



THURBER ENGINEERING LTD.

**FOUNDATION INVESTIGATION REPORT
MILE CREEK CULVERT REPLACEMENT
HIGHWAY 599, SITE No. 48W-191/C
DISTRICT OF KENORA
ONTARIO
G.W.P. No. 6839-14-00**

GEOCRES Number: 52J-18

Latitude 50.051205 ° , Longitude -90.942757 °

Report

to

HATCH Corporation

Date: February 8, 2018
File: 17077



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PART 1: FACTUAL INFORMATION

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 Mile Creek Culvert on Highway 599, located in the District of Kenora.

The purpose of this investigation was to explore the subsurface conditions at the culvert site 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 Corporation (Hatch) to carry out this foundation investigation under the Ministry of Transportation Ontario (MTO) Agreement Number 6016-E-0030.

2. SITE DESCRIPTION

The site is located on Highway 599, approximately 36.5 km north of the intersection of Highway 599 and Highway 642 in Silver Dollar, Ontario. The key plan showing the general location of the culvert site is presented on the Borehole Location and Soil Strata Drawings in Appendix D.

Highway 599 runs in a general east-west direction with the culvert generally perpendicular to the centreline of the highway. The culvert allows Mile Creek to flow in an southerly direction beneath the highway.

The Ontario Structural Inspection Manual (OSIM) prepared by MTO dated November 2, 2015 indicates that the existing structure is a 27 m long, two span open footing, timber structure culvert. Each span is 1.34 m wide. The timber culvert is 1.3 m high. The grade level of Highway 599 at

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the existing culvert is at an approximate Elevation of 439.1 m. The height of the existing fill cover is approximately 4.0 m. The culvert invert is at approximately Elevation 434.1 m at the inlet and 433.4 m at the outlet. The upstream and downstream water levels of Mile Creek were measured at Elevation 434.22 m and 433.54 m, respectively, in April 2016, as shown on drawings provided by Hatch.

The lands surrounding the Mile Creek Culvert site predominantly consist of heavily forested areas with occasional marsh lands and lakes. Local topography is described as knobby, hummocky, and ridged and is generally of high relief. 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 sandy tills of ground moraines overlying shallow bedrock. Bedrock geology maps of the area show the site lies in an area consisting of mafic to intermediate metavolcanics rocks.

3. INVESTIGATION PROCEDURES

The borehole investigation and field testing program for this project was carried out between July 10 and July 31, 2017 and consisted of drilling and sampling six (6) boreholes, designated as Boreholes ML17-01 to ML17-06. Boreholes ML17-01 to ML17-04 were drilled along the culvert alignment. Boreholes ML17-01 and ML17-04 were drilled at the inlet and outlet, respectively, and terminated upon refusal at 0.6 m and 7.8 m depth (Elevation 433.8 and 425.8). Due to the site constraints and difficult access to the borehole locations, the drilling operations for Boreholes ML17-01 and ML17-04, were conducted using portable tripod equipment. The tripod equipment allowed us to drill at the proposed borehole location, however it encountered refusal and was not able to advance further. Multiple attempts were made in the area to advance the borehole deeper, but were unsuccessful.

Boreholes ML17-02 and ML17-03 were drilled through the highway embankment. Bedrock was proved by NQ core size diamond in Borehole ML17-02 and was advanced 3.1 m into bedrock and terminated at 10.6 m depth (Elevation 428.3). Borehole ML17-03 was advanced to 9.8 m depth (Elevation 429.4). A Dynamic Cone Penetration Test (DCPT) was carried out in Borehole ML17-03 from 9.8 m (Elevation 429.4) to cone refusal reached at 13.4 m (Elevation 425.8).



Boreholes ML17-05 and ML17-06 were drilled through the paved section of Highway 599, approximately 15.5 m and 17.5 m to the west and east and of the existing culvert, respectively. These boreholes were advanced to assess the subsurface conditions for a temporary modular bridge planned at this site for traffic staging purposes, during replacement of the culvert. Bedrock was proved by NQ size diamond in both boreholes. Boreholes ML17-05 and ML17-06 were advanced 3.4 m and 1.3 m into bedrock and terminated at 10.0 m and 13.7 m depth (Elevations 428.7 and 425.9), 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. The approximate locations of the boreholes are shown on the Borehole Locations and Soil Strata Drawing included in Appendix D.

All boreholes within the paved portion of Highway 599 were drilled using a rubber track mounted drill rig equipped with continuous flight hollow and solid stem augers. Boreholes ML17-01 and ML17-04 were drilled using the wash boring method on tripod equipment. NQ coring methods were used to advance three boreholes through bedrock. 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).

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.

All rock cores were logged, and the Total Core Recovery (TCR), Solid Core Recovery (SCR), Rock Quality Designation (RQD) and the Fracture Indices (FI) were determined. Photos of the rock cores are included in Appendix B.

Groundwater conditions were observed in the open boreholes throughout the drilling operations and upon completion of drilling. A piezometer was installed in Borehole ML17-03 and a piezometer reading was taken on July 25, 2017. The piezometer was also decommissioned on July 25, 2017. Upon completion of drilling operations, the boreholes were backfilled in general accordance with Ontario Regulation 903. Completion details of the boreholes are summarized in Table 3.1.

Table 3.1 – Borehole Completion Details

Borehole Number	Borehole Depth / Base Elevation (m)	Piezometer Tip Depth / Elevation (m)	Completion Details
ML17-01	0.6 / 433.8	None installed	Borehole backfilled with auger cuttings to surface.
ML17-02	10.6 / 428.3	None installed	Borehole backfilled with bentonite holeplug to 4.0 m, gravel to 0.3 m, cement to 0.2 m, then asphalt cold patch to surface.
ML17-03	13.4 / 425.8	9.1 / 430.1	Screened from 9.8 m to 7.6 m, sand backfill from 9.8 m to 7.0 m, bentonite holeplug from 7.0 m to surface.
ML17-04	7.8 / 425.8	None installed	Borehole backfilled with bentonite holeplug to surface
ML17-05	10.0 / 428.7	None installed	Borehole backfilled with bentonite holeplug and cuttings to 3.1 m, gravel to 0.3 m, cement to 0.2 m, then asphalt cold patch to surface
ML17-06	13.7 / 425.9	None installed	Borehole backfilled with bentonite holeplug to 11.9 m, auger cuttings to 1.3 m, gravel to 0.3 m, cement to 0.2 m, then asphalt cold patch to surface

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). 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.

Point load tests were carried out on selected samples of intact bedrock upon arrival at the laboratory to assist in evaluation of the compressive strength of the bedrock. Results of point load tests on the rock core samples are included in Appendix B and on the Record of Borehole sheets in Appendix A.

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 existing 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 presented in Appendix B.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets included in Appendix A. A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following paragraphs. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description and should be used for interpretation of 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 drilled through Highway 599 platform generally consists of embankment fill over layers of native loose to compact sand, sandy silt, silt, sand and silt, and cobbles/boulders underlain by bedrock. The embankment fill consisted of interlayers of silty sand, gravelly sand and rockfill. The thickness of the embankment fill ranged from 5.4 m to 6.7 m. Within the embankment fill, the total rockfill thickness ranged from 2.1 m to 5.1 m. Cobbles and boulders were encountered immediately above the bedrock in Boreholes ML17-02 and ML-06. Descriptions of the individual strata are presented below.

5.1 Topsoil

A 600-mm thick layer of topsoil, containing some sand, was encountered surficially in Borehole ML17-04.

The topsoil thickness may vary between and beyond the borehole locations and the data is not intended for the purpose of estimating quantities.

5.2 Asphalt

The boreholes that were drilled through the paved portion of Highway 599 encountered approximately 25 mm to 200 mm of asphalt at the ground surface. The ground surface elevation of the boreholes drilled on the highway platform ranged from 438.7 to 439.6.



5.3 Embankment Fill

Roadbed materials consisting of 0.7 m to 0.9 m thick silty sand and gravelly sand with trace to some silt, trace clay, and occasional cobbles, was encountered below the asphalt in all boreholes drilled on Highway 599. Below the roadbed materials, the embankment consists of gravelly sand fill and coarse rock fill. The rock fill was typically 100 mm to 1200 mm in size, with thickness ranging from 0.9 m to 5.1 m. The thickness of the gravelly sand ranged from 0.6 m to 3.7 m. The embankment fill extended to depths ranging from 5.4 m to 6.7 m (Elevations 432.5 to 435.5)

SPT 'N' values in the silty sand fill and gravelly sand fill ranged from 4 to 42 blows for 0.3 m penetration, indicating a loose to dense relative density. An SPT 'N' value of 50 blows per 0.075 m of penetration, indicating a very dense state, was measured in Borehole ML17-03 at the base of the roadbed material. The high blow counts recorded were likely the result of the presence of cobbles and rock fill. Measured moisture contents in the gravelly sand fill ranged from 2 to 11 percent.

The results of grain size distribution analyses conducted on a sample of the gravelly sand fill is presented on the Record of Borehole sheets included in Appendix A and is summarized in the following table. The results are also presented on Figure B1 in Appendix B.

Soil Particle	Sand (percent)
Gravel	23
Sand	71
Silt and Clay	6

5.1 Sand and Gravel

Sand and gravel containing trace silt and occasional organics was contacted surficially in Borehole ML17-01.

Borehole ML17-01 was terminated within the sand and gravel upon auger refusal.

An SPT 'N' value recorded in the sand and gravel was 50 blows for 0.3 m penetration, indicating a very dense relative density. Measured moisture content was 17 percent.



5.2 Sand

A 600-mm thick upper layer of grey sand containing trace silt and trace clay was encountered at 0.6 m (Elevation 433.0) in Borehole ML17-04. Lower layers of grey sand were also encountered at depths of approximately 6.0 m to 10.7 m (Elevations 427.6 and 433.2) in Boreholes ML17-04 and ML17-06. The thickness of the lower layers of sand ranged from 0.6 m to 2.7m.

The depth to the base of the upper sand in Boreholes ML17-04 was at 1.2 m (Elevation 432.4). The depth to the base of the lower sand layers in Borehole ML17-06 were at 9.1 m and 11.3 m (Elevations 430.5 and 428.3).

Borehole ML17-04 was terminated within the lower sand layer at 7.8 m (Elevation 425.8).

SPT 'N' values recorded in the sand ranged from 18 to 64 blows for 0.3 m penetration, indicating a compact to very dense relative density. An SPT 'N' value of 34 blows per 0.15 m of penetration, indicating very dense state, was measured in Borehole ML17-04 near borehole termination depth. Measured moisture contents ranged 10 percent to 19 percent.

The results of grain size distribution analyses conducted on two samples of the sand are presented on the Record of Borehole sheets included in Appendix A and is summarized in the following table. The results are also presented on Figure B2 in Appendix B.

Soil Particle	Sand (percent)
Gravel	0 to 1
Sand	88 to 92
Silt	6
Clay	2
Silt and Clay	11

5.3 Sand and Silt, Sandy Silt and Silt

Layers of sand and silt, sandy silt, and silt, containing trace to some clay and trace gravel, were encountered at depths between 1.2 m and 9.1 m (Elevations 433.2 to 430.5) in Boreholes ML17-03 to ML17-06.



The thickness of the sandy silt, silt and, sand and silt layers, where fully penetrated, ranged between 1.1 m and 4.8 m and extended to depths of between 6.0 m and 10.7 m (Elevations 427.6 to 432.1).

Borehole ML17-03 was terminated within the sand and silt layer at 9.8 m (Elevation 429.4).

SPT 'N' values recorded in the sandy silt, silt and, sand and silt layers ranged from 9 to 42 blows for 0.3 m penetration, indicating a compact to dense relative density. An SPT 'N' value of 1 blow per 0.3 m of penetration, was measured in Borehole ML17-03 below Elevation 430.0, indicating a very loose state. The very loose conditions were noted within approximate Elevation 430.0, and may have been the result of hydraulic ground disturbance during drilling operations. Measured moisture contents in the sandy silt, silt and, sand and silt ranged from 13 percent to 26 percent.

The results of grain size analyses conducted on samples of the silt to sand and silt are provided on the Record of Borehole sheets in Appendix A, and illustrated in Figure B3 of Appendix B. The results are summarized as follows:

Soil Particle	Silt to Sand and Silt (Percent)
Gravel	0 to 6
Sand	19 to 35
Silt	57 to 70
Clay	8 to 11

5.4 Cobbles and Boulders

Cobbles and boulders, containing some sand and gravel, were encountered overlying the bedrock at a depth of 5.4 m and 11.3 m (Elevations 433.5 and 428.3) in Boreholes ML17-02 and ML17-06, respectively. The thickness of the cobbles and boulders was 2.1 m and 1.1 m and extended to 7.5 m and 12.4m depth (Elevations 431.4 and 427.2), in Boreholes ML17-02 and ML17-06, respectively.

5.5 Bedrock

The overburden soils described above are underlain by basalt and gabbro bedrock. The bedrock was black to grey with white cemented joints and occasional porphyritic inclusions. Occasional



mechanical breaks were noted throughout the bedrock cores. The bedrock is generally described as highly to slightly weathered. Bedrock was proved by coring in Boreholes ML17-02, ML17-05 and ML17-06. Table 5.1 summarizes depths and elevations to the top of bedrock.

Table 5.1 - Depths and Elevations of Top of Bedrock

Borehole	Top of Bedrock	
	Depth (m)	Elevation (m)
ML17-02	7.5	431.4
ML17-05	6.6	432.1
ML17-06	12.4	427.2

Total Core Recovery (TCR) in the bedrock ranged from 77% to 100% with Solid Core Recovery (SCR) ranging from 43% to 100%. The Rock Quality Designation (RQD) determined from the recovered cores generally ranged from 43% to 100%, indicating poor to excellent rock quality.

The Fracture Index (FI) of the rock, expressed as fractures per 0.3 m of core, ranged from 1 to greater than 10.

Average unconfined compressive strengths (UCS) of the rock ranged between 79 MPa to greater than 250 MPa, indicating the rock is strong to extremely strong. The UCS was 45 MPa and 47 MPa in two rock cores, indicating the rock is medium strong. These estimated rock strength values are interpreted from point load tests that were conducted on rock cores recovered from the boreholes. A summary of the Point Load Test Results and photographs of bedrock cores are presented in Appendix B.

5.6 Groundwater Conditions

Groundwater conditions were observed during drilling operations and groundwater levels were measured in the open boreholes upon completion of drilling. A piezometer was also installed in Borehole ML17-03. The piezometer was decommissioned upon taking a water level measurement on July 25, 2017.

The groundwater levels measured in the open boreholes and the piezometer are summarized in Table 5.2 below.



Table 5.2 - Groundwater Measurements

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
ML17-01	July 10, 2017	Dry	-	Open borehole
ML17-02	July 28, 2017	5.1	433.8	Open borehole
ML17-03	July 25, 2017	4.8	434.4	Piezometer
ML17-04	July 10, 2017	0.9	432.7	Open borehole
ML17-05	July 31, 2017	5.4	433.3	Open borehole
ML17-06	July 29, 2017	5.4	434.2	Open borehole

The upstream and downstream water levels of Mile Creek were measured at Elevation 434.22 m and 433.54 m, respectively, in April 2016, as shown on drawings provided by Hatch. The groundwater level should be assumed to reflect the local creek water level.

Groundwater levels are short-term readings and seasonal fluctuations of the groundwater levels are to be expected. In particular, the groundwater levels may be at a higher elevation after periods of significant or prolonged precipitation.

6. CORROSIVITY AND SULPHATE TEST RESULTS

A sample of the gravelly sand from Borehole ML17-03, and a sample of the creek water, taken from the inlet area, were submitted for analytical testing of corrosivity parameters and sulphate. The results of the analytical tests are shown in Table 6.1 below. The laboratory certificates of analysis are presented in Appendix B.



Table 6.1 - Analytical Test Results

Parameter	Units (Soil)	Units (Water)	Test Results	
			ML17-03 SS 3 Depth 2.4 m	Mile Creek
			(Soil Sample)	(Creek Water)
Sulphide	%	mg/L	<0.02	<0.006
Chloride	µg/g	mg/L	2.4	2.7
Sulphate	µg/g	mg/L	10	0.8
pH	No unit	No unit	8.27	7.62
Electrical Conductivity	µS/cm	µS/cm	35	63
Resistivity	Ohms.cm	Ohms.cm	28700	15800
Redox Potential	mV	mV	303	352

7. MISCELLANEOUS

Thurber obtained subsurface 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 Hatch.

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 either Mr. Ryan McCourt or Stephen Hillier of Thurber. Overall supervision of the field program was provided by Mr. Cory Zanatta, EIT 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 Mr. Cory Zanatta, EIT and Ms. R. Palomeque Reyna, The report was reviewed by Mr. Jason Lee, P.Eng and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.



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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

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


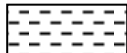



 Water Level
 Shear Strength Determination by Pocket Penetrometer

- (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			

EXPLANATION OF ROCK LOGGING TERMS


<u>ROCK WEATHERING CLASSIFICATION</u>		<u>SYMBOLS</u>	
Fresh (FR)	No visible signs of weathering.		
Fresh Jointed (FJ)	Weathering limited to the surface of major discontinuities.		CLAYSTONE
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.		SILTSTONE
Moderately Weathered (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.		SANDSTONE
Highly Weathered (HW)	Weathering extends throughout the rock mass and the rock is partly friable.		COAL
Completely Weathered (CW)	Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved.		Bedrock (general)

<u>DISCONTINUITY SPACING</u>		<u>STRENGTH CLASSIFICATION</u>			
Bedding	Bedding Plane Spacing	Rock Strength	Approximate Uniaxial Compressive Strength		Field Estimation of Hardness*
			(MPa)	(psi)	
Very thickly bedded	Greater than 2m	Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Thickly bedded	0.6 to 2m				
Medium bedded	0.2 to 0.6m	Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Thinly bedded	60mm to 0.2m	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Very thinly bedded	20 to 60mm				
Laminated	6 to 20mm	Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
Thinly Laminated	Less than 6mm				

<u>TERMS</u>					
Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.	Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.	Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a percentage of total core run length.	Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen				
Fracture Index: (FI)	Frequency of natural fractures per 0.3m of core run.				

RECORD OF BOREHOLE No ML17-01 1 OF 1 METRIC

GWP# 6839-14-00 LOCATION Mile Creek Culvert, MTM NAD 83 Zone 15 N 5 546 410.5 E 237 267.6 ORIGINATED BY STH
 HWY 599 BOREHOLE TYPE Tripod COMPILED BY AN
 DATUM Geodetic DATE 2017.07.10 - 2017.07.10 CHECKED BY RPR

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										
434.4	GROUND SURFACE							20	40	60	80	100						
0.0	SAND and GRAVEL , trace silt, occasional organics		1	SS	50		434											
433.8	Very Dense																	
0.6	Brown Moist																	
	END OF BOREHOLE AT 0.6m UPON AUGER REFUSAL. BOREHOLE OPEN AND DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH AUGER CUTTINGS TO SURFACE.																	

RECORD OF BOREHOLE No ML17-02 1 OF 2 METRIC

GWP# 6839-14-00 LOCATION Mile Creek Culvert, MTM NAD 83 Zone 15 N 5 546 394.7 E 237 271.7 ORIGINATED BY BRM
 HWY 599 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2017.07.28 - 2017.07.28 CHECKED BY RPR

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																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
438.9	GROUND SURFACE							20	40	60	80	100																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								

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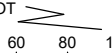
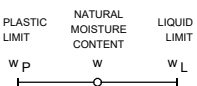
20
15
10

(%) STRAIN AT FAILURE

RUN #2
TCR=52%
SCR=27%
RQD=25%

RUN #3
TCR=100%
SCR=100%
RQD=100%
UCS=>250MPa

METRIC

SOIL PROFILE					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER TYPE "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
					DYNAMIC CONE PENETRATION RESISTANCE PLOT  SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE WATER CONTENT (%) 
	Continued From Previous Page				
428.3	BEDROCK (BASALT) slightly weathered, grey to black and white bands, occasional mechanical breaks				
10.6	END OF BOREHOLE AT 10.6m. WATER LEVEL AT 5.1m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 4.0m, GRAVEL TO 0.3m, CEMENT TO 0.2m, THEN ASPHALT COLD PATCH TO SURFACE.				

RECORD OF BOREHOLE No ML17-03

1 OF 2

METRIC

GWP# 6839-14-00 LOCATION Mile Creek Culvert, MTM NAD 83 Zone 15 N 5 546 401.1 E 237 283.1 ORIGINATED BY STH
 HWY 599 BOREHOLE TYPE Wash Boring/Dynamic Cone Penetration Test COMPILED BY AN
 DATUM Geodetic DATE 2017.07.25 - 2017.07.25 CHECKED BY RPR

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											
439.2	GROUND SURFACE							20	40	60	80	100							
0.8	ASPHALT: (30mm)																		
	Gravelly SAND , trace silt Very Dense Brown (FILL)		1	GS			439												
438.3			2	SS	50/ 0.075														
0.9	ROCKFILL: (size ranging from 100mm to 1200mm) Advanced by coring						438												
437.1																			
2.1	Gravelly SAND , with cobbles, trace silt and clay Loose to Compact Brown Moist (FILL)		3	SS	4		437												
			4	SS	11		436												
							435												
			5	SS	14		434												
433.4																			
5.8	ROCKFILL: (size ranging from 100mm to 1200mm) Advanced by coring		1	RUN			433												
432.5																			
6.7	SAND and SILT , trace clay, occasional organics Compact to Very Loose Grey Wet		6	SS	23		432												
							431												
							430												
429.4	Low SPT "N" values due to hydraulic ground disturbance at approx. elevation 430.0m		7	SS	1														
9.8	End of sampling and start DCPT																		

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No ML17-03

2 OF 2

METRIC

GWP# 6839-14-00 LOCATION Mile Creek Culvert, MTM NAD 83 Zone 15 N 5 546 401.1 E 237 283.1 ORIGINATED BY STH
 HWY 599 BOREHOLE TYPE Wash Boring/Dynamic Cone Penetration Test COMPILED BY AN
 DATUM Geodetic DATE 2017.07.25 - 2017.07.25 CHECKED BY RPR

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	W _p	W	W _L			
	Continued From Previous Page						20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	20 40 60						
425.8														
13.4	END OF BOREHOLE AT 13.4m UPON DCPT REFUSAL. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2017.07.25 4.8 434.4													

RECORD OF BOREHOLE No ML17-04

1 OF 1

METRIC

GWP# 6839-14-00 LOCATION Mile Creek Culvert, MTM NAD 83 Zone 15 N 5 546 385.1 E 237 289.1 ORIGINATED BY STH
 HWY 599 BOREHOLE TYPE Tripod/Wash Boring COMPILED BY AN
 DATUM Geodetic DATE 2017.07.10 - 2017.07.10 CHECKED BY RPR

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						
								20 40 60 80 100						
433.6	GROUND SURFACE													
0.0	TOPSOIL , some sand, occasional organics Very Loose Brown Moist		1	SS	1									
433.0														
0.6	SAND , trace silt and clay Compact Grey Wet		2	SS	22									
432.4														
1.2	Sandy SILT , trace clay Compact to Loose Grey Wet		3	SS	21									
			4	SS	22									
			5	SS	9									

ONTMT4S MTO-17077.GPJ 2017TEMPLATE(MTO).GDT 2/8/18

RECORD OF BOREHOLE No ML17-05

1 OF 2

METRIC

GWP# 6839-14-00 LOCATION Mile Creek Culvert, MTM NAD 83 Zone 15 N 5 546 384.9 E 237 270.1 ORIGINATED BY BRM
 HWY 599 BOREHOLE TYPE Hollow Stem Augers/Coring COMPILED BY AN
 DATUM Geodetic DATE 2017.07.31 - 2017.07.31 CHECKED BY RPR

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								
								○ UNCONFINED + FIELD VANE		● QUICK TRIAXIAL × LAB VANE						
438.7	GROUND SURFACE						20	40	60	80	100					
0.0	ASPHALT: (200mm)															
0.1	Gravelly SAND, trace silt Dense Brown Moist (FILL)		1	GS												
437.8			2	SS	41											
0.9	ROCKFILL:(size ranging from 100mm to 1200mm) Advanced by coring															
433.2																
5.5	SILT, some sand and clay, trace gravel Dense Grey Wet		3	SS	42											
432.1	Coring bedrock started at 6.6m															
6.6	BEDROCK (BASALT) slightly weathered, grey, occasional mechanical breaks		1	RUN												
			2	RUN												
			3	RUN												
428.7																

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

ONTMT4S MTO-17077.GPJ 2017TEMPLATE(MTO).GDT 2/8/18

RECORD OF BOREHOLE No ML17-05 2 OF 2 METRIC

GWP# 6839-14-00 LOCATION Mile Creek Culvert, MTM NAD 83 Zone 15 N 5 546 384.9 E 237 270.1 ORIGINATED BY BRM
 HWY 599 BOREHOLE TYPE Hollow Stem Augers/Coring COMPILED BY AN
 DATUM Geodetic DATE 2017.07.31 - 2017.07.31 CHECKED BY RPR

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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					W _p	W	W _L		
10.0	Continued From Previous Page END OF BOREHOLE AT 10.0m. WATER LEVEL AT 5.4m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND SLOUGH TO 3.1m, GRAVEL TO 0.3m, CEMENT TO 0.2m, THEN ASPHALT TO SURFACE.																

ONTMT4S MTO-17077.GPJ 2017TEMPLATE(MTO).GDT 2/8/18

RECORD OF BOREHOLE No ML17-06

1 OF 2

METRIC

GWP# 6839-14-00 LOCATION Mile Creek Culvert, MTM NAD 83 Zone 15 N 5 546 413.7 E 237 287.1 ORIGINATED BY BRM
 HWY 599 BOREHOLE TYPE Hollow Stem Augers/Coring COMPILED BY AN
 DATUM Geodetic DATE 2017.07.29 - 2017.07.29 CHECKED BY RPR

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 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
439.6	GROUND SURFACE							20	40	60	80	100				
0.8	ASPHALT: (25mm)		1	GS			439									
438.9	Gravelly SAND, trace silt Brown Moist (FILL)															
0.7	ROCKFILL: (size ranging from 100mm to 1200mm)						438									
							437									
435.9							436									
3.7	Gravelly SAND, trace silt and clay Dense Brown to Grey Moist (FILL)		2	SS	42											
435.3							435									
4.3	ROCKFILL: (size ranging from 100mm to 1200mm)						434									
							433									
433.2																
6.4	SAND, some silt and clay, trace gravel Compact Grey Wet		3	SS	18											
							432									
			4	SS	19											
							431									
430.5																
9.1	Sandy SILT, some clay Compact Grey Wet		5	SS	12		430									

Continued Next Page

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

RECORD OF BOREHOLE No ML17-06 2 OF 2 METRIC

GWP# 6839-14-00 LOCATION Mile Creek Culvert, MTM NAD 83 Zone 15 N 5 546 413.7 E 237 287.1 ORIGINATED BY BRM
 HWY 599 BOREHOLE TYPE Hollow Stem Augers/Coring COMPILED BY AN
 DATUM Geodetic DATE 2017.07.29 - 2017.07.29 CHECKED BY RPR

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 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
	Continued From Previous Page							20	40	60	80	100					
428.9	Sandy SILT , some clay Compact to Very Dense Grey Wet						429										
10.7	SAND , some silt and gravel, trace clay Very Dense Grey		6	SS	64									○			
428.3	Moist																
11.3	BOULDERS Advanced by coring						428										
	Coring bedrock started at 12.4m																
427.2																	
12.4	BEDROCK (GABBRO and BASALT) highly to moderately weathered, blue to grey and white bands		1	RUN			427										
	Mechanical breaks, broken zones																
425.9							426										
13.7	END OF BOREHOLE AT 13.7m. WATER LEVEL AT 5.4m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 11.9m, SLOUGH TO 1.3m, GRAVEL TO 0.3m, CEMENT TO 0.2m, THEN ASPHALT COLD PATCH TO SURFACE.																

ONTMT4S MTO-17077.GPJ 2017TEMPLATE(MTO).GDT 2/8/18



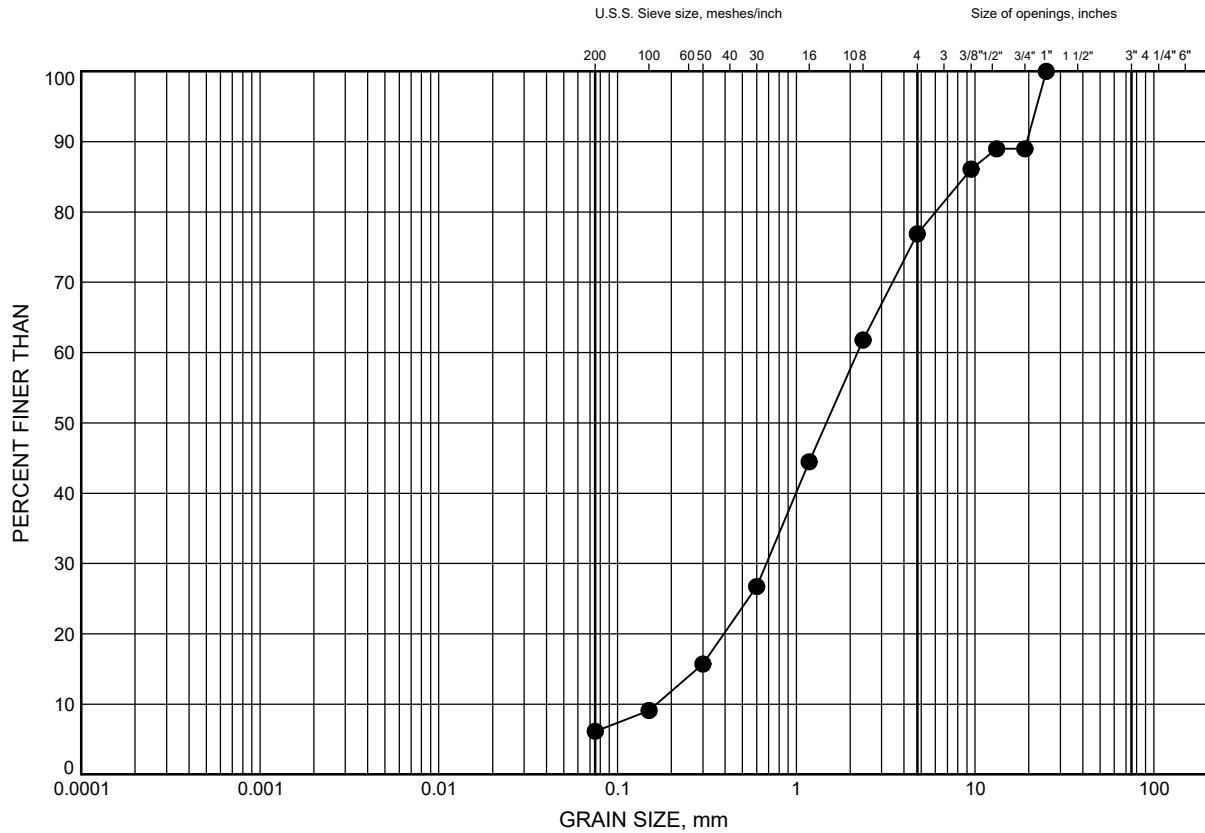
Appendix B

Geotechnical and Analytical Laboratory Test Results And Bedrock Core Photos

Mile 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)
●	ML17-02	3.8	435.1

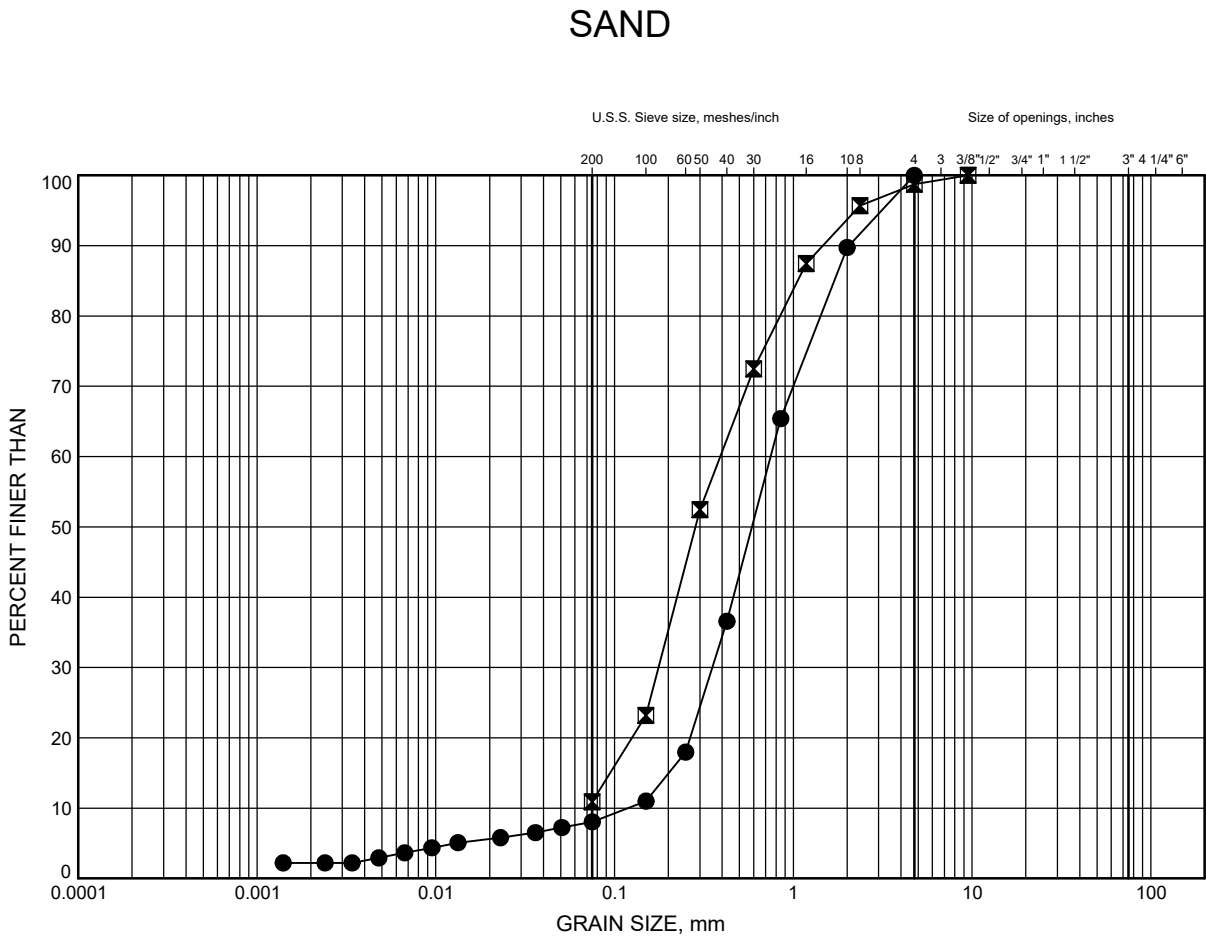
Date October 2017
GWP# 6839-14-00



Prep'd AN
Chkd. RPR

Mile 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)
●	ML17-04	0.9	432.7
⊠	ML17-06	6.7	432.9

Date October 2017
GWP# 6839-14-00

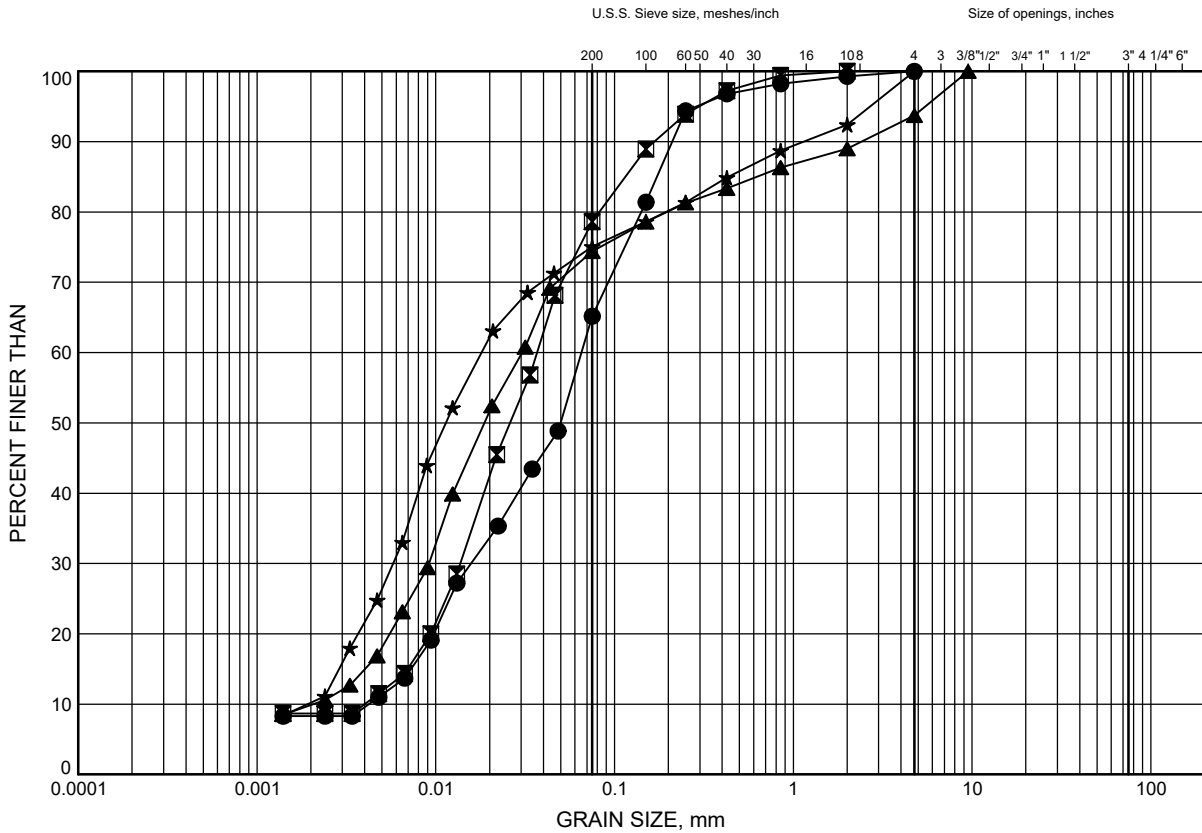


Prep'd AN
Chkd. RPR

Mile Creek Culvert GRAIN SIZE DISTRIBUTION

FIGURE B3

Sandy SILT to SAND, some silt



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	ML17-03	7.6	431.6
⊠	ML17-04	2.1	431.5
▲	ML17-05	5.8	432.9
★	ML17-06	9.4	430.2

Date ..October 2017.....
GWP# ..6839-14-00.....



Prep'dAN.....
Chkd.RPR.....



THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No: 17077
Client: Hatch
Project Name: Mile Creek Culvert
Core Size: NQ BH No : MI17-06

Date Drilled: 31-Jul-17
Date Tested: 10-Aug-17
Tester: KK
Reviewed by: CZ

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	11.5	D	30.4	46.0	93.8	13.1	314.8	Basalt	Extremely Strong
2	1	11.6	A	17.9	46.0	53.5	5.7	136.6	Basalt	Very Strong
3										
4										
5										
6										
7										
8										
9										
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32										
33										
34										
35										

* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1

Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

* Diametral Test should have $0.7 \times D$ on either side of test point.

* Correlation factor to obtain UCS values is 24.



THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No: 17077
Client: Hatch
Project Name: Mile Creek Culvert
Core Size: NQ BH No : MI17-05

Date Drilled: 31-Jul-17
Date Tested: 10-Aug-17
Tester: KK
Reviewed by: CZ

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_s(50)$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	6.7	A	20.0	47.0	54.8	6.1	147.3	Argillite	Very Strong
2	1	7.1	D	21.1	47.0	70.6	8.8	211.5	Argillite	Very Strong
3	1	7.5	D	30.0	47.0	101.9	12.5	300.2	Argillite	Extremely Strong
4	2	7.7	D	14.5	47.0	149.5	6.0	144.8	Argillite	Very Strong
5	2	8.0	A	15.0	47.0	59.4	4.3	103.8	Argillite	Very Strong
6	2	8.5	D	26.6	47.0	108.0	11.1	266.8	Argillite	Extremely Strong
7	2	8.6	A	9.5	47.0	55.1	2.9	69.8	Argillite	Strong
8	2	9.0	D	28.1	47.0	109.9	11.7	281.5	Argillite	Extremely Strong
9	3	9.2	A	15.0	47.0	54.8	4.6	110.6	Argillite	Very Strong
10	3	9.8	D	4.7	47.0	124.8	1.9	46.7	Argillite	Medium Strong
11										
12										
13										
14										
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35										

* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1

Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

* Diametral Test should have $0.7 \times D$ on either side of test point.

* Correlation factor to obtain UCS values is 24.

Last Modified: September 14, 2016



THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No: 17077
Client: Hatch
Project Name: Mile Creek Culvert
Core Size: NQ BH No : MI17-02

Date Drilled: 29-Jul-17
Date Tested: 14-Aug-17
Tester: KK
Reviewed by: CZ

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	3	9.1	A	35.0	47.0	47.8	12.0	287.0	Basalt	Extremely Strong
2	3	9.3	D	4.5	47.0	120.8	1.9	44.9	Basalt	Medium Strong
3	3	9.8	A	35.0	47.0	53.9	10.9	261.5	Basalt	Extremely Strong
4	3	10.2	A	35.0	47.0	53.7	10.9	262.2	Basalt	Extremely Strong
5	3	10.3	D	19.8	47.0	122.4	8.3	198.7	Basalt	Very Strong
6										
7										
8										
9										
10										
11										
12										
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33										
34										
35										

* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1

Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

* Diametral Test should have $0.7 \times D$ on either side of test point.

* Correlation factor to obtain UCS values is 24.

Last Modified: September 14, 2016



0 m

50 m

100 m

150 m

Core Photo 1: Borehole ML17-02 Run 2 to Run 3 (9.0 m to 10.6 m)



0 m

50 m

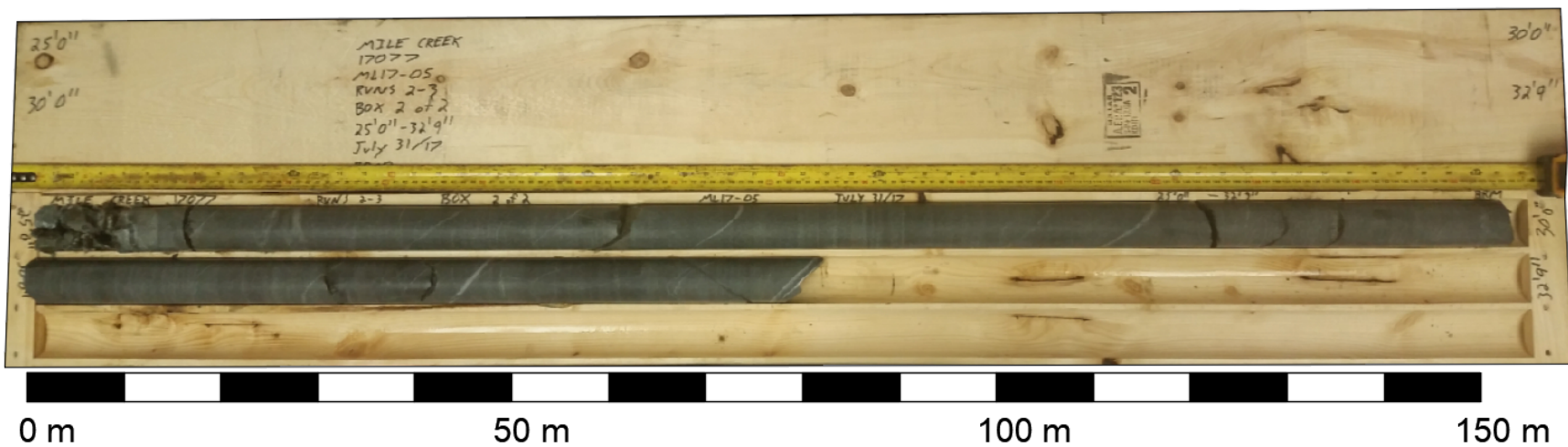
100 m

150 m

Core Photo 2: Borehole ML17-02 Rockfill (1.2 m to 2.0 m)



Core Photo 3: Borehole ML17-05 Rockfill and Run 1 (0.9 m to 5.5 m and 6.6 m to 7.6 m)



Core Photo 4: Borehole ML17-05 Run 2 to Run 3 (7.6 m to 10.0 m)



Core Photo 5: Borehole ML17-06 Rockfill and Boulders (0.7 m to 6.4 m and 11.3 m to 12.0 m)



Core Photo 6: Borehole ML17-06 Run 1 (12.0 m to 13.7 m)



Client
SGS LIMS Number
Analysis Package:

Attention: Cory Zanatta
Project#: 17077
Thurber Engineering Ltd.
CA15302-AUG17
Corrosivity (Soil)

SGS Canada Inc.
185 Concession St. Box 4300
Lakefield, Ont., Canada,
K0L 2H0

Sample ID	Unit	PR17-02 SS7	KE 17-03 SS5	ME 17-03 SS3	TU 17-02 SPT5	CO 17-03 SS4	AG 147-02 SS4
Sample Date/Time		30-Jul-17	30-Jul-17	30-Jul-17	30-Jul-17	30-Jul-17	30-Jul-17
Moisture	%	15.6	7.0	7.7	22.2	15.6	21.0
pH	no unit	8.25	6.40	8.27	8.14	8.65	8.33
Corrosivity Index	none	4.5	1.0	1.0	1.0	4.0	1.0
Soil Redox Potential	mV	325	338	303	301	295	290
Sulphide	mg/L	0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Chloride	mg/L	6.9	240	2.4	25	1.2	150
Sulphate	mg/L	26	10	10	1.2	46	6.1
Conductivity	uS/cm	49	269	35	81	83	213
Resistivity (calculated)	ohms.cm	20300	3720	28700	12400	12000	4690

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
Environment, Health and Safety

Certificate of Analysis

SGS Canada Inc.
185 Concession St. Box 4300
Lakefield, Ont., Canada, K0L 2H0



Client
SGS LIMS Number
Analysis Package:

Attention: Cory Zanatta
Project#: 17077 Hwy 599
Thurber Engineering Ltd.
CA15314-JUN17
Corrosivity (Solution)

Sample ID	Unit	RL	Tug Creek	Pratt Creek	Mile Creek	Cobb Bay	Kekwanzik Lake	Agimak River
			10-Jun-17 12:10	10-Jun-17 12:30	10-Jun-17 10:40	10-Jun-17 11:20	10-Jun-17 12:45	10-Jun-17 13:10
Sample Date/Time								
Temperature Upon Receipt	°C		10.0	10.0	10.0	10.0	10.0	10.0
Soil Redox Potential	mV		334	272	352	301	312	345
Sulphide	mg/L	0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
pH	no unit	0.05	7.78	7.81	7.62	7.70	7.38	7.26
Chloride	mg/L	0.04	2.1	2.9	2.7	1.7	8.8	7.8
Sulphate	mg/L	0.04	0.3	1.2	0.8	0.6	2.0	1.9
Conductivity	µS/cm	2	100	78	63	78	67	56
Resistivity (calculated)	ohms.cm		9990	12700	15800	12800	15000	17700

Corrosivity Index is based on the AWWA
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
Environment, Health and Safety

Data reported represents the sample submitted to SGS. Reproduction of this analytical report in full or in part is prohibited without prior written approval. Please refer to SGS General Conditions of Services located at http://www.sgs.com/terms_and_conditions_service.htm. (Printed copies are available upon request.). Test Method information available upon request. "Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples.



Appendix C

Selected Site Photographs



Photo 1: East bank of Highway 599 at Mile Creek Culvert looking south



Photo 2: West bank of Highway 599 at Mile Creek Culvert looking south



Photo 3: Mile Creek Culvert outlet

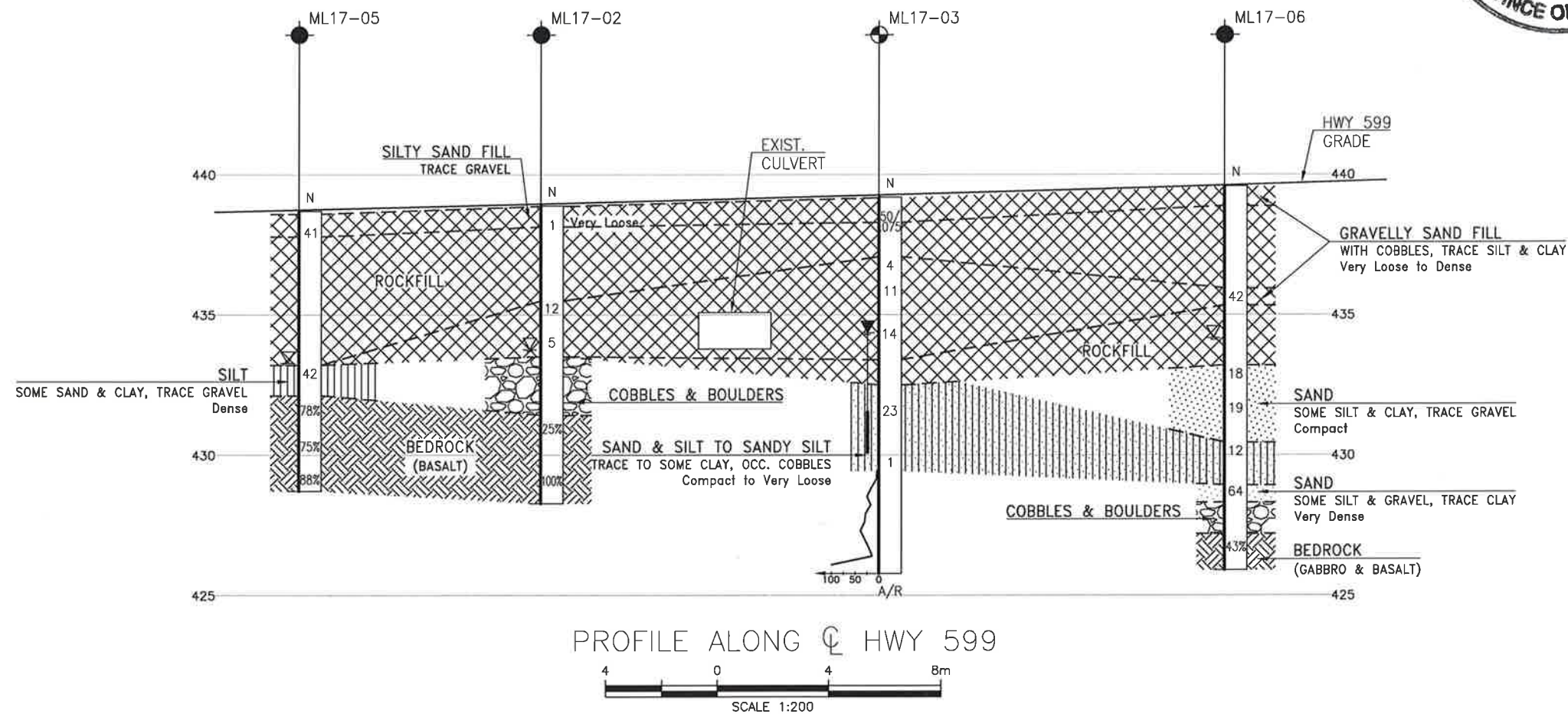
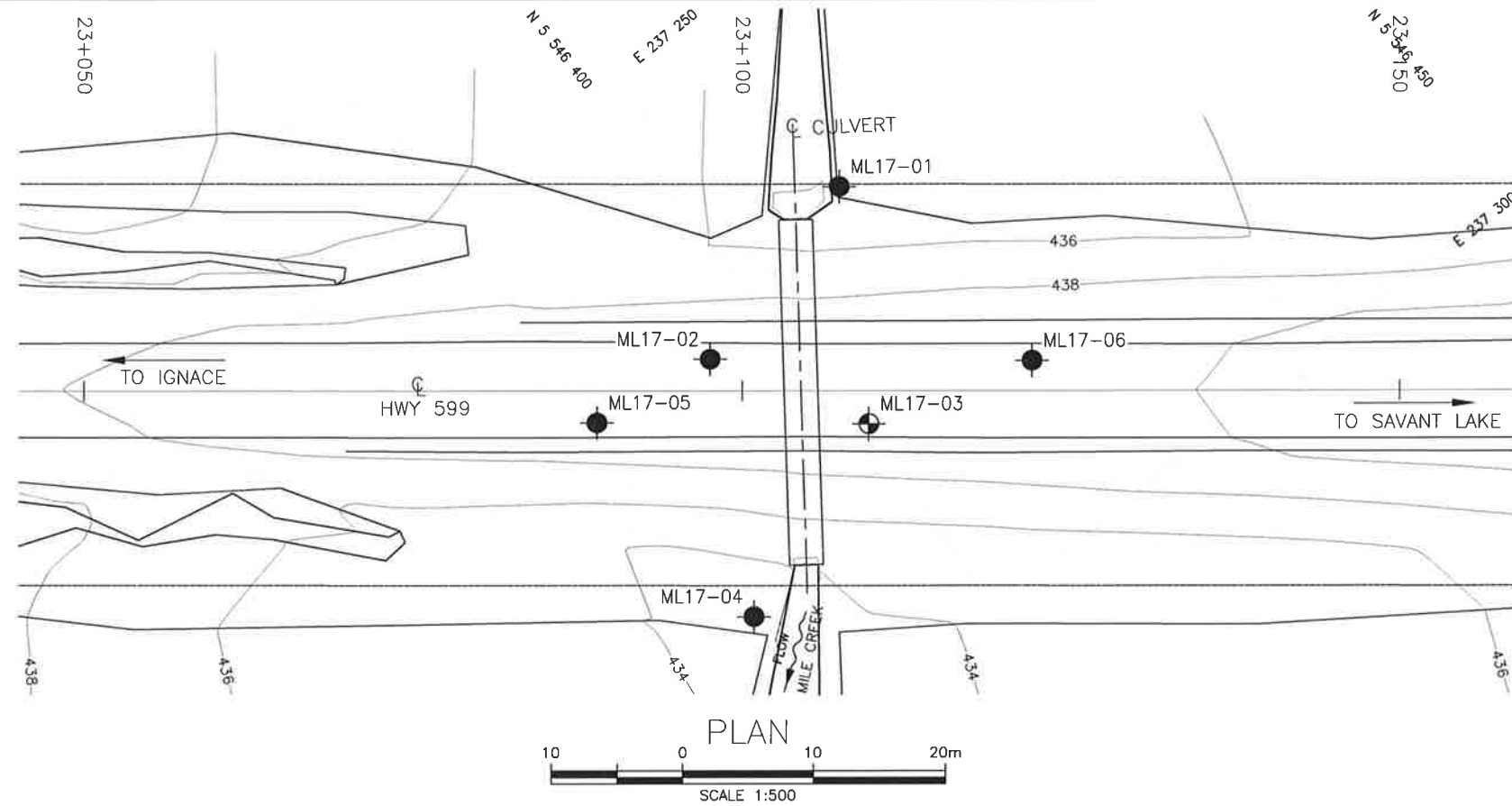


Photo 4: Mile Creek Culvert inlet



Appendix D

Borehole Locations and Soil Strata Drawing



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



CONT No 2018-6002
WP No 6841-14-01

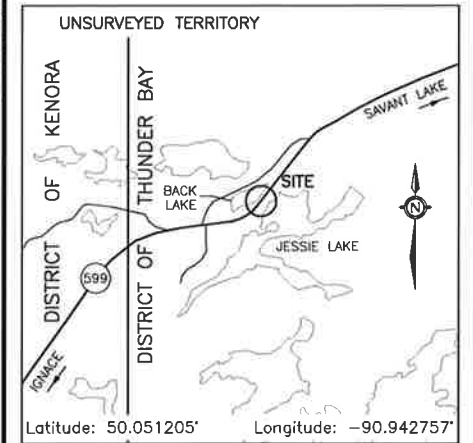
HIGHWAY 599
MILE CREEK CULVERT
REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET
38

HATCH



THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

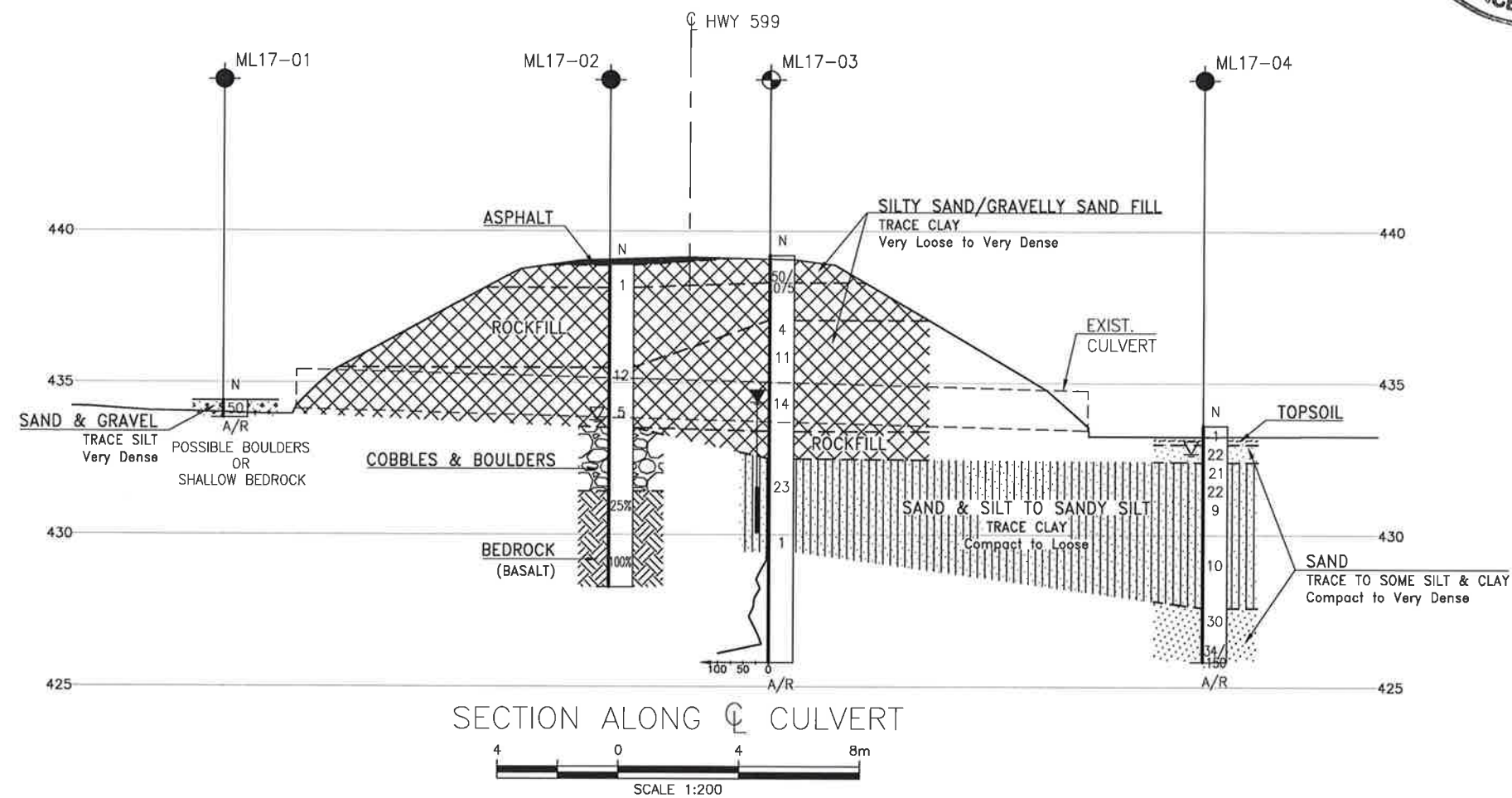
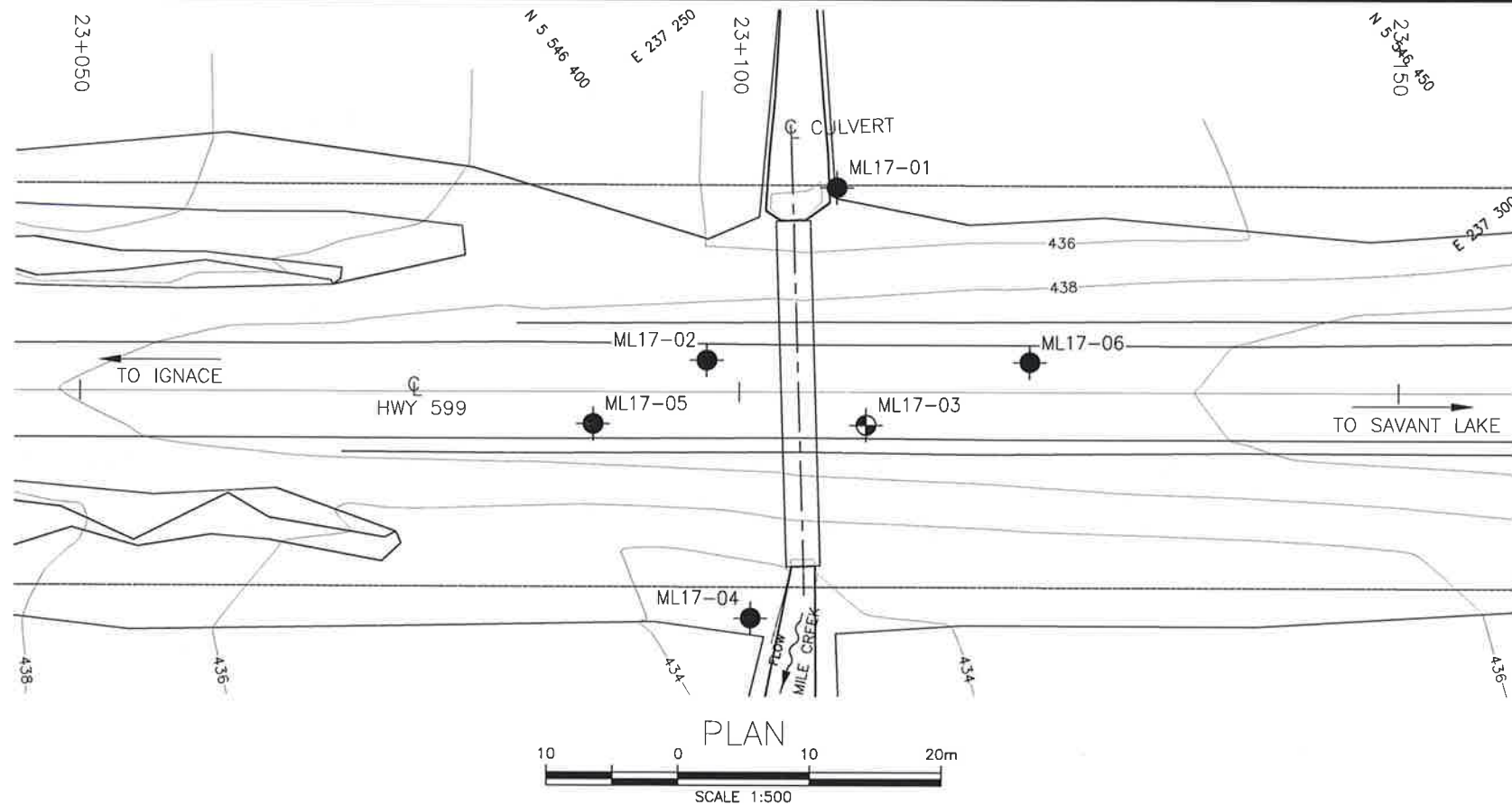
[illegible]

-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) Coordinate system is MTM NAD 83 Zone 15.

GEOCRES No. 52J-18

REVISIONS								
	DATE	BY			DESCRIPTION			
DESIGN	RPR	CHK	JPL	CODE	LOAD	DATE	JAN 2018	
DRAWN	AN	CHK	RPR	SITE	48W-191C	STRUCT	DWG	2



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

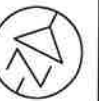


CONT No 2018-6002
WP No 6841-14-01

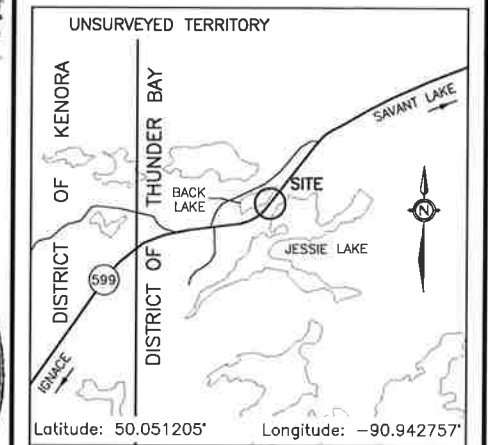
HIGHWAY 599
MILE CREEK CULVERT
REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

HATCH

THURBER ENGINEERING LTD.



SHEET
39



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
ML17-01	434.4	5 546 410.5	237 267.6
ML17-02	438.9	5 546 394.7	237 271.7
ML17-03	439.2	5 546 401.1	237 283.1
ML17-04	433.6	5 546 385.1	237 289.1
ML17-05	438.7	5 546 384.9	237 270.1
ML17-06	439.6	5 546 413.7	237 287.1

-NOTES-

- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
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- 3) Coordinate system is MTM NAD 83 Zone 15.

GEOCRES No. 52J-18

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	RPR	CHK JPL	CODE
DRAWN	AN	CHK RPR	SITE 48W-191C
LOAD	DATE	JAN 2018	DWG 3