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FOUNDATION INVESTIGATION AND DESIGN REPORT
REPLACEMENT OF STRUCTURAL CULVERT No. 39W-054/C
FIVE MILE CREEK CROSSING OF HIGHWAY 11
EILBER TOWNSHIP
DB 2016-5012

GEOCRES NUMBER: 42G-64

SUBMITTED TO

MCINTOSH PERRY CONSULTING ENGINEERS

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual data obtained from a foundation investigation conducted by Thurber Engineering Ltd. (Thurber) for the replacement of the Five Mile Creek Culvert located on Highway 11, within Eilber Township.

The proposed culvert replacement is being carried out as a Ministry of Transportation Design-Build procurement. Thurber carried out the current investigation as a subconsultant to McIntosh Perry Consulting Engineers (MPCE) under Contract No. DB 2016-5012.

The purpose of this investigation was to explore the subsurface conditions at the site and, based on this data, provide a borehole location plan, record of boreholes, a stratigraphic profile, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions was developed from the data obtained in the course of the current investigation and with data available from a previous investigation.

An earlier foundation investigation report that has been provided to Thurber and used in the preparation of this report is as follows:

> Final Foundation Investigation and Design Report, Culvert Replacement, Highway 11, Station 11+545 – Township of Eilber, Site No. 39W-054, GWP 5145-05-00 (GEOCRES 42G-57), dated February 2016 and prepared by Englobe.

The Record of Borehole sheets for the three boreholes (identified as Borehole Nos. 1 through 3) from the Englobe 2016 report are provided in Appendix B and have been incorporated into the Borehole Location and Soil Strata drawing included in Appendix A. It must be noted that Englobe is solely responsible for the accuracy and quality of the subsurface information in their report.

2 SITE DESCRIPTION

Culvert 39W-054/C is located on Highway 11, approximately 260 m east of 3rd Street in Mattice, Ontario. The location of the culvert is shown on the inset Key Plan on Drawing No. 1 in Appendix A. It is noted that for project orientation purposes, Highway 11 within the project limits, will be assumed to run east-west.

Within the project limits, Highway 11 is a two-lane, rural arterial, undivided highway. Based on the March 2016 General Arrangement (GA) drawing provided by MPCE, the roadway cross-section consists of two, 3.75 m wide paved lanes, and gravel shoulders with a width of 1.7 m and 2.0 m on the north and south sides, respectively. The culvert is located within a high fill section and cable guide rails are located on both sides of the highway.

Culvert 39W-054/C carries Five Mile Creek flow from the south to north side of the highway. The existing culvert is a cast-in-place, single span, reinforced concrete arch culvert with an internal height of 3.66 m, internal span of 7.32 m and an overall length of approximately 37 m.

The embankments adjacent to the culvert are approximately 8.2 m in height. The embankment slopes, with the exception of the area with a wood retaining wall at the north end of the culvert, are approximately 1.75H:1V and covered with a mix of vegetation and granular material. Some erosion of the granular slopes on the north side was noted. Based on the existing survey information the elevation of the center line of roadway was approximately 225.6 m and the top of culvert elevation at the inlet and outlet was 221.05 m and 221.2 m, respectively. The maximum height of soil cover above the top of the culvert is approximately 4.5 m.

It is understood that numerous buried utilities are present in the area.

The topography at the site is generally flat with Five Mile Creek being in a shallow valley. The lands adjacent to the culvert are mainly residential dwellings. An Ontario Northland Railway Line is located to the south of the highway alignment. Storm water drainage in the area is to ditches along the highway and to Five Mile Creek.

The site is located within a physiographic region known as the Cochrane Clay Plain which is characterized as a gently sloping and rolling plain of clay till and lacustrine clay, silt, and sand.

Site photographs showing the general conditions in the vicinity of the culvert site during the time of the field investigation are presented in Appendix D.

3 SITE INVESTIGATION AND FIELD TESTING

As a component of Thurber's standard procedures and due diligence, Ontario One Call was contacted to provide utility locate clearances for the intended borehole locations.

The current field investigation for this site included advancing three boreholes drilled from October 18, 2016 to October 26, 2016. The northing, easting and elevation of the boreholes are shown on the Borehole Location Plan and Soil Strata Drawing No. 1 in Appendix A and are summarized in Table 3-1.

Table 3-1: Borehole Summary

Borehole ID	Location	Northing (m)	Easting (m)	Ground Surface Elevation (m)	Depth Below Ground Level (m)
16-01	Culvert Inlet	5 497 226.9	358 471.3	218.4	4.9
16-02	Hwy 11 Westbound	5 497 239.0	358 492.0	225.6	17.3
16-03	Culvert Outlet	5 497 253.6	358 501.4	219.6	4.7

Borehole 16-02, advanced through the roadway embankment, was advanced with a truck mounted CME 75 drill rig equipped with NW casing. Borehole 16-01 and 16-03 were advanced with portable drilling equipment with B sized casing. The subsurface stratigraphy encountered in the boreholes was recorded in the field by Thurber personnel. Split spoon samples were collected at regular depth intervals in the boreholes via the completion of Standard Penetration Tests (SPT), following the methods described in ASTM Standard D1586. All soil samples recovered from the boreholes were transported to Thurber's Ottawa geotechnical laboratory for further examination and testing.

A 19 mm inside diameter PVC standpipe piezometer was installed in Borehole 16-01 to allow for measurement of the groundwater level after completion of drilling. The piezometer construction details are illustrated on the Record of Borehole sheet for Borehole 16-01, provided in Appendix B. The piezometer was decommissioned October 26, 2016

Boreholes 16-01 and 16-03 were backfilled with a low-permeability mixture of bentonite pellets and auger cuttings in general accordance with Ontario MOE Regulation 903. Borehole 16-02 was capped with 300 mm of cold patch asphalt.

The as-drilled locations of the boreholes and ground surface elevations at the borehole locations were surveyed by Thurber following completion of drilling. The vertical datum used was horizontal control point (HCP) 104 identified on base plans provided by MCPE as a steel bar with a geodetic elevation of 226.357 m. This HCP is located at Station 11+400, approximately 150 m west of the culvert site and 13 m north of the centerline of Highway 11.

From the report referenced earlier (GEOCRES 42G-57), Borehole Nos. 1, 2 and 3 were used within this report to supplement the subsurface stratigraphy at the culvert. The borehole locations, from the current and previous drilling investigation, are shown on the attached Borehole Location and Soil Strata Drawing included in Appendix A. The coordinates and elevation of the boreholes are provided on the drawing and on the individual Record of Borehole sheets included in Appendix B.

3.1 Laboratory Testing

Geotechnical laboratory testing consisted of natural moisture content determination and visual identification of all soil samples in accordance with the current MTO standards. Grain size distribution analyses testing was also carried out on selected samples to MTO and ASTM standards. Chemical analysis for determination of pH, resistivity, soluble sulphate and chloride concentrations was carried out on a sample of the native soil. The results of the geotechnical tests are summarized on the Record of Borehole sheets included in Appendix B and all laboratory results are presented on the laboratory figures included in Appendix C.

4 DESCRIPTION OF SUBSURFACE CONDITIONS

4.1 Overview / General

Reference is made to the Record of Borehole sheets in Appendix B for details of the soil stratigraphy encountered in the boreholes. A stratigraphic profile for the culvert area is presented on Drawing No. 1 in Appendix A for illustrative purposes. An overall description of the stratigraphy is given in the following paragraphs; however, the factual data presented in the Record of Boreholes governs any interpretation of the site conditions.

For reference, the stratigraphy through the embankment is generally characterized by the asphalt pavement structure and embankment fill overlying a clay layer overlying a glacial till deposit. More detailed descriptions of the individual strata based on Borehole 16-01 through 03 are presented below.

4.2 Asphalt

Borehole 16-02 was advanced through the Highway 11 pavement structure. The thickness of the asphalt encountered at surface was 175 mm. A buried layer of asphalt with a thickness of 150 mm was also encountered within the embankment fill at a depth of 1.7 m.

4.3 Embankment Fill

4.3.1 Granular Fill

Granular fill consisting predominantly of sand was encountered below both asphalt layers in Borehole 16-02 and from surface in Borehole 16-03. This layer has a top elevation of 225.3 m and 219.6 m and a thickness of 2.7 m and 1.8 m in Boreholes 16-02 and 16-03, respectively. The SPT 'N' values ranged from 27 to 84 blows per 0.3 m of penetration in Borehole 16-02 and from 6 to 8 blows per 0.3 m of penetration in Borehole 16-03; indicating a loose to very dense condition.

The moisture content of the samples tested ranged from 4% to 17%. The results of a grain size analysis test completed on a sample of this material indicated a gravel content of 2%, sand content of 77%, and a fines content (combined silt and clay size particles) of 21%. The grain size analysis is illustrated on Figure C1 in Appendix C.

4.3.2 Clay Fill

Clay fill was encountered from the surface in Borehole 16-01 and below the granular fill in Boreholes 16-02 and 16-03. Wood pieces were observed within the clay fill. The top elevation of this layer ranged from 217.8 m to 222.5 m, and the thickness ranged from 0.5 m to 3.4 m. The SPT 'N' values ranged from 4 to 34 blows per 0.3 m of penetration. All clay fill material was classified as being firm to hard.

The moisture content for the samples tested ranged from 19% to 33%. The results of grain size analysis conducted on two samples of this material are summarized in Table 4-1 and are illustrated on Figure C2 in Appendix C.

Table 4-1: Gradation Results for Clay Fill

Soil Particles	%
Gravel	0 to 4
Sand	4 to 23
Silt	44 to 48
Clay	29 to 48

Atterberg limit testing was carried out on two samples of the clay fill material. The results are shown on Figure C6 and in Appendix C and are summarized in Table 4-2 as follows:

Table 4-2: Atterberg Limits for Clay Fill

Test	%
Liquid Limit	30 to 37
Plasticity Index	15 to 19

4.4 Clay (CL), Sandy

A native clay layer was encountered below the fill in Boreholes 16-01 and 16-02. The surface of this deposit ranged in elevation from 217.2 m to 219.2 m and the thickness ranged from 2.0 m to 2.1 m. The SPT ‘N’ values ranged from 4 to 10 blows per 0.3 m of penetration. The clay, sandy material was classified as being firm to stiff.

The moisture content for the samples tested ranged from was 15% to 18%. The results of grain size analysis conducted on two samples of this material are summarized in Table 4-3 and are illustrated on Figure C3 in Appendix C.

Table 4-3: Gradation Results for Clay, Sandy

Soil Particles	%
Gravel	2 to 22
Sand	32 to 36
Silt	30 to 40
Clay	16 to 22

Atterberg limit testing was carried out on two samples of the clay fill material. The results are shown on Figure C7 and in Appendix C and are summarized in Table 4-4 as follows:

Table 4-4: Atterberg Limits for Clay, Sandy

Test	%
Liquid Limit	22 to 29
Plasticity Index	9 to 19

4.5 Sand with Silt (SP)

A sand with silt layer was encountered below the clay fill in Borehole 16-3. The surface of this deposit was 217.3 m in elevation and the thickness was 0.7 m. An SPT ‘N’ value of 50 blows for 0.3 m of penetration was observed, indicating a dense condition.

The recorded moisture content was 12%. The results of a grain size analysis conducted on this material indicated a gravel content of 8%, sand content of 82%, and a fines content (combined silt and clay size particles) of 10%. The grain size analysis is illustrated on Figure C4 in Appendix C.

4.6 Sandy Silt (ML): Till

A glacial till layer consisting of sandy silt was encountered in all boreholes. The surface of this deposit ranged in elevation from 215.2 m to 217.1 m. All boreholes were terminated in this stratum. The SPT ‘N’ values ranged from 35 blows per 0.3 m of penetration to 100 blows per 0.075 m of penetration; indicating a dense to very dense condition; but typically very dense. Boulders were encountered in this stratum at a depth of 14.3 m (elev. 211.3 m) in Borehole 16-02 and coring techniques were required to advance through the boulders.

The moisture content for the samples tested ranged from was 9% to 23%. The results of grain size analysis conducted on two samples of this material are summarized in Table 4-5 and are illustrated on Figure C5 in Appendix C.

Table 4-5: Gradation Results for Till

Soil Particles	%
Gravel	7
Sand	26 to 29
Silt	57 to 58
Clay	6 to 10

Atterberg limit testing attempted on the two samples indicated the sandy silt till to be non-plastic to low plastic. The sample with low plastic testing results had a liquid limit of 16% and a plasticity index of 2%. The results are shown on Figure C8 and in Appendix C.

Glacial till inherently contains cobbles and boulders.

4.7 Groundwater

The groundwater level was measured in the standpipe piezometer installed in Borehole 16-01 on October 26, 2016 at a depth of 0.6 m; corresponding to an elevation of 217.8 m. The water level in Five Mile Creek was measured at the time of Thurber’s field investigation at an elevation of 217.5 m and 217.4 m at the inlet and outlet respectively. The groundwater level in the area of the culvert is expected to reflect the creek water level.

These observations are considered short-term readings and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after the spring snowmelt or after periods of heavy and/or prolonged precipitation events.

5 MISCELLANEOUS

Thurber obtained utility clearances prior to drilling. Thurber surveyed the borehole locations and determined the northing, easting and ground surface elevations based on local benchmarks and contract drawings provided by McIntosh Perry Consulting Engineers. Ohlmann Geotechnical Services (OGS) Inc. of Almonte, Ontario and Downing George Estate Drilling Ltd. of Hawkesbury, Ontario supplied and operated the drilling equipment to carry out the drilling, sampling, in-situ testing and standpipe piezometer installation and decommissioning. The drilling, and sampling operations in the field were supervised on a full-time basis by Mr. Christopher Murray of Thurber. Laboratory testing was carried out by Thurber in its MTO-approved laboratory in Ottawa.

Overall project management and direction of the field program was provided by Mr. Stephen Peters, P.Eng. Interpretation of the field data and preparation of this report was completed by Mr. Christopher Murray, M.Sc., E.I.T. The report was reviewed by Dr. Fred Griffiths, P.Eng. and Dr. P.K. Chatterji, P.Eng., the Designated Principal Contact for MTO Foundations Projects.

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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

6 GENERAL

This section of the report provides an interpretation of the factual data and also presents geotechnical recommendations for design of a replacement culvert. The plans and profiles used for preparation of this report were provided by McIntosh Perry Consulting Engineers (MPCE). The discussion and recommendations presented in this report are based on the information provided by MPCE, the Design-Build Ready Design Package for Contract 2016-5012,the factual data obtained during the course of the investigation and the borehole investigation completed by Englobe (Geocres 42G-57).

The existing culvert built in 1939 is a cast-in-place, single span structure supported on spread footings. The existing footings have a width of 1.67 m and a height of 1.22 m and are estimated to be founded at approximate elevation 216.3 m. The bottom of the existing creek bed, estimated from the available survey information, is approximately at elevation 217.0 m.

Thurber carried out the current investigation as a sub-consultant to McIntosh Perry Consulting Engineers under Contract No. DB 2016-5012. It is a condition of this report that Thurber's performance of its professional services is subject to the attached Statement of Limitations and Conditions.

6.1 Proposed Structure

The proposed culvert structure, as shown on the General Arrangement (GA) drawing dated March 2016, is a single span precast 3-sided concrete culvert with an internal height of 3.6 m, internal span of 5.0 m and overall length of 30.0 m supported on cast-in-place footings.

Precast retaining walls with a length of 9.0 m and a height of 5.5 m are shown adjacent to the proposed replacement culvert at the south end of the culvert. At the north end, precast retaining walls with a length of 6.0 m and a height of 4.0 m are shown adjacent to the proposed replacement culvert.

6.2 Applicable Codes and Design Considerations

The geotechnical assessment presented below has been prepared based on the available data regarding the proposed foundations and existing ground conditions and in accordance with the Canadian Highway Bridge Design Code (CHBDC), version CSA S6-14.

It is understood that the culvert structure has a consequence classification of *Typical Consequence*, in accordance with Section 6.5.1 of the CHBDC. Accordingly, a consequence factor (Ψ) of 1.0, as per Table 6.1 of the CHBDC, has been used in assessing factored geotechnical resistances. If the consequence classification changes, the geotechnical assessment will need to be reviewed and revised.

7 SEISMIC CONSIDERATIONS

7.1 Spectral and Peak Acceleration Hazard Values

The seismic hazard data for the CHBDC is based on the fifth generation seismic model developed by the Geological Survey of Canada (GSC). Seismic hazard data for this site has been obtained from the GSC's seismic hazard calculator. The data includes peak ground acceleration (PGA), peak ground velocity (PGV), and the 5% damped spectral response acceleration values (Sa(T)) for the reference ground condition (Site Class C) for a range of periods (T) and for a range of return periods including the 475-year, 975-year and 2475-year events. The GSC seismic hazard calculation data sheet for this site is presented in Appendix F.

The site coefficients used to determine the design spectral acceleration and displacement values are a function of the Site Class and the peak ground acceleration (PGA).

7.2 CHBDC Seismic Site Classification

In accordance with the CHBDC, the selection of the seismic site classification is based on the soil conditions encountered in the upper 30 m of the stratigraphy.

The following soil stratigraphy was encountered at this site:

- Layer 1: Thickness = 2 m Typical N_{60} = 6 Clay Fill, Clay
- Layer 1: Thickness = 7 m Typical N_{60} = 50 Sandy Silt Till
- Layer 2: Thickness = 21 m Typical N_{60} = 100 Bedrock

The seismic site classification for this is site is based on the Typical N_{60} profile above. The harmonic mean of the typical N_{60} values provided above is 82, which corresponds to a Seismic Site Class C in accordance with Table 4.1 of the CHBDC.

7.3 Seismic Liquefaction

Based on the high N_{60} values observed at this site, the dense to very dense sandy silt glacial till deposit located below the groundwater level at this site, the foundation soils are not considered to be susceptible to liquefaction.

8 FOUNDATION DESIGN RECOMMENDATIONS

8.1 Foundation Bearing Resistances

The factored geotechnical resistances provided in this report include the following factors:

- Consequence factor (Ψ) of 1.0
- Geotechnical resistance factors (CHBDC Table 6.2):
  - ϕ_{gu} = 0.5 (static analysis; typical degree of understanding)
  - ϕ_{gs} = 0.8 (static analysis; typical degree of understanding)

The geotechnical resistances presented herein are for vertical concentric loading only and will need to be adjusted for the effects of inclined or eccentric loading, where applicable. The geotechnical resistance should be calculated as illustrated in the CHBDC Clause 6.10.3 and Clause 6.10.4.

Resistance to lateral forces through sliding resistance between concrete and native granular or bedding materials (Section 8.2) should be evaluated using an unfactored coefficient of 0.50 for cast-in-place concrete and 0.45 for pre-cast concrete.

It is noted that construction will extend below the measured water level in the creek. Control of creek flow and dewatering (Section 9.3) will be required to prepare the foundation subgrade and install the culvert in the dry.

8.1.1 Frost Depth

The depth of frost penetration at this site is 2.6 m as per OPSD 3090.100. Footings must be protected from frost with a minimum of 2.6 m of earth cover or thermal equivalent.

8.1.2 Culvert Footings

An open footed culvert structure may be founded on the native, undisturbed dense glacial till. Footings with an assumed width of 1.5 m, founded at or below the lower of elevation 215.0 m or the penetration depth of frost (ie. 2.6 m below creek bed), may be designed based on the following factored geotechnical resistances:

- Factored geotechnical resistance at ULS 350 kPa
- Factored geotechnical resistance at SLS 250 kPa

Foundation settlement, based on the supplied SLS resistance, is expected to be less than 25 mm.

8.1.3 Retaining Walls

Retaining wall footings should be founded at or below the penetration depth of frost on a leveling pad with a minimum thickness of 0.5 m consisting of Granular 'A" material. The engineered pad should be placed on a geotextile separation (Class II non-woven FOS 50 to 150 µm) and can bear on the native subgrade provided that it is undisturbed, uniformly competent and free of any soft and deleterious materials including peat and organics. The top of the Granular 'A' pad must extend to 0.5 m beyond the outside edge of all sides of the footing and sloped at 1H:1V, or flatter.

The following factored geotechnical resistance values are recommended for precast retaining walls at this site assuming a 3.0 and 3.7 m footing width (B):

	B = 3.0 m	B = 3.7 m
• Factored geotechnical resistance at ULS	300 kPa	325 kPa
• Factored geotechnical resistance at SLS	200 kPa	175 kPa

It is recommended that the footing for the precast retaining wall segments and cast in place culvert footing be founded at the same elevation to avoid differential settlement and to minimize load transfer from retaining walls to the culvert.

If the Granular 'A' pad for the precast retaining walls are to be founded at a higher elevation on firm to stiff undisturbed Clay (CL), sandy, assuming a 3.0 and 3.7 m footing width (B), then the following factored geotechnical resistances should be used:

	B = 3.0 m	B = 3.7 m
• Factored geotechnical resistance at ULS	250 kPa	275 kPa
• Factored geotechnical resistance at SLS	150 kPa	125 kPa

The use of a stepped foundation to reach a higher founding elevation shall still maintain a founding depth of at or below the depth of frost penetration and individual foundation steps shall be limited to no greater than 20% of the lesser of the footing width or stepped footing length.

8.2 Subgrade Preparation and Culvert Backfilling

Excavation and backfilling for installation of the new culvert should be carried out in accordance DBSP0902.

Subgrade preparation for the culvert replacement should include excavation and removal of the existing culvert, culvert foundations and backfill materials. The existing fill, alluvial deposits, any soft or organic materials and disturbed subgrades must be removed and replaced with compacted Granular A. The subgrade within the footprint of the culvert should consist of undisturbed native dense glacial till. Any boulders encountered at the subgrade elevation should be removed and excavation should be then backfilled with Granular A.

The glacial till will be readily disturbed from construction activities when saturated and should be protected with a 100 mm thick concrete mud slab after excavation and inspection as soon as practical to protect the subgrade from disturbance during construction. Alternatively, the footing can be placed on a concrete plug.

Backfill to structures should be in accordance with DBSP0902. Backfill for the culvert and retaining walls must consist of free draining granular material conforming to OPSS Granular A or Granular B Type II material specifications.

Compaction should be carried out in accordance with OPSS.PROV 501. Heavy compaction equipment used adjacent to the structures must be restricted in accordance with OPSS.PROV 501.

8.3 Embankment Design and Reinstatement

Embankment reinstatement should be carried out in accordance with OPSS.PROV 206. The embankment should be reinstated with side slopes of 2H:1V (or flatter) if constructed using Select Subgrade Material (SSM) or Granular B.

Granular fill should be placed and compacted in accordance with OPSS.PROV 501. Where new embankment fill is placed against existing embankment slopes or on a sloping ground surface steeper than 3H:1V, benching of the existing slope should be carried out in accordance with OPSD 208.010.

Provided the subgrade is prepared as outlined and embankment fill is reinstated to the existing design grade as recommended herein, an embankment slope inclined at 2H:1V or flatter, will remain stable.

It is understood that no grade raise is anticipated along the alignment of Highway 11 and therefore negligible embankment foundation settlement is expected to occur. The magnitude of the embankment compression constructed with granular materials is in the order of 0.5% of the embankment height and is expected to occur following fill placement. Placement of the final lift of asphalt should be delayed for at least a month.

Foundation settlement outside of the embankment footprint is also anticipated to be negligible provided heavy equipment, fill and stockpiling of materials are not placed above the current grades.

A settlement monitoring plan will be developed as per Section 2.4.9.10 of the RFP. This will include installation of monitoring points at the culvert under the rail alignment.

8.4 Lateral Earth Pressures

The lateral earth pressure parameters provided in Table 8-1 and 8-2 in the sections below are based on the assumption that the backfill is fully drained so that there are no unbalanced hydrostatic pressures. If adequate drainage cannot be confirmed, the potential for buildup of hydrostatic pressures should be considered in the design.

8.4.1 Static Lateral Earth Pressure Coefficients

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

$$P_h = K^*(\gamma h + q)$$

where:

P_h = horizontal pressure on the wall (kPa)
K = earth pressure coefficient
γ = unit weight of retained soil (kN/m^3)
h = depth below top of fill where pressure is computed (m)
q = value of any surcharge (kPa)

The recommended lateral earth pressure parameters for use in the design for a horizontal back-slope are provided in Table 8-1. Where ground surfaces are sloped, lateral earth pressure coefficients incorporating inclined ground surfaces should be used as provided in Table 8-2.

Table 8-1: Static Lateral Earth Pressure Coefficient, Horizontal Backslope

Parameter	OPSS Granular A & B Type II	Existing Granular Fill	Existing Clay Fill	Glacial Till
Soil Unit Weight, kN/m^3, γ	21.0	20.0	17.0	20.0
Angle of Internal Friction, ϕ	35°	30°	-	33°
Undrained Shear Strength, kPa	-	-	75	-
Coefficient of at Rest Earth Pressure, K_o (Restrained Wall)	0.43	0.50	-	0.46

Parameter	OPSS Granular A & B Type II	Existing Granular Fill	Existing Clay Fill	Glacial Till
Coefficient of Active Earth Pressure, K_a (Unrestrained Wall)	0.27	0.33	-	0.29

Table 8-2: Static Lateral Earth Pressure Coefficient, 2H:1V Inclined Backslope

Parameter	OPSS Granular A & B Type II	Existing Granular Fill	Existing Clay Fill	Glacial Till
Soil Unit Weight, kN/m^3, γ	21.0	20.0	17.0	20.0
Angle of Internal Friction, ϕ	35°	30°	-	33°
Undrained Shear Strength, kPa	-	-	75	-
Coefficient of Active Earth Pressure, K_a (Unrestrained Wall)	0.40	0.54	-	0.44

The parameters in the tables correspond to full mobilization of earth pressures and require a certain relative movement between the wall and adjacent soils to produce these conditions. For rigid structures it is recommended that at-rest horizontal lateral earth pressures be used for design. Active pressures should be used for the design of unrestrained walls.

For static analysis, passive earth resistance should be ignored, and therefore K_p values have not been provided. A lateral pressure due to backfill compaction should be added to the calculated lateral earth pressure in accordance with Section 6.12.3 of the CHBDC.

8.4.2 Combined Static and Seismic Lateral Earth Pressure Parameters

Retaining structures should be designed using dynamic earth pressure coefficients that incorporate the effects of earthquake loading. The following recommendations are per Section C4.6.5 of the Commentary of the CHBDC which states that seismically induced lateral soil pressures may be calculated using the Mononobe- Okabe Method with:

- k_h = ½ F(PGA)•PGA for structures that allow 25 mm to 50 mm of movement, and
- k_h = F(PGA)•PGA for non-yielding walls

The ratio of wall movement to wall height required to mobilize the active condition would be approximately 0.002 for a yielding structure with respect to the assessment of seismically induced lateral earth pressures.

The recommended seismic lateral earth pressure parameters for use in the design that are provided in Tables 8-3 and 8-4 assume the following:

- Seismic Site Class of C, and a PGA with a 2% probability of exceedance in 50 years of 0.048g; as outlined in Section 7.0

Table 8-3: Lateral Earth Pressure Under Seismic Loads, Horizontal Backslope

Parameter	OPSS Granular A & B Type II	Existing Granular Fill	Existing Clay Fill	Glacial Till
Soil Unit Weight, kN/m^3, γ	21.0	20.0	17.0	20.0
Angle of Internal Friction, ϕ	35°	30°	-	33°
Undrained Shear Strength, kPa	-	-	75	-
Non-Yielding Wall				
Dynamic Active Earth Pressure Coefficient, K_{AE}	0.30	0.36	-	0.32
Yielding Wall				
Dynamic Active Earth Pressure Coefficient, K_{AE}	0.28	0.35	-	0.31

Table 8-4: Lateral Earth Pressure Under Seismic Loads, 2H:1V Inclined Backslope

Parameter	OPSS Granular A & B Type II	Existing Granular Fill	Existing Clay Fill	Glacial Till
Soil Unit Weight, kN/m^3, γ	21.0	20.0	17.0	20.0
Angle of Internal Friction, ϕ	35°	33°	-	33°
Undrained Shear Strength, kPa	-	-	75	-
Non-Yielding Wall				
Dynamic Active Earth Pressure Coefficient, K_{AE}	0.46	0.68	-	0.52
Yielding Wall				
Dynamic Active Earth Pressure Coefficient, K_{AE}	0.42	0.59	-	0.48

The total pressure due to combined static and seismic loads acting at a specific depth below the top of the wall may be determined using the following equation that includes consideration of material properties and the soil profile:

$$\sigma_h = K\gamma d + (K_{AE} - K)\, \gamma\, (H - d)$$

where:

σ_h = lateral earth pressure at depth, d (kPa)
d = depth below the top of the wall (m)
K = static active earth pressure coefficient
(K_a for yielding walls, K_o for non-yielding walls)
γ = unit weight of the backfill soil (kN/m^3)
K_{AE} = combined static and seismic earth pressure coefficient
H = total height of the wall (m)

8.5 Cement Type and Corrosion Potential

A sample of the native silty sand till was submitted to Paracel Laboratories in Ottawa, Ontario for analysis of pH, water soluble sulphate and chloride concentrations, and resistivity. The analysis was completed to determine the potential for degradation of the concrete in the presence of soluble sulphates and the potential for corrosion of exposed steel used in foundations and buried infrastructure. The analysis results are summarized in the Table 8-5.

Table 8-5: Results of Chemical Analysis

Borehole	Sample	Depth (m)	pH (-)	Resistivity (Ohm-cm)	Chloride (µg/g)	Sulphate (µg/g)
16-01	SS3	1.5	7.55	2300	143	17

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. Type GU Portland Cement should therefore be suitable for use in concrete at this site.

The pH, resistivity and chloride concentration provide an indication of the degree of corrosiveness of the sub-surface environment. The soil pH measured was within what is considered the normal range for soil pH of 5.5 to 9.0. The resistivity of the soil indicates a moderate susceptibility to corrosion and should be considered during the culvert design. The test results provided in the Table 8-3 may be used to aid in the selection of coatings and corrosion protection systems for buried steel objects.

9 CONSTRUCTION CONSIDERATIONS

9.1 Excavations

It is anticipated that temporary excavations as deep as 9 m will be required for the removal of the existing culvert and foundations and construction of the new culvert.

All excavations must be conducted in accordance with the requirements of the Occupational Health & Safety Act & Regulations (OHSA) for Construction Projects. The granular fills at the site should be classified as Type 3 above the groundwater table and Type 4 below the groundwater table in accordance with OHSA. The clay fill and glacial till should both be classified as Type 3.

Subgrade preparation must be carried out in the dry.

At locations where there are space restrictions or where a slope has to be retained, the excavations will need to be carried out within a protection system as discussed in Section 9.2. Selection of the equipment and methodology to excavate and prepare the founding surface is the responsibility of the Contractor. Cobbles and boulders were observed in the boreholes, the contractor should be prepared to dislodge and remove these obstructions and extend the excavations to the design depths.

9.2 Temporary Protection Systems

It is understood that the culvert will be replaced by staged construction. Traffic will be reduced to a single lane and controlled with temporary signals. A temporary protection system (TPS) will be installed parallel to the roadway centreline. It is understood that TPSs may be utilized on both sides of the proposed culvert footings to reduce excavation volumes and to act as form work.The protection system to be installed parallel to the alignment of the culverts should be installed at a sufficient distance away from the new culvert to limit the disturbance to subgrade associated with removal of the projection system following completion of construction. Alternatively, the sheet piles could be left in place and cut off at or below 2.6 m beneath the finished pavement grade.

TPSs should be provided in accordance with DBSP0539 and designed for Performance Level 2. A suitable bracing system may need to be incorporated into the protection design. Consideration can be given to lowering the highway alignment during constructing stages to reduce the overall height of traffic protection required. The earth pressure parameters, under fully mobilized conditions, provided in Table 8-1 and Table 8-2 can be used in design.

Increased difficulty with the installation of roadway protection should be anticipated due to the presence of boulders within the glacial till. The design of protection systems is the responsibility of the Contractor. All protection systems should be designed by a licenced Professional Engineer experienced in such designs and retained by the Contractor. The designer of the roadway protection system should ensure that the penetration depth is sufficient to provide base fixity and the design should incorporate traffic loading and surcharge loading due to construction equipment and operations.

9.3 Dewatering

It is understood that a contiguous sheet pile wall will be installed parallel to the culverts between the existing and new footings, therefore temporary water course diversion is not anticipated to be required during replacement of the culvert. Water from surface flow and the creek must be diverted away from the excavation at all times to maintain a dry and stable condition.

Excavation below the groundwater level without prior dewatering is not recommended The Contractor must be prepared to control the groundwater and surface water flow at the site to permit the proposed culvert replacement to be constructed in a dry and stable excavation. The groundwater level will fluctuate and the minimum groundwater elevation for the site at the time of the proposed replacement should be taken as the water level in the creek at the time of construction.

Excavations below the groundwater level are anticipated. Pumping with sump pumps to maintain the groundwater level at least 0.5 m below the final subgrade elevation is recommended. Dewatering and surface water diversion must remain operational and effective until the culvert is replaced and backfilled to above the high water mark. If dewatering is not effective, the culvert subgrade in sand and silt till is prone to boil and reduce subgrade strength. Decisions regarding dewatering, must be carried out by the Contractor.

9.4 Erosion Protection

Slope protection and drainage measures will be required to ensure the long-term surficial stability 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. 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.

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

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

10 CONSTRUCTION CONCERNS

The planned construction methodology includes an open cut excavation for the installation of a new culvert.

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

- Construction will extend below groundwater and the water level in the creek. An adequate and effective creek/surface water management and dewatering plan must be implemented to construct the replacement culvert and retaining walls in the dry.
- Boulders may be encountered in the glacial till subgrade surface at the founding elevation and may require localized sub-excavation and replacement.
- The culvert is in close proximity to an Ontario Northland Rail culvert/embankment to the south of Highway 11 alignment. It is estimated that the toe of the railway embankment is approximately 10 m from the face of the new culvert and that the that the footing elevation will be outside a 2H:1V slope down from the toe of the railway embankment. No interaction with the railway embankment or railway culvert is anticipated. Nonetheless it is recommended that the monitoring plan for the culvert replacement include points established on the railway culvert.

The successful performance of the culvert will depend largely upon good workmanship and quality control during construction. Observation of the excavation and backfilling operations by the QVE will be required during construction to confirm that the foundation recommendations are correctly implemented and material specifications are met.

11 CLOSURE

Engineering analysis and preparation of this report was completed by Mr. Christopher Murray, E.I.T. The report was reviewed by Fred Griffiths, P.Eng. and Dr. P.K. Chatterji, P.Eng., the Designated Principal Contact for MTO Foundations Projects.

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Review Principal
Designated MTO Contact

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This Report has been prepared in accordance with generally accepted engineering or environmental consulting practices in the applicable jurisdiction. No other warranty, expressed or implied, is intended or made.

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All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report, which is of a summary nature and is not intended to stand alone without reference to the instructions given to Thurber by the Client, communications between Thurber and the Client, and any other reports, proposals or documents prepared by Thurber for the Client relative to the specific site described herein, all of which together constitute the Report.

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a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.

b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.

c) Design Services: The Report may form part of design and construction documents for information purposes even though it may have been issued prior to final design being completed. Thurber should be retained to review final design, project plans and related documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the Report's recommendations and the final design detailed in the contract documents should be reported to Thurber immediately so that Thurber can address potential conflicts.

d) Construction Services: During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause the escape, release or dispersal of those substances. Thurber shall have no liability to the Client under any circumstances, for the escape, release or dispersal of pollutants or hazardous substances, unless such pollutants or hazardous substances have been specifically and accurately identified to Thurber by the Client prior to the commencement of Thurber's professional services.

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The information, interpretations and conclusions in the Report are based on Thurber's interpretation of conditions revealed through limited investigation conducted within a defined scope of services. Thurber does not accept responsibility for independent conclusions, interpretations, interpolations and/or decisions of the Client, or others who may come into possession of the Report, or any part thereof, which may be based on information contained in the Report. This restriction of liability includes but is not limited to decisions made to develop, purchase or sell land.

APPENDIX A

BOREHOLE LOCATIONS AND SOIL STRATA DRAWINGS

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

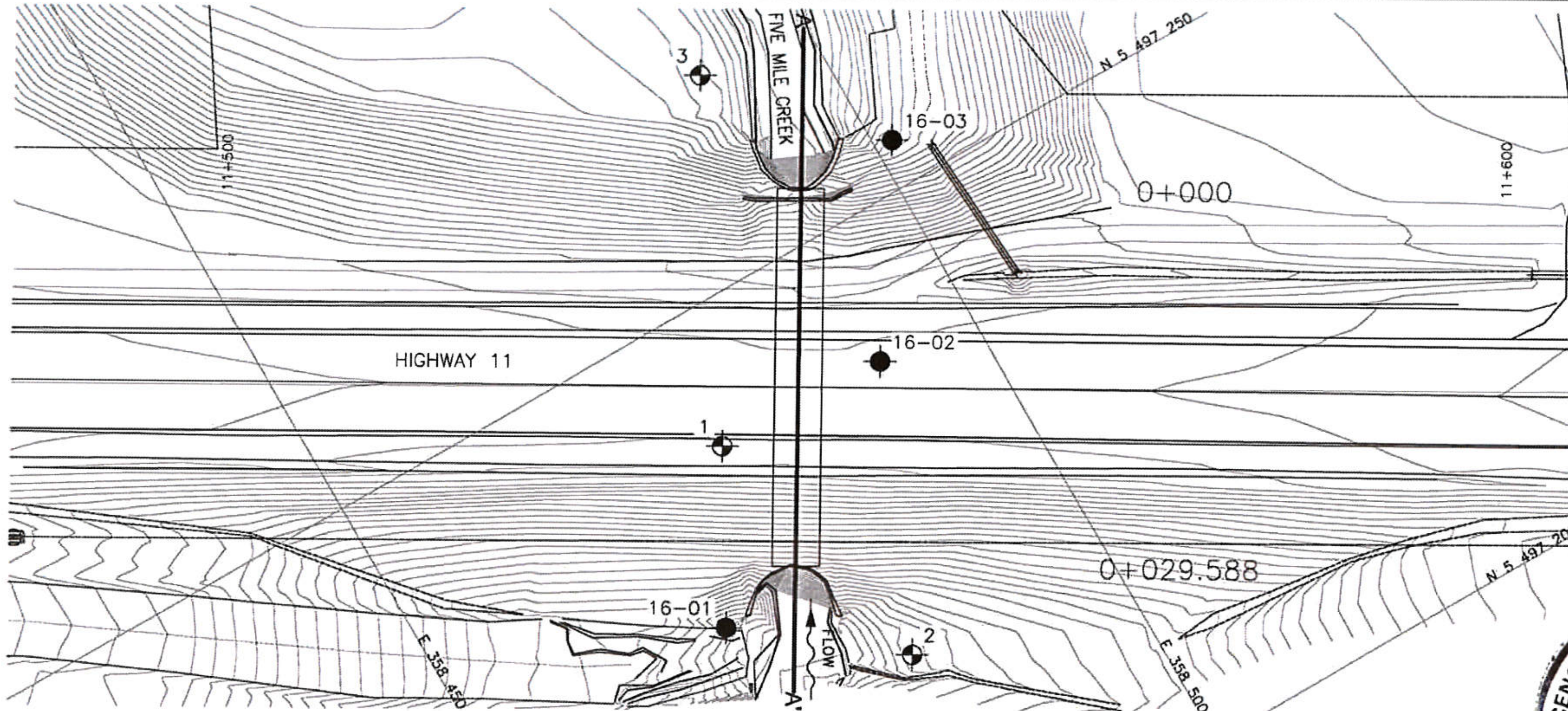
CONT No
GWP No

HIGHWAY 11
FIVE MILE CREEK
CULVERT
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

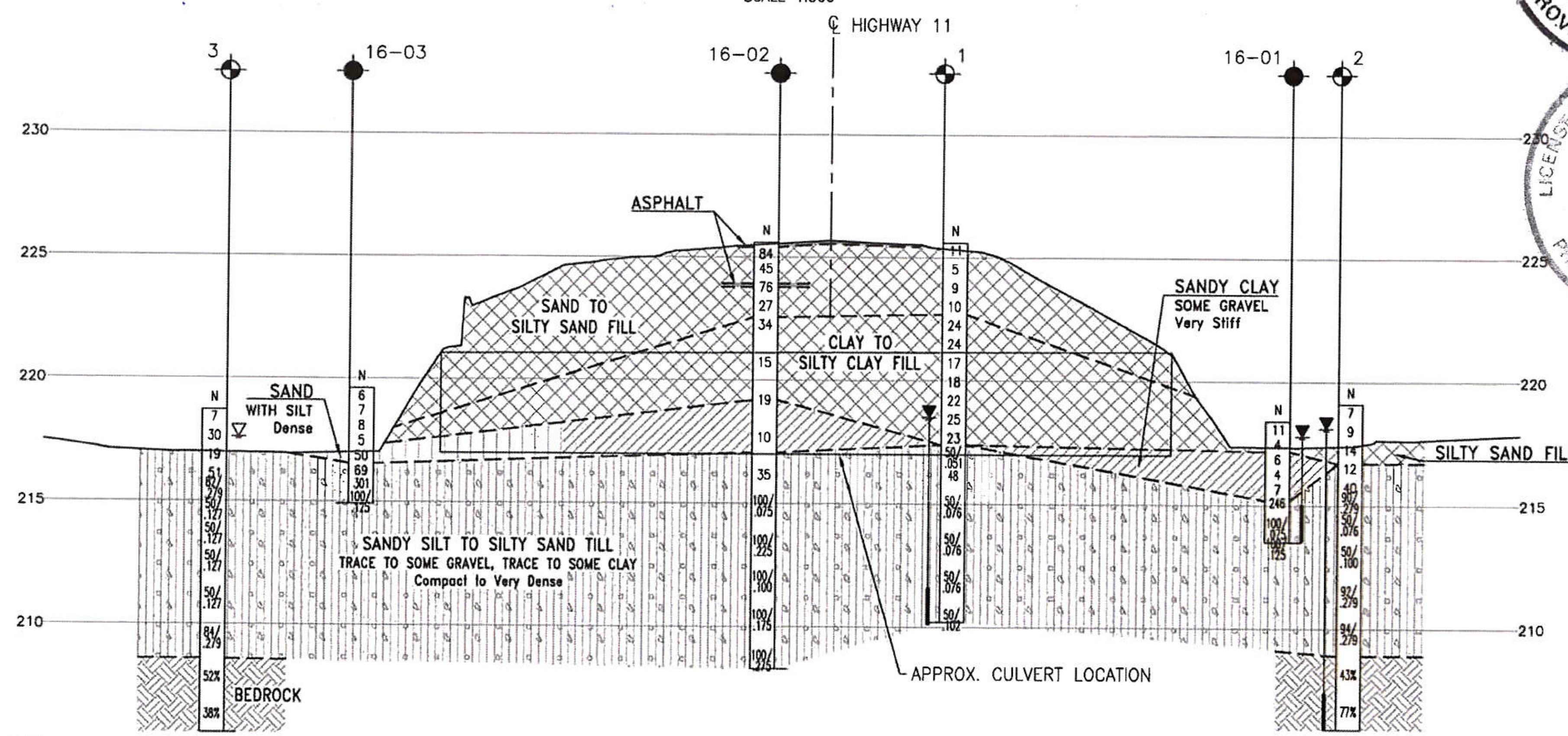
McINTOSH PERRY

THURBER ENGINEERING LTD.



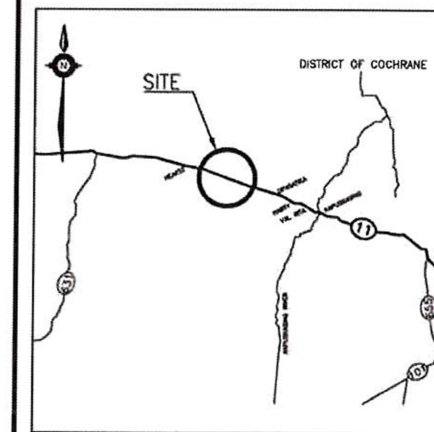
PLAN

SCALE 1:500



SECTION A–A'

SCALE 1:250



KEYPLAN

LEGEND

Symbol	Description
⯁	Borehole by Thurber
⯁	Borehole by Others
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
16-01	218.4	5 497 226.9	358 471.3
16-02	225.6	5 497 239.0	358 492.0
16-03	219.6	5 497 253.6	358 501.4
1	225.6	5 497 239.4	358 478.1
2	219.1	5 497 217.8	358 482.8
3	218.7	5 497 265.5	358 491.0

-NOTES-

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

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GEOCRES No.

REVISIONS

DATE	BY	DESCRIPTION		
DESIGN CM	CHK –	CODE	LOAD	DATE DEC 2016
DRAWN MFA	CHK CM	SITE	STRUCT	DWG 1

FILENAME: H:\Drafting\14000\14178\TED-14178-BHPP.dwg
PLOTDATE: 12/13/2016 10:33 AM

MINISTRY OF TRANSPORTATION, ONTARIO

APPENDIX B

RECORD OF BOREHOLE SHEETS

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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.

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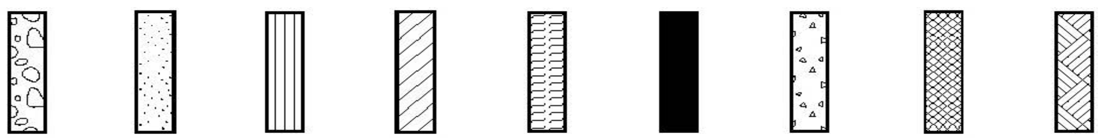
STRATA PLOT:
Strata plots symbolize the soil and bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.



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

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 (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.

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

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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

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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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 16-01

METRIC

GWP# 2016-5012 | LOCATION Hwy 11 - Five-Mile Creek Culvert N 5 497 226.9 E 358 471.3 | ORIGINATED BY CM

HWY 11 | BOREHOLE TYPE Portable with B Casing | COMPILED BY JM

DATUM Geodetic | DATE 2016.10.18 - 2016.10.18 | CHECKED BY SP

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
218.4							
0.0	Silty CLAY, Stiff to Firm, Brown, **FILL**	1	SS	11	218		
		2	SS	4			
217.2 / 1.2	**CLAY (CL),** Sandy with Gravel, Firm, Grey	3	SS	6	217		
		4	SS	4			22 32 30 16
		5	SS	7	216		
215.2 / 3.2	**Sandy SILT (ML) TILL**, Very Dense, Grey	6	SS	246	215		7 29 58 6
		7	SS	100/ 75mm	214		
213.5		8	SS	100/ 125mm			
4.9	End of Borehole Splitspoon refusal Groundwater level was measured in piezometer at 0.6 m BGS (elev. 217.8 m) on 2016/10/26						

Column headings: SOIL PROFILE; SAMPLES; GROUND WATER CONDITIONS; STRAT PLOT; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m^3

+3, ×3: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 16-02

METRIC

GWP# 2016-5012	LOCATION Hwy 11 - Five-Mile Creek Culvert N 5 497 239.0 E 358 492.0		ORIGINATED BY CM
HWY 11	BOREHOLE TYPE HSA / N Casing		COMPILED BY JM
DATUM Geodetic	DATE 2016.10.26 - 2016.10.26		CHECKED BY SP

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
225.6 / 0.0	**175 mm ASPHALT**					
225.3 / 0.3	SAND with Gravel, Very Dense, Brown, **FILL**	1	SS	84	225	
	Silty SAND, Very Dense to Dense, Brown, **FILL**	2	SS	45		2 77 21 (SI+CL)
223.9 / 1.7	**ASPHALT**				224	
223.8 / 1.8	Silty SAND with Gravel, Compact, Brown, **FILL**	3	SS	76		
		4	SS	27	223	
222.5 / 3.0	CLAY, Very Stiff to Hard, Grey, **FILL**	5	SS	34	222	
		6	SS	15	221	0 4 48 48
					220	
219.2 / 6.4	**CLAY (CL),** Sandy, Stiff, Grey	7	SS	19	219	
		8	SS	10	218	2 36 40 22
217.1 / 8.5	**Sandy SILT (ML) TILL**, Dense to Very Dense, Grey				217	
		9	SS	35	216	7 26 57 10

Column headings (charts): GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L, WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

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

ONTMT4S 14178 - HWY 11 MATTICE - FOUNDATION.GPJ 2012TEMPLATE(MTO).GDT 11/1/17

RECORD OF BOREHOLE No 16-02

METRIC

GWP# 2016-5012 LOCATION Hwy 11 - Five-Mile Creek Culvert N 5 497 239.0 E 358 492.0 ORIGINATED BY CM

HWY 11 BOREHOLE TYPE HSA / N Casing COMPILED BY JM

DATUM Geodetic DATE 2016.10.26 - 2016.10.26 CHECKED BY SP

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS
	Sandy SILT (ML) TILL Dense to Very Dense Grey					
					215	
		10	SS	100/ 75mm		
					214	
		11	SS	100/ 225mm		
					213	
					212	
		12	SS	100/ 100mm		
	- Boulder from 14.3 m to 14.5 m					
					211	
		13	SS	100/ 175mm		
					210	
					209	
		14	SS	100/ 275mm		
208.3 17.3	End of Borehole Auger refusal on probable bedrock					

Column headings: SOIL PROFILE; SAMPLES; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

+³, ×³: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 16-03

METRIC

GWP# 2016-5012 | LOCATION Hwy 11 - Five-Mile Creek Culvert N 5 497 253.6 E 358 501.4 | ORIGINATED BY CM

HWY 11 | BOREHOLE TYPE Portable with B Casing | COMPILED BY JM

DATUM Geodetic | DATE 2016.10.19 - 2016.10.19 | CHECKED BY SP

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
219.6 / 0.0	SAND, Loose, Brown, **FILL**	1	SS	6	219	○				
	- 150 mm Silty CLAY seam	2	SS	7		○				
		3	SS	8	218	○				
217.8 / 1.8	CLAY trace wood, Firm, Grey, **FILL**	4	SS	5		├─┤	4	23	44	29
217.3 / 2.3	**SAND (SW-SM)** with Silt, Dense, Brown	5	SS	50	217	○	8	82	10 (SI+CL)	
216.5 / 3.0	**Sandy SILT (ML) TILL**, Very Dense, Grey	6	SS	69	216	○				
		7	SS	301		○				
		8	SS	100/125mm	215	○				
214.9 / 4.7	End of Borehole, Portable Casing Refusal									

Column headings: SOIL PROFILE (ELEV/DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20, 40, 60, 80, 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20, 40, 60); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) (GR SA SI CL)

+³, ×³: Numbers refer to Sensitivity

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

ENCLOSURE NO.:2 (Pg. 1 of 2)

METRIC

RECORD OF BOREHOLE NO. 1

Englobe

REFERENCE 15/05/15059-F5	DATUM Geodetic	LOCATION N 5497239.4 E 358478.1 - Eilber Twp., Station 11+539	ORIGINATED BY JL
PROJECT GWP 5145-05-00, Highway 11		BOREHOLE TYPE Track Mounted CME 45 - Hollow Stem Augers	COMPILED BY SH
CLIENT AECOM		DATE (Started) 24 July 2015 / DATE (Completed) 25 July 2015 / TIME (Completed) 12:50:00 PM	CHECKED BY MAM

Ground Surface: ELEV 225.6

ELEV / DEPTH	DESCRIPTION (see Enclosure No. 1)	NUMBER	TYPE	"N" VALUES	WATER CONTENT (%) (approx.)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
225.6 / 0.0	FILL- sand, some to with gravel, some to with silt, trace clay; seams of silt encountered at depths from 1.8 m to 2.7 m; brown, moist; (loose/compact)	1	SS	11		
		2	SS	5		23 63 (14)
		3	SS	9		
		4	SS	10		12 50 30 8 (NP)
222.7 / 2.9	FILL - silty clay trace sand; trace organics; brown; (very stiff)	5	SS	24		
		6	SS	24		
		7	SS	17		0 4 45 51
	Grey to greyish brown	8	SS	18		
		9	SS	22		
		10	SS	25		
		11	SS	23		
217.4 / 8.2	sandy SILT TILL - some gravel trace clay; Gravel size rock pieces encountered at depths from 8.4 m to 8.7 m. Auger refusal encountered at 8.4 m depth. Advanced casing continuously to allow sampling. Trace wood encountered at depths from 9.1 m to 9.6 m; grey; (dense/very dense)	12	SS	50/51 mm		
		13	SS	48		
215.5 / 10.1	silty SAND TILL - trace gravel, trace clay; Wood encountered at depths from 10.4 m to 10.7 m. Borehole terminated due to wood. Borehole moved to 1 m west. Wash bored to a depth of 10.7 m.; grey; (very dense)	14	SS	50/76 mm		2 62 (36)
		15	SS	50/76 mm		
		16	SS	50/76 mm		

Continued Next Page

COMMENTS

The stratification lines represent approximate boundaries. The transition may be gradual.

+3, ×3: Numbers on right refer to Sensitivity. Numbers on left refer to values greater than 120 kPa

○ 3% STRAIN AT FAILURE

WATER LEVEL RECORDS

Date (dd/mm/yy)/Time	Water Depth (m)	Cave In (m)
1) 25/7/15 1:30:00 PM	7.7	-
2) 13/8/15 11:00:00 AM	7.1	-
3) 14/8/15 3:30:00 PM	7.1	-

MEL-GEO 15059 - F5 BOREHOL LOGS.GPJ MEL-GEO.GDT 23/2/16

EnGlobe Corp.
120 Progress Court, North Bay, On P1A 0C2 Phone: (705)476-2550 Fax: (705)476-8882 Email: northbay@lvm.ca

METRIC

RECORD OF BOREHOLE NO. 1

Englobe

REFERENCE 15/05/15059-F5	DATUM Geodetic	LOCATION N 5497239.4 E 358478.1 - Eilber Twp., Station 11+539	ORIGINATED BY JL
PROJECT GWP 5145-05-00, Highway 11		BOREHOLE TYPE Track Mounted CME 45 - Hollow Stem Augers	COMPILED BY SH
CLIENT AECOM		DATE (Started) 24 July 2015 / DATE (Completed) 25 July 2015 / TIME (Completed) 12:50:00 PM	CHECKED BY MAM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
ELEV DEPTH	DESCRIPTION (see Enclosure No. 1)	STRATA PLOT	NUMBER	TYPE	"N" VALUES						
	Continued from Previous Page										
							211				
210.2			17	SS	50/102 mm				○		
15.4	End of Sampling End of Borehole										

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ENCLOSURE NO.:3 (Pg. 1 of 1)

METRIC

RECORD OF BOREHOLE NO. 2

Englobe

REFERENCE 15/05/15059-F5 DATUM Geodetic LOCATION N 5497217.8 E 358482.8 - Eilber Twp., Station 11+553.5 ORIGINATED BY JL

PROJECT GWP 5145-05-00, Highway 11 BOREHOLE TYPE Track Mounted CME 45 - Hollow Stem Augers COMPILED BY SH

CLIENT AECOM DATE (Started) 13 August 2015 DATE (Completed) 13 August 2015 TIME (Completed) 4:25:00 PM CHECKED BY MAM

ELEV DEPTH	DESCRIPTION (see Enclosure No. 1)	NUMBER	TYPE	"N" VALUES	Water content (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
219.1	Ground Surface					
0.0	FILL- mixture of silty sand and silty clay, trace gravel, trace black organics; brown to grey; moist; (stiff)	1	SS	7		
		2	SS	9		
		3	SS	14		
217.3 1.8	FILL - silty sand, some clay; decayed wood encountered at depth from 1.8 m to 1.9 m; grey; (compact)					
216.7 2.4	sandy SILT TILL - trace to some gravel, trace to some clay; grey, moist; (compact/very dense)	4	SS	12		19 32 41 8 (NP)
		5	SS	40		9 37 46 8
		6	SS	90/279 mm		
		7	SS	50/76 mm		
		8	SS	50/100 mm		
		9	SS	92/279 mm		5 28 55 12
		10	SS	94/279 mm		
208.9 10.2	Start Rock Coring; Bedrock - pink granite/black gneiss; poor to good quality	11	RC	Rec.=97% RQD=43%		
		12	RC	Rec.=100% RQD=77%		
205.9 13.2	End of Sampling; End of Borehole					

Column headings: SOIL PROFILE; SAMPLES; STRATA PLOT; GROUND WATER CONDITIONS; ELEVATION SCALE (219–206); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE, 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³

COMMENTS

The stratification lines represent approximate boundaries. The transition may be gradual.

+3, ×3: Numbers on right refer to Sensitivity. Numbers on left refer to values greater than 120 kPa

○ 3% STRAIN AT FAILURE

WATER LEVEL RECORDS

Date (dd/mm/yy)/Time	Water Depth (m)	Cave In (m)
1) 13/8/15 4:35:00 PM	1.1	-
2) 14/8/15 7:40:00 AM	1	-
3) 14/8/15 3:30:00 PM	1	-

MEL-GEO 15059 - F5 BOREHOL LOGS.GPJ MEL-GEO.GDT 23/2/16

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ENCLOSURE NO.:4 (Pg. 1 of 1)

METRIC

RECORD OF BOREHOLE NO. 3

Englobe

REFERENCE 15/05/15059-F5 DATUM Geodetic LOCATION N 5497265.5 E 358491.0 - Eilber Twp., Station 11+537 ORIGINATED BY JL

PROJECT GWP 5145-05-00, Highway 11 BOREHOLE TYPE Track Mounted CME 45 - Hollow Stem Augers COMPILED BY SH

CLIENT AECOM DATE (Started) 14 August 2015 DATE (Completed) 14 August 2015 TIME (Completed) 4:30:00 PM CHECKED BY MAM

ELEV DEPTH	DESCRIPTION (see Enclosure No. 1)	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
218.7	Ground Surface					
0.0	FILL- mixture grey and brown silty clay, some gravel, trace grass rootlets moist (stiff)	1	SS	7		
218.1 / 0.6	sandy SILT TILL - trace to with gravel, trace clay grey moist (compact/very dense)	2	SS	30	▽	22 33 41 4
		3	SS	19		
		4	SS	51		
		5	SS	82/279 mm		2 25 67 6 (NP)
		6	SS	50/127 mm		
	clayey silt, sandy, some gravel	7	SS	50/127 mm		14 37 39 10
		8	SS	50/127 mm		
		9	SS	50/127 mm		
		10	SS	84/279 mm		
208.6 / 10.1	Start Rock Coring Bedrock - pink granite/black gneiss fair to poor quality	11	RC	Rec.=98% RQD=52%		
		12	RC	Rec.=95% RQD=38%		
205.6 / 13.1	End of Sampling End of Borehole					

Column headings: SOIL PROFILE; SAMPLES; STRATA PLOT; ELEVATION SCALE (218 to 206); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L, WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³

COMMENTS

The stratification lines represent approximate boundaries. The transition may be gradual.

+3, ×3: Numbers on right refer to Sensitivity. Numbers on left refer to values greater than 120 kPa

○ 3% STRAIN AT FAILURE

WATER LEVEL RECORDS Date (dd/mm/yy)/Time	Water Depth (m)	Cave In (m)
1) 14/8/15 4:30:00 PM	1.1	-
2)	-	-
3)	-	-

MEL-GEO 15059 - F5 BOREHOL LOGS.GPJ MEL-GEO.GDT 23/2/16

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APPENDIX C

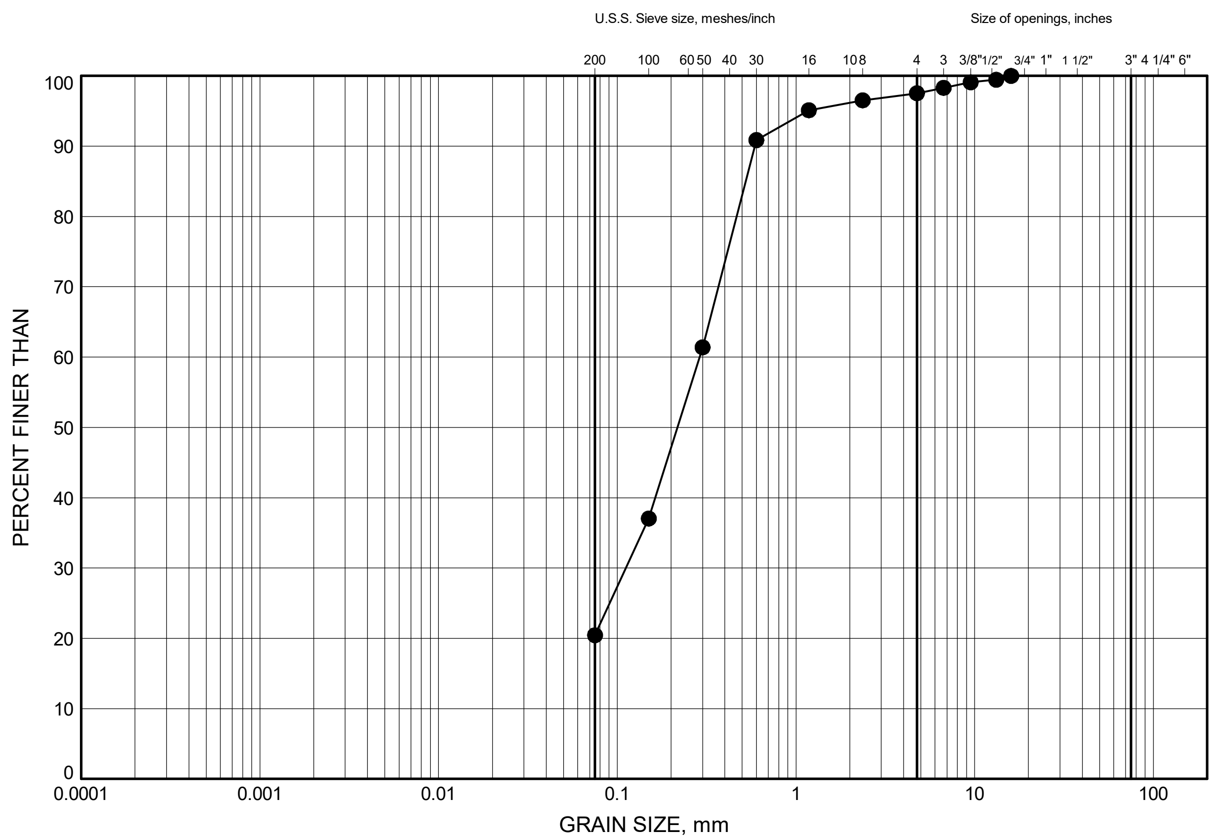
LABORATORY TEST RESULTS

Hwy 11 Mattice

GRAIN SIZE DISTRIBUTION

FIGURE C1

GRANULAR FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-02	1.07	224.53

Date November 2016

GWP# 2016-5012

THURBER

Prep'd JSM

Chkd. FJG

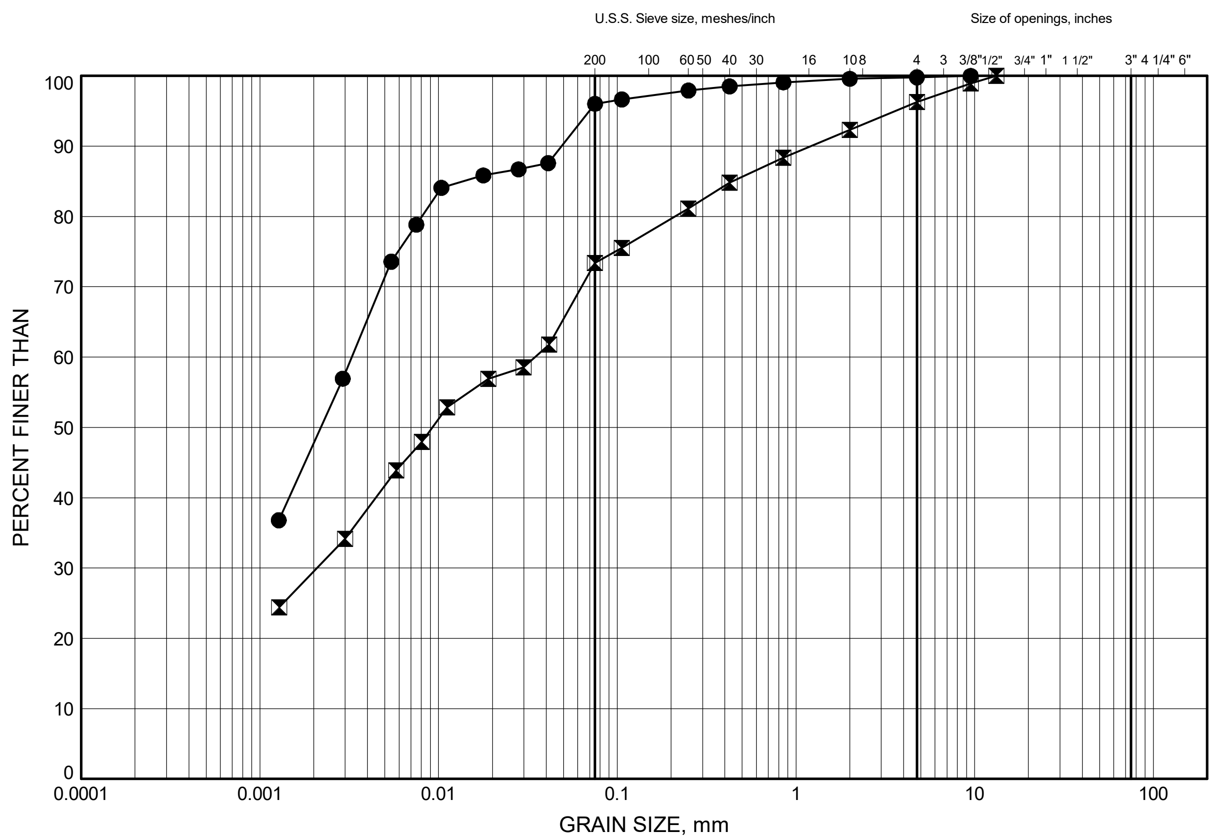
GRAIN SIZE DISTRIBUTION - THURBER 14178 - HWY 11 MATTICE - FOUNDATION.GPJ 30/11/16

Hwy 11 Mattice

GRAIN SIZE DISTRIBUTION

FIGURE C2

CLAY FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-02	4.88	220.72
⧗	16-03	2.13	217.46

Date November 2016

GWP# 2016-5012

THURBER

Prep'd JSM

Chkd. FJG

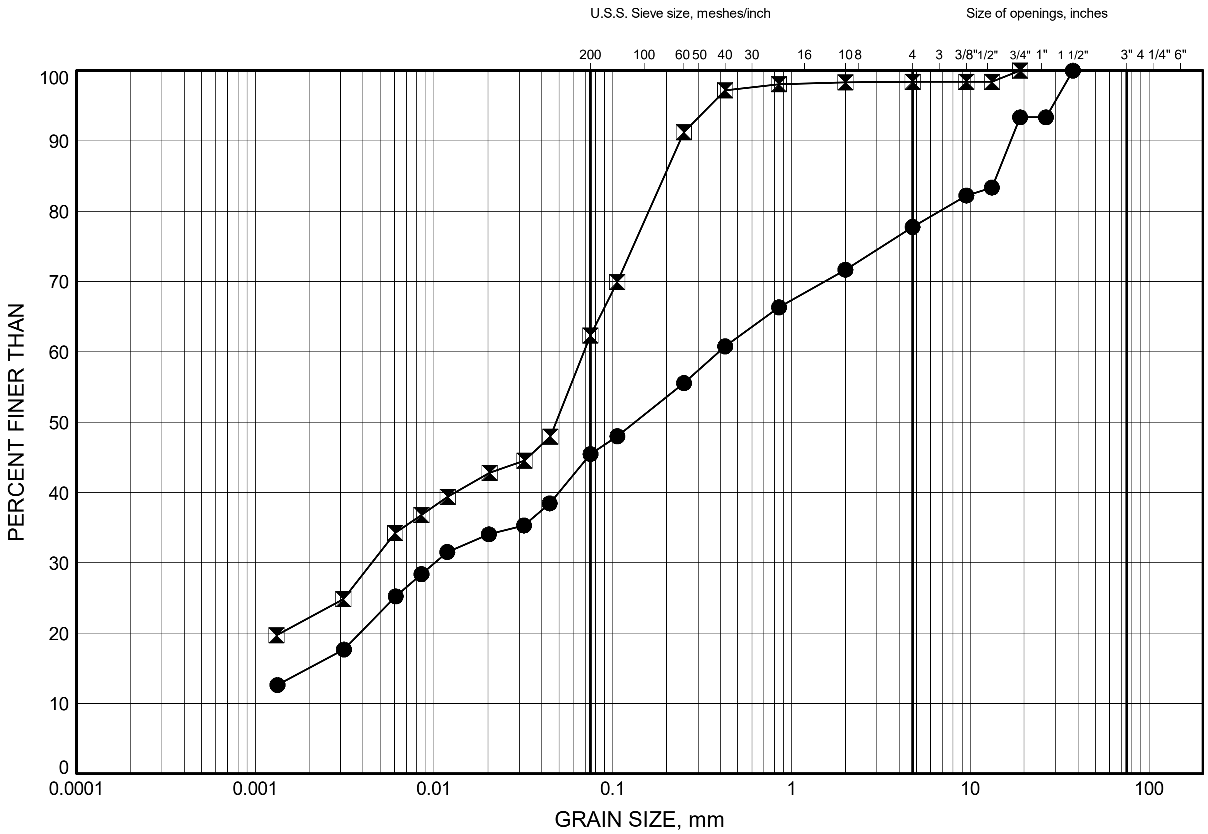
GRAIN SIZE DISTRIBUTION - THURBER 14178 - HWY 11 MATTICE - FOUNDATION.GPJ 30/11/16

Hwy 11 Mattice

GRAIN SIZE DISTRIBUTION

FIGURE C3

CLAY, SANDY



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-01	2.13	216.26
⧗	16-02	7.92	217.67

Date November 2016

GWP# 2016-5012

THURBER

Prep'd JSM

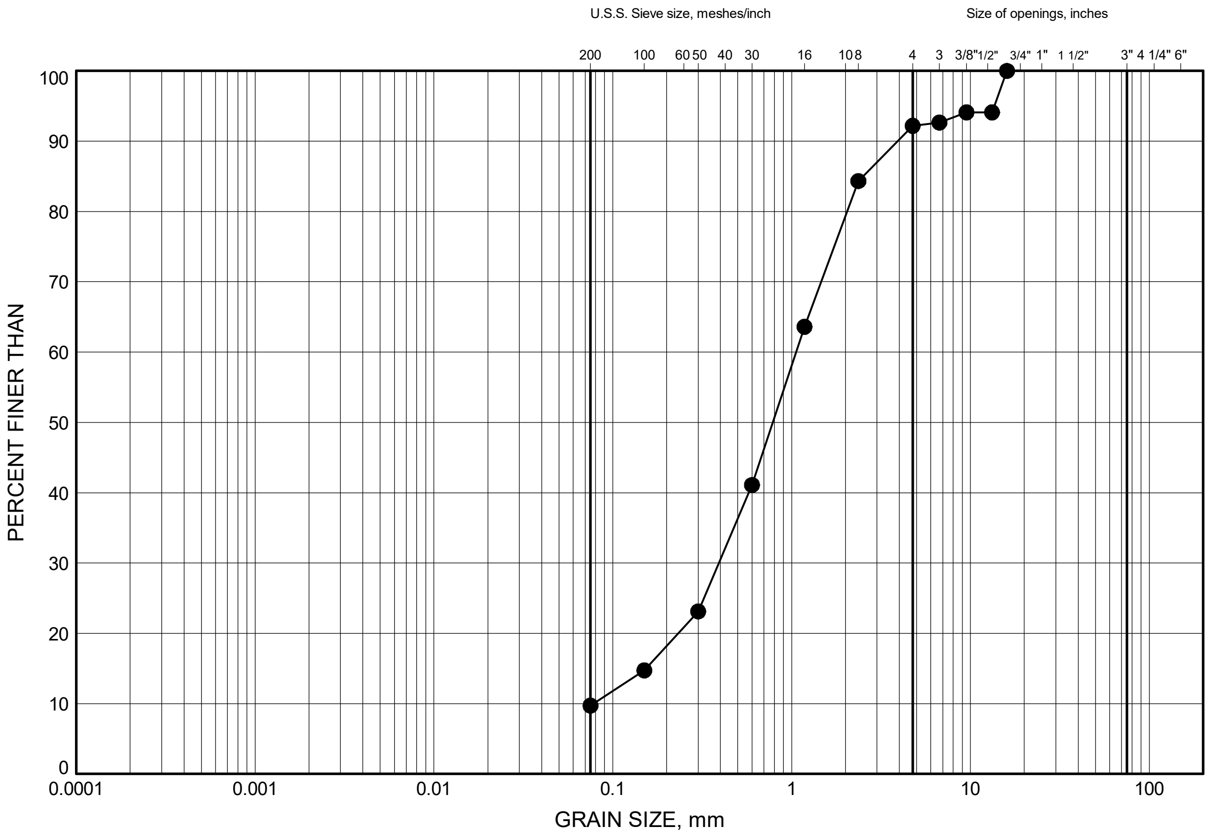
Chkd. FJG

Hwy 11 Mattice

GRAIN SIZE DISTRIBUTION

FIGURE C4

SAND with Silt



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-03	2.74	216.85

Date November 2016

GWP# 2016-5012

THURBER

Prep'd JSM

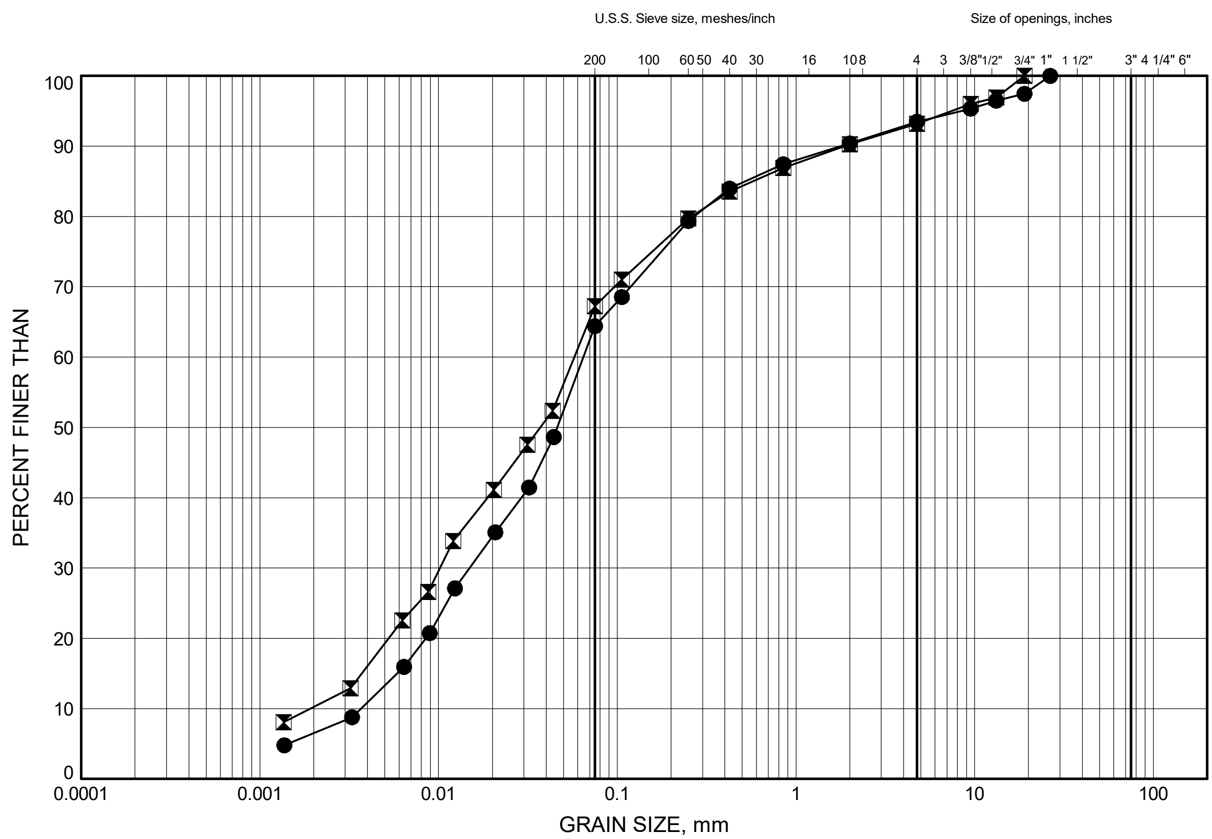
Chkd. FJG

Hwy 11 Mattice

GRAIN SIZE DISTRIBUTION

FIGURE C5

SANDY SILT: TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-01	3.35	215.04
⧗	16-02	9.45	216.14

Date November 2016

GWP# 2016-5012

THURBER

Prep'd JSM

Chkd. FJG

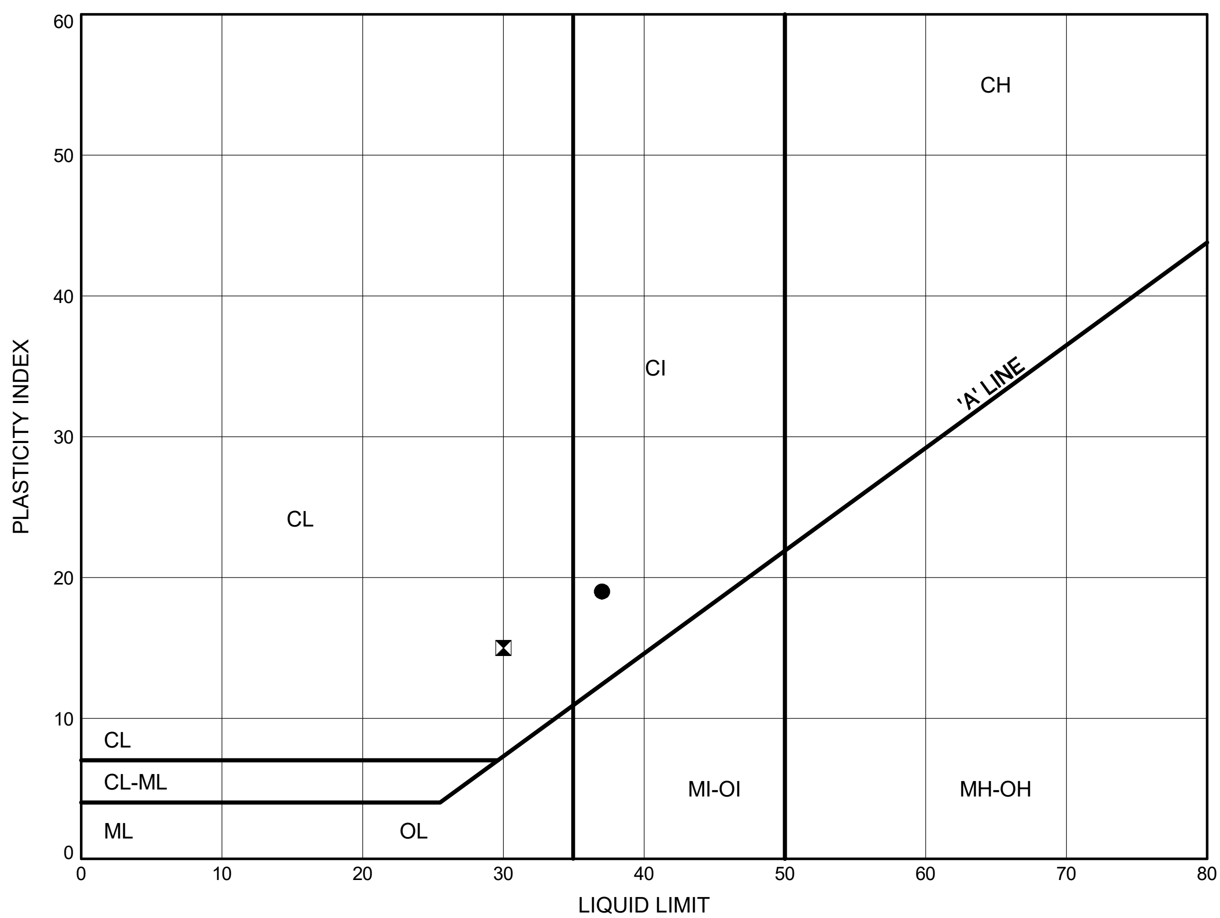
GRAIN SIZE DISTRIBUTION - THURBER 14178 - HWY 11 MATTICE - FOUNDATION.GPJ 30/11/16

Hwy 11 Mattice

ATTERBERG LIMITS TEST RESULTS

FIGURE C6

CLAY FILL



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-02	4.88	220.72
⧗	16-03	2.13	217.46

Date November 2016

GWP# 2016-5012

THURBER

Prep'd JSM

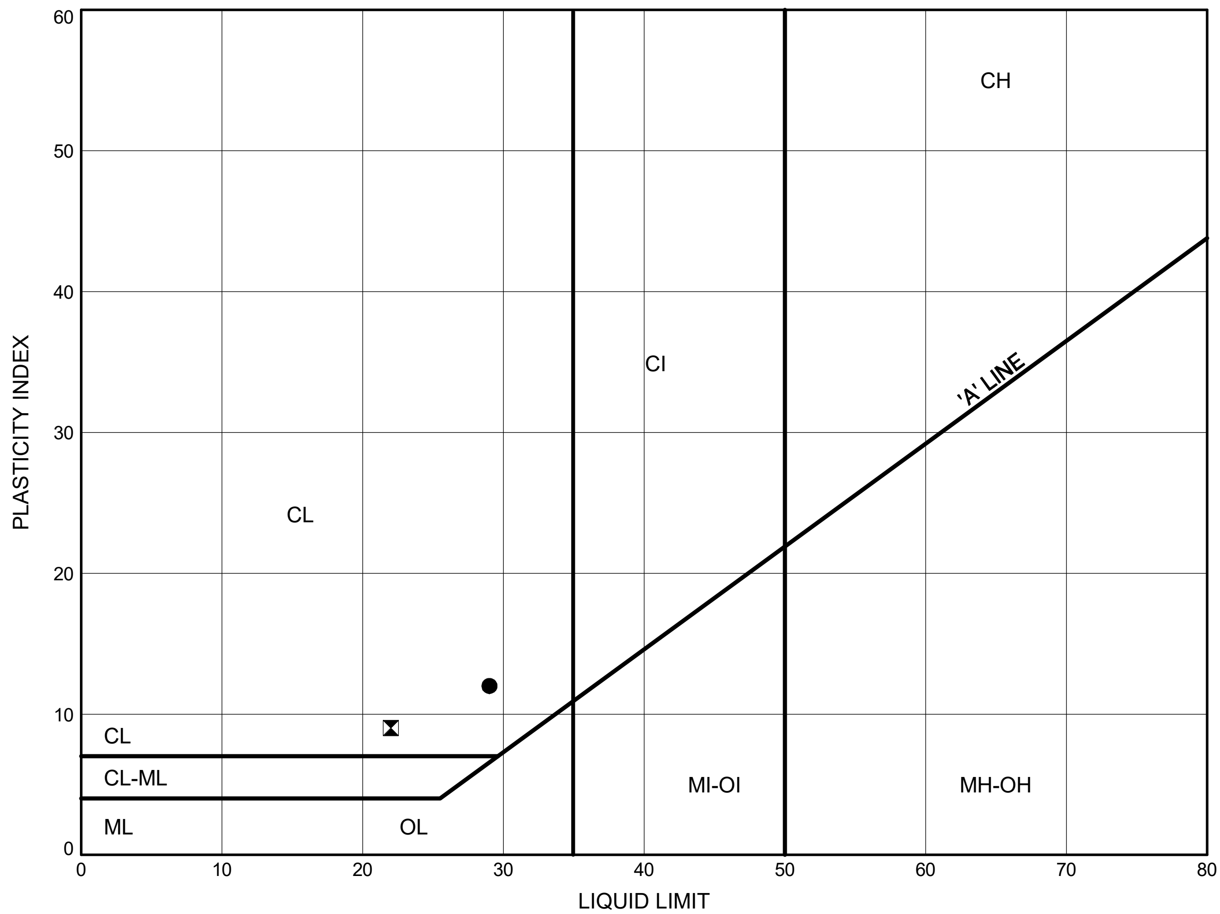
Chkd. FJG

Hwy 11 Mattice

ATTERBERG LIMITS TEST RESULTS

FIGURE C7

CLAY, SANDY



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-01	2.13	216.26
⧗	16-02	7.92	217.67

Date November 2016

GWP# 2016-5012

THURBER

Prep'd JSM

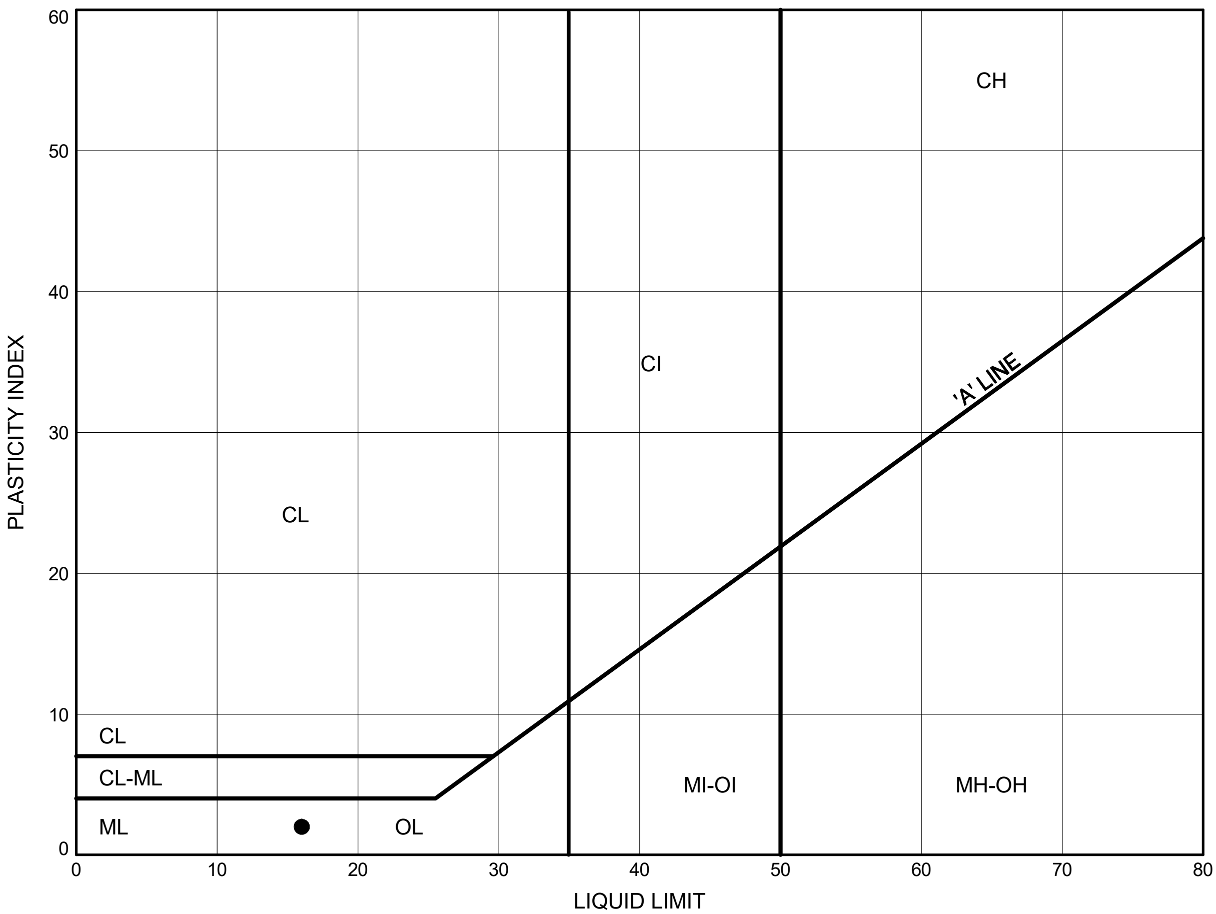
Chkd. FJG

Hwy 11 Mattice

ATTERBERG LIMITS TEST RESULTS

FIGURE C8

SANDY SILT: TILL



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-02	9.45	216.14

THURBALT 14178 - HWY 11 MATTICE - FOUNDATION.GPJ 30/11/16

Date November 2016

GWP# 2016-5012

THURBER

Prep'd JSM

Chkd. FJG

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Certificate of Analysis

Thurber Engineering Ltd.

2460 Lancaster Rd, Suite 104
Ottawa, ON K1B4S5
Attn: Stephen Peters

Client PO:
Project: 14178
Custody: 14044

Report Date: 17-Nov-2016
Order Date: 11-Nov-2016

Order #: 1646367

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

Paracel ID	Client ID
1646367-01	16-1 SS3 4'-6'

Approved By: Mark Foto

Mark Foto, M.Sc.
Lab Supervisor

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

Report Date: 17-Nov-2016
Order Date: 11-Nov-2016
Project Description: 14178

Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	16-Nov-16	16-Nov-16
Conductivity	MOE E3138 - probe @25 °C, water ext	15-Nov-16	16-Nov-16
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	17-Nov-16	17-Nov-16
Resistivity	EPA 120.1 - probe, water extraction	15-Nov-16	16-Nov-16
Solids, %	Gravimetric, calculation	12-Nov-16	12-Nov-16

PARACEL LABORATORIES LTD.

Order #: 1646367

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

Report Date: 17-Nov-2016
Order Date: 11-Nov-2016
Project Description: 14178

	Client ID:	16-1 SS3 4'-6'	-	-	-
	Sample Date:	18-Oct-16	-	-	-
	Sample ID:	1646367-01	-	-	-
	MDL/Units	Soil	-	-	-
Physical Characteristics					
% Solids	0.1 % by Wt.	85.6	-	-	-
General Inorganics					
Conductivity	5 uS/cm	435	-	-	-
pH	0.05 pH Units	7.55	-	-	-
Resistivity	0.10 Ohm.m	23.0	-	-	-
Anions					
Chloride	5 ug/g dry	143	-	-	-
Sulphate	5 ug/g dry	17	-	-	-

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: 17-Nov-2016
Order Date: 11-Nov-2016
Project Description: 14178

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	139	5	ug/g dry	143			3.1	20	
Sulphate	14.6	5	ug/g dry	16.8			13.9	20	
General Inorganics									
Conductivity	354	5	uS/cm	351			0.8	6.2	
pH	7.42	0.05	pH Units	7.41			0.1	10	
Resistivity	28.3	0.10	Ohm.m	28.5			0.8	20	
Physical Characteristics									
% Solids	86.5	0.1	% by Wt.	85.6			1.0	25	

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

Report Date: 17-Nov-2016
Order Date: 11-Nov-2016
Project Description: 14178

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	240	5	ug/g	143	96.7	78-113			
Sulphate	118	5	ug/g	16.8	101	78-111			

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

Report Date: 17-Nov-2016
Order Date: 11-Nov-2016
Project Description: 14178

Qualifier Notes:

Login Qualifiers :

Sample not received in Paracel verified container / media
Applies to samples: 16-1 SS3 4'-6'

Sample Data Revisions

None

Work Order Revisions / Comments:

None

Other Report Notes:

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

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

APPENDIX D

SELECTED PHOTOGRAPHS

Figure 1: Roadway Platform Over Culvert Looking East

Figure 2: Roadway Platform Over Culvert Looking West

Figure 3: Borehole 16-01 in Relation to the South Culvert Inlet

Figure 4: Borehole 16-03 in Relation to the North Culvert Outlet

Figure 5: South Embankment Looking West

Figure 6: North Embankment Looking West

Figure 7: Looking Upstream (Towards ONR Culvert) from South Inlet

Figure 8: Looking Downstream from North Outlet

APPENDIX E

GSC SEISMIC HAZARD CALCULATION
LIST OF REFERENCED SPECIFICATIONS

2015 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

November 18, 2016

Site: 49.6105 N, 83.257 W User File Reference: Five Mile Creek

Requested by: Chris Murray, Thurber Engineering

National Building Code ground motions: 2% probability of exceedance in 50 years (0.000404 per annum)

Sa(0.05)	Sa(0.1)	**Sa(0.2)**	Sa(0.3)	**Sa(0.5)**	**Sa(1.0)**	**Sa(2.0)**	**Sa(5.0)**	**Sa(10.0)**	**PGA (g)**	**PGV (m/s)**
0.064	0.087	**0.080**	0.065	**0.051**	**0.029**	**0.014**	**0.0034**	**0.0014**	**0.048**	**0.038**

Notes. Spectral (Sa(T), where T is the period in seconds) and peak ground acceleration (PGA) values are given in units of g (9.81 m/s^2). Peak ground velocity is given in m/s. Values are for "firm ground" (NBCC 2015 Site Class C, average shear wave velocity 450 m/s). NBCC2015 and CSAS6-14 values are specified in **bold** font. Three additional periods are provided - their use is discussed in the NBCC2015 Commentary. Only 2 significant figures are to be used. ***These values have been interpolated from a 10-km-spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the directly calculated values.***

Ground motions for other probabilities:

Probability of exceedance per annum	0.010	0.0021	0.001
Probability of exceedance in 50 years	40%	10%	5%
Sa(0.05)	0.0048	0.020	0.034
Sa(0.1)	0.0080	0.029	0.049
Sa(0.2)	0.0094	0.030	0.047
Sa(0.3)	0.0084	0.026	0.040
Sa(0.5)	0.0063	0.021	0.032
Sa(1.0)	0.0031	0.012	0.018
Sa(2.0)	0.0012	0.0049	0.0084
Sa(5.0)	0.0003	0.0010	0.0018
Sa(10.0)	0.0003	0.0006	0.0009
PGA	0.0044	0.016	0.027
PGV	0.0036	0.014	0.023

References

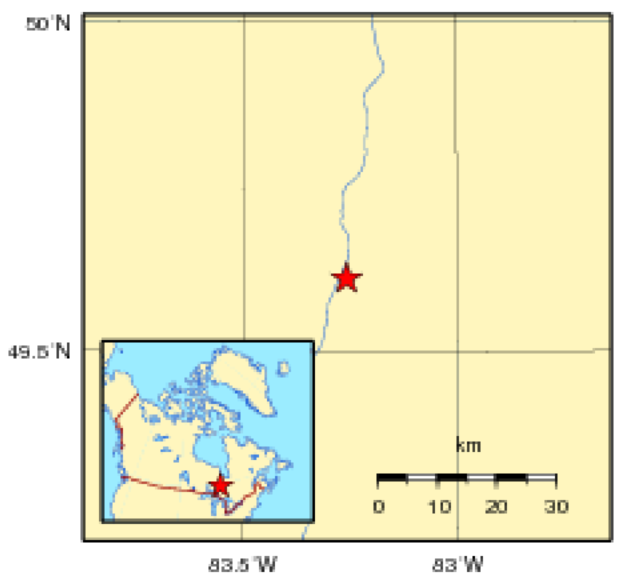
National Building Code of Canada 2015 NRCC no. 56190;
Appendix C: Table C-3, Seismic Design Data for Selected Locations in Canada

User's Guide - NBC 2015, Structural Commentaries NRCC no. xxxxxx (in preparation)
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File 7893 Fifth Generation Seismic Hazard Model for Canada: Grid values of mean hazard to be used with the 2015 National Building Code of Canada

See the websites *www.EarthquakesCanada.ca* and *www.nationalcodes.ca* for more information

Aussi disponible en français



LIST OF REFERENCED SPECIFICATIONS

OPSD 208.010	Benching of Earth Slopes
OPSD 810.010	General Rip-Rap Layout for Sewer and Culvert Outlets
OPSD 3090.100	Foundation, Frost Penetration Depths for Northern Ontario
OPSS.PROV 206	Construction Specification for Grading
OPSS 209	Construction Specification for Embankments over Swamps and Compressible Soils
OPSS.PROV 501	Construction Specification for Compacting
DBSP0539	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
DBSP902	Construction Specification for Excavating and Backfilling-Structures
OPSS.PROV 1010	Material Specification for Aggregates-Base, Subbase, Select Subgrade, and Backfill Material