FOUNDATION INVESTIGATION REPORT
OZONE CREEK CULVERT REHABILITATION
HIGHWAY 17, TOWNSHIP OF PATIENCE
DISTRICT OF THUNDER BAY, ONTARIO
W.P. 6101-10-01, SITE 48C-112

Geocres Number: 52H-29

Report to

MMM Group Limited

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PART 1 FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted at the site of the Ozone Creek Culvert located on Highway 17 east of Nipigon, in the Township of Patience, Thunder Bay District, Ontario.

The purpose of the investigation was to explore the subsurface conditions at the site, and based on the data obtained, to provide a borehole location plan, record of borehole sheets, a 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 (MMM), under the Ministry of Transportation Ontario (MTO) Agreement Number 6010-E-0011.

2 SITE DESCRIPTION

The culvert site is located on Highway 17 approximately 18 km east of the intersection of Highways 11 and 17 in Nipigon, in the Thunder Bay District, Ontario. The Ozone Creek meanders southerly into Lake Superior (Nipigon Bay) approximately 500 m to the south.

The existing culvert was built in 1960 and rehabilitated in 1996 under Contract No. 96-219. The culvert is a twin concrete box structure with cell widths of 4.9 m each and a cell height of 6.1 m. The total length of the culvert is 15.2 m. The culvert invert (top of base slab) indicated on the archive design drawings is at Elev. 187.3, and the base slab is 0.9 m thick.

Concrete flumes are provided at both ends of the culvert. The flumes are 8.4 m (south) and 8.5 m (north) in length, with the outer 2.1 m of the north flume wall (inlet) angled outwards at 30°. The

existing approach embankments decrease in height from as much as 6.7 m adjacent to the culvert to approximately 4.6 m some 15 m away from the culvert.

The land surrounding the site is gently undulating and treed, with occasional clearings. Bedrock is exposed adjacent to the highway approximately 70 m to the west and 300 m to the east of the culvert. A railway crosses the creek about 75 m to the south. Photographs of the culvert and surrounding area are presented in Appendix C.

The site lies within the physiographical region known as the Quetico Subprovince of the Superior Province, which is characterized by granitic and metasedimentary bedrock. The bedrock is either exposed or overlain by a thin glaciolacustrine and quiet basin deposits consisting of silts and clays with minor sands.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing for this project were carried out between June 17 and 20, 2013. A total of four boreholes, denoted as OZC-01 to OZC-04, were advanced to depths ranging from 10.2 m to 17.0 m below the existing highway grade. The locations of the boreholes are shown on the attached Borehole Locations and Soil Strata Drawing included in Appendix D.

Details of the borehole depths and completion are summarized in Table 3.1 below.

Table 3.1 – Borehole Summary

Borehole	Drilling and Coring Depth/ Base of Hole Elevation(m)	Completion Details
OZC-01	10.2 / 184.5	Borehole backfilled with bentonite holeplug and cuttings to 0.8 m, concrete to 0.1 m then asphalt cold patch to surface.
OZC-02	14.6 / 180.1	Standpipe piezometer consisting of 19 mm diameter Schedule 40 PVC pipe with a 4.5 m slotted screen installed.
OZC-03	17.0 / 177.7	Standpipe piezometer consisting of 19 mm diameter Schedule 40 PVC pipe with a 4.5 m slotted screen installed.
OZC-04	15.8 /178.9	Borehole backfilled with bentonite holeplug and cuttings to 0.6 m, concrete to 0.1 m then asphalt cold patch to surface.

All boreholes were advanced using a CME75 truck-mounted drill rig in combination with hollow stem augers and NW casing methods to advance the boreholes in the overburden. Samples of the overburden soils were obtained from the boreholes at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT).

Core samples of the underlying bedrock were recovered from two boreholes using NQ rock coring equipment. All rock cores were logged, photographed and the Total Core Recovery (TCR), Solid Core Recovery (SCR), Rock Quality Designation (RQD) and the Fracture Indices (FI) were determined.

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 and rock samples for transport to Thurber's laboratory for further examination and testing.

Groundwater conditions in the open boreholes were observed during the drilling operations. Standpipe piezometers consisting of 19 mm PVC pipe with a slotted screen were installed in Boreholes OZC-02 and OZC-03. Following the final water level reading, the piezometers were decommissioned in general accordance with MOE Regulation 903.

4 LABORATORY TESTING

The recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. The results of this testing are shown on the Record of Borehole sheets included in Appendix A. Selected samples were also subjected to gradation analysis and Atterberg Limits testing, and the results of this testing program are summarized on the Record of Borehole sheets in Appendix A and shown on the figures included in Appendix B.

Point load tests (PLT) were performed on selected intact rock core samples. Unconfined compressive strengths (UCS) of the rock cores correlated from the PLT results are shown on the Record of Borehole sheets in Appendix A, and the results of the testing are enclosed in Appendix B. Photographs of the rock cores are also included 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 stratigraphic profile 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.

The subsurface stratigraphy encountered below the existing embankment fill at the site generally consists of a glaciolacustrine silty clay deposit underlain by bedrock. In the boreholes advanced some 15 m away from the culvert, the silty clay was underlain by a layer of silt.

More detailed descriptions of the individual strata are presented below.

5.1 Asphalt and Concrete

An asphalt pavement layer was encountered in all boreholes. The thickness of the asphalt layer ranged from 90 to 150 mm. Boreholes OZC-02 and OZC-03 were advanced through the approach slabs of the culvert and encountered 250 and 400 mm of concrete below the asphalt.

5.2 Fill

Granular embankment fill was encountered below the asphalt or concrete slab in all boreholes. The fill consists of various proportions of sand and gravel with trace silt and was classified as sand, trace gravel to sandy gravel. Occasional cobbles were encountered in the fill. The thickness of the fill ranged from 4.5 to 6.2 m, with the base of the fill encountered at depths of 4.6 to 6.7 m (Elev. 190.1 to 188.0 m).

SPT 'N' values recorded in the embankment fill ranged from 11 to 98 blows per 0.3 m penetration, indicating a variable compact to very dense relative density. 'N' values in excess of 50 blows for 0.3 m penetration are probably indicative of the presence of cobbles.

Moisture contents of the granular fill ranged from 2 to 20%.

The results of grain size analyses conducted on fill samples are provided on the Record of Borehole sheets in Appendix A, and are illustrated in Figures B1 and B2 of Appendix B. The results are summarized as follows:

Soil Particles	Percentage
Gravel	38 to 72
Sand	27 to 56
Silt and Clay	1 to 6

5.3 Silty Clay

A layer of grey silty clay was encountered directly below the fill in all boreholes. The thickness of the layer ranged from 4.0 m in Borehole OZC-01 located west of the culvert (within the west approach embankment) to 10.3 m in Borehole OZC-04 located within the east approach embankment. The silty clay extended to depths of 9.0 to 14.9 m (Elev. 185.7 to 179.8).

SPT 'N' values recorded in the silty clay varied between 2 and 14 blows per 0.3 m of penetration, typically between 2 and 5 blows per 0.3 m of penetration. The higher values of 7 to 14 blows per 0.3 m of penetration may indicate on the presence of a crust in the clay deposit. The vane shear tests (VST) measured in-situ undrained shear strengths ranging

from 17 to 21 kPa. Based on the SPT and VST data, the consistency of the silty clay was described as soft with a discontinuous firm to very stiff crust.

The sensitivity of the silty clay, calculated as a ratio of undisturbed strength to remoulded strength, ranged from 3 to 4, suggesting that the silty clay is of normal sensitivity.

The results of grain size analyses conducted on samples of the silty clay are provided on the Record of Borehole sheets in Appendix A, and illustrated in Figure B3 of Appendix B.

The results are summarized as follows:

Soil Particles	Percentage
Gravel	0
Sand	0 to 2
Silt	24 to 40
Clay	60 to 76

The results of Atterberg Limits tests conducted on samples of the silty clay are provided on the Record of Borehole sheets in Appendix A and illustrated in Figure B5 of Appendix B. The results indicate that the deposit has plastic limits ranging from 18 to 24% and liquid limits ranging from 41 to 58%, suggesting medium to high plasticity. Plasticity indices, determined as the difference between the plastic limit and liquid limit, ranged from 23 to 35%. Natural moisture contents of the silty clay ranged from 35 to 55%.

5.4 Silt

A layer of grey silt with trace to some sand and clay was encountered below the silty clay in Boreholes OZC-01 and OZC-04. The boreholes were terminated in this deposit at depths of 10.2 and 15.8 m (Elev. 184.5 and 178.9).

Two SPT ‘N’ values recorded in the silt were 11 and 29 blows per 0.3 m penetration, indicating a compact relative density of the deposit. Moisture contents of 21 and 23% were measured.

The results of grain size analyses conducted on two samples of the silt are provided on the Record of Borehole sheets in Appendix A, and illustrated in Figure B4 of Appendix B. The results are summarized as follows:

Soil Particles	Percentage
Gravel	0
Sand	2 to 19
Silt	75 to 86
Clay	6 to 12

5.5 Bedrock

Bedrock was encountered below the silty clay in Boreholes OZC-02 and OZC-03 at depths of 11.6 m (Elev. 183.1) and 13.4 m (Elev. 181.3).

The bedrock in the boreholes was classified as a granitic gneiss and consisted of white and pink granite incorporated into the black and white gneiss. In the recovered rock cores, the rock was coarse grained, fresh with occasional horizontal joints. Some mechanical breaks were noted in the recovered core samples. The measured Total Core Recovery (TCR) were 100% for all core runs, and the Rock Quality Designation (RQD) ranged from 83% to 100%, indicating a good to excellent rock quality. Fracture Index (FI) values between 0 and 3 were obtained for the recovered rock cores.

The unconfined compressive strength (UCS) of the rock, estimated from the results of point load tests conducted on the rock core samples, ranged from 113 to 122 MPa (average for each run), indicating a very strong intact rock. The point load test results are included on the borehole logs in Appendix A. The point load test sheets with details of the testing and photographs of the rock core are enclosed in Appendix B.

5.6 Water Levels

The water levels in the boreholes were measured upon completion of drilling operations. It should be noted that water was used during the wash-boring and coring operations, therefore, the measured water levels in open boreholes may not reflect prevailing groundwater levels at the site.

Standpipe piezometers were installed in Boreholes OZC-02 and OZC-03 to monitor groundwater levels after drilling. The water levels measured in the open boreholes upon completion of drilling and in the piezometers are summarized in Table 5.1.

Table 5.1 - Water Level Measurements

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
OZC -01	Jun.19, 2013	2.1	192.6	Open borehole
OZC-02	Jun. 19, 2013	5.8	188.9	Open borehole
	Jun. 20, 2013	2.5	192.2	In piezometer
	Jul. 09, 2013	2.4	192.3	
OZC-03	Jun. 20, 2013	3.0	191.7	Open borehole
	Jun. 26, 2013	2.5	192.2	In piezometer
	Jul. 09, 2013	3.5	191.2	
OZC-04	Jun. 18, 2013	3.4	191.3	Open borehole

The high water level in Ozone Creek was shown on the preliminary GA drawing at Elev. 190.7.

The water level in the creek and groundwater levels are expected to fluctuate seasonally and are subject to precipitation patterns, and may vary from the levels presented above.

6 MISCELLANEOUS

Eastern Ontario Diamond Drilling Ltd. supplied the drill rig and conducted the drilling, sampling and in-situ testing operations. A truck-mounted CME 75 drill rig was used for the duration of the investigation.

The drilling and sampling operations were supervised in the field by Mr. George Azzopardi of Thurber Engineering. Mr. Mark Farrant, P.Eng. directed the field operations.

The report was prepared by Ms. Anna Piascik, P.Eng., and reviewed by Mr. Murray Anderson, P.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations projects.

THURBER ENGINEERING LTD.

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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

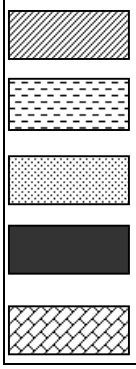
ROCK WEATHERING CLASSIFICATION

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 OZC-01 1 OF 2 METRIC

WP# 6101-10-00 LOCATION Ozone Creek Bridge N 5 432 043.1 E 228 896.0 ORIGINATED BY GA

HWY 17 BOREHOLE TYPE Hollow Stem Augers/NW Casing COMPILED BY AN

DATUM Geodetic DATE 2013.06.19 - 2013.06.19 CHECKED BY MEF

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS
194.7	GROUND SURFACE					
0.0	**ASPHALT:**(150mm)					
0.2	**SAND**, some gravel Dense to Very Dense Brown Wet (FILL)		1	SS	39	
			2	SS	45	
			3	SS	56	▽
			4	SS	47	
191.7						
3.0	**SAND** and **GRAVEL**, trace silt Compact to Dense Brown Wet (FILL)		5	SS	40	
189.7			6	SS	18	
5.0	Silty **CLAY**, trace sand Soft to Firm Grey Wet		7	SS	5	
			8	SS	2	
185.7						
9.0	**SILT**, some sand, trace clay Compact Grey Wet		9	SS	11	

ELEVATION SCALE: 194, 193, 192, 191, 190, 189, 188, 187, 186, 185

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
	55	41	4 (SI+CL)	
	0	2	25	73
	0	19	75	6

3.0

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+ 3, × 3: Numbers refer to Sensitivity

20
15 5
10
(%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No OZC-01 2 OF 2 METRIC

WP# 6101-10-00 LOCATION Ozone Creek Bridge N 5 432 043.1 E 228 896.0 ORIGINATED BY GA

HWY 17 BOREHOLE TYPE Hollow Stem Augers/NW Casing COMPILED BY AN

DATUM Geodetic DATE 2013.06.19 - 2013.06.19 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
184.5	Continued From Previous Page										
10.2	END OF BOREHOLE AT 10.2m. BOREHOLE OPEN TO 10.2m AND WATER LEVEL AT 2.1m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.8m, CONCRETE TO 0.1m, THEN ASPHALT PATCH TO SURFACE.										

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

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

ONTMT4S 1197.GPJ 2015TEMPLATE(MTO).GDT 6/4/15

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RECORD OF BOREHOLE No OZC-02 1 OF 2 METRIC

WP# 6101-10-00 LOCATION Ozone Creek Bridge N 5 432 049.8 E 228 909.7 ORIGINATED BY GA

HWY 17 BOREHOLE TYPE NW Casing/NQ Coring COMPILED BY AN

DATUM Geodetic DATE 2013.06.18 - 2013.06.19 CHECKED BY MEF

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
194.7	GROUND SURFACE										
0.0	**ASPHALT:** (115mm)										
0.1 / 194.3	**CONCRETE:** (250mm)										
0.4	Sandy **GRAVEL**, trace silt Compact Brown Moist to Wet (FILL)		1	SS	14		194		○		
			2	SS	29		193		○		64 33 3 (SI+CL)
			3	SS	11	▼	192		○		
			4	SS	20		191		○		72 27 1 (SI+CL)
			5	SS	19		190		○		
188.6							189				
6.1	Silty **CLAY**, trace sand Soft to Firm Grey Wet		6	SS	7		188	3.0 +	○		
			7	SS	2		187		○		
							186				
							185				

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

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

ONTMT4S 1197.GPJ 2015TEMPLATE(MTO).GDT 6/4/15

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No OZC-02 2 OF 2 METRIC

WP# 6101-10-00 LOCATION Ozone Creek Bridge N 5 432 049.8 E 228 909.7 ORIGINATED BY GA

HWY 17 BOREHOLE TYPE NW Casing/NQ Coring COMPILED BY AN

DATUM Geodetic DATE 2013.06.18 - 2013.06.19 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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	Silty **CLAY**, trace sand Soft to Firm Grey Wet							3.0 +			
							184				
	Sand layer at 11.3m		8	SS	2						0 0 40 60
183.1	End of sampling at 11.6m and start coring										
11.6	**GRANITIC GNEISS**, fresh, coarse grained, pink/white and black/white, very strong, occasional horizontal joints and mechanical breaks						183			FI 1 0	RUN #1 TCR=100% SCR=100% RQD=97% UCS=118MPa (Average)
			1	RUN						0	
	Horizontal joint at 11.6m						182			0	
										0	
	Sub-horizontal joint at 13.4m									1	RUN #2 TCR=100% SCR=100% RQD=100% UCS=119MPa (Average)
							181			0	
	Horizontal joint at 13.7m and 13.9m		2	RUN						2	
180.1										0	
14.6	END OF BOREHOLE AT 14.6m. BOREHOLE OPEN TO 14.6m AND WATER LEVEL AT 5.8m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 4.5m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Jun. 20/13 2.5 192.2 Jul. 09/13 2.4 192.3										

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

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

ONTMT4S 1197.GPJ 2015TEMPLATE(MTO).GDT 6/4/15

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No OZC-03 1 OF 2 METRIC

WP# 6101-10-00 LOCATION Ozone Creek Bridge N 5 432 043.0 E 228 923.3 ORIGINATED BY GA

HWY 17 BOREHOLE TYPE NW Casing/NQ Coring COMPILED BY AN

DATUM Geodetic DATE 2013.06.19 - 2013.06.20 CHECKED BY MEF

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
194.7	GROUND SURFACE						
0.0	**ASPHALT:** (90mm)						
0.1	**CONCRETE:** (400mm)						
194.2							
0.5	**SAND** and **GRAVEL**, trace silt Compact to Dense Brown Wet (FILL)		1	SS	16		
			2	SS	42		
	Occasional cobbles		3	SS	40		
191.7							
3.0	Sandy **GRAVEL**, trace silt Compact Brown/Grey Wet (FILL)		4	SS	13		
			5	SS	13		
188.8							
5.9	**SAND**, occasional gravel Compact Grey Wet (FILL)		6	SS	11		
188.0							
6.7	Wood fragments (0.3m) at 6.7m						
	Silty **CLAY** Soft Grey Wet		7	SS	2		
			1	TW			

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/m^3

REMARKS & GRAIN SIZE DISTRIBUTION (%)

GR	SA	SI	CL	
51	46	3		(SI+CL)
0	0	24	76	

ELEVATION SCALE: 194 193 192 191 190 189 188 187 186 185

3.0

Continued Next Page

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

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

ONTMT4S 1197.GPJ 2015TEMPLATE(MTO).GDT 6/4/15

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No OZC-03 2 OF 2 METRIC

WP# 6101-10-00 LOCATION Ozone Creek Bridge N 5 432 043.0 E 228 923.3 ORIGINATED BY GA

HWY 17 BOREHOLE TYPE NW Casing/NQ Coring COMPILED BY AN

DATUM Geodetic DATE 2013.06.19 - 2013.06.20 CHECKED BY MEF

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page							20 40 60 80 100	20 40 60		
	Silty **CLAY** Soft Grey Wet							3.0			
			8	SS	2		184		○		
							183	3.0			
			2	TW			182				
181.3	End of sampling at 13.4m and start coring									FI	
13.4	**GRANITIC GNEISS**, fresh, coarse grained, pink/white and black/white, very strong, occasional horizontal joints and mechanical breaks		1	RUN			181			0 0 0 0 1	RUN #1 TCR=100% SCR=100% RQD=83% UCS=113MPa (Average)
	Horizontal joint at 15.6m, 15.8m, 16.0m, 16.2m Sub-vertical joint at 15.5m, 16.1m, 16.7m		2	RUN			180 179			0 0 2 2 3	RUN #2 TCR=100% SCR=100% RQD=90% UCS=113MPa (Average)
177.7	Horizontal joint at 16.7m, 16.8m		3	RUN			178			2 1	RUN #3 TCR=100% SCR=100% RQD=86% ~~UCS=122MPa~~ (Average)
17.0	END OF BOREHOLE AT 17.0m. BOREHOLE OPEN TO 17.0m AND WATER LEVEL AT 3.0m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 4.5m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Jun. 26/13 2.5 192.2 Jul. 09/13 3.5 191.2										

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

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

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Ontario

THURBER

RECORD OF BOREHOLE No OZC-04 1 OF 2 METRIC

WP# 6101-10-00 LOCATION Ozone Creek Bridge N 5 432 049.9 E 228 936.3 ORIGINATED BY GA

HWY 17 BOREHOLE TYPE NW Casing COMPILED BY AN

DATUM Geodetic DATE 2013.06.17 - 2013.06.18 CHECKED BY MEF

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS
194.7	GROUND SURFACE					
0.0	**ASPHALT:**(100mm)					
0.1	**SAND** and **GRAVEL**, trace silt Very Dense Brown Wet (FILL)		1	SS	54	
			2	SS	50	
			3	SS	50	
			4	SS	89	
191.7						
3.0	**SAND**, trace gravel Very Dense Brown Wet (FILL)		5	SS	98	▽
190.1						
4.6	Silty **CLAY**, varved Soft to Stiff Grey Wet		6	SS	14	
	Occasional sand layers		7	SS	9	
			8	SS	3	
			9	SS	2	

ELEVATION SCALE: 194, 193, 192, 191, 190, 189, 188, 187, 186, 185

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
	38	56	6 (SI+CL)	

4.0

Continued Next Page

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

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

ONTMT4S 1197.GPJ 2015TEMPLATE(MTO).GDT 6/4/15

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No OZC-04 2 OF 2 METRIC

WP# 6101-10-00 LOCATION Ozone Creek Bridge N 5 432 049.9 E 228 936.3 ORIGINATED BY GA

HWY 17 BOREHOLE TYPE NW Casing COMPILED BY AN

DATUM Geodetic DATE 2013.06.17 - 2013.06.18 CHECKED BY MEF

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page							20 40 60 80 100	20 40 60		
	Silty **CLAY**, varved Soft to Stiff Grey Wet						184				
			10	SS	2				○		
							183	3.0 +			
			11	SS	2				○		0 0 38 62
							182				
			12	SS	2		181		○		
179.8											
14.9	**SILT**, some clay, trace sand Compact Grey Wet						180				
			13	SS	29				○		0 2 86 12
178.9							179				
15.8	END OF BOREHOLE AT 15.8m. BOREHOLE OPEN TO 15.8m AND WATER LEVEL AT 3.4m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.6m, CONCRETE TO 0.1m THEN ASPHALT PATCH TO SURFACE.										

+ 3 , × 3 : Numbers refer to Sensitivity

20
15 5
10
(%) STRAIN AT FAILURE

ONTMT4S 1197.GPJ 2015TEMPLATE(MTO).GDT 6/4/15

Appendix B

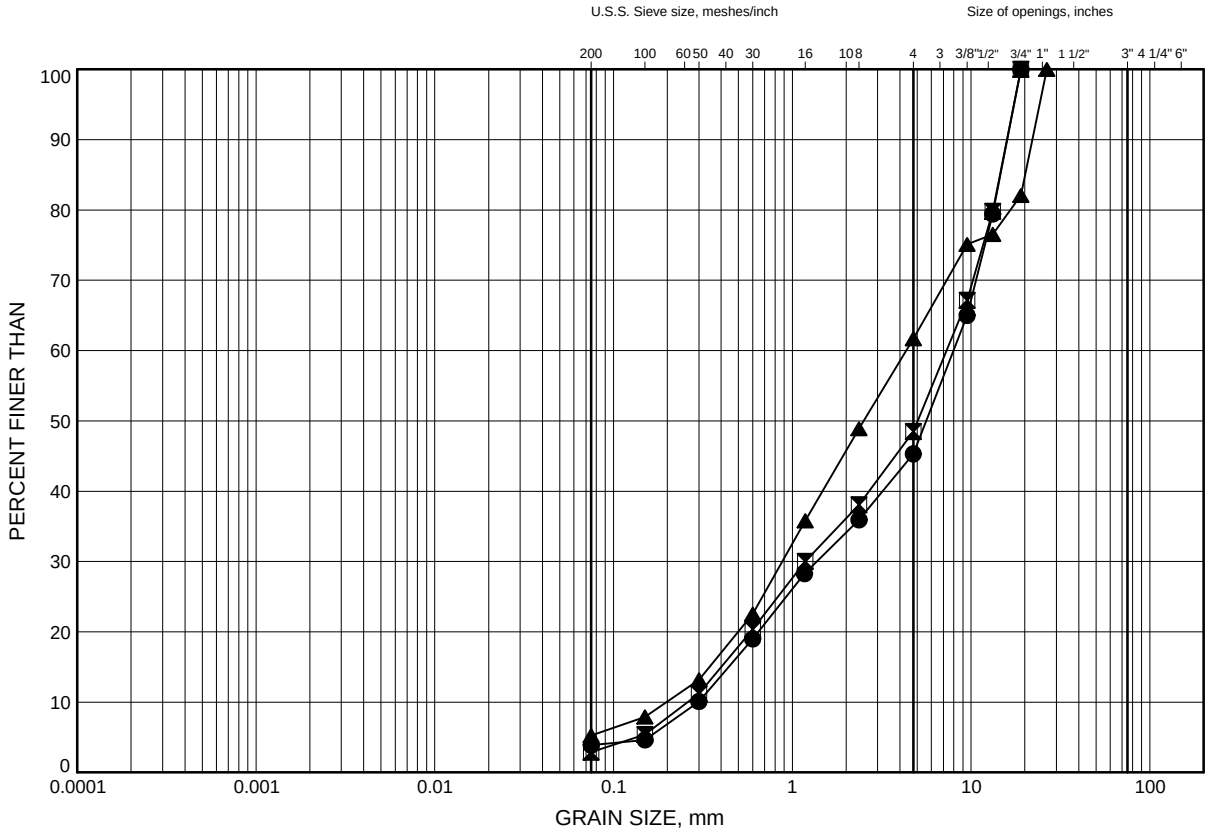
Laboratory Test Results
Soil and Rock

Ozone Creek Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B1

SAND & GRAVEL FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	OZC-01	4.88	189.82
⊠	OZC-03	2.59	192.11
▲	OZC-04	2.59	192.11

Date June 2015

WP# 6101-10-00

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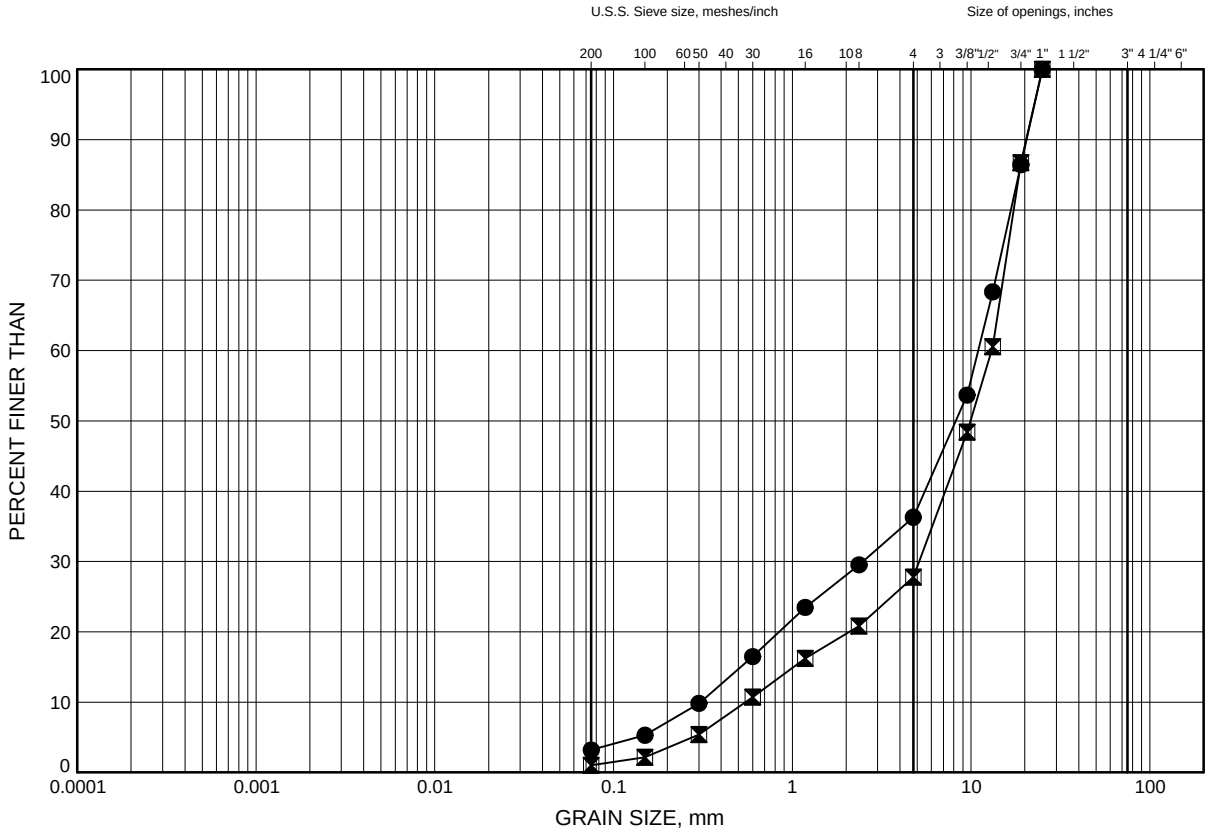
GRAIN SIZE DISTRIBUTION - THURBER 1197.GPJ 6/4/15

Ozone Creek Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B2

SANDY GRAVEL FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	OZC-02	1.83	192.87
⧓	OZC-02	3.35	191.35

GRAIN SIZE DISTRIBUTION - THURBER 1197.GPJ 6/4/15

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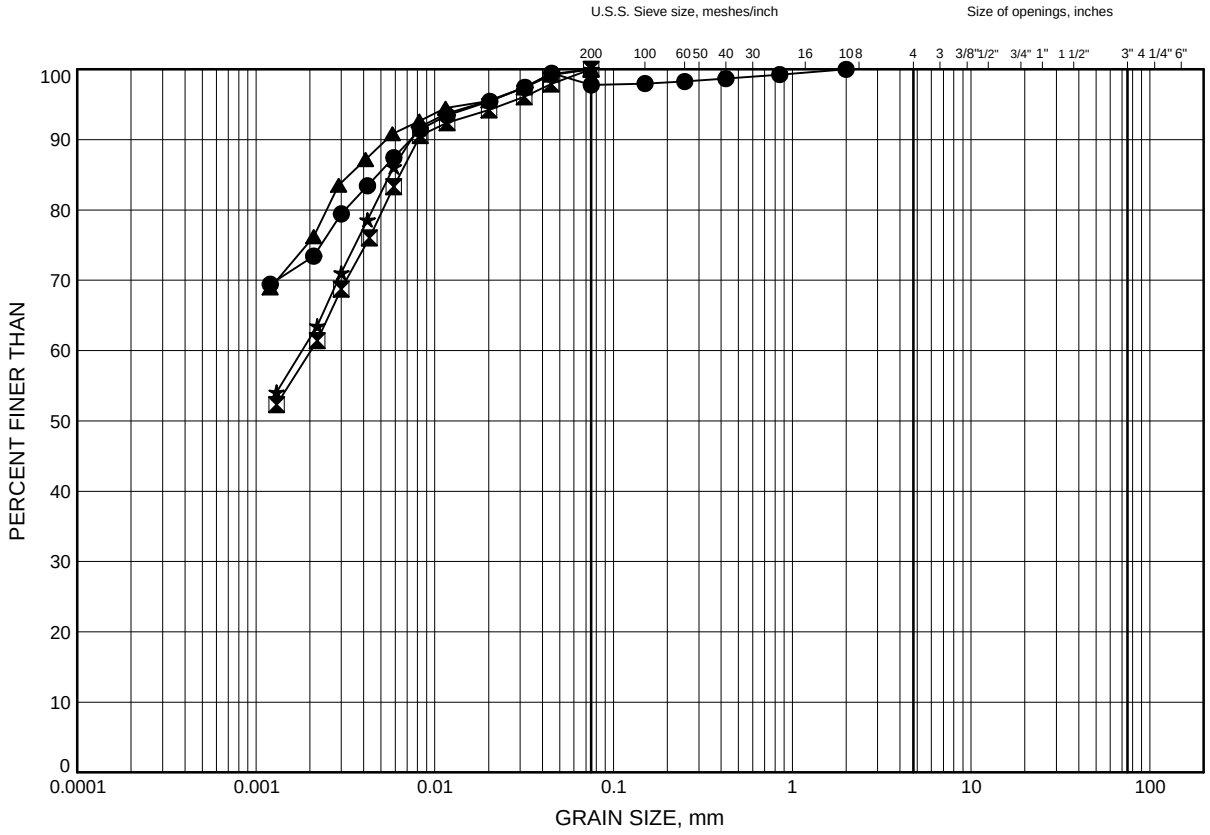
Ozone Creek Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B3

SILTY CLAY



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	OZC-01	6.40	188.30
⊠	OZC-02	10.97	183.73
▲	OZC-03	7.92	186.78
★	OZC-04	12.50	182.20

Date June 2015

WP# 6101-10-00

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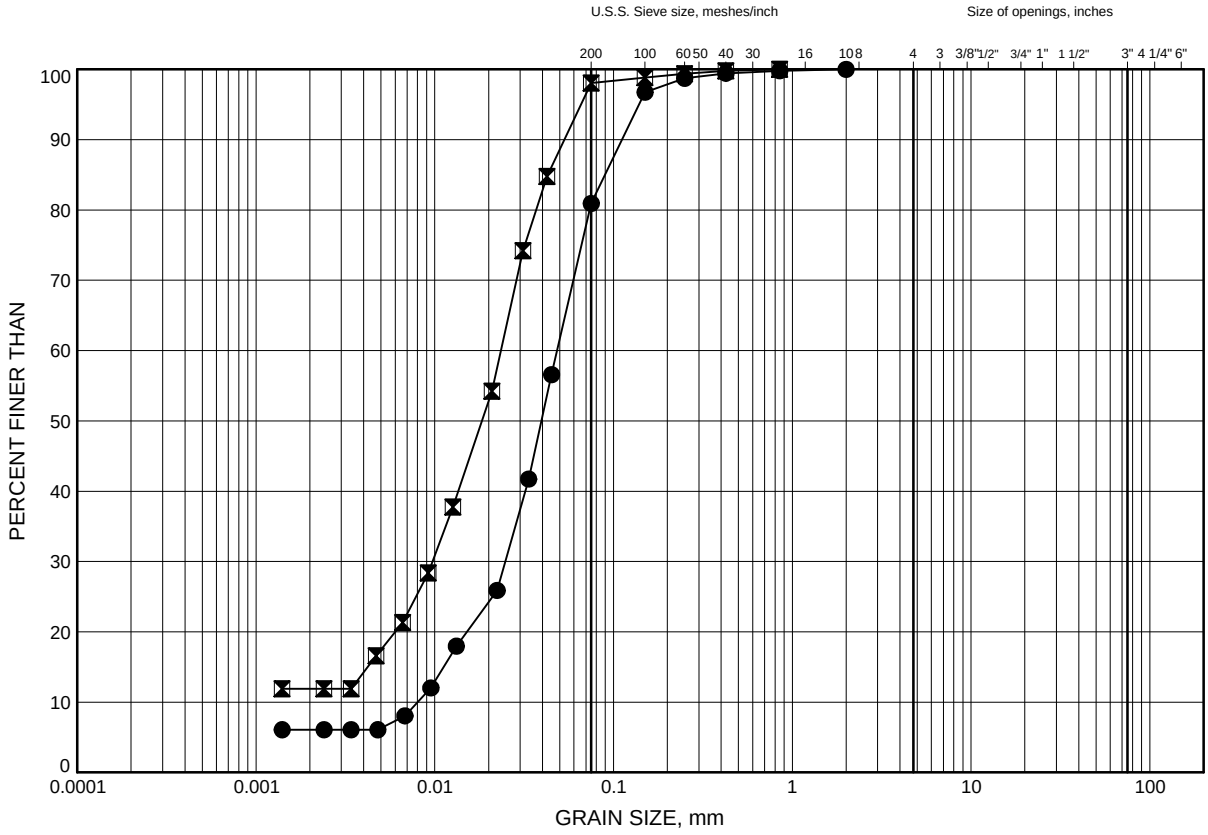
GRAIN SIZE DISTRIBUTION - THURBER 1197.GPJ 6/4/15

Ozone Creek Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B4

SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	OZC-01	9.45	185.25
⧓	OZC-04	15.54	179.16

GRAIN SIZE DISTRIBUTION - THURBER 1197.GPJ 6/4/15

Date June 2015

WP# 6101-10-00

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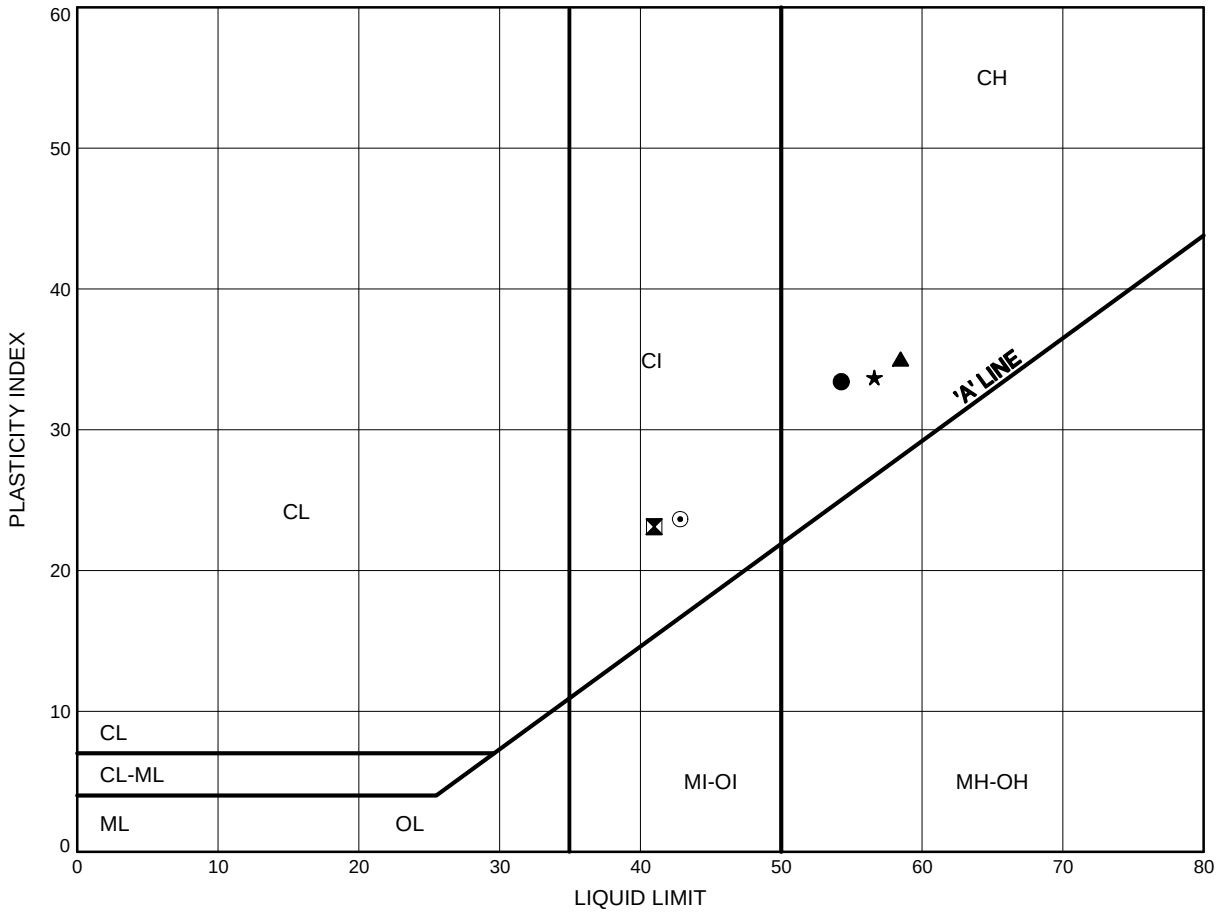
Ozone Creek Bridge

ATTERBERG LIMITS TEST RESULTS

FIGURE B5

SILTY CLAY



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	OZC-01	6.40	188.30
⊠	OZC-02	10.97	183.73
▲	OZC-03	7.92	186.78
★	OZC-04	6.40	188.30
⊙	OZC-04	12.50	182.20

Date June 2015

WP# 6101-10-00

THURBER

Prep'd AN

Chkd. AMP

THURBALT 1197.GPJ 6/4/15

THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS

POINT LOAD TEST SHEET

Job No :	19-1351-197	**Client :**	MRC
		Date Drilled :	22/6/2013
Project Name :	Ozone Creek / HWY 17	**Date Tested :**	3/7/2013
Core Size :	NQ **BH No :** OZC-02	**Tester :**	ISP

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (kPa)	Diameter (mm)	Length (mm)	UCS (MPa)	Rock Type	Notes
1	1	11.7	D	7260	47.3	103.5	72.0	Granite	
2	1	12.0	D	12140	47.1	89.7	121.2	Granite	
3	1	12.4	D	9060	47.2	99.0	90.1	Granite	
4	1	12.8	D	19030	47.3	105.8	188.6	Granite	
5	2	13.2	D	4410	47.4	92.4	43.6	Granite	
6	2	13.6	D	16030	47.4	112.2	158.5	Granite	
7	2	14.1	D	16630	47.3	87.2	165.1	Granite	
8	2	14.6	D	10780	47.2	102.7	107.2	Granite	
9									
10									
11						Run 1	118.0		Very Strong
12						Run2	118.6		Very Strong
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									
23									
24									
25									
26									
27									
28									
29									
30									

* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

* Diametral Test should have 0.7 x D on either side of test point.

THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS

POINT LOAD TEST SHEET

Job No :	19-1351-197	**Client :**	MRC
		Date Drilled :	20/6/2013
Project Name :	Ozone Creek / HWY17	**Date Tested :**	3/7/2013
Core Size :	NQ **BH No :** OZC-03	**Tester :**	ISP

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (kPa)	Diameter (mm)	Length (mm)	UCS (MPa)	Rock Type	Notes
1	1	13.5	D	12530	46.8	83.7	126.2	Granite	
2	1	13.6	D	10970	47.1	116.2	109.6	Granite	
3	1	14.3	D	14950	47.0	125.2	149.7	Granite	
4	1	14.8	D	12720	47.6	128.3	125.0	Granite	
5	2	15.0	D	12550	47.4	103.0	124.3	Granite	
6	2	15.5	D	15960	47.4	129.1	157.8	Granite	
7	2	16.0	D	22010	47.2	96.7	219.0	Granite	
8	2	16.4	D	9030	47.3	123.1	89.4	Granite	
9	3	16.5	D	18730	47.3	108.2	185.7	Granite	
10	3	16.8	D	15220	47.3	134.9	151.2	Granite	
11									
12					RUN1	113.4			
13					RUN2	113.0			
14					RUN3	121.5			
15									
16									
17									
18									
19									
20									
21									
22									
23									
24									
25									
26									
27									
28									
29									
30									

* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

* Diametral Test should have 0.7 x D on either side of test point.

Photograph 1 – Rock core recovered from Borehole OZC-02

Photograph 2 – Rock core recovered from Borehole OZC-03

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Appendix C

Site Photographs

Photograph 1 – Ozone Creek Culvert looking east along Highway 17

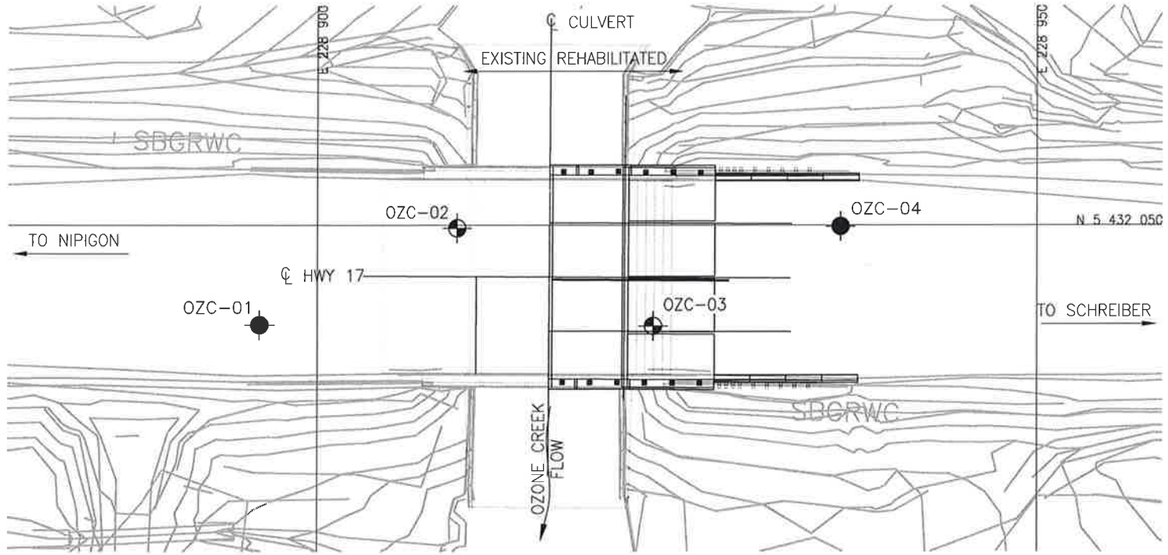
Photograph 2 – Ozone Creek Culvert looking west along Highway 17

Photograph 3 – North Elevation of Ozone Creek Culvert

Photograph 4 – South Elevation of Ozone Creek Culvert

Appendix D

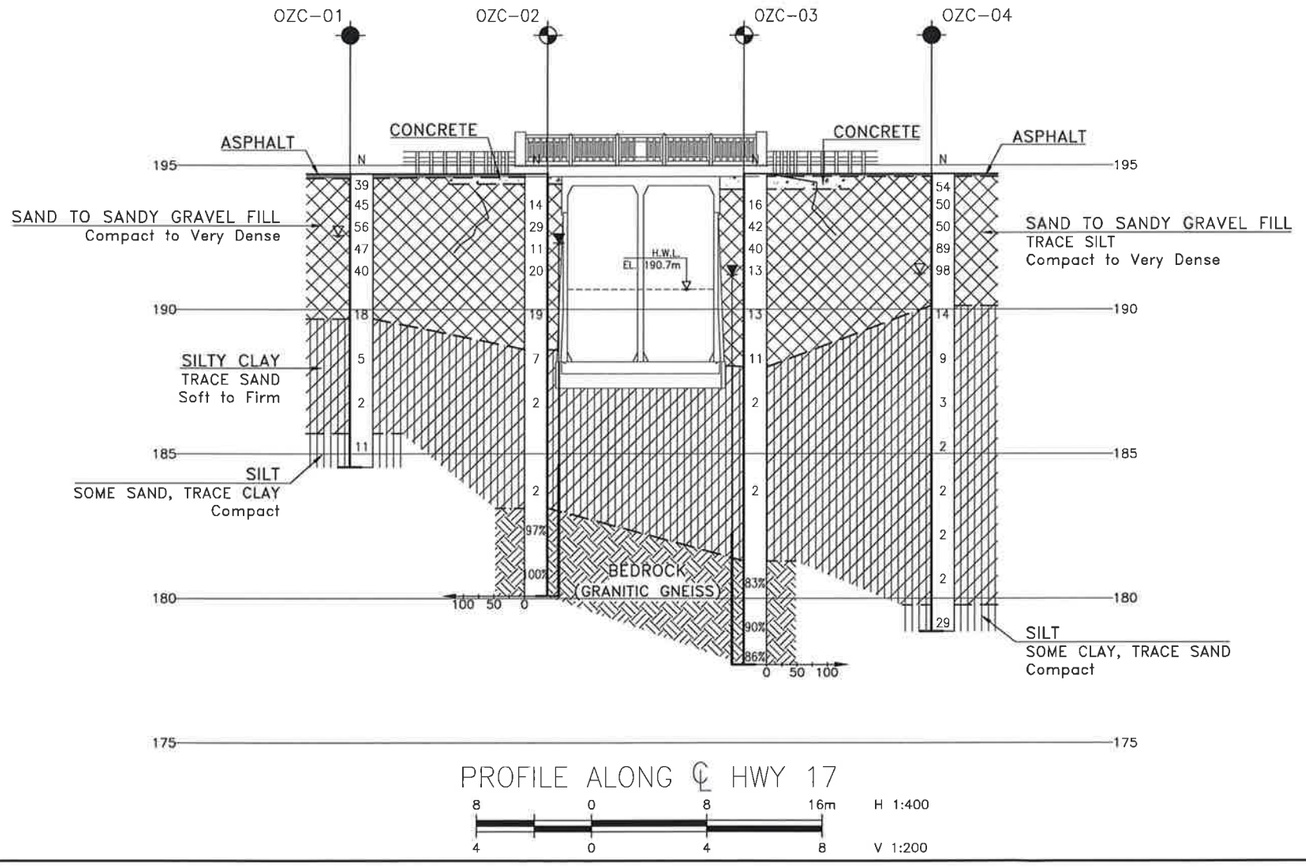
Borehole Locations and Soil Strata Drawing



PLAN

8 0 8 16m

SCALE 1:400



PROFILE ALONG ℄ HWY 17

8 0 8 16m H 1:400

4 0 4 8 V 1:200

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

LICENSED PROFESSIONAL ENGINEER
M. R. ANDERSON
June 8/15
PROVINCE OF ONTARIO

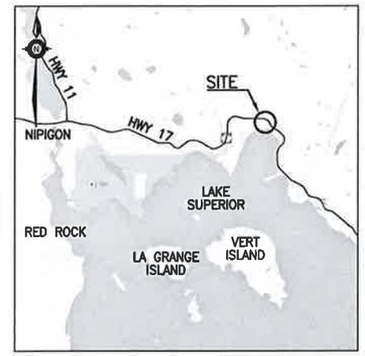
LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
June 8/15
PROVINCE OF ONTARIO

CONT No
WP No 6101–10–01

HIGHWAY 17
OZONE CREEK CULVERT
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET 11

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

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

NO	ELEVATION	NORTHING	EASTING
OZC–01	194.7	5 432 043.1	228 896.0
OZC–02	194.7	5 432 049.8	228 909.7
OZC–03	194.7	5 432 043.0	228 923.3
OZC–04	194.7	5 432 049.9	228 936.3

-NOTES-

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

GEOCRES No. 52H-29

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN ANP	CHK ANP	CODE	LOAD	DATE JUNE 2015	
DRAWN AN	CHK	SITE 48C–112	STRUCT	DWG 1	

FILENAME: H:\Drafting\19\135\197\Ozone Creek Culvert\Ued1197-BoreholePlan&Profile (Ozone Creek).dwg
PLOTDATE: 6/8/2015 11:05 AM