



THURBER ENGINEERING LTD.



**FOUNDATION INVESTIGATION REPORT
MOOSE CREEK CULVERT REPLACEMENT
HIGHWAY 622, SITE No. 45-258/C
UNSURVEYED TERRITORY, DISTRICT OF RAINY RIVER
G.W.P. No. 6845-14-00**

GEOCRES No.: 52B-31

Report

to

Hatch

Date: March 14, 2017
File: 13983

TABLE OF CONTENTS

1.	INTRODUCTION	1
2.	SITE DESCRIPTION	1
3.	INVESTIGATION PROCEDURES	2
4.	LABORATORY TESTING	4
5.	DESCRIPTION OF SUBSURFACE CONDITIONS	4
5.1	Asphalt and Topsoil	4
5.2	Gravelly Sand Fill	5
5.3	Rockfill	5
5.4	Silt to Sand and Silt	5
5.5	Groundwater Conditions	6
6.	CORROSIVITY AND SULPHATE TEST RESULTS	7
7.	MISCELLANEOUS	7

APPENDICES

Appendix A	Record of Borehole Sheets
Appendix B	Geotechnical and Analytical Laboratory Test Results
Appendix C	Selected Site Photographs
Appendix D	Borehole Location Plan and Soil Strata Drawing

**FOUNDATION INVESTIGATION REPORT
MOOSE CREEK CULVERT REPLACEMENT
HIGHWAY 622, SITE No. 45-258/C
UNSURVEYED TERRITORY, DISTRICT OF RAINY RIVER
G.W.P. No. 6320-11-00**

GEOCRES No: 52B-31

1. INTRODUCTION

This report presents the factual data obtained from a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) for the proposed replacement of the Moose Creek Culvert on Highway 622, located in Unsurveyed Territory in the District of Rainy River, Ontario.

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

Thurber was retained by Hatch Ltd. (Hatch) to carry out this foundation investigation under the Ministry of Transportation Ontario (MTO) Agreement Number 6015-E-0018-05.

The information on the existing Moose Creek Culvert has been provided on the Survey Plan B-485914-0-2/E-485914-622-1 prepared by MTO Geomatic Section, dated April 2016 and in the Terms of Reference for this project.

2. SITE DESCRIPTION

The Moose Creek Culvert site is located on Highway 622, approximately 26 km north of Highway 11B in the Unsurveyed Territory of the District of Rainy River, Ontario. The key plan showing the general location of the culvert site is presented on the Borehole Location Plan and Soil Strata Drawing in Appendix D.

Highway 622 runs in a general northwest-southeast direction with the culvert perpendicular to the centreline of the highway. Moose Creek flows from northeast to southwest in a meandering course crossing the highway and drains into Eye Lake.

The existing structure is a corrugated steel pipe (CSP) culvert with a diameter of 3.8 m and a length of 35 m constructed in 1985. The highway embankment is approximately 6.6 m high with approximately 3.5 m of fill present above the culvert. The grade level of Highway 622 at the centreline of the existing culvert is at approximate Elevation 431.8 m. The culvert invert was indicated approximately at Elevation 424.3 m at the inlet and Elevation 424.6 at the outlet. The creek water level was measured at Elevation 426.1 m in April 2016.

The MTO Structure Inspection Report generated on November 2, 2015 with a documented site visit of June 2, 2015, concluded that the culvert structure was “in overall poor condition with medium to severe corrosion of the barrel in isolated locations”.

The culvert is situated within the flood plain of Moose Creek which consists of marsh lands on each side of the highway embankment. The lands outside of the flood plain are covered by heavily forested areas consisting of a mixture of mature trees and brush. Local topography at the culvert site is generally of low relief with bedrock outcrops visible along Highway 622 approximately 180 m and 140 m, southeast and northwest of the site, respectively. Rock fill was noted near the embankment toes and the existing culvert. Photographs of the culvert and surrounding area are presented in Appendix C.

Based on published geological information, the subsurface soils at the site generally consist of organic deposits of mainly peat/muck and thin glacial deposits bordering with areas of undulating to rolling bedrock knobs. Bedrock in the area has been identified as massive to foliated granodiorite to granite of the Quetico Subprovince of the Superior Province.

3. INVESTIGATION PROCEDURES

The borehole investigation and field program was carried out on between August 30 and September 10, 2016, during which a total of six (6) boreholes, designated as Boreholes 16-25 to 16-30, were advanced on site. Boreholes 16-28 and 16-25 were located near the inlet and outlet of the existing culvert while the remaining boreholes were drilled from the top of Highway 622. Boreholes 16-27 and 16-26 were located northwest and southeast of the culvert and drilled to a depth of 15.8 m. Boreholes 16-29 and 16-30 were located approximately 15 m northwest and southeast of the culvert for a frost taper investigation and drilled to depths of 13.7 m and 15.8 m, respectively.

Utility clearances were obtained prior to the start of drilling. The ground surface elevations for the boreholes were derived from cross sections and topographic drawings provided to Thurber by Hatch (MTO Survey Plan B-485914-0-2 / E-485914-622-1). The coordinate system MTM NAD

83, Zone 16 was used to establish locations of the boreholes. The approximate locations of the boreholes are shown on the Borehole Location Plan and Soil Strata Drawings included in Appendix D.

A rubber track mounted CME 55 drill rig was used to advance the boreholes from the top of the embankment (Boreholes 16-26, 16-27, 16-29 and 16-30) using hollow stem augers and wash boring techniques. Boreholes 16-25 and 16-28 at the toe of the embankment were drilled using a portable tripod drill rig using wash boring techniques.

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) procedures as per ASTM D1586. The drilling and sampling operations were supervised on a full time basis by a member of Thurber's technical staff. The supervisor logged the boreholes and processed the recovered soil samples for transport to Thurber's laboratory for further examination and testing.

Groundwater conditions were observed in the open boreholes throughout the drilling operations. The boreholes were backfilled in general accordance with Ontario Regulation 903.

Completion details of the borehole are summarized in the table below.

Borehole Number	Borehole Depth / Base Elevation (m)	Completion Details
16-25	5.8 / 420.6	Borehole backfilled with bentonite holeplug and cuttings to surface.
16-26	15.8 / 416.0	Borehole backfilled with bentonite holeplug and cuttings and surface reinstated with asphalt.
16-27	15.8 / 415.9	Borehole backfilled with bentonite holeplug and cuttings to 0.1 m and surface reinstated with asphalt.
16-28	5.6 / 420.8	Borehole backfilled with bentonite holeplug and cuttings to surface.
16-29	13.7 / 418.0	Borehole backfilled with bentonite holeplug and cuttings and surface reinstated with asphalt.
16-30	15.8 / 416.0	Borehole backfilled with bentonite holeplug and cuttings to 0.1 m and surface reinstated with asphalt.

4. LABORATORY TESTING

All 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 (sieve and/or hydrometer) and plasticity testing (Atterberg Limits) where appropriate. The results of this laboratory testing program are shown on the Record of Borehole sheets included in Appendix A and 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. The samples were submitted to SGS Canada Inc., a CALA accredited analytical laboratory in Lakefield, Ontario, for analytical testing of corrosivity parameters and sulphate content. The results of the analytical testing are summarized in Section 6 and are enclosed in Appendix B.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets included in Appendix A. Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets and on the "Borehole Locations and Soil Strata" drawings included in Appendix D. 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 should be used for interpretation of the site conditions. It must be recognized and expected that soil conditions may vary between and beyond the borehole locations.

In general, the subsurface conditions encountered in the boreholes consisted of embankment fill comprising gravelly sand to gravel with cobbles and boulders, underlain by a deposit of silt with varying content of sand. Descriptions of the individual strata are presented below.

5.1 Asphalt and Topsoil

Approximately 25 mm to 50 mm of asphalt was encountered in Boreholes 16-26, 16-27, 16-29 and 16-30 which were drilled from the top of the embankment.

In Boreholes 16-28 and 16-25 located at the inlet and outlet of the culvert, a layer of topsoil approximately 200 mm in thickness was encountered. The topsoil thickness may vary across the site.

5.2 Gravelly Sand Fill

Underlying the asphalt was a granular fill, consisting of gravelly sand with trace to some silt, trace clay, trace organics and occasional cobbles. The gravelly sand fill thickness varied from 0.9 m to 1.5 m in the boreholes drilled from the top of the embankment. Borehole 16-28 drilled at the east toe of the embankment encountered approximately 0.6 m of fill. The base of the gravelly sand fill ranged from depths of 0.8 m to 1.5 m or from Elevation 425.6 m to Elevation 430.9 m. The relative density of the gravelly sand fill ranged from loose to very dense. The recorded SPT 'N' values greater than 50 blows per 0.125 m of penetration were likely indicative of the presence of cobbles in the fill.

The measured moisture content of the gravelly sand fill generally ranged from 2 percent to 15 percent. The results of grain size distribution analyses conducted on samples of the gravelly sand fill are presented on the Record of Borehole sheets included in Appendix A and are summarized in the following table. The results are also presented on Figure B1 in Appendix B.

Soil Particle	Percentage (%)
Gravel	30 to 38
Sand	50 to 60
Silt and Clay	10 to 13

5.3 Rockfill

Underlying the gravelly sand fill, rockfill was encountered in Boreholes 16-26, 16-27, 16-29, and 16-30, which were drilled through the top of the embankment. The rockfill contained cobbles and boulders as well as sand and gravel. The rockfill thickness varied from 4.6 m to 5.2 m and extended to depths of m to 5.5 to 6.1 m or from Elevation 425.6 m to Elevation 426.3 m. SPT 'N' values greater than 50 blows per 0.025 m of penetration were recorded within the rockfill and were likely indicative of the presence of cobbles and boulders. Casing was required to penetrate the cobbles and boulders. The approximate locations of the cobbles and boulders are shown on the borehole logs. A 590 mm diameter boulder was encountered at 4.3 m depth in Borehole 16-26.

5.4 Silt to Sand and Silt

A native deposit of silt with varying proportions of sand, clay and gravel were encountered in all boreholes beneath the embankment fill. The laboratory testing indicated that the deposit can be classified as silt, sandy silt and sand and silt. Occasional clayey silt lenses were encountered in

Boreholes 16-27 at depth, as well as cobbles and boulders were inferred during drilling in Boreholes 16-25 and 16-28.

All boreholes were terminated in this deposit at depths ranging from 5.6 m to 15.8 m, or Elevation 420.8 m to 415.9 m.

The recorded SPT 'N' values varied from 2 to in excess of 100 blows per 0.3 m of penetration, however, typically the SPT 'N' values ranged from 4 blows to 44 blows per 0.3 m penetration indicating a loose to dense relative density. The high 'N' values were recorded in the boreholes advanced at the toe of the embankment and may indicate presence of cobbles or boulders or rockfill. The measured moisture content of the silt typically ranged from 15 percent to 45 percent. The moisture content of two silt samples underlying the topsoil and fill in Boreholes 16-25 and 16-28, containing trace organics ranged from 55 percent to 72 percent.

The results of grain size analyses conducted on samples of the silt and sandy silt/sand and silt are provided on the Record of Borehole sheets in Appendix A and are summarized in the following table. The results are also presented on Figures B2 and B3 of Appendix B. The results are summarized as follows:

Soil Particle	Percentage (%)	
	Silt	Sandy Silt/Sand and Silt
Gravel	0	0 to 16
Sand	3 to 7	22 to 40
Silt	82 to 87	43 to 70
Clay	7 to 15	5 to 8

5.5 Groundwater Conditions

Groundwater conditions were observed during drilling operations. However, water was used to advance the boreholes and, therefore, the observation may not reflect the actual groundwater conditions. The water level in Moose Creek was measured at Elevation 426.1 m in April 2016. The groundwater level should be assumed 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

A sample of the native silt from Borehole 16-26, and a sample of the surface water from the creek were submitted for analytical testing of corrosivity parameters and sulphate. The results of the analytical tests are shown in Table 6.1. The laboratory certificates of analysis are presented in Appendix B.

Table 6.1 – Analytical Test Results

Parameter	Units (Soil)	Units (Water)	Test Results	
			16-26 SS#3, 6.1 m to 6.7 m	Moose Creek Water
Sulphide	%	mg/L	<0.02	<0.006
Chloride	µg/g	mg/L	39	0.52
Sulphate	µg/g	mg/L	8.3	0.31
pH	No unit	No unit	6.62 - 6.77	6.05
Electrical Conductivity	µS/cm	µS/cm	58	17
Resistivity	Ohms.cm	Ohms.cm	17200	5880
Redox Potential	mV	mV	224	203
Corrosivity Index	-	-	1	< 1

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. Troy MacKinnon of Thurber. Overall supervision of the field program was provided by Mr. Mark Farrant, P.Eng. of Thurber.

Geotechnical laboratory testing was carried out at Thurber's geotechnical laboratory. Analytical laboratory testing was carried out by SGS Canada Inc.

Interpretation of the field data and preparation of this report was carried out by Ms. Anna Piascik, P.Eng. and Mr. Mark Farrant, P.Eng. The report was reviewed by 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
 Shear Strength Determination by Pocket Penetrometer

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

UNIFIED SOILS CLASSIFICATION

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS W _L < 50%	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. (W _L < 30%).
		CI	Inorganic clays of medium plasticity, silty clays. (30% < W _L < 50%).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS W _L > 50%	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

RECORD OF BOREHOLE No 16-25

1 OF 1

METRIC

WP# 6845-14-01 LOCATION Moose Creek Culvert N 5 417 230.4 E 400 573.0 ORIGINATED BY TM
 HWY 622 BOREHOLE TYPE Tripod COMPILED BY AN
 DATUM Geodetic DATE 2016.09.10 - 2016.09.10 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																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
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0.2	SILT, trace sand to sandy, trace clay, trace gravel, occasional cobbles and boulders Loose to Very Dense Brown Wet		1	SS	2		426																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											

ONTMT4S 13983-MTO.GPJ 2015TEMPLATE(MTO).GDT 3/14/17

RECORD OF BOREHOLE No 16-26

1 OF 2

METRIC

WP# 6845-14-01 LOCATION Moose Creek Culvert N 5 417 233.5 E 400 593.6 ORIGINATED BY TS
 HWY 622 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.08.30 - 2016.09.01 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 (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	WATER CONTENT (%)									
431.8	GROUND SURFACE						20	40	60	80	100	PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	GR	SA	SI	CL
0.0	ASPHALT: (25mm)		1	GS														
430.9	Gravelly SAND, trace to some silt, occasional cobbles Compact to Very Dense Moist (FILL) Possible cobble at 0.3m		1	SS	16/ 0.025													33 55 12 (SI+CL)
0.9	ROCKFILL, with sand and gravel Auger refusal at 0.9m, switched to NW Casing and NQ Coring Cobbles and boulders																	
	590mm diameter boulder noted at 4.3m		2	SS	50/ 0.100													
426.3	SILT, trace sand to sandy, trace to some clay, trace gravel Compact to Dense Grey Wet		3	SS	21													
5.5																		
			4	SS	38													
			5	SS	29													0 22 70 8

Continued Next Page

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

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 16-27

1 OF 2

METRIC

WP# 6845-14-01 LOCATION Moose Creek Culvert N 5 417 245.3 E 400 590.0 ORIGINATED BY TM
 HWY 622 BOREHOLE TYPE Solid Stem Augers/Wash Boring COMPILED BY AN
 DATUM Geodetic DATE 2016.09.08 - 2016.09.08 CHECKED BY AMP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w _P	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
431.7	GROUND SURFACE							20	40	60	80	100					
0.0	ASPHALT: (50mm)																
	Gravelly SAND, trace to some silt, occasional cobbles Very Dense Brown Moist (FILL)		1	SS			431										38 50 12 (SI+CL)
			2	SS	50/ 0.125												
430.2			3	SS	50/ 0.025		430										
1.5	ROCKFILL with sand and gravel Auger refusal at 1.5m, switched to NW Casing and NQ Coring																
	Cobbles between 1.5m to 2.1m						429										
	Boulders between 3.0m to 4.3m						428										
							427										
	Boulders between 4.9m to 6.7m						426										
425.6																	
6.1	SILT, trace to some clay, trace sand, trace gravel, decayed wood, rootlets in the upper 1.0m zone Loose to Compact Brown Wet						425										
			4	SS	4		424										
							423										
			5	SS	23		422										0 6 84 10

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

METRIC

SOIL PROFILE						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES	GROUND WATER CONDITIONS	ELEVATION SCALE	
<div>DYNAMIC CONE PENETRATION RESISTANCE PLOT</div> <div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div> <div><div>PLASTIC LIMITNATURAL MOISTURE CONTENTLIQUID LIMIT</div><div>w_p w w_L</div><div>WATER CONTENT (%)</div><div>204060</div></div> <div><div>UNIT WEIGHT</div><div>γ</div><div>kN/m³</div></div> <div><div>REMARKS & GRAIN SIZE DISTRIBUTION (%)</div><div>GR SA SI CL</div></div>						
Continued From Previous Page						
<div>SILT, trace to some clay, trace sand, trace gravel, decayed wood, rootlets Dense to Compact Brown Wet</div> <div>Occasional clayey silt lenses below 13.5m depth</div>						
	6	SS	38		421	
					420	
	7	SS	27		419	
					418	
	8	SS	34		417	
					416	
9	SS	17				
END OF BOREHOLE AT 15.8m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.1m, THEN ASPHALT COLD PATCH TO SURFACE.						

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 16-28

1 OF 1

METRIC

WP# 6845-14-01 LOCATION Moose Creek Culvert N 5 417 245.4 E 400 613.0 ORIGINATED BY TM
 HWY 622 BOREHOLE TYPE Tripod COMPILED BY AN
 DATUM Geodetic DATE 2016.09.09 - 2016.09.09 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 (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
426.4	GROUND SURFACE							20 40 60 80 100																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
0.0	TOPSOIL: (200mm)							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						WATER CONTENT (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
0.2	Gravelly SAND, some silt, trace organics, trace rootlets, decayed wood		1	SS	6		426																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								

ONTMT4S 13983-MTO.GPJ 2015TEMPLATE(MTO).GDT 3/14/17

RECORD OF BOREHOLE No 16-29

1 OF 2

METRIC

WP# 6845-14-01 LOCATION Moose Creek Culvert N 5 417 251.5 E 400 581.0 ORIGINATED BY TS
 HWY 622 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.08.30 - 2016.08.31 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
431.7	GROUND SURFACE							20	40	60	80	100								
0.8	ASPHALT: (25mm)		1	GS			431													
	Gravelly SAND , some silt, trace clay Loose to Compact Brown Dry to Moist (FILL)																			
430.8	ROCKFILL , with sand and gravel																			
0.9																				
	Auger refusal at 1.5m and set for coring Possible cobbles (<120mm in diamter) between 1.5m to 2.4m						430													
							429													
							428													
							427													
							426													
425.6			1	SS	100/ 0.075															
6.1	SILT , trace to some clay, trace sand, trace gravel Loose to Dense Grey Wet																			

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 16-29

2 OF 2

METRIC

WP# 6845-14-01 LOCATION Moose Creek Culvert N 5 417 251.5 E 400 581.0 ORIGINATED BY TS
 HWY 622 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.08.30 - 2016.08.31 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 (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)						
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				W _P W W _L						
	Continued From Previous Page		3	SS	27			20	40	60	80	100		20	40	60		
	SILT, trace to some clay, trace sand, trace gravel Compact to Dense Grey Wet						421							○				0 7 86 7
							420							○				
				4	SS	36												
								419										
				5	SS	33									○			
418.0							418											
13.7	END OF BOREHOLE AT 13.7m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS THEN ASPHALT COLD PATCH TO SURFACE.																	

RECORD OF BOREHOLE No 16-30

1 OF 2

METRIC

WP# 6845-14-01 LOCATION Moose Creek Culvert N 5 417 227.1 E 400 602.8 ORIGINATED BY TM
 HWY 622 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.09.07 - 2016.09.07 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 (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
431.8	GROUND SURFACE							20	40	60	80	100						
0.0	ASPHALT: (50mm)		1	SS			431											
	Gravelly SAND , some silt, occasional cobbles																	
	Compact to Very Dense																	
430.9	Brown Moist (FILL)		2	SS	50/													
0.9	ROCKFILL , with sand and gravel				0.125													
	No recovery Auger grinding on boulder		3	SS	50/		430											No recovery
	Boulders from 1.5m to 5.5m				0.125													
							429											
							428											
							427											
							426											
425.7																		
6.1	SILT , trace to some sand to sand and silt, trace to some clay Loose to Dense Grey Wet		4	SS	40		425											
			5	SS	8		424											0 40 54 6
							423											
			6	SS	20													
							422											

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

METRIC

SOIL PROFILE						SAMPLES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		NATURAL MOISTURE CONTENT	LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES	PLASTIC LIMIT			P	W	L				
									SHEAR STRENGTH kPa		WATER CONTENT (%)				
									O UNCONFINED + FIELD VANE						
Continued From Previous Page															
416.0 15.8	SILT , trace to some sand to sand and silt, trace to some clay Dense Grey Wet		7	SS	44		421						○	0 3 87 10	
			8	SS	36		420								
			9	SS	36		419								0 3 82 15
			10	SS	14		418								
						417									
						416						○			
	END OF BOREHOLE AT 15.8m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS, THEN TOPPED WITH ASPHALT COLD PATCH TO SURFACE.														

+³, ×³: Numbers refer to Sensitivity



Appendix B

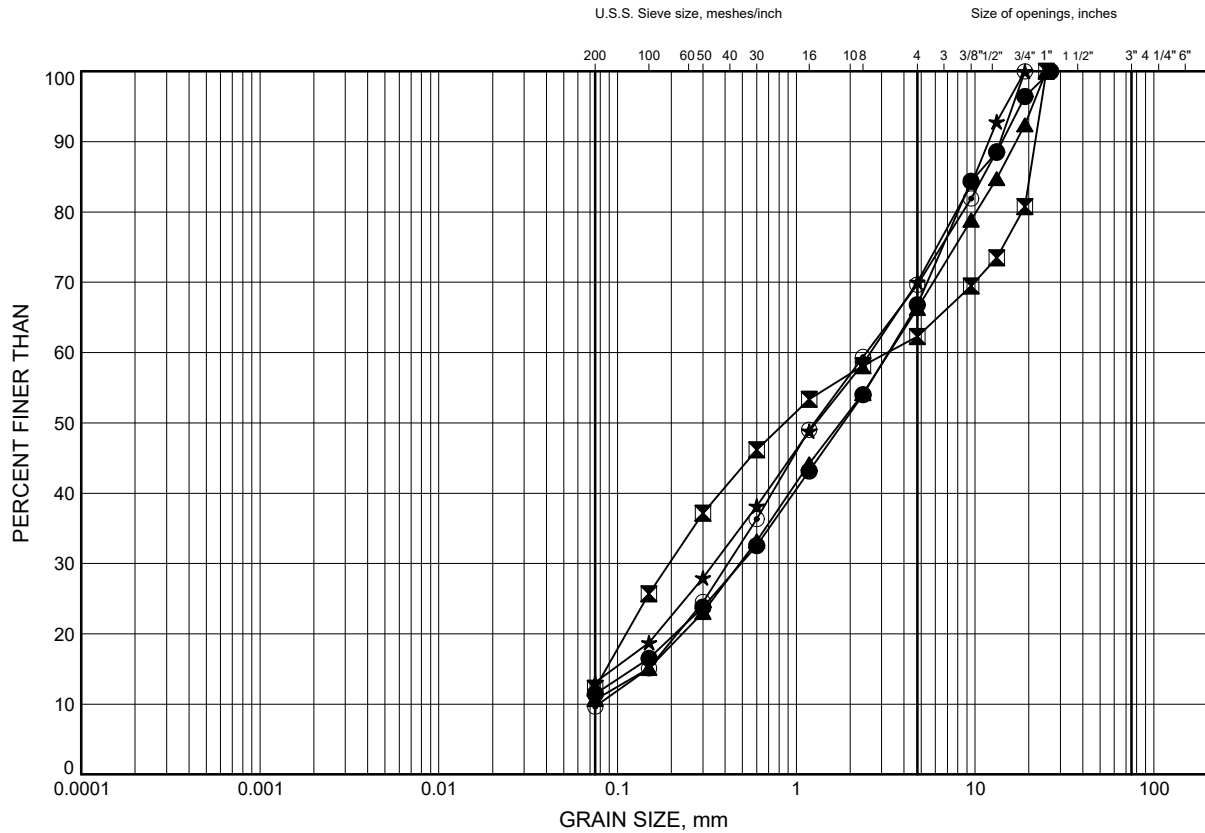
Geotechnical and Analytical Laboratory Test Results

Moose Creek Culvert

GRAIN SIZE DISTRIBUTION

FIGURE B1

Gravelly SAND FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-26	1.00	430.80
⊠	16-27	0.30	431.40
▲	16-28	0.30	426.10
★	16-29	0.30	431.40
⊙	16-30	1.07	430.73

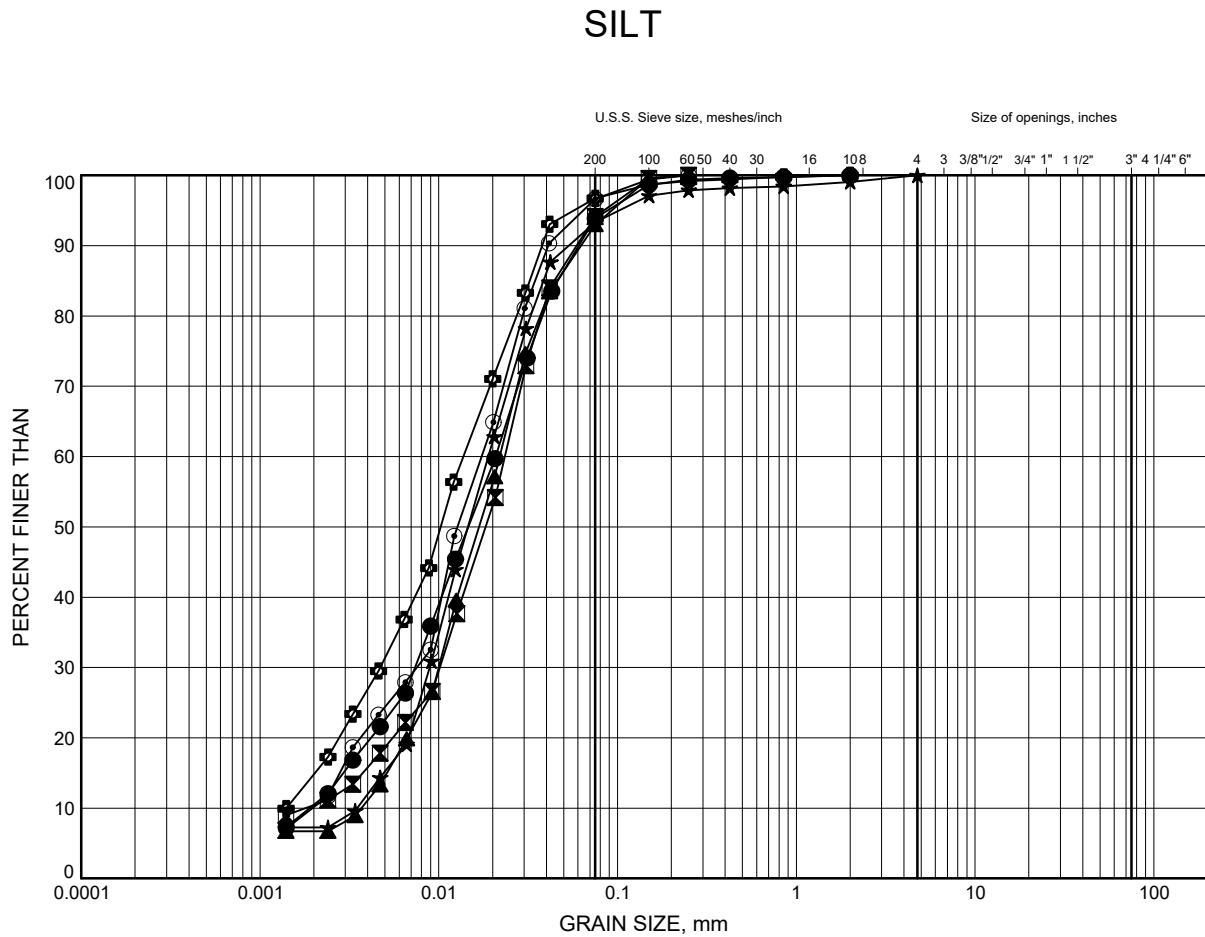
Date March 2017
 WP# 6345-14-01



Prep'd AN
 Chkd. AMP

Moose Creek Culvert GRAIN SIZE DISTRIBUTION

FIGURE B2



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-26	14.02	417.78
⊠	16-27	9.45	422.25
▲	16-27	12.50	419.20
★	16-29	10.97	420.73
⊙	16-30	10.97	420.83
⊕	16-30	14.02	417.78

Date March 2017
WP# 6345-14-01

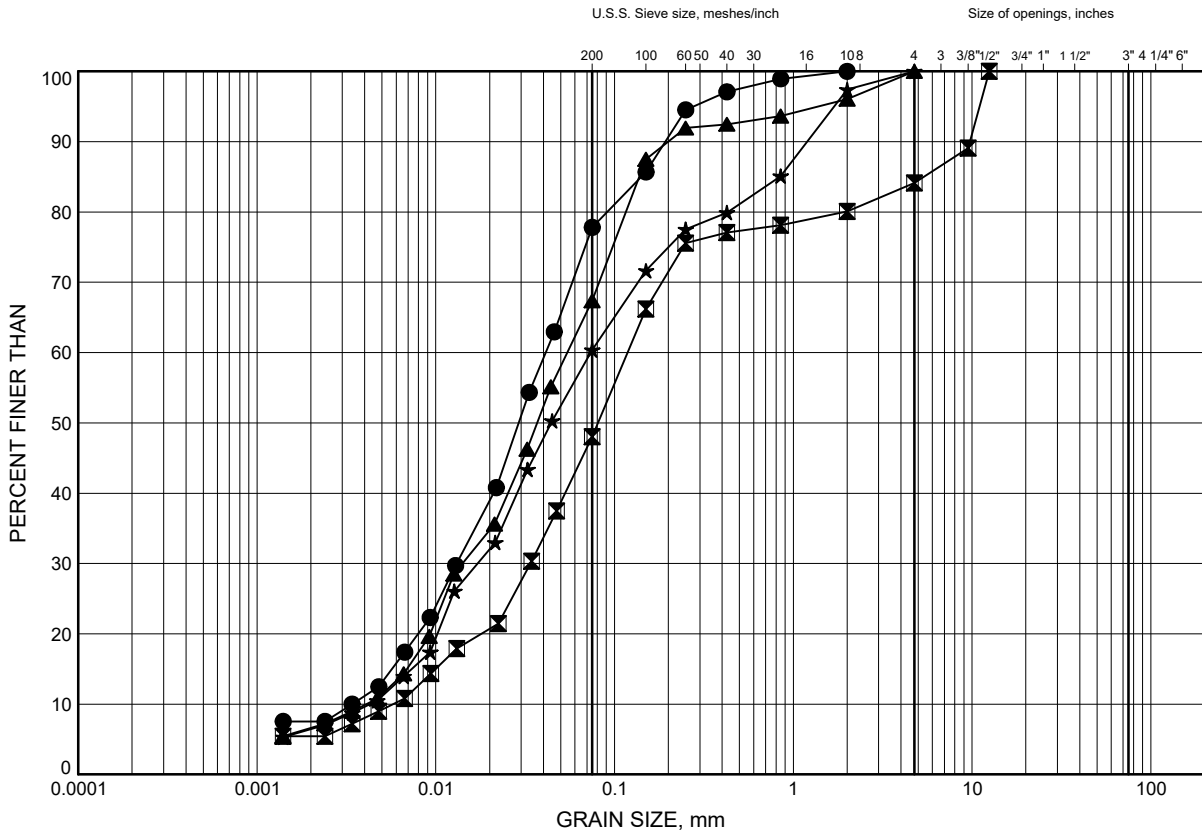


Prep'd AN
Chkd. AMP

Moose Creek Culvert GRAIN SIZE DISTRIBUTION

FIGURE B3

Sandy SILT to SAND and SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-26	9.45	422.35
⊠	16-28	1.52	424.88
▲	16-28	4.67	421.73
★	16-30	7.92	423.88

Date March 2017
WP# 6345-14-01



Prep'd AN
Chkd. AMP

**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - K0L 2H0
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	5: 16-26 SS#3 20'-22'
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	6.62
Soil Redox Potential [mV]	19-Sep-16	16:42	20-Sep-16	10:53	224
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	15.6
pH [no unit]	19-Sep-16	06:59	20-Sep-16	10:41	6.77
Chloride [µg/g]	20-Sep-16	20:39	21-Sep-16	16:30	39
Sulphate [µg/g]	20-Sep-16	20:39	21-Sep-16	16:30	8.3
Conductivity [µS/cm]	19-Sep-16	06:59	20-Sep-16	10:42	58
Resistivity (calculated) [Ohms.cm]	21-Sep-16	10:49	21-Sep-16	10:49	17200


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



SGS Canada Inc.

P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - K0L 2H0
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 2H0

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 2H0

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				LCS / Spike Blank			Matrix Spike / Reference Material		
							RPD	Acceptance Criteria	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)
						%	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 - K0L 2H0
Phone: 705-652-2000 FAX: 705-652-6365

Project : 13983**Thurber Engineering Ltd.****Attn : Mark Farrant**

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

Phone: 905-829-8666 x 228
Fax:

17-November-2016

Date Rec. : 19 September 2016**LR Report: CA13496-SEP16****Reference: 13983 Mark Farrant****Copy: #1**

CERTIFICATE OF ANALYSIS

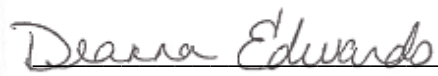
Final Report

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Approval Date	4: Analysis Approval Time	5: MDL	6: Moose Creek Culvert
Sample Date & Time						09-Sep-16 10:00
Temperature Upon Receipt [°C]	---	---	--	--	---	19.0
pH [no unit]	20-Sep-16	07:23	21-Sep-16	11:11	0.05	6.05
Conductivity [µS/cm]	20-Sep-16	07:23	21-Sep-16	11:11	2	17
Resistivity (calculated) [Ohms.cm]	21-Sep-16	21-Sep-16			---	5880
Redox Potential [mV]	19-Sep-16	16:42	20-Sep-16	10:53	---	203
Chloride [mg/L]	20-Sep-16	07:42	21-Sep-16	10:05	0.04	0.52
Sulphate [mg/L]	20-Sep-16	07:42	21-Sep-16	10:05	0.04	0.31
Sulphide [mg/L]	20-Sep-16	11:00	21-Sep-16	09:09	0.006	< 0.006
Corrosivity Index [none]	21-Sep-16	11:48	21-Sep-16	11:48		< 1

Temperature of samples upon receipt 19 degrees C
Cooling Agent Present
Custody Seal Present and Intact

Sulphide bottle received broken, solution from the general bottle containing zero headspace was used to fill a new Sulphide bottle.

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

**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - K0L 2H0
Phone: 705-652-2000 FAX: 705-652-6365

Project : 13983**LR Report : CA13496-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 2H0

Phone: 705-652-2000 FAX: 705-652-6365

Project : 13983

LR Report : CA13496-SEP16

Quality Control Report

Inorganic Analysis												
Parameter	Reporting Limit	Unit	Method Blank				LCS / Spike Blank			Matrix Spike / Reference Material		
					RPD	Acceptance Criteria	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
						%		Low	High		Low	High
Anions by IC - QCBatchID: DIO0257-SEP16												
Chloride	0.04	mg/L	<0.04		4	20	100	80	120	104	75	125
Sulphate	0.04	mg/L	<0.04		7	20	95	80	120	103	75	125
Conductivity - QCBatchID: EWL0255-SEP16												
Conductivity	2	µS/cm	< 2		0	10	99	90	110	NA		
pH - QCBatchID: EWL0255-SEP16												
pH	0.05	no unit	NA		0		100			NA		
Redox Potential - QCBatchID: EWL0252-SEP16												
Redox Potential	no	mV	NA		9	20	100	80	120	NA		
Sulphide by SFA - QCBatchID: SKA0137-SEP16												
Sulphide	0.006	mg/L	<0.006		100	20	90	80	120	99	75	125



Appendix C

Selected Site Photographs



Photograph 1 –Moose Creek, looking west



Photograph 2 – East end of the existing culvert

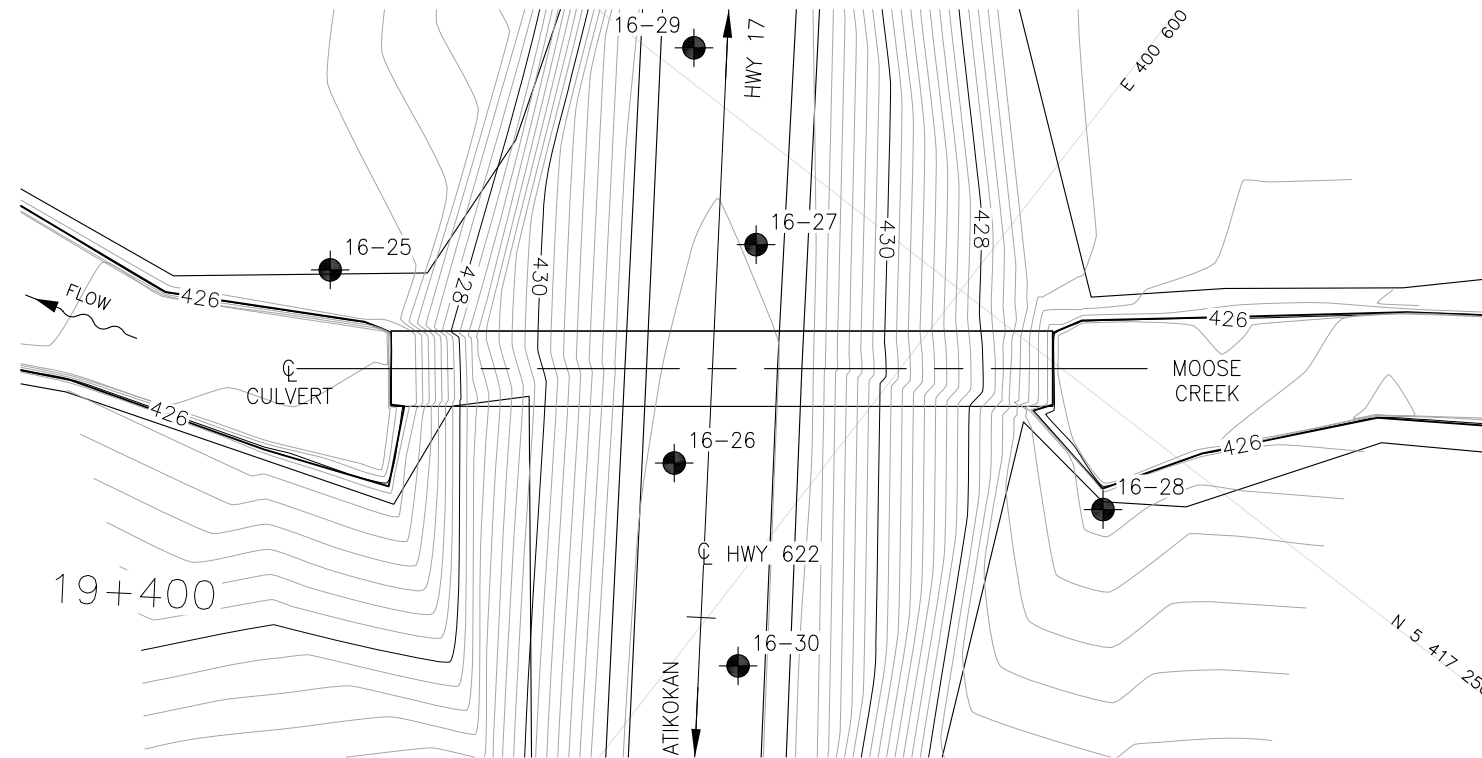


Photograph 3 –Rock fill at the toe of the embankment near the existing culvert

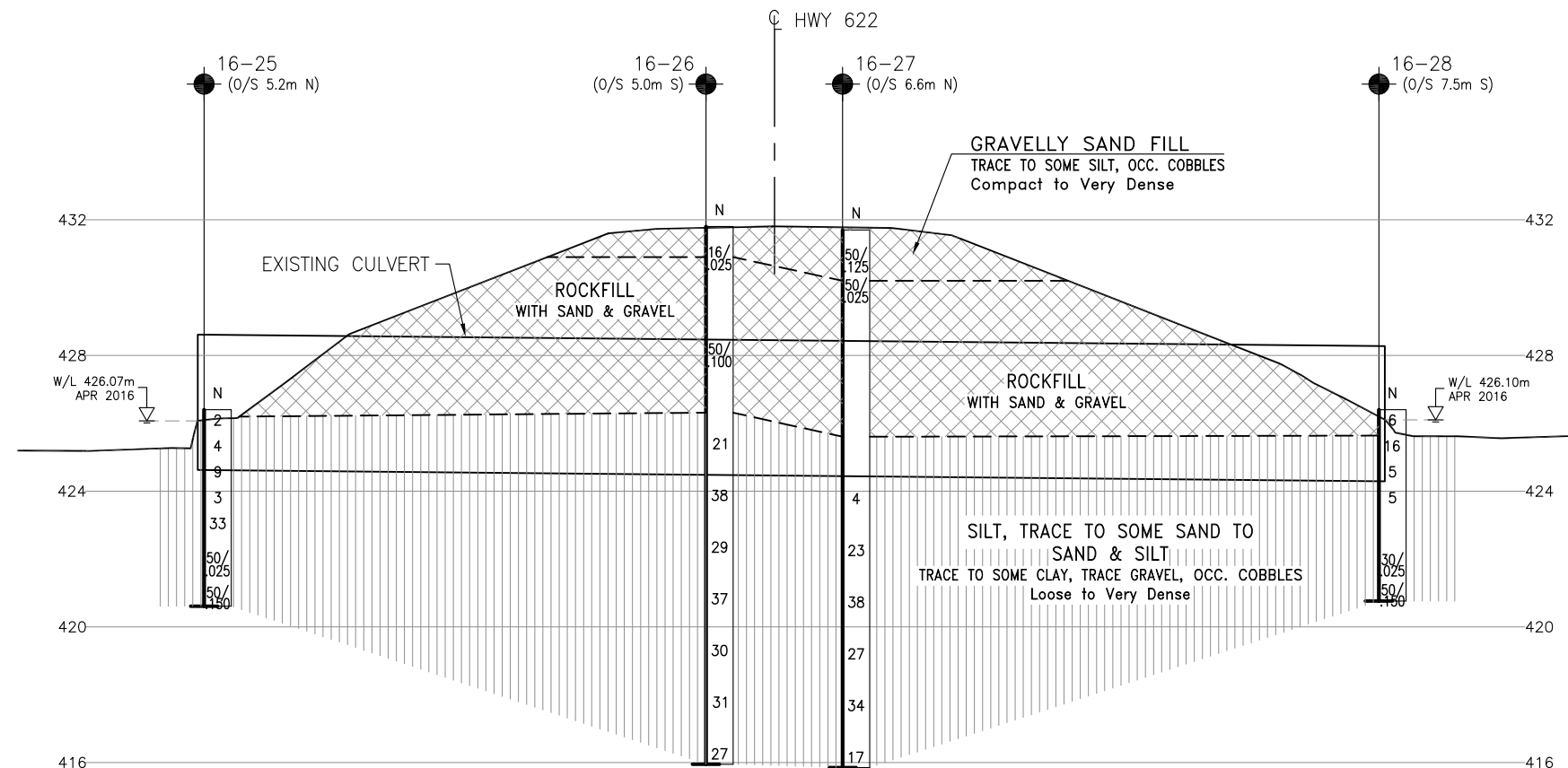
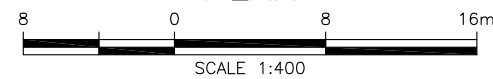


Appendix D

Borehole Locations and Soil Strata Drawing



PLAN

SECTION ALONG \mathbb{C}_L CULVERT

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



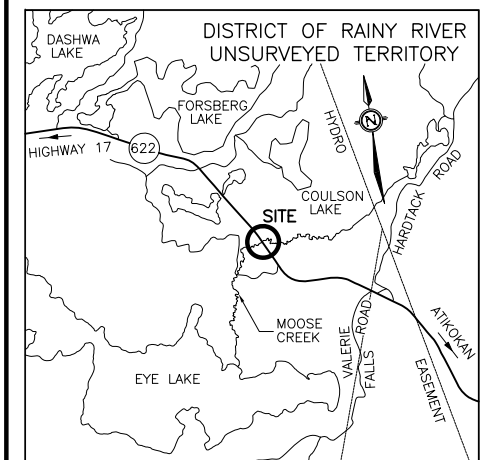
CONT No
WP No 6845-14-01

HIGHWAY 622
MOOSE 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

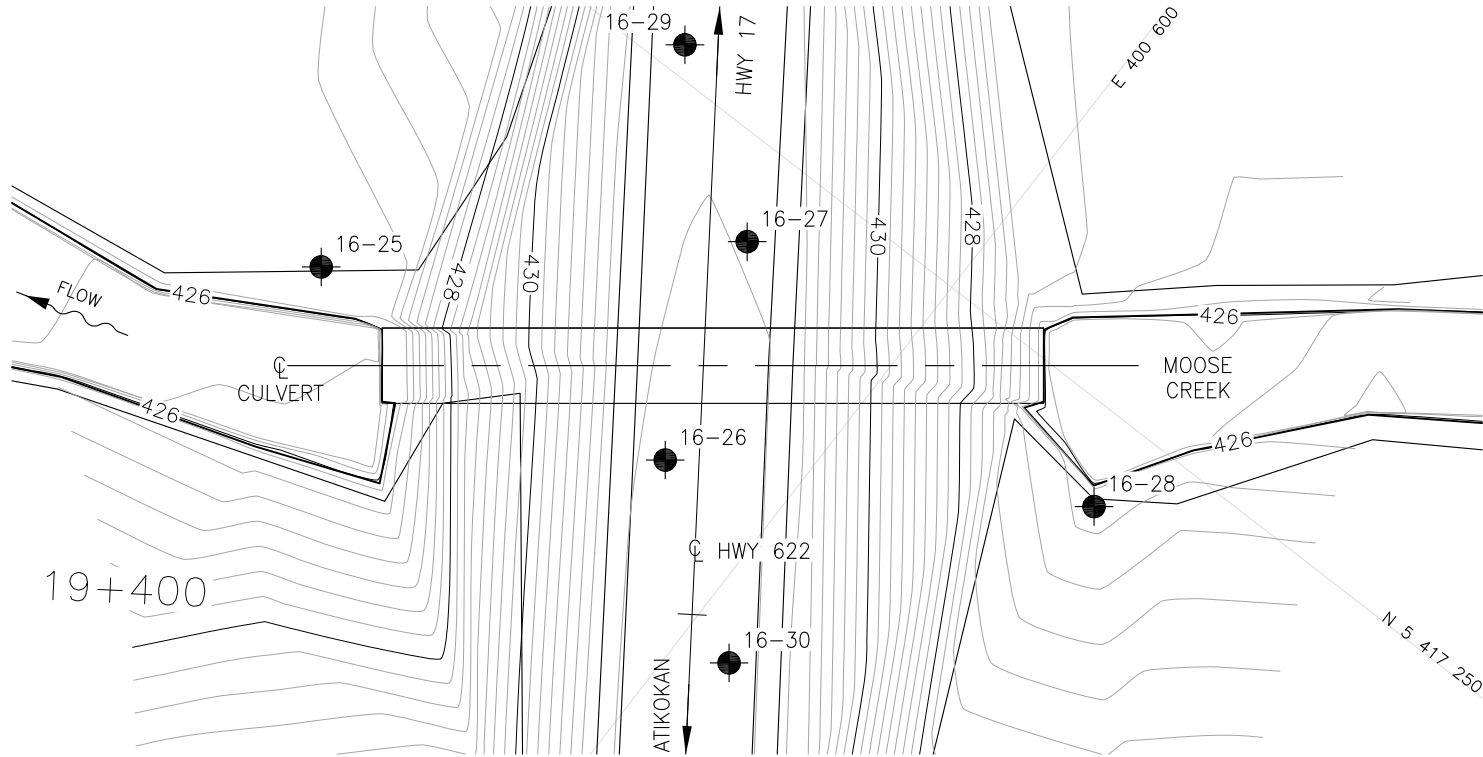
NO	ELEVATION	NORTHING	EASTING
16-25	426.4	5 417 230.4	400 573.0
16-26	431.8	5 417 233.5	400 593.6
16-27	431.7	5 417 245.3	400 590.0
16-28	426.4	5 417 245.4	400 613.0
16-29	431.7	5 417 251.5	400 581.0
16-30	431.8	5 417 227.1	400 602.8

-NOTES-

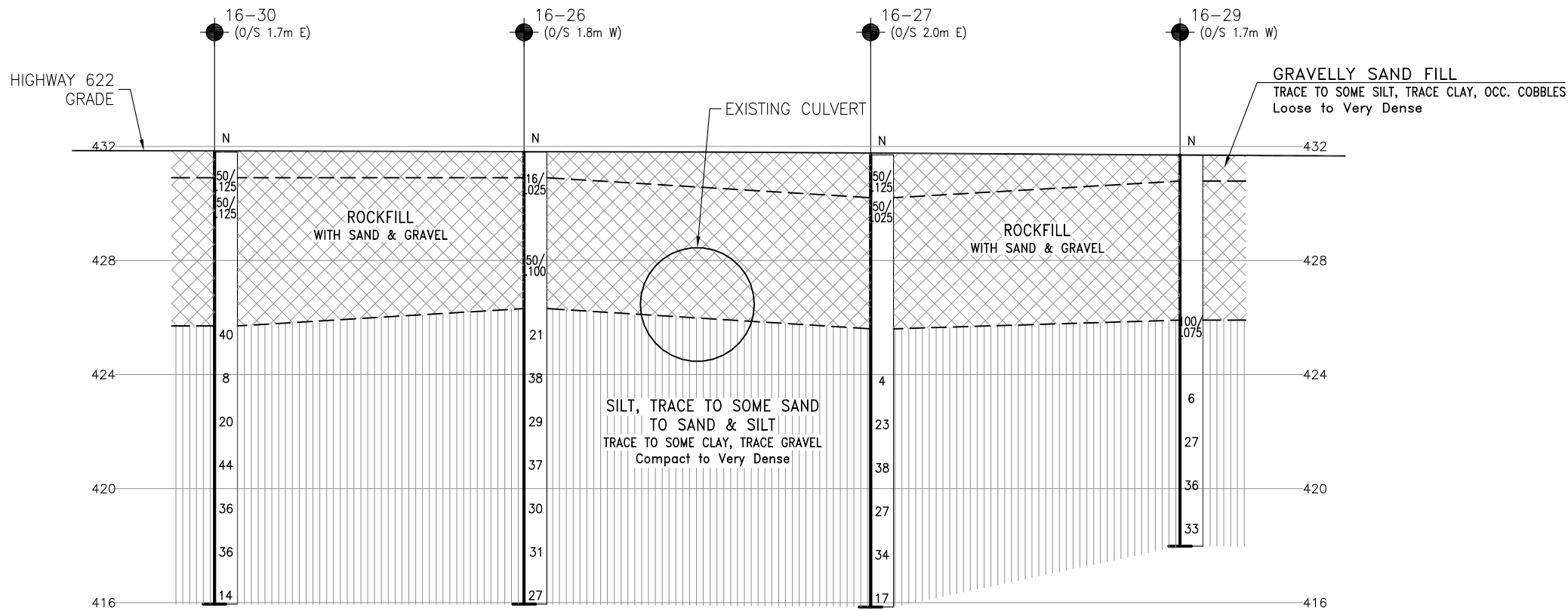
- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- 2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- 3) MTM, Zone 16 co-ordinate system was used to obtain borehole Northings and Eastings.

GEOCRES No. 52B-31

[illegible]



PLAN



SECTION ALONG ϕ HIGHWAY 622



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



CONT No
WP No 6845-14-01

HIGHWAY 622
MOOSE CREEK CULVERT
REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

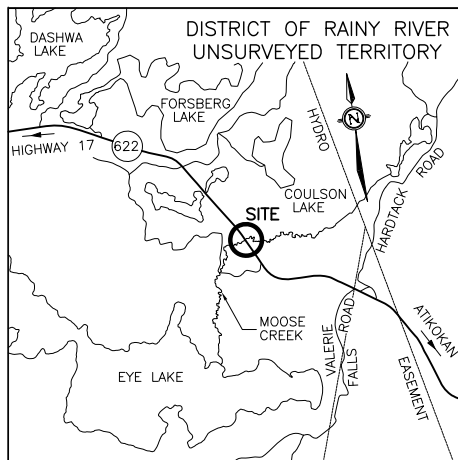


SHEET
11

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
16-25	426.4	5 417 230.4	400 573.0
16-26	431.8	5 417 233.5	400 593.6
16-27	431.7	5 417 245.3	400 590.0
16-28	426.4	5 417 245.4	400 613.0
16-29	431.7	5 417 251.5	400 581.0
16-30	431.8	5 417 227.1	400 602.8

-NOTES-

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- MTM, Zone 16 co-ordinate system was used to obtain borehole Northings and Eastings.

GEOCRES No. 52B-31

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	AMP	CHK AEG	CODE
DRAWN	AN	CHK AMP	SITE
LOAD	DATE	MAR 2017	
STRUCT	DWG	3	