

**FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 407/BROCK ROAD INTERCHANGE CONNECTION
STRUCTURE M-6 (SITE 101)
REALIGNED HIGHWAY 7
OVER BROUGHAM CREEK TRIBUTARY 'A'
Contract No: E2-2012**

Report to

MMM Group Limited

Thurber Engineering Ltd.
2010 Winston Park Drive, Suite 103
Oakville, Ontario
L6H 5R7
Phone: (905) 829 8666
Fax: (905) 829 1166

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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 replacement culvert (Structure M-6) that will carry Brougham Creek Tributary 'A' under the proposed realigned Highway 7, in Pickering, Ontario. The replacement culvert (and realigned Highway 7) is planned 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 boreholes, stratigraphic profiles, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions was developed from the data obtained in 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 proposed culvert runs approximately north-south and is located approximately 315 m east of Brock Road at the existing Highway 7. The new culvert will extend north of the existing Highway 7. The proposed culvert site is located at the east edge of the community of Brougham.

At the location of the proposed culvert, Brougham Creek Tributary 'A' flows from north to south. At the time of the field investigation, the creek was dry at this location. Lands surrounding the culvert site consist primarily of agricultural fields and community developments such as private residences and the Don Beer Memorial Park. At the southwest corner of the culvert site, there is an abandoned commercial lot. Photographs in Appendix C show the existing conditions of the surrounding land.

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' as produced by The Ontario Geological Survey shows that the culvert 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 project were carried out on September 24, 2012 and consisted of drilling and sampling a total of three boreholes (identified as SM6-01 to SM6-03). Boreholes SM6-02 and SM6-03 were drilled at the east 'abutment' and Borehole SM6-01 was drilled at the west 'abutment'. Two boreholes drilled in 2009 (identified as C25-A and C25-B) have been used to complete the data set at the west 'abutment'. The approximate borehole locations are shown on the attached Borehole Locations and Soil Strata Drawing included in Appendix E. The stratigraphy obtained from these 5 boreholes (SM6-01, SM6-02, SM6-03, C25-A, and C25-B) are summarized herein.

The boreholes (SM6-01, SM6-02, SM6-03, C25-A, and C25-B) were advanced to depths ranging from 7.7 m to 17.0 m below the existing ground surface (Elevation 175.8 to 184.8 m). The Record of Borehole sheets are included in Appendix A.

Three other boreholes (M6-1, M6-2, and C25-C) were previously drilled in the vicinity of this structure. Since these boreholes are not at the proposed structure, the data collected in these three boreholes is not summarized in this report.

The location of the recent boreholes (SM6-01 to SM6-03) were marked in the field and utility clearances were obtained prior to drilling. Permission to Enter was obtained by way of a Memorandum of Understanding between Transport Canada (who owns this land) and MTO.

Drilling of the recent boreholes (SM6-01 to SM6-03) was carried out using a track mounted drill rig and solid stem augers were used to advance the boreholes. Samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT).

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

Where practical, groundwater conditions were observed in the open boreholes upon completion of the drilling operations. Two standpipe piezometers, consisting of 25 mm diameter PVC pipe with a 1.5 m long slotted screen, were installed at this site – one at each abutment. The completion details of the piezometers and boreholes are summarized in Table 3.1.

Table 3-1. Borehole Completion and Piezometer Installation Details

Borehole	Piezometer Tip Depth/ Elevation (m)	Completion/Installation Details
SM6-01	7.5 / 183.9	Piezometer with 1.5 m slotted screen installed with sand filter to 4.9 m, bentonite from 4.9 to 0.6 m, then cuttings to surface.
SM6-02	None installed	Backfilled with bentonite holeplug to 1.5 m, then cuttings to surface.
SM6-03	7.4 / 185.2	Piezometer with 1.5 m slotted screen installed with sand filter to 5.5 m, bentonite from 5.5 to 0.9 m, then cuttings to surface.

4 LABORATORY TESTING

The recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected samples were also 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.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendix A and on the "Borehole Locations and Soil Strata" drawing included in Appendix E. An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented on the Record of Borehole sheets governs any interpretation of the site conditions.

In general, the native subsurface stratigraphy encountered at the site consists of layers of silt and sand underlain by a layer clayey silt. More detailed descriptions of the individual strata are presented below.

5.1 Topsoil

A 50 mm thick layer of topsoil was encountered at the surface in Borehole SM6-03, located on the existing Highway 7 embankment. A localized 2.0 m thick layer of topsoil fill was encountered at surface at Borehole C25-A.

As made evident by the topsoil thickness at these two boreholes, the thickness of the topsoil layer may vary significantly between and beyond the borehole locations.

SPT N-values recorded in the thick topsoil layer ranged from 6 to 7 blows for 0.3 m penetration, indicating a loose relative density. Moisture contents ranged from 18 to 26%.

5.2 Embankment Fill

Embankment fill was encountered below the thin layer of topsoil in Borehole SM6-03 and below a thin layer of concrete in Borehole C25-B. These boreholes were drilled from the existing Highway 7. In Borehole SM6-03 the embankment fill consisted of 1 m of sand, overlying 0.5 m of clayey silt, overlying 0.8 m of gravelly sand. In Borehole C25-B, the embankment fill consisted of 2.1 m of sand.

The embankment fill was 2.3 m thick in Borehole SM6-03 and 2.1 m thick in Borehole C25-B. The lower boundary of the embankment fill was encountered at depths of 2.1 to 2.3 m (Elevation 190.3 to 190.7 m).

SPT N-values recorded in the embankment fill ranged from 6 to 24 blows for 0.3 m penetration, indicating a relative density of loose to compact. Moisture contents ranged from 4 to 10%.

One sample of the embankment fill from Borehole SM6-03 underwent laboratory grain size analysis testing. The results of this test are summarized below and are presented on the corresponding Record of Borehole sheet included in Appendix A. The grain size distribution curve for this sample is plotted on Figure B1, Appendix B.

Soil Particles	Percentage (%)
Gravel	31
Sand	41
Silt	18
Clay	10

5.3 Silt and Sand

A layer of silt and sand was encountered locally in Boreholes SM6-01 and SM6-02, at the surface. These two boreholes were drilled in a farmer's field. The silt and sand was dark brown and contained trace to some clay, trace organics, and trace roots and rootlets.

The surficial silt and sand layer was 0.8 m thick in Borehole SM6-01 and 1.9 m thick in Borehole SM6-02. The lower boundary of the surficial silt and sand layer was encountered at depths of 0.8 to 1.9 m (Elevation 190.6 to 188.5 m).

SPT N-values recorded in the silt and sand ranged from 6 to 10 blows for 0.3 m penetration, indicating a loose relative density. The moisture contents ranged from 14 to 18%.

One sample of the silt and sand layer was selected for laboratory grain size analysis testing. The results of this test are summarized as follows:

Soil Particles	Percentage (%)
Gravel	0
Sand	39
Silt	49
Clay	12

These results are also presented on the corresponding Record of Borehole sheet included in Appendix A and the grain size distribution curve for this sample is plotted on Figure B2, Appendix B.

5.4 Clayey Silt

A layer of clayey silt was encountered below the surficial silt and sand in Boreholes SM6-01 and SM6-02, below the embankment fill in Borehole SM6-03, and below the thick topsoil deposit in Borehole C25-A. In Borehole C25-A, the clayey silt was identified as fill. The clayey silt was typically dark brown to brown and contained some sand and trace gravel at some locations. Occasional cobbles were noted in this layer in Borehole SM6-01.

The thickness of the clayey silt ranged from 0.4 m (in Borehole SM6-02) to 2.4 m (in Borehole SM6-03). The lower boundary of the clayey silt was encountered at depths of 2.1 to 4.7 m (Elevation 189.3 to 187.9 m).

SPT N-values recorded in the clayey silt layer ranged from 7 to 34 blows for 0.3 m penetration, indicating a variable consistency ranging from firm to hard. Moisture contents ranged from 9 to 18%

5.5 Silt and Sand Till

Sand and silt till was encountered in Borehole C25-B, below the embankment fill. The sand and silt till was grey and contained some clay and trace gravel.

The till was 4.0 m thick, with the lower boundary of this deposit encountered at a depth of 6.1 m (Elevation 186.7 m).

SPT N-values recorded in the till ranged from 5 to 16 blows for 0.3 m penetration, indicating a loose to compact relative density. Moisture contents ranged from 4 to 22% and decreased with depth.

One sample of the till underwent laboratory grain size analysis testing. The results of this test are presented on the corresponding Record of Borehole sheet included in Appendix A and are summarized as follows:

Soil Particles	Percentage (%)
Gravel	1
Sand	41
Silt	41
Clay	17

The grain size distribution curve for this sample is plotted on Figure B3, Appendix B.

A thin layer (0.6 m) of very dense sandy silt till was also encountered in Borehole SM6-01, below the clayey silt.

5.6 Sand

A deposit of sand was encountered below a thin layer of sandy silt till in Borehole SM6-01, below the clayey silt in Boreholes SM6-02, SM6-03, and C25-A, and below the silt and sand till in Borehole C25-B. The sand was described as light brown to brown, some silt to silty, trace to some clay, and trace gravel. Occasional cobbles were noted in Borehole SM6-02.

Where fully penetrated, the thickness of the sand ranged from 2.4 to 5.0 m, with the lower boundary of the sand encountered at depths of 7.0 to 8.5 m (Elevation 182.9 to 184.4 m). In Borehole SM6-03, the sand was encountered at a depth of 4.7 m (Elevation 187.9 m) and the borehole was terminated in the sand at a depth of 7.8 m (Elevation 184.8 m).

SPT N-values recorded in the sand typically ranged from 68 blows for 0.3 m penetration to 50 blows for 0.05 m penetration, indicating a very dense relative density. Loose to compact zones (SPT N-values of 9 to 15) were encountered in the sand layer near its upper boundary in Borehole SM6-02 and C25-A. Moisture contents ranged from 4 to 17%.

Five samples of the sand underwent laboratory grain size analysis testing, the results of which are summarized below. These results are also presented on the corresponding Record of Borehole sheets included in Appendix A. The grain size distribution curves for these samples are plotted on Figures B4 and B5, Appendix B.

Soil Particles	Percentage (%)	
	Silty Sand	Sand
Gravel	0 to 4	0
Sand	47 to 61	83 to 88
Silt	32 to 48	12 to 16
Clay	5 to 12	

5.7 Clayey Silt

A deposit of clayey silt was encountered at depth in Boreholes SM6-01, SM6-02, and C25-A, below the sand layer. The clayey silt was generally grey and contained some sand.

The clayey silt deposit was encountered at depths of 7.0 to 7.8 m (Elevation 182.9 to 184.4 m) and was not fully penetrated in any of the boreholes. Boreholes SM6-01 and SM6-02 were terminated at a depth of 7.7 m and Borehole C25-A was terminated at a depth of 10.8 m (Elevation 179.9 to 183.7 m).

SPT N-values recorded in the clayey silt were 100 blows for less than 0.3 m penetration, indicating a hard consistency. Moisture contents ranged from 9 to 19%, typically around 10%.

Three samples of the clayey silt were selected for 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 three samples are plotted on Figure B6, Appendix B.

Soil Particles	Percentage (%)
Gravel	0 to 1
Sand	11 to 16
Silt	47 to 66
Clay	21 to 42

5.8 Lower Sand and Silt Till

A layer of sand and silt till was encountered at depth, locally in Borehole C25-B, below the sand layer.

This lower unit of sand and silt till was 6.1 m thick, with the lower boundary of this unit encountered at a depth of 14.6 m (Elevation 178.2 m).

SPT N-values recorded in the lower sand and silt till were all 50 blows for 0.15 m penetration, indicating a very dense relative density. Moisture contents ranged from 10 to 15%.

5.9 Lower Sand

A lower unit of sand was encountered below the lower silt and sand till deposit in Borehole C25-B. The sand was grey and contained trace silt and trace gravel.

The lower sand unit was encountered at a depth of 14.6 m (Elevation 178.2 m) and was not fully penetrated. The borehole was terminated at a depth of 17.0 m (Elevation 175.8 m) within the lower sand unit.

SPT N-values recorded in the lower sand unit ranged from 87 blows for 0.3 m penetration to 50 blows for 0.15 m penetration, indicating a very dense relative density. Moisture contents ranged from 15 to 16%.

One sample of the lower sand layer underwent laboratory grain size analysis testing. The results of this test are presented on the corresponding Record of Borehole sheet included in Appendix A and are summarized as follows:

Soil Particles	Percentage (%)
Gravel	5
Sand	85
Silt and Clay	9

The grain size distribution curve for this sample is plotted on Figure B5, Appendix B.

5.10 Groundwater Levels

Where present, groundwater levels were observed in the open boreholes upon completion of the drilling. Two standpipe piezometers were installed at this site, in Boreholes SM6-01 and SM6-03, to monitor groundwater levels. The water levels measured in the piezometer are summarized in Table 5.1, along with the measurements in the open boreholes upon completion of drilling.

Table 5-1 – Measured Groundwater Levels

Borehole	Date	Groundwater Level (m)		Comment
		Depth (m)	Elevation (m)	
SM6-01	Oct. 16, 2012	7.0	184.4	Piezometer
	Dec. 5, 2012	6.8	184.6	Piezometer
	Jan. 9, 2013	6.8	184.6	Piezometer
SM6-02	Sept. 24, 2012	Dry	-	Open borehole
SM6-03	Oct. 16, 2012	Dry	-	Piezometer
	Dec. 5, 2012	Dry	-	Piezometer
	Jan. 9, 2013	Dry	-	Piezometer
C25-A	Dec. 12, 2008	6.1	184.6	Open borehole
C25-B	Oct. 10, 2008	5.4	187.4	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 periods of significant or prolonged precipitation events.

6 MISCELLANEOUS

The borehole locations were selected by Thurber Engineering Ltd. and staked in the field using 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.

The drilling and sampling operations in the field were supervised on a full time basis by Ms. Eckie Siu 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 Ms. Lindsey Blaine, E.I.T and Mr. Alastair Gorman, P.Eng. Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations projects, reviewed the report.

Thurber Engineering Ltd.

L. Blaine
Jan 17/13

Lindsey Blaine, E.I.T.
Project Manager



Alastair Gorman, P.Eng.
Senior Geotechnical Engineer



P. K. Chatterji, P.Eng.
Review Principal, Designated MTO Contact



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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 INTRODUCTION

This section of the report provides an interpretation of the factual data and also presents geotechnical recommendations for design of the replacement culvert that will carry Brougham Creek Tributary 'A' under the realigned Highway 7. The plan and profile used for preparation of this report were provided by MMM Group Limited.

The proposed culvert, as shown on the draft General Arrangement (GA) drawing received on November 30, 2012, is 3.6 m wide by 1.5 m high concrete box culvert with a total length of 43.5 m. The culvert is located at approximate Sta. 9+184. The inlet and outlet elevation shown are 191.1 and 190.2 m, respectively. The earth cover at the centreline of the highway is 2.6 m with a maximum of 2.8 m occurring along the culvert's length.

In general, the native subsurface stratigraphy encountered at the site consists of layers of silt and sand underlain by a layer clayey silt. The groundwater level at the site was measured at approximate elevation 184.6 m within the standpipe installed at the northwest corner of the culvert alignment.

8 CULVERT FOUNDATIONS

Foundation recommendations for the proposed culvert are provided in the following section. The culvert must be designed to resist frost forces, lateral earth forces, hydrostatic pressures, weight of embankment fill, traffic loading and surcharge due to construction equipment.

8.1 Culvert Subgrade

Based on the boreholes within, or close to the footprint of the culvert, the highest permissible founding elevations are as follows:

Table 8-1. Highest Permissible Founding Elevations

Borehole	Elevation (m)
SM6-01	190.5
SM6-02	189.0
SM6-03	191.0
C25-A	187.8
C25-B	189.0

With the exception of Borehole C25-A, the data indicates that Elevation 189.0 is the highest acceptable elevation for founding the base of a cast-in-place culvert or for the subgrade for the bedding of a precast culvert. Borehole C25-A was drilled in the ditch to the north of Highway 7 and thus may be indicative of soil conditions along the ditch but not necessarily beyond the ditch. Accordingly, it is recommended that Elevation 189.0 be shown as the founding elevation but the contract documents must contain a warning that deeper local excavation is required along the ditch to approximately Elevation 187.8 and direction to the contractor that the base of the excavation must be inspected by a geotechnical engineer to determine the required extent of sub-excavation. The sub-excavated area must be restored to the design founding elevation using Granular A compacted in accordance with OPSS 501.

The above procedure applies for a subgrade at or below Elevation 189.0 and a cast-in-place culvert may be founded directly on that subgrade. For a precast culvert, a 300 mm thick bedding layer consisting of Granular A compacted in accordance with OPSS 501 must be incorporated below the culvert.

If a higher subgrade elevation is required, the area must be excavated as described above and brought up using Granular A compacted in accordance with OPSS 501. In all cases, a precast culvert must have 300 mm of bedding below it. The bedding must extend a minimum of 0.5 m beyond the footprint of the culvert.

8.2 Bearing Resistance

The bearing resistance below a culvert founded on a subgrade prepared as described above will be 250 kPa at SLS and 375 kPa at ULS_f. However, the performance of a box culvert within an embankment is not governed by bearing resistance but by the settlement of the embankment.

The horizontal resistance against sliding between cast-in-place concrete founded on engineered fill can be computed using an ultimate friction factor of 0.60.

8.3 Frost Cover

Frost tapers must be included in accordance with the requirements of OPSD 803.030 or 803.031, as appropriate. The design depth of frost penetration is 1.2 m.

9 EXCAVATION AND GROUNDWATER CONTROL

All excavation must be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the fill forming the existing Highway 7 embankment are classified as Type 3 soils. The native soils above the recommended culvert founding elevation Table 8-1 are also classed as Type 3 soils. The underlying foundation soils are classed as a Type 2 soil.

The sides of temporary excavations must be sloped in accordance with the requirements of the OHSA. Where space does not permit the sides to be sloped, roadway protection must be used.

Selection of the equipment and methodology to excavate and prepare the founding surface is the responsibility of the Contractor. Based on the preliminary GA and recorded ground water levels, excavation below the groundwater level to construct the culvert is not anticipated. However, the Contractor must be prepared to pump from sumps to remove any remaining seepage water or surface water collecting in an excavation. Placement of the culvert must be done in the dry. Unwatering must remain operational and effective until the culvert is installed and backfilled. .

Furthermore, the excavation and backfilling for foundations must be carried out in accordance with OPSS 902

10 SCOUR PROTECTION AND EROSION CONTROL

Culvert foundation must be provided with scour protection. Erosion control must be provided at the culvert inlet and outlet areas as applicable. Design of the scour and erosion protection measures must consider hydrologic and hydraulic concerns and must be carried out by a specialist experienced in this field.

Typically, rock protection should be provided over all surfaces with which stream flow is likely to be in contact. Treatment at the outlets should be in accordance with OPSD 810.010. A vegetation cover should be established on all other exposed surfaces to protect against surficial erosion, in general accordance with OPSS 804.

It is recommended that a clay seal or a concrete cut-off wall be used to minimize the potential for flow of water through the granular backfill and accompanying risk of erosion. The clay seal should extend at least 0.3 m above the high water level and laterally for the width of the granular material, and have a minimum thickness parallel to the culvert of 0.5 m. The material requirements should be in accordance with OPSS 1205. A prefabricated geosynthetic clay liner, such as Bentofix NSL, may be used as an alternative to clay.

11 BACKFILL

The culvert backfill must consist of free-draining granular material conforming to OPSS Granular A or Granular B Type II material meeting the requirements of Special Provisions 110S13 "Amendment to OPSS 1010, April 2004". The granular material should be placed at least to the general extents shown in OPSD 803.010.

Backfill must be placed and compacted in simultaneous equal lifts on both sides of the culvert, and the top of the backfill elevation must be within 400 mm on both sides of the culvert at all times. Compaction equipment to be used adjacent to culvert must be restricted in accordance with OPSS 501. Compaction must be carried out in accordance with OPSS 501.

12 EARTH PRESSURE

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

$$p_h = K(\gamma h + q) \quad (\text{kN/m}^3)$$

where	p_h	=	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)

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 the 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.

Earth pressure coefficients for backfill to the culvert are dependent on the material used as backfill. Typical values are shown in Table 12-1. The at-rest coefficients should be employed for closed box culverts.

Table 12-1. Earth Pressure Coefficients

Condition	Earth Pressure Coefficient (K)			
	OPSS Granular A or OPSS Granular B Type II $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$		Existing Sand Fill or OPSS Granular B Type I $\phi = 32^\circ, \gamma = 21.2 \text{ kN/m}^3$	
	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)
Active (unrestrained mass)	0.27	0.40	0.31	0.48
Passive (movement towards soils mass)	3.7		3.3	
At Rest (restrained mass)	0.43		0.47	

The factors in Table 12-1 are “ultimate” values and require certain movements for the respective conditions to be mobilized. The values to be used in design can be estimated from Figure C6.16 in the Commentary to the CHBDC.

The design of the culvert must incorporate measures such as weepholes or subdrains to permit drainage of the culvert backfill, or alternatively the culvert walls should be designed to withstand the potential build-up of hydrostatic pressures behind the walls.

13 SEISMIC CONSIDERATIONS

13.1 Seismic Design Parameters

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.

13.2 Dynamic Earth Pressures

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 13-1 may be used:

Table 13-1. Earth Pressure Coefficients for Earthquake Loading

Condition	Earth Pressure Coefficient (K)			
	OPSS Granular A or OPSS Granular B Type II $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$		Existing Sand Fill or OPSS Granular B Type I $\phi = 32^\circ, \gamma = 21.2 \text{ kN/m}^3$	
	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)
Active (K_{AE})*	0.3	0.47	0.34	0.58
Passive (K_{PE})	3.6		3.2	
At Rest (K_{OE})**	0.53		0.58	

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

** After Woods

13.3 Liquefaction Potential

The potential for liquefaction of the foundations soils was assessed using the Seed and Idriss (1971) method¹. 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.

14 EMBANKMENT

Embankment construction must be carried out in accordance with OPSS 206. The embankment material should consist of earth fill or Select Subgrade Material (SSM) in compliance with Special Provisions 110S13 "Amendment to OPSS 1010, April 2004".

In general, surface vegetation, topsoil, organic matter, disturbed material or other loose/soft soils should be stripped from the new culvert and embankment footprint. Inspection and approval of the foundation surfaces by qualified geotechnical personnel is recommended.

Provided that the earth fill or SSM is placed as recommended, it is anticipated that a slope inclination of 2H:1V or flatter should remain stable. The existing earth slope surface should be benched as per OPSD 208.10 in order to enhance the keying in of the new fill.

15 ROADWAY PROTECTION

If roadway protection is required, it must be implemented in accordance with OPSS 539 and designed for Performance Level 2.

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.

Trench boxes or conventional steel soldier piles and timber lagging walls may be considered to provide temporary support to the soils during excavation. Timber lagging boards should be installed as soon as the soil face is exposed and properly prepared.

The design of roadway protection is the responsibility of the Contractor. The actual pressure distribution acting on the shoring system is a function of the construction sequence and the relative flexibility of the wall and these factors must be considered when designing the shoring system. All shoring systems must be designed by a Professional Engineer experienced in such designs, who will determine an appropriate support system.

Temporary surface water control measures will be required during construction.

16 CONSTRUCTION CONCERNS

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

- Deeper excavation required along the ditch to remove layer of topsoil fill.
- Roadway protection must be provided to maintain traffic during construction. Temporary shoring systems should be properly designed by a Professional Engineer experienced in such designs.
- The side embankment slopes should be inspected after construction for surficial disturbance. Where necessary, erosion control measures must be implemented.
- Care must be taken during excavation to avoid disturbing the subgrade. The exposed subgrade should be protected from physical disturbance and the granular bedding must be placed on the approved subgrade expeditiously following excavation
- Confirmation that the culvert backfills and approach fills are adequately placed and compacted to specifications

The successful performance of the culvert installation will depend largely upon good workmanship and quality control during construction. 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.

17 CLOSURE

Engineering analysis and preparation of the report was carried out by Mr Stephen Peters P.Eng(MB) and Mr Alastair Gorman, P.Eng.

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

Thurber Engineering Ltd.

Stephen Peters, P.Eng(MB)
Geotechnical Engineer

Steph Peters
Jun 17/13



Alastair Gorman, P.Eng.
Senior Foundation Engineer

P. K. Chatterji, P.Eng.
Review Principal



Appendix A
Record of Borehole Sheets

RECORD OF BOREHOLE No SM6-01

1 OF 1

METRIC

WP# E2-2012 LOCATION N 4 864 506.1 E 336 674.4 ORIGINATED BY ES
 HWY 407 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2012.09.24 - 2012.09.24 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)		
								○ UNCONFINED	+	FIELD VANE									
								● QUICK TRIAXIAL	×	LAB VANE									
191.4							20	40	60	80	100								
0.0	SILT and SAND , trace clay, trace organics, trace roots and rootlets Loose Dark Brown Moist		1	SS	6								○						
190.6																			
0.8	Clayey SILT , some sand, trace gravel, occasional cobbles Very Stiff to Hard Dark Brown to Brown		2	SS	27								○						
			3	SS	32								○						
189.3																			
2.1	Sandy SILT , some clay, trace gravel Very Dense Brown Damp (TILL)		4	SS	87								○						
188.7																			
2.7	SAND , some silt to silty, trace clay, trace gravel Very Dense Light Brown Damp		5	SS	50/ 0.100								○			0 61 32 7			
			6	SS	50/ 0.075								○						
			7	SS	50/ 0.050								○						
184.4																			
7.0	Clayey SILT , some sand Hard Grey																		
183.7			8	SS	100/ 0.075								○			0 16 63 21			
7.7	END OF BOREHOLE AT 7.7m. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Oct. 16/12 7.0 184.4 Dec. 05/12 6.8 184.6 Jan. 03/13 6.8 184.6																		

ONTMT4S 1130A.GPJ 1/17/13

RECORD OF BOREHOLE No SM6-02

1 OF 1

METRIC

WP# E2-2012 LOCATION N 4 864 515.3 E 338 686.8 ORIGINATED BY ES
 HWY 407 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2012.09.24 - 2012.09.24 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
190.3								20	40	60	80	100		
0.0	SILT and SAND , some clay, mixed with organics, trace roots and rootlets Loose to Compact Dark Brown Damp		1	SS	7		190							
			2	SS	10		189							0 39 49 12
188.4			3	SS	34		188							
1.9	Clayey SILT , some sand Brown Hard		4	SS	14		187							
188.0			5	SS	57/ 0.200		186							
2.3	SAND , some silt to silty Compact to Very Dense Brown Damp		6	SS	50/ 0.050		185							
	Occasional cobbles at 3.4m		7	SS	50/ 0.125		184							
	Trace gravel Light Brown						183							
183.1			8	SS	100/ 0.125									0 11 47 42
7.2	Clayey SILT , some sand Hard Grey													
182.6														
7.7	END OF BOREHOLE AT 7.7m. BOREHOLE OPEN AND DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH HOLEPLUG TO 1.5m, THEN CUTTINGS TO SURFACE.													

ONTMT4S 1130A.GPJ 1/17/13

RECORD OF BOREHOLE No SM6-03

1 OF 1

METRIC

WP# E2-2012 LOCATION N 4 864 490.1 E 336 700.1 ORIGINATED BY SLL
 HWY 407 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2012.09.24 - 2012.09.24 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
192.6								20	40	60	80	100		
0.0	TOPSOIL: (50mm)													
	SAND , trace to some gravel Loose Dark Brown Moist (FILL)		1	SS	6		192							
191.6														
1.0	Clayey SILT , some sand, trace gravel Firm Brown (FILL)		2	SS	6									
191.1														
1.5	Gravelly SAND , some silt, trace clay Compact Dark Brown Moist (FILL)		3	SS	23		191							31 41 18 10
190.3														
2.3	Clayey SILT , some sand, trace roots and rootlets Stiff to Very Stiff Dark Brown to Brown		4	SS	11		190							
			5	SS	24		189							
							188							0 47 48 5
187.9			6	SS	108/ 0.250									
4.7	Silty SAND , trace clay Very Dense Light Brown Damp						187							
	Trace gravel		7	SS	50/ 0.100		186							
							185							
184.8			8	SS	50/ 0.050									
7.8	END OF BOREHOLE AT 7.8m. BOREHOLE OPEN AND DRY UPON COMPLETION. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.													
	WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Oct. 16/12 Dry Dec. 05/12 Dry Jan. 03/13 Dry													

ONTMT4S 1130A.GPJ 1/17/13

+³, ×³: Numbers refer to
Sensitivity

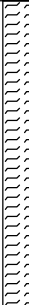


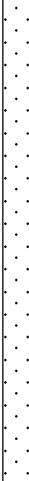

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No C25-A

1 OF 2

METRIC

W.P. 2075-08-00 LOCATION N 4 864 492.24 E 336 685.57 ORIGINATED BY LH
 HWY 7 - Brock Rd. to Hwy 12 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2008.12.12 - 2008.12.12 CHECKED BY DE

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				W _P W W _L							
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	WATER CONTENT (%)										
190.7	Geodetic							20	40	60	80	100							
0.0	TOPSOIL (2030mm) (FILL)		1	SS	6		190							○					
			2	SS	7									○					
188.7			3	SS	6		189							○					
2.0	Clayey SILT, some sand, trace rootlets Dark Brown Firm (FILL)		4	SS	7		188							○					
187.9														○					
2.8	Silty SAND, some clay, trace gravel Compact Light Brown Moist		5	SS	15		187							○				4 52 32 12	
			6	SS	9									○					
186.2							186							○				0 83 16 (SI+CL)	
4.6	SAND, some silt Compact to Dense Light Brown Moist		7	SS	15		185												
			8	SS	82		184							○					
182.9			9	SS	100/		183							○	○				
7.8	Clayey SILT, some sand, trace gravel Light Brown Hard Moist				0.125		182								○			1 11 66 23	
			10	SS	100/ 0.150		181												

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10


(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No C25-A

2 OF 2

METRIC

W.P. 2075-08-00 LOCATION N 4 864 492.24 E 336 685.57 ORIGINATED BY LH
 HWY 7 - Brock Rd. to Hwy 12 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2008.12.12 - 2008.12.12 CHECKED BY DE

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	Continued From Previous Page																
179.9	Clayey SILT , some sand, trace gravel Light Brown Hard Moist		11	SS	100/												
10.8	END OF BOREHOLE AT 10.8m. WATER LEVEL AT 6.1m UPON COMPLETION OF DRILLING.				0.125												

RECORD OF BOREHOLE No C25-B

1 OF 2

METRIC

W.P. 2075-08-00 LOCATION N 4 864 484.67 E 336 689.63 ORIGINATED BY LH
 HWY 7 - Brock Rd. to Hwy 12 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2008.10.10 - 2008.10.10 CHECKED BY DE

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						WATER CONTENT (%)			
								20 40 60 80 100		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT				W P W W L			
192.8	Geodetic																
190.7	CONCRETE (150mm)		1	SS	24												
	SAND, some silt, trace clay, trace gravel Compact to Loose Brown Moist (FILL)		2	SS	17												
			3	SS	6												
190.7			4	SS	6												
	SAND and SILT, some clay, trace gravel Loose to Compact Grey Moist (TILL)		5	SS	5												
			6	SS	15												
			7	SS	16												
186.7			8	SS	68												
	SAND, some silt Very Dense Brown Moist		9	SS	82												
184.3			10	SS	50/ .150												
8.5	SAND and SILT, some clay, trace gravel Very Dense Grey Moist (TILL)																

Continued Next Page


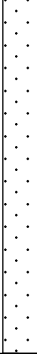
+³, ×³: Numbers refer to Sensitivity
 20
 15
 10
 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No C25-B

2 OF 2

METRIC

W.P. 2075-08-00 LOCATION N 4 864 484.67 E 336 689.63 ORIGINATED BY LH
HWY 7 - Brock Rd. to Hwy 12 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2008.10.10 - 2008.10.10 CHECKED BY DE

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									WATER CONTENT (%)	
	Continued From Previous Page							20	40	60	80	100						
178.2	SAND and SILT , some clay, trace gravel Very Dense Grey Moist (TILL)		11	SS	50/ .150		182								○			
			12	SS	50/ .150				181									○
			13	SS	50/ .150		180								○			
14.6	SAND , trace silt, trace gravel Very Dense Grey Wet		14	SS	87		178								○	5 85 9 (SI+CL)		
175.8			15	SS	50/ .150		177											
17.0	END OF BOREHOLE AT 16.9m. WATER LEVEL AT 5.4m UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH CUTTINGS AND BENTONITE TO SURFACE.						176								○			

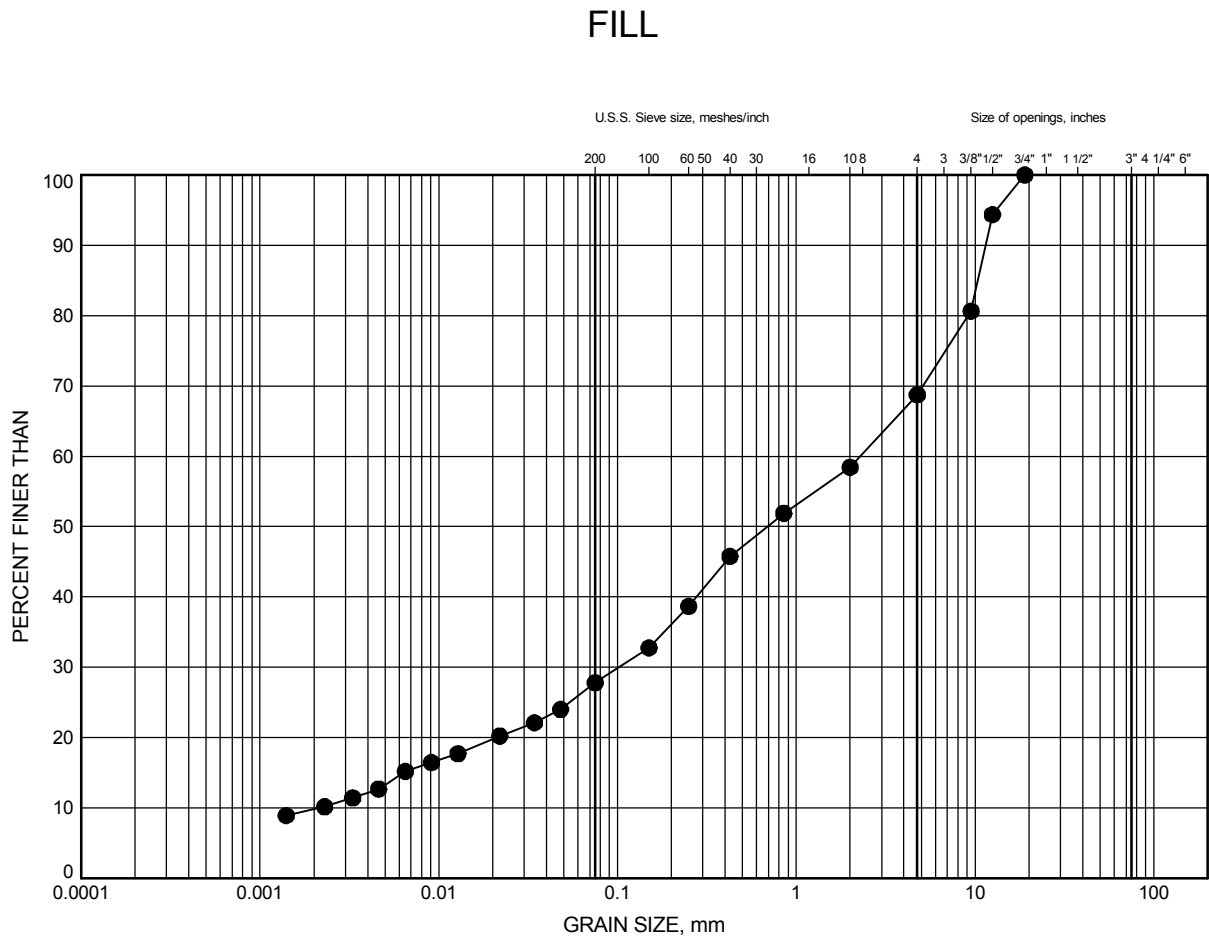
+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

Appendix B
Laboratory Test Results

Hwy 407 Brock Road Connection - Foundations

GRAIN SIZE DISTRIBUTION

FIGURE B1



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SM6-03	1.83	190.77

Date December 2012
W.P.# E2-0212



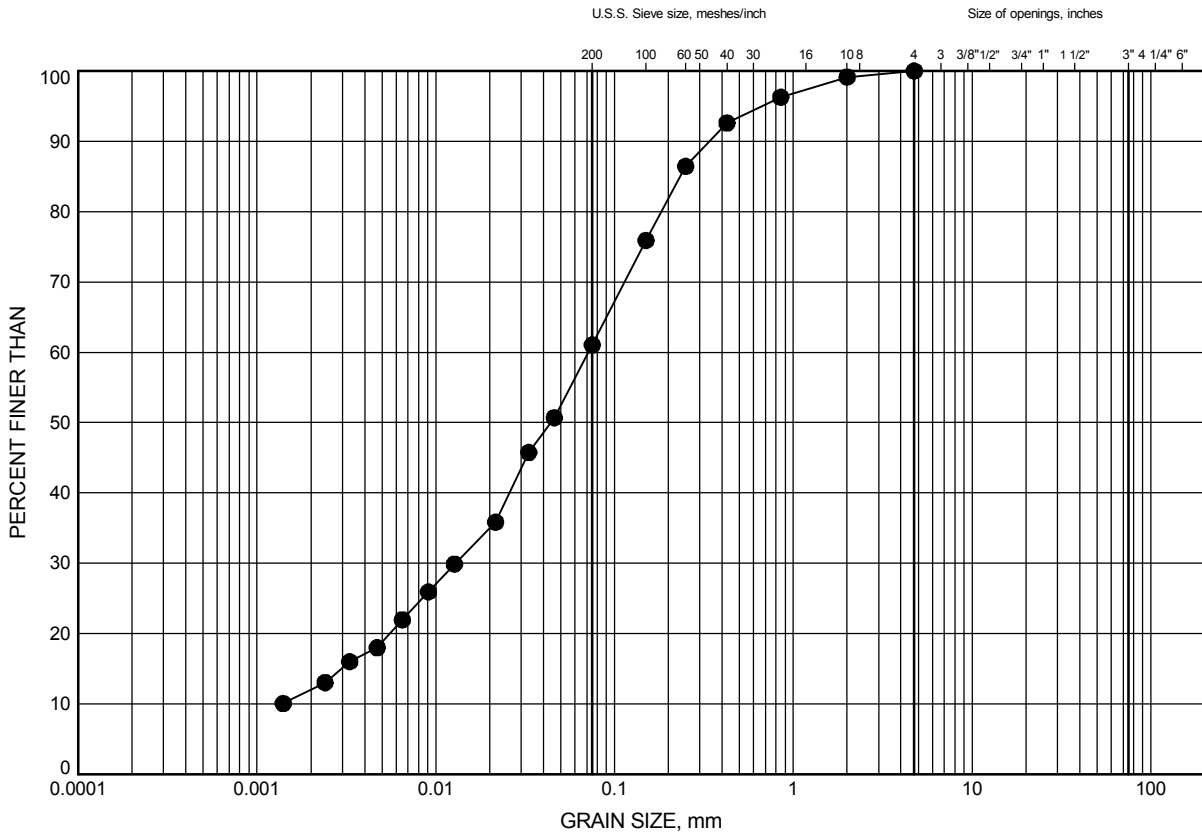
Prep'd SBP
Chkd.

Hwy 407 Brock Road Connection - Foundations

GRAIN SIZE DISTRIBUTION

FIGURE B2

SILT and SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SM6-02	1.07	189.23

Date December 2012
W.P.# E2-0212



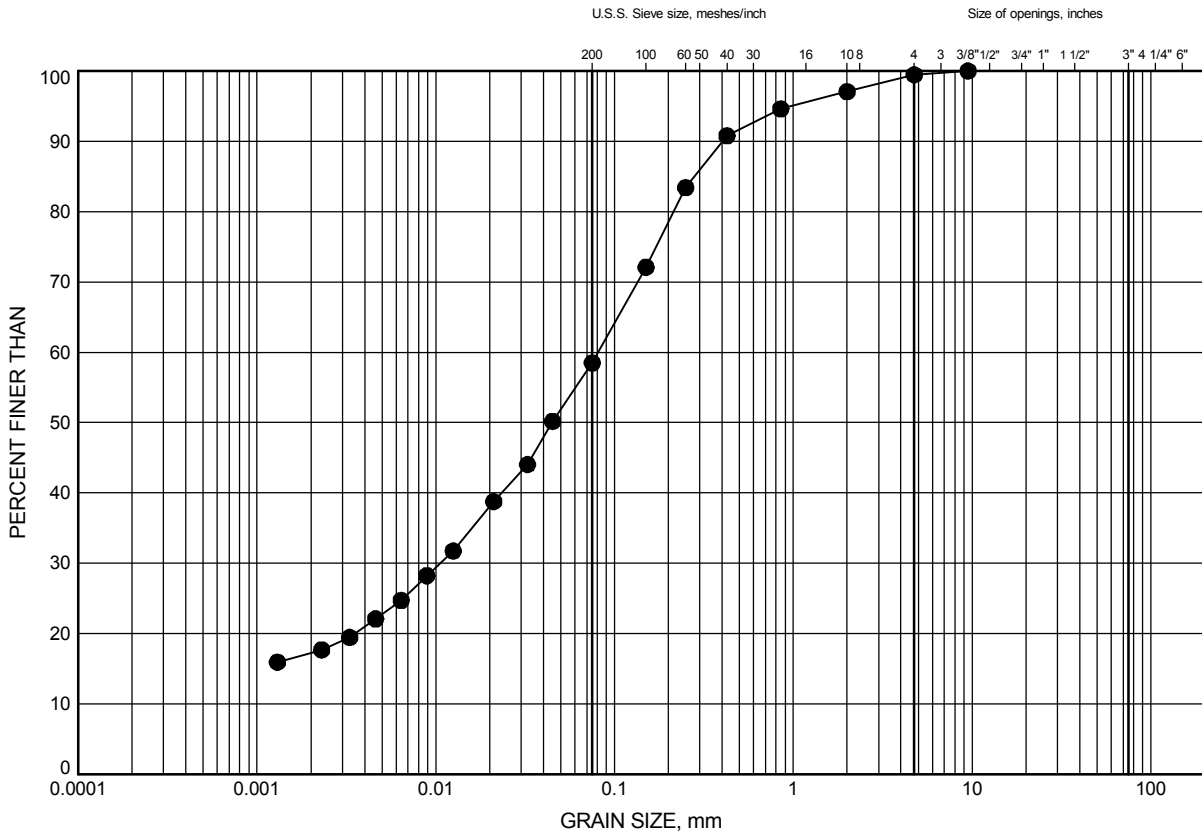
Prep'd SBP
Chkd.

Hwy 7 Brock to Hwy 12

GRAIN SIZE DISTRIBUTION

FIGURE B3

SILT and SAND TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C25-B	3.35	189.46

Date December 2012
W.P.# 2075-08-00



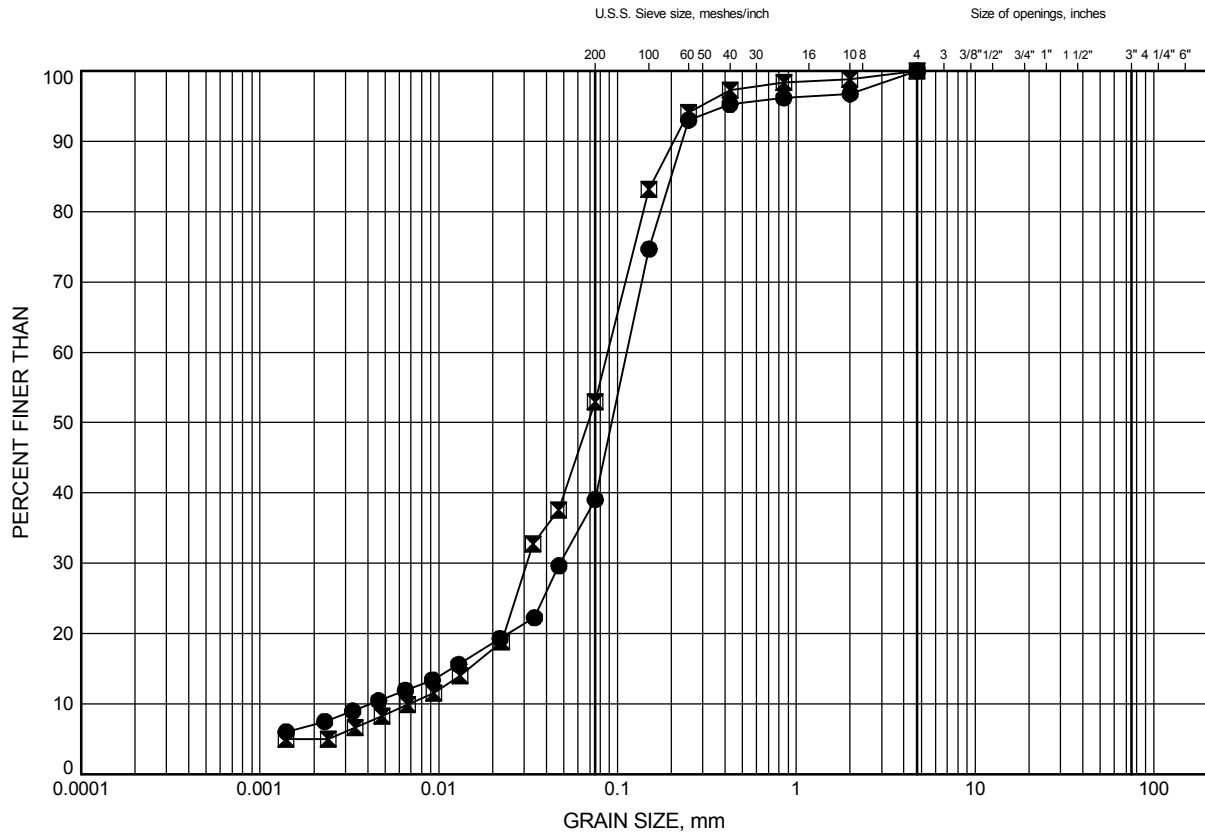
Prep'd SBP
Chkd.

Hwy 407 Brock Road Connection - Foundations

GRAIN SIZE DISTRIBUTION

FIGURE B4

SILTY SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SM6-01	3.18	188.22
⊠	SM6-03	4.78	187.82

Date December 2012
W.P.# E2-0212



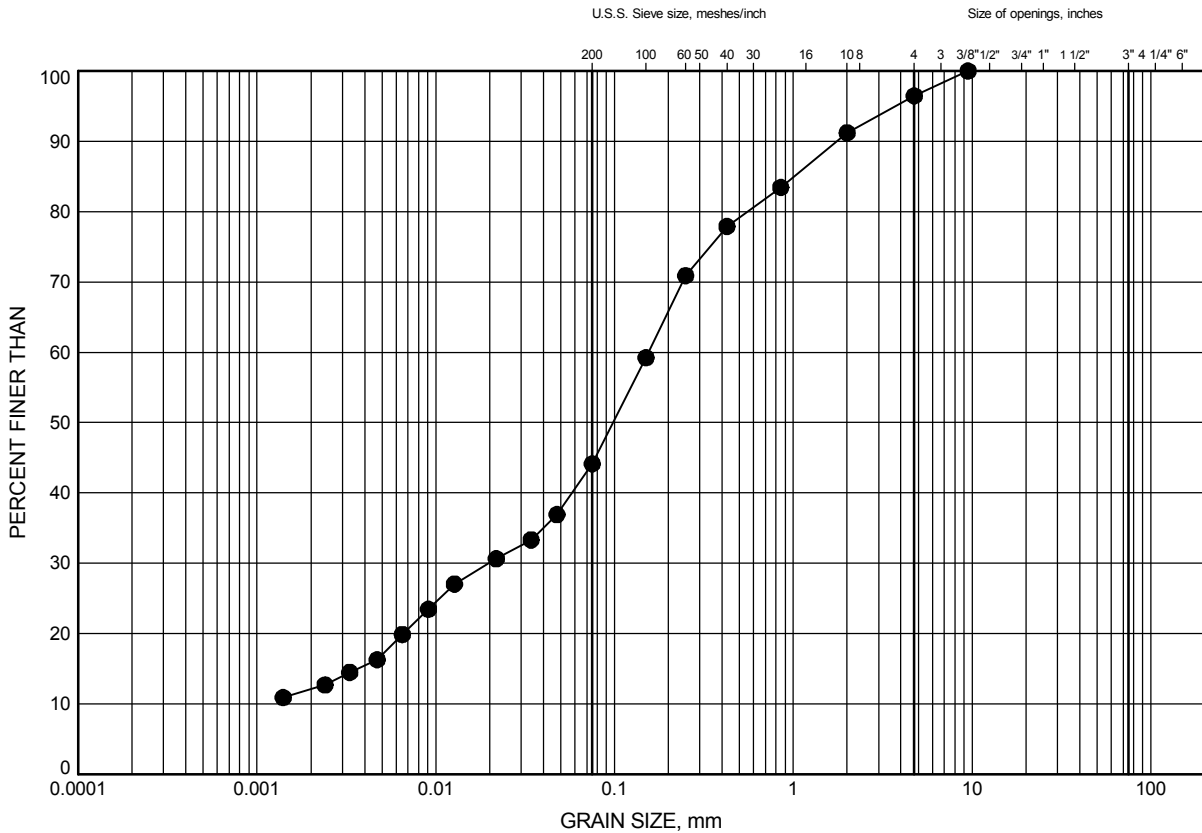
Prep'd SBP
Chkd.

Hwy 7 Brock to Hwy 12

GRAIN SIZE DISTRIBUTION

FIGURE B4

SILTY SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C25-A	3.35	187.38

Date December 2012
W.P.# 2075-08-00

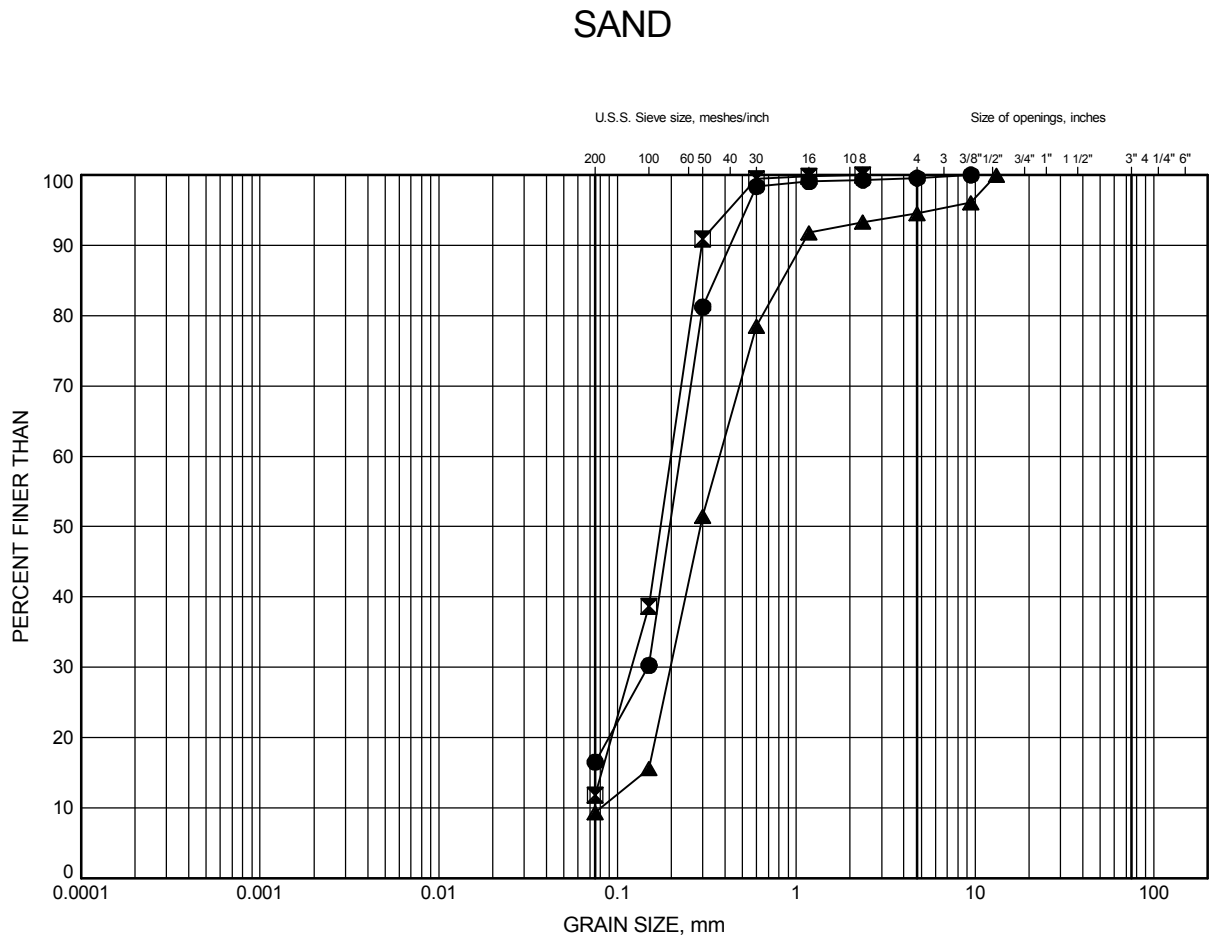


Prep'd SBP
Chkd.

Hwy 7 Brock to Hwy 12

GRAIN SIZE DISTRIBUTION

FIGURE B5



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C25-A	4.88	185.85
⊠	C25-B	6.40	186.41
▲	C25-B	15.44	177.37

Date December 2012
W.P.# 2075-08-00



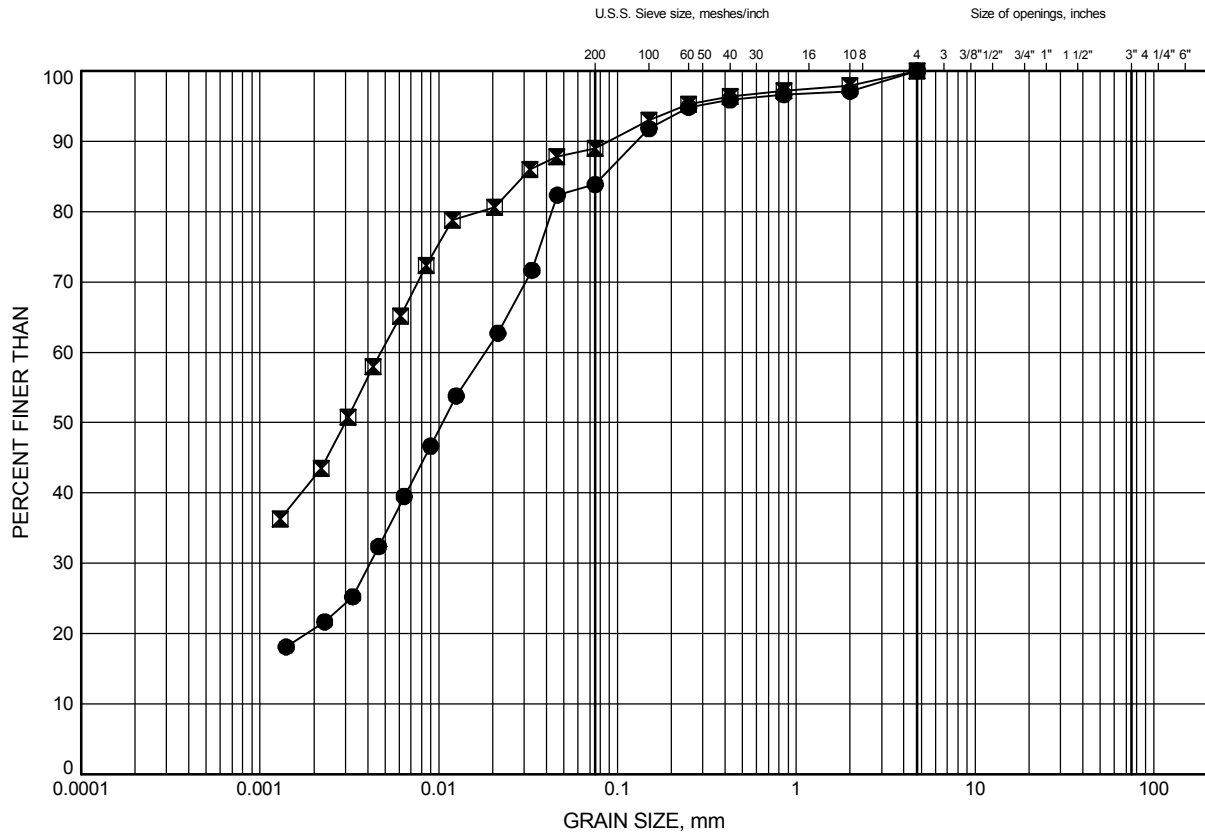
Prep'd SBP
Chkd.

Hwy 407 Brock Road Connection - Foundations

GRAIN SIZE DISTRIBUTION

FIGURE B6

CLAYEY SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SM6-01	7.66	183.74
⊠	SM6-02	7.68	182.62

Date December 2012
W.P.# E2-0212



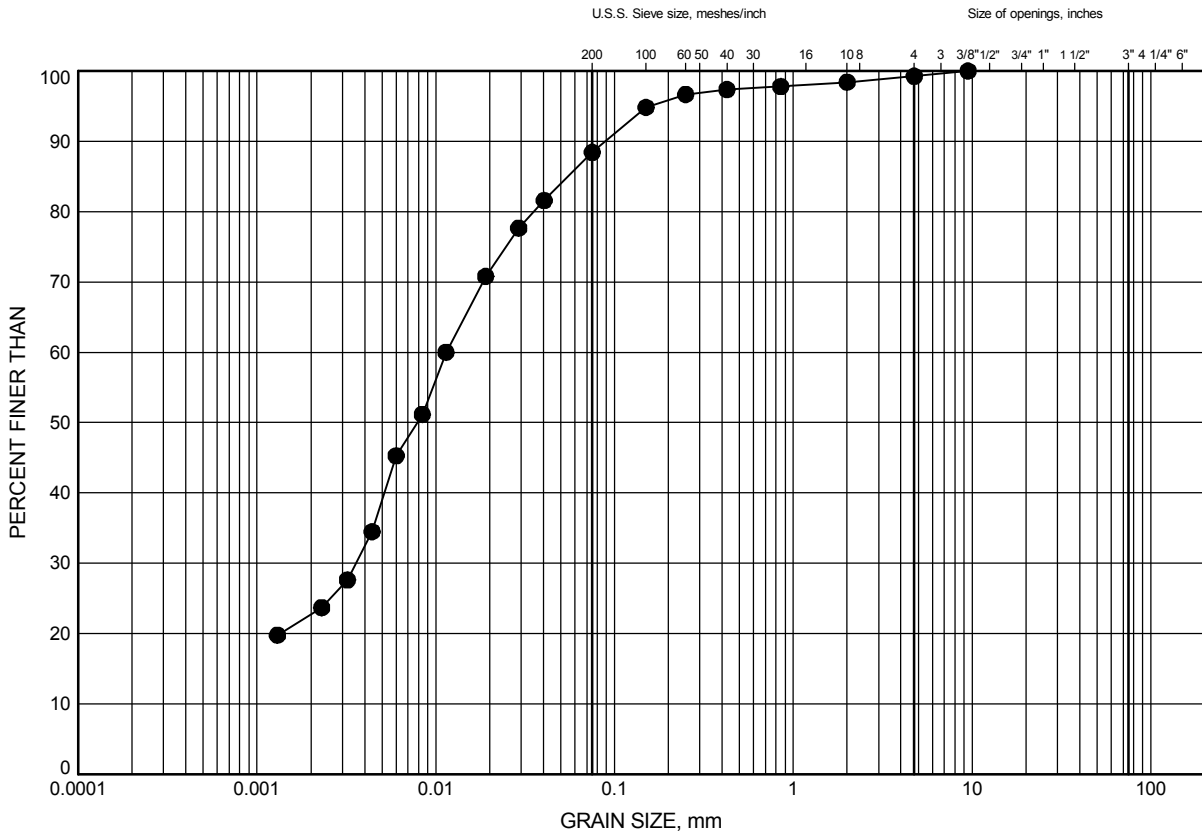
Prep'd SBP
Chkd.

Hwy 7 Brock to Hwy 12

GRAIN SIZE DISTRIBUTION

FIGURE B6

CLAYEY SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C25-A	9.22	181.51

Date December 2012
W.P.# 2075-08-00



Prep'd SBP
Chkd.

Appendix C
Site Photographs

Structure M-6: Realigned Highway 7 over Brougham Creek Tributary 'A'
Highway 407/Brock Road Interchange Connection



Photograph 1: Looking south, toward inlet of culvert



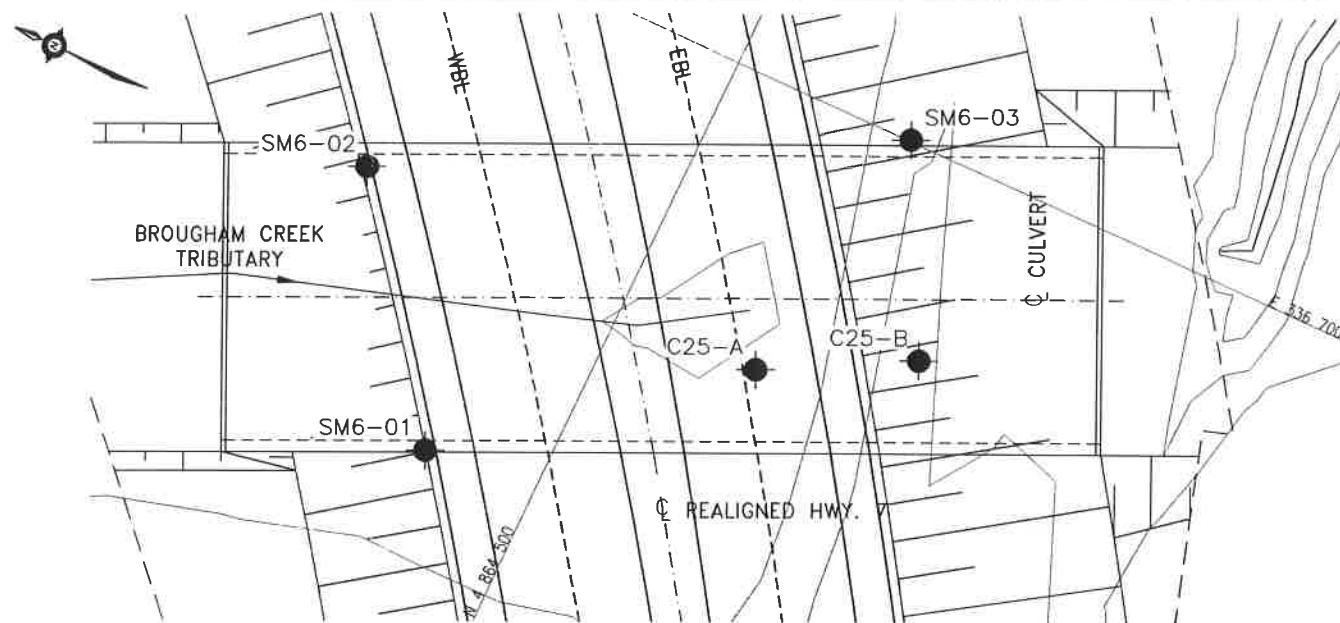
Photograph 2: Looking south, away from outlet of culvert

Appendix D
List of SPs and OPSS

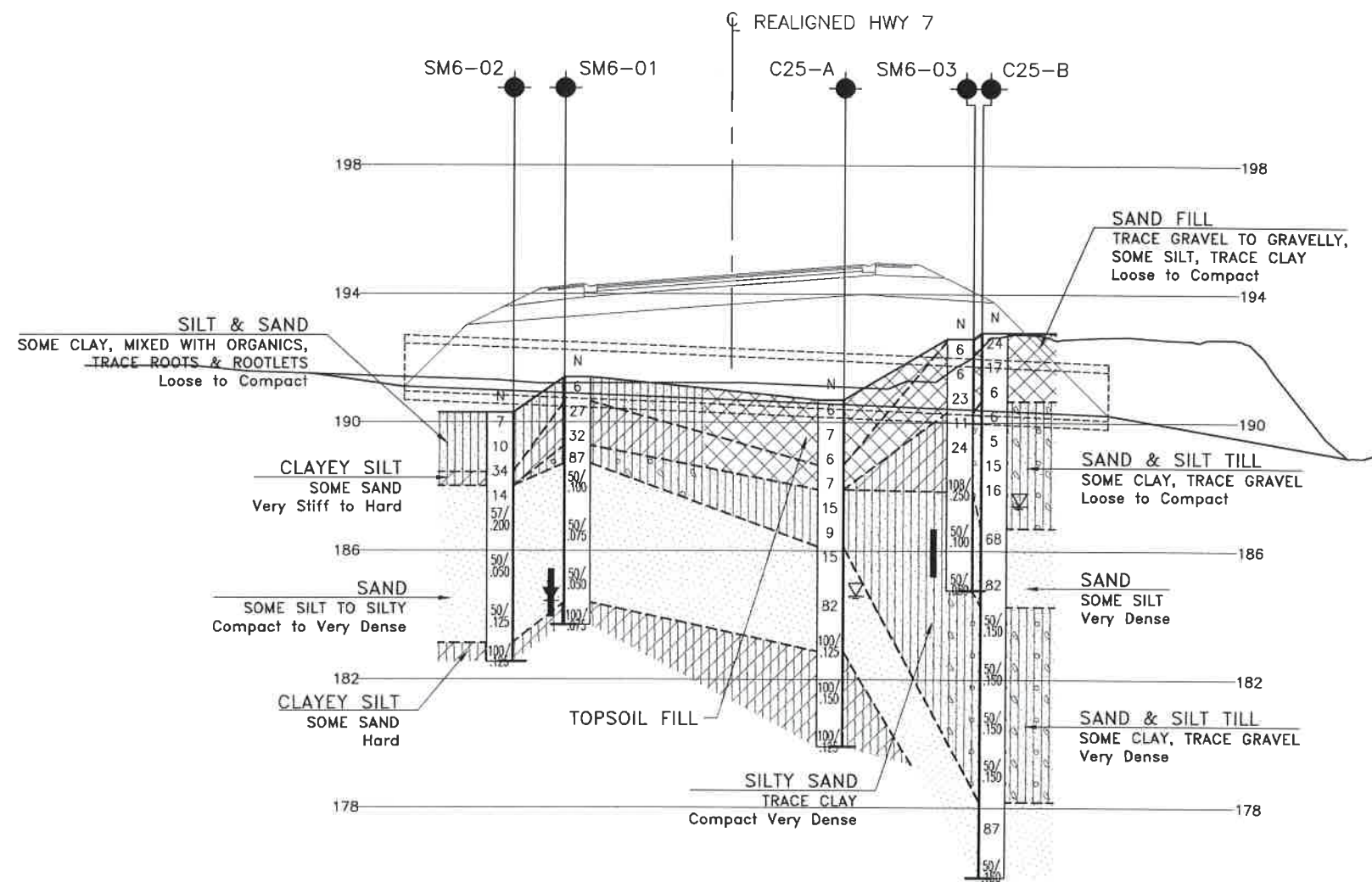
1. List of Special Provisions and OPSS Documents Referenced in this Report

- OPSS 206
- OPSS 501
- OPSS 539
- OPSS 804
- OPSS 902
- OPSS 1205
- OPSD 208.010
- OPSD 810.010
- OPSD 803.010
- OPSD 803.030
- Special Provisions 110S13

Appendix E
Borehole Locations and Soil Strata Drawing



PLAN



PROFILE ALONG ϕ CULVERT M-6

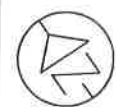


H 1:400
V 1:200

NO.	DATE	REVISIONS	BY	CHK	LOAD	PROJ.

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

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



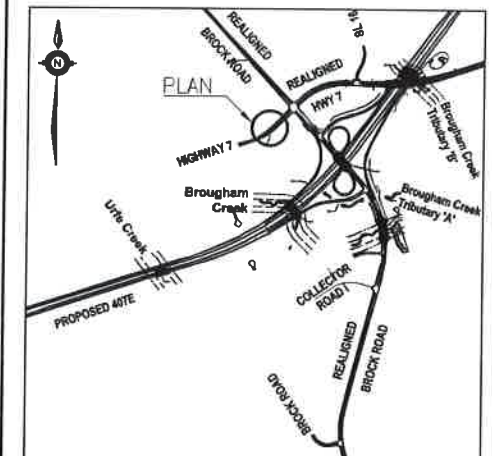
STRUCTURE M-6 (SITE 101)
REALIGNED HIGHWAY 7 OVER
BROUGHAM CREEK TRIBUTARY 'A'
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

407 ETR
Express Toll Route

MMM GROUP

THURBER ENGINEERING LTD.



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
SM6-01	191.4	4 864 506.1	336 674.4
SM6-02	190.3	4 864 515.3	336 686.8
SM6-03	192.6	4 864 490.1	336 700.1
C25-A	190.7	4 864 492.2	336 685.6
C25-B	192.8	4 864 484.7	336 689.6

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.

