



THURBER ENGINEERING LTD.

FINAL
FOUNDATION INVESTIGATION REPORT
HIGHWAY 17 TWINNING, RENFREW AREA
PRIVATE DRIVE CULVERT (ANDERSON ROAD LOCHA CREEK)
WP 4068-09-00 / ASSIGNMENT NO. 4018-E-0009

Geocres No.: 31F-212

Report to:

Ministry of Transportation Ontario

Latitude: 45.443700
Longitude: -76.534900

July 2021
Thurber File No.: 24726



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PART 1. FACTUAL INFORMATION

1 INTRODUCTION

Thurber Engineering Ltd. (Thurber) has been engaged by the Ministry of Transportation Ontario (MTO) under Assignment No. 4018-E-0009 to carry out Foundation Investigations to support the design of the Highway 17 Twinning Project which extends from Scheel Drive westerly to 3 km west of Bruce Street in the Renfrew area.

This report addresses the replacement of a structural culvert and embankment modifications to a service road on the south side of Highway 17 approximately 150 m west of the current intersection with Anderson Road. The service road is currently known as Daisy Lane but will be realigned to become an extension to Anderson Road.

This section of the report presents the factual findings obtained from the foundation investigation completed for the replacement of the existing culvert under the extended Anderson Road, as well as for the high fill resulting from the alignment shift.

The purpose of this investigation was to explore the subsurface conditions at the site and, based on the data obtained, to provide a borehole location plan, records of boreholes, stratigraphic profile, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions influencing design and construction was developed in the course of the current investigation.

Previous foundation investigation information from boreholes completed in 2017 and 2018 for the Highway 17 Locha Creek Culvert (Site No. 29-249/C1) was available under Geocres 31F-205.

2 SITE DESCRIPTION

2.1 General

The existing culvert is located on Daisy Lane, a private unpaved roadway that extends from Anderson Road and runs south of and parallel to the existing Highway 17 alignment for a short distance. The culvert facilitates the flow of Locha Creek under Daisy Lane, approximately 150 m west of where Anderson Road currently meets Highway 17. Creek flow is from the south to the north.



At the location of the culvert, Daisy Lane is a one-lane roadway with a rural cross-section and gravel surface. The road surface is at approximate elevation 135 m. The existing embankment side slopes did not show any visible signs of distress at the time of the investigation and were sloped at approximately 2H:1V to 3H:1V. During a site visit on April 27, 2020, the measured width of Locha Creek ranged from approximately 5 m to 7 m and had an average depth of approximately 1.0 m.

The existing Highway north of this consists of a two-lane undivided highway with gravel shoulders. The Locha Creek Culvert crossing Highway 17 (Site No. 29-249/C1) is present downstream (north) of the site.

The land adjacent to the site typically consists of forests and agricultural fields. The terrain is relatively flat except where bisected by the Locha Creek Valley. The existing culvert is a structural multi-plate corrugated steel pipe arch with a span of 4.8 m, a rise of 3.0 m and a length of 9.7 m. The creek bed and culvert invert is at approximate elevation of 131.4 m. The fill height above the culvert is approximately 0.7 m.

Photographs showing the existing conditions in the area of the culvert at the time of the field investigation are included in Appendix D for reference.

2.2 Site Geology

Based on published geological information in *The Physiography of Southern Ontario* by Chapman and Putnam (1984), the culvert site lies within the physiographic region known as the Ottawa Valley Clay Plains. This physiographic region is characterized primarily by clay plains interrupted by ridges of rock or sand.

Ontario Geological Survey Map P.3784 for Precambrian Geology for the Horton Area, Grenville Province, suggests the bedrock is comprised of calcitic carbonate metasedimentary bedrock including calcite marble.

3 SITE INVESTIGATION AND FIELD TESTING

The current site investigation and field testing program was carried out between July 22 and September 30, 2019. The field investigation consisted of advancing three main boreholes identified as AND19-1, AND19-2 and AND19-3 as well as one borehole for the Anderson Road high fill section, AND19-4. AND19-1 was divided into 4 parts: AND19-1 for soil sampling, AND19-1B for a well installation at 10.4 m below ground surface, AND19-1C for a well installation at 4.6 m below ground surface and AND19-1D for rock coring. AND19-2 was divided into two parts, with AND19-2A for the collection of thin-walled tube samples. Prior to commencement of drilling, utility clearances were obtained in the vicinity of the borehole locations.

Historical Borehole 18-103 which was drilled by Thurber in June 2018 for the replacement of the Locha Creek culvert under the existing Highway 17 is located near the outlet of the subject culvert. Data from Borehole 18-103 has been fully incorporated into this report.



The northing, easting and elevation of the boreholes are shown on the Borehole Location and Soil Strata Drawing No. 1 in Appendix A, the individual Record of Borehole sheets in Appendix B, and in Table 3-1 below. The site is located within MTM Zone 9.

Table 3-1: Borehole Summary

Borehole No.	Drilled Location	Northing (m)	Easting (m)	Ground Surface Elevation (m)	Termination Depth (m)	Comments
18-103	Outlet	5 033 766.1	302 084.0	133.9	28.4	-
AND19-1	Inlet	5 033 735.8	302 065.1	132.6	17.5	-
AND19-1B	Inlet	5 033 744.5	302 063.2	132.9	10.4	Well Install only
AND19-1C	Inlet	5 033 739.8	302 062.3	132.9	4.6	Well Install only
AND19-1D	Inlet	5 033 736.4	302 061.2	132.8	21.1	Rock coring only
AND19-2	On-Road	5 033 754.1	302 078.4	134.8	28.7	-
AND19-2A	On-Road	5 033 753.9	302 079.4	134.8	7.5	Tube samples
AND19-3	Outlet	5 033 769.5	302 062.6	133.7	21.3	-
AND19-4	10+370 Toe of Slope	5 033 740.3	302 088.1	132.6	10.7* 20.4**	-

Notes: * - Termination of Sampled Borehole

** - DCPT refusal

The drilling was carried out using track-mounted CME 850 and CME 45 drill rigs equipped with hollow stem augers and rotary diamond drilling equipment.

Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). Upon achieving casing refusal, Boreholes 19-1D, AND19-2 and 18-103 were drilled into bedrock while collecting NQ core.

50 mm diameter monitoring wells were installed in Boreholes AND19-1B and AND19-1C. A 19 mm diameter monitoring well was installed in Borehole AND19-4. The installation details are illustrated on the Record of Borehole sheets provided in Appendix B. The boreholes were backfilled in accordance with MOE requirements (O.Reg 903, as amended). The wells will be utilized as part of a hydrogeological study and subsequently decommissioned by Thurber.

The drilling and sampling operations were supervised on a full-time basis by a member of Thurber's geotechnical staff. The drilling supervisor logged the boreholes and processed the recovered soil and bedrock samples for transport to Thurber's Ottawa geotechnical laboratory for further examination and testing.



4 LABORATORY TESTING

Laboratory testing was selected in accordance with the current MTO Guideline for Foundation Engineering Services, Section 5. Geotechnical laboratory testing consisted of natural moisture content determination and visual identification of all retained soil samples. At least 25% of the recovered soil samples were subjected to grain size distribution analysis and Atterberg limits tests, where appropriate. The testing was carried out to MTO and ASTM standards. A one-dimensional consolidation test was carried out on a thin-walled tube sample from AND19-2A. All rock cores were photographed and their total core recovery (TCR), solid core recovery (SCR) and rock quality designation (RQD) were measured. Chemical analysis for determination of pH, conductivity, resistivity, sulphide, sulphate and chloride concentrations was carried out on one soil sample from AND19-2.

The results of the geotechnical tests are summarized on the Record of Borehole sheets included in Appendix B and all laboratory results are presented on the figures included in Appendix C.

5 GENERAL DESCRIPTION OF SUBSURFACE CONDITIONS

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendix B and the Borehole Location and Soil Strata Drawing included in Appendix A. A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following sections. However, the factual data presented on the Borehole Records takes precedence over the Soil Strata Drawing and the general description. It must be recognized that the soil and groundwater conditions may vary between and beyond borehole locations. Soil classification is in accordance with ASTM D2487. Cohesive soils are described per current MTO protocols for the boreholes drilled in 2019; historic boreholes have based classification on ASTM D2487.

In general terms, the site was found to be underlain by sands, silts or embankment fill overlying a native deposit of clay, which is underlain by a sand till deposit with variable quantities of clay, gravel and cobbles. The overburden soils are underlain by marble bedrock.

5.1 Fill

A fill consisting of sand with silt to silty sand to silt with sand to sandy clay with silt, was encountered in Boreholes AND19-2, AND19-3, AND19-4 and 18-103. The underside of the fill was encountered at depths from 2.3 m to 3.0 m or elevations ranging from 130.3 to 131.8 m.

SPT tests conducted in this layer gave N-values ranging from Weight of Hammer to 8 in AND19-3, AND19-4 and 18-103, indicating a very loose to loose relative density. In AND19-2 which was advanced through the existing embankment gave SPT N-values ranging from 5 to 25, indicating a loose to compact relative density.

The moisture content of the samples tested ranged from 3 to 65%. The results of grain size analysis tests conducted on three samples of the fill material are summarized below in Table 5-1 and are illustrated on Figure C1 in Appendix C.

Table 5-1: Summary of Grain Size Distribution Testing

Soil Particle	Percentage (%)
Gravel	0 to 10
Sand	79 to 94
Silt and Clay	6 to 14

5.2 Sand with Silt (SP-SM)

A layer of sand with silt, trace to some roots was observed at ground surface in Borehole AND19-1. The sand with silt layer had a thickness of 0.6 m and a base elevation of 132.0 m.

SPT tests conducted in the layer gave an N-value of Weight of Hammer, indicating a relative density of very loose.

The moisture content of the sample tested was 37%.

5.3 Silty Sand (SM) to Silt with Sand (ML) to Sandy Clayey Silt (CL)

A soil with variable quantities of sand, silt, and clay was encountered below the fill in Boreholes AND19-2, AND19-4 and 18-103, below the sand with silt in AND19-1. This layer ranged in thickness from 0.9 m to 1.9 m, with base elevations from 128.9 m to 131.1 m.

SPT tests conducted in the layer gave N-values of Weight of Hammer to and 6, indicating a very loose to loose relative density.

The moisture content of the samples tested ranged from 29 to 137%. The results of grain size analysis tests conducted on four samples of this material are summarized below in Table 5-2 and are illustrated on Figure C2 in Appendix C.

Table 5-2: Summary of Grain Size Distribution Testing

Soil Particle	Percentage (%)
Gravel	0 – 19
Sand	16 – 45
Silt	24 – 44
Clay	16 – 40

The results of Atterberg Limits testing carried out on the fines of samples of this material are summarized in Table 5-3 below and are illustrated on Figure C7 in Appendix C and indicate the fines to be variable and range from non-plastic to medium plastic (MI-OI to CL).



Table 5-3: Summary of Atterberg Limit Testing

Parameter	AND19-2 SS4	AND19-4 SS4	18-103 SS5	18-103 SS6
Liquid Limit	46	-	34	30
Plastic Limit	31	NP	20	16
Plasticity Index	15	-	14	14
Soil Symbol (fines)	MI to OI	ML	CL	CL

5.4 Clayey Silt to Clay (CL to CH)

A cohesive native deposit of clayey silt to clay was encountered in all boreholes. The top of the deposit was encountered at elevations ranging from 128.9 m to and 131.1 m. The thickness of the deposit, where fully penetrated ranged from 11.9 m to 18.6 m with an underside elevation ranging from 110.7 m to 119.2 m.

SPT tests conducted in the layer gave N-values ranging from weight of hammer to 8. In-situ shear vane test results indicated undrained shear strengths ranging from 34 kPa to greater than 100 kPa; indicating a firm to very stiff consistency, but typically firm to stiff. The measured sensitivity ranged from 3 to 30; indicating a medium sensitivity to quick clay deposit, but typically of medium to high sensitivity.

The moisture content of the samples tested ranged from 28 to 54%. The results of grain size analysis tests conducted on samples of this deposit are summarized below in Table 5-4 and are illustrated on Figures C3, C4 and C5 in Appendix C.

Table 5-4: Summary of Grain Size Distribution Testing

Soil Particle	Percentage (%)
Gravel	0 – 7
Sand	0 –22
Silt	37 – 64
Clay	30 – 62

The results of Atterberg Limits testing carried out on samples of this material are summarized in Table 5-5 below and are illustrated on Figures C8, C9 and C10 in Appendix C and indicate the material is a clayey silt to clay ranging from low to high plasticity (CL to CH); but typically low to intermediate plasticity (CL to CI). It should be noted in accordance with the MTO Guideline for Foundation Engineering Services (May 2019) this cohesive deposit is described as a “clayey silt” where Atterberg limits tests indicate a CL material. The historic logs from Geocres 31F-205 referenced in and appended to this report do not follow this guideline and describe the CL material as “clay”. For the purposes of this report, they are considered the same material.



Table 5-5: Summary of Atterberg Limit Testing

Parameter	Value
Liquid Limit	22 – 52
Plastic Limit	13 – 22
Plasticity Index	9 – 30

The results of one laboratory oedometer (one-dimensional consolidation) test carried on an undisturbed sample in the deposit is presented in Appendix C and summarized below in Table 5-6. Also presented in Table 5-6 are the test results from four consolidation tests reported in Geocres 31F-205 from the adjacent site.

Table 5-6: Consolidation Test Results

Parameter	Results				
Borehole	19-2A	17-2	17-3	18-101	18-101
Sample	ST2	ST9	ST17	ST5	ST9
Sample Depth, (m)	7.2	10.2	15.6	4.9	11
Sample Elevation, (m)	127.6	121.7	123.3	127.7	121.5
Approx. Existing Effective Stress, P_0 , (kPa)	94	83	193	37	85
Moisture Content, (%)	47	45	49	43	45
Liquid Limit, %	31	-	-	-	-
Plastic Limit, %	21	-	-	-	-
Liquidity Index	2.6	-	-	-	-
Unit Weight, γ (kN/m ³)	17.1	17.5	16.8	17.5	17.6
Specific Gravity, G_s	2.747	2.746	2.746	2.750	2.750
Initial Void Ratio e_0	1.325	1.229	1.383	1.197	1.211
Pre-consolidation Pressure, P_c' , (kPa)	320	210	200	285	185
Over Consolidation Ratio, OCR	3.4	2.5	1.0	7.7	2.2
Compression Index, C_c	0.53	0.65	0.75	0.48	0.65
Recompression Index, C_r	0.06	0.05	0.08	0.02	0.02
Coefficient of consolidation, c_v (mm ² /s)	0.05	0.05	0.04	0.06	0.03
Coefficient of re-consolidation, c_{vr} (mm ² /s)	0.4	0.3	0.5	1.3	0.7



5.5 Glacial Till

A glacial till deposit ranging from gravelly silty sand to clayey sand with gravel was encountered beneath the clay in Boreholes AND19-1, AND19-2, AND19-3 and 18-103. The top of this layer ranges from elevation 110.7 m to 119.2 m. The thickness of the layer ranges from 1.4 m to 4.1 m. Occasional cobbles and boulders were noted within the glacial till, particularly within the lower portion and coring techniques were required to penetrate the layer.

SPT tests conducted in this layer gave N-values ranging from 13 to greater than 100, indicating a compact to very dense relative density. The higher blow counts could be due to the presence of cobbles or a boulder within the deposit rather than the relative density of the soil matrix. On the other hand, artesian conditions were noted in this layer which may have decreased N-values.

The moisture content of two samples were 18% and 28%. The results of grain size analysis on two samples of the till are summarized in Table 5-7 below and are illustrated on Figure C6 in Appendix C.

Table 5-7: Summary of Grain Size Distribution Testing

Soil Particle	Percentage (%)	
Gravel	23 – 25	
Sand	30 – 59	
Silt	30	16
Clay	17	

The results of Atterberg Limits testing completed on the material with 47% fines indicated that the fines were of low plasticity (CL). Atterberg Limits analysis results are illustrated on Figure C11 in Appendix C.

5.6 Refusal and Bedrock

In Boreholes AND19-1 and AND19-3, boreholes were terminated at casing refusal at elevation 115.1 m and 112.4 m respectively. A dynamic cone penetration test (DCPT) for AND19-4 began at 10.7 m deep (elevation 121.9 m) and terminated at 20.4 m deep (elevation 112.2 m) at cone refusal.

Bedrock was proven by coring in boreholes AND19-1D, AND19-2 and 18-103. A summary of the bedrock surface information is provided in Table 5-8 below:



Table 5-8: Summary of Bedrock Depth/Elevation

Borehole No.	Depth to Bedrock Surface (mbgs)	Bedrock Surface Elevation (m)
AND19-1	17.5*	115.1*
AND19-1D	17.1	115.7
AND19-2	24.9	109.9
AND19-3	21.3*	112.4*
AND19-4	20.4**	112.2**
18-103	24.6	109.3

Notes: * – Inferred, Casing refusal
 ** – Inferred, DCPT refusal

The bedrock surface generally slopes downwards from south to north and from the east and west sides to the centerline of the culvert.

The bedrock encountered within boreholes AND19-1D, AND19-2 and 18-103 consisted of freshly weathered, very strong, grey to white marble with close joint spacing. The Total Core Recovery (TCR) measured on the recovered bedrock core ranged from 82 to 100%, the Solid Core Recovery (SCR) ranged from 30 to 100% and the Rock Quality Designation (RQD) ranged from 20 to 97%.

Unconfined compressive strength testing was carried out on one sample of the bedrock in Borehole 18-103; the result was 156 MPa.

Based on the measured RQD values, the bedrock is classified as poor to excellent quality. Based on the unconfined compressive strength testing the bedrock is very strong. Photographs of the bedrock core are provided in Appendix C.

5.7 Groundwater Conditions

The water level in Locha Creek was measured at an approximate elevation of 131.9 m on July 24th, 2019. The groundwater level in the area of the culvert is expected to reflect the creek level.

Artesian conditions were noted at the site during and upon completion of drilling in Boreholes AND19-1, AND19-1D, AND19-2, AND19-3 and 18-103 originating from the glacial till layer which is overlain clay in all boreholes. The non-stabilized artesian levels were measured from the base of the borehole and are presented in Table 5-9. The artesian flow was sealed at the source with bentonite pellets while decommissioning the boreholes.



Table 5-9: Summary of Artesian Groundwater Conditions

Borehole	Approximate Depth (mbgs)	Groundwater Elevation (m)	Date of Measurement
AND19-1	-3.5	136.1	July 23, 2019
AND19-1D	-3.5	136.3	July 29, 2019
AND19-2	-1.5	136.3	August 2, 2019
AND19-3	-2.3	136.0	July 30, 2019
18-103	-2.4	136.3	June 15, 2018

Note: Negative depth indicates artesian conditions

Two 50 mm diameter monitoring wells (AND19-1B and AND19-1C) and one 19 mm piezometer (AND19-4) were installed at the site. Groundwater levels were recorded and are presented in Table 5-10 below:

Table 5-10: Summary of Groundwater Levels

Borehole No.	Bottom of Screen Elevation (m)	Depth (mbgs)	Groundwater Elevation (m)	Date of Measurement
AND19-1B	122.5	0.5	132.4	August 23, 2019
		0.4	132.5	September 5, 2019
		-0.1	133.0	November 26, 2019
		0.3	132.6	July 20, 2021
AND19-1C	128.3	0.5	132.4	August 23, 2019
		0.3	132.6	September 5, 2019
		0.2	132.7	November 26, 2019
		0.1	132.8	July 20, 2021
AND19-4	124.2	-0.5	133.1	August 23, 2019
		-0.3	132.9	September 5, 2019
		-0.4	133.0	November 26, 2019
		>-2.1	>134.7	July 20, 2021

Note: Negative depth indicates artesian conditions

These observations are considered short term and it should be noted that the groundwater level at the time of construction may be different and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after periods of significant and/or prolonged precipitation.



The General Arrangement Drawing for the Highway 17 Locha Creek Culvert shows a high water level elevation of 133.86 m for a 50 year return period.

5.8 Analytical Testing

Samples of the native soils were submitted to Paracel Laboratories in Ottawa, Ontario for analysis of pH, water soluble sulphate, sulphides, chloride concentrations, resistivity and electrical conductivity. The analysis results are summarized in Table 5-11. Copies of the test results are provided in Appendix C.

Table 5-11: Results of Chemical Analysis

Sample	Depth (m)	pH	Resistivity (Ohm-cm)	Chloride ($\mu\text{g/g}$)	Sulphate ($\mu\text{g/g}$)	Sulphide (%)	Conductivity $\mu\text{S/cm}$
AND19-2 SS5	4.1	7.57	1740	227	116	0.2	576



6 MISCELLANEOUS

Borehole locations were selected by Thurber relative to existing site features and the existing culvert location. The as-drilled locations and ground surface elevation of the boreholes were surveyed by Thurber following completion of the field program. The elevation survey was carried out in reference to geodetic elevation benchmarks provided by the MTO.

Marathon Drilling of Greely, Ontario supplied and operated the drilling equipment and carried out the drilling, soil sampling, in-situ testing, standpipe installation and borehole decommissioning. The field investigation was supervised on a full-time basis by Mr. Michael Wong of Thurber. Overall supervision of the investigation program was provided by Mr. Justin Gray, P.Eng.

Routine geotechnical laboratory testing was completed by Thurber's laboratory in Ottawa, Ontario. Analytical testing was completed by Paracel Laboratories in Ottawa, Ontario. Unconfined Compressive Strength Testing of the bedrock and oedometer testing was carried out by Stantec Consulting Ltd. in its MTO-approved laboratory in Ottawa.

Overall project management and direction of the field program was provided by Dr. Fred Griffiths, P.Eng. Interpretation of the factual data and preparation of this report were carried out by Mr. Justin Gray, P.Eng. and by Dr. Fred Griffiths, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.



Justin Gray, P.Eng.
Geotechnical Engineer



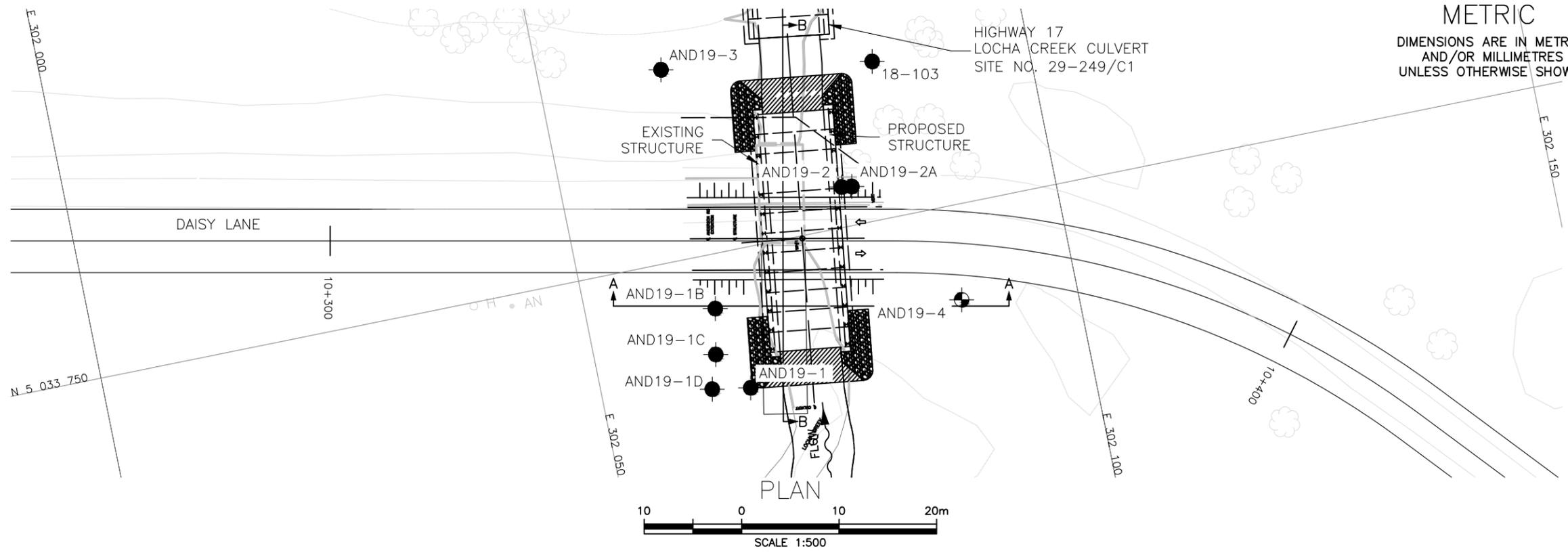
Dr. Fred Griffiths, Ph.D., P.Eng.
Senior Geotechnical Engineer



Dr. P.K. Chatterji, P.Eng.
MTO Review Principal,
Senior Geotechnical Engineer

Appendix A.

Borehole Location Plan and Stratigraphic Drawings



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

CONT No
WP No 4068-09-00

HIGHWAY 17
ANDERSON ROAD EXTENSION
LOCHA CREEK CULVERT
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

THURBER ENGINEERING LTD.



KEYPLAN

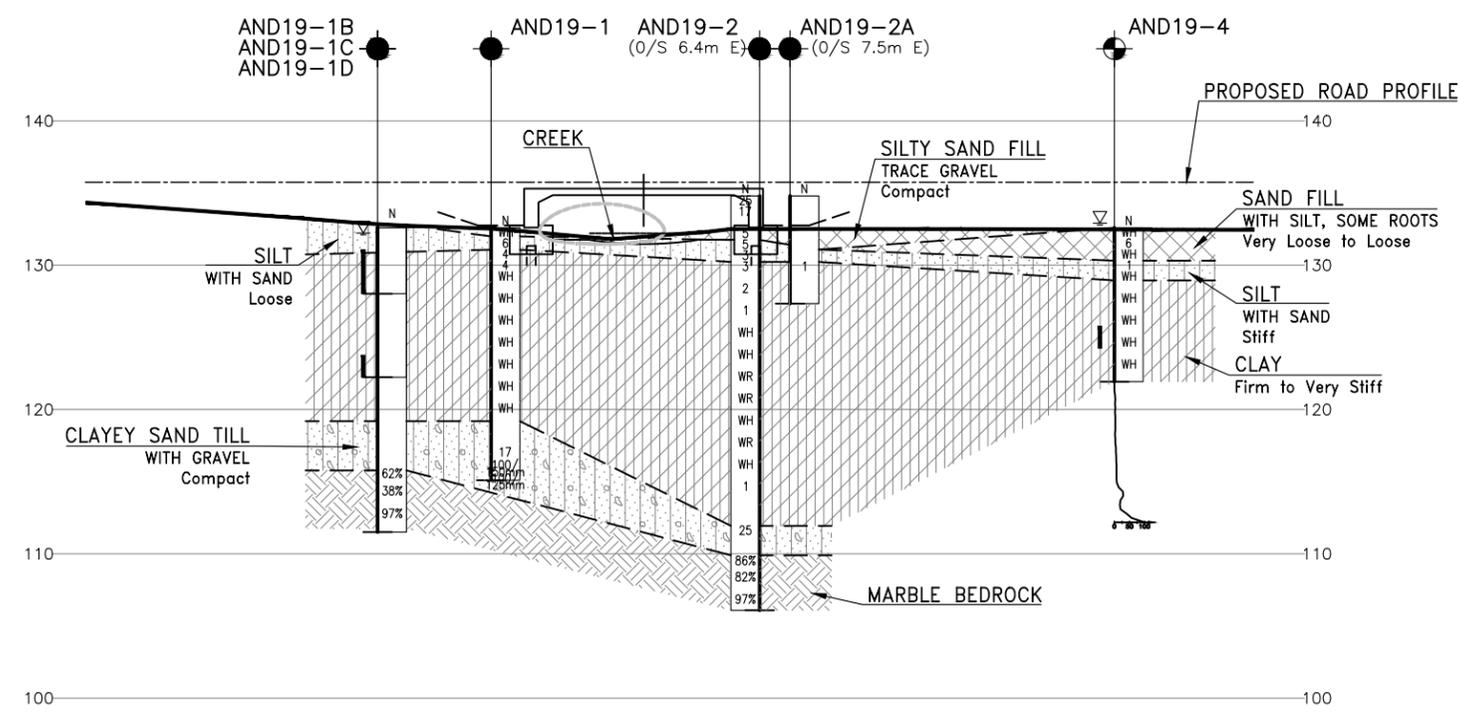
LEGEND

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

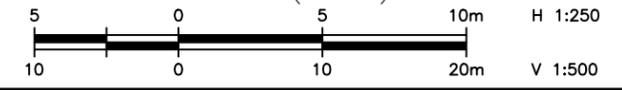
NO	ELEVATION	NORTHING	EASTING
AND19-1	132.6	5 033 735.8	302 065.1
AND19-1B	132.9	5 033 744.5	302 063.2
AND19-1C	132.9	5 033 739.8	302 062.3
AND19-1D	132.8	5 033 736.4	302 061.2
AND19-2	134.8	5 033 754.1	302 078.4
AND19-2A	134.8	5 033 753.9	302 079.4
AND19-3	133.7	5 033 769.5	302 062.6
AND19-4	132.6	5 033 740.3	302 088.1
18-103	133.9	5 033 766.1	302 084.0

- 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. Structural elements, surface details and features are for conceptual illustration.
 - Coordinate system is MTM NAD 83 Zone 9.

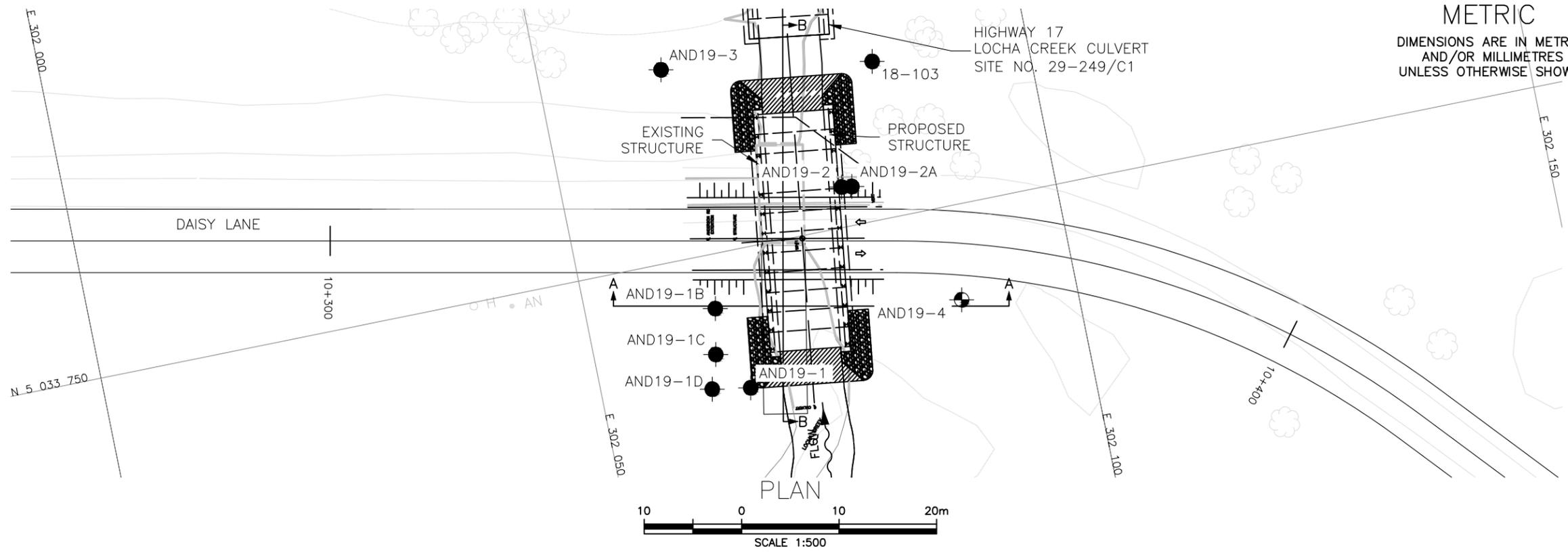
GEOCRES No. 31F-212



SECTION (A-A)



DATE	BY	DESCRIPTION
DESIGN	JG	CHK FJ
DRAWN	BH	CHK JG



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

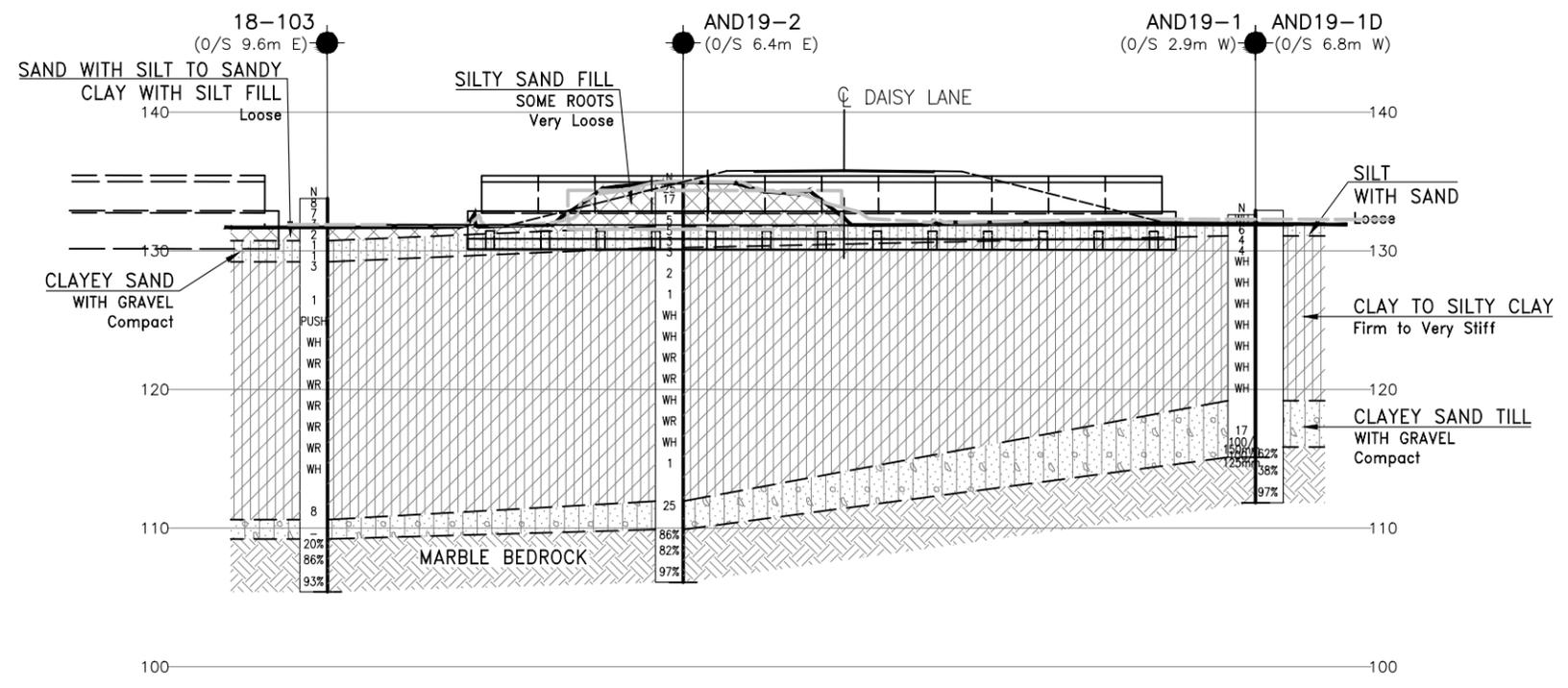
HIGHWAY 17
LOCHA CREEK CULVERT
SITE NO. 29-249/C1

CONT No
WP No 4068-09-00



HIGHWAY 17
ANDERSON ROAD EXTENSION
LOCHA CREEK CULVERT
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



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
AND19-1	132.6	5 033 735.8	302 065.1
AND19-1B	132.9	5 033 744.5	302 063.2
AND19-1C	132.9	5 033 739.8	302 062.3
AND19-1D	132.8	5 033 736.4	302 061.2
AND19-2	134.8	5 033 754.1	302 078.4
AND19-2A	134.8	5 033 753.9	302 079.4
AND19-3	133.7	5 033 769.5	302 062.6
AND19-4	132.6	5 033 740.3	302 088.1
18-103	133.9	5 033 766.1	302 084.0

- 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. Structural elements, surface details and features are for conceptual illustration.
 - Coordinate system is MTM NAD 83 Zone 9.

GEOCRES No. 31F-212



DATE	BY	DESCRIPTION
DESIGN	JG	CHK FJ
DRAWN	BH	CHK JG

Appendix B.

Record of Borehole Sheets



SYMBOLS, ABBREVIATIONS AND TERMS USED ON TEST HOLE RECORDS

TERMINOLOGY DESCRIBING COMMON SOIL GENESIS

Topsoil	mixture of soil and humus capable of supporting vegetative growth
Peat	mixture of fragments of decayed organic matter
Till	unstratified glacial deposit which may include particles ranging in sizes from clay to boulder
Fill	material below the surface identified as placed by humans (excluding buried services)

TERMINOLOGY DESCRIBING SOIL STRUCTURE:

Desiccated	having visible signs of weathering by oxidization of clay materials, shrinkage cracks, etc.
Fissured	having cracks, and hence a blocky structure
Varved	composed of alternating layers of silt and clay
Stratified	composed of alternating successions of different soil types, e.g. silt and sand
Layer	> 75 mm in thickness
Seam	2 mm to 75 mm in thickness
Parting	< 2 mm in thickness

RECOVERY:

For soil samples, the recovery is recorded as the length of the soil sample recovered.

N-VALUE:

Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 63.5 kg hammer falling 0.76 m, required to drive a 50 mm O.D. split spoon sampler 0.3 m into undisturbed soil. For samples where insufficient penetration was achieved and N-value cannot be presented, the number of blows are reported over the sampler penetration in millimetres (e.g. 50/75).

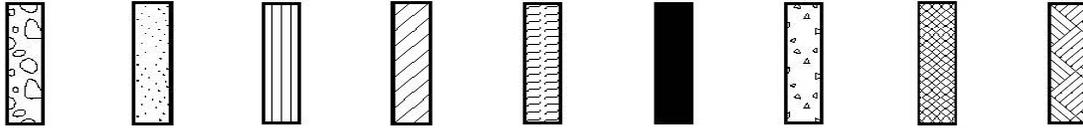
DYNAMIC CONE PENETRATION TEST (DCPT):

Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to an "A" size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone 0.3 m into the soil. The DCPT is used as a probe to assess soil variability.



STRATA PLOT:

Strata plots symbolize the soil and bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.



Boulders
Cobbles
Gravel Sand Silt Clay Organics Asphalt Concrete Fill Bedrock

TEXTURING CLASSIFICATION OF SOILS

Classification	Particle Size
Boulders	Greater than 200 mm
Cobbles	75 – 200 mm
Gravel	4.75 – 75 mm
Sand	0.075 – 4.75 mm
Silt	0.002 – 0.075 mm
Clay	Less than 0.002 mm

SAMPLE TYPES

SS	Split spoon samples
ST	Shelby tube or thin wall tube
DP	Direct push sample
PS	Piston sample
BS	Bulk sample
WS	Wash sample
HQ, NQ, BQ etc.	Rock core sample obtained with the use of standard size diamond coring equipment

TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

Descriptive Term	Undrained Shear Strength (kPa)
Very Soft	12 or less
Soft	12 – 25
Firm	25 – 50
Stiff	50 – 100
Very Stiff	100 – 200
Hard	Greater than 200

NOTE: Clay sensitivity is defined as the ratio of the undisturbed strength over the remolded strength.

TERMS DESCRIBING CONSISTENCY (COHESIONLESS SOILS ONLY)

Descriptive Term	SPT "N" Value
Very Loose	Less than 4
Loose	4 – 10
Compact	10 – 30
Dense	30 – 50
Very Dense	Greater than 50



MODIFIED UNIFIED SOIL CLASSIFICATION

Major Divisions		Group Symbol	Typical Description
COARSE GRAINED SOIL	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	SILT AND CLAY SOILS $W_L < 35\%$	ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clayey silts of low plasticity, gravelly clays, sandy clays.
		OL	Organic silts and organic silty-clays of low plasticity.
	SILT AND CLAY SOILS $35\% < W_L < 50\%$	MI	Inorganic compressible fine sandy silt with clay of medium plasticity, clayey silts.
		CI	Inorganic clays of medium plasticity, silty clays.
		OI	Organic silty clays of medium plasticity.
	SILT AND CLAY SOILS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy of silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other organic soils.

Note - W_L = Liquid Limit



EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION

Fresh (FR)	No visible signs of weathering.
Fresh Jointed (FJ)	Weathering limited to surface of major discontinuities.
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock materials.
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 structures are preserved.

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 0.1 m in length or larger, as a percentage of total core length
Unconfined Compressive Strength: (UCS)	Axial stress required to break the specimen.
Fracture Index: (FI)	Frequency of natural fractures per 0.3 m of core run.

DISCONTINUITY SPACING

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

STRENGTH CLASSIFICATION

Rock Strength	Approximate Uniaxial Compressive Strength (MPa)
Extremely Strong	Greater than 250
Very Strong	100 – 250
Strong	50 – 100
Medium Strong	25 – 50
Weak	5 – 25
Very Weak	1 – 5
Extremely Weak	0.25 – 1

RECORD OF BOREHOLE No AND19-1

2 OF 2

METRIC

WP# 4068-09-00 LOCATION Anderson Road, MTM Zone 9 N 5 033 735.8 E 302 065.1 ORIGINATED BY MW
 HWY 17 BOREHOLE TYPE CME 850 Track, NW Casing COMPILED BY MW
 DATUM Geodetic DATE 2019.07.22 - 2019.07.23 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60					
	Continued From Previous Page														
119.2	CLAYEY SILT to CLAY (CL to CI) Stiff Grey		10	SS	WH				5.7						
							122								
							121		5.0						
			11	SS	WH		120		3.5					0	2 37 61
13.4	Clayey SAND with gravel occasional cobbles Compact (TILL) -Artesian conditions encountered at 13.7 m -Poor sample recovery - Frequent cobbles below 16.8 m - Artesian pressure increase (Observed)		12	NQ											
							119								
							118								
			13	SS	17		117		4.8						
							116								
115.1	Casing Refusal		14	SS	100/ 150mm										
17.5	End of Borehole -Borehole terminated at bedrock surface due to artesian conditions, See AND19-1D for bedrock coring -Artesian head in casing at approx. 3.5 m above ground surface (elevation 136.1 m) upon completion		15	SS	100/ 125mm										

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

RECORD OF BOREHOLE No AND19-1B

2 OF 2

METRIC

WP# 4068-09-00 LOCATION Anderson Road, MTM Zone 9 N 5 033 744.5 E 302 063.2 ORIGINATED BY MW
 HWY 17 BOREHOLE TYPE CME 850 Track, NW Casing COMPILED BY MW
 DATUM Geodetic DATE 2019.07.25 - 2019.07.25 CHECKED BY FG

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							
122.5 10.4	Continued From Previous Page No sampling Cased to 10.4 m for well installation See AND19-1 for stratigraphy End of Borehole 0.6 m Stickup on well WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2019.08.23 0.5 132.4 2019.09.05 0.4 132.5 2019.11.25 0.1 above g.s. 133.0 2021.07.20 0.3 132.6														

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RECORD OF BOREHOLE No AND19-1C

1 OF 1

METRIC

WP# 4068-09-00 LOCATION Anderson Road, MTM Zone 9 N 5 033 739.8 E 302 062.3 ORIGINATED BY MW
 HWY 17 BOREHOLE TYPE CME 850 Track, NW Casing COMPILED BY MW
 DATUM Geodetic DATE 2019.07.25 - 2019.07.25 CHECKED BY FG

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 20 40 60 80 100								
						PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W _p W W _L WATER CONTENT (%) 20 40 60								
132.9 0.0	Ground Surface No sampling Cased to 4.6 m for well installation See AND19-1 for stratigraphy													
128.3 4.6	End of Borehole 0.9 m stickup on well WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2019.08.23 0.5 132.4 2019.09.05 0.3 132.6 2019.11.25 0.2 132.7 2021.07.20 0.1 132.8													

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RECORD OF BOREHOLE No AND19-1D

1 OF 3

METRIC

WP# 4068-09-00 LOCATION Anderson Road, MTM Zone 9 N 5 033 736.4 E 302 061.2 ORIGINATED BY MW
 HWY 17 BOREHOLE TYPE CME 850 Track, NW Casing COMPILED BY MW
 DATUM Geodetic DATE 2019.07.29 - 2019.07.29 CHECKED BY FG

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	20 40 60 80 100			20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT w		
132.8	Ground Surface												
0.0	No sampling of overburden Cased 17.1 m to bedrock surface See AND19-1 for stratigraphy												
							132						
							131						
							130						
							129						
							128						
							127						
							126						
							125						
							124						
							123						

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RECORD OF BOREHOLE No AND19-1D

2 OF 3

METRIC

WP# 4068-09-00 LOCATION Anderson Road, MTM Zone 9 N 5 033 736.4 E 302 061.2 ORIGINATED BY MW
 HWY 17 BOREHOLE TYPE CME 850 Track, NW Casing COMPILED BY MW
 DATUM Geodetic DATE 2019.07.29 - 2019.07.29 CHECKED BY FG

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			20	40	60					
	Continued From Previous Page														
	No sampling of overburden Cased 17.1 m to bedrock surface See AND19-1 for stratigraphy						122								
	-Artesian conditions encountered at 13.6 m						121								
							120								
							119								
							118								
							117								
							116								
115.7	MARBLE Freshly weathered Very Strong Close joint spacing Poor to excellent quality Coarse grained Grey to White -Occasional vertical fracture from 18 m to 19.5 m -Increased artesian flow after 19.5 m		1	Run			115						FI	RUN #1 TCR=97% SCR=69% RQD=62%	
17.1			2	Run				114							3
							113						3		

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+³, ×³: Numbers refer to Sensitivity
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RECORD OF BOREHOLE No AND19-1D

3 OF 3

METRIC

WP# 4068-09-00 LOCATION Anderson Road, MTM Zone 9 N 5 033 736.4 E 302 061.2 ORIGINATED BY MW
 HWY 17 BOREHOLE TYPE CME 850 Track, NW Casing COMPILED BY MW
 DATUM Geodetic DATE 2019.07.29 - 2019.07.29 CHECKED BY FG

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									
	Continued From Previous Page					20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W _p — W — W _L				
						20 40 60 80 100 WATER CONTENT (%)					20 40 60				
111.7	MARBLE BEDROCK Freshly weathered Very Strong Close joint spacing Poor to excellent quality Coarse grained White		3	Run									1	RUN #3 TCR=98% SCR=92% RQD=97%	
21.1	End of Borehole -Artesian head in casing at approx. 3.5 m above ground surface (elevation 136.1 m) upon completion												1		

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RECORD OF BOREHOLE No AND19-2

1 OF 3

METRIC

WP# 4068-09-00 LOCATION Anderson Road, MTM Zone 9 N 5 033 754.1 E 302 078.4 ORIGINATED BY MW
 HWY 17 BOREHOLE TYPE CME 850 Track, NW Casing COMPILED BY MW
 DATUM Geodetic DATE 2019.08.01 - 2019.08.02 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE							
134.8	Ground Surface														
0.0	Silty SAND, trace gravel Compact Brown (FILL)		1	SS	25									7 79 14 (SI+CL)	
			2	SS	17										
			3	SS	5										
131.8	Silty SAND (SM) with gravel, some clay, trace roots Very Loose to Loose Grey-Brown		4	SS	5									19 37 28 16	
			5	SS	3										
130.2	CLAYEY SILT to CLAY (CL to CI) Firm to Stiff Grey		6	SS	3									0 6 57 37	
			7	SS	2										
			8	SS	1										
			9	SS	WH										

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

RECORD OF BOREHOLE No AND19-2A

1 OF 1

METRIC

WP# 4068-09-00 LOCATION Anderson Road, MTM Zone 9 N 5 033 753.9 E 302 079.4 ORIGINATED BY MJJ
 HWY 17 BOREHOLE TYPE CME 45 Trackmount, HSA COMPILED BY JP
 DATUM Geodetic DATE 2019.09.30 - 2019.09.30 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
							20 40 60 80 100								
134.8	Ground Surface														
0.0	No sampling from 0 m to 4.6 m See AND19-2 for stratigraphy														
130.2	CLAYEY SILT (CL), trace sand Very Loose Grey		1	SS	1										
4.6			1	ST											
			2	ST											
127.3	End of Borehole														
7.5															

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RECORD OF BOREHOLE No AND19-3

2 OF 3

METRIC

WP# 4068-09-00 LOCATION Anderson Road, MTM Zone 9 N 5 033 769.5 E 302 062.6 ORIGINATED BY MW
 HWY 17 BOREHOLE TYPE CME 850 Track, NW Casing COMPILED BY MW
 DATUM Geodetic DATE 2019.07.30 - 2019.07.30 CHECKED BY FG

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			20	40	60					
	Continued From Previous Page														
	CLAYEY SILT to CLAY (CL to CI) Firm to Very Stiff Grey														
			9	SS	WH										0 0 64 36
			10	SS	WH										
			11	SS	WH										
			12	SS	WH										
			13	SS	WH										
			14	SS	WH										0 2 52 46
113.9															
19.8	Clayey SAND (SC) with gravel														

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Continued Next Page

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

RECORD OF BOREHOLE No AND19-3

3 OF 3

METRIC

WP# 4068-09-00 LOCATION Anderson Road, MTM Zone 9 N 5 033 769.5 E 302 062.6 ORIGINATED BY MW
 HWY 17 BOREHOLE TYPE CME 850 Track, NW Casing COMPILED BY MW
 DATUM Geodetic DATE 2019.07.30 - 2019.07.30 CHECKED BY FG

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			W _p	W	W _L
	Continued From Previous Page		15	SS	13												
112.4	Clayey SAND (SC) with gravel Compact Grey (TILL)																23 30 30 17
21.3	Casing refusal																
	End of Borehole																
	-Artesian head in casing at approx. 2.3 m above ground surface (elevation 136.0 m) upon completion																

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RECORD OF BOREHOLE No AND19-4

2 OF 3

METRIC

WP# 4068-09-00 LOCATION Anderson Road, MTM Zone 9 N 5 033 740.3 E 302 088.1 ORIGINATED BY MW
 HWY 17 BOREHOLE TYPE CME 850 Track, NW Casing COMPILED BY MW
 DATUM Geodetic DATE 2019.07.31 - 2019.07.31 CHECKED BY FG

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			20	40	60					
121.9	CLAYEY SILT (CL) Firm to Stiff Grey						122								
10.7	End of Borehole DCPT completed from 10.7 m to 20.4 m														

Continued Next Page

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

ONTMT4S 24726 ANDERSON ROAD.GPJ 2012TEMPLATE(MTO).GDT 21/7/21

RECORD OF BOREHOLE No AND19-4

3 OF 3

METRIC

WP# 4068-09-00 LOCATION Anderson Road, MTM Zone 9 N 5 033 740.3 E 302 088.1 ORIGINATED BY MW
 HWY 17 BOREHOLE TYPE CME 850 Track, NW Casing COMPILED BY MW
 DATUM Geodetic DATE 2019.07.31 - 2019.07.31 CHECKED BY FG

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					
	Continued From Previous Page															
112.2	DCPT continued															
20.4	DCPT Refusal															
	0.9 m Stickup on piezometer															
	WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2019.08.23 0.5 above g.s. 133.1 2019.09.05 0.3 above g.s. 132.9 2019.11.25 0.4 above g.s. 133.0 2021.07.20 >2.1 above g.s. >134.7															

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RECORD OF BOREHOLE No 18-103

2 OF 3

METRIC

GWP# 4061-17-00 LOCATION Lat: 45.4438208°, Long: -76.5347193° MTO Zone 9: N 5 033 766.1 E 302 084.0 ORIGINATED BY CM
 HWY 17 BOREHOLE TYPE HSA / NW / NQ COMPILED BY KP
 DATUM Geodetic DATE 2018.06.14 - 2018.06.15 CHECKED BY PC

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			20	40	60					
	Continued From Previous Page														
	CLAY (CL) Firm to stiff		10	SS	WH										
							123	5.1							
								12.0							
			11	SS	WR		122							1 3 57 39	
								13.0							
							121	7.7							
			12	SS	WR		120								
	- becomes stiff below 14 m							5.2							
								10.0							
			13	SS	WR		119								
								7.4							
							118	5.8							
			14	SS	WR		117								
								6.0							
								4.0							
			15	SS	WR		116								
								3.5							
							115	8.0							
			16	SS	WH		114								

DOUBLE LINE LOCHA CREEK REPLACEMENT.GPJ_2012TEMPLATE(MTO).GDT 29/11/19

Continued Next Page

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

RECORD OF BOREHOLE No 18-103

3 OF 3

METRIC

GWP# 4061-17-00 LOCATION Lat: 45.4438208°, Long: -76.5347193° MTO Zone 9: N 5 033 766.1 E 302 084.0 ORIGINATED BY CM
 HWY 17 BOREHOLE TYPE HSA / NW / NQ COMPILED BY KP
 DATUM Geodetic DATE 2018.06.14 - 2018.06.15 CHECKED BY PC

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			20	40	60	80					
Continued From Previous Page																
110.7	CLAY (CL) Stiff															
	- fine sand seams below 22 m		17	SS	8										7 22 41 30	
23.2	Silty Clayey SAND with Gravel TILL Grey Wet															
	- cored 160 mm cobble at 24 m		1	RUN	-											
109.3	MARBLE BEDROCK Freshly weathered Very strong Close joint spacing Poor to excellent quality Coarse grained White															
			2	RUN										FI	RUN #2 TCR=92% SCR=65% RQD=20%	
			3	RUN										1	RUN #3 TCR=94% SCR=91% RQD=86%	
			4	RUN										1	RUN #4 TCR=100% SCR=100% RQD=93% UCS=156MPa	
105.5	End of Borehole Groundwater rose to at least 2.4 m above existing grade (elev. 136.3 m) on 2018-06-15, just prior to decommissioning															
28.4																

DOUBLE LINE LOCHA CREEK REPLACEMENT.GPJ_2012TEMPLATE(MTO).GDT_29/11/19

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

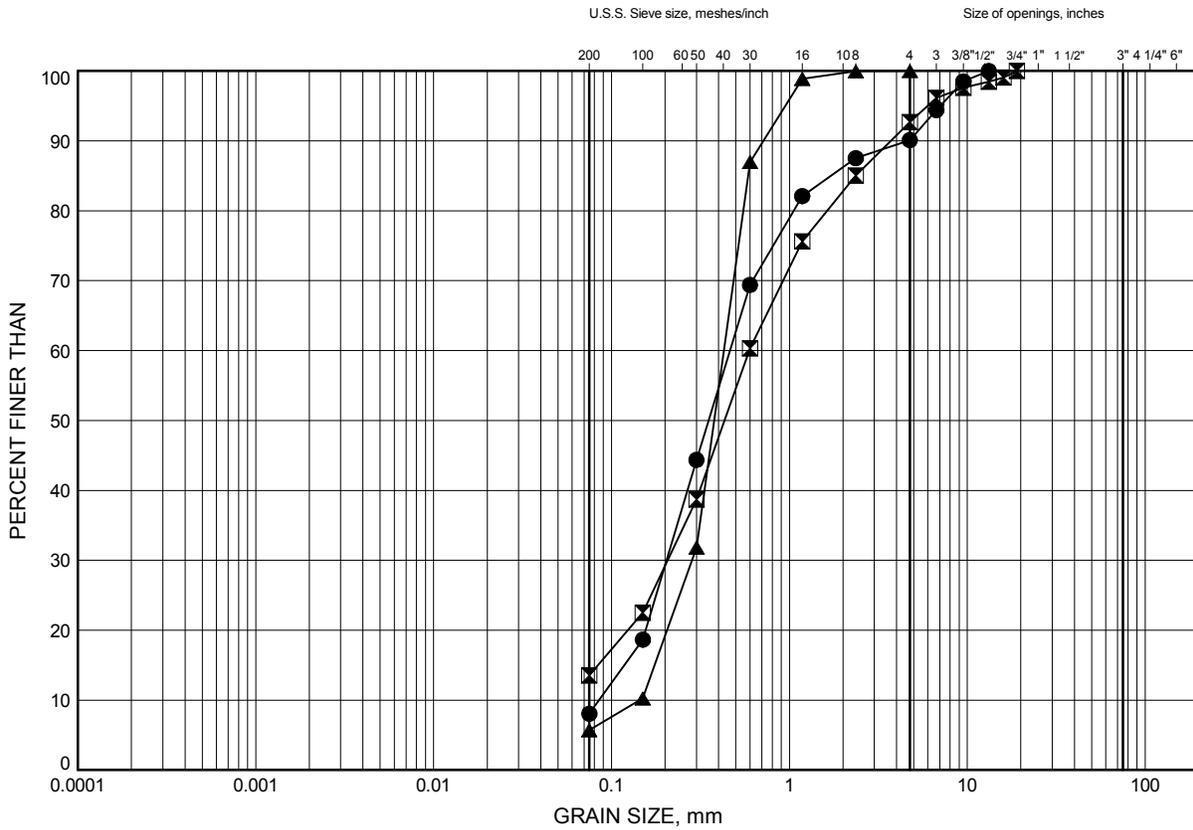
Appendix C.
Laboratory Testing

Appendix C.1
Particle Size Analysis Figures
Atterberg Limit Test Results
One-Dimensional Consolidation Test Results

Anderson Road Culvert
GRAIN SIZE DISTRIBUTION

FIGURE C1

FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-103	0.3	133.6
⊠	AND19-2	0.3	134.5
▲	AND19-4	1.1	131.5

GRAIN SIZE DISTRIBUTION - THURBER 24726 ANDERSON ROAD.GPJ 12/12/19

Date December 2019
 WP# 4068-09-00

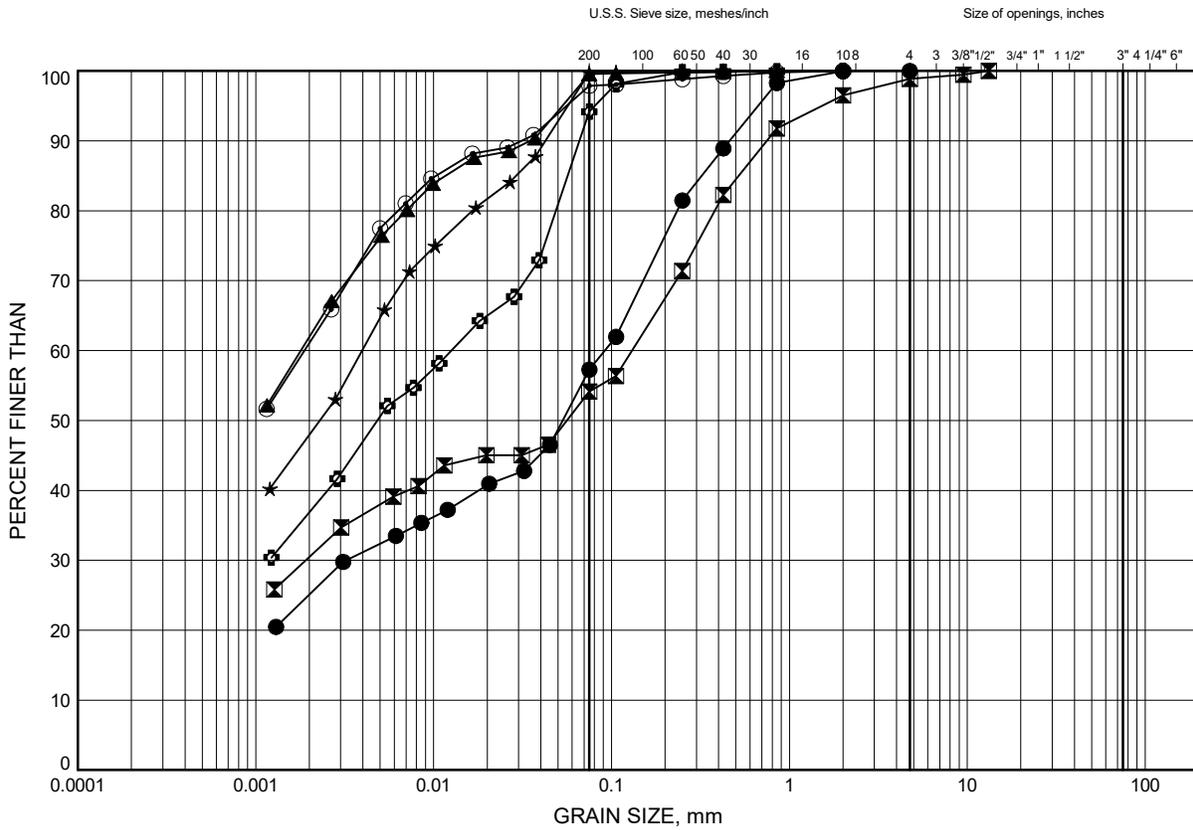


Prep'd JG
 Chkd. FG

Anderson Road Culvert
GRAIN SIZE DISTRIBUTION

FIGURE C3

Clayey SILT to CLAY (CL to CH)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-103	3.4	130.5
⊠	18-103	4.1	129.8
▲	AND19-1	2.6	130.0
★	AND19-1	6.4	126.2
⊙	AND19-1	12.5	120.1
⊕	AND19-2	4.9	129.9

GRAIN SIZE DISTRIBUTION - THURBER 24726 ANDERSON ROAD.GPJ 21/7/21

Date July 2021
 WP# 4068-09-00

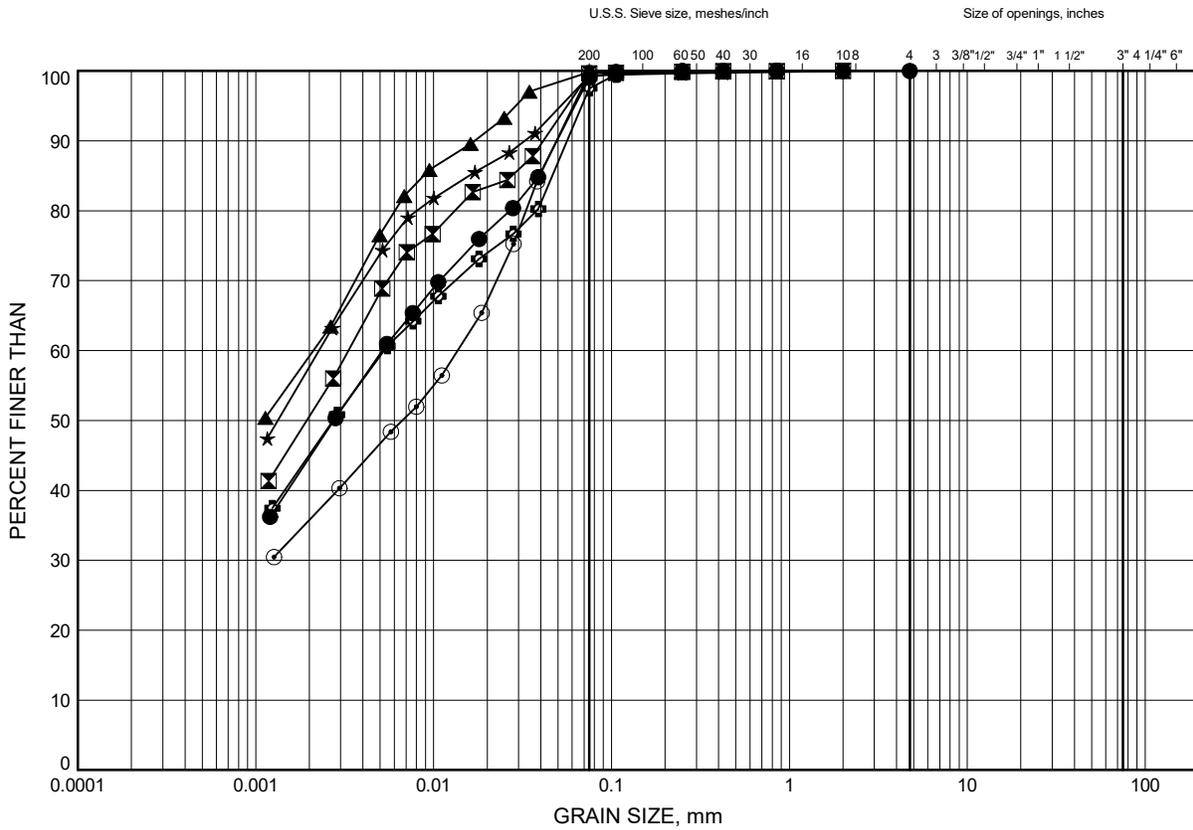


Prep'd JG
 Chkd. FG

Anderson Road Culvert
GRAIN SIZE DISTRIBUTION

FIGURE C4

Clayey SILT to CLAY (CL to CH)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	AND19-2	12.5	122.3
⊠	AND19-2	20.1	114.7
▲	AND19-2A	7.2	127.6
★	AND19-3	3.4	130.3
⊙	AND19-3	11.0	122.7
⊕	AND19-3	18.6	115.1

GRAIN SIZE DISTRIBUTION - THURBER 24726 ANDERSON ROAD.GPJ 21/7/21

Date July 2021
 WP# 4068-09-00

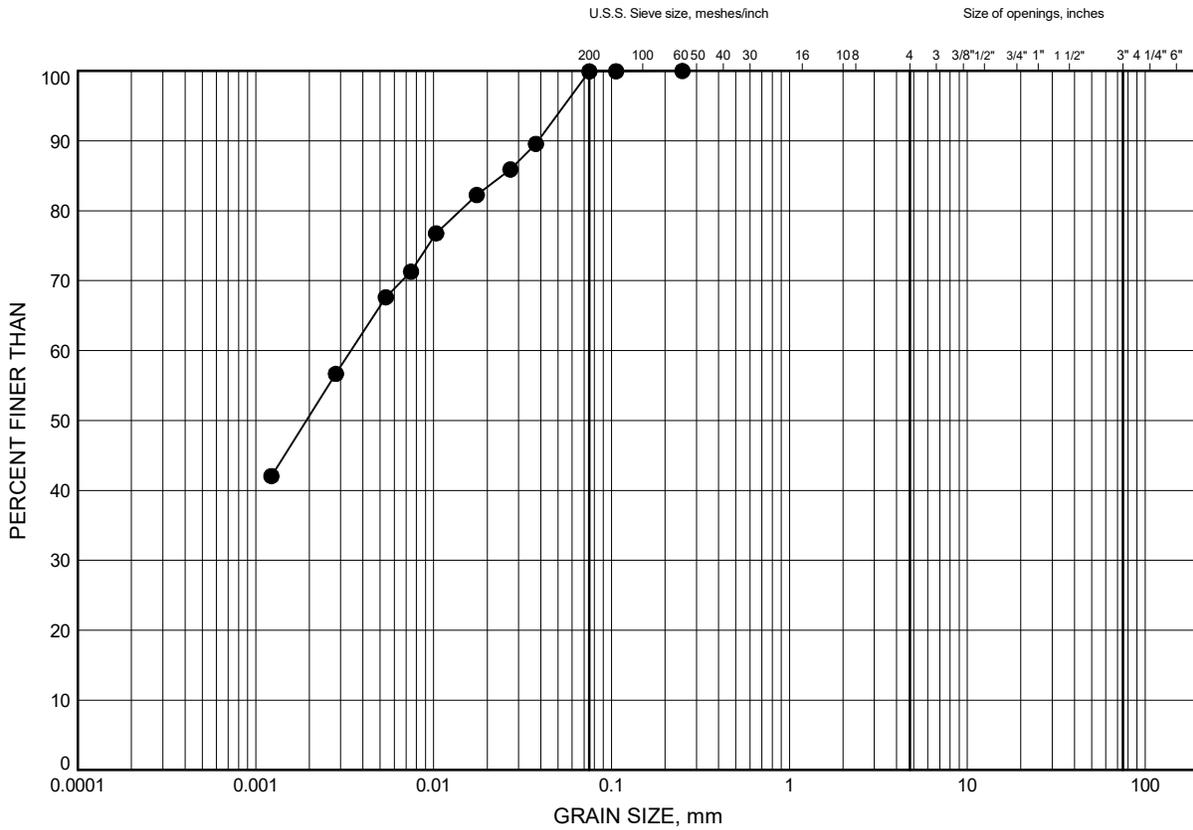


Prep'd JG
 Chkd. FG

Anderson Road Culvert
GRAIN SIZE DISTRIBUTION

FIGURE C5

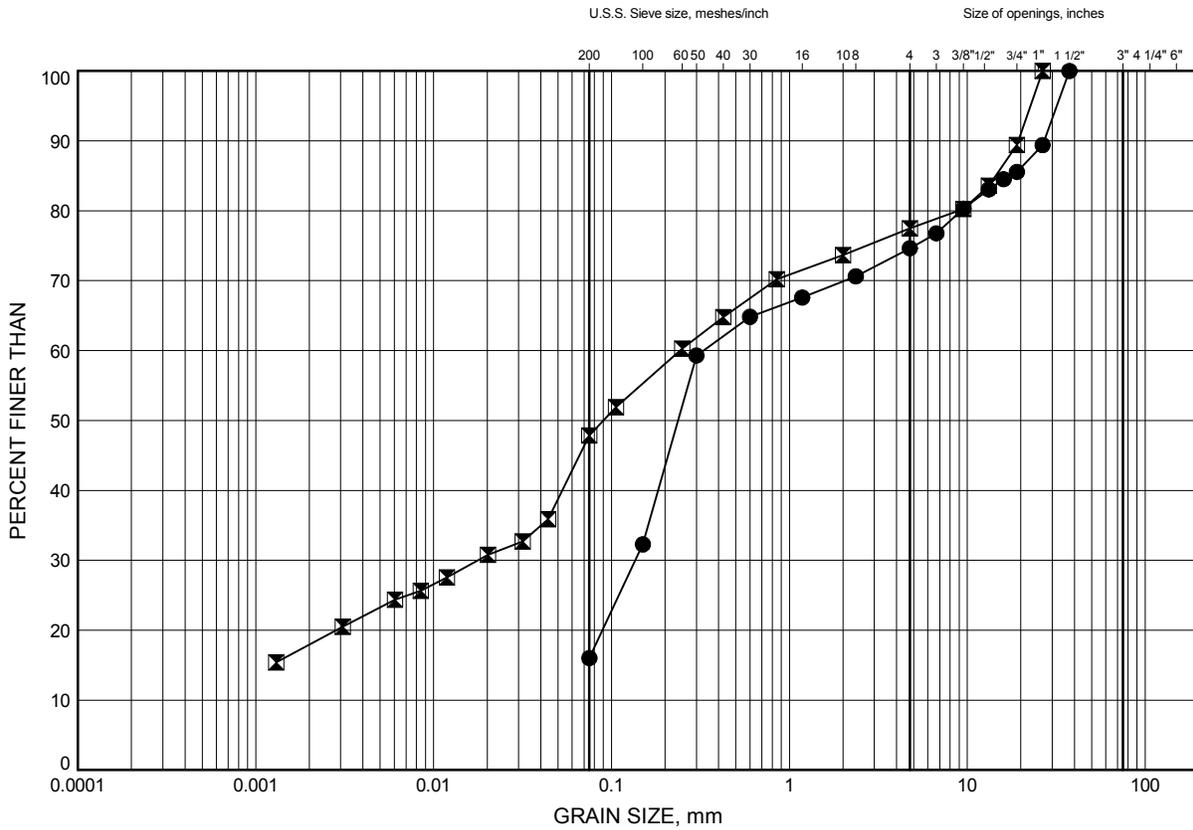
Clayey SILT to CLAY (CL to CH)



Anderson Road Culvert
GRAIN SIZE DISTRIBUTION

FIGURE C6

Glacial TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	AND19-2	23.2	111.6
⊠	AND19-3	20.1	113.6

GRAIN SIZE DISTRIBUTION - THURBER 24726 ANDERSON ROAD.GPJ 12/12/19

Date December 2019
 WP# 4068-09-00

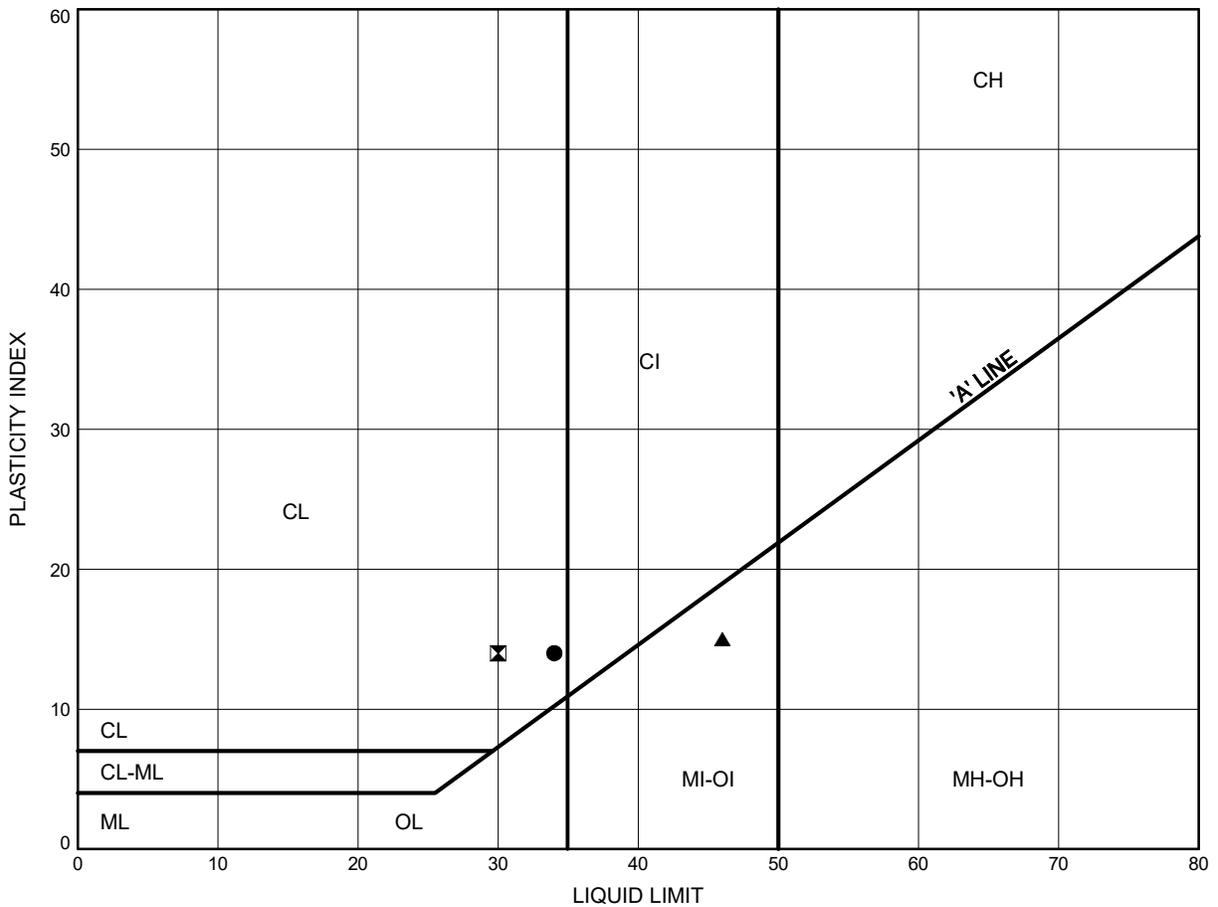


Prep'd JG
 Chkd. FG

Anderson Road Culvert
ATTERBERG LIMITS TEST RESULTS

FIGURE C7

Silty SAND (SM) to SILT with Sand (ML) to Sandy Clayey SILT (CL)



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-103	3.4	130.5
⊠	18-103	4.1	129.8
▲	AND19-2	3.4	131.4

THURBALT 24726 ANDERSON ROAD.GPJ 4/3/21

Date .. March 2021 ..
 WP# .. 4068-09-00 ..

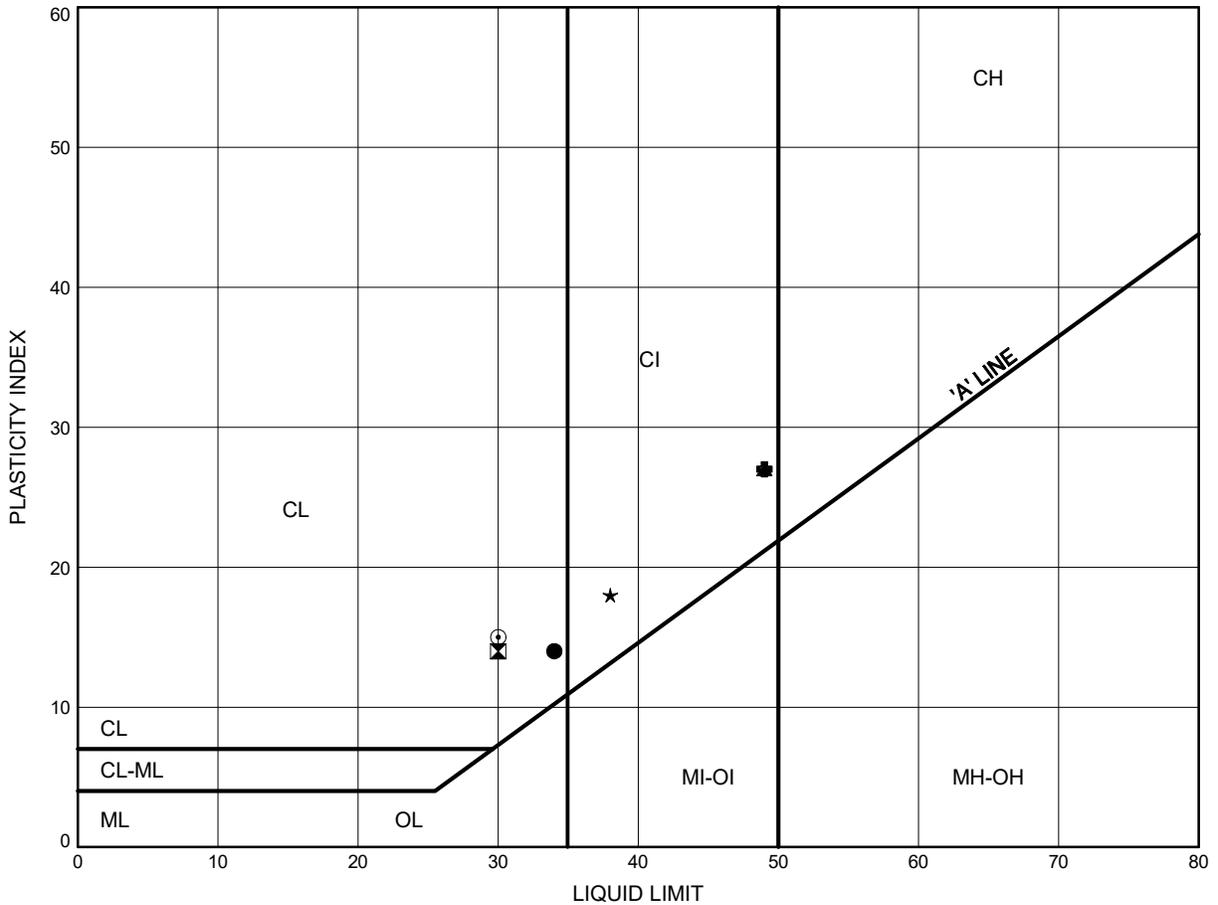


Prep'd JG
 Chkd. FG

Anderson Road Culvert
ATTERBERG LIMITS TEST RESULTS

FIGURE C8

Clayey SILT to CLAY (CL to CH)



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-103	3.4	130.5
⊠	18-103	4.1	129.8
▲	AND19-1	2.6	130.0
★	AND19-1	6.4	126.2
⊙	AND19-1	12.5	120.1
⊕	AND19-2	4.9	129.9

THURBALT 24726 ANDERSON ROAD.GPJ 2/17/21

Date July 2021
 WP# 4068-09-00

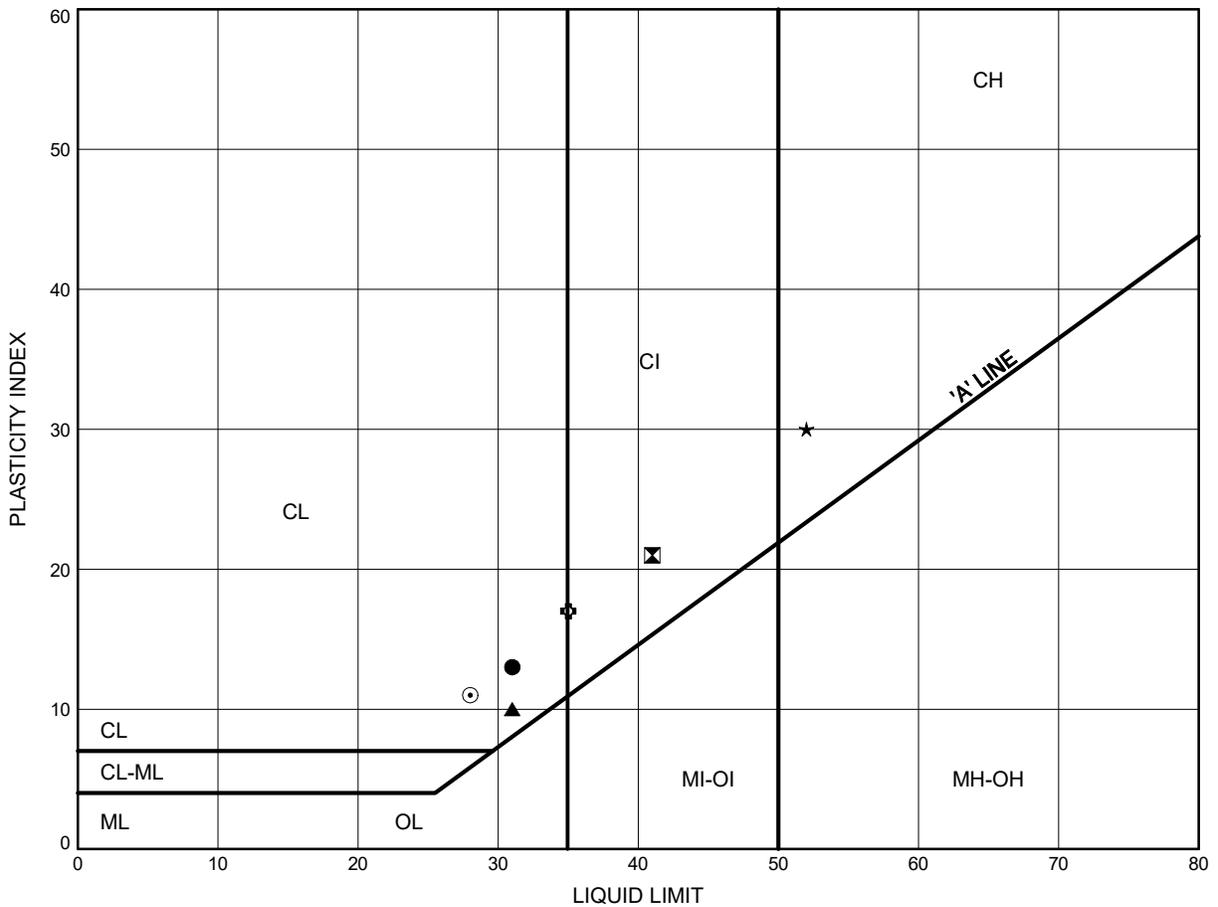


Prep'd JG
 Chkd. FG

Anderson Road Culvert
ATTERBERG LIMITS TEST RESULTS

FIGURE C9

Clayey SILT to CLAY (CL to CH)



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	AND19-2	12.5	122.3
⊠	AND19-2	20.1	114.7
▲	AND19-2A	7.2	127.6
★	AND19-3	3.4	130.3
⊙	AND19-3	11.0	122.7
⊕	AND19-3	18.6	115.1

THURBALT 24726 ANDERSON ROAD.GPJ 2/17/21

Date July 2021
 WP# 4068-09-00

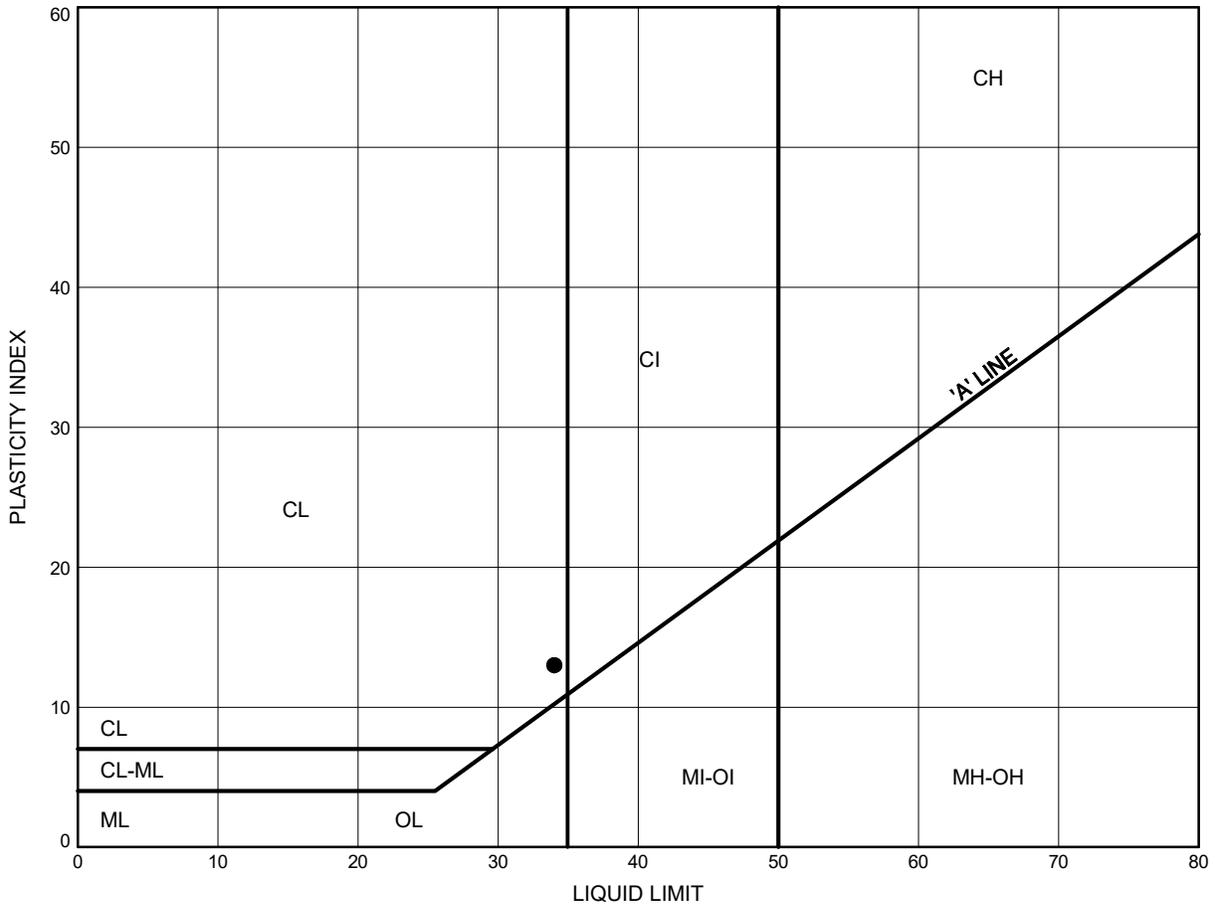


Prep'd JG
 Chkd. FG

Anderson Road Culvert
ATTERBERG LIMITS TEST RESULTS

FIGURE C10

Clayey SILT to CLAY (CL to CH)



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	AND19-4	6.4	126.2

THURBALT 24726 ANDERSON ROAD.GPJ 2/17/21

Date July 2021
 WP# 4068-09-00

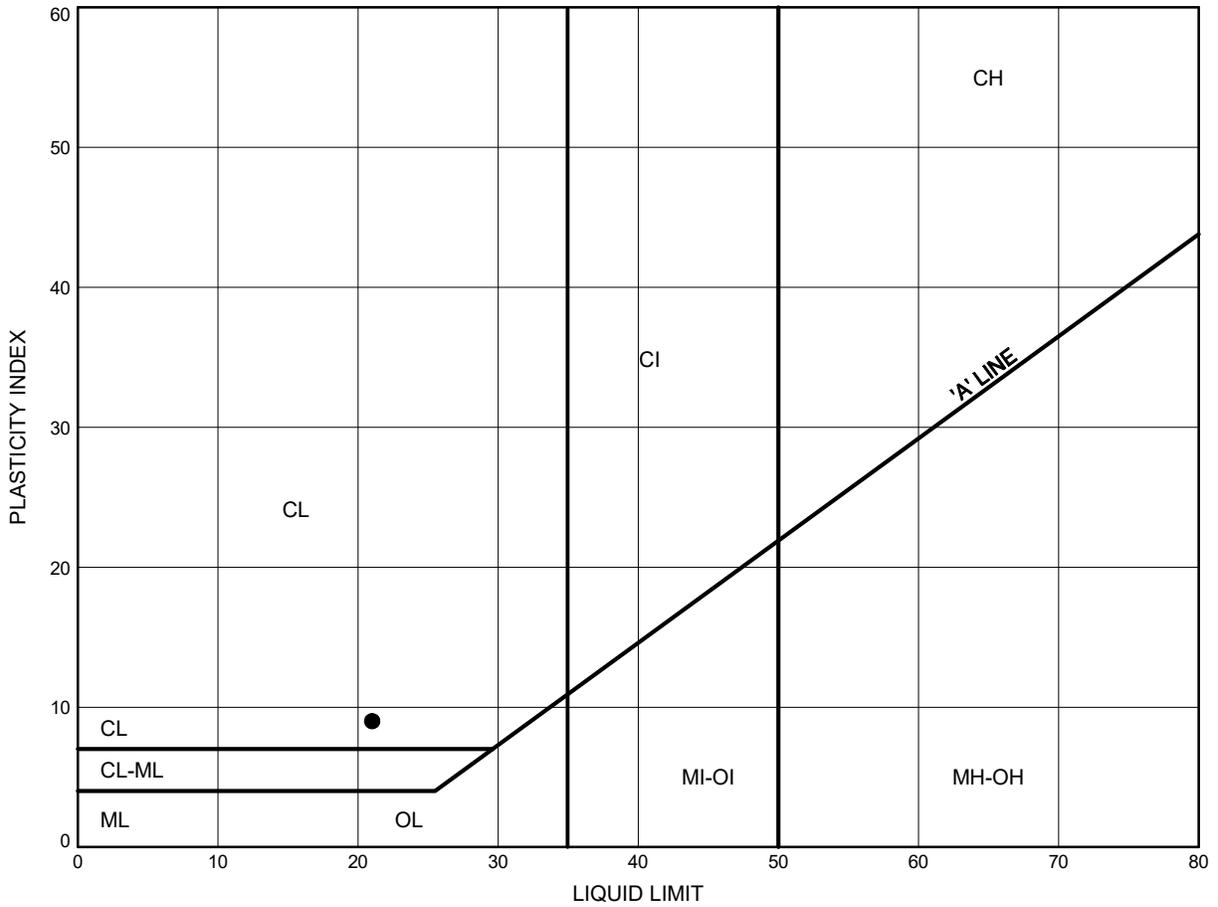


Prep'd JG
 Chkd. FG

Anderson Road Culvert
ATTERBERG LIMITS TEST RESULTS

FIGURE C11

Glacial TILL



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	AND19-3	20.1	113.6

THURBALT 24726 ANDERSON ROAD.GPJ 4/3/21

Date March 2021
 WP# 4068-09-00



Prep'd JG
 Chkd. FG



Stantec Consulting Ltd.
400 - 1331 Clyde Avenue, Ottawa ON K2C 3G4

November 1, 2017
File: 122410864

Attention: Kenton Power
Thurber Engineering Ltd.
104 – 2460 Lancaster Road
Ottawa, Ontario, Canada, K1B 4S5
Tel: 613-274-2121
E-mail: kpower@thurber.ca

Dear Mr. Power,

**Reference: Consolidation Test Results for Lochiel Project, Thurber Consulting Ltd.,
File #20482: BH 17-3, ST 17 & BH 17-2, ST 9, sampled on September 12 & 25, 2017**

This letter presents the results of one-dimensional consolidation tests carried out on the above referenced samples in accordance with ASTM D2435/D2435M - 11. The test results are provided in the attached tables and figures.

This letter provides test results only and does not constitute any interpretation or engineering recommendations with respect to material suitability or specification compliance.

We trust the information presented herein meets your present requirements. Should you have any questions or require additional information, please do not hesitate to contact us.

Regards,

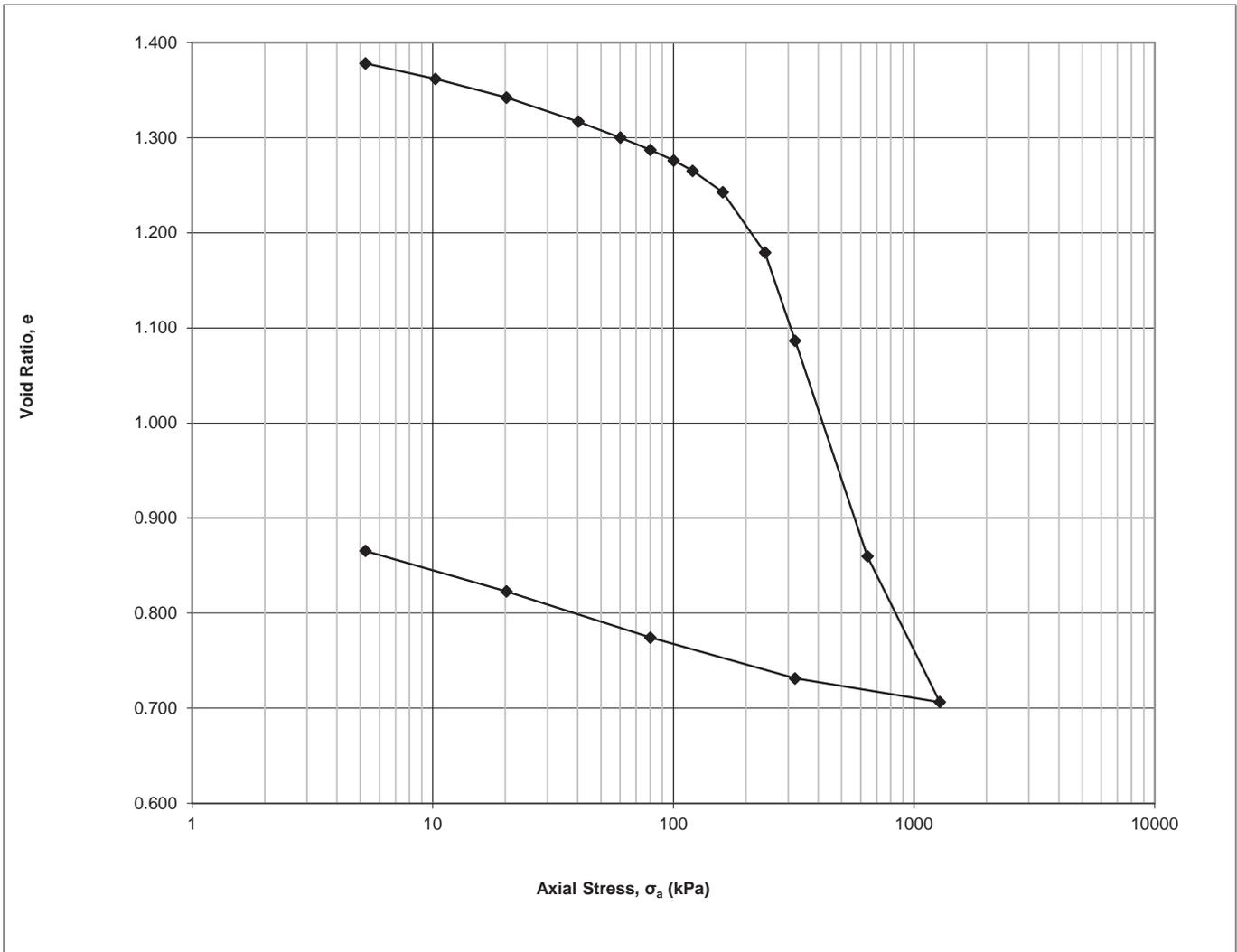
STANTEC CONSULTING LTD.

A handwritten signature in blue ink, appearing to read "Ramy Saadeldin", written over a horizontal line.

Ramy Saadeldin, Ph.D., P.Eng.
Geotechnical Engineering
Phone: (613) 738-6047
Fax: (613) 722-2799
Ramy.Saadeldin@stantec.com

Project
Project No.
Borehole No.
Sample No.
Sample Depth

Thurber Engineering, File# 20482
122410864
17-3
ST 17
50-52 ft



One-Dimensional Consolidation Test using Incremental Loading
ASTM D2435/D2435M - 11

1-Nov-17
1-Nov-17

Date:
Date:

D. Boateng
R. Hache

Checked by:
Approved by:

Specimen Details

Project Name	Thurber Engineering, File# 20482
Project Location	Lochiel, ON
Borehole	17-3
Sample No.	ST 17
Depth	50-52 ft
Sample Date	September 12, 2017
Test Number	One
Technician Name	Daniel Boateng

Soil Description & Classification

Not Requested	
Specific Gravity of Solids	2.746
Average water content of trimmings %	49
Additional Notes (information source, occurrence and size of large isolated particles etc.)	

Initial Specimen Conditions

Height	mm	20.00
Diameter	mm	50.00
Area	mm ²	1963
Volume	mm ³	39270
Mass	g	67.42
Dry Mass	g	45.26
Density	Mg/m ³	1.717
Dry Density	Mg/m ³	1.153
Water Content	%	48.96
Degree of Saturation	%	97.2
Height of Solids	mm	8.39
Initial Void Ratio		1.383

Final Specimen Conditions

Water Content	%	33.74
Final Void Ratio		0.865

One-Dimensional Consolidation Test using Incremental Loading
ASTM D2435/D2435M - 11

1-Nov-17
1-Nov-17

Date:
Date:

D. Boateng
R. Hache

Specimen Details

Project Name	Thurber Engineering, File# 20482
Project Location	Lochiel, ON
Borehole	17-3
Sample No.	ST 17
Depth	50-52 ft
Sample Date	September 12, 2017
Test Number	One
Technician Name	Daniel Boateng

Checked by:
Approved by:

Test Procedure

Date Started	October 30, 2017
Date Finished	November 1, 2017
Machine Number	Frame C
Cell Number	C
Ring Number	C
Trimming Procedure	Turntable
Moisture Condition	Inundated
Axial Stress at Inundation	5 kPa
Water Used	Distilled
Test Method	B
Interpretation Procedure for c_v	2

All Departures from Outlined ASTM D2435/D2435M-11 Procedure

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Filename:
Date:

1-Nov-17

Calculations

Load Increment	Increment Duration min	Axial Stress σ_a kPa	Corrected Deformation ΔH mm	Specimen Height H mm	Axial Strain ϵ_a %	Void Ratio e
Seating	0.0	5	0.0000	20.0000	0.00	1.383
1	10.0	5	0.0372	19.9628	0.19	1.378
2	16.5	10	0.1754	19.8246	0.88	1.362
3	18.3	20	0.3391	19.6609	1.70	1.342
4	19.8	40	0.5514	19.4486	2.76	1.317
5	21.5	60	0.6935	19.3065	3.47	1.300
6	29.8	80	0.8005	19.1995	4.00	1.287
7	29.8	100	0.8948	19.1052	4.47	1.276
8	36.5	120	0.9858	19.0142	4.93	1.265
9	53.0	160	1.1741	18.8259	5.87	1.243
10	116.5	240	1.7085	18.2915	8.54	1.179
11	168.8	320	2.4859	17.5141	12.43	1.086
12	128.8	640	4.3883	15.6117	21.94	0.860
13	95.3	1280	5.6756	14.3244	28.38	0.706
14	18.3	320	5.4660	14.5340	27.33	0.731
15	36.8	80	5.1055	14.8945	25.53	0.774
16	63.5	20	4.6979	15.3021	23.49	0.823
17	103.8	5	4.3408	15.6592	21.70	0.865

One-Dimensional Consolidation Test using Incremental Loading
ASTM D2435/D2435M - 11

1-Nov-17
1-Nov-17

Date:
Date:

D. Boateng
R. Hache

Checked by:
Approved by:

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1-Nov-17

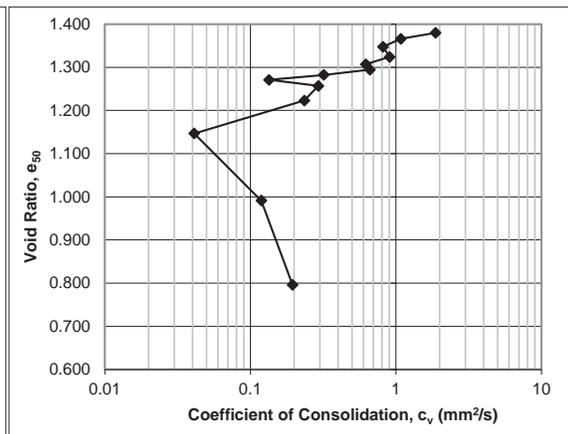
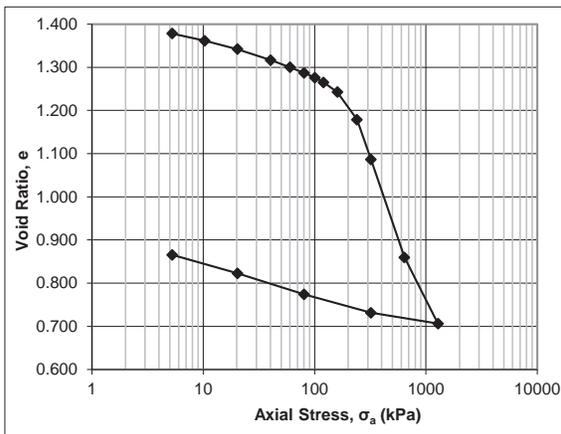
Filename:
Date:

Specimen Details

Project Name	Thurber Engineering, File# 20482
Project Location	Lochiel, ON
Borehole	17-3
Sample No.	ST 17
Depth	50-52 ft
Sample Date	September 12, 2017
Test Number	One
Technician Name	Daniel Boateng

Calculations

Load Increment	Axial Stress $\sigma_{a, average}$ kPa	Calculated using Interpretation Procedure 2				Interpretation Procedure 1		Interpretation Procedure 2	
		Corrected Deformation ΔH_{50} mm	Specimen Height H_{50} mm	Axial Strain $\epsilon_{a,50}$ %	Void Ratio e_{50}	Time t_{50} sec	Coeff. Consol. c_v mm ² /s	Time t_{90} sec	Coeff. Consol. c_v mm ² /s
Seating	3								
1	5	0.0226	19.9774	0.11	1.380			45	1.87E+00
2	8	0.1394	19.8606	0.70	1.366			77	1.08E+00
3	15	0.2925	19.7075	1.46	1.348			101	8.13E-01
4	30	0.4904	19.5096	2.45	1.324			89	9.05E-01
5	50	0.6325	19.3675	3.16	1.307			128	6.20E-01
6	70	0.7391	19.2609	3.70	1.295			119	6.62E-01
7	90	0.8403	19.1597	4.20	1.282			244	3.19E-01
8	110	0.9366	19.0634	4.68	1.271			575	1.34E-01
9	140	1.0537	18.9463	5.27	1.257			260	2.93E-01
10	200	1.3376	18.6624	6.69	1.223			314	2.35E-01
11	280	1.9795	18.0205	9.90	1.147			1673	4.11E-02
12	480	3.2838	16.7162	16.42	0.991			497	1.19E-01
13	960	4.9221	15.0779	24.61	0.796			247	1.95E-01
14	800	5.5093	14.4907	27.55	0.726				
15	200	5.2302	14.7698	26.15	0.760				
16	50	4.8678	15.1322	24.34	0.803				
17	13	4.6825	15.3175	23.41	0.825				





Project No.: 122410864

Project Name: Thurber, File # 20482

Photo Log

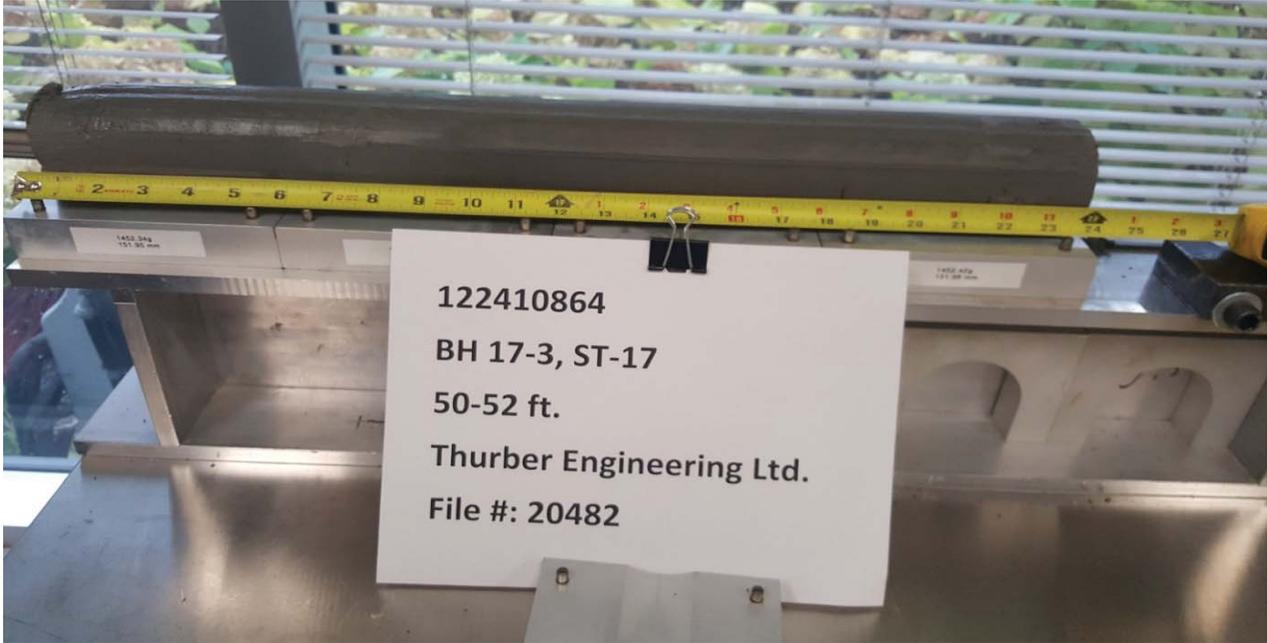


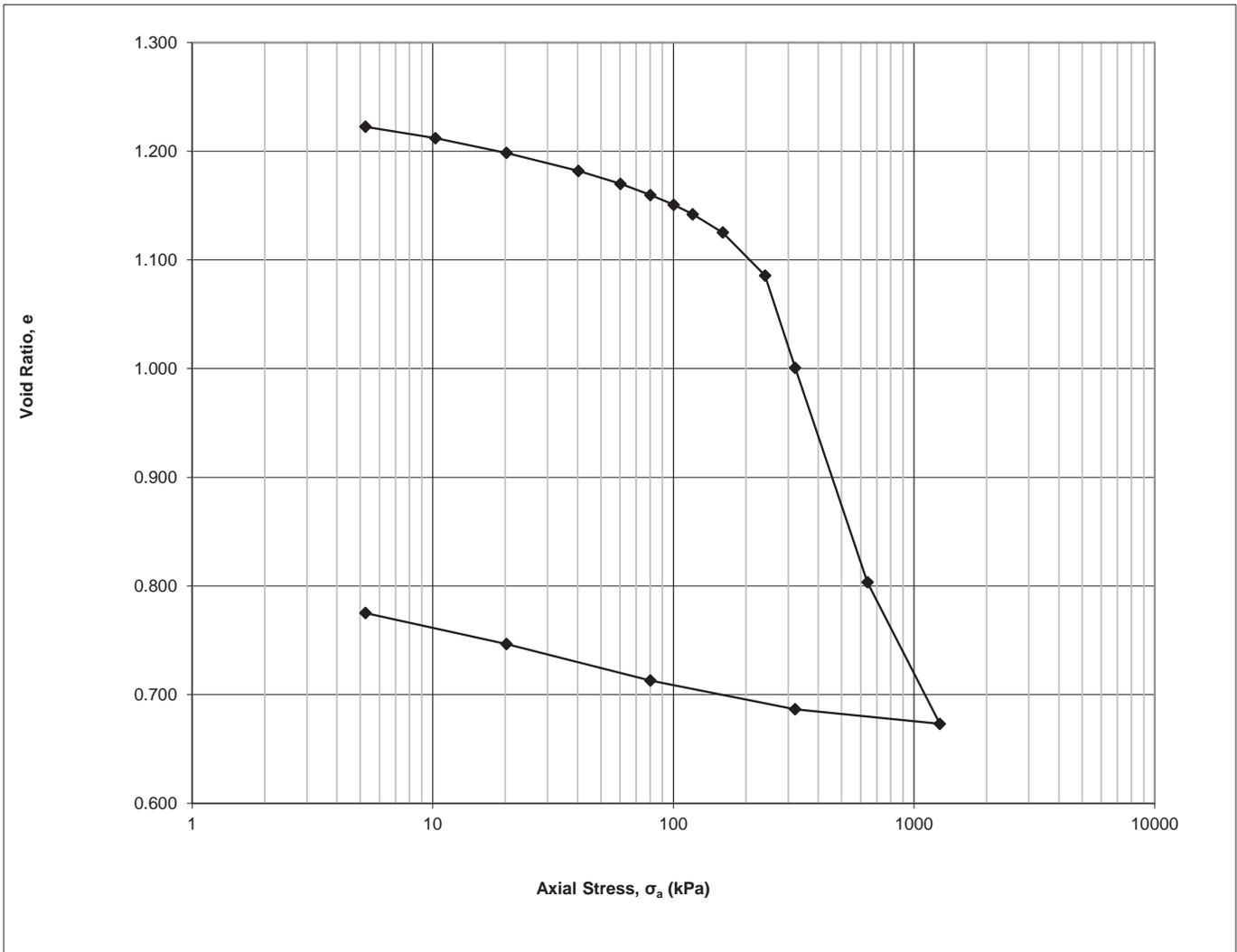
Photo No.: 1 | Borehole: BH 17-3, ST 17 | Depth: 50-52 ft



Photo No.: 2 | Borehole: BH 17-3, ST 17 | Depth: 50-52 ft

Project
Project No.
Borehole No.
Sample No.
Sample Depth

Thurber Engineering, File# 20482
122410864
17-2
ST 9
35-37 ft



One-Dimensional Consolidation Test using Incremental Loading
ASTM D2435/D2435M - 11

1-Nov-17
1-Nov-17

Date:
Date:

D. Boateng
R. Hache

Checked by:
Approved by:

Specimen Details

Project Name	Thurber Engineering, File# 20482
Project Location	Lochiel, ON
Borehole	17-2
Sample No.	ST 9
Depth	35-37 ft
Sample Date	September 25, 2017
Test Number	Two
Technician Name	Daniel Boateng

Soil Description & Classification

Not Requested	
Specific Gravity of Solids	2.746
Average water content of trimmings %	45
Additional Notes (information source, occurrence and size of large isolated particles etc.)	
Specific Gravity of Solids Assumed	

Initial Specimen Conditions

Height	mm	20.00
Diameter	mm	50.00
Area	mm ²	1963
Volume	mm ³	39270
Mass	g	69.92
Dry Mass	g	48.38
Density	Mg/m ³	1.780
Dry Density	Mg/m ³	1.232
Water Content	%	44.52
Degree of Saturation	%	99.5
Height of Solids	mm	8.97
Initial Void Ratio		1.229

Final Specimen Conditions

Water Content	%	30.07
Final Void Ratio		0.775

One-Dimensional Consolidation Test using Incremental Loading
ASTM D2435/D2435M - 11

1-Nov-17
1-Nov-17

Date: Date:

D. Boateng
R. Hache

Checked by:
Approved by:

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Filename:
Date:

Specimen Details

Project Name	Thurber Engineering, File# 20482
Project Location	Lochiel, ON
Borehole	17-2
Sample No.	ST 9
Depth	35-37 ft
Sample Date	September 25, 2017
Test Number	Two
Technician Name	Daniel Boateng

Test Procedure

Date Started	October 30, 2017
Date Finished	November 1, 2017
Machine Number	Frame D
Cell Number	D
Ring Number	D
Trimming Procedure	Turntable
Moisture Condition	Inundated
Axial Stress at Inundation	5 kPa
Water Used	Distilled
Test Method	B
Interpretation Procedure for c_v	2

All Departures from Outlined ASTM D2435/D2435M-11 Procedure

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Calculations

Load Increment	Increment Duration min	Axial Stress σ_a kPa	Corrected Deformation ΔH mm	Specimen Height H mm	Axial Strain ϵ_a %	Void Ratio e
Seating	0.0	5	0.0000	20.0000	0.00	1.229
1	14.8	5	0.0576	19.9424	0.29	1.223
2	14.8	10	0.1507	19.8493	0.75	1.212
3	21.5	20	0.2735	19.7265	1.37	1.198
4	19.8	40	0.4214	19.5786	2.11	1.182
5	19.8	60	0.5284	19.4716	2.64	1.170
6	28.3	80	0.6203	19.3797	3.10	1.160
7	24.8	100	0.7016	19.2984	3.51	1.151
8	29.8	120	0.7803	19.2197	3.90	1.142
9	34.8	160	0.9306	19.0694	4.65	1.125
10	64.8	240	1.2849	18.7151	6.42	1.086
11	183.5	320	2.0464	17.9536	10.23	1.001
12	132.0	640	3.8172	16.1828	19.09	0.804
13	87.0	1280	4.9864	15.0136	24.93	0.673
14	15.0	320	4.8663	15.1337	24.33	0.687
15	28.3	80	4.6286	15.3714	23.14	0.713
16	53.3	20	4.3271	15.6729	21.64	0.747
17	68.5	5	4.0719	15.9281	20.36	0.775

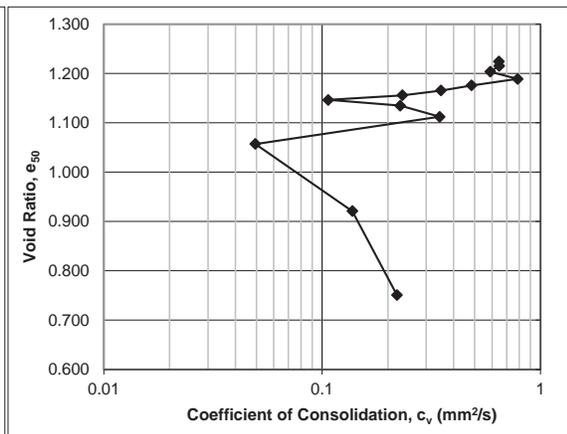
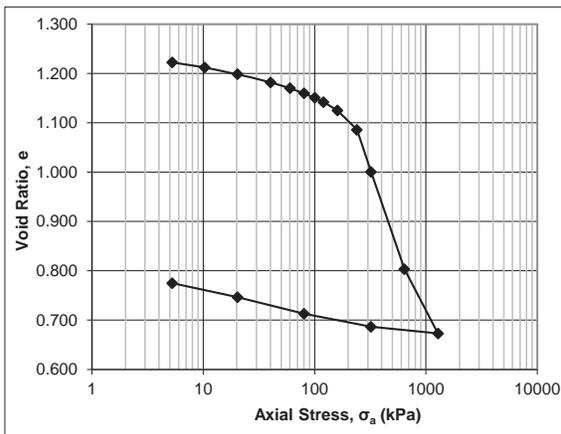
One-Dimensional Consolidation Test using Incremental Loading
ASTM D2435/D2435M - 11

Specimen Details

Project Name	Thurber Engineering, File# 20482
Project Location	Lochiel, ON
Borehole	17-2
Sample No.	ST 9
Depth	35-37 ft
Sample Date	September 25, 2017
Test Number	Two
Technician Name	Daniel Boateng

Calculations

Load Increment	Axial Stress $\sigma_{a, average}$ kPa	Calculated using Interpretation Procedure 2				Interpretation Procedure 1		Interpretation Procedure 2	
		Corrected Deformation ΔH_{50} mm	Specimen Height H_{50} mm	Axial Strain $\epsilon_{a,50}$ %	Void Ratio e_{50}	Time t_{50} sec	Coeff. Consol. c_v mm ² /s	Time t_{90} sec	Coeff. Consol. c_v mm ² /s
Seating	3								
1	5	0.0411	19.9589	0.21	1.224			131	6.44E-01
2	8	0.1198	19.8802	0.60	1.216			129	6.48E-01
3	15	0.2283	19.7717	1.14	1.203			141	5.89E-01
4	30	0.3571	19.6429	1.79	1.189			104	7.86E-01
5	50	0.4767	19.5233	2.38	1.176			167	4.83E-01
6	70	0.5692	19.4308	2.85	1.165			229	3.50E-01
7	90	0.6562	19.3438	3.28	1.156			341	2.33E-01
8	110	0.7406	19.2594	3.70	1.146			737	1.07E-01
9	140	0.8425	19.1575	4.21	1.135			342	2.28E-01
10	200	1.0466	18.9534	5.23	1.112			221	3.45E-01
11	280	1.5415	18.4585	7.71	1.057			1461	4.95E-02
12	480	2.7615	17.2385	13.81	0.921			458	1.38E-01
13	960	4.2882	15.7118	21.44	0.751			238	2.20E-01
14	800	4.8863	15.1137	24.43	0.684				
15	200	4.7122	15.2878	23.56	0.704				
16	50	4.4499	15.5501	22.25	0.733				
17	13	4.3078	15.6922	21.54	0.749				



1-Nov-17
1-Nov-17

Date:
Date:

D. Boateng
R. Hache

Checked by:
Approved by:

V:\01216\active\laboratory_standing_offers\2017 Laboratory Standing Offers\122

Filename:
Date:



Project No.: 122410864

Project Name: Thurber, File# 20482

Photo Log

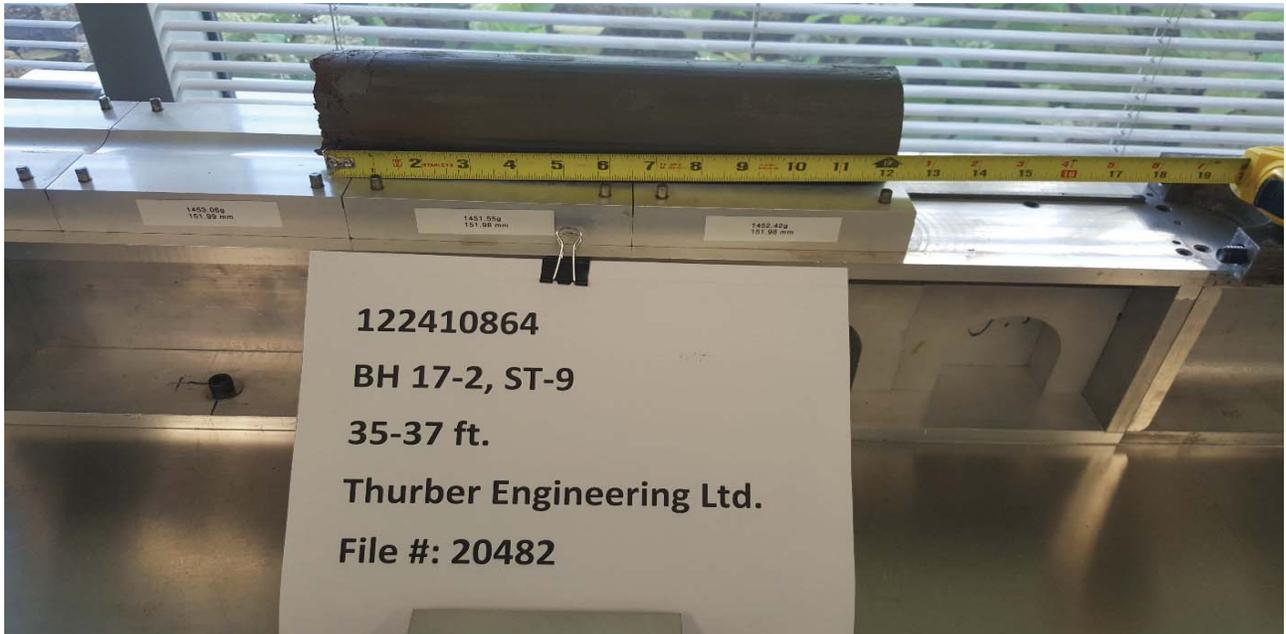


Photo No.: 1 | Borehole: BH 17-2, ST 9 | Depth: 35-37 ft

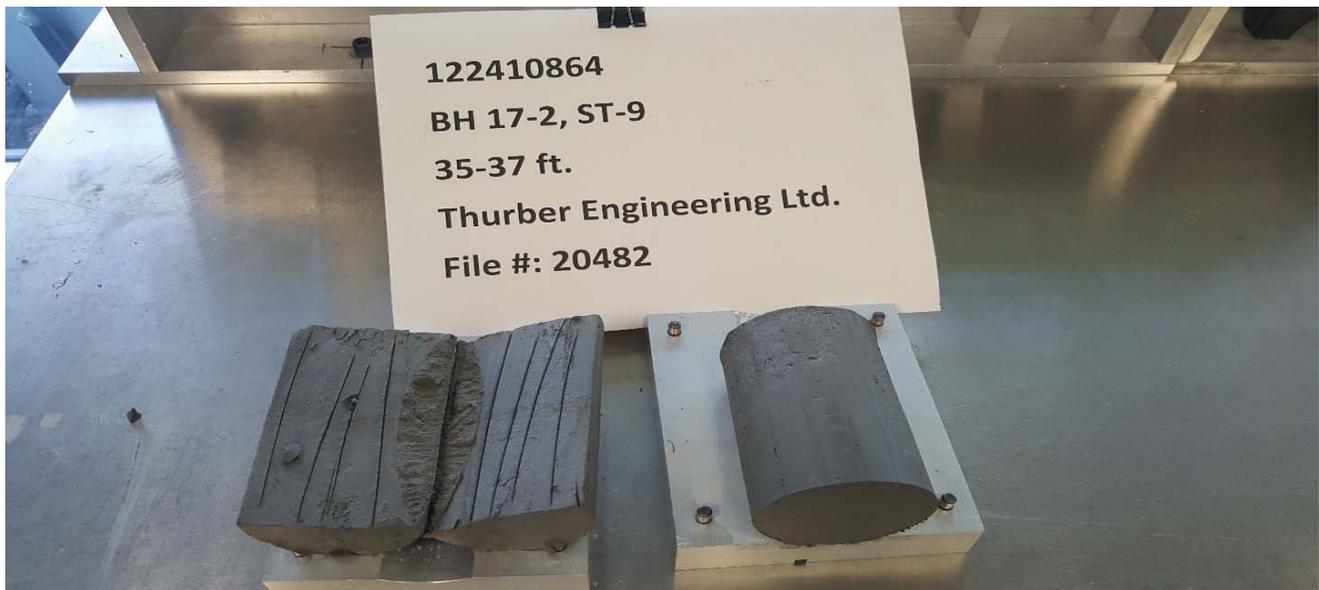


Photo No.: 2 | Borehole: BH 17-2, ST 9 | Depth: 35-37 ft



Stantec Consulting Ltd.
400 - 1331 Clyde Avenue, Ottawa ON K2C 3G4

July 9, 2018
File: 122410864

Attention: Kenton Power
Thurber Engineering Ltd.
104 – 2460 Lancaster Road
Ottawa, Ontario, Canada, K1B 4S5
Tel: 613-274-2121
E-mail: kpower@thurber.ca

Dear Mr. Power,

**Reference: Consolidation Test Results for Locha Creek Culvert Project, Thurber Consulting Ltd.,
File #20482: BH 18-101, ST 5 & 9, sampled on June 11, 2018**

This letter presents the results of one-dimensional consolidation tests carried out on the above referenced samples in accordance with ASTM D2435/D2435M - 11. The test results are provided in the attached tables and figures.

This letter provides test results only and does not constitute any interpretation or engineering recommendations with respect to material suitability or specification compliance.

We trust the information presented herein meets your present requirements. Should you have any questions or require additional information, please do not hesitate to contact us.

Regards,

STANTEC CONSULTING LTD.

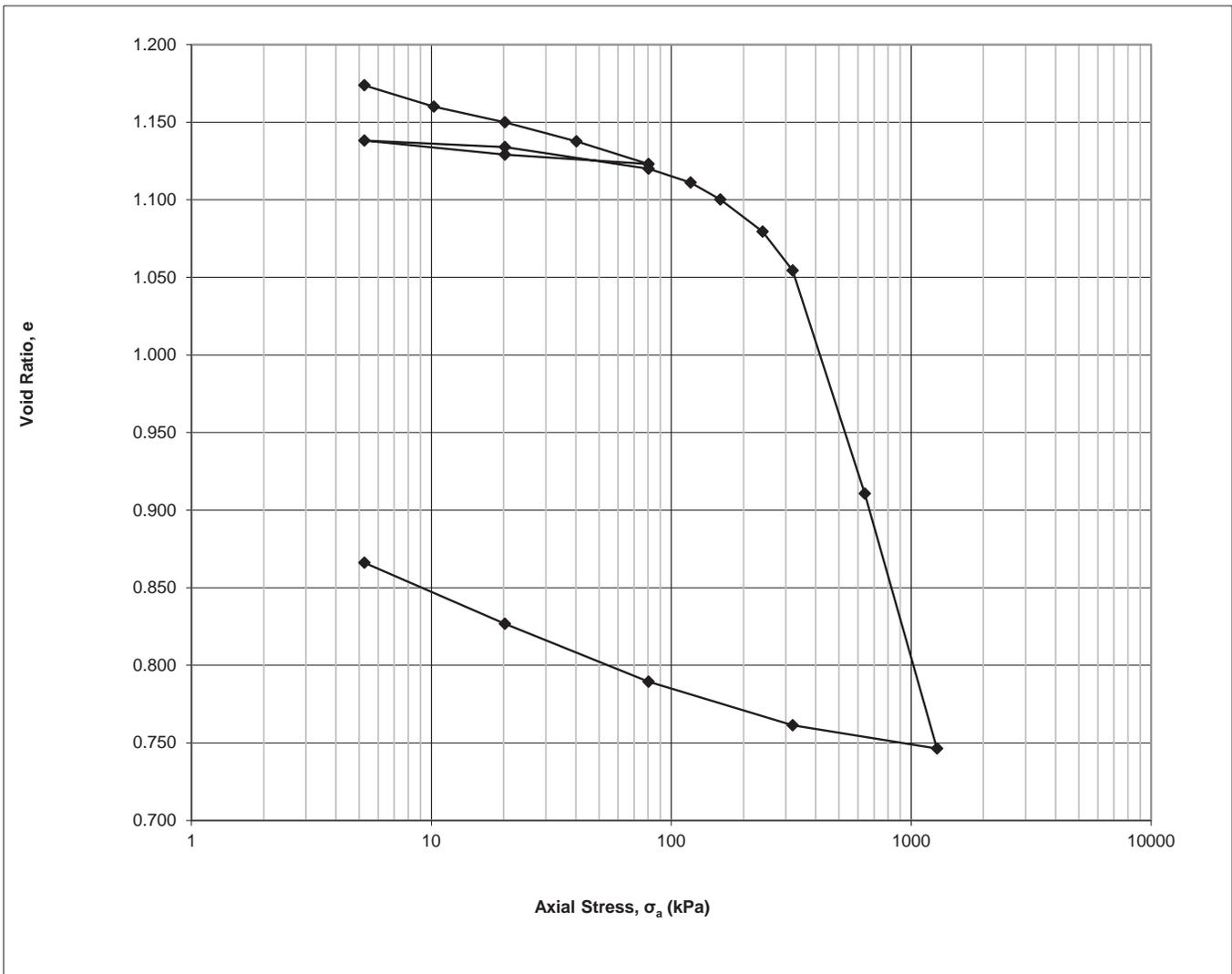
A handwritten signature in blue ink, appearing to read "Ramy Saadeldin", written over a horizontal line.

Ramy Saadeldin, Ph.D., P.Eng.
Geotechnical Engineering
Phone: (613) 738-6047
Fax: (613) 722-2799
Ramy.Saadeldin@stantec.com

v:\01216\active\laboratory_standing_offers\2018 laboratory standing offers\122410864 thurber engineering ltd\june 11, two consolidation, one specific gravity\consolidation letter & results\122410864_let_consolidationresults_bh 18-101 st 5 9.docx

Project
Project No.
Borehole No.
Sample No.
Sample Depth

Thurber Engineering, File# 20482
122410864
BH 18-101
ST 5
15 - 17 ft.



One-Dimensional Consolidation Test using Incremental Loading
 ASTM D2435/D2435M - 11

 7-Jul-18
 7-Jul-18

Date: Date:

 D. Boateng
 R. Hachte

 Checked by:
 Approved by:

Specimen Details

Project Name	Thurber Engineering, File# 20482
Project Location	HWY 17, Ontario
Borehole	BH 18-101
Sample No.	ST 5
Depth	15 - 17 ft.
Sample Date	June 11, 2018
Test Number	One
Technician Name	Daniel Boateng

Soil Description & Classification

Silty Clay, Brown/Grey, Fissured, Moist	
Specific Gravity of Solids	2.750
Average water content of trimmings %	43
Additional Notes (information source, occurrence and size of large isolated particles etc.)	

Initial Specimen Conditions

Height	mm	20.00
Diameter	mm	50.00
Area	mm ²	1963
Volume	mm ³	39270
Mass	g	70.21
Dry Mass	g	49.16
Density	Mg/m ³	1.788
Dry Density	Mg/m ³	1.252
Water Content	%	42.82
Degree of Saturation	%	98.4
Height of Solids	mm	9.10
Initial Void Ratio		1.197

Final Specimen Conditions

Water Content	%	34.86
Final Void Ratio		0.866

One-Dimensional Consolidation Test using Incremental Loading
ASTM D2435/D2435M - 11

7-Jul-18
7-Jul-18

Date: Date:
D. Boateng
R. Hache

Checked by:
Approved by:

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7-Jul-18

Filename:
Date:

Specimen Details

Project Name	Thurber Engineering, File# 20482
Project Location	HWY 17, Ontario
Borehole	BH 18-101
Sample No.	ST 5
Depth	15 - 17 ft.
Sample Date	June 11, 2018
Test Number	One
Technician Name	Daniel Boateng

Test Procedure

Date Started	June 22, 2018
Date Finished	July 3, 2018
Machine Number	Frame C
Cell Number	C
Ring Number	C
Trimming Procedure	Turntable
Moisture Condition	Inundated
Axial Stress at Inundation	5 kPa
Water Used	Distilled
Test Method	A
Interpretation Procedure for c_v	2

All Departures from Outlined ASTM D2435/D2435M-11 Procedure

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Calculations

Load Increment	Increment Duration	Axial Stress	Corrected Deformation	Specimen Height	Axial Strain	Void Ratio
	min	σ_a kPa	ΔH mm	H mm	ϵ_a %	e
Seating	0.0	5	0.0000	20.0000	0.00	1.197
1	720.0	5	0.2093	19.7907	1.05	1.174
2	720.0	10	0.3335	19.6665	1.67	1.160
3	720.0	20	0.4253	19.5747	2.13	1.150
4	720.0	40	0.5376	19.4624	2.69	1.138
5	720.0	80	0.6706	19.3294	3.35	1.123
6	720.0	20	0.6159	19.3841	3.08	1.129
7	720.0	5	0.5332	19.4668	2.67	1.138
8	720.0	20	0.5716	19.4284	2.86	1.134
9	720.0	80	0.6981	19.3019	3.49	1.120
10	1440.0	120	0.7793	19.2207	3.90	1.111
11	1440.0	160	0.8794	19.1206	4.40	1.100
12	1440.0	240	1.0681	18.9319	5.34	1.079
13	720.0	320	1.2957	18.7043	6.48	1.054
14	720.0	640	2.6039	17.3961	13.02	0.911
15	720.0	1280	4.1005	15.8995	20.50	0.746
16	720.0	320	3.9638	16.0362	19.82	0.761
17	720.0	80	3.7079	16.2921	18.54	0.789
18	720.0	20	3.3679	16.6321	16.84	0.827
19	720.0	5	3.0108	16.9892	15.05	0.866

One-Dimensional Consolidation Test using Incremental Loading
ASTM D2435/D2435M - 11

7-Jul-18
7-Jul-18

Date:
Date:

D. Boateng
R. Hache

Checked by:
Approved by:

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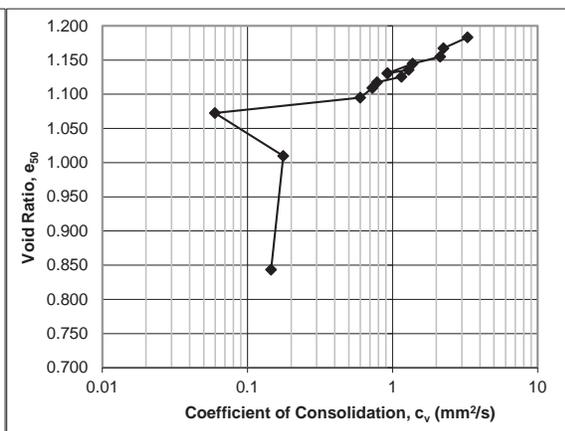
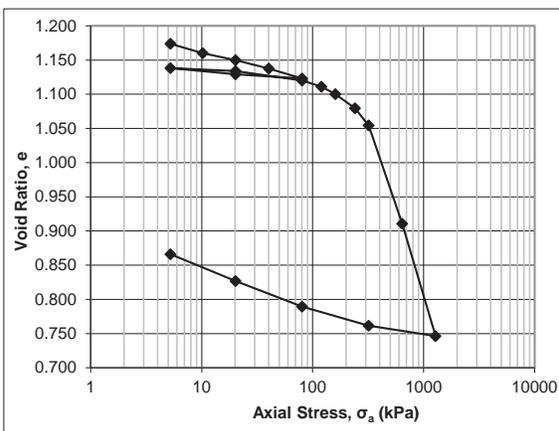
Filename:
Date:

Specimen Details

Project Name	Thurber Engineering, File# 20482
Project Location	HWY 17, Ontario
Borehole	BH 18-101
Sample No.	ST 5
Depth	15 - 17 ft.
Sample Date	June 11, 2018
Test Number	One
Technician Name	Daniel Boateng

Calculations

Load Increment	Axial Stress $\sigma_{a, average}$ kPa	Calculated using Interpretation Procedure 2				Interpretation Procedure 1		Interpretation Procedure 2	
		Corrected Deformation ΔH_{50} mm	Specimen Height H_{50} mm	Axial Strain $\epsilon_{a,50}$ %	Void Ratio e_{50}	Time t_{50} sec	Coeff. Consol. c_v mm ² /s	Time t_{90} sec	Coeff. Consol. c_v mm ² /s
Seating	3								
1	5	0.1235	19.8765	0.62	1.183			25	3.29E+00
2	8	0.2685	19.7315	1.34	1.167			37	2.24E+00
3	15	0.3807	19.6193	1.90	1.155			38	2.13E+00
4	30	0.4727	19.5273	2.36	1.145			59	1.38E+00
5	60	0.6017	19.3983	3.01	1.131			86	9.26E-01
6	50	0.6319	19.3681	3.16	1.127				
7	13	0.5718	19.4282	2.86	1.134				
8	13	0.5570	19.4430	2.79	1.136			62	1.29E+00
9	50	0.6480	19.3520	3.24	1.126			69	1.15E+00
10	100	0.7217	19.2783	3.61	1.117			101	7.83E-01
11	140	0.7983	19.2017	3.99	1.109			108	7.26E-01
12	200	0.9248	19.0752	4.62	1.095			129	6.00E-01
13	280	1.1317	18.8683	5.66	1.072			1264	5.97E-02
14	480	1.7040	18.2960	8.52	1.010			401	1.77E-01
15	960	3.2145	16.7855	16.07	0.844			410	1.46E-01
16	800	4.0149	15.9851	20.07	0.756				
17	200	3.8295	16.1705	19.15	0.776				
18	50	3.5539	16.4461	17.77	0.806				
19	13	3.2472	16.7528	16.24	0.840				





Project No.: 122410864

Project Name: Thurber Engineering, File# 20482

Photo Log

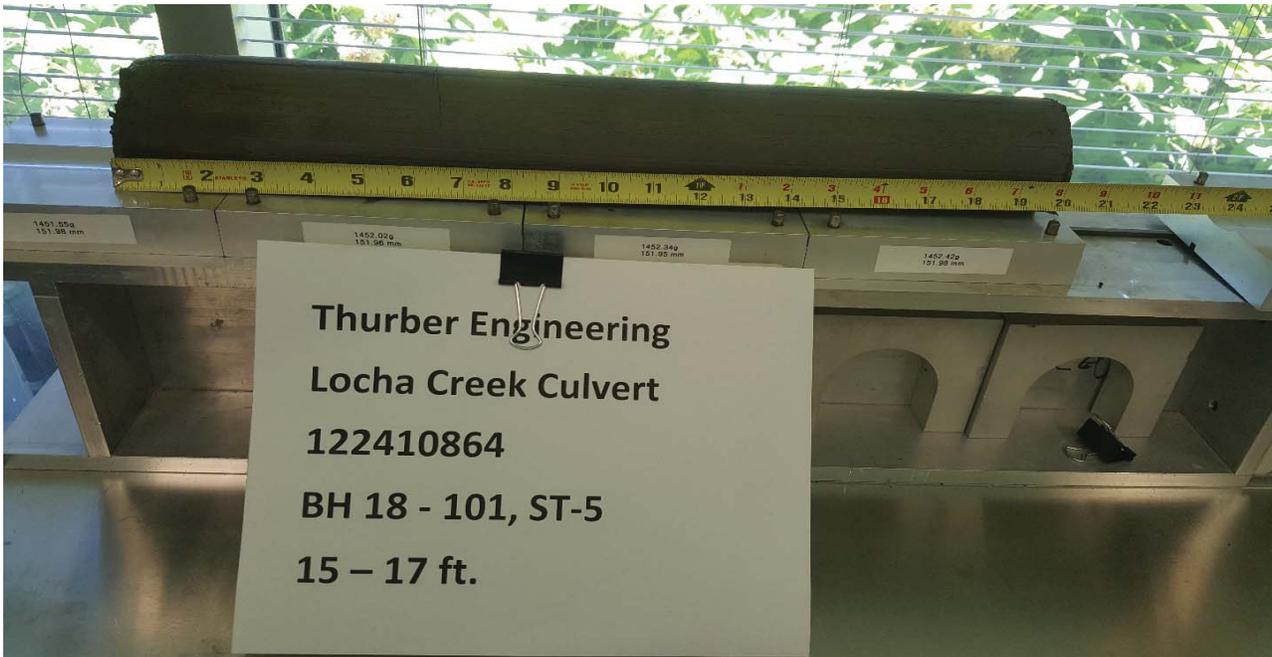


Photo No.:

1

Borehole: BH 18-101 ST 5

Depth: 15 - 17 ft.



Photo No.:

2

Borehole: BH 18-101 ST 5

Depth: 15 - 17 ft.



Project No.: 122410864

Photo Log

Project Name: Thurber Engineering, File# 20482



Photo No.:

3

Borehole: BH 18-101 ST 5

Depth: 15 - 17 ft.



Photo No.:

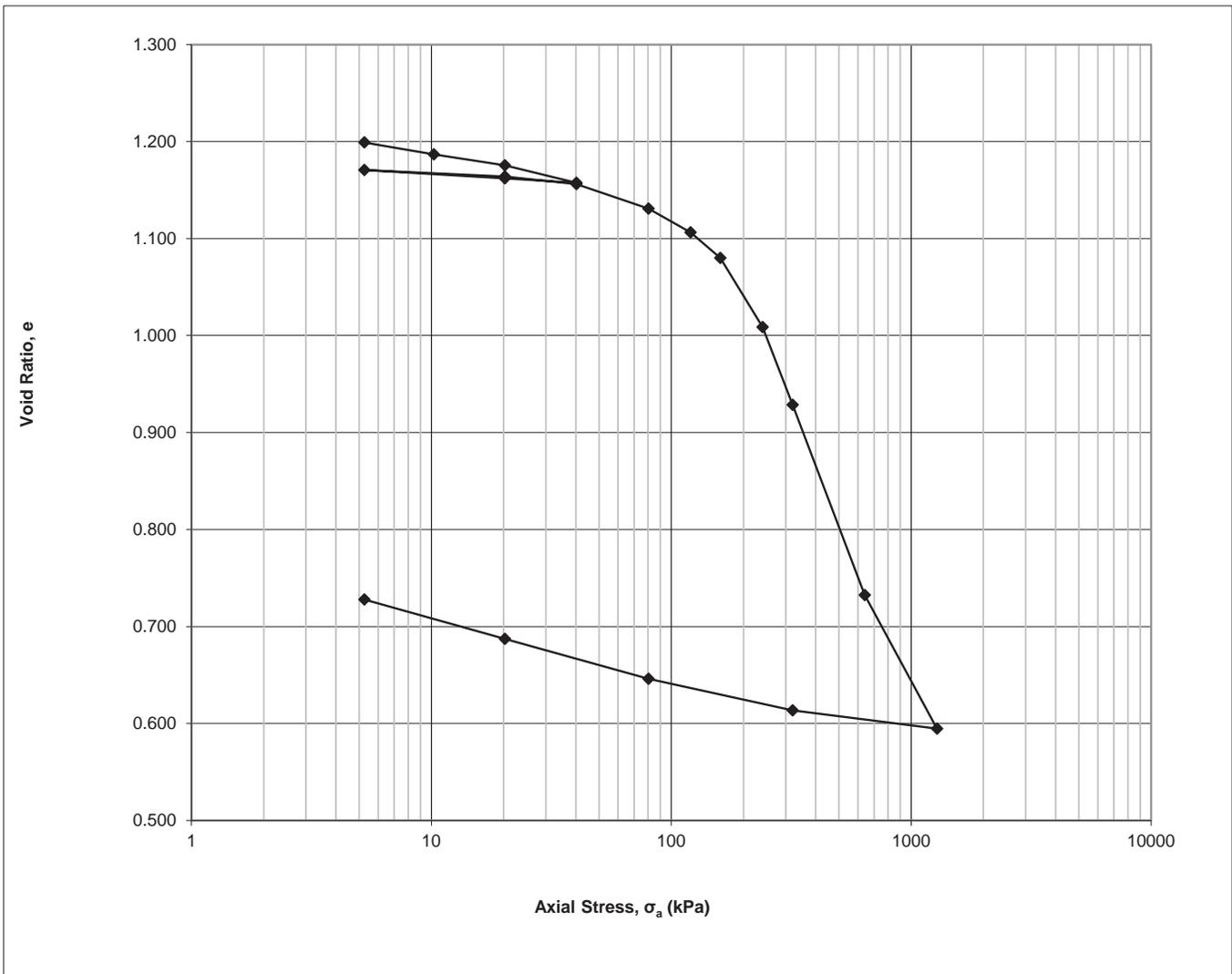
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Borehole: BH 18-101 ST 5

Depth: 15 - 17 ft.

Project
Project No.
Borehole No.
Sample No.
Sample Depth

Thurber Engineering, File# 20482
122410864
BH 18-101
ST 9
35 - 37 ft.



One-Dimensional Consolidation Test using Incremental Loading
ASTM D2435/D2435M - 11

 7-Jul-18
 7-Jul-18

Date: Date:

 D. Boateng
 R. Hachte

 Checked by:
 Approved by:

Specimen Details

Project Name	Thurber Engineering, File# 20482
Project Location	HWY 17, Ontario
Borehole	BH 18-101
Sample No.	ST 9
Depth	35 - 37 ft.
Sample Date	June 11, 2018
Test Number	Two
Technician Name	Daniel Boateng

Soil Description & Classification

Silty Clay, Grey, Wet	
Specific Gravity of Solids	2.750
Average water content of trimmings %	45
Additional Notes (information source, occurrence and size of large isolated particles etc.)	
Specific Gravity of Solids Assumed	

Initial Specimen Conditions

Height	mm	20.00
Diameter	mm	50.00
Area	mm ²	1963
Volume	mm ³	39270
Mass	g	70.81
Dry Mass	g	48.84
Density	Mg/m ³	1.803
Dry Density	Mg/m ³	1.244
Water Content	%	44.98
Degree of Saturation	%	100.0
Height of Solids	mm	9.05
Initial Void Ratio		1.211

Final Specimen Conditions

Water Content	%	33.27
Final Void Ratio		0.728

One-Dimensional Consolidation Test using Incremental Loading
ASTM D2435/D2435M - 11

7-Jul-18
7-Jul-18

Date: Date:

D. Boateng
R. Hache

Checked by:
Approved by:

V:\01216\inactive\laboratory_standing_offers\2018 Laboratory Standing Offers\122:

Filename: 7-Jul-18
Date:

Specimen Details

Project Name	Thurber Engineering, File# 20482
Project Location	HWY 17, Ontario
Borehole	BH 18-101
Sample No.	ST 9
Depth	35 - 37 ft.
Sample Date	June 11, 2018
Test Number	Two
Technician Name	Daniel Boateng

Test Procedure

Date Started	June 22, 2018
Date Finished	July 3, 2018
Machine Number	Frame D
Cell Number	D
Ring Number	D
Trimming Procedure	Turntable
Moisture Condition	Inundated
Axial Stress at Inundation	5 kPa
Water Used	Distilled
Test Method	A
Interpretation Procedure for c_v	2

All Departures from Outlined ASTM D2435/D2435M-11 Procedure

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Calculations

Load Increment	Increment Duration min	Axial Stress σ_a kPa	Corrected Deformation ΔH mm	Specimen Height H mm	Axial Strain ϵ_a %	Void Ratio e
Seating	0.0	5	0.0000	20.0000	0.00	1.211
1	720.0	5	0.1089	19.8911	0.54	1.199
2	720.0	10	0.2195	19.7805	1.10	1.187
3	720.0	20	0.3210	19.6790	1.61	1.176
4	720.0	40	0.4844	19.5156	2.42	1.158
5	720.0	20	0.4446	19.5554	2.22	1.162
6	720.0	5	0.3650	19.6350	1.83	1.171
7	720.0	20	0.4256	19.5744	2.13	1.164
8	720.0	40	0.4975	19.5025	2.49	1.156
9	1440.0	80	0.7250	19.2750	3.63	1.131
10	1440.0	120	0.9479	19.0521	4.74	1.106
11	1440.0	160	1.1869	18.8131	5.93	1.080
12	720.0	240	1.8311	18.1689	9.16	1.009
13	720.0	320	2.5549	17.4451	12.77	0.929
14	720.0	640	4.3293	15.6707	21.65	0.733
15	720.0	1280	5.5757	14.4243	27.88	0.595
16	720.0	320	5.4056	14.5944	27.03	0.614
17	720.0	80	5.1101	14.8899	25.55	0.646
18	720.0	20	4.7390	15.2610	23.70	0.687
19	720.0	5	4.3705	15.6295	21.85	0.728

One-Dimensional Consolidation Test using Incremental Loading
ASTM D2435/D2435M - 11

7-Jul-18
7-Jul-18

Date:
Date:

D. Boateng
R. Hache

Checked by:
Approved by:

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7-Jul-18

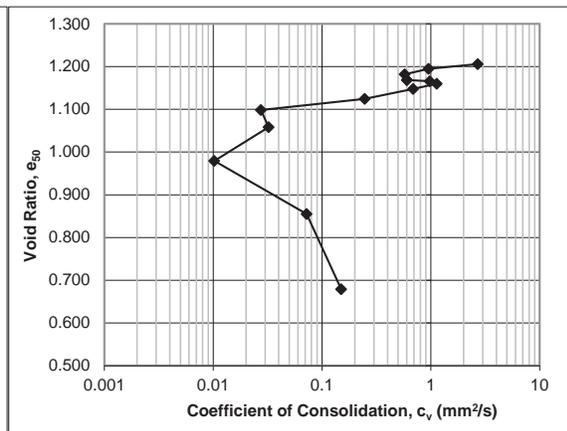
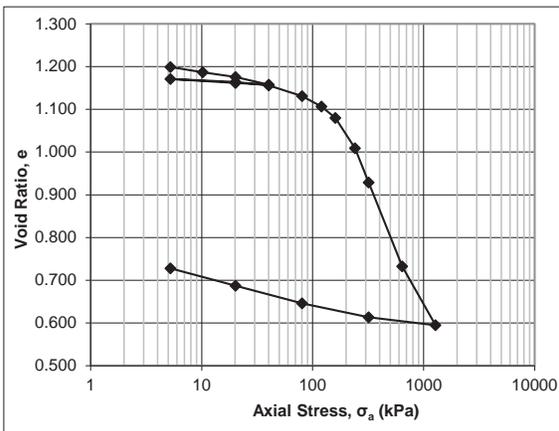
Filename:
Date:

Specimen Details

Project Name	Thurber Engineering, File# 20482
Project Location	HWY 17, Ontario
Borehole	BH 18-101
Sample No.	ST 9
Depth	35 - 37 ft.
Sample Date	June 11, 2018
Test Number	Two
Technician Name	Daniel Boateng

Calculations

Load Increment	Axial Stress $\sigma_{a, average}$ kPa	Calculated using Interpretation Procedure 2				Interpretation Procedure 1		Interpretation Procedure 2	
		Corrected Deformation ΔH_{50} mm	Specimen Height H_{50} mm	Axial Strain $\epsilon_{a,50}$ %	Void Ratio e_{50}	Time t_{50} sec	Coeff. Consol. c_v mm ² /s	Time t_{90} sec	Coeff. Consol. c_v mm ² /s
Seating	3								
1	5	0.0473	19.9527	0.24	1.206			31	2.70E+00
2	8	0.1455	19.8545	0.73	1.195			88	9.55E-01
3	15	0.2642	19.7358	1.32	1.182			143	5.76E-01
4	30	0.3842	19.6158	1.92	1.169			135	6.05E-01
5	30	0.4595	19.5405	2.30	1.160				
6	13	0.3947	19.6053	1.97	1.168				
7	13	0.4081	19.5919	2.04	1.166			83	9.77E-01
8	30	0.4614	19.5386	2.31	1.160			71	1.13E+00
9	60	0.5709	19.4291	2.85	1.148			116	6.90E-01
10	100	0.7809	19.2191	3.90	1.125			317	2.47E-01
11	140	1.0188	18.9812	5.09	1.099			2775	2.75E-02
12	200	1.3809	18.6191	6.90	1.058			2277	3.23E-02
13	280	2.0988	17.9012	10.49	0.979			6626	1.03E-02
14	480	3.2219	16.7781	16.11	0.855			825	7.23E-02
15	960	4.8114	15.1886	24.06	0.679			326	1.50E-01
16	800	5.4659	14.5341	27.33	0.607				
17	200	5.2376	14.7624	26.19	0.632				
18	50	4.9354	15.0646	24.68	0.665				
19	13	4.5921	15.4079	22.96	0.703				





Project No.: 122410864

Project Name: Thurber Engineering, File# 20482

Photo Log

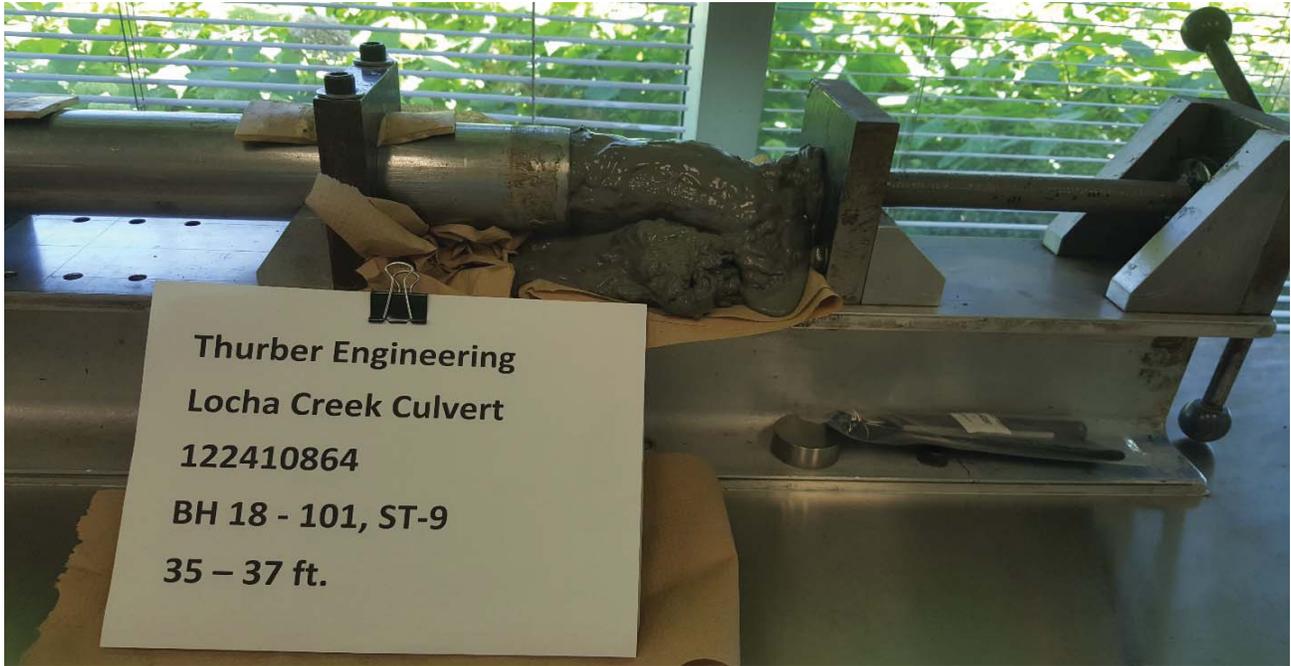


Photo No.: 1

Borehole: BH 18-101 ST 9

Depth: 35 - 37 ft.

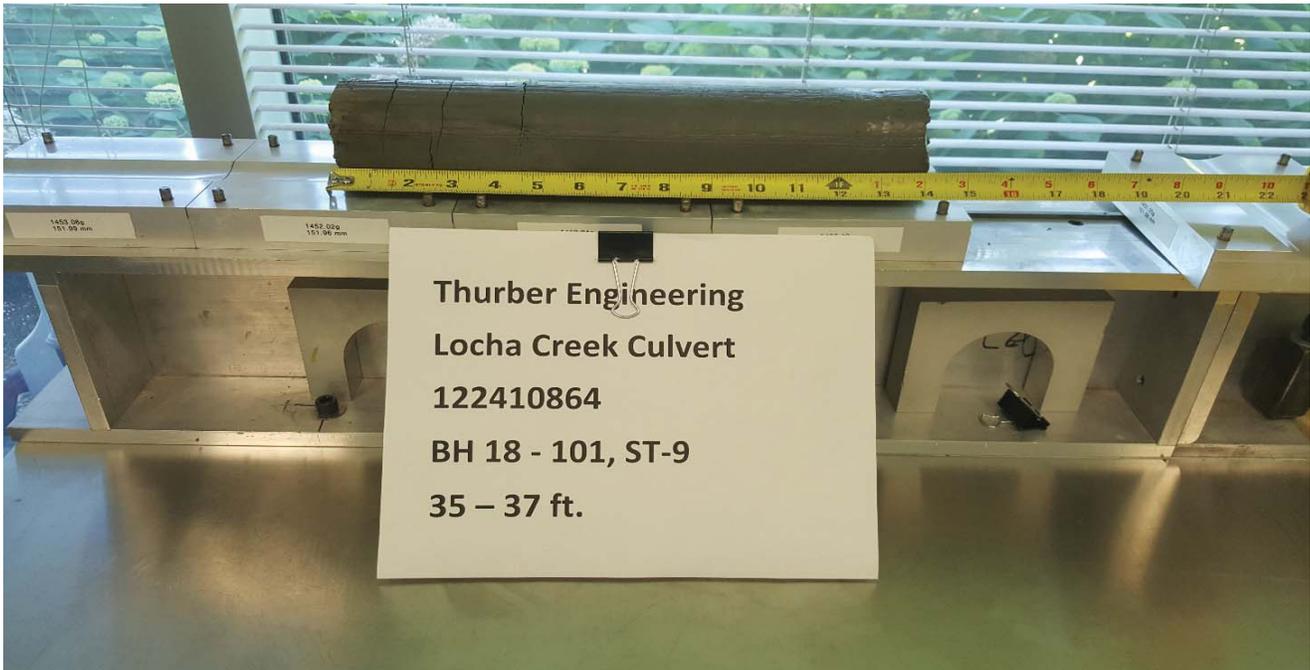


Photo No.: 2

Borehole: BH 18-101 ST 9

Depth: 35 - 37 ft.



Project No.: 122410864

Photo Log

Project Name: Thurber Engineering, File# 20482

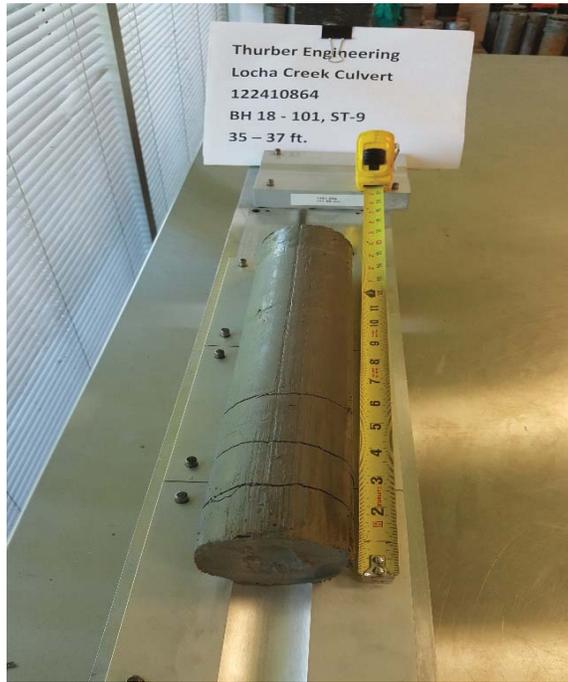


Photo No.: 3

Borehole: BH 18-101 ST 9

Depth: 35 - 37 ft.

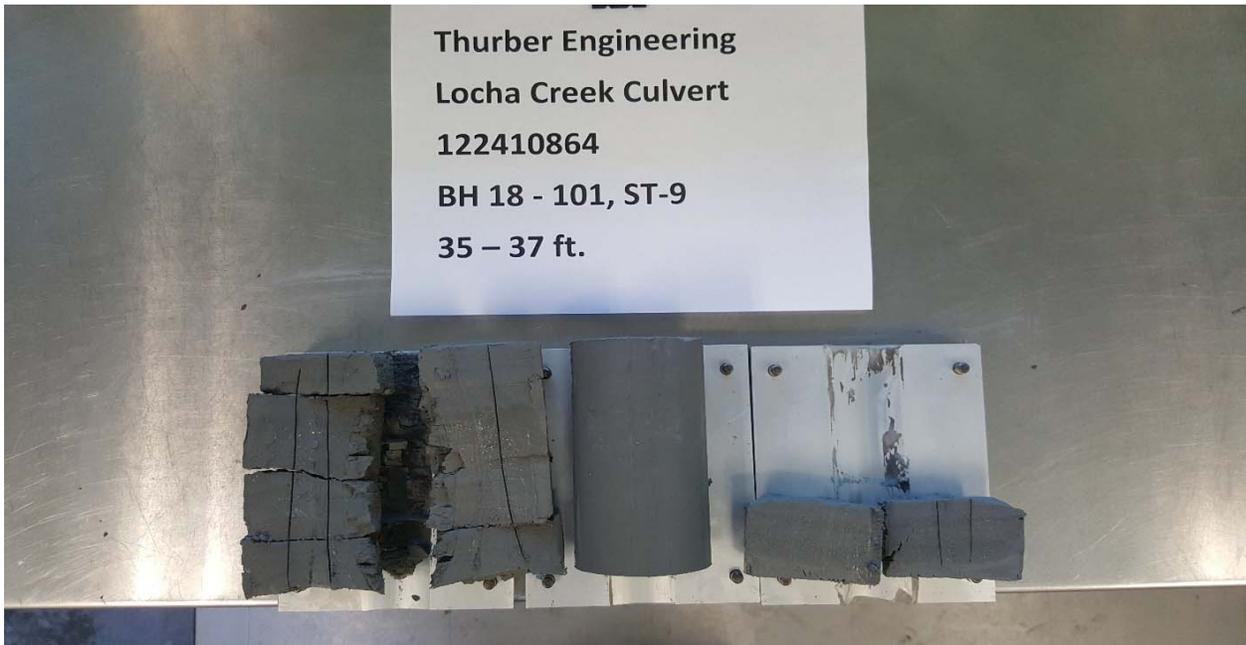


Photo No.: 4

Borehole: BH 18-101 ST 9

Depth: 35 - 37 ft.



Stantec Consulting Ltd.
400 - 1331 Clyde Avenue, Ottawa ON K2C 3G4

October 21, 2019
File: 122410864

Attention: Justin Gray, P.Eng.
Thurber Engineering Ltd.
104 – 2460 Lancaster Road
Ottawa, Ontario, Canada, K1B 4S5
Tel: 343-700-1316
E-mail: jgray@thurber.ca

Dear Mr. Gray,

**Reference: Consolidation Test Results for HWY 17, Anderson Road Project, Thurber Consulting Ltd.,
File #24726: BH AND19-2A, ST 2, sampled on September 30, 2019**

This letter presents the results of one-dimensional consolidation tests carried out on the above referenced sample in accordance with ASTM D2435/D2435M - 11. The test results are provided in the attached tables and figures.

This letter provides test results only and does not constitute any interpretation or engineering recommendations with respect to material suitability or specification compliance.

We trust the information presented herein meets your present requirements. Should you have any questions or require additional information, please do not hesitate to contact us.

Regards,

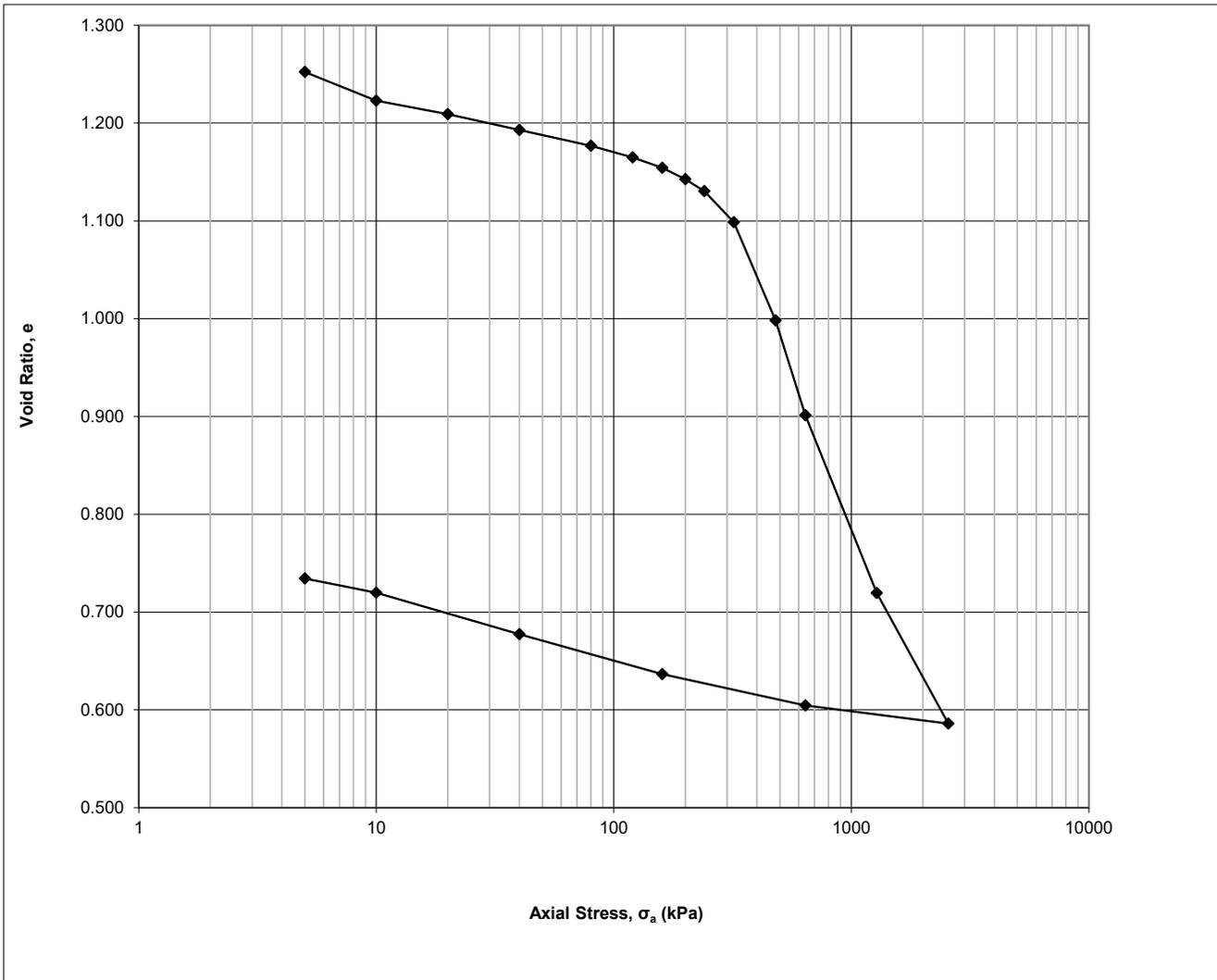
STANTEC CONSULTING LTD.

A handwritten signature in blue ink, appearing to read "Bridgit Bocage".

Bridgit Bocage, M.Eng., P.Eng.
Geotechnical Engineering
Phone: (613) 738-6045
Fax: (613) 722-2799
Bridgit.Bocage@stantec.com

Project
Project No.
Borehole No.
Sample No.
Sample Depth

Thurber Engineering, File# 24726
122410864
BH AND 19-2A
ST 2
22½ - 24½ ft.





One-Dimensional Consolidation Test using Incremental Loading
ASTM D2435/D2435M - 11

October 21, 2019
October 21, 2019

Date: Date:
D. Boateng B. Bocage

Checked by: Approved by:

Filename: C:\Users\bocage\Documents\19-2A Anderson cc
Date:

Specimen Details

Project Name	Thurber Engineering, File# 24726
Project Location	Anderson Road, Ottawa, ON
Borehole	BH AND 19-2A
Sample No.	ST 2
Depth	22½ - 24½ ft.
Sample Date	September 30, 2019
Test Number	One
Technician Name	Daniel Boateng

Soil Description & Classification

Clay and silt, dark grey, friable, moist - CI	
Specific Gravity of Solids	2.747
Liquid Limit %	31
Plastic Limit %	21
Plasticity Index %	10
Average water content of trimmings %	47
Additional Notes (information source, occurrence and size of large isolated particles etc.)	

Initial Specimen Conditions

Height	mm	20.00
Diameter	mm	50.00
Area	mm ²	1963
Volume	mm ³	39270
Mass	g	68.36
Dry Mass	g	46.39
Density	Mg/m ³	1.741
Dry Density	Mg/m ³	1.181
Water Content	%	47.36
Degree of Saturation	%	98.2
Height of Solids	mm	8.60
Initial Void Ratio		1.325

Final Specimen Conditions

Water Content	%	32.49
Final Void Ratio		0.734
Differential Height	mm	14.92

One-Dimensional Consolidation Test using Incremental Loading
ASTM D2435/D2435M - 11

Specimen Details

Project Name	Thurber Engineering, File# 24726
Project Location	Anderson Road, Ottawa, ON
Borehole	BH AND 19-2A
Sample No.	ST 2
Depth	22½ - 24½ ft.
Sample Date	September 30, 2019
Test Number	One
Technician Name	Daniel Boateng

Test Procedure

Date Started	October 7, 2019
Date Finished	October 9, 2019
Machine Number	Frame C
Cell Number	C
Ring Number	C
Trimming Procedure	Turntable/Cutting ring
Moisture Condition	Inundated
Axial Stress at Inundation	5 kPa
Water Used	Deaired tap water
Test Method	B
Interpretation Procedure for c_v	2

All Departures from Outlined ASTM D2435/D2435M-11 Procedure

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Calculations

Load Increment	Increment Duration	Axial Stress σ_a	Corrected Deformation ΔH	Specimen Height H	Axial Strain ϵ_a	Void Ratio e
	min	kPa	mm	mm	%	
Seating	0.0	0	0.0000	20.0000	0.00	1.325
1	25.1	5	0.6905	19.3095	3.15	1.252
2	25.1	10	0.8738	19.1262	4.40	1.223
3	25.1	20	0.9947	19.0053	5.00	1.209
4	25.1	40	1.1292	18.8708	5.69	1.193
5	25.1	80	1.2611	18.7389	6.39	1.177
6	29.9	120	1.3581	18.6419	6.90	1.165
7	31.6	160	1.4472	18.5528	7.36	1.154
8	43.2	200	1.5328	18.4672	7.86	1.143
9	44.9	240	1.6463	18.3537	8.38	1.131
10	71.4	320	1.8369	18.1631	9.75	1.099
11	177.4	480	2.3463	17.6537	14.06	0.998
12	194.0	640	3.3727	16.6273	18.24	0.901
13	131.0	1280	4.8847	15.1153	26.05	0.720
14	87.9	2560	6.1275	13.8725	31.80	0.586
15	25.1	640	6.1975	13.8025	31.00	0.605
16	34.9	160	5.9154	14.0846	29.61	0.637
17	69.7	40	5.5760	14.4240	27.86	0.678
18	114.4	10	5.2123	14.7877	26.04	0.720
19	74.7	5	5.2016	14.7984	25.41	0.734

October 21, 2019
October 21, 2019

Date: Date:
D. Boateng B. Boccage

Checked by: Approved by:

Filename: C:\Users\bocage\Documents\19-2A Anderson consol report.xlsx\Report
Date: October 21, 2019

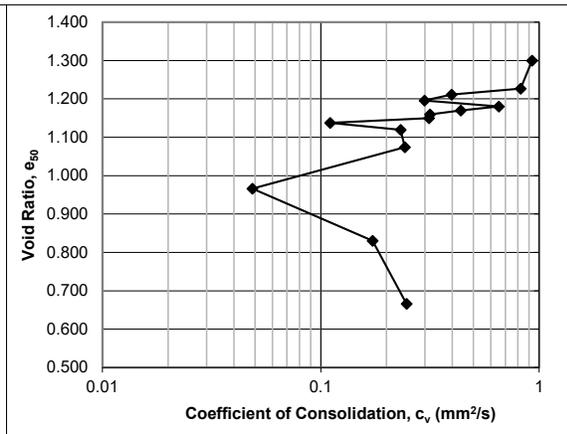
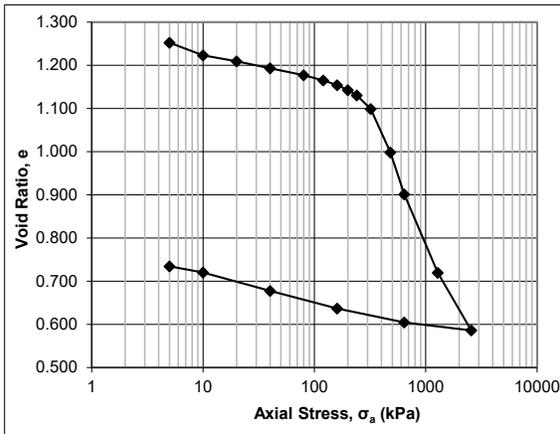
One-Dimensional Consolidation Test using Incremental Loading
ASTM D2435/D2435M - 11

Specimen Details

Job Ref.	Thurber Engineering, File# 24726
Job Location	Anderson Road, Ottawa, ON
Borehole	BH AND 19-2A
Sample No.	ST 2
Depth	22½ - 24½ ft.
Sample Date	September 30, 2019
Test Number	One
Technician Name	Daniel Boateng

Calculations

Load Increment	Axial Stress σ_a , average kPa	Calculated using Interpretation Procedure 2				Interpretation Procedure 1		Interpretation Procedure 2	
		Corrected Deformation ΔH_{50} mm	Specimen Height H_{50} mm	Axial Strain $\epsilon_{a,50}$ %	Void Ratio e_{50}	Time t_{50} sec	Coeff. Consol. c_v mm ² /s	Time t_{90} sec	Coeff. Consol. c_v mm ² /s
Seating	0								
1	3	0.2228	19.7772	1.11	1.299			89	9.28E-01
2	8	0.8503	19.1497	4.25	1.227			95	8.22E-01
3	15	0.9841	19.0159	4.92	1.211			193	3.97E-01
4	30	1.1178	18.8822	5.59	1.195			253	2.99E-01
5	60	1.2466	18.7534	6.23	1.180			114	6.53E-01
6	100	1.3394	18.6606	6.70	1.170			169	4.38E-01
7	140	1.4268	18.5732	7.13	1.159			231	3.16E-01
8	180	1.5107	18.4893	7.55	1.150			231	3.13E-01
9	220	1.6164	18.3836	8.08	1.137			649	1.10E-01
10	280	1.7726	18.2274	8.86	1.119			304	2.32E-01
11	400	2.1592	17.8408	10.80	1.074			278	2.43E-01
12	560	3.0898	16.9102	15.45	0.966			1246	4.86E-02
13	960	4.2588	15.7412	21.29	0.830			305	1.72E-01
14	1920	5.6727	14.3273	28.36	0.666			176	2.47E-01
15	1600	6.2322	13.7678	31.16	0.601				
16	400	6.0346	13.9654	30.17	0.624				
17	100	5.7471	14.2529	28.74	0.657				
18	25	5.3902	14.6098	26.95	0.699				
19	8	5.2040	14.7960	26.02	0.720				



October 21, 2019
October 21, 2019

Date:
Date:
D. Boateng
B. Boccage

Checked by:
Approved by:

C:\Users\boccage\Documents\19-2A Anderson consol report.xlsx\Report
October 21, 2019

Filename:
Date:



Project No.: 122410864

Project Name: Thurber Engineering, File# 24726

Photo Log

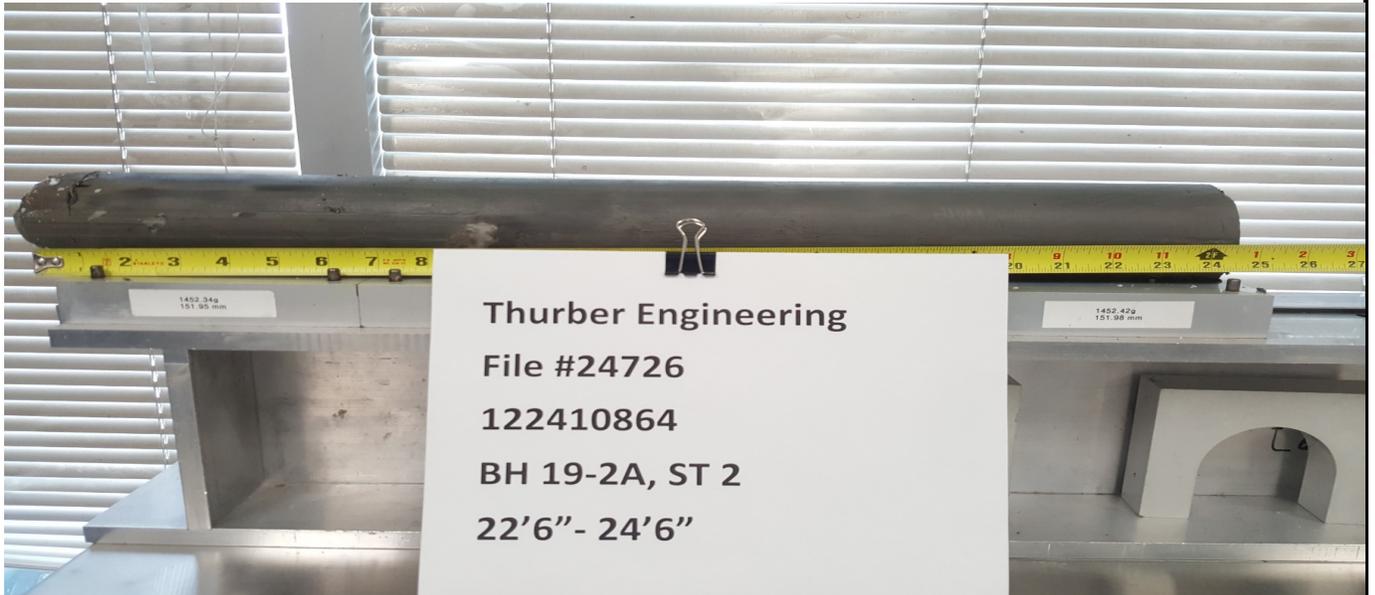


Photo No.: 1 | Borehole: BH AND19-2A ST-2 | Depth: 22½ – 24½ ft



Photo No.: 2 | Borehole: BH AND19-2A ST-2 | Depth: 22½ – 24½ ft



Project No.: 122410864

Project Name: Thurber Engineering, File# 24726

Photo Log



Photo No.:

3

Borehole: BH AND19-2A ST-2

Depth: 22½ – 24½ ft

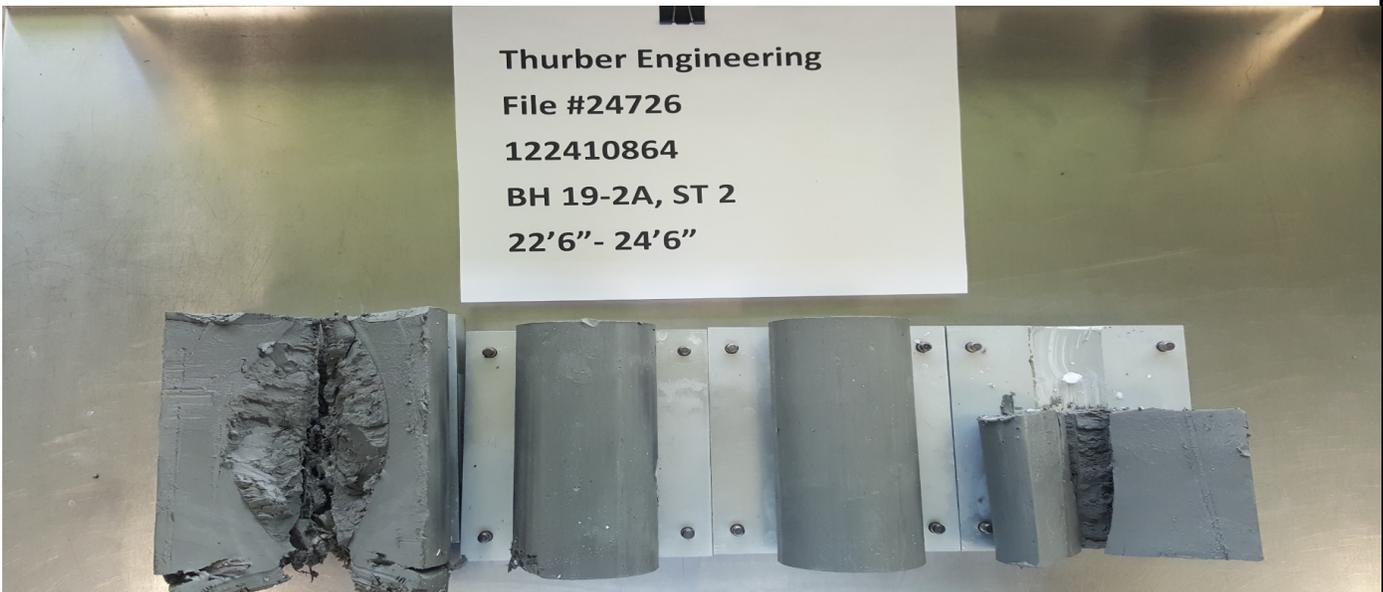


Photo No.:

4

Borehole: BH AND19-2A ST-2

Depth: 22½ – 24½ ft

Appendix C.2
Analytical Testing Results

Certificate of Analysis

Thurber Engineering Ltd.

2460 Lancaster Rd, Suite 104
Ottawa, ON K1B 4S5
Attn: Justin Gray

Client PO: 24726 Task 200a.201
Project: Anderson Rd. Culvert
Custody: 40231

Report Date: 16-Aug-2019
Order Date: 8-Aug-2019

Order #: 1932412

This Certificate of Analysis contains analytical data applicable to the following samples as submitted:

Parcel ID	Client ID
1932412-01	And19-2,SS5 (12'6"-14'6")

Approved By:



Mark Foto, M.Sc.
Lab Supervisor

Certificate of Analysis
Client: **Thurber Engineering Ltd.**
Client PO: **24726 Task 200a.201**

Report Date: 16-Aug-2019

Order Date: 8-Aug-2019

Project Description: Anderson Rd. Culvert

Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	13-Aug-19	14-Aug-19
Conductivity	MOE E3138 - probe @25 °C, water ext	14-Aug-19	14-Aug-19
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	13-Aug-19	14-Aug-19
Resistivity	EPA 120.1 - probe, water extraction	14-Aug-19	14-Aug-19
Solids, %	Gravimetric, calculation	13-Aug-19	13-Aug-19

Certificate of Analysis
 Client: Thurber Engineering Ltd.
 Client PO: 24726 Task 200a.201

Report Date: 16-Aug-2019

Order Date: 8-Aug-2019

Project Description: Anderson Rd. Culvert

Client ID:	And19-2,SS5 (12'6"-14'6")	-	-	-
Sample Date:	01-Aug-19 12:00	-	-	-
Sample ID:	1932412-01	-	-	-
MDL/Units	Soil	-	-	-

Physical Characteristics

% Solids	0.1 % by Wt.	78.6	-	-	-
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General Inorganics

Conductivity	5 uS/cm	576	-	-	-
pH	0.05 pH Units	7.57	-	-	-
Resistivity	0.10 Ohm.m	17.4	-	-	-

Anions

Chloride	5 ug/g dry	227	-	-	-
Sulphate	5 ug/g dry	116	-	-	-

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO: 24726 Task 200a.201

Report Date: 16-Aug-2019

Order Date: 8-Aug-2019

Project Description: Anderson Rd. Culvert

Method Quality Control: Blank

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	ND	5	ug/g						
Sulphate	ND	5	ug/g						
General Inorganics									
Conductivity	ND	5	uS/cm						
Resistivity	ND	0.10	Ohm.m						

Certificate of Analysis
 Client: Thurber Engineering Ltd.
 Client PO: 24726 Task 200a.201

Report Date: 16-Aug-2019

Order Date: 8-Aug-2019

Project Description: Anderson Rd. Culvert

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	219	5	ug/g dry	227			3.5	20	
Sulphate	116	5	ug/g dry	116			0.3	20	
General Inorganics									
Conductivity	1900	5	uS/cm	1940			2.2	5	
pH	10.49	0.05	pH Units	10.51			0.2	2.3	
Resistivity	5.27	0.10	Ohm.m	5.15			2.2	20	
Physical Characteristics									
% Solids	94.0	0.1	% by Wt.	93.7			0.2	25	

Certificate of Analysis
 Client: Thurber Engineering Ltd.
 Client PO: 24726 Task 200a.201

Report Date: 16-Aug-2019

Order Date: 8-Aug-2019

Project Description: Anderson Rd. Culvert

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	320	5	ug/g	227	93.0	82-118			
Sulphate	219	5	ug/g	116	103	80-120			

Certificate of Analysis
Client: **Thurber Engineering Ltd.**
Client PO: **24726 Task 200a.201**

Report Date: 16-Aug-2019
Order Date: 8-Aug-2019
Project Description: Anderson Rd. Culvert

Qualifier Notes:

Login Qualifiers :

Received at temperature > 25C
Applies to samples: And19-2,SS5 (12'6"-14'6")

Sample Data Revisions

None

Work Order Revisions / Comments:

None

Other Report Notes:

n/a: not applicable
ND: Not Detected
MDL: Method Detection Limit
Source Result: Data used as source for matrix and duplicate samples
%REC: Percent recovery.
RPD: Relative percent difference.

Soil results are reported on a dry weight basis when the units are denoted with 'dry'.
Where %Solids is reported, moisture loss includes the loss of volatile hydrocarbons.

Subcontracted Analysis

Thurber Engineering Ltd.

2460 Lancaster Rd, Suite 104
Ottawa, ON K1B 4S5

Attn: Justin Gray

Tel: (613) 408-6795

Fax: (613) 247-2185

Paracel Report No **1932412**

Client Project(s): **Anderson Rd. Culvert**

Client PO: **24726 Task 200a.201**

Reference: **Standing Offer**

CoC Number: **40231**

Order Date: 08-Aug-19

Report Date: 16-Aug-19

Sample(s) from this project were subcontracted for the listed parameters. A copy of the subcontractor's report is attached

Paracel ID	Client ID	Analysis
1932412-01	And19-2,SS5 (12'6"-14'6")	Sulphide, solid

SGS Canada Inc.

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

Paracel Laboratories

Attn : Dale Robertson

300-2319 St.Laurent Blvd.
Ottawa, ON
K1G 4K6, Canada

Phone: 613-731-9577
Fax:613-731-9064

19-August-2019

Date Rec. : 13 August 2019
LR Report: CA12524-AUG19
Reference: Project#: 1932412

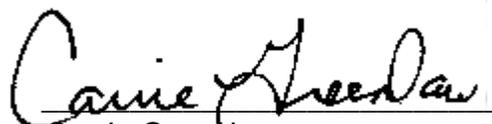
Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Sample ID	Sample Date & Time	Sulphide %
1: Analysis Start Date		16-Aug-19
2: Analysis Start Time		14:26
3: Analysis Completed Date		16-Aug-19
4: Analysis Completed Time		15:50
5: QC - Blank		< 0.02
6: QC - STD % Recovery		110%
7: QC - DUP % RPD		ND
8: RL		0.02
9: AND19-2, SS5 (12'6"-14'6")	01-Aug-19 12:00	0.20

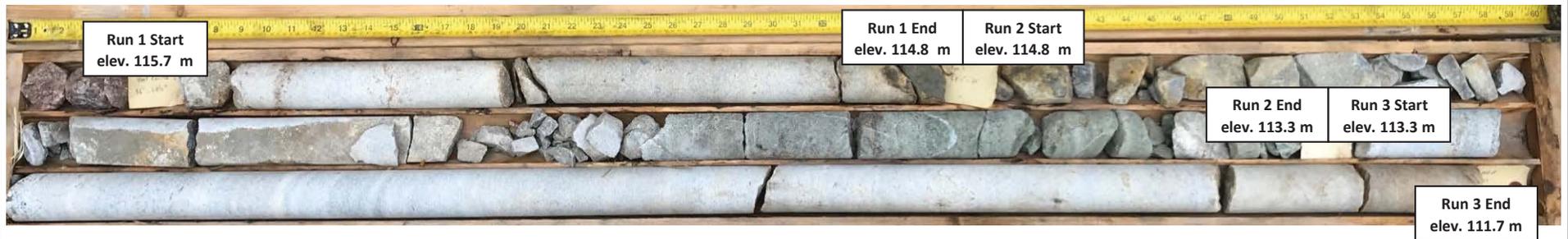
RL - SGS Reporting Limit



Carrie Greenlaw
Carrie Greenlaw
Project Specialist,
Environment, Health & Safety

Appendix C.3
Bedrock Core Photographs

Borehole AND19-1D
Run 1 to 3 (of 3)
Elevation 115.7 m to 111.7 m



Geotechnical Investigation
HWY 17 Twinning (Anderson Road)
Renfrew, Ontario

WP: 4068-09-00
Project No.: 24726

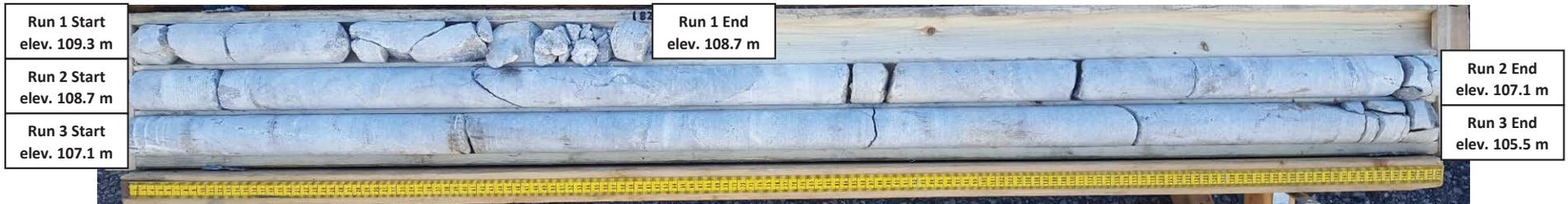
Borehole AND19-2
Run 1 to 3 (of 3)
Elevation 109.9 m to 106.1 m



Geotechnical Investigation
HWY 17 Twinning (Anderson Road)
Renfrew, Ontario

WP: 4068-09-00
Project No.: 24726

Borehole 18-103
Run 1 to 3 (of 3)
Elevation 109.3 m to 105.5 m



THURBER ENGINEERING LTD.

Geotechnical Investigation
HWY 17 Twinning (Anderson Road)
Renfrew, Ontario

WP: 4068-09-00

Project No.: 24726

Appendix D.

Site Photographs



**Photo 1. Looking North towards culvert inlet
(2019/09/20)**



**Photo 2. Looking South towards AND19-1, AND19-1B, AND19-1C and AND19-1D
(2019/09/20)**



**Photo 3. Looking South-east towards AND19-3 and culvert outlet
(2019/08/08)**



**Photo 4. Looking East along existing roadway towards high fill area
(2019/06/24)**



**Photo 5. Google Earth imagery showing the location of the Anderson Road Culvert. The construction for the replacement of the Highway 17 Locha Creek Culvert is visible to the north.
(Imagery Date 2019/10/10)**