THURBER ENGINEERING LTD.

FOUNDATION INVESTIGATION AND DESIGN REPORT
ELLIS CREEK BRIDGES – EBL & WBL
HIGHWAY 7-NEW, KITCHENER TO GUELPH
G.W.P. 408-88-00

GEOCRES No. 40P9-59

Report

to

WSP

Date: May 1, 2020
File: 11375

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PART 1: FACTUAL INFORMATION

1. INTRODUCTION

This report presents the factual findings obtained from a detailed foundation investigation conducted for the proposed Ellis Creek bridges along the proposed Highway 7-New mainline alignment in the Regional Municipality of Waterloo, Ontario. Two bridges are proposed to carry the westbound and eastbound lanes (WBL and EBL) of Highway 7-New over Ellis Creek.

The purpose of this investigation was to explore the subsurface conditions at the site and, based on the data obtained, to provide a borehole location plan, records of boreholes, stratigraphic profiles, cross sections, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions under the potential foundation footprint was developed from the data obtained in the course of the investigation.

Thurber was retained by WSP to carry out the site investigation under the Ministry of Transportation Ontario (MTO) Agreement Order Number 3014-E-0013.

2. SITE DESCRIPTION

At the site of the proposed Ellis Creek bridges, the Highway 7-New alignment runs parallel to the existing Hwy 7 and is approximately 750 m to the north. The site lies at the eastern edge of the City of Waterloo, and it is approximately 200 m east of Township Road 3 (Guelph Road 3).

Based on the Ontario Geological Survey Special Volume 2, The Physiography of Southern Ontario, Third Edition by Chapman and Putnam, the site lies within an area referred to as the Guelph Drumlin Field, an area of drumlinized till plain, also mapped as containing eskers. The till is described as stony with boulders at the surface. Chapman and Putnam give a typical gradation of the till as being 50% sand, 35% silt and 15% clay. Swampy valleys are reported to occur between the drumlins and associated gravel terraces.

Ellis creek is part of the spillway landform and the drift thickness is shallow with the overburden soil underlain by bedrock of the Guelph Formation consisting of shale and dolostone. The locations of the proposed bridges around Ellis Creek is a flood plain that is prone to flooding.

3. INVESTIGATION PROCEDURES

The geotechnical investigation was conducted at the site from December 4, 2017 to January 19, 2018 and July 9, 2018 to July 10, 2019. Borehole drilling for EC16-07 and EC16-08 was delayed until July of 2018 due to flooding of Ellis Creek. Thirteen boreholes, numbered EC16-01 to EC16-13, were drilled at the proposed bridge foundation units. The boreholes drilled near the east and west approaches of the WBL and EBL ranged from 9.5 m to 9.8 m depth (Elevations 314.5 to 313.4). Boreholes drilled at the foundation units (abutments and piers) were terminated at depths ranging from 12.2 m to 15.0 m (Elevations 311.1 to 308.4). Five boreholes (EC16-04 to EC16-08) were further advanced into dolostone bedrock by coring to depths of 15.5 m to 17.8 m (Elevations 307.8 to 305.5), with a minimum 3.0 m of rock core recovered in each borehole. The Record of Borehole sheets are included in Appendix A.

Details of the location of the boreholes are presented in Table 3.1.

Table 3.1 – Borehole locations

Foundation Element		Borehole
Hwy 7-New EBL	West approach	EC16-02
	West abutment	EC16-04
		EC16-05
	Pier	EC16-07
		EC16-08
	East abutment	EC16-10
		EC16-11
	East approach	EC16-13
Hwy 7-New WBL	West approach	EC16-01
	West abutment	EC16-03
		EC16-04
	Pier	EC16-06

<table>
<tr><th colspan="2">Foundation Element</th><th>Borehole</th></tr>
<tr><td rowspan="4"></td><td></td><td>EC16-07</td></tr>
<tr><td rowspan="2">East abutment</td><td>EC16-09</td></tr>
<tr><td>EC16-10</td></tr>
<tr><td>East approach</td><td>EC16-12</td></tr>
</table>

The approximate locations of the boreholes are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix C. The coordinates and elevations of the boreholes are given on the drawings and on the individual Record of Borehole Sheets in Appendix A.

The ground surface elevations and coordinates of the as-drilled boreholes were provided by WSP.

Prior to commencing the site investigation, utility clearances were obtained for all borehole locations.

During the current investigation, track mounted D52 and truck mounted CME75 drill rigs were used in conjunction with hollow-stem augers and tricone equipment to advance the boreholes through the overburden. NQ and HQ rock coring equipment were used to recover core samples of the underlying bedrock in selected boreholes. In general, soil samples were obtained at selected intervals using a 50mm diameter split spoon sampler in conjunction with the Standard Penetration Testing (SPT). All rock cores were logged and the Total Core Recovery (TCR), Rock Quality Designation (RQD) and Fracture Indices (FI) were determined.

The drilling, sampling and in-situ testing operations were supervised on a full-time basis by a member of Thurber's technical staff. The supervisor logged the boreholes and processed the recovered soil samples and rock cores for transport to Thurber's laboratory for further examination and testing. Results of field drilling and sampling are presented on the Record of Borehole sheets in Appendix A.

Groundwater conditions in the open boreholes were observed throughout the drilling operations.

Seven standpipe piezometers were installed in selected boreholes (EC16-01, EC16-03, EC16-04, EC16-07, EC16-10, EC16-11 and EC16-13). Each piezometer consisted of a 19 mm or 25 mm Schedule 40 PVC pipe with a 1.5 m or 3.0 m long slotted screen enclosed in a column of filter sand to permit groundwater level monitoring. Piezometer installation details, groundwater level observations and water level readings are shown on the Record of Borehole sheets. Upon

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completion of the drilling operations, the boreholes without piezometers were abandoned in general accordance with Ontario Regulation 903. The details of standpipe piezometer installation and borehole completion are summarized in Table 3.2. Upon completion of the investigation in the summer of 2020, the piezometer installations will be decommissioned as per O.Reg. 903.

Table 3.2 – Borehole Completion Details

Foundation Element		Borehole	Borehole Ground Surface Elevation (m)	Borehole Depth / Base Elevation (m)	Piezometer Tip Depth / Elevation (m)	Completion Details
Hwy 7- New EBL	West approach	EC16-02	323.9	9.8/314.2	None Installed	Borehole backfilled with bentonite and auger cuttings to surface.
	West abutment	EC16-04	323.3	17.8/305.5	13.8/309.6	Piezometer with 3.0 m slotted screen installed. Sand filter from 17.8 m to 9.7 m, bentonite holeplug from 9.7 m to surface.
		EC16-05	323.1	16.5/306.6	None Installed	Borehole backfilled with bentonite and auger cuttings to surface.
	Pier	EC16-07	323.3	15.5/307.8	12.2/311.1	Piezometer with 3.0 m slotted screen installed. Bentonite from 15.5 m to 12.5 m, sand filter from 12.5 m to 8.5 m, bentonite holeplug from 8.5 m to 6.1 m, grout from 6.1 m to 0.3 m, then holeplug to surface.
		EC16-08	323.1	15.7/307.4	None Installed	Borehole backfilled with grout to 0.2 m, then holeplug to surface.
	East abutment	EC16-10	323.0	12.3/310.8	12.3/310.8	Piezometer with 1.5 m slotted screen installed. Sand filter from 12.3 m to 9.2 m, bentonite holeplug from 9.2 m to surface.
		EC16-11	323.3	12.2/311.1	12.2/311.1	Piezometer with 1.5 m slotted screen installed. Sand filter from 12.2 m to 10.1 m, bentonite holeplug from 10.1 m to surface.
	East approach	EC16-13	323.2	9.5/313.7	9.1/314.1	Piezometer with 1.5 m slotted screen installed. Sand filter from 9.5 m to 7.0 m, bentonite holeplug from 7.0 m to surface.
Hwy 7- NewW BL	West approach	EC16-01	324.2	9.8/314.5	9.1/315.1	Piezometer with 3.0 m slotted screen installed. Sand filter from 9.8 m to 5.5 m, bentonite holeplug from 5.5 m to surface.

Foundation Element		Borehole	Borehole Ground Surface Elevation (m)	Borehole Depth / Base Elevation (m)	Piezometer Tip Depth / Elevation (m)	Completion Details
	West abutment	EC16-03	323.4	15.0/308.4	12.2/311.2	Piezometer with 3.0 m slotted screen installed. Sand filter from 15.0 m to 8.5 m, bentonite holeplug from 8.5 m to surface.
	Pier	EC16-06	323.3	17.8/305.6	None Installed	Borehole backfilled with bentonite and auger cuttings to surface.
	East abutment	EC16-09	323.2	12.2/310.9	None Installed	Borehole backfilled with bentonite and auger cuttings to surface.
	East approach	EC16-12	323.2	9.8/313.4	None Installed	Borehole backfilled with bentonite and auger cuttings to surface.

4. LABORATORY TESTING

All recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected samples were also subjected to grain size analysis and Atterberg Limits testing. All the laboratory tests were carried out in accordance with MTO and/or ASTM Standards, as appropriate. The results of this testing program are shown on the Record of Borehole sheets in Appendix A and on the figures contained in Appendix B.

Core samples of the bedrock were carefully protected to prevent drying during transport to the laboratory. Point load tests were carried out on selected samples of intact dolostone upon arrival at the laboratory to assist in evaluation of the compressive strength of the bedrock. Results of point load tests on the selected rock core samples are included in Appendix B and on the Record of Borehole sheets in Appendix A.

In order to assess the potential for sulphate attack on concrete foundations, as well as the potential for corrosion associated with the structure, a sample of the existing native soil was collected. The sample was submitted to SGS Canada Inc., a CALA accredited analytical laboratory in Lakefield, Ontario, for analytical testing of corrosivity parameters and sulphate content. The results of the analytical testing are summarized in Section 6 and are presented in Appendix B.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets in Appendix A. Details of the encountered soil and bedrock stratigraphy along the proposed alignment are presented in this Appendix and on the “Borehole Locations and Soil Strata” drawings in Appendix C. An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented in the Record of Borehole Sheets governs any interpretation of the site conditions.

In general, topsoil and organics were encountered surficially at this site. Below the topsoil/organics, layers of native silty sand, sand and gravel, silty clay, silty clay till and silty sand to sand and silt till were encountered. Grey dolostone bedrock was encountered below the native soils. Descriptions of the individual strata are presented below.

5.1 Topsoil

A layer of topsoil was encountered surficially in Borehole EC16-01 and EC16-13. The thickness of topsoil was 400 mm in EC 16-01 and 200 mm in EC 16-13.

Moisture content measured in the topsoil in Borehole EC16-01 was 23 percent.

The topsoil thickness may vary between and beyond the borehole locations, and the data is not intended for the purpose of estimating quantities.

5.2 Topsoil and Organics

A layer of dark brown to black topsoil and organics containing occasional rootlets and wood pieces was encountered surficially in all the boreholes, except in Boreholes EC16-01 and EC 16-13. The organic layer within the floodplain ranged in thickness from 0.5 m to 1.8 m.

The depth to the base of the organic layer ranged from 0.5 m to 1.8 m (Elevations 323.4 to 321.5).

The organic layer is classified as very loose to loose, based on SPT 'N' values ranging from 0 to 5 blows for 0.3 m of penetration. The natural moisture content ranged from 21 percent to 745 percent.

5.3 Upper Sand and Gravel and Gravelly Sand

Upper layers of native brown to grey sand and gravel and gravelly sand containing trace to some silt, trace clay and occasional cobbles were contacted below the topsoil, silty clay or sand and silt at depths ranging from 0.4 m to 4.9 m (Elevations 323.8 to 318.4) in Boreholes EC16-01, EC16-03, EC16-07 and EC16-09 to EC16-13. The thickness of the layer ranged from 1.1 m to 3.8 m. The depth to the base of the sand and gravel and gravelly sand layers ranged from 3.0 m to 7.2 m (Elevations 321.2 to 316.1).

The SPT 'N" values of the upper sand and gravel and gravelly sand ranged from 16 to 96 blows per 0.3 m of penetration indicating a compact to very dense relative density. SPT 'N' values of 4 and 8 blows per 0.3 m of penetration, indicating a loose state, were measured in Borehole EC16-07. The natural moisture contents generally lay in the range of 6 percent to 25 percent.

Grain size distribution curves for the upper sand and gravel and gravelly sand samples tested are presented on the Record of Borehole sheets in Appendix A and on Figure B1 of Appendix B. The results of a gradation test carried out on selected sample is summarized follows:

Soil Particles	Percentage (%)
Gravel	18 to 58
Sand	35 to 79
Silt and Clay	3 to 22

5.4 Upper Silt to Silty Sand

Layers of native brown to grey silt, sandy silt, silty sand and sand and silt containing trace to some gravel and trace to some clay were contacted below the topsoil and organics in all the boreholes, except Boreholes EC16-01 and EC16-07, at depths ranging from 0.2 m to 1.6 m (Elevations 321.5 to 323.4). The thickness of the upper silt to silty sand layers ranged from 1.0 m to 5.6 m.

The depth to the base of these layers ranged from 2.1 m to 7.2 m (Elevations 321.7 to 315.9).

The SPT 'N" values of the sand ranged from 0 to 34 blows per 0.3 m of penetration indicating a very loose to compact state. The natural moisture contents generally lay in the range of 10 percent to 22 percent.

Results of grain size distribution testing carried out on upper silt to silty sand samples are presented on the Record of Borehole sheets in Appendix A and on Figure B3 of Appendix B. The results of the gradation tests are summarized below:

Soil Particles	Sandy Silt to Silty Sand Percentage (%)	Silt Percentage (%)
Gravel	0 to 16	0
Sand	31 to 71	11
Silt	20 to 59	71
Clay	5 to 14	18

The results of Atterberg Limits testing conducted in the clayey zones within this layer are presented on the Record of Borehole sheets in Appendix A and on Figure B9 of Appendix B. The results of Atterberg Limits testing are summarized below:

Liquid Limit	19
Plastic Limit	13
Plasticity Index	6 to 7

The above results show that the clayey zones within this layer are of slight plasticity with a group symbol of CL-ML.

5.5 Lower Silt to Silty Sand

A lower layer of native brown to grey silt, sandy silt, sand and silt and silty sand containing trace to some gravel, trace to some clay and occasional cobbles was encountered either below the silty clay till, upper sand and sand and gravel to gravelly sand or upper silt to silty sand deposits in Boreholes EC 16-01 to EC 16-07 and EC 16-13 at depths ranging from 2.2 m to 8.7 m (Elevations 321.1 to 314.6). The thickness of this layer, where fully penetrated, ranged from 6.7 m to 12.1 m. Boreholes EC 16-01 to EC 16-03 and EC16-13 were terminated within this layer at depths ranging from 9.5 m to 15.0 m (Elevations 314.5 to 308.4).

The depth of the base of this layer, where fully penetrated, ranged from 12.3 m to 14.7 m (Elev. 311.0 to 308.6).

The SPT ‘N’ values of this layer typically ranged from 12 to greater than 100 blows for 0.3 m of penetration indicating a compact to very dense relative density. One value of 8 blows per 0.3 m of penetration was recorded in Borehole EC 16-04 at the top of this layer, indicating a loose relative density. The natural moisture content ranged from 8 percent to 22 percent.

Results of grain size distribution testing carried out on samples collected from this layer are presented on the Record of Borehole sheets in Appendix A and on Figures B4 and B5 in Appendix B. The results are summarized in the table below:

Soil Particles	Silty Sand to Sand and Silt Percentage (%)	Sandy Silt to Silt Percentage (%)
Gravel	0 to 15	0 to 3
Sand	42 to 64	6 to 26
Silt	20 to 48	54 to 88
Clay	2 to 6	6 to 17

5.6 Silty Clay

Layers of silty clay containing trace sand and trace to gravel were encountered in Boreholes EC 16-03, EC 16-04, EC 16-08 to EC 16-10, EC 16-12 and EC 16-13 below the upper sand and gravel to gravelly sand, upper silt to silty sand layer, within the lower silt to silty sand layer and within the lower sand and gravel layer. The upper boundary of the silty clay was contacted at depths ranging from 2.1 m to 12.2 m (Elevations 321.3 to 311.1). The thickness of the silty clay layer ranged from 0.8 m to 3.1 m. The depth to the base of the silty clay layers varied from 2.9 m to 13.4 m (Elevations 320.5 to 309.9 m).

SPT ‘N’ values measured in the silty clay varied from 4 per 0.3 m of penetration to 100 blows for 275 mm of penetration, indicating a firm to hard consistency. The natural moisture content ranged from 15 percent to 22 percent.

Results of grain size distribution testing carried out on the silty clay are presented on the Record of Borehole sheets in Appendix A, and on Figure B2 of Appendix B. The results are summarized in the table below:

Soil Particle	Silty clay Percentage (%)
Gravel	0
Sand	0 to 6
Silt	61 to 79
Clay	21 to 37

The results of Atterberg Limits testing are presented on the Record of Borehole sheets in Appendix A and on Figure B10 of Appendix B. The results of Atterberg Limits testing are summarized below:

Liquid Limit	20 to 22
Plastic Limit	13
Plasticity Index	7 to 9

The above results show that the silty clay is of low plasticity with a group symbol of CL.

5.7 Silty Clay Till

Layers of silty clay till containing some sand to with sand and trace to some gravel were encountered in Boreholes EC 16-01 to EC 16-03, EC 16-06, EC 16-11, and EC 16-13 below the

the upper sand and gravel to gravelly sand, upper silt to silty sand layer. The upper boundary of the silty clay till was contacted at depths ranging from 2.2 m to 7.2 m (Elevations 321.7 to 316.1). The thickness of the silty clay layer ranged from 1.5 m to 3.7 m. The depth to the base of the silty clay layers varied from 5.8 m to 8.7 m (Elevations 318.5 to 314.6 m).

SPT ‘N’ values measured in the silty clay till varied from 13 to 89 per 0.3 m of penetration to 100 blows for 250 mm of penetration, indicating a stiff to hard consistency. The natural moisture content ranged from 9 percent to 21 percent.

Results of grain size distribution testing carried out on the silty clay are presented on the Record of Borehole sheets in Appendix A, and on Figures B6 and B11 of Appendix B. The results are summarized in the table below:

Soil Particle	Silty clay Percentage (%)
Gravel	2 to 14
Sand	27 to 40
Silt	29 to 50
Clay	17 to 31

The results of Atterberg Limits testing are presented on the Record of Borehole sheets in Appendix A and on Figure B10 of Appendix B. The results of Atterberg Limits testing are summarized below:

Liquid Limit	20 to 25
Plastic Limit	10 to 13
Plasticity Index	10 to 12

The above results show that the silty clay is of low plasticity with a group symbol of CL.

5.8 Sand and Silt to Silty Sand Till

Native grey sand and silt to silty sand till containing some gravel, some clay and occasional cobbles, was contacted below the silty clay in Borehole EC 16-10 and below the upper sand and gravel and gravelly sand in Borehole EC 16-12. This cohesionless till was contacted at a depth of 5.6 m (Elevations 317.6 and 317.4). The thickness of the cohesionless till ranged from 1.6 m to 3.1 m.

The depth to the base of the cohesionless till ranged from 7.2 m to 8.7 m (Elevations 316.0 and 314.3).

SPT 'N' values measured in the till varied from 39 to 63 blows per 0.3 m of penetration, indicating a dense to very dense state. The natural moisture content ranged from 8 percent to 20 percent.

Results of grain size distribution testing carried out on cohesionless till samples are presented on the Record of Borehole sheets in Appendix A, and on Figure B7 of Appendix B. The results of laboratory tests carried out on selected samples are as follows:

Soil Particle	Percentage (%)
Gravel	14 to 16
Sand	38 to 49
Silt	23 to 37
Clay	11 to 12

5.9 Lower Sand and Gravel

A lower layer of sand and gravel containing trace silt and trace to some clay was encountered in Boreholes EC16-08 to EC16-12 at depths ranging from 7.2 m to 8.7 m (Elevation 315.9 to 314.3).

Boreholes EC16-09 to EC16-12 were terminated in the lower sand and gravel layer at depths ranging from 9.8 m to 12.3 m (Elevation 313.4 to 310.8). Borehole EC 16-08 fully penetrated the lower sand and gravel layer and the layer was 5.3 m thick.

The SPT 'N" values of the lower sand and gravel ranged from 64 to over 100 blows per 0.3 m of penetration indicating a very dense relative density. The natural moisture contents generally lay in the range of 7 percent to 10 percent.

Results of grain size distribution testing carried out on lower sand and gravel samples are presented on the Record of Borehole sheets in Appendix A and on Figure B8 of Appendix B. The results of the gradation tests are summarized below:

Soil Particles	Percentage (%)
Gravel	34 to 59
Sand	33 to 46
Silt and Clay	8 to 23

5.10 Bedrock

The overburden soils described above are underlain by grey slightly weathered to fresh dolostone bedrock. Occasional mechanical breaks were noted throughout the bedrock cores. A rubble zone was encountered within the bedrock at 15.1 m depth (Elevation 308.2) in Borehole EC16-07.

Depths and elevations of the top of bedrock are shown in Table 5.1.

Table 5.1 – Elevation of Top of Bedrock

Foundation Element		Borehole	Top of Bedrock Depth (m)	Top of Bedrock Elevation (m)
Hwy 7- New EBL	West abutment	EC16-04	14.3	309.0
		EC16-05	13.1	310.0
	Pier	EC16-07	12.3	311.0
		EC16-08	12.5	310.6
Hwy 7- New WBL	West abutment	EC16-04	14.3	309.0
	Pier	EC16-06	14.7	308.6
		EC16-07	12.3	311.0

Total Core Recovery (TCR) in the bedrock ranged from 77% and 100% with Solid Core Recovery (SCR) of 58% and 100%. The Rock Quality Designation (RQD) determined from the recovered cores was 0% to 95%, indicating very poor to excellent rock quality.

The Fracture Index (FI) of the rock, expressed as fractures per 0.3 m of core, ranged from 0 to 6.

Average unconfined compressive strengths (UCS) of the rock ranged from 110 MPa to 250 MPa, indicating that the rock is strong to very strong. These estimated rock strength values are interpreted from point load tests that were conducted on rock cores recovered from the boreholes. A summary of the Point Load Test Results are presented in Appendix B.

5.11 Groundwater Conditions

Groundwater conditions were observed during drilling operations, and groundwater levels were measured in the open boreholes upon completion of drilling. Standpipe piezometers were installed in Boreholes EC16-01, EC16-03, EC16-04, EC16-07, EC16-10, EC16-11, EC16-13 to monitor the groundwater level at the site. The groundwater levels measured in the open boreholes and in the standpipe piezometers are summarized below. Decommissioning of piezometers is planned to take place in the summer of 2020.

Table 5.1 – Water Level Measurements for EBL

Foundation Unit	Borehole	Date	Water Level (m)		Remark
			Depth	Elevation	
West Approach	EC16-02	January 9, 2018	3.7	320.2	Open borehole
West Abutment	EC16-04	August 31, 2018	-0.5	323.8[1]	Piezometer
	EC16-05	January 18, 2018	Water level not taken due to the use of mud while drilling		-
Pier	EC16-07	August 31, 2018	-0.1	323.4[1]	Piezometer
	EC16-08	July 10, 2018	Water level not taken due to the use of mud while drilling		-
East Abutment	EC16-10	December 7, 2017 March 23, 2018 May 1, 2018 August 31, 2108	1.5 -0.2 0.3 0.2	321.5 323.2[1] 322.7 322.8	Open borehole Piezometer Piezometer Piezometer
	EC16-11	December 5, 2017 March 23, 2018 May 1, 2018 August 31, 2108	1.5 0.1 0.0 0.0	321.8 323.2 323.3 323.3	Open borehole Piezometer Piezometer Piezometer
East Approach	EC16-13	December 4, 2017 March 23, 2018 May 1, 2018 August 31, 2018	1.5 0.0 -0.2 0.3	321.7 323.2 323.4[1] 322.9	Open borehole Piezometer Piezometer Piezometer

[1] Artesian conditions observed, as groundwater level was measured above ground surface.

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Table 5.2 – Water Level Measurements for WBL

Foundation Unit	Borehole	Date	Water Level (m)		Remark
			Depth	Elevation	
West Approach	EC16-01	January 10, 2018 March 23, 2018 August 31, 2018	4.3 0.4 0.6	319.9 323.9 323.6	Open borehole Piezometer Piezometer
West Abutment	EC16-03	January 10, 2018 March 23, 2018 August 31, 2018	3.7 -0.3 -0.1	319.7 323.7(1) 323.5(1)	Open borehole Piezometer Piezometer
	EC16-04	August 31, 2018	-0.5	323.8(1)	Piezometer
Pier	EC16-06	January 11, 2018	Water level not taken due to the use of mud while drilling		-
	EC16-07	August 31, 2018	-0.1	323.4(1)	Piezometer
East Abutment	EC16-09	December 9, 2017	1.5	321.7	Open borehole
	EC16-10	December 7, 2017 March 23, 2018 May 1, 2018 August 31, 2108	1.5 -0.2 0.3 0.2	321.5 323.2(1) 322.7 322.8	Open borehole Piezometer Piezometer Piezometer
East Approach	EC16-12	December 5, 2017	1.8	321.4	Open borehole

(2) Artesian conditions observed, as groundwater level was measured above ground surface.

The above values are 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 rainfall.

The General Arrangement (GA) drawings provided by WSP indicate that the water levels at Ellis Creek are estimated to be at following elevations:

- 100-year water level – Elevation 324.12
- 2-year water level – Elevation 323.85

6. CORROSIVITY AND SULPHATE TEST RESULTS

A sample of the native silty sand was submitted for analytical testing of corrosivity parameters and sulphate. The results of the analytical tests are shown in Table 6.1. The laboratory certificates of analysis are presented in Appendix B.

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Table 6.1 – Analytical Test Results

Parameter	Units (Soil)	EC16-08 SS3 Depth 1.8 m
		Silty sand
Sulphide	%	0.86
Chloride	µg/g	4.4
Sulphate	µg/g	710
pH	No unit	8.15
Electrical Conductivity	µS/cm	227
Resistivity	Ohms.cm	4410
Redox Potential	mV	169

7. MISCELLANEOUS

Altech Drilling & Investigative Services of Elmira, Ontario supplied a D-120 track-mounted drill rig and conducted the drilling, sampling and in-situ testing operations for the present investigation, except for Boreholes EC16-07 and EC16-08 which were completed by Landshark Drilling of Brantford, Ontario , who supplied a rubber-track mounted B-57 drill rig and conducted the drilling, sampling and in-situ testing operations.

The coordinates for the boreholes were obtained with GPS equipment by Thurber, and the elevations were provided by WSP.

The drilling and sampling operations in the field for the current investigation, were supervised on a full-time basis by Thurber field technicians.

Overall supervision of the field program for the present investigation was conducted by Dr. Nancy Berg, P.Eng. Interpretation of the data and preparation of the current report was carried out by Ms. R. Palomeque Reyna, P.Eng. and Dr. Nancy Berg, P.Eng.

Mr. Jason Lee, P.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations projects, reviewed the report.

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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

8. GENERAL

This report presents interpretation of the geotechnical data in the factual report and presents geotechnical design recommendations to assist the design team to select and design a suitable foundation system for the two new bridge structures carrying the proposed Highway 7-New EBL and WBL over Ellis Creek.

Based on the preliminary General Arrangement (GA) drawing, provided by WSP, dated July 2012, each bridge will be a two-span structure supported on two abutments and one pier. The length and width of each bridge are proposed to be approximately 66.0 m and 14.0 m, respectively. The east and west abutments of each bridge are proposed to be supported on a single row of driven steel H-piles and the piers are planned to be supported on a single row of driven steel H-piles as well.

Based on the proposed finished grade levels of Highway 7-New EBL and WBL structures and the existing ground surface near the proposed bridge abutments, the anticipated heights of the west and east approach embankments are presented in Table 8.1.

Table 8.1 – Anticipated Approach Embankment Height

Foundation Unit		Borehole	Proposed finished grade levels of Highway 7-New (1)	Approximate Existing ground surface at the Borehole Locations	Approximate Approach Embankment Height (m)
Hwy 7-New EBL	West abutment	EC16-04 EC16-05	329.4	323.1 to 323.3	6.1 to 6.3
	East abutment	EC16-10 EC16-11	329.8	323.0 to 323.3	6.5 to 6.8
Hwy 7-	West abutment	EC16-03 EC16-04	329.4	323.3 to 323.4	6.0 to 6.1

Foundation Unit		Borehole	Proposed finished grade levels of Highway 7-New [1]	Approximate Existing ground surface at the Borehole Locations	Approximate Approach Embankment Height (m)
New WBL	East abutment	EC16-09 EC16-10	329.7	323.0 to 323.2	6.5 to 6.7

[1] Finished grade level of Highway 7-New at the abutments, obtained from the GA drawings

The forward and side embankment slopes are proposed to be at inclination of 2H:1V.

This foundation investigation and design report with the interpretation and recommendations are intended for the use of the Ministry of Transportation, and shall not be used or relied upon for any other purposes or by any other parties including the construction or design-build contractor. The 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 information provided as it may affect equipment selection, proposed construction methods and scheduling.

The discussion and recommendations presented in this report are based on the information provided by WSP and on the factual data obtained in the course of this investigation.

9. STRUCTURE CLASSIFICATION

In accordance with the currently applicable Canadian Highway Bridge Design Code (CHBDC) (2014) CSA S6-14, the analysis and design of structures are influenced by its importance category and consequence classification. Such designations are defined by the Regulatory Authority which, in this case, is the Ministry of Transportation of Ontario (MTO).

For the purpose of reporting, this structure has been classified as a Major-Route Bridge with Typical Consequence based on CHBDC S6-14 Sections 4.4.2 and 6.5.2, respectively.

Based on the above classification and Table 6.1 in Section 6.5.2 in the CHBDC, a consequence factor, ψ, of 1.0 has been used for assessing ULS and SLS geotechnical resistances. Should the consequence classification change, the geotechnical assessment and recommendations will need to be reviewed and revised as necessary.

10. STRUCTURE FOUNDATIONS

The stratigraphy identified in the investigation consisted primarily of topsoil and organics over layers of native loose to very dense silt to silty sand, loose to very dense sand and gravel to gravelly sand, firm to hard silty clay, stiff to hard silty clay till and dense to very dense silty sand till. Dolostone bedrock was encountered below the native soils at depths ranging from 12.3 m to 14.7 m (Elevations 308.6 and 311.0). The groundwater levels measured in the piezometers ranged from 0.5 m above ground surface to 0.4 m below the ground surface (Elevations 323.9 to 323.2). Flowing artesian conditions were noted in five of the piezometers.

In the preparation of the geotechnical design recommendations, consideration was given to the following foundation types:

1. Spread footings bearing on native soil
2. Spread footings on engineered fill pads
3. Augered Caissons (drilled shafts) in the very dense soil or to bedrock
4. Steel H-piles or open ended steel pipe piles driven into the very dense soil or to bedrock

A comparison of the foundation alternatives based on advantages and disadvantages of each is included in Appendix D.

10.1 Spread Footings on Native Soil

Spread footings on native soil are not considered to be a cost-effective and a practical alternative at this site due to the need for a relatively deep excavation required to reach competent soils. Additionally, the constructability of the footings adjacent to/ in the creek requiring substantial amount of dewatering prior to footing excavation and the danger of undermining of the footings by future scour of the creek bed have been taken into consideration. Accordingly, spread footings on native soils are not recommended at this site. For this reason, recommendations for spread footings have not been developed further.

10.2 Spread Footing on Engineered Fill

Spread footings on engineered fill are not considered to be a cost-effective and a practical alternative at this site due to the need for a relatively deep excavation required to reach competent soils and the similar risks associated with spread footing on native soils indicated in Section 10.1

above. Accordingly, spread footings on engineered fill are not recommended at this site. For this reason, recommendations for this option have not been developed further.

10.3 Augered Caissons (Drilled Shafts)

Augered caissons (drilled shaft) foundations founded on bedrock, very dense sand and gravel, gravelly sand, sand and silt, silty sand or silt were considered for the support of structural loads at this site. However, augered caissons (drilled shafts) are not recommended for use as foundation support at this site due to high groundwater levels and the presence of cohesionless soils at the site. These conditions will cause caisson installation difficulties and therefore this option is not recommended and has not been developed further.

10.4 Steel H-Piles and Steel Pipe Piles

From a foundation engineering perspective, it is feasible to support the structure on steel H-piles or open ended steel pipe piles driven to practical refusal.

It is recommended that the H-piles or open ended pipe piles be driven to achieve resistance on the bedrock, or in very dense sand and gravel and very dense sand and silt to silty sand encountered at this site.

The GA drawing indicates that the underside elevation of the abutment stem at the east and west abutments are 324.7 and 324.3, at the proposed Highway 7-New WBL bridge. The underside elevation of the proposed shaft at the pier of the Highway 7-New WBL bridge is 321.8. At the proposed Highway 7-New EBL, the underside elevation of the abutment stem at the east and west abutments are 325.0 and 324.6, respectively. The underside elevation of the proposed shaft at the pier of the Highway 7-New EBL bridge is 321.5.

10.4.1 Axial Resistance

The factored geotechnical resistances of HP 310 X 110 and HP 360 x 132 steel piles, and 324-mm diameter and 356-mm diameter open ended pipe piles driven to refusal in very dense soils or to refusal on bedrock were assessed based on the subsurface conditions encountered at the abutment and pier locations. The estimated factored Ultimate Limit States (ULS) and factored geotechnical resistance at Serviceability Limit States (SLS), as well as the recommended pile tip elevations for H-piles and pipe piles are summarized in Tables 10.3 and 10.4, respectively.

Table 10.3 – Estimated Axial Resistance and Pile Tip Elevation for H-piles

Foundation Unit		Borehole	Approx. Pile Tip Elevation (m)	Minimum Pile Length Assumed (m)	Geotechnical Resistance			
					Pile Section HP 310 X 110		Pile Section HP 360 X 132	
					Factored ULS (kN)	Factored SLS (kN)	Factored ULS (kN)	Factored SLS (kN)
Hwy 7- New EBL	West Abutment	EC16-04 EC16-05	309.0[(1)] 310.0[(1)]	15.6 14.6	2,500	Does not govern	3,000	Does not govern
	Pier	EC16-07 EC16-08	311.0[(1)] 310.6[(1)]	10.5 10.9	2,000	Does not govern	2,400	Does not govern
	East Abutment	EC16-10 EC16-11	312.0	13.0	1,600	1,400	1,800	1,600
Hwy 7- New WBL	West Abutment	EC16-03 EC16-04	309.0	15.3	2,000	1,700	2,400	2,100
	Pier	EC16-06 EC16-07	308.6[(1)] 311.0[(1)]	13.2 10.8	2,500	Does not govern	3,000	Does not govern
	East Abutment	EC16-09 EC16-10	312.0	12.7	1,600	1,400	1,800	1,600

(1) Top of bedrock elevation encountered in borehole.

10.4 – Estimated Axial Resistance and Pile Tip Elevation for Pipe Piles

Foundation Unit		Borehole	Approx. Pile Tip Elevation (m)	Minimum Pile Length Assumed (m)	Geotechnical Resistance			
					Pipe Pile Section 324 mm diameter Wall thickness 12.7 mm		Pipe Pile Section 356 mm diameter Wall thickness 12.7 mm	
					Factored ULS (kN)	Factored SLS (kN)	Factored ULS (kN)	Factored SLS (kN)
Hwy 7-	West Abutment	EC16-04 EC16-05	309.0[(1)] 310.0[(1)]	15.6 14.6	2,100	Does not govern	2,400	Does not govern

Foundation Unit		Borehole	Approx. Pile Tip Elevation (m)	Minimum Pile Length Assumed (m)	Geotechnical Resistance			
					Pipe Pile Section 324 mm diameter Wall thickness 12.7 mm		Pipe Pile Section 356 mm diameter Wall thickness 12.7 mm	
					Factored ULS (kN)	Factored SLS (kN)	Factored ULS (kN)	Factored SLS (kN)
New EBL	Pier	EC16-07 EC16-08	311.0[1] 310.6[1]	10.5 10.9	2,100	Does not govern	2,400	Does not govern
	East Abutment	EC16-10 EC16-11	311.0	13.0	1,300	1,100	1,600	1,400
Hwy 7-New WBL	West Abutment	EC16-03	309.0	15.3	1,300	1,100	1,600	1,400
		EC16-04	309.0[1]	15.3	2,100	Does not govern	2,400	Does not govern
	Pier	EC16-06 EC16-07	308.6[1] 311.0[1]	13.2 10.8	2,100	Does not govern	2,400	Does not govern
	East Abutment	EC16-09 EC16-10	311.0	12.7	1,300	1,100	1,600	1,400

(1) Top of bedrock elevation encountered in borehole.

The values of the Factored Geotechnical Resistance at ULS were assessed assuming a Consequence Factor equal to 1 (Typical), and a Resistance Factor equal to 0.4 (Typical degree of understanding of the subsurface conditions), as per CHBDC 2014. The SLS values correspond to a maximum pile settlement of 25 mm. The Factored Geotechnical Resistance at SLS was assessed assuming a factor of 0.8 for typical degree of understanding of the subsurface conditions.

The axial geotechnical resistances based on the bedrock strength are expected to exceed the factored structural capacity of the piles. Accordingly, the structural capacity of the various pile types indicated above will govern the design and should be used for design.

The structural resistance of the pile must be checked by the structural designer.

10.4.2 Downdrag

Downdrag on the piles is not anticipated to be an issue at this site.

10.4.3 Lateral Resistance

The geotechnical lateral resistance of a pile may be calculated using the coefficient of horizontal subgrade reaction (k_s) and the ultimate lateral resistance (P_{ult}) as follows:

Cohesive Soils

	k_s	=	$67\ C_u / B$	(kN/m^3)
	p_{ult}	=	$9\ C_u$	(kPa) at and below a depth of 3B reduced to zero at ground surface
where	p_{ult}	=	ultimate lateral resistance mobilized by a pile, kPa	
	C_u	=	undrained shear strength of cohesive soils, kPa	
	γ	=	unit weight of soil, kN/m^3	
	B	=	width of pile, m	

Cohesionless Soils

	k_s	=	$n_h\ .\ z / B$	(kN/m^3)
	p_{ult}	=	$3\ .\ \gamma'\ .\ z\ .\ K_p$	(kPa)
where	z	=	depth of embedment of pile, m	
	B	=	pile width, m	
	n_h	=	coefficient related to soil density, kN/m^3 , Table 10.5	
	γ'	=	Bouyant unit weight of soil, kN/m^3, Table 10.5	
	K_p	=	passive earth pressure coefficient, Table 10.5	

The above equations and recommended parameters may be used to analyze the interaction between a pile and the surrounding soil. The lateral pressure obtained from the analysis should not exceed the ultimate lateral resistance.

The spring constant, K, for analysis may be obtained by the expression, $K = k_s \times d_z \times B$ (kN/m), where k_s is the coefficient of horizontal subgrade reaction (kN/m^3), B is the pile width (m), d_z is the length (m) of the pile segment used in the analysis. The ultimate lateral resistance on any one segment of pile, Pult, may be obtained from the expression, $P_{ult} = p_{ult} \times d_z \times B$. This represents the ultimate load at which the pile fails and will not support any additional load at greater displacements.

Parameters for lateral pile resistance are shown in Table 10.5.

Table 10.5 – Recommended Geotechnical Parameters for Lateral Resistance Design

Location	Reference Boreholes	Approx. Elevation (m)	Undrained Shear Strength C_u (kPa)	Unit Weight γ (kN/m^3)	K_p	n_h (kN/m^3)	Soil Conditions
Hwy 7- New EBL West Abutment	EC16-04 EC16-05	322.0 to 320.8	-	10*	3.0	2,000	Loose to compact sandy silt
		320.8 to 317.0	-	10*	3.2	3,000	Compact silty sand
		317 to 310.0 (bedrock)	-	10*	3.8	6,000	Very dense silty sand
Hwy 7- New EBL Pier	EC16-07 EC16-08	321.5 to 318.5	-	9*	2.9	2,500	Loose gravelly sand to silty sand
		318.5 to 315.0	-	10*	3.8	6,000	Dense to very dense sand and gravel to sandy silt
		315.0 to 313.0	200	10*	-	-	Hard silty clay
		313.0 to 310.6 (bedrock)	-	11*	4.2	10,000	Very dense sand and gravel to sandy silt
Hwy 7- New EBL East Abutment	EC16-10 EC16-11	321.6 to 319.0	-	10*	3.1	2,500	Compact to loose sand and silt
		319.0 to 317.5	50	10*	-	-	Firm silty clay
		317.5 to 314.3	-	10*	3.8	8,000	Very dense to dense silty sand till
		314.3 to 310.8 (bedrock)	-	11*	4.2	10,000	Very dense sand and gravel
Hwy 7- New WBL	EC16-03 EC16-04	322.0 to 321.3	-	10*	3.0	2,000	Loose to compact sand

West Abutment							and silt to silty sand
		321.3 to 320.5	75	10*	-	-	Stiff silty clay
		320.5 to 318.8	-	10*	3.8	8,000	Dense sand and gravel
		318.8 to 316.2	100	10*	-	-	Stiff to very stiff silty clay till
		316.2 to 311.0	-	10*	3.5	5,500	Compact to very dense sand and silt to silty sand
		311.0 to 308.4	-	11*	4.2	10,000	Very dense sand and silt to silty sand
Hwy 7- New WBL Pier	EC16-06 EC16-07	321.5 to 320.3	-	9*	2.9	1,500	Very loose to compact silty sand to gravelly sand
		320.3 to 316.5	175	10*	-	-	Very stiff to hard silty clay till
		316.5 to 308.6 (bedrock)	-	11*	3.8	8,000	Dense to very dense sandy silt
Hwy 7- New WBL East Abutment	EC16-09 EC16-10	321.6 to 320.0	-	10*	3.0	2,000	Compact to loose sand and silt
		320.0 to 319.0	40	10*	-	-	Firm silty clay
		319.0 to 317.5	-	10*	3.3	3,500	Compact sand and gravel
		317.5 to 314.5	200	10*	-	-	Hard silty clay
		314.5 to 311.0	-	11*	4.2	10,000	Very dense sand and gravel

* Bouyant unit weight below water table

The group efficiency factors can be calculated based on side-by-side and line-by-line factors shown in Figures C6.11.3(r), C6.11.3(s), and C6.11.3(t) of the CHBDC (2014), S6.1-14 (Commentary).

10.4.4 Pile Installation

All piles shall be installed in accordance with OPSS 903 and SP 109F57.

Pile driving in overburden soils must be controlled in accordance with Standard Provision SS103-11 (Hiley Formula) and an ultimate pile resistance must be specified by the designer. The Hiley formula does not need to be used until the pile tip is within 2 m of the design tip elevation. The appropriate pile driving note to be shown on the contract drawing is "Piles to be driven in accordance with Standard SS103-11 using an ultimate geotechnical resistance of R kN per pile" where "R" must have a minimum value of twice the factored design load at ULS. It is recommended that Pile Driving Analysis (PDA) testing be conducted in conjunction with the Hiley tests at this site, to ensure the integrity of the pile and to verify pile ultimate geotechnical resistance. PDA testing should be completed for 10 percent the piles for each foundation element or a minimum of 2 piles tested at each foundation element, whichever is more.

For piles driven to bedrock, the appropriate pile driving note is "Piles to be driven to bedrock".

To facilitate pile installation, embankment fill through which piles will be driven must not contain any material with particle sizes greater than 75 mm.

Glacially derived soils inherently contain cobbles and boulders. Hard driving conditions through the hard and very dense soils should be expected. In order to minimize pile damage while driving through boulders, cobbles and harder/dense zones to achieve the required tip elevations and soil resistance, it is recommended that the pile tips be reinforced with Titus steel (Standard H-point) or equivalent.

The tips of piles driven to bedrock should be fitted with pile tip protection from an approved manufacturer such as Titus Steel (Standard H-point) or approved equivalent.

Appropriate pile tip protection should be provided for open ended piles.

The Contract Documents must contain a NSSP alerting the Bidders to the presence of cobbles and boulders in the glacial tills. Suggested texts for the NSSP's are included in Appendix F. The NSSP should contain a requirement to terminate driving before the pile is damaged by overdriving.

10.5 Abutment Design Considerations

From a geotechnical perspective, the conditions at this site are considered suitable for the design of conventional, semi-integral or integral abutments.

For integral abutments, the flexibility of the upper portion of the pile may be provided by a single corrugated steel pipe (CSP) system filled with loose uniform sand. Reference should be made to the integral abutment manual for details of this system. Piles should be driven first before pouring in sand.

10.6 Frost Cover

The design depth of frost penetration for this site is 1.4 m. All footing bases and undersides of pile caps/abutment stems must be provided with at least 1.4 m of soil cover.

10.7 Recommended Foundation

From a geotechnical perspective, and based on current information, the recommended abutment and pier foundations for the proposed Hwy 7-New Ellis Creek WBL and EBL bridges consist of steel H-piles driven to bedrock, into the very dense sand and gravel or into the very dense sand and silt to silty sand.

11. LATERAL EARTH PRESSURES

Earth pressures acting on a structure (e.g. abutment or retaining wall), may be assumed to be triangular and to be governed by the characteristics of the abutment backfill. For a fully drained condition, the pressures should be computed in accordance with the CHBDC 2014 but are generally given by the expression:

$$p_h = K (\gamma h + q)$$

where:
p_h = horizontal pressure on the wall at depth h (kPa)
K = earth pressure coefficient (see Table 11.1)
γ = unit weight of retained soil (see Table 11.1)
h = depth below top of fill where pressure is computed (m)
q = value of any surcharge (kPa).

In accordance with Clause 6.12.3 of the CHBDC 2014, a compaction surcharge should be added. Compaction equipment to be used adjacent to retaining structures should be restricted in accordance with OPSS.PROV 501.

Earth pressure coefficients for backfill to the abutment wall are dependent on the material used as backfill. Typical values are shown in Table 11.1.

Table 11.1 – Earth Pressure Coefficients

Wall Condition	Earth Pressure Coefficient (K)			
	OPSS Granular A or OPSS Granular B Type II $\phi = 35°$, $\gamma = 22.8$ kN/m^3		OPSS Granular B Type I $\phi = 32°$, $\gamma = 21.2$ kN/m^3	
	Horizontal Surface Behind Wall	Sloping Backfill (2H:1V)	Horizontal Surface Behind Wall	Sloping Backfill (2H:1V)
Active (Unrestrained Wall)	0.27	0.40	0.31	0.48
At rest (Restrained Wall)	0.43	0.62	0.47	0.70
Passive (Movement Towards Soil Mass)	3.7	-	3.2	-

Note: Submerged unit weight should be used below the groundwater level.

If the support system allows yielding of the wall (unrestrained system), active horizontal earth pressure may be used in the geotechnical design of the structure. If the support system does not allow yielding (restrained system), at-rest horizontal earth pressures should be used.

In conventional design, the use of a material with a high friction angle and low active pressure coefficient (e.g. Granular A, Granular B Type II) might be preferred as it results in lower earth pressures acting on the wall.

The factors in Table 11.1 are “ultimate” values and require certain movements for the respective conditions to be mobilized. The values to be used in the design can be estimated from Figure C6.16 in the Commentary to the CHBDC 2014.

It is recommended that perforated sub-drains and/or weep holes be installed, where applicable, to provide positive drainage of the granular backfill behind the abutment walls. Reference may be made to OPSD 3102.100 where appropriate.

12. APPROACH EMBANKMENTS

Based on the GA drawings, the finished grade levels of Highway 7-New EBL structure will be at about Elevations 329.4 and 329.8, at the west to east abutments, respectively. The finished grade levels of Highway 7-New WBL structure will be at about Elevations 329.4 and 329.7, at the west to east abutments, respectively. At the west abutments of the EBL and WBL structures, the ground surface is at about elevation 323.1 to 323.4 resulting in approach embankments of about 6.0 m to 6.3 m. At the east abutments of the EBL and WBL structures, the ground surface ranges from 323.0 to 323.3, resulting in approach embankments of about 6.5 m to 6.8 m.

All embankment fill must be constructed with adequate quality control in accordance with OPSS.PROV 206 and OPSS.PROV 501 requirements. Medium to high plastic soils must not be used for embankment construction.

It is also recommended that all permanent and temporary slope surfaces be vegetated and seeded in accordance with current MTO practice with reference to OPSS.PROV 804. It is important to note that slopes steeper than 2H:1V may be subject to surficial instability which may include sloughing and gullying. Surface runoff and precipitation must be prevented from flowing perpendicularly down any slope surface. Erosion protection measures will have to be taken as necessary to maintain slope stability.

Prior to fill placement, the subgrade must be adequately prepared to receive the new fill. All vegetation, topsoil, organics, soft/loosened or wet soils must be sub-excavated and removed in the approach embankment areas.

12.1 Slope Stability

The global, internal and surficial stability of the approach embankment fills will depend on the slope geometry and also to a large degree on the material used to construct the embankments. Embankments constructed using granular material, select subgrade material or clean earth fill (i.e. unfrozen soils free of organics, deleterious materials and debris) will have stable side slopes at inclinations of up to 2H:1V.

The analyses of global stability for a typical sideslope configuration was analysed. The Morgenstern-Price method was employed in conjunction with a commercially available slope stability program GEO-SLOPE to carry out the analyses. The computed factors of safety are as shown in Table 12.1. Graphical outputs of these analyses are included in Appendix E.

Table 12.1 – Computed Factors of Safety

Condition	Factor of Safety	Figure (Appendix F)
Side Slope		
Drained	1.4	1E
Undrained	1.4	2E

Condition	Factor of Safety	Figure (Appendix F)
Seismic = 0.078g	1.2	3E

As per typical MTO requirements, a F.S. of 1.3 is acceptable for drained and undrained conditions in cohesionless soils. In the case of static loading, the factor of safety against global failure was 1.4 for drained conditions and 1.4 for undrained conditions. Under the estimated seismic loading, the minimum factor of safety calculated was 1.2. These range of factors of safety are considered to be acceptable for this site.

12.2 Settlement

It is estimated that at the abutments, settlement of up to 25 mm will occur in the foundation soils under the loading imposed by up to 6.8 m of new approach fill. Due to the non-cohesive nature of the foundation soils, this settlement will be immediate and essentially complete when construction of the fill is completed.

No long term settlement or global stability issues are anticipated for approach embankments built at this site, provided that the surficial layer of organics and topsoil are removed/sub-excavated. The thickness of the topsoil/organics ranges from 0.4 m to 1.8 m at the borehole locations.

13. TEMPORARY EXCAVATION

All excavations at this site must be carried out in accordance with the Occupational Health and Safety Act (OHSA). The excavation and backfilling for foundations must be carried out in accordance with OPSS.PROV 902.

Excavation for foundation construction will be extended through the very loose to loose layer of organics/topsoil, stiff to very stiff silty clay till, firm to stiff silty clay, very loose to compact sandy silt to silty sand and loose to compact sand and gravel to gravelly sand.

For the purposes of the OHSA, the very loose to compact cohesionless soils above the groundwater table or when dewatered are classified as Type 3. Below the groundwater table the cohesionless soils are classified as Type 4. The cohesive soils are classified as Type 3 soils. The organic soils are classified as Type 4 soils.

The selection of the method of excavation is the responsibility of the contractor and must be based on his equipment, experience and interpretation of the site conditions. Excavations should be regularly inspected for evidence of instability if they have been left open for extended periods of time and following periods of heavy rain or thawing. If required, remedial actions must be taken to maintain the stability of the excavation and the safety of workers.

14. BACKFILL TO ABUTMENTS

For backfilling immediately behind the new abutment walls, it is recommended that the backfill be Granular A or Granular B Type II materials meeting the gradation and relevant requirements stipulated in OPSS.PROV 1010.

The backfill should be in accordance with OPSS.PROV 206 requirements and OPSD 3101.150. Compaction equipment to be used adjacent to abutments/retaining structures should must be restricted in accordance to OPSS.PROV 501.

The design of the abutment must incorporate a subdrain as shown in OPSD 3102.100.

15. GROUNDWATER AND SURFACE WATER CONTROL

The groundwater levels measured in the piezometers ranged from 0.5 m above the ground surface to 0.4 m below the ground surface. Flowing artesian conditions were observed at this site. Seasonal fluctuations of the groundwater level are to be expected.

The General Arrangement (GA) drawings provided by WSP indicate that the water levels at Ellis Creek are estimated to be at following elevations:

- 100-year water level – Elevation 324.12
- 2-year water level – Elevation 323.85

Temporary excavation for footing/engineered fill pad construction (if applicable) or pile cap (if applicable) will extend below the measured groundwater levels. Also, seepage, perched water from the granular layers and/or creek water flow is to be expected. Excavation of the cohesionless native soils below the groundwater level without prior dewatering is not recommended since the inflow of groundwater will cause boiling and sloughing of the soil below the water table making it difficult to maintain a dry, sound base on which to work.

Based on the grain size distribution curves, the estimated coefficients of permeability (k) of the native soils are as follows:

Soil	Coefficient of Permeability, k (cm/sec)
Upper Sand and Gravel and Gravelly Sand	8×10^{-5} to 9×10^{-2}
Silty Clay	1×10^{-10}

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Upper Silt to Silty Sand	1 x 10^{-6} to 8 x 10^{-5}
Lower Silt to Silty Sand	1 x 10^{-6} to 1 x 10^{-3}
Silty clay till	1 x 10^{-8}
Sand and Silt to Silty Sand Till	2 x 10^{-6} to 6 x 10 $^{-6}$
Lower Sand and Gravel	4 x 10^{-4} to 1 x 10^{-2}

Dewatering of all excavations should be carried out in accordance with OPSS. PROV 517, SP 517F01 Amendment to OPSS 517, November 2016 (issued July 2017), and OPSS. PROV 902.

The design of the dewatering system that may be required, is the responsibility of the Contractor, and the Contract Documents must alert them to this responsibility. The design the dewatering system must take account of the maximum creek level likely to occur during construction. Suitable systems that might be considered to maintain an unwatered condition at this site include sheeted excavation (cofferdam) and/or vacuum well-points. Filtered sumps must be properly designed to control loss of fines/ground loss. Suggesting wording for an NSSP in this regard is included in Appendix F.

The groundwater and surface (flood) water must be controlled during construction to maintain a stable excavation and to allow concrete to be placed in an unwatered excavation. Any accumulation of water from the base of the excavation should be removed prior to placing concrete or compacting granular fill. Placement of concrete or compacting engineered fill must be done in the dry. Unwatering must remain operational and effective until the pile caps are constructed and backfilled. The dewatering scheme must be effective to lower the groundwater level to at least 0.5 m below the footing/pile cap grade level to avoid base boiling in the native soils.

A Ministry of Environment (MOE) Permit to Take Water (PTTW) or requesting with Environmental Activity and Sector Registry (EASR), depending on the groundwater pumping volume, will likely be required prior to construction and should be anticipated by the Contractor.

Water discharged from unwatering operations or displaced during concrete placement may not be suitable for direct discharge to the creek. The contract documents must alert the contractor to this fact and include an item for treatment of the water to the satisfaction of MOE, Ministry of Natural Resources (MNR), Department of Fisheries and Oceans (DFO) or other agencies having jurisdiction, prior to discharge to the creek.

THURBER

16. SCOUR AND EROSION PROTECTION

If piles are the selected foundation for the bridges and if a pile cap is designed at creek level, then it is recommended that scour protection measures be designed to prevent undermining of the pile cap. The depth of scour must be determined by a river/creek hydraulics specialist based on Section 1.9 of the CHBDC 2014 and the depth of pile embedment to achieve fixity must be measured from the predicted scour level. Any erosion and scour protection measures developed by the Hydraulics Engineer should be checked by the Foundations Engineer to ensure that they are feasible from a foundations engineering perspective.

Erosion protection should be provided along the toe of any slopes that may be in contact with the creek flow.

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

Erosion and scour protection measures for pile caps and slopes should be designed by a qualified and experienced professional.

17. SEISMIC CONSIDERATIONS

In accordance with the CHBDC 2014, the selection of the seismic site classification is based on the averaged soil conditions encountered in the upper 30 m of the stratigraphy. The stratigraphy of the site consists of topsoil/organics overlying layers of native loose to very dense sand and gravel, loose to compact sand and silt and stiff to hard silty clay till, underlain by deposits of compact to very dense sand and silt till and dense to very dense sand and gravel. Grey dolostone bedrock was encountered below the native sand and silt till and sand and gravel.

This would correspond to a Seismic Site Class C in accordance with Table 4.1, Clause 4.4.3.2 of the CHBDC. The peak ground acceleration, PGA, for a 2% in 50 year probability of exceedance at this site is 0.078 g as per the National Building Code of Canada (NBCC). Since this site is classified as Class C the factored PGA for a 2% in 50 year probability of exceedance at this site is 0.078 g.

In accordance with Clause 4.6.5 of the CHBDC 2014, retaining structures should be designed using active (K_{AE}) and passive (K_{PE}) earth pressure coefficients that incorporate the effects of earthquake loading. The coefficients of horizontal earth pressure for seismic loading presented in Table 17.1 may be used:

THURBER

Table 17.1 – Earth Pressure Coefficients for Earthquake Loading

Condition	Earth Pressure Coefficient (K)	
	OPSS Granular A or Granular B Type II $\phi = 35°$, $\gamma = 22.8$ kN/m3	OPSS Granular B Type I $\phi = 32°$, $\gamma = 21.2$ kN/m3
Active (K_{AE})*	0.30	0.34
Passive (K_{PE})	3.6	3.2
At Rest (K_{OE})**	0.53	0.57

* After Mononobe and Okabe, passive case assumes a horizontal surface in front of the wall.
** After Woods

The site is underlain typically by layers of native loose to very dense sand and gravel (mostly compact to very dense), loose to compact sand (mostly compact) and silt and stiff to hard silty clay till, and deeper deposits of compact to very dense sand and silt till and dense to very dense sand and gravel. The native soils are underlain by grey dolostone. Therefore, liquefaction is not considered to be a concern at this site.

18. CORROSION AND SULPHATE ATTACK POTENTIAL

The results of the corrosivity and sulphate analytical tests conducted on the native soils during the current investigation indicates the following conditions at the locations tested:

- The potential for sulphate attack on concrete foundations from the surrounding native soils is considered to be negligible due to the low (710 ppm) concentration of sulphate in the samples tested. The selection of class of concrete should consider the effects of the road de-icing salts.
- The potential for soil corrosion on metal is considered to be moderate.
- Appropriate protection measures commensurate with the above are recommended if metal structural elements are used. The effects of road de-icing salts should be also considered.

19. CONSTRUCTION CONCERNS

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

1. Pile Installation

Although there was little direct evidence of their presence during drilling, glacial till deposits inherently contain cobbles and boulders. It is possible that a pile will achieve refusal at a higher elevation than anticipated due to encountering a boulder.

Some possible impacts that must be taken into consideration include, but are not necessarily limited to:

- The cobbles and boulders may impede the driving of the piles resulting in more arduous driving in the very dense soils.
- Piles may meet refusal at varying depths on boulders that are large enough not to be dislodged or broken by the pile driving.

2. Piles driven to bedrock

If driven H-piles are employed, Standard H-points are recommended to protect the pile tips while driving.
Since the bedrock surface is variable, the actual pile tip elevation and length of pile required may vary.

3. Excavation

Hydraulic equipment is expected to be capable of excavating to the required depths at this site. If excavations advance below the existing groundwater level, groundwater control measures may have to be implemented in order to maintain stable sides and base in the excavation.

The glacial till may contain cobbles and boulders. Equipment selected for excavation must be capable of penetrating, handling and/or removing these obstructions.

4. Groundwater Control

Depending of the selected foundation system, excavations may extend below the groundwater levels (slight artesian conditions) measured at this site. Proper groundwater and surface water control measures must be in place prior to commencing excavation to avoid destabilizing the sides or base of the excavation. All pile caps must be constructed in the dry.

The Contractor's unwatering plan must be in place prior to commencing excavation.

20. CLOSURE

Engineering analysis and preparation of the report were carried out by Ms. R. Palomeque Reyna, P.Eng.

The report was reviewed by Mr. Jason Lee, P.Eng., and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.

Rocío Palomeque Reyna, P.Eng.
Geotechnical Engineer

Jason Lee, P.Eng.,
Principal/Senior Geotechnical Engineer

P.K. Chatterji, P.Eng.
Review Principal, Designated MTO Contact

Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	Less than 0.002mm	Plastic particles, not visible to the naked eye

2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT(1) 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction
1) Laboratory Triaxial Testing
2) Field Insitu Vane Testing
3) Laboratory Vane Testing
4) SPT value
5) Pocket Penetrometer

4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE

SS Split Spoon Sample
WS Wash Sample
AS Auger (Grab) Sample
TW Thin Wall Shelby Tube Sample
TP Thin Wall Piston Sample
PH Sampler Advanced by Hydraulic Pressure
PM Sampler Advanced by Manual Pressure
WH Sampler Advanced by Self Static Weight
RC Rock Core
SC Soil Core

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$

▼ Water Level

C_{pen} Shear Strength Determination by Pocket Penetrometer

(1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.

(2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

UNIFIED SOILS CLASSIFICATION

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	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	SILTS AND CLAYS $W_L < 50\%$	ML	Inorganic silts and 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. ($W_L < 30\%$).
		CI	Inorganic clays of medium plasticity, silty clays. ($30\% < W_L < 50\%$).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION

Fresh (FR)	No visible signs of weathering.
Fresh Jointed (FJ)	Weathering limited to the surface of major discontinuities.
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.
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 structure are preserved.

SYMBOLS

CLAYSTONE

SILTSTONE

SANDSTONE

COAL

Bedrock (general)

DISCONTINUITY SPACING

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

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 0.1m in length or larger as a percentage of total core run length.
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen
Fracture Index: (FI)	Frequency of natural fractures per 0.3m of core run.

STRENGTH CLASSIFICATION

Rock Strength	**Approximate Uniaxial Compressive Strength (MPa)**	**(psi)**	**Field Estimation of Hardness***
Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No EC16-01

METRIC

GWP# 408-88-00 LOCATION Ellis Creek, MTM NAD 83 Zone 10: N 4 821 606.7 E 237 101.1 ORIGINATED BY SB

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP

DATUM Geodetic DATE 2018.01.09 - 2018.01.10 LATITUDE 43.531316 LONGITUDE -80.337579 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	GR	SA	SI	CL
324.2	GROUND SURFACE								
0.0	**TOPSOIL**	1	SS	4					
323.8 / 0.4	Gravelly **SAND**, some silt, trace clay Dense Brown Moist to Wet	2	SS	31					
		3	SS	38		31	47	17	5
		4	SS	36					
321.2 / 3.0	Silty **CLAY**, sandy, trace gravel, occasional cobbles Very Stiff to Hard Grey Moist (TILL)	5	SS	29		6	27	46	21
	Auger grinding from 4.4m to 4.6m	6	SS	60					
318.5 / 5.8	**SILT**, trace to some sand, trace clay Dense Grey Wet	7	SS	38					
		8	SS	47		0	6	88	6
		9	SS	48					
314.5 / 9.8	END OF BOREHOLE AT 9.8m.								

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE (324, 323, 322, 321, 320, 319, 318, 317, 316, 315); 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

Continued Next Page

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No EC16-01

METRIC

GWP# 408-88-00 | LOCATION Ellis Creek, MTM NAD 83 Zone 10: N 4 821 606.7 E 237 101.1 | ORIGINATED BY SB

DIST | HWY 7 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY MP

DATUM Geodetic | DATE 2018.01.09 - 2018.01.10 | LATITUDE 43.531316 | LONGITUDE -80.337579 | CHECKED BY RPR

ELEV DEPTH	SOIL PROFILE 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
	Continued From Previous Page										
	WATER LEVEL AT 4.3m UPON COMPLETION. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 3.1m slotted screen.										

WATER LEVEL READINGS

DATE	DEPTH(m)	ELEV.(m)
2018.03.23	0.4	323.9
2018.08.31	0.6	323.6

+ ³, × ³ : Numbers refer to Sensitivity

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

ONTMT4S2 MTO-11375.GPJ 2017TEMPLATE(MTO).GDT 11/9/18

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No EC16-02

METRIC

GWP#	408-88-00	LOCATION	Ellis Creek, MTM NAD 83 Zone 10: N 4 821 593.3 E 237 130.8	ORIGINATED BY	SB
DIST	HWY 7	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	MP
DATUM	Geodetic	DATE	2018.01.09 - 2018.01.09 LATITUDE 43.531198 LONGITUDE -80.337210	CHECKED BY	RPR

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
323.9	GROUND SURFACE							
0.0	**ORGANICS** Loose, Dark Brown, Wet	1	SS	5				
323.4 / 0.5	Silty **SAND**, some gravel, some clay. Compact, Brown, Moist	2	SS	15		323		11 58 20 11
		3	SS	13		322		
321.7 / 2.2	Silty **CLAY**, with sand, trace to some gravel, occasional cobbles. Very Stiff to Hard, Grey, Moist to Wet (TILL)	4	SS	20		321		14 40 29 17
		5	SS	37	∇	320		
		6	SS	79		319		3 35 39 23
318.1 / 5.8	Silty **SAND**, trace gravel, trace clay. Dense to Very Dense, Grey, Wet	7	SS	47		318, 317		
		8	SS	68		316, 315		
		9	SS	84				
314.2 / 9.8	END OF BOREHOLE AT 9.8m.							

Chart headers: 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

$+^3, \times^3$: Numbers refer to Sensitivity — 20 / 15 / 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No EC16-02

METRIC

GWP# 408-88-00 LOCATION Ellis Creek, MTM NAD 83 Zone 10: N 4 821 593.3 E 237 130.8 ORIGINATED BY SB

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP

DATUM Geodetic DATE 2018.01.09 - 2018.01.09 LATITUDE 43.531198 LONGITUDE -80.337210 CHECKED BY RPR

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	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page										
	BOREHOLE CAVED IN TO 4.6m. WATER LEVEL AT 3.7m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND AUGER CUTTINGS TO SURFACE.										

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

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No EC16-03

METRIC

GWP# 408-88-00 LOCATION Ellis Creek, MTM NAD 83 Zone 10: N 4 821 622.9 E 237 107.3 ORIGINATED BY SB

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP

DATUM Geodetic DATE 2018.01.10 - 2018.01.10 LATITUDE 43.531463 LONGITUDE -80.337503 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	GR	SA	SI	CL
323.4	GROUND SURFACE								
0.0	**ORGANICS** Loose Dark Brown Wet	1	SS	4	122				
322.7 / 0.8	**SAND** and **SILT**, trace gravel Loose to Compact Brown Wet	2	SS	6					
		3	SS	19					
321.3 / 2.1	Silty **CLAY** Stiff Brown to Grey Moist	4	SS	12		0	0	68	32
320.5 / 2.9	**SAND** and **GRAVEL**, trace silt, occasional cobbles Dense Brown Wet	5	SS	37					
318.8 / 4.6	Silty **CLAY**, sandy to with sand, trace to some gravel Stiff to Very Stiff Grey Wet (TILL)	6	SS	13		11	35	34	20
	Moist	7	SS	19		9	29	43	19
316.2 / 7.2	Silty **SAND** to **SAND** and **SILT**, trace gravel, trace clay Compact to Dense Grey Wet	8	SS	14					
		9	SS	38					

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

(%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No EC16-03

METRIC

GWP# 408-88-00 | LOCATION Ellis Creek, MTM NAD 83 Zone 10: N 4 821 622.9 E 237 107.3 | ORIGINATED BY SB

DIST ___ HWY 7 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY MP

DATUM Geodetic | DATE 2018.01.10 - 2018.01.10 | LATITUDE 43.531463 | LONGITUDE -80.337503 | CHECKED BY RPR

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Silty **SAND** to **SAND** and **SILT**, trace gravel, trace clay Dense to Very Dense Grey Wet				313		
		10	SS	36		o	
					312		
		11	SS	100	311	o	
					310		
		12	SS	100/ 0.075		o	
					309		
308.4		13	SS	100/ 0.250		o	3 45 46 6
15.0	END OF BOREHOLE AT 9.8m. WATER LEVEL AT 3.7m UPON COMPLETION. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 3.1m slotted screen.						

WATER LEVEL READINGS

DATE	DEPTH(m)	ELEV.(m)
2018.03.23	-0.3	323.7
Artesian Condition		
2018.08.31	-0.1	323.5
Artesian Condition		

Legend: 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; UNIT WEIGHT γ kN/m³

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No EC16-04

METRIC

GWP# 408-88-00 | LOCATION Ellis Creek, MTM NAD 83 Zone 10: N 4 821 613.2 E 237 126.4 | ORIGINATED BY SB

DIST ___ HWY 7 | BOREHOLE TYPE Hollow Stem Augers/NQ Coring | COMPILED BY MP

DATUM Geodetic | DATE 2018.01.19 - 2018.01.19 | LATITUDE 43.531377 | LONGITUDE -80.337267 | CHECKED BY RPR

ELEV / DEPTH (m)	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
323.3	GROUND SURFACE					
0.0	**ORGANICS**, occasional roots Very Loose to Loose Black Wet	1	SS	1	323	
		2	SS	4		
322.1 / 1.2	Sandy **SILT**, trace clay Loose to Compact Grey Wet				322	
		3	SS	11		0 33 59 8
321.1 / 2.2	Silty **SAND**, trace to some gravel, trace clay Loose to Dense Brown Wet to Moist				321	
		4	SS	8		
		5	SS	13	320	
					319	
		6	SS	15		15 63 20 2
					318	
		7	SS	12	317	
					316	
	Grey	8	SS	36		
					315	
					314	
		9	SS	29		7 64 26 3

Natural moisture content plot: sample 1 plotted at 745%.

Plot axes: 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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No EC16-04

METRIC

GWP# 408-88-00 | LOCATION Ellis Creek, MTM NAD 83 Zone 10: N 4 821 613.2 E 237 126.4 | ORIGINATED BY SB

DIST ____ HWY 7 | BOREHOLE TYPE Hollow Stem Augers/NQ Coring | COMPILED BY MP

DATUM Geodetic | DATE 2018.01.19 - 2018.01.19 | LATITUDE 43.531377 | LONGITUDE -80.337267 | CHECKED BY RPR

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	UNIT WEIGHT / FI	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Silty **SAND**, trace clay, trace gravel Very Dense Brown to Grey Moist	10	SS	53		
311.1 12.2	Silty **CLAY** Hard Brown Wet	11	SS	50		0 0 78 22
309.9 13.4	Silty **SAND**, some gravel, occasional cobbles Very Dense Brown Wet Coring started at 14.3m	12	SS	63		
309.0 14.3	**BEDROCK**, dolostone, slightly weathered to fresh, very strong, grey, occasional vertical joints: (Guelph Formation) sub horizontal joint at 14.6m horizontal joint at 14.6m sub-vertical joint at 15.3m sub-vertical joint at 15.6m horizontal joint at 14.7m, 14.8m, 15.0m, 15.1m, 15.4m and 15.6m horizontal joint at 16.5m, 16.8m, 17.0m and 17.4m	1	RUN		FI: 2, 3	RUN #1 TCR=77% SCR=58% RQD=0% UCS=197MPa
		2	RUN		4, 2, 2, 0	RUN #2 TCR=77% SCR=75% RQD=42% UCS=208MPa (Average)
		3	RUN		0, 2, 1, 1, 1	RUN #3 TCR=100% SCR=100% RQD=95% UCS=250MPa (Average)
305.5 17.8	END OF BOREHOLE AT 17.8m Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen.					

Natural moisture content (approx. %): Sample 10 ≈ 19; Sample 11 ≈ 20; Sample 12 ≈ 15.

Elevation scale: 313, 312, 311, 310, 309, 308, 307, 306

Column headings: 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

WATER LEVEL READINGS

DATE	DEPTH(m)	ELEV.(m)
2018.08.31	-0.5	323.8

Artesian Condition

+3, ×3: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No EC16-05

METRIC

GWP# 408-88-00	LOCATION Ellis Creek, MTM NAD 83 Zone 10: N 4 821 605.1 E 237 149.4		ORIGINATED BY SB
DIST HWY 7	BOREHOLE TYPE Hollow Stem Augers/NQ Coring		COMPILED BY MP
DATUM Geodetic	DATE 2018.01.17 - 2018.01.18	LATITUDE 43.531307 LONGITUDE -80.336981	CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	GR	SA	SI	CL
323.1	GROUND SURFACE								
0.0	**ORGANICS**, occasional roots Very Loose to Loose Black Wet	1	SS	1	171				
322.1 / 1.0	Sandy **SILT**, trace to some clay, trace gravel Loose to Compact Grey Moist	2	SS	4					
	clayey zone	3	SS	14		0	31	59	10
320.8 / 2.3	Silty **SAND**, trace clay, trace gravel Compact to Very Dense Brown Wet	4	SS	16					
		5	SS	100/ 0.250					
		6	SS	52					
		7	SS	29					
		8	SS	43		0	63	32	5
		9	SS	65					

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE (323, 322, 321, 320, 319, 318, 317, 316, 315, 314); 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

Continued Next Page

+³, ×³: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No EC16-05

METRIC

GWP# 408-88-00 | LOCATION Ellis Creek, MTM NAD 83 Zone 10: N 4 821 605.1 E 237 149.4 | ORIGINATED BY SB

DIST ______ HWY 7 | BOREHOLE TYPE Hollow Stem Augers/NQ Coring | COMPILED BY MP

DATUM Geodetic | DATE 2018.01.17 - 2018.01.18 | LATITUDE 43.531307 | LONGITUDE -80.336981 | CHECKED BY RPR

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT (FI)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Silty **SAND**, trace clay, trace gravel Very Dense Brown Wet				313			
		10	SS	82	312	~20		
		11	SS	100/ 0.075	311			
310.0	Coring started at 13.1m				310		FI	
13.1	**BEDROCK**, dolostone, slightly weathered to fresh, very strong, grey, occasional vertical joints: (Guelph Formation) sub-horizontal joint at 13.3m	1	RUN				1 2	RUN #1 TCR=91% SCR=64% RQD=0% UCS=169MPa
	horizontal joint at 13.6m, 13.7m, 13.9m, 14.2m, 14.3m, 14.5m, 14.9m and 15.0m sub-vertical joint at 14.2m vertical joint at 14.4m and 15.0m	2	RUN		309		3 4 2 3	RUN #2 TCR=93% SCR=77% RQD=29% UCS=147MPa (Average)
	horizontal joint at 15.3m, 15.7m, 15.8m, 16.0m, 16.1m and 16.2m	3	RUN		308 307		3 1 2 2 1	RUN #3 TCR=84% SCR=84% RQD=47% UCS=178MPa
306.6 16.5	END OF BOREHOLE AT 16.5m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND AUGER CUTTINGS TO SURFACE.							

Column headings also include: STRAT PLOT; 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.

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

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No EC16-06

METRIC

GWP# 408-88-00 | LOCATION Ellis Creek, MTM NAD 83 Zone 10: N 4 821 648.0 E 237 126.2 | ORIGINATED BY SB

DIST ___ HWY 7 | BOREHOLE TYPE Hollow Stem Augers/NQ Coring | COMPILED BY MP

DATUM Geodetic | DATE 2018.01.11 - 2018.01.17 | LATITUDE 43.531690 | LONGITUDE -80.337274 | CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
323.3	GROUND SURFACE							
0.0	**ORGANICS** Very Loose, Dark Brown, Wet	1	SS	2				
		2	SS	2				
321.9 / 1.4	Silty **SAND**, some clay, some gravel. Compact, Grey, Wet	3	SS	12				
		4	SS	14	16	40	30	14
320.3 / 3.0	Silty **CLAY**, some sand to sandy, trace gravel. Very Stiff to Hard, Grey, Wet (TILL)	5	SS	29				
		6	SS	32				
		7	SS	32	3	27	39	31
316.6 / 6.7	Sandy **SILT**, trace gravel, trace clay. Very Dense to Dense, Grey, Wet	8	SS	58				
		9	SS	43				

Elevation scale: 323, 322, 321, 320, 319, 318, 317, 316, 315, 314

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 (%)

Continued Next Page

+³, ×³: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No EC16-06

METRIC

GWP# 408-88-00 | LOCATION Ellis Creek, MTM NAD 83 Zone 10: N 4 821 648.0 E 237 126.2 | ORIGINATED BY SB

DIST ______ HWY 7 | BOREHOLE TYPE Hollow Stem Augers/NQ Coring | COMPILED BY MP

DATUM Geodetic | DATE 2018.01.11 - 2018.01.17 | LATITUDE 43.531690 | LONGITUDE -80.337274 | CHECKED BY RPR

Column headers: 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)

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT	UNIT WEIGHT	REMARKS & GRAIN SIZE (GR SA SI CL)
	Sandy **SILT**, trace gravel, trace clay Dense Grey Wet				313			
		10	SS	39		~19		0 20 74 6
					312			
		11	SS	40	311	~19		
					310			
	Possible hydraulic disturbance Compact	12	SS	12		~19		
					309			
308.6	Coring started at 14.7m							
14.7	**BEDROCK**, dolostone, slightly weathered to fresh, very strong, grey, occasional vertical joints: (Guelph Formation) vertical joint at 14.7m sub-vertical joint at 14.9m sub-horizontal joint at 15.2m horizontal joint at 15.0m, 15.1m, 15.3m, 15.4m, 15.8m and 16.1m	1	RUN		308		FI 3 3 6 2 2	RUN #1 TCR=100% SCR=95% RQD=62% UCS=185MPa (Average)
	vertical joint at 17.1m horizontal joint at 16.4m, 16.6m, 16.9m, 17.3m, 17.4m and 17.5m	2	RUN		307 306		1 1 2 2 1	RUN #2 TCR=98% SCR=95% RQD=82% UCS=159MPa (Average)
305.6 17.8	END OF BOREHOLE AT 12.2m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND AUGER CUTTINGS TO SURFACE.							

+³, ×³: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No EC16-07

METRIC

GWP# 408-88-00 — LOCATION Ellis Creek, MTM NAD 83 Zone 10: N 4 821 633.1 E 237 149.8 — ORIGINATED BY SJ

DIST ____ HWY 7 — BOREHOLE TYPE Hollow Stem Augers/Tricone/NQ Coring — COMPILED BY MP

DATUM Geodetic — DATE 2018.07.09 - 2018.07.09 — LATITUDE 43.531558 — LONGITUDE -80.336980 — CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
323.3	GROUND SURFACE				
0.0	**ORGANICS** Very Loose to Loose, Dark Brown, Wet	1	SS	1	
		2	SS	1	
321.5 / 1.8	Gravelly **SAND**, trace silt, trace clay, Loose, Grey, Wet	3	SS	4	
		4	SS	4	
		5	SS	8	26 70 4 (SI+CL)
		6	SS	60	
317.6 / 5.6	Sandy **SILT**, trace to some clay, trace gravel, Dense, Grey, Moist	7	SS	39	
		8	SS	35	3 26 54 17
		9	SS	67	

Elevation scale: 323, 322, 321, 320, 319, 318, 317, 316, 315, 314

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

Water content annotation: 95

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity — 20 / 15 -◯- 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S2 MTO-11375.GPJ 2017TEMPLATE(MTO).GDT 11/9/18

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No EC16-07

METRIC

GWP# 408-88-00 | LOCATION Ellis Creek, MTM NAD 83 Zone 10: N 4 821 633.1 E 237 149.8 | ORIGINATED BY SJ

DIST | HWY 7 | BOREHOLE TYPE Hollow Stem Augers/Tricone/NQ Coring | COMPILED BY MP

DATUM Geodetic | DATE 2018.07.09 - 2018.07.09 | LATITUDE 43.531558 | LONGITUDE -80.336980 | CHECKED BY RPR

ELEV DEPTH	DESCRIPTION (SOIL PROFILE)	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page							
	Sandy **SILT**, trace to some clay, trace gravel Very Dense Grey Moist				313			
		10	SS	80		○		0 11 72 17
					312			
311.0		~~11~~	~~SS~~	~~100/~~ 0.075	311	○	FI	
12.3	**BEDROCK**, dolostone, slightly weathered to fresh, very strong, grey, occasional vertical joints: (Guelph Formation) vertical joint (75mm) at 12.9m horizontal joint at 12.5m, 12.6m, 12.7m, 12.9m, 13.0m, 13.2m, 13.4m, 13.6m, 13.7m and 13.8m vertical joint at (150mm) at 13.8m	1	RUN		310		4 4 1 1 3	RUN #1 TCR=100% SCR=95% RQD=45% UCS=116MPa (Average)
	horizontal joint at 14.0m, 14.1m, 14.3m, 14.5m, 14.6m, 14.9m, 15.0m, 15.1m, 15.2m and 15.3m rubble zone at 15.1m	2	RUN		309 308		2 2 1 4 3	RUN #2 TCR=100% SCR=93% RQD=72% UCS=110MPa (Average)
307.8 15.5	END OF BOREHOLE AT 15.5m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen.							

WATER LEVEL READINGS

DATE	DEPTH(m)	ELEV.(m)
2018.08.31	-0.1	323.4

Artesian Condition

Chart headings: 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; STRAT PLOT; GROUND WATER CONDITIONS.

+ 3, × 3: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No EC16-08

METRIC

GWP# 408-88-00 LOCATION Ellis Creek, MTM NAD 83 Zone 10: N 4 821 625.7 E 237 172.3 ORIGINATED BY SJ

DIST ___ HWY 7 BOREHOLE TYPE Hollow Stem Augers/Tricone/NQ Coring COMPILED BY MP

DATUM Geodetic DATE 2018.07.10 - 2018.07.10 LATITUDE 43.531494 LONGITUDE -80.336700 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
323.1	GROUND SURFACE												
0.0	**ORGANICS** Very Loose Dark Brown Wet		1	SS	2		323						
			2	SS	1		322						
321.5 / 1.6	Silty **SAND**, trace gravel, trace clay, occasional cobbles Very Loose to Dense Grey Moist		3	SS	3		321						
			4	SS	5					4	71	20	5
			5	SS	11		320						
							319						
	Wet		6	SS	34		318						
			7	SS	25		317						
	Auger grinding at 6.7m												
315.9 / 7.2	**SAND** and **GRAVEL**, occasional cobbles Very Dense Grey Wet		8	SS	100/ 0.300		316						
314.9 / 8.2	Silty **CLAY**, trace sand Hard Grey Wet		9	SS	75		315			0	1	70	29
			10	SS	100/ 0.275		314						

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
REMARKS & GRAIN SIZE DISTRIBUTION (%)

Continued Next Page

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

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

RECORD OF BOREHOLE No EC16-08

METRIC

GWP# 408-88-00 | LOCATION Ellis Creek, MTM NAD 83 Zone 10: N 4 821 625.7 E 237 172.3 | ORIGINATED BY SJ

DIST ____ HWY 7 | BOREHOLE TYPE Hollow Stem Augers/Tricone/NQ Coring | COMPILED BY MP

DATUM Geodetic | DATE 2018.07.10 - 2018.07.10 | LATITUDE 43.531494 | LONGITUDE -80.336700 | CHECKED BY RPR

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page						
313.0 10.1	**SAND** and **GRAVEL**, trace to some silt, trace to some clay Very Dense Grey Wet				313		
		11	SS	100/ 0.200		o	39 46 15 (SI+CL)
	Auger grinding at 11.1m				312		
		12	SS	100/ 0.050	311	o	
310.6	Coring started at 12.5m						
12.5	**BEDROCK**, dolostone, slightly weathered to fresh, very strong, grey, occasional vertical joints: (Guelph Formation) vertical joint (75mm) at 12.5m horizontal joint at 12.6m sub vertical joint (50mm) at 13.1m	1	RUN		310		RUN #1 TCR=84% SCR=68% RQD=45% UCS=161MPa
	horizontal joint at 13.6m, 13.7m, 14.4m and 14.8m sub vertical joint (25mm) at 14.0m vertical joint (200mm) at 14.2m, (125mm) at 14.5m	2	RUN		309		RUN #2 TCR=100% SCR=82% RQD=45% UCS=112MPa (Average)
	vertical joint (100mm) at 14.8m horizontal joint at 15.3m	3	RUN		308		RUN #3 TCR=83% SCR=81% RQD=81% UCS=159MPa
307.4 15.7	END OF BOREHOLE AT 15.7m. BOREHOLE BACKFILLED WITH GROUT TO 0.2m, THEN HOLEPLUG TO SURFACE.						

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

RECORD OF BOREHOLE No EC16-09

METRIC

GWP# 408-88-00	LOCATION Ellis Creek, MTM NAD 83 Zone 10: N 4 821 672.5 E 237 150.3		ORIGINATED BY GA
DIST HWY 7	BOREHOLE TYPE Hollow Stem Augers		COMPILED BY MP
DATUM Geodetic	DATE 2017.12.07 - 2017.12.09	LATITUDE 43.531913 LONGITUDE -80.336978	CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	Water content (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
323.2	GROUND SURFACE						
0.0	**ORGANICS**, occasional roots, Very Loose, Black, Wet	1	SS	0		111	
		2	SS	2		113	
321.7 / 1.4	**SAND** and **SILT**, some clay, trace gravel, Compact to Loose, Grey to Brown, Wet	3	SS	11	∇ (water level at approx. 321.7)		
		4	SS	8			
320.2 / 3.0	Silty **CLAY**, Firm, Brown, Wet	5	SS	4			0 0 73 27
319.1 / 4.1	**SAND** and **GRAVEL**, trace silt, trace clay, Compact, Grey, Wet	6	SS	19			58 35 7 (SI+CL)
317.5 / 5.6	Silty **CLAY**, Hard, Grey, Wet	7	SS	33			
		8	SS	40			0 0 79 21
314.5 / 8.7	**SAND** and **GRAVEL**, some silt, Very Dense, Grey, Wet	9	SS	100/ 0.200			

Elevation scale: 323, 322, 321, 320, 319, 318, 317, 316, 315, 314

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No EC16-09

METRIC

GWP# 408-88-00 | LOCATION Ellis Creek, MTM NAD 83 Zone 10: N 4 821 672.5 E 237 150.3 | ORIGINATED BY GA

DIST | HWY 7 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY MP

DATUM Geodetic | DATE 2017.12.07 - 2017.12.09 | LATITUDE 43.531913 | LONGITUDE -80.336978 | CHECKED BY RPR

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
	SAND and **GRAVEL**, some silt Very Dense Grey Wet				313					
		10	SS	100/ 0.275		~4 (natural moisture content, plotted)	43	45	12 (SI+CL)	
					312					
310.9 / 12.2	END OF BOREHOLE AT 12.2m. WATER LEVEL AT 1.5m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND AUGER CUTTINGS TO SURFACE.	11	SS	100/ 0.050	311					

Legend: 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 (%).

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No EC16-10

METRIC

GWP# 408-88-00 LOCATION Ellis Creek, MTM NAD 83 Zone 10: N 4 821 662.3 E 237 171.6 ORIGINATED BY GA

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP

DATUM Geodetic DATE 2017.12.07 - 2017.12.07 LATITUDE 43.531823 LONGITUDE -80.336713 CHECKED BY RPR

ELEV / DEPTH (m)	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	GR	SA	SI	CL
323.0	GROUND SURFACE								
0.0	**ORGANICS**, occasional roots, occasional wood pieces, Very Loose, Black, Wet	1	SS	2	133				
		2	SS	2	199				
321.6 / 1.4	**SAND** and **SILT**, trace gravel, trace clay, Compact to Loose, Grey, Wet	3	SS	16		3	55	36	6
		4	SS	7					
320.0 / 3.0	Gravelly **SAND**, trace silt, trace clay, Compact, Grey, Wet	5	SS	16		29	63	8 (SI+CL)	
318.9 / 4.1	Silty **CLAY**, trace sand, Firm, Brown, Wet	6	SS	6					
317.4 / 5.6	Silty **SAND**, some gravel, some clay, Very Dense to Dense, Grey, Wet, (TILL)	7	SS	54		16	49	23	12
		8	SS	39					
314.3 / 8.7	**SAND** and **GRAVEL**, trace silt, Very Dense, Grey, Wet	9	SS	100/0.250		59	33	8 (SI+CL)	

Elevation scale: 322, 321, 320, 319, 318, 317, 316, 315, 314

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

Continued Next Page

+³, ×³: Numbers refer to Sensitivity

(%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No EC16-10

METRIC

GWP# 408-88-00 | LOCATION Ellis Creek, MTM NAD 83 Zone 10: N 4 821 662.3 E 237 171.6 | ORIGINATED BY GA

DIST | HWY 7 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY MP

DATUM Geodetic | DATE 2017.12.07 - 2017.12.07 | LATITUDE 43.531823 | LONGITUDE -80.336713 | CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (20 40 60 80 100)	WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	SAND and **GRAVEL**, trace silt Very Dense Grey Wet		10	SS	100/ 0.225		312		o		
							311				
310.8 / 12.3	END OF BOREHOLE AT 12.3m. WATER LEVEL AT 1.5m UPON COMPLETION. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.5m slotted screen.		11	SS	100/ 0.075						

WATER LEVEL READINGS

DATE	DEPTH(m)	ELEV.(m)
2018.03.23	-0.2	323.2
Artesian Condition		
2018.05.01	0.3	322.7
2018.08.31	0.2	322.8

Legend: O UNCONFINED; + FIELD VANE; ● QUICK TRIAXIAL; × LAB VANE. PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L.

+ 3, × 3: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No EC16-11

METRIC

GWP# 408-88-00 | LOCATION Ellis Creek, MTM NAD 83 Zone 10: N 4 821 653.4 E 237 193.2 | ORIGINATED BY GA

DIST | HWY 7 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY MP

DATUM Geodetic | DATE 2017.12.05 - 2017.12.05 | LATITUDE 43.531745 | LONGITUDE -80.336445 | CHECKED BY RPR

ELEV / DEPTH (m)	DESCRIPTION	NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	GR	SA	SI	CL
323.3	GROUND SURFACE								
0.0	**ORGANICS**, occasional roots Very Loose Black Wet	1	SS	2	110				
		2	SS	2					
321.8 / 1.4	**SAND** and **SILT**, trave gravel, trace clay Loose to Compact Brown to Grey Wet	3	SS	8		0	59	36	5
		4	SS	12					
		5	SS	12					
319.2 / 4.1	Gravelly **SAND**, trace silt, trace clay Compact Brown Wet	6	SS	15		18	79	3 (SI+CL)	
	Very Dense Grey	7	SS	83					
316.1 / 7.2	Silty **CLAY**, sandy, trace gravel Hard Grey Wet (TILL)	8	SS	89		2	27	50	21
314.6 / 8.7	**SAND** and **GRAVEL**, some silt to silty Very Dense Grey Wet	9	SS	100/0.200					

Elevation scale: 323, 322, 321, 320, 319, 318, 317, 316, 315, 314

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 (%)

Continued Next Page

+³, ×³: Numbers refer to Sensitivity; (%) STRAIN AT FAILURE

ONTMT4S2 MTO-11375.GPJ 2017TEMPLATE(MTO).GDT 11/9/18

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No EC16-11

METRIC

GWP# 408-88-00 | LOCATION Ellis Creek, MTM NAD 83 Zone 10: N 4 821 653.4 E 237 193.2 | ORIGINATED BY GA

DIST ___ HWY 7 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY MP

DATUM Geodetic | DATE 2017.12.05 - 2017.12.05 | LATITUDE 43.531745 | LONGITUDE -80.336445 | CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page						
	SAND and **GRAVEL**, some silt to silty Very Dense Grey Wet				313		
		10	SS	100/ 0.150		○	34 43 23 (SI+CL)
					312		
311.1 / 12.2	END OF BOREHOLE AT 12.2m. WATER LEVEL AT 1.5m UPON COMPLETION. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.5m slotted screen.	11	SS	100/ 0.050			

WATER LEVEL READINGS

DATE	DEPTH(m)	ELEV.(m)
2018.03.23 (Frozen)	0.1	323.2
2018.05.01 At surface	0.0	323.3
2018.08.31	0.0	323.2

Column headings: SOIL PROFILE; STRAT PLOT; 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

+ ³, × ³: Numbers refer to Sensitivity

15 20 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No EC16-12

METRIC

GWP# 408-88-00
LOCATION Ellis Creek, MTM NAD 83 Zone 10: N 4 821 669.9 E 237 170.2
ORIGINATED BY GA

DIST ____ HWY 7
BOREHOLE TYPE Hollow Stem Augers
COMPILED BY MP

DATUM Geodetic
DATE 2017.12.05 - 2017.12.05
LATITUDE 43.531892
LONGITUDE -80.336732
CHECKED BY RPR

ELEV / DEPTH (m)	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
323.2	GROUND SURFACE							
0.0	**ORGANICS**, occasional roots, Very Loose, Black, Wet	1	SS	2		323	108	
		2	SS	3		322	121	
321.7 / 1.4	**SILT**, trace to some sand, some clay, Compact to Loose, Grey to Brown, Wet	3	SS	17	▽			
		4	SS	11		321		0 11 71 18
	clayey zone	5	SS	9		320		
319.1 / 4.1	**SAND** and **GRAVEL**, Dense, Grey, Wet	6	SS	32		319		
317.6 / 5.6	**SAND** and **SILT**, some gravel, some clay, Very Dense, Grey, Wet (TILL)	7	SS	63		318, 317		14 38 37 11
316.0 / 7.2	Silty **CLAY**, trace sand, Hard, Grey, Wet	8	SS	64		316, 315		0 6 61 33
314.5 / 8.7	**SAND** and **GRAVEL**, some silt, Very Dense, Grey, Wet	9	SS	64		314		
313.4 / 9.8	END OF BOREHOLE AT 9.8m.							

Column headings also include: STRAT PLOT; 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

ONTMT4S2 MTO-11375.GPJ 2017TEMPLATE(MTO).GDT 11/9/18

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No EC16-12

METRIC

GWP#	408-88-00	LOCATION	Ellis Creek, MTM NAD 83 Zone 10: N 4 821 669.9 E 237 170.2	ORIGINATED BY	GA
DIST	HWY 7	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	MP
DATUM	Geodetic	DATE	2017.12.05 - 2017.12.05 LATITUDE 43.531892 LONGITUDE -80.336732	CHECKED BY	RPR

SOIL PROFILE			SAMPLES								
ELEV DEPTH	DESCRIPTION Continued From Previous Page	STRAT PLOT	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
	WATER LEVEL AT 1.8m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND AUGER CUTTINGS TO SURFACE.										

ONTMT4S2 MTO-11375.GPJ 2017TEMPLATE(MTO).GDT 11/9/18

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

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

RECORD OF BOREHOLE No EC16-13

METRIC

GWP# 408-88-00 | LOCATION Ellis Creek, MTM NAD 83 Zone 10: N 4 821 671.4 E 237 198.6 | ORIGINATED BY GA

DIST ____ HWY 7 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY MP

DATUM Geodetic | DATE 2017.12.04 - 2017.12.04 | LATITUDE 43.531908 | LONGITUDE -80.336381 | CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
323.2	GROUND SURFACE									
0.0	**TOPSOIL**									
0.2	Silty **SAND**, trace to some gravel, occasional roots Very Loose to Compact Brown to Grey Wet	1	SS	0	323					
		2	SS	8	322					
		3	SS	20	321					
320.7 2.6	Silty **CLAY** Firm to Stiff Brown Wet	4	SS	5						
		5	SS	8	320		0	0	63	37
					319					
318.4 4.9	**SAND** and **GRAVEL** Compact to Very Dense Brown to Grey Wet	6	SS	12	318					
316.8 6.4	Silty **CLAY**, sandy, trace gravel Hard Grey Wet (TILL)	7	SS	96	317		5	30	37	28
		8	SS	100/ 0.250	316 315					
314.6 8.7	**SAND** and **SILT**, trace gravel, trace clay Very Dense Grey Wet	9	SS	100/ 0.225	314		5	42	48	5
313.7 9.5	END OF BOREHOLE AT 9.5m. WATER LEVEL AT 1.5m UPON COMPLETION.									

Column headings: SOIL PROFILE; STRAT PLOT; 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 (%).

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No EC16-13

METRIC

GWP# 408-88-00 | LOCATION Ellis Creek, MTM NAD 83 Zone 10: N 4 821 671.4 E 237 198.6 | ORIGINATED BY GA

DIST | HWY 7 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY MP

DATUM Geodetic | DATE 2017.12.04 - 2017.12.04 | LATITUDE 43.531908 | LONGITUDE -80.336381 | CHECKED BY RPR

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	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page										
	Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.5m slotted screen.										

WATER LEVEL READINGS

DATE	DEPTH(m)	ELEV.(m)
2018.03.23	0.0	323.3
Artesian Condition		
2018.05.01	-0.2	323.4
Artesian Condition		
2018.08.31	0.3	322.9

+ ³, × ³ : Numbers refer to Sensitivity

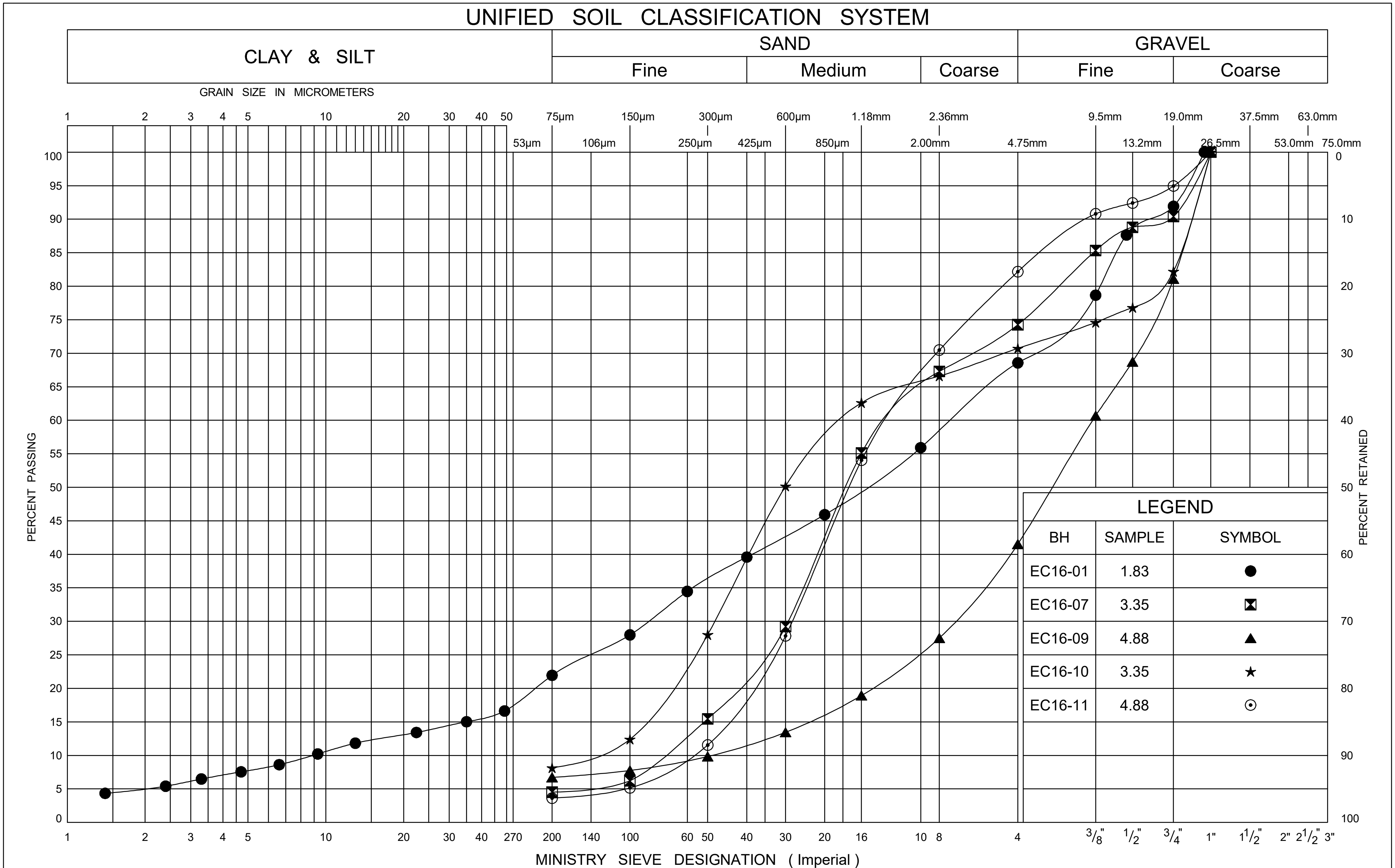
20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

THURBER

Appendix B

Laboratory Test Results
and
Analytical Laboratory Test Results

78 12 M



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Ontario

GRAIN SIZE DISTRIBUTION

Upper Sand and Gravel and Gravelly Sand

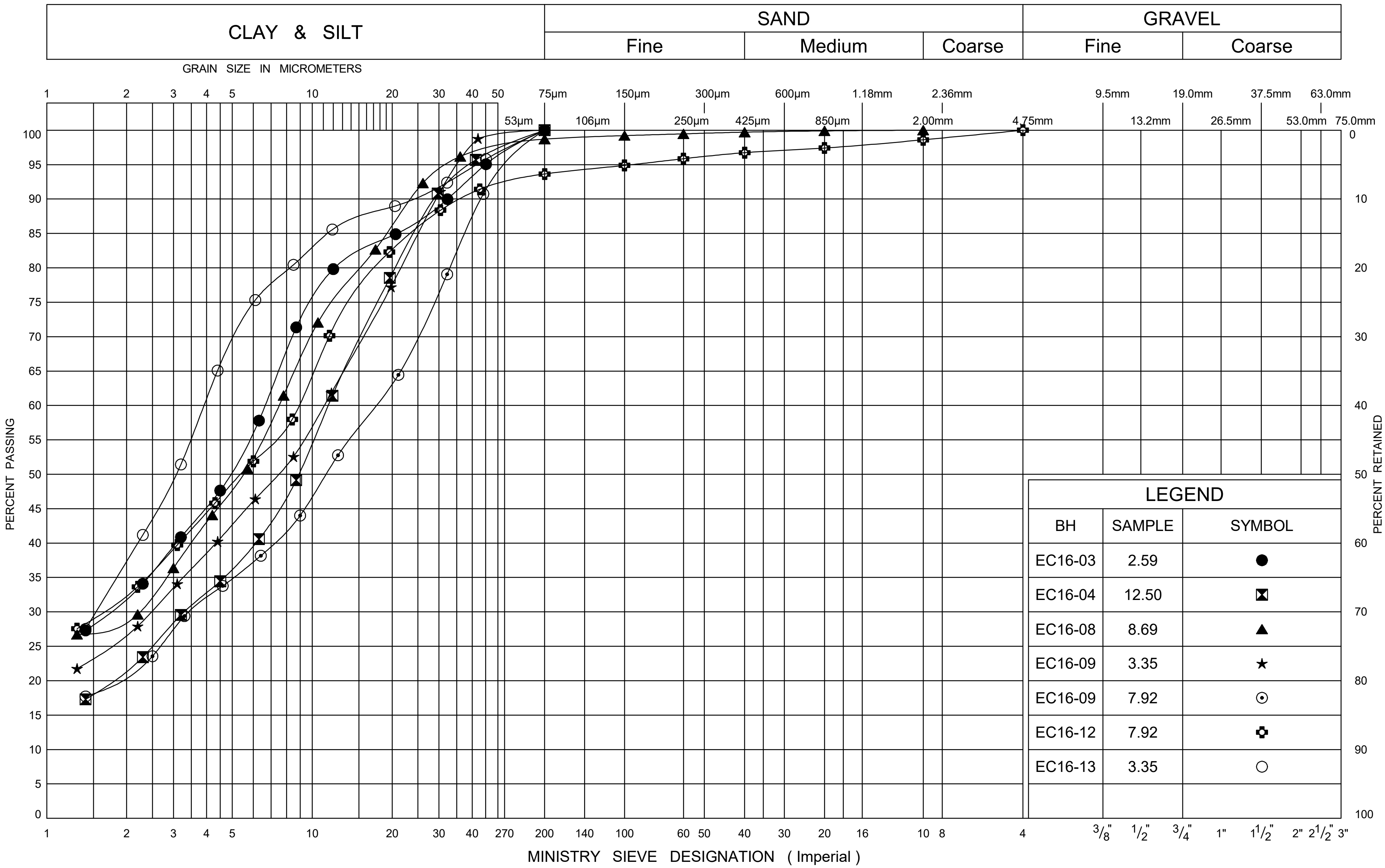
FIG No B1

W P 408-88-00

Ellis Creek

ONTARIO MOT GRAIN SIZE MTO-11375.GPJ ONTARIO MOT.GDT 11/9/18

UNIFIED SOIL CLASSIFICATION SYSTEM



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Ontario

GRAIN SIZE DISTRIBUTION

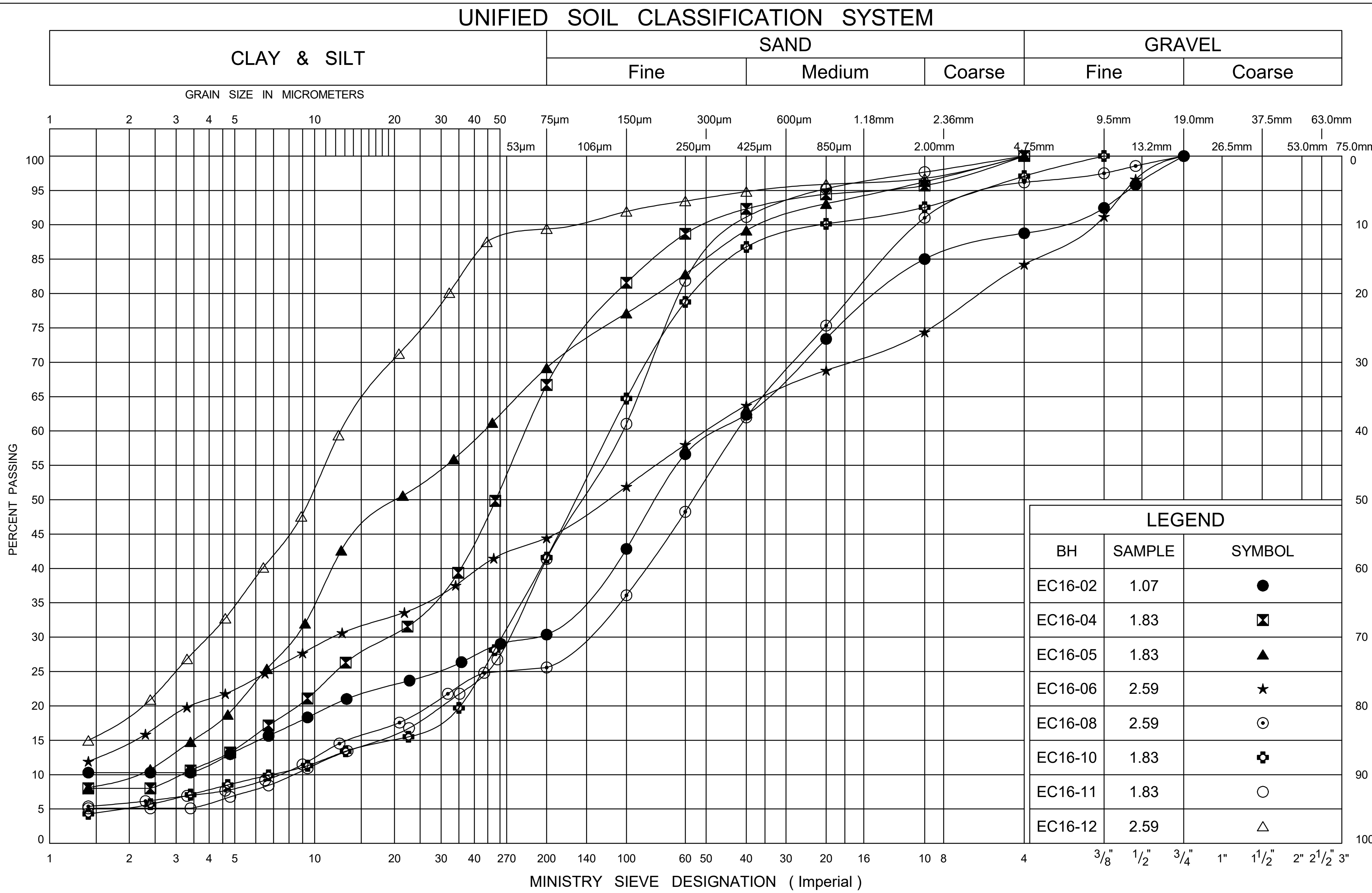
Silty Clay

FIG No B2

W P 408-88-00

Ellis Creek

ONTARIO MOT GRAIN SIZE MTO-11375.GPJ ONTARIO MOT.GDT 11/9/18



LEGEND		
BH	SAMPLE	SYMBOL
EC16-02	1.07	●
EC16-04	1.83	⊠
EC16-05	1.83	▲
EC16-06	2.59	★
EC16-08	2.59	⊙
EC16-10	1.83	✪
EC16-11	1.83	○
EC16-12	2.59	△

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Ontario

GRAIN SIZE DISTRIBUTION

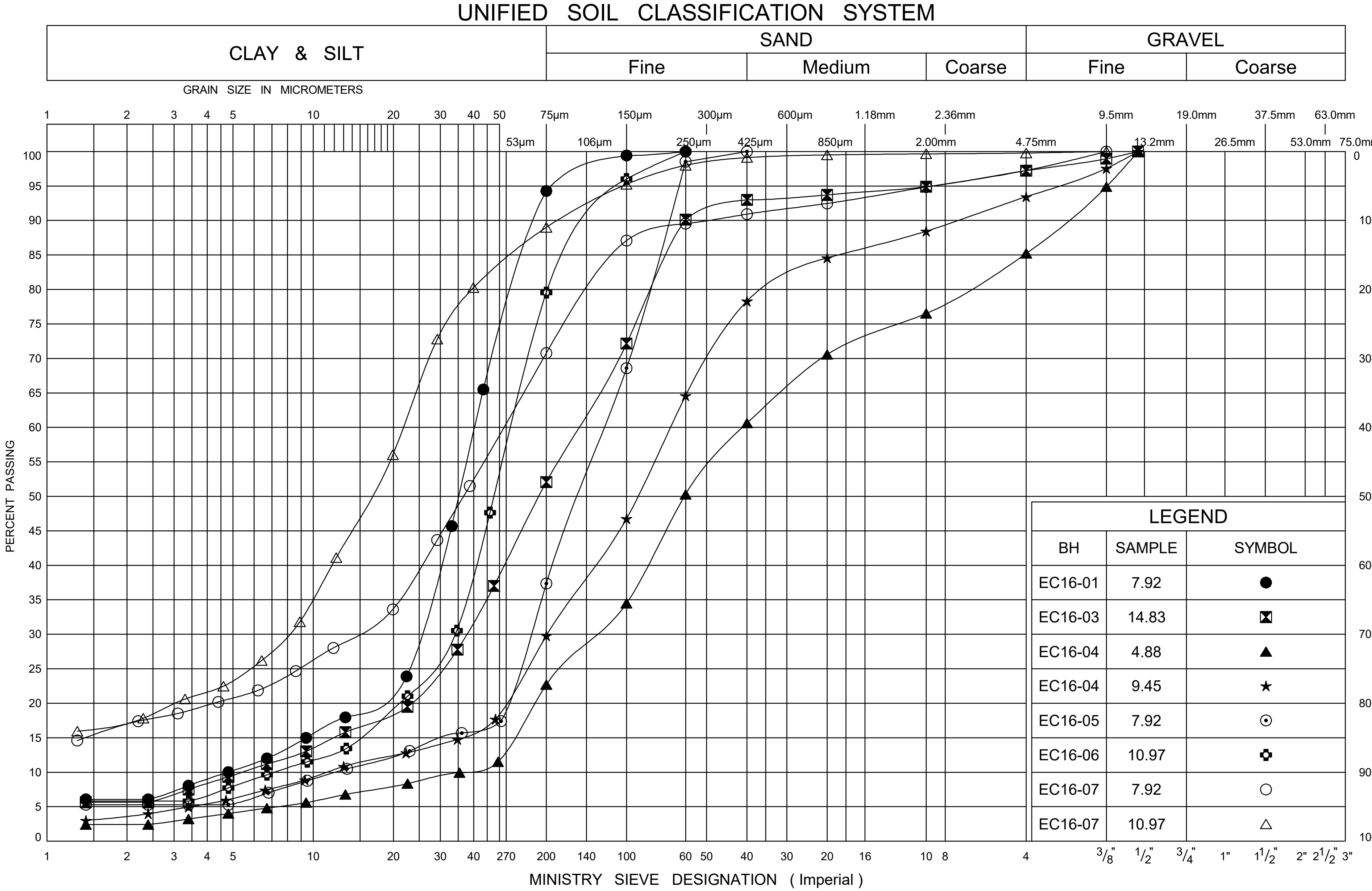
Upper Silt to Silty Sand

FIG No B3

W P 408-88-00

Ellis Creek

78 12 M



BH	SAMPLE	SYMBOL
EC16-01	7.92	●
EC16-03	14.83	⊠
EC16-04	4.88	▲
EC16-04	9.45	★
EC16-05	7.92	⊙
EC16-06	10.97	✿
EC16-07	7.92	○
EC16-07	10.97	△

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GRAIN SIZE DISTRIBUTION

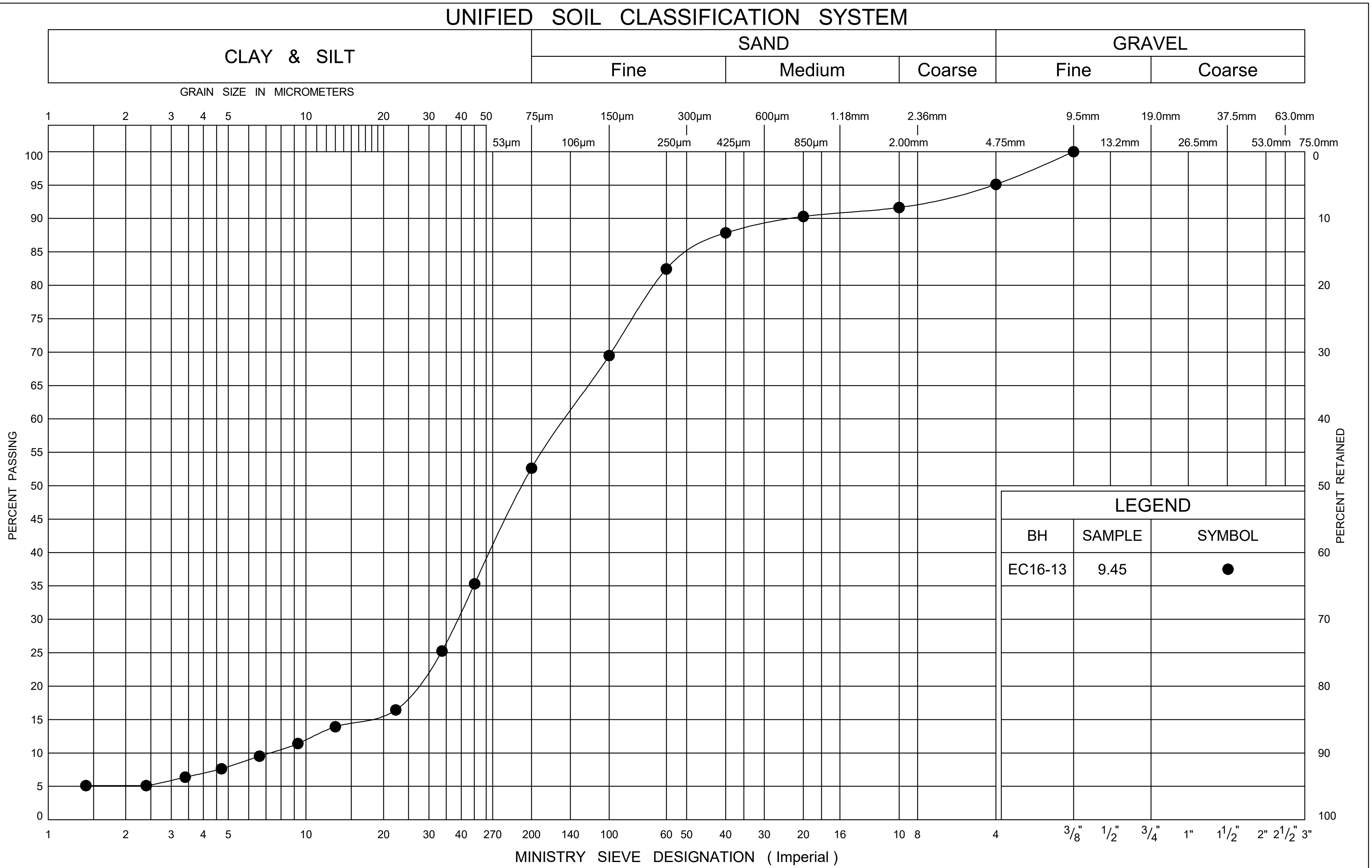
Lower Silt to Silty Sand

FIG No B4

W P 408-88-00

Ellis Creek

78 12 M



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Ontario

GRAIN SIZE DISTRIBUTION

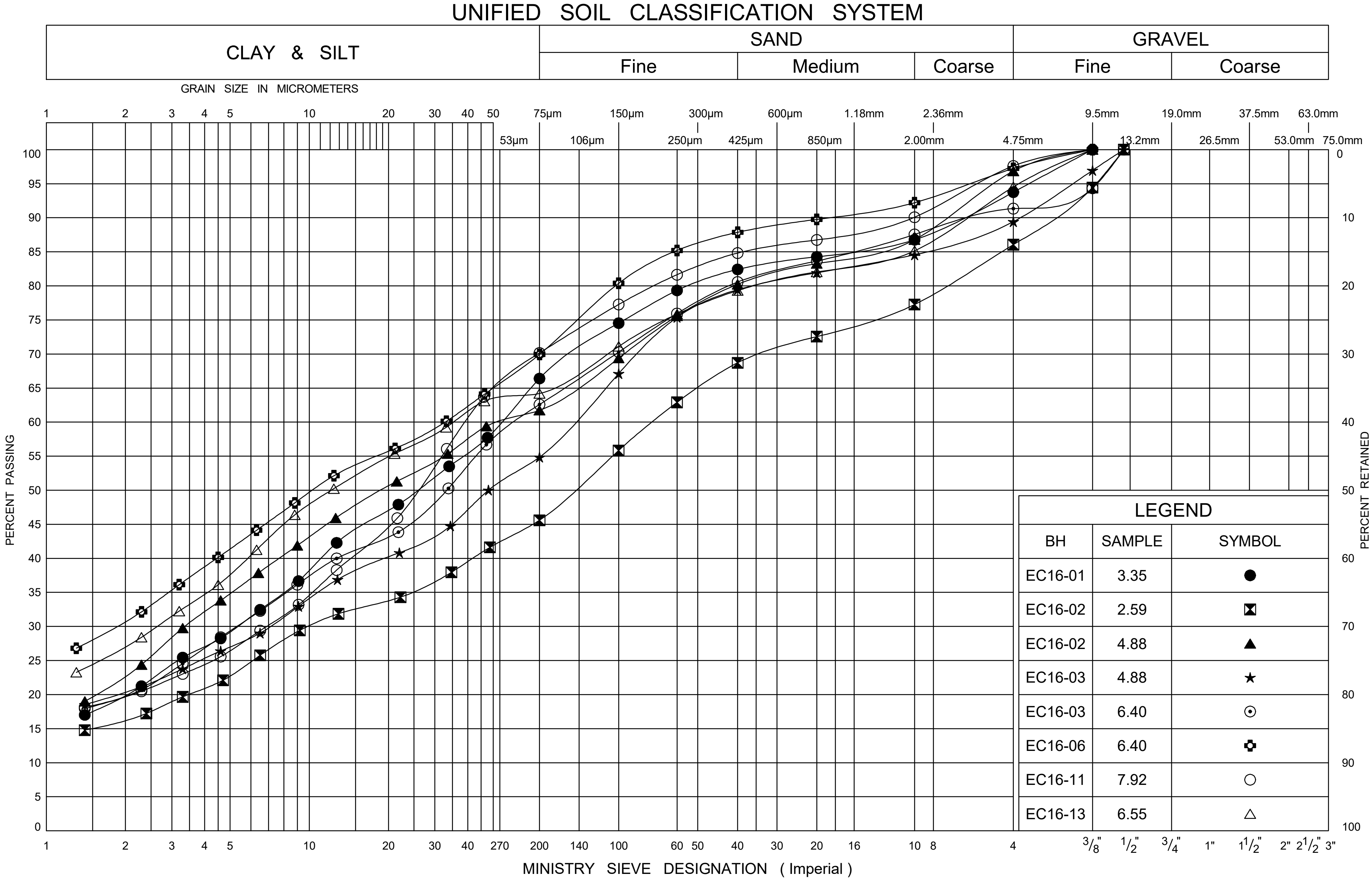
Lower Silt to Silty Sand

FIG No B5

W P 408-88-00

Ellis Creek

ONTARIO MOT GRAIN SIZE MTO-11375.GPJ ONTARIO MOT.GDT 11/9/18



LEGEND

BH	SAMPLE	SYMBOL
EC16-01	3.35	●
EC16-02	2.59	⧗
EC16-02	4.88	▲
EC16-03	4.88	★
EC16-03	6.40	⊙
EC16-06	6.40	✿
EC16-11	7.92	○
EC16-13	6.55	△

Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

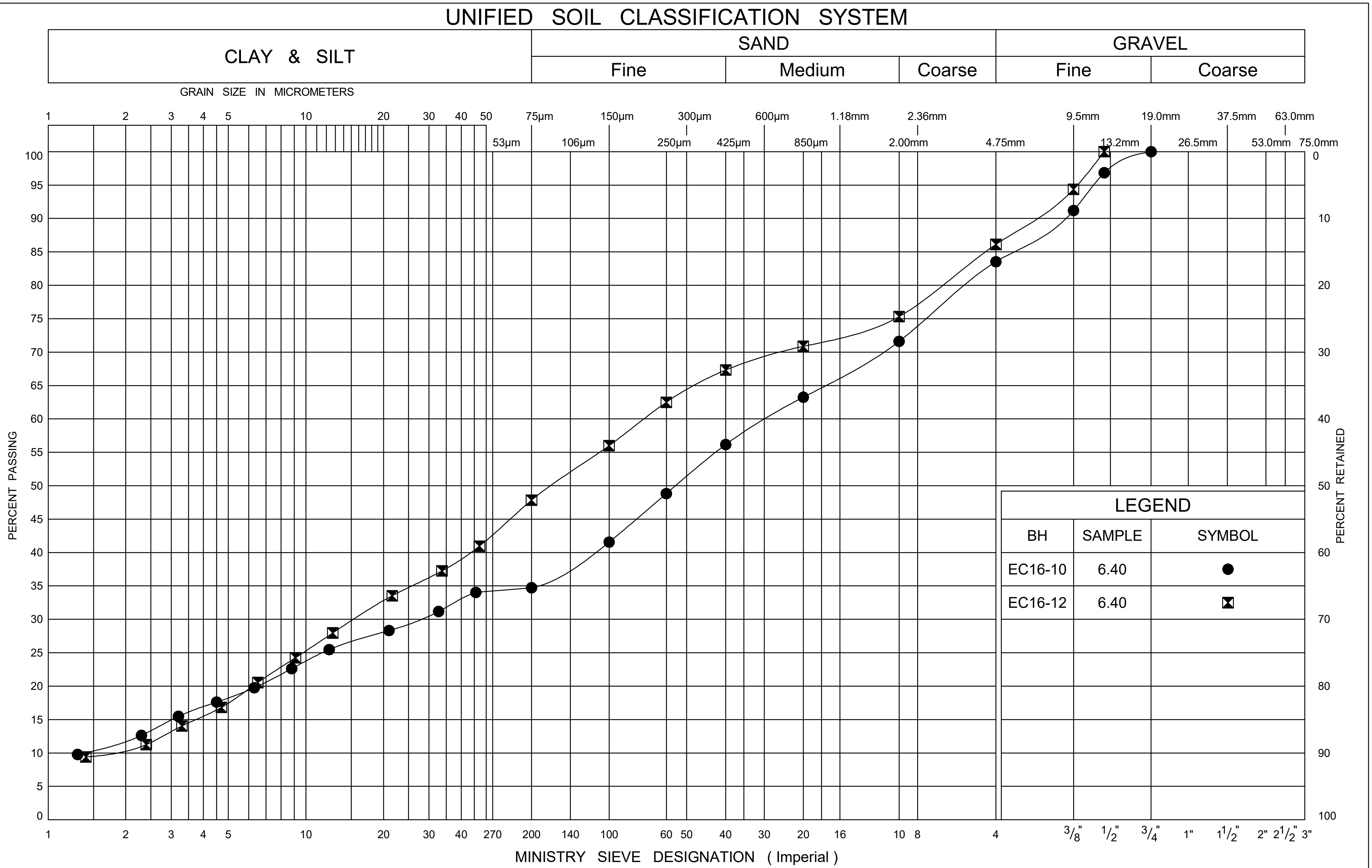
Silty Clay Till

FIG No B6

W P 408-88-00

Ellis Creek

78 12 M



BH	SAMPLE	SYMBOL
EC16-10	6.40	●
EC16-12	6.40	⧗

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GRAIN SIZE DISTRIBUTION

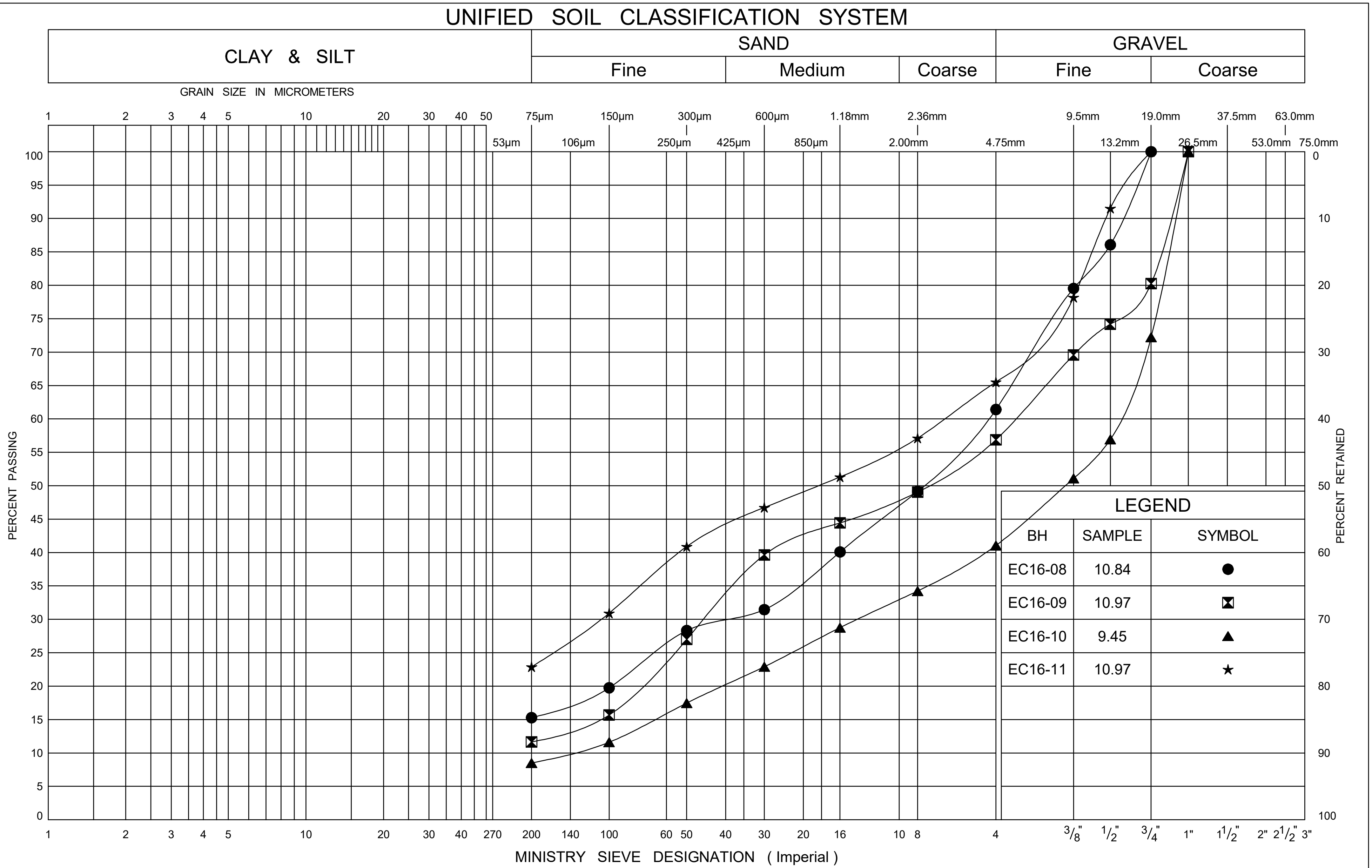
Sand and Silt to Silty Sand Till

FIG No B7

W P 408-88-00

Ellis Creek

ONTARIO MOT GRAIN SIZE MTO-11375.GPJ ONTARIO MOT.GDT 11/9/18



LEGEND

BH	SAMPLE	SYMBOL
EC16-08	10.84	●
EC16-09	10.97	⊠
EC16-10	9.45	▲
EC16-11	10.97	★

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GRAIN SIZE DISTRIBUTION

Lower Sand and Gravel

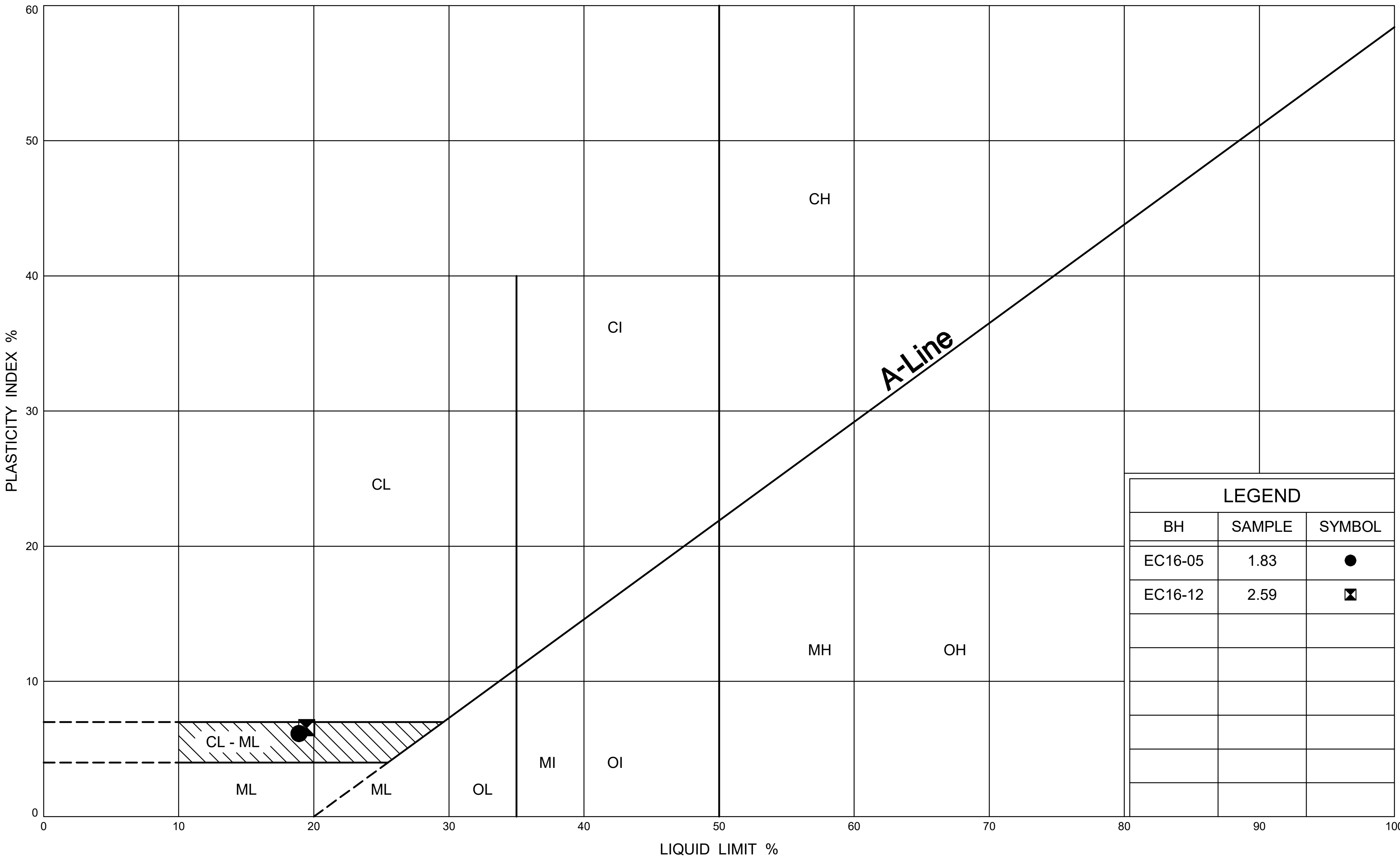
FIG No B8

W P 408-88-00

Ellis Creek

ONTARIO MOT GRAIN SIZE MTO-11375.GPJ ONTARIO MOT.GDT 11/9/18

Oct 75, FF - S - 21



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PLASTICITY CHART

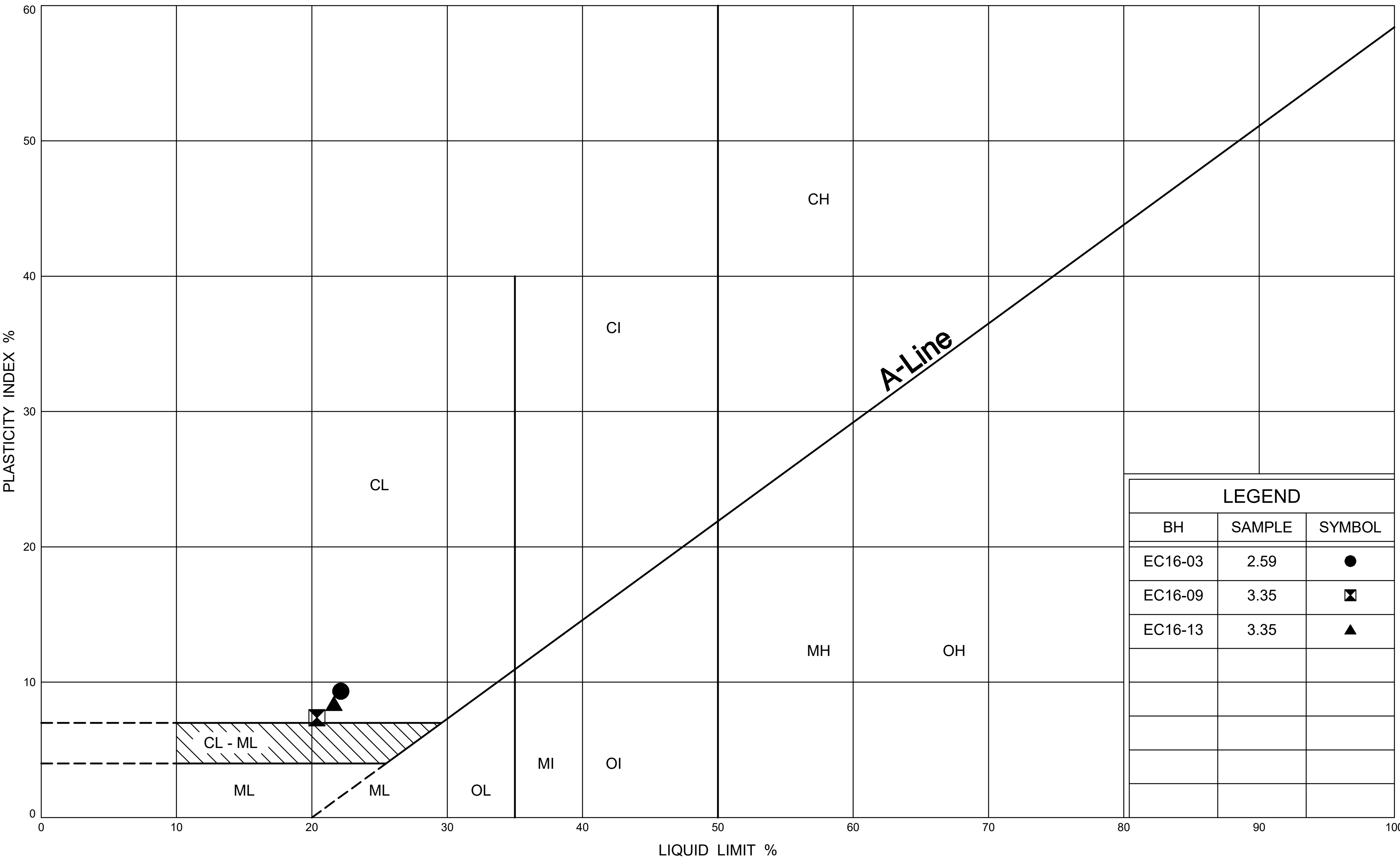
Upper Silt to Silty Sand (Clayey Zones)

FIG No B9

W P 408-88-00

Ellis Creek

Oct 75, FF - S - 21



LEGEND

BH	SAMPLE	SYMBOL
EC16-03	2.59	●
EC16-09	3.35	⧗
EC16-13	3.35	▲

Ministry of Transportation
Ontario

PLASTICITY CHART

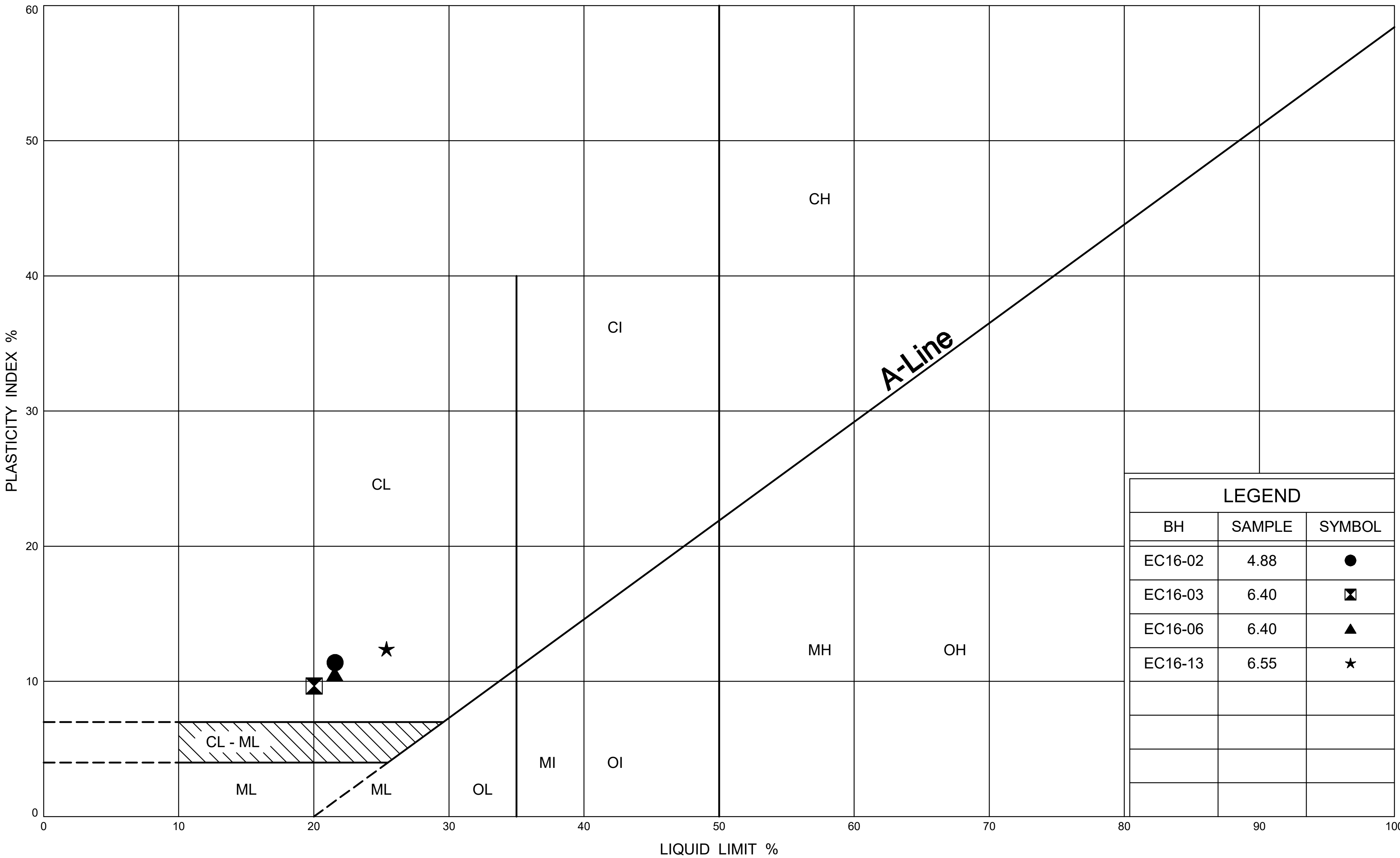
Silty Clay

FIG No B10

W P 408-88-00

Ellis Creek

ONTARIO MOT PLASTICITY CHART MTO-11375.GPJ ONTARIO MOT.GDT 11/9/18



LEGEND		
BH	SAMPLE	SYMBOL
EC16-02	4.88	●
EC16-03	6.40	⧗
EC16-06	6.40	▲
EC16-13	6.55	★

Ministry of Transportation
Ontario

PLASTICITY CHART

Silty Clay Till

FIG No B11

W P 408-88-00

Ellis Creek

THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No:	11375	**Date Drilled:**	19-Jan-18
Client:	WSP	**Date Tested:**	25-Jan-18
Project Name:	Hwy 7-New Ellis Creek Bridges	**Tester:**	KF
Core Size:	NQ **BH No :** EC16-04	**Reviewed by:**	

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	14.5	D	19.6	46.8	78.3	8.2	197.2	Dolostone	Very Strong
2	2	15.0	D	21.1	46.9	114.4	8.8	212.3	Dolostone	Very Strong
3	2	15.5	D	20.5	47.2	97.3	8.5	203.8	Dolostone	Very Strong
4	3	16.6	D	30.2	47.3	103.0	12.5	299.5	Dolostone	Extremely Strong
5	3	17.4	D	20.2	47.1	94.1	8.4	201.3	Dolostone	Very Strong
6										
7										
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* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
Long pieces of core can be tested diametrically to produce suitable lengths for axial testing
* Diametral Test should have 0.7 x D on either side of test point.
* Correlation factor to obtain UCS values is 24.

THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No:	11375	**Date Drilled:**	18-Jan-18
Client:	WSP	**Date Tested:**	22-Jan-18
Project Name:	Hwy 7-New Ellis Creek Bridges	**Tester:**	KF
Core Size:	NQ **BH No :** EC16-05	**Reviewed by:**	

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	13.3	D	16.9	47.0	78.6	7.0	169.1	Dolostone	Very Strong
2	2	13.6	A	17.5	47.5	52.5	5.5	132.2	Dolostone	Very Strong
3	2	14.7	D	16.3	47.3	82.0	6.7	161.9	Dolostone	Very Strong
4	3	16.1	D	18.0	47.4	138.3	7.4	177.7	Dolostone	Very Strong
5										
6										
7										
8										
9										
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34										
35										

* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

* Diametral Test should have 0.7 x D on either side of test point.

* Correlation factor to obtain UCS values is 24.

THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No:	11375	**Date Drilled:**	17-Jan-18
Client:	WSP	**Date Tested:**	22-Jan-18
Project Name:	Hwy 7-New Ellis Creek Bridges	**Tester:**	KF
Core Size:	NQ **BH No :** EC16-06	**Reviewed by:**	

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	14.7	D	20.7	46.9	88.8	8.7	208.7	Dolostone	Very Strong
2	1	15.5	D	16.3	47.2	107.5	6.7	161.6	Dolostone	Very Strong
3	2	16.3	D	14.6	47.3	131.5	6.1	145.3	Dolostone	Very Strong
4	2	17.0	D	17.5	47.5	179.4	7.2	172.2	Dolostone	Very Strong
5										
6										
7										
8										
9										
10										
11										
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34										
35										

* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

* Diametral Test should have 0.7 x D on either side of test point.

* Correlation factor to obtain UCS values is 24.

THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No:	11375	**Date Drilled:**	09-Jul-18
Client:	WSP	**Date Tested:**	17-Jul-18
Project Name:	Hwy 7-New Ellis Creek Bridges	**Tester:**	BS
Core Size:	HQ **BH No :** EC16-07	**Reviewed by:**	

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	12.6	D	15.1	62.4	64.5	4.1	97.4	Dolostone	Strong
2	1	13.2	D	16.4	62.3	62.3	4.4	106.1	Dolostone	Very Strong
3	1	13.8	D	22.5	62.4	67.7	6.0	145.1	Dolostone	Very Strong
4	2	14.2	D	4.1	62.4	61.5	1.1	26.2	Dolostone	Medium Strong
5	2	14.8	D	22.1	62.3	66.0	5.9	142.8	Dolostone	Very Strong
6										
7										
8										
9										
10										
11										
12										
13										
14										
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31										
32										
33										
34										
35										

* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

* Diametral Test should have 0.7 x D on either side of test point.

* Correlation factor to obtain UCS values is 24.

Last Modified: September 14, 2016

THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No: 11375
Date Drilled: 10-Jul-18
Client: WSP
Date Tested: 17-Jul-18
Project Name: Hwy 7-New Ellis Creek Bridges
Tester: BS
Core Size: HQ **BH No :** EC16-08
Reviewed by:

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	2	13.8	D	18.7	62.4	63.5	5.0	120.7	Dolostone	Very Strong
2	2	14.4	D	16.1	62.3	62.0	4.4	104.5	Dolostone	Very Strong
3	3	15.2	D	24.5	62.2	64.3	6.6	158.8	Dolostone	Very Strong
4										
5										
6										
7										
8										
9										
10										
11										
12										
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16										
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31										
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33										
34										
35										

* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

* Diametral Test should have 0.7 x D on either side of test point.

* Correlation factor to obtain UCS values is 24.

FINAL REPORT

CA14445-AUG18 R1

11375

Prepared for

Thurber Engineering Ltd.

FINAL REPORT

First Page

CLIENT DETAILS		LABORATORY DETAILS	
Client	Thurber Engineering Ltd.	Project Specialist	Deanna Edwards, B.Sc, C.Chem
		Laboratory	SGS Canada Inc.
Address	103, 2010 Winston Park Drive Oakville, ON L6H 5R7, Canada	Address	185 Concession St., Lakefield ON, K0L 2H0
Contact	Rocío Palomeque	Telephone	705-652-2000
Telephone	905-829-8666 x 263	Facsimile	705-652-6365
Facsimile		Email	deanna.edwards@sgs.com
Email	rreyna@thurber.ca	SGS Reference	CA14445-AUG18
Project	11375	Received	08/16/2018
Order Number		Approved	08/23/2018
Samples	Soil (5)	Report Number	CA14445-AUG18 R1
		Date Reported	08/23/2018

COMMENTS

Temperature of Sample upon Receipt: 6 degrees C

Cooling Agent Present.

Custody Seal Present&intact.

Corrosivity Index is based on the American Water Works Corrosivity Scale according to AWWA C-105. An index greater than 10 indicates the soil matrix may be corrosive to cast iron alloys.

SIGNATORIES

Deanna Edwards, B.Sc, C.Chem

TABLE OF CONTENTS

FINAL REPORT

Client: Thurber Engineering Ltd.
Project: 11375
Project Manager: Rocío Palomeque
Samplers: N/A

PACKAGE: **- Corrosivity Index** (SOIL)

			Sample Number	5	6	7	8	9
			Sample Name	RS16-03-SS4	RW7-01-SS3	RW1-04-SS2	NE16-10 SS4	EC16-08 SS3
			Sample Matrix	Soil	Soil	Soil	Soil	Soil
			Sample Date	18/05/2018	05/06/2018	06/06/2018	27/04/2018	27/04/2018
Parameter	**Units**	**RL**		**Result**	**Result**	**Result**	**Result**	**Result**
Corrosivity Index								
Corrosivity Index	none	1		4.0	4.0	6.5	4.0	4.5
Soil Redox Potential	mV	-		246	362	187	205	169
Sulphide	%	0.02		< 0.02	< 0.02	0.04	< 0.02	0.86
pH	no unit	0.05		8.87	9.36	10.7	9.02	8.15
Resistivity (calculated)	ohms.cm	-9999		3320	10500	4120	4070	4410

PACKAGE: **- General Chemistry** (SOIL)

			Sample Number	5	6	7	8	9
			Sample Name	RS16-03-SS4	RW7-01-SS3	RW1-04-SS2	NE16-10 SS4	EC16-08 SS3
			Sample Matrix	Soil	Soil	Soil	Soil	Soil
			Sample Date	18/05/2018	05/06/2018	06/06/2018	27/04/2018	27/04/2018
Parameter	**Units**	**RL**		**Result**	**Result**	**Result**	**Result**	**Result**
General Chemistry								
Conductivity	uS/cm	2		301	95	243	246	227

PACKAGE: **- Metals and Inorganics** (SOIL)

			Sample Number	5	6	7	8	9
			Sample Name	RS16-03-SS4	RW7-01-SS3	RW1-04-SS2	NE16-10 SS4	EC16-08 SS3
			Sample Matrix	Soil	Soil	Soil	Soil	Soil
			Sample Date	18/05/2018	05/06/2018	06/06/2018	27/04/2018	27/04/2018
Parameter	**Units**	**RL**		**Result**	**Result**	**Result**	**Result**	**Result**
Metals and Inorganics								
Moisture Content	%	0.1		19.4	3.0	7.6	11.0	13.9
Sulphate	µg/g	0.4		70	6.6	270	9.1	710

FINAL REPORT

CA14445-AUG18 R1

Client: Thurber Engineering Ltd.
Project: 11375
Project Manager: Rocío Palomeque
Samplers: N/A

PACKAGE: **- Other (ORP)** (SOIL)

			Sample Number	5	6	7	8	9
			Sample Name	RS16-03-SS4	RW7-01-SS3	RW1-04-SS2	NE16-10 SS4	EC16-08 SS3
			Sample Matrix	Soil	Soil	Soil	Soil	Soil
			Sample Date	18/05/2018	05/06/2018	06/06/2018	27/04/2018	27/04/2018
Parameter	**Units**	**RL**		**Result**	**Result**	**Result**	**Result**	**Result**
Other (ORP)								
Chloride	µg/g	0.4		240	13	60	130	4.4

FINAL REPORT

QC SUMMARY

Anions by IC

Method: EPA300/MA300-Ions1.3 | Internal ref.: ME-CA-[ENV]IC-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Chloride	DIO0280-AUG18	µg/g	0.4	<0.4	2	20	96	80	120	97	75	125
Sulphate	DIO0280-AUG18	µg/g	0.4	<0.4	5	20	97	80	120	81	75	125

Carbon/Sulphur

Method: ASTM E1915-07A | Internal ref.: ME-CA-[ENV]ARD-LAK-AN-020

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Sulphide	ECS0022-AUG18	%	0.02	<0.02	99	20	99	80	120			

Conductivity

Method: SM 2510 | Internal ref.: ME-CA-[ENV]EWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Conductivity	EWL0253-AUG18	uS/cm	2	< 0.002	0	10	99	90	110	NA		

QC SUMMARY

pH

Method: SM 4500 I Internal ref.: ME-CA-[ENV]EWL-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
pH	EWL0253-AUG18	no unit	0.05	NA	0		101			NA		

Method Blank: a blank matrix that is carried through the entire analytical procedure. Used to assess laboratory contamination.

Duplicate: Paired analysis of a separate portion of the same sample that is carried through the entire analytical procedure. Used to evaluate measurement precision.

LCS/Spike Blank: Laboratory control sample or spike blank refer to a blank matrix to which a known amount of analyte has been added. Used to evaluate analyte recovery and laboratory accuracy without sample matrix effects.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate laboratory accuracy with sample matrix effects.

Reference Material: a material or substance matrix matched to the samples that contains a known amount of the analyte of interest. A reference material may be used in place of a matrix spike.

RL: Reporting limit

RPD: Relative percent difference

AC: Acceptance criteria

Multielement Scan Qualifier: as the number of analytes in a scan increases, so does the chance of a limit exceedance by random chance as opposed to a real method problem. Thus, in multielement scans, for the LCS and matrix spike, up to 10% of the analytes may exceed the quoted limits by up to 10% absolute and the spike is considered acceptable.

Duplicate Qualifier: for duplicates as the measured result approaches the RL, the uncertainty associated with the value increases dramatically, thus duplicate acceptance limits apply only where the average of the two duplicates is greater than five times the RL.

Matrix Spike Qualifier: for matrix spikes, as the concentration of the native analyte increases, the uncertainty of the matrix spike recovery increases. Thus, the matrix spike acceptance limits apply only when the concentration of the matrix spike is greater than or equal to the concentration of the native analyte.

LEGEND

FOOTNOTES

NSS Insufficient sample for analysis.
RL Reporting Limit.
↑ Reporting limit raised.
↓ Reporting limit lowered.
NA The sample was not analysed for this analyte
ND Non Detect

Samples analysed as received. Solid samples expressed on a dry weight basis. “Temperature Upon Receipt” is representative of the whole shipment and may not reflect the temperature of individual samples.

Analysis conducted on samples submitted pursuant to or as part of Reg. 153/04, are in accordance to the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act” published by the Ministry and dated March 9, 2004 as amended.

-- End of Analytical Report --

SGS

Request for Laboratory Services and CHAIN OF CUSTODY

No: 00864

Page 1 of 1

SGS Environment, Health and Safety

- Lakefield: 185 Concession St., Lakefield, ON K0L 2H0 Phone: 705-652-2000 Toll Free: 877-747-7658 Fax: 705-652-6365
- London: 657 Consortium Court, London, ON, N6E 2S8 Phone: 519-672-4500 Toll Free: 877-848-8060 Fax: 519-672-0361 Web: www.ca.sgs.com

Laboratory Information Section - Lab use only

Received By: Julio Coll

Received Date: 08/16/18 (mm\dd\yy)

Received Time: 12 : 00 am / pm (circle)

Received By (signature): [signature]

Custody Seal Present: Y / N (circle)

Custody Seal Intact: Y / N

Cooling Agent Present: Y / N Type:

Temperature Upon Receipt (°C) 13,14,12

LAB LIMS #: CA 14445-AUG18

6x3

REPORT INFORMATION

Company: Thurber Engineering Ltd.

Contact: Rocio Palomeque Reyna

Address: 103-2010 Winston Park Dr. Oakville, ON L6H 5R7

Phone: 905-829-8666 x260

Fax: rreyna@thurber.ca

Email: [redacted]

INVOICE INFORMATION

☐ (same as Report Information)

Company:

Contact:

Address:

Phone:

Email:

PROJECT INFORMATION

Quotation #: P.O. #:

Project #: 11375 Site Location/ID:

TURNAROUND TIME (TAT) REQUIRED

☑ Regular TAT (5-7days)

TAT's are quoted in business days (exclude statutory holidays & weekends). Samples received after 3pm or on weekends : TAT begins the next business day

RUSH TAT (Additional Charges May Apply) ☐ 1 Day ☐ 2 Days ☐ 3-4 Days

PLEASE CONFIRM RUSH FEASIBILITY WITH SGS REPRESENTATIVE PRIOR TO SUBMISSION

Specify Due Date: Rush Confirmation ID:

DRINKING WATER SAMPLES (POTABLE WATER FOR HUMAN CONSUMPTION) MUST BE SUBMITTED WITH SGS DRINKING WATER CHAIN OF CUSTODY

REGULATIONS

Regulation 153 (2011):

☐ Table 1 ☐ Res/Park Soil Texture:
☐ Table 2 ☐ Ind/Com ☐ Coarse
☐ Table 3 ☐ Agri/Other ☐ Medium
☐ Table ____ ☐ Fine

Other Regulations:

☐ Reg 347/558 (3 Day min TAT)
☐ PWQO ☐ MMER
☐ CCME ☐ Other:
☐ MISA

Sewer By-Law:

☐ Sanitary
☐ Storm

Municipality:

RECORD OF SITE CONDITION (RSC) ☐ YES ☐ NO

ANALYSIS REQUESTED

	SAMPLE IDENTIFICATION	DATE SAMPLED	TIME SAMPLED	# OF BOTTLES	MATRIX	Corrosivity	COMMENTS: Field Filtered (F) Preserved (P)
1	RS16-03 - SS4	May 18, 2018		1	Soil	✓	
2							
3	RW7-01 -SS3	June 5, 2018		1	Soil	✓	
4							
5	RW1-04 -SS2	June 6, 2018		1	Soil	✓	
6							
7	NE16-10 SS4	April 27, 2018		1	Soil	✓	
8							
9	EC16-08 SS3	July 10, 2018		1	Soil	✓	
10							

Observations/Comments/Special Instructions

Sampled By (NAME): Signature: [signature] Date: 08 / 15 / 2018 (mm/dd/yy) Pink Copy - Client

Relinquished by (NAME): Signature: Date: __ / __ / __ (mm/dd/yy) Yellow & White Copy - SGS

Revision #: 1.1
Date of Issue: 25 July, 2016

SGS

SAMPLE INTEGRITY REPORT

Project Number: 11375

ONTARIO REGULATION 153/04

SGS Sample ID CA14445-Aug18

Date / Time Sampled see CofC

Client Sample ID

ALL

Sample Submission General Sample Integrity Violations

Temperature >10 C upon receipt if not sampled same day	☐
No evidence of cooling trend initiated if sampled same day	☐
Chain of Custody not submitted	☐
Chain of Custody incomplete	☐
Chain of Custody not signed / dated	☑
Chain of Custody not a current version	☐
Bottles / Samples listed on CoC but not received	☐
Bottles / Samples received but not listed on the CoC	☐
Sample container received empty	☐

Sample Specific Sample Integrity Violations

Sample received past hold time	☐	☐	☐	☐	☐	☐	☐
Incorrect preservation (including no preservation where required)	☐	☐	☐	☐	☐	☐	☐
Headspace present in VOC vial (aqueous)	☐	☐	☐	☐	☐	☐	☐
Sample(s) received frozen	☐	☐	☐	☐	☐	☐	☐
Bottle(s) broken or damaged in transport	☐	☐	☐	☐	☐	☐	☐
Discrepancy between sample label and chain of custody	☐	☐	☐	☐	☐	☐	☐
Analysis requirements absent / unclear	☐	☐	☐	☐	☐	☐	☐
Missing or incorrect sample label(s)	☐	☐	☐	☐	☐	☐	☐
Inappropriate sample container used	☐	☐	☐	☐	☐	☐	☐
Insufficient number of bottles received	☐	☐	☐	☐	☐	☐	☐
Limited sample volume	☐	☐	☐	☐	☐	☐	☐
Insufficient sample volume	☐	☐	☐	☐	☐	☐	☐
Sample contains multiple phases	☐	☐	☐	☐	☐	☐	☐

Sediment Log

Groundwater samples contain visible sediment / particulate	☐	☐	☐	☐	☐	☐	☐
Groundwater contains greater than 1cm of sediment / particulate matter in bottle	☐	☐	☐	☐	☐	☐	☐

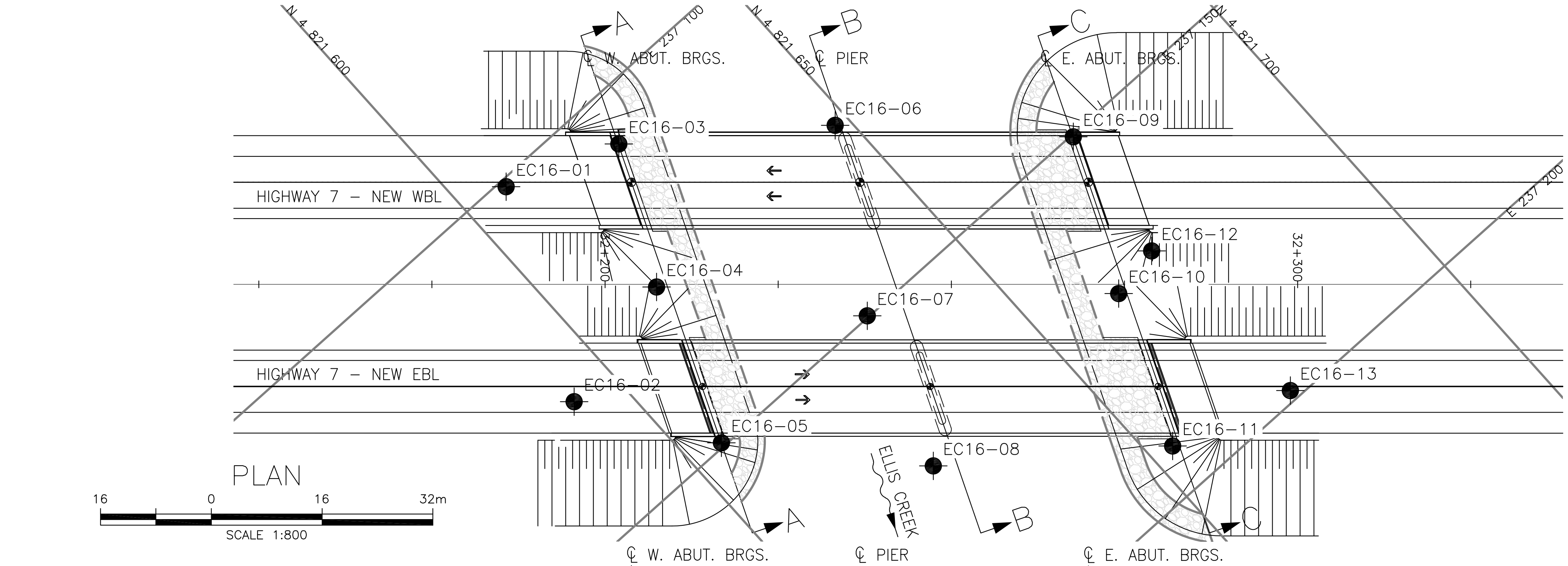
Additional Comments/Remarks:

No issues upon receipt ☐ Initials: KH

THURBER

Appendix C

Borehole Locations and Soil Strata Drawings

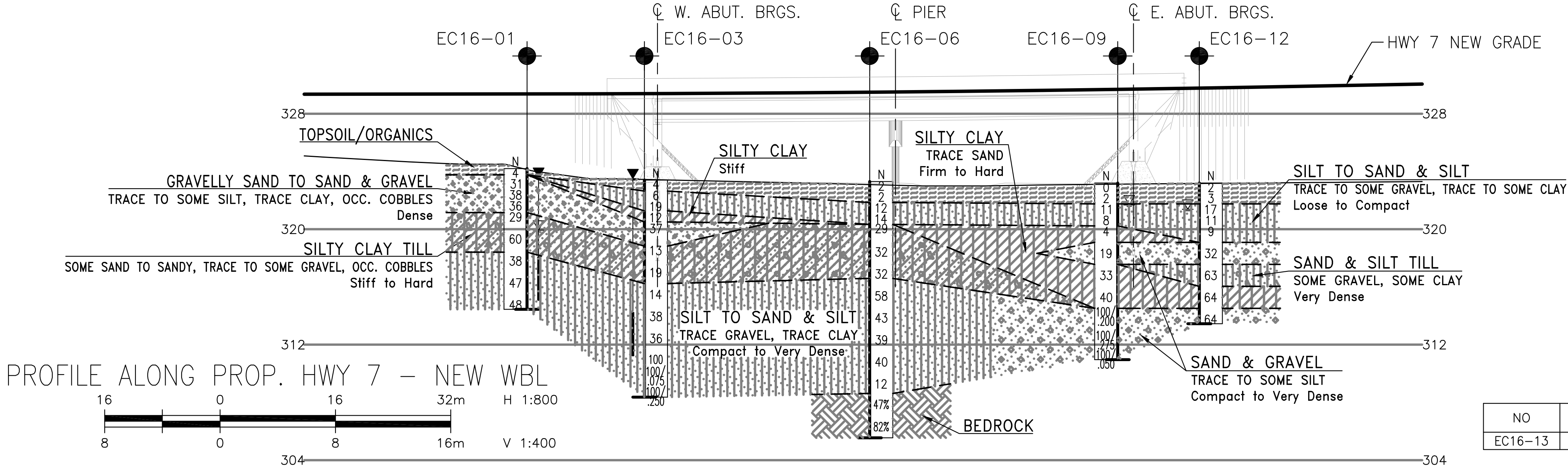


METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
05/01/2020
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
J.P.K. LEE
100086735
05/01/2020
PROVINCE OF ONTARIO



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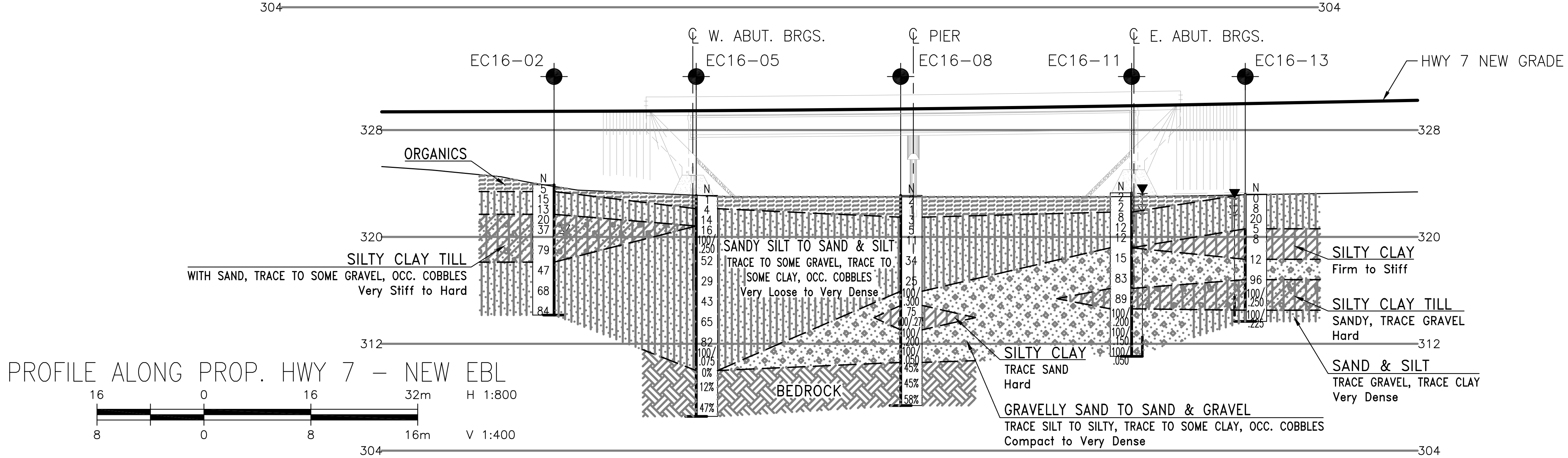
EC16-13	323.2	4 821 671.4	237 198.6



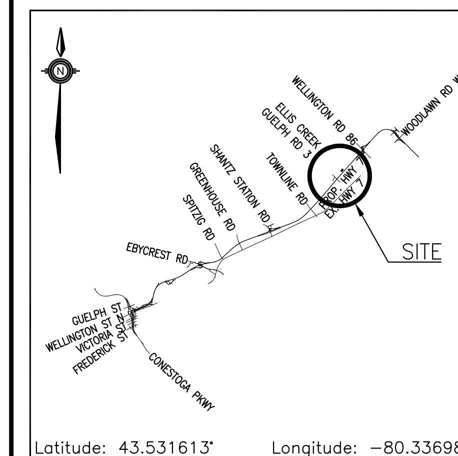
CONT No
GWP No 408-88-00

HIGHWAY 7 – NEW
ELLIS CREEK
PROPOSED BRIDGE
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

wsp

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

●	Borehole (Current Investigation)
⊕	Borehole (2008 Investigation)
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
EC16-01	324.2	4 821 606.7	237 101.1
EC16-02	323.9	4 821 593.3	237 130.8
EC16-03	323.4	4 821 622.9	237 107.3
EC16-04	323.3	4 821 613.2	237 126.4
EC16-05	323.1	4 821 605.1	237 149.4
EC16-06	323.3	4 821 648.0	237 126.2
EC16-07	323.3	4 821 633.1	237 149.8
EC16-08	323.1	4 821 625.7	237 172.3
EC16-09	323.2	4 821 672.5	237 150.3
EC16-10	323.0	4 821 662.3	237 171.6
EC16-11	323.3	4 821 653.4	237 193.2
EC16-12	323.2	4 821 669.9	237 170.2

-NOTES-

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

GEOCRES No. 40P9-59

REVISIONS	DATE	BY	DESCRIPTION

DESIGN RPR	CHK PKC	CODE	LOAD	DATE MAY 2020
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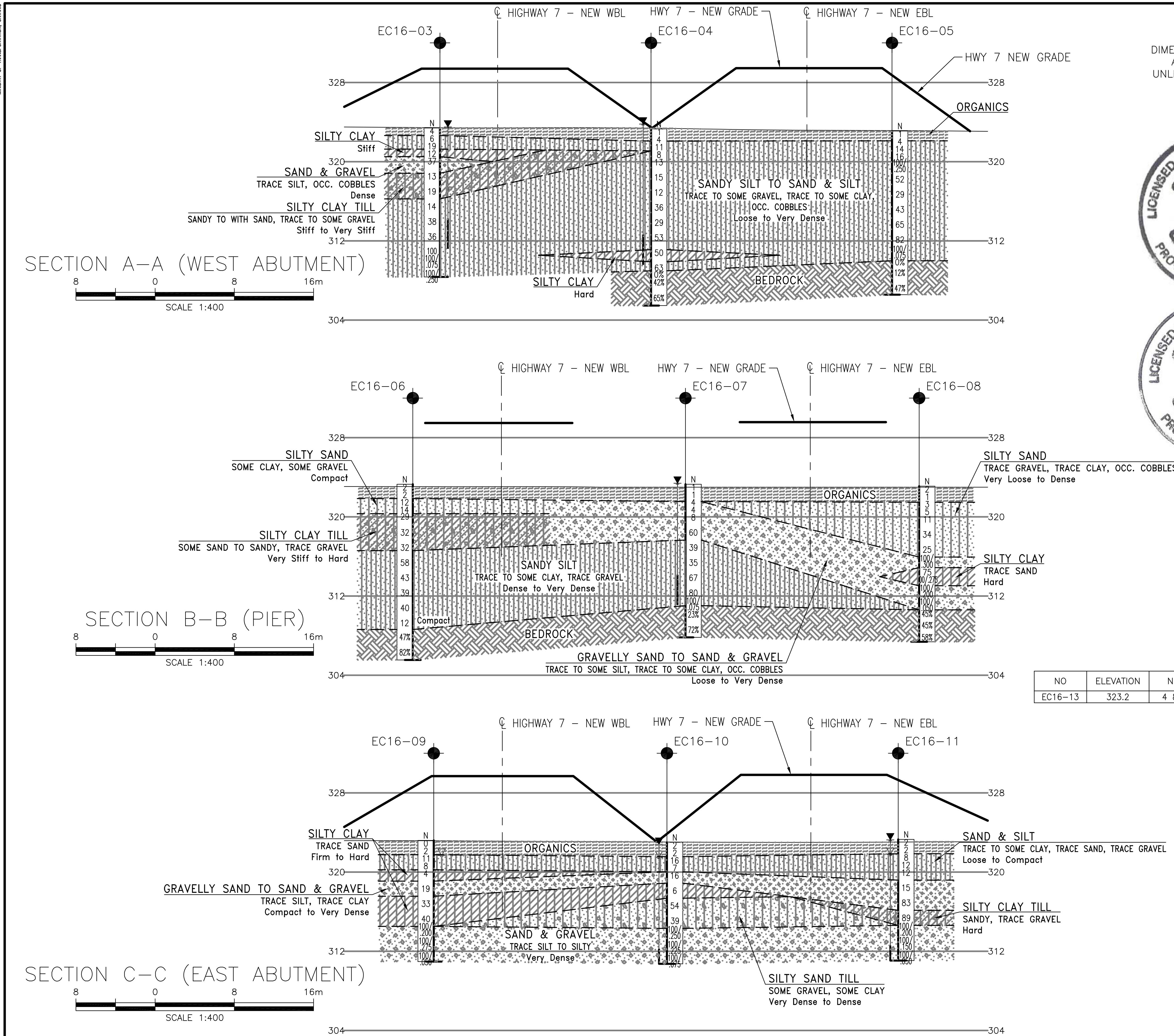
PLOTDATE: 4/30/2020 11:54 AM



METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
05/01/2020
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
J. P. K. LEE
100086735
05/01/2020
PROVINCE OF ONTARIO

NO	ELEVATION	NORTHING	EASTING
EC16–13	323.2	4 821 671.4	237 198.6

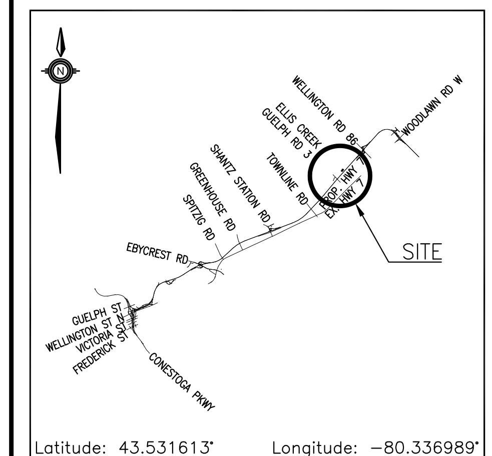
CONT No
GWP No 408–88–00

HIGHWAY 7 – NEW
ELLIS CREEK
PROPOSED BRIDGE
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

wsp

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

(symbol)	Borehole (Current Investigation)
(symbol)	Borehole (2008 Investigation)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60˚ Cone, 475J/blow)
PH	Pressure, Hydraulic
(symbol)	Water Level
(symbol)	Head Artesian Water
(symbol)	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
EC16–01	324.2	4 821 606.7	237 101.1
EC16–02	323.9	4 821 593.3	237 130.8
EC16–03	323.4	4 821 622.9	237 107.3
EC16–04	323.3	4 821 613.2	237 126.4
EC16–05	323.1	4 821 605.1	237 149.4
EC16–06	323.3	4 821 648.0	237 126.2
EC16–07	323.3	4 821 633.1	237 149.8
EC16–08	323.1	4 821 625.7	237 172.3
EC16–09	323.2	4 821 672.5	237 150.3
EC16–10	323.0	4 821 662.3	237 171.6
EC16–11	323.3	4 821 653.4	237 193.2
EC16–12	323.2	4 821 669.9	237 170.2

-NOTES-

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

GEOCRES No. 40P9-59

REVISIONS	DATE	BY	DESCRIPTION		
DESIGN RPR	CHK PKC	CODE	LOAD	DATE MAY 2020	
DRAWN MFA	CHK RPR	SITE	STRUCT	DWG 2	

FILENAME: H:\Drafting\11000\11375\TED-11375-BHPP-EC.dwg
PLOTDATE: 4/30/2020 11:55 AM

THURBER

Appendix D

Foundation Comparison

COMPARISON OF FOUNDATION ALTERNATIVES FOR EACH FOUNDATION ELEMENT

Foundation Element	Spread Footings	Spread Footings on Engineered Fill	Driven Piles	Caisson
Abutments	***Advantages:*** i. Generally less costly construction than deep foundation elements. ***Disadvantages:*** i. Low available geotechnical resistance in native soils. ii. Dewatering will be required. iii. Possible scour and undermining problems for abutments adjacent to the creek. **NOT RECOMMENDED**	***Advantages:*** i. Generally less costly construction than deep foundation elements. ii. Better geotechnical resistance than spread footings on native soils. ***Disadvantages:*** i. Excavation (up to 3.0 m deep) of existing fill will be required to place the engineered fill on competent native soils. ii. Dewatering will be required. iii. Possible scour and undermining problems for abutments adjacent to the creek. **NOT RECOMMENDED**	***Advantages:*** i. High geotechnical resistance may be developed by driving the piles into very dense soils or in the bedrock. ii. Comparatively short abutment stem possible iii. Permits integral abutment design. iv. Readily installed. v. Independent of groundwater conditions. ***Disadvantages:*** i. Higher unit cost compared to footings. ii. When driven into very dense soils or bedrock, pipe piles are more prone to pile tip damage in comparison to H-piles. iii. Construction concerns related to the possibility of piles being obstructed by a boulder during driving. **RECOMMENDED**	***Advantages:*** i. Construction of caissons could continue in freezing weather. ii. High geotechnical resistance available for units founded on very dense soil. ***Disadvantages:*** i. Higher cost than spread footings. ii. Specialized installation measures such as temporary liners and drilling mud will be required to install caissons under the water table. iii. Potential difficulty in cleaning and inspecting bases. **NOT RECOMMENDED**
Pier	***Advantages:*** i. Generally less costly construction than deep foundation elements. ii. High geotechnical resistances available on the very dense native soils. ***Disadvantages:*** i. Dewatering will be required. ii. Construction will be done in the creek, requiring dewatering. iii. Scour and undermining problems for pier constructed in the creek. **NOT RECOMMENDED**	***Advantages:*** i. Generally less costly construction than deep foundation elements. ii. Better geotechnical resistance than spread footings on native soils. ***Disadvantages:*** i. Dewatering will be required. ii. Construction will be done in the creek, requiring dewatering. iii. Scour and undermining problems for pier construction in the creek. **NOT RECOMMENDED**	***Advantages:*** i. High geotechnical resistance may be developed by driving the piles into very dense soils ii. Comparatively short abutment stem possible iii. Readily installed. iv. Independent of groundwater conditions. ***Disadvantages:*** i. Higher unit cost compared to footings. ii. When driven into hard/very dense soils, pipe piles are more prone to pile tip damage in comparison to H-piles. iii. Construction concerns related to the possibility of piles being obstructed by a boulder during driving. **RECOMMENDED**	***Advantages:*** i. Construction of caissons could continue in freezing weather. ii. High geotechnical resistance available for units founded on very dense soil. ***Disadvantages:*** i. Higher cost than spread footings ii. Specialized installation measures such as temporary liners and drilling mud will be required to install caissons under the water table. iii. Potential difficulty in cleaning and inspecting bases. **NOT RECOMMENDED**

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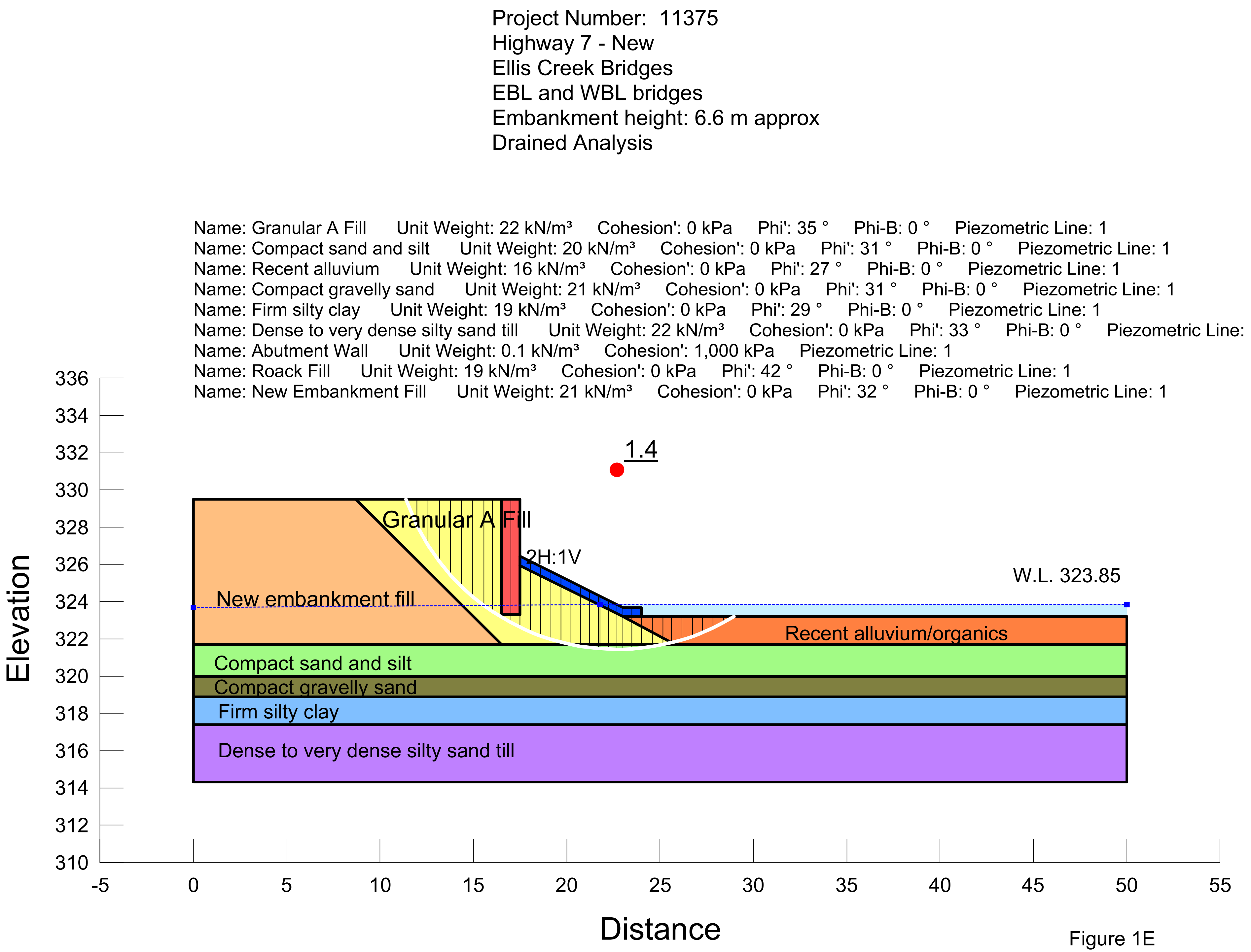
Appendix E

Slope Stability Output



Project Number: 11375
Highway 7 - New
Ellis Creek Bridges
EBL and WBL bridges
Embankment height: 6.6 m approx
Drained Analysis
Name: Granular A Fill Unit Weight: 22 kN/m³ Cohesion': 0 kPa Phi': 35 ° Phi-B: 0 ° Piezometric Line: 1
Name: Compact sand and silt Unit Weight: 20 kN/m³ Cohesion': 0 kPa Phi': 31 ° Phi-B: 0 ° Piezometric Line: 1
Name: Recent alluvium Unit Weight: 16 kN/m³ Cohesion': 0 kPa Phi': 27 ° Phi-B: 0 ° Piezometric Line: 1
Name: Compact gravelly sand Unit Weight: 21 kN/m³ Cohesion': 0 kPa Phi': 31 ° Phi-B: 0 ° Piezometric Line: 1
Name: Firm silty clay Unit Weight: 19 kN/m³ Cohesion': 0 kPa Phi': 29 ° Phi-B: 0 ° Piezometric Line: 1
Name: Dense to very dense silty sand till Unit Weight: 22 kN/m³ Cohesion': 0 kPa Phi': 33 ° Phi-B: 0 ° Piezometric Line: 1
Name: Abutment Wall Unit Weight: 0.1 kN/m³ Cohesion': 1,000 kPa Piezometric Line: 1
Name: Roack Fill Unit Weight: 19 kN/m³ Cohesion': 0 kPa Phi': 42 ° Phi-B: 0 ° Piezometric Line: 1
Name: New Embankment Fill Unit Weight: 21 kN/m³ Cohesion': 0 kPa Phi': 32 ° Phi-B: 0 ° Piezometric Line: 1
1.4
Granular A Fill
2H:1V
W.L. 323.85
New embankment fill
Recent alluvium/organics
Compact sand and silt
Compact gravelly sand
Firm silty clay
Dense to very dense silty sand till
Elevation
336
334
332
330
328
326
324
322
320
318
316
314
312
310
-5
0
5
10
15
20
25
30
35
40
45
50
55
Distance

Figure 1E

Project Number: 11375
Highway 7 - New
Ellis Creek Bridges
EBL and WBL bridges
Embankment height: 6.6 m approx
Undrained Analysis

Name: Granular A Fill Unit Weight: 22 kN/m³ Cohesion': 0 kPa Phi': 35 ° Phi-B: 0 ° Piezometric Line: 1
Name: Compact sand and silt Unit Weight: 20 kN/m³ Cohesion': 0 kPa Phi': 31 ° Phi-B: 0 ° Piezometric Line: 1
Name: Recent alluvium Unit Weight: 16 kN/m³ Cohesion': 0 kPa Phi': 27 ° Phi-B: 0 ° Piezometric Line: 1
Name: Compact gravelly sand Unit Weight: 21 kN/m³ Cohesion': 0 kPa Phi': 31 ° Phi-B: 0 ° Piezometric Line: 1
Name: Firm silty clay Unit Weight: 19 kN/m³ Cohesion': 50 kPa Piezometric Line: 1
Name: Dense to very dense silty sand till Unit Weight: 22 kN/m³ Cohesion': 0 kPa Phi': 33 ° Phi-B: 0 ° Piezometric Line: 1
Name: Abutment Wall Unit Weight: 0.1 kN/m³ Cohesion': 1,000 kPa Piezometric Line: 1
Name: Roack Fill Unit Weight: 19 kN/m³ Cohesion': 0 kPa Phi': 42 ° Phi-B: 0 ° Piezometric Line: 1
Name: New Embankment Fill Unit Weight: 21 kN/m³ Cohesion': 0 kPa Phi': 32 ° Phi-B: 0 ° Piezometric Line: 1

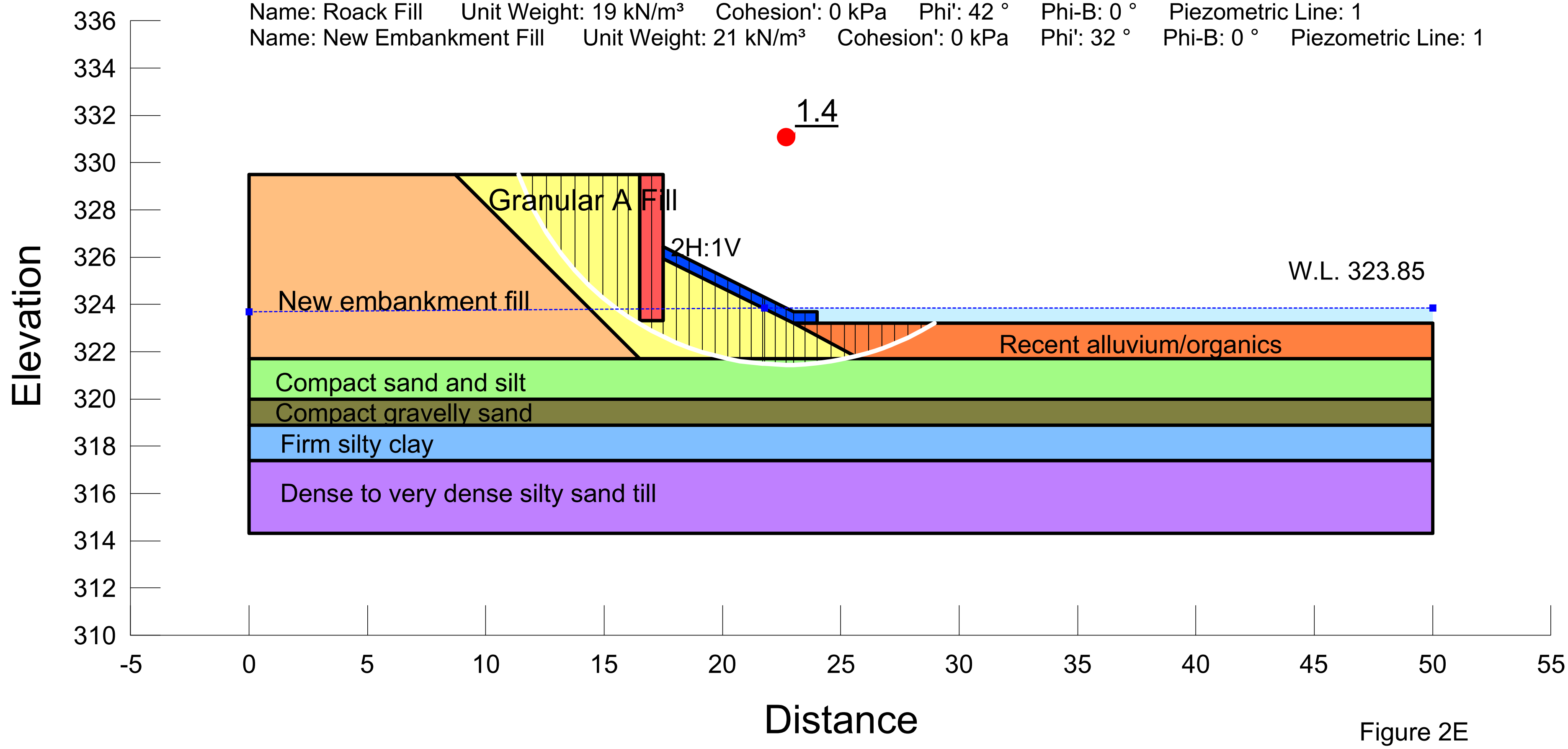


Figure 2E

Project Number: 11375
Highway 7 - New
Ellis Creek Bridges
EBL and WBL bridges
Embankment height: 6.6 m approx
Seismic Analysis PGA=0.078g

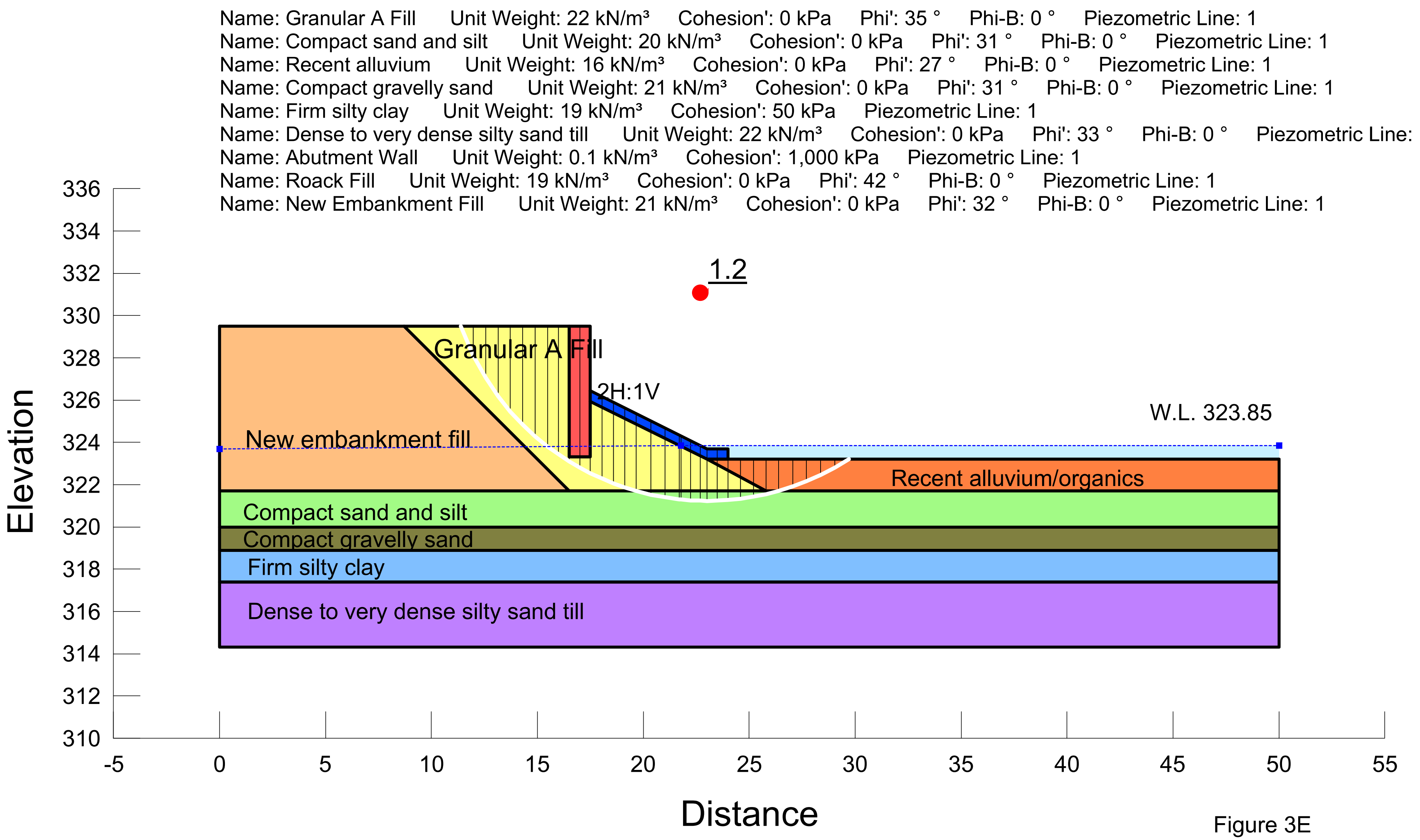


Figure 3E

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Appendix F

List of OPSS Documents and NSSP Wording

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1. List of Special Provisions and OPSS Documents Referenced in this Report

-	OPSS PROV 206	Construction specification for grading
-	OPSS PROV 501	Construction specification for compacting
-	OPSS.PROV 517	Construction specification for dewatering
-	SP 517F01	Amendment to OPSS 517
-	OPSS PROV 539	Construction specification for temporary protection systems
-	OPSS PROV 804	Construction specification for seed and cover
-	OPSS PROV 902	Construction specification for excavating and backfilling - Structures
-	OPSS PROV 903	Construction specification for deep foundations
-	SP 109F57	Amendment to OPSS 903
-	OPSS PROV 1010	Material specification for aggregates - base, subbase, select subgrade, and backfill material
-	OPSD 3102.100	Wall abutments, backfill drain
-	OPSD 208.010	Benching of earth slopes

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2. Suggested text for a NSSP on Pile Installation

The presence of cobbles and boulders will potentially have an impact on the installation of piles at the site. Some possible impacts that must be taken into consideration include, but are not necessarily limited to:

- The cobbles and boulders may impede the driving of the piles resulting in more arduous driving in the very dense soils.
- Some piles may meet refusal on boulders that are large enough not to be dislodged or broken by the pile driving.
- As a result of the presence of boulders, piles may meet refusal at varying depths.
- Pile driving must be controlled according to the criteria specified for the site.

At some locations, steel H-piles driven at this site must be founded on bedrock. All driven piles shall be fitted with cast steel, pile tip protector from an approved manufacturer such as Titus Steel (Standard H-point) or approved equivalent.

3. Suggested Text for NSSP on Groundwater Control

The soils at this site are predominantly cohesionless and will be readily disturbed by unbalanced water heads or by flow of water. Water seepage due to perched water in the slope, random fill, surface runoff and precipitation should be expected. Excavation below the creek and groundwater level will lead to subgrade softening. Artesian conditions were also noted at this site.

Excavations at the abutments will penetrate below the groundwater level. Excavations carried out at the pier locations will penetrate below the groundwater level and below the creek level.

For temporary excavations at the abutments, groundwater control that might be considered to maintain an unwatered condition at this site include sheeted excavation (cofferdam) and/or vacuum well-points. Filtered sumps must be properly designed to control loss of fines/ground loss. Dewatering systems must be installed and made operational prior to excavating below the groundwater level. It is also important to minimize disturbance of the exposed cohesionless till surfaces by limiting construction traffic.

Particular attention must be paid to the design of unwatering systems and shoring systems at the pier locations, which will be constructed in the creek. The overburden soils at this site are generally cohesionless.

The Contractor must design, install and operate systems that shall:

- Unwater the excavations to 0.5 m below the base of excavation
- Control the flow of groundwater, surface water and creek water into the excavations
- Prevent the disturbance of the base of the excavation
- Prevent the sloughing of soil into the excavations.

The selection and design of suitable unwatering and shoring systems shall remain the responsibility of the Contractor. However, factors that might influence the selection and design of unwatering and shoring systems include, but are by no means limited to:

- The probable level of the creek during construction. The selected systems must prevent flooding of the work area due to rising creek levels.
- If a steel sheet pile cofferdam is selected, it will not be possible to drive the sheeting into the bedrock. Accordingly, attention must be paid to developing adequate lateral support for the cofferdam.

In general, effective dewatering shall be designed and provided by the Contractor during excavation to allow the work to proceed in the dry.

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4. Suggested Text for NSSP on Removal of Organics

A layer of very loose to loose soils/organics/alluvum was encountered surficially at this site. Removal and sub-excavation of these very loose to loose soils/organics shall be conducted by the Contractor, to avoid settlement issues at the approach embankments behind the abutments.

5. Suggested Text for NSSP on Embankment Construction

Medium to high plastic clay soils shall not be used for embankment construction.