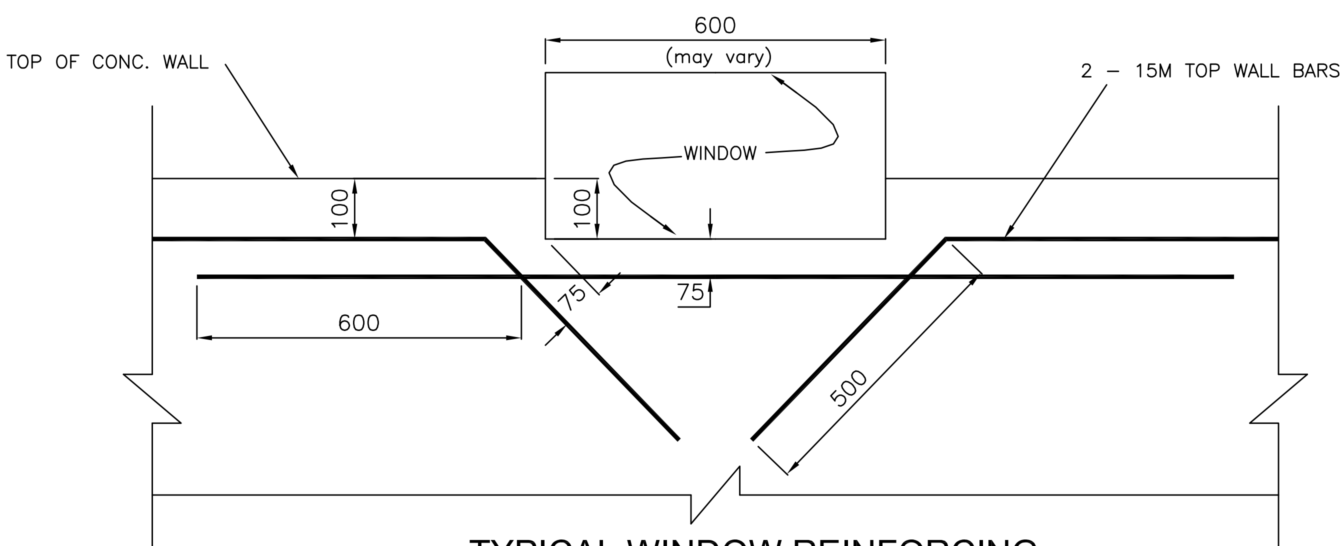
Z:\1-Project Files\11-Geo\2014\11-14-4090 Waldemar\A. Dwgs, Logs\AutoCAD\11-14-4090 Figure 1 & 2----_UPDATED_2.dwg, sandys



TYPICAL
REINFORCED WALL
NOT TO SCALE



TYPICAL SPLICING
AT CORNERS
NOT TO SCALE

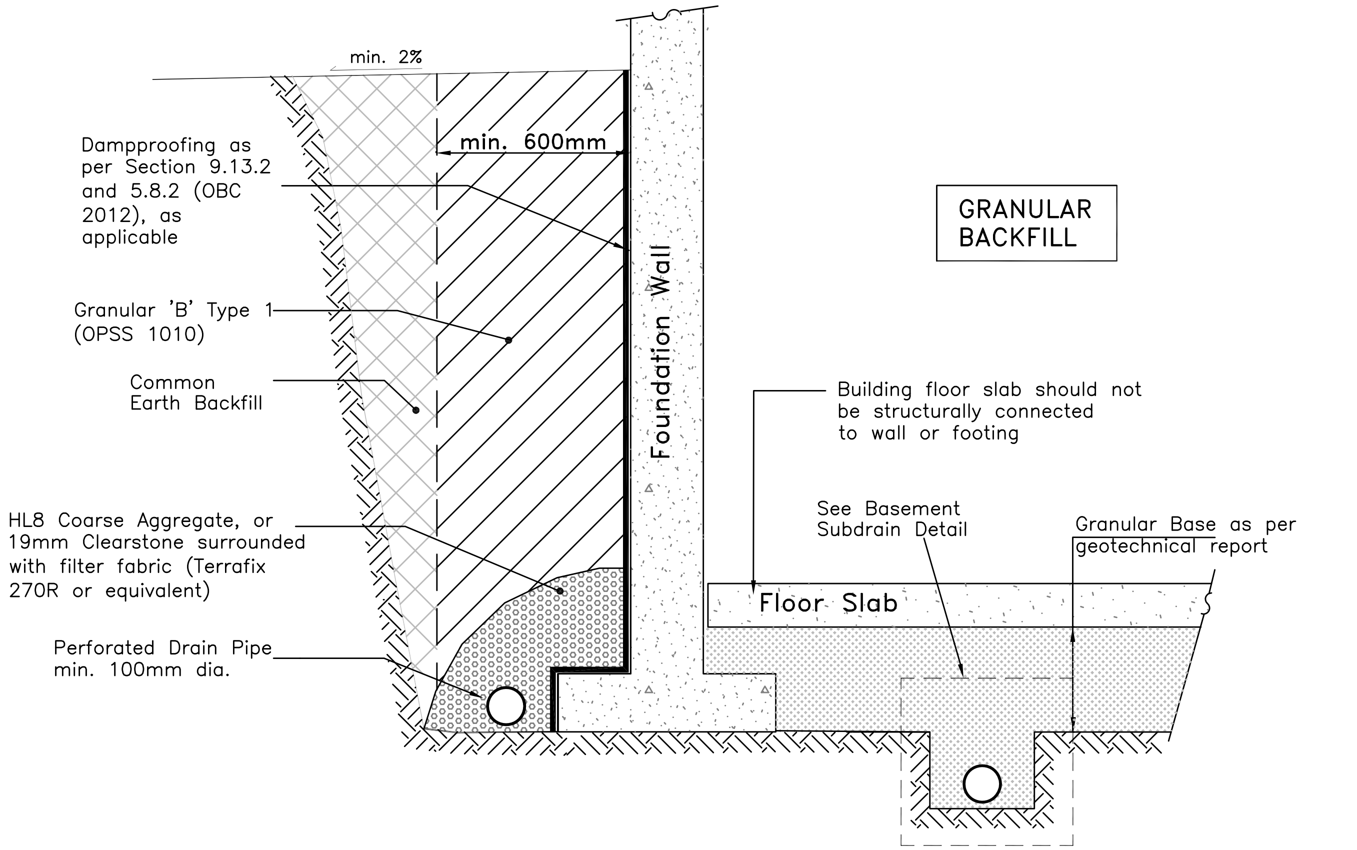


TYPICAL WINDOW REINFORCING
NOT TO SCALE

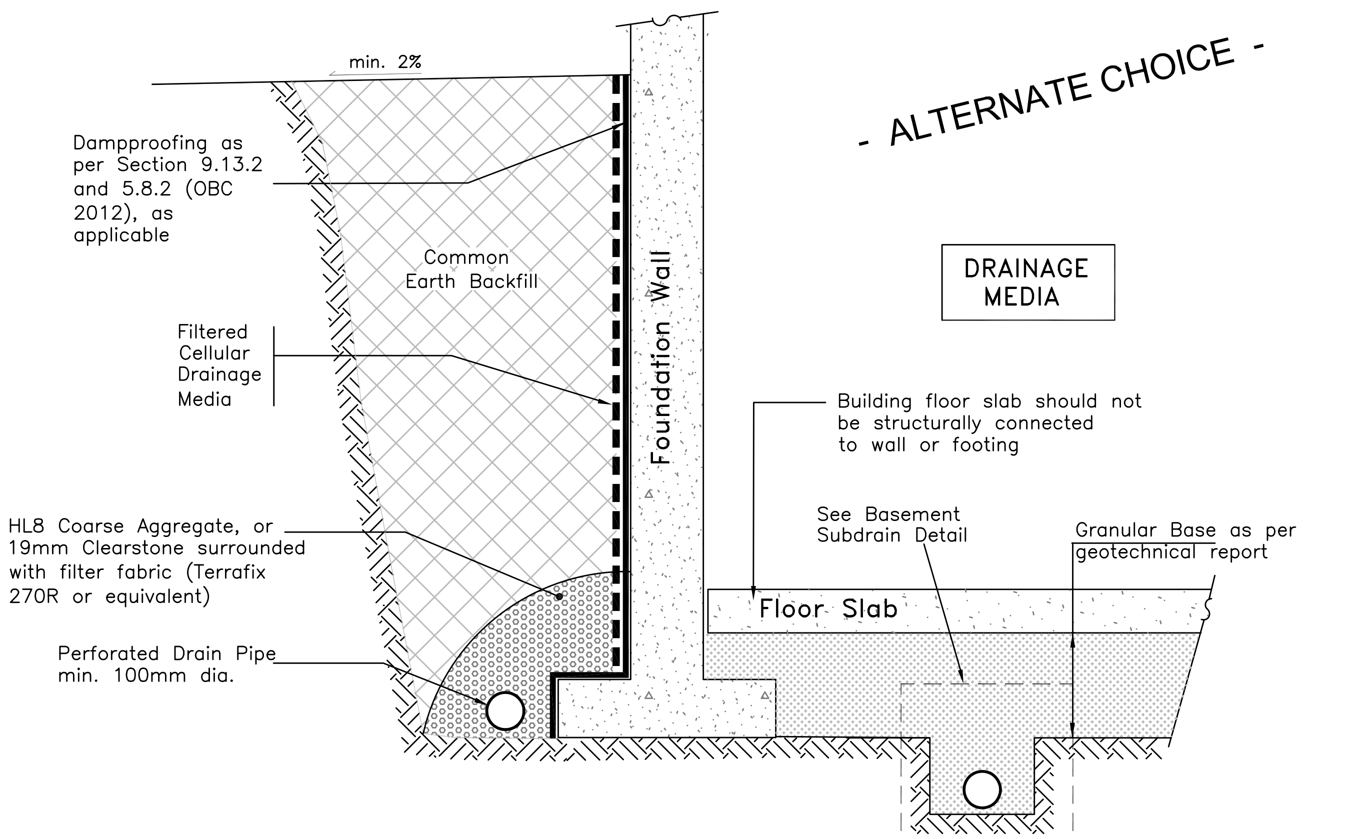
NOTES:
1. Reinforcing steel C.S.A. G30.18–09 Grade 400
2. Concrete min. 28 day strength 20MPa (3000psi)
3. Base of all footing excavations to be inspected and approved prior to placing formwork.
4. All dimensions are in mm.

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

Title:	TYPICAL REINFORCED WALL DETAILS FOR HOUSES ON ENGINEERED FILL
File No.	11-14-4090
FIGURE :	3



\- ALTERNATE CHOICE -



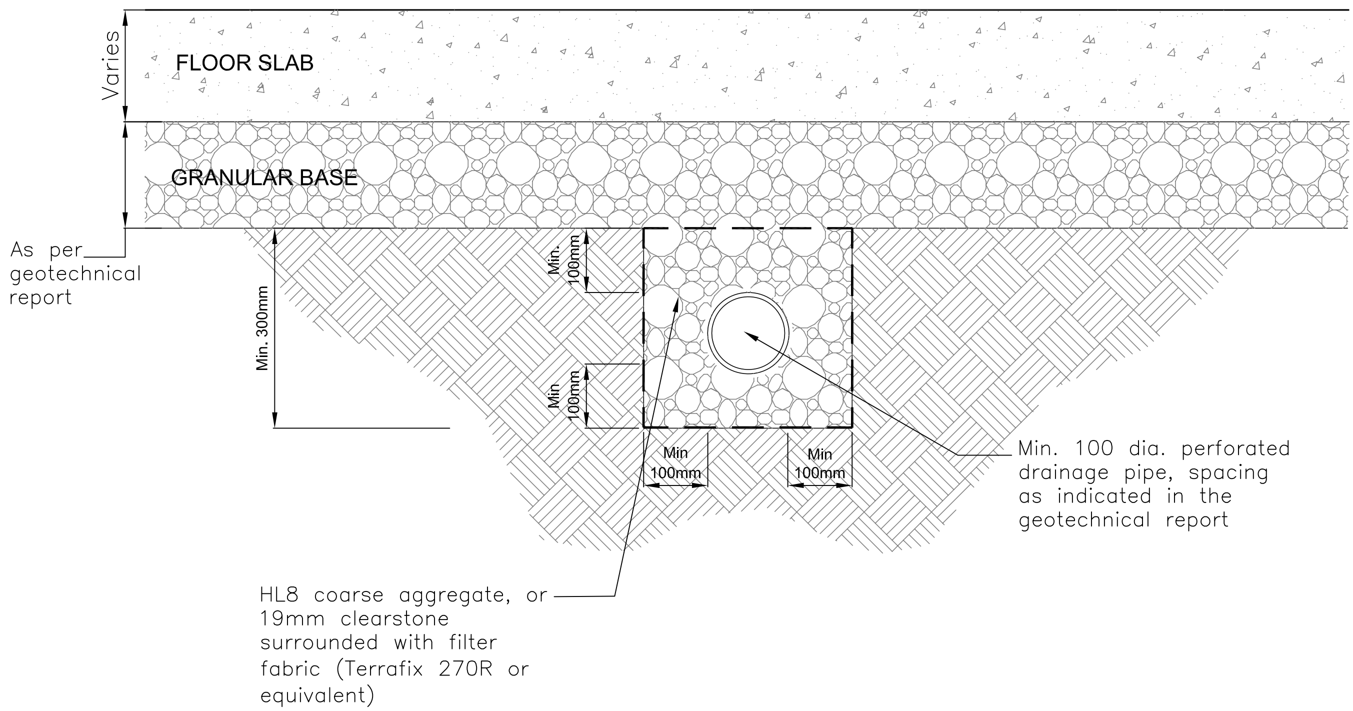
Schematic Only
Not to Scale

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

Title: BASEMENT DRAINAGE DETAIL

File No. 11-14-4090

FIGURE : 4



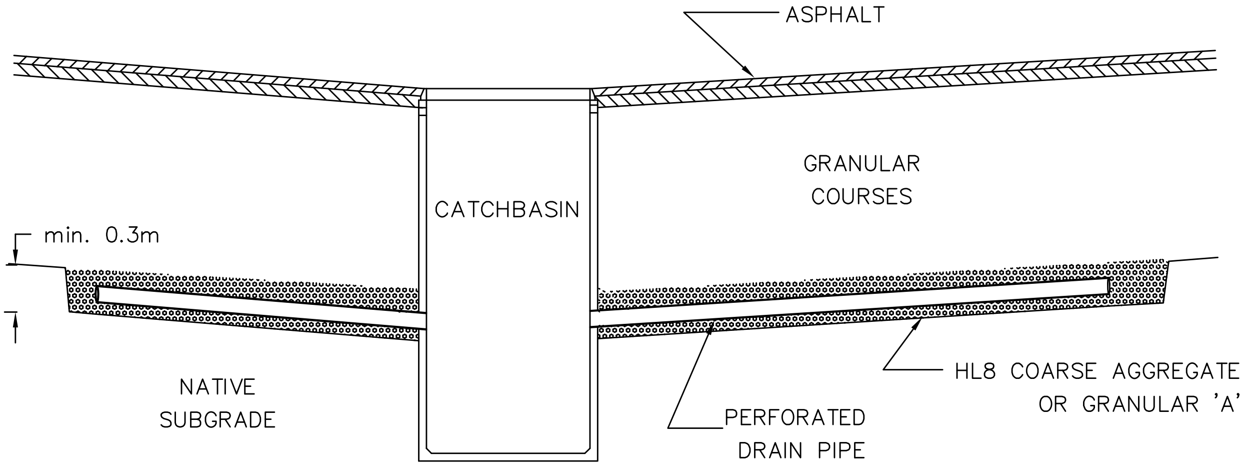
Schematic Only
Not to Scale

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

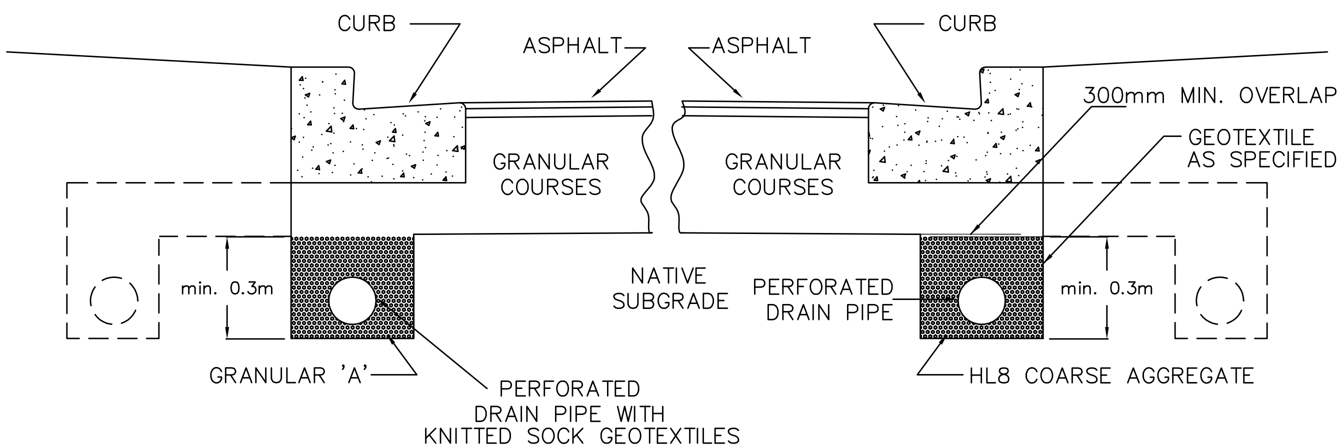
Title: BASEMENT FLOOR SUBDRAIN DETAIL

Figure: 5

File No. 11-14-4090



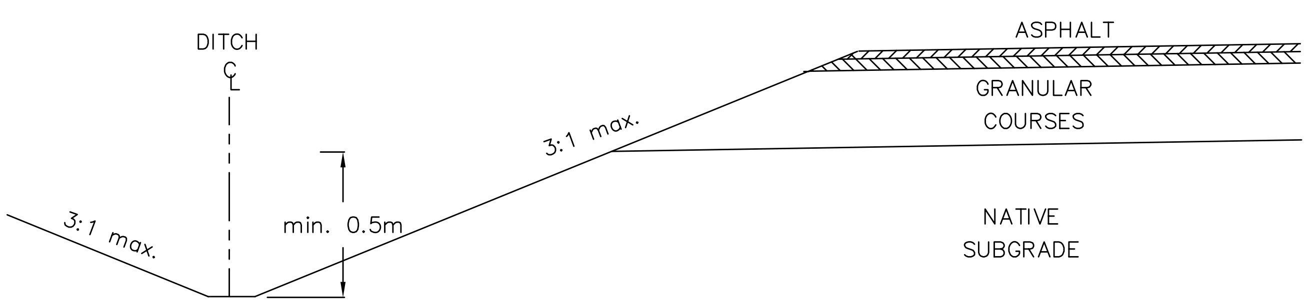
Longitudinal Subdrain Connection to Catchbasin



Unwrapped Trench

Wrapped Trench

Urban Cross Sections



Rural Cross Section

Terraprobe

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

Title: **PAVEMENT DRAINAGE ALTERNATIVES**

File No. 11-14-4090

FIGURE : 6

BOREHOLE LOGS

TERRAPROBE INC.

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

Client : Sarah Properties Ltd Developments
Project No.: 11-14-4090

Project : Waldemar Development
Date started : April 9, 2014

Location : Township of Amaranth, Ontario

Position : E: 557124, N: 4859399 (UTM 17T)
Elevation Datum : Geodetic

Rig type : Track-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)
474.2	**GROUND SURFACE**				Artesian conditions encountered
473.9 / 0.3	300mm **TOPSOIL**				
	Trace rootlets (WEATHERED/DISTURBED)	1	SS	9	
473.4 / 0.8	**CLAYEY SILT**, trace to some sand, trace gravel, very stiff to hard, greyish brown to brown, moist (GLACIAL TILL)	2	SS	26	0 9 54 37
		3	SS	40	
		4	SS	44	
		5	SS	43	
		6	SS	46	
		7	SS	44	
466.6 / 7.6	**SAND AND GRAVEL**, some silt to silty, compact to very dense, brown, wet	8	SS	29	
		9	SS	68	47 42 (11)

Penetration Test Values (Blows / 0.3m): × Dynamic Cone (10, 20, 30, 40)
Undrained Shear Strength (kPa): ○ Unconfined, + Field Vane, ● Pocket Penetrometer, ■ Lab Vane (40, 80, 120, 160)
Moisture / Plasticity: Plastic Limit (PL), Natural Water Content (MC), Liquid Limit (LL) (10, 20, 30)
Headspace Vapour | Instrument Details | Unstabilized Water Level

Depth Scale (m): 0–10; Elevation Scale (m): 474–465

(continued next page)

Terraprobe

LOG OF BOREHOLE 1

Client	: Sarah Properties Ltd Developments	Project No.:	11-14-4090
Project	: Waldemar Development	Date started :	April 9, 2014
Location	: Township of Amaranth, Ontario	Sheet No. :	2 of 2

Position	: E: 557124, N: 4859399 (UTM 17T)	Elevation Datum	: Geodetic
Rig type	: Track-mounted	Drilling Method	: Solid stem augers

Elev / Depth (m)	Description	Number	Type	SPT 'N' Value	Elevation Scale (m)	Lab Data and Comments
	(continued)					
463.5 / 10.7	**SAND AND GRAVEL**, some silt to silty, compact to very dense, brown, wet *(continued)*				464	Artesian conditions encountered
462.0 / 12.2	**SANDY SILT**, trace to some clay, trace gravel, very dense, brown, moist (GLACIAL TILL)	10	SS	50 / 100mm	463	
		11	SS	50 / 50mm	462	

Depth Scale (m): 11, 12

Column headings: SOIL PROFILE; SAMPLES; Graphic Log; Penetration Test Values (Blows / 0.3m) — Dynamic Cone 10 20 30 40; Undrained Shear Strength (kPa) — Unconfined, Field Vane, Pocket Penetrometer, Lab Vane 40 80 120 160; Moisture / Plasticity — Plastic Limit, Natural Water Content, Liquid Limit, PL MC LL 10 20 30; Headspace Vapour; Instrument Details; Unstabilized Water Level; GRAIN SIZE DISTRIBUTION (%) (MIT) GR SA SI CL

END OF BOREHOLE

Unstabilized water level measured at 3.0 m below ground surface; borehole was open upon completion of drilling.

50 mm monitoring well installed.

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Jun 5, 2014	-0.9	475.1
Jul 3, 2014	1.3	472.9

Terraprobe

LOG OF BOREHOLE 2

Client : Sarah Properties Ltd Developments

Project : Waldemar Development

Location : Township of Amaranth, Ontario

Project No.: 11-14-4090

Date started : April 9, 2014

Sheet No. : 1 of 1

Position : E: 557049, N: 4859627 (UTM 17T)

Rig type : Track-mounted

Elevation Datum : Geodetic

Drilling Method : Solid stem augers

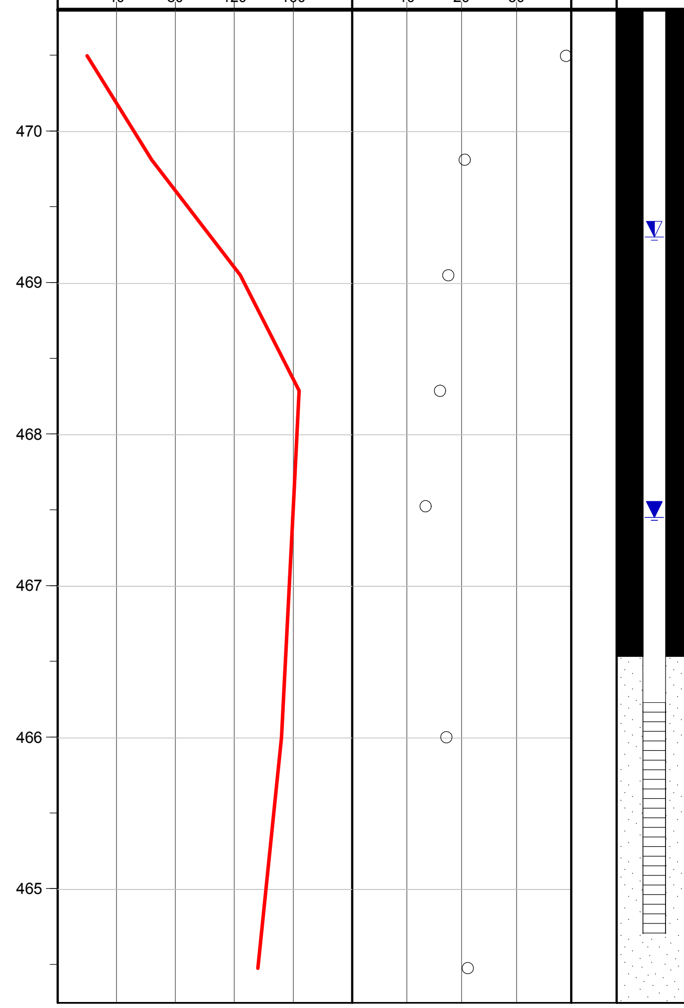
Depth Scale (m)	Elev Depth (m)	Description (SOIL PROFILE)	Sample Number	Type	SPT 'N' Value
0	470.8	**GROUND SURFACE**			
		300mm **TOPSOIL**			
	470.5 / 0.3	Trace rootlets (WEATHERED/DISTURBED)	1	SS	5
	470.0 / 0.8	**CLAYEY SILT**, trace to some sand, trace gravel, very stiff to hard, greyish brown to brown, moist to wet (GLACIAL TILL)			
1			2	SS	16
2			3	SS	31
			4	SS	41
3			5	SS	40
4–5			6	SS	38
6			7	SS	34
	464.2 / 6.6	**END OF BOREHOLE**			

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

Undrained Shear Strength (kPa): ○ Unconfined, + Field Vane, ● Pocket Penetrometer, ■ Lab Vane; 40, 80, 120, 160

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

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



Unstabilized water level measured at 4.6 m below ground surface; borehole was open upon completion of drilling.

50 mm monitoring well installed.

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Jun 5, 2014	1.5	469.3
Jul 3, 2014	3.4	467.5

library: library - terraprobe gint.glb **report:** terraprobe soil log **file:** 11-14-4090.gpj

LOG OF BOREHOLE 3

Terraprobe

Client	: Sarah Properties Ltd Developments	Project No.:	11-14-4090
Project	: Waldemar Development	Date started :	March 10, 2014
Location	: Township of Amaranth, Ontario	Sheet No. :	1 of 2

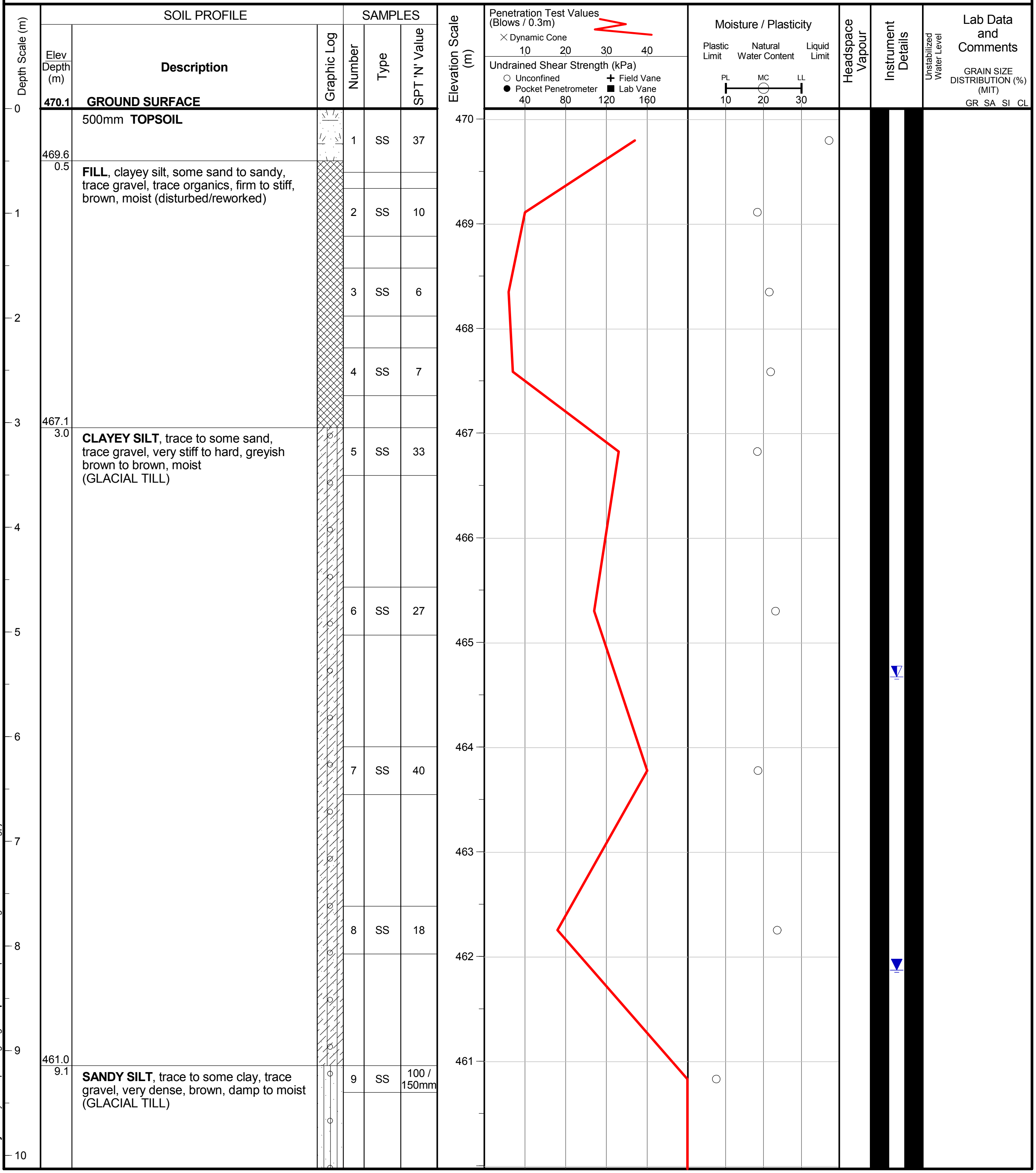
Position	: E: 557013, N: 4859848 (UTM 17T)	Elevation Datum	: Geodetic
Rig type	: Track-mounted	Drilling Method	: Solid stem augers

SOIL PROFILE

Elev Depth (m)	Description
470.1	**GROUND SURFACE**
469.6 / 0.5	500mm **TOPSOIL**
467.1 / 3.0	**FILL**, clayey silt, some sand to sandy, trace gravel, trace organics, firm to stiff, brown, moist (disturbed/reworked)
461.0 / 9.1	**CLAYEY SILT**, trace to some sand, trace gravel, very stiff to hard, greyish brown to brown, moist (GLACIAL TILL)
	SANDY SILT, trace to some clay, trace gravel, very dense, brown, damp to moist (GLACIAL TILL)

SAMPLES

Number	Type	SPT 'N' Value
1	SS	37
2	SS	10
3	SS	6
4	SS	7
5	SS	33
6	SS	27
7	SS	40
8	SS	18
9	SS	100 / 150mm



(continued next page)

Terraprobe

LOG OF BOREHOLE 3

Client : Sarah Properties Ltd Developments
Project : Waldemar Development
Location : Township of Amaranth, Ontario

Project No.: 11-14-4090
Date started : March 10, 2014
Sheet No. : 2 of 2

Position : E: 557013, N: 4859848 (UTM 17T)
Rig type : Track-mounted
Elevation Datum : Geodetic
Drilling Method : Solid stem augers

Depth Scale (m)	Elev Depth (m)	Description *(continued)*	Graphic Log	Number	Type	SPT 'N' Value	Elevation Scale (m)
		SANDY SILT, trace to some clay, trace gravel, very dense, brown, damp to moist (GLACIAL TILL) *(continued)*					
11				10	SS	92 / 275mm	459
12							458
	457.8 12.3			11	SS	50 / 125mm	

Penetration Test Values (Blows / 0.3m): × Dynamic Cone 10 20 30 40
Undrained Shear Strength (kPa): ○ Unconfined + Field Vane ● Pocket Penetrometer ■ Lab Vane 40 80 120 160
Moisture / Plasticity: Plastic Limit, Natural Water Content, Liquid Limit (PL, MC, LL) 10 20 30
Headspace Vapour | 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.

50 mm monitoring well installed.

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Jun 5, 2014	5.4	464.7
Jul 3, 2014	8.2	461.9

LOG OF BOREHOLE 4

Terraprobe

Client	: Sarah Properties Ltd Developments	Project No.:	11-14-4090
Project	: Waldemar Development	Date started :	March 10, 2014
Location	: Township of Amaranth, Ontario	Sheet No. :	1 of 1

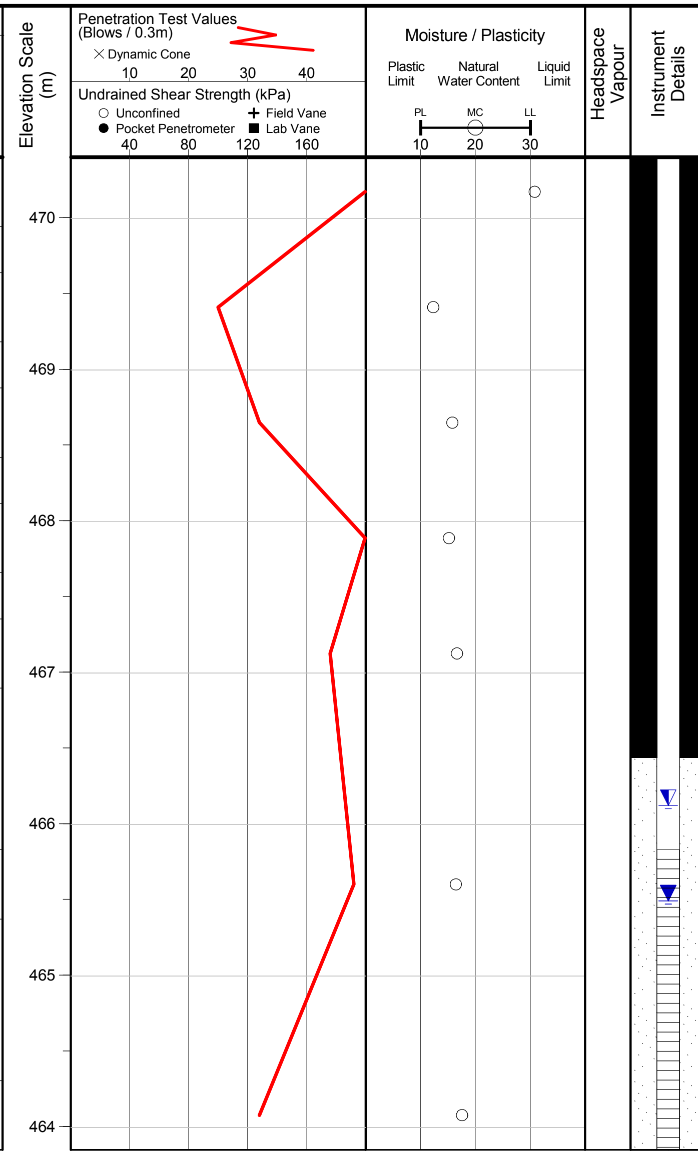
Position	: E: 556988, N: 4860008 (UTM 17T)	Elevation Datum	: Geodetic
Rig type	: Track-mounted	Drilling Method	: Solid stem augers

SOIL PROFILE

Elev / Depth (m)	Description
470.4	GROUND SURFACE
469.9 / 0.5	500mm **TOPSOIL**
469.6 / 0.8	Trace organics (WEATHERED/DISTURBED)
463.8 / 6.6	**CLAYEY SILT**, trace to some sand, trace gravel, very stiff to hard, greyish brown to brown, moist (GLACIAL TILL)

SAMPLES

Number	Type	SPT 'N' Value
1	SS	86
2	SS	25
3	SS	32
4	SS	53
5	SS	44
6	SS	48
7	SS	32



Lab Data and Comments

GRAIN SIZE DISTRIBUTION (%) (MIT)

GR SA SI CL

END OF BOREHOLE

Borehole was dry and open upon completion of drilling.

50 mm monitoring well installed.

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Jun 5, 2014	4.3	466.1
Jul 3, 2014	4.9	465.5

LOG OF BOREHOLE 5

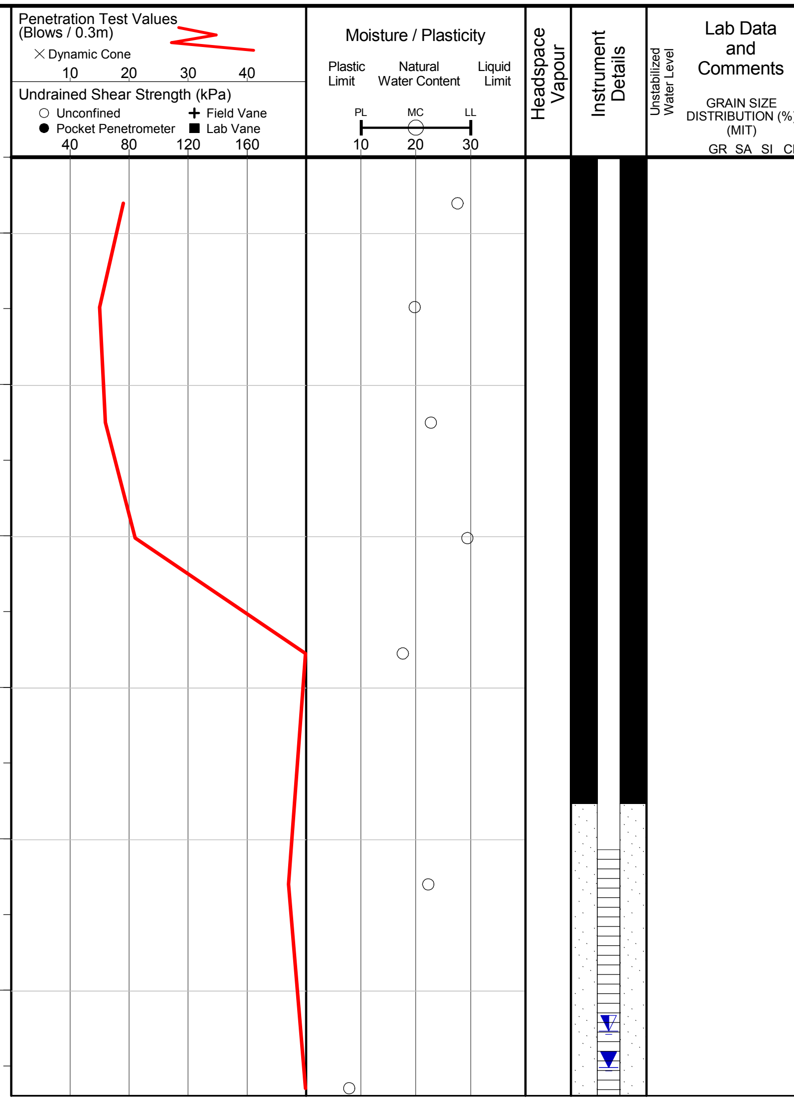
Terraprobe

Client	: Sarah Properties Ltd Developments	Project No.:	11-14-4090
Project	: Waldemar Development	Date started :	April 11, 2014
Location	: Township of Amaranth, Ontario	Sheet No. :	1 of 1

Position : E: 556958, N: 4860174 (UTM 17T) Elevation Datum : Geodetic

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

Elev / Depth (m)	Description (SOIL PROFILE)	Sample Number	Sample Type	SPT 'N' Value
468.5	GROUND SURFACE			
468.3 / 0.2	150mm **TOPSOIL**			
	Trace rootlets (WEATHERED/DISTURBED)	1	SS	19
467.7 / 0.8	**CLAYEY SILT**, trace to some sand, trace to some gravel, very stiff to hard, brown, moist (GLACIAL TILL)	2	SS	15
		3	SS	16
		4	SS	21
		5	SS	52
		6	SS	47
462.3 / 6.2		7	SS	50 / 100mm



END OF BOREHOLE

Borehole was dry and open upon completion of drilling.

50 mm monitoring well installed.

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Jun 5, 2014	5.8	462.7
Jul 3, 2014	6.0	462.5

Terraprobe

LOG OF BOREHOLE 6

Client : Sarah Properties Ltd Developments	Project No.: 11-14-4090
Project : Waldemar Development	Date started : April 11, 2014
Location : Township of Amaranth, Ontario	Sheet No. : 1 of 1

Position : E: 556934, N: 4860321 (UTM 17T)	Elevation Datum : Geodetic
Rig type : Track-mounted	Drilling Method : Solid stem augers

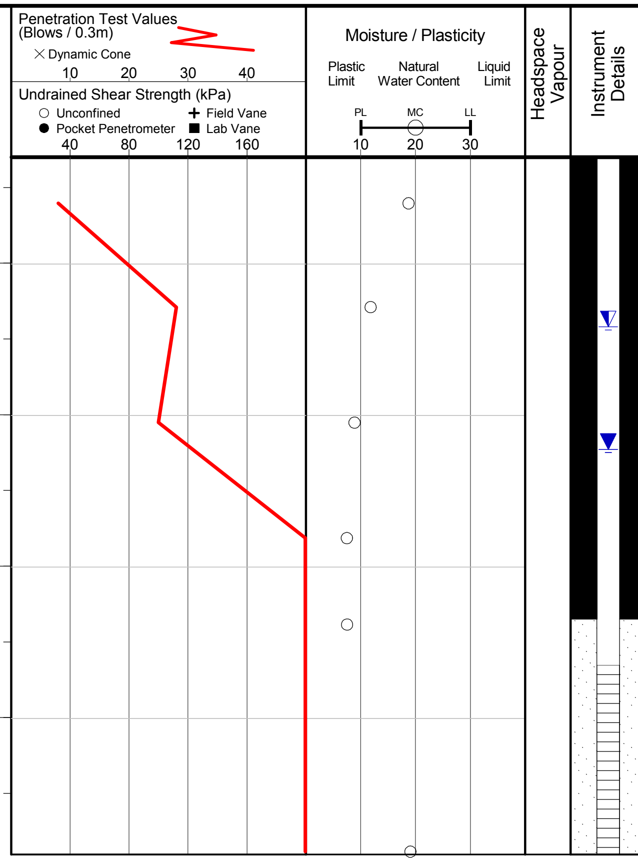
SOIL PROFILE / SAMPLES

Depth Scale (m)	Elev Depth (m)	Description	Graphic Log	Number	Type	SPT 'N' Value	Elevation Scale (m)
0	466.7	**GROUND SURFACE**					
	466.4 / 0.3	300mm **TOPSOIL**		1	SS	8	
	466.2 / 0.5	Trace rootlets (WEATHERED/DISTURBED)					466
1		**SANDY SILT to SILT AND SAND**, trace to some gravel, trace clay, compact to very dense, brown, damp to moist (GLACIAL TILL)		2	SS	28	
2		...sand and silt		3	SS	25	465
				4	SS	78	464
3				5	SS	50 / 75mm	463
4	462.1 / 4.6			6	SS	50 / 25mm	

END OF BOREHOLE
Auger refusal

Borehole was dry and open upon completion of drilling.

50 mm monitoring well installed.



Lab Data and Comments

GRAIN SIZE DISTRIBUTION (%) (MIT)

GR	SA	SI	CL
10	41	40	9

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Jun 5, 2014	1.1	465.6
Jul 3, 2014	1.9	464.8

Terraprobe

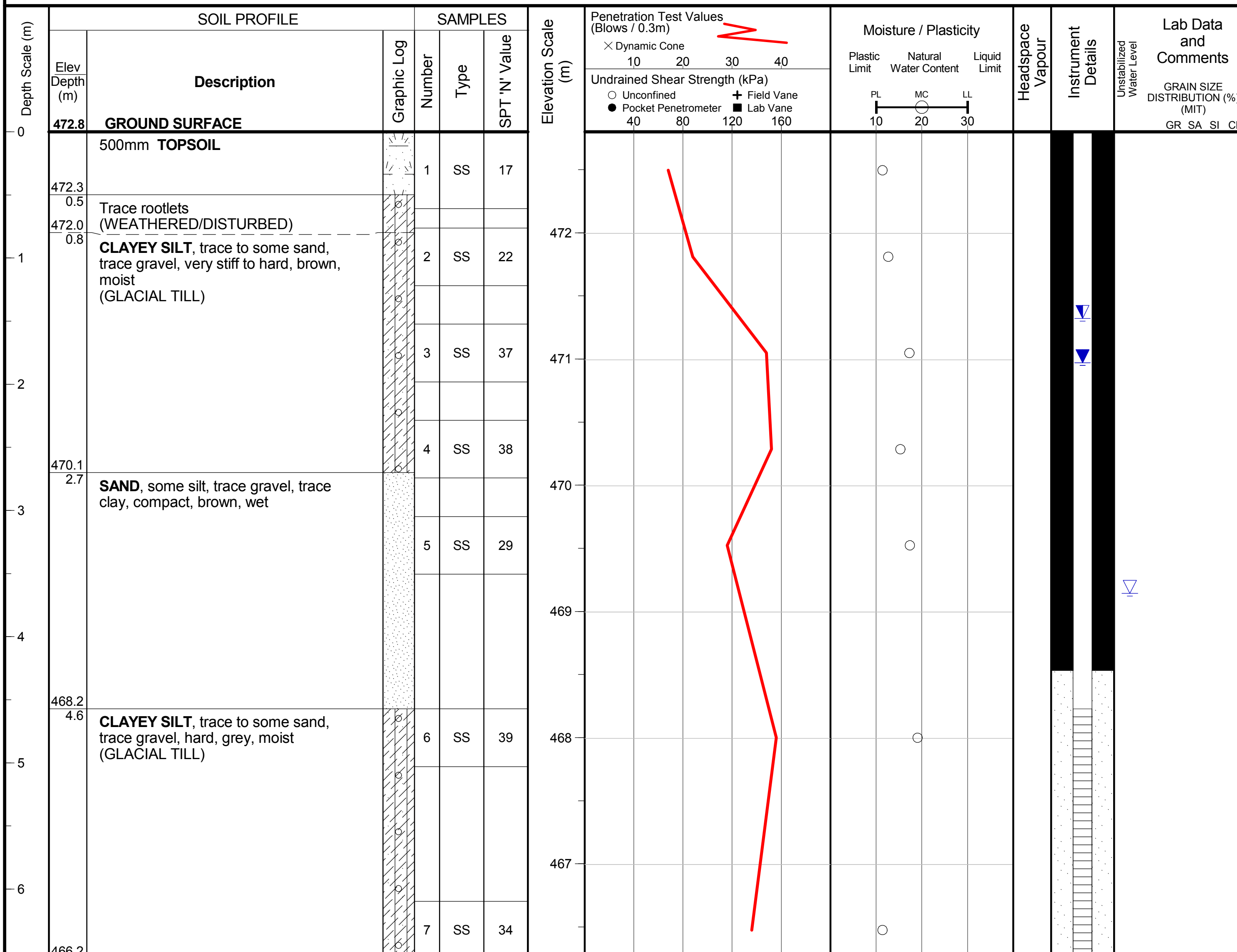
LOG OF BOREHOLE 7

Client : Sarah Properties Ltd Developments
Project : Waldemar Development
Location : Township of Amaranth, Ontario

Project No.: 11-14-4090
Date started : April 11, 2014
Sheet No. : 1 of 1

Position : E: 557275, N: 4859408 (UTM 17T)
Elevation Datum : Geodetic
Rig type : Track-mounted
Drilling Method : Solid stem augers

Elev / Depth (m)	Description (SOIL PROFILE)	Sample Number	Type	SPT 'N' Value
472.8	**GROUND SURFACE**			
	500mm **TOPSOIL**	1	SS	17
472.3 / 0.5	Trace rootlets (WEATHERED/DISTURBED)			
472.0 / 0.8	**CLAYEY SILT**, trace to some sand, trace gravel, very stiff to hard, brown, moist (GLACIAL TILL)	2	SS	22
		3	SS	37
		4	SS	38
470.1 / 2.7	**SAND**, some silt, trace gravel, trace clay, compact, brown, wet	5	SS	29
468.2 / 4.6	**CLAYEY SILT**, trace to some sand, trace gravel, hard, grey, moist (GLACIAL TILL)	6	SS	39
		7	SS	34
466.2 / 6.6	**END OF BOREHOLE**			



Unstabilized water level measured at 3.7 m below ground surface; borehole was open upon completion of drilling.

50 mm monitoring well installed.

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Jun 5, 2014	1.5	471.3
Jul 3, 2014	1.8	471.0

Terraprobe

LOG OF BOREHOLE 8

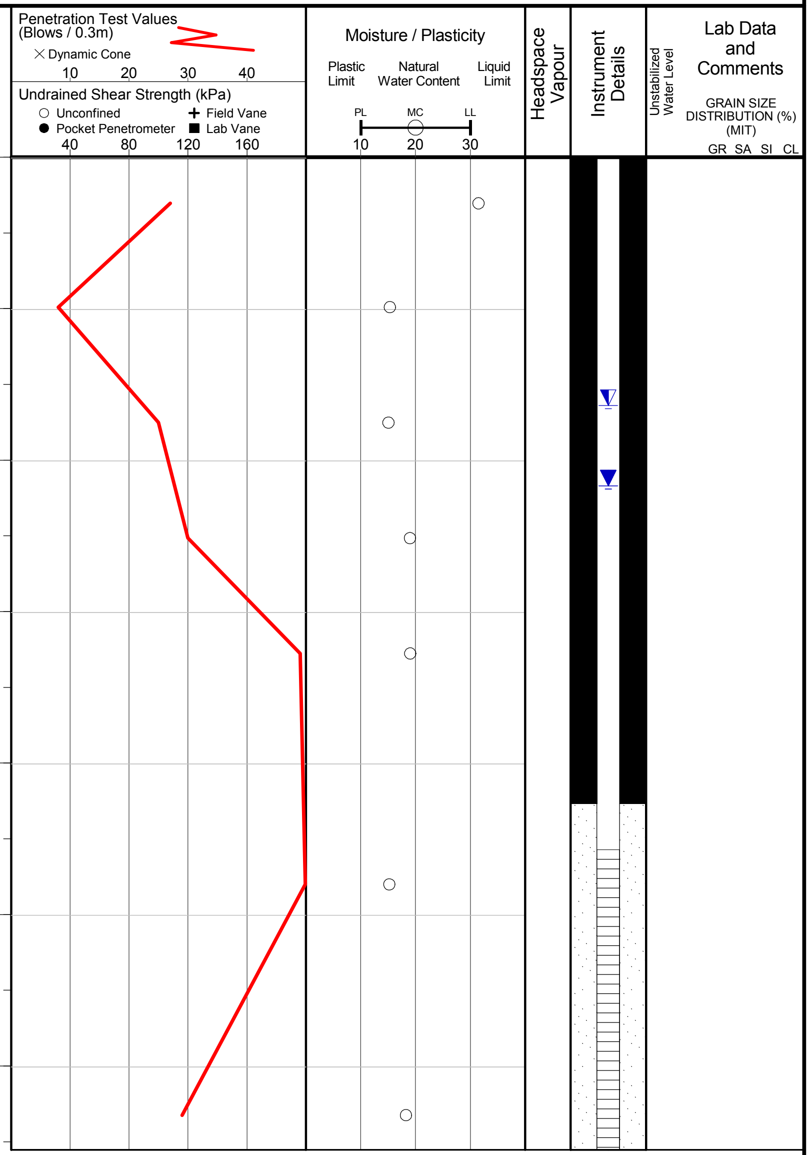
Client : Sarah Properties Ltd Developments
Project : Waldemar Development
Location : Township of Amaranth, Ontario

Project No.: 11-14-4090
Date started : April 9, 2014

Position : E: 557321, N: 4859620 (UTM 17T)
Rig type : Track-mounted
Elevation Datum : Geodetic
Drilling Method : Solid stem augers

SOIL PROFILE

Depth Scale (m)	Elev Depth (m)	Description	Sample Number	Type	SPT 'N' Value	Elevation Scale (m)
0	469.0	**GROUND SURFACE**				469
		500mm **TOPSOIL**	1	SS	27	
	468.5 / 0.5	Trace rootlets (WEATHERED/DISTURBED)				
1			2	SS	8	468
	467.8 / 1.2	**CLAYEY SILT**, trace to some sand, trace gravel, very stiff to hard, brown, moist (GLACIAL TILL)				
			3	SS	25	
2						467
			4	SS	30	
3						466
			5	SS	49	
4						465
			6	SS	94	
5						464
6						463
			7	SS	29	
	462.4 / 6.6	**END OF BOREHOLE**				



END OF BOREHOLE

Borehole was dry and open upon completion of drilling.

50 mm monitoring well installed.

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Jun 5, 2014	1.6	467.4
Jul 3, 2014	2.2	466.8

LOG OF BOREHOLE 9

Client : Sarah Properties Ltd Developments
Project : Waldemar Development
Location : Township of Amaranth, Ontario

Project No.: 11-14-4090
Date started : April 11, 2014
Sheet No. : 1 of 1

Position : E: 557171, N: 4859886 (UTM 17T)
Rig type : Track-mounted
Elevation Datum : Geodetic
Drilling Method : Solid stem augers

SOIL PROFILE

Elev / Depth (m)	Description
466.0	GROUND SURFACE
465.7 / 0.3	300mm **TOPSOIL**
465.2 / 0.8	Trace rootlets (WEATHERED/DISTURBED)
	CLAYEY SILT, trace to some sand, trace gravel, stiff to hard, greyish brown to brown, moist (GLACIAL TILL)
	...wet, sand
461.0 / 5.0	**END OF BOREHOLE**

SAMPLES

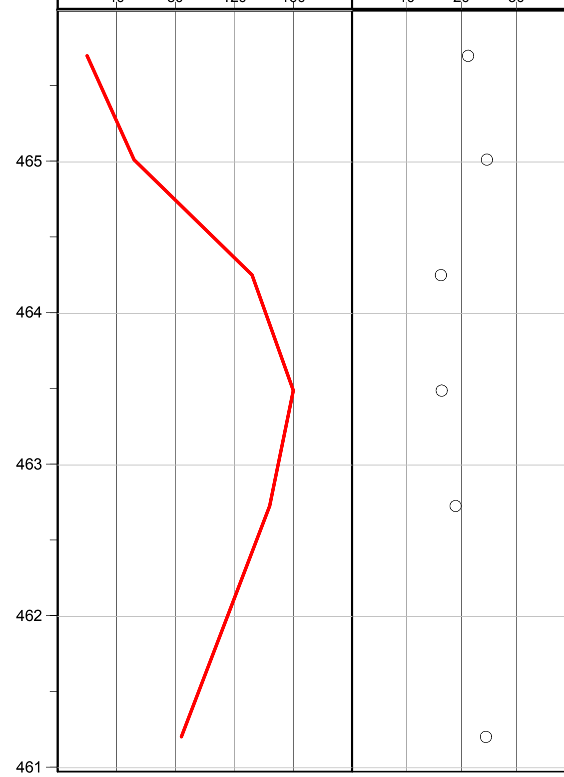
Number	Type	SPT 'N' Value
1	SS	5
2	SS	13
3	SS	33
4	SS	40
5	SS	36
6	SS	21

Elevation Scale (m): 465, 464, 463, 462, 461

Penetration Test Values (Blows / 0.3m) — × Dynamic Cone — 10 20 30 40
Undrained Shear Strength (kPa) — ○ Unconfined, + Field Vane, ● Pocket Penetrometer, ■ Lab Vane — 40 80 120 160

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

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



Borehole was dry and open upon completion of drilling.

50 mm monitoring well installed.

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Jun 5, 2014	1.1	464.9
Jul 3, 2014	1.5	464.5

LOG OF BOREHOLE 10

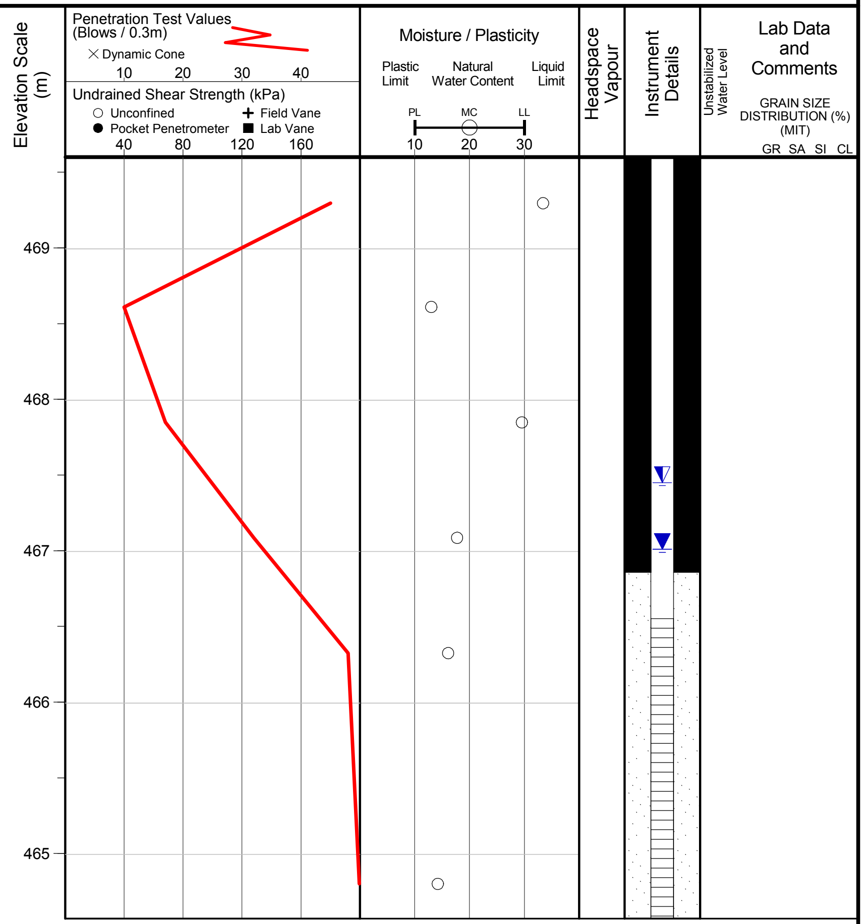
Terraprobe

Client	: Sarah Properties Ltd Developments	Project No.:	11-14-4090
Project	: Waldemar Development	Date started :	March 10, 2014
Location	: Township of Amaranth, Ontario	Sheet No. :	1 of 1

Position : E: 557109, N: 4860013 (UTM 17T) | Elevation Datum : Geodetic

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

Depth Scale (m)	Elev Depth (m)	Description (SOIL PROFILE)	Sample Number	Type	SPT 'N' Value
0	469.6	**GROUND SURFACE**			
	469.3 / 0.3	300mm **TOPSOIL**			
		Trace rootlets (WEATHERED/DISTURBED)	1	SS	45
1	468.8 / 0.8	**CLAYEY SILT**, trace to some sand, trace gravel, stiff to hard, greyish brown to brown, moist (GLACIAL TILL)	2	SS	10
2			3	SS	17
			4	SS	32
3			5	SS	48
4					
5	464.6 / 5.0		6	SS	54



END OF BOREHOLE

Borehole was dry and open upon completion of drilling.

50 mm monitoring well installed.

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Jun 5, 2014	2.2	467.5
Jul 3, 2014	2.6	467.0

Terraprobe

LOG OF BOREHOLE 11

Client	: Sarah Properties Ltd Developments	Project No.:	11-14-4090
Project	: Waldemar Development	Date started :	April 15, 2014
Location	: Township of Amaranth, Ontario	Sheet No. :	1 of 2

Position	: E: 557053, N: 4860109 (UTM 17T)	Elevation Datum	: Geodetic
Rig type	: CME 55, track-mounted	Drilling Method	: Solid stem augers

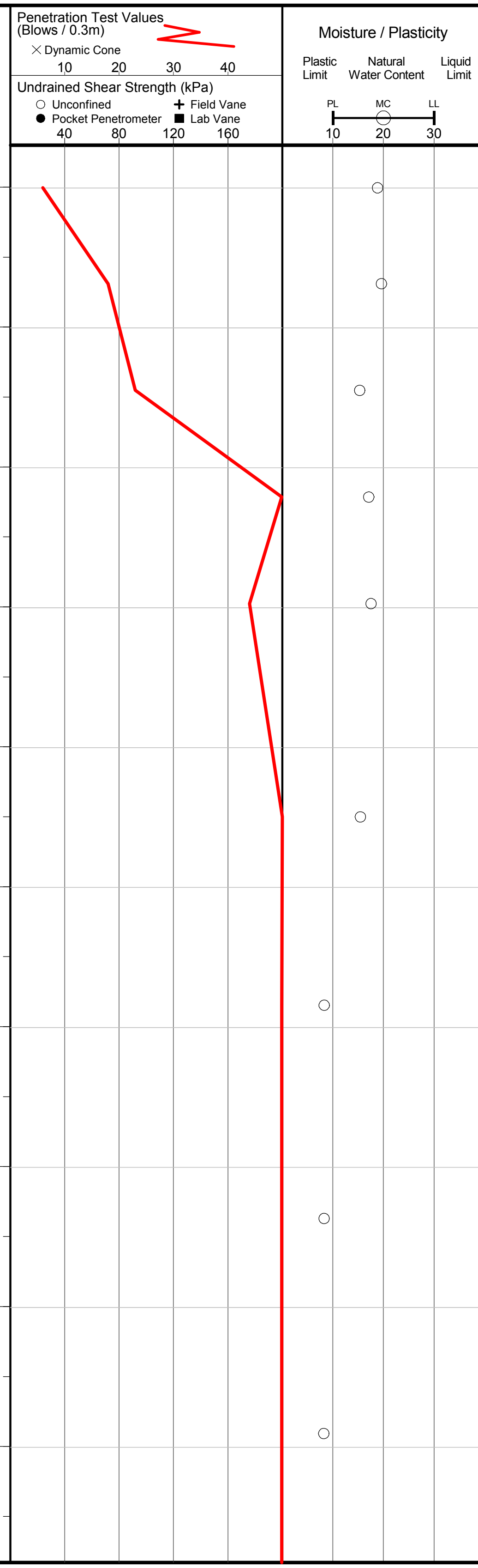
SOIL PROFILE

Elev / Depth (m)	Description
468.3	**GROUND SURFACE**
468.1 / 0.2	150mm **TOPSOIL**
	Trace rootlets (WEATHERED/DISTURBED)
467.7 / 0.6	**CLAYEY SILT**, trace to some sand, trace gravel, very stiff to hard, brown (GLACIAL TILL)
462.2 / 6.1	**SANDY SILT to SAND AND SILT**, trace to some gravel, trace clay, very dense, brown, damp to wet (GLACIAL TILL)

SAMPLES

Number	Type	SPT 'N' Value
1	SS	6
2	SS	18
3	SS	23
4	SS	67
5	SS	44
6	SS	50
7	SS	50 / 100mm
8	SS	50 / 100mm
9	SS	50 / 125mm

Depth Scale (m): 0 – 10. Elevation Scale (m): 468 – 459.



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

(continued next page)

Terraprobe

LOG OF BOREHOLE 11

Client : Sarah Properties Ltd Developments		Project No.:	11-14-4090
Project : Waldemar Development		Date started :	April 15, 2014
Location : Township of Amaranth, Ontario		Sheet No. :	2 of 2

Position : E: 557053, N: 4860109 (UTM 17T) — Elevation Datum : Geodetic

Rig type : CME 55, track-mounted — Drilling Method : Solid stem augers

Depth Scale (m)	Elev Depth (m)	Description	Graphic Log	Number	Type	SPT 'N' Value	Elevation Scale (m)	Penetration Test Values (Blows / 0.3m) / Undrained Shear Strength (kPa)	Moisture / Plasticity	Headspace Vapour	Instrument Details	Unstabilized Water Level	Lab Data and Comments (GRAIN SIZE DISTRIBUTION (%) (MIT) GR SA SI CL)
		(continued)											
		SANDY SILT to SAND AND SILT, trace to some gravel, trace clay, very dense, brown, damp to wet (GLACIAL TILL) *(continued)*		10	SS	50 / 25mm	458						
11							457						
12	456.1 12.2			11	SS	50 / 25mm							

Legend: Dynamic Cone (10, 20, 30, 40); Unconfined; Field Vane; Pocket Penetrometer; Lab Vane (40, 80, 120, 160); Plastic Limit (PL), Natural Water Content (MC), Liquid Limit (LL) (10, 20, 30)

END OF BOREHOLE

Borehole was dry and open upon completion of drilling.

50 mm monitoring well installed.

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Jun 5, 2014	5.3	463.0
Jul 3, 2014	5.6	462.7

Terraprobe

LOG OF BOREHOLE 12

Client : Sarah Properties Ltd Developments
Project : Waldemar Development
Location : Township of Amaranth, Ontario

Project No.: 11-14-4090
Date started : April 14, 2014
Sheet No. : 1 of 1

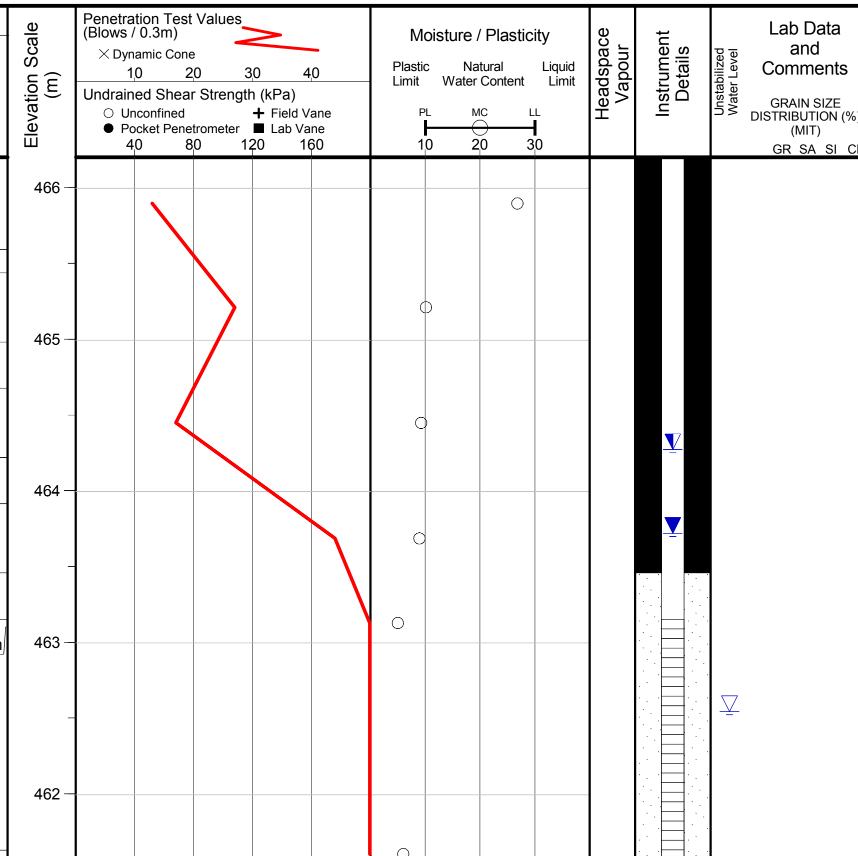
Position : E: 557046, N: 4860208 (UTM 17T)
Elevation Datum : Geodetic
Rig type : Track-mounted
Drilling Method : Solid stem augers

SOIL PROFILE

Elev / Depth (m)	Description
466.2	GROUND SURFACE
465.9 / 0.3	300mm **TOPSOIL**
465.6 / 0.6	Trace rootlets (WEATHERED/DISTURBED)
461.6 / 4.6	**SANDY SILT to SAND AND SILT**, trace to some gravel, trace clay, compact to very dense, brown, moist (GLACIAL TILL)

SAMPLES

Number	Type	SPT 'N' Value
1	SS	13
2	SS	27
3	SS	17
4	SS	44
5	SS	50 / 50mm
6	SS	50 / 50mm



END OF BOREHOLE

Unstabilized water level measured at 3.7 m below ground surface; borehole was open upon completion of drilling.

50 mm monitoring well installed.

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Jun 5, 2014	1.9	464.3
Jul 3, 2014	2.5	463.7

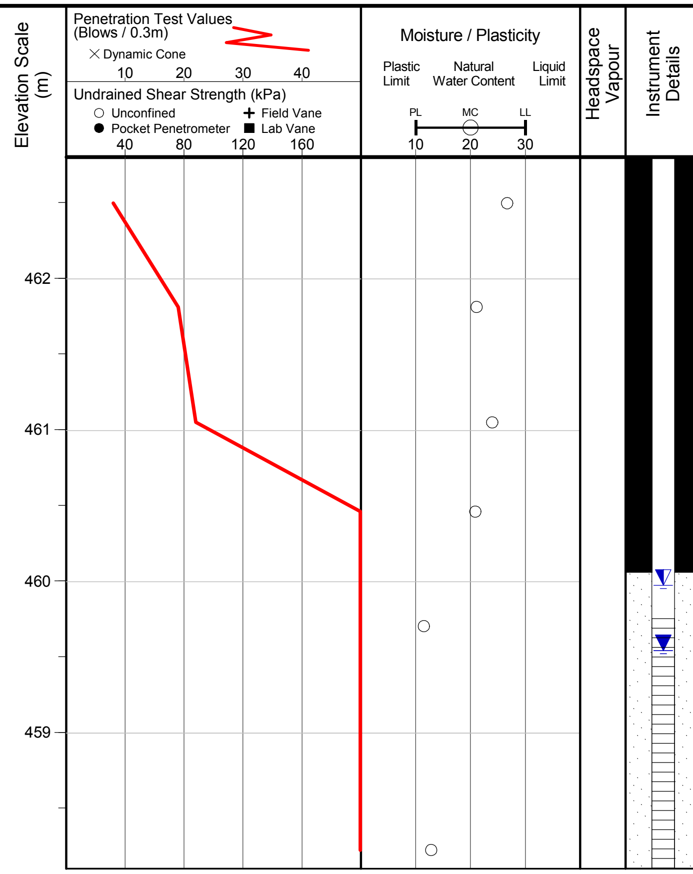
LOG OF BOREHOLE 13

Terraprobe

Client	: Sarah Properties Ltd Developments	Project No.:	11-14-4090
Project	: Waldemar Development	Date started :	April 14, 2014
Location	: Township of Amaranth, Ontario	Sheet No. :	1 of 1

Position : E: 557165, N: 4860133 (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	462.8	GROUND SURFACE			
		300mm **TOPSOIL**			
	462.5 / 0.3	Trace rootlets (WEATHERED/DISTURBED)	1	SS	8
1	462.0 / 0.8	**CLAYEY SILT**, trace to some sand, trace gravel, very stiff to hard, brown, moist (GLACIAL TILL)	2	SS	19
2			3	SS	22
			4	SS	50 / 50mm
3	459.8 / 3.0	**SANDY SILT to SAND AND SILT**, trace to some gravel, trace clay, very dense, brown, damp to moist (GLACIAL TILL)	5	SS	50 / 0mm
4					
	458.1 / 4.7		6	SS	50 / 10mm



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

END OF BOREHOLE

Unstabilized water level measured at 4.0 m below ground surface; borehole was open upon completion of drilling.

50 mm monitoring well installed.

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Jun 5, 2014	2.8	460.0
Jul 3, 2014	3.3	459.5

LOG OF BOREHOLE 14

Terraprobe

Client : Sarah Properties Ltd Developments		Project No.:	11-14-4090
Project : Waldemar Development		Date started :	April 14, 2014
Location : Township of Amaranth, Ontario		Sheet No. :	1 of 1

Position : E: 557096, N: 4860199 (UTM 17T) — Elevation Datum : Geodetic

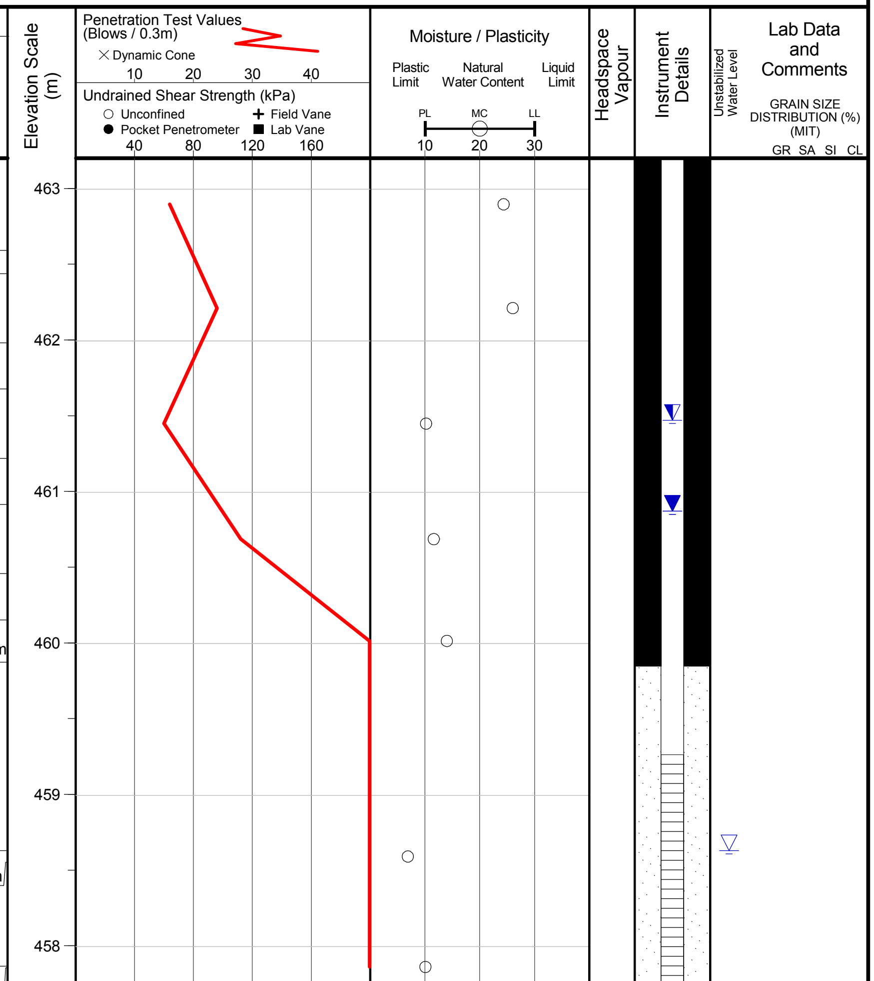
Rig type : Track-mounted — Drilling Method : Solid stem augers

SOIL PROFILE

Depth Scale (m)	Elev Depth (m)	Description
0	463.2	**GROUND SURFACE**
		500mm **TOPSOIL**
	462.7 / 0.5	Trace rootlets (WEATHERED/DISTURBED)
	462.0 / 1.2	**SANDY SILT to SAND AND SILT**, trace to some clay, trace gravel, compact to very dense, brown, damp to moist (GLACIAL TILL)
	457.7 / 5.5	**END OF BOREHOLE**

SAMPLES

Number	Type	SPT 'N' Value
1	SS	16
2	SS	24
3	SS	15
4	SS	28
5	SS	50 / 125mm
6	SS	50 / 75mm
7	SS	50 / 10mm



END OF BOREHOLE

Unstabilized water level measured at 4.6 m below ground surface; borehole was open upon completion of drilling.

50 mm monitoring well installed.

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Jun 5, 2014	1.7	461.5
Jul 3, 2014	2.3	460.9

LOG OF BOREHOLE 15

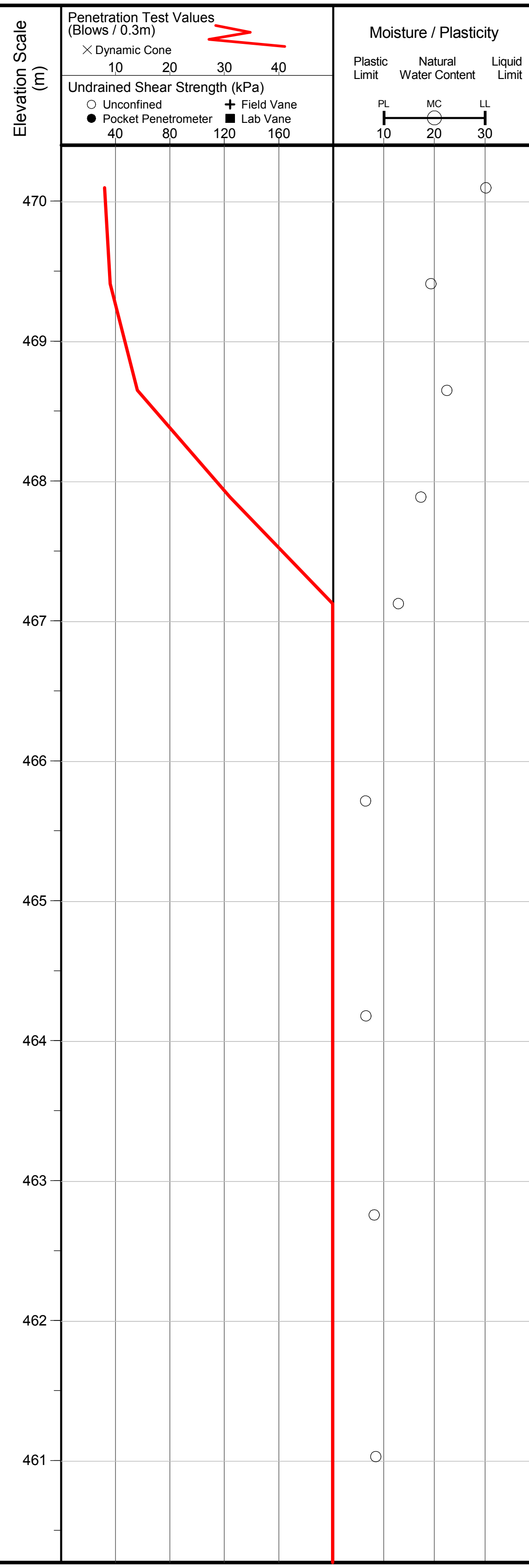
Terraprobe

Client : Sarah Properties Ltd Developments
Project : Waldemar Development
Location : Township of Amaranth, Ontario

Project No.: 11-14-4090
Date started : April 10, 2014
Sheet No. : 1 of 2

Position : E: 557417, N: 4859437 (UTM 17T)
Rig type : Track-mounted
Elevation Datum : Geodetic
Drilling Method : Solid stem augers

Elev / Depth (m)	Description	Sample Number	Type	SPT 'N' Value
470.4	**GROUND SURFACE**			
	300mm **TOPSOIL**			
470.1 / 0.3	Trace rootlets (WEATHERED/DISTURBED)	1	SS	8
		2	SS	9
469.2 / 1.2	**CLAYEY SILT**, trace to some sand, trace gravel, stiff to hard, dark brown, moist (GLACIAL TILL)	3	SS	14
		4	SS	31
		5	SS	57
465.8 / 4.6	**SANDY SILT to SAND AND SILT**, trace to some clay, trace gravel, very dense, brown, damp to moist (GLACIAL TILL)	6	SS	50 / 75mm
		7	SS	50 / 100mm
		8	SS	50 / 50mm
		9	SS	56



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

(continued next page)

LOG OF BOREHOLE 15

Terraprobe

Client : Sarah Properties Ltd Developments
Project : Waldemar Development
Location : Township of Amaranth, Ontario

Project No.: 11-14-4090
Date started : April 10, 2014

Position : E: 557417, N: 4859437 (UTM 17T)
Rig type : Track-mounted
Elevation Datum : Geodetic
Drilling Method : Solid stem augers

Depth Scale (m)	Elev Depth (m)	Description	Graphic Log	Number	Type	SPT 'N' Value	Elevation Scale (m)
		(continued)					
		SANDY SILT to SAND AND SILT, trace to some clay, trace gravel, very dense, brown, damp to moist (GLACIAL TILL) *(continued)*		10	SS	50 / 50mm	460
11							459
12	458.2 12.2			11	AS	50 / 25mm	

Penetration Test Values (Blows / 0.3m): Dynamic Cone 10 20 30 40
Undrained Shear Strength (kPa): Unconfined, Field Vane, Pocket Penetrometer, Lab Vane 40 80 120 160
Moisture / Plasticity: Plastic Limit, Natural Water Content, Liquid Limit; PL MC LL; 10 20 30
Headspace Vapour
Instrument Details
Unstabilized Water Level
Lab Data and Comments: GRAIN SIZE DISTRIBUTION (%) (MIT) GR SA SI CL

END OF BOREHOLE

Unstabilized water level measured at 9.1 m below ground surface; borehole was open upon completion of drilling.

50 mm monitoring well installed.

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Jun 5, 2014	6.2	464.2
Jul 3, 2014	7.1	463.3

LOG OF BOREHOLE 16

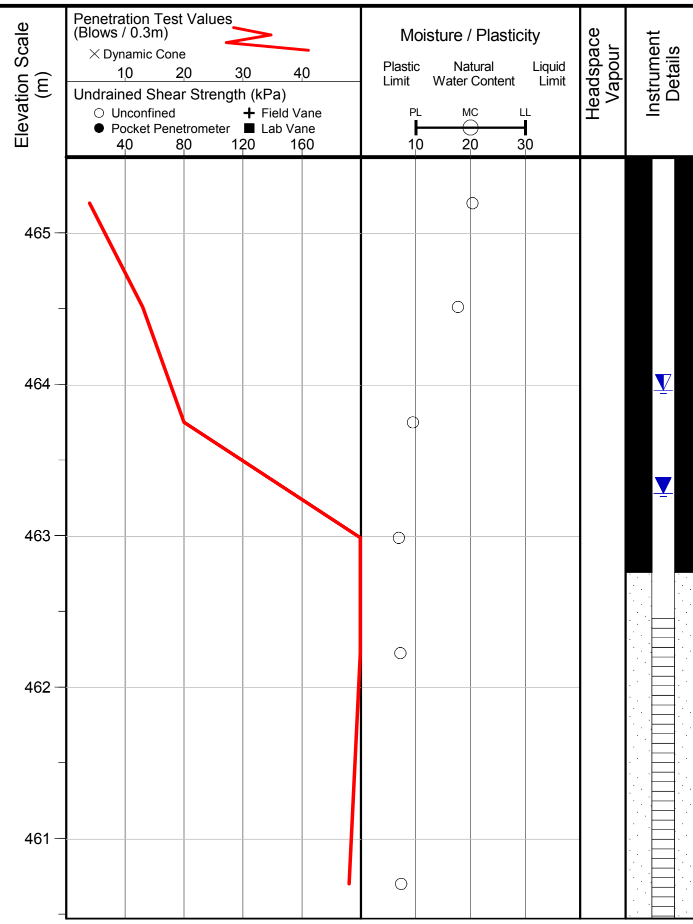
Terraprobe

Client	: Sarah Properties Ltd Developments	Project No.:	11-14-4090
Project	: Waldemar Development	Date started :	April 10, 2014
Location	: Township of Amaranth, Ontario	Sheet No. :	1 of 1

Position : E: 557522, N: 4859474 (UTM 17T) Elevation Datum : Geodetic

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

Elev (m)	Depth (m)	Description	Graphic Log	Sample Number	Type	SPT 'N' Value
465.5	0	**GROUND SURFACE**				
465.2	0.3	300mm **TOPSOIL**		1	SS	4
465.0	0.5	Trace rootlets (WEATHERED/DISTURBED)				
		CLAYEY SILT, trace to some sand, trace gravel, stiff, brown, moist (GLACIAL TILL)		2	SS	13
464.0	1.5	**SANDY SILT to SAND AND SILT**, trace to some gravel, trace to some clay, compact to very dense, brown, moist (GLACIAL TILL)		3	SS	20
				4	SS	76
				5	SS	85
				6	SS	48
460.5	5.0	**END OF BOREHOLE**				



Lab Data and Comments — GRAIN SIZE DISTRIBUTION (%) (MIT)

Sample	GR	SA	SI	CL
5	14	38	37	11

Unstabilized water level measured at 4.3 m below ground surface; borehole was open upon completion of drilling.

50 mm monitoring well installed.

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Jun 5, 2014	1.5	464.0
Jul 3, 2014	2.2	463.3

Terraprobe

LOG OF BOREHOLE 17

Client : Sarah Properties Ltd Developments
Project No.: 11-14-4090

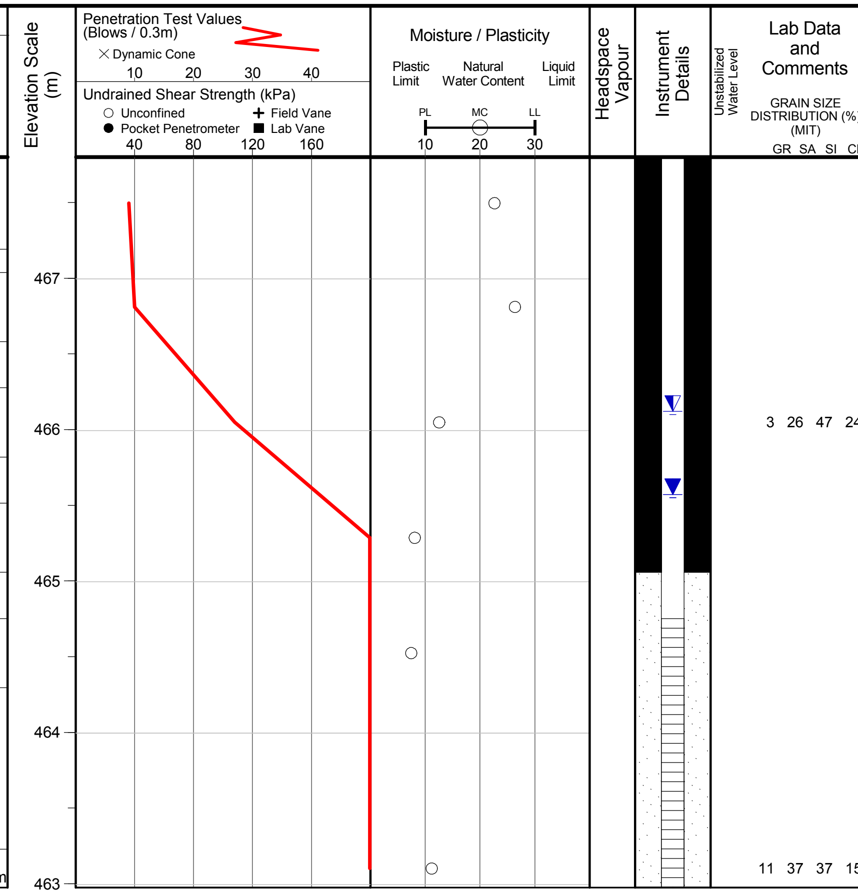
Project : Waldemar Development
Date started : April 10, 2014

Location : Township of Amaranth, Ontario
Sheet No. : 1 of 1

Position : E: 557469, N: 4859542 (UTM 17T)
Elevation Datum : Geodetic

Rig type : Track-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)
467.8	GROUND SURFACE				
467.6 / 0.2	150mm **TOPSOIL**				
	Trace rootlets (WEATHERED/DISTURBED)	1	SS	9	
467.0 / 0.8	**CLAYEY SILT**, some sand to sandy, trace gravel, stiff to very stiff, brown, moist (GLACIAL TILL)	2	SS	10	
		3	SS	27	3 26 47 24
465.5 / 2.3	**SANDY SILT to SAND AND SILT**, trace to some gravel, trace to some clay, very dense, brown, moist (GLACIAL TILL)	4	SS	80	
		5	SS	75	
463.0 / 4.8		6	SS	50 / 100mm	11 37 37 15



END OF BOREHOLE

Borehole was dry and open upon completion of drilling.

50 mm monitoring well installed.

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Jun 5, 2014	1.7	466.1
Jul 3, 2014	2.2	465.6

LOG OF BOREHOLE 18

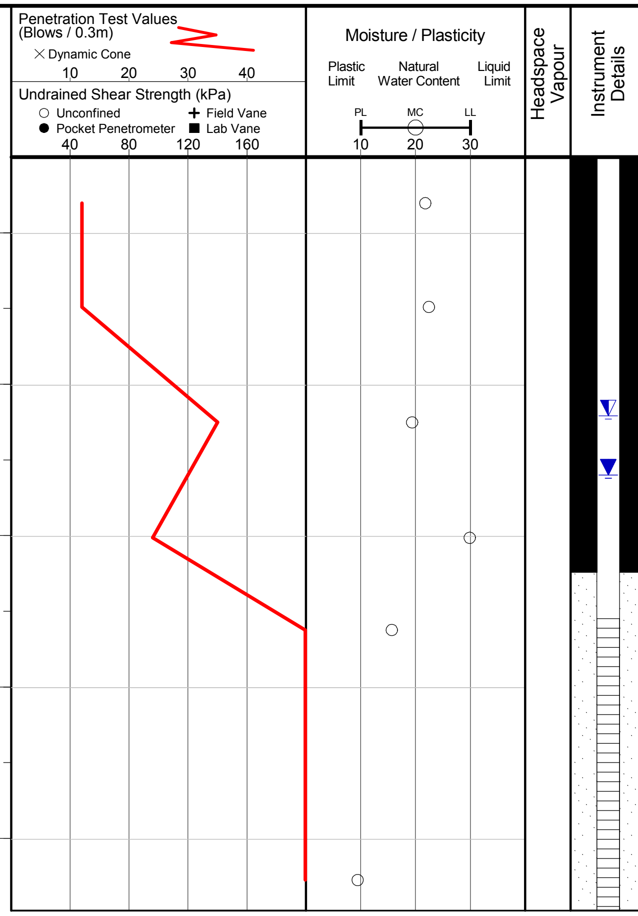
Terraprobe

Client : Sarah Properties Ltd Developments
Project : Waldemar Development
Location : Township of Amaranth, Ontario

Project No.: 11-14-4090
Date started : April 10, 2014
Sheet No. : 1 of 1

Position : E: 557411, N: 4859702 (UTM 17T)
Elevation Datum : Geodetic
Rig type : Track-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)
463.5	**GROUND SURFACE**				
463.3 / 0.2	150mm **TOPSOIL**				
	Trace rootlets (WEATHERED/DISTURBED)	1	SS	12	
462.7 / 0.8	**CLAYEY SILT**, trace gravel, trace sand to sandy, stiff to hard, brown, moist (GLACIAL TILL)	2	SS	12	
		3	SS	35	
	...wet lens	4	SS	24	
		5	SS	50 / 150mm	3 26 49 22
458.5 / 5.0		6	SS	83 / 250mm	



END OF BOREHOLE

Borehole was dry and open upon completion of drilling.

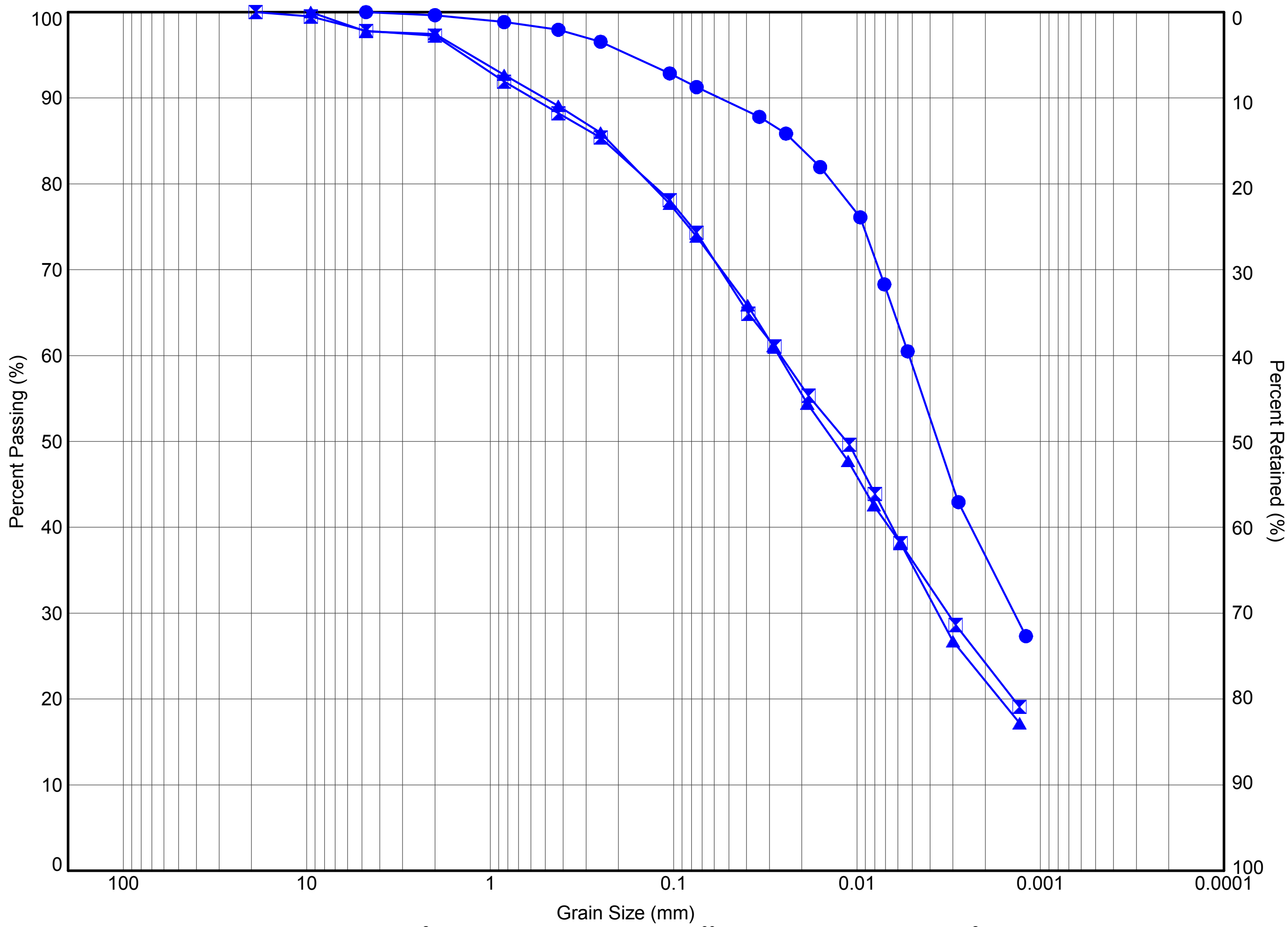
50 mm monitoring well installed.

WATER LEVEL READINGS

Date	Water Depth (m)	Elevation (m)
Jun 5, 2014	1.7	461.8
Jul 3, 2014	2.1	461.4

LABORATORY TEST RESULTS

TERRAPROBE INC.



MIT SYSTEM	COBBLES	GRAVEL			SAND			SILT	CLAY
		COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE		

MIT SYSTEM

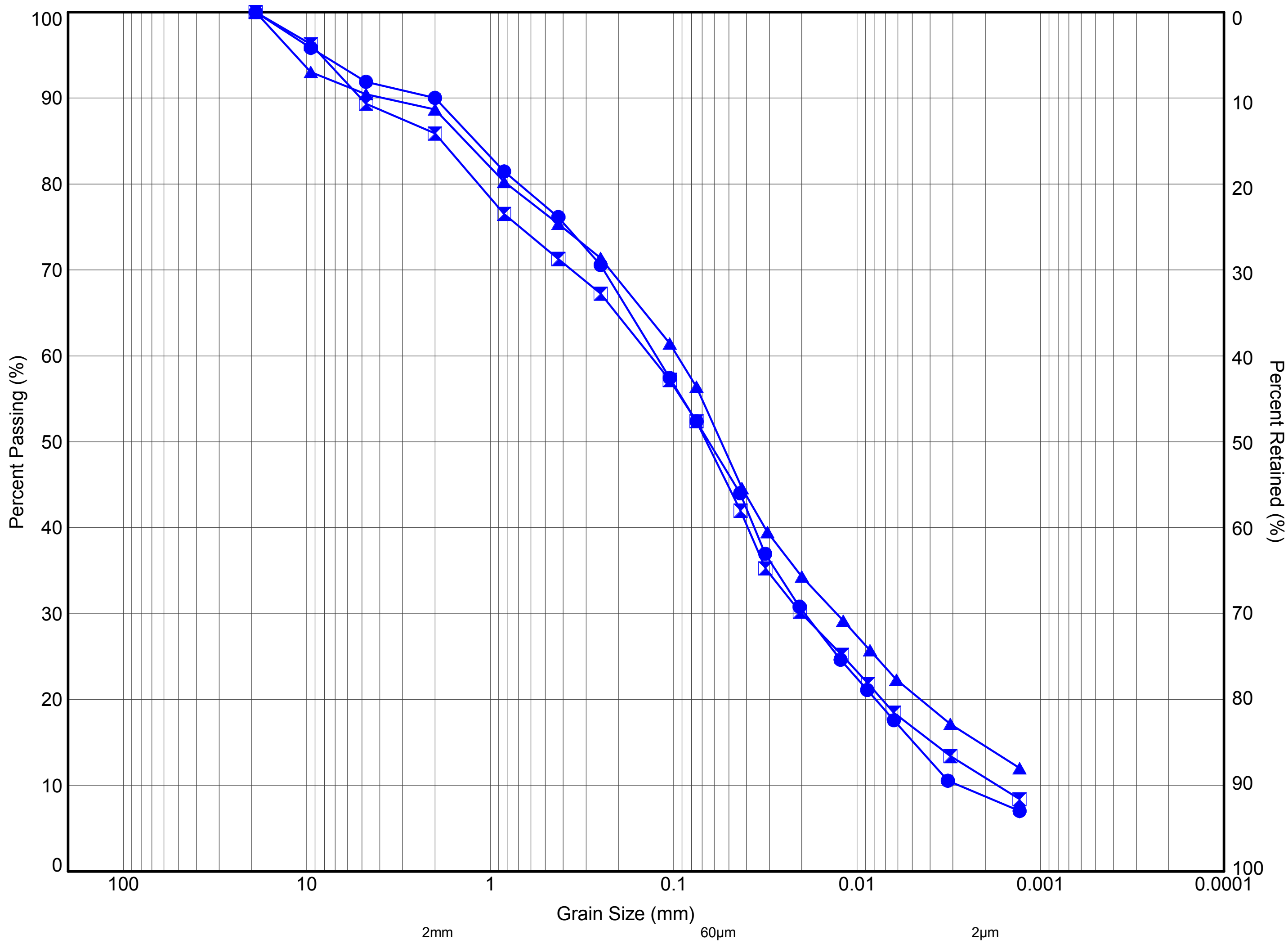
	Hole ID	Sample	Depth (m)	Elev. (m)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	*(Fines, %)*
●	**1**	SS2	1.0	473.2	0	9	54	37	
⧗	**17**	SS3	1.8	466.0	3	26	47	24	
▲	**18**	SS5	3.1	460.4	3	26	49	22	

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

Title:

GRAIN SIZE DISTRIBUTION
CLAYEY SILT, TRACE SAND TO SANDY, TRACE GRAVEL

File No.: **11-14-4090**



MIT SYSTEM	COBBLES	GRAVEL			SAND			SILT	CLAY
		COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE		

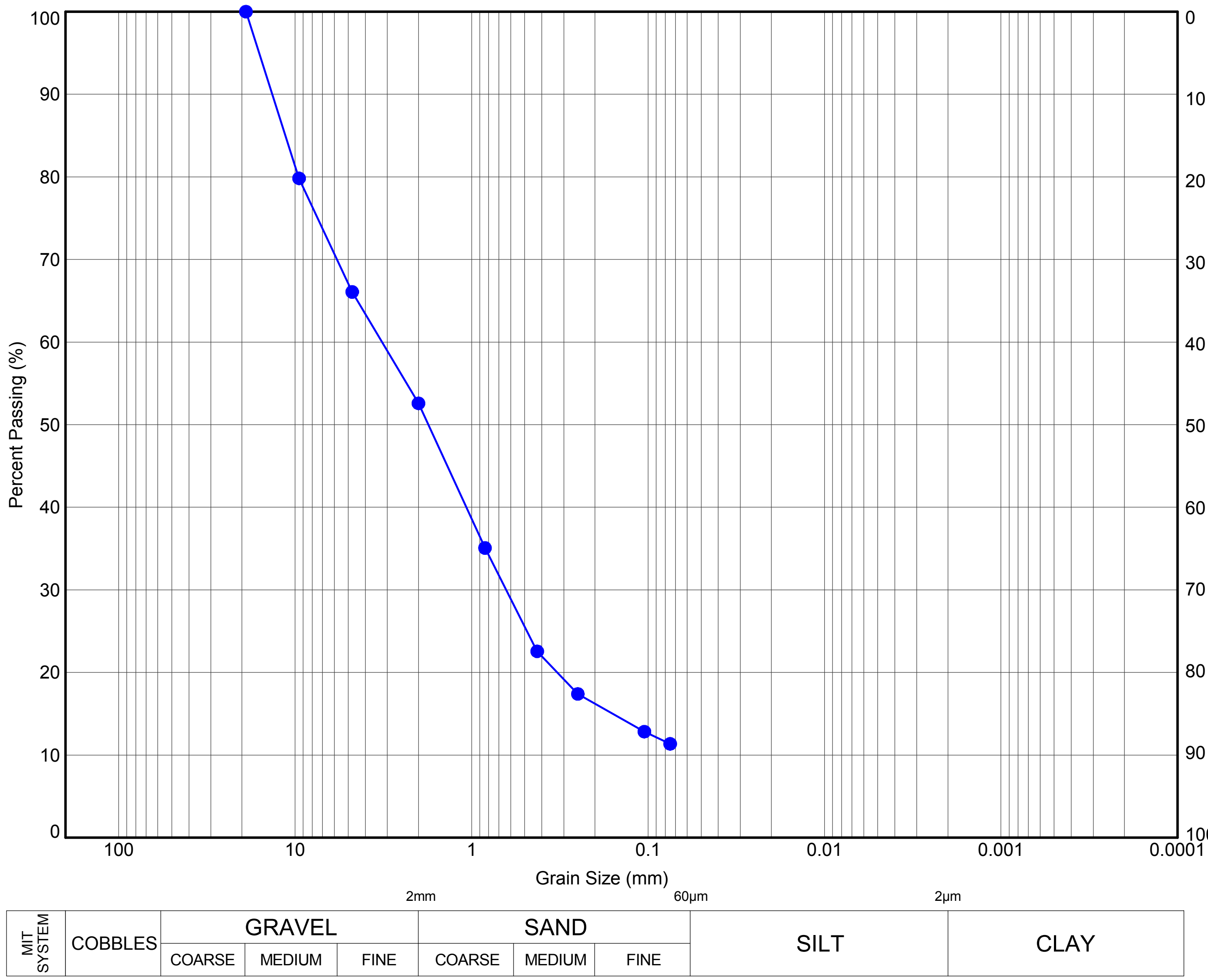
MIT SYSTEM

	Hole ID	Sample	Depth (m)	Elev. (m)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	*(Fines, %)*
●	**6**	SS3	1.8	464.9	10	41	40	9	
⧗	**16**	SS5	3.3	462.2	14	38	37	11	
▲	**17**	SS6	4.7	463.1	11	37	37	15	

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

Title: **GRAIN SIZE DISTRIBUTION**
SAND AND SILT, TRACE TO SOME CLAY, TRACE TO SOME GRAVEL

File No.: **11-14-4090**



MIT SYSTEM

	Hole ID	Sample	Depth (m)	Elev. (m)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	*(Fines, %)*
●	**1**	SS9	9.4	464.8	47	42			*(11)*

Terraprobe

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

Title: **GRAIN SIZE DISTRIBUTION**
GRAVEL AND SAND, SOME SILT

File No.: **11-14-4090**

ENGINEERED FILL EARTHWORKS SPECIFICATIONS

TERRAPROBE INC.

PART 1 GENERAL

1.01 Description

Engineered Fill refers to earth fill (earthworks) designed and constructed with engineering inspection and testing, so as to be capable of supporting structure foundations and slabs without excessive settlement. Poured concrete foundation walls must be provided with nominal reinforcing steel to provide stiffening of the foundation walls and to protect against excessive crack formation within the foundation walls.

Preparation for Engineered Fill and Engineered Fill operations must only be conducted under full time inspection and testing by the Geotechnical Engineer, in order to ensure adequate compaction and fill quality.

The work for the construction of Engineered Fill, is shown on the Design Drawings prepared by the Design Civil Engineer and as described by these specifications. The work included in this section includes the following:

a) Stripping of the existing topsoil, fill layer, and weathered/disturbed soil as needed from the ground surface below all areas to be covered with Engineered Fill,

b) Excavation of Test Holes into the subgrade to investigate the suitability of subsurface conditions for support of the Engineered Fill and determine if any prior existing fill materials are present,

c) Proof-rolling or visual inspection (as directed by the geotechnical engineer) of the subgrade below areas to be covered with Engineered Fill, to detect the presence and extent of unstable ground conditions,

d) Excavation and removal of unstable subgrade materials or other approved stabilization measures, if required prior to the placement of Engineered Fill,

e) Surveying of ground elevations prior to placing Engineered Fill,

f) Supply, placement, and compaction of approved clean earth as specified herein, with full time inspection and testing,

g) Surveying of ground elevations on completion of Engineered Fill placement,

h) Providing and maintaining survey layout of areas to receive Engineered Fill, and monitoring of ground elevations throughout the construction of Engineered Fill.

1.02 The Project Parties

A) The term Contractor shall refer to the individual or firm who will be carrying out the earthworks related to preparation and construction of Engineered Fill.

B) The term Geotechnical Engineer shall refer to the individual or firm who will be carrying out the full time inspection and testing of the earthworks related to preparation and construction of Engineered Fill.

C) The term Design Civil Engineer shall refer to the individual or firm who will be carrying out the Site Grading Design (pre-grading), the determination of Design Foundation Grades for the structures on the site, and the choice of lots and site areas to receive Engineered Fill.

PART 2 MATERIALS

2.01 Definitions

A) Topsoil Layer is the surface layer of naturally organic soil typically found at the ground surface and with thickness on the order of 25 to 250 mm thick.

B) Earth fill is soil material which has been placed by man-made effort and has not been deposited by nature over a long period of time.

C) Weathered/disturbed soil is natural or native soil that has been disrupted by weathering processes such as frost damage.

D) Subgrade soil is the “in situ” (in place) natural or native soil beneath any earth fill and/or weathered/disturbed soil and/or topsoil layer(s).

E) Engineered Fill soils must consist of clean earth materials (not excessively wet), free of organics and topsoil, free of deleterious materials such as building rubble, wood, plant materials, placed in thin lifts not exceeding 150 mm in thickness. Cohesionless soils such as sand or gravel, are the easiest to handle and compact.

F) All values stated in metric units shall be considered as accurate.

PART 3 ENGINEERED FILL DESIGN

3.01 Design Foundation Pressure

A) Engineered Fill can be expected to experience post-construction settlement on the order of 1 percent of the depth of the Engineered Fill. The time period over which most of this settlement typically occurs, depends on the composition of the Engineered Fill as follows (after initial placement);

a) Sand or gravel soil; several days,

b) Silt soil; several weeks,

c) Clay or clayey soil; several months.

The placement of Engineered Fill might also result in post-construction settlement of the underlying natural soil.

The timing of foundation construction must take into account the post-construction settlement of the Engineered Fill and the foundation soil.

B) Unless otherwise stated, the Engineered Fill is to be placed over the entire lot or site area.

C) The Engineered Fill is to extend up to 1 m above the highest level of required foundation support. Typically this can be within 1 m of the design final grades. Additional common fill can be placed over the Engineered Fill to provide protection against environmental factors such as wind, frost, precipitation, and the like.

E) A geotechnical reaction at SLS of 150 kPa for 25 mm of settlement is typically recommended for the Engineered Fill, unless it consists of glaciolacustrine silt and clay in which case a lower design foundation pressure will need to be determined on a site specific basis. Foundations shall have minimum widths of 0.6 m for continuous strip footings, and minimum dimensions of 1 m for column footings.

F) At the foundation level, sufficient Engineered Fill shall be constructed to ensure that it extends at least 1.0 m laterally beyond the edge of any foundations, and that it extends outward within an area defined by a 1 to 1 line downward from the edge of any Engineered Fill.

G) Foundations placed on the Engineered Fill must be provided with nominal reinforcing steel for protection against excessive minor cracking. The reinforcing steel must consist of 2-15M bars continuous at the top of the foundation wall, and 2-15M bars continuous at the bottom of the foundation walls.

H) At the time of foundation construction, foundation excavations must be reviewed by the Geotechnical Engineer to confirm suitable bearing capacity of the Engineered Fill. The Geotechnical Engineer must inspect the foundation subgrade immediately after excavation, and must inspect the foundation subgrade immediately prior to placement of concrete for footings. The Geotechnical Engineer must also inspect the placement of reinforcing steel in the foundation walls. Written approval must be obtained from the Geotechnical Engineer prior to,

a) placement of footing concrete, and

b) placement of foundation wall concrete.

PART 4 CONSTRUCTION

4.01 Survey Layout

A) The survey layout shall be carried out and maintained throughout the construction of Engineered Fill activities. A suitable layout stake shall be placed at the corners of the start and finish of every block or work area to receive Engineered Fill.

B) At least two temporary survey elevation benchmarks shall be provided for every work area to receive Engineered Fill, to assist in monitoring the level of the Engineered Fill as it is constructed.

C) The ground elevations of the subgrade approved for receiving Engineered Fill shall be surveyed and recorded on a regular grid pattern. Engineered Fill shall not be placed on any work area without the written approval of the Geotechnical Engineer.

D) The ground elevations of the Engineered Fill on each work area shall be surveyed and recorded on a regular grid pattern at the end of each day during the placement of Engineered Fill.

E) On completion of Engineered Fill construction, the final ground elevations shall be surveyed and recorded on a regular grid pattern.

4.02 Topsoil Stripping

A) The Geotechnical Engineer must observe the stripping of topsoil from the areas proposed for Engineered Fill, from start to finish.

B) Topsoil must be stripped from the entire building site area. The Geotechnical Engineer must photograph the work areas which have had the earth fill suitably stripped.

4.03 Test Holes Into Subgrade

A) After the topsoil has been stripped, the exposed subgrade must be investigated for the presence of weak zones or deleterious material, which may be unsuitable for the support of Engineered Fill.

B) Exploratory test holes must be dug using a small backhoe, on a suitable pattern to obtain a representative indication of the entire site area.

C) The Geotechnical Engineer must observe the digging and backfilling of the test holes; must log the test hole stratigraphy; must obtain soil samples at maximum depth intervals of 0.3m; and must photograph each dug test hole.

D) If the test holes discover any old buried fill or deleterious materials, it must be excavated and removed from the lot area down to undisturbed, stable native soil.

E) All test holes must be properly backfilled and compacted in loose lifts of maximum 150 mm thickness to at least 98 percent Standard Proctor Maximum Dry Density (SPMDD), at the optimum water content plus or minus 2 percent. The Geotechnical Engineer must observe the backfilling and compaction of the test holes.

4.04 Subgrade Proof-rolling

A) Prior to placing any Engineered Fill, the exposed subgrade must be proof-rolled with a static smooth-drum roller and the Geotechnical Engineer must observe the proof-rolling.

B) Cohesive soil will be disrupted by proof-rolling. Competency must be determined by a geotechnical engineer by cutting and inspecting the soil.

C) If unstable subgrade conditions are encountered, the unstable subgrade must be sub-excavated. If wet site conditions exist during filling, stabilization with granular materials may be required.

4.05 Engineered Fill Placement

A) Engineered fill must not be placed without the approval of the Geotechnical Engineer. Prior to placing any Engineered Fill, the existing fill must be removed down to native soil subgrade, the subgrade must be investigated for old buried fill or deleterious material, the subgrade must be proof-rolled, and the subgrade elevations must be surveyed.

B) Prior to the placement of Engineered Fill, the source or borrow area for the Engineered Fill must be evaluated for its suitability. Some of the existing site fill that is removed prior to placement of Engineered Fill may be sorted and reused as Engineered Fill, but must first be approved by the Geotechnical Engineer. Samples of the proposed fill material must be obtained by the Geotechnical Engineer and tested in the geotechnical laboratory for Standard Proctor Maximum Dry Density, prior to approval of the material for use as Engineered Fill. The Engineered Fill must be free of organics and other deleterious material (wood, building debris, rubble, cobbles, boulders, and the like).

C) The Engineered Fill must be placed in maximum loose lift thicknesses of 150 mm. Each lift of Engineered Fill must be compacted with a heavy roller, to at least 98 percent Standard Proctor Maximum Dry Density (SPMDD), at the optimum water content plus or minus 2 percent.

D) Field density tests must be taken by the Geotechnical Engineer, on each lift of Engineered Fill, on each lot area. Any Engineered Fill which is tested and found to not meet the specifications, shall be either removed or, reworked and retested.

E) Engineered fill must not be placed during the period of the year when cold weather occurs, i.e., when there are freezing ambient temperatures during the daytime and overnight.