THURBER ENGINEERING LTD.

FINAL

FOUNDATION INVESTIGATION AND DESIGN REPORT
REHABILITATION OF ROOT RIVER CULVERT #4 (SITE 38S-053)
HIGHWAY 17 - 1.9 KM SOUTH OF HIGHWAY 556
AWERES TOWNSHIP
G.W.P. 5181-13-00

5016-E-0040

Geocres No.: 41K-104

Report to:

Ministry of Transportation Ontario

Latitude: 46.625692°
Longitude: -84.309784°

July 2018
Thurber File: 17848

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TABLE OF CONTENTS

APPENDICES

FINAL
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PART 1. FACTUAL INFORMATION

1 INTRODUCTION

This section of the report presents the factual findings obtained from a foundation investigation completed at Highway 17 Root River Culvert #4 (38S-053) which is located approximately 1.9 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 Proposed Highway 17 - Root River #4 Crossing (W.P. 909-57), Township of Aweres for Department of Highways of Ontario, dated 19th July, 1958.

2 SITE DESCRIPTION

The existing culvert is a twin celled open footed concrete culvert, each cell is reported to have a width of 4.3 m, a height of 2.7 m and a length of 26.8 m with obvert elevations of 314.9 m and strembed elevations of approximately 312.2 m. The culvert has a generally east to west alignment with flow through the culvert to the west.

At the location of the culvert, Highway 17 is a two-lane highway with paved shoulders. The Highway 17 fill height above the culvert is approximately 1.5 m with the centreline of the road surface at approximate elevation 316.9 m. The existing embankment slopes are inclined between 2.5H:1V and 3H: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.

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 19th and December 10th, 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 first order vertical benchmark 0011993U466 which is a tablet set in a rock outcrop just north of the Root River #4 culvert site with an elevation of 321.162 m.

Table 3-1: Borehole Summary

Borehole No.	Drilled Location	Approximate Northing (m)	Approximate Easting (m)	Ground Surface Elevation (m)	Sample Termination Depth (m)
17-07	Northbound Roadway	5 165 154.0	281 076.0	316.7	12.4
17-08	Southbound Roadway	5 165 175.0	281 074.0	317.0	10.7
17-09	East side – inlet	5 165 165.0	281 090.0	313.7	11.3
17-10A	East side – inlet	5 165 188.0	281 094.0	313.3	6.7[1]
17-10B[2]	East side – inlet	5 165 209.0	281 097.0	314.4	3.2
17-10C[2]	East side – inlet	5 165 190.0	281 091.0	314.7	8.7
17-11	West side – outlet	5 165 138.0	281 055.0	314.5	11.3[3]
17-12	West side – outlet	5 165 170.0	281 057.0	313.7	1.8[4]

[1] - Early termination due to Root River water level increase
[2] - Rock Probehole – Overburden not sampled
[3] - Borehole was advanced beyond sample termination depth by dynamic cone
[4] - Early termination due to cave in

The drilling was carried out using portable drilling equipment for Borehole 17-12, a truck mounted CME 75 drill rig for Borehole 17-08 and a track mounted CME 550 rig for all remaining off-road Boreholes. Borehole 17-07 was drilled starting with a truck mounted CME 75 drill rig and finishing with a track mounted CME 550 drill rig.

Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). A 25.6 kg drop hammer was used to advance the splitspoon in Borehole 17-12. The N-values have been corrected to provide an estimate of the N-value that would have been obtained with a standard 64 kg hammer. Bedrock core samples were acquired with NQ sized coring equipment.

A 19 mm diameter standpipe piezometer was installed in Borehole 17-09 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 well 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 was also carried out on selected samples to MTO and ASTM standards. Chemical analysis for determination of pH, conductivity, resistivity, soluble sulphate and chloride concentrations was carried out on one soil sample.

The results of the geotechnical tests are summarized on the Record of Borehole sheets included in Appendix B and all laboratory results are presented on the figures included in Appendix C.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

5.1 General

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendix B and the Borehole Location and Soil Strata Drawing included in Appendix A. An overall description of the stratigraphy is given in the following paragraphs; however, the factual data presented in the Record of Boreholes governs any interpretation of the site conditions. It must be recognized that soil and groundwater conditions may vary between and beyond sampled locations.

The stratigraphy encountered through the embankment near the culvert is generally characterized by fill materials overlying sand and gravel deposits. Granite bedrock was encountered in the northeastern section of the site.

5.2 Fill Material

5.2.1 Asphalt

Boreholes 17-07 and 17-08 were drilled through the existing Highway 17 pavement and encountered a layer of asphalt with a thickness of 150 mm.

5.2.2 Fill: Sand, Gravel and Silty Sand

Below the asphalt in Borehole 17-07 and 17-08, below the organics in Borehole 17-09 and at ground surface in Borehole 17-11 was a layer of fill consisting of a granular deposit with varying amounts of sand, gravel and silt. The underside of the granular fill ranged from 1.5 to 4.0 m below surface (elev. 312.2 to 313.2 m). Occasional to frequent cobbles and

occasional boulders were present throughout the fill. Coring techniques were utilized to advance through the cobbles and boulders.

SPT tests conducted within the granular fill gave N-values ranging from 4 to greater than 100 blows, indicating a loose to very dense relative density, however the fill materials at this site are typically dense to very dense.

Moisture contents ranged from 2 to 14%. The results of grain size analyses conducted on six 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	25 to 56
Sand	40 to 60
Silt and Clay	4 to 15

5.3 Organics

Boreholes 17-09 and 17-10A encountered a layer of organics consisting of wood and roots at ground surface with a thickness of 100 mm.

5.4 Sand to Silty Sand

5.4.1 Sand

A sand deposit with varying amounts of silt and gravel was encountered in Boreholes 17-07, 17-08, 17-09, 17-10A and 17-11. Borehole 17-11 encountered an upper and lower sand deposit separated by a 2.6 m thick gravel deposit as described in the following Section 5.5. Borehole 17-11 was terminated within the lower sand deposit at a final sampled depth of 11.3 m (elev. 303.2 m). Where the sand layer was fully penetrated, the sand deposit ranged in thickness from 4.0 to 8.7 m with an underside elevation ranging from 303.5 to 309.2 m. Borehole 17-11 was extended below termination depth by performing a dynamic cone penetration test (DCPT) to a final elevation of 301.1 m.

SPT tests gave N-values ranging from 7 to greater than 100 blows per 300 mm of penetration indicating a loose to very dense relative density. In general the deposit is considered to be compact to dense.

The moisture content ranged between 3 to 19%. Gradation analyses were completed on five samples of the sand deposit. The results are summarized on the Record of Borehole sheets in Appendix B and the grain size distribution curves for this material are included in Figure C2 of Appendix C. The results of the laboratory test are summarized as follows:

Table 5-2: Gradation Results for Sand

Soil Particle	Percentage (%)
Gravel	15 to 33
Sand	62 to 82
Silt and Clay	3 to 11

5.4.2 Silty Sand (SM)

A silty sand deposit with gravel was encountered underlying the sand deposit in Borehole 17-09. The Borehole was terminated within this layer at a final depth of 11.3 m (elev. 302.4 m).

SPT tests conducted within the silty sand gave an N-value of 30 blows, indicating a dense relative density.

The moisture content was 10%. The results of grain size analysis conducted on one sample of the silty sand material indicate the material consists of 10% gravel, 49% sand and 41% silt and clay. The results are illustrated on Figure C3 in Appendix C.

5.5 Gravel

At ground surface in Borehole 17-12 and below the sand in Boreholes 17-07, 17-08 and 17-10A was a deposit of gravel with silt and sand. These boreholes were terminated within the gravel deposit at final depths of 1.8 to 12.4 m (elev. 304.3 to 311.9 m). A 2.6 m thick gravel deposit was encountered at a depth of 6.1 m (elev. 308.4 m) in Borehole 17-11 between the upper and lower sand deposit as described in the previous Section 5.4.1. Occasional to frequent cobbles and occasional boulders were encountered throughout this cohesionless deposit. Coring techniques were utilized to advance through the cobbles and boulders.

SPT tests gave N-values ranging from 76 to greater than 100 blows per 300 mm of penetration indicating a dense to very dense state of packing; the deposit was typically very dense. The N-values in Borehole 17-12 ranged from 1 to 18, indicating a very loose to compact relative density at this very shallow location.

Moisture contents ranged from 6 to 15%. Higher values of 19% and 49% were measured for the very loose surficial gravel in Borehole 17-12. Gradation analyses were completed on three 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 C4 of Appendix C. The results of the laboratory tests are summarized as follows:

Table 5-3: Gradation Results for Gravel

Soil Particle	Percentage (%)
Gravel	52 to 70
Sand	24 to 47
Silt and Clay	1 to 6

5.6 Bedrock

Bedrock was proven by coring in Borehole 17-10B and 17-10C. Information on the bedrock surface is summarized in the following table:

Table 5-4: Summary of Bedrock Elevations

Borehole No.	Depth to Bedrock (m)	Bedrock Elevation (m)
17-10B	0.1	314.3
17-10C	5.5	309.2

The bedrock encountered within Boreholes 17-10B and 17-10C consisted of granite with occasional quartz veins. The Total Core Recovery (TCR) measured on the recovered bedrock core was 100%, the Solid Core Recovery (SCR) ranged from 45 to 78% and the Rock Quality Designation (RQD) ranged from 24 to 81%. Based on the measured RQD values, the bedrock is classified as very poor to good quality but predominantly ranges from poor to fair quality. The granite bedrock is estimated to be strong to very strong. Photographs of the bedrock core are provided in Appendix C.

5.7 Groundwater

Reliable water levels could not be recorded in most of the open boreholes due to water being introduced as part of the drilling operations. The groundwater water levels presented in Table 5-5: Groundwater Level Observations were measured in the standpipe piezometer installed in Borehole 17-09 and within the cased hole in Borehole 17-08, which was left in place overnight.

Table 5-5: Groundwater Level Observations

Borehole	Groundwater Level		Date of Measurement
	Depth (mbgs)	Elevation (m)	
17-08	3.1	313.9	November 14, 2017
17-09	0.05 0.00	313.65 313.70	December 1, 2017 December 9, 2017

The creek water level was also surveyed during the field investigation measured to be at a depth of 1.72 m below the culvert obvert (elev. 313.2 m) on December 12, 2017.

A rising head test was performed in Piezometer 17-09 to determine the hydraulic conductivity. The results indicated a K value of $1.3x10^{-4}$ 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.

5.8 Analytical Testing

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

Table 5-6: Analytical Results Summary

Borehole	Sample	Depth (m)	Sulphate (μg/g)	pH	Resistivity (Ohm-cm)	Conductivity (μS/cm)	Chloride (μg/g)
17 - 10	SS2	0.8 – 1.4	69	6.20	3320	301	114

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. 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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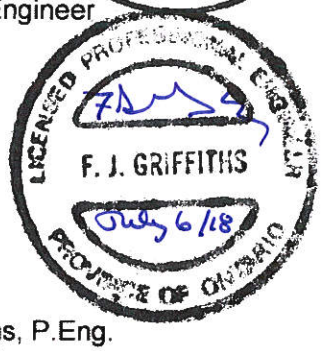

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PART 2. ENGINEERING DISCUSSION AND RECOMMENDATIONS

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 1.9 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 deposits of sand over gravel. Bedrock was encountered in the northeastern area of the culvert in Boreholes 17-10B and 17-10C. The water level of Root River was recorded during the off-road portion of the field work at an elevation 313.2 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 REINSTATMENT

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 Culvert Backfilling and Lateral Earth Pressures

It is recommended that where culvert cover has been removed as part of the rehabilitation work, that structural cover 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 $\phi = 35^o$, $\gamma = 22.8$ kN/m^3		OPSS Granular B Type I $\phi = 32^o$, $\gamma = 21.2$ kN/m^3		OPSS SSM and Existing Fill $\phi = 30^o$, $\gamma = 20.0$ 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 are not horizontal or sloped at 2H:1V behind the walls, the coefficients provided in the 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 beneath 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.

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 5.8 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 (<1.5m) 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 to frequent cobbles and occasional boulders observed in the fill and native soils at this site, as well as the presence of shallow bedrock at some locations.

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 sand and gravel deposits are given below:

Native Sand

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

Native Gravel

γ	=	21 kN/m^3	(reduced to submerged unit weight below water table)
K_A	=	0.29	
K_P	=	3.4	

Temporary protection systems are the responsibility of the Contractor and should be designed by a licensed Professional Engineer experienced in such designs and retained by the Contractor. The lateral pressure distribution acting on the protection system is a function of the construction sequencing, dewatering and traffic loading; these factors must be considered during design. The Contractor must undertake an assessment of the foundation soils ability to support the weight of the crane used during installation of the protection system. Lateral support may require enhancement with soil anchors, dead man 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:

- * 46.625692°, -84.309784°
- ** Root River Culvert #4 Crossing of Highway 17 (Site 38S-053)
- ***** 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

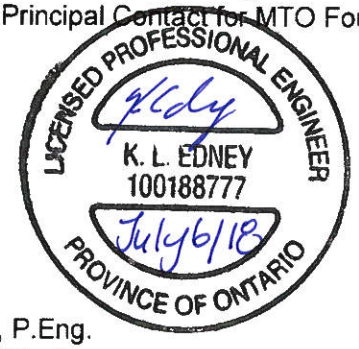
Potential construction concerns include, but are not necessarily limited to:

- 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 will 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.



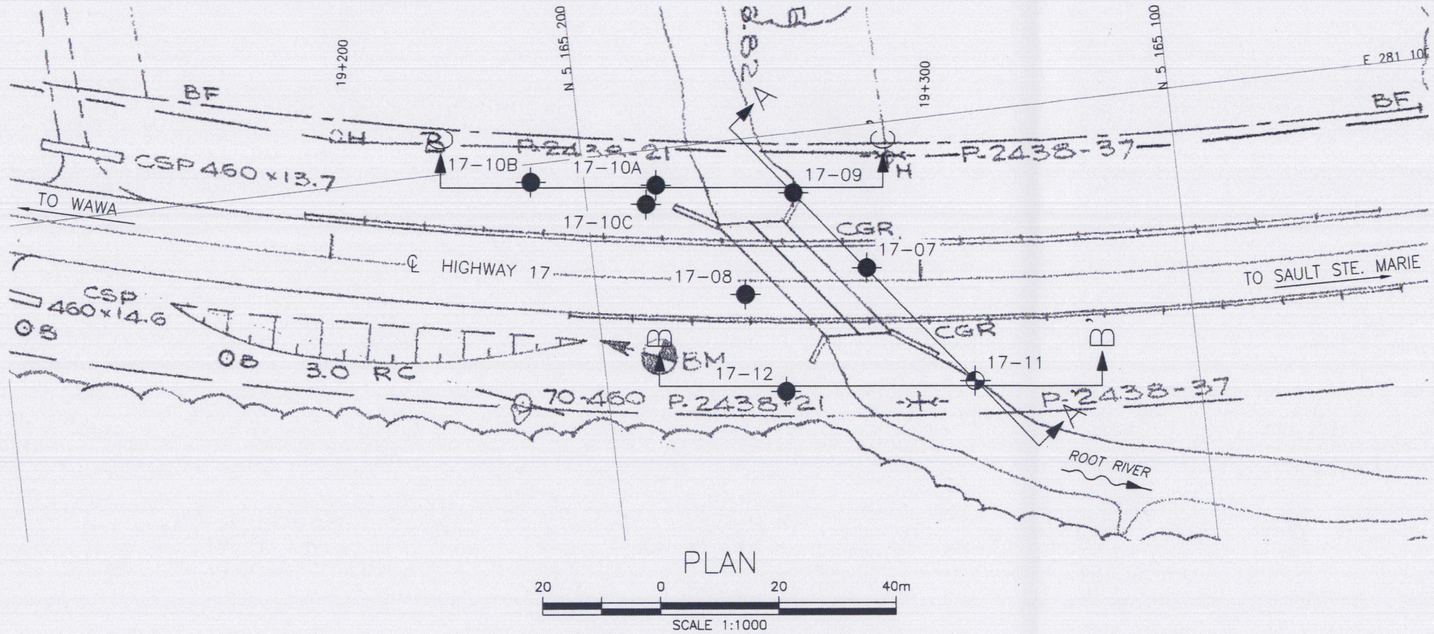
Katya Edney, P.Eng.
Geotechnical Engineer

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

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

Appendix A.

Borehole Location Plan and Stratigraphic Drawings

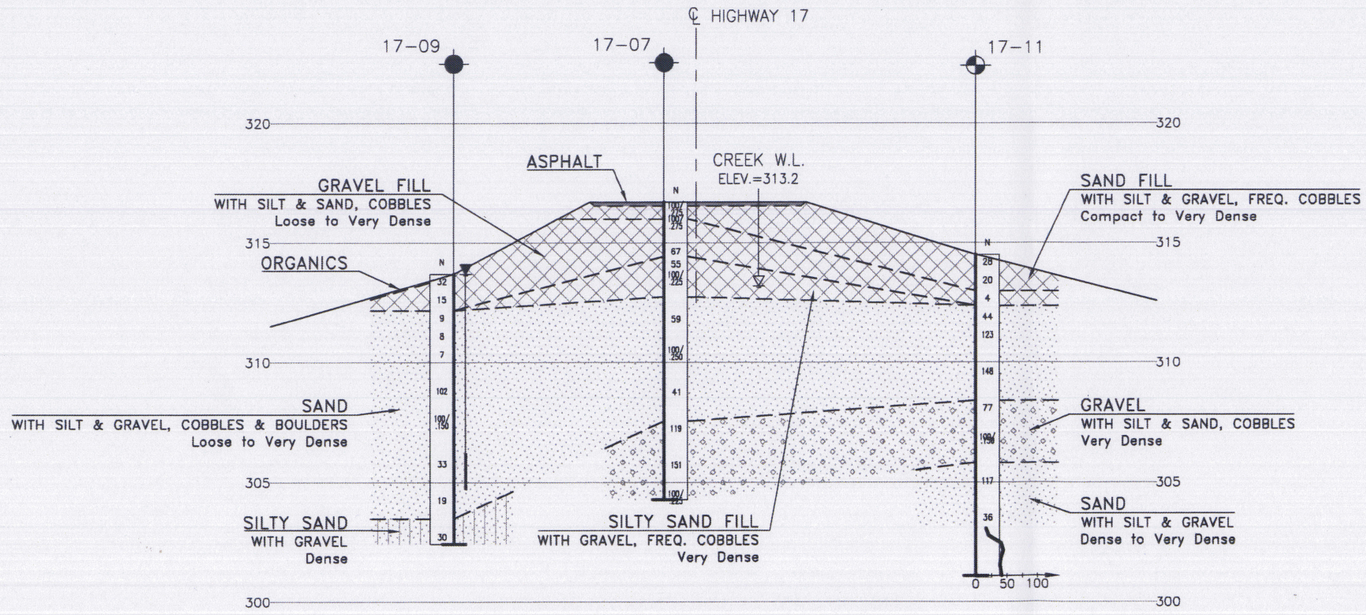


PLAN

20 0 20 40m

SCALE 1:1000

NOTE: Ground surface in the stratigraphy plot is inferred between borehole elevations and is not based on elevation data.



SECTION A–A'

10 0 10 20m H 1:500

5 0 5 10m V 1:250

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

The existing culvert is a twin celled open footed concrete culvert, each cell is reported to have a width of 4.3 m, a height of 2.7 m and a length of 26.8 m with obvert elevations of 314.9 m and invert elevations of approximately 312.2 m. The highway 17 fill height above the culvert is approximately 1.5 m with the centreline of the road surface at approximate elevation 316.9 m. The existing embankment slopes are inclined between 2.5H:1V and 3H:1V.

CONT No
GWP No 5181-13-00

SHEET

HIGHWAY 17
ROOT RIVER CULVERT #4
REHABILITATION
BOREHOLE LOCATIONS AND SOIL STRATA

Ontario

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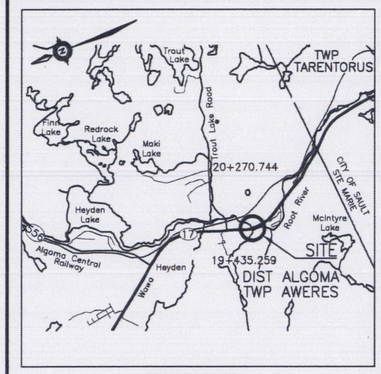

KEYPLAN

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
17-07	316.7	5 165 154.0	281 076.0
17-08	317.0	5 165 175.0	281 074.0
17-09	313.7	5 165 165.0	281 090.0
17-10A	313.3	5 165 188.0	281 094.0
17-10B	314.4	5 165 209.0	281 097.0
17-10C	314.7	5 165 190.0	281 091.0
17-11	314.5	5 165 138.0	281 055.0
17-12	313.7	5 165 170.0	281 057.0

-NOTES-

1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
3) Coordinate system is MTM NAD 83 Zone 13.

GEOCRES No. 41K-104

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
July 6/18
PROVINCE OF ONTARIO

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K. L. EDNEY
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July 6/18
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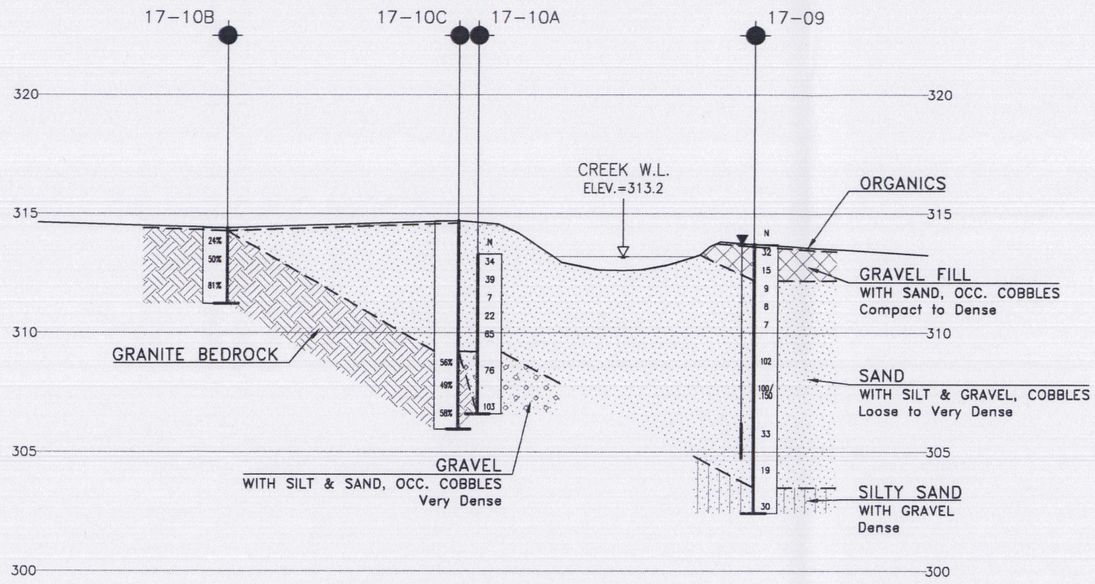
REVISIONS		
DATE	BY	DESCRIPTION

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

FILENAME: H:\Drafting\17000\17848\TED-17848-RR #4 Culvert.dwg
PLOTDATE: 7/9/2018 4:43 PM

NOTE: Ground surface in the stratigraphy plot is inferred between borehole elevations and is not based on elevation data.

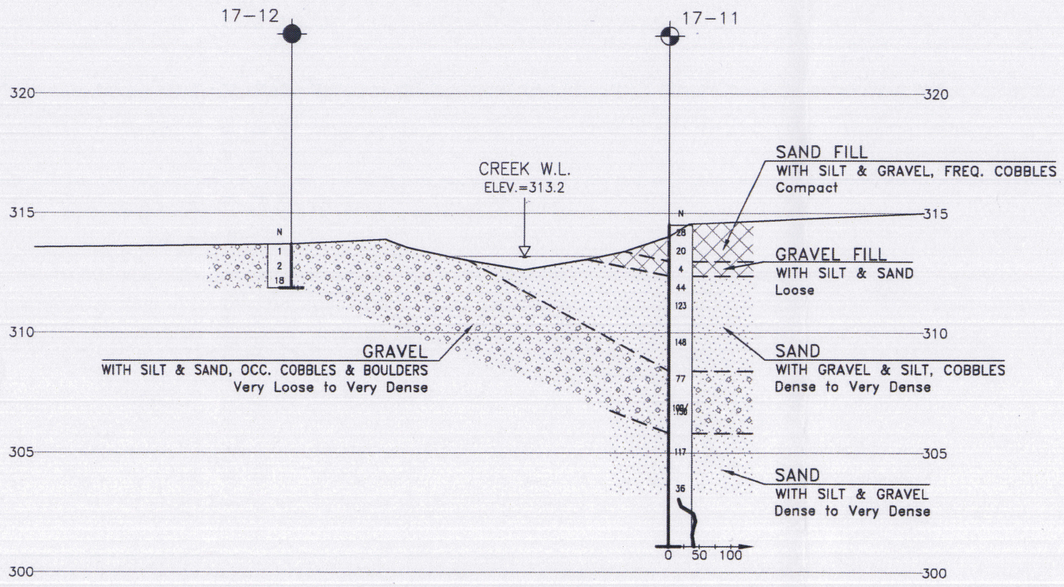


SECTION C–C'

10 0 10 20m H 1:500

5 0 5 10m V 1:250

NOTE: Ground surface in the stratigraphy plot is inferred between borehole elevations and is not based on elevation data.



SECTION B–B'

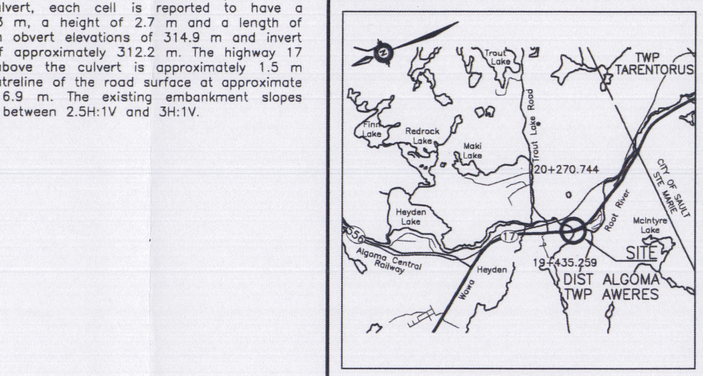
10 0 10 20m H 1:500

5 0 5 10m V 1:250

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

The existing culvert is a twin celled open footed concrete culvert, each cell is reported to have a width of 4.3 m, a height of 2.7 m and a length of 26.8 m with obvert elevations of 314.9 m and invert elevations of approximately 312.2 m. The highway 17 fill height above the culvert is approximately 1.5 m with the centreline of the road surface at approximate elevation 316.9 m. The existing embankment slopes are inclined between 2.5H:1V and 3H:1V.



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
17–07	316.7	5 165 154.0	281 076.0
17–08	317.0	5 165 175.0	281 074.0
17–09	313.7	5 165 165.0	281 090.0
17–10A	313.3	5 165 188.0	281 094.0
17–10B	314.4	5 165 209.0	281 097.0
17–10C	314.7	5 165 190.0	281 091.0
17–11	314.5	5 165 138.0	281 055.0
17–12	313.7	5 165 170.0	281 057.0

-NOTES-

1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
3) Coordinate system is MTM NAD 83 Zone 13.

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CONT No
GWP No 5181-13-00

HIGHWAY 17
ROOT RIVER CULVERT #4
REHABILITATION
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

Ontario

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REVISIONS		
DATE	BY	DESCRIPTION

DESIGN	CM	CHK	CODE	LOAD	DATE JUL 2018
DRAWN	MFA	CHK CM	SITE	STRUCT	DWG 2

PLOTDATE: 7/9/2018 4:43 PM
PLOTNAME: H:\Drafting\17000\17848\TED-17848-RR #4 Culvert.dwg

MINISTRY OF TRANSPORTATION, ONTARIO

Appendix B.

Record of Borehole Sheets

THURBER

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:

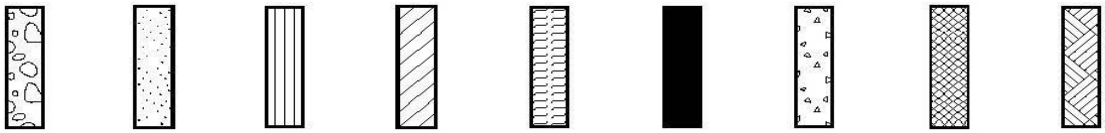
Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 63.5 kg hammer falling 0.76 m, required to drive a 50 mm O.D. split spoon sampler 0.3 m into undisturbed soil. For samples where insufficient penetration was achieved and N-value cannot be presented,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

THURBER

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

THURBER

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

THURBER

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

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THURBER

RECORD OF BOREHOLE No 17-07 1 OF 2 METRIC

GWP# 5181-13-00 LOCATION Root River Culvert #4, MTM Zone 13: N 5 165 154.0 E 281 076.0 ORIGINATED BY DJP/NW

HWY 17 BOREHOLE TYPE NW Casing COMPILED BY KE

DATUM Geodetic DATE 2017.10.19 - 2017.11.28 CHECKED BY FG

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
316.7											
0.0	**ASPHALT (150 mm)**										
0.2	**FILL** SAND with silt and gravel frequent cobbles very dense brown		1	SS	100\ 275mm				○		39 49 12 (SI+CL)
316.0			2	SS	100\ 275mm		316		○		
0.7	**FILL** GRAVEL with silt and sand frequent cobbles very dense brown - zone of cobbles and boulders at 0.9 m										
314.4			3	SS	67		315		○		
2.3	**FILL** SILTY SAND with gravel frequent cobbles very dense brown		4	SS	55		314		○		
312.7			5	SS	100\ 225mm		313		○		
4.0	**SAND (SP-SM)** with silt and gravel occasional to frequent cobbles and boulders dense to very dense grey		6	SS	59		312		○		27 62 11 (SI+CL)
	- 180 mm cobble at 5.2 m										
	- 100 mm cobble at 5.8 m						311				
			7	SS	100\ 250mm				○		
	- 80 mm cobble at 6.5 m						310				
	- 120 mm cobble at 6.8 m										
	- 100 mm cobble at 7.2 m										
			8	SS	41		309		○		
307.6							308				
9.1	**GRAVEL(GP-GM)** with silt and sand frequent cobbles very dense brown		9	SS	119		307		○		70 24 6 (SI+CL)

Continued Next Page

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

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

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THURBER

RECORD OF BOREHOLE No 17-07 2 OF 2 METRIC

GWP# 5181-13-00 LOCATION Root River Culvert #4, MTM Zone 13: N 5 165 154.0 E 281 076.0 ORIGINATED BY DJP/NW

HWY 17 BOREHOLE TYPE NW Casing COMPILED BY KE

DATUM Geodetic DATE 2017.10.19 - 2017.11.28 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa 20 40 60 80 100 (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page										
	GRAVEL(GP-GM) with silt and sand frequent cobbles very dense brown						306		○		
			10	SS	151						
							305				
304.3			11	SS	100\				○		
12.4	End of Borehole				225mm						

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

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

ONTMT4S 17848_ROOTRIVER4.GPJ 2012TEMPLATE(MTO).GDT 6/7/18

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THURBER

RECORD OF BOREHOLE No 17-08 1 OF 2 METRIC

GWP# 5181-13-00 LOCATION Root River Culvert #4, MTM Zone 13: N 5 165 175.0 E 281 074.0 ORIGINATED BY NW

HWY 17 BOREHOLE TYPE HW Casing / NW Casing COMPILED BY KE

DATUM Geodetic DATE 2017.11.14 - 2017.11.15 CHECKED BY FG

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
317.0							317
0.0	**ASPHALT (150 mm)**						
0.2	**FILL** SAND with silt and gravel very dense to dense brown		1	SS	110		
316.0			2	SS	37		316
1.1	**FILL** SILTY SAND with gravel dense brown						
315.5							315
1.5	**FILL** GRAVEL with silt and sand - occasional to frequent cobbles below 1.5 m very dense to dense brown		3	SS	60		
			4	SS	43		
			5	SS	40	▽	314
313.2							
3.8	**SAND (SP-SM)** with silt and gravel occasional to frequent cobbles loose to very dense brown		6	SS	12		313
			7	SS	11		312
			8	SS	17		
			9	SS	7		311
			10	SS	100\ 100mm		310
307.9							309
9.1	**GRAVEL (GP-GM)** with silt and sand frequent cobbles very dense brown		11	SS	100\ 50mm		308

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L
WATER CONTENT (%)
20 40 60

UNIT WEIGHT γ kN/m^3

REMARKS & GRAIN SIZE DISTRIBUTION (%)	GR	SA	SI	CL
	38	52	10	(SI+CL)
	25	60	15	(SI+CL)
	50	42	8	(SI+CL)

Continued Next Page

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

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

ONTMT4S 17848_ROOTRIVER4.GPJ 2012TEMPLATE(MTO).GDT 6/7/18

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THURBER

RECORD OF BOREHOLE No 17-08 2 OF 2 METRIC

GWP# 5181-13-00 LOCATION Root River Culvert #4, MTM Zone 13: N 5 165 175.0 E 281 074.0 ORIGINATED BY NW

HWY 17 BOREHOLE TYPE HW Casing / NW Casing COMPILED BY KE

DATUM Geodetic DATE 2017.11.14 - 2017.11.15 CHECKED BY FG

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	GRAVEL (GP-GM) with silt and sand frequent cobbles very dense brown						307				
306.4											
10.7	End of Borehole Groundwater observed in cased BH at elev. 313.9 m on Nov. 15, 2017 during drilling operations		12	SS	100\ 0mm						

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

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

ONTMT4S 17848_ROOTRIVER4.GPJ 2012TEMPLATE(MTO).GDT 6/7/18

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THURBER

RECORD OF BOREHOLE No 17-09 1 OF 2 METRIC

GWP# 5181-13-00 LOCATION Root River Culvert #4, MTM Zone 13: N 5 165 165.0 E 281 090.0 ORIGINATED BY NW

HWY 17 BOREHOLE TYPE HW Casing / NW Casing COMPILED BY KE

DATUM Geodetic DATE 2017.11.28 - 2017.11.30 CHECKED BY FG

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
313.7											
0.0	**ORGANICS** wood and roots										
0.1	**FILL** GRAVEL with sand occasional cobbles compact to dense brown		1	SS	32		313		○		
			2	SS	15				○		56 40 4 (SI+CL)
312.2											
1.5	**SAND (SW-SM)** with silt and gravel loose to very dense grey		3	SS	9		312		○		
			4	SS	8		311				
	frequent to occasional cobbles below 3m		5	SS	7		310		○		
			6	SS	102		309		○		
			7	SS	100\ 150mm		308				
			8	SS	33		306		○		16 77 7 (SI+CL)
			9	SS	19		305		○		
							304				

Continued Next Page

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

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

ONTMT4S 17848_ROOTRIVER4.GPJ 2012TEMPLATE(MTO).GDT 6/7/18

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-09 2 OF 2 METRIC

GWP# 5181-13-00 LOCATION Root River Culvert #4, MTM Zone 13: N 5 165 165.0 E 281 090.0 ORIGINATED BY NW

HWY 17 BOREHOLE TYPE HW Casing / NW Casing COMPILED BY KE

DATUM Geodetic DATE 2017.11.28 - 2017.11.30 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
303.5	Continued From Previous Page										
10.2	**SILTY SAND (SM)** with gravel dense brown						303				
302.4			10	SS	30				○		10 49 41 (SI+CL)
11.3	End of Borehole Water Levels in Well 2017.12.01 0.05 mbgs 2017.12.09 0.00 mbgs										

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

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

ONTMT4S 17848_ROOTRIVER4.GPJ 2012TEMPLATE(MTO).GDT 6/7/18

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-10A 1 OF 1 METRIC

GWP# 5181-13-00 LOCATION Root River Culvert #4, MTM Zone 13: N 5 165 188.0 E 281 094.0 ORIGINATED BY NW

HWY 17 BOREHOLE TYPE HW Casing / NW Casing COMPILED BY KE

DATUM Geodetic DATE 2017.12.03 - 2017.12.03 CHECKED BY FG

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
313.3											
0.0	**ORGANICS** wood and roots										
0.1	**SAND (SP)** with gravel, occasional cobbles loose to very dense brown		1	SS	34		313	○	○		
			2	SS	39		312		○		
			3	SS	7				○		
			4	SS	22		311		○		15 82 3 (SI+CL)
			5	SS	65		310		○		
309.2											
4.1	**GRAVEL (GP-GM)** with silt and sand occasional cobbles very dense		6	SS	76		309		○		53 42 5 (SI+CL)
			7	SS	103		308				
306.6							307		○		
6.7	Borehole terminated due to flooding										

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

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

ONTMT4S 17848_ROOTRIVER4.GPJ 2012TEMPLATE(MTO).GDT 6/7/18

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-10B 1 OF 1 METRIC

GWP# 5181-13-00 LOCATION Root River Culvert #4, MTM Zone 13: N 5 165 209.0 E 281 097.0 ORIGINATED BY DJP

HWY 17 BOREHOLE TYPE HW Casing / HQ Coring COMPILED BY KE

DATUM Geodetic DATE 2017.12.04 - 2017.12.04 CHECKED BY FG

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
314.4											
0.0	**Unsampled Overburden**										
0.1	**GRANITE BEDROCK** occasional quartz veins moderately weathered to fresh strong grey with pink intrusions		1	RUN			314				RUN #1 TCR=100% SCR=45% RQD=24%
			2	RUN			313				RUN #2 TCR=100% SCR=61% RQD=50%
			3	RUN			312				RUN #3 TCR=100% SCR=78% RQD=81%
311.2											
3.2	End of Borehole										

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

(%) STRAIN AT FAILURE

ONTMT4S 17848_ROOTRIVER4.GPJ 2012TEMPLATE(MTO).GDT 6/7/18

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-10C 1 OF 1 METRIC

GWP# 5181-13-00 LOCATION Root River Culvert #4, MTM Zone 13: N 5 165 190.0 E 281 091.0 ORIGINATED BY DJP

HWY 17 BOREHOLE TYPE HW Casing / HQ Coring COMPILED BY KE

DATUM Geodetic DATE 2017.12.08 - 2017.12.09 CHECKED BY FG

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
314.7											
0.0	**Unsampled Overburden**						314				
							313				
							312				
							311				
							310				
309.2											
5.5	**GRANITE BEDROCK** occasional quartz veins slightly to highly weathered grey with pink intrusions		1	RUN			309				RUN #1 TCR=100% SCR=65% RQD=56%
			2	RUN			308				RUN #2 TCR=100% SCR=56% RQD=49%
			3	RUN			307				RUN #3 TCR=100% SCR=62% RQD=58%
306.0							306				
8.7	End of Borehole										

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

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

ONTMT4S 17848_ROOTRIVER4.GPJ 2012TEMPLATE(MTO).GDT 6/7/18

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-11 1 OF 2 METRIC

GWP# 5181-13-00 LOCATION Root River Culvert #4, MTM Zone 13: N 5 165 138.0 E 281 055.0 ORIGINATED BY NW

HWY 17 BOREHOLE TYPE HW Casing / NW Casing COMPILED BY KE

DATUM Geodetic DATE 2017.11.30 - 2017.11.30 CHECKED BY FG

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
314.5											
0.0	**FILL** SAND with silt and gravel frequent cobbles compact brown		1	SS	28		314		○		42 51 7 (SI+CL)
			2	SS	20						
313.0							313				
1.5	**FILL** GRAVEL with silt and sand loose brown		3	SS	4				○		
312.4							312				
2.1	**SAND (SP)** with gravel and silt occasional to frequent cobbles dense to very dense grey		4	SS	44				○		26 64 10 (SI+CL)
			5	SS	123		311		○		
			6	SS	148		310				
308.4							309				
6.1	**GRAVEL (GP-GM)** with silt and sand occasional cobbles very dense grey		7	SS	77				○		
			8	SS	100\ 150mm		308				
305.8							307		○		
8.7	**SAND (SP)** with silt and gravel very dense to dense grey		9	SS	117		306				
							305		○		

Continued Next Page

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

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

ONTMT4S 17848_ROOTRIVER4.GPJ 2012TEMPLATE(MTO).GDT 6/7/18

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-11 2 OF 2 METRIC

GWP# 5181-13-00 LOCATION Root River Culvert #4, MTM Zone 13: N 5 165 138.0 E 281 055.0 ORIGINATED BY NW

HWY 17 BOREHOLE TYPE HW Casing / NW Casing COMPILED BY KE

DATUM Geodetic DATE 2017.11.30 - 2017.11.30 CHECKED BY FG

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
303.2	**SAND (SP)** with silt and gravel very dense to dense grey		10	SS	36		304 303 302	○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	o		33 62 5 (SI+CL)
301.1	End of sampled Borehole DCPT carried out from 11.3 to 13.4 m										
13.4	End of DCPT at 13.4 m										

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

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

ONTMT4S 17848_ROOTRIVER4.GPJ 2012TEMPLATE(MTO).GDT 6/7/18

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-12 1 OF 1 METRIC

GWP# 5181-13-00 LOCATION Root River Culvert #4, MTM Zone 13: N 5 165 170.0 E 281 057.0 ORIGINATED BY DJP

HWY 17 BOREHOLE TYPE Manual COMPILED BY KE

DATUM Geodetic DATE 2017.12.10 - 2017.12.10 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
313.7											
0.0	**GRAVEL (GP)** with sand occasional cobbles and boulders very loose to compact brown		1	SS	1						52 47 1 (SI+CL)
			2	SS	2		313				
			3	SS	18						
311.9							312				
1.8	Borehole terminated due to cave-in Note: A 40% (25.6 kg) drop hammer was used to advance the splitspoon sampler. The "N" values presented above have been corrected to provide an estimate of the "N" value that would have been obtained with a standard 64 kg hammer.										

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

15 20 10 5 (%) STRAIN AT FAILURE

ONTMT4S 17848_ROOTRIVER4.GPJ 2012TEMPLATE(MTO).GDT 6/7/18

Appendix C.

Laboratory Testing

Appendix C.1

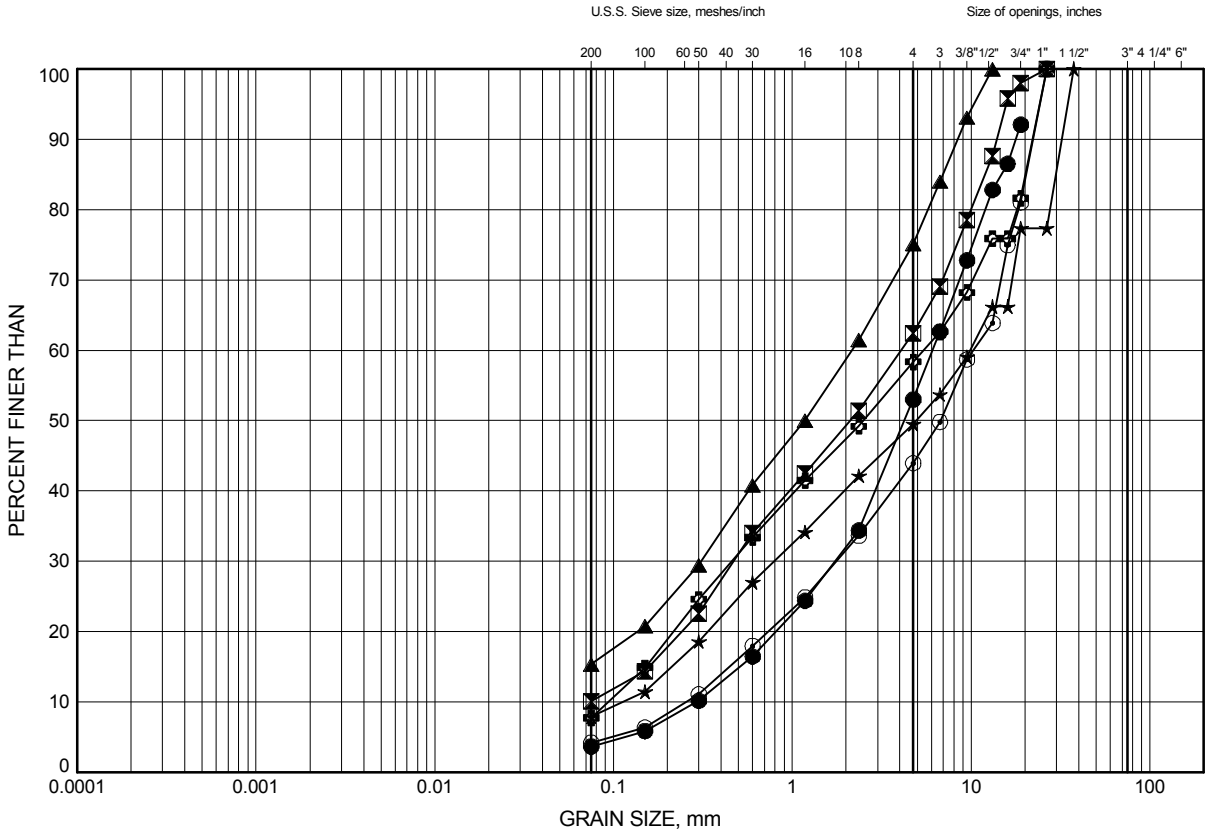
Particle Size Analysis Figures

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)
●	17-07	0.37	316.34
⊠	17-08	0.38	316.66
▲	17-08	1.22	315.82
★	17-08	2.59	314.45
⊙	17-09	1.07	312.64
✿	17-11	0.30	314.22

Date February 2018

GWP# 5181-13-00

THURBER

Prep'd KE

Chkd. FG

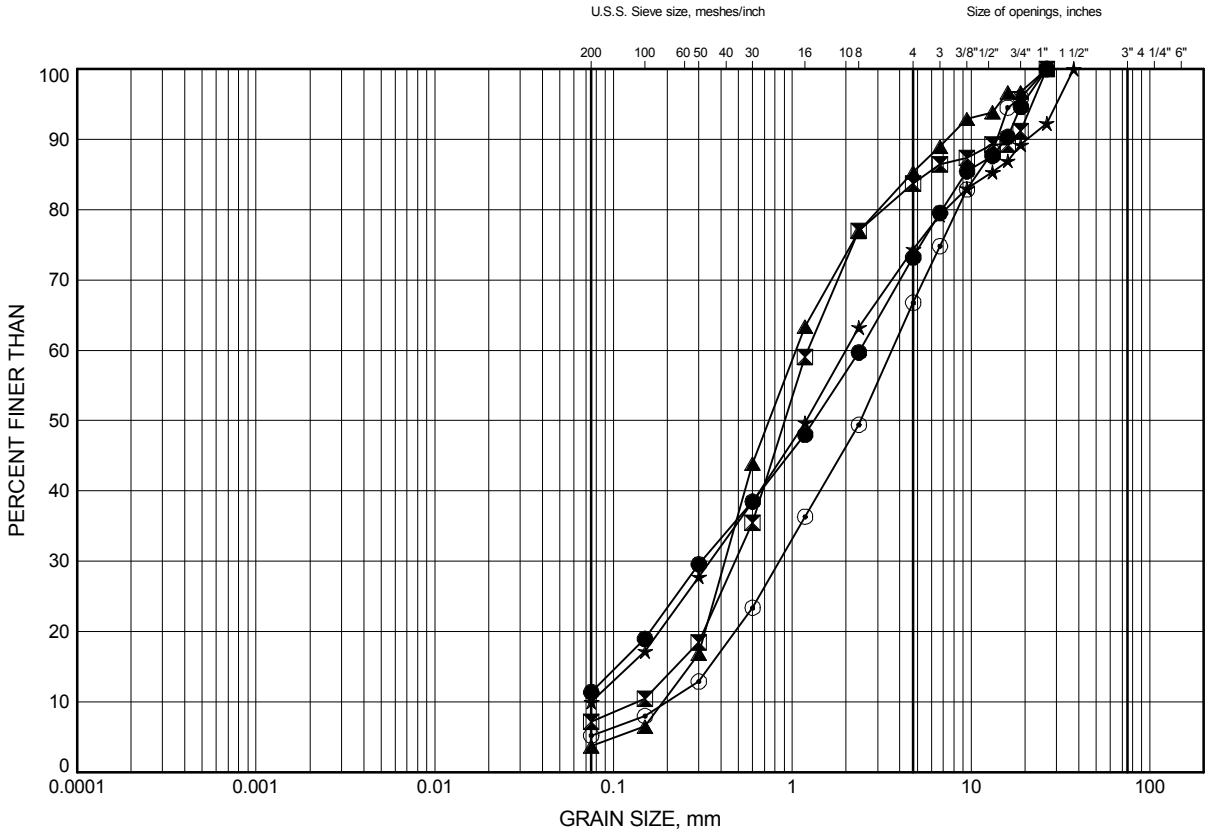
GRAIN SIZE DISTRIBUTION - THURBER 17848_ROOTRIVER4.GPJ 13/2/18

SSM to Goulais River

GRAIN SIZE DISTRIBUTION

FIGURE C2

SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-07	4.88	311.83
⊠	17-09	7.92	305.78
▲	17-10A	2.59	310.73
★	17-11	2.59	311.93
⊙	17-11	10.97	303.55

Date February 2018

GWP# 5181-13-00

THURBER

Prep'd KE

Chkd. FG

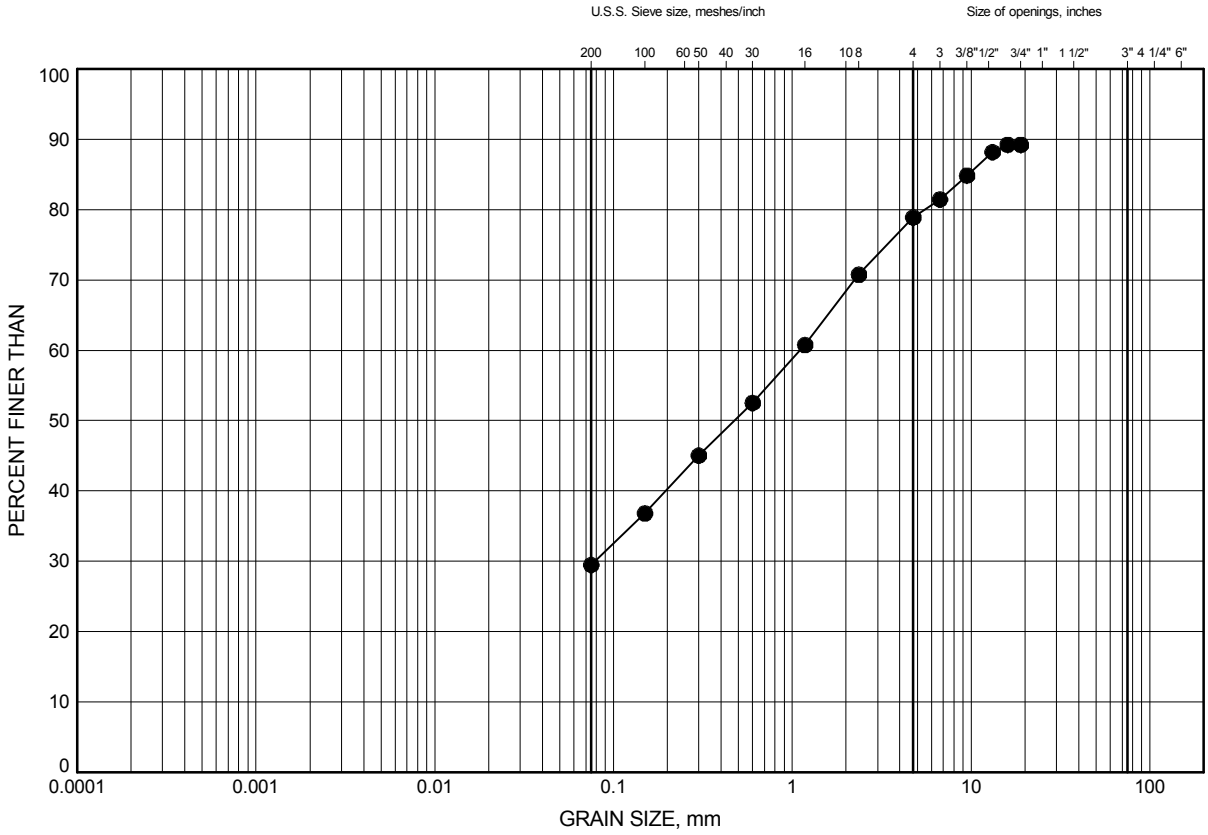
GRAIN SIZE DISTRIBUTION - THURBER 17848_ROOTRIVER4.GPJ 13/2/18

SSM to Goulais River

GRAIN SIZE DISTRIBUTION

FIGURE C3

SILTY SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-09	10.97	302.73

Date February 2018

GWP# 5181-13-00

THURBER

Prep'd KE

Chkd. FG

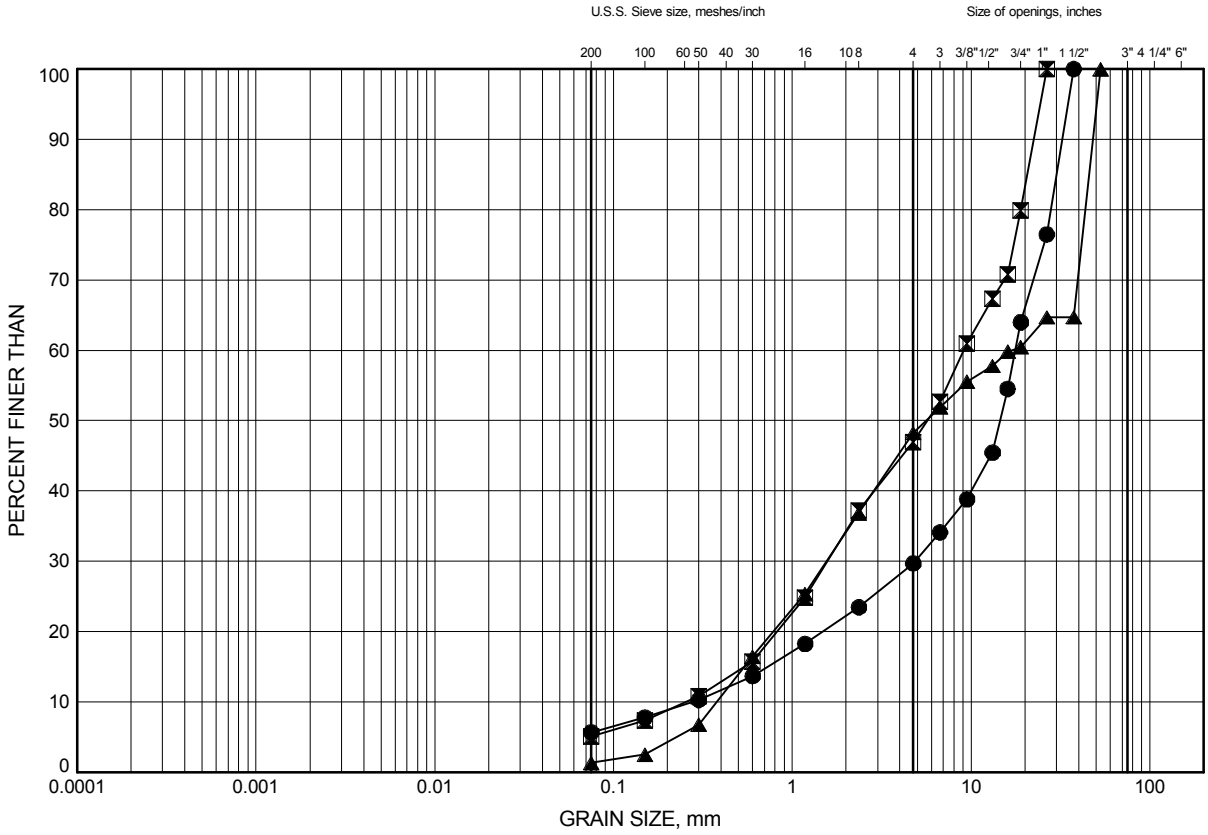
GRAIN SIZE DISTRIBUTION - THURBER 17848_ROOTRIVER4.GPJ 13/2/18

SSM to Goulais River

GRAIN SIZE DISTRIBUTION

FIGURE C4

GRAVEL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-07	9.45	307.26
⊠	17-10A	4.88	308.44
▲	17-12	0.15	313.55

Date February 2018

GWP# 5181-13-00

THURBER

Prep'd KE

Chkd. FG

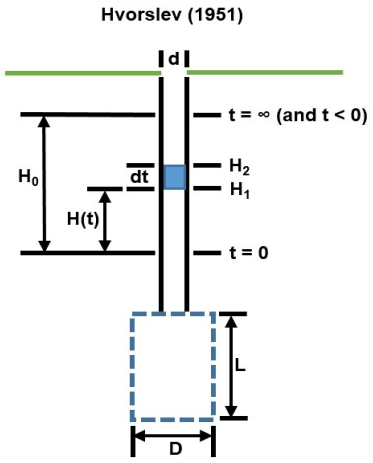
GRAIN SIZE DISTRIBUTION - THURBER 17848_ROOTRIVER4.GPJ 13/2/18

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 17-09		
Static Water Level	0.0	mbgs
Well Diameter (d)	0.051	m
Borehole Diameter (D)	0.114	m
Length of Intake (L)	4.27	m
Initial Unbalanced Head (Ho)	3.13	m
Shape Factor (F)	6.21	

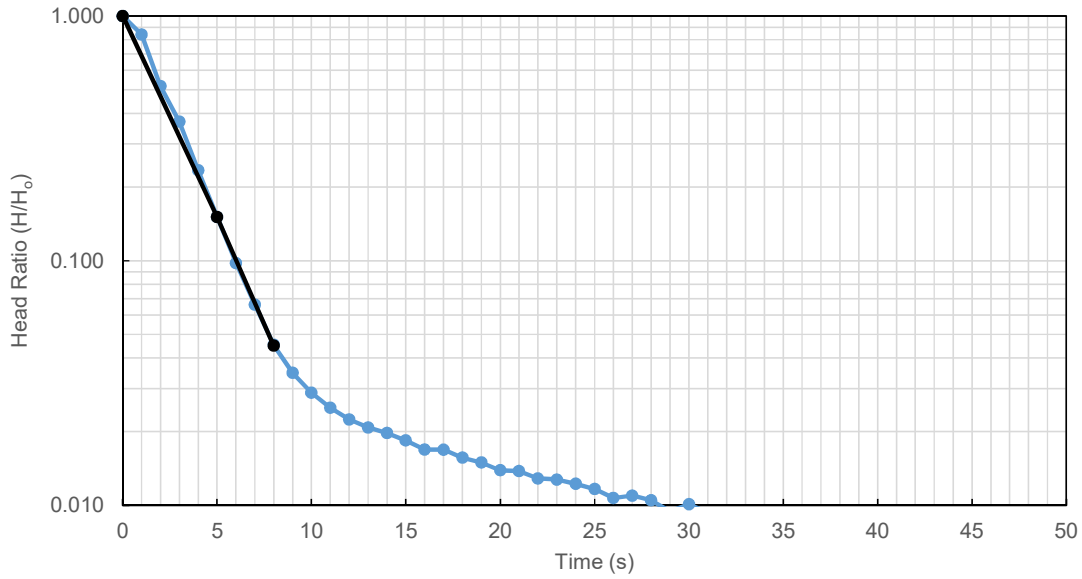


$$K = \frac{A}{F(t_2 - t_1)} \ln\left(\frac{H_1}{H_2}\right)$$

For piezometers of perforated extension of length "L"

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

K = 1.3E-04 m/s



DATE: 12-Feb-18 PREPARED: KE

PROJECT: 17848 CHECKED: FG

Appendix C.3

Bedrock Core Photos

Borehole 17-10B

Run 1 to 3 (of 3)

Elevation 314.3 m to 311.3 m

THURBER ENGINEERING LTD.

Foundation Investigation
Highway 17 SSM to Goulais
Township of Aweres, Ontario

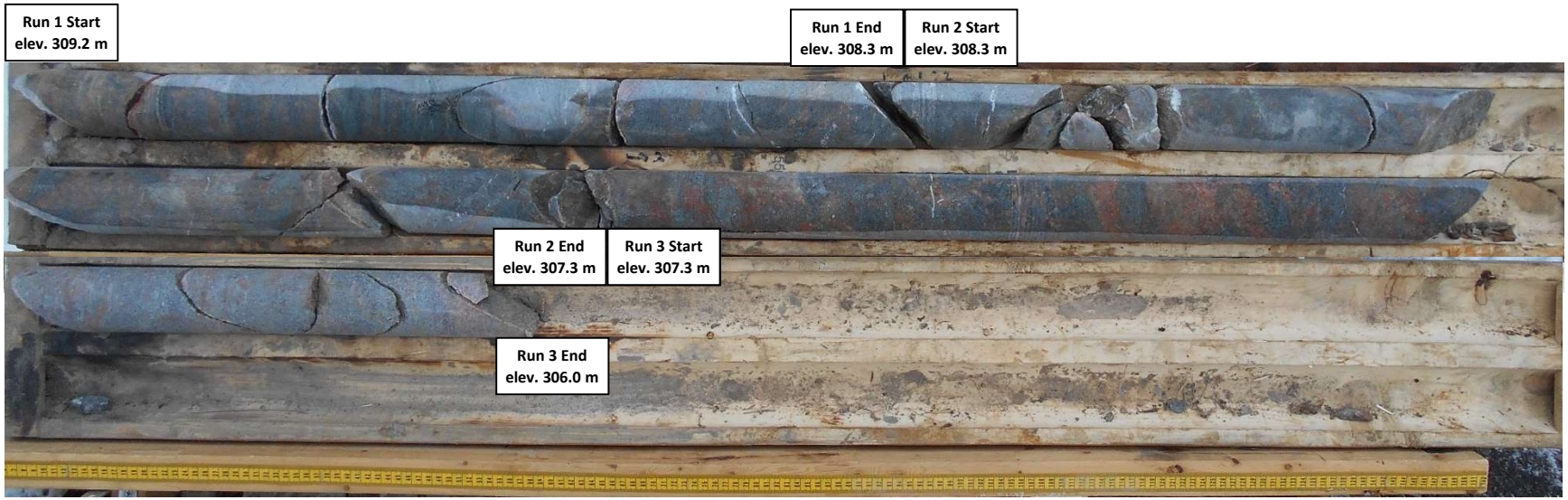
Root River Culvert #4

Project No.: 17848

Borehole B17-10C

Run 1 to 3 (of 3)

Elevation 309.2 m to 306.0 m



THURBER ENGINEERING LTD.

Foundation Investigation
Highway 17 SSM to Goulais
Township of Aweres, Ontario

Root River Culvert #4

Project No.: 17848

Appendix C.4

Analytical Testing Results

PARACEL LABORATORIES LTD.
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www.paracellabs.com

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

PARACEL LABORATORIES LTD.

Order #: 1804148

Certificate of Analysis

Report Date: 29-Jan-2018

Client: Thurber Engineering Ltd.

Order Date: 23-Jan-2018

Client PO:

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			

Qualifier Notes:

Login Qualifiers :

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

Sample Qualifiers :

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

Sample Data Revisions

None

Work Order Revisions / Comments:

None

Other Report Notes:

n/a: not applicable
ND: Not Detected
MDL: Method Detection Limit
Source Result: Data used as source for matrix and duplicate samples
%REC: Percent recovery.
RPD: Relative percent difference.

Soil results are reported on a dry weight basis when the units are denoted with 'dry'.
Where %Solids is reported, moisture loss includes the loss of volatile hydrocarbons.

Appendix D.

Site Photographs

Photo 1. Looking south along Highway 17 at the Root River #4 Culvert crossing (October 10, 2017)

Photo 2. Looking north along Highway 17 at the Root River #4 Culvert crossing (October 10, 2017)

Photo 3. Looking east (upstream) from Root River #4 Culvert (October 10, 2017)

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

Photo 5. Looking west (downstream) from Root River #4 Culvert (October 10, 2017)

Photo 6. Looking at Root River #4 Culvert Outlet (October 10, 2017)

Appendix E.

List of Special Provisions
OPSS Documents Referenced in this Report

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, boulders and shallow bedrock may potentially have an impact on the installation of protection systems at this site. Contractors shall consider this in their equipment selection.

3. Suggested text for a NSSP on “Obstructions”

   “The presence of cobbles, boulders and buried obstruction within the fill and native soils as well as shallow bedrock may have an impact on excavation as well as the installation of protection systems and for coffer dams as this site. Contractors shall consider this in their equipment selection.”