THURBER ENGINEERING LTD.

FINAL

FOUNDATION INVESTIGATION REPORT
HIGHWAY 118 CULVERT STA. 18+550, DRAPER TOWNSHIP
ASSIGNMENT NO. 5017-E-0003
G.W.P. 5287-14-00

Geocres No.: 31E-400

Report to:

McIntosh Perry Consulting Engineers Limited

Latitude: 44.991287
Longitude: -79.197889

August 2019
Thurber File No.: 20244

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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 at a culvert at Sta. 18+550 on Highway 118. The culvert crossing is located approximately 0.2 km west of River Road within Draper Township in the District of Muskoka. Thurber Engineering Limited (Thurber) carried out the field investigation as a sub-consultant to McIntosh Perry Consulting Engineers Ltd. (MPCE) under Assignment No. 5017-E-0003.

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. A Project Assessment Report (PAR) and a historical base plan survey drawing was provided by MPCE.

2 SITE DESCRIPTION

For project purposes, Highway 118 will be considered to be oriented east-west with chainage increasing to the east. The existing culvert conveys (unnamed) creek flow from the south to the north under a high fill embankment supporting Highway 118. As shown on the historical base plan drawings provided by MPCE, the existing culvert is a non-structural corrugated steel pipe (CSP) culvert with a diameter of 0.8 m and a length of 33.1 m. The invert of the culvert was surveyed at- approximate elevation of 307.8 and 306.9 m at the inlet (south) and outlet (north), respectively. No signs of erosion or slope instability were noted on the existing highway embankments during the field investigation. The roadway surface over the culvert was generally in good condition with no dips or bumps noted during the field investigation. The existing culvert, as assessed by MPCE, showed minor signs of corrosion.

At the location of the culvert, Highway 118 is a two-lane highway with paved shoulders. The Highway 118 fill height above the culvert is approximately 4.5 m with the road surface at approximate elevation 312.8 m. The existing embankment slopes are inclined at approximately 2.4H:1V. A vertical curve in the highway profile exists west of the culvert. Cable guidewires with wooden posts are present on both sides of the highway in the vicinity of the culvert. The land adjacent to the highway and creek alignment is densely vegetated with shrubs and trees. Bedrock outcrops are present to the west of the site on the south side of the highway. Single family dwellings are located approximately 150 m west and 100 m east of the culvert. A dam with a spillway is present at Matthiasville Falls, located approximately 400 m northwest of the culvert. Overhead utility lines run parallel to the highway immediately south of Highway 118. Traffic volumes on this section of Highway 118 are understood to be 4,300 AADT (2016).

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.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing program was carried out between September 17th and 23rd, 2018. The field investigation consisted of advancing four boreholes identified as 18-1 through 18-4. The drilling was carried out using portable equipment for off-road boreholes 18-1 and 18-4 and a truck mounted CME 75 drill rig for the on-road boreholes 18-2 and 18-3. Prior to commencement of drilling, utility clearances were obtained in the vicinity of the borehole locations.

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. The termination depth of each of the boreholes are also provided, below. The site is within MTM Zone 10. The borehole elevations were surveyed with a Nikon-AP-8 with an accuracy of +/- 1.5 mm. The survey referenced Benchmark MTCBM 828005 (elev. 314.169 m) shown on the historical baseplan drawing provided by MPCE. Horizontal locations were measured relative to existing site features.

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Table 3-1: Borehole Summary

Borehole No.	Drilled Location	Northing (m)	Easting (m)	Ground Surface Elevation (m)	Termination Depth Below Ground Surface (m)
18-1	Near Culvert Outlet	4 983 533.6	328 612.5	307.5	5.6
18-2	Westbound Lane HWY 118	4 983 521.4	328 619.1	312.8	10.1
18-3	Eastbound Lane HWY 118	4 983 515.5	328 623.1	312.7	10.7
18-4	Near Culvert Inlet	4 983 502.8	328 628.7	307.8	5.3

Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT) following ASTM D1586. A half-weight (32 kg) hammer was used during SPT testing in Boreholes 18-1 and 18-4, which were drilled with portable equipment. The N-values reported herein for these off road boreholes have been corrected to an equivalent standard weight hammer (64 kg). Testing in the on road boreholes was carried out with a standard weight hammer and no correction was necessary. Boreholes 18-1 through 18-4 were advanced into bedrock with either NW or NWT coring techniques.

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

A 19 mm diameter standpipe piezometer was installed in Borehole 18-1 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. The boreholes were backfilled in accordance with MOE requirements (O.Reg 903, as amended). Boreholes 18-2 and 18-3 were backfilled with granulars within the depth of pavement structure and capped with 150 mm of cold patch asphalt to reinstate the travelling surface.

4 LABORATORY TESTING

The recovered soil samples were subjected to visual identification and to natural moisture content determination. Selected samples were also subjected to gradation analysis (hydrometer and/or sieve) and Atterberg Limit testing. The results of these tests are summarized on the Record of Borehole sheets included in Appendix B. One sample of soil recovered from within each of Boreholes 18-1 and 18-4 was selected and submitted for analytical testing of corrosivity parameters. Select rock core samples were submitted for unconfined compression strength testing. All laboratory test results are provided 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 paragraphs. However, the factual data presented on the Record of Borehole sheets governs any 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, the site was found to be underlain by a pavement structure and granular fill overlying native deposits of sandy silt to silty sand over glacial till. Granite bedrock was encountered at relatively shallow depth in all boreholes.

5.1 Embankment

5.1.1 Asphalt

Boreholes 18-2 and 18-3 were drilled through the existing Highway 118 embankment and encountered a layer of asphalt at ground surface with a thickness of 100 mm.

5.1.2 Fill: Sand

Below the surficial asphalt in Boreholes 18-2 and 18-3 was a layer of fill consisting of sand with gravel to sand with silt and varying amounts of gravel. Frequent cobbles and boulders were encountered below a depth of 3.0 m (elev. 309.8 m). Coring techniques were required to advance through the cobbles and boulders below elevation 308.6 m. The underside of this fill was at 5.3 and 5.7 m below the existing roadway surface (elev. 307.5 and 307.0 m) in Boreholes 18-2 and 18-3, respectively.

The SPT tests conducted in the sand with silt fill gave N-values ranging from 4 to 61 blows, indicating a varying relative density of loose to very dense.

Recorded moisture contents ranged from 7 to 18%. The results of grain size analyses conducted on three samples of the sand fill are summarized in in the table below and are illustrated on Figure C1 in Appendix C.

Soil Particle	Percentage (%)
Gravel	9 – 33
Sand	66 – 82
Silt	1 – 10
Clay	

5.2 Sandy Silt (ML) to Silt (ML) with Sand

A native deposit of silt with sand to sandy silt was encountered at ground surface in off-road Boreholes 18-1 and 18-4 and below the fill in Borehole 18-2 with thicknesses ranging from 1.2 to 1.6 m. The underside of the silt ranged in elevation from 305.9 to 306.6 m. Gravel, cobbles, and boulders were noted in the sandy silt in Borehole 18-2 and some organics were encountered in the upper 0.6 m of the silt in Borehole 18-4.

SPT tests conducted this layer gave N-values ranging from 2 to 7 blows indicating a relative density of very loose to loose. Refusal blow counts were also encountered within the layer on probable cobbles.

Recorded moisture contents of the silt typically ranged from 15 to 32%. A moisture content of 42% was recorded in a sample containing organics from within Borehole 18-4. The results of grain size analyses conducted on three samples of the silt are summarized in **Error! Reference source not found.** and are illustrated on Figure C2 in Appendix C.

Soil Particle	Percentage (%)
Gravel	0 – 11
Sand	23 – 33
Silt	52 – 71
Clay	4 – 7

Atterberg Limit tests were completed on three samples of the deposit and indicated that the material is non-plastic.

5.3 Silty Sand (SM) – (Glacial Till)

A deposit of glacial till consisting of silty sand was encountered below the silt in Boreholes 18-1 and 18-4 and below the fill in Borehole 18-3. Frequent cobbles and boulders were encountered throughout the till deposit in Boreholes 18-1 and 18-4 and coring techniques

were required to advance the borehole. The thickness of this layer ranged from 0.6 to 1.0 m with underside elevations ranging from 305.4 to 306.0 m.

The SPT tests conducted in this layer gave N-values ranging from 9 to 44 blows, indicating a relative density of loose to dense. Refusal blow counts were also encountered within the layer on probable cobbles.

Recorded moisture contents ranged from 12 to 29%. The results of a grain size analysis conducted on one sample of the till indicated this material to consist of 3% gravel, 59% sand, 33% silt and 5% clay. These results are illustrated on Figure C3 in Appendix C.An Atterberg Limit test was completed on one sample of the till and indicated that the material is non-plastic.

5.4 Bedrock

Bedrock was proven by coring in Boreholes 18-1 through 18-4. Information on the bedrock surface is summarized in Table 5-1.

Table 5-1: Summary of Bedrock Elevations

Borehole No.	Depth to Bedrock below Existing Ground Surface (m)	Bedrock Elevation (m)
18-1	2.1	305.4
18-2	6.9	305.9
18-3	6.7	306.0
18-4	2.2	305.6

The bedrock consisted of slightly weathered to fresh granite. The Total Core Recovery (TCR) measured on the recovered bedrock core ranged from 85 to 100%, the Solid Core Recovery (SCR) ranged from 63 to 100% and the Rock Quality Designation (RQD) ranged from 38 to 100%. Based on the measured RQD values, the bedrock is typically classified as very poor to excellent quality(Table 3.10, Canadian Foundation and Engineering Manual 2006). The surface of the bedrock in Borehole 18-3 was poor quality

Unconfined Compressive Strength (UCS) testing was carried out on two samples of the intact bedrock. UCS test results of 115 and 141 MPa were obtained, indicating the intact granite bedrock to be very strong. Photographs of the bedrock core are provided in Appendix C.

5.5 Groundwater

Representative water levels were not obtained in the open boreholes due to water being introduced as part of the coring operations. The groundwater water level measured in the standpipe piezometer installed within the bedrock in Borehole 18-1 was recorded at a depth of 3.6 m below the ground surface (elev. 303.9 m) on September 24, 2018. The culvert was dry at the time of the field investigation.

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.

5.6 Analytical Testing

Two samples of the native soils encountered at the site were submitted for analysis of pH, water soluble sulphate and chloride concentrations, and resistivity. The analysis results are summarized in Table 5-2. A copy of the test results is provided in Appendix C.

Table 5-2: Results of Chemical Analysis

Borehole (Sample)	Depth (mbgs)	Sulphate (μg/g)	pH (-)	Resistivity (Ohm-cm)	Conductivity (uS/cm)	Chloride (μg/g)	Sulphide (%)
18-1 (SS3)	1.2 – 1.4	10	7.47	2,880	347	211	< 0.02
18-4 (SS4)	0.6 – 1.2	21	5.65	8,510	117	55	< 0.02

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 measured by Thurber following completion of the field program. Survey elevation benchmarks were provided by MPCE.

George Downing Estate Drilling Ltd. and Forage M3 Drilling Services Inc. both of Hawksbury, Ontario supplied and operated the drilling equipment to conduct the drilling, soil sampling, in-situ testing, standpipe installation and borehole decommissioning. NC Traffic of Kirkland Lake, Ontario supplied the traffic control equipment and personnel for lane and shoulder closures required for the field. The field investigation was supervised on a full time basis by Miss Allison Chow, EIT and Mr. Sean O'Bryan, C.E.T. of Thurber. Overall supervision of the investigation program was provided by Ms. Katya Edney, P.Eng.

Routine geotechnical laboratory testing was completed by Thurber's laboratory in Ottawa, Ontario. UCS testing was completed by Stantec's laboratory in Ottawa, Ontario. Analytical

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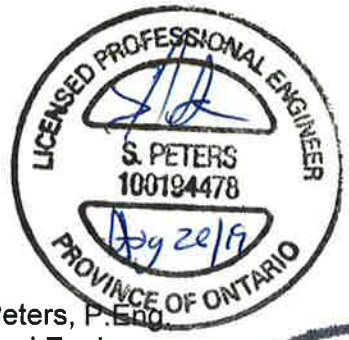
testing was completed by Paracel Laboratories in Ottawa, Ontario. Interpretation of the factual data and preparation of this report were carried out by Miss Allison Chow, EIT, and Mr. Stephen Peters P.Eng. The report was reviewed by Dr. Fred Griffiths, P.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundation Projects.

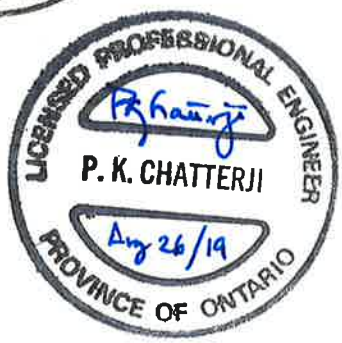
Allison Chow
August 26, 2019

Allison Chow, E.I.T.
Geotechnical Engineer-in-Training



Stephen Peters, P.Eng.
Geotechnical Engineer

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



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

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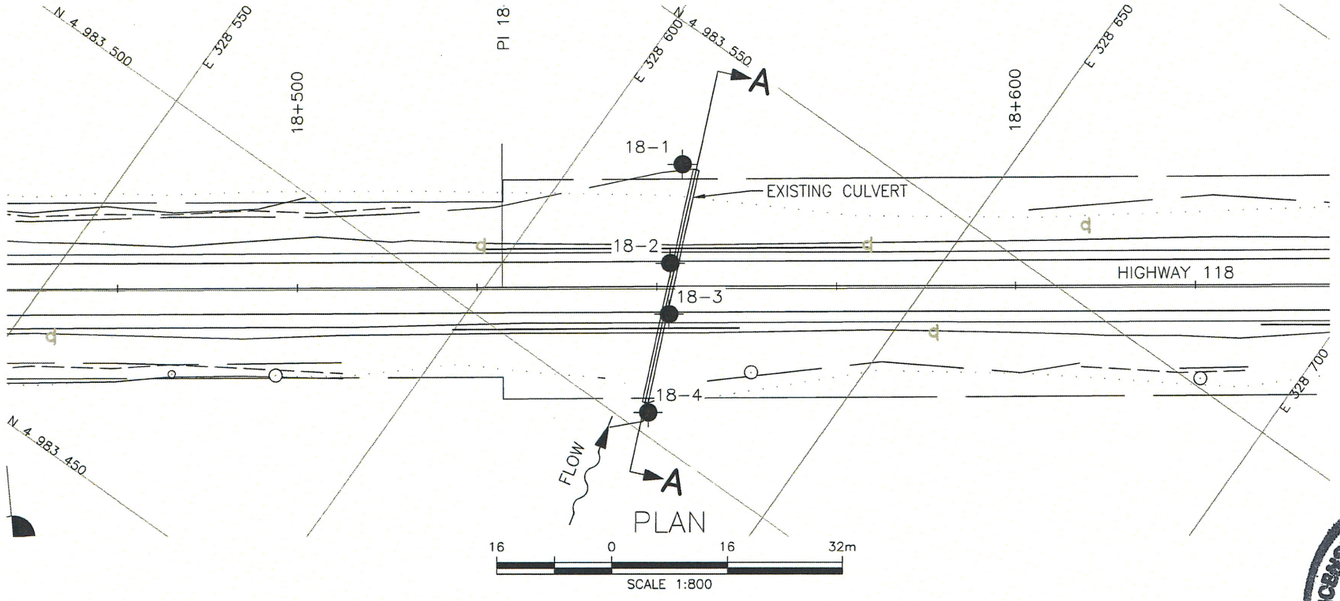
Appendix A.

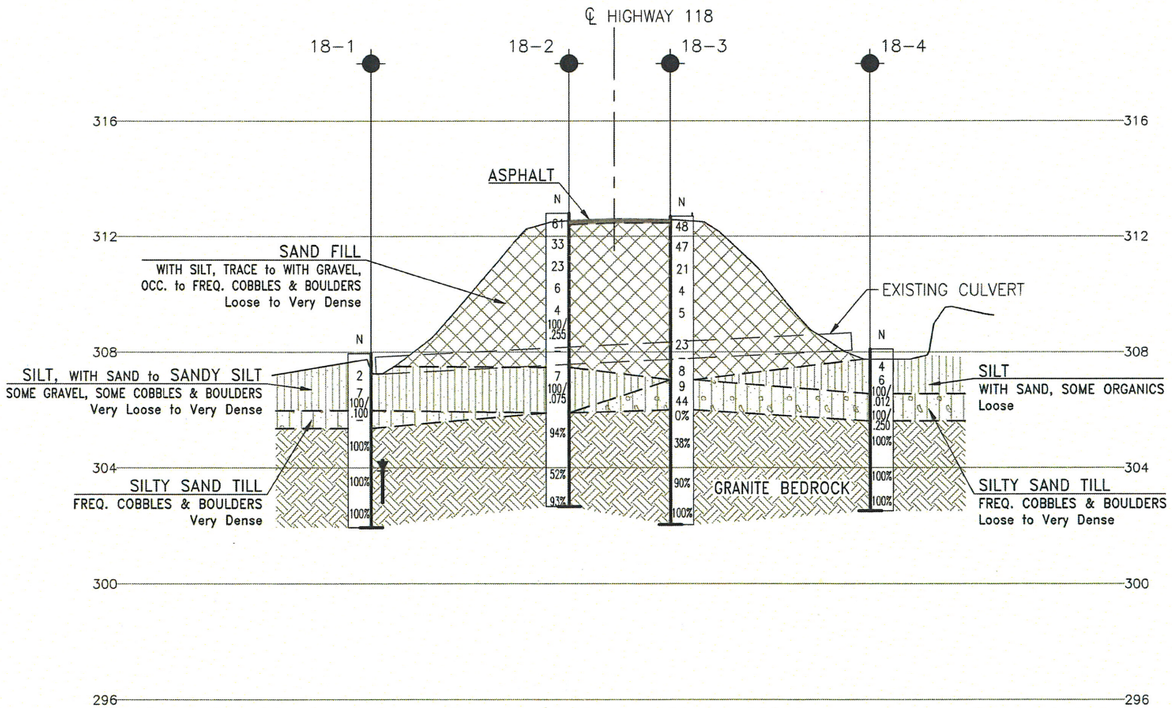
Borehole Location Plan and Stratigraphic Drawing



PLAN

16 0 16 32m

SCALE 1:800



SECTION A–A

8 0 8 16m H 1:400

4 0 4 8m V 1:200

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

LICENSED PROFESSIONAL ENGINEER
F. J. GRIFFITHS
90360280
Aug 26/19
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
Aug 26/19
PROVINCE OF ONTARIO

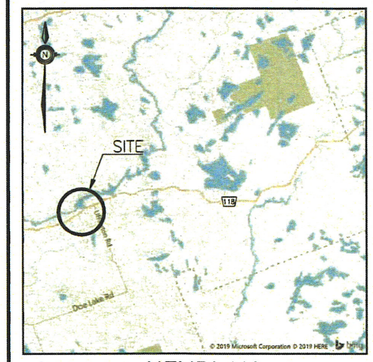
CONT No
GWP No 5287-14-00

HIGHWAY 118
STATION 18+550
CULVERT REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

McINTOSH PERRY

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

●	Current Borehole by Thurber
⊕	Previous Borehole by Others (Approx.)
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
18-1	307.5	4 983 533.6	328 612.5
18-2	312.8	4 983 521.4	328 619.1
18-3	312.7	4 983 515.5	328 623.1
18-4	307.8	4 983 502.8	328 628.7

-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 10.

GEOCRES No. 31E-400

REVISIONS			
	DATE	BY	DESCRIPTION

DESIGN	KE	CHK	SP	CODE	LOAD
DRAWN	MFA	CHK	KE	SITE	STRUCT

DATE APR 2019
DWG

FILENAME: H:\Drafting\20000\20244\TED-20244-BHPP-CVS.dwg
PLOTDATE: 8/20/2019 12:45 PM

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Appendix B.

Record of Borehole Sheets

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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.

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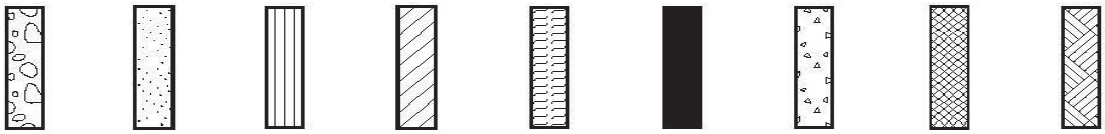
STRATA PLOT:
Strata plots symbolize the soil and bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.



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

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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

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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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 18-1

1 OF 1

METRIC

GWP# 5287-14-00 LOCATION Lat: 44.991391°, Long: -79.198005° St. 18+550 N 4 983 533.6 E 328 612.5 ORIGINATED BY SOB

HWY 118 BOREHOLE TYPE Portable NWT Coring COMPILED BY AC

DATUM Geodetic DATE 23.09.2018 - 23.09.2018 CHECKED BY KE

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
308.0											
0.0 307.5	STAND										
0.5	**SILT (ML)** with sand very loose to dense brown		1	SS	2		307		○		
			2	SS	7				○		0 23 71 6 non-plastic
306.0			3	SS	100/ 100 mm		306		○		
2.0 305.4	**SILTY SAND TILL** frequent cobbles and boulders very dense brown		4	NQ	-						FI
2.6	**BEDROCK** GRANITE fresh coarse grained very strong grey and black		1	RUN			305				0 0 0 0
			2	RUN		▼	304				1 0 1 0
			3	RUN			303				0 0 0 0
301.9							302				
6.0	End of Borehole A half-weight (32 kg) drop hammer was used to advance the split-spoon sampler. The N values presented have been adjusted to provide an equivalent N value that would have been obtained with a standard 64 kg hammer. Water level in 19 mm diameter standpipe: 23/09/2018 at 0.0 mbgs (el. 307.5 m) 24/09/2018 at 3.6 mbgs (el. 303.9 m)										

RUN #1 TCR=100% SCR=100% RQD=100%

RUN #2 TCR=100% SCR=100% RQD=100%

RUN #3 TCR=100% SCR=100% RQD=100%

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE

DOUBLE LINE ST 18+550.GPJ 2012TEMPLATE(MTO).GDT 23/8/19

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 18-2 1 OF 2 METRIC

GWP# 5287-14-00 LOCATION Lat: 44.991281°, Long: -79.197922° St. 18+550 N 4 983 521.4 E 328 619.1 ORIGINATED BY AC

HWY 118 BOREHOLE TYPE NW Washboring COMPILED BY AC

DATUM Geodetic DATE 17.09.2018 - 17.09.2018 CHECKED BY KE

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
312.8											
0.0	**ASPHALT** (100 mm)										
0.1	SAND with silt and gravel loose to very dense grey to brown **FILL**		1	SS	61		312	○			19 71 10 (SI+CL)
			2	SS	33			○			
			3	SS	23		311	○			
			4	SS	6		310	○			
309.8											
3.0	SAND with gravel cobbles and boulders loose to very dense brown **FILL**		5	SS	4			○			33 66 1 (SI+CL)
			6	SS	100/ 255 mm		309	○			
			7	NQ	-		308				
307.5											
5.3	**SANDY SILT (ML)** some gravel cobbles and boulders loose to very dense brown		8	SS	7			○			11 33 52 4 non-plastic
			9	SS	100/ 75 mm		307				
305.9							306			FI	
6.9	**BEDROCK** GRANITE slightly weathered to fresh medium grained very strong grey with black and pink		1	RUN						0 1 0 1	RUN #1 TCR=94% SCR=94% RQD=94% UCS=115.0MPa
							305			5 3	RUN #2 TCR=98% SCR=63% RQD=52%
	vertical fracture from 9.3 to 9.8 m		2	RUN			304			0 1 2	RUN #3 TCR=100% SCR=100% RQD=93%
			3	RUN			303			2	

Continued Next Page

$+^3$, $\times^3$: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

DOUBLE LINE ST 18+550.GPJ 2012TEMPLATE(MTO).GDT 23/8/19

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 18-2 2 OF 2 METRIC

GWP# 5287-14-00 LOCATION Lat: 44.991281°, Long: -79.197922° St. 18+550 N 4 983 521.4 E 328 619.1 ORIGINATED BY AC

HWY 118 BOREHOLE TYPE NW Washboring COMPILED BY AC

DATUM Geodetic DATE 17.09.2018 - 17.09.2018 CHECKED BY KE

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
302.7											
10.1	**BEDROCK** GRANITE										
	End of Borehole										

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE
10

DOUBLE LINE ST 18+550.GPJ 2012TEMPLATE(MTO).GDT 23/8/19

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 18-3

1 OF 2

METRIC

GWP# 5287-14-00 LOCATION Lat: 44.991228°, Long: -79.197872° St. 18+550 N 4 983 515.5 E 328 623.1 ORIGINATED BY AC

HWY 118 BOREHOLE TYPE NW Washboring COMPILED BY AC

DATUM Geodetic DATE 19.09.2018 - 19.09.2018 CHECKED BY KE

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
312.7											
0.0	**ASPHALT** (100 mm)										
0.1	SAND with silt trace gravel occasional to frequent cobbles and boulders loose to dense grey-brown to brown **FILL**		1	SS	48		312	○			
			2	SS	47			○			9 82 9 (SI+CL)
			3	SS	21		311	○			
			4	SS	4		310	○			
			5	SS	5		309	○			
			6	SS	23		308	○			
	frequent cobbles and boulders below 4.8 m		7	NQ	-						
			8	SS	8		307				
307.0											
5.7	**SILTY SAND (SM) TILL** loose to dense grey-brown to red-brown		9	SS	9		307	○			
			10	SS	44			○			3 59 33 5 non-plastic
306.0										FI	
6.7	**BEDROCK** GRANITE slightly weathered to fresh medium to coarse grained very strong grey with pink vertical fracture from 6.7 to 7.0 m		1	RUN			306			>10	RUN #1 TCR=100% SCR=0% RQD=0%
			2	RUN			305			>10 7 6 0 1	RUN #2 TCR=85% SCR=63% RQD=38%
			3	RUN			304			1 0 0 1	RUN #3 TCR=98% SCR=90% RQD=90%
							303			1	

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

DOUBLE LINE ST 18+550.GPJ 2012TEMPLATE(MTO).GDT 23/8/19

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 18-3 2 OF 2 METRIC

GWP# 5287-14-00 LOCATION Lat: 44.991228°, Long: -79.197872° St. 18+550 N 4 983 515.5 E 328 623.1 ORIGINATED BY AC

HWY 118 BOREHOLE TYPE NW Washboring COMPILED BY AC

DATUM Geodetic DATE 19.09.2018 - 19.09.2018 CHECKED BY KE

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page										
302.0	**BEDROCK** GRANITE fresh to slightly weathered medium to coarse grained very strong grey with pink		4	RUN						0 0	RUN #4 TCR=100% SCR=100% RQD=100%
10.7	End of Borehole										

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE
10

DOUBLE LINE ST 18+550.GPJ 2012TEMPLATE(MTO).GDT 23/8/19

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 18-4

1 OF 1

METRIC

GWP# 5287-14-00 LOCATION Lat: 44.991113°, Long: -79.197801° St. 18+550 N 4 983 502.8 E 328 628.7 ORIGINATED BY SOB

HWY 118 BOREHOLE TYPE Portable NWT Coring COMPILED BY AC

DATUM Geodetic DATE 22.09.2018 - 22.09.2018 CHECKED BY KE

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
308.1											
0.0 307.8	STAND						308				
0.3 307.2	**SILT (ML)** with sand some organics loose dark brown		1	SS	4				o		0 26 67 7 non-plastic
0.9 306.6	**SILT (ML)** with sand loose brown		2	SS	6		307		o		
1.5 305.6	**SILTY SAND TILL** frequent cobbles and boulders very dense brown		3 4	~~SS~~ NQ	~~100/~~ 12 mm -		306		o	FI	
2.5 302.5	**BEDROCK** GRANITE fresh coarse grained very strong grey and pink		5 1	SS RUN	100/ 250 mm		305			0 0 0 0 3	RUN #1 TCR=100% SCR=100% RQD=100% UCS=141.6MPa
			2	RUN			304			2 0 0	RUN #2 TCR=100% SCR=100% RQD=100%
			3	RUN			303			0 1	RUN #3 TCR=100% SCR=100% RQD=100%
5.6	End of Borehole A half-weight (32 kg) drop hammer was used to advance the split-spoon sampler. The N values presented have been adjusted to provide an equivalent N value that would have been obtained with a standard 64 kg hammer.										

$+^3$, $\times^3$: Numbers refer to Sensitivity

20
15 5
10
(%) STRAIN AT FAILURE

DOUBLE LINE ST 18+550.GPJ 2012TEMPLATE(MTO).GDT 23/8/19

THURBER

Appendix C.

Laboratory Testing

THURBER

Appendix C.1

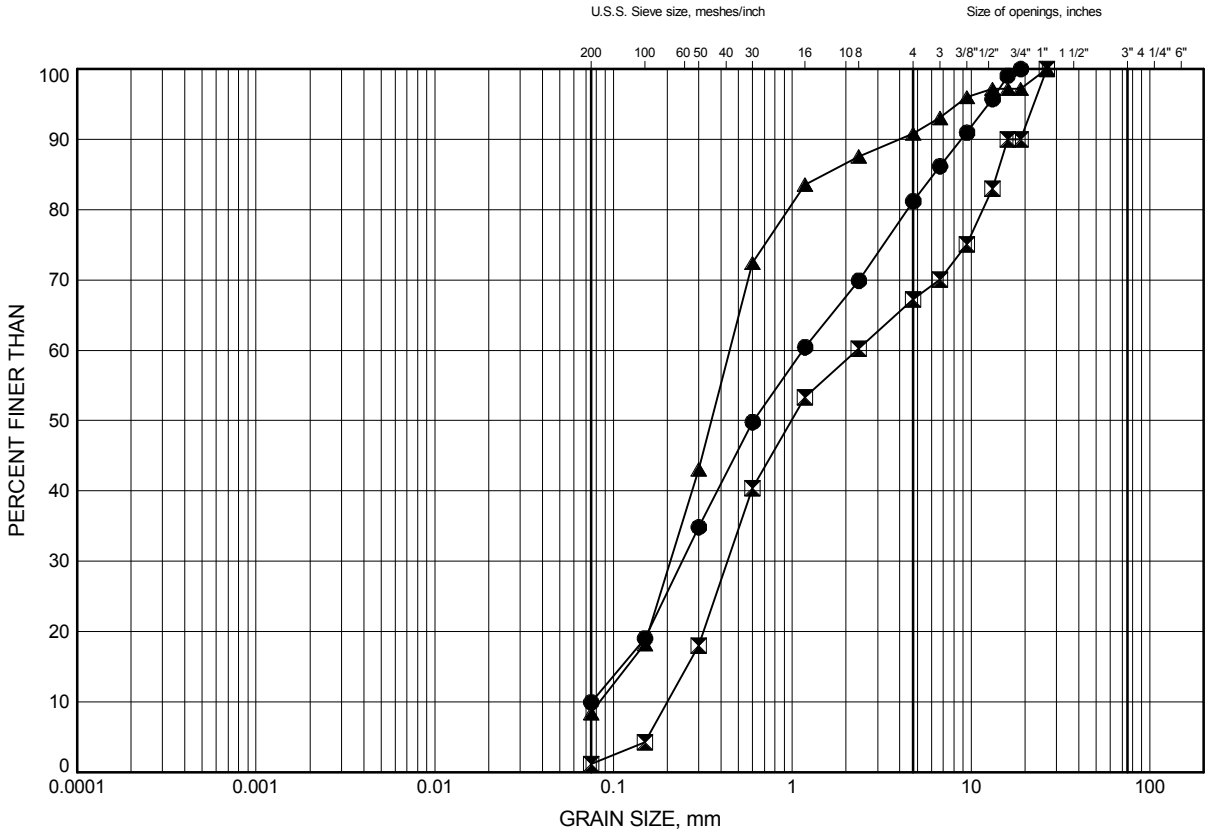
Particle Size Analysis Figures

HWY 118 Culverts Station 18+550

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)
●	18-2	0.4	312.4
⊠	18-2	3.4	309.4
▲	18-3	1.1	311.6

Date October 2018

GWP# 5287-14-00

THURBER

Prep'd AC

Chkd. KE

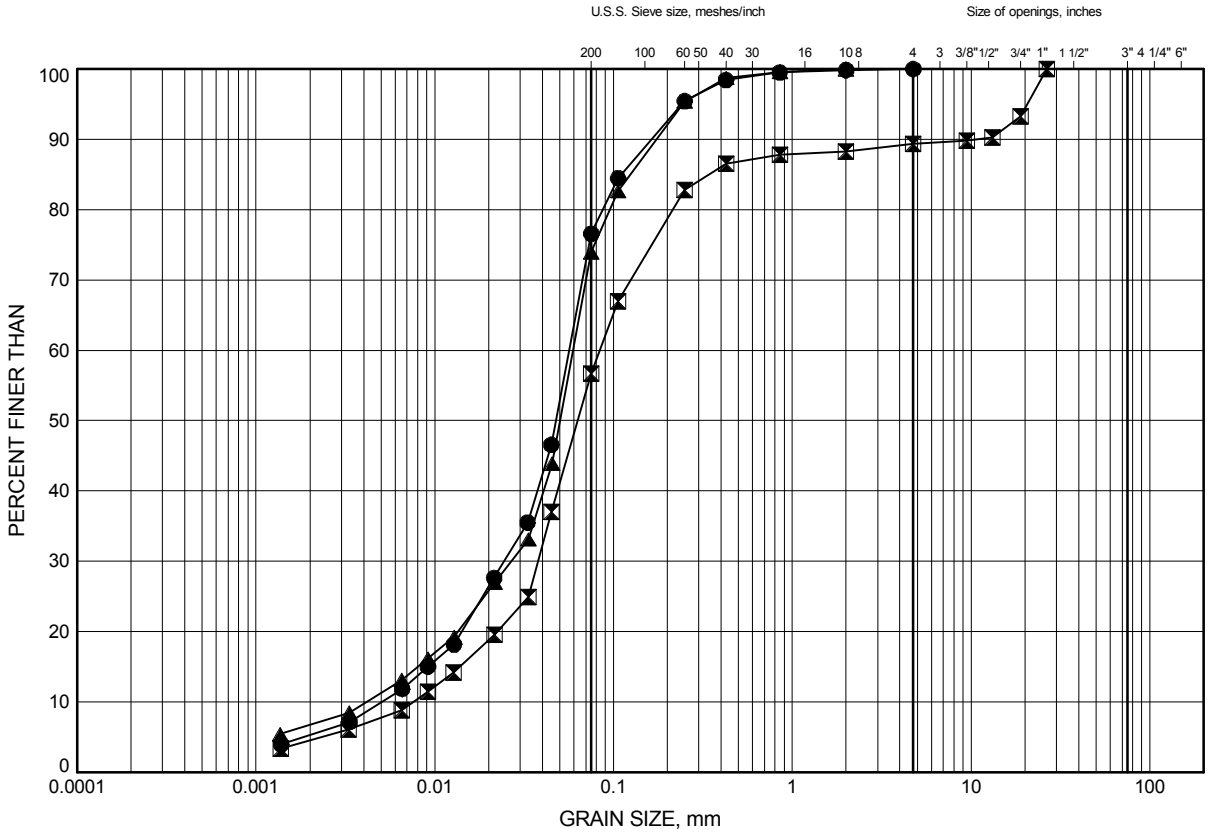
GRAIN SIZE DISTRIBUTION - THURBER ST 18+550.GPJ 24/10/18

HWY 118 Culverts Station 18+550

GRAIN SIZE DISTRIBUTION

FIGURE C2

SANDY SILT (ML) to SILT (ML) with sand



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-1	0.9	306.6
⊠	18-2	5.6	307.2
▲	18-4	0.3	307.5

Date October 2018

GWP# 5287-14-00

THURBER

Prep'd AC

Chkd. KE

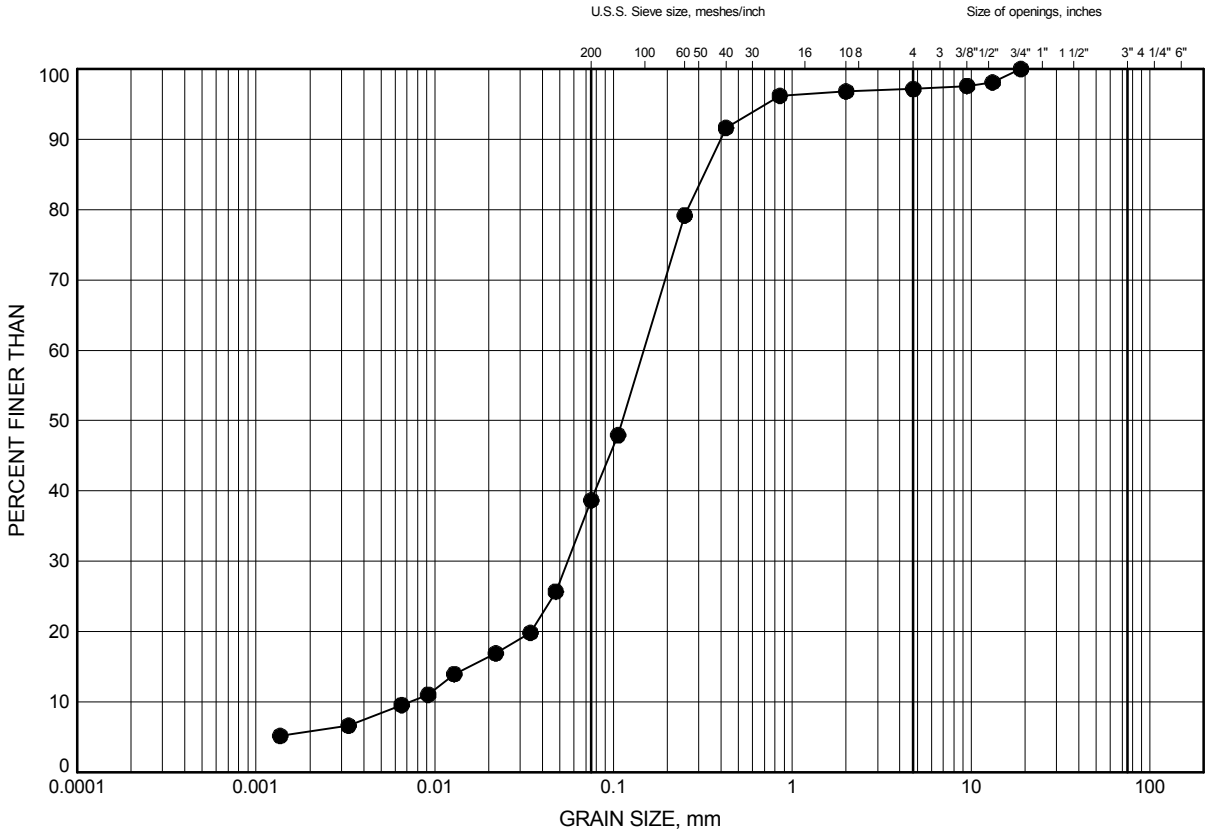
GRAIN SIZE DISTRIBUTION - THURBER ST 18+550.GPJ 24/10/18

HWY 118 Culverts Station 18+550

GRAIN SIZE DISTRIBUTION

FIGURE C3

SILTY SAND (SM) (TILL)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-3	6.4	306.3

Date October 2018

GWP# 5287-14-00

THURBER

Prep'd AC

Chkd. KE

GRAIN SIZE DISTRIBUTION - THURBER ST 18+550.GPJ 24/10/18

THURBER

Appendix C.2

Rock Core Photos

Rock Core Testing Results

Borehole 18-1

Run 1 to 3 (of 3)

Elevation 305.4 m to 301.9 m

THURBER ENGINEERING LTD.

Foundation Investigation
Hwy 118 Culverts St. 18+550
Foundations

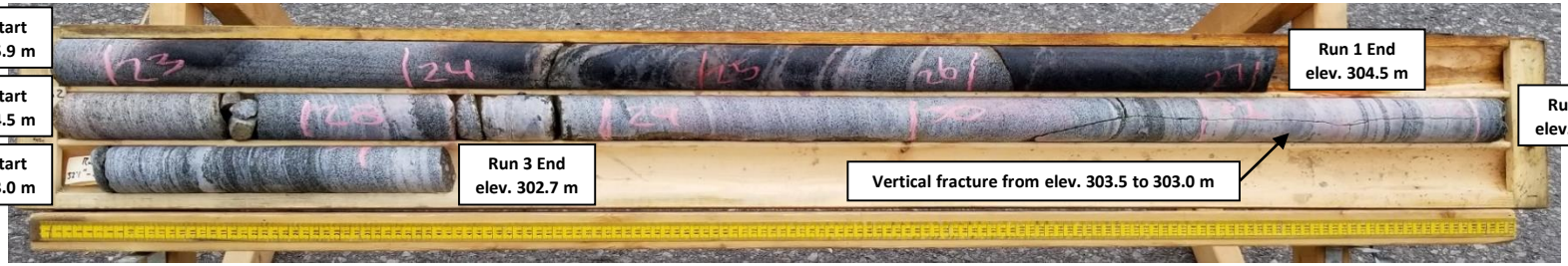
GWP: 5287-14-00

Project No.: 20244

Borehole 18-2

Run 1 to 3 (of 3)

Elevation 305.9 m to 302.7 m



THURBER ENGINEERING LTD.

Foundation Investigation
Hwy 118 Culverts St. 18+550
Foundations

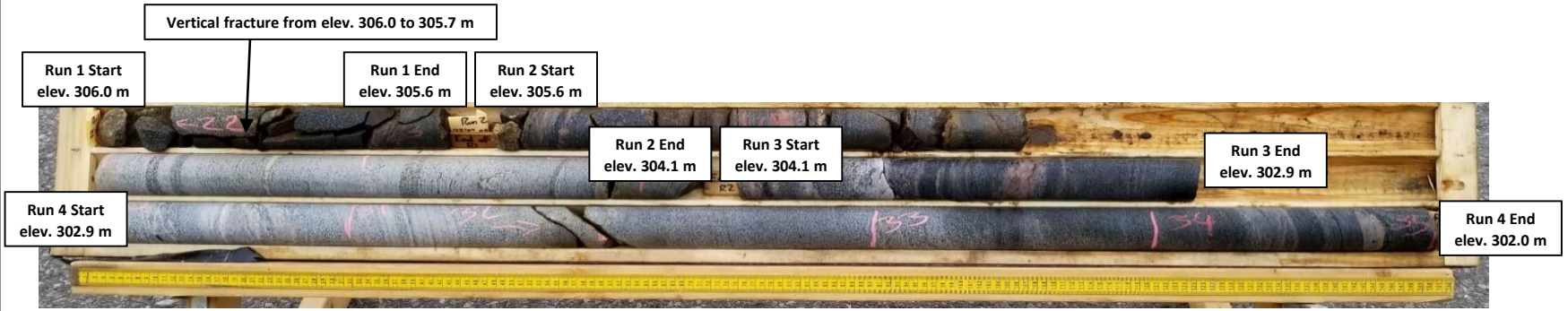
GWP: 5287-14-00

Project No.: 20244

Borehole 18-3

Run 1 to 4 (of 4)

Elevation 306.0 m to 302.0 m



THURBER ENGINEERING LTD.

Foundation Investigation
Hwy 118 Culverts St. 18+550
Foundations

GWP: 5287-14-00

Project No.: 20244

Borehole 18-4

Run 1 to 3 (of 3)

Elevation 305.6 m to 302.5 m

THURBER ENGINEERING LTD.

Foundation Investigation
Hwy 118 Culverts St. 18+550
Foundations

GWP: 5287-14-00

Project No.: 20244

Stantec Consulting Ltd
2781 Lancaster Rd, Suite 100 A&B
Ottawa, ON K1B 1A7
Tel: (613) 738-6075
Fax: (613) 722-2799

Stantec

October 17, 2018
File: 122410864

Attention: **Thurber Engineering Ltd., File #20244**

Reference: **ASTM D7012, Method C, Unconfined Compressive Strength of Intact Rock Core**

The table below summarizes five (5) rock core unconfined compressive strength results.

Location	Sample Depth	Compressive Strength (MPa)	Description of Break
18+550, 18-2 Run-1	26'1"-27'1"	115.0	Diagonal Fracture with no cracking through ends
18+550, 18-4 Run-1	11'6"-12'1"	141.6	Well-formed cone on one end. Vertical crack, no well-defined cone on the other end
18+875, 18-1 Run-2	7'7"-8'1"	127.8	Well-formed cone on one end. Vertical crack, no well-defined cone on the other end
18+875, 18-4 Run-1	7'2"-7'9"	76.2	Columnar vertical crack through both ends, no well-defined cones
11+490, 18-1 Run-2	23';7"-24'3"	88.4	Columnar vertical crack through both ends, no well-defined cones

Sincerely,

Stantec Consulting Ltd

Brian Prevost

Brian Prevost
Laboratory Supervisor
Tel: 613-738-6075
brian.prevost@stantec.com

THURBER

Appendix C.3

Analytical Testing Results

PARACEL LABORATORIES LTD.
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Certificate of Analysis

Thurber Engineering Ltd.

2460 Lancaster Rd, Suite 104
Ottawa, ON K1B 4S5
Attn: Katya Edney

Client PO: 20244
Project: HWY11+118
Custody: 39863

Report Date: 9-Oct-2018
Order Date: 2-Oct-2018

Order #: 1840220

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

Paracel ID	Client ID
1840220-01	18+550 18-1 SS3 5'6"-6'2"
1840220-02	18+550 18-4 SS2 3-5
1840220-03	18+875 18-4 SS1 2'6"-4'6"
1840220-04	11+490 18-4 SS3 5-7
1840220-05	22+590 18-1 SS2 4-6
1840220-06	22+590 18-4 SS3 6-8'

Depths shown in results are measured from the top of the drilling platform not shown in the Record of Borehole Sheets. Platform height measured 0.5 m at Borehole 18-1 and 0.3 m at Borehole 18-4.

Approved By:

Mark Foto

Mark Foto, M.Sc.
Lab Supervisor

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO: 20244

Report Date: 09-Oct-2018
Order Date: 2-Oct-2018
Project Description: HWY11+118

Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	5-Oct-18	5-Oct-18
Conductivity	MOE E3138 - probe @25 °C, water ext	4-Oct-18	5-Oct-18
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	5-Oct-18	5-Oct-18
Resistivity	EPA 120.1 - probe, water extraction	4-Oct-18	5-Oct-18
Solids, %	Gravimetric, calculation	3-Oct-18	3-Oct-18

PARACEL LABORATORIES LTD.

Order #: 1840220

Certificate of Analysis

Report Date: 09-Oct-2018

Client: Thurber Engineering Ltd.

Order Date: 2-Oct-2018

Client PO: 20244

Project Description: HWY11+118

	Client ID:	18+550 18-1 SS3 5'6"-6'2"	18+550 18-4 SS2 3-5	18+875 18-4 SS1 2'6"-4'6"	11+490 18-4 SS3 5-7
	Sample Date:	09/23/2018 09:00	09/22/2018 09:00	09/20/2018 09:00	09/28/2018 09:00
	Sample ID:	1840220-01	1840220-02	1840220-03	1840220-04
	MDL/Units	Soil	Soil	Soil	Soil
Physical Characteristics					
% Solids	0.1 % by Wt.	85.4	79.7	90.5	82.8
General Inorganics					
Conductivity	5 uS/cm	347	117	124	225
pH	0.05 pH Units	7.47	5.65	6.26	6.22
Resistivity	0.10 Ohm.m	28.8	85.1	80.9	44.5
Anions					
Chloride	5 ug/g dry	211	55	19	124
Sulphate	5 ug/g dry	10	21	6	7

	Client ID:	22+590 18-1 SS2 4-6	22+590 18-4 SS3 6-8'	-	-
	Sample Date:	09/25/2018 09:00	09/26/2018 09:00	-	-
	Sample ID:	1840220-05	1840220-06	-	-
	MDL/Units	Soil	Soil	-	-
Physical Characteristics					
% Solids	0.1 % by Wt.	86.5	85.5	-	-
General Inorganics					
Conductivity	5 uS/cm	302	15	-	-
pH	0.05 pH Units	6.44	5.59	-	-
Resistivity	0.10 Ohm.m	33.1	653	-	-
Anions					
Chloride	5 ug/g dry	168	<5	-	-
Sulphate	5 ug/g dry	11	<5	-	-

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO: 20244

Report Date: 09-Oct-2018
Order Date: 2-Oct-2018
Project Description: HWY11+118

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: 20244

Report Date: 09-Oct-2018
Order Date: 2-Oct-2018
Project Description: HWY11+118

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	205	5	ug/g dry	211			2.7	20	
Sulphate	9.29	5	ug/g dry	9.98			7.2	20	
General Inorganics									
Conductivity	364	5	uS/cm	347			4.6	6.2	
pH	11.69	0.05	pH Units	11.61			0.7	10	
Resistivity	27.5	0.10	Ohm.m	28.8			4.6	20	
Physical Characteristics									
% Solids	90.9	0.1	% by Wt.	94.3			3.8	25	

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO: 20244

Report Date: 09-Oct-2018
Order Date: 2-Oct-2018
Project Description: HWY11+118

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	308	5	ug/g	211	97.2	78-113			
Sulphate	110	5	ug/g	9.98	100	78-111			

Qualifier Notes:

None

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.

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Subcontracted Analysis

Thurber Engineering Ltd.
2460 Lancaster Rd, Suite 104
Ottawa, ON K1B 4S5
Attn: Katya Edney

Tel: (613) 247-2121
Fax: (613) 247-2185

Paracel Report No	**1840220**
Client Project(s):	**HWY11+118**
Client PO:	**20244**
Reference:	**Standing Offer**
CoC Number:	**39863**

Order Date:	02-Oct-18
Report Date:	9-Oct-18

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
1840220-01	18+550 18-1 SS3 5'6"-6'2"	Sulphide, solid
1840220-02	18+550 18-4 SS2 3-5	Sulphide, solid
1840220-03	18+875 18-4 SS1 2'6"-4'6"	Sulphide, solid
1840220-04	11+490 18-4 SS3 5-7	Sulphide, solid
1840220-05	22+590 18-1 SS2 4-6	Sulphide, solid
1840220-06	22+590 18-4 SS3 6-8'	Sulphide, solid

Depths shown in results are measured from the top of the drilling platform not shown in the Record of Borehole Sheets. Platform height measured 0.5 m at Borehole 18-1 and 0.3 m at Borehole 18-4.

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

10-October-2018

Paracel Laboratories
Attn : Dale Robertson

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

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

Date Rec. : 04 October 2018
LR Report: **CA12131-OCT18**
Reference: Project#:1840220

Copy: #1

CERTIFICATE OF ANALYSIS
Final Report

Sample ID	Sample Date & Time	Sulphide %
1: Analysis Start Date		05-Oct-18
2: Analysis Start Time		13:35
3: Analysis Completed Date		05-Oct-18
4: Analysis Completed Time		14:36
5: QC - Blank		< 0.02
6: QC - STD % Recovery		99%
7: QC - DUP % RPD		1%
8: RL		0.02
9: 18+550 18-1 SS3 5'6"-6'2"	23-Sep-18	< 0.02
10: 18+550 18-4 SS2 3-5	22-Sep-18	< 0.02
11: 18+875 18-4 SS1 2'6"-4'6"	20-Sep-18	< 0.02
12: 11+490 18-4 SS3 5-7	28-Sep-18	< 0.02
13: 22+590 18-1 SS2 4-6	25-Sep-18	< 0.02
14: 22+590 18-4 SS3 6-8'	26-Sep-18	< 0.02

RL - SGS Reporting Limit

Kimberley Didsbury
Project Specialist
Environmental Services, Analytical

OnLine LIMS

0001537088

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Appendix D.

Site Photographs

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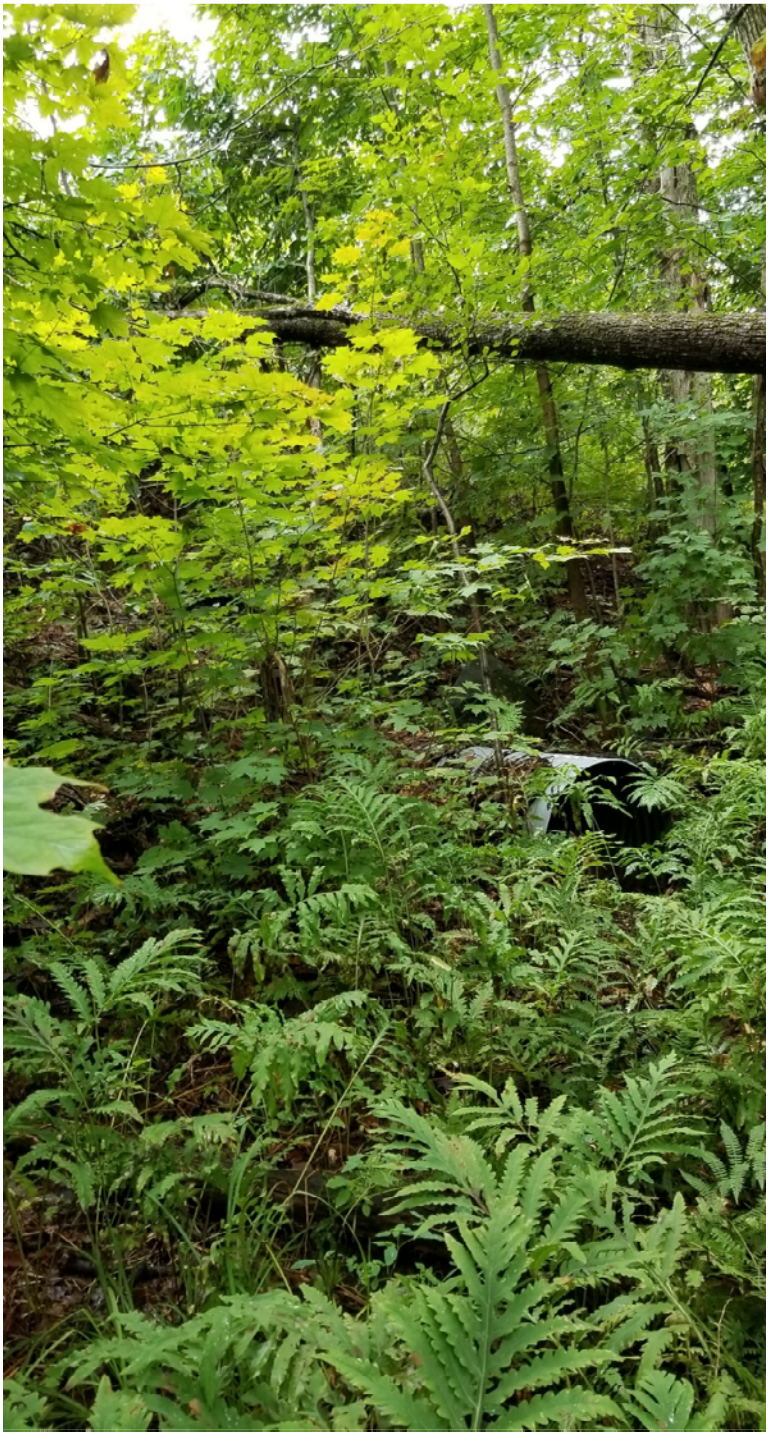

Photo 1. Looking Southwest at Culvert Outlet at Sta. 18+550 (2018/09/11)

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Photo 2. Looking Northeast at Culvert Inlet at Sta.18+550 (2018/09/11)

Photo 3. Looking West on HWY 118 (2018/09/17)

Photo 4. Looking East on HWY 118 (2018/09/19)