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FOUNDATION INVESTIGATION AND DESIGN REPORT
DEEP CUT
HIGHWAY 17, STA. 12+360 TO 12+910
TOWNSHIP OF HODGSON
6015-E-0039
GWP 6001-14-00

GEOCRES NO.: 52F-051

Report to:

True Grit Consulting Limited

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PART 1. FACTUAL INFORMATION

1 INTRODUCTION

This section of the report presents the factual findings obtained from a foundation investigation completed for the proposed deep cut along Highway 17 between Sta. 12+360 and 12+910 required as part of the Highway 17 Revell River Curve Realignment project. The full project extends from 7.4 km west to 3.7 km west of the intersection of Highway 17/Highway 622.

The purpose of this investigation was to explore the subsurface conditions and, based on the data obtained, to provide a borehole location plan, records of boreholes, stratigraphic profile, laboratory test results and a generalized written description of the subsurface conditions. A model was produced of the anticipated geotechnical conditions influencing design and construction of the cut within the investigated section. No relevant historical investigation reports were available in the Geocres Library.

Thurber carried out the investigation as a sub-consultant to True Grit Consulting Limited under Contract No. 6015-E-0039.

2 SITE DESCRIPTION

The existing Highway 17 is a two lane undivided highway with auxiliary passing lanes near the west extent of the project area. The existing Highway 17 consists of a south facing curve with two structures spanning the Revell River. The general orientation of the proposed Highway 17 re-alignment will be located south of the existing alignment and runs in an approximate west to east direction.

The deep cut portion of the new alignment discussed within this report is from approximately Station 12+360 to 12+910. The terrain in the vicinity of the proposed deep cut ranges from a high of 469 m to a low of 451 m and currently is vegetated with a mix of deciduous and coniferous trees. The maximum depth of cut below the existing grade is

approximately 15.5 m. Several photographs of the alignment showing the conditions observed during the time of the field investigation are provided in Appendix D.

3 SITE INVESTIGATION AND FIELD TESTING

Thurber carried out the site investigation and field testing program at the deep cut location as identified in the scope of work, dated April 5, 2016. The site investigation was carried out on September 30th, 2016 and consisted of drilling six foundation boreholes (identified as Boreholes 16-01 through 16-06). The investigation was completed in conjunction with the pavement investigation which included test pits, hand augers and recorded bedrock outcrops. The northing, easting and elevation of the foundation boreholes are shown on the Borehole Location and Soil Strata Drawing No. 1 in Appendix A and are summarized in Table 3-1.

Table 3-1: Borehole Summary

Borehole	Station	Offset(*) (m)	Northing (m)	Easting (m)	Elevation (m)	Depth (m)
16-06	12+362	16.0 RT	5 488 546.4	368 931.4	460.5	7.2
16-05	12+409	CL	5 488 536.9	368 980.0	467.2	0.6
16-04	12+460	CL	5 488 508.6	369 021.1	469.2	0.9
16-03	12+510	CL	5 488 481.1	369 059.4	467.8	0.3
16-02	12+556	CL	5 488 452.6	369 099.7	461.3	2.0
16-01	12+610	CL	5 488 425.1	369 146.4	458.8	2.7

Note: (*) relative to proposed re-alignment centerline

Prior to the commencement of the subsurface investigation, utility clearances were obtained for the investigated locations along this section of the proposed highway embankment. The drilling was carried out with a track mounted CME drill rig, supplied and operated by RPM Drilling Inc. utilizing solid and hollow stem augers. Soil samples were obtained at select intervals using a split spoon sampler in conjunction with Standard Penetration testing (SPT). The investigation extended to depths ranging from 0.3 to 7.2 m below the existing ground surface.

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

Groundwater conditions in the open boreholes were observed upon completion of drilling.

During a site reconnaissance, the rock cuts and bedrock outcrops in the area were investigated for joint orientations. Fifty strike-and-dip measurements were taken to aid with rock slope stability assessment.

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

5 DESCRIPTION OF SUBSURFACE CONDITIONS

A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following paragraphs. 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 cut 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. It must be recognized that conditions may vary between and beyond borehole and sample locations.

For reference, the stratigraphy in the area of the deep cut section from Station 11+360 to 12+910 is generally characterized by silty sand overlying inferred bedrock.

5.1 Topsoil

A 50 to 100 mm thick layer of topsoil was encountered at the surface in all boreholes except Borehole 16-06. Topsoil thickness may vary in other areas of the site.

5.2 Silty Sand

A silty sand deposit was encountered in all boreholes at surface or immediately below the surficial topsoil layer. The silty sand ranged from 0.2 to 7.2 m thick with base elevations between 453.4 to 468.2 m. SPT tests performed within this material gave N-values ranging from 2 to greater than 100 blows per 300 mm of penetration indicating a loose to

very dense relative density. The moisture contents were recorded to range between 4% and 43%.

Gradation analyses were completed on eight samples of the silty sand. The results are summarized on the Record of Borehole sheets in Appendix B and the grain size distribution curves are included in Figure C1 and C2 of Appendix C. The results of the laboratory tests are summarized as follows and indicate an SM material.

Table 5-1: Gradation Results for Silty Sand

Soil Particle	Percentage (%)
Gravel	0 to 18
Sand	47 to 84
Silt and Clay	16 to 43

5.3 Bedrock

From geology mapping the eastern portion of the new alignment is underlain by granite bedrock, with a westerly transition to basaltic and andesitic massive lava (Map 2115, Kenora-Fort Frances Sheet, Ontario Geological Society, 1966).

Bedrock outcrops and rock cuts in the area were investigated for joint orientations. Outcrops were massive, and visible half barrels were present at one cut. Well-spaced joints were persistent throughout the rock cuts. Joint spacing is estimated to be approximately 1 m or greater. Fifty strike-and-dip measurements were taken to aid with rock slope stability assessment. From this data, three mean joint sets were identified and are provided in Table 5-2. It is noted that not all joint sets were observed at all locations.

Table 5-2: Joint Set Data

Joint Set	Strike (degrees, clockwise from north)	Dip (perpendicular, clockwise from strike)
1m	28	66
2m	307	67
3m	227	81

An inferred bedrock surface was encountered at auger advancement refusal in all boreholes within this cut section. Inferred bedrock was found at depths ranging from 0.3 to 7.2 m (surface elevations 453.4 to 468.2m).

The depth to bedrock within this cut section was further explored as part of the pavement investigation. Supplemental depths and elevations for 10 test pits on centreline and eight

surveyed rock outcrops locations are provided below in Table 5-3. It is noted that additional information is available in the Geotechnical Design Report at offsets from the centreline.

Table 5-3: Inferred Bedrock Elevation Summary

Location(*) ID	Station	Offset(**) (m)	Northing (m)	Easting (m)	Surface Elevation (m)	Depth to Inferred Bedrock (m)	Bedrock Inferred Elevation (m)
RO-46	12+360	3.0 RT	5488559.5	368935.6	461.7	0.0	461.7
RO-43	12+374	3.0 LT	5488558.5	368951.3	466.0	0.0	466.0
BH-180	12+380	0 CL	5488548.9	368957.0	466.2	0.9	465.3
RO-40	12+400	8.0 LT	5488549.0	368975.6	467.0	0.0	467.0
RO-38	12+435	4.0 LT	5488516.7	369000.0	469.5	0.0	469.5
RO-37	12+465	4.0 LT	5488502.0	369022.1	469.9	0.0	469.9
BH-219	12+520	0 CL	5488475.2	369068.4	467.0	1.4	465.6
RO-36	12+530	0 CL	5488468.4	369079.0	466.7	0.0	466.7
RO-34	12+553	2.0 LT	5488455.8	369098.5	464.1	0.0	464.1
RO-27	12+685	0 CL	5488381.9	369207.4	459.6	0.0	459.6
BH-332	12+680	0 CL	5488387.1	369202.1	459.4	2.5	456.9
BH-252	12+720	0 CL	5488363.4	369235.7	458.2	1.3	456.9
BH-240	12+760	0 CL	5488340.0	369270.7	455.7	0.9	454.8
BH-234	12+780	0 CL	5488331.9	369287.6	455.1	0.6	454.5
BH-226	12+820	0 CL	5488307.6	369319.0	457.1	3.2	453.9
BH-256	12+840	0 CL	5488295.2	369336.7	456.0	3.5	452.5
BH-277	12+880	0 CL	5488273.8	369371.3	455.0	4.1	450.9
BH-293	12+920	2.0 LT	5488250.8	369407.3	448.8	0.5	448.3

Note: (*) from Geotechnical Design Report, Thurber 2016 (**) relative to proposed re-alignment centerline

5.4 Groundwater

Ground water levels were not observed in any of the open boreholes upon completion of the drilling. Boreholes 16-01 through 16-05 were open and dry upon completion, while Borehole 16-06 exhibited cave and wet soils at a depth of 5.2 m.

It should be noted that the depths to groundwater are very 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 periods of significant and/or prolonged precipitation events.

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Borehole locations were selected and located relative to existing site features and proposed highway centerline. Ground surface elevations were obtained from topographic survey data provided by True Grit Consulting Limited.

RPM Drilling Inc. from Thunder Bay, Ontario supplied the drill rig and conducted the drilling, sampling, in-situ testing and borehole decommissioning for the field program. The field investigation was supervised on a full time basis by Mr. Justin Gray, E.I.T of Thurber. Overall supervision of the investigation program was conducted by Mr. Stephen Peters, P.Eng.

Routine geotechnical laboratory testing was carried out by Thurber's laboratory in Ottawa, Ontario. Interpretation of the data and preparation of this report were carried out by Mr. Justin Gray, E.I.T. and Dr. Fred Griffiths, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng a Designated Principal Contact for MTO Foundation Projects.

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5015-E-0039

GWP 6001-14-00

GEOCRES No. 52F-051

PART 2. ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 GENERAL

This section of the report provides an interpretation of the factual data and also presents geotechnical recommendations for design of a deep cut required for the proposed Revell River Curve Realignment of Highway 17 in the Township of Hodgson, Ontario

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. Contractors 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.

The overall project consists of realigning Highway 17 and the associated tie-ins to the existing highway.

The area of deep cut along the new alignment of Highway 17 addressed in this report is between approximate Sta. 12+360 and 12+910. The proposed cut depth along this section is greatest at approximately Sta. 12+450 where it is in the order of 15.5 m below the existing grade. Within this section the proposed cut depth below existing grade ranges from less than 4.5 m to approximately 15.5 m.

The project information used for the preparation of this report was provided by True Grit Consulting Limited and includes plans and profile drawings of the proposed Highway 17 alignment as of November 6th, 2016. The discussion and recommendations presented in

this report are based on the information provided by True Grit and the factual data obtained during the course of the investigation.

Thurber carried out the current investigation as a sub-consultant to True Grit Consulting Limited under Assignment number 6015-E-0039.

8 SEISMIC CONSIDERATIONS

8.1 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). The PGA value for this site is 0.044 g.

8.2 CHBDC Seismic Site Classification

In accordance with Table 4.1 of the CHBDC, the site has been determined to be Site Class C based on the properties of the soil within the upper 30 m of the ground profile.

8.3 Seismic Liquefaction

The compact to dense silty sand deposit located below the groundwater level at this site are not considered to be susceptible to liquefaction.

9 CUT CONSTRUCTION

The final cut slopes are to be constructed in sections containing both native earth slopes and blasted rock faces.

All excavations to form the cut slopes must be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the overburden cut material at this site is classified as Type 3 soil above the water level and Type 4 soil below the water level.

Construction should be carried out in accordance with OPSS.PROV 206. Much of the required cut will be through bedrock. The selection of the method of excavating and removing the bedrock is the responsibility of the contractor. Overburden should be removed prior to commencing drilling and blasting operations to accurately establish the bedrock surface. Rock excavation should be completed in accordance with OPSS.PROV 206. The design of temporary slopes is the responsibility of the contractor, however vertical slopes in the bedrock will remain stable in the short term.

To maintain stability of the cut slopes, it is required that drainage measures be incorporated into the design. An interceptor ditch should be provided at the top of earth cuts as per OPSD 200.010 and 201.010. Roadside ditches are expected to provide an adequate level of surface drainage.

9.1 Earth Cuts

In earth cuts, final slopes constructed no steeper than 2 horizontal to 1 vertical (2H:1V) is expected remain stable. Should the earth cut slopes be in excess of 6 m in total height, a 2 m wide mid-height bench must be provided along the length of the earth cut. The finished earth cut slopes should be inspected for ongoing seepage emerging from the cut slopes. Gravel sheeting or rock protection may be required to provide drainage of the seepage to prevent erosion of the slope face.

9.2 Rock Cuts

The construction of the rock cut should be carried out in accordance with OPSD 201.010. Rock cuts should be designed in conformity with the Northwestern Region Rock Cut Design Guidelines.

In rock cuts 10 m and over, the rock face must be back-sloped to 0.25H:1V and a minimum clear zone width must be provided.

In rock cuts under 10 m, the rock face can remain vertical provided the required clear zone is maintained.

The required clear zone is the greater of that defined by the Northwestern Region Rock Cut Design Guidelines (5 m for a 10 m cut and 8.5 m for a 15 m high cut) and the Roadside Safety Manual. A ditch depth of at least 0.75 m is required for rock catchment. Carefully controlled excavation techniques will minimize face instabilities and long-term maintenance problems resulting from damage to the rock mass. Where final cuts are to have earth slopes on top of the rock cut, the toe of the earth slope must be set back a minimum of 3 m from the top of the rock face and constructed no steeper than 2 horizontal to 1 vertical (2H:1V).

Rock excavation utilizing blasting should be carried out in accordance with OPSS 120, including blast design by a qualified Engineer/firm, explosive use by a competent blasting

contractor, monitoring by a blast monitoring consultant, preparation of a pre-blast survey, and notification of any nearby utility authorities.

Joint analysis was carried out utilizing the commercially available structural analysis software Dips (Version 7.0) developed by Rocscience Inc. The regional mean joint sets were analyzed to assess the instability compared to the possible orientation of the cut section. The results of the structural analysis are shown in Appendix E.

The cut section is to be blasted with rock faces approximately parallel to the new alignment, with a slope of 0.25H :1V. With this geometry, the north cut face would have a strike of approximately 124° and dip of 76°, and the south cut face would have a strike of 304° and dip of 76°. The feasibility for instability in the cut section is detailed in Table 9-1.

Table 9-1: Feasibility of Instability Mechanisms

	Feasibility	
Mechanism	North Cut Face	South Cut Face
Planar Sliding	Not Feasible	Feasible
Toppling	Feasible	Not Feasible
Wedge Failure	Not Feasible	Feasible

Joint Set 2m meets the criteria for possible planar sliding at the south cut face; the joint is nearly parallel to the slope face, has a dip slightly lower than the slope face, and has an angle greater than the angle of friction for the plane. However, the intersection of Joint Set 2m and the south face is anticipated to be acute, thus the horizontal distance into the rock face that could be affected is limited to approximately 3 m for a 15 m high cut. It is recommended that the cut be constructed with the typical 0.25H:1V slope but that the width of the cleared bench (the distance between the top of the rock cut and the toe of the overlying overburden slope) be increased to 5 m.

Flexural or direct toppling is possible between joint set 2m and the north cut face; this joint set is nearly parallel to the slope face, and is steeply dipping away from the cut. Given the regional estimate of joint spacing, there is a risk that overhanging blocks as thick as 1 m may be presented after blasting. This risk can be mitigated with a scaling operation upon completion of the blasting operations.

The intersection of Joint Set 1m and Joint Set 3m presents a possibility for wedge failure to occur within the south cut face. This mode of failure is less likely as the plunge of the line of intersection is approximately equal to the to the average friction angle of the sliding planes.

It is noted that the assessment is based on regional data and that the identified joint sets were not consistently present at all observations points. Variations in strike, dip and

frequency of joint sets should be anticipated. After blasting, the rock cuts should be examined by a rock slope specialist to identify any areas of unstable rock requiring removal or stabilization.

9.3 Transitional Areas

A transitional treatment is required between rock cuts and earth cuts (OPSD 205.050), rock cuts and earth fills (OPSD 205.030) and rock cuts and rock fills (OPSD 205.020).

9.4 Erosion Protection

Slope protection and drainage measures will be required to ensure the long-term surficial stability of the earth cut slopes. Normal slope vegetation should be established as soon as possible after completion of the earth cut slopes 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/sediments from running off the site as per OPSS 805.

A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion in general accordance with OPSS.PROV 804.

Additional comments on erosion protection are provided in the Geotechnical Design Report.

9.5 Drainage

Prior dewatering of the site is not considered necessary, however groundwater seepage is expected to enter the open excavation and may require action on the part of the contractor in order to proceed with construction. Some sloughing may occur as a result of groundwater seepage during excavation. The cut should begin at the low end of the highway and proceed eastward to allow drainage as excavation progresses.

10 CONSTRUCTION CONCERNS

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

- Excavation difficulties due to the presence of obstructions such as potential for cobbles and boulders in the overburden material. Provision must be made for the removal of cobbles and boulders.
- Control of groundwater seepage during excavation and permanent drainage in the cut section.
- The thickness and presence of fill, topsoil and alluvial deposits were investigated at the borehole locations along the proposed embankment centerline only. These

deposits may extend to greater depths/extents or be encountered at other locations between boreholes.

- Access of construction equipment to this cut section may be limited by adjacent low lying areas containing loose and/or organic deposits.

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11 CLOSURE

Engineering analysis and preparation of this report were carried out by Justin Gray, E.I.T. 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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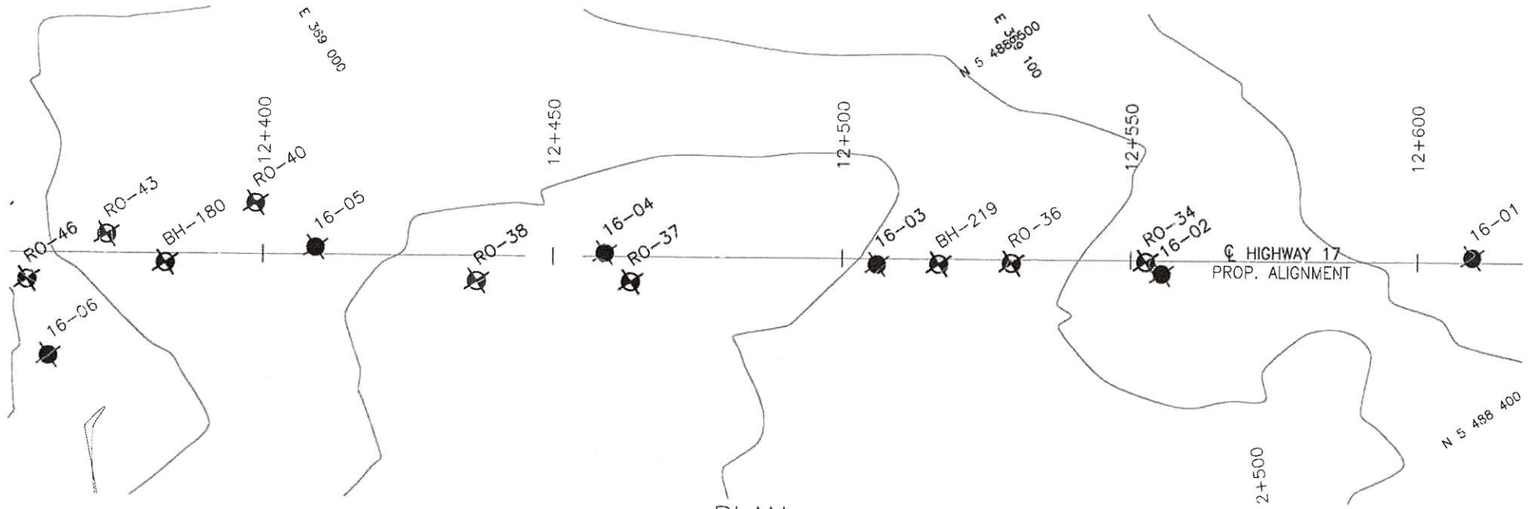
Appendix A.

Borehole Location Plan and Stratigraphic Drawings

MINISTRY OF TRANSPORTATION ONTARIO

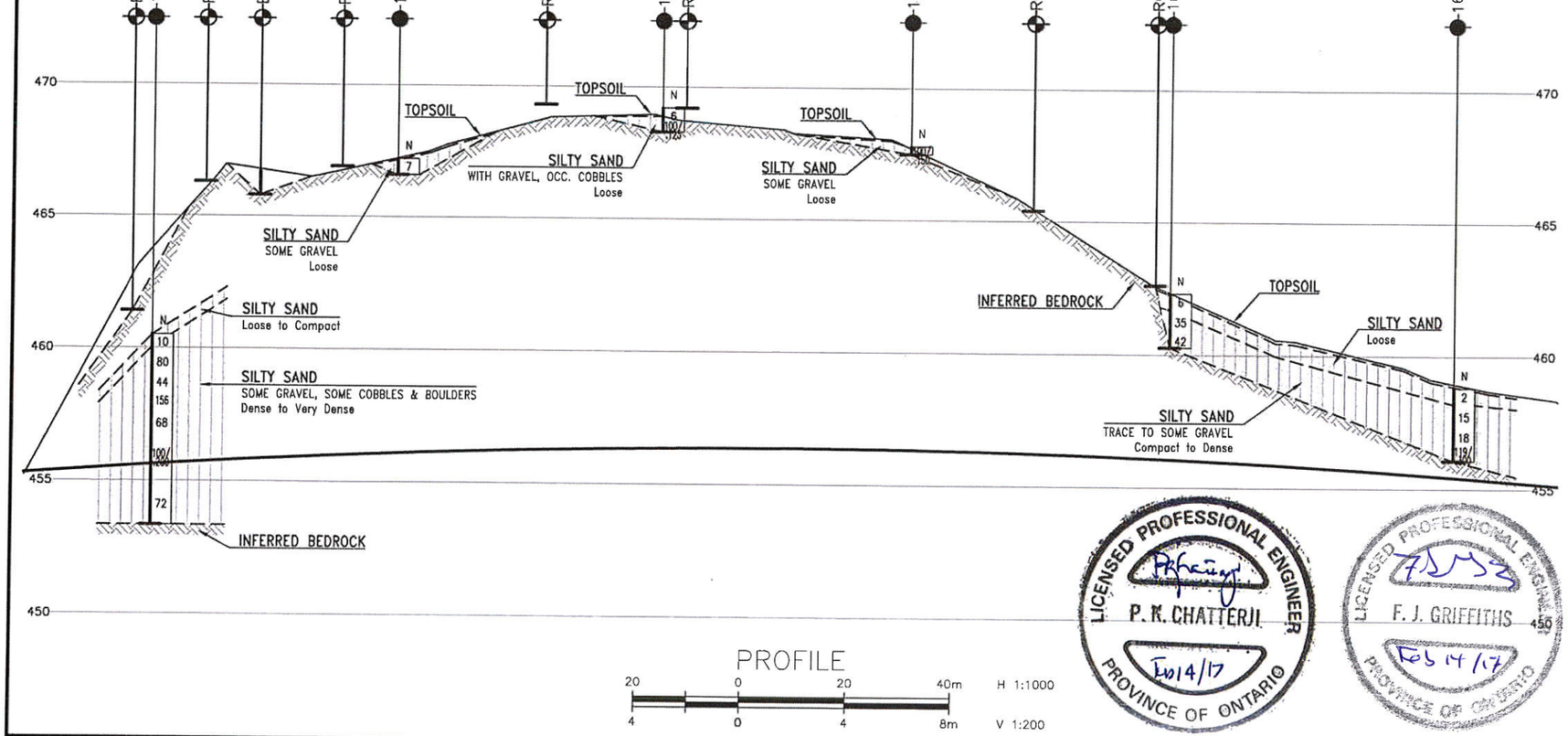


PLAN

20 0 20 40m

SCALE 1:1000

NO	ELEVATION	NORTHING	EASTING
RO-38	469.3	5 488 516.7	369 000.0
RO-40	466.9	5 488 549.0	368 975.6
RO-43	466.3	5 488 558.5	368 951.3
RO-46	461.4	5 488 559.5	368 935.6



PROFILE

20 0 20 40m H 1:1000

4 0 4 8m V 1:200

METRIC

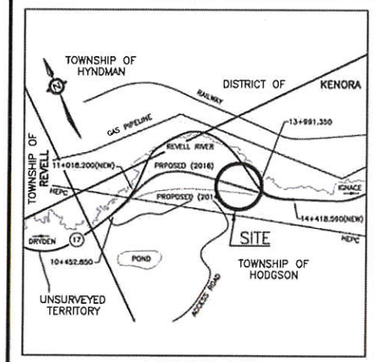
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No
GWP No 6015-E-0039

SHEET

HIGHWAY 17
DEEP CUT SECTION
STATION 12+360 TO 12+620
BOREHOLE LOCATIONS AND SOIL STRATA

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

	Borehole
	Rock Probe
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	458.8	5 488 425.1	369 146.4
16-02	462.3	5 488 452.6	369 099.7
16-03	467.8	5 488 481.1	369 059.4
16-04	469.2	5 488 508.6	369 021.1
16-05	467.2	5 488 536.9	368 980.0
16-06	460.5	5 488 546.4	368 931.4
BH-180	466.7	5 488 548.9	368 957.0
BH-219	466.6	5 488 475.2	369 068.4
RO-34	462.6	5 488 455.8	369 098.5
RO-36	465.4	5 488 468.4	369 079.0
RO-37	469.2	5 488 502.0	369 022.1

-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 16 coordinates.

GEOCRES No. 52F-051

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REVISIONS		
DATE	BY	DESCRIPTION

DESIGN CM	CHK –	CODE	LOAD	DATE	FEB 2017
DRAWN MFA	CHK CM	SITE	STRUCT	DWG	1

FILENAME: H:\Drafting\13000\13772\TED-13772-BHPP-3.dwg
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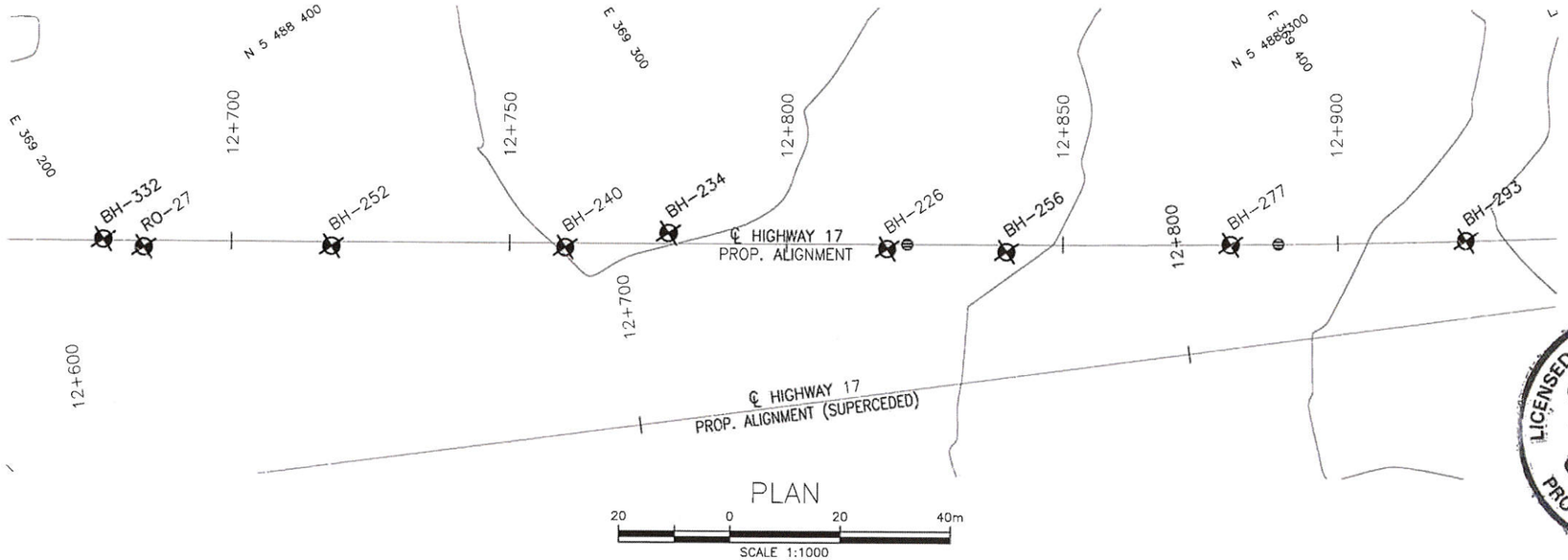
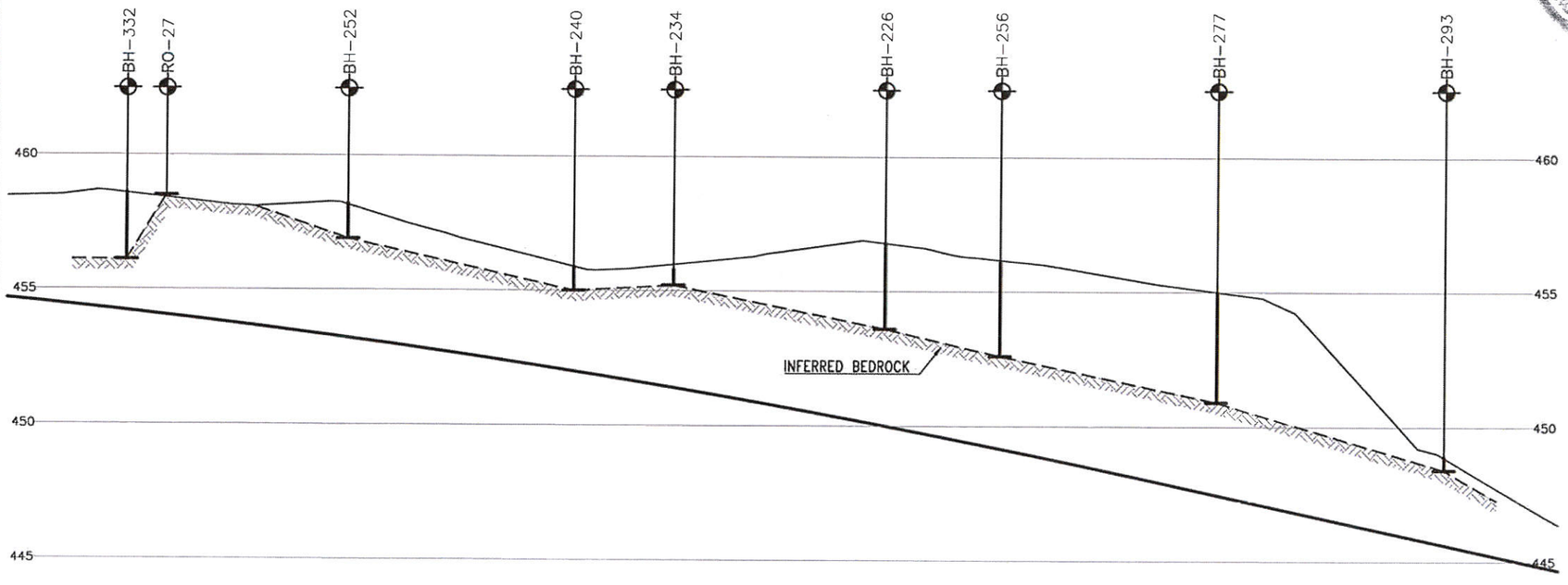
MINISTRY OF TRANSPORTATION, ONTARIO



PLAN

20 0 20 40m

SCALE 1:1000



PROFILE

20 0 20 40m H 1:1000

4 0 4 8m V 1:200

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
Feb 14/17
PROVINCE OF ONTARIO

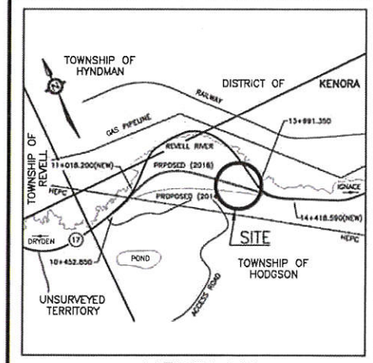
LICENSED PROFESSIONAL ENGINEER
F. J. GRIFFITHS
Feb 14/17
PROVINCE OF ONTARIO

CONT No
GWP No 6015-E-0039

SHEET

HIGHWAY 17
DEEP CUT SECTION
STATION 12+660 TO 12+910
BOREHOLE LOCATIONS AND SOIL STRATA

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

●	Borehole
⊖	Rock Probe
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
BH-226	456.8	5 488 307.6	369 319.0
BH-234	455.8	5 488 331.9	369 287.6
BH-240	455.9	5 488 340.0	369 270.7
BH-252	458.2	5 488 363.4	369 235.7
BH-256	456.1	5 488 295.2	369 336.7
BH-277	455.0	5 488 273.8	369 371.3
BH-293	448.9	5 488 250.8	369 407.3
BH-332	458.6	5 488 387.1	369 202.1
RO-27	458.5	5 488 381.9	369 207.4

-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 16 coordinates.

GEOCRES No. 52F-051

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN	CM	CHK –	CODE	LOAD	DATE FEB 2017
DRAWN	MFA	CHK CM	SITE	STRUCT	DWG 2

FILENAME: H:\Drafting\13000\13772\TED-13772-BHPP-3.dwg
PLOTDATE: 2/13/2017 4:55 PM

Appendix B.

Record of Borehole Sheets

THURBER

SYMBOLS, ABBREVIATIONS AND TERMS USED ON TEST HOLE RECORDS

TERMINOLOGY DESCRIBING COMMON SOIL GENESIS

Topsoil	mixture of soil and humus capable of supporting vegetative growth
Peat	mixture of fragments of decayed organic matter
Till	unstratified glacial deposit which may include particles ranging in sizes from clay to boulder
Fill	material below the surface identified as placed by humans (excluding buried services)

TERMINOLOGY DESCRIBING SOIL STRUCTURE:

Desiccated	having visible signs of weathering by oxidization of clay materials, shrinkage cracks, etc.
Fissured	having cracks, and hence a blocky structure
Varved	composed of alternating layers of silt and clay
Stratified	composed of alternating successions of different soil types, e.g. silt and sand
Layer	> 75 mm in thickness
Seam	2 mm to 75 mm in thickness
Parting	< 2 mm in thickness

RECOVERY:

For soil samples, the recovery is recorded as the length of the soil sample recovered.

N-VALUE:

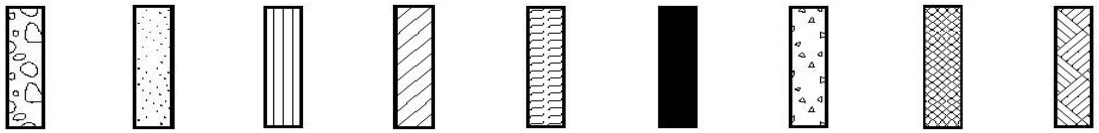
Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 63.5 kg hammer falling 0.76 m, required to drive a 50 mm O.D. split spoon sampler 0.3 m into undisturbed soil. For samples where insufficient penetration was achieved and N-value cannot be presented, the number of blows are reported over the sampler penetration in millimetres (e.g. 50/75).

DYNAMIC CONE PENETRATION TEST (DCPT):

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

THURBER

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



Boulders
Cobbles
Gravel
Sand
Silt
Clay
Organics
Asphalt
Concrete
Fill
Bedrock

TEXTURING CLASSIFICATION OF SOILS

Classification	Particle Size
Boulders	Greater than 200 mm
Cobbles	75 – 200 mm
Gravel	4.75 – 75 mm
Sand	0.075 – 4.75 mm
Silt	0.002 – 0.075 mm
Clay	Less than 0.002 mm

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

THURBER

MODIFIED UNIFIED SOIL CLASSIFICATION

Major Divisions		Group Symbol	Typical Description
COARSE GRAINED SOIL	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILT AND CLAY SOILS $W_L < 35\%$	ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
		OL	Organic silts and organic silty-clays of low plasticity.
	SILT AND CLAY SOILS $35\% < W_L < 50\%$	MI	Inorganic compressible fine sandy silt with clay of medium plasticity, clayey silts.
		CI	Inorganic clays of medium plasticity, silty clays.
		OI	Organic silty clays of medium plasticity.
	SILT AND CLAY SOILS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy of silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other organic soils.

Note - W_L= Liquid Limit

THURBER

EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION

Fresh (FR)	No visible signs of weathering.
Fresh Jointed (FJ)	Weathering limited to surface of major discontinuities.
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock materials.
Moderately Weathered (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.
Highly Weathered (HW)	Weathering extends throughout the rock mass and the rock is partly friable.
Completely Weathered (CW)	Rock is wholly decomposed and in a friable condition, but the rock texture and structures are preserved.

TERMS

Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.
Solid Core Recovery: (SCR)	Percent ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1 m in length or larger, as a percentage of total core length
Unconfined Compressive Strength: (UCS)	Axial stress required to break the specimen.
Fracture Index: (FI)	Frequency of natural fractures per 0.3 m of core run.

DISCONTINUITY SPACING

Bedding	Bedding Plane Spacing
Very thickly bedded	Greater than 2 m
Thickly bedded	0.6 to 2 m
Medium bedded	0.2 to 0.6 m
Thinly bedded	60 mm to 0.2 m
Very thinly bedded	20 to 60 mm
Laminated	6 to 20 mm
Thinly laminated	Less than 6 mm

STRENGTH CLASSIFICATION

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

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THURBER

RECORD OF BOREHOLE No 16-01 1 OF 1 METRIC

GWP# 6015-E-0039 LOCATION Hwy 17 - Revell River Curve Realignment N 5 488 425.1 E 369 146.4 ORIGINATED BY JG

HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY JG

DATUM Geodetic DATE 2016.09.30 - 2016.09.30 CHECKED BY SP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
458.8	**12+610 0 CL**										
0.0	100mm **TOPSOIL**										
0.1	**SILTY SAND (SM)** loose brown		1	SS	2				○		0 84 16 (SI+CL)
458.2											
0.6	**SILTY SAND (SM)**, trace gravel compact grey		2	SS	15		458		○		
			3	SS	18		457		○		7 52 41 (SI+CL)
			4	SS	119/ 300mm				○ ○		
456.1	- blue/green weathered rock at 2.6m										
2.7	End of Borehole on Inferred Bedrock Borehole open and dry upon completion										

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

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

ONTMT4S 13772 HWY 17 REVELL CURVE - FOUNDATION.GPJ 2012TEMPLATE(MTO).GDT 14/2/17

Ministry of Transportation
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THURBER

RECORD OF BOREHOLE No 16-02 1 OF 1 METRIC

GWP# 6015-E-0039 LOCATION Hwy 17 - Revell River Curve Realignment N 5 488 452.6 E 369 099.7 ORIGINATED BY JG

HWY 17 BOREHOLE TYPE Solid Stem Auger COMPILED BY JG

DATUM Geodetic DATE 2016.09.30 - 2016.09.30 CHECKED BY SP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
461.3	12+556 0 CL										
0.0	50mm **TOPSOIL**										
0.0	**SILTY SAND (SM)** loose brown		1	SS	6		461		○		
460.7											
0.6	**SILTY SAND (SM)**, some gravel dense grey -gravelly layer at 1.1m		2	SS	35		460		○		
			3	SS	42				○		11 52 34 3
459.3											
2.0	End of Borehole on Inferred Bedrock Borehole open and dry upon completion										

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

15 20 10 5 (%) STRAIN AT FAILURE

ONTMT4S 13772 HWY 17 REVELL CURVE - FOUNDATION.GPJ 2012TEMPLATE(MTO).GDT 14/2/17

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THURBER

RECORD OF BOREHOLE No 16-03 1 OF 1 METRIC

GWP# 6015-E-0039 LOCATION Hwy 17 - Revell River Curve Realignment N 5 488 481.1 E 369 059.4 ORIGINATED BY JG

HWY 17 BOREHOLE TYPE Solid Stem Auger COMPILED BY JG

DATUM Geodetic DATE 2016.09.30 - 2016.09.30 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
467.8	**12+510 0 CL**										
0.0	100mm **TOPSOIL**		1	SS	100/ 150mm				○		13 54 33 (SI+CL)
467.5	**SILTY SAND (SM)**, some gravel										
0.3	loose brown to grey										
	End of Borehole on Inferred Bedrock Borehole open upon completion										

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

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

ONTMT4S 13772 HWY 17 REVELL CURVE - FOUNDATION.GPJ 2012TEMPLATE(MTO).GDT 14/2/17

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THURBER

RECORD OF BOREHOLE No 16-04 1 OF 1 METRIC

GWP# 6015-E-0039 LOCATION Hwy 17 - Revell River Curve Realignment N 5 488 508.6 E 369 021.1 ORIGINATED BY JG

HWY 17 BOREHOLE TYPE Solid Stem Auger COMPILED BY JG

DATUM Geodetic DATE 2016.09.30 - 2016.09.30 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
469.2	**12+460 0 CL**										
0.0	50mm **TOPSOIL**										
0.0	**SILTY SAND (SM)**, with gravel, occasional cobbles loose brown		1	SS	6		469		○		18 57 25 (SI+CL)
468.2			2	SS	100/ 125mm				○		
0.9	End of Borehole on Inferred Bedrock Borehole open and dry upon completion										

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

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

ONTMT4S 13772 HWY 17 REVELL CURVE - FOUNDATION.GPJ 2012TEMPLATE(MTO).GDT 14/2/17

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THURBER

RECORD OF BOREHOLE No 16-05 1 OF 1 METRIC

GWP# 6015-E-0039 LOCATION Hwy 17 - Revell River Curve Realignment N 5 488 536.9 E 368 980.0 ORIGINATED BY JG

HWY 17 BOREHOLE TYPE Solid Stem Auger COMPILED BY JG

DATUM Geodetic DATE 2016.09.30 - 2016.09.30 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
467.2	**12+409 0 CL**										
0.0	50mm **TOPSOIL**										
0.0	**SILTY SAND (SM)**, some gravel loose brown		1	SS	7		467		○		13 48 36 3
466.6 0.6	End of Borehole on Inferred Bedrock Borehole open and dry upon completion										

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

20
15 ⊕ 5
10
(%) STRAIN AT FAILURE

ONTMT4S 13772 HWY 17 REVELL CURVE - FOUNDATION.GPJ 2012TEMPLATE(MTO).GDT 14/2/17

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 16-06 1 OF 1 METRIC

GWP# 6015-E-0039 LOCATION Hwy 17 - Revell River Curve Realignment N 5 488 546.4 E 368 931.4 ORIGINATED BY JG

HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY JG

DATUM Geodetic DATE 2016.09.30 - 2016.09.30 CHECKED BY SP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
460.5	**12+362 16.0 RT CL**										
0.0 460.1	**SILTY SAND (SM)** loose to compact brown		1	SS	10		460		○		
0.5	**SILTY SAND (SM)**, some gravel dense to very dense grey - Occasional cobbles and boulders		2	SS	80				○		
			3	SS	44		459		○		10 47 43 (SI+CL)
			4	SS	156		458		○		
			5	SS	68		457		○		
	- Frequent cobbles and boulders										
			6	SS	100/200mm		456				
	- wet at 5.2m						455				
			7	SS	72		454		○		8 54 38 (SI+CL)
453.4											
7.2	End of Borehole on Inferred Bedrock Borehole open to 5.2m upon completion										

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

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

ONTMT4S 13772 HWY 17 REVELL CURVE - FOUNDATION.GPJ 2012TEMPLATE(MTO).GDT 14/2/17

THURBER

60 YEARS

Appendix C.

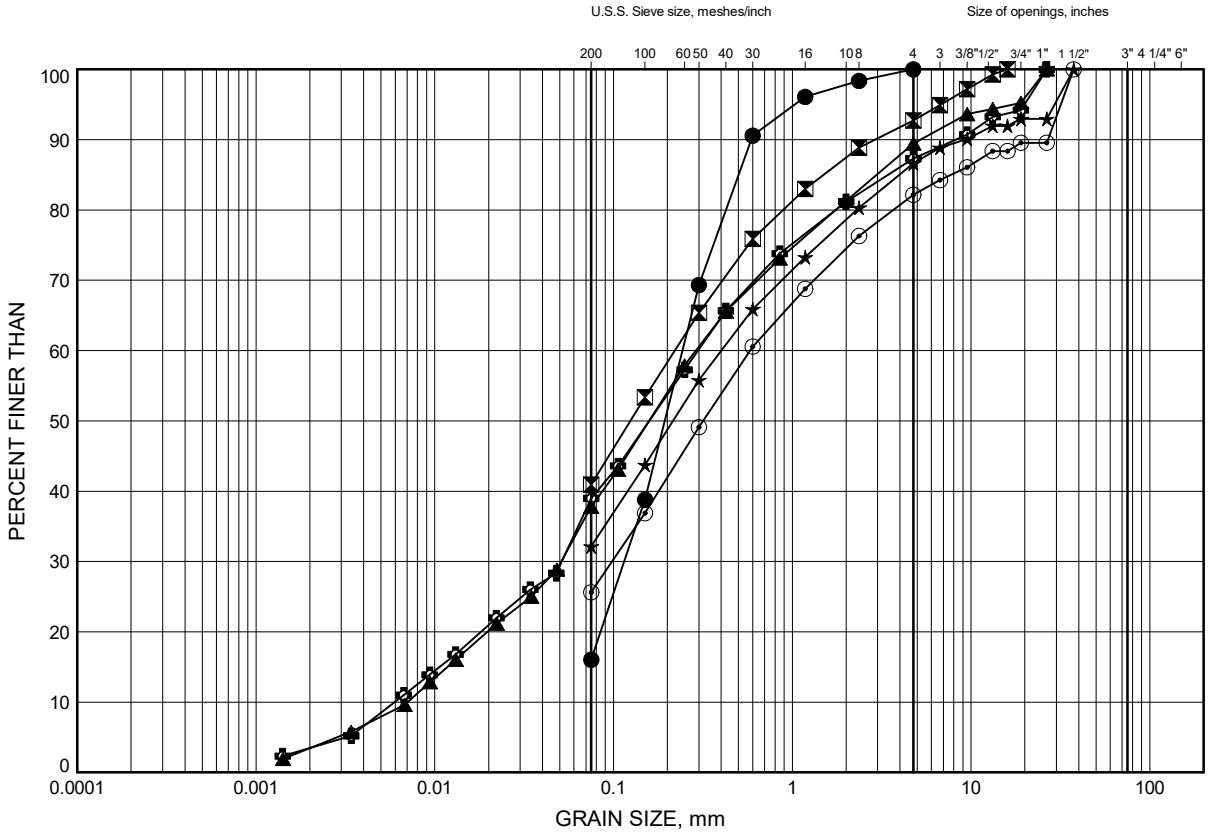
Laboratory Testing

Hwy 17 - Revell River Curve Realignment

GRAIN SIZE DISTRIBUTION

FIGURE C1

SILTY SAND (SM)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-01	0.30	458.52
⊠	16-01	1.83	457.00
▲	16-02	1.77	459.57
★	16-03	0.15	467.65
⊙	16-04	0.30	468.86
✿	16-05	0.30	466.94

Date November 2016

GWP# 6015-E-0039

THURBER

Prep'd .....

Chkd. .....

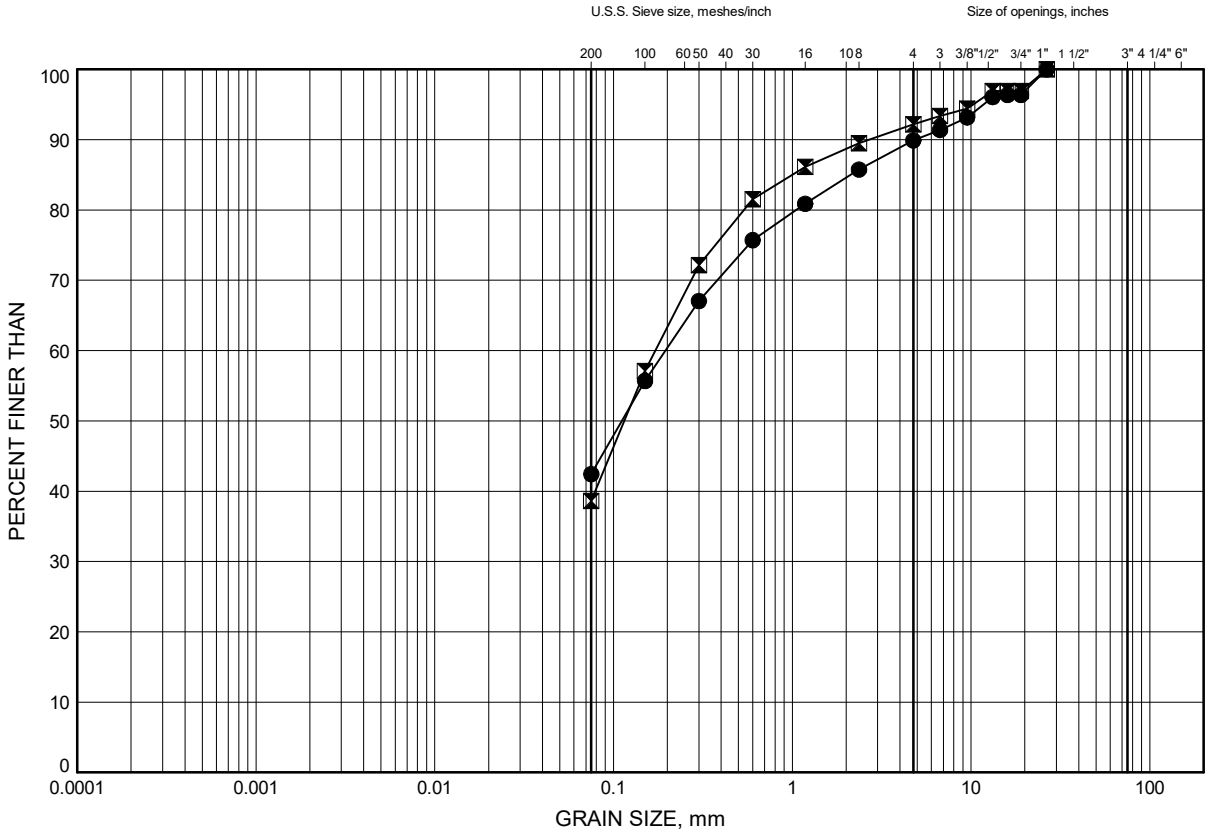
GRAIN SIZE DISTRIBUTION - THURBER 13772 HWY 17 REVELL CURVE - FOUNDATION.GPJ 30/11/16

Hwy 17 - Revell River Curve Realignment

GRAIN SIZE DISTRIBUTION

FIGURE C2

SILTY SAND (SM)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-06	1.83	458.72
⧓	16-06	6.40	454.14

Date November 2016

GWP# 6015-E-0039

THURBER

Prep'd .....

Chkd. .....

GRAIN SIZE DISTRIBUTION - THURBER 13772 HWY 17 REVELL CURVE - FOUNDATION.GPJ 30/11/16

Appendix D.

Site Photographs

Photo 1. Looking east at Station 12+300

Photo 2. Looking east at Station 12+400

Photo 3. Looking east at Station 12+500

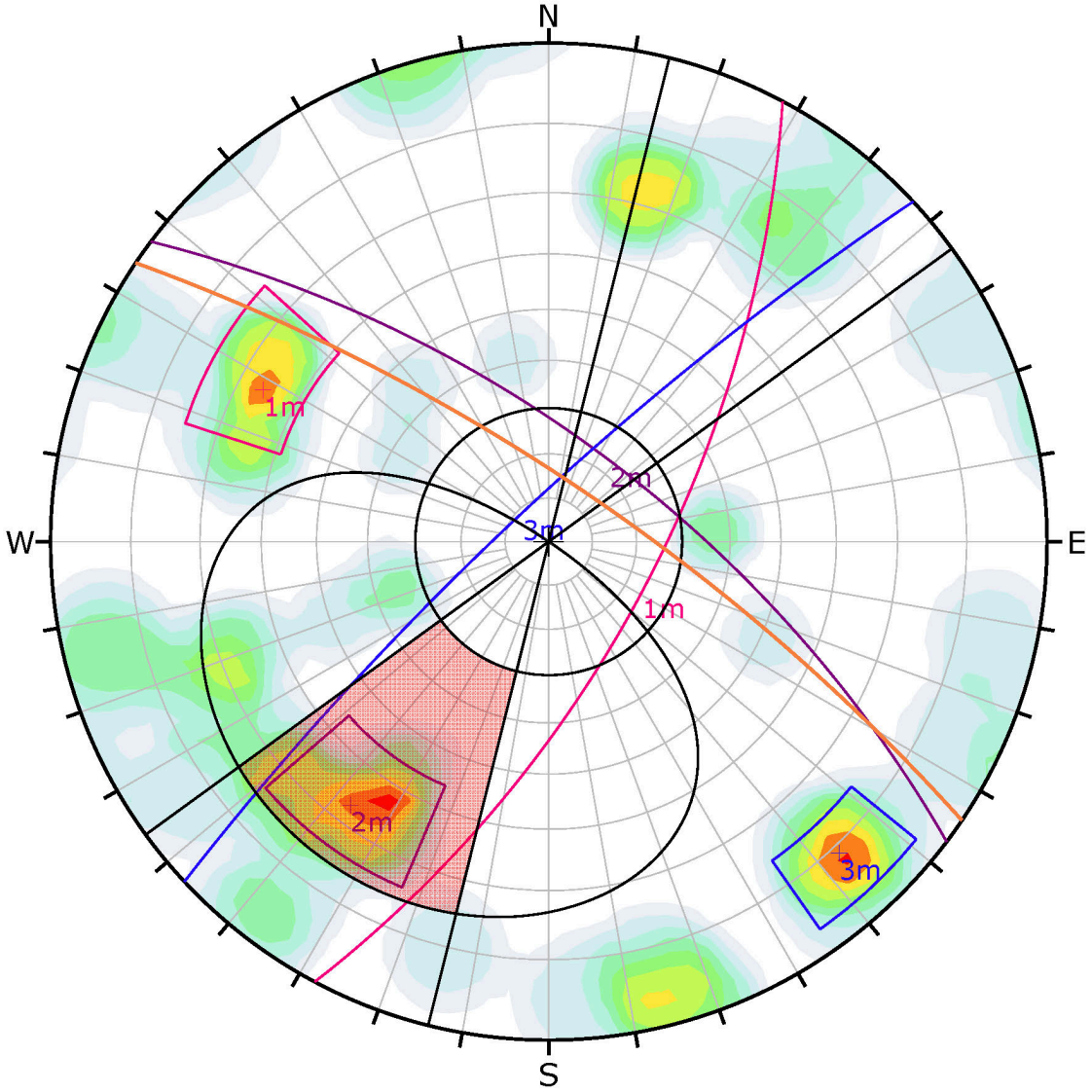
Photo 4. Looking east at Station 12+700

THURBER

60 YEARS

Appendix E.

Analysis of Failure Mechanisms in Rock Cuts



Color	Density Concentrations
	0.00 - 0.80
	0.80 - 1.60
	1.60 - 2.40
	2.40 - 3.20
	3.20 - 4.00
	4.00 - 4.80
	4.80 - 5.60
	5.60 - 6.40
	6.40 - 7.20
	7.20 - 8.00

Contour Data	Pole Vectors
Maximum Density	7.74%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Planar Sliding
Slope Dip	76
Slope Dip Direction	34
Friction Angle	30°
Lateral Limits	20°

	Critical	Total	%
Planar Sliding (All)	8	50	16.00%
Planar Sliding (Set 2)	6	6	100.00%

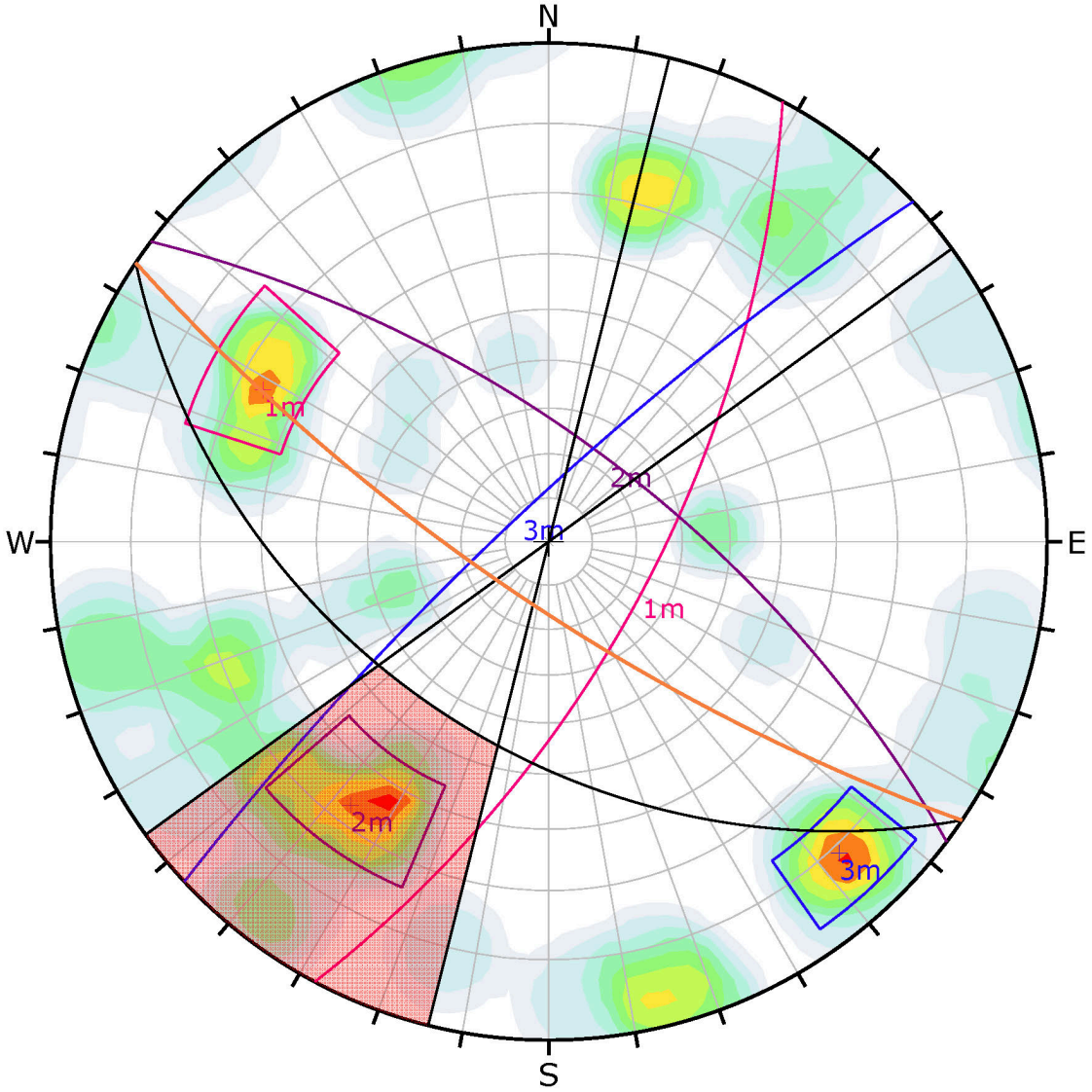
	Color	Strike (Right)	Dip	Label
Mean Set Planes				
1m		28	66	
2m		307	67	
3m		227	81	

Plot Mode	Pole Vectors
Vector Count	50 (50 Entries)
Hemisphere	Lower
Projection	Equal Angle

THURBER ENGINEERING LTD.

DIPS 7.007

Project	Revell River Curve Realignment		
Analysis Description	Planar Sliding (South Rock Cut)		
Drawn By	JM	*Company*	Thurber Engineering Ltd.
Date	12/13/2016	*File Name*	Planar Sliding South Wall.dips7



Color	Density Concentrations
	0.00 - 0.80
	0.80 - 1.60
	1.60 - 2.40
	2.40 - 3.20
	3.20 - 4.00
	4.00 - 4.80
	4.80 - 5.60
	5.60 - 6.40
	6.40 - 7.20
	7.20 - 8.00

Contour Data	Pole Vectors
Maximum Density	7.74%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Flexural Toppling
Slope Dip	76
Slope Dip Direction	214
Friction Angle	30°
Lateral Limits	20°

	Critical	Total	%
Flexural Toppling (All)	11	50	22.00%
Flexural Toppling (Set 2)	6	6	100.00%

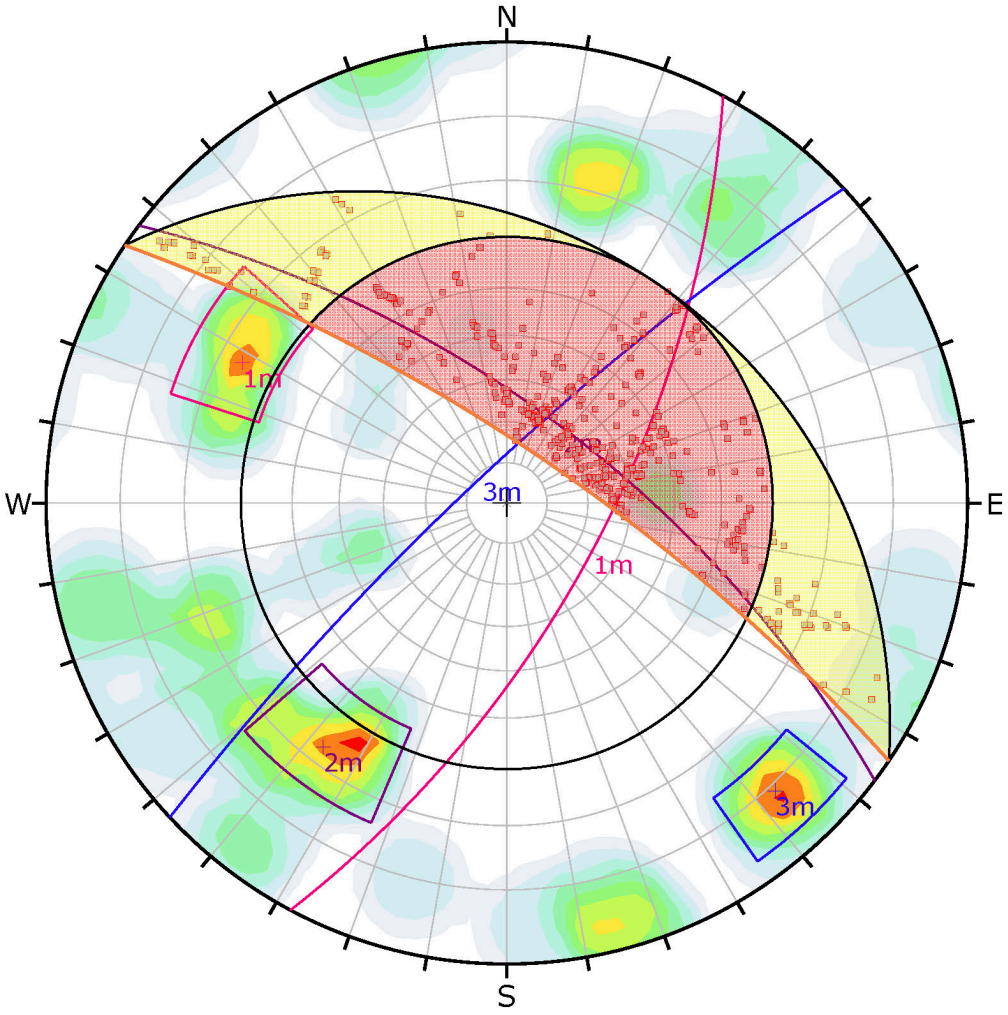
	Color	Strike (Right)	Dip	Label
Mean Set Planes				
1m		28	66	
2m		307	67	
3m		227	81	

Plot Mode	Pole Vectors
Vector Count	50 (50 Entries)
Hemisphere	Lower
Projection	Equal Angle

THURBER ENGINEERING LTD.

DIPS 7.007

Project	Revell River Curve Realignment		
Analysis Description	Flexural Toppling (North Rock Cut)		
Drawn By	JM	*Company*	Thurber Engineering Ltd.
Date	12/13/2016	*File Name*	Flexural Toppling North Wall.dips7



Symbol	Feature
▪	Critical Intersection

Color	Density Concentrations
	0.00 - 0.80
	0.80 - 1.60
	1.60 - 2.40
	2.40 - 3.20
	3.20 - 4.00
	4.00 - 4.80
	4.80 - 5.60
	5.60 - 6.40
	6.40 - 7.20
	7.20 - 8.00

Contour Data	Pole Vectors
Maximum Density	7.74%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Wedge Sliding
Slope Dip	76
Slope Dip Direction	34
Friction Angle	30°

	Critical	Total	%
Wedge Sliding	476	1224	38.89%

	Color	Strike (Right)	Dip	Label
Mean Set Planes				
1m		28	66	
2m		307	67	
3m		227	81	

Plot Mode	Pole Vectors
Vector Count	50 (50 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	1224
Hemisphere	Lower
Projection	Equal Angle

THURBER ENGINEERING LTD.

DIPS 7.007

Project	Revell River Curve Realignment		
Analysis Description	Wedge Failure (South Rock Cut)		
Drawn By	JM	*Company*	Thurber Engineering Ltd.
Date	12/13/2016	*File Name*	Wedge South Wall.dips7

THURBER

60 YEARS

Appendix F.

GSC Seismic Hazard Calculation

List of Special Provisions and OPSS Documents

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

February 13, 2017

Site: 49.5342 N, 92.1189 W User File Reference: Revell Curve

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)**
0.060	0.081	**0.072**	0.057	**0.040**	**0.019**	**0.0077**	**0.0015**	**0.0007**	**0.044**	**0.028**

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)	0.0022	0.015	0.029
Sa(0.1)	0.0037	0.022	0.042
Sa(0.2)	0.0043	0.022	0.039
Sa(0.3)	0.0038	0.018	0.031
Sa(0.5)	0.0027	0.013	0.022
Sa(1.0)	0.0011	0.0057	0.011
Sa(2.0)	0.0004	0.0022	0.0041
Sa(5.0)	0.0002	0.0005	0.0008
Sa(10.0)	0.0001	0.0003	0.0005
PGA	0.0020	0.012	0.022
PGV	0.0013	0.0076	0.014

References

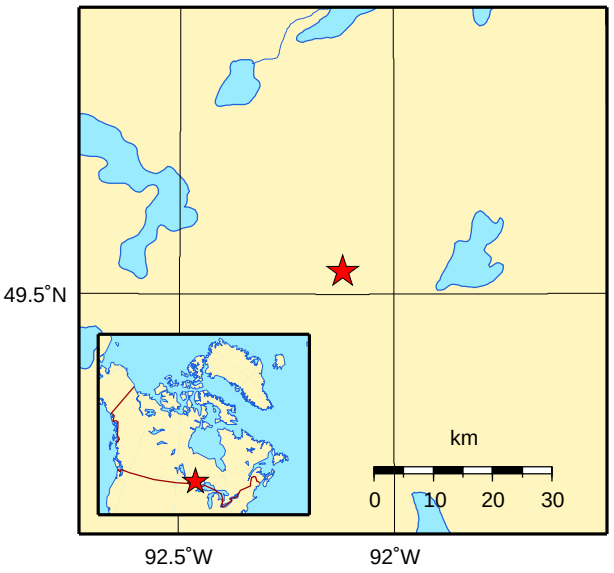
National Building Code of Canada 2015 NRCC no. 56190;
Appendix C: Table C-3, Seismic Design Data for Selected Locations in Canada

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



Natural Resources Canada Ressources naturelles Canada

Canada

The following Standard Specifications and Special Provisions are referenced in this report:

OPSS 120	The Use of Explosives
OPSS.PROV 206	Construction Specification for Grading
OPSS.PROV 804	Construction Specification for Seed and Cover
OPSS 805	Construction Specification for Temporary Erosion and Sediment Control Measures
OPSD 200.010	Benching of Earth Slopes
OPSD 201.010	Benching of Earth Slopes
OPSD 205.020	Transition Treatment, Rock Cut to Rock Fill
OPSD 205.030	Transition Treatment, Rock Cut to Earth Fill
OPSD 205.050	Transition Treatment, Rock Cut to Earth Cut
OPSD 208.010	Benching of Earth Slopes