



**THURBER** ENGINEERING LTD.

**FINAL**  
**FOUNDATION INVESTIGATION AND DESIGN REPORT**  
**HIGHWAY 11 BULLEN CREEK CULVERTS, DISTRICT OF MUSKOKA**  
**AGREEMENT NO. 5017-E-0003**  
**Site Nos.: 42X-0034/C1 & 42X-0034/C2**

**G.W.P. 5138-13-00**

Geocres No.: 31E-390

Report to:

**McIntosh Perry Consulting Engineers Limited**

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**PART 1. FACTUAL INFORMATION**

**1 INTRODUCTION**

This section of the report presents the factual findings obtained from a foundation investigation completed at the Highway 11 crossings of Bullen Creek located approximately 0.5 km south of Allensville Road within the District of Muskoka. Thurber Engineering Limited (Thurber) carried out the current field investigation as a sub-consultant to McIntosh Perry Consulting Engineers Ltd. (MPCE) under Assignment No. 5017-E-0003.

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. The following historical foundation investigation report was obtained from the online Geocres library and reviewed in preparation of this report.

Foundation Investigation Report for The Proposed Crossing at Unnamed Creek and Bullen (Lancelot) Creek, Highway 11, Line E (North Bound Lane), District 11 (Huntsville), District of Muskoka, W.P. 149-73-01, Ministry of Transportation and Communications - Ontario (1976). [Geocres 31E-33]

**2 SITE DESCRIPTION**

Separate culverts convey Bullen Creek from west to east beneath the Highway 11 southbound and northbound embankments.

The west culvert (Structure No. 42X-0034/C2) is located under the southbound lanes and has a span width of 6.1 m, a height of 3.6 m and a length of 33 m. The structure is understood to have been constructed in 1956. No wingwalls or headwalls are present at the culvert ends. This culvert is described in the RFP for this assignment as an open footing, rigid frame concrete culvert.

The east culvert (Structure No. 42X-0034/C1) is located under the northbound lanes and has a span width of 6.1 m, a height of 3.0 m and a length of 38.4 m. The structure is understood to have been constructed in 1978. No wingwalls or headwalls are present at the culvert ends. This culvert is described in the RFP as a rigid frame concrete box culvert. The

historic foundation report recommends a closed box culvert or an open bottom culvert supported on piles for this site.

The creek bed elevations are 281.0 m at the inlet of the west culvert and 280.6 m at the outlet of the east culvert.

At the location of the culverts, Highway 11 is a four-lane divided highway with a rural cross-section and paved shoulders. The Highway 11 fill height above the culverts is approximately 2.8 m with the road surfaces at approximate elevations 287.4 and 287.3 m for the southbound and northbound lanes, respectively. The existing embankment slopes are inclined at approximately 2H:1V. Near the culverts, steel guiderails with steel posts are present along both the outside and median shoulders.

The land adjacent to the highway is vegetated with grasses, shrubs and trees. Traffic volumes on this section of Highway 11 are understood to be 19,700 AADT (2016).

Select photographs showing the existing conditions in the area of the culverts at the time of the field investigation are included in Appendix D for reference.

### **3 SITE INVESTIGATION AND FIELD TESTING**

The site investigation and field testing program was carried out between April 19<sup>th</sup> and April 21<sup>st</sup>, 2018. The field investigation consisted of advancing four boreholes identified as 18-1 through 18-4. The drilling was carried out using a truck mounted CME 55 drill rig. Prior to commencement of drilling, utility clearances were obtained in the vicinity of the borehole locations.

Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). A thin walled (Shelby) tube sample was attempted at 6.1 m depth in Borehole 18-2, however a soil sample was not recovered. The boreholes were all sampled to 18.4 m (elev. 268.7 to 269.1 m) below the existing ground surface.

The drilling and sampling operations were supervised on a full time basis by an experienced member of Thurber's technical staff. The drilling supervisor logged the boreholes and processed the recovered soil samples for transport to Thurber's Ottawa geotechnical laboratory for further examination and testing.

The approximate borehole locations are shown on the Borehole Locations and Soil Strata Drawing included in Appendix A. The coordinates and elevation of the boreholes are provided on this drawing and on the individual Record of Borehole sheets. The northing and easting (MTM zone 10), elevation, and termination depth of the boreholes are summarized below in Table 3-1. The borehole elevations were surveyed relative to benchmark VCP 313 (elev. 285.649 m) provided by MPCE, with a Nikon-AP-8 with an accuracy of +/- 1.5 mm. Horizontal locations were measured relative to existing site features.

**Table 3-1: Borehole Summary**

<b>Borehole No.</b>	<b>Drilled Location</b>	<b>Northing (m)</b>	<b>Easting (m)</b>	<b>Ground Surface Elevation (m)</b>	<b>Termination Depth (m)</b>
18-1	SB Lane 1, north of culvert	5 012 371.2	320 684.5	287.4	18.4
18-2	SB Lane 1, south of culvert	5 012 358.9	320 682.7	287.5	18.4
18-3	NB Lane 1, north of culvert	5 012 366.0	320 714.7	287.2	18.4
18-4	NB Lane 1, south of culvert	5 012 354.2	320 713.0	287.3	18.4

Following completion of the field investigation the boreholes were backfilled in accordance with MOE requirements (O.Reg. 903 as amended). All boreholes were backfilled with granulars within the depth of pavement structure and capped with 150 mm of cold patch asphalt to reinstate the traveling surface.

#### **4 LABORATORY TESTING**

The recovered soil samples were subjected to visual identification and to natural moisture content determination. Selected samples were also subjected to gradation analysis (hydrometer and/or sieve) and Atterberg Limit testing. The results of these tests are summarized on the Record of Borehole sheets included in Appendix B. One sample from the native silt deposit in Borehole 18-2 was selected for organic content testing. One sample of soil recovered from within each of Boreholes 18-1 and 18-4 was selected and submitted for analytical testing of corrosivity parameters and sulphate content. All laboratory test results from the field investigation are provided in Appendix C.

#### **5 DESCRIPTION OF SUBSURFACE CONDITIONS**

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. A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following paragraphs. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description for interpretation of the site conditions. It must be recognized that the soil and groundwater conditions may vary between and beyond borehole locations.

The historic boreholes from Geocres Report 31E-33 have also been included in Appendix B and their locations indicated on Drawing No. 1497301-B in Appendix A. The locations and ground surface elevation for these boreholes are approximate. It is expected that conditions have changed due to the roadway and culvert construction that have occurred since these holes were drilled in 1974, therefore the historic documents have not been included in the following descriptions.

In general terms, the site was found to be underlain by a pavement structure, sand or silt fill overlying, native silt and sandy silt deposits. The native silt directly below the fill was noted to contain organics. Bedrock was not encountered within the depth of the current investigation.

## **5.1 Fill**

### **5.1.1 Asphalt**

All boreholes were drilled through the existing Highway 11 embankment and encountered a layer of asphalt with a thickness of 200 to 210 mm.

### **5.1.2 Pavement Structure**

Below the asphalt a layer of granular pavement material consisting of sand some gravel to gravel with sand was encountered. The underside of the pavement granular was at 0.4 to 1.5 m (elev. 285.7 to 287.0 m) below the existing roadway.

Two SPT tests were conducted in this fill with N-values of 9 and 15 blows indicating a relative density of loose to compact.

Recorded moisture contents ranged from 3 to 13%. The results of a grain size analysis conducted on a single sample of the pavement granular are summarized below and are illustrated on Figure C1 in Appendix C.

Soil Particle	Percentage (%)
Gravel	37
Sand	62
Silt	1
Clay	

### **5.1.3 Embankment Fill: Silt**

Below the pavement structure in Boreholes 18-3 and 18-4 was a layer of fill consisting predominantly of silt some clay. The underside of the silt fill was at 3.2 and 3.5 m (elev. 283.9 and 283.8 m) below the existing roadway surface in Boreholes 18-3 and 18-4, respectively.

The SPT tests conducted in this fill gave N-values ranging from 13 to 23 blows indicating a relative density of compact.

Recorded moisture contents ranged from 14 to 23%. An Atterberg Limits test indicated that the material is non-plastic. The results of grain size analysis conducted on a single sample of the silt embankment fill are summarized below and are illustrated on Figure C2 in Appendix C.

Soil Particle	Percentage (%)
Gravel	0
Sand	1
Silt	86
Clay	13

#### 5.1.4 Embankment Fill: Sand

Below the pavement structure in Boreholes 18-1 and 18-2 and below the silt fill in Boreholes 18-3 and 18-4 was a layer of fill consisting of sand with silt and gravel to silty sand some gravel. Occasional cobbles were noted within this layer. The fill had a thickness of 3.1 to 5.4 m and an underside depth of 4.4 to 6.6 m (elev. 280.7 to 283.0 m) below the existing roadway surface.

The SPT tests conducted in this fill gave typical N-values ranging from 2 to 30 blows indicating a relative density of very loose to compact. A single N-value equivalent to the weight of hammer was noted in Borehole 18-4.

Recorded moisture contents ranged from 4 to 16%. The results of grain size analyses conducted on four samples of the sand fill are summarized below and are illustrated on Figure C2 in Appendix C.

Soil Particle	Percentage (%)
Gravel	14 - 27
Sand	62 - 75
Silt	6 - 17
Clay	

## 5.2 Silt (ML) to Sandy Silt with Organics/Wood

Directly below the embankment fill in all boreholes was a native silt to sandy silt material. Organics and/or wood fragments were encountered within this layer. The thickness of this layer ranged from 1.1 to 2.0 m with a base elevation ranging from 279.0 to 281.4 m.

The SPT tests conducted in this layer gave N-values ranging from 1 to 13 indicating a relative density of very loose to compact.

Recorded moisture contents ranged from 22 to 55%. Organic content testing was completed on one sample of the silt from Borehole 18-2 with a result of 7.5% organic content. The Atterberg Limit testing indicated the silt with organics was non-plastic. The results of grain size analyses conducted on four samples of the silt to sandy silt are summarized below and illustrated on Figure C3 in Appendix C.



Soil Particle	Percentage (%)
Gravel	0 - 1
Sand	6 - 46
Silt	50 - 83
Clay	3 - 11

### 5.3 Silt (ML) to Sandy Silt (ML)

All boreholes encountered a layer of silt with varying amounts of sand below the organic silt layer. Boreholes 18-1, 18-3, and 18-4 were terminated within this layer at a depth of 18.4 m with corresponding termination elevations ranging from 268.7 to 269.1 m. The thickness of this layer in Borehole 18-2 was 11.3 m with a base elevation 270.1 m.

The SPT tests conducted in this layer gave N-values ranging from weight of hammer (WH) to 26 indicating a relative density of very loose to compact. A thin walled (Shelby) tube sample was attempted in Borehole 18-2 however no material was recovered.

Recorded moisture contents ranged from 17 to 31%. Atterberg Limit testing on seven samples all indicated the material is non-plastic. The results of grain size analyses conducted on seven samples of the silt are summarized below and illustrated on Figures C4 and C5 in Appendix C.

Soil Particle	Percentage (%)
Gravel	0 - 1
Sand	0 - 36
Silt	64 - 95
Clay	0 - 10

### 5.4 Sand (SP)

A 0.8 m thick deposit of sand was encountered within the silt deposit in Borehole 18-2 at an elevation of 276.2 m. Borehole 18-2 was terminated within a deeper sand layer at a termination elevation of 269.0 m.

The SPT N-values in the sand layers were 12 and 17 blows indicating a relative density of compact.

The moisture content of the samples tested was 19%.

### 5.5 Bedrock

Bedrock was not encountered within the depth of the current investigation. Granitic gneiss bedrock was reported in historical Borehole 4, from Geocres Report No. 31E-33, at approximate elevation 265.9 m which corresponds to an approximate depth of 21.5 m below the existing pavement surface.

## 5.6 Groundwater

Accurate water levels could not be recorded in the open boreholes due to water being introduced as part of the drilling operations, however an unstabilized water level was recorded in Borehole 18-4 at a depth of 4.7 m (elev. 282.6 m) prior to switching drilling methods. It is expected that the groundwater level is likely to reflect the water level in the creek. The water level of Bullen's Creek was recorded at an elevation 281.5 m on April 19<sup>th</sup>, 2018.

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

## 5.7 Analytical Testing

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

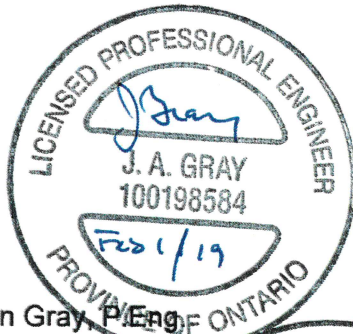
Borehole (sample)	Depth (mbgs)	Sulphate (µg/g)	pH (-)	Resistivity (Ohm-cm)	Conductivity (µS/cm)	Chloride (µg/g)	Sulphide %
18-1 (SS11)	7.1 - 7.7	200	7.44	2,500	400	23	0.40
18-4 (SS8)	5.3 - 5.9	5	6.10	2,130	469	291	<0.02

## 6 MISCELLANEOUS

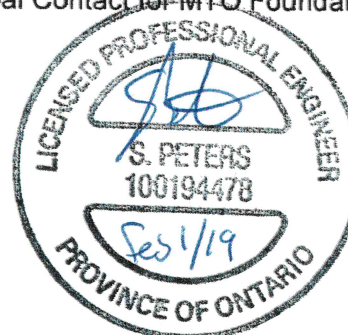
Borehole locations were selected by Thurber relative to the culvert and existing site features. The as-drilled locations and ground surface elevation of the boreholes were measured by Thurber following completion of the field program. Base plan drawings and survey benchmarks were provided by MPCE.

George Downing Estate Drilling Ltd. of Hawkesbury, Ontario supplied and operated the drilling equipment to conduct the drilling, soil sampling, in-situ testing and borehole decommissioning of the boreholes. The field investigation was supervised on a full-time basis by Miss Katya Edney P.Eng. of Thurber. Overall supervision of the field investigation program was provided by Mr. Stephen Peters, P.Eng.

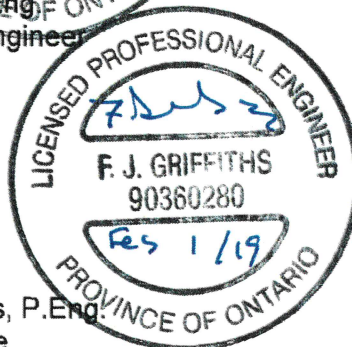
Routine geotechnical laboratory testing was completed by Thurber's laboratory in Ottawa, Ontario. Organic content testing was completed by Stantec's laboratory in Ottawa, Ontario. Analytical testing was completed by Paracel Laboratories in Ottawa, Ontario. Interpretation of the factual data and preparation of this report were carried out by Justin Gray, P.Eng. and Mr. Stephen Peters P.Eng. The report was reviewed by Dr. Fred Griffiths, P.Eng and Dr. P.K. Chatterji, P.Eng. a Designated Principal Contact for MTO Foundation Projects.



Justin Gray, P.Eng.  
Geotechnical Engineer



Stephen Peters, P.Eng.  
Associate  
Geotechnical Engineer



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



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

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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 works at the Highway 11 crossings of Bullen Creek located approximately 0.5 km south of Allensville Road within the District of Muskoka. The discussion and recommendations presented in this report are based on the information provided by McIntosh Perry Consulting Engineers Ltd. (MPCE) 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 embankment fill overlying silt deposits. Based on historical Geocres Report No. 31E-33, bedrock was encountered or inferred at depths of more than 21 m below the current road surface. The water level of Bullen Creek was recorded during the current field investigation at an elevation of 281.5 m on April 19<sup>th</sup>, 2018.

**7.1 Proposed Structure Rehabilitations**

At the time of preparation of this final Foundation Investigation and Design Report, the proposed rehabilitation of the culverts as described in the RFP and shown on the General Arrangement Drawing, dated December 2018, is to include the repair of deteriorated areas of concrete inside the culvert, waterproofing of the top slab and filling a void beneath the south footing of the west culvert with tremie concrete.

**8 GEOTECHNICAL RECOMMENDATIONS**

Cover over the culverts is estimated to be approximately 2.8 m. For each of the two embankments, temporary protection systems are being considered to allow excavation to

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the top of the culvert in one lane and shoulder while traffic is directed to the other lane on Highway 11. To support the design team with the rehabilitation of the Bullen Creek culverts and in accordance with the RFP, geotechnical recommendations are provided herein for temporary protection systems and reinstatement of the highway embankments.

## **8.1 Excavation**

All temporary excavation must be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of OHSA, the existing fills above the water table may be classified as Type 3. The existing fills and soils below the water table are classified as Type 4 soil. New granular fill placed and compacted as part of the culvert rehabilitation contract in accordance with OPSS.PROV 501 can be considered as Type 2 soil.

At locations where there are space restrictions, the excavations will need to be carried out within a protection system. Further discussion is presented in Section 8.2.

## **8.2 Temporary Protection Systems**

An unsupported open excavation may be feasible for shallow depths by making use of the existing shoulder and shifting the traffic away from the excavation. A temporary protection system consisting of an adequate temporary side slope and jersey barrier walls is considered a possible option.

Temporary Protection Systems may be required during construction and 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. An interlocking sheet pile system is likely the preferred approach. Additional bracing may be required in areas with minimal penetration, such as where spanning across the culvert.

Cobbles were noted within the fill, an NSSP should be included in the contract describing potential obstructions, see suggested wording in Appendix E.

Loose native silt deposits were encountered below the embankment soils. These loose deposits are sensitive to disturbance and vibrations. Using vibratory methods will induce settlement of both the culvert footings and embankment. If the Temporary Protection System extends below the existing fill materials, vibratory equipment should not be permitted at this site for installation or removal of the temporary protections system. The sheet piles could be left in place provided they are cut-off in accordance with OPSS. PROV 539. Suggested wording for an NSSP is provided in Appendix E. However, if the Temporary Protection Systems remain within the fill materials, vibratory equipment is permitted at this site for installation or removal of the system.

Typical lateral earth pressure coefficients for the soils encountered at this site are provided in Section 8.3.

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 designer must undertake an assessment of the foundation soils ability

to support the weight of cranes and/or other construction equipment used during the installation of the protection system and the culvert rehabilitation works.

### 8.3 Lateral Earth Pressures

The lateral earth pressures parameters provided in Table 8-1 and in the text 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 vertical 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)
$\gamma$	=	unit weight of retained soil (must adjust 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. Static Earth Pressure Coefficients with Level Backfill and a Vertical Wall**

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 Sand Fill $\phi = 30^\circ$ , $\gamma = 21.0 \text{ kN/m}^3$	Existing Silt Fill and Native Silt $\phi = 28^\circ$ , $\gamma = 19.0 \text{ kN/m}^3$
Active, $K_A$ (Movement away from Soil Mass)	0.27	0.31	0.33	0.36
At Rest, $K_O$ (Non-Yielding Wall)	0.43	0.47	0.50	0.53
Passive, $K_P$ (Movement towards Soil Mass)	3.7	3.3	3.0	2.8
Soil Group(*)	"medium dense sand"	"loose to medium dense sand"	"loose sand"	"loose sand"

Note: (\*) for use with Figure C6.16 of the Commentary to the CHBDC.

The parameters in the table above correspond to full mobilization of active and passive earth pressures and require certain relative movements between a vertical 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 sloped behind the walls, the coefficients provided in Table 8-1 are not applicable.

## **8.4 Embankment Design and Reinstatement**

### **8.4.1 Embankment Reconstruction**

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

Culvert backfill above the granular cover and below the pavement sub-base layer should be in accordance with OPSS 902 and consist of material meeting the requirements of OPSS Select Subgrade Material or better and should be compacted in regular lifts as per OPSS.PROV 501.

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 culvert. 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).

### **8.4.2 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 culvert rehabilitation and therefore no permanent grade raise or embankment widening is required. 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 permanent grade raise is anticipated along the alignment of Highway 11, negligible settlement in the soils beneath the embankment is expected to occur.

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

### 8.5 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 5.7 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.

### 8.6 Surface and Groundwater Control

Excavation to expose the tops of the culverts, if required for waterproofing, is not expected to intersect either groundwater or creek flow. Culvert backfilling and embankment reinstatement if required as part of the culvert rehabilitation must be carried out in the dry. The Contractor must be prepared to control the surface water flow at this site to permit construction in a dry and stable excavation. Temporary surface water control measures will be required to remain operational during construction until the culvert rehabilitation is completed and backfilled.

A temporary flow passage system will be required while repair works are carried out within the culverts. It is anticipated that flow into the culverts will be blocked at the inlet inside the culvert with a sand bag or aqua dam and water will be pumped through the work zone. The contract should include SP 517F01 for the temporary flow passage system with “No” inserted for fill-in \*\*\*\*\*.

Dewatering will be required to allow the void noted under the south footing of the west culvert to be filled. A sump and pump system is anticipated to be sufficient. The contract should include SP 517F01 for the dewatering system with “No” inserted for fill-in \*\*\*\*\* and “N/A” inserted for \*\*\*\*\*.

### 8.7 Scour Protection and Erosion Control

Based on the subsurface conditions encountered at the drilled locations through the embankment at this site, the existing and proposed embankment materials are considered to have low to high susceptibility to erosion as per the Wischmeier Nomograph. The native soils at or below the creek level are considered to have moderate to high 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.

## **9 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 were observed within the embankment fill in all boreholes.
- 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 fill.

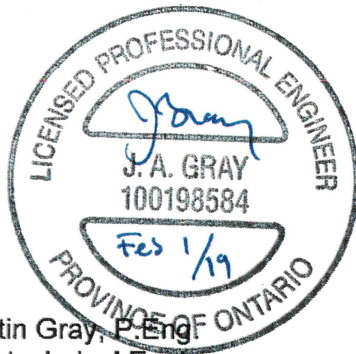
The successful performance of the rehabilitated culvert will depend largely upon good workmanship and quality control during construction.

## 10 CLOSURE

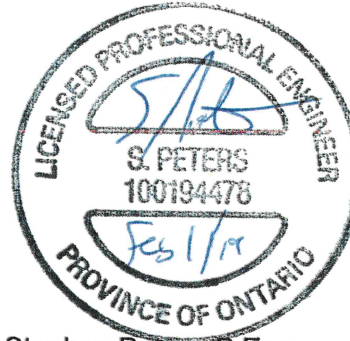
Engineering analysis and preparation of this report were carried out by Mr. Justin Gray, P.Eng. and Mr. Stephen Peters, P.Eng. The report was reviewed by Dr. Fred Griffiths, P.Eng and Dr. P.K. Chatterji, P.Eng a Designated Principal Contact for MTO Foundation Projects.

Thurber Engineering Ltd.

Report Prepared By:



Justin Gray, P.Eng.  
Geotechnical Engineer



Stephen Peters, P.Eng.  
Associate  
Geotechnical Engineer



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



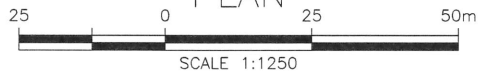
Dr. P.K. Chatterji, P.Eng.  
Review Principal  
Senior Geotechnical Engineer

FINAL

**Appendix A.**

**Borehole Location Plan and Stratigraphic Drawings**





LICENSED PROFESSIONAL ENGINEER  
 P. K. CHATTERJI  
 14000  
 PROVINCE OF ONTARIO  
 Feb 1/19

A circular professional engineer seal for the Province of Ontario. The outer ring contains the text "LICENSED PROFESSIONAL ENGINEER" at the top and "PROVINCE OF ONTARIO" at the bottom. In the center, the name "F. J. GRIFFITHS" and the number "90360280" are printed. Handwritten in blue ink are a stylized signature above the name, the date "Feb 1/19" below the number, and a wavy line above the date.





SHEET  
74

A diagram of a trapezoid with a horizontal top base and a horizontal bottom base. A vertical line segment connects the midpoints of the top and bottom bases, dividing the trapezoid into three regions: a central rectangle and two triangles on either side.

**THURBER** ENGINEERING LTD.



KEYPLAN  
LEGEND

	Borehole
	Borehole & 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

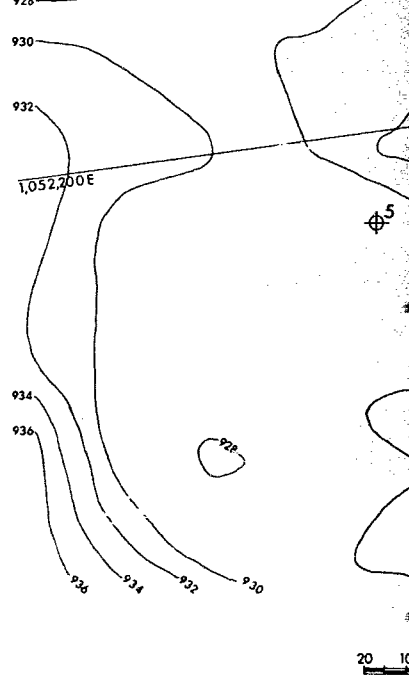
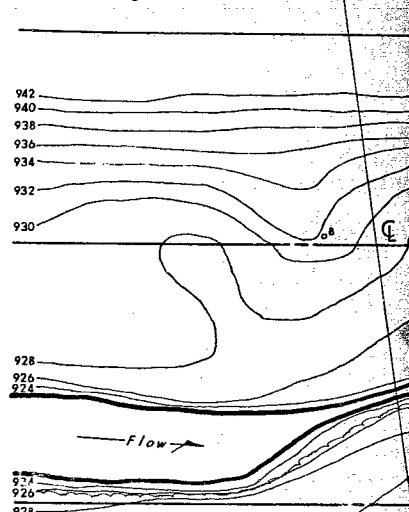
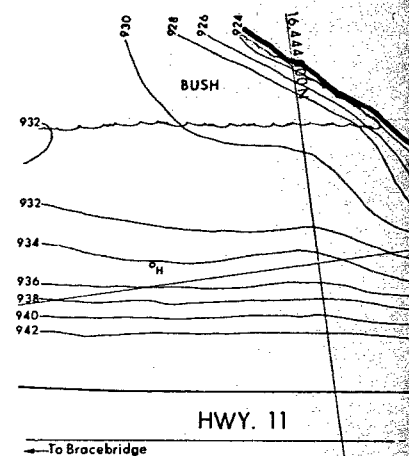
NO	ELEVATION	NORTHING	EASTING
18-1	287.4	5 012 371.2	320 684.5
18-2	287.5	5 012 358.9	320 682.7
18-3	287.2	5 012 366.0	320 714.7
18-4	287.3	5 012 354.2	320 713.0

-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 10.

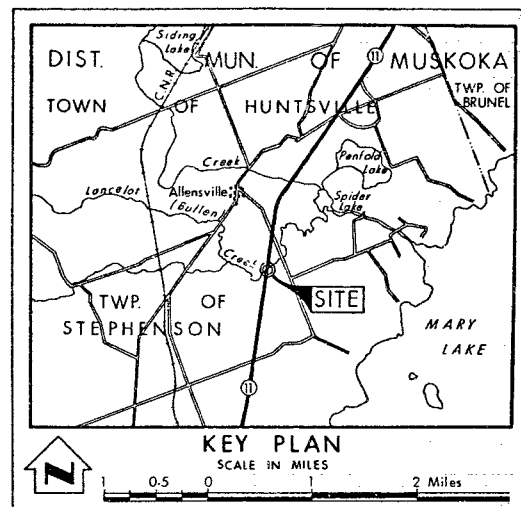
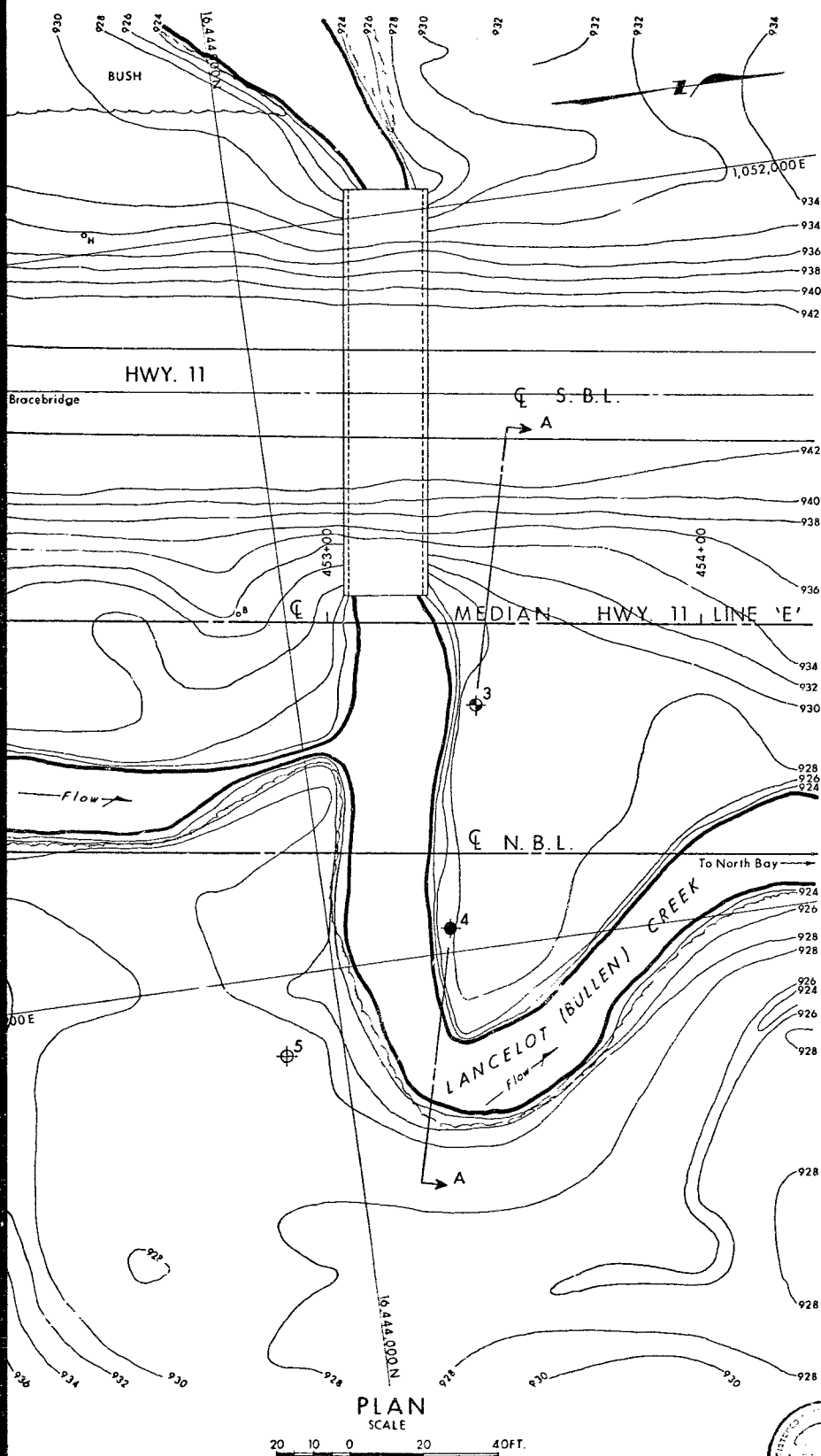
**GEOCRES No. 31E-390**

[illegible]



SCALE FOR SECTION &amp; PROFILES





### LEGEND

- Bore Hole
- ⊕ Cone Penetration Test
- ⊕ Bore Hole & Cone Test
- ⊕ Water Levels established at time of field investigation, Nov. 1974
- ⊕ Head ARTESIAN CONDITIONS Encountered

NO.	ELEVATION	STATION	OFFSET
3	929.2	453+80	22' RT.
4	928.8	453+34	82' RT.
5	928.3	452+90	117' RT.

### NOTE FOR CONTRACT DOCUMENT

The complete foundation investigation report for this structure may be examined at the Structural Office and Foundations Office, Downsview, and at the HUNTSVILLE District Office.

### NOTE

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

REVISIONS	DATE	BY	DESCRIPTION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO  
ENGINEERING SERVICES BRANCH—GEOTECHNICAL OFFICE

### LANCELOT CREEK (BULLEN CREEK)

HIGHWAY NO. 11 LINE 'E' DIST. NO. 11  
Dist. Mun. of MUSKOKA Town of HUNTSVILLE  
TWP. STEPHENSON LOT 25 CON X

### BORE HOLE LOCATIONS & SOIL STRATA

SUSWD A P	CHECKED	WP NO. 149-73-01	DRAWING NO.
DRAWN	CHECKED	W.O. NO.	1497301-B
DATE Dec. 18, 1974	SITE NO.	BRIDGE DRAWING NO.	
APPROVED	CON. NO.		

**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):**

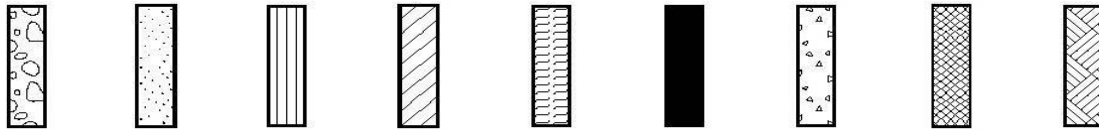
Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to an "A" size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone 0.3 m into the soil. The 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 18-1

1 OF 2

METRIC

GWP# 5138-13-00 LOCATION Lat: 45.251121°, Long: -79.297634° Bullen Creek, MTM Zone 10: N 5 012 371.2 E 320 684.5 ORIGINATED BY KE/RH  
 HWY 11 BOREHOLE TYPE CME55 Truck with HSA / NW Casing COMPILED BY KE  
 DATUM Geodetic DATE 2018.04.20 - 2018.04.21 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
287.4 0.0	Southbound Lane ASPHALT (200 mm)												
287.8 0.4	SAND with gravel grey, moist FILL		1	BS	N/A								
286.6 0.8	GRAVEL with sand grey, moist FILL		2	BS	N/A								
			3	SS	27								
	SAND with silt and gravel compact to very loose, brown, moist occasional cobbles FILL		4	SS	7								
			5	SS	7								
	moist to wet below 3.1 m		6	SS	3								
			7	SS	10								
			8	SS	8								
	- becoming red-brown below 5.3 m		9	SS	20								
281.2	wet below 6.1 m												
6.2	SANDY SILT (ML) trace wood fragments loose, grey, wet		10	SS	4								
	- trace clay pockets below 7.1 m		11	SS	7								
279.3													
8.2	SILT (ML) to SILT (ML) trace sand compact to very loose, grey, wet		12	SS	19								

Continued Next Page

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

DOUBLE LINE 20244\_BULLEN CREEK.GPJ 2012TEMPLATE(MTO).GDT 1/2/19

# RECORD OF BOREHOLE No 18-1

2 OF 2

METRIC

GWP# 5138-13-00 LOCATION Lat: 45.251121°, Long: -79.297634° Bullen Creek, MTM Zone 10: N 5 012 371.2 E 320 684.5 ORIGINATED BY KE/RH  
 HWY 11 BOREHOLE TYPE CME55 Truck with HSA / NW Casing COMPILED BY KE  
 DATUM Geodetic DATE 2018.04.20 - 2018.04.21 CHECKED BY SP

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 <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)					
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE				W P                      W                      W L					
	Continued From Previous Page							20	40	60	80	100					
269.1 18.4	SILT (ML) to SILT (ML) trace sand compact to very loose, grey, wet		13	SS	13		277										0 8 88 4 non-plastic
							276										
			14	SS	16												
							275										
			15	SS	11		274										
							273										
			16	SS	14												
							272										
			17	SS	WH		271										
							270										
						18	SS	2									
	End of Borehole																

DOUBLE LINE 20244\_BULLEN CREEK.GPJ 2012TEMPLATE(MTO).GDT 1/2/19

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

# RECORD OF BOREHOLE No 18-2

1 OF 2

METRIC

GWP# 5138-13-00 LOCATION Lat: 45.251011°, Long: -79.297658° Bullen Creek, MTM Zone 10: N 5 012 358.9 E 320 682.7 ORIGINATED BY KE/RH  
 HWY 11 BOREHOLE TYPE CME55 Truck with HSA / NW Casing COMPILED BY KE  
 DATUM Geodetic DATE 2018.04.21 - 2018.04.21 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						WATER CONTENT (%)			
287.5	Southbound Lane																
0.0	ASPHALT (210 mm)																
0.2	SAND with gravel brown, moist FILL  SAND with silt and gravel compact to loose, brown, moist occasional cobbles FILL		1	BS	N/A										37 62 1 (SH+CL)		
287.0																	
0.4																	
			2	SS	25												
			3	SS	19												
			4	SS	10												
			5	SS	7												
			6	SS	4												
283.0																	
4.4	SILT (ML) with organics trace sand very loose, grey-brown, moist																
282.5															0 6 83 11 non-plastic		
5.0	SILT (ML) with organics very loose, black-brown, moist		7	SS	1										organic content 7.5%		
281.4																	
6.1	SILT (ML) compact, grey, wet trace wood fragments		8	ST	PUSH												
				9	SS	15										1 1 88 10 non-plastic	
			10	SS	15												

## METRIC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		NATURAL MOISTURE CONTENT	UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)	GR SA SI CL	
	Continued From Previous Page														
276.2	SILT (ML) compact, grey, wet		11	SS	14										
275.3	SAND (SP) compact, grey-brown, wet		12	SS	12										
272.7	SILT (ML) trace sand compact, wet		13	SS	18										
270.1	SANDY SILT (ML) compact to very loose, grey, wet		14	SS	13										
269.0	SAND (SP) compact, grey-brown, wet		15	SS	3										
269.0	End of Borehole		16	SS	17										

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity

# RECORD OF BOREHOLE No 18-3

1 OF 2

METRIC

GWP# 5138-13-00 LOCATION Lat: 45.251074°, Long: -79.297249° Bullen Creek, MTM Zone 10: N 5 012 366.0 E 320 714.7 ORIGINATED BY KE/RH  
 HWY 11 BOREHOLE TYPE CME55 Truck with HSA / NW Casing COMPILED BY KE  
 DATUM Geodetic DATE 2018.04.19 - 2018.04.20 CHECKED BY SP

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 <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				GR	SA	SI	CL
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL      × LAB VANE											
287.2	Northbound Lane																		
0.0	ASPHALT (200 mm)						287												
286.8	GRAVEL with sand																		
0.4	grey, moist FILL		1	BS	N/A														
	SAND, trace to some gravel																		
	compact, brown, moist FILL		2	SS	9														
285.9							286												
1.3	SILT compact, grey, moist FILL																		
			3	SS	16														
							285												
			4	SS	15														
283.9							284												
3.2	SILTY SAND, some to with gravel very loose to dense, brown, moist occasional cobbles FILL		5	SS	30														
			6	SS	7		283												
			7	SS	14		282												
	wet below 5.5 m		8	SS	2		281												
280.8																			
6.4	SANDY SILT (ML) with organics with wood fragments very loose, grey, wet		9	SS	2		280												
			10	SS	13		279												
279.6																			
7.5	SILT (ML) compact to loose, grey, wet																		
							278												
			11	SS	23														

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10  
(%) STRAIN AT FAILURE



# RECORD OF BOREHOLE No 18-3

2 OF 2

METRIC

GWP# 5138-13-00 LOCATION Lat: 45.251074°, Long: -79.297249° Bullen Creek, MTM Zone 10: N 5 012 366.0 E 320 714.7 ORIGINATED BY KE/RH  
 HWY 11 BOREHOLE TYPE CME55 Truck with HSA / NW Casing COMPILED BY KE  
 DATUM Geodetic DATE 2018.04.19 - 2018.04.20 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT      NATURAL LIMIT      MOISTURE      LIQUID CONTENT      LIMIT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR   SA   SI   CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)					
								20   40   60   80   100				W   P                      W                      W   L					
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL      × LAB VANE									
Continued From Previous Page																	
	SILT (ML) compact to loose, grey, wet		12	SS	10		277									0   2   95   3 non-plastic	
							276										
			13	SS	6		275										
							274										
			14	SS	8		273										
							272										
			15	SS	20		271										
							270										
			16	SS	8		269										
268.7	End of Borehole																
18.4																	

DOUBLE LINE 20244\_BULLEN CREEK.GPJ 2012TEMPLATE(MTO).GDT 1/2/19

# RECORD OF BOREHOLE No 18-4

1 OF 2

METRIC

GWP# 5138-13-00 LOCATION Lat: 45.250968°, Long: -79.297271° Bullen Creek, MTM Zone 10: N 5 012 354.2 E 320 713.0 ORIGINATED BY KE/RH  
 HWY 11 BOREHOLE TYPE CME55 Truck with HSA / NW Casing COMPILED BY KE  
 DATUM Geodetic DATE 2018.04.19 - 2018.04.19 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
287.3	Northbound Lane												
0.0	ASPHALT (200 mm)												
286.9	GRAVEL with sand												
0.4	grey FILL		1	BS	N/A								
	SAND, some gravel compact, brown, moist FILL		2	SS	15								
285.7													
1.5	SILT compact, grey, moist FILL		3	SS	23								
			4	SS	13								
	- becoming sandy below 3.0 m		5	SS	24								
283.8													
3.5	SAND with silt and gravel very loose to compact, brown, moist occasional cobbles FILL		6	SS	17								
			7	SS	26								
	wet below 5.5 m		8	SS	WH								
280.7			9	SS	8								
6.6	SANDY SILT (ML) with organics trace gravel, trace wood fragments very loose, grey, wet												
			10	SS	2								
279.0													
8.2	SILT (ML) compact, grey, wet												
			11	SS	18								

DOUBLE LINE 20244\_BULLEN CREEK.GPJ 2012TEMPLATE(MTO).GDT 1/2/19

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 18-4

2 OF 2

METRIC

GWP# 5138-13-00 LOCATION Lat: 45.250968°, Long: -79.297271° Bullen Creek, MTM Zone 10: N 5 012 354.2 E 320 713.0 ORIGINATED BY KE/RH  
 HWY 11 BOREHOLE TYPE CME55 Truck with HSA / NW Casing COMPILED BY KE  
 DATUM Geodetic DATE 2018.04.19 - 2018.04.19 CHECKED BY SP

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 <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR   SA   SI   CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)							
								20   40   60   80   100					W P                      W                      W L							
	Continued From Previous Page							○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL      × LAB VANE												
								20   40   60   80   100					20   40   60							

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

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS-ONTARIO

ENGINEERING SERVICES BRANCH-GEOTECHNICAL OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE NO 3

W.P. 149-73-01

LOCATION Sta. 453+40 O/S 22' RT. & Highway 11 Line "E"  
Co-ords. 16,444,048 N. 1,052,135E.

ORIGINATED BY A.P.

DIST. 11 HWY. 11

BORING DATE October 31st, and November 1st, 1974

COMPILED BY G.P.

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger & Cone Test

CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER ELEV.	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT $w_L$ PLASTIC LIMIT $w_P$ WATER CONTENT $w$			UNIT WEIGHT $\gamma$	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	N° VALUES		20	40	60	80	100	$w_p$	$w$	$w_L$		
929.2	Ground Level															
0.0	Sandy silt traces of clay very loose		1	SS	1/18"											0 41 (59)
920.7	organics		2	SS	2/15"											Org. cont. 2-78%
8.5	Silt traces of sand and clay loose		3	SS	9	920										0 0 91 9
			4	SS	13											0 3 96 1
			5	SS	9											
			6	SS	8	910										
			7	SS	6											0 8 91 1
			8	SS	8											
			9	SS	13	900										
			10	SS	5											0 1 93 6
880.2						890										
49.0	Sandy silt traces of gravel and clay compact		11	SS	15	880										4 42 49 5
869.2			12	SS	6/6"	870										
60.0	End of borehole Refusal Probable bedrock										100/0" refusal					

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS-ONTARIO  
ENGINEERING SERVICES BRANCH-GEOTECHNICAL OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 4

W.P. 149-73-01

LOCATION Sta. 453+34 O/S 82' RT. 4 Highway 11 Line "F"

ORIGINATED BY A.P.

DIST. 11 HWY. 11

BORING DATE November 4th and 5th, 1974

COMPILED BY G.P.

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger, Axt Core

CHECKED BY [Signature]

SOIL PROFILE			SAMPLES			GROUND WATER ELEV.	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT — $w_L$			UNIT WEIGHT $\gamma$	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	PLASTIC LIMIT — $w_p$	WATER CONTENT — $w$			
928.8	Ground Level															
0.0	Sandy silt with organics Traces of clay		1	SS	1											0 26 13 1
			2	SS	1	920									Org. 6.31%	0 49 17 4
	very loose		3	SS	1											
913.8			4	SS	1										Org. 4.7%	0 39 57 4
15.0	Silt		5	SS	8	910										0 9 87 4
	Traces of sand and clay		6	SS	8											
			7	SS	8											
	Loose		8	SS	6	900										0 3 96 1
			9	SS	6											
	1 ft. boulder					890										
872.3																
56.5	Granitic Gneiss bedrock		10	Axt RC	Rec 48%	870										Artesian encountered Elev. 871.3
866.6	sound		11	Axt RC	Rec 100%											
62.2	End of borehole															

Sta. 452+90 O/S 117' RT. @ Highway 11 Line "E"

LOCATION Co-ords. 16.443.985 N. 1.052.222E

ORIGINATED BY A.P.

BORING DATE November 5th, 1974

COMPILED BY G.P.

BOREHOLE TYPE Dynamic Cone Penetration Test

CHECKED BY CE

20  
15-0.5 % STRAIN AT FAILURE

**Appendix C.**

**Laboratory Testing**

**Appendix C.1**

**Particle Size Analysis Figures**

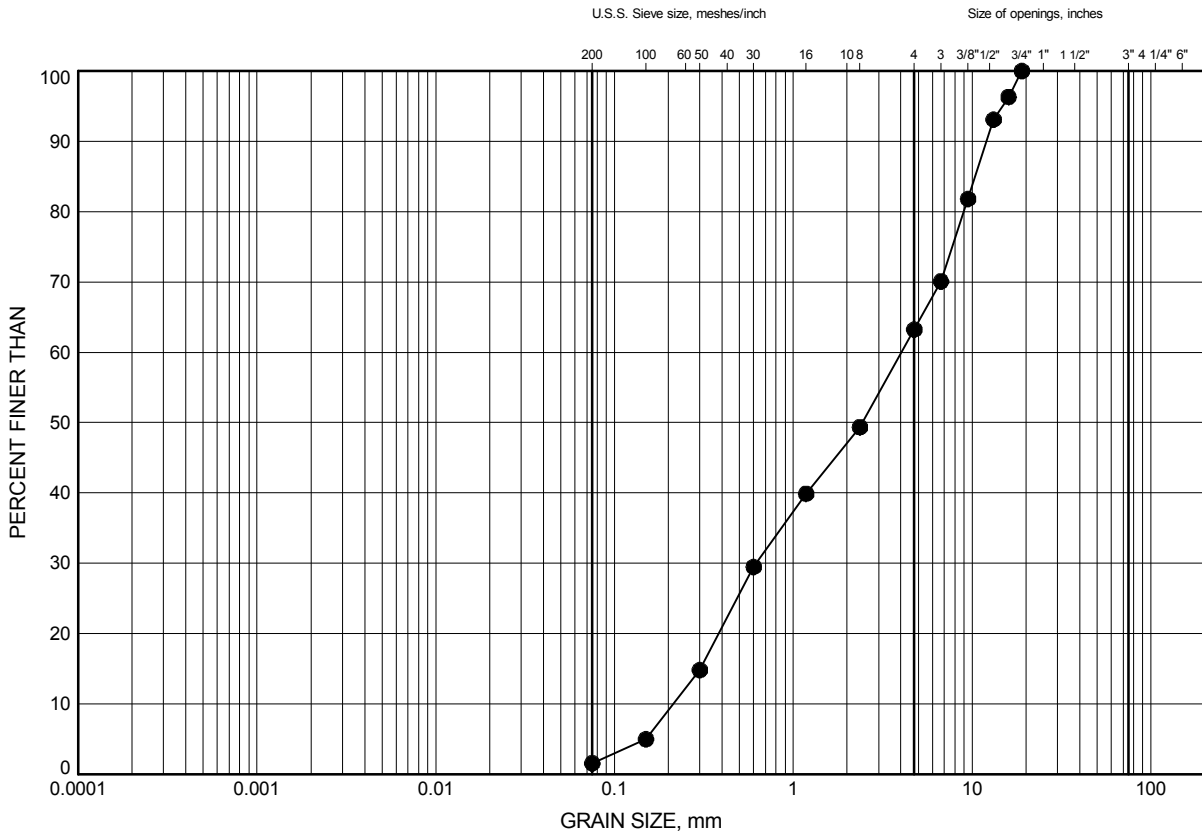


# Hwy 11 - Bullen Creek Culverts

## GRAIN SIZE DISTRIBUTION

FIGURE C1

### FILL-Pavement Granular



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-2	0.3	287.1

Date January 2019  
GWP# 5138-13-00



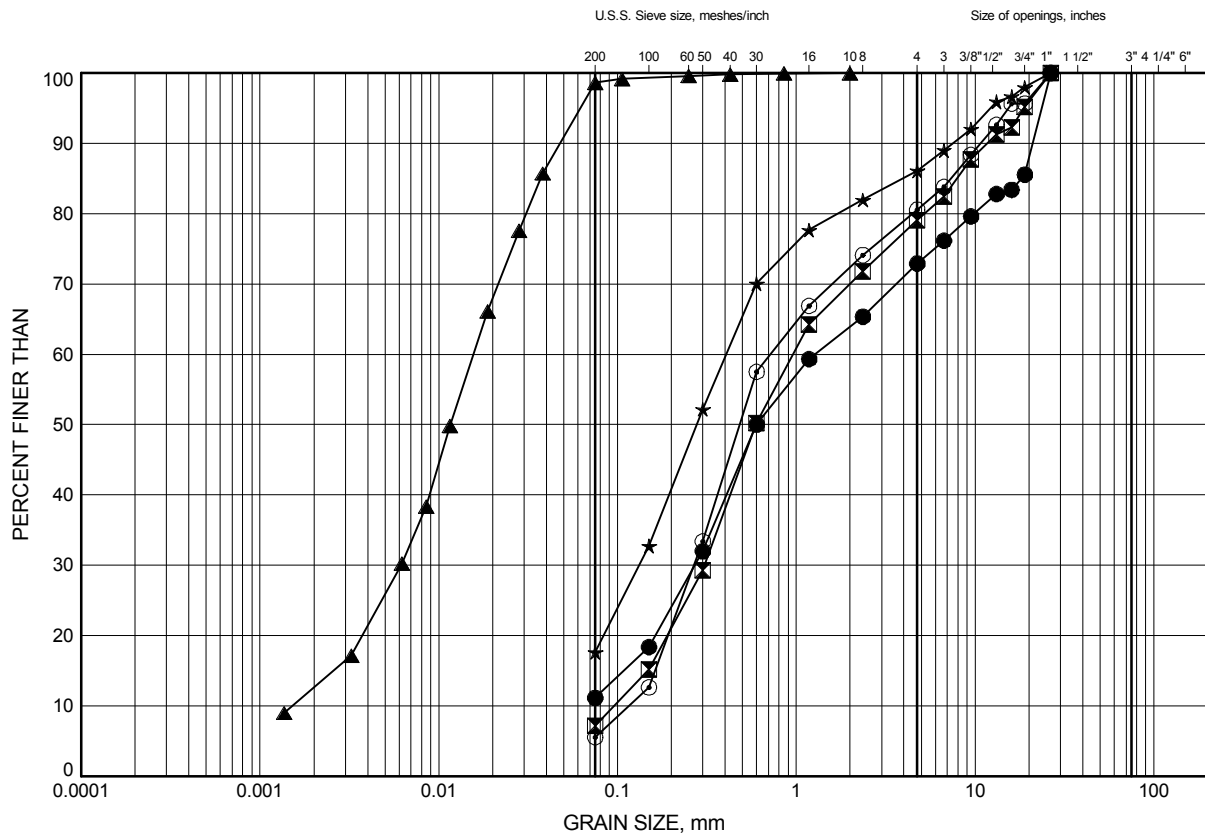
Prep'd KE  
Chkd. SP

# Hwy 11 - Bullen Creek Culverts

## GRAIN SIZE DISTRIBUTION

FIGURE C2

### EMBANKMENT FILL



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-1	1.1	286.4
⊠	18-1	4.1	283.3
▲	18-3	1.8	285.3
★	18-3	3.5	283.7
⊙	18-4	4.9	282.4

Date January 2019

GWP# 5138-13-00



Prep'd KE

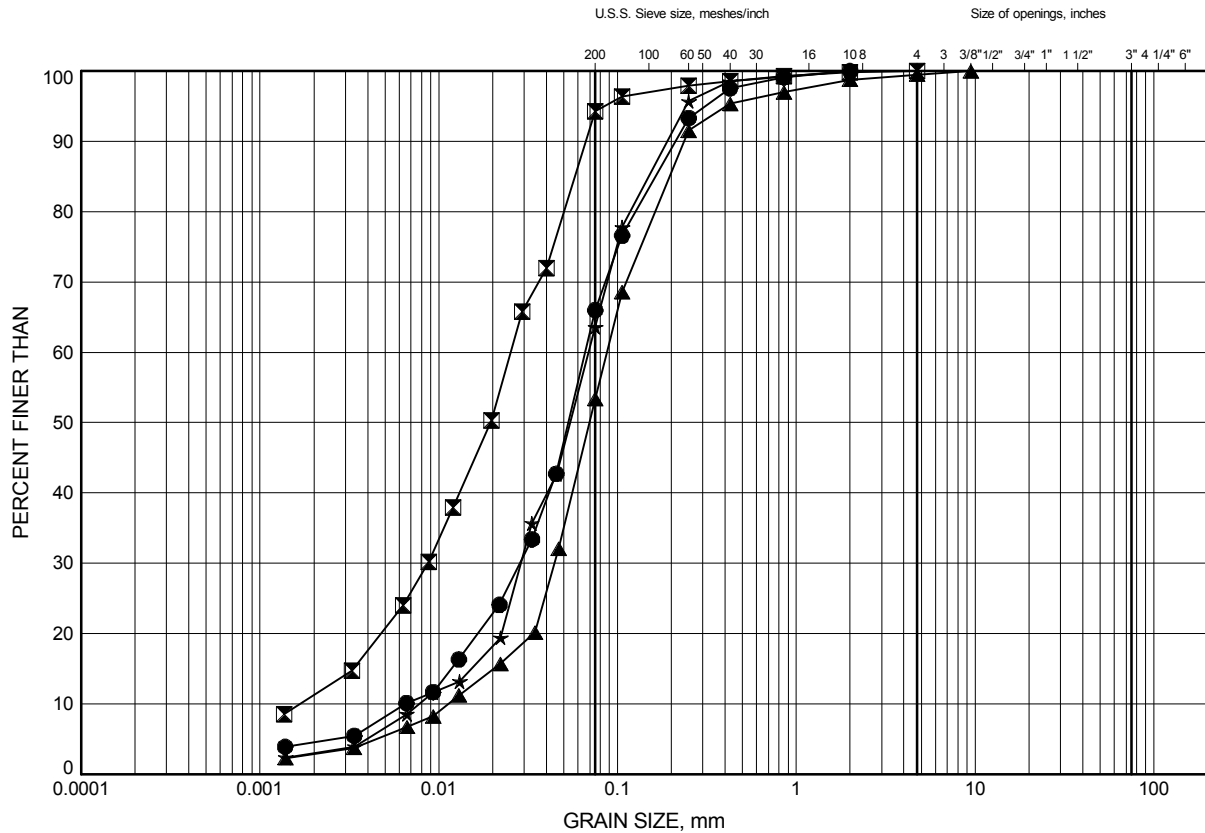
Chkd. SP

# Hwy 11 - Bullen Creek Culverts

## GRAIN SIZE DISTRIBUTION

FIGURE C3

### SILT (ML) with Organics



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-1	6.4	281.0
⊠	18-2	4.7	282.7
▲	18-3	6.6	280.6
★	18-4	7.5	279.8

Date January 2019

GWP# 5138-13-00



Prep'd KE

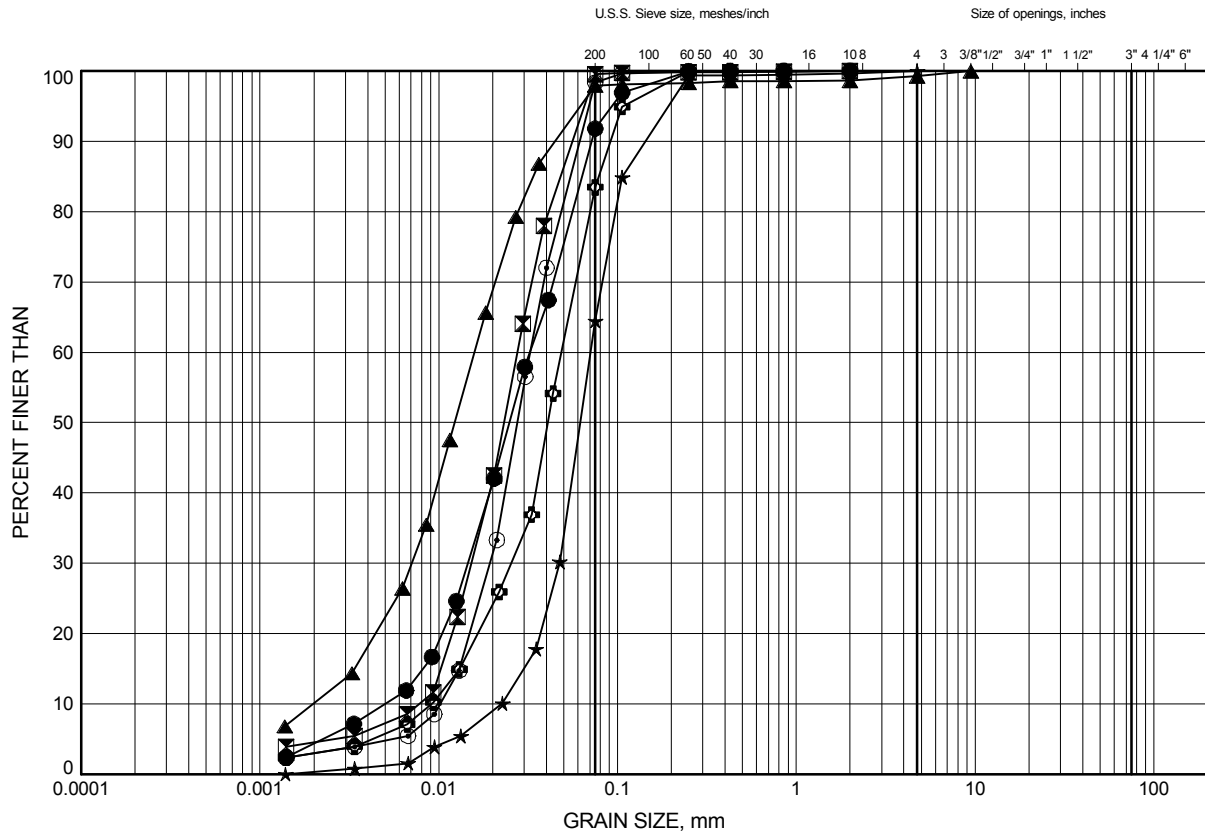
Chkd. SP

# Hwy 11 - Bullen Creek Culverts

## GRAIN SIZE DISTRIBUTION

FIGURE C4

### SILT (ML) to SANDY SILT (ML)



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-1	12.0	275.5
⊠	18-1	15.0	272.4
▲	18-2	7.5	280.0
★	18-2	16.6	270.8
⊙	18-3	15.1	272.1
⊕	18-4	12.0	275.2

Date January 2019

GWP# 5138-13-00



Prep'd KE

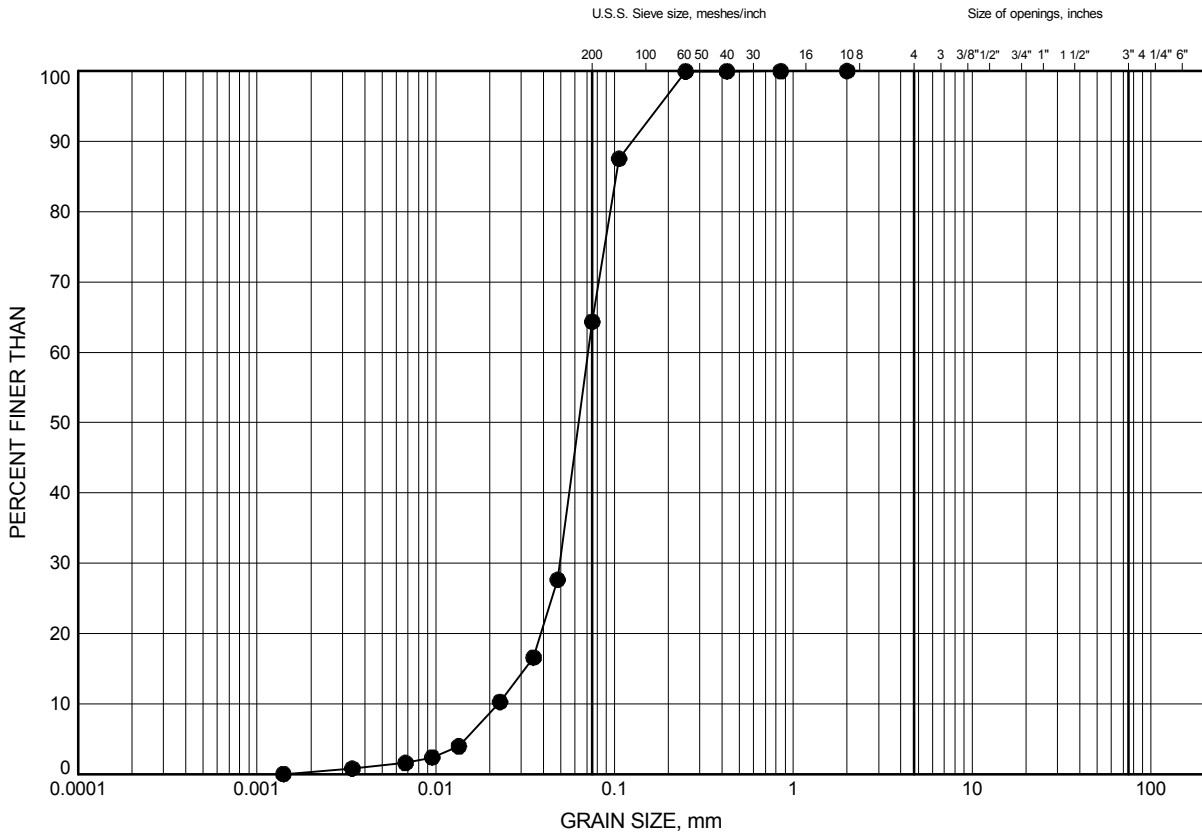
Chkd. SP

# Hwy 11 - Bullen Creek Culverts

## GRAIN SIZE DISTRIBUTION

FIGURE C5

### SILT (ML) to SANDY SILT (ML)



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-4	16.6	270.6

Date January 2019  
GWP# 5138-13-00



Prep'd KE  
Chkd. SP

**Appendix C.2**  
**Analytical Testing Results**

## Certificate of Analysis

**Thurber Engineering Ltd.**

2460 Lancaster Rd, Suite 104  
Ottawa, ON K1B 4S5  
Attn: Katya Edney

Client PO: 20244  
Project: HWY 11+118  
Custody: 39844

Report Date: 1-May-2018  
Order Date: 25-Apr-2018

**Order #: 1817326**

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

**Paracel ID**  
1817326-01  
1817326-02

**Client ID**  
18-4 SS8 (17'6" - 19'6")  
~~18-3 SS8B (18'6" - 17')~~

**Bullen Culvert**

Approved By:

*Mark Foto*

Mark Foto, M.Sc.  
Lab Supervisor

Certificate of Analysis  
Client: Thurber Engineering Ltd.  
Client PO: 20244

Report Date: 01-May-2018  
Order Date: 25-Apr-2018  
Project Description: HWY 11+118

### Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	27-Apr-18	28-Apr-18
Conductivity	MOE E3138 - probe @25 °C, water ext	30-Apr-18	30-Apr-18
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	30-Apr-18	30-Apr-18
Resistivity	EPA 120.1 - probe, water extraction	30-Apr-18	30-Apr-18
Solids, %	Gravimetric, calculation	1-May-18	1-May-18



Certificate of Analysis  
**Client: Thurber Engineering Ltd.**  
**Client PO: 20244**

Report Date: 01-May-2018

Order Date: 25-Apr-2018

**Project Description: HWY 11+118**

<b>Client ID:</b>	18-4 SS8 (17'6" - 19'6")	18-3 SS8B (16'6" - 17')	-	-
<b>Sample Date:</b>	04/19/2018 09:00	04/22/2018 09:00	-	-
<b>Sample ID:</b>	1817326-01	1817326-02	-	-
<b>MDL/Units</b>	Soil	Soil	-	-

#### Physical Characteristics

% Solids	0.1 % by Wt.	87.1	79.2	-	-
----------	--------------	------	------	---	---

#### General Inorganics

Conductivity	5 uS/cm	469	322	-	-
pH	0.05 pH Units	6.10	6.45	-	-
Resistivity	0.10 Ohm.m	21.3	31.1	-	-

#### Anions

Chloride	5 ug/g dry	291	148	-	-
Sulphate	5 ug/g dry	5	5	-	-

Certificate of Analysis  
Client: Thurber Engineering Ltd.  
Client PO: 20244

Report Date: 01-May-2018  
Order Date: 25-Apr-2018  
Project Description: HWY 11+118

### Method Quality Control: Blank

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
<b>Anions</b>									
Chloride	ND	5	ug/g						
Sulphate	ND	5	ug/g						
<b>General Inorganics</b>									
Conductivity	ND	5	uS/cm						
Resistivity	ND	0.10	Ohm.m						

Certificate of Analysis  
Client: Thurber Engineering Ltd.  
Client PO: 20244

Report Date: 01-May-2018  
Order Date: 25-Apr-2018  
Project Description: HWY 11+118

**Method Quality Control: Duplicate**

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
<b>Anions</b>									
Chloride	660	5	ug/g dry	668			1.3	20	
Sulphate	1940	5	ug/g dry	2000			3.0	20	
<b>General Inorganics</b>									
Conductivity	502	5	uS/cm	472			6.2	6.2	
pH	7.56	0.05	pH Units	7.57			0.1	10	
Resistivity	19.9	0.10	Ohm.m	21.2			6.2	20	
<b>Physical Characteristics</b>									
% Solids	89.6	0.1	% by Wt.	87.3			2.6	25	

Certificate of Analysis  
Client: Thurber Engineering Ltd.  
Client PO: 20244

Report Date: 01-May-2018  
Order Date: 25-Apr-2018  
Project Description: HWY 11+118

### Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
<b>Anions</b>									
Chloride	748	5	ug/g	668	79.8	78-113			
Sulphate	103	5	ug/g		103	78-111			

Certificate of Analysis  
Client: Thurber Engineering Ltd.  
Client PO: 20244

Report Date: 01-May-2018  
Order Date: 25-Apr-2018  
Project Description: HWY 11+118

**Qualifier Notes:**

None

**Sample Data Revisions**

None

**Work Order Revisions / Comments:**

None

**Other Report Notes:**

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

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

## Subcontracted Analysis

**Thurber Engineering Ltd.**  
2460 Lancaster Rd, Suite 104  
Ottawa, ON K1B 4S5  
Attn: Katya Edney

Tel: (613) 247-2121  
Fax: (613) 247-2185

Paracel Report No **1818495**  
Client Project(s): **HWY 11+ 118**  
Client PO: **20244**  
Reference: **Standing Offer**  
CoC Number: **39844**

Order Date: 03-May-18  
Report Date: 15-May-18

Sample(s) from this project were subcontracted for the listed parameters. A copy of the subcontractor's report is attached

Paracel ID	Client ID	Analysis
1818495-01	18-4 SS8 (17'6" - 19'6")	Sulphide, solid
1818495-02	<del>18-5 SS8B (16'0" - 17')</del>	<del>Sulphide, solid</del>

**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.  
Lakefield - Ontario - K0L 2H0  
Phone: 705-652-2000 FAX: 705-652-6365

**Paracel Laboratories**

Attn : Dale Robertson

300-2319 St.Laurent Blvd.  
Ottawa, ON  
K1G 4K6,

Phone: 613-731-9577  
Fax:613-731-9064

15-May-2018

**Date Rec. :** 04 May 2018  
**LR Report:** CA15112-MAY18  
**Reference:** Project#: 1818495

**Copy:** #1

## CERTIFICATE OF ANALYSIS

### Final Report

Sample ID	Sample Date & Time	Sulphide %
1: Analysis Start Date		14-May-18
2: Analysis Start Time		13:09
3: Analysis Completed Date		14-May-18
4: Analysis Completed Time		14:54
5: QC - Blank		< 0.02
6: QC - STD % Recovery		101%
7: QC - DUP % RPD		ND
8: RL		0.02
9: 18-4 SS8 (17'6"-19'6")	19-Apr-18	< 0.02
10: <del>18-8 SS8D (18'0"-17")</del>	<del>22-Apr-18</del>	<del>&lt; 0.02</del>

RL - SGS Reporting Limit

Carrie Greenlaw  
Project Specialist  
Environmental Services, Analytical

## Certificate of Analysis

### Thurber Engineering Ltd.

2460 Lancaster Rd, Suite 104  
Ottawa, ON K1B 4S5  
Attn: Katya Edney

Client PO:  
Project: HWY 11 + 118  
Custody: 39845

Report Date: 10-May-2018  
Order Date: 4-May-2018

**Order #: 1818669**

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

Paracel ID	Client ID
1818669-01	Road 117 18-1'ss13 40-42'
1818669-02	Road 117 18-2 'SS12 35-37'
1818669-03	Fraserburg '18-1SS10 22'6-24'6"
1818669-04	Fraserburg'18-2 SS12A 35-36'6"
1818669-05	Road 2 '18-1 SS9 20-22'
1818669-06	Road 2 '18-2 SS10 25-27'
1818669-07	Bullens '18-1 SS11 23'3"-25'3"
1818669-08	Road 3 18-1 SS10 25-27'
1818669-09	Road 3 18-2 SS10 25-27'
1818669-10	Siding 18-2SS5 10-12'
1818669-11	Siding 18-3 SS5 10-12'

Approved By:



Dale Robertson, BSc  
Laboratory Director



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

Report Date: 10-May-2018  
Order Date: 4-May-2018  
Project Description: HWY 11 + 118

### Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	8-May-18	8-May-18
Conductivity	MOE E3138 - probe @25 °C, water ext	8-May-18	9-May-18
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	7-May-18	7-May-18
Resistivity	EPA 120.1 - probe, water extraction	8-May-18	9-May-18
Solids, %	Gravimetric, calculation	7-May-18	7-May-18

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

Report Date: 10-May-2018

Order Date: 4-May-2018

Project Description: HWY 11 + 118

<b>Client ID:</b>	Road 117 18-1'ss13 40-42'	Road 117 18-2 'SS12 35-37'	Fraserburg '18-1SS10 22'6-24'6"	Fraserburg'18-2 SS12A 35-36'6"
<b>Sample Date:</b>	04/30/2018 09:00	04/30/2018 09:00	04/29/2018 09:00	04/29/2018 09:00
<b>Sample ID:</b>	1818669-01	1818669-02	1818669-03	1818669-04
<b>MDL/Units</b>	Soil	Soil	Soil	Soil

**Physical Characteristics**

% Solids	0.1 % by Wt.	83.9	83.9	68.9	70.1
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**General Inorganics**

Conductivity	5 uS/cm	133	234	469	262
pH	0.05 pH Units	5.84	6.14	5.56	5.32
Resistivity	0.10 Ohm.m	75.0	42.7	21.3	38.1

**Anions**

Chloride	5 ug/g dry	82	113	246	120
Sulphate	5 ug/g dry	12	9	51	10

<b>Client ID:</b>	Road 2 '18-1 SS9 20-22'	Road 2 '18-2 SS10 25-27'	Bullens '18-1 SS11 23'3"-25'3"	Road 3 18-1 SS10 25-27'
<b>Sample Date:</b>	04/28/2018 09:00	05/01/2018 09:00	04/21/2018 09:00	04/27/2018 09:00
<b>Sample ID:</b>	1818669-05	1818669-06	1818669-07	1818669-08
<b>MDL/Units</b>	Soil	Soil	Soil	Soil

**Physical Characteristics**

% Solids	0.1 % by Wt.	87.0	72.7	77.5	80.3
----------	--------------	------	------	------	------

**General Inorganics**

Conductivity	5 uS/cm	218	1780	400	61
pH	0.05 pH Units	6.41	5.76	7.44	6.39
Resistivity	0.10 Ohm.m	45.8	5.61	25.0	164

**Anions**

Chloride	5 ug/g dry	124	1170	23	21
Sulphate	5 ug/g dry	7	10	200	11

<b>Client ID:</b>	Road 3 18-2 SS10 25-27'	Siding 18-2SS5 10-12'	Siding 18-3 SS5 10-12'	-
<b>Sample Date:</b>	04/27/2018 09:00	04/24/2018 09:00	04/23/2018 09:00	-
<b>Sample ID:</b>	1818669-09	1818669-10	1818669-11	-
<b>MDL/Units</b>	Soil	Soil	Soil	-

**Physical Characteristics**

% Solids	0.1 % by Wt.	82.5	79.5	72.3	-
----------	--------------	------	------	------	---

**General Inorganics**

Conductivity	5 uS/cm	158	2120	428	-
pH	0.05 pH Units	6.44	6.34	6.13	-
Resistivity	0.10 Ohm.m	63.1	4.71	23.4	-

**Anions**

Chloride	5 ug/g dry	83	1590	154	-
Sulphate	5 ug/g dry	9	19	76	-

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

Report Date: 10-May-2018  
Order Date: 4-May-2018  
Project Description: HWY 11 + 118

**Method Quality Control: Blank**

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
<b>Anions</b>									
Chloride	ND	5	ug/g						
Sulphate	ND	5	ug/g						
<b>General Inorganics</b>									
Conductivity	ND	5	uS/cm						
Resistivity	ND	0.10	Ohm.m						

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

Report Date: 10-May-2018  
Order Date: 4-May-2018  
Project Description: HWY 11 + 118

**Method Quality Control: Duplicate**

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
<b>Anions</b>									
Chloride	55.9	5	ug/g dry	55.6			0.7	20	
Sulphate	23.4	5	ug/g dry	22.9			2.1	20	
<b>General Inorganics</b>									
Conductivity	443	5	uS/cm	424			4.4	6.2	
pH	7.77	0.05	pH Units	7.77			0.0	10	
Resistivity	22.6	0.10	Ohm.m	23.6			4.4	20	
<b>Physical Characteristics</b>									
% Solids	98.2	0.1	% by Wt.	98.0			0.2	25	

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

Report Date: 10-May-2018  
Order Date: 4-May-2018  
Project Description: HWY 11 + 118

**Method Quality Control: Spike**

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
<b>Anions</b>									
Chloride	149	5	ug/g	55.6	93.2	78-113			
Sulphate	119	5	ug/g	22.9	95.8	78-111			

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

Report Date: 10-May-2018  
Order Date: 4-May-2018  
Project Description: HWY 11 + 118

**Qualifier Notes:**

***Login Qualifiers :***

Container(s) - Bottle and COC sample ID don't match -

*Applies to samples: Road 117 18-1'ss13 40-42', Road 117 18-2 'SS12 35-37', Fraserburg '18-1SS10 22'6-24'6",  
Bullens '18-1 SS11 23'3"-25'3"*

**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.



## Subcontracted Analysis

**Thurber Engineering Ltd.**2460 Lancaster Rd, Suite 104  
Ottawa, ON K1B 4S5  
Attn: Katya EdneyTel: (613) 247-2121  
Fax: (613) 247-2185Paracel Report No **1818669**Client Project(s): **HWY 11 + 118**

Client PO:

Reference: **Standing Offer**CoC Number: **39845**Order Date: 04-May-18  
Report Date: 15-May-18

Sample(s) from this project were subcontracted for the listed parameters. A copy of the subcontractor's report is attached

Paracel ID	Client ID	Analysis
1818669-01	Road 117 18-1'ss13 40-42'	Sulphide, solid
1818669-02	Road 117 18-2 'SS12 35-37'	Sulphide, solid
1818669-03	Fraserburg '18-1SS10 22'6-24'6"	Sulphide, solid
1818669-04	Fraserburg'18-2 SS12A 35-36'6"	Sulphide, solid
1818669-05	Road 2 '18-1 SS9 20-22'	Sulphide, solid
1818669-06	Road 2 '18-2 SS10 25-27'	Sulphide, solid
1818669-07	Bullens '18-1 SS11 23'3"-25'3"	Sulphide, solid
1818669-08	Road 3 18-1 SS10 25-27'	Sulphide, solid
1818669-09	Road 3 18-2 SS10 25-27'	Sulphide, solid
1818669-10	Siding 18-2SS5 10-12'	Sulphide, solid
1818669-11	Siding 18-3 SS5 10-12'	Sulphide, solid

**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.  
Lakefield - Ontario - K0L 2H0  
Phone: 705-652-2000 FAX: 705-652-6365

**Paracel Laboratories**

Attn : Dale Robertson

300-2319 St.Laurent Blvd.  
Ottawa, ON  
K1G 4K6,

Phone: 613-731-9577  
Fax: 613-731-9064

15-May-2018

**Date Rec. :** 08 May 2018  
**LR Report:** CA13203-MAY18  
**Reference:** Project#: 1818669

**Copy:** #1

## CERTIFICATE OF ANALYSIS

### Final Report

Sample ID	Sample Date & Time	Sulphide %
1: Analysis Start Date		14-May-18
2: Analysis Start Time		13:09
3: Analysis Completed Date		14-May-18
4: Analysis Completed Time		14:54
5: QC - Blank		< 0.02
6: QC - STD % Recovery		101%
7: QC - DUP % RPD		ND
8: RL		0.02
9: Road 117 18-1'ss13 40-42'	30-Apr-18	< 0.02
10: Road 117 18-2 'SS12 35-37'	30-Apr-18	< 0.02
11: Fraserburg '18-1SS10 22'6-24'6"	29-Apr-18	< 0.02
12: Fraserburg '18-2 SS12A 35-36'6"	29-Apr-18	< 0.02
13: Road 2 '18-1 SS9 20-22'	28-Apr-18	< 0.02
14: Road 2 '18-2 SS10 25-27'	01-May-18	< 0.02
15: Bullens '18-1 SS11 23'3"-25'3"	21-Apr-18	0.40
16: Road 3 18-1 SS10 25-27'	27-Apr-18	< 0.02
17: Road 3 18-2 SS10 25-27'	27-Apr-18	< 0.02
18: Siding 18-2SS5 10-12'	24-Apr-18	< 0.02
19: Siding 18-3 SS5 10-12'	23-Apr-18	< 0.02

RL - SGS Reporting Limit

Carrie Greenlaw  
Project Specialist  
Environmental Services, Analytical



**Appendix D.**

**Site Photographs**



**Photo 1. Looking north along Highway 11 Northbound**



**Photo 2. Looking south along Highway 11 Southbound**



**Photo 3. Northbound outlet (42X-0034/C1) looking east**



**Photo 4. Looking north at culvert ends in median**





**Photo 5. Southbound inlet (42X-0034/C2) looking west**

**Appendix E.**

**List of Special Provisions and 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 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 810.010	General Rip-Rap Layout for Sewer and Culvert Outlets
SP 517F01	Design Storm Return Period and Preconstruction Survey
2. Suggested text for a NSSP on "Installation of Temporary Protection System"

Vibratory equipment is not permitted for installation or removal of temporary protection systems below elevation 283.0 m.
3. Suggested text for a NSSP on "Obstructions"

The Contractor is alerted to the presence of cobbles within the fill which may have an impact on excavations as well as the installation of protection systems at this site.