FOUNDATION INVESTIGATION AND DESIGN REPORT
PROPOSED CULVERT EXTENSIONS AND NEW CULVERT
HIGHWAY 400 WIDENING
MAJOR MACKENZIE DRIVE TO KING ROAD
YORK REGION, ONTARIO
G.W.P. 192-00-00 AND 2539-04-00
ASSIGNMENT NOS. 2005-E-0036 AND -0037

GEOCRES Number: 30M13-190

Report to

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation carried out at the locations of the proposed culvert extensions and replacement along the Highway 400 right-of-way between Major MacKenzie Drive and King Road. The project involves widening of the highway to accommodate additional lanes of traffic. It is understood that the Ministry of Transportation Ontario (MTO) requires the design to accommodate the ultimate 10-lane configuration including one HOV lane in each direction, while the current MTO right-of-way is to be maintained.

The purpose of this investigation was to determine the subsurface conditions near the locations of the culvert extensions and replacement, provide borehole location plans and soil strata drawings, records of boreholes, laboratory test results, and a generalized description of the subsurface conditions. A model of the subsurface conditions was developed for each culvert location based on data obtained from this and previous investigations.

Thurber Engineering Ltd. (Thurber) carried out this investigation as a sub-consultant to SNC-Lavalin Inc. (SNC-Lavalin) under MTO Assignment Nos. 2005-E-0036 and 0037.

2 SITE DESCRIPTION

The highway alignment covered in this report extends along Highway 400 from north of Major Mackenzie Drive northerly to just north of the King Road Underpass. The general location of each of the relevant culverts covered in this report is shown on the key plans on the Borehole Locations and Soil Strata drawings in Appendix C.

The project area is located within the physiographic region known as the South Slope of the Oak Ridges Moraine, which comprised predominantly of the Halton till. The Halton till is an interbedded complex of clayey silt to silt till and sand. This till comprises a slightly hummocky till plain, into which the surface watercourses have eroded 10 to 15 m deep gullies. Relatively recent fluvial

sediments have been deposited in the gullies. The Halton till overlies bedrock at depths in the order of 100 m in the vicinity of the project area.

Drainage in the vicinities of the project areas is largely controlled by the Humber River and its tributaries. Localized drainage is facilitated by the creeks flowing within the gullies. Many of the culverts are located in theses gullies allowing the creek to flow under the highway embankment.

The land use adjacent to this section of Highway 400 is largely rural and agricultural, although there is increasing residential and commercial development in recent years.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing for this Highway 400 widening project was carried out during several periods, between December 2006 and February 2007, September 2008, March 2009, February 2010 and March 2011. The 2010 and 2011 programs for investigating the culvert areas consisted of drilling and sampling ten (10) and eight (8) boreholes, respectively, in addition to the boreholes completed during previous investigations for this Highway 400 widening project.

Information obtained from other reports from the current and previous investigations have been utilized where appropriate. These reports are listed as follows:

- Thurber report titled "Foundation Investigation Report, High Mast Lighting Poles, Teston Road to North of King Road, Highway 400 Widening, Vaughan, Ontario, G.W.P. 2539-04-00, Agreement 2005-E-0037", GEOCRES No. 30M13-193, File:19-92-68, dated December 17, 2011 (Reference 1).
- Thurber report titled "Foundation Investigation Report, High Embankments, Teston Road to King Road, Highway 400 Widening, Vaughan, Ontario, G.W.P. 2539-04-00, Assignment 2005-E-0036", GEOCRES No. 30M13-178, File:19-92-68, dated April 6, 2010 (Reference 2).
- Thurber report titled "Foundation Investigation and Design Report, Culvert Extensions and High Fill, Highway 400 / Teston Road Interchange" (for Region of York), File: 19-1351-66, dated January 26, 2005 (Reference 3).
- Thurber report titled "Foundation Investigation and Design Report, Highway 400 – Retaining Structure, Teston Road Interchange, Region of York, Ontario" (for Region of York), File: 19-1351-66, dated January 26, 2005 (Reference 4).
- AMEC report titled "Foundation Investigation Report, Proposed Kirby Sideroad Overpass Widening, Highway 400 Interim Widening, Vaughan, Ontario", W.P. 192-00-00, Central Region, GEOCRES No. 30M13-159, File: TT22852A, dated September, 2003 (Reference 5).

The boreholes for the present investigation were initially marked and/or staked in the field by Thurber. Prior to commencement of drilling, utility clearances were obtained for all borehole locations. Right-of-way usage and lane closure permits were also obtained as required. The as-drilled borehole

locations were either tied in by surveyors co-ordinated by SNC-Lavalin and the survey data provided to Thurber, or were established using Thurber's in-house GPS survey unit. Approximate borehole locations are shown on the Borehole Locations and Soil Strata drawings in Appendix C.

Track and truck mounted drill rigs were used to undertake the drilling, sampling and in-situ testing operations.

The depths of the boreholes ranged from approximately 5.2 m to 17.9 m below existing ground surface. Hollow and solid stem augers were used to advance the boreholes. Soil samples were obtained at selected intervals using a 50 mm outside diameter split spoon sampler in conjunction with Standard Penetration Tests (SPT).

Groundwater conditions in the open boreholes were observed throughout the drilling operations. Standpipe piezometers of 19 mm in diameter were installed in selected boreholes for monitoring of groundwater levels. The installation details are presented on the Record of Boreholes in Appendix A. Details of borehole grouting and sealing for boreholes advanced by Thurber relevant to this investigation are presented in Table A1 in Appendix A.

A member of Thurber's technical staff supervised the drilling and sampling operations on a full time basis. The supervisor logged the boreholes, secured the soil samples in labelled and sealed containers, which were then transported to Thurber's laboratory for further examination and testing.

4 LABORATORY TESTING

Visual identification and natural moisture content determination was undertaken on all recovered soil samples returned to the laboratory. Selected soil samples were subjected to grain size distribution analysis. Selected cohesive soil samples underwent Atterberg Limits tests. The results of this testing program are shown on the Record of Borehole sheets in Appendix A and on the accompanying figures in Appendix B.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Details of the encountered soil stratigraphy are presented on Record of Borehole sheets, and on the "Borehole Locations and Soil Strata" drawings in Appendices A and C, respectively. A general description of the stratigraphy established at relevant boreholes near the culverts is presented in the following paragraphs. Applicable borehole information from previous investigations has also been incorporated. It should be noted that the subsurface conditions may vary between and beyond the borehole locations.

Results of grain size distribution analyses conducted on selected samples of various types of soils from this investigation are presented in Figures B1 to B9 and B13 to B16 in Appendix B. Results of Atterberg Limits tests carried out on selected cohesive soil samples are shown on

the plasticity charts on Figures B10 to B12 and B17 to B19 in Appendix B. The Borehole Locations and Soil Strata Drawings in Appendix C present the inferred subsurface conditions at the culvert locations.

5.1 Topsoil and Asphalt

Topsoil of thicknesses ranging from 25 mm to 180 mm was encountered in Boreholes 06-05W, 06-12W, 06-05E, 06-16E, 06-17E, 10-05, 10-06, C-16A, C-16B, C-17A, C-17B and C-18B. In Boreholes 08-01 and 08-02 located within the Cold Creek floodplain, topsoil mixed with organics and rootlets was between 0.6 and 1.4 m thick. In Borehole C-18A, the topsoil measured 0.4 m in thickness. Topsoil thickness may vary between and beyond the borehole locations.

A 150 mm thick layer of asphalt was encountered at ground surface in Borehole 06-08E.

5.2 Fill

Fill was encountered beneath the topsoil, or occasionally beneath asphalt and at ground surface in Boreholes 06-08E, 06-12W, 06-16E, 06-17E, 10-06 and 09-05W. The thickness and base elevation of the fill are presented in Table 5.2.1.

Table 5.2.1: Fill Thickness and Base Elevation

Borehole Number	Fill Thickness (m)	Base Elevation (m)
06-08E	2.3	271.4
06-12W	0.6	270.9
06-16E	1.2	276.0
06-17E	1.3	276.5
10-06	1.0	262.9
09-05W	1.4	295.4

The fill is comprised predominantly of brown to dark brown silty clay and some clayey silt, trace to some sand and gravel with occasional roots and rootlets. Sand to gravelly sand overlies the cohesive fill in Boreholes 06-08E, 06-12W and 09-05W. SPT 'N' values of the cohesive fill typically ranged from 4 to 26 blows per 0.3 m penetration indicating firm to very stiff conditions. An occasional 'N' value of 38 blows measured in Borehole 06-08E indicated the presence of a hard zone. Moisture contents typically ranged between 9% and 26%.

Figure B1 presents the grain size distribution curves of selected silty clay or clayey silt fill samples. The test results are summarized in the tables below.

Soil Particles	%
Gravel	1 – 2
Sand	18 – 35
Silt	49 to 50
Clay	15 to 31

5.3 Silty Clay and Clayey Silt

Surficial cohesive deposits of silty clay and clayey silt containing trace to some organics, some sand and trace gravel was encountered in Boreholes CV-12A, CV-12B, CV-13A, CV-13B, 06-05E, 06-08E, 10-06, C-14, C-16A, C-17A, C-18A and C-20 on the east side of the highway, CV-12A, 08-01, 08-02, 10-05, 09-05W, C-16B, C-17B and C-18B on the west side of the highway. The thickness and base elevation of these deposits are summarized in Table 5.3.1:

Table 5.3.1 Silty Clay/Clayey Silt Thickness and Base Elevation

Borehole Number	Silty Clay / Clayey Silt Thickness (m)	Base Elevation (m)
CV-12B	1.5	238.5
CV-13A	2.0	227.0
CV-13B	0.7	228.9
06-05E	1.4	241.7
06-08E	1.5	270.0
10-06	1.0	261.9
CV12A	0.8	238.5
08-01	3.7	222.3
08-02	0.4	225.4
10-05	1.2	261.1
09-05W	0.8	294.6
C-14	1.4	243.2
C-16A	0.9	257.1
C-17A	2.0	258.3
C-18A	1.9	258.1
C-20	1.6	275.5
C-16B	1.4	254.0
C-17B	0.9	257.5
C-18B	1.3	260.1

These soils are dark brown, brown to brown and grey in colour, and have a typically firm to hard consistency as indicated by SPT 'N' values of 4 to 35 blows per 0.3 m penetration. Occasional 'N' values of 0 to 3 blows indicate the presence of softened zones immediately

below ground surface. Moisture contents ranged typically between 10% and 25%, with occasional higher values of 28% to 35%.

Figures B2 and B3 present the grain size distribution curves of selected silty clay and clayey silt samples. Figure B10 presents Atterberg limits test results of selected silty clay samples. The test results are summarized in the tables below.

Silty Clay

Soil Particles	%
Gravel	0 – 3
Sand	12 – 29
Silt	49 to 55
Clay	19 to 33

Index Property	%
Liquid Limit	27 – 33
Plasticity Index	11 – 15

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

Clayey Silt

Soil Particles	%
Gravel	0
Sand	23
Silt	61
Clay	16

5.4 Silty Clay Till

Silty clay till containing some sand and trace gravel was encountered in Boreholes CV-12A, CV-13B, 06-05E, 06-08E, 06-16E, 10-06, C-16A, C-17A and C-18A on the east side of the highway, CV-12B, 06-05W, 06-12W, C-16B, C-17B, C-18B and C20 on the west side of the highway. Some of these boreholes terminated within the till deposit. The thickness and base elevation of this till deposit are summarized in Table 5.4.1:

Table 5.4.1 Silty Clay Till Thickness and Base Elevation

Borehole Number	Silty Clay Till Thickness (m)	Base Elevation (m)
CV-12A	5.3	233.2
CV-13B	4.6	223.1
06-05E	3.6	237.4
06-08E	At least 5.8	Lower than 264.2

10-06	At least 3.0	Lower than 258.9
06-16E	At least 5.3	Lower than 270.7
06-17E	At least 5.3	Lower than 271.2
CV-12B	3.1	235.4
06-05W	2.9	237.9
06-12W	8.6	262.3
C-16A	2.9	251.1
C-17A	At least 6.0	Lower than 252.2
C-18A	At least 5.9	Lower than 252.1
C-16B	At least 6.7	Lower than 247.4
C-17B	6.3	251.2
C-18B	6.4	253.7
C-20	At least 6.6	Lower than 268.9

This till is typically brown in colour, becoming grey with depth. It is generally stiff to hard as indicated by SPT 'N' values ranging between 8 to greater than 75 blows per 0.3 m penetration. Occasional 'N' values greater than 50 blows for less than 0.3 m penetration infer the presence of cobbles or boulders. Moisture contents were typically between 10% and 20%.

Figures B4, B5, B13 and B14 present the grain size distribution curves of silty clay till samples. Figures B11, B12, B17 and B18 present Atterberg limits test results of selected silty clay till samples. The test results are summarized in the tables below.

Soil Particles	**%**
Gravel	0 – 4
Sand	6 – 31
Silt	43 to 63
Clay	16 to 40

Index Property	**%**
Liquid Limit	20 – 33
Plasticity Index	8 – 17

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

Glacial tills inherently contain cobbles and boulders.

5.5 Clayey Silt Till

Clayey silt till containing some sand and trace gravel was encountered in Boreholes 09-05W, 10-05, C-14 and C-16A. The thickness and base elevation of this till deposit are summarized in Table 5.5.1:

Table 5.5.1 Clayey Silt Till Thickness and Base Elevation

Borehole Number	Clayey Silt Till Thickness (m)	Base Elevation (m)
09-05W	2.1	292.5
10-05	2.7	258.4
C-14	5.3	237.3
C-16	3.1	254.0

This till is typically brown in colour. Its consistency varies from stiff to hard as indicated by SPT 'N' values ranging between 9 and 42 blows per 0.3 m penetration. Moisture contents were typically between 15% and 22%.

Figures B6 and B15 present the grain size distribution curve of clayey silt till samples. The test results are summarized in the tables below. Figure B19 presents Atterberg limits test results of selected clayey silt till samples.

Soil Particles	%
Gravel	0 to 1
Sand	5 to 27
Silt	55 to 86
Clay	9 to 17

Index Property	%
Liquid Limit	22 – 27
Plasticity Index	9 – 12

The above results show that the clayey silt till has low plasticity with a group symbol of CL.

Glacial tills inherently contain cobbles and boulders.

5.6 Sands and Silts

Deposits of sands, silts, silty sands and sandy silts with trace clay and gravel with occasional cobbles were encountered in Boreholes CV-13A, CV-13B, 06-05E, C-14, C-16A and C-18A on the east side of the highway, 08-01, 08-02, 10-05, 09-05W, C-17B and C-18B on the west side of the highway. A number of these boreholes terminated within these cohesionless deposits. The minimum thickness and termination elevation of the boreholes within these soils are summarized in Table 5.6.1:

Table 5.6.1 Sands and Silts Thickness and Base Elevation

Borehole Number	Sands and Silts Minimum Thickness (m)	Borehole Termination Elevation Within Sands and Silts (m)
CV-13A	2.2	219.2
CV-13B	3.2	219.9
06-05E	3.6	233.7
08-01	13.6	208.7
08-02	15.6	209.8
10-05	2.6	255.8
09-05W	2.8	287.0
C-14	0.6 (upper interlayer) \ and 0.8 (lower)	242.6* (upper interlayer) and 236.5 (lower)
C-16A	1.1	250.1
C-18A	0.2 (interlayer)	255.2*
C-17B	1.0	250.1
C-18B	2.0	251.7

* Not end of borehole

These soils are typically brown in colour becoming grey with depth, non-plastic, and in a typically compact to very dense state as indicated by SPT 'N' values ranging between 12 and 73 blows per 0.3 m penetration. The presence of cobbles and/or boulders could be inferred at locations where the 'N' value was greater than 50 blows for less than 0.3 m penetration. Some loose zones, as indicated by 'N' values of less than 10 blows, were encountered in Boreholes 08-01, 08-02 and 10-05. Moisture contents were typically between 10% and 22%, except for Borehole 09-05W where the moisture contents were lower than 5%.

Figures B7, B8 and B16 present the grain size distribution curves of selected samples of silt and sand. The test results are summarized in the tables below.

Silt to Sandy Silt

Soil Particles	%
Gravel	0 – 3
Sand	2 – 47
Silt	48 – 91
Clay	4 – 9

Sand

Soil Particles	%
Gravel	0
Sand	65 – 70
Silt and Clay	30 – 35

5.7 Sandy Silt to Sand and Silt Till

Deposits of sandy silt to sand and silt tills were encountered in Boreholes CV-12A and CV-13A on the east side of the highway, CV-12B, 06-05W, 06-12W and 09-05W on the west side of the highway. Some of these boreholes terminated within the glacial tills. The minimum thickness and base elevation of till or boreholes within these soils are summarized in Table 5.7.1:

Table 5.7.1 Sandy Silt/Sand and Silt Till Thickness and Base Elevation

Borehole Number	Sands and Silts Minimum Thickness (m)	Base Elevation Till or Borehole (m)
CV-12A	3.7	229.6
CV-13A	5.6	221.4
CV-12B	6.3	229.1
06-05W	5.2	232.6
06-12W	2.0	260.3
09-05W	2.7	289.8

These soils are typically brown to grey in colour, non-plastic, and in a typically compact to very dense state as indicated by SPT 'N' values ranging from 15 blows per 0.3 m penetration to greater than 100 blows per 0.3 m penetration. Moisture contents were typically between 10% and 20%.

Figure B9 presents the grain size distribution curves of selected samples of silts and sands. The test results are summarized in the tables below.

Sandy Silt / Sand and Silt Till

Soil Particles	%
Gravel	0
Sand	22 – 36
Silt	61 – 69
Clay	3 – 9

Glacial tills inherently contain cobbles and boulders.

5.8 Groundwater

Free water was encountered in Boreholes 06-05E, 06-05W and C-18A between 1.5 and 5.0 m depths, respectively, upon completion of drilling. A standpipe piezometer was installed in nine selected boreholes and the measured water levels are presented in Table 5.8.1:

Table 5.8.1 Water Level Measurements

Borehole (Screen location)	Date	Depth (m)	Elevation (m)
CV-12B (sandy silt till)	August 4, 2005	10.8	229.2
CV-13B (sand/silty sand)	July 15, 2004 August 5, 2004	1.8 0.6	227.9 229.1
06-12W (silty clay till/ sandy silt Till)	February 20, 2007 March 27, 2007	5.1 4.9	266.5 266.7
10-05 (silt / sand)	April 9, 2010	3.2	259.3
C-14 (Clayey Silt Till / Silt and Sand)	October 5, 2011	3.3	241.3
C-16A (Silty Clay Till / Silt and Sand)	October 5, 2011	5.0	253.2
C-16B (Silty Clay Till)	October 5, 2011	2.2	253.3
C-17B (Silty Clay Till / Sand)	October 5, 2011	3.4	255.0
C-18B (Silty Clay Till / Silt)	October 5, 2011	3.9	257.6
C-20 (Silty Clay Till)	October 5, 2011	2.8	274.3

Based on the above readings, the stabilized groundwater levels varied widely between approximate Elevations 229 and 275 m. These water levels reflect localized terrain and drainage conditions associated with the creek valleys. The groundwater levels are expected to vary seasonally and are subject to climatic events.

6 MISCELLANEOUS

Thurber Engineering Ltd. (Thurber) selected the borehole locations in the field relative to existing site features with consideration of access restraints, terrain conditions, utility locations and previous site investigation data.

DBW Drilling Ltd of Ajax, Ontario and Kodiak Environmental Ltd., of Oakville, Ontario conducted drilling, sampling and in-situ testing operations. Traffic control was provided by Barricade Traffic Services Inc. (BTS) where required. Messrs. Stephane Loranger and

George Azzopardi of Thurber supervised the drilling and sampling operations in the field on a full time basis.

Messrs. Tony Harte, M.Sc., L. Gilarski, E.I.T. and Dr. Sydney Pang, P.Eng. directed the field operations.

Dr. Sydney Pang, P.Eng. prepared this report.

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

THURBER ENGINEERING LTD.

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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 GENERAL

This report presents interpretation of the geotechnical data in the factual report and presents foundation recommendations for the design of culvert extensions and construction of one new culvert.

It is noted that the current field borehole program was based on the original foundation engineering terms of reference dated May 2006 and a McCormick Rankin Corporation (MRC) "Preliminary Design, Environmental Assessment Study (PDEAS)" dated July 2003 from the proposal package and subsequent information provided by SNC-Lavalin. The following Table 7.1 presents selected culvert details and extension requirements subsequently provided by SNC-Lavalin.

Table 7.1
Selected Culvert Details

Culvert #	General Location	Approximate Station*	Existing Type	Existing Opening Size	Comments
12	South of Teston Road	Sta. 19+725	Concrete Box	1.24 m x 1.22 m (high)	Extension on east side of Highway 400
13	North of Teston Road (Cold Creek)	Sta. 20+662	Concrete (Open)	1.53 m x 1.53 m (high)	Extension on west side of Highway 400
14	North of Teston Road (near service station)	Sta. 21+214	Concrete (Open)	1.22 m x 1.22 m (high)	Extension on both sides of Highway 400
15	North of Teston Road (near service station)	Sta. 21+757	Concrete Box	1.84 m x 1.40 m (high)	Extension on east side of Highway 400
16	North of Kirby Road	Sta. 22+551	Concrete (Open)	1.22 m x 1.00 m (high)	Extension on both sides of Highway 400
17	Between Kirby Road and King-Vaughan Road	Sta. 23+006	Concrete (Open)	1.23 m x 1.00 m (high)	Extension on both sides of Highway 400
18	Between Kirby Road and King-Vaughan Road	Sta. 23+223	Concrete (Open - with upstream CSP extension)	1.53 m x 1.22 m (high)	Extension on both sides of Highway 400

19	Between Kirby Road and King-Vaughan Road	Sta. 24+113	Concrete (Open)	1.23 m x 1.06 m (high)	Extension on both sides of Highway 400**
19A		Sta. 24+200**	Concrete Box	1.8 m x 1.2 m	New culvert
20	North of King-Vaughan Road	Sta. 10+079	Concrete (Open)	1.26 m x 1.00 m (high)	Extension on both sides of Highway 400
21	South of Humber Arch	Sta. 10+815	Concrete (Open)	3.00 x 1.83 (high)	Extension on both sides of Highway 400
25	North of King Road	Sta. 12+230	Concrete (Open)	1.2 m x 1.2 m (high)	Extension on east side of Highway 400

Note: * Refers to Highway 400 centreline.
** From 2011 information (2006 information indicates replacement adjacent to existing culvert).

The discussions and recommendations presented in this report are based on information provided by SNC-Lavalin and on the factual data obtained during the course of this investigation. Factual data obtained during previous investigations is also referenced where appropriate.

Plans and information for these locations were provided by SNC-Lavalin. The original foundations terms of reference stipulate that one borehole be drilled at each of nine culvert locations (not specified) where extension is required, and that a new culvert be constructed adjacent to the existing Culvert #19. SNC-Lavalin information in January 2012 indicates that a new 1.8 m x 1.2 m concrete box culvert is to be installed some 87 m to the north of the existing Culvert #19.

8 CULVERT FOUNDATIONS

8.1 General

The current project requirements involve accommodation of the ultimate 10-lane configuration with one HOV lane in each direction.

Existing invert elevations provided by SNC-Lavalin and approximate top of native soil elevations at the upstream and downstream limits are presented in the following Table 8.1.

Table 8.1
Elevations of Invert and Native Soil

Culvert #	Borehole Numbers	Existing Invert Elevations ** (m)		Top of Native Soil Approximate Elevations* (m)	
		Upstream	Downstream	Upstream	Downstream
12	CV-12A, CV-12B	239.51	238.85	~240.0	~239.3
13	CV-13A, CV13B, 08-01, 08-02	228.58	226.23	~229.0	~226.0
14	06-05W, C-14	243.62	239.38	~244.6	~240.8
15	06-05E	241.95	240.19	~243.1	-
16	C-16A, C-16B	254.76	254.49	~258.1	~255.4
17	C-17A, C-17B	258.04	257.62	~260.2	~258.3

18	C-18A, C-18B	258.73	258.67	~259.9	~261.4
19	06-08E, 06-12W	271.23	270.85	~271.4	~270.9
19A	11-16	271.69	270.92	~270.3 (median)	
20	06-16E, C-20	276.06	276.05	~276.0	~277.1
21	10-05, 10-06	262.39	260.04	~262.9	~262.3
25	09-05W	297.64***	296.00***	Not Applicable	~295.4

Note : * These elevations are estimated based on results of boreholes closest to the culvert inlets and/or outlets, and the local topography.
** From SNC-Lavalin.
*** From PDEAS.

8.2 Foundation Alternatives

This section presents discussions on available types of culverts and extensions, foundation alternatives, and provides recommendations for feasible and/or preferred foundation option(s).

Several common types of culverts and associated foundations are listed as follows:

- Concrete box (closed) culverts
- Concrete (open frame) culverts on footings
- Corrugated Steel Pipe (CSP)

A comparison of the foundation alternatives based on their respective advantages and disadvantages is included in Appendix D.

For the purpose of this report, we have assumed that each culvert is to be extended with the same size and at the existing invert slope. From Table 7.1, it is understood that most of the existing culverts are of the concrete open frame type although some of them are box culverts or with existing CSP extensions.

For all new and extension of culverts, it is preferable to use precast concrete sections rather than cast-in-place construction since the former type can be installed more expediently with less potential for disturbance of the founding soils during installation. Any wingwall or headwall may use the cast-in-place method of construction.

8.3 Foundation Design and Construction

The culvert extensions should be founded at the same level as the existing base of culverts in order to avoid undermining of the existing structures and to reduce disturbance of the foundation soils. Where the culverts are located within high fill areas (6 m or higher), stability and settlement analysis, and related design and construction issues have been discussed in Reference 2. Foundation design issues for the culvert extensions and installation are subgrade conditions, bearing resistances, settlement of foundation soils and stability of

widening embankments adjacent to the culverts. All box culverts and open culvert footings should be founded at or below the elevations presented in Table 8.2 below.

Table 8.2
Recommended Highest Founding Elevations and Geotechnical Resistances

Culvert #	Assumed Founding Conditions for Design	Highest Founding Elevations * (m)	Geotechnical Resistance	
			Factored ULS (kPa)	SLS (kPa)
12	Clayey Silt (very stiff)	240.0 (east)	300	200
13	Clayey Silt (firm) Silty Clay (very stiff to firm)	225.4 (west)	180	120
		224.3 (west)	300	200
14	Silty Clay to Clayey Silt Till (stiff to very stiff)	243.0 (east) 239.5 (west)	300	200
15	Silty Clay/Silty Clay Till (firm/very stiff to hard) Silty Sand (dense)	242.4 (east)	180	120
		241.0 (east)	375	250
16	Clayey Silt Till (very stiff to hard)	255.7 (east) 254.3 (west)	375	250
17	Silty Clay Till (very stiff to hard)	257.5 (east) 257.0 (west)	450 375	300 250
18	Silty Clay Till (very stiff to hard)	258.0 (east) 258.3 (west)	450 375	300 250
19	Silty Clay/Silty Clay Till (stiff to hard)	271.4 (east) 271.0 (west)	300	200
19A (new)	Silty Clay Till (stiff to hard)	270.3	300	200
20	Silty Clay Till (very stiff to hard)	275.5 (east) 275.5 (west)	300	200
21	Silty Clay/Clayey Silt Till (very stiff to hard)	261.0 (east) 259.0 (west)	300	200
25	Silty Clay/Clayey Silt Till (stiff)	297.0 (east)	225	150
General	Engineered Granular Fill **	At least 1.0 m thick	300	200

* These elevations were estimated based on surface topography, culvert invert levels and information from the closest borehole(s).

** Resting on prepared subgrade of undisturbed native soils.

During design of each culvert, if the combined loading of the embankment fill and the culvert necessitate footing geotechnical resistances higher than those values presented in Table 8.2 above, Thurber should be consulted for further recommendations.

Recommendations on subgrade preparation procedures including sub-excavation, backfilling, bedding and inspection are provided in subsequent sections.

It is recommended that the culverts be designed to resist external loadings including frost forces, lateral earth pressures, hydrostatic pressure, weight of embankment fill, traffic loadings and surcharge due to construction equipment.

From Table 7.1, nine (9) of the culverts (#13, #14, #16, #17, #18, #19, #20, #21 and #25) requiring extensions are concrete open footing culverts of which one (#18) has an existing CSP extension on the upstream side. The existing Culverts #12 and #15 are concrete box culverts. For the proposed extensions, it is recommended that the same type of culvert at the respective locations be used where applicable. It is also possible to interchange the open footing and box type culverts provided other design requirements such as environmental concerns are satisfied. CSPs may also be considered for use as extensions.

8.3.1 Concrete (Open Frame) Culverts on Footings

Concrete open frame culvert extensions on spread footings, and any wingwall/headwall footings should be founded on the typically stiff to very stiff clayey silt/silty clay or clayey silt/silty clay till at or below the elevations indicated in Table 8.2 above.

The geotechnical resistances for culvert footing design vary between locations. Based on the subsurface conditions established at the boreholes and assuming the subgrade preparation procedures recommended in this report are followed, the recommended geotechnical resistances at or below the founding elevations at each of the culvert locations are presented in Table 8.2 above.

The geotechnical resistances in Table 8.2 are for vertical, concentric loads only. Effects of load inclination and eccentricity should be taken into account as illustrated in the CHBDC (2006) Clause 6.7.3 and Clause 6.7.4.

The geotechnical resistances at SLS quoted above correspond to 25 mm settlement of an individual culvert footing under the applied load. Further comments on settlements are presented in the following Sections 8.3.4 and 8.4.

Resistance to lateral forces / sliding resistance between precast concrete and the underlying undisturbed, typically stiff to hard (occasionally firm) native cohesive soils or engineered fill should be evaluated in accordance with the CHBDC (2006) assuming an ultimate coefficient of friction of 0.55.

For frost protection purposes, the culvert design should incorporate 1.2 m of earth cover, or its thermal equivalent, to the foundation base.

8.3.2 Concrete Box (Closed) Culverts

From Table 7.1, two (2) of the culverts (#12 and #15) requiring extensions are concrete box culverts.

Following excavation to the design base level of the culvert extension, any remaining fill, topsoil, streambed deposits, soft or loose soils and any deleterious materials within the culvert extension footprint should be sub-excavated to undisturbed native soils at or below the elevations shown in Table 8.2 above. The exposed surface must be inspected to confirm that the subgrade is suitable and uniformly competent. Any soft areas should be sub-excavated and replaced with well compacted granular fill. Any fill placed below the culvert extension to re-establish the founding level should consist of compacted Granular A or B Type II material. This work should be carried in accordance with OPSS 902.

In order to provide a more uniform foundation subgrade condition, a 300 mm thick layer of bedding material conforming to OPSS Granular A requirements should be provided under the base of box culverts as per OPSD 803.010. The bedding material should be placed as soon as practicable for protection from disturbance during construction following inspection and approval of the final subgrade.

Settlement of the culvert will be governed by compression of the foundation soils under the weight of the road embankment fill. Comments in this regard are presented in Sections 8.3.4 and 8.4 of this report.

Resistance to lateral forces / sliding resistance between the concrete slab and the underlying Granular A should be calculated assuming an ultimate coefficient of friction of 0.6, which requires a certain extent of sliding movement to fully mobilize the resistance.

Foundation design for any wingwalls or headwalls associated with the box culvert extensions are discussed in the following Section 8.3.2.

8.3.3 Corrugated Steel Pipe (CSP)

Consideration may be given to using CSPs as extensions especially at locations where this type of extensions are already in use. Subgrade preparation procedures are similar to those described above for box culvert. Reference should be made to OPSD 800.011 for detailed requirements.

8.3.4 Settlements

Foundation settlements will occur primarily as a result of loading due to the new fill that are to be placed in the vicinity of the culvert extensions for embankment widening purposes. The

native, predominantly cohesive soils are over-consolidated and have a generally stiff to hard consistency. Any settlement at these locations should be immediate in nature and should be essentially completed by the end of construction. Post construction settlement should be considered negligible. In specific areas where the surficial soils are firm, sub-excavation and replacement with engineered granular fill may be required to improve the founding conditions. Section 8.4 discusses specific design and construction requirements for each culvert extension.

8.3.5 Subgrade Preparation

Although not encountered in the boreholes, the presence of alluvial and organic deposits should be expected at creek channels and streambeds where the culverts are located. In order to minimize total and differential settlements, it is recommended that once the excavation reaches the required elevation, all remaining fill, topsoil, organics, alluvial deposits, loose and/or soft surficial native soils or otherwise disturbed materials should be removed. The exposed surface should then be inspected by qualified geotechnical personnel to confirm that the subgrade is uniform and competent to support the culvert. The depth of excavation varies between sites (see following sections) but for planning purposes, it may be assumed that a minimum of 0.5 m of surficial materials will need to be excavated.

Backfill to any sub-excavation for reinstating the founding elevation should consist of Granular A or B Type II material placed and compacted in accordance with SP 902S01. Mass concrete may be used as an alternative to compacted granular backfill. In submerged areas, or areas where surficial ponding water prohibits adequate compaction of granular materials, it is recommended that materials that do not require compaction, such as OPSS 1004 clear crushed stone, be used as backfill to the sub-excavation.

Any additional, location specific, subgrade preparation requirements other than those outlined above are discussed in the following Section 8.4.

8.4 Specific Foundation Design Considerations

In addition to the foundation design recommendations presented above, the following presents further comments and recommendations, and discussion on settlements, specific to each culvert location.

Design geotechnical resistances, subgrade preparation, embankment stability, excavation and groundwater control requirements are discussed in other sections of this report.

8.4.1 Culverts #12, #16, #17, #18, #19, #20 and #25

8.4.1.1 Founding Conditions

Culvert #12

Based on Borehole CV-12B, very stiff clayey silt overlying hard silty clay till are present beneath the culvert extension footprint on the east (inlet) side. These soils are considered suitable for providing a competent subgrade for the culvert extension.

Culvert #16

Based on Boreholes C-16A and C-16B, stiff to hard silty clay to clayey silt till is present in the general vicinity of the culvert extensions on both sides of the highway. Sub-excavation up to the order of 3 to 4 m should be anticipated on the east side and in the order of 2 m on the west side to reach the founding elevation. The actual depths of sub-excavation will vary between and beyond the borehole locations.

Culvert #17

Based on Boreholes C-17A and C-17B, firm to hard clayey silt overlying very stiff to hard silty clay till are present in the general vicinity of the culvert extensions on both sides of the highway. Sub-excavation in the order of 2 to 3 m should be anticipated to reach the founding elevation, but the actual depths of sub-excavation will vary between and beyond the borehole locations.

Culvert #18

Based on Boreholes C-18A and C-18B, firm to very stiff clayey silt overlying stiff to hard silty clay till are present in the general vicinity of the culvert extensions on both sides of the highway. Sub-excavation in the order of 2 to 3 m should be anticipated to reach the founding elevation, but the actual depths of sub-excavation will vary between and beyond the borehole locations.

Culvert #19

Based on Boreholes 06-12W and 06-08E, fill and stiff to hard silty clay to silty clay till are present in the general vicinity of the culvert extensions on both sides of the highway. Sub-excavation in the order of 0.7 to 1.5 m should be anticipated to reach the founding elevation, but the actual depths of sub-excavation will vary between and beyond the borehole locations.

Culvert #20

Based on Borehole 06-16E and C-20, fill overlying very stiff to hard silty clay till are present beneath the culvert extension footprint on the east side. Surficial stiff clayey silt overlies very stiff to hard silty clay till on the west side. Sub-excavation in the order of 2 to 3 m should be

anticipated to reach the founding elevation, but the actual depths of sub-excavation will vary between and beyond the borehole locations.

Culvert #25

Based on Borehole 09-05W, fill and stiff silty clay and clayey silt till overlying very dense sandy silt till are present on the west side of the highway embankment. It is assumed that the subsurface conditions are similar beneath the culvert extension footprint on the east (inlet) side. Sub-excavation in the order of 1.5 to 2 m depth should be anticipated but the actual depths of sub-excavation will vary beyond the borehole location.

8.4.1.2 Foundation Recommendations and Settlements

It is recommended that the culvert extensions be founded on the typically very stiff to hard, native undisturbed silty clay to clayey silt till (see Table 8.2).

Relatively low embankment widening fill up to the order of 3 m is proposed at all the locations discussed in Section 8.4.1.1. Total and differential settlements of less than 25 mm and 15 mm, respectively, are anticipated, provided that the culvert extensions are designed and constructed as outlined in this report. All settlements are expected to be completed by the end of construction.

8.4.2 Culvert #13 (Cold Creek Area)

Based on Boreholes 08-01 and 08-02, a layer of topsoil/organics and firm to very stiff clayey silt/silty clay overlying loose to compact sandy silt/sandy silt till are present beneath the culvert extension footprint on the west (outlet) side. It is recommended that the culvert extension be founded on the native undisturbed clayey silt/silty clay (see Table 8.2). Between 1.2 and 1.4 m of sub-excavation should be anticipated but the actual depths of sub-excavation will vary beyond the borehole locations.

Up to 9 m of embankment widening fill is proposed at this location. Stability issues related to the high fills at this site are discussed in Reference 1. At this site, foundation settlement comprises elastic settlement of cohesionless soils and recompression of the cohesive soils. Foundation settlement is greatest within the section between the existing toe of slope and the crest of the widened embankment where the full height of fill is constructed. The estimated foundation settlements on the west (outlet) side are presented in the following table.

Culvert #	Estimated Foundation Settlement (mm)				
	West Toe of Widening Fill	Mid-Height Bench of Widening Fill	Toe of Existing Embankment Fill	Shoulder Crest of Widening Fill	Crest of Existing Embankment Fill
13	10	40	70	90	5

In order to mitigate the adverse effects of foundation settlements on the new culvert sections, it is recommended that preloading be carried out by placing the embankment widening fill to induce foundation settlements prior to culvert construction. A waiting period of 3 months after the top of fill is reached should be allowed to minimize post construction foundation settlement, which is estimated to be less than 25 mm if preloading is carried out as outlined above.

For box sections, consideration should be given to incorporating a camber along the culvert extension alignment to accommodate the settlements shown in the table above. Articulated joints and shorter culvert sections should be considered to mitigate the adverse effects of differential settlements between adjacent sections.

8.4.3 Culvert #14

Based on Borehole 06-05W and C-14, stiff to very stiff silty clay till overlying compact to dense sandy silt till are present beneath the culvert extension footprint on the west side. Surficial soft to very soft clayey silt and compact silt and sand overlie very stiff to hard clayey silt till on the east side. It is recommended that the culvert extensions be founded on the stiff to very stiff silty clay to clayey silt till (see Table 8.2). Sub-excavation in the order of 2 m should be anticipated but the actual depths of sub-excavation will vary between and beyond the borehole locations.

Embankment widening fill up to the order of 6 m and 4 m is proposed at the west and east extensions, respectively. Stability issues related to the high fills at this site are discussed in Reference 1. At this location, foundation settlement comprises elastic settlement of cohesionless soils and recompression of cohesive soils. Foundation settlement will occur as the fill is placed and is estimated to be largely complete by the end of construction. Up to 40mm of foundation settlement is estimated to occur under the new fill at the east extension. Total and differential settlements of less than 25 mm and 15 mm, respectively, are anticipated for the west extension. For box sections, the incorporation of a camber along the alignment, articulated joints and shorter culvert sections should be considered to mitigate the adverse effects of differential settlements between adjacent sections.

8.4.4 Culvert #15

Based on Borehole 06-05E, firm silty clay and loose sand overlying very stiff to hard silty clay till are present beneath the culvert extension footprint on the east (inlet) side. It is recommended that the culvert extension be founded on the very stiff to hard silty clay till (see Table 8.2). Sub-excavation in the order of 1 to 2.2 m should be anticipated but the actual depths of sub-excavation will vary beyond the borehole location.

Embankment widening fill up to the order of 8 m is proposed at this location. Stability issues related to the high fills at this site are discussed in Reference 1. At this location, foundation

settlement comprises elastic settlement of cohesionless soils and recompression of the cohesive soils. Total and differential settlements of less than 25 mm and 15 mm, respectively, are anticipated. The founding stratum of very stiff to hard silty clay till is over-consolidated. Foundation settlement will occur as the fill is placed and is estimated to be largely complete by the end of construction. For box sections, the incorporation of a camber along the alignment, articulated joints and shorter culvert sections should be considered to mitigate the adverse effects of differential settlements between adjacent sections.

8.4.5 Culvert 19A (New)

The original foundations terms of reference stipulated that the existing Culvert #19 at Station 24+115 is to be replaced with a larger culvert immediately adjacent to the existing one. Subsequent design information from SNC-Lavalin indicated that the existing Culvert #19 will be extended instead and a new concrete box Culvert #19A will be constructed at Station 24+200.

An existing Borehole 11-16 from Reference 1 has been advanced near the highway median for the high mast lighting poles in the vicinity of the new culvert and is used to address the foundation aspects of culvert design and construction. This borehole revealed the presence of embankment fill overlying stiff to hard clayey silt till.

Information from SNC-Lavalin indicates that the cut and cover method is adopted for construction. Protection systems (shoring) with a Performance Level of 2 (see later section) is recommended for use at this site. Some elastic rebound of the foundation soils will take place upon removal of the overlying embankment fill. Recompression will also occur upon installation of the replacement culvert and the placement of embankment fill above it. Since installation of the new culvert would result in net unloading of the underlying foundation soils, post construction foundation settlement may be considered negligible provided that the design and construction of the new culverts are completed as outlined in this report.

Box culvert foundation design and subgrade preparation have been discussed in Sections 8.3.2 and 8.3.5, respectively. More specifically at this site, up to 1.2 m of firm silty clay fill will have to be sub-excavated and replaced with compacted granular materials as per the recommendations in Section 8.3.5.

New fill will be placed for widening the embankment. Total and differential settlements of less than 25 mm and 15 mm, respectively, are anticipated provided that the culvert is designed and constructed as outlined in this report. All settlements are expected to be completed by the end of construction.

Embankment stability, excavation and groundwater control requirements are included in other sections of this report.

8.4.6 Culvert #21

Based on Boreholes 10-05 and 10-06, fill and firm to stiff clayey silt/silty clay overlying very stiff to hard clayey silt till are present at the east and west (inlet and outlet) locations of this culvert. It is recommended that culvert extensions be founded on the very stiff to hard clayey silt till (see Table 8.2). Sub-excavation in the order of 2.1 m and 2.5 m on the west and east sides, respectively, should be anticipated but the actual depths of sub-excavation will vary beyond the borehole locations.

Embankment widening fill up to the order of 5 m and 6 m is proposed at the east and west extensions, respectively. Stability issues related to the high fills at this site are discussed in Reference 1. At this location, foundation settlement comprises recompression of the over-consolidated cohesive soils. Up to 45 mm of foundation settlement is estimated to occur under the new fill. Foundation settlement will occur as the fill is placed and is estimated to be largely complete by the end of construction. For box sections, the incorporation of a camber along the alignment, articulated joints and shorter culvert sections should be considered to mitigate the adverse effects of differential settlements between adjacent sections.

8.5 Embankment Design and Construction Adjacent to Culverts

New fills are to be placed adjacent to and over the culvert extensions in order to widen the existing highway embankment. Embankment construction should be carried out in accordance with Special Prevision No. 206S03 "Amendment to OPSS 206, December 1993" dated November 2006. The embankment material should consist of earth fill or Select Subgrade Material (SSM) in compliance with OPSS 1010.

Provided that the foundation subgrade is prepared as recommended in this report, it is recommended that widening embankments with a slope inclination not steeper than 2H : 1V are considered stable. Benching of existing earth slope surfaces as per OPSD 208.010 should be carried out to enhance keying in of the new fill.

8.6 Erosion Control

Erosion protection should be provided at the culvert inlet and outlet areas where the extensions are to be located. Design of the erosion protection measures must consider hydrologic and hydraulic concerns and should be carried out by specialists experienced in this field.

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

It is recommended that a clay seal or a concrete cut-off wall be used to minimize the potential for erosion near the inlet areas. The clay seal should extend at least 0.3 m above the high water level and laterally for the width of the granular material, and have a minimum thickness of 0.5 m. The material requirements should be in accordance with OPSS 1205.

9 CULVERT BACKFILL AND LATERAL EARTH PRESSURES

It is recommended that backfill to the culvert and headwalls consists of free-draining, non-frost susceptible granular materials such as Granular A or B Type II conforming to OPSS 1010. Reference should be made to the backfill arrangements stipulated in OPSD 803.01 or OPSD 803.02, as appropriate. The existing embankment fill is largely comprised of cohesive materials and is therefore not suitable for backfilling adjacent to the culvert walls and headwalls.

All fills should be placed in regular lifts and be compacted in accordance with Special Provision No. 105S10 "Amendment to OPSS 501, February 1996", dated November 2004. The backfill should be placed and compacted in simultaneous lifts on both sides of a culvert, and the top of backfill elevation should be the same on both sides of the culvert at all times. Heavy compaction equipment must not be used adjacent to the walls and roofs of the culverts.

Earth pressure coefficients for backfill to the culvert are dependent on the material used as backfill. For rigid structures such as concrete open frame or box culverts where lateral yielding is not allowed, the at-rest coefficients should be used. The active coefficients should be used for any wingwalls, headwalls or otherwise unrestrained walls.

Earth pressures acting on the structure may be assumed to impose a triangular distribution. For a fully drained backfill, the pressures should be computed in accordance with the CHBDC 2006, 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 9.1 below)
γ = bulk unit weight of retained soil (see Table 9.1 below)
h = depth below top of fill where pressure is computed (m)
q = value of any surcharge (kPa)

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

Earth pressure coefficients for backfill to the culverts, wingwalls and headwalls are dependent on the material used as backfill. Typical unfactored values are shown in the following Table 9.1.

Table 9.1 Earth Pressure Coefficients (K)

Wall Condition	Earth Pressure Coefficient (K)					
	OPSS Granular A or OPSS Granular B Type II $\phi = 35°; \gamma = 22.8$ kN/m^3		OPSS Granular B Type I (modified) $\phi = 32°; \gamma = 21.2$ kN/m^3		Embankment Fill $\phi = 30°; \gamma = 20.0$ kN/m^3	
	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	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	0.33	0.54
At rest (Restrained Wall)	0.43	0.62	0.47	0.70	0.50	0.76
Passive (Movement Towards Soil Mass)	3.7	-	3.3	-	3.0	-

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 the table above are "ultimate" values and require certain movements for the respective conditions to be mobilized. The values to be used in design can be estimated from Figure C6.9.1 (a) in the Commentary to the CHBDC 2006.

10 EXCAVATION AND GROUNDWATER CONTROL

10.1 Excavation

In general, surface vegetation, topsoil, organic deposits, alluvium, loose/soft soils or otherwise disturbed material should be stripped from the culvert extension area and embankment footprint prior to culvert installation/extension.

Excavations for culvert extension and new culvert construction will extend through the existing embankment fill, alluvium and surficial native soils.

At locations where there is space restriction prohibiting unsupported open cutting or where a slope has to be retained, the excavations will need to be carried out in conjunction with a protection (temporary shoring) system. Any protection system should be designed by licensed Professional Engineers experienced in such designs. OPSS 539 "Construction

Specification for Protection Systems" will have to be included in the contract documents. Typically, a Performance Level 2 as per Clause 539.04.02.01 (maximum horizontal displacement of 25 mm) should be specified for these culvert extension sites.

All excavations must be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the native clayey silts to silty clays at this site are classified as Type 2 soils above the water table. All existing embankment fills are classified as Type 3 soils. Below the water table, all cohesive and cohesionless soils are classified as Type 3 soils.

10.2 Groundwater Control

Groundwater perched within the embankment fill will seep into excavations for culvert construction. Surface runoff will also tend to accumulate in these excavations. Beyond the toe of the embankment, the groundwater level varies between locations but is expected to be governed by the water level in the watercourses (creeks/streams). Excavation for culvert extensions and construction is typically up to the order of 2 to 3 m depth. The Contractor must make provisions to control any water seepage, surface runoff and ponding by measures including pumping from filtered sumps to maintain dry excavations during construction. In general, surface water must be diverted away from any excavation at all times. Temporary water course diversion may be required where feasible.

11 SEISMIC CONSIDERATIONS

11.1 Seismic Design Parameters

The following seismic parameters 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 0.05

The Soil Profile Type at this site is classified as Type I. According to Clause 4.4.6.1 and Table 4.4 of the CHBDC 2006, a Site Coefficient "S" (ground motion amplification factor) of 1.0 should be used in seismic design.

11.2 Liquefaction Potential

Based on the CHBDC (2006) Section C4.6, the native silty clays/clayey silts below the footprints of the proposed widening embankments are unlikely to undergo liquefaction.

Based on the Seed and Idriss method, it is considered that the liquefaction potential of the typically compact, cohesionless foundation sands and silts is low.

The new fill for embankment widening is expected to consist of free-draining granular material or SSM. The existing embankment fill comprises clayey silts to silty clays that are unlikely to liquefy. The groundwater levels are below the base level of the embankments. As such, it is considered that there is negligible potential for liquefaction of the embankments.

12 CONSTRUCTION CONCERNS

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

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

- daily visual inspection of the pavement surface must be carried out in the vicinity of each culvert under construction; any form of cracks, pavement distress or settlement that are observed must be immediately brought to the attention of the CA for determining if remedial action is required (suggested wording for an NSSP addressing this issue is included in Appendix E),
- groundwater control is essential for maintaining reasonably dry excavations,
- removal of organics, soft soils and alluvial deposits near creek and stream channels,
- avoid disturbance of the soil subgrade within the culvert foundation footprints,
- confirmation that the culvert backfills and approach fills are adequately placed and compacted to specifications.

It is recommended that provision(s) be included in the contract requiring the QVE to confirm that the above issues are adequately addressed. Should there be any doubts about issues such as depth of sub-excavation, these provisions should require the QVE to alert the CA.

13 CLOSURE

Engineering analysis and preparation of this foundation design report was carried out by Dr. Sydney Pang, P.Eng. The report was reviewed by Dr. P. K. Chatteriji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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Appendix A

Record of Borehole Sheets

Table A1

Borehole Completion Details

Borehole	Piezometer Tip Depth/ Elevation (m)	Completion Details
CV-12B	11.2 / 229.4	Piezometer with 1.5 m slotted screen installed with sand filter to 6.9 m (Elevation 231.1 m), bentonite seal to 6.4 m depth, then grout to surface.
08-01	None installed	Bentonite to surface.
08-02	None installed	Bentonite to surface.
06-05W	None installed	Bentonite to surface.
06-05E	None installed	Bentonite to surface.
06-08E	None installed	Bentonite to surface.
06-12W	11.3 / 260.3	Piezometer with 1.5 m slotted screen installed with sand filter to 7.5 m (Elevation 264.1 m), grout from 7.5 to 1.4 m depths, then bentonite seal to 0.3 m depth, cuttings to ground surface.
06-16E	None installed	Bentonite to surface.
10-05	6.0 / 256.5	Piezometer with 1.5 m slotted screen installed with sand filter to 4.0 m (Elevation 258.5 m), then bentonite seal to 0.2 m, cuttings to surface.
10-06	None installed	Bentonite to surface.
09-05W	None installed	Bentonite to surface.
C-14	7.5 / 237.1	Piezometer with 1.5 m slotted screen installed with sand filter to 5.7 m (Elevation 238.9 m), then bentonite seal to surface.
C-16A	7.6 / 250.6	Piezometer with 1.5 m slotted screen installed with sand filter to 6.0 m (Elevation 252.2 m), then bentonite seal to surface.
C-16B	7.4 / 248.1	Piezometer with 1.5 m slotted screen installed with sand filter to 5.7 m (Elevation 249.8 m), then bentonite seal to surface.
C-17A	None installed	Bentonite to 2.4 m depth, then cuttings to surface.
C-17B	7.4 / 251.0	Piezometer with 1.5 m slotted screen installed with sand filter to 5.7 m (Elevation 252.7 m), then bentonite seal to surface.
C-18A	None installed	Bentonite to 2.5 m depth, then cuttings to surface.
C-18B	9.1 / 252.4	Piezometer with 1.5 m slotted screen installed with sand filter to 7.3 m (Elevation 254.2 m), then bentonite seal to surface.
C-20	7.9 / 269.2	Piezometer with 1.5 m slotted screen installed with sand filter to 6.2 m (Elevation 270.9 m), then bentonite seal to surface.

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction

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

4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE

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

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

▼ Water Level

C_{pen} Shear Strength Determination by Pocket Penetrometer

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

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

UNIFIED SOILS CLASSIFICATION

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

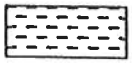
EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION

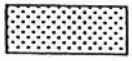
Fresh (FR)	No visible signs of weathering.
Fresh Jointed (FJ)	Weathering limited to the surface of major discontinuities.
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.
Moderately Weathered (MW)	Weathering extends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

SYMBOLS

CLAYSTONE



SILTSTONE



SANDSTONE

COAL

Bedrock (general)

DISCONTINUITY SPACING

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

TERMS

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

STRENGTH CLASSIFICATION

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

THURBER

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No C-14 1 OF 1 METRIC

W.P. 2539-04-00 LOCATION N 4 859 214.9 E 300 433.5 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2011.03.18 - 2011.03.18 CHECKED BY MEF

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
244.6											
0.0	Clayey **SILT**, some sand, trace roots Very Soft to Soft Dark Brown Moist		1	SS	2				○		
243.2			2	SS	2		244		○		
1.4	**SILT** and **SAND**, some clay, trace gravel Compact Brown Moist		3	SS	15		243		○ ○		3 34 52 11
242.6											
2.0	Clayey **SILT**, some sand, trace gravel Very Stiff to Hard Brown Moist (TILL) Occasional sand seams, occasional oxide staining		4	SS	24		242		○		
			5	SS	24	▼	241		○		
			6	SS	84/ 0.250		240		⊕		1 27 55 17
			7	SS	73		239		○		
237.3							238				
7.3	**SILT** and **SAND**, trace clay, trace gravel, occasional oxide staining Dense Brown Moist		8	SS	43		237		○		0 47 48 5
236.5											
~~238.1~~ 8.2	Clayey **SILT** (TILL)										
	END OF BOREHOLE AT 8.2m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Oct.05/11 3.3 241.3										

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

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

ONTMT4S 9268.GPJ 3/5/12

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No C-16A 1 OF 1 METRIC

W.P. 2539-04-00 LOCATION N 4 860 492.9 E 300 211.0 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2011.03.21 - 2011.03.21 CHECKED BY MEF

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
258.2											
0.0 / 0.1	**TOPSOIL:** (75mm)										
	Clayey **SILT**, some sand, trace gravel, trace organics Firm Brown Moist		1	SS	7		258		o		
257.1											
1.0	Clayey **SILT**, some sand, trace gravel Stiff to Very Stiff Brown Moist (TILL)		2	SS	10		257		o		
	Mottled Brown/Grey		3	SS	18				⊢●⊣		0 25 61 14
	Occasional sand seams		4	SS	17		256		o		
255.2											
3.0	Hard		5	SS	31		255		o		
254.0											
4.1	Silty **CLAY**, some sand, trace gravel Hard Brown Moist (TILL)		6	SS	61	▼	254		⊢●⊣		0 14 60 26
	Occasional sand seams, occasional oxide staining		7	SS	64		253				
251.1							252		o		
7.0	**SILT** and **SAND**, trace clay, trace gravel Very Dense Grey Moist		8	SS	52		251		o		1 34 56 9
250.1											
8.1	END OF BOREHOLE AT 8.1m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Oct.05/11 5.0 253.2										

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

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

ONTMT4S 9268.GPJ 12/21/11

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No C-16B 1 OF 1 METRIC

W.P. 2539-04-00 LOCATION N 4 860 480.3 E 300 154.3 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Solid Stem Augers (Mini Moe) COMPILED BY AN

DATUM Geodetic DATE 2011.03.18 - 2011.03.18 CHECKED BY MEF

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
255.5											
0.0	**TOPSOIL:** (25mm)										
	Clayey **SILT**, some sand, occasional wood fibres Frim to Very Stiff Dark Brown to Brown Moist		1	SS	5		255				
			2	SS	20						
254.0							254				
1.4	Silty **CLAY**, some sand, trace gravel, occasional oxide staining Stiff to very stiff Brown Moist (TILL)		3	SS	14						
			4	SS	26		253				0 26 51 23
252.5											
3.0	Occasional sand seams Hard		5	SS	51						
							252				
			6	SS	48		251				
	Becomes Grey										
			7	SS	57		250				0 12 58 30
							249				
							248				
247.4			8	SS	45						
8.1	END OF BOREHOLE AT 8.1m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Oct.05/11 2.2 253.3										

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

(%) STRAIN AT FAILURE

ONTMT4S 9268.GPJ 12/21/11

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No C-17A 1 OF 1 METRIC

W.P. 2539-04-00 LOCATION N 4 860 941.6 E 300 132.9 ORIGINATED BY SLL

HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2010.12.16 - 2010.12.16 CHECKED BY MEF

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
260.4											
0.0	**TOPSOIL:** (150mm)										
0.2	Clayey **SILT**, topsoil stained with rootlets, occasional sand pockets Firm to Hard Brown Moist		1	SS	6		260		○		
			2	SS	11		259		○		
258.3			3	SS	35				○		
2.2	Silty **CLAY**, some sand, trace gravel Hard Brown Moist (TILL)		4	SS	63		258		○—⊣		0 13 55 32
			5	SS	60		257		○		
	Becomes grey		6	SS	50		256		○		
			7	SS	37		255 254		⊢○⊣		0 20 47 33
252.2	Occasional silty sand seams		8	SS	30		253		○		
8.2	END OF BOREHOLE AT 8.2m. BOREHOLE OPEN AND DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 2.4m, THEN CUTTINGS TO SURFACE.										

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

$\overset{20}{15\text{-}\oplus\text{-}5}_{10}$ (%) STRAIN AT FAILURE

ONTMT4S 9268.GPJ 9/26/11

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No C-17B 1 OF 1 METRIC

W.P. 2539-04-00 LOCATION N 4 860 927.5 E 300 072.3 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Solid Stem Augers (Mini Moe) COMPILED BY AN

DATUM Geodetic DATE 2011.03.21 - 2011.03.21 CHECKED BY MEF

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
258.4											
0.0	**TOPSOIL:** (50mm)										
	Clayey **SILT**, some sand, trace roots Firm Dark Brown to Brown Moist		1	SS	4		258				
257.5											
0.9	Silty **CLAY**, some sand, trace gravel, occasional sand pockets Very Stiff to Hard Brown to Grey Moist (TILL)		2	SS	17		257				0 21 51 28
			3	SS	23						
			4	SS	38		256				
			5	SS	47	▼	255				
			6	SS	34		254				0 13 53 34
			7	SS	24		253				
251.2							252				
7.2	**SAND**, fine grained Compact Grey Moist		8	SS	28		251				
250.1											
8.2	END OF BOREHOLE AT 8.2m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Oct.05/11 3.4 255.0										

+ ³, × ³: Numbers refer to Sensitivity

(%) STRAIN AT FAILURE

ONTMT4S 9268.GPJ 12/21/11

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No C-18A 1 OF 1 METRIC

W.P. 2539-04-00 LOCATION N 4 861 185.1 E 300 092.0 ORIGINATED BY SLL
HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2010.12.16 - 2010.12.16 CHECKED BY MEF

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
260.3											
0.0 / 260.0	**TOPSOIL**, with roots and rootlets, fibrous, Black, Moist to Wet		1	SS	7		260		○		
0.4	Clayey **SILT**, some sand, topsoil stained, with roots and rootlets, Firm to Very Stiff, Dark Brown, Moist		2	SS	5				○		
			3	SS	18		259		○		
258.1											
2.3	Silty **CLAY**, some sand, trace gravel, Hard, Brown, Moist, (TILL)		4	SS	55		258		⊕		0 13 47 40
	Becomes grey		5	SS	31	▽	257		○		
255.4							256		○ ○ ○		
255.8	Silty **SAND**		6	SS	25						
5.1	Brown, Wet						255				
	With sand		7	SS	33		254		⊕		1 31 43 25
							253				
252.1			8	SS	38				○		
8.2	END OF BOREHOLE AT 8.2m. BOREHOLE OPEN AND WATER LEVEL AT 3.7m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 2.5m, THEN CUTTINGS TO SURFACE.										

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

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE
10

ONTMT4S 9268.GPJ 9/28/11

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No C-18B 1 OF 2 METRIC

W.P. 2539-04-00 LOCATION N 4 861 115.5 E 300 049.8 ORIGINATED BY ES
HWY 400 BOREHOLE TYPE Solid Stem Augers (Mini Moe) COMPILED BY AN
DATUM Geodetic DATE 2011.03.22 - 2011.03.22 CHECKED BY MEF

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
261.5											
0.0 / 0.1	**TOPSOIL:** (75mm)										
	Clayey **SILT**, some organics, trace roots and rootlets Firm Dark Brown to Brown Moist		1	SS	5		261				
			2	SS	4						
260.1											
1.4	Silty **CLAY**, some sand, trace gravel, occasional oxide staining Stiff to Very Stiff Mottled Brown to Grey Moist (TILL)		3	SS	12		260				
			4	SS	24		259				0 14 50 36
258.5											
3.0	Hard		5	SS	37		258				
257.4						▼					
4.1			6	SS	14		257				
			7	SS	23		256				
							255				
253.7							254				
7.8	**SILT**, some sand, trace clay Dense to Compact Grey Moist to Wet		8	SS	46						0 17 79 4
			9	SS	26		253				
251.7							252				
9.8	END OF BOREHOLE AT 9.8m.										

Continued Next Page

+ ³ . × ³ : Numbers refer to Sensitivity

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

ONTMT4S 9268.GPJ 12/21/11

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No C-18B 2 OF 2 METRIC

W.P. 2539-04-00 LOCATION N 4 861 115.5 E 300 049.8 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Solid Stem Augers (Mini Moe) COMPILED BY AN

DATUM Geodetic DATE 2011.03.22 - 2011.03.22 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: O UNCONFINED + FIELD VANE; ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	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) Oct.05/11 3.9 257.6										

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

$\frac{20}{15 \diamond 5}$ (%) STRAIN AT FAILURE
10

ONTMT4S 9268.GPJ 12/21/11

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No C-20 1 OF 1 METRIC

W.P. 2539-04-00 LOCATION N 4 862 554.4 E 299 795.3 ORIGINATED BY SLL

HWY 400 BOREHOLE TYPE Solid Stem Augers (Mini Moe) COMPILED BY AN

DATUM Geodetic DATE 2011.03.17 - 2011.03.17 CHECKED BY MEF

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
277.1											
0.0	Clayey **SILT**, some sand, trace gravel, trace roots Stiff Brown Moist		1	SS	13		277		○		
	Brown to Dark Brown		2	SS	0		276		○		
275.5											
1.6	Silty **CLAY**, some sand, trace gravel Very Stiff to Hard Mottled Brown/Grey Moist (TILL)		3	SS	16				○		
			4	SS	25	▼	275		○		
			5	SS	33		274		⊕		0 18 49 33
			6	SS	36		273		○		
			7	SS	35		272		○		
			8	SS	34		271		⊕		1 15 47 37
268.9							270				
8.2	END OF BOREHOLE AT 8.2m. BOREHOLE DRY UPON COMPLETION. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Oct.05/11 2.8 274.3						269				

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

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

ONTMT4S 9268.GPJ 1/18/12

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No CV-12A 1 OF 2 METRIC

G.W.P. 2539-04-00 LOCATION Hwy 400, Teston Road to King Road N 4 857 700.10 E 300 620.00 ORIGINATED BY TK
HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY SL/SS
DATUM Geodetic DATE 2004.07.15 - 2004.07.15 CHECKED BY SMS

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
239.3											
0.0	Clayey, **SILT**, some sand, trace gravel, occasional organic layer Stiff Brown		1	SS	11		239		○		
238.5											
0.8	Silty **CLAY**, with sand, trace gravel Hard Brown (TILL)(CL-ML)		2	SS	37		238		⊢○⊣		1 23 53 23
							237				
			3	SS	86/ 254		236		○		
	Becoming Grey		4	SS	79/ 279		235		○		
233.2							234				
6.1	Sandy **SILT**, trace clay, trace gravel Very Dense Grey (TILL)(ML-NONPLASTIC)		5	SS	87/ 279		233		○		
							232				
			6	SS	50/ .127				○		
							231				
			7	SS	50/ .102		230		○		
229.6											
9.8	END OF BOREHOLE AT 9.8 m.										

Continued Next Page

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

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

ONTMT4S 9268.GPJ 5/7/10

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No CV-12A 2 OF 2 METRIC

G.W.P. 2539-04-00 LOCATION Hwy 400, Teston Road to King Road N 4 857 700.10 E 300 620.00 ORIGINATED BY TK

HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY SL/SS

DATUM Geodetic DATE 2004.07.15 - 2004.07.15 CHECKED BY SMS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	Continued From Previous Page										
	BOREHOLE OPEN TO 9.8 m. BOREHOLE WET AT 6.6 m. BOREHOLE BACKFILLED WITH BENSEAL.										

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

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

ONTMT4S 9268.GPJ 5/7/10

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No CV-12B 1 OF 2 METRIC

G.W.P. 2539-04-00 LOCATION Hwy 400, Teston Road to King Road N 4 857 709.0 E 300 687.0 ORIGINATED BY TK

HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY SL/SS

DATUM Geodetic DATE 2004.07.16 - 2004.07.16 CHECKED BY SMS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: O UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
240.0											
0.0	Clayey SILT, with sand, trace gravel, trace organics Very Stiff Dark Brown		1	SS	17		240		o		
238.5							239				
1.5	Silty CLAY, with sand, trace gravel, occasional iron oxide staining Hard Brown to Grey (TILL)(CL-ML)		2	SS	56		238		o		
			3	SS	50/.150		237		o⊢		2 20 52 26
235.4							236				
4.6	Sandy SILT, trace clay, trace gravel, occasional cobbles Very Dense Grey (TILL)(ML)		4	SS	50/.102		235		o		
			5	SS	89		234		o		
			6	SS	50/.279		233				
			7	SS	50/.127		232		o		
							231		o		

Continued Next Page

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

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

ONTMT4S 9268.GPJ 8/10/10

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No CV-12B 2 OF 2 METRIC

G.W.P. 2539-04-00 LOCATION Hwy 400, Teston Road to King Road N 4 857 709.0 E 300 687.0 ORIGINATED BY TK

HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY SL/SS

DATUM Geodetic DATE 2004.07.16 - 2004.07.16 CHECKED BY SMS

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (O UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page							20 40 60 80 100	20 40 60		
	Sandy SILT, trace clay, trace gravel, occasional cobbles Very Dense Grey (TILL)(ML)						230		o		
229.1			8	SS	50/.127						
10.9	END OF BOREHOLE AT 11.0 m. Piezometer installation consists of 19 mm diameter Schedule 40 PVC pipe with a 1.52 m slotted screen. WATER LEVEL READINGS: DATE DEPTH(m) ELEV.(m) 05.08.04 10.8 229.2										

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

$\begin{matrix}20\\15\\10\end{matrix}\oplus 5$ (%) STRAIN AT FAILURE

ONTMT4S 9268.GPJ 8/10/10

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No CV-13A 1 OF 2 METRIC

G.W.P. 2539-04-00 LOCATION Hwy 400, Teston Road to King Road N 4 858 645.00 E 300 534.00 ORIGINATED BY TK

HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY SL/SS

DATUM Geodetic DATE 2004-07-14 - 2004-07-14 CHECKED BY SMS

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
229.0							229				
0.0	Clayey **SILT**, some sand, some gravel, some organic pockets Firm to Stiff Brown		1	SS	8				○		
							228				
227.0			2	SS	15				○		
2.0	Sandy **SILT**, trace clay, trace gravel, occasional cobbles Compact Grey (TILL)(ML-NONPLASTIC)						227				
			3	SS	15		226		○		0 22 69 9
							225				
	Becoming Dense to Very Dense		4	SS	39		224		○		
			5	SS	50/.229		223		○		
221.4							222				
7.6	Silty **SAND**, fine grained, trace gravel, occasional cobbles Very Dense Grey (SM)		6	SS	50/.279		221		○		
220.4											
8.5	**SILT**, trace sand Very Dense Grey (ML-NONPLASTIC)						220				
219.2			7	SS	65				○		
9.8	END OF BOREHOLE AT 9.8 m.										

Continued Next Page

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

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

ONTMT4S 9268.GPJ 10/05/07

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No CV-13A 2 OF 2 METRIC

G.W.P. 2539-04-00 LOCATION Hwy 400, Teston Road to King Road N 4 858 645.00 E 300 534.00 ORIGINATED BY TK

HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY SL/SS

DATUM Geodetic DATE 2004-07-14 - 2004-07-14 CHECKED BY SMS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	Continued From Previous Page										
	BOREHOLE OPEN TO 9.8 m. BOREHOLE WET AT 2.1 m. BOREHOLE BACKFILLED WITH BENSEAL.										

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

20
15 5
10
(%) STRAIN AT FAILURE

ONTMT4S 9268.GPJ 10/05/07

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No CV-13B 1 OF 2 METRIC

G.W.P. 2539-04-00 LOCATION Hwy 400, Teston Road to King Road N 4 858 657.00 E 300 558.00 ORIGINATED BY TK
HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY SL/SS
DATUM Geodetic DATE 1899.12.30 - 1899.12.30 CHECKED BY SMS

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
229.7											
0.0	Clayey **SILT**, some sand, some organics, trace rootlets, occasional silt pockets Soft Dark Brown		1	SS	3				o		
228.9							229				
0.7	Silty **SAND**, trace clay, occasional silt layers Dense Grey		2	SS	41		228		o		
227.7											
2.0	Silty **CLAY**, some sand, trace gravel, occasional silt layers, occasional cobbles Hard Grey (TILL)(CL)		3	SS	48		227		o		0 12 63 24
							226				
			4	SS	75		225		⊢		4 25 49 21
							224				
			5	SS	33				o		
223.1							223				
6.6	**SAND**, trace to some silt Compact Brown (SP/SM)										
221.7			6	SS	34		222		o		
8.0	Silty **SAND**, trace gravel Dense to Very Dense Grey (SM)										
			7	SS	73		221		o		
219.9							220				
9.8	END OF BOREHOLE AT 9.8 m.										

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

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

ONTMT4S 9268.GPJ 5/7/10

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No CV-13B 2 OF 2 METRIC

G.W.P. 2539-04-00 LOCATION Hwy 400, Teston Road to King Road N 4 858 657.00 E 300 558.00 ORIGINATED BY TK

HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY SL/SS

DATUM Geodetic DATE 1899.12.30 - 1899.12.30 CHECKED BY SMS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	Continued From Previous Page										
	Piezometer installation consists of 19 mm diameter Schedule 40 PVC pipe with a 1.52 m slotted screen.										
	WATER LEVEL READINGS: DATE DEPTH(m) ELEV.(m) 15/07/04 1.8 227.9 05/08/04 0.6 229.1										

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

$\overset{20}{15\oplus 5}$ $\underset{10}{}$ (%) STRAIN AT FAILURE

ONTM4S 9268.GPJ 5/7/10

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 08-01 1 OF 2 METRIC

G.W.P. 2539-04-00 LOCATION Hwy 400, Teston Road to King Road N 4 858 612.1 E 300 459.8 ORIGINATED BY LG
HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2008.09.15 - 2008.09.15 CHECKED BY SKP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS
226.6						
0.0	**TOPSOIL**, rootlets, grass					
226.0						
0.6	Clayey **SILT**, trace sand, trace rootlets, some black staining Firm Brown to Grey Moist		1	SS	5	
			2	SS	6	
224.3						
2.3	Silty **CLAY**, trace gravel Very Stiff to Firm Grey Moist to Wet		3	SS	16	
			4	SS	6	
222.3						
4.3	Sandy **SILT**, trace clay Very Loose Grey Wet		5	SS	0	
	Compact Grey Wet		6	SS	19	
			7	SS	19	
			8	SS	25	

ELEVATION SCALE: 226, 225, 224, 223, 222, 221, 220, 219, 218, 217

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

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

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

UNIT WEIGHT γ kN/m^3

REMARKS & GRAIN SIZE DISTRIBUTION (%)
GR SA SI CL

Continued Next Page

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

$\frac{20}{15}\oplus\frac{5}{10}$ (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 08-01 2 OF 2 METRIC

G.W.P. 2539-04-00 LOCATION Hwy 400, Teston Road to King Road N 4 858 612.1 E 300 459.8 ORIGINATED BY LG
HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2008.09.15 - 2008.09.15 CHECKED BY SKP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
216.5	Continued From Previous Page										
10.1	Silty SAND, trace clay Dense Grey Wet										
			9	SS	32		216		○		
214.9											
11.7	SAND Compact Grey Wet						215				
			10	SS	29		214		○		
213.3											
13.3	Dense						213				
			11	SS	43				○		
211.8							212				
14.8											
			12	SS	25		211		○		
208.7							210				
							209				
17.9	END OF BOREHOLE AT 17.93m BOREHOLE WET AT 4m DEPTH. BOREHOLE SEALED WITH GROUT THEN BENTONITE HOLEPLUG TO SURFACE.										

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

20
15 5
10
(%) STRAIN AT FAILURE

ONTMT4S 9268.GPJ 8/10/10

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 08-02 1 OF 2 METRIC

G.W.P. 2539-04-00 LOCATION Hwy 400, Teston Road to King Road N 4 858 604.7 E 300 441.2 ORIGINATED BY LG
HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2008.09.16 - 2008.09.16 CHECKED BY SKP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS
227.2						
0.0	**TOPSOIL and ORGANICS**, some silt, trace clay, rootlets Soft Brown to Black Moist		1	SS	3	
225.8						
1.4	Clayey **SILT**, trace sand, trace gravel Stiff Brown Wet		2	SS	12	
225.4						
1.8	Silty **SAND**, some gravel Compact Grey Wet		3	SS	27	
224.9						
2.3	Sandy **SILT**, trace to some clay Compact to Loose Grey Wet		4	SS	29	
			5	SS	19	
			6	SS	6	
220.0						
7.2	Dense		7	SS	39	
218.5						
8.7			8	SS	20	

ELEVATION SCALE: 227, 226, 225, 224, 223, 222, 221, 220, 219, 218

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

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

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

UNIT WEIGHT γ kN/m^3

REMARKS & GRAIN SIZE DISTRIBUTION (%)
GR SA SI CL

Continued Next Page

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

$\frac{20}{15}\oplus\frac{5}{10}$ (%) STRAIN AT FAILURE

ONTMT4S 9268.GPJ 8/10/10

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 08-02 2 OF 2 METRIC

G.W.P. 2539-04-00 LOCATION Hwy 400, Teston Road to King Road N 4 858 604.7 E 300 441.2 ORIGINATED BY LG
HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2008.09.16 - 2008.09.16 CHECKED BY SKP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
217.1	Continued From Previous Page										
10.1	SAND, some silt Compact Grey Wet						217				
			9	SS	24		216		○		
							215		○		
			10	SS	23		214				
							213				
							212				
							211				
209.8							210				
17.4	END OF BORE HOLE AT 17.37m BOREHOLE WET AT 1.5m DEPTH. BOREHOLE SEALED WITH GROUT TO 0.6m DEPTH, THEN BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.										

+ ³, × ³: Numbers refer to Sensitivity

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

ONTMT4S 9268.GPJ 8/10/10

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 06-05W 1 OF 1 METRIC

G.W.P. 2539-04-00 LOCATION Hwy 400, Teston Road to King Road N 4 859 131.21 E 300 359.10 ORIGINATED BY SLL
HWY 400 BOREHOLE TYPE Solid Stem Auger COMPILED BY MFA
DATUM Geodetic DATE 2007.02.05 - 2007.02.05 CHECKED BY TJH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
240.9											
0.0	**TOPSOIL:** (100mm)										
0.1	**Silty CLAY**, with sand, some sand seams Stiff to Very Stiff Dark Brown Moist (TILL)(CL)		1	SS	8		240				
			2	SS	17		239				0 22 52 26
237.9			3	SS	27		238				
3.0	**SAND and SILT**, trace clay Compact to Dense Brown Moist (TILL)		4	SS	34		237				
			5	SS	26	▼	236				0 36 61 3
			6	SS	25		235				
232.6			7	SS	34		234				
8.2	END OF BOREHOLE AT 8.23m BOREHOLE CAVED TO 5.39m. BOREHOLE BACKFILLED WITH HOLEPLUG UPON COMPLETION. WATER LEVEL READINGS: DATE DEPTH(m) ELEV.(m) 05.02.07 5.0 235.9						233				

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

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE
10

ONTMT4S 9268.GPJ 5/7/10

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 06-05E 1 OF 2 METRIC

G.W.P. 2539-04-00 LOCATION Hwy 400, Teston Road to King Road N 4 859 708.59 E 300 349.57 ORIGINATED BY SLL
HWY 400 BOREHOLE TYPE Solid Stem Auger COMPILED BY MFA
DATUM Geodetic DATE 2007.02.01 - 2007.02.01 CHECKED BY TJH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
243.2											
0.0											
0.1	TOPSOIL: (75mm)										
	Silty CLAY, with sand, trace gravel, with roots Firm Dark Brown Moist		1	SS	8		243		o		3 29 49 19
241.7	topsoil-stained, trace rootlets						242				
1.5	SAND, some silt, trace clay, trace rootlets Loose Dark Brown		2	SS	4				o		
241.0							241				
2.2	Silty CLAY, some sand, trace gravel Very Stiff to Hard Brown Moist (TILL)		3	SS	25				o		
			4	SS	51		240		o		
	Grey						239				
	occasional inferred cobbles		5	SS	90/ 275				d		1 28 51 20
237.4							238				
5.8	Silty SAND, trace clay Dense Grey Wet		6	SS	48		237		o		0 65 32 3
			7	SS	48		236		o		
							235				
233.7			8	SS	50/ 150		234		o		
9.4	END OF BOREHOLE AT 9.45m. BOREHOLE CAVED TO 4.88m, BACKFILLED WITH BENTONITE										

Continued Next Page

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

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

ONTMT4S 9268.GPJ 8/10/10

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 06-05E 2 OF 2 METRIC

G.W.P. 2539-04-00 LOCATION Hwy 400, Teston Road to King Road N 4 859 708.59 E 300 349.57 ORIGINATED BY SLL

HWY 400 BOREHOLE TYPE Solid Stem Auger COMPILED BY MFA

DATUM Geodetic DATE 2007.02.01 - 2007.02.01 CHECKED BY TJH

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 (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE; ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100	WATER CONTENT (%) 20 40 60		GR SA SI CL
	Continued From Previous Page										
	HOLEPUG TO SURFACE.										
	WATER LEVEL READINGS: DATE DEPTH(m) ELEV.(m) 01.02.07 1.5 241.7										

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

$\overset{20}{15\oplus 5}$ $\underset{10}{}$ (%) STRAIN AT FAILURE

ONTMT4S 9268.GPJ 8/10/10

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 06-08E 1 OF 1 METRIC

G.W.P. 2539-04-00 LOCATION Hwy 400, Teston Road to King Road N 4 862 025.75 E 299 939.66 ORIGINATED BY SLL
HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY WM
DATUM Geodetic DATE 2007.01.19 - 2007.01.19 CHECKED BY TJH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
273.9								20 40 60 80 100	20 40 60		
0.0	**ASPHALT**: (150 mm)						274				
0.2	**SAND**, some gravel Brown Moist										
273.2	(FILL)										
0.7	Silty **CLAY**, some sand, trace gravel Very Stiff to Hard Brown Moist (FILL)		1	SS	26		273		o		
			2	SS	38		272		o		
271.4											
2.5	Silty **CLAY**, with sand, trace roots Stiff Brown Moist		3	SS	14		271		o		
			4	SS	12				⊢●⊣		0 22 50 28
270.0							270				
4.0	Silty **CLAY**, some sand, trace gravel Hard Grey Moist (TILL)(CL)		5	SS	44		269		o⊢⊣		1 20 51 28
			6	SS	72		268		o		
							267				
			7	SS	46		266		⊢o⊣		1 10 50 39
							265				
264.2			8	SS	14				o		
9.6	END OF BOREHOLE AT 9.75 m.										

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

20
15 ⊕ 5
10
(%) STRAIN AT FAILURE

ONTMT4S 9268.GPJ 5/7/10

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 06-12W 1 OF 2 METRIC

G.W.P. 2539-04-00 LOCATION Hwy 400, Teston Road to King Road N 4 862 017.2 E 299 889.3 ORIGINATED BY SLL
HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY WM
DATUM Geodetic DATE 2007.01.12 - 01/120/7 CHECKED BY TJH

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	UNIT WEIGHT kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
271.6							
0.0	TOPSOIL, black with roots: (100 mm)						
270.3							
0.3	SAND: (FILL)	1	SS	4			
270.9	Silty CLAY, trace roots and rootlets Dark Brown Moist (FILL)						
0.7	Silty CLAY, some sand, trace gravel Stiff to Hard Brown Moist (TILL)(CL)	2	SS	12	271		
		3	SS	34	270		3 18 47 32
		4	SS	32	269		
		5	SS	32			
					268		
		6	SS	26	267		0 6 57 37
	sand seam layer at 5.13 to 5.18 m						
					266		
		7	SS	17			
					265		
					264		
		8	SS	46			1 30 47 22
					263		
262.3							
9.3	Sandy SILT, trace clay, trace gravel Dense Grey Wet (TILL)	9	SS	43	262		

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100
PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L
WATER CONTENT (%) 20 40 60

Continued Next Page

+³, ×³: Numbers refer to Sensitivity

20
15 ⊕ 5 (%) STRAIN AT FAILURE
10

ONTMT4S 9268.GPJ 5/7/10

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 06-12W 2 OF 2 METRIC

G.W.P. 2539-04-00 LOCATION Hwy 400, Teston Road to King Road N 4 862 017.2 E 299 889.3 ORIGINATED BY SLL

HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY WM

DATUM Geodetic DATE 2007.01.12 - 01/120/7 CHECKED BY TJH

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	Continued From Previous Page										
	Sandy SILT, trace clay, trace gravel Dense Grey Wet (TILL)						261				
260.3			10	SS	47				o		
11.3	END OF BOREHOLE AT 11.28 m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH(m) ELEV.(m) 20.02.07 5.1 266.5 27.03.07 4.9 266.7										

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

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

ONTMT4S 9268.GPJ 5/7/10

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 06-16E 1 OF 1 METRIC

G.W.P. 2539-04-00 LOCATION Hwy 400, Teston Road to King Road N 4 862 563.7 E 299 856.8 ORIGINATED BY SLL

HWY 400 BOREHOLE TYPE Solid Stem Auger COMPILED BY MFA

DATUM Geodetic DATE 2006.12.18 - 2006.12.18 CHECKED BY SKP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
277.4											
0.0	**TOPSOIL**, black: (175 mm)										
0.2	Silty **CLAY**, some sand, trace roots and rootlets Soft to Very Stiff Dark Brown (FILL)		1	SS	2		277		o		
			2	SS	19				o		1 18 50 31
276.0							276				
1.4	Silty **CLAY**, some sand, trace gravel Very Stiff to Hard Brown (TILL)(CL)		3	SS	22				o		
			4	SS	40		275		o		
	occasional sand seams		5	SS	37				o		
							274				
			6	SS	25		273		d		0 18 52 30
							272				
			7	SS	33				c		
270.7							271		o		
6.7	END OF BOREHOLE AT 6.7m. BOREHOLE OPEN AND DRY TO BOTTOM UPON COMPLETION. BOREHOLE GROUTED WITH BENTONITE AND BACKFILLED WITH AUGER CUTTINGS TO SURFACE.										

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

$\overset{20}{15\oplus 5}$ (%) STRAIN AT FAILURE
$\underset{10}{}$

ONTMT4S 9288.GPJ 5/7/10

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 10-05 1 OF 1 METRIC

G.W.P. 2539-04-00 LOCATION Hwy 400, Teston Road to King Road N 4 863 274.9 E 299 659.3 ORIGINATED BY SLL
HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2010.02.04 - 2010.02.04 CHECKED BY SKP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (o UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
262.5											
0.0	TOPSOIL, with root and rootlets: (150mm)										
0.2	Silty CLAY, Stiff, Brown, Moist		1	SS	11		262				0 12 55 33
261.1											
1.4	Clayey SILT, some sand, trace gravel, Hard, Brown, Moist, (TILL)		2	SS	36		261				
			3	SS	42		260				0 5 86 9
			4	SS	12	▼	259				
258.4											
4.1	SILT, trace sand, trace clay, Loose, Grey, Wet		5	SS	5		258				0 2 91 7
256.9							257				
5.6	SAND, some silt, some clay, Compact, Grey, Wet		6	SS	12		256				0 70 30 (SI+CL)
255.8											
6.7	END OF BOREHOLE AT 6.7m> Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.										

WATER LEVEL READINGS:
DATE DEPTH(m) ELEVATION(m)
04.09.10 3.2 259.3

+^{3}, ×^{3}: Numbers refer to Sensitivity

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

ONTMT4S 9268.GPJ 8/10/10

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 10-06 1 OF 1 METRIC

G.W.P. 2539-04-00 LOCATION Hwy 400, Teston Road to King Road N 4 863 310.9 E 299 733.6 ORIGINATED BY SLL
HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2010.02.04 - 2010.02.04 CHECKED BY SKP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
264.1									
0.0	**TOPSOIL**, with roots and rootlets:						264		
0.2	(180mm)								
	Clayey **SILT**, with sand, trace gravel Firm Brown Moist (FILL)		1	SS	4				1 35 49 15
262.9							263		
1.2	Clayey **SILT**, trace roots and rootlets Firm Brown Moist		2	SS	3				0 23 61 16
261.9							262		
2.2	Silty **CLAY**, some sand, trace gravel Very Stiff Brown Moist (TILL)		3	SS	18				
			4	SS	18		261		1 18 54 27
			5	SS	16		260		
258.9							259		
5.2	END OF BOREHOLE AT 5.2m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 2.3m, THEN CUTTINGS TO SURFACE.								

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH kPa 20 40 60 80 100
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE

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

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

$^{20}_{15}\oplus^{5}_{10}$ (%) STRAIN AT FAILURE

ONTMT4S 9268.GPJ 5/7/10

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 09-05W 1 OF 2 METRIC

G.W.P. 2539-04-00 LOCATION Hwy 400, Teston Road to King Road N 4 864 671.4 E 299 417.9 ORIGINATED BY WB
HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2009.03.09 - 2009.03.09 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100) o UNCONFINED + FIELD VANE • QUICK TRIAXIAL × LAB VANE	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
296.8											
0.0 / 296.2	Gravelly **SAND** Loose Wet (FILL)										
0.6 / 295.4	Clayey **SILT**, some sand, trace gravel Stiff Brown Moist (FILL)		1	SS	14		296				
1.4 / 294.6	Silty **CLAY**, some sand, trace gravel Stiff Brown Moist		2	SS	9		295				
2.2 / 292.5	Clayey **SILT**, some sand, trace gravel Stiff Brown Moist (TILL)		3	SS	9		294				
			4	SS	13						
4.3 / 289.8	Sandy **SILT**, trace clay, trace gravel Very Dense Brown Moist (TILL)		5	SS	61		293 292				
			6	SS	100/ 0.275		291				
7.0 / 287.0	**SAND**, some silt Compact to Very Dense Brown Moist		7	SS	29		290 289				
			8	SS	63		288				
9.8	END OF BOREHOLE AT 9.8m.										

Continued Next Page

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

(%) STRAIN AT FAILURE

ONTMT4S 9268.GPJ 5/7/10

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 09-05W 2 OF 2 METRIC

G.W.P. 2539-04-00 LOCATION Hwy 400, Teston Road to King Road N 4 864 671.4 E 299 417.9 ORIGINATED BY WB
HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2009.03.09 - 2009.03.09 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (N) 20 40 60 80 100 / SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	Continued From Previous Page										
	BOREHOLE DRY UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.										

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

$15 \oplus^{20}_{10} 5$ (%) STRAIN AT FAILURE

ONTMT4S 9268.GPJ 5/7/10

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 11-16 1 OF 2 METRIC

W.P. 2539-04-00 LOCATION N 4 862 124.3 E 299 902.5 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2011.01.28 - 2011.01.28 CHECKED BY MEF

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
274.5									
0.0 / 274.2	**ASPHALT:** (280mm)								
0.3 / 273.9	**SAND**, some gravel Brown Moist (FILL)		1	GS			274		
0.7 / 273.3	**SAND**, trace gravel Compact Brown Moist (FILL)		1	SS	26				
1.2	Silty **CLAY**, with sand, trace gravel Very Stiff to Firm Brown (FILL) Becomes grey		2	SS	16		273		
			3	SS	14		272		0 22 52 26
	Occasional roots and rootlets		4	SS	7	▽	271		
270.3									
4.3	Clayey **SILT**, with sand, trace gravel, occasional clay seams Stiff to Hard Brown Moist (TILL)		5	SS	14		270		
	Occasional oxide staining		6	SS	39		269		
	Becomes grey		7	SS	47		268		
265.4							267		
9.1	Silty **CLAY**, trace sand, trace gravel Very Stiff Grey Moist (TILL)		8	SS	18		266		0 4 36 60
							265		

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

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

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

Continued Next Page

+³, ×³: Numbers refer to Sensitivity

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

ONTMT4S 9268.GPJ 3/5/12

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 11-16 2 OF 2 METRIC

W.P. 2539-04-00 LOCATION N 4 862 124.3 E 299 902.5 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2011.01.28 - 2011.01.28 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: o UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	Continued From Previous Page										
	Silty **CLAY**, trace sand, trace gravel Very Stiff Grey Moist (TILL)						264				
263.3			9	SS	21				o		
11.3	END OF BOREHOLE AT 11.3m. BOREHOLE OPEN AND WATER LEVEL AT 3.6m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 10.0m, CUTTINGS TO 0.9m, BENTONITE HOLEPLUG TO 0.4m, CONCRETE TO 0.1m, THEN ASPHALT TO SURFACE.										

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

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

ONTMT4S 9268.GPJ 3/5/12

Appendix B

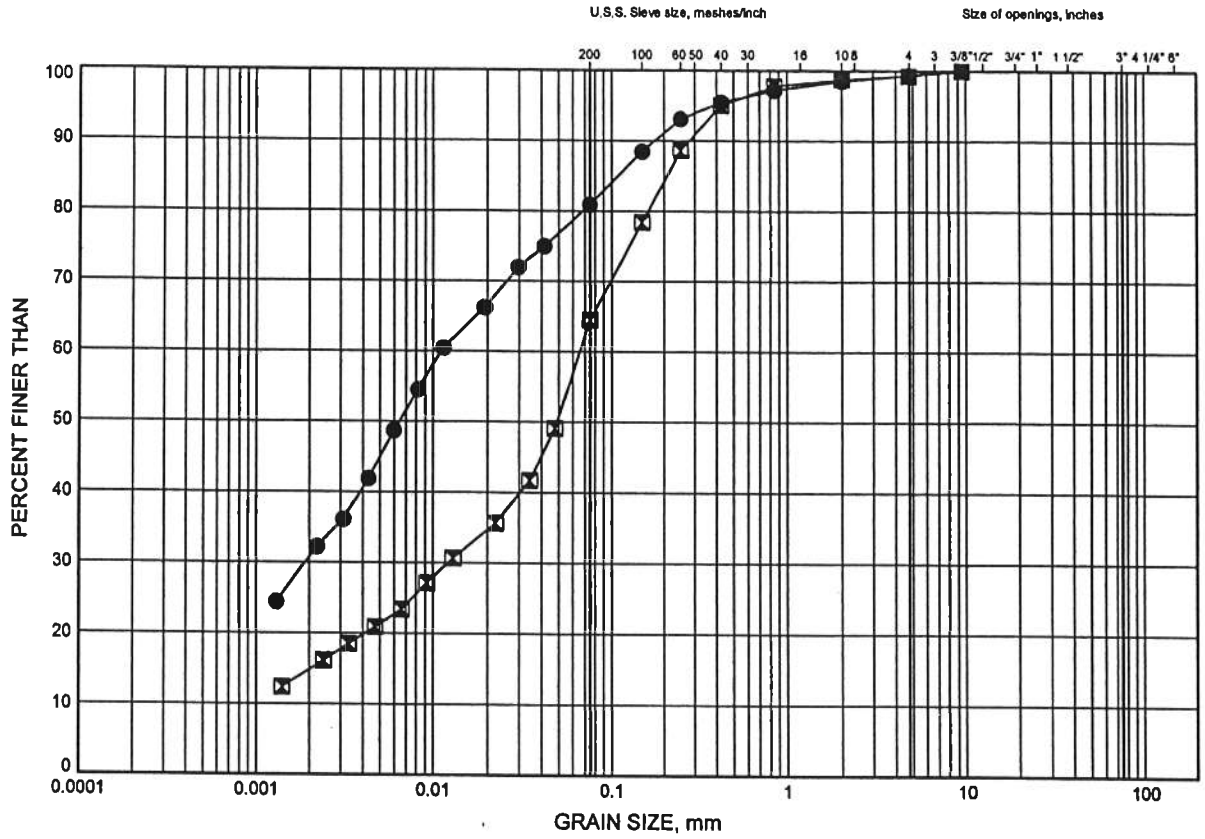
Laboratory Test Results

Widening of Hwy 400, Major Mackenzie to King Road

GRAIN SIZE DISTRIBUTION

FIGURE B1

SILTY CLAY/CLAYEY SILT FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	06-16E	1.07	276.35
⊠	10-06	0.99	263.11

W.P.# 2539-04-00
Prepared By AN
Checked By SKP

THURBER

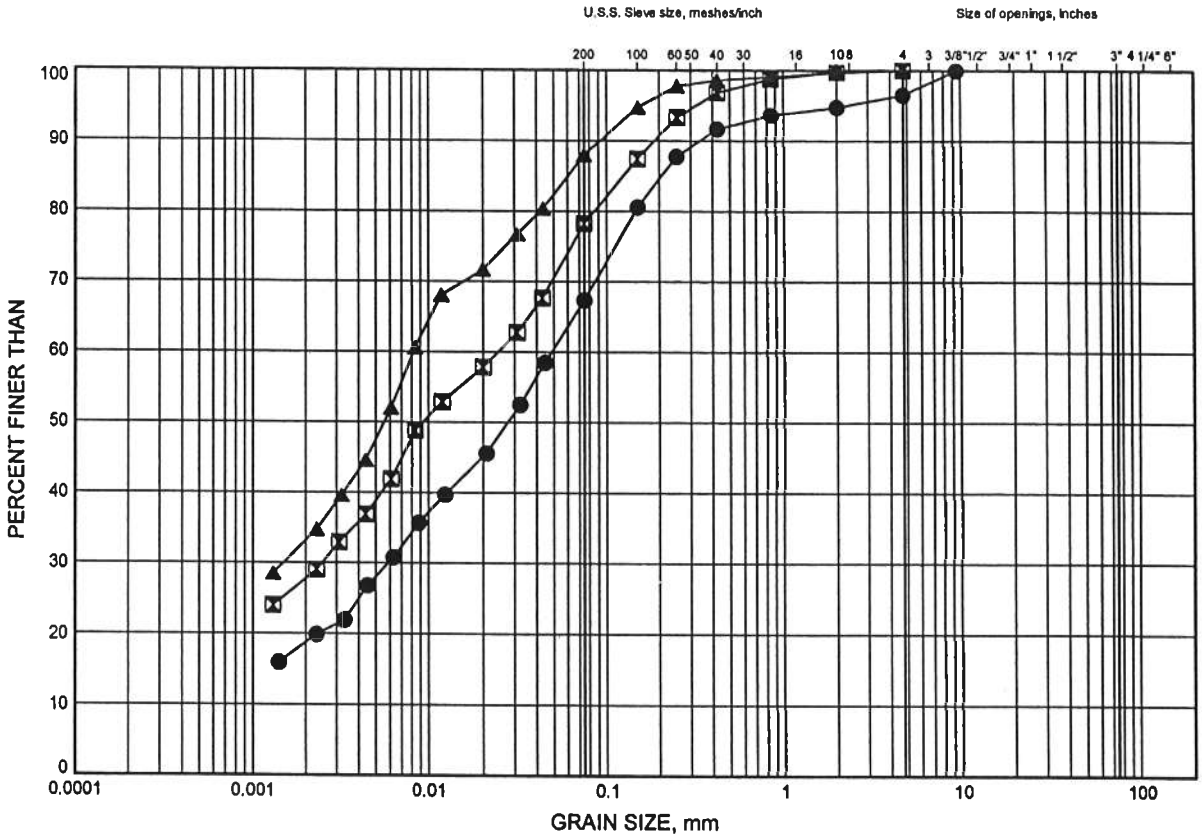
GRAIN SIZE DISTRIBUTION - THURBER 9268.GPJ 8/10/10

Widening of Hwy 400, Major Mackenzie to King Road

GRAIN SIZE DISTRIBUTION

FIGURE B2

SILTY CLAY



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	06-05E	1.07	242.10
⊠	06-08E	3.35	270.58
▲	10-05	1.07	261.45

W.P.# 2539-04-00
Prepared By AN
Checked By SKP

THURBER

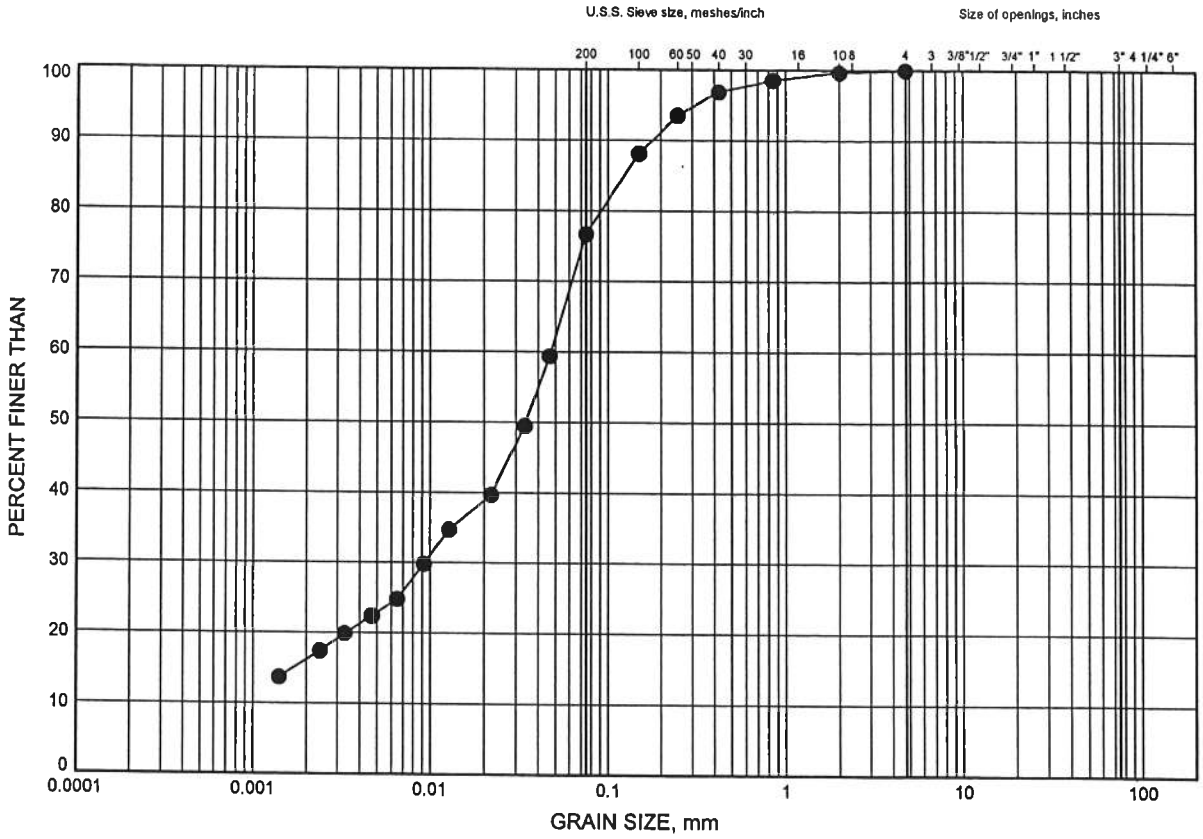
GRAIN SIZE DISTRIBUTION - THURBER 9268.GPJ 8/10/10

Widening of Hwy 400, Major Mackenzie to King Road

GRAIN SIZE DISTRIBUTION

FIGURE B3

CLAYEY SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	10-06	1.83	262.27

W.P.# 2539-04-00
Prepared By AN
Checked By SKP

THURBER

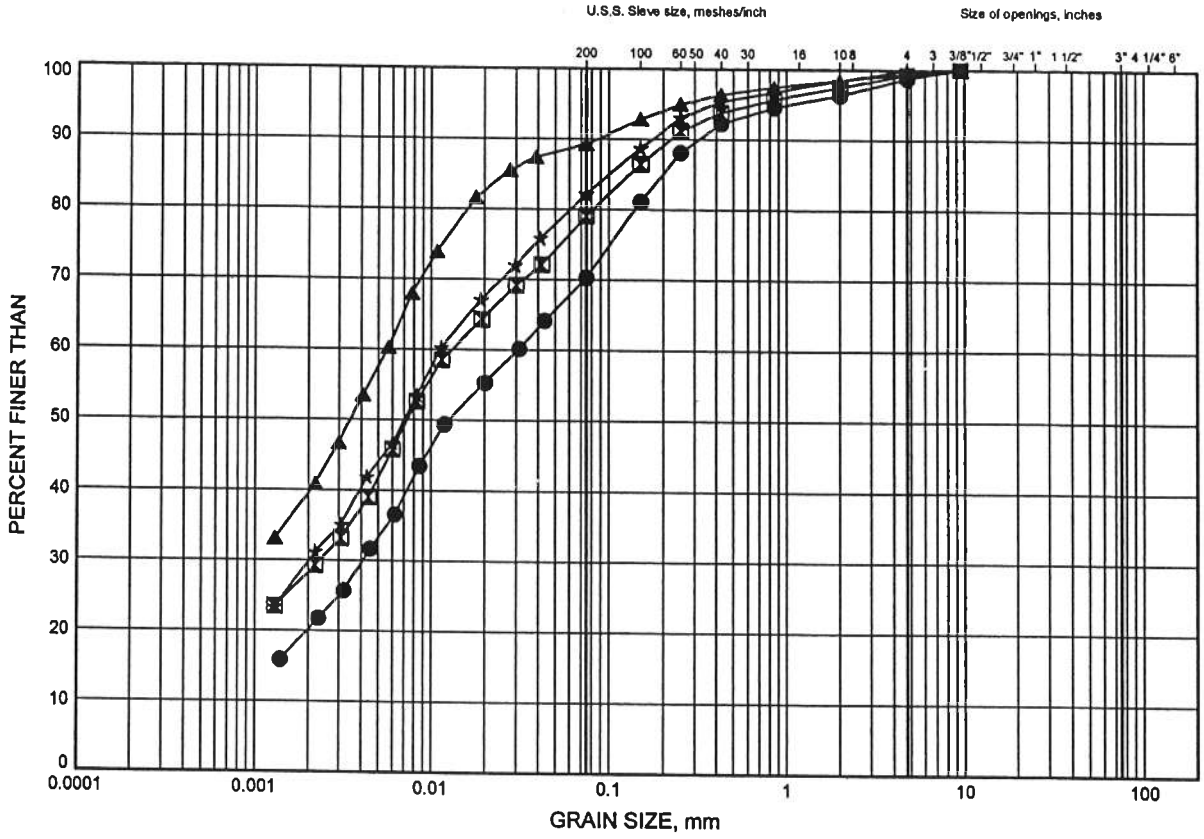
GRAIN SIZE DISTRIBUTION - THURBER 9268.GPJ 5/7/10

Widening of Hwy 400, Major Mackenzie to King Road

GRAIN SIZE DISTRIBUTION

FIGURE B4

SILTY CLAY TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	06-05E	4.80	238.37
⊠	06-08E	4.88	269.05
▲	06-08E	7.92	266.01
★	06-16E	4.88	272.54

W.P.# 2539-04-00
Prepared By AN
Checked By SKP

THURBER

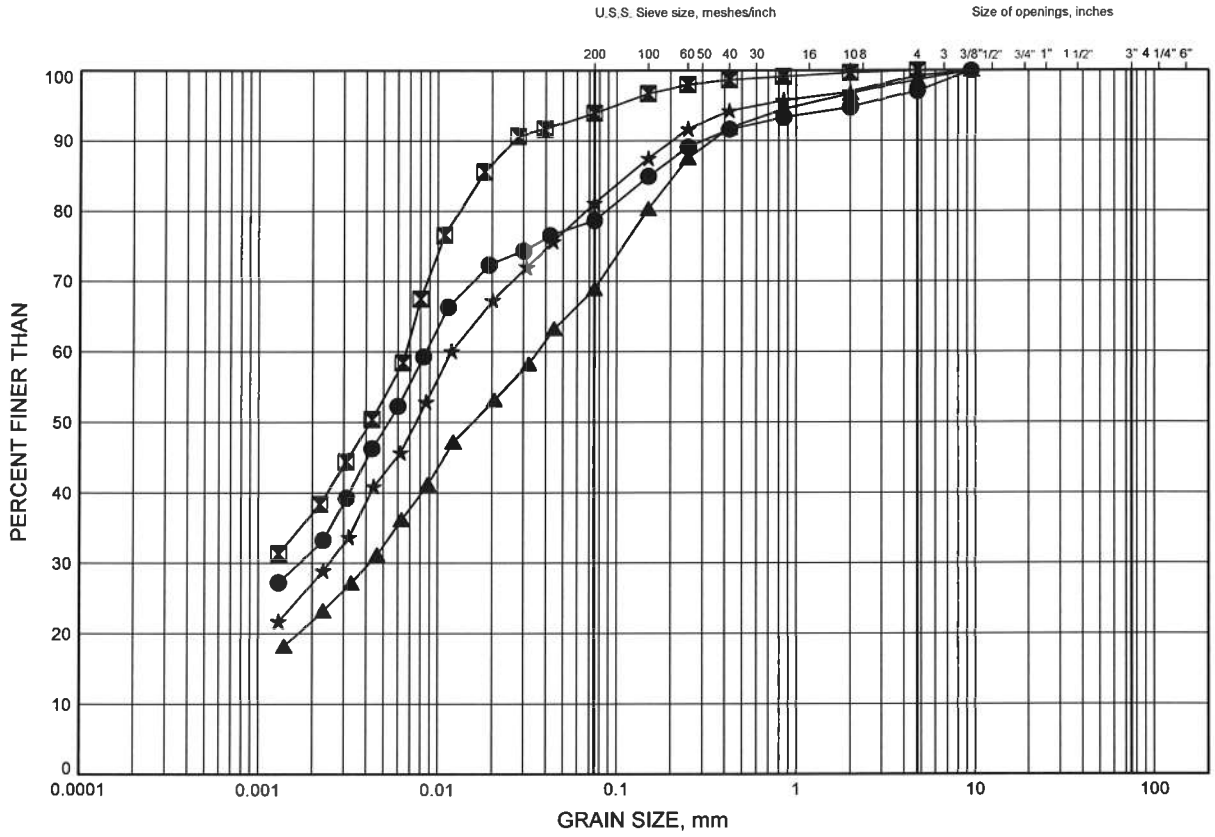
GRAIN SIZE DISTRIBUTION - THURBER 9268.GPJ 8/10/10

Widening of Hwy 400, Major Mackenzie to King Road

GRAIN SIZE DISTRIBUTION

FIGURE B5

SILTY CLAY TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	06-12W	1.83	269.77
⊠	06-12W	4.88	266.72
▲	06-12W	7.92	263.68
★	10-06	3.35	260.75

W.P.# 2539-04-00
Prepared By AN
Checked By SKP

THURBER

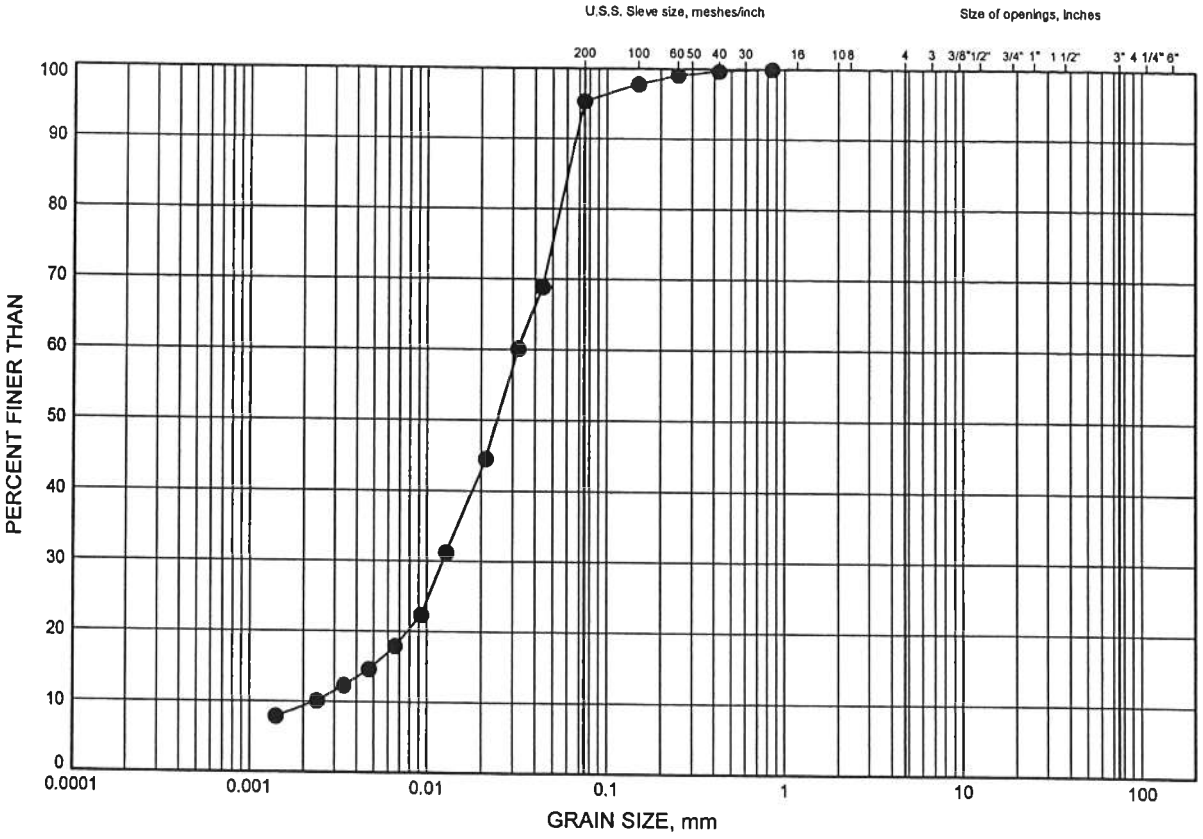
GRAIN SIZE DISTRIBUTION - THURBER 9268.GPJ 1/26/12

Widening of Hwy 400, Major Mackenzie to King Road

GRAIN SIZE DISTRIBUTION

FIGURE B6

CLAYEY SILT TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	10-05	2.59	259.93

W.P.# 2539-04-00
Prepared By AN
Checked By SKP

THURBER

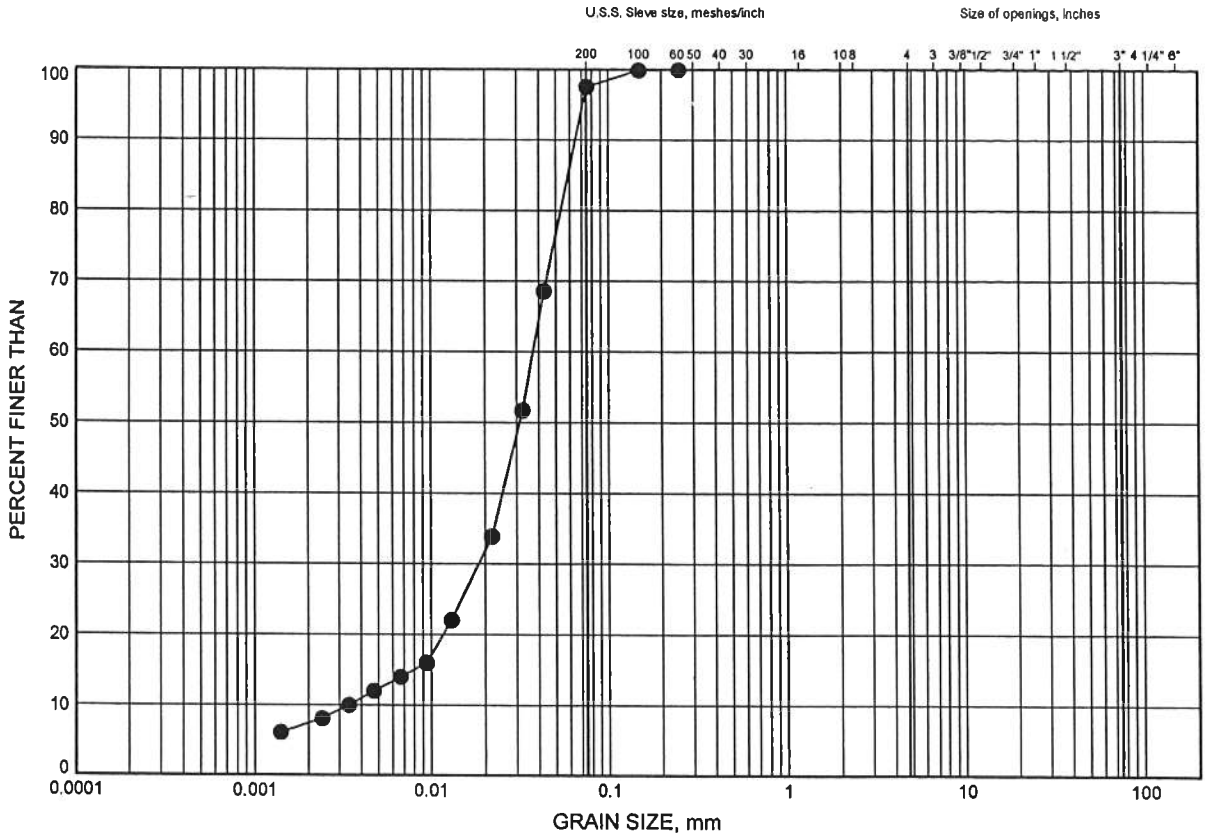
GRAIN SIZE DISTRIBUTION - THURBER 9268.GPJ 5/7/10

Widening of Hwy 400, Major Mackenzie to King Road

GRAIN SIZE DISTRIBUTION

FIGURE B7

SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	10-05	4.88	257.64

W.P.# 2539-04-00
Prepared By AN
Checked By SKP

THURBER

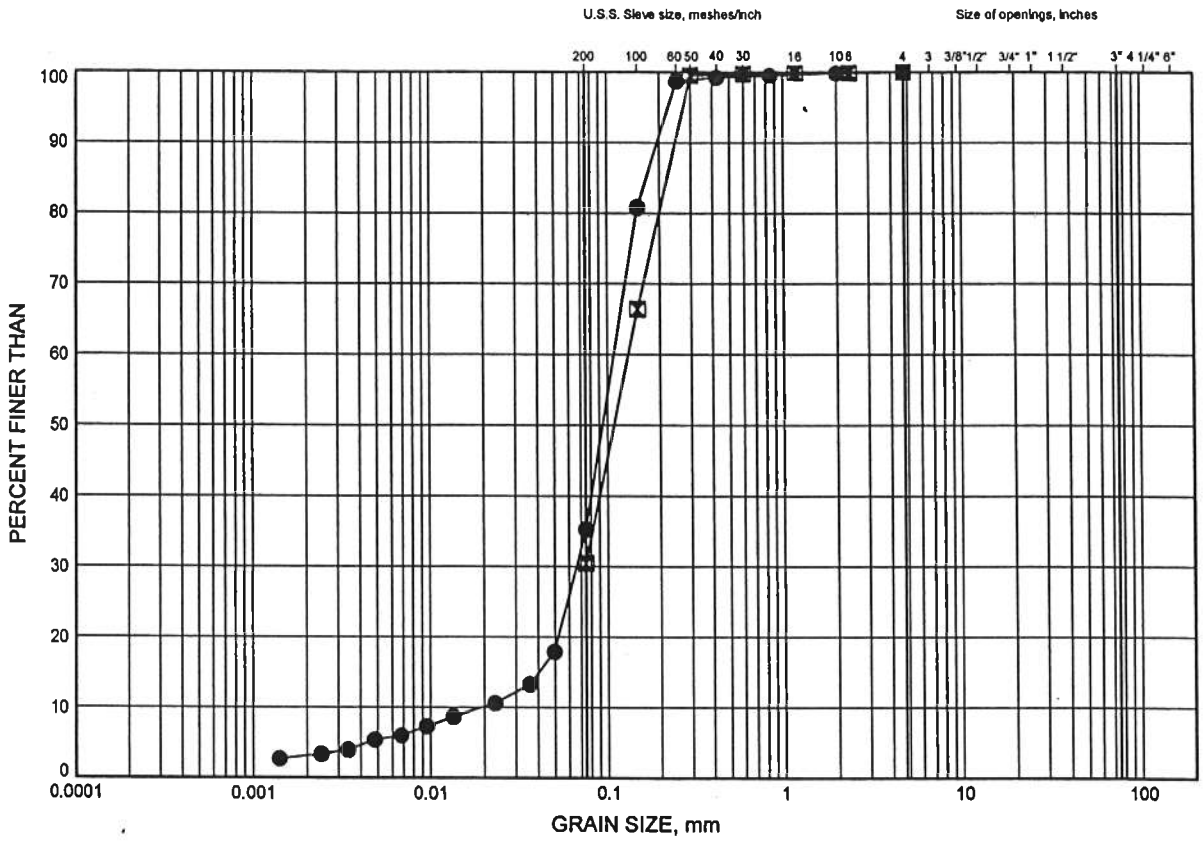
GRAIN SIZE DISTRIBUTION - THURBER 9266.GPJ 5/7/10

Widening of Hwy 400, Major Mackenzie to King Road

GRAIN SIZE DISTRIBUTION

FIGURE B8

SAND to SILTY SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	06-05E	6.40	236.77
⊠	10-05	6.40	256.12

W.P.# 2539-04-00
Prepared By AN
Checked By SKP

THURBER

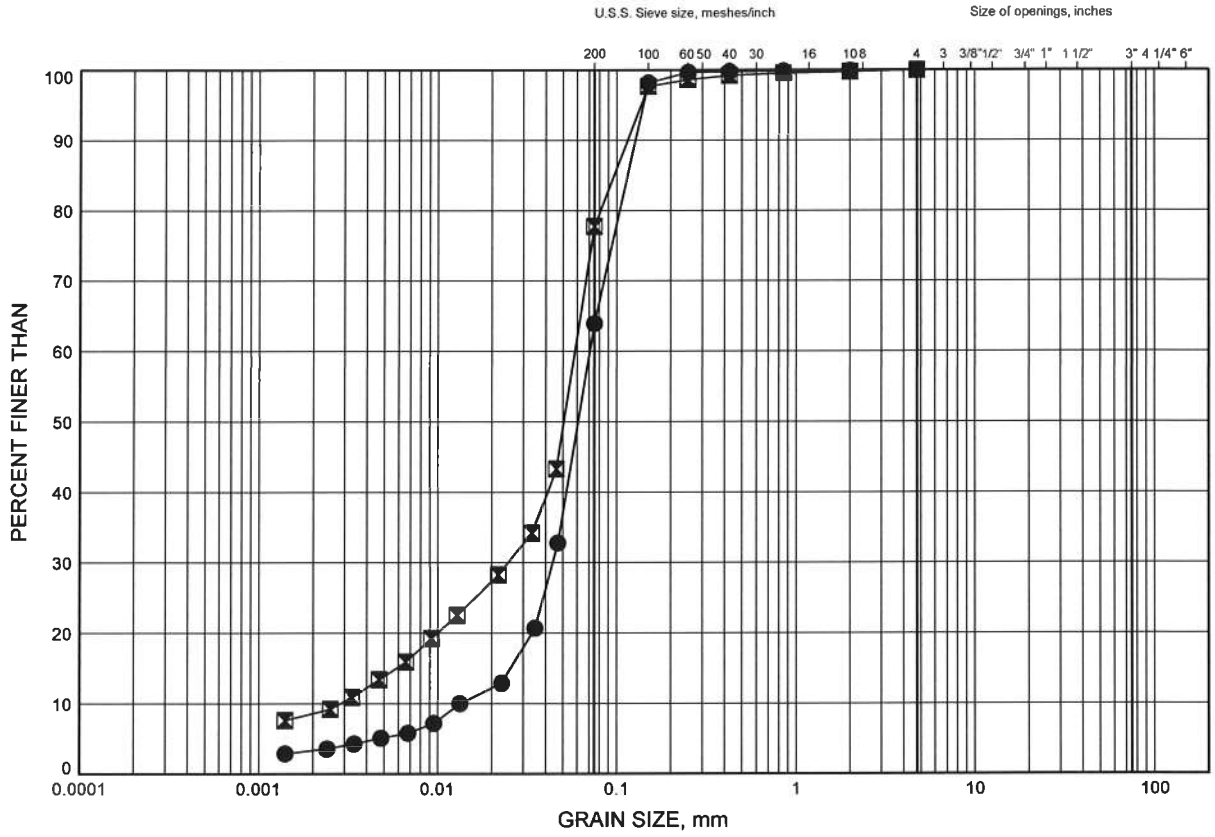
GRAIN SIZE DISTRIBUTION - THURBER 9268.GPJ 8/10/10

Widening of Hwy 400, Major Mackenzie to King Road

GRAIN SIZE DISTRIBUTION

FIGURE B9

SANDY SILT/SAND & SILT TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	06-05W	4.88	235.99
⊠	CV-13A	3.35	225.62

W.P.# 2539-04-00
Prepared By AN
Checked By SKP

THURBER

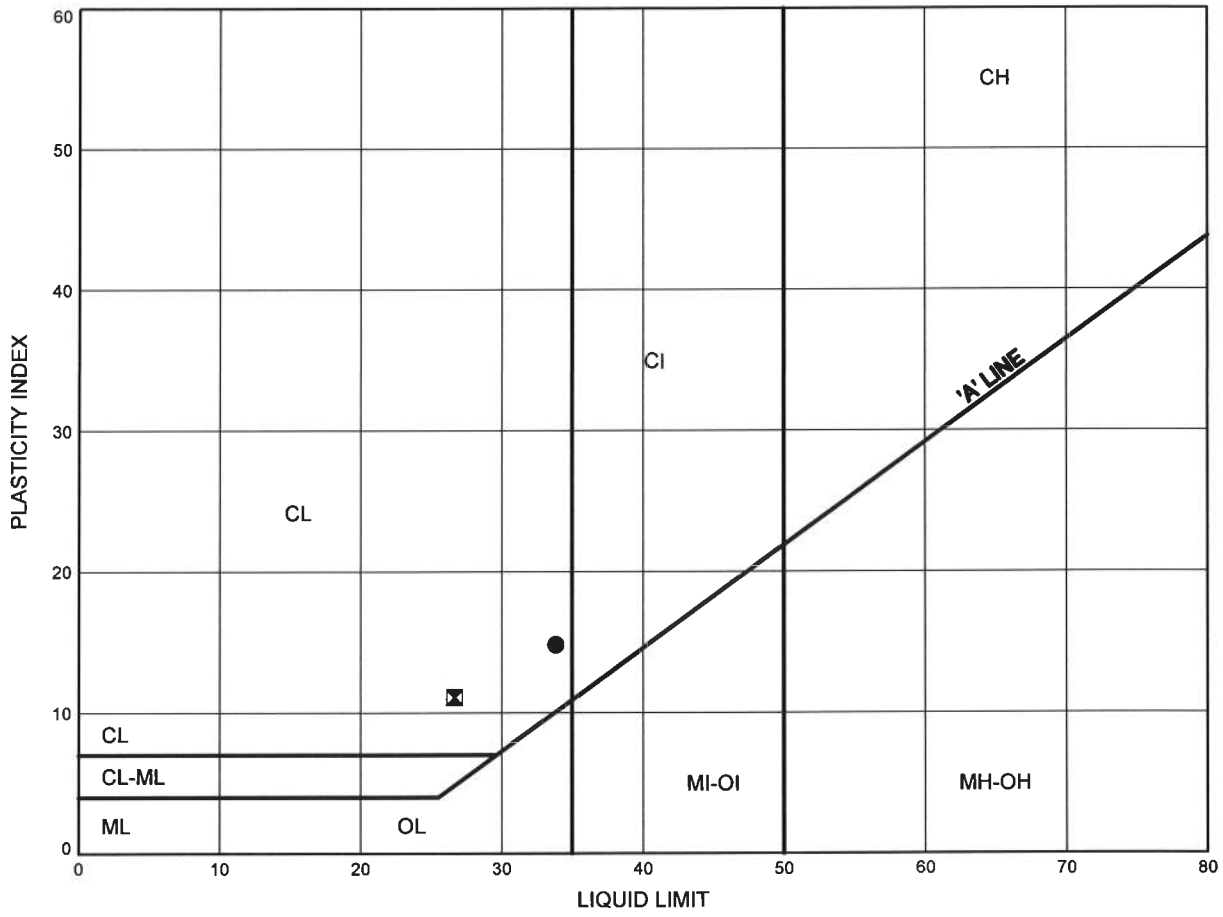
GRAIN SIZE DISTRIBUTION - THURBER 9268.GPJ 1/26/12

Widening of Hwy 400, Major Mackenzie to King Road

ATTERBERG LIMITS TEST RESULTS

FIGURE B10

SILTY CLAY



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	06-08E	3.35	270.58
⊠	10-05	1.07	262.13

Date January 2012

Project 2539-04-00

THURBER

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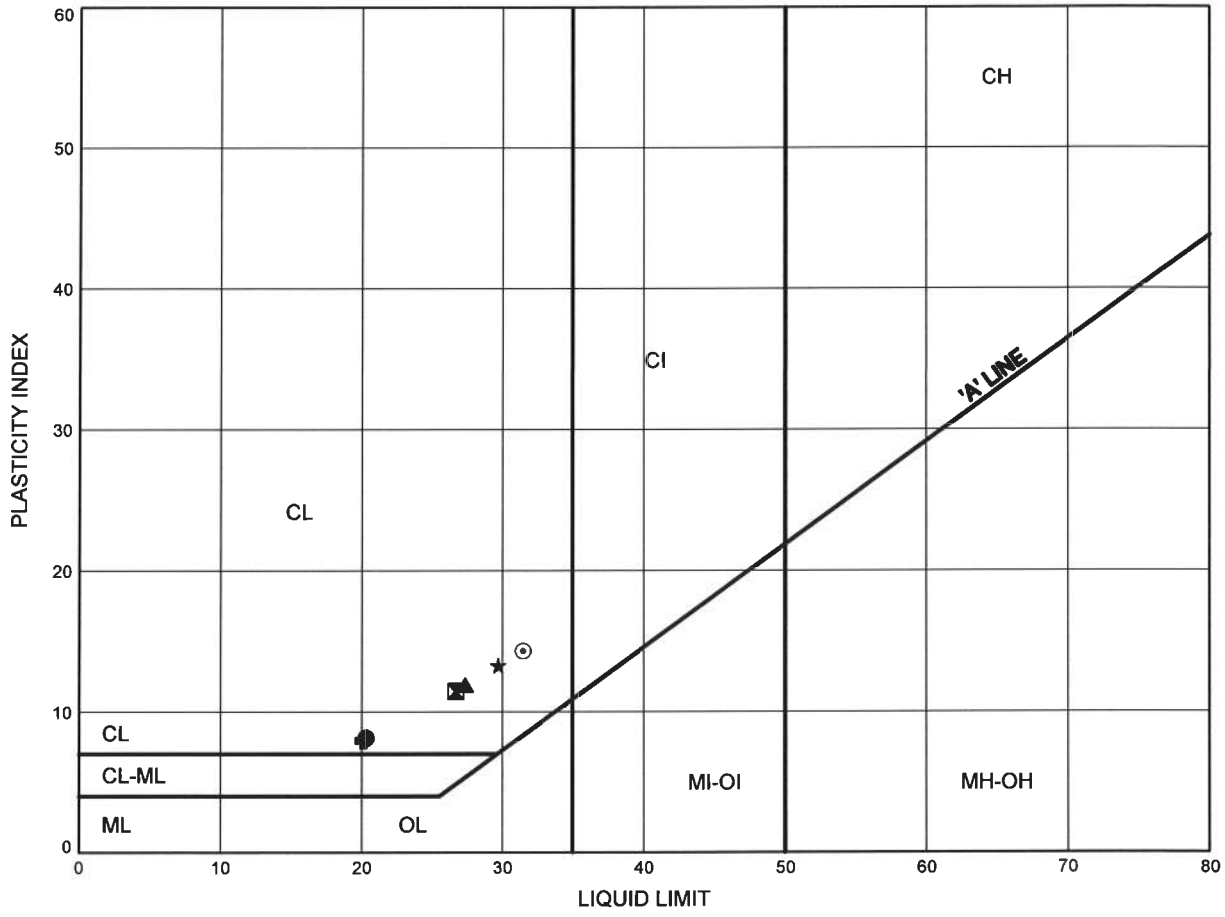
THURBALT 9268.GPJ 1/26/12

Widening of Hwy 400, Major Mackenzie to King Road

ATTERBERG LIMITS TEST RESULTS

FIGURE B11

SILTY CLAY TILL



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	06-05E	4.80	238.37
⊠	06-08E	4.88	269.05
▲	06-08E	7.92	266.01
★	06-12W	1.83	269.77
⊙	06-12W	4.88	266.72
✿	06-12W	7.92	263.68

Date January 2012

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Chkd. SKP

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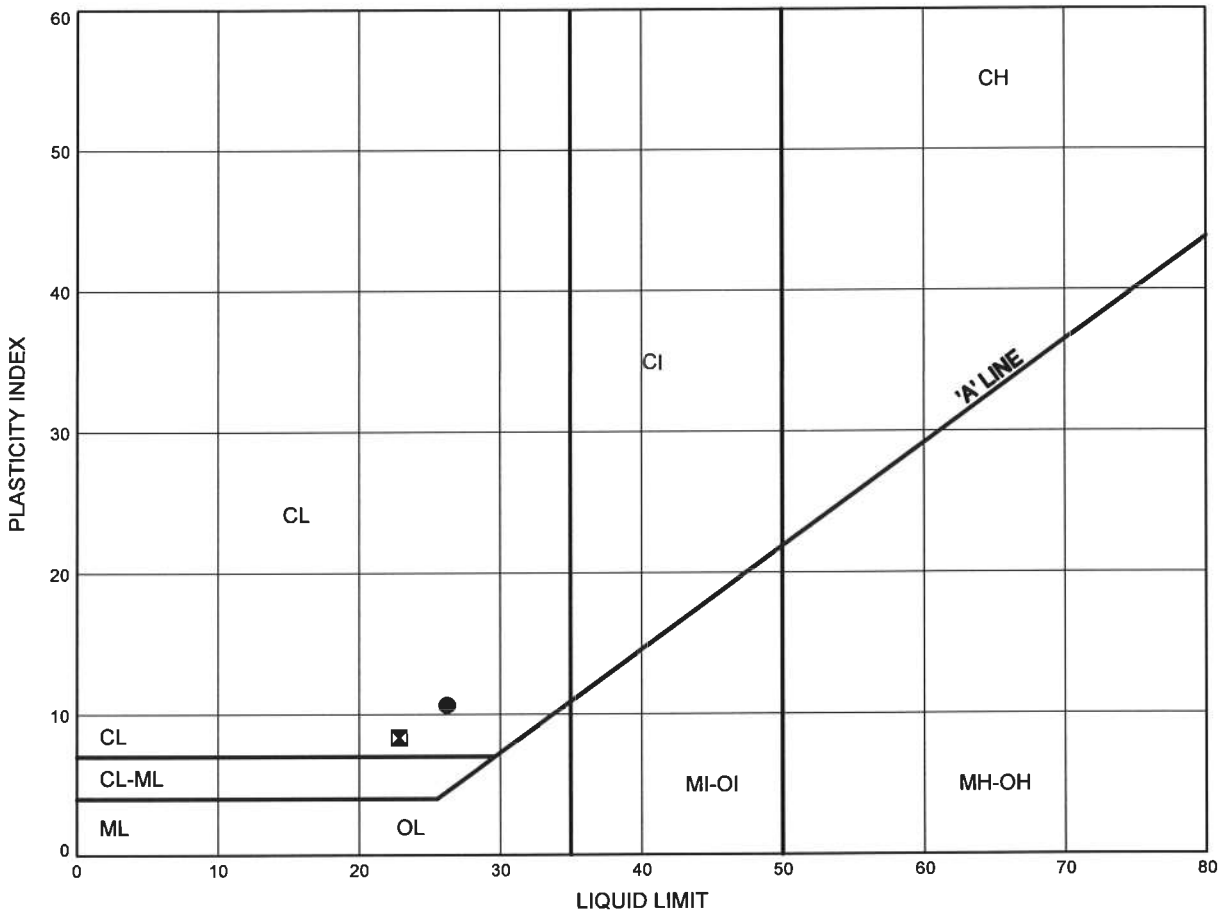
Widening of Hwy 400, Major Mackenzie to King Road

ATTERBERG LIMITS TEST RESULTS

FIGURE B12

SILTY CLAY TILL



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	06-16E	4.88	272.54
⊠	10-06	3.35	260.75

Date January 2012

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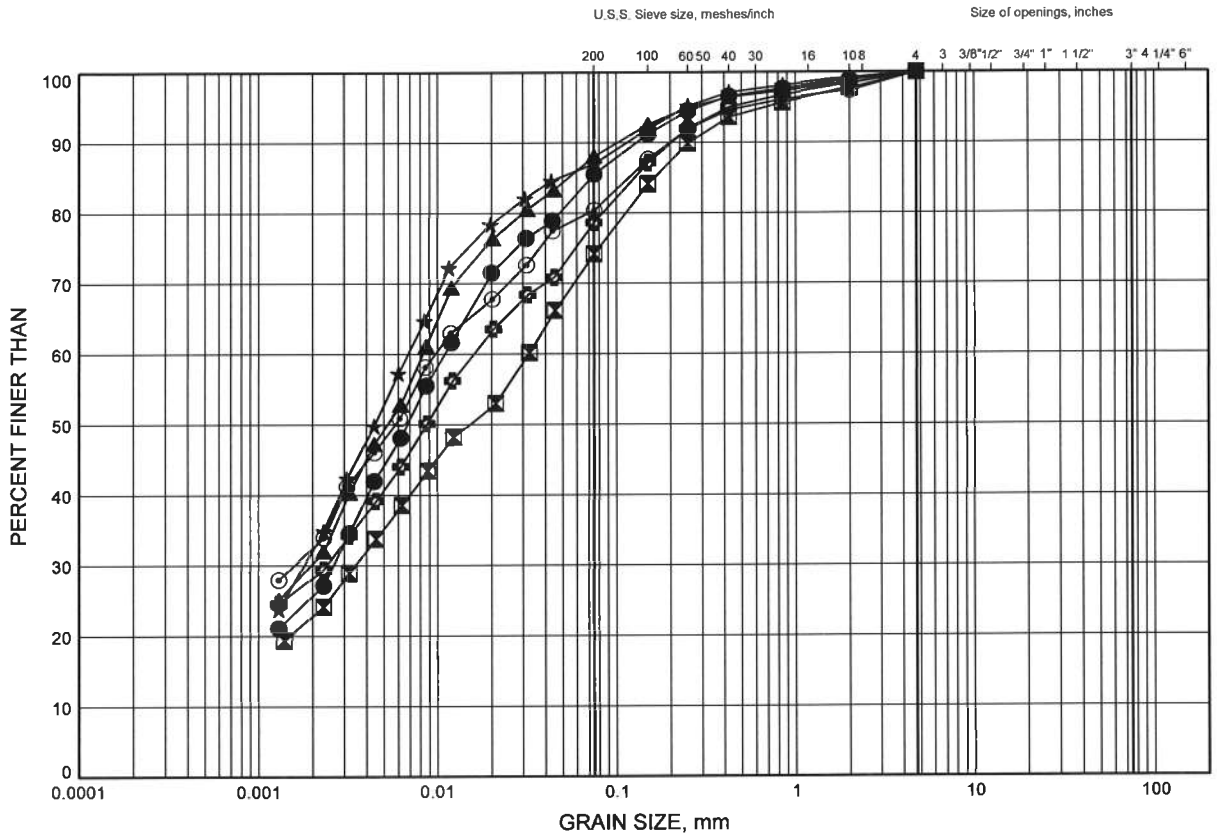
THURBALT 9268.GPJ 1/26/12

Widening of Hwy 400, Major Mackenzie to King Road

GRAIN SIZE DISTRIBUTION

FIGURE B13

SILTY CLAY TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C-16A	4.80	253.36
⊠	C-16B	2.59	252.90
▲	C-16B	6.32	249.17
★	C-17A	2.59	257.85
⊙	C-17A	6.40	254.04
✿	C-17B	1.07	257.29

W.P.# 2539-04-00
Prepared By AN
Checked By SKP

THURBER

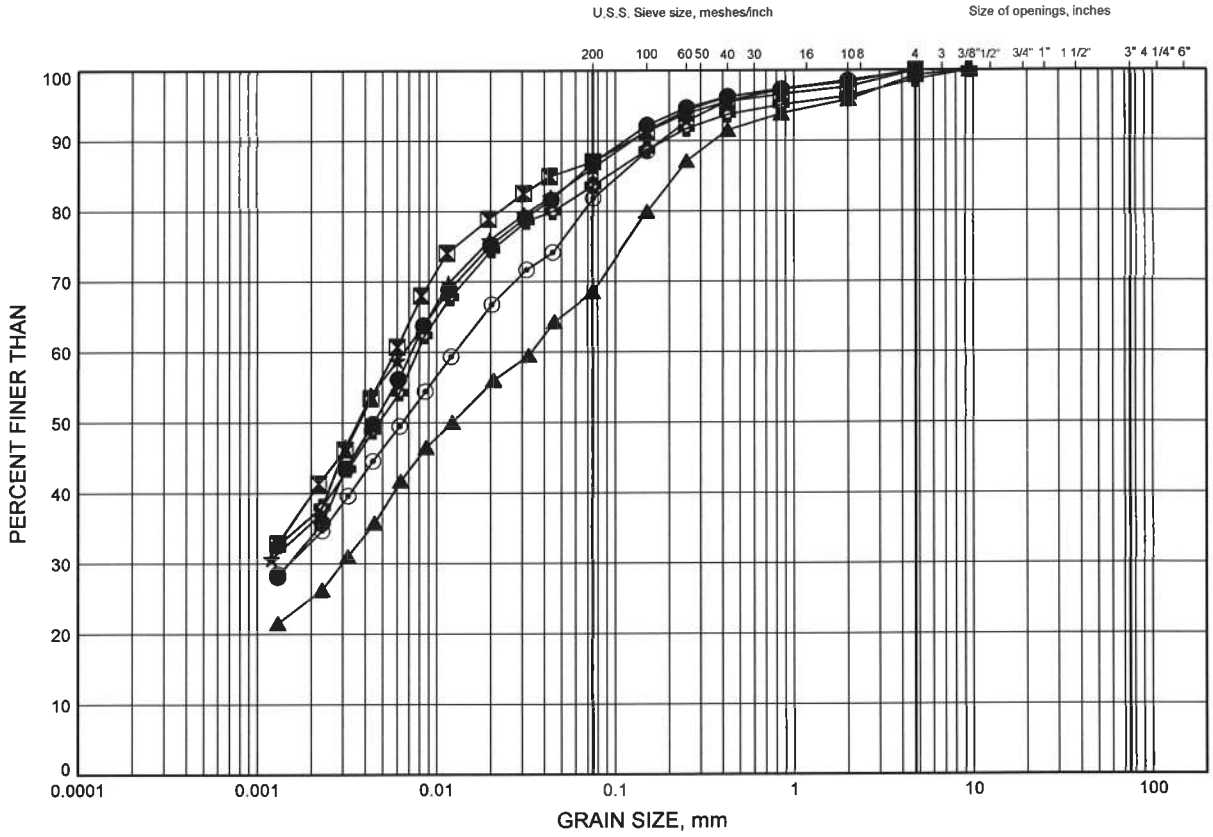
GRAIN SIZE DISTRIBUTION - THURBER 9268.GPJ 1/26/12

Widening of Hwy 400, Major Mackenzie to King Road

GRAIN SIZE DISTRIBUTION

FIGURE B14

SILTY CLAY TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C-17B	4.88	253.48
⊠	C-18A	2.59	257.72
▲	C-18A	6.40	253.91
★	C-18B	2.59	258.90
⊙	C-20	3.35	273.75
✿	C-20	7.92	269.17

W.P.# 2539-04-00
Prepared By AN
Checked By SKP

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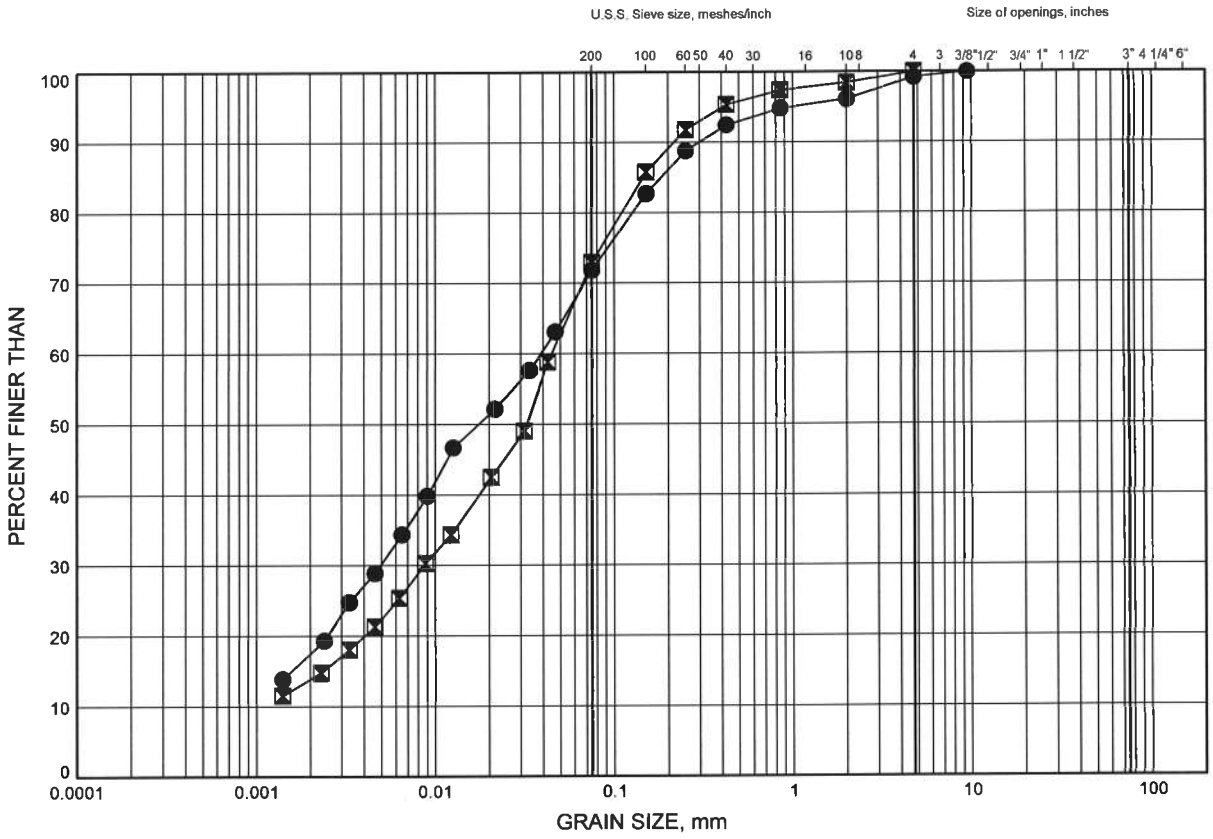
GRAIN SIZE DISTRIBUTION - THURBER 9268.GPJ 1/26/12

Widening of Hwy 400, Major Mackenzie to King Road

GRAIN SIZE DISTRIBUTION

FIGURE B15

CLAYEY SILT TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C-14	4.78	239.84
⊠	C-16A	1.83	256.33

W.P.# 2539-04-00
Prepared By AN
Checked By SKP

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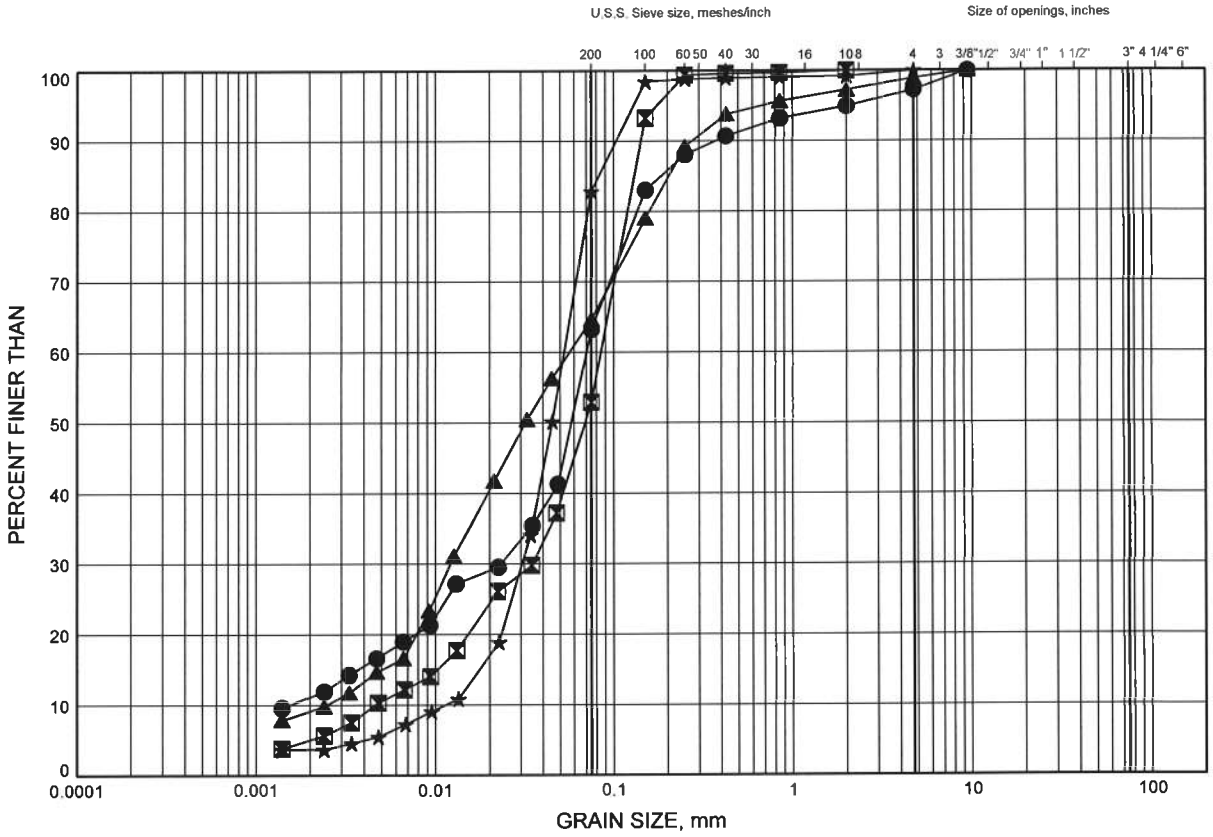
GRAIN SIZE DISTRIBUTION - THURBER 9268.GPJ 1/26/12

Widening of Hwy 400, Major Mackenzie to King Road

GRAIN SIZE DISTRIBUTION

FIGURE B16

SILT to SILT and SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C-14	1.76	242.85
⊠	C-14	7.88	236.74
▲	C-16A	7.85	250.31
★	C-18B	7.92	253.57

W.P.# 2539-04-00
Prepared By AN
Checked By SKP

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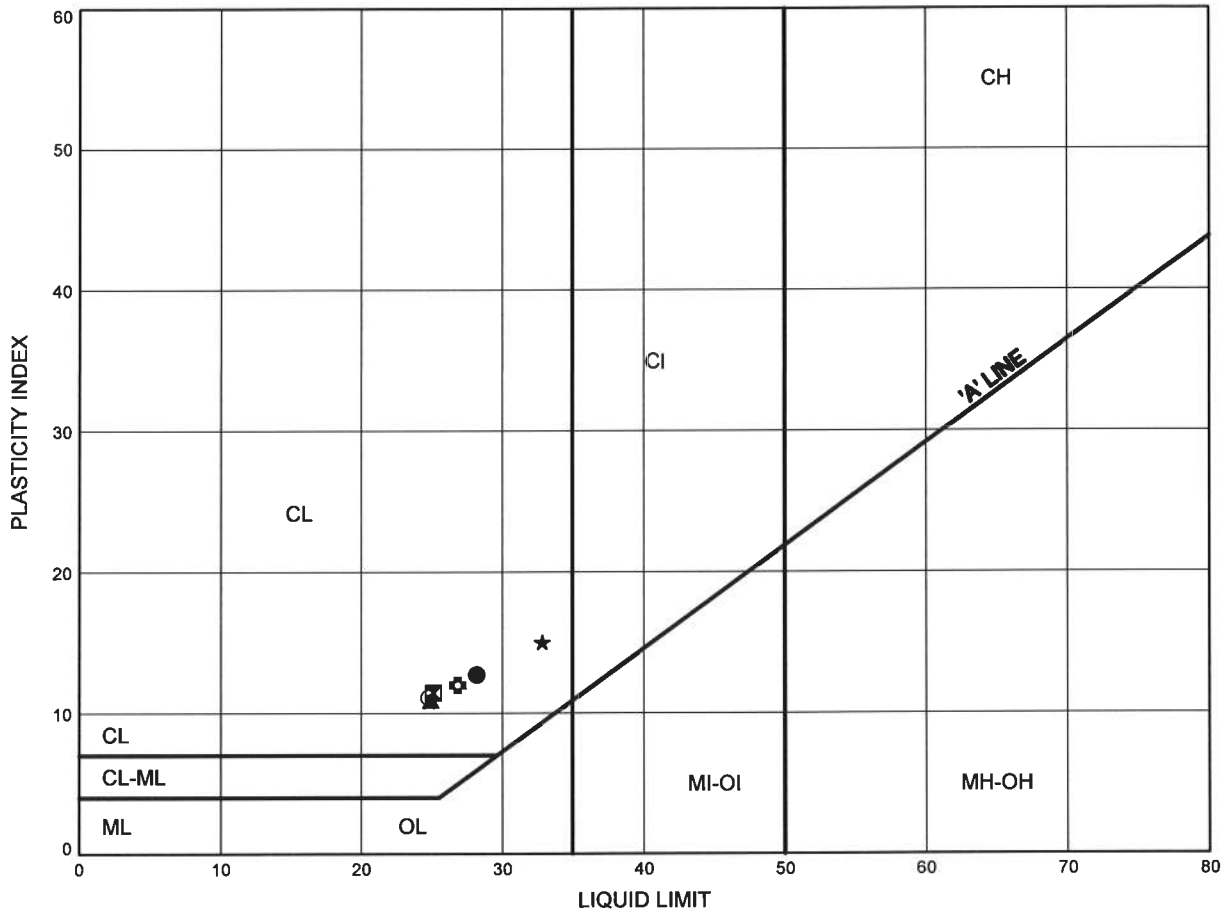
GRAIN SIZE DISTRIBUTION - THURBER 9268.GPJ 1/26/12

Widening of Hwy 400, Major Mackenzie to King Road

ATTERBERG LIMITS TEST RESULTS

FIGURE B17

SILTY CLAY TILL



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	C-16A	4.80	253.36
⊠	C-16B	2.59	252.90
▲	C-16B	6.32	249.17
★	C-17A	2.59	257.85
⊙	C-17A	6.40	254.04
✿	C-17B	1.07	257.29

Date January 2012

Project 2539-04-00

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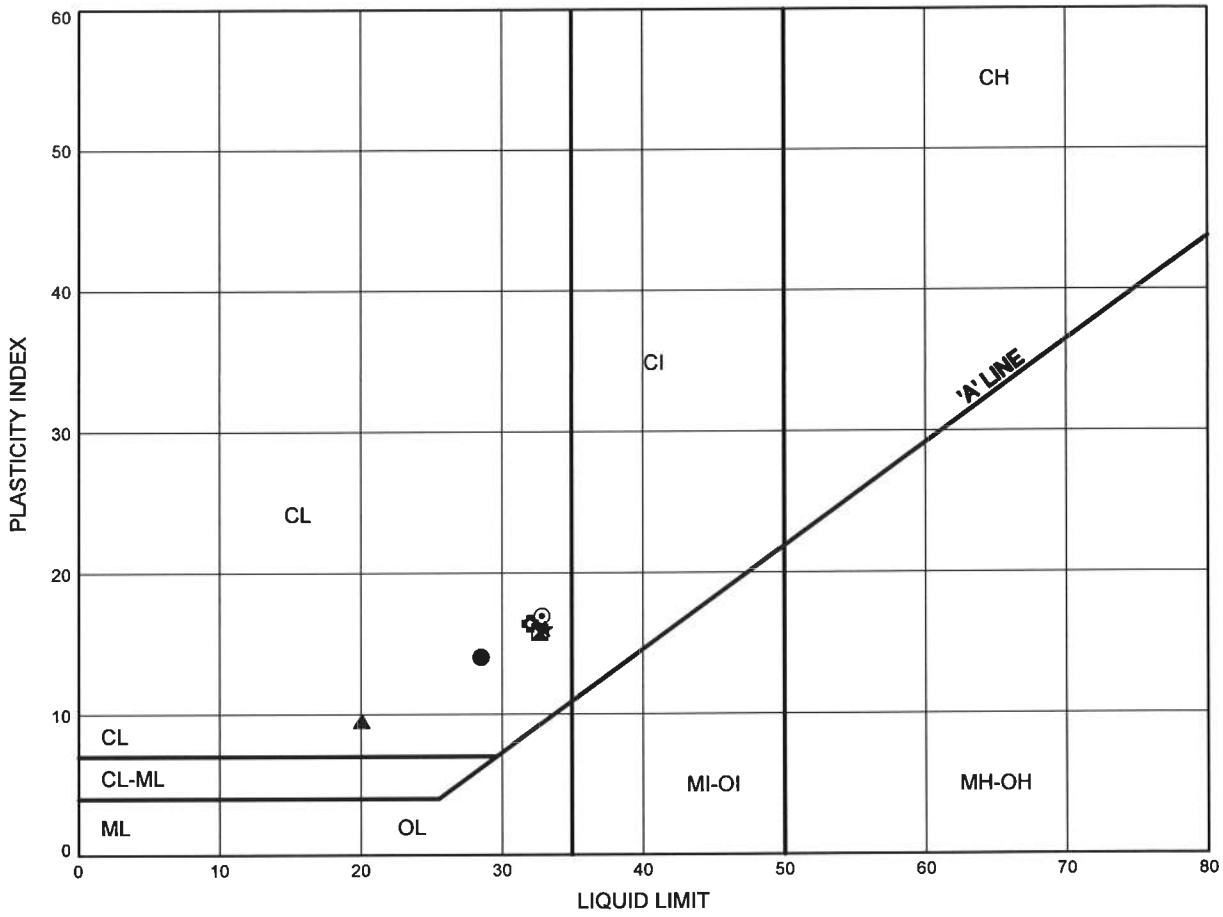
THURBALT 9268.GPJ 1/26/12

Widening of Hwy 400, Major Mackenzie to King Road

ATTERBERG LIMITS TEST RESULTS

FIGURE B18

SILTY CLAY TILL



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	C-17B	4.88	253.48
⊠	C-18A	2.59	257.72
▲	C-18A	6.40	253.91
★	C-18B	2.59	258.90
⊙	C-20	3.35	273.75
✿	C-20	7.92	269.17

Date January 2012

Project 2539-04-00

THURBER

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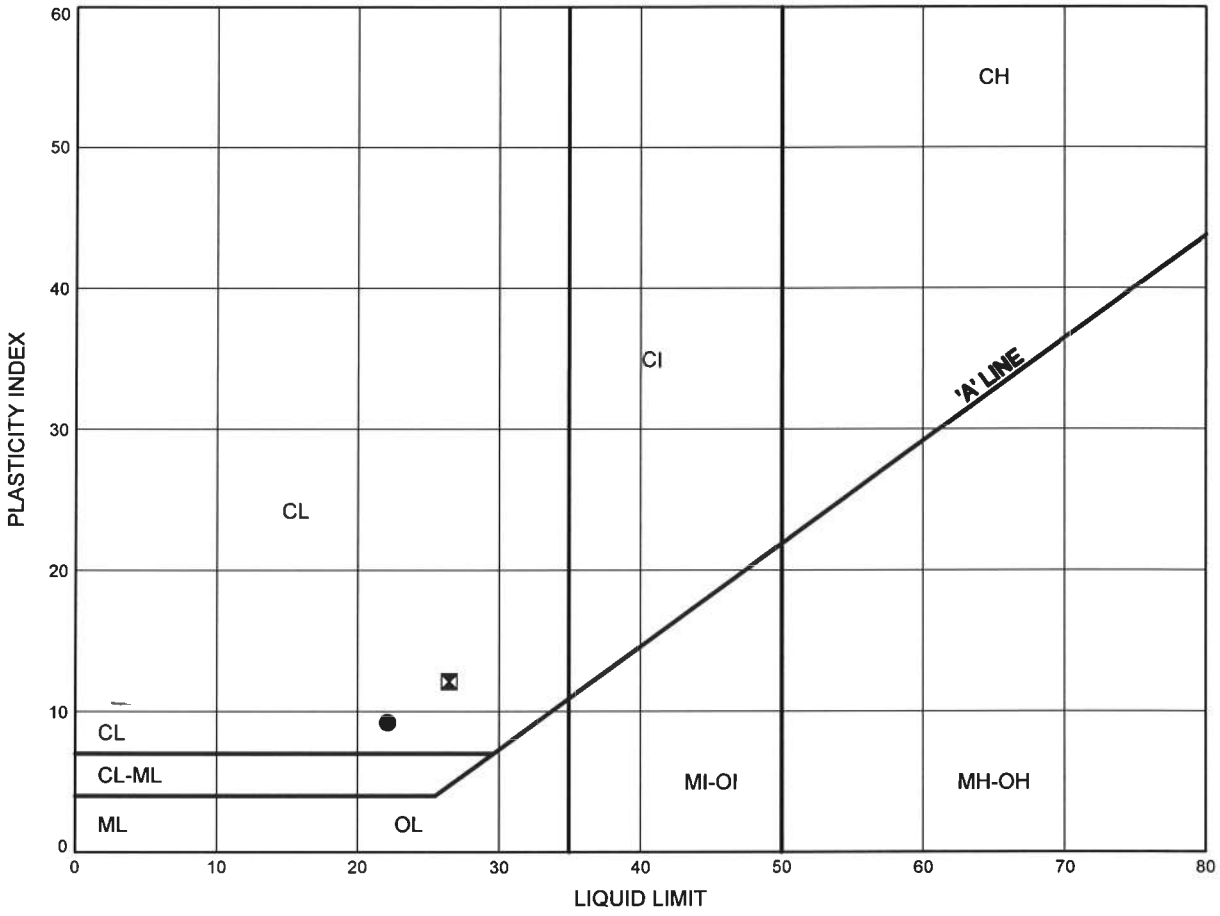
THURBALT 9268.GPJ 1/26/12

Widening of Hwy 400, Major Mackenzie to King Road

ATTERBERG LIMITS TEST RESULTS

FIGURE B19

CLAYEY SILT TILL



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	C-14	4.78	239.84
⊠	C-16A	1.83	256.33

Date January 2012

Project 2539-04-00

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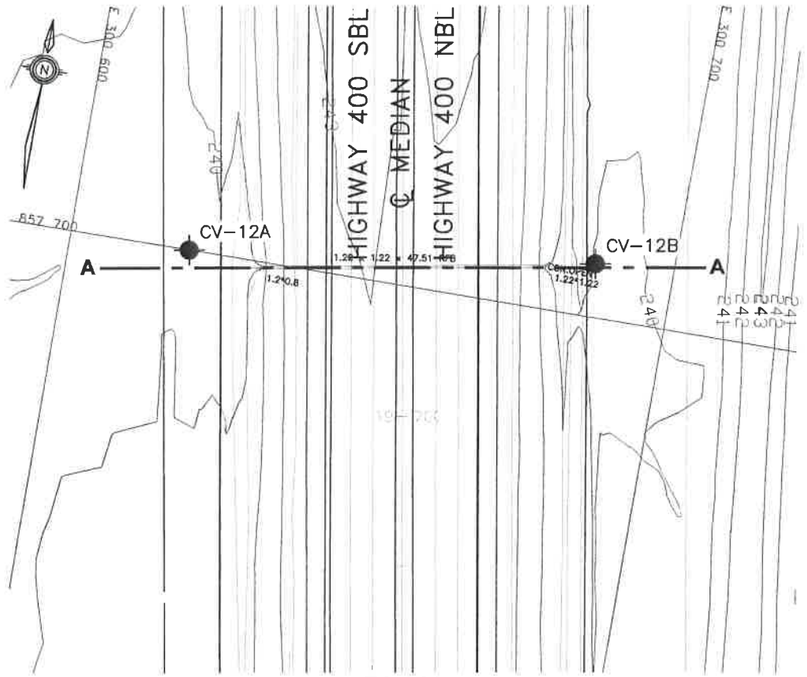
THURBALT 9268.GPJ 1/26/12

Appendix C

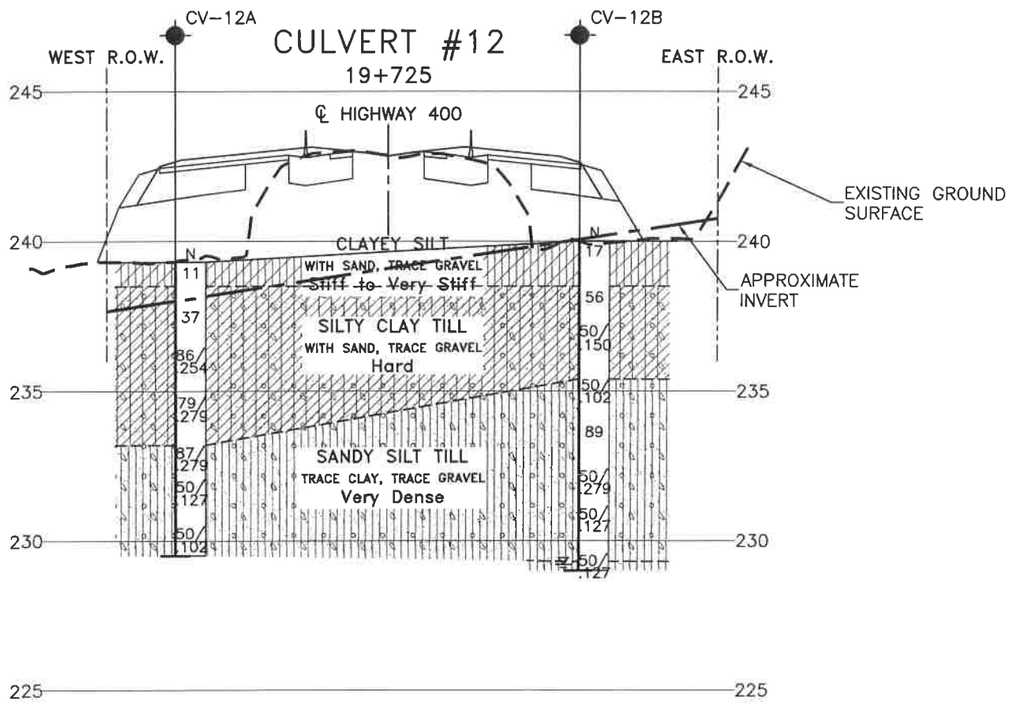
Borehole Locations and Soil Strata Drawings

MINISTRY OF TRANSPORTATION, ONTARIO



PLAN

5 0 10 20m



SECTION A-A

1 0 2 4m VER
5 0 10 20m HOR

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No
WP No 2539–04–00

SHEET

TESTON ROAD TO KING ROAD
CULVERT #12
BOREHOLE LOCATIONS AND SOIL STRATA

SNC·LAVALIN

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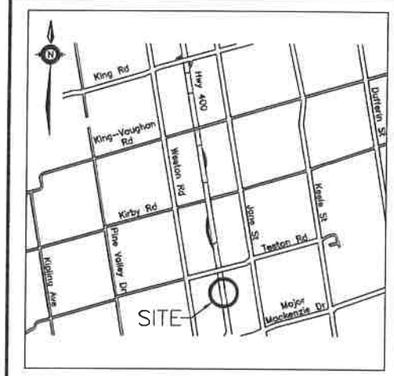

KEYPLAN

LEGEND

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

NO	ELEVATION	NORTHING	EASTING
CV–12A	239.3	4 857 700.1	300 620.0
CV–12B	240.0	4 857 709.0	300 687.0

LICENSED PROFESSIONAL ENGINEER
S. PANG
Mar 7/12
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
Mar 7/12
PROVINCE OF ONTARIO

-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.

GEOCRES No. 30M13-190

REVISIONS			
DATE	BY	DESCRIPTION	
DESIGN SKP	CHK PKC	CODE	LOAD
DRAWN MFA	CHK SKP	SITE	STRUCT
			DATE MAR. 2012
			DWG

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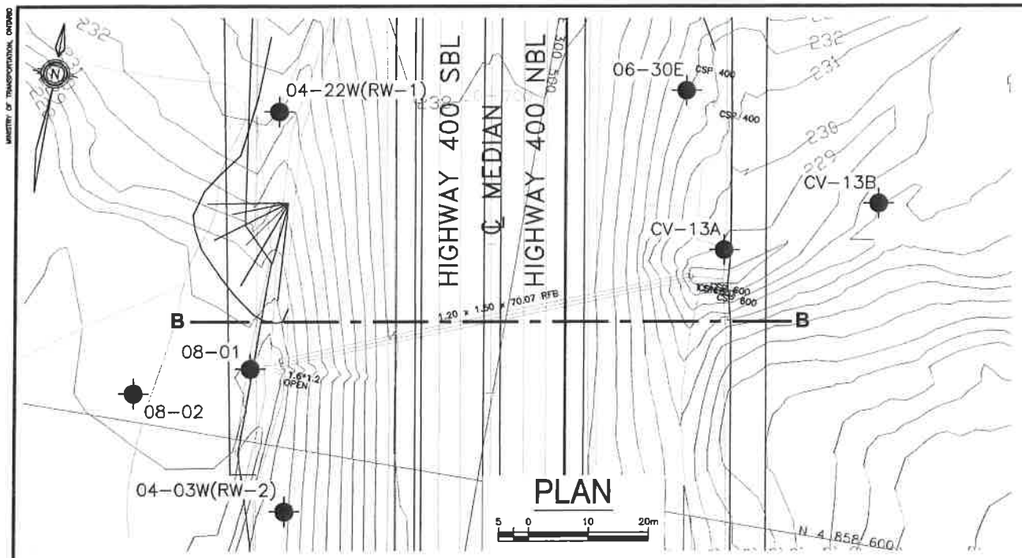
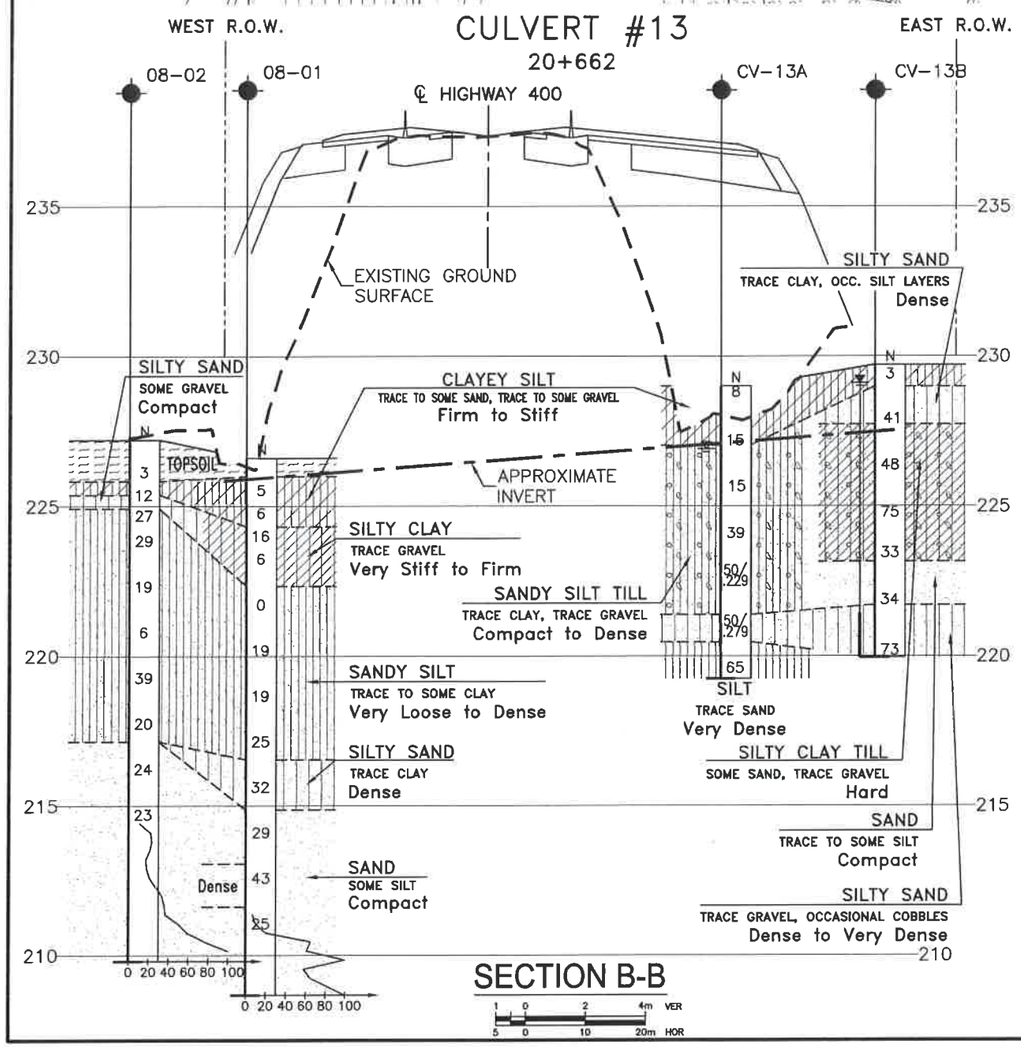
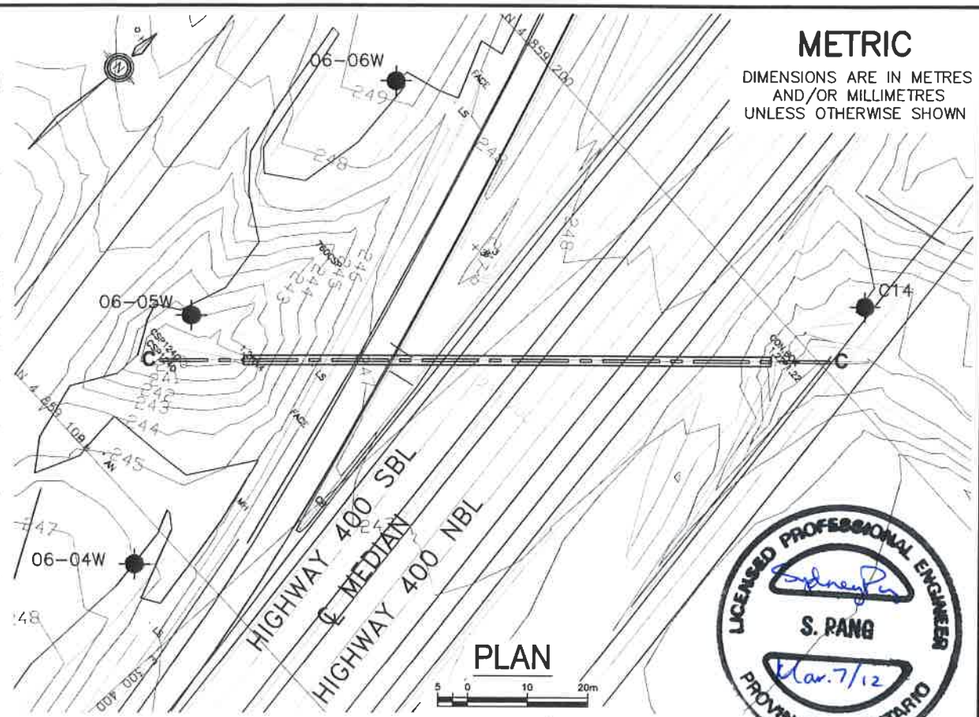


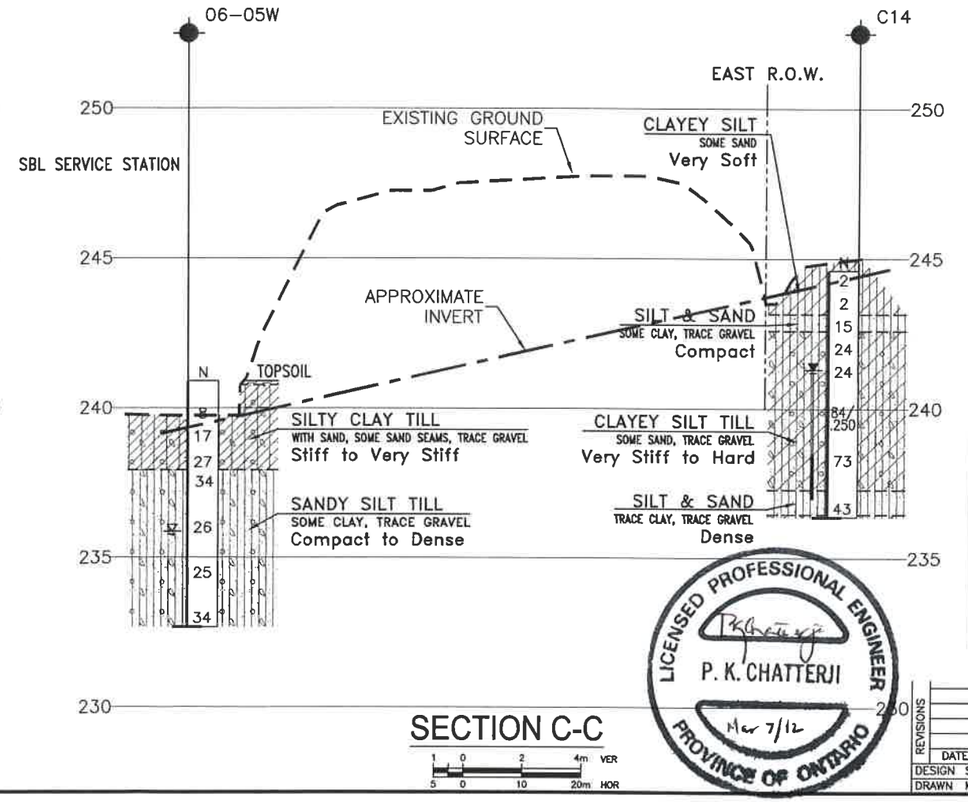
CULVERT #13
20+662



SECTION B-B



CULVERT #14
21+214



SECTION C-C

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

CONT No
WP No 2539-04-00

SHEET

TESTON ROAD TO KING ROAD
CULVERTS #13 & #14
BOREHOLE LOCATIONS AND SOIL STRATA

SNC·LAVALIN

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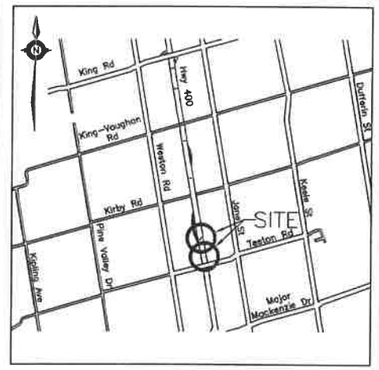

KEYPLAN

LEGEND

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

NO	ELEVATION	NORTHING	EASTING
04-03W(RW-2)	229.1	4 858 589.5	300 469.5
CV-13A	229.0	4 858 645.0	300 534.0
CV-13B	229.7	4 858 657.0	300 558.0
08-01	226.6	4 858 612.1	300 459.8
08-02	227.2	4 858 604.7	300 441.2
06-04W	246.1	4 859 096.3	300 383.5
06-05W	240.9	4 859 131.2	300 359.1
06-06W	249.5	4 859 182.8	300 352.5
C-14	244.6	4 859 214.9	300 433.5

-NOTES-

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

GEOCRES No. 30M13-190

LICENSED PROFESSIONAL ENGINEER
S. PANG
Mar. 7/12
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
Mar 7/12
PROVINCE OF ONTARIO

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN	SKP	CHK	PKC	CODE	LOAD
DRAWN	MFA	CHK	SKP	SITE	STRUCT

DATE MAR. 2012
DWG

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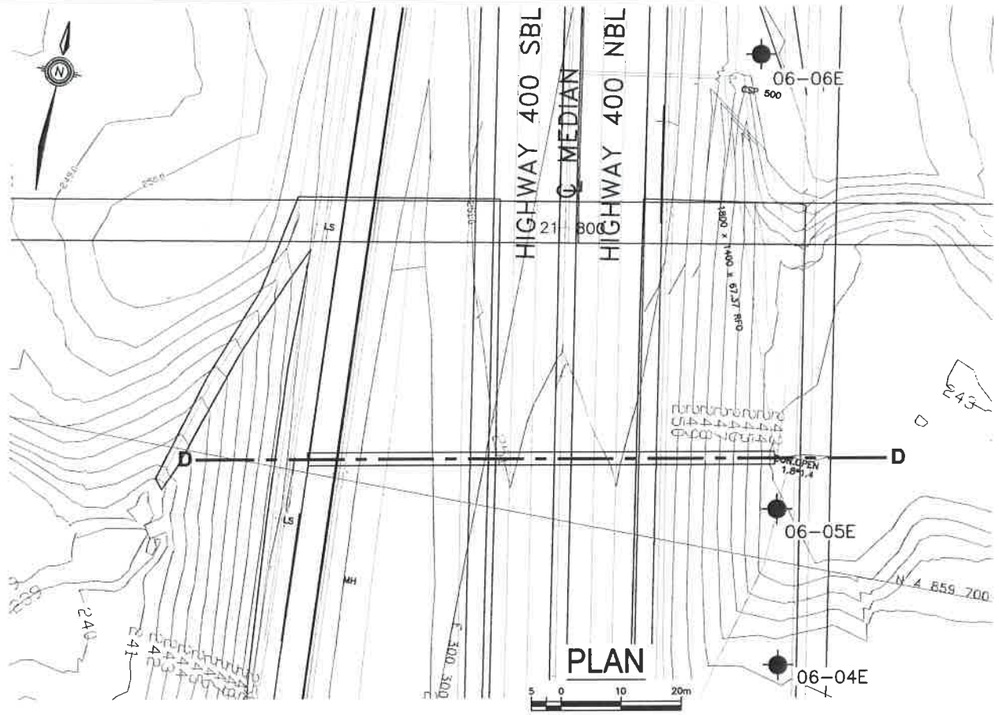
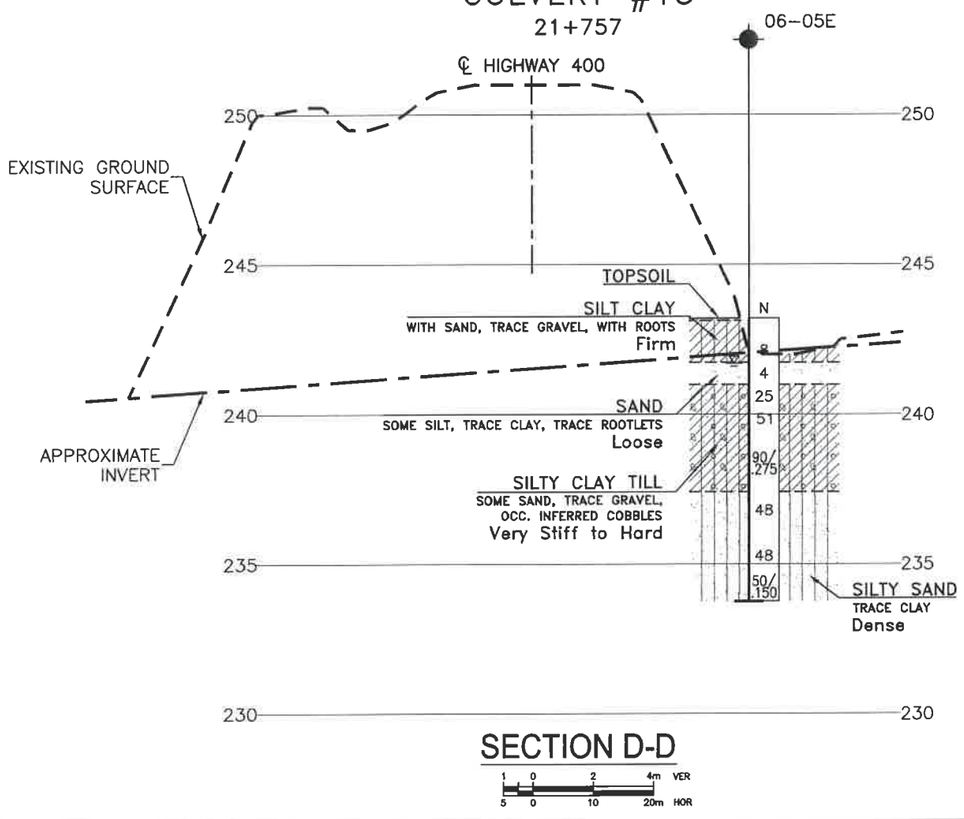
PLOTTED: Mar. 7, 2012 - 4:24 PM

MINISTRY OF TRANSPORTATION, ONTARIO



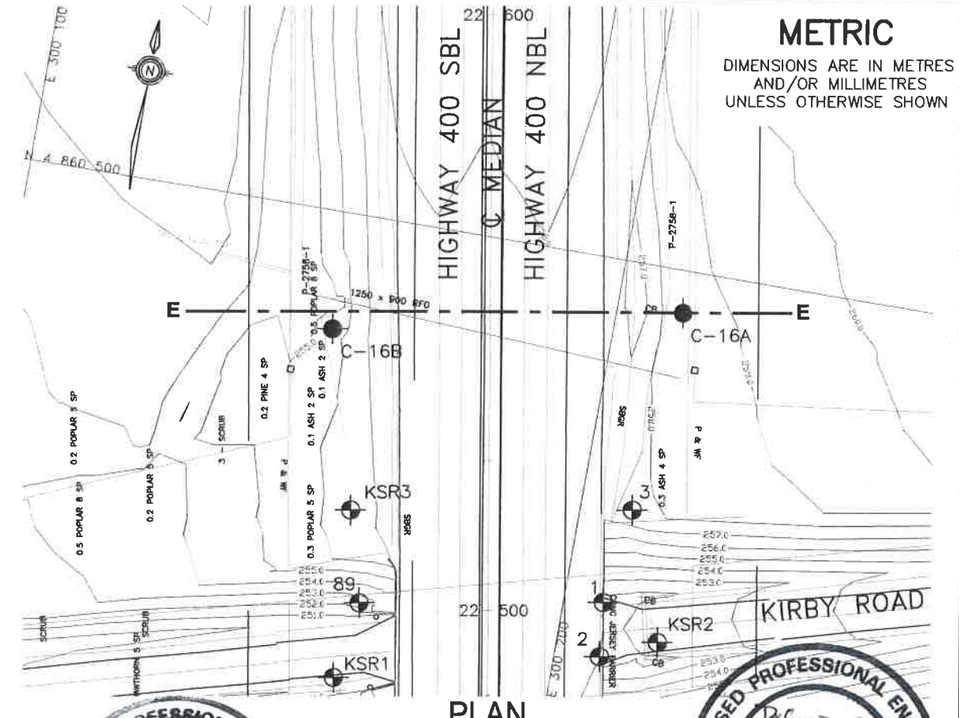
CULVERT #15

21+757



SECTION D-D

1 0 2 4m VER
5 0 10 20m HOR



CULVERT #16

22+550

SECTION E-E

1 0 2 4m VER
5 0 10 20m HOR

LICENSED PROFESSIONAL ENGINEER
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PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
Mar 7/12
PROVINCE OF ONTARIO

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

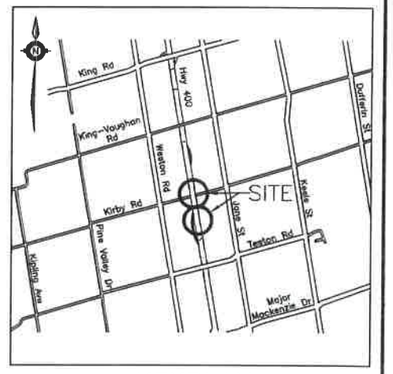
CONT No
WP No 2539-04-00

SHEET

TESTON ROAD TO KING ROAD
CULVERTS #15 & #16
BOREHOLE LOCATIONS AND SOIL STRATA

SNC·LAVALIN

THURBER ENGINEERING LTD



KEYPLAN

LEGEND

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

NO	ELEVATION	NORTHING	EASTING
06-04E	247.9	4 859 683.1	300 354.7
06-05E	243.2	4 859 708.6	300 349.6
06-06E	248.5	4 859 783.1	300 332.4
KSR3	256.4	4 860 451.0	300 163.0
3	257.8	4 860 459.0	300 209.0
C-16A	258.2	4 860 492.9	300 211.0
C-16B	255.5	4 860 480.3	300 154.3

-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.

GEOCRES No. 30M13-190

REVISIONS			
DATE	BY	DESCRIPTION	
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			DATE MAR. 2012

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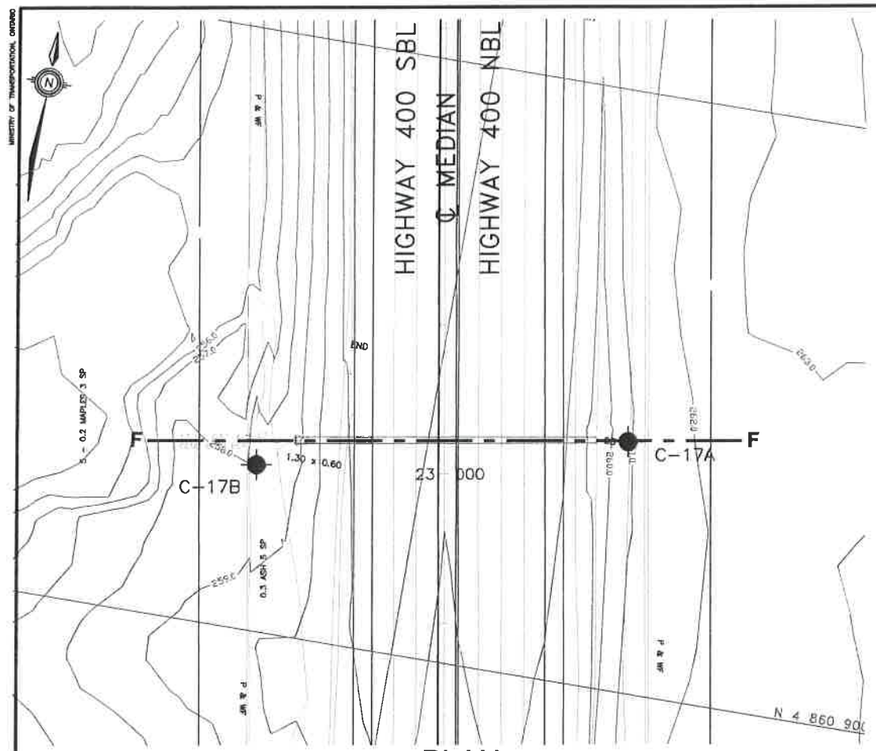
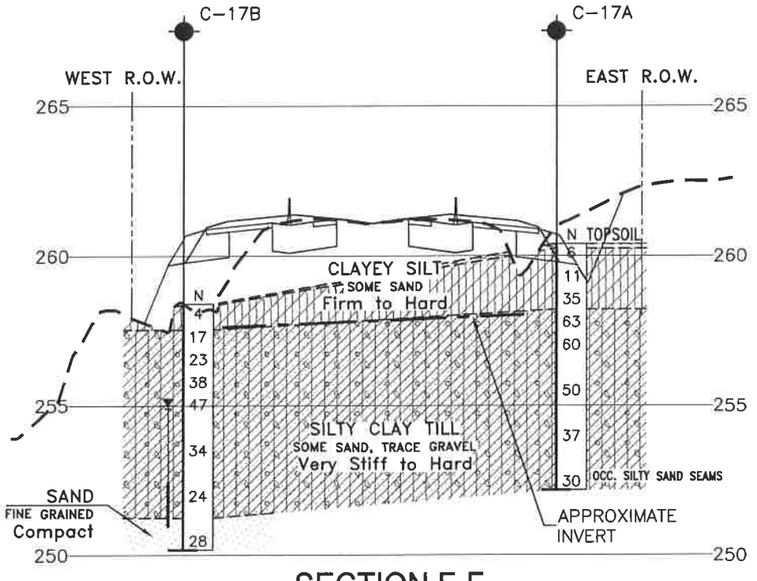


PLAN

5 0 10 20m

CULVERT #17
23+005



SECTION F-F

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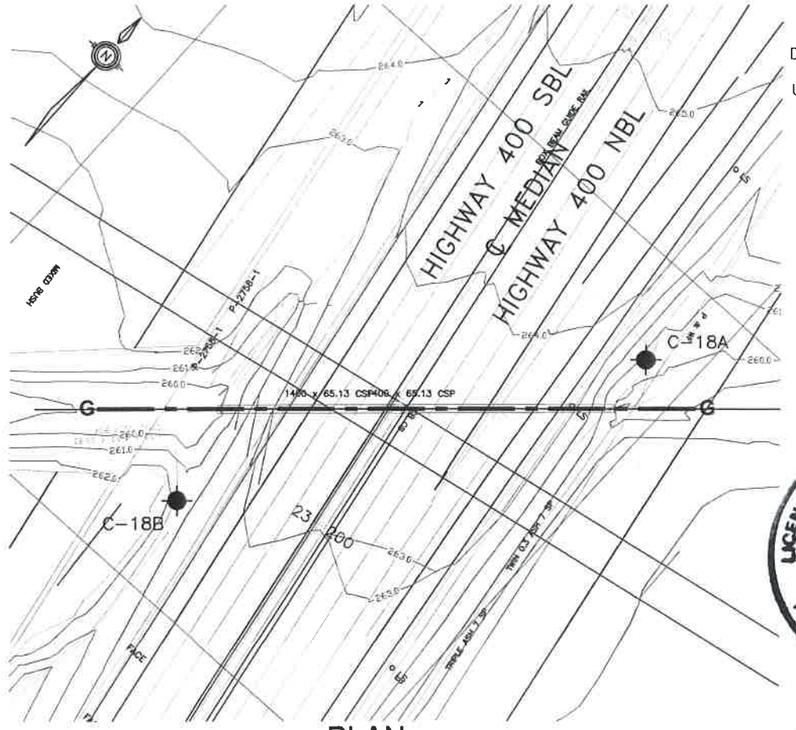
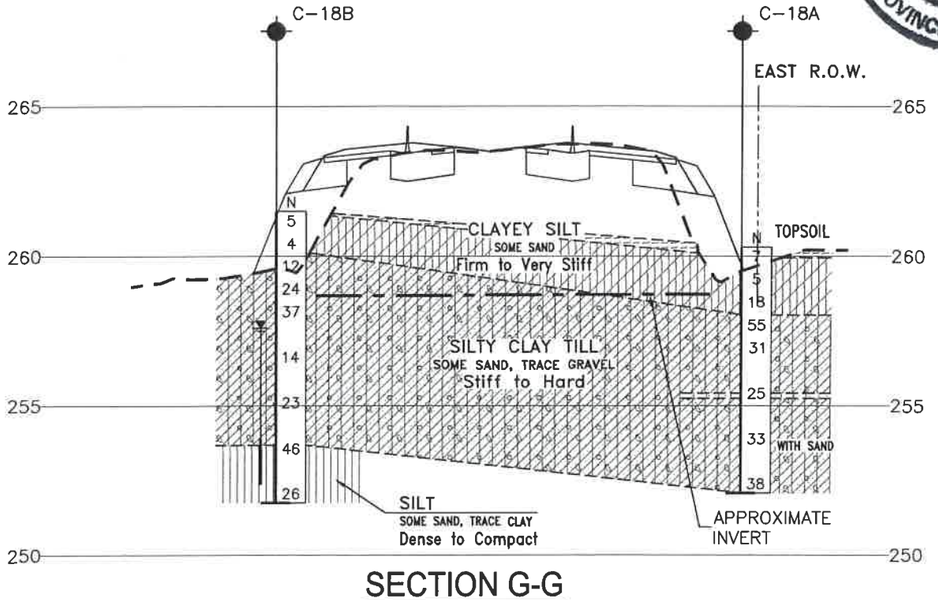
5 0 10 20m HOR



PLAN

5 0 10 20m

CULVERT #18
23+225



SECTION G-G

1 0 2 4m VER
5 0 10 20m HOR

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

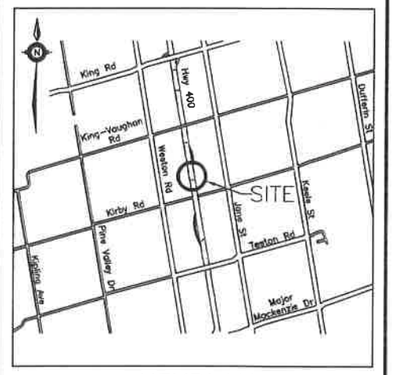
CONT No
WP No 2539-04-00

SHEET

TESTON ROAD TO KING ROAD
CULVERTS #17 & #18
BOREHOLE LOCATIONS AND SOIL STRATA

SNC·LAVALIN

THURBER ENGINEERING LTD.



KEYPLAN

LICENSED PROFESSIONAL ENGINEER
S. PANG
Mar. 7/12
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
Mar 7/12
PROVINCE OF ONTARIO

LEGEND

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

NO	ELEVATION	NORTHING	EASTING
C-17A	260.4	4 860 941.6	300 132.9
C-17B	258.4	4 860 927.5	300 072.3
C-18A	260.3	4 861 185.1	300 092.0
C-18B	261.5	4 861 115.5	300 049.8

-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.

GEOCRES No. 30M13-190

REVISIONS		
DATE	BY	DESCRIPTION

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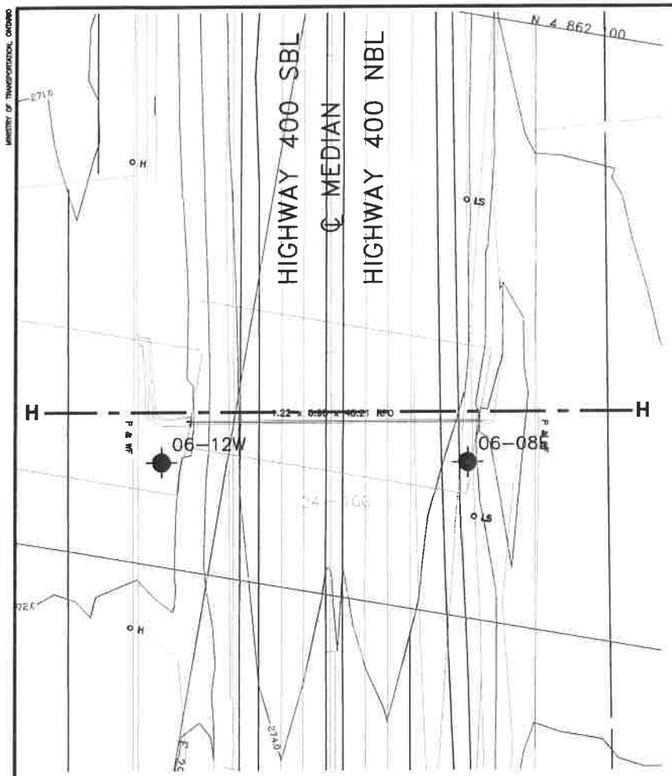
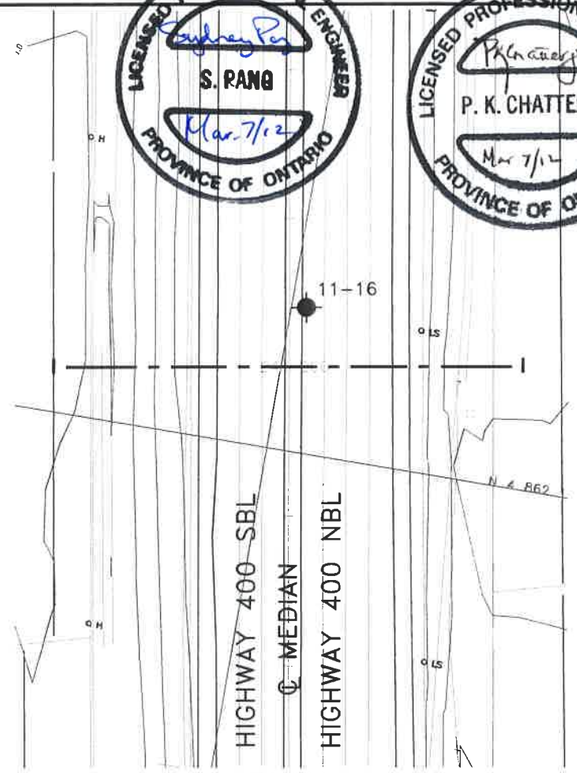
MINISTRY OF TRANSPORTATION, ONTARIO



PLAN

5 0 10 20m



PLAN

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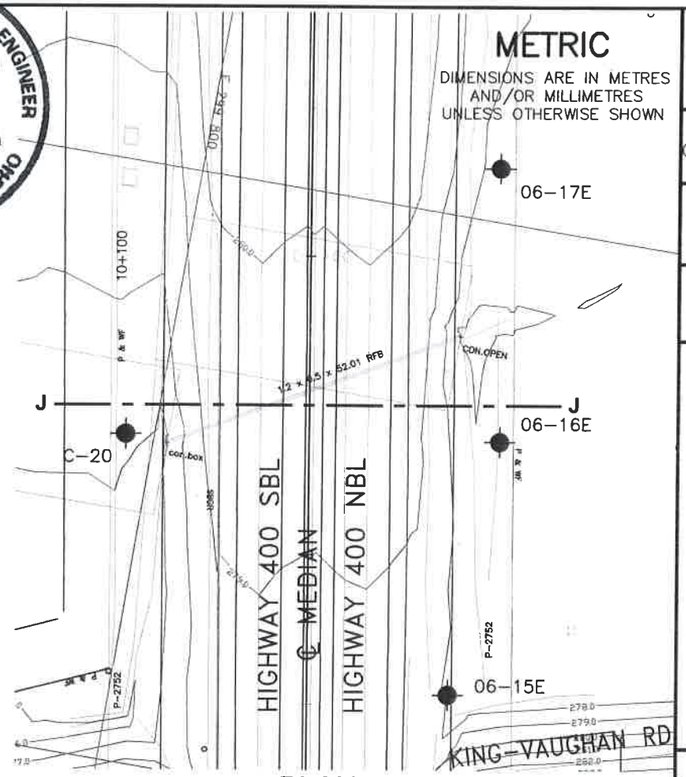


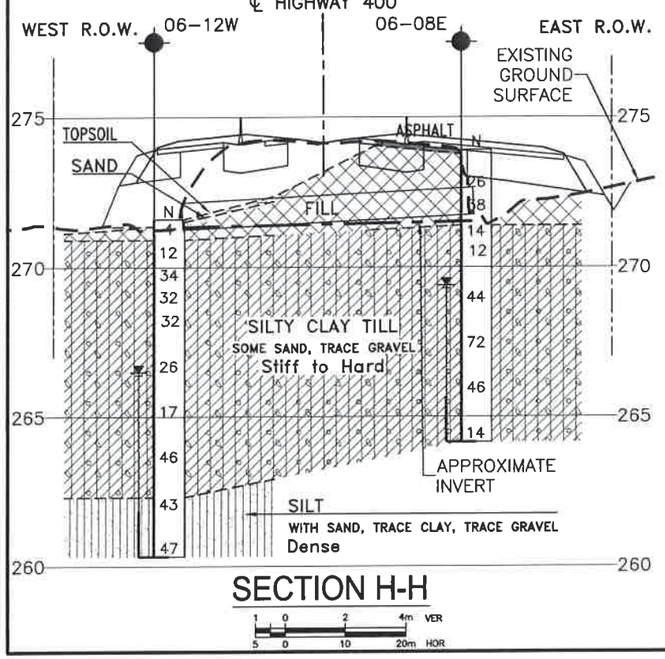
PLAN

5 0 10 20m

CULVERT #19

24+115

℄ HIGHWAY 400



SECTION H-H

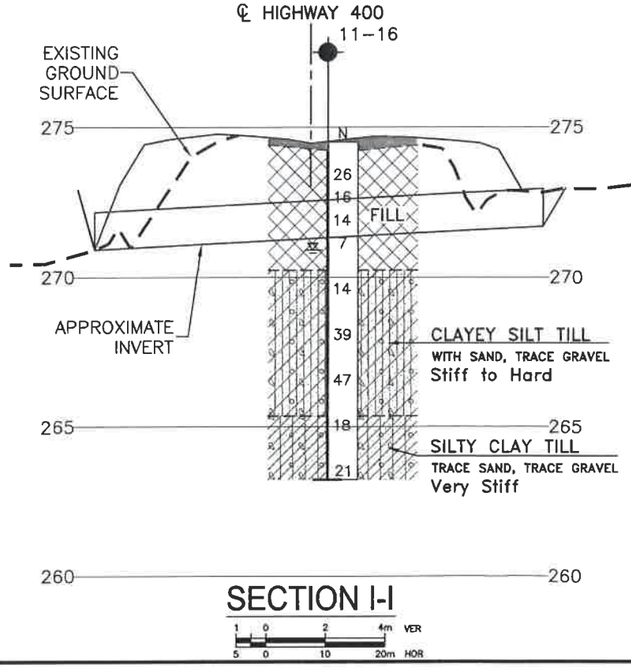
1 0 2 4m VER

5 0 10 20m HOR

CULVERT #19A

24+200

℄ HIGHWAY 400



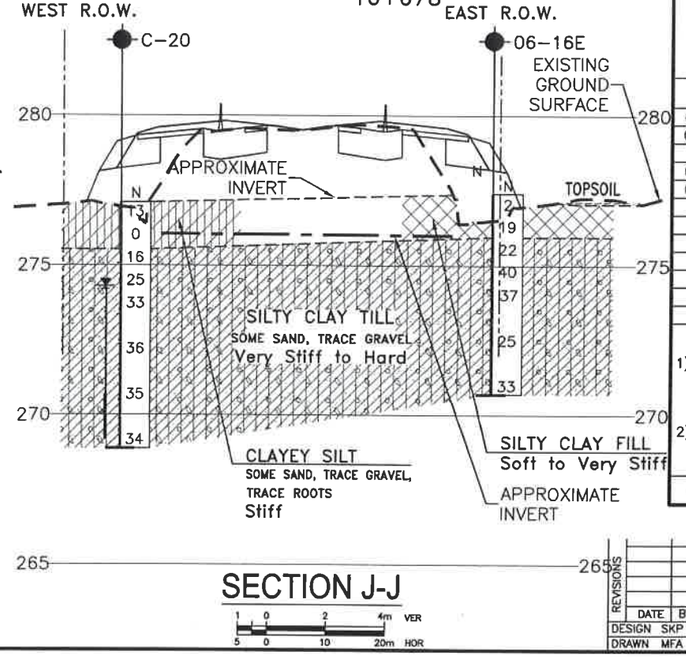
SECTION I-I

1 0 2 4m VER

5 0 10 20m HOR

CULVERT #20

10+078



SECTION J-J

1 0 2 4m VER

5 0 10 20m HOR

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No

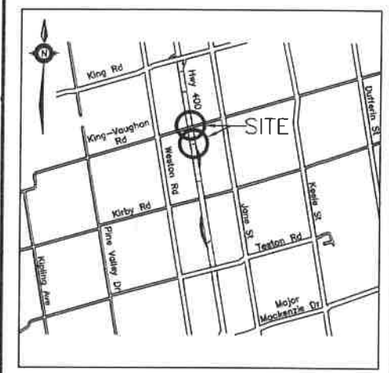
WP No 2539-04-00

SHEET

TESTON ROAD TO KING ROAD
CULVERTS # 19, #19A & #20
BOREHOLE LOCATIONS AND SOIL STRATA

SNC·LAVALIN

THURBER ENGINEERING LTD



KEYPLAN

LEGEND

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

NO	ELEVATION	NORTHING	EASTING
06-08E	273.9	4 862 025.8	299 939.7
06-12W	271.6	4 862 017.2	299 889.3
11-16	274.5	4 862 124.3	299 902.5
06-16E	277.4	4 862 563.7	299 856.8
06-17E	277.9	4 862 609.0	299 848.8
C-20	277.1	4 862 554.4	299 795.3

-NOTES-

1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
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GEOCRES No. 30M13-190

REVISIONS		
DATE	BY	DESCRIPTION

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PLOTDATE: Mar. 5, 2012 - 4:25 PM

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

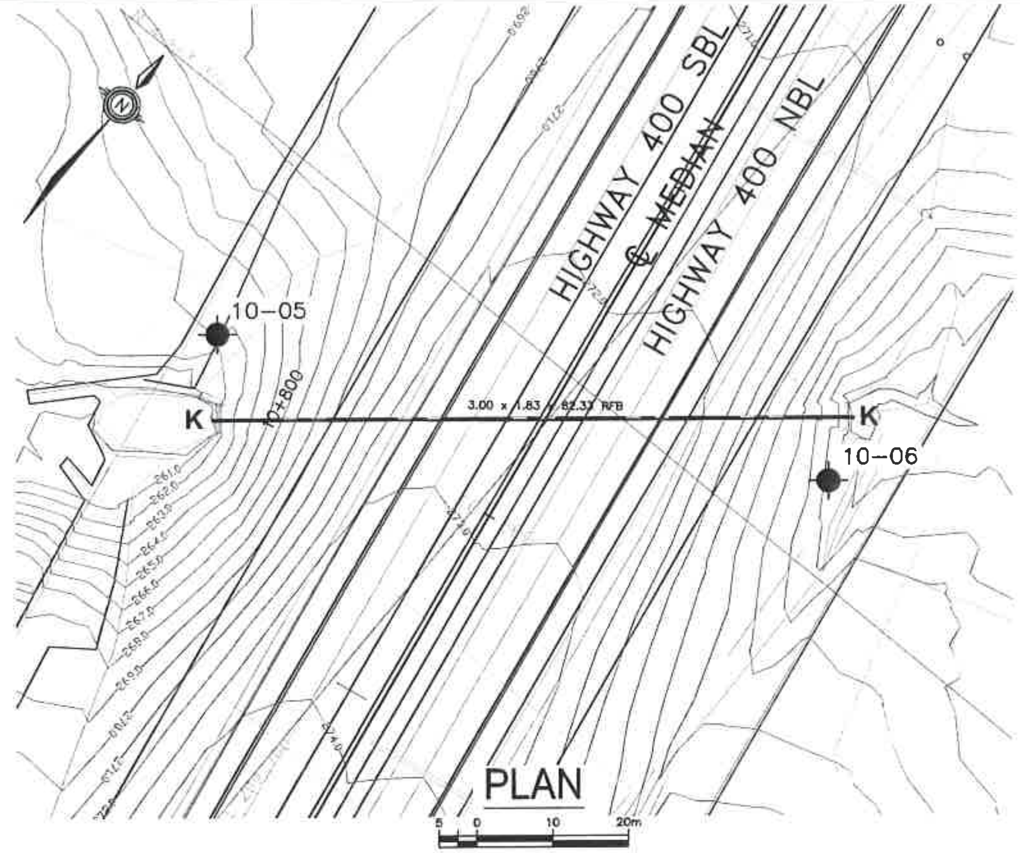
CONT No
WP No 2539-04-00

TESTON ROAD TO KING ROAD
CULVERT #21
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

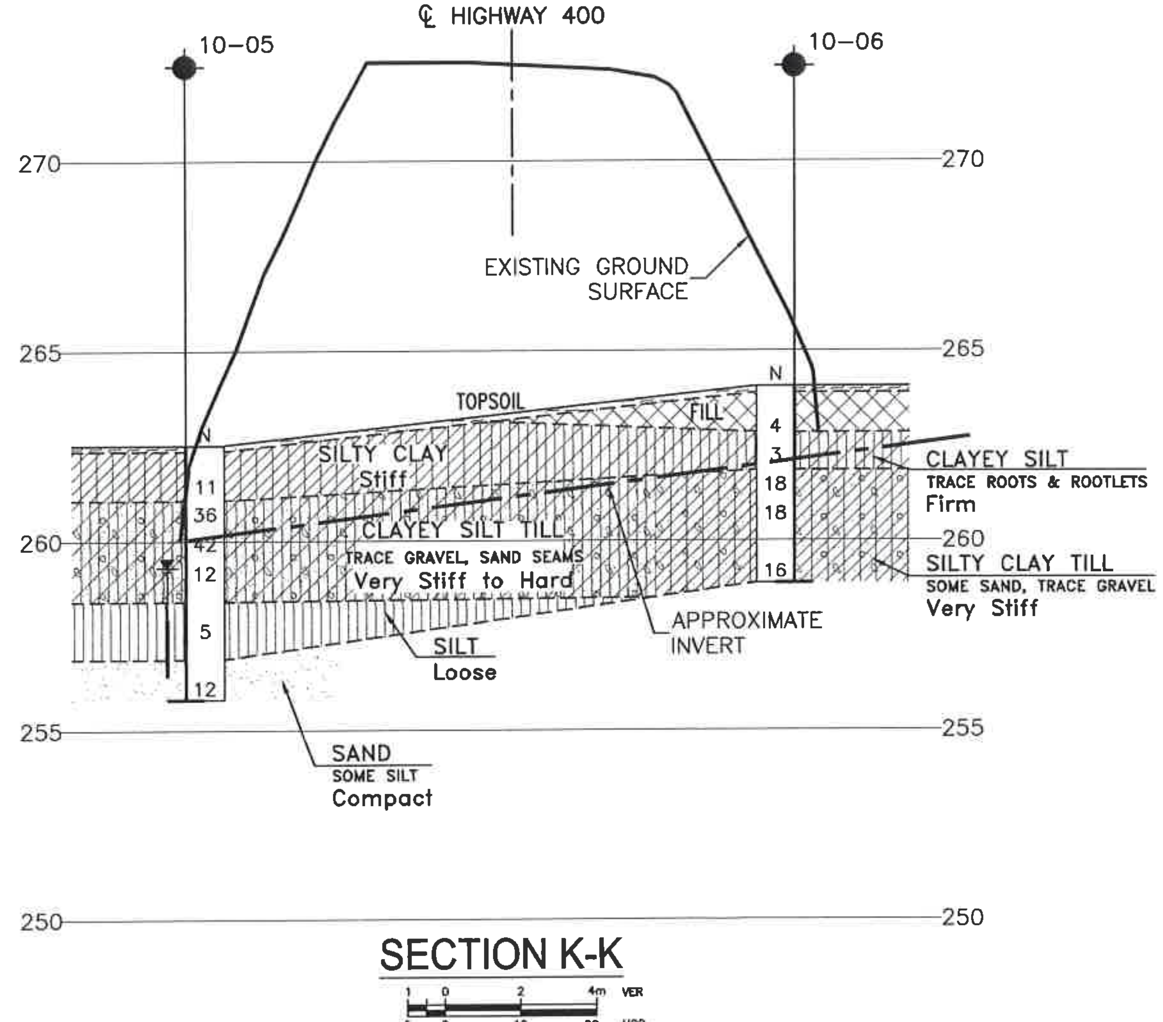
SNC·LAVALIN

THURBER ENGINEERING LTD



PLAN

CULVERT #21
10+815
℄ HIGHWAY 400



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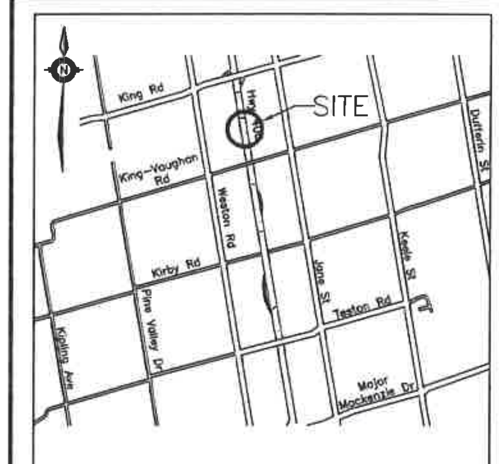

KEYPLAN

LEGEND

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

NO	ELEVATION	NORTHING	EASTING
10-05	262.5	4 863 274.9	299 659.3
10-06	264.1	4 863 310.9	299 733.6

-NOTES-

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GEOCRES No. 30M13-190

REVISIONS	DATE	BY	DESCRIPTION

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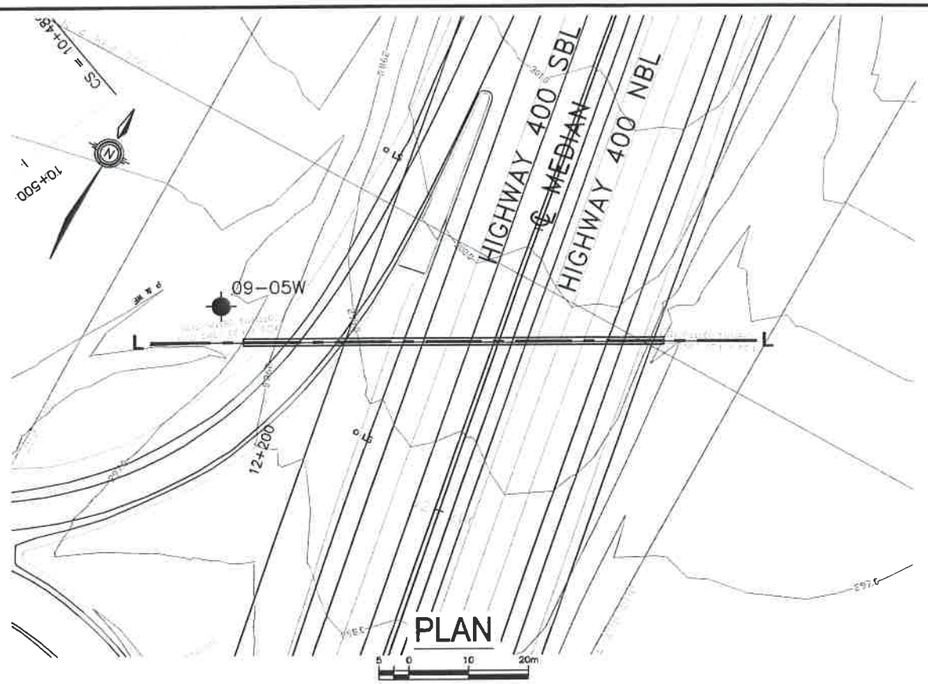
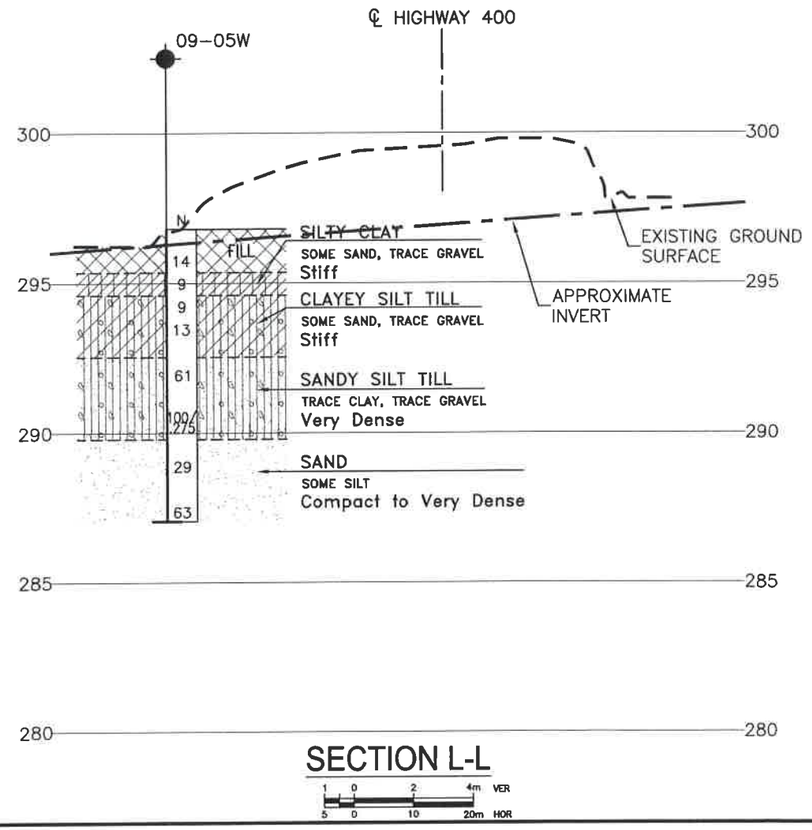


CULVERT #25

12+230



SECTION L-L

1 0 2 4m VER
5 0 10 20m HOR

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

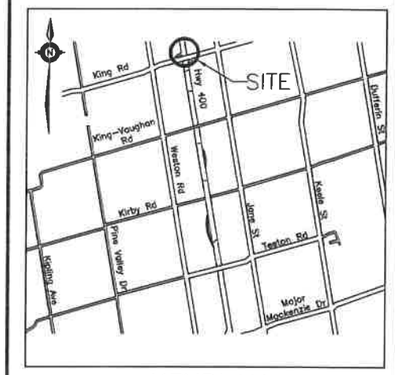
CONT No
WP No 2539-04-00

SHEET

TESTON ROAD TO KING ROAD
CULVERT #25
BOREHOLE LOCATIONS AND SOIL STRATA

SNC·LAVALIN

THURBER ENGINEERING LTD



KEYPLAN

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

NO	ELEVATION	NORTHING	EASTING
09-05W	296.8	4 864 671.4	299 417.9

LICENSED PROFESSIONAL ENGINEER
S. RANG
Mar. 7/12
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
Mar 7/12
PROVINCE OF ONTARIO

-NOTES-

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GEOCRES No. 30M13-190

REVISIONS			
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			DATE MAR. 2012
			DWG

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PLOTDATE: Mar. 5, 2012 - 4:28 PM

Appendix D

Foundation Alternatives

COMPARISON OF ALTERNATIVE CULVERT TYPES

Location	Concrete Open Footing Culvert	Concrete Rigid Box Culvert	Corrugated Steel Pipe Culvert
Culvert Extensions And New Culvert	***Advantages:*** i. Compatible to some existing culvert types. ii. Relatively expedient installation if precast units are used. ***Disadvantages:*** i. May require deeper sub-excavation for footing construction.	***Advantages:*** i. Compatible to most existing culvert types. ii May require less sub-excavation than open footing culvert. iii. Relatively expedient installation if precast units are used. ***Disadvantages:*** i. May require compacted granular pad on subgrade. ii. May create environmental issues such as those involving spawning fish species.	***Advantages:*** i. Can tolerate larger foundation settlements than concrete culverts. ii. Lower cost than concrete culverts. ***Disadvantages:*** i. May only be used as temporary extensions since the main purpose of this project is to install permanent extensions compatible to existing culverts. ii. Not as durable as concrete culverts.

Appendix E

List of SPs and Suggested Wording for NSSP

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

- SP 206S03
- OPSS 538
- OPSS 804
- OPSS 902
- OPSS 1010
- OPSS 1205
- OPSD 803.010
- OPSD 800.011
- OPSD 810.010

2. Suggested Text for NSSP on "Impact on Adjacent Roadways"

- It is critical that Contractor's excavation and construction activities do not undermine or have any adverse impact on the integrity and performance of the travelled lanes of Highway 400. Daily visual inspection of the pavement surface must be carried out in the vicinity of each culvert under construction. Any form of cracks, pavement distress or settlement that are observed must be immediately brought to the attention of the Contract Administrator for determining if remedial action is required