



THURBER ENGINEERING LTD.

FINAL
FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 11 SIDING LAKE CREEK CULVERTS,
DISTRICT OF MUSKOKA
AGREEMENT NO. 5017-E-0003
Site Nos.: 42X-0184/C1 & 42X-0184/C2

G.W.P. 5138-13-00

Geocres No.: 31E-395

Report to:

McIntosh Perry Consulting Engineers Limited

Latitude: 45. 259734
Longitude: -79. 295235

February 2019
Thurber File: 20244

TABLE OF CONTENTS

PART 1. FACTUAL INFORMATION

1	INTRODUCTION	1
2	SITE DESCRIPTION	1
3	SITE INVESTIGATION AND FIELD TESTING.....	2
4	LABORATORY TESTING.....	3
5	DESCRIPTION OF SUBSURFACE CONDITIONS	3
5.1	Embankment.....	4
5.1.1	Asphalt	4
5.1.2	FILL: Sand	4
5.2	Silt (ML) to Silty Sand (SM) with Organics.....	4
5.3	Silt (ML) to Sandy Silt (ML).....	5
5.4	Clay (CL - CI)	5
5.5	Groundwater	6
5.6	Analytical Testing.....	6
6	MISCELLANEOUS	7

PART 2. ENGINEERING DISCUSSION AND RECOMMENDATIONS

7	INTRODUCTION	8
7.1	Proposed Structure Rehabilitations	8
8	GEOTECHNICAL RECOMMENDATIONS	9
8.1	Excavation	9
8.2	Temporary Protection Systems.....	9
8.3	Lateral Earth Pressures	10
8.4	Embankment Design and Reinstatement	11
8.4.1	Embankment Reconstruction	11
8.4.2	Embankment Settlement and Stability.....	12
8.5	Cement Type and Corrosion Potential.....	12
8.6	Surface and Groundwater Control	12
8.7	Scour Protection and Erosion Control.....	13
9	CONSTRUCTION CONCERNS	13

10	CLOSURE	14
----	---------------	----

APPENDICES

Appendix A.	Borehole Location Plan and Stratigraphic Drawings
Appendix B.	Record of Borehole Sheets
Appendix C.	Laboratory Testing
Appendix D.	Site Photographs
Appendix E.	List of Special Provisions and OPSS Documents Referenced in this Report

FINAL
FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 11 SIDING LAKE CREEK CULVERTS,
DISTRICT OF MUSKOKA
AGREEMENT NO. 5017-E-0003

G.W.P. 5138-13-00

Geocres No.: 31E-395

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 Siding Lake Creek located approximately 5.5 km north of the Highway 141 Interchange 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]

It is understood that the Unnamed Creek in the historic report is now known as Siding Lake Creek.

2 SITE DESCRIPTION

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

The west culvert (Structure No.42X-0184/C2) is located under the southbound lanes and has a span width of 6.1 m, height of 2.4 m, and a length of 30 m. The structure is understood to be a concrete rigid frame box constructed in 1956. Based on photos provided in Appendix D, no wingwalls or headwalls are present at the culvert ends.

The east culvert (Structure No.42X-0184/C1) is located under the northbound lanes and has a span width of 6.1 m, height of 2.4 m, and a length of 30 m. The structure is understood to be a concrete rigid frame box constructed in 1976. Based on site photos provided in Appendix D, headwalls are present at the culvert ends.

The creek bed elevations are 280.5 m at the inlet of the west culvert and 280.5 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 0.8 m with the road surfaces at approximate elevation 283.9 m for both the southbound and northbound lanes. 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. The ditch vegetation indicates the potential of a prolonged presence of ponded water. 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 on April 23rd and April 24th, 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). The boreholes were sampled to depths of 14.3 m to 15.2 m (elev. 268.7 to 269.6 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 304 and VCP 308 (elev. 282.460 and 283.068 m, respectively), 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

Borehole No.	Drilled Location	Northing (m)	Easting (m)	Ground Surface Elevation (m)	Termination Depth (m)
18-1	SB Lane 1, north of culvert	5 013 745.5	321 064.6	283.9	15.2
18-2	SB Lane 1, south of culvert	5 013 734.0	321 057.1	283.9	15.2
18-3	NB Lane 1, north of culvert	5 013 736.4	321 095.3	283.9	14.3
18-4	NB Lane 1, south of culvert	5 013 725.7	321 088.2	283.9	14.3

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. Three samples were selected for organic content testing. One sample of soil recovered from within each of Boreholes 18-2 and 18-3 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.

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

The historic boreholes from Geocres Report 31E-33 have also been included in Appendix B and their locations indicated on Drawing No. 1497301-A 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 boreholes were drilled, therefore the historic documents have not been included in the following descriptions. The 1974 boreholes extended deeper than the 2018 boreholes and noted silt to sandy silt to refusal at approximate elevation 255.7 m and 252.8 m. Artesian conditions were noted in Borehole 1 with the groundwater level 2 m above ground surface at the time of the investigation.

5.1 Embankment

5.1.1 Asphalt

All boreholes were drilled through the existing Highway 11 embankments and encountered a layer of asphalt with a thickness of 130 to 175 mm.

5.1.2 FILL: Sand

Below the asphalt in all boreholes was a layer of fill consisting of sand with variable amounts of gravel. The underside of this fill was at 2.3 to 3.2 m (elev. 280.7 to 281.6 m) below the existing roadway surface. The upper 0.6 m of this layer in the southbound embankment boreholes (18-1 and 18-2) is likely part of the pavement structure. The pavement base/subbase layers in the northbound embankment boreholes (18-3 and 18-4) was not discernible from the underlying fill.

The SPT tests conducted in the fill gave blow counts ranging from 3 blows per 300 mm to 100 blows for 175 mm of penetration indicating a relative density of very loose to very dense.

Recorded moisture contents ranged from 2 to 17%. The results of a grain size analysis conducted on a sample of the sand fill are summarized below and are illustrated on Figure C1 in Appendix C.

Soil Particle	Percentage (%)
Gravel	17
Sand	79
Silt	4
Clay	

5.2 Silt (ML) to Silty Sand (SM) with Organics

Directly below the sand fill in all boreholes was a native silt to silty sand material. Organics and trace wood fragments were encountered within this layer. The thickness of this layer ranged from 0.8 to 2.9 m with a base elevation ranging from 277.8 to 280.1 m.

The SPT tests conducted in this layer gave N-values ranging from weight of hammer (WH) to 5 blows indicating a relative density of very loose to loose.

Recorded moisture contents ranged from 24 to 129%. Atterberg Limits testing on two samples indicated that the material is non-plastic. Organic content testing was completed on three samples of this silt with results ranging from 5.2% to 6.5% organic content. The results of grain size analyses conducted on two samples of this silt are summarized below and illustrated on Figure C2 in Appendix C.

Soil Particle	Percentage (%)
Gravel	0 - 1
Sand	6 - 20
Silt	72 - 82
Clay	7 - 12

5.3 Silt (ML) to Sandy Silt (ML)

All boreholes encountered a native layer of silt with varying amounts of sand below the organic silt layer. The thickness of this layer ranged from 7.2 to 9.5 m with a base elevation ranging from 270.6 to 271.7 m.

The SPT tests conducted in this layer gave N-values ranging from weight of hammer (WH) to 6 blows indicating a relative density of very loose to loose.

Recorded moisture contents ranged from 20 to 80%. Atterberg Limits testing on eight samples indicated that the material is non-plastic. The results of grain size analyses conducted on eight samples of this silt are summarized below and illustrated on Figures C3 and C4 in Appendix C.

Soil Particle	Percentage (%)
Gravel	0 - 4
Sand	1 - 35
Silt	64 - 82
Clay	1 - 19

5.4 Clay (CL - CI)

A native deposit of clay was encountered below the silt deposits in all boreholes. All boreholes were terminated within this layer at a depth of 14.3 to 15.2 m with corresponding termination elevations ranging from 268.7 to 269.6 m.

In-situ shear vane test results indicated undrained shear strength ranging from 36 kPa to 68 kPa indicating a firm to stiff consistency. All SPT N-values in this layer were equivalent to the weight of hammer (WH) suggesting a soft to very soft consistency.

The moisture content of the samples tested ranged from 30 to 64%. The results of grain size analyses conducted on three samples of the clay are summarized below and illustrated on Figure C5 in Appendix C.

Soil Particle	Percentage (%)
Gravel	0
Sand	1 - 2
Silt	39 - 59
Clay	40 - 60

Atterberg Limits testing completed on three samples of this material indicated a liquid limit ranging from 28 to 44, a plastic limit ranging from 16 to 26, and a plasticity index ranging from 7 to 23. The laboratory results indicate that the clay generally has low to intermediate plasticity (CL to CI). One sample of this deposit plotted below the 'A' Line indicating a silt of slight plasticity (ML). The results are summarized on the Record of Borehole sheets in Appendix B and the Atterberg Limit graph is included in Figure C6 of Appendix C.

5.5 Groundwater

Unstabilized water levels in open Boreholes 18-1, 18-3 and 18-4 were recorded during drilling operations at depths ranging from of 2.1 m to 2.7 m (elevations 281.2 m to 281.8). It is expected that the groundwater level will likely reflect the water level in the creek. The water level of Siding Lake Creek was recorded at elevation 281.5 m on April 24th, 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.

5.6 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:

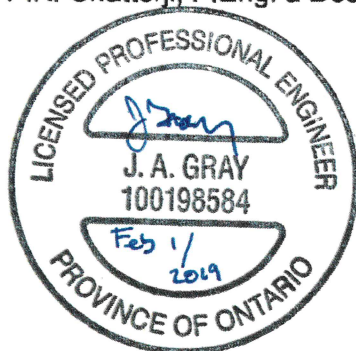
Borehole (sample)	Depth (mbgs)	Sulphate (µg/g)	pH (-)	Resistivity (Ohm-cm)	Conductivity (uS/cm)	Chloride (µg/g)	Sulphide %
18-2 (SS5)	3.0 - 3.6	19	6.34	471	2,120	1,590	<0.02
18-3 (SS5)	3.0 - 3.6	76	6.13	2,340	428	154	<0.02

6 MISCELLANEOUS

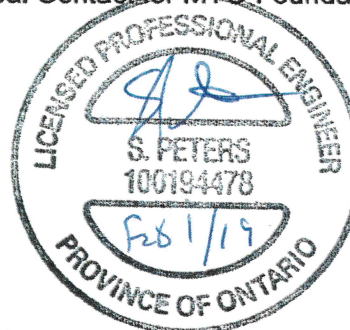
Borehole locations were selected by Thurber relative to the culvert and existing site features. The as-drilled locations and ground surface elevation of the boreholes were measured by Thurber following completion of the field program. Base plan drawings and survey benchmarks were provided by MPCE.

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. The field investigation was supervised on a full time basis by Mr. Sean O'Bryan of Thurber. Overall supervision of the investigation program was provided by Mr. Stephen Peters, P.Eng.

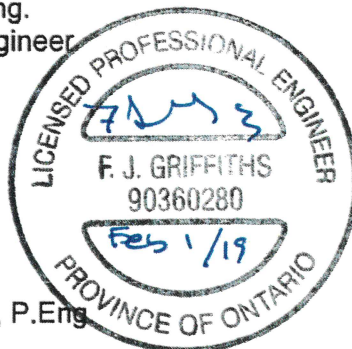
Routine geotechnical laboratory testing was completed by Thurber's laboratory in Ottawa, Ontario. Organic content testing was completed by Stantec's Laboratory in Ottawa, Ontario. Analytical testing was completed by Paracel Laboratories in Ottawa, Ontario. Interpretation of the factual data and preparation 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

FINAL
FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 11 SIDING LAKE CREEK CULVERTS,
DISTRICT OF MUSKOKA
AGREEMENT NO. 5017-E-0003
Site Nos.: 42X-0184/C1 & 42X-0184/C2

G.W.P. 5138-13-00
Geocres No.: 31E-395

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 Siding Lake Creek located approximately 5.5 km north of the Highway 141 Interchange 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 granular fill overlying a native silt deposit overlying a clay deposit. Based on historical Geocres Report No. 31E-33, refusal was encountered at elevations between 252.7 and 255.6. The water level of Siding Lake Creek was recorded during the current field investigation at an elevation of 281.5 m on April 24th, 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, is to include the repair of deteriorated areas of concrete on the top slab and the inside walls as well as the waterproofing of the top slab.

8 GEOTECHNICAL RECOMMENDATIONS

Cover over the culverts is estimated to be approximately 0.8 m. For each of the two embankments, temporary protection systems are being considered to allow excavation to 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 Siding Lake 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 excavations must be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of OHSA, the existing fills and native silt above the water table may be classified as Type 3 soil, all soils below the water table are classified as Type 4 soil. New granular fill placed and compacted as part of the culvert rehabilitation in accordance with OPSS.PROV 501, can be considered as Type 2 soils.

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

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

Temporary Protection Systems required during construction 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. For temporary deeper excavations, 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.

Loose to very loose native silt deposits were encountered below the embankment soils. These deposits are sensitive to disturbance and vibrations. Using vibratory methods will induce settlement of both the culvert footings and the embankment and would limit the available vertical resistance for the protection system. If the Temporary Protection Systems 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. 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 the crane 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)
γ	=	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 $\phi = 30^\circ$, $\gamma = 21.0 \text{ kN/m}^3$	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 (if any) 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 rehabilitated 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 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 permanent grade raise is anticipated along the alignment of Highway 11, negligible settlement is expected to occur in the soils beneath the embankment.

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 5.6 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 is not expected to intersect either groundwater or creek flow. Culvert backfilling and embankment reinstatement 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 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 *****.

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 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:

- 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.

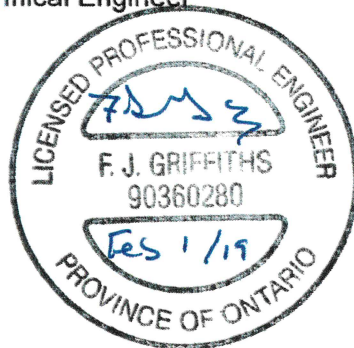
Report Prepared By:



Justin Gray, P.Eng.
Geotechnical Engineer



Stephen Peters, P.Eng.
Associate
Geotechnical Engineer



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

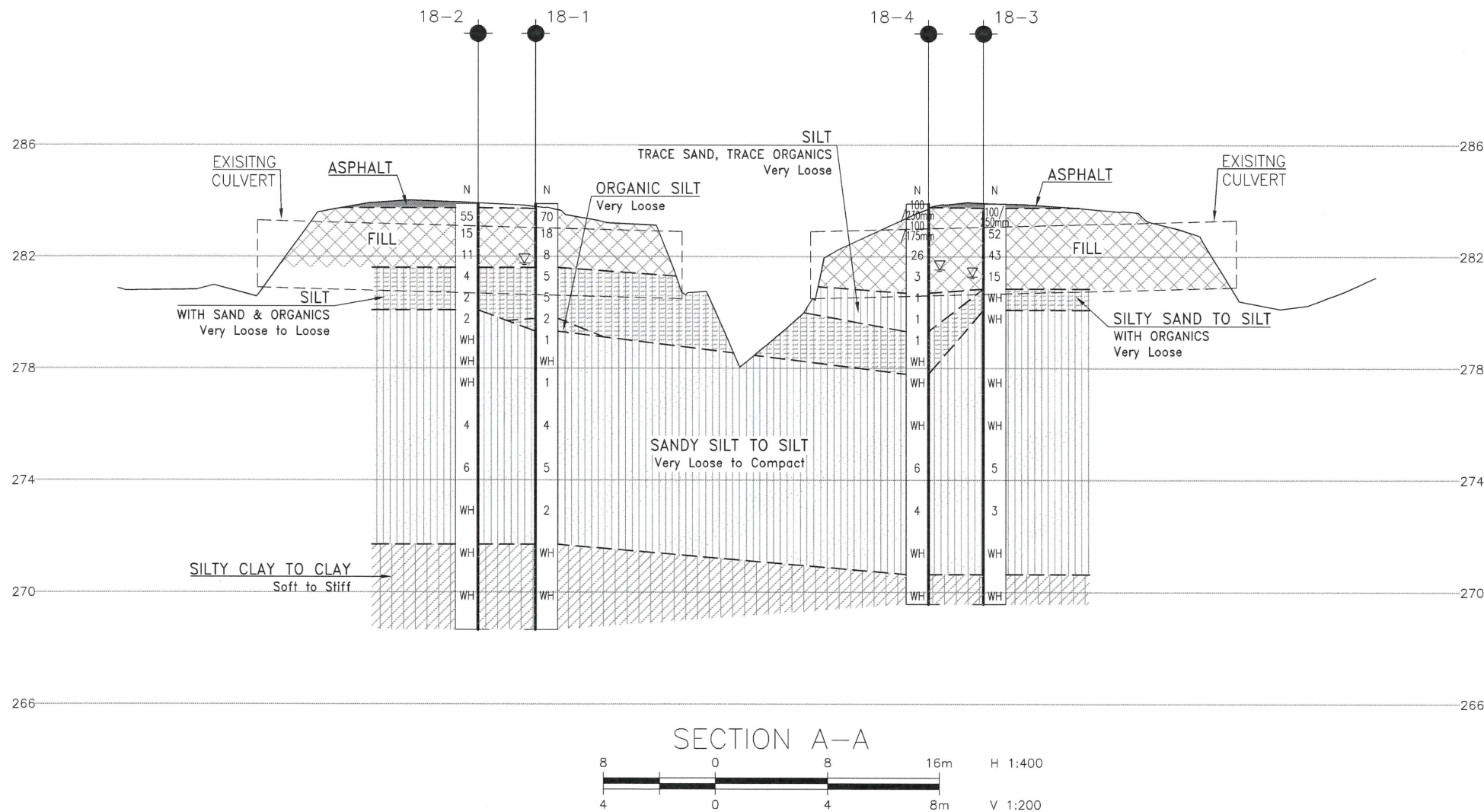
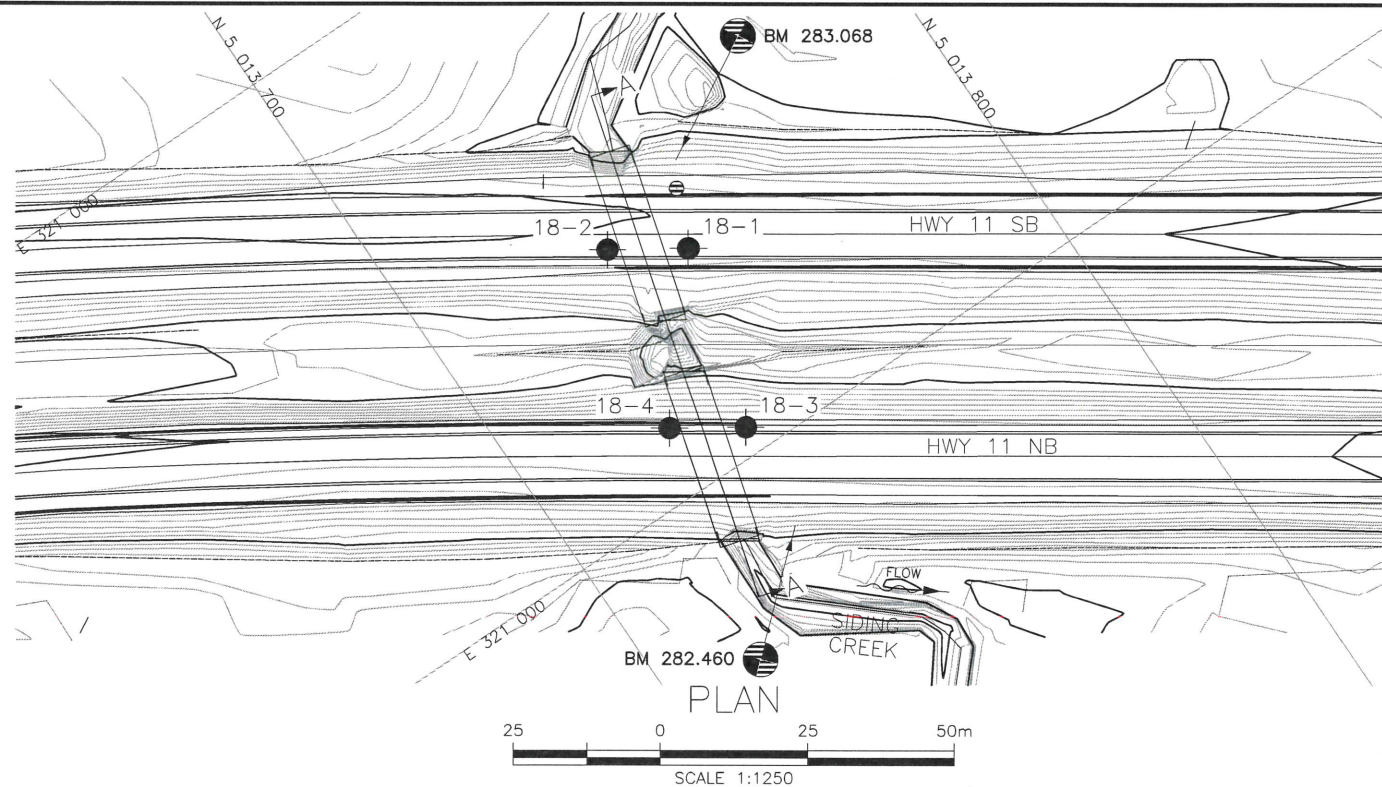


Dr. P.K. Chatterji, P.Eng.
Review Principal
Senior Geotechnical Engineer

FINAL

Appendix A.

Borehole Location Plan and Stratigraphic Drawings



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



CONT No 2019-XXXX
WP 5509-15-02, 5509-05-03

SIDING LAKE CREEK
CULVERT REHABILITATION
BOREHOLE LOCATIONS AND SOIL STRATA

McINTOSH PERRY



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

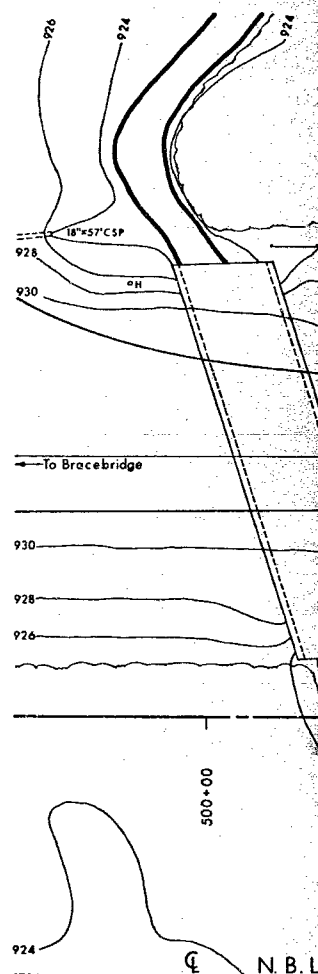
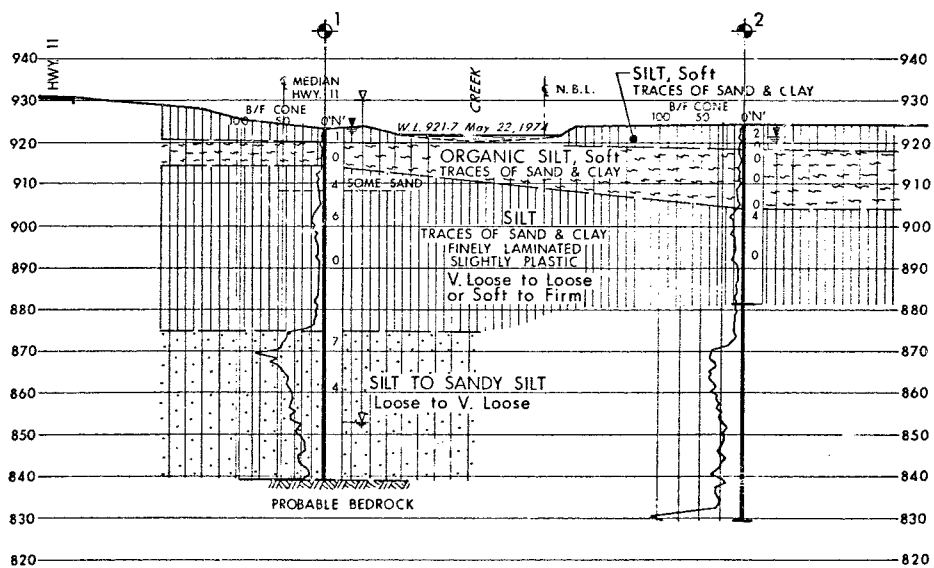
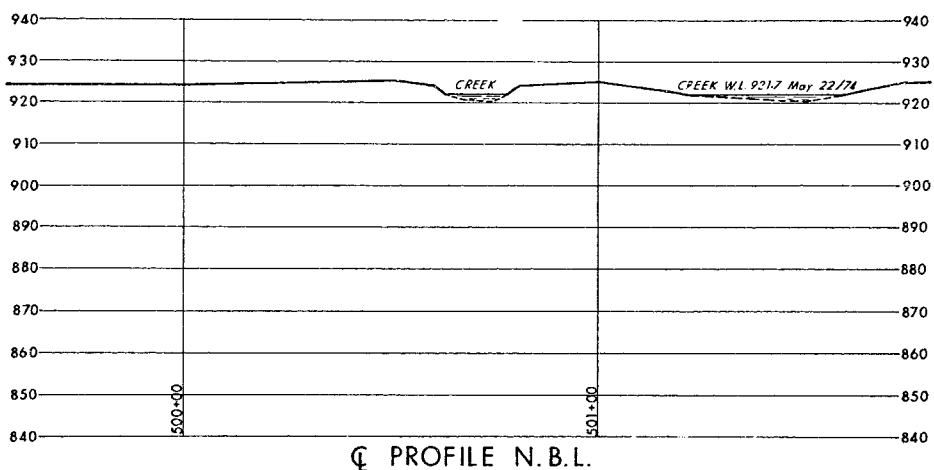
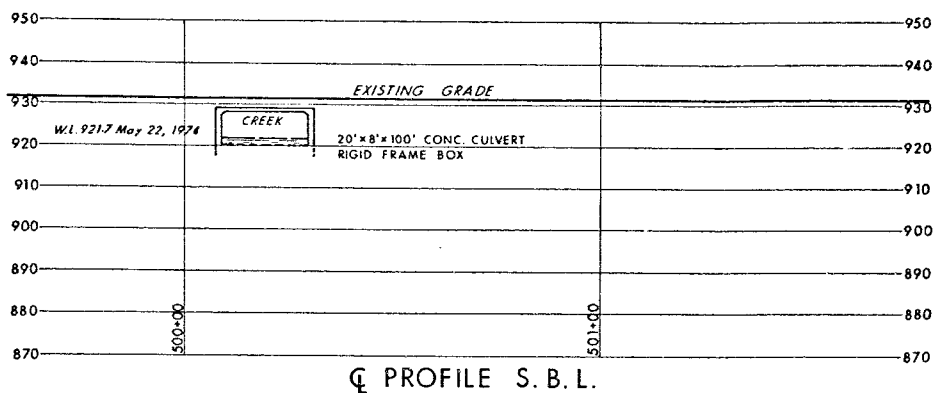
NO	ELEVATION	NORTHING	EASTING
18-1	283.9	5 013 745.5	321 064.6
18-2	283.9	5 013 734.0	321 057.1
18-3	283.9	5 013 736.4	321 095.3
18-4	283.9	5 013 725.7	321 088.2

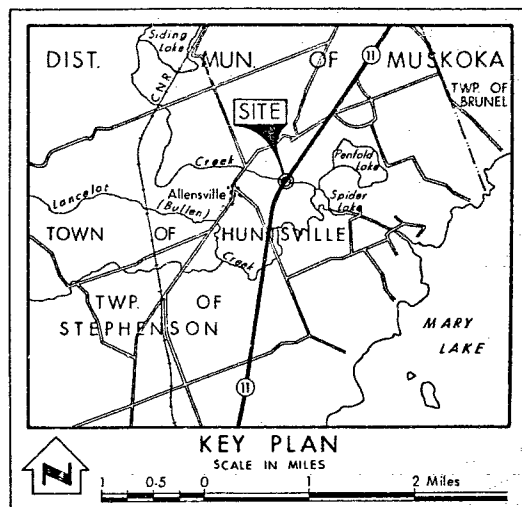
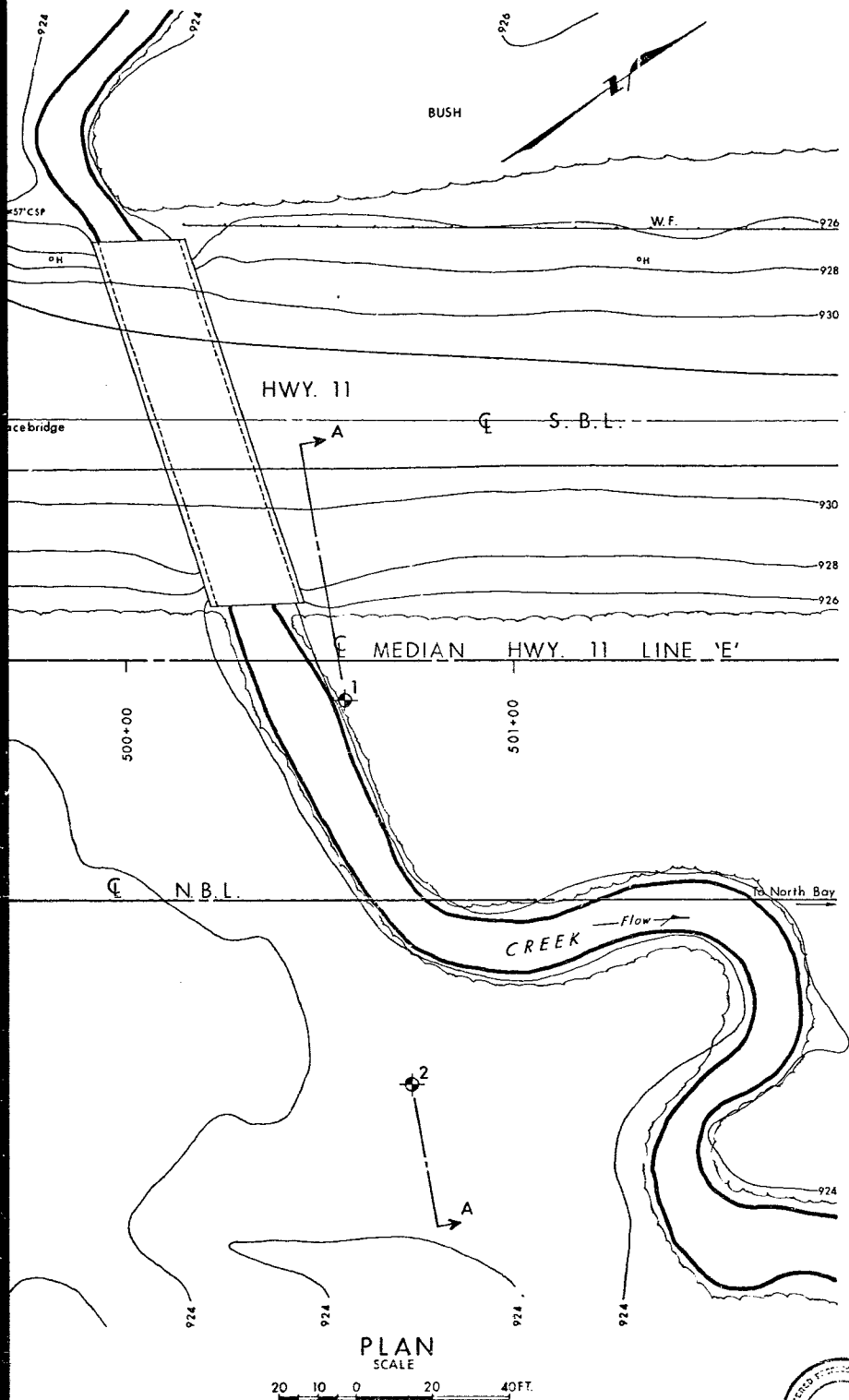
-NOTES-

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- Coordinate system is MTM NAD 83 Zone 10.

GEOCREs No. 31E-395

REVISIONS		DATE	BY	DESCRIPTION
DESIGN	KE	CHK	SP	CODE
DRAWN	AN	CHK	KE	SITE 42X-0184/C1,C2
		LOAD	DATE	FEB 2019
		STRUCT	DWG	R5-02





LEGEND			
	Bore Hole		
	Cone Penetration Test		
	Bore Hole & Cone Test		
	Water Levels established at time of field investigation, Oct 31, 1974		
	Head ARTESIAN CONDITIONS Encountered		
NO.	ELEVATION	STATION	OFFSET
1	923.0	500+56	10' RT.
2	924.4	500+74	110' 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

CREEK
APPROX. 0.85 MILE NORTH OF LANCELOT (BULLEN) CREEK

Highway No. 11 Line 'E' DIST. NO. 11
Dist. Mun. of MUSKOKA Town of HUNTSVILLE
TWP. STEPHENSON LOT 27 CON. XI

BORE HOLE LOCATIONS & SOIL STRATA

SUBMD A.P.	CHECKED	WP NO. 149-73-01	DRAWING NO.
DRAWN	CHECKED	WO NO.	1497301-A
DATE Dec. 16, 1974	SITE NO.	BRIDGE DRAWING NO.	
APPROVED	CONT. 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).

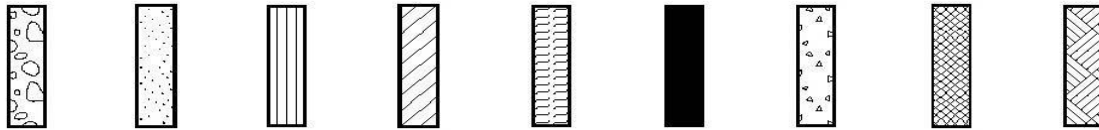
DYNAMIC CONE PENETRATION TEST (DCPT):

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: 45.263481°, Long: -79.292746° Siding Lake Creek, MTM Zone 10: N 5 013 745.5 E 321 064.6 ORIGINATED BY SOB
 HWY 11 BOREHOLE TYPE CME55 Truck with HSA COMPILED BY KE
 DATUM Geodetic DATE 2018.04.24 - 2018.04.24 CHECKED BY SP

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

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

DOUBLE LINE 20244_SIDINGCREEK.GPJ 2012TEMPLATE(MTO).GDT 22/11/19

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 18-2

1 OF 2

METRIC

GWP# 5138-13-00 LOCATION Lat: 45.263377°, Long: -79.292842° Siding Lake Creek, MTM Zone 10: N 5 013 734.0 E 321 057.1 ORIGINATED BY SOB
 HWY 11 BOREHOLE TYPE CME55 Truck with HSA / NW Casing COMPILED BY KE
 DATUM Geodetic DATE 2018.04.24 - 2018.04.24 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
								20 40 60 80 100					
283.9	Southbound Lane												
0.0	ASPHALT (150 mm)												
0.2	SAND some gravel very dense, dark brown, moist		1	SS	55								
283.1	FILL												
0.8	SAND some gravel compact, brown, moist		2	SS	15								
	FILL												
	wet below 1.5 m		3	SS	11								
281.6													
2.3	SILT (ML-OL) with sand and organics loose, grey-dark brown, wet		4	SS	4								
			5	SS	2								
280.1													
3.8	SANDY SILT (ML) very loose, grey, wet		6	SS	2								
			7	SS	WH								
278.6													
5.3	SILT (ML) some sand very loose, brown-grey, wet		8	SS	WH								
277.8													
6.1	SILT (ML) very loose to loose, grey-dark brown, wet		9	SS	WH								
			10	SS	4								
			11	SS	6								

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

DOUBLE LINE 20244_SIDINGCREEK.GPJ 2012TEMPLATE(MTO).GDT 22/11/19

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

DOUBLE LINE 20244 SIDINGCREEK.GPJ 2012TEMPLATE(MTO).GDT 22/1/19

RECORD OF BOREHOLE No 18-3

2 OF 2

METRIC

GWP# 5138-13-00 LOCATION Lat: 45.263397°, Long: -79.292356° Siding Lake Creek, MTM Zone 10: N 5 013 736.4 E 321 095.3 ORIGINATED BY SOB
HWY 11 BOREHOLE TYPE CME55 Truck with HSA COMPILED BY KE
DATUM Geodetic DATE 2018.04.23 - 2018.04.23 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 ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				W P W W L				GR SA SI CL				
								○ UNCONFINED + FIELD VANE				WATER CONTENT (%)								
								● QUICK TRIAXIAL × LAB VANE												
	Continued From Previous Page							20	40	60	80	100								
	SILT (ML) very loose, grey, wet		10	SS	3		273								○					
							272													
				11	SS	WH		271							○					
270.6																				
13.3	CLAY (Cl) soft, grey																			
				12	SS	WH		270							◡			0	1	39
269.6																				
14.3	End of Borehole Water level in HSA at 2.7 m (elev. 281.2 m)																			

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

RECORD OF BOREHOLE No 18-4

1 OF 2

METRIC

GWP# 5138-13-00 LOCATION Lat: 45.263301°, Long: -79.292446° Siding Lake Creek, MTM Zone 10: N 5 013 725.7 E 321 088.2 ORIGINATED BY SOB
 HWY 11 BOREHOLE TYPE CME55 Truck with HSA COMPILED BY KE
 DATUM Geodetic DATE 2018.04.23 - 2018.04.23 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
								20 40 60 80 100					
283.9	Northbound Lane												
0.0	ASPHALT (130 mm)												
0.1	SAND with gravel very dense to very loose, brown, moist FILL		1	SS	100								
					230mm								
			2	SS	100								
					175mm								
			3	SS	26								
	wet below 2.4 m		4	SS	3								
280.7													
3.2	SILT (ML) trace sand, trace organics very loose, grey to brown, wet		5	SS	1								
			6	SS	1								
279.3													
4.6	SILT (ML-OL) with organics very loose, dark brown, wet		7	SS	1								
			8	SS	WH								
277.8													
6.1	SILT (ML) with sand very loose, brown-grey, wet		9	SS	WH								
276.3													
7.6	SILT (ML) loose to very loose, grey, wet		10	SS	WH								
			11	SS	6								

Continued Next Page

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

DOUBLE LINE 20244_SIDINGCREEK.GPJ 2012TEMPLATE(MTO).GDT 22/11/19

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

ENGINEERING SERVICES BRANCH - GEOTECHNICAL OFFICE - SOIL MECHANICS SECTION

W.P. 149-73-01 LOCATION Sta. 500 + 56 O/s 10' RT. & Highway 11 Line 'E' ORIGINATED BY A.P.
DIST. 11 HWY. 11 BORING DATE October 28th and October 29th, 1974 COMPILED BY G.P.
DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger & Cone Test CHECKED BY C.P.

SOIL PROFILE			SAMPLES			GROUND WATER ELEV.	DYNAMIC CONE PENETRATION RESISTANCE PLOT	LIQUID LIMIT ——— w_L	UNIT WEIGHT γ	Artesian Head Elev. 7930.0
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20 40 60 80 100	PLASTIC LIMIT ——— w_p		REMARKS
							SHEAR STRENGTH	WATER CONTENT ——— w		
							○ UNCONFINED + FIELD VANE	$w_p \quad w \quad w_L$		
							● QUICK TRIAXIAL x LAB VANE	WATER CONTENT %		
							400 800 1200 1600 2000	20 40 60		
923.0	Ground level									
0.0	Silt - some sand, Traces of clay		1	SS	1				Org. 0.46%	0 4 88 8
920.0			2	TW	PM	+ s=8.0				
3.0	Organic silt Traces of sand and clay soft		3	SS	0	+ s=2.7			Org. 3.44%	0 19 79 2
914.5			4	TW	PM	+ s=3.3			Org. 0.76%	0 19 77 4
8.5	some sand		5	SS	4	+ s=5.0			Org. 0.84%	0 1 79 20
	-----		6	TW	PM	+ s=11.3				
	Silt Traces of sand & clay finely laminated		7	SS	6	+ s=2.7			Org. 0.07%	0 3 89 8
	(possesses slight plasticity)		8	TW	PM	+ s=4.4				
	Soft to firm very loose to loose		9	SS	0	+ s=4.0				
			10	TW	PM	+ s=4.4				
875.0						+ s=3.4				
48.0	Silt to sandy silt		11	SS	7					
	Loose to very loose		12	SS	4					0 11 88 1
839.0										Artesian Encountered Elev. 853.0
84.0	End of borehole Refusal Probable bedrock					bouncing 100/2"				

OFFICE REPORT ON SOIL EXPLORATION

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

RECORD OF BOREHOLE NO 2

W.P. 149-73-01 LOCATION Sta. 500 + 74 0/s 110' RT. E Highway 11 Line "E" ORIGINATED BY A.P.
DIST. 11 HWY. 11 BORING DATE October 30th and 31st, 1974 COMPILED BY G.R.
DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger & Cone Test CHECKED BY

SOIL PROFILE		STRAT. PLOT	SAMPLES			GROUND WATER ELEV.	DYNAMIC CONE PENETRATION RESISTANCE PLOT		LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w		UNIT WEIGHT γ	REMARKS		
ELEV. DEPTH	DESCRIPTION		NUMBER	TYPE	'N' VALUES		20	40	60	80			100	w_p
924.4	Ground Level													
0.0	Silt		1	SS	2	920	+s=4.0							Org. 1.52%
918.4	Some sand, traces of clay soft		2	TW	PM									1.23%
6.0			3	SS	0		+s=2.7							0.49%
	Organic silt		4	SS	0									Org. 0.573%
	Traces of sand and clay		5	TW	PM		+s=2.2							Org. 3.27%
			6	SS	0	910	+s=4.0							
	Soft to firm		7	TW	PM		+s=5.5							
904.4			8	SS	0		+s=9.6							Org. 1.49%
20.0	Silt		9	SS	4									
	traces of sand and clay		10	TW	PM	900	+s=6.7							
	Finely laminated (possesses slight plasticity)		11	SS	0		+s=4.0							
	Soft to firm or very loose to loose		12	TW	PM	890								
881.4							+s=3.2							
43.0	End of Borehole					880								
873.4														
51.0	probable silt to sandy silt					870								
	loose to very loose					860								
						850								
						840								
829.4						830								
95.0	End of cone test													

Appendix C.

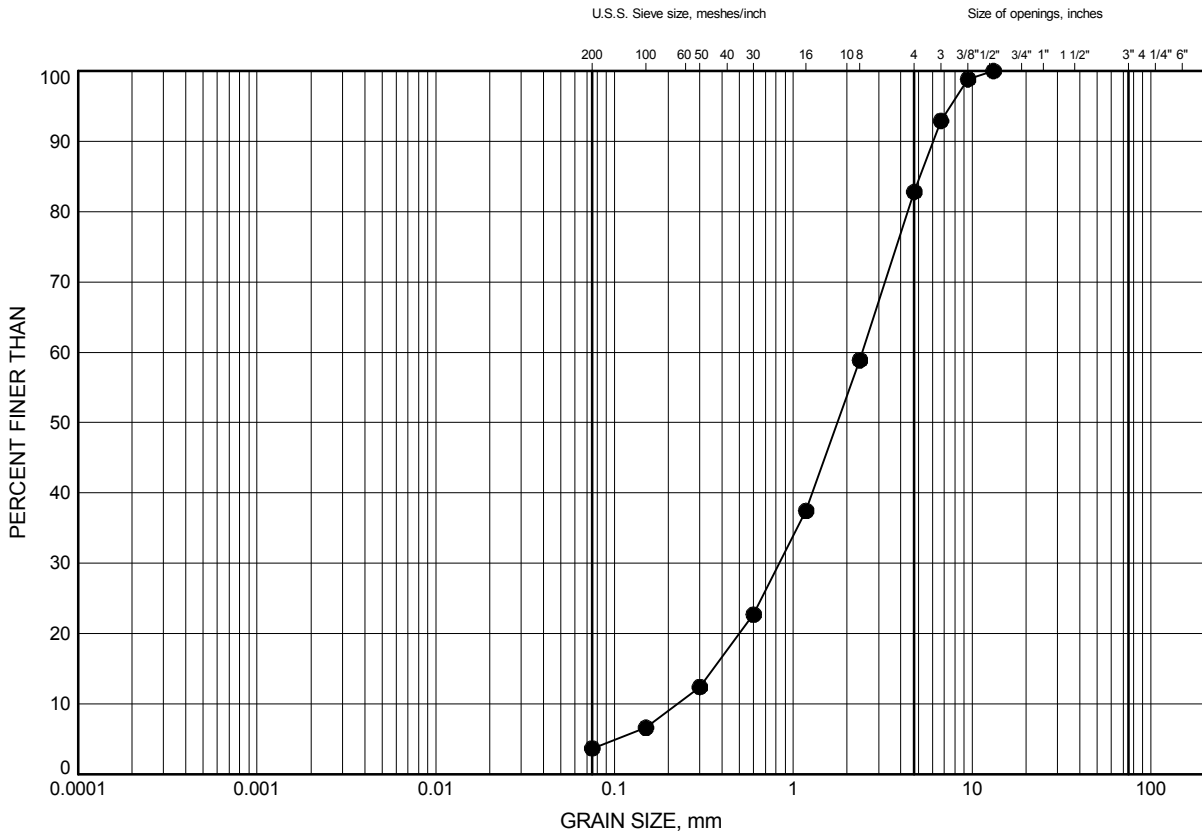
Laboratory Testing

Appendix C.1
Particle Size Analysis Figures

Hwy's 11 and 118 - Siding Lake Creek GRAIN SIZE DISTRIBUTION

FIGURE C1

FILL: SAND with gravel



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-4	1.8	282.1

Date January 2019
GWP# 5138-13-00

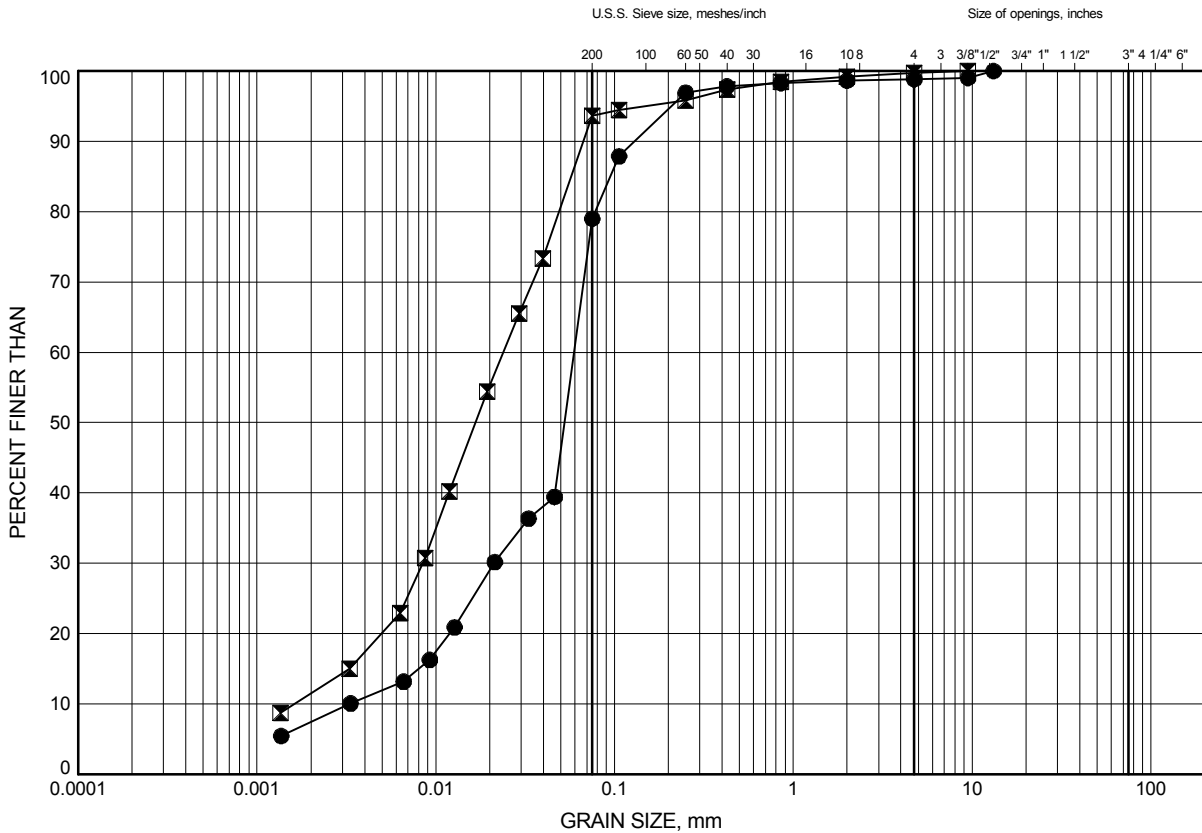


Prep'd KE
Chkd. SP

Hwy's 11 and 118 - Siding Lake Creek GRAIN SIZE DISTRIBUTION

FIGURE C2

SILT (ML) to SILT with Organics (ML-OL)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-1	2.6	281.3
⊠	18-4	4.1	279.8

Date January 2019

GWP# 5138-13-00



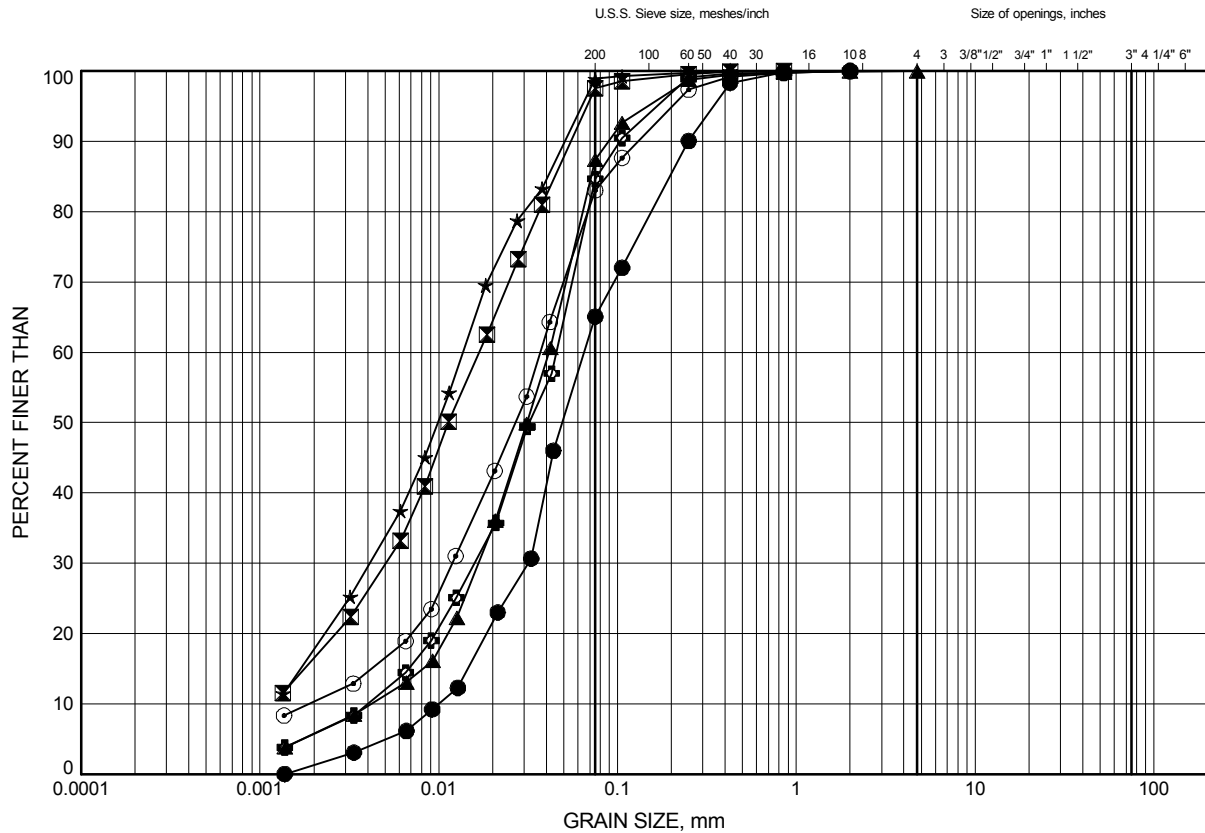
Prep'd KE

Chkd. SP

Hwy's 11 and 118 - Siding Lake Creek GRAIN SIZE DISTRIBUTION

FIGURE C3

SILT 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	5.6	278.3
⊠	18-1	7.9	276.0
▲	18-2	5.6	278.3
★	18-2	7.9	276.0
⊙	18-3	4.1	279.8
⊕	18-3	6.4	277.5

Date January 2019

GWP# 5138-13-00



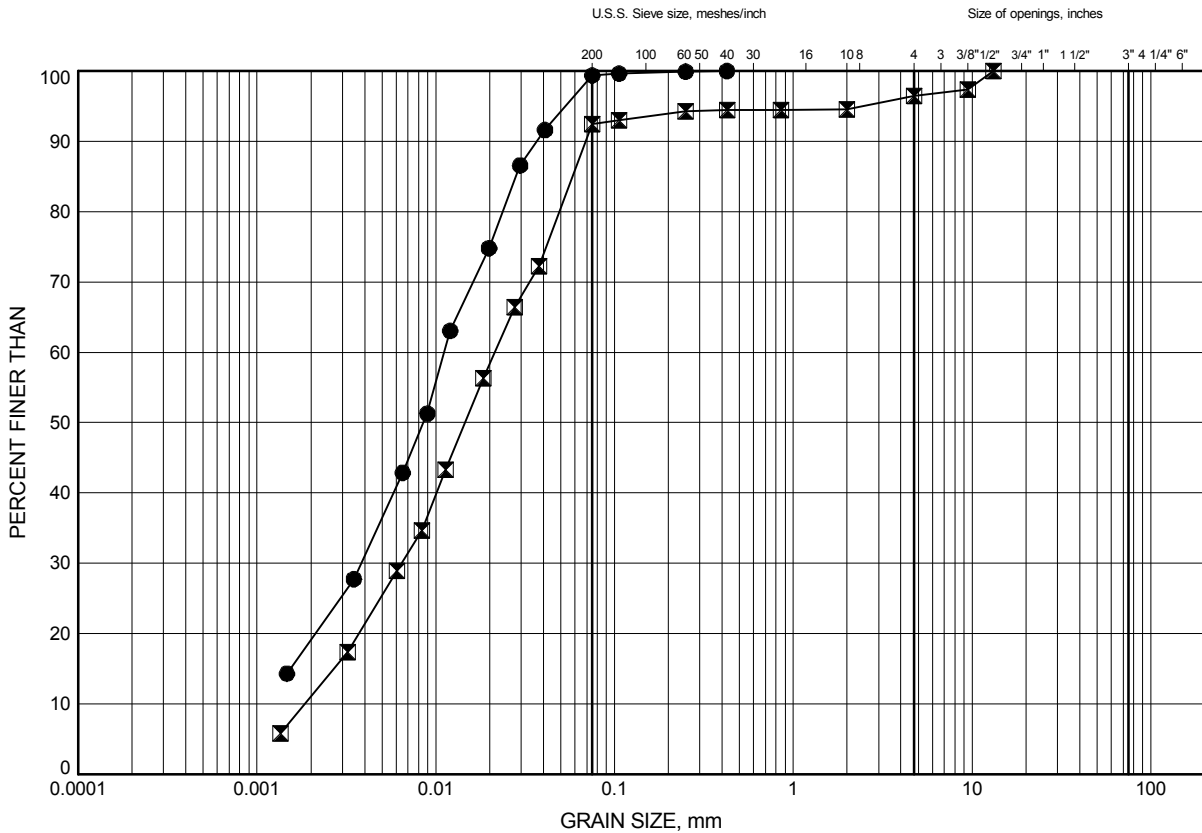
Prep'd KE

Chkd. SP

Hwy's 11 and 118 - Siding Lake Creek GRAIN SIZE DISTRIBUTION

FIGURE C4

SILT 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)
●	18-3	7.9	276.0
⊠	18-4	9.4	274.5

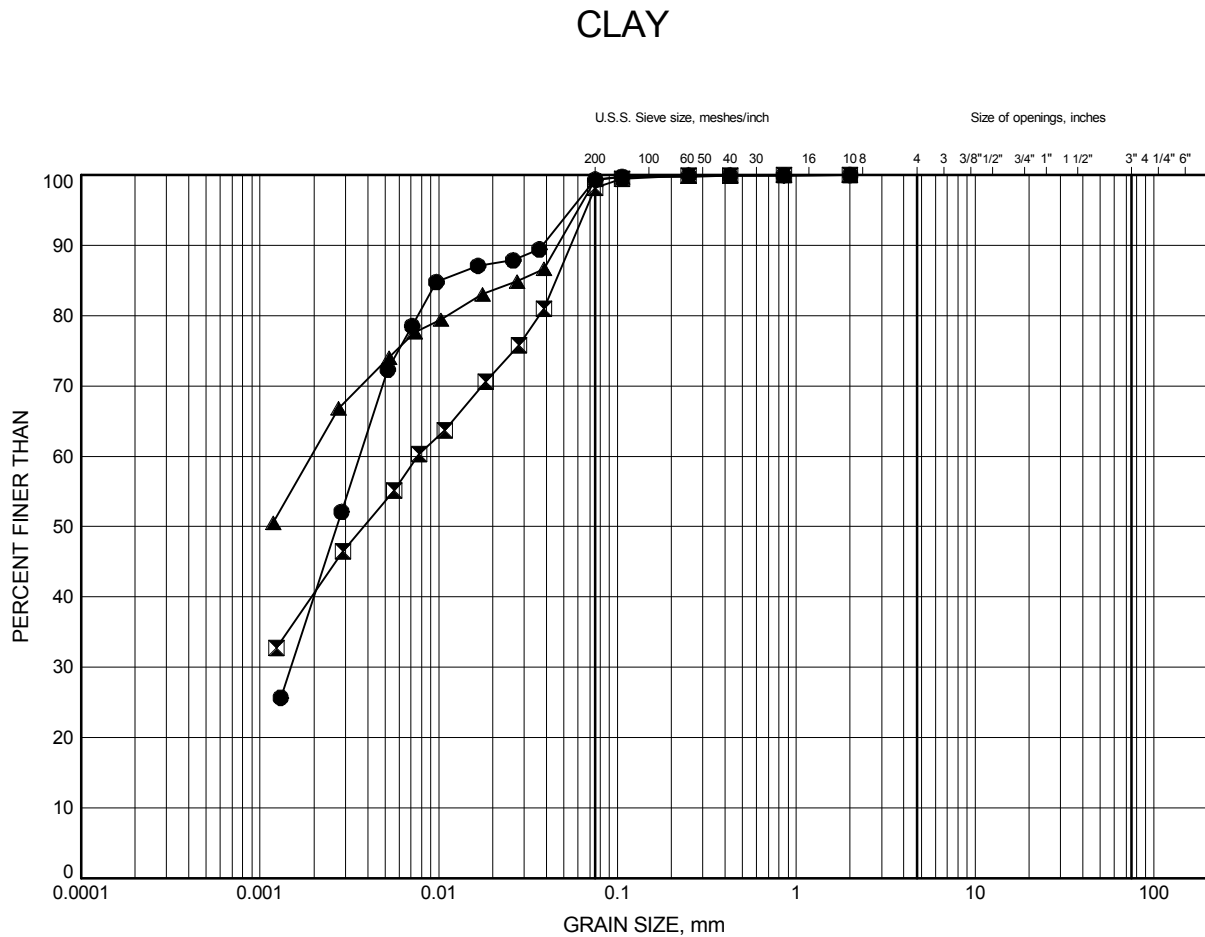
Date January 2019
GWP# 5138-13-00



Prep'd KE
Chkd. SP

Hwy's 11 and 118 - Siding Lake Creek GRAIN SIZE DISTRIBUTION

FIGURE C5



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-1	14.0	269.9
⊠	18-2	12.5	271.4
▲	18-3	14.0	269.9

Date January 2019

GWP# 5138-13-00



Prep'd KE

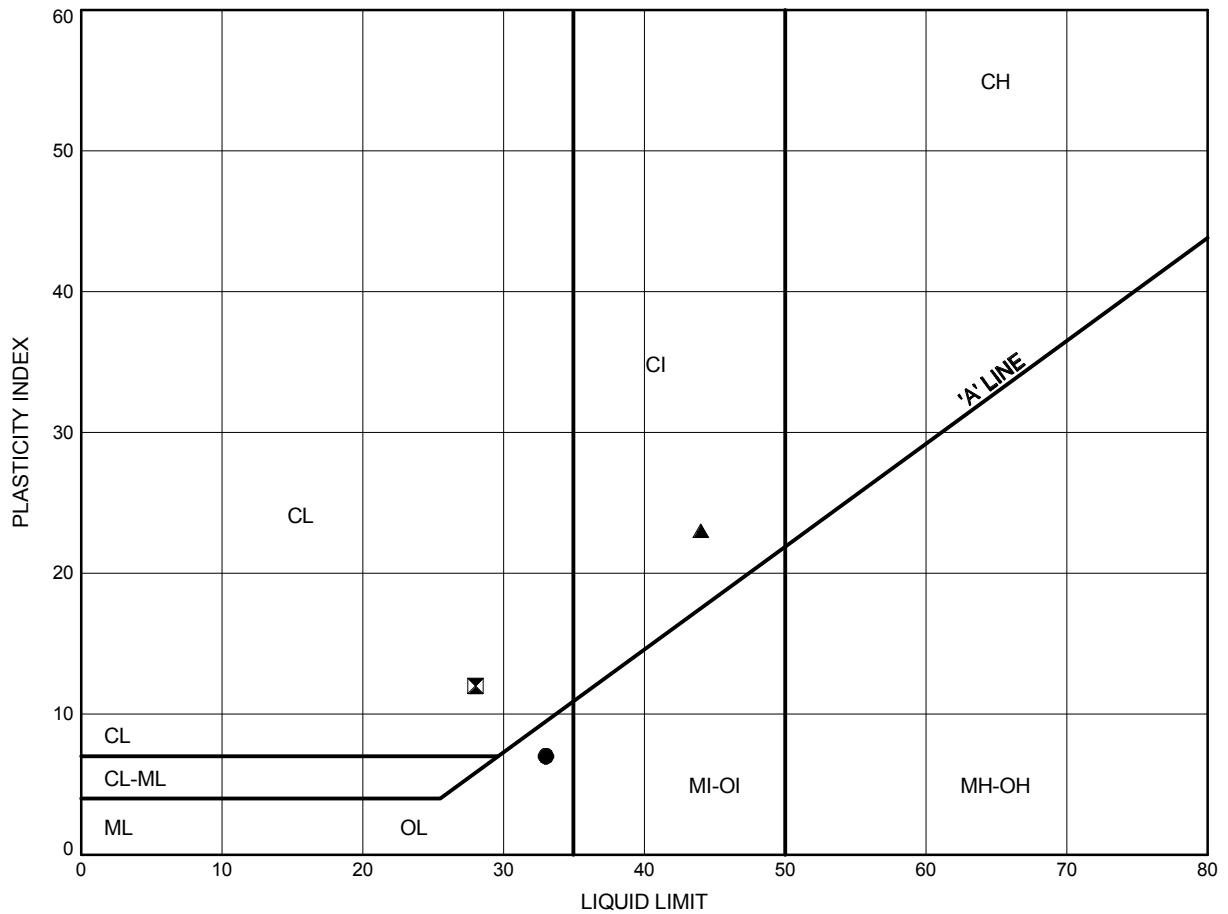
Chkd. SP

Appendix C.2
Atterberg Limits Figures

Hwy's 11 and 118 - Siding Lake Creek

ATTERBERG LIMITS TEST RESULTS

FIGURE C6



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-1	14.0	269.9
⊠	18-2	12.5	271.4
▲	18-3	14.0	269.9

Date January 2019
GWP# 5138-13-00



Prep'd KE
Chkd. SP

Appendix C.3
Analytical Testing Results

Certificate of Analysis

Thurber Engineering Ltd.

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

Client PO:
Project: 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

Client ID:	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"
Sample Date:	04/30/2018 09:00	04/30/2018 09:00	04/29/2018 09:00	04/29/2018 09:00
Sample ID:	1818669-01	1818669-02	1818669-03	1818669-04
MDL/Units	Soil	Soil	Soil	Soil

Physical Characteristics

% Solids	0.1 % by Wt.	83.9	83.9	68.9	70.1
----------	--------------	------	------	------	------

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

Client ID:	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'
Sample Date:	04/28/2018 09:00	05/01/2018 09:00	04/21/2018 09:00	04/27/2018 09:00
Sample ID:	1818669-05	1818669-06	1818669-07	1818669-08
MDL/Units	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

Client ID:	Road 3 18-2 SS10 25-27'	Siding 18-2SS5 10-12'	Siding 18-3 SS5 10-12'	-
Sample Date:	04/27/2018 09:00	04/24/2018 09:00	04/23/2018 09:00	-
Sample ID:	1818669-09	1818669-10	1818669-11	-
MDL/Units	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
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: 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
Anions									
Chloride	55.9	5	ug/g dry	55.6			0.7	20	
Sulphate	23.4	5	ug/g dry	22.9			2.1	20	
General Inorganics									
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	
Physical Characteristics									
% 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
Anions									
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-0184/C1) looking southeast



Photo 4. Looking west at culvert ends in median



Photo 5. Southbound inlet (42X-0184/C2) looking south

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 281.6 m.