



THURBER ENGINEERING LTD.

**FOUNDATION INVESTIGATION AND DESIGN REPORT
N-E RAMP/OVERPASS OVER HIGHWAY 85
HIGHWAY 7-NEW, KITCHENER TO GUELPH
G.W.P. 408-88-00**

GEOCRES No. 40P8-283

Latitude 43.466618° , Longitude -80.472576°

Report

to

WSP

Date: August 10, 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 at the site of the proposed N-E Ramp over the existing Highway 85, in the Regional Municipality of Waterloo. The proposed N-E Ramp is part of the Highway 7-New project.

The purpose of the 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, a stratigraphic profile, 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.

Reference has been made to information on subsurface conditions contained in a previous foundation report prepared for this site during the preliminary design phase. The title of the report is:

- Preliminary, Foundation Investigation and Design Report, E-S Ramp over Kitchener Waterloo Expressway and Wellington Street, Highway 7-New, Kitchener to Guelph, G.W.P. 408-88-00, Geocres No. 40P8-161, Report to Ministry of Transportation Ontario West Region, File: 15-64-17, dated June 2, 2009. (Reference 1).

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2. SITE DESCRIPTION

The site lies within the Kitchener-Waterloo Expressway (KWE) and Wellington Street interchange. At this location, the proposed N-E Ramp will cross over Highway 85 (Kitchener Waterloo Expressway) and the proposed S-W Ramp and E-S Ramp.

The site lies within an area of industrial and commercial lands and is generally flat.

Based on the Ontario Geological Survey Special Volume 2, The Physiography of Southern Ontario, Third Edition by Chapman and Putnam, the site lies within the physiographic region known as the Waterloo Hills, characterized by ridges of sandy till kames or kame moraines, with outwash sands occupying the intervening hollows.

3. INVESTIGATION PROCEDURES

A detailed geotechnical investigation was conducted between April 25, 2018 and September 8, 2019 and consisted of drilling seven boreholes (numbered NE16-06 to NE16-12) near the proposed foundation units of the ramp/overpass. The boreholes ranged in depth from 14.1 m to 29.2 m (Elevations 304.0 to 289.4). The Record of Borehole sheets are included in Appendix A.

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. A road occupancy permit was also obtained to complete the site investigation.

During the current investigation, a rubber track-mounted B-57 drill rig was used in conjunction with hollow-stem augers and tricone to advance the boreholes. Samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT) in the overburden soils.

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 for transport to Thurber's laboratory for further examination and testing.

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Results of field drilling and sampling from the investigation are presented on the Record of Borehole sheets in Appendix A.

Groundwater conditions in the open boreholes were observed throughout the drilling operations. In Boreholes NE16-07, and NE16-10, a standpipe piezometer consisting of 19 mm and 25 mm diameter PVC pipe respectively with a slotted screen was installed and enclosed in filter sand to permit longer-term groundwater level monitoring. Boreholes without piezometer installations were backfilled in general accordance with O. Reg. 903. The borehole completion details are also shown in Table 3.1.

The completion of the boreholes were carried out in accordance with the requirements of O. Reg. 903 (as amended by O. Reg. 372/07). The piezometers are planned to be decommissioned in the summer of 2020.

Table 3.1 – Borehole Completion Details

Borehole	Ground Surface Elevation (m)	Borehole Depth / Base Elevation (m)	Piezometer Tip Elevation (m)	Completion Details
NE16-06	318.3	14.3/304.0	None installed	Borehole backfilled with grout to surface.
NE16-07	318.6	29.2/289.4	29.0/289.6	Piezometer with 3.0 m slotted screen installed with a sand filter to 25.6 m, bentonite from 25.6 m to ground surface.
NE16-08	318.4	21.7/296.7	None installed	Borehole backfilled with grout to surface.
NE16-09	318.8	26.0/292.8	None installed	Borehole backfilled with grout and holeplug to surface.
NE16-10	318.8	18.6/300.2	18.3/300.5	Piezometer with 3.0 m slotted screen installed with a sand filter to 14.6 m, bentonite mixed with auger cuttings from 14.6 m to 0.3 m, the cement from 0.3 m to ground surface.
NE16-11	317.8	17.1/300.6	None installed	Borehole backfilled with bentonite holeplug to 0.3 m, then auger cuttings to surface.
NE16-12	318.1	14.1/304.0	None installed	Borehole backfilled with bentonite holeplug to 0.3 m, then auger cuttings to surface.



4. LABORATORY TESTING

The 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 the laboratory testing are summarized on the Record of Borehole sheets in Appendix A, and also presented on the figures included in Appendix B.

In order to assess the potential for sulphate attack on concrete foundations, as well as the potential for corrosion associated with the structure, samples of the existing fill was collected. Two samples were 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

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendix A. A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following paragraphs. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description and must be used for interpretation of the site conditions. It should be recognized and expected that soil conditions may vary between and beyond borehole locations.

In general, the site is underlain by sand fill and silty clay fill overlaying layers of native silty clay, silt, and sand, underlain by a deposit of silty clay and in turn by silty sand to sandy silt till. Topsoil and asphalt were encountered surficially in some boreholes. Descriptions of the individual strata are presented below.

5.1 Topsoil

A layer of topsoil was encountered surficially in one borehole drilled at this site, NE16-07. It was generally dark brown in colour, with a thickness of 200 mm. The topsoil thickness may vary between the borehole locations and in other areas of the site.



5.2 Asphalt

Asphalt with a thickness of 130 mm and 150 mm, was encountered surficially at Boreholes NE16-06 and Borehole NE16-09, respectively.

5.3 Cohesionless Fill

A layer of cohesionless fill was encountered immediately below the asphalt in Boreholes NE16-06 and NE16-09, and below the topsoil in Borehole NE16-07. Cohesionless fill was encountered surficially at the other boreholes at this site, Boreholes NE16-08 to NE16-12.

The cohesionless fill generally consisted of sand, silty sand and gravelly sand, or sandy silt, and contained some silt to silty, trace gravel to gravelly and trace to some clay. The fill was generally brown to grey in colour.

Occasional to trace roots and rootlets were encountered in the cohesionless fill in Boreholes NE16-07 and NE16-11. Occasional organics and cobbles were encountered in the cohesionless fill in Borehole NE16-09.

The thickness of the cohesionless fill ranged from 1.4 m to 7.0 m, with an underside depth ranging from 1.5 m to 7.0 m (Elevation 316.8 to 311.4). A pocket of silty sand fill was also encountered within the silty clay fill in Borehole NE16-07, with a thickness of 1.3 m and an underside depth of 5.6 m.

SPT N-values recorded in the cohesionless fill generally ranged from 6 blows to 67 blows for 0.3 m penetration, indicating a loose to very dense relative density.

Moisture content of samples of the cohesionless fill generally ranged from 4 percent to 22 percent.

Select samples of the cohesionless fill underwent laboratory gradation analysis. These results are summarized on the Record of Borehole sheets included in Appendix A and the grain size distribution curves for these samples are plotted on Figure B1 and B2 of Appendix B. The results of this testing are summarized as follows:



Soil Particle	Percentage (%) Silty Sand Fill	Percentage (%) Gravelly Sand Fill	Percentage (%) Sandy Silt Fill
Gravel	0 to 3	35	0
Sand	55 to 77	46	25 to 31
Silt	16 to 27	19	53 to 60
Clay	5 to 16		15 to 16

5.4 Silty Clay Fill

A layer of silty clay fill was encountered below the cohesionless fill in Boreholes NE16-06 and NE16-07, with a thickness of 5.7 m and 5.1 m, and an underside depth of 7.2 m and 8.7 m (Elevation 311.2 and 309.9). The silty clay fill contained some sand to sandy and trace gravel.

SPT N-values recorded in the silty clay fill ranged from 7 blows to 20 blows for 0.3 m penetration, indicating a firm to very stiff consistency.

Moisture content of samples of the silty clay fill generally ranged from 11 percent to 23 percent.

Two samples of the silty clay fill underwent laboratory gradation analysis and three samples underwent Atterberg Limits testing, the results of which are summarized below. These results are also presented on the Record of Borehole sheets in Appendix A, the grain size distribution curves for these samples are plotted on Figure A3 and the results of the Atterberg Limits tests are plotted on Figure A9.

Soil Particles	Percentage (%)
Gravel	0 to 4
Sand	31
Silt	36 to 38
Clay	27 to 33

Index Property	Percentage (%)
Liquid Limit	21 to 28
Plastic Limit	13 to 14
Plasticity Index	9 to 13

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



5.5 Sand to Sand and Silt

A sand to sand and silt layer was encountered below the fill in Boreholes NE16-07, NE16-09, NE16-10 and NE16-12; below the silty clay in Borehole NE16-08 and below the silt layer in Borehole NE16-11.

The deposit ranged from silty sand and sand and silt in Boreholes NE16-07 to NE16-09 to sand in Boreholes NE16-10 to NE16-12. The deposit also contained trace to some gravel, trace silt and trace clay.

The thickness of the sand to sand and silt layer ranged from 1.7 m to 7.2 m, with an underside depth ranging from 7.2 m to 13.1 m (Elevation 311.6 to 305.3).

SPT N-values recorded in the sand to sand and silt ranged from 3 blows to 71 blows for 0.3 m penetration, indicating a very loose to very dense relative density.

Moisture content of samples of the sand to sand and silt generally ranged from 19 percent to 26 percent.

One sample of sand and one sample of sand and silt underwent laboratory gradation analysis. The results are summarized on the Record of Borehole sheets included in Appendix A and the grain size distribution curves for the samples are plotted on Figure A4. The results of this testing are summarized as follows:

Soil Particles	Percentage (%) Sand	Percentage (%) Sand and Silt
Gravel	0	0
Sand	93	49
Silt	5	48
Clay	2	3

5.6 Silt

Silt layers were encountered below the cohesionless fill in Borehole NE16-11, and below the native sand in Boreholes NE16-07 and NE16-10. The thickness of the silt layers ranged from 2.9 to 3.4 m, with the underside depth ranging from 5.6 m to 13.3 m (Elevation 312.2 to 305.4).



The silt was brown in colour and contained trace to some clay and trace to some sand. Clayey zones were encountered in the silt layer in Borehole NE16-10.

SPT N-values recorded in the silt ranged from 16 blows to 71 blows for 0.3 m penetration, indicating a compact to very dense relative density.

Moisture content of samples of the silt generally ranged from 18 percent to 20 percent.

Two samples of the silt and one sample of silt within a clayey zone underwent laboratory gradation analysis. The results are summarized on the Record of Borehole sheets included in Appendix A and the grain size distribution curves for these samples are plotted on Figure A5 and A6. The results of this testing are summarized as follows:

Soil Particles	Percentage (%) Silt	Percentage (%) Clayey Zone
Gravel	0	0
Sand	4	11
Silt	88 to 90	64
Clay	6 to 8	25

5.7 Silty Clay

A layer of silty clay was encountered below the fill in Borehole NE16-06, below the silt layers in Boreholes NE16-07 and NE16-10, and below the native sand in Boreholes NE16-08, NE16-09, NE16-11 and NE16-12. A layer of silty clay was also encountered below the fill in Borehole NE16-08.

The silty clay was generally brown to grey in colour and contained trace sand and trace gravel. Dark brown organics and rootlets were encountered in Boreholes NE16-06 and NE16-08.

Borehole NE16-06 was terminated in the silty clay layer at a depth of 14.3 m (Elevation 304.0).

In Boreholes NE16-07 to NE16-12, the thickness of the silty clay ranged from 3.0 m to 9.5 m, with an underside depth ranging from 13.3 m to 20.9 m (Elevation 304.9 to 297.7). The upper layer of silty clay in Borehole NE16-08 had a thickness of 3.2 m, and an underside depth of 10.2 m (Elevation 308.2).

SPT N-values recorded in the silty clay ranged from 7 blows for 0.3 m penetration to 100 blows for 0.125 m penetration, indicating a firm to hard consistency.



Moisture content of samples of the silty clay generally ranged from 18 percent to 32 percent. Two samples of silty clay in Boreholes NE16-06 and NE16-08 were measured to contain a moisture content of 70 percent and 63 percent, indicating the presence of organics within the samples.

Select samples of the silty clay underwent laboratory gradation analysis and Atterberg Limits testing, the results of which are summarized below. These results are also presented on the Record of Borehole sheets in Appendix A and the grain size distribution curves for these samples are plotted on Figure A7. The results of the Atterberg Limits tests are plotted on Figure A10.

Soil Particles	Percentage (%)
Gravel	0
Sand	0 to 6
Silt	33 to 46
Clay	48 to 67

Index Property	Percentage (%)
Liquid Limit	33 to 45
Plastic Limit	15 to 20
Plasticity Index	18 to 25

The above results show that the silty clay is of low to medium plasticity with group symbols of CL to CI.

5.8 Sandy Silt to Silty Sand Till

A sandy silt to silty sand till layer was encountered below the silty clay in six boreholes at this site, Boreholes NE16-07 to NE16-12, at depths ranging from 13.3 m to 20.9 m (Elevation 304.9 to 297.7). Boreholes NE16-07 to NE16-12 were terminated in the sandy silt to silty sand till at depths ranging from 14.1 m to 29.2 m (Elevation 304.0 to 289.4).

The sandy silt to silty sand till was generally brown to grey in colour and contained some clay and trace to some gravel. Clayey zones were encountered in the sandy silt till in Borehole NE16-07. Occasional cobbles were encountered in Borehole NE16-09.

SPT N-values recorded in the sandy silt to silty sand till ranged from 52 blows for 0.3 m penetration to 100 blows for 0.1 m penetration, indicating a very dense relative density.



Moisture content of samples of the sandy silt to silty sand till generally ranged from 7 percent to 21 percent.

Selected samples of the sandy silt to silty sand till underwent laboratory gradation analysis and four samples within clayey zones underwent Atterberg Limits testing, the results of which are summarized below. These results are also presented on the Record of Borehole sheets in Appendix A and the grain size distribution curves for these samples are plotted on Figure A8. The results of the Atterberg Limits tests are plotted on Figure A11.

Soil Particles	Percentage (%)
Gravel	2 to 17
Sand	28 to 48
Silt	28 to 47
Clay	11 to 23

Index Property	Percentage (%)
Liquid Limit	15 to 17
Plastic Limit	10 to 13
Plasticity Index	3 to 5

The above results show that the clayey zones in the sandy silt to silty sand till is of low plasticity with group symbols of CL-ML or ML.

It should be noted that glacial tills are known to contain cobbles and boulders.

5.9 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 NE16-07 and NE16-10 to monitor the groundwater level at the site. The groundwater levels measured in the open boreholes and in the standpipe piezometers are summarized below.

Table 5.1 – Water Level Measurements

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
NE16-06	May 23, 2018	5.2	313.1	Open borehole
NE16-07	May 31, 2018	9.9	308.7	Piezometer
	June 25, 2018	10.8	307.8	
NE16-08	May 25, 2018	5.8	312.6	Open borehole
NE16-09	Sept 8, 2019	-	-	Water level upon completion N/A due to use of drilling mud
NE16-10	April 30, 2018	9.0	309.7	Piezometer
	May 31, 2018	9.7	309.0	
	June 25, 2018	10.1	308.7	
NE16-11	April 26, 2018	-	-	Water level upon completion N/A due to use of drilling mud
NE16-12	April 30, 2018	-	-	Water level upon completion N/A due to use of drilling mud

The groundwater levels above are short-term readings, and seasonal fluctuations of the groundwater levels are to be expected. The groundwater levels may be at a higher elevation after periods of significant or prolonged precipitation.

6. CORROSIVITY AND SULPHATE TEST RESULTS

Two samples of cohesionless fill were 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.

Table 6.1 – Analytical Test Results

Parameter	Units (Soil)	NE16-09 SS4 Depth 2.6 m	NE16-10 SS4 Depth 2.6 m
		Silty Sand Fill	Sandy Silt Fill
Soil Redox Potential	mV	227	205
Sulphide	%	< 0.02	< 0.02
pH	no unit	8.66	9.02
Chloride	µg/g	430	130



Parameter	Units (Soil)	NE16-09 SS4 Depth 2.6 m	NE16-10 SS4 Depth 2.6 m
		Silty Sand Fill	Sandy Silt Fill
Sulphate	µg/g	13	9.1
Conductivity	uS/cm	736	246
Resistivity (calculated)	ohms.cm	1400	4070

7. MISCELLANEOUS

Landshark Drilling of Brantford, Ontario supplied a rubber track-mounted B-57 drill rig and conducted the drilling, sampling and in-situ testing operations for the present investigation.

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.

Geotechnical laboratory testing was carried out at Thurber's geotechnical laboratory. Analytical laboratory testing was carried out by SGS Canada Inc.

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. Judy Mei, EIT and Mr. Jason Lee, P.Eng.

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



Thurber Engineering Ltd.

Judy Mei, E.I.T
Geotechnical Engineer-in-Training



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



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



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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

8. GENERAL

This report presents an 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 a new structure to carry the N-E Ramp structure over Highway 85 (Kitchener-Waterloo Expressway) north of Wellington Street in the Regional Municipality of Waterloo, Ontario.

The General Arrangement (GA) drawing provided by WSP, dated July 2012, indicates that the new N-E ramp has four spans, with a total length of 170 m and is approximately 9.3 m wide, supported by two abutments (west and east) and three piers (Piers 1 to 3). The two conventional abutments and the three piers are designed to be supported by driven piles. The length of each span (from west to east abutments) is 38.0 m, 55.0 m, 45.0 m, and 32.0 m.

The proposed grades of the N-E ramp over Highway 85 varies from the West Abutment to the East Abutment from Elevations 324.9 to 331.2. The existing ground surface near the west abutment is at Elevation 318.6, therefore the west approach fill will be approximately 6.3 m high. The existing ground surface at the East Abutment, is near Elevation 317.8 resulting in an approach fill height of 13.4 m at the East Abutment.

This foundation investigation and design report, with the interpretation and recommendations, is 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) (2019) CSA S6-19, 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 S6-19 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 (2019), a consequence factor, ψ , of 1.0 has been used for assessing ULS and SLS factored 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 geotechnical investigations consisted primarily of sand fill and silty clay fill overlaying layers of native silty clay, silt, and sand, underlain by a deposit of silty clay followed by silty sand to sandy silt till. Topsoil and asphalt were encountered surficially in some boreholes. The groundwater levels measured in the piezometers for this bridge site ranged from 5.2 m to 10.8 m below the ground surface (Elevations 313.1 to 307.8). The groundwater levels observed at the adjacent bridge sites ranged from 2.4 m to 15.6 m below the ground surface (Elevations 318.5 to 305.1).

In 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
3. Augered caissons (drilled shafts)
4. Steel H-piles or steel pipe driven into the very dense glacial till soils

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

10.1 Spread Footing on Native Soil

Spread footings bearing on native soil generally are feasible at this site, however deep excavation is required at the foundation elements.

The existing fill is not considered suitable for the support of spread footings, and the spread footings should bear on native undisturbed compact to dense silty sand or silt. Provided a minimum footing width of 2 m is maintained, the spread footings may be designed in accordance with the elevations and bearing resistances given in Table 10.1.

Table 10.1 – Geotechnical Resistances for Spread Footings

Foundation Element	Borehole	Approximately Founding Elevation (m)	Depth from ground surface (m)	Founding strata	Factored ULS _f (kPa)	Factored SLS _f (up to 25 mm settlement) (kPa)
West Abutment	NE16-07	309.5	9.1	Compact Silty Sand	400	300
Pier 1	NE16-08	308.0	10.4	Dense Sand and Silt	500	350
Pier 2	NE16-09	311.0	7.8	Compact Silty Sand	400	300
Pier 3	NE16-10	314.5	4.3	Dense sand	500	350
East Abutment	NE16-11	315.5	2.3	Compact Silt	400	300

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 0.5 (Typical degree of understanding of the subsurface conditions), as per CHBDC 2019. The factored Geotechnical



Resistance at SLS was assessed assuming a factor of 0.8 for typical degree of understanding of the subsurface conditions.

The bearing resistances in Table 10.1 are for vertical, concentric loading. In the case of eccentric or inclined loading, the bearing resistance must be adjusted as shown in the CHBDC (2019) Clauses 6.10.2 to 6.10.5.

The geotechnical SLS values given above are based on an estimated total settlement not exceeding 25 mm. This settlement is expected to be substantially complete by the end of construction. Differential settlement is not expected to exceed 20 mm across the width of the structure or between foundation elements.

The sliding resistance of cast-in-place concrete placed on the native, undisturbed sand and silt may be computed based on an ultimate coefficient of friction, $\tan \delta$, of 0.40. A resistance Factor of 0.8 should be applied for cohesionless soils, as indicated in Table 6.2 in the CHBDC (2019).

The founding elevations of spread footing will extend below the measured groundwater levels. Local groundwater control and prior dewatering will be required to construct the footing in the dry and to prevent disturbance of the footing base.

The bases of the foundation excavations should be inspected by a Foundation Specialist to confirm that the exposed subgrade conforms to the design requirements and has been adequately prepared to receive concrete. Once approved, the subgrade should be protected by a working mat with a minimum thickness of 100 mm and consisting of concrete of the same strength and class as that of the footing. Where sub-excavation is required to remove unsuitable material from below the design founding level, the founding surface should be re-established using the same class of concrete.

10.2 Spread Footing on Engineered Fill

Spread footings founded on Granular “A” engineered fill pads are a feasible foundation option, where this is beneficial to the overall design. However, it should be noted that construction of engineered fill pads will require deep excavations for some of the foundation elements.

If this foundation option is selected, all topsoil or other deleterious materials must be stripped from the footprint of the foundation to expose competent native subgrade material. Subexcavation of



existing fill soils will be required. The engineered fill should bear on native compact to dense sand and silt and firm silty clay, and the highest permitted founding/base elevations at which engineered fill pads may be placed, are given in Table 10.2.

Table 10.2 – Highest Founding Elevations for Engineered Fill Pads

Foundation Element	Borehole	Approximately Founding Elevation (m)	Depth from ground surface (m)
West Abutment	NE16-07	309.5	9.1
Pier 1	NE16-08	308.5	9.9
Pier 2	NE16-09	312.0	6.8
Pier 3	NE16-10	314.5	4.3
East Abutment	NE16-11	315.5	2.3

Provided a minimum footing width of 2 m is maintained, footings bearing on the well compacted engineered fill pad, at least 2-m thick, may be designed for the following geotechnical resistances:

Factored Geotechnical Resistance at ULS 900 kPa

Factored Geotechnical Resistance at SLS 350 kPa

These resistance values are for concentric, vertical loads only. In the case of eccentric or inclined loading, the geotechnical resistance must be calculated as illustrated in the CHBDC (2019) Clauses 6.10.2 to 6.10.5.

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 0.5 (Typical degree of understanding of the subsurface conditions), as per CHBDC 2019. The Factored Geotechnical Resistance at SLS was assessed assuming a factor of 0.8 for typical degree of understanding of the subsurface conditions.

The founding elevations of engineered fill pad will extend below the measured groundwater levels. Local groundwater control and prior dewatering will be required to construct the engineered fill pad in the dry and to prevent disturbance of the engineered fill pad base.



For footings designed on the basis of the geotechnical resistance values given above, total settlement under a footing is expected to not exceed 25 mm. Differential settlements are not expected to exceed 20 mm across the width of the structure.

The sliding resistance of cast-in-place concrete placed on the engineered fill may be computed based on an ultimate coefficient of friction, $\tan \delta$, of 0.55. Resistance Factor of 0.8 should be applied for cohesionless soils, as indicated in Table 6.2 in the CHBDC (2019).

The bases of the foundation excavations should be inspected by a Foundation Engineering Specialist to confirm that the exposed surface conforms to the design requirements and has been adequately prepared to place the engineered fill. The Granular A for the engineered fill pad must be compacted to 100% Standard proctor maximum dry density (SPMDD) at optimum moisture content of $\pm 2\%$, and placed in 300 mm lifts. The geometry of the fill pad must conform to the general requirements shown in Figure 1 in Appendix D.

10.3 Augered Caissons (Drilled Shafts)

Drilled shaft foundations founded on very dense silt and sand till were considered for the support of foundation loads at this site. However, augered caissons (drilled shafts) are not recommended for use as foundation support at this site due to the depth to suitable bearing material being greater than 20 m, and potential caisson installation difficulties through water bearing cohesionless sand, silt, and sand and silt till. Basal boiling and heave in the cohesionless deposits may be encountered and sealing of the caisson liner into the founding stratum may be difficult. Therefore this option 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 driven to practical refusal in the very dense sand and silt till. Open ended steel pipe piles may also be considered as an alternate foundation option. It should be noted that pipe piles driven into very dense sand and silt till deposits are more prone to pile tip damage in comparison to H-piles.

The GA drawing indicates that the approximate underside elevations of the abutment and pier pile cap are as indicated in Table 10.3 below.



Table 10.3 – Underside pile cap elevation

Foundation Unit	Borehole	Approx. U/S pile cap Elevation (m)
West Abutment	NE16-07	318.0
Pier 1	NE16-08	316.0
Pier 2	NE16-09	316.0
Pier 3	NE16-10	315.0
East Abutment	NE16-11	321.5

10.4.1 Axial Resistance

The axial resistances of HP 310 X 110 and HP 360 x 132 steel piles, and 324 mm diameter and 356 mm diameter steel piles driven to refusal in the very dense till were assessed based on the subsurface conditions encountered at the abutment and pier locations. The estimated Ultimate Limit States (ULS) and geotechnical resistance at Serviceability Limit States (SLS), as well as the recommended pile tip elevations are summarized in Tables 10.4 and 10.5.

Table 10.4 – Estimated Axial Resistance and Pile Tip Elevation for H-Piles

Foundation Unit	Borehole	Approx. Pile Tip Elevation (m)	Minimum Pile Length Assumed (m)	Pile Section HP 310 X 110		Pile Section HP 360 X 132	
				Factored ULS (kN)	Factored SLS _r (kN)	Factored ULS (kN)	Factored SLS _r (kN)
West Abutment	NE16-07	291.5	26.5	1,400	1,200	1,600	1,400
Pier 1	NE16-08	298.0	18	1,200	1,000	1,400	1,200
Pier 2	NE16-09	296.0	20	1,400	1,200	1,600	1,400
Pier 3	NE16-10	302.5	12.5	1,000	800	1,200	1,000
East Abutment	NE16-11	302.0	19.5	1,400	1,200	1,600	1,400



Table 10.5 – Estimated Axial Resistance and Pile Tip Elevation for pipe piles

Foundation Unit	Borehole	Approx. Pile Tip Elevation (m)	Minimum Pile Length Assumed (m)	Pile Section 324 mm diameter Wall Thickness 12.7 mm		Pile Section 356 mm diameter Wall Thickness 12.7 mm	
				Factored ULS (kN)	Factored SLS _r (kN)	Factored ULS (kN)	Factored SLS _r (kN)
West Abutment	NE16-07	291.5	26.5	1,300	1,100	1,450	1,250
Pier 1	NE16-08	298.0	18	1,050	900	1,200	1,000
Pier 2	NE16-09	296.0	20	1,300	1,100	1,450	1,250
Pier 3	NE16-10	302.5	12.5	800	650	950	800
East Abutment	NE16-11	302.0	19.5	1,300	1,100	1,450	1,250

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 2019. 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 structural resistance of the pile must be checked by the structural designer.

10.4.2 Downdrag

Downdrag on the piles is not 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:

Silty Clay (cohesive soils)

$$k_s = 67 C_u / B \quad (\text{kN/m}^3)$$

$$P_{ult} = 9 C_u \quad (\text{kPa}) \text{ at and below a depth of } 3B \text{ reduced to zero at ground surface}$$



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/m³
 B = width of pile, m

Sand, silt, sand and silt till (cohesionless soils)

k_s = $n_h \cdot z / B$ (kN/m³)
 p_{ult} = $3 \cdot \gamma \cdot z \cdot K_p$ (kPa)
where z = depth of embedment of pile, m
 B = pile width, m
 n_h = coefficient related to soil density, kN/m³, Table 10.6
 γ = Unit weight of soil, kN/m³, Table 10.6, use submerged unit weight below water table
 K_p = passive earth pressure coefficient, Table 10.6

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/m³), B is the pile width (m), d_z is the length (m) of the pile segment or element used in the analysis. The ultimate lateral resistance on any one segment of pile, P_{ult} , 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.

For pile lateral resistance design below the flexible zone, soil-pile interaction analyses may be carried out using the geotechnical parameters provided in Table 10.6 below.



Table 10.6 – 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
West Abutment	NE16-07	318.4 to 316.3	-	20	3.0	3,000	Loose to Compact Sand Fill
		316.3 to 309.9	60	19	-	-	Firm Silty Clay Fill
		309.9 to 305.4	-	11*	3.4	5,000	Compact to Very Dense Silt
		305.4 to 297.7	200	9*	-	-	Very Stiff to Hard Silty Clay
		297.7 to 289.4	-	11*	4.0	10,000	Very Dense Sandy Silt to Silty Sand Till
Pier 1	NE16-08	318.4 to 311.4	-	20	3.0	3,500	Loose to Compact Sand Fill
		311.4 to 308.2	60	9*	-	-	Firm Silty Clay
		308.2 to 305.3	-	11*	3.7	8,000	Dense to Very Dense Sand and Silt
		305.3 to 299.1	200	9*	-	-	Hard Silty Clay
		299.1 to 296.7	-	11*	4.0	10,000	Very Dense Sand and Silt Till
Pier 2	NE16-09	318.1 to 313.2	-	20	3.0	5,000	Dense to Very Dense Silty Sand Fill
		313.2 to 310.1	-	10*	3.1	3,500	Very loose to Compact Silty Sand
		310.1 to 302.5	200	9*	-	-	Very Stiff to Hard Silty Clay
		302.5 to 292.8	-	11*	4.0	10,000	Very Dense Sand and Silt Till
Pier 3	NE16-10	318.8 to 314.7	-	20	3.0	2,500	Loose to Compact Gravelly Sand and Sandy Silt Fill

		314.7 to 311.6	-	11*	3.4	5,000	Dense Sand
		311.6 to 308.6	-	11*	3.5	8,000	Dense to Very Dense Silt
		308.6 to 304.0	200	9*	-	-	Very Stiff to Hard Silty Clay
		304.0 to 300.2	-	11*	4.0	10,000	Very Dense Silty Sand
East Abutment	NE16-11	317.8 to 315.6	-	20	3.0	3,000	Loose to Very Dense Sandy Silt Fill
		315.6 to 312.2	-	10*	3.3	3,500	Compact Silt
		312.2 to 309.9	-	11*	3.4	7,000	Dense Sand
		309.9 to 304.5	200	9*	-	-	Hard Silty Clay
		304.5 to 300.6	-	11*	4.0	10,000	Very Dense Sand and Silt Till

* Buoyant unit weight below the water table

The group efficiency factors can be calculated based on side-by-side and line-by-line factors shown in Figures C6.22, C6.23 and C6.24 of the CHBDC (2019), S6:19 (Commentary).

The lateral resistance within the frost depth should be ignored for design purpose. Depending on the construction sequence, embankment loadings from the S-W Ramp adjacent to the East Abutment may need to be included as part of the lateral pile analysis.

10.4.4 Pile Installation

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

At this site, the piles will have to be driven through dense sand and hard silty clay into very dense sand and silt till.

Pile driving 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 of the piles for each foundation element or a minimum of 2 piles tested at each foundation element, whichever is more.

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

Auger grinding was noted during drilling in the sand and silt till deposit. Glacially derived soils inherently contain cobbles and boulders. Hard driving conditions through the 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.

Pile tip protection should be provided for open ended pipe 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 G. 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 to be 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. Reference should be made to the integral abutment manual for details of this system. Piles should be driven first before pouring in loose uniform sand between the CSP surround and the pile.

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 available information, the recommended foundations at this site are that the abutments and piers be supported on steel H-piles driven into the very dense sand and silt till.

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 2019 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 2019, 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 $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$		OPSS Granular B Type I $\phi = 32^\circ, \gamma = 21.2 \text{ kN/m}^3$	
	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	-

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) is preferred as it results in lower earth pressures acting on the wall.

The factors in Table 12.1 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 C6.27 in the Commentary to the CHBDC 2019.

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 drawing dated July 2012, the proposed finished grade at the structure will be at about Elevations 324.9 and 331.2 at the west and east abutments, respectively. The existing ground surface at the west and east abutments is near Elevations 318.6 and 317.8. As a result, placement of new fill of approximately 6.3 m and 13.4 m, will be required for the west and east approaches, respectively, of the proposed N-E ramp over Highway 85.



All embankment fill must be constructed with adequate quality control in accordance with OPSS.PROV 206 and OPSS.PROV 501 requirements and the clean earth fill must not contain medium or high plastic clay.

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. 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 should be sub-excavated.

12.1 Slope Stability of Side Slope

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 and clean earth fill will have stable side slopes at inclinations of up to 2H:1V.

Where earth fill embankments are higher than 8 m, mid-height berms should be incorporated in each 8 m vertical interval. The berms should:

- extend for the length through which the embankment height exceeds 8 m
- be at least 2 m wide
- have 2% positive grade to shed run-off water

The analyses of global stability for the typical side slope configuration for the critical embankment section at East Approach have been 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 F.



Table 12.1 Computed Factors of Safety

Condition	Factor of Safety	Figure (Appendix F)
Side Slope, Max. height 13 m		
Drained	1.6	1F
Undrained	1.6	2F
Seismic = 0.097g	1.2	3F

As per typical MTO requirements, a Factor of Safety (F.S.) of 1.3 is acceptable for short term conditions and for total stress (undrained) conditions. A F.S. of 1.5 is acceptable for effective stress (drained) conditions. Under the assumed seismic loading, the minimum acceptable factor of safety is 1.1. In the case of static loading, the factors of safety against global failure were 1.6 for drained and 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 approach embankments, settlements of 40 mm to 80 mm will occur in the foundation soils under the loading imposed by new approach embankments with proposed fill height up to 6.6 m and 13.4 m behind the west and east abutments, respectively.

This settlement will be essentially complete when construction of the fills is completed.

Embankment settlement due to fill compression is estimated to 0.5% of the fill height. Approximately 50% of the total fill compression (or 0.25% of the fill height) will occur during construction and the remaining 50% or approximately 15 to 35 mm at this site will occur after construction. It is recommended to allow a one month waiting period after embankment fill is placed to allow settlement to occur before paving is completed.

No long-term foundation settlement is anticipated for the approach embankments built at this site.



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, if required, will be extended through the sand fill, silty clay fill, native firm to stiff silty clay, and into the native compact to very dense sand/silt.

For the purposes of the OHSA, the sand and silty clay fill and native compact to dense sand/silt above the water table are classified as Type 3. The native firm to stiff silty clay may be classified as Type 3. Cohesionless soils below the water table are classified as Type 4.

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 regularly be 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 ensure 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 new fill be Granular A or Granular B Type II materials meeting the gradation and relevant requirements stipulated in OPSS.PROV 1010. Beyond this zone, Granular B Type I, Select Subgrade Material (SSM) or clean earth fill may be used.

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 be restricted in accordance with 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 5.2 m and 10.8 m below the ground surface (Elevations 313.1 to 307.8). Based on groundwater levels measured in the piezometers and open boreholes, the excavation for footing or pile cap construction will extend below the groundwater level. Also, seepage from perched water from the granular fill should also be expected.

Excavation of the cohesionless soils below the groundwater level without prior dewatering is not recommended since the inflow of groundwater will cause base boiling and side wall sloughing of the soil below the water table making it difficult to maintain a dry, sound base on which to work. Suitable systems that might be considered to maintain a dewatered condition at this site, include pumping from filtered sumps for nominal penetration below the groundwater level, and sheeted excavation (cofferdam) or vacuum well-points for deeper penetration below the ground water table, particularly in cohesionless soils. The dewatering system must be effective to maintain the water level at a minimum depth of 0.5 m below the final footing/pile cap grade throughout construction.

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

Soil	Permeability, k (cm/sec)
Sandy Silt to Silty Sand Fill	1.0×10^{-6} to 8.1×10^{-5}
Silty Clay Fill	1×10^{-7}
Sand to Sand and Silt	2.0×10^{-4} to 2.3×10^{-2}
Silt	2.8×10^{-5}
Silty Clay	1×10^{-8}
Silty Sand to Sandy Silt Till	1.5×10^{-6}

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 him to this responsibility.



The groundwater and surface runoff must be controlled during construction to maintain a stable excavation and to allow concrete to be placed in a dewatered excavation. Placement of concrete or compacting engineered fill must be done in the dry. Dewatering must remain operational and effective until the footings or pile caps are constructed and backfilled. Suggested wording for an NSSP in the regard is included in Appendix G.

16. ROADWAY PROTECTION

If roadway protection is required during construction of the proposed ramp, an item titled “Protection System” as per OPSS 539 should be included in the contract documents. It is recommended that Performance Level 2 as per Clause 539.04.01.01 and the alignment of the shoring be specified on the contract drawings.

The design of roadway protection should be the responsibility of the Contractor. However, one option that is considered to be suitable for use as temporary shoring at this site is a soldier pile and lagging wall. It may be difficult to drive sheetpiles through the very dense sand fill.

A temporary soldier pile and lagging wall may be designed using the parameters given below:

γ	=	20 kN/m ³
γ_w	=	10 kN/m ³
K_a	=	0.33 (fills)
	=	0.36 (silty clay)
	=	0.31 (sand, silt)
K_p	=	3.0 (fills)
	=	2.8 (silty clay)
	=	3.2 (sand, silt)

The actual pressure distribution acting on the shoring system is a function of the construction sequence, and the relative flexibility of the wall and these factors must be considered when designing the shoring system. All shoring systems should be designed by a Professional Engineer experienced in such designs.

17. SEISMIC CONSIDERATIONS

The site is underlain by sand fill and silty clay fill overlaying layers of native silty clay, silt, and sand, underlain by deposits of silty clay and silty sand to sandy silt till. Topsoil and asphalt were encountered surficially in some boreholes.

In accordance with the CHBDC 2019, 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, asphalt and fill overlaying layers of native silt and sand, underlain by deposits of silty clay and silty sand to sandy silt till. This would correspond to a Seismic Site Class D in accordance with Table 4.1, Clause 4.4.3.2 of the CHBDC (2019). The peak ground acceleration, PGA, for a 2% in 50-year probability of exceedance at this site is 0.075 g as per the National Building Code of Canada (NBCC). Since this site is classified as Class D, the factored PGA for a 2% in 50-year probability of exceedance at this site is 0.097 g.

In accordance with Clause 6.14.7 of the CHBDC 2019, 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 18.1 may be used:

Table 18.1 – Earth Pressure Coefficients for Earthquake Loading

Condition	Earth Pressure Coefficient (K)	
	OPSS Granular A or Granular B Type II $\phi = 35^\circ$, $\gamma = 22.8 \text{ kN/m}^3$	OPSS Granular B Type I $\phi = 32^\circ$, $\gamma = 21.2 \text{ kN/m}^3$
Active (K_{AE})*	0.31	0.35
Passive (K_{PE})	3.6	3.1
At Rest (K_{OE})**	0.55	0.6

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

** After Woods

Liquefaction is not considered to be a concern at this site.

18. ADJACENT STRUCTURES AND BURIED UTILITIES

The potential presence of underground utilities at the site should be confirmed prior to construction. It is recommended that the exact locations and elevations of any utilities be



established by the designer and compared with the extent of the potential work zones related to the foundations of the proposed replacement structures and associated works. Protection and/or relocation of utilities may be required. Underground utilities should not be undermined or damaged during new foundation construction. The proposed N-E ramp will be located approximately 70 m north of the existing Wellington St North bridge over the Kitchener Waterloo Expressway (KWE) and the proposed S-E ramp over the KWE and S-W Ramp.

19. CORROSION AND SULPHATE ATTACK POTENTIAL

The results of the corrosivity and sulphate analytical tests conducted on two fill samples indicate the following conditions at the locations tested:

- The potential for sulphate attack on concrete foundations from the surrounding fill is considered to be negligible due to the low concentration of sulphate and chloride 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 to severe.
- 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.

20. CONSTRUCTION CONCERNS

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

1. Pile Installation

Presence of cobbles and tri-cone grinding were noted during drilling and glacial till deposits inherently contain cobbles and boulders. Pile tips should be reinforced with Titus steel (Standard H-point) to protect the driven piles from damage.

2. Excavation

Hydraulic equipment is expected to be capable of excavating to the required depths at this site. Groundwater control measures will have to be implemented in order to maintain stable sides and base in the excavation. Equipment selected for excavation must be capable of penetrating, handling and/or removing potential obstructions such as cobbles and boulders.

3. Groundwater Control

Seepage and perched groundwater may be encountered within the cohesionless fill and native cohesionless soils. The impact of seepage or surface water could destabilize the sides and or base of the excavation. The Contractor's dewatering plan must be available for rapid implementation should the need arise. Proper groundwater and surface water control measures must be in place prior to commencing excavation. All footings/pile caps must be constructed in the dry.

21. CLOSURE

Engineering analysis and preparation of the report were carried out by Dr. Nancy Berg, P.Eng. and Mr. Jason Lee, P.Eng.

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

Thurber Engineering Ltd.



Nancy Berg, 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

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


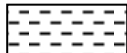



 Water Level
 Shear Strength Determination by Pocket Penetrometer

- (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

<u>ROCK WEATHERING CLASSIFICATION</u>		<u>SYMBOLS</u>	
Fresh (FR)	No visible signs of weathering.		
Fresh Jointed (FJ)	Weathering limited to the surface of major discontinuities.		CLAYSTONE
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.		SILTSTONE
Moderately Weathered (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.		SANDSTONE
Highly Weathered (HW)	Weathering extends throughout the rock mass and the rock is partly friable.		COAL
Completely Weathered (CW)	Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved.		Bedrock (general)

<u>DISCONTINUITY SPACING</u>		<u>STRENGTH CLASSIFICATION</u>			
Bedding	Bedding Plane Spacing	Rock Strength	Approximate Uniaxial Compressive Strength		Field Estimation of Hardness*
			(MPa)	(psi)	
Very thickly bedded	Greater than 2m	Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Thickly bedded	0.6 to 2m				
Medium bedded	0.2 to 0.6m	Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Thinly bedded	60mm to 0.2m				
Very thinly bedded	20 to 60mm	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Laminated	6 to 20mm				
Thinly Laminated	Less than 6mm	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

<u>TERMS</u>	
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.

RECORD OF BOREHOLE No NE16-06

1 OF 2

METRIC

GWP# 408-88-00 LOCATION N-E Ramp Highway 85 Overpass, MTM NAD 83 Zone 10: N 4 814 603.9 E 226 026.5 ORIGINATED BY AF
DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP
DATUM Geodetic DATE 2018.05.23 - 2018.05.23 LATITUDE 43.467204 LONGITUDE -80.473563 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	WATER CONTENT (%)						
318.3	GROUND SURFACE														
0.0	ASPHALT(130mm)														
0.1	SAND, some silt, trace gravel Compact Brown Moist (FILL)		1	SS	17										
316.8															
1.5	Silty CLAY, some sand to sandy, trace gravel Stiff to Very Stiff Brown Moist (FILL)		2	SS	18										
			3	SS	20										
			4	SS	12										
			5	SS	7										
	Firm		6	SS	12										
			7	SS	28										
311.2	Silty CLAY, trace to some sand, trace gravel, occasional organics Stiff to Very Stiff Brown Moist		8	SS	8										
7.2															

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

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RECORD OF BOREHOLE No NE16-06

2 OF 2

METRIC

GWP# 408-88-00 LOCATION N-E Ramp Highway 85 Overpass, MTM NAD 83 Zone 10: N 4 814 603.9 E 226 026.5 ORIGINATED BY AF
DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP
DATUM Geodetic DATE 2018.05.23 - 2018.05.23 LATITUDE 43.467204 LONGITUDE -80.473563 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE								
							20	40	60	80	100	20	40	60		
308.3	Continued From Previous Page															
10.1	Silty CLAY , trace sand, trace gravel Very Stiff Brown Moist		9	SS	18											
			10	SS	15											
	becoming grey		11	SS	38											
304.0																
14.3	END OF BOREHOLE AT 14.3m. WATER LEVEL AT 5.2m UPON COMPLETION. BOREHOLE BACKFILLED WITH GROUT TO SURFACE.															

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No NE16-07

1 OF 4

METRIC

GWP# 408-88-00 LOCATION N-E Ramp Highway 85 Overpass, MTM NAD 83 Zone 10: N 4 814 589.6 E 226 032.1 ORIGINATED BY AF
 DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Tricone COMPILED BY MP
 DATUM Geodetic DATE 2018.05.28 - 2018.05.28 LATITUDE 43.467076 LONGITUDE -80.473492 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
318.6	GROUND SURFACE							20	40	60	80	100					
0.0	TOPSOIL (200mm)							20	40	60	80	100					
0.2	SAND, some silt, trace gravel, trace roots and rootlets Loose to Compact Brown Moist (FILL)		1	SS	7		318								○		
			2	SS	21											○	
316.3							317								○		
			3	SS	17										○		
2.3	Silty CLAY, some sand to sandy, trace gravel Firm Brown Moist (FILL)		4	SS	7		316								○		
			5	SS	8		315									○	
314.3							314										
			6	SS	6										○		
4.3	Silty SAND, trace gravel Loose Grey Wet (FILL)						313										
			7	SS	10		312								○		
313.0	Silty CLAY, some sand, trace gravel Stiff Brown Wet (FILL)		8	SS	15		311								○		
309.9							310										
			9	SS	18		309								○		
8.7	Silty SAND, trace gravel Compact Grey Wet																

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

ONTMT4S2 MTO-11375(GINTDATA)\GPU 2017TEMPLATE(MTO).GDT 6/1/20

RECORD OF BOREHOLE No NE16-07

2 OF 4

METRIC

GWP# 408-88-00 LOCATION N-E Ramp Highway 85 Overpass, MTM NAD 83 Zone 10: N 4 814 589.6 E 226 032.1 ORIGINATED BY AF
 DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Tricone COMPILED BY MP
 DATUM Geodetic DATE 2018.05.28 - 2018.05.28 LATITUDE 43.467076 LONGITUDE -80.473492 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						WATER CONTENT (%)				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						w _p w w _L				
	Continued From Previous Page							20	40	60	80	100						
308.3																		
10.4	SILT , trace clay, trace sand Dense to Very Dense Brown Wet		10	SS	36		308							○				
							307											
				11	SS	52		306						○				0 4 90 6
305.4	Silty CLAY , trace sand, trace gravel Very Stiff to Hard Grey Moist						305							○				
13.3							304											
				13	SS	37		303						○				
								302						○	—			0 0 38 62
				14	SS	39		301										
								300						○				
				15	SS	23		299										

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+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

ONTMT4S2 MTO-11375(GINTDATA)\GPU 2017TEMPLATE(MTO).GDT 6/1/20

RECORD OF BOREHOLE No NE16-07

3 OF 4

METRIC

GWP# 408-88-00 LOCATION N-E Ramp Highway 85 Overpass, MTM NAD 83 Zone 10: N 4 814 589.6 E 226 032.1 ORIGINATED BY AF
DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Tricone COMPILED BY MP
DATUM Geodetic DATE 2018.05.28 - 2018.05.28 LATITUDE 43.467076 LONGITUDE -80.473492 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60					
	Continued From Previous Page		16	SS	55/ 0.125										
297.7															
20.9	Sandy SILT to Silty SAND, some clay, trace gravel, with clayey seams Very Dense Grey Moist (TILL)		17	SS	77										5 48 36 11
			18	SS	100/ 0.100										
			19	SS	52										
			20	SS	33/ 0.050										
			21	SS	100/ 0.100										
289.4	Clayey zone		22	SS	100/ 0.125										2 28 47 23
29.2	END OF BOREHOLE AT 29.2m. Well installation consists of 19mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen.														

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15 10 5 0
(%) STRAIN AT FAILURE

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METRIC

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METRIC

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RECORD OF BOREHOLE No NE16-08

2 OF 3

METRIC

GWP# 408-88-00 LOCATION N-E Ramp Highway 85 Overpass, MTM NAD 83 Zone 10: N 4 814 563.1 E 226 059.4 ORIGINATED BY AF
 DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Tricone COMPILED BY MFA
 DATUM Geodetic DATE 2018.05.25 - 2018.05.25 LATITUDE 43.466840 LONGITUDE -80.473150 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	
	Continued From Previous Page							SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	WATER CONTENT (%)			
308.2								20 40 60 80 100	20 40 60			
10.2	SAND and SILT, trace clay Dense to Very Dense Grey Wet to Moist		10	SS	39		308					
							307					
			11	SS	71		306					0 49 48 3
305.3							305					
13.1	Silty CLAY, trace sand, trace gravel Hard Grey Moist		12	SS	31		304					
							303					0 6 34 60
			13	SS	37		302					
							301					
	Very Stiff		14	SS	27		300					
			15	SS	100/ 0.125		299					
299.1												
19.4	SAND and SILT, some clay, some gravel Very Dense Grey		16	SS	100/ 0							

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+³, ×³: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No NE16-08

3 OF 3

METRIC

GWP# 408-88-00 LOCATION N-E Ramp Highway 85 Overpass, MTM NAD 83 Zone 10: N 4 814 563.1 E 226 059.4 ORIGINATED BY AF
DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Tricone COMPILED BY MFA
DATUM Geodetic DATE 2018.05.25 - 2018.05.25 LATITUDE 43.466840 LONGITUDE -80.473150 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
	Continued From Previous Page				0.250			20 40 60 80 100	○ UNCONFINED + FIELD VANE	W _P W W _L				GR SA SI CL
	SAND and SILT, some clay, some gravel Very Dense Grey Moist (TILL)						298						kN/m ³	10 41 36 13
								297						
296.7			17	SS	100/0.225									
21.7	END OF BOREHOLE AT 21.7m. WATER LEVEL AT 5.8m UPON COMPLETION. BOREHOLE BACKFILLED WITH GROUT TO SURFACE.													

RECORD OF BOREHOLE No NE16-09

1 OF 3

METRIC

GWP# 408-88-00 LOCATION N-E Ramp Highway 85 Overpass, MTM NAD 83 Zone 10: N 4 814 537.9 E 226 105.7 ORIGINATED BY BL
 DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Tricone COMPILED BY BH
 DATUM Geodetic DATE 2019.09.07 - 2019.09.08 LATITUDE 43.466618 LONGITUDE -80.472576 CHECKED BY JM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						WATER CONTENT (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT w _p w w _L																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
318.8	GROUND SURFACE							20	40	60	80	100																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		

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

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METRIC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		SHEAR STRENGTH kPa		WATER CONTENT (%)		UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100	PLASTIC LIMIT w _P			NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	GR	SA	SI	CL
	Continued From Previous Page																				
	Silty CLAY , trace sand, trace gravel Very Stiff to Hard Grey Moist		10	SS	25		308						○								
							307						○								
			11	SS	35		306						○								
							305						○								
			12	SS	43		304						○								
							303						○								
			13	SS	23		302						○								
302.5							301						○								
16.3	SAND and SILT , some gravel, some clay Very Dense Grey Moist (TILL) occasional cobbles		14	SS	100/ 0.175		300						○								
			15	SS	100/ 0.150		299						○								

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No NE16-09

3 OF 3

METRIC

GWP# 408-88-00 LOCATION N-E Ramp Highway 85 Overpass, MTM NAD 83 Zone 10: N 4 814 537.9 E 226 105.7 ORIGINATED BY BL
 DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Tricone COMPILED BY BH
 DATUM Geodetic DATE 2019.09.07 - 2019.09.08 LATITUDE 43.466618 LONGITUDE -80.472576 CHECKED BY JM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
	Continued From Previous Page																
	SAND and SILT, some gravel, some clay Very Dense Grey Moist (TILL)		16	SS	78												
			17	SS	100/ 0.275												
			18	SS	100/ 0.150												
			19	SS	100/ 0.100												
292.8																	
26.0	END OF BOREHOLE AT 26.0m. BOREHOLE BACKFILLED WITH GROUT AND HOLEPLUG. WATER LEVEL AND CAVE-IN NOT AVAILABLE DUE TO USE OF MUD ROTARY METHOD.																

ONTMT4S2 MTO-11375(GINTDATA).GPJ 2017TEMPLATE(MTO).GDT 6/1/20

RECORD OF BOREHOLE No NE16-10

1 OF 2

METRIC

GWP# 408-88-00 LOCATION N-E Ramp Highway 85 Overpass, MTM NAD 83 Zone 10: N 4 814 516.2 E 226 147.0 ORIGINATED BY MB
DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP
DATUM Geodetic DATE 2018.04.27 - 2018.04.27 LATITUDE 43.466427 LONGITUDE -80.472062 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _P	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)			GR	SA	SI	CL
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE															
318.8	GROUND SURFACE							20	40	60	80	100											
0.0	Gravelly SAND , trace silt Compact Brown Moist (FILL)		1	SS	11																		
			2	SS	16																		
317.3																							
1.4	Sandy SILT , some clay Compact to Loose Brown Moist (FILL)		3	SS	16																		
			4	SS	9																		
			5	SS	20																		
314.7																							
4.1	SAND , trace gravel Dense Brown Moist		6	SS	46																		
				7	SS	41																	
311.6																							
7.2	SILT , some clay, some sand, with clayey seams Dense to Very Dense Brown Moist		8	SS	58																		
				9	SS	43																	

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

ONTMT4S2 MTO-11375(GINTDATA)GPJ 2017TEMPLATE(MTO).GDT 6/1/20

RECORD OF BOREHOLE No NE16-10

2 OF 2

METRIC

GWP# 408-88-00 LOCATION N-E Ramp Highway 85 Overpass, MTM NAD 83 Zone 10: N 4 814 516.2 E 226 147.0 ORIGINATED BY MB
DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP
DATUM Geodetic DATE 2018.04.27 - 2018.04.27 LATITUDE 43.466427 LONGITUDE -80.472062 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			WATER CONTENT (%)				GR SA SI CL				
Continued From Previous Page								20 40 60 80 100			w _P w w _L								
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE											
308.6																			
10.2	Silty CLAY Very Stiff to Hard Brown Moist		10	SS	22		308												
							307												
			11	SS	29		306								0	0	36	64	
							305												
			12	SS	44		304												
304.0							303												
14.8	Silty SAND , some gravel, some clay Very Dense Brown Moist (TILL)		13	SS	100/ 0.125		302												
							301												
			14	SS	100/ 0.200														
			15	SS	100/ 0.150														
300.2																			
18.6	END OF BOREHOLE AT 18.6m. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2018.04.30 9.0 309.7 2018.05.31 9.7 309.0 2018.06.25 10.1 308.7																		

ONTMT4S2 MTO-11375(GINTDATA)\GPJ 2017TEMPLATE(MTO).GDT 6/1/20

RECORD OF BOREHOLE No NE16-11

1 OF 2

METRIC

GWP# 408-88-00 LOCATION N-E Ramp Highway 85 Overpass, MTM NAD 83 Zone 10: N 4 814 509.0 E 226 178.2 ORIGINATED BY MB
DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP
DATUM Geodetic DATE 2018.04.25 - 2018.04.26 LATITUDE 43.466366 LONGITUDE -80.471675 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)									
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa											WATER CONTENT (%)				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE											PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT w _p w w _L				
317.8	GROUND SURFACE							20	40	60	80	100		20	40	60		GR	SA	SI	CL		
0.0	Sandy SILT , trace to some clay, occasional rootlets Loose to Very Dense Brown Moist (FILL)		1	SS	7		317							○				0	25	60	15		
			2	SS	54									○									
			3	SS	56		316							○									
315.6																							
2.2	SILT , trace clay, trace sand Compact Brown Moist		4	SS	24		315							○									
			5	SS	16									○									
							314																
	Very Dense		6	SS	71		313							○				0	4	88	8		
312.2																							
5.6	SAND Dense Brown Moist		7	SS	42		312							○									
							311																
309.9			8	SS	50		310							○									
7.9	Silty CLAY Hard Brown Moist						309							○									
			9	SS	34		308							○									

Continued Next Page

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

ONTMT4S2 MTO-11375(GINTDATA).GPJ 2017TEMPLATE(MTO).GDT 6/1/20

RECORD OF BOREHOLE No NE16-11

2 OF 2

METRIC

GWP# 408-88-00 LOCATION N-E Ramp Highway 85 Overpass, MTM NAD 83 Zone 10: N 4 814 509.0 E 226 178.2 ORIGINATED BY MB
DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP
DATUM Geodetic DATE 2018.04.25 - 2018.04.26 LATITUDE 43.466366 LONGITUDE -80.471675 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE			WATER CONTENT (%) W _P W W _L				GR	SA	SI	CL		
	Continued From Previous Page							20 40 60 80 100												
	Silty CLAY , trace sand Hard Brown Moist																			
304.5			10	SS	50		307										0	6	46	48
							306													
			11	SS	62		305													
13.3	SAND and SILT , some clay, trace gravel Very Dense Brown Moist (TILL)		12	SS	100/ 0.175		304													
							303													
			13	SS	100/ 0.225		302													
300.6			14	SS	100/ 0.225		301													
17.1	END OF BOREHOLE AT 17.1m. BOREHOLE OPEN TO 17.1m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.3m AND CUTTINGS TO SURFACE.																			



ONTMT4S2 MTO-11375(GINTDATA)GPJ 2017TEMPLATE(MTO).GDT 6/1/20

RECORD OF BOREHOLE No NE16-12

1 OF 2

METRIC

GWP# 408-88-00 LOCATION N-E Ramp Highway 85 Overpass, MTM NAD 83 Zone 10: N 4 814 505.0 E 226 200.5 ORIGINATED BY MB
 DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP
 DATUM Geodetic DATE 2018.04.30 - 2018.04.30 LATITUDE 43.466332 LONGITUDE -80.471399 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			WATER CONTENT (%)							
								20 40 60 80 100	W _P W W _L									
						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
318.1	GROUND SURFACE																	
0.0	SAND , some silt, trace clay Loose to Dense Brown Moist (FILL)		1	SS	6		318							○				
			2	SS	45		317								○			
			3	SS	35		316							○		0 77 18 5		
			4	SS	21									○				
315.2																		
3.0	SAND , some silt, trace clay Compact to Very Dense Brown Moist		5	SS	31		315								○			
			6	SS	24		314								○			
			7	SS	55		313									○		
			8	SS	62		312									○		0 93 5 2
			9	SS	16		311											
							310							○				
							309								○			

Continued Next Page

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

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No NE16-12

2 OF 2

METRIC

GWP# 408-88-00 LOCATION N-E Ramp Highway 85 Overpass, MTM NAD 83 Zone 10: N 4 814 505.0 E 226 200.5 ORIGINATED BY MB
 DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP
 DATUM Geodetic DATE 2018.04.30 - 2018.04.30 LATITUDE 43.466332 LONGITUDE -80.471399 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						WATER CONTENT (%) w _p w w _L			
								20 40 60 80 100	PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT								
	Continued From Previous Page																
307.9							308										
10.2	Silty CLAY Hard Brown Moist		11	SS	33		307										
							306										
			12	SS	30												
304.9							305										
13.3	SAND and SILT , some clay, trace gravel Very Dense Brown Moist (TILL)		13	SS	100/ 0.225												
304.0																	
14.1	END OF BOREHOLE AT 14.1m. BOREHOLE OPEN TO 14.1m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.3m AND CUTTINGS TO SURFACE.																

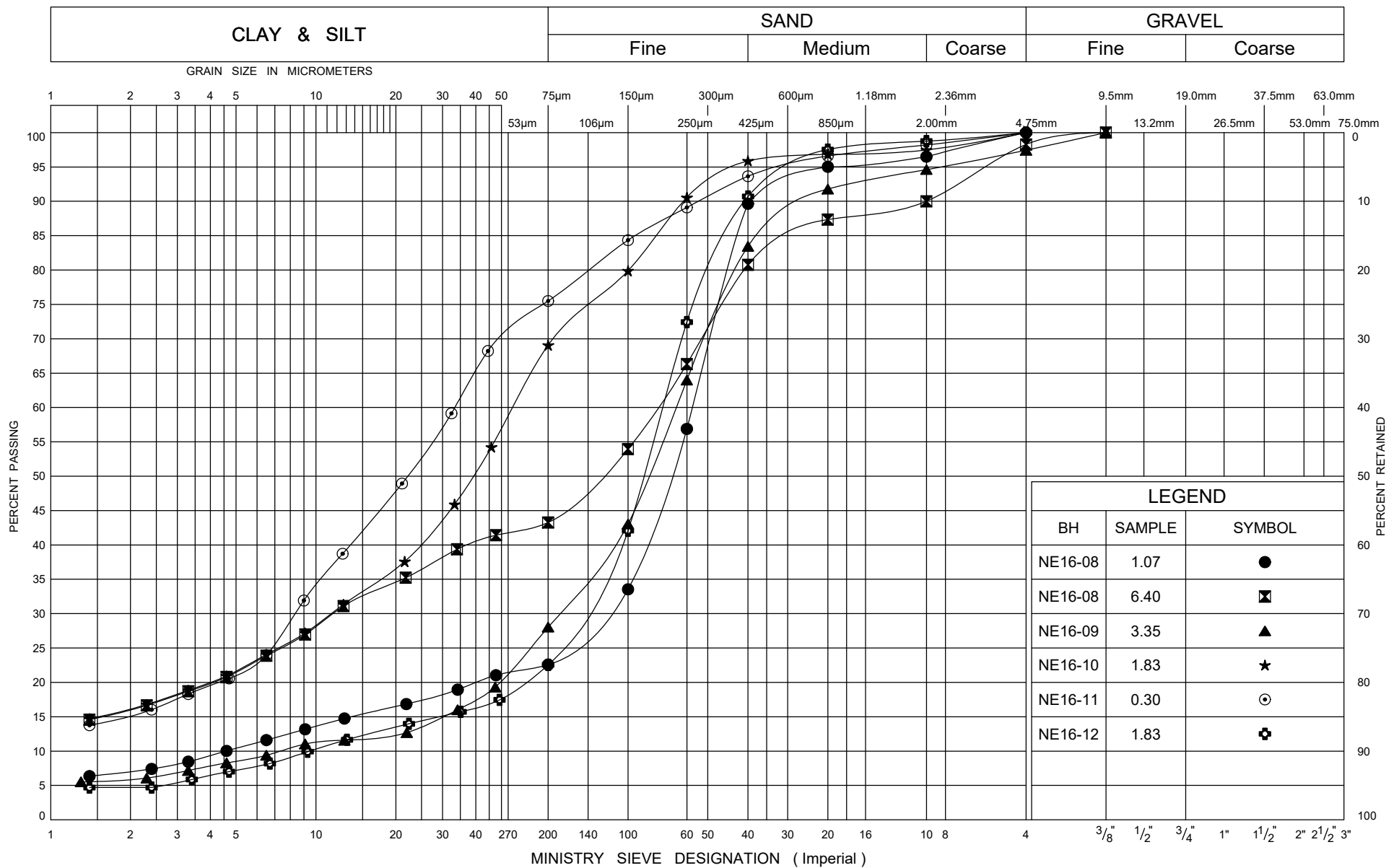
+³, ×³: Numbers refer to
Sensitivity

20
15 10 5
(%) STRAIN AT FAILURE

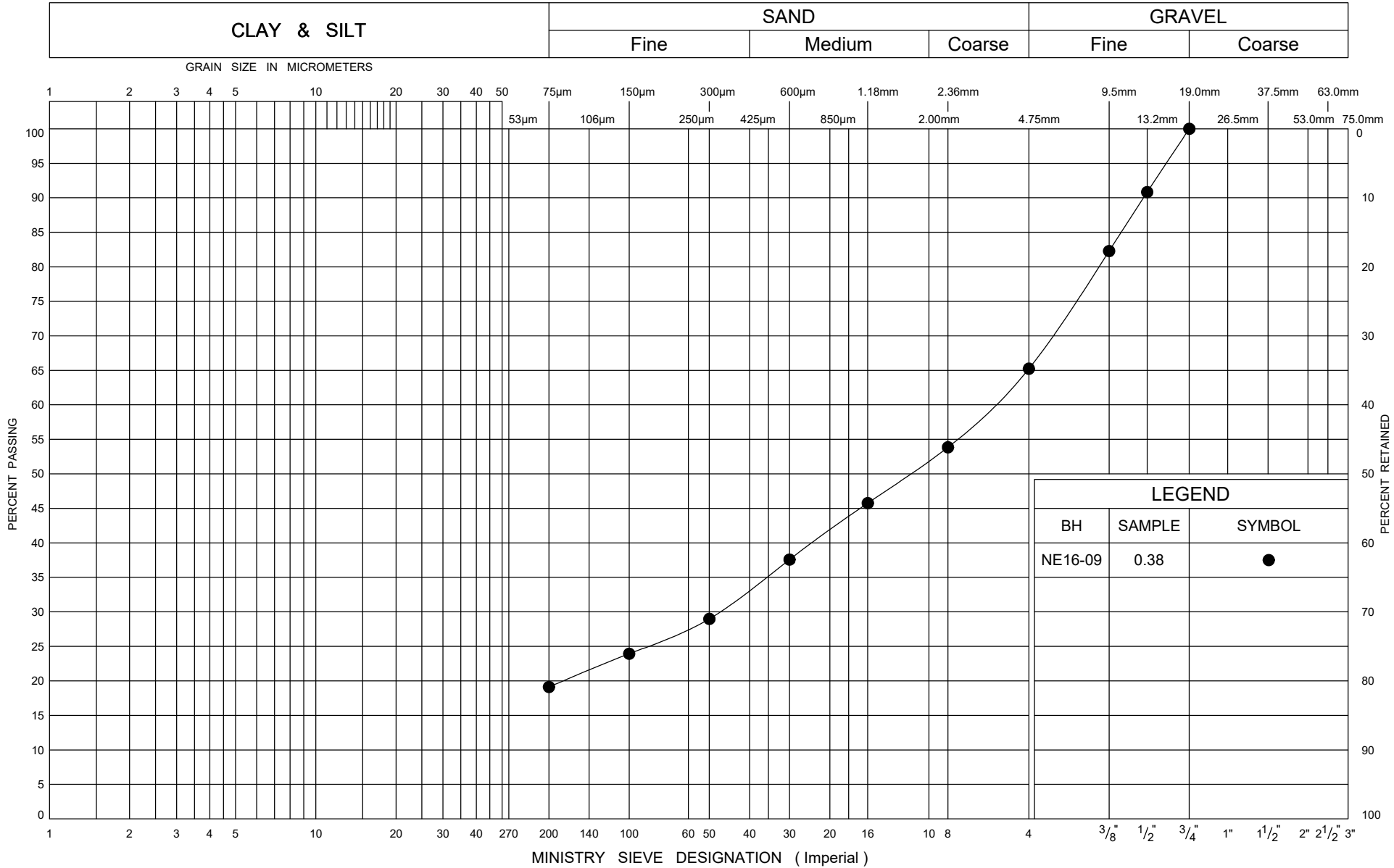


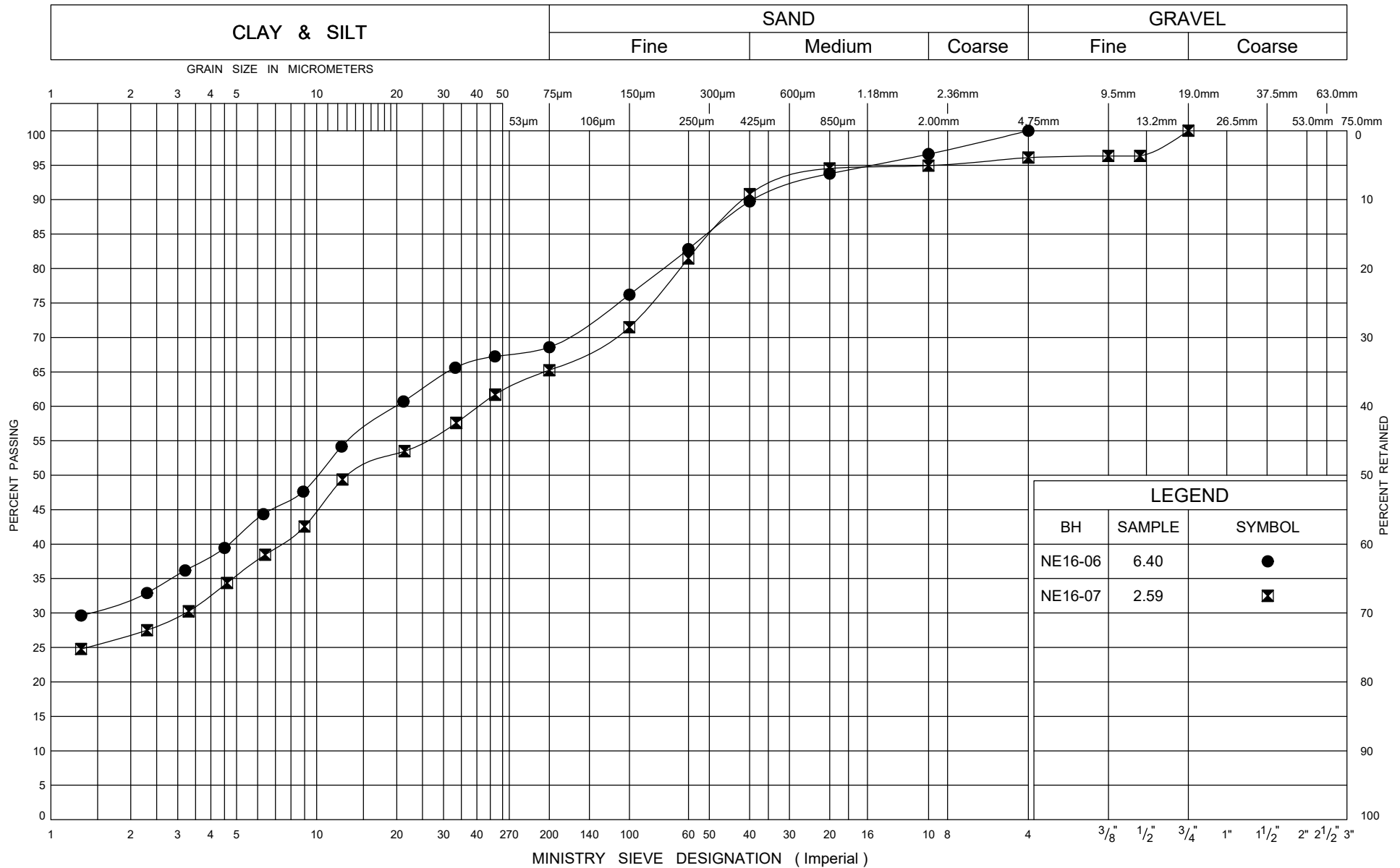
Appendix B

Geotechnical and Corrosivity Test Results



ONTARIO MOT GRAIN SIZE 2 MTO-11375(GINTDATA)\GPJ_ONTARIO MOT.GDT 5/21/20





Ministry of
Transportation

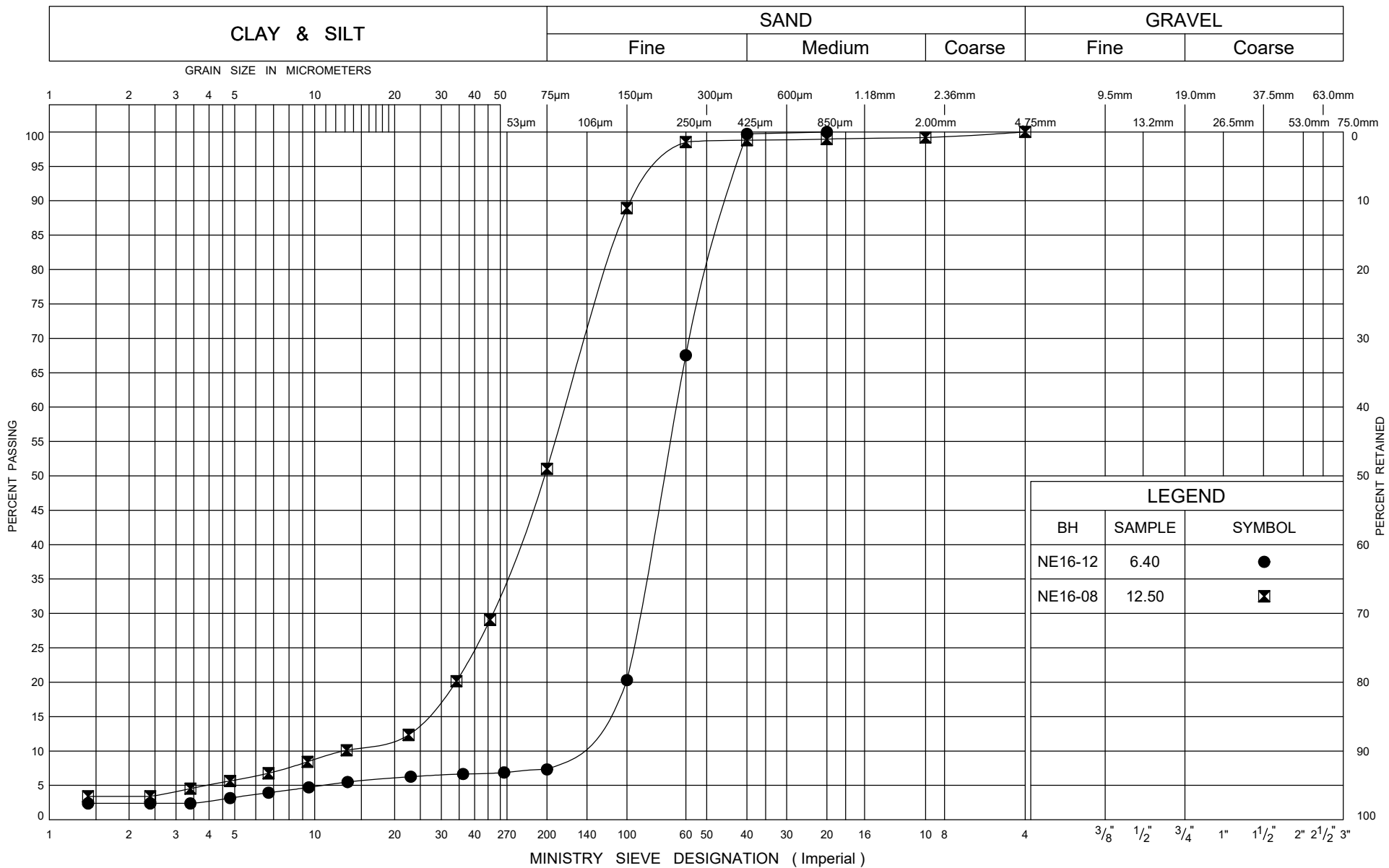
GRAIN SIZE DISTRIBUTION

Silty CLAY FILL

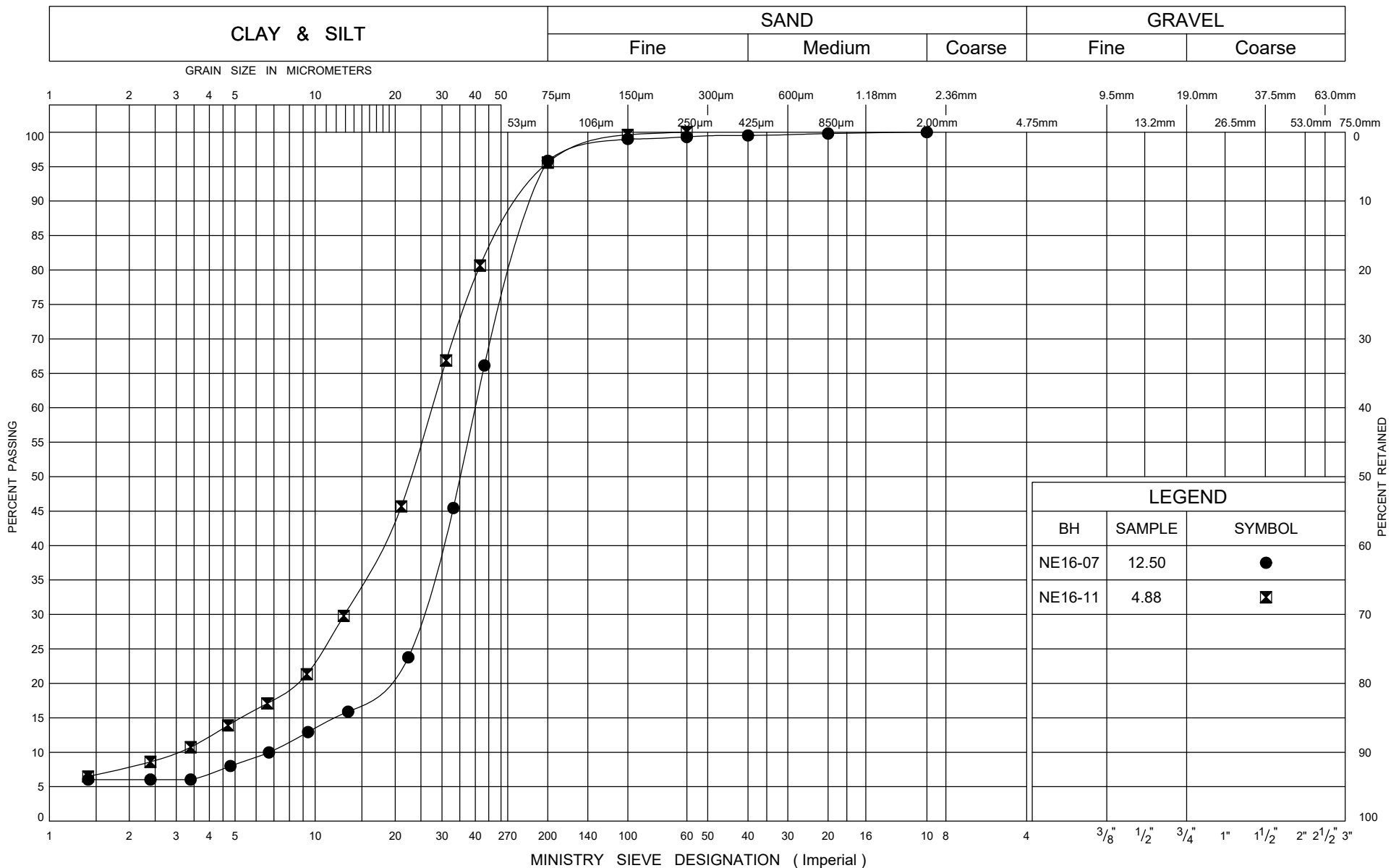
FIG No B3

W P 408-88-00

N-E Ramp over Hwy 85



LEGEND		
BH	SAMPLE	SYMBOL
NE16-12	6.40	●
NE16-08	12.50	⊠

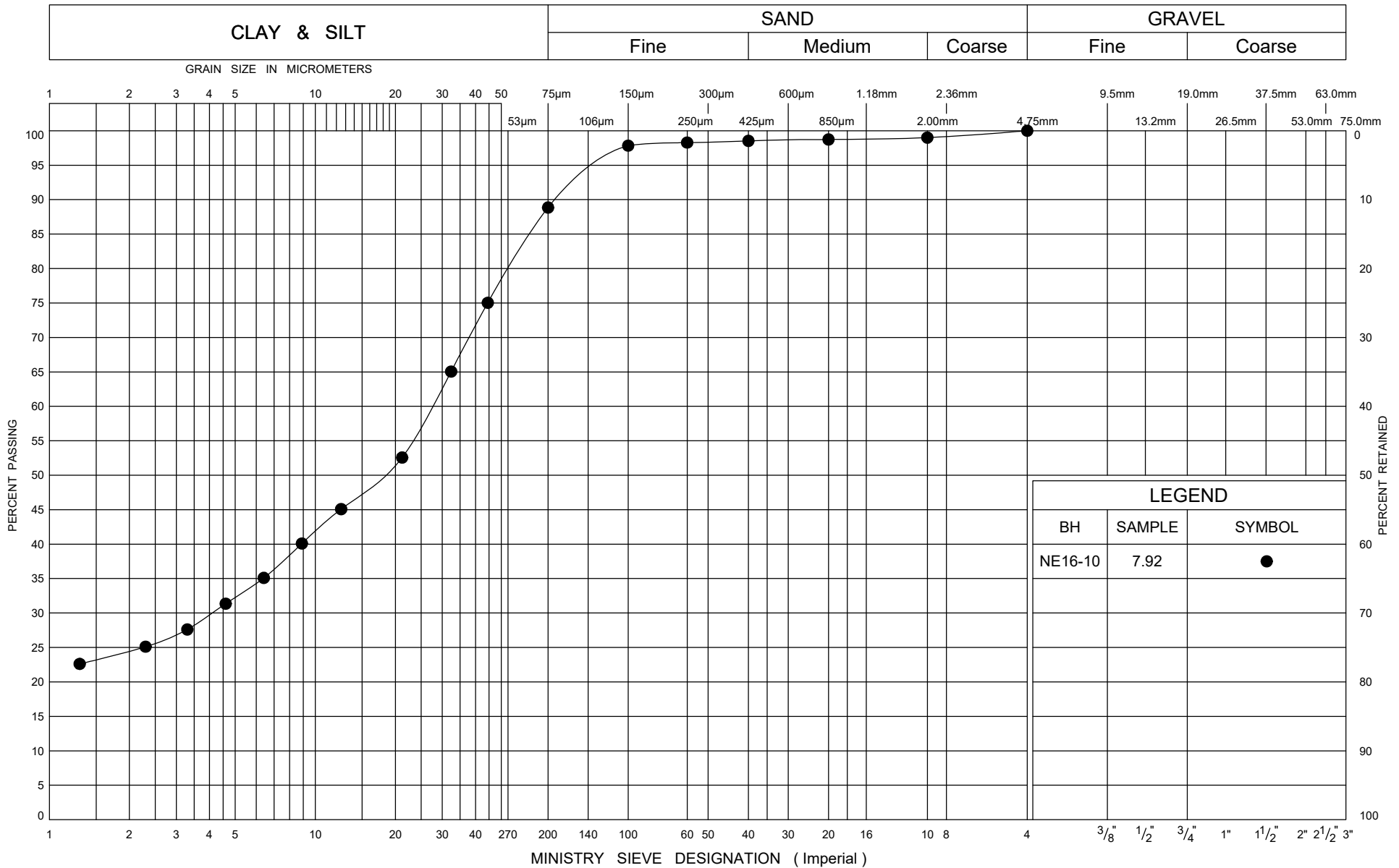


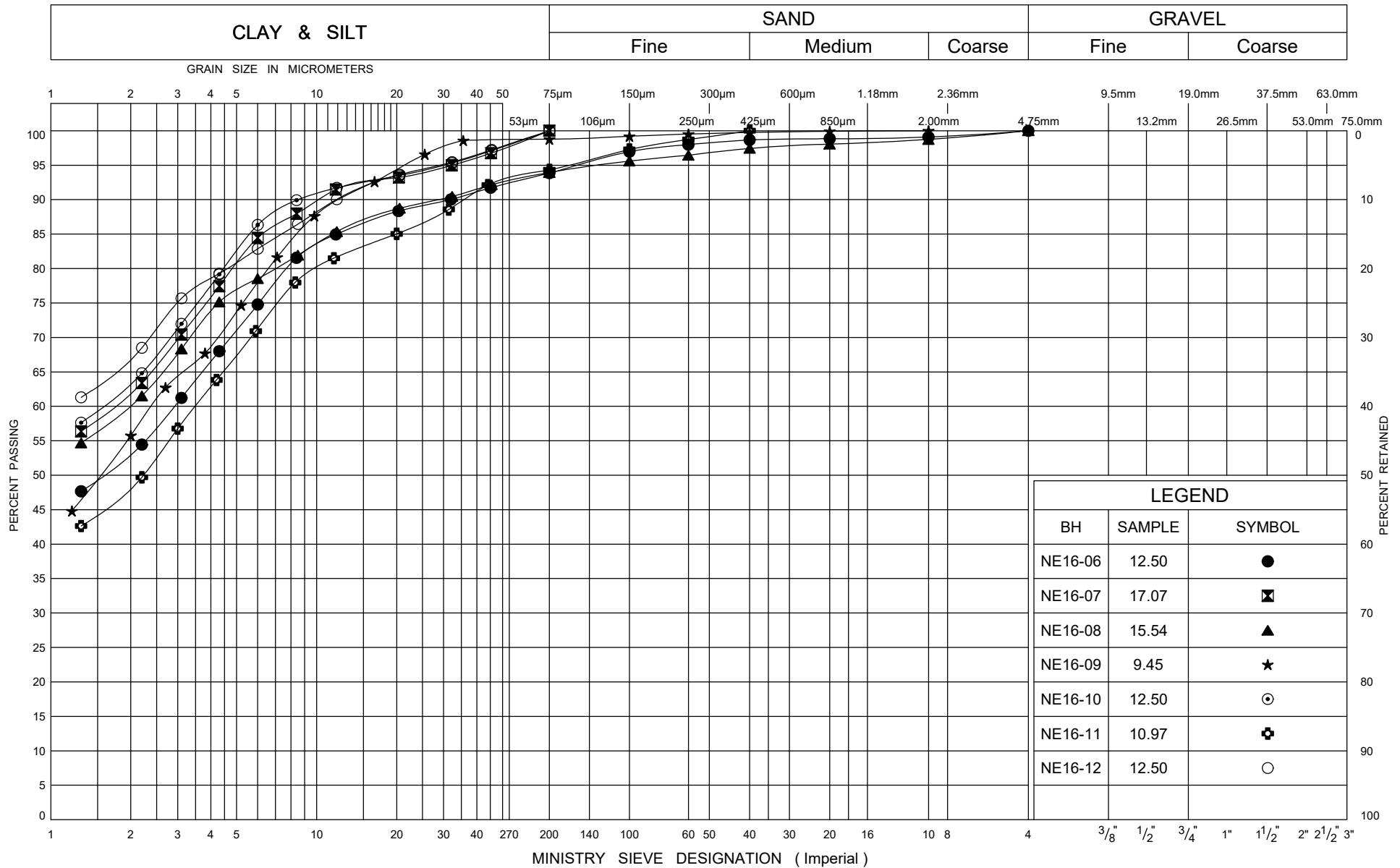
LEGEND		
BH	SAMPLE	SYMBOL
NE16-07	12.50	●
NE16-11	4.88	⊠



GRAIN SIZE DISTRIBUTION
SILT

FIG No B5
W P 408-88-00
N-E Ramp over Hwy 85





Ministry of
Transportation

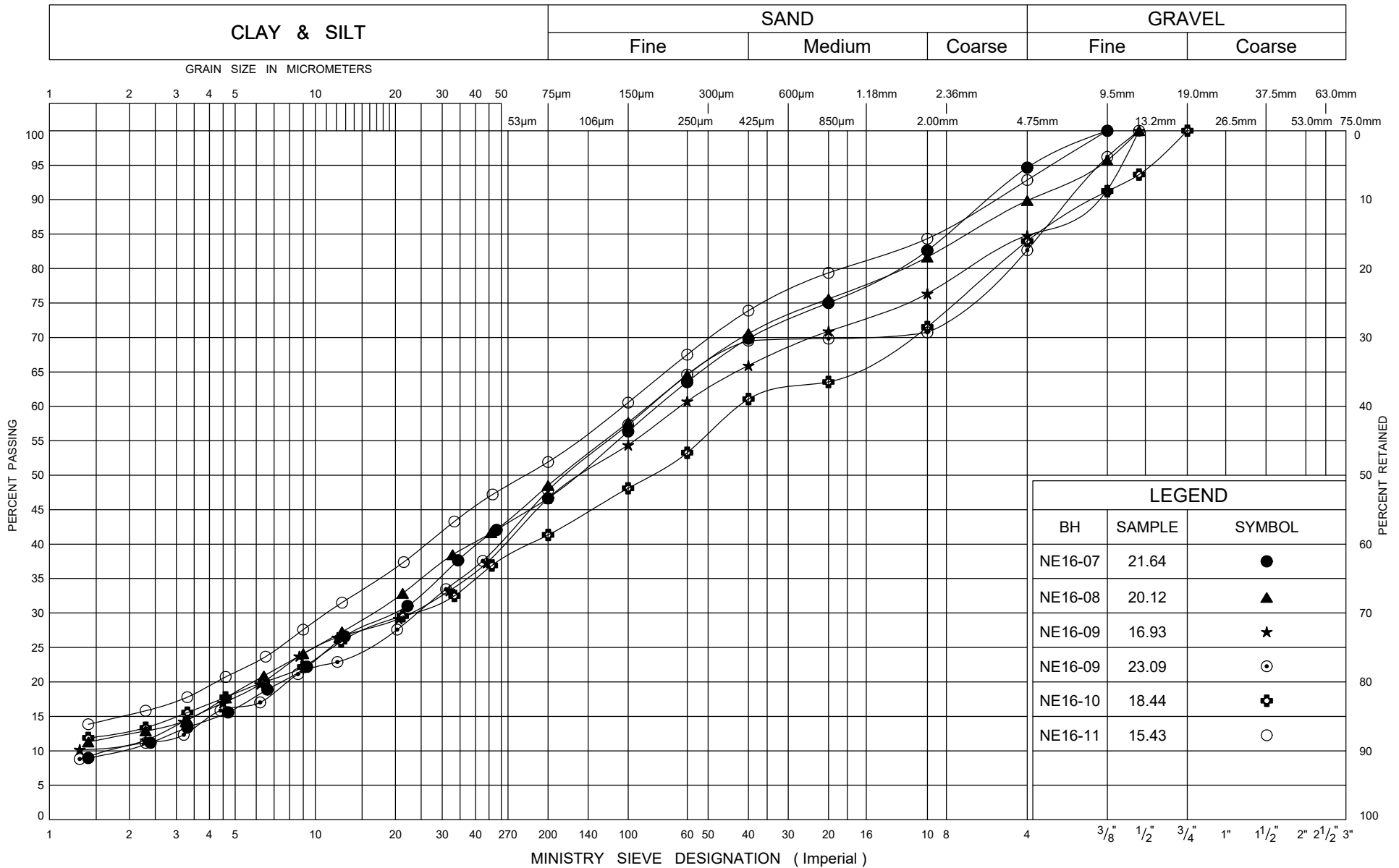
GRAIN SIZE DISTRIBUTION

Silty CLAY

FIG No B7

W P 408-88-00

N-E Ramp over Hwy 85



Ministry of
Transportation

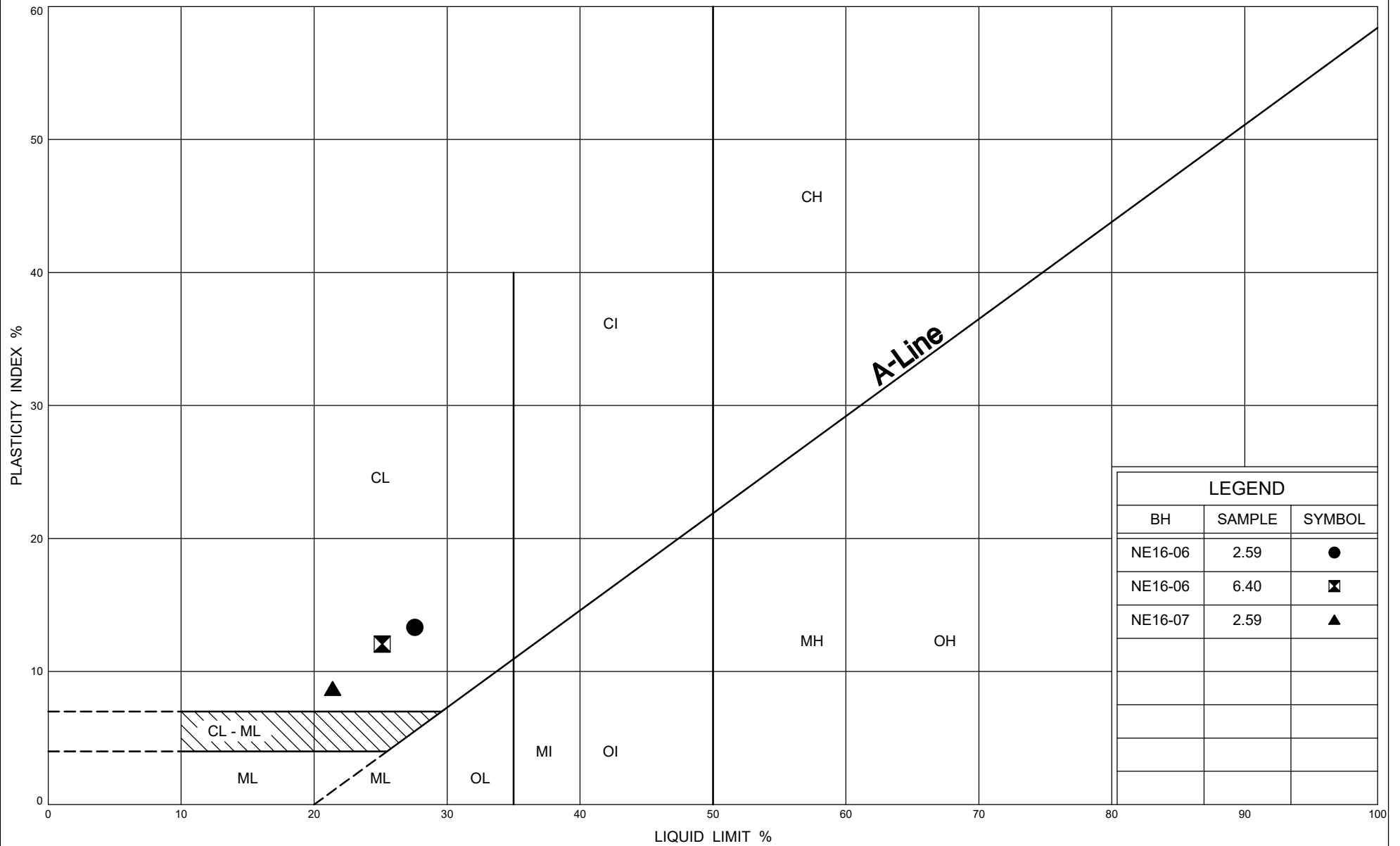
GRAIN SIZE DISTRIBUTION

Silty SAND to Sandy SILT TILL

FIG No B8

W P 408-88-00

N-E Ramp over Hwy 85



Ministry of
Transportation

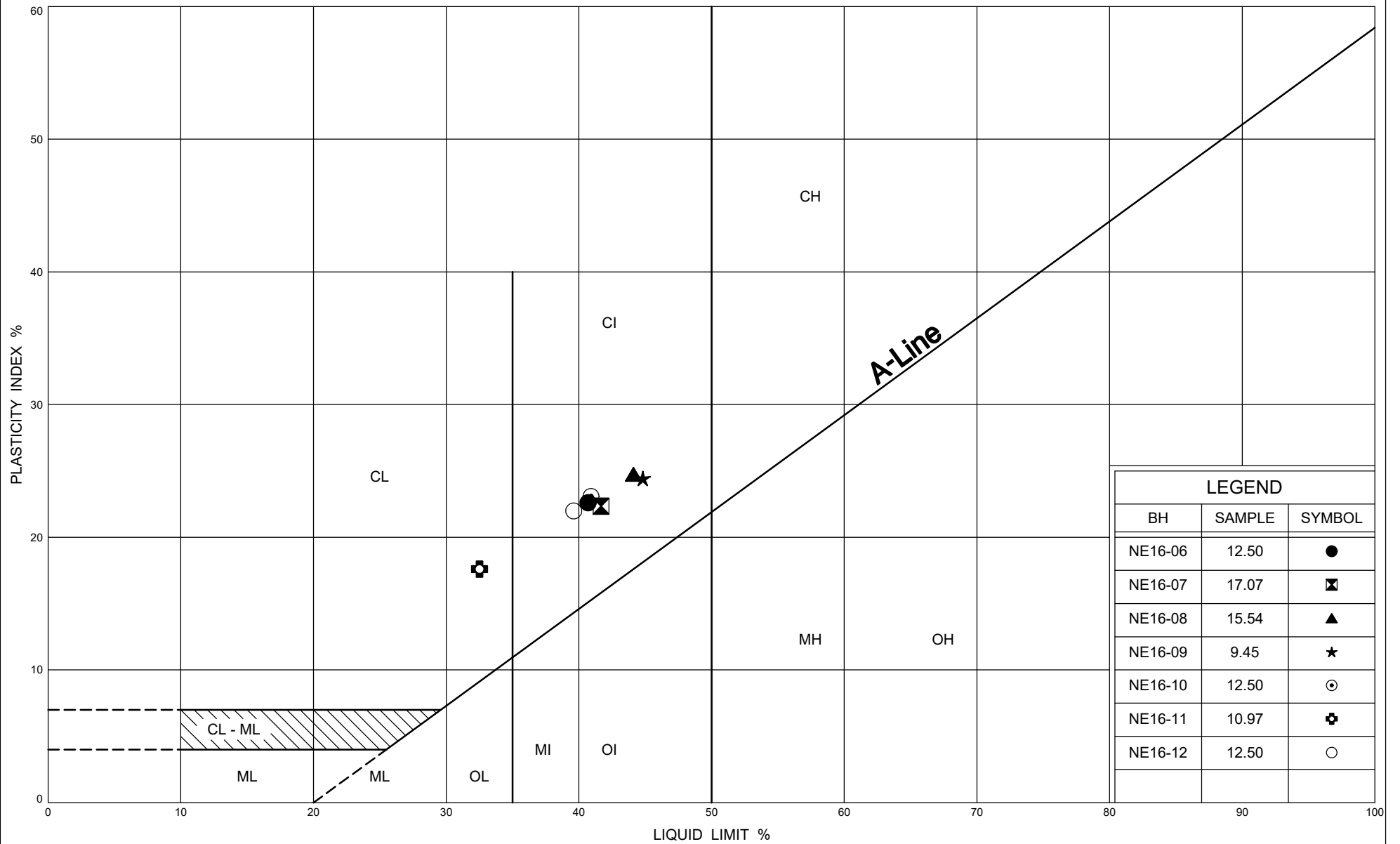
PLASTICITY CHART

Silty CLAY FILL

FIG No B9

W P 408-88-00

N-E Ramp over Hwy 85



Ministry of
Transportation

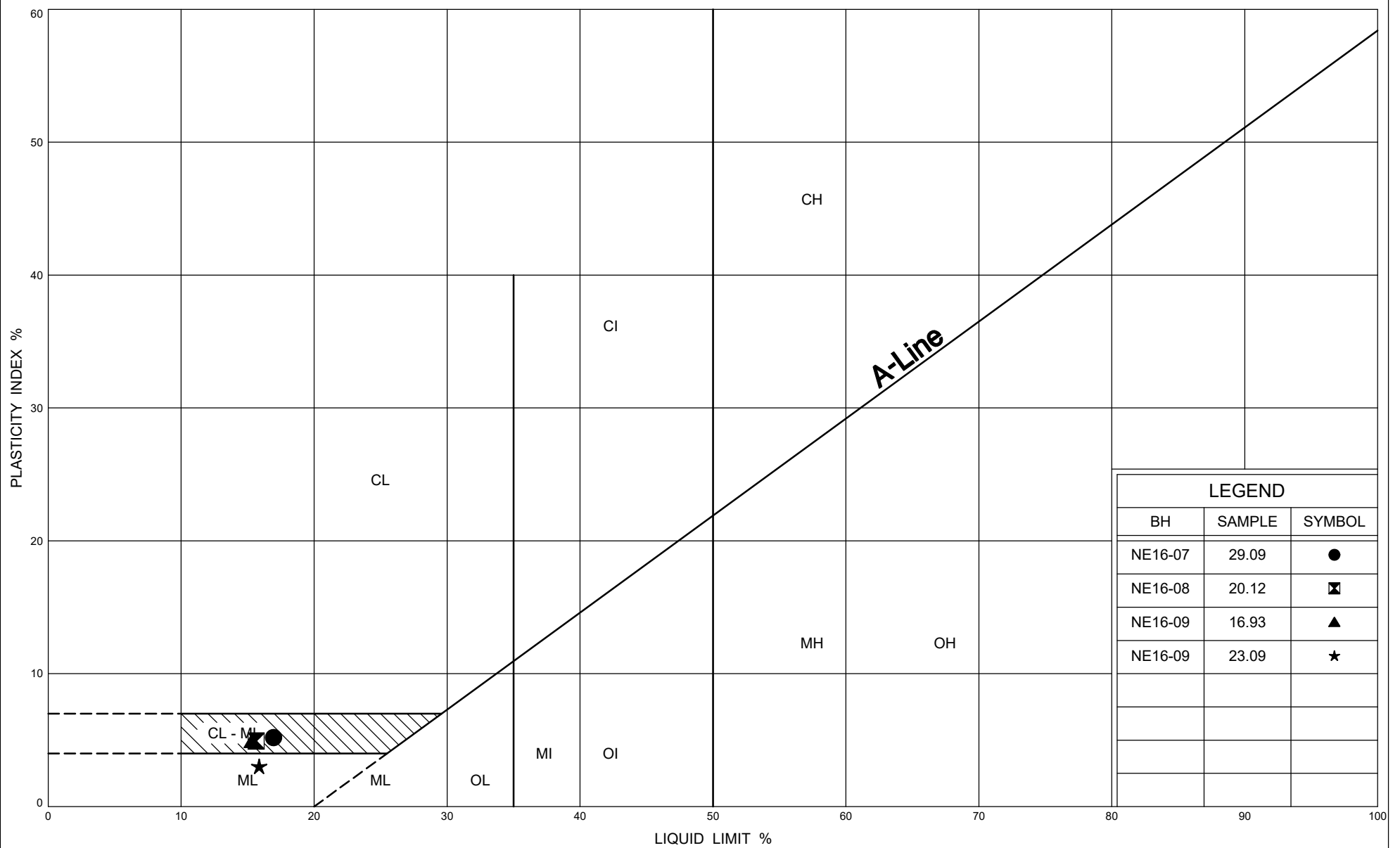
PLASTICITY CHART

Silty CLAY

FIG No B10

W P 408-88-00

N-E Ramp over Hwy 85



Ministry of
Transportation

PLASTICITY CHART Silty SAND to Sandy SILT TILL (Clayey Zone)

FIG No B11

W P 408-88-00

N-E Ramp over Hwy 85



FINAL REPORT

CA14437-AUG19 R1

11375 Hwy 7 New, Kitchener

Prepared for

Thurber Engineering Ltd.

First Page

CLIENT DETAILS

Client Thurber Engineering Ltd.

Address 103, 2010 Winston Park Drive
Oakville, ON
L6H 5R7, Canada

Contact Nancy Berg

Telephone 905-829-8666 x 228

Facsimile

Email nberg@thurber.ca

Project 11375 Hwy 7 New, Kitchener

Order Number

Samples Soil (5)

LABORATORY DETAILS

Project Specialist Rob Irwin B.Sc., C.Chem

Laboratory SGS Canada Inc.

Address 185 Concession St., Lakefield ON, K0L 2H0

Telephone 705-652-2361

Facsimile 705-652-6365

Email rob.irwin@sgs.com

SGS Reference CA14437-AUG19

Received 08/13/2019

Approved 08/19/2019

Report Number CA14437-AUG19 R1

Date Reported 08/19/2019

COMMENTS

Temperature of Sample upon Receipt: 4 degrees C

Cooling Agent Present: yes

Custody Seal Present: no

Chain of Custody Number: 009972

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

Rob Irwin B.Sc., C.Chem





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FINAL REPORT

CA14437-AUG19 R1

Client: Thurber Engineering Ltd.

Project: 11375 Hwy 7 New, Kitchener

Project Manager: Nancy Berg

Samplers: Nancy Berg

PACKAGE: - Corrosivity Index (SOIL)

Sample Number	5	6	7	8	9
Sample Name	CN16-10 SS5	CN16-04 SS4	CN16-15 SS4	RW24-02 SS4	NE16-09 SS4
Sample Matrix	Soil	Soil	Soil	Soil	Soil
Sample Date	19/07/2019	23/07/2019	18/07/2019	06/08/2019	06/08/2019

Parameter	Units	RL		Result	Result	Result	Result	Result
Corrosivity Index								
Corrosivity Index	none	1		4	1	5	11	14
Soil Redox Potential	mV	-		306	312	255	263	227
Sulphide	%	0.02		< 0.02	< 0.02	0.02	< 0.02	< 0.02
pH	pH Units	0.05		8.56	8.29	7.88	8.18	8.66
Resistivity (calculated)	ohms.cm	-9999		5100	3200	2500	780	1400

PACKAGE: - General Chemistry (SOIL)

Sample Number	5	6	7	8	9
Sample Name	CN16-10 SS5	CN16-04 SS4	CN16-15 SS4	RW24-02 SS4	NE16-09 SS4
Sample Matrix	Soil	Soil	Soil	Soil	Soil
Sample Date	19/07/2019	23/07/2019	18/07/2019	06/08/2019	06/08/2019

Parameter	Units	RL		Result	Result	Result	Result	Result
General Chemistry								
Conductivity	uS/cm	2		195	317	400	1280	736

PACKAGE: - Metals and Inorganics (SOIL)

Sample Number	5	6	7	8	9
Sample Name	CN16-10 SS5	CN16-04 SS4	CN16-15 SS4	RW24-02 SS4	NE16-09 SS4
Sample Matrix	Soil	Soil	Soil	Soil	Soil
Sample Date	19/07/2019	23/07/2019	18/07/2019	06/08/2019	06/08/2019

Parameter	Units	RL		Result	Result	Result	Result	Result
Metals and Inorganics								
Moisture Content	%	0.1		20.1	6.1	24.6	13.1	6.5
Sulphate	µg/g	0.4		25	12	100	31	13



FINAL REPORT

CA14437-AUG19 R1

Client: Thurber Engineering Ltd.

Project: 11375 Hwy 7 New, Kitchener

Project Manager: Nancy Berg

Samplers: Nancy Berg

PACKAGE: - Other (ORP) (SOIL)

Sample Number	5	6	7	8	9
Sample Name	CN16-10 SS5	CN16-04 SS4	CN16-15 SS4	RW24-02 SS4	NE16-09 SS4
Sample Matrix	Soil	Soil	Soil	Soil	Soil
Sample Date	19/07/2019	23/07/2019	18/07/2019	06/08/2019	06/08/2019

Parameter	Units	RL		Result	Result	Result	Result	Result
Other (ORP)								
Chloride	µg/g	0.4		25	7.8	60	760	430



FINAL REPORT

CA14437-AUG19 R1

QC SUMMARY

Anions by IC
Method: EPA300/MA300-Ions1.3 | Internal ref.: ME-CA-IENVIIC-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	DIO0262-AUG19	µg/g	0.4	<0.4	9	20	93	80	120	98	75	125
Sulphate	DIO0262-AUG19	µg/g	0.4	<0.4	13	20	94	80	120	96	75	125

Carbon/Sulphur
Method: ASTM E1915-07A | Internal ref.: ME-CA-IENVIARD-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	ECS0029-AUG19	%	0.02	<0.02	ND	20	110	80	120			

Conductivity
Method: SM 2510 | Internal ref.: ME-CA-IENVIEWL-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	EWL0246-AUG19	uS/cm	2	< 0.002	0	10	100	90	110	NA		



QC SUMMARY

pH
Method: SM 4500 | Internal ref.: ME-CA-1ENVIEWL-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	EWL0246-AUG19	pH Units	0.05	NA	0		100			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.

SGS provides criteria information (such as regulatory or guideline limits and summary of limit exceedances) as a service. Every attempt is made to ensure the criteria information in this report is accurate and current, however, it is not guaranteed. Comparison to the most current criteria is the responsibility of the client and SGS assumes no responsibility for the accuracy of the criteria levels indicated. This document is issued, on the Client's behalf, by the Company under its General Conditions of Service available on request and accessible at http://www.sgs.com/terms_and_conditions.htm. The Client's attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein. Any other holder of this document is advised that information contained hereon reflects the Company's findings at the time of its intervention only and within the limits of Client's instructions, if any. The Company's sole responsibility is to its Client and this document does not exonerate parties to a transaction from exercising all their rights and obligations under the transaction documents.

This report must not be reproduced, except in full. This report supersedes all previous versions.

-- End of Analytical Report --

REPORT INFORMATION				INVOICE INFORMATION				PROJECT INFORMATION			
Received By: <u>Oleg Mozhin</u>				Received By (signature): <u>[Signature]</u>				Quotation #: _____			
Received Date (mm/dd/yy): <u>8/15/19</u> (mm/dd/yy)				Custody Seal Present: <input checked="" type="checkbox"/> <u>ice</u>				Project #: <u>11375</u>			
Received Time: <u>11:05</u>				Custody Seal Intact: <input checked="" type="checkbox"/> <u>no</u>				Site Location/ID: <u>How 7 New, Kitchens</u>			
Company: <u>Thurber Engineering Ltd</u>				<input type="checkbox"/> (same as Report Information)				P.O. #: _____			
Contact: <u>Nancy Berg</u>				Company: _____				TURNAROUND TIME (TAT) REQUIRED			
Address: <u>103 - 2010 Winston Park Dr</u>				Contact: _____				TAT's are quoted in business days (exclude statutory holidays & weekends).			
City: <u>Oakville On L6H 5A7</u>				Address: _____				Samples received after 6pm or on weekends: TAT begins next business day			
Phone: <u>647-633-8411</u>				Phone: _____				<input checked="" type="checkbox"/> Regular TAT (5-7days)			
Email: <u>nberg@thurber.ca</u>				Email: _____				<input type="checkbox"/> 1 Day <input type="checkbox"/> 2 Days <input type="checkbox"/> 3 Days <input type="checkbox"/> 4 Days			
Rush Confirmation ID: _____				Specify Due Date: _____				RUSH TAT (Additional Charges May Apply):			
NOTE: DRINKING (POTABLE) WATER SAMPLES FOR HUMAN CONSUMPTION MUST BE SUBMITTED WITH SGS DRINKING WATER CHAIN OF CUSTODY				NOTE: DRINKING (POTABLE) WATER SAMPLES FOR HUMAN CONSUMPTION MUST BE SUBMITTED WITH SGS DRINKING WATER CHAIN OF CUSTODY				PLEASE CONFIRM RUSH FEASIBILITY WITH SGS REPRESENTATIVE PRIOR TO SUBMISSION			
REGULATIONS				REGULATIONS				COMMENTS:			
Regulation 153/04:				Regulation 153/04:				ANALYSIS REQUESTED			
<input type="checkbox"/> Table 1 <input type="checkbox"/> R/P/I <input type="checkbox"/> Soil Texture: <input type="checkbox"/> Coarse <input type="checkbox"/> Medium <input type="checkbox"/> Fine				<input type="checkbox"/> Reg 347/558 (3 Day min TAT) <input type="checkbox"/> PWQO <input type="checkbox"/> MMER <input type="checkbox"/> CCOME <input type="checkbox"/> MISA <input type="checkbox"/> NO				<input type="checkbox"/> PAH <input type="checkbox"/> ABN <input type="checkbox"/> SVOC(all) <input type="checkbox"/> PCB Total <input type="checkbox"/> Aroclor <input type="checkbox"/> PHC F1-F4 <input type="checkbox"/> VOC <input type="checkbox"/> BTEX <input type="checkbox"/> BTEX/F1 <input type="checkbox"/> F2-F4 <input type="checkbox"/> VOC <input type="checkbox"/> BTEX <input type="checkbox"/> THM <input type="checkbox"/> Pesticides OC <input type="checkbox"/> OP <input type="checkbox"/> TCLP M&I <input type="checkbox"/> VOC <input type="checkbox"/> PCB <input type="checkbox"/> B(a)P <input type="checkbox"/> ABN <input type="checkbox"/> Ignit. <input type="checkbox"/> Water Pkg Gen. <input type="checkbox"/> Ext. <input type="checkbox"/> Sewer Use:			
RECORD OF SITE CONDITION (RSC) <input type="checkbox"/> YES <input type="checkbox"/> NO				Sewer By-Law: <input type="checkbox"/> Sanitary <input type="checkbox"/> Storm <input type="checkbox"/> Municipality:				Field Filtered (Y/N)			
SAMPLE IDENTIFICATION				DATE SAMPLED				TIME SAMPLED			
1 CN16-10 555				July 19/19				1 Soil			
2 CN16-04 554				July 23/19				1 Soil			
3 CN16-15 554				July 18/19				1 Soil			
4 RW24-02 554				Aug 6/19				1 Soil			
5 NE16-09 554				Aug 7/19				1 Soil			
6											
7											
8											
9											
10											
11											
12											
Observations/Comments/Special Instructions											
Sampled By (NAME): <u>Nancy Berg</u>				Signature: <u>[Signature]</u>				Date: <u>08/11/19</u> (mm/dd/yy)			
Relinquished by (NAME): <u>Nancy Berg</u>				Signature: <u>[Signature]</u>				Date: <u>08/11/19</u> (mm/dd/yy)			
								Pink Copy - Client			
								Yellow & White Copy - SGS			



FINAL REPORT

CA14445-AUG18 R1

11375

Prepared for

Thurber Engineering Ltd.

First Page

CLIENT DETAILS

Client Thurber Engineering Ltd.

Address 103, 2010 Winston Park Drive
Oakville, ON
L6H 5R7, Canada

Contact Rocio Palomeque

Telephone 905-829-8666 x 263

Facsimile

Email rreyna@thurber.ca

Project 11375

Order Number

Samples Soil (5)

LABORATORY DETAILS

Project Specialist Deanna Edwards, B.Sc, C.Chem

Laboratory SGS Canada Inc.

Address 185 Concession St., Lakefield ON, K0L 2H0

Telephone 705-652-2000

Facsimile 705-652-6365

Email deanna.edwards@sgs.com

SGS Reference CA14445-AUG18

Received 08/16/2018

Approved 08/23/2018

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





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QC Summary..... 5-6

Legend..... 7

Annexes..... 8-9



FINAL REPORT

CA14445-AUG18 R1

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

CA14445-AUG18 R1

QC SUMMARY

Anions by IC
Method: EPA300/MA300-Ions1.3 | Internal ref.: ME-CA-IENVIIC-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-IENVIARD-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-IENVIEWL-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		



FINAL REPORT

CA14445-AUG18 R1

QC SUMMARY

pH
Method: SM 4500 | Internal ref.: ME-CA-|ENVIEWL-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.

SGS provides criteria information (such as regulatory or guideline limits and summary of limit exceedances) as a service. Every attempt is made to ensure the criteria information in this report is accurate and current, however, it is not guaranteed. Comparison to the most current criteria is the responsibility of the client and SGS assumes no responsibility for the accuracy of the criteria levels indicated. This document is issued, on the Client's behalf, by the Company under its General Conditions of Service available on request and accessible at http://www.sgs.com/terms_and_conditions.htm. The Client's attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein. Any other holder of this document is advised that information contained hereon reflects the Company's findings at the time of its intervention only and within the limits of Client's instructions, if any. The Company's sole responsibility is to its Client and this document does not exonerate parties to a transaction from exercising all their rights and obligations under the transaction documents.

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-- End of Analytical Report --



Request for Laboratory Services and CHAIN OF CUSTODY

No: 00864
Page 1 of 1

SGS Environment,
Health and Safety

- Lakeland: 185 Concession St., Lakeland, 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: Volko Col
Received Date: 08/15/18 (mm/dd/yy)
Received Time: 12:00 am (pm) (circle)

Received By (signature): [Signature]
Custody Seal Present: Y (circle)
Custody Seal Intact: Y (circle)

Cooling Agent Present: Y (circle)
Temperature Upon Receipt (°C): 13.14, 12

CA 14445-
LAB LIMS #: 603
Accession #: 18

REPORT INFORMATION

Company: T Huber Engineering Ltd.
Contact: Rocio Palomeque Reyna
Address: 103-2010 Winston Park Dr.
Oakville, ON L6H 5R7
Phone: 905-829-8666 x260
Fax: 905-829-8666
Email: [Redacted]

INVOICE INFORMATION

☐ (same as Report Information)
Company: _____
Contact: _____
Address: _____
Phone: _____
Email: _____

PROJECT INFORMATION

Quotation #: 11375 P.O. #: _____
Project #: _____ Site Location/ID: _____
TURNAROUND TIME (TAT) REQUIRED
☒ Regular TAT (5-7 days) TATs 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

ANALYSIS REQUESTED

COMMENTS:
Field Filtered (F)
Preserved (P)

REGULATIONS

Regulation 153 (2011):
☐ Table 1 ☐ Res/Park ☐ Soil Texture: ☐ Reg 347/558 (3 Day min TAT)
☐ Table 2 ☐ Ind/Com ☐ Coarse ☐ PW/QO ☐ MMER
☐ Table 3 ☐ Agr/Other ☐ Medium ☐ CCME ☐ Other: _____
☐ Table _____ ☐ Fine ☐ MISA _____
Sewer By-Law: ☐ Sanitary ☐ Storm
Municipality: _____

RECORD OF SITE CONDITION (RSC)

☐ YES ☐ NO

SAMPLE IDENTIFICATION

	DATE SAMPLED	TIME SAMPLED	# OF BOTTLES	MATRIX	
1	RS16-03 - Sg4	May 18, 2018	1	Soil	✓
2					
3	RW7-01 - S533	June 5, 2018	1	Soil	✓
4					
5	RW1-04 - S552	June 6, 2018	1	Soil	✓
6					
7	NE16-10 S54	Aug 14, 2018	1	Soil	✓
8					
9	EC16-08 S53	July 16, 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



SAMPLE INTEGRITY REPORT

Project Number: 11375

ONTARIO REGULATION 153/04

SGS Sample ID CAK4445-Aug18

Date / Time Sampled see CoC

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

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

Sediment Log

- | | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
|----------------------------------------------------------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Groundwater samples contain visible sediment / particulate | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Groundwater contains greater than 1cm of sediment / particulate matter in bottle | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

Additional Comments/Remarks:

No issues upon receipt

☐

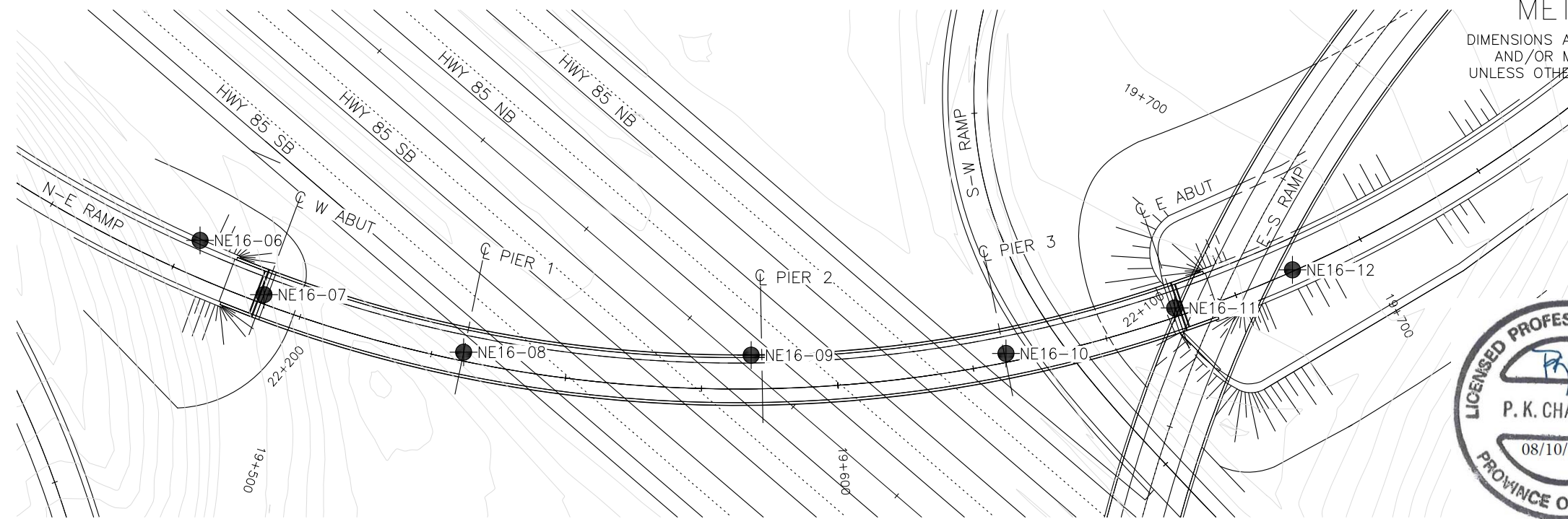
Initials:

KH



Appendix C

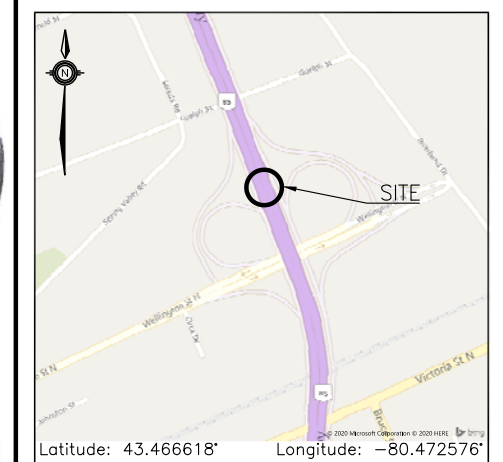
Borehole Locations and Soil Strata Drawing



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






CONT No
GWP No 408-88-00

HIGHWAY 7
N-E RAMP HIGHWAY 85 OVERPASS
PROPOSED BRIDGE
BOREHOLE LOCATIONS AND SOIL STRATA



KEYPLAN

LEGEND

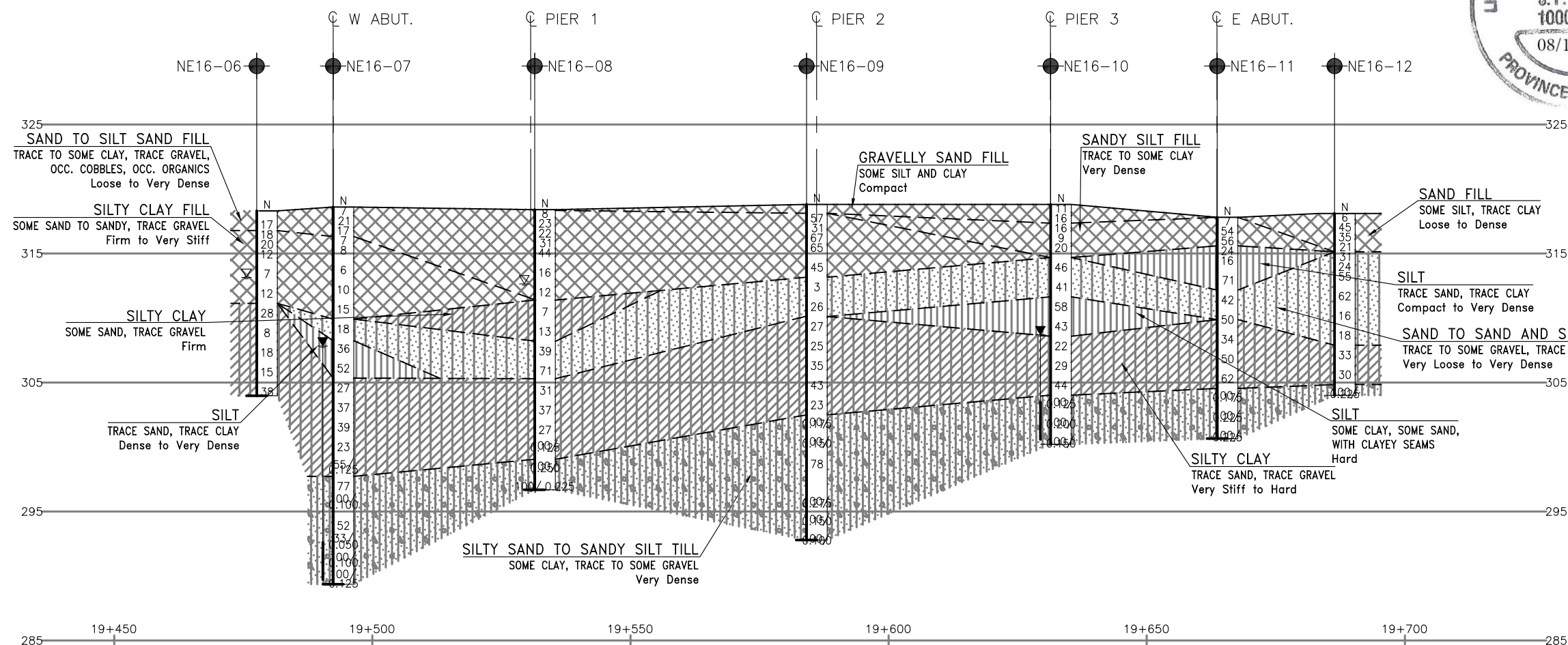
	Borehole (Current Investigation)
	Borehole (Previous Investigation By Thurber)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
NE16-06	318.3	4 814 603.9	226 026.5
NE16-07	318.6	4 814 589.6	226 032.1
NE16-08	318.4	4 814 563.1	226 059.4
NE16-09	318.8	4 814 537.9	226 105.7
NE16-10	318.8	4 814 516.2	226 147.0
NE16-11	317.8	4 814 509.0	226 178.2
NE16-12	318.1	4 814 505.0	226 200.5

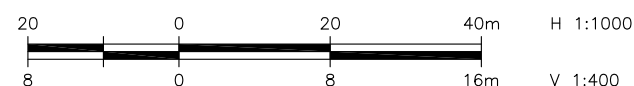
-NOTES-

- 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. 40P8-283



PROFILE ALONG N-E RAMP HIGHWAY 85 OVERPASS

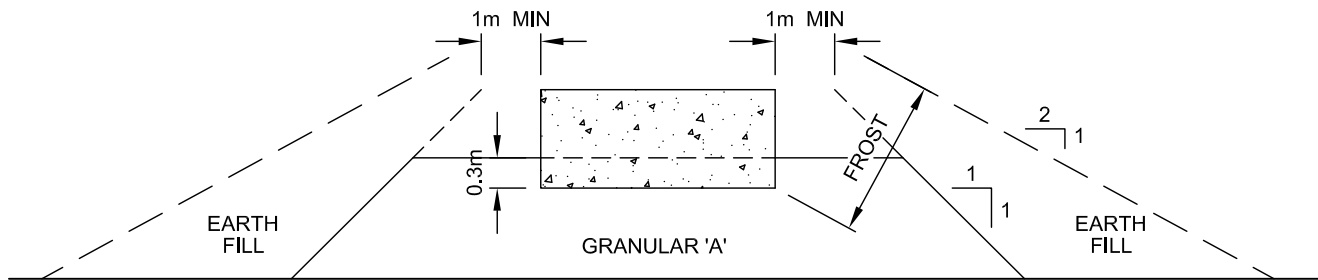


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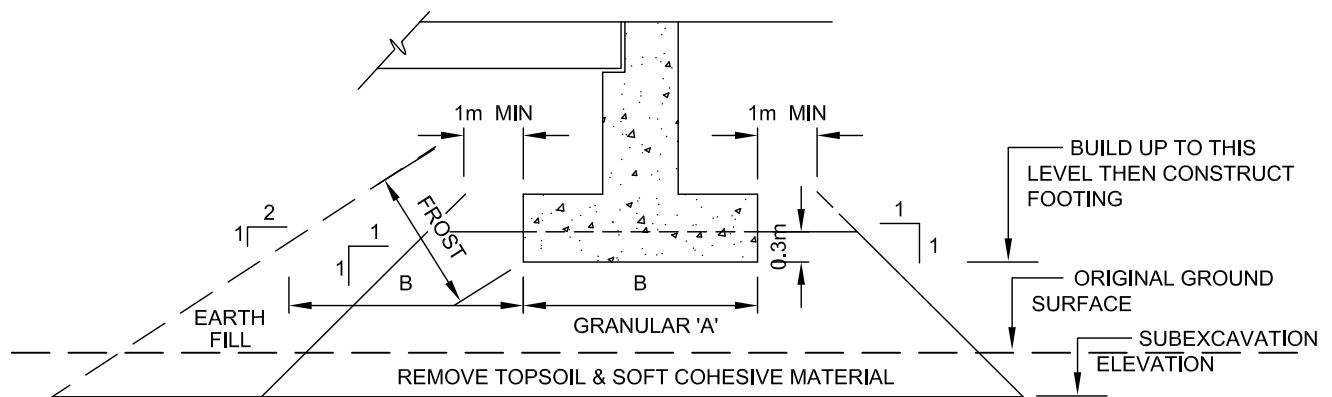


Appendix D

Figure For Engineered Fill Pad



CROSS-SECTION



LONGITUDINAL SECTION

NOTES:

1. REMOVE TOPSOIL AND OR SOFT SUBSOIL UNDER AREA OF COMPACTED GRANULAR 'A' AND EARTH FILL.
2. PLACE GRANULAR 'A' AND EARTH FILL TO BOTTOM OF FOOTING LEVEL, COMPACTED ACCORDING TO O.P.S.S. 501.
3. CONSTRUCT CONCRETE FOOTING.
4. PLACE REMAINDER OF GRANULAR 'A' AND EARTH FILL AS REQUIRED.
5. SOURCE M.T.C. 1982.

ABUTMENT ON COMPACTED FILL
SHOWING GRANULAR 'A' CORE



THURBER ENGINEERING LTD.

ENGINEER :

-

DRAWN :

MFA

APPROVED :

-

DATE :

SEPTEMBER 2016

SCALE :

N.T.S.

DRAWING No.

FIGURE 1



Appendix E

Foundation Comparison

COMPARISON OF FOUNDATION ALTERNATIVES FOR EACH FOUNDATION ELEMENT

Foundation Element	Spread Footings	Spread Footings on Engineered Fill	Driven Piles	Caisson
Abutments	<p>Advantages:</p> <ul style="list-style-type: none"> i. Generally less costly construction than deep foundation elements. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Dewatering may be required, depending on depth of excavation. <p style="text-align: center;">FEASIBLE</p>	<p>Advantages:</p> <ul style="list-style-type: none"> i. Generally less costly construction than deep foundation elements. ii. Better geotechnical resistance than spread footings on native soils. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Excavation (up to 4.0 m deep) of existing fill will be required to place the engineered fill on competent native soils. ii. Dewatering may be required, depending on depth of excavation. <p style="text-align: center;">FEASIBLE</p>	<p>Advantages:</p> <ul style="list-style-type: none"> ii. High geotechnical resistance may be developed by driving the piles into very dense till. iii. Comparatively short abutment stem possible. iv. Permits integral abutment design. v. Readily installed. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Higher unit cost compared to footings. ii. When driven into hard/very dense till deposits, 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. <p style="text-align: center;">RECOMMENDED</p>	<p>Advantages:</p> <ul style="list-style-type: none"> i. Construction of caissons could continue in freezing weather. ii. High geotechnical resistance available for units founded on very dense till. <p>Disadvantages:</p> <ul style="list-style-type: none"> 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. <p style="text-align: center;">NOT RECOMMENDED</p>
Piers	<p>Advantages:</p> <ul style="list-style-type: none"> i. Generally less costly construction than deep foundation elements. ii. High geotechnical resistances available on the very dense native soils. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Dewatering will be required, depending on depth of excavation. <p style="text-align: center;">FEASIBLE</p>	<p>Advantages:</p> <ul style="list-style-type: none"> i. Generally less costly construction than deep foundation elements. ii. Better geotechnical resistance than spread footings on native soils. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Dewatering may be required, depending on depth of excavation. <p style="text-align: center;">FEASIBLE</p>	<p>Advantages:</p> <ul style="list-style-type: none"> i. High geotechnical resistance may be developed by driving the piles into very dense till ii. Comparatively short abutment stem possible iii. Permits integral abutment design. iv. Readily installed. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Higher unit cost compared to footings. ii. When driven into hard/very dense till deposits, 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. <p style="text-align: center;">RECOMMENDED</p>	<p>Advantages:</p> <ul style="list-style-type: none"> i. Construction of caissons could continue in freezing weather. ii. High geotechnical resistance available for units founded on very dense till. <p>Disadvantages:</p> <ul style="list-style-type: none"> 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. <p style="text-align: center;">NOT RECOMMENDED</p>



Appendix F

Slope Stability Output



Project Number: 11375
 Highway 7 - New
 N-E Ramp over Hwy 85
 Embankment - Side slope
 Height: 13 m approx
 Drained Analysis

Color	Name	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line
	01 - New embankment Fill	20	0	30	0	1
	02 - Compact Sand Fill	19	0	28	0	1
	03 - Compact to very dense sand	20	0	31	0	1
	04 - Hard silty clay	21	0	30	0	1

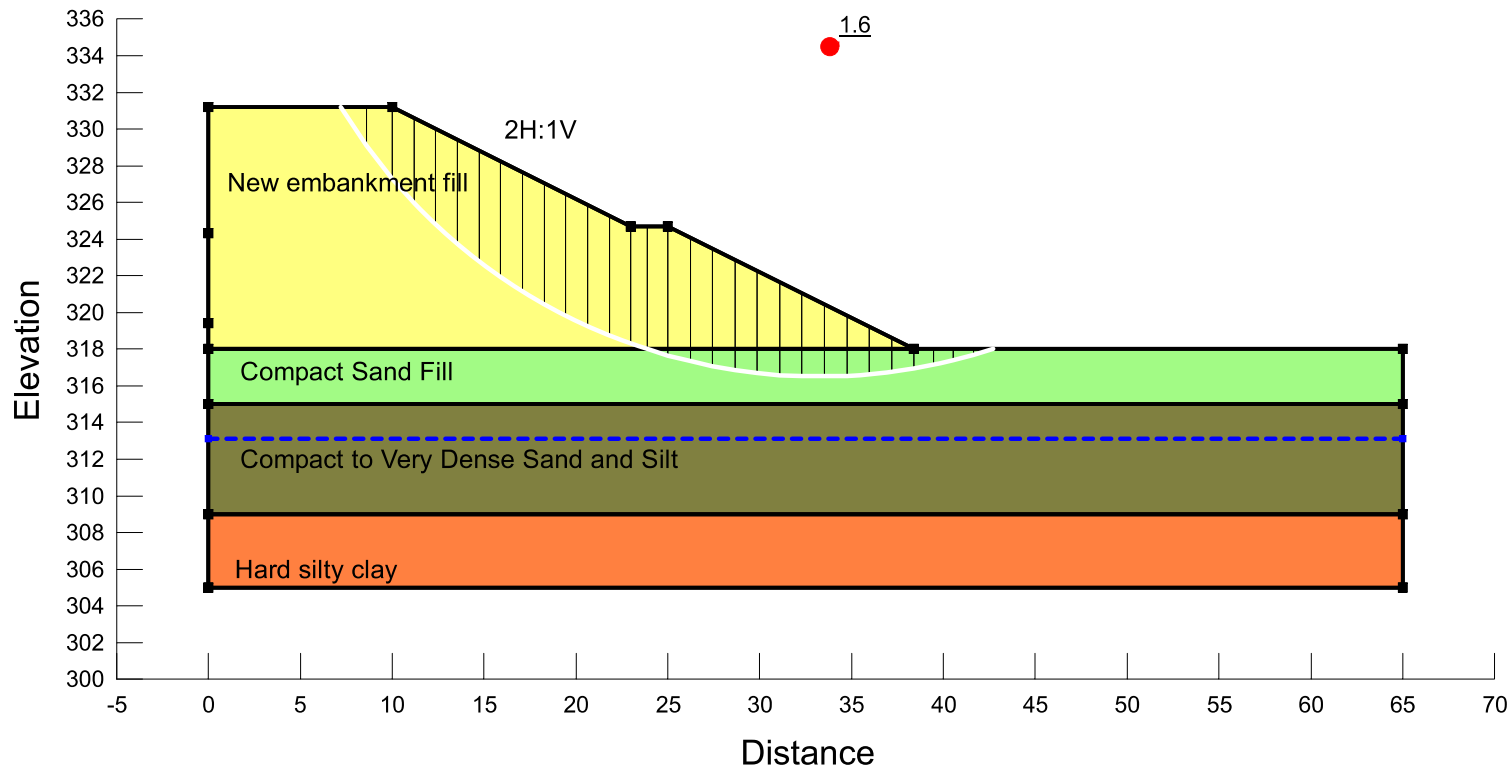


Figure 1F



Project Number: 11375
 Highway 7 - New
 N-E Ramp over Hwy 85
 Embankment - Side slope
 Height: 13 m approx
 Undrained Analysis

Color	Name	Unit Weight (kN/m³)	Cohesion (kPa)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line
	01 - New embankment Fill	20		0	30	0	1
	02 - Compact Sand Fill	19		0	28	0	1
	03 - Compact to very dense sand	20		0	31	0	1
	04 - Hard silty clay	21	150				1

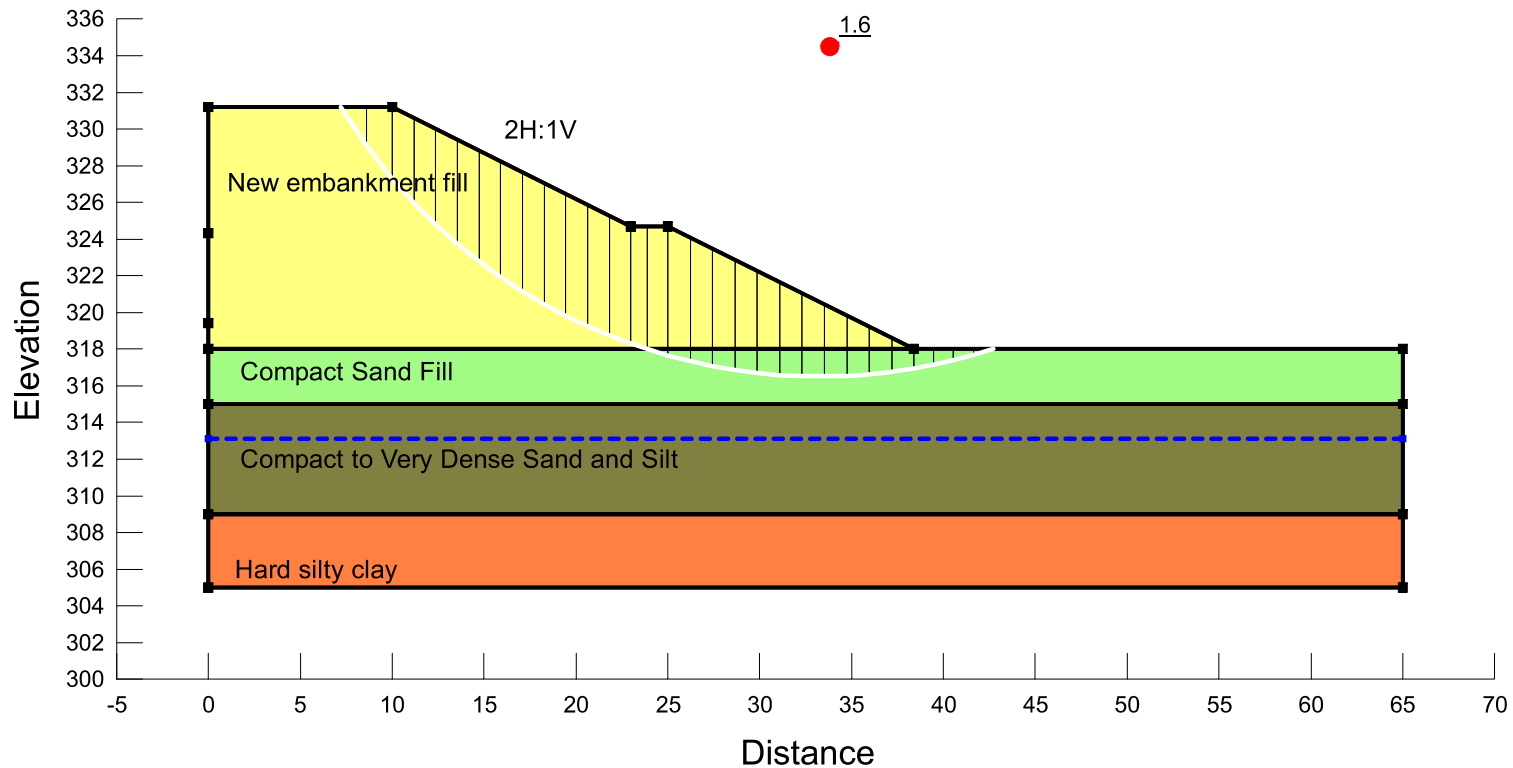


Figure 2F



Project Number: 11375
 Highway 7 - New
 N-E Ramp over Hwy 85
 Embankment - Side slope
 Height: 13 m approx
 Seismic Analysis PGA=0.097g

Color	Name	Unit Weight (kN/m³)	Cohesion (kPa)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line
	01 - New embankment Fill	20		0	30	0	1
	02 - Compact Sand Fill	19		0	28	0	1
	03 - Compact to very dense sand	20		0	31	0	1
	04 - Hard silty clay	21	150				1

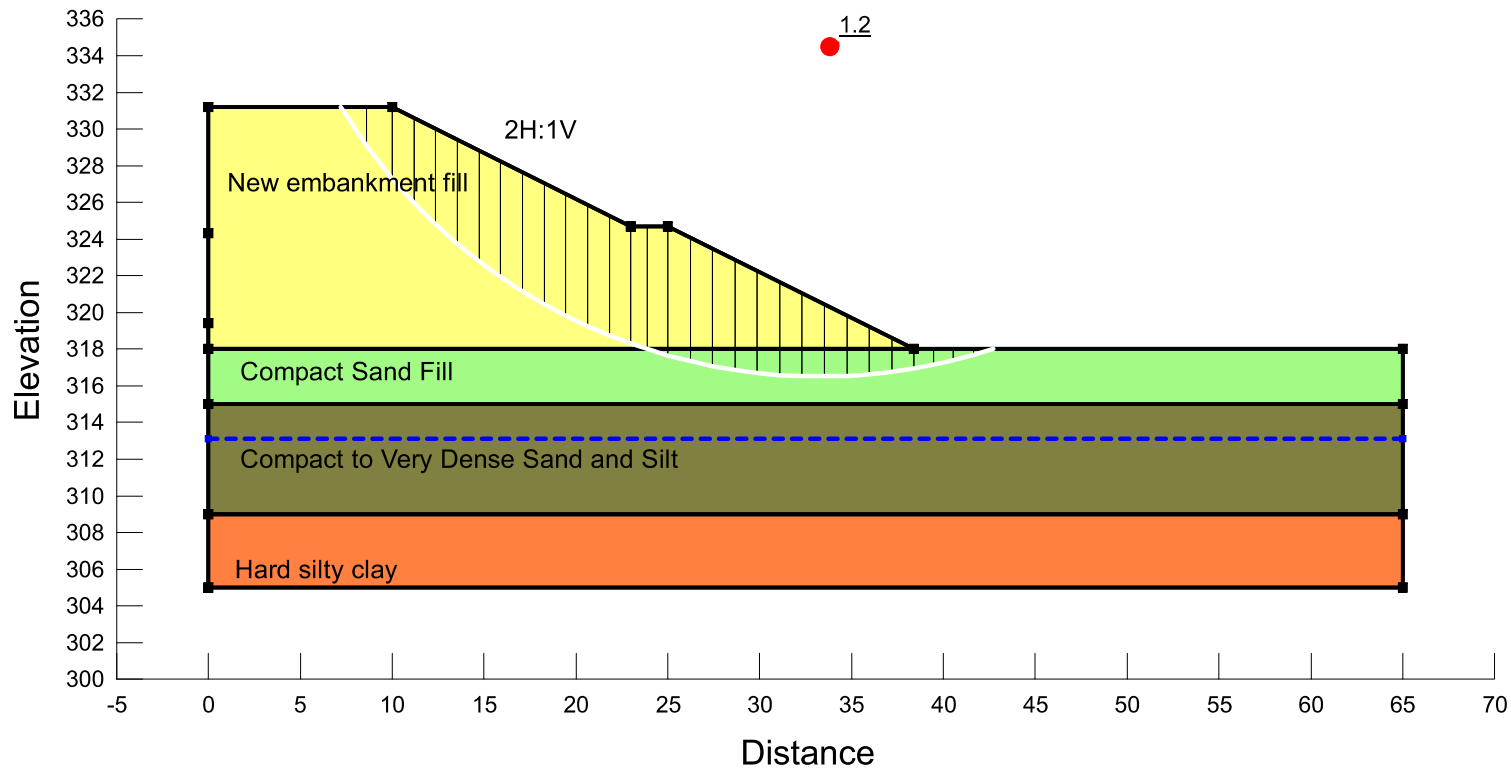


Figure 3F



Appendix G

List of OPSS Documents and Nssp Wording



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
- SP 109S12 Amendment to OPSS 902
- OPSS PROV 903 Construction specification for deep foundations
- SP109F57 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 3101.150 Wall abutment, backfill minimum granular requirement



2. Suggested text for a NSSP on Pile Installation

Installation of H-piles shall be in accordance with OPSS.PROV 903 and the following.

The native soils at the NE Ramp over Highway 85 are comprised of glacial till and are known to contain cobbles and boulders. Appropriate equipment and construction procedures will be required to penetrate or remove obstructions, such as cobbles and boulders, to permit pile installation. Pile driving must be controlled according to the criteria specified for the site.

Should a pile achieve the design ultimate geotechnical resistance or refusal at a tip elevation higher than that indicated in the contract, the Contract Administrator (CA) shall be informed immediately who should consult with the design team for resolution. Over-driving must be avoided to minimize the risk of damaging the pile.

3. Suggested Text for NSSP on Groundwater Control

Water seepage due to perched water in the slope, random fill, surface runoff and precipitation should be expected. For temporary excavations for retaining wall construction at this site, groundwater control will likely be limited to diverting surface runoff and preventing precipitation from entering the excavations supplemented by sump pumping and use of perimeter ditches where required. Filtered sumps must be designed properly so that construction drainage water containing eroded soil and fines do not flow onto the existing roadways. For bridge foundation construction, appropriate dewatering systems must be installed and made operational prior to excavating below the groundwater level. The dewatering scheme must be effective to lower the groundwater level at least 0.5 m below the footing/pile cap grade level to avoid base boiling in the native soils. It is also important to minimize disturbance of the exposed silty sand surfaces by limiting construction traffic.



4. Suggested Text for NSSP on “Impact on Adjacent Structure”

It is critical that Contractor’s excavation and construction activities do not undermine or have any adverse impact on the integrity and performance of any adjacent structures or underground utilities:

- The lanes of the Kitchener-Waterloo Express way and Wellington Street will be open to traffic during excavation and foundation construction of NE Ramp over Highway 85.
- Protection of structure foundations and utilities (if present at this site) during excavation and pile driving.
- Protection of existing approach fills.