

**FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 407/BROCK ROAD INTERCHANGE CONNECTION
STORMWATER MANAGEMENT PONDS**

Contract No: E2-2012

Report to

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted at the locations of three proposed stormwater management ponds. These ponds are planned as part of the Highway 407/Brock Road Interchange Connection project in the City of Pickering, Ontario.

The purpose of this investigation was to explore the subsurface conditions at the three pond sites and, based on the data obtained, to provide borehole location plans, stratigraphic sections, records of boreholes, 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 for each of the ponds.

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 three stormwater management ponds (SWMPs) addressed in this report are located within the vicinity of the existing Highway 407 – Sideline 16 intersection near the community of Brougham, in The City of Pickering. The approximate pond locations and other relevant pond details are summarized below. A fourth pond location, 07W, was also investigated but this pond was cancelled from the final design. Details of the three ponds are presented in Table 2.1 below.

Table 2.1 – Pond Details

Pond ID	Approximate Location	Permanent Pool Elevation (m)	Bottom of Pond Elevation (m)	Top of Pond Elevation (m)
03W	160 m east of Brock Road and 95 m south of Highway 407	186.50	184.50	188.10
07E	60 m north of Highway 7 and 450 m west of Sideline 14	166.00	164.00	167.40
07S	105 m east of Sideline 16 and 125 m south of Highway 7	168.00	166.00	169.70

Lands surrounding the proposed pond sites consist primarily of agricultural fields and undeveloped grass areas.

The proposed pond sites are situated in the physiographic region known as the South Slope, which lies between the Oak Ridges Moraine and the Iroquois Plain, and is typically characterized by overburden deposits consisting of sand and silt 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 Ponds 03W and 07S are located in an area underlain by sandy silt to silty sand till, and Pond 07E is located in the vicinity of an area covered by coarse-textured glaciolacustrine deposits.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing for the SWMPs were carried out from August 17 to 27, on October 24 and 25, and on December 18, 2012. Two boreholes were drilled at each proposed pond location. The location of Pond 03W was changed after the initial field investigation so an additional two boreholes were drilled at the revised location. Only the subsurface conditions encountered in Boreholes P3W-03 and P3W-04 will be directly referenced in the text given that Boreholes P3W-01 and P3W-02 are located outside of the pond footprint. Pond 07W was part of the original design but was cancelled from the final design, and therefore a description of the conditions encountered at this site is not included in this report. The boreholes were advanced to depths of 9.3 m to 18.6 m (Elevation 180.3 to 153.7 m). The Record of Borehole sheets for each pond are included in Appendices A to C.

Stormwater Management Pond ID	Boreholes	Corresponding Appendix
03W	P3W-01 to P3W-04	A
07E	P7E-01 and P7E-02	B
07S	P7S-01 and P7S-02	C

The approximate borehole locations are shown on the attached Borehole Locations and Soil Strata drawings included in Appendices A to C.

The borehole locations were marked in the field and utility clearances were obtained prior to drilling. As well, Permission to Enter was obtained by MTO for the private properties accessed for this investigation.

The boreholes were drilled using a B-57 and CME-55 track-mounted drill rigs using solid stem augers, except Borehole P7E-2 which was advanced with hollow stem augers. Soil 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 during and upon completion of the drilling operations. A monitoring well was installed in one selected borehole at each pond site for subsequent monitoring of groundwater levels. The installation details of the monitoring wells and completion details for the boreholes are summarized in Table 3.1.

Table 3.1 – Borehole Completion and Monitoring Well Installation Details

Borehole	Piezometer Tip Depth/ Elevation (m)	Completion/ Installation Details
P3W-01	12.2 / 177.5	50 mm diameter well with 1.5 m screen installed with filter sand to 7.9 m, bentonite holeplug from 7.9 to 0.9 m, then cuttings to surface.
P3W-02	None installed	Backfilled with bentonite holeplug to 1.4 m, then cuttings to surface.
P3W-03	9.1 / 178.8	50 mm diameter well with 3.0 m screen installed with filter sand to 5.8 m and bentonite holeplug from 5.8 to surface.
P3W-04	None installed	Backfilled with bentonite holeplug to surface.
P7S-01	17.8 / 154.5	50 mm diameter well with 1.5 m screen installed with filter sand to 14.7 m, bentonite holeplug from 14.7 to 2.3 m, then cuttings to surface.
P7S-02	None installed	Backfilled with bentonite holeplug to 1.9 m, then cuttings to surface.
P7E-01	None installed	Borehole caved to 4.5 m, then backfilled with bentonite holeplug from 4.5 m to 1.0 m, then cuttings to surface.
P7E-02	10.5 / 158.9	50 mm diameter well with 1.5 m screen installed with filter sand to 8.2 m, bentonite holeplug from 8.2 to 1.5 m, cuttings from 1.5 to 0.6 m, then holeplug to surface.

4 LABORATORY TESTING

The recovered soil samples were subjected to visual identification and 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 and figures included in Appendices A to C.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets included in Appendices A to C. An overall description of the stratigraphy encountered at each pond 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.

5.1 Pond 03W (Boreholes P3W-03 and P3W-04)

In general, the subsurface stratigraphy encountered at this site (in Boreholes P3W-03 and P3W-04) consisted of a thin layer of topsoil overlying sandy silt (in Boreholes P3W-03 only) overlying sand and silt till. More detailed descriptions of the individual strata are presented below.

Boreholes P3W-01 and P3W-02 were drilled before the final location of the pond was determined. They are not located within the final pond footprint and are therefore not included in the soil descriptions below. The piezometer readings taken at Borehole P3W-01 are, however, used for determining the groundwater level at this site.

5.1.1 Topsoil

A layer of topsoil was encountered surficially in Boreholes P3W-03 and P3W-04. The thickness of the topsoil was 200 mm in both boreholes. It should be noted that topsoil thickness may vary between and beyond the boreholes, and in other areas of the site.

5.1.2 Sandy Silt

A layer of sandy silt was encountered below the topsoil in Borehole P3W-03. The sandy silt was brown and contained trace clay.

The sandy silt layer was 0.7 m thick with a lower boundary at a depth of 0.9 m (Elevation 187.0 m).

An SPT N-value of 9 blows for 0.3 m penetration was recorded in the sandy silt layer, indicating a loose state. A moisture content of 14% was measured in one sample of the sandy silt.

5.1.3 Sand and Silt Till

Sand and silt till was encountered below the topsoil in Borehole P3W-04 and below the sandy silt layer in Borehole P3W-03. The till was brown to grey in colour and contained trace to some clay, trace gravel, and occasional inferred cobbles. Occasional clayey zones were also noted within the till. The presence of occasional boulders and/or cobbles was inferred during the drilling process.

The sand and silt till layer was not penetrated in either Borehole P3W-03 or P3W-04. These boreholes were terminated within the till at depths of 9.8 and 9.3 m, respectively (Elevation 178.1 and 180.3 m).

SPT N-values recorded in the till ranged from 6 blows for 0.3 m penetration to 100 blows for 0.15 m penetration, indicating a loose to very dense state. In general, the till is in a dense to very dense state and the relative density of the till increased with depths. Measured moisture contents ranged from 7 to 17%.

From Boreholes P3W-03 and P3W-04, four samples of the till were selected for laboratory grain size analysis testing. The results of these tests are summarized below and are presented on the corresponding Record of Borehole sheets included in Appendix A.

Soil Particles	Percentage (%)
Gravel	1 to 6
Sand	42 to 55
Silt	34 to 43
Clay	5 to 15

The grain size distribution curves for these samples are plotted on Figures A1 and A2, along with the grains size curves for the till samples from Boreholes P3W-01 and P3W-02. Glacial tills inherently contain cobbles and boulders.

5.1.4 Groundwater Conditions

Water levels were observed in the open boreholes during and upon completion of drilling. One standpipe piezometer was installed in two selected boreholes south of this pond site to monitor water levels after completion of drilling. The water levels measured in the piezometer are summarized in Table 5.1.1, along with the measurements in the open boreholes upon completion of drilling.

Table 5.1.1 – Water Level Measurements

Borehole	Date	Water Level (m)		Comment
		Depth	Elevation	
P3W-01	Aug. 28, 2012	5.8	183.9	Piezometer
	Oct. 16, 2012	5.9	183.8	
	Nov. 22, 2012	5.0	184.7	
	Dec. 19, 2012	4.3	185.4	
	Jan. 2, 2012	5.6	184.1	
P3W-03	Dec. 18, 2012	6.1	181.8	Open borehole Piezometer
	Jan. 2, 2012	3.9	184.0	
P3W-04	Dec. 18, 2012	5.3	184.3	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 rainfall.

5.2 Pond 07E (Boreholes P7E-01 and P7E-02)

In general, the subsurface stratigraphy encountered at this site consisted of a thin layer of topsoil overlying an extensive sand deposit. In Borehole P7E-01, a thin layer of clayey silt till was encountered within the sand at a depth of 2.8 m. More detailed descriptions of the individual strata are presented below.

5.2.1 Topsoil

A layer of topsoil was encountered at surface in both boreholes drilled at this pond location. The topsoil was mixed with sandy silt to sand and contained some roots and rootlets. The thickness of the topsoil ranged from 175 to 300 mm. It should be noted that topsoil thickness may vary between and beyond the borehole locations, and in other areas of the site.

5.2.2 Sand

A sand deposit was encountered below the topsoil in both boreholes. The sand was brown to yellowish brown in colour in Borehole P7E-01 and brown to grey in Borehole P7E-02. The sand contained trace to some silt, trace gravel, and occasional sandy silt layers.

Both boreholes were terminated within the sand deposit at depths of 11.0 m to 11.3 m (Elevation 157.9 and 158.1 m).

SPT N-values recorded in the sand deposit ranged from 10 blows for 0.3 m penetration to 100 blows for 0.15 m penetration, indicating a compact to very dense state. In Borehole P7E-01, 100 blow material was encountered at approximately 6 m depth. In Borehole P7E-02, N-values generally increased from 10 to 49 with depth.

Measured moisture contents ranged from 3 to 19%. In Borehole P7E-01, moisture contents greater than 10% were measured below approximately 4.5 m depth while in Borehole P7E-02 moisture contents greater than 10% were encountered below approximately 9 m depth.

Four samples of the sand 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 B. The grain size distribution curves for these samples are plotted on Figure B1, Appendix B.

Soil Particles	Percentage (%)
Gravel	0
Sand	80 to 90
Silt and Clay	10 to 20

5.2.3 Clayey Silt Till

A thin layer of clayey silt till was encountered within the sand deposit in Borehole P7E-01. This till layer was brown in colour with sand and trace gravel. This layer of till was 0.5 m thick with a lower boundary encountered at a depth of 3.3 m (Elevation 165.6 m).

Moisture contents of 13% were measured in two samples of the clayey silt till.

A sample of this till was selected for laboratory grain size analysis testing. The results of this test are presented on the corresponding Record of Borehole sheet included in Appendix B and are summarized below. The grain size distribution curve for this sample is plotted on Figure B2, Appendix B.

Soil Particles	Percentage (%)
Gravel	2
Sand	48
Silt	27
Clay	23

5.2.4 Groundwater Conditions

Water levels were observed in the open boreholes during and upon completion of drilling. One standpipe piezometer was installed at this pond site to monitor water levels after completion of drilling. The water levels measured in the piezometer are summarized in Table 5.2.1, along with the measurements in the open boreholes upon completion of drilling.

Table 5.2.1 – Water Level Measurements

Borehole	Date	Water Level (m)		Comment
		Depth	Elevation	
P7E-01	Oct. 24, 2012	4.3	164.6	Open borehole
P7E-02	Oct. 25, 2012	10.0	159.4	Piezometer
	Oct. 26, 2012	9.7	159.7	
	Nov. 29, 2012	9.7	159.7	
	Dec. 19, 2012	9.7	159.7	
	Jan. 2, 2012	9.9	159.5	

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 rainfall.

5.3 Pond 07S (Boreholes P7S-01 and P7S-02)

In general, the subsurface stratigraphy at this pond site consisted of a thin layer of topsoil overlying surficial sandy silt to sand and silt till, a silty sand to sand deposit, a lower layer of sand and silt till with sand and silt interlayers. More detailed descriptions of the individual strata are presented below.

5.3.1 Topsoil

A layer of topsoil containing roots and rootlets was encountered surficially in Boreholes P7S-01 and P7S-02. The topsoil was sandy in Borehole P7S-02. The thickness of the topsoil was 200 mm in both boreholes. It should be noted that topsoil thickness may vary between and beyond the borehole locations, and in other areas of the site.

5.3.2 Sandy Silt

A layer of sandy silt was encountered locally in Borehole P7S-02 below the topsoil. The sandy silt was brown and contained trace gravel.

This layer was 1.2 m thick with a lower boundary at a depth of 1.4 m (Elevation 170.4 m).

A SPT N-value of 23 blows for 0.3 m penetration was recorded in the sandy silt, indicating a compact relative density. Measured moisture content of a sample of the sandy silt was 10%.

5.3.3 Upper Sandy Silt to Sand and Silt Till

A layer of till consisting of sandy silt to sand and silt, was encountered directly below the topsoil in Borehole P7S-01 and below the sandy silt layer in Borehole P7S-02. The till was brown and contained trace to some gravel and some clay. A 540 mm thick sand layer was noted within the till layer in Borehole P7S-01.

The thickness of the till ranged from 1.6 to 2.0 m with a lower boundary at depths of 2.2 to 3.0 m (Elevation 170.1 to 168.8 m).

SPT N-values recorded in this upper till ranged from 19 blows for 0.3 m penetration to 50 blows for 0.15 m penetration, indicating a compact to very dense state. Measured moisture contents ranged from 8 to 12%.

One sample of this upper till underwent laboratory grain size analysis testing. The results of this test are presented on the corresponding Record of Borehole sheet in Appendix C and the

grain size distribution curve for this sample is plotted on Figure C1, Appendix C. The grain size analysis results are summarized below.

Soil Particles	Percentage (%)
Gravel	4
Sand	43
Silt	39
Clay	14

Glacial tills inherently contain cobbles and boulders.

5.3.4 Silty Sand to Sand

A deposit of silty sand to sand was encountered below the till in both boreholes. The silty sand to sand was brown in colour becoming grey with increased depth and contained trace clay and trace to some gravel. Thin layers of sandy silt were observed within the deposit.

The thickness of the silty sand to sand deposit ranged from 6.9 m to 10.0 m with a lower boundary at depths of 9.9 m to 12.2 m (Elevations 161.9 to 160.1 m).

SPT N-values recorded in the silty sand to sand ranged from 57 blows for 0.3 m penetration to 50 blows for 0.1 m penetration, indicating a very dense state throughout. Measured moisture contents ranged from 3 to 14%.

Three samples collected from this deposit were selected for 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 C. The grain size distribution curves for these samples are plotted on Figure C2.

Soil Particles	Silty Sand	Sand
Gravel	0	13
Sand	72 to 75	75
Silt	20 to 26	-
Clay	2 to 5	-
Silt and Clay	-	12

5.3.5 Lower Sandy Silt to Silty Sand Till

A lower unit of till was encountered below the silty sand to sand layer in both boreholes. The till ranged from brown sand and silt to grey silty sand and contained trace to some gravel and trace clay.

The thickness of this lower till layer ranged from 3.6 m to 4.9 m with a lower boundary at a depth of 14.8 to 15.8 m (Elevation 157.0 to 156.5 m).

The SPT N-values recorded in the lower till layer were all 50 blows or greater for less than 0.3 m penetration, indicating a very dense state throughout. Measured moisture contents ranged from approximately 8 to 10%.

Two samples of the lower till underwent laboratory grain size analysis testing. The results of these tests are presented on the corresponding Record of Borehole sheets in Appendix C and the grain size distribution curves for these samples are plotted on Figure C1, Appendix C. The grain size analysis results are summarized below.

Soil Particles	Percentage (%)
Gravel (%)	9 to 15
Sand (%)	42 to 58
Silt (%)	28 to 38
Clay (%)	5

Glacial tills inherently contain cobbles and boulders.

5.3.6 Silt to Sandy Silt

A layer of grey silt to sandy silt was encountered below the lower till unit in both boreholes. This layer was 1.5 to 1.8 m thick with a lower boundary at depths of 16.3 to 17.6 m (Elevation 155.5 to 154.7 m).

SPT N-values for this silt layer were recorded at 50 to 70 blows for less than 0.3 m penetration indicating a very dense state. Measured moisture contents ranged from 10 to 18%.

5.3.7 Sand

Below the silt, a sand layer was encountered in both boreholes. The sand was grey and contained trace to some silt.

Neither borehole fully penetrated this sand layer. The boreholes were terminated at depths of 18.6 and 17.1 m, respectively (Elevation 153.7 and 154.7 m) within the sand layer.

Based on SPT N-values of 50 blows for less than 0.3 m penetration, this sand layer is in a very dense state. Measured moisture contents ranged from 19 to 21%.

5.3.8 Groundwater Conditions

Water levels were observed in the open boreholes during and upon completion of drilling. One standpipe piezometer was installed at Pond 07S to monitor water levels after completion of drilling. The water levels measured in the piezometer are summarized in Table 5.3.1, along with the measurements in the open boreholes upon completion of drilling.

Table 5.3.1 – Water Level Measurements

Borehole	Date	Water Level (m)		Comment
		Depth	Elevation	
P7S-01	Aug. 24, 2012	9.8	162.5	Piezometer
	Aug. 28, 2012	9.7	162.6	
	Oct. 16, 2012	9.6	162.7	
	Nov. 27, 2012	9.4	162.9	
	Dec. 19, 2012	9.4	162.9	
P7S-02	Aug. 24, 2012	15.4	156.4	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 the spring snowmelt or after periods of heavy rainfall.

6 MISCELLANEOUS

The borehole locations were selected by MMM and staked in the field by Thurber using a Trimble Pathfinder ProXRT differential GPS prior to drilling. 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 by Mr. Stephane Loranger, C.E.T. and Mr. George Azzopardi 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 Dr. Sydney Pang, P.Eng.

Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations projects, reviewed the report.

THURBER ENGINEERING LTD.

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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 GENERAL

This report presents interpretation of the geotechnical data in the factual report and presents foundation recommendations for the design of the three stormwater management ponds designated as Ponds 03W, 07E and 07S.

The discussions and recommendations presented in this report are based on project information provided by MMM and on the factual data obtained during the course of this investigation.

The general arrangements of the ponds and design information on pond geometry, dimensions, slopes and water levels have been provided by MMM.

Pond 03W will have a longitudinal dimension of approximately 120 m (along main axis) and a transverse dimension of approximately 50 m. Pond 07E will have a longitudinal dimension of approximately 80 m (along main axis) and a transverse dimension of approximately 40 m. Pond 07S will have a longitudinal dimension of approximately 150 m (along main axis) and transverse a dimension of approximately 50 m.

Information from MMM indicates that all three oval shaped ponds are currently designed to have a 5H : 1V inclination for sideslopes of the permanent pool, 4H : 1V inclination above the permanent pool, and 3H : 1V elsewhere. There will be a 5 m wide service road surrounding each of the ponds. It is understood that the ponds are designed to operate as “wet” ponds, i.e. a water level is to be continuously maintained.

8 STORMWATER MANAGEMENT POND DESIGN

8.1 Design Criteria

The major foundation/geotechnical aspects of pond design that are addressed herein include the following.

- The stability of the proposed pond sideslopes.

- Confirmation of stability of the pond sideslopes under the unlikely scenario of “rapid drawdown”.
- Water retention capabilities based on estimated hydraulic conductivities of the soils at the base and sides of a pond.
- Potential impact on the stability of highway embankments and creek valleys.

8.2 Stability Analysis Methodology

For the purpose of slope stability analyses, the commercially available limit equilibrium slope stability program GSLOPE developed by Mitre Software Inc. was used.

For global stability and site specific conditions, the criteria of minimum Factors of Safety (F.S.) of 1.5 for the “drained” (long term) case and 1.3 for the “rapid drawdown” case have been used in this report.

9 SLOPE STABILITY ANALYSIS

9.1 General

The proposed ponds are to be located in the interchange area within flat terrain. The pond crests will be located at distances, from the proposed highway alignments, ranging between about 40 m at Pond 07E and 80 m at Pond 03W. Available design information for the ponds is presented in Table 9.1 below.

Table 9.1 Pond Design Information

Pond I.D.	Pond Bottom Elev. (m)	Top of Pond Elev. (m)	Depth of Pond (m)	Permanent Pool Water Elev. (m)	100-yr. Water Elev. (m)	Ground -water Elev. (m)	Other features
03W	184.50	188.10	3.6	186.50	187.60	184.1	5 m wide service road and forebay berm
07E	164.00	167.40	3.4	166.00	166.90	159.5	
07S	166.00	169.70	3.7	168.00	169.20	162.9	

Within the footprints of the ponds, the borehole results indicate that the subsurface condition consists of predominantly dense to very dense sands and silts including cohesionless glacial tills. At each pond, the groundwater level is generally lower than the pond base elevation.

9.2 Selected Cases for Stability Analysis

Given the predominant presence of relatively permeable sands and silts at all three sites, only the drained condition has been analysed as appropriate.

9.2.1 Existing Creek Valleys and Proposed Embankments

In view of separation distances between 40 and 80 m, it is considered that the existence of the ponds will not have any adverse impact on the stability of the proposed highway embankments and existing creek valleys from a geotechnical standpoint.

9.2.2 Pond Sideslopes

Pond sideslopes of 5H : 1V to 4H : 1V will be stable against global stability under normal pond operating conditions. The F.S.'s are greater than 2.0 for all three ponds.

The pond sideslopes are to be formed within typically cohesionless sands and silts including tills. However, there is substantial amount of clay particles (up to 15%) that will impede water flow in the short term. Accordingly, in the event of rapid drawdown where the water level in the pond drops abruptly (in a matter of hours) from a high elevation, say 100-year level, temporarily saturated sideslopes will be developed. Stability of the sideslopes under rapid drawdown has been analysed (see Table 9.2).

9.3 Stability Analysis Results

The F.S.'s obtained from stability analysis of selected cases of rapid drawdown and saturated ground are summarized in Table 9.2 below.

Table 9.2 Stability Analysis Results

Location	Type of Analysis	Factor of Safety
Pond 03W		
Pond Slope (5H : 1V to 4H : 1V)	Rapid Drawdown	1.56
Pond 07E		
Pond Slope (5H : 1V to 4H : 1V)	Rapid Drawdown	1.74
Pond 07S		
Pond Slope (5H : 1V to 4H : 1V)	Rapid Drawdown	1.54

Figures D1 to D3 in Appendix D present graphically stability analysis results of the above cases. The soil properties assumed in the analyses are shown on these figures.

All rapid drawdown cases analysed satisfy the $F.S. \geq 1.3$ criterion used for short term conditions in this report. Results of these analyses indicate that global stability of the pond sideslopes can be maintained under these extreme conditions.

10 POND DESIGN AND CONSTRUCTION

From a geotechnical engineering perspective, the stormwater management ponds as currently designed by MMM should be stable and have no adverse impact on the stability conditions of the nearby creek valley slopes and the proposed Highway 407 embankments. Hydrogeologic considerations should be addressed by specialists in this field.

10.1 Excavation and Groundwater Control

Pond construction will require excavating up to 5.5 m of dense to very dense sand and silt till at Pond 03W, up to 5 m of compact to dense sand at Pond 07E, and up to 6.5 m of dense glacial tills overlying very dense silty sand to sand at Pond 07S. Groundwater control in the form of pumping from filtered sumps will be required during construction. Glacially derived soils inherently contain cobbles and boulders (inferred by high 'N' values at some borehole locations) and, as such, the contractor should be equipped to handle and/or remove such obstructions.

Excavation, grading and compaction must be carried out with reference to the requirements of OPSS 206, OPSS 401 and OPSS 501.

10.2 Water Retention

Existing borehole information indicates that typically cohesionless, dense to very dense sands and silts will be exposed across the sideslopes and at the base of the ponds. These soils have relatively high hydraulic conductivities, especially the uniformly graded sand encountered at Ponds 07E and 07S, and the sand and gravel encountered elsewhere. Such properties will have adverse impact on the water retention capabilities of the ponds. For design purposes, the following hydraulic conductivities may be assumed:

- Sand and Gravel ($> 10^{-4}$ m/s)
- Sand (10^{-4} to 10^{-5} m/s)
- Sands and silts (10^{-5} to 10^{-7} m/s)

It is understood that all three ponds are designed to operate as wet ponds. A head of water will need to be maintained in the pond at all times. Given the presence of the permeable sands and silts at the pond bases and on the sideslopes, it is recommended that the following be considered:

- Place a compacted clay liner on the entire base and sideslope areas inside each pond. A typical clay liner should be approximately 0.6 m in thickness. Clayey soils will have to be imported from off site to be used as the clay liner.
- Alternatively, geosynthetic clay liners may be considered for use.

For a natural clay liner, OPSS 1205 should be referenced for material selection. In particular, the following minimum physical properties should be satisfied.

Parameter	Minimum Value
Liquid Limit	> 40%
Plasticity Index	> 15%
Clay Content	> 25%

10.3 Other Pond Features

At the time of preparation of this report, no information is available for other typical stormwater management pond features such as weir structures, drainage pipes and ditches.

10.4 Erosion Protection

Erosion protection must be provided for selected surfaces of the pond sideslopes and drainage channels as required. Design of the erosion protection measures must consider hydrologic and hydraulic concerns. Typically, rip-rap should be provided in areas of high velocity or concentrated water flow. Other surfaces may be treated with vegetation, hydroseeding and/or erosion control blanket as required. Reference should be made to OPSS 804 for erosion protection requirements. Detailed design of these aspects of the ponds should be carried out by professionals experienced in such designs.

11 CONSTRUCTION CONCERNS

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

- The pond base and sideslopes should be inspected periodically, or as required, during construction to confirm stability. The subgrade material should remain undisturbed prior to installation of the compacted clay liner.
- Groundwater control likely in the form of sump pumping and gravity drainage are essential for maintaining reasonably dry excavations during construction. Surface runoff should be diverted away from the excavations at all times.

12 CLOSURE

Engineering analysis and preparation of this foundation design report was carried out by Dr. Sydney Pang, P.Eng. The report was reviewed by Mr. Alastair Gorman, P.Eng. and Dr. P.K. Chatterji, P.Eng.

THURBER ENGINEERING LTD.



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Principal, Designated MTO Contact

Appendix A
Pond 03W
Record of Borehole Sheets
Geotechnical Laboratory Test
Boreholes Locations and Soil Strata Drawings

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

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


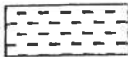



 Water Level
 Shear Strength Determination by Pocket Penetrometer

- (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
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

EXPLANATION OF ROCK LOGGING TERMS

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

DISCONTINUITY SPACING		STRENGTH CLASSIFICATION			
Bedding	Bedding Plane Spacing	Rock Strength	Approximate Uniaxial Compressive Strength		Field Estimation of Hardness*
			(MPa)	(psi)	
Very thickly bedded	Greater than 2m	Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Thickly bedded	0.6 to 2m				
Medium bedded	0.2 to 0.6m	Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Thinly bedded	60mm to 0.2m				
Very thinly bedded	20 to 60mm	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Laminated	6 to 20mm				
Thinly Laminated	Less than 6mm	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

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.

METRIC

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		WATER CONTENT (%)				
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE	w _p	w	w _L		
189.7 0.0 0.2	TOPSOIL, with roots and rootlets: (200mm)													
189.0 0.7	Sandy SILT, some clay, trace gravel, topsoil stained Dark Brown Moist		1	SS	46									
	SAND and SILT, trace to some clay, trace gravel, occasional cobbles Dense to Very Dense Brown Moist (TILL)		2	SS	34									3 45 42 10
	Occasional black shale fragments		3	SS	65									
	Grey		4	SS	75/ 0.250									
	Inferred boulder (325mm) at 3.4m													
			5	SS	50/ 0.125									9 53 32 6
			6	SS	100/ 0.100									
	Inferred boulder (300mm) at 6.6m													
			7	SS	50/ 0.075									
180.9 8.8	SAND and GRAVEL, trace silt and clay Very Dense Grey Wet		8	SS	55/ 0.125									52 44 4 (SI+CL)

+ 3, \times 3: Numbers refer to Sensitivity

RECORD OF BOREHOLE No P3W-01

2 OF 2

METRIC

WP# E2-2012 LOCATION N 4 863 821.5 E 336 790.0 ORIGINATED BY SLL
 HWY 407 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2012.08.17 - 2012.08.17 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			20	40	60	80	100		
	Continued From Previous Page							SHEAR STRENGTH kPa						
								○ UNCONFINED + FIELD VANE						
								● QUICK TRIAXIAL × LAB VANE						
								20	40	60	80	100		
								WATER CONTENT (%)						
								20	40	60				
								PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT				
								W _P	W	W _L				
177.8	SAND and GRAVEL, trace silt and clay Very Dense Grey Wet		9	SS	100/ 0.125		179							
11.9	SAND, fine grained, some silt Very Dense Grey Wet		10	SS	50/ 0.125		178							
177.2														
12.5	END OF BOREHOLE AT 12.5m. MONITORING WELL INSTALLATION CONSISTS OF 50mm DIAMETER SCHEDULE 40 PVC PIPE WITH A 1.52m SLOTTED SCREEN.													
	WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Aug. 28/12 5.8 183.9 Oct. 16/12 5.9 183.8 Nov. 22/12 5.0 184.7 Dec. 19/12 4.3 185.4 Jan. 02/13 5.6 184.1													

RECORD OF BOREHOLE No P3W-02

1 OF 2

METRIC

WP# E2-2012 LOCATION N 4 863 789.7 E 336 838.6 ORIGINATED BY SLL
HWY 407 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2012.08.20 - 2012.08.20 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			20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	
188.9 0.0 188.6 0.3	TOPSOIL, with roots and rootlets: (250mm) Sandy SILT, trace gravel, trace clay Compact to Dense Brown Moist		1	SS	21		188					
186.9 2.0	SAND and SILT, some clay, trace gravel, occasional cobbles Very Dense Brown Moist (TILL)		2	SS	36		187					
			3	SS	51		186					
			4	SS	52		185					4 38 46 12
	Grey		5	SS	78		184					
	Inferred boulder (325mm) at 5.6m						183					
	Becoming wet		6	SS	100/ 0.250		182					
	Clayey zone		7	SS	74		181					
	Some wet sand seams		8	SS	50/ 0.125		180					1 50 39 10
							179					

Continued Next Page

+ 3 x 3 Numbers refer to
Sensitivity 20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No P3W-02

2 OF 2

METRIC

WP# E2-2012 LOCATION N 4 863 789.7 E 336 838.6 ORIGINATED BY SLL
HWY 407 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2012.08.20 - 2012.08.20 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						
	Continued From Previous Page							20 40 60 80 100	20 40 60					
178.1			9	SS	50/									
10.8	END OF BOREHOLE AT 10.8m. BOREHOLE OPEN AND WATER LEVEL AT 7.7m ON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH BENTONITE HOELPLUG TO 1.4m, THEN CUTTINGS TO SURFACE.				0.100									

RECORD OF BOREHOLE No P3W-03

1 OF 2

METRIC

WP# E2-2012 LOCATION N 4 863 861.1 E 336 809.1 ORIGINATED BY GA
 HWY 407 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2012.12.18 - 2012.12.18 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			20 40 60 80 100	PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT		
187.9													
0.0	TOPSOIL: (200mm)												
0.2	Sandy SILT, trace clay Loose Brown Moist		1	SS	9								
187.0													
0.9	SAND and SILT, trace to some clay, trace gravel Compact to Dense Brown Moist (TILL)		2	SS	20		187						
			3	SS	35		186						5 48 37 10
			4	SS	53		185						
	Very Dense		5	SS	65		184						
			6	SS	50/ 0.150		183						
			7	SS	50/ 0.150		182						
	Wet		8	SS	50/ 0.150		181						
			9	SS	73		180						6 55 34 5
	Silty sand layer at 7.6m						179						
178.1													
9.8	END OF BOREHOLE AT 9.8m.												

Continued Next Page

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

RECORD OF BOREHOLE No P3W-03

2 OF 2

METRIC

WP# E2-2012 LOCATION N 4 863 861.1 E 336 809.1 ORIGINATED BY GA
 HWY 407 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2012.12.18 - 2012.12.18 CHECKED BY LRB

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			20 40 60 80 100	20 40 60 80 100	W _p W W _L				
	Continued From Previous Page BOREHOLE OPEN TO 9.1m AND WATER LEVEL AT 6.1m UPON COMPLETION. Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Jan. 02/13 3.9 184.0													

RECORD OF BOREHOLE No P3W-04

1 OF 2

METRIC

WP# E2-2012 LOCATION N 4 863 836.6 E 336 727.5 ORIGINATED BY GA
 HWY 407 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2012.12.18 - 2012.12.18 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			20	40	60	80	100		
189.6														
0.0	TOPSOIL: (200mm)													
0.2	SAND and SILT, some clay, trace gravel Loose to Compact Brown Moist (TILL)		1	SS	6		189							1 42 42 15
			2	SS	10									
			3	SS	42		188							
	Dense to Very Dense		4	SS	32		187							
			5	SS	28		186							
			6	SS	83		185							2 45 43 10
	Wel						184							
			7	SS	50/ 0.150		183							
			8	SS	100/ 0.150		182							
	Grey						181							
			9	SS	106/ 0.150									
180.3														
9.3	END OF BOREHOLE AT 9.3m. BOREHOLE OPEN TO 9.1m AND WATER LEVEL AT 5.3m UPON COMPLETION. BOREHOLE BACKFILLED WITH													

Continued Next Page

+³ ×³: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No P3W-04

2 OF 2

METRIC

WP# E2-2012 LOCATION N 4 863 836.6 E 336 727.5 ORIGINATED BY GA
HWY 407 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2012.12.18 - 2012.12.18 CHECKED BY LRB

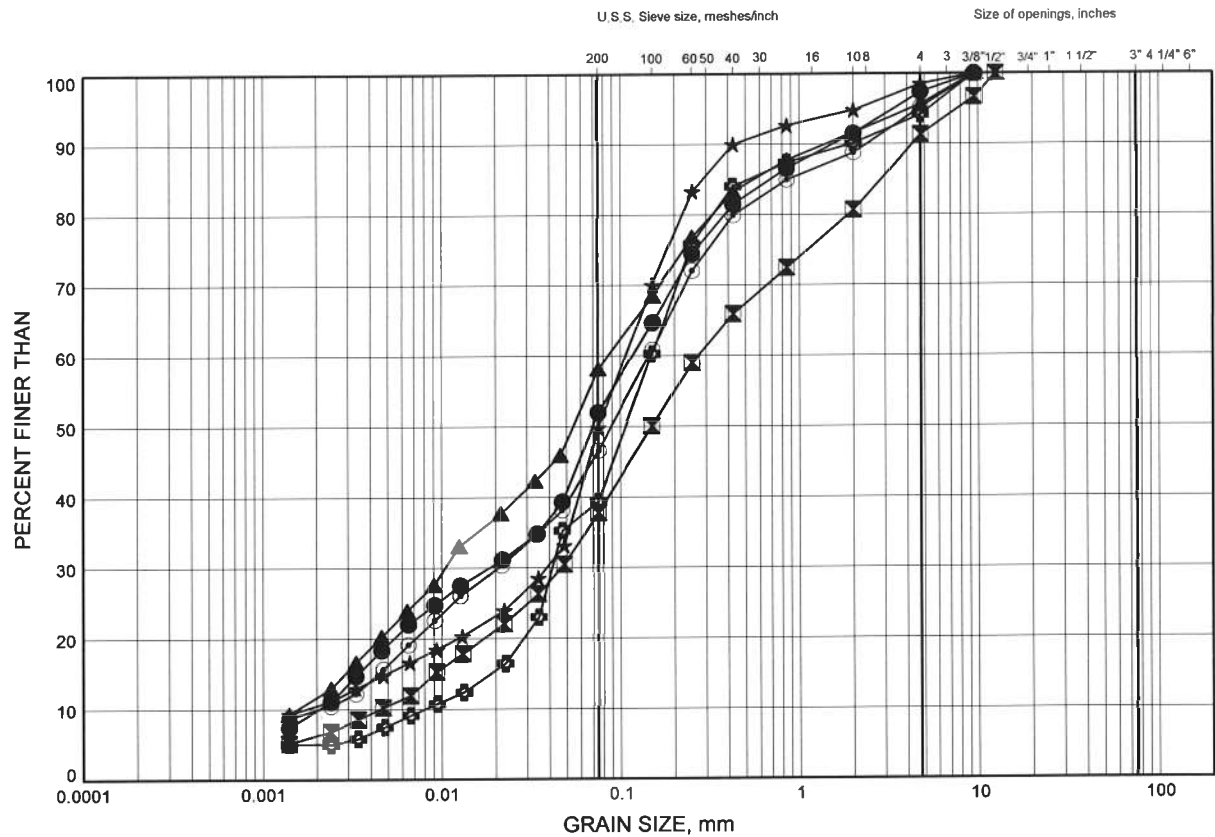
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
	Continued From Previous Page BENTONITE HOLEPLUG TO SURFACE.																

Hwy 407 Brock Road Connection - Foundations

GRAIN SIZE DISTRIBUTION

FIGURE A1

SAND & SILT TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	P3W-01	1.83	187.87
⊠	P3W-01	4.70	185.00
▲	P3W-02	3.35	185.55
★	P3W-02	9.28	179.62
⊙	P3W-03	1.83	186.07
⊕	P3W-03	7.92	179.98

GRAIN SIZE DISTRIBUTION - THURBER 1130A.GPJ 1/2/13

Date January 2013
WP# E2-2012



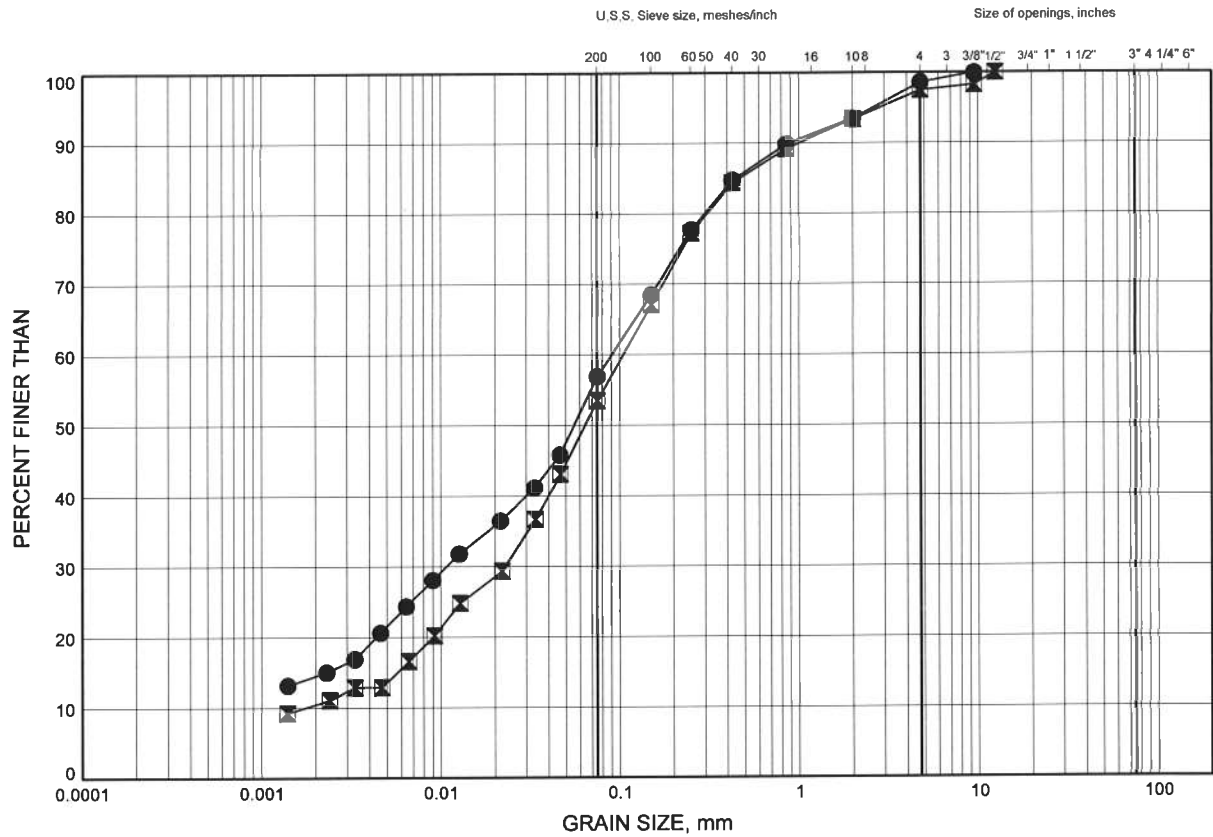
Prep'd AN
Chkd. LRB

Hwy 407 Brock Road Connection - Foundations

GRAIN SIZE DISTRIBUTION

FIGURE A2

SAND & SILT TILL

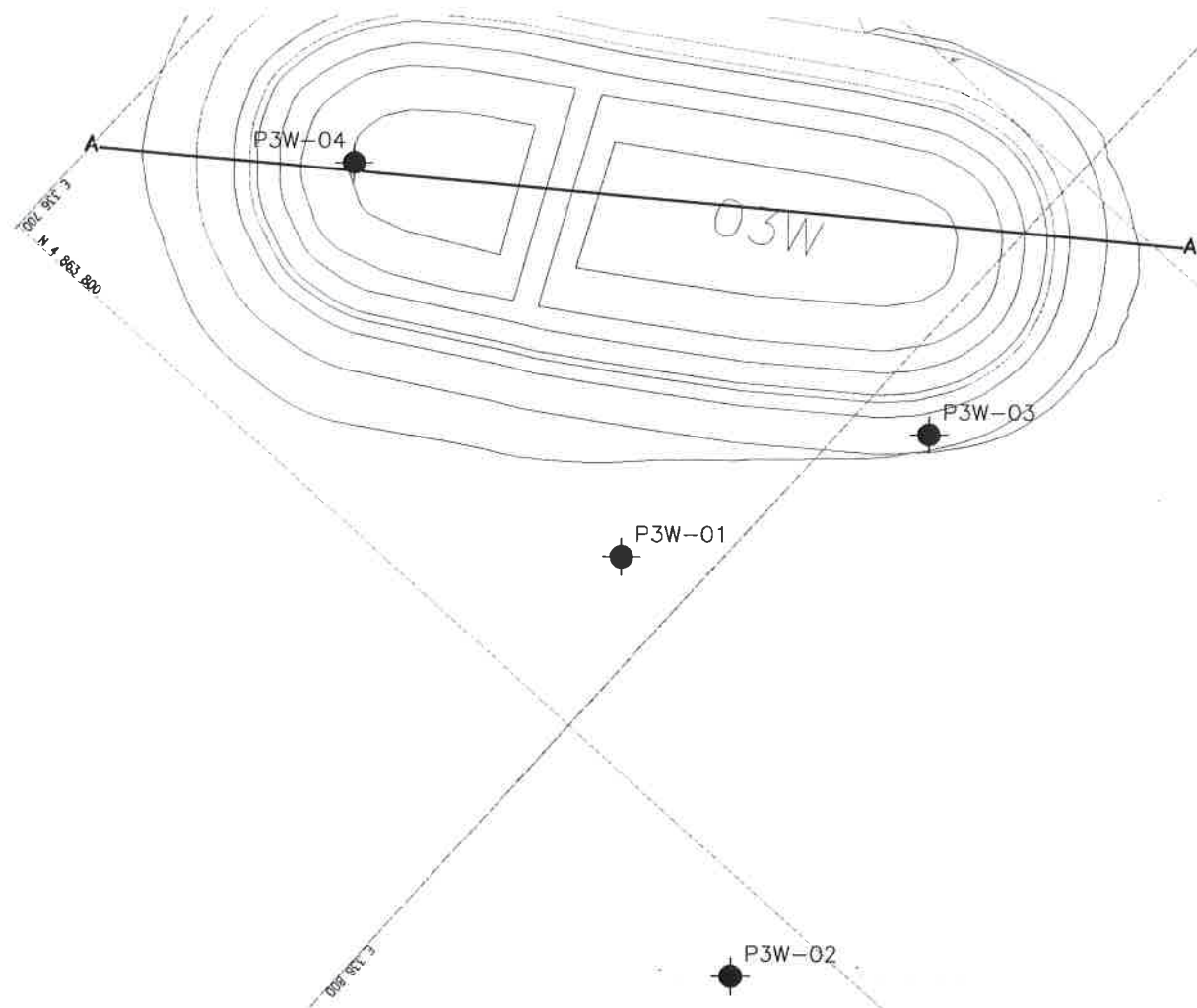


SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

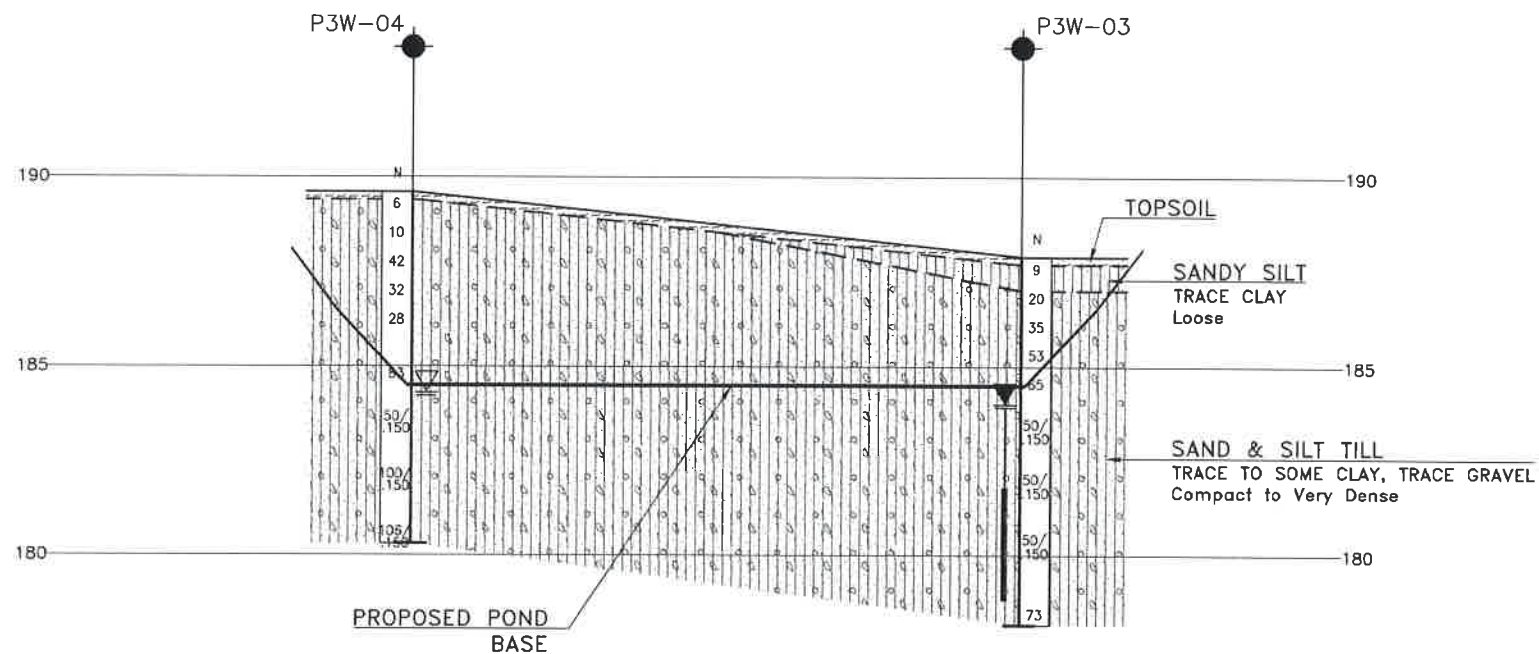
LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	P3W-04	1.07	188.53
×	P3W-04	4.88	184.72

DRAWING NAME: H:\Drafting\19\5161\130\led130-HW407-BrockRoad-Plan.dwg
CREATED: November 21, 2012
MODIFIED: January 25, 2013



PLAN
SCALE 1:1000



PROFILE ALONG A-A

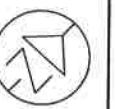
SCALE 1:1000
SCALE 1:200

NO.	DATE	REVISIONS	BY	CHK	LEAD	PROJ

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

BROUGHAM CREEK

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



STORMWATER MANAGEMENT PONDS
POND 03W
BOREHOLE LOCATIONS AND SOIL STRATA

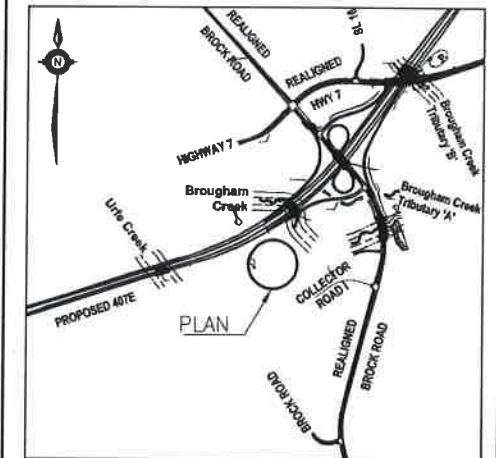
SHEET

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
P3W-01	189.7	4 863 821.5	336 790.0
P3W-02	188.9	4 863 789.7	336 838.6
P3W-03	187.9	4 863 861.1	336 809.1
P3W-04	189.6	4 863 836.6	336 727.5

-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	LRB	CHK	LRB	CODE	LOAD	DATE	JAN. 2013
DRAWN	AN	CHK	SKP	SITE	STRUCT	DWG	1

Appendix B
Pond 07E
Record of Borehole Sheets
Geotechnical Laboratory Test
Boreholes Locations and Soil Strata Drawings

RECORD OF BOREHOLE No P7E-01

1 OF 2

METRIC

WP# E2-2012 LOCATION N 4 864 868.4 E 337 598.5 ORIGINATED BY SLL
HWY 407 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2012.10.24 - 2012.10.24 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	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	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES								
168.9													
0.0	TOPSOIL, some sand: (175mm)												
0.2	SAND, some silt Dense Brown Moist		1	SS	39		168						0 80 20 (SI+CL)
			2	SS	45		167						
			3	SS	42								
166.1													
2.8	Clayey SILT, with sand, trace gravel Hard Brown Moist (TILL)		4	SS	36		166						2 48 27 23
165.6													
3.3	SAND, some silt Dense to Very Dense Brown Moist						165						
	Sandy silt layers (75mm) at 4.8m Yellowish Brown		5	SS	40		164						
							163						
	Grey Wet		6	SS	100								0 83 17 (SI+CL)
							162						
			7	SS	100/ 0.175		161						
							160						
			8	SS	100								
							159						

Continued Next Page

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

RECORD OF BOREHOLE No P7E-01

2 OF 2

METRIC

WP# E2-2012 LOCATION N 4 864 868.4 E 337 598.5 ORIGINATED BY SLL
HWY 407 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2012.10.24 - 2012.10.24 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									
	Continued From Previous Page																
157.9	SAND, some silt Very Dense Grey Wet		9	SS	100/ 0.150												
11.0	END OF BOREHOLE AT 11.0m. BOREHOLE CAVED TO 4.5m AND WATER LEVEL AT 4.3m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 1.0m, THEN CUTTINGS TO SURFACE.																

METRIC

[illegible]

+ 3, x 3: Numbers refer to Sensitivity

RECORD OF BOREHOLE No P7E-02

2 OF 2

METRIC

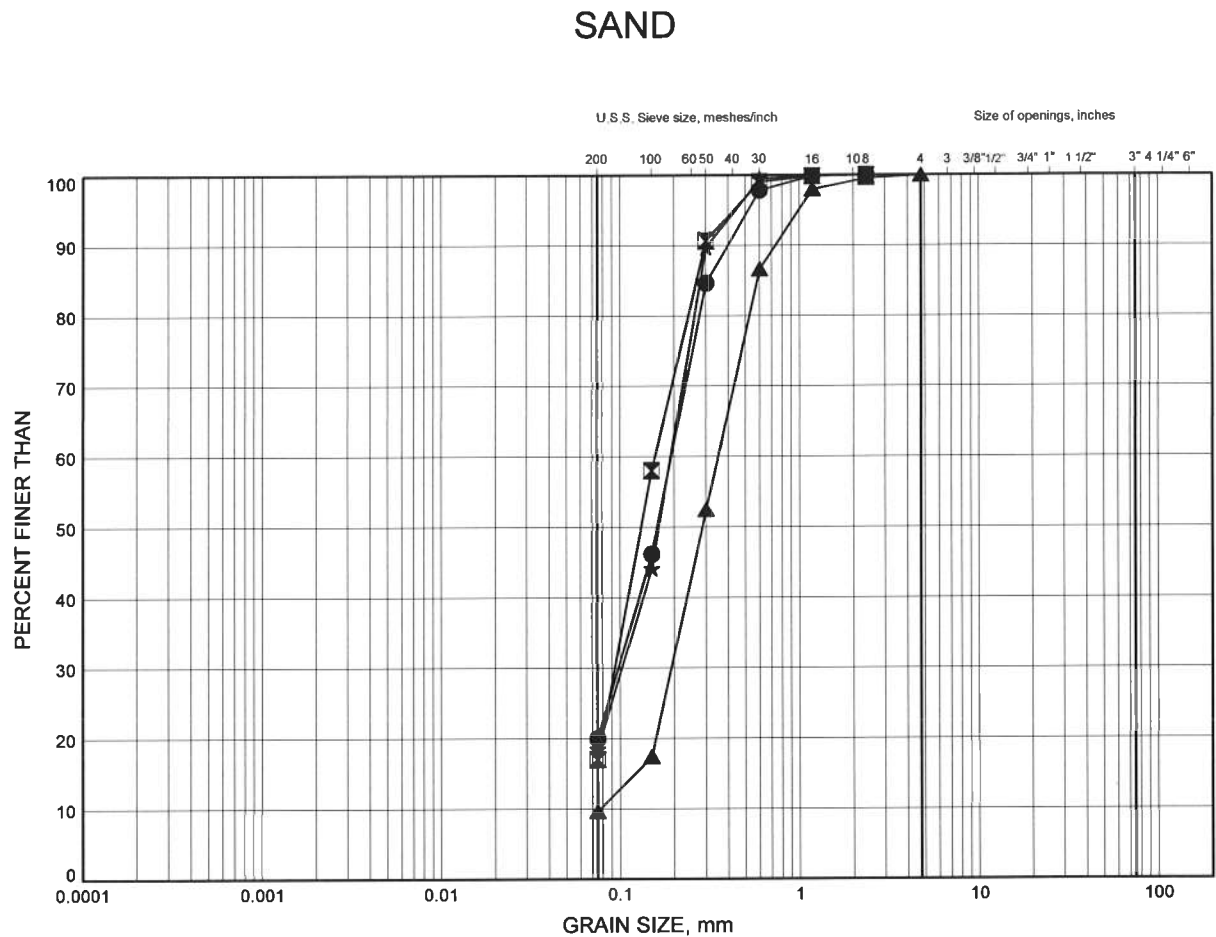
WP# E2-2012 LOCATION N 4 864 890.0 E 337 649.1 ORIGINATED BY SLL
 HWY 407 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2012.10.25 - 2012.10.25 CHECKED BY LRB

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			20	40	60	80	100		
	Continued From Previous Page						SHEAR STRENGTH kPa						
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						
							20	40	60	80	100		
							WATER CONTENT (%)						
							20	40	60				
158.1	SAND, some silt Dense Grey Well		9	SS	47	159							
11.3	END OF BOREHOLE AT 11.3m. Monitoring well installation consists of 50mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Oct. 25/12 10.0 159.4 Oct. 26/12 9.7 159.7 Nov. 29/12 9.7 159.7 Dec. 19/12 9.7 159.7 Jan. 02/13 9.9 159.5												

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)
●	P7E-01	1.07	167.83
⊠	P7E-01	6.32	162.58
▲	P7E-02	2.59	166.81
★	P7E-02	9.45	159.95

Date January 2013
 WP# E2-2012

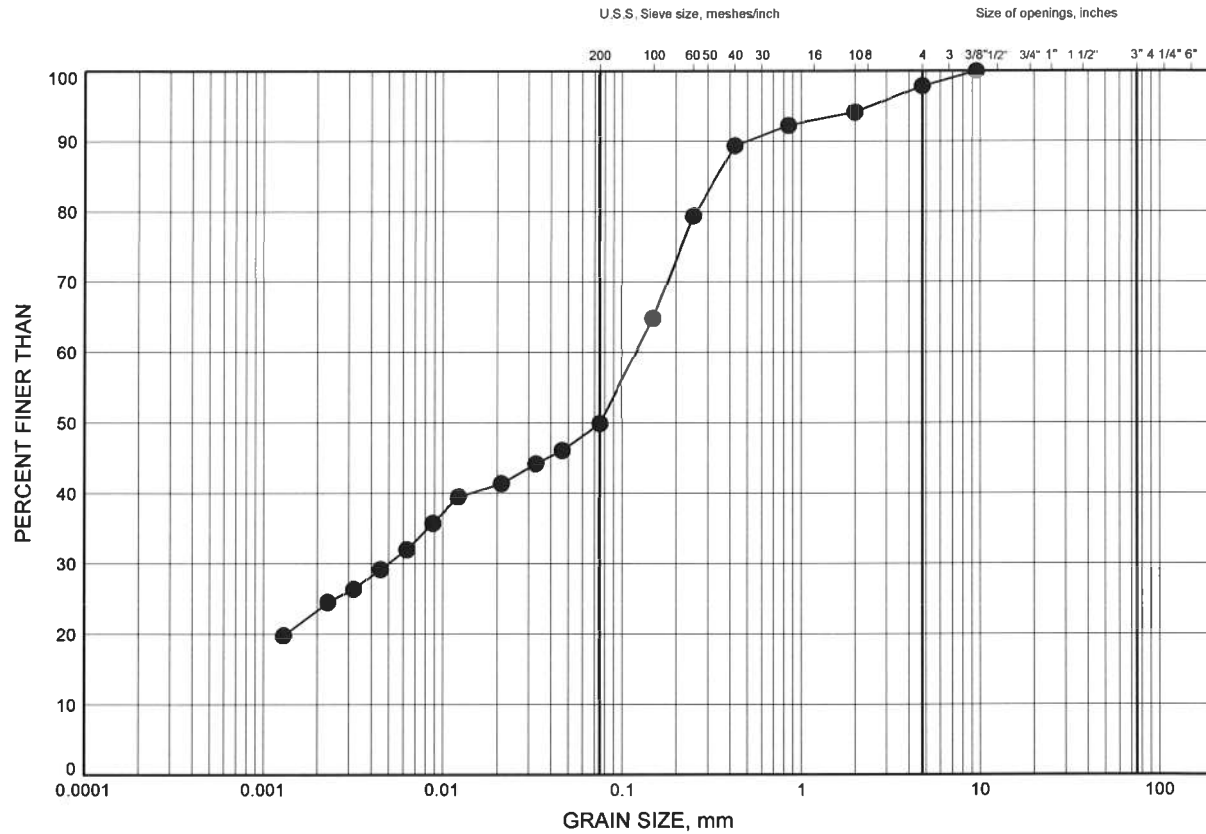


Prep'd AN
 Chkd. LRB

HWY 407 Brock Road Connection - Foundations GRAIN SIZE DISTRIBUTION

FIGURE B2

CLAYEY SILT TILL



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

LEGEND

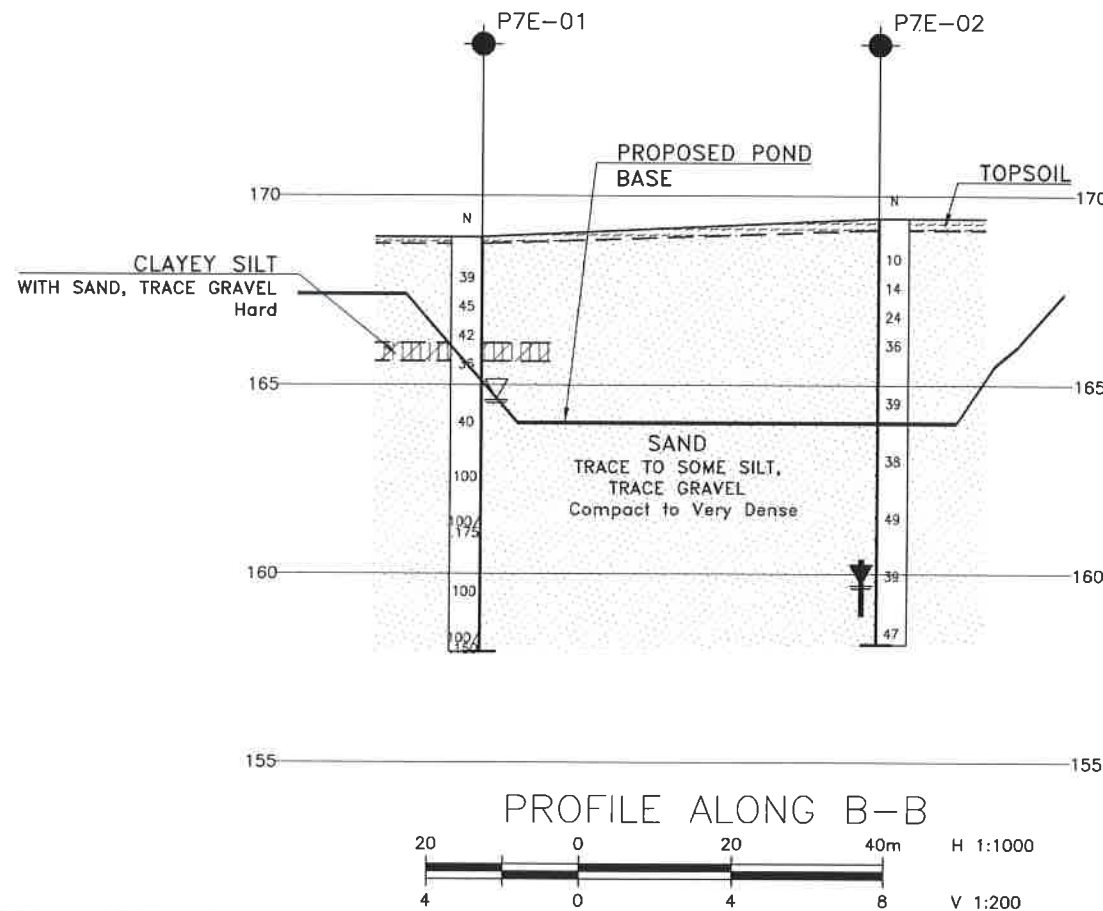
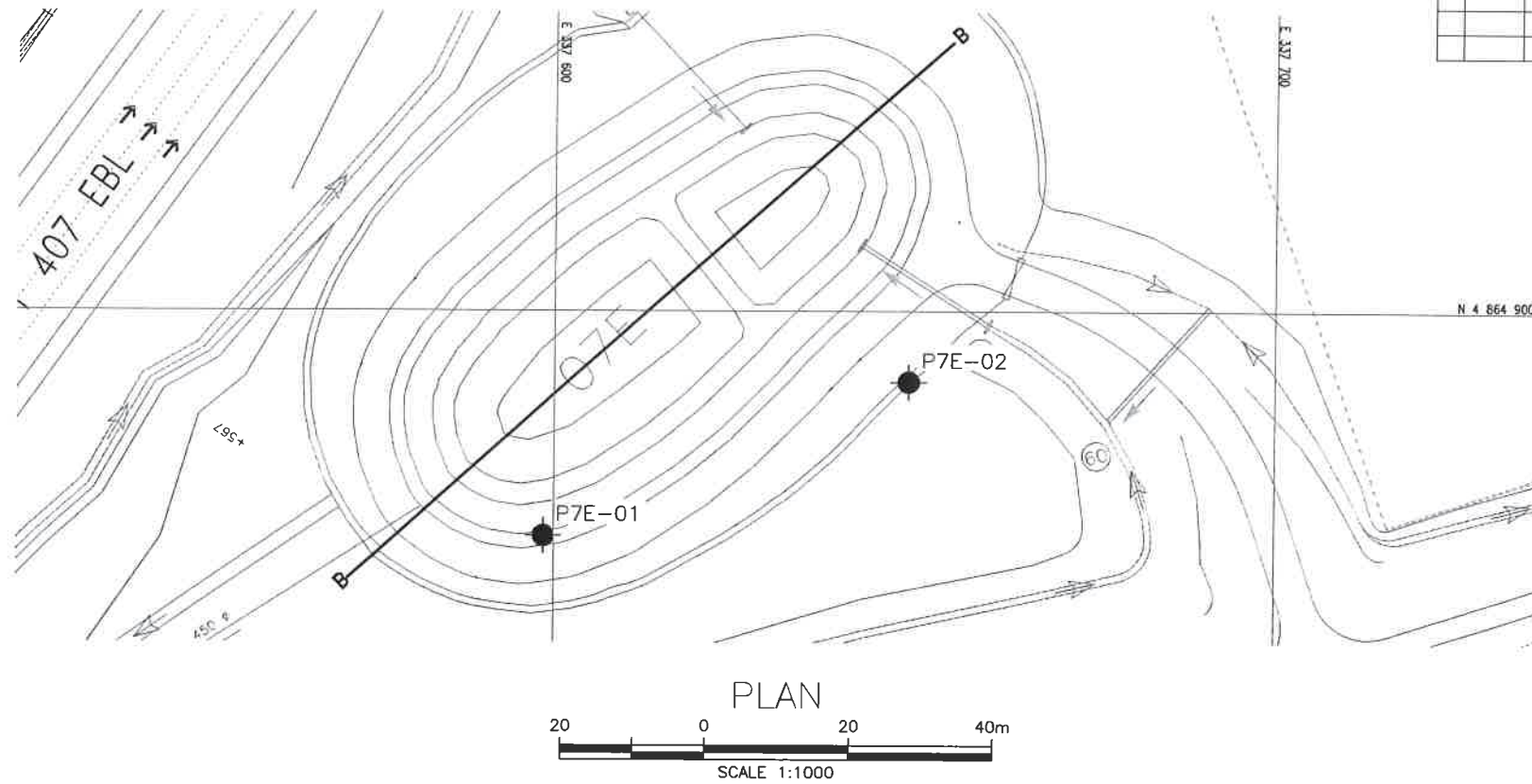
SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	P7E-01	3.16	165.74

Date January 2013
 WP# E2-2012



Prep'd AN
 Chkd. LRB

DRAWING NAME: H:\Drafting\19\516\130\130-Hwy407-BrockRoad-Plan.dwg
CREATED: November 21, 2012
MODIFIED: January 25, 2013



NO.	DATE	REVISIONS	BY	CHK	LEAD	PROJ.

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

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



SHEET

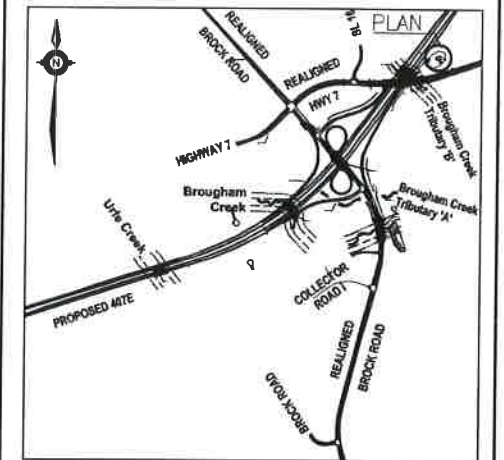
STORMWATER MANAGEMENT PONDS
POND 07E
BOREHOLE LOCATIONS AND SOIL STRATA

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
P7E-01	168.9	4 864 868.4	337 598.5
P7E-02	169.4	4 864 890.0	337 649.1

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	LRB	CHK	LRB	CODE	LOAD	DATE	JAN. 2013
DRAWN	AN	CHK	SKP	SITE	STRUCT	DWG	2

Appendix C
Pond 07S
Record of Borehole Sheets
Geotechnical Laboratory Test
Boreholes Locations and Soil Strata Drawings

RECORD OF BOREHOLE No P7S-01

1 OF 3

METRIC

WP# E2-2012 LOCATION N 4 864 347.6 E 337 347.4 ORIGINATED BY SLL
 HWY 407 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2012.08.23 - 2012.08.23 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			20 40 60 80 100	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	
172.3												
0.0	TOPSOIL, with roots and rootlets: (200mm)						172					
0.2	Sandy SILT, some clay, trace gravel Dense Brown Moist (TILL)		1	SS	45		171					
	Sand layer (540mm)		2	SS	39		170					
170.1							170					
2.2	Silty SAND, trace clay, occasional sand seams Very Dense Brown Moist		3	SS	76		169					0 75 20 5
	Occasional black shale fragments		4	SS	77		168					
	Grey		5	SS	85/ 0.275		167					
			6	SS	84/ 0.275		166					
			7	SS	76		165					
	Trace gravel		8	SS	50/ 0.100		164					0 72 26 2
162.7							163					
9.6	SAND, coarse grained, some gravel Very Dense											

Continued Next Page

+³ ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

CONTMT4S 1130A.GPJ 1/8/13

RECORD OF BOREHOLE No P7S-01

3 OF 3

METRIC

WP# E2-2012 LOCATION N 4 864 347.6 E 337 347.4 ORIGINATED BY SLL
 HWY 407 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2012.08.23 - 2012.08.23 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			20	40	60	80	100		
	Continued From Previous Page													
	Aug. 28/12 9.7 162.6													
	Oct. 16/12 9.6 162.7													
	Nov. 27/12 9.4 162.9													
	Dec. 19/12 9.4 162.9													

RECORD OF BOREHOLE No P7S-02

1 OF 2

METRIC

WP# E2-2012 LOCATION N 4 864 477.4 E 337 342.6 ORIGINATED BY SLL
HWY 407 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2012.08.24 - 2012.08.24 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			20 40 60 80 100	PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	
171.8 0.0	TOPSOIL, sandy, with rootlets: (200mm)											
0.2	Sandy SILT, trace gravel Compact Brown Moist		1	SS	23		171					
170.4												
1.4	SAND and SILT, some clay, trace to some gravel Compact to Very Dense Brown Moist (TILL)		2	SS	19		170					4 43 39 14
			3	SS	50/ 0.150							
168.8							169					
3.0	SAND, trace to some silt, trace to some gravel Very Dense Brown Moist		4	SS	82/ 0.275		168					
	Grey		5	SS	50/ 0.150		167					
							166					
	Becoming wet		6	SS	63		165					13 75 12 (SI+CL)
			7	SS	50/ 0.150		164					
							163					
	With sandy silt layers		8	SS	57							
161.9							162					

Continued Next Page

+ 3, x 3: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No P7S-02

2 OF 2

METRIC

WP# E2-2012 LOCATION N 4 864 477.4 E 337 342.6 ORIGINATED BY SLL
 HWY 407 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2012.08.24 - 2012.08.24 CHECKED BY LRB

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			WATER CONTENT (%)				
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE						
	Continued From Previous Page							20 40 60 80 100				w _p w w _L			
9.9	Silty SAND , trace clay, trace gravel Very Dense Grey Moist (TILL)		9	SS	50/ 0.125		161								9 58 28 5
							160								
			10	SS	50/ 0.100										
							159								
			11	SS	50/ 0.125		158								
157.0															
14.8	SILT , with sandy silt layers Very Dense Grey Moist		12	SS	50/ 0.125	▽	157								
							156								
155.5															
16.3	SAND , some silt Very Dense Grey Wet		13	SS	50/ 0.150		155								
154.7															
17.1	END OF BOREHOLE AT 17.1m. BOREHOLE OPEN AND WATER LEVEL AT 15.4m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 1.9m, THEN CUTTINGS TO SURFACE.														

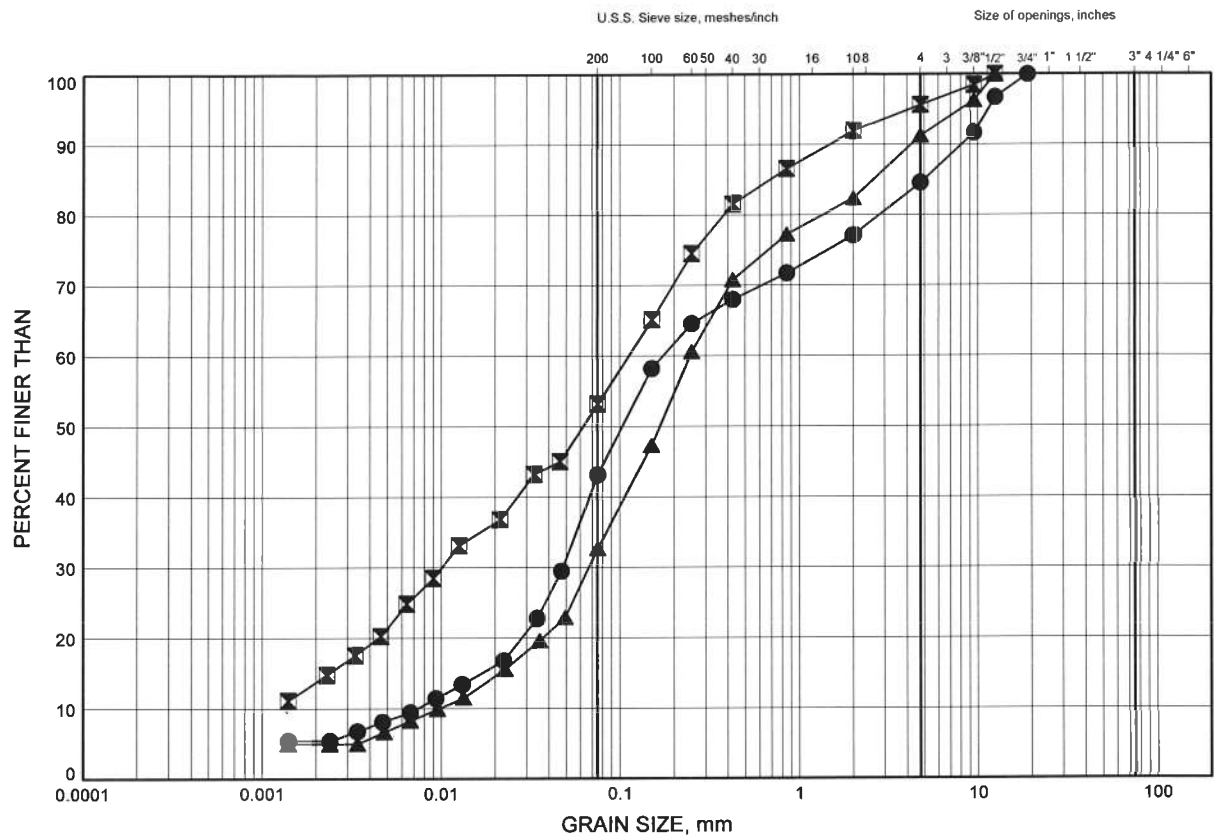
ONTMT4S 1130A GPJ 1/8/13

Hwy 407 Brock Road Connection - Foundations

GRAIN SIZE DISTRIBUTION

FIGURE C1

SAND & SILT TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	P7S-01	15.44	156.86
■	P7S-02	1.83	169.97
▲	P7S-02	10.81	160.99

Date January 2013
 WP# E2-2012



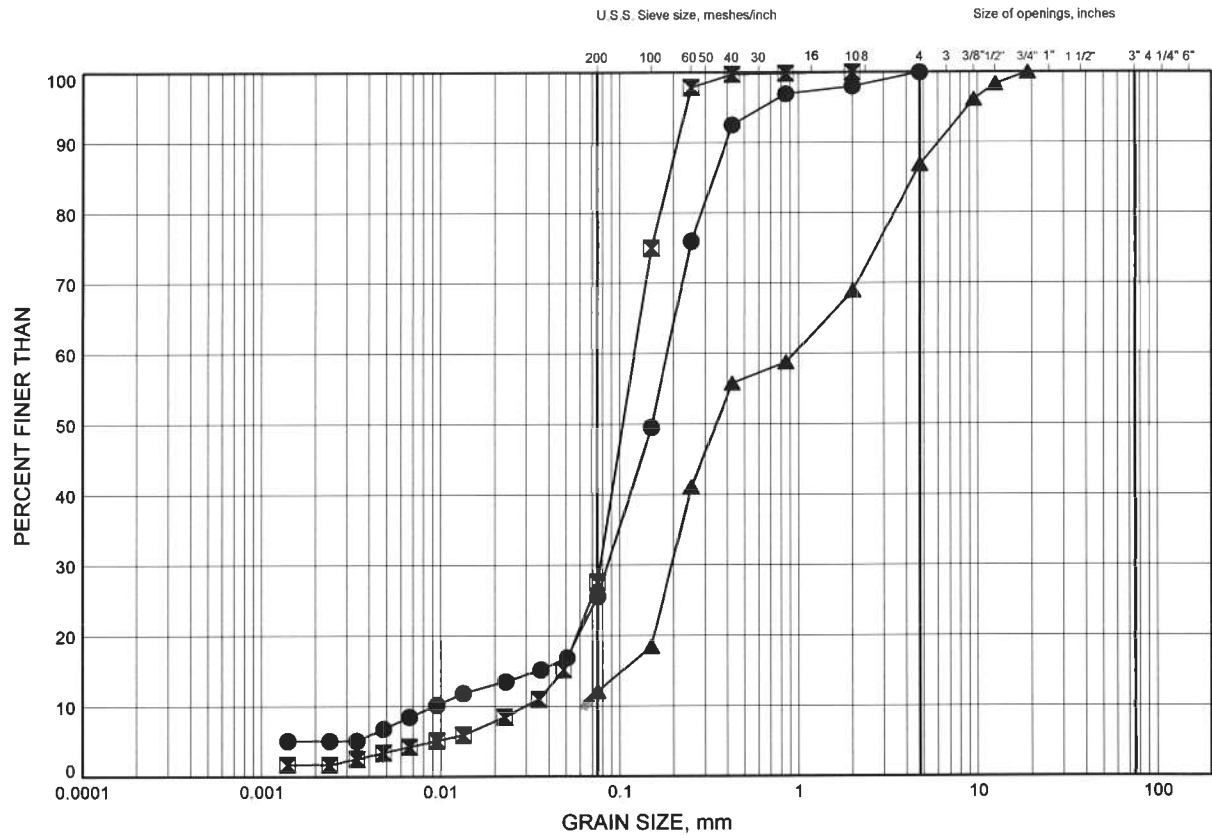
Prep'd AN
 Chkd. LRB

Hwy 407 Brock Road Connection - Foundations

GRAIN SIZE DISTRIBUTION

FIGURE C2

SILTY SAND to SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	P7S-01	2.58	169.72
⊠	P7S-01	7.92	164.38
▲	P7S-02	6.40	165.40

Date January 2013
 WP# E2-2012



Prep'd AN
 Chkd. LRB

Appendix D

Selected Stability Analysis Results

	Gamma C kN/m3	Phi deg	Piezo Surf.
SANDY SILT	20	0	30
SAND & SILT TILL	21	0	33
SAND & GRAVEL	21	0	38

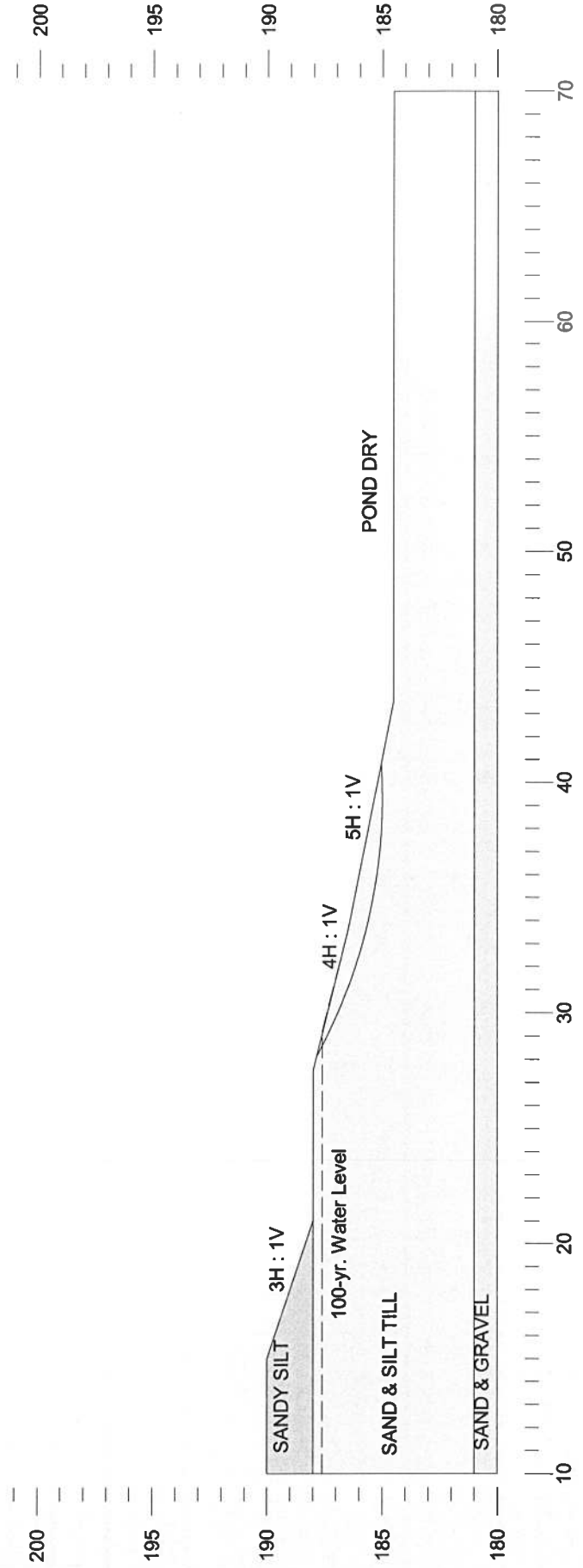
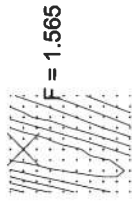


FIGURE D1

	Gamma C kN/m ³	Phi deg	Plezo Surf.
SAND compact	20	0	30
SAND dense to v. den	21	0	35

$F = 1.737$

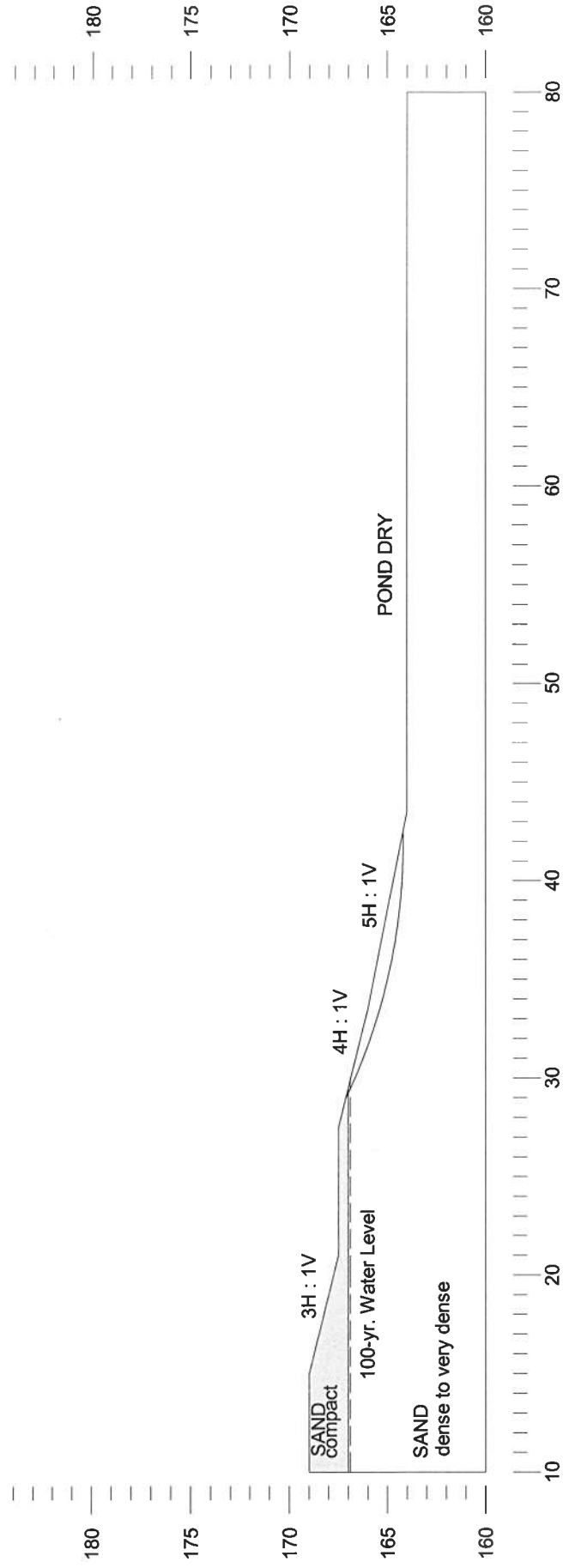



FIGURE D2

Thurber Engineering Ltd. - Toronto
19-5161-130
SWM Pond 07S
January 7, 2013
Cut Slope at 3:1; Pond Slope at 5H:1V to 4H:1V
Pond Sideslope Stability - Rapid Drawdown

	Gamma C kN/m3	Phi deg	Piezo Surf.
SANDY SILT TILL	20	0	32
SILTY SAND TO SAND	21	0	33
SAND AND SILT TILL	21	0	35

 F = 1.539

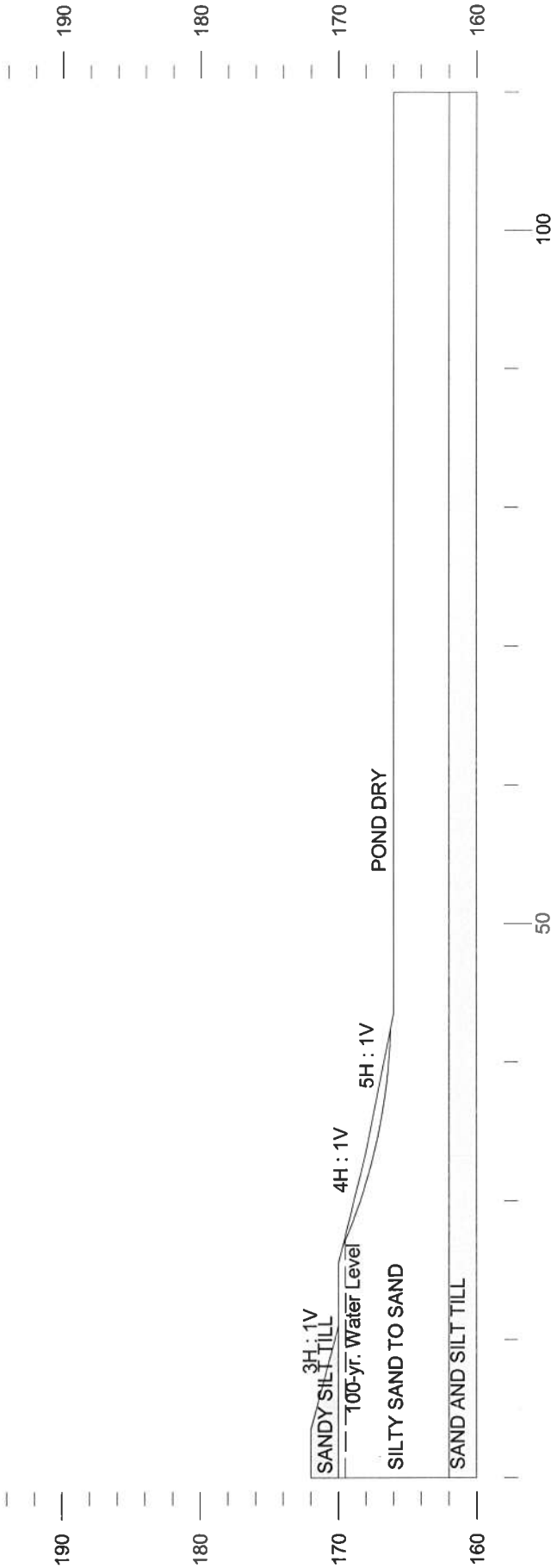


FIGURE D3

Appendix E

List of SPs and NSSPs

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

- OPSS 206
- OPSS 401
- OPSS 501
- OPSS 804
- OPSS 1205