

**FOUNDATION INVESTIGATION REPORT
HIGHWAY 527 ROUSSEAU LAKE CULVERT
81.0 KM NORTH OF HIGHWAY 11/17, THUNDER BAY UNORGANIZED
SITE NO.: 48C-242/C
ASSIGNMENT NO. 6017-E-0013**

G.W.P. 6827-14-00

Geocres No.: 52H-46

Report to:

Hatch Corporation

Latitude: 49.111033°
Longitude: -89.312142°

December 2018
Thurber File: 19773

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PART 1. FACTUAL INFORMATION

1 INTRODUCTION

This section of the report presents the factual findings obtained from a foundation investigation completed for Rousseau Lake Culvert on Highway 527. The culvert is located approximately 81.0 km north of Highway 11/17 within the Unorganized Thunder Bay District and conveys an unnamed creek between Rousseau Lake and Curzon Lake. Thurber Engineering Limited (Thurber) carried out the current investigation as a sub-consultant to Hatch Corporation (Hatch) under Assignment No. 6017-E-0013.

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. No previous foundation investigation information was available for the subject culvert site within the online Geocres Library.

2 SITE DESCRIPTION

The existing culvert, conveying an unnamed creek under Highway 527 from Rousseau Lake to Curzon Lake, is a twin cell timber culvert with an unknown construction date. A site survey plan from Hatch indicates that each cell is approximately 2.2 m wide, 1.5 m high and approximately 18 m long. The culvert alignment is generally west to east with the flow through the culvert toward the west.

At the location of the culvert, Highway 527 is a two-lane highway with a rural cross-section and gravel shoulders. The embankment fill height above the culvert is approximately 1.5 m. The elevation of the road surface at the centreline is approximately 448.2 m. The existing embankment slopes are approximately inclined between 1.8H:1V and 2.6H:1V. The land adjacent to the highway is undeveloped and densely vegetated with trees. Traffic volumes on this section of Highway 527 are understood to be between 170 and 420 AADT (2016).

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

3 SITE INVESTIGATION AND FIELD TESTING

Thurber contacted Ontario One Call in advance of the field investigation to obtain utility locate clearances in the vicinity of the intended boreholes.

The site investigation and field testing program was carried out between May 30th and June 16th, 2018. The northing, easting and elevation of the boreholes are shown on the Borehole Location and Soil Strata Drawing No. 1 in Appendix A and are summarized in Table 3-1. The site is within MTM Zone 15.

Table 3-1: Borehole Summary

Borehole No.	Drilled Location	Northing (m)	Easting (m)	Ground Surface Elevation (m)	Termination Depth (m)
18-101A	South of culvert – SB Lane	5 441 649.9	355 009.2	448.2	5.2
18-101B	South of culvert – SB Lane	5 441 649.4	355 009.4	448.2	15.6
18-102	Bypass culvert – NB Lane	5 441 670.5	355 006.8	448.1	13.1
18-103	East end – culvert inlet	5 441 653.0	355 021.9	446.4	3.7
18-104	West end – culvert outlet	5 441 656.2	354 997.7	446.0	6.2

The drilling was carried out using a truck mounted CME 75 drill rig for on-road Boreholes 18-101A, 18-101B and 18-102 and portable drilling equipment for off-road Boreholes 18-103 and 18-104.

An obstruction was encountered in Borehole 18-101A which caused the casing to deflect at a depth of 5.2 m, prohibiting advancing past elevation 443.0 m and therefore the borehole was terminated at this elevation. To continue, Borehole 18-101B was advanced 0.6 m south of Borehole 18-101A and continued sampling below a depth of 5.2 m.

Boreholes 18-103 and 18-104 were terminated at depths of 3.7 and 6.2 m, respectively, upon encountering practical refusal of the portable drilling equipment within the very dense glacial till layer.

Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). Boreholes 18-103 and 18-104, which were drilled with portable equipment, also utilized a full-weight hammer for SPT testing. Bedrock was cored and collected in Boreholes 18-101B and 18-102 using NQ coring equipment where encountered.

A 19 mm diameter standpipe piezometer was installed in Borehole 18-103 to allow for measurements of the groundwater level after completion of drilling. The piezometer installation details are illustrated on the respective Record of Borehole sheet provided in

Appendix B. All other boreholes were backfilled with a low-permeability mixture of cuttings and bentonite pellets in accordance with Ontario MOE Regulation 903 as amended. Boreholes advanced within paved areas were capped with granular fill followed by 150 mm of cold patch asphalt to reinstate the travelling surface. The piezometer installed during the investigation was decommissioned in accordance with Ontario MOE Regulation 903 on August 11, 2018.

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 laboratory for further examination and testing.

4 LABORATORY TESTING

Geotechnical laboratory testing consisted of natural moisture content determination and visual identification of all retained soil samples. Testing for grain size distribution and Atterberg Limits was also carried out on selected samples to MTO and ASTM standards. 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, sulphate and chloride concentrations was carried out on two soil samples and one surface water sample. Chemical analysis for determination of sulphide concentration was carried out on one soil sample.

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 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 Locations 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 paragraphs. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description for interpretation of the site conditions. It must be recognized that the soil and groundwater conditions may vary between and beyond borehole locations.

In general terms, subsurface conditions at the site consist of pavement structure and granular embankment fill overlying a native silt deposit, which is underlain by glacial till over bedrock.

5.1 Embankment Fill

5.1.1 Asphalt

Boreholes 18-101A and 18-102 were drilled through the travelled lanes of the Highway 527 embankment and encountered a layer of asphalt with a thickness ranging from 75 mm to 125 mm.

5.1.2 Fill: Sand

Below the asphalt pavement within the on-road boreholes were layers of granular base (sand with gravel) over silty sand embankment fill. The underside of the embankment fill was at 2.4 to 3.7 m below the existing roadway surface (elev. 444.5 to 445.7 m).

The SPT tests conducted in the fill typically gave N-values ranging from 31 to 94 blows indicating a relative density of dense to very dense. A single N-value of 4 was recorded below the groundwater table near the base of the embankment fill in Borehole 18-101A. Recorded moisture contents ranged from 2 to 29%.

Gradation analyses were completed on two samples of the embankment fill. The grain size distribution curves for these samples are included in Figure C1 of Appendix C. The results of the tests are summarized in Table 5-1 below and are presented on the corresponding Record of Borehole sheets in Appendix B.

Table 5-1: Gradation Results for Embankment Fill

Soil Particle	Percentage (%)
Gravel	1 to 26
Sand	59 to 62
Silt and Clay	12 to 40

5.2 Silty Sand with Organics

A thin layer of silty sand with organics was encountered from surface in off-road Boreholes 18-103 and 18-104. The underside of this layer ranged from 0.6 to 1.2 m below the existing ground surface (elev. 444.8 to 445.8 m). SPT tests conducted in the silty sand gave N-values ranging from 2 to 10 blows indicating relative density of very loose to compact. Very poor sample recovery within the split spoon sampler was noted within this layer. A single moisture content of 47% was measured.

5.3 Peat

A thin layer of fine fibrous peat was encountered directly below the embankment fill in Borehole 18-102 at the culvert bypass location. This layer had a thickness of 1.0 m and an underside depth of 3.4 m below the existing ground surface (elev. 444.7 m). The recorded moisture contents of the peat ranged from 153% to 188%.

5.4 Silt to Sandy Silt

A deposit of silt to sandy silt was encountered below the fill in Borehole 18-101A, below the peat in Borehole 18-102, and below the silty sand in Boreholes 18-103 and 18-104. The thickness of this layer ranged from 0.9 to 3.1 m with underside depths ranging from 1.9 to 5.3 m below ground surface (elev. 444.5 to 441.7 m).

SPT tests conducted in this deposit gave N-values ranging from 3 to 39 blows were recorded within the layer indicating a relative density of very loose to dense. The recorded moisture contents ranged from 24 to 49%.

Gradation analyses were completed on three samples of the silt to sandy silt layer. The grain size distribution curves are included in Figure C2 of Appendix C. The results of the tests are summarized in Table 5-2 below and are presented on the corresponding Record of Borehole sheets in Appendix B.

Table 5-2: Gradation Results for Silt to Sandy Silt

Soil Particle	Percentage (%)
Gravel	0 to 6
Sand	0 to 29
Silt	56 to 88
Clay	9 to 12

Atterberg Limit testing was completed on three samples of the native silt deposit. Two of the samples were found to be non-plastic; one sample was found to have a liquid limit of 34%, a plastic limit of 27% and a plasticity index of 7% indicating a low plasticity (ML). The results of the Atterberg Limit testing are summarized on the Record of Borehole sheets in Appendix B and the plasticity chart included in Figure C5 of Appendix C.

5.5 Silty Sand to Sandy Clay (Glacial Till)

A deposit of glacial till was encountered below the silt to sandy silt layers in all boreholes. The glacial till varies in composition from silty sand with gravel, to sandy silt with gravel, to sandy clay some gravel, to silty clay. Cobbles were noted in the till in all boreholes and boulders were noted in in Boreholes 18-101A, 18-101B, 18-103 and 18-104.

Boreholes 18-103 and 18-104 were terminated within the glacial till layer at base elevations of 442.7 and 439.8 m respectively upon SPT and/or casing advancement refusal. Where fully penetrated, the thickness of the glacial till deposit ranged from 4.5 to 7.5 m and the underside depth ranged from 9.8 to 12.1 m below the existing ground surface (elev. 436.1 to 438.3 m).

SPT tests conducted in the non-cohesive till deposits gave N-values ranging from 9 blows for 300 mm of penetration to 100 blows for 100 mm indicating a relative density of loose to very dense; but typically dense to very dense. SPT tests conducted in the cohesive till deposit gave N-values ranging from 72 to 140 blows indicating a hard consistency. The recorded moisture contents ranged from 9 to 23% within the glacial till layers.

Gradation analyses were completed on four samples of the non-cohesive till and two samples of the cohesive till. The grain size distribution curves are included in Figures C3 and C4 of Appendix C. The results of the tests are summarized in Table 5-3 below and are presented on the corresponding Record of Borehole sheets in Appendix B.

Table 5-3: Gradation Results for Glacial Till

Soil Particle	Percentage (%)	
	Non-Cohesive Sand/Silt Till	Cohesive Clay Till
Gravel	9 to 26	0 to 11
Sand	28 to 46	1 to 21
Silt	35 to 53	31
Clay	3 to 6	

Atterberg limit testing completed on three samples of the non-cohesive till indicate that the material is non-plastic. Atterberg limit testing completed on two samples of the cohesive clay till indicate a low plasticity (CL-ML to CL). The results are summarized in Table 5-4 below, on the Record of Borehole sheets in Appendix B and on the plasticity chart in Figure C6 of Appendix C.

Table 5-4: Atterberg Limit Results for Clay Till

Parameter	Water Content (%)
Liquid Limit	21 to 22
Plastic Limit	13 to 15
Plasticity Index	7 to 8

5.6 Refusal and Bedrock

Practical refusal to advancement of the portable drilling equipment was encountered at off-road Boreholes 18-103 and 18-104 within the very dense glacial till present at this site. Bedrock was not cored in these boreholes since practical refusal occurred prior to encountering bedrock.

Bedrock was proven by coring in on-road Boreholes 18-101B and 18-102. Information on the confirmed bedrock surface is summarized in Table 5-5 below:

Table 5-5: Summary of Bedrock Depth/Elevation

Borehole No.	Depth to Bedrock Surface (mbgs)	Bedrock Surface Elevation (m)
18-101B	12.1	436.1
18-102	9.8	438.3

The bedrock encountered within Boreholes 18-101B and 18-102 consisted of fine to medium grained mafic metavolcanic bedrock. The Total Core Recovery (TCR) measured on the recovered bedrock core was 100%, the Solid Core Recovery (SCR) ranged from 55 to 100% and the Rock Quality Designation (RQD) ranged from 33 to 89%. Based on the

measured RQD values, the bedrock is classified as poor to good quality. The bedrock is estimated to be very strong. Photographs of the bedrock core are provided in Appendix C.

5.7 Groundwater

The water level was measured in the piezometer installed in Borehole 18-103 and is presented in Table 5-6 below:

Table 5-6: Groundwater Level Observations

Borehole	Groundwater Level		Date of Measurement
	Depth (mbgs)	Elevation (m)	
18-103	0.3	446.1	June 15, 2018
	0.3	446.1	August 11, 2018

The creek water level was surveyed at the culvert inlet and outlet and the measured elevations are provided in Table 5-7 below:

Table 5-7: Creek Water Level Observations

Location	Surface Water Elevation (m)	Date of Measurement
Culvert Inlet	446.0	June 1, 2018
Culvert Outlet	446.0	June 1, 2018

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

5.8 Analytical Testing

Two samples of soil were submitted to Paracel Laboratories in Ottawa, Ontario for analysis of pH, water soluble sulphate and chloride concentrations, resistivity and conductivity. One of the submitted samples was also tested for sulphide. The analysis results are provided in Appendix C and are summarized in Table 5-8 below:

Table 5-8: Analytical Results Summary (Soil)

Borehole	18-101A	18-103
Sample	SS6	SS5
Depth (m)	3.8 – 4.4	2.5 – 3.1
Chloride (µg/g)	9	8
Sulphate (µg/g)	16	12
Sulphide (%)	< 0.02	-
pH (-)	7.8	7.4
Resistivity (Ohm-cm)	7430	7610
Conductivity (uS/cm)	135	131

A surface water sample was obtained on November 30, 2018 upstream of the existing culvert and was also submitted to Paracel Laboratories in Ottawa, Ontario for analysis of conductivity, pH, resistivity, chloride and sulphate. The analysis results are provided in Appendix C and are summarized in Table 5-9 below.

Table 5-9: Analytical Results Summary (Surface Water)

Parameter	Result
Chloride (mg/L)	7
Sulphate (mg/L)	1
pH (-)	7.5
Resistivity (Ohm-cm)	7,990
Conductivity (μ S/cm)	125

6 MISCELLANEOUS

Borehole locations were selected in consultation with Hatch and the Ministry of Transportation relative to the existing culvert and the existing site features. The as-drilled locations and ground surface elevations were surveyed by Thurber.

George Downing Estate Drilling Ltd. of Hawkesbury, Ontario and OGS Drilling of Almonte, Ontario supplied and operated the drilling equipment for the on-road and off-road boreholes respectively, to carry out the drilling, soil sampling, in-situ testing, piezometer installation and borehole decommissioning. Traffic control was provided by NC Traffic Management Inc of Kirkland Lake, Ontario. The field investigation was supervised on a full-time basis by Mr. Nick Weil and Mr. Sean O'Bryan, C.E.T., of Thurber. Overall supervision of the investigation program was conducted by Mr. Stephen Dunlop, 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.

Interpretation of the factual data and preparation of this report were carried out by Mr. Christopher Murray, P.Eng. and Mr. Stephen Dunlop, P.Eng. The report was reviewed by Dr. Fred Griffiths, P.Eng., a Designated Principal Contact for MTO Foundation Projects.



Christopher Murray, M.A.Sc., P.Eng.
Geotechnical Engineer



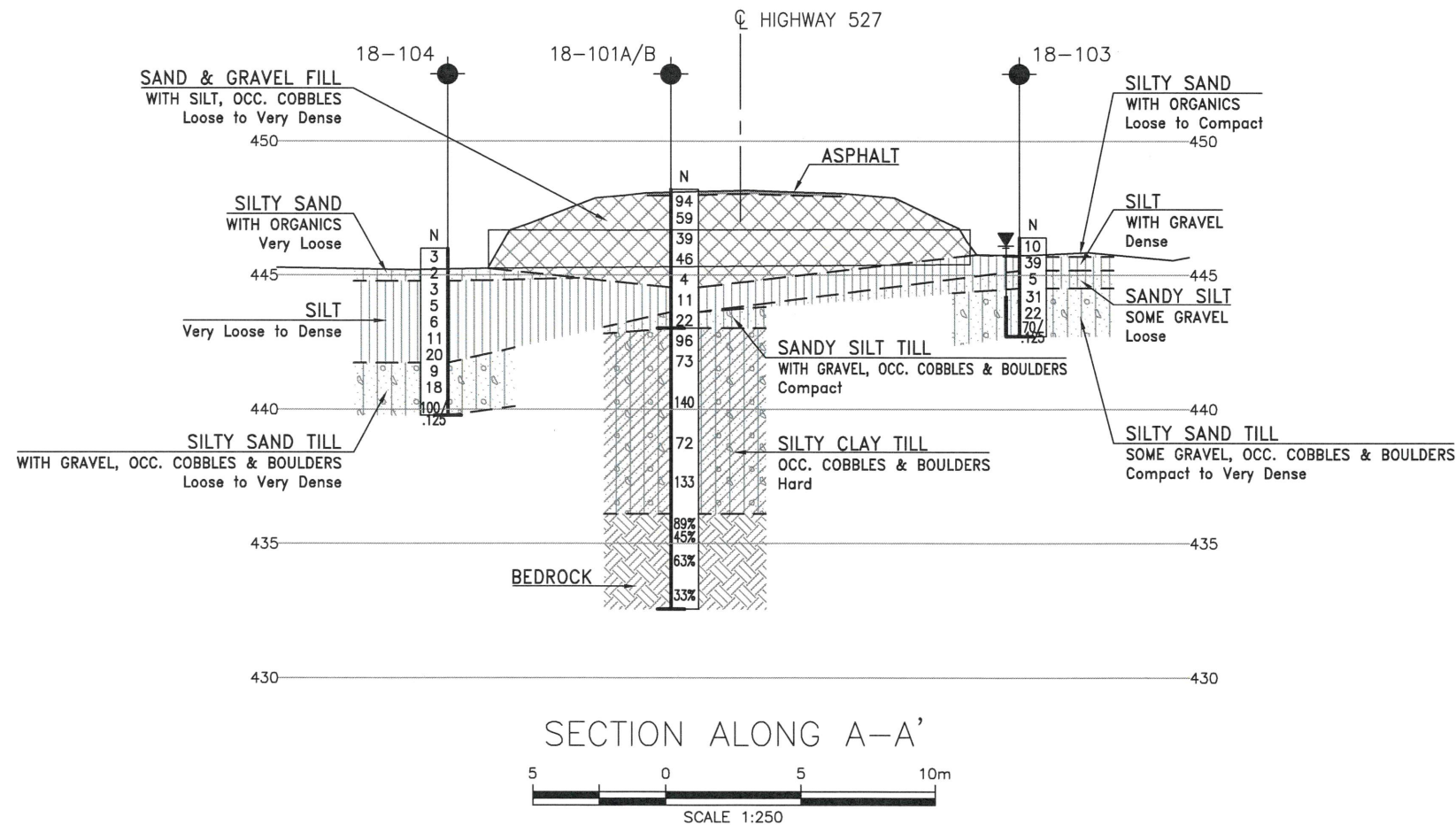
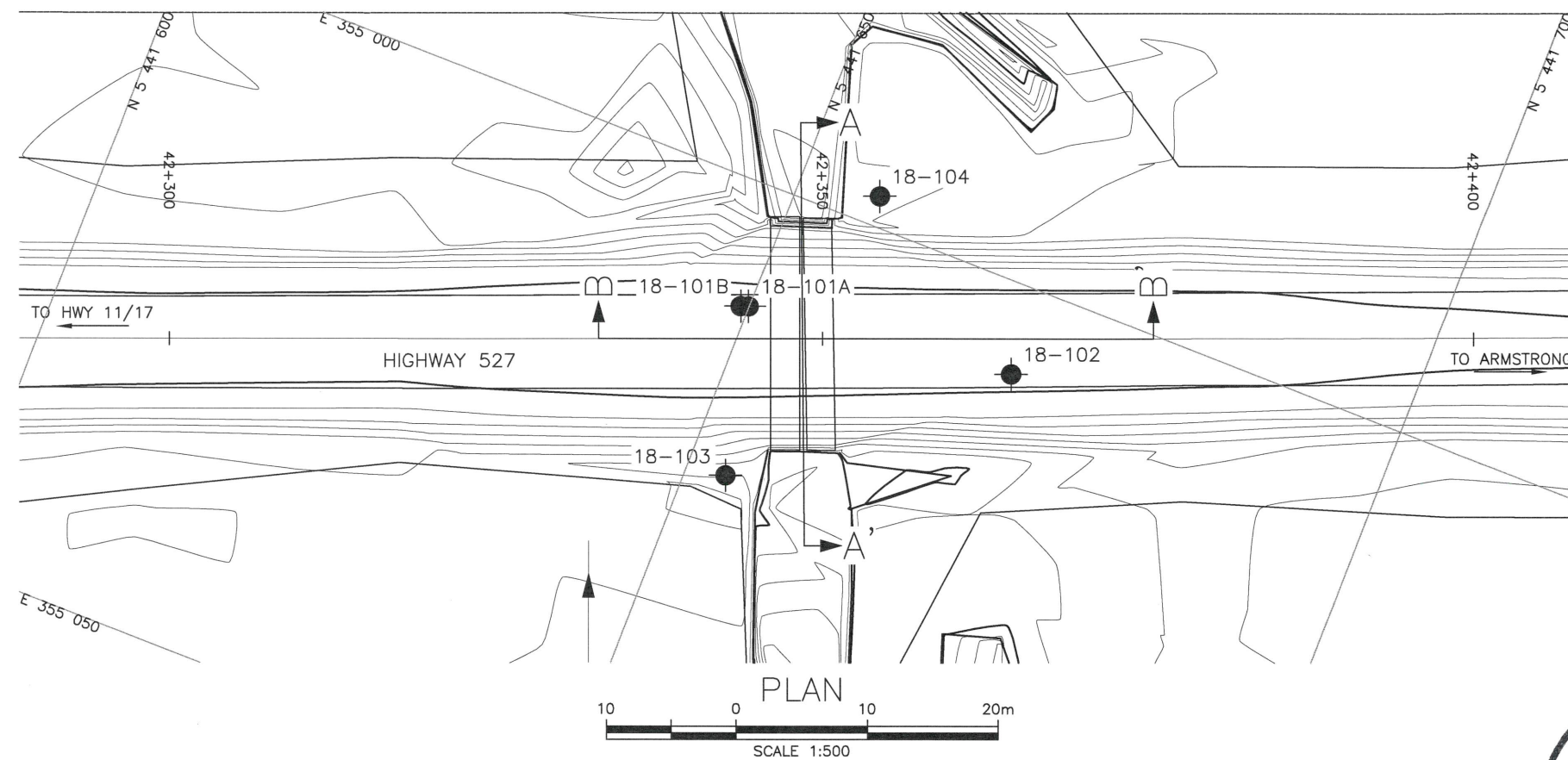
Stephen Dunlop, M.A.Sc., P.Eng.
Senior Geotechnical Engineer



Dr. Fred Griffiths, P.Eng.
Senior Associate
Senior Geotechnical Engineer

Appendix A.

Drawings



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

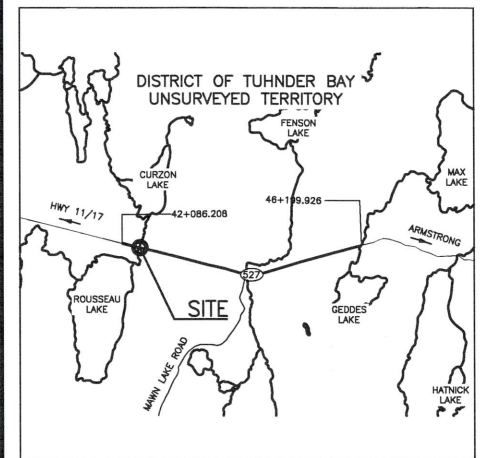
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GWP No 6827-14-00

HIGHWAY 527
ROUSSEAU LAKE CULVERT
REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

HATCH



THURBER ENGINEERING LTD.



LEGEND

●	Borehole
⊕	Borehole & 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

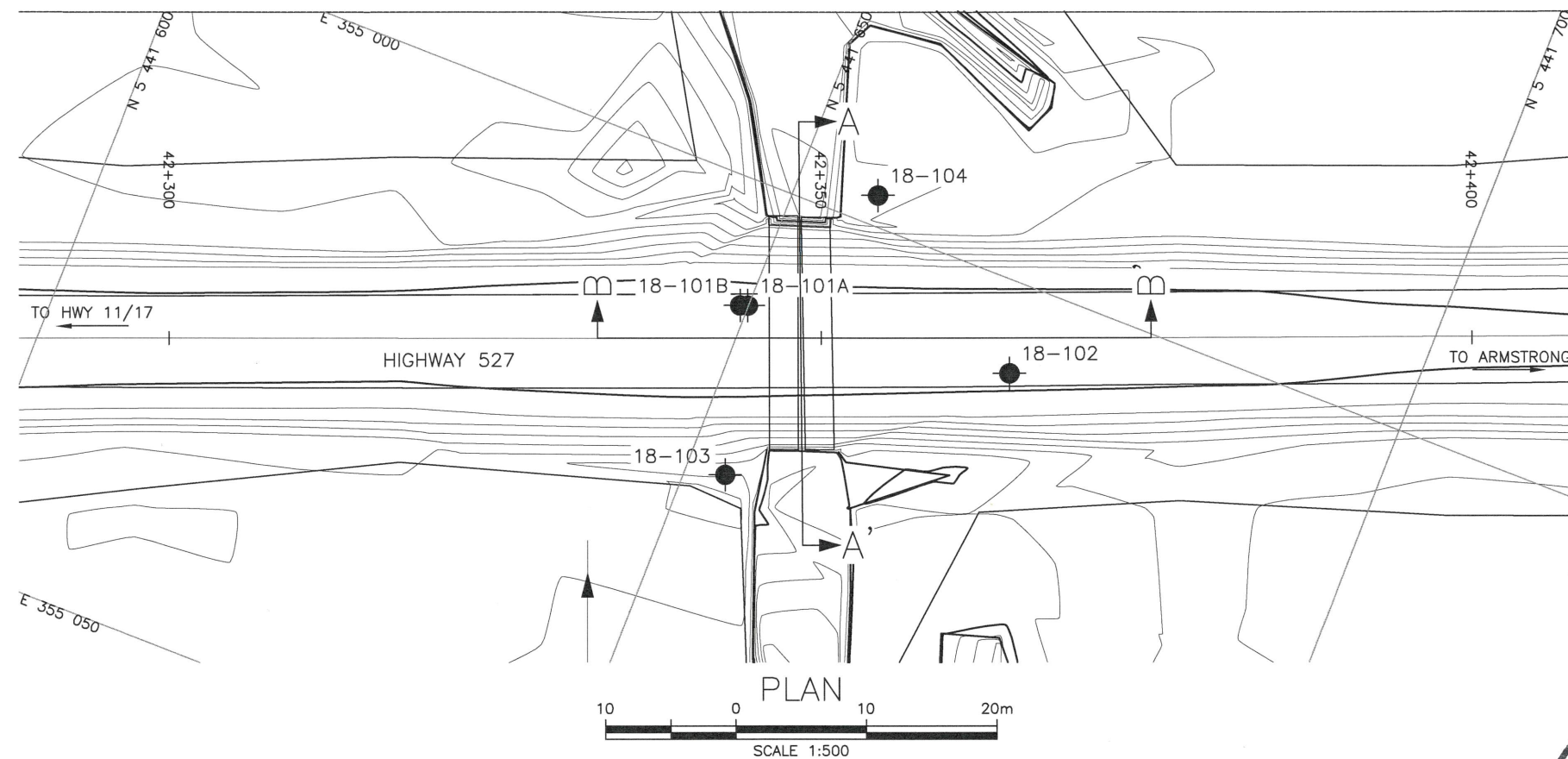
NO	ELEVATION	NORTHING	EASTING
18-101A	448.2	5 441 649.9	355 009.2
18-101B	448.2	5 441 649.4	355 009.4
18-102	448.1	5 441 670.5	355 006.8
18-103	446.4	5 441 653.0	355 021.9
18-104	446.0	5 441 656.2	354 997.7

-NOTES-

- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- 2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- 3) Coordinate system is MTM NAD 83 Zone 15.

GEOCRES No. 52H-46

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	DP	CHK SP	CODE
DRAWN	MFA	CHK CM	SITE
LOAD	DATE	DEC 2018	
STRUCT	DWG	1	



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

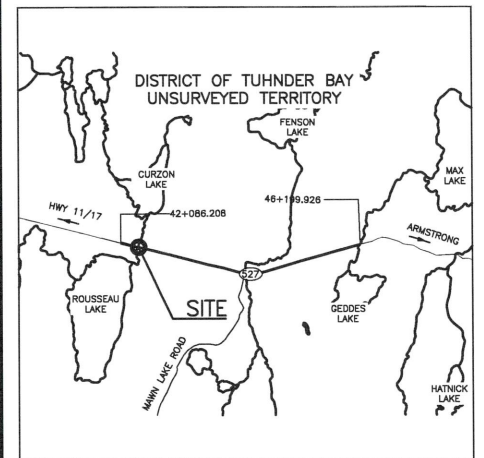
CONT No
GWP No 6827-14-00

HIGHWAY 527
ROUSSEAU LAKE CULVERT
REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

HATCH



THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

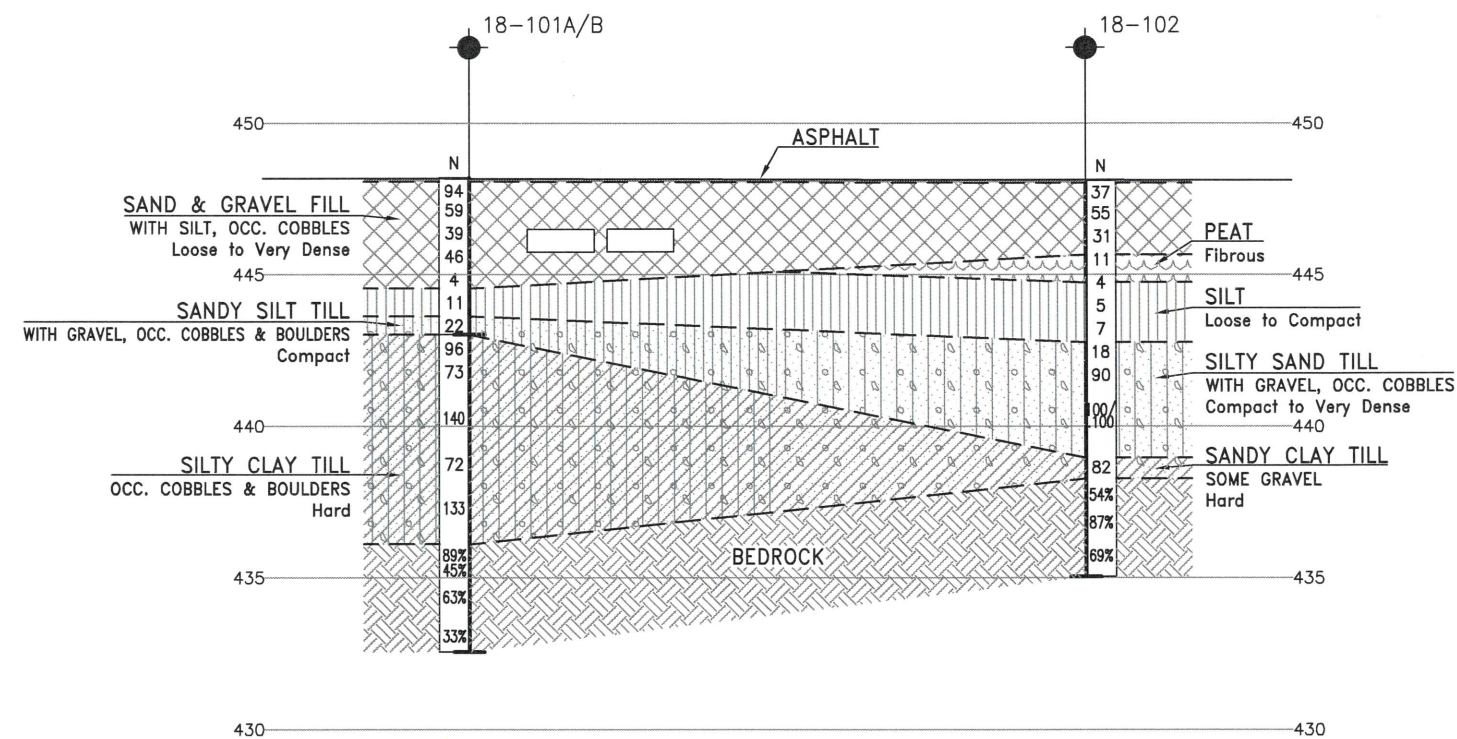
●	Borehole
⊕	Borehole & Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60' Cone, 475J/blow)
PH	Pressure, Hydraulic
▽	Water Level
▽	Head Artesian Water
↑	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
18-101A	448.2	5 441 649.9	355 009.2
18-101B	448.2	5 441 649.4	355 009.4
18-102	448.1	5 441 670.5	355 006.8
18-103	446.4	5 441 653.0	355 021.9
18-104	446.0	5 441 656.2	354 997.7

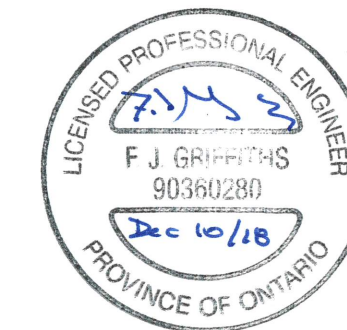
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GEOCRES No. 52H-46



PROFILE ALONG B-B'



REVISIONS	DATE	BY	DESCRIPTION
DESIGN	DP	CHK SP	CODE
DRAWN	MFA	CHK CM	SITE
			LOAD
			STRUCT
			DWG 2
			DATE DEC 2018

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).

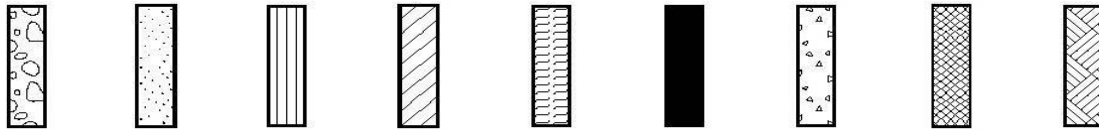
DYNAMIC CONE PENETRATION TEST (DCPT):

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

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.

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 (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 clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean 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 18-101A

1 OF 1

METRIC

GWP# 6827-14-00 LOCATION Lat: 49.1109485°, Long: -89.3122175°
Rousseau Lake Culvert, MTM z15: N 5 441 649.9 E 355 009.2 ORIGINATED BY NW
HWY 527 BOREHOLE TYPE HSA / NW Casing COMPILED BY SOB
DATUM Geodetic DATE 2018.05.30 - 2018.05.30 CHECKED BY SD

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					
448.2													
0.0	125 mm ASPHALT												
0.1	SAND with Gravel, FILL		1	SS	94								
447.7	Very Dense												
0.5	Brown		2	SS	59								
	Silty SAND with Gravel, FILL												
	Dense to Loose												
	Brown		3	SS	39								
			4	SS	46								
			5	SS	4								
444.5													
3.7	SILT (ML)		6	SS	11								
	Compact												
	Grey												
443.6													
4.6	Sandy SILT (ML) with Gravel,		7	SS	22								
	occasional Cobbles and Boulders,												
	TILL												
443.0	Compact												
5.2	Grey												
	Casing deflected at 5.2 m depth and could not be advanced, Borehole Terminated at 5.2 m Continued in BH 18-101B												

DOUBLE LINE 19773 ROUSSEAU LAKE.GPJ 2012TEMPLATE(MTO).GDT 12/12/18

METRIC[illegible]

+³, ×³: Numbers refer to Sensitivity

DOUBLE LINE 19773 ROUSEAU LAKE.GPJ 2012TEMPLATE(MTO).GDT 12/12/18

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 18-102

1 OF 2

METRIC

GWP# 6827-14-00 LOCATION Lat: 49.111338°, Long: -89.3122485°
Rousseau Lake Culvert, MTM z15: N 5 441 670.5 E 355 006.8 ORIGINATED BY NW
HWY 527 BOREHOLE TYPE NW Casing / NQ Coring COMPILED BY SOB
DATUM Geodetic DATE 2018.06.01 - 2018.06.01 CHECKED BY SD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W P W W L			
								20 40 60 80 100					
								○ UNCONFINED + FIELD VANE					
								● QUICK TRIAXIAL × LAB VANE					
								20 40 60 80 100					
448.1													
0.0	75 mm ASPHALT						448						
0.1													
447.8	SAND with Gravel, FILL		1	SS	37								
0.3	Dense Brown												
	Silty SAND some Gravel, FILL		2	SS	55		447						
	Very Dense Brown												
446.6													
1.5	Silty SAND, FILL		3	SS	31		446						1 59 40 (SI+CL)
	Dense Grey												
445.7													
2.4	Fine Fibrous PEAT		4	SS	11		445						
444.7			5	SS	4								
3.4	SILT (ML)												
	Loose Grey												
			6	SS	5		444						0 0 88 12 Non-plastic
			7	SS	7		443						
442.8													
5.3	Silty SAND (SM) with Gravel, occasional Cobbles, TILL		8	SS	18		442						26 43 31 (SI+CL)
	Compact to Very Dense Grey												
			9	SS	90		441						
			10	SS	100/		440						
					100mm								
439.0							439						
9.1	Sandy CLAY (CL) some Gravel, TILL		11	SS	82								11 21 42 26
	Hard Grey												
438.3													
9.8	Mafic Metavolcanic Bedrock												

Continued Next Page

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

DOUBLE LINE 19773 ROUSSEAU LAKE.GPJ 2012TEMPLATE(MTO).GDT 12/12/18

RECORD OF BOREHOLE No 18-102

2 OF 2

METRIC

GWP# 6827-14-00 LOCATION Lat: 49.1111338°, Long: -89.3122485°
Rousseau Lake Culvert, MTM z15: N 5 441 670.5 E 355 006.8 ORIGINATED BY NW
HWY 527 BOREHOLE TYPE NW Casing / NQ Coring COMPILED BY SOB
DATUM Geodetic DATE 2018.06.01 - 2018.06.01 CHECKED BY SD

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					
	Continued From Previous Page						20 40 60 80 100						
	Mafic Metavolcanic Bedrock Fresh Fine to Medium Grained Dark Grey to Black Very Strong		1	RUN			20 40 60 80 100					3	RUN #1 TCR=100% SCR=78% RQD=54%
			2	RUN			20 40 60 80 100					2	
			3	RUN			20 40 60 80 100					1	
							20 40 60 80 100					1	RUN #2 TCR=100% SCR=100% RQD=87%
							20 40 60 80 100					0	
							20 40 60 80 100					1	
435.0						20 40 60 80 100					1	RUN #3 TCR=100% SCR=100% RQD=69%	
13.1	End of Borehole					20 40 60 80 100					4		

RECORD OF BOREHOLE No 18-103

1 OF 1

METRIC

GWP# 6827-14-00 LOCATION Lat: 49.1109752°, Long: -89.3120427°
Rousseau Lake Culvert, MTM z15: N 5 441 653.0 E 355 021.9 ORIGINATED BY SOB
HWY 527 BOREHOLE TYPE Portable / NW Casing COMPILED BY SOB
DATUM Geodetic DATE 2018.06.15 - 2018.06.15 CHECKED BY SD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa											
446.4							20	40	60	80	100	PLASTIC LIMIT W P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W L	GR	SA	SI	CL	
0.0	Silty SAND (SM) with Organics Loose to Compact Brown		1	SS	10														
445.8																			
0.6	SILT (ML) with Gravel Dense Grey Brown		2	SS	39														
445.2																			
1.2	Sandy SILT (ML) some Gravel Loose Grey Brown		3	SS	5														
444.5																			
1.9	Silty SAND (SM) some Gravel, occasional Cobbles and Boulders, TILL Compact to Very Dense Grey		4	SS	31														
			5	SS	22														
			6	SS	100/ 275mm														
442.7																			
3.7	End of Borehole on Practical Refusal Standpipe Readings: DATE DEPTH (m) ELEV. (m) 2018.06.15 0.3 446.1 2018.08.11 0.3 446.1																		

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

RECORD OF BOREHOLE No 18-104

1 OF 1

METRIC

GWP# 6827-14-00 LOCATION Lat: 49.1110058°, Long: -89.3123745°
Rousseau Lake Culvert, MTM z15: N 5 441 656.2 E 354 997.7 ORIGINATED BY SOB
HWY 527 BOREHOLE TYPE Portable / NW Casing COMPILED BY SOB
DATUM Geodetic DATE 2018.06.15 - 2018.06.16 CHECKED BY SD

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	WATER CONTENT (%)						
446.0							20	40	60	80	100							
0.0	Silty SAND (SM) with Organics Very Loose Brown		1	SS	3													
			2	SS	2													
444.8																		
1.2	SILT (ML) Very Loose to Compact Grey		3	SS	3													
			4	SS	5													
			5	SS	6													
			6	SS	11													
			7	SS	20													
441.7																		
4.3	Silty SAND (SM) with Gravel, occasional Cobbles and Boulders, TILL Loose to Very Dense Grey		8	SS	9													
			9	SS	18													
439.8			10	SS	100/													
6.2	End of Borehole on Practical Refusal				125mm													

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

Appendix C.

Laboratory Testing

Appendix C.1

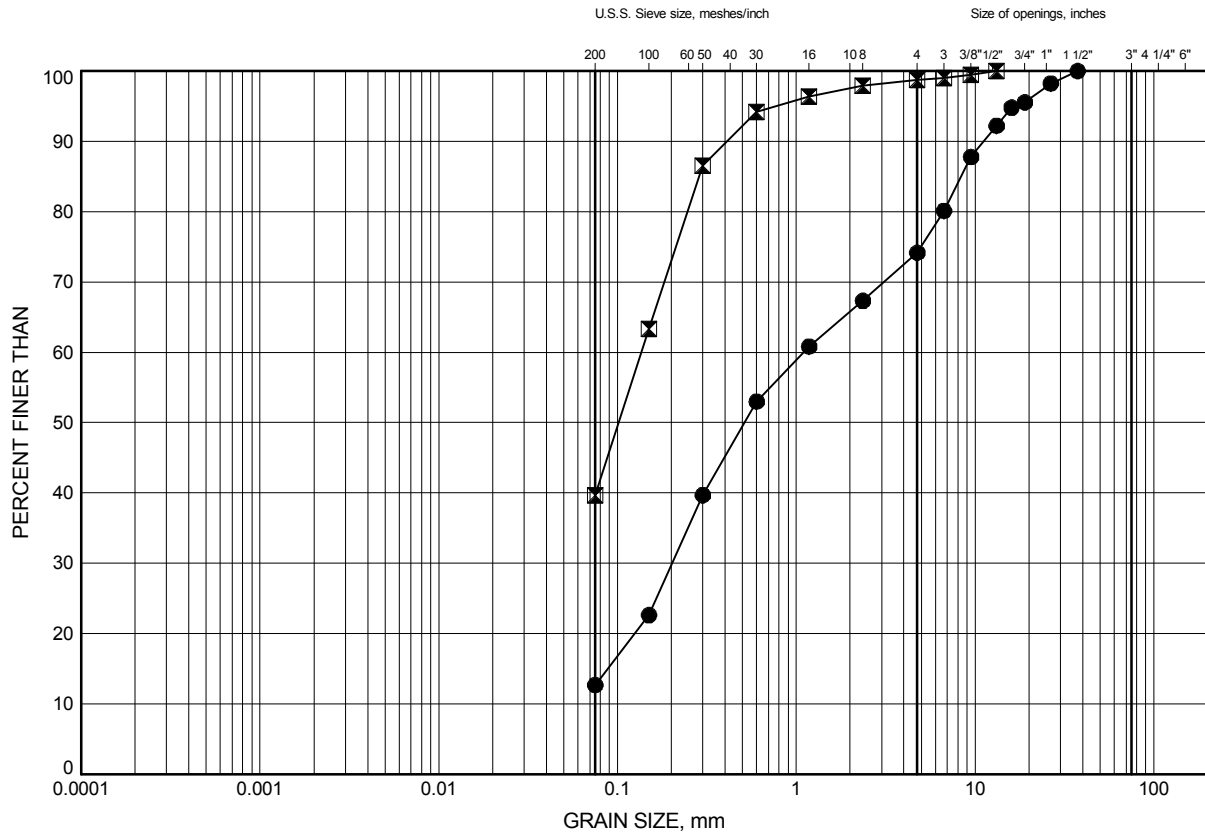
Particle Size Analysis Figures

Rousseau Lake Culvert

GRAIN SIZE DISTRIBUTION

FIGURE C1

Embankment Fill



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-101A	1.07	447.13
◻	18-102	1.83	446.27

Date July 2018
GWP# 6827-14-00

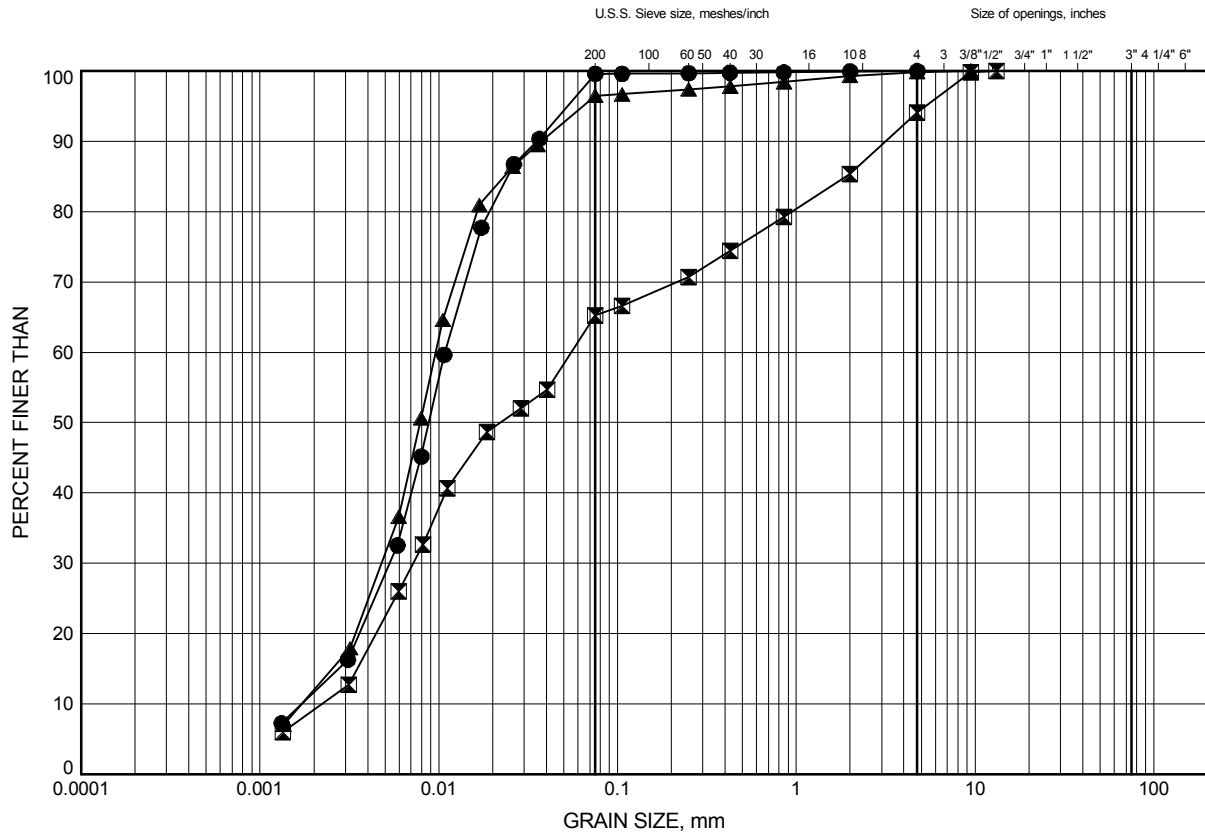


Prep'd CM
Chkd. SD

Rousseau Lake Culvert GRAIN SIZE DISTRIBUTION

FIGURE C2

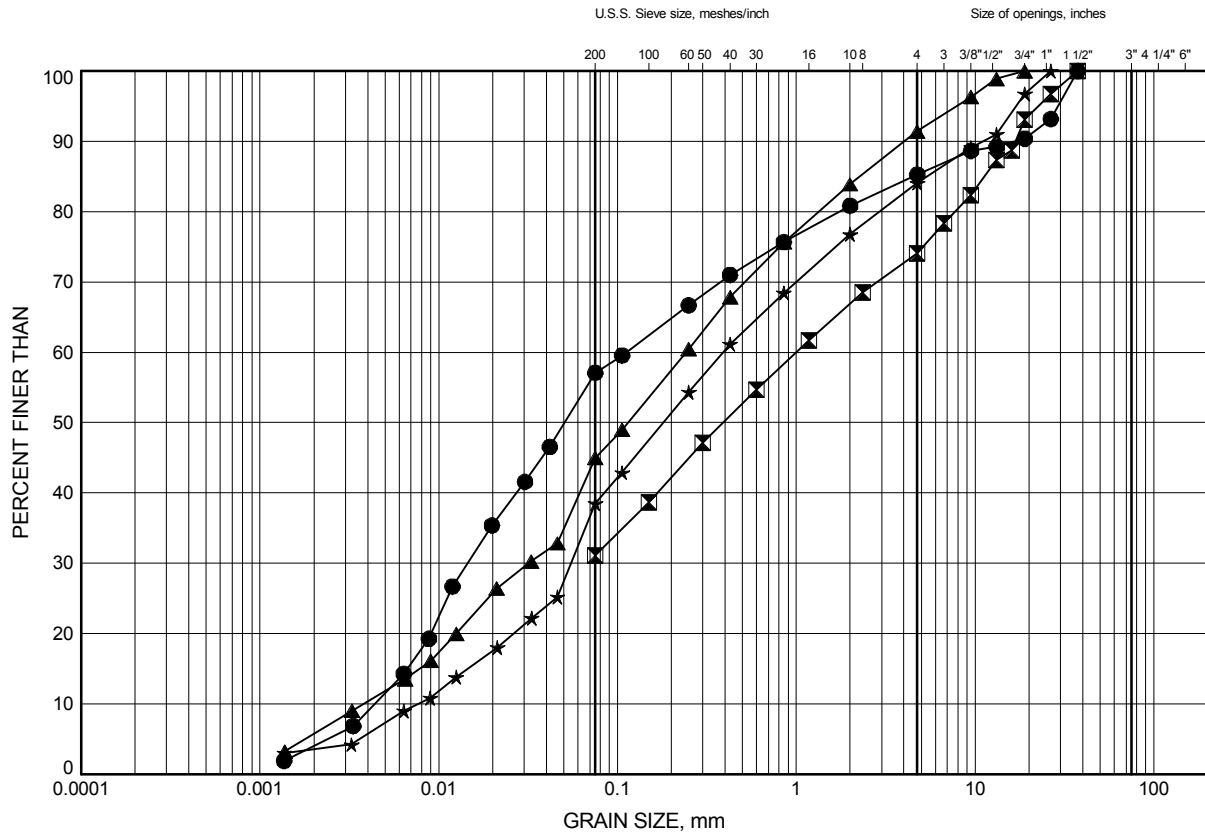
Silt to Sandy Silt



Rousseau Lake Culvert GRAIN SIZE DISTRIBUTION

FIGURE C3

Non-Cohesive Till



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-101A	4.88	443.32
⊠	18-102	5.64	442.46
▲	18-103	3.39	443.01
★	18-104	4.57	441.43

Date July 2018

GWP# 6827-14-00



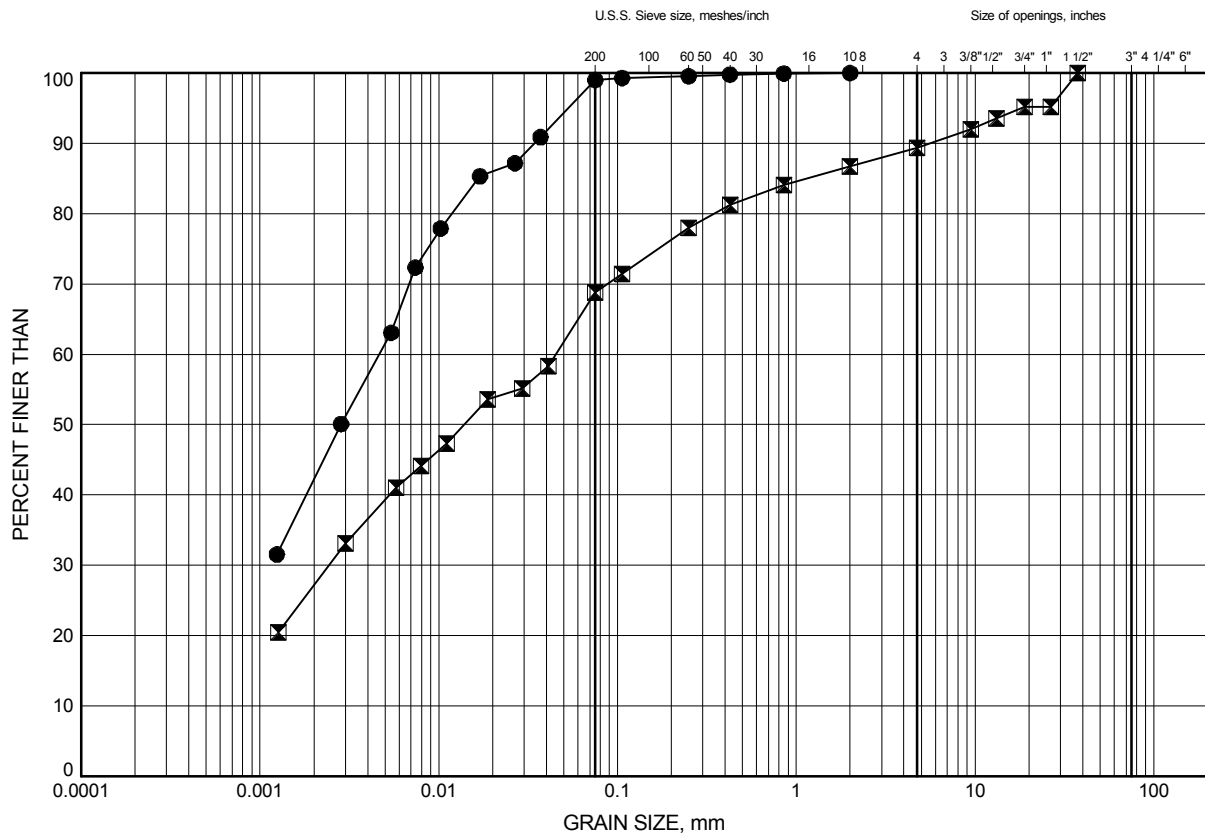
Prep'd CM

Chkd. SD

Rousseau Lake Culvert GRAIN SIZE DISTRIBUTION

FIGURE C4

Cohesive Till



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-101B	9.45	438.75
◻	18-102	9.45	438.65

Date July 2018
GWP# 6827-14-00



Prep'd CM
Chkd. SD

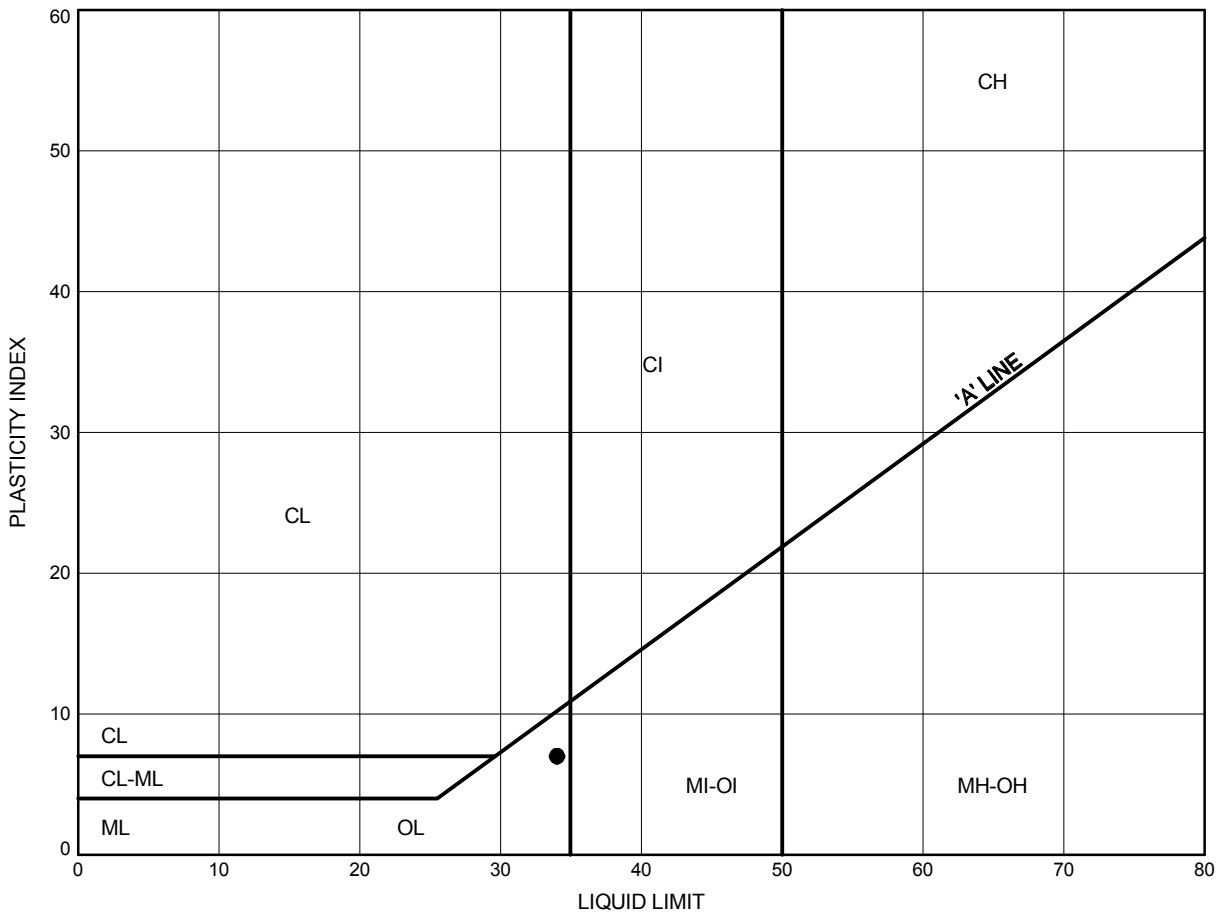
Appendix C.2

Atterberg Limit Analysis Figures

Rousseau Lake Culvert ATTERBERG LIMITS TEST RESULTS

FIGURE C5

Sandy Silt



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-103	1.52	444.88

Date July 2018
GWP# 6827-14-00

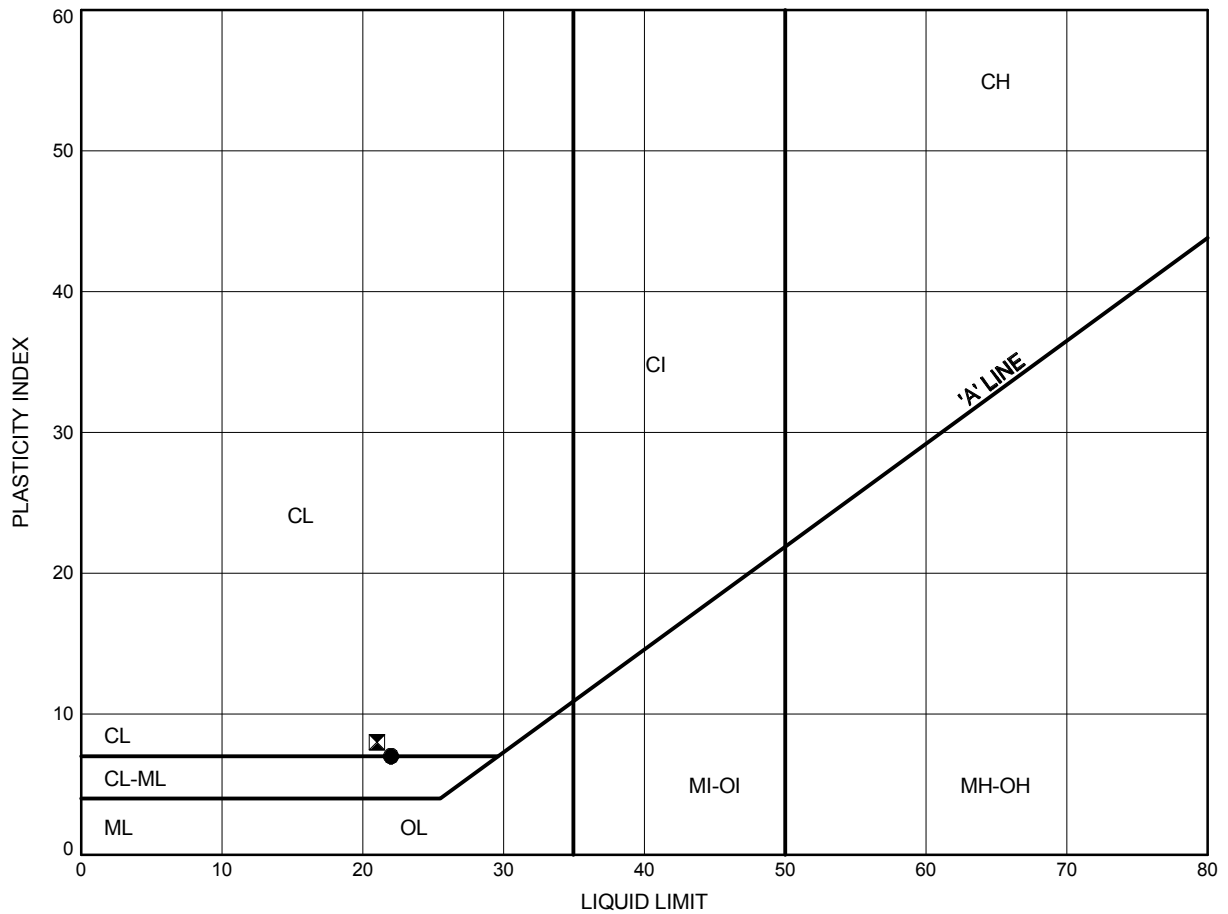


Prep'd CM
Chkd. SD

Rousseau Lake Culvert
ATTERBERG LIMITS TEST RESULTS

FIGURE C6

Cohesive Till



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-101B	9.45	438.75
⊠	18-102	9.45	438.65

Date July 2018
 GWP# 6827-14-00

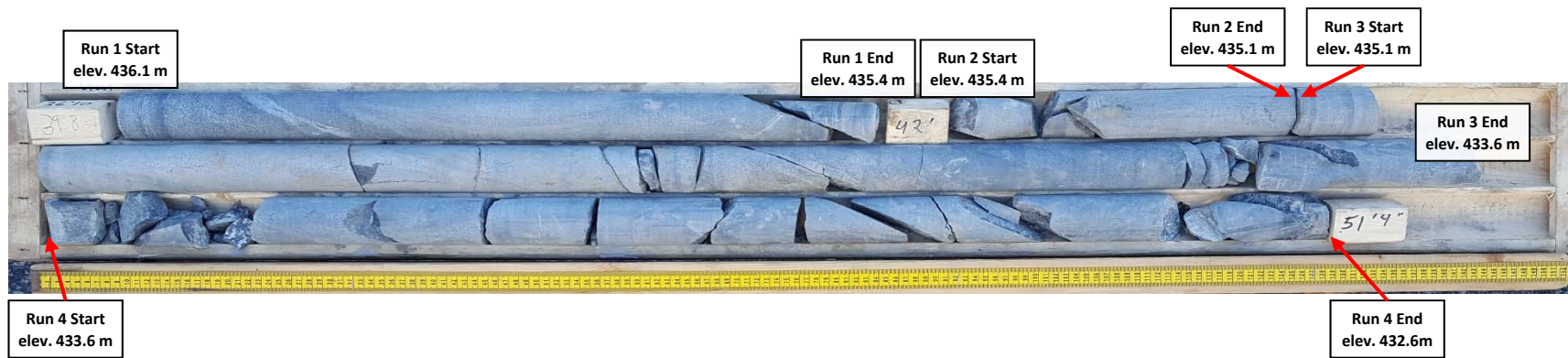


Prep'd CM
 Chkd. SD

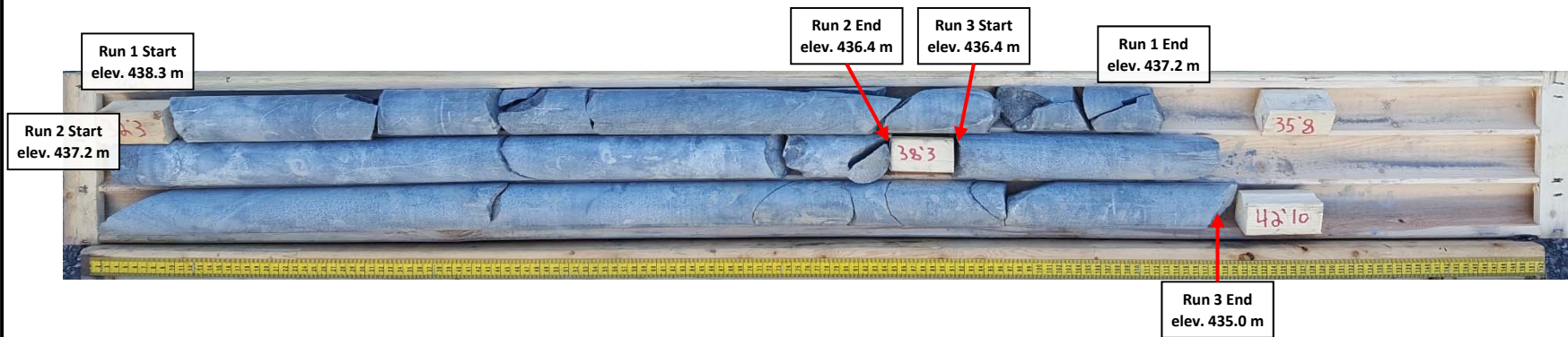
Appendix C.3

Rock Core Photos

Borehole 18-101B
Run 1 to 4 (of 4)
Elevation 436.1 m to 432.6 m



Borehole 18-102
Run 1 to 3 (of 3)
Elevation 438.3 m to 435.0 m



THURBER ENGINEERING LTD.

**Foundation Investigation
Rousseau Lake Culvert
Highway 527**

GWP 6827-14-00

Project No.: 19773

Appendix C.4

Analytical Testing Results

Certificate of Analysis
 Client: Thurber Engineering Ltd.
 Client PO:

Report Date: 26-Jun-2018

Order Date: 20-Jun-2018

Project Description: 19773

Client ID:	18-101, SS6, 12'6"-14'6"	18-203, SS3, 5'10"-7'10"	18-204, SS4, 10'4"-12'4"	18-401, SS5, 10'-12'
Sample Date:	05/30/2018 11:00	06/12/2018 14:30	06/13/2018 09:45	06/07/2018 13:30
Sample ID:	1825441-01	1825441-02	1825441-03	1825441-04
MDL/Units	Soil	Soil	Soil	Soil

Physical Characteristics

% Solids	0.1 % by Wt.	80.0	88.0	89.3	92.4
----------	--------------	------	------	------	------

General Inorganics

Conductivity	5 uS/cm	135	156	98	90
pH	0.05 pH Units	7.81	7.76	7.76	7.56
Resistivity	0.10 Ohm.m	74.3	64.3	102	111

Anions

Chloride	5 ug/g dry	9	25	29	9
Sulphate	5 ug/g dry	16	46	7	28

Client ID:	18-502, SS8, 17'6"-19'6"	18-301, SS8A, 17'6"-19'4"	-	-
Sample Date:	06/12/2018 11:15	06/05/2018 15:30	-	-
Sample ID:	1825441-05	1825441-06	-	-
MDL/Units	Soil	Soil	-	-

Physical Characteristics

% Solids	0.1 % by Wt.	89.9	90.0	-	-
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General Inorganics

Conductivity	5 uS/cm	47	50	-	-
pH	0.05 pH Units	7.14	7.38	-	-
Resistivity	0.10 Ohm.m	213	198	-	-

Anions

Chloride	5 ug/g dry	13	19	-	-
Sulphate	5 ug/g dry	10	6	-	-

**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,

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

28-June-2018

Date Rec. : 22 June 2018
LR Report: CA12773-JUN18
Reference: Project#:1825441

Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Sample ID	Sample Date & Time	Sulphide %
1: Analysis Start Date		28-Jun-18
2: Analysis Start Time		13:23
3: Analysis Completed Date		28-Jun-18
4: Analysis Completed Time		14:45
5: QC - Blank		< 0.02
6: QC - STD % Recovery		105%
7: QC - DUP % RPD		ND
8: RL		0.02
9: 18-101,SS6, 12'6"-14'16"	30-May-18	< 0.02
10: 18-204,SS4, 10'4"-12'4"	13-Jun-18	< 0.02
11: 18-401,SS5, 10'-12'	07-Jun-18	< 0.02
12: 18-502,SS8, 17'6"-19'6"	12-Jun-18	< 0.02
13: 18-301,SS8A, 17'6"-19'4"	05-Jun-18	< 0.02

RL - SGS Reporting Limit
ND - Not Detected

Kimberley Didsbury
Project Specialist
Environmental Services, Analytical

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO:

Report Date: 06-Jul-2018

Order Date: 29-Jun-2018

Project Description: 19773

Client ID:	18-103,SS5, 8'2"-10'2"	18-304,SS5,8'10"	-	-
Sample Date:	06/15/2018 10:00	06/16/2018 12:15	-	-
Sample ID:	1826630-01	1826630-02	-	-
MDL/Units	Soil	Soil	-	-

Physical Characteristics

% Solids	0.1 % by Wt.	82.2	78.1	-	-
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General Inorganics

Conductivity	5 uS/cm	131	181	-	-
pH	0.05 pH Units	7.44	7.28	-	-
Resistivity	0.10 Ohm.m	76.1	55.1	-	-

Anions

Chloride	5 ug/g dry	8	26	-	-
Sulphate	5 ug/g dry	12	52	-	-

Certificate of Analysis
 Client: Thurber Engineering Ltd.
 Client PO:

Report Date: 07-Dec-2018

Order Date: 3-Dec-2018

Project Description: 19773

	Client ID:	Rousseau	Max	Rinker	Wabikon
	Sample Date:	11/30/2018 12:00	11/30/2018 11:45	11/30/2018 11:30	11/30/2018 11:00
	Sample ID:	1849062-01	1849062-02	1849062-03	1849062-04
	MDL/Units	Water	Water	Water	Water

General Inorganics

Conductivity	5 uS/cm	125	74	52	84
pH	0.1 pH Units	7.5	7.4	7.3	7.5
Resistivity	0.01 Ohm.m	79.9	135	193	119

Anions

Chloride	1 mg/L	7	2	1	4
Sulphate	1 mg/L	1	1	1	1

	Client ID:	Waweig	-	-	-
	Sample Date:	11/30/2018 10:00	-	-	-
	Sample ID:	1849062-05	-	-	-
	MDL/Units	Water	-	-	-

General Inorganics

Conductivity	5 uS/cm	56	-	-	-
pH	0.1 pH Units	7.4	-	-	-
Resistivity	0.01 Ohm.m	180	-	-	-

Anions

Chloride	1 mg/L	1	-	-	-
Sulphate	1 mg/L	<1	-	-	-

Appendix D.

Site Photographs



Photo 1. Looking northward at culvert inlet (2018/05/30)



Photo 2. Looking southward at culvert outlet (2018/06/16)



Photo 3. Looking north along Highway 527 from culvert (2018/05/30)



Photo 4. Looking south along Highway 527 from culvert (2018/05/30)