



THURBER ENGINEERING LTD.



**FOUNDATION INVESTIGATION REPORT
SAWMILL CREEK CULVERT REPLACEMENT
HIGHWAY 17
THUNDER BAY DISTRICT, ONTARIO**

G.W.P. No. 6366-14-00, W.P. No. 6366-14-01, SITE No. 48E-50/C

GEOCRES Number: 42D-44

Report

to

HATCH

Date: August 25, 2017
File: 13662

TABLE OF CONTENTS

1.	INTRODUCTION	1
2.	SITE DESCRIPTION	2
3.	INVESTIGATION PROCEDURES	2
4.	LABORATORY TESTING	3
5.	DESCRIPTION OF SUBSURFACE CONDITIONS	4
5.1	Asphalt	4
5.2	Fill.....	5
5.3	Peat.....	5
5.4	Silty Sand to Sandy Silt	6
5.5	Silty Clay	6
5.6	Silt to Sandy Silt	7
5.7	Gravelly Silty Sand	8
5.8	Bedrock	8
5.9	Groundwater Conditions	8
6.	CORROSIVITY AND SULPHATE TEST RESULTS.....	9
7.	MISCELLANEOUS	10

APPENDICES

Appendix A	Record of Borehole Sheets
Appendix B	Geotechnical and Analytical Laboratory Test Results
Appendix C	Site Photographs
Appendix D	Borehole Locations and Soil Strata Drawing
Appendix E	Factual Data from 2015 Golder Preliminary Foundation Report



**FOUNDATION INVESTIGATION REPORT
SAWMILL CREEK CULVERT REPLACEMENT
HIGHWAY 17
THUNDER BAY DISTRICT, ONTARIO**

G.W.P. No. 6366-14-00, W.P. No. 6366-14-01, SITE No. 48E-50/C

GEOCRES NUMBER: 42D-44

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 Sawmill Creek Culvert on Highway 17, located in the Township of Syine, Thunder Bay District, Ontario.

The purpose of this investigation was to explore the subsurface conditions at the culvert location to supplement the existing information obtained during preliminary design of the project 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-0018-004.

A preliminary foundation investigation carried out at this site was documented in the report titled "Revised Preliminary Foundation Investigation and Design Report, Sawmill Creek Culvert, Highway 17, District of Thunder Bay, Township of Syine", prepared by Golder Associates, dated July 14, 2017; Geocres No. 42D-39. Reference should be made to the Golder report for a written description of the subsurface conditions, borehole location plan, stratigraphic profile, record of borehole sheets and laboratory test results. It should be noted that Golder is solely responsible for the subsurface information provided in the Preliminary Foundation Report. The Record of Borehole sheets and Borehole Locations and Soil Strata drawing from the Golder report have been enclosed in Appendix E of this report for reference, and the subsurface information presented in the Golder report was incorporated in the current report, as appropriate.

Client: Hatch
File No.: 13662

Date: August 25, 2017
Page: 1 of 11

E file: H:\13000-13999\13662 MTO NWR Retainer Assignment 4 - Chicken Farm, Chowder, Flynn, Sawmill Culverts\Reports & Memos\Sawmill Creek Culvert\Revised Elevations-REV 2\Sawmill Creek Culvert - FIR FINAL-REV 2.docx

Reference is also made to a Structural Design Report (SDR) titled, "Structural Design Report, Sawmill Creek Culvert, Site No. 48E-050C, Highway 17", prepared by Hatch Mott MacDonald (Hatch), dated December 2015.

2. SITE DESCRIPTION

The site is located on Highway 17, approximately 18 km east of Mill Road in Terrace Bay, Ontario. The culvert allows Sawmill Creek to flow from east to west from Sawmill Lake under Highway 17 to Jackfish Lake. Highway 17 generally runs in a north-south direction at the culvert site.

The SDR indicates that the existing structure is a 27.3 m long, 6.1 m span by 1.8 m high, cast-in-place, rigid concrete box, with a height of fill of 4.2 m over the culvert. The culvert barrel is noted to be generally in fair to poor condition with settlement at the centre, a 130 mm wide crack at midspan, delamination, eroded sections of the walls, spalled faces at the inlet and outlet, exposed rebar, cracking, and deformation of the foundations. Based on the 2014 structural inspection report, about 400 mm of settlement has reportedly occurred at the midpoint of the culvert.

The grade level of Highway 17 at the existing culvert is at approximate Elevation 188 m.

Naturally low-lying areas are present near the inlet and outlet of the culvert, with vegetation consisting of grass, shrubs and frequent trees. Sawmill Lake is located approximately 250 m east of the site, and Jackfish Lake is located approximately 60 m west of the site. Photographs in Appendix C show the general nature of the site and the existing culvert.

Based on published geological information, the culvert lies within an area of lacustrine deposits of varved or massive clay, silt, fine sand and sand, and is bordered by bare bedrock knobs. The bedrock at the site consists of massive granodiorite to granite.

3. INVESTIGATION PROCEDURES

The borehole investigation and field testing program for this project was carried out on July 27 and August 9, 2016, and consisted of drilling and sampling a 16.6 m deep borehole, designated as Borehole 16-15. The borehole was located on the east shoulder of Highway 17, approximately 13 m south of the centreline of the existing culvert, near the alignment of the proposed creek diversion pipe.

Utility clearances were obtained prior to the start of drilling. The coordinates and ground surface elevation for the borehole were derived from topographic plans provided to Thurber by Hatch.

The coordinate system MTM NAD 83, Zone 14 was used for the borehole. The approximate location of the borehole is shown on the Borehole Locations and Soil Strata Drawing included in Appendix D.

A track-mounted CME 55 drill rig was used to advance Borehole 16-15 using hollow stem augers to a depth of 12.5 m, followed by an NQ core barrel to advance the borehole into bedrock to a depth of 16.6 m. Soil samples were obtained at selected intervals in the borehole with a 50 mm outside diameter split spoon sampler driven in conjunction with the Standard Penetration Test (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 borehole and processed the recovered soil samples for transport to Thurber's laboratory for further examination and testing.

Groundwater conditions were observed in the open borehole throughout the drilling operations. The borehole was backfilled on completion of drilling in general accordance with Ontario Regulation 903.

Completion details of the Borehole 16-15 are summarized in Table 3.1.

Table 3.1 – Borehole Completion Details

Borehole Number	Borehole Depth / Base Elevation (m)	Completion Details
16-15	16.6 / 171.3	Bentonite holeplug and cuttings from 16.6 m to 0.18 m and asphalt patch to ground surface.

The previous investigation by Golder included four (4) boreholes, numbered SW-1 to SW-4, which were drilled to depths of 10.1 to 15.8 m. The approximate locations of the Golder boreholes are shown on the Borehole Locations and Soil Strata Drawing included in Appendix D, and on the 2015 Golder report's Borehole Locations and Soil Strata Drawing included in Appendix E.

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), plasticity testing (Atterberg Limits) and point load testing on bedrock where appropriate. A consolidation test and additional hydrometer and Atterberg Limits tests were also conducted by TBT Engineering Ltd. (TBTE) on a thin-walled tube sample of silty clay from Borehole 16-15. 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 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 Appendices A and D. Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets and on the “Borehole Locations and Soil Strata” drawings included in Appendices D and E. 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 from the current and previous investigations consisted of asphalt pavement overlying granular fill and embankment fill, which was in turn underlain by native soil consisting of silty sand, silty clay, silt, gravelly silty sand, and granite bedrock. A thin peat layer was also noted below the fill at one borehole. Descriptions of the individual strata are presented below.

5.1 Asphalt

Boreholes SW-2 and SW-3 were drilled through the existing asphalt lanes on Highway 17. The asphalt thickness measured in the boreholes was 140 mm. Borehole 16-15 was drilled through the asphalt shoulder, where the asphalt thickness was 150 mm.

5.2 Fill

Underlying the asphalt, a 0.75 m thick layer of granular fill consisting of gravelly sand with some silt was encountered in Borehole 16-15, which extended to a depth of 0.9 m (Elev. 187.0 m). The measured moisture content of a sample of the granular fill was 10%. The results of a grain size analysis conducted on a sample the granular fill is presented on the Record of Borehole sheet in Appendix A, and on Figure B1 in Appendix B. The results are summarized in the following table:

Soil Particle	Percentage (%)
Gravel	21
Sand	66
Silt and Clay	13

A sand and silt to silt and sand embankment fill containing trace to some gravel, trace clay and trace organics was encountered below the asphalt in Boreholes SW-2 and SW-3, below the granular fill in Borehole 16-15, and at the ground surface in Boreholes SW-1 and SW-4. The embankment fill ranged in thickness from 1.1 to 5.5 m, and extended to depths from 1.1 to 5.5 m (Elev. 182.5 to 184.9 m). SPT 'N' values within the embankment fill ranged from 1 to 10 blows per 0.3 m penetration, indicating a very loose to compact relative density. Higher 'N' values from 12 to greater than 100 blows per 0.3 m penetration were recorded in frozen soils in Boreholes SW-1 to SW-3, and are not considered to be representative of the density of the embankment fill.

The measured moisture content of the embankment fill ranged from 6% to 34%. The results of grain size analyses conducted on samples of the embankment fill are presented on the Record of Borehole sheets included in Appendices A and E, are summarized in the following table. The results from Borehole 16-15 are presented on Figure B2 in Appendix B.

Soil Particle	Percentage (%)
Gravel	0 to 6
Sand	35 to 66
Silt	28 to 60
Clay	3 to 5

5.3 Peat

A 200 mm thick layer of peat was encountered below the embankment fill at a depth of 5.6 m in Borehole SW-2. The peat extended to a depth of 5.8 m (Elev. 182.3 m). A moisture content of 46% was measured in the peat.

5.4 Silty Sand to Sandy Silt

A deposit of silty sand to sandy silt with trace to some clay was encountered below the embankment fill in Boreholes 16-15, SW-1, SW-3 and SW-4. The deposit ranged in thickness from 0.3 to 3.1 m, and extended to depths ranging from 1.4 to 6.8 m (Elev. 181.3 to 182.6 m). The deposit was very loose to loose, based on SPT 'N' values from 1 to 7 blows per 0.3 m of penetration.

Measured moisture contents on samples of the silty sand to sandy silt ranged from 16% to 24%. The results of grain size distribution analyses conducted on a sample of the silty sand to sandy silt are presented on the Record of Borehole sheets included in Appendix E and are summarized in the following table.

Soil Particle	Percentage (%)
Gravel	0
Sand	25
Silt	65
Clay	10

5.5 Silty Clay

Underlying the peat and silty sand to sandy silt deposits, a deposit of silty clay was encountered in all of the boreholes. The silty clay also contained trace sand and trace organics below the peat in Borehole SW-2. The layer ranged in thickness from 3.0 to 5.5 m, and extended to depths from 6.4 to 9.1 m (Elev. 177.1 to 178.8 m), except in Boreholes SW-2 and SW-3, which were terminated in the silty clay at depths of 10.5 and 10.1 m respectively (Elev. 177.6 and 178 m).

Measured SPT 'N' values in the silty clay ranged from 0 (weight of hammer) to 6 blows per 0.3 m penetration. In situ field vane tests measured undrained shear strengths of 12 to 24 kPa in Boreholes SW-1 and SW-4, which were drilled beyond the roadway embankment, and 20 to 35 kPa in Boreholes 16-15, SW-2 and SW-3, which were drilled through the roadway. Therefore, the silty clay is considered to generally have a soft consistency outside of the embankment fill, and a firm consistency below the embankment fill. The sensitivity of the silty clay was measured to range from 1 to 4, indicating low to medium sensitivity. Field vane tests measurements of 62 to greater than 100 kPa were also recorded near Elev. 178 in Boreholes SW-2 and SW-3, near the termination depth of the boreholes, and are likely due to the proximity of the underlying silt to sandy silt deposit. These values are not considered to be representative of the consistency of the entire silty clay deposit.

The measured moisture content of samples recovered from the silty clay ranged from 47% to 65%. 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 in Appendices A and E, and are summarized in the following table. The results from Borehole 16-15 are presented on Figures B3 and B5 in Appendix B.

Soil Particle	Percentage (%)
Gravel	0
Sand	0
Silt	13 to 37
Clay	63 to 87
Soil Property	Percentage (%)
Liquid Limit	49 to 69
Plasticity Limit	17 to 24

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

A consolidation test was performed on an undisturbed sample of the silty clay (thin walled tube sample), collected from Borehole 16-15. The results of the testing are presented in Appendix B and are summarized in the following table.

Consolidation Test Results

Borehole	Sample Depth (m)	e_o	C_c	C_r	p_c' (kPa)	p_o' (kPa)	OCR	c_v (m ² /yr)
16-15	7.6 – 8.2	1.17	0.30	0.03	110	105	1.05	5×10^{-4}

5.6 Silt to Sandy Silt

A deposit of silt with trace to some sand and trace to some clay, ranging to sandy silt with trace clay was encountered below the silty clay in Boreholes 16-15, SW-1 and SW-4. The silt to sandy silt deposit ranged in thickness from 3.4 to 7.4 m, and extended to depths ranging from 11.8 to 14.3 m (Elev. 169.7 to 175.4 m). Borehole SW-1 was terminated upon split spoon refusal at the anticipated base of the deposit at a depth of 11.8 m (Elev. 173.2 m). SPT 'N' values within the silt to silty sand ranged from 1 to 14 blows per 0.3 m of penetration, indicating a very loose to compact relative density. SPT 'N' values of greater than 100 blows per 0.3 m were also recorded at the base of the deposit upon the interface with the underlying very dense deposit or bedrock.

Measured moisture contents within the silt to sandy silt deposit ranged between 15% and 25%. The results of grain size distribution analyses conducted on selected samples of the silt to sandy silt are presented on the Record of Borehole sheets included in Appendices A and E and are summarized in the following table. The results from Borehole 16-15 are presented on Figure B4 in Appendix B.

Soil Particle	Percentage (%)
Gravel	0
Sand	4 to 24
Silt	72 to 89
Clay	4 to 9

5.7 Gravelly Silty Sand

A deposit of gravelly silt sand was encountered below the silt to sandy silt in Borehole SW-4. The Borehole was terminated at the anticipated base of the deposit at a depth of 15.8 m (Elev. 168.2 m). An SPT 'N' value of 114 blows per 0.3 m penetration was recorded within the gravelly silty sand deposit, indicating a very dense relative density.

5.8 Bedrock

Granite bedrock was encountered in Borehole 16-15 below the silt to sandy silt deposit at a depth of 12.5 m (Elev. 175.4 m), and was proven by coring 4.1 m into the bedrock. The bedrock is generally described as slightly weathered and grey. Total Core Recovery (TCR) in the bedrock ranged from 80 to 96% with Solid Core Recovery (SCR) ranging from 67 to 92%. The Rock Quality Designation (RQD) determined from the recovered cores generally ranged from 39 to 84%, indicating poor to good rock quality. Average unconfined compressive strengths (UCS) of the rock ranged between 209 and 279 MPa based on correlations with the point load tests (PLT), indicating very strong to extremely strong rock strength.

5.9 Groundwater Conditions

Groundwater conditions were observed during drilling operations and groundwater levels were measured in the open boreholes upon completion of drilling. The groundwater levels measured in the open boreholes are summarized in Table 5.1 below. Groundwater levels reported in the Golder report are also included.

Table 5.1 – Groundwater Measurements

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
16-15	August 9, 2016	3.8	184.1	Open borehole following coring operation
SW-1	March 23, 2015	2.6	182.4	Open borehole
SW-2	March 13, 2015	5.3	182.8	Open borehole
SW-3	March 13, 2015	5.3	182.8	Open borehole
SW-4	March 24, 2015	1.2	182.8	Open borehole

Water level measurements in the creek were reported in the Hatch Structural Design Report and the Golder preliminary investigation, and are summarized in Table 5.1 below. The groundwater level should be assumed to reflect the local creek water level.

Table 5.2 – Creek Level Measurements

Date	Elevation (m)	Source
May 12, 2014	182.9 (outlet)	Hatch Structural Design Report
Nov. 2014	183.1	Hatch Structural Design Report
March 13, 2015	183.9 (outlet)	Golder Preliminary FIDR

The groundwater levels above 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 native silty sand from Borehole 16-01, 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. The results of testing on a sample of surface water are also included in the preliminary FIDR.

Table 6.1 – Analytical Test Results

Parameter	Units (Soil)	Units (Water)	Test Results	
			16-15, SS#4, 10'-12'	Sawmill Creek
			(Silty Sand)	(Creek Water)
Sulphide	%	mg/L	<0.02	<0.006
Chloride	µg/g	mg/L	120	1.0
Sulphate	µg/g	mg/L	1.2	3.9
pH	No unit	No unit	7.85 to 9.32	7.42
Electrical Conductivity	µS/cm	µS/cm	305	87
Resistivity	Ohms.cm	Ohms.cm	3280	11500
Redox Potential	mV	mV	243	289

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 and Mr. Tim Sivak 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, with consolidation and additional geotechnical testing conducted at TBTE's laboratory in Thunder Bay, Ontario. 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


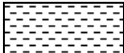



ROCK WEATHERING CLASSIFICATION

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

TERMS

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

UNIFIED SOILS CLASSIFICATION

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

RECORD OF BOREHOLE No 16-15

1 OF 2

METRIC

W.P. 6366-14-01 LOCATION Sawmill Creek Culvert N 5 409 628.1 E 309 033.1 ORIGINATED BY OA/TS
 HWY 17 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2016.07.27 - 2016.08.09 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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	W _P W W _L	WATER CONTENT (%)							
187.9	GROUND SURFACE																
0.0	ASPHALT: (150mm)																
0.2	Gravelly SAND, some silt Brown Moist (FILL)		1	GS												21 66 13 (SI+CL)	
187.0																	
0.9	SAND and SILT, trace to some gravel, trace clay Compact to Loose Grey Moist (FILL)		1	SS	10												
			2	SS	10												
			3	SS	6											0 51 46 3	
184.9																	
3.0	Silty SAND Loose to Very Loose Grey Wet		4	SS	4												
			5	SS	2												
181.8																	
6.1	Silty CLAY Soft Grey Wet (Cl to CH)		6	SS	0											0 0 37 63	
			1	TW												0 0 13 87	
178.8																	
9.1	SILT, some sand, trace clay Very Loose Grey Wet		7	SS	4												

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

ONTMT4S 13662-MTO.GPJ 2017TEMPLATE(MTO).GDT 8/15/17

RECORD OF BOREHOLE No 16-15

2 OF 2

METRIC

W.P. 6366-14-01 LOCATION Sawmill Creek Culvert N 5 409 628.1 E 309 033.1 ORIGINATED BY OA/TS
 HWY 17 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2016.07.27 - 2016.08.09 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							
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE							
								WATER CONTENT (%)							
	Continued From Previous Page						20	40	60	80	100	PLASTIC LIMIT W P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W L	
175.4	SILT , some sand, trace clay Very Loose Grey Wet		8	SS	3										0 13 78 9
12.5	GRANITE BEDROCK , slightly weathered, extremely strong to very strong, grey		9	SS	50/ .050										RUN #1 TCR=80% SCR=67% RQD=39% UCS=279MPa (Average)
			1	RUN											RUN #2 TCR=96% SCR=84% RQD=77% UCS=270MPa (Average)
			2	RUN											RUN #3 TCR=95% SCR=92% RQD=84% UCS=209MPa (Average)
			3	RUN											
171.3															
16.6	END OF BOREHOLE AT 16.6m. WATER LEVEL AT 3.8m IN OPEN BOREHOLE. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.18m, THEN ASPHALT PATCH TO SURFACE.														

ONTMT4S 13662-MTO.GPJ 2017TEMPLATE(MTO).GDT 8/15/17

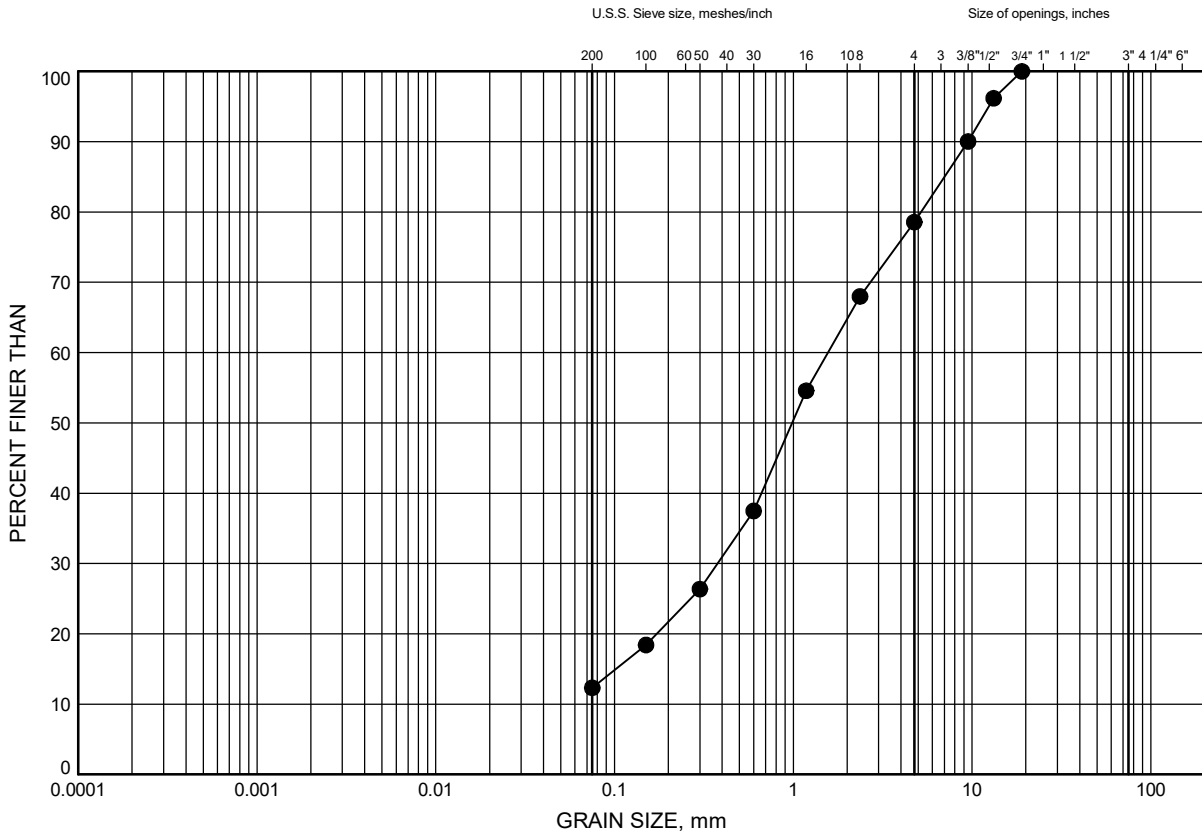
Appendix B

Geotechnical and Analytical Laboratory Test Results

Sawmill Creek Culvert Replacement
GRAIN SIZE DISTRIBUTION

FIGURE B1

Gravelly SAND FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-15	0.3	187.6

Date August 2017
W.P. 6366-14-01



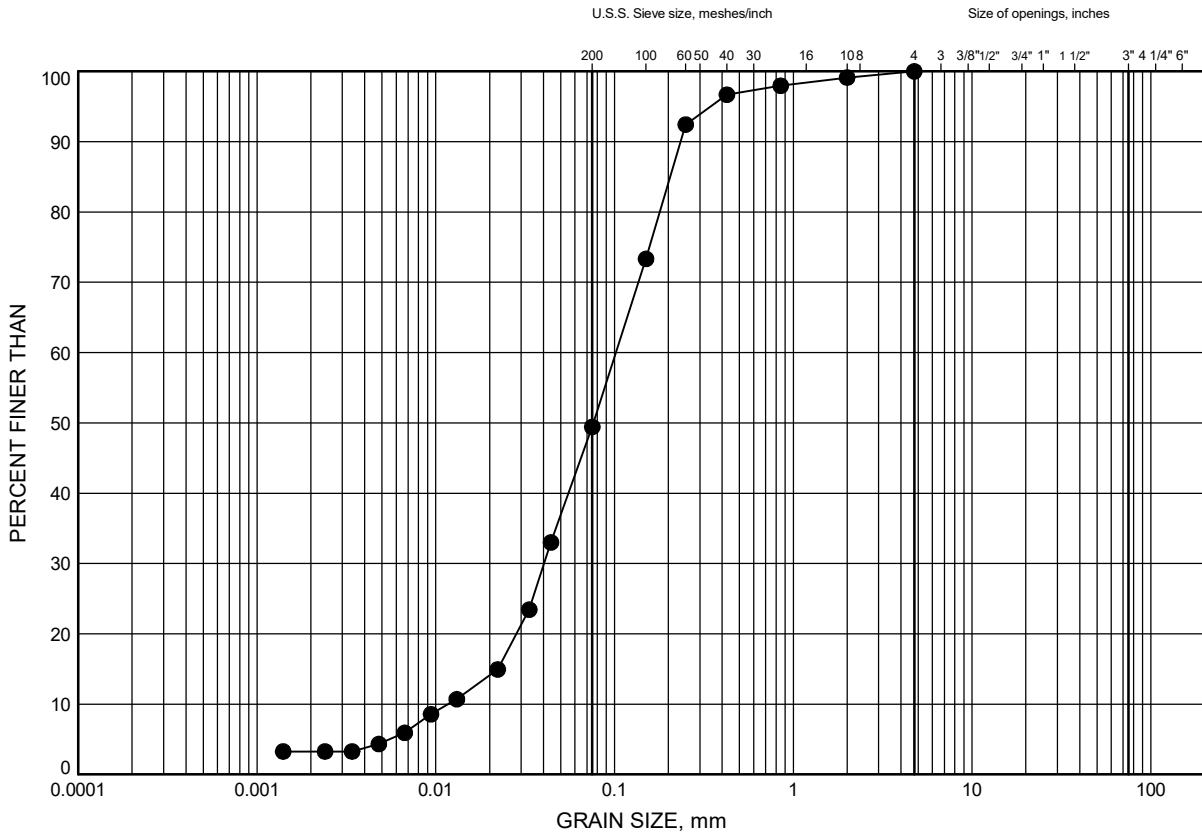
Prep'd MFA
Chkd. MEF

Sawmill Creek Culvert Replacement

GRAIN SIZE DISTRIBUTION

FIGURE B2

SAND and SILT FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-15	2.6	185.3

Date August 2017
W.P. 6366-14-01



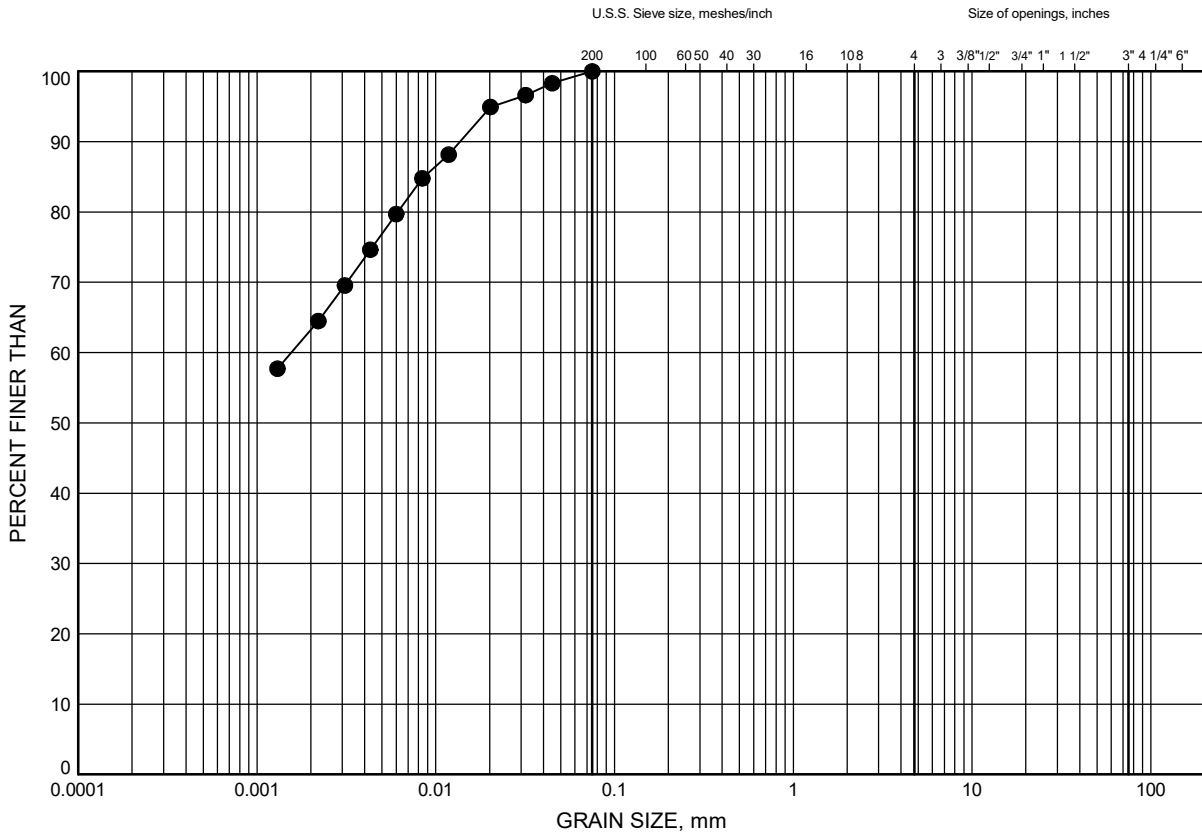
Prep'd MFA
Chkd. MEF

Sawmill Creek Culvert Replacement

GRAIN SIZE DISTRIBUTION

FIGURE B3

Silty CLAY



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-15	6.4	181.5

Date August 2017
W.P. 6366-14-01

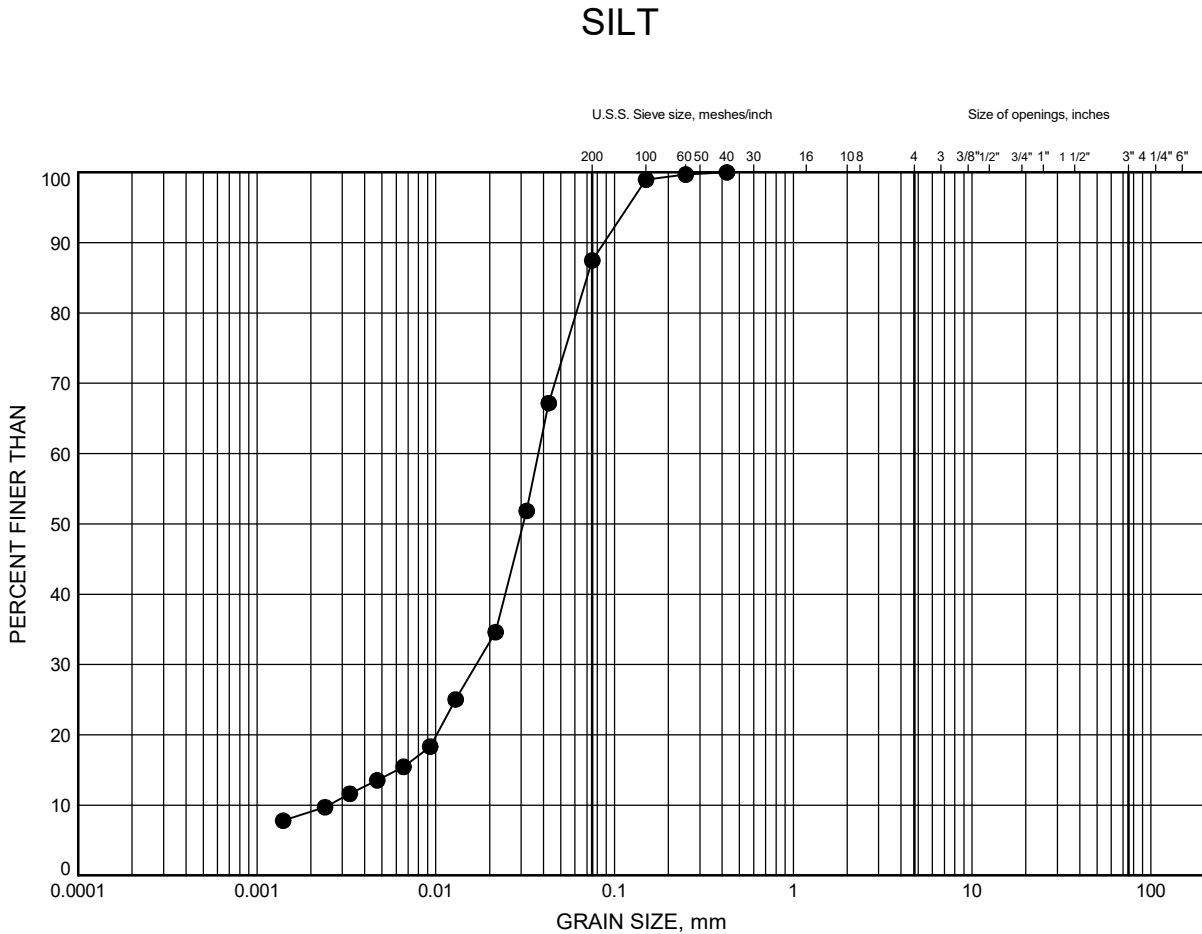


Prep'd MFA
Chkd. MEF

Sawmill Creek Culvert Replacement

GRAIN SIZE DISTRIBUTION

FIGURE B4



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-15	11.0	176.9

Date August 2017
W.P. 6366-14-01

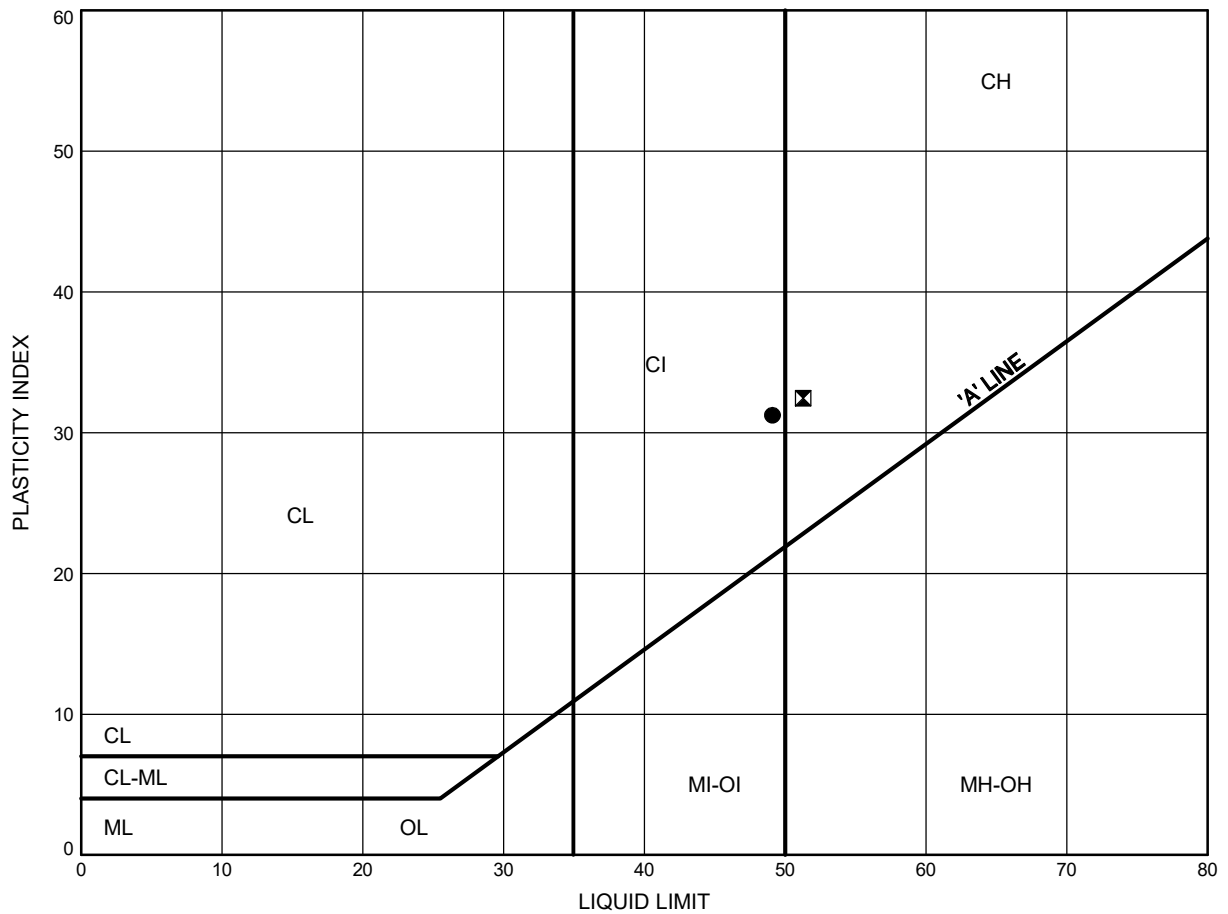


Prep'd MFA
Chkd. MEF

Sawmill Creek Culvert Replacement
ATTERBERG LIMITS TEST RESULTS

FIGURE B5

Silty CLAY



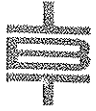
LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-15	6.4	181.5
⊠	16-15	7.9	180.0

Date August 2017
W.P. 6366-14-01



Prep'd MFA
Chkd. MEF



Grain Size Analysis of Soil By Hydrometer

Client:	Thurber Engineering Ltd.	TBTE Project No.:	16-239
Project No.:		Lab No.:	16-1010
Location:	Sawmill Creek Culvert	Borehole No.	16-15
	Hwy 17, Terrace Bay On Area	Sample No.:	ST 1
Reported To:	Mark Farrant	Depth:	25' - 27'
Sampled By/Date:	Client / N/A	Tested By/Date:	FV / GH / August 23, 2016
Reported By:	Forch Valela	Reviewed By:	Tim Fummerton

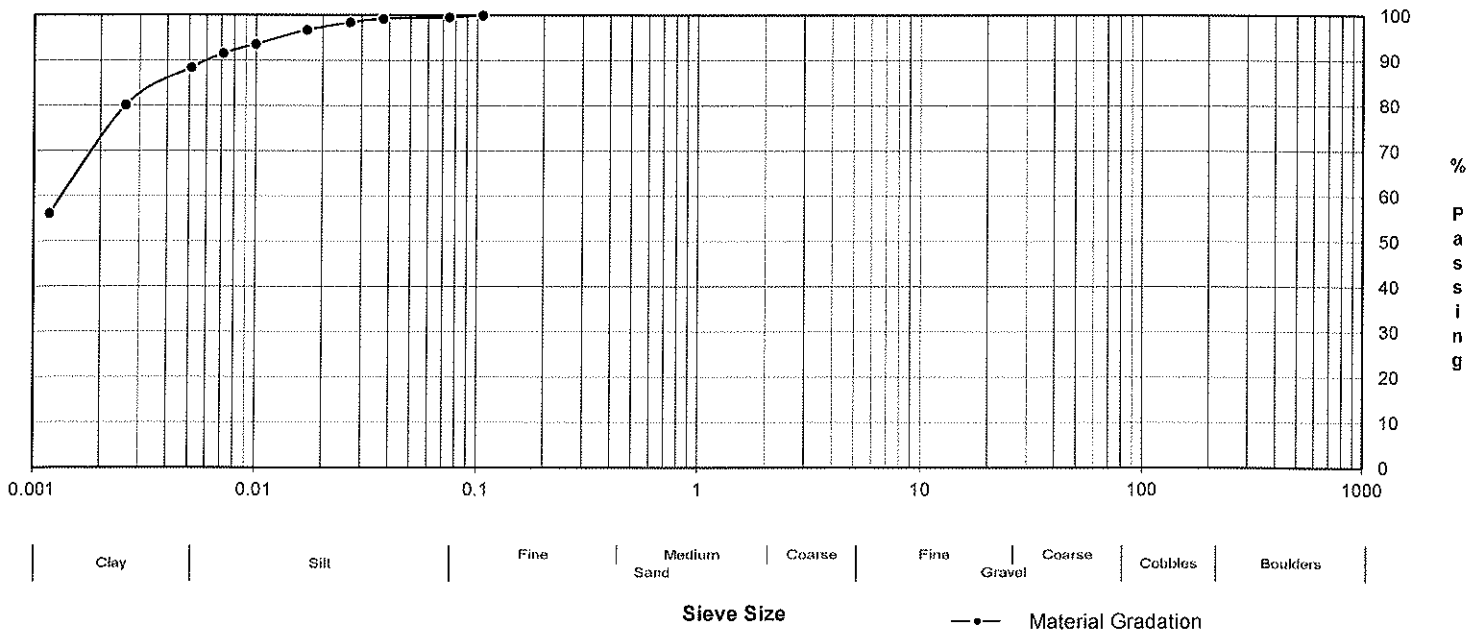
Sieve Analysis

Sieve (mm)	% Passing
50.0	
37.5	
25.0	
19.0	
13.2	
9.5	
4.75	
2.00	
0.850	
0.425	
0.250	
0.106	100.0
0.075	99.6

Hydrometer Analysis

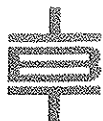
Diameter (mm)	% Finer
0.037541	99.2
0.026657	98.4
0.017000	96.7
0.009665	93.6
0.007143	91.5
0.005123	88.4
0.002593	80.1
0.001182	56.2
5 µm	87.0
2 µm	72.5

Grain Size Analysis



%Gravel		% Silt	12.6	% NMC	47.1	Soil Relative Density	2.625	Soil Classification	CH
% Sand	0.4	% Clay	87.0	PI	32				

Remarks: Test Method LS 701, 702, ASTM D2216, D4318



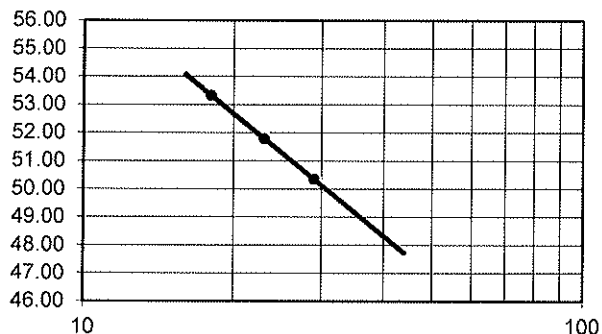
Atterberg Limits

Client:	Thurber Engineering Ltd.	TBTE Project No.:	16-239
Project No.:		Lab No.:	16-1010
Location:	Sawmill Creek Culvert	Borehole No.	16-15
	Hwy 17, Terrace Bay On Area	Sample No.:	ST 1
Reported To:	Mark Farrant	Depth:	25' - 27'
Sampled By/Date:	Client / N/A	Tested By/Date:	G.Homac / August 22, 2016
Reported By:	Forch Valela	Reviewed By:	Tim Fummerton <i>TF</i>

Liquid Limit Determination

Dish No.:	0	uu	ll		Liquid Limit 25 Blows
Wet Soil + Dish:	39.59	41.591	40.423		
Dry Soil + Dish:	35.883	37.084	36.299		
Moisture:	3.707	4.507	4.124		
Dish:	28.521	28.383	28.568		
Dry Soil:	7.362	8.701	7.731		
% Moisture:	50.35	51.80	53.34		
No. of Blows:	29	23	18		
Liquid Limits:	51	51	51		51

Liquid Limit



Liquid Limit, %:	51
Plastic Limit, %:	19
Plasticity Index:	32

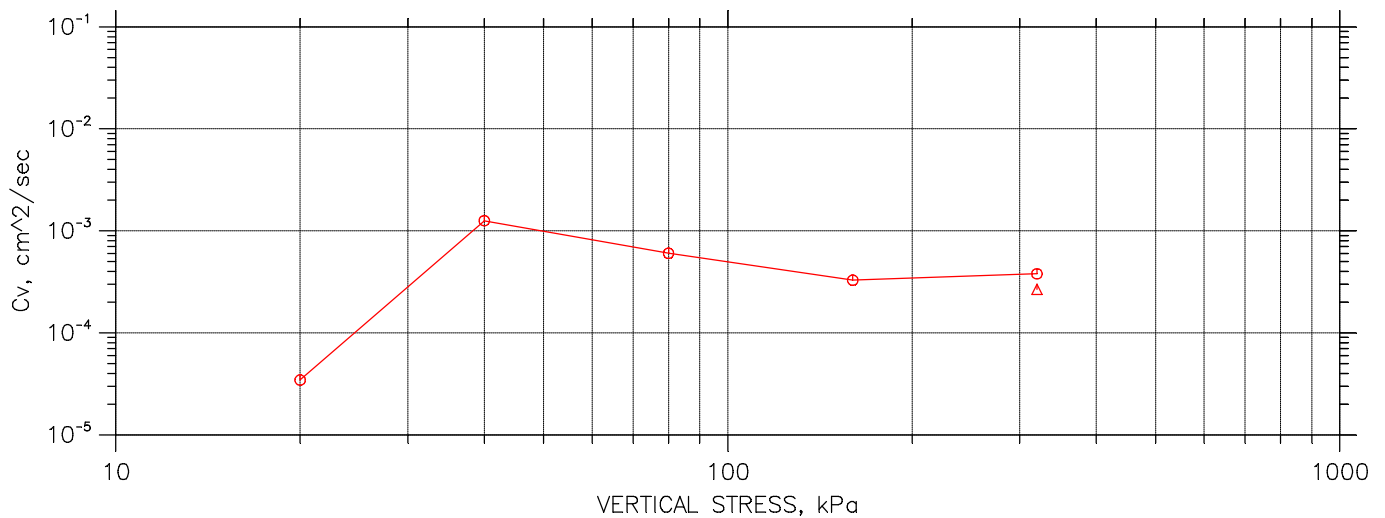
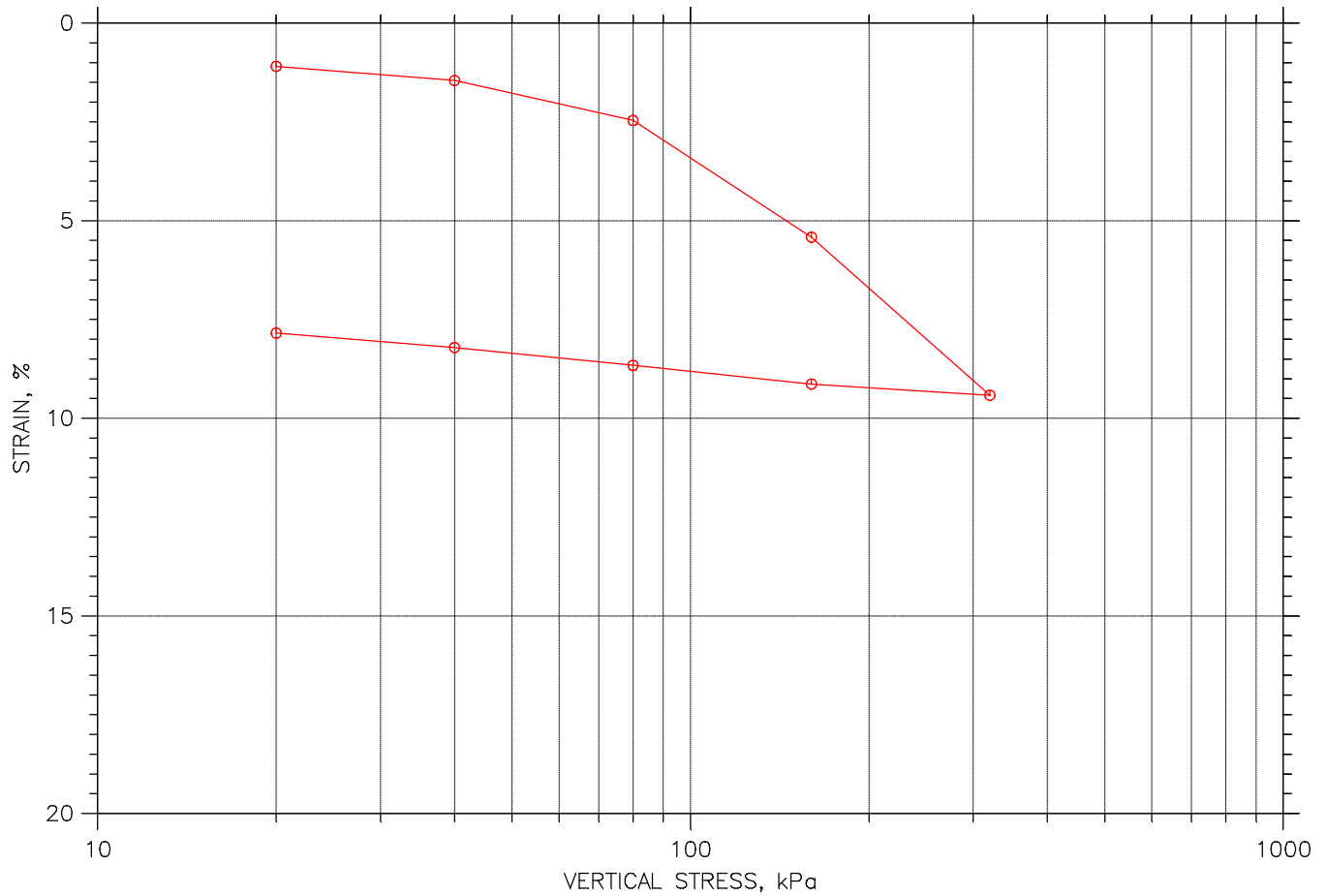
Plastic Limit Determination


Dish No.:	1	2		Natural Moisture
Wet Soil + Dish:	26.859	26.389		184.65
Dry Soil + Dish:	25.69	25.254		164.52
Moisture:	1.169	1.135		20.13
Dish:	19.498	19.216		121.77
Dry Soil:	6.192	6.038		42.75
% Moisture:	18.88	18.80		47.1
Average:		19		

Test Method : ASTM: D4318, D2216

CONSOLIDATION TEST DATA

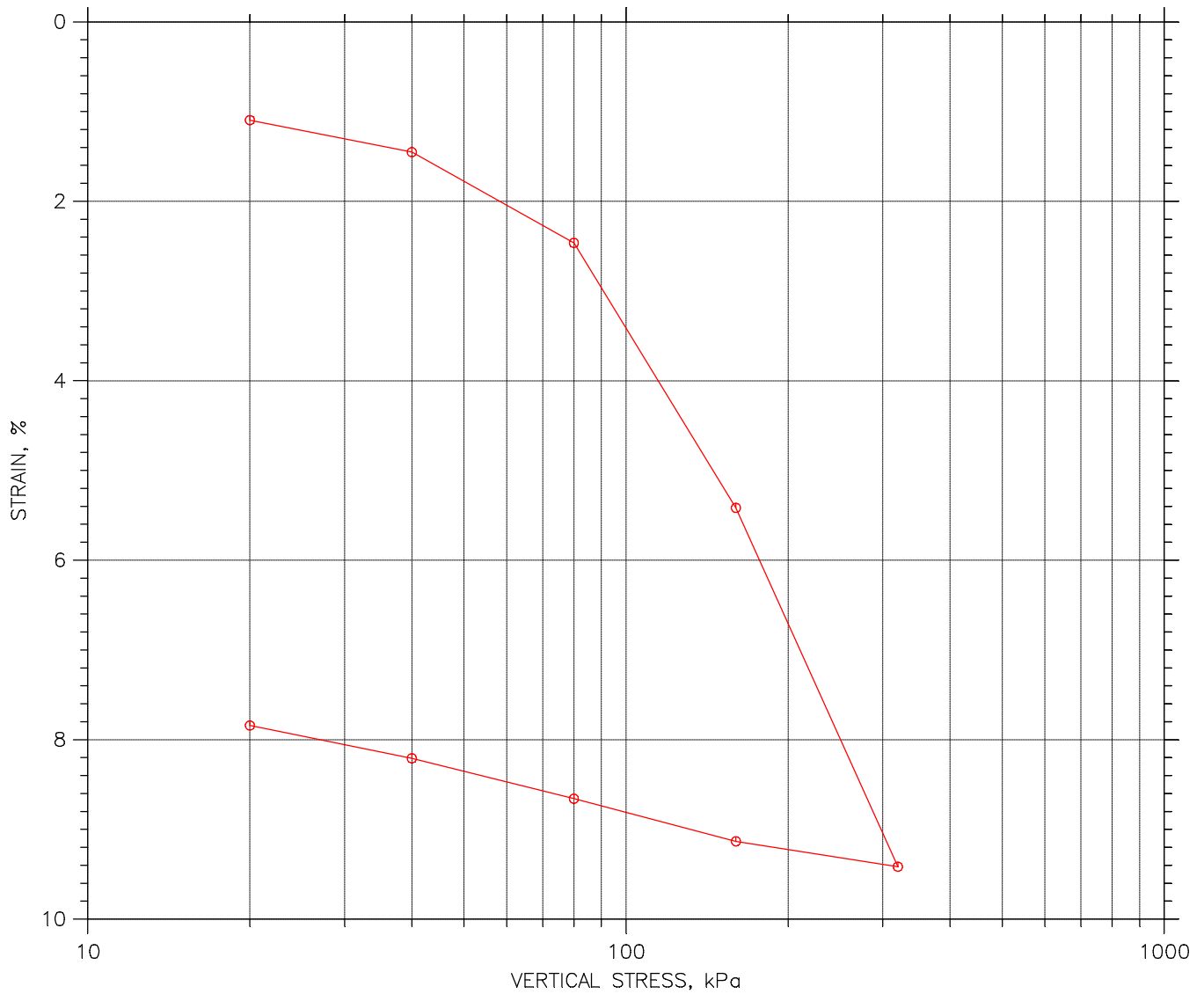
SUMMARY REPORT




	Project: Hwy 17	Location: Sawmill Creek Culvert	Project No.:
	Boring No.:	Tested By: Tim	Checked By: GM
	Sample No.: ST 1	Test Date: Aug 18/16	Depth: 25'-27'
	Test No.: 1	Sample Type: TW	Elevation:
	Description: Soft Grey Clay		
	Remarks:		

CONSOLIDATION TEST DATA

SUMMARY REPORT

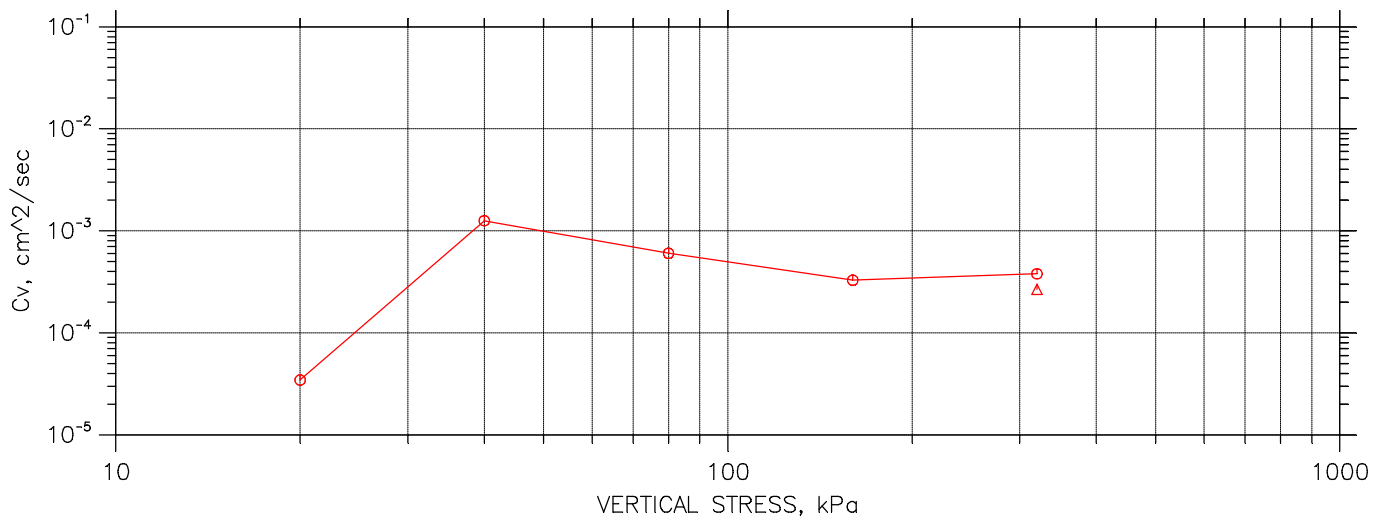
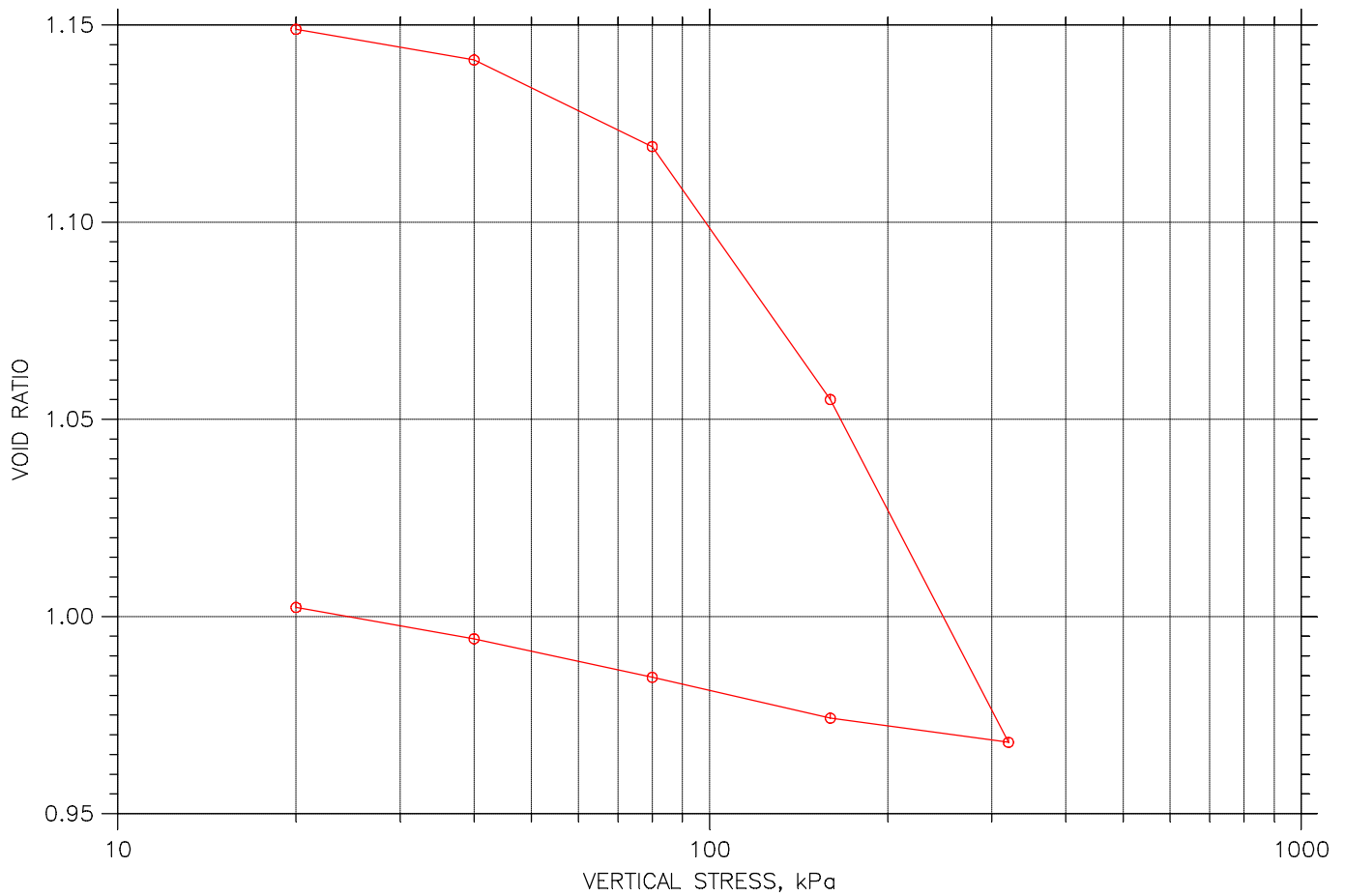



				Before Test	After Test
Overburden Pressure: 0 kPa		Water Content, %		44.32	37.62
Preconsolidation Pressure: 0 kPa		Dry Unit Weight, N/m ³		11850	12860
Compression Index: 0		Saturation, %		99.22	98.53
Diameter: 63.55 mm	Height: 26.04 mm		Void Ratio	1.17	1.00
LL: 51	PL: 19	PI: 32	GS: 2.63		

	Project: Hwy 17		Location: Sawmill Creek Culvert	Project No.:
	Boring No.:		Tested By: Tim	Checked By: GM
	Sample No.: ST 1		Test Date: Aug 18/16	Depth: 25'-27'
	Test No.: 1		Sample Type: TW	Elevation:
	Description: Soft Grey Clay			
	Remarks:			

CONSOLIDATION TEST DATA

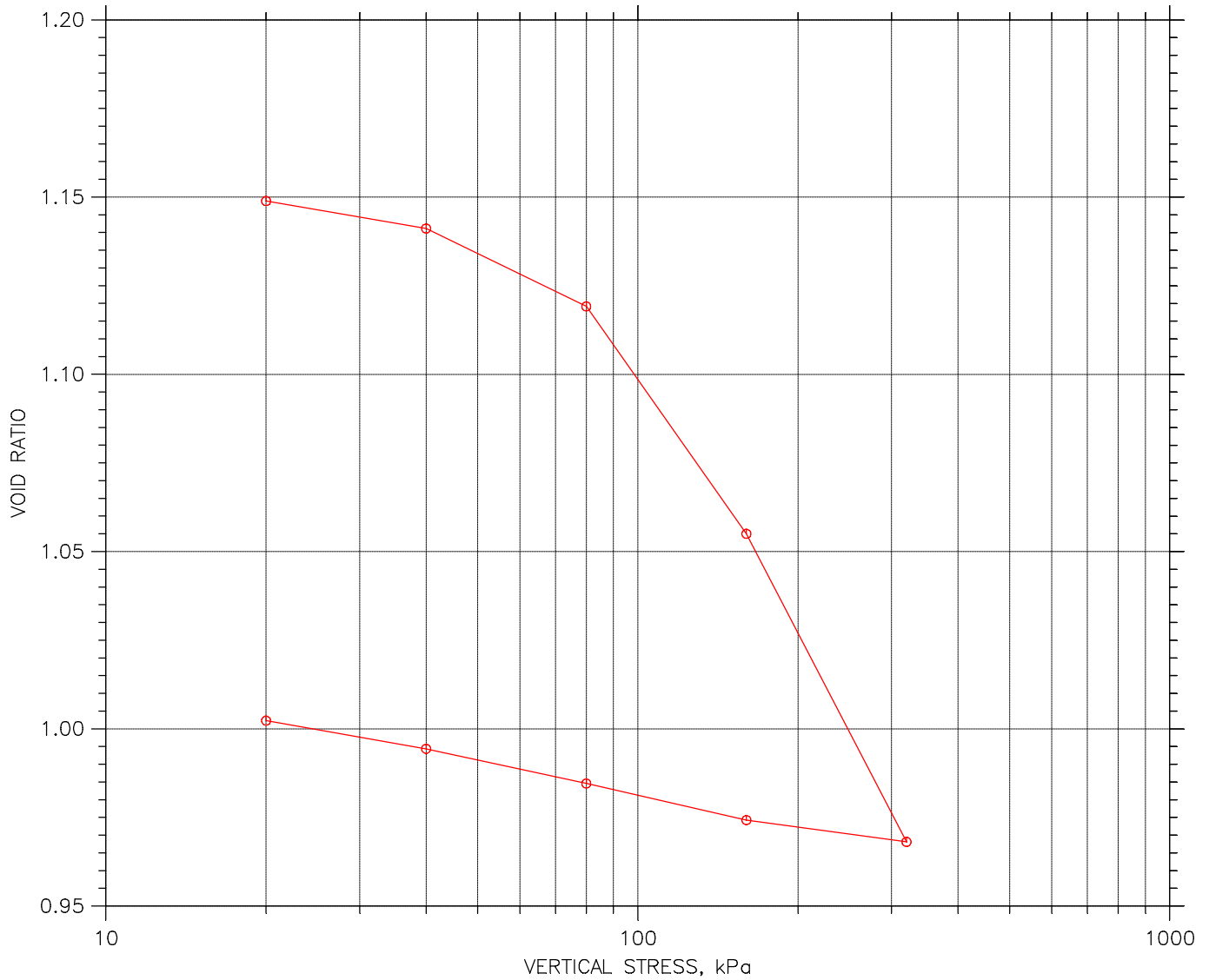
SUMMARY REPORT




	Project: Hwy 17	Location: Sawmill Creek Culvert	Project No.:
	Boring No.:	Tested By: Tim	Checked By: GM
	Sample No.: ST 1	Test Date: Aug 18/16	Depth: 25'-27'
	Test No.: 1	Sample Type: TW	Elevation:
	Description: Soft Grey Clay		
	Remarks:		

CONSOLIDATION TEST DATA

SUMMARY REPORT



				Before Test	After Test
Overburden Pressure: 0 kPa		Water Content, %		44.32	37.62
Preconsolidation Pressure: 0 kPa		Dry Unit Weight, N/m ³		11850	12860
Compression Index: 0		Saturation, %		99.22	98.53
Diameter: 63.55 mm	Height: 26.04 mm		Void Ratio	1.17	1.00
LL: 51	PL: 19	PI: 32	GS: 2.63		

	Project: Hwy 17	Location: Sawmill Creek Culvert	Project No.:
	Boring No.:	Tested By: Tim	Checked By: GM
	Sample No.: ST 1	Test Date: Aug 18/16	Depth: 25'-27'
	Test No.: 1	Sample Type: TW	Elevation:
	Description: Soft Grey Clay		
	Remarks:		

**SGS Canada Inc.**

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

Project : 13662**Thurber Engineering Ltd.****Attn : Mark Farrant**

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

Phone: 905-829-8666 x 228
Fax:

09-August-2016

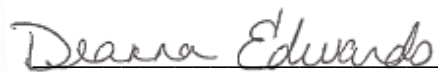
Date Rec. : 03 August 2016
LR Report: CA14112-AUG16
Reference: 13662

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 16-15, SS4, 10'-12'	6:
Sample Date & Time						27-Jul-16
Temperature Upon Receipt [°C]	---	---	---	---		24.2
Corrosivity Index [none]	09-Aug-16	13:29	09-Aug-16	14:28		1
pH [no unit]	08-Aug-16	11:40	09-Aug-16	09:32		7.85
Soil Redox Potential [mV]	08-Aug-16	18:47	09-Aug-16	08:27		243
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		14.5
pH [no unit]	04-Aug-16	09:56	04-Aug-16	15:49		9.32
Chloride [µg/g]	05-Aug-16	18:51	09-Aug-16	09:15		120
Sulphate [µg/g]	05-Aug-16	18:51	09-Aug-16	09:15		1.2
Conductivity [uS/cm]	04-Aug-16	09:56	04-Aug-16	15:49		305
Resistivity (calculated) [Ohms.cm]	09-Aug-16	12:55	09-Aug-16	14:28		3280


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



SGS Canada Inc.

P.O. Box 4300 - 185 Concession St.

Lakefield - Ontario - KOL 2H0

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

Project : 13662

LR Report : CA14112-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.**

P.O. Box 4300 - 185 Concession St.

Lakefield - Ontario - K0L 2H0

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

Project : 13662**LR Report :** CA14112-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
Metals Prep	ME-CA-[ENV]ARD-LAK-AN-013	
pH	ME-CA-[ENV]EWL-LAK-AN-001	SM 4500



SGS Canada Inc.

P.O. Box 4300 - 185 Concession St.

Lakefield - Ontario - KOL 2H0

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

Project : 13662

LR Report : CA14112-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.**

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

Project : 13662

12-April-2017

Thurber Engineering Ltd.

Attn : Mark Farrant

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

Phone: 905-829-8666 x 228
Fax:

Date Rec. : 02 August 2016
LR Report: CA13006-AUG16
Reference: 13662

Copy: #1

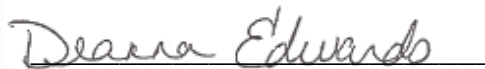
CERTIFICATE OF ANALYSIS

Final Report

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Approval Date	4: Analysis Approval Time	5: MDL	7: Sawmill Creek
Sample Date & Time						27-Aug-16 17:00
Temperature Upon Receipt [°C]	---	---	--	--	---	26.0
Corrosivity Index [none]	04-Aug-16	15:49	04-Aug-16	15:49		2
pH [no unit]	03-Aug-16	07:59	04-Aug-16	10:21	0.05	7.42
Conductivity [µS/cm]	03-Aug-16	07:59	04-Aug-16	10:21	2	87
Resistivity (calculated) [Ohms.cm]	03-Aug-16	07:59			---	11500
Redox Potential [mV]	02-Aug-16	17:51	03-Aug-16	12:43	---	289
Chloride [mg/L]	03-Aug-16	08:25	04-Aug-16	09:21	0.04	1.0
Sulphate [mg/L]	03-Aug-16	08:25	04-Aug-16	09:21	0.04	3.9
Sulphide [mg/L]	03-Aug-16	08:00	03-Aug-16	12:20	0.006	< 0.006

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

Temperature of samples upon receipt 26 degrees C
Cooling Agent Present
Custody Seal not used to seal cooler


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

**SGS Canada Inc.**

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

Project : 13662**LR Report :** CA13006-AUG16

Method Descriptions

Parameter	SGS Method Code	Reference Method Code
Anions by IC	ME-CA-[ENV]IC-LAK-AN-001	EPA300/MA300-Ions1.3
Conductivity	ME-CA-[ENV]EWL-LAK-AN-006	SM 2510
pH	ME-CA-[ENV]EWL-LAK-AN-006	SM 4500
Redox Potential		SM 2580
Sulphide by SFA	ME-CA-[ENV]SFA-LAK-AN-008	SM 4500



SGS Canada Inc.

P.O. Box 4300 - 185 Concession St.

Lakefield - Ontario - KOL 2H0

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

Project : 13662

LR Report : CA13006-AUG16

Quality Control Report

Inorganic Analysis												
Parameter	Reporting Limit	Unit	Method Blank		RPD		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: DIO0016-AUG16												
Chloride	0.04	mg/L	<0.04		1	20	95	80	120	NV	75	125
Sulphate	0.04	mg/L	<0.04		0	20	100	80	120	110	75	125
Anions by IC - QCBatchID: DIO0024-AUG16												
Chloride	0.04	mg/L	<0.04		0	20	102	80	120	90	75	125
Sulphate	0.04	mg/L	<0.04		0	20	102	80	120	88	75	125
Conductivity - QCBatchID: EWL0020-AUG16												
Conductivity	2	µS/cm	< 2		0	10	101	90	110	NA		
pH - QCBatchID: EWL0020-AUG16												
pH	0.05	no unit	NA		0		100			NA		
Redox Potential - QCBatchID: EWL0019-AUG16												
Redox Potential	no	mV	NA		1	20	106	80	120	NA		
Sulphide by SFA - QCBatchID: SKA0010-AUG16												
Sulphide	0.006	mg/L	<0.006		ND	20	103	80	120	125	75	125

Appendix C

Site Photographs



Photo 1: Culvert inlet, looking northwest



Photo 2: Culvert outlet, looking southeast



Photo 3: Looking north at west side of north approach embankment



Photo 4: Looking north at east side of north approach embankment



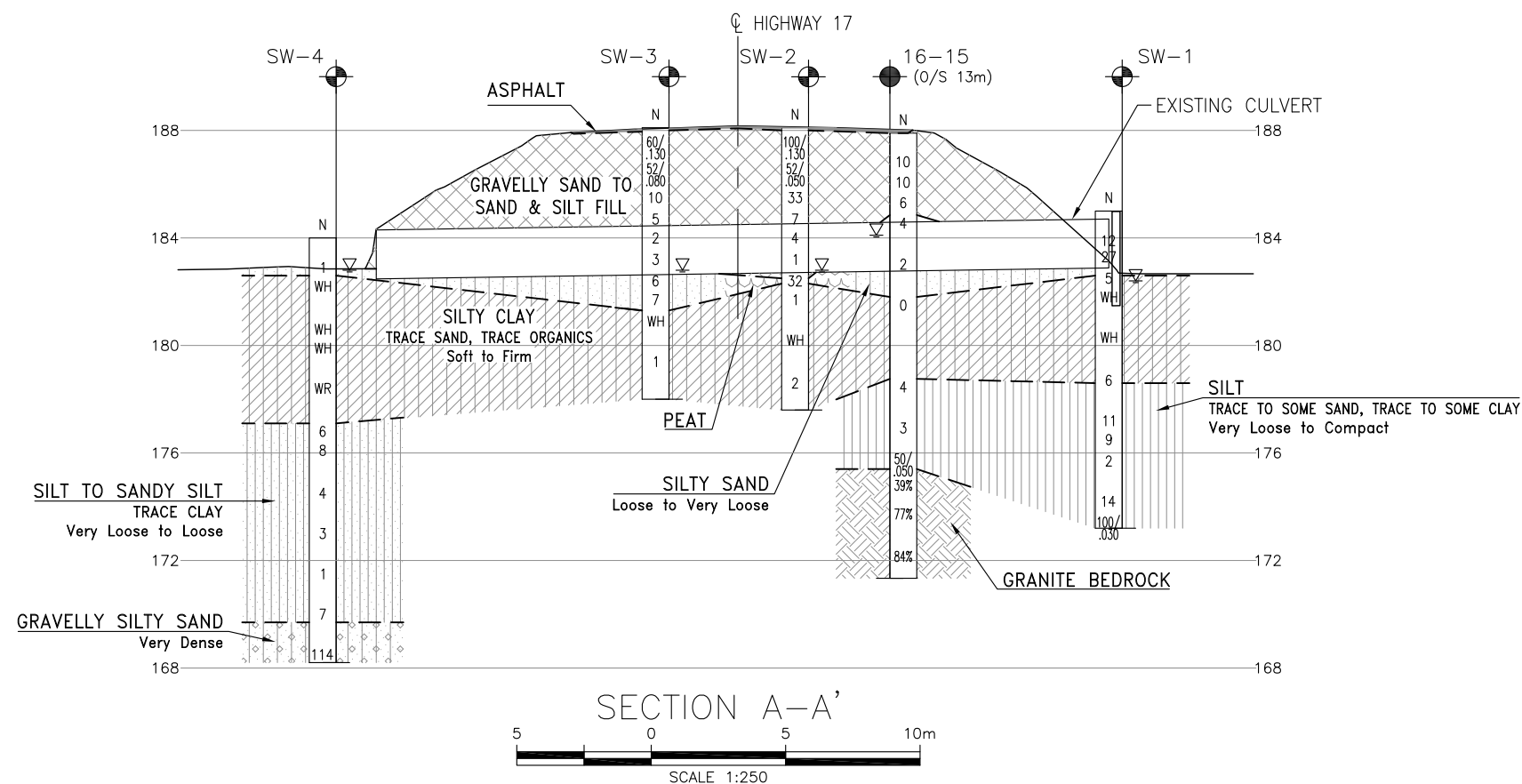
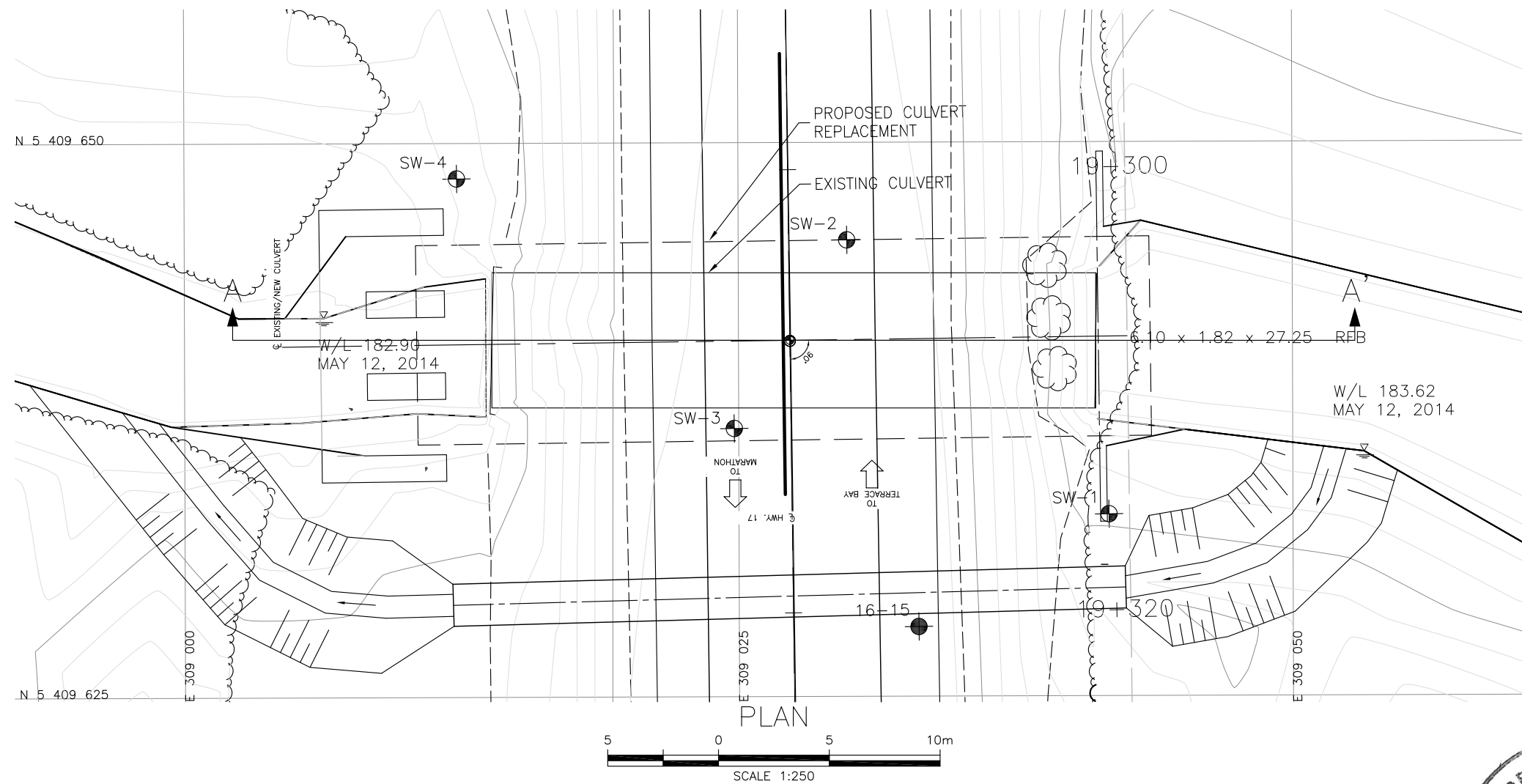
Photo 5: Looking south at east side of south approach embankment



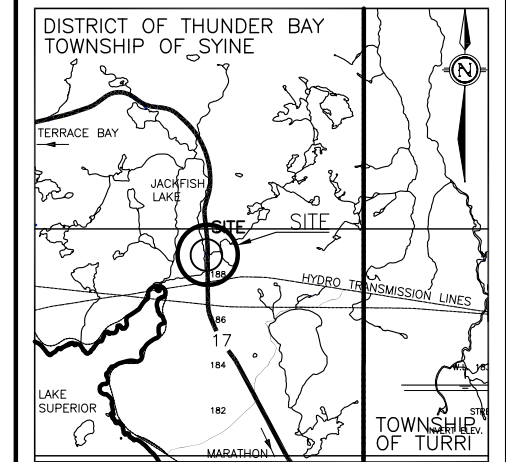
Photo 6: Looking south at west side of south approach embankment

Appendix D

Borehole Locations and Soil Strata Drawing








HATCH



KEYPLAN

LEGEND

	Borehole (by Thurber)
	Borehole (by Others)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
16-15	187.9	5 409 628.1	309 033.1
SW-1	185.0	5 409 633.2	309 041.7
SW-2	188.1	5 409 645.6	309 029.9
SW-3	188.1	5 409 637.1	309 024.8
SW-4	184.0	5 409 648.4	309 012.3

-NOTES-

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

GEOCRES No. 42D-44

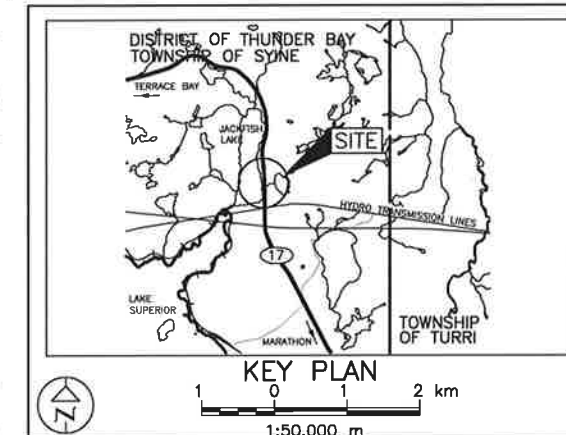
[illegible]

Appendix E

Factual Data from 2015 Golder Foundation Investigation Report



SHEET



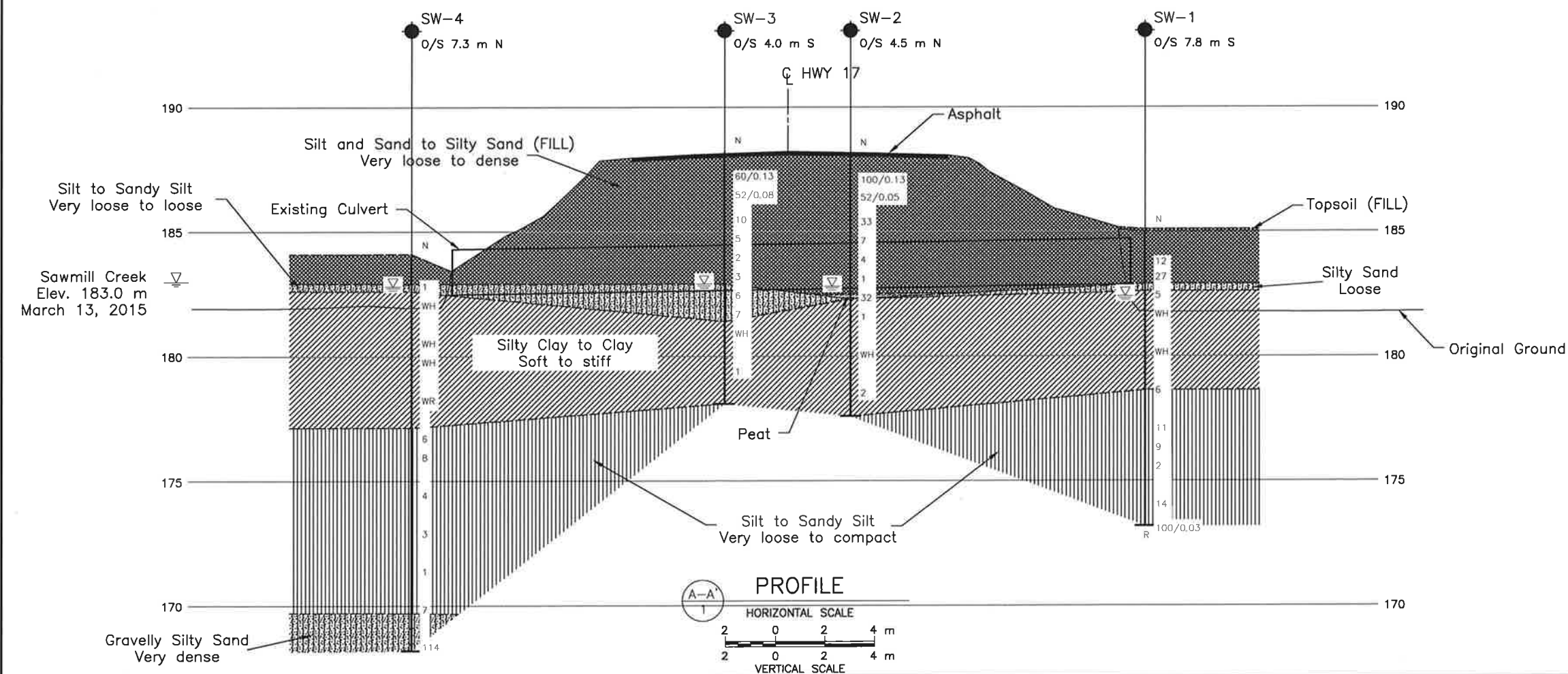
	Borehole
N	Standard Penetration Test Value
16	Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
	WL upon completion of drilling
R	Refusal

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
SW-1	185.0	5409633.2	309041.7
SW-2	188.1	5409645.6	309029.9
SW-3	188.1	5409637.1	309024.8
SW-4	184.0	5409648.4	309012.3

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

Base plans provided in digital format by MTO, drawing file no. E581171
(Revised) dwg. dated MAY 2017, received JUN 21 2017.



NO.	DATE	BY	REVISION		

Geocres No. 42D-39

HWY. 17		PROJECT NO. 1411523	DIST.
SUBM'D. AC	CHKD.	DATE: 7/14/2017	SITE: 48E-50/
DRAWN: TB	CHKD. DAM	APPD. JMAC	DWG. 1

PROJECT 1411523

RECORD OF BOREHOLE No SW-1

1 OF 1 **METRIC**

G.W.P. 6366-14-00

LOCATION N 5409633.2; E 309041.7

ORIGINATED BY RI

DIST HWY 17

BOREHOLE TYPE 108 mm I. D. Continuous Flight Hollow Stem Augers, NW Casing

COMPILED BY MT

DATUM GEODETIC

DATE March 22 and 23, 2015

CHECKED BY SEMP

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			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
185.0	GROUND SURFACE											
0.9	Topsail (FILL)											
	Silty sand, some gravel, trace organics (FILL)											
	Brown											
	Frozen*											
182.9			1	SS	12*		184					
			2	SS	27*							
182.6	Silty SAND						183					
2.4	Loose		A	SS	5							
	Grey		3									
	Wet		B									
	CLAY		4	SS	WH		182					
	Soft											
	Grey											
	Wet											
							181					
			5	SS	WH		180					0 0 27 73
							179					
178.6	SILT, trace to some sand, trace to some clay		A	SS	6							
6.4	Very loose to compact		6									
	Grey											
	Wet											
							178					
			7	SS	11		177					
			8	SS	9							
	Approximately 2.1 m of heave inside augers at 9.0 m depth. Switched to NW casing.		9	SS	2		176					0 16 78 6
							175					
			10	SS	14		174					
173.2	Spoon bouncing at 11.8 m depth.		11	SS	100/0.93							
11.8	END OF BOREHOLE SPLIT-SPOON REFUSAL											
	Note:											
	1. Water level at a depth of 2.6 m below ground surface (Elev. 182.4 m) upon completion of drilling.											

+ 3, x 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

SUD-MTO 001: 1411523.GPJ GAL-MISS.GDT 14/07/17 DATA INPUT:

PROJECT 1411523

RECORD OF BOREHOLE No SW-2

1 OF 1 **METRIC**

G.W.P. 6366-14-00

LOCATION N 5409645.6; E 309029.9

ORIGINATED BY RI

DIST HWY 17

BOREHOLE TYPE 108 mm I. D. Continuous Flight Hollow Stem Augers

COMPILED BY MT

DATUM GEODETIC

DATE March 13, 2015

CHECKED BY SEMP

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			20	40	60			80	100
188.1	GROUND SURFACE													
0.0	ASPHALT (140 mm)													
0.1	Silty sand, trace to some gravel, trace clay, trace organics (FILL) Very loose to dense Brown Frozen* to wet		1	SS	100/ 0.13*									
			2	SS	52/ 0.05*									
			3	SS	33									
			4	SS	7									
			5	SS	4									
			6	SS	1									
182.5	Auger grinding at 5.3 m depth on inferred cobbles.		A											
5.8	PEAT Black Wet		7 B C	SS	32									
	CLAY, trace sand, trace organics Firm to stiff Grey Wet		8	SS	1									
			9	SS	WH									
			10	SS	2									
177.6														
10.5	END OF BOREHOLE													
	Note: 1. Water level at a depth of 5.3 m below ground surface (Elev. 182.8 m) upon completion of drilling.													

SUD-MTO 001 1411523.GPJ GAL-MASS.GDT 14/07/17 DATA INPUT:

+ 3, x 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT 1411523

RECORD OF BOREHOLE No SW-3

1 OF 1 **METRIC**

G.W.P. 6366-14-00

LOCATION N 5409637.1; E 309024.8

ORIGINATED BY RI

DIST HWY 17

BOREHOLE TYPE 108 mm I. D. Continuous Flight Hollow Stem Augers

COMPILED BY MT

DATUM GEODETTIC

DATE March 13, 2015

CHECKED BY SEMP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT		UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60	W _p W W _L	WATER CONTENT (%)		
188.1	GROUND SURFACE						188						
0.0	ASPHALT (140 mm)												
0.1	Silt and sand, trace gravel, trace clay, trace organics (FILL) Very loose to compact Brown to grey Frozen* to wet		1	SS	60/ 0.13*		187						
			2	SS	52/ 0.08*								
			3	SS	10		186						
			4	SS	5		185						
			5	SS	2		184						1 35 60 4
			6	SS	3		183						
182.8	Sandy SILT, trace to some clay Loose Grey Wet		7	SS	6		182						0 25 65 10
			8	SS	7								
181.3	CLAY Firm Grey Wet		9	SS	WH		181						
6.8							180	2 + 2 +					
			10	SS	1		179	2 + 2 +					
178.0	END OF BOREHOLE						178						
10.1	Note: 1. Water level at a depth of 5.3 m below ground surface (Elev. 182.8 m) upon completion of drilling.												

SUD-MTO 001 1411523.GPJ GAL-MISS.GDT 14/07/17 DATA INPUT:

+ 3, X 3; Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE



PROJECT 1411523

RECORD OF BOREHOLE No SW-4

1 OF 2 METRIC

G.W.P. 6366-14-00

LOCATION N 5409648.4; E 309012.3

ORIGINATED BY RI

DIST HWY 17

BOREHOLE TYPE 108 mm I. D. Continuous Flight Hollow Stem Augers

COMPILED BY MT

DATUM GEODETIC

DATE March 23 and 24, 2015

CHECKED BY SEMP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)			
184.0	GROUND SURFACE							20 40 60 80 100		20 40 60			GR SA SI CL
0.0	Silt and sand, trace clay, trace gravel, some organics (FILL) Grey Frozen												
182.9			A				183						2 40 53 5
182.6	Silty SAND Very loose Grey Wet		1 B	SS	1								
1.4	SILTY CLAY to CLAY Very soft to soft Grey Wet Trace organics in Sample 2.		2	SS	WH		182						
							181	2 +					
			3	SS	WH		180	+					
			4	SS	WH		179	2 +					
			5	SS	WR		178	+					
							177	2 +					
177.1							176	1 +					
6.9	SILT to Sandy SILT, trace clay Very loose to loose Grey Wet		6	SS	6		175	2 +					
			7	SS	8		174						
							173						0 24 72 4
			8	SS	4		172						
							171						
			9	SS	3		170						
			10	SS	1								
			11	SS	7								
169.7													
14.3													

Continued Next Page

+ 3, X 3

Numbers refer to Sensitivity

O 3%

STRAIN AT FAILURE

SUD-MTO 001 1411523.GPJ GAL-MISS.GDT 14/07/17 DATA INPUT:

PROJECT 1411523		RECORD OF BOREHOLE No SW-4		2 OF 2 METRIC	
G.W.P. 6366-14-00		LOCATION N 5409648.4; E 309012.3		ORIGINATED BY RI	
DIST HWY 17		BOREHOLE TYPE 108 mm I. D. Continuous Flight Hollow Stem Augers		COMPILED BY MT	
DATUM GEODETIC		DATE March 23 and 24, 2015		CHECKED BY SEMP	

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			20 40 60 80 100	W _p W W _L	WATER CONTENT (%)			
	--- CONTINUED FROM PREVIOUS PAGE ---							<div><div>○ UNCONFINED</div><div>● QUICK TRIAXIAL</div><div>+ FIELD VANE</div><div>× REMOULDED</div></div>					
168.2	Gravelly Silty SAND Very dense Grey Wet		12	SS	114								
15.8	Approximately 1.8 m of heave noted in augers at a depth of 15.2 m. END OF BOREHOLE Notes: 1. Water level at a depth of 1.2 m below ground surface (Elev. 182.8 m) upon completion of drilling. 2. Moved 1.2 m west of borehole and retrieved Shelby Tube samples at depths of 2.4 m, 3.0 m and 4.9 m below existing ground surface.												