FOUNDATION INVESTIGATION REPORT
BOSTON CREEK BRIDGE REHABILITATION
NEW LISKEARD DISTRICT, ONTARIO
G.W.P. 5027-14-00, SITE NO. 47-098
Geocres Number: 31M-112

Report to:

MMM GROUP LIMITED

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

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted at the existing Boston Creek Bridge along Pacaud Concession Road 2 in the Township of Pacaud, New Liskeard District, Ontario.

The purpose of this investigation was to explore the subsurface conditions at the site and, based on the data obtained, to provide a borehole location plan, records of boreholes, stratigraphic profile, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions was developed from the data obtained in the course of the investigation.

Thurber carried out the investigation as a sub-consultant to MMM Group Limited, under the Ministry of Transportation Ontario (MTO) Agreement Number 5014-E-0024.

2 SITE DESCRIPTION

The existing Boston Creek Bridge is located on Pacaud Concession Road 2, approximately 7.5 km east of Highway 11.

The existing bridge is a steel bailey bridge with a timber deck supported on timber sills. The approximate length and width of the structure is 21.6 and 3.4 m, respectively. The bridge was constructed in 1957. The structure is in fair condition; deterioration of the abutment walls and structural elements is evident.

Boston Creek flows from north to south at the bridge location. The creek banks are well vegetated with tall grass and shrubs and frequent trees. The local topography is of low relief with no visible bedrock outcrops. Photographs in Appendix C show the general nature of the site and the existing bridge.

Based on published geological information, the general area of the project is covered by glaciolacustrine sediments of clays and silts deposited during the Pleisocene period. These deposits

are often varved clays, but massive clays are also present in the area. The clays are underlain by bedrock comprising Precambrian intrusive massive granodiorite to granite.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing program for this project was carried out between July 26 and July 28, 2015. The program consisted of drilling and sampling two (2) boreholes numbered BC-01 to BC-02 to depths of 20.2 m and 29.6 m respectively. Borehole BC-01 was drilled to the south west of the west abutment and BC-02 was drilled to the north east of the east abutment. Coring with an NQ size core barrel was used below the overburden portion on Borehole BR-01 to a depth of 23.3 m. A Dynamic Cone Penetration Test (DCPT) was conducted below the sampled portion of Borehole BR-02 from 29.6 m to 34.7 m depth, where the SPT N value of 100 blows per 0.3 m penetration was encountered.

Prior to the start of drilling, the borehole locations were marked in the field and utility clearances were obtained. The coordinates and ground surface elevations for the boreholes were derived from topographic plans provided to Thurber by MMM Group Limited. The approximate locations of the boreholes are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix D.

A truck-mounted CME 75 hi-torque drill rig was used to advance the Boreholes BC-01 and BC-02 to the target depth using NW casing and wash boring technique. A granular pad was constructed to facilitate the drilling of BC-02. Soil samples were obtained at selected intervals using a 50 mm diameter split spoon sampler in conjunction with Standard Penetration Testing (SPT). Field vane shear testing using an MTO "N" size vane were carried out in very soft to soft cohesive soils.

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

Groundwater conditions in the open boreholes were observed throughout the drilling operations. Groundwater conditions observed immediately after completion of drilling were not representative of site conditions as water was used during wash boring operations. A standpipe piezometer was installed in Borehole BC-01 to monitor the groundwater level after drilling. The boreholes were backfilled in general accordance with MOE Regulation 903. Completion details of the piezometer and borehole are summarized in Table 3.1.

Table 3.1 – Borehole Completion Details

Foundation Unit	Boreholes	Piezometer Tip Depth/ Elevation (m)	Completion Details
West Abutment	BC-01	20.1 / 204.7	Sand filter from 20.1 m to 16.5 m, bentonite holeplug from 16.5 m to 15.5 m, bentonite and cuttings to 1.0 m and bentonite holeplug to surface.
East Abutment	BC-02	None	Bentonite holeplug and cuttings from 34.7 m to surface.

The results of the field drilling and sampling are presented on the Record of Borehole sheets in Appendix A.

4 LABORATORY TESTING

All recovered soil samples were subjected to visual identification (VI) and natural moisture content determination. Selected samples were also subjected to grain size distribution analyses (sieve and hydrometer) and plasticity testing (Atterberg Limits). The results of the geotechnical laboratory program are summarized on the Record of Borehole sheets included in Appendix A and on the figures presented in Appendix B.

In order to assess the potential for sulphate attack on concrete, as well as the potential for corrosion associated with the structure, a sample of the existing native soil, and a sample of surface water from the creek upstream of the bridge were collected. The samples were submitted to AGAT Laboratories of Mississauga, Ontario for analytical testing of corrosivity parameters and sulphate. The results of the analytical testing are summarized in Section 6 below and are presented in Appendix B.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets included in Appendix A. Details of the encountered soil stratigraphy are presented in these sheets and on the "Borehole Locations and Soil Strata" drawing included 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. The subsurface conditions may vary between and beyond the borehole locations.

In general, the site is underlain by an extensive cohesive deposit comprising a layer of brown silty clay that grades to sandy silty clay, which overlies a grey silty clay. Bedrock was encountered at a depth of 20.2 m in the borehole drilled on the west side of the creek. Water level in Boston Creek was inferred to be at Elev. 222.5 m. More detailed description of the individual strata are presented below.

5.1 Topsoil

A layer of topsoil was encountered at the surface of Borehole BC-01. The topsoil layer had a thickness of 250 mm at the borehole location. The topsoil thickness may vary in other areas of the site and this limited data is not intended for estimating purposes.

5.2 Fill

A silty clay fill was encountered in Borehole BC-01 underlying the topsoil. Some gravel, trace cobbles, and organic inclusions (roots and rootlets) were noted at shallow depths in the fill. This layer was 1.4 m thick and extended to a depth of 1.4 m or to Elevation 223.4 m. SPT 'N' values of 13 and 15 blows per 0.3 m penetration were recorded in this layer, indicating a stiff to very stiff consistency. A moisture content of 8% was recorded in this fill layer. It is probable that this fill layer is the native silty clay reworked during road/bridge construction.

A layer of brown sand and gravel fill with trace silt was encountered in Borehole BC-02. This fill was placed to accommodate access of the drilling equipment to the borehole location. The fill extended from the ground surface to 0.6 m depth (Elev. 224.5).

5.3 Silty Clay to Sandy Silty Clay

A layer of silty clay grading to sandy silty clay was encountered beneath the fill in Borehole BC-01 and underlying the granular fill in Borehole BC-02. The deposit was brown in colour with trace to some gravel and trace organic inclusions at shallow depths. This layer ranged in thickness from 2.7 to 3.5 m with the base at a depth of 4.1 m or at Elevations 221.0 to 220.7 m.

SPT 'N' values recorded in this layer ranged from 0 to 12 blows per 0.3 m penetration, indicating a very soft to stiff consistency. A very soft layer of this deposit was encountered at approximate Elevation of 222.8, which seems to coincide with the creek water level. Moisture contents in this layer ranged from 20 to 46%. The grain size analyses conducted on samples of the silty clay/sandy silty clay are presented in Figure B1, and Atterberg Limits test results are presented in Figure B3 in Appendix B. The results are summarized in the following table.

Soil Particles	**%**
Gravel	0 to 16
Sand	5 to 35
Silt	30 to 41
Clay	31 to 46
Soil Property	**%**
Liquid Limit	35 to 41
Plasticity Index	16 to 21

The results of the Atterberg Limits tests indicate that this silty clay is of low plasticity (CL) to intermediate plasticity (CI).

The results of laboratory testing are included in the Record of Borehole sheets in Appendix A.

5.4 Silty Clay

Underlying the brown silty clay/sandy silty clay in both boreholes was a deposit of grey silty clay with trace sand. Where fully penetrated in Borehole BC-01, the thickness of the silty clay was 16.1 m and the base of the deposit was encountered at a depth of 20.2 m or at Elevation of 204.6 m. Borehole BC-02 was terminated in the silty clay at a depth of 29.6 m or at Elevation of 195.5 m.

SPT 'N' values recorded in this layer ranged from 0 to 6 blows per 0.3 m penetration. In conjunction with measured field vane shear strength ranging from 19 to 53 kPa, the clayey silt was described to have a soft to stiff consistency. Moisture contents in this layer varied between 34 and 69% with most values ranging from 40 to 60%. The grain size analyses conducted on samples are presented in Figure B2, and Atterberg Limits test results are presented in Figure B4 in Appendix B. The results are summarized in the following table.

Soil Particles	**%**
Gravel	0
Sand	0
Silt	33 to 45
Clay	55 to 67
Soil Property	**%**
Liquid Limit	32 to 48
Plasticity Index	13 to 23

The results of the Atterberg Limits tests indicate that the silty clay is typically of low plasticity (CL) to intermediate plasticity (CI).

Below the sampled depth of Borehole BC-02, a DCPT was carried out from a depth of 29.6 m to practical refusal (100 blows per 0.3 m) at 34.7 m (Elev. 190.4).

5.5 Bedrock

Granite bedrock was encountered below the silty clay in Borehole BC-01 at a depth of 20.2 m (Elev. 204.6). The bedrock was cored for 3.1 m length to a depth so 23.3 m (Elev. 201.5).

Total Core Recovery (TCR) in the bedrock ranged from 83% to 100%. The measured RQD of the rock cores ranged from 11% to 26%, indicating a very poor to poor quality of rock. The Fracture Index (FI) of the rock, expressed as fractures per 0.3 m of core, ranged from 5 to greater than 25.

5.6 Water Levels

Water levels were observed in the open boreholes during drilling operations. Wash boring technique was used to advance the boreholes and therefore water levels recorded during or upon completion of drilling may not reflect natural groundwater levels. A standpipe piezometer was installed in one borehole to monitor the groundwater level after completion. The water level measured in the piezometer is shown in Table 5.1.

Table 5.1 – Water Level Measurements

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
BC-01	July 27, 2015 July 28, 2015	1.2 1.3	223.6 223.5	In piezometer
BC-02	July 28, 2015	3.0	222.1	Open borehole

Based on the General Arrangement (GA) Drawing dated February 2016, the water level in Boston Creek was noted at Elev. 221.7 on May 14, 2015.

The above levels are short-term readings and seasonal fluctuations of the groundwater and creeklevels are to be expected. In particular, the water level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

6 CORROSIVITY AND SULPHATE TEST RESULTS

A sample of the native soil below the embankment fill and a sample of the surface water from the creek were submitted for analytical testing of corrosivity parameters and sulphate. The results of the analytical tests are shown in Table 6.1. The laboratory certificates of analysis are presented in Appendix B.

Table 6.1 – Analytical Test Results

Parameter	Units (Soil)	Units (Water)	Test Results	
			Borehole BC-02 Soil Sample	Boston Creek Water
			(Soil, 0.76-2.1 m deep)	(Creek Water)
Sulphide	%	mg/L	0.02	<0.05
Chloride	µg/g	mg/L	3	2.96
Sulphate	µg/g	mg/L	11	17.5
pH	pH Units	pH Units	7.7	7.96
Electrical Conductivity	mS/cm	µS/cm	0.162	-
Resistivity	ohm.cm	ohm.cm	6170	3820
Redox Potential	mV	mV	302	312
Langlier Index	-	-	-	0.34
Total Hardness (as $CaCO_3$)	-	mg/L	-	127
Total Dissolved Solids	-	mg/L	-	138
Alkalinity (as $CaCO_3$)	-	mg/L	-	112

7 MISCELLANEOUS

Thurber staked and/or marked the borehole locations in the field and obtained utility clearances prior to drilling. Thurber obtained the northing and easting coordinates and ground surface elevations from measurements taken in the field relative to the topographic plans provided by MMM Group Limited.

Eastern Ontario Diamond Drilling of Hawkesbury, Ontario supplied a track-mounted CME-45 hi-torque drill rig and conducted the drilling, sampling and in-situ testing operations for the boreholes. The drilling operations were supervised by Mr. Amir Fereidouni 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. The report was prepared by Ms. Deanna Pizycki, EIT and Ms. Anna Piascik, P.Eng.

The report was reviewed by Mr. Alastair Gorman, P.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.

Deanna Pizycki, EIT
Geotechnical Engineer-in-Training

Alastair Gorman, P.Eng.
Senior Geotechnical Engineer/Senior Associate

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

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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

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.

EXPLANATION OF ROCK LOGGING TERMS

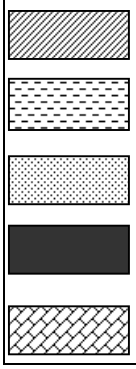
ROCK WEATHERING CLASSIFICATION

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.

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

SYMBOLS



CLAYSTONE

SILTSTONE

SANDSTONE

COAL

BEDROCK

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

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 % 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.

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			

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RECORD OF BOREHOLE No BC-01 1 OF 3 METRIC

GWP# 5027-14-00 LOCATION Boston Creek Bridge N 5 314 683.1 E 385 125.3 ORIGINATED BY AHF

HWY Local Rd. BOREHOLE TYPE NW Casing/NQ Coring COMPILED BY MFA

DATUM Geodetic DATE 2015.07.26 - 2015.07.27 CHECKED BY AMP

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
224.8	GROUND SURFACE										
0.0 / 224.5	**TOPSOIL:** (250mm)		1	SS	15						
0.3 / 223.4	Silty **CLAY**, some gravel, trace cobbles, trace organics (roots and rootlets) Stiff to Very Stiff Brown Moist (FILL)		2	SS	13		224				
1.4 / 220.7	Silty **CLAY**, trace to some gravel, trace sand, grading to sandy Very Soft to Stiff Brown Moist		3	SS	4		223				16 5 41 38
			4	SS	0		222				0 35 34 31
			5	SS	12		221				
4.1	Silty **CLAY**, trace sand Soft to Firm Grey Wet		6	SS	0		220				
			7	SS	0		219	8.0			0 0 33 67
			8	SS	0		218	9.5			
			9	SS	1		217	14.0			
							216				
							215				

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

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

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RECORD OF BOREHOLE No BC-01 2 OF 3 METRIC

GWP# 5027-14-00 LOCATION Boston Creek Bridge N 5 314 683.1 E 385 125.3 ORIGINATED BY AHF

HWY Local Rd. BOREHOLE TYPE NW Casing/NQ Coring COMPILED BY MFA

DATUM Geodetic DATE 2015.07.26 - 2015.07.27 CHECKED BY AMP

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) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × 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
	Continued From Previous Page										
							214	4.4	○		
			10	SS	0						
							213	3.0			
			11	SS	1				○		
							212	8.5			
			12	SS	2		211		○		
							210	4.9			
			13	SS	1					○	
							209	4.9			
			14	SS	3		208		○		0 0 34 66
							207	2.5			
			15	SS	0				○		
							206	2.0			
							205				

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

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

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RECORD OF BOREHOLE No BC-01 3 OF 3 METRIC

GWP# 5027-14-00 LOCATION Boston Creek Bridge N 5 314 683.1 E 385 125.3 ORIGINATED BY AHF

HWY Local Rd. BOREHOLE TYPE NW Casing/NQ Coring COMPILED BY MFA

DATUM Geodetic DATE 2015.07.26 - 2015.07.27 CHECKED BY AMP

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 (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)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
204.6			16	SS	100/125				○		
20.2	**GRANITE**, moderately weathered, medium strong to strong, pink Subvertical fractures at 20.37 to 20.52 and 20.65 to 20.73m Horizontal fractures at 20.42 and 20.50m		1	RUN			204			FI 5 >25	RUN #1 TCR=100% SCR=48% RQD=26%
	Subvertical fractures at 21.13 to 21.21, 21.24 to 21.36, 21.39 to 21.44 and 21.51 to 21.56m Horizontal fractures at 21.13 and 21.26m		2	RUN						>25 >25 >25	RUN #2 TCR=100% SCR=20% RQD=11%
	Horizontal fractures at 21.92, 21,97, 22.17 and 22.23m Subvertical fractures at 22.20 to 22.27, 22.40 to 22.53, 22.53 to 22.58, 22.61 to 22.68, 22.71 to 22.76, 22.76 to 22.86, and 22.91 to 23.01m		3	RUN			203 202			8 5 >25 >25	RUN #3 TCR=83% SCR=20% RQD=15%
201.5										>25 >25	
23.3	END OF BOREHOLE AT 23.3m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen.										

WATER LEVEL READINGS:

DATE	DEPTH (m)	ELEV. (m)
2015.07.27	1.2	223.6
2015.07.28	1.3	223.5

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

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No BC-02 1 OF 4 METRIC

GWP# 5027-14-00 LOCATION Boston Creek Bridge N 5 314 677.4 E 385 165.9 ORIGINATED BY AHF

HWY Local Rd. BOREHOLE TYPE NW Casing COMPILED BY MFA

DATUM Geodetic DATE 2015.07.27 - 2015.07.28 CHECKED BY AMP

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
225.1	GROUND SURFACE										
0.0	**SAND** and **GRAVEL**, trace silt Compact Brown Moist		1	SS	11		225				
224.5	(FILL)										
0.6	Silty **CLAY**, some sand, trace gravel, trace organics (roots and rootlets) in the upper 0.5m zone, grading to sandy Very Soft to Firm Brown Moist to Wet		2	SS	6		224				
			3	SS	3		223				0 17 37 46
			4	SS	0	▽					
			5	SS	2		222				0 35 30 35
221.0											
4.1	Silty **CLAY**, trace sand Firm to Stiff Grey Moist to Wet		6	SS	0		221				0 0 36 64
							220	13.0			
			7	SS	1		219				
							218	26.0			
			8	SS	2		217				
								6.0			
			9	SS	0		216				

Continued Next Page

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

15 20 10 5 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No BC-02 2 OF 4 METRIC

GWP# 5027-14-00 LOCATION Boston Creek Bridge N 5 314 677.4 E 385 165.9 ORIGINATED BY AHF

HWY Local Rd. BOREHOLE TYPE NW Casing COMPILED BY MFA

DATUM Geodetic DATE 2015.07.27 - 2015.07.28 CHECKED BY AMP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	WATER CONTENT (%)	γ kN/m³	GR SA SI CL
	Continued From Previous Page						215	14.0			
			10	SS	1		214				
								6.0			
			11	SS	1		213				
							212	8.0			
			12	SS	1		211				
								7.2			
			13	SS	1		210				
							209	7.6			
			14	SS	4		208				
								4.5			
			15	SS	4		207				
							206	4.4			

Continued Next Page

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

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

ONTMT4S 19-5161-252.GPJ 2015TEMPLATE(MTO).GDT 2/5/16

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No BC-02 3 OF 4 METRIC

GWP# 5027-14-00 LOCATION Boston Creek Bridge N 5 314 677.4 E 385 165.9 ORIGINATED BY AHF

HWY Local Rd. BOREHOLE TYPE NW Casing COMPILED BY MFA

DATUM Geodetic DATE 2015.07.27 - 2015.07.28 CHECKED BY AMP

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
	Continued From Previous Page		16	SS	5		205				
							204	5.8			
							203				
			17	SS	5		202			○	0 0 45 55
							201	2.0			
							200				
			18	SS	6		199			○	
							198				
							197				
195.5			19	SS	4		196			○	
29.6	End of sampling at 29.6m and start of DCPT.										

Continued Next Page

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

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

ONTMT4S 19-5161-252.GPJ 2015TEMPLATE(MTO).GDT 2/5/16

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No BC-02 4 OF 4 METRIC

GWP# 5027-14-00 LOCATION Boston Creek Bridge N 5 314 677.4 E 385 165.9 ORIGINATED BY AHF

HWY Local Rd. BOREHOLE TYPE NW Casing COMPILED BY MFA

DATUM Geodetic DATE 2015.07.27 - 2015.07.28 CHECKED BY AMP

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 (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page										
							195				
							194				
							193				
							192				
							191				
190.4											
34.7	END OF BOREHOLE. WATER LEVEL AT 3.0m UPON COMPLETION. BOREHOLE BACKFILLED WITH CUTTINGS AND BENTONITE TO SURFACE.										

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

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

Appendix B

Geotechnical and Analytical

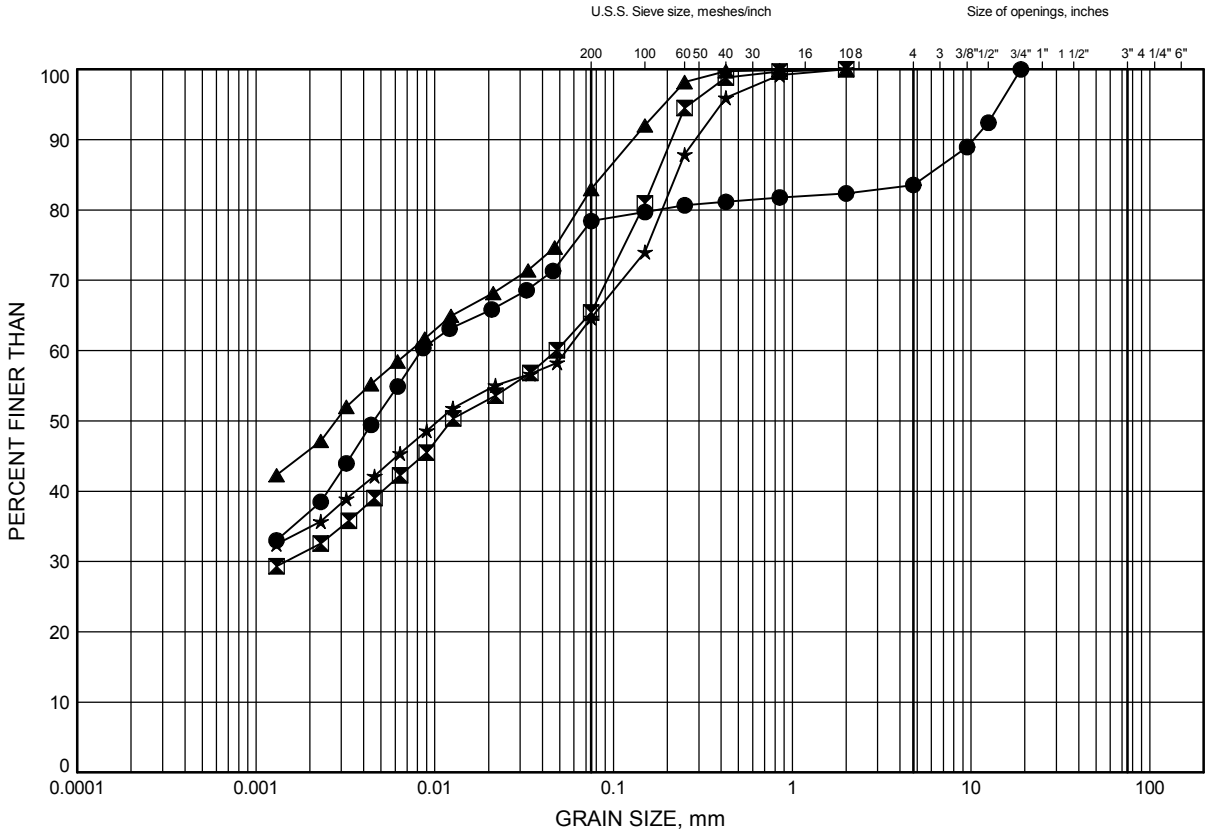
Laboratory Test Results

Boston Creek Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B1

Silty CLAY to Silty CLAY and SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BC-01	1.83	222.97
⊠	BC-01	2.59	222.21
▲	BC-02	1.83	223.27
★	BC-02	3.35	221.75

Date February 2016

GWP# 5027-14-00

THURBER

Prep'd MFA

Chkd. DJP

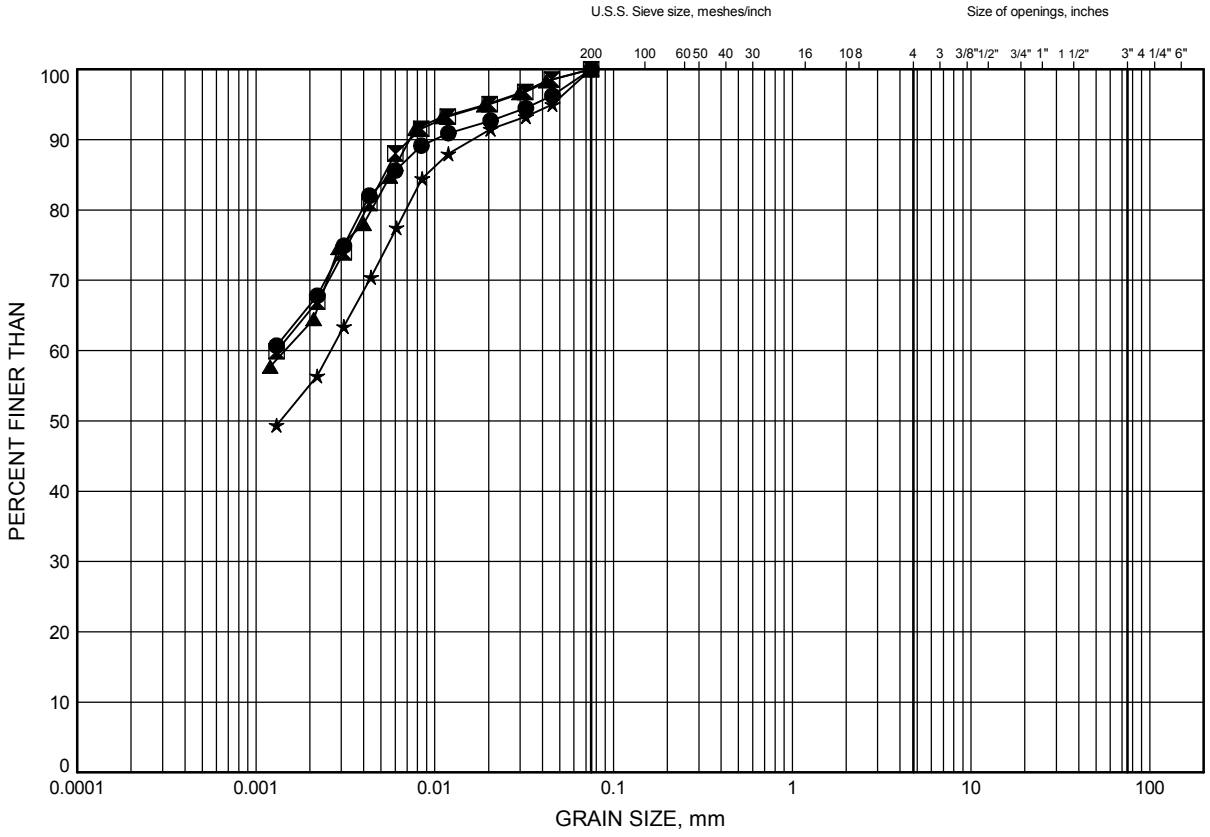
GRAIN SIZE DISTRIBUTION - THURBER 19-5161-252.GPJ 2/5/16

Boston Creek Bridge

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)
●	BC-01	6.40	218.40
⊠	BC-01	17.07	207.73
▲	BC-02	4.88	220.22
★	BC-02	23.16	201.94

Date February 2016

GWP# 5027-14-00

THURBER

Prep'd MFA

Chkd. DJP

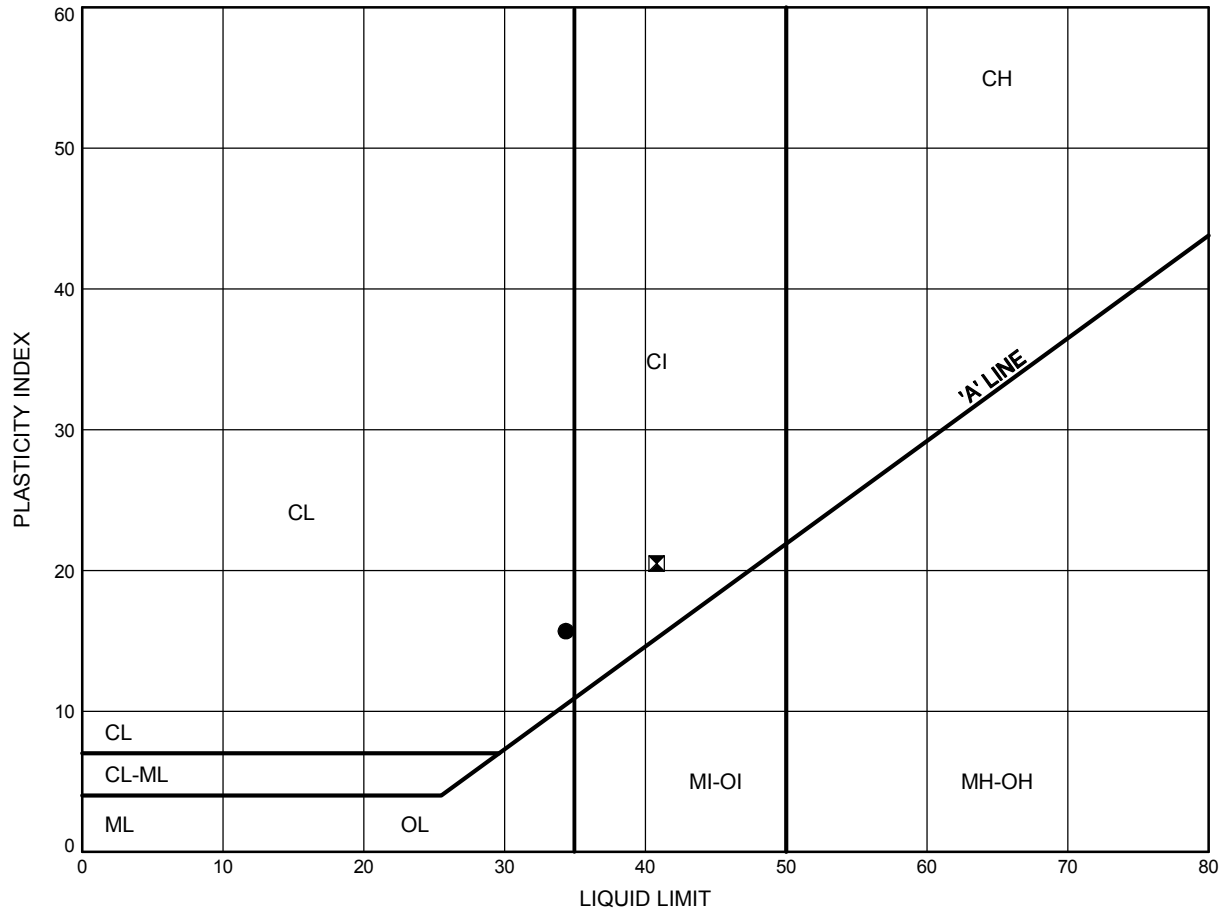
GRAIN SIZE DISTRIBUTION - THURBER 19-5161-252.GPJ 2/5/16

Boston Creek Bridge

ATTERBERG LIMITS TEST RESULTS

FIGURE B3

Silty CLAY to Silty CLAY and SAND



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BC-01	2.59	222.21
⊠	BC-02	1.83	223.27

Date February 2016

GWP# 5027-14-00

THURBER

Prep'd MFA

Chkd. DJP

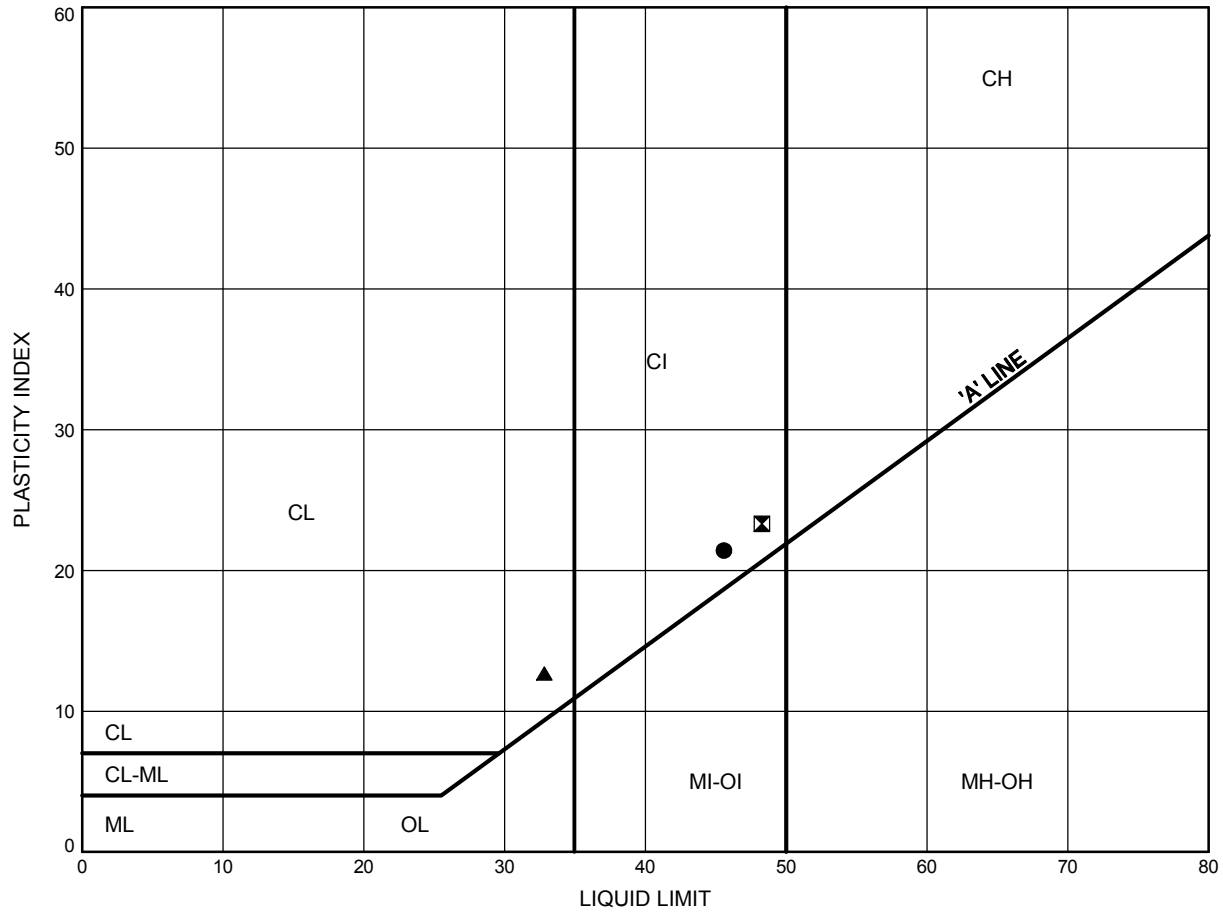
THURBALT 19-5161-252.GPJ 2/5/16

Boston Creek Bridge

ATTERBERG LIMITS TEST RESULTS

FIGURE B4

Silty CLAY



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BC-01	6.40	218.40
⊠	BC-02	4.88	220.22
▲	BC-02	14.02	211.08

Date February 2016

GWP# 5027-14-00

THURBER

Prep'd MFA

Chkd. DJP

THURBALT 19-5161-252.GPJ 2/5/16

AGAT Laboratories

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Certificate of Analysis

CLIENT NAME: THURBER ENGINEERING LTD

AGAT WORK ORDER: 15T004093

PROJECT: 19-5161-252

ATTENTION TO: Deanna Pizycki

SAMPLING SITE:

SAMPLED BY:DP

Corrosivity Package

SAMPLE TYPE: Soil **SAMPLE ID: 6816995** **DATE RECEIVED: Aug 06, 2015**

DATE SAMPLED: Aug 05, 2015 **DATE REPORTED: Aug 12, 2015**

SAMPLE DESCRIPTION: BC-2 SS2 2'6"-4'6"

PARAMETER	UNIT	RESULT	G / S	RDL	DATE ANALYZED	INITIAL	DATE PREPARED
Sulfide	%	0.02		0.01	Aug 11, 2015	ME	Aug 10, 2015
Chloride (2:1)	µg/g	3		2	Aug 11, 2015	JC	Aug 11, 2015
Sulphate (2:1)	µg/g	11		2	Aug 11, 2015	JC	Aug 11, 2015
pH (2:1)	pH Units	7.70		NA		TM	
Electrical Conductivity (2:1)	mS/cm	0.162		0.005	Aug 11, 2015	TM	Aug 11, 2015
Resistivity (2:1)	ohm.cm	6170		1	Aug 11, 2015	SYS	Aug 11, 2015
Redox Potential (2:1)	mV	302		5	Aug 11, 2015	TM	Aug 11, 2015

COMMENTS:

RDL - Reported Detection Limit; G / S - Guideline / Standard
* Sulphide analysis was performed at AGAT Laboratories Vancouver.

EC/Resistivity, pH, Chloride, Sulphate and Redox Potential were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil).

Certified By: Amanjot Bhela

AGAT Laboratories

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Certificate of Analysis

CLIENT NAME: THURBER ENGINEERING LTD

AGAT WORK ORDER: 15T004153

PROJECT: 19-5161-252

ATTENTION TO: Deanna Pizycki

SAMPLING SITE:

SAMPLED BY:

Inorganic Chemistry (Water)

SAMPLE TYPE: Water | SAMPLE ID: 6825043 | DATE RECEIVED: Aug 06, 2015

DATE SAMPLED: Jul 28, 2015 | DATE REPORTED: Aug 13, 2015

SAMPLE DESCRIPTION: Boston Creek

PARAMETER	UNIT	RESULT	G / S	RDL	DATE ANALYZED	INITIAL	DATE PREPARED
pH	pH Units	7.96		NA	Aug 10, 2015	BP	Aug 10, 2015
Langelier Index		0.34			Aug 11, 2015	SYS	Aug 11, 2015
Total Dissolved Solids	mg/L	138		20		AP	Aug 10, 2015
Alkalinity (as CaCO3)	mg/L	112		5	Aug 10, 2015	BP	Aug 10, 2015
Total Hardness (as CaCO3)	mg/L	127		0.5	Aug 11, 2015	SYS	Aug 11, 2015
Chloride	mg/L	2.96		0.10	Aug 07, 2015	JC	Aug 07, 2015
Sulphate	mg/L	17.5		0.10	Aug 07, 2015	JC	Aug 07, 2015
Sulphide	mg/L	<0.05		0.05	Aug 11, 2015	SN	Aug 11, 2015
Resistivity	ohms.cm	3820			Aug 10, 2015	SYS	Aug 10, 2015
Redox Potential	mV	312		5	Aug 12, 2015	BG	Aug 12, 2015

COMMENTS:

RDL - Reported Detection Limit; G / S - Guideline / Standard

Certified By: Amanjot Bhela

Appendix C
Site Photographs

Photograph 1 – Bridge Approach Looking East

Photograph 2 – Bridge Approach Looking West

Photograph 3 – South Elevation Looking East

Photograph 4 – North Elevation Looking East

Photograph 5 – East Front Slope, July 26, 2015

Photograph 6 - East Abutment, July 26, 2015

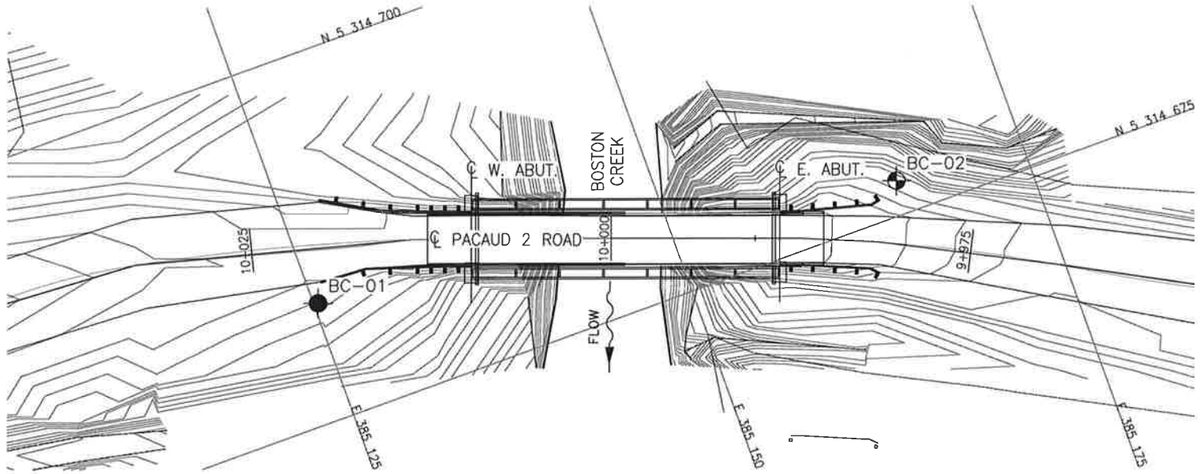
Photograph 7 – Looking South (Downstream)

Photograph 8 – Looking North (Upstream)

Photograph 9 – East Front Slope – close-up

Appendix D

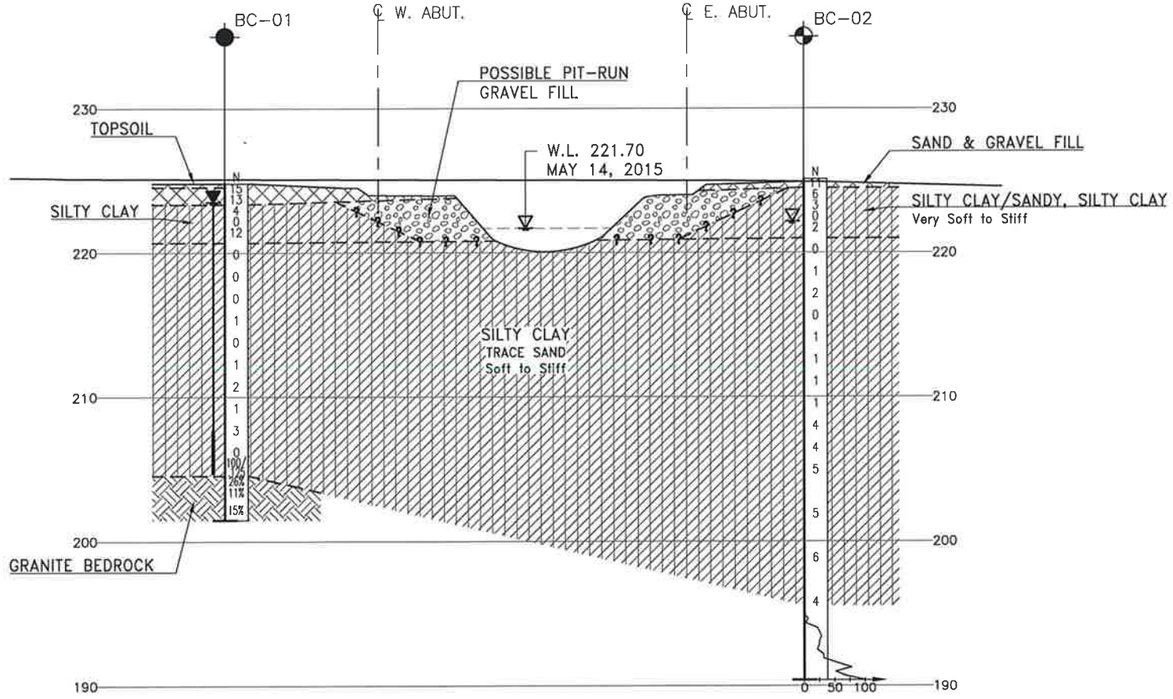
Borehole Locations and Soil Strata Drawing



PLAN

8 0 8 16m

SCALE 1:400



PROFILE ALONG ℄ PACAUD 2 ROAD

8 0 8 16m

SCALE 1:400

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No

GWP No 5027-14-00

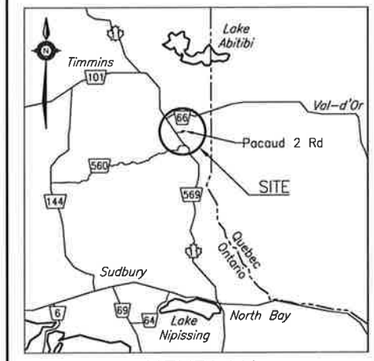
BOSTON CREEK BRIDGE REHABILITATION

BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

MMM GROUP

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

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

NO	ELEVATION	NORTHING	EASTING
BC-01	224.8	5 314 683.1	385 125.3
BC-02	225.1	5 314 677.4	385 165.9

LICENSED PROFESSIONAL ENGINEER
A. PIASCIK
Apr. 28/16
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
Apr 28/16
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. 31M-112

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN	DJP	CHK MEF	CODE	LOAD	DATE APR 2016
DRAWN	MFA	CHK DJP	SITE 47-098	STRUCT	DWG 1

FILENAME: H:\Drafting\191516\1252\sed1252-PlanProfile(BostonCreekBridge).dwg
PLOTDATE: 4/29/2016 1:22 PM