



THURBER ENGINEERING LTD.

**FOUNDATION INVESTIGATION REPORT
CULVERT REPLACEMENT 15+818 TILLEY TOWNSHIP
HIGHWAY 17 NEAR GOULAIS RIVER
SAULT STE MARIE AREA
G.W.P. 545-00-00**

GEOCRES Number: 41K-103

Report

to

WSP Canada Inc.

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November 2, 2016
19-5308-95



TABLE OF CONTENTS

PART 1 FACTUAL INFORMATION

1	INTRODUCTION.....	1
2	SITE DESCRIPTION.....	1
3	SITE INVESTIGATION AND FIELD TESTING	2
4	LABORATORY TESTING	3
5	DESCRIPTION OF SUBSURFACE CONDITIONS.....	3
5.1	General.....	3
5.2	Pavement Structure	3
5.3	Embankment Fill.....	4
5.4	Sand with Silt, trace organics.....	4
5.5	Silty Sand to Sand	4
5.6	Clay	5
5.7	Groundwater Conditions	6
6	MISCELLANEOUS.....	7

APPENDICES

APPENDIX A	Borehole Locations and Soil Strata Drawings
APPENDIX B	Record of Borehole Sheets
APPENDIX C	Laboratory Test Results
APPENDIX D	Selected Photographs of Culvert Location



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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual data obtained from a foundation investigation conducted by Thurber Engineering Ltd. (Thurber) for replacement of a culvert under Highway 17 near Goulais River, Ontario.

No previous foundation investigation information for the subject culvert was available.

The purpose of this investigation was to obtain subsurface information at the site and, based on the data obtained, to provide a model of the subsurface conditions including borehole location plans, stratigraphic profiles, records of boreholes, laboratory test results and a written description of the subsurface conditions.

Thurber was retained by WSP Canada Inc. (WSP) to carry out this foundation investigation under MTO Agreement Number 5014-E-0008.

2 SITE DESCRIPTION

The culvert site is located on Highway 17, approximately 25.2 kilometres north of the intersection of Highway 552 and Highway 17 in the Township of Tilley. A 1.4 m diameter by 36 m long corrugated steel pipe culvert (CSP) is present at the site with approximately 4 m of fill above the pipe. The culvert carries stormwater under Highway 17 from east to west, towards Lake Superior. The invert elevation is 196.6 m at the east end or left and 195.1 m at the west end or right.

The grade of the existing Highway 17 in the vicinity of the culvert is at 201.3 m geodetic. The culvert is located within a fill section. The embankment is constructed with side slopes approximately 3 horizontal to 1 vertical (3H:1V) and 2H:1V corresponding to the east and west

slopes, respectively. The maximum embankment fill height measured from roadway to pipe invert is approximately 4.3 m at the east side and approximately 5.9 m at the west side.

The highway includes one southbound and two northbound lanes. The shoulders were snow covered at the time of the investigation but are gravel shoulders beyond a limited width of pavement. Guide rails are present on both sides of the highway.

The site is located in a rural area with forests, swamps, and creeks. Local topography generally consists of undulating hills and valleys. Selected photographs of the culvert site are attached in Appendix D.

The surficial geology of the area is typical of the Wisconsin glaciation. Soil cover consists primarily of glaciolacustrine (clay, silt, and sand) deposits underlain by glacial till.

3 SITE INVESTIGATION AND FIELD TESTING

The borehole investigation and field testing program was carried out between January 12, 2016 and January 23, 2016. The program consisted of drilling and sampling four boreholes (numbered 15-01, 15-02, 15-03, and 15-04) to depths ranging from 3.0 to 17.4 m. Of these boreholes, one was located near the culvert inlet (15-01), one located near the culvert outlet (15-04), and two (15-02 and 15-03) were located through the embankment on opposite sides of the road near the culvert.

Prior to the start of drilling, the borehole locations were established in the field and utility clearances were obtained. The co-ordinates and elevations of the as-drilled boreholes were subsequently determined by Thurber based on elevation data provided by WSP.

A truck-mounted drill rig equipped with hollow stem augers was used to drill and sample the boreholes on the roadway, and a portable tripod drill rig was used to drill and sample the culvert inlet and outlet boreholes. Soil samples were obtained at selected intervals using a 50 mm diameter split spoon sampler in conjunction with Standard Penetration Testing (SPT).

Results of the field drilling and sampling are presented on the Record of Borehole sheets in Appendix B.

A member of Thurber's technical staff supervised the drilling and sampling operations on a full time basis. The supervisor logged the boreholes, secured the recovered soil samples in labelled containers, and transported the samples to Thurber's laboratory for further examination and testing.

A 25 mm diameter PVC monitoring well was installed in BH 15-04. The screen extended from a depth of 1.2 m to 3.0 m below ground surface. A bentonite seal was placed from 1.2 m depth up to ground surface.

The boreholes were backfilled with soil cuttings mixed with bentonite and topped to surface with the existing granular material.

4 LABORATORY TESTING

All recovered soil samples were subjected to Visual Identification and to Natural Moisture Content determination. Selected soil samples were subjected to Grain Size Distribution analyses (sieve and hydrometer) and Atterberg Limit testing. The results of the laboratory testing program are shown on the Record of Borehole sheets in Appendix B and on the Figures in Appendix C.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

5.1 General

Reference is made to the Record of Borehole sheets in Appendix B for details of the soil stratigraphy encountered in the boreholes. A stratigraphic profile for the culvert replacement alignment is presented on the Borehole Locations and Soil Strata Drawing in Appendix A for illustrative purposes. 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.

In general, the subsurface conditions encountered in the boreholes consist of granular embankment fill overlying silty sand and sand with silt deposits underlain by clay or sand layers. Bedrock was not encountered in any of the four boreholes. More detailed descriptions of the individual strata are presented below.

5.2 Pavement Structure

Boreholes 15-02 and 15-03 were drilled through the gravel shoulders of the roadway, thus asphalt thickness was not measured.

Sand with gravel likely placed as part of the pavement structure extended to a depth of 0.8 m below ground surface. The base of the pavement structure was encountered at elevations ranging from 200.3 to 200.8 m.

The moisture content of the granular fill was 6%. The ground was frozen at the time of the field investigation thus the density and gradation of this layer could not be determined reliably.

5.3 Embankment Fill

Embankment fill was encountered below the pavement granulars in Boreholes 15-02 and 15-03. The thickness of the embankment fill ranged from 3.3 to 3.8 m. A 0.6 m layer of fill was also encountered at the surface in Boreholes 15-01 and 15-04 beneath a 25 mm thick layer of topsoil. The base of the embankment fill was encountered at elevations ranging from 195.1 to 197.6 m.

The embankment fill was observed to be sand with silt trace gravel to sand with gravel.

The SPT N-value for the embankment fill ranged from 4 to 15 blows per 0.3 m penetration, indicating a loose to compact state. The water contents of the recovered embankment fill samples ranged between 7% and 16%. The colour of the embankment fill is brown.

The results of grain size analyses conducted on three samples of the fill are presented on Fig. No 1 in Appendix C. The results are summarized in the following table.

Soil Particles	%
Gravel	8 to 12
Sand	82 to 85
Silt and Clay	4 to 7

5.4 Sand with Silt, trace organics

Underlying the embankment fill, a native soil deposit sand with silt was encountered in two boreholes (15-02 and 15-03). This layer was observed to range from 0.5 m to 0.6 m in thickness with the elevation of the base of the unit ranging from 195.9 m to 197.0 m. There was a 25 mm thick organic layer at the top of this layer in Borehole 15-02 and trace organic material in Borehole 15-03.

The SPT N-value for this deposit was 3 blows per 0.3 m penetration, indicating a very loose state. The water contents of the recovered samples ranged between 19% and 28%. The colour of this deposit is brown to dark brown.

5.5 Silty Sand to Sand

A native soil deposit ranging from silty sand to sand was encountered in all boreholes. This soil was found just below the sand with silt layer (15-02 and 15-03) and the embankment fill (15-01 and 15-04). Three of the four boreholes were terminated within this deposit. The thickness observed in Borehole 15-02 was 12.2 m with the base of the unit at 184.8 m. The upper portion

of this deposit contained occasional to frequent cobbles in three boreholes (15-01, 15-02, and 15-04). In Borehole 15-02, this deposit contained some wood and organics between 7 m and 14 m.

The SPT N-value for this deposit varied from 2 to greater than 100 blows per 0.3 m penetration, indicating a very loose to very dense state. The water content of the recovered samples ranged between 12% and 38%. The colour of this deposit is brown to grey.

Grain size analyses conducted on eight samples of the soil are presented on Fig. No 2 and Fig. No 3 in Appendix C. These results are summarized in the following table.

Soil Particles	%
Gravel	0 to 39
Sand	55 to 95
Silt and Clay	4 to 37

5.6 Clay

Clay with trace sand and gravel was encountered underlying the sand deposit in Borehole 15-02. Borehole 15-02 was terminated in this clay layer.

The SPT N-value in the clay deposit was 13 blows per 0.3 m penetration, coinciding with a stiff consistency. Sampling ceased in this layer in Borehole 15-02, however a dynamic cone (DCPT) was driven 6.4 m further to assess the consistency of the soils at the base of the borehole. The DCPT revealed the material below the clay ranged from 17 to 71 blows per 0.3 m penetration, indicating the presence of a compact (or very stiff, if cohesive) to very dense (or hard) material.

The colour of the clay is reddish brown. The water content of the recovered clay sample was 41%.

The results of a grain size analyse conducted on a sample of the clay are presented on Fig. No 4 in Appendix C. The results are summarized in the following table.

Soil Particles	%
Gravel	9
Sand	5
Silt	21
Clay	65

Atterberg limit testing was carried out on a sample of the clay. The liquid limit was 57% and the plasticity index was 37%. The sample can be classified as clay of high plasticity (CH). The results are presented on Fig. No 5 in Appendix C and summarized in the table below.

Test	%
Plastic Limit	20
Liquid Limit	57
Plasticity Index	37

5.7 Groundwater Conditions

Groundwater was observed in Boreholes 15-02, 15-03, and 15-04 at the completion of drilling. The results are summarized in the following table.

Borehole	Depth of observed water (m)	Elevation of observed water (m)
15-02	6.6	195.0
15-03	6.5	194.6
15-04	1.8	193.9

A 25 mm inside diameter PVC monitoring well was installed in Borehole 15-04. The results are summarized in the following table. The monitoring well was decommissioned on February 19, 2016.

Date	Depth of observed water (m)	Elevation of observed water (m)
January 24, 2016	1.86	193.84
January 25, 2016	1.91	193.79
February 19, 2016	1.99	193.71

Where surface water is present, the groundwater level should be assumed to coincide with the local surface or creek water level. Local high water levels and the effects of heavy rainfalls must also be taken into consideration.

6 MISCELLANEOUS

Thurber staked and/or marked the borehole locations in the field and obtained utility clearances prior to drilling. The borehole locations were surveyed by Thurber.

Marathon Drilling Ltd. of Greely, Ontario, supplied and operated a truck-mounted CME 55 drill rig to carry out the drilling, sampling and in-situ testing operations on the existing highway platform. Ohlmann Geotechnical Services (OGS) Inc. of Almonte, Ontario, supplied and operated the portable drill rig.

The drilling and sampling operations in the field were supervised on a full time basis by Mr. Justin Gray E.I.T. and Mr. Chris Murray E.I.T. of Thurber. Laboratory testing was carried out by Stantec (Ottawa) in its MTO-approved laboratory.

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



Justin A. Gray
Geotechnical E.I.T.



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Review Principal, Designated MTO Contact

Appendix A

Borehole Locations and Soil Strata Drawings

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Appendix B

Record of Boreholes Sheets

19-5308-95



SYMBOLS, ABBREVIATIONS AND TERMS USED ON TEST HOLE RECORDS

TERMINOLOGY DESCRIBING COMMON SOIL GENESIS

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

TERMINOLOGY DESCRIBING SOIL STRUCTURE:

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

RECOVERY:

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

N-VALUE:

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

DYNAMIC CONE PENETRATION TEST (DCPT):

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

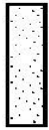


STRATA PLOT:

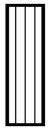
Strata plots symbolize the soil and bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.



Boulders
Cobbles
Gravel



Sand



Silt



Clay



Organics



Asphalt



Concrete



Fill



Bedrock

TEXTURING CLASSIFICATION OF SOILS

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

SAMPLE TYPES

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

TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

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

TERMS DESCRIBING CONSISTENCY (COHESIONLESS SOILS ONLY)

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

MODIFIED UNIFIED SOIL CLASSIFICATION

Major Divisions		Group Symbol	Typical Description
COARSE GRAINED SOIL	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILT AND CLAY SOILS $W_L < 35\%$	ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
		OL	Organic silts and organic silty-clays of low plasticity.
	SILT AND CLAY SOILS $35\% < W_L < 50\%$	MI	Inorganic compressible fine sandy silt with clay of medium plasticity, clayey silts.
		CI	Inorganic clays of medium plasticity, silty clays.
		OI	Organic silty clays of medium plasticity.
	SILT AND CLAY SOILS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy of silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other organic soils.

Note - W_L = Liquid Limit



EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION

Fresh (FR)	No visible signs of weathering.
Fresh Jointed (FJ)	Weathering limited to surface of major discontinuities.
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock materials.
Moderately Weathered (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.
Highly Weathered (HW)	Weathering extends throughout the rock mass and the rock is partly friable.
Completely Weathered (CW)	Rock is wholly decomposed and in a friable condition, but the rock texture and structures are preserved.

TERMS

Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.
Solid Core Recovery: (SCR)	Percent ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1 m in length or larger, as a percentage of total core length
Unconfined Compressive Strength: (UCS)	Axial stress required to break the specimen.
Fracture Index: (FI)	Frequency of natural fractures per 0.3 m of core run.

DISCONTINUITY SPACING

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

STRENGTH CLASSIFICATION








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

RECORD OF BOREHOLE No 15-01

1 OF 1

METRIC

GWP# 545-00-00 LOCATION Culvert 15+818, Highway 17 Goulais River N 5 198 035.6 E 273 218.6 ORIGINATED BY CAM
 HWY 17 BOREHOLE TYPE Portable COMPILED BY SML
 DATUM Geodetic DATE 2016.01.22 - 2016.01.23 CHECKED BY FJG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								20 40 60 80 100						
198.2														
0.8	ROOTMAT (25 mm)		1	SS	4		198							
197.6	SAND with silt and gravel Loose Brown		2	SS	6									
0.6	FILL		3	SS	18		197							
196.4	SILTY SAND some gravel Loose to Compact Brown Moist		4	SS	55		196							
1.8	SAND with silt and gravel occasional cobbles Very Dense		5	SS	80									
			6	SS	79		195							
194.5			7	SS	100									
3.7	End of Borehole at 3.68 m Borehole Dry Upon Completion				25mm									

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

RECORD OF BOREHOLE No 15-02

1 OF 3

METRIC

GWP# 545-00-00 LOCATION Culvert 15+818, Highway 17 Goulais River N 5 198 031.8 E 273 204.3 ORIGINATED BY JAG
 HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SML
 DATUM Geodetic DATE 2016.12.01 - 2016.12.01 CHECKED BY FJG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)					GR	SA	SI	CL
								20 40 60 80 100				w _p w w _L								
								○ UNCONFINED + FIELD VANE	● QUICK TRIAXIAL × LAB VANE											
201.6																				
0.0	SAND with gravel Brown Moist FILL		1	AS																
200.8							201													
0.8	SAND with silt some gravel Compact Brown Moist FILL		2	SS	15													11	82	7 (SI+CL)
			3	SS	13		200													
199.3																				
2.3	SAND some gravel Loose Brown Moist FILL		4	SS	6		199											12	84	4 (SI+CL)
			5	SS	4		198													
197.5																				
197.5	ORGANICS (25mm)		6	SS	3															
4.1	SAND with silt Very loose Brown Wet																			
197.0							197													
4.6	SAND with silt and gravel, occasional cobbles Compact to very dense Brown Moist to wet		7	SS	31													39	55	6 (SI+CL)
			8	SS	100 /0mm		196													
			9	SS	61		195													
194.6																				
7.0	SILTY SAND, occasional wood, occasional organics Very Loose Grey Wet		10	SS	125		194											2	84	14 (SI+CL)
			11	SS	31															
			12	SS	38		193													
			13	SS	21		192													

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 15-02

2 OF 3

METRIC

GWP# 545-00-00 LOCATION Culvert 15+818, Highway 17 Goulais River N 5 198 031.8 E 273 204.3 ORIGINATED BY JAG
 HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SML
 DATUM Geodetic DATE 2016.12.01 - 2016.12.01 CHECKED BY FJG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			WATER CONTENT (%)					
								○ UNCONFINED + FIELD VANE	○ UNCONFINED							
								● QUICK TRIAXIAL × LAB VANE								
	Continued From Previous Page						20 40 60 80 100				20 40 60					
	some wood some organics		14	SS	3		191							0 63 29 8		
							190									
189.4																
12.2	SAND with silt some gravel Very loose to very dense Brown Wet		15	SS	4		189									
	some wood		16	SS	2		188									
	running sands						187									
	occasional cobbles		17	SS	100		186									
					7/127 mm											
184.8							185									
16.8	CLAY Stiff Red to Brown Moist		18	SS	13									9 5 21 65		
184.2																
17.4	DCPT driven to 23.8m						184									
							183									
							182									

Continued Next Page

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

RECORD OF BOREHOLE No 15-02

3 OF 3

METRIC

GWP# 545-00-00 LOCATION Culvert 15+818, Highway 17 Goulais River N 5 198 031.8 E 273 204.3 ORIGINATED BY JAG
 HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SML
 DATUM Geodetic DATE 2016.12.01 - 2016.12.01 CHECKED BY FJG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	W _p	W	W _L	WATER CONTENT (%)		
	Continued From Previous Page							20 40 60 80 100						
								20 40 60 80 100						
								20 40 60 80 100						
								20 40 60 80 100						
177.8								20 40 60 80 100						
23.8	End of Borehole at 23.8 m Groundwater at 6.6 m							20 40 60 80 100						

RECORD OF BOREHOLE No 15-03

1 OF 2

METRIC

GWP# 545-00-00 LOCATION Culvert 15+818, Highway 17 Goulais River N 5 198 016.9 E 273 205.4 ORIGINATED BY JAG
 HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SML
 DATUM Geodetic DATE 2016.01.13 - 2016.01.13 CHECKED BY FJG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)							
								20 40 60 80 100				w _P w w _L							
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE											
201.1	0.0	Sand with gravel Compact Brown Moist FILL		1	AS														
200.3	0.8	Sand with silt trace gravel Loose Brown Moist FILL		2	SS	6													
				3	SS	5													
				4	SS	4													
				5	SS	6													
196.5	4.6	SAND WITH SILT, trace organics Very loose Dark brown Wet		6	SS	3													
195.9	5.2	SAND WITH SILT trace gravel Compact to very dense Brown Wet		7	SS	26													
				8	SS	35													
				9	SS	80													
				10	SS	49													
				11	SS	49													
				12	SS	42													

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 15-03

2 OF 2

METRIC

GWP# 545-00-00 LOCATION Culvert 15+818, Highway 17 Goulais River N 5 198 016.9 E 273 205.4 ORIGINATED BY JAG
 HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SML
 DATUM Geodetic DATE 2016.01.13 - 2016.01.13 CHECKED BY FJG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)								
								20 40 60 80 100				w _p w w _L								
Continued From Previous Page									○ UNCONFINED + FIELD VANE											
								● QUICK TRIAXIAL × LAB VANE												
								20 40 60 80 100				20 40 60								
190.8							191													
10.3	SAND Compact to very dense Brown Wet		13	SS	12		190							○						
							189													
				14	SS	27		188						○						
							187													
				15	SS	21		186						○						
							185													
				16	SS	31		184						○						
							183													
183.9			17	SS	73		182						○							
17.2	End of Borehole at 17.2 m Groundwater at 6.46 m																			











ONTMT4S 19-5308-95.GPJ 2012TEMPLATE(MTO).GDT 10-28-16

RECORD OF BOREHOLE No 15-04

1 OF 1

METRIC

GWP# 545-00-00 LOCATION Culvert 15+818, Highway 17 Goulais River N 5 198 007.3 E 273 189.6 ORIGINATED BY CAM
 HWY 17 BOREHOLE TYPE Portable COMPILED BY SML
 DATUM Geodetic DATE 2016.01.23 - 2016.01.23 CHECKED BY FJG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa											
195.7								20	40	60	80	100							
0.0	ROOTMAT (25 mm)		1	SS	9		195												
195.1	SAND with gravel, frequent cobbles Loose to very dense Brown Wet		2	SS	62														
0.6	SAND with silt some gravel, frequent to occasional cobbles Very Dense Brown Wet		3	SS	63														
			4	SS	52			194											
			5	SS	157/ 229 mm			193											
192.7																			
3.0	End of Borehole at 2.97 m Groundwater at 1.83 m Well Measurements: depth (m) date 1.86 2016.01.24 1.91 2016.01.25 1.99 2016.02.19																		

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

Appendix C

Laboratory Test Results

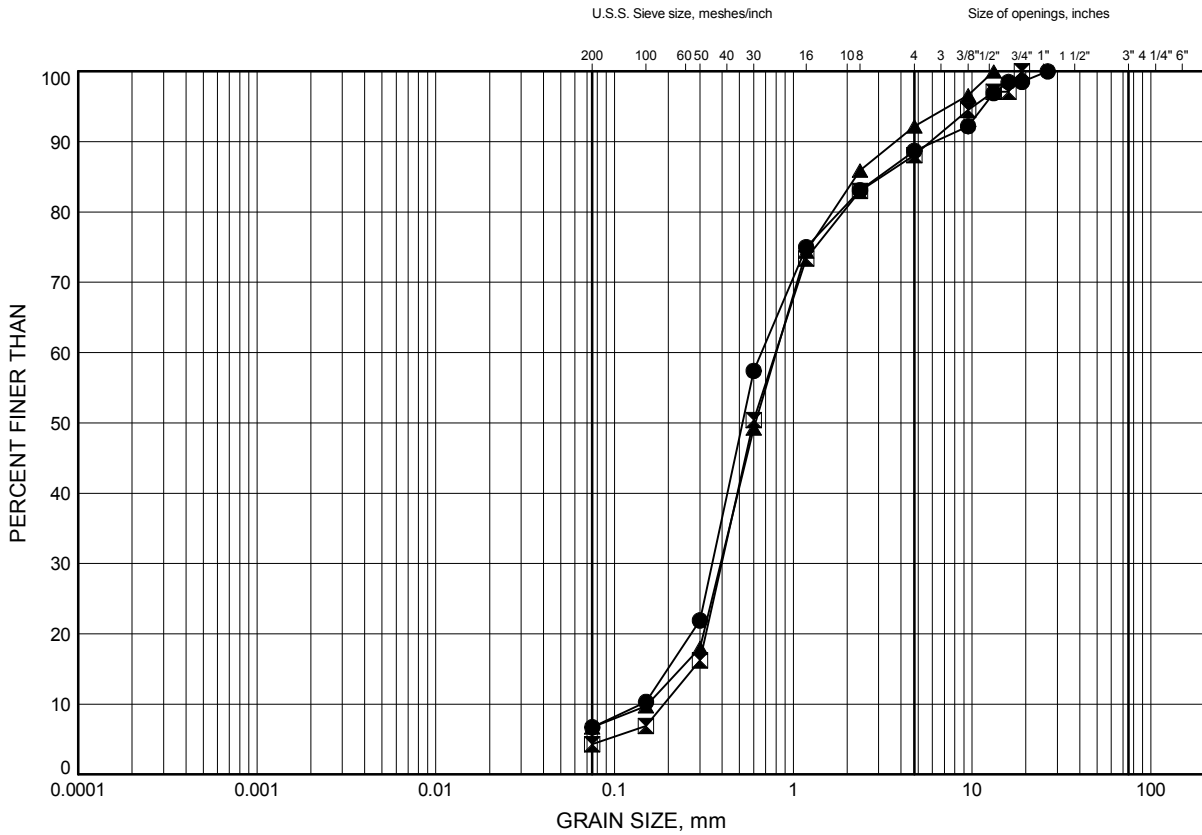
19-5308-95

Culvert 15+818, Highway 17 Goulais River

GRAIN SIZE DISTRIBUTION

FIGURE 1

Embankment Fill



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-02	1.07	200.53
⊠	15-02	2.59	199.01
▲	15-03	3.35	197.75

Date March 2016
GWP# 545-00-00

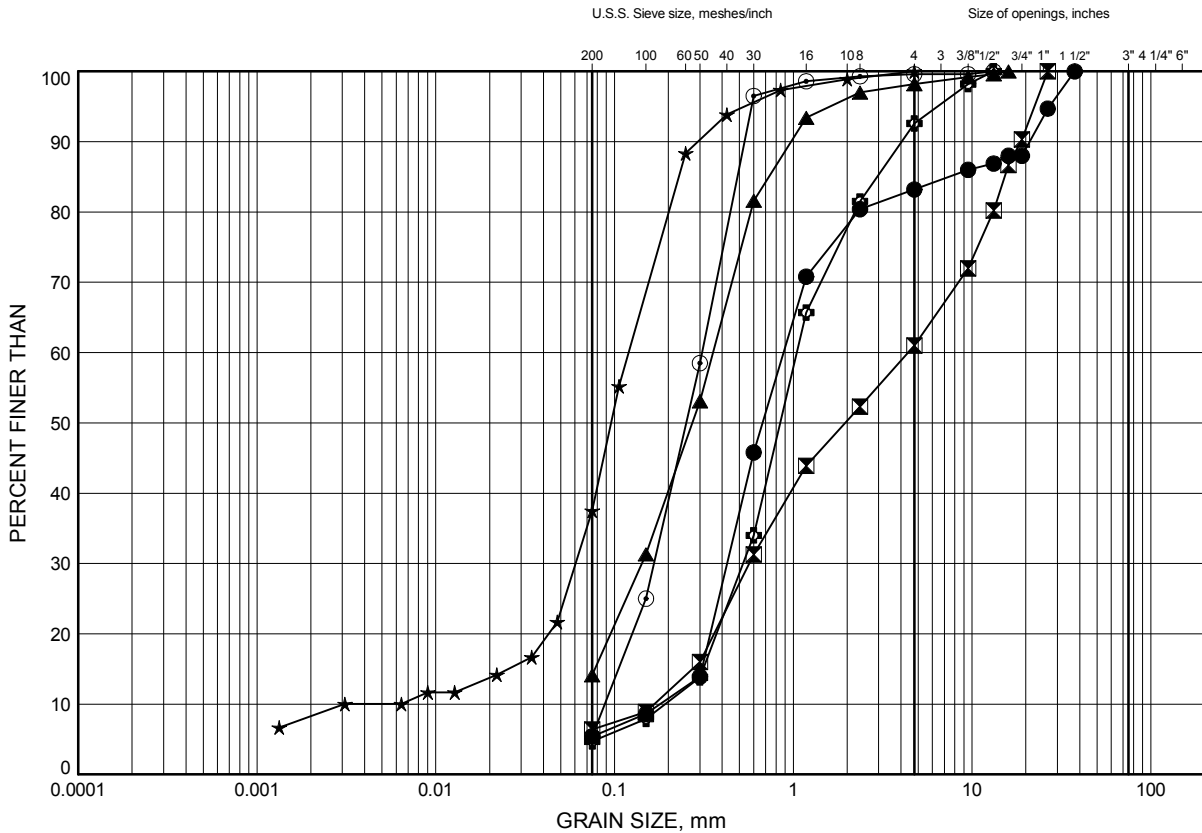


Prep'd JAG
Chkd. FJG

Culvert 15+818, Highway 17 Goulais River
GRAIN SIZE DISTRIBUTION

FIGURE 2

Silty Sand, Sand with Silt, and Sand



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-01	2.13	196.07
⊠	15-02	4.88	196.72
▲	15-02	7.92	193.68
★	15-02	10.97	190.63
⊙	15-03	5.64	195.46
⊕	15-03	7.92	193.18

Date March 2016
 GWP# 545-00-00

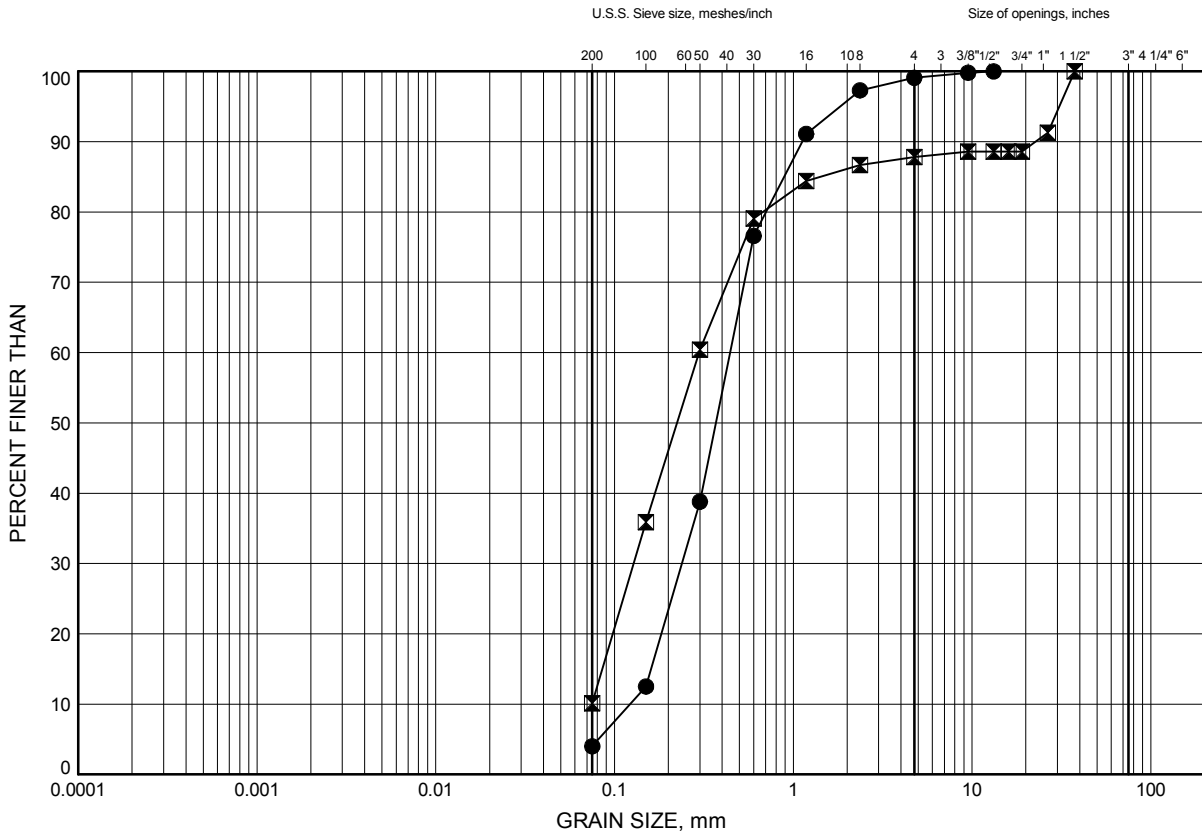


Prep'd JAG
 Chkd. FJG

Culvert 15+818, Highway 17 Goulais River
GRAIN SIZE DISTRIBUTION

FIGURE 3

Silty Sand, Sand with Silt, and Sand



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-03	15.54	185.56
⊠	15-04	2.13	193.57

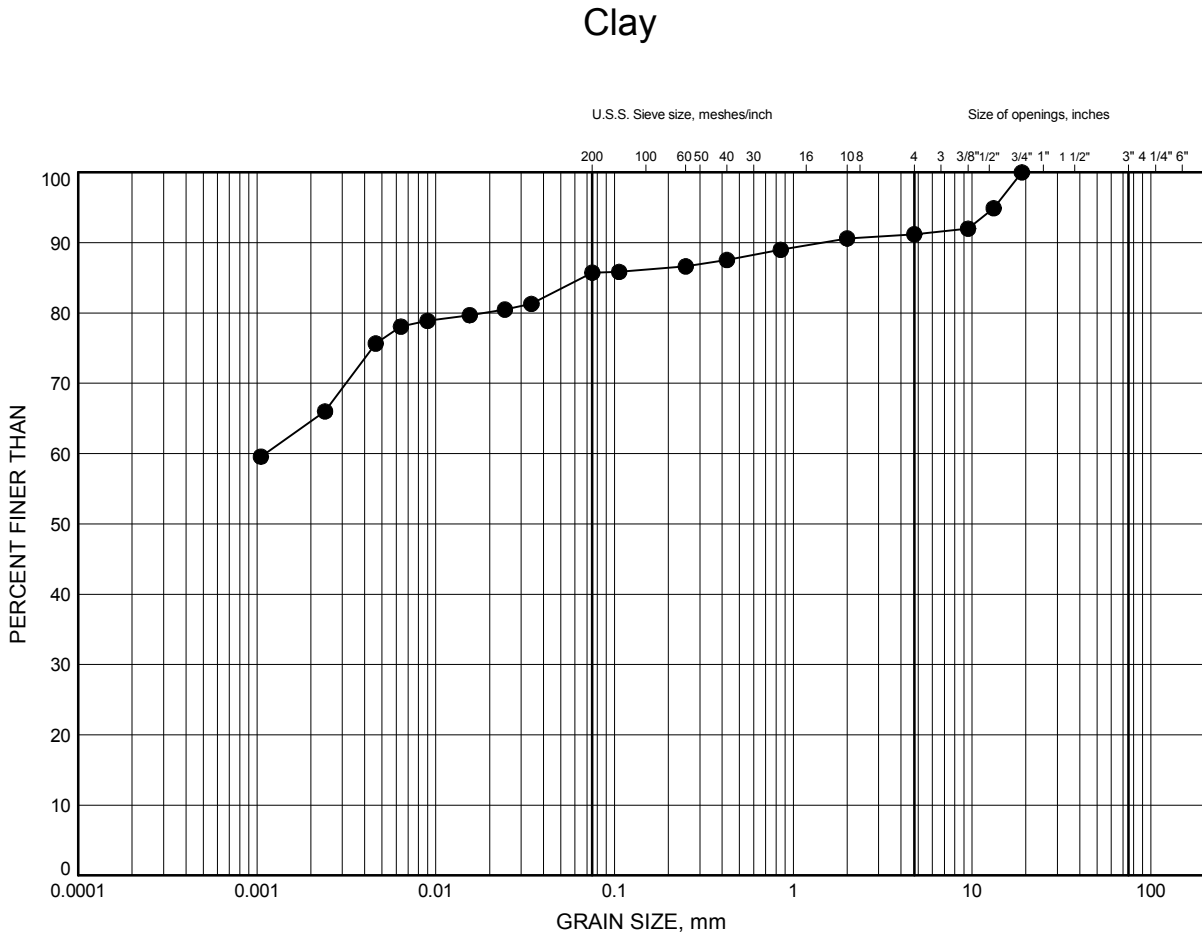
Date March 2016
 GWP# 545-00-00



Prep'd JAG
 Chkd. FJG

Culvert 15+818, Highway 17 Goulais River
GRAIN SIZE DISTRIBUTION

FIGURE 4



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-02	17.07	184.53

Date March 2016
 GWP# 545-00-00

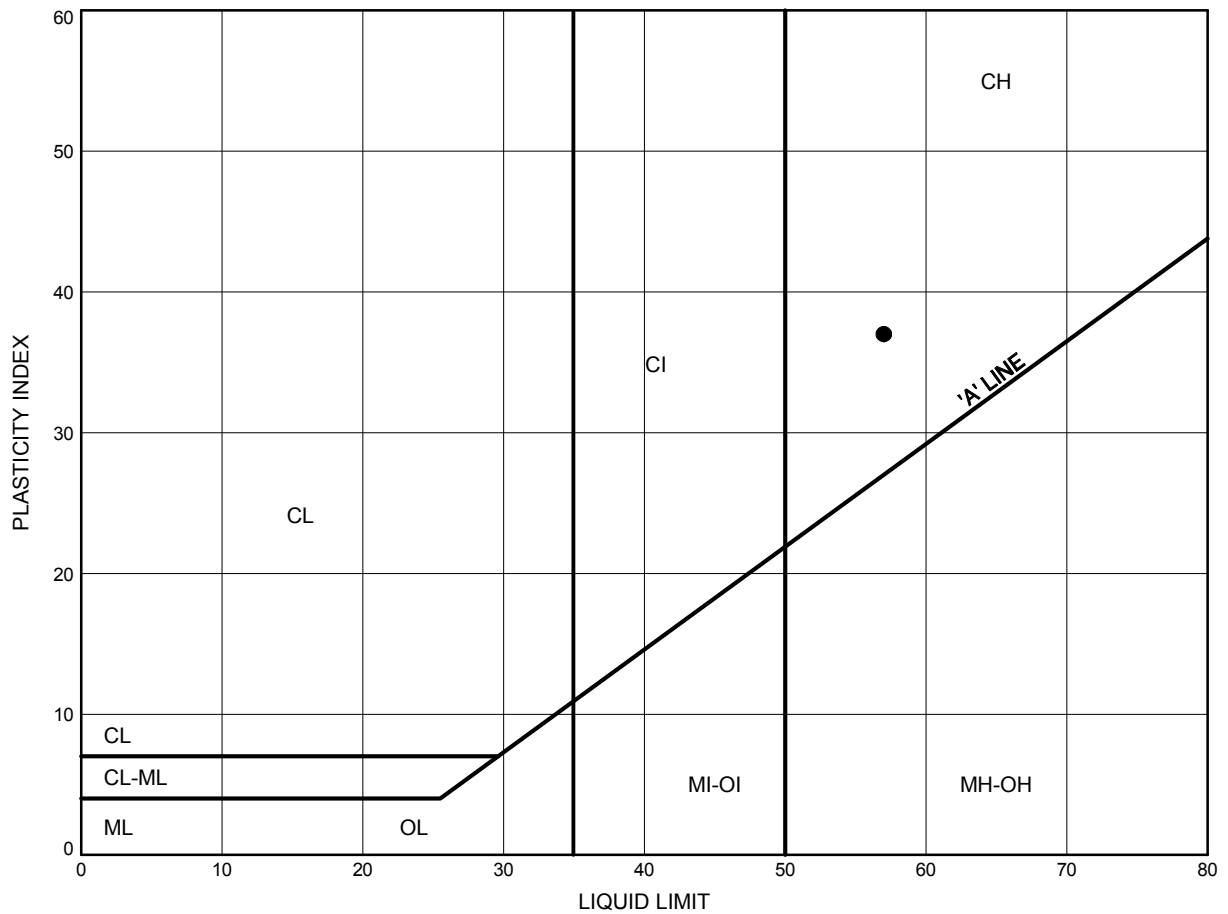


Prep'd JAG
 Chkd. FJG

Culvert 15+818, Highway 17 Goulais River

ATTERBERG LIMITS TEST RESULTS

FIGURE 5



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-02	17.07	184.53

Date March 2016
GWP# 545-00-00



Prep'd JAG
Chkd. FJG

Certificate of Analysis

Thurber Engineering Ltd.

2460 Lancaster Rd, Suite 104
Ottawa, ON K1B4S5
Attn: Shawn Lapain

Client PO:
Project: 19-5308-95
Custody: 27346

Report Date: 4-Feb-2016
Order Date: 29-Jan-2016

Order #: 1605367

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

Paracel ID	Client ID
1605367-01	BH15-23 SS11 (25'-27')
1605367-02	BH15-3 SS8 (20'-22')
1605367-03	BH15-32 SS3 (4'-6')
1605367-04	BH15-33 GS3 (2.5'-3.5')

Approved By:



Dale Robertson, BSc
Laboratory Director

Certificate of Analysis

Client: **Thurber Engineering Ltd.**

Client PO:

Report Date: 04-Feb-2016

Order Date: 29-Jan-2016

Project Description: **19-5308-95****Analysis Summary Table**

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	3-Feb-16	3-Feb-16
Conductivity	MOE E3138 - probe @25 °C, water ext	2-Feb-16	3-Feb-16
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	1-Feb-16	1-Feb-16
Resistivity	EPA 120.1 - probe, water extraction	2-Feb-16	2-Feb-16
Solids, %	Gravimetric, calculation	30-Jan-16	30-Jan-16

Certificate of Analysis

Client: **Thurber Engineering Ltd.**

Client PO:

Report Date: 04-Feb-2016

Order Date: 29-Jan-2016

Project Description: 19-5308-95

Client ID:	BH15-23 SS11 (25'-27')	BH15-3 SS8 (20'-22')	BH15-32 SS3 (4'-6')	BH15-33 GS3 (2.5'-3.5')
Sample Date:	07-Jan-16	18-Jan-16	18-Jan-16	21-Jan-16
Sample ID:	1605367-01	1605367-02	1605367-03	1605367-04
MDL/Units	Soil	Soil	Soil	Soil

Physical Characteristics

% Solids	0.1 % by Wt.	85.0	84.7	79.0	85.3
----------	--------------	------	------	------	------

General Inorganics

Conductivity	5 uS/cm	1400	138	114	108
pH	0.05 pH Units	6.14	6.11	5.34	5.70
Resistivity	0.10 Ohm.m	7.17	72.4	87.8	92.3

Anions

Chloride	5 ug/g dry	747	73	61	14
Sulphate	5 ug/g dry	22	11	11	17

Certificate of Analysis

Client: **Thurber Engineering Ltd.**

Client PO:

Report Date: 04-Feb-2016

Order Date: 29-Jan-2016

Project Description: **19-5308-95**

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:

Report Date: 04-Feb-2016

Order Date: 29-Jan-2016

Project Description: **19-5308-95**

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	8.7	5	ug/g dry	8.4			2.5	20	
Sulphate	298	5	ug/g dry	335			11.5	20	
General Inorganics									
Conductivity	749	5	uS/cm	758			1.3	6.2	
pH	7.76	0.05	pH Units	7.79			0.4	10	
Physical Characteristics									
% Solids	77.8	0.1	% by Wt.	78.6			1.0	25	

Certificate of Analysis

Client: **Thurber Engineering Ltd.**

Client PO:

Report Date: 04-Feb-2016

Order Date: 29-Jan-2016

Project Description: **19-5308-95**

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	10.3		mg/L	0.8	94.3	78-113			
Sulphate	41.8		mg/L	33.5	83.3	78-111			

Certificate of Analysis

Client: **Thurber Engineering Ltd.**

Client PO:

Report Date: 04-Feb-2016

Order Date: 29-Jan-2016

Project Description: **19-5308-95**

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.

Appendix D

Selected Photographs

19-5308-95

Photo 1: West side – end of culvert



Photo 2: East side – end of culvert



Photo 3: Looking south at culvert crossing.



Photo 4: Looking north towards culvert crossing.

