THURBER ENGINEERING LTD.

FINAL

FOUNDATION INVESTIGATION REPORT
CULVERT REPLACEMENT AT STATION 17+230
HIGHWAY 17 – 0.1 KM EAST OF GOULAIS RIVER
VANKOUGHNET TOWNSHIP
G.W.P. 5181-13-00

5016-E-0040

Geocres No.: 41K-106

Report to:

Ministry of Transportation Ontario

Latitude: 46.729310°
Longitude: -84.348530°

July 2018
Thurber File: 17848

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FINAL
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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 the Highway 17 culvert for an unnamed creek located approximately 0.1 km east of the Goulais River within the Township of Vankoughnet (Sta. 17+230). Thurber Engineering Limited (Thurber) carried out the current investigation under Agreement No. 5016-E-0040.

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 reports were available for the subject culvert site within the Geocres library.

2 SITE DESCRIPTION

The existing culvert is a corrugated steel pipe (CSP) culvert reported to have a diameter of 1,200 mm, a length of 39 m and invert elevations of 191.6 m upstream and 190.8 m downstream. The culvert has a generally east to west alignment with flow through the culvert to the west.

At the location of the culvert, Highway 17 is a two-lane highway with gravel shoulders. The Highway 17 fill height above the culvert is approximately 5.0 m with the centreline of the road surface at approximate elevation 197.6 m. The existing embankment slopes are inclined between approximately 1.5H:1V and 2H:1V. Steel cable guide rails are present on the east side of the embankment in the vicinity of the culvert. The land adjacent to the highway consists of occasional side roads with residential properties and is mainly vegetated with trees and shrubs. Traffic volumes on this section of Highway 17 are understood to be 3,700 AADT (2016).

Select 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. It is noted that fibreoptic lines are buried near the toe of slope on both sides of the highway.

The site investigation and field testing program was carried out between December 6th and December 11th, 2017. 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 13. The elevations were surveyed relative to the first order vertical benchmark tablet 0011969U391 provided by the ministry which has an elevation of 193.496 m.

Table 3-1: Borehole Summary

Borehole No.	Drilled Location	Approximate Northing (m)	Approximate Easting (m)	Ground Surface Elevation (m)	Sample Termination Depth (m)
17-14	West end – near culvert outlet	5 176 723.0	278 133.0	191.4	2.4
17-15	West shoulder – near culvert	5 176 707.0	278 150.0	197.1	15.8*
17-16	East shoulder – near culvert	5 176 705.0	278 169.0	197.1	16.5*
17-17	East end – near culvert inlet	5 176 688.0	278 183.0	193.0	11.3
17-18	West shoulder – north of culvert	5 176 737.0	278 143.0	196.4	15.8

* - Borehole was further advanced beyond sample termination depth by dynamic cone

The drilling was carried out using portable or manual equipment for off-road Boreholes 17-14 and 17-17, a track mounted CME 550 rig for Boreholes 17-16 and 17-18 and a truck mounted CME 75 drill rig for Borehole 17-15.

Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). Borehole 17-17 which was drilled with portable equipment, also utilized a full-weight hammer for SPT testing. Borehole 17-14 utilized a 40% weight hammer for SPT testing; the blow counts detailed within the borehole log have been adjusted accordingly. Undrained shear strength values were determined in-situ using an MTO-N sized vane

A 19 mm diameter standpipe piezometer was installed in Borehole 17-16 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.

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 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. Grain size distribution analyses testing was also carried out on selected samples to MTO and ASTM standards. Chemical analysis for determination of pH, conductivity, resistivity, soluble sulphate and chloride concentrations 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

5.1 General

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. An overall description of the stratigraphy is given in the following paragraphs; however, the factual data presented in the Record of Boreholes governs any interpretation of the site conditions. It must be recognized that soil and groundwater conditions may vary between and beyond sampled locations.

The stratigraphy encountered through the embankment near the culvert is generally characterized by non-cohesive fill overlying native silt to sand overlying clay.

5.2 Topsoil

Boreholes 17-14, 17-16 and 17-17 encountered a layer of topsoil at ground surface ranging in thickness from 25 mm to 125 mm. The topsoil thickness may vary between boreholes and in other areas of the site.

5.3 Non-Cohesive Fill

Non-cohesive fill material classified as gravel with sand to silty sand with gravel to silt some sand was encountered from surface or beneath the topsoil in Boreholes 17-15, 17-16 and 17-18. Frequent cobbles and boulders were noted in the upper portion of the fill in Borehole 17-15. The underside of the fill ranged from 2.4 to 8.7 m below surface (elev. 188.4 to 194.1 m).

SPT tests conducted within the fill gave N-values ranging from 1 to 18 blows, indicating a very loose to compact relative density.

Moisture contents ranged from 1 to 37%. The results of grain size analyses conducted on five samples of the fill materials are summarized below and are illustrated on Figure C1 in Appendix C.

Table 5-1: Gradation Results for Non-Cohesive Fill

Soil Particle	Percentage (%)	
Gravel	0 to 32	
Sand	10 to 91	
Silt	4 to 45	81
Clay		9

Atterberg Limit testing on one sample of the fill indicated a non-plastic material.

5.4 Organic Silt to Sandy Silt with Organics

A thin layer ranging from organic silt to sandy silt with organics was encountered below the fill in Boreholes 17-15 and 17-16 and within the silt to sand deposit in Borehole 17-17. This layer had a thickness of 0.5 m (underside elev. 187.9 to 190.8 m).

SPT tests gave N-values ranging from 4 to 5 blows per 300 mm of penetration indicating a loose relative density. The moisture content ranged between 67 and 78%.

Organic content testing on two samples of the organic silt indicated an organic content ranging from 6.6 to 10.1%. Atterberg Limit testing on one sample of the sandy silt with organics indicated a non-plastic material. Gradation analysis was completed on one sample of sandy silt with organics. The results are summarized on the Record of Borehole sheets in Appendix B and the grain size distribution curve for this sample is included in Figure C2 of Appendix C. The results of the laboratory test are summarized as follows:

Table 5-2: Gradation Results for Sandy Silt with Organics

Soil Particle	Percentage (%)
Gravel	0
Sand	39
Silt	53
Clay	8

5.5 Silt to Sand

Beneath the materials noted above were deposits of cohesionless soils in all boreholes except Borehole 17-15 in which the cohesionless soils were encountered below a thin layer of high plastic clay as described in Section 5.6. The deposits varied from sandy silt to silt with sand to silty sand to sand trace silt. Boreholes 17-14 and 17-18 were terminated within the cohesionless deposits. The termination depths ranged from of 2.4 to 15.8 m (elev. 188.9 to 180.6 m). Where fully penetrated the silt and sand was found to have a thickness ranging from 0.8 to 7.1 m (underside elev. 184.3 to 186.9 m). A layer with organics was observed within the silt and sand in Borehole 17-17 and is described in Section 5.4 above.

SPT tests in the silt and sand unit gave N-values ranging from 0 to 40 blows per 300 mm of penetration indicating a very loose to dense relative density. The cohesionless deposit is

generally in a very loose to loose state. The moisture content in the silt deposits typically ranged between 21 and 57% and the moisture content in the sand deposits typically ranged between 15 and 41%.

Atterberg Limit testing on five samples indicated a non-plastic material. Gradation analysis were completed on five silt samples and five sand samples. The results are summarized on the Record of Borehole sheets in Appendix B and the grain size distribution curves for these samples are included in Figure C3 and C4 of Appendix C. The results of the laboratory tests are summarized as follows:

Table 5-3: Gradation Results for Silt to Sand

Soil Particle	Percentage (%)	
	Sands	Silts
Gravel	0 to 1	0
Sand	51 to 97	6 to 48
Silt	3 to 49	40 to 80
Clay		11 to 14

5.6 Clay (CH)

A thin layer of native high plastic clay was encountered in Borehole 17-15 just below the organic silt layer. This layer had a thickness of a thickness of 0.4 m (underside elev. 187.5 m).

The high plastic clay was also encountered below the silt to sand deposit in Boreholes 17-15, 17-16 and 17-17. Very thin silt interbeds were noted within the top 2.6 m of the clay deposit in Borehole 17-15. All three boreholes were terminated within this deposit at depths ranging from 11.3 to 16.5 m. Boreholes 17-15 and 17-16 were extended below termination depth by performing a dynamic cone penetration test (DCPT). The DCPT tests extended as deep as 31.4 m below ground surface (elev. 165.7 m) and was terminated on refusal. The SPT N-values ranged from weight of hammer to 9 blows per 300 mm penetration. Field vane tests performed within the deposit recorded undrained shear strengths ranging from 42 to greater than 106 kPa indicating a firm to very stiff consistency, but typically stiff. Remolded field vane testing indicates that the clay shows moderate sensitivity.

The moisture content of the samples tested ranged from 24 to 57%. The results of grain size analyses conducted on three samples of the clay are summarized below and are illustrated on Figure C5 in Appendix C.

Table 5-4: Gradation Results for Clay (CH)

Soil Particle	Percentage (%)
Gravel	0
Sand	1 to 4
Silt	26 to 37
Clay	60 to 70

Atterberg Limit testing was completed on three samples of the clay deposit. The results are summarized on the Record of Borehole sheets in Appendix B and the Atterberg Limit graphs are included in Figure C6 of Appendix C. The laboratory results are summarized below and indicate that the clay is of high plasticity (CH).

Table 5-5: Atterberg Limit Results for Clay (CH)

Parameter	Value
Liquid Limit	52 to 64
Plastic Limit	21 to 23
Plasticity Index	31 to 41

5.7 Groundwater

The water level was measured in the piezometer installed in Borehole 17-16 and is presented in the table below:

Table 5-6: Groundwater Level Observations

Borehole	Groundwater Level		Date of Measurement
	Depth (mbgs)	Elevation (m)	
17-16	8.5	188.6	December 7, 2017
	8.2	188.9	December 9, 2017
	8.2	188.9	December 10, 2017
	8.1	189.0	December 11, 2017

It should be noted that Borehole 17-14 was uncased and caved in to surface, preventing a water level from being taken. Water was used to advance the drilling casing in Boreholes 17-15 and 17-17 which prevented reliable groundwater measurements on completion of drilling. Borehole 17-18 was dry within the hollow-stem augers on completion of drilling and the open borehole caved to 6 m below ground surface when the augers were pulled on completion of drilling, preventing a groundwater table measurement.

The creek water level was surveyed at the culvert inlet and outlet during the field investigation and the measured elevations are detailed in the below table:

Table 5-7: Creek Water Level Observations

Location	Surface Water Elevation (m)	Date of Measurement
Culvert Inlet	192.0	December 11, 2017
Culvert Outlet	191.4	December 11, 2017

These observations are considered short term and it should be noted that the groundwater level at the time of construction 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 events.

5.8 Analytical Testing

One sample of soil was submitted to Paracel Laboratories in Ottawa, Ontario for analysis of pH, water soluble sulphate and chloride concentrations, resistivity and conductivity. The analysis results are summarized in the table below:

Table 5-8: Analytical Results Summary

Borehole	Sample	Depth (m)	Sulphate (μg/g)	pH	Resistivity (Ohm-cm)	Conductivity (μS/cm)	Chloride (μg/g)
17-14	SS3A	1.2 – 1.4	88	6.20	1990	502	247

6 MISCELLANEOUS

Borehole locations were selected by Thurber relative to existing site features and the anticipated foundation locations. The as-drilled locations and ground surface elevation were measured by Thurber following completion of the field program.

George Downing Estate Drilling Ltd. of Hawksbury, Ontario supplied and operated the drilling equipment to conduct the drilling, soil sampling, in-situ testing, standpipe piezometer installation and borehole decommissioning. All work was performed within short duration TL-6 shoulder closures in conformance with the requirements set in Ontario Book 7; all signs and cones were provided by Thurber. The field investigation was supervised on a fulltime basis by Ms. Deanna Pizycki, E.I.T. and Ms. Katya Edney, P.Eng. of Thurber. Overall supervision of the investigation program was provided by Mr. Paul Carnaffan, P.Eng.

Routine geotechnical laboratory testing was completed by Thurber's laboratory in Ottawa, Ontario. Organic content tests were carried out by Stantec Limited 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 Dr. Fred Griffiths, P.Eng.. The report was reviewed by Dr. P.K. Chatterji, P.Eng. a Designated Principal Contact for MTO Foundation Projects.

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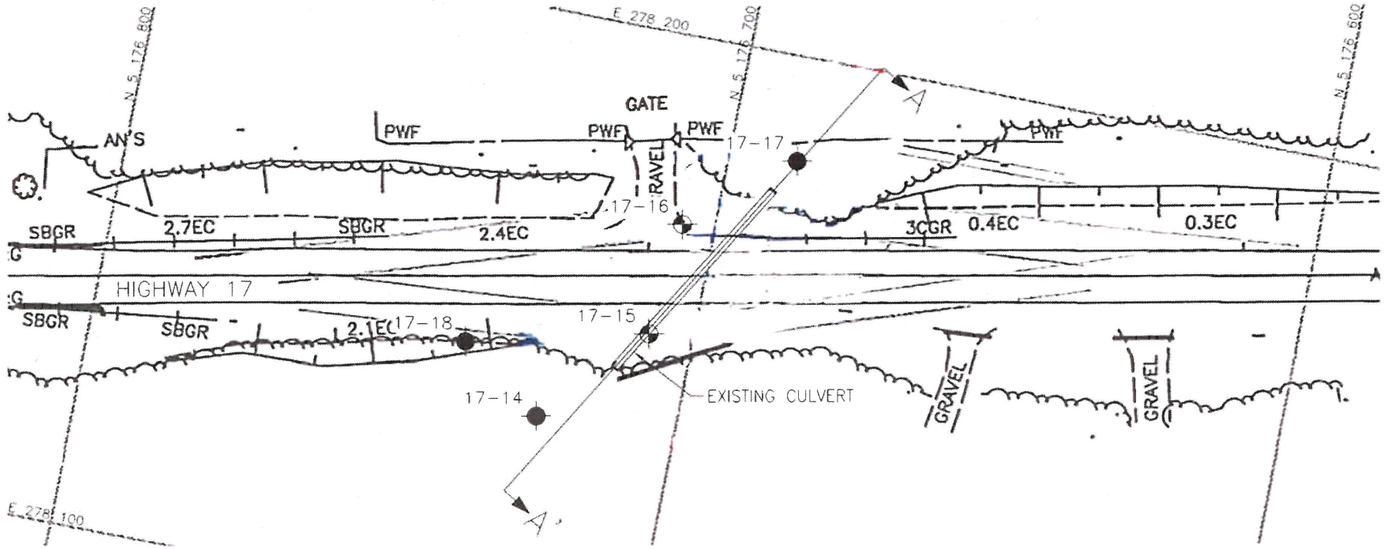
Senior Geotechnical Engineer

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

Appendix A.

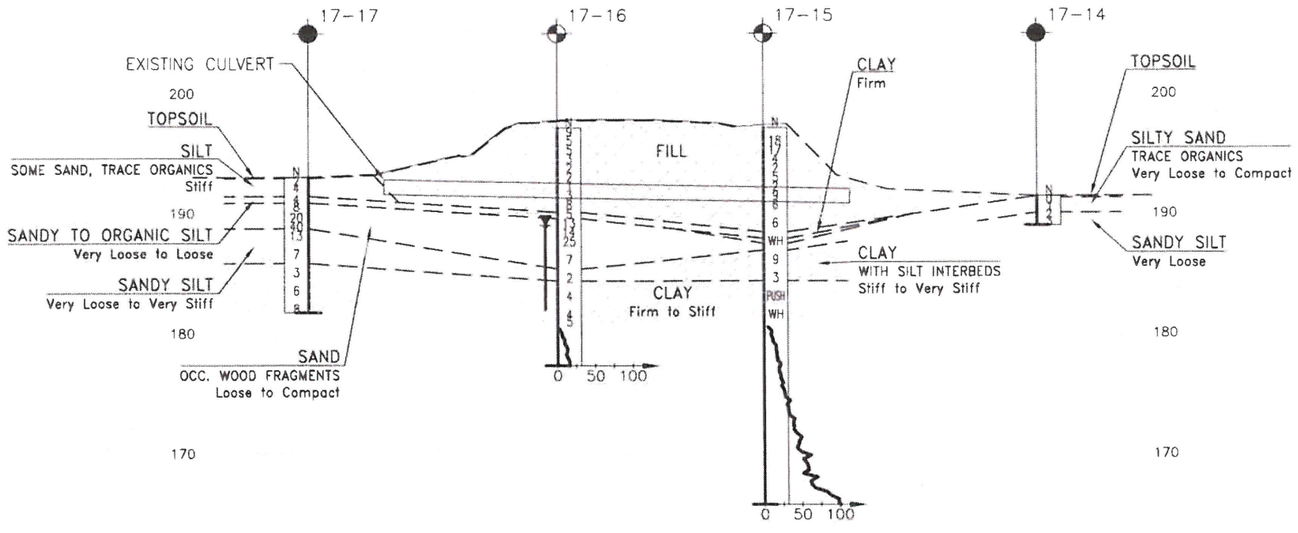
Borehole Location Plan and Stratigraphic Drawings



PLAN

20 0 20 40m

SCALE 1:1000



PROFILE

10 0 10 20m

SCALE 1:500

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

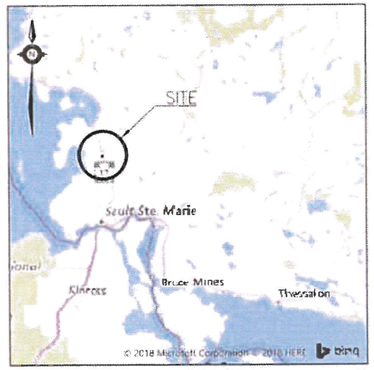
CONT No
GWP No 5181-13-00

HIGHWAY 17
CULVERT AT
STATION 17+230
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

Ontario

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
17-14	191.4000	5176723.0000	278133.0000
17-15	197.1000	5176707.0000	278150.0000
17-16	197.1000	5176705.0000	278169.0000
17-17	193.0000	5176688.0000	278183.0000
17-18	196.4000	5176737.0000	278143.0000

-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 13.

GEOCRES No. 41K-106

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
July 3/18
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
F. J. GRIFFITHS
July 3/18
PROVINCE OF ONTARIO

REVISIONS

DATE	BY	DESCRIPTION

DESIGN	CM	CHK PK	CODE	LOAD	DATE MAY 2018
DRAWN	MFA	CHK CM	SITE	STRUCT	DWG 1

FILENAME: H:\Drafting\17000\17848\TED-17848-Hwy17 Culvert.dwg
PLOTDATE: 5/29/2018 3:23 PM

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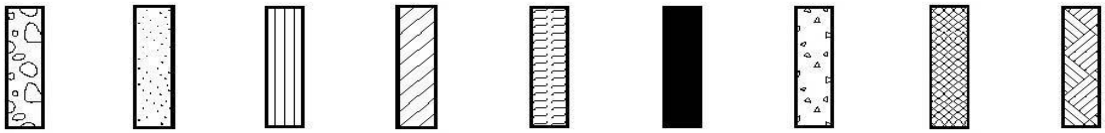
STRATA PLOT:
Strata plots symbolize the soil and bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.



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 17-14 1 OF 1 METRIC

GWP# 5181-13-00 LOCATION Culvert at Station 17+230, MTM z13: N 5 176 723.0 E 278 133.0 ORIGINATED BY DJP

HWY 17 BOREHOLE TYPE Manual COMPILED BY KE

DATUM Geodetic DATE 2017.12.10 - 2017.12.10 CHECKED BY FG

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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
191.4											
0.0	**125 mm Topsoil**										
0.1	**Silty SAND (SM)** Very Loose Brown		1	SS	0		191				
			2	SS	1						0 72 28 (SI+CL)
190.0											
1.4	**Sandy SILT (ML)** Very Loose Brown		3	SS	2		190				
			4	SS	3						
188.9							189				
2.4	End of Borehole at 2.4 m due to cave in to surface Note: A 40% (25.6 kg) drop hammer was used to advance the splitspoon sampler. The "N" values presented above have been corrected to provide an estimate of the "N" value that would have been obtained with a standard 64 kg hammer										

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

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

ONTMT4S 17848_CULVERT17+230.GPJ 2012TEMPLATE(MTO).GDT 3/7/18

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-15 1 OF 4 METRIC

GWP# 5181-13-00 LOCATION Culvert at Station 17+230, MTM z13: N 5 176 707.0 E 278 150.0 ORIGINATED BY KE

HWY 17 BOREHOLE TYPE NW Casing COMPILED BY KE

DATUM Geodetic DATE 2017.12.09 - 2017.12.09 CHECKED BY FG

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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
197.1											
0.0	GRAVEL with Sand, frequent Cobbles and Boulders **FILL** Compact Grey						197				
			1	SS	18		196				
195.6											
1.5	Silty SAND with Gravel, frequent Cobbles and Boulders **FILL** Compact Brown		2	SS	17		195				32 47 21 (SI+CL)
195.0											
2.1	SAND **FILL** Very Loose to Loose Brown		3	SS	4		194				
			4	SS	2		193				5 91 4 (SI+CL)
			5	SS	5		192				
			6	SS	2		191				
			7	SS	9		190				
			8	SS	6		189				
			9	SS	6		188				
188.4											
8.7	**Organic SILT** Very Loose Grey-Black										organic content 6.6%
187.9											
9.2	**CLAY (CH)** Firm Red-Grey		10	SS	WH						
187.5											
9.6	**Silty SAND (SM)**, trace Organics										

Continued Next Page

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

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-15 2 OF 4 METRIC

GWP# 5181-13-00 LOCATION Culvert at Station 17+230, MTM z13: N 5 176 707.0 E 278 150.0 ORIGINATED BY KE

HWY 17 BOREHOLE TYPE NW Casing COMPILED BY KE

DATUM Geodetic DATE 2017.12.09 - 2017.12.09 CHECKED BY FG

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
186.9 / 10.2	Very Loose Grey-Black						187				
	CLAY (CH) with Silt Interbeds Stiff to Very Stiff Red-Grey		11	SS	9		186				
	- Shear Strength >106 kPa		12	SS	3		185				0 3 37 60
184.3 / 12.8	**CLAY (CH)** Stiff Red-Grey		13	TW	PUSH		184				
			14	SS	WH		183				0 1 34 65
181.3 / 15.8	End of Sampled Borehole DCPT carried out from 15.8 to 31.4 m						182 181 180 179 178				

Continued Next Page

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

(%) STRAIN AT FAILURE

ONTMT4S 17848_CULVERT17+230.GPJ 2012TEMPLATE(MTO).GDT 3/7/18

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-15 3 OF 4 METRIC

GWP# 5181-13-00 LOCATION Culvert at Station 17+230, MTM z13: N 5 176 707.0 E 278 150.0 ORIGINATED BY KE

HWY 17 BOREHOLE TYPE NW Casing COMPILED BY KE

DATUM Geodetic DATE 2017.12.09 - 2017.12.09 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa 20 40 60 80 100 (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	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 (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	Continued From Previous Page										
	DCPT continued						177 176 175 174 173 172 171 170 169 168				

Continued Next Page

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

15 10 20 5 (%) STRAIN AT FAILURE

ONTMT4S 17848_CULVERT17+230.GPJ 2012TEMPLATE(MTO).GDT 3/7/18

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-15 4 OF 4 METRIC

GWP# 5181-13-00 LOCATION Culvert at Station 17+230, MTM z13: N 5 176 707.0 E 278 150.0 ORIGINATED BY KE

HWY 17 BOREHOLE TYPE NW Casing COMPILED BY KE

DATUM Geodetic DATE 2017.12.09 - 2017.12.09 CHECKED BY FG

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										
	DCPT continued						167				
165.7							166				
31.4	DCPT refusal at 31.4 m due to skin friction										

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

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

ONTMT4S 17848_CULVERT17+230.GPJ 2012TEMPLATE(MTO).GDT 3/7/18

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-16 1 OF 3 METRIC

GWP# 5181-13-00 LOCATION Culvert at Station 17+230, MTM z13: N 5 176 705.0 E 278 169.0 ORIGINATED BY DJP

HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY KE

DATUM Geodetic DATE 2017.12.06 - 2017.12.06 CHECKED BY FG

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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
197.1											
0.0	**100 mm Topsoil**						197				
0.1	Silty SAND **FILL** Loose Brown		1	SS	9						
			2	SS	5		196				0 55 45 (SI+CL)
			3	SS	5		195				
194.6											
2.4	SILT some Sand **FILL** Very Loose to Loose Grey-Brown		4	SS	3						
			5	SS	2		194				
			6	SS	2		193				
			7	SS	1						0 10 81 9 non-plastic
			8	SS	3		192				
190.5			9	SS	8		191				
6.6	Silty SAND **FILL** Loose										
190.1	Brown										
7.0	**Organic SILT** Loose Grey		10	SS	5		190				organic content 10.1%
189.5											
7.5	**Silty SAND (SM)** Compact Brown		11	SS	13		189				
			12	SS	14						1 78 21 (SI+CL)
			13	SS	25		188				

Continued Next Page

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

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

ONTMT4S 17848_CULVERT17+230.GPJ 2012TEMPLATE(MTO).GDT 3/7/18

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-16 2 OF 3 METRIC

GWP# 5181-13-00 LOCATION Culvert at Station 17+230, MTM z13: N 5 176 705.0 E 278 169.0 ORIGINATED BY DJP

HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY KE

DATUM Geodetic DATE 2017.12.06 - 2017.12.06 CHECKED BY FG

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page								
185.3	**Silty SAND (SM)** Compact Brown						187		
			14	SS	7		186		
11.7									
184.3	**Sandy SILT (ML)** Very Loose Grey		15	SS	2		185		0 44 42 14 non-plastic
12.7	**CLAY (CH)** Stiff Red-Brown						184		
			16	SS	4		183		0 4 26 70
			17	SS	4		182		
			18	SS	5		181		
180.6									
16.5	End of Sampled Borehole DCPT carried out from 16.5 to 19.8 m						180		
							179		
							178		
177.3									
19.8	End of DCPT at 19.8 m								

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

2.3
2.6
3.6
3.6

Continued Next Page

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

20
15 5
10
(%) STRAIN AT FAILURE

ONTMT4S 17848_CULVERT17+230.GPJ 2012TEMPLATE(MTO).GDT 3/7/18

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-16 3 OF 3 METRIC

GWP# 5181-13-00 LOCATION Culvert at Station 17+230, MTM z13: N 5 176 705.0 E 278 169.0 ORIGINATED BY DJP

HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY KE

DATUM Geodetic DATE 2017.12.06 - 2017.12.06 CHECKED BY FG

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 (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	Continued From Previous Page										
	Water Level in Standpipe 2017.12.07 8.46 mbgs 2017.12.09 8.22 mbgs 2017.12.10 8.16 mbgs 2017.12.11 8.12 mbgs										

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

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-17 1 OF 2 METRIC

GWP# 5181-13-00 LOCATION Culvert at Station 17+230, MTM z13: N 5 176 688.0 E 278 183.0 ORIGINATED BY DJP

HWY 17 BOREHOLE TYPE Portable COMPILED BY KE

DATUM Geodetic DATE 2017.12.07 - 2017.12.07 CHECKED BY FG

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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
193.0											
0.0	**25 mm Topsoil**										
0.1	**SILT (ML)** some Sand trace Organics Very Loose to Loose Brown-Grey		1	SS	2				○		
			2	SS	4		192		○		0 13 75 12 non-plastic
191.4											
1.6	**Sandy SILT (ML)** with Organics Loose Grey		3	SS	4		191		○		0 39 53 8 non-plastic
190.8											
2.1	**SAND (SP)**, occasional Wood fragments Loose to Compact Brown		4	SS	8				○		
			5	SS	20		190		○		0 97 3 (SI+CL)
			6	SS	40		189		○		
188.7											
4.3	**Sandy SILT (ML)** Compact to Loose Grey		7	SS	13		188		○		0 48 40 12 non-plastic
			8	SS	7		187		○		
185.8											
7.2	**CLAY (CH)** Firm to Stiff Red-Brown		9	SS	3		186		○		
							185	4.0 + 3.7 +	○		
			10	SS	6		184		○		
							183				

Continued Next Page

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

(%) STRAIN AT FAILURE

ONTMT4S 17848_CULVERT17+230.GPJ 2012TEMPLATE(MTO).GDT 3/7/18

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-17 2 OF 2 METRIC

GWP# 5181-13-00 LOCATION Culvert at Station 17+230, MTM z13: N 5 176 688.0 E 278 183.0 ORIGINATED BY DJP

HWY 17 BOREHOLE TYPE Portable COMPILED BY KE

DATUM Geodetic DATE 2017.12.07 - 2017.12.07 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT / WATER CONTENT (%)	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60	γ kN/m³	GR SA SI CL
	Continued From Previous Page										
	CLAY (CH) Firm to Stiff Red-Brown							6.0 5.2			
181.7			11	SS	8		182				
11.3	End of Borehole										

+ ³, × ³: Numbers refer to Sensitivity

20
15 5
10
(%) STRAIN AT FAILURE

ONTMT4S 17848_CULVERT17+230.GPJ 2012TEMPLATE(MTO).GDT 3/7/18

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-18 1 OF 2 METRIC

GWP# 5181-13-00 LOCATION Culvert at Station 17+230, MTM z13: N 5 176 737.0 E 278 143.0 ORIGINATED BY DJP

HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY KE

DATUM Geodetic DATE 2017.12.11 - 2017.12.11 CHECKED BY FG

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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
196.4											
0.0	SAND with Silt, some Gravel **FILL** Compact Brown		1	SS	16		196		○		13 80 7 (SI+CL)
195.7											
0.7	Silty SAND **FILL** Compact to Loose Brown-Grey		2	SS	10		195		○		
			3	SS	6				○		
194.1											
2.4	**SILT (ML)** trace Sand Very Loose Grey		4	SS	1		194		○		
			5	SS	2		193		○		0 6 80 14 non-plastic
191.9											
4.5	**Silty SAND (SM)** Compact to Loose Grey to Brown-Grey		6	SS	11		192		○		
			7	SS	8		191		○		
			8	SS	5		190		○		0 51 49 (SI+CL)
			9	SS	6		189		○		
			10	SS	8		188		○		
187.6			11	SS	10				○		
8.8	**SAND (SP)** trace Silt Compact Red-Brown		12	SS	20		187		○		

Continued Next Page

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

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-18 2 OF 2 METRIC

GWP# 5181-13-00 LOCATION Culvert at Station 17+230, MTM z13: N 5 176 737.0 E 278 143.0 ORIGINATED BY DJP

HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY KE

DATUM Geodetic DATE 2017.12.11 - 2017.12.11 CHECKED BY FG

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / 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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	SAND (SP) trace Silt Compact Red-Brown						186				
			13	SS	8				○		1 90 9 (SI+CL)
184.7							185				
11.7	**SILT (ML)** with Sand, occasional Clay interbeds Loose to Compact Red-Grey		14	SS	8		184		○		
							183				
			15	SS	5				○		0 24 65 11 non-plastic
							182				
			16	SS	14		181		○		
180.6											
15.8	End of Borehole Borehole caved to 6.0 m B.G.S. when augers were pulled										

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

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

ONTMT4S 17848_CULVERT17+230.GPJ 2012TEMPLATE(MTO).GDT 3/7/18

Appendix C.

Laboratory Testing

Appendix C.1

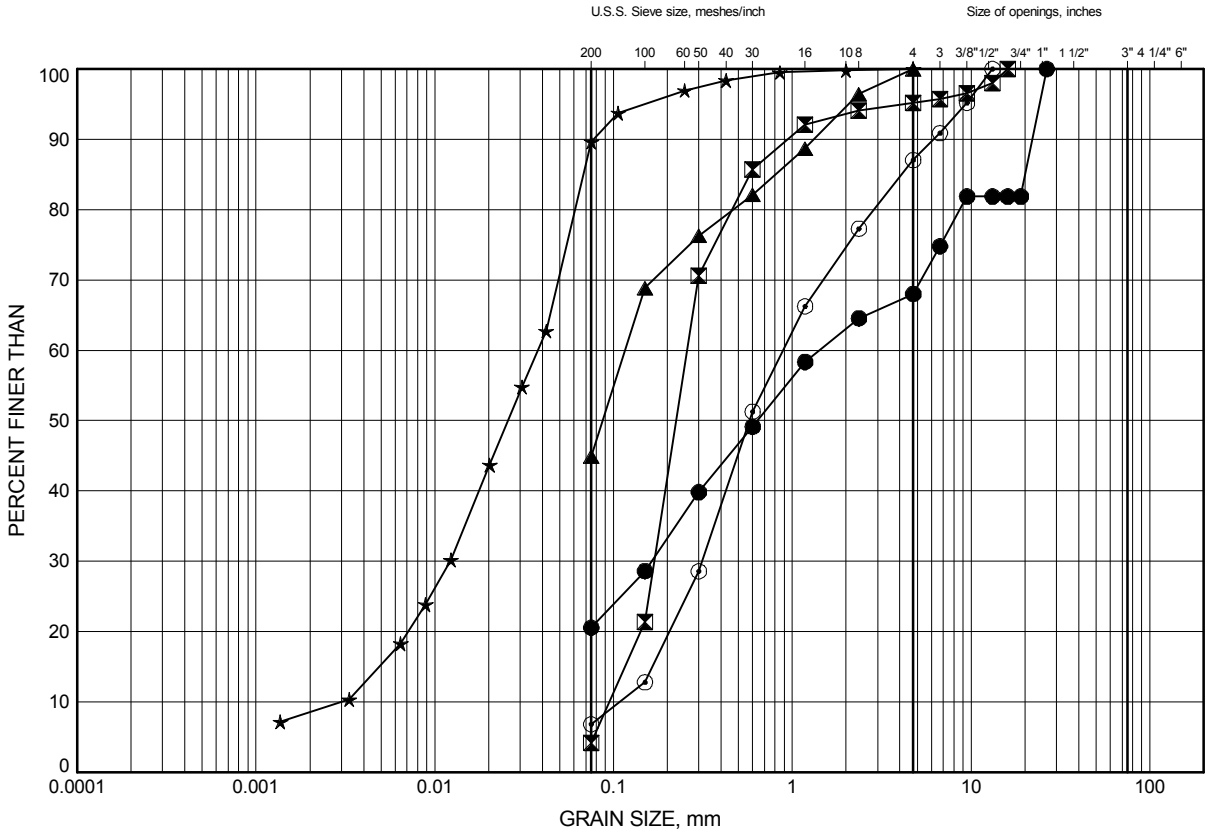
Particle Size Analysis Figures

Culvert at Station 17+230

GRAIN SIZE DISTRIBUTION

FIGURE C1

Non-Cohesive Fill



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-15	1.83	195.29
⊠	17-15	3.35	193.77
▲	17-16	1.07	196.01
★	17-16	4.88	192.20
⊙	17-18	0.30	196.13

Date May 2018

GWP# 5181-13-00

THURBER

Prep'd CM

Chkd. FJG

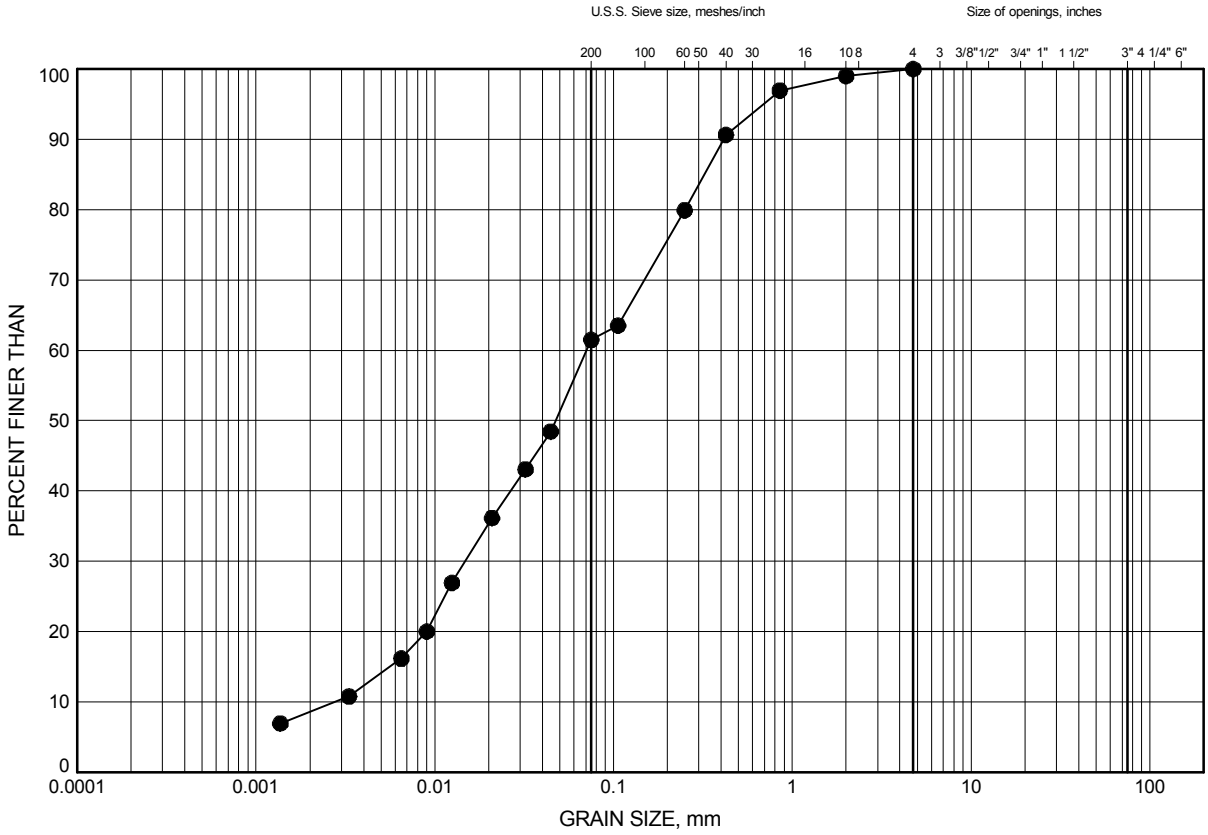
GRAIN SIZE DISTRIBUTION - THURBER 17848_CULVERT17+230.GPJ 29/5/18

Culvert at Station 17+230

GRAIN SIZE DISTRIBUTION

FIGURE C2

Sandy Silt with Organics



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-17	1.83	191.15

Date May 2018

GWP# 5181-13-00

THURBER

Prep'd CM

Chkd. FJG

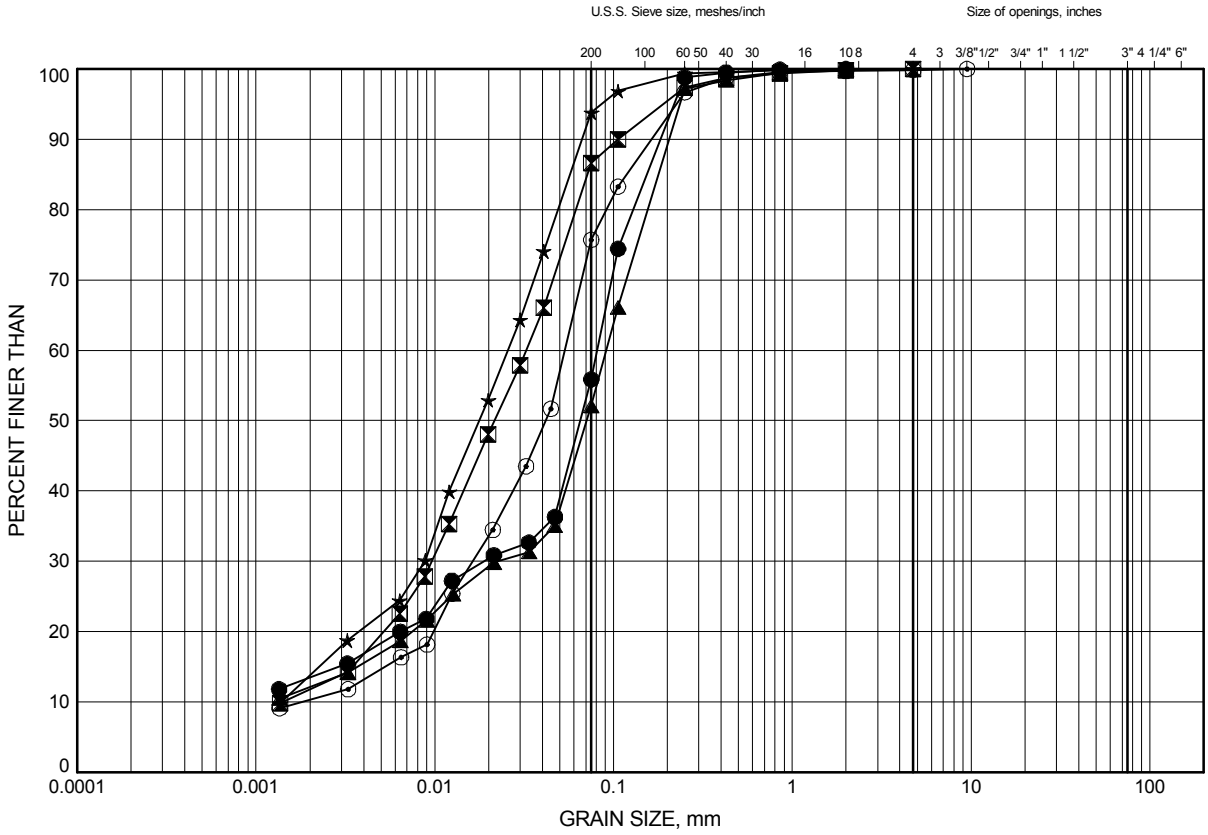
GRAIN SIZE DISTRIBUTION - THURBER 17848_CULVERT17+230.GPJ 29/5/18

Culvert at Station 17+230

GRAIN SIZE DISTRIBUTION

FIGURE C3

Silt



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-16	12.50	184.58
⊠	17-17	0.91	192.07
▲	17-17	4.88	188.10
★	17-18	3.35	193.08
⊙	17-18	14.02	182.41

Date May 2018

GWP# 5181-13-00

THURBER

Prep'd CM

Chkd. FJG

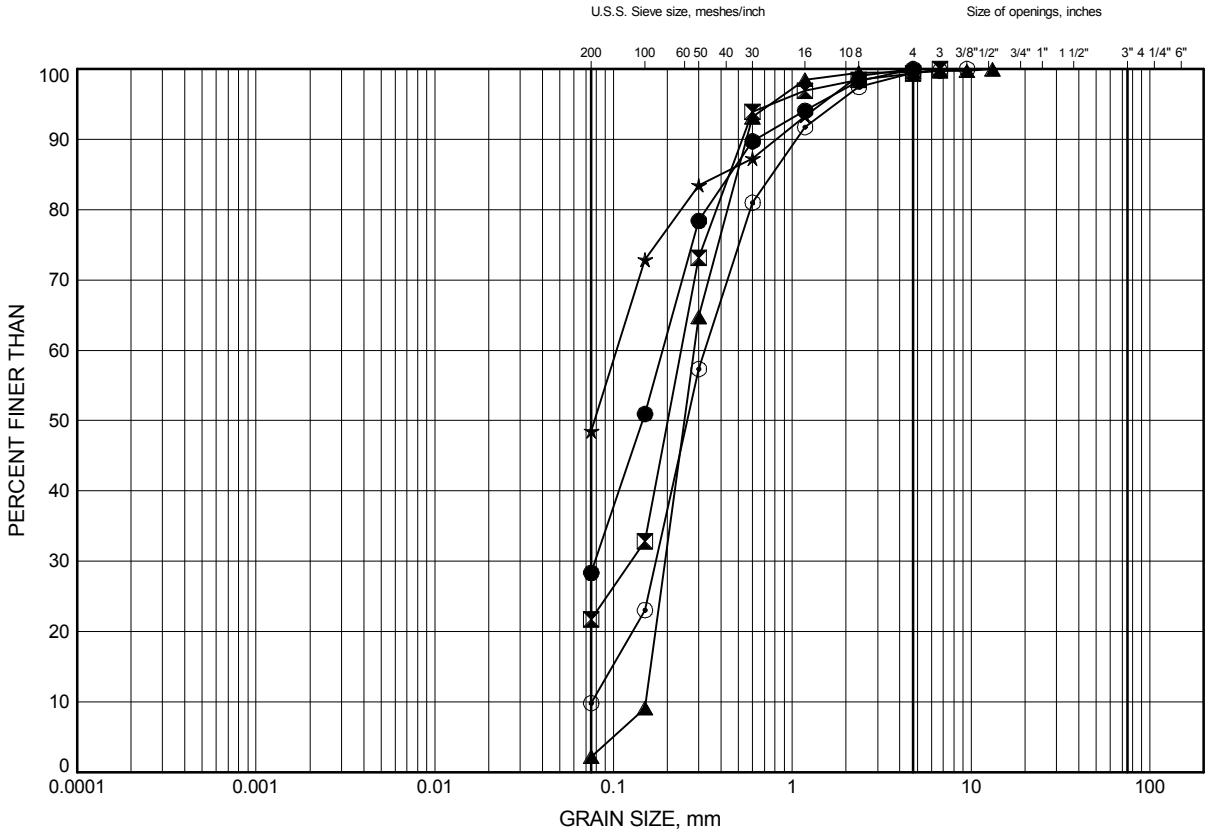
GRAIN SIZE DISTRIBUTION - THURBER 17848_CULVERT17+230.GPJ 29/5/18

Culvert at Station 17+230

GRAIN SIZE DISTRIBUTION

FIGURE C4

Sand



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-14	0.91	190.44
⊠	17-16	8.69	188.39
▲	17-17	3.35	189.63
★	17-18	6.40	190.03
⊙	17-18	10.97	185.46

Date May 2018

GWP# 5181-13-00

THURBER

Prep'd CM

Chkd. FJG

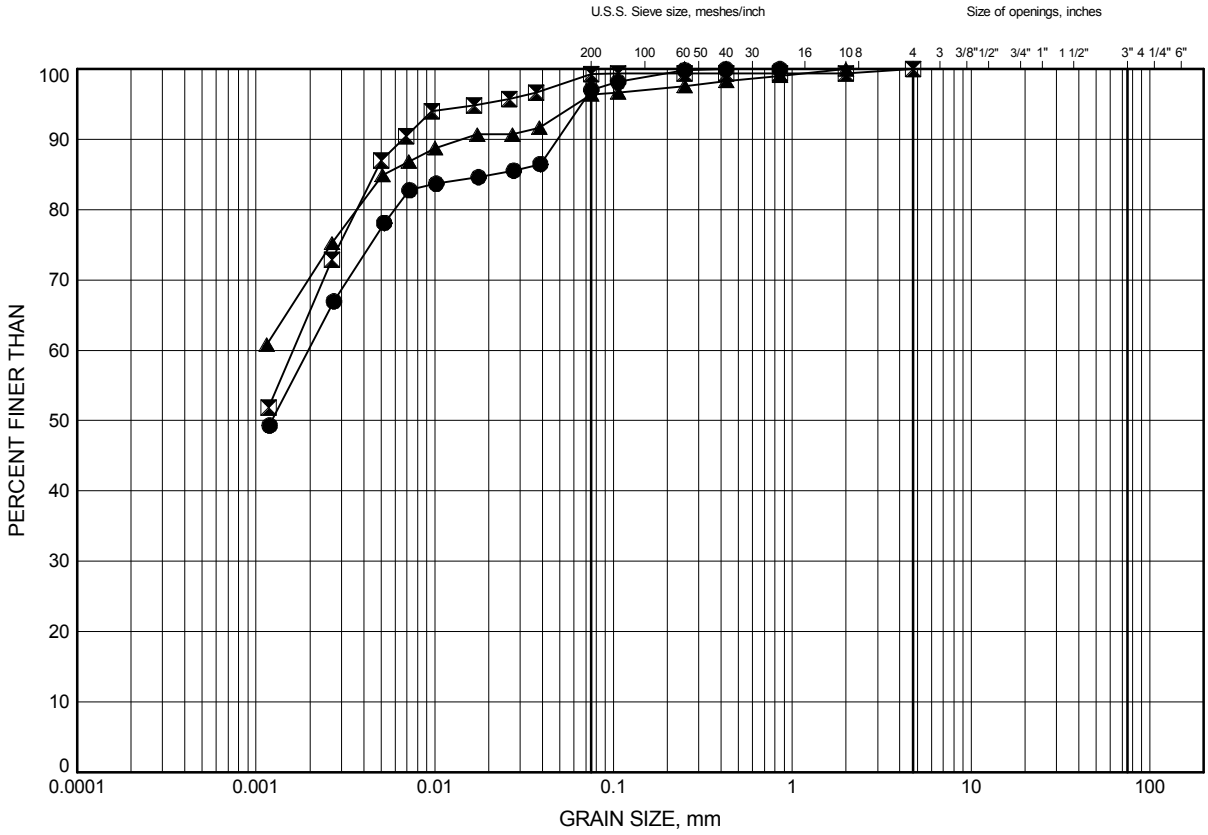
GRAIN SIZE DISTRIBUTION - THURBER 17848_CULVERT17+230.GPJ 29/5/18

Culvert at Station 17+230

GRAIN SIZE DISTRIBUTION

FIGURE C5

Clay



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-15	12.48	184.64
⊠	17-15	15.54	181.58
▲	17-16	14.02	183.06

Date February 2018

GWP# 5181-13-00

THURBER

Prep'd CM

Chkd. FJG

GRAIN SIZE DISTRIBUTION - THURBER 17848_CULVERT17+230.GPJ 23/2/18

Appendix C.2

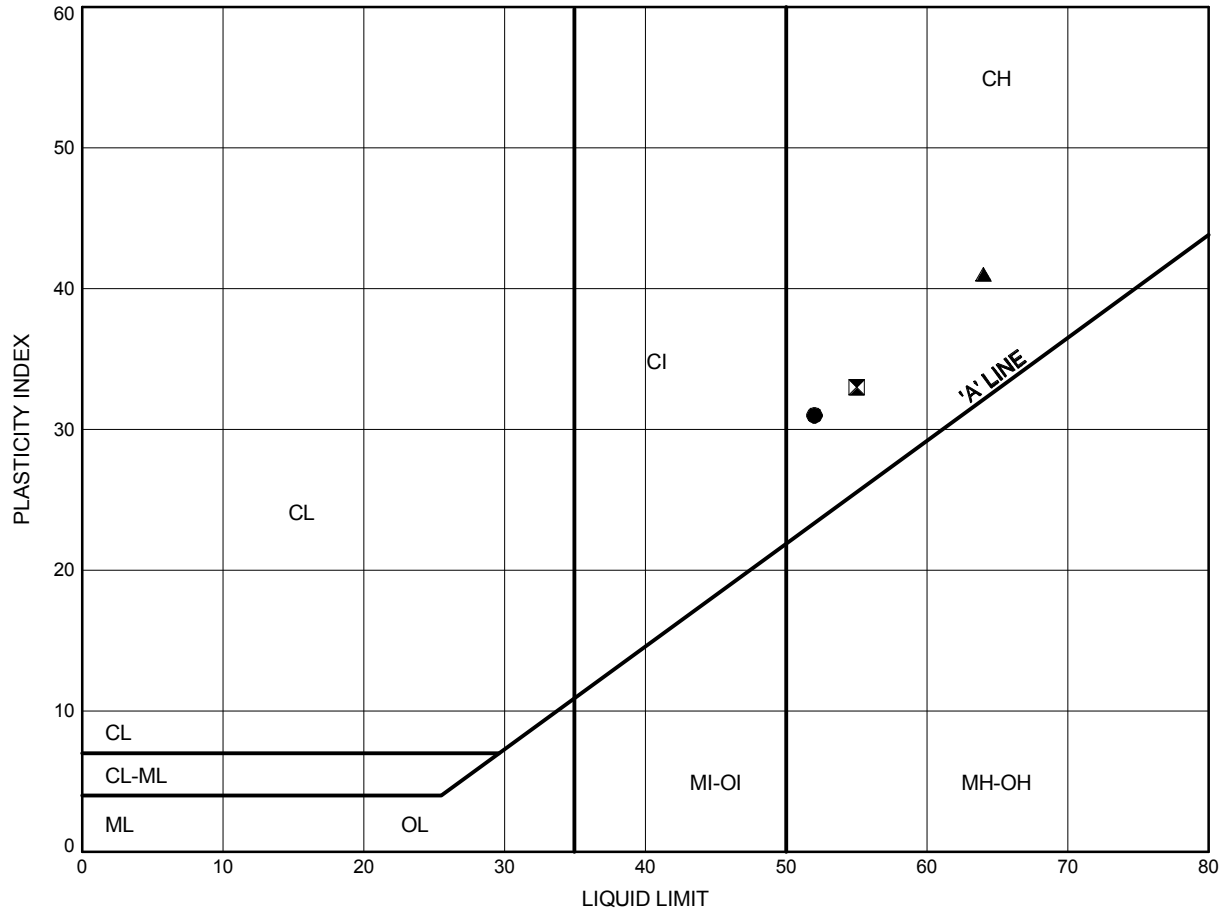
Atterberg Limit Analysis Figures

Culvert at Station 17+230

ATTERBERG LIMITS TEST RESULTS

FIGURE C6

Clay



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-15	12.48	184.64
⧓	17-15	15.54	181.58
▲	17-16	14.02	183.06

Date February 2018

GWP# 5181-13-00

THURBER

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Chkd. FJG

THURBALT 17848_CULVERT17+230.GPJ 23/2/18

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:
Project: 17848 SSM to Goulais
Custody: 39588

Report Date: 29-Jan-2018
Order Date: 23-Jan-2018

Order #: 1804148

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

Paracel ID	Client ID
~~1804148-01~~	~~17-4 SS3 5-7'~~
~~1804148-02~~	~~17-6 SS2 2'6"-4'6"~~
~~1804148-03~~	~~17-10 SS2 2'6"-4'6"~~
1804148-04	17-14 SS 3A 4'-4'6"

Approved By:

Mark Foto, M.Sc.
Lab Supervisor

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Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	25-Jan-18	25-Jan-18
Conductivity	MOE E3138 - probe @25 °C, water ext	25-Jan-18	25-Jan-18
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	23-Jan-18	24-Jan-18
Resistivity	EPA 120.1 - probe, water extraction	25-Jan-18	25-Jan-18
Solids, %	Gravimetric, calculation	26-Jan-18	29-Jan-18

PARACEL LABORATORIES LTD.

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	Client ID:	17-4 SS3 5-7'	17-6 SS2 2'6"-4'6"	17-10 SS2 2'6"-4'6"	17-14 SS 3A 4'-4'6"
	Sample Date:	21-Nov-17	25-Nov-17	10-Dec-17	10-Dec-17
	Sample ID:	1804148-01	1804148-02	1804148-03	1804148-04
	MDL/Units	Soil	Soil	Soil	Soil
Physical Characteristics					
% Solids	0.1 % by Wt.	94.9	94.2	87.0	83.4
General Inorganics					
Conductivity	5 uS/cm	165	605	301	502
pH	0.05 pH Units	7.01	6.36	6.20	6.20
Resistivity	0.10 Ohm.m	60.7	16.5	33.2	19.9
Anions					
Chloride	5 ug/g dry	29 [1]	234 [1]	114 [1]	247 [1]
Sulphate	5 ug/g dry	103 [1]	230 [1]	69 [1]	88 [1]

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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						

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Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	85.2	5	ug/g dry	87.4			2.5	20	
Sulphate	47.3	5	ug/g dry	48.0			1.5	20	
General Inorganics									
Conductivity	1250	5	uS/cm	1250			0.2	6.2	
pH	7.61	0.05	pH Units	7.58			0.4	10	
Resistivity	7.99	0.10	Ohm.m	7.97			0.2	20	
Physical Characteristics									
% Solids	83.2	0.1	% by Wt.	83.4			0.3	25	

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Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	187	5	ug/g	87.4	99.2	78-113			
Sulphate	153	5	ug/g	48.0	105	78-111			

Qualifier Notes:

Login Qualifiers :

Sample - One or more parameter received past hold time - pH, Chloride, Sulphate, and Conductivity.
Applies to samples: 17-4 SS3 5-7', 17-6 SS2 2'6''-4'6'', 17-10 SS2 2'6''-4'6'', 17-14 SS 3A 4'-4'6''

Sample Qualifiers :

1 : Holding time had been exceeded upon receipt of the sample at the laboratory.

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.

Appendix D.

Site Photographs

Photo 1. Looking east (upstream) of Highway 17

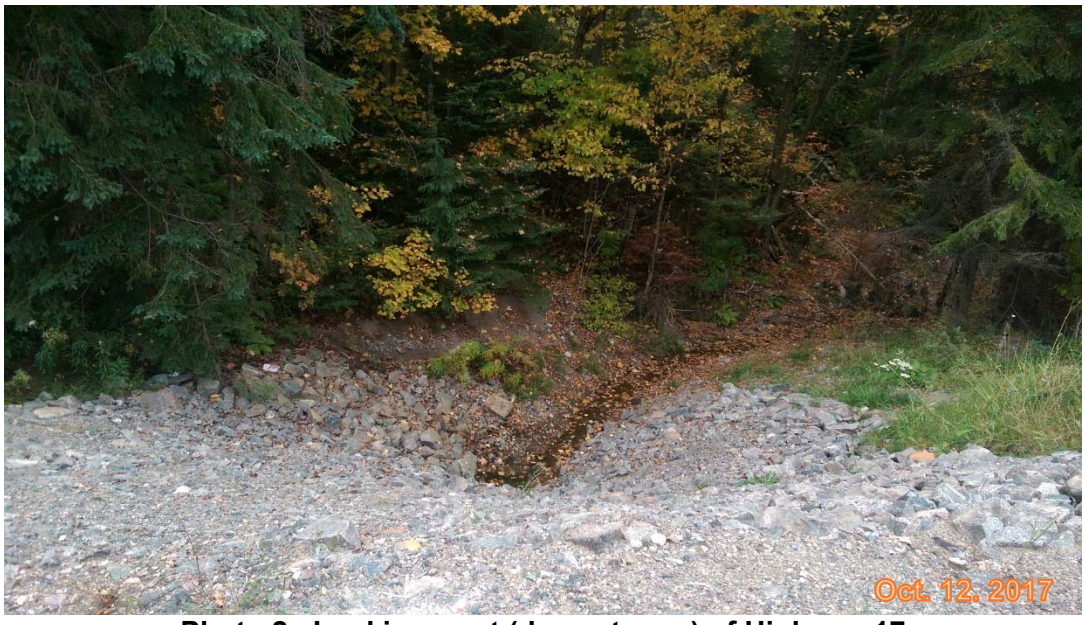

Photo 2. Looking west (downstream) of Highway 17

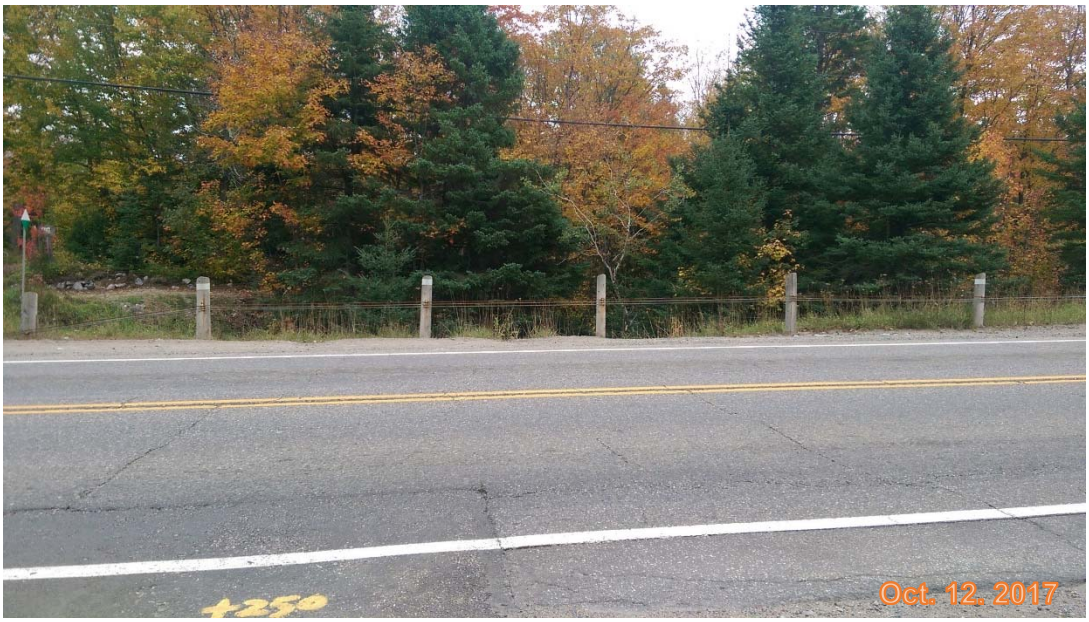

Photo 3. Looking east at Highway 17 over culvert alignment

Photo 4. Looking east at Culvert outlet

Photo 5. Looking west at Culvert inlet