



THURBER ENGINEERING LTD.

FINAL
FOUNDATION INVESTIGATION REPORT
REHABILITATION OF ROOT RIVER CULVERT #3 (SITE 38S-054)
HIGHWAY 17 - 2.9 KM SOUTH OF HIGHWAY 556
AWERES TOWNSHIP
G.W.P. 5181-13-00
5016-E-0040

Geocres No.: 41K-105

Report to:

Ministry of Transportation Ontario

Latitude: 46.619110°
Longitude: -84.306919°

July 2018
Thurber File: 17848

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	Fill Material.....	3
5.2.1	Asphalt.....	3
5.2.2	Fill: Sand with Silt and Gravel to Gravel with Silt and Sand.....	3
5.2.3	Fill: Sand.....	4
5.3	Peat.....	4
5.4	Organic Silt.....	4
5.5	Gravel	4
5.6	Sand to Silty Sand.....	5
5.6.1	Sand	5
5.6.2	Silty Sand (SM).....	6
5.7	Silt to Sandy Silt	6
5.8	Refusal.....	6
5.9	Groundwater	6
5.10	Analytical Testing	7
6	MISCELLANEOUS	8

APPENDICES

Appendix A.	Borehole Location Plan and Stratigraphic Drawings
Appendix B.	Record of Borehole Sheets
Appendix C.	Laboratory Testing
Appendix D.	Site Photographs

FINAL
FOUNDATION INVESTIGATION REPORT
REHABILITATION OF ROOT RIVER CULVERT #3 (SITE 38S-054)
HIGHWAY 17 - 2.9 KM SOUTH OF HIGHWAY 556
AWERES TOWNSHIP
G.W.P. 5181-13-00

5016-E-0040
Geocres No.: 41K-105

PART 1. FACTUAL INFORMATION

1 INTRODUCTION

This section of the report presents the factual findings obtained from a foundation investigation completed at Highway 17 Root River Culvert #3 (38S-054) which is located approximately 2.9 km south of Highway 556 at Heyden within the Township of Aweres. 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. A previous foundation investigation report that was obtained from the online Geocres library and reviewed in preparation of this report is as follows:

Soil Site Investigation at Highway 17 and Root River #3 Crossing (W.P. 909-57), Algoma, Ontario for Department of Highways of Ontario, dated 16th July, 1956.

2 SITE DESCRIPTION

The existing culvert is a twin celled open footed concrete culvert; each cell is reported to have a width of 4.9 m, a height of 3.1 m and a length of 26.8 m with obvert elevations of 314.0 m and a streambed at approximately 310.9 m. The culvert has a generally east to west alignment with flow through the culvert to the east.

At the location of the culvert, Highway 17 is a two-lane highway with paved shoulders. The Highway 17 fill height above the culvert is approximately 0.8 m with the centreline of the road surface at approximate elevation 315.4 m. The existing embankment slopes are inclined between 2H:1V and 4H:1V. Steel cable guide rails are present on both sides of the highway in the vicinity of the culvert. The land adjacent to the highway has 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 6,300 AADT (2016).

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

FINAL

3 SITE INVESTIGATION AND FIELD TESTING

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

The site investigation and field testing program was carried out between October 11th and November 25th, 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 top of culvert at the outlet which had a historical elevation of 314.63 m.

Table 3-1: Borehole Summary

Borehole No.	Drilled Location	Northing (m)	Easting (m)	Ground Surface Elevation (m)	Sample Termination Depth (m)
17-01	West side – inlet	5 164 447.2	281 261.5	313.0	11.3
17-02	Southbound Roadway	5 164 442.9	281 283.2	315.6	17.4*
17-03	Northbound Roadway	5 164 418.3	281 304.3	315.2	12.8
17-04	West side – inlet	516 4420.1	281 277.7	312.2	11.3
17-05	East side – outlet	5 164 436.9	281 308.2	313.4	11.3
17-06	East side – outlet	5 164 407.8	281 323.3	312.3	11.3

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

The drilling was carried out using a truck mounted CME 75 drill rig for Boreholes 17-02 and 17-03 and a track mounted CME 550 rig for all remaining off-road Boreholes.

Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT).

A 19 mm diameter standpipe piezometer was installed in Borehole 17-01 to allow for measurements of the groundwater level after completion of drilling. The piezometer installation details are illustrated on the Record of Borehole sheet provided in Appendix B. Rising head hydraulic conductivity testing was carried out in the piezometer prior to its abandonment. 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. Organic content was determined on one sample. Chemical analysis for determination of pH, conductivity, resistivity, soluble sulphate and chloride concentrations was carried out on two soil samples.

The results of the geotechnical tests are summarized on the Record of Borehole sheets included in Appendix B and all laboratory test 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 fill materials overlying gravel and granular sand and silt deposits.

5.2 Fill Material

5.2.1 Asphalt

Boreholes 17-02 and 17-03 were drilled through the existing Highway 17 embankment and encountered a layer of asphalt at ground surface with a thickness of 150 and 100 mm, respectively.

5.2.2 Fill: Sand with Silt and Gravel to Gravel with Silt and Sand

Below the asphalt in Borehole 17-02 was a layer of fill consisting of sand with silt and gravel and in Borehole 17-03 was interlayered fill consisting of sand with silt and gravel and gravel with silt and sand. The underside of the granular fill ranged from 3.0 to 4.0 m below surface (elev. 311.6 to 312.2 m). Occasional to frequent cobbles and occasional boulders were present in the fill layers.

SPT tests conducted within the granular fill gave N-values ranging from 42 to greater than 100 blows, indicating a very dense relative density.

Moisture contents ranged from 1 to 16% in the fill samples. The results of grain size analyses conducted on two samples of the granular fill materials are summarized below and are illustrated on Figure C1 in Appendix C.

Table 5-1: Gradation Results for Granular Fill

Soil Particle	Percentage (%)
Gravel	32 to 39
Sand	50 to 61
Silt and Clay	7 to 11

5.2.3 Fill: Sand

Boreholes 17-05 and 17-06 encountered a layer of fill materials at ground surface consisting of sand with silt, with the layer ranging in thickness from 0.2 to 1.2 m. Gravel and frequent to occasional cobbles and occasional boulders were noted in Borehole 17-05.

SPT tests conducted within the sand fill gave N-values ranging from 7 to 15 blows, indicating a loose to compact relative density.

Moisture contents ranged from 8 to 25% in the sand fill. The results of grain size analyses conducted on one sample of the fill material indicate the material to consist of 39% gravel, 52% sand and 9% silt and clay. The results are illustrated on Figure C1 in Appendix C.

5.3 Peat

Boreholes 17-01 and 17-04 encountered a layer of peat with silt and varying amounts of sand and gravel at ground surface ranging in thickness from 0.1 to 1.5 m. A thin 0.2 m and 75 mm thick peat layer was also encountered below the surficial fill at Boreholes 17-05 and 17-06, respectively, at depths ranging from 0.2 to 1.2 m (elev. 312.1 to 312.2 m) as described in Section 5.2.

SPT tests conducted within the peat gave N-values ranging from 11 to 17 blows, indicating a compact relative density.

Moisture contents ranged from 36 to 85% for the peat. The organic content of one sample of the peat was measured to be 43.5%.

5.4 Organic Silt

The peat in Borehole 17-01 was underlain by an organic silt layer at a depth of 1.5 m (elev. 311.4 m) with a thickness of 0.8 m.

SPT tests conducted within the organic silt gave an N-value of 33 blows, indicating a dense relative density.

Moisture content of the organic silt was measured to be 89%. Atterberg Limit testing was completed on one sample of the organic silt. The laboratory results indicated this material to be non-plastic.

5.5 Gravel

Beneath the organic silt in Borehole 17-01 and the peat in Boreholes 17-04, 17-05 and 17-06 was a deposit of poorly graded to well graded gravel with silt and sand. Frequent to occasional cobbles were encountered throughout this cohesionless deposit. The gravel

deposit extended to depths ranging from 6.1 to 7.6 m below ground surface (elev. 304.6 to 306.9 m).

SPT tests gave N-values ranging from 24 to greater than 100 blows per 300 mm of penetration indicating a compact to very dense relative density. Coring techniques were utilized within this deposit to advance the casing.

Moisture contents ranged from 5 to 18% in the gravel layer. Gradation analysis were completed on four samples of the gravel. 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 C2 of Appendix C. The results of the laboratory tests are summarized as follows:

Table 5-2: Gradation Results for Gravel

Soil Particle	Percentage (%)
Gravel	51 to 76
Sand	21 to 41
Silt and Clay	3 to 9

5.6 Sand to Silty Sand

5.6.1 Sand

A sand deposit with varying amounts of silt and gravel was encountered in Boreholes 17-01, 17-02, 17-03 and 17-05. Borehole 17-01 was terminated within this layer at a final depth of 11.3 m (elev. 301.7 m). Where fully penetrated, the sand deposit ranged in thickness of 3.0 to 7.2 m with an underside elevation ranging from 303.2 to 305.4 m.

SPT tests gave N-values ranging from 11 to greater than 100 blows per 300 mm of penetration indicating a compact to very dense relative density.

The moisture content ranged between 1 to 19%. Gradation analysis was completed on four samples of the sand deposit. 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 C3 of Appendix C. The results of the laboratory test are summarized as follows:

Table 5-3: Gradation Results for Sand

Soil Particle	Percentage (%)
Gravel	25 to 38
Sand	54 to 68
Silt and Clay	5 to 12

5.6.2 Silty Sand (SM)

A silty sand deposit with traces of gravel was encountered within the sand deposit in Borehole 17-01 with a thickness of 1.6 m at a depth of 9.1 m below ground surface (elev. 303.8 m).

SPT tests conducted within the silty sand gave an N-value of 26 blows, indicating a compact relative density.

The recorded moisture content was 19%. The results of grain size analyses conducted on one sample of the silty sand material indicate the material to consist of 9% gravel, 71% sand and 20% silt and clay. The results are illustrated on Figure C4 in Appendix C.

5.7 Silt to Sandy Silt

Boreholes 17-02, 17-03 and 17-05 encountered a deposit of silt to sandy silt beneath the sand deposit and Boreholes 17-04 and 17-06 encountered a sandy silt deposit underlying the gravel deposit. All Boreholes were terminated within this silt to sandy silt deposit, reaching final sampled depths of 11.3 to 17.4 m (elev. 298.2 to 302.4 m). Borehole 17-02 to 17-05, inclusive, were extended below sample termination depth by performing a dynamic cone penetration test (DCPT) to final elevations of 291.3 to 301.5 m.

SPT tests conducted within the silty sand gave N-values ranging from 3 to 30 blows, indicating a very loose to compact relative density.

Moisture contents ranged from 13 to 26%. The results of grain size analyses conducted on five samples of the silt deposit are summarized below and are illustrated on Figure C5 in Appendix C.

Table 5-4: Gradation Results for Silt to Sandy Silt

Soil Particle	Percentage (%)	
Gravel	0 to 5	
Sand	12 to 45	
Silt	60 to 87	50 to 88
Clay		0 to 1

Atterberg limit testing was completed on three samples of the silt to sandy silt. All samples were found to be non-plastic.

5.8 Refusal

Bedrock was not encountered in any of the boreholes. Dynamic cone refusal was observed at a depth of 24.2 m (elevation 291.3 m) in Borehole 17-02. This could indicate bedrock but could also be due to the presence of cobbles or boulders.

5.9 Groundwater

Reliable water levels could not be recorded in the open boreholes due to water being introduced as part of the drilling operations. The water level was measured in the standpipe piezometer installed in Borehole 17-01 and the results are presented in the table below:

Table 5-5: Groundwater Level Observations

Borehole	Groundwater Level		Date of Measurement
	Depth (mbgs)	Elevation (m)	
17-01	0.82	312.2	November 21, 2017
	1.07	311.9	November 26, 2017

The creek water level was also surveyed during the field investigation measured to be at elevation 311.9 m on December 12, 2017.

A rising head test was performed in Borehole 17-01 to determine the composite hydraulic conductivity of the soils in contact with the well filter sand. The results indicated a composite K value of 4.0×10^{-5} m/s and are shown in Appendix C.

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.

5.10 Analytical Testing

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

Table 5-6: Analytical Results Summary

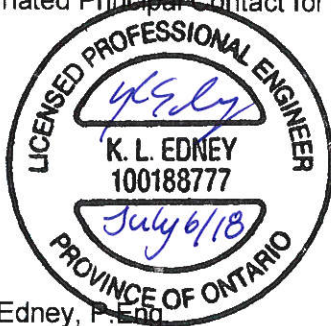
Borehole	Sample	Depth (m)	Sulphate ($\mu\text{g/g}$)	pH	Resistivity (Ohm-cm)	Conductivity ($\mu\text{S/cm}$)	Chloride ($\mu\text{g/g}$)
17 - 4	SS3	1.5 – 2.1	103	7.01	6070	165	29
17 - 6	SS2	0.8 – 1.4	230	6.36	1650	605	234

6 MISCELLANEOUS

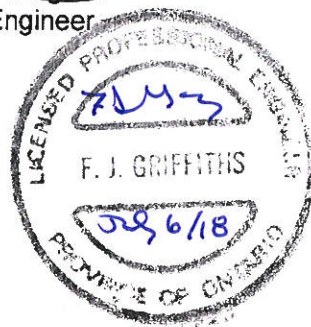
Borehole locations were selected by Thurber relative to existing site features and the anticipated foundation locations. The as-drilled locations and ground surface elevation were measured by Thurber following completion of the field program.

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. Leroy Construction of Blind River, Ontario supplied the traffic control equipment and personnel for TL-20A lane closures required for the on-road boreholes in conformance with Ontario Book 7 requirements. Short duration TL-6 shoulder closures were used for all off-road boreholes; all signs and cones for the shoulder closures were provided by Thurber. The field investigation was supervised on a full-time basis by Ms. Deanna Pizycki, E.I.T. and Mr. Nick Weil 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 testing was 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 Miss Katya Edney, 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.



Katya Edney, 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

FINAL

Appendix A.
Borehole Location Plan and Stratigraphic Drawings

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

CONT No
GWP No 5181-13-00

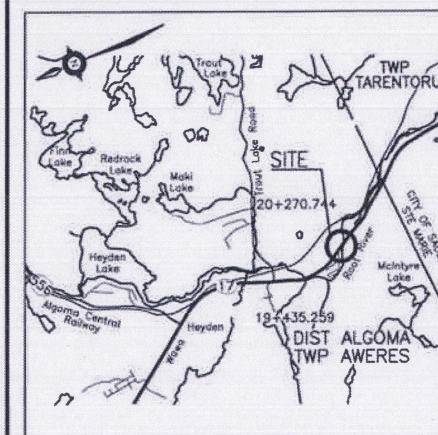


HIGHWAY 17
ROOT RIVER CULVERT #3
REHABILITATION
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET








THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

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

NO	ELEVATION	NORTHING	EASTING
17-01	313.0	5 164 447.2	281 261.5
17-02	315.6	5 164 442.9	281 283.2
17-03	315.2	5 164 418.3	281 304.3
17-04	312.2	5 164 420.1	281 277.7
17-05	313.4	5 164 436.9	281 308.2
17-06	312.3	5 164 407.8	281 323.3

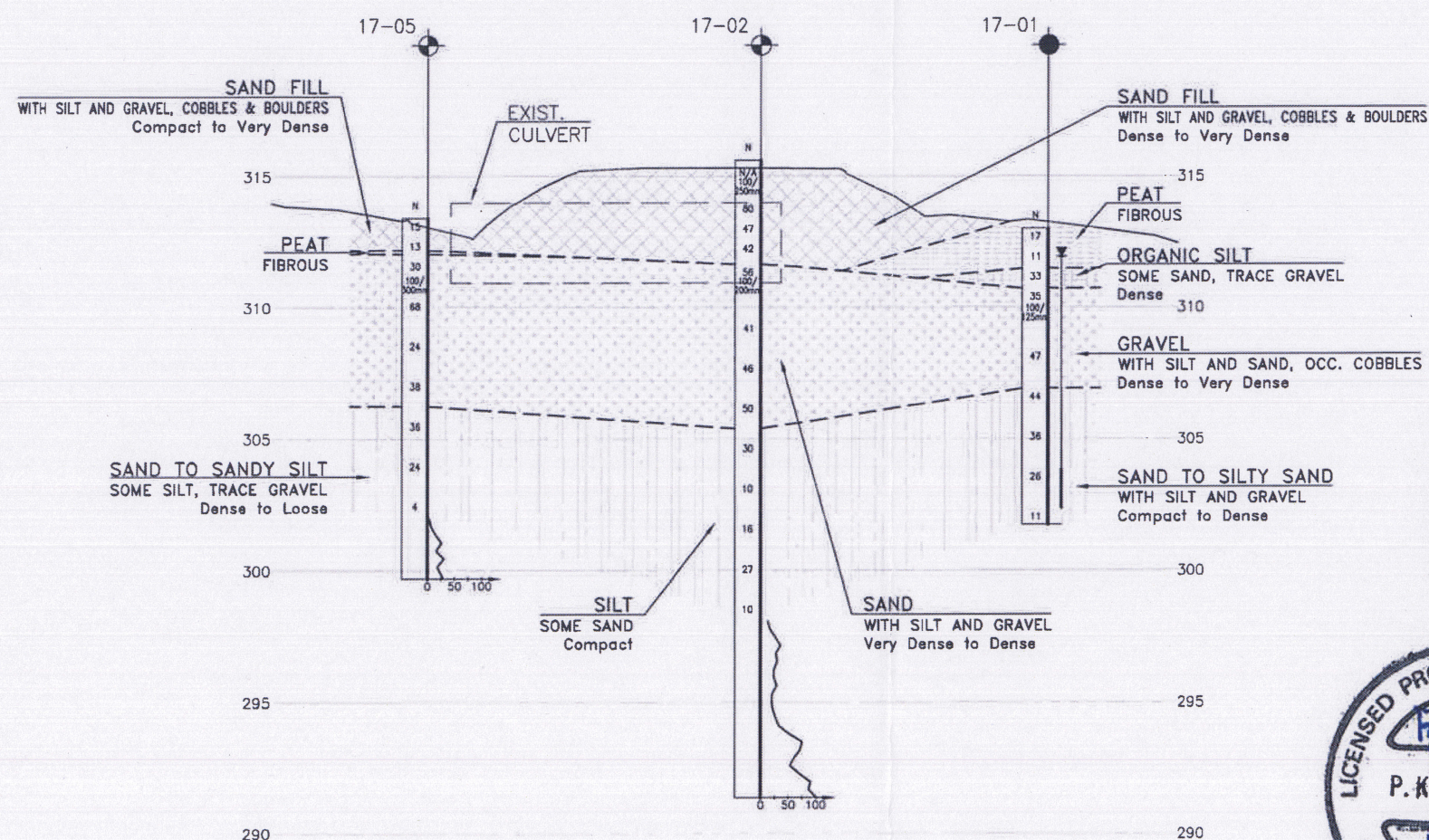
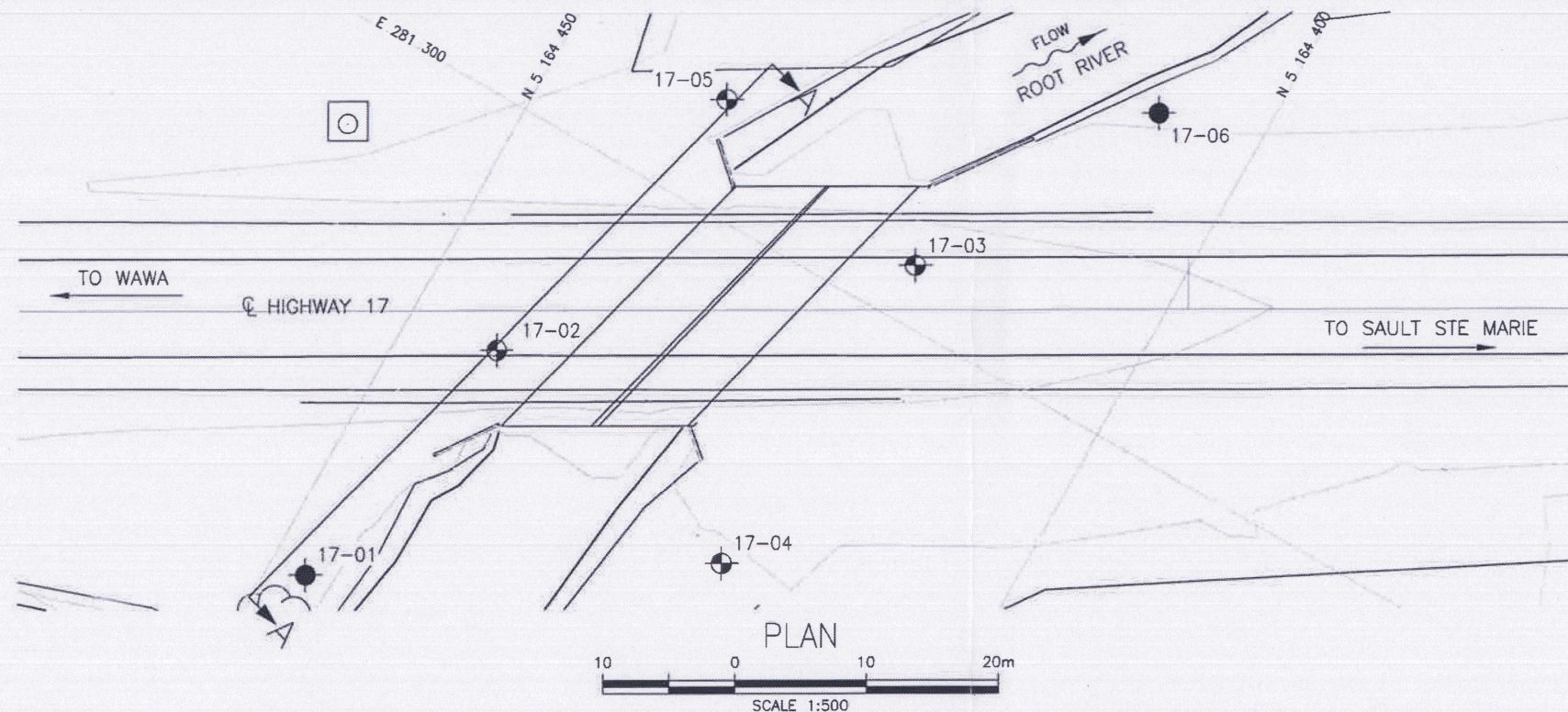
-NOTES-

- 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.

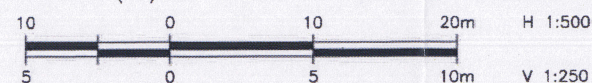
GEOCRES No. 41K-105

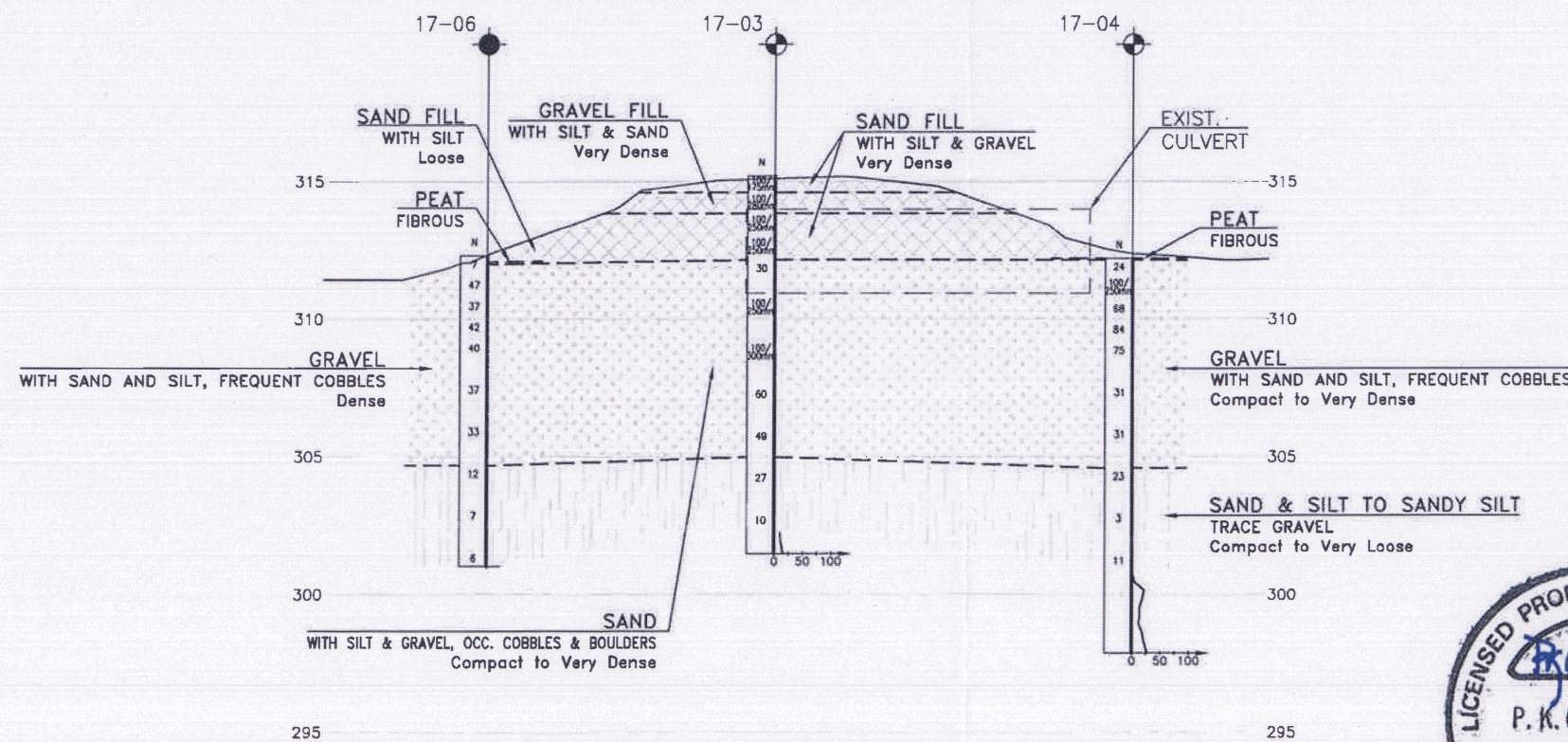
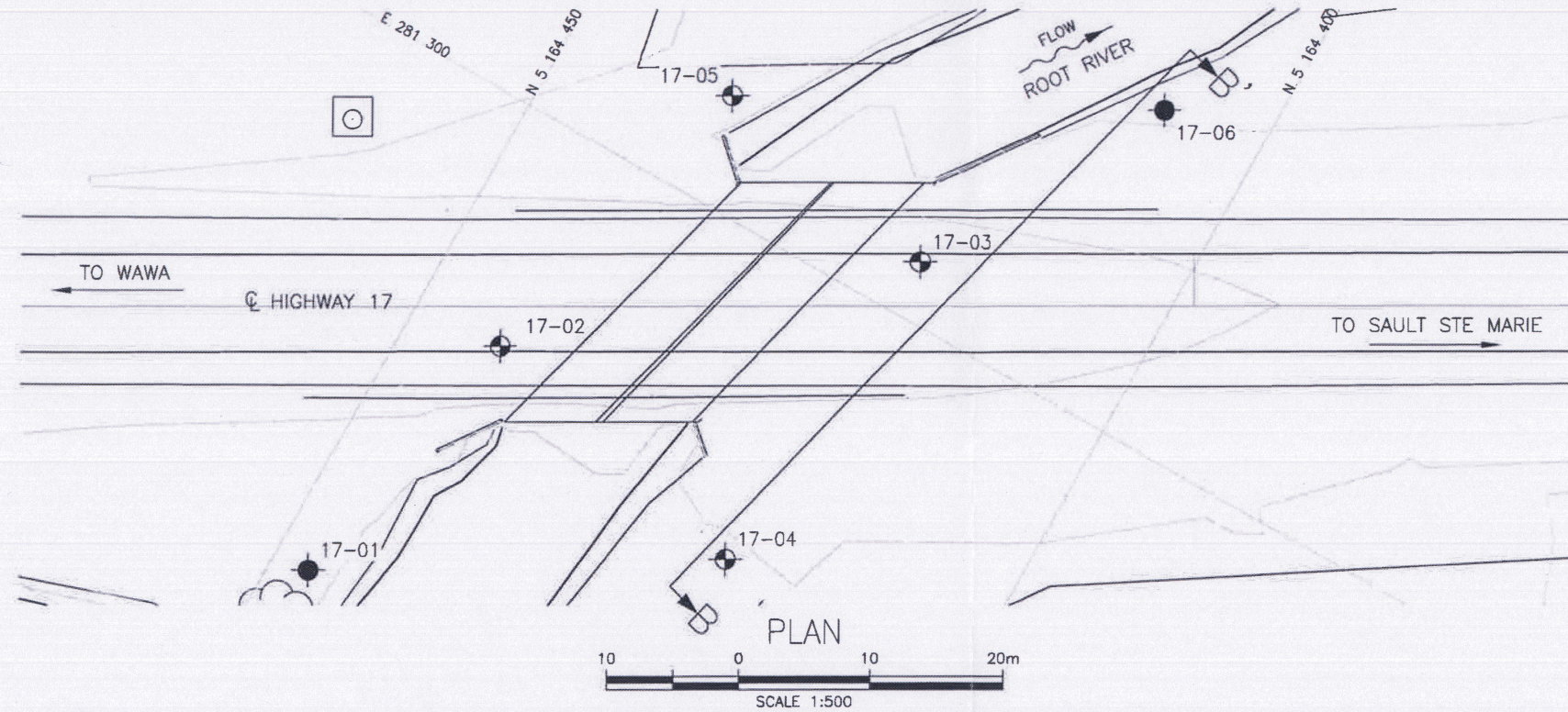
REVISIONS									
	DATE	BY					DESCRIPTION		
DESIGN	CM		CHK		CODE		LOAD	DATE	JUL 2018
DRAWN	AN		CHK	CM	SITE		STRUCT	DWG	1

FILENAME: H:\Drafting\17000\17848\TED-17848-RR #3 Culvert.dwg



SECTION A-A (O/S 7m N. OF \odot CULVERT)





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

CONT No
GWP No 5181-13-00

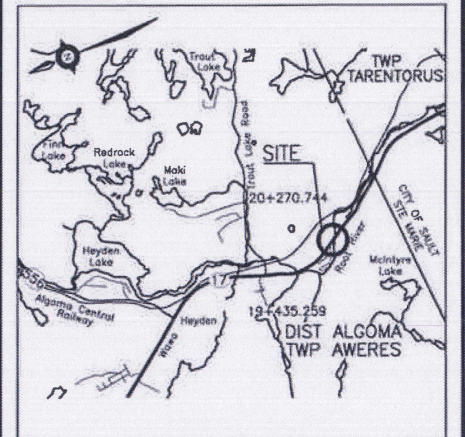
HIGHWAY 17
ROOT RIVER CULVERT #3
REHABILITATION
BOREHOLE LOCATIONS AND SOIL STRATA



SHEET



THURBER ENGINEERING LTD.



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
W	Water Level
HA	Head Artesian Water
P	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
17-01	313.0	5 164 447.2	281 261.5
17-02	315.6	5 164 442.9	281 283.2
17-03	315.2	5 164 418.3	281 304.3
17-04	312.2	5 164 420.1	281 277.7
17-05	313.4	5 164 436.9	281 308.2
17-06	312.3	5 164 407.8	281 323.3

NOTES-

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 41K-105



REVISIONS	DATE	BY	DESCRIPTION
DESIGN CM	CHK	CODE	LOAD
DRAWN AN	CHK CM	SITE	STRUCT
			DWG 2

Appendix B.

Record of Borehole Sheets



SYMBOLS, ABBREVIATIONS AND TERMS USED ON TEST HOLE RECORDS

TERMINOLOGY DESCRIBING COMMON SOIL GENESIS

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

TERMINOLOGY DESCRIBING SOIL STRUCTURE:

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

RECOVERY:

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

N-VALUE:

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

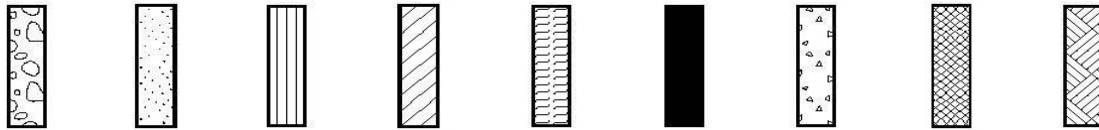
DYNAMIC CONE PENETRATION TEST (DCPT):

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



STRATA PLOT:

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



Boulders
Cobbles
Gravel Sand Silt Clay Organics Asphalt Concrete Fill Bedrock

TEXTURING CLASSIFICATION OF SOILS

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

TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

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

SAMPLE TYPES

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

TERMS DESCRIBING CONSISTENCY (COHESIONLESS SOILS ONLY)

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

MODIFIED UNIFIED SOIL CLASSIFICATION

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

Note - W_L = Liquid Limit



EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION

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

TERMS

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

DISCONTINUITY SPACING

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

STRENGTH CLASSIFICATION

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

RECORD OF BOREHOLE No 17-01

1 OF 2

METRIC

GWP# 5181-13-00 LOCATION Root River Culvert #3, MTM Zone 13: N 5 164 447.2 E 281 261.5 ORIGINATED BY NW
 HWY 17 BOREHOLE TYPE HW Casing / NW Casing COMPILED BY KE
 DATUM Geodetic DATE 2017.11.19 - 2017.11.20 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
313.0							20	40	60	80	100																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												

Continued Next Page

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

ONTMT4S 17848_ROOTRIVER3.GPJ 2012TEMPLATE(MTO).GDT 6/7/18

RECORD OF BOREHOLE No 17-01

2 OF 2

METRIC

GWP# 5181-13-00 LOCATION Root River Culvert #3, MTM Zone 13: N 5 164 447.2 E 281 261.5 ORIGINATED BY NW
 HWY 17 BOREHOLE TYPE HW Casing / NW Casing COMPILED BY KE
 DATUM Geodetic DATE 2017.11.19 - 2017.11.20 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
	Continued From Previous Page																
302.3	SILTY SAND (SM) trace gravel brown compact																
10.7	SAND with silt brown-grey compact		10	SS	11												
301.7																	
11.3	End of Borehole at 11.3 m Water Levels in Well 2017.11.21 0.82 mbgs 2017.11.26 1.07 mbgs																

ONTMT4S 17848_ROOTRIVER3.GPJ 2012TEMPLATE(MTO).GDT 6/7/18

RECORD OF BOREHOLE No 17-02

1 OF 3

METRIC

GWP# 5181-13-00 LOCATION Root River Culvert #3, MTM Zone 13: N 5 164 442.9 E 281 283.2 ORIGINATED BY DJP
 HWY 17 BOREHOLE TYPE HSA / NW Casing COMPILED BY KE
 DATUM Geodetic DATE 2017.10.11 - 2017.10.12 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				W P W W L							
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				WATER CONTENT (%)							
315.6								20	40	60	80	100							
0.0	ASPHALT (150 mm)																		
0.2	FILL SAND with silt and gravel very dense brown - occasional cobbles (75 to 100 mm) below 0.49 m		1	GS	N/A		315							○					32 61 7 (SH+CL)
			1	SS	100/ 250mm									○					
			2	SS	80		314							○					39 50 11 (SH+CL)
	becoming dense below 2.3 m		3	SS	47		313							○					
			4	SS	42		312							○					
311.6	- 150 mm cobble at 3.8 m																		
4.0	SAND (SW-SM) with silt and gravel very dense to dense grey to brown		5	SS	56		311							○					
			6	SS	100/ 200mm									○					
							310												
			7	SS	41		309							○					
			8	SS	46		308							○					38 57 5 (SH+CL)
							307												
			9	SS	50		306							○					

Continued Next Page

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

RECORD OF BOREHOLE No 17-02

2 OF 3

METRIC

GWP# 5181-13-00 LOCATION Root River Culvert #3, MTM Zone 13: N 5 164 442.9 E 281 283.2 ORIGINATED BY DJP
 HWY 17 BOREHOLE TYPE HSA / NW Casing COMPILED BY KE
 DATUM Geodetic DATE 2017.10.11 - 2017.10.12 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
305.4	Continued From Previous Page													
10.2	SILT (ML) some sand compact grey		10	SS	30		305							
							304							
			11	SS	10		303							
							302							
			12	SS	16		301							
							300							
	- 150 mm silt seam at 15.7 m		13	SS	27		299							
							298							
298.2	End of sampled Borehole DCPT carried out from 17.4 to 24.2 m		14	SS	10		297							
17.4							296							

Continued Next Page

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

ONTMT4S 17848_ROOTRIVER3.GPJ 2012TEMPLATE(MTO).GDT 6/7/18

RECORD OF BOREHOLE No 17-02

3 OF 3

METRIC

GWP# 5181-13-00 LOCATION Root River Culvert #3, MTM Zone 13: N 5 164 442.9 E 281 283.2 ORIGINATED BY DJP
 HWY 17 BOREHOLE TYPE HSA / NW Casing COMPILED BY KE
 DATUM Geodetic DATE 2017.10.11 - 2017.10.12 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
	Continued From Previous Page DCPT continued													
291.3														
24.2	End of DCPT on inferred bedrock at 24.2 m													

ONTMT4S 17848_ROOTRIVER3.GPJ 2012TEMPLATE(MTO).GDT 6/7/18

RECORD OF BOREHOLE No 17-03

1 OF 2

METRIC

GWP# 5181-13-00 LOCATION Root River Culvert #3, MTM Zone 13: N 5 164 418.3 E 281 304.3 ORIGINATED BY DJP
 HWY 17 BOREHOLE TYPE NW Casing COMPILED BY KE
 DATUM Geodetic DATE 2017.10.18 - 2017.10.18 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa											
								WATER CONTENT (%)											
315.2							20	40	60	80	100								
0.0	ASPHALT (100 mm)		1	SS	100/														
0.1	FILL SAND with silt and gravel frequent cobbles very dense brown				175mm														
314.6			2	SS	100/														
0.6	FILL GRAVEL with silt and sand frequent cobbles very dense brown				280mm														
313.8			3	SS	100/														
1.4	- 145 mm cobble at 1.0 m				250mm														
	FILL SAND with silt and gravel frequent cobbles very dense brown		4	SS	100/														
					250mm														
312.2			5	SS	30														
3.0	- 100 mm cobble at 2.9 m																		
	SAND (SW-SM) with silt and gravel occasional cobbles and boulders compact to very dense grey 150 mm root at 3.2 m		6	SS	100/														
					250mm														
			7	SS	100/														
					300mm														

Continued Next Page

+ ³ , × ³ : Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

ONTMT4S 17848_ROOTRIVER3.GPJ 2012TEMPLATE(MTO).GDT 6/7/18

RECORD OF BOREHOLE No 17-03

2 OF 2

METRIC

GWP# 5181-13-00 LOCATION Root River Culvert #3, MTM Zone 13: N 5 164 418.3 E 281 304.3 ORIGINATED BY DJP
 HWY 17 BOREHOLE TYPE NW Casing COMPILED BY KE
 DATUM Geodetic DATE 2017.10.18 - 2017.10.18 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE LIQUID CONTENT 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				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				WATER CONTENT (%)				
	Continued From Previous Page						20 40 60 80 100									
305.0																
10.2	SILT (ML) some sand compact brown						305								0 12 88 0 non-plastic	
		10	SS	27		304										
						303										
302.4		11	SS	10												
12.8	End of sampled Borehole DCPT carried out from 12.8 to 13.7 m						302									
301.5	End of DCPT at 13.7 m															
13.7																

ONTMT4S 17848_ROOTRIVER3.GPJ 2012TEMPLATE(MTO).GDT 6/7/18

RECORD OF BOREHOLE No 17-04

1 OF 2

METRIC

GWP# 5181-13-00 LOCATION Root River Culvert #3, MTM Zone 13: N 5 164 420.1 E 281 277.7 ORIGINATED BY NW
 HWY 17 BOREHOLE TYPE HW Casing / NW Casing COMPILED BY KE
 DATUM Geodetic DATE 2017.11.21 - 2017.11.21 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				W P W W L				GR SA SI CL			
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				WATER CONTENT (%)							
312.2							20	40	60	80	100								
0.9	coarse fibrous PEAT		1	SS	24														
	GRAVEL (GP-GM) with silt and sand frequent cobbles compact to very dense brown		2	SS	100/ 250mm														56 37 7 (SH+CL)
310.7																			
1.5	GRAVEL (GW-GM) with silt and sand frequent to occasional cobbles dense grey		3	SS	68														
			4	SS	84														56 35 9 (SH+CL)
			5	SS	75														
			6	SS	31														
	becoming brown below 6.1m	7	SS	31															
304.6																			
7.6	SANDY SILT (ML) compact to very loose grey		8	SS	23														
			9	SS	3														0 38 61 1 non-plastic

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

ONTMT4S 17848_ROOTRIVER3.GPJ 2012TEMPLATE(MTO).GDT 6/7/18

RECORD OF BOREHOLE No 17-04

2 OF 2

METRIC

GWP# 5181-13-00 LOCATION Root River Culvert #3, MTM Zone 13: N 5 164 420.1 E 281 277.7 ORIGINATED BY NW
 HWY 17 BOREHOLE TYPE HW Casing / NW Casing COMPILED BY KE
 DATUM Geodetic DATE 2017.11.21 - 2017.11.21 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	W P	W	W L	WATER CONTENT (%)		
	Continued From Previous Page													
301.0	SANDY SILT (ML) compact to very loose grey		10	SS	11									
11.3	End of sampled Borehole DCPT carried out from 11.3 to 14.3 m													
297.9														
14.3	End of DCPT at 14.3 m													

ONTMT4S 17848_ROOTRIVER3.GPJ 2012TEMPLATE(MTO).GDT 6/7/18

RECORD OF BOREHOLE No 17-05

1 OF 2

METRIC

GWP# 5181-13-00 LOCATION Root River Culvert #3, MTM Zone 13: N 5 164 436.9 E 281 308.2 ORIGINATED BY NW
 HWY 17 BOREHOLE TYPE HW Casing / NW Casing COMPILED BY KE
 DATUM Geodetic DATE 2017.11.17 - 2017.11.18 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
								20 40 60 80 100																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
								20 40 60 80 100																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
313.4																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-05

2 OF 2

METRIC

GWP# 5181-13-00 LOCATION Root River Culvert #3, MTM Zone 13: N 5 164 436.9 E 281 308.2 ORIGINATED BY NW
 HWY 17 BOREHOLE TYPE HW Casing / NW Casing COMPILED BY KE
 DATUM Geodetic DATE 2017.11.17 - 2017.11.18 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE LIQUID CONTENT 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	w p w w L							
							● QUICK TRIAXIAL × LAB VANE									
							20 40 60 80 100				20 40 60					
303.2	Continued From Previous Page															
10.2	SANDY SILT (ML) trace gravel loose brown						303									
			10	SS	4											
302.1																
11.3	End of sampled Borehole DCPT carried out from 11.3 to 13.7 m						302									
							301									
							300									
299.7																
13.7	End of DCPT at 13.7 m															

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

RECORD OF BOREHOLE No 17-06

1 OF 2

METRIC

GWP# 5181-13-00 LOCATION Root River Culvert #3, MTM Zone 13: N 5 164 407.8 E 281 323.3 ORIGINATED BY NW
 HWY 17 BOREHOLE TYPE HW Casing / NW Casing COMPILED BY KE
 DATUM Geodetic DATE 2017.11.25 - 2017.11.25 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									WATER CONTENT (%)
312.3								20	40	60	80	100					
0.0	FILL SAND with silt loose brown fine fibrous PEAT GRAVEL (GW-GM) with sand and silt frequent to occasional cobbles dense brown to grey		1	SS	7		312							○			
312.0															○		
0.2															○		
0.3																	
															○		
			2	SS	47		311										
			3	SS	37		310							○			
			4	SS	42		309							○			
			5	SS	40		308										
			6	SS	37		307							○			
			7	SS	33		306							○			
														</			

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-06

2 OF 2

METRIC

GWP# 5181-13-00 LOCATION Root River Culvert #3, MTM Zone 13: N 5 164 407.8 E 281 323.3 ORIGINATED BY NW
 HWY 17 BOREHOLE TYPE HW Casing / NW Casing COMPILED BY KE
 DATUM Geodetic DATE 2017.11.25 - 2017.11.25 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					W P	W	W L		
	Continued From Previous Page																
301.0	SANDY SILT (ML) compact to loose grey		10	SS	6		302										
11.3	End of Borehole																

ONTMT4S 17848_ROOTRIVER3.GPJ 2012TEMPLATE(MTO).GDT 6/7/18

Appendix C.
Laboratory Testing

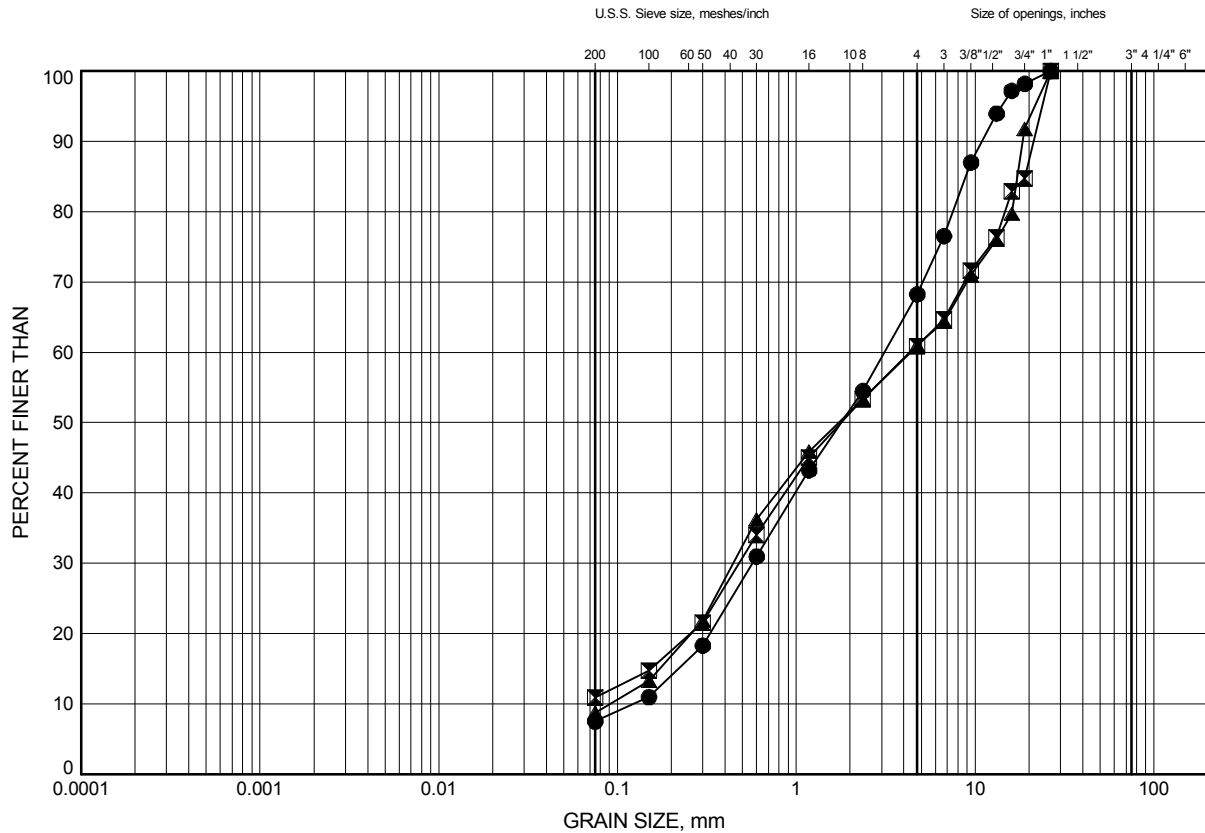
Appendix C.1

Particle Size Analysis Figures

SSM to Goulais River GRAIN SIZE DISTRIBUTION

FIGURE C1

FILL MATERIALS



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-02	0.46	315.11
⊠	17-02	1.83	313.74
▲	17-05	0.30	313.10

Date February 2018

GWP# 5181-13-00

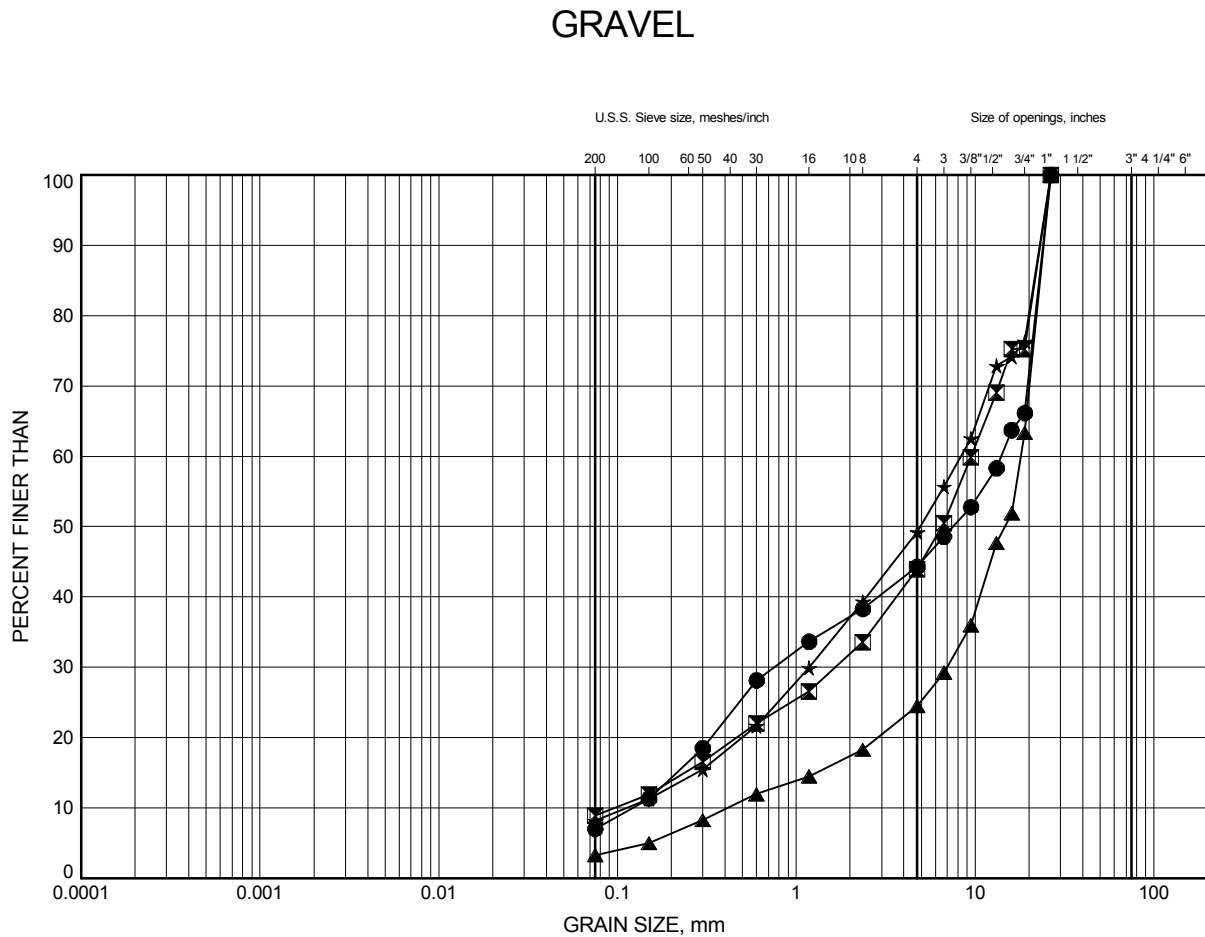


Prep'd KE

Chkd. FG

SSM to Goulais River GRAIN SIZE DISTRIBUTION

FIGURE C2



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-04	0.96	311.28
⊠	17-04	2.59	309.65
▲	17-05	3.35	310.05
★	17-06	2.59	309.71

Date February 2018

GWP# 5181-13-00

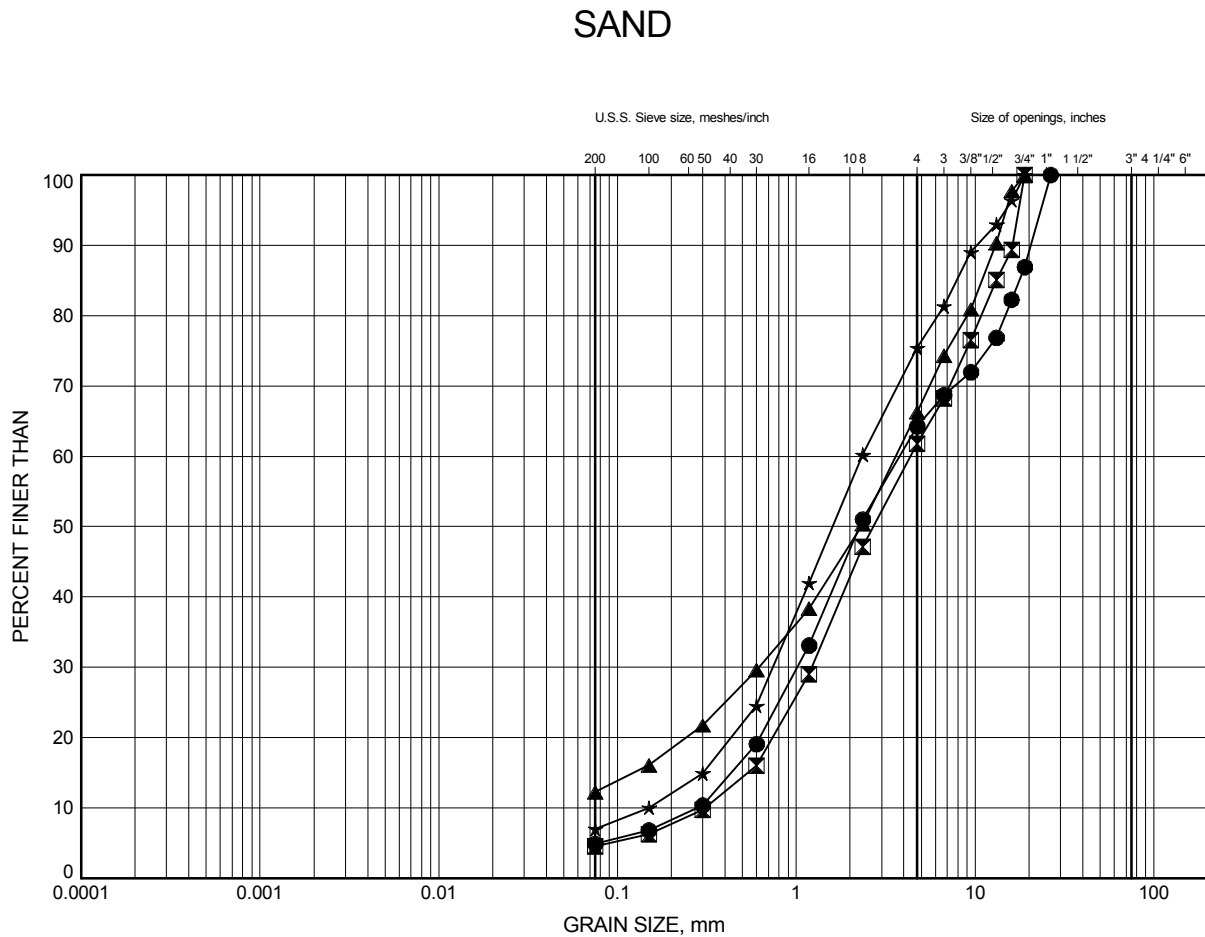


Prep'd KE

Chkd. FG

SSM to Goulais River GRAIN SIZE DISTRIBUTION

FIGURE C3



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-01	6.40	306.57
⊠	17-02	7.92	307.64
▲	17-03	6.32	308.88
★	17-03	9.45	305.75

Date February 2018

GWP# 5181-13-00



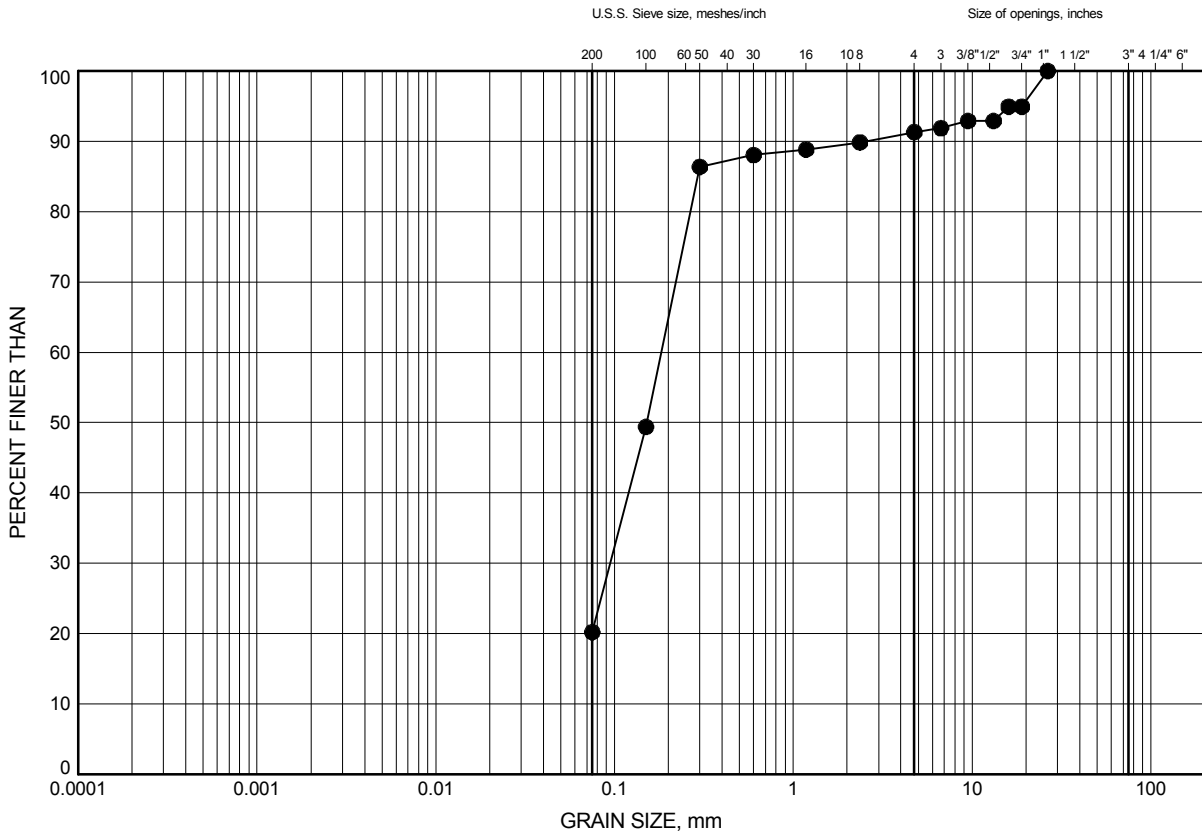
Prep'd KE

Chkd. FG

SSM to Goulais River GRAIN SIZE DISTRIBUTION

FIGURE C4

SILTY SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-01	9.45	303.52

Date February 2018

GWP# 5181-13-00



Prep'd KE

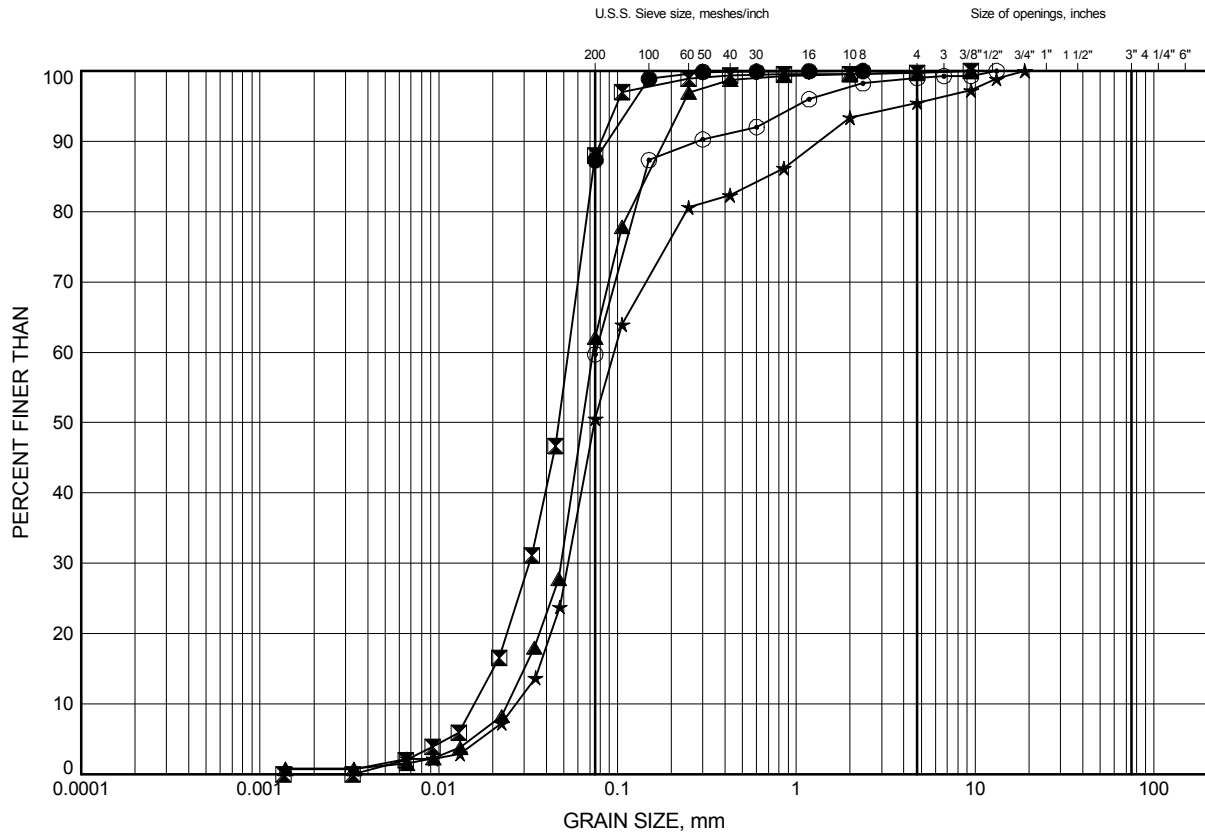
Chkd. FG

SSM to Goulais River

GRAIN SIZE DISTRIBUTION

FIGURE C5

SILT to SANDY SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-02	14.02	301.55
⊠	17-03	12.50	302.70
▲	17-04	9.45	302.79
★	17-05	10.97	302.43
⊙	17-06	7.92	304.38

Date February 2018

GWP# 5181-13-00



Prep'd KE

Chkd. FG

Appendix C.2

Hydraulic Conductivity Analysis

In-Situ Hydraulic Conductivity Test
Hvorslev Analysis
Method based on NAFAC Soil Mechanics Design Manual 7.01

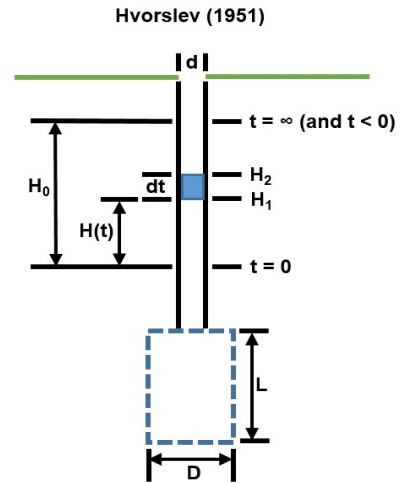
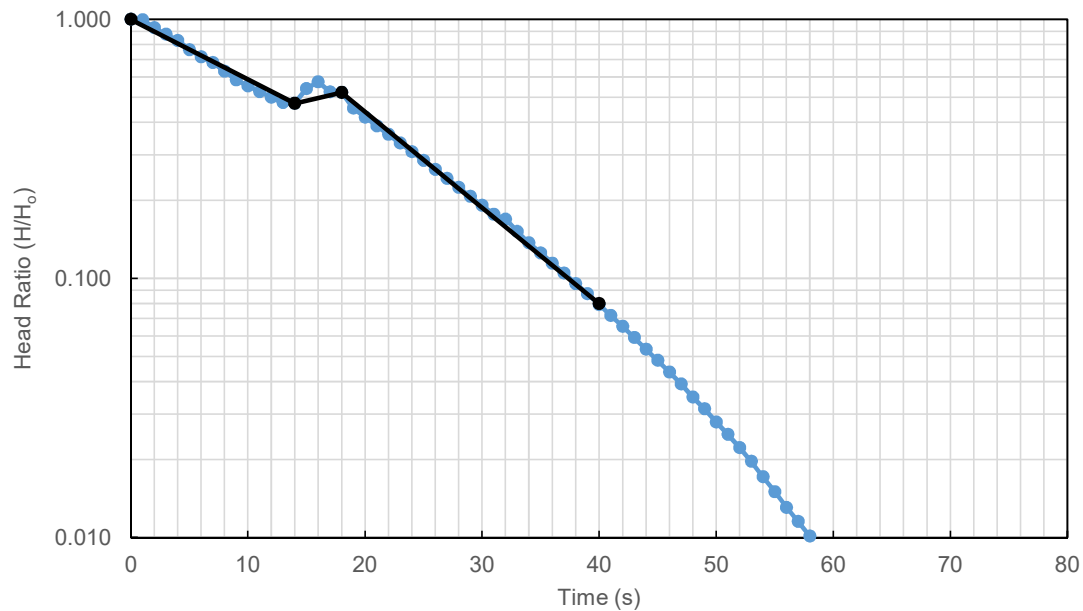
INPUT DATA	Rising Head Test
Borehole 17-01	
Static Water Level	1.1 mbgs
Well Diameter (d)	0.051 m
Borehole Diameter (D)	0.114 m
Length of Intake (L)	2.03 m
Initial Unbalanced Head (H ₀)	4.92 m
Shape Factor (F)	3.57

$$K = \frac{A}{F(t_2 - t_1)} \ln \left(\frac{H_1}{H_2} \right)$$

For piezometers of perforated extension of length "L"

$$F = \frac{2\pi L}{\ln \left(\frac{L}{R} \right)}$$

K = 4.0E-05 m/s



DATE: 12-Feb-18

PREPARED: KE

PROJECT: 17848

CHECKED: FG

Appendix C.3
Analytical Testing Results

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

Mark Foto, M.Sc.
Lab Supervisor

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

Report Date: 29-Jan-2018

Order Date: 23-Jan-2018

Project Description: 17848 SSM to Goulais

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

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

Report Date: 29-Jan-2018

Order Date: 23-Jan-2018

Project Description: 17848 SSM to Goulais

	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]

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

Report Date: 29-Jan-2018

Order Date: 23-Jan-2018

Project Description: 17848 SSM to Goulais

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: 29-Jan-2018

Order Date: 23-Jan-2018

Project Description: 17848 SSM to Goulais

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	

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

Report Date: 29-Jan-2018

Order Date: 23-Jan-2018

Project Description: 17848 SSM to Goulais

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			

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

Report Date: 29-Jan-2018

Order Date: 23-Jan-2018

Project Description: 17848 SSM to Goulais

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

REHABILITATION OF ROOT RIVER CULVERT #3 (SITE 38S-054)
HIGHWAY 17 - 2.9 KM SOUTH OF HIGHWAY 556



**Photo 1. Looking south along Highway 17 at the Root River #3 Culvert crossing
(October 10, 2017)**



**Photo 2. Looking north along Highway 17 at the Root River #3 Culvert crossing
(October 10, 2017)**

REHABILITATION OF ROOT RIVER CULVERT #3 (SITE 38S-054)
HIGHWAY 17 - 2.9 KM SOUTH OF HIGHWAY 556



Photo 3. Looking west (upstream) from Root River #3 Culvert (October 10, 2017)



Photo 4. Looking at Root River #3 Culvert Inlet (October 10, 2017)

REHABILITATION OF ROOT RIVER CULVERT #3 (SITE 38S-054)
HIGHWAY 17 - 2.9 KM SOUTH OF HIGHWAY 556



Photo 5. Looking east (downstream) from Root River #3 Culvert (October 10, 2017)



Photo 6. Looking at Root River #3 Culvert Outlet (October 10, 2017)