

**FOUNDATION INVESTIGATION AND DESIGN REPORT
HURONTARIO NORTH ACCESS ROAD / N-W RAMP
STRUCTURE AND RETAINING WALLS
HWY 401 WIDENING, HWY 410 TO CREDIT RIVER
MISSISSAUGA, ONTARIO
G.W.P. 2107-05-00, WP 2107-05-04, SITE 24-759**

Geocres Number: 30M12-267

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 site of a proposed grade separation structure and two retaining walls to be located at the northwest quadrant of the Highway 401 – Hurontario Street (Highway 10) interchange area in Mississauga, Ontario. The overpass structure is to carry the proposed Hurontario Street North Access Road over a new North-West Ramp. This project is part of the widening of Highway 401 from Highway 10 to Credit River.

The purpose of the investigation was to explore the subsurface conditions at the sites and, based on the data obtained, provide borehole location plans, borehole logs, stratigraphic profiles, cross-sections and a written description of the subsurface conditions. A model of the subsurface conditions was developed to describe the geotechnical conditions influencing design and construction of the foundations and approach embankments for the structure, as well as for the retaining walls.

Thurber carried out the investigation as a sub-consultant to MMM Group Limited (MMM) under the Ministry of Transportation Ontario (MTO) Agreement Number 2005-A-000347.

2 SITE DESCRIPTION

The site is located at the northwest quadrant of the Highway 401 and Hurontario Street interchange in Mississauga, Ontario.

The lands at the northwest quadrant of Highway 401 and Hurontario Street are generally vacant and undeveloped. Vegetation is moderate consisting mainly of tall grass and shrubs. To the east of Hurontario Street and south of Highway 401, lands have been developed for commercial and industrial uses. The topography is typically flat across the site.

The general site area is located within the physiographic region known as the Peel Plain, characterized by a level to undulating cohesive glacial till deposits underlain by reddish brown shale of the Queenston Formation with limestone layers.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing for the main ramp structure and approaches were carried out on October 2 to 17 and from December 6 to 11, 2006 and consisted of drilling and sampling fourteen boreholes (numbered NAR1 to NAR14) at the site. Two more boreholes (NAR15 and NAR16) were advanced on October 2, 2007. Boreholes were drilled at locations of the structure abutments, approaches and wingwalls along the alignment of the proposed North Access Road and N-W ramp.

Ten boreholes were terminated upon auger or split spoon refusal in shale bedrock at depths of 2.4 to 6.4 m. Six boreholes were advanced into shale bedrock by coring to depths of 4.7 m to 9.3 m, with a minimum 3.0 m of rock cores recovered in each borehole.

A subsequent site investigation and field testing for two retaining walls were carried out on October 3 and 4, 2007, and consisted of drilling and sampling six boreholes (numbered RW1-1 to RW1-3, RW2-1 to RW2-3). Boreholes were drilled along the alignments of the proposed North Access Road/N-W Ramp wall (Retaining Wall 1) and the Hurontario SBL wall (Retaining Wall 2). The six boreholes were terminated upon auger refusal in shale bedrock at depths of 3.1 to 6.1 m.

The approximate borehole locations are shown on the Borehole Locations and Soil Strata Drawings in Appendix E. The coordinates and elevations of the boreholes are given on these drawings and on the individual Record of Borehole Sheets in Appendix A.

Prior to commencement of drilling, utility clearances were obtained for all borehole locations. Road occupancy and lane closure permits were also obtained.

Solid stem augers were used to advance the boreholes in the overburden and into the weathered shale. Samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). NQ rock coring equipment was used to recover core samples of the shale in selected boreholes.

A member of Thurber's engineering staff supervised the drilling and sampling operations on a full time basis. The supervisor logged the boreholes, visually examined the recovered samples, and transported them to Thurber's laboratory for further examination and testing.

All rock cores were logged, and the Total Core Recovery (TCR), Rock Quality Designation (RQD) and the Fracture Indices (FI) were determined.

Groundwater conditions in the boreholes were observed throughout the drilling operations. Standpipe piezometers consisting of 19 mm PVC pipes with screens were installed in selected boreholes to permit monitoring of groundwater levels. Details of the piezometer installations and other borehole completion details are as shown in Table 3.1.

Table 3.1 – Borehole Completion Details

Borehole Location	Piezometer Details			Completion Details
	Screen Depth (m)	Screen Elevation (m)	Sand Filter Stratum	
NAR1	None Installed			Bentonite grout for full depth
NAR2	2.2 – 4.0	191.7 – 189.9	Silty Sand Till	Bentonite grout to surface
NAR3	2.9 – 4.7	190.2 – 188.4	Silty Sand Till	Bentonite grout to surface
NAR4	7.4 – 9.2	185.7 – 183.9	Shale Bedrock	Bentonite to 6.7 m, grout to 0.9 m and bentonite to surface
NAR5	None Installed			Bentonite grout for full depth
NAR6	0.9 – 2.4	191.3 – 189.8	Shale Bedrock / Silty Clay Fill	Bentonite to surface.
NAR7	None Installed			Bentonite to surface.
NAR8	7.3 – 9.3	186.4 – 184.4	Shale Bedrock	Bentonite to surface.
NAR9	None Installed			Bentonite grout to 0.9 m and bentonite to surface
NAR10	2.8 – 4.6	190.0 – 188.2	Shale Bedrock / Silty Sand Till	Bentonite to surface.
NAR11	None Installed			Bentonite to surface.
NAR12	None Installed			Bentonite grout to 0.9 m and bentonite to surface.
NAR13	None Installed			Bentonite to surface.
NAR14	None Installed			Bentonite to surface.
NAR15	None Installed			Bentonite to surface.
NAR16	2.1 – 3.7	188.2 – 189.8	Shale Bedrock	Bentonite to surface.
RW1-1	1.5 – 3.0	188.3 – 186.7	Shale Bedrock / Silty Clay Till	Bentonite to surface.
RW1-2	None Installed			Bentonite to surface.
RW1-3	None Installed			Bentonite to surface.
RW2-1	None Installed			Bentonite to surface.
RW2-2	None Installed			Bentonite to surface.
RW2-3	4.5 – 6.1	188.8 – 190.4	Shale Bedrock	Bentonite to surface.

4 LABORATORY TESTING

All recovered samples were subjected to Visual Identification (VI). At least 25% of the recovered samples were also subjected to grain size distribution analyses (sieve and hydrometer) and Atterberg Limits testing where appropriate. Moisture content determinations were carried out on all soil samples. The results of this testing program are shown on the Record of Borehole sheets in Appendix A and on the figures in Appendix B.

Core samples of the shale bedrock were carefully protected to prevent drying during transport to the laboratory. All rock cores were subjected to geological logging.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

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

In general, the soil stratigraphy encountered at this site consists of topsoil and fill overlying native sands and silts, sand and silt to silty sand till with occasional silty clay till deposits. Weathered shale bedrock is present below the till deposits. More detailed descriptions of the major strata are presented below.

5.1 Topsoil

Topsoil was identified at ground surface in Boreholes NAR1 through NAR16 located at the structure and approaches. The topsoil thickness generally ranged from 50 mm to 150 mm.

Topsoil was identified at ground surface in Boreholes RW1-1 to RW1-3, RW2-1 and RW2-3 located along the two retaining wall alignments. The topsoil thickness generally ranged from 50 mm to 75 mm.

The topsoil thickness may vary between and beyond the borehole locations and the data is not intended for the purpose of estimating quantities.

5.2 Fill

Structure and Approaches

Fill was encountered below the topsoil in Boreholes NAR1 to NAR16, except in Borehole NAR13. The fill generally consists of brown silty clay with trace of gravel and sand, and occasional rootlets, except in Boreholes NAR15 and NAR16 where sand fill and shale fill were present immediately below the topsoil. The base of the fill encountered in the boreholes ranged from 0.6 m to 2.3 m depths below existing ground surface, or between Elevations 193.3 m and 190.5 m.

SPT N-values measured in the silty clay fill typically range from 5 to 24 blows per 0.3 m penetration indicating a firm to very stiff consistency. Occasional N-values of greater than 30 blows per 0.3 m penetration in Boreholes NAR7, NAR11 and NAR15 indicate a hard consistency. The moisture content of the recovered silty clay fill samples ranged approximately from 7% to 23%.

In Borehole NAR15, a 0.4 m thick sand fill was encountered above the silty clay fill. An SPT 'N' value of 84 blows per 0.3 m penetration in this sand fill indicates a very dense state. In Borehole NAR16, a 0.7 m thick shale fill was encountered below the topsoil. An SPT 'N'

value of 42 blows per 0.3 m penetration indicates a dense state. Measured moisture contents of these samples varied from about 2% to 5%.

Three silty clay fill samples were subjected to grain size distribution analyses and Atterberg Limits testing. Grain size distribution results are presented on the Record of Borehole sheets and on Figure B1 of Appendix B. Atterberg Limit test results are presented on Figure B2 of Appendix B. Results of these tests are summarized as follows:

Soil Particles	%
Gravel	1 to 2
Sand	21 to 33
Silt	42 to 53
Clay	23 to 25

Index Property	%
Liquid Limit	24 to 36
Plastic Limit	15 to 21
Plasticity Index	9 to 15

The above results show that the silty clay fill is of low to medium plasticity with a group symbol of CL to CI.

Retaining Walls 1 and 2

Fill was encountered below the topsoil in Boreholes RW1-1, RW2-2 and RW2-3. The fill generally consists of brown silty clay with trace of gravel and sand, and occasional rootlets, except in Borehole RW2-3 where 1.5 m m of shale fill was found below the silty clay fill. The base of the fill encountered in these boreholes ranged from 0.6 m to 3.0 m depths below existing ground surface, or between Elevations 191.8 and 189.0 m.

SPT N-values measured in the silty clay fill range from 20 blows per 0.3 m penetration to greater than 50 blows for less than 0.3 m penetration, indicating a very stiff to hard consistency. An N-value of 8 blows per 0.3 m penetration measured for the shale interlayer indicates a loose condition. The moisture content of the recovered fill samples ranged approximately from 3% to 18%.

5.3 Sandy Silt and Silty Sand

Structure and Approaches

Native brown sandy silt and silty sand layers were noted between till deposits in Borehole NAR8, and below the fill in Borehole NAR14. These layers were 1.4 m to 2.0 m in thickness, and extended to 4.7 m and 3.7 m depths. The base of these deposits were at approximate Elevations 188.9 m and 190.0 m in Boreholes NAR8 and NAR14, respectively.

SPT N-values collected in the native sandy silt and silty sand range from 34 blows per 0.3 m penetration to greater than 50 blows for less than 0.3 m penetration, indicating a dense to very dense relative density. The moisture content of samples collected ranged from 7% to 16%.

Two samples from the sand and silt layers were subjected to grain size distribution analyses. The analysis results are presented on the Record of Borehole sheets and Figure B3 of Appendix B, and are also summarized as follows:

Soil Particles	%
Gravel	0 to 3
Sand	27 to 70
Silt and Clay	30 to 73

5.4 Sand and Silt to Silty Sand Till

Structure and Approaches

Deposits of brown to grey sand and silt till and silty sand till with trace of gravel and trace to some clay were encountered below the fill or sandy silt/silty sand layer. Occasional shale fragments and oxidized stains were observed within these soils. The till deposits were encountered in most of the boreholes except Boreholes NAR5, NAR6, NAR13 and NAR16. These layers were approximately 1.2 m to 4 m thick, and extended to 2.7 m and 5.5 m depths. The base of these deposits varied between Elevations 188.2 m and 190.9 m.

Most of the SPT N-values measured in these cohesionless tills range from 50 blows per 0.3 m penetration to greater than 50 blows for less than 0.3 m penetration, indicating very dense conditions throughout. Occasional SPT N-values of 24 and 43 blows per 0.3 m penetration measured in Boreholes NAR8 and NAR9 indicate a compact to dense relative density. The measured natural moisture contents ranged from 4% to 17%.

Fifteen samples from these till deposits were subjected to grain size distribution analyses. The analysis results are presented on the Record of Borehole sheets and Figures B4 to B6 of Appendix B, and are also summarized as follows:

Sand and Silt Till

Soil Particles	%
Gravel	1 to 7
Sand	36 to 49
Silt	35 to 47
Clay	8 to 14

Silty Sand Till

Soil Particles	%
Gravel	3 to 10
Sand	53 to 72
Silt and Clay	25 to 41

Although not encountered in the boreholes, glacial tills inherently contain cobbles and boulders which may explain some of the high N-values and resistance to augering.

5.5 Silty Clay Till*Structure and Approaches*

A deposit of reddish brown to brown silty clay till was contacted below the sandy silt at 4.7 m depth in Boreholes NAR8, below the fill at 1.5 m depth in Borehole NAR15, and below the fill at 0.8 m depth in Borehole NAR16. The base of this till was encountered at Elevation 188.2 m in Borehole NAR8, Elevation 191.3 m in Borehole NAR15, and Elevation 190.3 m in Borehole NAR16.

SPT N-values ranging from 58 blows per 0.3 m penetration to greater than 50 blows for less than 0.3 m penetration indicate a hard consistency. Measured moisture contents ranged between about 7% and 18%.

One silty clay till sample was subjected to both grain size distribution analyses and Atterberg Limits testing. Grain size distribution results and Atterberg Limits test results are presented on Figures B7 and B8, respectively, in Appendix B, and are summarized as follows:

Soil Particles	%
Gravel	2
Sand	29
Silt	47
Clay	22

Index Property	%
Liquid Limit	22
Plastic Limit	13
Plasticity Index	9

The above results show that the silty clay till is of low plasticity with a group symbol of CL.

Retaining Walls 1 and 2

The silty clay till was encountered below the topsoil and/or fill in Boreholes RW1-1 to RW1-3, and RW2-1 to RW2-3. The thickness of this till ranges from 0.5 m to 1.3 m. The base of this till was encountered between Elevations 188.3 m and 191.2 m.

SPT N-values measured in this till vary from 17 blows per 0.3 m penetration to greater than 50 blows for less than 0.3 m penetration, indicating a very stiff to hard consistency. Measured moisture contents ranged between about 6% and 20%.

Four silty clay till samples were subjected to grain size distribution analyses and two of those samples were subject to Atterberg Limits testing. Grain size distribution results and Atterberg Limits test results are presented on Figures B9 and B10, respectively, in Appendix B. Results of these tests are summarized as follows:

Soil Particles	%
Gravel	1
Sand	16 to 26
Silt	53 to 63
Clay	20 to 26

Index Property	%
Liquid Limit	23 to 37
Plastic Limit	14 to 21
Plasticity Index	9 to 16

The above results show that the silty clay till is of low to medium plasticity with a group symbol of CL to CI.

Although not encountered in the boreholes, glacial tills are known to contain cobbles and boulders.

5.6 Shale Bedrock

The soils described above were found to be underlain by shale bedrock. The shale encountered in the boreholes is described as fine grained, thinly bedded and reddish brown in colour that is typical of the Queenston Formation. It contains numerous hard limestone and some siltstone interbeds. The shale bedrock is typically in a highly to moderately weathered state within the upper 2 m. Below this zone, the degree of weathering decreases with depth, and the rock becomes moderately to slightly weathered. The hard limestone interbeds in the rock cores range from 25 mm to 200 mm in thickness.

In all boreholes except Boreholes NAR1 and NAR2, inclusive, augering and SPT sampling was carried out within the upper part of the shale. N-values were typically greater than 50 blows per 0.15 m penetration. Relatively higher resistance to augering was encountered at several locations within the weathered shale, inferring the presence of hard interbeds. Moisture contents of the disturbed samples ranged from 6% to 10%. Depths and elevations of the top of shale in the vicinity of the structure and approaches are presented in Table 5.1 below.

Table 5.1 – Elevation of Top of Bedrock

Borehole	Shale Depth (m)	Shale Elevation (m)
NAR1	4.7*	189.3*
NAR2	4.0	189.9
NAR3	4.5	188.6
NAR4	4.0*	189.0*
NAR5	0.6*	191.8*
NAR6	1.4	190.8
NAR7	5.5	188.2
NAR8	5.5*	188.2*
NAR9	4.0*	188.8*
NAR10	3.7	189.1
NAR11	3.0	189.0
NAR12	3.0*	189.0*
NAR13	0.1	193.3
NAR14	5.5	188.2
NAR15	4.3	190.1
NAR16	1.5	190.3

* Proved by coring below augered depth.

Depths and elevations of the top of shale along the alignments of the two retaining walls are presented in Table 5.2 below.

Table 5.2 – Elevation of Top of Bedrock

Borehole	Shale Depth (m)	Shale Elevation (m)
RW1-1	1.5	188.3
RW1-2	0.6	190.1
RW1-3	1.4	190.3
RW2-1	0.8	189.5
RW2-2	1.2	189.8
RW2-3	3.7	191.2

Bedrock cores were recovered using NQ sized coring equipment in six boreholes. Total Core Recovery (TCR) in the bedrock was 100% in most core runs. Lower TCR values of 27% and 52% were observed in Runs 1 and 2, respectively, of Borehole NAR4.

The Rock Quality Designation (RQD) values recorded for eight of the fourteen core runs ranged from 27% to 62% indicating poor to fair rock quality. Lower RQD values of 0 to 22%

were obtained in Boreholes NAR4, NAR5, NAR8 and NR9, between approximate Elevations 185.6 m and 189.2 m, indicating very poor rock quality. The Fracture Index (FI) of the rock, expressed as fractures per 0.3 m of core, generally ranged from 1 to 8, and higher values of 11 to 14 were observed locally in Run 2 of Borehole NAR1.

Based on point load tests carried out for rock cores from nearby sites of the interchange project, average inferred Unconfined Compressive Strength (UCS) values for the shale and shale/siltstone are typically less than 10 MPa; the UCS values for the limestone and siltstone interbeds typically range from 15 to greater than 100 MPa. It must be noted, however, that point load tests were possible only on less weathered shale or higher strength limestone samples as the more typical weathered shale cores tended to disintegrate or split under point loading.

In this site area, shale bedrock typically contains layers of limestone that can be significantly harder than the shale itself. The distribution, thickness and strength of these layers vary from location to location, and these layers typically exhibit less pronounced weathering than the shale. Sampling and interpretation from small diameter boreholes may underestimate the frequency and strength of the strong layers and therefore geological expertise and past experience must be applied in any decision making process regarding the bedrock.

5.7 Water Levels

Upon completion of drilling, water was measured at depths of 3.6 m to 4.5 m in open Boreholes NAR3, NAR7, NAR9 and NAR12. Standpipe piezometers were installed in nine boreholes to monitor the water levels after completion of drilling. The water levels measured in the piezometers are summarized in Table 5.3, along with the measurements in the open boreholes upon completion of drilling.

Table 5.3 – Measured Groundwater Levels

Borehole	Date	Water Level (m)		Comment
		Depth	Elevation	
NAR2	13-Nov-2006	1.4	192.4	In piezometer
	29-Jan-2007	1.0	192.9	
	21-Sep-2007	2.8	191.1	
NAR3	7-Dec-2006	3.9	189.2	In open borehole
	8-Dec-2006	0.4	192.7	In piezometer
	29-Jan-2007	0.5	192.6	
	21-Sep-2007	2.4	190.7	
NAR4	12-Dec-2006	0.4	192.7	In piezometer
	29-Jan-2007	0.5	192.6	
	21-Sep-2007	1.8	191.3	
NAR6	29-Jan-2007	0.8	191.4	In piezometer
	21-Sep-2007	2.4	189.8	
NAR7	17-Oct-2006	4.5	189.1	In open borehole
NAR8	8-Dec-2006	0.8	192.8	In piezometer
	29-Jan-2007	0.7	193.0	
	01-Nov-2007	5.9	187.8	
NAR9	10-Dec-2006	3.9	188.9	In open borehole
NAR10	29-Jan-2007	-	-	Frozen
	21-Sep-2007	2.0	190.8	In piezometer
NAR12	7-Dec-2006	3.6	188.4	In open borehole
NAR16	05-Oct-2007	1.9	190.0	In piezometer
	18-Oct-2007	2.0	189.9	
	01-Nov-2007	1.9	190.0	
RW1-1	18-Oct-2007	1.4	188.4	In piezometer
	01-Nov-2007	0.9	188.9	
	15-Nov-2007	1.3	188.5	
RW2-3	05-Oct-2007	5.0	189.9	In piezometer
	18-Oct-2007	2.8	192.1	
	01-Nov-2007	2.9	192.0	
	15-Nov-2007	2.7	192.2	

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. Further, perched water may be encountered at higher levels in pockets or zones of more permeable sands and silts within the heterogeneous tills, or within the fill.

6 MISCELLANEOUS

The borehole locations were marked on site and the co-ordinates and ground surface elevations at those locations were supplied to Thurber by MMM Group Limited.

The drilling and sampling equipment was supplied and operated by DBW Drilling of Ajax, Ontario. The field work was supervised on a full time basis by Mr. George Azzopardi and Mr. Stephane Loranger of Thurber.

Laboratory testing was carried out at Thurber's Laboratory in Oakville.

Supervision of the field program and interpretation of the field data was conducted by Mr. A. E. Gorman, P. Eng. and Ms. R. Palomeque Reyna, P.Eng.

The Foundation Investigation Report was prepared by Dr. S. Pang, P.Eng. and Ms. R. Palomeque Reyna, P.Eng.

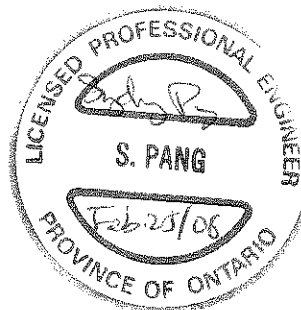
Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects, reviewed the report.

THURBER ENGINEERING LTD.

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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 GENERAL

This report provides an interpretation of the geotechnical data in the factual report and presents geotechnical design recommendations to assist the design team to select and design a suitable foundation system and approach fills for the proposed overpass and associated retaining structures.

It is understood that the proposed overpass structure is to carry the new Highway 10 North Access Road over a new N-W Ramp, which connects Highway 10 SBL with Highway 401 WBL. The new N-W Ramp under the access road will be formed in a cut of approximately 2 m in depth below existing ground surface. The proposed Retaining Wall 1 alignment extends from the west abutment in a southwesterly direction along the proposed ramp. The proposed Retaining Wall 2 alignment extends westward from the north abutment of the Hurontario Street Underpass structure. Retaining Walls 1 and 2 will be approximately 120 m and 100 m in length, respectively.

The preliminary General Arrangement (GA) drawing provided by MMM indicates that the proposed structure is a single span, concrete, rigid frame structure with a span of 14.7 m (perpendicular to the N-W Ramp alignment), and an approximate length of 38.5 m (parallel to the N-W Ramp alignment). In the vicinity of the overpass, the access road grade will be at approximate Elevation 198.0 m, and the ramp grade will vary between Elevations 190.3 m and 191.4 m.

At the east approach, the original ground lies between Elevations 192.0 m and 193.7 m, requiring an approach fill of approximately 4.3 m to 6.0 m high. At the west approach, the original ground varies from approximate Elevations 192.2 m to 193.9 m, requiring an approach fill of approximately 4.1 m to 5.8 m high.

The discussion and recommendations presented in this report are based on our understanding of the project and on the factual data obtained during the course of the investigation.

8 STRUCTURE FOUNDATION

In general, the stratigraphy of the site consists of topsoil and fill overlying native sand and silt to silty sand tills, underlain by shale bedrock at depths ranging from 0.1 m to 5.5 m (Elevations 193.3 m to 188.2 m). The groundwater level is anticipated to range between 1.3 m and 5.9 m depth (Elevations 187.8 m to 193.0 m). Bedrock and ground surface elevations, and the proposed N-W Ramp grades at the borehole locations, are presented in Table 8.1.

**Table 8.1 Elevations of Bedrock, Ground Surface and Ramp Grade
Overpass Structure**

Location	Borehole Number	Elevations (m)			Depth of Shale Below Ramp Grade (m)
		Existing Ground Surface	Proposed N-W Ramp Centreline	Top of Weathered Shale	
West Abutment					
Northwest	NAR1	194.0	≈191.2	189.3	1.9
Northeast	NAR2	193.9	≈191.2	189.9	1.3
Centre West	NAR3	193.1	≈190.5	188.6	1.9
Centre East	NAR4	193.1	≈190.5	189.0	1.5
Southwest	NAR5	192.4	≈190.0	191.8*	-1.8*
Southeast	NAR6	192.2	≈190.0	190.8*	-0.8*
East Abutment					
Northwest	NAR7	193.6	≈191.4	188.2	3.2
Northeast	NAR8	193.7	≈191.4	188.2	3.2
Centre West	NAR9	192.8	≈190.8	188.8	2.0
Centre East	NAR10	192.8	≈190.8	189.1	1.7
Southwest	NAR11	192.0	≈190.2	189.0	1.2
Southeast	NAR12	192.0	≈190.2	189.0	1.2

* Bedrock above proposed ramp grade.

The elevations at which bedrock was encountered at the abutment wingwall and retaining wall locations are as presented in Tables 8.2 and 8.3.

**Table 8.2 Elevations of Bedrock, Ground Surface and Ramp Grade
Abutment Wingwall and Retaining Wall**

Location	Borehole Number	Elevations (m)			Depth of Shale Below Ramp Grade (m)
		Existing Ground Surface	Proposed N-W Ramp Centreline	Top of Weathered Shale	
Northwest Wingwall	NAR1	194.0	≈191.2	189.3	1.9
	NAR2	193.9	≈191.2	189.9	1.3
Southwest Wingwall/ Retaining Wall 1	NAR5	192.4	≈190.0	191.8*	-1.8*
	NAR6	192.2	≈190.0	190.8*	-0.8*
	RW1-3	191.6	≈189.8	190.3	-0.5
	RW1-2	190.7	≈190.1	190.1	0.0
	RW1-1	189.8	≈190.5	188.3	2.2
Northeast Wingwall	NAR7	193.6	≈191.4	188.2	3.2
	NAR8	193.7	≈191.4	188.2	3.2
	NAR15	194.3	≈191.9	190.1	1.8
Southeast Wingwall	NAR11	192.0	≈190.2	189.0	1.2
	NAR12	192.0	≈190.2	189.0	1.2
	NAR16	191.8	≈189.8	190.3	-0.5*

*Bedrock above proposed ramp grade.

**Table 8.3 Elevations of Bedrock, Ground Surface and Ramp Grade
Abutment Wingwall and Retaining Wall**

Location	Borehole Number	Elevations (m)			Depth of Shale Below Ramp Grade (m)
		Existing Ground Surface	HWY 401 WB-Collector Centreline	Top of Weathered Shale	
Retaining Wall 2	RW2-3	194.9	≈192.2	191.2	1.0
	RW2-2	191.0	≈191.5	189.8	1.7
	RW2-1	190.3	≈191.9	189.5	2.4

8.1 Foundation Alternatives

8.1.1 Overpass Structure

The following alternate foundation types were considered at this site:

- Spread footings on shale bedrock
- Spread footings on native dense soil
- Augered Caissons (drilled shafts)
- Driven steel H-piles

A comparison of these foundation alternatives based on advantages and disadvantages of each is included in Appendix C.

Given the design of the proposed structure, geometry of the proposed cut and the presence of bedrock at typically shallow depths below the base of the final ramp grade, it is considered impractical and not cost effective to use deep foundations such as piles and caissons for this structure and deep foundations are accordingly not recommended.

The GA drawing indicates that the proposed rigid frame structure is to be supported on spread footings founded below the final grade of the N-W Ramp.

Based on assessment of foundation alternatives footings founded on very dense silty sand till or weathered bedrock is considered the most cost effective foundation option for supporting the rigid frame structure.

8.1.2 Retaining Walls

The following retaining wall alternatives were considered at this site:

- Retained Soils System (RSS) Walls
- Concrete Toe Walls

Existing GA drawings show the proposed retaining wall alignments. More detailed information on the proposed profiles and cross-sections is not available at the time of preparation of this report. Foundation design recommendations for the walls, based on subsurface data obtained from the boreholes, are presented in subsequent sections of this report.

8.2 Footings on Very Dense Till or Shale Bedrock

The GA drawings indicate that the elevation of the underside of the footing foundation varies from 189.1 m to 190.1 m. At these elevations the underside of the foundation will generally lie in very dense till or in the weathered shale bedrock.

The depth of shale below the proposed ramp grade varies approximately from 1.3 m to 1.9 m at the west abutment (exposed shale at the south portion), and from 1.2 m to 3.2 m at the east abutment. The footings should be designed to be founded on very dense silty sand till or weathered bedrock.

In areas where the underside of the footing is higher than the bedrock subgrade due to over-excavation or otherwise, mass concrete fill of the same class as the footings should be used to raise the subgrade to the design footing level. Within the southern portion of the west abutment, footing construction will have to be carried out by excavating through weathered shale.

8.2.1 Bearing and Lateral Resistance

Footings bearing on very dense silty sand till at the founding elevations recommended above may be designed for the following value:

- Factored geotechnical resistance of 700 kPa at Ultimate Limit States (ULS).

Spread footings bearing on undisturbed weathered shale bedrock may be designed for the following geotechnical resistances:

- Factored geotechnical resistance of 750 kPa at Ultimate Limit States (ULS)

Due to the shallow depth to bedrock below the proposed footing elevation, it is recommended that the footings be extended to be founded on weathered shale bedrock.

The SLS condition does not govern design for footings founded on very dense till or bedrock.

The factored geotechnical resistance quoted above is for vertical, concentric loads. Where eccentric or inclined loads are applied, the resistance used in design must be reduced in accordance with the CHBDC 2006 Clause 6.7.3 and Clause 6.7.4. The design of the footing may be governed by other criteria such as sliding resistance or overturning moment.

The same geotechnical resistance may be used where mass concrete, including working mats, of the same class as footings is placed in neat contact with undisturbed till or a clean, sound bedrock surface.

Where bedrock slopes within the foundation footprint, the footing subgrade should be prepared either by forming a horizontal surface in bedrock by excavation, or by stepping of the footing bases.

Resistance to lateral forces / sliding resistance between mass concrete placed for the footings founded on dense till or shale may be computed using an unfactored coefficient of friction of 0.6. This is an “ultimate” value and requires a degree of sliding movement to occur to fully mobilize the resistance.

8.2.2 Footing Subgrade Preparation

The bearing surface should be prepared by removing all loose/disturbed material, shattered rock, rock slabs and protecting the shale from exposure to air and water by placing concrete or mud slab within 4 hours of completing the excavation. Shale is prone to rapid deterioration upon exposure to water and air. The mud slab should be formed with the same class of concrete as the footings and have a minimum thickness of 100 mm. All footing excavations should be inspected by qualified geotechnical personnel prior to placing concrete to confirm that the base has been adequately cleaned. Hand cleaning or air blasting may be required to remove loose rock and softened materials. Areas where sub-excavation beneath the underside of footing is carried out should be backfilled with the same class of concrete as the footings.

The mass concrete fill must extend beyond the footing perimeter by a sufficient distance to distribute the shear stresses from the footing and prevent stress concentrations under the edge of the footing. This condition must be checked structurally but extension of the mass concrete to 200 mm beyond the edge of the footing is typically sufficient. Similarly, the maximum depth of mass concrete that may be permitted below the footing is a function of the structural behaviour of the concrete and is not an issue of geotechnical resistance. All footing concrete must be placed in the dry.

8.3 Frost Protection

All footings should be provided with a minimum of 1.2 m of earth cover, or its thermal equivalent, over the footing base (founding elevation) as protection against frost action. This frost protection is required for both soil and shale founding surfaces. It is noted that although Queenston Shale is geologically defined as bedrock, it is susceptible to frost action.

9 TEMPORARY EXCAVATION

9.1 General

All temporary excavations must be carried out in accordance with the requirements of the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the native soils (sands, silts, tills) may be classed as Type 2 soils above the groundwater table and Type 3 soils below the groundwater table. All fills are classed as Type 3 soils. The upper 2 m of the shale (weathered zone) may be classed as a Type 2 material.

The selection of the method of excavation is the responsibility of the contractor and must be based on his equipment, experience and interpretation of the site conditions. Excavations should be inspected regularly for evidence of instability if they have been left open for extended periods of time and following periods of heavy rain or thawing. If required, remedial actions must be taken to ensure the stability of the excavation and the safety of workers.

The requirements for unwatering during excavation are discussed in Section 10.

The excavation and backfilling for foundations must be carried out in accordance with SP 902S01.

9.2 Earth Excavation

Earth excavations required at this site will penetrate through a variety of overburden soils including fills, native sands, silts, sand and silt/silty sand tills. The soils, especially the tills, may contain cobbles, boulders and slabs of rock. It is anticipated that temporary excavations through a majority of soils at this site may be formed with side slopes not steeper than

1H : 1V. Flatter slopes may be required at locations where the soils are less competent than what is assumed during design or where water seepage affects surficial stability.

A NSSP should be included in the contract alerting the Contractor to the possible presence of cobbles, boulders and bedrock fragments in the overburden, particularly in the very dense silty sand till layer above the bedrock.

The NSSP should also alert the contractor to the fact that some of the fill may have originated from excavated shale, including limestone interbeds, which has softened as a result of exposure to weathering.

9.3 Rock Excavation

Any rock excavation should be carried out in accordance with the Special Provision (SP), Amendment to OPSS 120, 1994.

For foundation construction at some locations such as within the southerly portion of the west abutment, the excavation will extend through the upper weathered shale into the relatively sound shale with hard limestone and siltstone interbeds.

The selection of the method of excavating and removing the bedrock is the responsibility of the contractor and the contractor is solely responsible for assessing the type, size and power rating of the required equipment. However, from the point of view of assessing constructability, the following points should be taken into consideration:

- The silty clay till grades into weathered bedrock and there is often not a distinct boundary between the two and, accordingly, excavation of the upper, more weathered layers of the bedrock may be similar to excavation of the overburden.
- Rock excavation will be required at this site. Bidders must be alerted to the fact that the shale bedrock gets stronger with depth and contains frequent very strong interbeds, and rock-breaking equipment must be provided for rock excavation.
- Excavation of the bedrock will become more arduous with increasing depth into the deposit and the contractor may have to employ specialized methods such as ripping, and pneumatic breaking to dislodge the rock.

The contract documents should contain a Non Standard Special Provision (NSSP) alerting the contract bidders that rock excavation may require the use of such equipment. Suggested wording for this NSSP is provided in Appendix D.

9.4 Roadway Protection

It is anticipated that roadway protection will be required during construction. An item titled "Protection System" as per SP 105S19 should be included in the contract documents. It is

recommended that Performance Level 2 as per Clause 539.04.02.01 and the alignment of the shoring be specified on the contract drawings.

The design of roadway protection should be the responsibility of the Contractor. However, one option that is considered to be suitable for use as temporary shoring at this site is a soldier pile and lagging wall. The soldier piles will need to be installed through pre-drilled holes and socketted into the very dense/hard glacial tills and/or bedrock in order to develop the required toe resistance. It is anticipated that the shoring system may be stiffened by cross bracings, where applicable.

A temporary braced soldier pile and lagging wall may be designed using the parameters given below.

γ	=	20 kN/m ³
γ_w	=	10 kN/m ³
K_a	=	0.35 (road embankment fill)
	=	0.33 (sand and silt to silty sand tills, silty clay tills)
h_w	=	0 (assuming no hydrostatic pressure build-up behind a presumably permeable wall)
H	=	depth to base of excavation (rock surface) (m)

For pile sockets formed within the very dense/hard glacial tills or the upper weathered portion of the shale, the ultimate passive force that can be mobilized by the embedded portion of a socket is given by:

$$P_p = 1.5 \gamma' L^2 D K_p$$

where γ' = submerged unit weight of soil, kN/m³
 D = diameter of socket, m
 L = depth of socket, m
 K_p = 3.5

The actual pressure distribution acting on the shoring system is a function of the construction sequence and the relative flexibility of the wall. These factors must be considered when designing the shoring system. All shoring systems should be designed by a Professional Engineer experienced in such designs.

10 PERMANENT CUT

10.1 General

Permanent earth and rock cuts are required to construct the new North-West Ramp at this site.

Vegetative cover should be established on all exposed earth slopes to protect against surficial erosion. Reference may be made to special provision SP572S01 for more detailed requirements, where applicable.

10.2 Cuts in Fill and Native Soil

Based on the stratigraphy encountered at this site, cuts through the fill and native soil are expected to reach a maximum depth of approximately 2.0 to 4.5 m. At that maximum depth, the slopes are expected to be stable at inclinations not exceeding 2H:1V.

It is anticipated that the base of the cut in soil will be in dense to very dense sand/silt till. The base of this cut will be stable.

10.3 Cuts in Bedrock

Rock cut in the order of 1.0 m to 2.0 m deep will be required along the proposed rigid frame structure.

Short term excavations of moderate depth in the shale will generally be stable with near-vertical faces. However, the shale is prone to weathering and on the longer term steep slopes are expected to slough and ravel. Taking account of the properties of the shale, it is recommended that permanent slopes be formed no steeper 2H:1V for the anticipated maximum depth of less than 4 m.

10.4 Drainage

Drainage will be required in the depressed section of the cut to remove water originating from

- Storm runoff
- Seepage from the sides of the cut.

It is recommended that the ramp be designed as an urban section to contain the runoff and direct it to a storm sewer.

11 UNWATERING

11.1 General

In the vicinity of the cut, the groundwater levels observed in the piezometers range from approximate Elevations 188 m to 193 m, but typically lie between Elevations 188.5 m and 192.5 m. Groundwater seepage from the perched water in the predominantly silty clay fill is anticipated to be small.

11.2 Permanent Cut

The proposed N-W Ramp grade ranges approximately between Elevations 190.0 m and 191.5m. The groundwater levels range between Elevations 188.4 m and 192.5 m, or up to the order of 2 m below to 2.5 m above the ramp grade. As the excavation proceeds, seepage from the more permeable sands and silts, the seams and fractures within the shale, and surface water accumulating within the cut must be controlled and drained. It is estimated, however, that the rate of seepage will decrease over time as the groundwater table is drawn down locally due to the cut. Continued seepage is expected in the long term and a permanent drainage system must be designed and implemented.

During excavation, drainage ditches supplemented by pumping from filtered sumps can be used to control groundwater seepage, surface runoff and precipitation. Surface runoff should be diverted away from the cut at all times.

11.3 Temporary Footing Excavations

Temporary excavations for footing construction are anticipated to extend to the order of 3 m to 5 m below the existing groundwater level. The footings must be constructed in the dry as the cohesionless tills and shale are prone to rapid deterioration upon exposure to water and air.

For footing construction, groundwater control measures such as perimeter ditches and pumping from filtered sumps should be implemented to remove water accumulated at the footing base prior to placing concrete. Concrete must be placed in the dry.

11.4 Permanent Drainage

The detailed design of a permanent drainage system is beyond the scope of this investigation. A drainage measure that is considered feasible for this site includes longitudinal sub-drains running along the side(s) of the new N-W ramp that are connected to positive drainage outlets.

The design of temporary unwatering systems that will be required during construction must remain the responsibility of the Contractor.

12 APPROACH EMBANKMENTS

The approach embankments for the North Access Road / N-W Ramp structure will be constructed on variable depths of existing, typically firm to very stiff, silty clay fill overlying native dense to very dense sands, silts and sand/silt till deposits, underlain by shale bedrock. The proposed embankment height ranges from approximately 4.1 m to 5.8 m at the west approach, and from 4.3 m to 6.0 m at the east approach.

The embankment foundation soils underlain by shallow bedrock will provide adequate stability to the new earth fills with side slope inclinations of 2H : 1V or flatter.

Considering the embankment height, consistency/relative density of the foundation soils and the presence of bedrock at relatively shallow depth, foundation settlement induced by the new embankment loading will be less than 25 mm and is expected to occur as the fill is placed. However, surface settlement due to compression of the new fill itself will occur. It is estimated that the magnitudes of such settlements will range from 20 mm to 30 mm for Select Subgrade Material (SSM) fill, and 10 mm to 15 mm for compacted granular fill. This settlement will be immediate and essentially complete when construction of the fill is completed. Compression of cohesive earth fill is estimated to range from 40 mm to 60 mm of which a portion is expected to take place during the months immediately following completion of placement.

It is therefore recommended that embankment construction be completed at least three months in advance of road paving in order to minimize any time-dependent settlement due to consolidation or particle re-organization in the embankment fill itself.

All topsoil and organic soils should be stripped from the footprint of the approach fills. Particular attention should be paid to existing ditches to remove all softened material.

Embankment construction should be in accordance with OPSS 206, as amended by Special Provision “Amendment to OPSS 206, December 1993”, dated November 2002. It is recommended that earth fill should consist of SSM or granular materials in compliance with Special Provision 110F13, “Amendment to OPSS 1010 March 1993”. Any existing fill slopes must be benched in accordance with OPSD 208.010 prior to placing new fill.

Earth fill embankment slopes must be provided with erosion protection in accordance with Special Provision 572S01.

13 RETAINING WALLS

It is understood that two retaining walls are required within the project area covered by this report. Retaining Wall 1 is parallel to the proposed N-W Ramp alignment and is to extend from the southwest corner of the N-W Ramp structure for an approximate length of 130 m. Retaining Wall 2 is parallel to Highway 401 and is to extend from the west limit of the north abutment of the Hurontario overpass structure for an approximate length of 100 m. Along both wall alignments, the borehole information indicates that the foundation conditions are typically comprised of up to 3 m of fill overlying 0.5 to 1.5 m of native, very stiff to hard silty clay till, which is underlain by shale bedrock.

Design information on proposed profiles, cross-sections and retained heights is unavailable to Thurber at the time of preparation of this report. Based on the subsurface data and the general project requirements, consideration may be given to using Retained Soil Systems (RSS) walls or conventional concrete toe walls.

13.1 RSS Foundations

The soil conditions encountered on site are generally suitable for the support of RSS walls. RSS walls should be specified as “High Performance” and “High Appearance”. The contract drawings should include information on the longitudinal alignment of the wall in plan, the top and base elevations of the wall in profile, cross-sectional space constraints and an NSSP for the RSS wall.

The performance of a RSS is dependent on, among other factors, the characteristics of its foundation. Failure to provide an adequate foundation may lead to settlement and distortion of the RSS and, in severe cases, to possible failure of the system. It is critical that the RSS walls are not subject to settlement due to compression of the foundation soils and embankment fill. The foundation of the entire RSS mass must be considered, i.e. from the face of the wall to the furthest extent of the reinforcement.

To provide an acceptable foundation performance, the RSS mass must be founded on the native, undisturbed very stiff to hard silty clay till, the weathered shale, or on compacted Granular A fill constructed on dense soils where grade raising is required. The highest recommended base levels for the underside of the wall or the Granular A fill are presented in Table 12.1.

Table 12.1 – Maximum Elevation at Underside of Wall Base or Granular A Fill

Foundation Unit	Borehole	Depth to Native Very Stiff/Hard Silty Clay Till (m)	Native Very Stiff/Hard Silty Clay Till Elevation (m)	Depth to Shale Bedrock (m)	Top of Shale Bedrock Elevation (m)
Retaining Wall 1	NAR5	-	-	0.6	191.8
	NAR6	-	-	1.4	190.8
	RW1-3	0.1	191.5	1.4	190.3
	RW1-2	0.1	190.6	0.6	190.1
	RW1-1	0.8	189.0	1.5	188.3
Retaining Wall 2	RW2-3	3.0	191.9	3.7	191.2
	RW2-2	0.6	190.4	1.2	189.8
	RW2-1	0.1	190.2	0.8	189.5

A wall founded on native, very stiff to hard silty clay till and/or weathered shale, at or below the elevations shown in Table 12.1 should be designed for a factored geotechnical resistance of 400 kPa at ULS and a geotechnical resistance of 250 kPa at SLS.

Alternatively, the RSS may be founded on engineered fill resting on the native very stiff to hard silty clay till and/or weathered shale. Engineered fill placed under the RSS mass to achieve the design founding level must consist of OPSS Granular “A” compacted to 100% of

its SPMDD at a moisture content within 2% of optimum. The engineered pad must be at least 500 mm beyond the limits of the RSS mass and levelling strip.

The geotechnical resistances provided above are for concentric, vertical loading. The effects of load inclination and eccentricity need to be taken into account according to the CHBDC 2006 Section 6.7.

The entire block of reinforced earth must be designed against various modes of failure including sliding and overturning. Sliding resistance along the base of the wall may be estimated using an ultimate friction coefficient of 0.55 for engineered granular fill and an ultimate friction coefficient of 0.45 for native silty clay till or weathered shale.

Topsoil, loose fill, and any soft/wet material should be stripped from the footprint of the RSS. The subgrade soil under the RSS foundation should be proofrolled to detect and replace any soft areas.

The proprietary RSS system must meet the Ministry's specifications for performance and appearance. The RSS supplier/designer may specify more stringent criteria or other requirements related to the particular design. The internal stability of the RSS wall should be analyzed by the supplier/designer of the proprietary product selected for this site.

If a RSS wall system is selected, the global stability must be analyzed after the configuration of the wall is known. The global stability of the RSS wall is dependent on the characteristics of the retained soil and the foundation soil/rock and the wall geometry. Typically, global stability should not be a major concern for a RSS wall founded on the very stiff to hard till and/or shale at this site.

13.2 Concrete Toe Wall

Consideration may be given to using a concrete toe wall along some sections of the retaining walls where the retained height immediately behind the wall is 1.8 m or lower, and the maximum height of slope above the top of wall is 4 m. The design of concrete toe walls should be carried out with reference to OPSD 3120.100, and also in accordance with the requirements of the CHBDC 2006.

The toe walls may be founded on native very stiff to hard till or bedrock at the following recommended elevations:

- Retaining Wall 1 (Boreholes NAR5 and RW1-1):-
Approximate Elevations 191.8 m to 189.0 m (north to south).
- Retaining Wall 2 (Boreholes RW2-3 to RW2-1):-
Approximate Elevations 191.9 m to 190.2 m (east to west).

It is recommended that concrete walls founded on native, undisturbed very stiff to hard silty clay till or weathered shale be designed for a factored geotechnical resistance at Ultimate Limit States (ULS) of 300 kPa and a geotechnical resistance at Serviceability Limit States (SLS) of 200 kPa.

The above values are for vertical concentric loads only. Effects of load inclination and eccentricity need to be taken into account as per the CHBDC 2006.

Resistance to lateral forces/sliding resistance between the concrete surface and undisturbed, native very stiff to hard till subgrade should be calculated in accordance with the CHBDC 2006 assuming an ultimate coefficient of friction of 0.55.

Once the desired founding subgrade level is reached, careful inspection should be carried out to delineate any loose/softened or otherwise disturbed areas. Such areas should be sub-excavated to the native very stiff to hard tills or weathered shale, and the sub-excavation backfilled with engineered granular fill or mass concrete.

14 BACKFILL TO ABUTMENTS

Backfill to the abutments should consist of Granular A or Granular B Type II material meeting the requirements of Special Provision 110F13 “Amendment to OPSS 1010, March 1993”. The backfill must be in accordance with OPSS 902 as amended by Special Provision 902S01, and placed to the extents shown in OPSD 3101.150.

Excavated shale is prone to deterioration and is difficult to compact adequately. Therefore, excavated shale must not be used as backfill to the abutments.

Compaction equipment to be used adjacent to retaining structures must be restricted in accordance with SP105S01. The design of the abutment must include a subdrain as shown in OPSD 3102.100.

15 STATIC EARTH PRESSURE

Earth pressures acting on the structure 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 expression:

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

where: P_h	=	horizontal pressure on the wall at depth h (kPa)
K	=	earth pressure coefficient (see Table 14.1)
γ	=	unit weight of retained soil (see Table 14.1)
H	=	depth below top of fill where pressure is computed (m)
q	=	value of any surcharge (kPa)

If the support system allows yielding of the wall (unrestrained system), active horizontal earth pressure may be used in the geotechnical design of the structure. If the support system does not allow yielding (restrained system), at-rest horizontal earth pressures should be used. The amount of wall movement required for the development of active, passive and at-rest earth pressures may be interpreted using Figure C6.9.1(a) in the Commentary to the CHBDC 2006.

Earth pressure coefficients for backfill to the abutment wall are dependent on the material used as backfill. Typical values are shown in Table 14.1.

Table 14.1 – Earth Pressure Coefficients (K)

Wall Condition	Earth Pressure Coefficient (K)			
	OPSS Granular A or OPSS Granular B Type II $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$		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 Wall)	0.27	0.40*	0.31	0.48*
At rest (Restrained Wall)	0.43	-	0.47	-
Passive (Movement Towards Soil Mass)	3.7	-	3.3	-

* For wing walls.

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

In conventional design, the use of a material with a high friction angle and low active pressure coefficient (e.g. Granular A, Granular B Type II) might be preferred as it results in lower earth pressures acting on the wall.

The factors in Table 14.1 are “ultimate” values and require certain movements for the respective conditions to be mobilized. The values to use in design can be estimated from Figure C6.9.1 (a) in the Commentary to the CHBDC 2006.

16 SEISMIC CONSIDERATIONS

16.1 Seismic Design Parameters

The following seismic parameters are provided in Table A3.1.7 of the CHBDC for the Mississauga area, and should be used for design:

- Velocity Related Seismic Zone 0
- Zonal Velocity Ratio 0.05
- Acceleration Related Seismic Zone 1
- Zonal Acceleration Ratio 0.05
- Peak Horizontal Acceleration 0.04

The soil profile type at this site has been classified as Type I. Therefore, according to Table 4.4.6.1 of the CHBDC 2006, a Site Coefficient “S” (ground motion amplification factor) of 1.0 should be used in seismic design.

16.2 Liquefaction Potential

There is no potential for liquefaction of structures founded on bedrock.

For structure and new embankments founded on the cohesionless sand and silt tills overlying bedrock, the potential for liquefaction of the cohesionless soils was assessed using the Seed and Idriss (1971)¹ method. Based on this method, the foundation soils are assessed as not being prone to liquefaction. The embankments themselves will be constructed above groundwater level that is expected to be maintained below the final N-W Ramp grade and are, therefore, not considered to be in danger of liquefaction.

16.3 Retaining Wall 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.

In calculating the active, passive and at rest earth pressure coefficients, the angle of friction between the wall and the backfill material, δ , is assumed to be 0.5ϕ , where ϕ is the angle of internal friction of the backfill.

For the design of retaining walls, the coefficients of horizontal earth pressure in Table 15.1 may be used:

¹ Seed, H.B. and Idriss, I.M. (1971), “Simplified Procedure for Evaluating Soil Liquefaction Potential”, *Journal of Soil*

Table 15.1 – Earth Pressure Coefficient for Earthquake Loading

Wall Condition	Earth Pressure Coefficient (K) for Earthquake Loading			
	Granular A or Granular B Type II $\phi = 35^\circ; \delta = 17.5^\circ, \gamma = 22.8 \text{ kN/m}^3$		OPSS Granular B Type I $\phi = 32^\circ; \delta = 16^\circ, \gamma = 21.2 \text{ kN/m}^3$	
	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	0.45	0.33	0.54
Passive (K_{PE})	6.3	6.3	5.4	5.4
At Rest (K_{OE})**	0.59	-	0.63	-

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

** After Woods

17 CONSTRUCTION CONCERNS

During construction, the Contract Administrator (CA) should employ experienced geotechnical staff to observe construction activities related to foundation construction.

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

- excavation of the shale bedrock will likely require the use of rock excavation methods such as pneumatic rock breakers/splitters to penetrate hard limestone interbeds and other hard zones within the shale.
- undulations in the shale surface, necessitating the use of mass concrete fill to prepare the design founding elevation.
- the sand and silt/silty sand tills may contain cobbles or boulders requiring removal during excavation.
- care must be exercised during excavation to avoid disturbing the founding subgrade. The exposed subgrade soils should be expeditiously inspected, approved and protected from disturbance.
- perched water may be encountered within the existing fills and associated with sand and silt tills. The impact of this perched groundwater is not expected to be significant. However, the Contractor's unwatering plan must be available for rapid implementation should the need arise.

18 CLOSURE

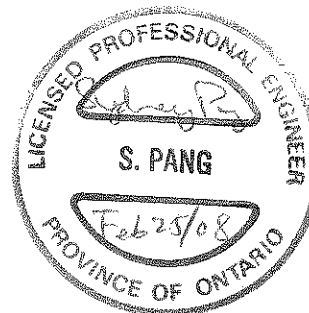
Engineering analysis and preparation of the foundation design report was carried out by Dr. S. Pang, P.Eng. and Ms. R. Palomeque Reyna, P.Eng. The report was reviewed by Dr. P. K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

THURBER ENGINEERING LTD.

Rocio Palomeque Reyna, P.Eng.
Geotechnical Engineer



Sydney Pang, P.Eng.
Associate, Senior Project Engineer



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



Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction

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



4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

5. LEGEND FOR RECORDS OF BOREHOLES

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

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






 Water Level
 C_{pen} Shear Strength Determination by Pocket Penetrometer

- (1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

UNIFIED SOILS CLASSIFICATION

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

EXPLANATION OF ROCK LOGGING TERMS

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

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 0.3 m of core run.

RECORD OF BOREHOLE No NAR01

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION Proposed North Access Road/N-W Ramp N 4 823 313.3 E 289 729.6 ORIGINATED BY SLL
 HWY 401 BOREHOLE TYPE Solid Stem Augers/NQ Coring COMPILED BY MFA
 DATUM Geodetic DATE 2006-12-06 - 2006-12-06 CHECKED BY RPR

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					
194.0							20 40 60 80 100						
0.0	TOPSOIL: (50 mm)		1	SS	8		194						
193.3	Silty CLAY, topsoil stained Firm to Stiff Brown (FILL)												
0.7	SAND and SILT, trace clay, trace gravel Dense to Very Dense Brown Moist (TILL)		2	SS	41		193						
			3	SS	80		192						
			4	SS	50/ .100								5 50 37 8
191.3													
2.7	Silty SAND, trace clay, trace to some gravel Very Dense Brown Moist (TILL)		5	SS	50/ .125		191						10 62 28 (SI+CL)
							190						
189.3			6	SS	50/ 125								
4.7	SHALE, highly weathered, fine grained, thinly bedded, reddish brown, with rubble zones						189						RUN 1# TCR=100%, SCR=96%, RQD=30%
	Limestone interbeds at 5.36m to 5.46m, 6.02m to 6.10m		1	RUN									
							188						RUN 2# TCR=100%, SCR=96%, RQD=60%
	Rubble zones from 6.81m to 6.91m, 7.11m to 7.21m Clay seam from 7.11m to 7.16m		2	RUN			187						
186.3													
7.6	END OF BOREHOLE AT 7.64m BOREHOLE GROUTED WITH BENTONITE TO SURFACE.												

+³, X³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No NAR02

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION Proposed North Access Road/N-W Ramp N 4 832 315.9 E 289 734.8 ORIGINATED BY GA/BJ
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY MFA
 DATUM Geodetic DATE 2006-12-11 - 2006-12-11 CHECKED BY RPR

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		
193.9														
0.0	TOPSOIL: (150 mm)													
0.2	Silty CLAY, trace sand, trace gravel Firm (FILL)		1	SS	7									
193.1														
0.8	SAND and SILT, trace to some clay, trace gravel, occasional oxide staining Very Dense Brown Moist to Wet (TILL)		2	SS	50/ .150		193							
			3	SS	50/ .125		192							
			4	SS	50/ .150		191							
			5	SS	50/ .150		190							
189.9														
4.0	END OF BOREHOLE AT 3.96m. AUGER REFUSAL ON PROBABLE BEDROCK OR BOULDERS. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH(m) ELEV.(m) 13.11.06 1.40 192.4 29.01.07 1.02 192.9 21.09.07 2.83 191.1													

+ 3 . X 3 : Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No NAR04

1 OF 2

METRIC

G.W.P. 2107-05-00 LOCATION Proposed North Access Road/N-W Ramp N 4 832 296.7 E 289 733.6 ORIGINATED BY SLL
 HWY 401 BOREHOLE TYPE Solid Stem Augers/NQ Coring COMPILED BY MFA
 DATUM Geodetic DATE 2006-12-06 - 2006-12-06 CHECKED BY RPR


SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT Y kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
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Continued Next Page

+ 3 x 3 Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

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 (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE			"N" VALUES	20 40 60 80 100	W _p W W _L	20 40 60			
	Continued From Previous Page												
							SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	WATER CONTENT (%) 20 40 60					

[illegible]

RECORD OF BOREHOLE No NAR05

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION Proposed North Access Road/N-W Ramp N 4 832 274.9 E 289 727.2 ORIGINATED BY GA
 HWY 401 BOREHOLE TYPE Solid Stem Augers/NQ Coring COMPILED BY MFA
 DATUM Geodetic DATE 2006-12-07 - 2006-12-07 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT Y KN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
192.4							20	40	60	80	100	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	
0.0	TOPSOIL: (50 mm)		1	SS	24										
191.8	Silty CLAY, trace to some sand, trace gravel, occasional rootlets Very Stiff		2	SS	50/ .150										
0.6	Brown (FILL)		3	SS	50/ .100										
	SHALE, highly weathered, fine grained, thinly bedded, reddish brown, with frequent rubble zones and limestone interbeds		1	RUN											
	Limestone interbeds at 1.73m to 1.76m, 2.21m to 2.24m, 2.29m to 2.39m, 2.54m to 2.59m, 2.87m to 2.90m Clay seams at 1.95m to 1.98m, 2.13m to 2.16m, 2.64m to 2.67m, 2.85m to 2.87m, 3.00m to 3.05m		2	RUN											
	Rubble zones from 3.08m to 3.32m, 3.96m to 4.16m Limestone interbeds at 3.35m to 3.43m, 3.76m to 3.78m, 3.96m to 3.99m, 4.62m to 4.67m														
187.7															
4.7	END OF BOREHOLE AT 4.67m. BOREHOLE GROUTED WITH BENTONTIE TO SURFACE.														

+ 3. X 3: Numbers refer to Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No NAR06

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION Proposed North Access Road/N-W Ramp N 4 832 277.5 E 289 732.3 ORIGINATED BY GA
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY MFA
 DATUM Geodetic DATE 2006-12-07 - 2006-12-07 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT Y kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								20 40 60 80 100						
192.2														
0.0 0.1	TOPSOIL: (75 mm)		1	SS	6		192							
	Silty CLAY, some sand, trace gravel, occasional black staining, occasional rootlets Firm to Very Stiff Brown (FILL)		2	SS	16		191							1 21 53 25
190.8														
1.4	SHALE, highly weathered, fine grained, thinly bedded, reddish brown		3	SS	50/ .150									
189.8			4	SS	50/ .100		190							
2.4	END OF BOREHOLE AT 2.44m. BOREHOLE OPEN TO 2.33m UPON COMPLETION. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. <													

ONTMT4S 2311.GPJ 2/26/08

+ ³ . X ³ : Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No NAR07

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION Proposed North Access Road/N-W Ramp N 4 832 322.1 E 289 747.3 ORIGINATED BY GA
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY MFA
 DATUM Geodetic DATE 2006-10-17 - 2006-10-17 CHECKED BY RPR

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			
193.6															
0.0	TOPSOIL: (125 mm)														
0.1	Silty CLAY, with sand, trace gravel, occasional rootlets Stiff to Hard Brown (FILL)		1	SS	9										
			2	SS	31										
192.1															
1.5	Silty SAND, trace clay, trace gravel, occasional iron oxide staining Very Dense Brown to Grey Moist (TILL)		3	SS	87										
			4	SS	50/ .150										
			5	SS	50/ .150										
	occasional shale fragments		6	SS	50/ .150										
188.2															
5.5	SHALE, highly weathered, thinly bedded, reddish brown														
187.3			7	SS	50/ .125										
6.4	END OF BOREHOLE AT 6.37m. BOREHOLE OPEN TO 6.37m AND WATER LEVEL AT 4.57m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG.														

+ 3 . X 3 : Numbers refer to
Sensitivity

20
15 10 5
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No NAR08

1 OF 2

METRIC

G.W.P. 2107-05-00 LOCATION Proposed North Access Road/N-W Ramp N 4 832 324.6 E 289 752.5 ORIGINATED BY GA
 HWY 401 BOREHOLE TYPE Solid Stem Augers/NO Coring COMPILED BY MFA
 DATUM Geodetic DATE 2006-10-17 - 2006-10-17 CHECKED BY RPR

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 (%)		
								20 40 60 80 100										

193.7	0.0	0.1	TOPSOIL: (100 mm)												
			Silty CLAY, some sand, trace gravel, occasional rootlets Firm to Very Stiff Mottled Brown to Grey (FILL)	1	SS	6									
				2	SS	24									
192.1															
1.5			SAND and SILT, some clay, trace gravel Dense to Very Dense Brown Moist (TILL)	3	SS	43									
				4	SS	50/ .150									4 36 47 13
190.9															
2.7			Sandy SILT, trace clay Very Dense Brown Moist	5	SS	50/ .150									0 27 69 4
			becoming Grey												
188.9				6	SS	80									
4.7			Silty CLAY, trace sand, trace gravel, occasional shale fragments Hard Reddish Brown (TILL)												
188.2															
5.5			SHALE, highly to moderately weathered, fine grained, thinly bedded, reddish brown, with frequent rubble zones and limestone interbeds	7	SS	50/ .150									
			Rubble zone from 6.43m to 6.74m												
			Limestone interbeds at 6.76m to 6.79m, 7.52m to 7.55m	1	RUN										RUN 1# TCR=100%, SCR=75%, RQD=22%
			Moderately to slightly weathered Limestone interbeds at 7.77m to 7.89m, 8.28m to 8.33m, 8.72m to 8.77m, 8.92m to 9.07m, 9.14m to 9.17m, 9.24m to 9.30m	2	RUN										RUN 2# TCR=100%, SCR=97%, RQD=53%
184.4															
9.3			END OF BOREHOLE AT 9.30m. BOREHOLE OPEN TO BOTTOM UPON COMPLETION.												

Continued Next Page

+ 3 X 3 Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

ONTMT4S 2311.GPJ 2/26/08

RECORD OF BOREHOLE No NAR08

2 OF 2

METRIC

G.W.P. 2107-05-00 LOCATION Proposed North Access Road/N-W Ramp N 4 832 324.6 E 289 752.5 ORIGINATED BY GA
 HWY 401 BOREHOLE TYPE Solid Stem Augers/NQ Coring COMPILED BY MFA
 DATUM Geodetic DATE 2006-10-17 - 2006-10-17 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 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								
	Continued From Previous Page												
	Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH(m) ELEV.(m) 08.12.06 0.80 192.8 29.01.07 0.70 193.0 01.11.07 5.89 187.8												

RECORD OF BOREHOLE No NAR09

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION Proposed North Access Road/N-W Ramp N 4 832 302.8 E 289 746.1 ORIGINATED BY GA
 HWY 401 BOREHOLE TYPE Solid Stem Augers/NQ Coring COMPILED BY MFA
 DATUM Geodetic DATE 2006-10-12 - 2006-10-12 CHECKED BY RPR

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						
192.8 0.0 0.1	TOPSOIL: (75 mm) Silty CLAY, trace to some sand, trace gravel Firm Reddish Brown (FILL)		1	SS	7		192							1 44 43 12
192.0 0.8	SAND and SILT, some clay, trace gravel, occasional iron oxide staining Compact to Very Dense Brown Moist (TILL)		2	SS	24		191							
			3	SS	68		190							
			4	SS	50/ .150		189							
			5	SS	50/ .150		188							
			6	SS	50/ .100		187							
188.8 4.0	SHALE, highly weathered, fine grained, thinly bedded, reddish brown, with frequent rubble zones and limestone interbeds Clay seams at 4.67m to 4.77m, 4.96m to 5.01m Rubble zones from 5.49m to 5.54m, 5.79m to 5.82m Rubble zone from 6.60m to 6.65m Limestone interbed at 6.96m to 7.01m		1	RUN			186							RUN 1# TCR=100%, SCR=83%, RQD=13%
185.1 7.7	END OF BOREHOLE AT 7.74m. BOREHOLE OPEN TO 7.74m AND WATER LEVEL AT 3.90m UPON COMPLETION. BOREHOLE GROUTED TO 0.91 m AND BACKFILLED WITH BENTONITE HOLEPLUG.		2	RUN										RUN 2# TCR=100%, SCR=92%, RQD=35%, UCS=3MPa

ONTMT4S 2311.GPJ 2/26/08

+³ X³: Numbers refer to
Sensitivity

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(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No NAR10

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION Proposed North Access Road/N-W Ramp N 4 832 305.4 E 289 751.3 ORIGINATED BY GA/BJ
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY MFA
 DATUM Geodetic DATE 2006-10-12 - 2006-10-12 CHECKED BY RPR

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									
192.8								20	40	60	80	100					
0.0	TOPSOIL: (150 mm)																
0.2	Silty CLAY, trace sand, trace gravel, some rootlets Stiff Brown (FILL)		1	SS	8		192										
			2	SS	11												
191.0																	
1.8	Silty SAND, some clay, trace gravel, occasional oxide staining, occasional shale fragments Dense to Very Dense Brown Moist (TILL)		3	SS	37		191									6	53 30 11
			4	SS	50/ .100		190										
			5	SS	50/ .125												
189.1																	
3.7	SHALE, highly weathered, fine grained, thinly bedded, reddish brown						189										
188.2																	
4.6	END OF BOREHOLE AT 4.57m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH(m) ELEV.(m) 29.01.07 Frozen at surface 21.09.07 2.02 190.8		6	SS	50/ .050												

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

RECORD OF BOREHOLE No NAR11

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION Proposed North Access Road/N-W Ramp N 4 832 283.7 E 289 744.9 ORIGINATED BY GA
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY MFA
 DATUM Geodetic DATE 2006-12-07 - 2006-12-07 CHECKED BY RPR

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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE		WATER CONTENT (%) w _p w w _L				
192.0							20 40 60 80 100							
0.0 0.1	TOPSOIL: (75 mm)		1	SS	11									
	Silty CLAY, some sand, trace gravel Stiff Brown to Reddish Brown (FILL)													
	Becoming Hard, Dark Brown		2	SS	58									
190.5														
1.5	SAND and SILT, some clay, trace gravel, some shale fragments Very Dense Brown to Reddish Brown Moist (TILL)		3	SS	50/ .125									4 42 43 11
			4	SS	50/ .150									
189.0														
188.8 3.2	SHALE, highly weathered, thinly bedded, reddish brown		5	SS	50/ .150									
	END OF BOREHOLE AT 3.18m. BOREHOLE OPEN AND DRY TO BOTTOM UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.													

+³ . X³: Numbers refer to
Sensitivity

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15 10 5
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No NAR12

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION Proposed North Access Road/N-W Ramp N 4 832 286.2 E 289 750.0 ORIGINATED BY GA
 HWY 401 BOREHOLE TYPE Solid Stem Augers/NQ Coring COMPILED BY MFA
 DATUM Geodetic DATE 2006-12-07 - 2006-12-07 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT Y kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
192.0								20 40 60 80 100					
0.0	TOPSOIL: (50 mm)		1	SS	7		192						
	Silty CLAY, some sand, trace gravel Firm to Very Stiff Brown (FILL)		2	SS	24		191						1 28 48 23
190.5													
1.5	Silty SAND, trace gravel Very Dense Brown Wet (TILL)		3	SS	86/ 250		190						
			4	SS	70/ 225								
189.0													
3.0	SHALE, highly to moderately weathered, fine grained, thinly bedded, reddish brown, with rubble zones and limestone interbeds		5	SS	50/ .150		189						
							188						
	Rubble zone from 4.65m to 4.68m		6	SS	95/ .225		187						
	Limestone interbeds at 5.03m to 5.08m, 5.15m to 5.23m, 5.76m		1	RUN			186						
			2	RUN			185						
184.4													
7.6	END OF BOREHOLE AT 7.57m. BOREHOLE OPEN TO 7.57m AND WATER LEVEL AT 3.61m UPON COMPLETION. BOREHOLE GROUTED TO 0.91 m AND BACKFILLED WITH BENTONITE HOLEPLUG.												

+ 3, X 3: Numbers refer to
Sensitivity

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(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No NAR13

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION Proposed North Access Road/N-W Ramp N 4 832 277.4 E 289 710.3 ORIGINATED BY GA
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY MFA
 DATUM Geodetic DATE 2006-12-07 - 2006-12-07 CHECKED BY RPR

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							PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE									
							20	40	60	80	100	WATER CONTENT (%) 20 40 60					
193.4																	
0.0	TOPSOIL: (50 mm)		1	SS	23												
	SHALE, highly weathered, fine grained, thinly bedded, reddish brown		2	SS	50/ .150												
			3	SS	60/ .025												
			4	SS	50/ .075												
191.0																	
2.4	END OF BOREHOLE AT 2.37m. BOREHOLE OPEN AND DRY TO BOTTOM UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG.																

+ ³ × ³ : Numbers refer to
Sensitivity

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15 10 5
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No NAR14

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION Proposed North Access Road/N-W Ramp N 4 832 320.9 E 289 769.3 ORIGINATED BY GA
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY MFA
 DATUM Geodetic DATE 2006-10-17 - 2006-10-17 CHECKED BY RPR

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						
								20 40 60 80 100						
								20 40 60 80 100						
193.7								20 40 60 80 100						
0.0	TOPSOIL: (125 mm)							20 40 60 80 100						
0.1	Silty CLAY, trace to some sand, trace gravel, occasional rootlets Firm to Stiff Brown (FILL)		1	SS	5		193							
			2	SS	10									
			3	SS	11		192							
191.4														
2.3	Silty SAND, trace clay, trace gravel Dense Brown Moist		4	SS	34		191							3 67 27 3
			5	SS	50/ .150									
190.0														
3.7	SAND and SILT, trace to some clay, trace gravel Very Dense Brown Moist (TILL) becoming Mottled Grey to Reddish Brown		6	SS	50/ .150		189							2 43 41 14
188.2														
5.5	SHALE, highly weathered, fine grained, thinly bedded, reddish brown		7	SS	60/ .150		188							
187.3														
6.4	END OF BOREHOLE AT 6.40 m. BOREHOLE OPEN AND DRY TO BOTTOM UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG.													

+ ³ . X ³ : Numbers refer to
Sensitivity

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(%) STRAIN AT FAILURE

METRIC

G.W.P.	2107-05-00	LOCATION	Proposed North Access Road/N-W Ramp N 4 832 342.5 E 289 748.0	ORIGINATED BY	GA
HWY	401	BOREHOLE TYPE	Solid Stem Augers	COMPILED BY	ES
DATUM	Geodetic	DATE	2007-10-02 - 2007-10-02	CHECKED BY	RPR

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ONTMT4S 2311.GPJ 2/26/08

+ 3, x 3: Numbers refer to Sensitivity

RECORD OF BOREHOLE No NAR16

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION Proposed North Access Road/N-W Ramp N 4 832 269.4 E 289 744.6 ORIGINATED BY GA
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY ES
 DATUM Geodetic DATE 2007-10-02 - 2007-10-02 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT Y kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
191.8								20	40	60	80	100		
0.0 0.1	TOPSOIL: (50mm)		1	SS	42									
191.1	SHALE, highly weathered Dense Reddish brown (FILL)		2	SS	50/ .150		191							
0.8	CLAY, silty, trace to some sand, trace gravel Very dense Grey to brown (TILL)		3	SS	50/ .75									
190.3	SHALE, highly weathered, fine grained, thinly bedded Reddish brown		4	SS	50/ .125		190							
1.5			5	SS	100/ .75		189							
188.2														
3.7	END OF BOREHOLE AT 3.7m. AUGER REFUSAL AT 3.7m ON POSSIBLE LIMESTONE LAYER. BOREHOLE OPEN AND DRY UPON COMPLETION. Piezometer installation consists of 19mm diameter schedule PVC pipe. WATER LEVEL READINGS: DATE DEPTH(m) ELEV.(m) Oct 05/07 1.9 190.0 Oct 18/07 2.0 189.9 Nov 01/07 1.9 190.0													

RECORD OF BOREHOLE No RW1-1

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION Hurontario St. North - HWY 401 West Ramp, N 4 832 167.797 E 289 673.658 ORIGINATED BY GA
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY ES
 DATUM Geodetic DATE 2007-10-04 - 2007-10-04 CHECKED BY RPR

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						
								20 40 60 80 100						
189.8														
0.0 0.1	TOPSOIL: (75mm)		1	SS	37									
189.0	Silty CLAY, trace sand, trace shale fragments, occasional rootlets Hard Reddish brown (FILL)													
0.8			2	SS	17									
188.3	Silty CLAY, some sand, trace gravel, occasional shale fragments Very stiff Brown to reddish brown (TILL)		3	SS	50/ .150									
1.5	SHALE, highly weathered, fine grained, thinly bedded, reddish brown Occasional green siltstones		4	SS	100/ .125									
186.7														
3.0	END OF BOREHOLE AT 3.05m. AUGER REFUSAL ON PROBABLE LIMESTONE LAYER. BOREHOLE OPEN AND DRY TO BOTTOM UPON COMPLETION. Piezometer installation consists of 19mm diameter schedule PVC pipe. WATER LEVEL READINGS: DATE DEPTH(m) ELEV.(m) Oct 18/07 1.4 188.4 Nov 01/07 0.9 188.9 Nov 15/07 1.3 188.5													







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

RECORD OF BOREHOLE No RW1-2

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION Hurontario St. North - HWY 401 West Ramp, N 4 832 201.428 E 289 703.136 ORIGINATED BY GA
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY ES
 DATUM Geodetic DATE 2007-10-04 - 2007-10-04 CHECKED BY RPR

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										
190.7							20	40	60	80	100							
0.0	TOPSOIL: (50mm)		1	SS	34													
190.1	Silty CLAY, trace to some sand, trace gravel, occasional rootlets		2	SS	50/													
0.6	Hard Brown to reddish brown (TILL)		3	SS	100/													
	SHALE, highly weathered, fine grained, thinly bedded, reddish brown		4	SS	100/													
			5	SS	100/													
	Moderate to slightly weathered, 50mm thick limestone layer																	
187.0																		
3.7	END OF BOREHOLE AT 3.66m. AUGER REFUSAL ON PROBABLE LIMESTONE LAYER. BOREHOLE OPEN AND DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.																	


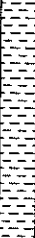
+³, ×³: Numbers refer to Sensitivity
 20
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 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No RW1-3

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION Hurontario St. North - HWY 401 West Ramp, N 4 832 242.122 E 289 722.765 ORIGINATED BY GA
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY ES
 DATUM Geodetic DATE 2007-10-03 - 2007-10-03 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT Y kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
191.6								20	40	60	80	100		
0.9	TOPSOIL: (50mm)		1	SS	21		191							1 16 63 20
	Silty CLAY, some sand, trace gravel, occasional rootlets Very stiff to hard Brown to dark brown (TILL)		2	SS	50/ .150									
190.3							190							
1.4	SHALE, highly to moderately weathered, fine grained, thinly bedded, reddish brown		3	SS	50/ .75									
			4	SS	100/ .125		189							
	Slightly weathered		5	SS	100/ .150									
187.7							188							
4.0	END OF BOREHOLE AT 3.96m. AUGER REFUSAL ON PROBABLE LIMESTONE LAYER. BOREHOLE OPEN AND DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.													

RECORD OF BOREHOLE No RW2-1

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION Northwest Quadrant of HWY 401 & Hurontario St., N 4 832 206.495 E 289 756.121 ORIGINATED BY GA
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY ES
 DATUM Geodetic DATE 2007-10-03 - 2007-10-03 CHECKED BY RPR

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	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	TOPSOIL: (75mm)		1	SS	20		190										
0.1	Silty CLAY, some sand, trace gravel, occasional rootlets Very stiff Brown																
189.5	(TILL)		2	SS	50/ .150												
0.8	SHALE, highly to moderately weathered, fine grained, thinly bedded, reddish brown						189										
			3	SS	100/ .150												
	Occasional green siltstone interbeds		4	SS	100/ .150		188										
			5	SS	50/ .000		187										
186.6	END OF BOREHOLE AT 3.66m. AUGER REFUSAL ON PROBABLE LIMESTONE LAYER. BOREHOLE OPEN AND DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.																
3.7																	

+³, x³: Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No RW2-2

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION Northwest Quadrant of HWY 401 & Hurontario St., N 4 832 232.272 E 289 800.127 ORIGINATED BY GA
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY ES
 DATUM Geodetic DATE 2007-10-03 - 2007-10-03 CHECKED BY RPR

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					
191.0								20 40 60 80 100		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	
0.0	Silty CLAY, trace to some sand, trace gravel, occasional rootlets Hard Brown (FILL)		1	SS	50/ .150								
190.4													
0.6	Silty CLAY, some sand, trace gravel, occasional rootlets Hard		2	SS	50/ .150								
189.8	Dark grey (TILL)												
1.2	SHALE, highly weathered, fine grained, thinly bedded, reddish brown		3	SS	100/ .125								
			4	SS	100/ .150								
188.0													
3.0	END OF BOREHOLE AT 3.05m. AUGER REFUSAL ON PROBABLE LIMESTONE BEDROCK. BOREHOLE OPEN AND DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.												

+ 3. X 3. Numbers refer to
Sensitivity

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(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No RW2-3

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION Northwest Quadrant of HWY 401 & Hurontario St., N 4 832 256.327 E 289 842.838 ORIGINATED BY GA
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY ES
 DATUM Geodetic DATE 2007-10-03 - 2007-10-03 CHECKED BY RPR

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
194.9							20	40	60	80	100									
0.0	TOPSOIL: (75mm)																			
0.1	Silty CLAY, trace to some sand, trace gravel, occasional rootlets Hard to Very Stiff Brown to Mottled Grey and Brown (FILL)		1	SS	48															
			2	SS	23															
193.3																				
1.5	SHALE, highly weathered, thinly bedded, reddish brown (FILL)		3	SS	8															
			4	SS	20															
191.9																				
3.0	Silty CLAY, some sand, trace gravel, occasional rootlets Hard Dark grey (TILL)		5	SS	71															
191.2																				
3.7	SHALE, highly weathered, fine grained, thinly bedded, reddish brown																			
			6	SS	100/ .125															
188.8																				
6.1	END OF BOREHOLE AT 6.10m. AUGER REFUSAL ON PROBABLE LIMESTONE LAYER. BOREHOLE OPEN AND DRY UPON COMPLETION. Piezometer installation consists of 19mm diameter schedule PVC pipe. WATER LEVEL READINGS: DATE DEPTH(m) ELEV.(m) Oct 05/07 5.0 189.9 Oct 18/07 2.8 192.1 Nov 01/07 2.9 192.0 Nov 15/07 2.7 192.2																			

+ 3 x 3: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

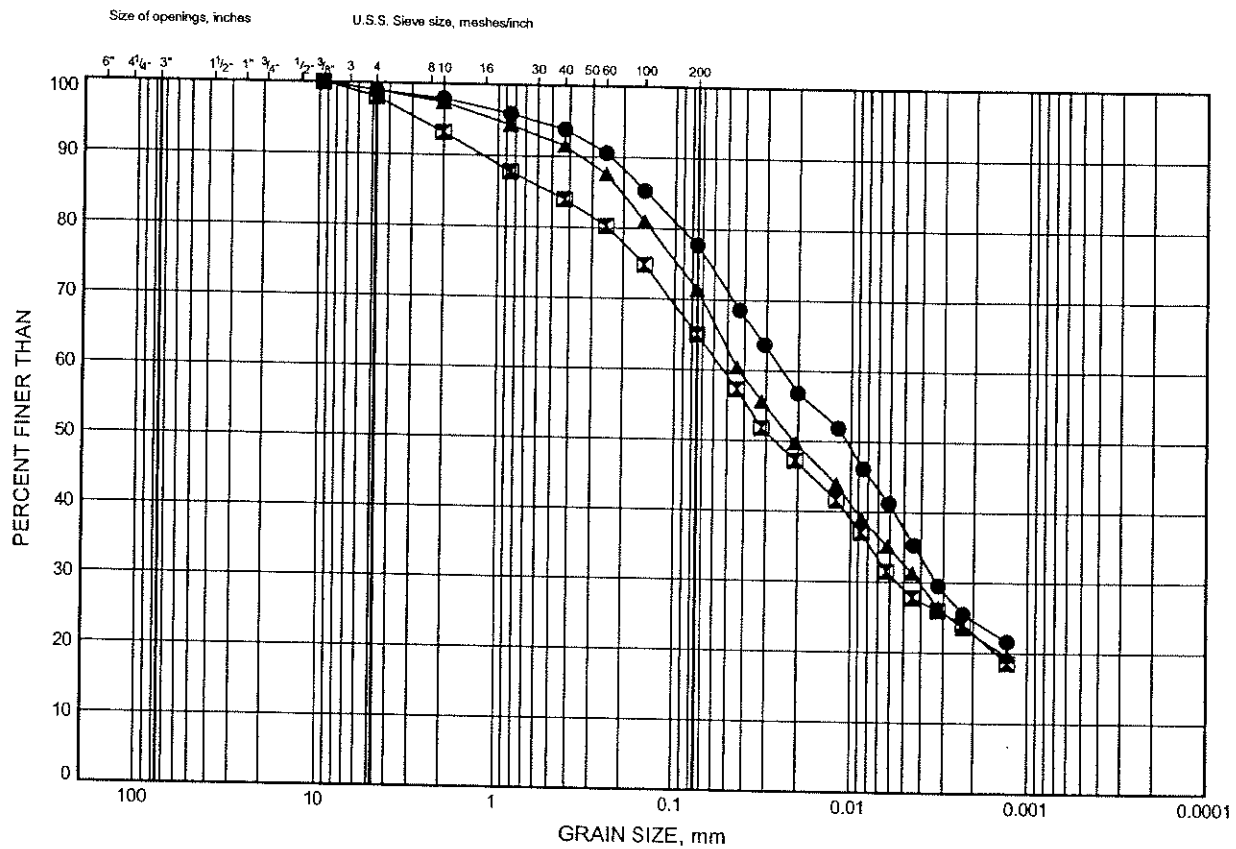
Appendix B

Laboratory Test Results

Hwy 401/410 to Credit River GRAIN SIZE DISTRIBUTION

FIGURE B1

SILTY CLAY FILL



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	NAR06	1.07	191.15
⊠	NAR07	1.07	192.58
▲	NAR12	1.07	190.94



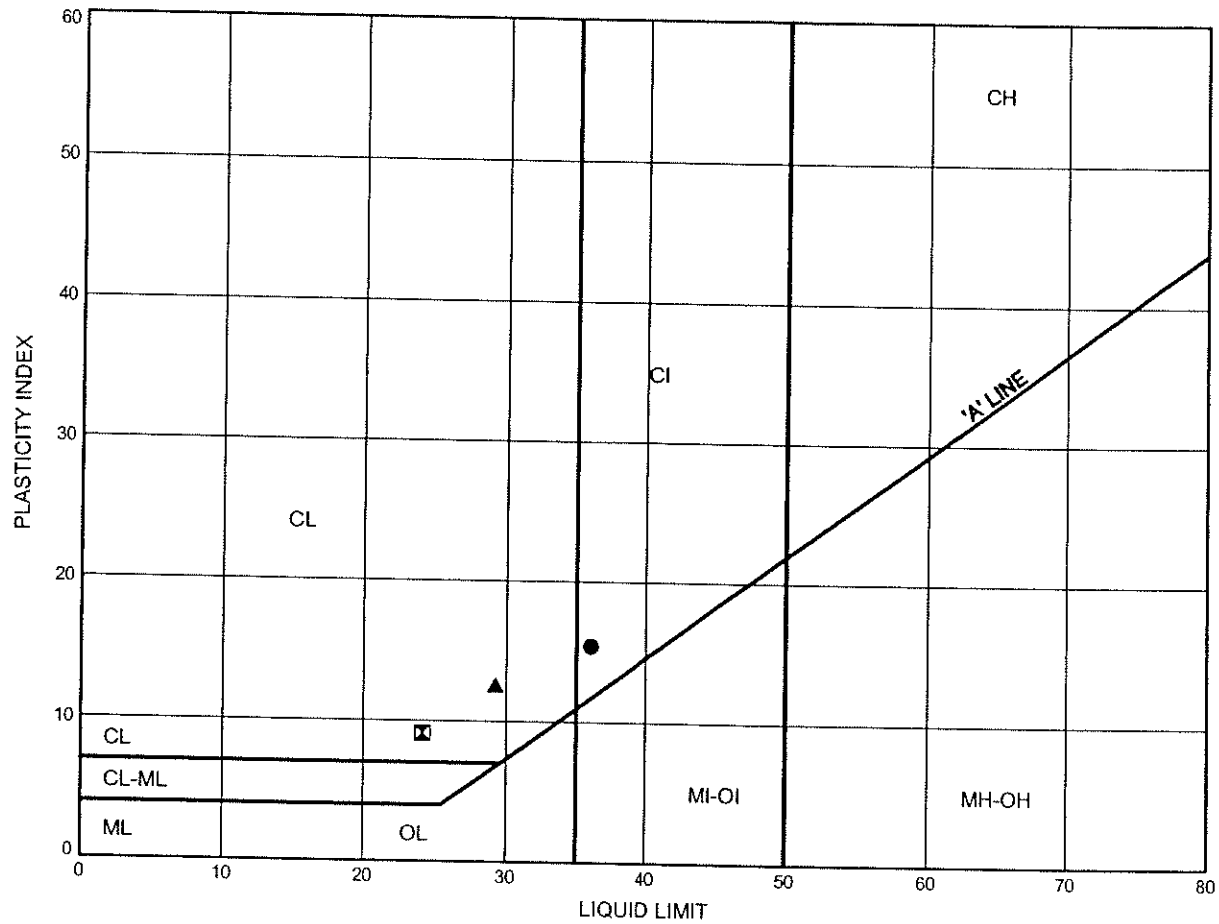
Date January 2008
Project 2107-05-00

Prep'd MFA
Chkd. SKP

Hwy 401/410 to Credit River ATTERBERG LIMITS TEST RESULTS

FIGURE B2

SILTY CLAY FILL

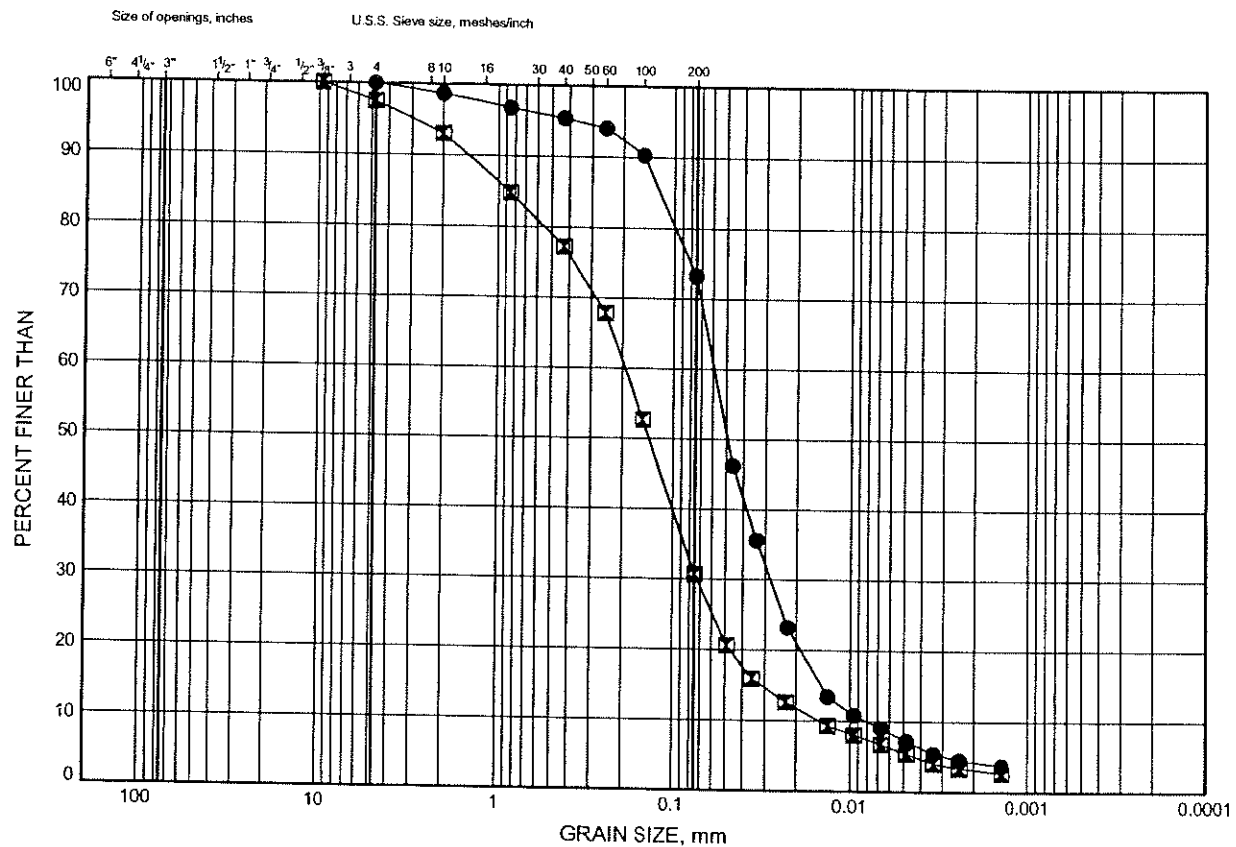


SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	NAR06	1.07	191.15
⊠	NAR07	1.07	192.58
▲	NAR12	1.07	190.94

Hwy 401/410 to Credit River GRAIN SIZE DISTRIBUTION

FIGURE B3

SILTY SAND TO SANDY SILT



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	NAR08	3.12	190.54
◻	NAR14	2.59	191.12

Date January 2008
Project 2107-05-00

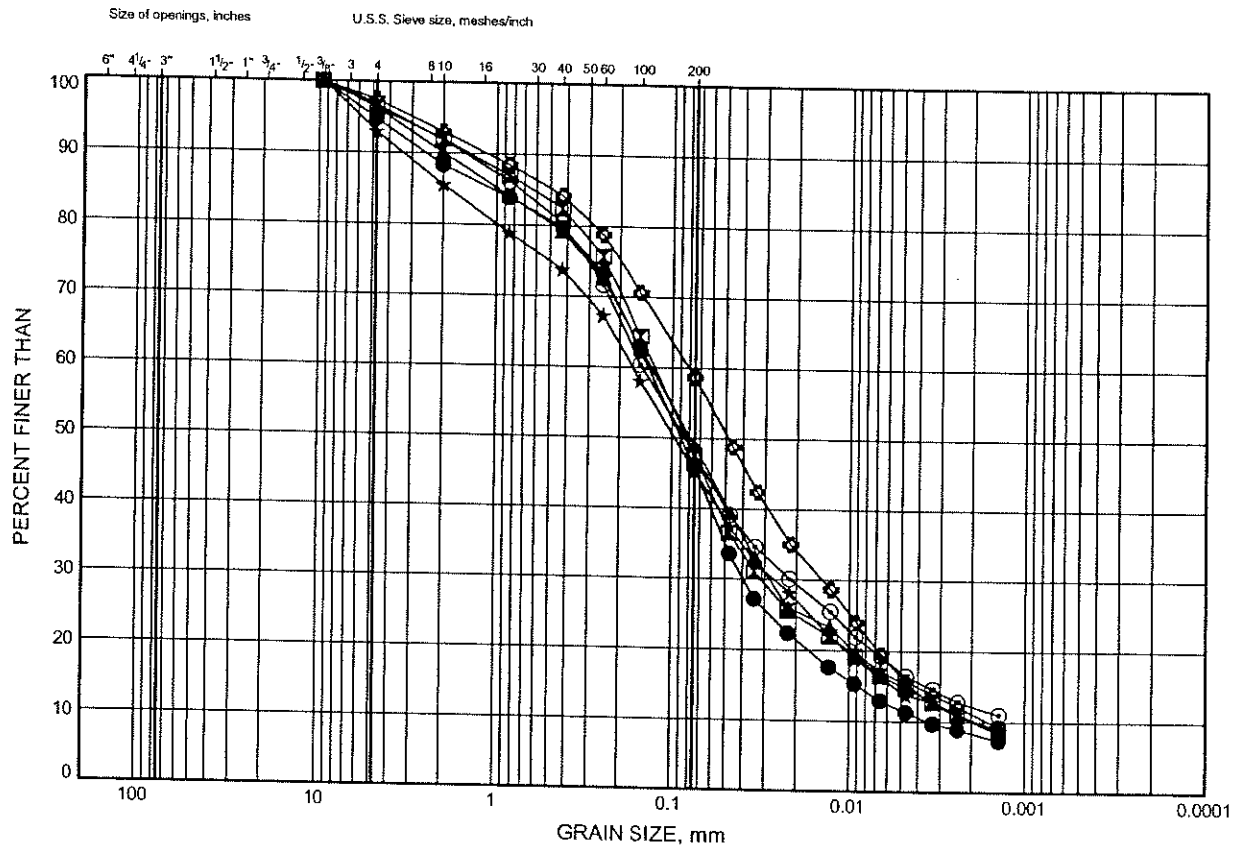


Prep'd MFA
Chkd. SKP

Hwy 401/410 to Credit River GRAIN SIZE DISTRIBUTION

FIGURE B4

SAND AND SILT TILL



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	NAR01	2.41	191.56
⊠	NAR02	2.36	191.49
▲	NAR03	1.83	191.30
★	NAR03	2.59	190.53
⊙	NAR04	1.68	191.41
⊛	NAR04	3.12	189.96

Date January 2008

Project 2107-05-00



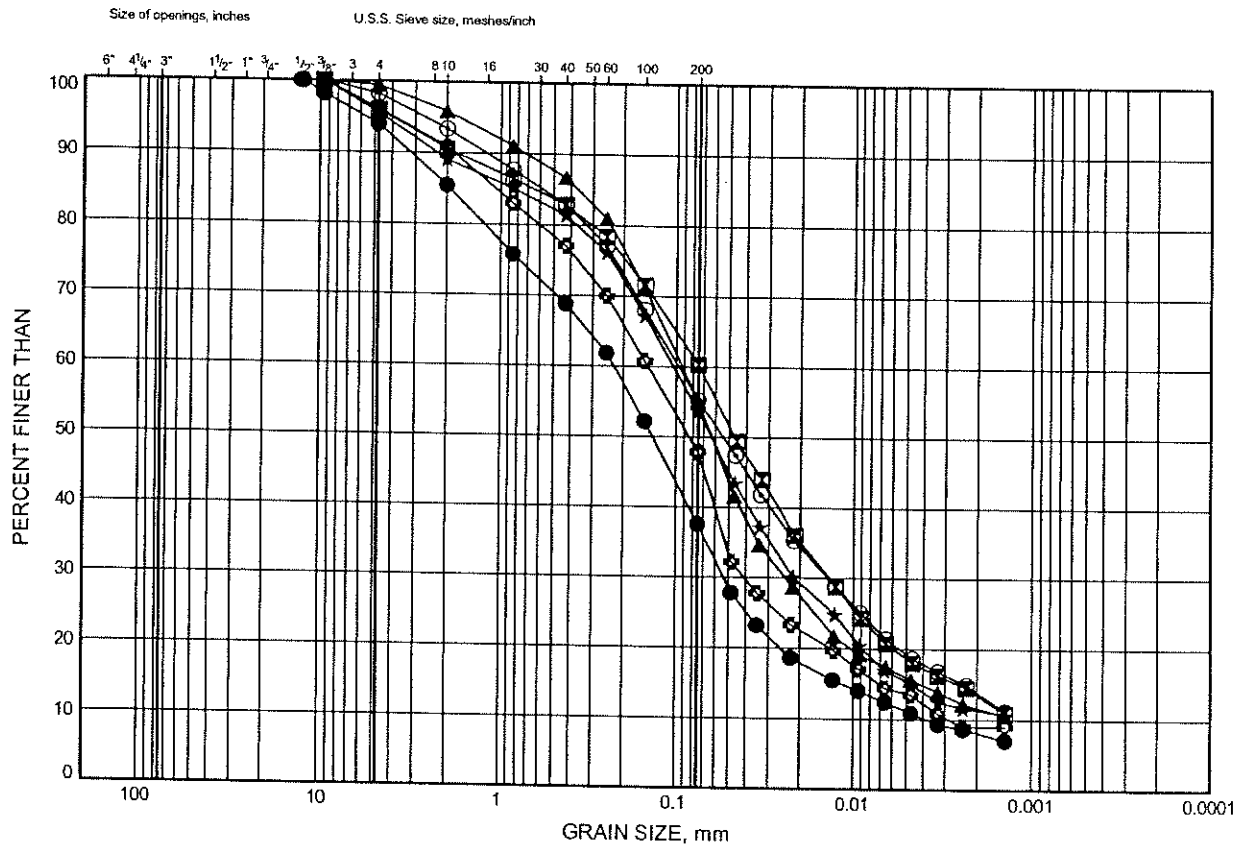
Prep'd MFA

Chkd. SKP

Hwy 401/410 to Credit River GRAIN SIZE DISTRIBUTION

FIGURE B5

SAND AND SILT TILL



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	NAR07	2.59	191.06
⊠	NAR08	2.36	191.30
▲	NAR09	1.83	190.96
★	NAR11	1.83	190.19
⊙	NAR14	4.88	188.84
⊛	NAR15	3.35	190.98



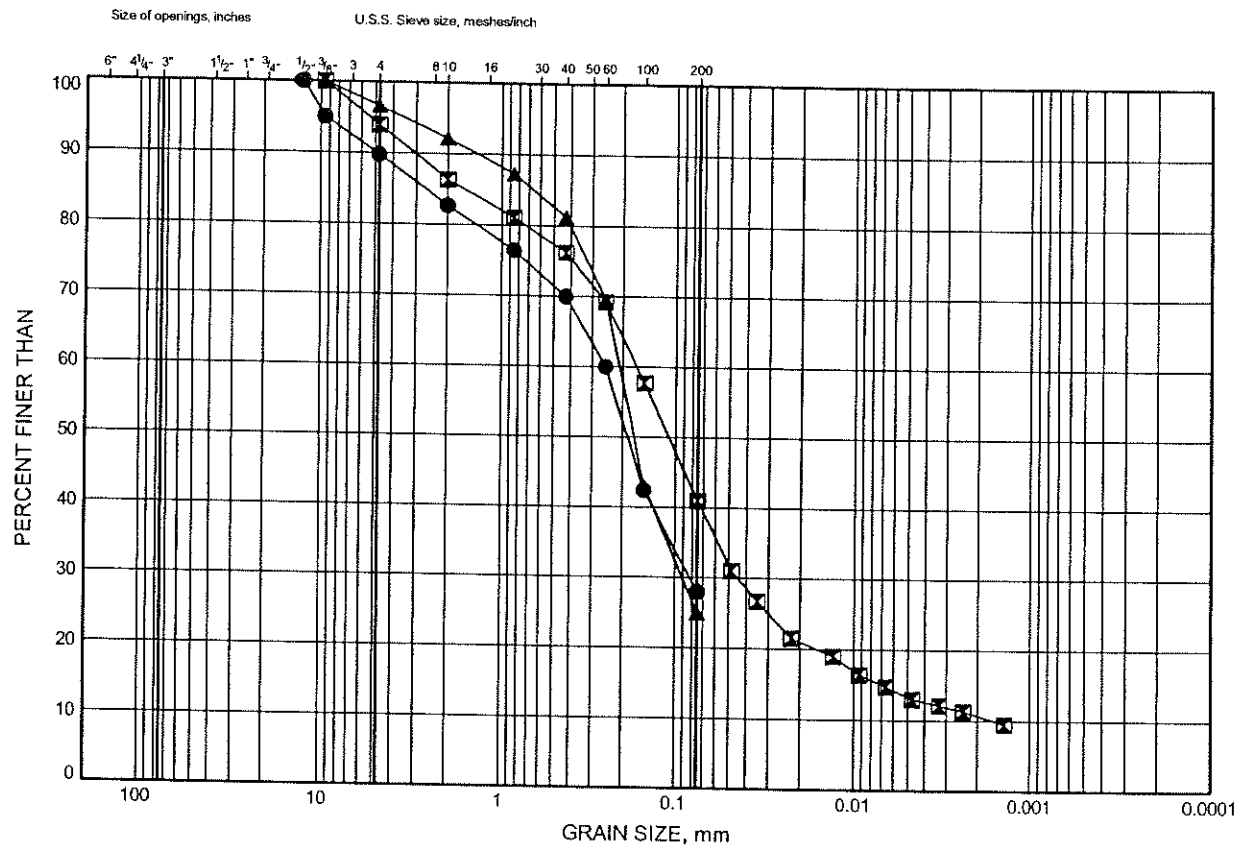
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Hwy 401/410 to Credit River GRAIN SIZE DISTRIBUTION

FIGURE B6

SILTY SAND TILL



Size of openings, inches

U.S.S. Sieve size, meshes/inch

Size of openings, inches	U.S.S. Sieve size, meshes/inch
6"	10
4 1/4"	16
3"	20
1 1/2"	10
1"	20
3/4"	20
1/2"	30
3/8"	40
3"	60
4"	80
8"	100
10"	120
16"	160
30"	200
40"	240
50"	280
60"	320
100"	400
200"	800

PERCENT FINER THAN

GRAIN SIZE, mm

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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	NAR15	1.83	192.50

Project 2107-05-00

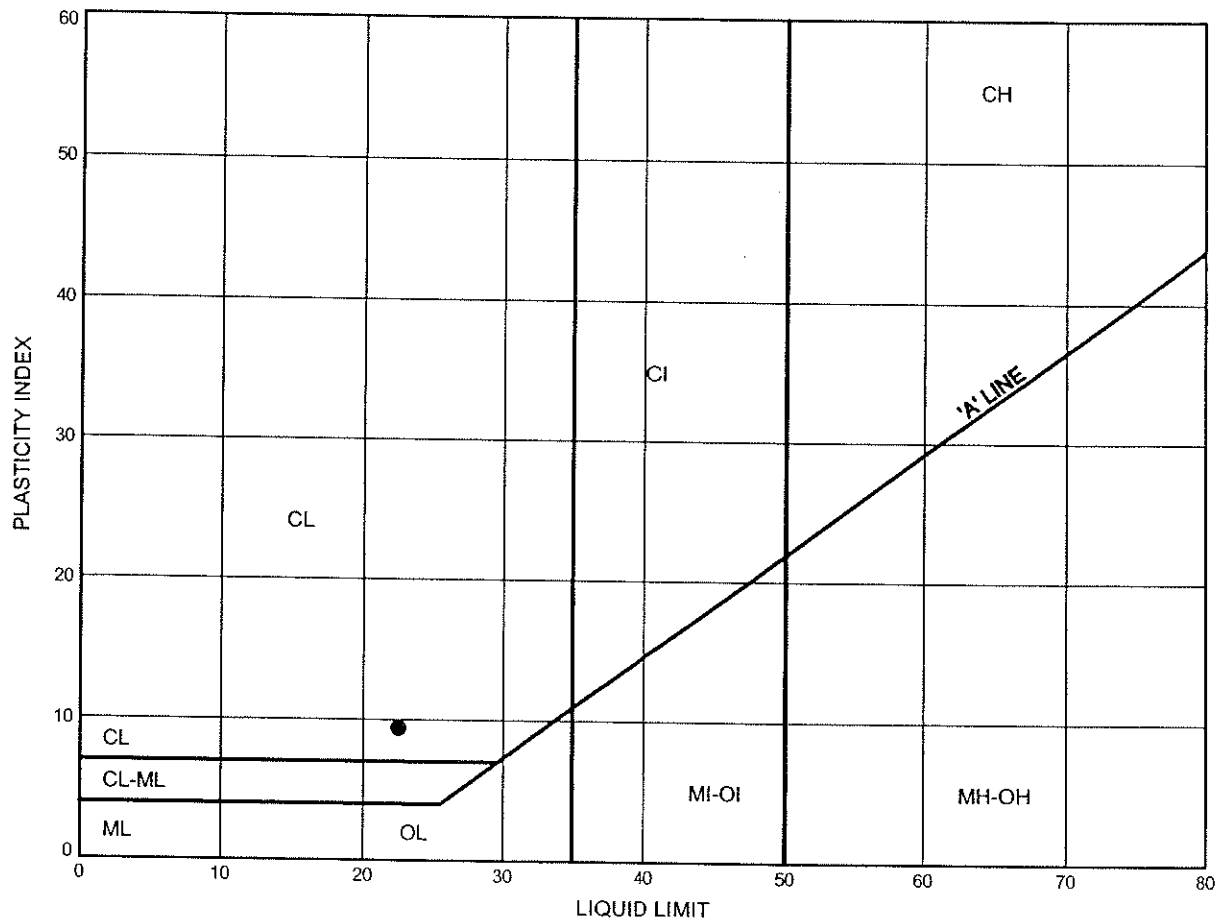


Chkd. SKP

Hwy 401/410 to Credit River
ATTERBERG LIMITS TEST RESULTS

FIGURE B8

SILTY CLAY TILL



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	NAR15	1.83	192.50



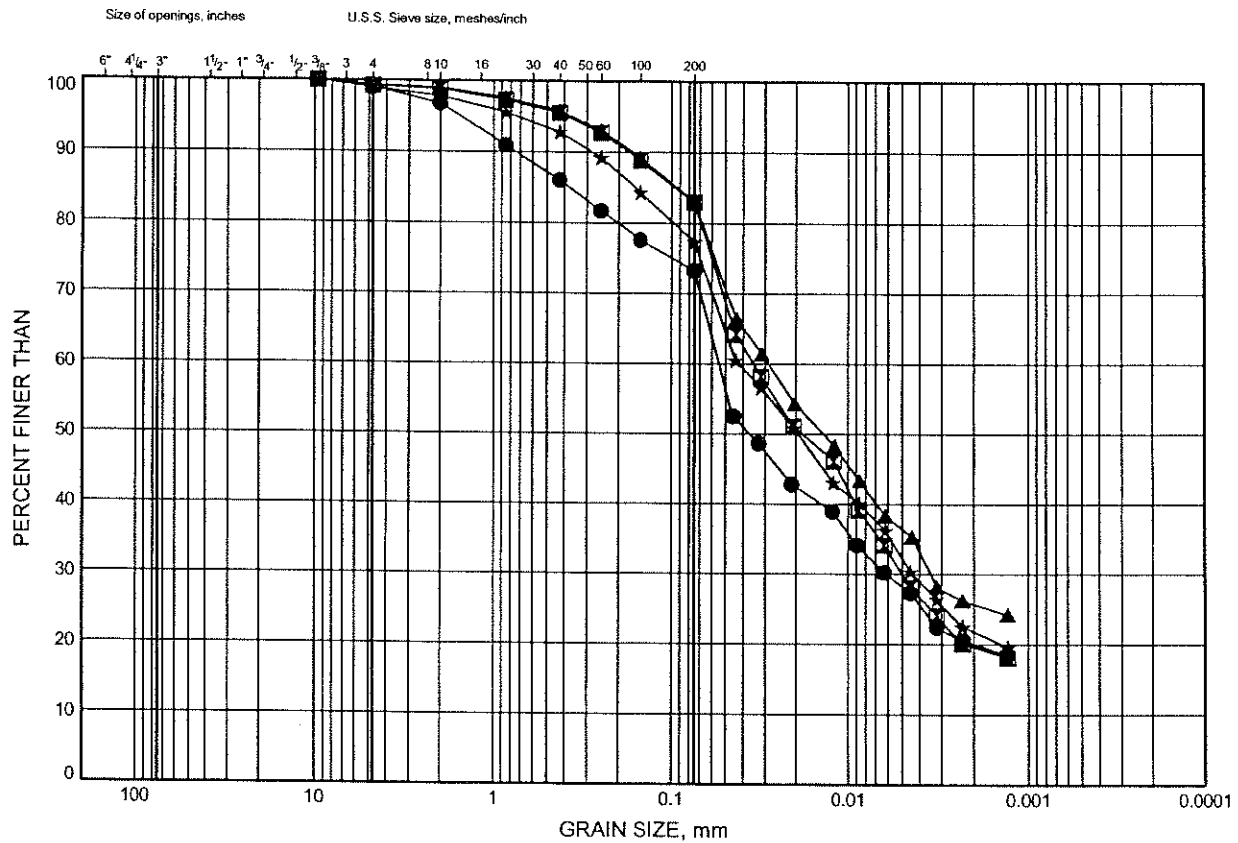
Date January 2008
 Project 2107-05-00

Prep'd MFA
 Chkd. SKP

Hwy 401/410 to Credit River GRAIN SIZE DISTRIBUTION

FIGURE B9

SILTY CLAY TILL



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	RW1-1	1.07	188.71
⊠	RW1-3	1.07	190.56
▲	RW2-2	1.07	189.97
★	RW2-3	3.35	191.52

Date January 2008

Project 2107-05-00



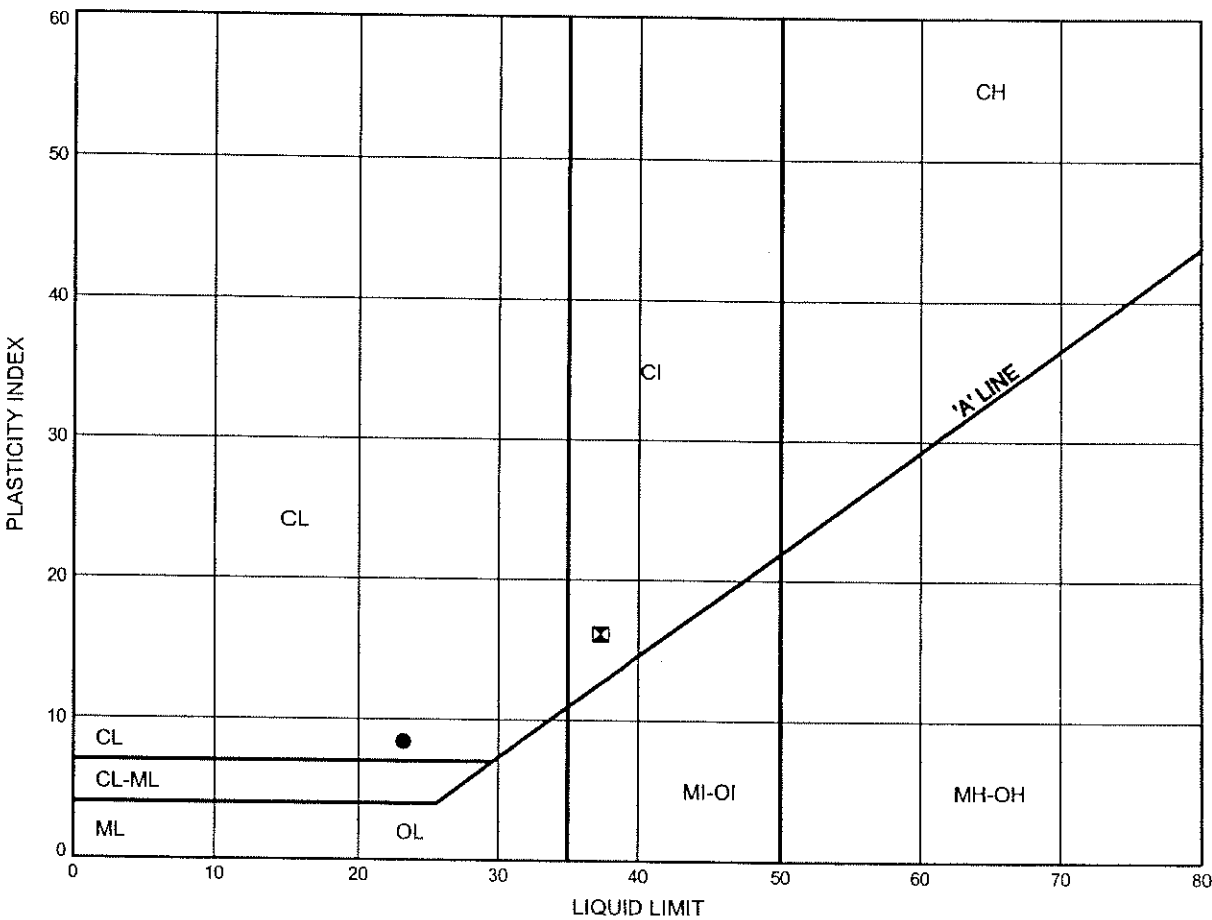
Prep'd MFA

Chkd. SKP

Hwy 401/410 to Credit River
ATTERBERG LIMITS TEST RESULTS

FIGURE B10

SILTY CLAY TILL



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	RW1-1	1.07	188.71
⊠	RW1-3	1.07	190.56

Date January 2008
 Project 2107-05-00



Prep'd MFA
 Chkd. SKP

Appendix C

Foundation Comparison

HWY 401 Widening – Hurontario North Access Road (N-W RAMP)

COMPARISON OF FOUNDATION ALTERNATIVES

Footings on Native Soil or Shale	Driven Piles	Caissons
<p>Advantages:</p> <ul style="list-style-type: none"> i. Ease of construction. ii. Presence of bedrock near design grade of the cut. iii. High values of geotechnical resistance are available on the dense till deposits and bedrock. iv. Lower cost than deep foundations. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Stepped footing may be required to accomodate undulation of bedrock. ii. Higher cost of excavation into bedrock. iii. Mass concrete fill may be required to raise the founding subgrade level. <p>RECOMMENDED</p>	<p>Advantages:</p> <ul style="list-style-type: none"> i. Piles will develop high geotechnical resistance in hard/dense soils. ii. Installation of piles could continue in freezing weather. iii. Readily installed. iv. Foundation construction requires less volume of excavation than footings <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Higher unit costs than footings. ii. Possibility that cobbles and boulders may be encountered in till. iii. Not practical to drive piles into shale bedrock. <p>NOT RECOMMENDED</p>	<p>Advantages:</p> <ul style="list-style-type: none"> i. High resistance is available for caissons founded in dense till/bedrock. ii. Construction of caissons could continue in freezing weather. iii. Subexcavation of fill and variable material not required. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Higher cost than spread footings ii. Possibility of boulders being encountered during augering. iii. Potential difficulties penetrating hard limestone layers in shale. iv. More likely to encounter groundwater. v. Potential difficulty in cleaning and inspecting bases. <p>NOT RECOMMENDED</p>

Appendix D

Special Provisions

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

- SP 902 S01
- OPSS 120 (1994)
- OPSS 206 (2002)
- OPSD 3501.000.
- OPSS 902
- SP 105S19
- SP572S01
- SP 110F13
- OPSD 208.010
- OPSD 3120.100

OPSS 206, as amended by Special Provision “Amendment to OPSS 206, December 1993”, dated November 2002.

2. Suggested Text for NSSP on “Native Very Dense Till” and “Rock Excavation”

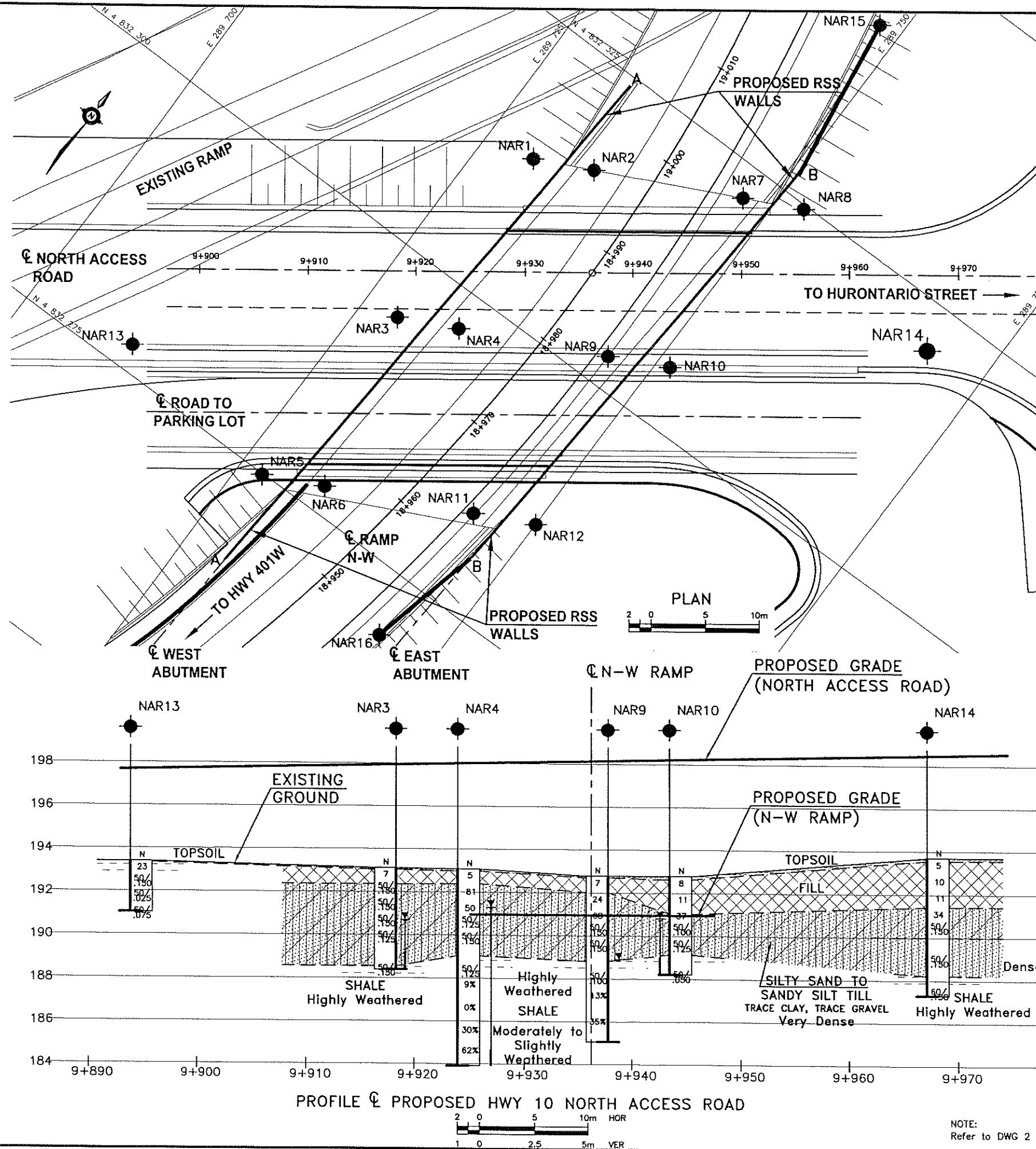
Cobbles and boulders should be expected within the sand and silt to silty sand till and silty clay till layers. The tills grade into weathered bedrock, accordingly, excavation of the lower zones of the till may be difficult.

The strength of the shale bedrock increases with depth and there is presence of very hard limestone and/or siltstone interbeds within the shale bedrock. Bulk excavation through the sound shale and the hard interbeds may be difficult. As such, rock coring equipment, pneumatic rock splitting/breaking equipment and ripping machinery should be available on site to assist in excavation and drilling.

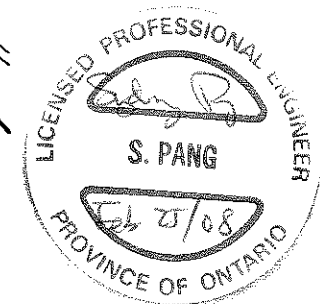
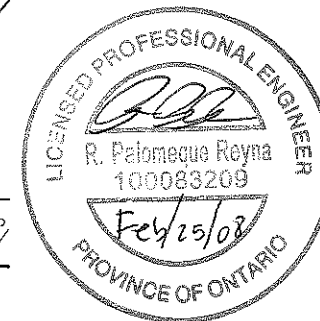
Although shale bedrock is intrinsically of low permeability, the possibility exists that concentrated seepage may be experienced from localized seams or fractures in the rock. Means to handle this seepage, such as additional pumps, should be made available.

Appendix E

Borehole Locations and Soil Strata Drawing



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

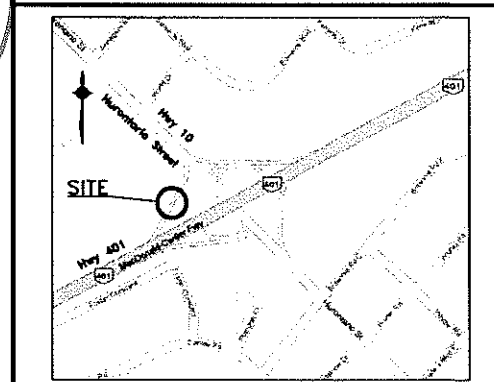


HWY 401
SITE No 24-759
GWP No 2107-05-00

HIGHWAY 10
NORTH ACCESS ROAD/N-W RAMP
BOREHOLE LOCATIONS AND SOIL STRATA

Marshall Macklin Monaghan
PROJECT MANAGERS • ENGINEERS • SURVEYORS • PLANNERS

THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS



KEYPLAN LEGEND

- ◆ Borehole (Present Investigation, 2007)
- ⊕ Borehole and Cone
- N Blows /0.3m (Std Pen Test, 475J/blow)
- CONE Blows /0.3m (60° Cone, 475J/blow)
- PH Pressure, Hydraulic
- W Water Level
- HA Head Artesian Water
- PZ Piezometer
- 90% Rock Quality Designation (RQD)
- A/R Auger Refusal

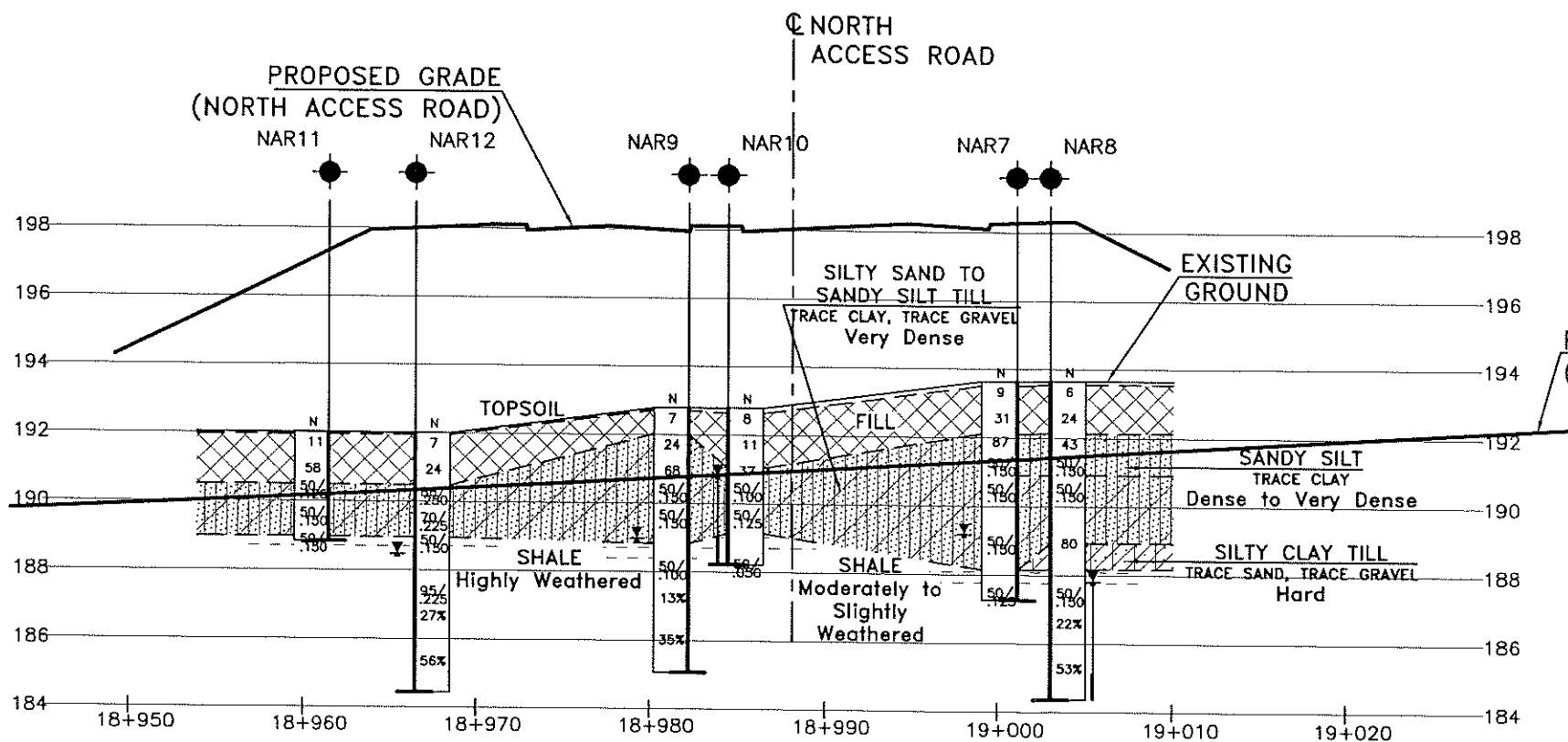
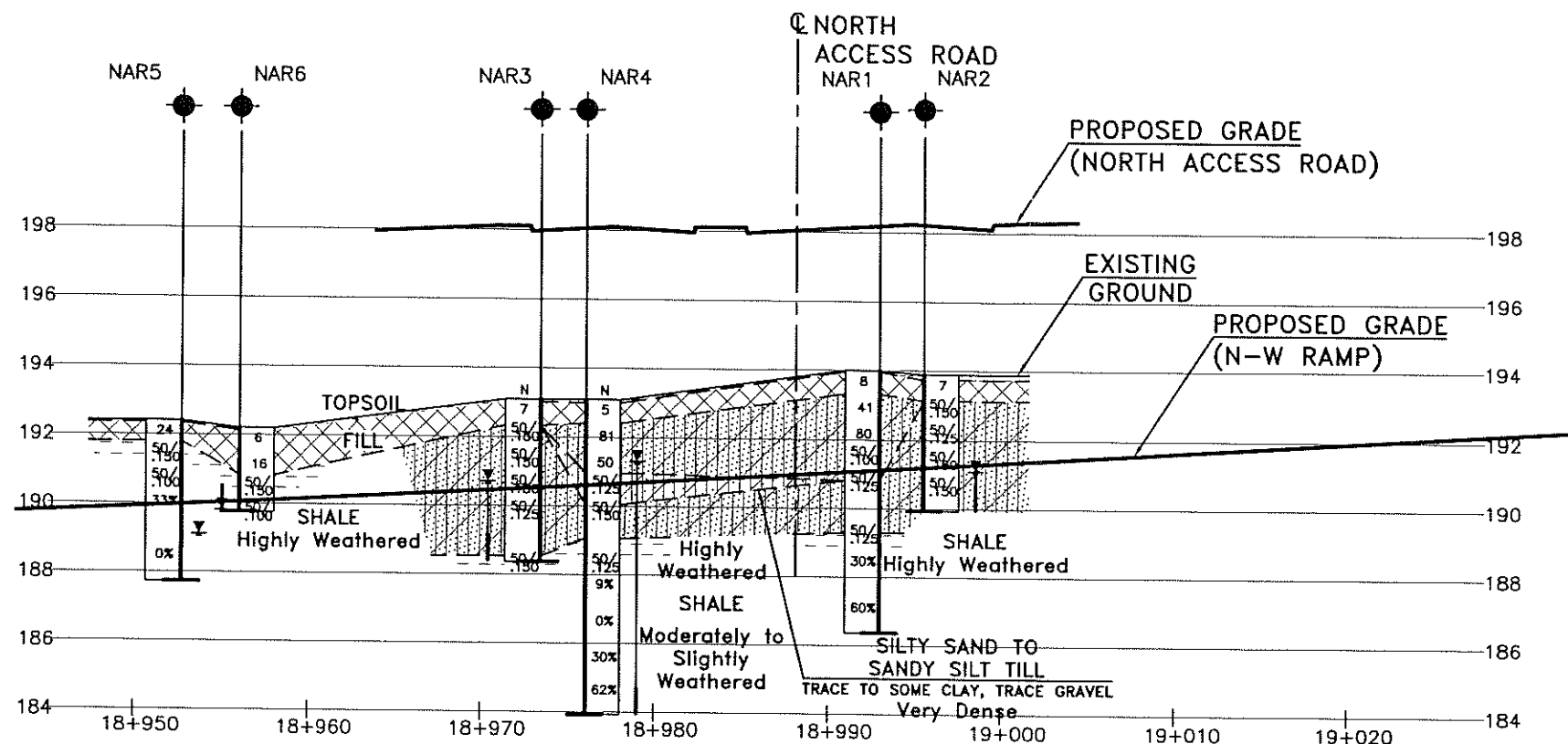
NO	ELEVATION	NORTHING	EASTING
NAR1	194.0	4 832 313.3	289 729.6
NAR2	193.9	4 832 315.9	289 734.8
NAR3	193.1	4 832 294.1	289 728.4
NAR4	193.1	4 832 296.7	289 733.6
NAR5	192.4	4 832 274.9	289 727.2
NAR6	192.2	4 832 277.5	289 732.3
NAR7	193.6	4 832 322.1	289 747.3
NAR8	193.7	4 832 324.6	289 752.5
NAR9	192.8	4 832 305.4	289 751.3
NAR10	192.8	4 832 305.4	289 751.3
NAR11	192.0	4 832 283.7	289 744.9
NAR12	192.0	4 832 286.2	289 750.0
NAR13	193.4	4 832 277.4	289 710.3
NAR14	193.7	4 832 320.9	289 769.3

- ### NOTES
- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
 - This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 30M12-267

NOTE:
Refer to DWG 2 for Section A-A and B-B

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	AEG	CHK	PKC/CODE
DRAWN	JHL	CHK	PKC/SITE
			LOAD
			STRUCT.
			SCHEME
			DWG 1

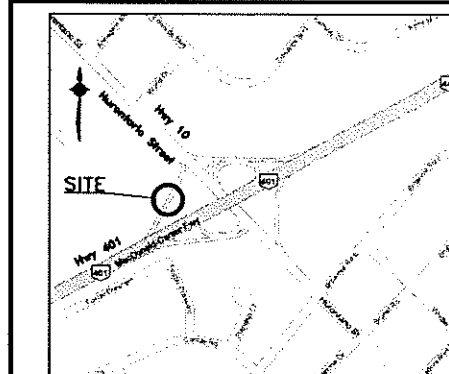


METRIC
 DIMENSIONS ARE IN METRES
 AND/OR MILLIMETRES
 UNLESS OTHERWISE SHOWN

HWY 401
 SITE No 24-759
 GWP No 2107-05-00

HIGHWAY 10
 NORTH ACCESS ROAD/N-W RAMP
 BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



KEYPLAN

LEGEND

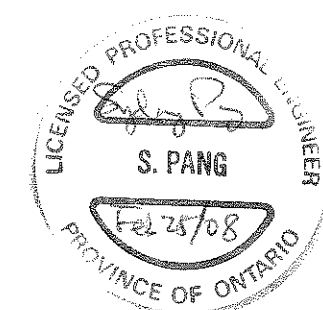
- ◆ Borehole (Present Investigation, 2007)
- ⊕ Borehole and Cone
- N Blows /0.3m (Std Pen Test, 475J/blow)
- CONE Blows /0.3m (60° Cone, 475J/blow)
- PH Pressure, Hydraulic
- Water Level
- Head Artesian Water
- Piezometer
- 90% Rock Quality Designation (RQD)
- A/R Auger Refusal

NO	ELEVATION	NORTHING	EASTING
NAR1	194.0	4 832 313.3	289 729.6
NAR2	193.9	4 832 315.9	289 734.8
NAR3	193.1	4 832 294.1	289 728.4
NAR4	193.1	4 832 296.7	289 733.6
NAR5	192.4	4 832 274.9	289 727.2
NAR6	192.2	4 832 277.5	289 732.3
NAR7	193.6	4 832 322.1	289 747.3
NAR8	193.7	4 832 324.6	289 752.5
NAR9	192.8	4 832 302.8	289 746.1
NAR10	192.8	4 832 305.4	289 751.3
NAR11	192.0	4 832 283.7	289 744.9
NAR12	192.0	4 832 286.2	289 750.0
NAR13	193.4	4 832 277.4	289 710.3
NAR14	193.7	4 832 320.9	289 769.3

NOTES-

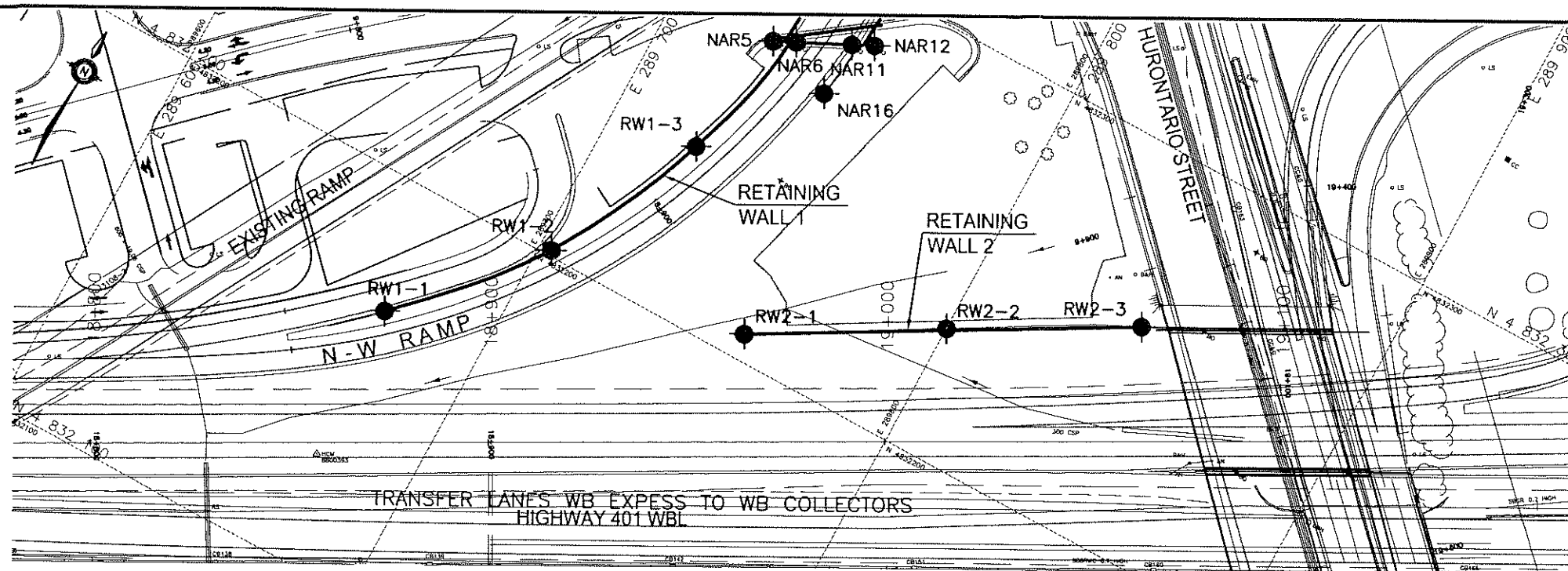
- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- 2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRE No. 30M12-267



NOTE:
 Refer to DWG 1 for Locations of Sections

REVISIONS	DATE	BY	DESCRIPTION
DESIGN RPR	CHK	PKC	CODE
DRAWN JHL	CHK	PKC	SITE
STRUCT.	SCHEME	DWG	2

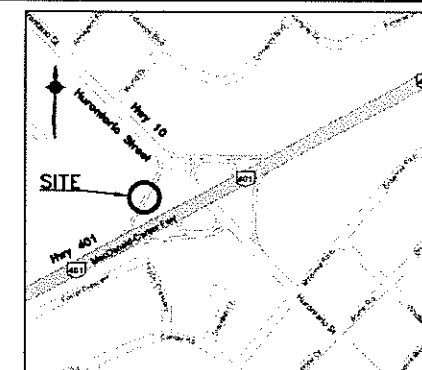


METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

HIGHWAY 401
SITE No 24-759
GWP No 2107-05-00






RETAINING WALLS AT 401E
AND HURONTARIO STREET
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



KEYPLAN

LEGEND

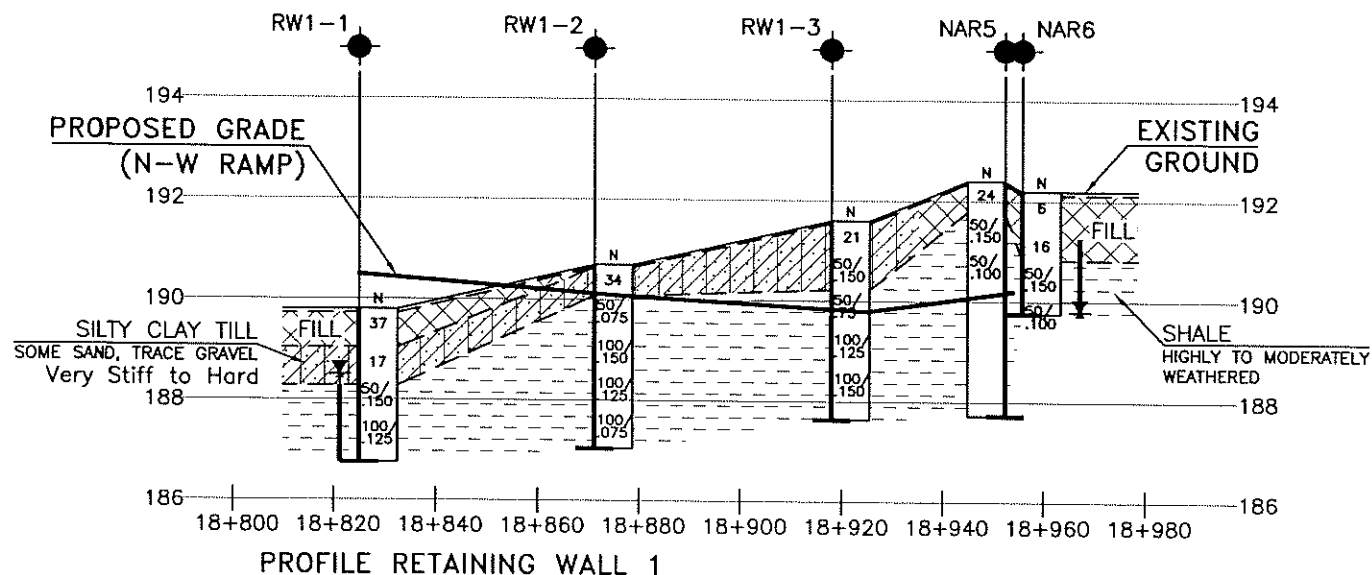
- | | |
|---|--|
|  | Borehole (Present Investigation, 2007) |
|  | Borehole and Cone |
| N | Blows /0.3m (Std Pen Test, 475J/blow) |
| CONE | Blows /0.3m (60° Cone, 475J/blow) |
| PH | Pressure, Hydraulic |
|  | Water Level |
|  | Head Artesian Water |
|  | Piezometer |
| 90% | Rock Quality Designation (RQD) |
| A/R | Auger Refusal |

NO	ELEVATION	NORTHING	EASTING
NAR5	192.4	4 832 274.9	289 727.2
NAR6	192.2	4 832 277.5	289 732.3
NAR11	192.0	4 832 283.7	289 744.9
NAR12	192.0	4 832 286.2	289 750.0
NAR16	191.8	4 832 269.4	289 744.6
RW1-1	189.8	4 832 167.8	289 673.7
RW1-2	190.7	4 832 201.4	289 703.1
RW1-3	191.6	4 832 242.1	289 722.8
RW2-1	190.3	4 832 206.5	289 756.6
RW2-2	191.0	4 832 232.3	289 800.1
RW2-3	194.9	4 832 256.3	289 842.8

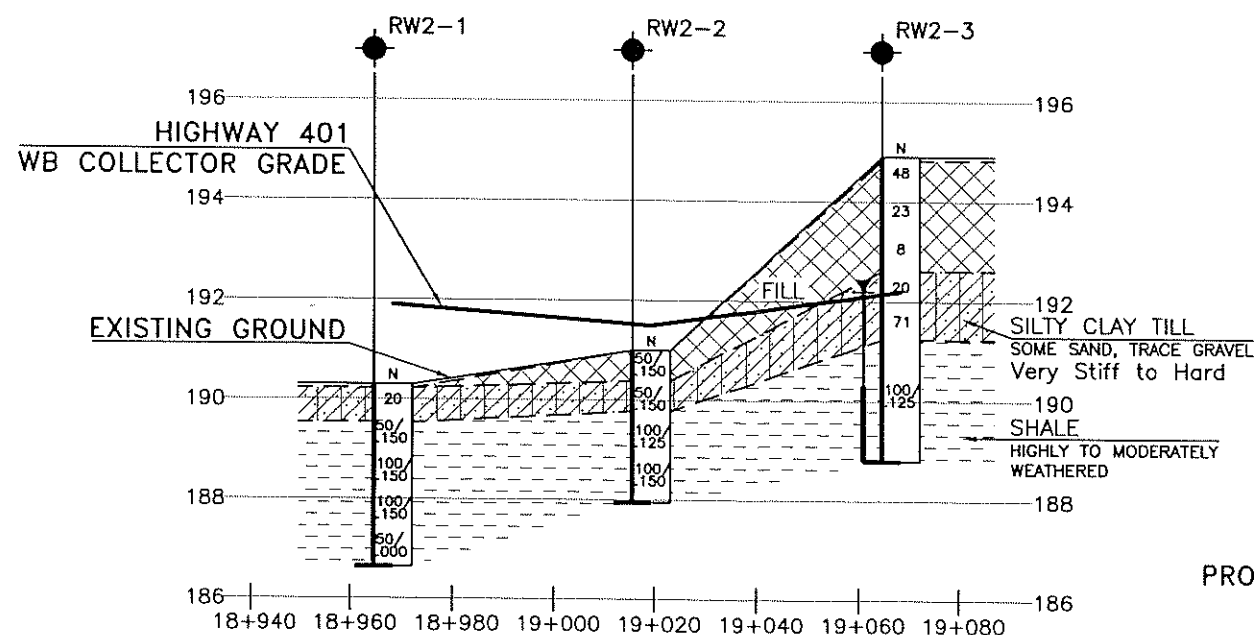
-NOTES-

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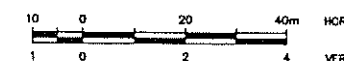
GEOCRES No. 30M12-267



PROFILE RETAINING WALL 1



PROFILE RETAINING WALL 2

[illegible]