



THURBER ENGINEERING LTD.



**FOUNDATION INVESTIGATION REPORT
SITCH CREEK CULVERT REPLACEMENT
TOWNSHIP OF GILLIES, DISTRICT OF THUNDER BAY, ONTARIO
SITE No. 48W-82/C
HIGHWAY 588**

ASSIGNMENT NO. 6015-E-0023

**GEOCRES Number: 52A-226
W.O.# 2017-11029**

Report

to

MINISTRY OF TRANSPORTATION ONTARIO

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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 Sith Creek Culvert on Highway 588, located in the Township of Gillies, District of Thunder Bay, Ontario.

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

Thurber was retained by the Ministry of Transportation Ontario (MTO) to carry out this foundation investigation under the MTO Retainer Assignment Number 6015-E-0023.

2. SITE DESCRIPTION

The Sith Creek Culvert site is located on Highway 588, in the Township of Gillies approximately 300 m west of Highway 595, in the District of Thunder Bay, Ontario. The key plan showing the general location of the culvert site is presented on the Borehole Location and Soil Strata drawing in Appendix D.

Highway 588 runs in the general east-west direction, in the vicinity of the culvert. The Sith Creek is a tributary of the Kaministiquia River and the creek flows from south to north at the culvert site. Local topography is generally of low relief.

The terrain in the culvert area is gently undulating and forested outside of the right-of-way. The existing culvert is a single 4.4 m diameter Corrugated Steel Pipe (CSP) culvert approximately 43 m long. The Structural Inspection Report (SIR) dated January 2014 indicated that the structure

is in fair condition apart from deterioration of cut-off wall due to erosion at the outlet of the culvert.

The MTO Site Plan Drawing, E-1078-595-3, indicates that the existing culvert invert is at approximate Elevation 268.2 m at the inlet and Elevation 268.0 m at the outlet. The stream water level was reported to be at about Elevation 268.4 m at the upstream end and about Elevation 267.4 m at the downstream end in June 2014. At the culvert location, the highway embankment grade is at approximately Elevation 278.0 m. The depth of cover over the existing culvert is approximately 5.5 m.

Photographs in Appendix C show the general nature of the site and the existing culvert.

Based on published geological information, the culvert lies within glaciolacustrine plains of clay and clayey deposits underlain by silts and sands in the vicinity of the culvert. Bedrock at the site is identified as granite.

3. INVESTIGATION PROCEDURES

The field investigation and testing program for this project was specified in the Terms of Reference. The field work was carried out on April 8, 9, 29, May 3 and July 5, 2017 during which time seven (7) boreholes designated as Boreholes 17-09 to 17-15 were advanced at the site. Boreholes 17-09 and 17-12 to 17-15 were advanced near the outlet and inlet of the culvert and Boreholes 17-10 and 17-11 were advanced through the highway embankment east and west of the culvert, respectively.

Utility clearances were obtained prior to the start of drilling. A rubber tire buggy mounted drill rig and a track-mounted CME 75 drill rig were used to advance Boreholes 17-09 to 17-11 at the site using hollow stem augers. Boreholes 17-12 to 17-15 were advanced using tripod drilling equipment since access to the inlet and outlet at the base of the steep embankment slope was not possible with a track mounted drilling equipment. An NQ core barrel was used to obtain about 3 m of rock core in Boreholes 17-10 and 17-11.

Since the initial Borehole 17-12 drilled near the inlet met refusal at a shallow depth (2.1 m), three additional boreholes (17-13 to 17-15) were drilled in the vicinity with a tripod equipment to determine the nature of refusal at shallow depth. All three additional boreholes also met refusal at shallow depths ranging between 0.9 m and 2.4 m.

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) procedures as per ASTM

D1586. Where bedrock was cored, rock quality (i.e., TCR, SCR, RQD, weathering and strength index), discontinuity characteristics and classification data was recorded in the field based on visual inspection of the recovered rock cores upon extraction from the core barrel. The bedrock was sequentially photographed and selected samples were transported to our laboratory for strength testing (point load index).

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 and rock samples for transport to Thurber's laboratory for further examination and testing.

Groundwater conditions were observed in the open boreholes throughout the drilling operations, and boreholes were backfilled on completion of drilling in general accordance with Ontario Regulation 903, as amended.

The coordinates and ground surface elevations for the boreholes were derived from topographic plans provided by the MTO. The coordinate system MTM NAD 83, Zone 14 was used for the boreholes. The approximate locations of the boreholes are shown on the Borehole Locations and Soil Strata Drawing included in Appendix D. The borehole coordinates, ground surface elevations, drilled depths and the completion details are summarized in Table 3.1.

Table 3.1 – Borehole Completion Details

Borehole Number	Coordinates (MTM NAD 83, Zone 14)		Ground Surface Elevation (m)	Borehole Depth (m)	Completion Details
	Northing (m)	Easting (m)			
17-09	5,350,696.3	326,810.1	272.4	9.8	Bentonite holeplug to 3.0 m, cuttings to ground surface.
17-10	5,350,677.0	326,800.7	278.2	19.5	Bentonite holeplug to 2.4 m, cuttings to 0.9 m then asphalt cold patch to ground surface.
17-11	5,350,676.0	326,790.8	277.7	19.2	Bentonite holeplug and cuttings to 0.6 m, cement to 0.1 m, then asphalt cold patch to ground surface.
17-12	5,350,651.6	326,798.9	269.6	2.1	Bentonite holeplug to ground surface.
17-13	5,350,647.3	326,797.4	268.7	0.9	Bentonite holeplug to ground surface.
17-14	5,350,647.3	326,797.1	268.7	0.9	Bentonite holeplug to ground surface.
17-15	5,350,646.3	326,798.5	268.8	2.4	Bentonite holeplug to ground surface.

4. LABORATORY TESTING

All recovered soil samples were subjected to visual identification and to natural moisture content determination. Selected soil samples were also subjected to grain size distribution analyses (sieve, hydrometer, and/or Atterberg limits). Selected bedrock core specimen were also subjected to point load strength index test. The results of the laboratory testing program are shown on the Record of Borehole sheets included in Appendix A and on the figures included in Appendix B.

In order to assess the potential for sulphate attack on concrete foundations, as well as the potential for corrosion associated with the structure, a sample of the native soil near the invert level, and a sample of the surface water from the creek upstream of the existing culvert were collected. The samples were submitted to SGS Canada Inc., a CALA accredited analytical laboratory in Lakefield, Ontario, for analytical testing of corrosivity parameters and sulphate content. The results of the analytical testing are summarized in Section 6 and are presented in Appendix B.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets included in Appendix A. 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 D. A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following paragraphs. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description and 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 embankment fill comprising of sand beneath the roadway and silty clay near the outlet of the culvert. The fill is overlying a deposit of native firm to stiff silty clay to clay and/or compact gravelly sand to sand which are in turn underlain by a layer of compact silt to silty sand over bedrock. Descriptions of the individual strata are presented below.

5.1 Asphalt

Boreholes 17-10 and 17-11 were drilled through the existing asphalt pavement on Highway 588. The asphalt was 25 mm thick at both borehole locations. The thickness of asphalt may vary along the highway.

5.2 Fill

Embankment fill was encountered below the asphalt in Boreholes 17-10 and 17-11, and at the ground surface in Borehole 17-09 east of the culvert outlet. The fill in Borehole 17-09 generally consisted of silty clay, and the fill in Boreholes 17-10 and 17-11 generally consisted of sand.

5.2.1 Silty Clay Fill

The silty clay fill in Borehole 17-09 extended to a depth of approximately 4.6 m (Elevation 267.8 m). The silty clay fill typically contained some sand and trace gravel, and was brown in colour. Rock fragments were observed in one of the samples taken from the silty clay.

SPT 'N' values within the silty clay fill ranged from 4 to 18 blows per 0.3 m of penetration, indicating a firm to very stiff consistency. The measured moisture content of the cohesive fill ranged from 26% to 38%.

The results of grain size analyses conducted on a selected sample of the silty clay fill are presented on the Record of Borehole sheets included in Appendix A, and on Figure B1 in Appendix B. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	2
Sand	15
Silt	40
Clay	43

The results of Atterberg Limits tests conducted on a sample of the silty clay fill are provided on the Record of Borehole sheets in Appendix A and illustrated in Figure B2 in Appendix B. The results are summarized as follows:

Measured Limit	Percentage (%)
Liquid Limit	43
Plastic Limit	23

The results of the Atterberg Limits testing indicate that the silty clay fill has an intermediate plasticity with group symbol CI.

5.2.2 Sand Fill

Sand fill in Boreholes 17-10 and 17-11 extended to depths of approximately 8.8 m and 8.7 m (Elevations 269.3 m and 269.0 m), respectively. The sand fill generally contains trace to some gravel and fines, and is brown in colour.

SPT 'N' values in the sand fill ranged between 8 and 50 blows for 0.3 m penetration, indicating a loose to very dense relative density, predominantly compact. Measured moisture content of the sand fill samples ranged from 3% to 8%.

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

Soil Particle	Percentage (%)
Gravel	14 to 18
Sand	64 to 67
Silt and Clay	16 and 19

5.3 Silty Clay

A layer of silty clay was encountered in Boreholes 17-09 and 17-10 below the fill, in Borehole 17-12 at the ground surface and in Borehole 17-15 within the silty sand layer. The silty clay layer was extended to depths of 7.2 m and 12.3 m (Elevations 265.3 m and 265.9 m) in Boreholes 17-09 and 17-10 and to a depth of about 1.5 m (Elevation 268.0 m) in Borehole 17-12 and to a depth of 2.1 m (Elevation 266.6 m) in Borehole 17-15. The layer generally contained trace to some sand and was brown to grey in colour.

SPT 'N' values in the deposit ranged from 3 to 9 blows per 0.3 m of penetration, indicating a soft to stiff consistency. A higher SPT-N value of 60 blows per 0.13 m of penetration was recorded in Borehole 17-12 due to split spoon sampler bouncing on possible cobbles. In situ vane testing was

conducted in the silty clay deposit and measured undrained shear strengths that are greater than 100 kPa indicating a very stiff consistency. Moisture contents in the silty clay layer ranged from 23% to 44%.

The results of grain size analyses conducted on two samples of the silty clay are presented on the Record of Borehole sheets included in Appendix A, and on Figure B4 in Appendix B. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0
Sand	4 and 20
Silt	45 and 58
Clay	22 and 51

The results of Atterberg Limits tests conducted on a sample of the silty clay is provided on the Record of Borehole sheets in Appendix A and illustrated in Figure B5 of Appendix B. The results are summarized as follows:

Measured Limit	Percentage (%)
Liquid Limit	35 and 53
Plastic Limit	23 and 25

The results of the Atterberg Limits testing indicate that the silty clay has a low plasticity with group symbol CI to CH.

5.4 Gravelly Sand to Sand

A 3.0 m thick layer of gravelly sand to sand, trace gravel was encountered below the fill at a depth of about 8.7 m (Elevation 269.0 m) in Borehole 17-11 and extended to a depth of about 11.7 m (Elevation 265.9 m). A very dense silty sand layer was also encountered below the silty clay in Borehole 17-12. The silty sand was also encountered in Boreholes 17-13 to 17-15 at the ground surface. Boreholes 17-12 to 17-15 were terminated at depths ranging between 0.9 m to 2.1 m in the gravelly sand to sand. The gravelly sand to sand contained trace fines, and was brown in colour and wet.

SPT 'N' values in the deposit were 10 and 18 blows per 0.3 m of penetration, indicating a compact relative density. Measured moisture content in the deposit were 13% and 22%.

The results of a grain size analyses conducted on a sample of the gravelly sand is presented on the Record of Borehole sheets included in Appendix A, and on Figure B6 in Appendix B. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	27
Sand	70
Silt and Clay	3

5.5 Silt to Silty Sand

A deposit of silt to silty sand was encountered below the silty clay and/or gravelly sand to sand in Boreholes 17-09 to 17-11 and extended to depths ranging from 9.8 m to 16.2 m (Elevations 261.5 m and 262.7 m). Borehole 17-09 was terminated in the silt layer due to auger refusal on inferred bedrock at a depth of 9.8 m.

SPT 'N' values in the silt to silty sand ranged from 10 to 21 blows per 0.3 m of penetration, indicating a compact relative density. Measured moisture contents in the deposit ranged from 8% to 29%.

The results of grain size analyses conducted on samples of the silt to silty sand are presented on the Record of Borehole sheets included in Appendix A, and on Figure B7 in Appendix B. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0 to 10
Sand	14 to 47
Silt	32 to 81
Clay	5 to 12

The results of Atterberg Limits tests conducted on the fine grained portion of a selected sample of the silty sand is provided on the Record of Borehole sheets in Appendix A and illustrated in Figure B8 of Appendix B. The results are summarized as follows:

Measured Limit	Percentage (%)
Liquid Limit	20
Plastic Limit	14

The results of the Atterberg Limits testing indicate that the fine portion of the silty sand is clayey silt of low plasticity (CL-ML).

5.6 Cobbles/Fractured Bedrock

Cobbles/fractured bedrock was encountered below the silty sand and just above the bedrock in Boreholes 17-10 and 17-11 at depths of 15.8 m and 16.2 m (Elevations 262.3 m and 261.5 m), respectively. The cobbles/fractured bedrock layer was approximately 0.3 m to 0.6 m thick.

5.7 Bedrock

Bedrock was encountered in Boreholes 17-10 and 17-11 at depths of about 16.4 m and 16.5 m (Elevations 261.7 m and 261.2 m), respectively. Auger refusal on probable bedrock was noted in Borehole 17-09 at a depth of 9.8 m (Elevation 262.7 m). Boreholes 17-12 to 17-15 also met refusal on cobbles and boulders, or probable bedrock at depth ranging between 0.9 m and 2.1 m. (Elevations 266.3 m to 267.8 m).

The bedrock was proven in Boreholes 17-10 and 17-11 by coring approximately 3 m in both boreholes. The bedrock is generally described as grey granite, greenish grey to grey in colour with some igneous intrusions. Total Core Recovery (TCR) in the bedrock ranged from 88% to 100% with Solid Core Recovery (SCR) ranging from 78% to 94%. The Rock Quality Designation (RQD) determined from the recovered cores generally ranged from 77% to 88%, indicating good rock quality. The interpreted average UCS values for each core run of the bedrock ranged between 106 MPa and 297 MPa based on correlations with the PLT, indicating the bedrock at the site is very strong to extremely strong.

5.8 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.

Table 5.1 – Groundwater Measurements

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
17-09	May 3, 2017	5.0	267.4	Open borehole
17-10	April 9, 2017	Not measured		Water added to the borehole for coring
17-11	April 8, 2017	Not measured		Water added to the borehole for coring
17-12	April 29, 2017	0.0	269.6	Water at surface
17-13	July 5, 2017	0.3	268.4	Open Borehole
17-14	July 5, 2017	Not measured		-
17-15	July 5, 2017	0.2	268.6	Open Borehole

The groundwater level should be assumed to reflect the local creek water level. Water level measurements in the creek were reported on the MTO Site Plan Drawing, E-872-588-3, at Elevation 268.4 m at the inlet and 267.4 m at the outlet on June 5, 2014. The above groundwater levels are short-term readings and seasonal fluctuations of the groundwater levels are to be expected. In particular, the groundwater levels may be at a higher elevation during spring and after periods of significant or prolonged precipitation.

6. CORROSIVITY AND SULPHATE TEST RESULTS

A sample of the native soils from Borehole 17-09, 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	
			17-09, SS#9, 6.1 m – 6.7 m	Sitch Creek
			(Silty Clay)	(Creek Water)
Sulphide	%	mg/L	0.67	<0.006
Chloride	µg/g	mg/L	16	3.0
Sulphate	µg/g	mg/L	54	3.0
pH	No unit	No unit	8.73	7.25

Parameter	Units (Soil)	Units (Water)	Test Results	
			17-09, SS#9, 6.1 m – 6.7 m	Sitch Creek
			(Silty Clay)	(Creek Water)
Electrical Conductivity	µS/cm	µS/cm	76	90
Resistivity	Ohms.cm	Ohms.cm	13,200	11,100
Redox Potential	mV	mV	139	303

7. MISCELLANEOUS


Thurber obtained the borehole northing and easting coordinates and ground surface elevations from measurements taken in the field and relative to the topographic plans provided by the MTO.

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. Amir Fereidouni and Ms. Eckie Siu of Thurber. Overall supervision of the field program was provided by Mr. Cory Zanatta, B.A.Sc. of Thurber.

Geotechnical laboratory testing was carried out at Thurber's geotechnical laboratory. Analytical laboratory testing was carried out by SGS Canada Inc. Interpretation of the field data and preparation of this report was carried out by Mr. Cory Zanatta, EIT Mr. Mehdi Mostakhdemi, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction

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



4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

5. LEGEND FOR RECORDS OF BOREHOLES

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

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

 Water Level
 Shear Strength Determination by Pocket Penetrometer

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

EXPLANATION OF ROCK LOGGING TERMS


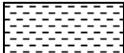



ROCK WEATHERING CLASSIFICATION

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 17-09

1 OF 2

METRIC

W.P. _____ LOCATION Sitch Creek N 5 350 696.3 E 326 810.1 ORIGINATED BY AHF
 HWY 588 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2017.05.03 - 2017.05.03 CHECKED BY CZ

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		
272.4	GROUND SURFACE													
0.0	Silty CLAY , some sand, trace gravel, roots and rootlets Firm to Very Stiff Brown Moist (FILL)(CI)		1	SS	4									
			2	SS	4									
			3	SS	5									
			4	SS	15									
	Rock fragments in split spoon		5	SS	18									
			6	SS	6									
267.8														
4.6	Silty CLAY , some sand, trace organics Firm Grey Wet (CL)		7	SS	5									
			8	SS	8									
			9	SS	8									
265.3														
7.2	SILT , some sand, trace clay Compact Grey Wet		10	SS	14									
	Rock fragments in split spoon		11	SS	10									
262.7														
9.8	END OF BOREHOLE AT 9.8m UPON													

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

METRIC

ELEV DEPTH	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
	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES							
								SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100				
	Continued From Previous Page							w _p ————— w ————— w _L WATER CONTENT (%) 20 40 60				

[illegible]

ONTMT4S MTO-17840.GPJ 2015TEMPLATE(MTO).GDT 6/2/17

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 17-10

1 OF 3

METRIC

W.P. _____ LOCATION Sitch Creek N 5 350 677.0 E 326 800.7 ORIGINATED BY ES
 HWY 588 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2017.04.09 - 2017.04.09 CHECKED BY CZ

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								
							20	40	60	80	100					
278.2	GROUND SURFACE															
0.0	ASPHALT: (25mm)															
	SAND, some gravel, some fines Loose to Compact Brown Moist (FILL)		1	GS												
			1	SS	19											18 64 18 (SI+CL)
			2	SS	21											
			3	SS	24											
			4	SS	16											
			5	SS	21											
			6	SS	33											14 67 13 6
			7	SS	8											
			8	SS	9											0 4 45 51
269.3	CLAY, trace sand, occasional sand seams Stiff Brown Moist (CH)															
8.8																

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-10

2 OF 3

METRIC

W.P. _____ LOCATION Sitch Creek N 5 350 677.0 E 326 800.7 ORIGINATED BY ES
 HWY 588 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2017.04.09 - 2017.04.09 CHECKED BY CZ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								20 40 60 80 100						
								<div><div></div><div>20406080100</div></div> <div><div>○ UNCONFINED</div><div>+ FIELD VANE</div><div>● QUICK TRIAXIAL</div><div>× LAB VANE</div></div> <div><div>PLASTIC LIMIT</div><div>NATURAL MOISTURE CONTENT</div><div>LIQUID LIMIT</div></div> <div><div>W_P</div><div>W</div><div>W_L</div></div> <div>WATER CONTENT (%)</div> <div>204060</div>						
Continued From Previous Page														
265.9							268							
			9	SS	8									
							267							
							266							
12.3	SILT, trace sand Compact Dark Grey Wet		10	SS	12									
264.9							265							
13.3	SILT and SAND to Silty SAND, trace to some clay, trace gravel Compact Dark Grey Wet		11	SS	10									
							264							1 47 47 5
							263							
262.3			12	SS	18									
15.8	COBBLES / FRACTURED BEDROCK		1	RUN			262							
261.7							261							
16.4	BEDROCK, medium strong, grey: (Granite) Occasional quartz interbeds Horizontal fracture (25mm) at 16.9m, 17.2m, 17.3m and 17.4m Sub-vertical fracture (150mm) at 17.9m Sub-vertical fracture (25mm) at 18.8m and (75mm) at 19.0m Horizontal fracture (25mm) at 18.7m, 18.9m, 19.1m and 19.2m Quartz layer (150mm) at 18.8m		2	RUN			260							
							259							
258.7			3	RUN										
19.5	END OF BOREHOLE AT 18.8m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 2.4m,													



Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

ONTMT4S MTO-17840.GPJ 2015TEMPLATE(MTO).GDT 6/2/17

METRIC

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	20 40 60		
	Continued From Previous Page											
							SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100					

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ONTMT4S MTO-17840.GPJ 2015TEMPLATE(MTO).GDT 6/2/17

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 17-11

1 OF 3

METRIC

W.P. _____ LOCATION Sitch Creek N 5 350 676.0 E 326 790.8 ORIGINATED BY ES
 HWY 588 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2017.04.08 - 2017.04.08 CHECKED BY CZ

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						
277.7	GROUND SURFACE							20	40	60	80	100		
8.8	ASPHALT: (25mm)							20	40	60	80	100		
	SAND, some to trace gravel, some fines Compact to Dense Brown Moist (FILL)		1	GS			277							
			1	SS	27		276							17 67 16 (SI+CL)
			2	SS	50		275							
			3	SS	16		274							
			4	SS	12		273							
			5	SS	39		272							
			6	SS	11		271							
			7	SS	25		270							
269.0							269							
8.7	Gravelly SAND, trace fines Compact Brown Wet		8	SS	18		268							27 70 3 (SI+CL)

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity



















20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-11

2 OF 3

METRIC

W.P. _____ LOCATION Sitch Creek N 5 350 676.0 E 326 790.8 ORIGINATED BY ES
 HWY 588 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2017.04.08 - 2017.04.08 CHECKED BY CZ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								20 40 60 80 100						
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						
Continued From Previous Page							WATER CONTENT (%) 20 40 60							
267.0							267							
10.7	SAND , medium grained, trace gravel Compact Brown Wet		9	SS	10									
265.9							266							
11.7	SILT , some sand, trace gravel Brown Wet													
265.3														
12.4	Sandy GRAVEL , trace clay Dense Brown Wet		10	SS	31		265							
264.4														
13.3	SILT , some sand to sandy, trace clay to clayey, trace gravel Compact Dark Grey Wet		11	SS	21		264							
							263							
			12	SS	15		262							
261.5														
16.2	COBBLES / FRACTURED													
261.2	BEDROCK													
16.5	BEDROCK , medium strong, occasional quartz interbeds: (Granite)		1	RUN			261							
	Sub-vertical fracture (25mm to 75mm) at 16.5m, 16.8m and 17.1m													
	Sub-vertical fracture (25mm) at 17.9m and 18.3m Horizontal fracture (25mm) at 18.1m						260							
	Quartz interbed (75mm) at 18.6m		2	RUN			259							
258.5														
19.2	END OF BOREHOLE AT 19.2m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.6m, CEMENT TO 0.1m, THEN ASPHALT TO													

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

ONTMT4S MTO-17840.GPJ 2015TEMPLATE(MTO).GDT 6/2/17

METRIC

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	20 40 60 80 100	W _P W W _L			
	Continued From Previous Page SURFACE.						SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						

RECORD OF BOREHOLE No 17-12

1 OF 1

METRIC

W.P. _____ LOCATION Sitch Creek N 5 350 651.6 E 326 798.9 ORIGINATED BY AHF
 HWY 588 BOREHOLE TYPE Tripod COMPILED BY AN
 DATUM Geodetic DATE 2017.04.29 - 2017.04.29 CHECKED BY CZ



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 (%)				
269.6	GROUND SURFACE							20	40	60	80	100					
0.0	Silty CLAY , trace sand and gravel Soft to Hard Brown Wet		1	SS	3		269										
	Split spoon bouncing		2	SS	60/ 0.133												
268.0																	
1.5	Silty SAND , gravelly Very Dense Brown Wet		3	SS	113		268										
267.5																	
2.1	END OF BOREHOLE AT 2.1m UPON REFUSAL OF TRIPOD EQUIPMENT. WATER LEVEL AT SURFACE. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.																

RECORD OF BOREHOLE No 17-13

1 OF 1

METRIC

W.P. _____ LOCATION Sitch Creek N 5 350 647.3 E 326 797.4 ORIGINATED BY STH
 HWY 588 BOREHOLE TYPE Tripod - Donut Hammer COMPILED BY AN
 DATUM Geodetic DATE 2017.07.05 - 2017.07.05 CHECKED BY CZ

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 (%) w _p w w _L			
268.7	GROUND SURFACE							20	40	60	80	100						
0.0	Silty SAND , organics		1	SS	50/													
268.4	Dark Brown				0.150													
0.3	Moist to Wet split spoon bouncing																	
267.8	Gravelly, silty SAND , some organics						268											
0.9	Dark Brown Wet																	
END OF BOREHOLE AT 0.9m UPON AUGER REFUSAL. WATER LEVEL AT 0.3m BELOW SURFACE. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.																		

RECORD OF BOREHOLE No 17-14

1 OF 1

METRIC

W.P. _____ LOCATION Sitch Creek N 5 350 647.3 E 326 797.1 ORIGINATED BY STH
 HWY 588 BOREHOLE TYPE Tripod - Donut Hammer COMPILED BY AN
 DATUM Geodetic DATE 2017.07.05 - 2017.07.05 CHECKED BY CZ

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									
							20	40	60	80	100						
268.7	GROUND SURFACE																
0.0	Silty SAND , organics																
267.8							268										
0.9	END OF BOREHOLE AT 0.9m UPON AUGER REFUSAL. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.																

RECORD OF BOREHOLE No 17-15

1 OF 1

METRIC

W.P. _____ LOCATION Sitch Creek N 5 350 646.3 E 326 798.5 ORIGINATED BY STH
 HWY 588 BOREHOLE TYPE Tripod - Donut Hammer COMPILED BY AN
 DATUM Geodetic DATE 2017.07.05 - 2017.07.05 CHECKED BY CZ

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						
268.8	GROUND SURFACE							20	40	60	80	100		
0.0	SILT , organics Dark Brown Wet		1	SS	9									
	Gravelly, silty SAND , organics Compact Dark Brown Wet						268							
267.2														
1.5	Silty CLAY , some sand, some gravel Hard Brown Wet		2	SS	65		267							
266.6														
2.1	Silty SAND		3	SS	53/									
266.3	Very Dense													
2.4	Brown Wet				0.100									
	END OF BOREHOLE AT 2.4m UPON SPLIT SPOON REFUSAL. WATER LEVEL AT 0.2m BELOW SURFACE. BOREHOLE BACKFILLED WITH BENTONIE HOLEPLUG TO SURFACE.													

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE



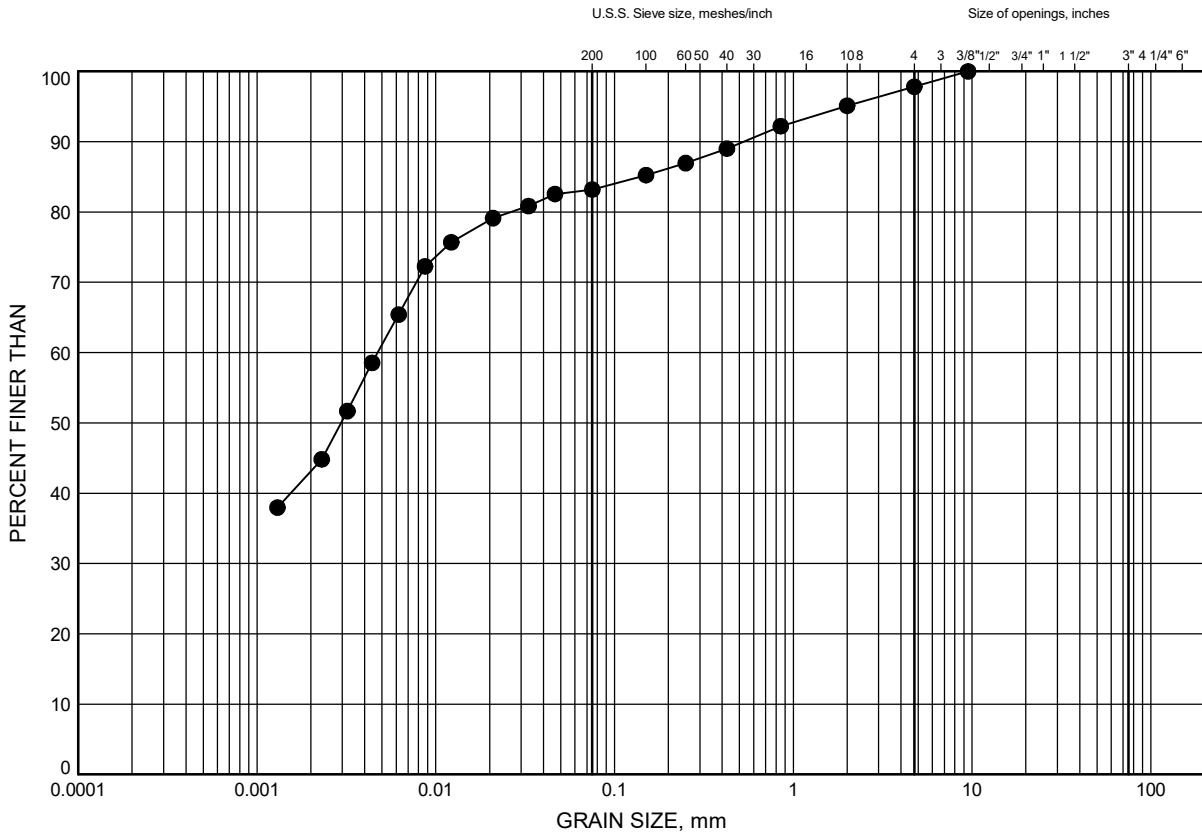
Appendix B

Geotechnical and Analytical Laboratory Test Results

Sitch Creek GRAIN SIZE DISTRIBUTION

FIGURE B1

Silty Clay Fill



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-09	2.6	269.8

Date June 2017
W.P.



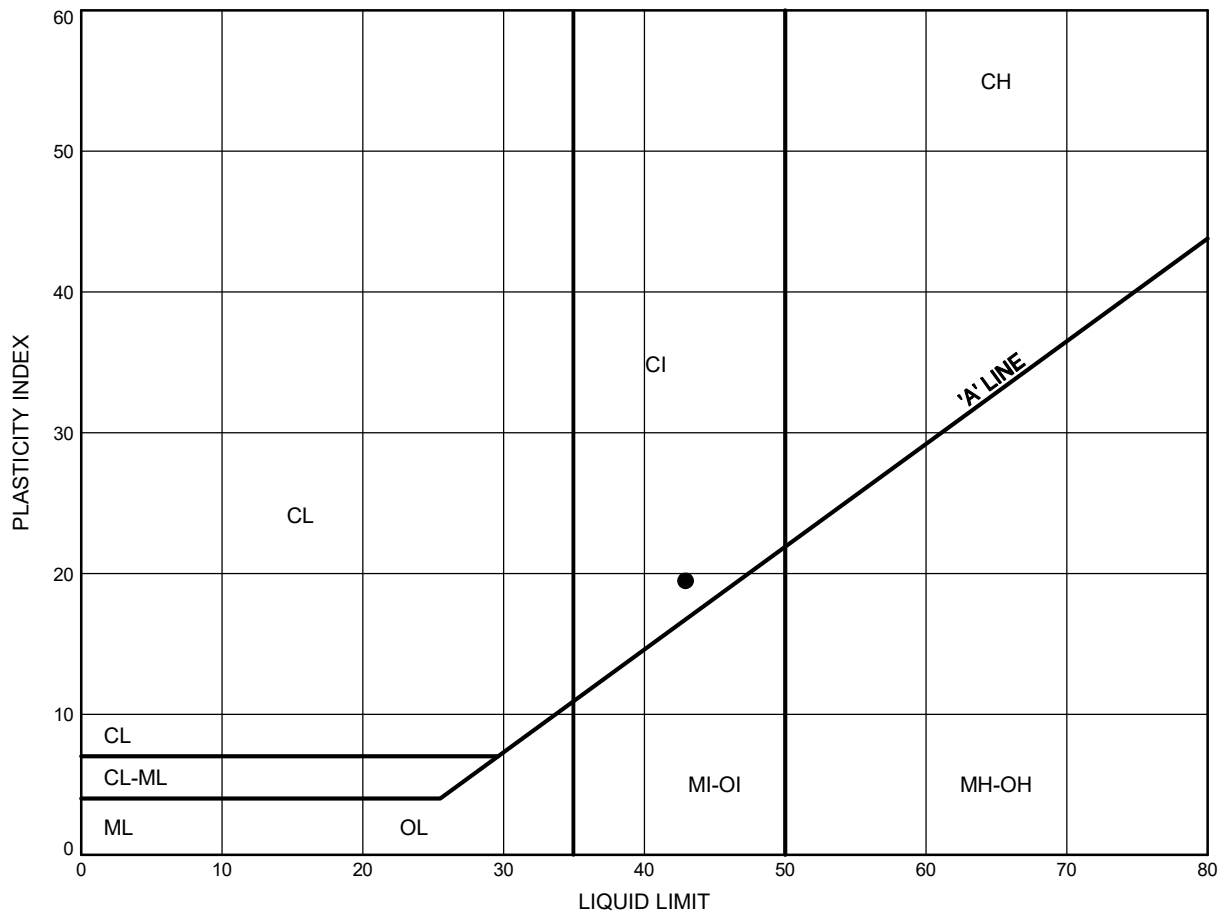
Prep'd MFA
Chkd. MM

Sitch Creek

ATTERBERG LIMITS TEST RESULTS

FIGURE B2

Silty Clay Fill



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-09	2.6	269.8

Date June 2017
W.P.

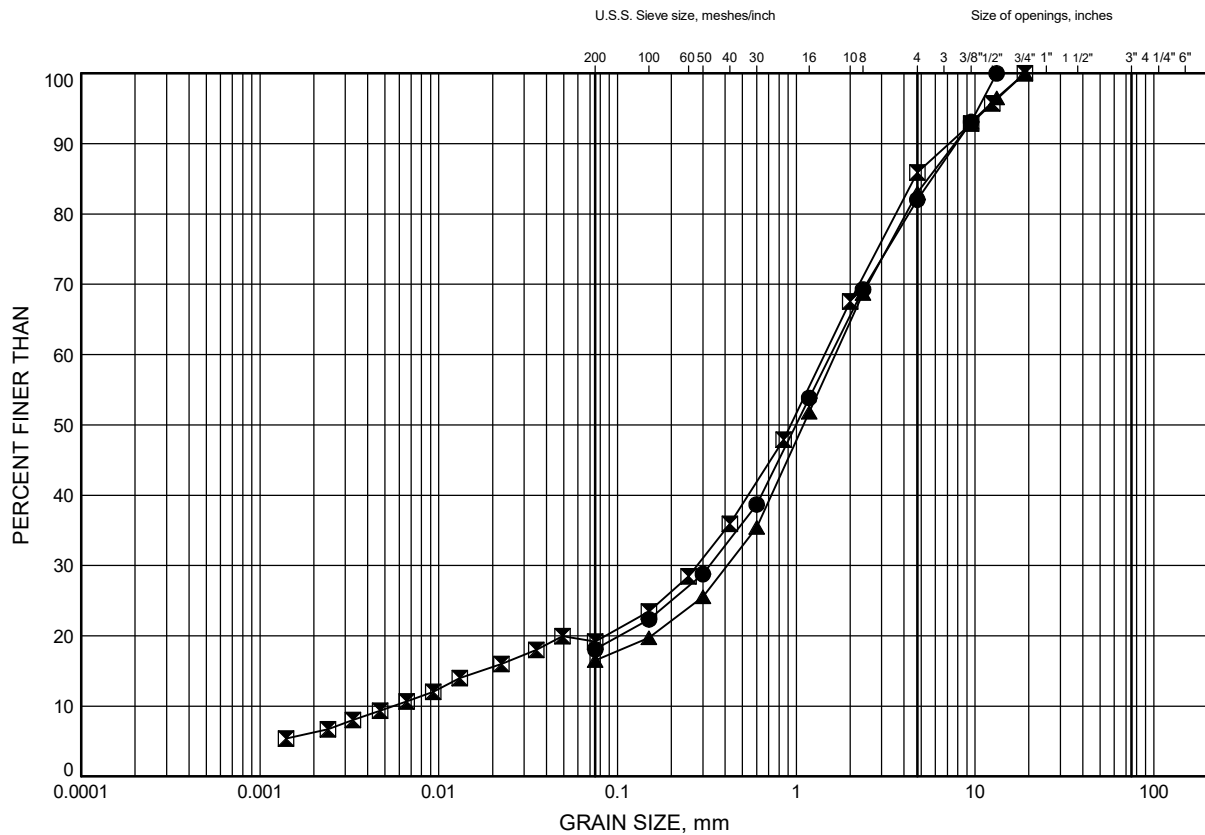


Prep'd MFA
Chkd. MM

Sitch Creek GRAIN SIZE DISTRIBUTION

FIGURE B3

Sand Fill



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-10	1.1	277.1
⊠	17-10	6.4	271.8
▲	17-11	1.1	276.6

Date June 2017
W.P.

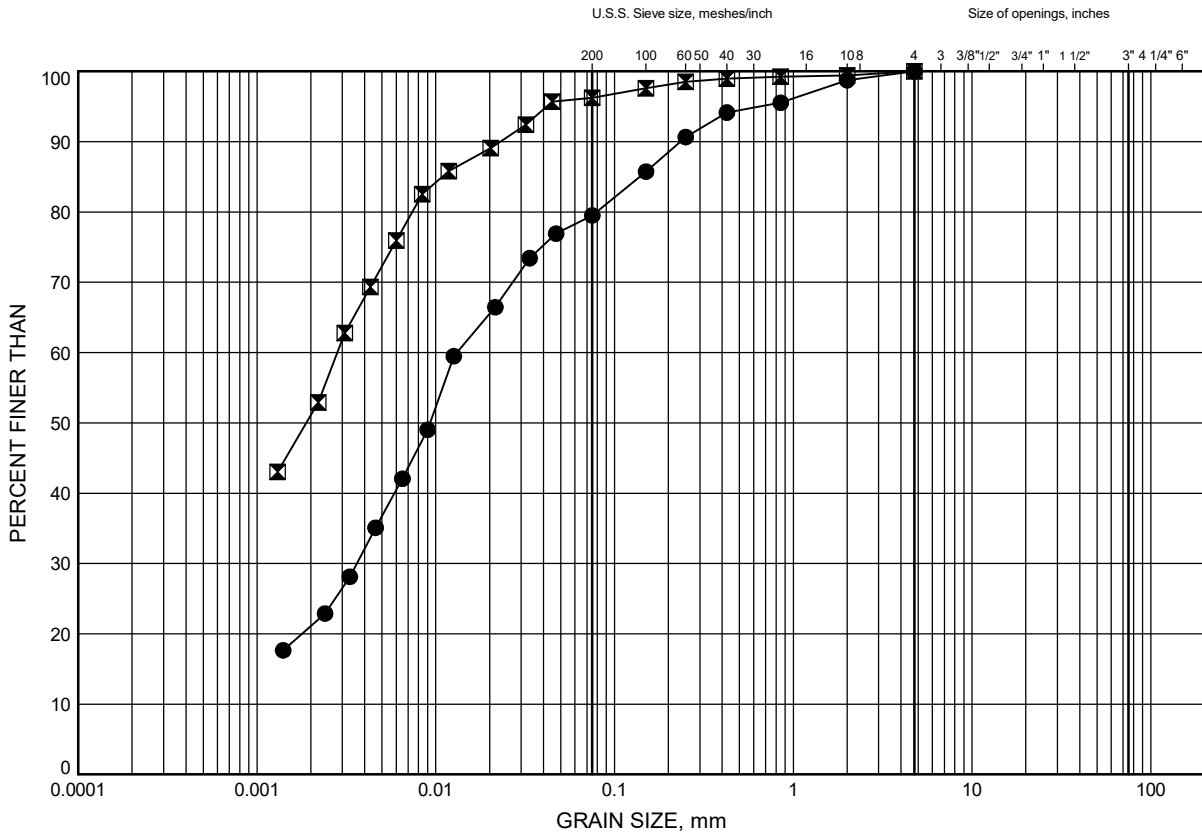


Prep'd MFA
Chkd. MM

Sitch Creek GRAIN SIZE DISTRIBUTION

FIGURE B4

Silty Clay to Clay



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-09	4.9	267.5
⊠	17-10	9.4	268.7

Date June 2017
W.P.

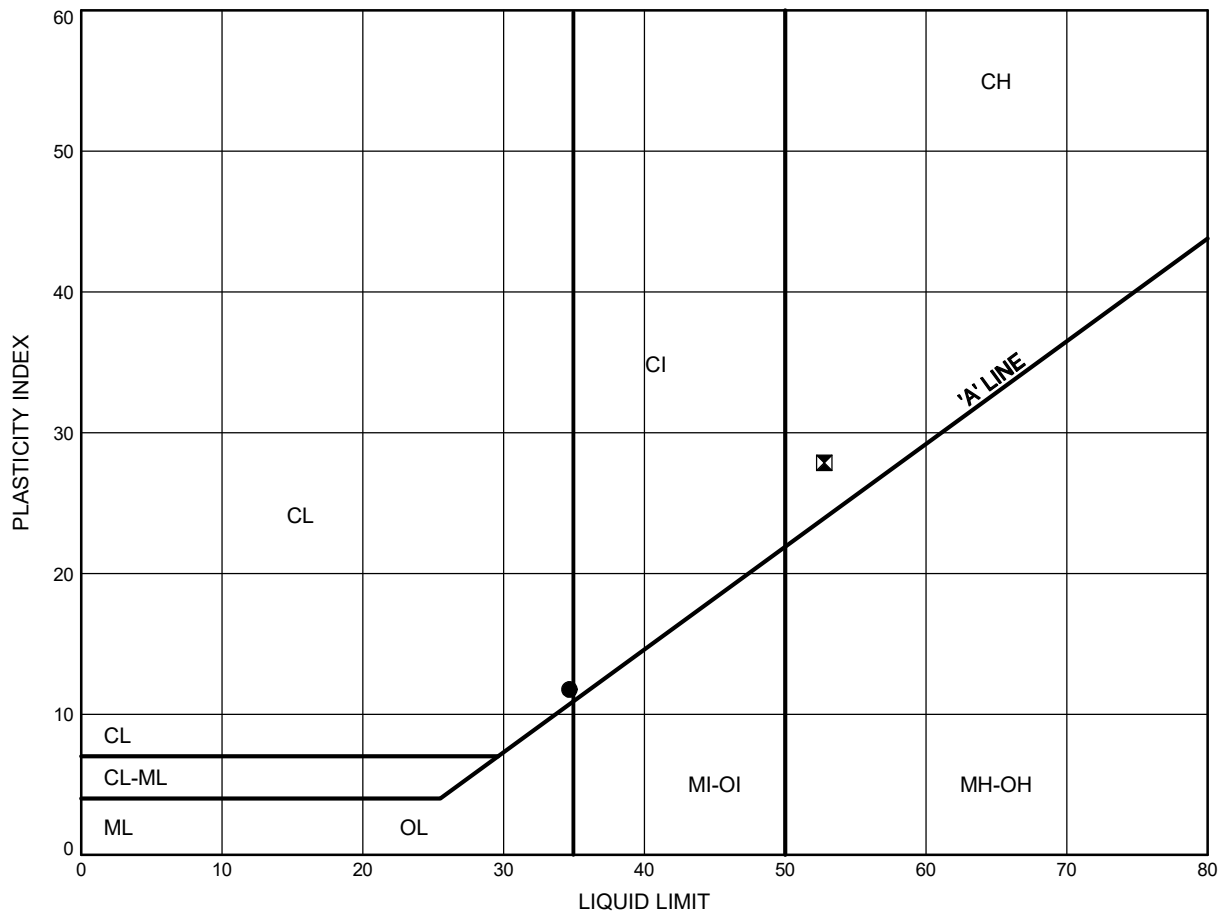


Prep'd MFA
Chkd. MM

Sitch Creek ATTERBERG LIMITS TEST RESULTS

FIGURE B5

Silty Clay to Clay



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-09	4.9	267.5
⊠	17-10	9.4	268.7

Date June 2017
W.P.

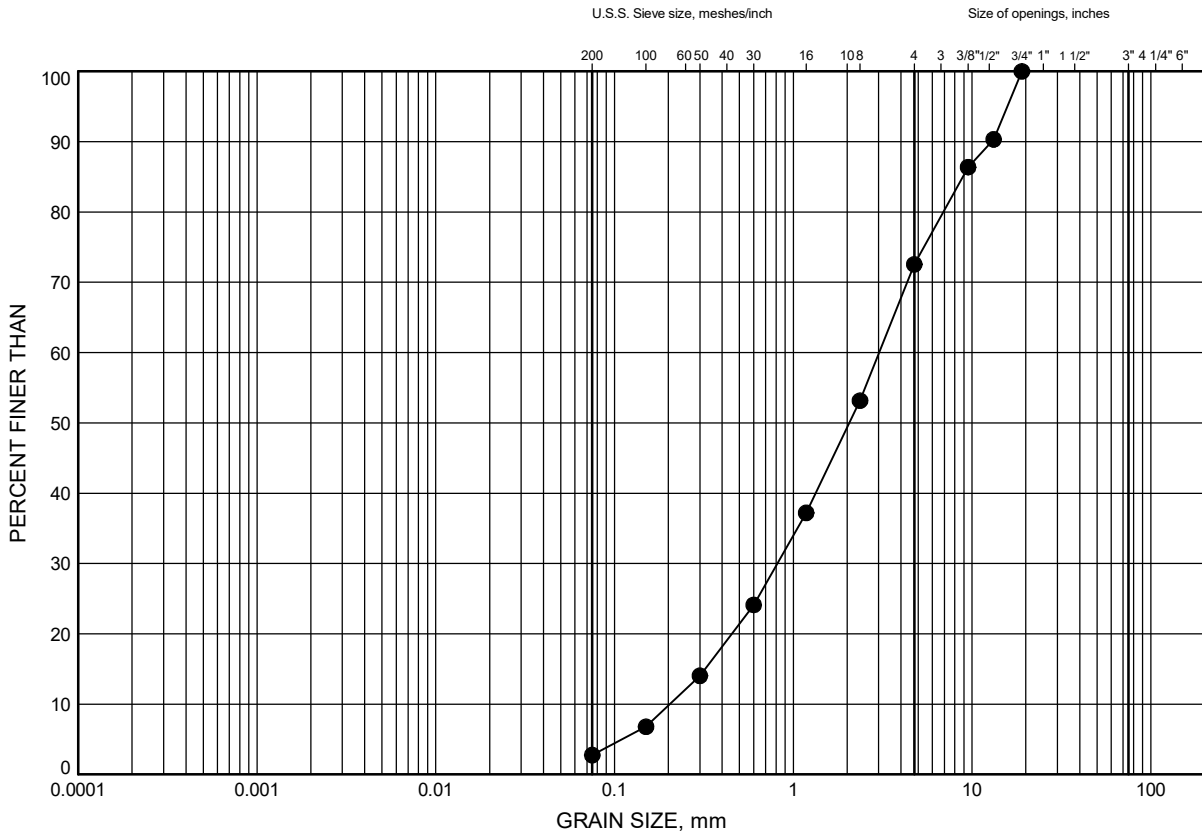


Prep'd MFA
Chkd. MM

Sitch Creek
GRAIN SIZE DISTRIBUTION

FIGURE B6

Gravelly Sand



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-11	9.4	268.2

Date June 2017
W.P.

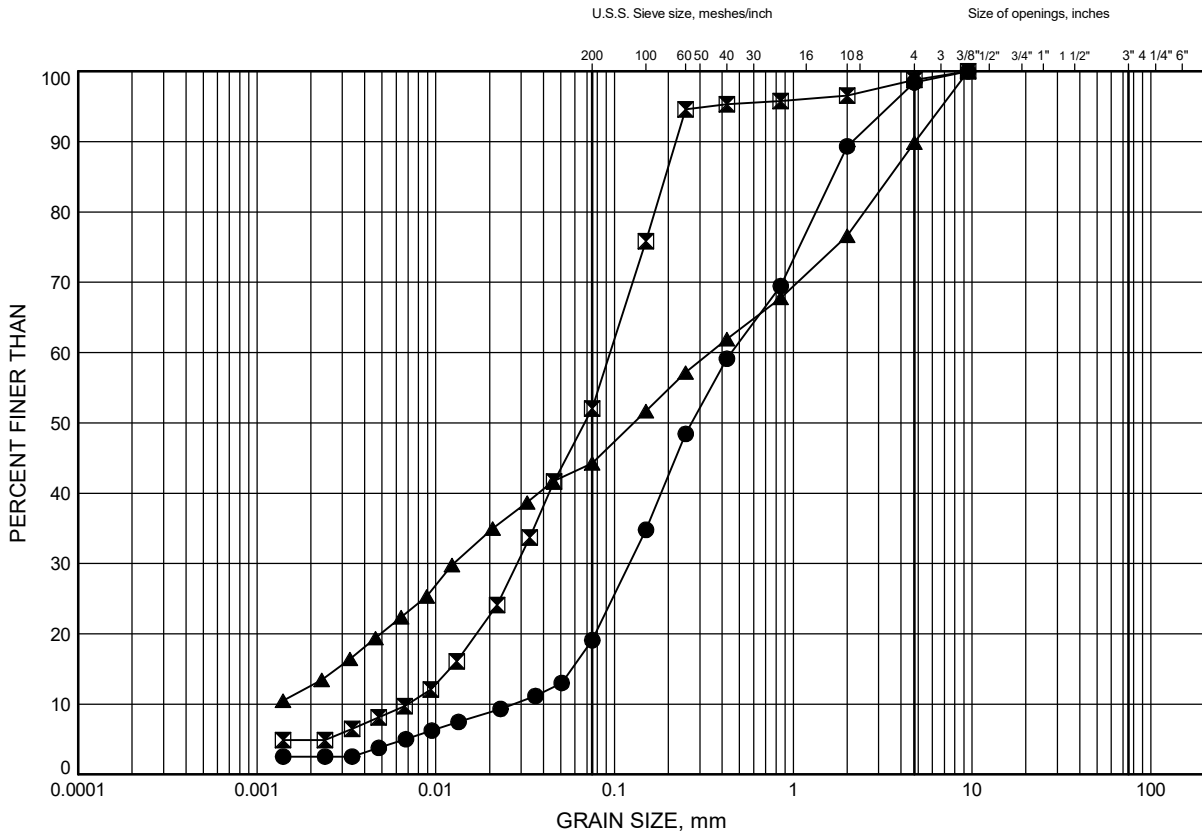


Prep'd MFA
Chkd. MM

Sitch Creek GRAIN SIZE DISTRIBUTION

FIGURE B7

Silt to Silty Sand



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-08	9.4	256.2
⊠	17-10	14.0	264.2
▲	17-10	15.5	262.6

Date June 2017
W.P.



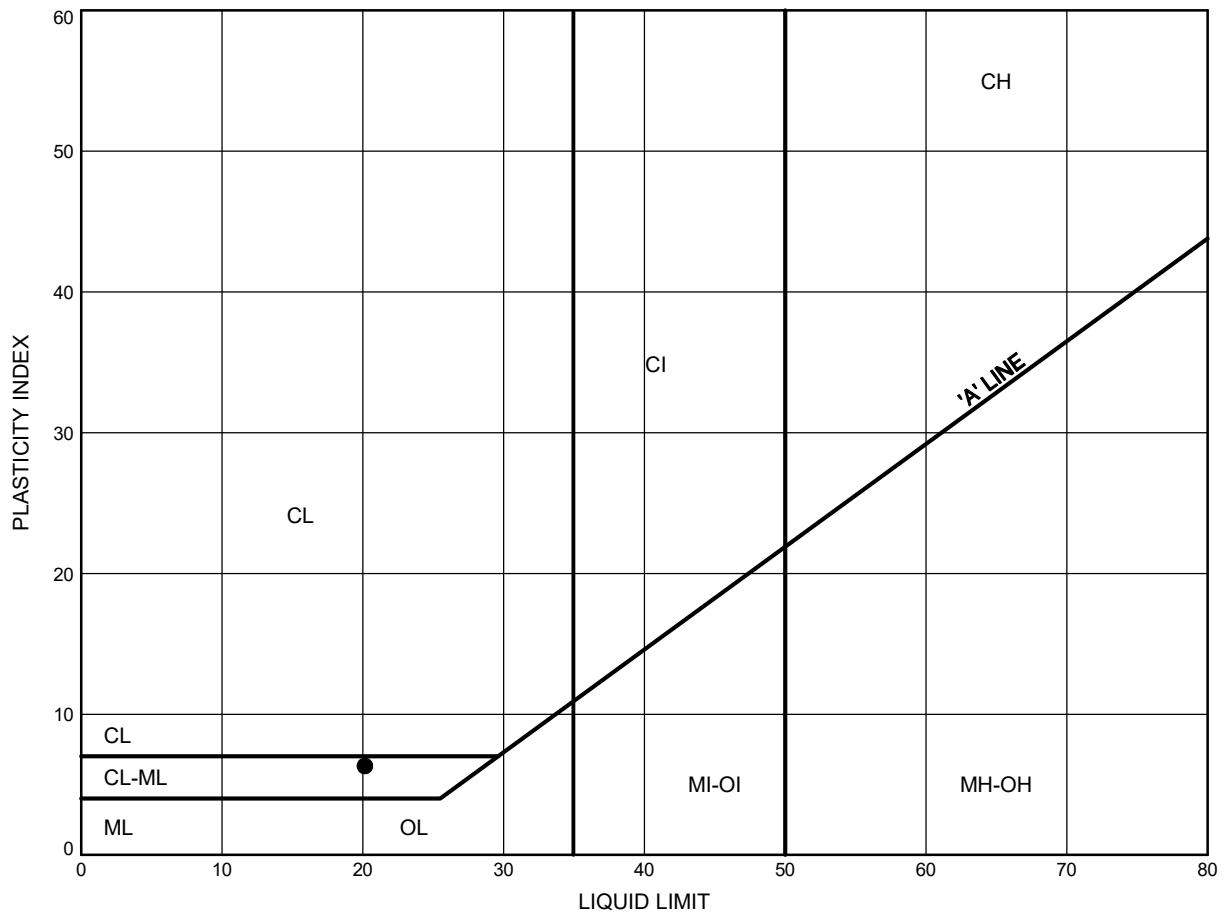
Prep'd MFA
Chkd. MM

Sitch Creek

ATTERBERG LIMITS TEST RESULTS

FIGURE B8

Clayey Silt



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-11	15.5	262.1

Date June 2017
W.P.



Prep'd MFA
Chkd. MM



ASTM D5731-08

Date Drilled:	09-Apr-17
Date Tested:	21-Apr-17
Tester:	WHW
Reviewed by:	CZ

[illegible]



ASTM D5731-08

Date Drilled:	09-Apr-17
Date Tested:	21-Apr-17
Tester:	WHW
Reviewed by:	CZ

[illegible]

**SGS Canada Inc.**

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

Project : 17840**Thurber Engineering Ltd.****Attn : Mark Farrant**

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

Phone: 905-829-8666 x 228
Fax:

19-April-2017

Date Rec. : 12 April 2017
LR Report: CA13544-APR17
Reference: 17840 Mark Farrant


Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Approval Date	4: Analysis Approval Time	5: MDL	7: Whitewood Creek Culvert	8: Sitch Creek Culvert Hwy 588
Sample Date & Time						06-Apr-17 18:00	09-Apr-17 18:30
Temperature Upon Receipt [°C]					---	13.0	13.0
pH [no unit]	13-Apr-17	08:53	17-Apr-17	14:39	0.05	7.46	7.25
Conductivity [uS/cm]	13-Apr-17	08:53	17-Apr-17	14:39	2	129	90
Resistivity (calculated) [Ohms.cm]	17-Apr-17	16:09			---	7750	11100
Redox Potential [mV]	12-Apr-17	13:31	13-Apr-17	11:41	---	295	303
Chloride [mg/L]	12-Apr-17	16:30	13-Apr-17	12:41	0.04	7.3	3.0
Sulphate [mg/L]	12-Apr-17	16:30	13-Apr-17	12:41	0.04	3.2	3.0
Sulphide [mg/L]	13-Apr-17	10:15	17-Apr-17	10:30	0.006	< 0.006	< 0.006

Temperature of Sample upon Receipt: 13 degrees C
Cooling Agent Present: No
Custody Seal Present: No


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 : 17840**LR Report :** CA13544-APR17

Method Descriptions

Parameter	Units	SGS Method Code	Reference Method Code
Anions by IC	mg/L	ME-CA-[ENV]IC-LAK-AN-001	EPA300/MA300-Ions1.3
Conductivity	uS/cm	ME-CA-[ENV]EWL-LAK-AN-006	SM 2510
pH	no unit	ME-CA-[ENV]EWL-LAK-AN-006	SM 4500
Redox Potential	mV		SM 2580
Sulphide by SFA	mg/L	ME-CA-[ENV]SFA-LAK-AN-008	SM 4500



SGS Canada Inc.

P.O. Box 4300 - 185 Concession St.

Lakefield - Ontario - KOL 2HO

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

Project : 17840

LR Report : CA13544-APR17

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: DIO0140-APR17												
Chloride	0.04	mg/L	<0.04		4	20	100	80	120	104	75	125
Sulphate	0.04	mg/L	<0.04		2	20	98	80	120	107	75	125
Conductivity - QCBatchID: EWL0169-APR17												
Conductivity	2	uS/cm	2		3	10	97	90	110	NA		
pH - QCBatchID: EWL0169-APR17												
pH	0.05	no unit	NA		0		100			NA		
Redox Potential - QCBatchID: EWL0152-APR17												
Redox Potential	no	mV	NA		4	20	104	80	120	NA		
Sulphide by SFA - QCBatchID: SKA0110-APR17												
Sulphide	0.006	mg/L	<0.006		ND	20	81	80	120	NV	75	125



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Thurber Engineering Ltd

Attn : Cory Zanatta

2010 Winston Park Dr
Oakville, ON
L6H 5R7,

Phone: 905-829-8666 x 240

Fax:

Project : 17742/17840

24-May-2017

Date Rec. : 17 May 2017

LR Report: CA14528-MAY17

Reference: 17742/17840 Cory Zanatta

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: 17840 17-09 SS9	6: 17840 17-08 SS6	7: 17840 17-06 SS7	8: 17840 17-03 SS5
Sample Date & Time					15-May-17	15-May-17	15-May-17	15-May-17
Temperature Upon Receipt [°C]	---	---	---	---	10.0	10.0	10.0	10.0
Corrosivity Index [none]	24-May-17	13:45	24-May-17	13:45	7.5	4.5	7.5	4.0
Soil Redox Potential [mV]	18-May-17	19:36	19-May-17	14:01	139	152	272	237
Sulphide [%]	23-May-17	12:52	23-May-17	13:09	0.67	0.53	0.51	< 0.02
% Moisture (wet wt) [%]	23-May-17	10:42	23-May-17	10:44	19.3	19.8	9.9	17.9
pH [no unit]	19-May-17	14:44	24-May-17	13:14	8.73	8.22	8.51	8.55
Chloride [µg/g]	19-May-17	12:04	23-May-17	11:42	16	5.9	15	25
Sulphate [µg/g]	19-May-17	12:04	23-May-17	11:42	54	68	200	61
Conductivity [uS/cm]	19-May-17	14:44	24-May-17	13:14	76	92	173	109
Resistivity (calculated) [Ohms.cm]	19-May-17	14:44	24-May-17	13:14	13200	10900	5780	9170



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LR Report : CA14528-MAY17

Analysis	9: 17840 17-02 SS6	10: 17840 17-07 SS7	11: 17792 17-03 SS3	12: 17792 17-02 SS4
Sample Date & Time	15-May-17	15-May-17	15-May-17	15-May-17
Temperature Upon Receipt [°C]	10.0	10.0	10.0	10.0
Corrosivity Index [none]	7.5	7.5	2.0	1.0
Soil Redox Potential [mV]	200	256	278	315
Sulphide [%]	0.05	0.39	< 0.02	< 0.02
% Moisture (wet wt) [%]	18.9	14.1	20.1	10.9
pH [no unit]	8.68	8.47	7.40	6.03
Chloride [µg/g]	55	59	260	66
Sulphate [µg/g]	110	200	8.3	32
Conductivity [uS/cm]	157	200	384	150
Resistivity (calculated) [Ohms.cm]	6370	5000	2600	6670

Temperature of Sample upon Receipt: 10 degrees C

Cooling Agent Present: Yes

Custody Seal Present: No

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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Method Descriptions

Parameter	SGS Method Code
Anions by IC	ME-CA-[ENV]IC-LAK-AN-001
Carbon/Sulphur	ME-CA-[ENV]ARD-LAK-AN-020
Conductivity	ME-CA-[ENV]EWL-LAK-AN-006
Metals Prep	ME-CA-[ENV]ARD-LAK-AN-013
pH	ME-CA-[ENV]EWL-LAK-AN-001



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Quality Control Report

Inorganic Analysis												
Parameter	Reporting Limit	Unit	Method Blank				LCS / Spike Blank			Matrix Spike / Reference Material		
							RPD	Acceptance Criteria	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)
					%	Low				High	Low	
Anions by IC - QCBatchID: DIO0347-MAY17												
Chloride	0.4	µg/g	<0.4		12	20	97	80	120	97	75	125
Sulphate	0.4	µg/g	<0.4		5	20	97	80	120	86	75	125
Carbon/Sulphur - QCBatchID: ECS0026-MAY17												
Sulphide	0.02	%	<0.02		ND	20	117	80	120			
Conductivity - QCBatchID: EWL0361-MAY17												
Conductivity	2	uS/cm	< 2		0	10	96	90	110	NA		
pH - QCBatchID: EWL0361-MAY17												
pH	0.05	no unit	NA		0		100			NA		



Appendix C

Selected Site Photographs



Photograph 1 – Sitch Creek Culvert, South End (Inlet)

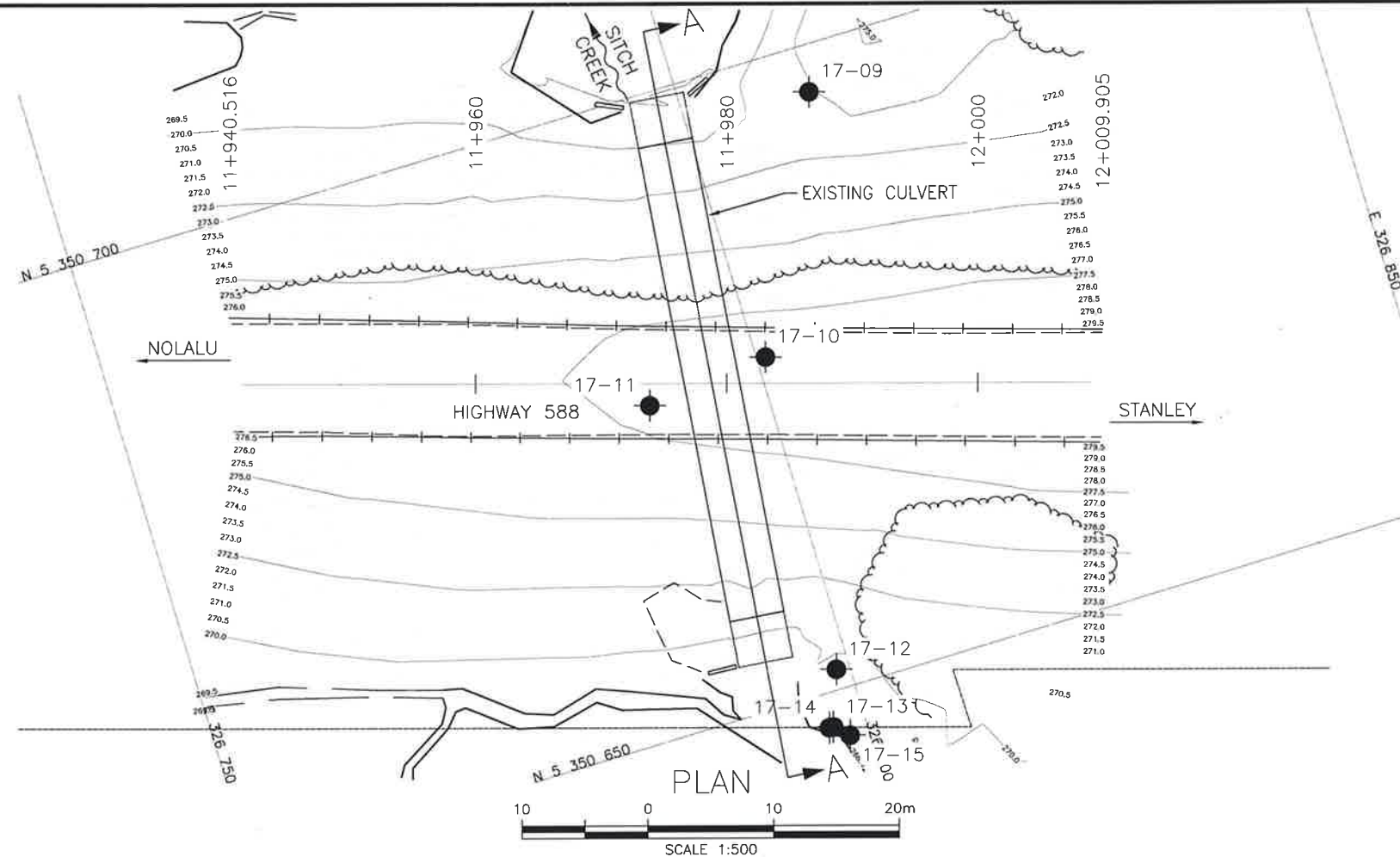


Photograph 2 – Sitch Creek Culvert, North End (Outlet)



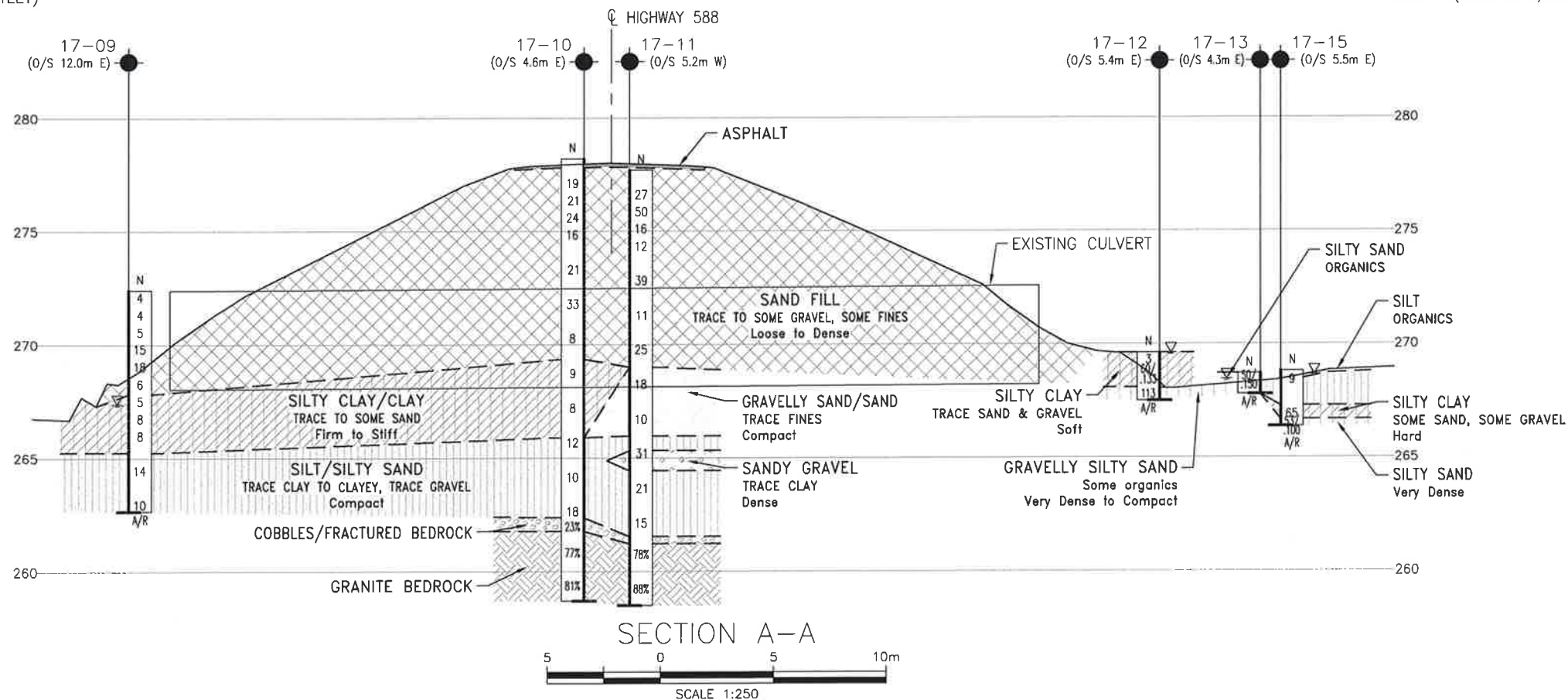
Appendix D

Borehole Locations and Soil Strata Drawing



NORTH (DOWNSTREAM/OUTLET)

SOUTH (UPSTREAM/INLET)

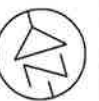


METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN



CONT No
WP No

HIGHWAY 588
SITCH CREEK
CULVERT
BOREHOLE LOCATIONS AND SOIL STRATA



SHEET



KEYPLAN

LEGEND

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

NO	ELEVATION	NORTHING	EASTING
17-09	272.4	5 350 696.3	326 810.1
17-10	278.2	5 350 677.0	326 800.7
17-11	277.7	5 350 676.0	326 790.8
17-12	269.6	5 350 651.6	326 798.9
17-13	268.7	5 350 647.3	326 797.4
17-14	268.7	5 350 647.3	326 797.1
17-15	268.8	5 350 646.3	326 798.5

-NOTES-

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

GEOCRES No. 52A-226

REVISIONS	DATE	BY	DESCRIPTION				
DESIGN	CZ	CHK	PKC	CODE	LOAD	DATE	AUG 2017
DRAWN	MFA	CHK	CZ	SITE	STRUCT	DWG	1