FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 407/BROCK ROAD INTERCHANGE CONNECTION
STRUCTURE M-4 (SITE 3A)
REALIGNED BROCK ROAD OVER BROUGHAM CREEK
Contract No: E2-2012

Report to

MMM Group

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January 28, 2013
File: 19-5161-130A

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted at the proposed location of a new bridge that will carry the new realigned Brock Road over Brougham Creek, in The City of Pickering, Ontario. The new bridge is part of the Highway 407 east extension and is to be completed as part of the Highway 407/Brock Road Interchange Connection project.

The purpose of this investigation was to explore the subsurface conditions at the site and, based on the data obtained, to provide a borehole location plan, records of borehole sheets, stratigraphic profile and sections, laboratory test results and written descriptions of the subsurface conditions. A model of the subsurface conditions was developed from the data obtained during the course of the investigation.

Thurber carried out the investigation as a sub-consultant to MMM Group Limited, under the Highway 407 ETR Contract Number E2-2012 (Design).

2 SITE DESCRIPTION

The bridge site is located approximately 100 m west of Sideline 16 and approximately 485 m south of the existing Highway 407-Sideline 16 intersection. The community of Brougham is located approximately 1 km northwest of the proposed bridge site.

At the location of the proposed bridge, Brougham Creek flows from west to east. The creek flows in a valley that is approximately 10 m deep at the proposed bridge location. Lands surrounding the bridge site consist primarily of agricultural fields and undeveloped areas.

The site is situated in the physiographic region known as the South Slope, which lies between the Oak Ridges Moraine and the Iroquois Plain and typically is characterized by overburden deposits consisting of sand and silt, underlying or overlying glacial till sheets. Lacustrine clay deposited by Lake Iroquois, is often encountered between or overlying the till sheets. 'Surficial Geology of Southern Ontario' published by The Ontario Geological Survey shows that the bridge site is located in an area covered by sandy silt to silty sand till.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing for this structure were carried out from September 10 to 17 and December 11 and 12, 2012, and consisted of drilling and sampling a total of nine boreholes (identified as SM4-01 to SM4-09). Two boreholes were drilled at each of the North and South Abutments and one borehole at each approach behind abutment. One borehole was drilled at the North Pier and two boreholes were drilled at the South Pier. The boreholes were extended to depths ranging from 6.4 to 24.5 m below the existing ground surface. One borehole (identified as F2) was drilled and sampled for south approach embankment on January 9, 2013. The Record of Borehole sheets are included in Appendix A.

The approximate borehole locations are shown on the attached Borehole Locations and Soil Strata Drawing included in Appendix G. Borehole F2 was located approximately 130 m south of the south abutment and was not shown on the drawing.

The borehole locations were marked in the field and utility clearances were obtained prior to drilling. Double row silt fencing with straw bales was installed at each drilling location to prevent sediment laden water from entering Brougham Creek and the adjacent habitat. An access route was cleared down the south slope of the creek valley, along the proposed centreline of the structure, to provide access to the boreholes located within the creek valley.

Drilling was carried out using various track-mounted drill rigs and a combination of solid stem augers/hollow stem augers and wash boring methods were used to advance the boreholes. Overburden samples were obtained at selected intervals using a split spoon sampler in conjunction with the Standard Penetration Test (SPT).

The drilling and sampling operations were supervised on a full time basis by a member of Thurber's technical staff. The supervisor logged the boreholes and processed the recovered soil samples for transport to Thurber's laboratory for further examination and testing.

Groundwater conditions were observed in the open boreholes upon completion of the drilling operations. A standpipe piezometer, consisting of 19 to 25 mm diameter PVC pipe with a 1.5 m long slotted screen, was installed near each of the two abutments and south pier. A monitoring well, consisting of a 50 mm diameter PVC pipe with a 3.0 m long slotted screen, was installed near the north pier. The completion details of the piezometers/monitoring well and boreholes are summarized in Table 3.1. Boreholes were backfilled in general accordance with O. Reg. 903.

Table 3.1 – Borehole Completion and Piezometer Installation Details

Borehole	Piezometer Tip Depth/ Elevation (m)	Borehole Backfilling Details
SM4-01	None installed	Backfilled with bentonite holeplug to 1.4 m then cuttings to surface.
SM4-02	21.3 / 150.9	Piezometer with 1.5 m slotted screen installed with sand filter to 16.3 m, bentonite to from 16.3 to 0.6 m, then cuttings to surface.

Borehole	Piezometer Tip Depth/ Elevation (m)	Borehole Backfilling Details
SM4-03	None installed	Backfilled with bentonite holeplug to 1.5 m then cuttings to surface.
SM4-04	24.4 / 147.0	Piezometer with 1.5 m slotted screen installed with sand filter to 19.7 m, bentonite to 0.5 m, then cuttings to surface.
SM4-05	None installed	Backfilled with bentonite holeplug to 1.9 m then cuttings to surface.
SM4-06	None installed	Backfilled with bentonite holeplug to 1.2 m then cuttings to surface.
SM4-07	None installed	Backfilled with bentonite holeplug to surface.
SM4-08	9.1 / 153.5	Piezometer with 3.0 m slotted screen installed with sand filter to 5.5 m and bentonite holeplug from 5.5 m to surface.
SM4-09	9.1 / 152.4	Monitoring well with 3.0 m slotted screen installed with sand filter to 5.3 m and bentonite holeplug from 5.3 m to surface.
F2	None installed	Backfilled with bentonite holeplug to 1.3 m then cutting to surface.

The standpipe piezometers will be decommissioned in accordance with O. Reg. 903 after a period of groundwater level monitoring.

4 LABORATORY TESTING

The recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected samples were subjected to gradation analysis (sieve and hydrometer) and Atterberg Limits testing, where appropriate. The results of this testing program are summarized on the Record of Borehole sheets included in Appendix A and are presented on the figures included in Appendix B.

Selected samples were also subjected to analytical lab testing consisting of pH test and soluble Sulphate content determination. The test results are included in Appendix B.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets included in Appendix A. Details of the encountered soil stratigraphy at the proposed bridge site are presented on the "Borehole Locations and Soil Strata" drawings included in Appendix G. An overall description of the stratigraphy encountered at the proposed bridge site is given in the following paragraphs. However, the factual data presented in the Record of Borehole Sheets governs any interpretation of the site conditions.

In general, a surficial organic layer was encountered at all borehole locations. At the proposed north abutment, a layer of clayey silt was found beneath the organic layer. The clayey silt was underlain by the silty sand to sand and silt till to a significant depth. At the proposed south abutment, the sand and silt till was encountered immediately beneath the organic layer. Within the creek valley, granular soils ranging from sandy silt to gravelly sand were encountered below the organic layer at the proposed pier locations.

5.1 Organics

A layer of organics was encountered at surface in all boreholes drilled at this site. The thickness of the organic layer ranged from 100 to 200 mm.

The thickness of the organic layer may vary between and beyond the borehole locations.

5.2 Clayey Silt

A layer of brown clayey silt, containing trace to some sand and trace gravel, was encountered below the organic layer in Boreholes SM4-01 to SM4-03. The upper portion of the clayey silt layer was topsoil stained and contained some rootlets.

The clayey silt layer was 1.2 m thick in all three boreholes, with the lower boundary of the clayey silt encountered at a depth of 1.4 m below the surface (Elevation 170.7 to 171.0).

SPT N-Values recorded in the clayey silt layer ranged from 28 blows for 0.3 m penetration to 50 blows for 0.15 m penetration, indicating a very stiff to hard consistency. Moisture contents ranged from 10 to 32%.

5.3 Silty Sand to Sand and Silt Till

Silty sand to sand and silt till was encountered directly below the organic layer in Boreholes SM4-04 to SM4-06 and below the clayey silt layer in Boreholes SM4-01 to SM4-03. The silty sand to sand and silt till was typically brown to grey and contained trace to some gravel and trace to some clay.

The silty sand to sand and silt till deposit was fully penetrated in Boreholes SM4-02, SM4-03, and SM4-04. The till was interbedded with sand layers in Borehole SM4-02. The thickness of the till deposit encountered in these three boreholes ranged from 10 to 17.5 m. Boreholes SM4-01, SM4-05, SM4-06 and F2 were terminated within the till deposit at depths of 6.4 to 14.0 m (Elevation 165.8 to 158.5).

SPT tests performed in this layer gave N-Values ranging from 26 to above 100, indicating a compact to very dense relative density. Moisture contents of the till varied typically from 8 to 20%.

Twelve samples of the silty sand to sand and silt till underwent laboratory grain size analysis testing, the results of which are summarized below. These results are also presented on the Record of Borehole sheets included in Appendix A. The grain size distribution curves for these samples are plotted on Figures B1 and B2 in Appendix B.

Soil Particles	Percentage (%)
Gravel	0 to 13
Sand	29 to 57
Silt	21 to 56
Clay	7 to 26

5.4 Sand

Sand layers with trace gravel and trace to some silt and clay were encountered in SM4-02. The sand layers were found interbedded with the till deposit at 2.0, 4.3, 11.4, 17.5 and 20.9m below the ground surface.

SPT tests performed in the sand gave N-Values ranging from 63 to above 100, indicating a very dense relative density. Moisture contents of the sand vary typically from 10 to 15%.

A grain size analysis performed on the sand sample indicated 84% of sand and 16% of silt and clay combined as shown on Figure B3 in Appendix B.

5.5 Gravelly Sand to Sand

A layer of gravelly sand to sand with some gravel was encountered below the surficial organic layer in SM4-08 and SM4-09. The thickness of this layer ranges from 1.2 to 1.8 m with the top of layer encountered at Elevation 161.4 to 162.4.

SPT tests performed in the sand gave N-Values ranging from 17 to 39, indicating a compact to dense relative density. Natural moisture contents in the deposit vary from 10 to 19%.

A grain size analysis performed on the soil indicated 37% of gravel, 49% of sand and 14% of silt and clay combined as shown on Figure B6 in Appendix B.

5.6 Silty Sand to Sandy Silt

A layer of silty sand to sandy silt was encountered below the silty sand till in SM4-03, directly beneath the organic layer in SM4-07, and below the gravelly sand to sand layer in SM4-08 and SM4-09. Elevations of the top of layer range from 160.2 to 161.6. The silty sand to sandy silt layer was only penetrated in SM4-08 and SM4-09 with the layer thickness ranging from 5.7 to 6.2 m.

SPT tests performed in the deposit gave N-Values ranging typically from 22 to above 100, indicating a compact to very dense relative density. Natural moisture contents in the deposit vary from 17 to 21%.

Four gradation analyses were completed on the samples collected in this layer. The results are summarized on the Record of Borehole sheets in Appendix A and the grain size distribution curve for this sample is included in Figures B4 and B5 of Appendix B. The results of the laboratory tests are summarized as follows:

Soil Particles	Percentage (%)
Gravel	0
Sand	13 to 53
Silt	35 to 78
Clay	9 to 12

5.7 Silt

A silt layer with trace to some clay was encountered within the till in SM4-02, below the till in SM4-04 and below the silty sand and sandy silt layer in SM4-08 and SM4-09. The thickness of the layer ranged from 1.7 to 4.6 m with the underside at Elevation ranging from 149.1 to 155.7.

SPT tests performed in the silt layer gave N-Values greater than 100 blows, indicating a very dense relative density. The moisture contents within the silt layer ranged between 16 and 20%.

The results of grain size analysis of the silt samples are summarized on the Record of Borehole sheets in Appendix A and the grain size distribution curves for these samples are included in Figure B4 of Appendix B. The results of the laboratory tests are summarized as follows:

Soil Particles	Percentage (%)
Gravel	0
Sand	6 to 11
Silt	71 to 82
Clay	12 to 20

5.8 Lower Gravelly Sand to Sand

A layer of gravelly sand to sand with some gravel was encountered below the silt in SM4-04 and SM4-09. The top of layer was encountered at Elevation 152.8 to 149.1. Both holes were terminated in this layer.

SPT tests performed in the deposit gave N-Values greater than 100 blows, indicating a very dense relative density. Natural moisture contents in the deposit vary from 8 to 9%.

A grain size analysis performed on the soil indicated 29% of gravel, 52% of sand and 19% of silt and clay combined as shown on Figure B6 in Appendix B.

5.9 Groundwater Levels

Where practical, groundwater levels were observed in the open boreholes upon completion of the drilling. Four standpipe piezometers/monitoring wells were installed at this site, as shown in Table 3.1, to monitor groundwater levels. The measured groundwater levels are summarized in Table 5.1.

Table 5.1 – Measured Groundwater Levels

Borehole	Date	Groundwater Level (m)		Comment
		Depth (m)	Elevation (m)	
SM4-01	Sep. 11, 2012	4.6	167.8	Open borehole
SM4-02	Sep. 12, 2012 Oct. 16, 2012 Oct. 26, 2012 Nov. 27, 2012 Dec. 19, 2012 Jan. 3, 2012	12.3 12.6 12.3 12.1 12.1 12.1	159.9 159.6 159.9 160.1 160.1 160.1	Piezometer
SM4-03	Sep. 12, 2012	3.8	168.3	Open borehole
SM4-04	Oct. 16, 2012 Oct. 26, 2012 Nov. 27, 2012 Dec. 19, 2012 Jan. 3, 2012	11.6 11.5 11.4 11.3 11.3	159.8 159.9 160.0 160.1 160.1	Piezometer
SM4-05	Sep. 17, 2012	10.0	162.5	Open borehole
SM4-06	Sep. 17, 2012	DRY	-	Open borehole
SM4-07	Dec. 11, 2012	2.0	159.8	Open borehole
SM4-08	Dec. 18, 2012 Dec. 19, 2012 Jan. 2, 2012 Jan. 9, 2012	1.9 1.6 1.1 1.6	160.7 161.0 161.5 161.0	Piezometer
SM4-09	Dec. 18, 2012 Dec. 19, 2012 Jan. 2, 2012 Jan. 9, 2012	1.5 1.1 2.6 1.1	160.0 160.4 158.9 160.4	Well
F2	Jan. 9, 2013	6.5	165.1	Open borehole

The above values are short-term readings and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after the spring snowmelt or after periods of heavy precipitation.

6 MISCELLANEOUS

The borehole locations were selected by Thurber Engineering Ltd. and staked in the field using a Trimble Pathfinder ProXRT differential GPS. The co-ordinates and ground surface elevations at the boreholes were surveyed by MMM upon completion of drilling.

Thurber obtained utility clearances for the borehole locations prior to drilling.

DBW Drilling of Ajax, Ontario supplied a track-mounted drill rig and conducted the drilling, sampling and in-situ testing operations for the boreholes located on the table lands and Walker Drilling of Barrie, Ontario supplied a track-mounted drill rig and conducted the drilling, sampling and in-situ testing operations for the boreholes located within the creek valley. A D7 dozer was used to assist the track-mounted rig up and down the valley slope.

The drilling and sampling operations in the field were supervised by Ms. Eckie Siu and Mr. Stephane Loranger of Thurber.

Routine laboratory testing was carried out by Thurber Engineering Ltd.

Overall supervision of the field program was conducted by Ms. Lindsey Blaine, E.I.T. Interpretation of the data and preparation of the report were carried out by Mr. Keli Shi, P.Eng. and Mr. Alastair Gorman, P.Eng. Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations projects, reviewed the report.

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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 INTRODUCTION

This section of the report provides an interpretation of the factual data, presented earlier, and also presents geotechnical recommendations for design of the realigned Brock Road overpass based on the factual information as well as our understanding of the project. The plans and profiles and General Arrangement drawing used for preparation of this report were provided by MMM Group.

The proposed overpass structure, on the General Arrangement (GA) drawing dated January 2013, is shown to be a three-span structure with a total supported length of 98.1 m and width of 32.3 m to carry six lanes of traffic. Each abutment is shown to be supported on a single row of HP 310x110 steel piles. The approach embankments will be approximately 10.5 to 8.2 m above the existing ground surface at the north and south abutments, respectively. The undersides of the abutments are shown at Elevation 177.20 and 174.20 m for the north and south abutment, respectively. The top of pier footings are shown at Elevation 164.10 and 160.60 m for the north and south piers, respectively.

8 STRUCTURE FOUNDATIONS

The general stratigraphy of the site was characterized by very dense till comprised predominantly of sand and silt with some clay, trace gravel and occasional cobbles. The till was covered by a surficial layer of organics at the proposed south abutment and by both surficial organics and very stiff to hard clayey silt at the proposed north abutment. In the creek valley where the bridge piers will be located, a deposit of dense to very dense sandy silt to silty sand was found in place of the very dense till.

The groundwater level measured at the installed piezometers and monitoring well on November 27 and December 18, 2012 varied from Elevation 160.0 to 160.7. Higher groundwater levels were recorded on completion of drilling in shallower boreholes at the abutments and approaches.

Consideration was given to the following foundation types:

- Spread footings:
  - founded on native soil
  - founded on engineered fill

- Augered caissons (drilled shafts)
- Driven steel H-piles

A comparison of the foundation alternatives, with their respective advantages and disadvantages, are included in Appendix D.

8.1 Spread Footings Founded on Native Soil

The spread footings must be placed on the underlying dense to very dense sand and silt till at the abutments and on the dense to very dense sand and silt at the piers. The design of spread footings founded on undisturbed dense to very dense sand and silt till or sand and silt must be in accordance with the elevations and factored geotechnical resistance at Ultimate Limit States (ULS) and geotechnical resistance at Serviceability Limit States (SLS) as provided in Table 8.1.

Table 8.1 – Founding Elevation and Bearing Resistances on Native Soil

Locations	Highest Base Elevation (m)	Factored ULS Resistance (kPa)	SLS Resistance (kPa)
North Abutment (SM4-02 & 03)	170.7	600	400
North Pier (SM4-09)	159.5	600	400
South Pier (SM4-07 & 08)	159.5	600	400
South Abutment (SM4-04 & 05)	169.3	600	400

The bearing resistances in Table 8.1 are for vertical, concentric loading. In the case of eccentric or inclined loading, the bearing resistance must be adjusted as shown in the CHBDC (2006) Clause 6.7.3 and Clause 6.7.4.

The geotechnical SLS resistance values given above are based on an estimated total settlement not exceeding 25 mm. This settlement is expected to be substantially complete by the end of construction. Differential settlement is not expected to exceed 20 mm across the width of the structure.

Founding elevations presented in Table 8.1 are near or below the groundwater level observed during the investigation at the piers. If temporary excavations required to construct these footings extend below the water table, local groundwater control will be required to construct the footing in the dry and to prevent disturbance of the footing base. Excavation and dewatering are addressed elsewhere in this report. Scour protection will be required for the footings.

8.2 Spread Footings Founded on Engineered Fill

If higher founding elevations are required, spread footings could be constructed on engineered fill pad consisting of OPSS Granular "A" fill material. This option would be suitable for abutment footing elevations which are currently shown on the GA to be above the existing ground surface elevation.

If an engineered fill pad is used, all organics or other deleterious materials must be stripped from the footprint of the foundation to expose competent native subgrade material. The engineered fill would be placed and compacted on native compact to very dense sand and silt till and the highest permitted base elevation, at which engineered fill pads may be founded, are provided in Table 8.2.

Table 8.2 – Founding Elevation and Bearing Resistances on Engineered Fill

Locations	Highest Base Elevation (m)	Factored ULS Resistance (kPa)	SLS Resistance (kPa)
North Abutment (SM4-02 & 03)	171.5	750	350
South Abutment (SM4-04 & 05)	170.7		

The geotechnical resistances shown in Table 8.2 are based on a minimum 2.0 m thick layer of engineered granular fill. The resistance values shown are for concentric, vertical loads only. For eccentric or inclined loading, the bearing resistance must be adjusted in accordance with the CHBDC (2006) Clause 6.7.3 and Clause 6.7.4.

The geotechnical SLS resistances given above are based on an estimated total settlement not exceeding 25 mm. This settlement is expected to be substantially complete by the end of construction. Differential settlement is not expected to exceed 20 mm across the width of the structure.

The Granular "A" must be compacted to 100% of Standard proctor maximum dry density (SPMDD) at optimum moisture content of ±2%. The geometry of the fill pad must conform to the general requirements shown in Figure 1 in Appendix E.

8.3 Augered Caissons (Drilled Shafts)

Augered caissons, 1.2 m in diameter, founded in the sand and silt till with SPT N greater than 100 blows, at or below elevation shown in Table 8.3, are considered as a feasible foundation for the abutments. Founding caissons in the silty sand to sandy silt at the piers is not recommended. The base of the caissons will be below the groundwater level at the pier locations, which may result in some difficulties in dewatering, base cleaning and base inspection. Construction of the caissons will require the use of a sealed liner extending above the groundwater level and/or slurry methods to control groundwater and to support the sidewalls of the shaft. The presence of cobbles within the till will cause difficulty for drilling operations.

Table 8.3 – Founding Elevation and Axial Resistance for Caissons

Locations	Highest Base Elevation (m)	Factored ULS Resistance (kN)	SLS Resistance (kN)
North Abutment (SM4-02 & 03)	162.0	4000	3200
South Abutment (SM4-04 & 05)	162.0		

8.4 Steel H-Pile Foundations

The soil conditions encountered at this site are considered to be suitable for the support of foundations on steel piles (HP 310x110) driven to refusal within the very dense sand and silt till at the abutments or the very dense silty sand to sandy silt at the piers. The recommended pile tip elevations and the recommended design resistances are shown in Table 8.4.

Table 8.4 – Recommended Axial Resistance for Steel H-Piles

Locations	Highest Pile Tip Elevation (m)	Factored ULS Resistance (kN)	SLS Resistance (kN)
North Abutment (SM4-02 & 03)	164.0	1800	1600
North Pier (SM4-09)	154.0	1600	1400
South Pier (SM4-07 & 08)	154.0	1600	1400
South Abutment (SM4-04 & 05)	164.0	1800	1600

The pile tips must be driven to the elevations shown, or to greater depth if this is necessary to develop the geotechnical resistance. Pre-augering may be necessary to reach these elevations, but pre-augering must not extend deeper than 3.0 m above the final tip elevation.

The structural resistance of the pile must be checked by the structural designer and pile installation should be carried out in accordance with OPSS 903.

The pile tip elevations have been chosen to satisfy all of the following requirements:

- Develop sufficient geotechnical resistance.
- Penetrate at least 5.0 m into native soil.
- Penetrate at least 3.0 m below the underside of the CSP.

8.4.1 Pile Tips

Due to the possible presence of cobble and boulders, the tips of all driven piles must be reinforced. This can be achieved by fitting the piles with steel H-pile driving shoes in accordance with OPSD 3000.100.

8.4.2 Pile Driving

Pile driving must be controlled by the Hiley Formula and an ultimate pile resistance should be specified by the designer in accordance with Clause 3.3.2 (b) Construction Stage of the Structural Manual. The Hiley formula need not be used until the piles are within 2.0 m of the bearing stratum. The appropriate pile driving note is "Piles to be driven in accordance with Standard SS 103-11 using an ultimate resistance of "R" kN per pile. "R" must have a minimum value of twice the design load at ULS, but must not exceed 3600 kN at the abutments and 3200 kN at the piers.

As boreholes encountered SPT refusal within the sand and silt till and noted the presence of cobbles, an NSSP should require the Contractor's Quality Verification Engineer (QVE) to terminate driving before the pile is damaged by overdriving. Suggested texts for NSSP's are included in Appendix F.

8.4.3 Downdrag

Downdrag on the piles is not considered to be an issue at this site, since the founding soils are generally dense to very dense with low clay content.

8.4.4 Lateral Pile Resistance

The geotechnical lateral resistance of an H-pile embedded in till may be calculated using a value for the coefficient of horizontal subgrade reaction (k_s) and ultimate lateral resistance (p_{ult}) as follows:

$$k_s = n_h\, z / D \qquad \text{(kN/m3)}$$

$$p_{ult} = 3\, \gamma\, z\, K_p \qquad \text{(kPa)}$$

where:

	z	=	depth of embedment of pile in metres
	D	=	pile width or diameter in metres
	n_h	=	coefficient of horizontal subgrade reaction
		=	12,000 kN/m^3 (in dense to very dense till)
	γ	=	21 kN/m^3 (very dense till above water table)
	γ_w	=	11 kN/m^3 (very dense till below water table)
	K_p	=	passive earth pressure coefficient
		=	3.7 (for dense to very dense till)

The above equations and recommended parameters may be used to analyze the pile-soil interaction. The lateral pressures obtained from the analysis must not exceed the ultimate lateral resistance.

The spring constant, K_s, for analysis may be obtained by the expression, $K_s = k_s$ x L x D (kN/m), where L is the length (m) of the pile segment or element used in the analysis and remaining variables are as defined earlier. The ultimate lateral resistance, P_{ult}, may be obtained from the expression, $P_{ult} = p_{ult}$ x L x D. This represents the ultimate load at which the pile fails and will not support any additional load at greater displacements. It is recommended, however, that the total lateral resistance of a single pile be limited to no more than 120 kN at ULS and 50 kN at SLS.

The coefficient of horizontal subgrade reaction may have to be reduced due to pile interaction, based on the centre-to-centre pile spacing. The reduction factors to be used for a single pile in a closely spaced pile group are provided in Table 8.5 with intermediate values obtained by linear interpolation. Alternatively, horizontal loads may be resisted by means of battered piles.

Table 8.5 – Reduction Factors for Coefficient of Subgrade Reaction due to Pile Spacing

Condition	Pile Spacing Centre-to-Centre	Reduction Factor
Pile alignment oriented perpendicular to direction of loading	4D	1.0
	1D	0.5
Pile alignment oriented parallel to direction of loading	8D	1.0
	6D	0.7
	4D	0.4
	3D	0.25

Note: D is the width or diameter of pile along the loading direction

8.5 Frost Cover

The depth of frost penetration at this site is 1.2 m. The base of all pile caps, caissons caps or spread footings, must be provided with a minimum of 1.2 m of earth cover as protection against frost action.

8.6 Proposed Foundation

From geotechnical perspective, and based on current information, the recommended foundation for both abutments and piers consists of steel H-piles driven into the dense to very dense sand and silt till or sandy silt to silty sand.

9 BRIDGE APPROACHES AND EMBANKMENTS

Based on the boreholes drilled within the approach areas, the embankments will be constructed on very stiff to hard clayey silt and compact to very dense sand and silt till. Embankments constructed using SSM or granular fill with side slopes of 2H:1V or flatter will be stable on the base. For embankment fill greater than 8 m in height, a 2 m wide, mid height berm should be provided.

Settlement in the underlying soil will be immediate and essentially complete when the embankment reaches full height. Allowance should be made for self-consolidation within the embankment equal to approximately 1% of the embankment height, which may take a few months to complete. Accordingly, paving should be delayed for as long as possible after construction of the embankment.

10 EXCAVATION AND GROUNDWATER CONTROL

All excavation must be carried out in accordance with the Occupational Health and Safety Act (OHSA). The very stiff to hard clayey silt and underlying dense to very dense till at the abutments are classified as Type 2 soil. It is recommended that the sandy silt soils at the pier locations be treated as Type 3 soil.

Based on the GA provided by MMM, no excavation is anticipated at the abutments. However, if excavation is required and there is insufficient space for sloped excavation, shoring by means of soldier piles and lagging, or driven steel sheet piles could be considered.

All temporary shoring must be designed by a licensed Professional Engineer experienced in design of shoring with consideration of adjacent surcharge loads and any sloping retained surfaces. Roadway protection, if required, should be supplied in accordance with OPSS 539 and designed for Performance Level 2.

Foundation construction at the piers will require excavation in non-cohesive soils below the recorded groundwater level. In order to control sloughing and disturbance of the base of the excavation, it is recommended that these excavations be carried out inside steel sheet pile cofferdams.

In the case of spread footings, the groundwater level must be depressed by positive dewatering techniques to a level at least 0.5 m below the required base of excavation prior to the excavation being carried out. Furthermore, in the case of spread footings, the cofferdam must be designed to be left in place permanently to provide scour protection and guard against undermining of the foundation.

In the case of driven steel pile foundations, the following points must be observed:

1. Footings shall be constructed in the dry in accordance with OPSS 902.
2. Positive control measures will be required in view of the high groundwater level in the cohesionless soil and proximity of the creek.

3. Groundwater and surface water control measures shall be designed by the Contractor but one possible method is a steel sheet pile cofferdam driven to sufficient depth to cut off upward flow of groundwater.
4. If effective cutoff of the groundwater cannot be achieved, consideration could be given to deepening the excavation inside the cofferdam and pouring a minimum 1m thick tremie concrete plug after the piles have been driven.

Consideration must be given to the risk of flooding at the pier locations if the stream level rises during construction.

In the case of pile caps at the pier locations, erosion protection must be provided to prevent undermining of the pile cap. Possible options include designing the cofferdam to be left in place, or riprap protection designed by a river hydrologist.

The design of any dewatering or groundwater control system, that may be required, is the responsibility of the Contractor and the Contract Documents must alert the Contractor to this responsibility and the need to engage a dewatering specialist. The Contractor should also be prepared to pump from sumps to remove any remaining seepage water or surface water collecting in an excavation. Placement of structural concrete must be done in the dry. Dewatering or groundwater control must remain operational and effective until the foundation is installed and backfilled. The excavation and backfilling for foundations must be carried out in accordance with OPSS 902.

11 BACKFILL AND LATERAL EARTH PRESSURES

The backfill to the abutment walls must be Granular B Type II material meeting the requirements of Special Provisions 110S13 "Amendment to OPSS 1010, April 2004". The backfill must be in accordance with OPSS 902 and placed to the extent shown in OPSD 3101.150.

Heavy compaction equipment should not be used adjacent to the abutment walls and wing walls. Compaction should be carried out in accordance with OPSS 501.

Earth pressures acting on the abutment walls may be assumed to impose a triangular distribution governed by the characteristics of the backfill. For a fully drained condition, the pressures should be computed in accordance with the CHBDC but generally are given by the expression:

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

Where: p = horizontal pressure on the wall at depth h (kPa)

K = earth pressure coefficient (see table below)

γ = unit weight of retained soil (see table below)

h = depth below top of fill where pressure is computed (m)

q = value of any surcharge (kPa)

Earth pressure coefficients for backfill behind abutments are dependent on the material used as backfill. Recommended unfactored values are shown in Table 11.1. The at-rest coefficients should be employed for conventional abutment walls. Active pressures may be used for walls when a degree of movement is permissible.

The parameters presented in the table correspond to full mobilization of active and passive earth pressures, and require certain relative movements between the wall and adjacent soil to produce these conditions. The values to be used in design should be assessed from Figure C6.16 of the Commentary to the CHBDC.

In accordance with Clause 6.9.3 of the CHBDC, a compaction surcharge should be added. The magnitude should be 12 kPa at the top of fill and decreasing to 0 kPa at a depth of 2.0 m for Granular B Type I or 1.7 m for Granular A or Granular B Type II.

Table 11.1 – Earth Pressure Coefficients

Condition	Earth Pressure Coefficient (K)			
	OPSS Granular A or OPSS Granular B Type II $\phi = 35°, \gamma = 22.8$ kN/m^3		OPSS Granular B Type I $\phi = 32°, \gamma = 21.2$ kN/m^3	
	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)
Active K_a (Unrestrained Wall)	0.27	0.40	0.31	0.48
At rest K_0 (Restrained Wall)	0.43	-	0.47	-
Passive K_p (Movement Towards Soil Mass)	3.7	-	3.3	-

The design of the abutments must incorporate measures such as subdrains to permit drainage of the backfill and avoid the potential build-up of hydrostatic pressures behind the walls. Alternatively, the abutment walls must be designed to withstand the potential build-up of hydrostatic pressures behind the walls.

12 SEISMIC CONSIDERATIONS

The following seismic parameters should be used for design:

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

The soil profile type at this site has been classified as Type II. Therefore, according to Table 4.4 of the CHBDC, a Site Coefficient "S" (ground motion amplification factor) of 1.2 should be used in seismic design.

In accordance with Clause 4.6.4 of the CHBDC, retaining structures should be designed using active (K_{AE}) and passive (K_{PE}) earth pressure coefficients that incorporate the effects of earthquake loading. The coefficients of horizontal earth pressure for seismic loading presented in Table 12.1 may be used:

Table 12.1 – Earth Pressure Coefficients for Earthquake Loading

Condition	Earth Pressure Coefficient (K_E) for Earthquake Loading			
	OPSS Granular A or OPSS Granular B Type II $\phi = 35°$, $\delta = 17°$		OPSS Granular B Type I $\phi = 32°$, $\delta = 16°$	
	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)
Active*, K_{AE} (Unrestrained Wall)	0.30	0.47	0.34	0.58
At rest**, K_{0E} (Restrained Wall)	0.53	-	0.58	-
Passive*, K_{PE} (Movement Towards Soil Mass)	3.6	-	3.2	-

* After Mononobe and Okabe, passive case assumes a horizontal surface in front of the wall.
** After Woods

The potential for liquefaction of the foundations soils was assessed using the Seed and Idriss (1971) method[1]. Using this method, it is estimated that under the existing conditions the foundation soils are not prone to liquefaction.

The existing embankments are above the groundwater level and are not considered to be in danger of undergoing liquefaction. Some toe failure may occur but it is expected to be of limited nature and readily repairable.

13 CONSTRUCTION CONCERNS

Potential construction concerns include, but are not necessarily limited to:

- The lengths of the driven piles may vary from the predicted values due to the inherent variable composition of the glacial and post-glacial deposits at this site. If the pile tip elevations vary by more than 3 m from the predicted values, the design team should be notified and permitted to review the possible implications.
- With respect to the CSPs to be installed below the existing ground surface, it must be noted that some of the pre-augering will be carried out in cohesionless soils below the groundwater level. These holes may be prone to collapse before the CSP can be installed.

[1] Seed, H.B. and Idriss, I.M. 1971, "Simplified Procedure for Evaluating Soil Liquefaction Potential" *Journal of Soil Mechanics and Foundations Division,* ASCE, Vol. 101, No. SM9, September, pp. 1249-1273.

The contract documents must contain a note warning the contractor that it may be necessary to use a temporary, oversize liner to maintain a stable pre-augered hole and permit installation of the CSP.

- Excavation below the water level, if required, will involve lowering of the groundwater level below the excavation base to maintain a reasonably dry excavation and stables side slopes or the use of cofferdams and tremie concrete.
- The embankment side slopes should be inspected after construction for surficial disturbance. Where necessary, erosion control measures must be implemented.

The successful performance of the overpass structure will depend largely upon good workmanship and quality control during construction. Pile driving supervision, subgrade examination and field density testing should be carried out by qualified geotechnical personnel during construction to confirm that foundation recommendations are correctly implemented and material specifications are met.

14 CLOSURE

Engineering analysis and preparation of the report was carried out by Mr. Keli Shi, P.Eng. and Mr. Alastair Gorman, P.Eng.

The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.

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Review Principal

Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	Less than 0.002mm	Plastic particles, not visible to the naked eye

2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT(1) 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

1) Laboratory Triaxial Testing
2) Field Insitu Vane Testing
3) Laboratory Vane Testing
4) SPT value
5) Pocket Penetrometer

4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE

SS Split Spoon Sample
WS Wash Sample
AS Auger (Grab) Sample
TW Thin Wall Shelby Tube Sample
TP Thin Wall Piston Sample
PH Sampler Advanced by Hydraulic Pressure
PM Sampler Advanced by Manual Pressure
WH Sampler Advanced by Self Static Weight
RC Rock Core
SC Soil Core

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$

▼ Water Level

C_{pen} Shear Strength Determination by Pocket Penetrometer

(1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.

(2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

UNIFIED SOILS CLASSIFICATION

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS $W_L < 50\%$	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. ($W_L < 30\%$).
		CI	Inorganic clays of medium plasticity, silty clays. ($30\% < W_L < 50\%$).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION

Fresh (FR)	No visible signs of weathering.
Fresh Jointed (FJ)	Weathering limited to the surface of major discontinuities.
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.
Moderately Weathered (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.
Highly Weathered (HW)	Weathering extends throughout the rock mass and the rock is partly friable.
Completely Weathered (CW)	Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved.

SYMBOLS

CLAYSTONE

SILTSTONE

SANDSTONE

COAL

Bedrock (general)

DISCONTINUITY SPACING

Bedding	**Bedding Plane Spacing**
Very thickly bedded	Greater than 2m
Thickly bedded	0.6 to 2m
Medium bedded	0.2 to 0.6m
Thinly bedded	60mm to 0.2m
Very thinly bedded	20 to 60mm
Laminated	6 to 20mm
Thinly Laminated	Less than 6mm

TERMS

Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a percentage of total core run length.
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen
Fracture Index: (FI)	Frequency of natural fractures per 0.3m of core run.

STRENGTH CLASSIFICATION

Rock Strength	**Approximate Uniaxial Compressive Strength** (MPa)	(psi)	**Field Estimation of Hardness***
Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail

THURBER

RECORD OF BOREHOLE No SM4-01

METRIC

WP#	E2-2012	LOCATION	N 4 864 027.7 E 337 305.0
HWY	407	BOREHOLE TYPE	Solid Stem Augers
DATUM	Geodetic	DATE	2012.09.11 - 2012.09.11

ORIGINATED BY SLL
COMPILED BY AN
CHECKED BY LRB

Soil Profile

ELEV / DEPTH	DESCRIPTION
172.4 / 0.0	**ORGANICS** with roots and rootlets: (200mm)
0.2	Clayey **SILT**, trace to some sand, trace gravel Hard Brown Moist
171.0 / 1.4	Silty **SAND**, trace gravel, trace clay, occasional cobbles Dense to Very Dense Brown Moist (TILL) Moist becoming wet
165.8 / 6.6	END OF BOREHOLE AT 6.6m. BOREHOLE OPEN AND WATER LEVEL AT 4.6m ON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 1.4m, THEN CUTTINGS TO SURFACE.

Samples

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	50/ 0.150	
2	SS	100/ 0.275	
3	SS	100/ 0.275	7 54 31 8
4	SS	100/ 0.275	
5	SS	34	
6	SS	100	

Ground water conditions: water level symbol (∇) at approx. elevation 167.8.

Elevation scale: 172, 171, 170, 169, 168, 167, 166

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa
O UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L

WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m³

+ ³, × ³: Numbers refer to Sensitivity

15-⊕-5 (20 / 10) (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No SM4-02

METRIC

WP# E2-2012 | LOCATION N 4 864 013.9 E 337 299.9 | ORIGINATED BY SLL

HWY 407 | BOREHOLE TYPE Hollow Stem Augers/Tricone | COMPILED BY AN

DATUM Geodetic | DATE 2012.09.10 - 2012.09.11 | CHECKED BY LRB

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
172.2						
0.0	**ORGANICS**, with roots and rootlets: (200mm)				172	
0.2	Clayey **SILT**, with rootlets, topsoil stained Very Stiff Dark Brown Moist	1	SS	28	171	
170.8 / 1.4	**SAND** and **SILT**, some clay, trace gravel Very Dense Brown Moist (TILL)	2	SS	63		
170.2 / 2.0	**SAND**, some silt and clay Very Dense Brown Moist	3	SS	63	170	0 84 16 (SI+CL)
169.4 / 2.8	**SAND** and **SILT**, some clay, trace gravel Very Dense Brown Moist (TILL)	4	SS	64	169, 168	
167.9 / 4.3	**SAND**, medium grained, some gravel, trace silt Very Dense Brown Wet	5	SS	100/ 0.275		
167.3 / 4.9	**SAND** and **SILT**, trace to some clay, trace gravel Very Dense Brown Moist (TILL)				167	
	Grey	6	SS	100/ 0.050	166, 165	
		7	SS	100/ 0.275	164	3 46 39 12
	Sand seam	8	SS	100/ 0.125	163	

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m³

Continued Next Page

+³, ×³: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No SM4-02

METRIC

WP# E2-2012	LOCATION N 4 864 013.9 E 337 299.9		ORIGINATED BY SLL
HWY 407	BOREHOLE TYPE Hollow Stem Augers/Tricone		COMPILED BY AN
DATUM Geodetic	DATE 2012.09.10 - 2012.09.11		CHECKED BY LRB

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SAND and **SILT**, trace to some clay, trace gravel, Very Dense, Grey, Moist (TILL)	9	SS	100/ 0.150	162	o	3 49 41 7
160.8 / 11.4	**SAND**, some silt, trace gravel, Very Dense, Grey, Wet	10	SS	100/ 0.150	161, 160	o	
158.8 / 13.4	Sandy **SILT**, some clay, trace gravel, Very Dense, Grey, Moist (TILL)	11	SS	100/ 0.175	159, 158	o	
157.6 / 14.6	**SILT**, some clay, trace to some sand, Very Dense, Grey, Moist	12	SS	100/ 0.150	157, 156	o	0 6 82 12
155.7 / 16.5	Sandy **SILT**, some clay, trace gravel, Very Dense, Grey, Moist (TILL)	13	SS	100/ 0.150	155	o	
154.7 / 17.5	**SAND**, trace to some silt, Very Dense, Grey, Wet	14	SS	100/ 0.200	154, 153	o	
152.6 / 19.6	Sandy **SILT**, trace gravel, Very Dense	15	SS	100/		o	

Groundwater level indicated at approx. elev. 160.2.

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE — 20 40 60 80 100

PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m³

Continued Next Page

+3, ×3: Numbers refer to Sensitivity

20 / 15-5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No SM4-02

METRIC

WP# E2-2012 | LOCATION N 4 864 013.9 E 337 299.9 | ORIGINATED BY SLL

HWY 407 | BOREHOLE TYPE Hollow Stem Augers/Tricone | COMPILED BY AN

DATUM Geodetic | DATE 2012.09.10 - 2012.09.11 | CHECKED BY LRB

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	SAMPLE TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page						
	Sandy **SILT**, trace gravel Very Dense Grey Moist (TILL)			0.125	152		
151.3 20.9	**SAND**, trace silt and gravel Very Dense Grey Wet	16	SS	100/ 0.150	151	o	
150.6 21.6	END OF BOREHOLE AT 21.6m. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.						

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20, 40, 60, 80, 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20, 40, 60); UNIT WEIGHT γ kN/m³

WATER LEVEL READINGS:

DATE	DEPTH (m)	ELEV.
Sep. 12/12	12.3	159.9
Oct. 16/12	12.6	159.6
Oct. 26/12	12.3	159.9
Nov. 27/12	12.1	160.1
Dec. 19/12	12.1	160.1
Jan. 03/13	12.1	160.1

ONTMT4S 1130A.GPJ 1/24/13

+ 3, × 3: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No SM4-03

METRIC

WP#	E2-2012	LOCATION	N 4 864 017.1 E 337 323.1	ORIGINATED BY	SLL
HWY	407	BOREHOLE TYPE	Solid Stem Augers	COMPILED BY	AN
DATUM	Geodetic	DATE	2012.09.12 - 2012.09.12	CHECKED BY	LRB

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
172.1	
0.0	**ORGANICS** with roots and rootlets: (175mm)
0.2	Clayey **SILT**, some sand, trace gravel Brown Moist
170.7 / 1.4	Silty **SAND**, trace to some clay, trace gravel Compact to Very Dense Brown Moist (TILL) Occasional cobbles Moist becoming wet Grey

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	33	
2	SS	40	
3	SS	100/ 0.275	6 53 32 9
4	SS	100/ 0.175	
5	SS	71	
6	SS	100	6 47 33 14
7	SS	100/ 0.150	
8	SS	100/ 0.125	

GROUND WATER CONDITIONS: water level symbol at approx. elev. 168.4

ELEVATION SCALE: 172, 171, 170, 169, 168, 167, 166, 165, 164, 163

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L

WATER CONTENT (%): 20 40 60

UNIT WEIGHT γ kN/m³

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S 1130A.GPJ 1/24/13

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No SM4-03

METRIC

WP# E2-2012	LOCATION N 4 864 017.1 E 337 323.1	ORIGINATED BY SLL
HWY 407	BOREHOLE TYPE Solid Stem Augers	COMPILED BY AN
DATUM Geodetic	DATE 2012.09.12 - 2012.09.12	CHECKED BY LRB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page						162				
			9	SS	100/ 0.150				o (~20)		
							161				
160.4 / 11.7	Silty **SAND**, trace clay Very Dense Grey Wet						160				
159.8 / 12.3	END OF BOREHOLE AT 12.3m. BOREHOLE OPEN TO 5.4m AND WATER LEVEL AT 3.8m ON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 1.5m, THEN CUTTINGS TO SURFACE.		10	SS	100/ 0.150				o (~20)		

Legend: Shear strength: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE. Water content: PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L.

+ ³, × ³: Numbers refer to Sensitivity   15-⊕-5 (20 / 10) (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No SM4-04

METRIC

WP# E2-2012	LOCATION N 4 863 923.3 E 337 341.8	ORIGINATED BY SLL
HWY 407	BOREHOLE TYPE Hollow Stem Augers/Tricone	COMPILED BY AN
DATUM Geodetic	DATE 2012.09.12 - 2012.09.14	CHECKED BY LRB

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20, 40, 60, 80, 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20, 40, 60); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
171.4 / 0.0	**ORGANICS** sandy, with rootlets: (200mm)									
0.2	Silty **SAND** to **SAND** and **SILT**, trace to some gravel, trace to some clay, occasional cobbles Compact to Very Dense Brown Moist (TILL)				171					
		1	SS	39		o	13	57	21	9
					170					
		2	SS	26		o				
					169					
		3	SS	81		o				
		4	SS	100/ 0.275		o				
	Grey				168					
					167					
		5	SS	100/ 0.275		o	4	47	36	13
					166					
		6	SS	100		o				
					165					
					164					
		7	SS	100/ 0.225		o				
					163					
		8	SS	100/ 0.125		o				
					162					

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

15-⊕-5 (20 above, 10 below) (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No SM4-04

METRIC

WP#	E2-2012	LOCATION	N 4 863 923.3 E 337 341.8	ORIGINATED BY	SLL
HWY	407	BOREHOLE TYPE	Hollow Stem Augers/Tricone	COMPILED BY	AN
DATUM	Geodetic	DATE	2012.09.12 - 2012.09.14	CHECKED BY	LRB

SOIL PROFILE — Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Medium grained Wet	9	SS	100/ 0.100	161	
					160 (groundwater level ▼)	
		10	SS	100/ 0.125	159	0 40 56 4
		11	SS	100/ 0.150	158 / 157	
		12	SS	100/ 0.150	156	
	With silt seams Wet	13	SS	100/ 0.150	155 / 154	
153.7 / 17.7	**SILT**, some clay, trace sand Very Dense Grey Moist	14	SS	100/ 0.150	153	0 8 72 20
	With sand layers	15	SS	100/	152	

Continued Next Page

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE: 20 40 60 80 100
PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L
WATER CONTENT (%): 20 40 60
UNIT WEIGHT γ kN/m³

+ 3, × 3: Numbers refer to Sensitivity

15 -⊕- 5 (20 above, 10 below) (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No SM4-04

METRIC

WP# E2-2012 LOCATION N 4 863 923.3 E 337 341.8 ORIGINATED BY SLL

HWY 407 BOREHOLE TYPE Hollow Stem Augers/Tricone COMPILED BY AN

DATUM Geodetic DATE 2012.09.12 - 2012.09.14 CHECKED BY LRB

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SILT, some clay, trace sand Very Dense Grey Moist			0.125	151		
		16	SS	100/ 0.175	150	o	
149.1 / 22.3	Gravelly **SAND**, some silt and clay Very Dense Grey Wet				149		
		17	SS	100/ 0.175		o	29 52 19 (SI+CL)
	Some cobbles from 23.4 to 24.4 m				148		
146.9		18	SS	100/ 0.075	147	o	
24.5	END OF BOREHOLE at 24.5 m Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.						

WATER LEVEL READINGS:

DATE	DEPTH (m)	ELEV.
Oct. 16/12	11.6	159.8
Oct. 26/12	11.5	159.9
Nov. 27/12	11.4	160.0
Dec. 19/12	11.3	160.1
Jan. 03/13	11.3	160.1

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; UNIT WEIGHT γ kN/m3

$+^3, \times^3$: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No SM4-05

METRIC

WP#	E2-2012	LOCATION	N 4 863 915.1 E 337 314.1	ORIGINATED BY	SLL
HWY	407	BOREHOLE TYPE	Solid Stem Augers	COMPILED BY	AN
DATUM	Geodetic	DATE	2012.09.17 - 2012.09.17	CHECKED BY	LRB

SOIL PROFILE

ELEV DEPTH	DESCRIPTION
172.5	
0.0	**ORGANICS** sandy, with roots and rootlets: (200mm)
0.2	**SAND** and **SILT**, some clay to clayey, trace gravel Very Dense Brown Moist (TILL)
	Grey

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	100/ 0.175	
2	SS	100/ 0.175	
3	SS	70	3 39 39 19
4	SS	101/ 0.275	
5	SS	100/ 0.250	
6	SS	100/ 0.125	
7	SS	100/ 0.125	
8	SS	100/ 0.200	

STRAT PLOT | GROUND WATER CONDITIONS | ELEVATION SCALE: 172, 171, 170, 169, 168, 167, 166, 165, 164, 163

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE: 20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L

WATER CONTENT (%): 20 40 60

UNIT WEIGHT γ kN/m³

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

15 ⊕ 5 (20, 10) (%) STRAIN AT FAILURE

ONTMT4S 1130A.GPJ 1/24/13

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No SM4-05

METRIC

WP# E2-2012	LOCATION N 4 863 915.1 E 337 314.1		ORIGINATED BY SLL
HWY 407	BOREHOLE TYPE Solid Stem Augers		COMPILED BY AN
DATUM Geodetic	DATE 2012.09.17 - 2012.09.17		CHECKED BY LRB

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	SAND and **SILT**, some clay to clayey, trace gravel Very Dense Brown Moist (TILL)						162				
			9	SS	100/ 0.275				o		
							161				
			10	SS	100/ 0.125				o		0 29 45 26
							160				
							159				
158.5	Moist becoming wet		11	SS	100/ 0.100				o		
14.0	END OF BOREHOLE AT 14.0m. BOREHOLE OPEN TO 10.4m AND WATER LEVEL AT 10.0m ON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 1.9m, THEN CUTTINGS TO SURFACE.										

ONTMT4S 1130A.GPJ 1/24/13

$+^3, \times^3$: Numbers refer to Sensitivity

15-⊕-5 (20 above, 10 below) (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No SM4-06

METRIC

WP#	E2-2012	LOCATION	N 4 863 902.6 E 337 328.8	ORIGINATED BY	SLL
HWY	407	BOREHOLE TYPE	Solid Stem Augers	COMPILED BY	AN
DATUM	Geodetic	DATE	2012.09.17 - 2012.09.17	CHECKED BY	LRB

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
172.1 / 0.0	**ORGANICS** sandy, with roots: (175mm)				172					
0.2	**SAND** and **SILT**, some clay, trace gravel Compact to Very Dense Brown Moist (TILL)	1	SS	28	171	o	3	46	33	18
		2	SS	100/ 0.200		o				
		3	SS	100/ 0.125	170	o				
		4	SS	100/ 0.225	169	o	3	34	45	18
					168					
		5	SS	100/ 0.250	167	o				
	Grey	6	SS	100/ 0.125	166	o				
165.7 / 6.4	END OF BOREHOLE AT 6.4m. BOREHOLE OPEN AND DRY ON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 1.2m, THEN CUTTINGS TO SURFACE.									

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

+ ³, × ³: Numbers refer to Sensitivity

20 / 15 - 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S 1130A.GPJ 1/24/13

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No SM4-07

METRIC

WP#	E2-2012	LOCATION	N 4 863 954.5 E 337 332.1	ORIGINATED BY	ES
HWY	407	BOREHOLE TYPE	Solid Stem Augers	COMPILED BY	AN
DATUM	Geodetic	DATE	2012.12.11 - 2012.12.11	CHECKED BY	LRB

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	GR	SA	SI	CL
161.8									
0.0	**ORGANICS**, sandy, trace roots (200mm)								
0.2	Sandy **SILT**, some clay, trace organics, occasional cobbles Loose Brown Moist	1	SS	9					
		2	SS	8					
160.2 / 1.6	Silty **SAND** to Sandy **SILT**, trace to some clay, trace gravel Compact Brown Moist	3	SS	22	▽	0	53	35	12
		4	SS	63					
	Wet Occasional oxide staining	5	SS	102/ 0.275					
		6	SS	50/ 0.125					
	Grey	7	SS	115					
		8	SS	104/ 0.250		0	27	62	11
152.5		9	SS	100/ 0.125					
9.3	END OF BOREHOLE AT 9.3m. BOREHOLE OPEN TO 4.9m AND WATER LEVEL AT 2.0m UPON COMPLETION. BOREHOLE BACKFILLED WITH								

Elevation scale: 161, 160, 159, 158, 157, 156, 155, 154, 153

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20 40 60 80 100)

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%): 20 40 60

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

20 / 15-○-5 / 10 (%) STRAIN AT FAILURE

ONTMT4S 1130A.GPJ 1/24/13

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No SM4-07

METRIC

WP# E2-2012
LOCATION N 4 863 954.5 E 337 332.1
ORIGINATED BY ES
HWY 407
BOREHOLE TYPE Solid Stem Augers
COMPILED BY AN
DATUM Geodetic
DATE 2012.12.11 - 2012.12.11
CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page										
	BENTONITE HOLEPLUG TO SURFACE.										

ONTMT4S 1130A.GPJ 1/24/13

+ ³, × ³: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No SM4-08

METRIC

WP#	E2-2012	LOCATION	N 4 863 947.8 E 337 312.7	ORIGINATED BY	ES
HWY	407	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	AN
DATUM	Geodetic	DATE	2012.12.11 - 2012.12.12	CHECKED BY	LRB

Ground surface elevation: 162.6

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
162.6 / 0.0	**ORGANICS**, sandy, trace roots Compact Dark Brown Moist
0.2	**SAND**, some gravel, trace silt Compact Brown Moist Occasional cobbles
160.6 / 2.0	Silty **SAND** to Sandy **SILT**, trace clay Very Dense Brown Moist Occasional cobbles Grey
154.4 / 8.2	**SILT**, some clay, trace to some sand Very Dense Grey Moist
153.3 / 9.3	END OF BOREHOLE AT 9.3m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen.

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	17	
2	SS	30	
3	SS	17	
4	SS	92/ 0.275	
5	SS	101/ 0.250	0 38 53 9
6	SS	104	
7	SS	113/ 0.225	
8	SS	50/ 0.100	
9	SS	50/ 0.050	0 11 71 18

Column headings: STRAT PLOT; GROUND WATER CONDITIONS; ELEVATION SCALE (162, 161, 160, 159, 158, 157, 156, 155, 154); DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No SM4-08

METRIC

WP#	E2-2012	LOCATION	N 4 863 947.8 E 337 312.7	ORIGINATED BY	ES
HWY	407	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	AN
DATUM	Geodetic	DATE	2012.12.11 - 2012.12.12	CHECKED BY	LRB

SOIL PROFILE			SAMPLES					DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE				
	Continued From Previous Page										

WATER LEVEL READINGS:

DATE	DEPTH (m)	ELEV.
Dec. 18/12	1.9	160.7
Dec. 19/12	1.6	161.0
Jan. 02/13	1.1	161.5
Jan. 09/13	1.6	161.0

ONTMT4S 1130A.GPJ 1/24/13

$+^3, \times^3$: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No SM4-09

METRIC

WP#	E2-2012	LOCATION	N 4 863 986.1 E 337 331.2	ORIGINATED BY	ES
HWY	407	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	AN
DATUM	Geodetic	DATE	2012.12.12 - 2012.12.12	CHECKED BY	LRB

Chart columns: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20, 40, 60, 80, 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20, 40, 60); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL.

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
161.5 / 0.0	**ORGANICS** trace roots				
0.1	Compact Dark Brown Moist	1	SS	23	
	Gravelly **SAND**, some silt, occasional cobbles Compact to Dense Brown Moist to Wet	2	SS	39	37 49 14 (SI+CL)
160.2 / 1.3	Silty **SAND** to Sandy **SILT**, trace clay Dense to Very Dense Brown Moist	3	SS	44	
		4	SS	81	
	Silt seam Occasional cobble	5	SS	100/ 0.275	0 13 78 9
		6	SS	74	
	Grey	7	SS	100/ 0.275	
154.5 / 7.0	**SILT**, trace sand, trace clay Very Dense Brown/Grey Moist	8	SS	100/ 0.175	
152.8 / 8.7	**SAND**, some gravel, some silt Very Dense Grey Wet	9	SS	105/ 0.175	
152.2 / 9.3	END OF BOREHOLE AT 9.3m. Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen.				

Elevation scale: 161, 160, 159, 158, 157, 156, 155, 154, 153

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No SM4-09

METRIC

WP# E2-2012 LOCATION N 4 863 986.1 E 337 331.2 ORIGINATED BY ES

HWY 407 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2012.12.12 - 2012.12.12 CHECKED BY LRB

SOIL PROFILE		SAMPLES						DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L; WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION (Continued From Previous Page)	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE				

WATER LEVEL READINGS:

DATE	DEPTH (m)	ELEV.
Dec. 18/12	1.5	160.0
Dec. 19/12	1.1	160.4
Jan. 02/13	2.6	158.9
Jan. 09/13	1.1	160.4

ONTMT4S 1130A.GPJ 1/24/13

+³, ×³: Numbers refer to Sensitivity

15-⊕-5 (20 above, 10 below) (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No BH-F2

METRIC

WP# E2-2012 LOCATION N 4 863 792.7 E 337 324.5 ORIGINATED BY SLL

HWY 407 BOREHOLE TYPE Solid Stem Augers COMPILED BY MA

DATUM Geodetic DATE 2013.01.09 - 2013.01.09 CHECKED BY LRB

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
171.6								
0.0	**ORGANICS:**(150mm)							
0.2	**SAND** and **SILT**, some clay to clayey, trace gravel Compact to Very Dense Brown Moist (TILL)					171		
		1	SS	26			o	
		2	SS	56		170	o	
		3	SS	68		169	o	3 42 38 17
		4	SS	50/. 125		168	o	
	Grey	5	SS	45		167	o	
	Sampler wet	6	SS	47	▽	166	o	
164.9 6.7	END OF BOREHOLE AT 6.7m. BOREHOLE OPEN TO 6.6m AND WATER LEVEL AT 6.5m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE TO 1.3m, THEN CUTTINGS TO SURFACE.					165		

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³.

+³, ×³: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Appendix B

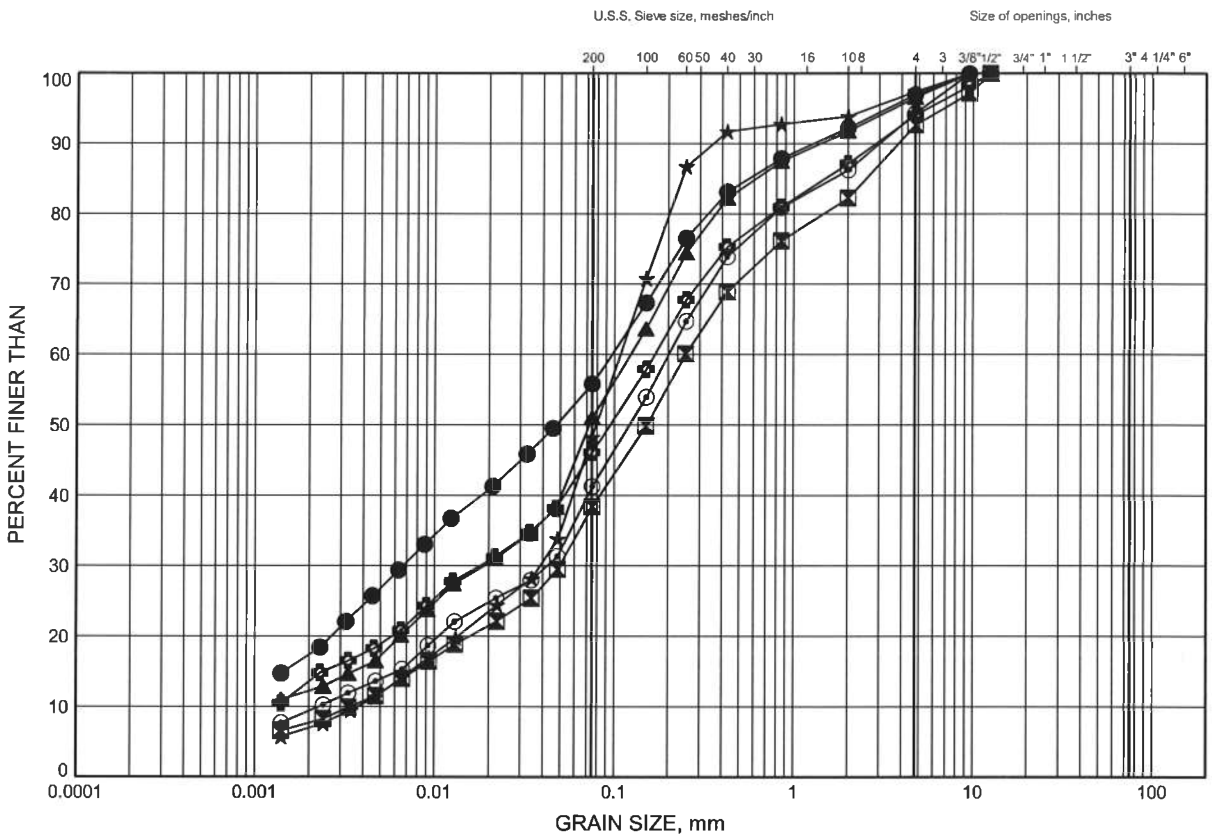
Laboratory Test Results

HWY 407 Brock Road Connection - Foundations

GRAIN SIZE DISTRIBUTION

FIGURE B1

SILTY SAND to SAND & SILT TILL



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BH-F2	2.59	169.01
⊠	SM4-01	2.50	169.90
▲	SM4-02	7.85	164.35
★	SM4-02	10.74	161.46
⊙	SM4-03	2.50	169.60
✿	SM4-03	6.32	165.78

Date January 2013

WP# E2-2012

THURBER

Prep'd MFA

Chkd. KS

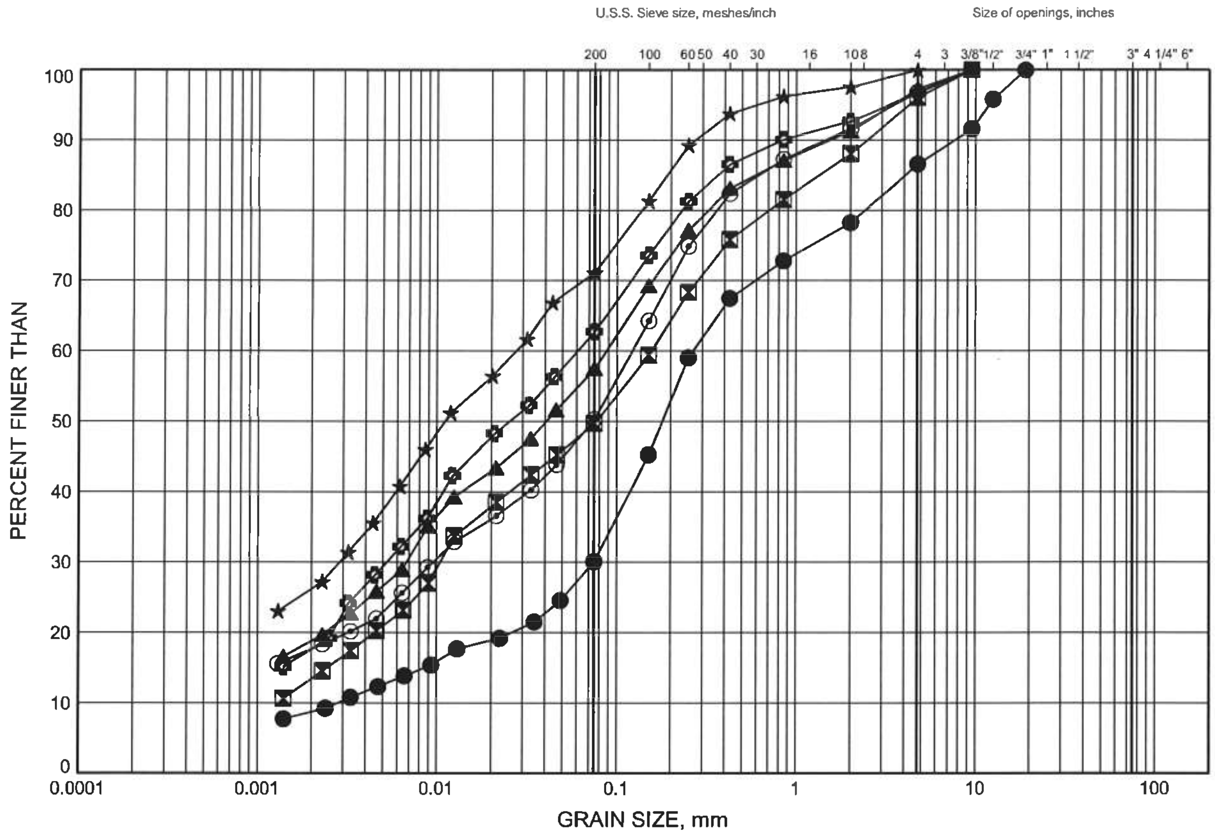
GRAIN SIZE DISTRIBUTION - THURBER 1130A.GPJ 1/28/13

HWY 407 Brock Road Connection - Foundations

GRAIN SIZE DISTRIBUTION

FIGURE B2

SILTY SAND to SAND & SILT TILL



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SM4-04	1.07	170.33
⊠	SM4-04	4.80	166.60
▲	SM4-05	2.59	169.91
★	SM4-05	12.32	160.18
⊙	SM4-06	1.07	171.06
✪	SM4-06	3.16	168.96

Date January 2013

WP# E2-2012

THURBER

Prep'd MFA

Chkd. KS

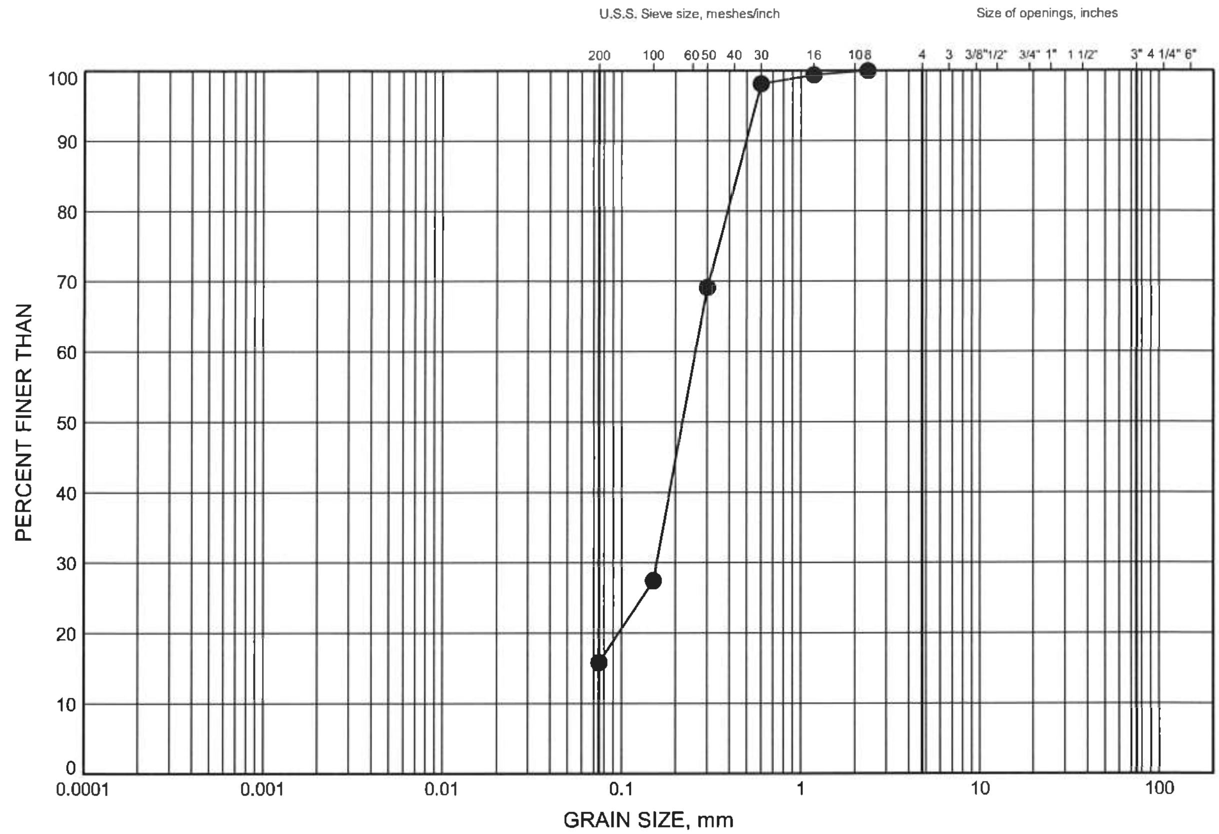
GRAIN SIZE DISTRIBUTION - THURBER 1130A.GPJ 1/28/13

HWY 407 Brock Road Connection - Foundations

GRAIN SIZE DISTRIBUTION

FIGURE B3

SAND, Some Silt



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SM4-02	2.06	170.14

GRAIN SIZE DISTRIBUTION - THURBER 1130A.GPJ 1/28/13

Date January 2013

WP# E2-2012

THURBER

Prep'd MFA

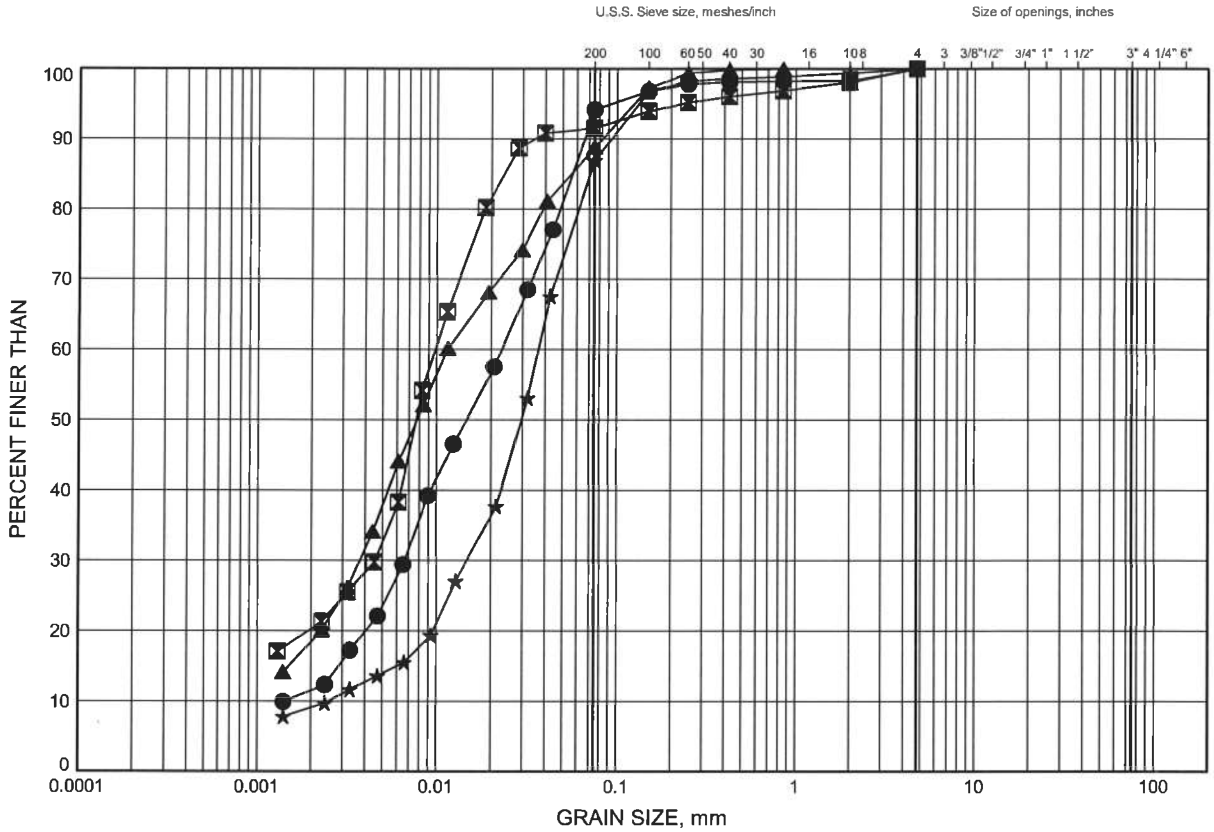
Chkd. KS

HWY 407 Brock Road Connection - Foundations

GRAIN SIZE DISTRIBUTION

FIGURE B4

SILT



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SM4-02	15.32	156.88
⊠	SM4-04	18.36	153.04
▲	SM4-08	9.24	153.36
★	SM4-09	3.19	158.31

GRAIN SIZE DISTRIBUTION - THURBER 1130A.GPJ 1/28/13

Date January 2013

WP# E2-2012

THURBER

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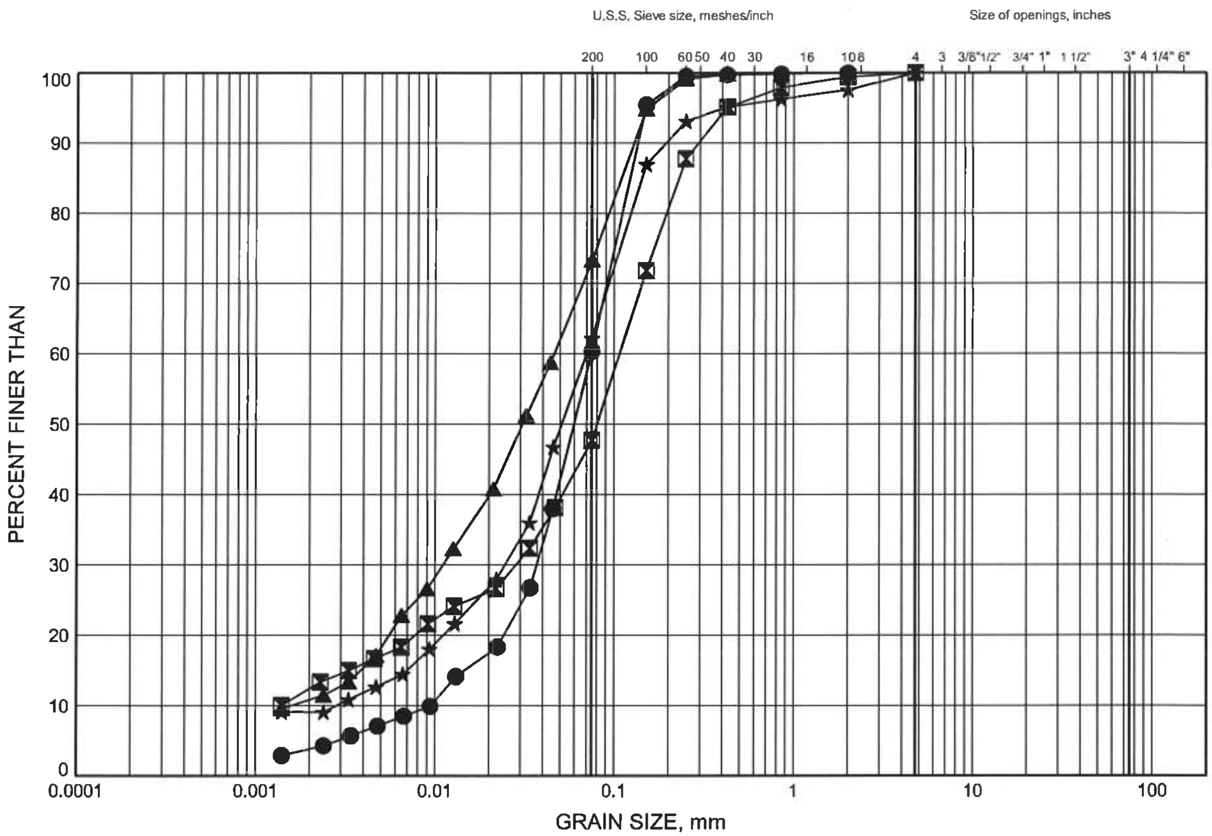
HWY 407 Brock Road Connection - Foundations

GRAIN SIZE DISTRIBUTION

FIGURE B5

SILT & SAND



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SM4-04	12.27	159.13
⊠	SM4-07	1.83	159.97
▲	SM4-07	7.85	153.95
★	SM4-08	3.25	159.35

GRAIN SIZE DISTRIBUTION - THURBER 1130A.GPJ 1/28/13

Date January 2013

WP# E2-2012

THURBER

Prep'd MFA

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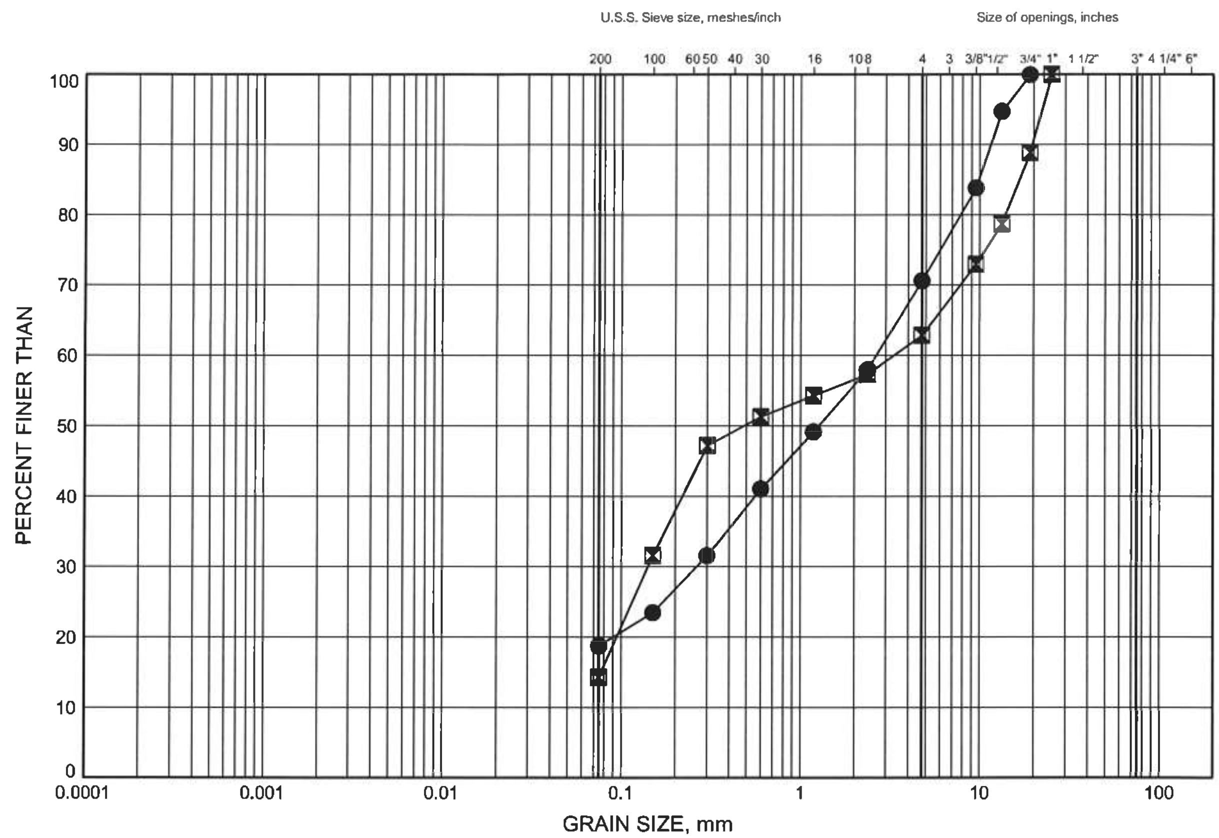
HWY 407 Brock Road Connection - Foundations

GRAIN SIZE DISTRIBUTION

FIGURE B6

GRAVELLY SAND



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SM4-04	22.95	148.45
⊠	SM4-09	1.07	160.43

Date January 2013

WP# E2-2012

THURBER

Prep'd MFA

Chkd. KS

GRAIN SIZE DISTRIBUTION - THURBER 1130A.GPJ 1/28/13

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

CLIENT NAME: THURBER ENGINEERING LTD
SUITE 103, 2010 WINSTON PARK DRIVE
OAKVILLE, ON L6H5R7
(905) 829-8666

ATTENTION TO: Lindsey Blaine

PROJECT NO: 19-5161-130A

AGAT WORK ORDER: 13T677837

SOIL ANALYSIS REVIEWED BY: Elizabeth Polakowska, MSc (Animal Sci), PhD (Agri Sci), Inorganic Lab Supervisor

TRACE ORGANICS REVIEWED BY: Oksana Gushyla, Analyst

DATE REPORTED: Jan 11, 2013

PAGES (INCLUDING COVER): 6

VERSION*: 3

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

*NOTES
VERSION 3:
Revised Report - pH added to analysis (January 17th 2013)
Reporting only Sulphate and pH (January 18th 2013)

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

Certificate of Analysis

AGAT WORK ORDER: 13T677837
PROJECT NO: 19-5161-130A

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

CLIENT NAME: THURBER ENGINEERING LTD

ATTENTION TO: Lindsey Blaine

O. Reg. 153(511) - ORPs (Soil) pH

DATE RECEIVED: 2013-01-08

DATE REPORTED: 2013-01-11

			SAMPLE DESCRIPTION:	SM1-02 SS#4	SM1-04 SS#6	SM2-02 SS#4	SM2-08 SS#3	SM2-11 SS#2	SM2-17 SS#4	SM4-02 SS#1	SM4-04 SS#2
			SAMPLE TYPE:	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
			DATE SAMPLED:	1/7/2013	1/7/2013	1/7/2013	1/7/2013	1/7/2013	1/7/2013	1/7/2013	1/7/2013
Parameter	Unit	G / S	RDL	4058631	4058632	4058634	4058636	4058638	4058640	4058642	4058644
pH, 2:1 CaCl2 Extraction	pH Units		NA	7.90	7.91	7.98	7.92	7.44	7.89	7.83	7.90

			SAMPLE DESCRIPTION:	SM4-07 SS#4	SM8-03 SS#5	SM8-04 SS#6	SM9-02 SS#2	SM9-06A SS#3	SM9-08 SS#4	SM10-09 SS#2
			SAMPLE TYPE:	Soil	Soil	Soil	Soil	Soil	Soil	Soil
			DATE SAMPLED:	1/7/2013	1/7/2013	1/7/2013	1/7/2013	1/7/2013	1/7/2013	1/7/2013
Parameter	Unit	G / S	RDL	4058646	4058648	4058650	4058652	4058654	4058656	4058658
pH, 2:1 CaCl2 Extraction	pH Units		NA	8.02	8.06	7.94	7.92	7.91	7.86	7.39

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

4058631-4058658 pH was determined on the 0.01M CaCl2 extract obtained from 2:1 leaching procedure (2 parts extraction fluid :1 part wet soil).

Certified By: Elizabeth Rolakowska

AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 13T677837
PROJECT NO: 19-5161-130A

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

CLIENT NAME: THURBER ENGINEERING LTD

ATTENTION TO: Lindsey Blaine

Sulphate (Soil)

DATE RECEIVED: 2013-01-08

DATE REPORTED: 2013-01-11

			SAMPLE DESCRIPTION:	SM1-02 SS#4	SM1-04 SS#6	SM2-02 SS#4	SM2-08 SS#3	SM2-11 SS#2	SM2-17 SS#4	SM4-02 SS#1	SM4-04 SS#2
			SAMPLE TYPE:	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
			DATE SAMPLED:	1/7/2013	1/7/2013	1/7/2013	1/7/2013	1/7/2013	1/7/2013	1/7/2013	1/7/2013
Parameter	Unit	G / S	RDL	4058631	4058632	4058634	4058636	4058638	4058640	4058642	4058644
Sulphate (2:1)	µg/g		2.0	3.0	9.7	157	3.9	181	35.8	11.6	6.0

			SAMPLE DESCRIPTION:	SM4-07 SS#4	SM8-03 SS#5	SM8-04 SS#6	SM9-02 SS#2	SM9-06A SS#3	SM9-08 SS#4	SM10-09 SS#2
			SAMPLE TYPE:	Soil	Soil	Soil	Soil	Soil	Soil	Soil
			DATE SAMPLED:	1/7/2013	1/7/2013	1/7/2013	1/7/2013	1/7/2013	1/7/2013	1/7/2013
Parameter	Unit	G / S	RDL	4058646	4058648	4058650	4058652	4058654	4058656	4058658
Sulphate (2:1)	µg/g		2.0	8.9	9.4	23.3	5.8	15.3	10.3	544

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
4058631-4058658 The soluble Sulphate was determined on the DI water extract obtained from the 2:1 leaching procedure (2 part DI water: 1 part dry soil).

Certified By: Elizabeth Rolakowska

AGAT Laboratories

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FAX (905)712-5122
http://www.agatlabs.com

Quality Assurance

CLIENT NAME: THURBER ENGINEERING LTD

PROJECT NO: 19-5161-130A

AGAT WORK ORDER: 13T677837

ATTENTION TO: Lindsey Blaine

Soil Analysis

RPT Date: Jan 11, 2013			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper
Sulphate (Soil)															
Sulphate (2:1)	1	4058631	3.0	2.7	10.5%	< 2.0	95%	70%	130%	97%	70%	130%	96%	70%	130%
Sulphate (Soil)															
Sulphate (2:1)	1	4058650	23.3	24.0	3.0%	< 2.0		70%	130%		70%	130%		70%	130%
O. Reg. 153(511) - ORPs (Soil) pH															
pH, 2:1 CaCl2 Extraction	1	4058631	7.90	7.93	0.4%	NA	100%	90%	110%	NA			NA		

Certified By: Elizabeth Polakowska

AGAT Laboratories
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TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Quality Assurance

CLIENT NAME: THURBER ENGINEERING LTD
AGAT WORK ORDER: 13T677837
PROJECT NO: 19-5161-130A
ATTENTION TO: Lindsey Blaine

Trace Organics Analysis

RPT Date: Jan 11, 2013			DUPLICATE				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper
O. Reg. 153(511) - PAHs (Soil)															
Naphthalene	1	4058640	< 0.05	< 0.05	0.0%	< 0.05	98%	50%	140%	96%	50%	140%	97%	50%	140%
Acenaphthylene	1	4058640	< 0.05	< 0.05	0.0%	< 0.05	104%	50%	140%	97%	50%	140%	93%	50%	140%
Acenaphthene	1	4058640	< 0.05	< 0.05	0.0%	< 0.05	99%	50%	140%	96%	50%	140%	91%	50%	140%
Fluorene	1	4058640	< 0.05	< 0.05	0.0%	< 0.05	102%	50%	140%	99%	50%	140%	92%	50%	140%
Phenanthrene	1	4058640	< 0.05	< 0.05	0.0%	< 0.05	94%	50%	140%	94%	50%	140%	93%	50%	140%
Anthracene	1	4058640	< 0.05	< 0.05	0.0%	< 0.05	96%	50%	140%	92%	50%	140%	93%	50%	140%
Fluoranthene	1	4058640	< 0.05	< 0.05	0.0%	< 0.05	87%	50%	140%	93%	50%	140%	98%	50%	140%
Pyrene	1	4058640	< 0.05	< 0.05	0.0%	< 0.05	90%	50%	140%	97%	50%	140%	92%	50%	140%
Benz(a)anthracene	1	4058640	< 0.05	< 0.05	0.0%	< 0.05	85%	50%	140%	84%	50%	140%	81%	50%	140%
Chrysene	1	4058640	< 0.05	< 0.05	0.0%	< 0.05	91%	50%	140%	98%	50%	140%	83%	50%	140%
Benzo(b)fluoranthene	1	4058640	< 0.05	< 0.05	0.0%	< 0.05	104%	50%	140%	85%	50%	140%	84%	50%	140%
Benzo(k)fluoranthene	1	4058640	< 0.05	< 0.05	0.0%	< 0.05	109%	50%	140%	99%	50%	140%	83%	50%	140%
Benzo(a)pyrene	1	4058640	< 0.05	< 0.05	0.0%	< 0.05	106%	50%	140%	82%	50%	140%	91%	50%	140%
Indeno(1,2,3-cd)pyrene	1	4058640	< 0.05	< 0.05	0.0%	< 0.05	93%	50%	140%	81%	50%	140%	80%	50%	140%
Dibenz(a,h)anthracene	1	4058640	< 0.05	< 0.05	0.0%	< 0.05	90%	50%	140%	79%	50%	140%	78%	50%	140%
Benzo(g,h,i)perylene	1	4058640	< 0.05	< 0.05	0.0%	< 0.05	93%	50%	140%	86%	50%	140%	91%	50%	140%
2-and 1-methyl Naphthalene	1	4058640	< 0.05	< 0.05	0.0%	< 0.05	105%	50%	140%	98%	50%	140%	95%	50%	140%

Certified By:

AGAT Laboratories
5835 COOPERS AVENUE
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CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Method Summary

CLIENT NAME: THURBER ENGINEERING LTD
AGAT WORK ORDER: 13T677837
PROJECT NO: 19-5161-130A
ATTENTION TO: Lindsey Blaine

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
pH, 2:1 CaCl2 Extraction	INOR-93-6031	MSA part 3 & SM 4500-H+ B	pH METER
Sulphate (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
Trace Organics Analysis			
Naphthalene	ORG-91-5106	EPA SW846 3541 & 8270	GC/MS
Acenaphthylene	ORG-91-5106	EPA SW846 3541 & 8270	GC/MS
Acenaphthene	ORG-91-5106	EPA SW846 3541 & 8270	GC/MS
Fluorene	ORG-91-5106	EPA SW846 3541 & 8270	GC/MS
Phenanthrene	ORG-91-5106	EPA SW846 3541 & 8270	GC/MS
Anthracene	ORG-91-5106	EPA SW846 3541 & 8270	GC/MS
Fluoranthene	ORG-91-5106	EPA SW846 3541 & 8270	GC/MS
Pyrene	ORG-91-5106	EPA SW846 3541 & 8270	GC/MS
Benz(a)anthracene	ORG-91-5106	EPA SW846 3541 & 8270	GC/MS
Chrysene	ORG-91-5106	EPA SW846 3541 & 8270	GC/MS
Benzo(b)fluoranthene	ORG-91-5106	EPA SW846 3541 & 8270	GC/MS
Benzo(k)fluoranthene	ORG-91-5106	EPA SW846 3541 & 8270	GC/MS
Benzo(a)pyrene	ORG-91-5106	EPA SW846 3541 & 8270	GC/MS
Indeno(1,2,3-cd)pyrene	ORG-91-5106	EPA SW846 3541 & 8270	GC/MS
Dibenz(a,h)anthracene	ORG-91-5106	EPA SW846 3541 & 8270	GC/MS
Benzo(g,h,i)perylene	ORG-91-5106	EPA SW846 3541 & 8270	GC/MS
2-and 1-methyl Naphthalene	ORG-91-5106	EPA SW846 3541 & 8270	GC/MS
Moisture Content	Org 5506	EPA SW-846 3540 & 8270	BALANCE
Chrysene-d12	ORG-91-5106	EPA SW846 3541 & 8270	GC/MS

Appendix C

Selected Site Photographs

Looking east at proposed South Pier

Looking northeast towards proposed North Pier

Looking north from top of south slope

Looking south from top of north slope

Appendix D

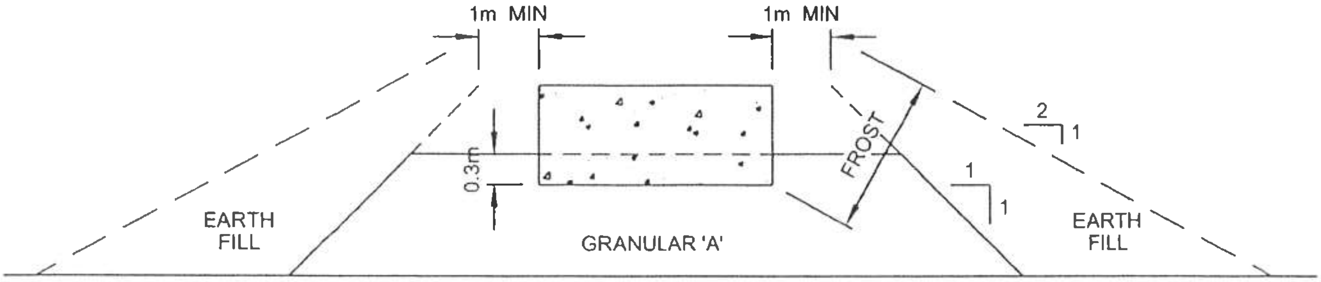
Foundation Comparison

COMPARISON OF FOUNDATION ALTERNATIVES

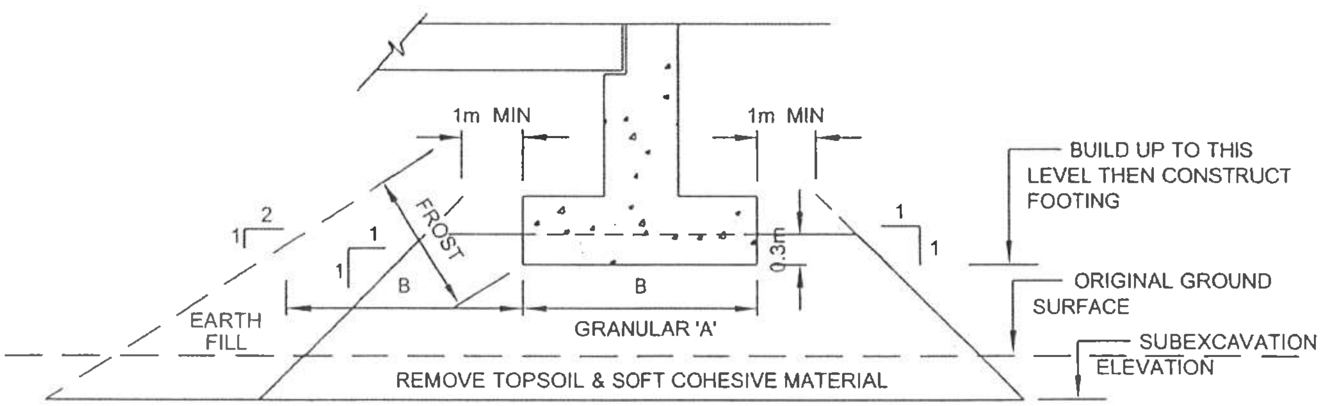
Footings on Native Soil	Footings on Engineered Fill	Caissons	Driven H-Piles
Advantages: i. Generally less costly construction than deep foundation elements. ii. Ease of construction.	***Advantages:*** i. Generally less costly construction than deep foundation elements. ii. Depth of excavation required will be shallower than footing on native soil.	***Advantages:*** i. Construction of caissons could continue in freezing weather. ii. Higher geotechnical resistance can be achieved than H-Piles.	***Advantages:*** i. Higher geotechnical resistances can be achieved if piles are driven to refusal. ii. Installation of piles could continue in freezing weather iii. Foundation construction may require less volume of excavation than footings. iv. Suitable for integral abutment.
Disadvantages: i. Excavation to base of foundation is required for footing construction. ii. Dewatering will be required.	***Disadvantages:*** i. Dewatering may be required, depending on depth of excavation. ii. Require compaction of engineered fill materials.	***Disadvantages:*** i. Higher cost than footings. ii. Specialized installation measures such as temporary liners and drilling mud will be required to install caissons in cohesionless soils below the water table. iii. Potential difficulty in cleaning and inspecting bases.	***Disadvantages:*** i. Higher unit costs than footings. ii. Pile lengths required to achieve design resistance may vary due to obstructions.
FEASIBLE FOR ABUTMENTS	**FEASIBLE FOR ABUTMENTS**	**NOT RECOMMENDED**	**RECOMMENDED FOR ABUTMENTS AND PIERS**

Appendix E

Figure 1 - Abutment on Compacted Fill



CROSS-SECTION



LONGITUDINAL SECTION

NOT TO SCALE

NOTES:

1. REMOVE TOPSOIL AND SOFT SILTY CLAY SUBSOIL UNDER FOOTPRINT OF COMPACTED GRANULAR 'A'.
2. PLACE GRANULAR 'A' AND EARTH FILL TO BOTTOM OF FOOTING LEVEL, COMPACTED ACCORDING TO O.P.S.S. 501.
3. CONSTRUCT CONCRETE FOOTING.
4. PLACE REMAINDER OF GRANULAR 'A' AND EARTH FILL AS REQUIRED.
5. SOURCE M.T.C. 1982.

ENGINEER	AEG
DRAWN	SS
DATE	April , 2004
APPROVED	PKC
SCALE	NTS

ABUTMENT ON COMPACTED FILL SHOWING GRANULAR A CORE

THURBER

DWG. NO. FIGURE 1

Appendix F

List of SPs and OPSS, and Suggested Text for NSSP

1. List of Special Provisions and OPSS Documents Referenced in this Report

- Special Provision 110S13
- OPSS 501
- OPSS 539
- OPSS 902
- OPSS 903
- OPSS 1010
- OPSD 3000.100
- OPSD 3101.150

2. Suggested text for a NSSP on Pile Installation

The presence of cobbles and boulders in the dense glacial till may potentially have an impact on the installation of piles at the site. Some possible impacts that must be taken into consideration include, but are not necessarily limited to:

- The cobbles and boulders may impede the driving of the piles resulting in more arduous driving in the very dense soils
- Some piles may meet refusal on boulders that are large enough not to be dislodged or broken by the pile driving
- As a result of the presence of boulders, piles may meet refusal at varying depths
- Pile driving must be controlled according to the criteria specified for the site

Appendix G

Borehole Locations and Soil Strata Drawings

NO.	DATE	REVISIONS	BY	CHK	LEAD DISC.	PROJ. MAN.

CONTRACT No. E2-2012

HWY 407/BROCK ROAD INTERCHANGE

STRUCTURE M-4 (SITE 3A) REALIGNED BROCK ROAD OVER BROUGHAM CREEK

BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

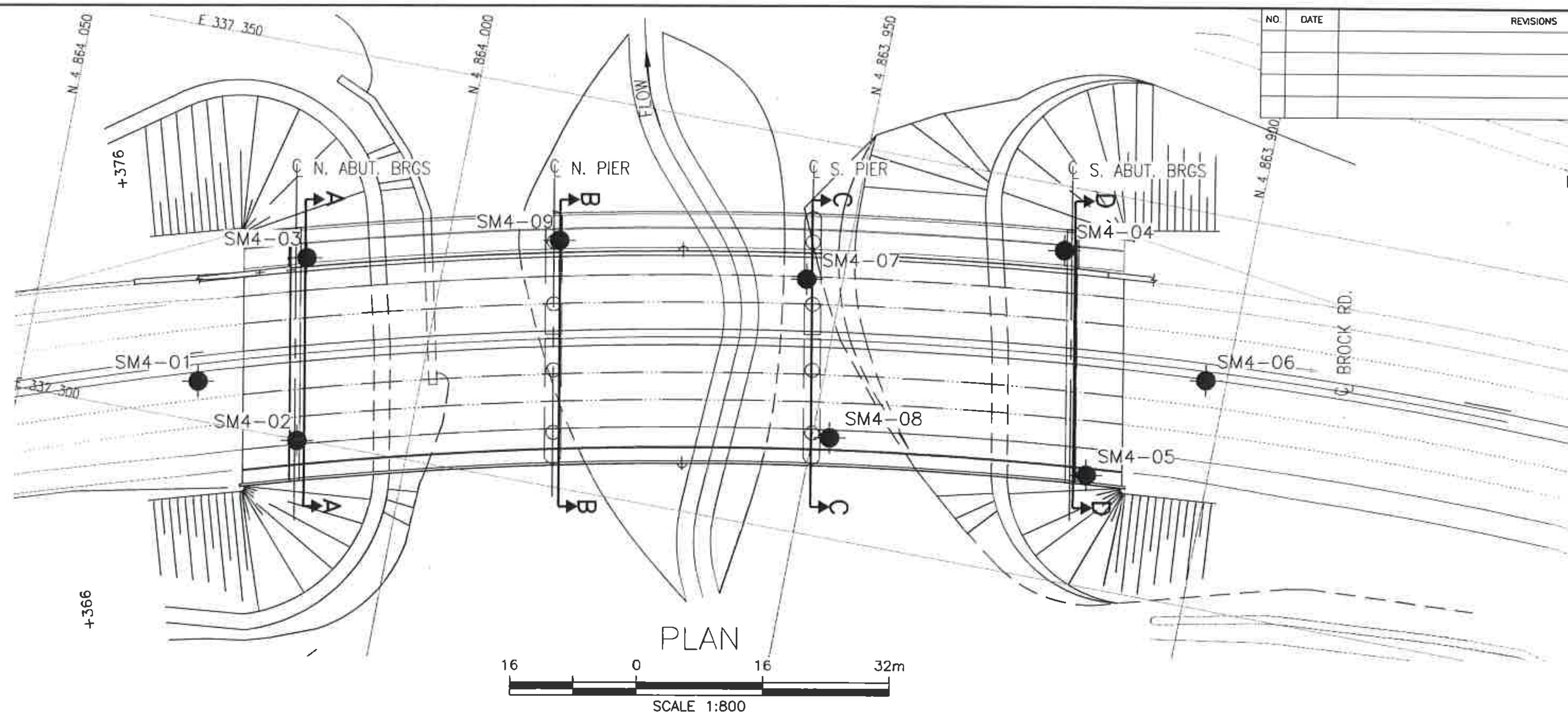
407 ETR Express Toll Route

MMM GROUP

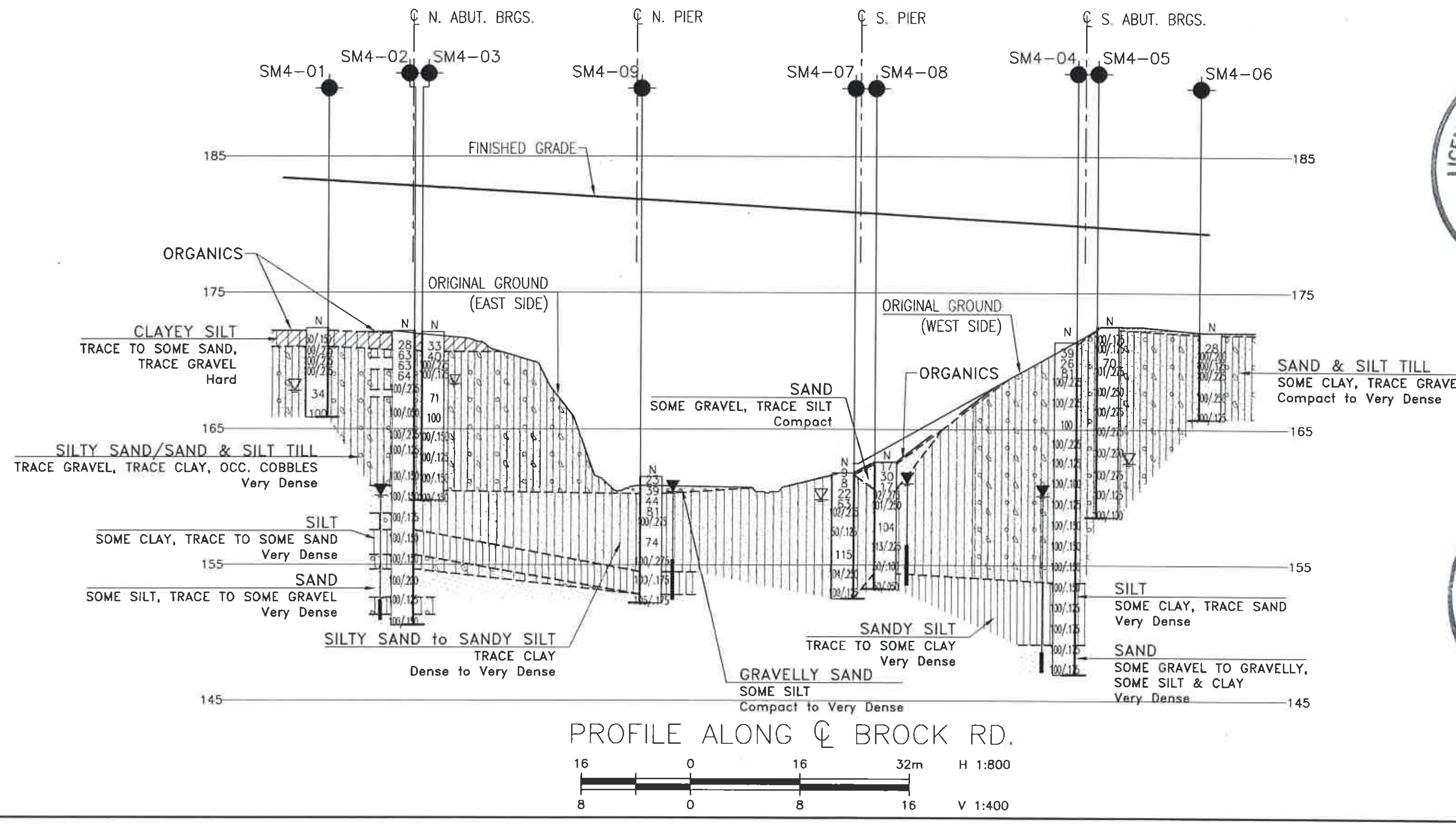
THURBER ENGINEERING LTD.

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN



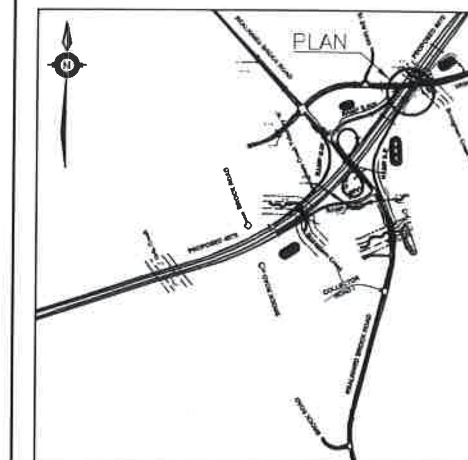
PLAN



PROFILE ALONG ℄ BROCK RD.

LICENSED PROFESSIONAL ENGINEER
K. L. SHI
100141639
Jan. 28, 2013
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
Jan 28/13
PROVINCE OF ONTARIO



KEYPLAN

LEGEND

⯃	Borehole
⯐	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
∇	Water Level
▼	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
SM4-01	172.4	4 864 027.7	337 305.0
SM4-02	172.2	4 864 013.9	337 299.9
SM4-03	172.1	4 864 017.1	337 323.1
SM4-04	171.4	4 863 923.3	337 341.8
SM4-05	172.5	4 863 915.1	337 314.1
SM4-06	172.1	4 863 902.6	337 328.8
SM4-07	161.8	4 863 954.5	337 332.1
SM4-08	162.6	4 863 947.8	337 312.7
SM4-09	161.5	4 863 986.1	337 331.2

-NOTES-

1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

DESIGN KS	CHK KS	CODE		LOAD	DATE JAN. 2013
DRAWN AN	CHK AEG	SITE 3A	STRUCT M-4	DWG 1	

DRAWING NAME: H:\Drafting\19\5161\130\ted1130A-M4-BoreholePlan&Profile.dwg
CREATED: December 17, 2012 MODIFIED: January 28, 2013

NO	DATE	REVISIONS	BY	CHK	LEAD DISC.	PROJ MAN.

CONTRACT No. E2-2012

HWY 407/BROCK ROAD INTERCHANGE

STRUCTURE M-4 (SITE 3A)
REALIGNED BROCK ROAD
OVER BROUGHAM CREEK
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

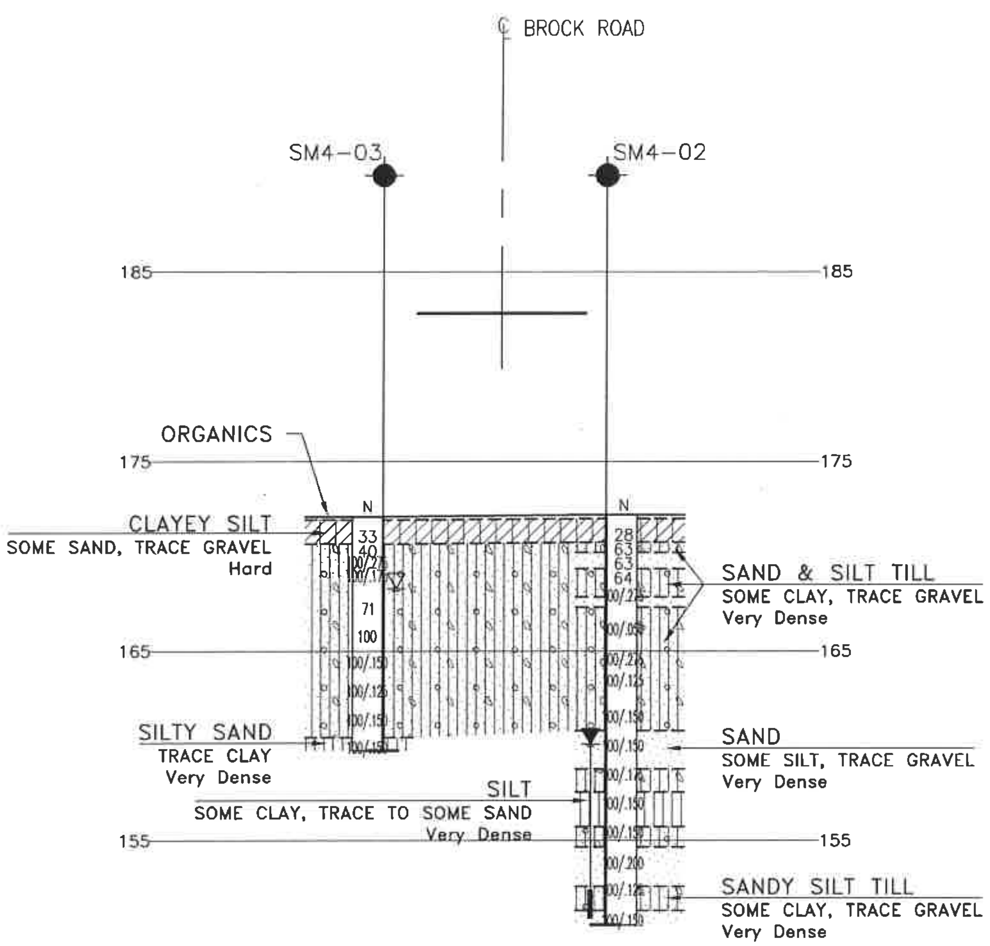
407 ETR Express Toll Route

MMM GROUP

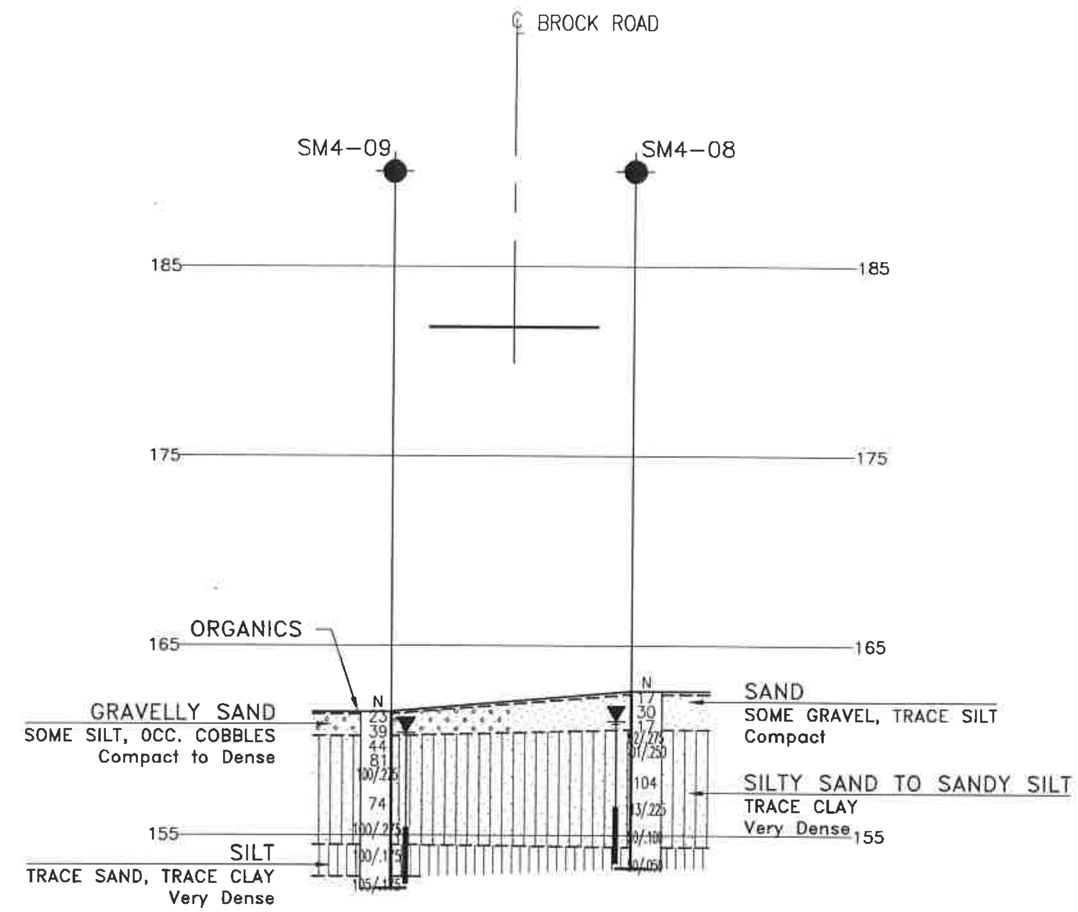
THURBER ENGINEERING LTD.

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN



SECTION A-A



SECTION B-B

16 0 16 32m H 1:800

8 0 8 16 V 1:400

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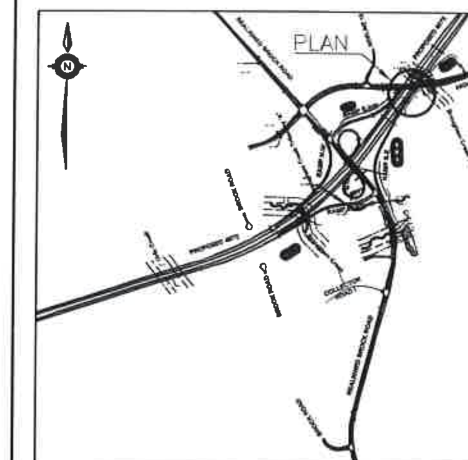


KEYPLAN

LEGEND

●	Borehole
◈	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
▽	Water Level
▼	Head Artesian Water
┃	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
SM4-01	172.4	4 864 027.7	337 305.0
SM4-02	172.2	4 864 013.9	337 299.9
SM4-03	172.1	4 864 017.1	337 323.1
SM4-04	171.4	4 863 923.3	337 341.8
SM4-05	172.5	4 863 915.1	337 314.1
SM4-06	172.1	4 863 902.6	337 328.8
SM4-07	161.8	4 863 954.5	337 332.1
SM4-08	162.6	4 863 947.8	337 312.7
SM4-09	161.5	4 863 986.1	337 331.2

-NOTES-

1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

DESIGN KS	CHK KS	CODE	LOAD	DATE JAN. 2013
DRAWN AN	CHK AEG	SITE 3A	STRUCT M-4	DWG 2

DRAWING NAME: H:\Drafting\19\5161\130\Ed11130A-M4-BoreholePlan&Profile.dwg
CREATED: December 17, 2012 MODIFIED: January 28, 2013

NO.	DATE	REVISIONS	BY	CHK	LEAD DISC.	PROJ. MAN.

CONTRACT No. E2-2012
HWY 407/BROCK ROAD INTERCHANGE

STRUCTURE M-4 (SITE 3A)
REALIGNED BROCK ROAD
OVER BROUGHAM CREEK
BOREHOLE LOCATIONS AND SOIL STRATA

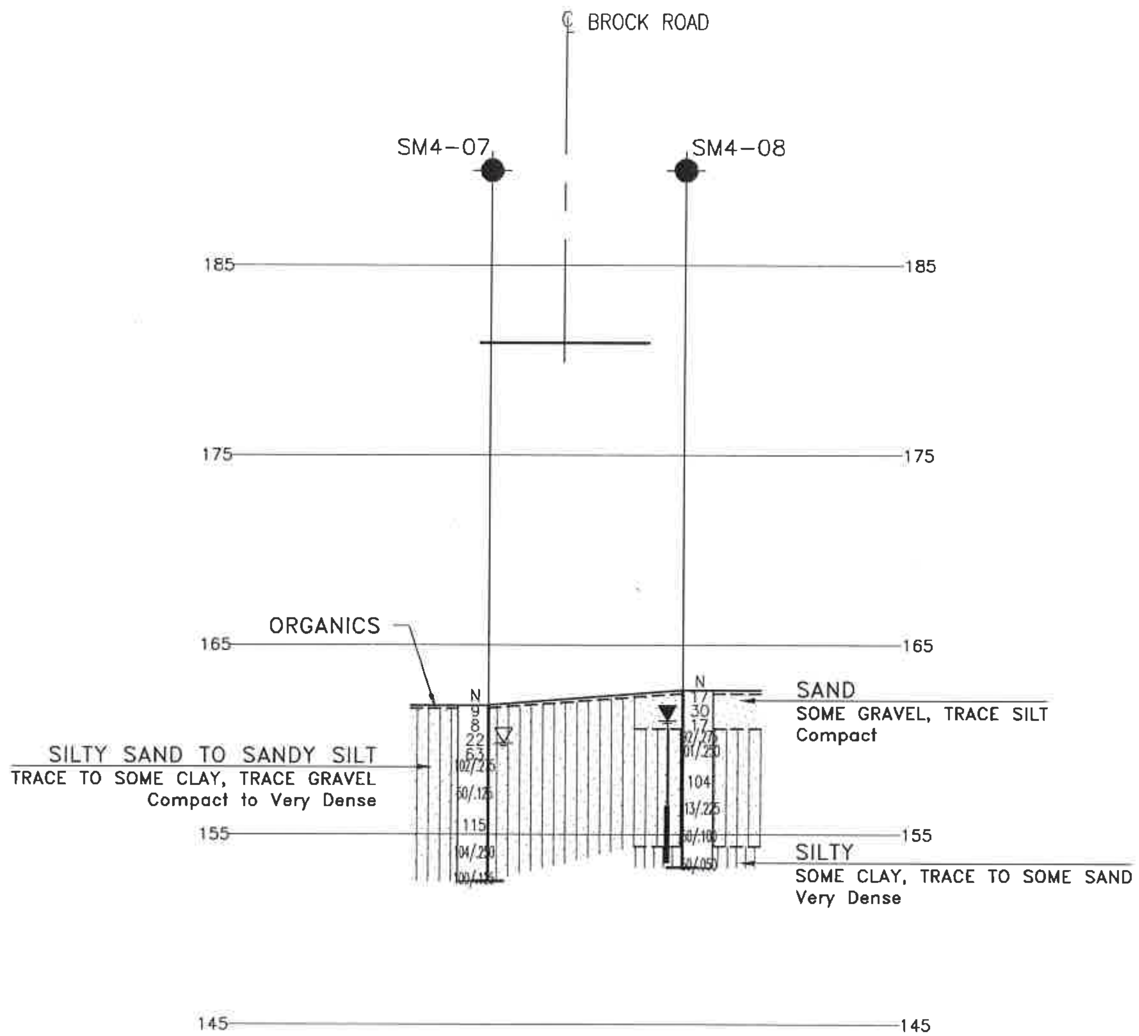
SHEET

407 ETR Express Toll Route

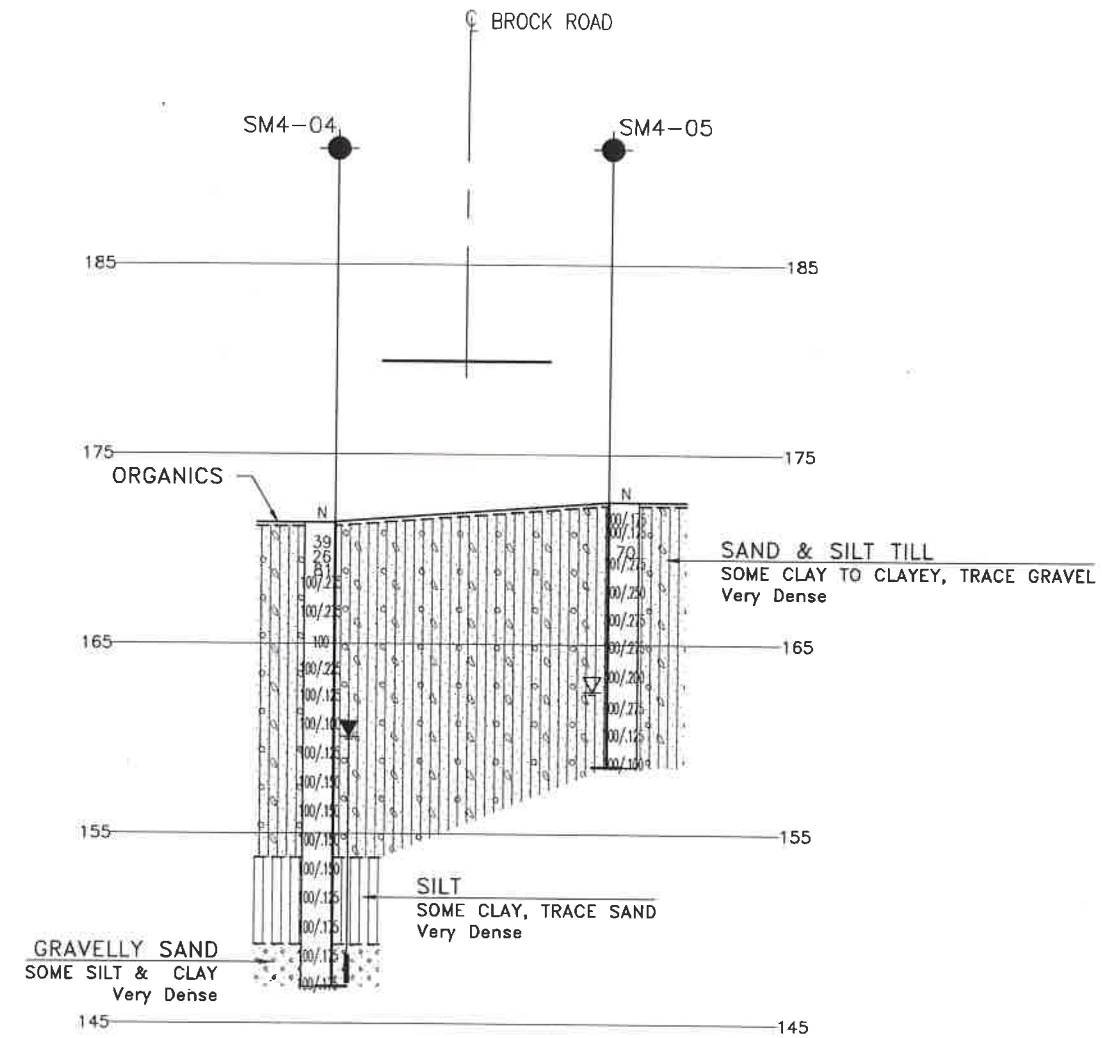
MMM GROUP

THURBER ENGINEERING LTD.

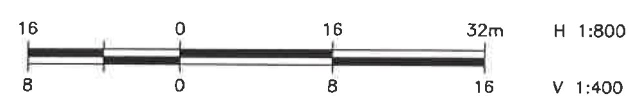
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN



SECTION C–C



SECTION D–D



KEYPLAN

LEGEND

Symbol	Description
●	Borehole
●	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
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DESIGN KS	CHK KS	CODE	LOAD	DATE JAN. 2013
DRAWN AN	CHK AEG	SITE 3A	STRUCT M-4	DWG 3

DRAWING NAME: H:\Drafting\19\5161\130\ted1130A-M4-BoreholePlan&Profile.dwg
CREATED: December 17, 2012 MODIFIED: January 28, 2013