THURBER ENGINEERING LTD.

celebrating 60 YEARS

FOUNDATION INVESTIGATION REPORT
SIMS CREEK CULVERT
HIGHWAY 71
TOWNSHIP OF DOBIE, DISTRICT OF RAINY RIVER, ONTARIO
G.W.P. 6813-14-00, SITE 45-281/C

GEOCRES No.: 52C-55

Report

to

HATCH

Date: February 17, 2017
File: 13983

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THURBER

60 YEARS

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PART 1: FACTUAL INFORMATION

1. INTRODUCTION

This report presents the results of a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) for the replacement of the Sims Creek Culvert located north of Emo, within the District of Rainy River in the Township of Dobie, Ontario.

The purpose of this investigation was to explore the subsurface conditions in the vicinity of the culvert and based on the findings, to provide a plan of borehole locations, records of boreholes, laboratory test results, a written description of the subsurface conditions.

Thurber carried out the investigation as a sub-consultant to Hatch under the Ministry of Transportation Ontario (MTO) Agreement Number 6015-E-0018-005.

2. SITE DESCRIPTION

The existing culvert carries Highway 71 over Sims Creek, approximately 4.1 km north of the junction of Highway 11 and Highway 71 near Emo. At the existing culvert, Sims Creek flows easterly while Highway 71 runs in a north-south direction. The site is surrounded by low-lying swampy areas with vegetation consisting of tall grass, shrubs and occasional trees. Surrounding the site are forested areas with occasional bedrock outcrops.

The existing structure is a three-span open footing timber culvert with an unknown construction date. Based on an Ontario Bridge Management System (OBMS) inspection report dated November 20, 2014, it is understood that the structure is in overall fair condition.

Photographs included in Appendix D show the general conditions observed at the culvert inlet during the time of investigation.

3. INVESTIGATION PROCEDURES

The field work for this investigation was carried out between August 22 and August 24, 2016 during which a total of four (4) boreholes (16-31 to 16-34) were advanced on site. The approximate locations of the boreholes are shown on the Borehole Location Plan and Soil Strata drawing provided in Appendix E.

The boreholes were drilled using a CME 55 drill rig supplied by RPM Drilling Inc. of Thunder Bay, Ontario using hollow stem augers. Soil samples were obtained at selected intervals of depth with a 50 mm outside diameter split spoon sampler driven in conjunction with the Standard Penetration Test (SPT) procedure. Field vane shear tests using an MTO "N" size vane were carried out in the soft to firm cohesive soils.

The field work was supervised on a full time basis by members of Thurber's engineering and technical staff, who staked the boreholes in the field, arranged for the clearance of subsurface utilities, directed the drilling, sampling and in-situ testing operations, 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 noted upon completion of drilling. All boreholes were backfilled in general accordance with Ontario Regulation (O. Reg.) 903. A standpipe piezometer was installed in Borehole 16-34 for monitoring of the groundwater level. The backfilling and installation details of the boreholes and standpipe piezometer are presented in the table below.

Borehole Number	Borehole Depth / Base Elevation (m)	Piezometer Tip Depth / Elevation (m)	Completion Details
16-31	9.8 / 343.3	None installed	Borehole backfilled with bentonite holeplug and auger cuttings to surface.
16-32	14.3 / 341.6	None installed	Borehole backfilled with bentonite holeplug and auger cuttings to 0.1 m, then asphalt to surface.
16-33	14.3 / 341.6	None installed	Borehole backfilled with bentonite holeplug and auger cuttings to 0.1 m, then asphalt to surface.
16-34	9.8 / 343.9	9.8 / 343.9	Sand filter from 9.8 m to 6.4 m, then bentonite holeplug from 6.4 m to ground 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 distribution analyses (hydrometer and/or sieve) and Atterberg Limits testing, where appropriate. Laboratory testing results are summarized on the Record of Borehole sheets included in Appendix A and are presented on the figures included in Appendix B.

In order to assess the potential for sulphate attack on concrete foundations, as well as the potential for corrosion associated with the structure, a sample of the native soil, and a sample of the surface water from the creek upstream of the existing culvert were collected and submitted to SGS Canada Inc., a CALA accredited analytical laboratory in Lakefield, Ontario, for analytical testing of corrosivity parameters. The results of the analytical testing are summarized in this report and also presented in Appendix C.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendix A. A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following paragraphs, however, the factual data presented on the Record of Borehole sheets takes precedence over this general description and must be used for interpretation of the site conditions. It should be recognized and expected that soil conditions may vary between and beyond the borehole locations.

In general, the subsurface conditions encountered in the boreholes on the highway platform consisted of asphalt pavement underlain by embankment fill consisting of gravelly sand to sand, overlying silty clay till. In the boreholes at the culvert inlet/outlet, the subsurface soils generally consisted of a surface layer of topsoil over silty clay till.

More detailed descriptions of the individual strata are provided in the following sections.

5.1 Topsoil / Organics

Topsoil/organics was encountered at the ground surface in Boreholes 16-31 and 16-34 advanced near the inlet and outlet of the culvert. The thickness of the topsoil/organics ranged from 0.7 m to 0.8 m.

5.2 Asphalt

Boreholes 16-32 and 16-33 were drilled through the existing pavement structure of Highway 71 and encountered a surface layer of asphalt having a thickness of about 150 mm.

5.3 Fill

Embankment fill was encountered below the asphalt in boreholes 16-32 and 16-33. The embankment fill consisted of sand to gravelly sand with total thicknesses between 2.1 m and 2.5 m. The base of the fill was at Elevation 353.2 m to 353.6 m.

SPT 'N' values within the fill ranged from 5 blows to 20 blows per 0.3 m of penetration, indicating a loose to compact relative density. The measured moisture contents of selected samples of the fill varied between 3 percent and 4 percent.

The results of grain size distribution analyses carried out on samples of the fill are presented on the Record of Borehole sheets in Appendix A, and on Figure B1 Appendix B. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	15 to 28
Sand	62 to 68
Silt & Clay	10 to 17

5.4 Silty Clay Till

A layer of silty clay till was encountered below the embankment fill or topsoil in all boreholes. The cohesive till layer was brown to grey in colour and contained some sand and trace amounts of gravel. Organics and rootlets were noted in the upper 0.5 m to 2 m of the till at the inlet and outlet boreholes. In all boreholes, the layer extended to the borehole termination depths of 9.8 m to 14.3 m (Elevation 341.6 m to 343.9 m).

SPT 'N' values within the cohesive till ranged from 0 blow to 12 blows per 0.3 m penetration, indicating a soft to stiff consistency. The 0 blow count was noted near the surface of the till in Borehole 16-34. One field vane shear test measured an undrained shear strength of greater than 100 kPa, indicating a stiff to very stiff consistency. The measured moisture contents of samples of the till varied between 15 percent and 34 percent.

The results of grain size distribution analyses carried out on samples of the cohesive till are presented on the Record of Borehole sheets in Appendix A and on Figures B2 and B3 of Appendix B. The results are summarized below:

Soil Particle	Percentage (%)
Gravel	0 to 4
Sand	0 to 36
Silt	26 to 44
Clay	28 to 61

The results of Atterberg Limits analyses carried out on selected samples of the layer are presented on the Record of Borehole sheets in Appendix A and on Figure B4 Appendix B. The results are summarized below:

Index Property	Percentage (%)
Plastic Limit	16 to 42
Liquid Limit	30 to 62

The results of the Atterberg Limits testing indicate the layer to be of typically high plasticity with group symbol CH except a shallow till sample from borehole 16-31 indicating low plasticity (CL).

Glacial tills inherently contain cobbles and boulders.

5.5 Groundwater Conditions

Water levels were observed in the open boreholes upon completion of drilling and prior to backfilling. The open hole water levels are summarized in the table below.

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
16-31	August 24, 2016	Dry	-	Open borehole
16-32	August 23, 2016	Dry	-	Open borehole
16-33	August 22, 2016	Dry	-	Open borehole
16-34	August 23, 2016	Dry	-	Standpipe piezometer

The groundwater levels observed in the open boreholes are unstabilized very short-term readings and are strongly influenced by the permeability of the deposits and length of time the borehole remains open. Since the boreholes were drilled in clay till and the standpipe piezometer was sealed in the relatively low permeability till, the boreholes remained dry in the short term. The base plan drawing indicated that the creek level was at Elevation 352.8 m in April 2015 and the groundwater level is expected to reflect the creek water level. It should be noted that the groundwater levels are expected to fluctuate seasonally. Higher groundwater levels are expected

during wet periods of the year such as spring or after periods of significant or prolonged precipitation.

6. CORROSIVITY AND SULPHATE TEST RESULTS

One representative sample of soil from Borehole 16-34 and a sample of surface water from the creek were submitted to SGS laboratories for chemical analysis related to potential for corrosion of buried steel and sulphate attack on buried concrete. The results are shown in the table below and included in Appendix C.

Parameter	Units (Soil)	Units (Water)	Test Results	
			Borehole 16-34 SS2 (0.8 m to 1.4 m) - Soil	Sims Creek - Water
Corrosivity Index	-	-		
pH	-	-	9.13	7.28
Conductivity	µS/cm	µS/cm	46	147
Resistivity	Ohms.cm	MOhms.cm	21700	3340
Redox Potential	mV	mV	323	299
Chloride	µg/g	mg/L	6.1	2.8
Sulphate	µg/g	mg/L	18	0.19
Sulphide	%	mg/L	< 0.02	< 0.006

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7. MISCELLANEOUS

Thurber marked the borehole locations in the field and obtained utility locates prior to drilling.

RPM Drilling Inc. of Thunder Bay, Ontario supplied and operated the drilling, sampling and in-situ testing equipment for the field investigation. The field investigation was supervised on a full-time basis by Mr. Tim Sivak of Thurber. Overall supervision of the field program was provided by Mr. Mark Farrant, P.Eng. of Thurber.

The coordinates and ground surface elevations at the borehole locations were established by measurements taken in the field by Thurber relative to the topographic plans provided by Hatch.

Interpretation of the field data and preparation of this report was carried out by Mr. Michael Eastman, EIT and Mr. Keli Shi, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.

Michael Eastman, EIT
Geotechnical Engineer-in-Training

Keli Shi, P.Eng.
Geotechnical Engineer

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

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

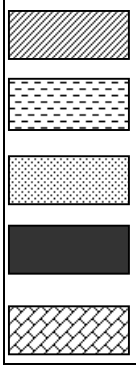
ROCK WEATHERING CLASSIFICATION

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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THURBER

RECORD OF BOREHOLE No 16-31 1 OF 2 METRIC

WP# 6813-14-00 LOCATION Sims Creek N 5 393 940.1 E 237 309.8 ORIGINATED BY TS

HWY 71 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.08.24 - 2016.08.24 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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
353.1	GROUND SURFACE										
0.0	**TOPSOIL/ORGANICS**		1	SS	1		353				
352.3											
0.8	Silty **CLAY**, some sand, trace organics (rootlets), occasional sand seams Firm to Very Stiff Brown Moist (TILL)		2	SS	5		352				0 24 44 32
			3	SS	7		351				
			4	SS	9		350				
			5	SS	8		349				
			6	SS	7		348				0 13 29 58
			7	SS	5		347				
			8	SS	8		346				
			9	SS	7		345				
343.3							344				0 12 31 57
9.8	END OF BOREHOLE AT 9.8m.										

Continued Next Page

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

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

ONTMT4S 13983-MTO.GPJ 2015TEMPLATE(MTO).GDT 11/16/16

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THURBER

RECORD OF BOREHOLE No 16-31 2 OF 2 METRIC

WP# 6813-14-00 LOCATION Sims Creek N 5 393 940.1 E 237 309.8 ORIGINATED BY TS

HWY 71 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.08.24 - 2016.08.24 CHECKED BY MEF

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										
	NO WATER ENCOUNTERED DURING DRILLING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.										

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

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

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RECORD OF BOREHOLE No 16-32 1 OF 2 METRIC

WP# 6813-14-00 LOCATION Sims Creek N 5 393 952.6 E 237 320.3 ORIGINATED BY TS

HWY 71 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.08.23 - 2016.08.23 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 (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 (%) GR SA SI CL
355.9	GROUND SURFACE										
0.0	**ASPHALT:** (150mm)										
0.2	**SAND**, some gravel, some silt Compact Brown Dry to Moist (FILL)		1	GS					○		15 68 17 (SI+CL)
			1	SS	20		355		○		
			2	SS	12		354		○		
353.2			3	SS	5				○		
2.7	Silty **CLAY**, some sand, trace gravel, occasional sand seams Firm to Very Stiff Brown to Grey Moist (TILL)		4	SS	5		353		○		4 36 32 28
							352				
			5	SS	10		351		○		
							350				
			6	SS	8		349		○		
							348		○		
			7	SS	6		347				
			8	SS	6		346		⊖		0 19 31 50

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

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

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THURBER

RECORD OF BOREHOLE No 16-32 2 OF 2 METRIC

WP# 6813-14-00 LOCATION Sims Creek N 5 393 952.6 E 237 320.3 ORIGINATED BY TS

HWY 71 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.08.23 - 2016.08.23 CHECKED BY MEF

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										
			9	SS	9		345		○		
							344				
			10	SS	10				○		
							343				
			11	SS	8		342		○		0 0 39 61
341.6											
14.3	END OF BOREHOLE AT 14.3m. BOREHOLE DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.1m, THEN COLD PATCH ASPHALT TO SURFACE.										

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

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

ONTMT4S 13983-MTO.GPJ 2015TEMPLATE(MTO).GDT 11/16/16

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 16-33 1 OF 2 METRIC

WP# 6813-14-00 LOCATION Sims Creek N 5 393 943.5 E 237 324.0 ORIGINATED BY TS

HWY 71 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.08.22 - 2016.08.22 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 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
355.9	GROUND SURFACE										
0.0	**ASPHALT:** (150mm)										
0.2	Gravelly **SAND**, trace silt Compact to Loose Brown Dry to Moist (FILL)		1	GS							
			2	SS	16		355				28 62 10 (SI+CL)
			3	SS	8		354				
353.6											
2.3	Silty **CLAY**, some sand, trace gravel, occasional sand seams Firm to Very Stiff Brown to Grey Moist (TILL)		4	SS	2		353				
			5	SS	3						0 26 41 33
							352				
			6	SS	8		351				
							350				
			7	SS	7						
							349				
			8	SS	6		348				0 17 26 57
							347				
			9	SS	6						
							346				

Continued Next Page

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

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 16-33 2 OF 2 METRIC

WP# 6813-14-00 LOCATION Sims Creek N 5 393 943.5 E 237 324.0 ORIGINATED BY TS

HWY 71 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.08.22 - 2016.08.22 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ 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										
			10	SS	6		345		○		
			11	SS	6		344		○		
			12	SS	7		343		○		0 17 34 49
341.6							342				
14.3	END OF BOREHOLE AT 14.3m. BOREHOLE DRY ON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.1m, THEN COLD PATCH ASPHALT TO SURFACE.										

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

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

ONTMT4S 13983-MTO.GPJ 2015TEMPLATE(MTO).GDT 11/16/16

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 16-34 1 OF 2 METRIC

WP# 6813-14-00 LOCATION Sims Creek N 5 393 955.1 E 237 334.9 ORIGINATED BY TS

HWY 71 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.08.23 - 2016.08.23 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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
353.7	GROUND SURFACE										
0.0	**TOPSOIL/ORGANICS**		1	SS	1		353				
353.0											
0.7	Silty **CLAY**, some sand Very Soft to Very Stiff Brown to Grey Moist (TILL) Trace organics from 0.7m to 2.1m		2	SS	0						
			3	SS	12		352				0 18 32 50
			4	SS	11		351				
			5	SS	10						
							350				
			6	SS	10		349				
			7	SS	12		348				
							347				
			8	SS	9		346				
							345				
			9	SS	9						0 16 36 48
343.9							344				
9.8	END OF BOREHOLE AT 9.8m.										

Continued Next Page

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

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 16-34 2 OF 2 METRIC

WP# 6813-14-00 LOCATION Sims Creek N 5 393 955.1 E 237 334.9 ORIGINATED BY TS

HWY 71 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.08.23 - 2016.08.23 CHECKED BY MEF

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										
	BOREHOLE DRY UPON COMPLETION OF DRILLING. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen.										

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

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

ONTMT4S 13983-MTO.GPJ 2015TEMPLATE(MTO).GDT 11/16/16

THURBER

60 YEARS

Appendix B

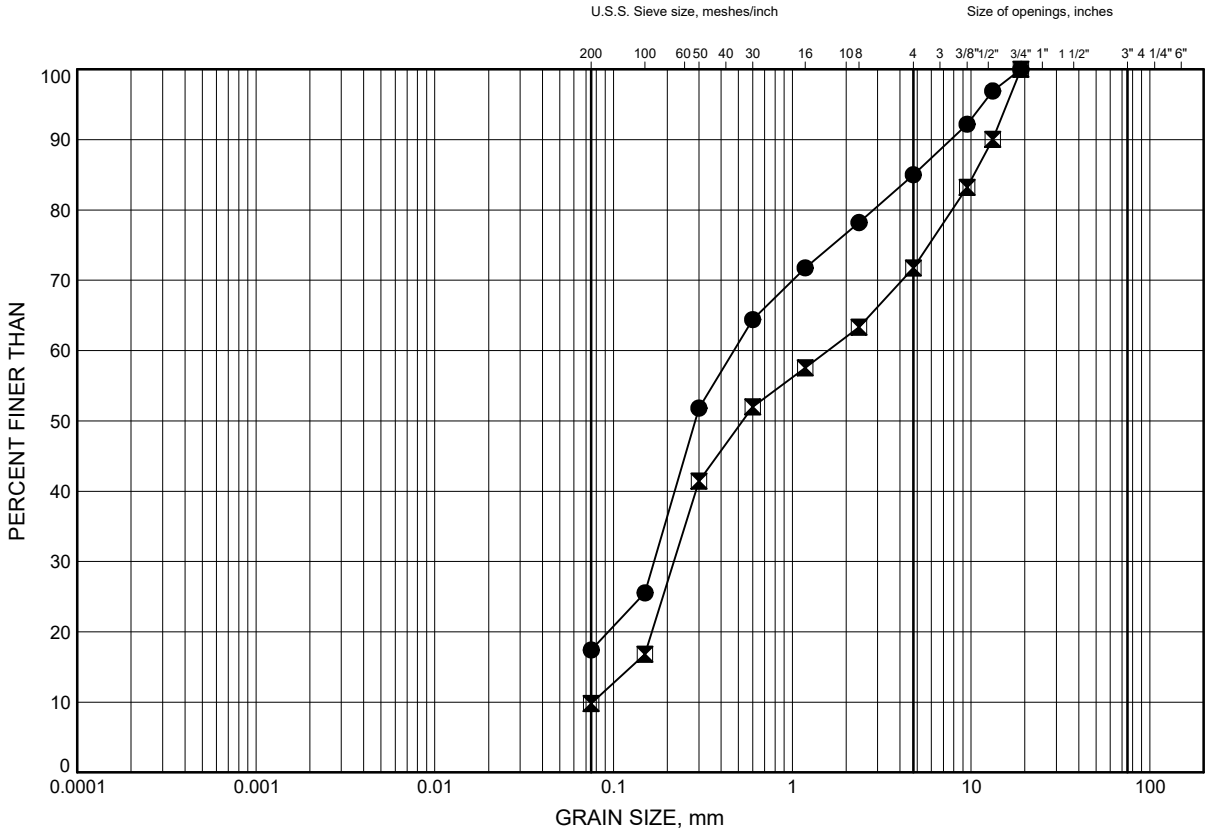
Laboratory Test Results

Sims Creek

GRAIN SIZE DISTRIBUTION

FIGURE B1

Gravelly SAND to SAND FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-32	0.38	355.52
⧓	16-33	1.07	354.83

Date November 2016

W.P. 6813-14-00

THURBER

Prep'd AN

Chkd. KS

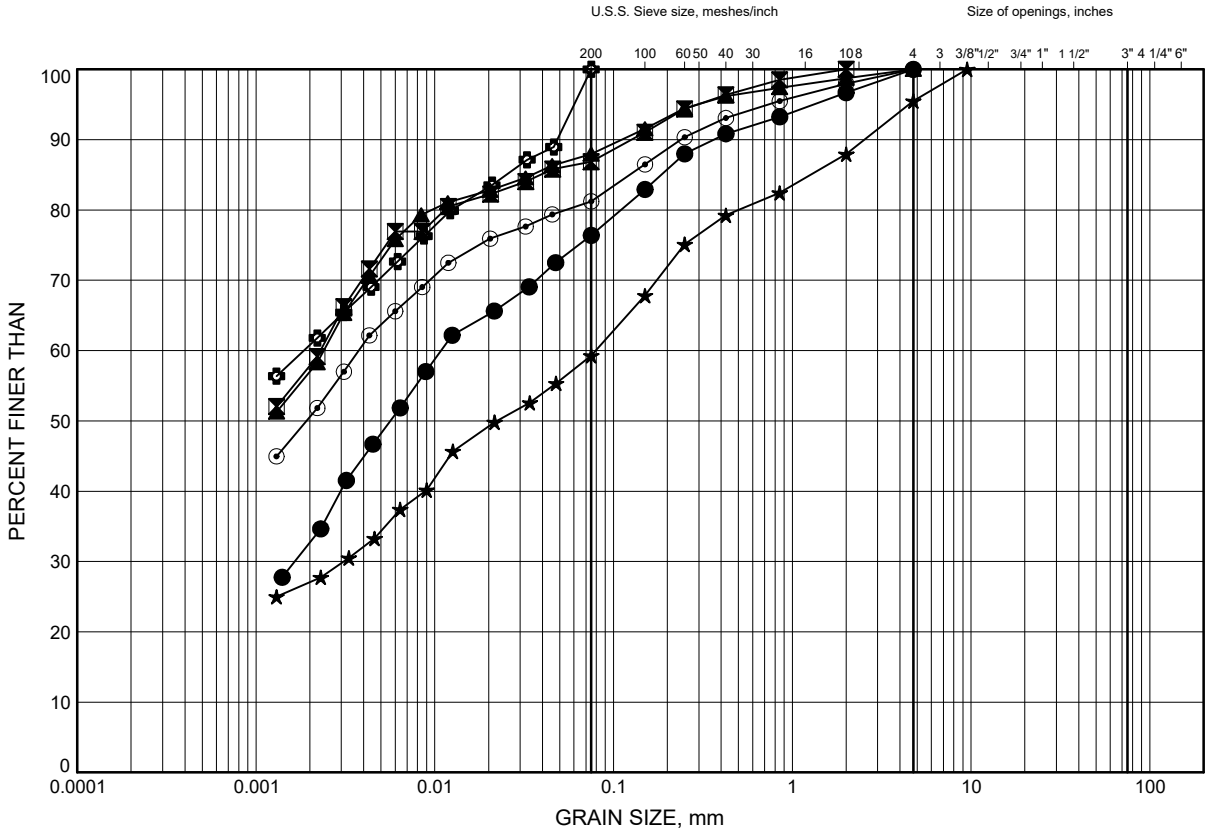
GRAIN SIZE DISTRIBUTION - THURBER 13983-MTO.GPJ 11/10/16

Sims Creek

GRAIN SIZE DISTRIBUTION

FIGURE B2

Silty CLAY TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-31	1.07	352.03
⊠	16-31	4.88	348.22
▲	16-31	9.45	343.65
★	16-32	3.35	352.55
⊙	16-32	9.45	346.45
✿	16-32	14.02	341.88

Date November 2016

W.P. 6813-14-00

THURBER

Prep'd AN

Chkd. KS

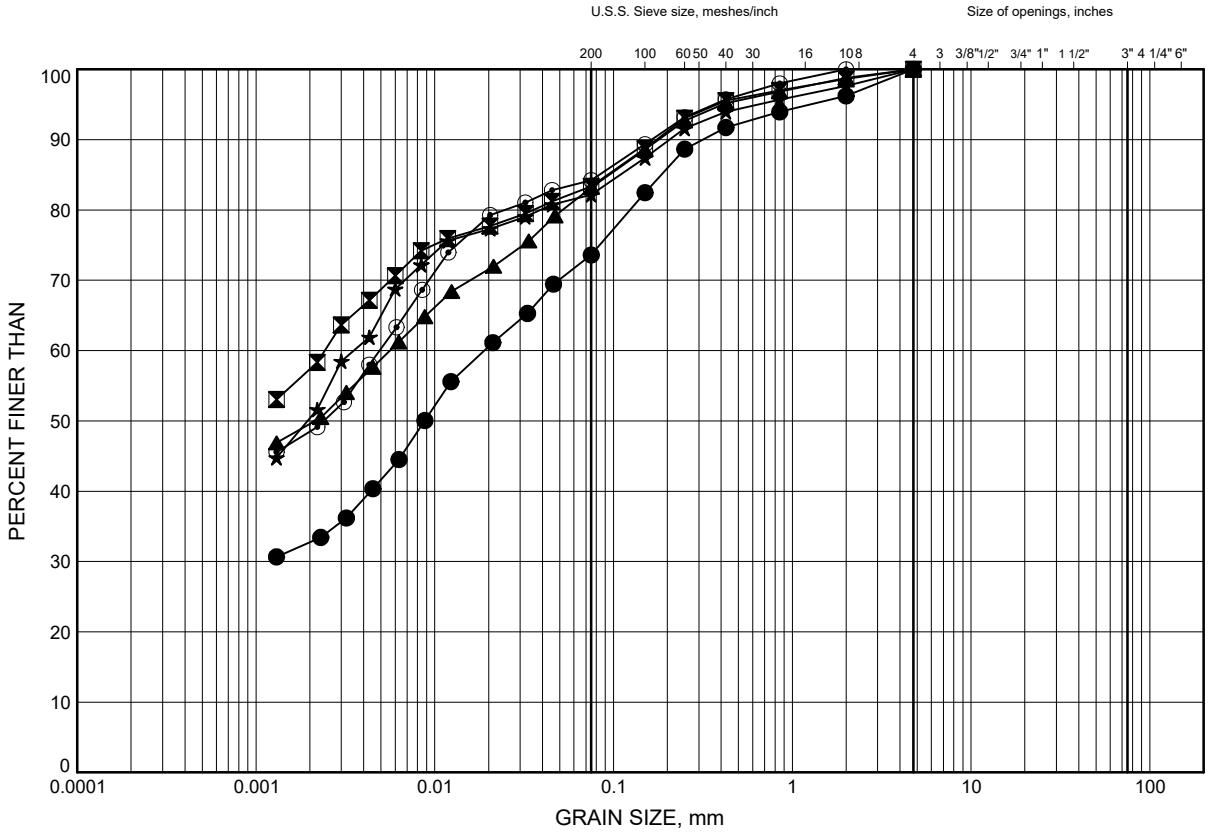
GRAIN SIZE DISTRIBUTION - THURBER 13983-MTO.GPJ 11/10/16

Sims Creek

GRAIN SIZE DISTRIBUTION

FIGURE B3

Silty CLAY TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-33	3.35	352.55
⊠	16-33	7.92	347.98
▲	16-33	14.02	341.88
★	16-34	1.83	351.87
⊙	16-34	9.45	344.25

Date November 2016

W.P. 6813-14-00

THURBER

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Chkd. KS

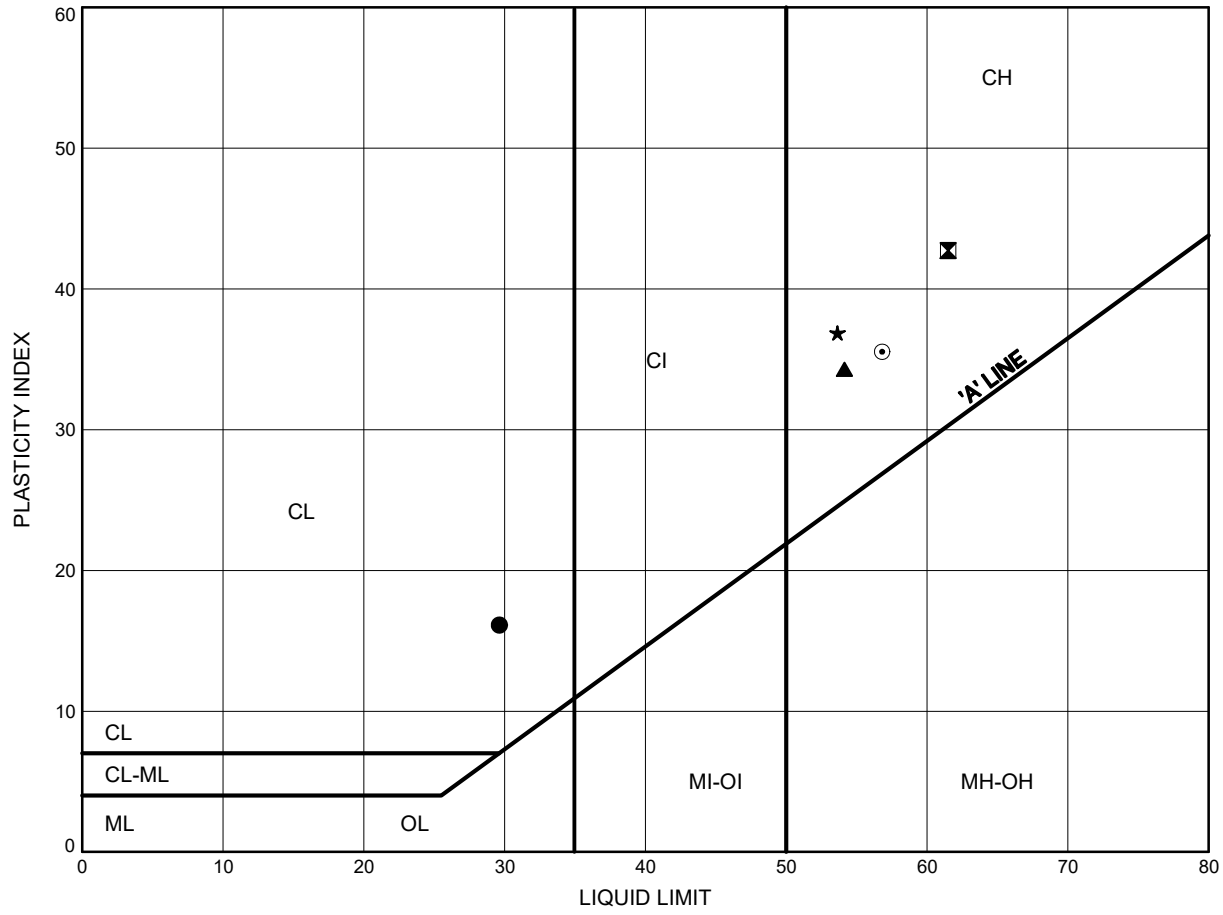
GRAIN SIZE DISTRIBUTION - THURBER 13983-MTO.GPJ 11/10/16

Sims Creek

ATTERBERG LIMITS TEST RESULTS

FIGURE B4

Silty CLAY TILL



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-31	1.07	352.03
⊠	16-31	4.88	348.22
▲	16-32	9.45	346.45
★	16-33	7.92	347.98
⊙	16-34	9.45	344.25

Date November 2016

W.P. 6813-14-00

THURBER

Prep'd AN

Chkd. KS

THURBALT 13983-MTO.GPJ 11/10/16

THURBER

60 YEARS

Appendix C

Chemical Analysis Results

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

Project : 13983

22-September-2016

Thurber Engineering Ltd.
Attn : Mark Farrant

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

Phone: 905-829-8666 x 228
Fax:

Date Rec. : 16 September 2016
LR Report: **CA14401-SEP16**
Reference: 13983 Mark Farrant

Copy: #1

CERTIFICATE OF ANALYSIS
Final Report

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Approval Date	4: Analysis Approval Time	6: 16-34 SS#2 2.5'-4.5'
Sample Date & Time					12-Sep-16
Temperature Upon Receipt [°C]	---	---	---	---	9.0
Corrosivity Index [none]	21-Sep-16	16:51	21-Sep-16	16:51	1
pH [no unit]	19-Sep-16	10:18	19-Sep-16	13:26	7.95
Soil Redox Potential [mV]	19-Sep-16	16:42	20-Sep-16	10:53	323
Sulphide [%]	21-Sep-16	11:12	21-Sep-16	11:40	< 0.02
% Moisture (wet wt) [%]	21-Sep-16	07:55	21-Sep-16	08:50	18.6
pH [no unit]	19-Sep-16	06:59	20-Sep-16	10:41	9.13
Chloride [µg/g]	20-Sep-16	20:39	21-Sep-16	16:30	6.1
Sulphate [µg/g]	20-Sep-16	20:39	21-Sep-16	16:30	18
Conductivity [uS/cm]	19-Sep-16	06:59	20-Sep-16	10:42	46
Resistivity (calculated) [Ohms.cm]	21-Sep-16	10:49	21-Sep-16	10:49	21700

Deanna Edwards, B.Sc, C.Chem
Project Specialist
Environmental Services, Analytical

OnLine LIMS

00007876

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

Project : 13983

LR Report : **CA14401-SEP16**

Temperature of Samples upon receipt 15 degrees C
No cooling agent present

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.

Temperature of Samples upon receipt 9 degrees C
Cooling agent present
Custody Seal not present

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

Project : 13983

LR Report : **CA14401-SEP16**

Method Descriptions

Parameter	SGS Method Code	Reference Method Code
Anions by IC	ME-CA-[ENV]IC-LAK-AN-001	EPA300/MA300-Ions1.3
Carbon/Sulphur	ME-CA-[ENV]ARD-LAK-AN-020	ASTM E1918
Conductivity	ME-CA-[ENV]EWL-LAK-AN-006	SM 2510
pH	ME-CA-[ENV]EWL-LAK-AN-001	SM 4500

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

Project : 13983
LR Report : **CA14401-SEP16**

Quality Control Report

Inorganic Analysis												
Parameter	Reporting Limit	Unit	Method Blank		RPD	Acceptance Criteria	LCS / Spike Blank			Matrix Spike / Reference Material		
							Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
						%		Low	High		Low	High
Anions by IC - QCBatchID: DIO0260-SEP16												
Chloride	0.4	µg/g	<0.4		1	20	107	80	120	105	75	125
Sulphate	0.4	µg/g	<0.4		0	20	101	80	120	100	75	125
Carbon/Sulphur - QCBatchID: ECS0026-SEP16												
Sulphide	0.02	%	<0.02		4	20	106	80	120			
Conductivity - QCBatchID: EWL0235-SEP16												
Conductivity	2	uS/cm	< 2		ND	10				NA		
pH - QCBatchID: ARD0047-SEP16												
pH	0.05	no unit			0	20	100	80	120			

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

Project : 13983

12-September-2016

Thurber Engineering Ltd.
Attn : Mark Farrant

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

Phone: 905-829-8666 x 228
Fax:

Date Rec. : 06 September 2016
LR Report: **CA15062-SEP16**
Reference: 13983 Mark Farrant

Copy: #1

CERTIFICATE OF ANALYSIS
Final Report

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Approval Date	4: Analysis Approval Time	5: MDL	6: Sims
Sample Date & Time						21-Aug-16
Temperature Upon Receipt [°C]	---	---	--	--	---	23.0
Corrosivity Index [none]	12-Sep-16	17:18	12-Sep-16	17:18		< 1
pH [no unit]	07-Sep-16	06:39	07-Sep-16	15:48	0.05	7.28
Conductivity [µS/cm]	07-Sep-16	06:39	07-Sep-16	15:48	2	147
Resistivity (calculated) [MOhms.cm]	07-Sep-16	14:35	07-Sep-16	14:35	---	3340
Redox Potential [mV]	06-Sep-16	14:30	07-Sep-16	08:34	---	299
Chloride [mg/L]	08-Sep-16	09:42	12-Sep-16	13:27	0.04	2.8
Sulphate [mg/L]	08-Sep-16	09:42	12-Sep-16	13:27	0.04	0.19
Sulphide [mg/L]	07-Sep-16	12:00	08-Sep-16	10:41	0.006	< 0.006

Temperature of Samples upon receipt 23 degrees C
Cooling Agent Present
Custody Seal not Present

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.

Deanna Edwards

Deanna Edwards, B.Sc, C.Chem
Project Specialist
Environmental Services, Analytical

OnLine LIMS

0000779931

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

Project : 13983

LR Report : **CA15062-SEP16**

Method Descriptions

Parameter	SGS Method Code	Reference Method Code
Anions by IC	ME-CA-[ENV]IC-LAK-AN-001	EPA300/MA300-Ions1.3
Conductivity	ME-CA-[ENV]EWL-LAK-AN-006	SM 2510
pH	ME-CA-[ENV]EWL-LAK-AN-006	SM 4500
Redox Potential		SM 2580
Sulphide by SFA	ME-CA-[ENV]SFA-LAK-AN-008	SM 4500

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

Project : 13983
LR Report : **CA15062-SEP16**

Quality Control Report

Inorganic Analysis												
Parameter	Reporting Limit	Unit	Method Blank		RPD	Acceptance Criteria	LCS / Spike Blank			Matrix Spike / Reference Material		
							Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
						%		Low	High		Low	High
Anions by IC - QCBatchID: DIO0089-SEP16												
Anions by IC - QCBatchID: DIO0105-SEP16												
Chloride	0.04	mg/L	<0.04		2	20	94	80	120	105	75	125
Sulphate	0.04	mg/L	<0.04		0	20	101	80	120	100	75	125
Conductivity - QCBatchID: EWL0061-SEP16												
Conductivity	2	µS/cm	< 2		0	10	98	90	110	NA		
pH - QCBatchID: EWL0061-SEP16												
pH	0.05	no unit	NA		0		100			NA		
Redox Potential - QCBatchID: EWL0056-SEP16												
Redox Potential	no	mV	NA		2	20	100	80	120	NA		
Sulphide by SFA - QCBatchID: SKA0038-SEP16												
Sulphide	0.006	mg/L	<0.006		ND	20	84	80	120	nv	75	125

Appendix D

Site Photographs

Photo 1: Sims Creek Culvert, inlet

Photo 2: Sims Creek Culvert, east side looking north

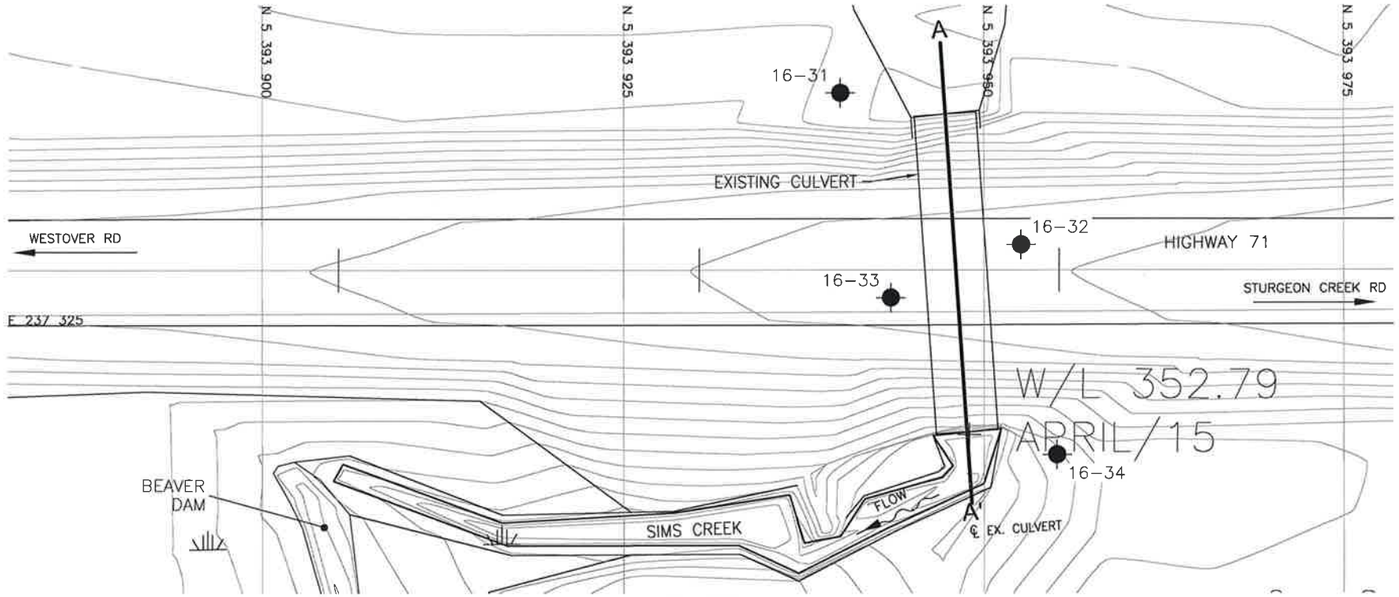
Photo 3: Sims Creek Culvert, west side looking north

Photo 4: Sims Creek Culvert, west side looking south

Photo 5: Sims Creek Culvert, looking south

Appendix E

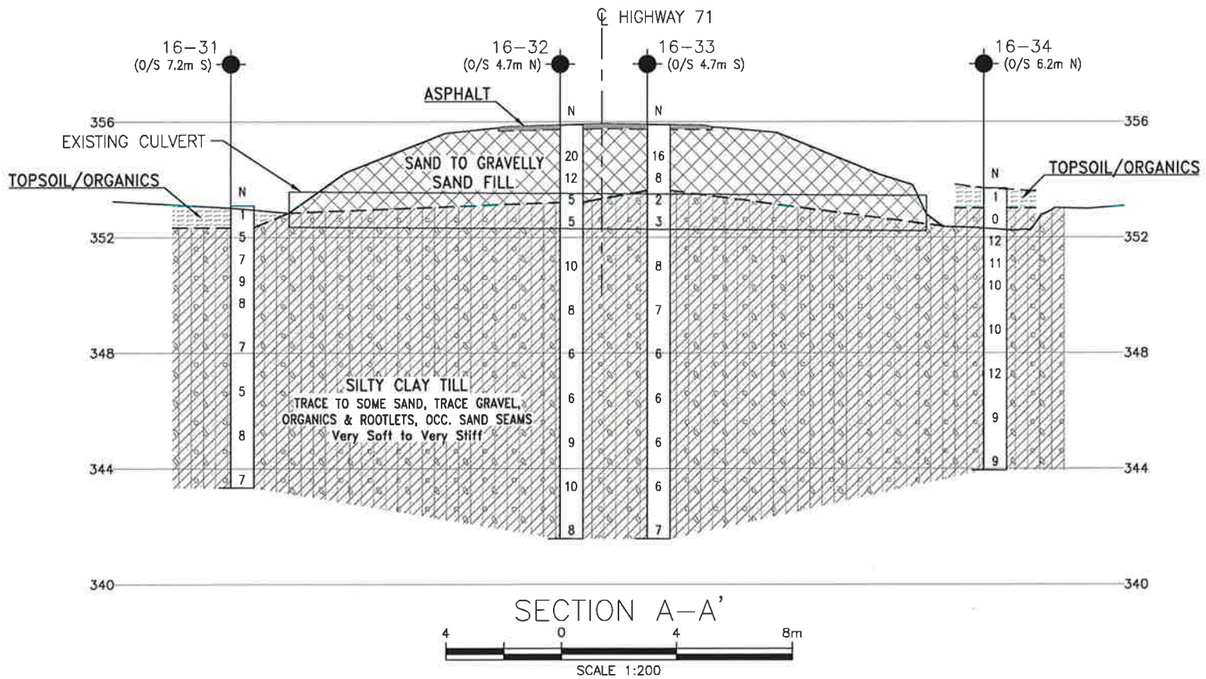
Borehole Location Plan and Stratigraphic Profile



PLAN

8 0 8 16m

SCALE 1:400



SECTION A–A'

4 0 4 8m

SCALE 1:200

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

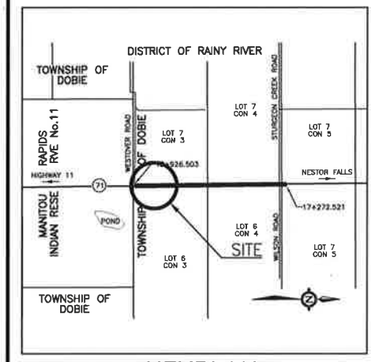
CONT No 6015-E-0018-005
WP No 6813-14-00

SHEET

HIGHWAY 71
SIMS CREEK
CULVERT REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

HATCH

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
16-31	353.1	5 393 940.1	237 309.8
16-32	355.9	5 393 952.6	237 320.3
16-33	355.9	5 393 943.5	237 324.0
16-34	353.7	5 393 955.1	237 334.9

-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.
3) MTM Zone 16 co-ordinate system used to obtain borehole Northings and Eastings.
4) Preliminary general arrangement drawing provided by Hatch in digital format.

GEOCRES No. 52C-55

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
Feb 17/17
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
K. L. SHI
100141639
Feb 17/17
PROVINCE OF ONTARIO

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN	MEF	CHK PKC	CODE	LOAD	DATE FEB 2017
DRAWN	MFA	CHK MEF	SITE	STRUCT	DWG 1

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