



**THURBER** ENGINEERING LTD.

**FINAL  
FOUNDATION INVESTIGATION AND DESIGN REPORT  
HIGHWAY 11 UNDERPASS STRUCTURE  
MUSKOKA RD 2, DISTRICT OF MUSKOKA  
AGREEMENT NO. 5017-E-0003  
Site No.: 42-168**

**G.W.P. 5336-11-00**

Geocres No.: 31E-392

Report to:

**McIntosh Perry Consulting Engineers Limited**

Latitude: 45.332368°  
Longitude: -79.236871°

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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 Muskoka Road 2 crossing of Highway 11, located approximately 1.7 km south of Highway 60 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, W.P. 74-74-05, Site No. 42-168, Hwy.11 District #11, Ravenscliffe Road, Muskoka Road No. 2, 1.2 Miles South of Hwy. 60 [Geocres No. 31E-77]

**2 SITE DESCRIPTION**

The project assignment includes an underpass structure that is a two span cast in place post tensioned voided concrete slab bridge. The existing underpass conveys Muskoka Road 2 in a west – east alignment at an approximate skew of 15 degrees over Highway 11.

The underpass (Structure No.42-168) has two spans of 36.6 m each, an overall width varying from 10.9 to 12.0 m and a varying overall roadway width varying from 8.5 to 9.6 m. The clearance under the structure is approximately 5 m. The structure is understood to have been constructed in 1979 and rehabilitated in 2000. The foundations are documented to consist of H-piles driven to refusal.

At the location of the underpass structure, Highway 11 includes two driving lanes plus a speed change lane in each direction. Highway 11 has a rural cross-section, paved

shoulders and a grassed median. Ramp intersection are located on Muskoka Road 2 approximately 120 m from both ends of the structure.

The approach fill height is approximately 7.7 m with the Muskoka Road 2 road surface at elevation 332.4 m. The existing Muskoka Road 2 embankment slopes are inclined at approximately 1.9H:1V to 4.3H:1V. Reinforced concrete barrier walls with railing are situated on each side of the deck as guardrails.

The land adjacent to Highway 11 is vegetated with grasses and trees. Adjacent to the highway right-of-way, the land consists of primarily commercial properties. Traffic volumes on this section of Highway 11 are understood to be 18,200 AADT (2016).

Select photographs showing the existing conditions in the area of the underpass 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 28<sup>th</sup> and May 1<sup>st</sup>, 2018. The field investigation consisted of advancing two boreholes, identified as 18-1, and 18-2 near the abutments of the structure. Additionally, an unsampled borehole, identified as 18-2A, was advanced east of Borehole 18-2 and extended by Dynamic Cone Penetration Test (DCPT) to refusal. The drilling was carried out using a truck mounted CME 55 drill rig equipped with hollow stem augers and casing. 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 a depth of 11.0 m in Borehole 18-2. The boreholes were sampled to depths of 18.0 and 16.5 m (elev. 314.5 and 315.9 m) below the existing ground surface in Boreholes 18-1 and 18-2, respectively. Borehole 18-2 was extended by DCPT to a final termination depth of 22.9 m (elev. 309.5 m). Borehole 18-2A was drilled to 5.2 m depth and then was extended using DCPT to refusal at a depth of 19.5 m (elev. 312.7 m).

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 elevations of the boreholes from the current investigation 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 HCP 113 (elev. 330.230 m), shown on Drawing B-625-11-10 dated April 20, 2017, 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	West of Structure, EB Lane	5 021 435.4	325 375.6	332.5	18.0
18-2	East of Structure, WB Lane	5 021 387.2	325 469.8	332.4	22.9
18-2A	East of Structure, WB Lane	5 021 383.8	325 475.4	332.2	19.5

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 of soil recovered from within Boreholes 18-1 and 18-2 was selected and submitted for analytical testing of corrosivity parameters. All laboratory test results 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 sand fill overlying native silt and sand, which was underlain by a clay deposit and a lower- silt deposit. Bedrock was not encountered within the depth of the current investigation.

A review of the historic Geocres report indicated elevation discrepancies with the current investigation and benchmarks, thus the information has not been included in the discussion provided herein.

## **5.1 Embankment**

### **5.1.1 Asphalt**

Both boreholes were drilled through the existing Muskoka Road 2 approach embankments and encountered a layer of asphalt at the surface with a thickness of 75 to 130 mm.

### **5.1.2 Fill: Sand**

Encountered below the asphalt in both boreholes was a layer of granular fill consisting of sand with varying amounts of silt and gravel. The underside depth of the granular fill was at 5.3 m below the existing roadway (elev. 327.1 to 327.2 m).

The SPT tests conducted in this fill gave N-values ranging from 8 to 89 blows indicating a variable relative density of loose to very dense, but was predominantly compact to dense.

Recorded moisture contents ranged from 2 to 11%. The results of grain size analyses conducted on two samples of the sand fill are summarized below and are illustrated on Figure C1 in Appendix C.

Soil Particle	Percentage (%)
Gravel	20 – 30
Sand	61 – 74
Silt & Clay	6 – 9

## **5.2 Silt with sand**

Below the embankment in both boreholes was a native deposit of silt with sand. The thickness of this silt deposit 0.8 m with a base elevation ranging from 326.3 to 326.4 m.

The SPT tests conducted in the silt layer gave N-values of 17 and 25 blows indicating a compact relative density.

Recorded moisture contents ranged from 17 to 20%. Atterberg Limits testing on one sample indicated that this material was non-plastic. The results of a grain size analysis conducted on one sample of the silt indicated the material consisted of 2% gravel, 16% sand, 73% silt and 9% clay, and the results are illustrated on Figure C2 in Appendix C.

## **5.3 Sand (SP-SM)**

A layer of sand with silt trace gravel was encountered in both boreholes below the silt with sand deposit (Section 5.2). This sand deposit had a thickness of 1.1 m and extended to an approximate underside elevation ranging from 325.2 to 325.3 m.

The SPT tests conducted in this sand layer gave N-values of 11 and 20 blows indicating a compact relative density.

The recorded moisture contents ranged from 8 to 13%. The results of a grain size analysis conducted on one sample of the sand deposit indicated the material consisted of 5% gravel, 89% sand and 6% fines, and the results are illustrated on Figure C3 in Appendix C.

#### 5.4 Silt

Below the sand was a deposit of silt with a thickness of 1.5 m and an underside depth of 8.7 m (elevation 323.7 to 323.8 m). SPT tests gave N-values of 6 and 15 blows indicating a loose to compact relative density. Moisture contents were recorded at 25 to 37%.

#### 5.5 Clay (CL)

Both boreholes encountered a clay deposit below the silt deposit. The thickness of this layer ranged from 3.2 to 3.5 m with a base elevation ranging from 320.2 to 320.6 m.

In-situ shear vane test results near the base of the layer indicated undrained shear strength ranging from 75 to 110 kPa indicating a stiff to very stiff consistency. The results of the in-situ shear vane tests indicate that the clay exhibits sensitivity. SPT tests gave N-values ranging from 3 to 6.

Recorded moisture contents ranged from 29 to 45%. The results of grain size analyses conducted on two samples of the clay are summarized below and illustrated on Figure C4 in Appendix C.

Soil Particle	Percentage (%)
Gravel	0
Sand	2 – 3
Silt	66 – 73
Clay	25 – 31

The results of Atterberg Limits testing completed on two samples of this material indicated a liquid limit ranging from 30 to 34, a plastic limit ranging from 20 to 24, and a plasticity index of 10. The laboratory results indicate that the clay has low plasticity (CL). The results are summarized on the Record of Borehole sheets in Appendix B and the Atterberg Limits graph is included in Figure C5 of Appendix C.

#### 5.6 Lower Silt to Silt with Sand (ML)

A lower deposit of silt with varying amounts of sand was encountered below the clay in both boreholes. Both boreholes were terminated within this lower silt layer at an elevation ranging from 315.9 to 314.5 m. Borehole 18-2 was extended further by DCPT to a final elevation of 309.5 m.

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

Recorded moisture contents ranged from 20 to 40%. Atterberg Limits testing on two samples indicated that this material was non-plastic. The results of grain size analysis conducted on two samples of the lower silt are summarized below and are illustrated on Figure C2 in Appendix C.

Soil Particle	Percentage (%)
Gravel	0
Sand	1 – 18
Silt	79 – 81
Clay	3 – 18

## 5.7 Refusal

Bedrock was not encountered within the depth of the current investigation.

DCPT Borehole 18-2A was extended to a refusal depth of 19.5 m (elev. 312.7 m), however it is expected that this refusal depth may not represent a bedrock surface.

## 5.8 Groundwater

The groundwater level measured in the boreholes during drilling operations on April 28<sup>th</sup> and May 1<sup>st</sup>, 2018 was recorded to be at an elevation of 326.1 and 325.5 m, respectively.

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

## 5.9 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 %
18-1 (SS9)	6.1 – 6.7	7	6.41	4,580	218	124	<0.02
18-2 (SS10)	7.6 – 8.2	10	5.76	561	1780	1170	<0.02

## 6 MISCELLANEOUS

Borehole locations were selected by Thurber relative to the bridge abutments and other site features. The as-drilled locations and ground surface elevation of the boreholes were surveyed 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 field investigation program was provided by Mr. Stephen Peters, P.Eng.

Routine geotechnical laboratory testing was completed by Thurber's laboratory in Ottawa, Ontario. Analytical testing was completed by Paracel Laboratories in Ottawa, Ontario. Interpretation of the factual data and preparation of this report were carried out by Miss Katya Edney, P.Eng. and 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.

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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 underpass rehabilitation works at the Muskoka Road 2 crossing of Highway 11 located 1.7 km south of Highway 60 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 sand fill overlying native silt and sand, which was underlain by a clay deposit and a lower- silt deposit. Bedrock was not encountered within the depth of the current investigation. The short-term groundwater level was recorded during drilling operations on April 28<sup>th</sup> and May 1<sup>st</sup>, 2018 at an elevation of 326.1 and 325.5 m.

The underpass (Structure No.42-168) is understood to have been constructed in 1979 and rehabilitated in 2000. The foundations are documented to consist of H-piles driven to refusal.

**7.1 Proposed Structure Rehabilitations**

At the time of preparation of this Foundation Investigation and Design Report, the proposed rehabilitation of the underpass structure, as per the General Arrangement Drawing dated May 2018, is to include abutment bearing replacements, patching the concrete to the interior face of barrier wall, concrete sealing to interior and exterior face of barriers and west

**FINAL**

abutment, reconstructing the concrete end dams and replacing the expansion joints, waterproofing and paving, replacement of missing deck drain extension at southeast corner, and repairing of deteriorated concrete. It is a possibility that the pier may be retrofitted to withstand new crash guidelines.

It is understood that the modifications will not add any further loading to the existing foundations.

## **8 GEOTECHNICAL RECOMMENDATIONS**

The embankments are 7.7 m in height above the adjacent ground level, with a clearance of approximately 5 m above Highway 11. At each end of the bridge structure, temporary protection systems are being considered to allow excavation behind the abutments while maintaining one lane of traffic. 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 native cohesionless soils below the water table are classified as Type 4 soil.

Newly placed granular fill constructed in accordance with OPSS 501 and the rehabilitation contract can be considered to be Type 2 soil.

It is anticipated that there will be space restrictions and excavations will need to be carried out within a protection system. Further discussion is presented in Section 8.2.

### **8.2 Temporary Protection Systems**

Temporary Protection Systems will likely 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 or a soldier pile and lagging system are considered to be two feasible options. Bracing may be required depending on the depth of the excavation.

Native deposits of loose to compact silt and compact sand were encountered just below the embankment. These deposits are sensitive to disturbance and vibrations. Using vibratory methods could induce settlement of the bridge approach embankments. Vibratory equipment should not be permitted at this site for installation or removal of the temporary protections system. Suggested wording for an NSSP is provided in Appendix E. Although not encountered within the boreholes, the Contractor should be aware that cobbles or obstructions could be present in the fill.

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 installation of the protection systems and rehabilitation works.

It is recommended that the TPS be left in place and cut off in accordance with OPSS 539.

### **8.3 Lateral Earth Pressures**

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 for 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 Horizontal Backfill**

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 the wall and adjacent soil to produce these conditions. The values to be used in design can be assessed from Figure C6.16 of the Commentary to the CHBDC using the soil group designation as outlined in Table 8-1. Active pressures should be used for unrestrained walls. For rigid structures, it is recommended that at-rest horizontal earth pressures be used for design. Where ground surfaces are sloped behind the walls, the coefficients provided in the Table 8-1 are not applicable and must be re-estimated.

## 8.4 Embankment Design and Reinstatement

### 8.4.1 Embankment Reconstruction

It is recommended that where the existing embankment has been removed as part of the rehabilitation work, that it be reinstated in accordance with OPSS 902 and consist of free draining, non- frost susceptible granular materials such as Granular A or Granular B Type II material meeting the requirements of OPSS.PROV 1010 and should be placed and compacted as per OPSS.PROV 501.

Pavement structure reinstatement should follow the recommendations provided in the Pavement Design Report (completed by others).

Heavy compaction equipment, used adjacent to the bridge abutments, must be restricted in accordance with OPSS.PROV 501. Care must be exercised when compacting the fill adjacent to the walls in order not to damage the structures. Embankment reconstruction after bridge 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 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 negligible settlement is expected to occur in the soils underlying the reinstated approach fills.

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

### **8.5 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 5.9 may be used to aid in the selection of coatings and corrosion protection systems for buried steel objects. The corrosive effects of road de-icing salts should also be considered.

## **9 CONSTRUCTION CONSIDERATIONS**

### **9.1 Surface and Groundwater Control**

Excavation for the rehabilitation is not expected to intersect the groundwater. Embankment reinstatement and structure backfilling required as part of the underpass structure rehabilitation must be carried out in the dry. The Contractor must be prepared to control the surface water flow and seepage from water perched in the fills 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 structure rehabilitation is completed and backfilled.

## **9.2 Scour Protection and Erosion Control**

Based on the subsurface conditions encountered in the boreholes, the embankment materials soils are considered to have low susceptibility to erosion as per the Wischmeier Nomograph. The native soils at the toe or below the embankment are considered to have moderate susceptibility to erosion.

Slope protection and drainage measures will be required to ensure the long-term surficial stability of the reinstatement of the embankment slopes. Slope vegetation should be established as soon as possible after completion of the embankment fills in order to control surficial erosion in general accordance with OPSS.PROV 804. The contractor should provide silt fences and erosion control blankets, as required, throughout the duration of the construction to prevent silt/sediment from running off the site as per OPSS 805.

## **10 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 structure will depend largely upon good workmanship and quality control during construction.

## 11 CLOSURE

Engineering analysis and preparation of this report were carried out by Miss Katya Edney, P.Eng. and 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.

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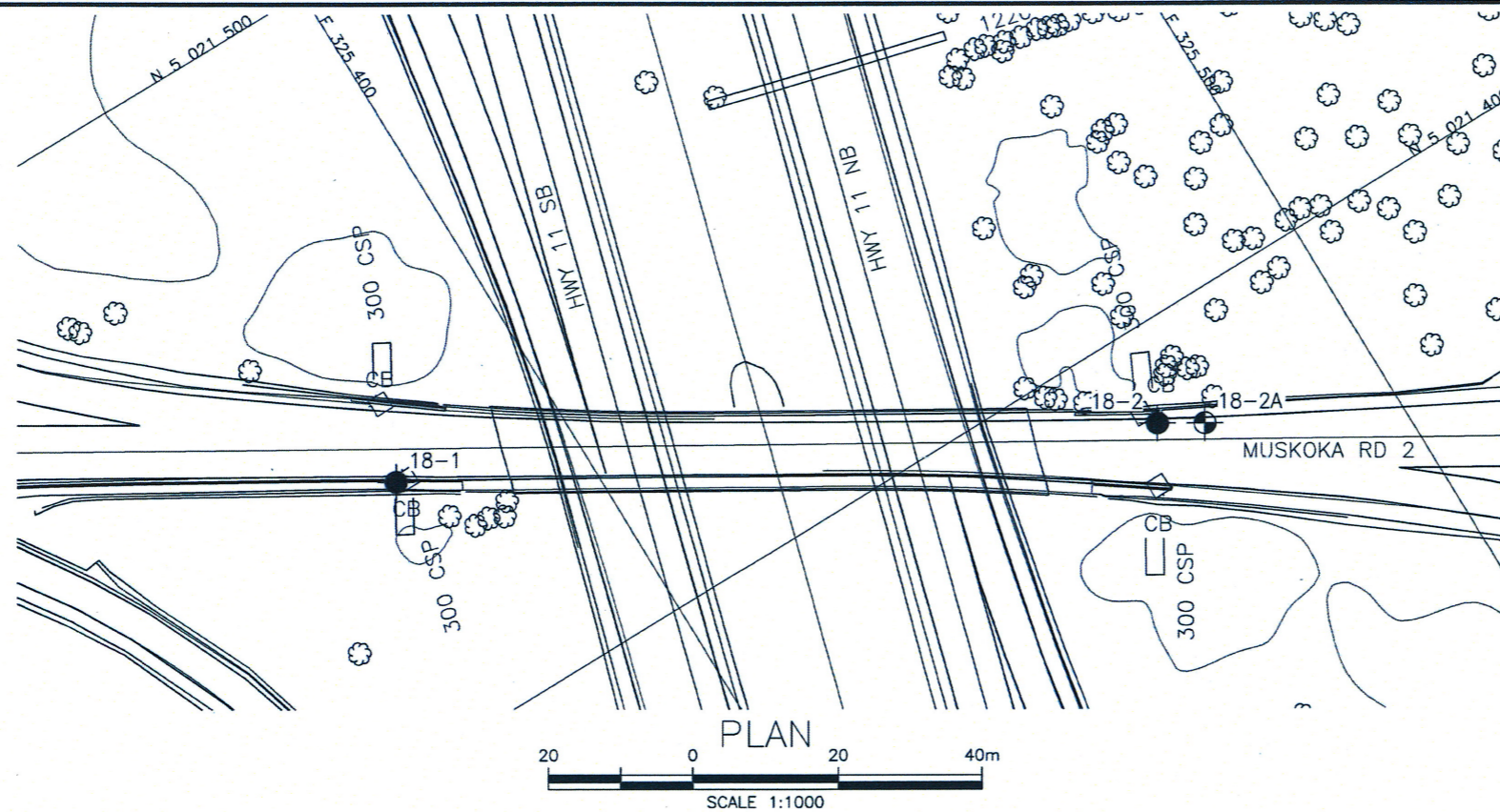


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## **Appendix A.**

### **Borehole Location Plan and Stratigraphic Drawings**



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

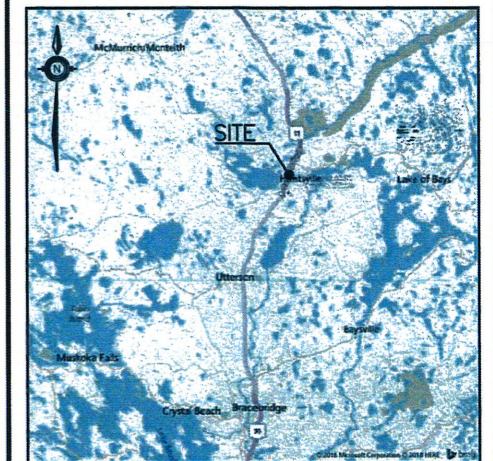


CONT No  
GWP No 5336-11-00

HIGHWAY 11  
MUSKOKA ROAD 2  
UNDERPASS  
BOREHOLE LOCATIONS AND SOIL STRATA

McINTOSH  
PERRY

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

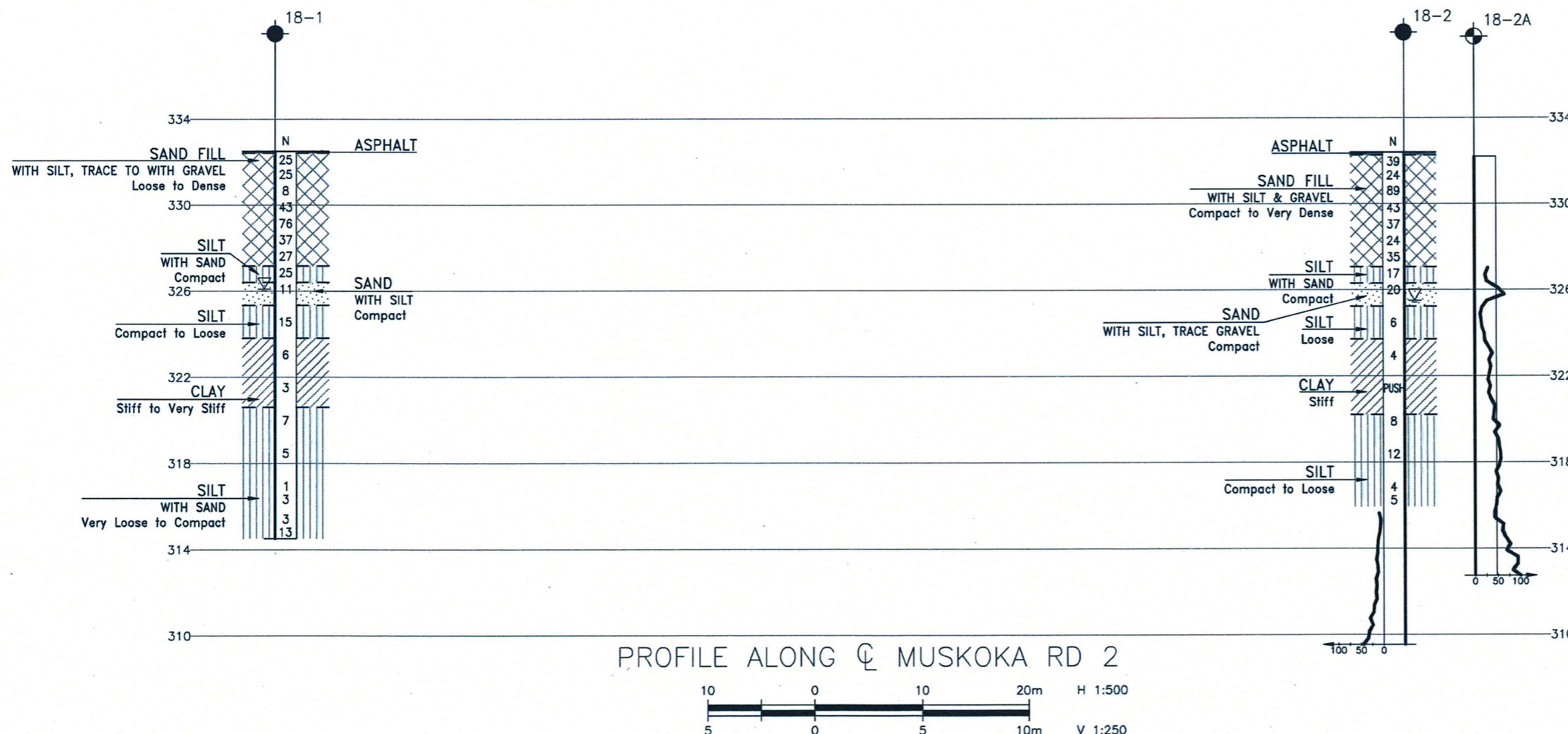
- Borehole
- ⊕ Borehole & Cone
- N Blows /0.3m (Std Pen Test, 475J/blow)
- CONE Blows /0.3m (60' Cone, 475J/blow)
- PH Pressure, Hydraulic
- ▽ Water Level
- ⬇ Head Artesian Water
- ⬇ Piezometer
- 90% Rock Quality Designation (RQD)
- A/R Auger Refusal

NO	ELEVATION	NORTHING	EASTING
18-1	332.5	5 021 435.4	325 375.6
18-2	332.4	5 021 387.2	325 469.8
18-2A	332.2	5 021 383.8	325 475.4

-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-392



REVISIONS	DATE	BY	DESCRIPTION
DESIGN	KE	CHK	SP
CODE	LOAD	DATE	JUL 2018

**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).

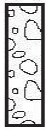
### **DYNAMIC CONE PENETRATION TEST (DCPT):**

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






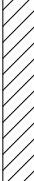
Rock Strength	Approximate Uniaxial Compressive Strength (MPa)
Extremely Strong	Greater than 250
Very Strong	100 – 250
Strong	50 – 100
Medium Strong	25 – 50
Weak	5 – 25
Very Weak	1 – 5
Extremely Weak	0.25 – 1

# RECORD OF BOREHOLE No 18-1

1 OF 2

METRIC

GWP# 5336-11-00 LOCATION Lat: 45.332565°, Long: -79.237495°  
HWY 11 BOREHOLE TYPE CME55 Truck with HSA / NW Casing ORIGINATED BY SOB  
DATUM Geodetic DATE 2018.04.28 - 2018.04.28 COMPILED BY KE  
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				W <sub>P</sub>	W	W <sub>L</sub>				
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL      × LAB VANE				WATER CONTENT (%)						
332.5							20	40	60	80	100							
0.0	ASPHALT (75 mm)																	
0.1																		
	SAND with silt and gravel compact, brown FILL		1	SS	25													
			2	SS	25													
331.0																		
1.5	SAND trace to some gravel loose to dense, brown FILL		3	SS	8													
				4	SS	43												
				5	SS	76												
				6	SS	37												
			7	SS	27													
327.2																		
5.3	SILT (ML) with sand compact, brown		8	SS	25													
326.4																		
6.1	SAND (SP-SM) with silt compact, brown		9	SS	11													
325.3																		
7.2	SILT (ML) compact, grey		10	SS	15													
323.8																		
8.7	CLAY (CL) stiff to very stiff, grey-brown		11	SS	6													

Continued Next Page

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

# RECORD OF BOREHOLE No 18-1

2 OF 2

METRIC

GWP# 5336-11-00 LOCATION Lat: 45.332565°, Long: -79.237495°  
HWY 11 BOREHOLE TYPE CME55 Truck with HSA / NW Casing ORIGINATED BY SOB  
DATUM Geodetic DATE 2018.04.28 - 2018.04.28 COMPILED BY KE  
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						
	Continued From Previous Page							20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						
								20 40 60 80 100 W P W W L WATER CONTENT (%)						
320.6	CLAY (CL) stiff to very stiff, grey-brown		12	SS	3		322							0 2 73 25
							321							
11.9	SILT (ML) with sand very loose to compact, grey		13	SS	7		320							
							319							
			14	SS	5		318							
							317							
			15	SS	1		316							0 18 79 3
			16	SS	3		315							Non-Plastic Switch to Casing
			17	SS	3									
			18	SS	13									
314.5	End of Borehole Water level during drilling operations at 6.4 mbgs (elev. 326.1 m) measured in HSA													
18.0														

+<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 3

METRIC

GWP# 5336-11-00 LOCATION Lat: 45.332129°, Long: -79.236294°  
HWY 11 BOREHOLE TYPE CME55 Truck with HSA ORIGINATED BY SOB  
DATUM Geodetic DATE 2018.05.01 - 2018.05.01 COMPILED BY KE  
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
								20 40 60 80 100				20 40 60							
332.4																			
0.0																			
0.1																			
	ASPHALT (130 mm)																		
	SAND with silt and gravel compact to very dense, brown FILL		1	SS	39		332												
			2	SS	24														
			3	SS	89		331												
			4	SS	43		330												
			5	SS	37		329												
			6	SS	24		328												
			7	SS	35														
327.1																			
5.3	SILT (ML) with sand compact, brown		8	SS	17		327												
326.3																			
6.1	SAND (SP-SM) with silt trace gravel compact, brown		9	SS	20		326												
325.2																			
7.2	SILT (ML) loose, grey		10	SS	6		325												
323.7							324												
8.7	CLAY (CL) stiff, grey-brown		11	SS	4		323												

Continued Next Page

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




DOUBLE LINE 20244\_MUSKOKARD2.GPJ 2012TEMPLATE(MTO).GDT 19/8/19

# RECORD OF BOREHOLE No 18-2

2 OF 3

METRIC

GWP# 5336-11-00 LOCATION Lat: 45.332129°, Long: -79.236294°  
HWY 11 BOREHOLE TYPE CME55 Truck with HSA ORIGINATED BY SOB  
DATUM Geodetic DATE 2018.05.01 - 2018.05.01 COMPILED BY KE  
CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	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													
	Continued From Previous Page							20 40 60 80 100					20 40 60								
320.2	CLAY (CL) stiff, grey-brown		12	ST	PUSH		322														
							321														
12.2	SILT (ML) compact to loose, grey		13	SS	8		320														
							319														
							318														
							317														
							316														
							315														
315.9	End of Sampled Borehole DCPT carried out from 16.5 to 22.9 m		14	SS	12		314														
							313														
16.5																					

Continued Next Page

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

RECORD OF BOREHOLE No 18-2

3 OF 3

METRIC

GWP# 5336-11-00 LOCATION Lat: 45.332129°, Long: -79.236294°  
HWY 11 BOREHOLE TYPE CME55 Truck with HSA  
DATUM Geodetic DATE 2018.05.01 - 2018.05.01

ORIGINATED BY SOB  
COMPILED BY KE  
CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	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 (%)					
	Continued From Previous Page DCPT continued													
							312							
							311							
							310							
309.5														
22.9	DCPT terminated at 22.9 m Water level during drilling operations at 6.9 mbgs (elev. 325.5 m) measured in HSA													

# RECORD OF BOREHOLE No 18-2A

1 OF 2

METRIC

GWP# 5336-11-00 LOCATION Lat: 45.332099°, Long: -79.236222°  
HWY 11 BOREHOLE TYPE DCPT HWY 11 UP at Muskoka Rd 2, MTM Zone 10: N 5 021 383.8 E 325 475.4  
DATUM Geodetic DATE 2018.05.01 - 2018.05.01

ORIGINATED BY SOB  
COMPILED BY KE  
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 ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE			WATER CONTENT (%) w <sub>p</sub> w      w <sub>L</sub>						
332.2								20	40	60	80	100	20	40	60		
0.0	Overburdon not sampled						332										
							331										
							330										
							329										
							328										
327.0							327										DCPT
5.2	DCPT carried out from 5.2 to 19.5 m						326										
							325										
							324										
							323										

Continued Next Page

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

RECORD OF BOREHOLE No 18-2A

2 OF 2

METRIC

GWP# 5336-11-00 LOCATION Lat: 45.332099°, Long: -79.236222°  
HWY 11 BOREHOLE TYPE DCPT HWY 11 UP at Muskoka Rd 2, MTM Zone 10: N 5 021 383.8 E 325 475.4  
DATUM Geodetic DATE 2018.05.01 - 2018.05.01

ORIGINATED BY SOB  
COMPILED BY KE  
CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT $\gamma$ 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		W <sub>p</sub>	W	W <sub>L</sub>		
	Continued From Previous Page							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE		WATER CONTENT (%)				
	DCPT continued						322							
							321							
							320							
							319							
							318							
							317							
							316							
							315							
							314							
							313							
312.7 19.5	DCPT terminated at 19.5 m													

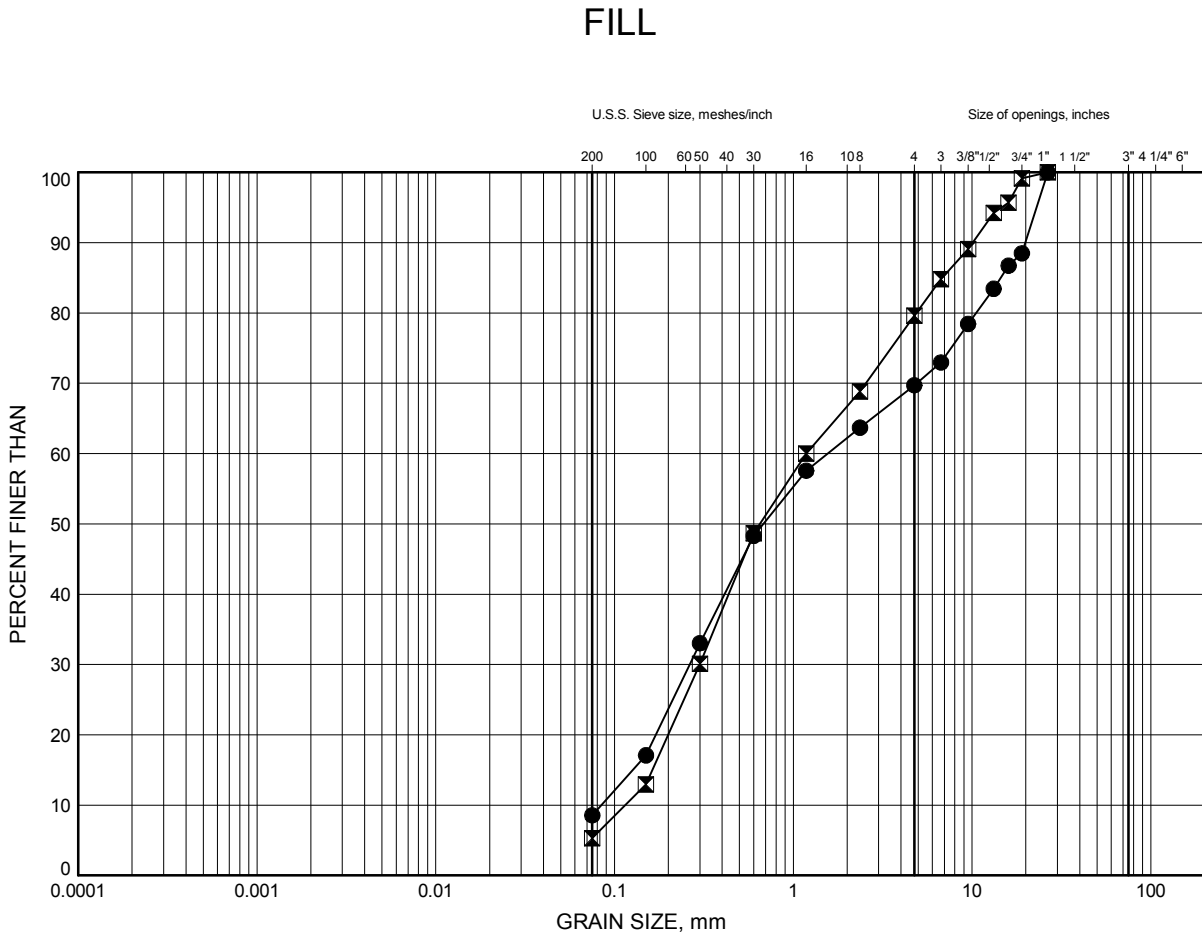
+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity  
20  
15  
10  
5  
0  
(%) STRAIN AT FAILURE

**Appendix C.**  
**Laboratory Testing**

# Hwy's 11 and 118 - Muskoka Road 2

## GRAIN SIZE DISTRIBUTION

FIGURE C1



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-1	0.4	332.1
⊠	18-2	2.6	329.8

Date August 2019  
GWP# 5336-11-00

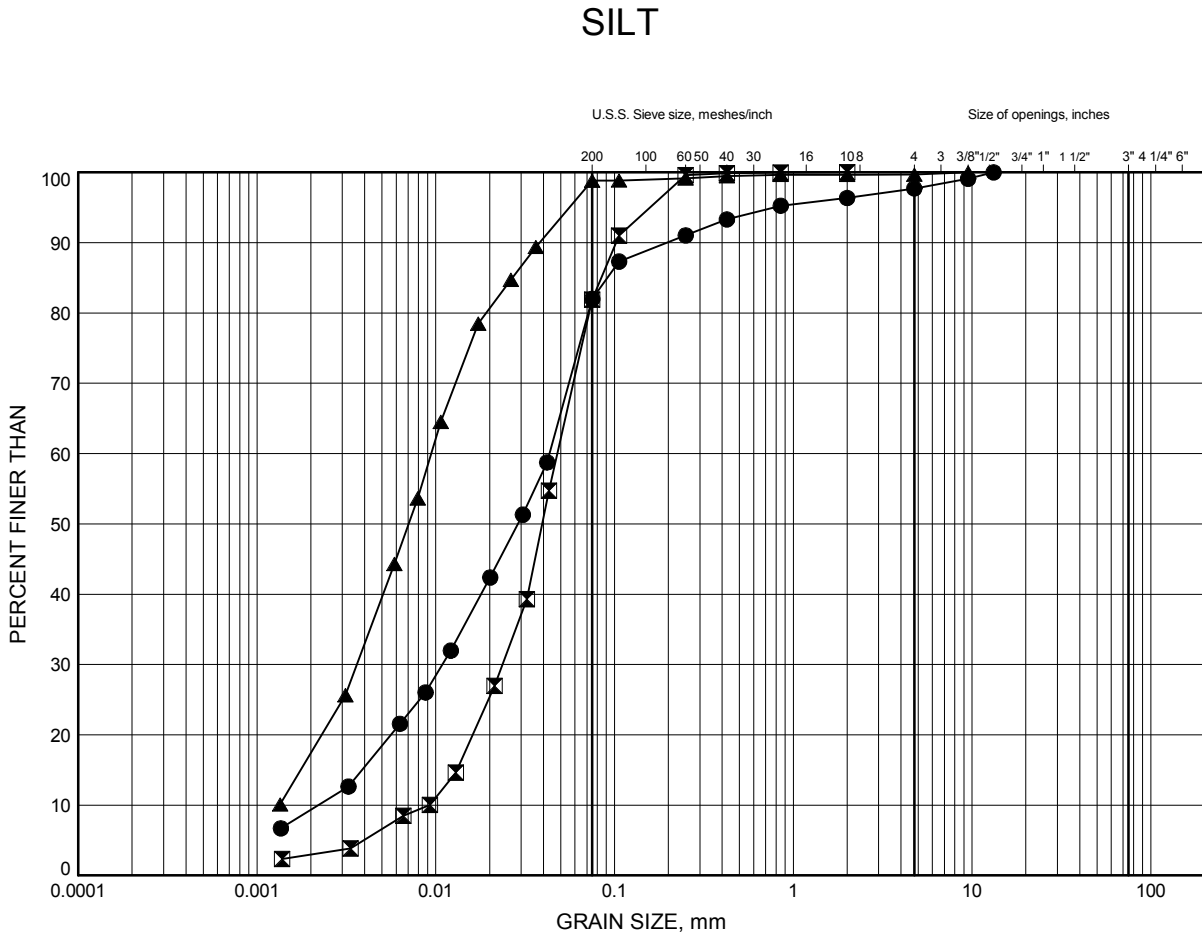


Prep'd KE  
Chkd. SP

# Hwy's 11 and 118 - Muskoka Road 2

## GRAIN SIZE DISTRIBUTION

FIGURE C2



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-1	5.6	326.9
⊠	18-1	16.2	316.3
▲	18-2	12.5	319.9

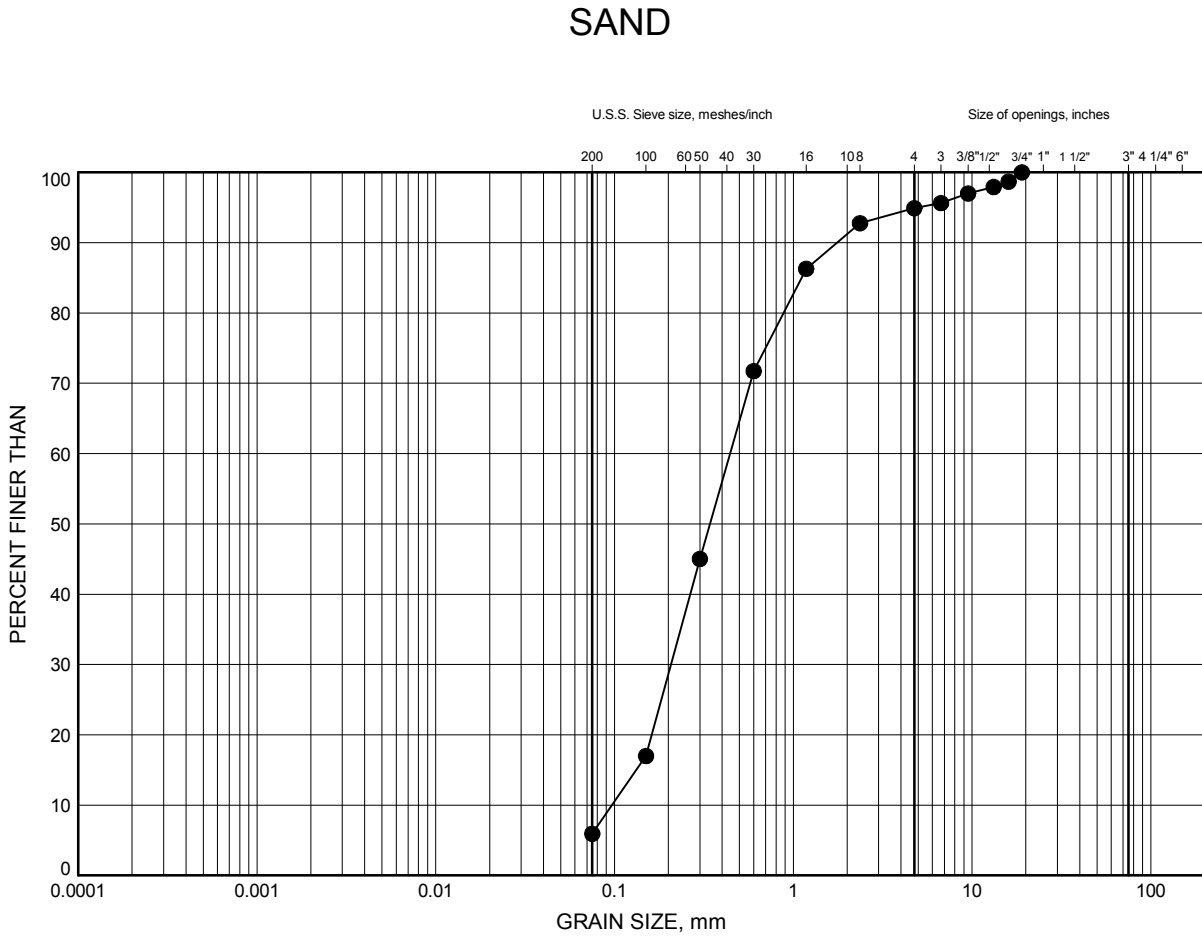
Date August 2019  
GWP# 5336-11-00



Prep'd KE  
Chkd. SP

Hwy's 11 and 118 - Muskoka Road 2  
**GRAIN SIZE DISTRIBUTION**

FIGURE C3



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

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-2	6.4	326.0

Date August 2019  
 GWP# 5336-11-00

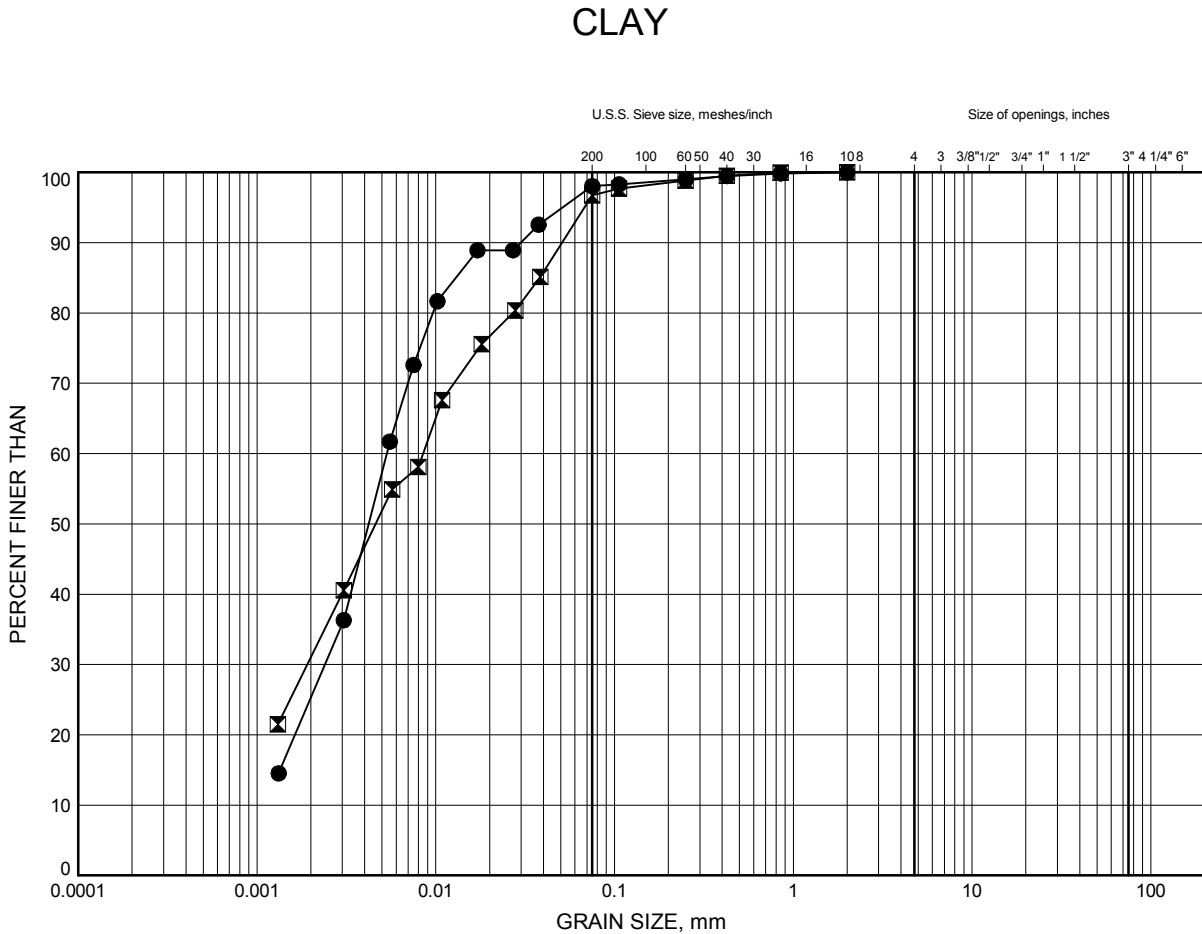


Prep'd KE  
 Chkd. SP

# Hwy's 11 and 118 - Muskoka Road 2

## GRAIN SIZE DISTRIBUTION

FIGURE C4



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-1	11.0	321.5
⊠	18-2	9.4	323.0

Date August 2019  
GWP# 5336-11-00

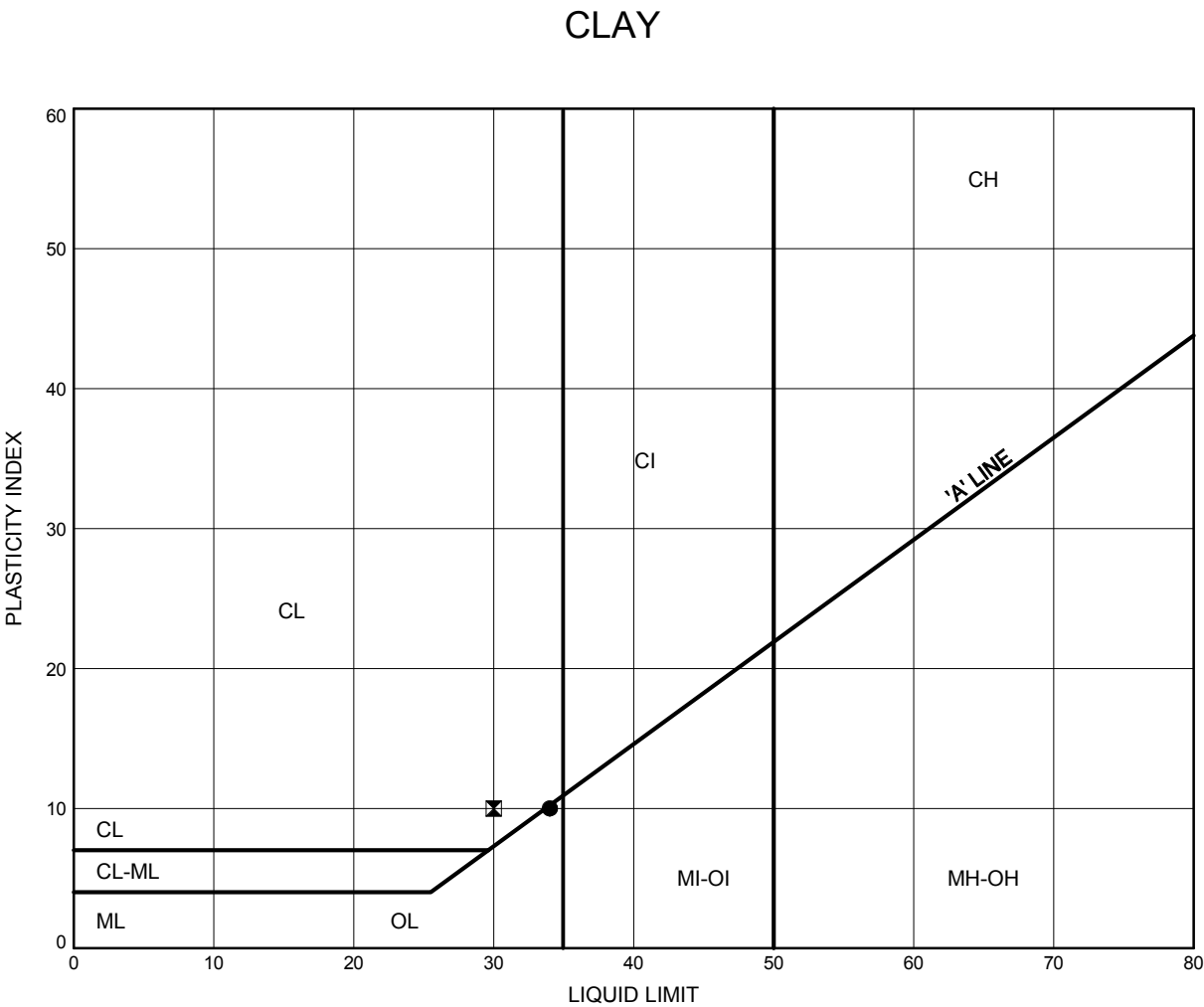


Prep'd KE  
Chkd. SP

Hwy's 11 and 118 - Muskoka Road 2

# ATTERBERG LIMITS TEST RESULTS

FIGURE C5



## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-1	11.0	321.5
⊠	18-2	9.4	323.0

THURBALT 20244\_MUSKOKARD2.GPJ 19/8/19

Date August 2019  
GWP# 5336-11-00



Prep'd KE  
Chkd. SP

## 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
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**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	-
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**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 Edney

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

Paracel 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 south along Highway 11 from West of Muskoka Road 2 Underpass Structure (April 28<sup>th</sup>, 2018)**



**Photo 2. Muskoka Road 2 Underpass Structure from east (May 1<sup>st</sup>, 2018)**



**Photo 3. Looking east along Muskoka Road 2 (May 1<sup>st</sup>, 2018)**



**Photo 4. Looking west along Muskoka Road 2 (April 28<sup>th</sup>, 2018)**

## **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 805	Construction Specification for Temporary Erosion and Sediment Control Measures
OPSS 902	Construction Specification for Excavating and Backfilling Structures
OPSS.PROV 1010	Material Specification for Aggregates Base, Subbase, Select Subgrade, and Backfill Material

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. Temporary protection systems shall be cut off and remain in place in accordance with OPSS.PROV 539.