

**FOUNDATION INVESTIGATION REPORT
CENTERLINE CULVERT REPLACEMENT
NEW LISKEARD DISTRICT, ONTARIO
G.W.P. No. 5196-13-00, W.P. No. 5141-14-01
Geocres Number: 42A-108**

Report to

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Replacement 5014-E-0019\Reports & Memos\Centerline
Culvert\Final FIDR & FIR\Final FIR\Centerline Culvert-Final
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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual data obtained from a foundation investigation conducted by Thurber Engineering Ltd. (Thurber) at the centerline culvert on Highway 572, located on the border of the Hislop and Guibord Townships, New Liskeard District, Ontario.

The purpose of this investigation was to obtain subsurface information at the culvert location and, based on the data obtained, to provide borehole location plans, stratigraphic profiles, records of boreholes, laboratory test results, and a written description of the subsurface conditions.

Thurber was retained by MMM Group Limited to carry out this foundation investigation under the MTO Assignment Number 5014-E-0019.

2 SITE DESCRIPTION

The culvert site is located on Highway 572, approximately 450 m north of the Pike River Bridge in the Township of Hislop/Guibord, New Liskeard District, Ontario. This culvert facilitates the flow of an unnamed creek, from west to east, under Highway 572. Highway 572 is oriented in the north-south direction at the culvert site.

Based on the terms of reference, the existing structure consists of a 2.4 m diameter and 23.4 m long corrugated steel pipe (CSP) culvert. The embankment fill at the culvert location is between 5.5 m and 6 m in height. The culvert is proposed for full replacement.

The grade level of Highway 572 at the existing culvert is at approximate Elevation 288.0 m.

The site is located approximately 14 km southwest of Matheson. Naturally elevated areas slope downwards towards the creek with vegetation consisting of tall grass and shrubs and frequent trees. The local topography is generally of low relief with no visible bedrock outcrops.

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

clays, but massive clays are also present in some areas. Below the clays are glacial outwash deposits of silts, sands and gravel underlain by Precambrian ultramafic to metavolcanic bedrock.

3 SITE INVESTIGATION AND FIELD TESTING

The borehole investigation and field testing program was carried out between February 20 and March 9, 2016. The program consisted of drilling and sampling 4 boreholes, numbered CC-01 to CC-04, to depths ranging from 5.2 to 15.4 m. Dynamic Cone Penetration Tests (DCPTs) were carried out below the sampled portion of Boreholes CC-01 and CC-02 to depths of 7.3 and 6.4 m respectively. Borehole CC-01 was located near the culvert inlet, and Borehole CC-04 was located near the culvert outlet, Boreholes CC-02 and CC-03 were located on the road embankment.

Prior to the start of drilling, the borehole locations were marked/staked 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 borehole locations are shown on the Borehole Locations and Soil Strata drawing included in Appendix D.

A track-mounted CME 45 drill rig was used to advance Borehole CC-02 and CC-03 to the target depth using NW casing/wash boring techniques. A portable tripod drill rig was used to advance Boreholes CC-01 and CC-04 to the target depth due to difficult access for a conventional drill rig beyond the road embankment. Soil samples were obtained at selected intervals using a 50 mm diameter split spoon sampler in conjunction with Standard Penetration Testing (SPT). Groundwater conditions in the open boreholes were observed throughout the drilling operations. Upon completion of drilling and final water reading, the boreholes were decommissioned in general accordance with O.Reg. 903. The details regarding borehole completion are summarized in Table 3.1.

Table 3.1 - Borehole Completion and Backfilling Details

Borehole	Borehole Depth/ Elevation (m)	DCPT Depth/ Elevation (m)	Borehole Backfilling Details
CC-01	6.7 / 276.3	7.3 / 275.7	Bentonite holeplug from 7.3 m to ground surface.
CC-02	15.4 / 272.6	N/A	Bentonite holeplug and cuttings from 15.4 m to 0.1 m and asphalt cold patch to ground surface.
CC-03	14.0 / 274.0	N/A	Bentonite holeplug from 14.0 m to 0.2 m and asphalt cold patch to ground surface.
CC-04	5.2 / 278.0	6.4 / 276.8	Bentonite holeplug from 6.4 m to ground surface.

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

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

4 LABORATORY TESTING

All recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected soil samples were subjected to grain size distribution analyses (sieve and hydrometer) and plasticity testing (Atterberg Limits). The results of this laboratory testing program are shown on the Record of Borehole sheets in Appendix A and on Figures in Appendix B.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

5.1 General

Reference is made to the Record of Borehole sheets in Appendix A for details of the soil stratigraphy encountered in the boreholes. A stratigraphic profile for this culvert site are presented on the Borehole Locations and Soil Strata Drawing in Appendix D for illustrative purposes. An overall description of the stratigraphy is given in the following paragraphs; however, the factual data presented in the records of boreholes governs any interpretation of the site conditions. The subsurface conditions may vary between and beyond borehole locations.

The boreholes were drilled at the locations shown on the Borehole Location and Soil Strata drawing. It was not feasible to investigate the ground conditions immediately under the existing culvert and these may vary from the conditions encountered in the boreholes.

In general, underlying the embankment fill is a deposit of silty clay which grades with depth to a clayey silt. The clayey silt is underlain by a cohesionless till ranging in composition from a silty sand to sand and silt. Near the culvert inlet and outlet, a thin veneer of topsoil overlies the silty clay and subsequent layers. More detailed descriptions of the encountered strata are presented below.

5.2 Topsoil

A layer of topsoil with a thickness of 150 mm was encountered at the ground surface in Boreholes CC-01 and CC-04, near the culvert inlet and outlet. The topsoil thickness may vary between and beyond the borehole locations, and the limited data is not suitable for estimating topsoil quantities.

5.3 Asphalt

Asphalt was encountered at the ground surface in Boreholes CC-02 and CC-03. The thickness of the asphalt ranged from 30 to 75 mm at the borehole locations.

5.4 Fill

Embankment fill was encountered in Boreholes CC-02 and CC-03 underlying the asphalt. This fill consisted of brown sand to sand and gravel with trace to some silt and occasional cobbles. Large size rock fill protection was observed at the outlet of the culvert and frequent cobbles were noted at the culvert inlet. The thickness of the embankment fill was 5.5 m with a lower boundary at depths of 5.5 to 5.6 m (base Elevations 282.4 to 282.5 m).

SPT N-values measured in the fill ranged from 1 blow per 0.3 m penetration to 50 blows per 0.15 m penetration indicating a typically very loose to very dense relative density. The high 'N' values may be attributed to the presence of cobbles in the fill. Measured moisture contents of the recovered fill samples ranged between 1% and 34%.

Grain size analyses conducted on samples of the fill are presented on Figure B1 in Appendix B. These results are summarized in the following table.

Soil Particles	%
Gravel	0 to 41
Sand	54 to 95
Silt and Clay	4 to 14

5.5 Silty Clay

Silty clay was encountered in all boreholes drilled at the site either underlying the topsoil or the embankment fill. The fill was brown to grey and contained trace sand and gravel and occasional rootlets and wood fibres at shallow depths. The thickness of the silty clay ranged from 1.7 to 3.1 m with a lower boundary at depths of 2.4 to 8.7 m (Elevations 280.8 to 279.3).

SPT N-values measured in the silty clay typically ranged between 5 and 23 blows per 0.3 m penetration, with most values lying between 10 and 14 blows which indicates a typically stiff consistency with occasional firm and very stiff zones. The measured water contents of samples recovered of the silty clay typically ranged from 14% to 43% with most values between 27% and 43%.

Grain size analyses conducted on samples of the silty clay are presented on Figure B2 and Atterberg Limits test results are presented on Figure B6 in Appendix B. The results are summarized in the following table.

Soil Particles	%
Gravel	0
Sand	0 to 3
Silt	46 to 49
Clay	51

Soil Property	%
Liquid Limit	38 to 44
Plasticity Index	22 to 24

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

5.6 Clayey Silt

Clayey silt with trace to some sand and gravel was encountered in Boreholes CC-01, CC-03 and CC-04 underlying the silty clay. The thickness of the clayey silt ranged from 1.3 to 3.0 m with a lower boundary at depths of 4.0 to 10.2 m (Elevations 279.0 to 277.8).

SPT N-values measured in the clayey silt typically ranged between 9 and 32 blows per 0.3 m penetration, indicating a stiff to hard consistency. The measured water contents of the clayey silt samples typically ranged from 27% to 39%.

Grain size analyses conducted on samples of the clayey silt are presented on Figure B3 and Atterberg Limits test results are presented on Figure B7 in Appendix B. The results are summarized in the following table.

Soil Particles	%
Gravel	0 to 20
Sand	0 to 14
Silt	46 to 76
Clay	20 to 24
Soil Property	%
Liquid Limit	24
Plasticity Index	6

The results of the Atterberg Limits tests indicate that the clayey silt is low plasticity (CL-ML).

5.7 Sand to Sand and Silt Till

A sand to sand and silt till deposit was encountered underlying the silty clay deposit in Borehole CC-02 and the clayey silt in Boreholes CC-01, CC-03 and CC-04. The till contained trace to some gravel, trace clay and occasional cobbles and boulders. All boreholes were terminated in this till at depths ranging from 5.2 m to 15.4 m (Elevations 278.0 to 272.6).

SPT N-values measured in the till typically ranged from 13 blows per 0.3 m penetration to more than 100 blows per 0.3 m penetration, indicating a compact to very dense relative density. The measured water contents of samples recovered of the deposit typically ranged from 9% to 21%.

A grain size analysis conducted on a sample of the sand and silt till is presented on Figure B4 in Appendix B. These results are summarized in the following table.

Soil Particles	%
Gravel	18
Sand	39
Silt and Clay	43

A layer of sand and gravel with trace silt was encountered in Borehole CC-02 within the sand to sand and silt deposit. Boulders were noted in this layer. The thickness of this layer was 1.4 m with a base depth of 11.2 m (Elevation 276.4). One SPT value recorded in this deposit was 35 blows per 0.3 m penetration indicating a dense relative density. One measured water content in the layer was 15%.

A grain size analysis conducted on a sample of the sand and gravel layer is presented on Figure B5 in Appendix B. These results are summarized in the following table.

Soil Particles	%
Gravel	49
Sand	41
Silt and Clay	10

Below the sampled depth in Boreholes CC-01 and CC-04, a DCPT was carried out within the till to depths of 7.3 and 6.4 m respectively (Elevation 275.7 and 276.8). Practical refusal was encountered in the DCPT in Borehole CC-04 (100 blows per 0.3 m penetration).

5.8 Groundwater Conditions

Free water was observed in most of the boreholes upon completion of drilling and are presented below.

Table 5.1 – Water Level Measurements in Open Boreholes

Borehole	Date of Reading	Water Level	
		Depth (m)	Elevation (m)
CC-01	March 4, 2016	1.2	281.8
CC-03	March 9, 2016	5.4	282.6
CC -04	March 4, 2016	2.1	281.1

These are short term observations and the groundwater level should be assumed to coincide with the local creek water level.

The surveyed water level in the creek was at Elev. 282.3 at the east end of the culvert and at Elev. 281.7 at the west end of the culvert on June 2015.

The groundwater levels and water level in the creek are expected to vary seasonally in response to severe weather events.

6 CORROSIVITY AND SULPHATE TEST RESULTS

A sample of the surface water from the creek was 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	Units	Centerline (Creek Water)
Sulphide	mg/L	<0.05
Chloride	mg/L	4.86
Sulphate	mg/L	1.49
pH	pH Units	7.73
Electrical Conductivity	µS/cm	175
Resistivity	ohm.cm	5710
Redox Potential	mV	385

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 and operated a track-mounted CME-45 hi-torque drill rig and portable tripod drill rig to carry out the drilling, sampling and in-situ testing operations for two boreholes on the road embankment, one borehole at the culvert inlet and one borehole at the culvert outlet. The drilling and sampling operations in the field were supervised on a full time basis by Mr. Amir Fereidouni and Mr. George Azzopardi 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.

Ms. Deanna Pizycki, EIT, interpreted the data and prepared the report. The report was reviewed by Ms. Anna Piascik, P.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

THURBER ENGINEERING LTD

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28 JUL 16

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Appendix A
Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction

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



4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

5. LEGEND FOR RECORDS OF BOREHOLES

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

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

 Water Level
 Shear Strength Determination by Pocket Penetrometer

- (1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

EXPLANATION OF ROCK LOGGING TERMS


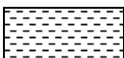



ROCK WEATHERING CLASSIFICATION

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		Field Estimation of Hardness*
	(MPa)	(psi)	
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			

RECORD OF BOREHOLE No CC-01

1 OF 1

METRIC

GWP# 5196-13-00 LOCATION Centerline Culvert N 5 374 041.1 E 358 351.9 ORIGINATED BY GA
 HWY 572 BOREHOLE TYPE Tripod/NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2016.03.04 - 2016.03.04 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 γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE				WATER CONTENT (%) w _P w w _L				GR	SA	SI	CL
283.0	GROUND SURFACE							20	40	60	80	100							
0.0	TOPSOIL: (150mm)							20	40	60	80	100							
0.2	Silty CLAY , trace sand, trace gravel, trace organic matter (rootlets) Stiff Dark Brown to Grey Moist		1	SS	14		282												
			2	SS	10														
			3	SS	10														
280.6								281											
2.4	Clayey SILT , some sand, some gravel Stiff Grey Moist		4	SS	12			280											
			5	SS	9														
279.0								279											
4.0	SAND and SILT to Silty SAND , some gravel, trace clay Compact Grey Wet (TILL)		6	SS	16		278												
							277												
			7	SS	20														
276.3							276												
6.7	End of sampling at 6.7m upon casing refusal. Start of DCPT																		
275.7																			
7.3	END OF DCPT AT 7.3m UPON CONE REFUSAL. BOREHOLE OPEN TO 7.3m AND WATER LEVEL AT 1.2m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.																		

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No CC-02

1 OF 2

METRIC

GWP# 5196-13-00 LOCATION Centerline Culvert N 5 374 027.1 E 358 365.7 ORIGINATED BY AHF
 HWY 572 BOREHOLE TYPE NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2016.02.20 - 2016.02.20 CHECKED BY DJP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)							
								20 40 60 80 100	20 40 60	20 40 60	20 40 60								
288.0	GROUND SURFACE																		
0.0 0.1	ASPHALT: (75mm)																		
	SAND and GRAVEL, trace silt Very Loose to Compact Brown Moist (FILL)		1	SS	28														
			2	SS	7														
			3	SS	1														
			4	SS	2														
283.9																			
4.1	SAND, trace silt Loose Brown Wet (FILL)		5	SS	7														
282.4																			
5.6	Silty CLAY, trace sand, trace gravel, occasional cobbles Stiff Grey Moist		6	SS	11														
			7	SS	10														
279.3																			
8.7	Silty SAND to SAND, some to trace gravel, occasional sand and gravel layer, occasional cobbles and boulders Compact to Very Dense Grey Wet (TILL)		8	SS	13														

Continued Next Page

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No CC-02

2 OF 2

METRIC

GWP# 5196-13-00 LOCATION Centerline Culvert N 5 374 027.1 E 358 365.7 ORIGINATED BY AHF
 HWY 572 BOREHOLE TYPE NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2016.02.20 - 2016.02.20 CHECKED BY DJP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div> <div><div>PLASTIC LIMIT</div><div>NATURAL MOISTURE CONTENT</div><div>LIQUID LIMIT</div><div>W_P W W_L</div><div>WATER CONTENT (%)</div></div>													
	Continued From Previous Page												
	300mm boulder at 10.4m	0 4 0											
	500mm sand and gravel layer at 10.7m	0 4 0	9	SS	35		277				○		
	300mm boulder at 11.6m	0 4 0											
		0 4 0	10	SS	180/ 0.200		276				○		
	Cobbles and boulders from 13.1m to 13.6m	0 4 0					275						
		0 4 0	11	SS	100/ 0.075		274				○		
	Cobbles and boulders from 14.0m to 14.9m	0 4 0					273				○		
272.6		0 4	12	SS	100/ 0.125								
15.4	END OF BOREHOLE AT 15.4m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.1m, THEN ASPHALT COLD PATCH TO SURFACE.												

ONTMT4S 19-5161-251.GPJ 2015TEMPLATE(MTO).GDT 4/11/16

RECORD OF BOREHOLE No CC-03

1 OF 2

METRIC

GWP# 5196-13-00 LOCATION Centerline Culvert N 5 374 035.5 E 358 369.6 ORIGINATED BY GA
 HWY 572 BOREHOLE TYPE NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2016.03.09 - 2016.03.09 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 γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)					GR	SA	SI	CL
								20	40	60	80	100	20	40	60					
288.0	GROUND SURFACE																			
0.0	ASPHALT: (30mm)																			
	SAND, trace to some gravel, trace to some silt, occasional cobbles Dense to Very Dense Brown Moist (FILL)		1	SS	59													12	74	14 (SI+CL)
			2	SS	89															
			3	SS	50/ 0.150															
			4	SS	40															
			5	SS	20															
	100mm cobble at 4.0m		6	SS	16															
282.5																				
5.5	Silty CLAY, trace sand, trace rootlets and wood fibres in upper 1.0m zone Stiff Grey Moist		7	SS	11															
280.8																				
7.2	Clayey SILT Very Stiff to Hard Grey Moist		8	SS	18															
			9	SS	32															

Continued Next Page

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

RECORD OF BOREHOLE No CC-03

2 OF 2

METRIC

GWP# 5196-13-00 LOCATION Centerline Culvert N 5 374 035.5 E 358 369.6 ORIGINATED BY GA
 HWY 572 BOREHOLE TYPE NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2016.03.09 - 2016.03.09 CHECKED BY AMP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
								20 40 60 80 100							
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE							
Continued From Previous Page							WATER CONTENT (%)								
277.8															
10.2	Silty SAND to SAND , some gravel, trace to some clay, occasional cobbles Very Dense Grey Wet (TILL)		10	SS	92		277								
							276								
			11	SS	114/ 0.150		275								
274.0			12	SS	124		274								
14.0	END OF BOREHOLE AT 14.0m. BOREHOLE OPEN TO 14.0m AND WATER LEVEL AT 5.4m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPUG TO 0.5m, CONCRETE TO 0.2m, THEN ASPHALT PATCH TO SURFACE.														


ONTMT4S 19-5161-251.GPJ 2015TEMPLATE(MTO).GDT 4/11/16

RECORD OF BOREHOLE No CC-04

1 OF 1

METRIC

GWP# 5196-13-00 LOCATION Centerline Culvert N 5 374 030.4 E 358 388.1 ORIGINATED BY GA
 HWY 572 BOREHOLE TYPE Tripod/NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2016.03.04 - 2016.03.04 CHECKED BY AMP

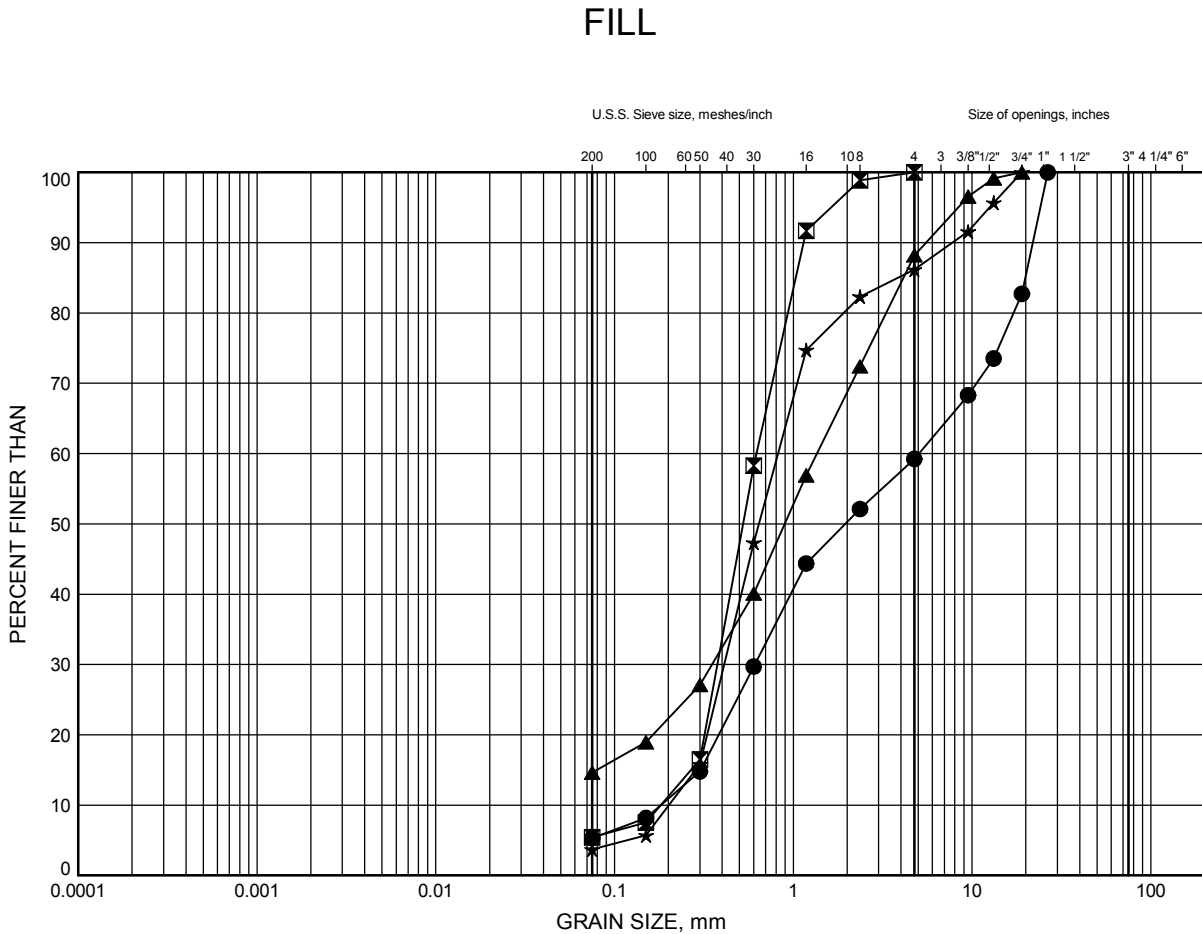
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT		UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W P W W L				
283.2	GROUND SURFACE													
0.0	TOPSOIL: (150mm)													
0.2	Silty CLAY , trace sand, occasional rootlets Firm to Very Stiff Grey Moist		1	SS	6		283							
			2	SS	7		282							
			3	SS	23		281							
			4	SS	5		280							
280.2	Clayey SILT Very Stiff Grey Moist		5	SS	24		279							
							278							
278.9	Silty SAND to SAND , some gravel, trace clay Dense Grey Wet (TILL)		6	SS	39									
278.0	End of sampling at 5.2m upon casing refusal. Start of DCPT													
276.8	END OF DCPT AT 6.4m UPON CONE REFUSAL. BOREHOLE OPEN TO 6.4m AND WATER LEVEL AT 2.1m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.													

ONTMT4S 19-5161-251.GPJ 2015TEMPLATE(MTO).GDT 4/11/16

Appendix B
Geotechnical and Analytical Laboratory Test Results

Centerline Culvert GRAIN SIZE DISTRIBUTION

FIGURE B1



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CC-02	1.07	286.93
⊠	CC-02	4.88	283.12
▲	CC-03	0.30	287.69
★	CC-03	3.35	284.64

Date April 2016
GWP# 5196-13-00

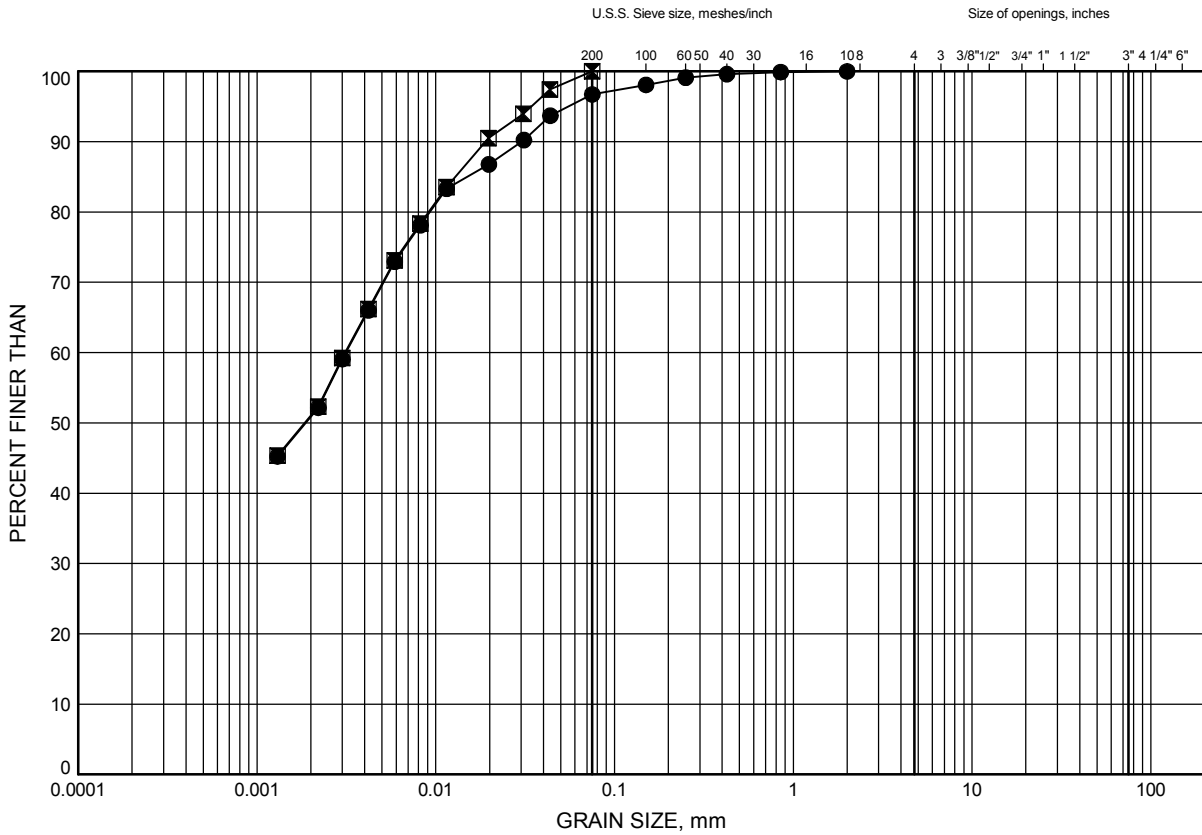


Prep'd MFA
Chkd. DJP

Centerline Culvert 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)
●	CC-03	6.40	281.60
⊠	CC-04	1.83	281.37

Date April 2016

GWP# 5196-13-00



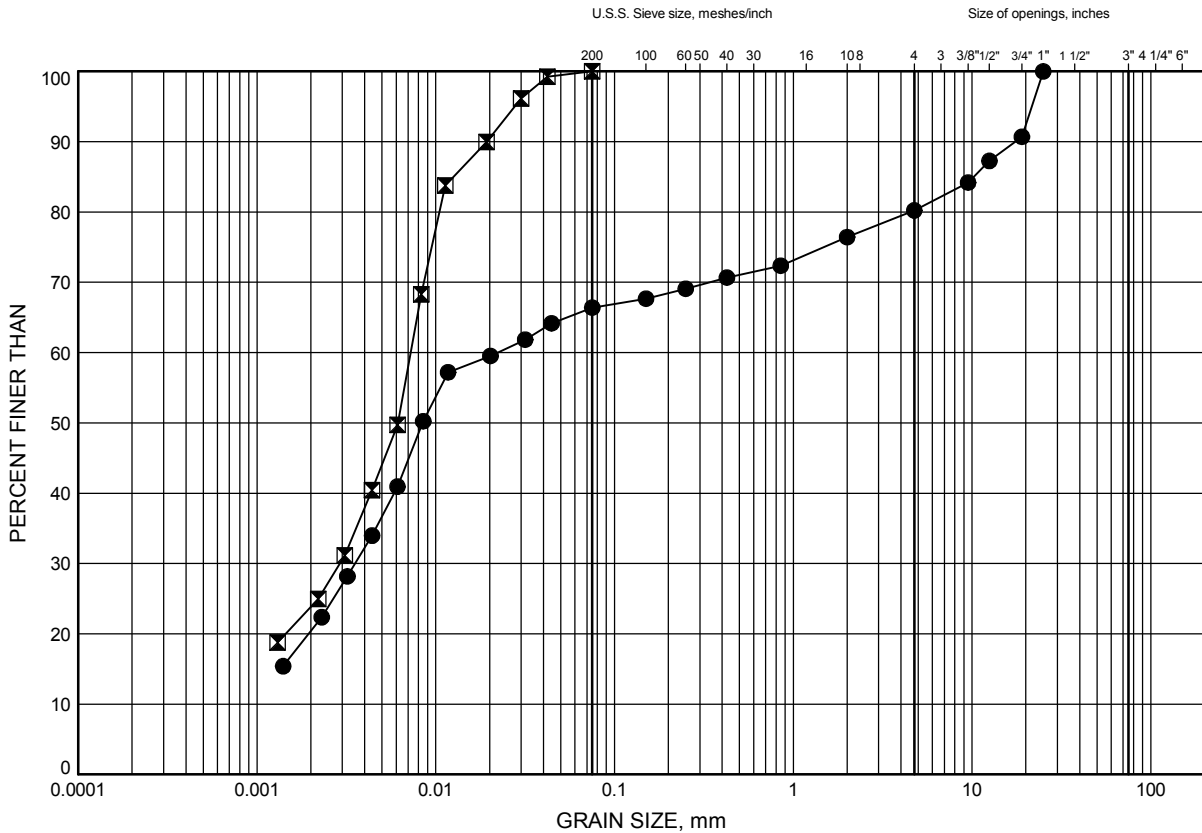
Prep'd MFA

Chkd. DJP

Centerline Culvert GRAIN SIZE DISTRIBUTION

FIGURE B3

Clayey SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CC-01	3.35	279.64
⊠	CC-04	3.35	279.84

Date April 2016
GWP# 5196-13-00

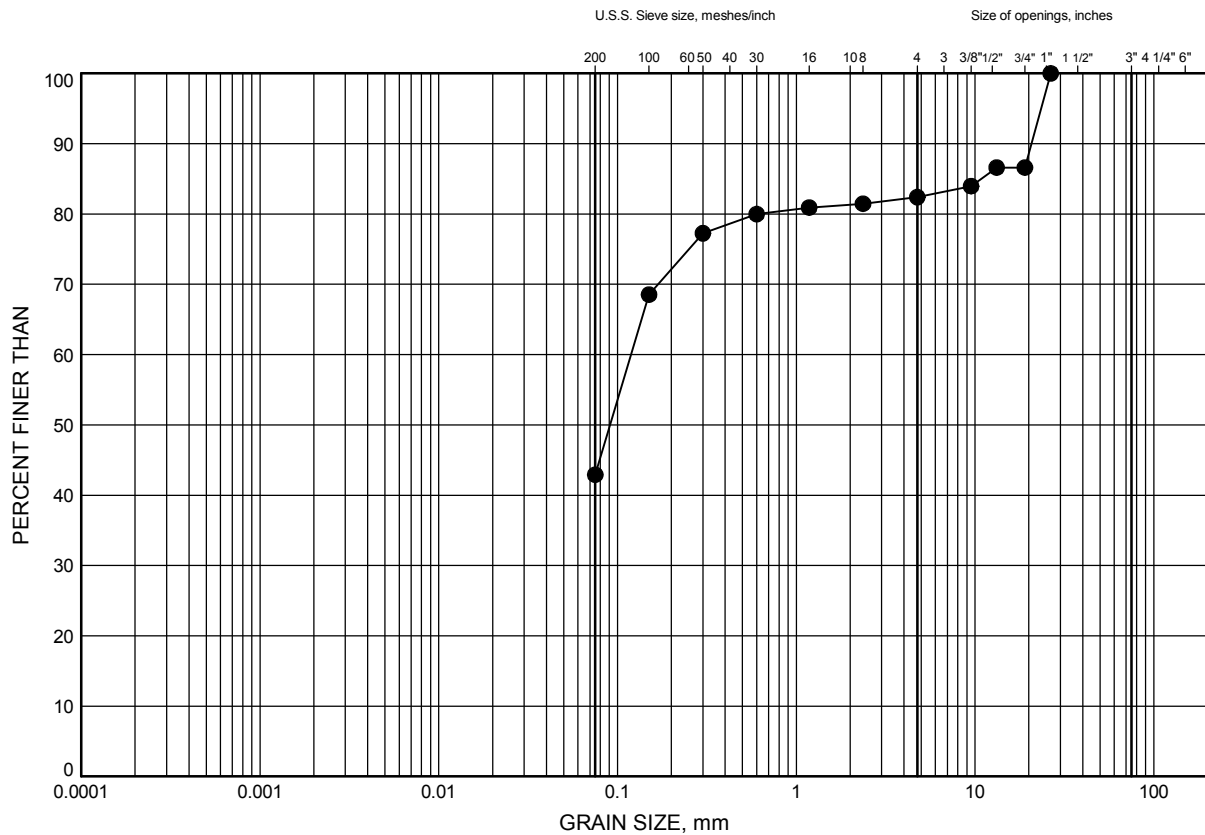


Prep'd MFA
Chkd. DJP

Centerline Culvert GRAIN SIZE DISTRIBUTION

FIGURE B4

SAND & SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CC-01	4.88	278.12

Date April 2016
GWP# 5196-13-00

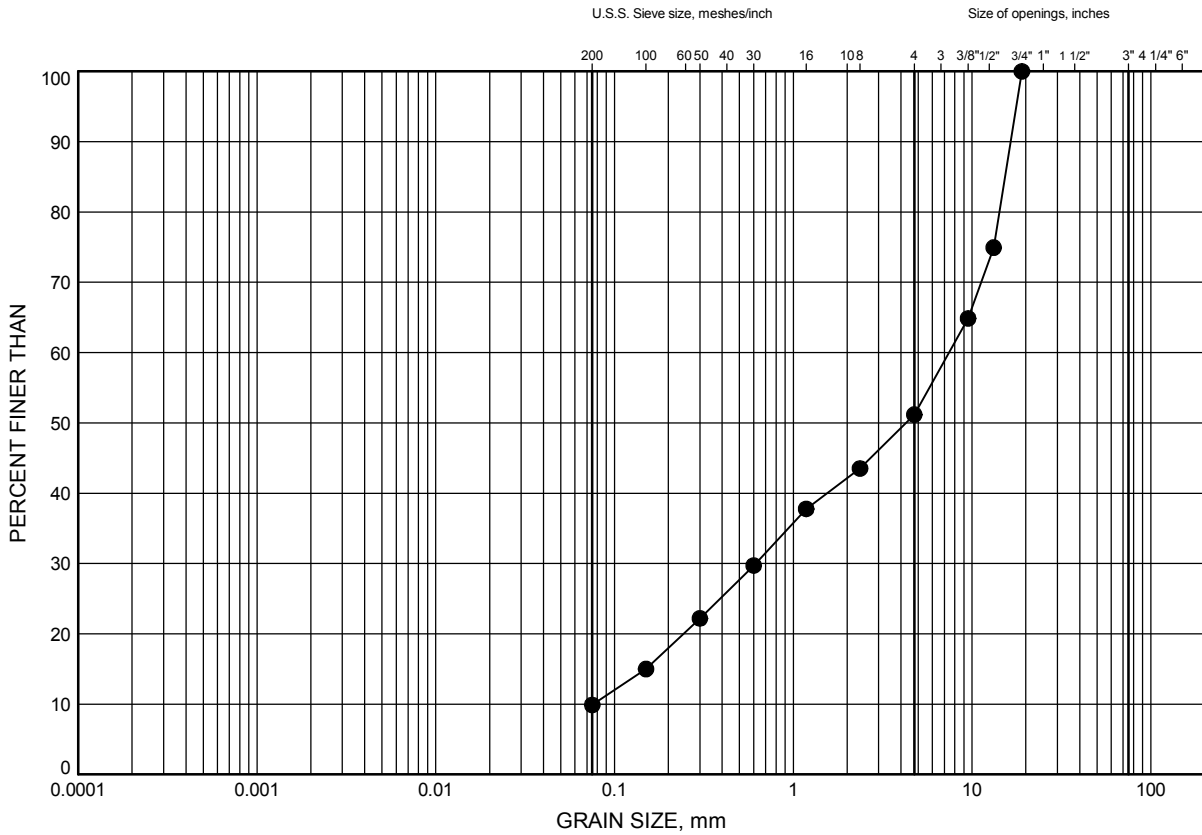


Prep'd MFA
Chkd. DJP

Centerline Culvert GRAIN SIZE DISTRIBUTION

FIGURE B5

SAND & GRAVEL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CC-02	10.97	277.02

Date April 2016
GWP# 5196-13-00

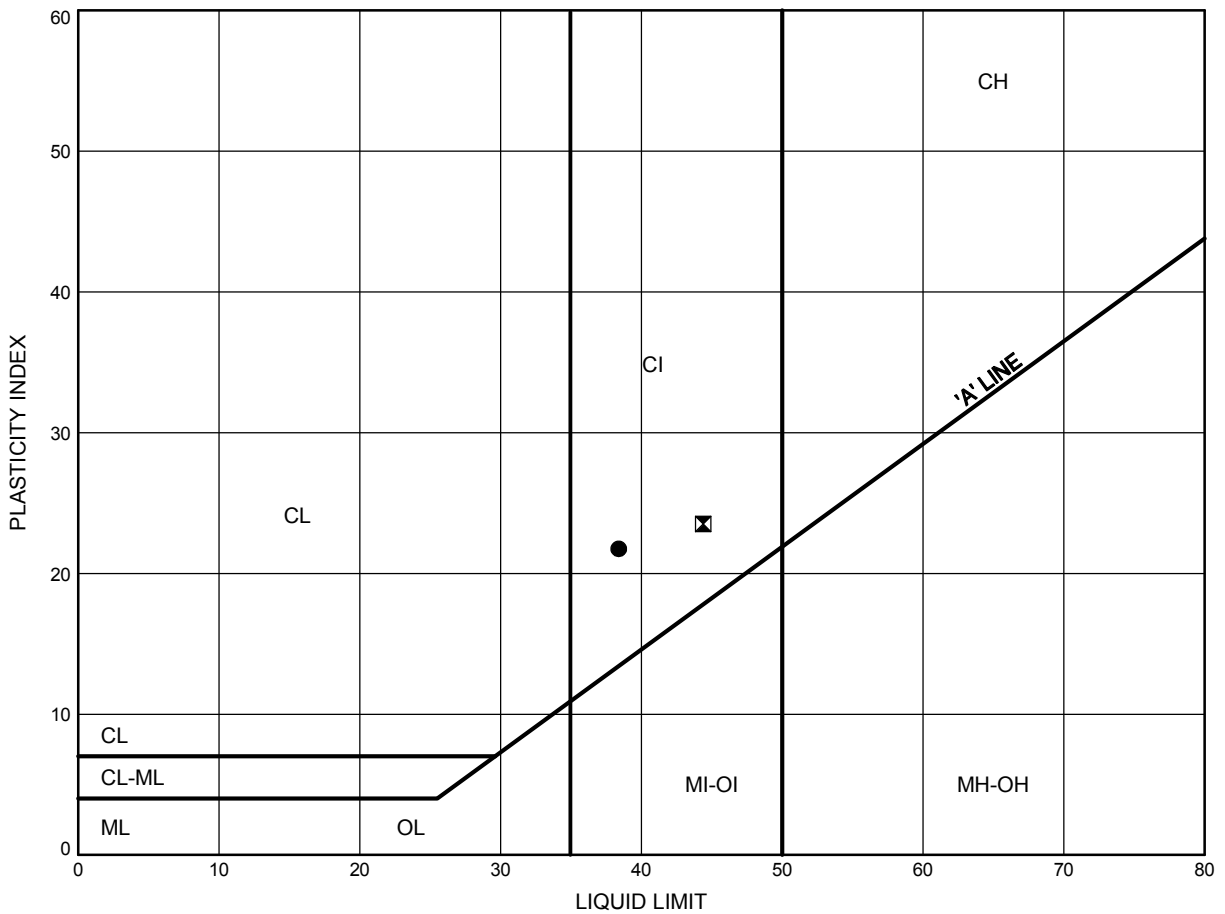


Prep'd MFA
Chkd. DJP

Centerline Culvert
ATTERBERG LIMITS TEST RESULTS

FIGURE B6

Silty CLAY



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CC-03	6.40	281.60
⊠	CC-04	1.83	281.37

Date April 2016
 GWP# 5196-13-00

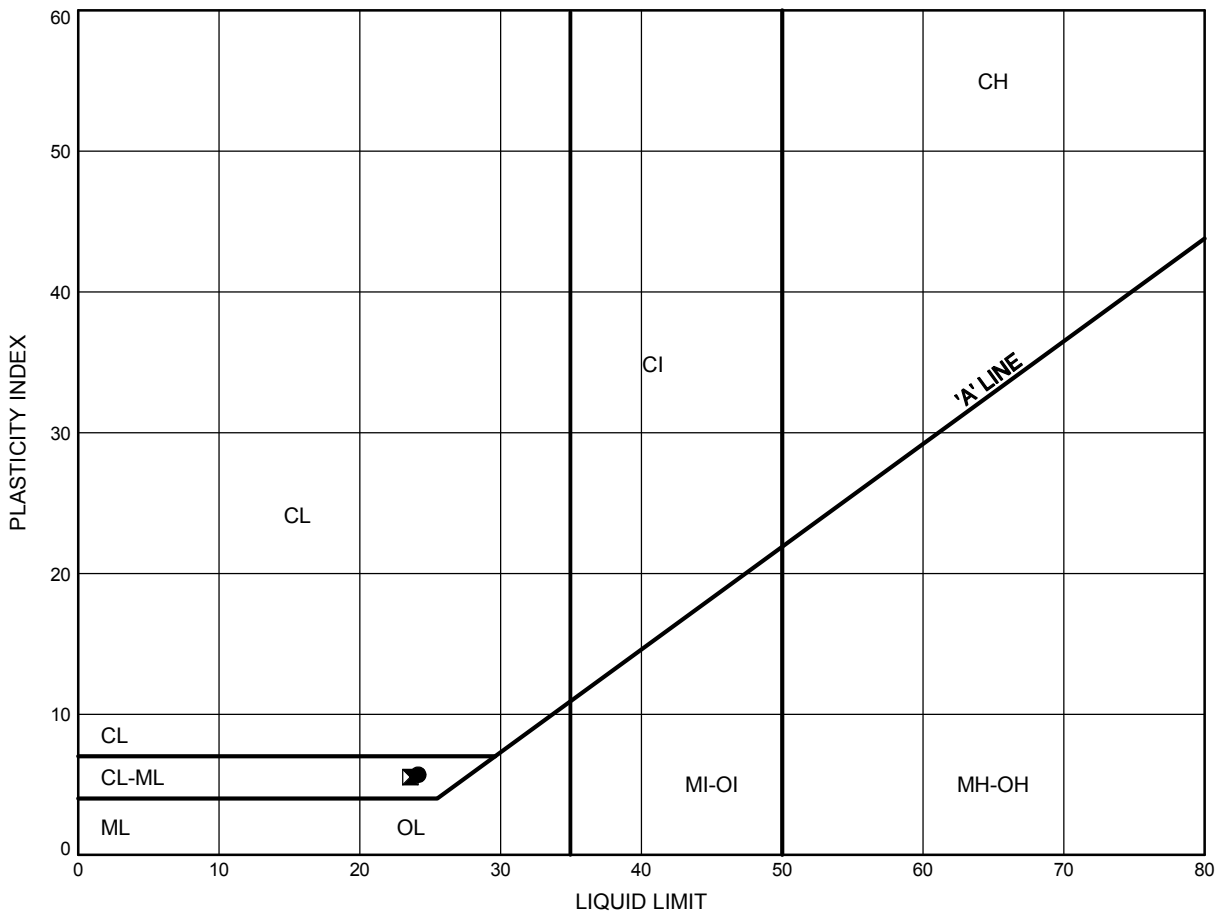


Prep'd MFA
 Chkd. DJP

Centerline Culvert
ATTERBERG LIMITS TEST RESULTS

FIGURE B7

Clayey SILT



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CC-01	3.35	279.64
⊗	CC-04	3.35	279.84

Date April 2016
 GWP# 5196-13-00



Prep'd MFA
 Chkd. DJP

CLIENT NAME: THURBER ENGINEERING LTD
SUITE 103, 2010 WINSTON PARK DRIVE
OAKVILLE, ON L6H5R7
(905) 829-8666

ATTENTION TO: Deanna Pizycki

PROJECT:

AGAT WORK ORDER: 16T076149

WATER ANALYSIS REVIEWED BY: Amanjot Bhela, Inorganic Coordinator

DATE REPORTED: Mar 18, 2016

PAGES (INCLUDING COVER): 5

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

*NOTES

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.



AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 16T076149

PROJECT:

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

CLIENT NAME: THURBER ENGINEERING LTD

ATTENTION TO: Deanna Pizycki

SAMPLING SITE:

SAMPLED BY:GA

Corrosivity Package (Water)

DATE RECEIVED: 2016-03-11

DATE REPORTED: 2016-03-18

		SAMPLE DESCRIPTION:		Centre Line
		SAMPLE TYPE:		Cul.572
		DATE SAMPLED:		Water
				3/9/2016
Parameter	Unit	G / S	RDL	7435578
Sulphide	mg/L		0.05	<0.05
Chloride	mg/L		0.10	4.86
Sulphate	mg/L		0.10	1.49
Electrical Conductivity	uS/cm		2	175
pH	pH Units		NA	7.73
Redox Potential	mV		5	385
Resistivity	ohms.cm			5710

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

Certified By:

Amanjot Bhela



Quality Assurance

CLIENT NAME: THURBER ENGINEERING LTD

AGAT WORK ORDER: 16T076149

PROJECT:

ATTENTION TO: Deanna Pizycki

SAMPLING SITE:

SAMPLED BY:GA

Water Analysis															
RPT Date: Mar 18, 2016			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
Corrosivity Package (Water)															
Sulphide	7430656		<0.05	<0.05	NA	< 0.05	100%	80%	120%	102%	85%	115%	102%	70%	130%
Chloride	7435391		149	148	0.7%	< 0.10	108%	90%	110%	110%	90%	110%	114%	80%	120%
Sulphate	7435391		10.0	10.0	0.0%	< 0.10	107%	90%	110%	109%	90%	110%	108%	80%	120%
Electrical Conductivity	7436969		2740	2750	0.4%	< 2	104%	80%	120%	NA			NA		
pH	7436969		8.07	8.03	0.5%	NA	99%	90%	110%	NA			NA		
Redox Potential	7435580	7435580	395	395	0.0%	< 5	109%	70%	130%	NA			NA		

Comments: NA signifies Not Applicable.

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

Certified By:

Amanjot Bhela

Method Summary

CLIENT NAME: THURBER ENGINEERING LTD

AGAT WORK ORDER: 16T076149

PROJECT:

ATTENTION TO: Deanna Pizycki

SAMPLING SITE:

SAMPLED BY:GA

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Water Analysis			
Sulphide	INOR-93-6054	SM 4500 S2- D	SPECTROPHOTOMETER
Chloride	INOR-93-6004	SM 4110 B	ION CHROMATOGRAPH
Sulphate	INOR-93-6004	SM 4110 B	ION CHROMATOGRAPH
Electrical Conductivity	INOR-93-6000	SM 2510 B	PC TITRATE
pH	INOR-93-6000	SM 4500-H+ B	PC TITRATE
Redox Potential		SM 2510 B	REDOX POTENTIAL ELECTRODE
Resistivity		SM 2510 B	EC METER



AGAT Laboratories

Mississauga, Ontario L4Z 1Y2
Ph: 905.712.5100 Fax: 905.712.5122
web@agatlabs.com

5835 Coopers Avenue
Mississauga, Ontario L4Z 1Y2
Ph: 905.712.5100 Fax: 905.712.5122
web@agatlabs.com

Chain of Custody Record

If this is a Drinking Water sample, please use Drinking Water Chain of Custody Form (potable water intended for human consumption)

Report Information:

Company: Thurman Engineering Ltd.
Contact: Deanna Puzicki
Address: 1010 Winstan Park Dr #102
Oakville, ON L6H 5N4
Phone: 905-819-8888 Fax: 905-819-1166
Reports to be sent to:
1. Email: agil@thurman.ca
2. Email:

Project Information:

Project: DE. Haddon
Site Location: Various Locations
Sampled By: G. Anderson
AGAT Quote #: PO: _____

Please note: If quotation number is not provided, client will be billed full price for analysis

Invoice Information:

Company: _____
Contact: _____
Address: _____
Email: _____
Bill To Same: Yes ☒ No ☐

Regulatory Requirements:

(Please check all applicable boxes)
☐ Regulation 153/04
Table _____
☐ Sewer Use
☐ Ind/Com
☐ Res/Park
☐ Agriculture
☐ Sanitary
☐ CCME
☐ Prov. Water Quality Objectives (PMOQ)
☐ Coarse
☐ Fine
☐ Other
Region _____
Soil Texture (check one)
Indicate One

Is this submission for a Record of Site Condition?

Yes ☐ No ☐

Report Guideline on Certificate of Analysis

Yes ☐ No ☐

Sample Matrix Legend

B Biotite
GW Ground Water
O Oil
P Paint
S Soil
SD Sediment
SW Surface Water

Metals and Inorganics

Metal Scan

Hydride Forming Metals

Client Custom Metals

ORPs: ☐ B-HWS ☐ Cl ☐ CN
☐ Cr⁶⁺ ☐ EC ☐ FOC ☐ NO₃/NO₂
☐ Total N ☐ Hg ☐ pH ☐ SAR

Nutrients: ☐ TP ☐ NH₃ ☐ TKN
☐ NO₃ ☐ NO₂ ☐ NO₃/NO₂

Volatiles: ☐ VOC ☐ BTEX ☐ THM

CCME Fractions 1 to 4

ABNs

PAHs

Chlorophenols

PCBs

Organochlorine Pesticides

TCLP Metals/Inorganics

Sewer Use

(Check Applicable)

Consistency

Laboratory Use Only

Work Order #: 10T076149

Cooler Quantity: _____

Arrival Temperatures: _____

Custody Seal Intact: Yes ☐ No ☐ N/A ☐

Notes: _____

Turnaround Time (TAT) Required:

Regular TAT

5 to 7 Business Days

Rush TAT (Rush Surcharges Apply)

3 Business Days ☐ 2 Business Days ☐ 1 Business Day ☐

OR Date Required (Rush Surcharges May Apply):

Please provide prior notification for rush TAT

*TAT is exclusive of weekends and statutory holidays

Sample Identification	Date Sampled	Time Sampled	# of Containers	Sample Matrix	Comments/Special Instructions	Metals and Inorganics	Metal Scan	Hydride Forming Metals	Client Custom Metals	ORPs: <input type="checkbox"/> B-HWS <input type="checkbox"/> Cl <input type="checkbox"/> CN <input type="checkbox"/> Cr ⁶⁺ <input type="checkbox"/> EC <input type="checkbox"/> FOC <input type="checkbox"/> NO ₃ /NO ₂ <input type="checkbox"/> Total N <input type="checkbox"/> Hg <input type="checkbox"/> pH <input type="checkbox"/> SAR	Nutrients: <input type="checkbox"/> TP <input type="checkbox"/> NH ₃ <input type="checkbox"/> TKN <input type="checkbox"/> NO ₃ <input type="checkbox"/> NO ₂ <input type="checkbox"/> NO ₃ /NO ₂	Volatiles: <input type="checkbox"/> VOC <input type="checkbox"/> BTEX <input type="checkbox"/> THM	CCME Fractions 1 to 4	ABNs	PAHs	Chlorophenols	PCBs	Organochlorine Pesticides	TCLP Metals/Inorganics	Sewer Use
Pike River	01/11/13	13:00	2	Water	Phase 2															
Central Ave Cul	01/11/13	13:15	2	Water	For construction															
Winstan	01/11/13	13:15	2	Water																

Samples Relinquished By (Print Name and Sign):

Samples Relinquished By (Print Name and Sign):

Date: 01/11/13

Date: 01/11/13

Time

Time

Samples Received By (Print Name and Sign):

Samples Received By (Print Name and Sign):

Date

Date

Time

Time

Page _____ of _____

Page _____ of _____

Samples Relinquished By (Print Name and Sign):

Date

Time

Samples Received By (Print Name and Sign):

Date

Time

No. T

022800

Appendix C
Selected Site Photographs

Centerline Culvert Replacement
Highway 572



Photograph 1: Culvert Inlet Looking West



Photograph 2: Culvert Outlet Looking East

Centerline Culvert Replacement
Highway 572

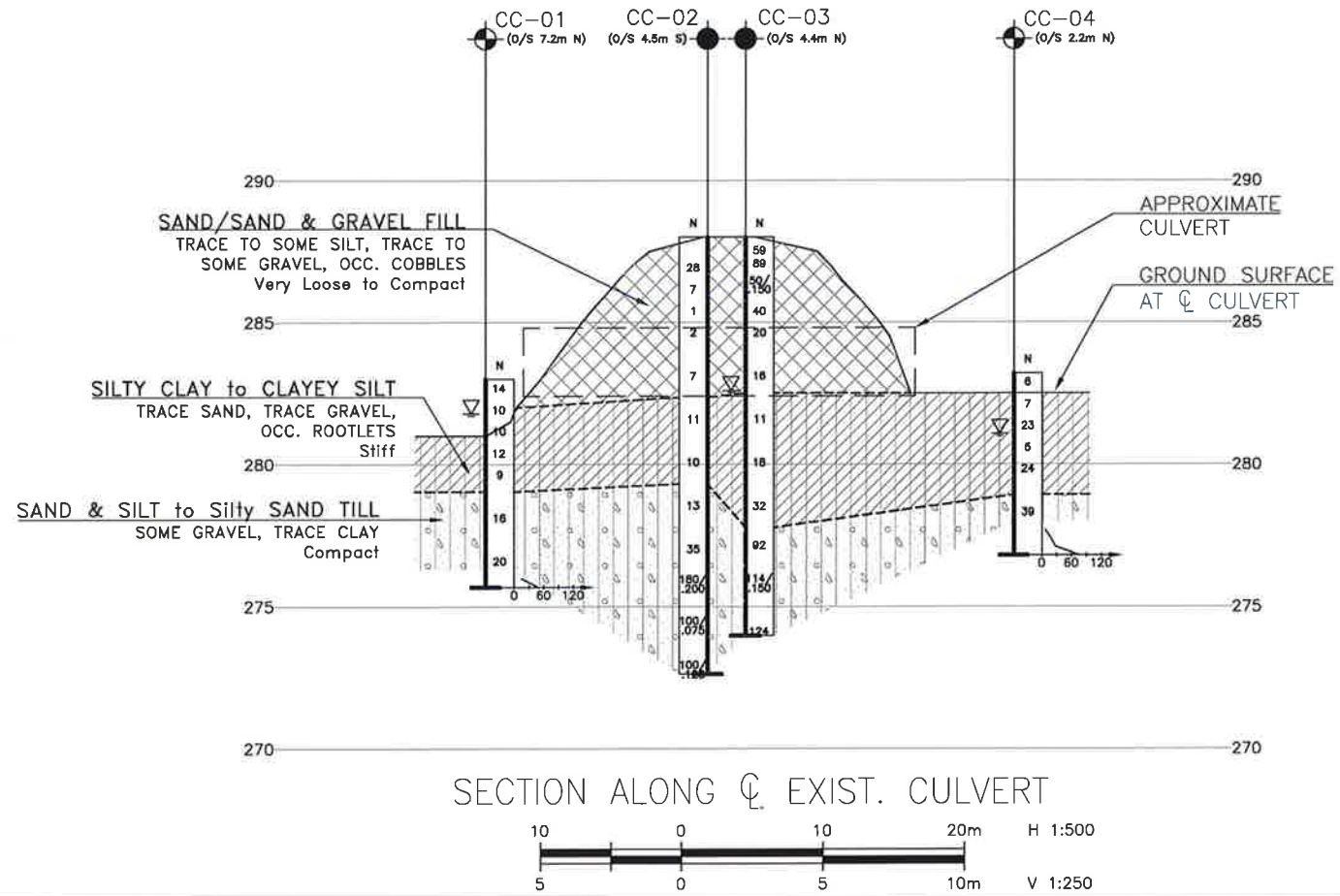
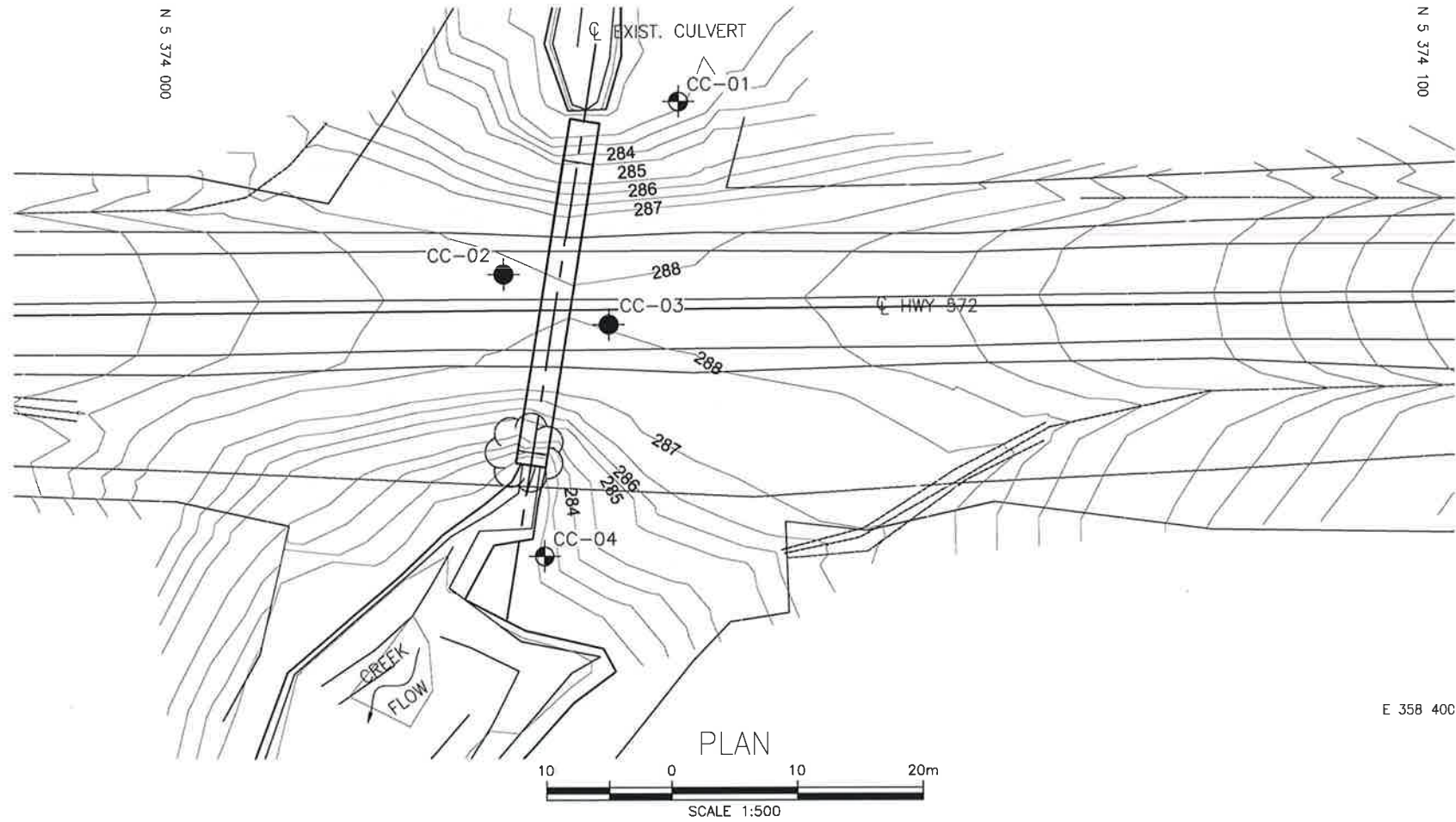


Photograph 3: Creek - Looking East



Photograph 4: Creek - Looking West

Appendix D
Borehole Locations and Soil Strata Drawing



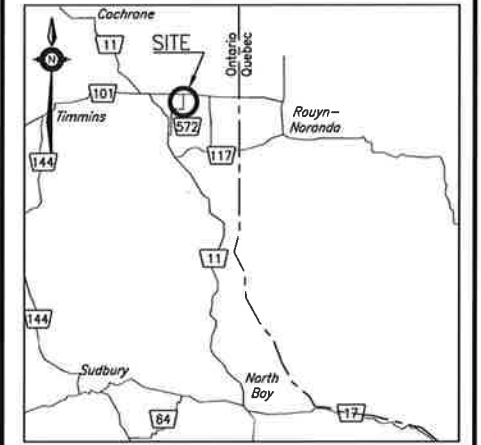
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No	
GWP No	5196-13-00

HIGHWAY 572
CENTRELINE CULVERT
REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA







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
	Water Level in Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
CC-01	283.0	5 374 041.1	358 351.9
CC-02	288.0	5 374 027.1	358 365.7
CC-03	288.0	5 374 035.5	358 369.6
CC-04	283.2	5 374 030.4	358 388.1

-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 12 co-ordinate system was used to obtain boreholes Northings and Eastings.

GEOCRES No. 42A-108

REVISIONS										
	DATE	BY	DESCRIPTION							
DESIGN	DJP	CHK	AMP	CODE	LOAD		DATE	JUL 2016		
DRAWN	AN	CHK	DJP	SITE	STRUCT		DWG	1		