



THURBER ENGINEERING LTD.

FINAL

**FOUNDATION INVESTIGATION AND DESIGN 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

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PART 1. FACTUAL INFORMATION

1 INTRODUCTION

This section of the report presents the factual findings obtained from a foundation investigation completed at 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.

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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

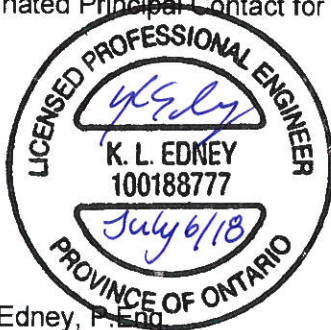
Borehole	Sample	Depth (m)	Sulphate ($\mu\text{g/g}$)	pH	Resistivity (Ohm-cm)	Conductivity ($\mu\text{S/cm}$)	Chloride ($\mu\text{g/g}$)
17 - 4	SS3	1.5 – 2.1	103	7.01	6070	165	29
17 - 6	SS2	0.8 – 1.4	230	6.36	1650	605	234

6 MISCELLANEOUS

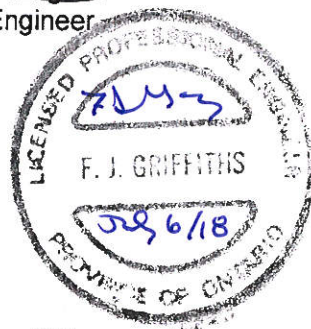
Borehole locations were selected by Thurber relative to existing site features and the anticipated foundation locations. The as-drilled locations and ground surface elevation were measured by Thurber following completion of the field program.

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.



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PART 2. ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 INTRODUCTION

This section of the report provides an interpretation of the factual data from Part 1 of this report and presents geotechnical recommendations to assist the project team in the design of the proposed culvert rehabilitation at the Highway 17 crossing of Root River located approximately 2.9 km south of Highway 556 at Heyden within Aweres Township. The discussion and recommendations presented in this report are based on the information provided by the Ministry of Transportation and on the factual data obtained during the course of the investigation.

This foundation investigation and design report with the interpretation and recommendations are intended for the use of the Ministry of Transportation, and shall not be used or relied upon for any other purposes or by any other parties including the construction or design-build contractor. The construction or design-build contractor must make their own interpretation based on the factual data in Part 1 of the report. Where comments are made on construction, they are provided only in order to highlight those aspects which could affect the design of the project. Contractors must make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods and scheduling.

In general terms, the site was found to be underlain by a pavement structure and granular fill overlying gravel, sand and non-cohesive silt deposits. The water level of Root River was recorded during the off-road portion of the field work at an elevation 311.9 m on December 12, 2017.

7.1 Proposed Structure

At the time of preparation of the draft Foundation Investigation and Design Report, the proposed rehabilitation of the culvert is expected to include the removal and patching of deteriorated areas of concrete in the walls of the existing culvert as well as waterproofing the top slab. The proposed rehabilitation measures are not expected to increase the load on the foundation soils.

8 EMBANKMENT REINSTATEMENT

8.1 Frost Depth

The depth of frost penetration at this site is estimated to be 2.0 m as per OPSD 3090.100. For any new permanent foundation element, a minimum 2.0 m of earth cover or thermal equivalent should be provided.

8.2 Backfilling and Lateral Earth Pressures

It is recommended that where culvert cover has been removed as part of the rehabilitation work, that it be reinstated in accordance with OPSS 902 and the backfill should consist of free-draining, non-frost susceptible granular materials such as Granular A or Granular B Type II material meeting the requirements of OPSS.PROV 1010.

Given the limited cover on the culvert, it is anticipated that the material above the structural cover will be part of the pavement. Please refer to the Pavement Design Report for comments on pavement reinstatement and frost tapers. Heavy compaction equipment, used adjacent to the culvert, must be restricted in accordance with OPSS.PROV 501. Care must be exercised when compacting the fill adjacent to and above the culvert in order not to damage the rehabilitated culvert.

Lateral earth pressures parameters provided in Table 8-1 and in the sections below are based on the assumption that the backfill is fully drained so that there are no unbalanced hydrostatic pressures. If adequate drainage cannot be confirmed, the potential for buildup of hydrostatic pressures should be considered in design.

Lateral earth pressures acting on structures should be computed in accordance with the CHBDC but generally are given by the following expression:

$$p_h = K * (\gamma h + q)$$

where:

p_h	=	horizontal pressure on the wall at depth h (kPa)
K	=	earth pressure coefficient (see table below)
γ	=	unit weight of retained soil (use submerged unit weight for soil below groundwater level)
h	=	depth below top of fill where pressure is computed (m)
q	=	value of any surcharge (kPa)

A lateral earth pressure due to backfill compaction should be added to the calculated lateral earth pressure in accordance with Clause 6.12.3 of the CHBDC. Typical earth pressure coefficients for backfill are shown in Table 8-1.

Table 8-1. Earth Pressure Coefficients

Condition	Earth Pressure Coefficient (K)					
	OPSS Granular A or OPSS Granular B Type II $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$		OPSS Granular B Type I $\phi = 32^\circ, \gamma = 21.2 \text{ kN/m}^3$		OPSS SSM and Existing Fill $\phi = 30^\circ, \gamma = 20.0 \text{ kN/m}^3$	
	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)
Active, K_A (Yielding Wall)	0.27	0.39	0.31	0.47	0.33	0.54
At Rest, K_O (Non-Yielding Wall)	0.43	-	0.47	-	0.50	-
Passive, K_P (Movement towards Soil Mass)	3.7	-	3.3	-	3.0	-
Soil Group ^(*)	"medium dense sand"		"loose to medium dense sand"		"loose sand"	

Note: (*) Figure C6.16 of the Commentary to the CHBDC.

The use of a material with a high friction angle and low active earth pressure coefficient (Granular A or Granular B Type II) is preferred as it results in lower earth pressures acting on the culvert.

The parameters in the table above correspond to full mobilization of active and passive earth pressures and require certain relative movements between the wall and adjacent soil to produce these conditions. The values to be used in design can be assessed from Figure C6.16 of the Commentary to the CHBDC using the soil group designation as outlined in Table 8-1. Active pressures should be used for unrestrained walls. For rigid structures, it is recommended that at-rest horizontal earth pressures be used for design. Where ground surfaces are not horizontal or sloped at 2H:1V behind the walls, the coefficients provided in Table 8-1 should not be used.

8.3 Embankment Design and Reinstatement

8.3.1 Embankment Reconstruction

Embankment reconstruction after culvert rehabilitation should be carried out in accordance with OPSS.PROV 206. The embankment should be reinstated with side slopes of 2H:1V (or flatter) if constructed using Select Subgrade Material (SSM) or Granular B Type I or II. The fill should be placed and compacted in accordance with OPSS.PROV 501.

Where new embankment fill is placed against existing embankment slopes or on a sloping ground surface steeper than 3H:1V, benching of the existing slope should be carried out in accordance with OPSD 208.010.

8.3.2 Embankment Settlement and Stability

The condition of the existing embankment slopes was examined in the field during the field investigation and no evidence of instability (tension cracks etc.) was noted at that time.

It is understood that the existing embankment geometry will not change following rehabilitation and therefore no grade raise or embankment widening is proposed. Provided proper construction methods are used, no long term or global stability issues are anticipated for embankments reinstated at this site. Material stockpiling above the existing grades is a temporary construction measure and the stability implications are the responsibility of the Contractor. The selection and placement of construction equipment (such as cranes) are also the Contractor's responsibility.

As no grade raise is anticipated along the alignment of Highway 17, settlement of the soils underlying the embankment is not expected to occur.

The magnitude of the embankment compression constructed with granular materials is in the order of 0.5% of the embankment height and is expected to occur during and following fill placement.

It should be noted that peat and organic soils were noted in Boreholes 17-01, 17-05 and 17-06. If any embankment widening is required as part of the rehabilitation works, the peat and organic soils must be removed from the area of the widening.

8.4 Cement Type and Corrosion Potential

Analytical tests were completed to determine the potential for degradation of the concrete in the presence of soluble sulphates and the potential for corrosion of exposed steel. The concentration of soluble sulphate provides an indication of the degree of sulphate attack that is expected for concrete in contact with soil and groundwater at the site. Soluble sulphate concentrations less than 1000 µg/g generally indicate that a low degree of sulphate attack is expected for concrete in contact with soil and groundwater. The class of concrete selected should consider the effects of road de-icing salts.

The pH, resistivity and chloride concentration provide an indication of the degree of corrosiveness of the sub-surface environment. The tests results provided in Section 5.10 may be used to aid in the selection of coatings and corrosion protection systems for buried steel objects. The corrosive effects of road de-icing salts should also be considered.

9 CONSTRUCTION CONSIDERATIONS

9.1 Excavation

All excavation must be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of OHSA, the fills above the water table may be classified as Type 2 soil, however all non-cohesive soils below the water table may be classified as Type 4 soil.

If excavation is required above the base of the culvert footings then the excavation should be carried out in stages no more than 1 m in length at a time. Excavations should at no point extend below the depth of footing and must be carried out in a manner that avoids

undermining or destabilizing the foundations of the existing culvert and any other adjacent structures and utilities, if any.

Excavation for the culvert rehabilitation must be carried out in accordance with OPSS 902 and will be carried out through the existing embankment fill.

At locations where there are space restrictions or where a slope has to be retained, the excavations will need to be carried out within a protection system. Further discussion is presented in Section 9.2.

9.2 Temporary Protection Systems

It is understood that the staging for the proposed structural rehabilitation work requires maintaining traffic on a single lane on Highway 17. It is also understood that excavations for the proposed top slab rehabilitation work will be limited to shallow depth (<1m) below the road surface.

Depending on highway geometry, if the single lane traffic during construction can be accommodated on the shoulder and lane, a temporary roadway protection system consisting of an adequate temporary side slope and jersey barrier walls is a possible option.

If highway geometry is insufficient to allow for the abovementioned option then a drilled in soldier pile and lagging system is a possible alternative. Installation of sheet piles is anticipated to be difficult due to the occasional frequent cobbles and occasional boulders observed in the fill and native soils at this site.

If required during construction, Temporary Protection Systems must be implemented in accordance with OPSS.PROV 539 and designed for Performance Level 2 (maximum 25 mm horizontal deflection). The actual pressure distribution acting on the shoring system is a function of the construction sequence and the relative flexibility of the wall and these factors must be considered when designing the shoring system. The protection system should be installed at a suitable distance away from the existing culvert to limit the disturbance to subgrade associated with removal of the protection system following completing of construction. Alternatively, the protection system near the culvert could be left in place and cut off as per OPSS. PROV. 539.

Lateral earth pressure coefficients, under fully mobilized conditions, that can be used in design of the protection system installed through embankment fill and culvert backfill are provided in Table 8-1. The lateral earth pressure coefficients for the underlying sand, silt and gravel deposits are given below:

Native Sand / Silt

γ	=	19 kN/m ³	(reduced to submerged unit weight below water table)
K_A	=	0.33	
K_P	=	3.0	

Native Gravel

$$\begin{aligned}\gamma &= 21 \text{ kN/m}^3 && \text{(reduced to submerged unit weight below water table)} \\ K_A &= 0.29 \\ K_P &= 3.4\end{aligned}$$

Temporary protection systems are the responsibility of the Contractor. The actual lateral pressure distribution acting on the protection system is a function of the construction sequence, dewatering and traffic loading, and these factors should be taken into consideration when designing the protection system. All protection systems should be designed by a Professional Engineer experienced in such designs, who will determine an appropriate support system. Lateral support may require enhancement with soil anchors, deadman anchors and/or rakers.

9.3 Surface and Groundwater Control

The groundwater level will fluctuate and the minimum groundwater elevation for the site at the time of the proposed culvert replacement should be taken as the design high water level in the creek at the time of construction.

It is understood that the rehabilitation work includes removal and patching of deteriorated areas of concrete in the walls of the existing culvert. If the culvert rehabilitation work is carried out above the normal creek level and if the work is carried out during low flow season, temporary diversion of creek flow may be sufficient to carry out the rehabilitation work in the dry. If rehabilitation work extends below the creek level, the Contractor must be prepared to control the groundwater and surface water flow at this site to permit construction in a dry and stable environment.

The design of dewatering systems is the responsibility of the Contractor. The Contract Documents must alert the Contractor to this responsibility and to design the system in accordance with SP No. FOUN0003 which amends OPSS 902. A preconstruction survey is recommended, thus Designer Fill-In ** in the SP should be "250m".

In accordance with SP FOUN0003, the dewatering system is to be designed in accordance with OPSS.PROV 517 and SP517F01.

The Dewatering Systems Designer Fill-in information for SP No. 517F01 are as follows:

- * 46.619110°, -84.306919°
- ** Root River Culvert #3 Crossing of Highway 17 (Site 38S-054)
- ***** Yes
- ***** Within a 250 m radius around the culvert site

Construction of cofferdams consisting of sand bags may be required to isolate the area of the work from surface water. Stream flow may be diverted through a diversion pipe. The groundwater level within the work zone should be lowered by pumping to below the underside of the culvert invert for the proposed rehabilitation work. As noted in Section 9.2, installation of sheet piles at this site will be difficult. Further assessment of dewatering requirements and the need for a PTTW should be carried out by specialists experienced in this field.

9.4 Scour Protection and Erosion Control

During rehabilitation, the entire length of the culvert and wingwalls should be inspected to assess whether erosion has caused the footings to become exposed. If any exposed footings are found, any gap or void between the footing base and founding soil should be filled with flowable concrete to re-establish the founding stratum and avoid stress concentration in the footings. Temporary formwork could be erected in front of the footings and flowable concrete could be pumped in as a possible method of filling the voids or gaps beneath the footings. Scour and erosion protection measures should be implemented as recommended in the following paragraphs following the footing repairs and backfilling if necessary.

Based on the subsurface conditions encountered at the drilled locations through the embankment at this site, the embankment materials soils are considered to have low susceptibility to erosion as per the Wischmeier Nomograph. The native soils at the inlet and outlet are also considered to have low susceptibility to erosion.

Scour and erosion protection should be provided for the culvert inlet and outlet areas. Design of the scour and erosion protection measures must consider hydrologic and hydraulic concerns and should be carried out by specialists experienced in this field.

Typically, rock protection should be provided over all earth surfaces subjected to flowing water. Treatment at the outlet should be in accordance with OPSD 810.010. A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion in general accordance with OPSS.PROV 804.

10 CONSTRUCTION CONCERNS

Potential construction concerns include, but are not necessarily limited to:

- Buried obstructions may be encountered during excavation in the embankment fill or interfere with driving of protection systems. Cobbles and boulders were observed across the site throughout the depth of investigation. An NSSP should be included in the contract alerting the Contractor to these conditions. Suggested wording for an NSSP is provided in Appendix E.
- River and groundwater levels may fluctuate. Rehabilitation will involve isolating the work zone from the river and lowering the groundwater level below the invert to maintain a reasonably dry excavation and stable side slopes.
- The Contractor's selection of construction equipment and methodology must include assessment of the capability of the existing embankment to support the proposed construction equipment and any temporary structure fill.

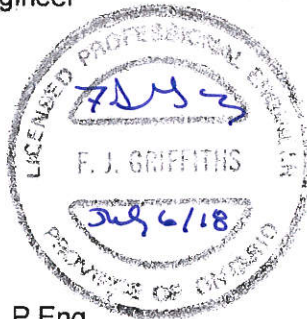
The successful performance of the rehabilitated culvert will depend largely upon good workmanship and quality control during construction.

11 CLOSURE

Engineering analysis 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



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Senior Associate
Senior Geotechnical Engineer



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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

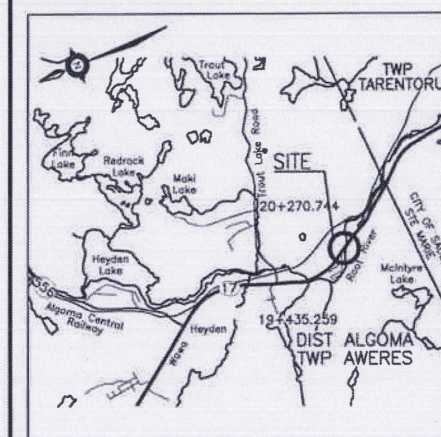


HIGHWAY 17
ROOT RIVER CULVERT #3
REHABILITATION
BOREHOLE LOCATIONS AND SOIL STRATA

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

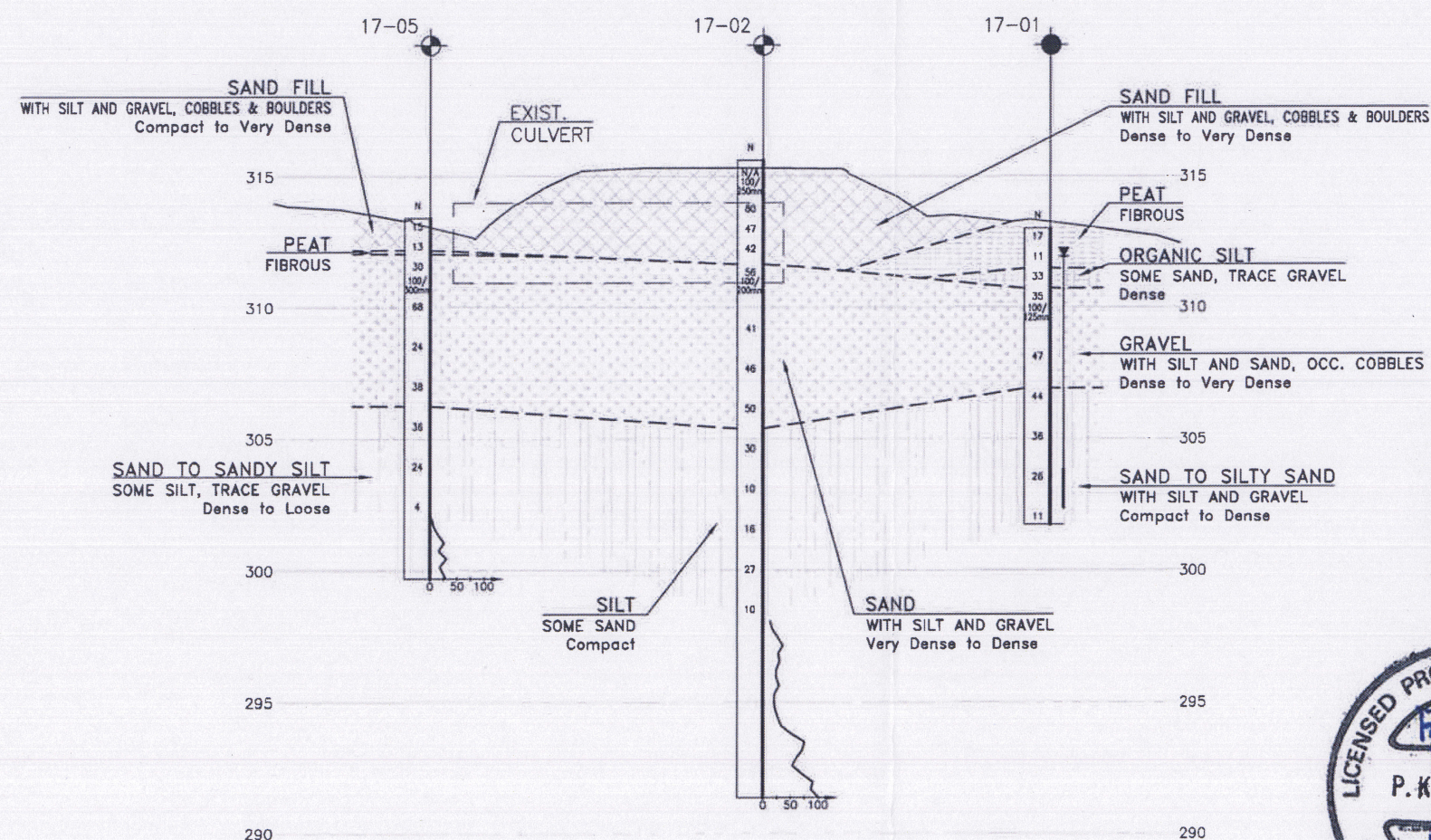
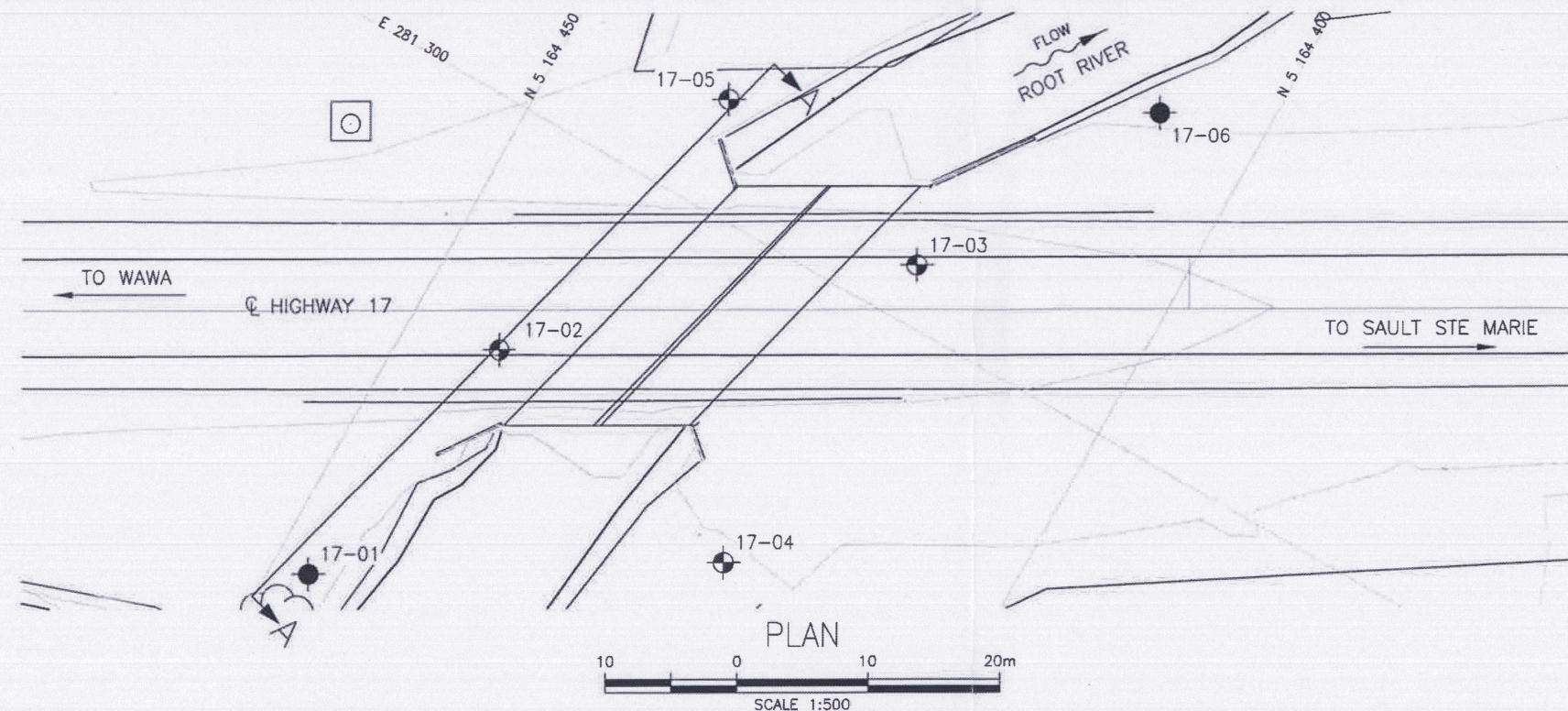
-NOTES-

- 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.

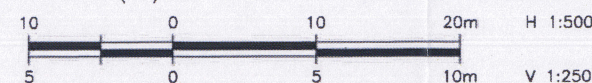
GEOCRES No. 41K-105

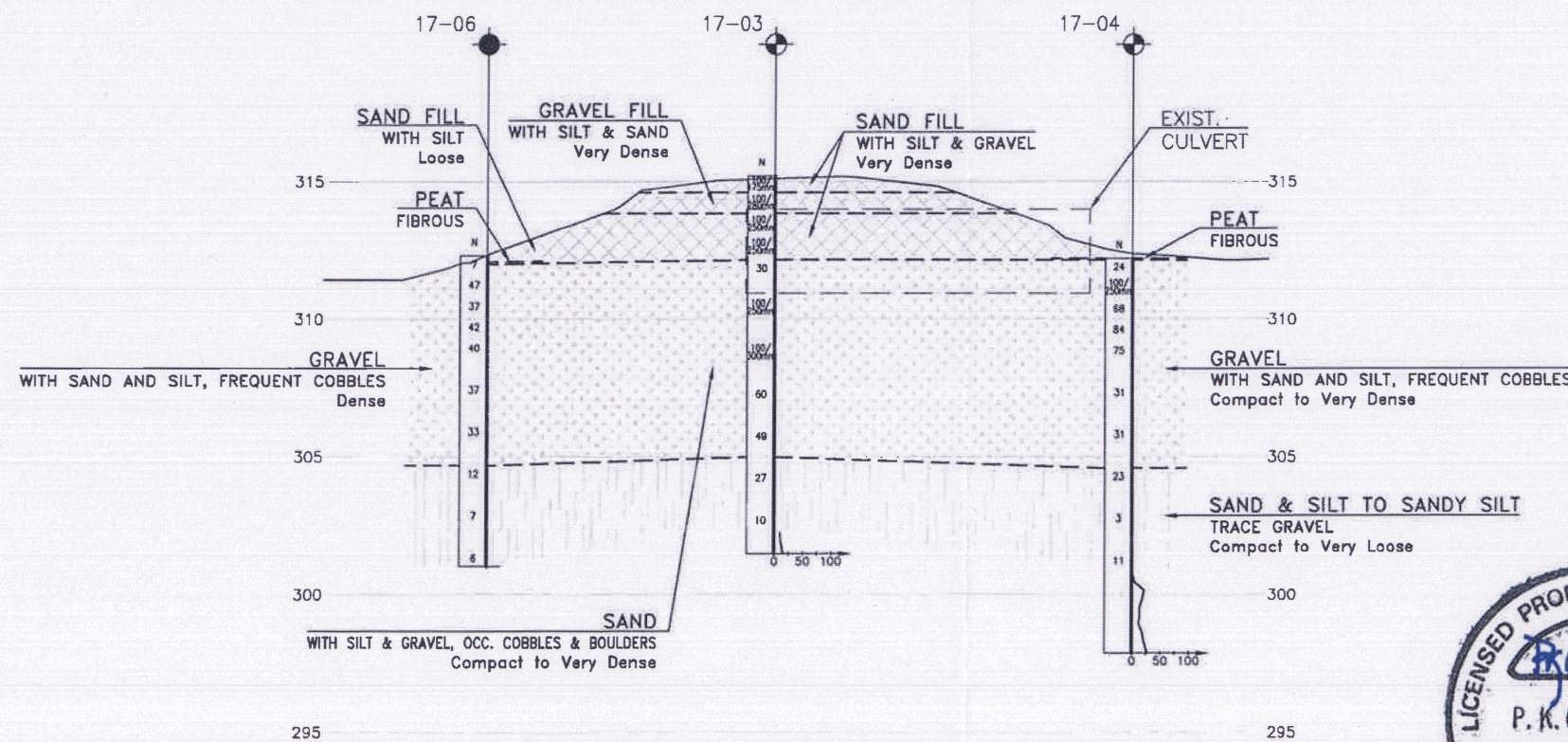
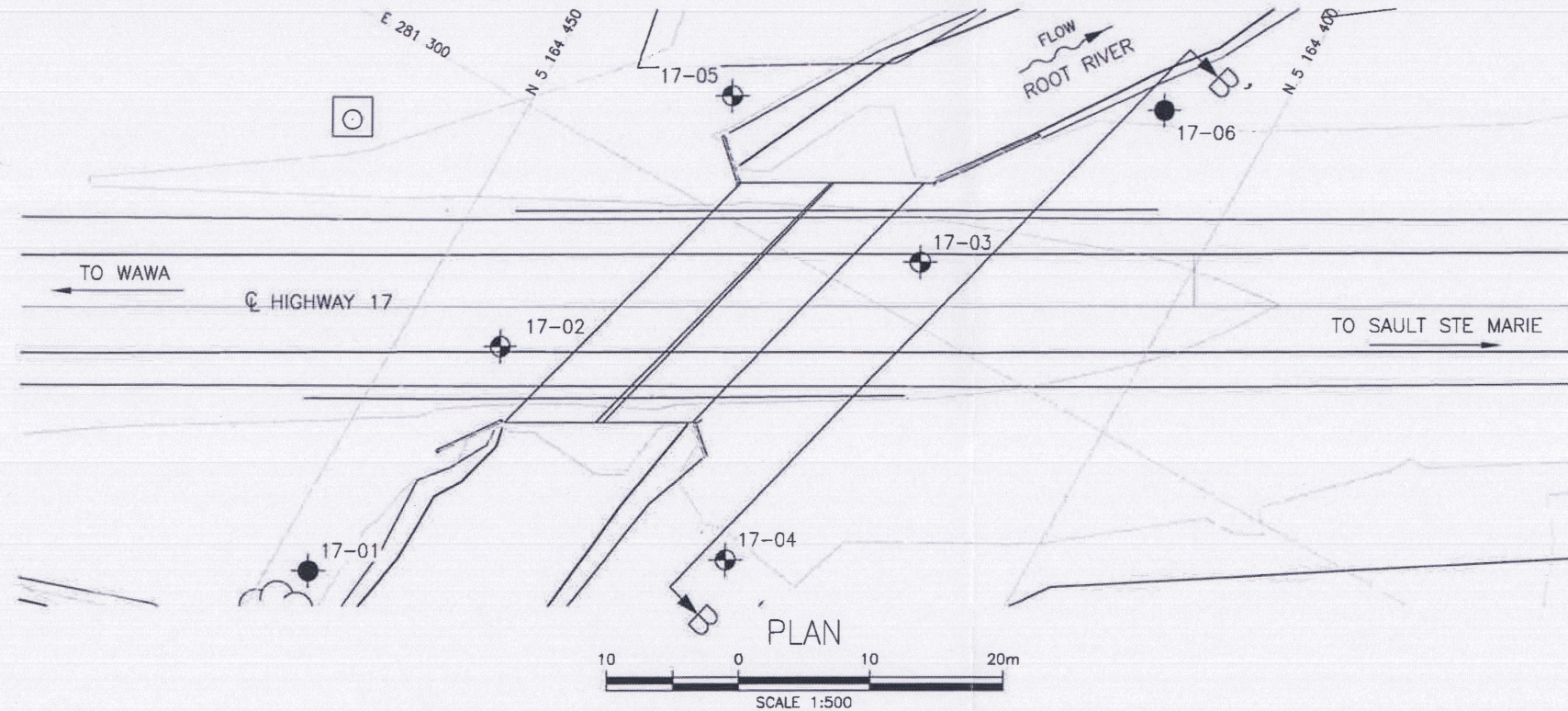
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SECTION A-A (O/S 7m N. OF \odot CULVERT)





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

CONT No
GWP No 5181-13-00

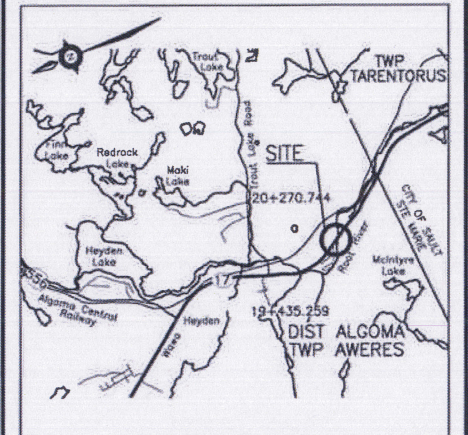
HIGHWAY 17
ROOT RIVER CULVERT #3
REHABILITATION
BOREHOLE LOCATIONS AND SOIL STRATA



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-

- 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
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).

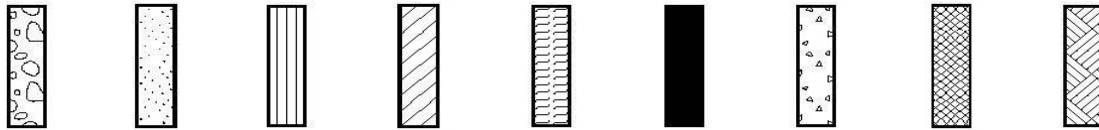
DYNAMIC CONE PENETRATION TEST (DCPT):

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								20 40 60 80 100						
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						
							WATER CONTENT (%)							
							PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W _P W W _L							
313.0														
0.0	fine to coarse fibrous PEAT with silt some sand, some gravel, occasional cobbles brown compact		1	SS	17							85	organic content 43.5%	
			2	SS	11		312							
311.4														
1.5	Organic SILT some sand, trace gravel grey dense		3	SS	33		311					86	non-plastic	
310.7														
2.3	GRAVEL with silt and sand, occasional cobbles grey dense to very dense		4	SS	35		310							
			5	SS	100/ 125mm									
							309							
			6	SS	47		308							
306.9							307							
6.1	SAND (SP) with gravel trace silt brown dense		7	SS	44		306						36 59 5 (SI+CL)	
			8	SS	36		305							
303.8							304							
9.1	SILTY SAND (SM) trace gravel brown compact		9	SS	26		303						9 71 20 (SI+CL)	

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									
	Continued From Previous Page																
302.3	SILTY SAND (SM) trace gravel brown compact																
10.7	SAND with silt brown-grey compact		10	SS	11		302										
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																

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

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				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 becoming dense below 2.3 m		1	GS	N/A		315												32 61 7 (SH+CL)
			1	SS	100/ 250mm														
			2	SS	80		314												39 50 11 (SH+CL)
			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												
							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							20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	20 40 60					
291.3							295							
							294							
							293							
							292							
24.2	End of DCPT on inferred bedrock at 24.2 m													

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

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 (%) 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 (%)							
							PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT							
							W P W W L							
							20 40 60 80 100							
							20 40 60 80 100							
							20 40 60							
315.2														
0.0														
0.1	ASPHALT (100 mm)		1	SS	100/		315							
	FILL SAND with silt and gravel frequent cobbles very dense brown				175mm									
314.6														
0.6			2	SS	100/		314							
	FILL GRAVEL with silt and sand frequent cobbles very dense brown				280mm									
313.8														
1.4			3	SS	100/		313							
	- 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														
3.0			5	SS	30		312							
	- 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/		311							
					250mm									
			7	SS	100/		309							
					300mm									
							308							
307.6														
7.6			8	SS	60		307							
	SAND (SP-SM) with silt and gravel very dense to dense brown													
			9	SS	49		306							

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						20 40 60			
305.0							305									
10.2	SILT (ML) some sand compact brown															
		10	SS	27			304									
		11	SS	10			303									
302.4																
12.8	End of sampled Borehole DCPT carried out from 12.8 to 13.7 m						302								0 12 88 0 non-plastic	
301.5																
13.7	End of DCPT at 13.7 m															

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				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 (%)					
312.2													
0.9	coarse fibrous PEAT												
	GRAVEL (GP-GM) with silt and sand frequent cobbles compact to very dense brown		1	SS	24		312						
			2	SS	100/ 250mm		311						56 37 7 (SI+CL)
310.7													
1.5	GRAVEL (GW-GM) with silt and sand frequent to occasional cobbles dense grey		3	SS	68		310						
			4	SS	84		309						56 35 9 (SI+CL)
			5	SS	75		308						
			6	SS	31		307						
			7	SS	31		306						
	becoming brown below 6.1m						305						
304.6							304						
7.6	SANDY SILT (ML) compact to very loose grey		8	SS	23		303						0 38 61 1 non-plastic
			9	SS	3								

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

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(%) 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			
	Continued From Previous Page						20 40 60 80 100	○ UNCONFINED + FIELD VANE	20 40 60				
							● QUICK TRIAXIAL × LAB VANE						
							20 40 60 80 100		WATER CONTENT (%)				
									20 40 60				



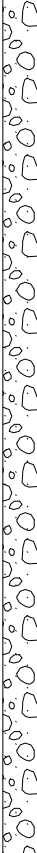

ONTMT4S 17848_ROOTRIVER3.GPJ 2012TEMPLATE(MTO).GDT 6/7/18

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									
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
							WATER CONTENT (%)										
							PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT w _p w w _L										
313.4																	
0.0	FILL SAND with silt and gravel frequent cobbles, occasional boulders compact brown		1	SS	15										39 52 9 (SI+CL)		
312.2			2	SS	13												
312.8	fine fibrous PEAT																
1.4	GRAVEL with silt and sand frequent cobbles dense to very dense brown-grey		3	SS	30												
					4	SS	100/ 300mm										
					5	SS	68										76 21 3 (SI+CL)
			6	SS	24												
			7	SS	38												
306.2																	
7.2	SAND some silt, trace gravel dense brown																
					8	SS	36										
			9	SS	24												

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

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(%) 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 (%)				
	Continued From Previous Page							20 40 60 80 100							
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE							
303.2															
10.2	SANDY SILT (ML) trace gravel loose brown						303								
			10	SS	4									5 45 50 0 non-plastic	
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														

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

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					WATER CONTENT (%) 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

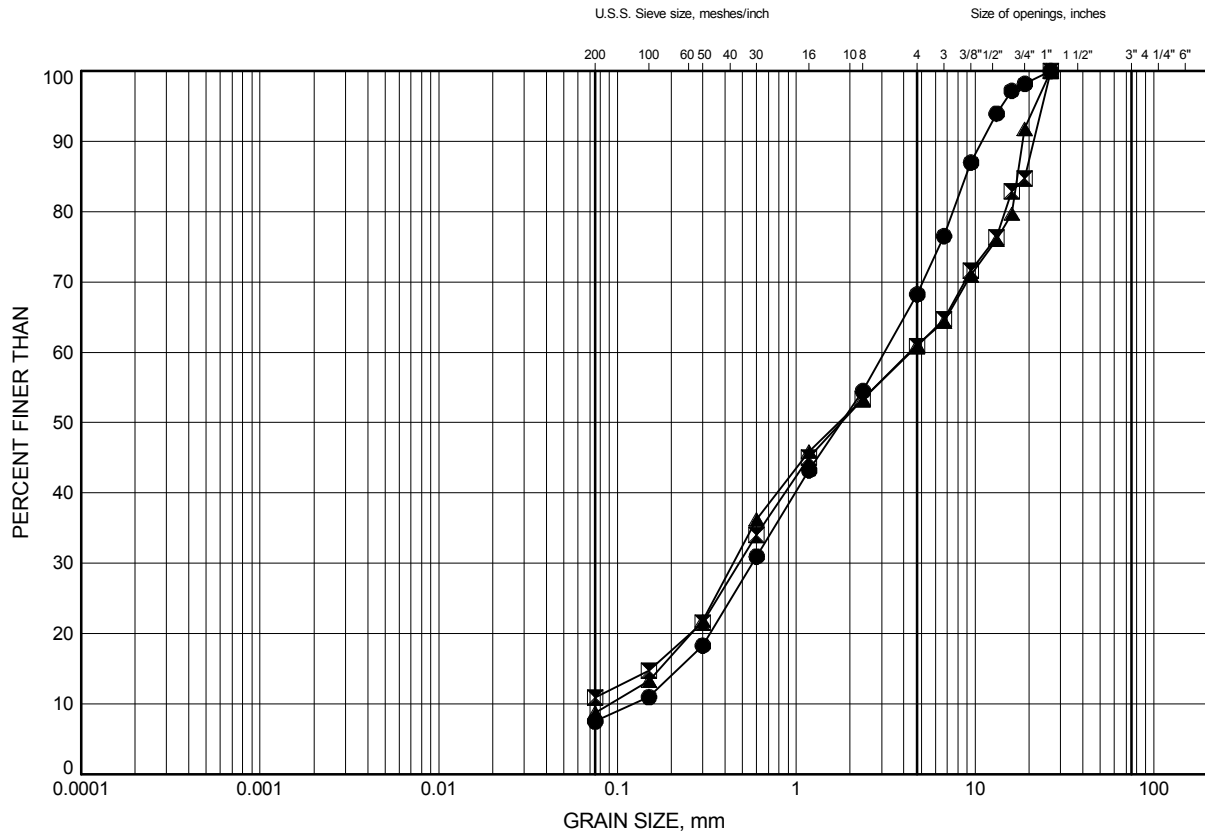
Appendix C.1

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

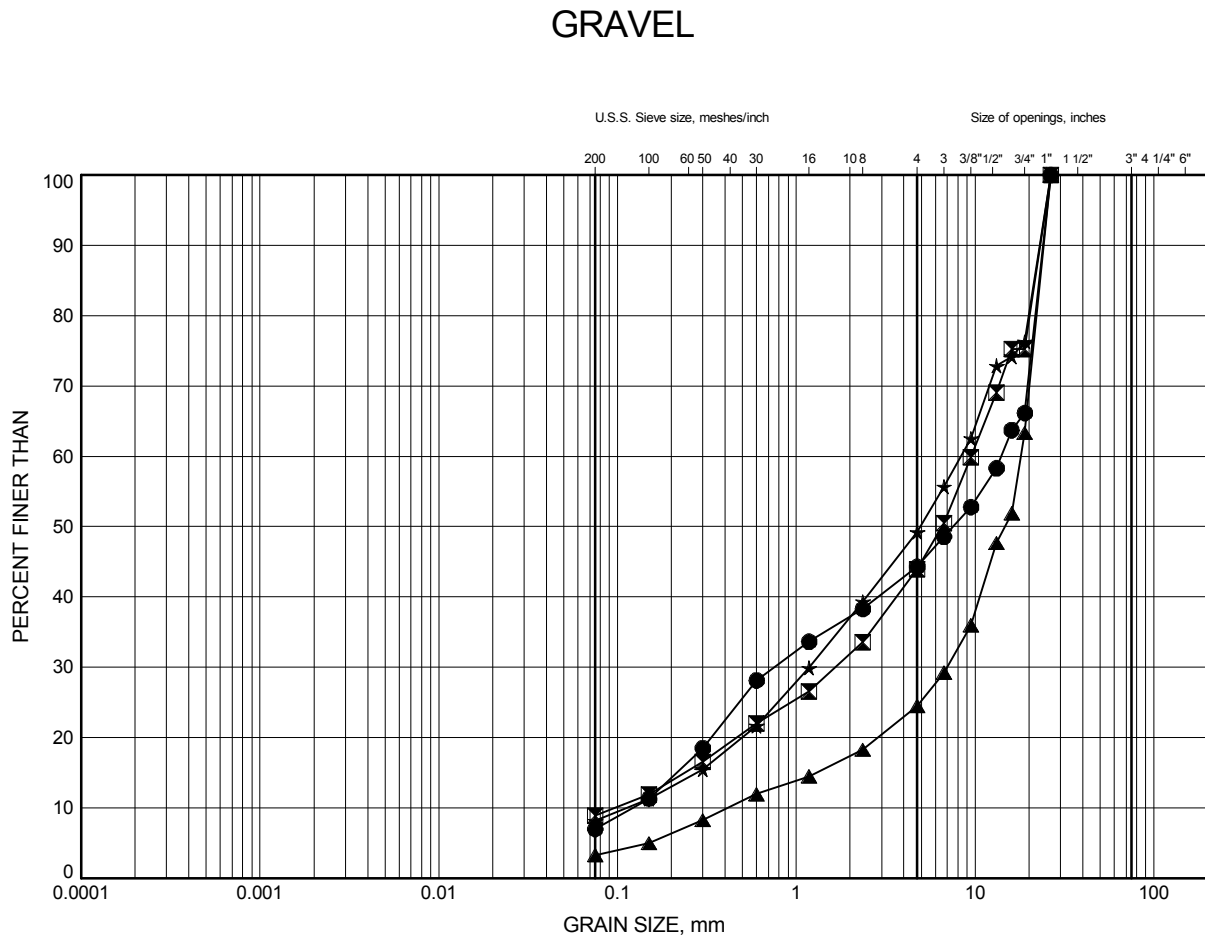


Prep'd KE

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

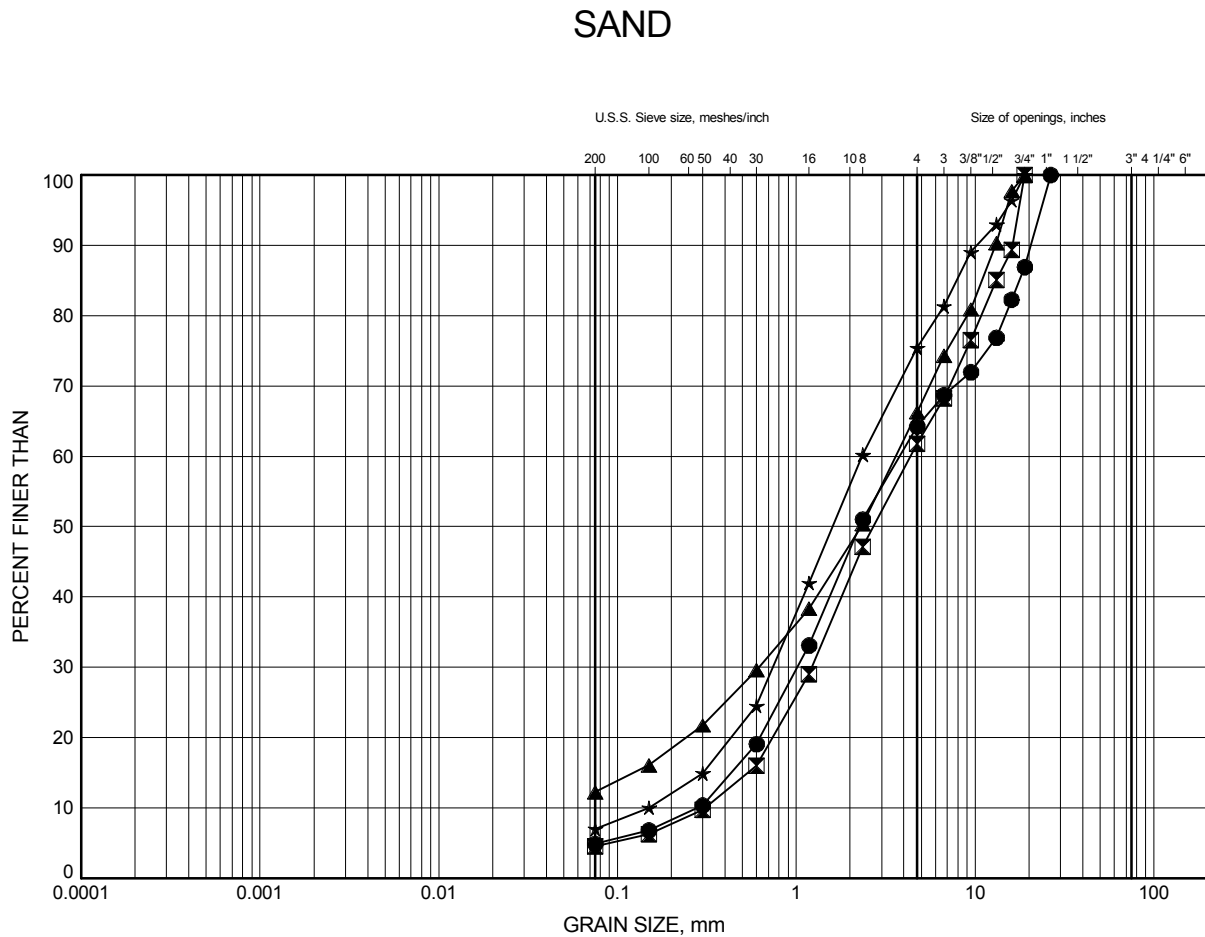


Prep'd KE

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

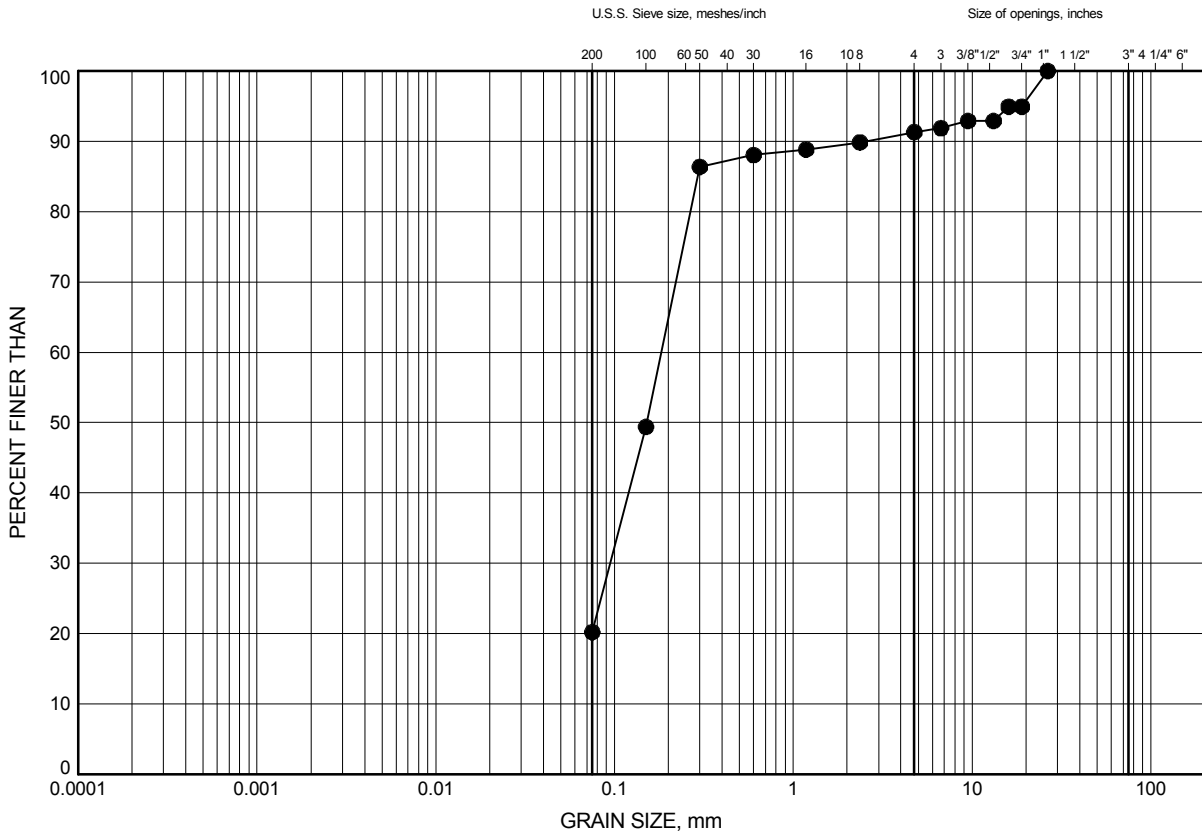


Prep'd KE
Chkd. FG

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



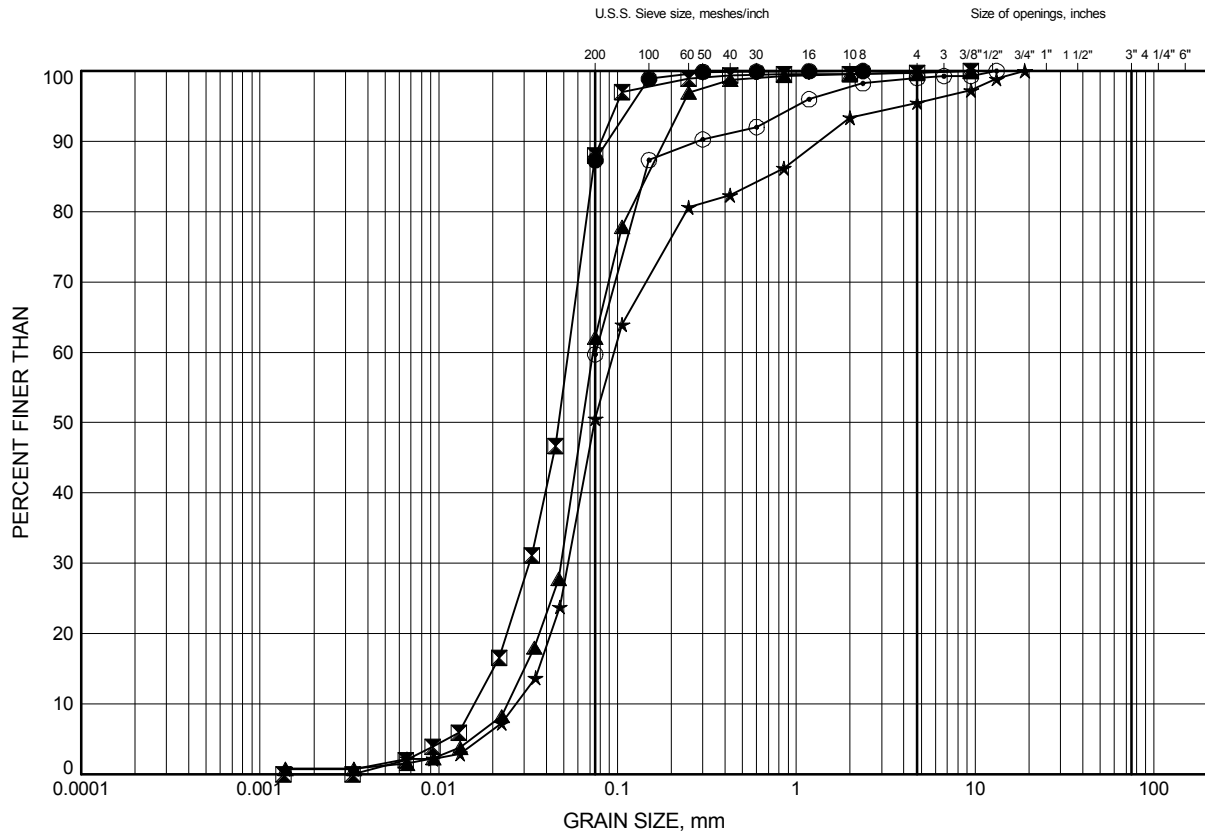
Prep'd KE

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

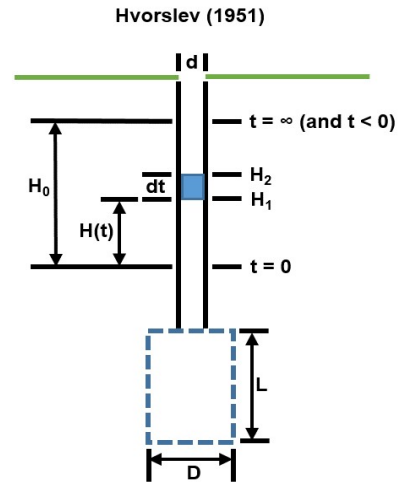
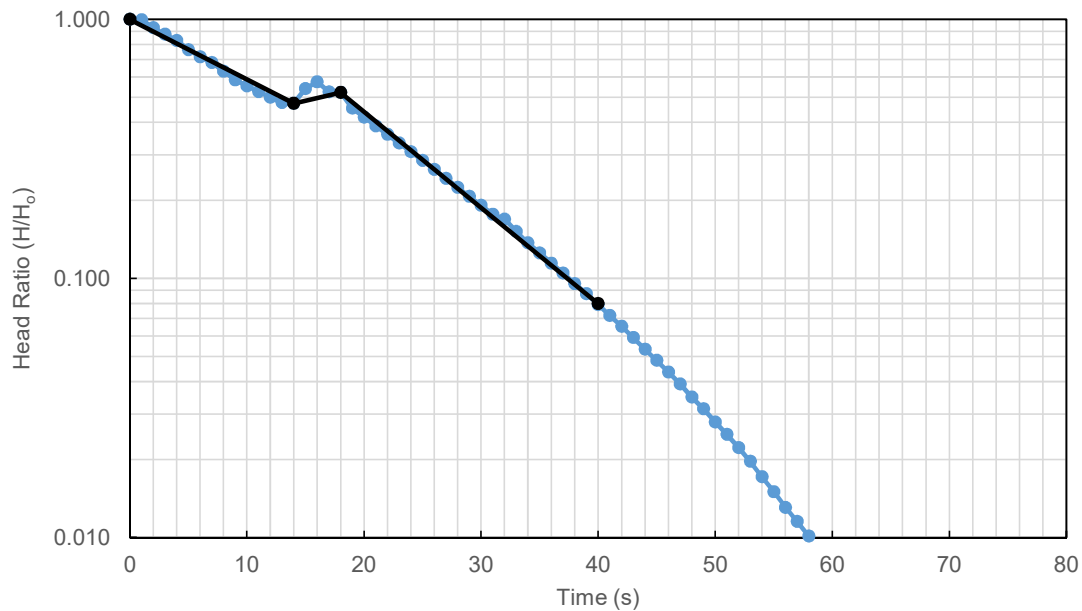
INPUT DATA	Rising Head Test
Borehole 17-01	
Static Water Level	1.1 mbgs
Well Diameter (d)	0.051 m
Borehole Diameter (D)	0.114 m
Length of Intake (L)	2.03 m
Initial Unbalanced Head (H ₀)	4.92 m
Shape Factor (F)	3.57

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

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, 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)

Appendix E.

**List of Special Provisions
OPSS Documents Referenced in this Report**

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

1. The following Special Provisions and OPSS Documents are referenced in this report:

OPSS.PROV 206	Construction Specification for Grading
OPSS.PROV 501	Construction Specification for Compacting
OPSS.PROV 517	Construction Specification for Dewatering of Pipeline, Utility and Associated Structure Excavation
NSSP FOUN0003	Dewatering Structure Excavations
SP 517F01	Design Storm Return Period and Preconstruction Survey
OPSS. 518	Construction Specification for Control of Water from Dewatering Operations
OPSS.PROV 539	Construction Specification for Temporary Protection Systems
OPSS.PROV 804	Construction Specification for Seed and Cover
OPSS 902	Construction Specification for Excavating and Backfilling Structures
OPSS.PROV 1010	Material Specification for Aggregates Base, Subbase, Select Subgrade, and Backfill Material
OPSD 208.010	Benching of Earth Slopes
OPSD 3090.100	Foundation Frost Depths for Northern Ontario
OPSD 810.010	General Rip-Rap Layout for Sewer and Culvert Outlets

2. Suggested text for a NSSP on “Installation of Temporary Protection System”

The presence of cobbles and boulders may potentially have an impact on the installation of protection systems at this site. Contractors should consider this in their equipment selection.

3. Suggested text for an NSSP on “Obstructions”

“The presence of cobbles, boulders and buried obstructions within the fill and native soils may have an impact on excavations as well as the installation of protection systems and/or coffer dams at this site. Contractors should consider this in their equipment selection.”