



THURBER ENGINEERING LTD.

**FOUNDATION INVESTIGATION REPORT
RAINY RIVER TRIBUTARY NO. 2 CULVERT REPLACEMENT
HIGHWAY 602
RAINY RIVER DISTRICT, ONTARIO**

G.W.P. No. 6602-15-00, SITE No. 45-280/C

GEOCRES Number: 52C-50

Report

to

HATCH

Date: December 21, 2016
File: 13372/15760



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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 Rainy River Tributary No. 2 Culvert on Highway 602, located in the geographical Township of Roddick, near Fort Frances, 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 to carry out this foundation investigation under the Ministry of Transportation Ontario (MTO) Agreement Number 6015-E-0018-002.

2. SITE DESCRIPTION

The site is located on Highway 602, approximately 12 km south of Highway 11, in the geographical Township of Roddick, Ontario. The culvert allows Rainy River Tributary No. 2 to flow from north to south under Highway 602 towards Rainy River. Highway 602 generally runs in an east-west direction at the culvert site.

The Terms of Reference indicates that the existing structure is a 15.4 m long, 3 m span, single cell open footing concrete box culvert, with a height of fill of 2.5 m above the culvert. An Ontario Structure Inspection Manual (OSIM) report prepared in 2015 notes severe wide cracking up to 170 mm wide through the foundation and continued settlement, and that the structure was considered to be in overall poor condition. Ongoing patching work has been required to address settlement of the structure. Photographs provided by Hatch of the interior of the culvert show that

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significant scour has occurred along and below the concrete footings of the culvert (Photo 5 in Appendix D). The scour and erosion of the foundation subgrade has likely led to push out of the culvert walls and settlement of the structure. The culvert was reportedly constructed in 1937.

The grade level of Highway 602 at the existing culvert is at an approximate Elevation of 337 m.

Naturally low-lying areas are present near the inlet and outlet of the culvert, with vegetation consisting of grass, shrubs and frequent trees. Photographs in Appendix D show the general nature of the site and the existing culvert, as well as foundation scour and cracks.

Based on published geological information, the culvert lies within an area of glaciomarine deposits of silt and clay, with minor sand basin and quiet water deposits. The bedrock at the site consists of metasedimentary rocks.

3. INVESTIGATION PROCEDURES

The borehole investigation and field testing program for this project was carried out from July 19 to 22, 2016, and consisted of drilling and sampling four (4) boreholes, designated as Boreholes 16-01 to 16-04. Boreholes 16-01 and 16-04 were located near the culvert inlet and outlet respectively. Both boreholes were advanced near the base of the highway embankment. Boreholes 16-02 and 16-03 were advanced through the Highway 602 embankment, near the existing culvert alignment.

An additional borehole investigation was carried out for a sheet-pile abutment culvert option between October 23 and 25, 2016, consisting of drilling two boreholes on the highway shoulders, i.e. 16-02A and 16-03A, in the vicinity of Boreholes 16-02 and 16-03. These two additional boreholes were drilled deeper to Elevation 315.1 m.

Utility clearances were obtained prior to the start of drilling. The coordinates and ground surface elevations for the boreholes were derived from topographic plans provided to Thurber by Hatch. The coordinate system MTM NAD 83, Zone 16 was used for the boreholes. The approximate locations of the boreholes are shown on the Borehole Locations and Soil Strata Drawing included in Appendix C.

A portable tripod drill rig was used to advance Boreholes 16-01 and 16-04 using NW casing and wash boring techniques, and a track-mounted CME 55 drill rig was used to advance Boreholes 16-02 and 16-03 using hollow stem augers. Boreholes 16-01 and 16-04 were advanced to depths of 3.7 m until encountering refusal where there was no further penetration of the tripod casing with the wash-bore method. Boreholes 16-02 and 16-03 were advanced to depths of 15.8 m each.



Borehole 16-02 was extended beyond 15.8 m depth by conducting a Dynamic Cone Penetration Test (DCPT) to a depth of 27.4 m. In all boreholes, soil samples were obtained at selected intervals with a 50 mm outside diameter split spoon sampler driven in conjunction with the Standard Penetration Test (SPT). Field vane shear testing using an MTO 'N' size vane was also carried out in firm cohesive soils.

The additional investigation was carried out using a CME 750 ATV drill rig in conjunction with continuous flight hollow stem augers. Boreholes 16-02A and 16-03A were both advanced with sampling to a depth of 21.9 m. Dynamic Cone Penetration Test (DCPT) was conducted in Borehole 16-03A below the sampled portion to a depth of 34.5 m.

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 on completion of drilling 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)	Completion Details
16-01	3.7 / 328.9	Bentonite holeplug from 3.7 m to ground surface.
16-02	15.8 / 321.2	Bentonite holeplug and cuttings from 15.8 m to 0.1 m, then asphalt patch to ground surface.
16-02A	21.9 / 315.1	Bentonite holeplug, dry concrete and asphalt patch to ground surface.
16-03	15.8 / 321.2	Bentonite holeplug and cuttings from 15.8 m to 0.1 m, then asphalt patch to ground surface.
16-03A	21.9 / 315.1	Bentonite holeplug, dry concrete and asphalt patch to ground surface.
16-04	3.7 / 328.9	Bentonite holeplug from 3.7 m to ground 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) 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 existing embankment fill near the culvert elevation, and a sample of the surface water from the tributary 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. Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets and on the "Borehole Locations and Soil Strata" drawing included in Appendix C. A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following paragraphs. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description and must be used for interpretation of the site conditions. It 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 bituminous surface treatment overlying granular fill and silty clay fill, which was in turn underlain by native soil consisting of silty clay. Topsoil was also noted at the surface of the boreholes located at the base of the embankment. Descriptions of the individual strata are presented below.

5.1 Bituminous Surface Treatment

Boreholes 16-02 and 16-03 were drilled through the existing lanes on Highway 602, which contained bituminous surface treatment at the ground surface. The surface treatment thickness measured in the boreholes was 50 mm.

5.2 Granular Fill

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Granular fill ranging in composition from sand with some gravel to gravelly sand was encountered below the surface treatment in Boreholes 16-02 and 16-03 and at the ground surface in 16-02A and 16-03A. The granular fill ranged in thickness from 1.3 to 2.3 m, and extended to depths ranging from 1.4 to 2.3 m (Elev. 334.7 to 335.6 m). SPT 'N' values within the granular fill ranged from 6 to 23 blows per 0.3 m penetration, indicating a loose to compact relative density.

The measured moisture content of the granular fill ranged typically from 3% to 12%. The results of grain size analyses conducted on four samples of the fill are presented on the Record of Borehole sheets included in Appendix A and on Figure B1 in Appendix B. The results are summarized in the following table:

Soil Particle	Percentage (%)
Gravel	12 to 34
Sand	57 to 81
Silt and Clay	4 to 10

5.3 Silty Clay Fill

Embankment fill consisting of silty clay that was sandy with trace gravel was encountered below the granular fill in Boreholes 16-02, 16-03, 16-02A and 16-03A. The cohesive fill contained trace rootlets and decayed wood pieces at the top of the layer in 16-02A and 16-03A. The silty clay fill ranged in thickness from 2.3 to 3.5 m, and extended to depths from 4.6 to 4.9 m (Elev. 332.1 to 332.4 m). SPT 'N' values measured in the silty clay fill ranged from 5 to 10 blows per 0.3 m penetration, indicating a firm to stiff consistency.

The measured moisture content of the silty clay fill ranged from 14% to 25%. The results of grain size analyses and Atterberg Limits tests conducted on samples of the silty clay fill are presented on the Record of Borehole sheets and on Figures B2 and B5 in Appendix B. The results are summarized in the following table:

Soil Particle	Percentage (%)
Gravel	0 to 3
Sand	24 to 37
Silt	29 to 39
Clay	29 to 46
Soil Property	Percentage (%)
Liquid Limit	47
Plasticity Limit	20 to 22



5.4 Topsoil / Sandy Silty Clay

The top 0.6 to 0.7 m of native soil at Boreholes 16-01 and 16-04 consisted of topsoil mixed with sandy, silty clay. In Borehole 16-04, the topsoil was underlain by sandy, silty clay with some roots and trace gravel, extending to a depth of 1.4 (Elev. 331.2 m). SPT 'N' values measured in these surficial soils were 5 to 13 blows per 0.3 m penetration, indicating a firm to stiff consistency. Moisture contents of 32 to 34% were measured in the surficial soils.

The results of grain size analyses conducted on two samples of the sandy, silty clay / topsoil are presented on the Record of Borehole sheets and on Figure B3 in Appendix B. The results are summarized in the following table.

Soil Particle	Percentage (%)
Gravel	0 to 2
Sand	29 to 36
Silt	22 to 35
Clay	36 to 40

The topsoil thickness may vary in other areas of the site and this limited data should not be relied upon for estimating stripping quantities.

5.5 Silty Clay

Underlying the embankment fill and topsoil / sandy silty clay layers, the native soil consisted of silty clay in all of the boreholes. The silty clay contained some sand, trace gravel, and occasional roots and wood fragments immediately below the fill in Borehole 16-03. All six boreholes drilled at the site were terminated within the silty clay at depths ranging from 3.7 to 21.9 m (Elev. 315.1 to 328.9 m). A Dynamic Cone Penetration Test was conducted at the base of Boreholes 16-02 and 16-03A, where cone refusal of greater than 100 blows per 0.3 m penetration was encountered at depths of 27.4 m and 34.5 m (Elev. 309.6 m and 302.5 m), respectively.

Measured SPT 'N' values in the silty clay ranged from 4 to 23 blows per 0.3 m penetration. In conjunction with in-situ field vane tests, which measured undrained shear strengths ranging from 45 to greater than 100 kPa, the silty clay was found to have a typically firm to very stiff consistency.

The measured moisture content of samples recovered from the silty clay ranged from 24% to 38%, with the exception of one sample below the fill, where the presence of organic material (wood and roots) likely contributed to a moisture content of 234%. The results of grain size analyses and Atterberg Limits tests conducted on samples of the silty clay are presented on the



Record of Borehole sheets and on Figures B4a, B4b, B6a and B6b in Appendix B. The results are summarized in the following table.

Soil Particle	Percentage (%)
Gravel	0
Sand	15 to 19
Silt	22 to 34
Clay	47 to 61
Soil Property	Percentage (%)
Liquid Limit	36 to 52
Plasticity Limit	14 to 25

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

Two incremental loading consolidation tests were carried out on the undisturbed silty clay samples recovered using Shelby Tube samplers. The results of the two consolidation tests are included in Appendix B.

5.6 Groundwater Conditions

Groundwater conditions were observed during drilling operations and the open boreholes were found to be dry upon completion of drilling.

Water level measurements near the inlet and outlet of the culvert were reported on the drawings provided by Hatch, which indicate a creek level at Elevation 332.46 to 332.03 m on April 26, 2016. The groundwater level should be assumed to reflect the local creek water level. These water 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 silty clay embankment fill from Borehole 16-03, 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	
			16-03, SS#4, 10'-12'	Rainy River Tributary 2
			(Silty Clay Fill)	(Creek Water)
Sulphide	%	mg/L	<0.02	<0.02
Chloride	µg/g	mg/L	43	3
Sulphate	µg/g	mg/L	46	20
pH	No unit	No unit	7.47 – 8.32	7.90
Electrical Conductivity	µS/cm	µS/cm	185	179
Resistivity	Ohms.cm	Ohms.cm	5400	5600
Redox Potential	mV	mV	306	278

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 Mr. Omar Ali 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 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.



Mark Farrant, P.Eng.
Project Manager, Geotechnical Engineer



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



Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction

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


4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

5. LEGEND FOR RECORDS OF BOREHOLES

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

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

 Water Level
 Shear Strength Determination by Pocket Penetrometer

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

EXPLANATION OF ROCK LOGGING TERMS


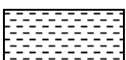

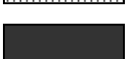

ROCK WEATHERING CLASSIFICATION

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

DISCONTINUITY SPACING

Bedding	Bedding Plane Spacing
Very thickly bedded	Greater than 2m
Thickly bedded	0.6 to 2m
Medium bedded	0.2 to 0.6m
Thinly bedded	60mm to 0.2m
Very thinly bedded	20 to 60mm
Laminated	6 to 20mm
Thinly Laminated	Less than 6mm

SYMBOLS

	CLAYSTONE
	SILTSTONE
	SANDSTONE
	COAL
	BEDROCK

STRENGTH CLASSIFICATION

Rock Strength	Approximate Uniaxial Compressive Strength (MPa)	Approximate Uniaxial Compressive Strength (psi)	Field Estimation of Hardness*
Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail

TERMS

Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length
Solid Core Recovery:(SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run
Rock Quality Designation:(RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a % of total core run length.
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen
Fracture Index:(FI)	Frequency of natural fractures per 0.3m of core run.

UNIFIED SOILS CLASSIFICATION

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

RECORD OF BOREHOLE No 16-01

1 OF 1

METRIC

GWP# 6602-15-00 LOCATION Rainy River Tributary 2 Culvert N 5 378 697.4 E 267 078.5 ORIGINATED BY OA
 HWY 602 BOREHOLE TYPE Tripod COMPILED BY AN
 DATUM Geodetic DATE 2016.07.22 - 2016.07.22 CHECKED BY MEF

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											
332.6	GROUND SURFACE							20	40	60	80	100							
0.0	TOPSOIL , mixed with sandy silty clay, some roots Firm Grey Moist Silty CLAY , some sand, trace gravel Firm to Stiff Grey Moist (Cl)		1	SS	5														
332.0																			
0.6																			
			2	SS	5														
			3	SS	5														
			4	SS	14														
			5	SS	8														
328.9																			
3.7	END OF BOREHOLE AT 3.7m DUE TO TRIPOD CASING REFUSAL. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.																		

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 16-02

1 OF 3

METRIC

GWP# 6602-15-00 LOCATION Rainy River Tributary 2 Culvert N 5 378 690.0 E 267 085.4 ORIGINATED BY OA
 HWY 602 BOREHOLE TYPE Solid Stem Augers/Dynamic Cone Penetration Test COMPILED BY AN
 DATUM Geodetic DATE 2016.07.19 - 2016.07.20 CHECKED BY MEF

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					
								WATER CONTENT (%)					
337.0	GROUND SURFACE												
0.0 0.1	ASPHALT: (50mm)												
	SAND, some gravel, some silt Brown Moist (FILL)		1	GS									
	Compact to Loose		1	SS	23		336						12 78 10 (SI+CL)
			2	SS	8		335						
334.8													
2.2	Silty CLAY, sandy, trace gravel Firm Grey Moist (FILL)		3	SS	6		334						2 36 30 32
			4	SS	6								
							333						
332.4													
4.6	Silty CLAY, some sand, trace gravel Firm Grey Wet (CI to CH)		5	SS	6		332						
								(>100)					
							331						
			6	SS	5								
							330						
			7	SS	5		329						0 17 22 61
								(>100)					
							328						
			8	SS	5								

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+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

METRIC[illegible]

+³, ×³: Numbers refer to Sensitivity

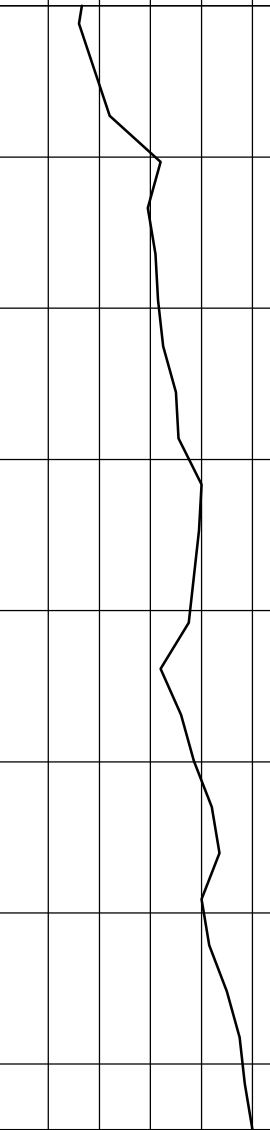
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RECORD OF BOREHOLE No 16-02

3 OF 3

METRIC

GWP# 6602-15-00 LOCATION Rainy River Tributary 2 Culvert N 5 378 690.0 E 267 085.4 ORIGINATED BY OA
 HWY 602 BOREHOLE TYPE Solid Stem Augers/Dynamic Cone Penetration Test COMPILED BY AN
 DATUM Geodetic DATE 2016.07.19 - 2016.07.20 CHECKED BY MEF

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	WATER CONTENT (%)					
	Continued From Previous Page							20 40 60 80 100	20 40 60				kN/m ³	GR SA SI CL
														
309.6														
27.4	END OF BOREHOLE AT 27.4m. BOREHOLE BACKFILLED WITH CUTTINGS AND BENTONITE HOLEPLUG TO 0.1m, THEN ASPHALT PATCH TO SURFACE.													

ONTMT4S 13372-MTO-GPJ 2015TEMPLATE(MTO).GDT 12/20/16

METRIC[illegible]

(%) STRAIN AT FAILURE

ONTMT4S 13372-MTO.GPJ 2015TEMPLATE(MTO).GDT 12/20/16

RECORD OF BOREHOLE No 16-03

2 OF 2

METRIC

GWP# 6602-15-00 LOCATION Rainy River Tributary 2 Culvert N 5 378 685.0 E 267 078.4 ORIGINATED BY OA
 HWY 602 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.07.19 - 2016.07.19 CHECKED BY MEF

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			20 40 60 80 100	SHEAR STRENGTH kPa				W _P W W _L	WATER CONTENT (%)					
								○ UNCONFINED + FIELD VANE											
							● QUICK TRIAXIAL × LAB VANE												
	Continued From Previous Page							20 40 60 80 100					20 40 60						
321.2 <																			

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 16-04

1 OF 1

METRIC

GWP# 6602-15-00 LOCATION Rainy River Tributary 2 Culvert N 5 378 676.5 E 267 085.7 ORIGINATED BY OA
 HWY 602 BOREHOLE TYPE Tripod COMPILED BY AN
 DATUM Geodetic DATE 2016.07.22 - 2016.07.22 CHECKED BY MEF

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									
332.6	GROUND SURFACE							20	40	60	80	100					
0.0	TOPSOIL, mixed with sandy silty clay, some roots Firm Grey Moist		1	SS	6		332							○			
331.9																	
0.7	Sandy, Silty CLAY, trace gravel, some roots Stiff Grey Moist		2	SS	13									○			2 36 22 40
331.2																	
1.4	Silty CLAY, sandy to some sand, trace gravel, some roots and topsoil in top 0.6m Stiff to Very Stiff Grey Moist (Cl)		3	SS	12		331							○			
			4	SS	19		330							○			
			5	SS	23									○			0 18 30 52
328.9							329							○			
3.7	END OF BOREHOLE AT 3.7m DUE TO TRIPOD CASING REFUSAL. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.																

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 16-02A

2 OF 3

METRIC

W.P. 6602-15-00 LOCATION N 5 378 691.1 E 267 086.0 ORIGINATED BY TM
 HWY 602 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.10.23 - 2016.10.24 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				
								20 40 60 80 100	○ UNCONFINED + FIELD VANE	● QUICK TRIAXIAL × LAB VANE	W _P W W _L					
	Continued From Previous Page							20 40 60 80 100				20 40 60		GR SA SI CL		
			9	SS	9		326						○			
							325									
			10	SS	8								○	0 18 33 49		
							324									
			11	SS	6		323						○			
							322									
			12	SS	5								○			
							321									
			13	SS	5		320						○			
							319									
			2	TW									○			
							318									

Continued Next Page

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

RECORD OF BOREHOLE No 16-02A

3 OF 3

METRIC

W.P. 6602-15-00 LOCATION N 5 378 691.1 E 267 086.0 ORIGINATED BY TM
 HWY 602 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.10.23 - 2016.10.24 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
							20	40	60	80	100	W _p	W	W _L			
	Continued From Previous Page		14	SS	4												
			15	SS	4												
315.1																	
21.9	END OF BOREHOLE AT 21.9m. WATER LEVEL AT 21.9m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG, DRY CONCRETE, AND COLD PATCH ASPHALT TO SURFACE.																

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 16-03A

1 OF 4

METRIC

W.P. 6602-15-00 LOCATION N 5 378 684.1 E 267 077.7 ORIGINATED BY TM
 HWY 602 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.10.24 - 2016.10.25 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				WATER CONTENT (%) w _p w w _L				GR	SA	SI	CL		
337.0	GROUND SURFACE							20	40	60	80	100									
0.0	Gravelly SAND , trace silt, occasional asphalt fragments Compact to Loose Brown Moist (FILL)		1	SS	19									○						29 62 9 (SI+CL)	
			2	SS	7										○						
335.5																					
1.5	Silty CLAY , sandy, trace gravel, trace organics (decayed wood) Stiff to Firm Brown to Grey Moist (FILL)		3	SS	9									○							
			4	SS	10										○	┌───┐				3 37 29 31	
			5	SS	7										○						
332.1			6	SS	7									○							
4.9	Silty CLAY , some sand Firm to Very Stiff Grey Moist																				
			7	SS	8										○						
			8	SS	6											┌─○─┐				0 15 34 51	

Continued Next Page

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

RECORD OF BOREHOLE No 16-03A

2 OF 4

METRIC

W.P. 6602-15-00 LOCATION N 5 378 684.1 E 267 077.7 ORIGINATED BY TM
 HWY 602 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.10.24 - 2016.10.25 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT		NATURAL MOISTURE CONTENT		LIQUID LIMIT		UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
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						20	40	60	80	100	20	40	60		kN/m ³	GR	SA	SI	CL	
											(>100)										
			9	SS	6		326					○									
											(>100)										
			10	SS	8		325					○									
							324				(>100)										
			11	SS	7		323					○						0	19	34	47
							322				(>100)										
			2	TW			321														
										1.5											
			12	SS	7		320					○									
							319			1.2											
			13	SS	11		318					○									
											(>100)										

Continued Next Page

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

METRIC

SOIL PROFILE						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	SAMPLES		SHEAR STRENGTH kPa			WATER CONTENT (%)						
			NUMBER	TYPE	"N" VALUES			UNCONFINED ○ QUICK TRIAXIAL ●	+ FIELD VANE × LAB VANE	PLASTIC LIMIT w _P			NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L
	Continued From Previous Page		14	SS	8									
315.1							(>100)							
21.9	Start of DCPT		15	SS	10							0 18 34 48		

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 16-03A

4 OF 4

METRIC

W.P. 6602-15-00 LOCATION N 5 378 684.1 E 267 077.7 ORIGINATED BY TM
HWY 602 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2016.10.24 - 2016.10.25 CHECKED BY KS

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	WATER CONTENT (%)		
	Continued From Previous Page							20 40 60 80 100						
302.5														
34.5	END OF BOREHOLE AT 34.5m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG, DRY CONCRETE, AND COLD PATCH ASPHALT TO SURFACE.													

ONTMT4S MTO-15760.GPJ 2015TEMPLATE(MTO).GDT 12/20/16



Appendix B

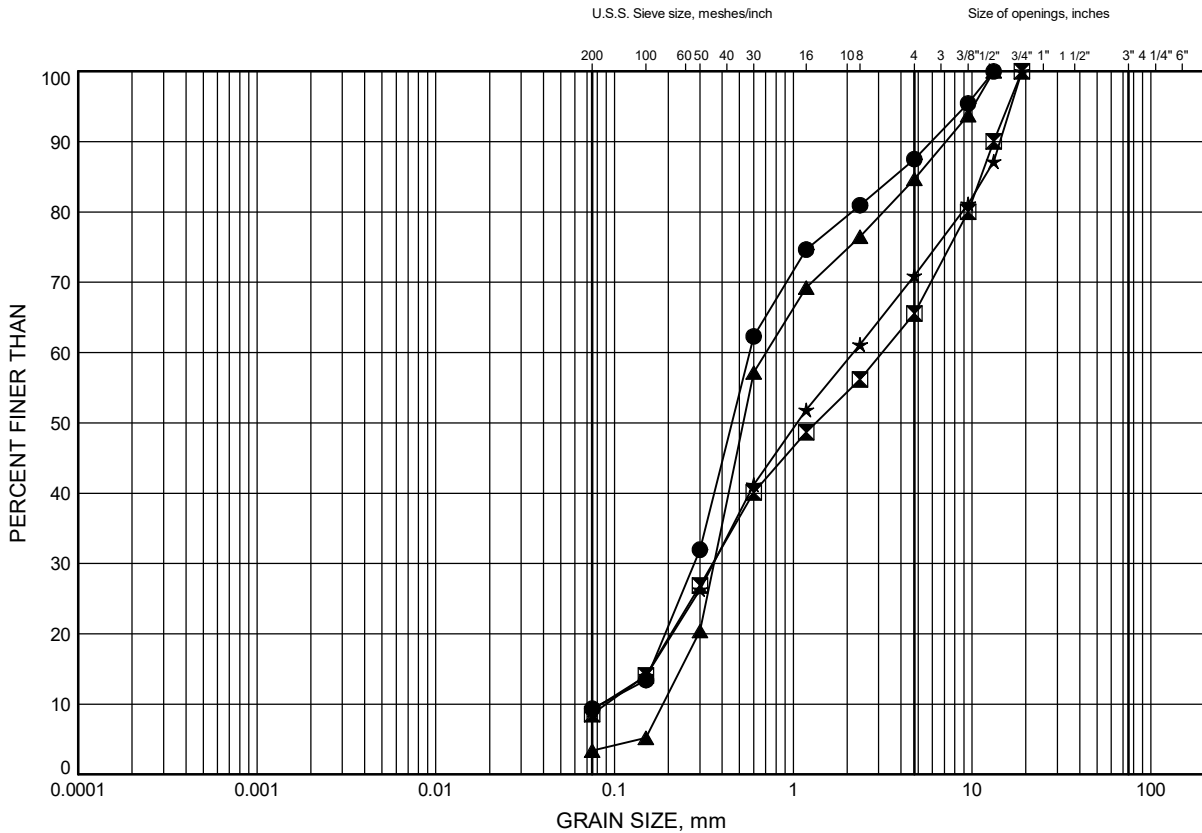
Geotechnical and Analytical Laboratory Test Results

Rainy River Tributary 2 Culvert

GRAIN SIZE DISTRIBUTION

FIGURE B1

Granular Fill



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-02	1.07	335.93
⊠	16-03	0.30	336.70
▲	16-02A	1.07	335.93
★	16-03A	0.30	336.70

Date December 2016

GWP# 6602-15-00



Prep'd MFA

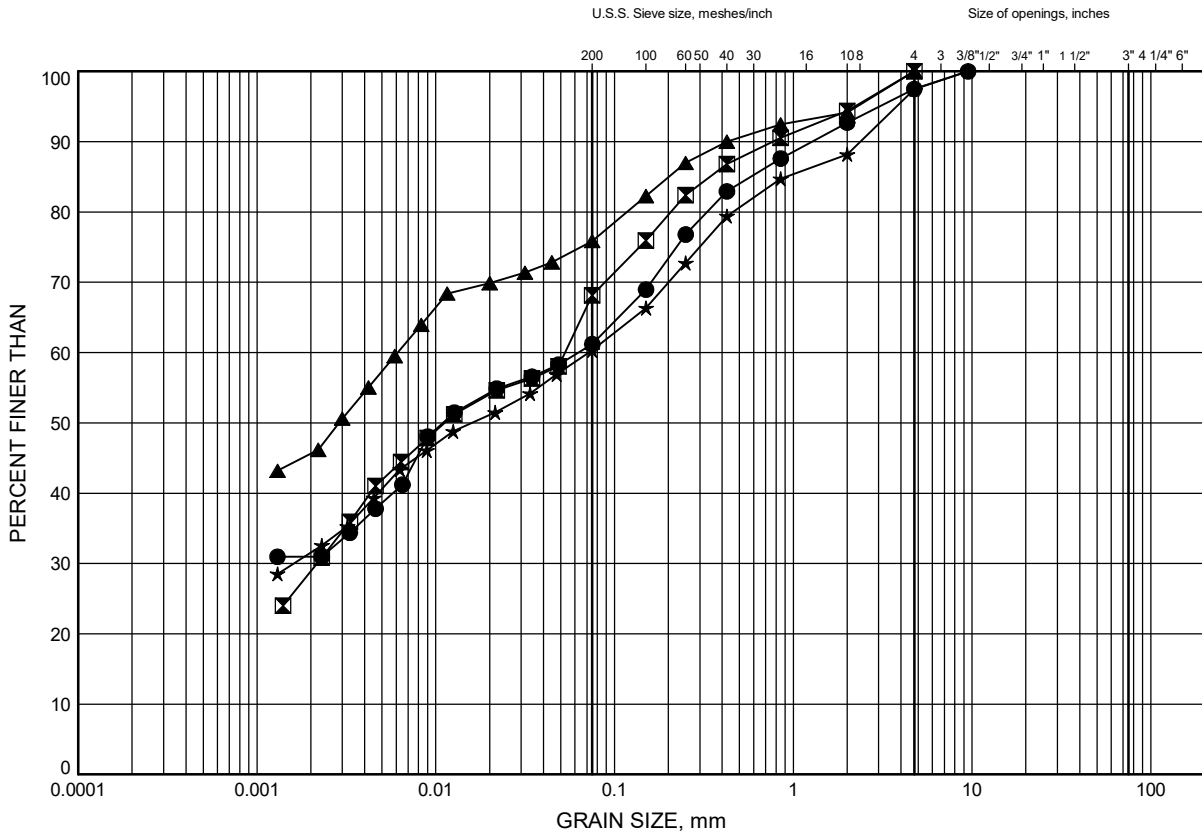
Chkd. MEF

Rainy River Tributary 2 Culvert

GRAIN SIZE DISTRIBUTION

FIGURE B2

Silty Clay Fill



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-02	3.35	333.65
⊠	16-03	2.59	334.41
▲	16-02A	3.35	333.65
★	16-03A	2.59	334.41

Date December 2016

GWP# 6602-15-00



Prep'd MFA

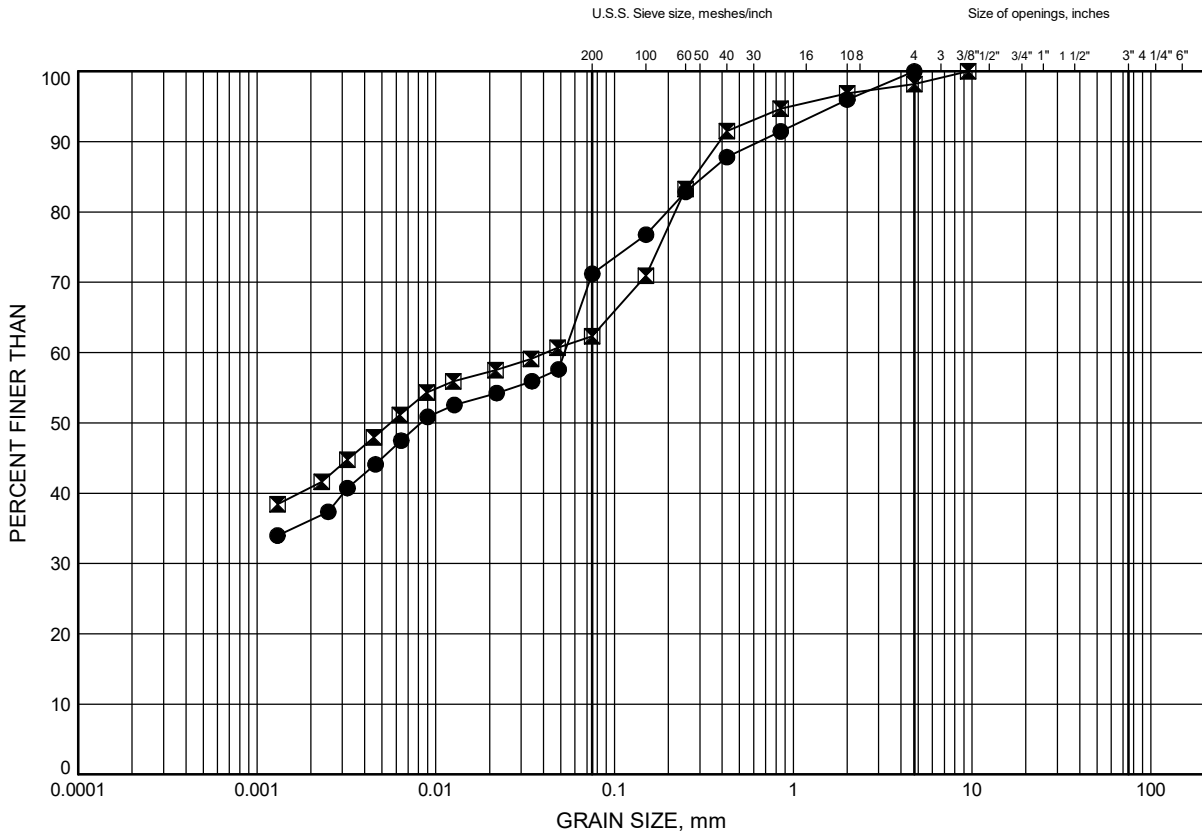
Chkd. MEF

Rainy River Tributary 2 Culvert

GRAIN SIZE DISTRIBUTION

FIGURE B3

Sandy, Silty Clay/Topsoil



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-01	0.30	332.30
⊠	16-04	1.07	331.53

Date December 2016

GWP# 6602-15-00



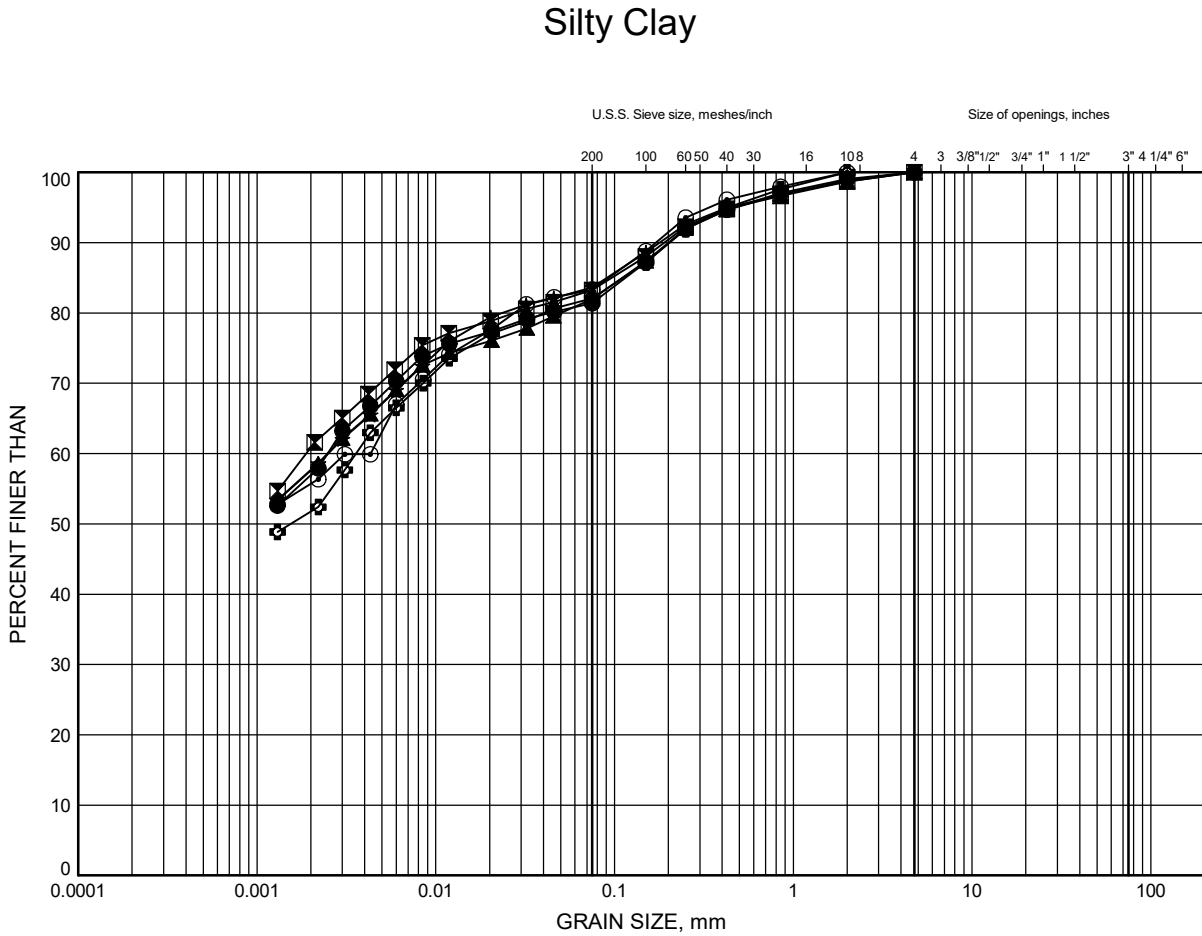
Prep'd MFA

Chkd. MEF

Rainy River Tributary 2 Culvert

GRAIN SIZE DISTRIBUTION

FIGURE B4a



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-01	2.59	330.01
⊠	16-02	7.92	329.08
▲	16-02	14.02	322.98
★	16-03	7.92	329.08
⊙	16-03	12.50	324.50
⊕	16-04	3.35	329.25

Date December 2016

GWP# 6602-15-00



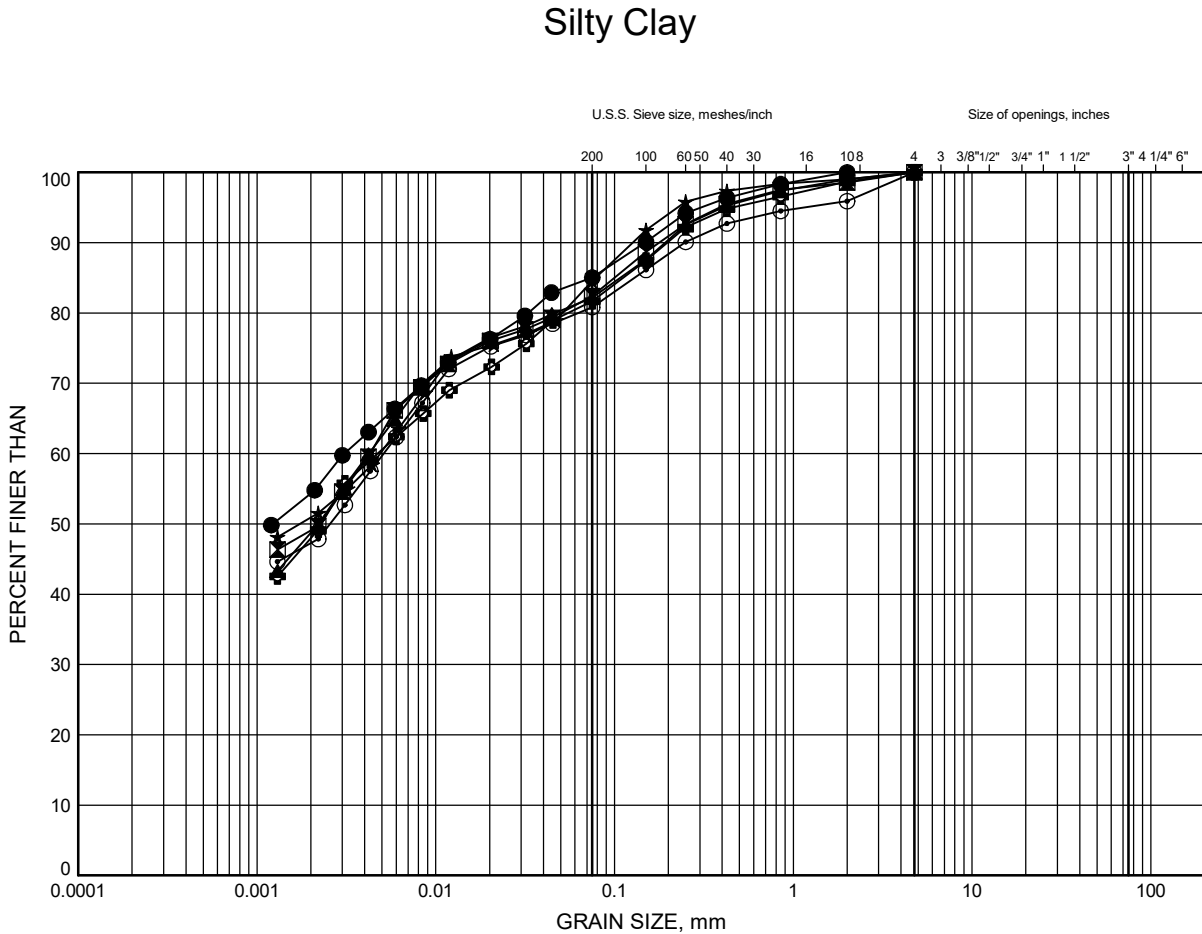
Prep'd MFA

Chkd. MEF

Rainy River Tributary 2 Culvert

GRAIN SIZE DISTRIBUTION

FIGURE B4b



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-02A	7.92	329.08
⊠	16-02A	12.50	324.50
▲	16-02A	20.12	316.88
★	16-03A	7.92	329.08
⊙	16-03A	14.02	322.98
⊕	16-03A	21.64	315.36

Date December 2016

W.P. 6602-15-00



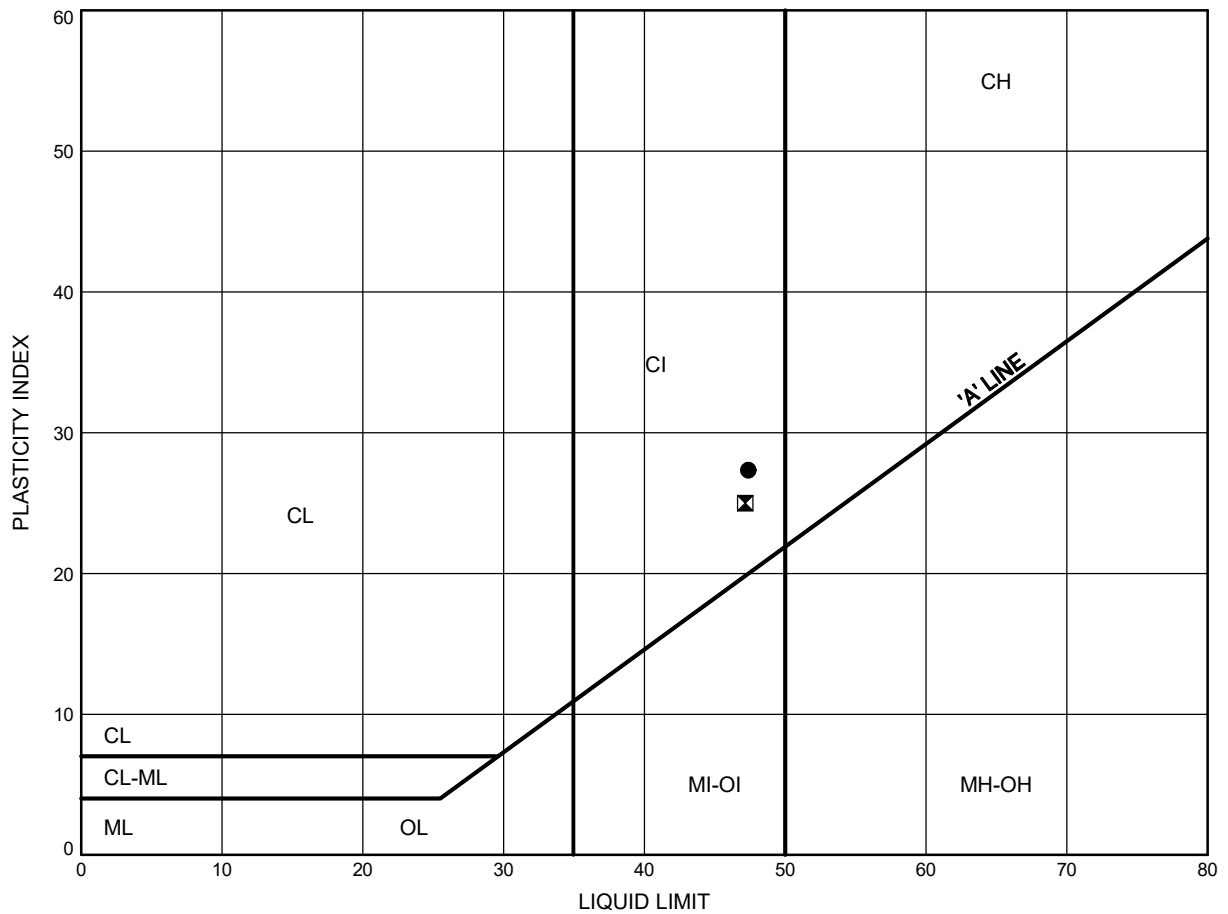
Prep'd MFA

Chkd. MEF

Rainy River Tributary 2 Culvert
ATTERBERG LIMITS TEST RESULTS

FIGURE B5

Silty Clay Fill



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-02A	3.35	333.65
⊠	16-03A	2.59	334.41

Date December 2016
 W.P. 6602-15-00

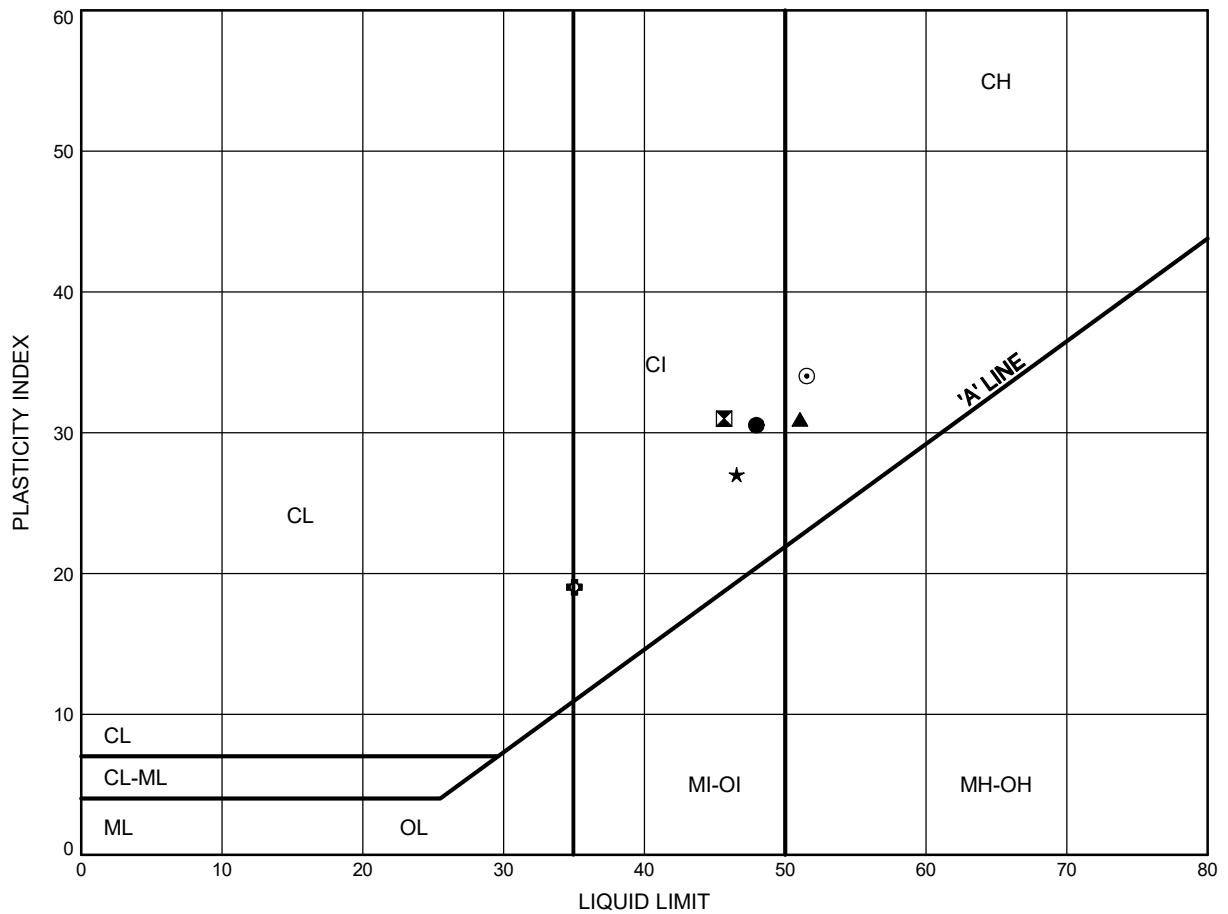


Prep'd MFA
 Chkd. MEF

Rainy River Tributary 2 Culvert
ATTERBERG LIMITS TEST RESULTS

FIGURE B6a

Silty Clay



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-01	2.59	330.01
⊠	16-02	7.92	329.08
▲	16-02	14.02	322.98
★	16-03	7.92	329.08
⊙	16-03	12.50	324.50
⊕	16-04	3.35	329.25

Date December 2016

GWP# 6602-15-00



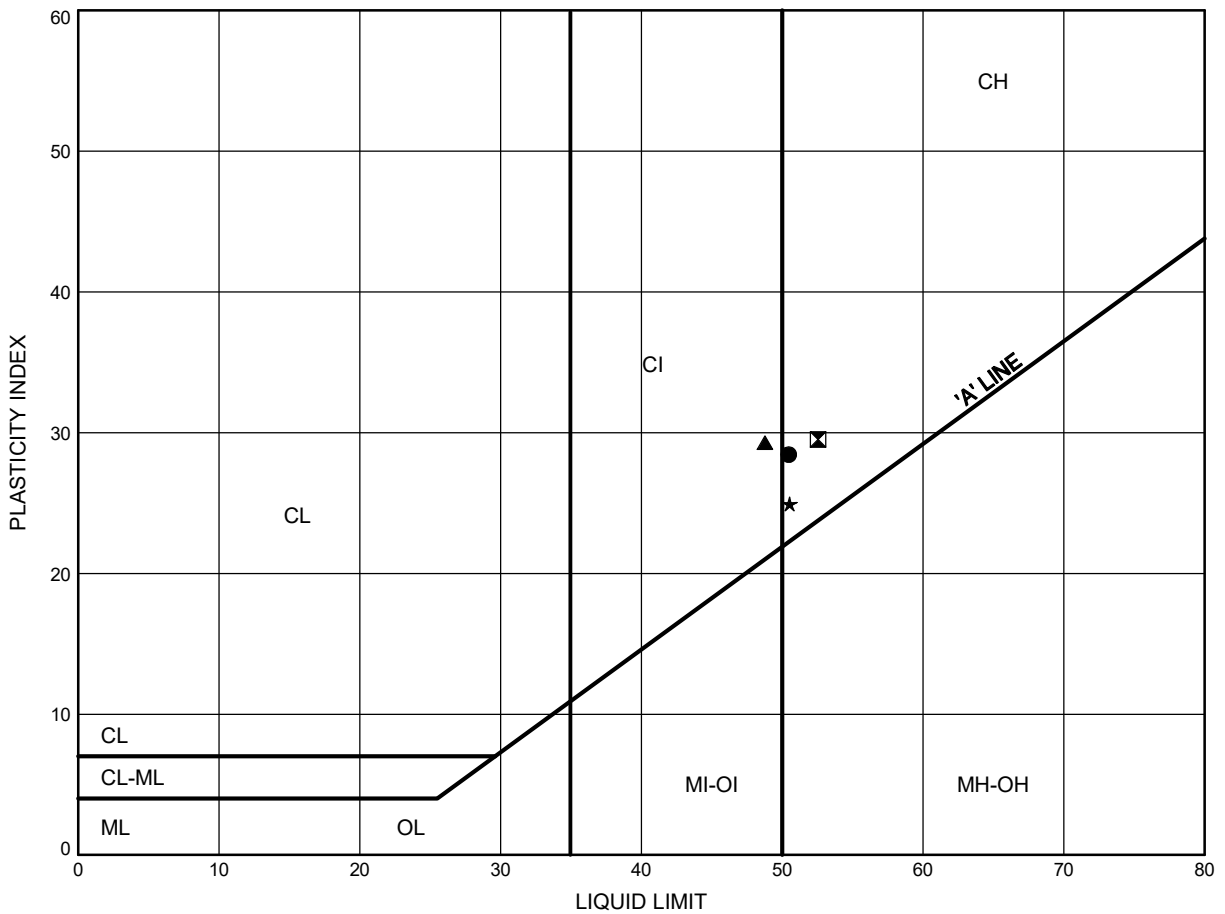
Prep'd MFA

Chkd. MEF

Rainy River Tributary 2 Culvert
ATTERBERG LIMITS TEST RESULTS

FIGURE B6b

Silty Clay



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-02A	7.92	329.08
⊠	16-02A	20.12	316.88
▲	16-03A	7.92	329.08
★	16-03A	21.64	315.36

Date December 2016
 W.P. 6602-15-00

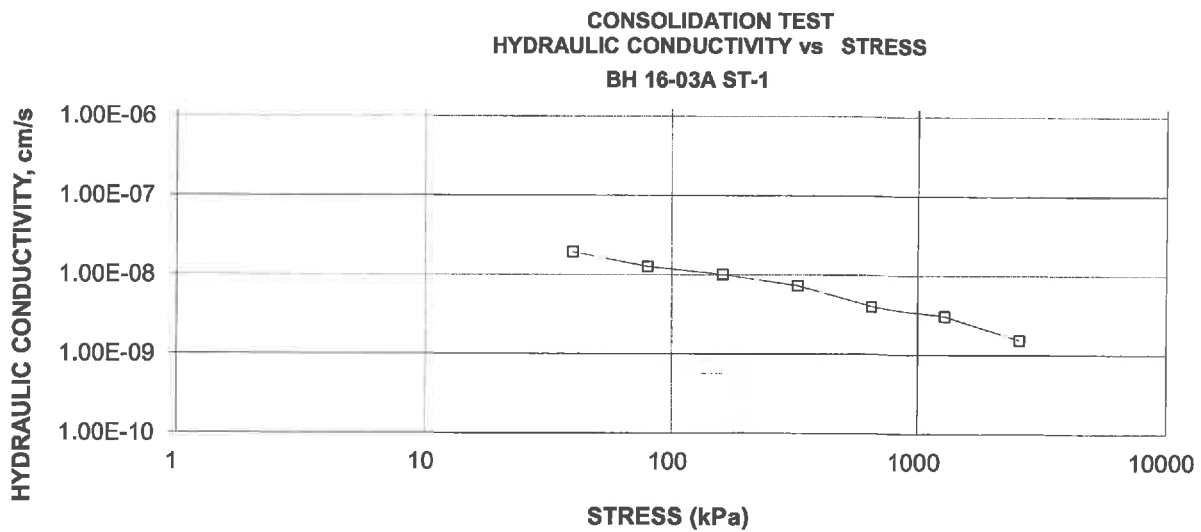
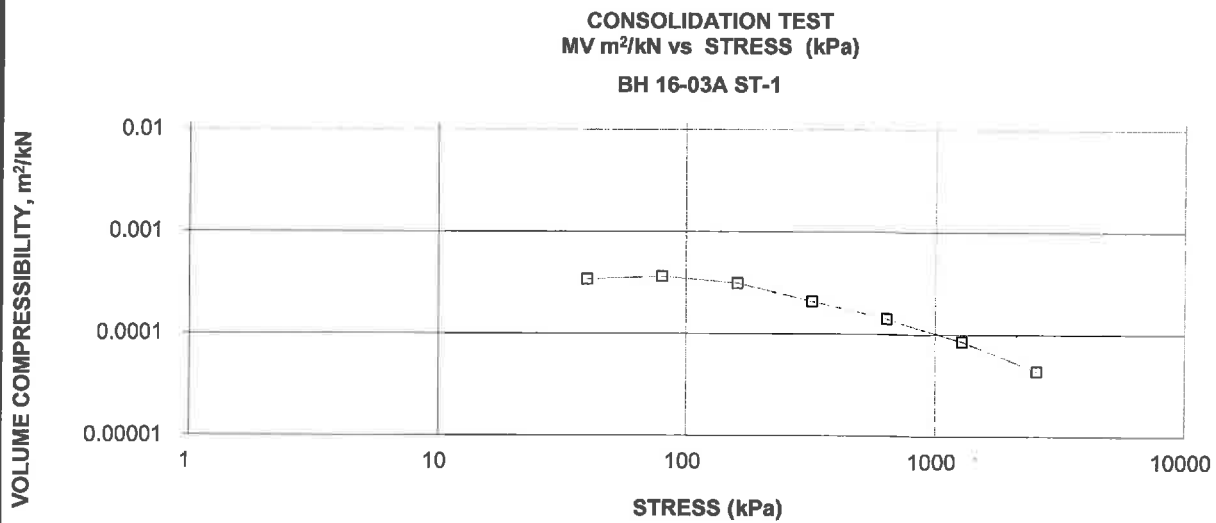
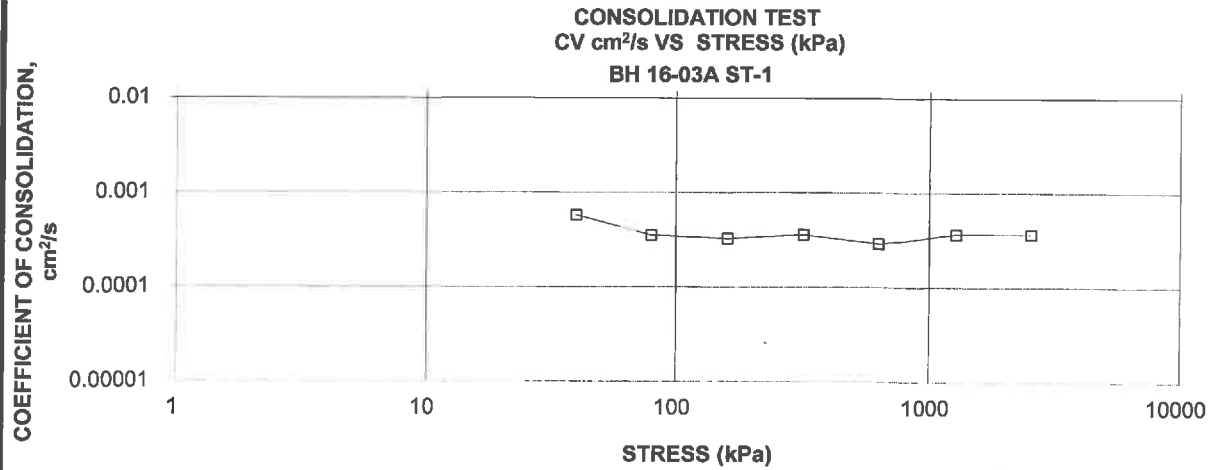


Prep'd MFA
 Chkd. MEF

CONSOLIDATION TEST SUMMARY ASTM D2435/D2435M					FIGURE		
SAMPLE IDENTIFICATION							
Project Number	1541891(9000)	Sample Number	ST-1				
Borehole Number	16-03A	Sample Depth, m	9.15-9.76				
TEST CONDITIONS							
Test Type	Laboratory Standard	Load Duration, hr	24				
Oedometer Number	7						
Date Started	11/04/2016						
Date Completed	11/12/2016						
SAMPLE DIMENSIONS AND PROPERTIES - INITIAL							
Sample Height, cm	1.26	Unit Weight, kN/m ³	19.23				
Sample Diameter, cm	4.97	Dry Unit Weight, kN/m ³	14.85				
Area, cm ²	19.43	Specific Gravity, measured	2.74				
Volume, cm ³	24.43	Solids Height, cm	0.695				
Water Content, %	29.49	Volume of Solids, cm ³	13.50				
Wet Mass, g	47.90	Volume of Voids, cm ³	10.93				
Dry Mass, g	36.99	Degree of Saturation, %	99.9				
TEST COMPUTATIONS							
Stress	Corr. Height	Void Ratio	Average Height	t ₉₀ sec	cv. cm ² /s	mv m ² /kN	k cm/s
kPa	cm		cm				
0.00	1.257	0.809	1.257				
4.89	1.258	0.811	1.258				
9.89	1.260	0.814	1.259				
19.88	1.258	0.811	1.259				
39.92	1.249	0.798	1.254	577	5.77E-04	3.41E-04	1.93E-08
79.90	1.231	0.772	1.240	923	3.53E-04	3.64E-04	1.26E-08
159.89	1.200	0.727	1.215	960	3.26E-04	3.13E-04	1.00E-08
319.88	1.158	0.667	1.179	821	3.59E-04	2.07E-04	7.29E-09
639.91	1.101	0.585	1.130	936	2.89E-04	1.41E-04	3.99E-09
1279.92	1.033	0.486	1.067	658	3.67E-04	8.54E-05	3.07E-09
2559.84	0.963	0.386	0.998	578	3.65E-04	4.34E-05	1.55E-09
1279.92	0.977	0.406	0.970				
319.88	1.015	0.460	0.996				
79.90	1.062	0.529	1.038				
9.89	1.127	0.622	1.095				
<p>Note:</p> <p>Consolidation loading and unloading schedule assigned by the client.</p> <p>k calculated using cv based on t₉₀ values.</p> <p>Specimen taken 8.5-13.5cm from bottom of the tube.</p>							
SAMPLE DIMENSIONS AND PROPERTIES - FINAL							
Sample Height, cm	1.13	Unit Weight, kN/m ³	20.89				
Sample Diameter, cm	4.97	Dry Unit Weight, kN/m ³	16.56				
Area, cm ²	19.43	Specific Gravity, measured	2.74				
Volume, cm ³	21.90	Solids Height, cm	0.695				
Water Content, %	26.09	Volume of Solids, cm ³	13.50				
Wet Mass, g	46.64	Volume of Voids, cm ³	8.40				
Dry Mass, g	36.99						
Prepared By: LH		Golder Associates			Checked By:		

CONSOLIDATION TEST SUMMARY

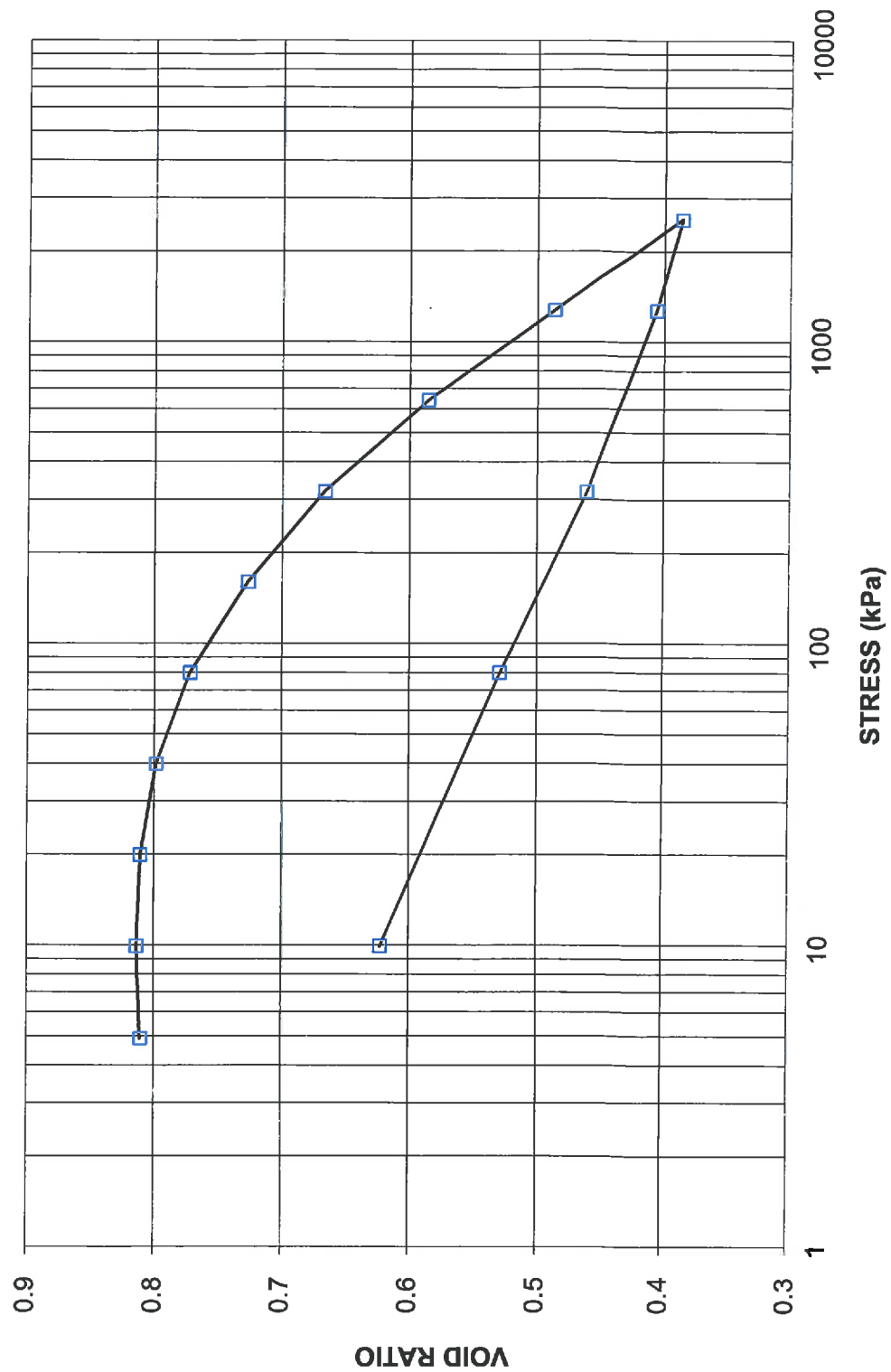
FIGURE



**CONSOLIDATION TEST
VOID RATIO VS LOG STRESS**

FIGURE

**CONSOLIDATION TEST
VOID RATIO vs STRESS
BH 16-03A ST-1**



Project No. 1541891(9000)

Prepared By: LH

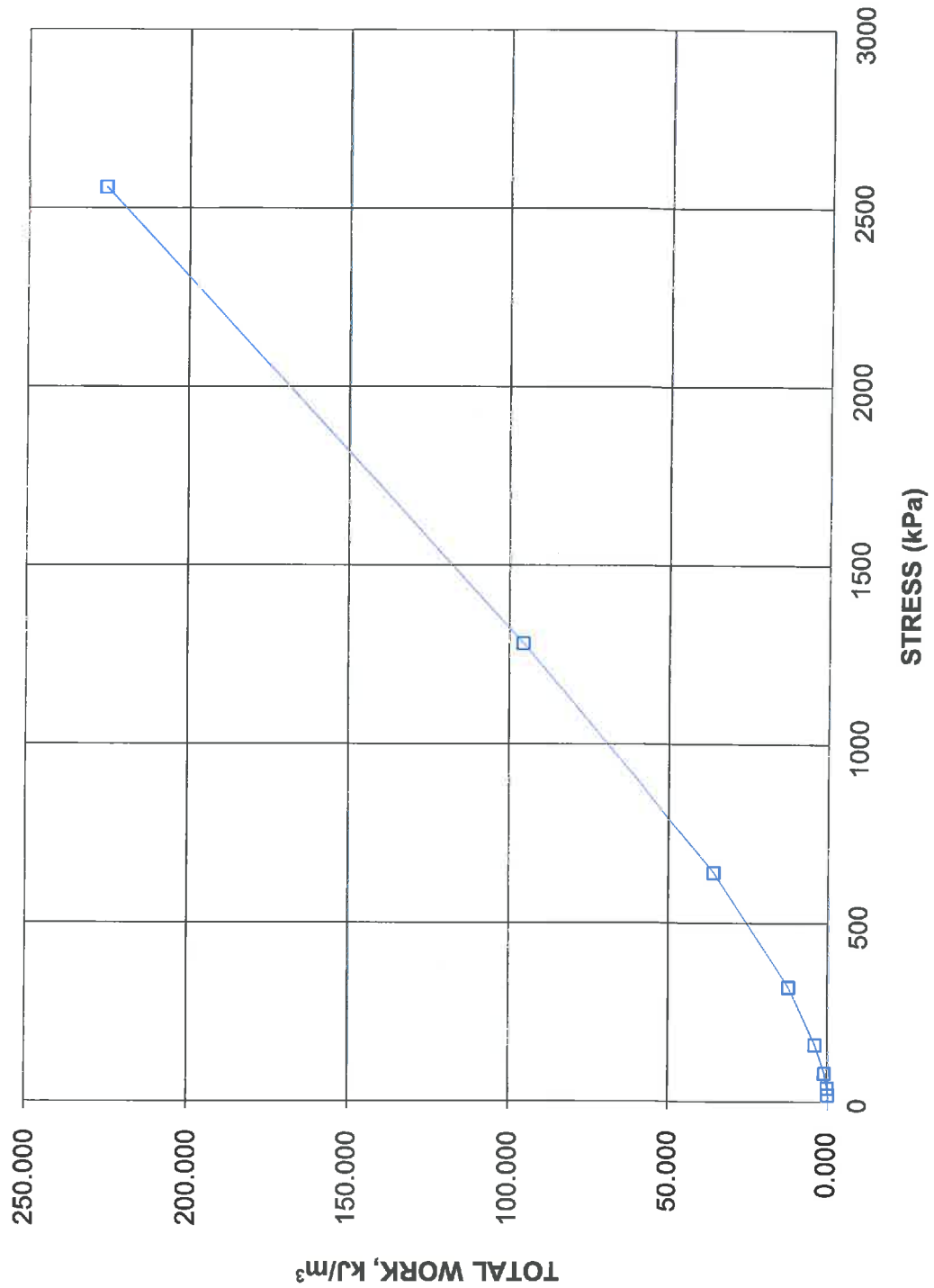
Golder Associates

Checked By: *[Signature]*

**CONSOLIDATION TEST
TOTAL WORK VS STRESS**

FIGURE

**CONSOLIDATION TEST
TOTAL WORK, kJ/m^3 vs STRESS
BH 16-03A ST-1**



Project No. 1541891(9000)

Prepared By: LH

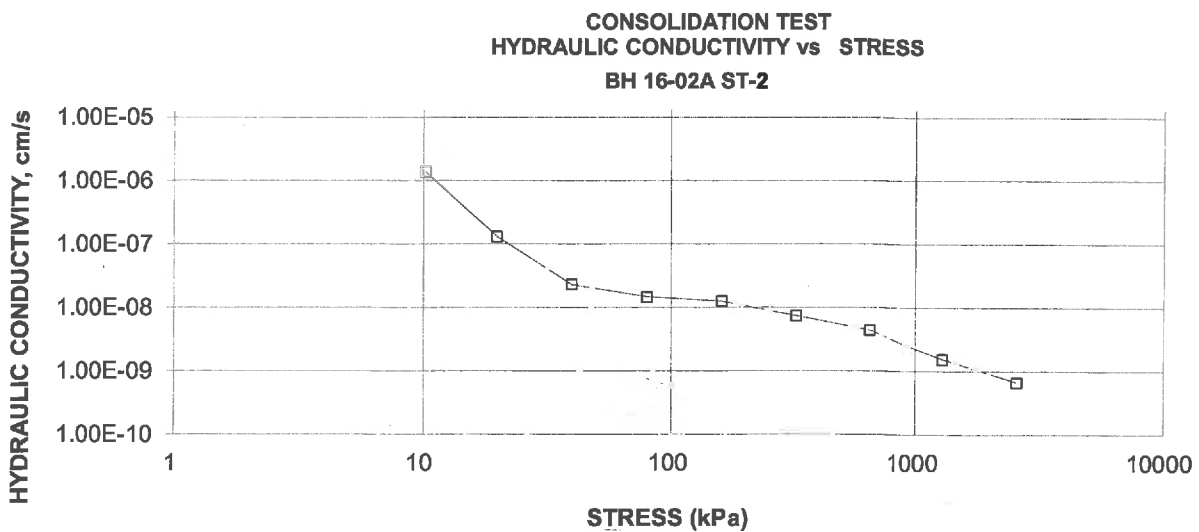
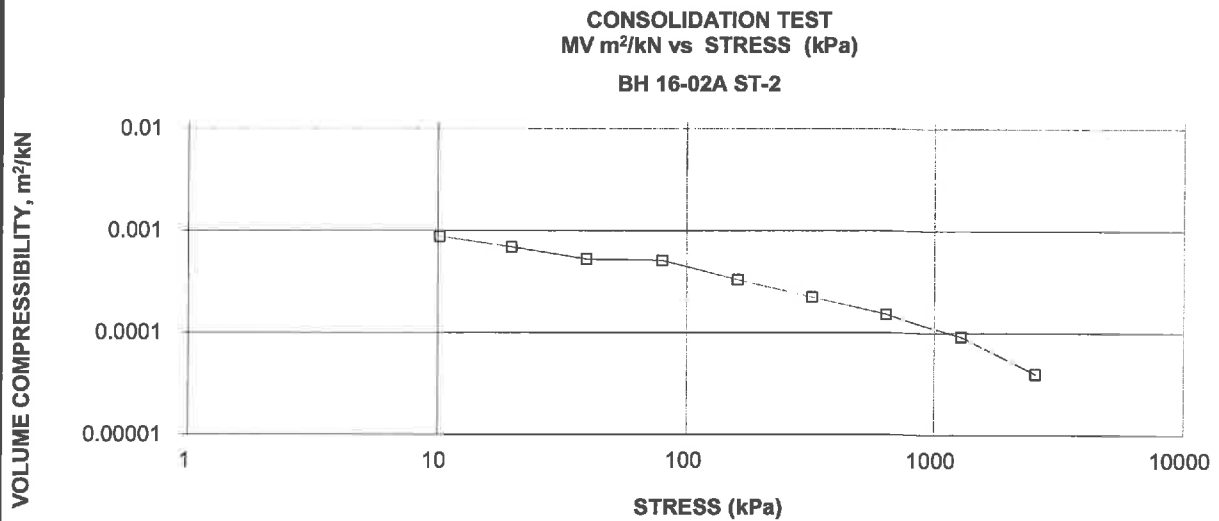
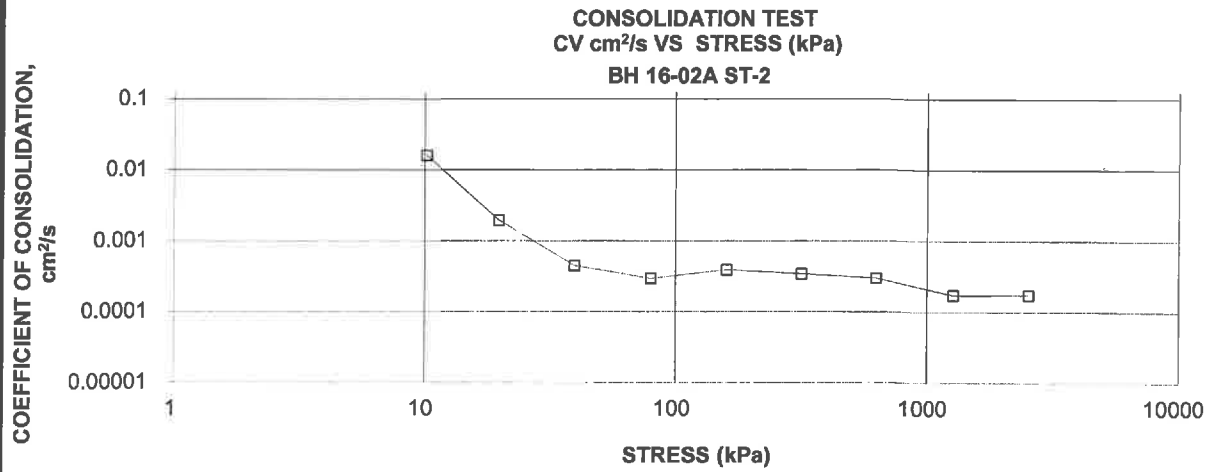
Golder Associates

Checked By: *sh*

CONSOLIDATION TEST SUMMARY					FIGURE		
ASTM D2435/D2435M							
SAMPLE IDENTIFICATION							
Project Number	1541891(9000)	Sample Number	ST-2				
Borehole Number	16-02A	Sample Depth, m	18.29-18.90				
TEST CONDITIONS							
Test Type	Laboratory Standard	Load Duration, hr	24				
Oedometer Number	8						
Date Started	11/04/2016						
Date Completed	11/12/2016						
SAMPLE DIMENSIONS AND PROPERTIES - INITIAL							
Sample Height, cm	1.26	Unit Weight, kN/m ³	19.11				
Sample Diameter, cm	4.97	Dry Unit Weight, kN/m ³	14.59				
Area, cm ²	19.43	Specific Gravity, measured	2.76				
Volume, cm ³	24.43	Solids Height, cm	0.678				
Water Content, %	30.96	Volume of Solids, cm ³	13.17				
Wet Mass, g	47.59	Volume of Voids, cm ³	11.26				
Dry Mass, g	36.34	Degree of Saturation, %	99.9				
TEST COMPUTATIONS							
	Corr.		Average				
Stress	Height	Void	Height	t ₉₀	cv.	mv	k
kPa	cm	Ratio	cm	sec	cm ² /s	m ² /kN	cm/s
0.00	1.257	0.855	1.257				
4.80	1.267	0.869	1.262				
10.19	1.261	0.861	1.264	21	1.61E-02	8.78E-04	1.39E-06
19.80	1.252	0.848	1.257	173	1.93E-03	6.91E-04	1.31E-07
39.81	1.239	0.829	1.246	735	4.48E-04	5.25E-04	2.30E-08
79.79	1.214	0.791	1.226	1084	2.94E-04	5.09E-04	1.47E-08
159.80	1.181	0.742	1.197	778	3.90E-04	3.28E-04	1.26E-08
319.80	1.136	0.676	1.158	833	3.41E-04	2.22E-04	7.43E-09
639.80	1.075	0.587	1.106	872	2.97E-04	1.51E-04	4.41E-09
1279.91	1.001	0.478	1.038	1326	1.72E-04	9.18E-05	1.55E-09
2559.80	0.938	0.384	0.969	1148	1.74E-04	3.95E-05	6.72E-10
1279.91	0.949	0.400	0.943				
156.92	1.012	0.494	0.981				
39.76	1.059	0.563	1.036				
9.80	1.108	0.635	1.084				
<p>Note:</p> <p>Consolidation loading and unloading schedule assigned by the client.</p> <p>k calculated using cv based on t₉₀ values.</p> <p>Specimen taken 10-15cm from the top of tube.</p>							
SAMPLE DIMENSIONS AND PROPERTIES - FINAL							
Sample Height, cm	1.11	Unit Weight, kN/m ³	21.09				
Sample Diameter, cm	4.97	Dry Unit Weight, kN/m ³	16.55				
Area, cm ²	19.43	Specific Gravity, measured	2.76				
Volume, cm ³	21.53	Solids Height, cm	0.678				
Water Content, %	27.41	Volume of Solids, cm ³	13.17				
Wet Mass, g	46.30	Volume of Voids, cm ³	8.37				
Dry Mass, g	36.34						
Prepared By: LH		Golder Associates			Checked By:		

CONSOLIDATION TEST SUMMARY

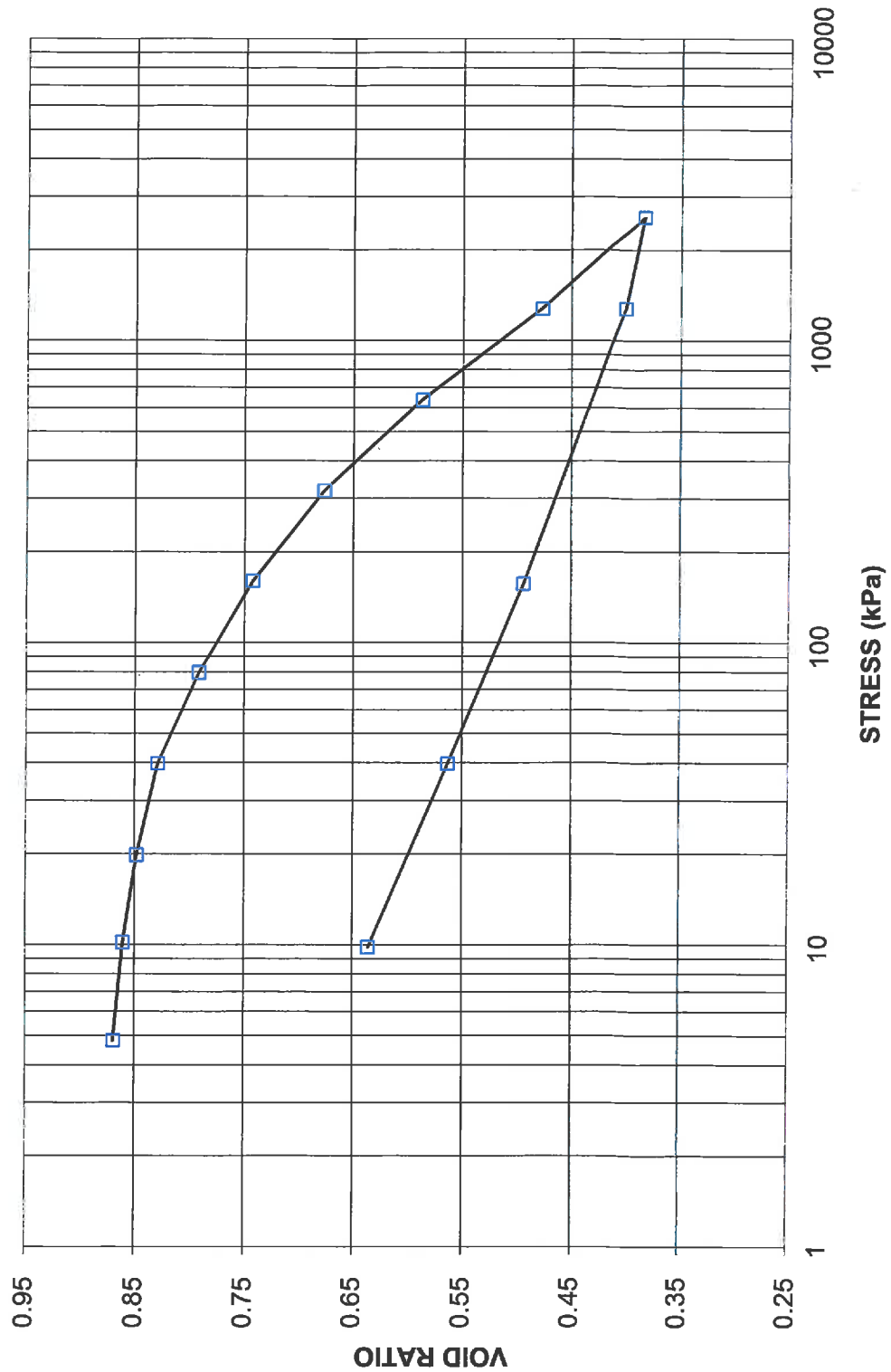
FIGURE



**CONSOLIDATION TEST
VOID RATIO VS LOG STRESS**

FIGURE

**CONSOLIDATION TEST
VOID RATIO vs STRESS
BH 16-02A ST-2**



Project No. 1541891(9000)

Prepared By: LH

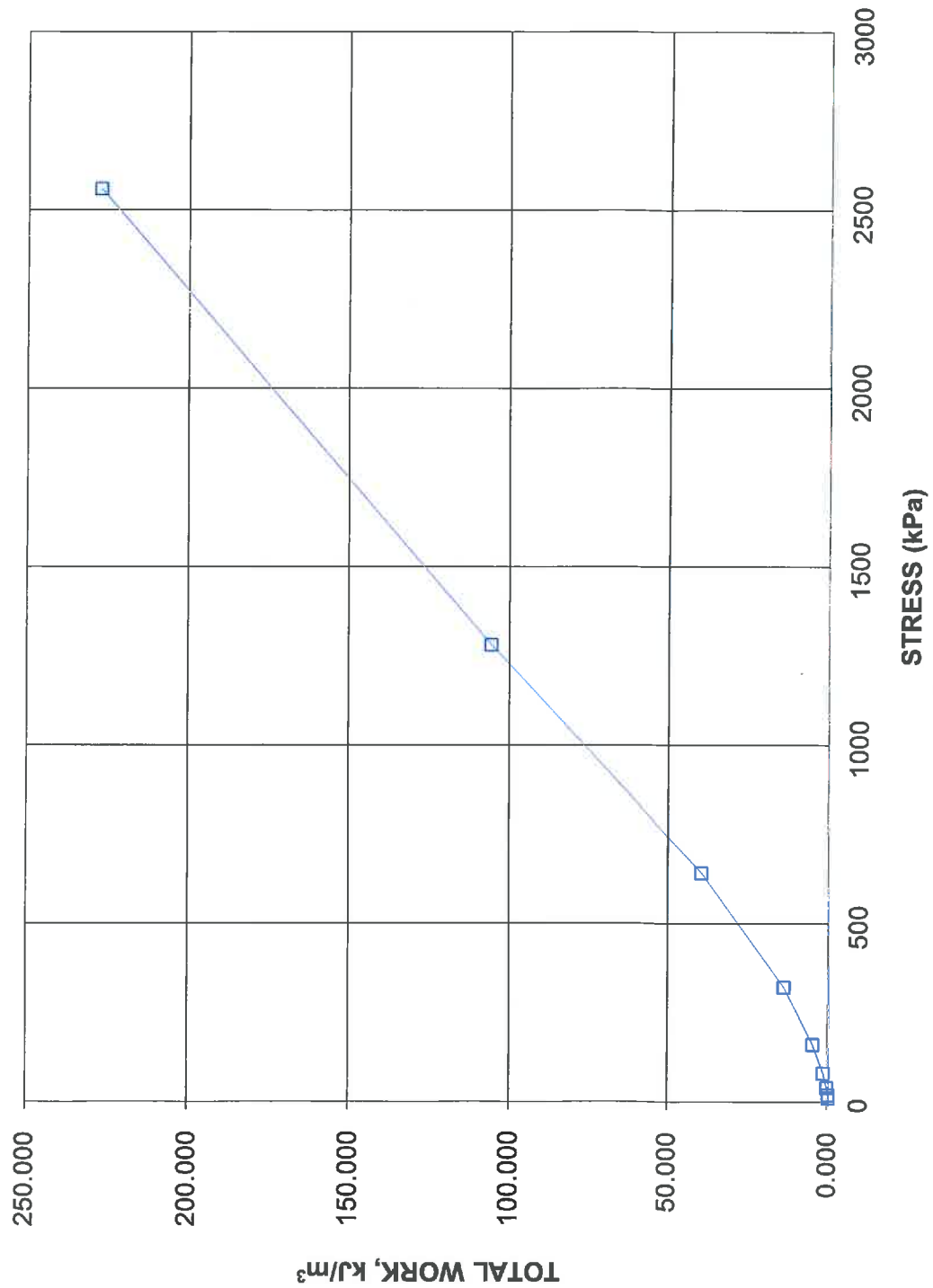
Golder Associates

Checked By: *shl*

CONSOLIDATION TEST TOTAL WORK VS STRESS

FIGURE

CONSOLIDATION TEST
TOTAL WORK, kJ/m^3 vs STRESS
BH 16-02A ST-2



Project No. 1541891(9000)

Prepared By: LH

Golder Associates

Checked By:

bl

**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.
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Phone: 705-652-2000 FAX: 705-652-6365

Project : 13372**Thurber Engineering Ltd.****Attn : Mark Farrant**

103, 2010 Winston Park Drive
Oakville, ON
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Phone: 905-829-8666 x 228
Fax:

09-August-2016

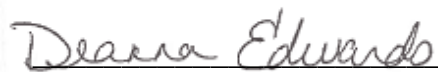
Date Rec. : 03 August 2016
LR Report: CA14114-AUG16
Reference: 13372

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: BH 16-03, SS4, 10'-12'
Sample Date & Time					19-Jul-16
Temperature Upon Receipt [°C]	---	---	---	---	24.2
Corrosivity Index [none]	09-Aug-16	13:34	09-Aug-16	14:29	1
pH [no unit]	08-Aug-16	11:40	09-Aug-16	09:32	7.47
Soil Redox Potential [mV]	08-Aug-16	18:47	09-Aug-16	08:28	306
Sulphide [%]	08-Aug-16	10:07	09-Aug-16	09:35	< 0.02
% Moisture (wet wt) [%]	05-Aug-16	07:02	05-Aug-16	09:08	15.8
pH [no unit]	04-Aug-16	09:56	04-Aug-16	15:49	8.32
Chloride [µg/g]	05-Aug-16	18:51	09-Aug-16	09:15	43
Sulphate [µg/g]	05-Aug-16	18:51	09-Aug-16	09:15	46
Conductivity [uS/cm]	04-Aug-16	09:56	04-Aug-16	15:50	185
Resistivity (calculated) [Ohms.cm]	09-Aug-16	13:33	09-Aug-16	14:29	5400


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



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Project : 13372

LR Report : CA14114-AUG16

Temperature of Samples upon receipt 24 degrees C
No cooling agent present
Custody Seal not Present

Corrosivity Index is based on the American Water Works Corrosivity Scale according to AWWA C-105. An index greater than 10 indicates the soil matrix may be corrosive to cast iron alloys.

**SGS Canada Inc.**

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Project : 13372**LR Report :** CA14114-AUG16

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



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Project : 13372

LR Report : CA14114-AUG16

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: DIO0053-AUG16												
Chloride	0.4	µg/g	<0.4		0	20	109	80	120	111	75	125
Sulphate	0.4	µg/g	<0.4		3	20	101	80	120	101	75	125
Carbon/Sulphur - QCBatchID: ECS0007-AUG16												
Sulphide	0.02	%	<0.02		NV	20	113	80	120			
Conductivity - QCBatchID: EWL0045-AUG16												
Conductivity	2	uS/cm	2		1	10	99	90	110	NA		
pH - QCBatchID: EWL0045-AUG16												
pH	0.05	no unit	NA		0		100			NA		

**SGS Canada Inc.**

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Project : 13372**02-August-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. : 27 July 2016
LR Report: CA15443-JUL16
Reference: 13372

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: Rainy River Tributary 2
Sample Date & Time					N/A
Temperature Upon Receipt [°C]	---	---	---	---	21.0
Corrosivity Index [none]	02-Aug-16	13:34	02-Aug-16	13:34	2
pH [no unit]	27-Jul-16	06:49	28-Jul-16	09:44	7.90
Redox Potential [mV]	27-Jul-16	13:39	02-Aug-16	10:55	278
Sulphide [mg/L]	29-Jul-16	13:00	29-Jul-16	12:19	< 0.02
Chloride [mg/L]	27-Jul-16	11:45	28-Jul-16	10:10	3
Sulphate [mg/L]	27-Jul-16	12:42	29-Jul-16	14:35	20
Conductivity [uS/cm]	27-Jul-16	06:49	28-Jul-16	09:44	179
Resistivity (calculated) [Ohms.cm]	27-Jul-16	06:49	02-Aug-16	13:33	5600

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.


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

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

Project : 13372**LR Report : CA15443-JUL16**

Method Descriptions

Parameter	SGS Method Code	Reference Method Code
Anions by discrete analyzer	ME-CA-[ENV]EWL-LAK-AN-026	US EPA 325.2
Anions by discrete analyzer	ME-CA-[ENV]EWL-LAK-AN-026	US EPA 375.4
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.

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

Project : 13372

LR Report : CA15443-JUL16

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 discrete analyzer - QCBatchID: DIO0458-JUL16												
Chloride	1	mg/L	<1		1	20	96	80	120	91	75	125
Sulphate	1	mg/L	1		1	20	93	80	120	109	75	125
Conductivity - QCBatchID: EWL0385-JUL16												
Conductivity	2	uS/cm	< 2		0	10	101	90	110	NA		
pH - QCBatchID: EWL0385-JUL16												
pH	0.05	no unit	NA		0		100			NA		
Redox Potential - QCBatchID: EWL0394-JUL16												
Redox Potential	no	mV	NA		1	20	107	80	120	NA		
Sulphide by SFA - QCBatchID: SKA0211-JUL16												
Sulphide	0.02	mg/L	<0.02		0	20	92	80	120	NV	75	125



Appendix C

Borehole Locations and Soil Strata Drawing



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

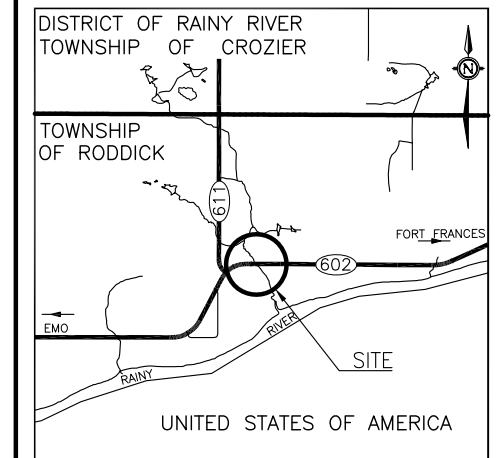


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GWP No	6602-15-00	

HIGHWAY 602
RAINY RIVER TRIBUTARY 2
CULVERT REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

HATCH



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.

GEOCRES No. 52C-50

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Appendix D

Site Photographs



Photo 1: Culvert inlet, looking south



Photo 2: Culvert outlet, looking north



Photo 3: Looking east over culvert towards east approach



Photo 4: Looking west over culvert towards west approach



Photo 5: Cracking and push-out of culvert wall