



THURBER ENGINEERING LTD.

**FOUNDATION INVESTIGATION REPORT
CULVERT C4 REPLACEMENT
HIGHWAY 404
SOUTH OF 19TH AVENUE
MARKHAM, ONTARIO
G.W.P. 2930-02-00**

GEOCRES NO. 30M14-467

Report

to

WSP Canada Inc.

Date: February 23, 2018
File: 15786



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PART 1: FACTUAL INFORMATION

1. INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted for the replacement of an existing culvert (designated as C4) that crosses under Highway 404 at Station 22+043, south of 19th Avenue in the City of Markham, Ontario.

The purpose of this investigation was to explore the subsurface conditions at selected locations near the alignment, and based on the data obtained, to provide a borehole location plan, stratigraphic profiles, records of boreholes, laboratory test results, and a written description of the subsurface conditions.

Thurber was retained by WSP Canada Inc. (WSP) to carry out this foundation investigation under the MTO Assignment Number 2016-E-0014.

For preparation of this report, reference has been made to culvert design information provided by WSP.

2. PROJECT AND SITE DESCRIPTION

The culvert is located on Highway 404, near Station 22+043, approximately 290 m south of 19th Avenue in Markham, Ontario. The general location of the proposed culvert replacement is shown on the key plan on the Borehole Locations and Soil Strata Drawing in Appendix D.

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E file: H:\15000-15999\15786 Hwy 404 Widening 2016-E-0014\Reports and Memos\Culverts C4 and C7\Culvert C4\Final\15786 Culvert C4 Hwy 404 FIR feb 18.docx



The existing culvert is a 1200 mm diameter corrugated steel pipe (CSP). The Highway 404 grade at the existing culvert is at approximate Elevation 241.0 m. The culvert invert is at approximate Elevation 238.2 m at the inlet and 237.7 m at the outlet. The existing culvert is reportedly in a good condition at the inlet but fair condition at the outlet. Holes were noted at the top of the culvert near the outlet, and corrosion of the culvert was observed.

The land use adjacent to this section of Highway 404 is largely rural and agricultural, although there is increasing residential and commercial development in recent years. The vegetation cover beyond the paved areas of the highway comprises grasses, bushes and stands of trees. Photographs of the culvert and surrounding area are presented in Appendix C.

The culvert site is located within the physiographic region known as Peel Plain. The topography is flat to gently undulating. The soil cover in the region typically comprises silty clay glacial tills with sand and silt layers. Shale bedrock of the Georgian Bay Formation is anticipated at an approximate depth of 50 m.

3. SITE INVESTIGATION AND FIELD TESTING

The borehole investigation and field testing program for this project was carried out from September 6 to 8, 2017, and consisted of drilling and sampling three (3) boreholes, designated as Boreholes C4-01 to C4-03, near the existing culvert alignment. The boreholes were terminated at 11.1 m depth (Elevations 229.5 to 230.5).

Lane closures and traffic control were carefully planned for drilling each borehole. Prior to commencement of drilling, utility clearances were obtained for all borehole locations.

The approximate locations of the boreholes are shown on the Borehole Locations and Soil Strata Drawing included in Appendix D. Northing and easting coordinates at the borehole locations were obtained by Thurber using a Trimble GPS Pathfinder ProXRT, and the corresponding ground surface elevations were provided by WSP based on the project DTM survey. The coordinates and elevations of the boreholes are given on these drawings and on the individual Record of Borehole Sheets in Appendix A.

The boreholes were advanced using a truck-mounted D-90 drill rig. Hollow stem augers were used to advance the boreholes, and soil samples were obtained at selected intervals using a 50 mm diameter split spoon sampler in conjunction with the Standard Penetration Test (SPT).



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

Groundwater conditions in the open boreholes were observed throughout the drilling operations. Standpipe piezometers were installed in boreholes near the inlet and outlet to permit monitoring of groundwater levels. The piezometers consisted of 25 mm and 50 mm PVC pipes with slotted screens. Upon completion, the boreholes were abandoned in general accordance with Ontario Regulation 903 amended by Ontario Reg. 372 (O.Reg. 903). Once the field investigation is completed, the piezometers will be decommissioned in general accordance with O.Reg. 903. The details of borehole completion are summarized in Table 3.1.

Table 3.1 – Borehole Completion Details

Borehole No.	Borehole Depth / Base Elevation (m)	Piezometer Tip Elevation (m)	Completion Details
C4-01	11.1/229.5	10.7/229.9	Borehole backfilled with a sand filter from 11.1 m to 7.0 m, bentonite holeplug from 7.0 m to 0.3 m, then cement to surface.
C4-02	11.1/229.8	None installed	Borehole backfilled with bentonite holeplug and auger cuttings to 0.3 m, cement to 0.1 m, then asphalt to surface.
C4-03	11.1/230.5	10.4/231.2	Borehole caved to 10.4 m, backfilled with sand filter from 11.1 m to 6.7 m, bentonite holeplug and auger cuttings from 6.7 m to 0.3, then cement to surface.

4. LABORATORY TESTING

The recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected samples were also subjected to grain size analysis and Atterberg Limits testing. All the laboratory tests were carried out in accordance with MTO and/or ASTM Standards, as appropriate. The results of the laboratory testing are summarized on the Record of Borehole sheets and on the accompanying figures in Appendix B.



5. DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets in Appendix A for details of the encountered soil stratigraphy. A soil profile along the culvert alignment is presented on the "Borehole Locations and Soil Strata" drawing in Appendix D. An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented in the Record of Borehole sheets governs any interpretation of the site conditions. It must be recognized that soil conditions may vary between and beyond borehole locations.

In general, the subsurface conditions encountered in the boreholes consist of a pavement structure and silty clay embankment fill overlying native silty clay till deposits, which is underlain by sand at some locations. The groundwater level in the boreholes varied from 3.7m to 4.2 m depths.

More detailed descriptions of the individual stratum are presented below.

5.1 Pavement Structure

A pavement structure consisting of asphalt overlying granular fill materials was encountered in Boreholes C4-01 to C4-03. The asphalt thickness ranged from 125 mm to 150 mm.

The granular fill consisted of brown sand and gravelly sand ranging between 0.6 m and 1.0 m in thickness, with base elevations varying between 239.5 and 240.8.

An SPT 'N' value measured in the gravelly sand fill was 24 blows per 0.3 m of penetration indicating a compact state. Measured moisture contents of the cohesionless fill ranged from 2 percent to 12 percent.

The results of a grain size distribution analysis carried out on a sample of this cohesionless fill is presented on the Record of Borehole Sheets included in Appendix A and on Figure B1 of Appendix B. Results of the gradation testing are summarized below:

Soil Particles	Percentage (%)
Gravel	21
Sand	54
Silt	16
Clay	9



5.2 Silty Clay Embankment Fill

The surficial sand fill was underlain by cohesive embankment fill at all three borehole locations. This cohesive fill was encountered at depths ranging from 0.8 m to 1.1 m. This fill consisted of brown to grey silty clay with sand and trace gravel. The silty clay fill ranged from 2.2 m to 3.0 m in thickness and extended to depths ranging from 3.0 m to 4.1 m (Elevations 238.6 to 236.5).

SPT 'N' values recorded in the silty clay fill ranged from 6 to 24 blows per 0.3 m of penetration, indicating a firm to very stiff consistency. Measured moisture contents of samples of the silty clay fill varied between 10 percent and 23 percent.

The results of grain size distribution analyses carried out on two samples of this cohesive fill are presented on the Record of Borehole Sheets included in Appendix A and on Figure B2 of Appendix B. The results of the gradation testing are summarized below:

Soil Particles	Percentage (%)
Gravel	0 to 1
Sand	35 to 39
Silt	36 to 38
Clay	23 to 28

The results of Atterberg Limits tests conducted on samples of the silty clay fill are provided on the Record of Borehole sheets in Appendix A and illustrated in Figure B5 of Appendix B. The results are summarized as follows:

Index Property	Percentage (%)
Plastic Limit	12 to 20
Liquid Limit	26 to 36
Plasticity Index	14 to 16

The results of the Atterberg Limits testing indicate that this deposit has low to medium plasticity with group symbols of CL and CI.

5.3 Silty Clay Till

Underlying the silty clay fill at all three borehole locations was a deposit of brown to grey native silty clay till with sand, containing trace gravel and occasional cobbles. This till was encountered at depths ranging from 3.0 m to 4.1 m. Sandy silt to sand interlayers were found embedded within the silty clay till (see Sections 5.4 and 5.5). The silty clay till was 3.5 m to 7.4 m in overall thickness, and extended to depths of 8.7 m and 10.4 m (Elevations 231.9 to 231.2) in Boreholes C4-01 and C4-03, respectively. Borehole C4-02 was terminated within the silty clay till at a depth of 11.1 m (Elevation 229.8).

SPT 'N' values recorded in the silty clay till ranged from 10 to 75 blows per 0.3 m of penetration indicating a stiff to hard consistency. An SPT 'N' value of 50 blows per 0.1 m of penetration was measured in Borehole C4-03, which inferred the presence of cobbles near Elevation 237.0. Measured moisture contents of samples of the silty clay till varied between 8 percent and 25 percent.

The results of grain size distribution analyses carried out on samples of the silty clay till are presented on the Record of Borehole Sheets included in Appendix A and on Figure B3 of Appendix B. The results of the gradation testing are summarized below:

Soil Particles	Percentage (%)
Gravel	0 to 3
Sand	5 to 36
Silt	37 to 48
Clay	23 to 48

The results of Atterberg Limits tests conducted on four samples of the silty clay till are provided on the Record of Borehole sheets in Appendix A and illustrated in Figure B6 of Appendix B. The results are summarized as follows:

Index Property	Percentage (%)
Plastic Limit	11 to 17
Liquid Limit	20 to 33
Plasticity Index	9 to 18



The results of the Atterberg Limits testing indicate that this deposit has low plasticity with a group symbol of CL.

Glacially derived soils inherently contain cobbles and boulders.

5.4 Sandy Silt Till

A 1.1-m thick layer of grey sandy silt till containing trace clay and trace gravel was encountered within the silty clay till layer in Borehole C4-01 and extended from 6.0 m to 7.1 m depth. Glacially derived soils inherently contain cobbles and boulders.

The SPT 'N' value recorded in the sandy silt till was 100 blows for less than 0.3 m of penetration indicating a very dense state. The measured moisture content of the sandy silt till was 9 percent.

5.5 Sand

A layer of grey sand containing trace to some silt and trace clay was encountered beneath the silty clay till at 8.7 m and 10.4 m depth in Boreholes C4-01 and C4-03, respectively. A layer of grey sand of approximately 1 m in thickness was found embedded within the silty clay till at 7.0 m depth in Borehole C4-02. Boreholes C4-01 and C4-03 were terminated within the sand layer at a depth of 11.1 m (Elevations 230.5 to 229.5).

SPT 'N' values recorded in the sand ranged from 15 blows to 39 blows per 0.3 m of penetration, indicating a compact to dense state. Measured moisture contents of samples of the sand varied between 13 percent and 19 percent.

The results of a grain size distribution analysis carried out on a sample of the sand is presented on the Record of Borehole Sheets included in Appendix A and on Figure B4 of Appendix B. The results of the gradation testing are summarized below:

Soil Particles	Percentage (%)
Gravel	0
Sand	86
Silt	13
Clay	1



5.6 Groundwater Conditions

Groundwater levels in the boreholes were observed during the drilling operations and measured upon completion of drilling. Standpipe piezometers were installed in Boreholes C4-01 and C4-03 to permit longer term monitoring. Water levels measured in the standpipes and open boreholes are presented below.

Table 5-1. Groundwater Level Measurements

Borehole Number	Date	Groundwater Level		Comments
		Depth (m)	Elevation (m)	
C4-01	September 7, 2017	4.3	236.3	Open borehole
	September 24, 2017	3.9	236.7	Piezometer
	October 23, 2017	3.7	236.9	
	February 15, 2018	3.3	237.3	
C4-02	September 6, 2017	4.7	236.2	Open borehole
C4-03	September 8, 2017	6.2	235.4	Open borehole
	September 24, 2017	5.6	236.0	Piezometer
	October 23, 2017	4.2	237.4	
	February 15, 2018	frozen	-	

The values shown in Table 5-1 are short-term readings, and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after periods of significant or prolonged precipitation.

6. CORROSIVITY TEST RESULTS

A sample of the silty clay fill from each of Boreholes C4-01 and C4-03 were submitted for analytical testing of corrosivity parameters. The results of the analytical tests are shown in Table 6.1 below. The laboratory certificates of analysis are presented in Appendix B.

Table 6.1- Analytical Test Results

Parameter	Units (Soil)	Test Results	
		C4-01 SS 3 Depth 1.7 m	C4-03 SS 3 Depth 2.5 m
		(Soil Sample)	(Soil Sample)
Sulphide	%	<0.02	<0.02
Chloride	µg/g	930	360
Sulphate	µg/g	72	7.1
pH	-	9.09	8.22
Electrical Conductivity	µS/cm	884	397
Resistivity	Ohm.cm	1130	2520
Redox Potential	mV	231	285

7. MISCELLANEOUS

Thurber staked and/or marked the borehole locations in the field and obtained utility clearances prior to drilling. WSP provided the northing and easting coordinates and ground surface elevations.

Walker Drilling of Utopia, Ontario, supplied and operated a track-mounted D-90 drill rig to carry out the drilling, sampling and in-situ testing operations for the boreholes.

The drilling and sampling operations in the field were supervised on a full-time basis by Ms. Eckie Siu of Thurber. Geotechnical laboratory testing was carried out by Thurber in its MTO-approved laboratory. Overall supervision of the field program was carried out by Mr. Stephane Loranger, CET.

Overall project management was provided by Ms. Rocio Palomeque Reyna, P.Eng. Interpretation of the field data and preparation of this report was completed by Dr. Nancy Berg, EIT. The report was reviewed by Dr. Sydney Pang, P.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.



THURBER ENGINEERING LTD.

Nancy Berg
Feb 23/18

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Client: WSP
File No.: 15786

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Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction

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



4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

5. LEGEND FOR RECORDS OF BOREHOLES

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

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


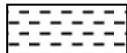



 Water Level
 Shear Strength Determination by Pocket Penetrometer

- (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

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

<u>DISCONTINUITY SPACING</u>		<u>STRENGTH CLASSIFICATION</u>			
Bedding	Bedding Plane Spacing	Rock Strength	Approximate Uniaxial Compressive Strength		Field Estimation of Hardness*
			(MPa)	(psi)	
Very thickly bedded	Greater than 2m	Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Thickly bedded	0.6 to 2m				
Medium bedded	0.2 to 0.6m	Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Thinly bedded	60mm to 0.2m	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Very thinly bedded	20 to 60mm				
Laminated	6 to 20mm	Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
Thinly Laminated	Less than 6mm				

<u>TERMS</u>					
Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.	Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.	Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
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.	Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen				
Fracture Index: (FI)	Frequency of natural fractures per 0.3m of core run.				

RECORD OF BOREHOLE No C4-01

1 OF 2

METRIC

W.P. 2930-02-00 LOCATION SB N 4 864 076.9 E 313 769.6 ORIGINATED BY ES
 HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP
 DATUM Geodetic DATE 2017.09.07 - 2017.09.07 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
240.6	GROUND SURFACE															
0.0	ASPHALT: (125mm)															
0.1	Gravelly SAND , some silt, trace clay Compact Brown Moist (FILL)		1	GS												
239.5			1	SS	24											21 54 16 9
1.1	Silty CLAY , with sand, trace gravel Firm to Stiff Brown to Grey (FILL)		2	SS	12											Corrosivity testing
	occasional rootlets Wet		3	SS	6											0 39 38 23
			4	SS	13											
236.5																
4.1	Silty CLAY with sand, trace gravel Hard Grey Moist (TILL)		5	SS	63											
234.6																
6.0	Sandy SILT , trace clay, trace gravel Very Dense Grey Moist (TILL)		6	SS	100/ .0.200											
233.5																
7.1			7	SS	41											
231.9																
8.7	SAND , some silt, trace clay Compact Grey Wet		8	SS	15											0 86 13 1

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

ONTMT4S MTO-15786 GPJ 2017TEMPLATE(MTO).GDT 2/22/18

RECORD OF BOREHOLE No C4-01

2 OF 2

METRIC

W.P. 2930-02-00 LOCATION SB N 4 864 076.9 E 313 769.6 ORIGINATED BY ES
 HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP
 DATUM Geodetic DATE 2017.09.07 - 2017.09.07 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	Continued From Previous Page																
229.5	SAND, some silt, trace clay Dense Grey Wet		9	SS	39		230										
11.1	END OF BOREHOLE AT 11.1m. BOREHOLE OPEN TO 10.7m AND WATER LEVEL AT 4.3m DEPTH UPON COMPLETION. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2017.09.24 3.9 236.7 2017.10.23 3.7 236.9 2018.02.15 3.3 237.3																

RECORD OF BOREHOLE No C4-02

1 OF 2

METRIC

W.P. 2930-02-00 LOCATION SB N 4 864 090.7 E 313 783.8 ORIGINATED BY ES
 HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP
 DATUM Geodetic DATE 2017.09.06 - 2017.09.06 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
240.9	GROUND SURFACE							20 40 60 80 100					
0.0	ASPHALT: (150mm)							20 40 60 80 100					
0.2	SAND, trace gravel Brown Moist (FILL)		1	GS				20 40 60 80 100					
240.1								20 40 60 80 100					
0.8	Silty CLAY with sand, trace gravel Very Stiff to Stiff Brown Moist (FILL)		1	SS	19		240	20 40 60 80 100					
			2	SS	16		239	20 40 60 80 100					1 35 36 28
			3	SS	12		238	20 40 60 80 100					
237.7			4	SS	13		237	20 40 60 80 100					
3.2	Silty CLAY, with sand, trace gravel Stiff to Hard Grey Wet (TILL)		5	SS	68		236	20 40 60 80 100					3 35 39 23
			6	SS	37		235	20 40 60 80 100					
233.9			7	SS	17		234	20 40 60 80 100					
7.0	SAND, trace silt Compact Grey Wet						233	20 40 60 80 100					
232.9			8	SS	34		232	20 40 60 80 100					
8.0							231	20 40 60 80 100					

Continued Next Page

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

RECORD OF BOREHOLE No C4-02

2 OF 2

METRIC

W.P. 2930-02-00 LOCATION SB N 4 864 090.7 E 313 783.8 ORIGINATED BY ES
HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP
DATUM Geodetic DATE 2017.09.06 - 2017.09.06 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
229.8	Silty CLAY with sand Hard Grey Moist (TILL)		9	SS	37		230									0 5 47 48	
11.1	END OF BOREHOLE AT 11.1m. BOREHOLE OPEN AND WATER LEVEL AT 4.7m DEPTH UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND AUGER CUTTINGS TO 0.3m, CEMENT TO 0.1m THEN ASPHALT TO SURFACE.																

RECORD OF BOREHOLE No C4-03

1 OF 2

METRIC

W.P. 2930-02-00 LOCATION NB N 4 864 108.1 E 313 815.1 ORIGINATED BY ES
 HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP
 DATUM Geodetic DATE 2017.09.08 - 2017.09.08 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
241.6	GROUND SURFACE							20 40 60 80 100					
0.0	ASPHALT: (150mm)							20 40 60 80 100					
0.2	SAND, trace gravel Brown Moist (FILL)		1	GS			241						
240.8													
0.8	Silty CLAY, with sand, trace gravel Very Stiff Brown Moist (FILL)		1	SS	18		240						
			2	SS	24								
			3	SS	20		239						Corrosivity testing
238.6													
3.0	Silty CLAY with sand, trace gravel Stiff to Hard Brown to Grey Moist (TILL)		4	SS	10		238						0 36 37 27
	Occasional cobbles												
			5	SS	50/ .100		237						
							236						
			6	SS	75		235						
							234						0 25 48 27
			7	SS	65		233						
			8	SS	34		232						

Continued Next Page

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

RECORD OF BOREHOLE No C4-03

2 OF 2

METRIC

W.P. 2930-02-00 LOCATION NB N 4 864 108.1 E 313 815.1 ORIGINATED BY ES
 HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP
 DATUM Geodetic DATE 2017.09.08 - 2017.09.08 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%) W _p W W _L				
231.2	Continued From Previous Page																
10.4	Silty CLAY with sand, trace gravel Hard Grey Moist (TILL)																
230.5	SAND , trace silt Compact Grey Wet		9	SS	17												
11.1	END OF BOREHOLE AT 11.1m. BOREHOLE OPEN TO 10.4m AND WATER LEVEL AT 6.2m DEPTH UPON COMPLETION Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2017.09.24 5.6 236.0 2017.10.23 4.2 237.4 2018.02.15 Frozen -																

ONTMT4S MTO-15786.GPJ 2017TEMPLATE(MTO).GDT 2/22/18



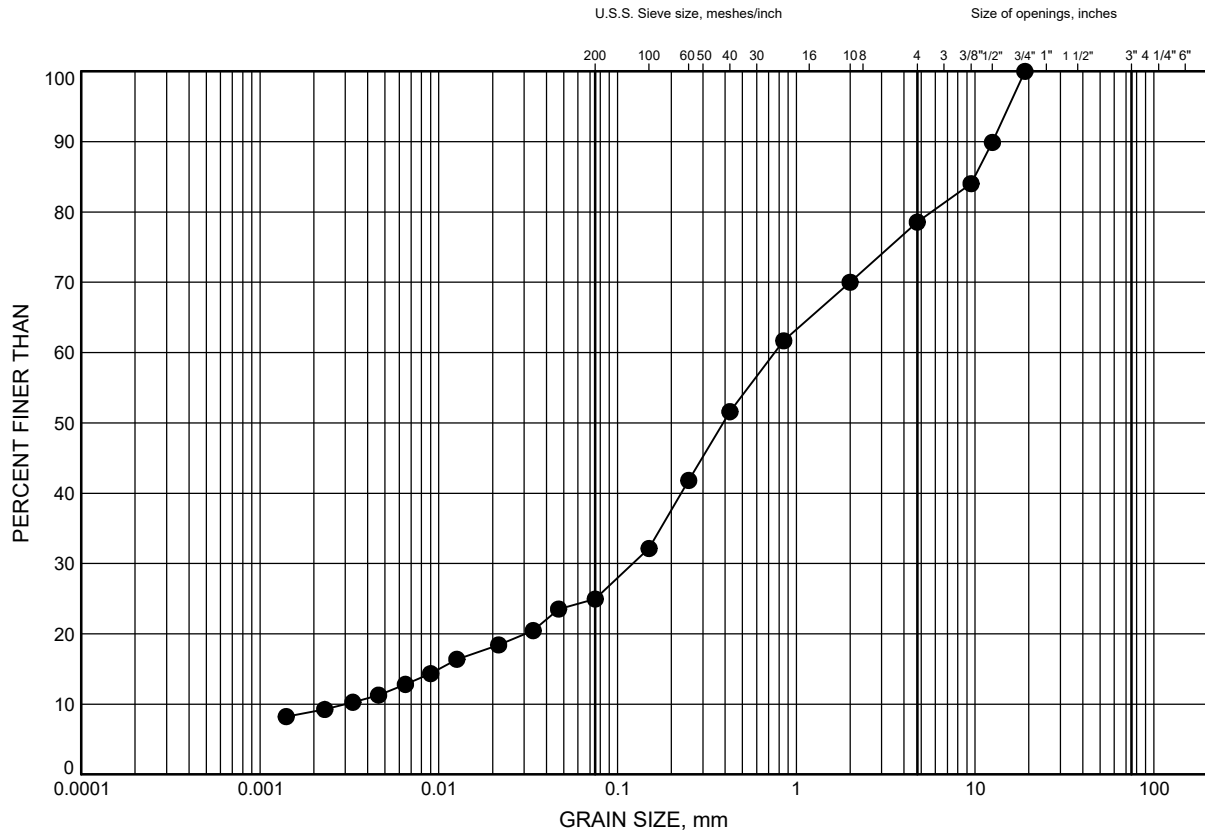
Appendix B

Geotechnical and Analytical Laboratory Test Results

HWY 404 Widening GRAIN SIZE DISTRIBUTION

FIGURE B1

Gravelly SAND FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C4-01	1.0	239.6

Date February 2018
W.P. 2930-02-00

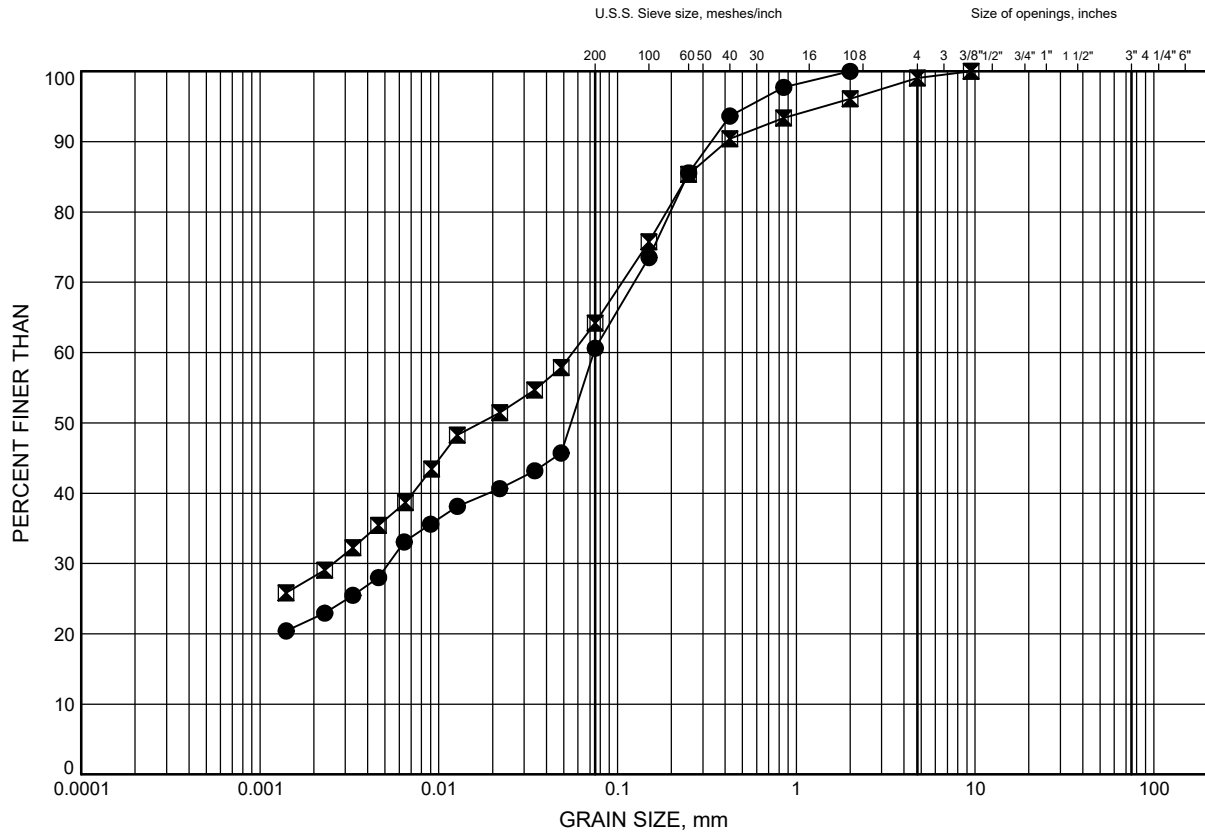


Prep'd AN
Chkd. RPR

HWY 404 Widening GRAIN SIZE DISTRIBUTION

FIGURE B2

Silty CLAY with SAND FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C4-01	2.5	238.1
⊠	C4-02	1.8	239.1

Date February 2018
W.P. 2930-02-00

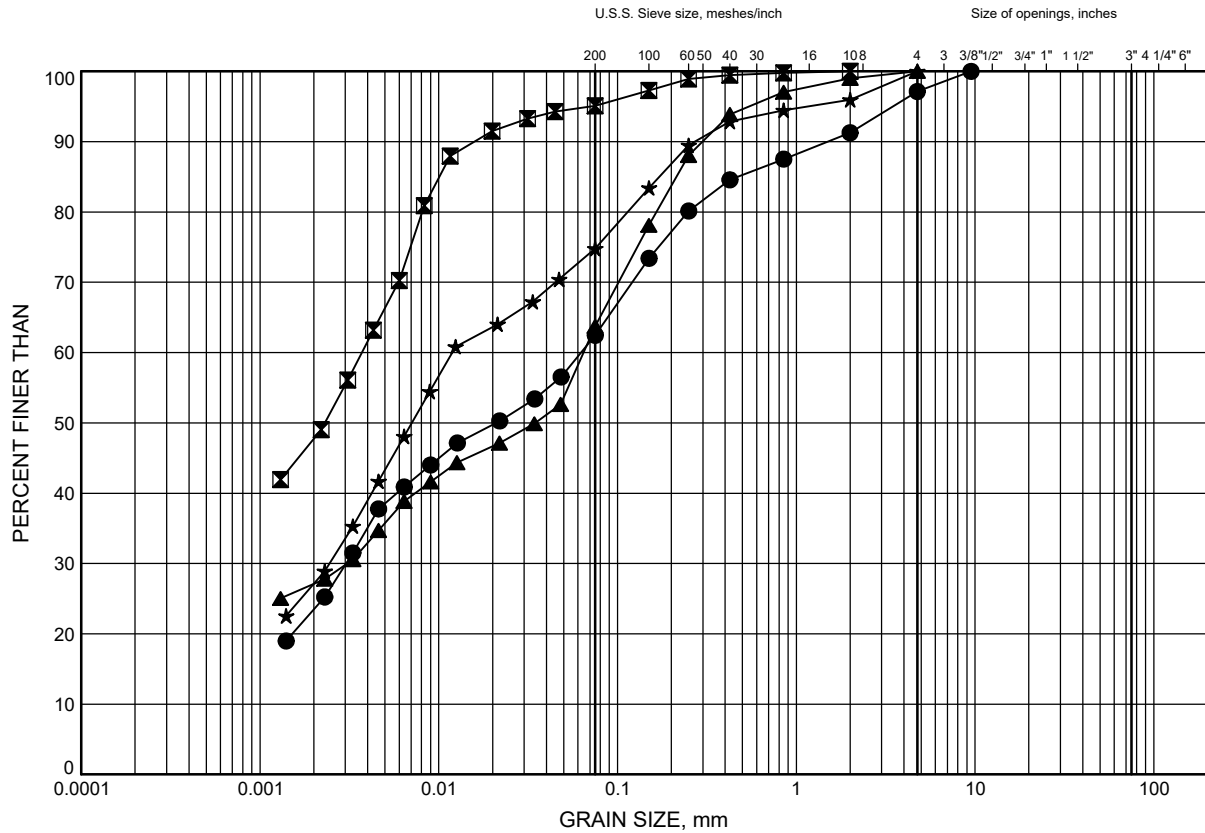


Prep'd AN
Chkd. RPR

HWY 404 Widening GRAIN SIZE DISTRIBUTION

FIGURE B3

Silty CLAY with SAND TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C4-02	4.8	236.1
■	C4-02	10.9	230.0
▲	C4-03	3.3	238.3
★	C4-03	7.8	233.8

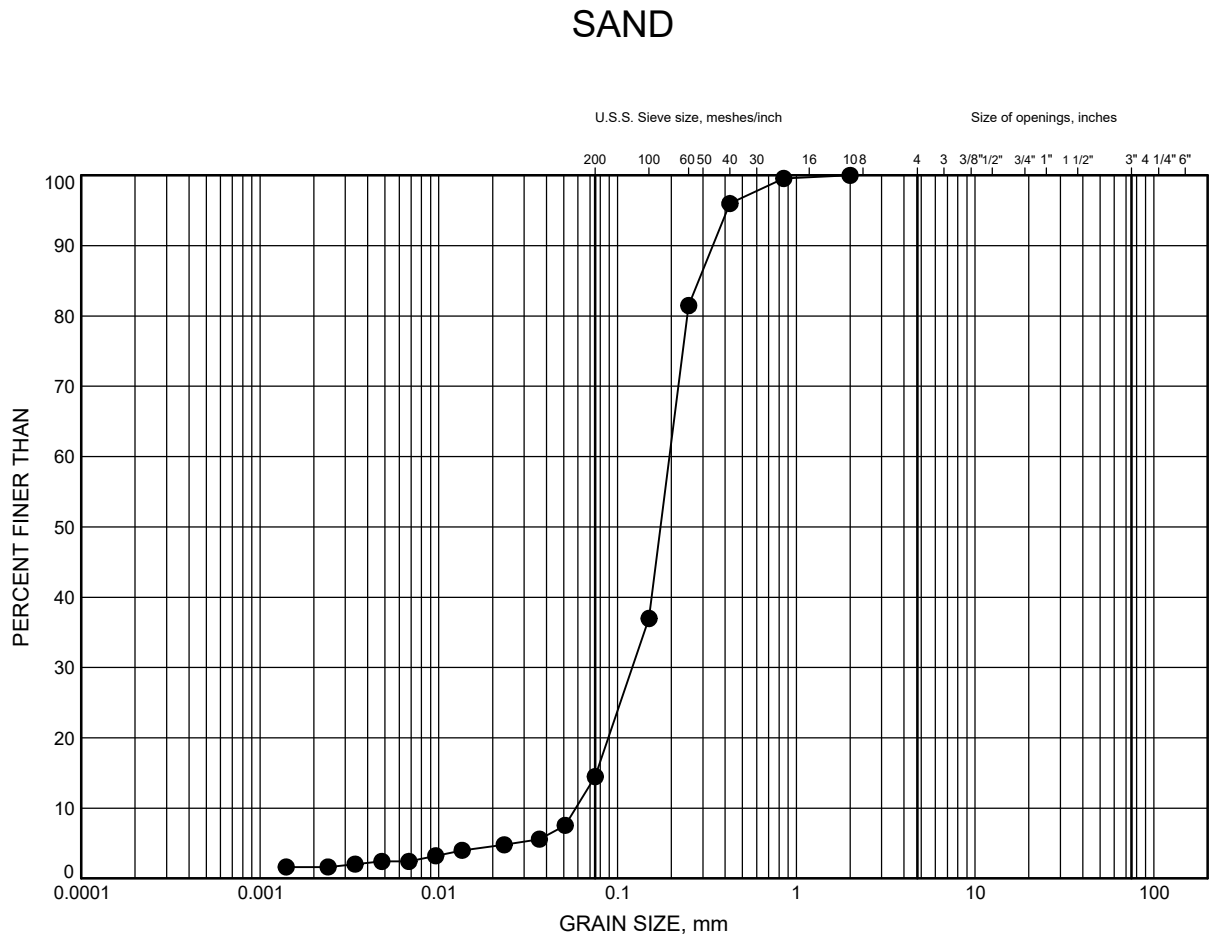
Date February 2018
W.P. 2930-02-00



Prep'd AN
Chkd. RPR

HWY 404 Widening GRAIN SIZE DISTRIBUTION

FIGURE B4



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C4-01	9.4	231.2

Date February 2018
W.P. 2930-02-00

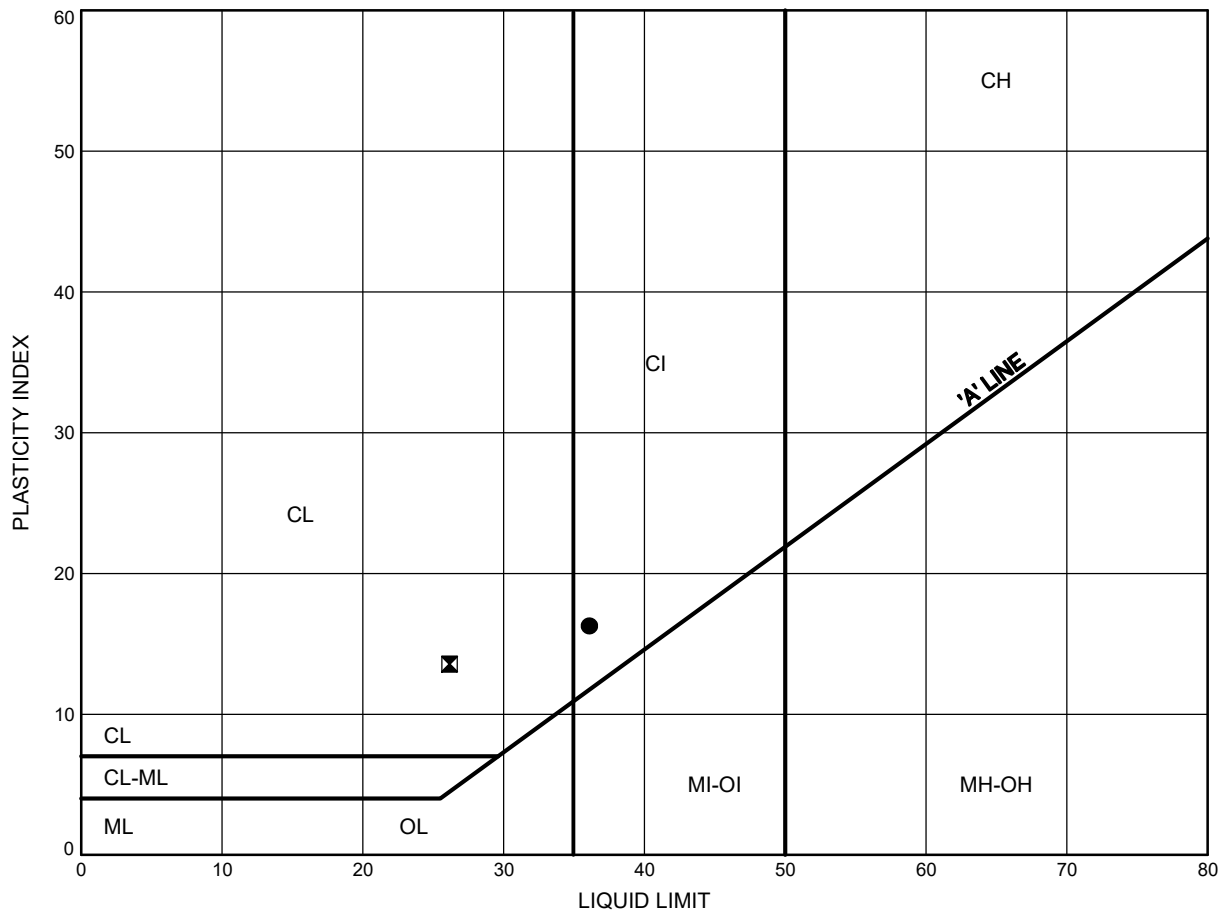


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Chkd. RPR

HWY 404 Widening ATTERBERG LIMITS TEST RESULTS

FIGURE B5

Silty CLAY with SAND FILL



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C4-01	2.5	238.1
⊠	C4-02	1.8	239.1

Date February 2018
W.P. 2930-02-00

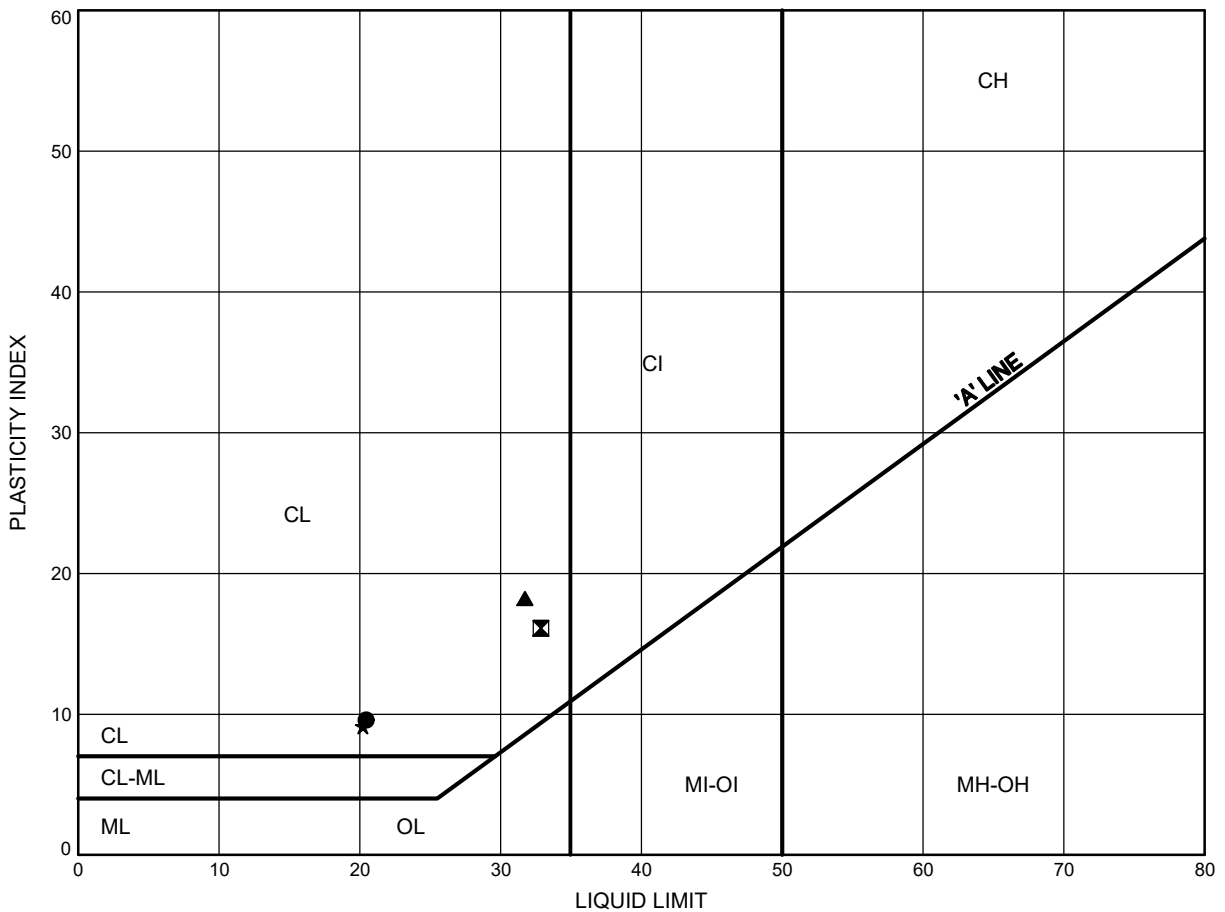


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HWY 404 Widening ATTERBERG LIMITS TEST RESULTS

FIGURE B6

Silty CLAY with SAND TILL



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C4-02	4.8	236.1
⊠	C4-02	10.9	230.0
▲	C4-03	3.3	238.3
★	C4-03	7.8	233.8

Date February 2018
W.P. 2930-02-00



Prep'd AN
Chkd. RPR



FINAL REPORT

CA15233-OCT17 R1

15786

Prepared for

Thurber Engineering Ltd.

First Page

CLIENT DETAILS

Client Thurber Engineering Ltd.

Address 103, 2010 Winston Park Drive
Oakville, ON
L6H 5R7.

Contact Rocio Palomeque

Telephone 905-829-8666 x 263

Facsimile

Email rreyna@thurber.ca

Project 15786

Order Number

Samples Soil (4)

LABORATORY DETAILS

Project Specialist Deanna Edwards, B.Sc, C.Chem

Laboratory SGS Canada Inc.

Address 185 Concession St., Lakefield ON, K0L 2H0

Telephone 705-652-2000

Facsimile 705-652-6365

Email deanna.edwards@sgs.com

SGS Reference CA15233-OCT17

Received 10/12/2017

Approved 10/18/2017

Report Number CA15233-OCT17 R1

Date Reported 10/18/2017

COMMENTS

Temperature of Sample upon Receipt: 17 degrees C

Cooling Agent Present: No

Custody Seal Present: No

Corrosivity Index is based on the American Water Works Corrosivity Scale according to AWWA C-105. An index greater than 10 indicates the soil matrix may be corrosive to cast iron alloys.

SIGNATORIES

Deanna Edwards, B.Sc, C.Chem





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FINAL REPORT

CA15233-OCT17 R1

Client: Thurber Engineering Ltd.

Project: 15786

Project Manager: Rocio Palomeque

Samplers: ,

PACKAGE: REG153 - 1.3 Other (ORP) (SOIL)

L1 = REG153 / SOIL / COARSE - TABLE 2 - Agricultural/Other - UNDEFINED

L2 = REG153 / SOIL / COARSE - TABLE 2 - Industrial/Commercial - UNDEFINED

				Sample Number	5	6	7	8
				Sample Name	C7-02-SS2	C7-04-SS4	C4-01-SS2	C4-03-SS3
				Sample Matrix	Soil	Soil	Soil	Soil
				Sample Date	06/09/2017	05/09/2017	09/09/2017	08/09/2017

Parameter	Units	RL	L1	L2	Result	Result	Result	Result
1.3 Other (ORP)								
Chloride	µg/g	0.4			320	890	930	360



FINAL REPORT

CA15233-OCT17 R1

Client: Thurber Engineering Ltd.

Project: 15786

Project Manager: Rocio Palomeque

Samplers: ,

PACKAGE: REG153 - Corrosivity Index (SOIL)

L1 = REG153 / SOIL / COARSE - TABLE 2 - Agricultural/Other - UNDEFINED

L2 = REG153 / SOIL / COARSE - TABLE 2 - Industrial/Commercial - UNDEFINED

			Sample Number		5	6	7	8
			Sample Name		C7-02-SS2	C7-04-SS4	C4-01-SS2	C4-03-SS3
			Sample Matrix		Soil	Soil	Soil	Soil
			Sample Date		06/09/2017	05/09/2017	09/09/2017	08/09/2017
Parameter	Units	RL	L1	L2	Result	Result	Result	Result
Corrosivity Index								
Corrosivity Index	none	1			15.5	17.5	14.0	3.0
Soil Redox Potential	mV	-			292	271	231	285
Sulphide	%	0.02			0.02	0.02	< 0.02	< 0.02
pH	no unit	0.05			9.38	9.30	9.09	8.22
Resistivity (calculated)	ohms.cm	-9999			1560	872	1130	2520



FINAL REPORT

CA15233-OCT17 R1

QC SUMMARY

Anions by IC
Method: EPA300/MA300-Ions1.3 | Internal ref.: ME-CA-IENVIIC-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Chloride	DIO0265-OCT17	µg/g	0.4	<0.4	0	20	99	80	120	109	75	125
Sulphate	DIO0265-OCT17	µg/g	0.4	<0.4	2	20	98	80	120	99	75	125

Carbon/Sulphur
Method: ASTM E1915-07A | Internal ref.: ME-CA-IENVIARD-LAK-AN-020

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Sulphide	ECS0027-OCT17	%	0.02	<0.02	ND	20	109	80	120			

Conductivity
Method: SM 2510 | Internal ref.: ME-CA-IENVIEWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Conductivity	EWL0213-OCT17	uS/cm	2	< 0.002	0	10	103	90	110	NA		



QC SUMMARY

pH
Method: SM 4500 | Internal ref.: ME-CA-1ENVIEWL-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
pH	EWL0213-OCT17	no unit	0.05	NA	0		100			NA		

Method Blank: a blank matrix that is carried through the entire analytical procedure. Used to assess laboratory contamination.

Duplicate: Paired analysis of a separate portion of the same sample that is carried through the entire analytical procedure. Used to evaluate measurement precision.

LCS/Spike Blank: Laboratory control sample or spike blank refer to a blank matrix to which a known amount of analyte has been added. Used to evaluate analyte recovery and laboratory accuracy without sample matrix effects.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate laboratory accuracy with sample matrix effects.

Reference Material: a material or substance matrix matched to the samples that contains a known amount of the analyte of interest. A reference material may be used in place of a matrix spike.

RL: Reporting limit

RPD: Relative percent difference

AC: Acceptance criteria

Multielement Scan Qualifier: as the number of analytes in a scan increases, so does the chance of a limit exceedance by random chance as opposed to a real method problem. Thus, in multielement scans, for the LCS and matrix spike, up to 10% of the analytes may exceed the quoted limits by up to 10% absolute and the spike is considered acceptable.

Duplicate Qualifier: for duplicates as the measured result approaches the RL, the uncertainty associated with the value increases dramatically, thus duplicate acceptance limits apply only where the average of the two duplicates is greater than five times the RL.

Matrix Spike Qualifier: for matrix spikes, as the concentration of the native analyte increases, the uncertainty of the matrix spike recovery increases. Thus, the matrix spike acceptance limits apply only when the concentration of the matrix spike is greater than or equal to the concentration of the native analyte.

LEGEND

FOOTNOTES

NSS Insufficient sample for analysis.

RL Reporting Limit.

↑ Reporting limit raised.

↓ Reporting limit lowered.

NA The sample was not analysed for this analyte

ND Non Detect

Samples analysed as received. Solid samples expressed on a dry weight basis. "Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples.

SGS provides criteria information (such as regulatory or guideline limits and summary of limit exceedances) as a service. Every attempt is made to ensure the criteria information in this report is accurate and current, however, it is not guaranteed. Comparison to the most current criteria is the responsibility of the client and SGS assumes no responsibility for the accuracy of the criteria levels indicated. This document is issued, on the Client's behalf, by the Company under its General Conditions of Service available on request and accessible at http://www.sgs.com/terms_and_conditions.htm. The Client's attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein. Any other holder of this document is advised that information contained hereon reflects the Company's findings at the time of its intervention only and within the limits of Client's instructions, if any. The Company's sole responsibility is to its Client and this document does not exonerate parties to a transaction from exercising all their rights and obligations under the transaction documents.

This report must not be reproduced, except in full. This report supersedes all previous versions.

-- End of Analytical Report --



SGS Environmental Services

Request for Laboratory Services and CHAIN OF CUSTODY

Lakefield: 185 Concession St., Lakefield, ON K0L 2H0 Phone: 705-652-2000 Toll Free: 877-747-7658 Fax: 705-652-6365
London: 657 Consortium Court, London, ON, N6E 2S8 Phone: 519-672-4500 Toll Free: 877-848-8060 Fax: 519-672-0361 Web: www.ca.sgs.com

No:

Page 1 of 1

Laboratory Information Section - Lab use only

Received By: Tammy Macleod

Received Date (mm/dd/yyyy): 09/12/17 (mm/dd/yy)

Received Time: 00:55

Received By (signature): [Signature]
Custody Seal Intact: ☐

Cooling Agent Present: ☒ No cooler
Temperature Upon Receipt (°C): 20.17, 17.18, 18.4

LAB LIMS #: 0415233

REPORT INFORMATION

Company: Thurber Env.

Contact: Rocio Palomeque

Address: 103-2015 Winston Park Dr.

Phone: 905-829-8666

Fax:

Email: Yregina@thurber.ca

INVOICE INFORMATION

☒ (same as Report Information)

Company:

Contact:

Address:

Phone:

Email:

PROJECT INFORMATION

Quotation #: 15786

Project #: 15786

P.O. #:

Site Location/ID:

TURNAROUND TIME (TAT) REQUIRED

☒ Regular TAT (5-7 days)

TATs are quoted in business days (exclude statutory holidays & weekends). Samples received after 3pm or on weekends: TAT begins the next business day

RUSH TAT (Additional Charges May Apply) ☐ 1 Day ☐ 2 Days ☐ 3-4 Days

PLEASE CONFIRM RUSH FEASIBILITY WITH SGS REPRESENTATIVE PRIOR TO SUBMISSION

Specify Due Date:

Rush Confirmation ID:

DRINKING WATER SAMPLES (POTABLE WATER FOR HUMAN CONSUMPTION) MUST BE SUBMITTED WITH SGS DRINKING WATER CHAIN OF CUSTODY

ANALYSIS REQUESTED

COMMENTS: Consistency Package

Field Filtered (F)

Preserved (P)

REGULATIONS

Regulation 153 (2011):

☐ Table 1 ☐ Res/Park ☐ Soil Texture: ☐ Reg 34/558 (3 Day min TAT) ☐ Sanitary ☐ Sewer By-Law: ☐ Storm ☐ Municipality: ☐ Table 2 ☐ Ind/Com ☐ Coarse ☐ PW/OO ☐ MMR ☐ Table 3 ☐ Agri/Other ☐ Medium ☐ CCME ☐ Other: ☐ Table ☐ Fine ☐ MISA

RECORD OF SITE CONDITION (RSC)

☐ YES ☐ NO

SAMPLE IDENTIFICATION

SAMPLE IDENTIFICATION	DATE SAMPLED	TIME SAMPLED	# OF BOTTLES	MATRIX
1 C2-02-552	09/16/17			
2 C2-04-554	09/16/17			
3 C4-01-552	09/19/17			
4 C4-03-553	09/18/17			
5				
6				
7				
8				
9				
10				

Observations/Comments/Special Instructions

Sampled By (NAME): Rocio Palomeque

Signature: [Signature]

Relinquished by (NAME): Rocio Palomeque

Signature: [Signature]

Date: 04/13/2017 (mm/dd/yy)

Date: 04/13/2017 (mm/dd/yy)

Date: 04/13/2017 (mm/dd/yy)

Date: 04/13/2017 (mm/dd/yy)

Pink Copy - Client

Yellow & White Copy - SGS



Appendix C

Selected Site Photographs



Photo 1: East end of culvert looking east



Photo 2: East end of culvert looking west



Photo 3: East embankment looking north



Photo 4: East embankment looking south

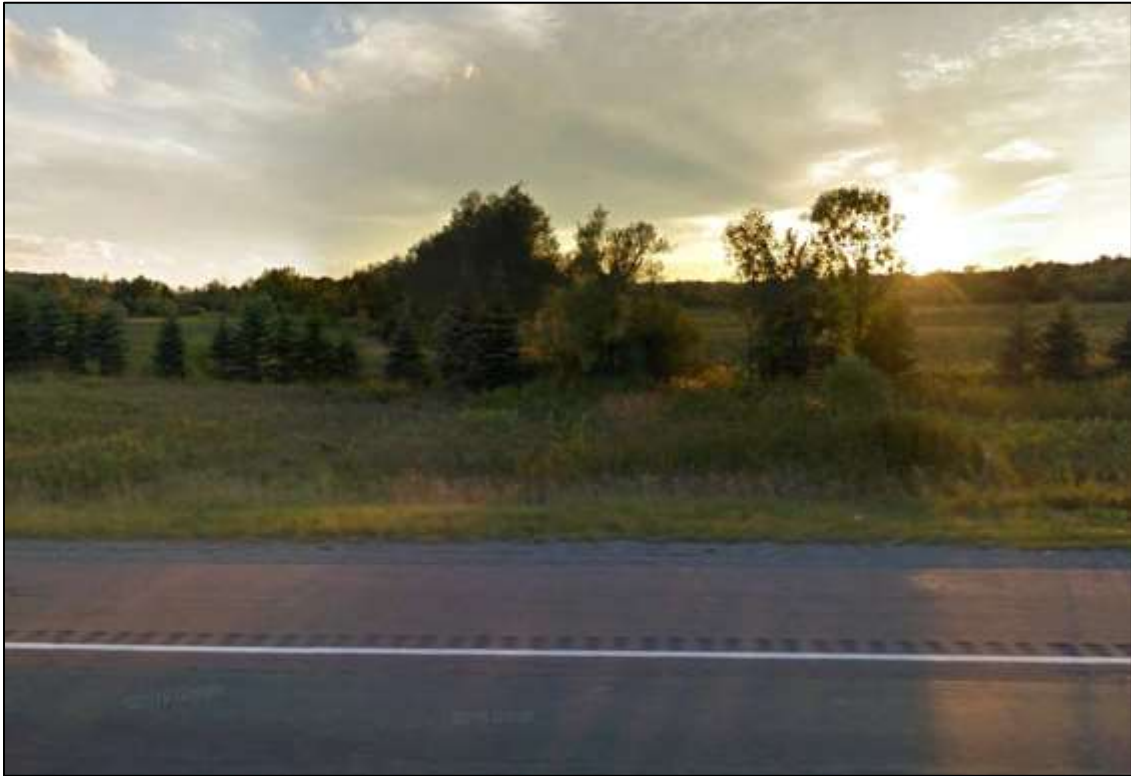


Photo 5: West end of culvert looking west

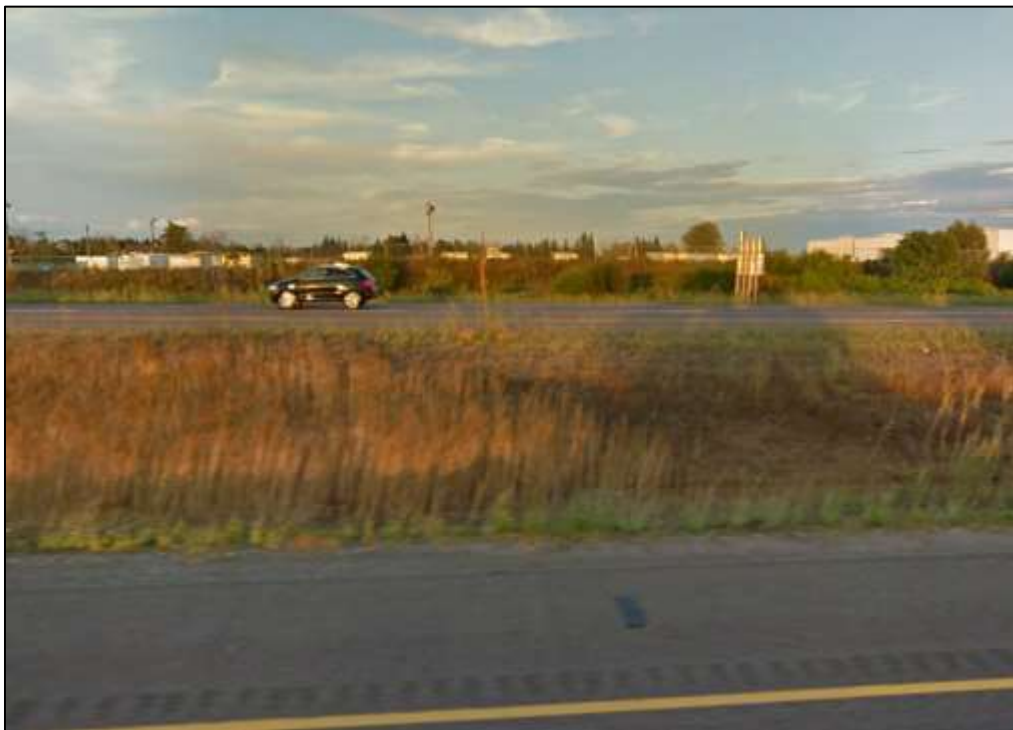


Photo 6: West end of culvert looking east



Photo 7: West embankment looking south



Photo 8: West embankment looking north



Appendix D

Borehole Locations and Soil Strata Drawing

SHEET

A map showing the location of the 'SITE' (indicated by a circle and an arrow) relative to Highway 404 and Highway 7. The map includes a north arrow and labels for various roads: Stouffville Road, 19th Avenue, Elgin Mills Road, Major Mackenzie Drive, 16th Avenue, Highway 7, and Highway 407.

LEGEND

[illegible]

- 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.

PROFILE ALONG EXISTING CULVERT C4

[illegible]